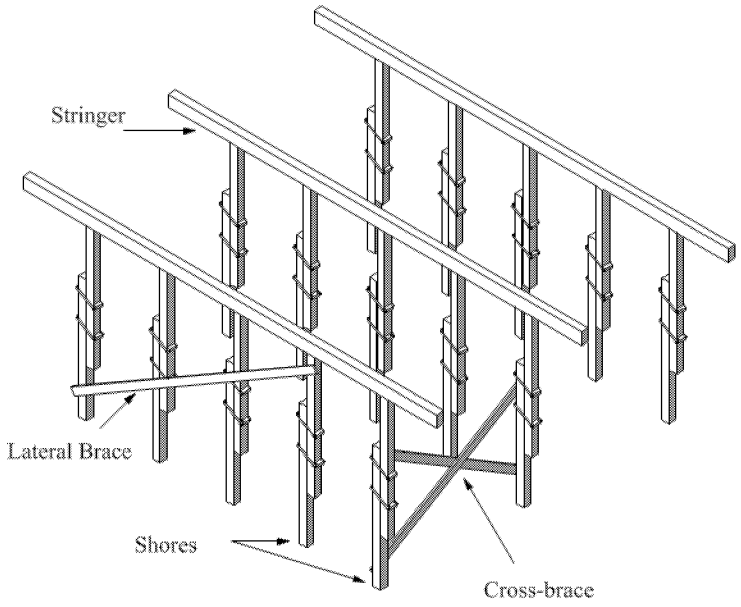
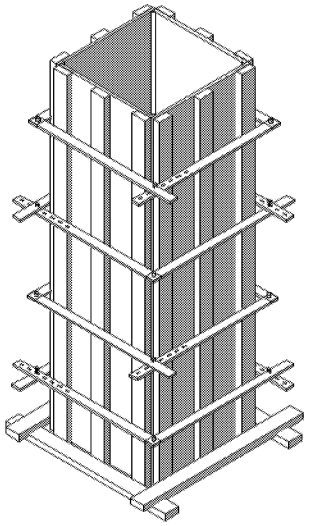
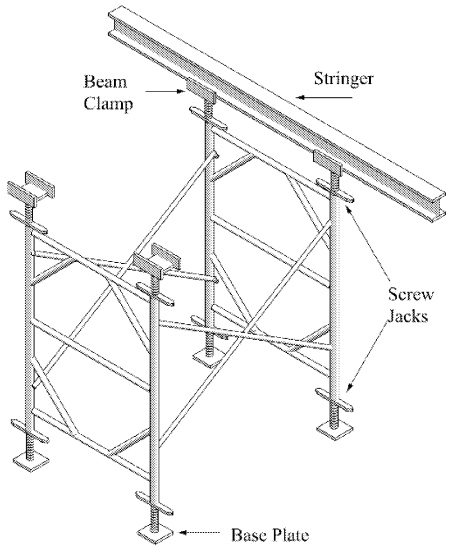
COMMERCIAL CONCRETE

018







CARPENTERS TRAINING COMMITTEE FOR NORTHERN CALIFORNIA

Carpenters Training Committee for Northern California (CTCNC)

CARPENTER APPRENTICESHIP PROGRAM

Course of Instruction

(For indentures after 03/01/09)

Year	Class#	Class Title (All classes 36 hours - Four (4) Days - 7:00am - 4:30pm)
1	000	❶ Introduction to Apprenticeship, *Fall Protection, *Scaffold User Safety
	004	Foundations & Floors
	005	Blueprint Reading – Basic & Union Benefits Presentation
	006	Wood Framing
	007	Concrete Formwork
2	008	Exterior Finish
	009	Blueprint Reading - Advanced
	010	Concrete Bridge Building
	011	Interior Finish
3	012	Layout Instruments
	013	Engineered Structural Systems
	014	Commercial Steel Framing
	015	Stair Building
4	016	Roof Framing
	017	Introduction to Welding & Cutting
	018	Commercial Concrete
	019	Rigging
	020	Commercial Door Hardware

❶ Required for Apprentices indentured through "exceptions".

