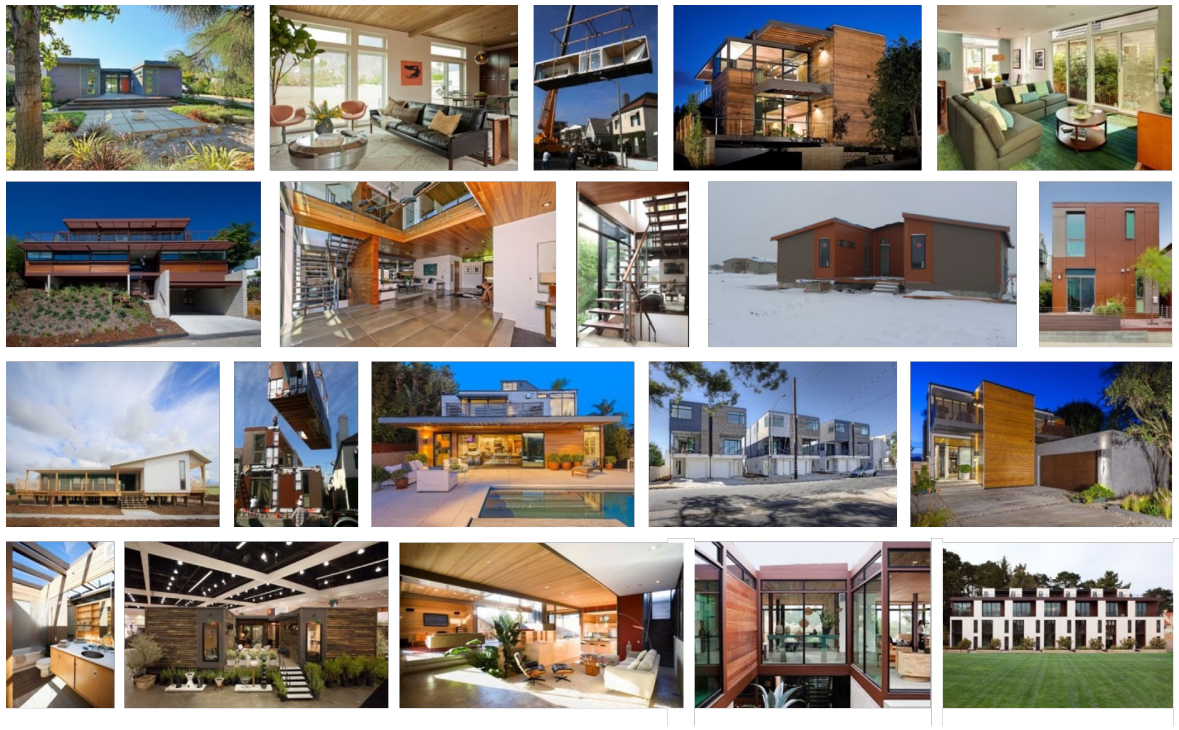
Plant Prefab

Modular Design Guidelines

Contents

5,250 sf single-family home designed by Ray Kappe, FAIA, 2 floors, 13 modules



Introduction

Plant Prefab was started to make it easy and efficient to build custom, single and multifamily homes. Unlike most prefabricators who focus on standard homes they design, market, and sell, we're focused on empowering architects—and on offering your clients a more time- and cost-efficient way to build the homes you design for them. In addition to high-quality construction and great attention to detail, we focus on sustainable and healthy construction materials and processes.

We know design matters. We've worked or are working with some of the industry's top architects/designers, including Ray Kappe, FAIA, KieranTimberlake, Yves Béhar, M-Rad, sagemodern, Toby Long, Brooks + Scarpa, and Kevin Daly Architects.

In California and most states, modular homes can be built anywhere—i.e., they can't be excluded from a site because they are modular—and banks cannot deny financing based on the fact that they are modular. (Note that cities and banks can and do exclude manufactured/mobile homes from many sites and financings.) There is no disclosure requirement on title for modular homes, and resale (at least for higher-end projects), appears to be the same.

The goal of this document is to provide you with the basic principles to design a project for modular construction at Plant. It also provides helpful guidelines for how to modify an existing design to optimize it for modular construction at Plant.

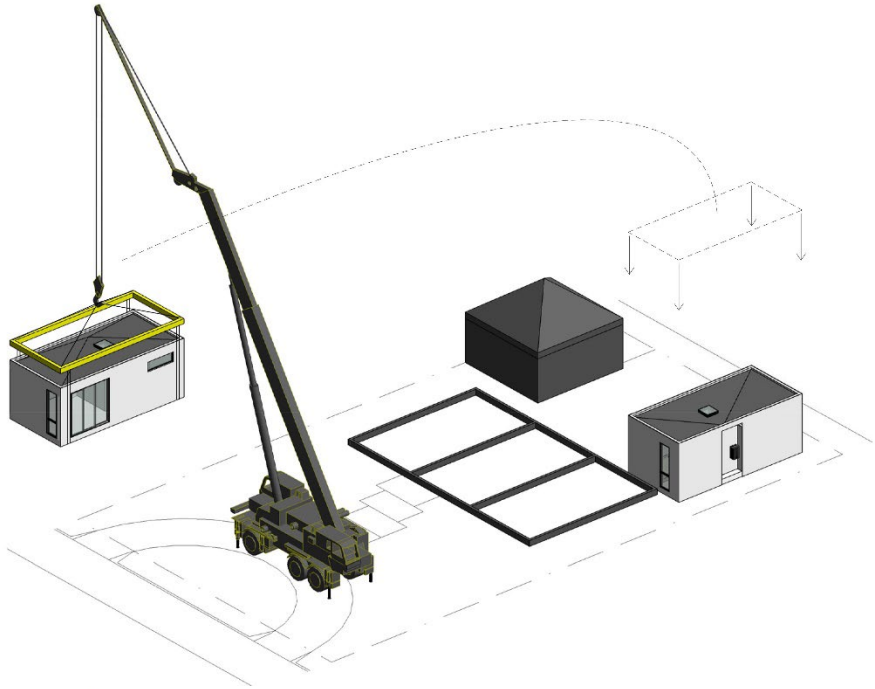
The guidelines are intended to be used as early in the design and planning process as possible, particularly before engineering is completed as engineering for modular differs from that of site-based construction. Adhering to these guidelines will help create a successful modular project at Plant, and departures from them that are identified later in the process will take more time and resources to resolve.

