Fire Safe Construction
Cost Comparison Study

Executive Summary Report

Cover Photo (center): Virginia Commonwealth University Fire
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Executive Summary Report

November 2, 2005
Commission Number 05119

Prepared By:

Haas Architects Engineers
1301 North Atherton Street
State College, Pennsylvania

Sponsored By:

New England/New York Fire Safety Construction Advisory Council
Pennsylvania Fire Safe Construction Advisory Council
Mid-Atlantic Fire Safety Construction Advisory Council
Northeast Cement Shippers Association

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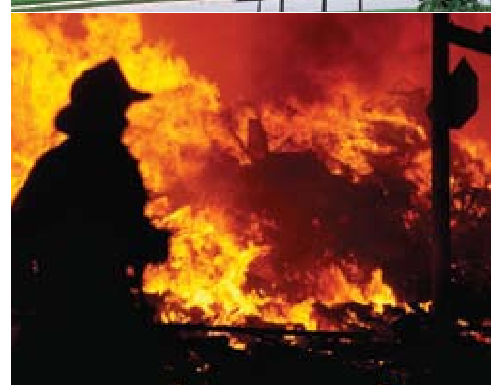
Introduction

With the phasing out of the three predominate model codes, BOCA National Building Code, Southern Building Code, and Uniform Building Code, and implementation of the new International Building Code and associated family of codes, there has been a shift in the approach to fire safety in the built environment. This shift has been characterized as a shift away from the use of passive construction techniques, such as compartmentalization and the use of fireproof construction materials, in favor of an increased reliance on active fire control techniques such as sprinkler systems, allowing for construction to occur using materials that are more susceptible to fire damage.

In conjunction with this shift there are also reservations with the current ASTM (American Society for Testing and Materials) methodology for testing fire assemblies ASTM E119, Standard Test Methods for Fire Tests of Building Construction and Materials. This test allows for the removal and replacement of the fire tested specimen prior to the initiation of the hose stream test. This test combination is intended to model the effects of the application of a fire suppression stream immediately after the intense heat from a compartment fire. The effect of this provision is that the specimen is a virgin test specimen when the fire suppression stream is applied, theoretically allowing certain materials to artificially perform at a higher level than would be expected in the field.

In addition, it has long been the opinion of legislators, code-officials, and design professionals that non-combustible concrete construction solutions are more costly than other alternatives such as gypsum fire walls with sprinklers.

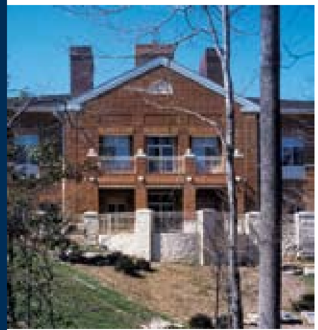


Due to the perception of elevated cost, and the aforementioned code and testing issues, the acceptance of a balanced design approach incorporating both passive and active protection systems has met with resistance. Passive design incorporates the compartmentalization of the fire, limiting fire spread and protecting both the building occupants and the responding firefighters. This system is in place at all times and is not subject to failure due to the loss of utility service. An example of this is the incorporation of fireproof materials in the construction of floors and walls used for fire control. The active portion of the design uses a combination of detection systems to warn occupants, and sprinklers to control fire spread until the fire department arrives.

Currently, there is no reliable published documentation available to refute the perception regarding the increased building cost associated with this approach. Based on this lack of information, the design of a comparative study was undertaken to accurately document the increased cost associated with the use of balanced design in a common multi-family residential building. It is our pleasure to present the outcomes of this study.

Objectives

The objective of this study was to develop a construction cost model to accurately evaluate the relative construction cost of a multi-family building constructed using five different construction materials. The concept of multi-family would include traditional apartment type buildings, condominium style buildings, student housing, elderly housing, and others.



Methodology

Introduction

To accurately evaluate the relative construction cost between each of the five building systems, it was determined that a multi-family residential structure should be schematically designed meeting all of the requirements of the International Building Code 2003 edition. Once designed, the building would be reviewed for code compliance, and cost estimates would be prepared for the building using each of the different building systems.

The design team assembled included:

ARCHITECT & ENGINEER: *Haas Architects Engineers*

CODE OFFICIAL: *Tim E. Knisely*

COST ESTIMATION: *Poole Anderson Construction*

Haas Architects Engineers is a multi-disciplinary architectural and engineering firm located in State College, Pennsylvania with a thirty year history of client centered service including commercial, single and multi-family residential, retail, and sports based projects. Some projects include the Bryce Jordan Center and 2001 Beaver Stadium Expansion, both at The Pennsylvania State University.

Tim E. Knisely is a senior fire and commercial housing inspector for the Centre Region Code Administration, in State College, Pennsylvania. Mr. Knisely currently holds a certification as a registered Building Code Official in the Commonwealth of Pennsylvania and holds more than eight certifications from the International Code Council. In addition, Mr. Knisely has been involved in the fire service for more than 20 years.

Poole Anderson Construction is one of the largest building contractors in Central Pennsylvania with a 75 year history and an annual construction volume exceeding 60,000,000 dollars.

A firm profile for Haas Architects Engineers and Poole Anderson Construction is provided in Appendix A* along with resumes for each of the professionals involved with the project.

Building Model

The building model chosen for the project was a 4 story multi-family residential structure encompassing approximately 25,000 gross square feet of building area per floor. Based on the proposed target building types, it was decided that to better evaluate the relative construction costs, two different floor layouts would be used. The first model is a building comprised exclusively of single bedroom dwelling units. The second model is assembled using a mix of one and two bedroom dwelling units.

The combination of the two different layout considerations would more realistically address the variety of construction configurations commonly found in the multi-family dwelling marketplace. Schematic floor plans, elevations and detailed wall sections for each of the building models are provided. In Appendix B* full size copies of these are provided for additional clarity.

*Appendix is part of a total report of 800 pages.






Construction Types

The following construction types and alternates were evaluated:

- Conventional wood framing with wood floor system (Type 5B Construction)
  Alternate: Conventional wood framing with wood floor system (Type 5A Construction)
- Light Gauge Steel Framing with cast-in-place concrete floor system on metal form deck
- Load bearing concrete masonry construction with precast concrete plank floor system
  Alternate: Cast-in-place concrete floor system
- Precast concrete walls and precast concrete floor system
- Insulated Concrete Form (ICF) walls and precast concrete plank floor system
  Alternate: Cast-in-place concrete floor system
  Alternate: Interior bearing walls constructed of concrete masonry units (CMU)

With respect to the conventional wood framing system presented, the primary system is an un-protected construction Type 5B with an alternate of protected construction Type 5A. The additional construction type was presented since the Type 5B construction is not permitted to be used for a building of this type that is four stories tall. For the proposed use and construction height using conventional wood frame Type 5A would need to be used. Both systems are presented since the remaining systems are presented as un-protected framing systems.

For all systems other than the conventional wood frame systems, it was assumed that the partition walls within the dwelling unit would be constructed using metal stud finished with gypsum board.

Code Review

Once design was completed on each of the buildings, Mr. Knisely performed a detailed code review following the requirements of the International Building Code 2003 edition. This review was conducted following the plan review forms provided by the International Code Council and these forms are provided for review in Appendix C*. This review was in addition to the review performed internally by the professionals at Haas Architects Engineers. The review forms used by Haas Architects Engineers are also provided for review in Appendix C*.

The reader is alerted to the fact that there are a number of items that are common to all of the buildings that were not addressed in this study and that are missing from the code review forms. These items are typically dealing with site issues, soils information, etc. All of these items are common to each of the buildings and would add identical cost to each project. This was verified with the cost estimation personnel at Poole Anderson Construction.

Cost Estimation

To increase the direct applicability of the cost study a decision was made to complete the study in three different locations. The locations were chosen by each of the contributing groups, feeling that they represented the construction climate in their respective area. The locations chosen are as follows:

- Framingham, Massachusetts
- Harrisburg, Pennsylvania
- Towson, Maryland
- Albany, New York (added after completion of the original study)

To allow for a fair and uniform comparison of the construction costs between trades it was determined that the cost study would use accepted prevailing wage rates published for each of the locations. These labor rates would be typical for a publicly funded project and will allow for a fair labor comparison, eliminating potential undercutting by any of the trades.

The cost estimate for each building model included the complete fit out of each building with the exception of movable appliances and furniture.

The labor rates used for each of the estimates are presented with the detailed cost estimate, located in Appendix D*.