018

COMMERCIAL CONCRETE

Carpenters Training Committee
for Northern California

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Microsoft Word™ 14.3.1
PhotoShop™ 10.0
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MOS™ 10.5.8
VectorWorks™ 13
FrameMaker™ 7.0

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COURSE OBJECTIVES

At the completion of the course, the student will be knowledgeable about the layout and construction of bolt patterns, concrete columns and gang forms. In addition, the student will be familiar with the types and methods used to safely build, shore and place column caps and concrete decks. The student will demonstrate the ability to complete various tasks essential to commercial concrete construction.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1. Read a set of commercial prints and lay out job grid lines
2. Construct a bolt pattern and place it at the proper location and elevation
3. Build, set and brace a round fiber form column at the correct location
4. Build, set and brace a square wood column at the correct location
5. Assemble, set and brace a wall using composite metal/plywood panels
6. Erect, line and brace a section of Alumawall with taper ties and strongbacks
7. Identify the components of a traditional wood-shore deck system, including Ellis shores, stringers, joists and deck plywood
8. Construct a wood shore deck with column caps included
9. Assemble a steel post shoring system and set it to the correct elevation
10. Identify the safety hazards of silica and the corrective measures to mitigate the danger
11. Correctly calculate the amount of concrete needed for various forms
12. Exhibit safe work practices in the stripping and storing of forms

CARPENTERS GRADING AND EVALUATION SCHEDULE

Grading

A uniform weighing system will be used as follows:

1. Class Participation and Attitude…….. 10%
2. All Tests Except for Final Exam……. 10%
3. Manipulative Lessons…….. 50%
4. Final Exam…….…….. 30%

Assignment of grades will be as follows:

1. 92-100% = **A**
2. 82- 91% = **B**
3. 73- 81% = **C**
4. 68-72% = **D**
5. Less than 68% = **F**

018 - COMMERCIAL CONCRETE

PRE-TEST

Instructions: In the following true/false questions, circle the correct answer.

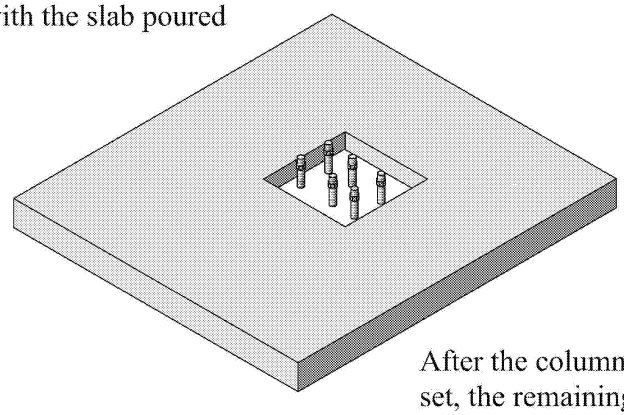
1.	T	F	Falsework is the temporary shoring that is used to support a concrete deck.
2.	T	F	Wood shores are generally 6 x 6s.
3.	T	F	Crushed rock is used to fill in the space between the top of the pier and the bottom of the column base plate.
4.	T	F	The bottom of a column form is held in place with a wooden collar.
5.	T	F	The formula for volume is length times width.
6.	T	F	Silica is harmful as both a solid and a dust.
7.	T	F	Gang panels are most efficient when used to construct low walls covering small areas.
8.	T	F	The metal pins that join together metal framed, plywood faced panels are known as wedge bolts.
9.	T	F	Unreinforced concrete is very strong in resisting tension.
10.	T	F	Pre-tensioned concrete is generally produced in a casting yard.
11.	T	F	Designing deck formwork is a relatively easy task that does not require the services of a professional engineer.
12.	T	F	A flat slab floor system is supported on columns with drop panels and capitals.
13.	T	F	Accuracy is not necessary when setting bolt patterns.
14.	T	F	A construction joint is formed when fresh concrete is placed against already hardened concrete.
15.	T	F	Most gang forms are lifted into position with a crane.
16.	T	F	A post clamp (Ellis clamp) is used to connect two post shores together.
17.	T	F	Stripping forms can be a hazardous procedure.
18.	T	F	A cubic yard contains 9 cubic feet.
19.	T	F	Waterstops are thin pieces of rubber or plastic placed across a construction joint to prevent water leakage.
20.	T	F	Prestressed concrete is made by adding tension to the concrete.