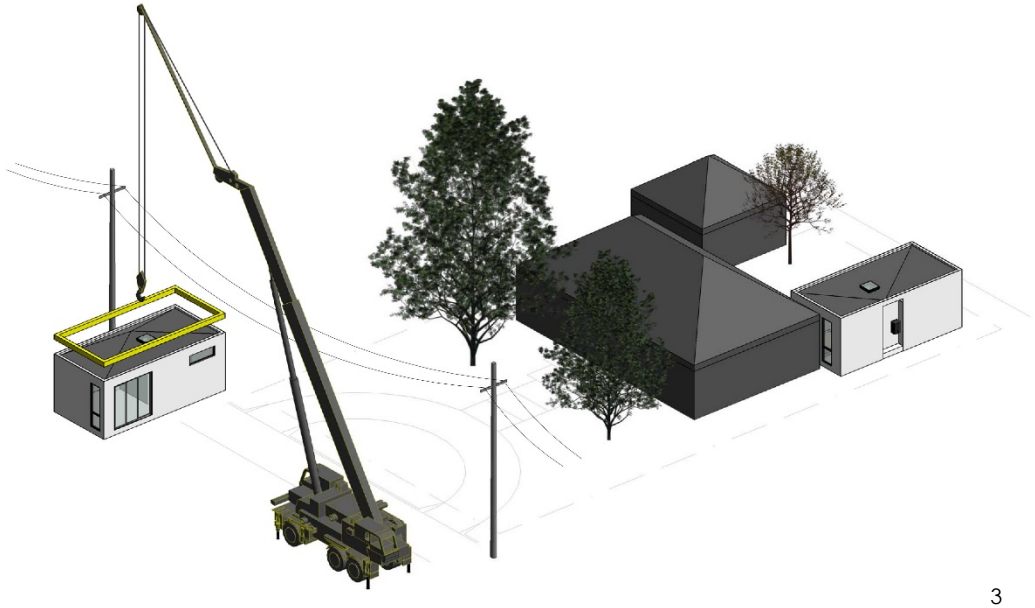
Feasibility

Not all sites are eligible for modular construction, because not all sites are accessible for the trucks that deliver the modules and/or the cranes that install the modules. Therefore, a comprehensive feasibility analysis must be performed before designs are finalized. This analysis determines:

- Truck access
    - Can the site be accessed by the large truck required to deliver the modules?
    - Is there a clear path of travel from the factory to the job site that is passable for modules?
    - What are the road restrictions due to weight and size?
    - Will pilot cars, police, and/or highway patrol escorts be required?
- Module width, height, and length
    - Are there road, bridge, or tunnel weight, height, or width limitations along the transportation route?
    - Are there any significantly steep, narrow, or non-linear sections of any portion of the transportation route?
- Crane size and access
    - What size crane will be required to install the mods, based on their dimensions and weight?
    - Will the required crane fit on the street, and/or the lot?
    - Are there any road or site obstacles that may prevent the use of a crane, such as power lines or trees?
    - If crane access is not possible, what other installation solutions can be utilized?
- Module staging
    - Is there space to stage modules prior to the day of installation?
- Site grading
    - Will site grading adjustments be required for module and crane staging?

Plant is available to do a free initial site analysis; simply send us your site address. If the site is determined to be a potential candidate for modular construction, Plant will complete the more detailed feasibility assessment described above for a small fee.





One-story Modular Installation without a Crane

When trees, power lines, or other site conditions prevent the use of a crane, modules can be installed using earth-moving equipment to slide them across the foundation on steel beams.

Modular Housing Approvals in California

As the architect/designer, you will be responsible for ensuring that your project complies with all applicable local zoning laws, regulations, and restrictions. The state approval agency who reviews the drawings (detailed below) is only reviewing fire and life/safety building codes as it applies to the California Building Standards Code, not local zoning or specific fire codes.

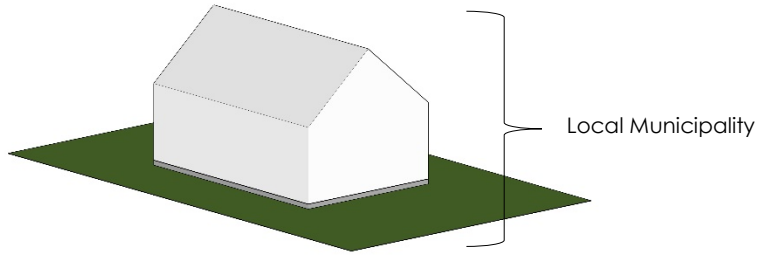
Modular homes must meet all local zoning requirements, including any specialty agency review (e.g., Coast Commission, Design Review). However, there is a bifurcated process for the building permit; the Local Enforcement Agency (LEA) is responsible for reviewing the construction set for the site work and completing their usual inspections, while the state's Housing and Community Development (HCD) is responsible for the modules and factory inspections. Modules inspected at the factory are delivered to the job site with walls sealed and local municipalities have no authority to do inspections behind the walls.

Factory-Built Housing (FBH) units are designed to the California Building Standards Code: Parts 2, 2.5, 3, 4, 5, 6, and 11 of Title 24, California Code of Regulations. A Design Approval Agency (DAA) approved by HCD reviews and approves FBH plans. FBH rules and regulations vary state by state, and there are thirteen designated DAAs in the state of California. Plant submits the drawing package to the DAA on behalf of the architect.

The LEA may have unique requirements in addition to the state requirements, such as snow load, wind pressure, fire zone, building setbacks and heights, site development, and property line requirements.

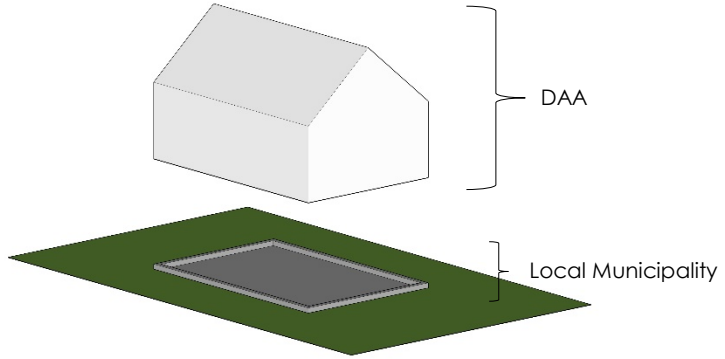
The HCD regularly updates a handbook that delineates what qualifies as Factory-Built Housing, the governing bodies responsible for oversight, and what local jurisdictions can and cannot do. The full handbook may be found on hcd.ca.gov.

