Importance and Impact of Material Standards

Kira Rosenbaum
2016-2017 Kompas Fellow

Research at a Glance: As a Kompas Fellow, I was afforded 20% of my fellowship term at Myefski Architects (MA) to research an innovative idea. I elected to investigate a new take on an idea that has been around for decades: a method of designing using standard material unit sizes to lower the overall cost, timeline and environmental impact on a project. I theorized that small adjustments to a design could significantly decrease the overall project budget. Implementing this methodology on both existing MA designs as well as hypothetical ones, I evaluated its merit based upon the quantified repercussions of such modifications. Through a monthly blog, Instagram posts, and presentations to my colleagues, I chronicled the successes and challenges of this research project.

Recognizing that there are already methods in existence that incorporate this material size based design idea, I sought to further investigate why and under what conditions architects adhere to or ignore these guidelines. Could derivative savings convince designers to use modular construction more frequently, or would an effectuated shortened timeline suffice? In studying the ramifications and implications of a material size based design practice, I also analyzed the associated environmental impacts and expected reductions to noise pollution, waste sent to landfills, and site degradation.

Initially, I asserted that room sizes and

exterior wall heights could be defined by using standard material unit sizes without compromising overall utility and design. I sought to establish the viability of this design methodology and subsequently aimed to generate a set of design guidelines accompanied by a material matrix to assist architects in the reduction of cost and time to erect their designs. I envisioned the material matrix would rank all the materials encountered during my research relative to their potential hypothetical monetary return and time an architect would have to invest in creating the design. I believed this process should have a direct impact on retaining clients and create a positive environmental impact on new construction without compromising functionality, aesthetics or satisfaction.

Breaking the research down into three sectors – modular interior, modular exterior and a synthesized design - led to the development of five separate studies. Each case study contains some history and background information in order to better understand why certain decisions or assumptions were made. This discussion covers: modular interior framing, modular kitchens, modular exterior veneer brick-masonry, modular exterior thin brick-masonry, and a final case exploring the integration of both interior and exterior modules.

Paramount to my research was the quantification of cost and time savings derived from implementing this methodology on a project. A substantial savings would be necessary in order to entice developers and clients to seek out this design method and to take on additional upfront design burdens. However, I suspected there would be a rapid inverse declining curve in the initial design related efforts as designers grew more accustomed to the size-based approach. Architecture is a client centric field: in order to make this size based method viable, clients would need to gain value while not compromising on the design they commission.

Difficulties: Given the time constraints, it was rather ambitious and naive to think I could provide a concrete cost benefit analysis illustrating the monetary benefit to the modular design approach. Construction bids are based on current, regional, and market demand. Even those who have been in the field for decades are not often able to accurately forecast estimates due to fluctuating labor and material costs. After contacting several brick manufacturers, general contractors, masonry contractors and the International Masonry Institute, the constant time delay in getting answers to any of my questions significantly delayed my research. The lack and lag in access to information made it evident I would need to reconsider my expectations in regards to what I would practically be able to quantify.

Modular Interiors:

A History:

Dimensioned Lumber Standardization -

At the turn of the twentieth century, the lumber market had expanded across North America, resulting in the need for a system encouraging the acquisition of materials sight-unseen. This led to the implementation of a set of standards for lumber grades and sizes. In exchange for quality control, lower material and shipping costs were achieved by eliminating substandard materials prior to shipment from vendors.[1] Previously, standards had been set by the most regionally dominant company but in 1953 the American Lumber Standard Committee was established to assist the industry in upholding these quality thresholds.[2]

Light Frame Construction –

Light frame construction gained popularity quickly in the nineteenth century and continues in current use. It is comprised of repeating structural components, typically using wood or metal studs. Buildings under four stories in height were are generally built of wood members rather than metal for financial reasons. Occupancy classifications and construction type requirements were two reasons why some low rise buildings require - metal stud construction instead of wood members. Light frame – metal stud construction typically satisfies the requirement for fire resistive, noncombustible and fire-rated buildings. Whereas light frame – wood construction is restricted to combustible structures, unless it has been treated, in order to meet the higher hour fire resistance rating. Light frame construction is therefore an encompassing construction type with a range of applications.

Balloon framing, the first the first iteration of light frame – wood construction, is best

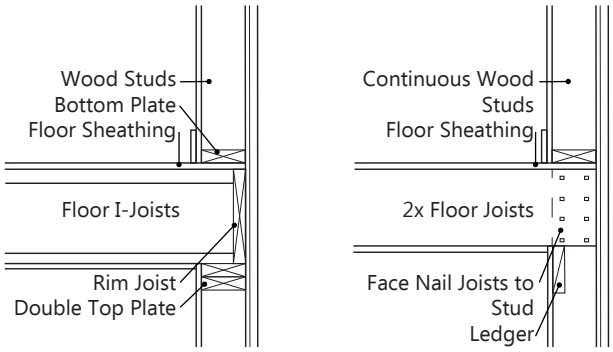


Image 1: Platform Versus Balloon Framing.[1]

1. Clement, Winston Wallace (2014). Standardization in the Lumber Industry: Trade Journals, Builder's Guides and the American Home. (Masters Thesis). University of Pennsylvania, Philadelphia, PA.
2. "History." General Info - History. American Lumber Standard Committee, Inc., 2017. Web. 07 Mar. 2017. <http://www.alsc.org/geninfo_history_mod.htm>.

known for its contribution to The Great Chicago Fire of 1871.[3] A principal element of balloon framing is its continuous exterior or bearing walls containing members that span from footings to roofs. Long uninterrupted members enabled fires to move vertically without any obstruction.[4] Platform framing, the prevailing method of light-frame wood construction, resolved this problem by stopping studs at each floor and by providing horizontal fireblocking within the wall cavities.[5] An unexpected benefit to these one story high studs was that they cost less than their longer counterparts. Additionally, due to the way platform structures are built, scaffolding is eliminated thereby decreasing cost and time to construct.[6] Image 1. Platform framing can be seen in Myefski Architects' 1620 Central project. Discussed in depth later on, 1620 Central is a new multi-family residential low rise on Central Street in Evanston, Illinois.

Light-frame wood construction is by far one of the more economical construction methods. This is primarily due to its non-labor intensive installations. However, light-wood construction slows down when projects are stick or site-built since laborers are frequently and continually confined by space within which they can alter, layout and construct walls in without impeding other progress. This problem is most often dealt with by fabricating off-site.

Prefabrication -

Prefabrication both resolves and mitigates numerous issues that arise during the construction phase of projects. Prefabrication is an umbrella term for off-site assembly. It can range from a kit home or modular and manufactured construction to flat pack that one purchases from IKEA. The only requirement for a project to be deemed "prefab" is that a certain portion of the construction is completed off-site. If a kitchen sink arrives already installed in the casework that component would be considered prefab. Despite having a negative association in the United States, prefabricated or factory built construction, "manufactured, modular, panelized, and precut or pre-engineered systems" are without question the most cost-effective way to build in terms of time, labor and material.[7] Looking beyond quality and lower material consumption, the benefits to building in a controlled environment such as a warehouse have been well documented.

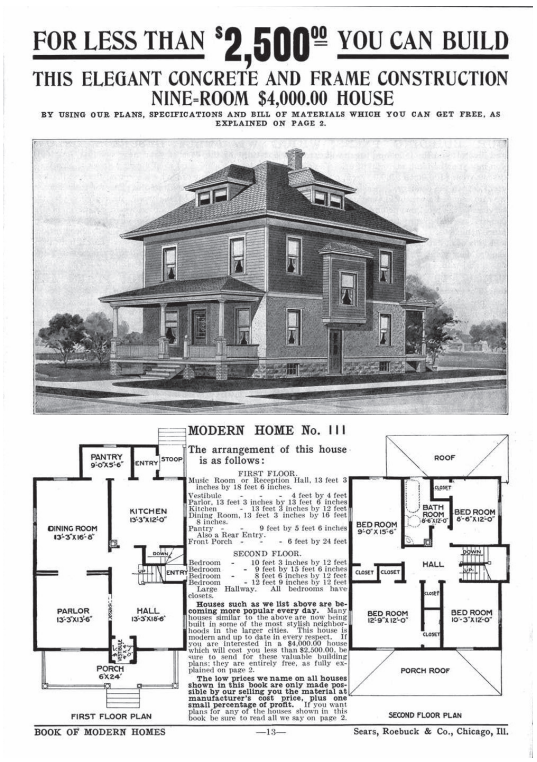
Box Homes -

One large scale modular construction

3. Janega, James. "Balloon Frame Construction (1833)." Chicagotribune.com. Chicago Tribune, 11 June 2015. Web. 02 May 2017. <http://www.chicagotribune.com/bluesky/series/chicago-innovations/chi-balloon-frame-construction-1833-innovations-bsi-series-story.html>.
4. Sidler, Scottt. "Timber, Balloon, or Platform Frame?" The Craftsman Blog. N.p., 6 Mar. 2012. Web. 02 May 2017. <https://thecraftsmanblog.com/framing-timber-balloon-platform/>.
5. Ochshorn, Jonathan. "ARCH 2615/5615 Lecture Notes." Jonathan Ochshorn - Lecture Notes, ARCH 2615/5615 Building Technology II: Structural Elements. Cornell University, 24 Aug. 2007. Web. 02 May 2017. <https://courses.cit.cornell.edu/arch264/notes/wood-systems.html>.
6. Sidler, Scott. "Timber, Balloon, or Platform Frame?" The Craftsman Blog. N.p., 21 July 2016. Web. 07 Mar. 2017.
7. Brock, Linda, and James Brown. "The Prefabricated House in the Twenty-First Century: What Can We Learn from Japan? A Case Study of the KST-Hokkaido House (n.d.): n. pag. Web. Mar. 2017. <http://timber.ce.wsu.edu/Resources/papers/4-2-3.pdf>.

fad that occurred in the United States was the box home. The catalog home and kit house came onto the scene in the early 1900's. Following the mass production typology, manufacturers - such as Sears - factory made all the necessary components for a home and shipped them in one complete package to the customer. Often cited to have top of the line material, these prefabricated homes could be individually tailored to some degree during installation. The only requirement for these box homes was assembly, a concept not too different from some present day approaches.[8] Precut studs were a legacy of the box home.[9] The end to the box home came in part due to external factors such as the Great Depression, a rising number of defaults with the Federal Housing Administration, and the desire for more custom and complex designs.[10]

BMC embraced this complexity in their twenty-first century revival of the box home. Their strategy, referred to as 'Ready-Frame Technology' generates a model based from submitted architectural plans. The plans are then analyzed by their proprietary optimization algorithm identifying and mitigating areas of waste. The end product results in entire walls systems and trusses arriving on-site with all of their components labeled and bundled together - from studs to blocking all cut to the correct dimensions.[11] Described by Bob Wetenhall, RBC Capital Market, as


FOR LESS THAN $2,500.00 YOU CAN BUILD

THIS ELEGANT CONCRETE AND FRAME CONSTRUCTION NINE-ROOM $4,000.00 HOUSE

BY USING OUR PLANS, SPECIFICATIONS AND BILL OF MATERIALS WHICH YOU CAN GET FREE, AS EXPLAINED ON PAGE 2.

