A SunCam online continuing education course

Cast, Lift, and Release
Tilt-Up Concrete Walls
Part 1: Construction

by

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Fig. 1 - Progress photo of a project with tilt-up concrete walls

Introduction

Focus of course:

This course focuses on informing the reader about the construction of tilt-up concrete walls. Background information on buildings and the sites they are built on, unique challenges, types of loading, design and construction methods, and recommendations for details. Ideally, readers should be familiar with structural drawings, as well as construction terms related to concrete.

This is the first of two courses on tilt-up wall panels. The second course, ***Cast, Lift, and Release, Tilt-Up Concrete Walls, Part 2: Design***, addresses the structural design of tilt-up concrete walls.

Background

Fig. 2, Erected tilt-up panels placed side-by-side

Tilt-up concrete walls are a building component that has been in use since the early 1900's. **The walls are constructed by pouring a series of reinforced concrete panels on the ground whose sides are formed with wood**. See Figs. 3 & 4. The panels are stood up one at a time using a crane (Figs. 5a & 5b), and moved into position to become part of the building wall assembly. Figs. 6a & 6b show rigging methods used to pick up panels. Most commonly, wall panel erection precedes the construction of a building's floor or roof, in which case the panels are then braced to the ground to provide stability against the wind (Fig. 7). **Wall panels are often the load-bearing elements that form the building's perimeter**. This is a big economic advantage in a steel-framed building if perimeter beams and columns can be eliminated.

Fig. 3, Separate panels being prepared for pour with reinforcment in place

Fig. 4, Panels in various stages: Finishing of poured panels, and panel ready for pour

Fig. 5a, Panel being picked by crane rigging

Fig. 5b, Crawler crane moving a panel

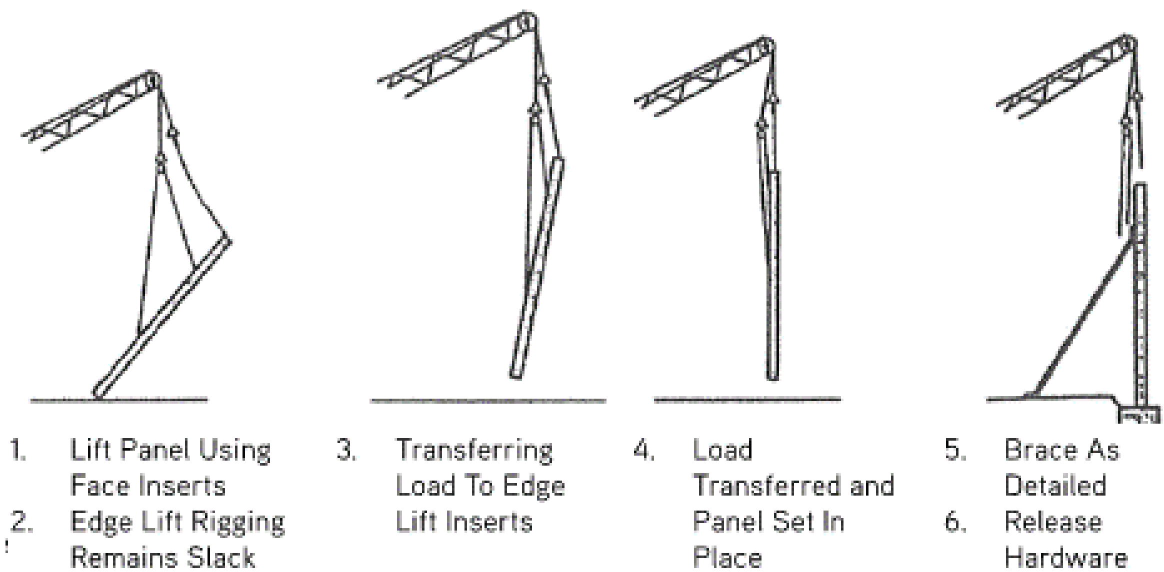


Fig. 6a, Transfer Method of placing panels (Dayton Superior)
<u>Use when crane has a second line to hold panel straight up and down</u>

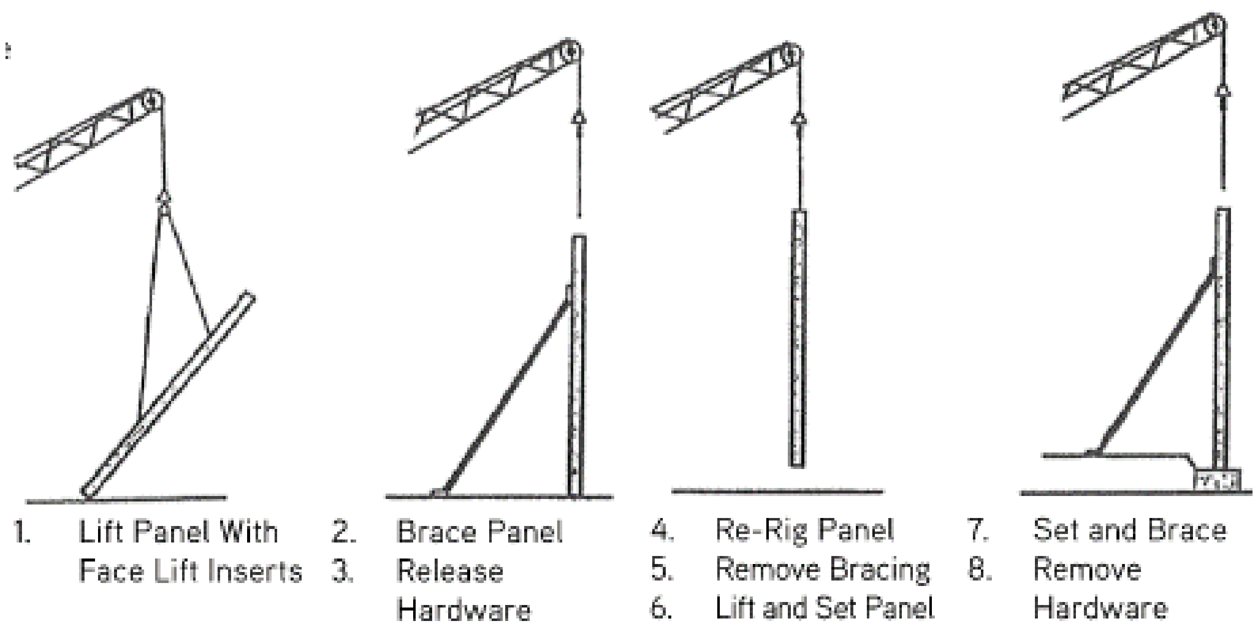


Fig. 6b, Brace and Re-rig Method of placing panels (Dayton Superior)
<u>Use when crane does not have a second line to hold panel straight up and down</u>

Fig. 7: Wall panels with diagonal braces to ground

Also known as site-cast or slender walls, tilt-up walls embody the favorable attributes of reinforced concrete in loading resistance. **Namely, 1) the concrete compressive strength to resist axial loads and to provide stiffness, and 2) the strength and ductility of steel reinforcing in tension to resist bending moments and cracking**. Walls serve as the base material to which waterproofing barriers are applied, as well as insulation and wall finishes. The end result is a strong, extremely solid, weatherproof exterior wall that is highly resistant to all manner of building conditions.

Tilt-up walls are a special subcategory of concrete walls in the ACI 318 code. There has been much research done to validate the use of walls that are more slender (greater height to thickness ratio), **but the walls must adhere to the limitations set forth in 11.8 of ACI 318.** This is discussed in detail in the second course.

With site-cast walls, the general contractor has control over fabrication and erection schedule as long as the weather cooperates. The intent is that there is no off-site fabrication and delivery. The process can go quickly with proper planning.

The American Concrete Institute (ACI) gives guidance on tilt-up concrete wall panels in several references. Two main ones are "Tilt-Up Concrete Structures (ACI 551)," and **"Design Guide for Tilt-Up Concrete Panels (ACI 551.2),"** Of course, the main body of concrete design is "Building Code Requirements for Structural Concrete (ACI 318)". All three of these will be referred to below.

ACI 551 is a comprehensive guide for the construction, design, and detailing of concrete tilt-up wall panels. From ACI 551, the definition of tilt-up walls is:
"a construction technique of casting concrete elements in a horizontal position at the jobsite and then tilting and lifting the panels to their final position in a structure."

Per ACI 551, advantages and disadvantages:

"***1.4-Advantages***
There are many advantages in tilt-up construction for low and even mid-rise buildings, including industrial plants, warehouses, office buildings, residential buildings, and commercial shopping centers."
"Some of these advantages are:
1) Elimination of expensive formwork and scaffolding
2) Fast, economical construction cycle time – from initial grading to move-in
3) Lower insurance rates that are typical for non-combustible construction
4) Wide variety of exterior finishes such as colored concrete, exposed aggregate, graphic painting and form liner finishes
5) Easily modified structures for building expansion
6) Durable, long-life and low maintenance building"

"Perhaps the greatest advantage of tilt-up is the ease and speed of construction. Panels can be tilted with high capacity mobile cranes and braced in less than ten minutes. It is possible to construct the complete building shell, from foundation through the roof, for a 100,000 sf warehouse with office space in ***30 days or less****."*

*“**1.5-Disadvantages***
1) Certain architectural treatment may become costly because of the construction techniques
2) Lack of availability of qualified personnel and contractors
3) Weight of the panels on certain soils
4) Available space to cast panels
5) Temporary bracing during construction
6) Availability of lifting equipment
7) Structural integrity requires careful consideration”

Panel Construction and Details

Building framing and exterior wall selection are just one piece of the building design puzzle. The driving forces behind the choices are a balance of many things at once. Owners choose buildings based on need and suitability. Construction arises as a result of speculative development or specific business needs. A business owner has a good idea of what brick-and-mortar edifice will suit them. The general idea is to construct a building that meets owner needs for function and projected image, while keeping an eye on costs and projected growth. So, an owner wants a building that meets needs and reasonable wants, but doesn’t have a lot of extra or unnecessary components or excessive strength or stiffness.

The choice of tilt-up concrete wall panels is part of the exterior wall system and superstructure selection. It goes hand-in-hand with the location and context within a development, and tilt-up wall panels need to make sense in the overall building design. **For buildings using tilt-up panels, these are often one-story warehouses or one- to two-story office buildings**. Some of the considerations involved include:

1) Location.

a) High wind. Recently, the author’s employer explored the I-25 corridor in Colorado for building sites on the eastern side of the Front Range of the Rocky Mountains. On occasion, wind comes screaming down the mountains into the flat and open plains where much development is taking place (Denver, Colorado Springs). It is an area known for sudden winds. An internet search will turn up videos of trucks tipping over on I-25. Depending on proximity to the mountains, design wind forces can be 1.5 to 2 times greater than just a dozen miles inland. The engineer needs to identify these things immediately.

b) High seismic. Obviously, the west coast has many areas where this is a challenge, but the use of tilt-up panels in California is quite common (Fig. 8). One thing to watch out for is special detailing. One may run into unexpected things as well. The author’s employer was proposing construction of a two-story building in Tennessee. With a second-story gym, the building heights exceeded 40 feet. For the mid-range seismic requirements of the site, **the code limits on the height of precast shear wall systems meant that tilt-up concrete shear walls (under the broader definition of precast) could not be used**.

Fig. 8. Retail store in San Jose, CA, with tilt-up wall panels (Google Earth)

c) Other local considerations such as high snow loads and associated snow drifting, as well as requried frost depths for footings. Some regions require special design loads. Certain sites in the Sacramento area, surprisingly enough, may require designing for floods.

d) Areas with a rainy season or extreme cold season may inhibit plans to pour panels, causing costs or delays.

e) Some jurisdictions may be more demanding than others. They may require the use of certain building materials (brick, glass, stone) on a certain percentage of a building exterior, require screening of rooftop units or impose limits on building heights. The author’s employer recently built a building in California, where the mission style of architecture needed to be used.

f) Local construction expertise and familiarity. If tilt-up panels are not commonly used in a specific region, it may be a challenge to find local wall panel suppliers and labor who have the expertise to execute such work. This is not insurmountable with mobile crews, but needs to be thought through.

2) Characteristics of the proposed property.

a) Site challenges. Rocky ground might involve blasting with dynamite to get to foundation depth. Sites with steep slopes may require a lot of dirt to be moved (cut and fill) to get flat areas. The fill areas may settle more than the cut areas, and the cut areas may have groundwater present to address.

b) Building versus site footprint. **Tilt-up concrete involves the use of a crane, which needs considerable space to maneuver**. The size and shape of the building in relation to that of the site and its clear and accesible area beyond the building will require this to be thought through. Property lines, for example, may be very close to the building on one or multiple sides.

