

Introduction

In 2005 the Fire Safety Construction Advisory Council contracted with Haas Architects Engineers of State College, Pennsylvania to develop a fair and impartial evaluation of multiple types of construction and their relative cost for multi-family housing. The study was developed in response to comments regarding the extreme cost associated with the upgrading of the construction type to a more robust construction model. After eleven years and many changes to the building codes and the construction industry as a whole, it was decided to revisit the original study to evaluate what changes have resulted and the impact of those changes to the cost of multi-family construction.

The 2005 study originally characterized 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 has continued. There has also been a shift in building contents toward more synthetic materials and increased fire loads.

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 an elevated level then would be expected in the field.

In addition, it has long been and in many cases is still the opinion of legislators, code-officials, and design professionals that non-combustible, more robust concrete construction solutions are significantly more costly than other alternatives such as gypsum fire walls with sprinklers. This was combatted with the original 2005 Fire Safety Construction Cost Study, which documented in many cases these types of construction models can be used on an equal financial footing as the more lightweight models like metal stud and light wood frame.

Due to the perception of elevated cost, and the afore mentioned code and testing issues, the acceptance of a balanced design approach incorporating both passive and active protection systems has met with resistance. The 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.

With the exception of the 2005 Fire Safe Construction Cost Comparison Study, 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, and perceived changes in the code and construction environment, the design of an updated 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.

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 six different construction materials. The concept of multi-family would include traditional apartment type buildings, condominium style buildings, student housing, elderly housing, and others.

Study Methodology

Introduction

To accurately evaluate the relative construction cost between each of the six 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, 2015 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:

Design & Code Review: Walter G. M. Schneider III, Ph.D., P.E., MCP, CBO, CFO
Ryan L. Solnosky, Ph.D., P.E.
Cost Estimation: Chad M. Maholtz

Dr. Schneider, the project manager and principal in charge of the 2005 Fire Safe Construction Cost Comparison Study for Haas Architects Engineers was selected to assemble the new design team. Dr. Schneider is registered as a professional engineer in six states, and a International Code Council (ICC) Master Code Professional, and has been actively designing buildings for more than twenty-three years, working on projects that include commercial, single and multi-family residential, retail, and sports based projects. Dr. Schneider currently holds a certification as a registered Building Code Official in the Commonwealth of Pennsylvania. In addition, Dr. Schneider has been involved in the fire service for more than 30 years, both as an active firefighter and fire chief, and as a State Fire Instructor in the Commonwealth of Pennsylvania.

Mr. Maholtz has been in the construction industry for more than twenty-four years, managing commercial construction projects in the Mid-Atlantic region. This includes both new construction and renovation projects, with a documented history of on-time and on-budget delivery with superior customer service.

A profiles for the entire project team are provided in Appendix A.

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. The 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.

The façade of all of the models was constructed using brick to be uniform in appearance. It is noted that with the light wood frame system this would not be allowed on a four (4) story structure under the requirements of the International Building Code, 2015 edition. However, it was kept to provide consistency in building appearance and uniformity in cost compared with other façade treatments. With the precast concrete wall systems, the façade was an embedded brick system that would be an integral part of the wall panel construction as would be provided from the fabricator.

It should be noted that the building designs that have been presented have not been done to reflect the absolute most cost effective construction options in any case. In contrast, in all cases the building design was done in such a way to represent a fair and un-bias construction model that represents a good performing building that would be representative of what would be constructed in the field.

Construction Types

The following construction types and alternates were evaluated:

- Conventional wood framing with wood floor system (Type VA Construction)
- Light Gage Steel Framing with cast-in-place concrete floor system on metal form deck (Type IIB Construction)
- Load bearing concrete masonry construction with precast concrete plank floor system (Type IIB Construction)
- Precast concrete walls and precast concrete floor system (Type IIB Construction)
- Insulated Concrete Form (ICF) walls and precast concrete plank floor system (Type IIB Construction)
- Insulated Concrete Form (ICF) walls and ICF concrete floor system (Type IIB Construction)

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.