Results and Discussion

The results of the construction cost study for each geographic location are presented in the following tables. The relative cost presented is a percentage of the minimum cost system presented.

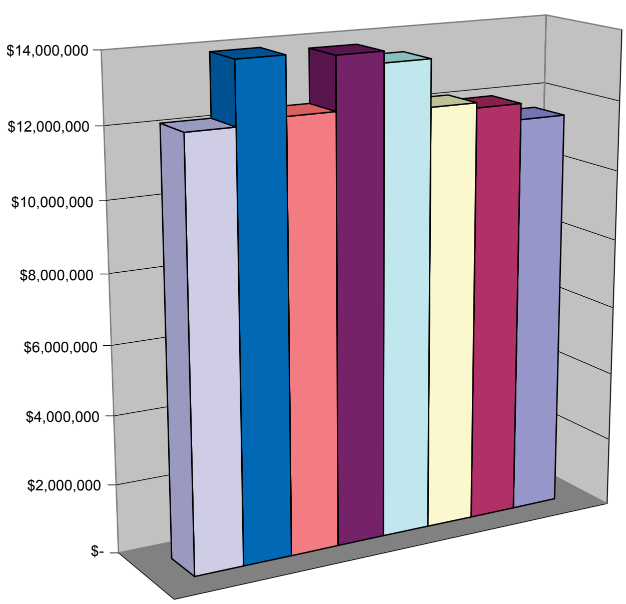
*Appendix is part of a total report of 800 pages.

Harrisburg, PENNSYLVANIA

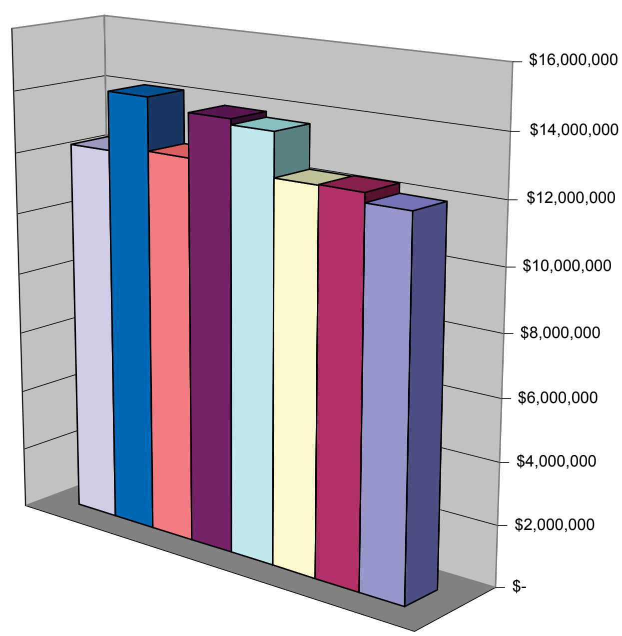
Building System	Cost	Relative Cost
Conventional Wood Framing Single Bedroom Scheme	$11,536,117.00	100
Type 5b 3 Stories Only	$ 9,323,705.00	
Conventional Wood Framing Mixed Bedroom Scheme	$11,993,226.00	100
Type 5b 3 Stories Only	$ 9,585,726.00	
Light Gauge Steel Framing Single Bedroom Scheme	$11,991,669.00	104
Light Gauge Steel Framing Mixed Bedroom Scheme	$12,297,143.00	103
Masonry & Precast Single Bedroom Scheme	$12,140,211.00	105
Masonry & Precast Mixed Bedroom Scheme	$12,276,406.00	102
Form In Place Concrete Floor Alternate (Single)	$13,463,378.00	117
Form In Place Concrete Floor Alternate (Mixed)	$13,667,826.00	114
Precast Construction Single Bedroom Scheme	$13,780,169.00	120
Precast Construction Mixed Bedroom Scheme	$13,851,510.00	116
ICF Walls & Precast Plank Single Bedroom Scheme	$12,279,484.00	106
ICF Walls & Precast Plank Mixed Bedroom Scheme	$12,445,030.00	104
Form In Place Concrete Floor Alternate (Single)	$13,901,442.00	121
Form In Place Concrete Floor Alternate (Mixed)	$14,154,962.00	118
Interior CMU Walls Alternate (Single)	$12,141,508.00	105
Interior CMU Walls Alternate (Mixed)	$12,262,224.00	102

The least expensive system for both building models is the conventional wood framing system. The relative cost of the most expensive framing system, the insulated concrete form system with cast-in-place concrete floor is 21 percent and 18 percent higher for the single bedroom model and mixed bedroom model respectively. The load bearing masonry wall system with precast concrete plank floor system and insulated concrete form wall system with precast concrete plank floor system both compare very favorably with both the conventional wood frame system and the light gauge steel framing system, with an increased cost of less than 6 percent over the conventional wood frame system.

Harrisburg, Pennsylvania Single Bedroom



Harrisburg, Pennsylvania Mixed Bedroom



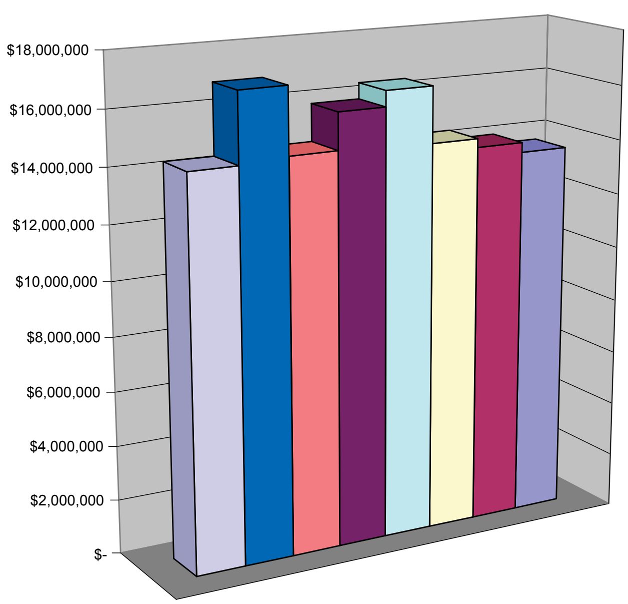
Conventional Wood Frame | Masonry/Precast Plank | Precast | ICF/Cast-in-place
Light Gauge Steel | Masonry/Cast-in-place | ICF/Precast | ICF/Masonry

Framingham, MASSACHUSETTS

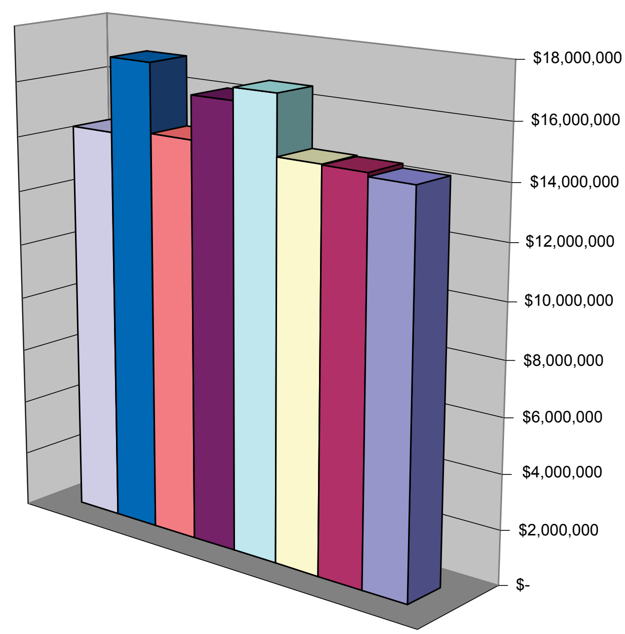
Building System	Cost	Relative Cost
Conventional Wood Framing Single Bedroom SCHEME	$13,636,238.00	100
Type 5b 3 Stories Only	$10,976,204.00	
Conventional Wood Framing Mixed Bedroom Scheme	$14,262,504.00	100
Type 5b 3 Stories Only	$11,394,511.00	
Light Gauge Steel Framing Single Bedroom Scheme	$13,996,424.00	103
Light Gauge Steel Framing Mixed Bedroom Scheme	$14,411,520.00	101
Masonry & Precast Single Bedroom Scheme	$14,316,223.00	105
Masonry & Precast Mixed Bedroom Scheme	$14,440,514.00	101
Form In Place Concrete Floor Alternate (Single)	$16,361,225.00	120
Form In Place Concrete Floor Alternate (Mixed)	$16,575,134.00	116
Precast Construction Single Bedroom Scheme	$15,786,386.00	116
Precast Construction Mixed Bedroom Scheme	$16,112,941.00	113
ICF Walls & Precast Plank Single Bedroom Scheme	$14,441,088.00	106
ICF Walls & Precast Plank Mixed Bedroom Scheme	$14,548,965.00	102
Form In Place Concrete Floor Alternate (Single)	$16,847,965.00	124
Form In Place Concrete Floor Alternate (Mixed)	$17,045,527.00	120
Interior CMU Walls Alternate (Single)	$14,299,993.00	105
Interior CMU Walls Alternate (Mixed)	$14,356,625.00	101

The least expensive system for both building models is the conventional wood framing system. The relative cost of the most expensive framing system, the insulated concrete form system with cast-in-place concrete floor is 24 percent and 20 percent higher for the single bedroom model and mixed bedroom model respectively. The load bearing masonry wall system with precast concrete plank floor system and insulated concrete form wall system with precast concrete plank floor system both compare very favorably with both the conventional wood frame system and the light gauge steel framing system, with an increased cost of less than 6 percent over the conventional wood frame system.