3) Characteristics of the proposed building.

a) Building specifics. Challenges arise if a building has a basement that requires open excavations and a deep hole to build in, or if there are **interior or exterior pools that need to be constructed**. These things do not lend themselves to the movement of cranes, nor to the laydown area for pouring panels. Also, on certain sides of the building, there may not be access. See Figs. 9a & 9b, where for one building it was possible to accommodate tilt-up construction and one where it was not.

Fig. 9a, Athletic club in the Houston area with pools and tilt-up walls (Google Earth)

Fig. 9b, Athletic club under construction at a mall where there is insufficient room for the sequencing of tilt-up walls (Google Earth)

b) Height of building. As mentioned above, taller building heights may preclude the use of tilt-up concrete walls based on pratical limits of handling the panels. For isolated areas of a building, the author was the engineer of record for a building where panels 60'-6" tall were used. The panels were just taller and skinnier than normal. (Fig.10).

c) Size of building. Mobilizing on site for tilt-up wall panel construction with the required crane, equipment and materials, and crew requires a minimum cost that may not be worth it for buildings of limited size.

d) Suitability of tilt-up panels will need to be studied for the wide variety of architectural features and building requirements specific to a buidling in question. Some things to think about include:

i) Usage of building. Tilt-up will not compete with unoccupied buidlings such as pole barns.

ii) Number of stories. The more stories, the more unlikely tilt-up is suitable.

iii) Area of slab versus area of wall and/or site. The greater the wall to slab area, the less likely tilt-up walls are viable. **If wall area exceeds 80% of the slab area available, the more likely casting beds will be required, or that stacking panels on site will be necessary.** (Smith)

iv) Excessively large of continuous windows or other similar openings. If openings for windows are such that wall panels need to be spandrels hung from the steel frame or from adjacent wall panels, such as would be required with continuous (ribbon) windows, other wall systems may be more suitable. Tilt-up wall panels are set up well for buildings with regularly spaced openings of reasonable size that stack floor-to-floor.

Fig. 10, Tall panels

4) Of course, as always, there are many wall systems possible for use in buidlings. Some of the common wall types that the tilt-up industry competes with:

a) Precast concrete (pre-fabbed, offsite). Built indoors and often with better quality control, but need to be shipped to site, and because of road restrictions, panels are less wide, and therefore there are more pieces to erect (crane and labor time).

b) Concrete block. May be less expensive, but concrete block has lower design strengths, especially at connections, and there is a dwindling labor pool that has the expertise required to built these walls correctly.

c) Cast-in-place concrete walls with vertical forms. More labor and scaffolding and often greater scheduling challenges.

d) Metal building walls. Stick-framed or as wall panels. For example, light gage steel studs with applied wall board.

i) Depending on finishes, costs can be lower with metal walls. However, tilt-up wall panels provide an inherent and abundant lateral system for the resistance of wind and seismic loads. That is generally unavailable with metal wall panels, so a supplemental lateral system must be devised (metal strapping, steel bracing, isolated cementitious shear walls).

ii) One aspect of building system selection that is not as obvious, but that can have a big impact on cost is the gravity load takedown at the perimeter of a building. Without examination, it seems clear that the contractor would use tilt-up concrete walls to support the building floor and roof structural members (deck, beams, girders). However, for reasons related to site logistics, scheduling or sequencing, the contractor may elect to erect the steel for the building prior to the walls. This unsually includes a perimeter steel frame including steel beams and columns, as well as column foundations. (Fig. 11) In this case, assuming adequate bracing of the steel structure is present, the tilt-up panels could simply be attached to the steel frame without the need for additional temporary bracing of the panels. It is worth asking up front to clarify the preference. One thing to investigate is the costs for the perimeter framing and foundations, and weigh that against using the tilt-up walls as natural load bearing elements. Using the tilt-up walls and eliminating perimeter framing can lead to significant cost savings.

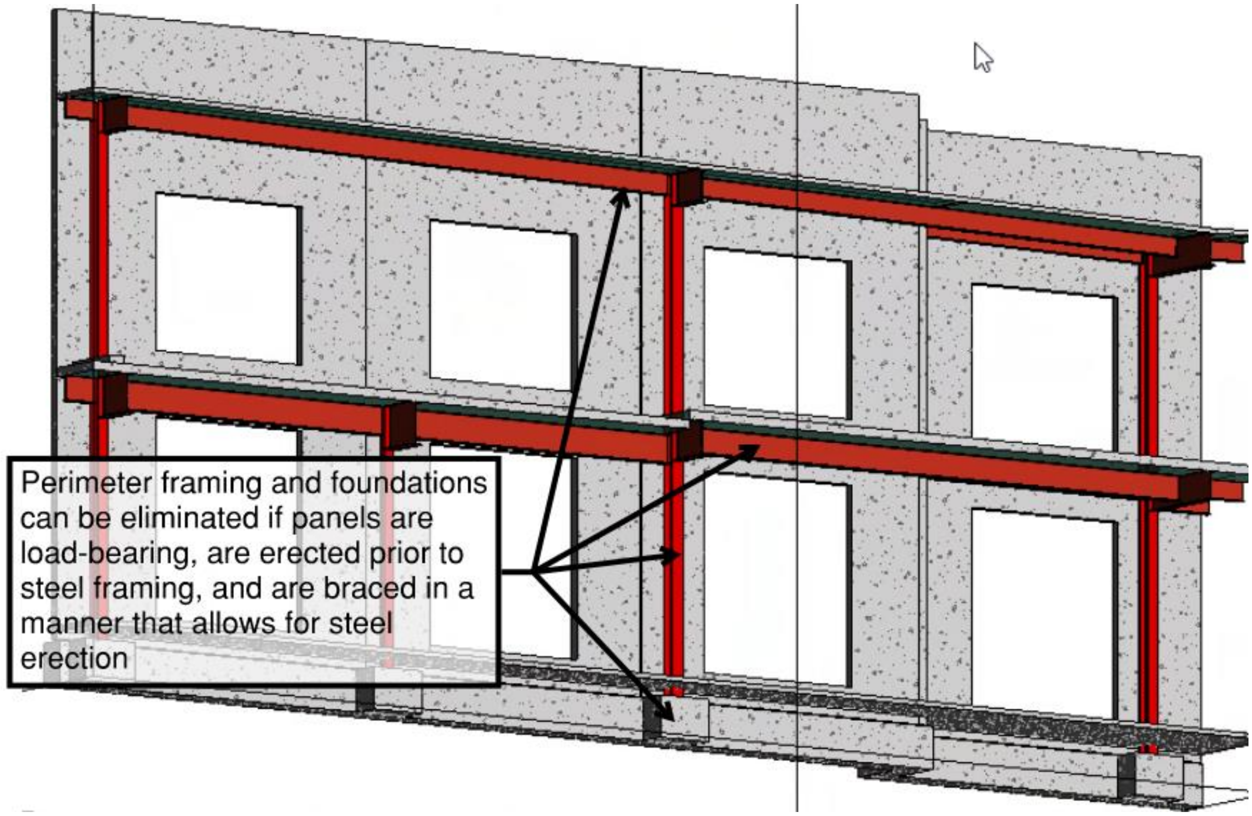


Fig. 11, Verify if wall panels will be load bearing, or if perimeter framing will be required

Once the wall system has been selected, the design of the wall panels may commence, and specific design design decisions can be made. The items impacting panel or building design need to be identified, and the list includes:
a) Roof and floor heights, setbacks/low roofs, high roofs
b) Buidling footprint including slab on grade information
c) Foundation type and layout
d) Site items: exterior grading (soil elevations around building), retaining walls, pools, adjacent buildings, property lines, locations of utilities
e) lower structures such as basements or mechanical pits
f) Architectural features: Wall finishes, insulation types, window openings, canopies hanging off of building, expansion joints
g) As mentioned, decision on perimeter framing and/or load-bearing walls. There may also be a hybrid approach.
h) Parapets: Understand variables such as a minimal gravel stop only, minimum heights to serve as guardrail, rooftop unit screening, variable heights for aesthetics

i) Roof drainage and slope. Include any need for scuppers through walls for roof drainage at edge of building or from high roof to low roof
j) Wall panel attributes, to be dicussed in detail (panel thickness, panel size in area, joint locations, concrete strength, reinforcing, etc.)
k) Input from contractor or wall panel suppplier on special preferences (thickness, limits, rules of thumb, etc.) or areas not to use tilt-up wall panels but to go with a different wall system.
l) Use of building slab to attach temporary wall panel braces and drive cranes upon.
m) Future construction considerations. Future additions or knock-out panels. This is common in warehouse design when planning for future needs.

Panel thickness will be based on a balance between load demands and the economy of concrete and reinforcing. The determination should include a cost analysis, ideally with input from the general contractor. Options include one layer of reinforcing centered in the wall, or reinforcing in two layers, one layer close to each face. The thickness of a row of panels with many may be controlled by the jamb design, as is the case for many walls at dock doors. **Some guidelines are shown in Fig.12**. Thickness in inches is usually in the range of 1/4 of the height of the panel in feet (30 ft height / 4 => 7.5 inches thickness). Also, tilt-up walls are fairly slender, so deflections may control the thickness of panels. Requirements for reinforcing, deflections, and slenderness are discussed in detail in upcoming portions of the next course.

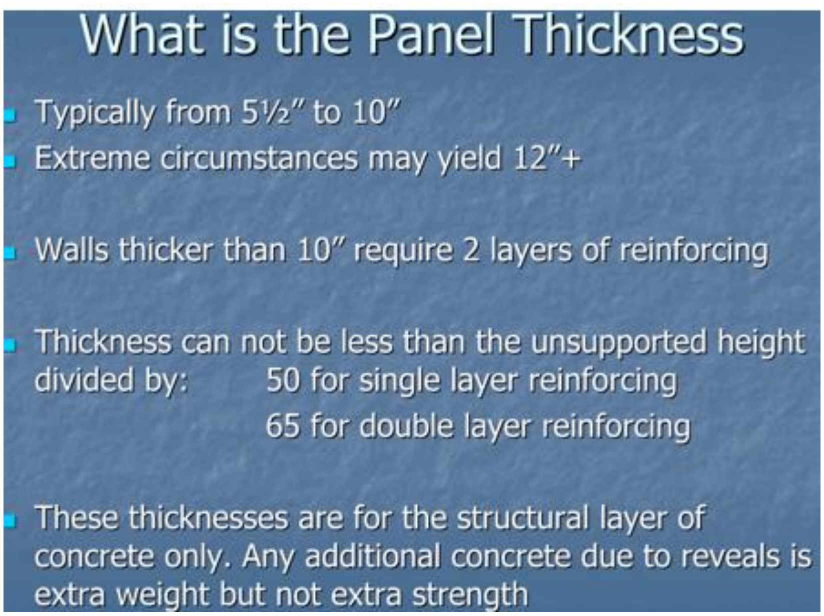


Fig. 12, Panel thickness, (Smith)

Options for wall construction are shown in Fig. 13. Sandwich panels include insulation and likely a concrete finish on the fascia side. The inside wythe is generally the structural wythe, and other than self weight of fascia side, **all loads should be resisted by the structrual wythe.** This includes loading during panel lifting.