Traditional Project



The local jurisdiction permits all facets of the project: setbacks, building extents, zoning, home, foundation, and additional structures.

Modular Project



The state DAA permits all factory-built portions of the project, while the local jurisdiction permits all sitework.

Basic Principles of Modular Design

The most successful modular projects are designed so that the bulk of construction is completed in the factory. This includes all finishes, fixtures, and appliances. Modules can be shipped with all these elements installed (e.g., finished plumbing and electrical fixtures, millwork, appliances, and tiling). Page 16 shows an example of a simple, single-story, two-module LivingHome project designed for minimal onsite finish work.

Structural Elements

The overall design will be engineered by a licensed structural engineer familiar with modular construction. There are unique limitations of modular construction that differ from site construction. Each module is designed for transportation and installation limits and then engineered to be tied together as one permanent structure (pages 13-14). The floor is the first part of the module constructed. Typical overall floor thickness is roughly 12", including sheathing. This can be 9 ½" TJI, 2x10 DF, 11 7/8" TJI, or 2x12 DF. The perimeter of each floor is created with double rim joists, DF for small units, and double LVL for larger modules.

Exterior walls are typically 2x6, and interior non-load-bearing walls 2x4. Plumbing walls that are located along an exterior wall require a 2x4 plumbing chase wall to allow for vents and waste lines to bypass the double rim joists (page 12). Rough plumbing drops straight down into the crawl space, while vents need to go to the roof or through stories above to the roof (page 19). Side-by-side modules typically require double walls along the length. It's best to design for this "worst-case scenario" until it is determined that all shear requirements can be met in other ways such that a wall can be removed (page 12).

Two lateral resistance systems are used at a separation of 90 degrees to avoid structural code penalties. Moment frames are used in the short or long direction when there are no shear walls present within the module. At least one shear wall per building length is required at the exterior, and one shear wall per building length is required at the seam between modules.

Transportation Parameters

Since modules need to be transported from Plant to a job site, it's important to understand some of the parameters that ultimately impact module dimensions (height, width, length) and cost (page 7).

Double-Height Spaces

Modules can be shipped without framing cut-outs and stacked to create double-height spaces.

Oversize Modules

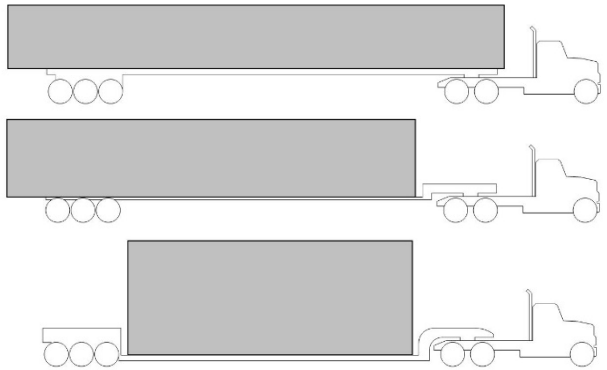
Roof overhangs that extend beyond the module can be accommodated in a few ways. The most common way is to hinge the portion that is over width back on top of the roof for transport. Upon installation, the hinged portion is rotated back to the overhang position and then roofing is completed onsite (page 10).

Transportation + Shipping Limits in California

The following factors are taken into consideration when determining module dimensions, which occurs during the comprehensive feasibility study described on page 3.

Module Height and Length

There are three main trailer types, identified below, and they determine module shipping height and length. Measured from the bottom of the floor structure to the top of the roof and/or parapet structure, the ideal module height is 13'4". The maximum total shipping height (including trailer) that will fit under most bridges and overpasses is 15'6". Taller modules may be transported on a case-by-case basis, dependent upon route and site. Depending on the type of trailer used, modules may be up to 60' long.



A standard trailer limits the module height to 8'

A single drop trailer allows for a module height up to 10'6"

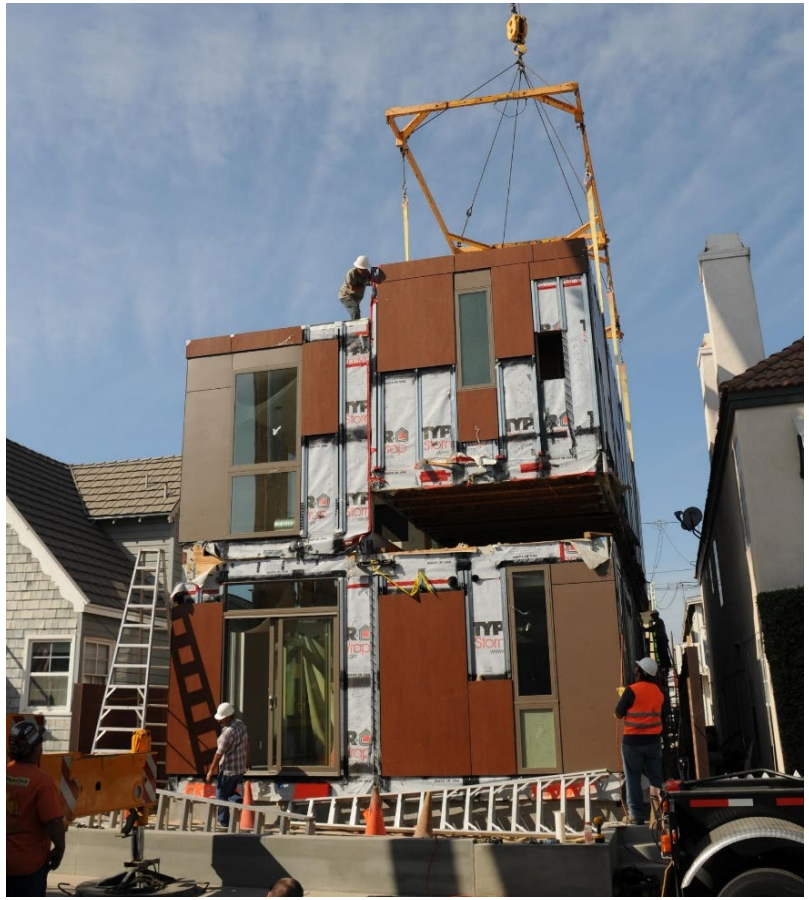
A double drop, lowboy, or modular trailer allows for a module height up to 13'4"

Module Width

Module widths are determined by site and access conditions. Notwithstanding these conditions, the California Department of Transportation (Caltrans) limits shipping width to 14', measured from the finished, outside face. Wider modules can be shipped, at additional cost, and with specific limitations set by Caltrans. Caltrans also determines when a pilot car is required (generally 12' or wider), and when a California Highway Patrol (CHP) escort is required. Specific California travel route limits can be found on dot.ca.gov.