For the ICF systems, the walls separating the dwelling units were constructed using concrete masonry units.

Code Review

Once design was completed on each of the buildings, a detailed code review following the requirements of the International Building Code 2015 edition was performed. A summary of this code review is provided 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. These items are typically dealing with site issues, soils information, etc. All of these items are common to each of the building and would add identical cost to each project. This was verified with Mr. Maholtz during the cost estimation phase of the project.

In addition to the building code review, an energy code review was completed to determine compliance with the International Energy Code, 2015 edition. This compliance check was completed using COMcheck. Developed by the U.S. Department of Energy, COMcheck is software specifically for demonstrating nationally recognized energy code compliance. COMcheck. The specific information used for construction the energy code model for this project is provided in Appendix D.

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 the funding partners, feeling that they represented the construction climate in their respective area. The locations chosen are as follows:

- Dallas, Texas
- Edgewater, New Jersey
- Towson, Maryland

To allow for a fair and uniform comparison of the construction costs between trades it was determined that the cost study would use accepted federal prevailing wage rates published for the Towson, Maryland and Edgewater, New Jersey 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. For the Dallas, Texas, location, it was decided that a compilation wage rate based on R.S. Means (Means) was going to be used for the comparison. This was done to evaluate the effect of the private-sector wages on the project cost. As part of the study model options were built in to allow evaluation of labor rates for union labor, federal prevailing wage, open shop, and R.S. Means based compilation for each city as needed.

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

During the cost estimation, material costs were predominately obtained using regional cost data sources, such as R.S. Means Cost Data with periodic local validation. For those materials where the cost data was not available, local contact was made and costs obtained from those sources.

In addition, due to the recent volatility of the construction industry, the cost comparison was completed for all three cities at three (3) separate times. The first was December 2016, the second was May 2017, and the third was September 2017. The data from each of these is presented in the results and discussion section of this report.

The labor rates used for each of the estimates are presented with the detailed cost estimate, located in Appendix E, F, and G for the December 2016, May 2017, and September 2017 cost estimates respectively.

Study 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.

Dallas, Texas

DALLAS, TEXAS - December 2016			
R.S. Means Wages			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 15,764,907.00	\$ 163.20	100
LIGHT GAGE STEEL FRAMING	\$ 17,394,965.00	\$ 180.07	110
MASONRY & PRECAST	\$ 16,697,776.00	\$ 172.85	106
PRECAST CONSTRUCTION	\$ 19,826,120.00	\$ 205.24	126
ICF WALLS & PRECAST PLANK	\$ 18,559,066.00	\$ 192.12	118
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 18,933,796.00	\$ 196.00	120

