Foundry at 41st
Final Report

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Lawrenceville, PA

Advisor: Dr. David Riley

April 3rd, 2017

Executive Summary

Depth 1: Kitchen Plumbing Manifolds

This analysis on the shared Kitchen and Bathroom walls tries to cut down on waste, schedule, and labor costs by prefabricating Kitchen Plumbing Manifolds offsite. After looking at the drawings, only the in wall plumbing for the unit 3 to unit 3 Kitchens were realistic to create a bathroom assembly. With schedule savings of a week, and reduced waste, the 43 plumbing manifolds were recommended.

Depth 2: Hollow-Core Concrete Plank with Structural Breadth

Hollow-core concrete plank was investigated in the structural depth for its material proprieties and connections as a replacement for a second story cast in place concrete slab. The main benefit of the precast plank is the schedule savings and exceeding necessary material properties. The Hollow-Core Concrete Plank was recommended on the basis of the schedule savings to move the tenants in quicker.

Depth 3: LEED Goals and Green Roof with Mechanical Breadth

By examining the current building with the LEED size adjustment, the Foundry at 41st would be eligible to be LEED certified. In order to become LEED silver, a green roof and air-water system are proposed. After looking at the economic benefits to both, the initial cost of the change to an air-water system is too high. The green roof is recommended on its ability to save the developer money.

Depth 4: Minimal Living Floor Research

At first glance, the specification appears to provide high end LEED certified finishes, but with more investigation the cost of the finishes could be lowered. When interviewing the Project Engineer and Superintendent on site, the cost of the finishes presented an opportunity for value engineering. By using the principals of minimalist architecture, a reduction of the floor plan by 40 percent of the 6th floor was redesigned. This redesign has large environmental and economic savings.

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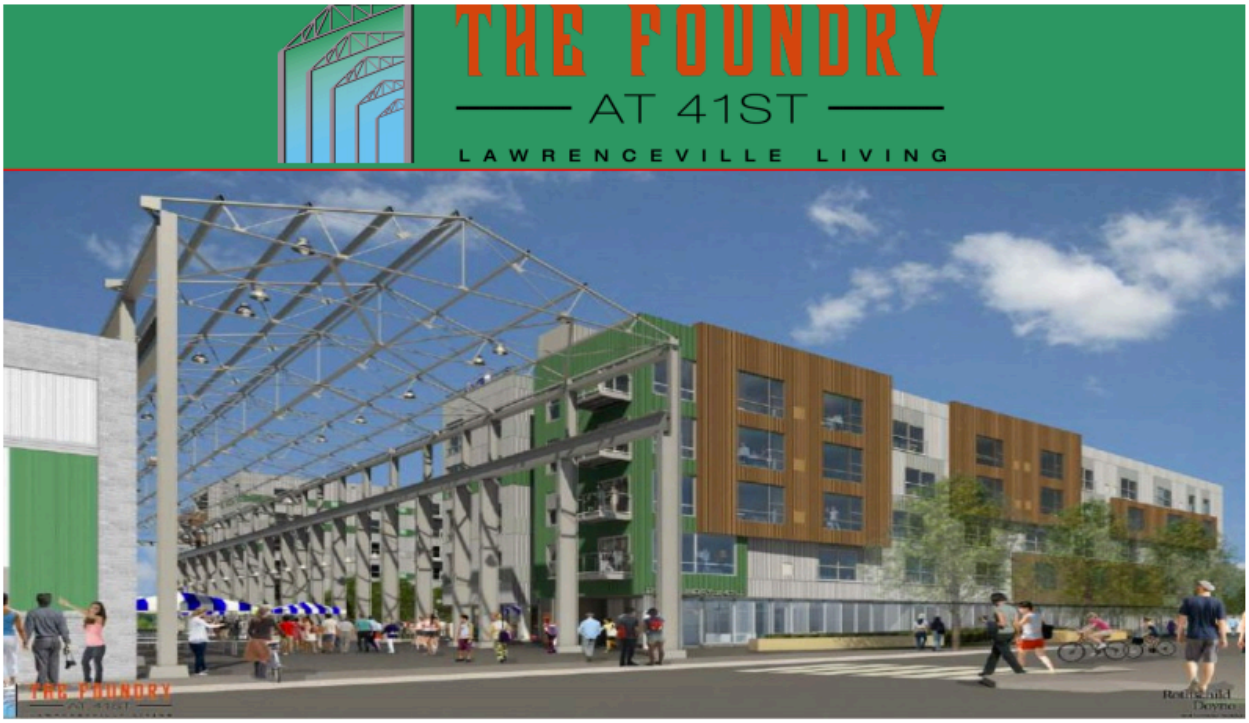
Acknowledgements

Thank you to everyone who has helped me throughout this experience. First off I would like to thank my parents for their support during my time at Penn State. Thank you for supporting me emotionally and financially for all six years in the program. As well thank you to my three siblings both near and far away for lending an ear when I talk about thesis or a problem going on in my life. In addition, I would like to thank Diana and members of Westminster Presbyterian Fellowship for being there during some of my toughest moments. Finally, I would like to thank my friends, Abby, David, Alexis, Shannon, and Yesha, who have brought joy to my life. Thank you again for your love and support as I start a new journey with my first job opportunity with MC Dean in State College.

PJ Dick	Project	Supports	Academic
Bryan Passarella	Walnut Capital	Mom and Dad	Dr. David Riley
Jude Champion	Rothschild Doyno	Diana Malcom	Dr. Robert Leicht
Bruce	AES	Ronda Stern	Dr. Moses Ling
Eric Pascucci	Allen & Sharriff	Matt Grimes	Dr. John Messner

Abstract



Building Statistics
Lawrenceville, PA
$35 million
CM Agency
Duration: Nov 2015-May 2017

Architecture
6 story apartment building with a 164 units. Bay 4 is historic to area. Park to be built under the Bay. In future commercial building to be added on site.

Project Team:
Owner: Fort Willow Developers
Architect: Rothschild Doyno
Contractor: PJ Dick
Structural: Atlantic Engineering Services
Mechanical: Allen & Shariff

Structure
Podium Style Post Tension First Floor Slab.
Wooden Frame 2nd-6th Floors.
Steel Joists for cantilevered balconies.

Mechanical
All Air:
Variable Air Volume
VAV System

Electrical
1 Generator
1 Transformer
6 Panels: 2 800A, 2 400A, 2 200A
2 MCB per floor

Emily Roarty
Construction

Project Background

The Foundry at 41st is a 162-unit apartment complex with six floors. Some of the units have balconies which make the structure more complex. On the sixth floor there is a roof terrace. The total occupancy is 1,821 people. The Foundry uses the 2009 ICC code. The building is zoned to be a residential building, but in the future commercial development might happen on the masonry building on the property. The Foundry is built in the historical site of Lawrenceville neighborhood of Pittsburgh. There are requirements to protect Bay 4, which is existing to the area.

General Building Facts

Project	The Foundry at 41st
Location	Lawrenceville, PA
Owner	Ft. Willow Developers
Type of Project	Residential
Gross Square Feet	202,616 square feet.
Stories	Six total stories
Project Team	Primary project team including owner, general contractor, CM, architects, engineers, etc.
Owner	Ft. Willow Developers
Construction Manager	PJ Dick
Architect	Rothschild Doyno
MEP	Allan & Shariff
Structural	Atlantic Engineering Services
Schedule	November 2015-May 2017
Budget	$35 million $175/ square feet
Delivery Method	Design Bid Build

Building Enclosure

The Foundry at 41st enclosure is a metal panel, and sections of the building jut out like box cars. There is a total of 23 different wall types in this building, so enclosures will face as a challenge. Especially in estimating the different types of material, and keeping all of the types straight. The first floor is a cast in place concrete slab and the rest of the floors are wooden. The roofing of the Foundry is a typical EPDM roofing. This item was selected by the owner because it has worked on other projects and is economical. In terms of sustainability, the roof top garden on the sixth floor is the main sustainable feature of the building. Local and sustainable plans will be maintained on the roof top garden for the occupants. Like most residential projects, sustainability is not the main driving force behind the project.

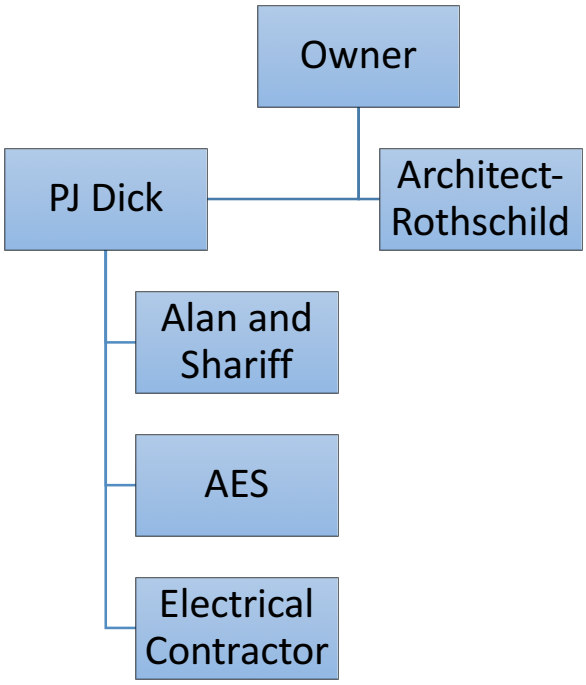
Client Information

Walnut Capital is one of Pittsburgh's best known and fastest growing real estate management, development and brokerage companies. The company is leading the way in the development and property management of luxury apartments, townhomes and commercial real estate in various prime Pittsburgh locations.

Walnut Capital continues to grow. With many exciting projects in the planning and development stages, Walnut Capital will feature 2,500 units by 2017. The developer creates apartments with innovative, exciting features are resident perks that make our locations more desirable and therefore more value

Project Delivery System

The project delivery system is Design, Bid, Building type with a lump sum contract. The contract between the Owner Walnut Capital and PJ Dick. Each subcontractor holds a contract with the Construction Manager, PJ Dick. The Architect has a separate contract with the owner. Please see the diagram below for clarification:



Depth 1: Mechanical Kitchen Plumbing Manifold

Summary

In this Analysis, a Kitchen Plumbing Manifold was designed in order to cut down waste and schedule savings on the project. First the shared walls were identified. Then the drawings were a good indicator if it was feasible to do an in wall manifold. Finally, a cost estimate, and schedule were prepared to justify the design. A Mechanical breadth was performed in this analysis.

Problem Identification

When looking at the architectural floor plans, it is clear that there are shared walls between a number of bathroom and kitchen units. In fact, there are 103 shared walls out of the 184 shared apartment units. The shared walls provide an opportunity to use less waste in between two back to back kitchen or bath units. The benefits of this opportunity could be less waste, less safety risk, more quality, schedule, and cost savings.

When examining the plumbing drawings however, only forty-three of the 103 shared walls can be used to do prefabrication. The bathroom unit 3 to unit 3 as well as a 3 to 1 unit did not work because the piping was under slab not in wall. In addition, a couple other Kitchen and Bath configurations were repeated 3 to 7 times, but this was not explored in this analysis due to efficiency. The focus of this analysis was the 43 shared walls between the kitchen design of two style 3 units (See Figure 1)The shared wall would have a prefabricated plumbing manifold to service the supply and drain waste vent (DWV) piping in the kitchens.

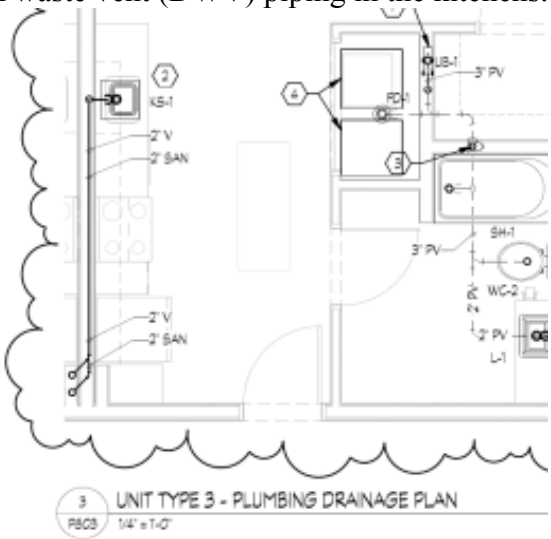


Figure 1. Unit 3 Drainage Plan.

Background

During research of plumping manifolds, they are typically found in the shared wall of public restrooms in commercial buildings to make easy construction and up keep. The shared wall allows for hook ups to appliances, sinks, carriers, etc. to be attached back to back. This can save on pipping, materials, and connections.

In order to organize the bathroom and kitchen units, a spreadsheet was made using floor, type of unit, and type of shared wall (example between 3 to 2 style unit). The Units were color coded on the excel sheet to categorize each type. A unit breakdown was created, which is shown below:

Key	Unit	Count
Kitchen	3 to 3	43
Bath	3 to 3	28
Bath	3 to 1	10
~~Bath~~	~~3 to 2~~	~~7~~
~~Kitchen~~	~~1 to 1~~	~~5~~
~~Kitchen~~	~~6 to 2~~	~~4~~
~~Kitchen~~	~~2 to 2~~	~~3~~
~~Kitchen~~	~~3 to 1~~	~~3~~
Kitchen	3 to 2	~~0~~

Table 1. Key to Unit Type of Shared Walls

Due to time constraints, only the Kitchen units 3 to 3 where explored because amount of in wall piping and fixtures. The bathrooms 3 to 3 and 3 to 1 where considered initially, but quickly ruled out when looking at the plumbing drawings. Note Table 1 above to see the breakdown of Unit types that have shared walls. The plumbing drawings reveal the majority of the piping in under the flooring.

The goals of the analysis are to see if prefabrication of Kitchen plumbing manifolds would decrease waste, and days on the critical path schedule as well as save cost.

Execution

With the background of the 43 shared kitchen walls for two type 3 units, the analysis was conducted in creating an estimate and schedule for a prefabricated plumbing manifold. The estimate revealed that the cost of a 43 shared kitchen walls would be $33,589.70 (See Appendix 1) to prefabricate with a schedule of 18 days on the critical path. The total amount of linear feet of pipe to be prefabricated would be 1,598 linear feet (See Table 2 for Estimate).

For the prefabrication cost and schedule, it would cost around $28,580 to manufacture, ship, and install on site. In terms of schedule it would take 10 days to install on site. That would create a savings of around $6,000 and schedule savings of a week on the critical path.

Table 2. Summary of Estimate

Item	Estimate
43 total Plumbing Manifolds Cost	$33,589.7
Single Plumbing Manifold Cost	$781
Total Number of Linear Feet for 43 Manifolds	1,598
Single Plumbing Manifold Linear Ft	37

According to a local plumbing prefabrication shop, McKamish construction has found an average of 6 percent cost savings and a range of 2 to 4 weeks in project schedule on plumbing projects. McKamish is just an example of a local prefabrication shop about a 7 minutes' drive away. Having buy in from the local plumbing contractor would be imperative for this prefabrication to save on schedule and budget.

Transportation Analysis

Calculation for Transportation Analysis.

Dimensions: 18.7 ft approximately 20 ft long
3.5 ft wide
Dimension of Truck: 48 ft long
8.5 ft wide
Approximately 11 truckloads of 4 manifold each to the site
$1.7/ mile * 7 miles*2 trips*11 truckloads= $275 rental
$67/ hour*8 hour days* 10= $5360
Total Cost of Transportation= $5635

After the transportation analysis, it was clear that the cost of transportation and the cost in prefabrication savings would be a wash. The cost savings is not the main driver of this analysis; however, the schedule saving truly saves the owner money.

Installation Analysis

In order to install the prefabricated units, the crane on site used during the time of framing the wooden walls would be used. The crane would install these prefabricated units at the time of the framing and would be protected until enclosed.

Recommendation

I would recommend prefabricating 43 shared kitchen plumbing manifolds because of the schedule, waste, and cost savings. Primarily the schedule savings of a week on the critical path schedule on site would be the main benefit of this opportunity. Seven days in addition to schedule savings in structural analysis of 10 days would add 17 days to the critical path. The developer would appreciate the added value of rent. A month savings of critical path would translate into at least $348,000 to $540,000 profit per month depending on if the developer can rent out the units. The schedule savings in more significant than the overall waste, labor, and material savings that might occur.

Figure 2. Prefabricated Pipe System in the shop.

Depth 2: Hollow-Core Concrete Plank

Summary

Problem Identification

The post tension concrete slab is typical for a podium style structure. It has an excellent span to depth ratio to park cars underneath, sound transmission coefficient (STC) ratings, and performs well to get extra story of wooden framed residential. However, the posttensioned system construction speed is slow, complex, and requires significant shoring. Walnut Capital, the developer, was to overturn these units quickly at a low cost. The largest time impact is the post tension concrete floor, and then floors 3 through 5 are the same.

In order to overcome the long lead time schedule items, double tee, hollow core concrete plank, and other structural systems were explored. The two main examined structural changes where two floors for parking (one double tee and the other hollow), and a single floor of parking with the concrete hollow-core concrete plank. Early in the research, a single floor of concrete hollow-core concrete plank met the program of the building because there are 108 parking spaces outside. The parking for the building only need to house around 60 covered parking spaces.

At first glance, the challenges with hollow-core plank would be mainly be cost. Could the contractor justify the cost to the owner of hollow-core concrete plank? Would the benefits of reduced safety risk, speed of construction, and quality control outweigh the cost? The previous questions were explored in the analysis.

Problem Background Research

In researching Hollow-core plank, the span to depth ratio was explored. The depth of the plank is 16” with an additional 2-3 inch topping slab. In the Foundry at 41st, the concrete cast in place slab on deck is 7.25 inches. Clearly the depth of the structure would increase with the Hollow-core plank, but the increase is not enough to interfere with height limitations. The span of the plank is 29 feet. The largest bay in the existing drawings was 27 feet. The span to depth ratio for the would span more area.

In terms of comparison with slab on 20 gauge metal deck, the comparable in holding load, fire resistance rating, and hollow core plank has a similar span. The superimposed load can be up to 390 psf on the hollow-core plank. The existing 2”-20 gauge composite steel deck with a 5 1/4” normal weight concrete slab has a total thickness of 7 ¼ inches. Using Vulcraft catalog, 2 VLI composite deck was found as a comparable to the used system. The slab on deck can hold the load of 276 psf. Therefore, the hollow-core plank exceeds the strength requirements for load. In addition, both systems have a 3 hour fire rating. Finally both the composite deck and hollow core plank span 27 to 29 feet respectively.

LEVEL 2 (SLAB/DECK) SCHEDULE

MARK	TYPE	REINFORCING	TOTAL THICKNESS
S3	5 1/4" N.WT. CONC. SLAB ON 2"-20 GA. COMP. STEEL DECK	REINF. W/ 6X6-W4.0XW4.0 W.W.F.	7 1/4"

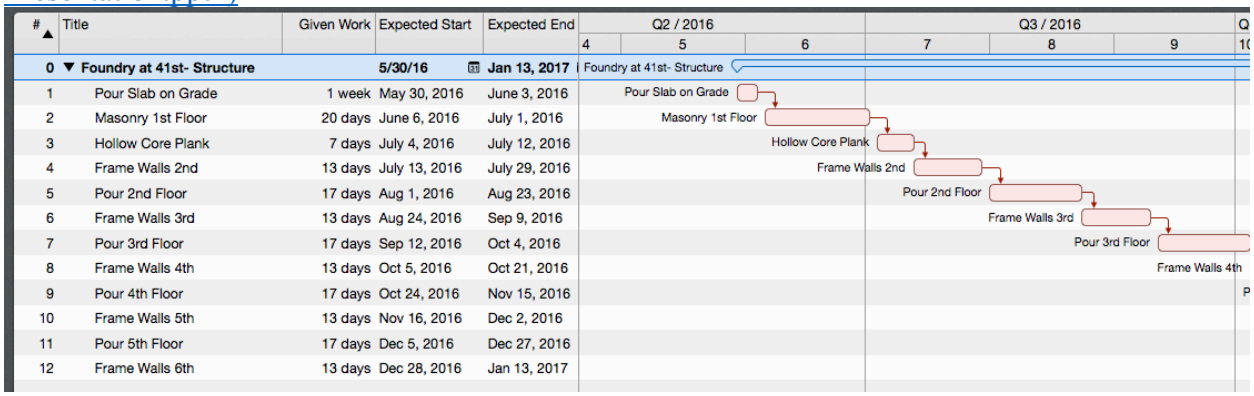
Beyond the material properties, the structural systems differ in their erection schedule. For the hollow-core plank, 4,500 sf per day can be erected, which would take 6 days to be erected on the Foundry project. One also must take into account the lead time of manufacturing off site, and the transportation from Chambersburg, PA which is 3 hours away from the site. It

would take 28 days or more to pour the slab on deck for the second floor. Clearly the hollow core plank has a reduction of 22 days on the schedule for pouring the second floor.

In researching the local manufacturer, Nitterhouse Concrete Product, the Hollow-Core plank is advantageous for the construction speed, the comparable span lengths, and the comparable fire rating. As well the reduced risk of accidents on site, and quality control off site. The table below details the differences between Hollow-Core and Post-Tension Cast in Place.