Bathrooms and Kitchens

Bathrooms and kitchens should be included entirely within one module. All walls need to be included in the module, so that all finishes, fixtures, and equipment can be completed prior to shipping. With good design planning, kitchens can cross modules so there is a natural break point at the mateline.



Multi-story Homes

Staircases can be designed to be constructed in the factory and completed onsite.

Overwidth Module: Hinged Roof

In the factory, the roof is constructed as complete and then separated for shipping.

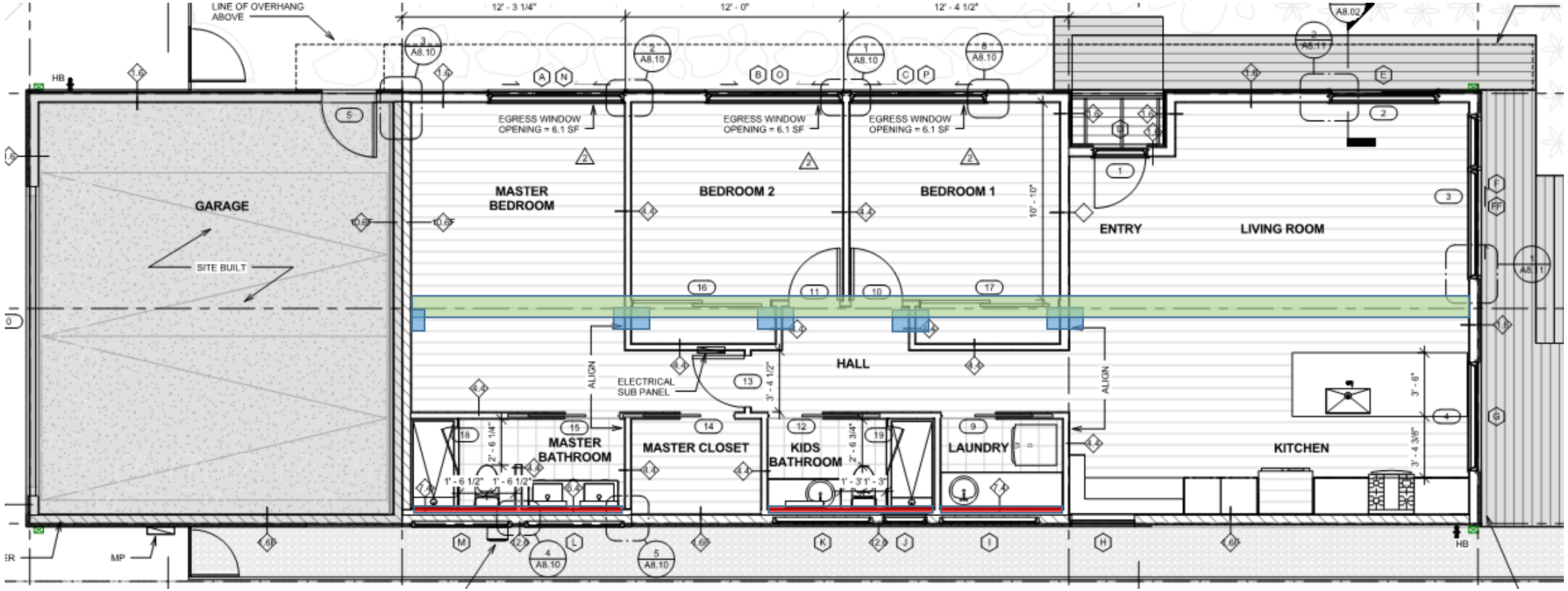
Post-installation, modules are attached to the foundation and the roof is flipped into position.

Modules are wrapped before departing the factory. On installation day (above), the hinged roof is visible beneath the plastic wrap, flipped up onto the main roof along the exterior walls.

Case Study: Installation Day

The foundation and utility connections are completed by a site general contractor while Plant builds the modules in our factory. On installation day (pictured), a crane is used the lift and set the mods in place. The mods are then secured to the foundation, and one another.