INTRODUCTION

As a union carpenter, a major part of our work is in the commercial concrete classification, with many apprentices involved in this kind of work. This includes tilt-up buildings, bridges, parking structures, multi-storied concrete buildings, tunnels and a host of other projects. In previous classes the student has learned the basics of formwork and has built a section of a freeway overpass. This class will cover the setting of bolt patterns, building of concrete walls with gang forms and the erection of various concrete columns. In addition, the student will learn to build deck forms and the falsework that supports the concrete deck.

After the site work is completed, the carpenter begins work on the foundation of the building. This usually includes footings and the preparation of the slab on grade. On large projects such as an overpass or a large building, concrete piles may have been driven many feet below the ground to provide adequate support for the massive weight of the structure above. Before the slab is poured, the locations of all columns are laid out and footings for the columns, called piers, are poured. When the columns are going to be tube steel or structural steel, anchor bolts are embedded into the footing at the correct height and location. Later the column will be connected to the bolts on the pier.

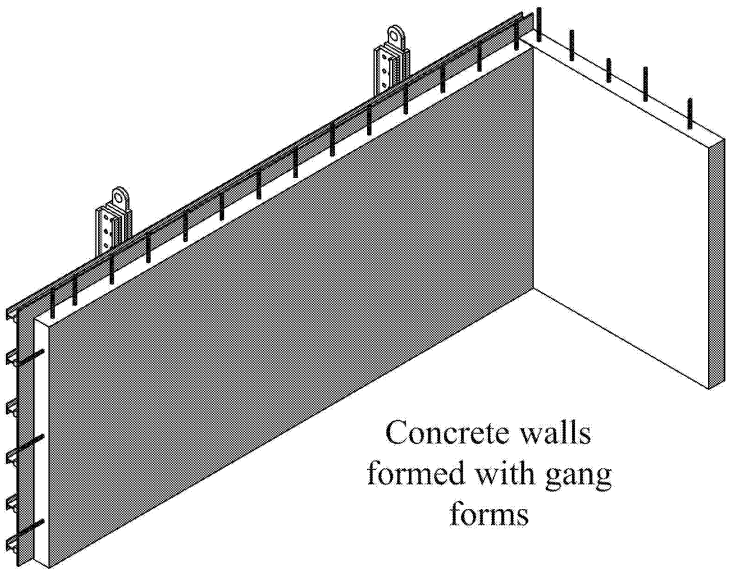
This shows the exposed anchor bolts extending from the pier footing with the slab poured around it.



After the column is set, the remaining slab area will be filled in

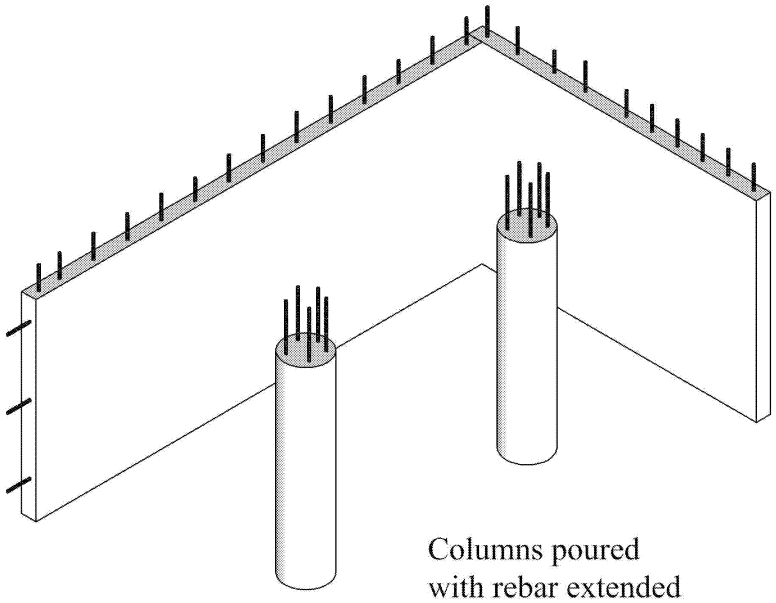
Once the slab is poured, the forms for the exterior and interior walls can be set. If the columns are to be made of concrete, work on forming the columns can also be done.