	Hollow-core	Double Tee	Post-Tensions Cast in place
Span to Depth Ratio	Excellent	Good	Excellent
Construction Speed	Excellent	Excellent	Poor
STC Ratings	Excellent	Good	Excellent
Shoring Required	No	No	Yes (Significant)
Immediate Safe Working Platform	Yes	Yes	No
Span Lengths	Up to 30 ft	Up to 62 ft	Up to 30 ft
Typical Use	Podium Slabs Residential Floors Hospitality	Parking Garages Office Buildings Warehouse	Podium Slabs Residential Floors Parking Garages Office Buildings
Fire Rating	2 Hour	2 Hour	2 Hour
Contractor Benefits	Reduced Risk Speed of Construction Design Assistance	Reduced Risk Speed of Construction Design Assistance	Self Performance

As well the connection of the concrete hollow core planks was researched: ([https://openlab.citytech.cuny.edu/buildingtech4posts/files/2013/09/BTech4_Research-Concrete-Presentation.pptx)](https://openlab.citytech.cuny.edu/buildingtech4posts/files/2013/09/BTech4_Research-Concrete-Presentation.pptx)



#	Title	Given Work	Expected Start	Expected End
0	Foundry at 41st- Structure		5/30/16	Jan 13, 2017
1	Pour Slab on Grade	1 week	May 30, 2016	June 3, 2016
2	Masonry 1st Floor	20 days	June 6, 2016	July 1, 2016
3	Hollow Core Plank	7 days	July 4, 2016	July 12, 2016
4	Frame Walls 2nd	13 days	July 13, 2016	July 29, 2016
5	Pour 2nd Floor	17 days	Aug 1, 2016	Aug 23, 2016
6	Frame Walls 3rd	13 days	Aug 24, 2016	Sep 9, 2016
7	Pour 3rd Floor	17 days	Sep 12, 2016	Oct 4, 2016
8	Frame Walls 4th	13 days	Oct 5, 2016	Oct 21, 2016
9	Pour 4th Floor	17 days	Oct 24, 2016	Nov 15, 2016
10	Frame Walls 5th	13 days	Nov 16, 2016	Dec 2, 2016
11	Pour 5th Floor	17 days	Dec 5, 2016	Dec 27, 2016
12	Frame Walls 6th	13 days	Dec 28, 2016	Jan 13, 2017

Design Considerations:

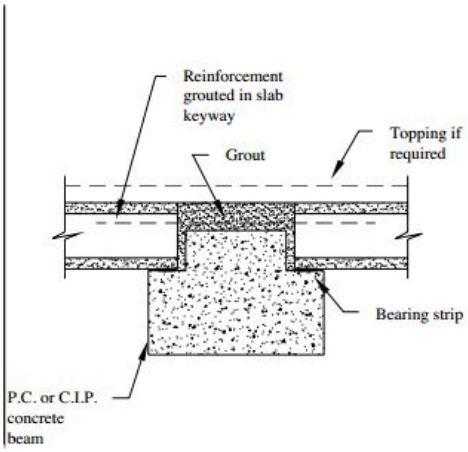
- Can transfer internal diaphragm forces
- Can be designed as structural integrity tie

Fabrication Considerations:

- May increase beam reinforcement for shallower beam
- Layout must have opposing slab joints lined up

Erection Considerations:

- Clean and simple



Design Considerations:

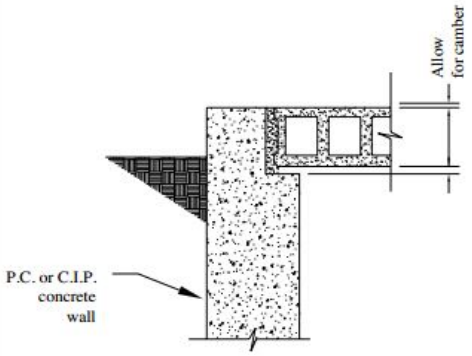
- Wall thrust from earth pressure can be resisted
- Can transfer diaphragm shear only with special detailing of keyway and reinforcement
- For long spans consider effects of restraint of vertical movement

Fabrication Considerations:

- Clean and simple

Erection Considerations:

- Edge joint must be grouted which may not be standard practice



Execution

To begin the structural depth, a cost estimate of Hollow Core Plank vs. the Composite Deck was performed. The cost of Hollow-Core Plank per sq ft is approximately $7.31. The total cost of the Hollow-Core Plank is $186,068. The cost of Composite deck is approximately $9.59 per square feet. The total of the Composite Metal deck is $244, 104.

Item	Rate
Material	8.40 / SF
Structural Steel Workers Apprentice ($37.31/hour for 0.01 hours)	0.34 / SF
Structural Steel Workers Foreman ($45.36/hour for 0.00 hours)	0.14 / SF
Structural Steel Workers ($44.24/hour for 0.02 hours)	0.67 / SF
WELDER, 200 AMP, W/1 AXLE TRLR ($8.43/hour for 0.01 hours)	0.06 / SF
Other	0.00 / SF
Total	**9.59 / SF**

After the cost estimate, a schedule analysis of Hollow Core Plank vs. the Composite Deck was performed. For the Hollow-Core Plank, the manufacturer estimates a 4,500 square feet per day erection, which would take approximately 6 days for the 25, 454 sq. ft. of parking garage. For the Composite Deck it would take two days to pour and 28 days till the Composite deck could fully handle load. The Hollow-Core Plank would save about 22 days on the construction schedule.

Structural : Hollow Core Plank

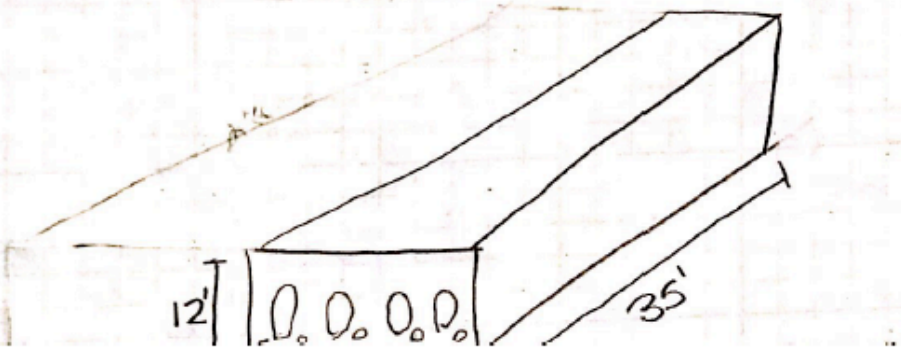
2 hour fire rating, 2" topping slab

Super imposed Dead Load 15 psf (4 ft) = 0.06 k/ft

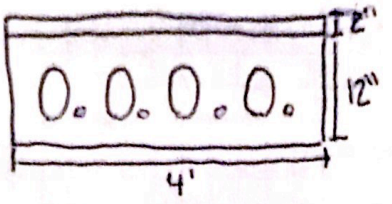
Live Load 20 psf (4 ft) = 0.08 k/ft

Self weight $\frac{361\ in^2}{\left(\frac{144\ in^2}{1\ ft^2}\right)} \times \left(\frac{0.15\ k}{ft^3}\right) = 0.38\ k/ft$

total load = 0.52 k/ft



Given: 12" topped plank,
35' span,
6, ½"Φ strands
87 psf given



SPAN to DEPTH RATIO

$$\frac{35'}{12"} \times \frac{12"}{1'} = 35 \text{ span to depth ratio}$$

Bending moment

$$M = \frac{w\ell^2}{8} = \frac{(.45 + .348)(35')^2}{8} = 122'k$$

Top + Bottom Stresses due to self wt

$$\text{Top Stress} = \frac{122'k}{1653\ in^3} \times \frac{12\ in}{1\ ft}(1000) = -887\ k/in$$

$$\text{Bottom Stress} = \frac{122'k}{1653\ in^3} \times \frac{12\ in}{1\ ft}(1000) = +1354\ k$$

Uniform Axial compression

$$\text{Top Stress} = \frac{25k\,(6\ strands)(1000)}{361\ in^2} = 416\ lb/in^2$$

$$\text{Bottom Stress} = \text{Top Stress} = 416\ lb/in^2$$

$e = 2.25\ in.$

Top and Bottom Stress Due to eccentricity

$$\text{Top Stress} = \frac{150\,(2.25\ in)}{361\ in^3}(1000) = +935$$

$$\text{Bottom Stress} = -935\ lb/in^2$$

Allowable Stresses

Top Stress = $-887 - 416 + 935 = -368\ lb/in^2 < -3600$ ✓

Bottom Stress = $+1864 - 416 - 936 = 312\ lb/in^2 = 10\sqrt{6000}$ ✓

$f'_c = 6000$ psi strength at 28 days

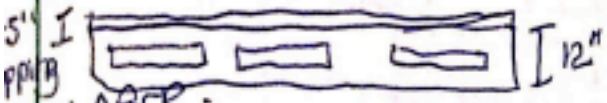
Precast slab, floor members, grouted, 12" thick, prestressed Pittsburgh, PA.
Bare Material $8.12/sf.

Material Cost = $8.12/sf (25454 sf) = $206,686.48

Daily output = 4000 sf/day ÷ (25454 sf) = 6.36 days ≈ 7 day

Equipt output = $0.49/sf (25454 sf) = $12,472.46

Live Load psf = 100 psf for floor

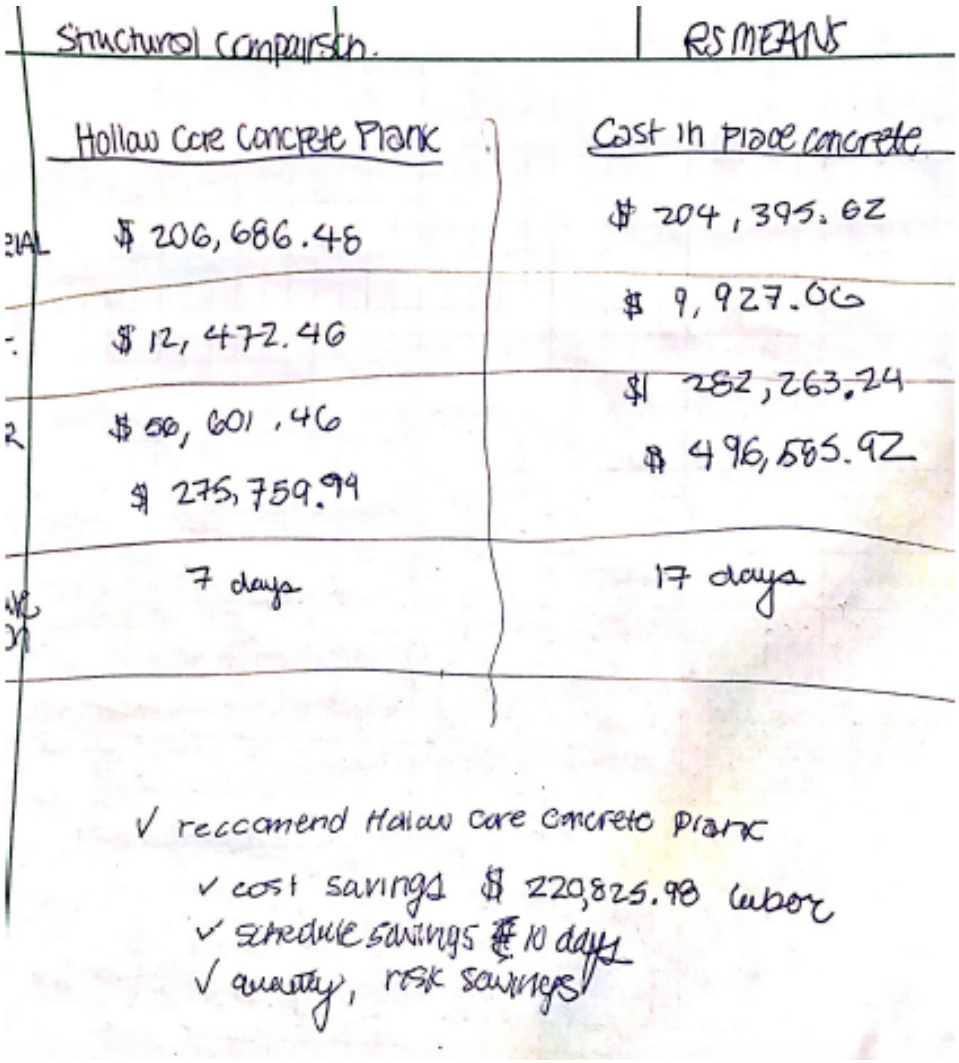


LABOR:

Crew	Hr.	Daily	O+P Hr	O+P Daily
1 Structural steel Forman	56.3	450.4	93.85	750.8
6 Struct. steel workers	54.3	2606.4	90.5	4344
1 Equipt. Op.	55.7	445	84.25	674
1 Equipt Op.	48	384	72.6	580.8
1 Boom Crane, 150 ton		2000		2200
Daily Total		$5886.4		$8549

Per labor hour $81.76

OP $118.76



Conclusion

With the savings in schedule of 22 days, I would justify the advantages of using Hollow-Core Plank. There are reduced labor savings, however the schedule savings are more imperative for the beginning of the project. It is important to get the structure on schedule early during construction.

Depth 3: LEED Implementation and Green Roof

Summary

The terrace on the sixth floor is currently a tiled terrace, but this analysis uncovers the benefits of becoming LEED certified and adding a Green Roof Terrace. The analysis starts by explaining the benefits of achieving LEED certification. Then it explores the cost and benefit analysis of the green roof. Finally, the design of the particular roof is explored.

Problem Identification

The Foundry at 41st design and construction team did not pursue LEED for Homes Certification, but with the midrise size adjustment lowers the standards by 5 LEED points. The levels for adjusted accreditation would be certified, 35; silver, 45; gold, 55; and Platinum 75 points. Studies show that tenants are willing to pay more money for LEED certified apartment buildings. The main objectives of this analysis are to create a more sustainable end project, and to save the developer money.

Figure #. Green Roof Area

Considering there is a baseline of LEED points for the building is 35 LEED points that they have already attained without changing anything about design or construction. A good goal for the design and construction team would to be focus on one subcategory and do it well. Below in the Execution plan, a mapped out process for LEED Silver at 47 points.. At a basis this project could easily be LEED certified, but the team did not pursue this path.

In order to achieve LEED silver, the path of constructing a green roof terrace was mapped out. The cost, and schedule were detailed, as well as the payback period. In the Background research, the economic drivers behind LEED certification were explored.

The area in question is the 3,325 square feet roof terrace that is on the sixth floor of the building. The plans show a terrace with tile flooring. This area would be most accessable for construction of a green roof.

Background

Studies show that tenants are willing to pay as much as 9 percent more a month on rent if the building is LEED certified. Tenants want a LEED certified building because of the environmental impacts, less cost of utilities, and community responsibility. Another study showed that renters are willing to pay $100/ month more on rent, while a typical green apartment costs an additional $560/ month. With the cost of an extra $100/ month in mind, the estimates performed in this analysis assumed a higher payback period.

The owner would benefit from LEED certification because of higher rent costs, and the environmental impact of the green roof. Tenants might be more willing to move into an apartment that is environmentally responsible and has green initiatives.

Execution: Focusing on Energy and Atmosphere Standards

Cost Benefit Analysis

In order to meet LEED Silver, the project team would need to earn at least 10 of the 15 LEED points in Sustainable Sites, Water Efficiency, and Materials and Resources sections. Please see the chart below for the description of potential LEED points. The process of designing a green roof would have to follow material reuse requirements in order to get LEED points.

Table 3. Summary of Potential LEED points for Green Roofs (See Appendix 3 for more detail)

Sustainable Sites
SS Credit 5.1 – Site Development – Protect or Restore Habitat (1 point)
SS Credit 5.2 – Site Development – Maximize Open Space (1 point)
SS Credit 6.1 – Storm Water Design: Quantity Control (1 point)
SS Credit 7.2 – Heat Island Effect: Roof (1 point)
SS Credit 7.2 – Heat Island Effect: Roof (1 point)
Water Efficiency
WE Credit 1 –Water Efficient Landscaping **(Potential: 2-4 Points)**
Energy and Optimization
EA Prerequisite 2: Minimum Energy Performance **(Required)**
EA Credit 1 – Optimize Energy Performance **(Potential: Up to 19 Points)**
Materials and Resources
MR Credit 3 – Material Reuse **(Potential: 1-2 Points)**
MR Credit 4 – Recycled Content **(Potential: 1-2 Points)**
MR Credit 5.1 – Regional Material **(Potential: 1-2 points)**

Then I explored the pros and cons of creating a green roof terrace. The benefits include a short payback period, increased rent for being LEED certified, and an environmental benefits. The drawbacks include potential water issues, and initial cost. In order to justify this cost, one must consider the extra profit earned from charging more for being certified. Studies have shown that rent increases 9% for LEED certified buildings. Lets assume that the owner only increases rent by 1%, if the building rents apartments for $1000 a month, and earns a profit of $184,000/ month. The monthly profit would increase to $1,840 per month or $22,080 per year. It would take approximately 3 years to pay back the investment of the green roof. The owners will see an annual profit of at least $22,080 per year from being LEED certified at the Silver level.

The chart below displays the cost-benefit of a green roof. In particular, the Foundry's roof terrace would be 3,500 sq ft level with a pay back of 4 years. The owner would want to choose the environmental benefits of the roof over the financial benefits.

Table 4. Green Roof Cost-Benefit Analysis

Table 8: Cost-benefit analysis results of green roof vs black roofs

NATIONAL LEVEL RESULTS	ROOF SIZE (ft²) 5,000	10,000	50,000
Impact on Owners/Occupants/Investors			
Initial Premium, $/ft² of roof (extra cost of installing a green roof instead of a black roof)	-$12.6	-$11.4	-$9.7
NPV of Installation, Replacement, & Maintenance, $/ft² of roof	-$18.2	-$17.7	-$17.0
NPV of Stormwater, $/ft² of roof (savings from reduced infrastructure improvements and/or stormwater fees)	$14.1	$13.6	$13.2
NPV of Energy, $/ft² of roof (energy savings from cooling and heating)	$6.6	$6.8	$8.2
Net Present Value (installation, replacement & maintenance + stormwater + energy NPV)	$2.5	$2.7	$4.5
Internal Rate of Return (IRR)	*5.0%*	*5.2%*	*5.9%*
***Payback**, years*	*6.4*	*6.2*	*5.6*
Return on Investment (ROI)	*220%*	*224%*	*247%*
Other Financial Impacts (less realizable)			
NPV of CO_2e, $/ft² of roof (emissions, sequestration & absorption)	$2.1	$2.1	$2.1
NPV of Real Estate Effect, $/ft² of roof (value, rent, absorption & vacancy)	$120.1	$111.3	$99.1
NPV of Community Benefits, $/ft² of roof (biodiversity, air quality, heat island, etc.)	$30.4	$30.4	$30.4

Table 5. Summary of Green Roof Cost and Schedule

Item	Estimate
Total Square Feet of Terrace	3,325 sq ft
Total Cost per square feet	$20/ sq ft
Total Investment	$66,500
Payback Period	4 years

Green Roof Design

There are four types of green roofs: Single course, Multicourse, Semi-Intensive, and Intensive. Intensive is the green roof chosen in this analysis, and an image below depicts the design of the roof. The semi-intensive was chosen because of cost and the type of vegetation that it can grow. It can be a selling point of the sixth floor units.

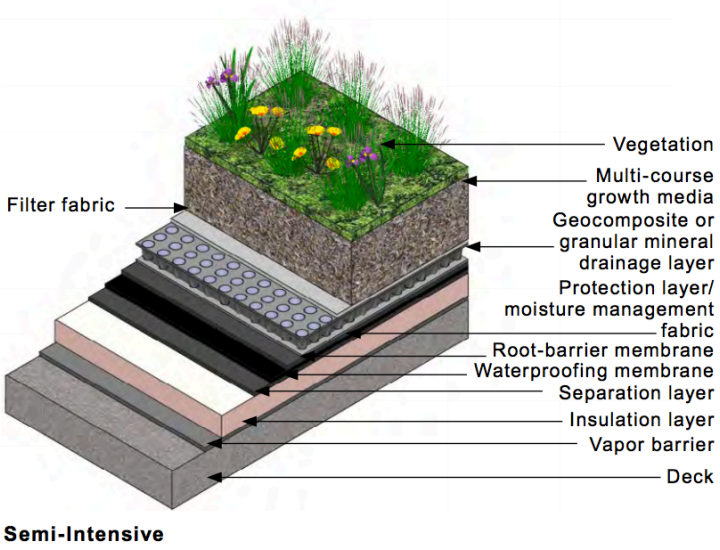


Figure #. Semi-Intensive Green Roof Design

Breadth- Mechanical

The Mechanical system for the Foundry at 41st is a forced all air system with PTAC units, which is a low initial cost but, not necessarily the most sustainable option for an apartment building. In this breadth, the objective is to make the mechanical system more energy efficient, and justify the first cost of the system. Figure 3 and Figure 4 below show the difference is the two system. The all air system uses different zones of supply ducts and return ducts. The air-water system uses an air system in addition to a chiller and boiler with Fan Coil Units.