Framingham, Massachusetts Single Bedroom



Framingham, Massachusetts Mixed Bedroom



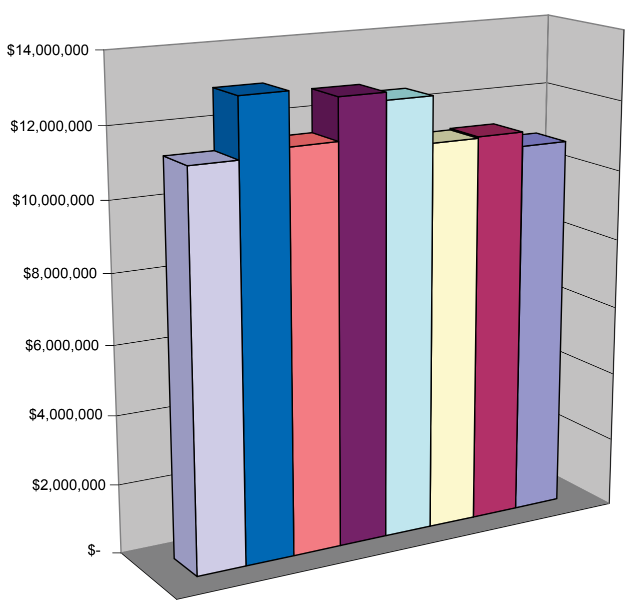
Conventional Wood Frame | Masonry/Precast Plank | Precast | ICF/Cast-in-place
Light Gauge Steel | Masonry/Cast-in-place | ICF/Precast | ICF/Masonry

Towson, MARYLAND

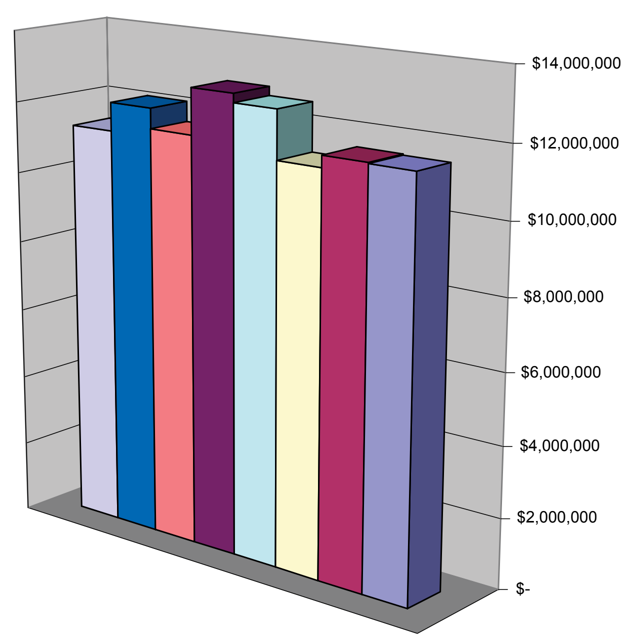
Building System	Cost	Relative Cost
Conventional Wood Framing Single Bedroom Scheme	$10,779,264.00	100
Type 5b 3 Stories Only	$ 8,496,437.00	
Conventional Wood Framing Mixed Bedroom Scheme	$11,540,327.00	100
Type 5b 3 Stories Only	$ 8,931,852.00	
Light Gauge Steel Framing Single Bedroom Scheme	$11,183,801.00	104
Light Gauge Steel Framing Mixed Bedroom Scheme	$11,573,002.00	100
Masonry & Precast Single Bedroom Scheme	$11,145,966.00	103
Masonry & Precast Mixed Bedroom Scheme	$11,249,743.00	98
Form In Place Concrete Floor Alternate (Single)	$12,453,743.00	116
Form In Place Concrete Floor Alternate (Mixed)	$12,599,629.00	109
Precast Construction Single Bedroom Scheme	$12,680,336.00	118
Precast Construction Mixed Bedroom Scheme	$12,850,342.00	111
ICF Walls & Precast Plank Single Bedroom Scheme	$11,475,947.00	107
ICF Walls & Precast Plank Mixed Bedroom Scheme	$11,565,232.00	100
Form In Place Concrete Floor Alternate (Single)	$12,957,185.00	120
Form In Place Concrete Floor Alternate (Mixed)	$12,129,126.00	105
Interior CMU Walls Alternate (Single)	$11,273,890.00	105
Interior CMU Walls Alternate (Mixed)	$11,326,383.00	98

The least expensive system for the single bedroom building is the conventional wood framing system; however the load bearing masonry wall system with precast concrete plank floor system was the least expensive system for the mixed bedroom building. The most expensive building system was found to be the insulated concrete form wall system with cast-in-place concrete floor with an increased cost of 20 percent for the single bedroom system. For the mixed bedroom building the precast concrete wall system with cast-in-place concrete floor system was deemed to be most expensive with an increased cost of 14 percent.

Towson, Maryland Single Bedroom



Towson, Maryland Mixed Bedroom



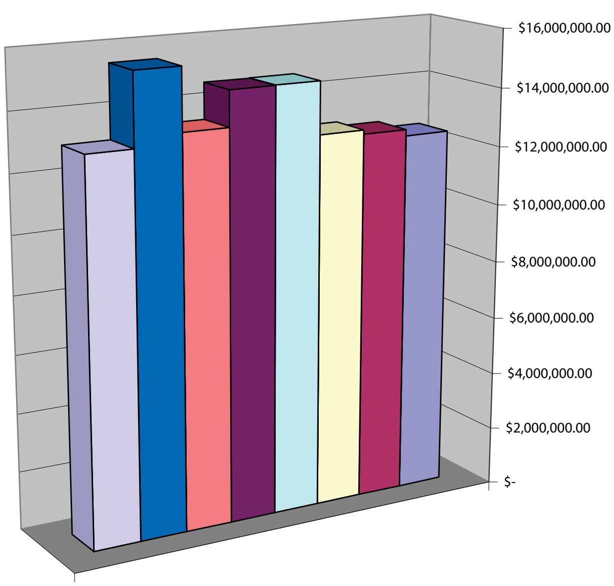
Conventional Wood Frame | Masonry/Precast Plank | Precast | ICF/Cast-in-place
Light Gauge Steel | Masonry/Cast-in-place | ICF/Precast | ICF/Masonry