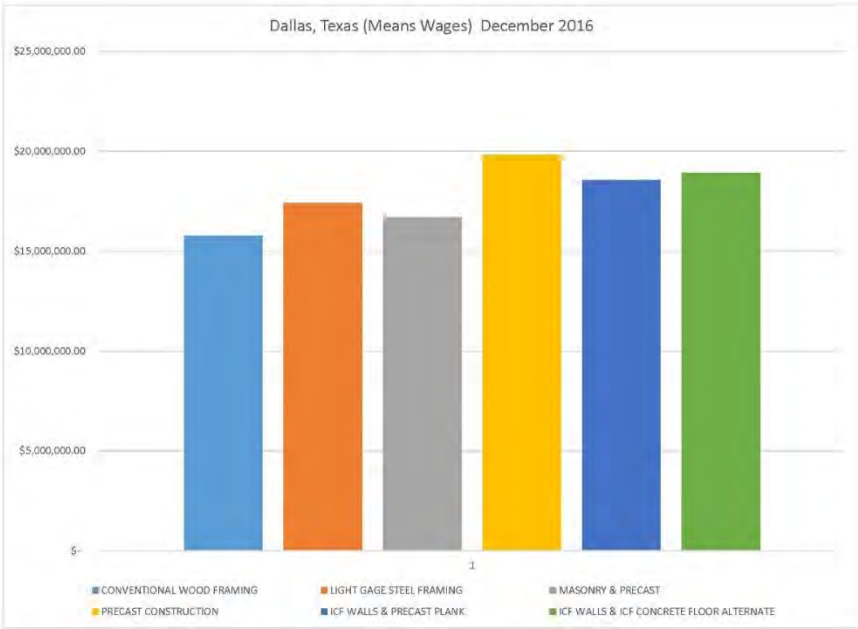
DALLAS, TEXAS - May 2017			
R.S. Means Wages			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 16,863,701.00	\$ 174.57	100
LIGHT GAGE STEEL FRAMING	\$ 18,522,017.00	\$ 191.74	110
MASONRY & PRECAST	\$ 16,258,489.00	\$ 168.31	96
PRECAST CONSTRUCTION	\$ 20,059,844.00	\$ 207.66	119
ICF WALLS & PRECAST PLANK	\$ 19,610,799.00	\$ 203.01	116
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 20,024,926.00	\$ 207.30	119

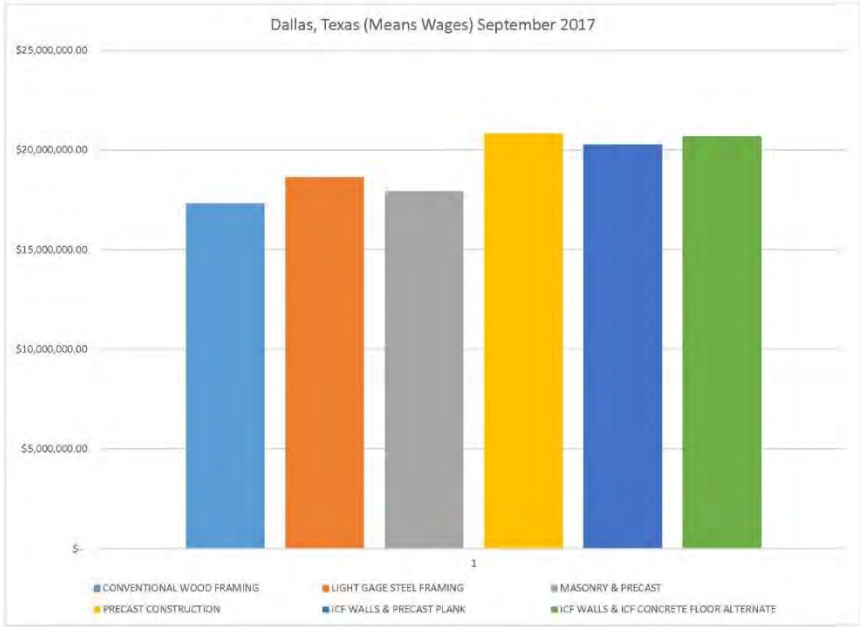
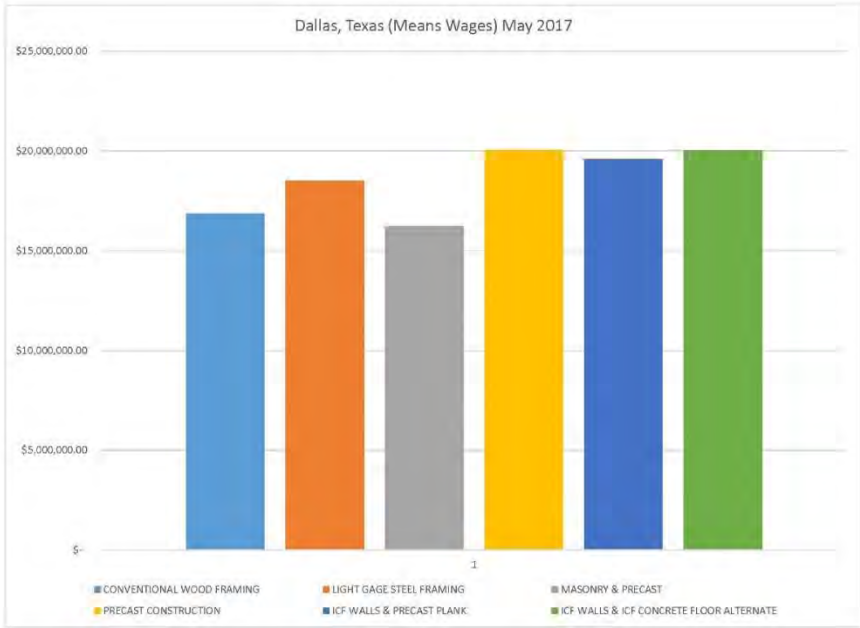
DALLAS, TEXAS - September 2017			
R.S. Means Wages			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 17,325,425.00	\$ 179.35	100
LIGHT GAGE STEEL FRAMING	\$ 18,644,736.00	\$ 193.01	108
MASONRY & PRECAST	\$ 17,943,306.00	\$ 185.75	104
PRECAST CONSTRUCTION	\$ 20,831,904.00	\$ 215.65	120
ICF WALLS & PRECAST PLANK	\$ 20,270,601.00	\$ 209.84	117
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 20,684,728.00	\$ 214.13	119