MODERN HOME No. 111

The arrangement of this house is as follows:

FIRST FLOOR.

Music Room or Reception Hall, 13 feet 3 inches by 18 feet 6 inches.
Vestibule - - - 4 feet by 4 feet
Parlor, 13 feet 3 inches by 13 feet 6 inches
Kitchen - - 13 feet 3 inches by 12 feet
Dining Room, 13 feet 3 inches by 16 feet 8 inches.
Pantry - - 9 feet by 5 feet 6 inches
Also a Rear Entry.
Front Porch - - - 6 feet by 24 feet

SECOND FLOOR.

Bedroom - - 10 feet 3 inches by 12 feet
Bedroom - - 9 feet by 13 feet 6 inches
Bedroom - - 8 feet 6 inches by 12 feet
Bedroom - - 12 feet 9 inches by 12 feet
Large Hallway. All bedrooms have closets.

Houses such as we list above are becoming more popular every day. Many houses similar to the above are now being built in some of the most stylish neighborhoods in the larger cities. This house is modern and up to date in every respect. If you are interested in a $4,000.00 house which will cost you less than $2,500.00, be sure to send for these valuable building plans; they are entirely free, as fully explained on page 2.

The low prices we name on all houses shown in this book are only made possible by our selling you the material at manufacturer's cost price, plus one small percentage of profit. Before you build, plan for any of these houses shown in this book, be sure to read all we say on page 2.

PANTRY 9'-0"X5'-6" ENTRY STOOP KITCHEN 13'-3"X12'-0" DINING ROOM 13'-3"X16'-8" DOWN ENTRY PARLOR 13'-3"X13'-6" HALL 13'-3"X18'-6" PORCH 6'X24'

FIRST FLOOR PLAN

ROOF CLOSET BATH ROOM 6'-6"X12'-0" BED ROOM 9'-0"X 15'-6" BED ROOM 6'-6"X12'-0" DOWN CLOSET CLOSET HALL CLOSET BED ROOM 12'-9"X 12'-0" BED ROOM 10'-3"X12'-0" CLOSET CLOSET PORCH ROOF

SECOND FLOOR PLAN

BOOK OF MODERN HOMES —13— Sears, Roebuck & Co., Chicago, Ill.

Image 2: Kit Home Advertisement. [2]

the "IPhone of building products", BMC's Ready-Frame Technology has incredible potential to make an industry that has been through numerous optimizations refinements even more efficient.[12] BMC has essentially made every new home a box home.

Although there is some additional upfront costs associated with using Ready-Frame Technology, many say it will be recouped through labor and time savings. BMC advertises a onetime fee for the use of their algorithm and machinery. Since this method ships unassembled wall systems, the same crew that would be hired on a normal project can still be used. The only difference in processes

8. Thornton, Rosemary. "Do You Have a Sears Kit Home?" The Arts and Crafts Society. The Arts and Crafts Society, 2007. Web. 10 March 2017. <http://www.arts-crafts.com/archive/kithome/rt-searskits.shtml>.
9. Friedman, Daniel. "History of Pre-Cut Lumber for Rapid Building Framing - A Guide to Estimating Building Age." History of Pre-Cut Lumber for Rapid Building Framing - Leavittown NY & Leavittown PA. InspectAPedia, n.d. Web. 03 May 2017.
10. Thornton, Rosemary. "Do You Have a Sears Kit Home?" The Arts and Crafts Society. The Arts and Crafts Society, 2007. Web. 10 March 2017. <http://www.arts-crafts.com/archive/kithome/rt-searskits.shtml>.
11. Ready-Frame®." Ready-Frame. BMC, n.d. Web. 03 May 2017. <http://www.buildwithbmc.com/bmc/s/ready-frame>.
12. Lumber Tariff 'just a Papercut' on Home Construction Prices. CNBC. 25 Apr. 2017. CNBC. Web. 3 May 2017. <http://video.cnbc.com/gallery/?video=3000613138>.

Image 3: Exterior Shot of 1620 Central Under Construction.[3]

Image 4: Exterior Shot of 1620 Central Under Construction.

is a complete elimination of all on-site material alterations – reportedly speeding up construction by 20%. Further, with this system, storing cut lumber is easier and less of a financial burden than fully assembled walls systems. Another benefit to the shipment of not yet assembled walls is that it circumvents shipping capacity constraints. The shipping bed size is a limiting and constant consideration in all prefabricated structures whether it be a single wall or an entire room or unit module. For a building type that has been standardized and value engineered to an extreme, Ready-Frame Technology mitigates a variety of problems that other methods have not yet been able to solve. By taking a different approach to prefabrication than panelized construction, Ready-Frame Technology is able to accomplish comparable speeds with seemingly less restrictions. I believe Ready-Frame Technology has the ability to transform the light-wood frame construction industry.[13]

13. "Ready-Frame®."<http://www.buildwithbmc.com/bmc/s/ready-frame>.

1620 Central Interior Modular Case Study - Framing:

For my investigation into existing projects at Myefski Architects, I selected a building for its proximity to the office and its light-wood platform construction. Located at 1620 Central Street in Evanston, Illinois, this four story residential project with a basement was under construction during my fellowship term. 1620 Central was designed to utilize light-wood construction in combination with precut studs for efficiency purposes. Precut studs are dimensioned lumber that has been cut prior to arrival to respective lengths in order to achieve either an eight, nine, or ten foot ceiling. This method lowers costs associated with altering materials such as labor and machinery as well as reducing end cuts of wood that would otherwise end up in landfills. An additional benefit would be the decreased liability achieved through the decline in on-site machine operations.

Precut studs have respective lengths that take into consideration thicknesses of vertically stacking components such as the bottom plate, double top plate, and ceiling drywall – elements in a typical

light-wood construction framing system. Consequently, precut studs come in lengths of 92-5/8" for eight foot ceilings, 104-5/8" for nine foot ceilings, and 116-5/8" for ten foot ceilings. This approach to using previously altered material enables immediate installation upon arrival on-site. By designing with precut sizes in mind, an architect inherently saves a project time and associated costs. However, it is not always feasible to use precut lumber. Projects containing elements such as two-story spaces or vaulted ceilings break from the typical light-wood framing system and are not suitable.

The initial step of my research was to observe 1620 Central through visitations and the documentation of its framing conditions. Engineers do not typically include framing plans for walls in construction drawings so the as-built structure would have to suffice in this regard. From there I would implement and analyze my proposed method of altering existing designs by small increments in order to accommodate for standard material unit sizes – stud framing interval - to decrease the overall project cost, timeline and environmental impact. This modified 1620 Central design would then be used to quantify the savings from the altered stud quantity as well as other associated savings through labor costs and time.

My goal in conducting a framing analysis and application on 1620 Central was to determine whether or not shifting interior elements to accommodate for modular planning could reduce the related amount of material alterations and ultimately generate less cost and waste. Adjusting walls by 'insignificant amounts' to achieve increments of either 16, 24 or the common multiple of 48 inches on the interior of spaces improves the consumption of materials such as sheet goods. If obtainable, the 48 inch unit size would

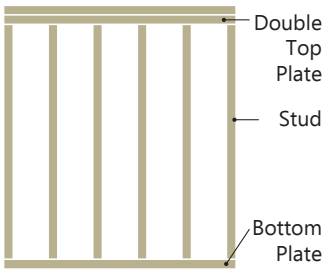


Image 5: Typical Framing Diagram.

also correlate with the masonry module. These dimensional adjustments would further influence the total number of studs necessary if elements such as doors and openings followed, and indeed, this is a tactic employed by the Advanced Framing Method.[14]

Initially, my case study effort was focused on four units per floor composed of the bottom portion of the building's "L" shape. For reference see Image 7. By intentionally selecting units with two exterior corners I was able to examine and resolve my


Image 6: 16" & 24" O.C. Spacing Comparison.

proposed design method within the building's city and client approved footprint. Cued into corner conditions and rough openings, I documented each wall's structural framing in the 16 units. However, upon closer review back at the office it was quite apparent that none

14. Advanced Wall Framing." Advance Wall Framing (2015): 799-826. Office of Building Technology. US Department of Energy. Web. Oct. 2016. <http://www.builditsolar.com/Projects/Conservation/Insulation/WallFraming26449.pdf>.

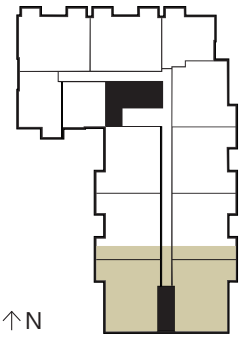


Image 7: Area of Focus. ↑N

of the photographed walls were being constructed as anticipated. This discovery brought my research to a halt since my next steps and analysis were dependent on accurately knowing and forecasting as-built conditions to measure projected savings. After bringing these findings to the attention of my fellowship mentor, we decided a formal site visit was warranted to investigate both the cause(s) of theses atypical situations, as well as to find more typical framing condition.

As expected, we found that not only did these 16 units have unexplainable and abnormally spaced studs, but none of the walls conditions were repeated on the other levels in the same locations. The as-builts ranged from studs spaced eight inches on center (O.C.) - using twice as many studs than called for (Image 8) - to studs 16 inches O.C. While this is the correct interval, it was noted that every other stud was doubled, as seen in Image 9. Shown in Image 10 is one of the few cases in which we found a 16 inch O.C. wall which was framed as specified. 1620 Central's project manager could not fathom why or how the wood structure was constructed the way it was and we were mystified as to the odd and irregular framing. Originally, we surmised things went wrong because that the walls were constructed simply without consulting the plans for truss locations, resulting in additional studs having to be installed after the fact. Instances such as Image 12

Image 8: 8" O.C. Studs.

Image 9: 16", Double Stud Every Other.

Image 10: Typical 16" O.C. Stud.