Albany, NEW YORK

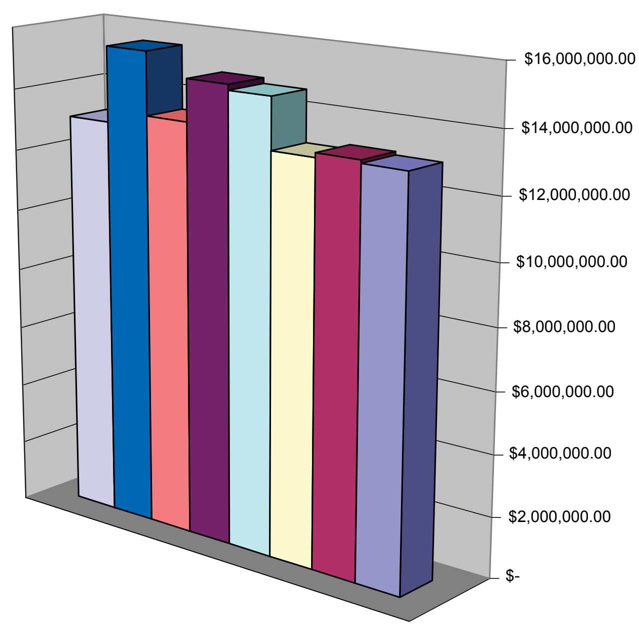
Building System	Cost	Relative Cost
Conventional Wood Framing Single Bedroom Scheme	$12,452,103.00	100
3 Story Only	$10,014,770.00	
Conventional Wood Framing Mixed Bedroom Scheme	$13,046,765.00	100
3 Story Only	$10,613,839.00	
Light Gauge Steel Framing Single Bedroom Scheme	$12,666,154.00	102
Light Gauge Steel Framing Mixed Bedroom Scheme	$13,148,239.00	101
Masonry & Precast Single Bedroom Scheme	$12,813,503.00	103
Masonry & Precast Mixed Bedroom Scheme	$13,004,986.00	100
Form In Place Concrete Floor Alternate (Single)	$14,583,356.00	117
Form In Place Concrete Floor Alternate (Mixed)	$14,647,415.00	112
Precast Construction Single Bedroom Scheme	$14,572,692.00	117
Precast Construction Mixed Bedroom Scheme	$14,832,562.00	114
ICF Walls & Precast Plank Single Bedroom Scheme	$13,365,117.00	107
ICF Walls & Precast Plank Mixed Bedroom Scheme	$13,476,170.00	103
Form In Place Concrete Floor Alternate (Single)	$15,464,431.00	124
Form In Place Concrete Floor Alternate (Mixed)	$15,530,200.00	119
Interior CMU Walls Alternate (Single)	$13,010,204.00	105
Interior CMU Walls Alternate (Mixed)	$13,090,202.00	100

The least expensive system for the single bedroom building is the conventional wood framing system. However, the load bearing masonry wall system with precast concrete plank floor system proved equal in cost to the conventional wood frame system in the mixed bedroom scheme. The most expensive building system was found to be the insulated concrete form wall system with cast-in-place concrete floor with an increased cost of 24% in the single bedroom scheme, and 19% in the mixed bedroom scheme. The insulated concrete form wall system combined with precast plank flooring and interior concrete masonry walls compared very favorably with both the wood framing and light gauge steel alternatives.

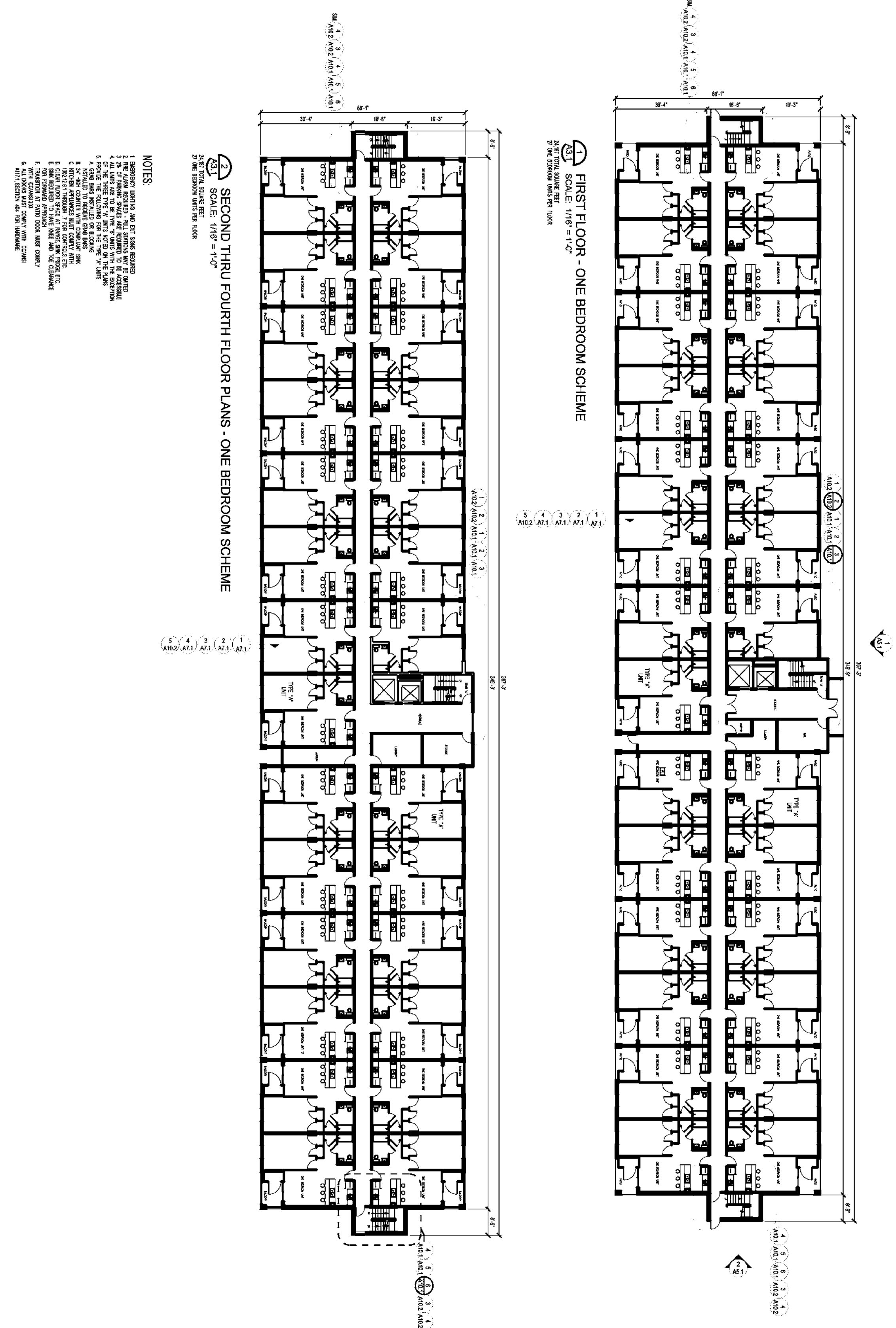
Albany, New York Single Bedroom



Albany, New York Mixed Bedroom



Conventional Wood Frame
Light Gauge Steel
Masonry/Precast Plank
Masonry/Cast-in-place
Precast
ICF/Precast
ICF/Cast-in-place
ICF/Masonry



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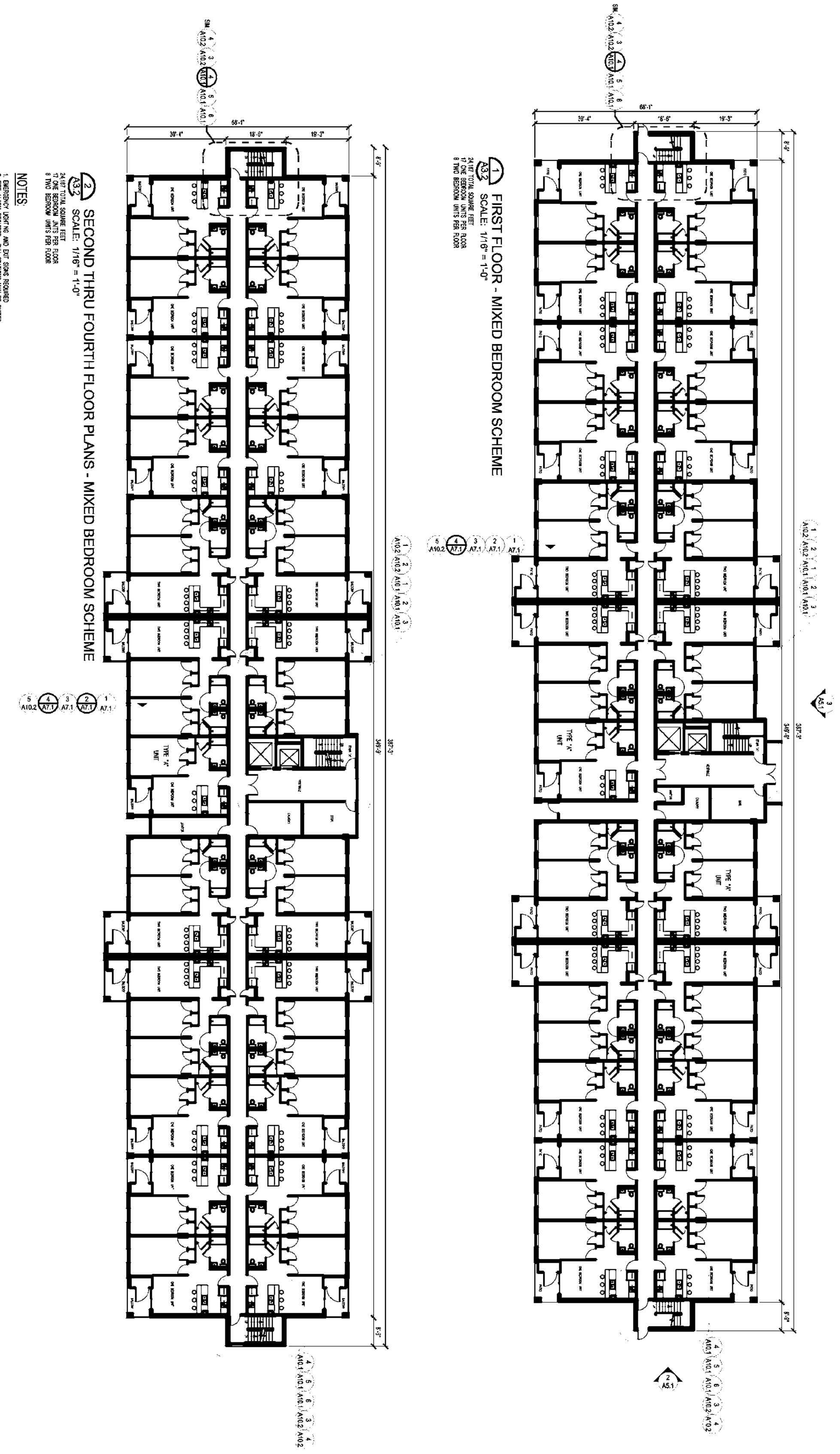
A3.1 FIRST AND SECOND FLOOR PLANS ONE BEDROOM UNITS	BUILDING COST COMPARISON STUDY	HAAS ARCHITECTS ENGINEERS