The forms for the walls are often done with the use of large sections of formwork known as gang forms. The student will be using this type of form for the project to be built. These gang or panel forms are made to be reused many times, particularly on a building with multiple stories having the same dimensions. Walls need to be straight and strong enough to contain the fresh concrete.



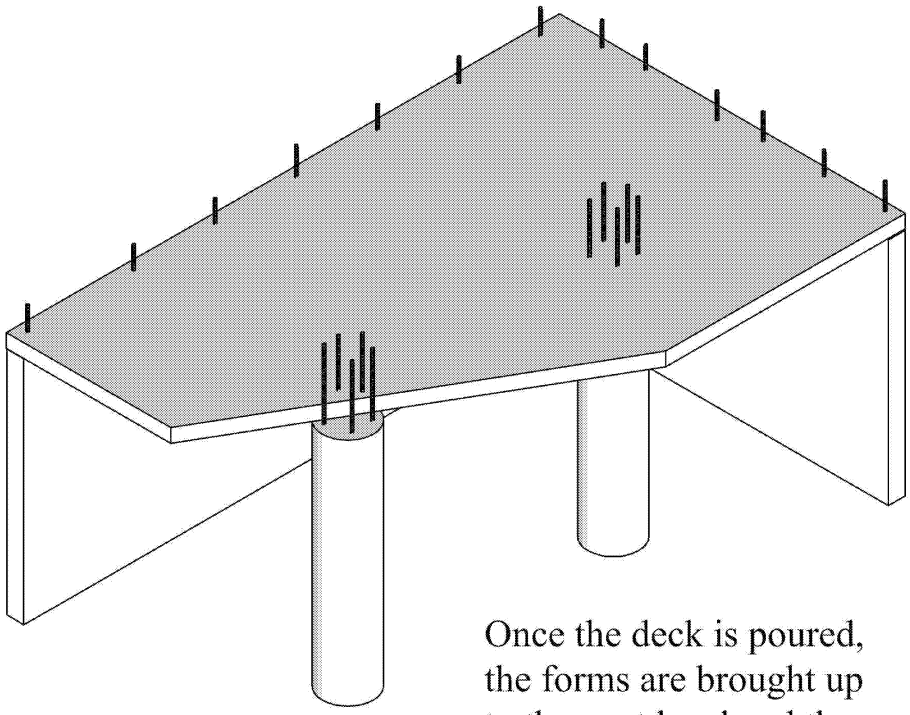
Concrete walls formed with gang forms

Concrete columns support the dead and live load imposed by the floor above. Columns can be built to various designs including square, rectangular and round. Column forms need to be placed in the correct location, braced in two directions and secured at the top and bottom. An engineer calculates the weight and stresses placed on the columns, and from that, decides how many and what size columns are needed.



Columns poured with rebar extended to continue through the next floor

Once the walls and columns have been poured, the work on the deck slab can be done. The slab will be supported by shoring, which is covered with plywood to form the bottom of the slab. The student will work with several kinds of shoring including wood and metal. The finished slab is allowed to attain a certain strength, and the falsework is removed. The process is then repeated on the next floor.