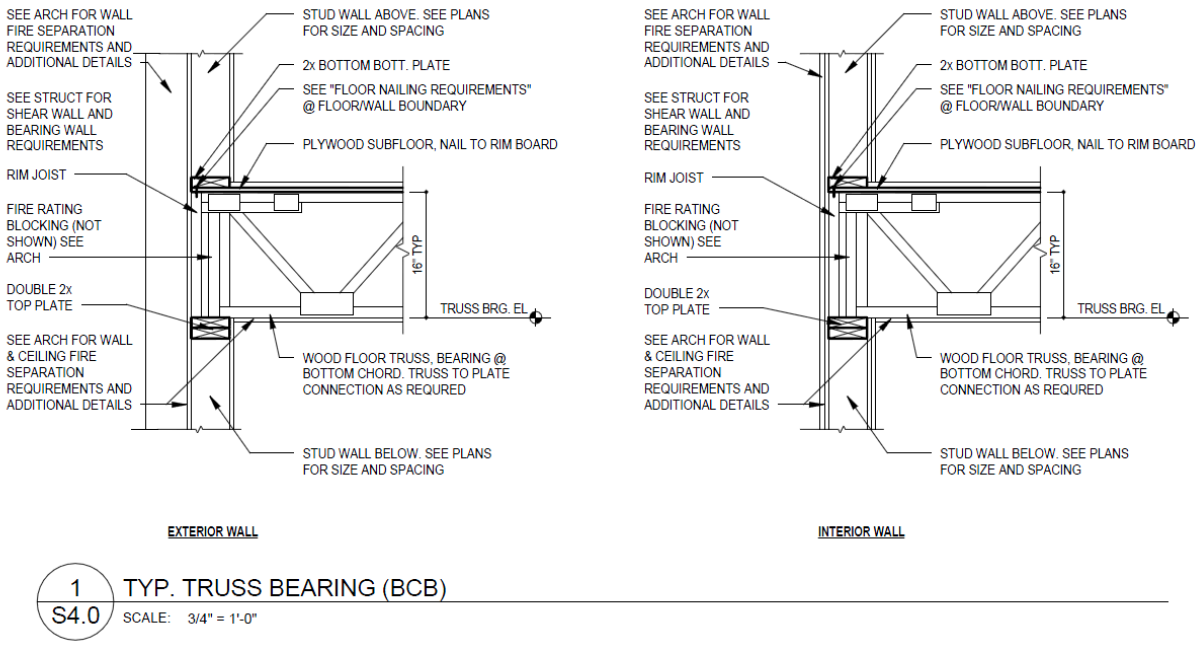


Image 11: 1620 Central Structural Drawings Excerpt from 8.27.2015 Set.

clearly indicated either someone had no idea what they were doing or they simply disregarded the structural plans. It was because of this experience that I came to terms with the notion that even if an architect were to spend the time designing for efficiently, there is no guarantee that those plans would be followed during construction. This made 1620 Central a great example of the importance for active oversight by a knowledgeable supervisor and the impact training might have had on novice laborers.

Image 12: Corner with 7 Additional Studs.

It was only at the very end of my fellowship term did I note that 1620 Central's structural drawing set repeatedly stated: "See plans for size and spacing", but it never defined what should be used for the interior truss walls on the plans. Image 11. Clearly this was a possible cause for the structure to be built per the imagination of the carpenter.

In light of 1620 Central being built with irregularly spaced studs, it no longer seemed relevant to complete an as-built Revit model for that portion of the building. My theoretical model, based upon the implicit 16 inch O.C. studs, would have shown a significantly lower consumption of materials not because of my design method but because it was comparing the actual stud count to my modified version based upon the intended stud count. Likewise, I could not substitute an as-built model for a built-as-intended

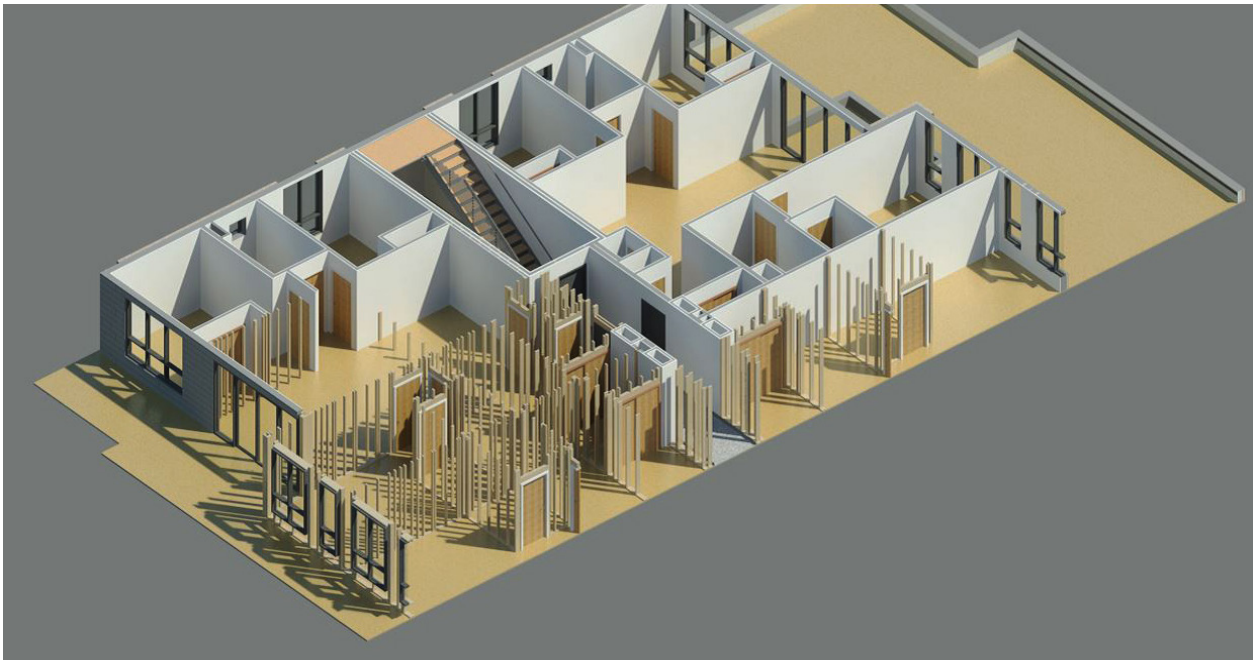


Image 13: Screen Shot of the In Progress As-Built Revit Model.

model in Revit because both my data and the analysis would be skewed by an unknown non-conformity to plans. In order to build a 'built-as-intended model', I would have had to arbitrarily decide which type of framing conditions were used in the areas that I was investigating for optimization, thereby compromising my findings. Further, had I assumed that everything in 1620 Central was framed in the most efficient manner, I would be shortchanging my modifications. An example of this would have been non-bearing walls being 2x4's studs framed at 24 inches O.C. On the other hand, had I presumed other, but still by-the-book, correct framing conditions were utilized I would give wrongful validation to my philosophy of material unit size based design.

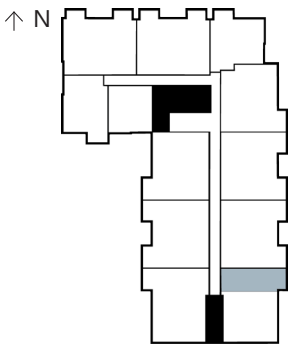


Image 14: Refined Scope.

Knowing my quantifications would be severely compromised, I decided to forgo adapting all four units per floor in lieu of only a small portion of the lower right unit in 1620 Central – Image 14. A sample containing only a few walls would still be able to provide me with an understanding of how my adjustment method would impact an interior layout.

I began with the 48 inch modular study. Despite 48 inches not being a standard material interval for either 2x4 or 2x6 studs, I thought it would be beneficial to explore how the least common multiple of both would fare. Consisting only of multiples of four foot walls, this module lends itself to the least amount of alterations to sheet goods of all the study investigations. These lengths would equate to one eight foot drywall panel cut into two, two eight feet panels etc. thus reducing the use of ten

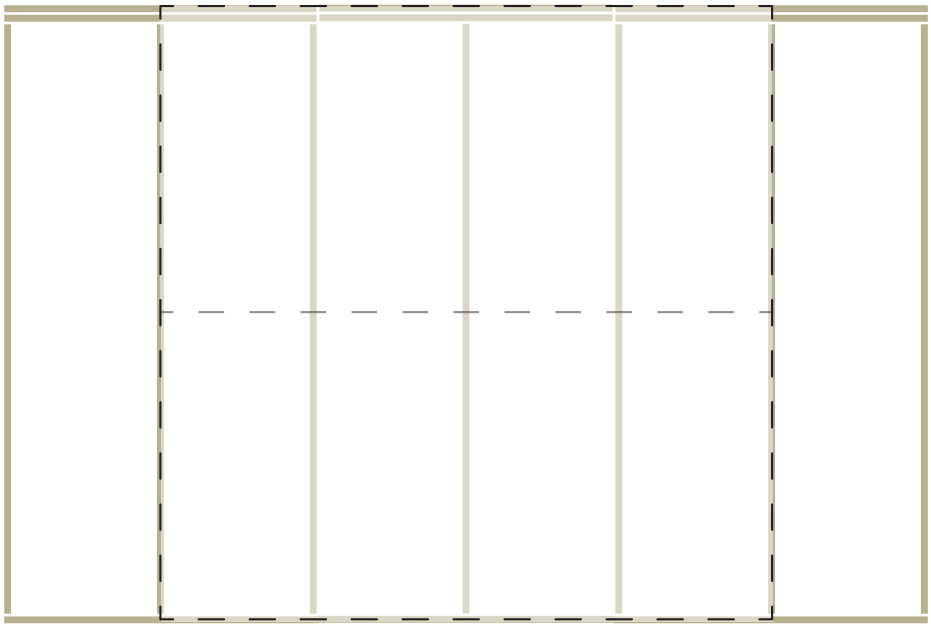


Image 15: Drywall Cutting Diagram (Eight Foot Sheets).

foot sheets. Image 15.

Immediately upon scrutinizing the 48 inch unit it became clear that this module compromised my initial objective of only making minor adjustments to the original plan. Furthermore, these modifications seemed to be at the detriment of the design rather than benefiting the interior experience. Reallocating one foot and eleven and three-quarter inches from the master bedroom to a hallway in order to save on a few studs and material modifications supported reasons not to deploy this method of design. All further exploration of this unit module was suspended.

The 24 inch module was the first detailed implementation of my method using a unit standard interval size. Similar to the previous probe, I soon realized reducing the dimensions by half did not help matters.

Disappointed in my results thus far, I decided to implement my proposed design method once more before I would need to revise my thesis. The 16 inch module stemmed from the typical stud interval. At issue was if the theory would work to the optimize use of sheet goods which are based on a standard of 96 inches, a 6-foldmultiple of 16. Included in the analysis would be whether or not the likelihood of only partially used sheets of material would increase as a function of the smaller interval, and any resultant ability to reuse remaining pieces.