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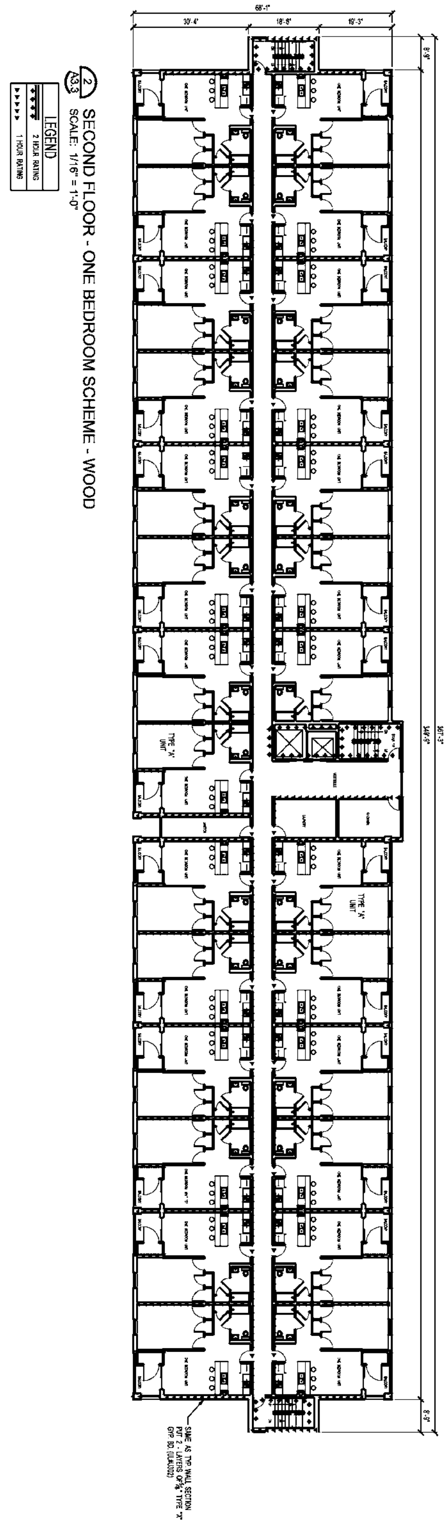
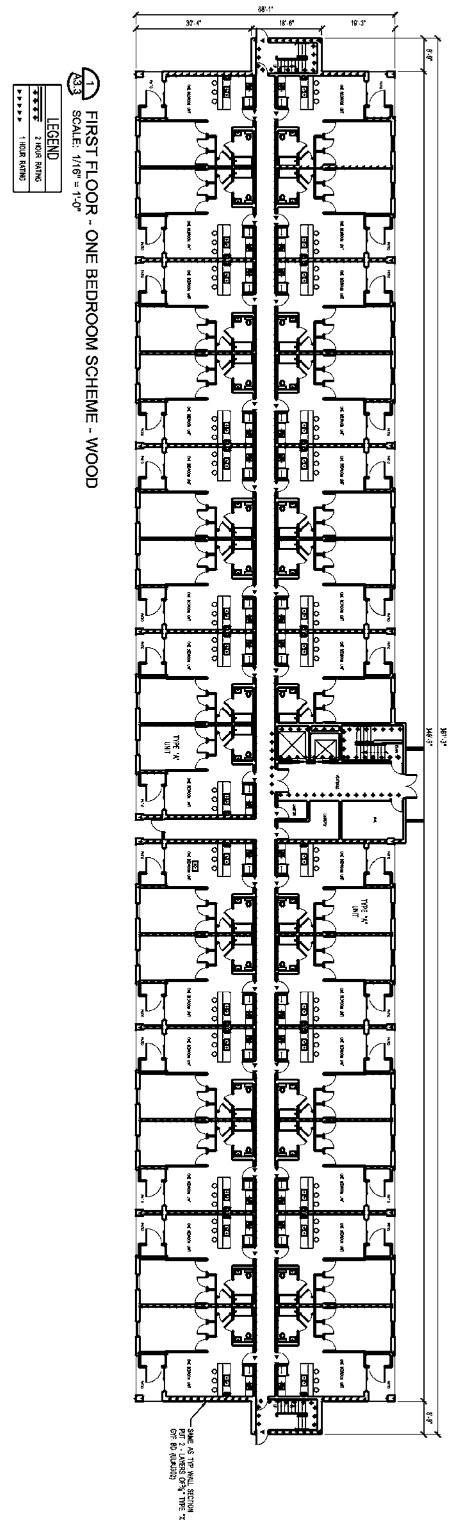
A3.2 FIRST AND SECOND FLOOR PLAN - MIXED BEDROOM UNITS 05119 CMC OCTOBER 19, 2005	BUILDING COST COMPARISON STUDY	HAAS ARCHITECTS ENGINEERS





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BUILDING COST COMPARISON STUDY

