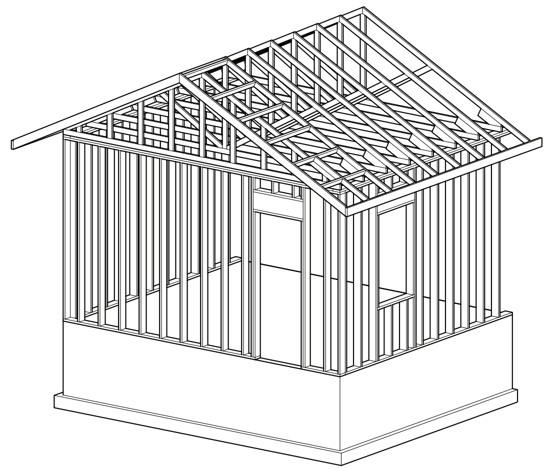

CROSS-CULTURAL TIES FOR CRAFTSMANSHIP IN CONSTRUCTION

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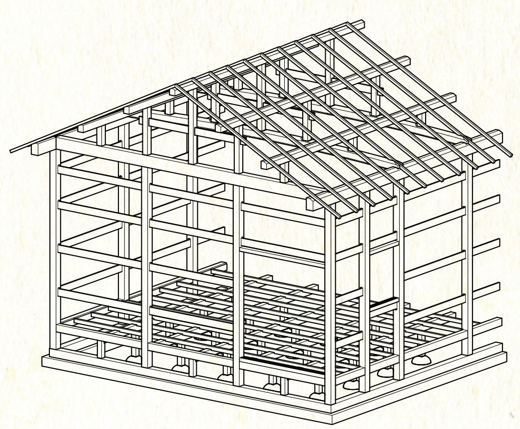
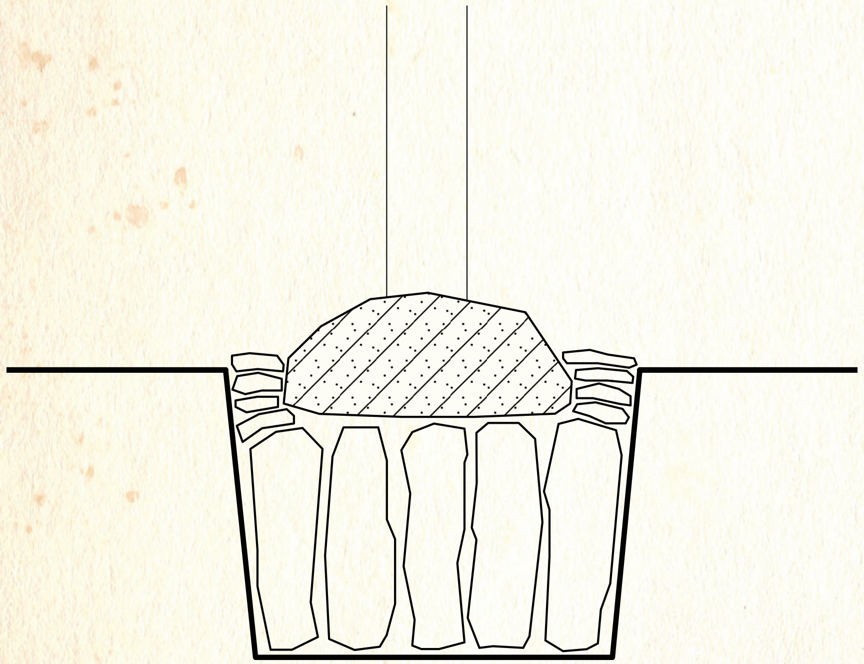


INTRODUCTION

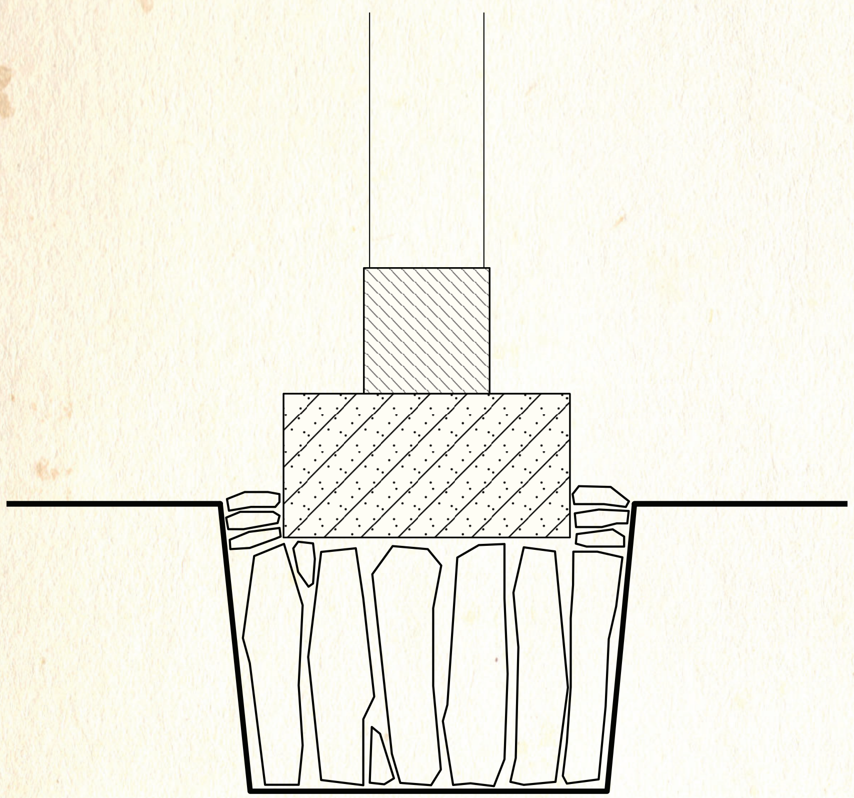
Construction methods have continued to change over time. These changes have caused the structure of our homes to become simplified in many aspects. This research project aims to analyze this change to identify its reasoning and explore a potential solution to bring back more craftsmanship into the structure of residential homes. Generations before us built structures with care and intent for longevity as to serve more than just their lifetime. Some of these qualities are of less importance than making a profit today. The goal of this research is to adapt the craftsmanship of traditional Japanese carpentry into today's light stick framing construction methods. This would provide insight into the features of both of these construction methods and identify if today's practices are the best solution.

METHODOLOGY

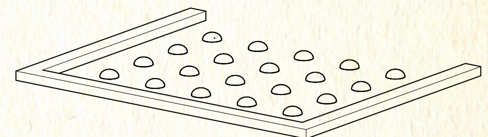
This project consisted of analyzing the tools, techniques, and materials of both traditional Japanese carpentry and modern stick frame construction. This was done through observation of former projects allowing for a documentation of strengths and weaknesses for both framing methods. This information was then taken and used to develop a detailed model of each framing system to understand its complexities and assembly process. Some of the key attributes considered in both systems were strength of members, workability, redundancy, and availability of resources. After completion of both models, this information was used to adapt positive qualities of the traditional Japanese carpentry methods into the pitfalls of modern stick frame construction. From that adaptation a third detailed model was produced to understand how it would be assembled. This was then analyzed to determine its strengths and weaknesses compared to the other two framing systems.



'tsukaishi-kiso'
(post-stone foundation)
support for minor structural members
scale 1 1/2" = 1'-0"



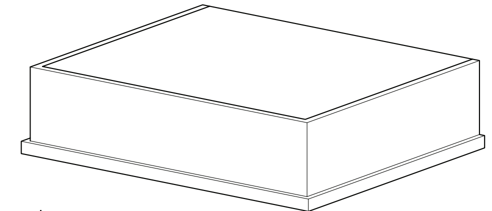
'narashiishi-kiso'
(flat stone foundation)
continuous support with stone slab
scale 1 1/2" = 1'-0"



scale 1" = 10'-0"

Japanese foundations

Two common foundation types in Japanese homes were the post stone foundation and the flat stone foundation. The main function of these foundations were to keep the wood elements away from the damp ground. These foundations also had no rigid connection allowing flexibility for horizontal stresses which provided an advantage during earthquakes. Today Japanese homes use a method that appears similar to the flat stone foundation, only it uses concrete instead of stone and incorporates anchor bolts for a rigid connection. The raised floor prevents moisture from reaching the wood to prevent rotting while also allowing a crawlspace for easier access to plumbing and other mechanical systems for repair. Extra precaution is necessary for preventing this crawl space from being used by unwanted pests.

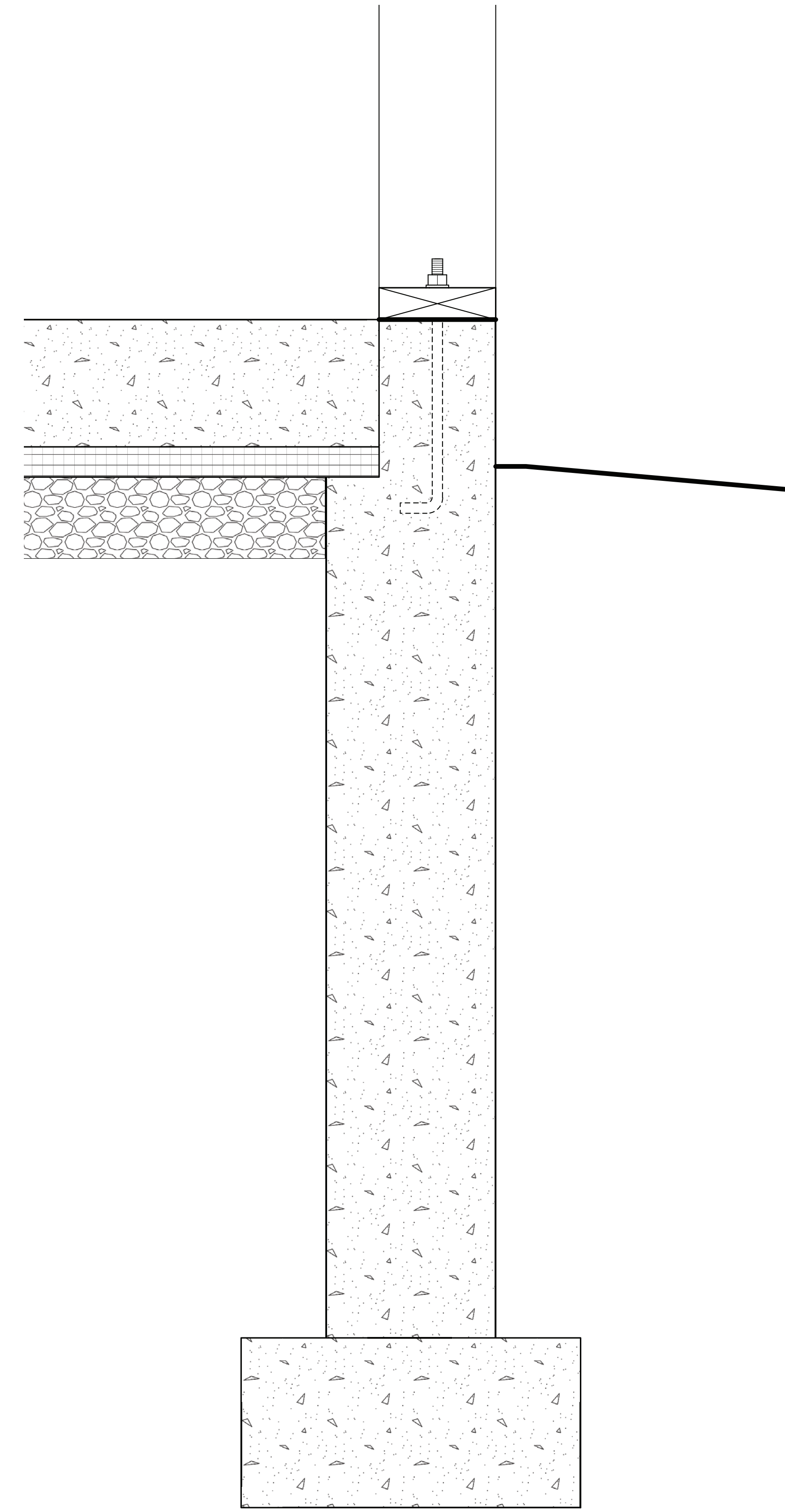


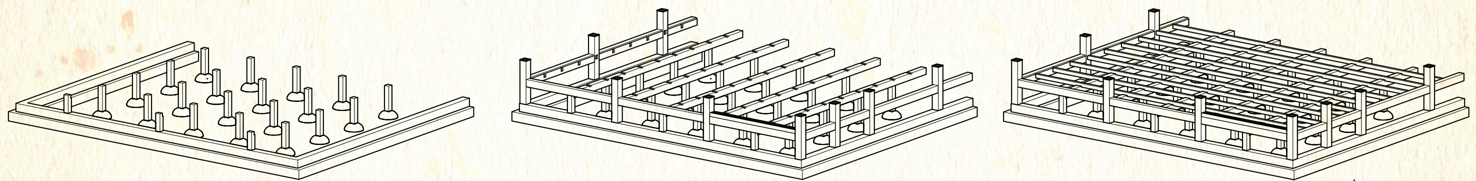
scale 1" = 10'-0"

Slab-on-grade foundation

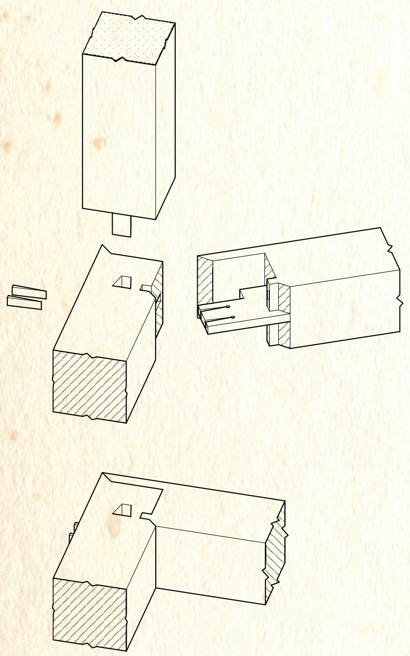
continuous support for load bearing walls
scale 1 1/2" = 1'-0"

A slab on grade foundation was chosen to compare as it is one of the most common foundation types for homes without basements. This foundation type consists of a thin layer of concrete over the area of the home with footings below load bearing walls. It is popular due to its simplicity, durability, and affordability. It uses a rigid connection to the ground sill using anchor bolts and drive pins. Another element of modern foundations is a sill seal that goes between the concrete foundation and the ground sill. This creates a seal keeping air and insects from entering under the wood and providing some moisture resistance. An important quality of footings especially in places where the ground freezes is that hey are places below the frost line. This prevents heaving and cracking of the foundation.