Once the deck is poured, the forms are brought up to the next level and the process begins over again

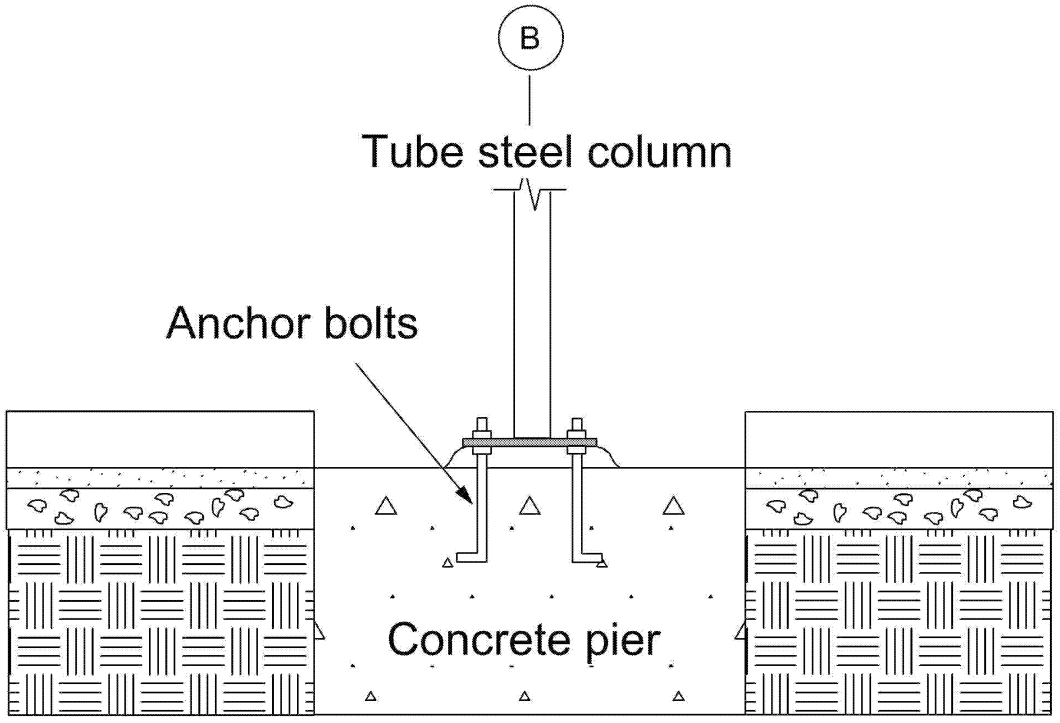
The following chapters and lessons will cover each of these aspects in a more detailed manner. Commercial concrete work involves many safety risks. The forms are heavy and the carpenter may be working high above the ground, so safety considerations must be adhered to and the individual must be aware of their surroundings.

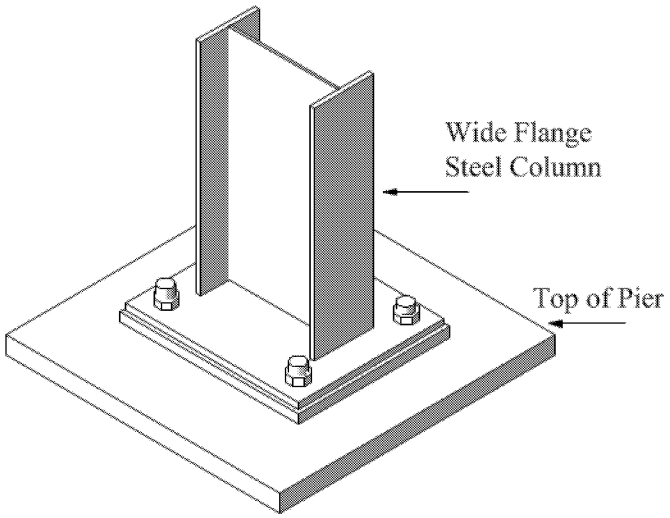
Chapter 1 Bolt Patterns

THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **How are metal columns secured to the foundation?**
- **What is the common layout for bolt patterns?**
- **What is the purpose of the grout?**
- **Why is accuracy needed in setting bolt patterns?**