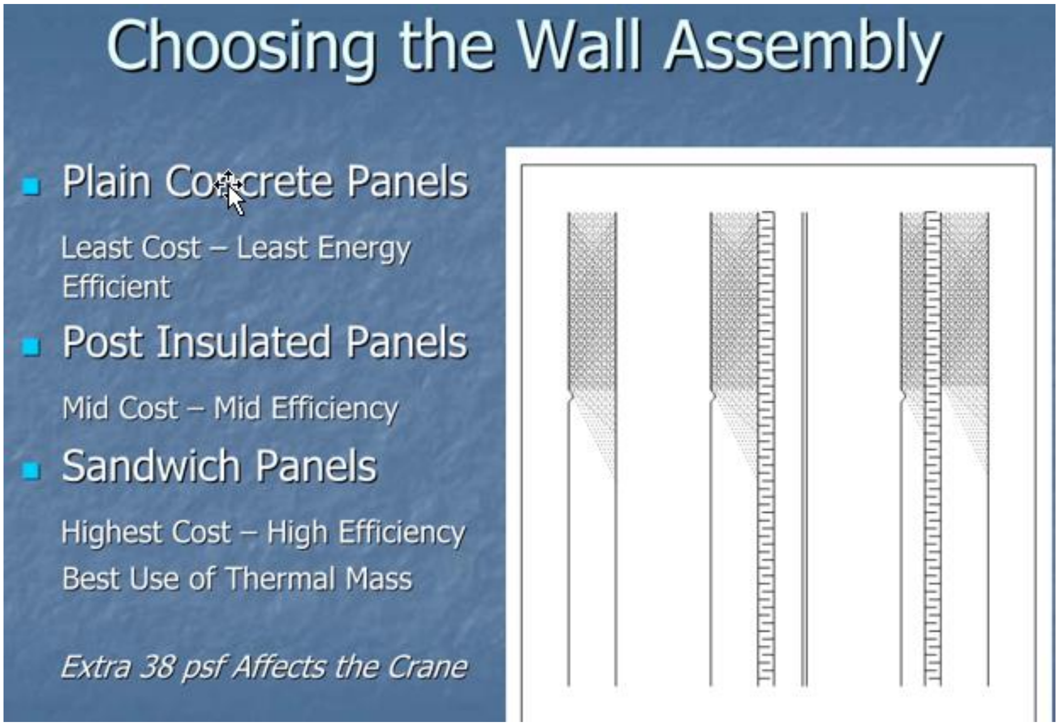


Fig. 13 (Smith)

Summary of recommendations for sandwich panels, (Smith):

“a. Supported wythe thickness should be as thin as possible, but not less than 2-1/2 in.
b. The structural wythe thickness should be properly sized to accommodate the additional load of the supported wythe.
c. Do not allow any structural loads to be transferred to the supported wythe.
d. Consideration must be given to thermal bridges and joints in design of non-composite panels.
e. Provide a solid rib of concrete or wooden member at the bottom of the panel to facilitate rotation when the panels are being tilted from the casting bed.
f. Cast the structural wythe on top to allow easy access to the lifting inserts.
g.Use only stainless steel or other non-corrosive connectors between the two wythes.
h. It is important that good curing practices described elsewhere are followed, since thin concrete sections are involved.

i. It is essential that a quality bond breaker or method of breaking the bond is employed to minimize bond between the supported wythe and casting bed. Adhesion to the casting bed or attempts to break the bond with too rapid a load application can delaminate the two wythes. Wedging non-composite panels from the casting bed can cause spalling and collapse of the insulation, and is therefore not recommended."

There are a variety of aesthetic treatments available for concrete panels. **These include smooth or rough panel surfaces (Figs.14a & 14b).** Generally, panels are cast exterior side down, facilitating the use of architectural textures and accents.

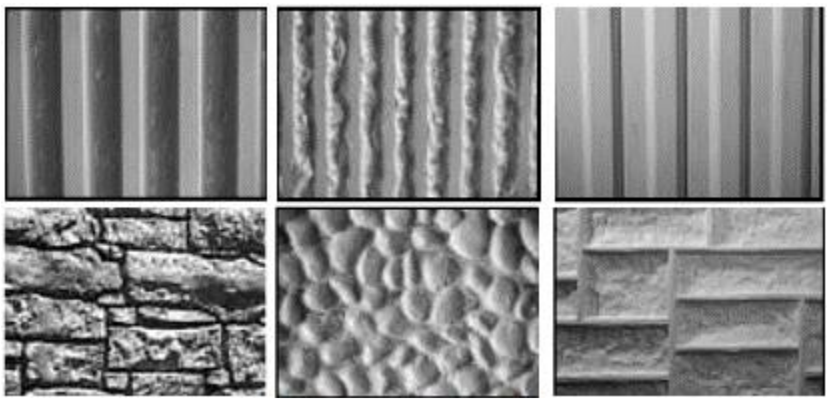


Fig. 14a: Textured Formork for wall finishes (Dayton Superior)

https://tilt-up.org/events/details/?event=15c95172-0078-cd34-d748-505c06094ae1
Fig. 14b: Textured panels

Zooming in from an aerial view, a typical tilt-up wall is shown in the following figures.

Fig.15: Aerial view of facility with tilt-up wall panels

Fig.16: Inside view of loading dock area with steel roof joists bearing on tilt-up panels

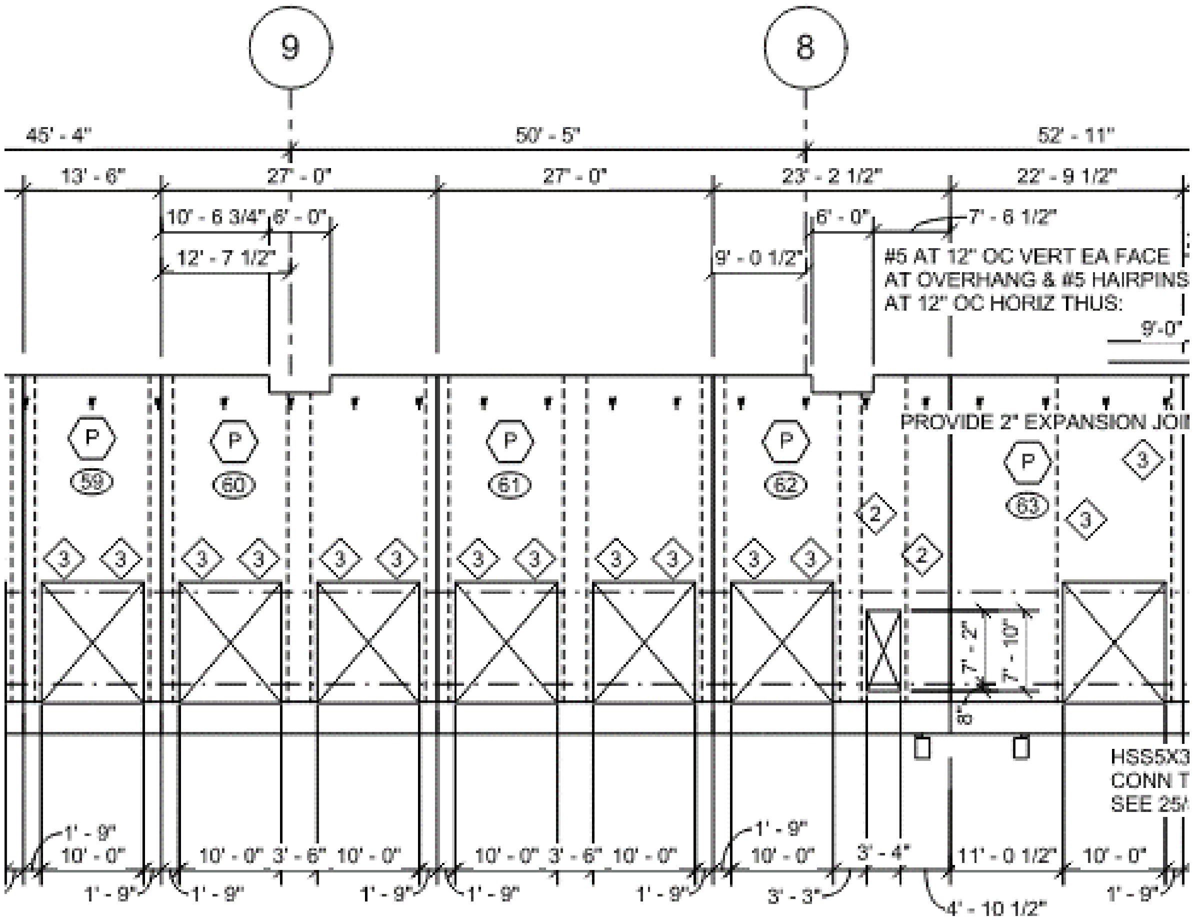


Fig.17: Elevation of loading dock area from structural drawings; Note dock door openings

PANEL REINFORCING SCHEDULE						
PANEL TYPE	TOTAL PANEL THICKNESS 'T'	HORIZ REINF O.C.	VERT REINF O.C.	HORIZ BOT REINF	TOP & EDGE REINF UNO	COMMENTS
P	0' - 9 1/4"	#4 @ 18"OC	#4 @ 18"OC	(2)- #5	(2)- #5	EACH FACE

NOTES:
1. JAMB REINFORCING MUST EXTEND FROM THE BOTTOM OF THE PANEL TO 2'-0" ABOVE THE ROOF ELEVATION, UNO.
2. JAMB REINFORCING AT ROOF SCUPPERS TO BE HOOKED AT TOP.