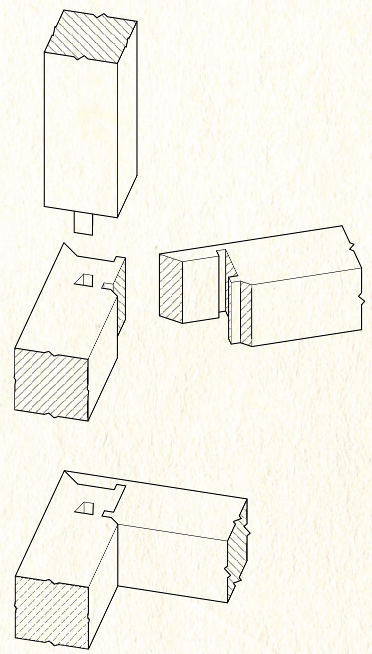




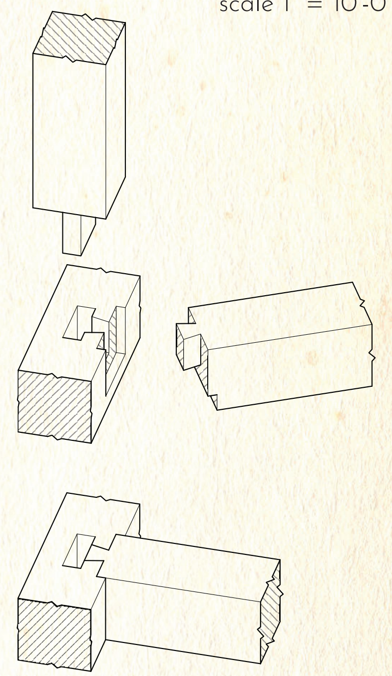
scale 1" = 10'-0"



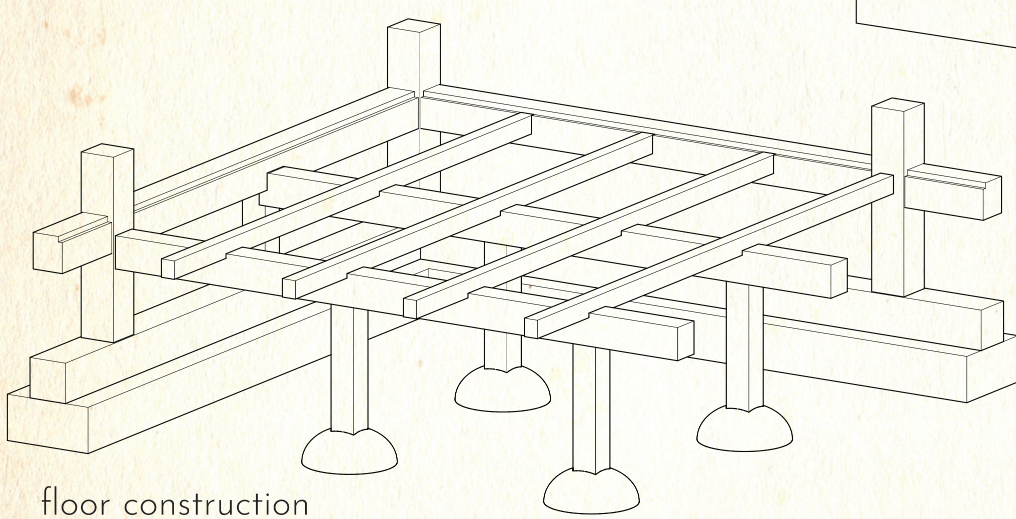
'sumikata-dome' corner joint
scale 1" = 1'-0"



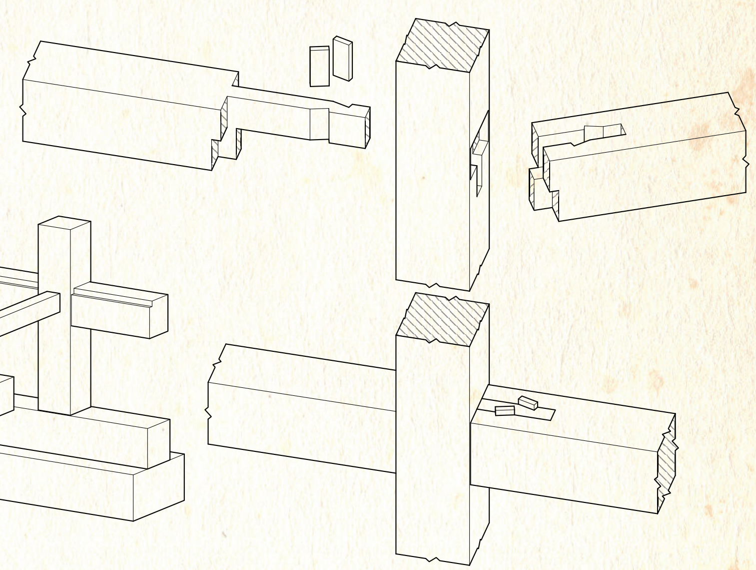
'daiwa-dome' corner joint
scale 1" = 1'-0"



'arigake' corner joint
scale 1" = 1'-0"



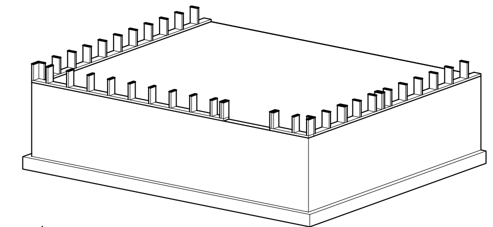
floor construction
scale 1/2" = 1'-0"



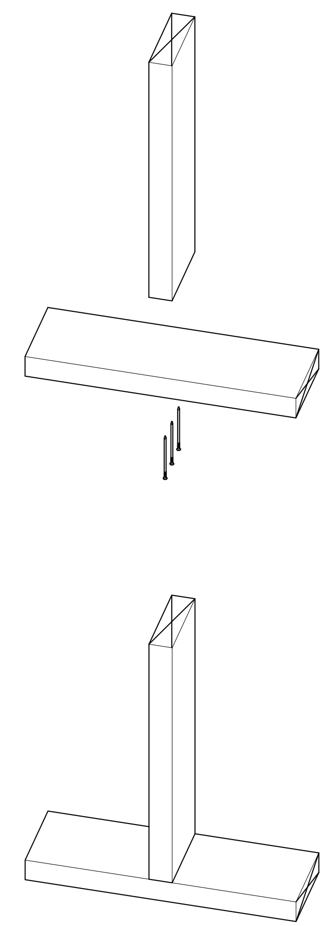
column-floor beam joint
scale 1" = 1'-0"

Ground sill comparison

Comparing the ground sill and its connections between the two systems there are some major differences. The Japanese home has thicker members to allow for joinery methods while the stick frame system uses nails and metal fasteners. The members of the Japanese system take longer to produce in a workshop but make for a fast assembly on a job site. There are far less metal fasteners and nails reducing the chances for rusting and rot in the wood that is closest to the damp ground. A skilled craftsman is needed to produce these elements and the laborers constructing the pieces need guidance throughout the construction process. They also must have some knowledge of the techniques used to make the elements in case there needs to be any changes or adjustments on site. The stick frame ground sill is straightforward. It is cut to size on site and nailed to the studs of the wall assembly. There is less of a learning curve in this process and it can be assembled very quickly. One downside is it solely relies on metal nails and fasteners that can rust and deteriorate over time.

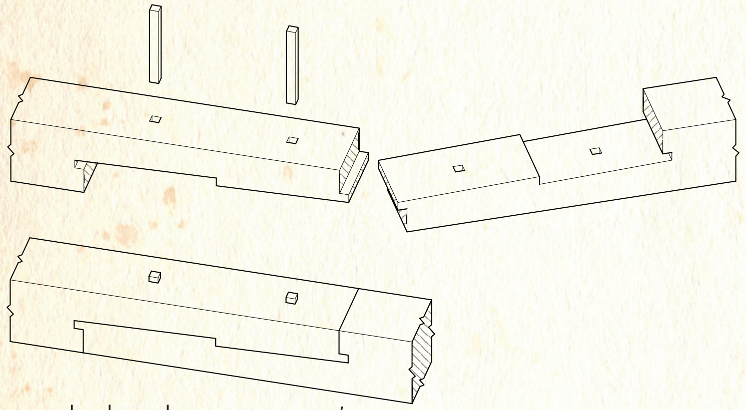


scale 1" = 10'-0"

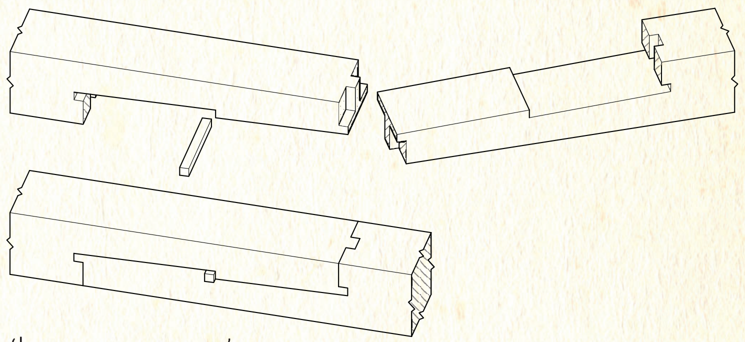


ground sill assembly
scale 1" = 1'-0"

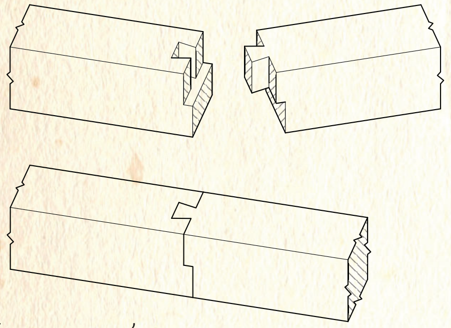
Longitudinal joints



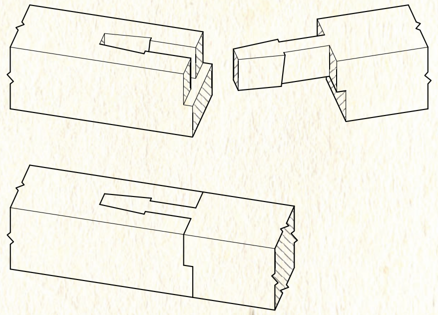
'atsukake-daisen-tsugi' joint
(dadoed and rabbeted oblique scarf joint)
uses - ground sill, eaves beam, purlin, ridge beam
scale 1" = 1'-0"



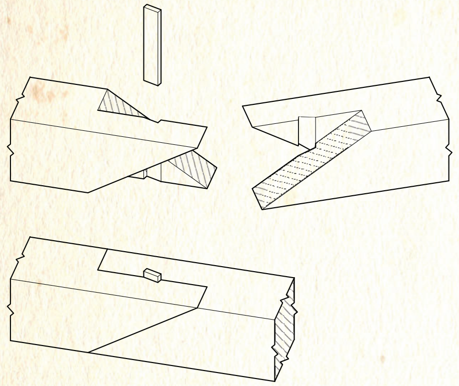
'kanawa-tsugi' joint
(half-blind tenoned, dadoed, and rabbeted scarf joint)
uses - ground sill, column base replacement
scale 1" = 1'-0"



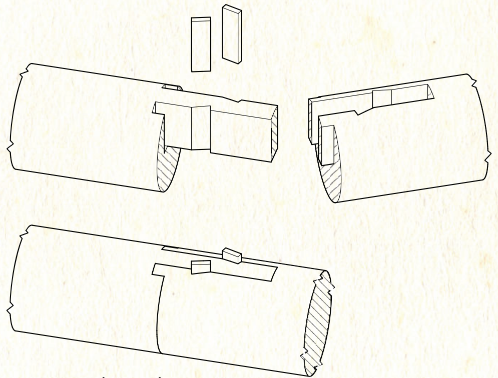
'ari-tsugi' joint
(dovetail joint)
uses - ground sill, eaves beam, purlin, ridge beam
scale 1" = 1'-0"



'kama-tsugi' joint
(half lapped gooseneck joint)
uses - ground sill, eaves beam, purlin, ridge beam
scale 1" = 1'-0"

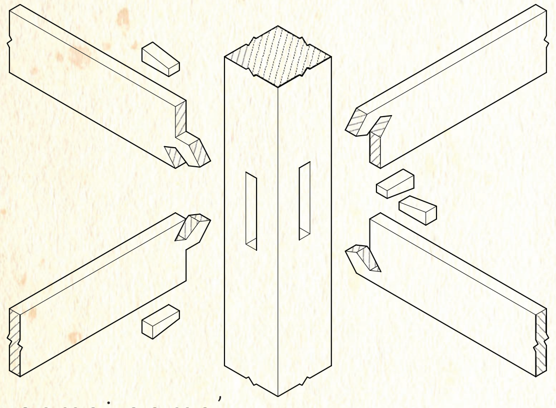


'isuka-tsugi' joint
(half rabbeted oblique scarf joint)
uses - veranda beam, ceiling rod, floor joist, rafter
scale 1" = 1'-0"



'sao-shachi-tsugi' joint
(pole tenon splice)
uses - veranda beam, interior beam, other natural circular beams
scale 1" = 1'-0"