To my delight, the adjustments required to restore the 16 inch module were closer to what I had in mind for small adjustments. For example, by moving the master bathroom wall to the right by one and five-eighths inches and the master bedroom door also to the right by five and seven-eighths inches, we achieved a 16 inch module. Unfortunately due to the bedroom door width of 34 inches, the only way to obtain an overall modular dimension would be to take six inches out

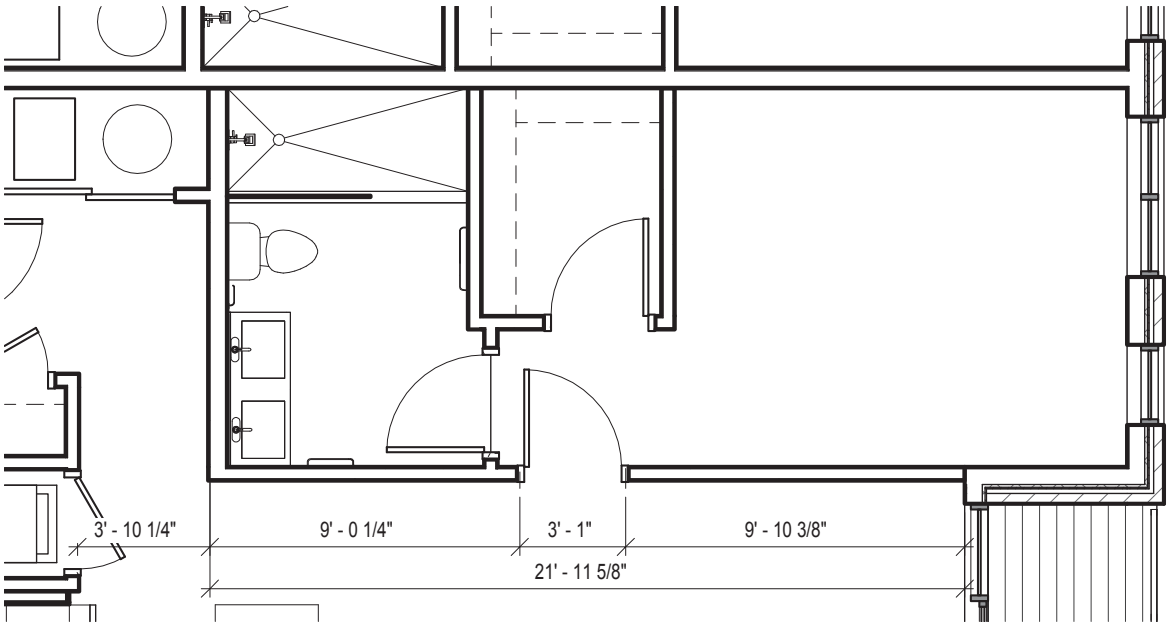


Image 16: Original 1620 Central Unit Plan.

of the master suite. Losing a total of seven and five-eighths in the master would then translate to growing the entry hall by that same amount. If one elected to increase the bedroom door to 36 inches and take two inches from the entry hall, the module could finally be achieved.

Although this restored some hope, the results were still not where I wanted. I decided to reconsider how I was interpreting using standard material sizes as my base interval for adjustments on existing designs when analyzing new projects. The idea occurred to me that since all of these modules were a multiple of four inches that maybe a four inch base interval rather than a full standard unit size may be worth investigating.

In order to implement a four inch module, minimal adjustments were achieved. By shifting the master bedroom door to the left by three-quarter of an inch and the bathroom wall to the left by three-eighths of an inch the four inch module was met. This accommodated for an overall span of 22 feet. The repercussions of such alterations would be the removal of three-eighths of an inch from the entry hall putting it at 3' 8 5/8". Although the module was achieved through minor changes, the intervals did not come out with the rough opening of the door naturally falling within the framing module. In order to accomplish this one would need to shift the door right by eight inches and the bathroom wall by four inches. Although I was unable to accomplish my main objective of quantifying my modifications to 1620 Central's design in terms of the speculated lower cost and time, the investigation was not a complete waste. Through the discovery of the four inch module, I was able to make to make the associations to other concepts I had encountered. In particular, one modular strategy I knew not only worked but is also widely accepted throughout the industry – the kitchen would become the subject for

my next investigation, as discussed below.

Ramifications –

The environmental consequence of 1620 Central's framing conditions can be seen in the additional lumber and labor required to pass inspection. Not only was the extra time and material financially irresponsible, but it also perpetuates the construction industry's high consumption of the earth's natural resources. Additionally, the installation of the extra materials caused further noise pollution to the surrounding neighborhood.

Noise pollution is often overlooked because it is a temporary and intangible affliction, as distinct from other ramifications like air pollution, waste, and negative impact on climate change. Over the past several decades society has accepted construction related noise as a tradeoff for newer structures resulting in less disputes about its occurrences. The prospective reduction to any one of these negative industry consequences increases with design efficiency hereby putting the responsibility back on the architect to design more consciously. Laying out components such as doors, windows and other spatial elements on a module is simply one route to achieving this sense of accountability.

Accountability -

Another means of designing more mindfully can be accomplished through the deployment of the Advanced Framing Method. Advanced framing is the practice of exclusively using 2x6 woods studs in a project in lieu of a combination of 2x4's and 2x6's and other substitutions. This approach typically cuts down on the total number of studs required with the increased spacing capabilities. 2x4's – unless used on non-truss bearing or structural walls – are typically restricted to intervals of 16 inches O.C. In the case

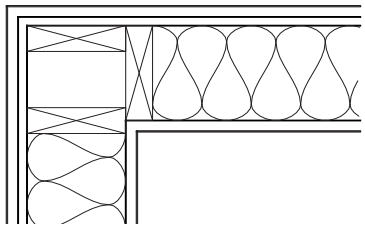


Image 17: Conventional Corner.

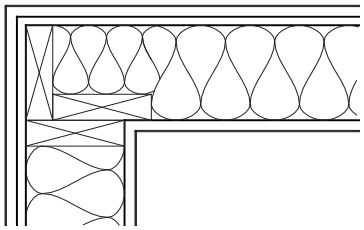


Image 18: California Outside Corner.

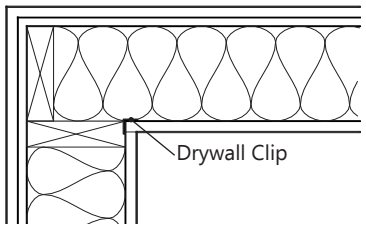


Image 19: Two Stud Corner with Drywall Clip.

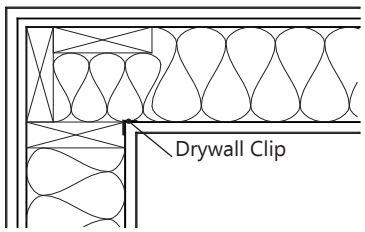


Image 20: Three Stud Corner with Drywall Clip.

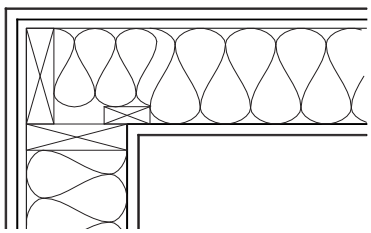


Image 21: Two Stud Corner with Scrap Wood.

of the non-truss bearing walls, engineers may increase this to 24 inches O.C. wall, whereas a 2x6 framed wall is typically 24 inches O.C. as a base interval.

Advanced Framing addresses how to assemble studs for maximum efficiency. The framing plan calls for a 24 inch module or grid to optimize material use. This is conducive not only for sheet goods, but also for windows, doors and other openings which can be positioned so that their rough openings fits between the wood framing. The ramifications include the reduction of structural headers along with the elimination of jack studs. Using a larger stud size accommodates for the majority of plumbing and pipes to be housed within all wall cavities. The larger stud sizes also provides ample space for electricians to work.

The Advanced Framing Method speaks to how one ought to detail corners in order to ensure optimal exterior insulation. This has a two-fold impact in that it lowers both consumption of construction material in addition to its lasting effect of lower energy bills. Detailing examples include typical alternatives to the common exterior corner condition like the insulated three-stud corner or 'California Outside Corner', Image 18, and the two-stud and three-stud corner with a drywall clip, Images 19 & 20. However, the advanced framing tactics for improving corner conditions goes on to describe a lesser known approach which is a two-stud corner with a scrap wood, Image 21. The scrap wood functions as a nailing surface – essentially acting as the third stud – for drywall and other finishing materials. This quite simple but extremely innovative idea eliminates the necessity for drywall clips on two-stud corners. By specifying or detailing this assembly in architectural drawings the monetary savings from a lower stud count and the omission of drywall clips will be reflected in construction bids. By repurposing end cuts of wood, a project inherently decreases the amount of material being sent to landfills. Taking only a matter of minutes to draw, architects only need to create this detail similar to Image 21 once in order to copy it onto other projects. Having trained engineers and construction team members is essential in order to implement the Advanced Framing Method effectively.[15]

Despite its many benefits, Advanced Framing poses a variety of problems, the first being that it precludes the use of precut studs. This forces alterations to be made on dimensioned lumber. If, however, a contractor or developer was set on using precut studs, the project would simply have abnormal ceiling heights. Additionally, with the deployment of a 24 inch module, greater attention is required when selecting finishes and exterior materials. One must rule out the options that require a nailing surface or similar structural link every 16 inches rather than the provided 24 inches.

There are many opposed to the Advanced Framing in the architectural industry largely due to a lack of education. While efforts are being made to educate code officials and inspectors, until that time, there is the potential for a code official to not recognize a structure's validity. Furthermore, there is no guarantee that the change in stud size will actually save money due to header hangers, potentially thicker subflooring and deeper floor joists. However, the other benefits such as lower labor time and reduction in construction waste should not be ignored. In the long run, a better insulated building envelope means a lower energy bill which

15. "Advanced Framing." Seattle Permits (2009): n. pag. Seattle Department of Construction and Inspections, 06 Dec. 2009. Web. 10 Nov. 2016. <http://www.seattle.gov/DPD/Publications/CAM/CAM341.pdf>.

is enticing for some building owners.[16]

Theoretical Interior Modular Case Study:

Stemming from the recognition of the validity and versatility to smaller modular intervals, I decided a tangential investigation into the kitchen layout would benefit my research. The vast majority of kitchens utilize a modular system. In elevation starting from the floor, the height of a toe kick is between three to four inches. The top of a standard base cabinet is 34.5 inches, and counter tops are one and a half inches thick. Resulting in the total height for a standard kitchen counter top of 36 inches. The typical distance between the counter and the upper cabinets is 15 to 18 inches. The standard height of the upper cabinets are 30 inches. Standard cabinet widths are in intervals of threes – nine, twelve, fifteen, etc. I thought this was particularly interesting since although smaller cabinets than nine and twelve inch are possible they are not standard for utility sake. A principle I could replicate and implement on the four inch interior framing module.

Most associate the initial kitchen layout refinements to Margarete Schütte-Lihotzky, the woman behind the Frankfurt Kitchen.[17] In the latter half of the 1920's Schütte-Lihotzky conducted studies investigating how one operates within primarily small spaces.[18] This was the

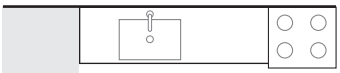


Image 22: Kitchen Diagram - One Wall.