HAAS ARCHITECTS ENGINEERS

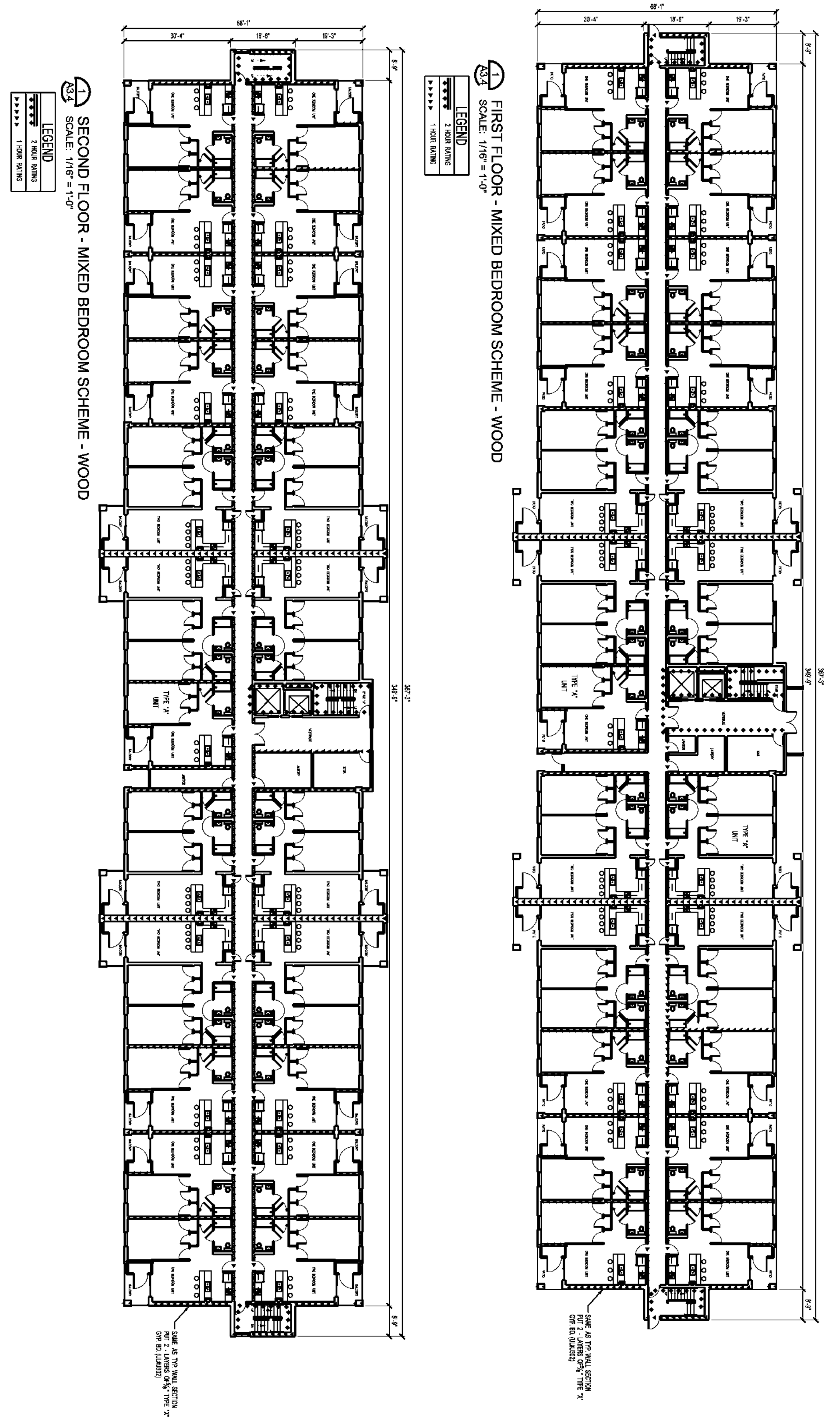
A3.3

FIRST AND SECOND ONE BEDROOM UNITS FLOOR PLANS - WOOD FIRE RATINGS

05119

CMC

OCTOBER 19, 2005



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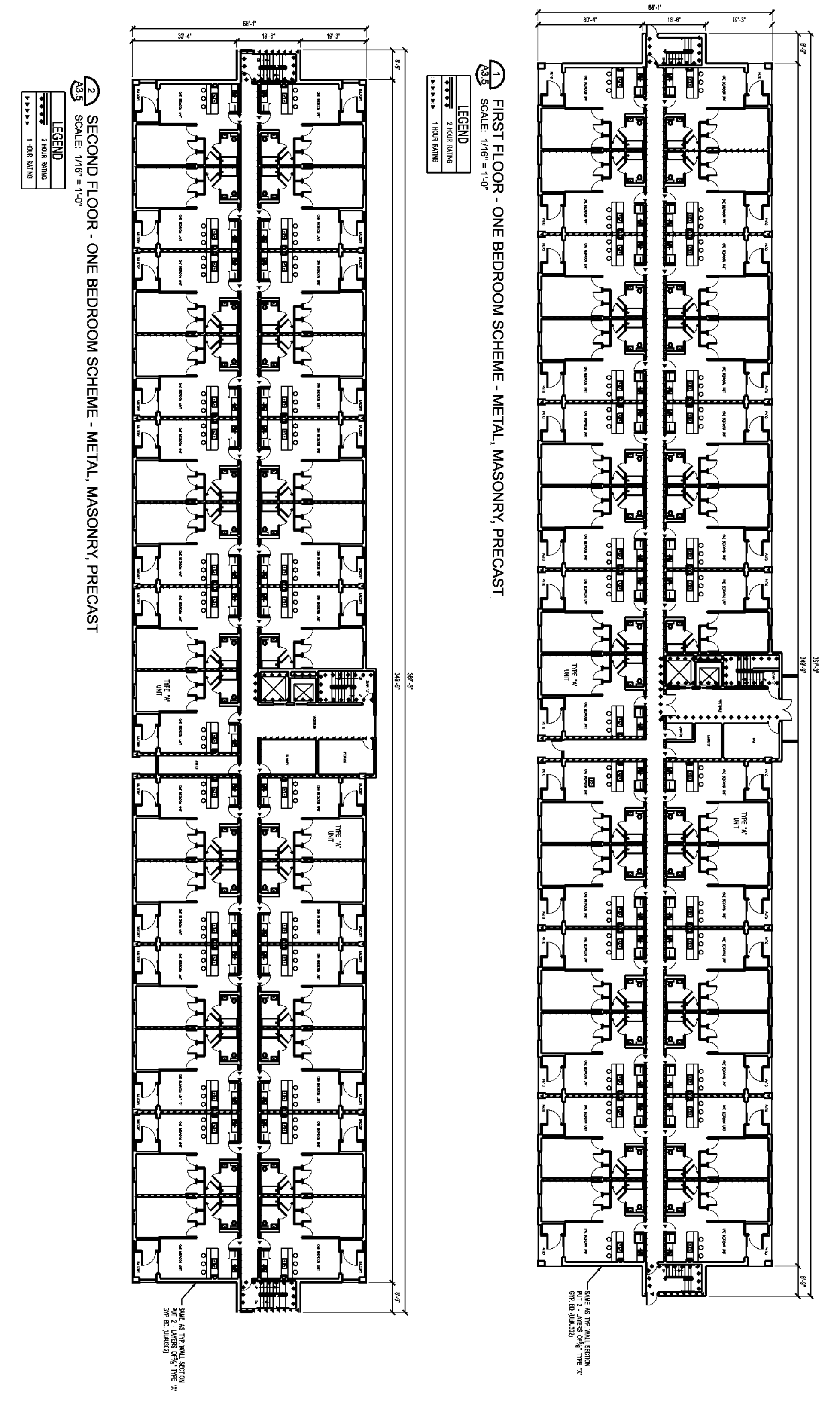
A3.4 FIRST AND SECOND MIXED BEDROOM UNITS FLOOR PLANS - WOOD FIRE RATINGS 05119 CMC OCTOBER 19, 2005	BUILDING COST COMPARISON STUDY	HAAS ARCHITECTS ENGINEERS



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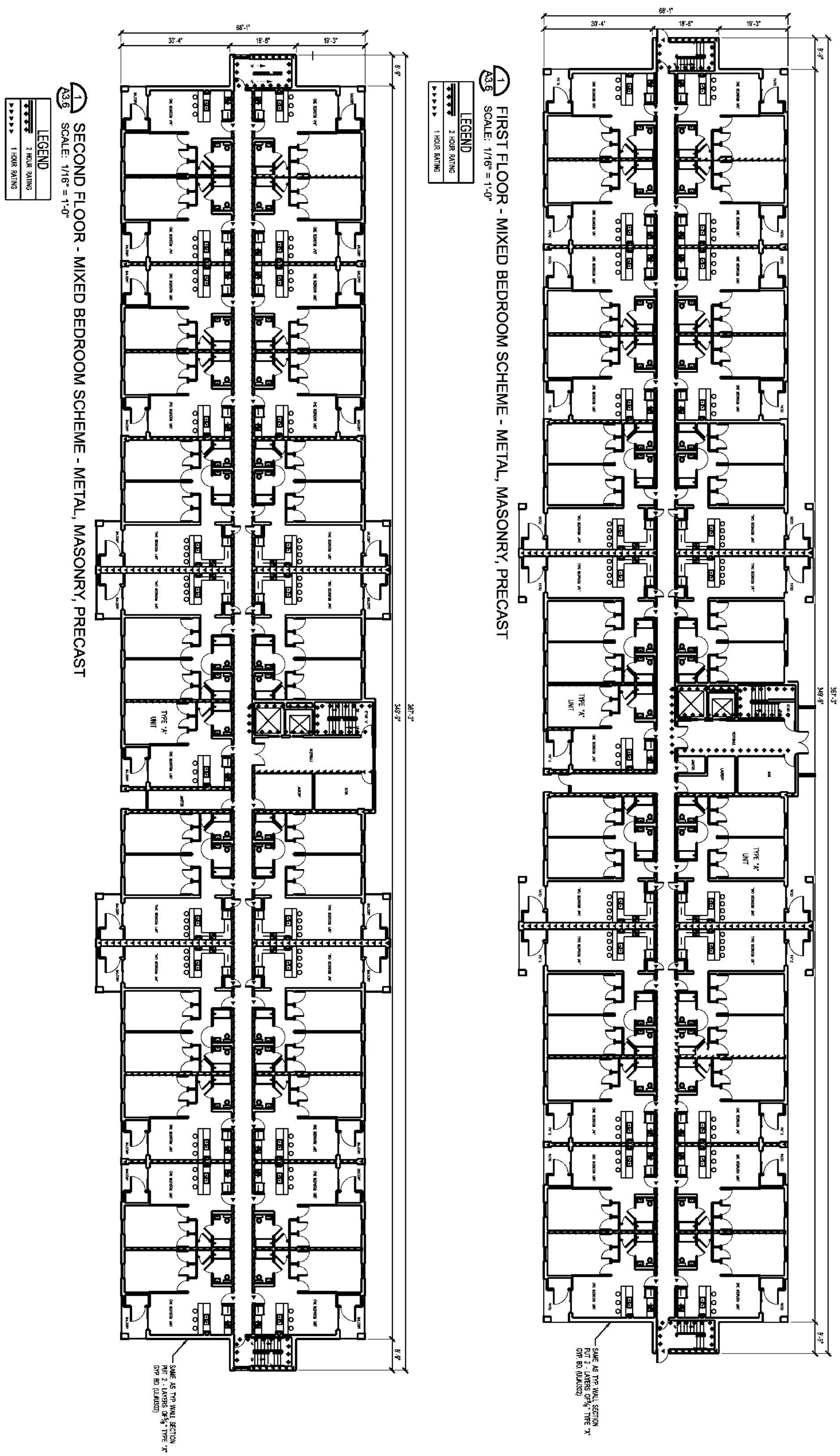
A3.5	FIRST AND SECOND ONE BEDROOM UNITS FLOOR PLANS - METAL, MASONRY, PRECAST FIRE RATINGS 0519 CMC OCTOBER 19, 2005	BUILDING COST COMPARISON STUDY	HAAS ARCHITECTS ENGINEERS