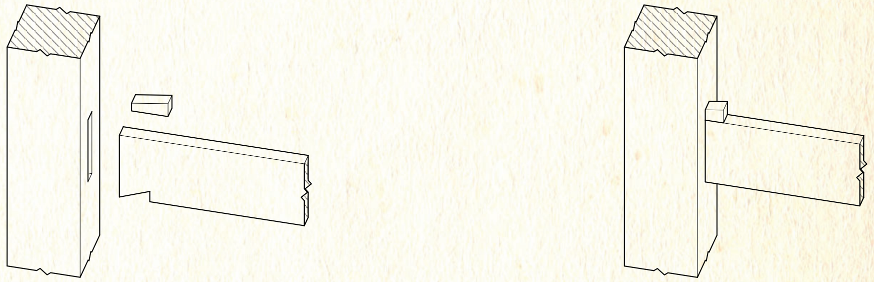
Column and tie joining



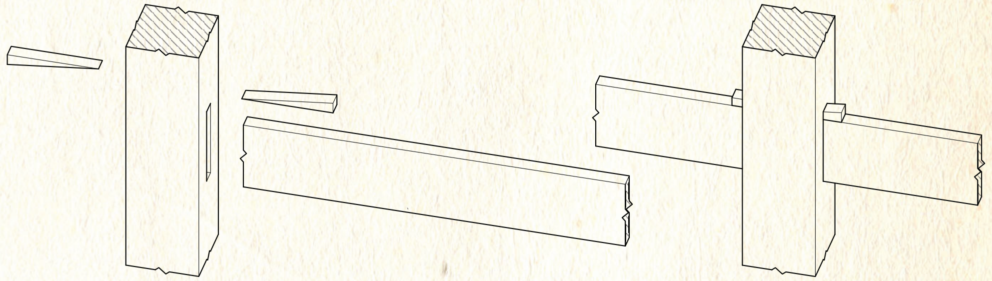
'yonmai-gama'
(tie in four directions)
scale 1" = 1'-0"

Japanese joinery

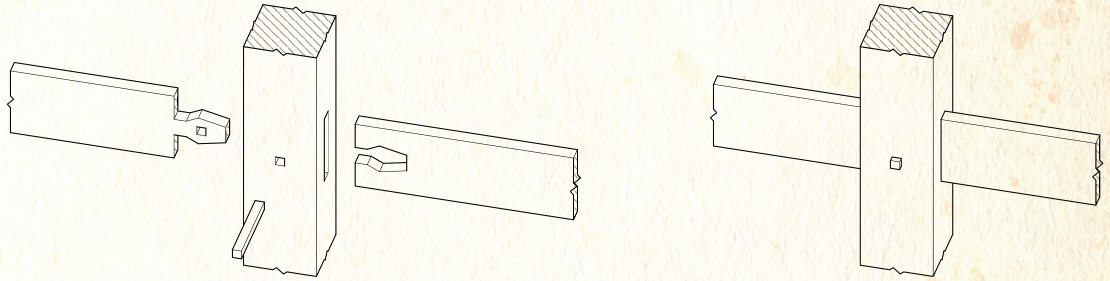
Another difference between the two framing systems is that the Japanese house uses many different sizes of lumber for different purposes. It also has many different joints that serve various functions as well. Some of these joints focus on simplicity and strength while others are for aesthetics especially where there are exposed members. One common feature between stick framing and traditional Japanese framing is that the length of pieces are kept shorter to make it easier to handle and transport. Certain Japanese joints can allow for long spans while maintaining shorter pieces by slicing them together. This also plays a big role in longevity of a home because replacing pieces is as easy as joining in a new section rather than tearing everything down and building new.



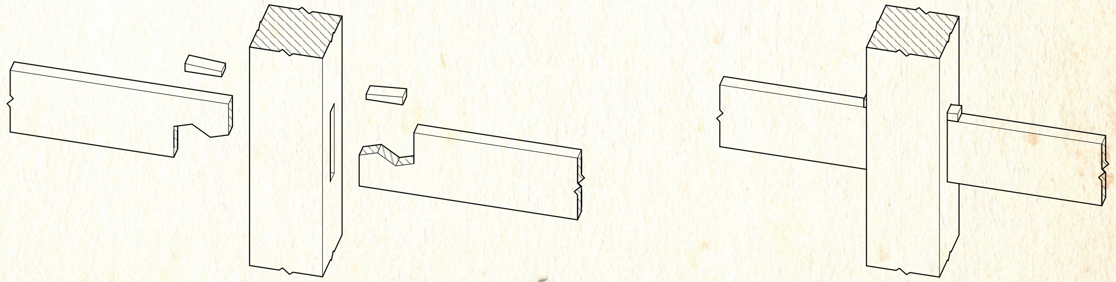
'nimai'-gama'
(tie from two directions)
scale 1" = 1'-0"



ordinary joint
(continous tie)
scale 1" = 1'-0"



'kamasen-uchi'
(tie with plug)
scale 1" = 1'-0"

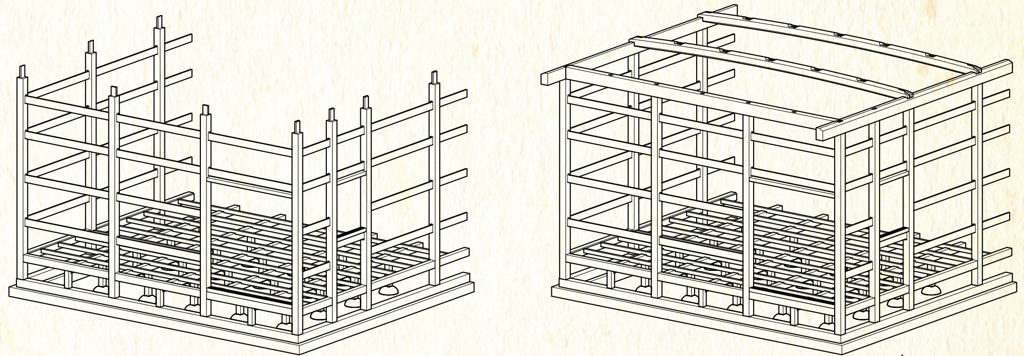


'nimai'-gama'
(tie from two directions)
scale 1" = 1'-0"

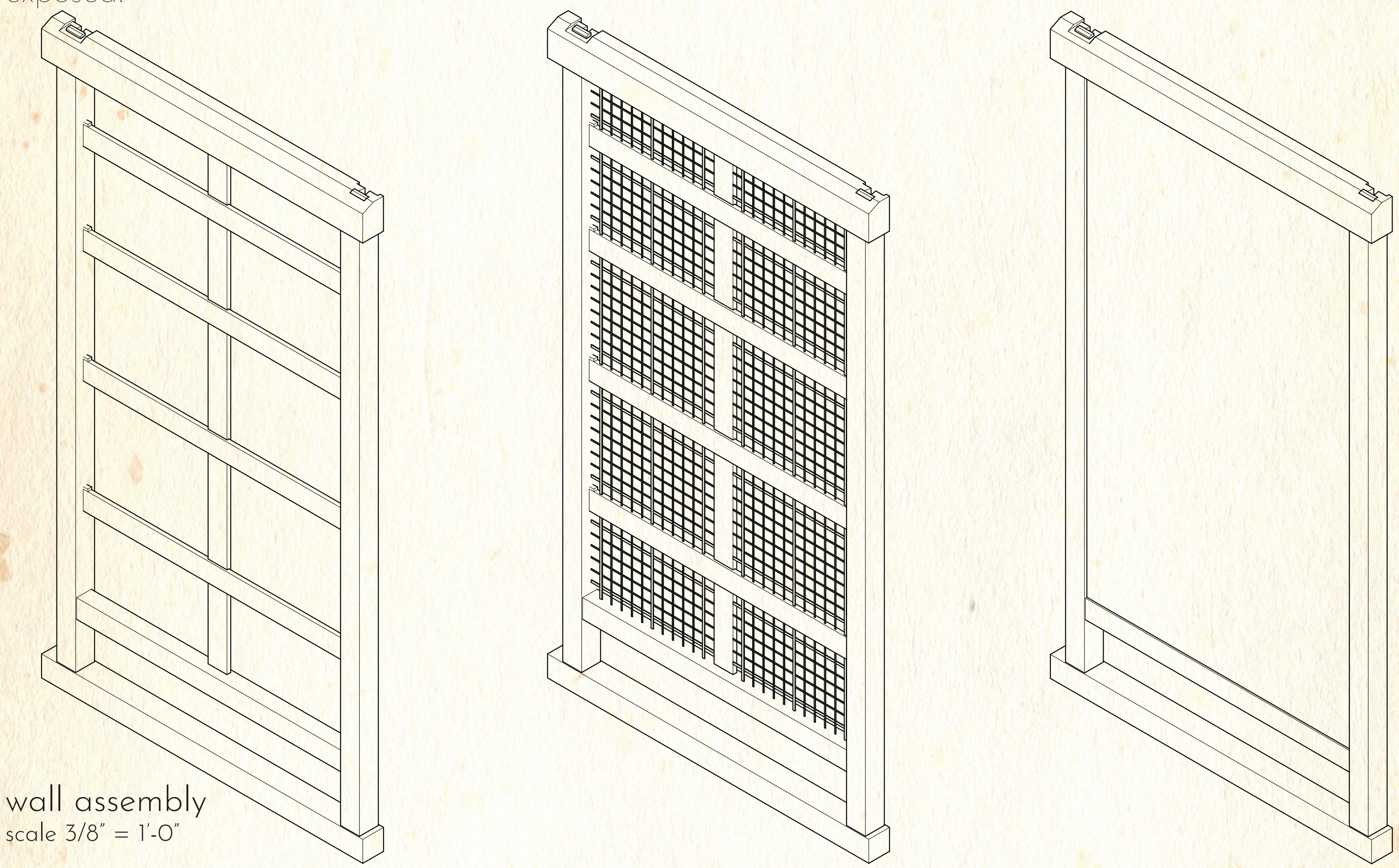
TRADITIONAL JAPANESE CONSTRUCTION

Wall assembly

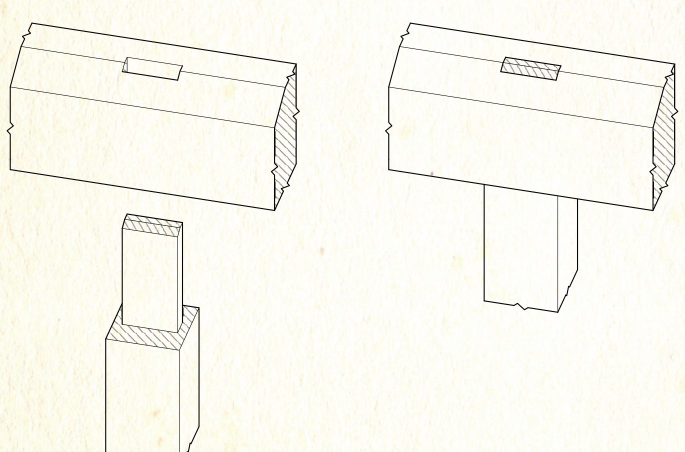
The Japanese wall uses horizontal members. This allows the walls to have more structural rigidity. The traditional Japanese wall also used bamboo and plaster for insulation. This meant the main structural elements were exposed.



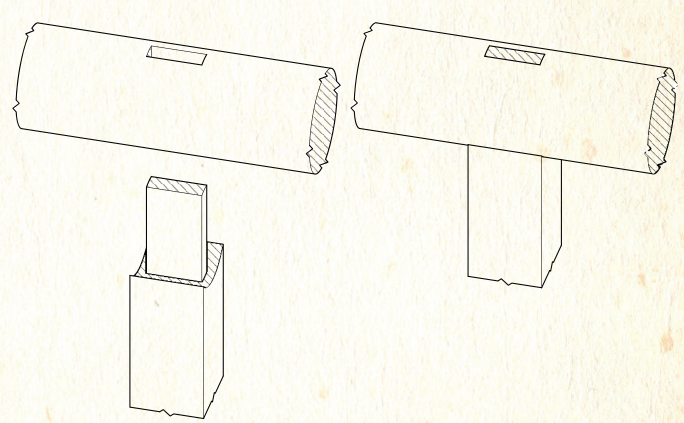
scale 1" = 10'-0"



wall assembly
scale 3/8" = 1'-0"



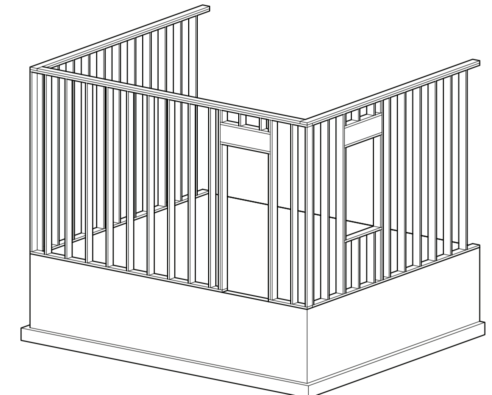
eaves beam - column joint
scale 1" = 1'-0"



veranda (interior) beam - column joint
scale 1" = 1'-0"