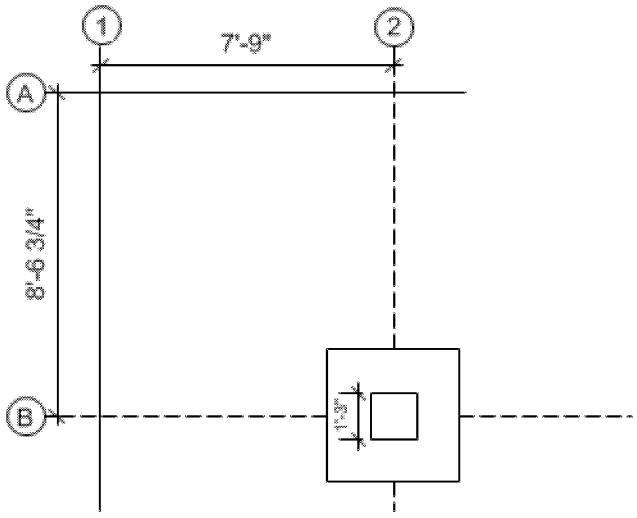
Most modern buildings contain columns that support the weight of the building. Columns may be concrete (discussed in following chapters), a tube steel column designed to support a glu-lam beam that carries the roof load, or it might be a huge wide flange beam the will help carry the weight of multiple stories. All structural columns bear a concentrated load, which means that the load from above is over a specific point. It is necessary to spread that load over a larger area, so concrete piers are used beneath the column to carry the load. Engineers calculate the stress that will be exerted on the column and design a footing that will provide adequate support for the weight from above. The mechanical connection between the concrete and the steel column is usually achieved with the use of anchor bolts. The anchor bolts are embedded in the pier concrete, and the column is later placed on the bolts and secured.





LAYOUT

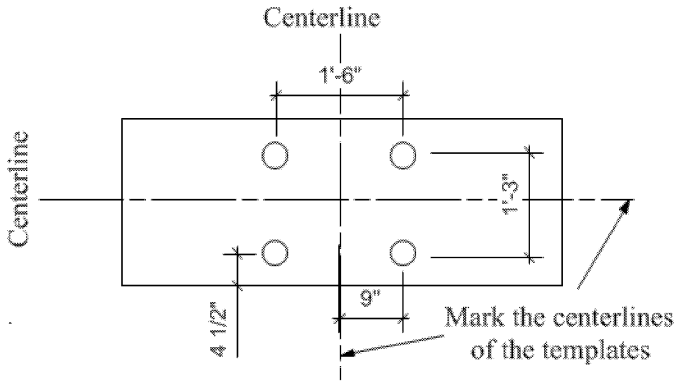
The column is designed for a specific location, so this makes the location of the bolts critical--there is little room for error. Most jobs are broken into a grid system, which divides the layout of the building into smaller increments. The grid operates like the grid on a map. Columns are often centered on a grid line, many are at the intersection of two grid lines.



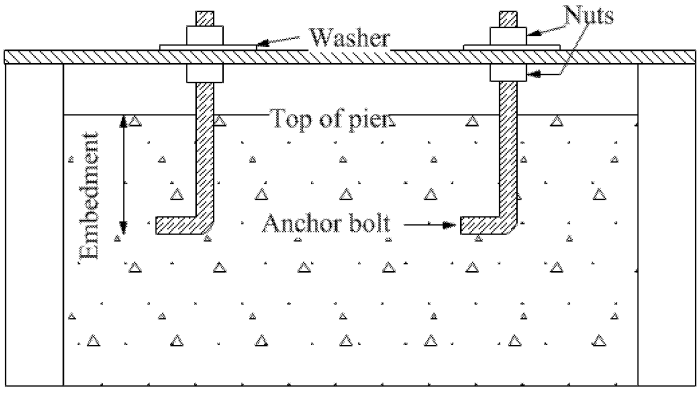
The blueprints or the shop drawings will show the base plate that will be welded to the bottom of the column. This will detail what size holes will be drilled in the base to fit over the anchor bolts. The anchor bolts must be in the correct location, not only to align with the column base, but also to ensure that the column itself is in its proper position. In addition, the bolts must be installed square to the layout lines to be sure that the column is not twisted.