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A3.6

FIRST AND SECOND MIXED BEDROOM UNITS FLOOR PLANS - METAL, MASONRY, PRECAST FIRE RATINGS

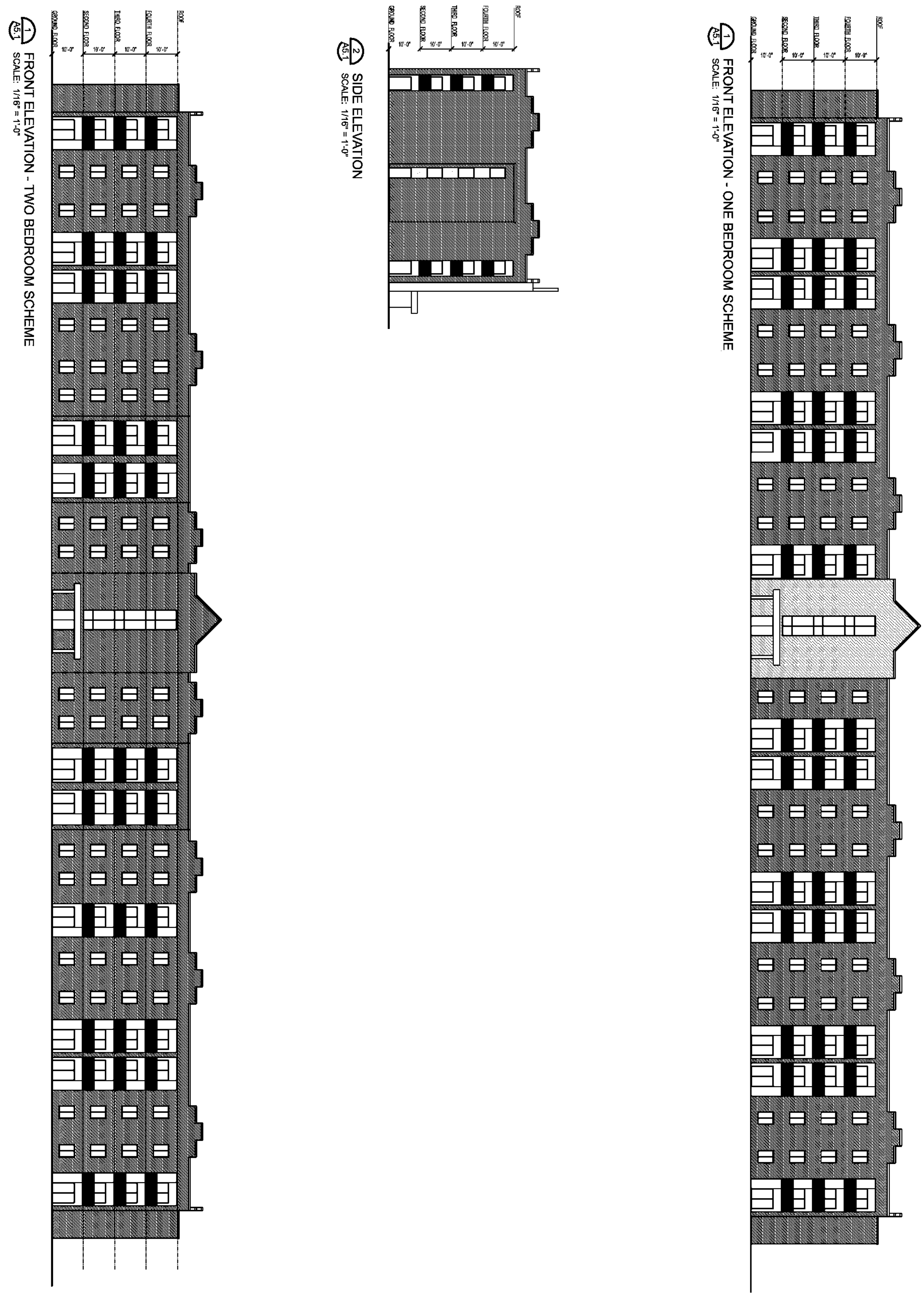
05519

CMC

OCTOBER 19, 2005

BUILDING COST COMPARISON STUDY

HAAS ARCHITECTS ENGINEERS



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ELEVATIONS

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REV. DATE

DATE: OCTOBER 19, 2005

SCALE

BUILDING COST COMPARISON STUDY

HAAS ARCHITECTS ENGINEERS
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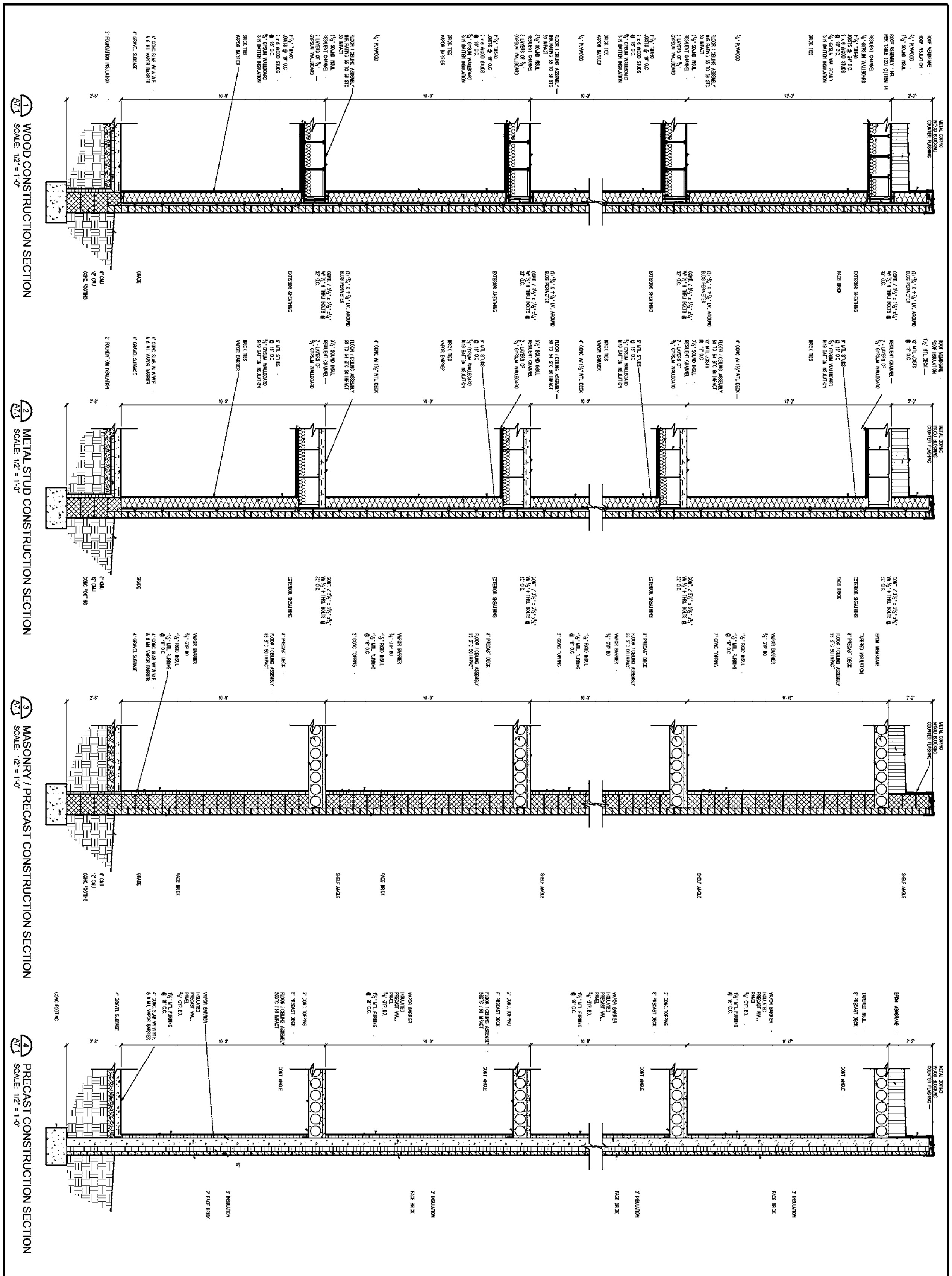