Fig.18: Wall panel reinforcing, with Panel type for elevation shown above

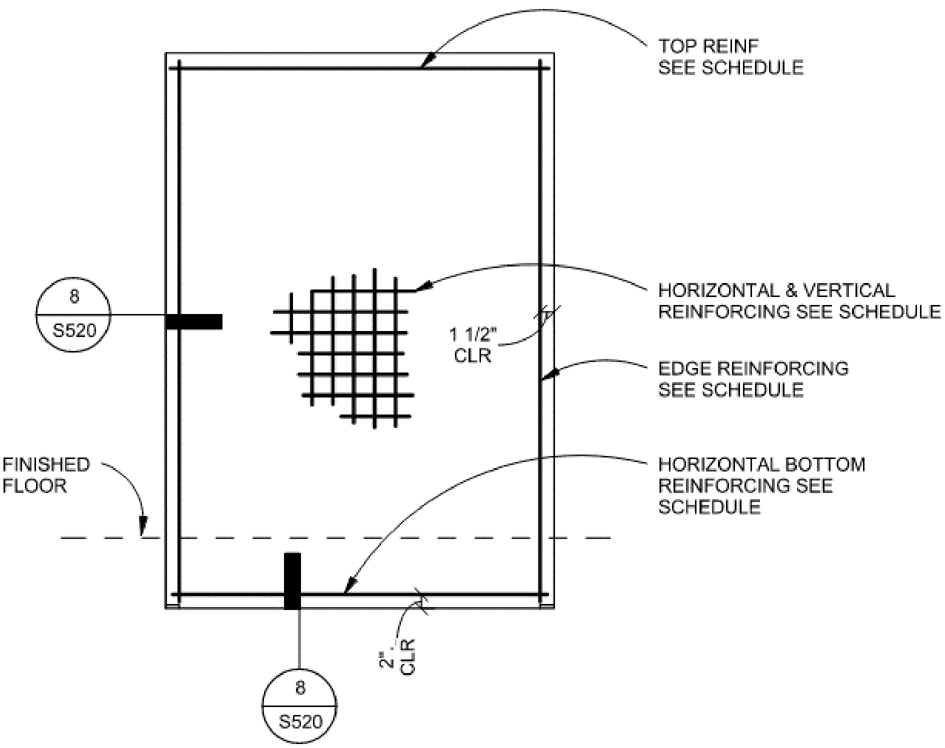


Fig. 19:Detail depicting a typical wall panel with no openings

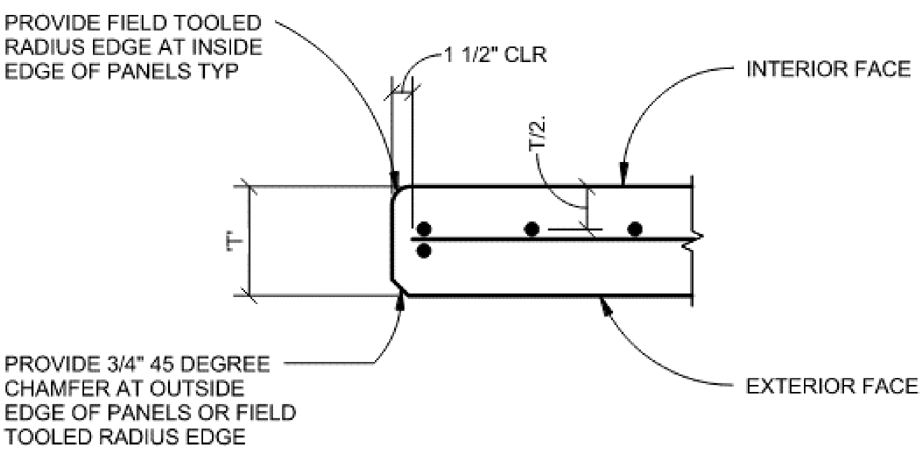


Fig. 20: Detail at edge of panel

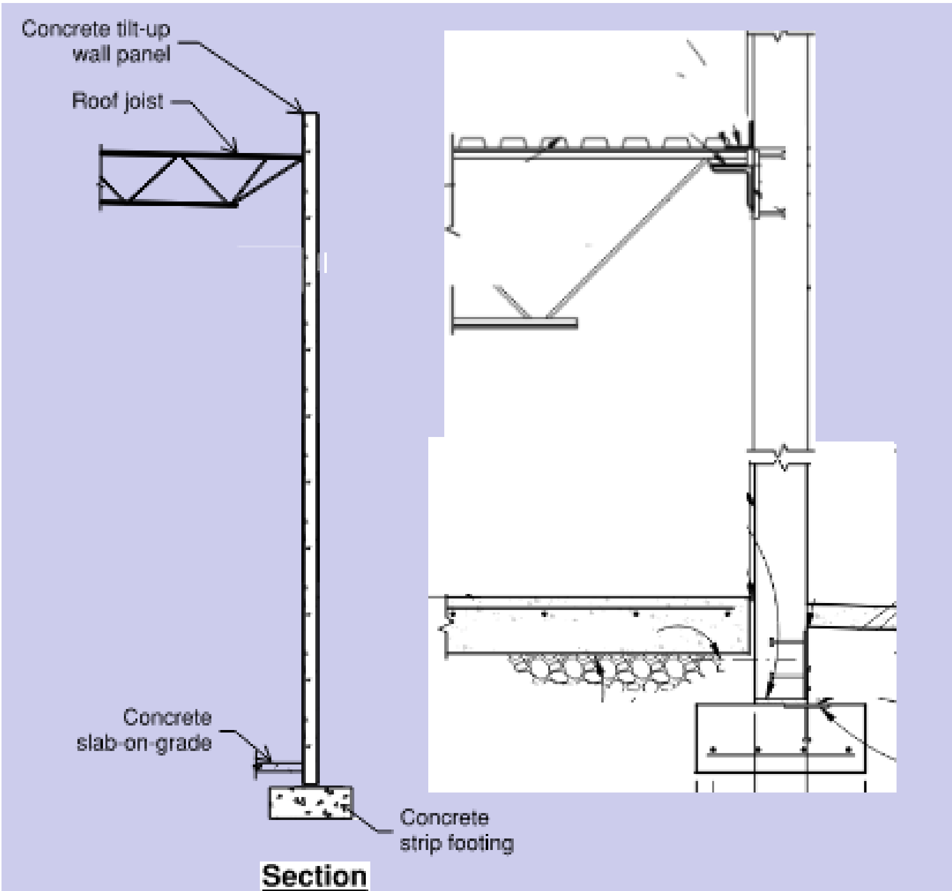


Fig.21: Building section at typical wall panel, with enlarged roof and foundation details

Options for foundations include those in Figs. 22 & 23 below. The pros and cons of each will need to be discussed with the architect and contractor. Note that one detail shows the wall panel *at the footing*. The other two show cast-in-place concrete *foundation walls*. **Panels are always placed on shims so they can be leveled, leaving a gap that gets filled with non-shrink grout later**. The design engineer needs to understand the required footing depth and desired sequence of the slab and wall panels. More guidance is provided elsewhere in this course.

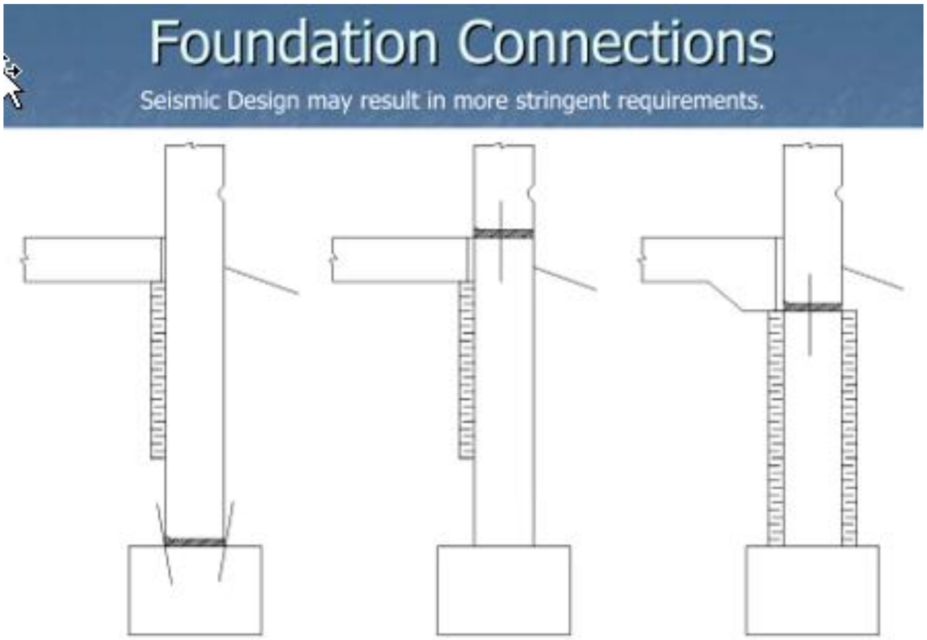


Fig. 22, Options for foundations (Smith)

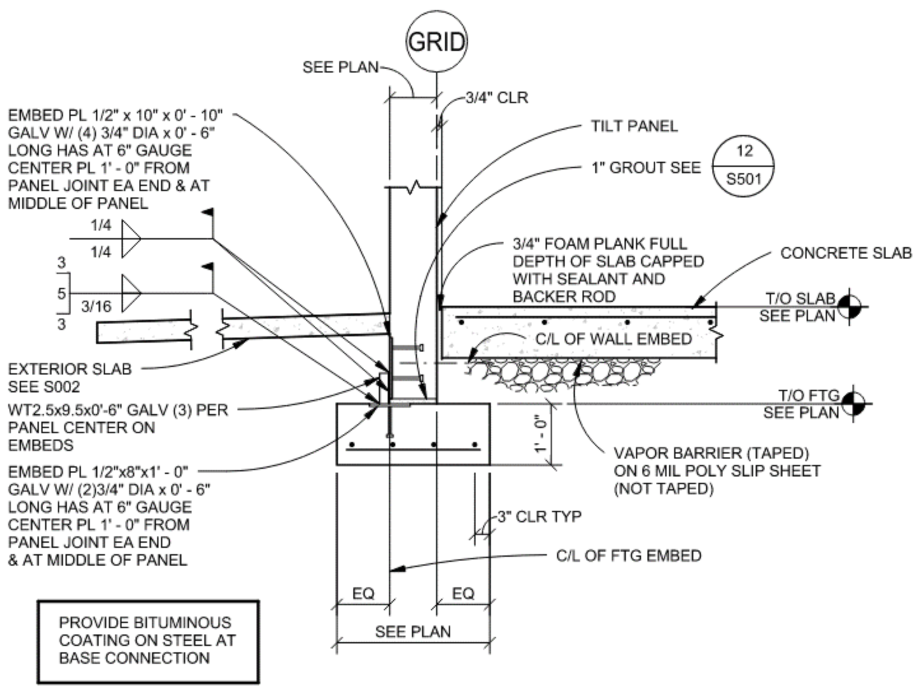


Fig. 23: Typical foundation detail for the following chosen sequence:

1) Tilt panel poured on casting slab, 2) panel erected, 3) slab poured

Author's pic

Photograph by Bill Bradley. billbeee 06:27, 13 June 2007
https://en.wikipedia.org/wiki/Tilt_up#/media/File:Tilt-slab-base-detal.jpg
Figs. 24a & 24b, Base of wall details

A typical top roof bearing detail is shown in Fig. 25. Steel plates, angles, and other steel components are used to make the connections from steel to concrete. **The embedded plates use welded headed studs or welded rebar to help transfer load deeper into the concrete wall**, so the concrete area engaged is greater, and more of the steel reinforcing is within the fracture zone for improved ductility (ability to stretch).

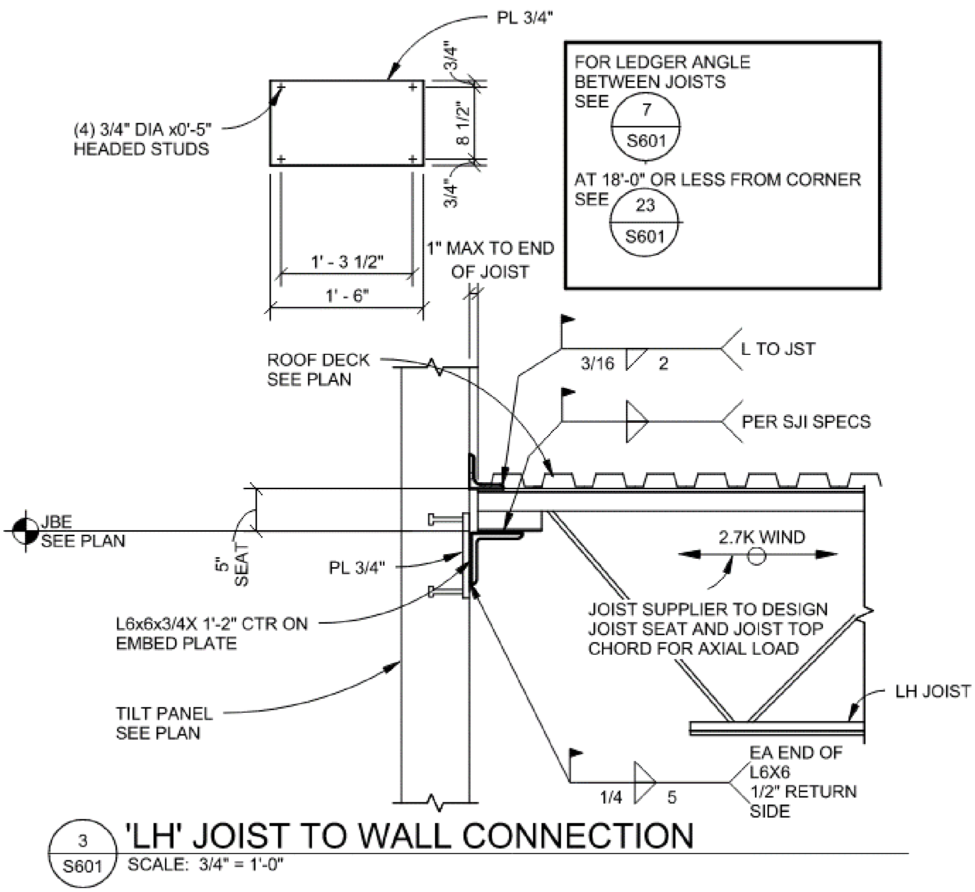
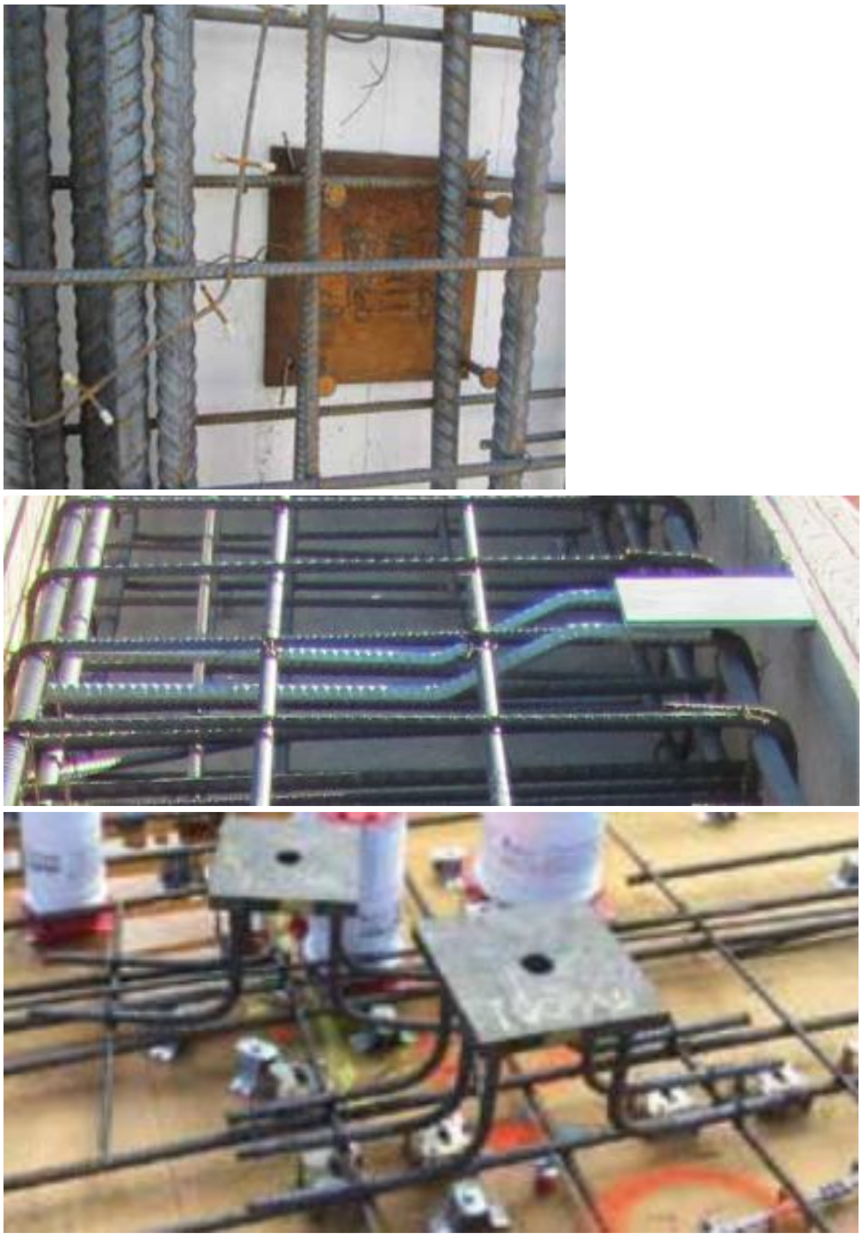
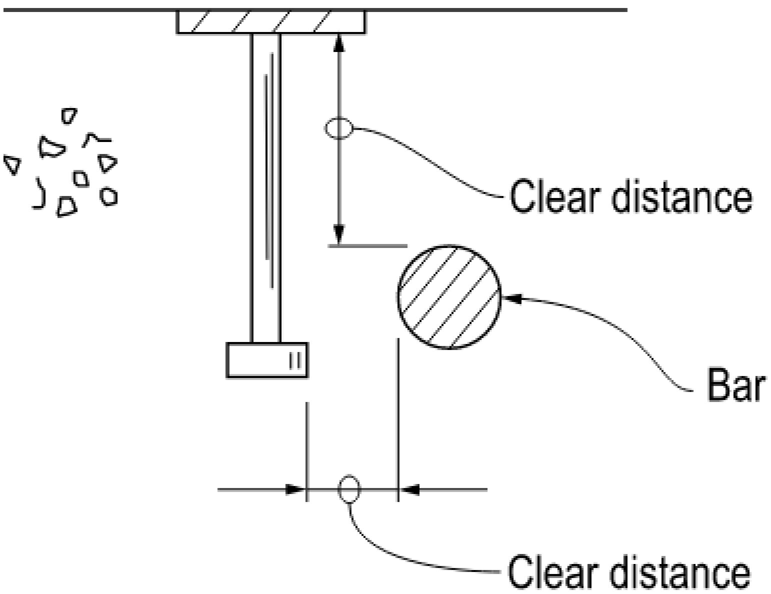