In the December 2016 estimate the least expensive system was the conventional wood framing system. The relative cost of the most expensive framing system, the precast concrete wall system with precast concrete floor system was 26 percent higher. The load bearing masonry wall system with precast concrete plank floor system compares very favorably with both the conventional wood frame system and the light gage steel framing system, with an increased cost of less than 6 percent over the conventional wood frame system.

This is contrasted in the May 2017 cost estimate where the least expensive system was the concrete masonry system with precast concrete plank floor. The relative cost of this system to the conventional wood frame system was 96 percent. The relative cost of the most expensive framing systems, the precast concrete wall system with precast concrete floor system and the insulated concrete form wall system with insulated concrete form floor system were 19 percent higher than the conventional wood frame system.

In September 2017 the relative cost of the concrete masonry system rebounded being 4 percent higher than the conventional wood frame system. This is still very favorable and well within the normal amount typically held for contingency. The relative cost of the most expensive framing systems, the precast concrete wall system with precast concrete floor system with the cost being 20 percent higher than the conventional wood frame system.





Edgewater, New Jersey

EDGEWATER, NEW JERSEY - December 2016			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 19,539,322.00	\$ 202.27	100
LIGHT GAGE STEEL FRAMING	\$ 21,528,150.00	\$ 222.86	110
MASONRY & PRECAST	\$ 19,523,679.00	\$ 202.11	100
PRECAST CONSTRUCTION	\$ 23,610,882.00	\$ 244.42	121
ICF WALLS & PRECAST PLANK	\$ 23,197,827.00	\$ 240.14	119
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 23,650,901.00	\$ 244.83	121