Case Study:1286ft^2, 2 modules



On-Site Finishes Installation

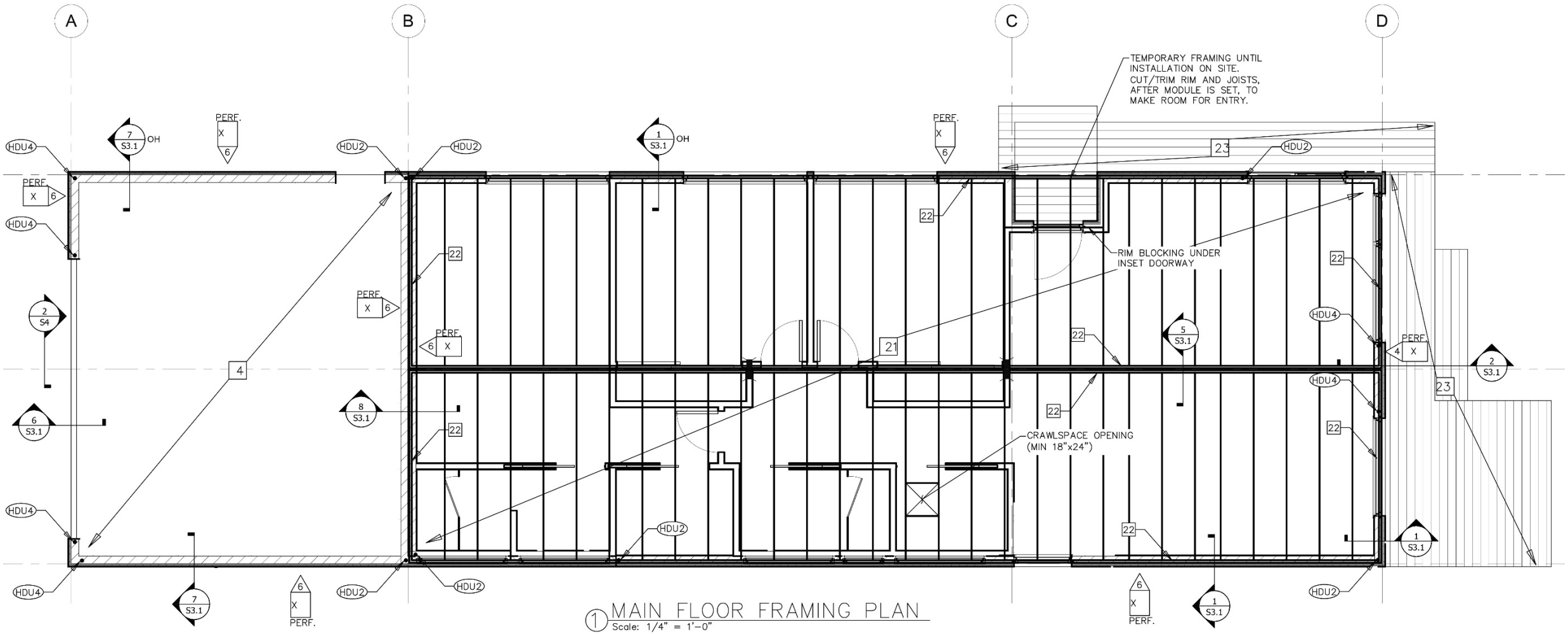
- Flooring is installed in factory and left off at matelines (green on plan).
- Interior ceiling is completed in factory and left off at matelines (green on plan) to allow for electrical, structural, mechanical, and sprinkler crossovers. 1' of drywall is left off each module.
- 6" of drywall is left off (vertically) at mateline connections for on-site connection (blue on plan).
- Closet doors are installed to minimize on-site finish work.

Plumbing Mod-to-Mod Connections

- Lowered ceiling in bathrooms allows for slim duct to blow across the top of closets into each bedroom. There are no ducted mod-to-mod crossovers.
- All plumbing is located in Mod 2 to minimize on-site connections.
- Rough plumbing is tested in the factory, then disconnected.
- A 2x4 plumbing wall (red on plan) is installed to ensure that vents and waste can bypass the double rim joists in both the roof and floor cavities.

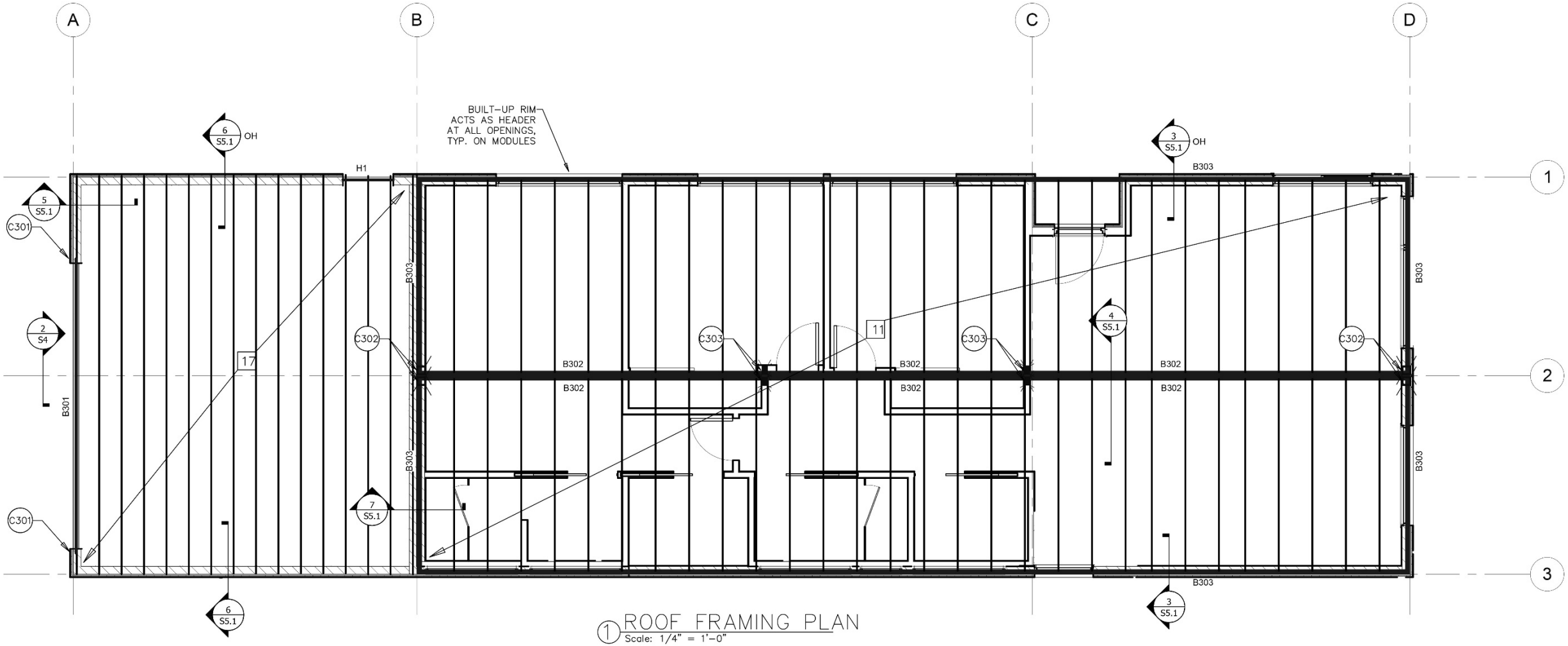
Shaded area on plan above indicates site-built portion.