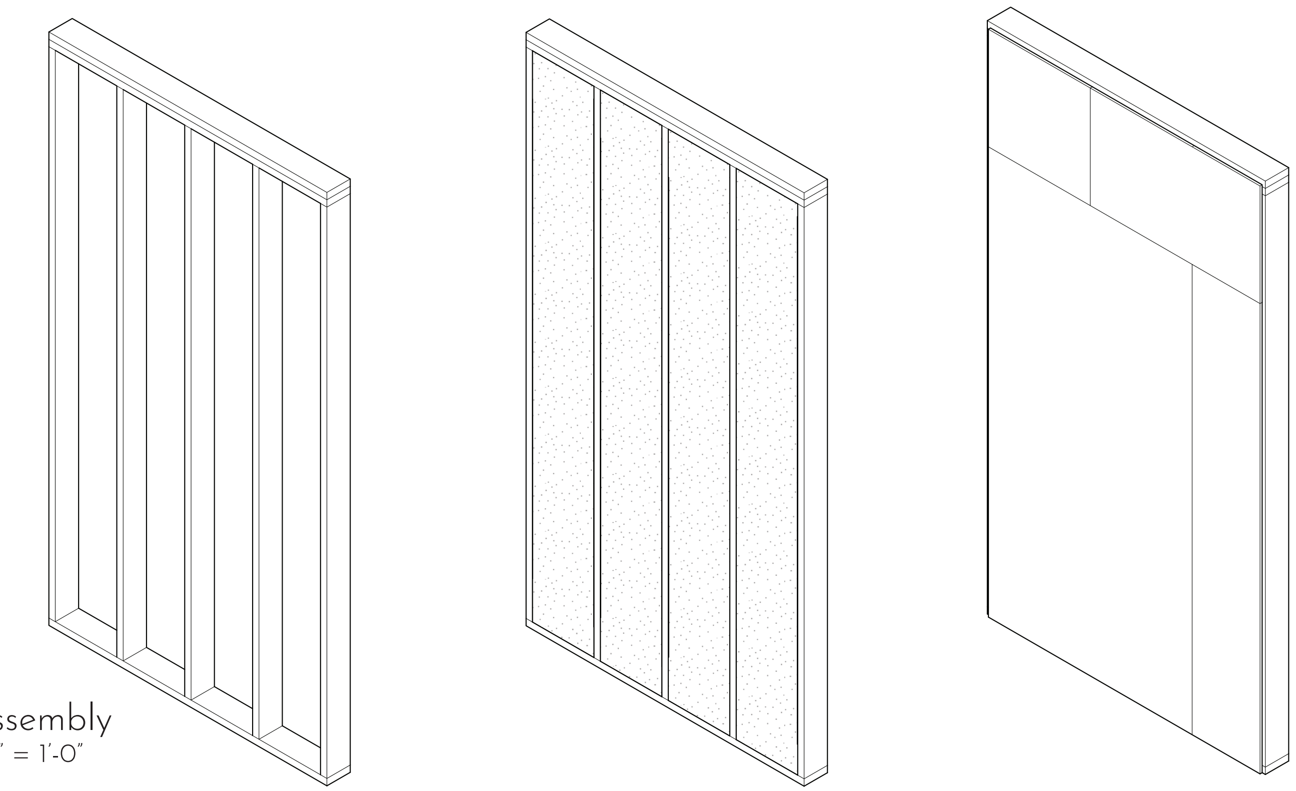
LIGHT STICK FRAME CONSTRUCTION

Wall assembly

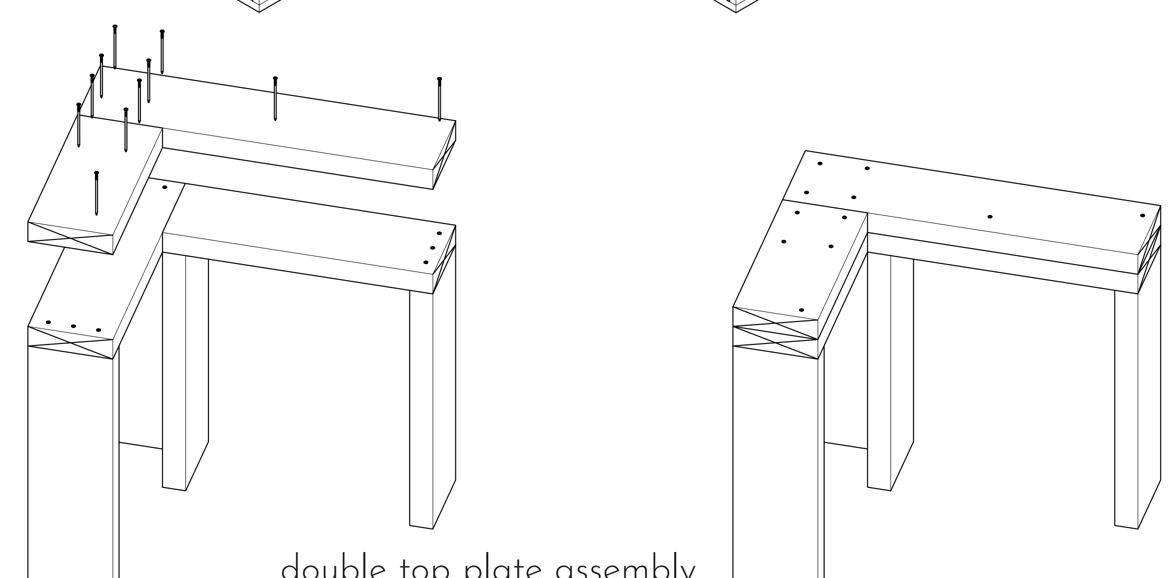


scale 1" = 10'-0"

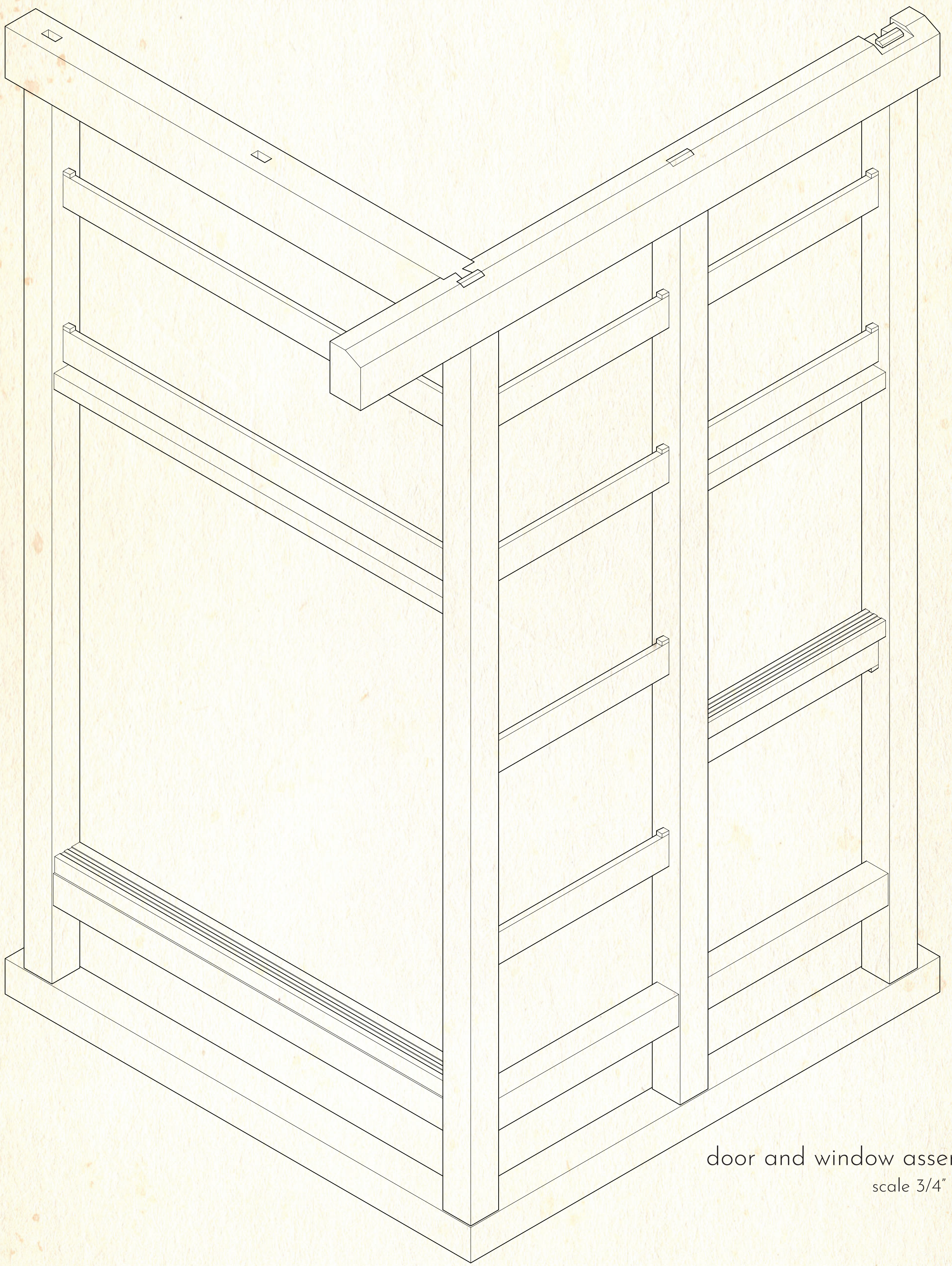
Stick frame construction consists of vertical members spaces at sixteen inches on center. This system depends on an exterior sheathing and overlapping of top plates to create rigidity as the framing on its own is not very stable. All of the structural components of this system all get covered by sheathing and siding leaving no exposed wood. Although because of the amount of vertical members that span the width of the wall it is more susceptible to thermal bridging if not insulated properly.



wall assembly
scale 3/8" = 1'-0"



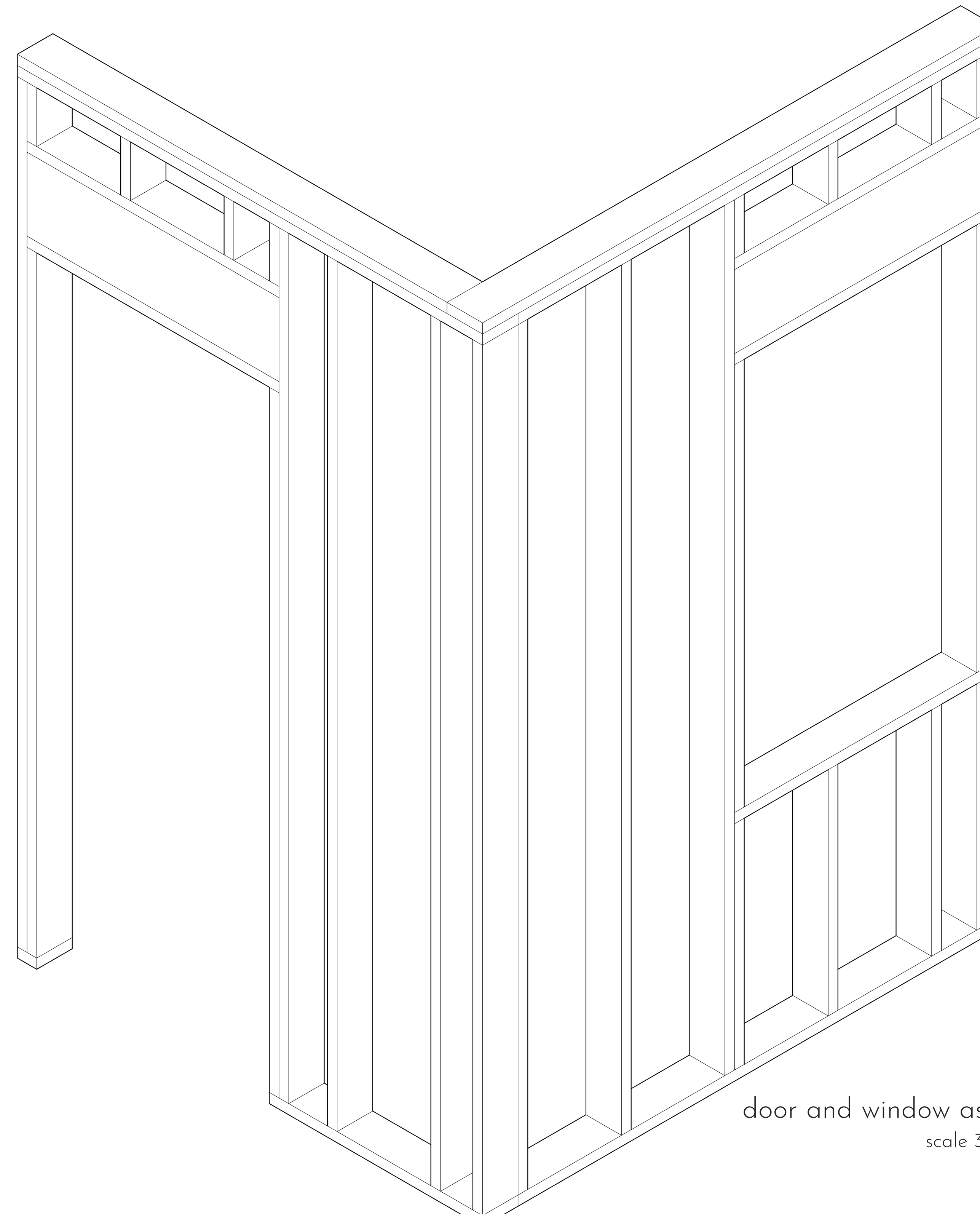
double top plate assembly
scale 1" = 1'-0"



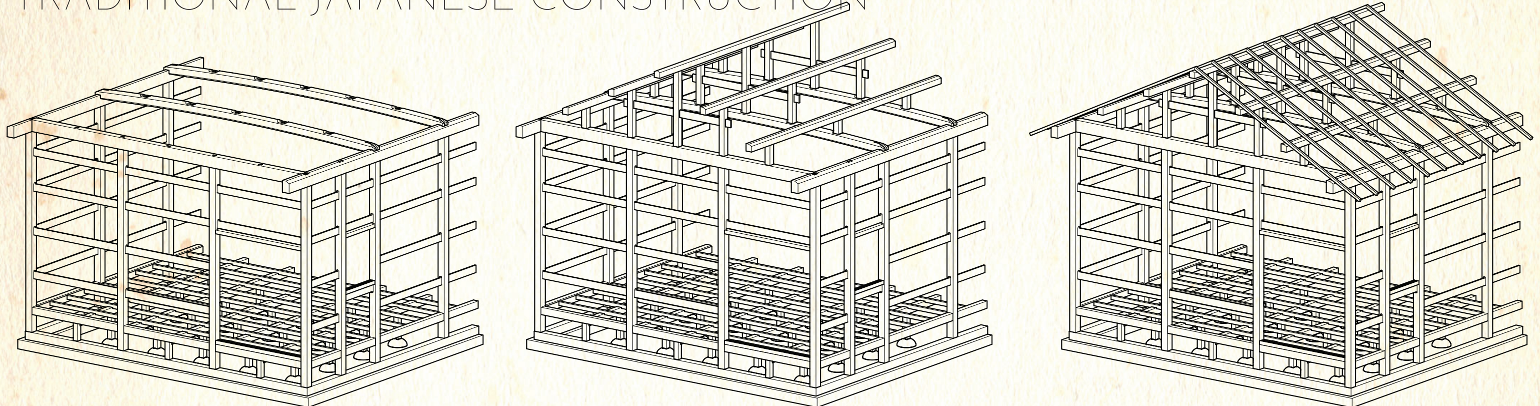
door and window assembly
scale 3/4" = 1'-0"