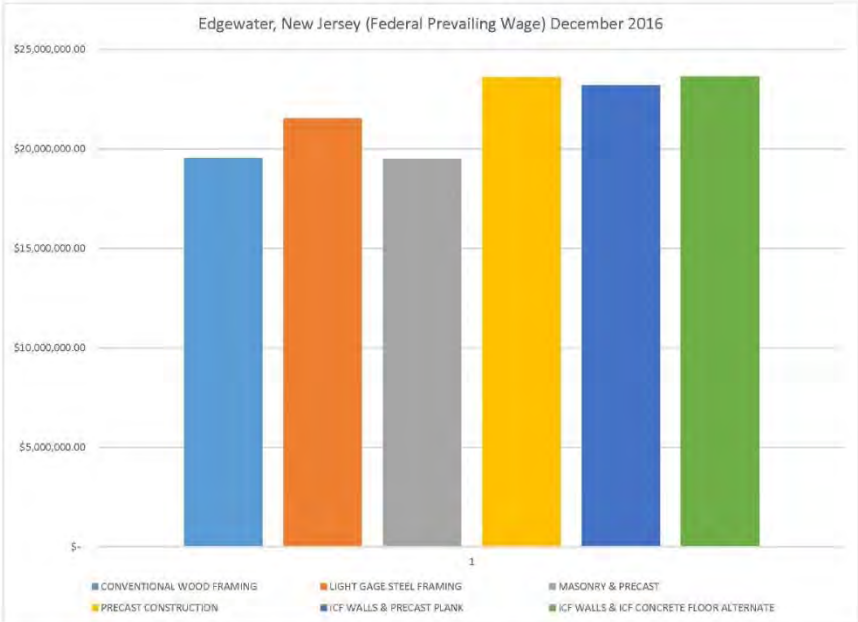
EDGEWATER, NEW JERSEY - May 2017			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 20,523,323.00	\$ 212.46	100
LIGHT GAGE STEEL FRAMING	\$ 22,546,115.00	\$ 233.40	110
MASONRY & PRECAST	\$ 20,015,924.00	\$ 207.20	98
PRECAST CONSTRUCTION	\$ 23,680,332.00	\$ 245.14	115
ICF WALLS & PRECAST PLANK	\$ 24,146,548.00	\$ 249.96	118
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 24,631,808.00	\$ 254.99	120

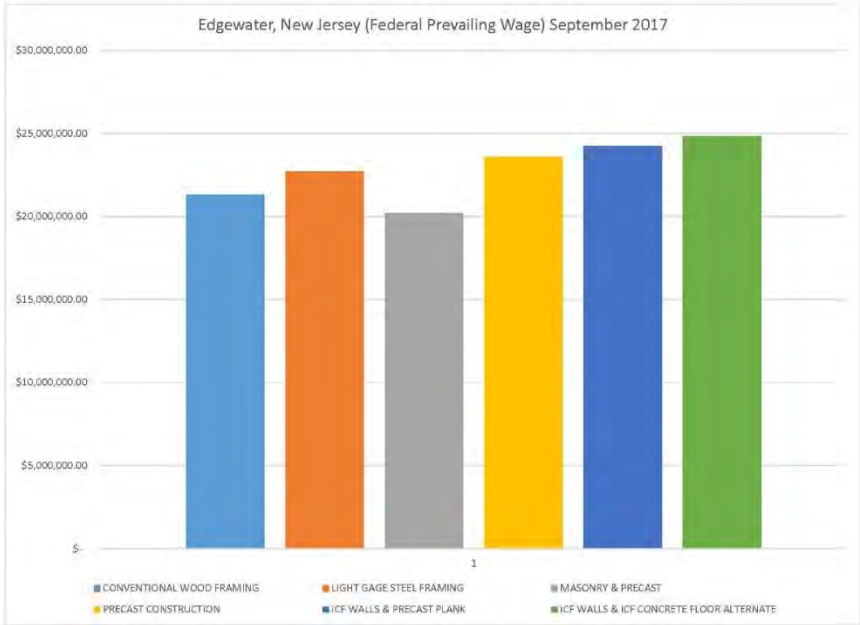
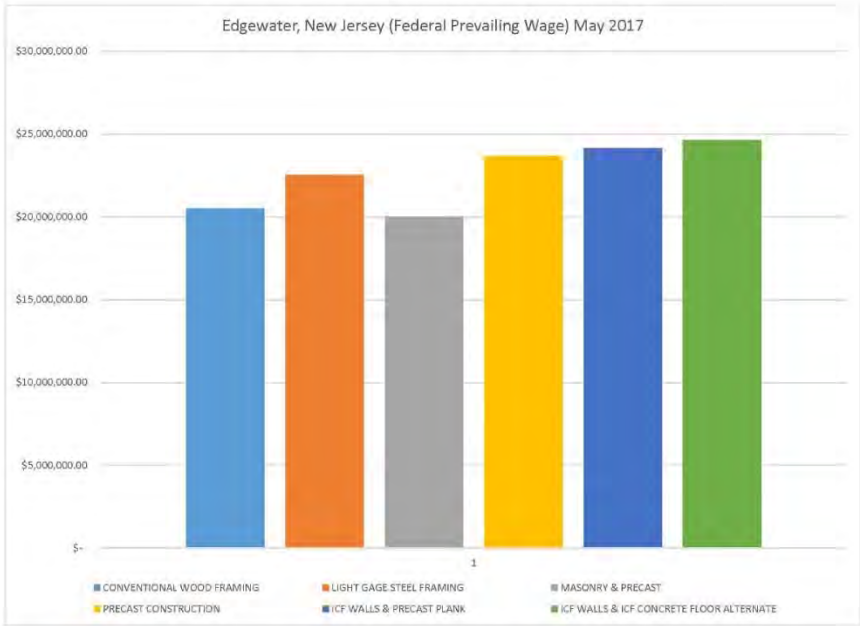
EDGEWATER, NEW JERSEY - September 2017			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 21,321,852.00	\$ 220.72	100
LIGHT GAGE STEEL FRAMING	\$ 22,706,148.00	\$ 235.05	106
MASONRY & PRECAST	\$ 20,206,036.00	\$ 209.17	95
PRECAST CONSTRUCTION	\$ 23,601,778.00	\$ 244.32	111
ICF WALLS & PRECAST PLANK	\$ 24,232,120.00	\$ 250.85	114
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 24,846,335.00	\$ 257.21	117