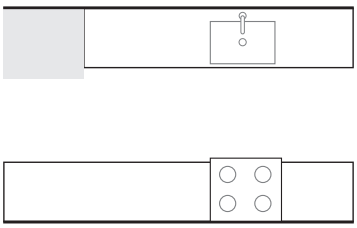


Image 23: Kitchen Diagram - Galley.

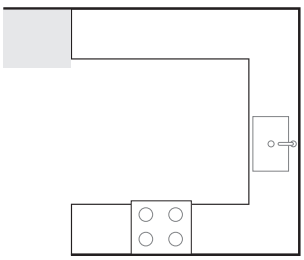


Image 24: Kitchen Diagram - "U".

16. "Advanced Wall Framing." Advance Wall Framing (2015): 799-826. Office of Building Technology. US Department of Energy. Web. Oct. 2016. <http://www.builditsolar.com/Projects/Conservation/Insulation/WallFraming26449.pdf>.
17. Rawsthorn, Alice. "Modernist Triumph in the Kitchen." The New York Times. The New York Times, 26 Sept. 2010. Web. 18 June 2017. <http://www.nytimes.com/2010/09/27/arts/27iht-design27.html>.
18. Carrie. "A Kitchen Design Timeline: 100 Years of Kitchen Evolution." Kitchen Design Blog. Kitchen Magic, 04 Oct. 2014. Web. 18 June 2017. <http://blog.kitchenmagic.com/blog/a-kitchen-design-timeline-100-years-of-kitchen-evolution>.

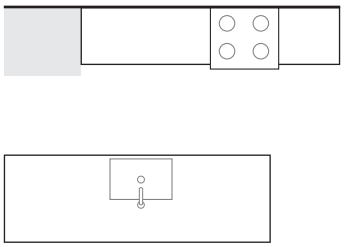


Image 25: Kitchen Diagram - Island.

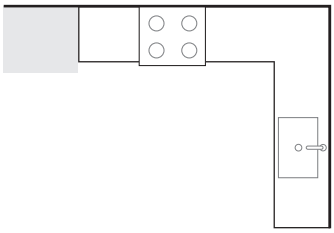


Image 26: Kitchen Diagram - "L".

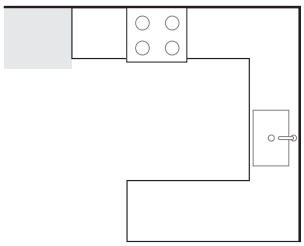


Image 27: Kitchen Diagram - Peninsula.

beginning of the work triangle and other design considerations still deployed today. Despite being based up such a defined module, kitchens come in a variety of styles or shapes. Kitchens layouts like houses are the result of both practically and size constraints. The most typical schemes are the one wall, the galley, the U, the island, the L and the peninsula.

Often forgotten or gone unnoticed, nearly all overall kitchen dimensions are in multiples of three inches i.e. the height to the countertop, distance between elements as well as their widths. In the instance of the countertop depth, the rule is intentionally broken in order to achieve a one inch overhang off the casework. Even if components such as sinks and refrigerators do not themselves adhere to the three inch rule, they fit within given three inch base caseworks permitting tolerances. Adhering to these standards ensures that all elements line up with one another. This is important not only for functionality but aesthetically.

Corners are one instance in which designers may break from the interval in order to maintain utility or accessibility of the space. A minimum of three inch filler panels are deployed to help preserve operability of drawers and cabinet doors in corners. Designers may choose to increase this up to an additional six inches where upon an extra standard size cabinet would fit. At this point would one may choose to grow the other cabinets sizes to fill or make up the unused space.

I wanted to test out how the module held up in situations that did not easily layout in intervals of three. Knowing that millwork – custom casework - costs more and requires additional lead time, it makes sense that it is a universal understanding in the MA office that one should spend the time to restore a kitchen layout

Image 28: 1620 Central Exposed Wall Framing.

to its module.[19] This would helped me understand how proven modules handle unfavorable conditions as well as what tactics are available such as the deployable filler panel for assistance.

When laying out kitchen islands, architects often consider the countertop material as a size parameter in addition to the three inch rule. Slabs come in a variety of sizes depending on the type of stone. Mindful architects keep to these dimensions in order to eliminate the hassle involved in matching color and grain patterns of multiple slabs as well as the associated extra costs. Furthermore, slab seams like cut masonry are frequently avoided for aesthetic reasons.

While some designers and clients may be more focused on finish materials, the job of an architect also involves thinking through how the composition and functionality of the components below. If one is not in tune to the latter, clients end up purchasing material that cannot be reused or resold. This fundamentally is standard material unit size driven design method.

Modular construction requires vigilance. I have concluded after reading about modern tactics and conducting my own investigations that interior modular design has more visible savings in places like the kitchen than in interior wall framing. Furthermore regardless of an

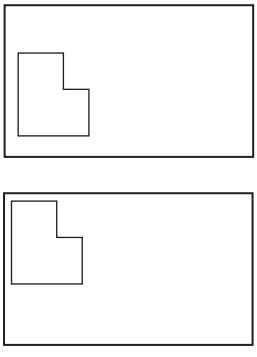


Image 29: Diagram of Slab Efficiency - Top image illustrating wasteful cut location compared to lower.

19. Boova, Katie. "The Difference Between Millwork and Casework – Real Estate Project Management." The Difference Between Millwork and Casework. Watch Dog Real Estate Project Management, 08 June 2017. Web. 18 June 2017. <http://watchdogpm.com/blog/difference-millwork-casework/>.

Image 30: 1620 Central Wall Closed Up.

architect's commitment to Advanced Framing, they can still pull ideas such as the two-stud corner with scrap wood. In the case of 1620 Central, once the walls are closed up residents have no way to visually assess that the structure does not follow a module unless they were to open the cavities. More likely the discovery would occur if someone tries installing a wall hung television or hanging pictures. The only other time ramifications for poorly placed studs would be noticeable is when stud cavities are too narrow for certain insulation materials resulting in an empty cavity.

I believe staying on module during the design phase will result in a predominantly monetary savings. With a secondary return in the lower associated time to construct unique conditions in the field. In regards to framing, I believe the best approach is to adhere to a 16 inch O.C. module for all new designs. When making adjustments to existing designs, one should attempt to obtain intervals of fours. This interval helps maintain the original design intent while still working to achieve a 16 inch module. Additionally - depending on exterior wall thickness - this smaller module can set up for an exterior 48 inch module that I envision yields a higher return.

It is therefore my recommendation when designing an interior layout to prioritize smaller base modules such as the three inch kitchen module. I believe that the logic behind standard kitchen doors starting at nine inches despite being controlled by a three inch module can be applied to the framing module. Thus intervals would begin at 12 inches, bumping up to 16, 20 and so forth. This spacing still enables the optimization of both 16 and 24 inch O.C. studs while still providing design flexibility.

Modular Exteriors:

I returned to 1620 Central for the exterior module investigation into masonry since I had previously noticed that some of the bounding walls were off the brick module. Although the project manager did take into consideration the module throughout the multifamily residential complex, like on the majority of projects rules are broken due to often external limitations. For the purpose of this research, I focused on the few exceptions in 1620 Central where the module was not able to be upheld. I also wanted to explore a bit of the history of brick usage and see if there was an opportunity to improve either the material shape or size and if installation could be improved with modular design.

A history:

Descending from the mud brick, the clay brick has undergone numerous iterations and advances both in terms of its composition as well as how it is produced. One characteristic that has not changed however is how easily it can be grasped. This feature makes bricks a very effective material for installation. With the shift towards mass production and the utilization of the kiln firing process at the turn of the Twentieth-Century, both the strength and durability of brick has improved significantly since the days of producing it with wood molds by hand.[20]

My exploration revealed that the brick itself, similar to lumber, has been engineered to the point where few modifications can be made to make it more efficient as a building material.

20. How It's Made Bricks. How It's Made Bricks. N.p., 22 May 2010. Web. 10 Mar. 2017. <https://www.youtube.com/watch?v=hoMkFtXJJ6o>.

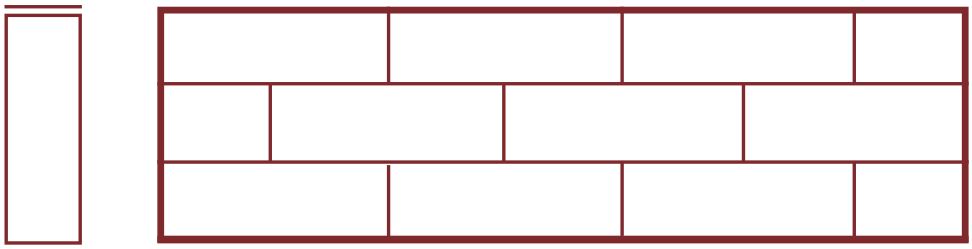
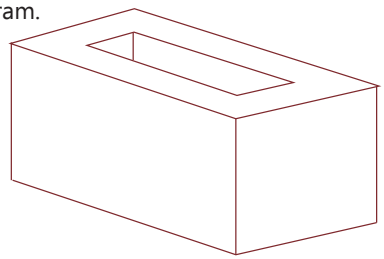


Image 31: Brick Ratio Diagram.

Various tactics have been deployed in its installation however; these include frogs, indentations or holes in the center, to laying only one row wide of bricks per coursing, commonly referred to as veneer brick to maximize installation speed. Ultimately the unit size held the most promise for savings.

Built on a 3 to 1 ratio, the height of three bricks with mortar joints is the height of one brick with a mortar joint and is four inches. Bricks are therefore considered at roughly eight inches in length and a turned length of four inches. Wall lengths ending in multiples four are considered to be modular. These proportions have been so methodologically thought-through that even toys modeled themselves after it. The Lego first appeared on the market in the 1930s, and has forever changed how kids play.[21] Known as an architectural admissions essay cliché, the simplicity and logic behind the brick form has truly shaped generations of designers.

Image 32:
Frog Diagram.



Brick can be used in a variety of patterns as well as a variety of systems. Patterns are the result of bond types such as Running Bond, One-third Running

21. Mortensen, Tine Froberg. "The LEGO History." The LEGO History - The LEGO Group. LEGO, 09 Jan. 2015. Web. 02 May 2017.

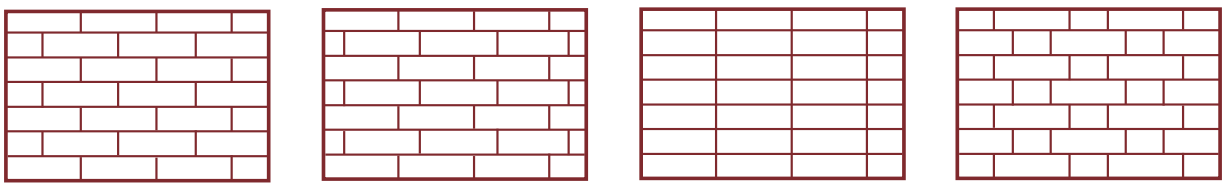


Image 33: Bond Patterns - from left to right - Running Bond, 1/3 Running Bond, Stack Bond & Flemish Bond.