Figure 3. All Air System

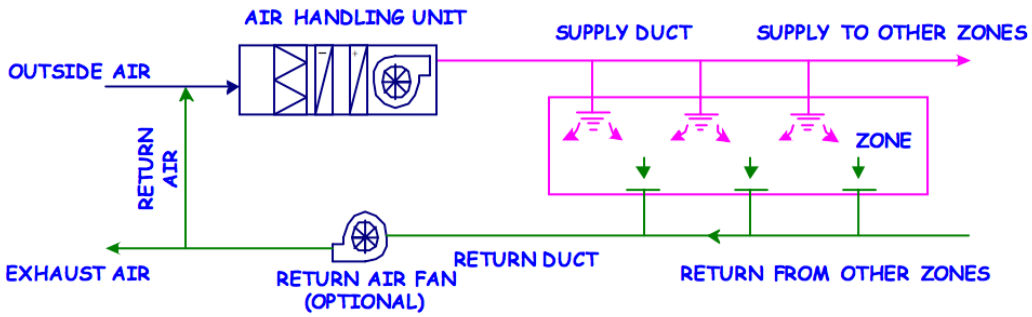
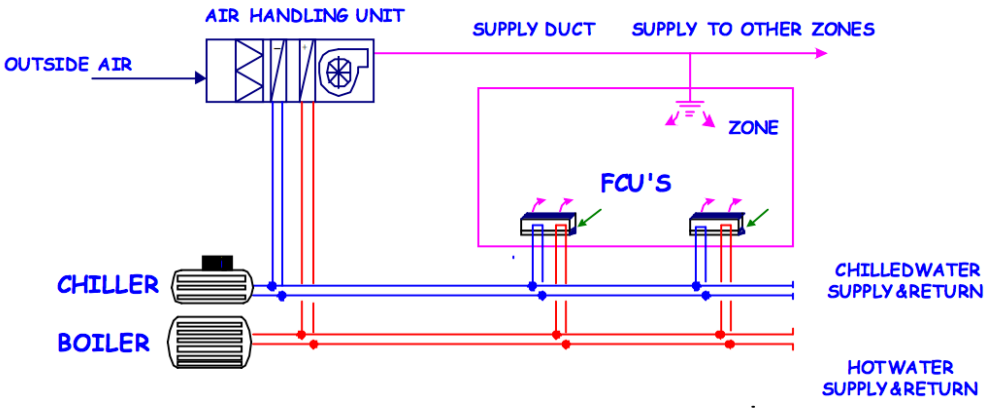


Fig. 4 Air-Water System



First Cost Estimate

Item	Estimate
All Air (current system)	$25/ square ft.
Air-Water System (alternative system)	$34/ square ft. (includes piping)
All Air Percentage of Budget	15%
Air-Water System Percentage of Budget	20%
All Air Total Cost	$5,250,000
Air-Water Total Cost	$6,870,000

Annual Cost Estimate

It is expected that the Air-Water System will have a lower operating cost due to smaller fan coil units, lower reheat requirements, and moisture recovery. For a more energy efficient mechanical system, the Air-Water system would be the better choice. The Air-Water System has a larger initial investment and a lower annual cost. The initial cost is too high to justify for the budget of the Foundry because the payback period would be roughly 20 years.

Recommendation

The recommendation for this analysis is to construct a green roof terrace, and provide the architectural plans for the building adjustment in order to meet the standards of the Energy and Atmosphere accreditation. I would not recommend changing the mechanical system, even though it might be more energy efficient, the initial cost cannot be justified. The objectives of this analysis to save the owner money, while improving the sustainability of the building are being met. A four-year payback is a reasonable estimate and could even be paid back faster is more profit is made.

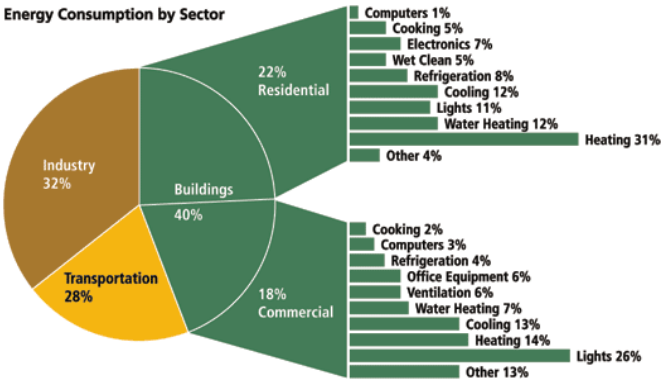
Depth 4: Minimal Living Floor Research

Summary

Due to the high price of luxury finishes, the analysis looked at lowering the cost of the finishes, while remaining environmentally friendly. The analysis began by looking at existing finishes. The finishes were sustainable, so I looked toward minimalist architecture for inspiration.

Critical Industry Research: Minimal Living Research

Critical Research Problem and Goals



Problem statement, audience, goals, and who benefits

The critical issue facing the construction industry is increasing floorplan that leads to the consumption of electrical, water, gas, and other utilities, which is leading to a negative impact on our environment. The building industry consumes 40 percent of energy with half coming from the residential sector. See Figure 5, for the breakdown of energy usage by sector.

It is imperative that all construction projects examine their impact on the environment because the problem is very real. During a talk on environmental climate change, I asked Dr. Richard Alley, a professor at Penn State on Climate, "What can a person do to make sustainable changes?" He replied, "Do one thing and do it well." He went on to explain that if stick to one thing like recycling, biking, or working in LEED projects and do our best to become an expert that sustainable change will come. It is important that all of us examine our actions to how they impact others. To further see the scale of the issue, look to the Literature Review section.

Beyond the scope of the problem, the goals of the Minimal Living Research are to research Minimalist architects, consultants, and engineer's advice, design a minimal living floorplan, and reflect on the economic and environmental impact of such a template. The expected outcome is that their willing be a high return environmentally, but marketing the units to the right demographic will be more complex.

Literature Review of Problem

The literature review examines three main studies on Minimal Living Research: storage industry in America, increase in floorplan size since the 1950's, and percent of space actually used by the average family in America. Clearly the size of floorplans and their impacts will be discussed in context of each of the three studies.

According to the Self-Storage Association it is "physically possible that every American could stand-all at the same time-under the total canopy of self-storage roofing." This fact proves that our building industry is upside down. How is it possible that we live in a world where our stuff (ranging anywhere from old TVs to wedding dresses) have a better shelter than those who are homeless? For many our homes fill up with stuff that the family has to rent a storage unit. To

the point where Storage Industry is a $2.2-Billion-dollar industry. We are buying stuff to be stored in a locker that we then have to pay for long term.

In addition to the shocking amount of personal storage units, since the 1950's the buildings in the United States have increased in size by three times the square footage. According to Juliet Shor, a researcher in Economics and Sociology at Boston College, "The American Dream started out more about opportunity, but now is increasing more in material terms." American families have increased the size of their houses at a time when the median family size has been shrinking. This brings to mind the familiar concept of "Keeping up with the Joneses", that we build bigger houses to impress our neighbors.

Finally, the third study that framed the context of the problem is a heat map study that found a family of four only uses 40 percent of their living space. This study was conducted at UCLA and was printed in the Wall Street Journal. As stated above residential properties are increasing by three times as much space, but only 40 percent of that space is being used. The study was done on a residential home, and

found rooms like Living Rooms, Dining Rooms, and Porches were used the least. Clearly Americans are not using their space efficiently.

Conclusion of Background Research

In summary the three studies show that Americans are consuming more space than ever before, and using less of it. To often the American Dream is becoming more material: more technology, clothes, household goods, cars, etc. A revised image of the American Dream could be how can we come together in community to help our environment. In order to create a project that is in line with the values of Minimal Living, the sixth floor of the Foundry at 41st is going to be redesigned.

Application to the Foundry

The issue of over consumption is going to be addressed at the Foundry by using principals of Minimal Living by reducing overall floorplan, using multifunctional furniture, and creating a green roof as well as a terrace with the extra space.

In order to reduce the overall floorplan of the sixth floor, the guidelines of 300-500 square feet for singles, and 500+ for couples and families was implemented. The two templates of floorplans include 15, 530 sq ft. Micro apartment designed for the Foundry in addition to 15, 675 sq ft. 2 bedroom apartments designed by the Architects at Life Edited, a consulting firm on minimal living. By reducing the floorplan, many benefits were seen which is explored in the last two sections.

As well as reducing the floorplan, investigating the benefits of multifunctional furniture was useful to free up space in the floorplan. Murphy beds were the main piece of folding furniture that was used in the two-bedroom floorplan that can allow a family of four to reside. See Figures to left for the two-bedroom layout and micro layout.

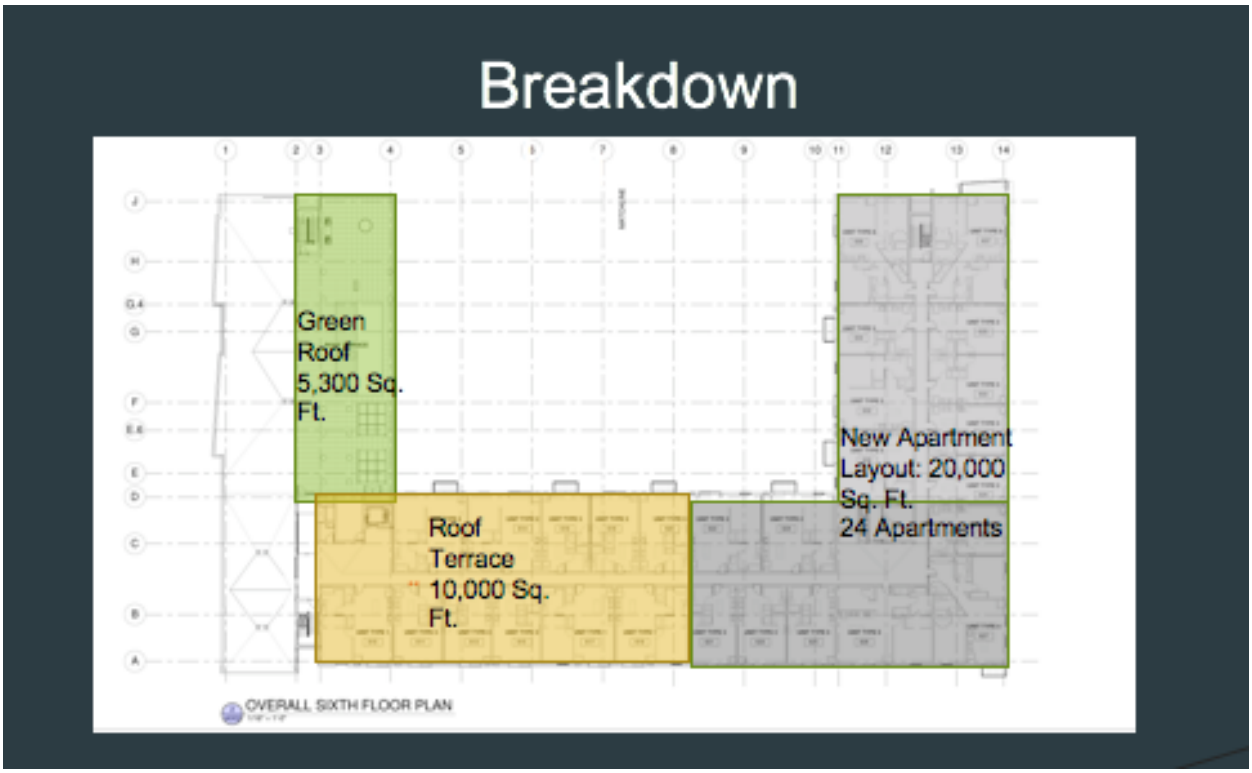
Finally, the reduction of overall size, frees up 10,000 square feet for a terrace as well as maintaining the green roof. The tenants will not have to choose between the two features. Being a luxury apartment, the Foundry will provide a unique set of environmentally friendly amenities, without having to enlarge the floorplan at the expense of others.

Background Research on Benefits and Drawbacks of Minimal Design

Doing basic calculations of the impact of the units, it is easy to see the floorplan is reduced by 40 percent. See Table # for the breakdown of the units. As well as the economic

breakdown, the owner will see an income of $37,500 for the sixth floor which is comparable to the $28,000 that the plan was making before. For the sake of argument, the environmental costs outweigh the rental cost; therefore, the conclusion is that the units break even in terms of rental cost.

As a result of the redesign, a reflection of the advantages and disadvantages of minimal living were outlined in the table below. Marketing Minimal Living style apartments to the right group of tenants will be imperative. The neighborhood of Lawrenceville within the last five years has seen an increase of 25 percent of young professionals to the area. In addition, it is one of the most Hipster Neighborhoods in the world named by Business Insider. If the developer could market the apartments to young professionals who want to save money on rent, but still live in a green space with luxury amenities.



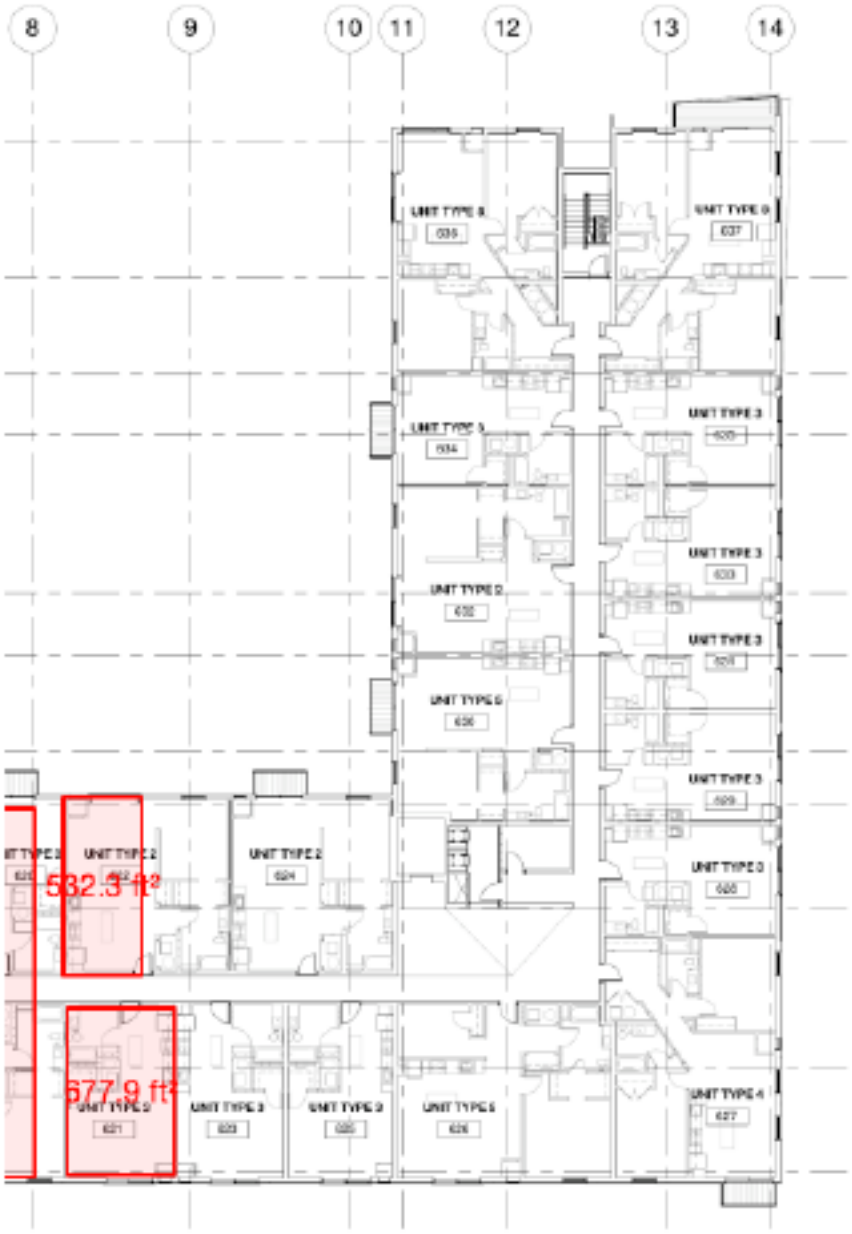


Fig. 6. 6th Floor Design Before

Fig. 7. 530 sq ft. Micro

Fig. 8. 670 sq ft. 2 bedroom design

Fig. 9. New 6th Floor Design

Table #. Reflection on a Minimal Living Floorplan

Advantages	Disadvantages
Reduction of Utilities	Harder to market specific group of tenants?*
Breakeven on selling units	
Promotes a sustainable residential community	
Research shows people willing to pay more for sustainable spaces	*Lawrenceville, PA has seen an increase in 25% of young professionals to area.

Conclusion of Minimal Living Research

In conclusion, I recommend the Minimal Living Floorplan Redesign for the Foundry at 41st on three criteria: environmental, economic, and wellness. First the environmental impact of reduction of the floorplan can be extrapolated to a reduction of utilities and household consumer goods. Economically tenants are willing to pay less for sustainable residential apartments. Finally, the Minimal Living Floorplan will bring wellness to the tenants by encouraging community involvement on environmental issues, and promote the use of outdoor space.

Beyond the research in Minimal Architecture, Minimalism as applied to lifestyle was studied by reading Minimalism: Live a Meaningful Life, Simplicity Lessons, and Essential. I highly recommend watching the documentaries Minimalism and Small is Beautiful (on tiny houses). Minimalism can be applied to possessions, technology, time, health, relationships, fitness, and other topics. Feel free to talk to me about my own experiments in minimal living like the Packing Party (where I boxed up all my possessions for 21 days), the Minimalism games (a challenge to give away stuff for 30 days), and giving up cable TV.

Minimalism Living Reference Material:

Books
Minimalism: Live a Meaningful Life by Joshua Fields Millburn
Essential by Joshua Fields Millburn
Simplicity Lessons by Linda Breen Pierce
Documentary
Minimalism by the Minimalists
Small is Beautiful: A Tiny House Documentary
Key Websites
Life Edited.com Theminimalists.com

References

Depth 1: Plumbing Manifold
Please See Appendix

Depth 2: Hollow Core Plank
Please See Appendix

Depth 3: LEED Certification
Please See Appendix

Depth 4: Minimal Living Research

Friedlander, David. "Residential Behavioral Architecture 101." *LifeEdited*. N.p., 20 Apr. 2015. Web. 26 Mar. 2017.

"Self Storage Association (SSA) Home." *Self Storage Association (SSA)*. N.p., n.d. Web. 26 Mar. 2017.

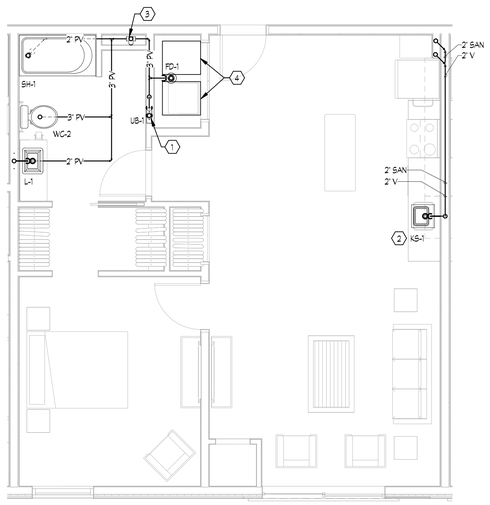
"U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Annual Energy Review - Energy Information Administration*. N.p., n.d. Web. 26 Mar. 2017.

Appendix Guide

DEPTH 1: PLUMBING MANIFOLD

APPENDIX

Emily Roarty
[Email address]



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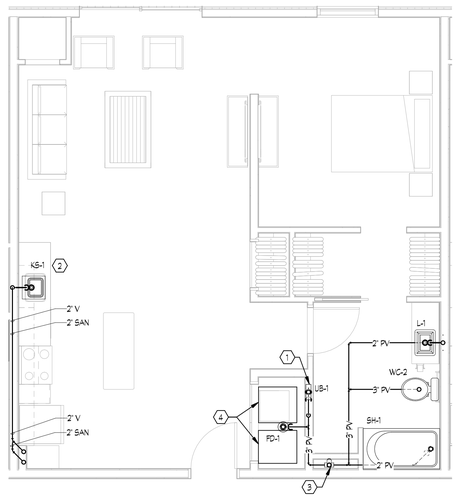

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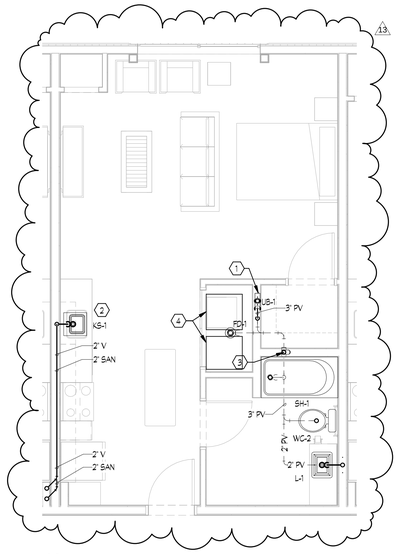

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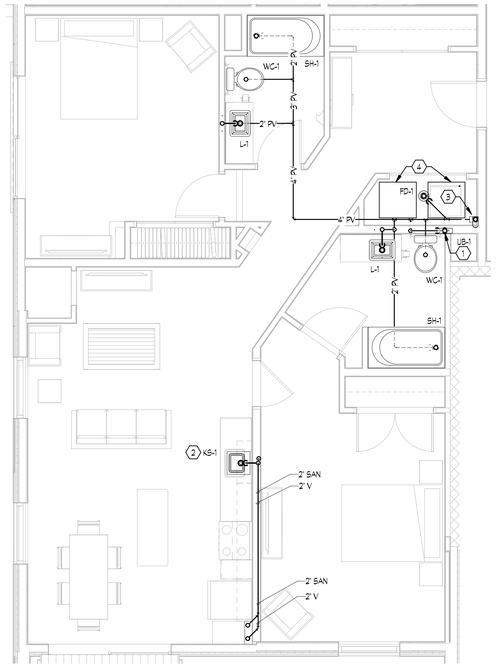

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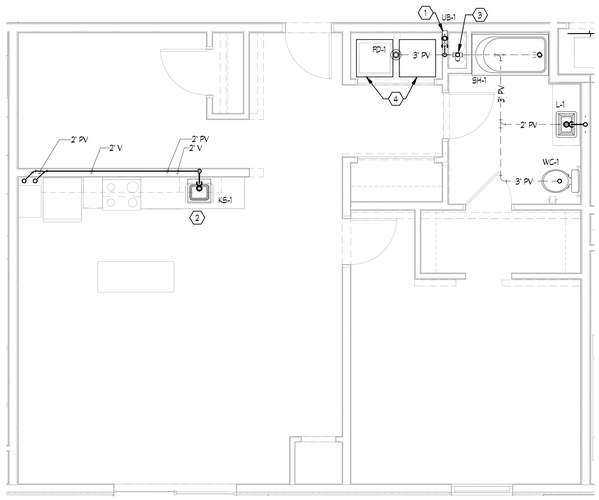

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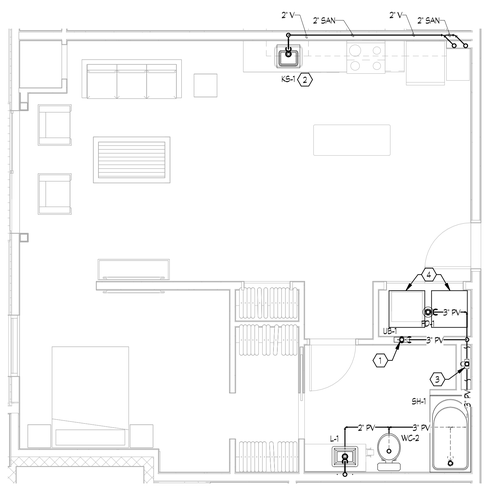

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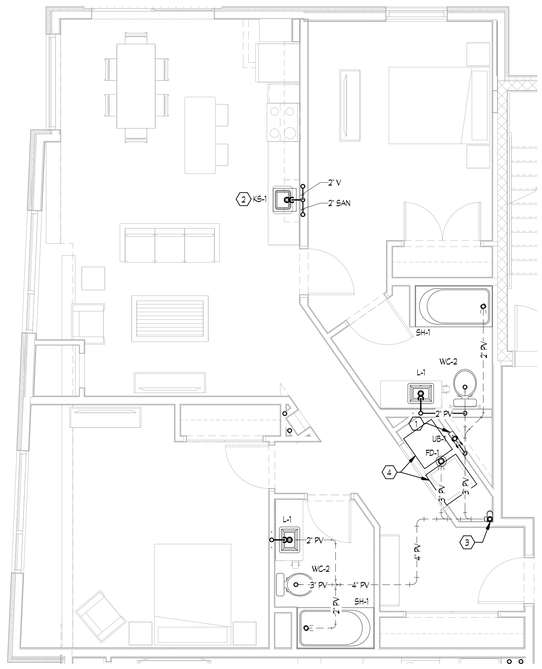

7 P803 UNIT TYPE 7 - PLUMBING DRAINAGE PLAN
1/4" = 1'-0"

PLUMBING GENERAL NOTES:

13. 1. SEE OVERALL FLOOR PLAN FOR SOVENT AND WASTE STACK.
2. ~~SEE DETAIL SHEET FOR PIPING DETAILS AND SIZES~~
3. ALL FLOOR DRAIN(S) SHALL BE PROVIDED WITH A CONNECTION FROM THE TRAP PRIMER LOCATED AT UB-1.