In the December 2016 estimate the least expensive systems were the conventional wood framing system and the concrete masonry framing system with precast concrete plank floor. The relative cost of the most expensive framing systems, the precast concrete wall system with precast concrete floor system and insulated concrete form wall system with insulated concrete form floor system were 21 percent higher.

This is contrasted in the May 2017 cost estimate where the least expensive system was the concrete masonry system with precast concrete plank floor. The relative cost of this system to the conventional wood frame system was 98 percent. The relative cost of the most expensive framing system, the insulated concrete form wall system with insulated concrete form floor system was 20 percent higher than the conventional wood frame system.

In September 2017 the least expensive system was the concrete masonry system with precast concrete plank floor. The relative cost of this system to the conventional wood frame system was 95 percent. The relative cost of the most expensive framing system, the insulated concrete form wall system with insulated concrete form floor system was 17 percent higher than the conventional wood frame system.





Towson, Maryland

TOWSON, MARYLAND - December 2016			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 17,563,491.00	\$ 181.82	100
LIGHT GAGE STEEL FRAMING	\$ 19,133,101.00	\$ 198.07	109
MASONRY & PRECAST	\$ 18,591,865.00	\$ 192.46	106
PRECAST CONSTRUCTION	\$ 21,370,393.00	\$ 221.23	122
ICF WALLS & PRECAST PLANK	\$ 20,931,428.00	\$ 216.68	119
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 21,116,275.00	\$ 218.59	120

TOWSON, MARYLAND - May 2017			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 17,890,382.00	\$ 185.20	100
LIGHT GAGE STEEL FRAMING	\$ 19,486,596.00	\$ 201.72	109
MASONRY & PRECAST	\$ 17,306,829.00	\$ 179.16	97
PRECAST CONSTRUCTION	\$ 20,831,303.00	\$ 215.64	116
ICF WALLS & PRECAST PLANK	\$ 21,222,180.00	\$ 219.69	119
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 21,439,213.00	\$ 221.94	120