Fig.25: Detail showing joist bearing at wall; This is for a heavy joist load at a tall wall, with significant wind.

Embed plates deserve special attention. Being a highly engineered component that transmits concentrated loads with required ductility and limited redundancy, the engineer should design and detail embed plates to give the contractor the best chance to install them correctly. It is the concrete contractor who will set the steel embeds, so consider that audience. Use a limited number of different embed plates, grouping them together if necessary, and use a schedule for easy organization. Clear distances need to be followed for headed studs to develop their capacity. Pains should be taken to provide for embed plates to easily fit in and around reinforcing, and hopefully in less congested areas. See Figs. 26 & 27. **Air holes 3/4" in diameter (for easy punching) should be used to allow air to exit from under the plate during consolidation of the concrete with a vibrator**. Concrete paste should be appearing through the hole. Nail holes should be provided for embeds hanging from side forms. (Klinger, et al).



Figs. 26a, 26b, 26c: Embed plates for panel connection; Headed studs and A706 weldable rebar are options (Klinger, et al, and Author)



Figs. 27a, 27b Clearance between headed studs and rebar can be a real challenge at embed plates (Klinger, et al)

Openings in wall panels are easily accommodated. They are simply formed as leave-outs. See Fig. 28. **Reinforcing is added to increase strength and stability at jambs**, and additional reinforcing is used to control cracks at points of probable propagation such as the corners of the openings.

https://www.wconline.com/articles/90884-advantages-and-disadvantages-of-tilt-up-walls
Fig. 28: Panels with significant openings

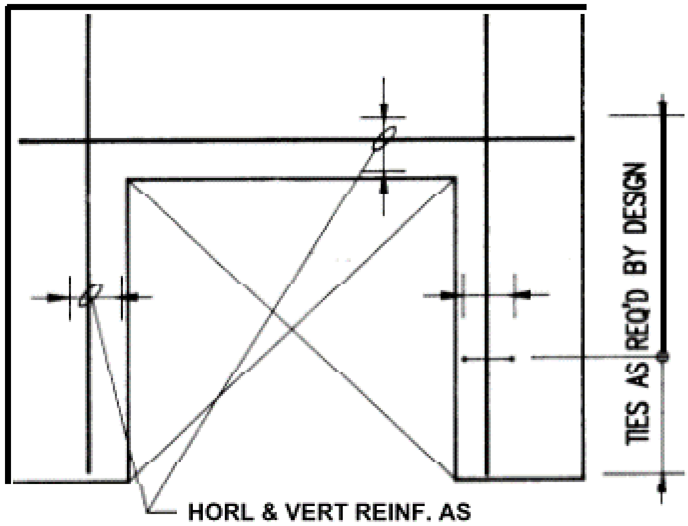


Fig. 29: Reinforcing in panel (ACI 551)

The increased reinforcing at jambs extends full height between lateral wall supports, such as the slab-on-grade and the roof line. See Fig. 30.

Fig. 30: Reinforcing with ties at window jambs

In the structural drawings, reinforcing at jambs is typically called out in a schedule to prevent panel elevations from being cluttered with excessive text. Note that a dedicated length, 'L', is used to define the size of the jamb element and therefore the placement of the vertical reinforcing. **If the axial load at the jamb is sufficiently large, ties are required**. Typical jamb reinforcing is shown in Figs 31 & 32 below. Sections depict both types of jambs: a) those without ties, and b) those with closed ties with 45 degree hooks for development.

JAMB REINFORCING SCHEDULE				
◇ JAMB MARK	# VERT EACH FACE 'N'	SIZE	LENGTH 'L'	DETAIL REF SECTION
2	2	#6	18"	9/S520
3	3	#6	21"	10/S520

Fig. 31: Jamb reinforcing at the side of openings. Refer to elevation in Fig. 18.

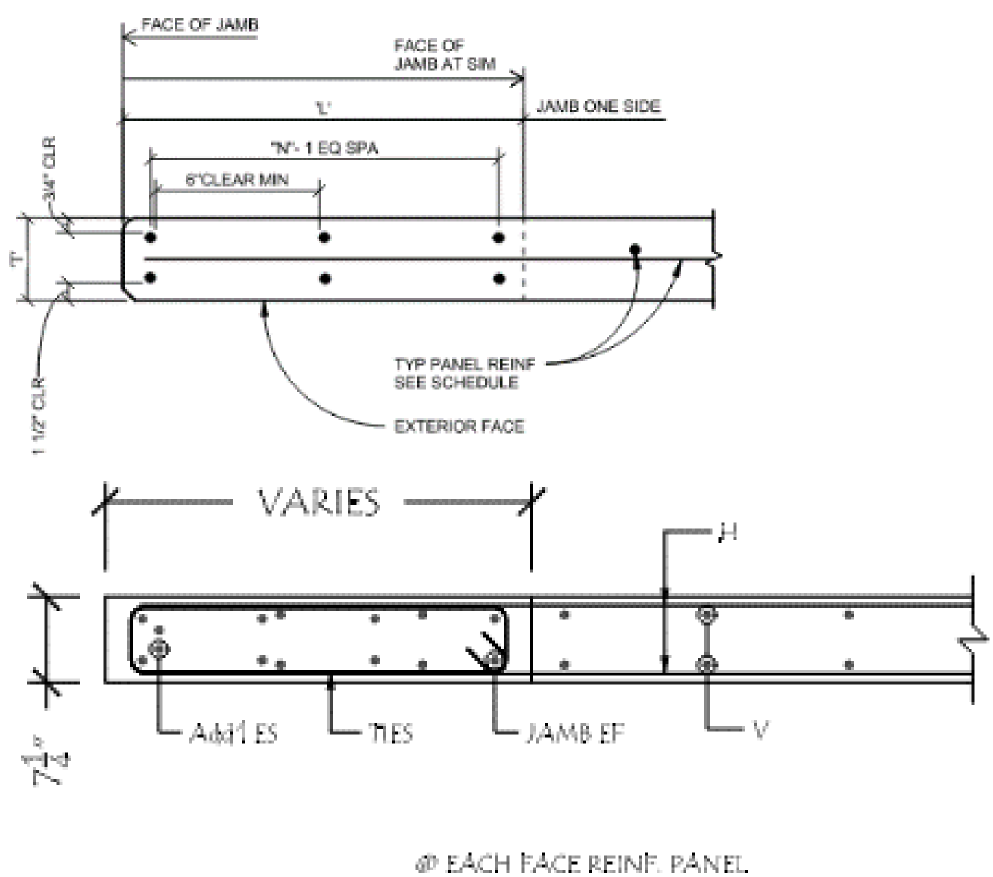
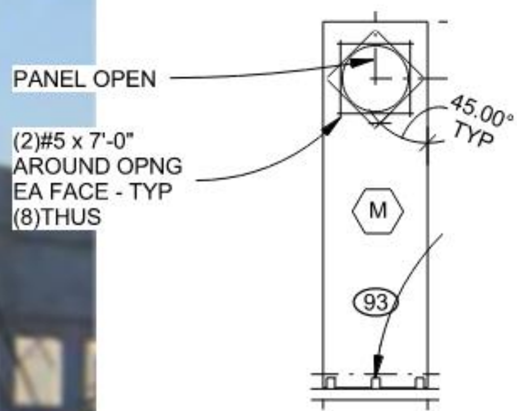


Fig. 32: Section through jamb at openings
Top: No ties
Bottom: Closed Ties with 135 degree hooks for development

Limited only by the abillity to provide smooth and stable formwork, formed elements such as the open circle in Figs 33a & 33b are simple enough to execute



Figs 33a & 33b: Architectural features are possible with tilt-up

For openings with a practical purpose, Fig. 34 details how openings can easily be accommodated with proper planning. Note the guidance on reinforcing for these panels.

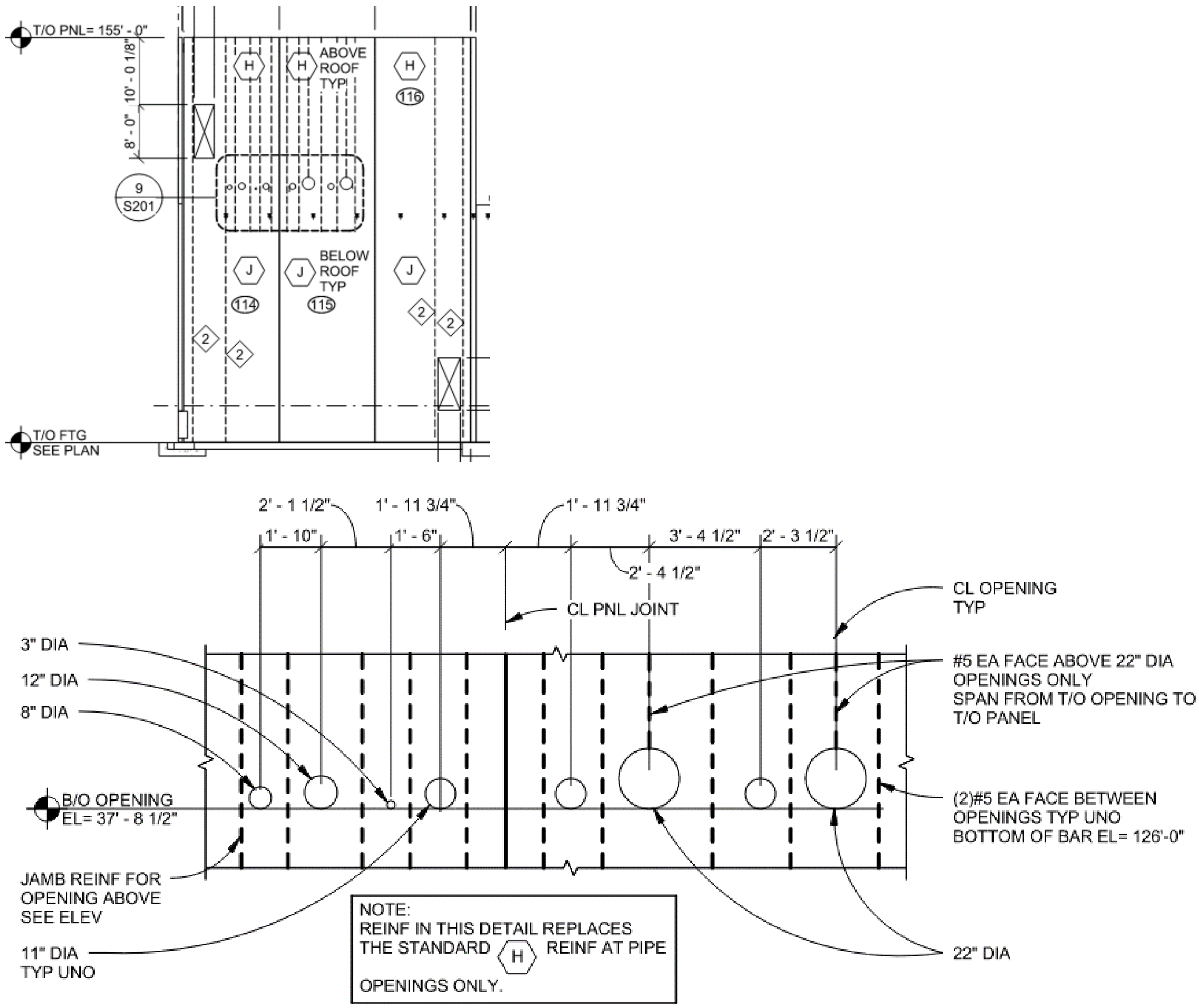


Fig. 34, Panel with formed pipe openings

With a general understanding of how panels are built, the construction sequence can be discussed. Tilt-up wall panels are generally poured on a concrete slab on ground. Fig. 35, Often, this is the slab-on-grade for the building. However, slabs may be poured solely for use in panel construction. **These are known as mud slabs or casting slabs.** They are temporary, and can be poured as thin as 3 inches.