PLUMBING KEY NOTES: (X)

1. UTILITY BOX (UB-1). REFER TO DETAIL #10 ON DRAWING P501.
2. PROVIDE DISHWASHER CONNECTION. REFER TO DETAIL #3 ON DRAWING P501.
3. PROVIDE VENTSTACK FITTING AT THIS LOCATION.
4. PROVIDE DRAIN PAN UNDER WATER HEATER AND WASHING MACHINE. DRAIN PAN SHALL DISCHARGE TO FLOOR DRAIN.

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7	Revision #7	11/06/15
13	Revision #13	02/12/16

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DRAWING
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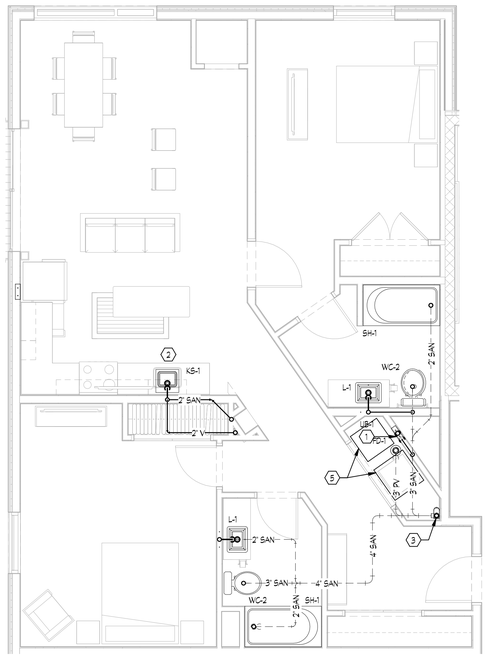

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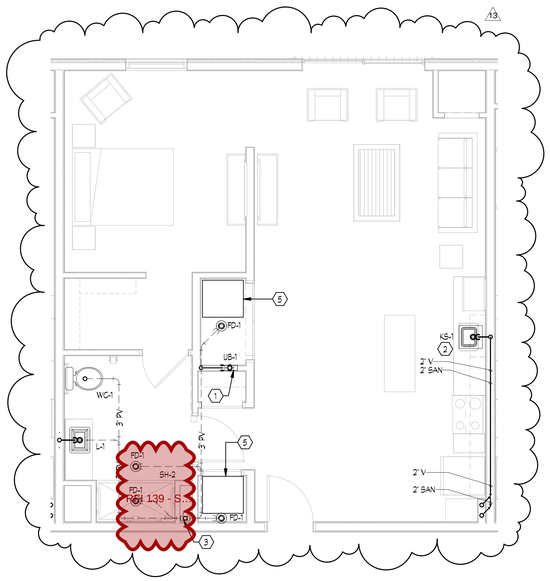

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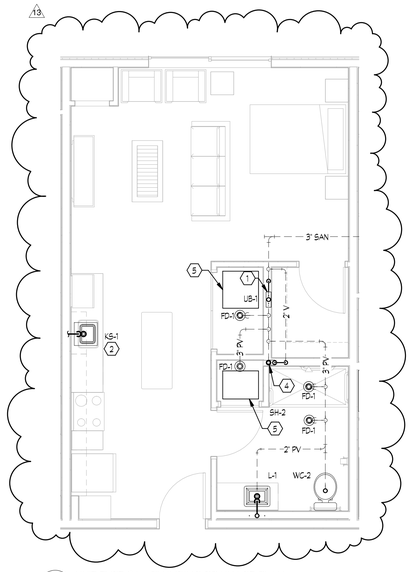

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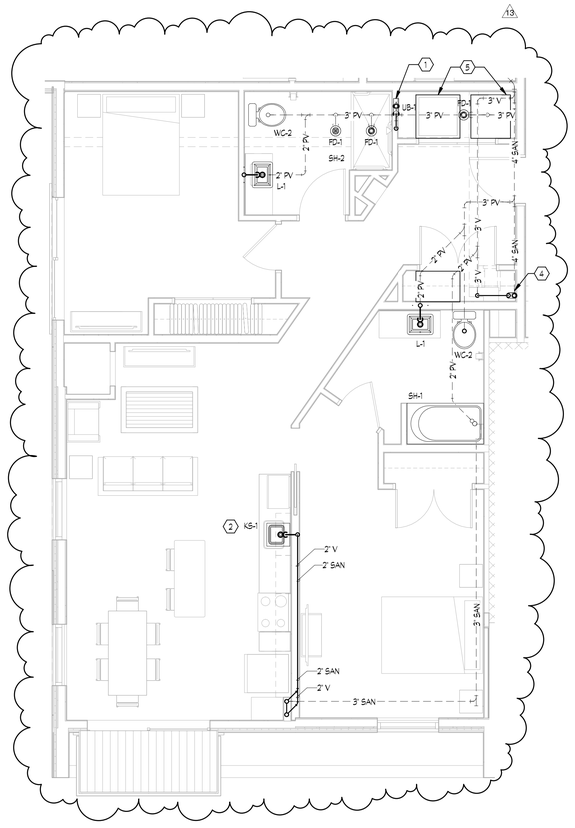
PLUMBING GENERAL NOTES:

1. SEE OVERALL FLOOR PLAN FOR SOVENT AND WASTE STACK.
2. ~~SEE DETAIL SHEET FOR ROOF VENTING LAYOUT.~~
3. ALL FLOOR DRAIN(S) SHALL BE PROVIDED WITH A CONNECTION FROM THE TRAP PRIMER LOCATED AT UB-1.

13

PLUMBING KEY NOTES: (X)

1. UTILITY BOX (UB-1), REFER TO DETAIL #10 ON DRAWING P801.
2. PROVIDE DISHWASHER CONNECTION. REFER TO DETAIL #3 ON DRAWING P801.
3. PROVIDE VENTSTACK FITTING AT THIS LOCATION.
4. PROVIDE BASESTACK FITTING AT THIS LOCATION.
5. PROVIDE DRAIN PAN UNDER WATER HEATER AND WASHING MACHINE. DRAIN PAN SHALL DISCHARGE TO FLOOR DRAIN.



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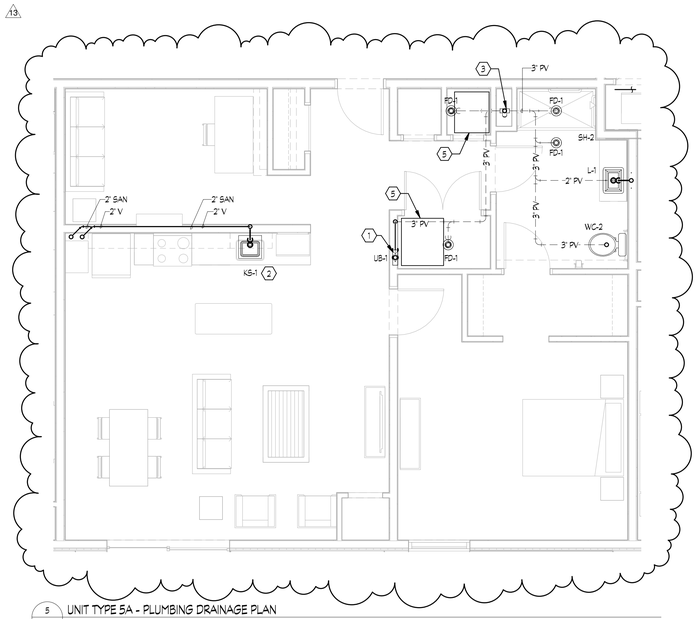

5 P804 UNIT TYPE 5A - PLUMBING DRAINAGE PLAN
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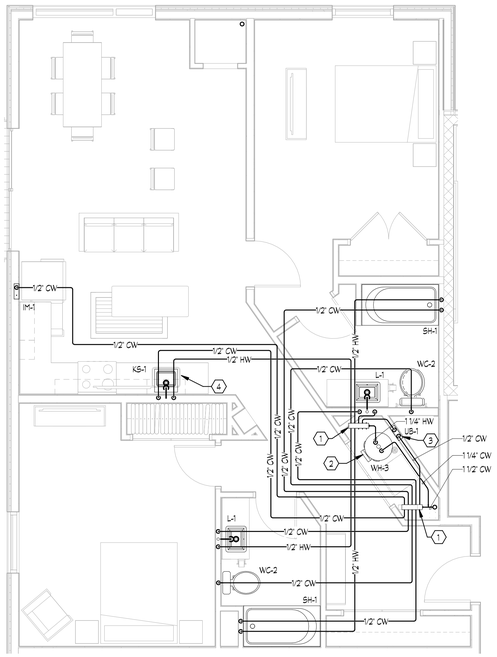

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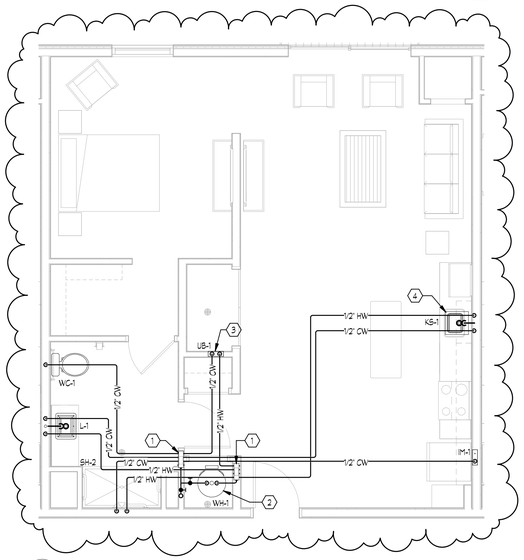

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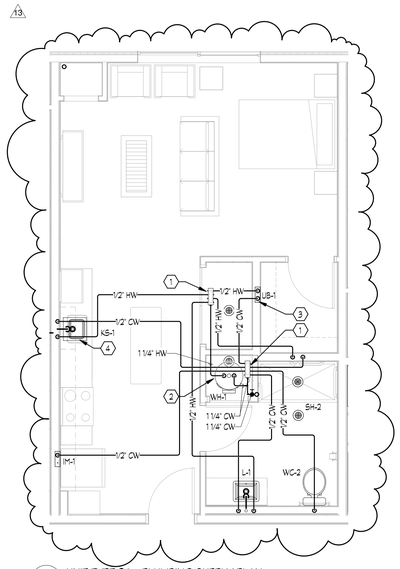

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PLUMBING GENERAL NOTES:

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PLUMBING KEY NOTES: (X)

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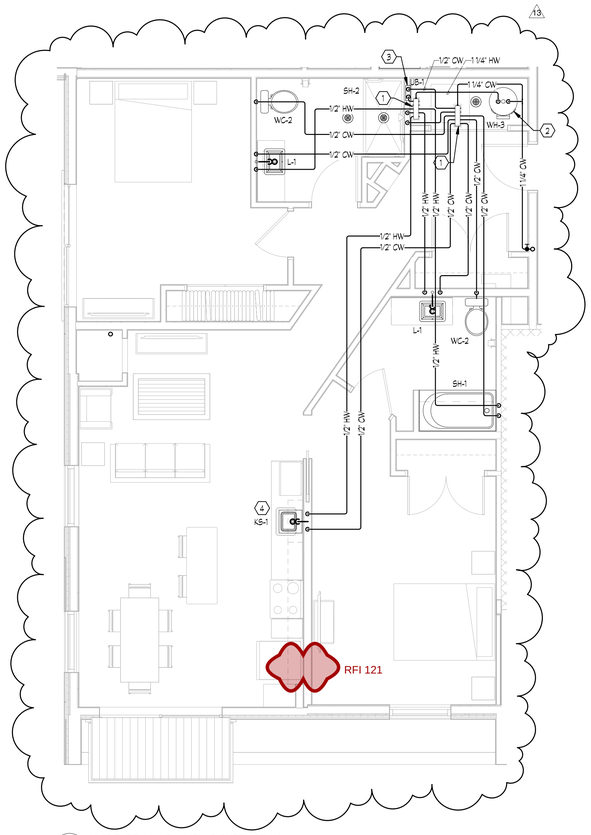
2. PROVIDE WATER HEATER. REFER TO DETAIL #3 ON DRAWING P501.
3. UTILITY BOX (UB-1). REFER TO DETAIL #10 ON DRAWING P501.
4. PROVIDE DISHWASHER CONNECTION. REFER TO DETAIL #8 ON DRAWING P501.



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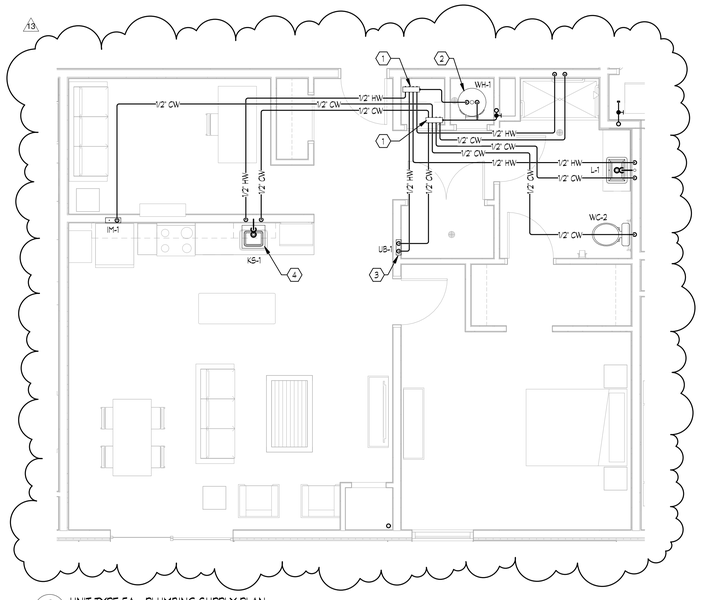

5 P802 UNIT TYPE 5A - PLUMBING SUPPLY PLAN
1/4" = 1'-0"

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PITTSBURGH, PA

Allen & Shariff
DESIGN | BUILD | MANAGE
Allen & Shariff Engineering, LLC
700 River Avenue, Suite 600
Pittsburgh, PA 15212
Tel: 412.322.9280

No.	Description	Date
13	Revision #13	02/12/16

Rothschild COLLABORATIVE Doyno
ARCHITECTURE AND URBAN DESIGN
PENN AT 28TH
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PITTSBURGH PA 15222
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100% CONSTRUCTION DOCUMENTS

JANUARY 13, 2015

TITLE
TYPICAL UNIT - PLUMBING SUPPLY PLANS

DRAWING
P802

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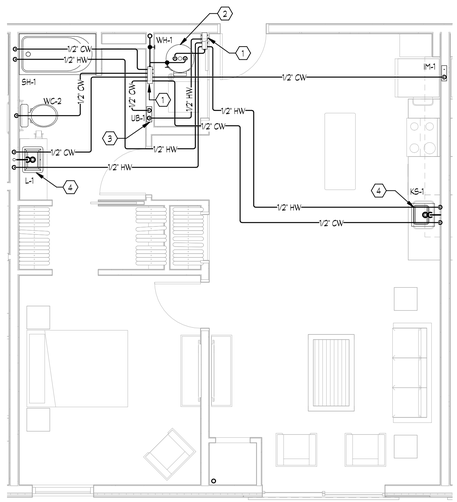
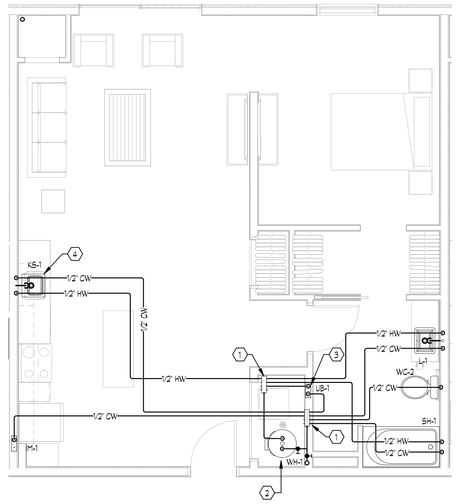


1 UNIT TYPE 1 - PLUMBING SUPPLY PLAN
P801 1/4" = 1'-0"



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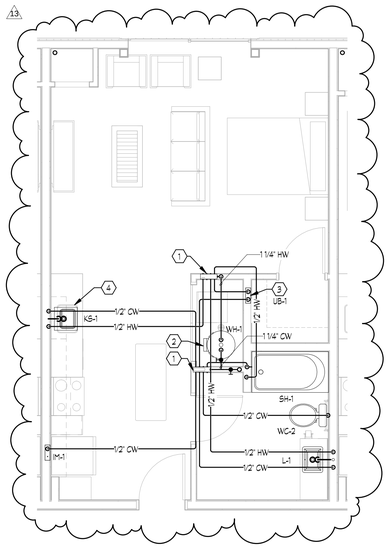
P801 1/4" = 1'-0"



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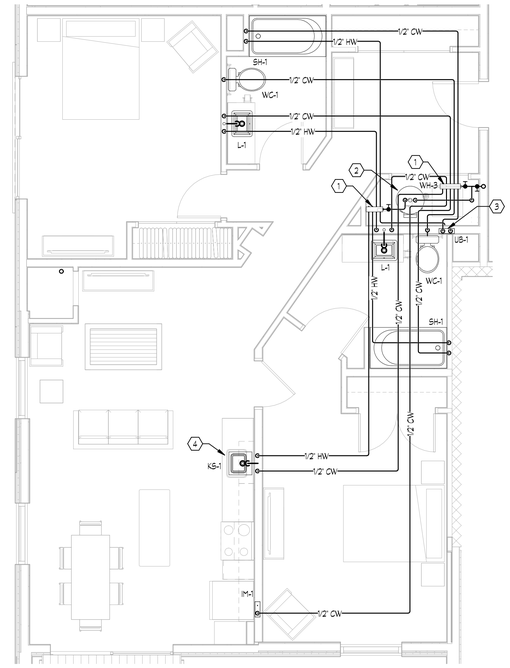
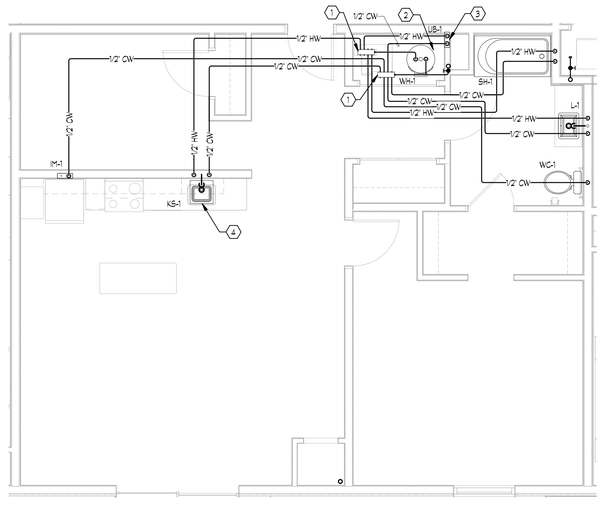


4 UNIT TYPE 4 - PLUMBING SUPPLY PLAN
P801 1/4" = 1'-0"



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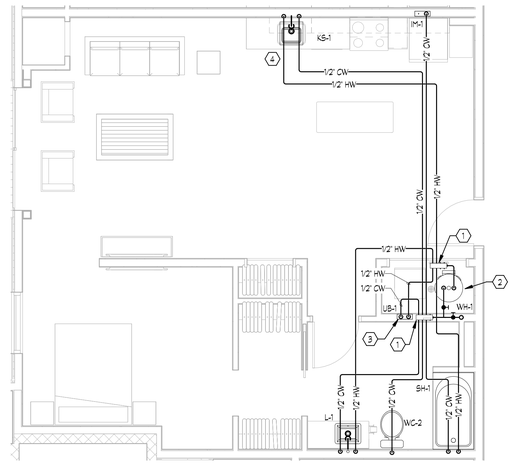


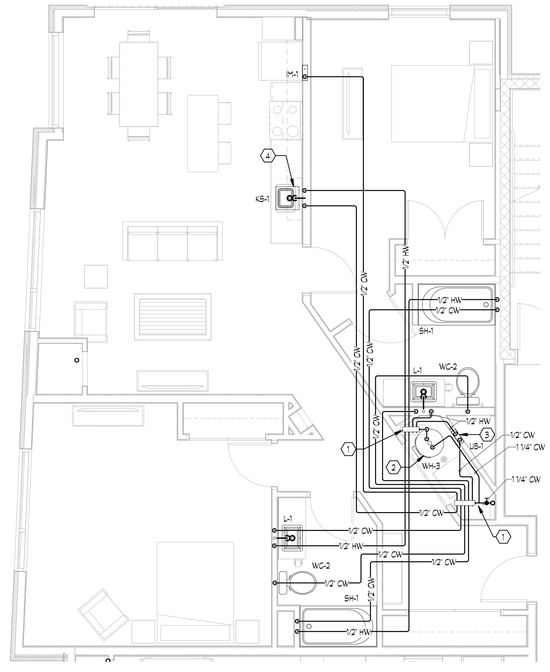
6 UNIT TYPE 6 - PLUMBING SUPPLY PLAN
P801 1/4" = 1'-0"

PLUMBING GENERAL NOTES:

1. SEE OVERALL FLOOR PLAN FOR CW RISERS.

PLUMBING KEY NOTES: (X)

1. CPVC TO PEX MANIFOLD. PROVIDE 1/2" PEX HOME RUNS TO EACH FIXTURE. PEX MANIFOLDS LOCATED ABOVE ATER HEATER
2. PROVIDE WATER HEATER. REFER TO DETAIL #3 ON DRAWING P801.
3. UTILITY BOX (UB-1), REFER TO DETAIL #10 ON DRAWING P801.
4. PROVIDE DISHWASHER CONNECTION. REFER TO DETAIL #3 ON DRAWING P801.