Door and window frame comparison

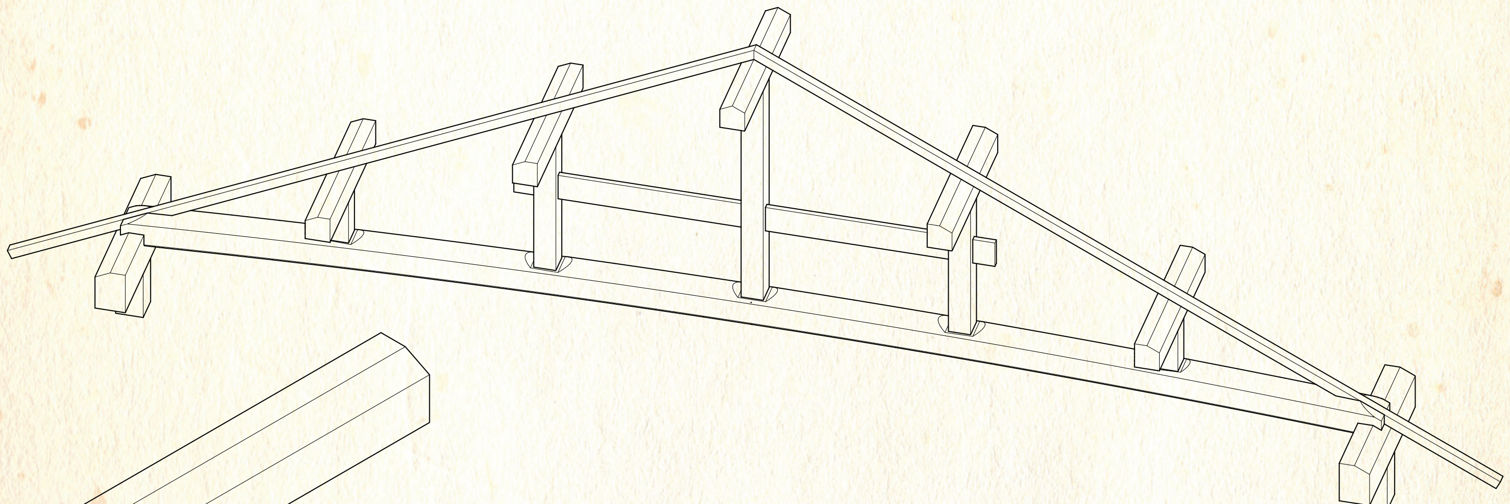
Japanese walls incorporate a post a beam assembly which allows for the vertical load taken away from any doors and windows. The modern light stick framing assembly needs additional headers and bracing to transfer that vertical load away from the top of doors and windows. Traditional Japanese doors and windows used a sliding system. This meant the frame incorporated two rails which allowed for the doors and windows to slide past each other to open or close.



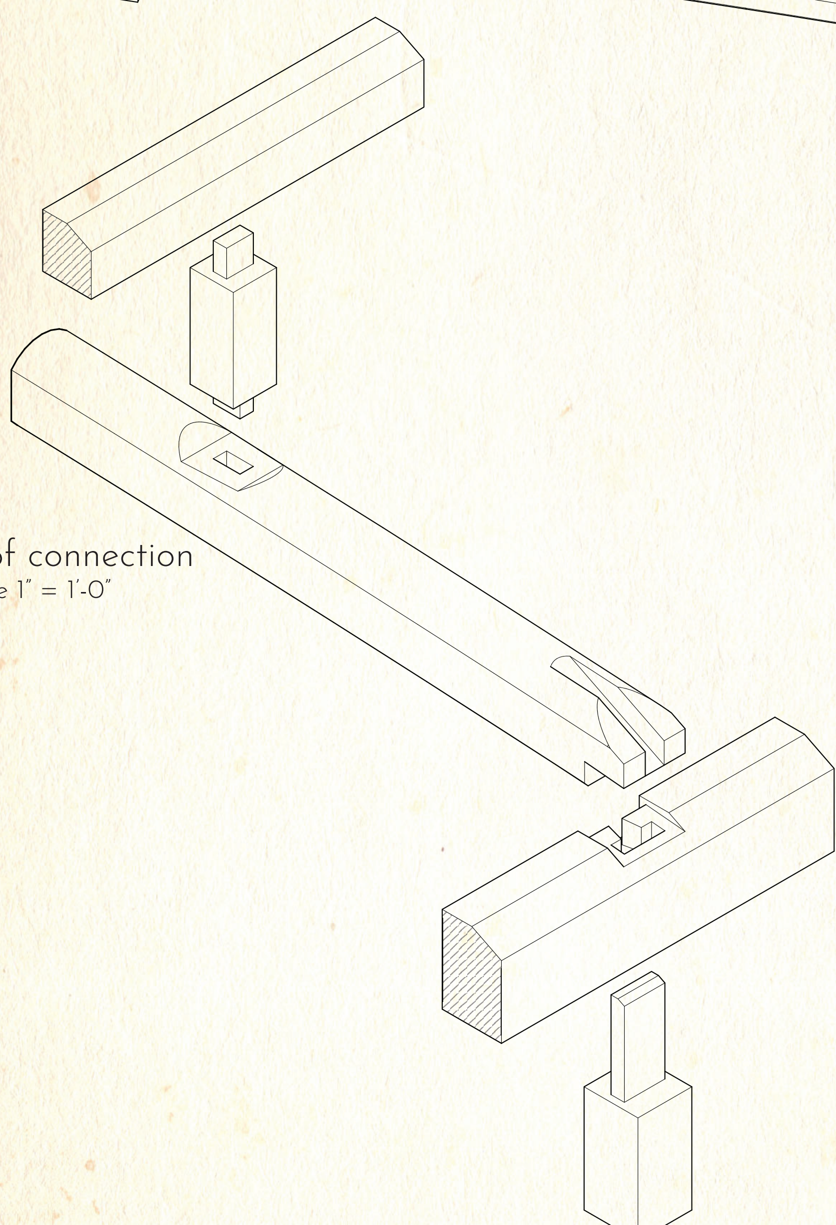
door and window assembly
scale 3/4" = 1'-0"



scale 1" = 10'-0"



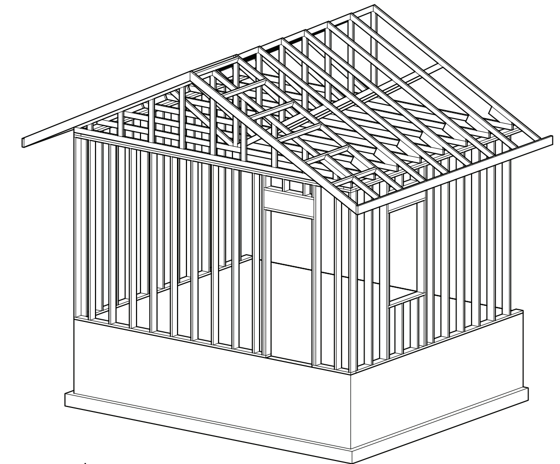
roof assembly
scale 3/8" = 1'-0"



roof connection
scale 1" = 1'-0"

Roof structure comparison

Comparing the roof structure of Japanese homes and stick frame construction it is clear to see there are assembled much differently. The Japanese roof uses crossbeams, posts, purlins, and rafters. All of these members and assembled separately compared to the truss which comes assembled from a manufacturer. Another key difference is the Japanese roof doesn't take advantage of triangulation which is very common in modern roof systems. The truss on the other hand is very light and uses mending plates instead of wood joints. Trusses are also fastened using nails and sometimes hurricane clips to prevent them from uplifting in heavy winds. The difficulty of placing trusses is lining them up and making sure the spacing is correct for roof sheathing.



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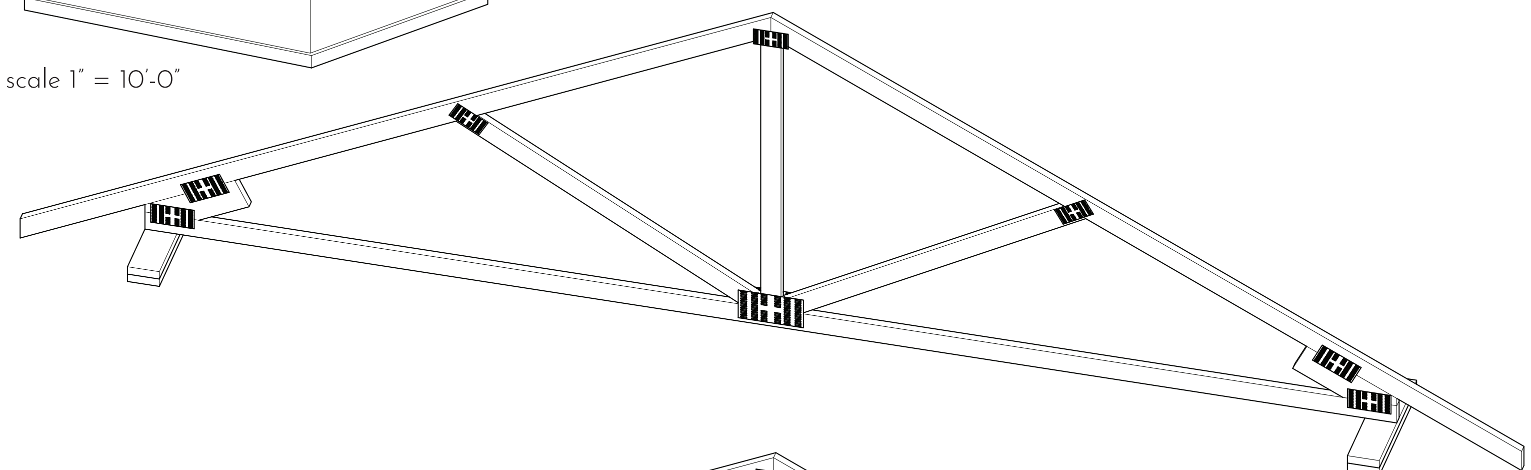
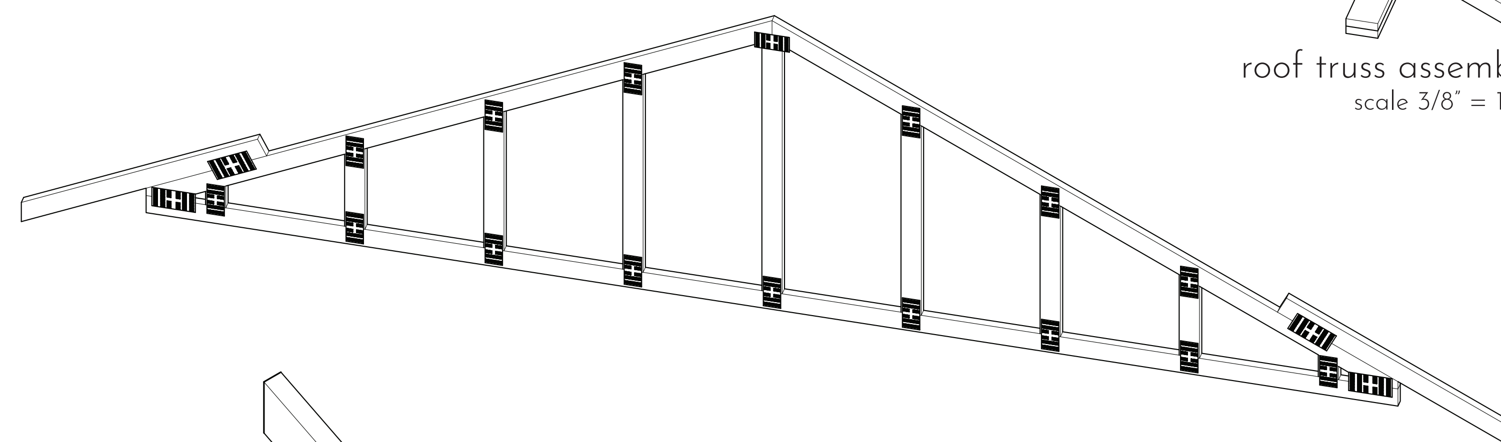
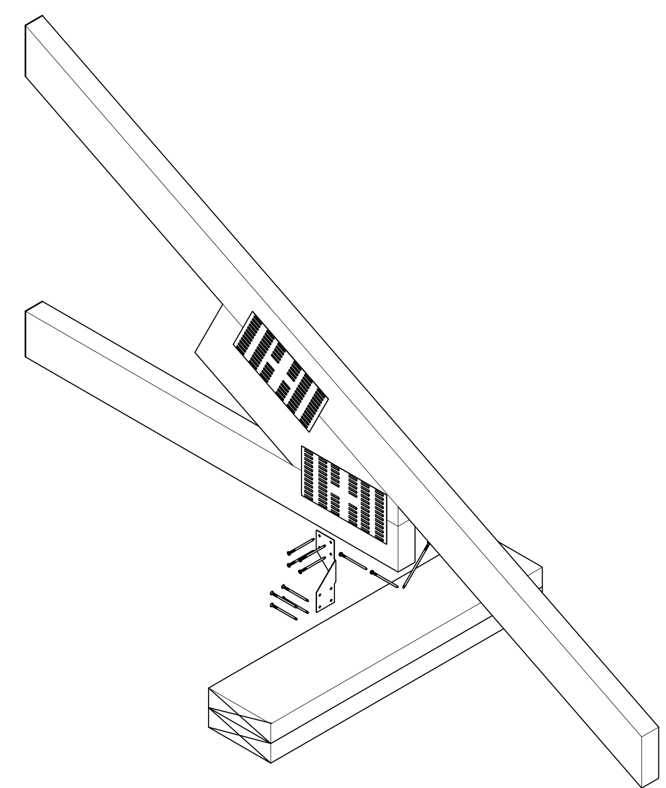


roof truss assembly
scale 3/8" = 1'-0"



gable-end roof truss assembly
scale 3/8" = 1'-0"



roof truss connection
scale 1" = 1'-0"