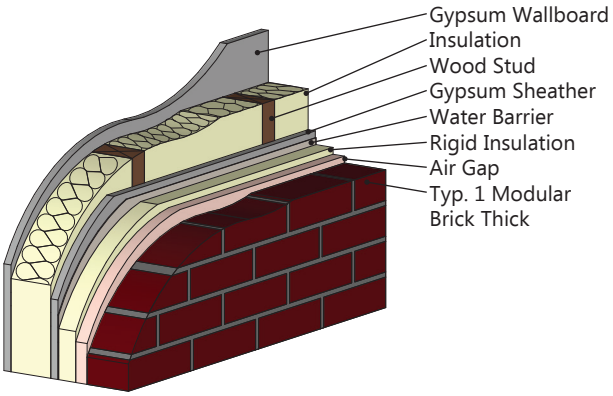


Image 34: Veneer Brick.

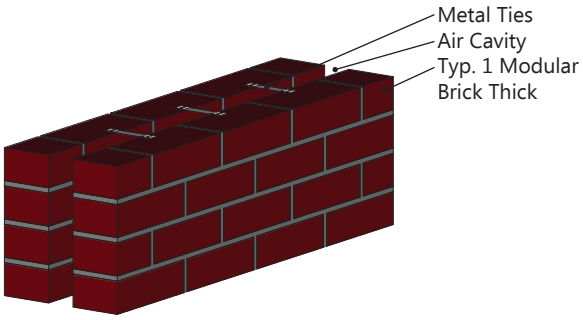


Image 35: Structural Brick (Double Wythe).

Bond, Stack Bond, and Flemish Bond.[22] Patterns describe where the bricks fall in relationship to the upper and lower courses of bricks. The system denotes the type of structure and sequence of the internal wall components. This ranges from structural brick, also known as solid or full brick, to veneer brick. Illustrated in Images 34 & 35.

The building industry was forever changed when Richard Felker debuted the diamond blade around the time of the Second World War.[23] The diamond blade made it feasible to cut stone, brick, and concrete on site to fit any condition.[24] This released architects and builders from material modules that were viewed as restrictive and controlling.

22. McMorrough, Julia. The Architecture Reference Specification Book: Everything Architects Need to Know Everyday. Beverly, MA: Rockport, 2013. 27. Print.
23. "Development History of the Notched Rim Lapidary Diamond Blade." Diamond Blades and Diamond Saw Blade Products, The Diamond Blade Depot. Barranca Diamond, n.d. Web. 20 Apr. 2017. <http://www.thediamondbladedepot.com/barranca-diamond.php>.
24. "The History and Evolution of Diamond Blades." History and Evolution of the Diamond Blade. Paver Saws, n.d. Web. 15 May 2017. <http://www.paver-saws.com/diamond-blade-evolution.htm>.

1620 Central Exterior Modular Case Study - Brick:

Returning to 1620 Central, I attempted to quantify costs to installation of partial bricks and to look at the aesthetics of their use. It was noted that instances which failed to maintain full brick intervals required the layout person on the masonry crew to hide the odd sized brick as much as possible. Image 36 depicts the installation process. Typically the layout person will

Image 36: Brick Installation at 1620.[4]

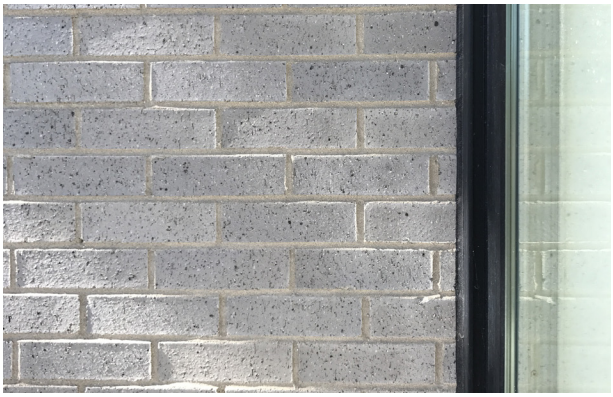


Image 37: Brick Cuts on Inside Corner.

Image 39: Interior Elevation of 1620 Central Wall Under Investigation.

locate the cuts on the inside corner of an exterior wall, Image 37.

For the same reasons the bottom units in the "L" were challenging in that they forced a resolution of my design method of material unit size based design in a finite space. The new area of focus, Image 38, also confronted how I would handle multiple materials at one time through prioritization. An issue I would need to deal with in order to complete the material matrix. Because any adjustment had to be minor in order to maintain the integrity of the original design, components could only be adjusted by small intervals and nothing could be outright eliminated for the sake of module. This limited the options for alterations to window size, placement and lengths of exterior walls.

This tested the validity and practicality of the proposed methodology in real life circumstances. A wall spanning less than ten feet in length at 1620 Central may not seem worth investigating, but this wall also happens to be one of two elements that dictated the length for six additional walls. Image 40.

Ideally a modification to the exterior shell and unit would be discovered that would positively impact the stacking floorplan. Working through this corner condition in plan and elevation led to the realization that by changing the window from 2'-4" x 2'-4" to 2'-0" x 2'-0" and moving the east exterior façade wall inward, closer to the building by two and one-eighth of an inch, a brick module could be achieved on all the remaining east façade walls. Image 41 shows a side by side comparison of the original design and the

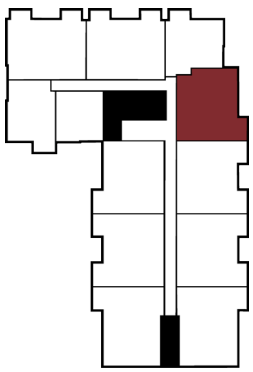


Image 38: Area of Focus.

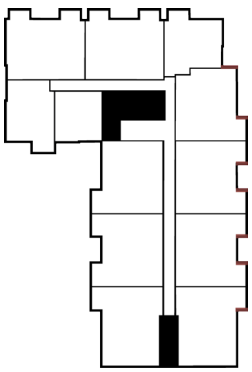


Image 40: Subsequent Impacted Walls.

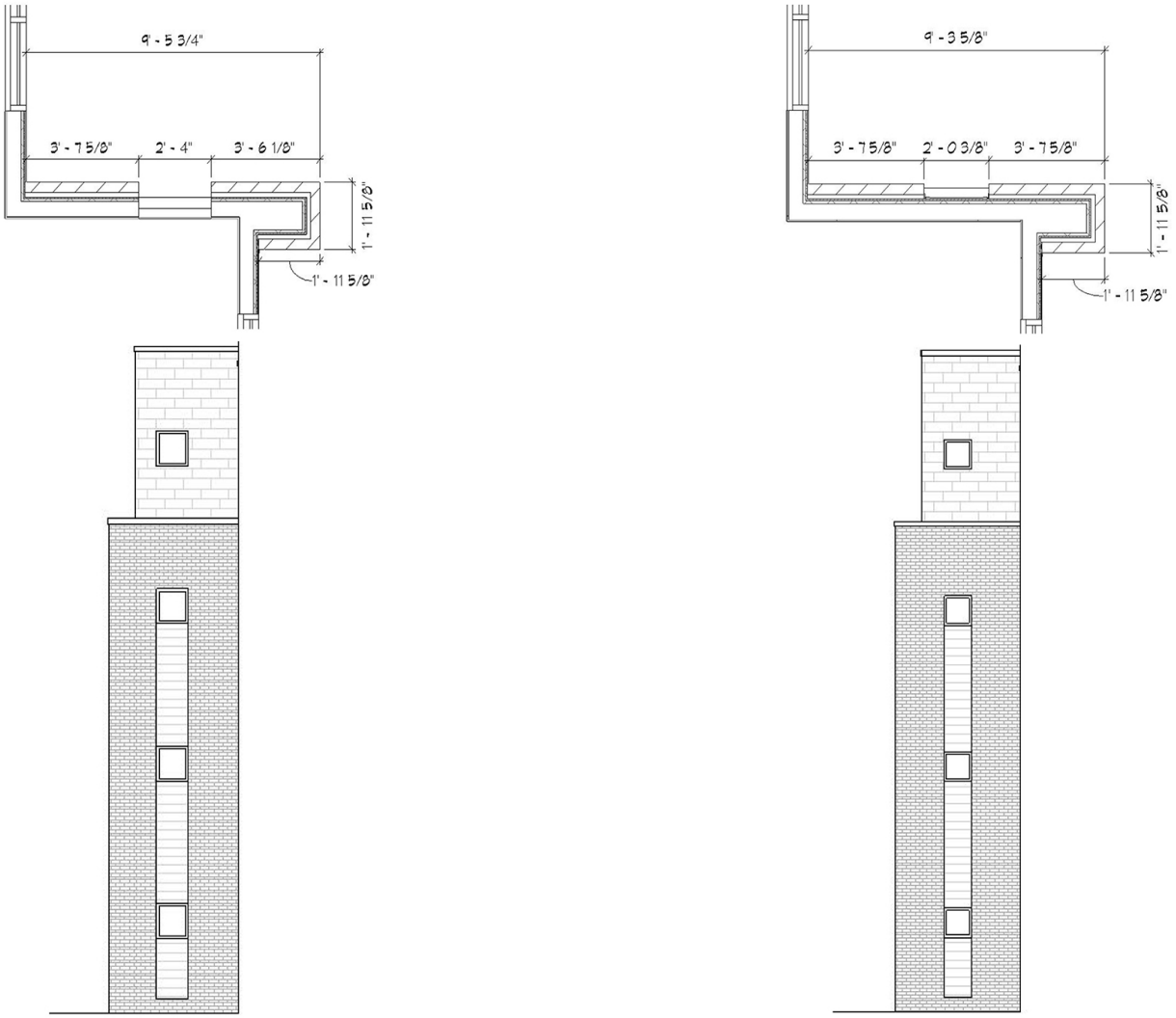


Image 41: Original (Left) and Modified (Right) Plan and Elevation Comparison.

altered design. Normally rough openings of windows coincide with the masonry module. However, to my surprise the 2'-4" x 2'-4" picture or single transom window specified in MA's drawings turned out to be a custom window size from the manufacturer. The difference in cost between the two types was estimated at $31.79. Equating to a savings of roughly $127.16 total - one window per floor - on this wall alone.[25]

As a result of these modifications the interior side of that wall shrunk to 10' 7 ½". This is significant since the closet would only have to shift over by half of an inch in order for the bedroom to hit the interior module of 16 inches. This adjustment can

25. "John from Home Depot." Telephone Interview. 16 Jun. 2017.