7 UNIT TYPE 7 - PLUMBING SUPPLY PLAN
P801 1/4" = 1'-0"

THE FOUNDRY
AT 41ST
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TITLE
TYPICAL UNIT - PLUMBING SUPPLY PLANS

DRAWING
P801

DEPTH 2: HOLLOW CORE CONCRETE PLANK

APPENDIX

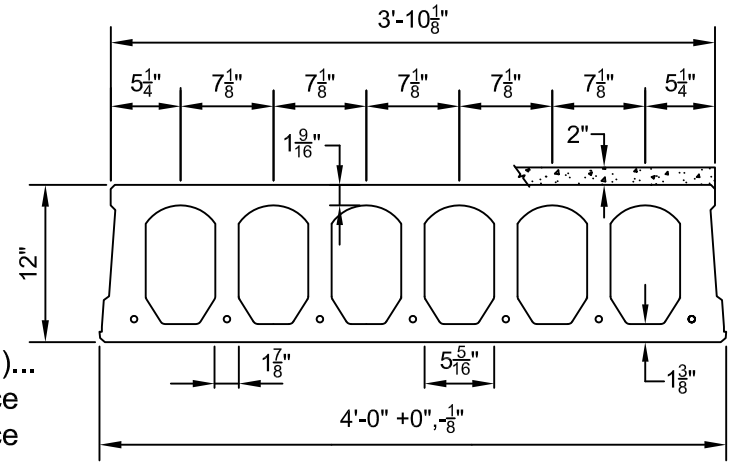
Emily Roarty
[Email address]

Prestressed Concrete
12"x4'-0" NiCore Plank

2 Hour Fire Resistance Rating With 2" Topping

PHYSICAL PROPERTIES
Composite Section

A_c = 361 in.^{2}	Precast b_w = 14.25 in.
I_c = 7840 in.^{4}	Precast S_{bcp} = 1081 in.^{3}
Y_{bcp} = 7.26 in.	Topping S_{tct} = 1644 in.^{3}
Y_{tcp} = 4.74 in.	Precast S_{tcp} = 1653 in.^{3}
Y_{tct} = 6.74 in.	Precast Wt. = 308 PLF
	Precast Wt. = 77.00 PSF



DESIGN DATA

1. Precast Strength @ 28 days = 6000 PSI
2. Precast Strength @ release = 3800 PSI
3. Precast Density = 150 PCF
4. Strand = 1/2"Ø and 0.6"Ø 270K Lo-Relaxation.
5. Strand Height = 1.75 in.
6. Ultimate moment capacity (when fully developed)...
   6-1/2"Ø, 270K = 205.4 k-ft at 60% jacking force
   7-1/2"Ø, 270K = 235.4 k-ft at 60% jacking force
7. Maximum bottom tensile stress is $10\sqrt{f'c}$ = 775 PSI
8. All superimposed load is treated as live load in the strength analysis of flexure and shear.
9. Flexural strength capacity is based on stress/strain strand relationships.
10. Deflection limits were not considered when determining allowable loads in this table.
11. Topping Strength @ 28 days = 3000 PSI. Topping Weight = 25 PSF.
12. These tables are based upon the topping having a uniform 2" thickness over the entire span. A lesser thickness might occur if camber is not taken into account during design, thus reducing the load capacity.
13. All load values are controlled by ultimate flexural strength or fire endurance limits.
14. Camber is inherent in all prestressed hollow core slabs and is a function of the amount of eccentric prestressing force needed to carry the superimposed design loads along with a number of other variables. Because prediction of camber is based on empirical formulas it is at best an estimate, with the actual camber usually higher than calculated values.
15. At 2 hours the calculated strand temperature is 790 degrees Farenheit @ 49% of yield strength.

SAFE SUPERIMPOSED SERVICE LOADS — IBC 2012 & ACI 318-11 (1.2 D + 1.6 L)

Strand Pattern		SPAN (FEET)																		
		26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
6 - 1/2"ø	LOAD (PSF)	242	217	194	174	156	140	125	111	99	87	77	68	59	51	43	36	29	23	18
7 - 1/2"ø	LOAD (PSF)	295	266	240	217	196	177	160	144	130	117	105	94	84	74	65	57	50	43	36

NITTERHOUSE CONCRETE PRODUCTS
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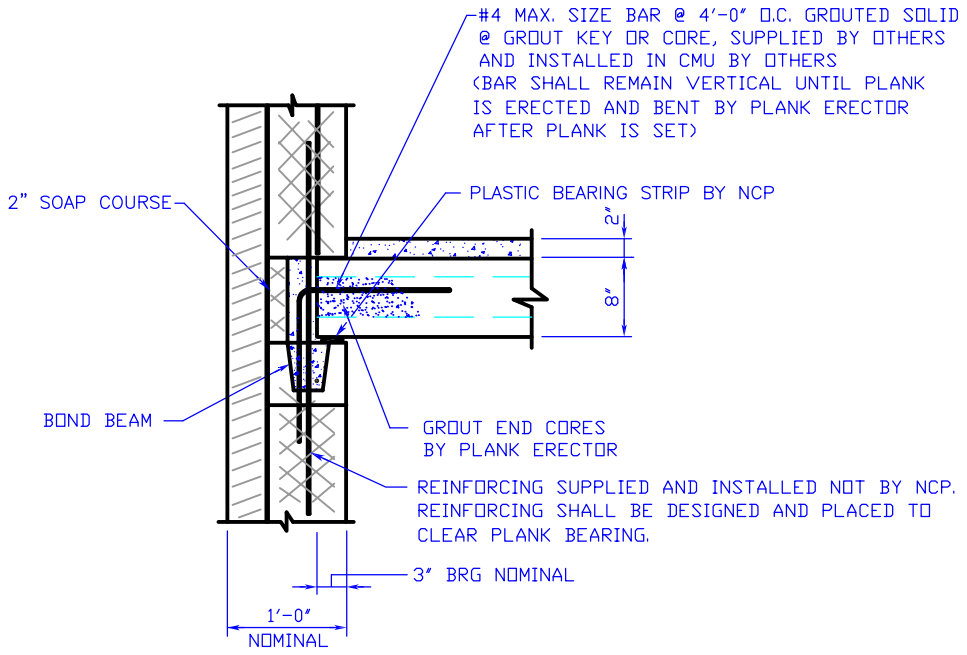
Chambersburg, PA 17202-9203
717-267-4505 Fax 717-267-4518

This table is for simple spans and uniform loads. Design data for any of these span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, flange or stem openings and narrow widths. The allowable loads shown in this table reflect a 2 Hour & 0 Minute fire resistance rating.

NiCore Connection Detail

HOLLOW CORE
PLANK CONNECTION

BEARING AT EXTERIOR WALL



NOTES:

1. N.C.P. WILL PROVIDE A BROOMED FINISH IN ORDER TO CREATE A COMPOSITE TOPPING. C.I.P. TOPPING BY OTHERS IS TO BE 3,000 PSI. (NORMAL WEIGHT CONCRETE).
2. THE DESIGN OF CONNECTIONS FOR HOLLOW CORE PLANK TO OTHER BUILDING COMPONENTS IS THE RESPONSIBILITY OF THE ENGINEER OF RECORD, SINCE THEY ARE PART OF THE GLOBAL DESIGN OF THE STRUCTURE.
3. IF GROUT KEYS DO NOT ALIGN, BREAK OUT TOP OF CORE IN PLANK AND GROUT REBAR IN CORE/GROUT KEY FOR FULL LENGTH OF REBAR.

NITTERHOUSE CONCRETE PRODUCTS
P. O. Box 2013
P: (717) 267-4505
Chambersburg, PA 17201
F: (717) 267-4518
www.nitterhouse.com

NITTERHOUSE CONCRETE PRODUCTS, INC.
2655 Molly Pitcher Highway South
Chambersburg, PA 17202-7220
Updated March 1, 2016

Website: **www.nitterhouse.com** **Phone:** **717-267-4505**
E-mail: **precast@nitterhouse.com** **FAX:** **717-267-4518**

GUIDE SPECIFICATION FOR NICORE™ PLANK (HOLLOW-CORE SLABS)

This Guide Specification is intended for the use of professional personnel competent to evaluate the significance and limitations of its contents, and who will accept responsibility for the application of the material it contains. It is to be used as a basis for the development of an office master specification or in the preparation of specifications for a particular project. **In either case this Guide Specification must be edited to fit the conditions of use.** Particular attention should be given to the deletion of inapplicable provisions or inclusion of appropriate requirements. Coordinate the specifications with the information shown on the contract drawings to avoid duplication or conflicts. *These guide specifications are subject to change without notice.*

Highlighted portions are Notes to the Specification Writer.

SECTION 034113
NICORE™ PLANK

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions of the contract. Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the performance criteria, materials, production, and erection of NiCore™ Plank as manufactured by Nitterhouse Concrete Products, Inc., including grouting

of joints between adjacent slab units for the entire project. The work performed under this Section includes all labor, material, equipment, related services, and supervision required for the manufacture and erection of the NiCore™ Plank shown on the Contract Drawings.

B. Related Sections include the following:

List below only products and construction that the reader might expect to find in this Section but are specified elsewhere. Other sections of the specifications not referenced below, shall also apply to the extent required for proper performance of this work.

1. Division 03 Section "Architectural Precast Concrete."
2. Division 03 Section "Structural Precast Concrete and Structural Precast Concrete with Commercial Architectural Finish (CA)."
3. Division 03 Section "Cast-in-Place Concrete" for installing connection anchors in concrete and structural topping.
4. Division 03 Section "Precast Post-Tensioned Concrete" for connecting precast units.
5. Division 03 Section "Cementitious Floor Underlayment" for floor and roof deck fill.
6. Division 04 Section "Unit Masonry Assemblies" for inserts or anchorages required for slab connections.
7. Division 05 Section "Structural Steel Framing" for structural steel framing and for furnishing and installing connections attached to structural-steel framing.
8. Division 05 Section "Metal Fabrications" for furnishing and installing loose hardware items.
9. Division 07 Section "Through Penetration Firestopping Systems" for joint filler materials for fire-resistance-rated construction.
10. Division 07 Section "Water Repellents" for water-repellent finish treatments.
11. Division 07 Section "Sheet Metal Flashing and Trim" for flashing receivers and reglets.
12. Division 07 Section "Joint Sealants" for elastomeric joint sealants and sealant backings between slab edges at exposed underside of floor and roof members and/or perimeter of members.
13. Division 07 Section "Roof and Deck Insulation" for insulation to meet energy code.
14. Division 09 Section "Carpet and Carpet Cushion" for covering on flooring members.
15. Division 09 Section "Exterior Paints."

1.3 PERFORMANCE REQUIREMENTS

Retain this Article and applicable subparagraphs below if delegating design responsibility for structural precast concrete members to contractor. AIA Document A201 requires Owner or Architect to specify performance and design criteria. Revise requirements below to suit Project, and add other performance and design criteria, if applicable.

A. Structural Performance: Provide structural precast concrete members and connections Capable of withstanding the following design loads within limits and under conditions indicated:

For NiCore™ Plank that are to receive concrete topping, state whether all superimposed dead and live loads on the NiCore™ Plank do or do not include the weight of the concrete topping. It is best to list the live load, superimposed dead load, topping weight, and weight of the NiCore™ Plank, all as separate loads. Where roof live loads are considered with snow loads indicate how they are to be combined. Show hanging utility support loads in addition to loads indicated on drawings.

NiCore™ Plank are cast in continuous steel forms. Therefore, connection devices on the formed surfaces must be contained within the member since penetration of the form is unacceptable.

Camber will generally occur in NiCore™ Plank due to eccentricity of the stressing force. If camber considerations are important, check with Nitterhouse Concrete Products, Inc. for estimates of the amount of camber and of camber movement with time and temperature change. Design details must recognize the existence of camber and camber movement in connection with:

1. Closures to interior non-load bearing partitions.
2. Closures parallel to NiCore™ Plank (whether masonry, windows, curtain walls or others) must be properly detailed for camber.
3. NiCore™ Plank receiving cast-in-place topping. The elevation of top of floor and amount of concrete topping must allow for camber of the NiCore™ Plank. Specifications must not be written for NiCore™ Plank to be flat under their self-weight.

1. Dead Loads: **<Insert applicable dead loads>**
2. Live Loads: **<Insert applicable live loads>**
3. Concrete Topping Thickness: **<Insert applicable thickness>**
4. Basic Ground Snow Load & Flat Roof Snow Load: **<Insert applicable snow loads>**
5. Wind Loads: **<Insert applicable wind loads>**
6. Seismic Loads: **<Insert applicable seismic loads>**

NiCore Plank specific load may include blast loads.

7. Project Specific Loads: **<Insert applicable loads>**

Indicate locations here or on Drawings if different movements are anticipated for different building elements. If deflection limits stricter than ACI 318 are required, the limits must be specified.

B. Design NiCore™ Plank and their connections to maintain clearances at openings, to allow for fabrication and construction tolerances, to accommodate live-load deflection, shrinkage and creep of primary building structure, and other building movements. Member deflections shall meet the limits of ACI 318.

Differential values in first subparagraph below are applicable to members exposed to the sun on one face. Insert the temperature range to suit local conditions. Temperature data is available from National Oceanic and Atmospheric Administration at www.ncdc.noaa.gov.

C. Thermal Movements: Provide for thermal movements noted.

1. The NiCore™ Plank design shall consider the maximum seasonal climatic temperature change.
2. In-plane thermal movements of NiCore™ Plank directly exposed to the sun shall consider a temperature range of <**Insert temperature range**>

Delete subparagraph below if fire resistance rating is not required. Fire ratings depend on occupancy and building construction type, and are generally a building code requirement. When required, fire-rated products should be clearly identified on the design drawings.

D. Fire Resistance Rating: The fire resistance rating for the NiCore™ Plank is calculated by IBC code-compliant rational means in lieu of U.L. testing and labels. Fire proofing of annular spaces and/or penetrations is by a different trade contractor. Provide NiCore™ Plank to meet the following fire resistance ratings:

1. Floors: **<Insert rating>**
2. Roof: **<Insert rating>**

1.4 SUBMITTALS

A. Product Data: Retain quality control records and certificates of compliance for 5 years or period of warranty, whichever is greater.

B. LEED Submittals

Retain subparagraph below if recycled content is required for LEED. Use products that meet at least 25% by cost of the total value of permanent building products on the project. Recycled content is the sum of post-consumer plus one-half of the pre-consumer recycled contents, based on cost. Products meeting recycled content are valued at 100% of their cost for the purpose of credit achievement calculation. Furthermore, products sourced (extracted, manufactured, and purchased) within 100 miles of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% of its total cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost. Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.

An alternative method of complying with the recycled content credit is to retain requirement in Division 01 SECTION “Sustainable Design Requirements” that gives the Contractor the option and responsibility for determining how requirements will be met.

1. Submit documentation conforming with LEED BD+C: New Construction v4 dated July 1, 2015 for the MR Credit: Building Product Disclosure and Optimization - Sourcing of Raw Materials, Option 2 (leadership extraction practices).

   a. Indicate recycled content; indicate percentage of pre-consumer and post-consumer recycled content per unit of NiCore™ Plank based on availability of materials such as fly ash.
   b. Indicate relative dollar value of recycled content product to total dollar value of NiCore™ Plank included in project.
   c. If recycled content product is part of an assembly, indicate the percentage of recycled content product in the assembly by weight.
   d. If recycled content product is part of an assembly, indicate relative dollar value of recycled content product to total dollar value of assembly.

e. Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
f. Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
g. Indicate dollar value of product containing local/regional materials; include materials cost only.
h. Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

Retain subparagraph below if environmental data is required in accordance with Table 1 of ASTM E 2129. Concrete is relatively inert once cured. Admixtures, form release agents, and sealers may emit VOCs, especially during the curing process; however, virtually all emissions are eliminated before enclosing the building.

2. Include MSDS product information showing that materials meet any environmental performance goals such as bio-based content.
3. For projects using FSC certified formwork, include chain-of-custody documentation with certification numbers for all certified wood products.
4. For projects using reusable formwork, include data showing how formwork is reused.

C. Design Mixtures: For each NiCore™ Plank mixture, include compressive strength tests.

D. Shop (Erection) Drawings: Detail fabrication and installation of NiCore™ Plank. Indicate member locations, plan views, elevations, dimensions, shapes, cross sections, openings, extent and location of each finish, connections, edge conditions, support conditions, types of reinforcement, including special reinforcement, and sequence of completing connections.

1. Indicate welded connections by AWS standard symbols and show size, length, and type of each weld. Detail loose and cast-in hardware, lifting inserts, connections, and joints.
2. Indicate locations, tolerances and details of anchorage devices to be embedded in or attached to structure or other construction.
3. Indicate plan views and/or elevations showing NiCore™ Plank locations with all openings 10” x 10” or larger shown and located. Sizes and locations of these openings are to be provided to Nitterhouse Concrete Products, Inc. by the respective trades. Include header design where additional structural support is required for large openings. Coordinate and indicate openings and inserts required by other trades.
4. Indicate location of each NiCore™ Plank by same identification mark placed on unit.
5. Indicate relationship of NiCore™ Plank to adjacent materials.
6. Indicate areas receiving toppings and magnitude of topping thickness.
7. Indicate estimated cambers for NiCore™ Plank receiving cast-in-place topping.
8. Design Modifications: If design modifications are proposed to meet performance requirements and field conditions, notify the Architect and submit design calculations and Shop Drawings. Do not affect the appearance, durability or strength of the NiCore™ Plank when modifying details or materials. Maintain the general design concept when altering size of members and alignment.

E. Provide handling procedures.

F. Comprehensive engineering design (signed and sealed) by a licensed design professional responsible for its preparation licensed in the jurisdiction in which the project is located.

G. Welding Certificates: Copies of certificates for welding procedure specifications (WPS) and personnel certification.

The NiCore™ Plank producer shall have a minimum of 15 years of production experience in structural precast concrete work comparable to that shown and specified, in not less than three projects of similar scope with the Owner or Architect determining the suitability of the experience.

H. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include list of completed projects with project names and addresses, names and addresses of architects, engineers and owners, and other information specified.

I. Material Test Reports: Reports on the following, for compliance with requirements indicated upon request.

J. Material Certificates: Material certificates signed by manufacturers or suppliers upon request certifying that each of the following items complies with requirements.

1. Cementitious materials.
2. Concrete aggregates.
3. Reinforcing materials and prestressing tendons.
4. Admixtures.
5. Bearing pads.
6. Structural steel shapes and hollow structural sections.