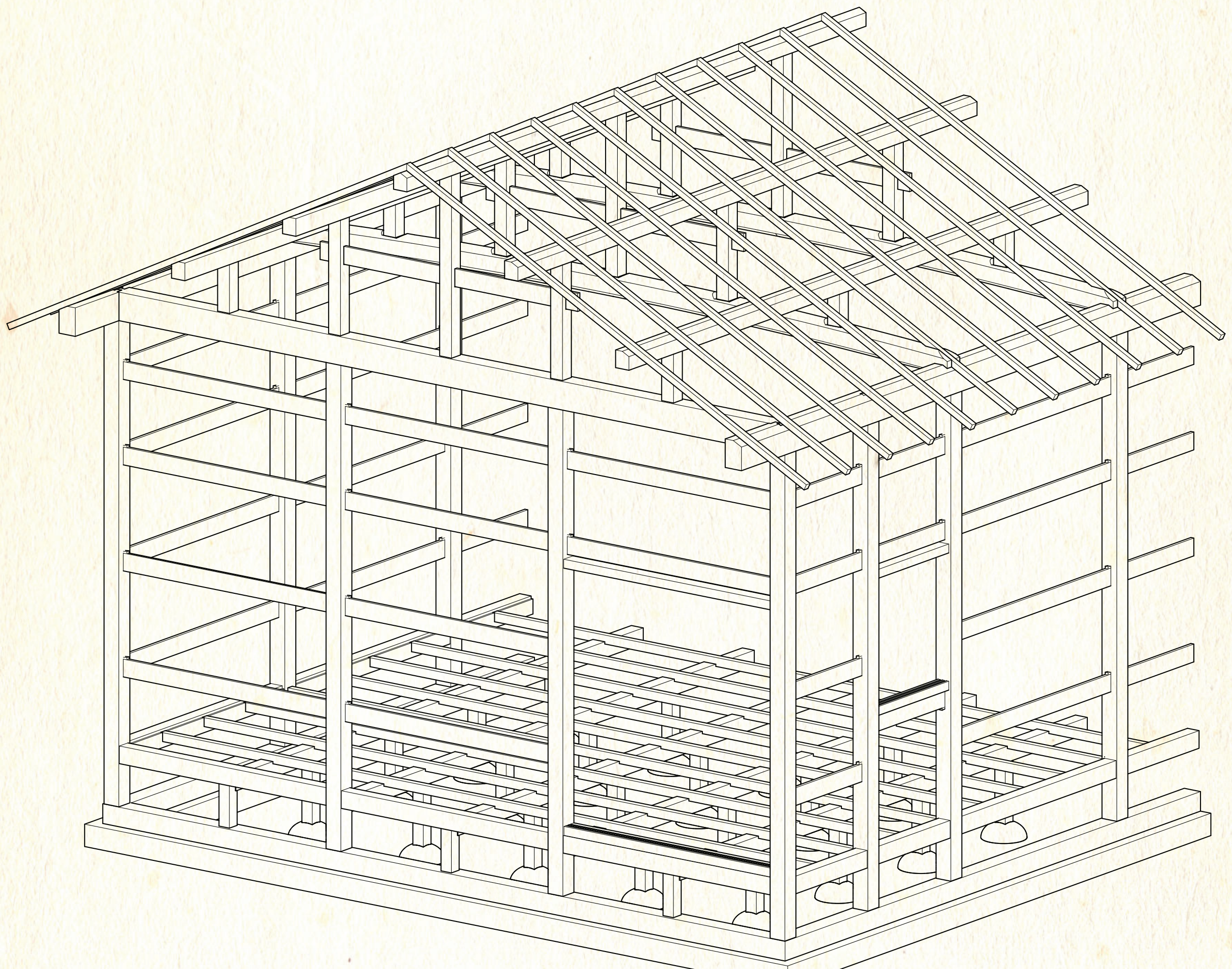
TRADITIONAL JAPANESE CONSTRUCTION

Strengths -

- Less metal fasteners and nails
- Prefabricated off site
- Repairing is more efficient
- Longevity
- No vertical load on doors and windows

Weaknesses -

- Expensive
- Expertise and training for tools and techniques
- Various wood dimensions
- Complex assembly
- Exposed structural members



complete assembly
scale 1/4" = 1'-0"

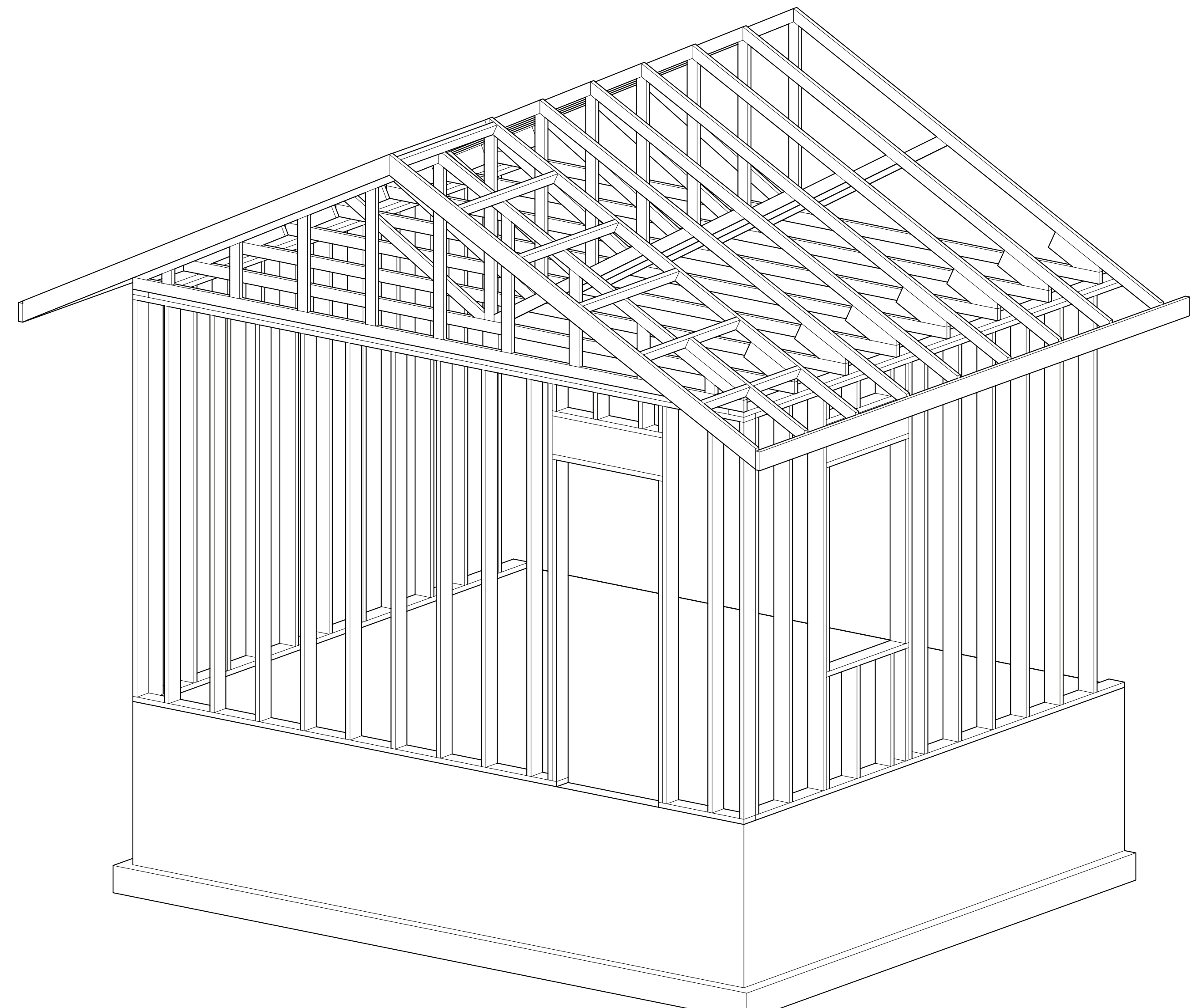
LIGHT STICK FRAME CONSTRUCTION

Strengths -

- Fast and simple assembly
- Cost effective
- Easy to learn
- Modern tools
- Dimensional lumber sizes

Weaknesses -

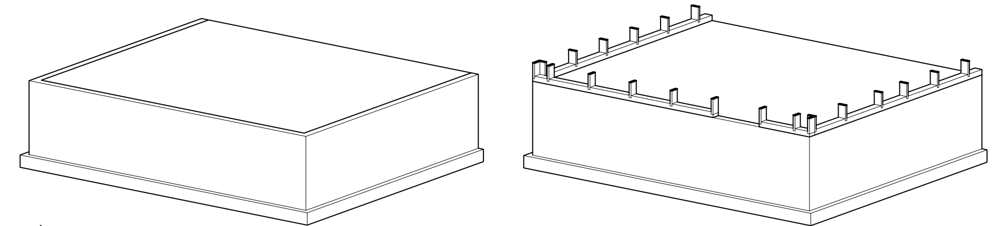
- Relies on metal fasteners and nails
- Thermal bridging
- Relies on sheathing for rigidity
- Extra framing for doors and windows
- Majority is on site construction



complete assembly
scale 1/4" = 1'-0"

RESULTS

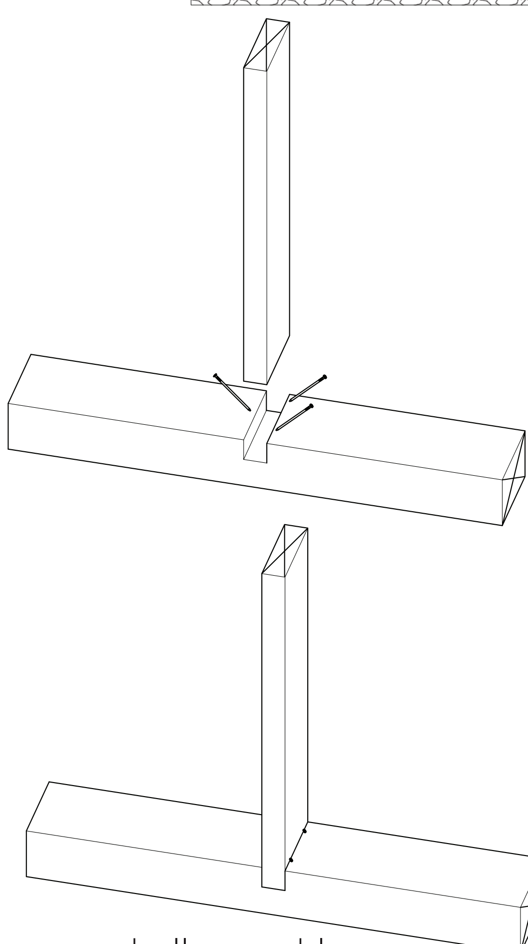
The goal of this adaptation was to combine some type of wood joinery along with the use of metal fasteners or nails. I assumed that the elimination of nails was unrealistic and would make it difficult for the structure to follow code. Doing this would create redundancy so the structure would not solely rely upon metal fasteners and nails but have additional support. Another goal was to create a system that is capable of being altered and constructed using the same tools found on a job site today. This means there is not need for additional specialty tools or training for construction workers. In order to do this it meant that all of the wood joints needed to consist of straight lines and simple cuts. Additionally, the adapted system would use all existing dimensional lumber sizes to eliminate material delays and keep today's measuring system and products interchangeable between this adaptation and light stick framing.



scale 1″ = 10′-0″

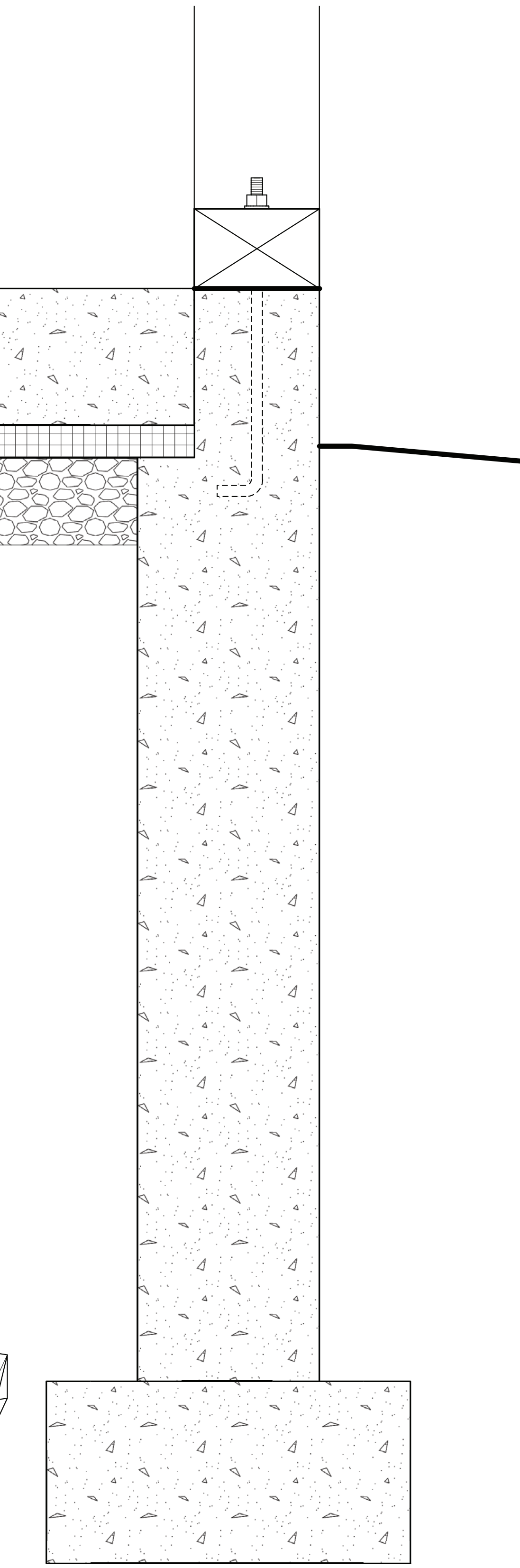
Foundation and ground sill

The adapted foundation incorporated the same slab-on-grade construction we use today. This was kept the same in order to focus the project solely upon the wood structure itself. This meant it still used anchor bolts and drive pins and sill seal to fasten the ground sill to the foundation. Once thing that changed was the thickness of the ground sill. Instead of a 2x6 or 2x4 it would use a 4x6 or 4x4. This allowed for a shallow ground to be cut in the ground sill keeping the vertical stud in place. It also allows the stud it be toe nailed from the top which is a stronger connection. This also eliminates any metal or additional holes underneath the ground sill that could lead to rust or rot.