Case Study: Main Floor Framing Plan



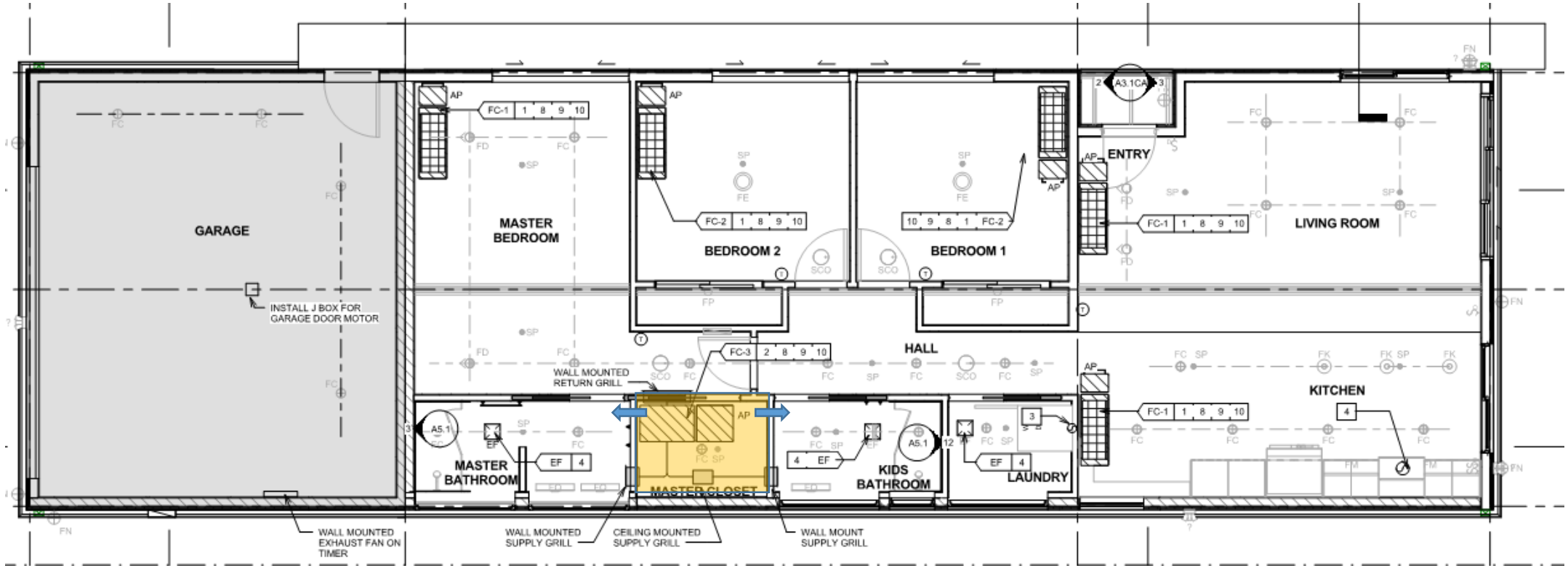
Posts for hold downs are installed in the foundation and actual HDUs are packaged and shipped inside modules and installed in the floor framing.

Case Study: Roof Framing Plan



The drop beam at gridline 2 is designed to continue the full length of the module to accommodate an open area between gridlines C and D, along gridline 1.

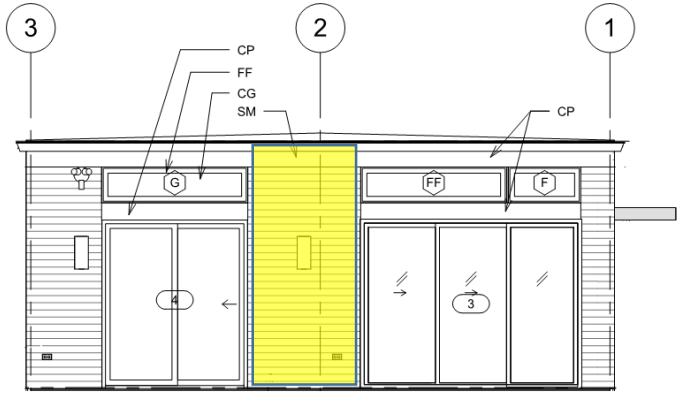
Case Study: Mechanical Design



Mechanical and sprinkler crossovers are located in the same bay to minimize areas that must be closed on site. In this example, ceiling cassettes in each bedroom are located adjacent to the interior wall for condensate and line sets to be installed. They drop into the crawl space for connection to the condensing unit that is shipped inside the module and installed in the backyard.

Master closet (yellow on plan) has a dropped ceiling to allow for slim duct to service bathrooms.