Retain paragraph below if Contractor is responsible for field quality control testing. Retain option if Contractor is responsible for special inspections.

K. Field quality-control test **[and special inspections]** reports.

1.5 QUALITY ASSURANCE

Erector should have a minimum of 5 years of experience in precast hollow core slab concrete Work comparable to that shown and specified in not less than three projects of similar scope with the Owner or Architect determining the suitability of the experience. The inclusion of erection in the precast concrete contract should be governed by local practices. Visit the PCI website at www.pci.org for current listing of PCI-Qualified and Certified Erectors. Retain first paragraph below if PCI-Certified Erector is not available in project location.

A. Erector Certification: A precast concrete erector with erecting organization and all erecting crews Certified and designated, prior to beginning work at project site, by PCI's Certificate of Compliance to erect **[Category S1 (Simple Structural Systems) for horizontal decking members]**

Retain paragraph below if PCI- Certified Erector is not available in Project location. Basis of the audit is PCI MNL 127, "PCI Erector's Manual – Standards and Guidelines for the Erection of Precast Concrete Products."

B. Erector Qualifications: A precast concrete erector that has retained a PCI Certified Field Auditor, at erector's expense, to conduct a field audit of a project in the same category as this Project prior to start of erection. Submits Erectors' Post Audit Declaration.

C. Fabricator Qualifications: A firm that complies with the following requirements and is experienced in producing precast concrete hollow core slab units similar to those indicated for this Project and with a record of successful in-service performance.

1. Assumes responsibility for engineering structural precast concrete units to comply with performance requirements. This responsibility includes preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
2. Professional Engineer Qualifications: A professional engineer licensed in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of precast hollow core slab units that are similar to those indicated for this Project in material, design, and extent.
3. Participates in PCI's Plant Certification program at the time of bidding and is designated a PCI-certified plant for Group C2 Category (Prestressed Hollow-Core and Repetitive Products).
4. Has sufficient production capacity to produce required members without delaying the Work.

Delete subparagraph below if fabricators are not required to be registered with and approved by authorities having jurisdiction. List approved fabricators in Part 2 if required.

5. Is registered with and approved by authorities having jurisdiction.

Retain first paragraph below if quality assurance testing in addition to that provided by the PCI Certification Program is required. The testing agency, if required, is normally engaged by Owner.

D. Testing Agency Qualifications: An independent testing agency, **[acceptable to authorities having jurisdiction]** qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated.

E. Design Standards: Comply with ACI 318 (ACI 318M) and the design recommendations of PCI MNL 120, "PCI Design Handbook – Precast and Prestressed Concrete," applicable to types of structural precast concrete members indicated.

F. Quality-Control Standard: For manufacturing procedures and testing requirements and quality control recommendations for the NiCore™ Plank, comply with PCI MNL 116, "Manual for Quality Control for Plants and Production of Structural Concrete Products."

1. Comply with camber and dimensional tolerances of PCI MNL 135, “Tolerance Manual for Precast and Prestressed Concrete Construction.”

Retain paragraph below to allow drawing details based on one fabricator’s product to establish requirements. Exact cross section of precast, prestressed concrete members may vary from producer to producer. Revise below to identify specific proprietary system or indicate on Drawings. Correlate with Division 1 requirements.

G. Product Options: Drawings indicate size, profiles and dimensional requirements of hollow core slabs and are based on NiCore™ Plank as indicated. Other fabricators’ precast concrete members complying with requirements may be considered. Refer to Division 1 Section “Substitutions”.

H. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel”; and AWS D1.4, “Structural Welding Code – Reinforcing Steel.”

I. Fire Resistance: Where indicated, provide NiCore™ Plank whose fire resistance meets the prescriptive requirements of the governing code or has been calculated according to PCI MNL 124, “Design for Fire Resistance of Precast Prestressed Concrete,”

1.6 PRODUCT STORAGE, DELIVERY AND HANDLING

A. Store NiCore™ Plank with adequate dunnage and bracing, and protect units to prevent contact with the ground, to prevent staining, and to control cracking, distortion, warping or other physical damage.

B. Unless otherwise specified or shown on Shop Drawings, store NiCore™ Plank with dunnage across full width of each bearing point.

C. Place stored members so identification marks are clearly visible, and units can be inspected.

D. Place dunnage of even thickness between each member.

E. Deliver all NiCore™ Plank in such quantities and at such times to assure compliance with the agreed upon project schedule and setting sequence to ensure continuity of installation.

F. Handle and transport NiCore™ Plank in a position consistent with their shape and design in order to avoid excessive stresses that could cause cracking or other damage.

G. Lift and support NiCore™ Plank only at designated points indicated on the Shop Drawings.

H. Do not use upper members of stacked tiers as storage for shorter members or heavy equipment.

1.7 SEQUENCING

Coordination and responsibility for supply of items to be placed on or in the structure to allow placement of NiCore™ Plank depends on type of structure and varies with local practice. Clearly specify responsibility for supply and installation of hardware. If not supplied by precast concrete fabricator, supplier should be listed and requirements included in related trade sections. Ensure that type and quantity of hardware items to be cast into precast concrete members for use by other trades are specified or detailed in Contract Drawings and furnished to fabricator, with instructions, in a timely manner in order not to delay the Work.

A. Furnish loose connection hardware and anchorage items to be embedded in or attached to other construction without delaying the Work. Provide locations, setting diagrams, templates, instructions, and directions, as required, for installation.

PART 2 – PRODUCTS

2.1 FABRICATORS

A. Fabricators: Subject to compliance with requirements, provide products by Nitterhouse Concrete Products, Inc. in Chambersburg, PA

2.2 FORM MATERIALS

A. Formwork: Rigid, dimensionally stable, steel material, warp and buckle free, that will provide continuous and true precast concrete surfaces within fabrication tolerances indicated; not reactive with concrete and suitable for producing required finish surfaces.

1. Form-Release Agent: Commercially produced bio-based oil form-release agent that will not bond with, stain or affect hardening of NiCore™ Plank and will not impair subsequent surfaces of NiCore™ Plank.

2.3 REINFORCING MATERIALS

Retain first paragraph below only if recycled content is required for LEED. Most of our cement and aggregates are produced locally within a 500-mile radius, and up to 60% of the prestressing strand may be composed of recycled steel for the precast to contribute to LEED participation.

A. Recycled Content of Steel Products: Provide products with an average recycled content of steel products so post-consumer recycled content plus one-half of pre-consumer recycled content is not less than **[25][60] <Insert number>** percent.

B. Reinforcing Bars: ASTM A 615, Grade 60 deformed.

C. Low-Alloy-Steel Reinforcing Bars: ASTM A 706 deformed when welded to hardware assemblies.

2.4 PRESTRESSING STRANDS

A. Prestressing Strand: ASTM A 416, Grade 270, uncoated, 7-wire, low-relaxation strand.

2.5 CONCRETE MATERIALS

A. Standard Gray Portland Cement: ASTM C 150, Type I or III.

B. Supplementary Cementitious Materials

1. Fly Ash (as available): ASTM C 618, Class C or F with maximum loss on ignition of 3%.

C. Normal weight Aggregates: Except as modified by PCI MNL 116, ASTM C 33 or C330, with coarse, non-reactive aggregates complying with **Class [4S] [4M] [5S] [5M]**.

D. Fine Aggregates: Selected, natural or manufactured sand of a material

E. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of concrete and complying with chemical limits of PCI MNL 116.

F. Air Entraining Admixture: NiCore™ Plank are cast with zero slump concrete (commonly referred to as dry mix concrete) using a slip former. There are no standardized test procedures for measuring the air content of zero slump concrete. PCI Manual MNL 126-98 entitled *Manual For The Design Of Hollow Core Slabs* in Section 1.2 reads, "Air entrained admixtures are not effective in the dry mix concrete. With the low water-cement ratios and compaction placing method, air is difficult to disperse well and maintain". A nominal amount of air entraining admixture may be used to improve workability in conformance with ASTM C 260, and certified by manufacturer to be compatible with other required admixtures.

G. Chemical Admixtures: Certified by manufacturer to be compatible with other admixtures and to not contain calcium chloride, or more than 0.15 percent chloride ions or other salts by weight of admixture.

1. Water-Reducing and Retarding Admixture: ASTM C 494 Type D.
2. Corrosion Inhibiting Admixture: ASTM C 1582
3. Viscosity Modifying Admixture: ASTM C 494 Type S
4. Manufacturing Aid Surfactant Admixture

2.6 STEEL CONNECTION MATERIALS

A. Carbon-Steel Shapes and Plates: ASTM A 36

B. Carbon-Steel Headed Studs: ASTM A 108, Grades 1010 through 1020, cold finished, AWS D1.1/D1.1M, Type A or B, with arc shields and with the minimum mechanical properties of PCI MNL 116, Table 3.2.3.

C. Carbon-Steel Structural Tubing: ASTM A 500, Grade B or C.

D. Carbon-Steel Bolts and Studs: ASTM A 307, Grade A or C (ASTM F 568M, Property Class 4.6) carbon-steel, hex-head bolts and studs; carbon-steel nuts (ASTM A 563, Grade A); and flat, unhardened steel washers (ASTM F 844).

High-strength bolts are used for friction-type connections between steel members and are not recommended between steel and concrete because concrete creep and crushing of concrete during bolt tightening reduce effectiveness. ASTM A 490 bolts should not be galvanized.

E. High-Strength Bolts and Nuts: ASTM A193/A193M, Grade B5 or B7, ASTM A 325 or ASTM A 490, Type 1, heavy hex steel structural bolts, heavy hex carbon-steel nuts, (ASTM A 563) and hardened carbon-steel washers (ASTM F 436).

Structural plate and shape steel connection hardware enclosed in wall cavities is provided uncoated in non-corrosive environments. Protection is required by painting or galvanizing on steel connection hardware when the corrosive environment is high or when connections are exposed to exterior weather conditions. Retain paragraph below if shop-primed finish is required. Indicate locations of priming, if required. MPI 79 in first option below provides some corrosion protection while SSPC-Paint 25, without top-coating, provides minimal corrosion protection. The need for protection from corrosion will depend on the actual conditions to which the connections will be exposed to in service. Select coatings that do not contain toxic chemicals and with less than 250 g/l VOCs.

F. Shop-Primed Finish: Prepare surfaces of nongalvanized steel items, except those surfaces to be embedded in concrete, according to requirements in SSPC-SP 3 and shop-apply lead- and chromate-free, rust–inhibitive primer, complying with performance requirements in MPI 79 (SSPC-Paint 25) according to SSPC-PA 1.

Retain paragraph and subparagraph below if galvanized finish is required. Indicate locations of galvanized items if required. Field welding should generally not be permitted on galvanized elements, unless the galvanizing is removed or acceptable welding procedures are submitted. Hot-dip galvanized finish provides greater corrosion resistance than electrodeposited zinc coating. Electrodeposition is usually limited to threaded fasteners.

G. Zinc-Coated Finish: For exterior steel items and items indicated for galvanizing, apply zinc coating by hot-dip process according to ASTM A 123 after fabrication, or ASTM A 153 as applicable (electrodeposition according to ASTM B 633, SC 3, Type 1).

1. For steel shapes, plates, and tubing to be galvanized, limit silicon content of steel to less than 0.03 percent or to between 0.15 and 0.25 percent or limit sum of silicon content and 2.5 times phosphorous content to 0.09 percent.
2. Galvanizing Repair Paint: Zinc paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20.

Retain paragraph below when more protection than a paint finish is required, but galvanizing is not required.

H. Galvanizing Paint: Zinc paint with dry film containing not less than 94 percent zinc dust by weight, and complying with DOD-P-21035A or SSPC-Paint 20. Comply with manufacturer's requirements for surface preparation.

2.7 STAINLESS-STEEL CONNECTION MATERIALS

Delete this Article if not required. Use when resistance to staining merits extra cost in high moisture or corrosive environments.

A. Stainless-Steel Plate: ASTM A 666, Type 304, Type 316, or Type 201, of grade suitable for application.

B. Stainless-Steel Bolts and Studs: ASTM F 593, alloy 304 or 316, hex-head bolts and studs; stainless-steel nuts; and flat, stainless-steel washers.

1. Lubricate threaded parts of stainless steel bolts with an anti-seize thread lubricant during assembly.

C. Stainless-Steel Headed Studs: ASTM A 276, with minimum mechanical properties for studs as indicated under MNL 116, Table 3.2.3.

2.8 BEARING PADS AND OTHER ACCESSORIES

Plastic pads are typically used with NiCore™ Plank. Compression stress in use is not normally over a few hundred psi and proof testing is not considered necessary. No standard guide specifications are available. On rare occasions elastomeric pads or ROF pads are used, so coordinate selection with structural engineer if required for bearing loads and rotation requirements.

A. Provide one of the following bearing pads for hollow core slabs**:**

1. High-Density Plastic: Multimonomer, nonleaching, plastic strip capable of supporting loads with no visible overall expansion.
2. Elastomeric Pads: AASHTO M 251, plain, vulcanized, 100 percent polychloroprene (neoprene) elastomer, molded to size or cut from a molded sheet, 50 to 70 Shore A durometer according to ASTM D 2240, minimum tensile strength 2,250 psi per ASTM D 412.
3. Random-Oriented, Fiber-Reinforced Elastomeric Pads: Preformed, randomly oriented synthetic fibers set in elastomer. Surface hardness of 70 to 90 Shore A durometer according to ASTM D2240. Capable of supporting a compressive stress of 3,000 psi with no cracking, splitting or delaminating in the internal portions of the pad. Test one specimen for each 200 pads used in the Project.
4. Cotton-Duck-Fabric-Reinforced Elastomeric Pads: Preformed, horizontally layered cotton-duck fabric bonded to an elastomer. Surface hardness of 80 to 100 Shore A durometer according to ASTM D 2240. Conforming to Division II, Section 18.10.2 of AASHTO LRFD Bridge Design Specifications or Military Specification, MIL-C-882E.
5. Frictionless Pads: Polytetrafluoroethylene (PTFE), glass-fiber reinforced, bonded to stainless or mild-steel plates, or random-oriented, fiber-reinforced elastomeric pads, of type required for in-service stress.

B. Erection Accessories: Provide clips, hangers, high density plastic or steel shims, and other accessories required to install structural precast concrete members.

C. Welding Electrodes: Comply with AWS standards for steel type and/or alloy being welded.

2.9 GROUT MATERIALS

Sand-cement grout is commonly used in keyed joints between NiCore™ Plank floor and roof members. Indicate required strengths on Contract Drawings.

A. Sand-Cement Grout: Portland cement, ASTM C 150, Type I, and clean, natural sand, ASTM C 144, or ASTM C 404. Typically mix at ratio of 1 part cement to 2 ½ to 3 parts sand, by volume, with minimum water required for placement and hydration. Water-soluble chloride ion content of grout less than 0.06% chloride ion by weight of cement

when tested in accordance with ASTM C 1218. Grouting of NiCore™ Plank topside, butt & end joints with a grout mixture having sufficient consistency to not require end core dams and having a minimum 28-day compressive strength of 3,000 psi. The ambient temperature must be at least 40°F and rising for the grouting operation. Alternatively, NiCore™ Planks need to be at least 32°F and held above freezing for a minimum of 24 hours. NCP is able to grout in ambient temperatures below 40°F if this is achieved by the general contractor heating the units and blanketing the grouted joints to assure the grout is not subjected to freezing for a 24 hour period, all other weather conditions permitting.

2.10 CONCRETE MIXTURES

A. Prepare design mix to achieve the required properties.

B. Design mixes may be prepared by qualified precast plant personnel at the precast hollow core slab fabricator's option.

C. Normal weight Concrete Mix: Proportion mixtures by either laboratory trial batch or field test data methods according to ACI 211, with materials to be used on Project, to provide normal weight concrete with the following properties:

1. Release Strength: 3,800 psi minimum.

2. Compressive Strength (28 Days): 6,000 psi minimum

3. Density (Unit Weight): Calculated equilibrium density of 145 lb/ft.^{3}, ± 5 lb/ft.^{3}.

4. Maximum Water-Cementitious Materials Ratio: 0.45.

5. Permissible use of fly ash is between 15 to 25 percent replacement of Portland cement by weight as available.

6. Limit water-soluble chloride ions to maximum percentage by weight of cement permitted by ACI 318 or PCI MNL 116 when tested in accordance with ASTM C 1218.

7. When included in design mixtures, add other admixtures to concrete mixtures according to manufacturer's written instructions.

8. Concrete Mixture Adjustments: Concrete mixture design adjustments may be proposed if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant.

2.11 FORM FABRICATION

A. Form: Accurately construct forms, mortar tight, of sufficient strength to withstand pressures due to concrete placement and vibration operations and temperature changes, and for prestressing and detensioning operations. Coat contact surfaces of forms with release agent before reinforcement is placed. Avoid contamination of reinforcement and prestressing tendons by release agent.

B. Maintain forms to provide completed NiCore™ Plank of shapes, lines, and dimensions indicated, within fabrication tolerances specified.

C. Edge and Corner Treatment: As built-in on standard forms.

2.12 FABRICATION

When required for anchorage or lateral bracing to structural steel members NiCore™ Plank are limited in the use of anchors and inserts. Coordinate with other trades for installation of cast-in items.

A. Cast-in Anchors, Inserts, Plates, Angles, and Other Anchorage Hardware: Fabricate anchorage hardware with sufficient anchorage and embedment to comply with design requirements. Accurately position for attachment of loose hardware and secure in place during casting operations. Locate anchorage hardware where it does not affect position of main reinforcement or concrete placement.

B. Weld headed studs and deformed bar anchors used for anchorage according to AWS D1.1 and AWS C5.4, “Recommended Practices for Stud Welding.”

Coordinate paragraph below with Division 05 Section “Metal Fabrications” for furnishing and installing loose hardware items.

C. Furnish loose hardware items including steel plates, clip angles, seat angles, anchors, dowels, cramps, hangers, and other hardware shapes for securing precast concrete members to supporting and adjacent construction.

D. Cast-in openings larger than 10” in each dimension as shown on the architectural and/or structural drawings at the time of bidding. Do not drill or cut openings or prestressing strand without Engineer’s approval.

E. Reinforcement: Comply with recommendations in PCI MNL 116 for fabricating, placing, and supporting reinforcement.

1. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy the bond with concrete. When damage to epoxy coated

reinforcing exceeds limits specified in ASTM A 775, repair with patching material compatible with coating material and epoxy coat bar ends after cutting.

2. Accurately position, support, and secure reinforcement against displacement during concrete placement and consolidation operations. Locate and support reinforcement by metal or plastic chairs, runners, bolsters, spacers, hangers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire reinforcement in place according to PCI MNL 116.
3. Place reinforcing steel and prestressing strand to maintain at least ¾ in. (19 mm) minimum concrete cover. Provide cover requirements in accordance with ACI 318 when units are exposed to corrosive environment or severe exposure conditions. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position while placing concrete. Direct wire tie ends away from finished, exposed concrete surfaces.

F. Reinforce structural precast concrete members to resist handling, transportation, erection stresses, and specified in-place loads, whichever governs.

G. Prestress strands for NiCore™ Plank by pre-tensioning. Comply with PCI MNL 116.

1. Delay detensioning of NiCore™ Plank until concrete has reached its indicated minimum design release compressive strength as established by test cylinders cured under the same conditions as concrete member.

2. Detension pre-tensioned strands by cutting strands, using a sequence and pattern to prevent shock or unbalanced loading.

3. If concrete has been heat cured, detension while concrete is still warm and moist to avoid dimensional changes that may cause cracking or undesirable stresses.

Retain the following subparagraph only when ends of NiCore™ Plank are exposed to severe environment and field installed grout or other building materials do not provide adequate corrosion protection.

4. Protect strand ends and anchorage exposed to severe environments with bitumastic, zinc-rich or epoxy paint.

H. Comply with requirements in PCI MNL 116 and requirements in this Section for measuring, mixing, transporting, and placing concrete. After concrete batching, no additional water may be added.

I. Place concrete in a continuous operation to prevent seams or planes of weakness from forming in NiCore™ Plank.

1. Thoroughly consolidate placed concrete by vibration without dislocating or damaging reinforcement and built-in items, and minimize pour lines, honeycombing or entrapped air on surfaces. Use equipment and procedures complying with PCI MNL 116.

2. Comply with PCI MNL 116 procedures for hot and cold-weather concrete placement.

3. Identify pickup points of precast concrete members and orientation in structure with permanent markings, complying with markings indicated on Shop Drawings. Imprint or permanently mark the Mark Number and I.D. Number on each precast concrete member on a surface that will not show in finished structure.

4. Cure concrete, according to requirements in PCI MNL 116, by accelerated heat curing using radiant heat. Cure members until the compressive strength is high enough to ensure that stripping does not have an effect on the performance or appearance of the final product.

2.13 FABRICATION TOLERANCES

Usually retain paragraph below unless tolerances for Project deviate from PCI recommendations. PCI MNL 135 product tolerances are standardized throughout the industry. Revise product tolerances if additional costs of more exacting tolerances are justified.

A. Fabricate NiCore™ Plank of shapes, lines and dimensions indicated, so each finished member complies with PCI MNL 135 product tolerances as well as position tolerances for cast-in items.

2.14 FINISHES

A. Bottom Standard Grade Steel Form Commercial Finish: Normal plant-run finish produced in forms that impart a smooth finish to concrete as defined in PCI MNL 116, Appendix C. Surface holes smaller than ½" caused by air bubbles, normal color variations, form joint marks, and minor chips and spalls are acceptable. Fill air holes greater than ¼" in width that occur in high concentration (more than one per 2 sq. in. Major or unsightly imperfections, honeycombs, or structural defects are not permitted. Allowable joint offset limited to 1/8". Any surface preparation for painting is by other trades.