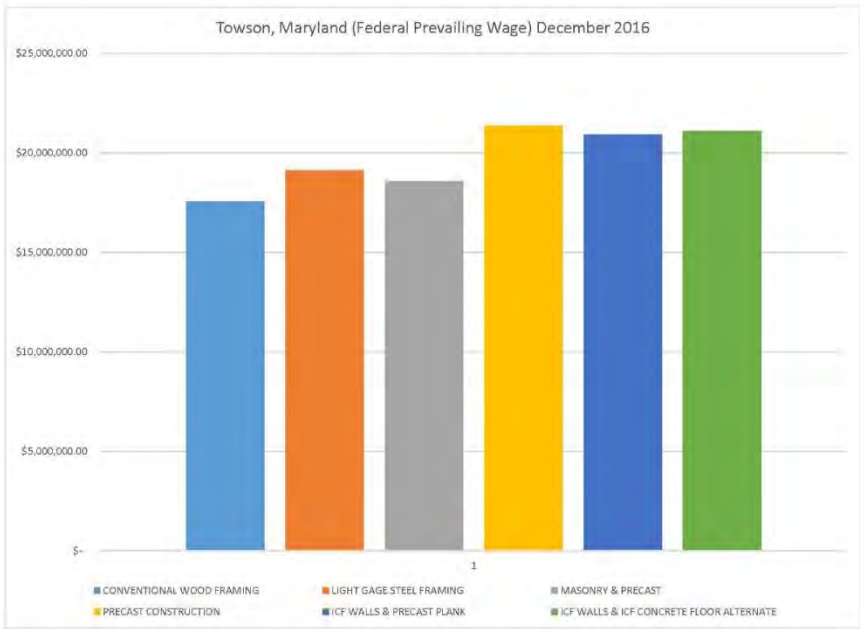
TOWSON, MARYLAND - September 2017			
Federal Prevailing Wage			
Building System	Cost	Cost/Sq Ft	Relative Cost
CONVENTIONAL WOOD FRAMING	\$ 18,410,313.00	\$ 190.58	100
LIGHT GAGE STEEL FRAMING	\$ 19,619,368.00	\$ 203.10	107
MASONRY & PRECAST	\$ 18,844,928.00	\$ 195.08	102
PRECAST CONSTRUCTION	\$ 18,844,928.00	\$ 195.08	102
ICF WALLS & PRECAST PLANK	\$ 21,586,537.00	\$ 223.46	117
ICF WALLS & ICF CONCRETE FLOOR ALTERNATE	\$ 21,306,021.00	\$ 220.56	116