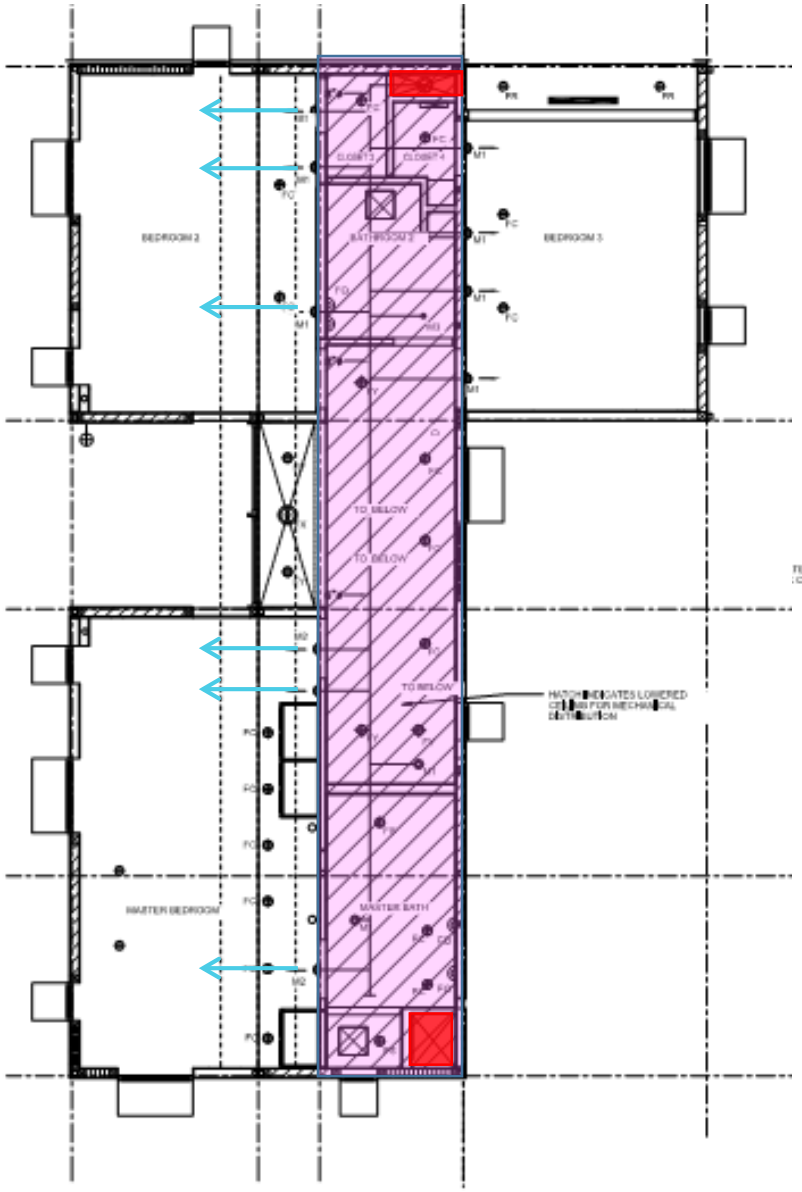
Case Study: Onsite Finishing

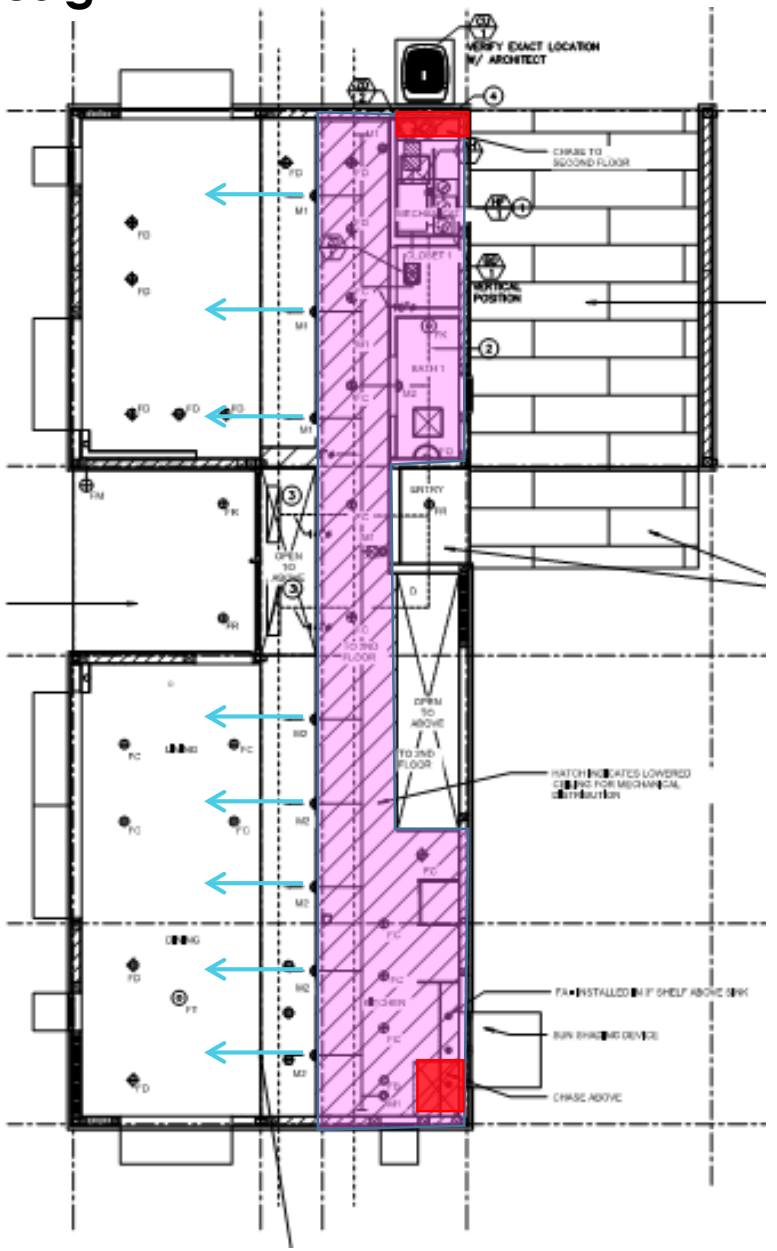


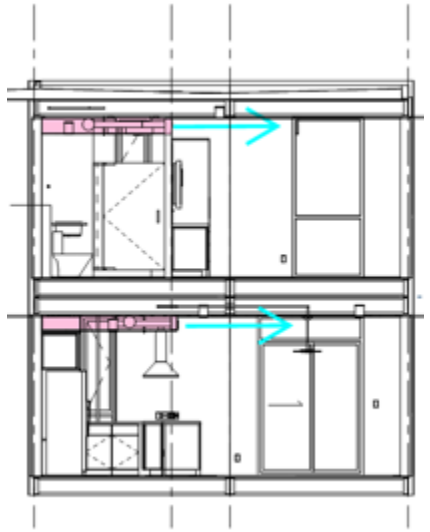
Most of the exterior siding is installed in the factory, with the exception of the roof overhang, the vertical module line, and the fascia at the foundation wall.

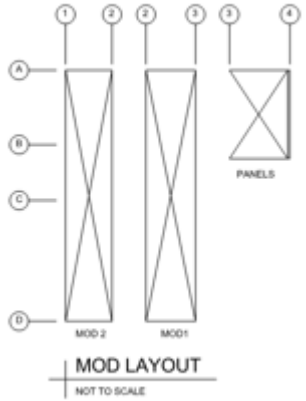
- The vertical module line on the short end of the mods (yellow on elevation) is sided after the mods are set and attached.
- The roof overhang along the length of the mods is built by the site general contractor after installation. Siding material is therefore left off of that area to allow for flashing.
- The garage is completed and TPO roof patch and all gutters/downspouts are also installed following mod set.