B. Top Screed Finish For Unformed Surface: Strike off and consolidate concrete with vibrating screeds to a uniform finish. Hand screed at projections. Normal color variations, minor indentations, minor chips, and spalls are permitted. No major imperfections, honeycombing, or defects are permitted.

C. Apply broom-roughened surface finish in accordance with ACI 318 to precast concrete members that will receive a structurally composite concrete topping after installation.

2.15 SOURCE QUALITY CONTROL

Always retain paragraph below because it establishes the minimum standard of plant testing and inspecting. PCI MNL 116 mandates source testing requirements and a plant "Quality Systems Manual." PCI certification also ensures periodic auditing of plants for compliance with requirements in PCI MNL 116.

A. Quality-Control Testing: Test and inspect precast concrete according to PCI MNL 116 requirements.

Delete first paragraph and subparagraph below if not required. PCI certification may be acceptable to authorities having jurisdiction without further monitoring of plant quality-control and testing program by Owner.

B. In addition to PCI Certification, Owner will employ an accredited independent testing agency to evaluate structural precast concrete fabricator's quality-control and testing methods.

1. Allow Owner's testing agency access to material storage areas, concrete production equipment, concrete placement, and curing facilities. Cooperate with Owner's testing agency and provide samples of materials and concrete mixtures as may be requested for additional testing and evaluation.

C. Strength of NiCore™ Plank will be considered deficient if units fail to comply with ACI 318 concrete strength requirements.

Review acceptance criteria with structural engineer. In paragraph below, add criteria for load tests if required.

D. Defective Work: Structural precast concrete members that do not comply with acceptability requirements in PCI MNL 116, including concrete strength, manufacturing tolerances, and texture range are unacceptable. Chipped, spalled or cracked members may be repaired. The Architect reserves the right to reject any member if it does not match the accepted samples. Replace unacceptable units with precast concrete members that comply with requirements.

PART 3 – EXECUTION

3.1 PREPARATION

A. Deliver anchorage devices for NiCore™ Plank that are embedded in or attached to the building structural frame or foundation before start of such work. Provide locations, setting diagrams, and templates for the proper installation of each anchorage device.

3.2 EXAMINATION

A. Examine supporting structural frame or foundation and conditions for compliance with requirements for installation tolerances, bearing surfaces tolerances, and other conditions affecting NiCore™ Plank performance.

B. Proceed with NiCore™ Plank installation only after unsatisfactory conditions have been corrected.

C. Do not install NiCore™ Plank until supporting cast-in-place concrete building structural framing has attained minimum allowable design compressive strength or supporting steel or other structure is structurally ready to receive loads from precast concrete members.

3.3 ERECTION

A. Site Access: The General Contractor shall be responsible for providing suitable access to the building, proper drainage, and firm level bearing for the hauling and erection equipment to operate under their own power.

B. Site Preparation: The General Contractor shall be responsible for…

1. Providing true, level bearing surfaces on all field-constructed bearing walls and other field-constructed supporting members.

2. All pipes, stacks, conduits, and other such items shall be stubbed-off at a level lower than the bearing plane of the hollow core slabs until after the latter are set.

C. Install loose clips, hangers, bearing pads, and other accessories required for connecting the hollow core slabs to supporting members and backup materials.

D. Erect NiCore™ Plank level, plumb and square within the specified allowable erection tolerances. Provide temporary structural framing, supports and bracing as required to maintain position, stability, and alignment of members until permanent connections are completed.

1. Install bearing pads as NiCore™ Plank are being erected.

2. Maintain horizontal and vertical joint alignment and uniform joint width as erection progresses.

3. Use sand-cement grout to fill voids within recessed lifting devices flush with surface of adjacent precast concrete surfaces when recess is exposed.

4. Provide and install headers of structural-steel shapes for openings larger than one slab width according to NiCore™ Plank fabricator's written recommendations.

E. Connect NiCore™ Plank in position by bolting, welding, grouting, or as otherwise indicated on approved Shop (Erection) Drawings. Remove temporary shims, and spacers as soon as practical after connecting and/or grouting are completed.

F. Welding: Comply with applicable AWS D1.1and AWS D1.4 requirements for welding, welding electrodes, appearance of welds, quality of welds, and methods used in correcting welding work.

1. Protect NiCore™ Plank and bearing pads from damage during field welding or cutting operations and provide noncombustible shields as required.

2. Welds not specified shall be continuous fillet welds, using not less than the minimum fillet as specified by AWS D1.1 or D1.4.

3. Clean-weld-affected metal surfaces with chipping hammer followed by brushing or power tool cleaning and then re-prime damaged painted surfaces in accordance with manufacturer's recommendations.

4. For galvanized metal, clean weld affected metal surfaces with chipping hammer followed by brushing or power tool cleaning, and apply a minimum 0.004”thick coat of galvanized repair paint to galvanized surfaces in conformance with ASTM A 780.

5. Visually inspect all welds critical to NiCore™ Plank connections. Visually check all welds for completion and remove, re-weld or repair all defective welds, if the services of an AWS-certified welding inspector are not furnished by Owner.

G. At bolted connections, use tack welding or other approved means to prevent loosening of nuts after final adjustment.

1. Unless indicated otherwise, all bolts to be installed to a snug-tight condition in accordance with AISC at a minimum.

2. For connections utilizing high-strength bolts and slip critical connections verify bolt position and tightness at installation. For sliding connections, properly secure bolt but allow bolt to move within connection slot. For slip critical connection, apply specified bolt torque and check 25 percent of bolts at random by calibrated torque wrench. If inadequate bolt torque is found, test all bolts.

H. Grouting Connections and Joints: Indicate joints to be grouted and any critical grouting sequences on Shop (Erection) Drawings. Grout open spaces at keyways, connections and joints where required or indicated. Where required at the bearings provide a grout mixture having sufficient consistency to not require end core dams. Provide reinforcing steel where indicated. Retain flowable grout in place until strong enough to support itself. Grout shall extend to at least the bottom of the shear keys without seepage to other surfaces. Settlement of the grout is structurally acceptable and can be feather leveled by others, if required. Place grout and finish smooth, level, and plumb with adjacent concrete surfaces. Promptly remove grout material from exposed surfaces before it affects finishes or hardens. Finish transitions due to different surface levels not steeper than 1 to 12.

I. Field cutting or coring of NiCore™ Plank is not permitted without approval of the Engineer.

J. Subject to approval of the Architect/Engineer, NiCore™ Plank may be drilled or “shot” with powder actuated fasteners provided no contact is made with the prestressing steel. If spalling should occur it shall be repaired by the trade installing the fasteners.

3.4 ERECTION TOLERANCES

A. Erect NiCore™ Plank level, plumb, square, true, and in alignment without exceeding the non-cumulative erection tolerances of PCI MNL 135.

B. “Level out” variations between adjacent NiCore™ Plank by jacking, loading, or any other feasible method as required by the approved shop drawings. Variations between adjacent members shall be reasonably “leveled-out” to within 3/8".

3.5 FIELD QUALITY CONTROL

Retain first option in paragraph below if Owner engages a special inspector. If authorities having jurisdiction permit Contractor to engage a special inspector, retain second option and retain option for submitting special inspection reports in Part 1 "Submittals" Article.

A. Special Inspections: **[Owner will engage][Contractor will engage]** a qualified special inspector to perform the following special inspections and prepare reports:

1. Erection of loadbearing precast concrete members.
2. **<Insert special inspections>**

Retain first paragraph below if field testing and inspecting are required, with or without paragraph above, to identify who shall perform tests and inspections. If retaining second option, retain requirement for field quality-control test reports in Part 1 "Submittals" Article.

B. Testing: Owner will engage accredited independent testing and inspecting agency to perform field tests and inspections and prepare reports.

1. Field welds will be subject to visual inspections and nondestructive testing in accordance with ASTM E 165 or ASTM E 1444 and ASTM E 709.

2. Testing agency will report test results promptly and in writing to Contractor and Architect.

C. Repair or remove and replace work where tests and inspections indicate that it does not comply with specified requirements.

D. Additional testing and inspecting, at Erector's expense, will be performed to determine compliance of corrected work with specified requirements.

3.6 REPAIRS

Production chips, cracks, and spalls should have been corrected at fabricator's plant. Defects occurring after delivery are normally repaired before final joint sealing and cleaning as weather permits.

A. Repairs and patches will be permitted provided structural adequacy, serviceability and durability of members and appearance are not impaired as evaluated by Nitterhouse Concrete Products' Engineering Department.

B. Prepare and repair damaged galvanized coatings with galvanizing repair paint according to ASTM A 780.

Retain paragraph above if using galvanized anchors, connections, and other items; retain first paragraph below if items are prime painted.

C. Wire brush, clean, and paint damaged prime-painted components with same type of shop primer.

D. Remove and replace damaged hollow core slabs when repairs do not comply with specified requirements.

3.7 CLEANING

A. As work progresses all excess or deleterious materials which would become difficult to remove from finished surfaces, or which would harden on finished surfaces, shall be removed immediately by the hollow core slab erector.

B. Upon completion of the work, all surplus materials, tools, equipment, and debris leaving the building in a clean condition shall be removed to the satisfaction of the Owner.

C. After the NiCore™ Plank have been erected it is the responsibility of the respective trade contractor(s) to clean exposed surfaces and to remove mortar splatter, weld marks, other markings, dirt, and stains. Final cleaning of all material is the responsibility of the general contractor or construction manager of the Project.

D. The top surface must be clean and free of deleterious materials prior to application of leveling coats or cast-in-place composite toppings.

E. Perform cleaning procedures, if necessary, according to Nitterhouse Concrete Products' recommendations. Protect adjacent work from staining or damage due to cleaning operations.

F. Do not use cleaning materials or processes that could change the appearance of exposed concrete finishes or damage adjacent materials. Biodegradable or bio-based cleaning products are preferred.

3.8 WARRANTY

A. The precast fabricator shall guarantee the NiCore™ Plank against defects in material and workmanship, for a period of one (1) year, after acceptance of the units by the owner.

END OF SECTION 034113

DEPTH 3: LEED CERTIFICATION

APPENDIX

Emily Roarty
[Email address]

Sustainable Sites
SS Credit 5.1 – Site Development – Protect or Restore Habitat (1 point)
▪ Projects earning SS Credit 2 (Development Density and Community Connectivity) may include vegetated roof surface in this calculation if the plants are native or adapted, provide habitat, and promote biodiversity.
▪ Once established, native/adapted plants require minimal or no irrigation; do not require active maintenance such as mowing or chemical inputs such as fertilizers, pesticides or herbicides; and provide habitat value and promote biodiversity through avoidance of monoculture plantings.
SS Credit 5.2 – Site Development – Maximize Open Space (1 point)
▪ Projects in urban areas earning SS Credit 2, vegetated roofs can contribute to credit compliance.
SS Credit 6.1 – Storm Water Design: Quantity Control (1 point)
▪ Specify vegetated roofs, pervious paving and other measures to minimize impervious surfaces.
SS Credit 7.2 – Heat Island Effect: Roof (1 point)
▪ Use alternative surfaces (e.g., vegetated roofs, pervious pavement, grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration and thereby reduce pollutant loadings.
SS Credit 7.2 – Heat Island Effect: Roof (1 point)
▪ Install a vegetated roof for at least 50% of the roof or Install high albedo and vegetated roof in combination (Area of SRI roof/0.75) + (Area of Veg Roof/0.50) ≥ Total Roof Area
Water Efficiency
WE Credit 1 –Water Efficient Landscaping **(Potential: 2-4 Points)**
▪ If this credit is pursued, be sure to design the green roof system without permanent irrigation, or if irrigation is necessary, minimize potable consumption with drip irrigation and/or irrigation with reclaimed water.
▪ Option 1: 2 points for reducing potable water for irrigation by 50%
▪ Option 2: 4 points for no potable water use for irrigation. Temporary irrigation systems for plant establishment acceptable if removed within 1 year to 18 months of installation.
▪ If the percent reduction of potable water is 100% and the percent reduction of total water is equal to or greater than 50%, both Option 1 and Option 2 are earned.
Energy and Optimization
EA Prerequisite 2: Minimum Energy Performance **(Required)**
▪ Establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.
EA Credit 1 – Optimize Energy Performance **(Potential: Up to 19 Points)**
▪ Vegetated roofs can aid in the reduction of the energy demand for the project. Demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating.
Materials and Resources
MR Credit 3 – Material Reuse **(Potential: 1-2 Points)**
▪ Reuse building materials and products to reduce demand for virgin materials and reduce waste, thereby lessening impacts associated with the extraction and processing of virgin resources.
▪ The sum of reused materials must constitute at least 5% or 10%, based on cost, of the total value of materials on the project.
MR Credit 4 – Recycled Content **(Potential: 1-2 Points)**
▪ Components like, pavers, edge treatments, and growth media components (compost) are from both pre-consumer and post-consumer materials.
▪ Contributes towards having 10% to 20% of the total value of project materials originating from recycled material
▪ The recycled content value of a material assembly is determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
MR Credit 5.1 – Regional Material **(Potential: 1-2 points)**
▪ 10% or 20% of product, depending on the overall percent of materials extracted, must be manufactured and assembled within 500 miles.

LEED v4 for Building Design and Construction: Homes and Multifamily Lowrise

Project Checklist

Project Name:
Date:

Y	?	N			
			Credit	Integrative Process	2

0	0	0	**Location and Transportation**		15
Y			Prereq	Floodplain Avoidance	Required
			PERFORMANCE PATH		
			Credit	LEED for Neighborhood Development Location	15
			PRESCRIPTIVE PATH		
			Credit	Site Selection	8
			Credit	Compact Development	3
			Credit	Community Resources	2
			Credit	Access to Transit	2

0	0	0	**Sustainable Sites**		7
Y			Prereq	Construction Activity Pollution Prevention	Required
Y			Prereq	No Invasive Plants	Required
			Credit	Heat Island Reduction	2
			Credit	Rainwater Management	3
			Credit	Non-Toxic Pest Control	2

0	0	0	**Water Efficiency**		12
Y			Prereq	Water Metering	Required
			PERFORMANCE PATH		
			Credit	Total Water Use	12
			PRESCRIPTIVE PATH		
			Credit	Indoor Water Use	6
			Credit	Outdoor Water Use	4

0	0	0	**Energy and Atmosphere**		38
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Energy Metering	Required
Y			Prereq	Education of the Homeowner, Tenant or Building Manager	Required
			PERFORMANCE PATH		
			Credit	Annual Energy Use	29
			BOTH PATHS		
			Credit	Efficient Hot Water Distribution System	5
			Credit	Advanced Utility Tracking	2
			Credit	Active Solar Ready Design	1
			Credit	HVAC Start-Up Credentialing	1
			PRESCRIPTIVE PATH		
Y			Prereq	Home Size	Required
			Credit	Building Orientation for Passive Solar	3
			Credit	Air Infiltration	2
			Credit	Envelope Insulation	2
			Credit	Windows	3
			Credit	Space Heating & Cooling Equipment	4

			EA PRES	
			Credit	Heating & Cooling Dis
			Credit	Efficient Domestic Ho
			Credit	Lighting
			Credit	High Efficiency Applia
			Credit	Renewable Energy

0	0	0	**Materials and Resources**	
Y			Prereq	Certified Tropical Wo
Y			Prereq	Durability Manageme
			Credit	Durability Manageme
			Credit	Environmentally Prefe
			Credit	Construction Waste M
			Credit	Material Efficient Fran

0	0	0	**Indoor Environmental Qu**	
Y			Prereq	Ventilation
Y			Prereq	Combustion Venting
Y			Prereq	Garage Pollutant Pro
Y			Prereq	Radon-Resistant Con
Y			Prereq	Air FIltering
Y			Prereq	Environmental Tobac
Y			Prereq	Compartmentalizatior
			Credit	Enhanced Ventilation
			Credit	Contaminant Control
			Credit	Balancing of Heating
			Credit	Enhanced Compartm
			Credit	Enhanced Combustio
			Credit	Enhanced Garage Po
			Credit	Low Emitting Product

0	0	0	**Innovation**	
Y			Prereq	Preliminary Rating
			Credit	Innovation
			Credit	LEED AP Homes

0	0	0	**Regional Priority**	
			Credit	Regional Priority: Spe
			Credit	Regional Priority: Spe
			Credit	Regional Priority: Spe
			Credit	Regional Priority: Spe

0	0	0	**TOTALS**

Certified: 40 to 49 points, **Silver:** 5

CRIPTIVE PATH (continued)	
eating & Cooling Distribution Systems	3
ficient Domestic Hot Water Equipment	3
	2
gh Efficiency Appliances	2
	4
nd Resources	**10**
ertified Tropical Wood	Required
urability Management	Required
urability Management Verification	1
nvironmentally Preferable Products	4
onstruction Waste Management	3
aterial Efficient Framing	2
vironmental Quality	**16**
	Required
	Required
arage Pollutant Protection	Required
adon-Resistant Construction	Required
	Required
nvironmental Tobacco Smoke	Required
ompartmentalization	Required
nhanced Ventilation	3
	2
alancing of Heating and Cooling Distribution Systems	3
nhanced Compartmentalization	1
nhanced Combustion Venting	2
nhanced Garage Pollutant Protection	2
w Emitting Products	3
	6
	Required
	5
	1
	4
egional Priority: Specific Credit	1
egional Priority: Specific Credit	1
egional Priority: Specific Credit	1
egional Priority: Specific Credit	1
Possible Points:	**110**

0 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

LEED v4 for Building Design and Construction: Multifamily Midrise

Project Checklist

Project N
Date:

Y	?	N				
		0	Credit	Integrative Process	2	
13	0	0	**Location and Transportation**		15	7 0
Y			Prereq	Floodplain Avoidance	Required	Y
			PERFORMANCE PATH			Y
	0		Credit	LEED for Neighborhood Development Location	15	Y
			PRESCRIPTIVE PATH			Y
6			Credit	Site Selection	8	Y
3			Credit	Compact Development	3	Y
2			Credit	Community Resources	2	Y
2			Credit	Access to Transit	2	
0	0	0	**Sustainable Sites**		7	3
Y			Prereq	Construction Activity Pollution Prevention	Required	
Y			Prereq	No Invasive Plants	Required	
		0	Credit	Heat Island Reduction	2	
		0	Credit	Rainwater Management	3	3
		0	Credit	Non-Toxic Pest Control	2	1
10	0	0	**Water Efficiency**		12	1 0
Y			Prereq	Water Metering	Required	Y
			PERFORMANCE PATH			
		0	Credit	Total Water Use	12	1
			PRESCRIPTIVE PATH			
6			Credit	Indoor Water Use	6	0 0
4			Credit	Outdoor Water Use	4	
0	0	0	**Energy and Atmosphere**		37	
Y			Prereq	Minimum Energy Performance	Required	
Y			Prereq	Energy Metering	Required	
Y			Prereq	Education of the Homeowner, Tenant or Building Manager	Required	36 0
		0	Credit	Annual Energy Use	30	Certif
		0	Credit	Efficieng Hot Water Distribution	5	
		0	Credit	Advanced Utility Tracking	2	
5	0	0	**Materials and Resources**		9	
Y			Prereq	Certified Tropical Wood	Required	
Y			Prereq	Durability Management	Required	
		0	Credit	Durability Management Verification	1	
5			Credit	Environmentally Preferable Products	5	
		0	Credit	Construction Waste Management	3	

Name:

0	**Indoor Environmental Quality**		**18**
	Prereq	Ventilation	Required
	Prereq	Combustion Venting	Required
	Prereq	Garage Pollutant Protection	Required
	Prereq	Radon-Resistant Construction	Required
	Prereq	Air FIltering	Required
	Prereq	Environmental Tobacco Smoke	Required
	Prereq	Compartmentalization	Required
0	Credit	Enhanced Ventilation	3
0	Credit	Contaminant Control	2
	Credit	Balancing of Heating and Cooling Distribution Systems	3
0	Credit	Enhanced Compartmentalization	3
0	Credit	Enhanced Combustion Venting	2
0	Credit	Enhanced Garage Pollutant Protection	1
	Credit	Low Emitting Products	3
	Credit	No Environmental Tobacco Smoke	1
0	**Innovation**		**6**
	Prereq	Preliminary Rating	Required
0	Credit	Innovation	5
	Credit	LEED AP Homes	1
0	**Regional Priority**		**4**
	Credit	Regional Priority: Specific Credit	1
	Credit	Regional Priority: Specific Credit	1
	Credit	Regional Priority: Specific Credit	1
	Credit	Regional Priority: Specific Credit	1
0	**TOTALS**	Possible Points:	**110**

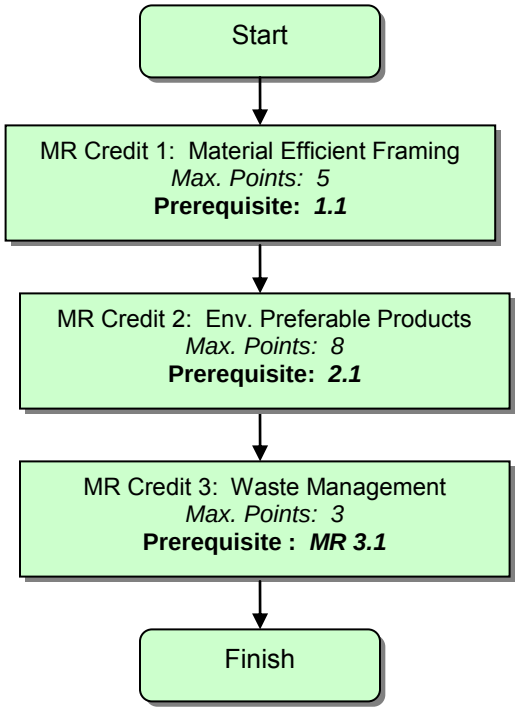
fied: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Materials and Resources (MR)

Pathway through the MR Category

Important Note:

*A minimum of **2 points** must be achieved in the MR category*



MR 1. Material-Efficient Framing

Maximum points: 5

Intent

Optimize the use of framing materials.