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A7.1 WALL SECTIONS	05119 · CMC · OCTOBER 19, 2006	BUILDING COST COMPARISON STUDY

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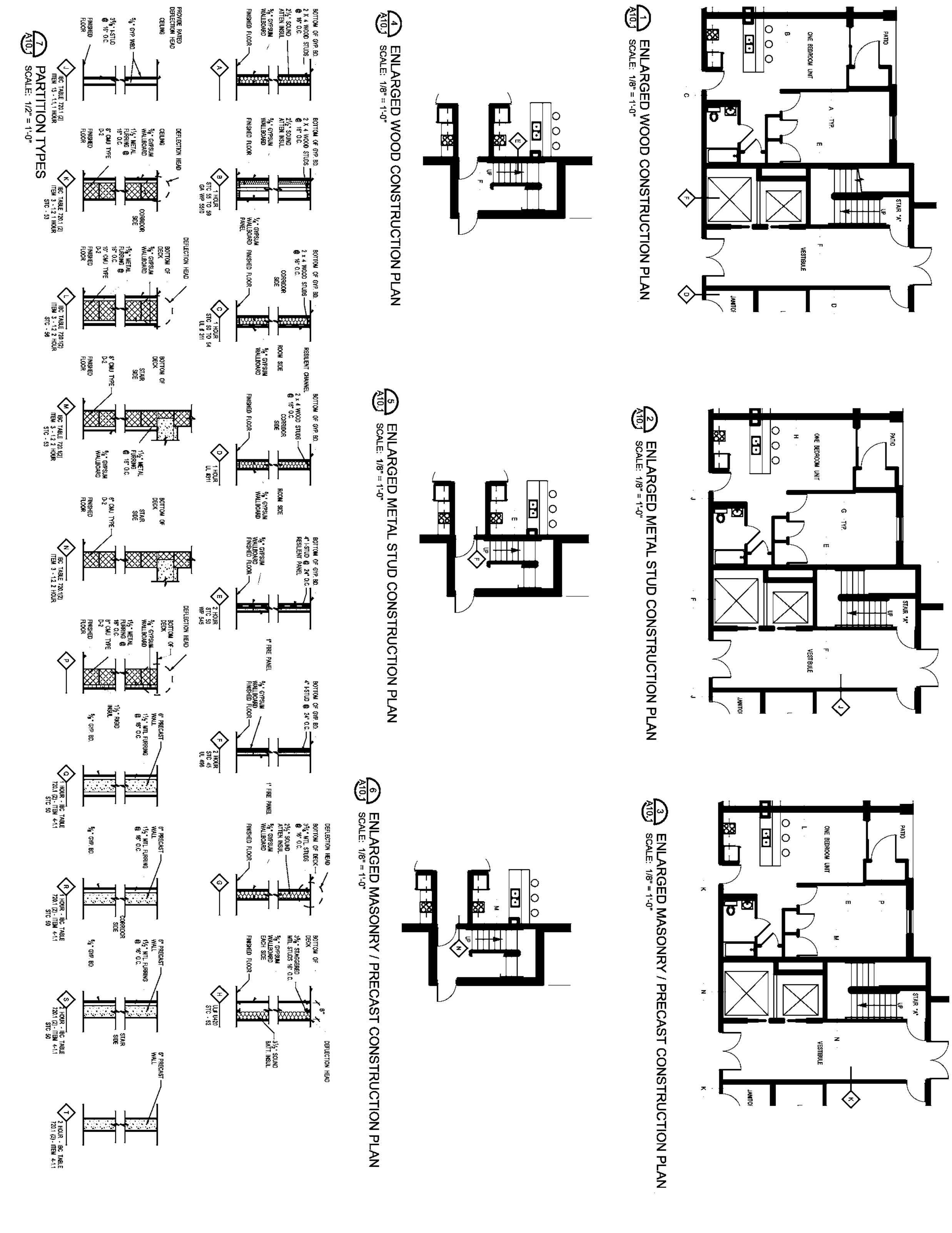

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A10.1	ENLAGED PLANS AND PARTITION TYPES	05119	CMC	OCTOBER 19, 2005	BUILDING COST COMPARISON STUDY	HAAS ARCHITECTS ENGINEERS 1301 NORTH ATHERTON STREET • STATE COLLEGE PA 16803 • 814-238-1551 FAX : 814-238-8046 www.HaasAEP.com mail@HaasAEP.com

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A10.2	ENLARGED PLANS AND WALL SECTION	OCTOBER 18, 2006	BUILDING COST COMPARISON STUDY

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Conclusion

Based on the construction cost estimates prepared by Poole Anderson Construction, the cost associated with a compartmentalized construction method utilizing a concrete based material was generally less than 5 percent of the overall construction cost. Comparatively speaking this amount is less than the contingency budget typically recommended for the owner to carry for unanticipated expenditures during the project.

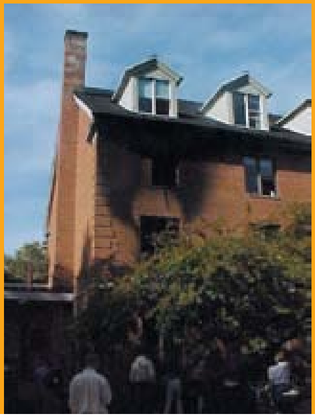
The minimal increase in construction cost can be paid for over the life of the structure. Materials like concrete masonry, precast concrete, and cast-in-place concrete have many other advantages beyond their inherent fire performance including resistance to mold growth, resistance to damage from vandalism, and minimal damage caused by water and fire in the event of a fire in the building. In many cases, with this type of construction the damage outside of the fire compartment is minimal. This provides for reduced cleanup costs and quicker reoccupation of the structure.

Containment Example: Dormitory Fire Contained

On October 11, 2001, fire engulfed the **Rees Hall Dormitory at Hobart and William Smith Colleges** in Geneva, New York. Temperatures soared as high 1800°F resulting in melted plastic picture frames, light fixtures, smoke detectors, metal hinges and the steel door of the room where the fire began. Within 20 minutes, the raging fire had caused approximately $100,000 in damages. This small repair bill was attributed to the fact that concrete construction contained the fire and saved the building from being completely destroyed.

Originally constructed in 1969 with concrete masonry and hollow-core floor planks, the building is **"durable and fire resistant,"** says Christopher J. Button, Senior Project Manager, HWS, **"and has much lower maintenance and insurance costs."** Replacing the entire structure would have cost as much as $5 million.

Button says he'd always believed any building with a smoke detector and non-combustible materials would withstand similar catastrophes, but after seeing how concrete stood up to the intense fire, he's ***"a believer in concrete construction."***



NE/NY Fire Safety Construction Advisory Council
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