Case Study: 2-Story Mechanical Design





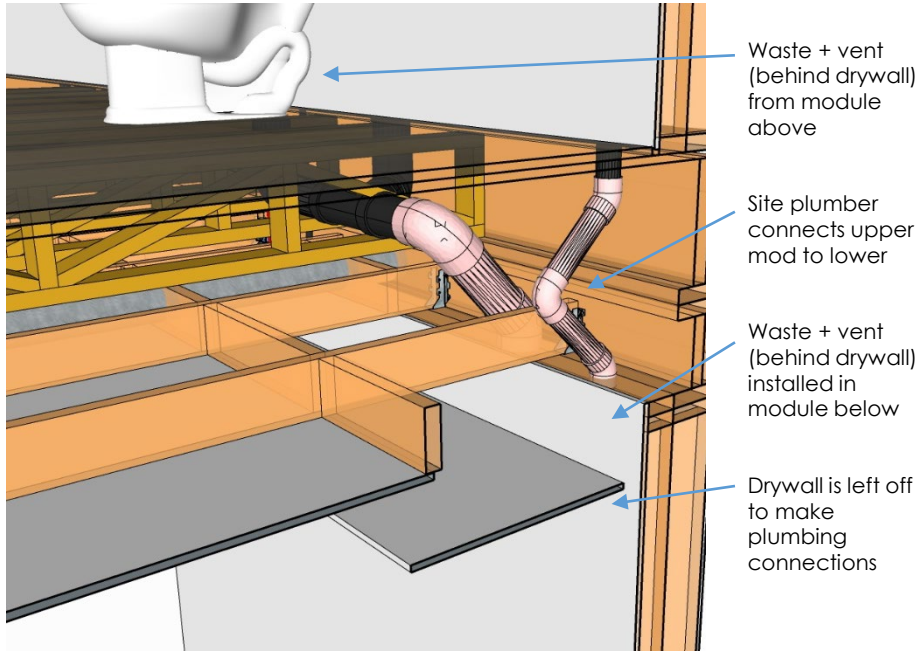




Mechanical design in this home is achieved with a mechanical/plumbing core. Dropped soffits are installed in Mod 1 on both levels. The main trunk line of the high-velocity air system and supplemental 3" lines are installed within this soffit (pink on plan). Supply ducts blow air across from one module to service the rooms in the adjacent module.

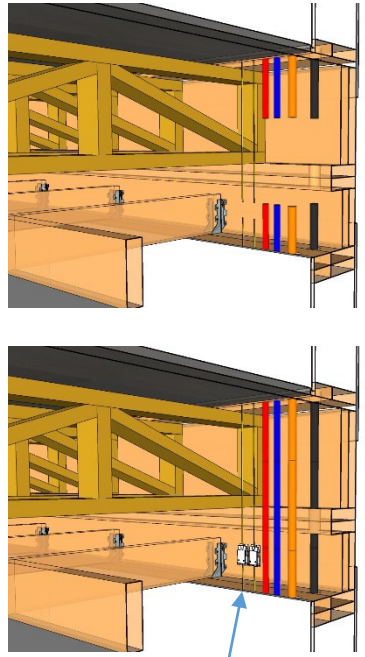
Plumbing is also limited to Mod 1. A vertical chase allows for sprinkler, plumbing (supply, vent, and drain), and duct work to travel between floors (red on plan).

Mechanical, Electrical, and Plumbing Mod-to-Mod Connections

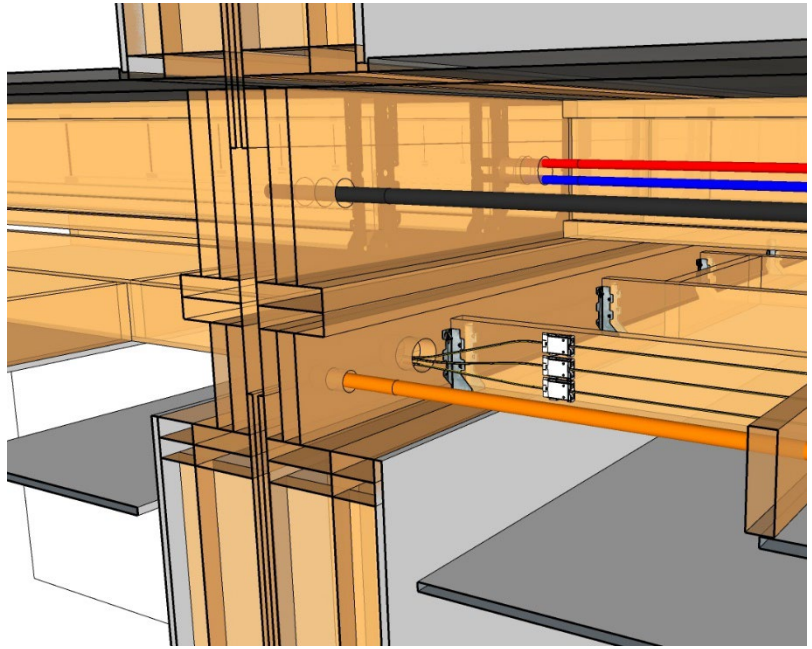


Interior Vertical Plumbing Wall Detail

The bathroom is stacked on top of the living space with no plumbing. A chase wall is still needed in order to bypass the double rim joists along the exterior of the module. Detail also shows the parts that must be installed onsite by the local general contractor. Drywall in the ceiling is left off in order to carry the plumbing from the floor above to the site utility.



Detail of electrical quick connect



Interior Horizontal Plumbing and Electrical Connection Detail

Drywall is left off the lower module to allow for electrical quick connect, sprinkler, gas line, and water supply. Best design practice allows for horizontal chases to minimize the amount of drywall left off and site connections to be made. The architect/designer is responsible for incorporating these chases into the project design.

What Next?

We would love to work with you to give your clients a proven, reliable, time- and cost-effective way to build an extremely high-quality home, based on your custom design.

If you'd like to learn more, we're happy to meet with your team at your or office or ours to to give you a presentation on prefab, what we do, how, and why. We can also arrange a guided tour of our factory in Rialto, CA and/or our showhome in Santa Monica, which was designed by Ray Kappe, FAIA, and was the first home in the nation to be certified LEED Platinum.

If you have a specific project you'd like to assess for prefab, send us your plans (ideally at a schematic level, but can be further along) and we'll conduct a complimentary review.

More generally, prior to production we're available to serve:

- as a consultant, to optimize your drawing set for modular construction and coordinate with your SMEP consultants;
- as an executive architect, to complete the drawing set and state approval package based on your schematic design and specifications;
- or any combination of the above.

To contact us, please email info@plantprefab.com.

To learn more, visit www.plantprefab.com.