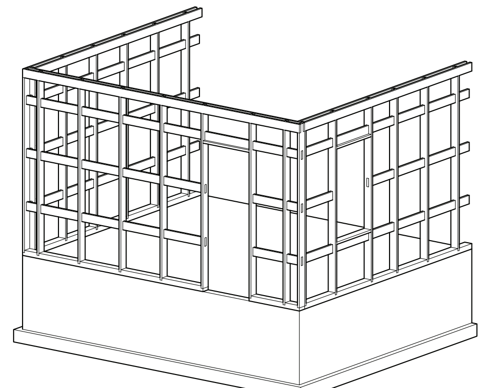


ground sill assembly
scale 1″ = 1′-0″

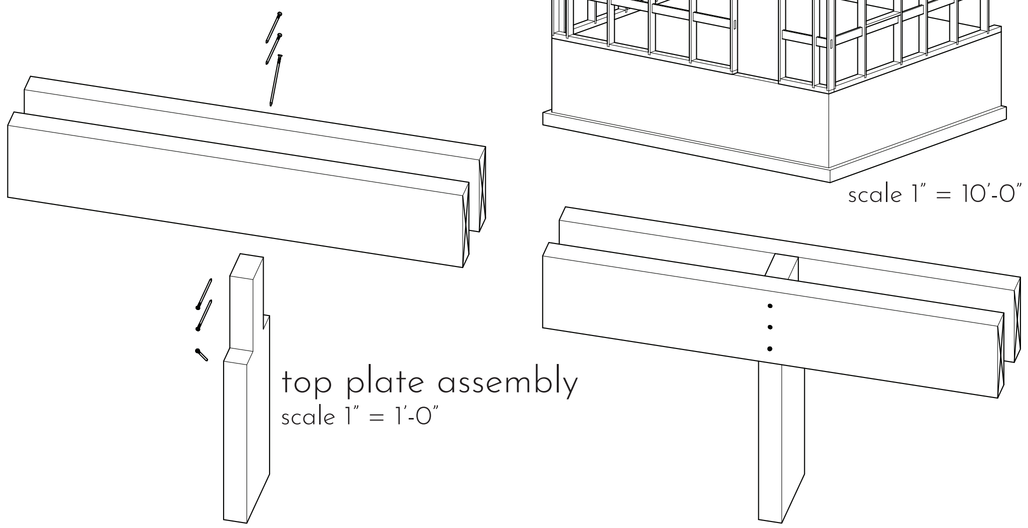
ground sill connection
scale 1 1/2″ = 1′-0″



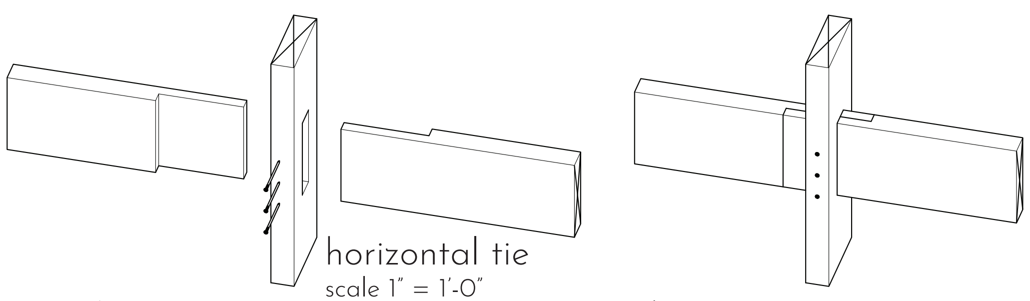
The adapted wall assembly used a combination of the dimensional lumber wall stud with the horizontal members used in the Japanese construction. This means that the wall doesn't rely on exterior sheathing for rigidity. This allows more siding options that could either eliminate the use of sheathing or reduce its thickness as it would no longer be structural. Instead of the studs being 16" on center they are 32" on center. This allows for sheathing to still work when laid horizontally. This wall system would assemble similar to a stud wall where it is assembled on the ground as one piece and then stood up.



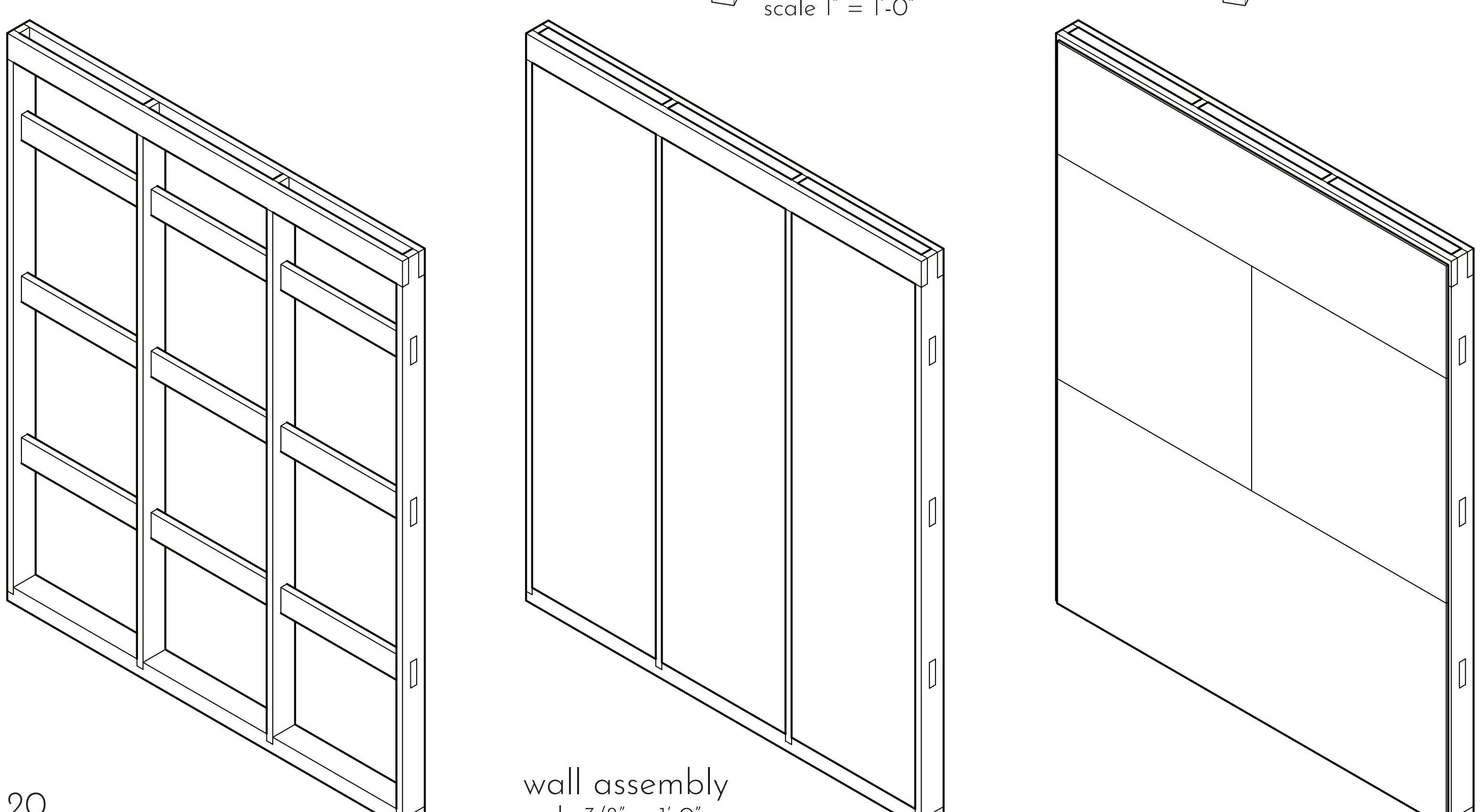
scale 1" = 10'-0"



top plate assembly
scale 1" = 1'-0"

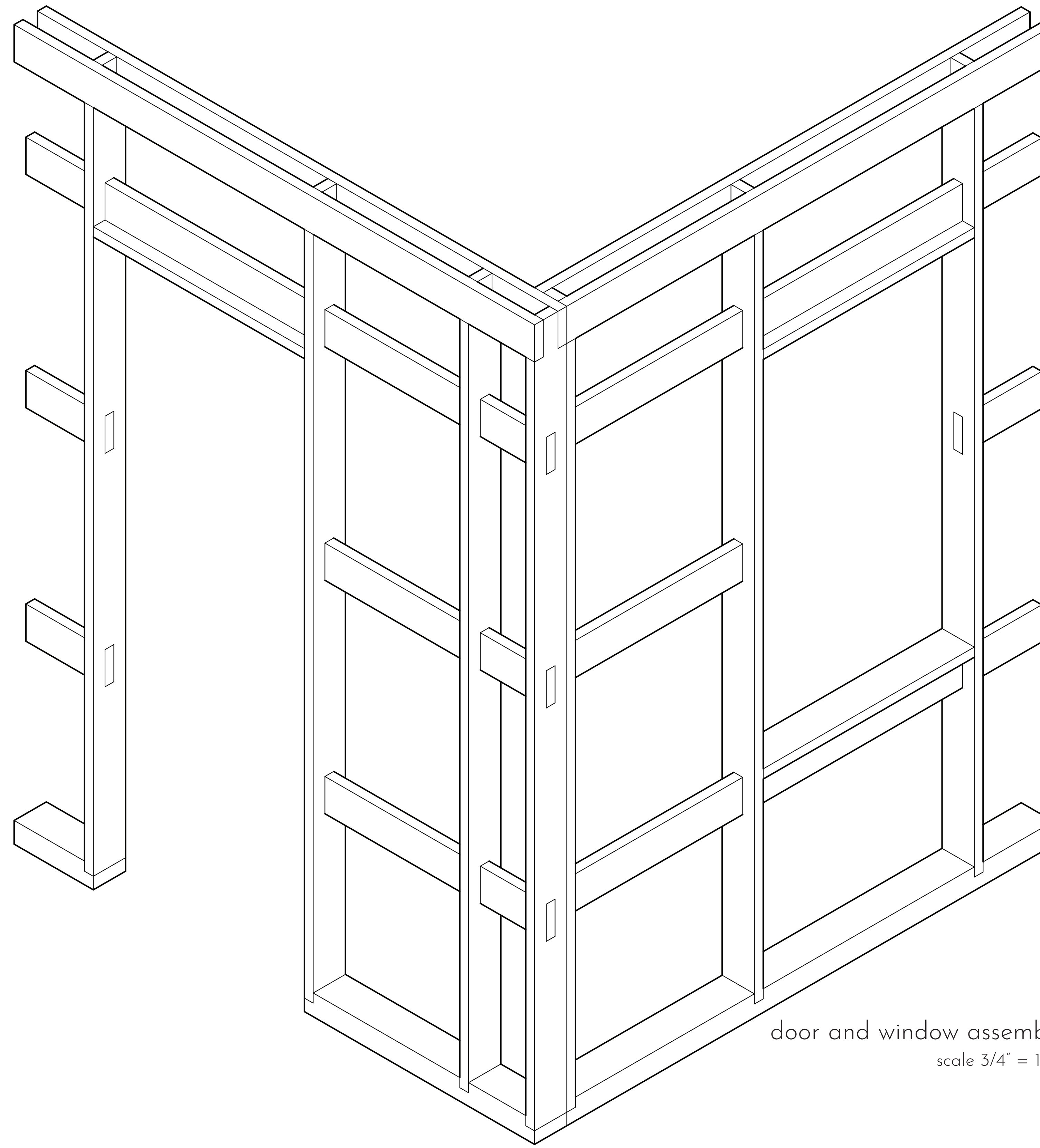


horizontal tie
scale 1" = 1'-0"



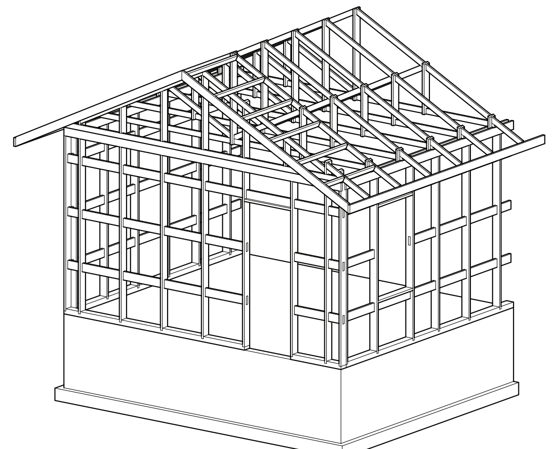
wall assembly
scale 3/8" = 1'-0"

Horizontal members are positioned at the header height of doors and windows and at the average sill height of the windows. This allows for doors and windows to be moved around much easier without as much deconstruction. There is also no additional headers or bracing needed as there is no vertical load on the doors and windows.