Requirements

Prerequisites

1.1 **Framing Order Waste Factor Limit.** Limit the overall estimated waste factor to 10% or less. If the waste factor on any portion of the framing order exceeds 10%, calculate the overall waste factor as shown in Table 22.

Waste factor is defined as the percentage of framing material ordered in excess of the estimated material needed for construction.

Table 22. Sample Framing Order Waste Factor Calculation

Framing component	*Total cost*	*Waste factor*	*Waste cost*
Random lengths	$1,000	15%	$150
Studs	$2,000	5%	$100
Beams and headers	$500	20%	$100
Roof deck	$2,000	0%	$0
Wall sheathing	$0	0%	$0
Rafters	$2,000	0%	$0
Ceiling joists	$1,500	10%	$150
Cornice work	$3,000	10%	$300
TOTAL	$12,000		$1,000
Overall waste factor (waste $ / cost $)			8.3%

Credits

1.2 **Detailed Framing Documents** (1 point). Prior to construction, create detailed framing plans or scopes of work and accompanying architectural details for use on the job site. Indicate the specific locations, spacing, and sizes of all framing members in the floors, walls, roof, and ceiling (if different from the roof).

1.3 **Detailed Cut List and Lumber Order** (1 point). The requirements in MR 1.2 must be met to earn this credit. Prior to construction, create a detailed cut list and lumber order that corresponds directly to the framing plans and/or scopes of work.

AND/OR

1.4 **Framing Efficiencies** (maximum 3 points). Implement measures from Table 23.

OR

1.5 **Off-Site Fabrication** (4 points). Use either of the following alternatives to on-site framing:

a) Panelized construction. Wall, roof, and floor components are delivered to the job site preframed.

b) Modular, prefabricated construction. All principal building sections are delivered to the job site as prefabricated modules.

Table 23. Efficient Framing Measures

Measure	*Points*
Precut framing packages	1.0
Open-web floor trusses	1.0
Structural insulated panel (SIP) walls	1.0
SIP roof	1.0
SIP floors	1.0
Stud spacing greater than 16” o.c	1.0
Ceiling joist spacing greater than 16” o.c.	0.5
Floor joist spacing greater than 16” o.c.	0.5
Roof rafter spacing greater than 16” o.c.	0.5
Implement any 2 of the following: • Size headers for actual loads • Use ladder blocking or drywall clips • Use 2-stud corners	0.5

Note: Alternative measures not listed in Table 23 may be eligible to earn points if they save comparable amounts of framing material. A formal credit interpretation request with full justification of any alternative measure’s potential savings must be submitted by the Provider to USGBC.

Synergies and Trade-Offs

Reduced framing can reduce the number and size of thermal breaks and increase the amount of insulation installed, leading to better energy performance (EA 1 and 2).

Credit MR 1.2 is a prerequisite for MR 1.3. A home that earns points for MR 1.2, 1.3 and 1.4 cannot earn points for MR 1.5, and vice versa.

Optimizing the use of framing will reduce the amount of construction waste (MR 3.2).

MR 2. Environmentally Preferable Products

Maximum points: 8

Intent

Increase demand for environmentally preferable products and products or building components that are extracted, processed, and manufactured within the region.

Requirements

Prerequisites

2.1 **FSC Certified Tropical Wood.** Meet the following two requirements, as applicable:

a) Provide all wood product suppliers with a notice (see Figure 6, below) containing all the following elements:
   i. a statement that the builder's preference is to purchase products containing tropical wood only if it is FSC-certified;
   ii. a request for the country of manufacture of each product supplied; *and*
   iii. a request for a list of FSC-certified tropical wood products the vendor can supply.

b) If tropical wood is intentionally used (i.e., specified in purchasing documents), use only FSC-certified tropical wood products. Reused or reclaimed materials are exempt.

Note: A species of wood is considered *tropical* for the purposes of this prerequisite if it is grown in a country that lies between the Tropics of Cancer and Capricorn.

Credits

2.2 **Environmentally Preferable Products** (0.5 point each, maximum 8 points). Use building component materials that meet one or more of the criteria below. Except as noted in Table 24, a material must make up 90% of the component, by weight or volume. A single component that meets each criterion (i.e., environmentally preferable, low emissions, and local sourcing) can earn points for each.

a) Environmentally preferable products (0.5 point per component). Use products that meet the specifications in Table 24.

   Note: Recycled content products must contain a minimum of 25% postconsumer recycled content, except as noted in Table 24. Postindustrial (preconsumer) recycled content must be counted at half the rate of postconsumer content.

AND/OR

b) Low emissions (0.5 point per component). Use products that meet the emissions specifications in Table 24.

AND/OR

c) Local production (0.5 point per component). Use products that were extracted, processed, *and* manufactured within 500 miles of the home.

Table 24. Environmentally Preferable Products

Assembly	Component	EPP specifications (0.5 point per component)	Emission specifications (0.5 point per component)	Local production (0.5 point per component)
Exterior wall	Framing / wall structure	Concrete wall structure: Use 30% fly ash or slag wood frame: FSC-certified or reclaimed or finger joint studs	*N/A*	Eligible
Exterior wall	Siding or masonry	Recycled content, reclaimed, or FSC-certified	*N/A*	Eligible
Floor	Flooring (45% of total floor area)	Linoleum, cork, bamboo, FSC-certified or reclaimed wood, sealed concrete, recycled-content flooring, *or combination*	Carpet & pad: all carpet & pad complies with Carpet & Rug Institute Green Label Plus program Hard flooring: automatic 1/2 point for 100% hard surface flooring Hard flooring: additional 1/2 point for using a product that is SCS FloorScore certified	Eligible
Floor	Flooring (90% of total floor area)	Meet specifications above to receive *additional* 0.5 point.		Eligible (*additional* 0.5 point)
Floor	Framing	FSC-certified or reclaimed	*N/A*	Eligible
Foundation	Aggregate	*N/A*	*N/A*	Eligible
Foundation	Cement	Use 30% fly ash or slag	*N/A*	Eligible
Interior wall	Framing	FSC-certified or reclaimed	*N/A*	Eligible
Interior walls AND ceilings	Gypsum board	*N/A*	*N/A*	Eligible
Interior walls AND ceilings AND millwork	Paints and coatings	Recycled paint that meets Green Seal standard GS-43	Use products that comply with all applicable standards in Table 25.	Not eligible
Landscape	Decking or patio material	Recycled content, FSC-certified, or reclaimed	*N/A*	Eligible
Other	Cabinets	Recycled content, FSC-certified, or reclaimed AND composite materials must contain no added urea-formaldehyde resins	*N/A*	Eligible
Other	Counters (kitchens and bathrooms)	Recycled content, FSC-certified, or reclaimed AND composite materials must contain no added urea-formaldehyde resins	*N/A*	Eligible
Other	Doors (not including garage or insulated doors)	Recycled content, FSC-certified, or reclaimed	*N/A*	Eligible
Other	Trim	Recycled content, FSC-certified, or reclaimed AND composite materials must contain no added urea-formaldehyde resins	*N/A*	Eligible
Other	Adhesives and sealants	*N/A*	Use products that comply with all applicable standards in Table 26.	Not eligible
Other	Window framing	Recycled content, FSC-certified, or reclaimed	*N/A*	Eligible
Roof	Framing	FSC-certified	*N/A*	Eligible
Roof	Roofing	Recycled content	*N/A*	Eligible
Roof AND floor AND wall	Insulation	Recycled content of 20% or more	Comply with California "Practice for Testing of VOCs from Building Materials Using Small Chambers": www.dhs.ca.gov/ehlb/IAQ/VOCS/Practice.htm	Eligible
Roof, floor, wall (2 of 3)	Sheathing	Recycled content, FSC-certified, or reclaimed	N/A	Eligible

Figure 6. Example Notice to Wood Products Suppliers

> **Notice to Vendors:** [The company] prefers to purchase products that contain tropical wood only if they are certified according to the guidelines of the Forest Stewardship Council (FSC). Please provide the country of manufacture of each product you expect to supply to us. Also please provide a list of FSC-certified products you can supply.

Table 25. Standards for Environmentally Preferable Paints and Coatings

Component	*Applicable standard (VOC content)*	*Reference*
Architectural paints, coatings and primers applied to interior walls and ceilings	Flats: 50 g/L Nonflats: 150 g/L	Green Seal Standard GS-11, Paints, 1st Edition, May 20, 1993
Anticorrosive and antirust paints applied to interior ferrous metal substrates	250 g/L	Green Seal Standard GC-03, Anti-Corrosive Paints, 2nd Edition, January 7, 1997
Clear wood finishes	Varnish: 350 g/L Lacquer: 550 g/L	South Coast Air Quality Management District Rule 1113, Architectural Coatings
Floor coatings	100 g/L	
Sealers	Waterproofing: 250 g/L Sanding: 275 g/L All others: 200 g/L	
Shellacs	Clear: 730 g/L Pigmented: 550 g/L	
Stains	250 g/L	

Table 26. Standards for Low-Emissions Adhesives and Sealants

(meet South Coast Air Quality Management District Rule #1168)

	Applicable standard (VOC content, g/L less water)
Architectural applications	
Indoor carpet adhesives	50
Carpet pad adhesives	50
Wood flooring adhesives	100
Rubber floor adhesives	60
Subfloor adhesives	50
VCT and asphalt adhesives	50
Drywall and panel adhesives	50
Cove base adhesives	50
Multipurpose construction adhesives	70
Structural glazing adhesives	100
Specialty applications	
PVC welding	510
CPVC welding	490
ABS welding	325
Plastic cement welding	250
Adhesive primer for plastic	550
Contact adhesive	80
Special-purpose contact adhesive	250
Structural wood member adhesive	140
Sheet-applied rubber lining operations	850
Top and trim adhesive	250
Substrate-specific applications	
Metal to metal	30
Plastic foams	50
Porous materials (except wood)	50
Wood	30
Fiberglass	80
Sealants	
Architectural	250
Nonmembrane roof	300
Roadway	250
Single-ply roof membrane	450
Other	420
Sealant primers	
Architectural nonporous	250
Architectural porous	775
Other	750

Synergies and Trade-Offs

Products with low emissions of volatile organic compounds (VOCs) may improve indoor air quality. Such products are included in this credit rather than in the EQ section in order to consolidate information pertaining to materials selection, specification, and purchase.

A substantial amount of energy is used to transport materials from product manufacturing plants to home construction sites. Choosing local products will reduce the embedded transportation energy usage associated with construction.

MR 3. Waste Management

Maximum points: 3

Intent

Reduce waste generation to a level below the industry norm.

Requirements

Prerequisites

3.1 **Construction Waste Management Planning.** Complete the following tasks related to management of construction waste:

a) Investigate and document local options for diversion (e.g. recycling, reuse) of all anticipated major constituents of the project waste stream, including cardboard packaging and household recyclables (e.g., beverage containers).

b) Document the diversion rate for construction waste. Record the diversion rate for land clearing and/or demolition, if applicable (e.g., on gut rehab project), separately from the rate for the new construction phase of the project.

Credits

3.2 **Construction Waste Reduction** (maximum 3 points). Reduce or divert waste generated from new construction activities from landfills and incinerators to a level below the industry norm. Use either of two options:

a) Reduced construction waste. Generate 2.5 pounds (or 0.016 cubic yards) or less of net waste (not including waste diverted for reclamation or recycling) per square foot of conditioned floor area. Use column 1 or 2 and column 5 of Table 27 to determine the score.[5]

b) Increased waste diversion. Divert 25% of more of the total materials taken off the construction site from landfills and incinerators. Use column 3 or 4 and column 5 of Table 27 to determine the score; calculate the percentage using either weight or volume.

Note*:* Land clearing and demolition waste (e.g., from removal of preexisting structures on the site) should not be counted in this calculation**.**

[5] The industry average is 4.2 pounds (0.0265 cubic yards) of waste per square foot of conditioned floor area, based on data provided by the National Association of Home Builders' Research Center.

Table 27. Waste Diversion

Amount to landfills and incinerators				
Reduced construction waste		*Increased waste diversion*		
Pounds / ft²	*Cubic yards / 1,000 ft²*	*Percentage waste*	*Percentage diverted*	*Points*
4.0	25.5	100%	0%	0.0
3.5	22.3	88%	13%	0.0
3.0	19.1	75%	25%	0.5
2.5	15.9	63%	38%	1.0
2.0	12.8	50%	50%	1.5
1.5	9.6	38%	63%	2.0
1.0	6.4	25%	75%	2.5
0.5	3.2	13%	88%	3.0

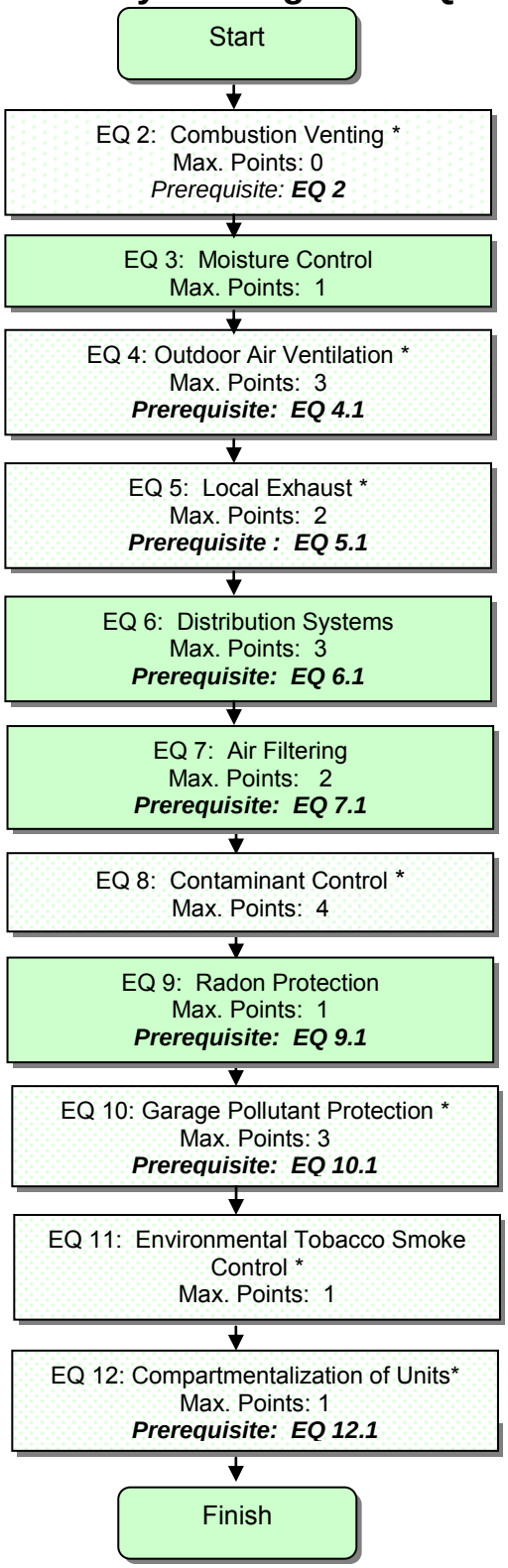
Synergies and Trade-Offs

Waste can be minimized by creating a detailed framing plan and using advanced framing techniques or off-site fabrication (MR 1).

The use of products with reclaimed or recycled content (MR 2.2) reduces both the production of new materials and the burden on landfills.

Indoor Environmental Quality (EQ)

Optional Pathways through the EQ Category



Important Note:

*A minimum of **3 points** must be achieved in the IEQ category*

***** *Please see revised EQ credits for Mid-rise Buildings*

EQ 2. Combustion Venting *in Mid-rise Buildings*

Maximum Points: 0

Intent

Minimize the leakage of combustion gases into the occupied space of the building.

Requirements

Prerequisites

2. **Basic Combustion Venting Measures.** Meet all of the following requirements:
   a) No unvented combustion appliances (e.g. decorative logs) are allowed.
   b) A carbon monoxide (CO) monitor must be installed on each floor of each unit.
   c) All fireplaces and woodstoves must have doors.
   d) Space and water heating equipment that involves combustion must meet one of the following. Space heating systems in buildings located in IECC-2006 climate zone 1 or 2 are exempt.
      i. It must be designed and installed with closed combustion (i.e. sealed supply air and exhaust ducting);
      ii. it must be designed and installed with power-vented exhaust; or
      iii. it must be located in a detached utility building or open-air facility.

Credits

None.

Table 29. Fireplace and Stove Combustion-Venting Requirements

Fireplace or stove	*Enhanced combustion-venting measures*	
	Better practice (1 point)	*Best practice (2 points)*
None	See 'best practice'.	Granted automatically.
Masonry wood-burning fireplace	Install masonry heater as defined by American Society for Testing and Materials Standard E-1602 and International Building Code 2112.1.	Meet requirement for 'better practice', *and* conduct back-draft potential test to ensure Δ P ≤ 5 Pascals (see "conducting a back-draft potential test" below).
Factory-built wood-burning fireplace	Install equipment listed by approved safety testing facility (e.g., UL, CSA, ETL) that either is EPA certified or meets the following: equipment with catalytic combustor must emit less than 4.1 g/hr of particulate matter, and equipment without catalytic combustor must emit less than 7.5 g/hr of particulate matter.	Meet requirement for better practice, *and* conduct back-draft potential test to ensure Δ P ≤ 5 Pascals (see "Conducting a Back-Draft Potential Test," below).
Woodstove and fireplace insert	Install equipment listed by approved safety testing facility that either is EPA certified or meets following requirement: equipment with catalytic combustor must emit less than 4.1 g/hr of particulate matter, and equipment without catalytic combustor must emit less than 7.5 g/hr of particulate matter.	Meet requirement for better practice, *and* conduct back-draft potential test to ensure Δ P ≤ 5 Pascals (see "conducting a back-draft potential test" below).
Natural gas, propane, or alcohol stove	Install equipment listed by approved safety testing facility that is power-vented or direct-vented and has permanently fixed glass front or gasketed door.	Meet requirement for better practice, *and* include electronic (not standing) pilot.
Pellet stove	Install equipment that is either EPA certified or listed by approved safety testing facility to have met requirements of ASTM E 1509-04, "Standard Specification for Room Heaters, Pellet Fuel-Burning Type."	Meet requirement for better practice, *and* include power venting or direct venting.

Conducting a Back-Draft Potential Test

Using the results from a blower-door test, measure the pressure difference created by the presence of a chimney-vented appliance. To ensure a limited risk of back-drafting, the pressure difference (Δ P) must be less than or equal to 5 Pascals, where

$$\Delta P = (Q/C)^{1/n} \quad \text{(must be} \leq 5 \text{ Pascals)}$$

and Q is equal to the sum of the rated exhaust provided by the two biggest exhaust appliances in the home, and C and n are both constants produced by the blower-door test results.

Synergies and Trade-Offs

A project receiving points for EQ 1 is not eligible to earn points in EQ 2.2. A project pursuing EQ 2.2 must meet all the prerequisites in EQ 2–10.

EQ 3. Moisture Control

Maximum points: 1

Intent

Control indoor moisture levels to provide comfort, reduce the risk of mold, and increase the durability of the home.

Requirements

Prerequisites

None.

Credits

3 **Moisture Load Control** (1 point). Install dehumidification equipment with sufficient latent capacity to maintain relative humidity at or below 60%. This must be achieved through one of the following:

a) Additional dehumidification system(s).

b) A central HVAC system equipped with additional controls to operate in dehumidification mode.

Note: LEED for Homes does not encourage active dehumidification for all projects. Work with the HVAC contractor to determine whether this credit is appropriate and/or necessary.

Synergies and Trade-Offs

A project receiving points for EQ 1 is not eligible to earn points in EQ 3. A project pursuing EQ 3 must meet all the prerequisites in EQ 2–10.

Water leakage through the building envelope can cause mold and other indoor environmental problems. Improved foundation, exterior walls, and roof water management should be addressed in the durability inspection checklist (ID 2).

In hot and humid climates, dehumidification can reduce the energy demands associated with air-conditioning (EA 1, 6).

DEPTH 4: MINIMAL LIVING RESEARCH

APPENDIX

Emily Roarty
[Email address]

CITADEL

ALL PRODUCTS

Citadel undefined

VINTAGE VISUALS, 21ST CENTURY PERFORMANCE

The hardwood floors of the Citadel Collection have the appearance of a reclaimed floor whose look could only be achieved through years of time and wear. Looks are deceiving! Citadel floors are created by combining 21ST century manufacturing techniques with artisan craftsmanship to create a vintage appearance characterized by deep, rustic character, smooth, sculpted surfaces, and rich, saturated patinas.

ENGINEERED TO PERFORM

Citadel Collection hardwood floors incorporate a 4 mm oak wear layer onto a multi-ply engineered structure for a dimensionally stable plank. designed to perform in multiple settings over concrete or raised floor systems. The wide plank engineered construction allows for a variety of installation methods based on the needs and requirements of your project.

Citadel

Fortress Series
Bastion Series
Traverse Series

FORTRESS SERIES

Nantes

Alcazar

Michel

Auray

Saumur

Blair

Lucknow

BASTION SERIES

Chevalier

Chateau

Segovia

Layout of 6th Floor

Layout of 6th Floor

Layout of 6th Floor

Layout of 6th Floor