Fig. 35, Sequenced panel construction:

1) **Casting slabs-on-grade ready for panel formwork (foreground right),**
2) **Panel formwork and reinforcing on casting slabs (upper right),**
3) **Erected and braced panels (left)**

If panels are cast on building slabs, or if, in addition, the crane will drive on the slab, there are a few things to think about. Slab thickness may certainly be controlled by the loads induced by a large crane weighing up to 140 tons. Some pros/cons from Smith:

Cons:	**Possibility of slab damage**
	Space planning and slab usage
	(Did I mention slab damage)
Pros:	Smooth work surface
	Better visibility for operator and crew
	Crane usually moves quicker

To the above, it should be added that if the building slab is used for panel pours, and the foundation is dropped for frost or grade differential, **a pour strip, a.k.a closure strip, may be required**. This is a continuous slab leave-out several wide feet used where the walls are to be placed. This allows for wall panels to be placed on foundations at an elevation several feet below the slab (frost footings, loading dock). This presents the additional step of final grading, compaction of the soil, and pouring the slab at the leave out after wall panel erection (Fig. 36). This can be avoided by: 1) the use of a foundation wall that terminates near the slab elevation, or 2) Placing the wall panel prior to pouring the building slab.

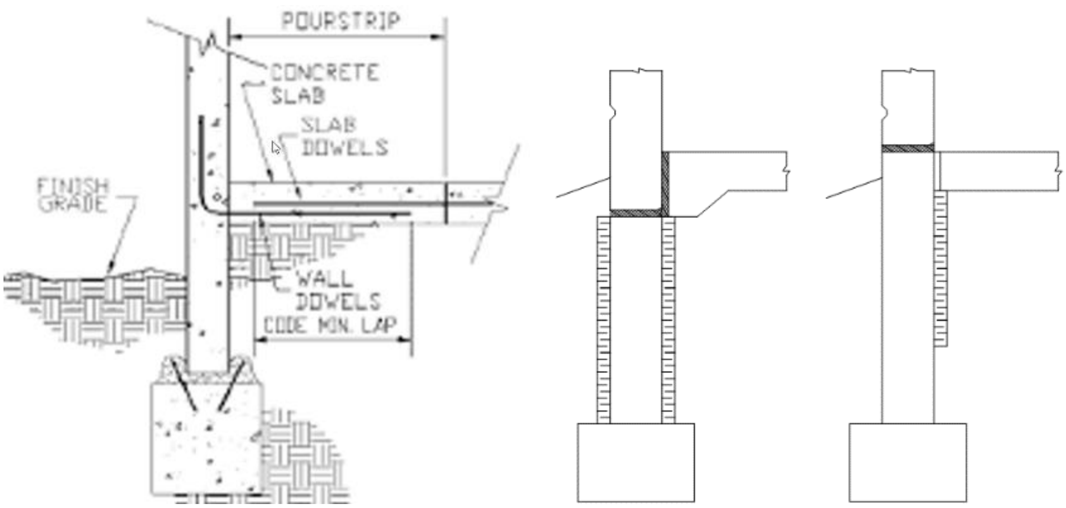


Fig. 36, Pour strip (left); Avoid by using one of the foundation walls at right

The sides of the panels are constructed using formwork. The formwork is most commonly wood that is sized conveniently for nominal dimension lumber (2x8, 2x10, etc.) or ripped to a specific size. The forms are braced around the perimeter to maintain stability during concrete pours. Openings in the panels are built the same way. (See Fig. 37). Reinforcing is held up by chairs (Fig. 38).

Fig. 37: Wood forms for tilt-up panels

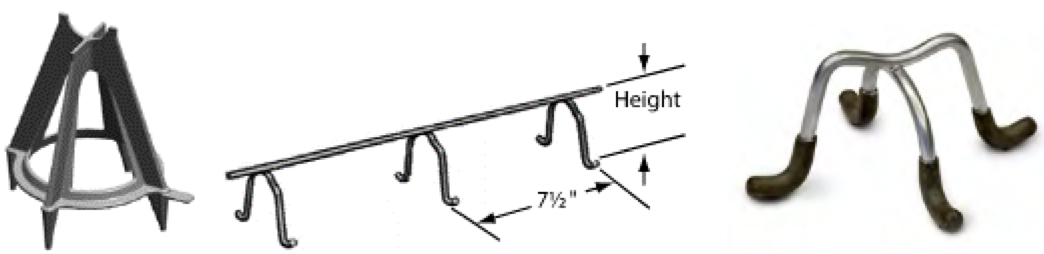


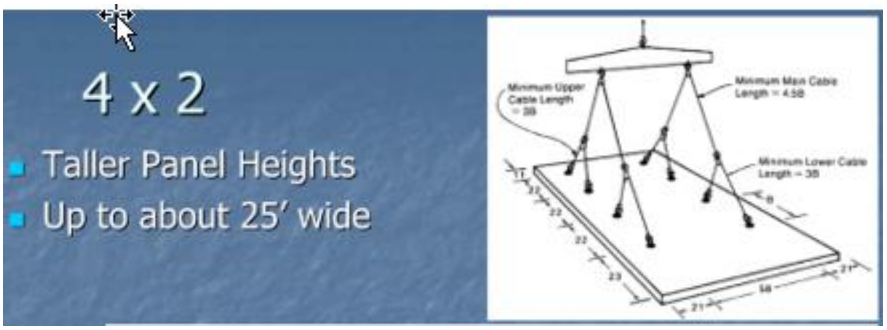
Fig. 38: Rebar chairs (Dayton Superior)

To allow the formwork to pull away from the wall panels and to ensure the panels will easily lift off of the slab, form release agents are used. These keep the wood form and panel from sticking to one another, and also prevent the concrete base slab from ahdering to the panel poured against it. The form release agent must work well with the curing compound of the slab it is poured on, and it must be readily cleaned before the slab is prepared for use.

The self weights of individual panels needs to be less than the working load of the crane being used by the contractor for the reaches that will be required. If a larger crane is required, the cost, schedule and availability of the crane needs to be accounted for. See rules of thumb in Fig. 55.

The lifting cables of the crane are attached to cast-in inserts that are normally in the upward facing face of the panel. This is called a face lift. Alternately, an edge lift may be used, where lifting inserts are attached to the top edge only. Figs. 39a & 39b show typical inserts used at pick points, and Figs. 40a & 40b show two varieties of picks.

Figs. 39a & 39b: Lifting insert (CMC Construction Services, https://www.cmc.com/en-us/what-we-do/america/construction-products/tilt-wall)



Figs. 40a & 40b, Two of the many types of crane picks (Smith)

Some panels require strongbacks at panels that are not strong enough under self weight on their own when being picked up and carried into place. See Figs. 41 & 42.

https://commons.wikimedia.org/wiki/File:Tilt_slab_construction.jpg Duk at English Wikipedia, CC BY-SA 3.0 <http://creativecommons.org/licenses/by-sa/3.0/>, via Wikimedia Commons

Fig. 41: Strongbacks attached to panels

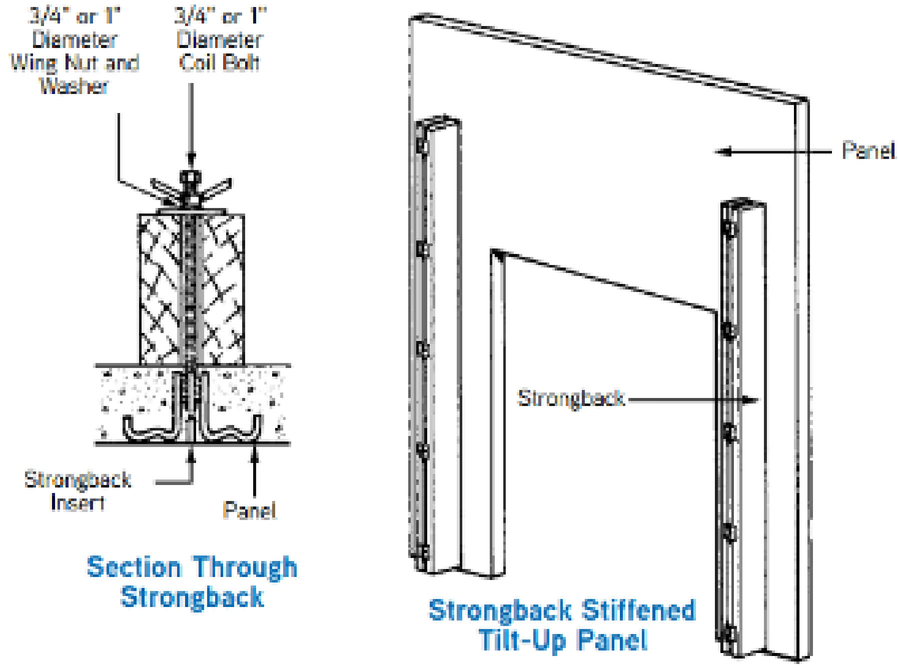


Fig. 42: Strongbacks (CMC Construction Services, https://www.cmc.com/en-us/what-we-do/america/construction-products/tilt-wall)

Once panels are stood up straight, braces can be attached. (Fig. 43). These braces serve to stabilize panels in the wind. Varieties of braces are shown in (Figs. 44a & 44b). Brace design is done by the panel supplier.