Image 42: 1620 under construction.[5]

Image 43: 1620 completed.

be accommodated for in the unit's entry hall without hindering any functionality of the space.

Spatially this modification amounted to a loss of 4.2 square feet of interior space spread over 23 and a half feet of the unit's 35 and a half feet width. The area removed did not impact the space's functionality despite it technically not being an 'insignificant' amount. Although 4.2SF over 23.5' of the unit seems rather low, when taking into consideration the implication it has on the price of renting, things get complicated. The respective cost of construction recuperated using this approach, at roughly $150/SF, and the potential resale value lost are both influential factors during the design phase. However, because developers will rent spaces at whatever rate they wish regardless of a 4.2SF loss, this consequence was negated.

Outside Help -

The following estimations were made possible with the assistance of Tom Kelley and the International Masonry Institute, along with Gary Porter and Mark Horn. Despite quantifying the number of bricks saved and estimating the material cost, calculating the labor aspect of the altered design proved to be incredibly difficult. The altered design called for 71 fewer bricks and 100 fewer alterations assuming all portions of the bricks were utilized in the original design. In reality, due to frequent poor cuts and material faults, these numbers could easily be double or triple. The proposed modified design required 99 bricks to be cut once shaving off the extra three-eighths of an inch with a brick hammer, a feasible task that could be completed within 1-1.5 hours according to several contractors.

Knowing contractors price based on the number of masonry pieces rather

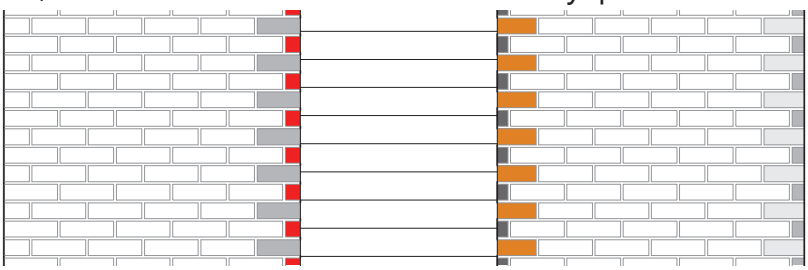


Image 44 : Original Design.

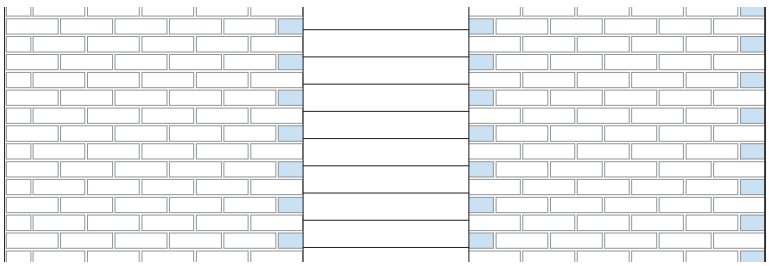


Image 45: Altered Design.

than size of pieces, the odd size cut bricks in 1620 Central's design had little impact on price. However, the four contractors consulted said they would bid a project differently if they saw dimensions were hitting a masonry module. They cited this as one area that gives their bid a competitive edge over another contractor. One company mentioned that they have received jobs where the architect was intentionally "messy" with their masonry wall dimensions and asked that the contractor simply match their design intent.[26] A common recommendation from the masonry contractors was that designs should incorporate larger masonry material such as utility brick in order to complete more linear feet in fewer pieces. Image-Utility brick size and dimension comparison.

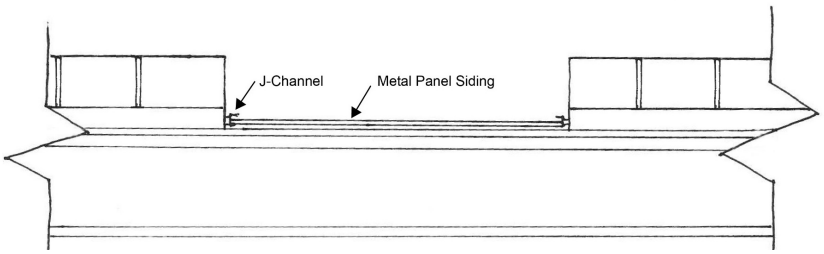


Image 45: J-Channel.

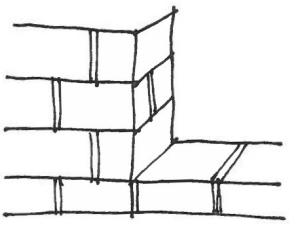


Image 46: Brick Return.

During those conversations two masonry contractors cited the additional time to construct 1620 Central as is would give my modified design an advantage. Supposedly an implication of the altered design could be the elimination of one or two mason tenders. Masonry crews are comprised of a foreman or mason, laborers and mason tender. Mason tenders are responsible for moving materials and assisting. They are in the unique position on the crew of belonging to a different trade than the other workers.[27]

The contractors commended 1620 Central's project manager for his decision to forgo a brick return, Image 46, in lieu of using a J-Channel. The J-Channel caps both ends of the metal siding where the siding meets the brick, Image 45. Identifying this as decisive move that on diminished most if not all of my potential monetary recuperation. Consequently reducing the prospective savings to roughly only a day's worth of labor, estimated to range from $800-1600 varying by location and union or non-union labor. Ultimately my modifications meant a shorter timeline. In the case of 1620 Central, cumulatively a day per adjusted East façade would have equated to the timeline being moved up by a full week. A magnitude that could be enough to incentivize clients, designers, and builders to consider adhering more strictly to material unit sizes and modules.

Had the project manager chosen to do a more traditional brick return the savings would be significantly higher, making my

Image 47: Closeup of Cut Brick in Wall.

26. "Cliff Horn." Telephone interview. 23 Jan. 2017.
27. "Scott Conwell." Telephone interview. 14 Jun. 2017.

Image 48: 1620 Central Exterior.

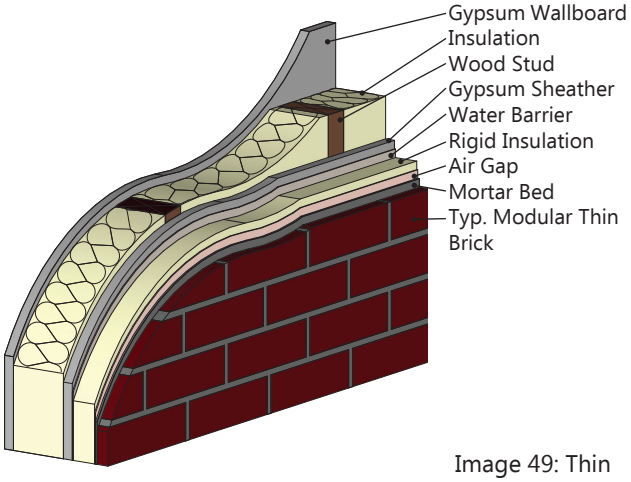


Image 49: Thin Brick.

alternative design more compelling from both a monetary and time perspective. The only major impact of the original design's odd dimensioned bricks was an extra day of labor to cut and layout each wall coming out at approximately $800 for a single wall on the lower end of the spectrum or $5,600 for the entire façade. For 1620 Central, the additional material cost for ordering more bricks and the price differential on windows was negligible. It was the conclusion for the 1620 Central masonry investigation that staying on a brick module was a monetary wash for both labor and material, however it equated to time savings.

Recognizing that contractors adjust their bids based upon if a projects maintains the masonry module to give themselves a competitive advantage, it seems frivolous for an architect not to take advantage of this opportunity. Time equates to money in this industry. Therefore designers should layout out projects mindfully or at least go back to adjust elements in order to capitalize on potential savings. The repercussion of forgoing a masonry module, even for practicality reasons, is time. This is especially important on projects with tight timelines because decisions made during the design phase can have a large impact during construction. As an exterior cladding material, bricks are considered to be on the higher end both in terms of material cost and labor. Clients are bound to be happier if an architect is able to reduce either of these two factors, making masonry a more viable option on a project without cutting corners.

Image 50: Exterior Elevation.

Image 51: South Elgin Rendering By Myefski Architects.[6]

South Elgin - Material Investigation:

At the request of the developer for a project in South Elgin, Illinois, MA is working on, the design team investigated and eventually switched from a veneer brick to a panelized thin brick system. The project in South Elgin – referred to here on out as South Elgin - is similar to 1620 Central in that it is a four story light-wood construction with a garage below. Thin brick took its cue from veneer brick providing only an aesthetic value (i.e. there is no structural component to the system). Image 49, Illustrates thin brick's structural composition for comparison to veneer brick. Initially used for interior finishes, it has recently begun transitioning into an acceptable exterior cladding material. The wall composition behind veneer and thick brick systems varies most noticeably in the depth of the air gap as well as amount of Water Resistant Boundary, WRB, dependent and particular to each product's specification sheet. On average, thin brick systems investigated call for a minimum of two WRB's, however the regional building code will supersede this. [28]

Initially loose thin brick – three-quarter inch thick brick - was adhered with mortar onto a lath or mesh. This method underwent efficiency reforms resulting in manufacturers putting forth distinctive systems that essentially holds the thin brick in place with adhesives or clip the brick. Construction crews then grout around the brick to give the appearance of a veneer or structural brick system rather than an inch of adhered cladding material. Images 52 & 53 were taken from one manufacturer's website to illustrate these alternative systems.[29]

The premise behind why the developer of

28. Industry Association, Oct. 2014, www.gobrick.com/ portals/25/ docs/technical%20notes/tn28c.pdf. Accessed 24 Apr. 2017.
29. BrickFast Panel Systems. N.p., n.d. Web. 25 May 2017. <https:// www.brickfastpanel.com/how-to>.