BOLT PATTERN

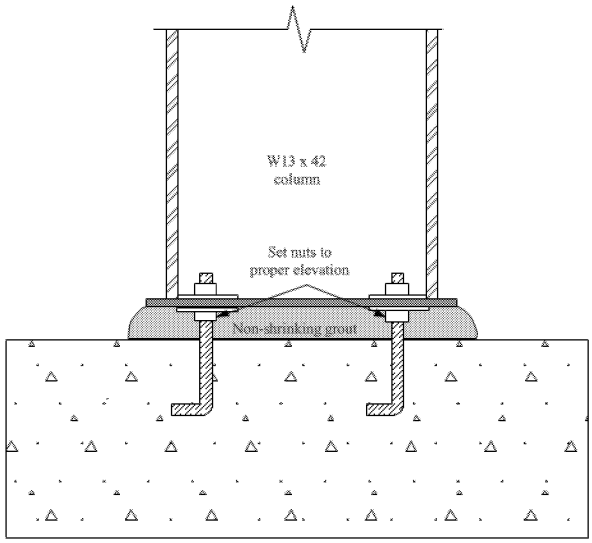
Once the layout of the piers is completed, the carpenter makes a template, or pattern, which is the guide for the bolts. This is usually a piece of plywood that is cut to at least the dimension of the base of the column. It is then drilled with the holes that will hold the bolts. The bolts are then inserted through the holes in the template and a nut and washer are threaded on the end. The template is cut long enough to span from one side of the form to the other.



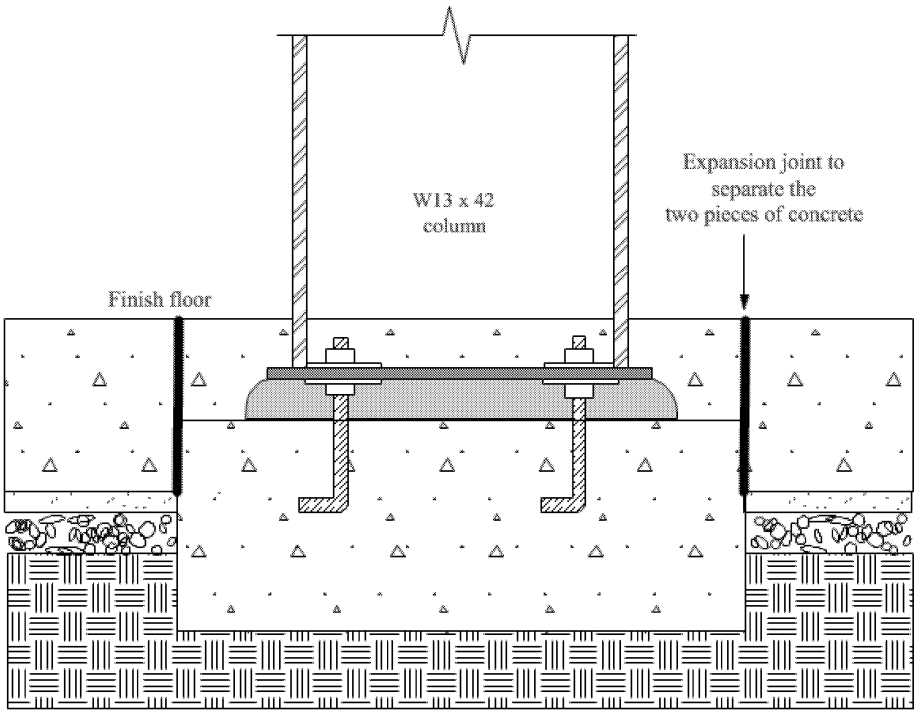
The template is often set above the top of the pier footing. This is because the top of the pier may not be finished level or it may not be set exactly to grade. The bolts should project above the pier by the amount needed to accommodate a nut, a washer and to allow for several inches of non-shrinking grout. To ensure that the column will be plumb when it is erected, the column base must be level and to grade.