Fig. 43: Braces for two-story panels with a second story gym with large openings

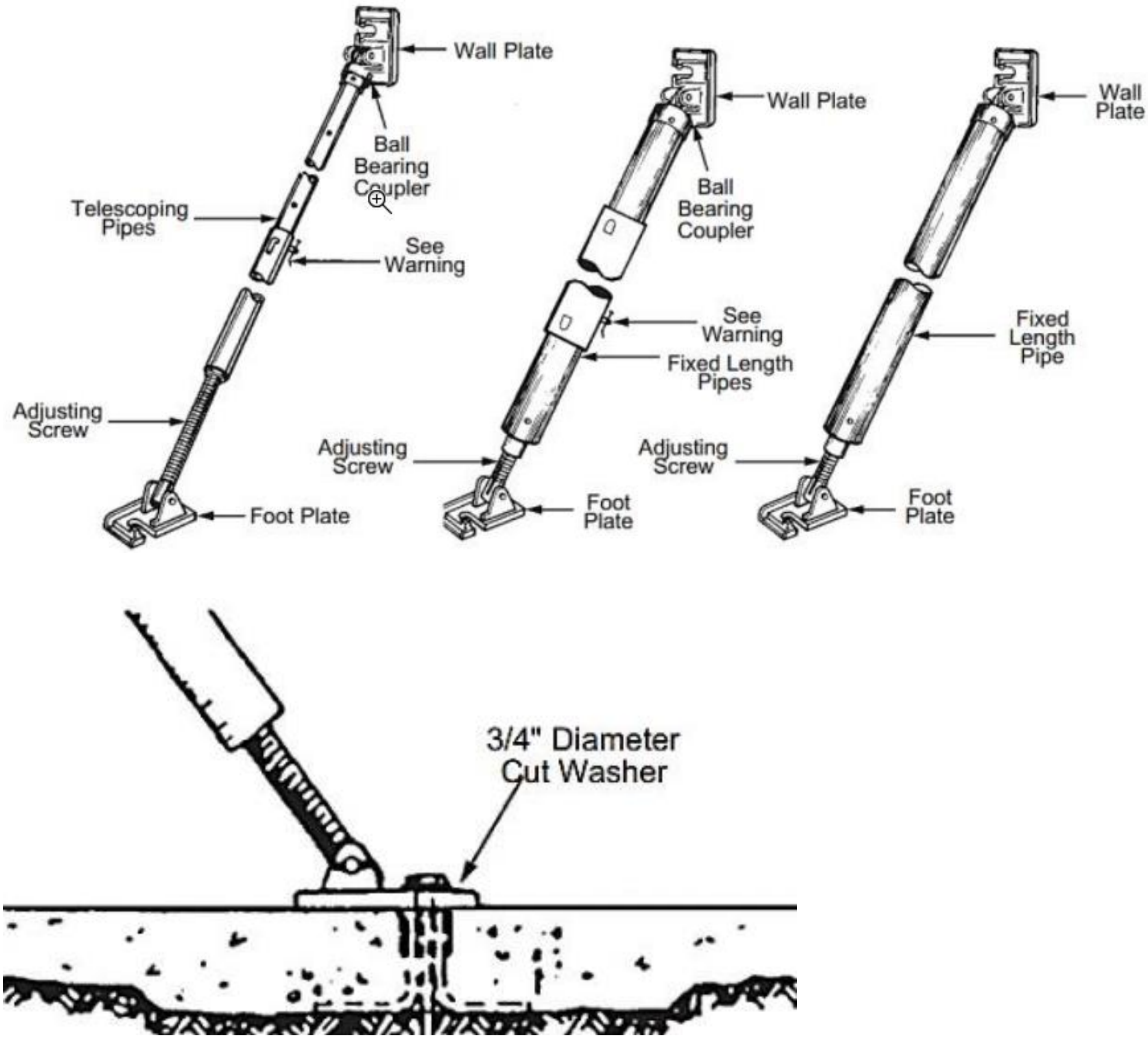


Fig. 44a & 44b: Braces and anchorage(CMC Construction Services, https://www.cmc.com/en-us/what-we-do/america/construction-products/tilt-wall)

Panel bracing can be can be a challenge. In a building that the author worked on, the standard practice of one wall panel supplier was to use an array of jersey barriers to resist brace forces. These are 5’x5’x5’ solid concrete blocks that act as deadmen to brace against, taking advantage of their sheer bulk weight. The contractor was going to need to significantly change the way they worked around the building with the jersey barriers and braces in the way around the perimeter. Add to this the logistics and costs of shipping and moving large concrete blocks for a 468,000sf building pad, and the field team was looking for alternatives. They proposed bracing the wall panels to the robust warehouse slab on the inside of the building. The slab was poured early, and it was well-designed to handle high-demand warehouse loads, so it was ready made for this purpose. The approach was agreed to by all parties, and the project benefited from time and money saved. Removable anchors were used for the braces, and the holes were patched.

Helical piers can also be used to anchor braces to the ground. (Fig. 45). These screw into the ground a set distance and targeted torque, are able to resist both push-down and pull-out, and are removable. One resource for these is https://intechanchoring.com/ab-chance/helical-piles/

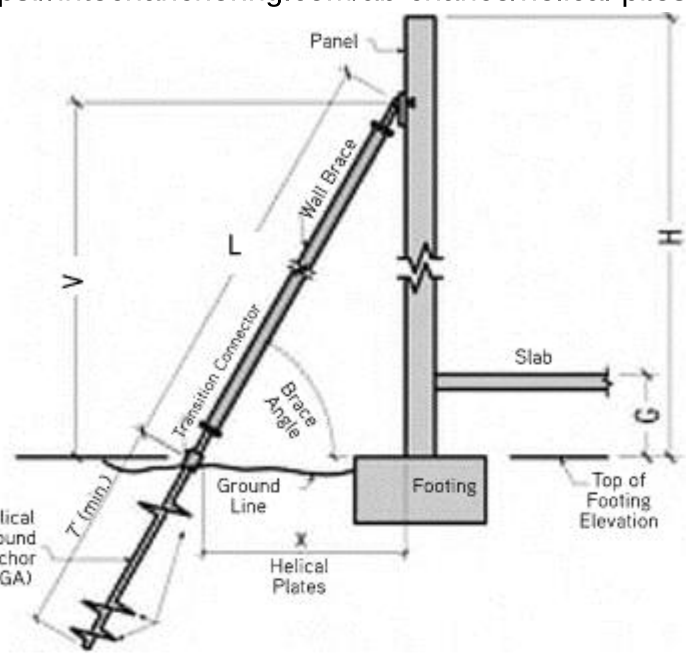


Fig. 45: Brace attaching to Helical Anchor in ground (Dayton Superior)

Panel braces should not be removed until the roof or floor deck that the walls attach to is fastened sufficiently in place to a roof or floor lateral resisting system that is adequate to handle lateral loads during construction. (Fig. 46)

Fig. 46: Roof steel being erected with braced panels: Panels to remain braced until roof deck fully welded to steel joists and walls for diaphragm action.

Tilt-Up Considerations:

1. Careful planning is required to identify a strategy to cast and erect panels on site. Often, site space is limited. Looking at Figures 47 through 49, to erect a building shell, a pour and erection sequence needs to account for:

a. available lay down area,

b. while allowing for room to move a crane around and pick up panels,

c. and place them in order

d. so the bracing can follow behind the travelling crane.

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Fig. 47: Building shell

Fig. 48: Lay down area

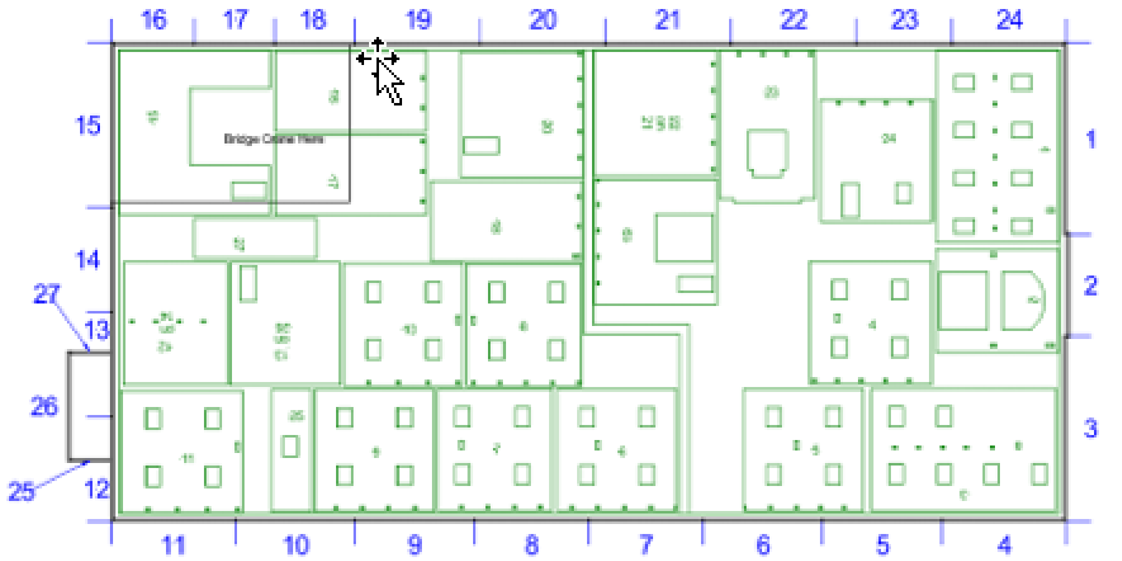
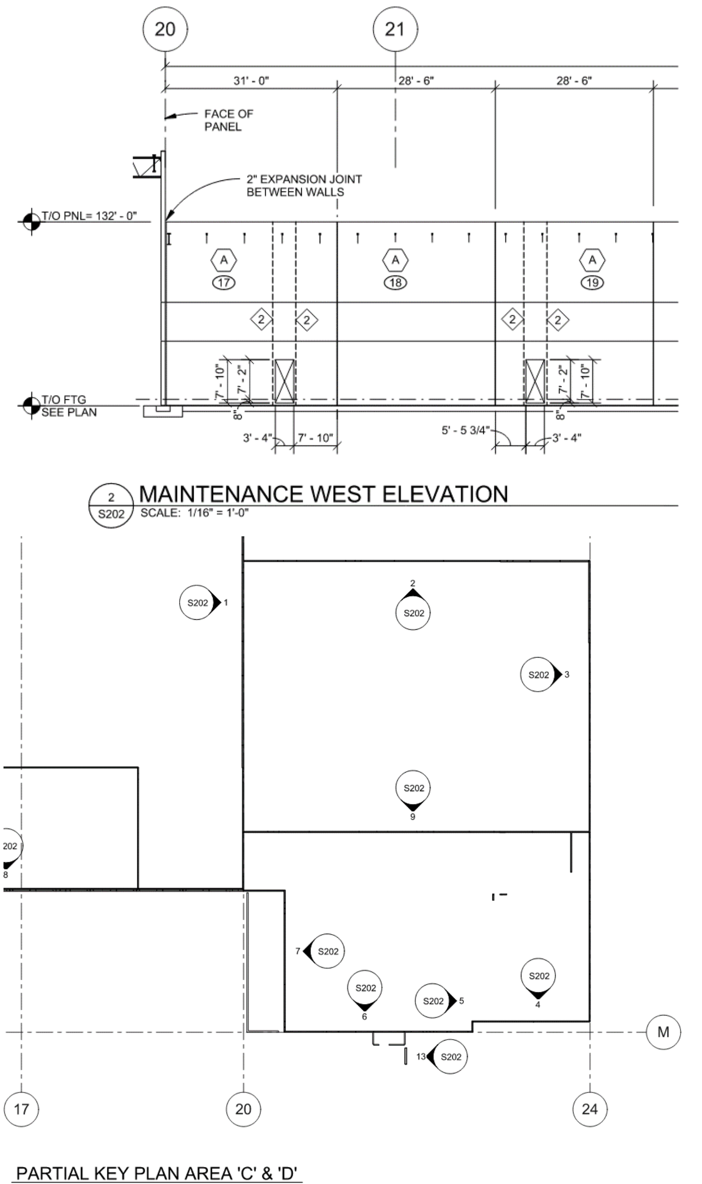


Fig. 49: Lay down plan and sequencing

This can be a major challenge for the panel supplier. If the building slab is too small, and casting slabs can not be used, sometimes panels are stacked to save room Fig. 50.

Photograph by Bill Bradley. billbeee 06:27, 13 June 2007
CC BY 2.5, https://en.wikipedia.org/w/index.php?curid=11742698
Fig. 50: Stacked panels

Once the wall assembly and roof/floor and parapet heights are known, panel heights can be chosen. The long walls of the building can then be divided into separate panels. Elevations for each side and articulation of the building are drawn. Figs. 51a & 51b. Panel sizes are usually chosen in a way that maximizing the lift capacity of the crane. **The fewer the pieces, the lesser the erection time**. Panelization will need to factor in the locations of punched openings. See Fig. 52 for some recommendations on panels.