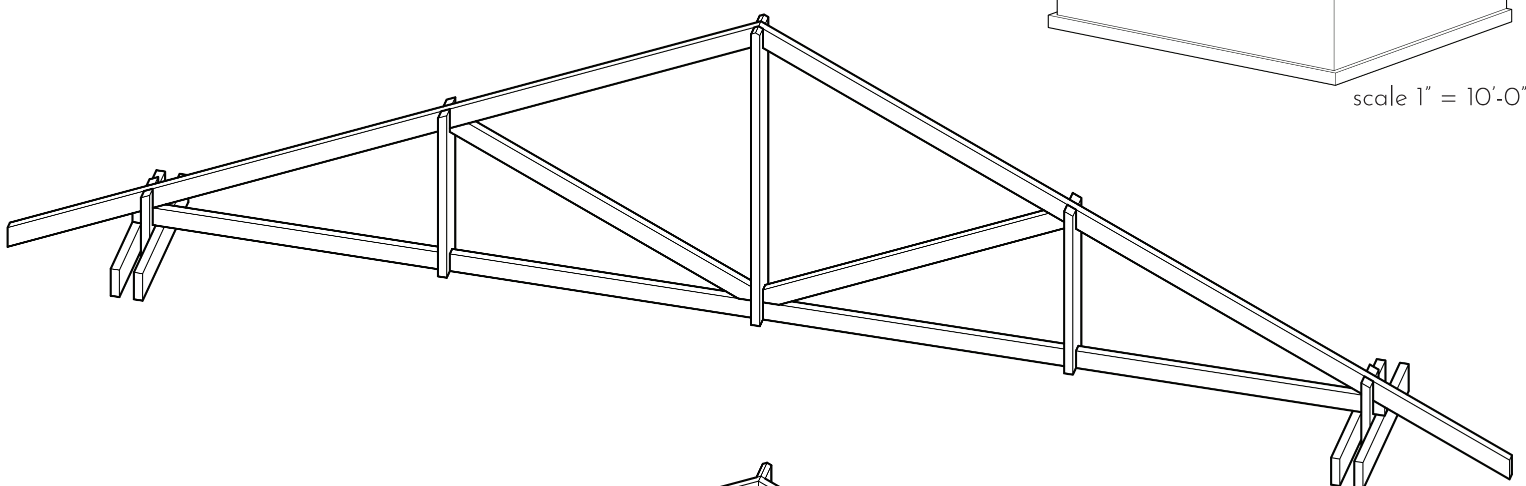


door and window assembly
scale 3/4" = 1'-0"

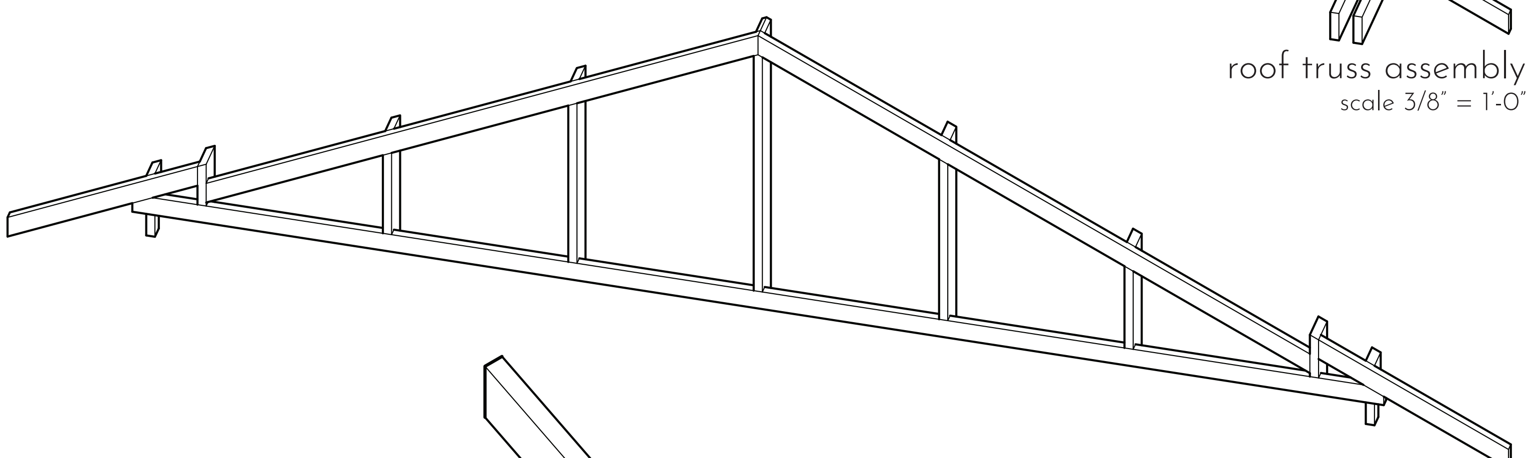
The roof system would work the same as a truss. In this case it could come completely assembled or be constructed on site to save space in transport. This truss doesn't rely on mending plates however. It uses the same simple wooden joinery with nails to secure it. One benefit of the top plates being turned on their edge is that the trusses can easily slide into this opening making it much easier to align and secure roof system.



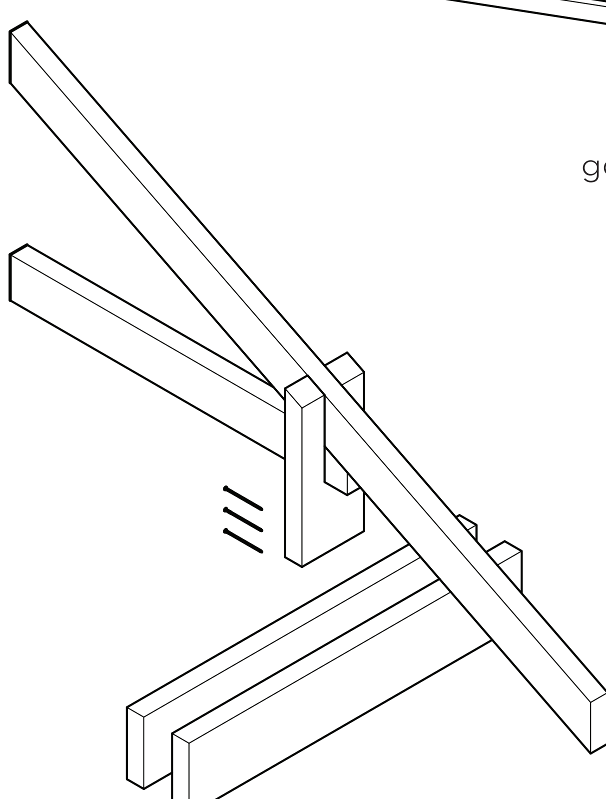
scale 1" = 10'-0"



roof truss assembly
scale 3/8" = 1'-0"



gable-end roof truss assembly
scale 3/8" = 1'-0"

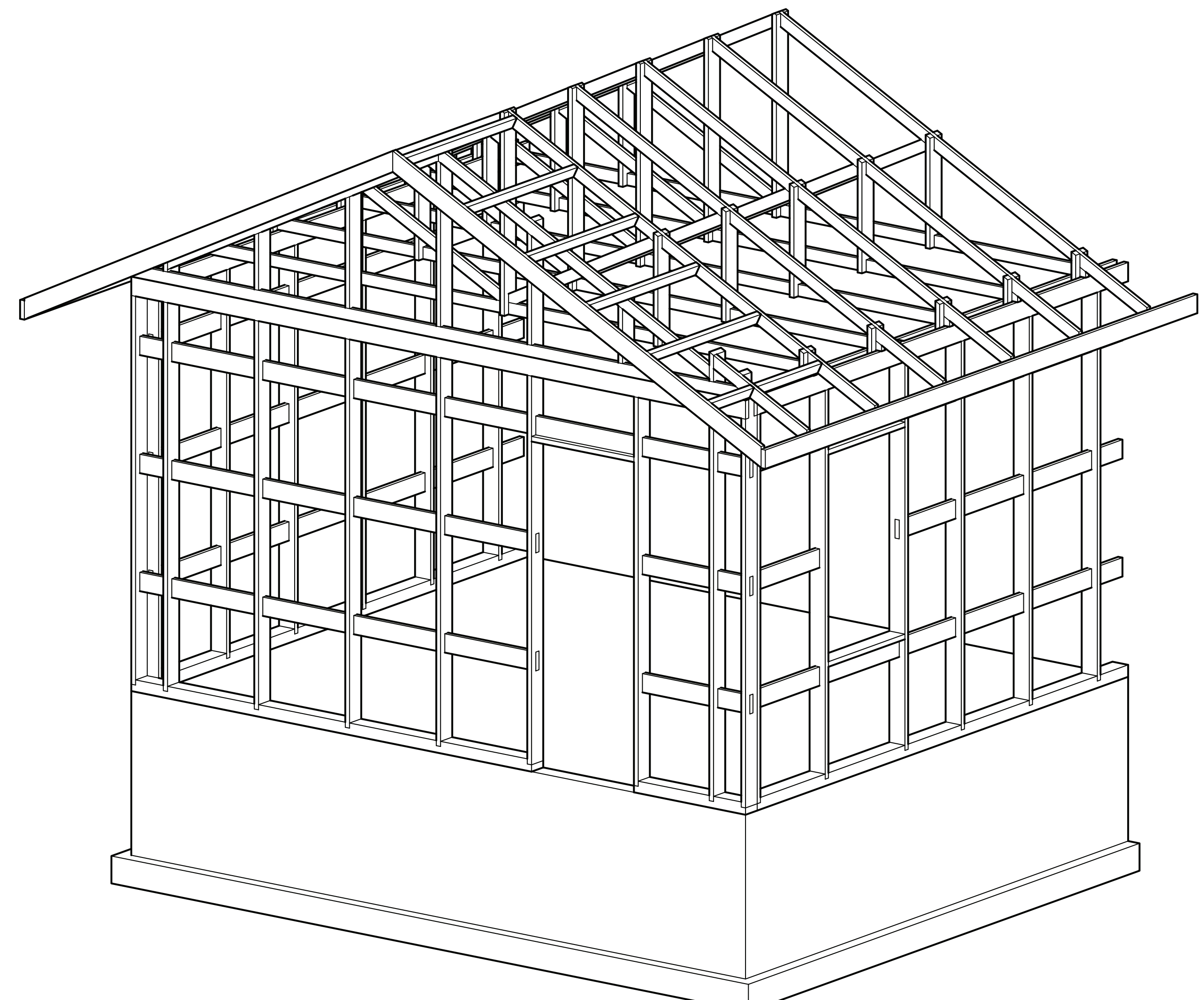


roof truss connection
scale 1" = 1'-0"

ADAPTATION CONSTRUCTION

Strengths -
- Redundancy
- Prefabricated off site
- Dimensional lumber sizes
- Modern tools
- No vertical load on doors and windows

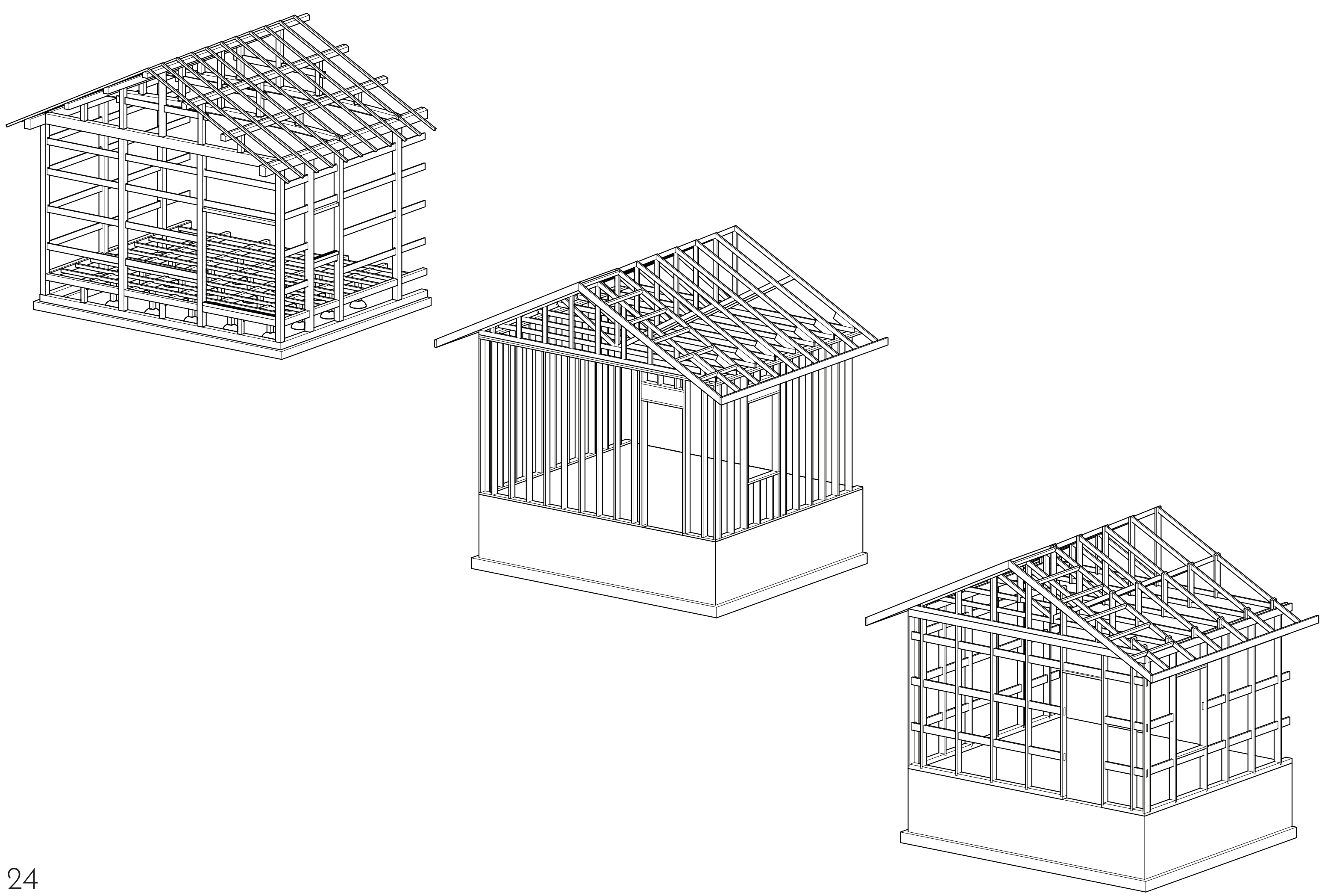
Weaknesses -
- Untested
- Heavier and more cumbersome truss
- Less of a fire break at top plate
- More steps than stick frame construction



complete assembly
scale 1/4" = 1'-0"

CONCLUSION

Construction methods will continue to adapt and change over time. Hopefully this study can allow others to start analyzing the way we construct our homes today and understand the value of bringing more craftsmanship into the process. If we can elongate the lifespan and quality of our homes we can save future generations from picking up the pieces of our fallen structures.



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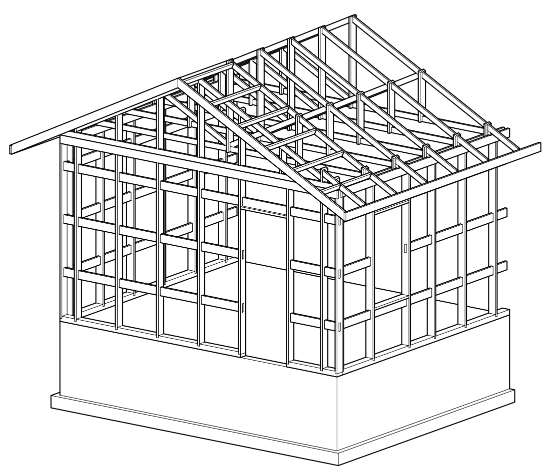

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