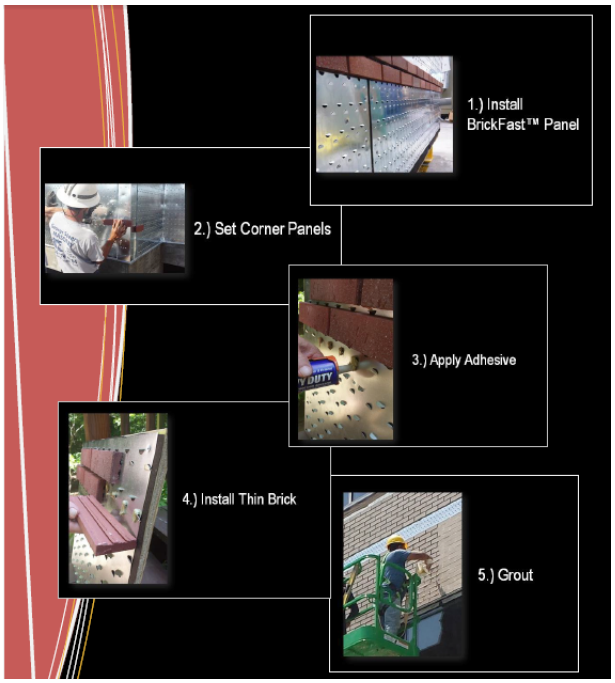


Image 52: Thin Brick system.[7]

Image 53: Thin Brick system.[8]

South Elgin was interested in substituting systems substitution a few weeks before sending out the drawings for permit boiled down to the removal of the steel reinforcement that would have been required with modular brick veneer. It was understood that when the systems were priced out for this project they resulted in nearly the same price. Steel angles are typically required for support on building façades over 30 vertical feet. For South Elgin panelized systems the steel angles were placed at the 30 foot mark and at each floor beyond that – 2 stories.[30] From an architectural perspective the difference between systems had relatively no savings in the amount of time that would have been spent detailing these circumstances in drawings. The manufacturers advertise that these systems save on labor since they can be installed by carpenters rather than trained masons. After all is said and done, the panelized system appears to offer savings for steel and labor, and secondarily through the time spent to construct or install the system is considerably less than it would be for laying loose brick.

Reflection -

In the end it was confirmed that abiding by a base masonry dimension one can achieve the coveted 48 inch module inherently saving the project predominately time and some financial savings. Through the deployment of other additional tactics and brick alternatives, designers can increase the financial return for their client. My recommendation as to which strategies have the highest yield alongside determining the overall lengths of walls based upon masonry sizes would be the elimination of the brick returns on openings. Furthermore architects should consider using thin brick systems more frequently. This would avoid the typical situation in which last minute budgetary substitutions are made causing designs to undergo changes after they have been drafted resulting in often over budget projects.

30. "Veneer Lintels, Shelf Angles." Masonry Wall Systems, Technical Notes, Masonry Resources, Project Galleries and More. Masonry Systems, n.d. Web. 03 May 2017. <http://www.masonrysystems.org/ knowledge/basics/veneer-lintels-shelf-angles/>.

Combined Interior and Exterior Modular Study:

Combination-

Due to the initial difficulty I had implementing my method of designing using standard material unit sizes to lower the overall cost, timeline and environmental impact on 1620 Central, I elected to do this next case study on a theoretical design rather than existing one. Picking up on the fact that both exterior and interior modular work with four inches, I would carry this forward. However, it was clear that there was a high probability I would have to compromise on one of modules since exterior wall thicknesses do not typically come out to be in intervals of fours, let alone clean numbers for that matter. Image 54 of Revit screen shot with 8" generic. Typical exterior thickness for an exterior veneer wall is 1' 1 5/8". Image 55 of Revit screen shot with typical veneer walls - illustrates this concern coming to volition.

Even if one were to increase their exterior wall thickness to a multiple of four, the interior module would not hold long since interior walls cannot go down to a four inch thick wall. The smallest stud size one can go down to is a 2x4 stud with a gypsum board finish on both sides equating to a four and three-quarters of an inch width.

Recognizing the cost differential both in material and time involved to construct, I concluded the interior module would give way to maintain the exterior's base four interval module. Although this can lead to wall lengths that do not fully optimize the use of drywall – the typical interior finish material for light-frame wood construction. Seams of drywall however are easily hidden by tape and paint. Unlike the exterior finish material such as exposed masonry that is forever visible. Despite giving up on upholding the interior 16 inch framing module, I do think it is beneficial to adhere to it wherever possible especially in regards to location of openings.

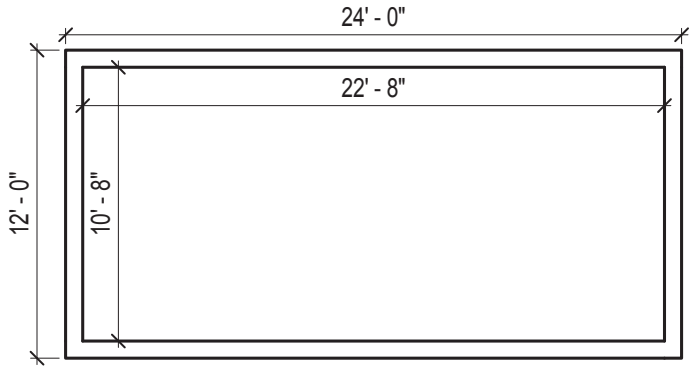


Image 54: Beginning Modular Combination Study With Generic Eight Inch Thick Walls.

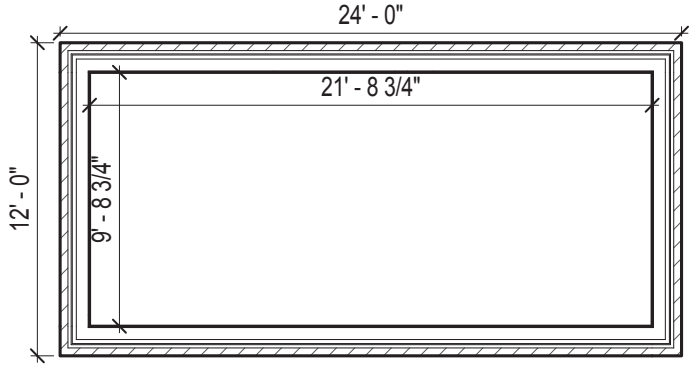


Image 55: Beginning Modular Combination Study With Typical Veneer Thick Walls.

Conclusion:

Impact of Utilizing Standard Sizes:

For the typical light-frame wood construction building, I believe there is the potential to achieve a material based design module that works out both on the interior and exterior in nearly all locations at the expense of one area. Both interior and exterior investigations resulted in the understanding that using smaller base intervals of material sizes as the design interval yields both design flexibility and client savings. My recommendation would be for the overall deployment of a four inch base module. Translating to a 48 inch module on the exterior and a 16 inch interior module. This picks up on the optimization of 16 and 24 inch O.C. studs, structure around openings, drywall, masonry both brick and CMU block as well as accommodates for the kitchen module. In terms of verticality, unless there are external limitations, adhering to this the four inch rule of thumb facilitates the use of either four inch or six inch CMU block heights. Four inch multiples appear to be the magic number for hitting the majority of standard material unit sizes.

Design tactics beyond the base module, that I believe architects should keep in mind while laying out a projects in order to capitalize on material efficiency, saving their clients both time and money are as follows. Regardless of a designs' commitment to advanced framing, architects can still deploy strategies such as the two-stud corner with scrap wood. The use of elements such as jogs, openings and other architectural features should be incorporated to the benefit of the module, rather than at its expense. Eliminating brick returns around openings, whenever possible, can account for a faster timeline which means the client can turn a profit faster. Additionally selecting larger masonry pieces will amount to a faster assembly as well as lower costs since bids are based on number of linear pieces required.

Even if a project does not have the budgetary capability to universally deploy panelized construction or use the proprietary BMC Ready-Frame Technology, one should still investigate the potential financial return for their project if they made all the necessary framing alterations at an off-site location. Theoretically this could be accomplished with only a few people cutting studs and bundling each wall together. Storing cut lumber is easier and less costly than an assembled wall system. This enables both the transporting of more material at one time as well as being able to accommodate a variety of transportation bed sizes.

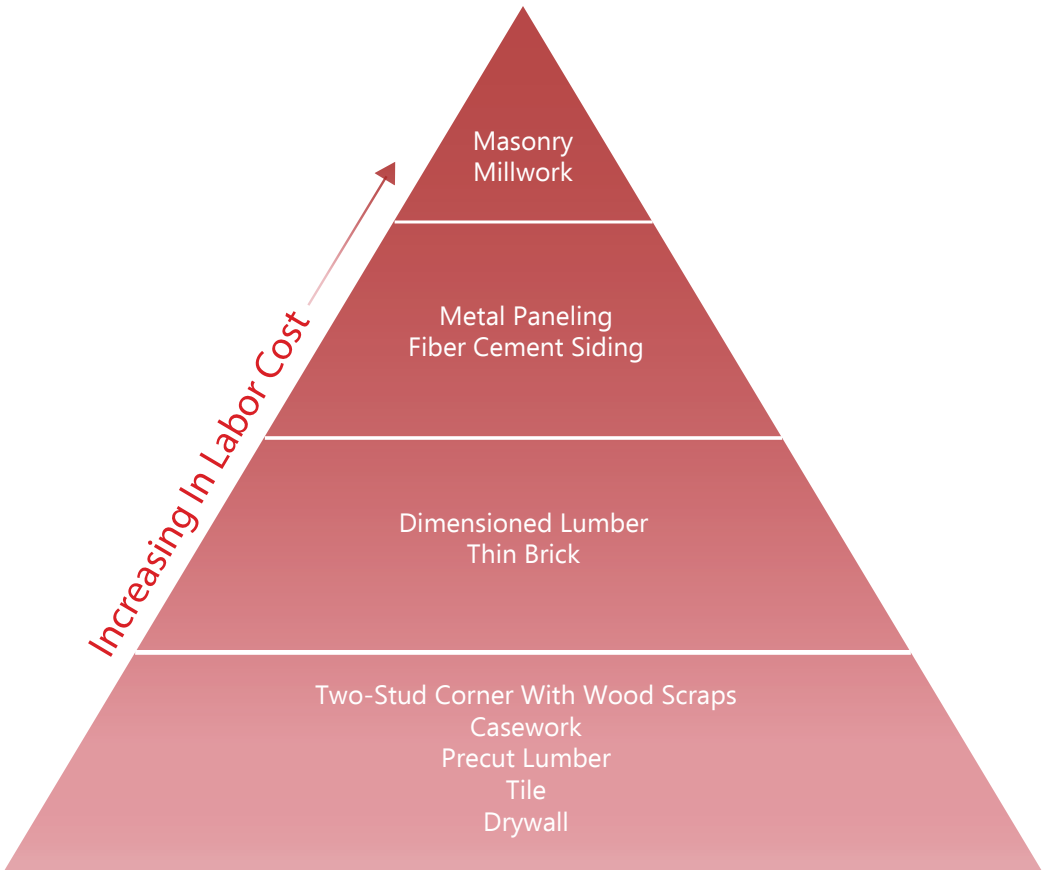
Above all I would recommend the deployment of the four inch base module. Upon which my notion that room sizes

Image 56: 1620 Central Brick Condition at Window.

and exterior wall heights can be set by without compromising overall utility and design is possible. If an architect were so inclined they could theoretically label dimensions as X multiples of four. However because four inches goes into one foot three times, one can simply do the mental math associated in converting. It is my conclusion that such a small base unit module yields the highest flexibility and feasibility for an architect to maintain it.

Material Matrix:

The purpose is to illustrate what materials an architect should invest more time in ensuring modules are adhered to in order to save time and money for the client.



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