Figs. 51a & 51b: Sample elevation and key plan

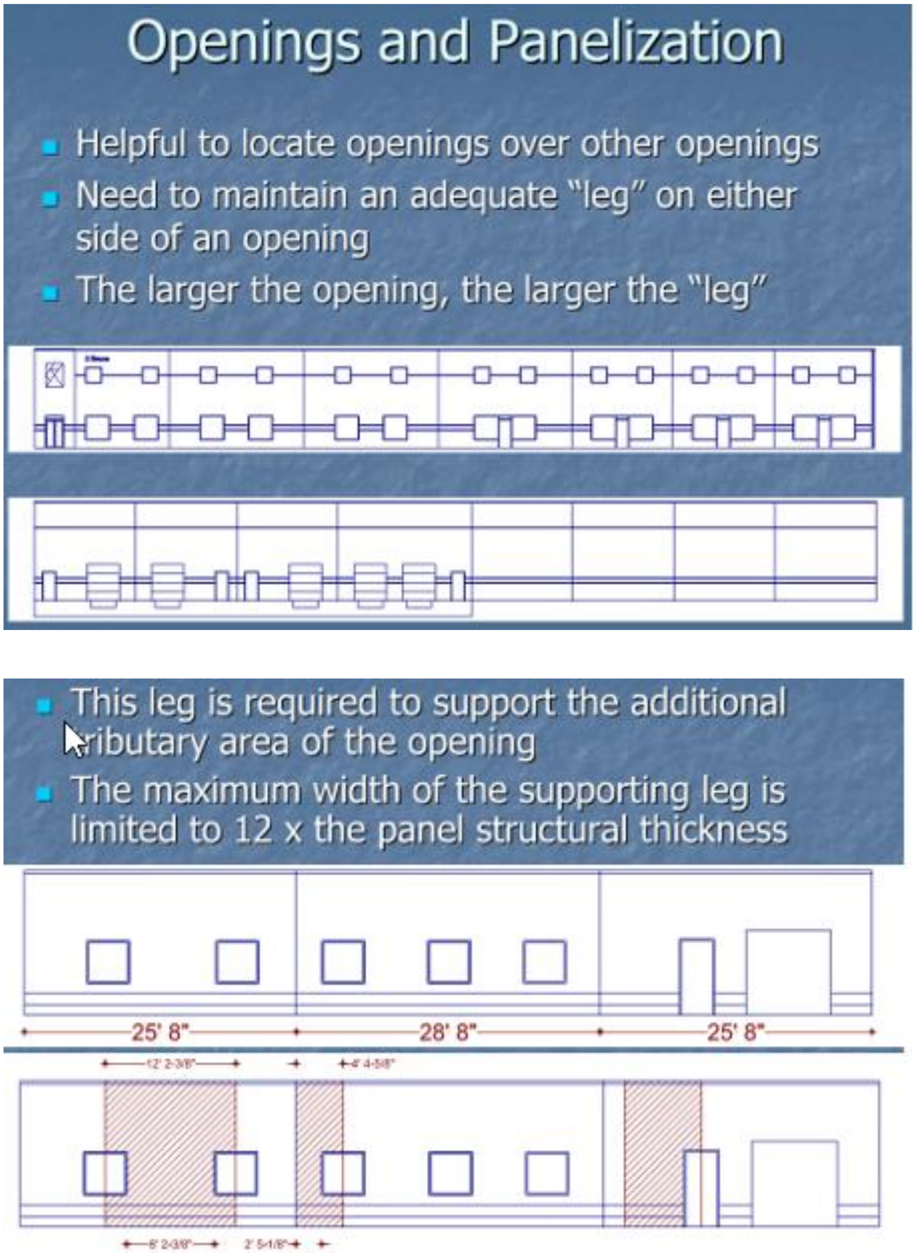


Fig. 52, Guidance on panelization (Smith)

Other guidelines are shown in Fig. 53.

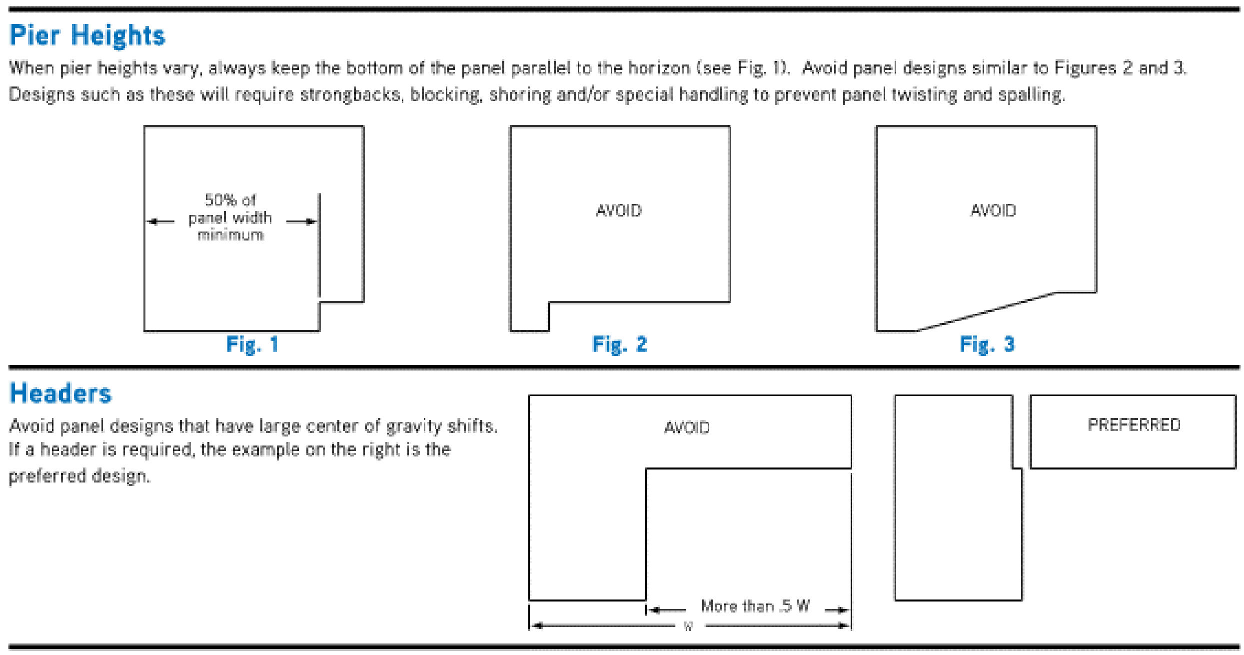


Fig.53: Panel shape recommendations (Dayton Superior)

Wall panel suppliers will create a panel book, where they detail information about each panel for the construction phase (portion shown in Fig. 54), including:

a. Lifting weights, pick/insert locations
b. Bracing info
c. Statement that reinforcing is adequate or added reinforcing for erection
d. Strongbacks
e. Panel insert, spreader, and cable info
f. Height, width, center of gravity of panel, thickness, panel number

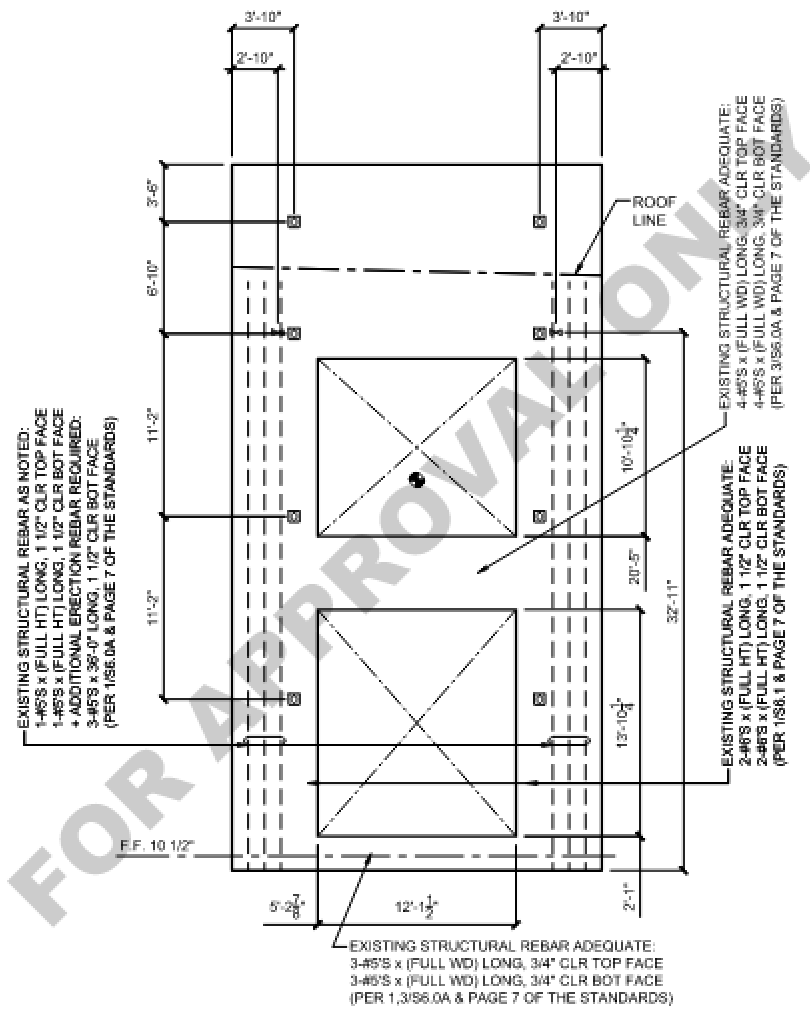


Fig. 54: Image from a panel book

One of the first questions upon starting a project is the type and specifics of the crane that will be used for the project.

Besides being a building owner of two- and three-story fitness centers throughout the United States (and a few in Canada), the author's current employer is also the general contractor on most of its projects. Conflicts on multiple concurrent projects forced the in-house construction team to find a very large crane on short notice. The only suitable one available in the country that could be found was a Japanese crane. All of the controls and specs for the crane were in Japanese. A Japanese translator was hired to interpret anything the crane operator and crew needed, so was continually present during crane operations.

Some rules of thumb are shown in Fig. 55. **Practical limits for panel weights are in the range of 80,000#,** but this is only for larger cranes. Crane types are shown in Fig. 56a & 56b.

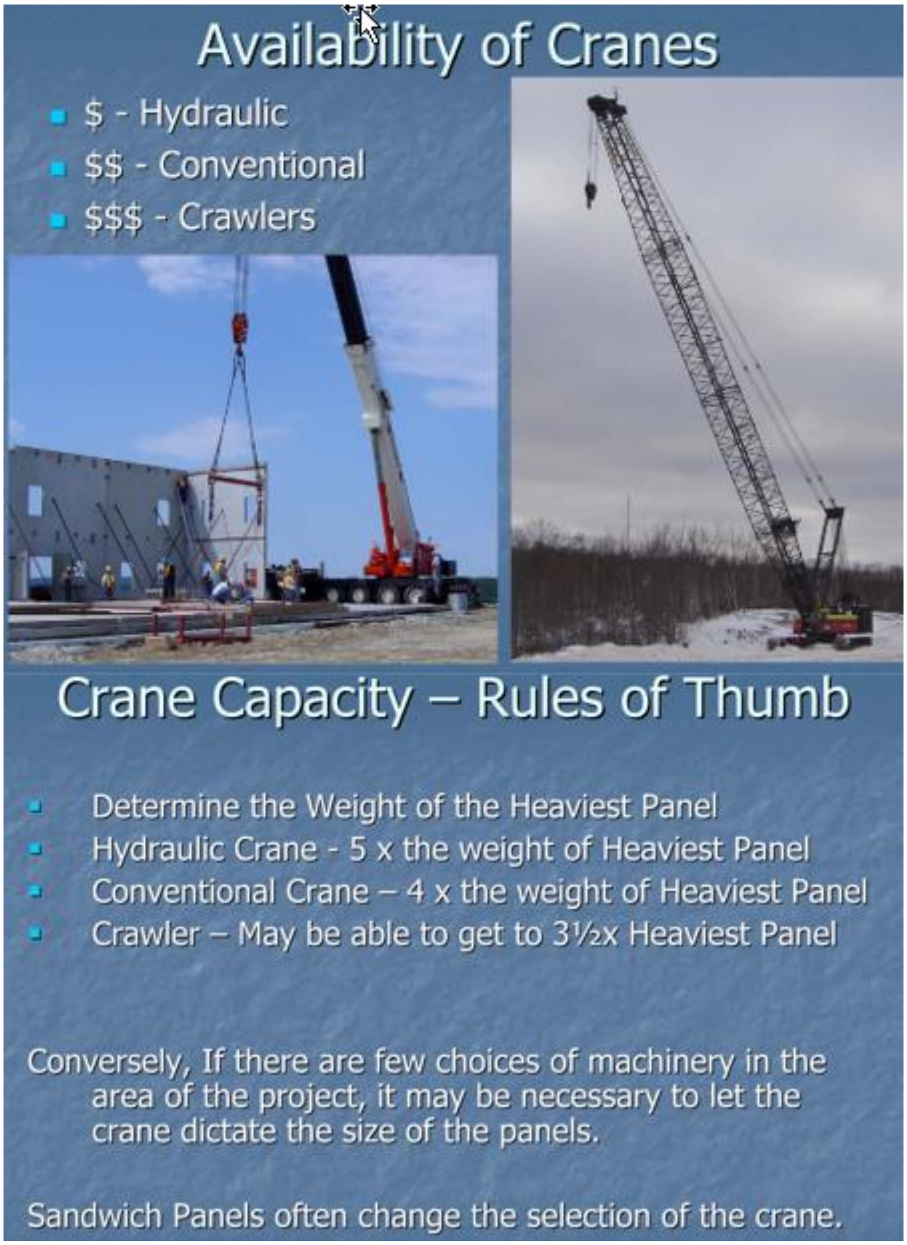


Fig. 55, Crane guidelines, (Smith)


(Author)


https://commons.wikimedia.org/wiki/File:09550jfSanta_Lucia_Tomas_San_Luis_Taruc_Park_Roads_Pampanga_Landmarksfvf_07.jpg

Figs. 56a & 56b: Crawler crane (above) and hydraulic crane (below)

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