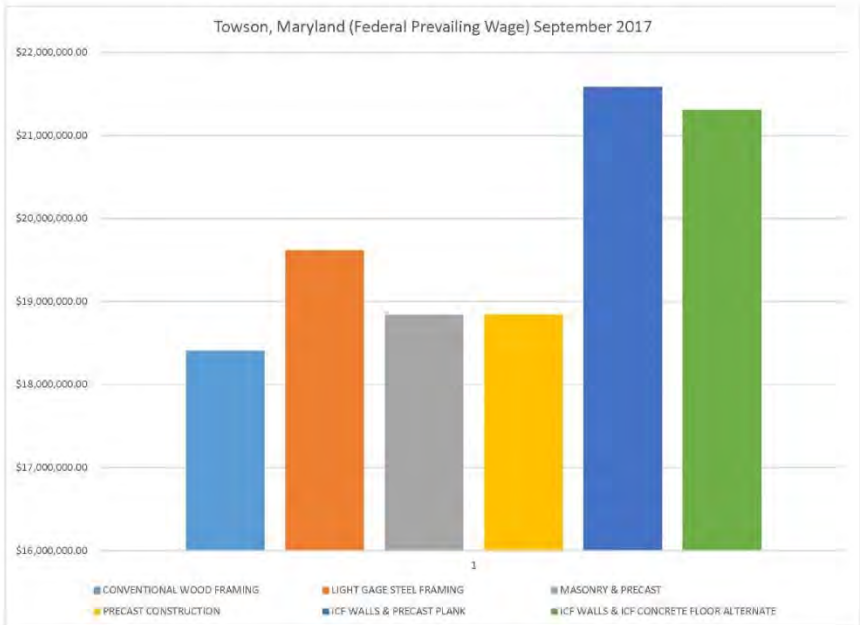
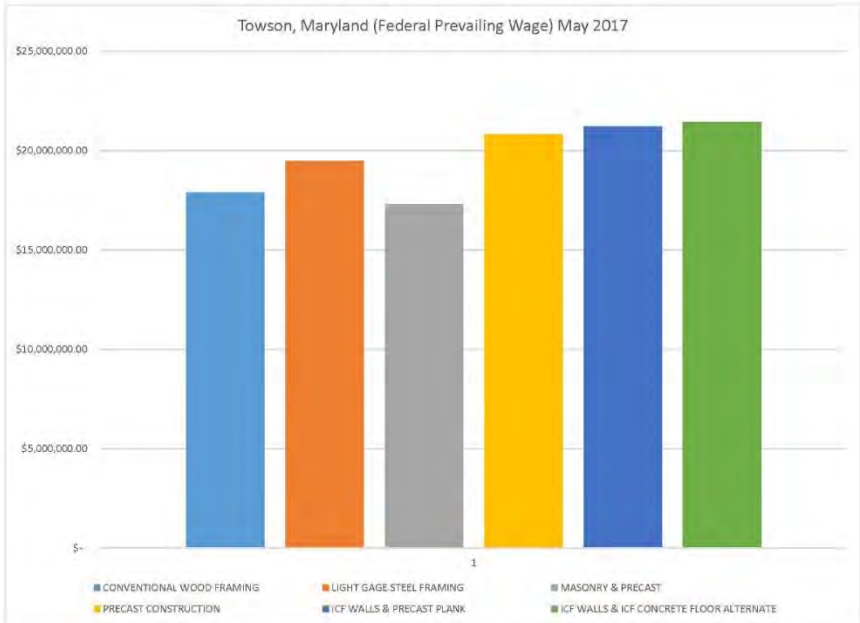
In the December 2016 estimate the least expensive system was the conventional wood framing system. The relative cost of the most expensive framing system, the precast concrete wall system with precast concrete floor system was 22 percent higher. The load bearing masonry wall system with precast concrete plank floor system compares very favorably with both the conventional wood frame system and the light gage steel framing

system, with an increased cost of less than 6 percent over the conventional wood frame system.

This is contrasted in the May 2017 cost estimate where the least expensive system was the concrete masonry system with precast concrete plank floor. The relative cost of this system to the conventional wood frame system was 97 percent. The relative cost of the most expensive framing system, the insulated concrete form wall system with insulated concrete form floor system was 20 percent higher than the conventional wood frame system.

In September 2017 the relative cost of the concrete masonry system rebounded being 2 percent higher than the conventional wood frame system along with the precast concrete system. This is still very favorable and well within the normal amount typically held for contingency. The relative cost of the most expensive framing systems, the insulated concrete form system with precast concrete floor system, with the cost being 17 percent higher than the conventional wood frame system.





Study Conclusions and Recommendations

Based on the construction cost estimates prepared by Mr. Maholtz, the cost associated with using a compartmentalized construction method utilizing a concrete based construction material was less expensive than the light weight conventional wood frame construction cost and light gage steel framing construction cost in all three cities as estimated in May 2017. Even the other concrete based construction systems were within a 20 percent increase over the light weight conventional wood frame construction system. In many cases this amount can be partially offset by the contingency budget typically recommended for the owner to carry for unanticipated expenditures during the project.

The minimal increase in construction cost can also help pay for itself 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.

Based on the results of this study, we recommend that a similar study be undertaken to evaluate use of similar construction techniques and their associated construction cost impact on other typical building types like, schools, retail establishments, and commercial office buildings.