The top and bottom nuts help to keep the bolts in place during the pour. For protection, the exposed parts of the bolts are covered with tape or greased up so that the concrete doesn't damage the threads. When the concrete has hardened, the form and the template are stripped. The lower nut remains on the bolts and is set to the exact elevation needed for the bottom of the base plate. Once the column is placed on the lower nuts, and checked for level and plumb, another nut and washer is used to secure the column.



The grout fills the area between the base and the pier. It is a type of grout that does not shrink and thus provides a firm base for the column. The area around the column is not filled until the dead load from above (the roof, for example) is applied. Once the column is set, the bolts tightened and the dead load is in place, the area is then filled in with concrete to make it flush with the finish floor. The area around the column needs to be isolated from the finish floor concrete, so an isolation (expansion) joint is made between the slab concrete and the concrete surrounding the column.



SUMMARY

Carpenters are often required to set the bolts for columns that will provide key support for the building. Accuracy is essential; the bolts must be at the correct location and also be set to the proper elevation. The carpenter uses a bolt pattern to hold the bolts in position during the pouring of the concrete pier. The bolt pattern is removed and the column is installed on the exposed bolts. The space between the top of the pier and the bottom of the base is filled with a non-shrinking grout. Concrete is then poured around the base and brought to the level of the top of the slab.

Lesson 1 Setting a Bolt Pattern

INTRODUCTION

In this lesson you will build and install a bolt pattern

LESSON OBJECTIVES

At the end of the lesson, the student will be able to lay out, build and set a bolt pattern from the information supplied on the plans.

SPECIFIC OBJECTIVES

Upon completion of the lesson, the student will be able to:

1. Read a set of plans to locate the grid lines of the column to be placed

2. Use the information given to build the form for the pier

3. Use the information given to drill the bolt layout on a plywood templates

4. Set the bolt pattern at the proper location and the proper elevation

APPLICATION IN THE FIELD

The accurate layout and placement of bolt patterns for columns is a skill that is a basic part of many commercial buildings today. In commercial concrete work, the foundation and the setting of bolt patterns are done by the carpenters. The responsibility for the bolts being in the right location rest with the carpenters. The setting of bolt patterns requires carpenters that are willing to pay attention to details.

EVALUATION

Each student will be evaluated on their participation in the constructing of the bolt pattern and the quality and accuracy of their work. In addition, a post test will be administered.

INTRODUCTION

In this lesson, two students will work together to lay out and construct a bolt pattern at the correct location as directed by the instructor.

PROCEDURES

1. The instructor will give a pair of students a grid line location for setting a bolt pattern. Using the plan labeled A1, lay out and construct the form for the column pier. Brace the form and check to make sure that it is at the correct elevation.

2. Using a piece of 5/8" plywood, cut the bolt template to the correct size. Carefully lay out and drill the 4 holes for the bolts.

3. Suspend the bolt template over the pier, making sure that the template is centered in both directions on the gridlines. In addition, make certain that the template is squared with the centerlines.

Chapter 2 Columns

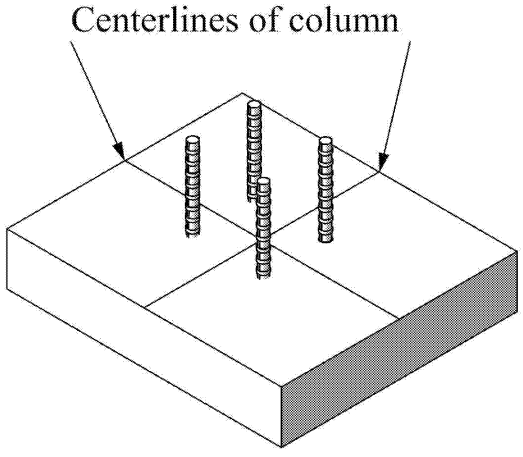
THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **What is the purpose of columns?**
- **How are wood column forms constructed?**
- **How are round columns formed and secured?**
- **What are drop panels and why are they used?**

Columns are structural members that transfer the weight of the structure above to the structure below. In floor slab construction, the columns support the floor above and transfer that load to either the foundation below or to the previous floor. The engineer calculates the size, shape and spacing of the column. The most common column designs that are used in heavy construction are square, rectangular, and round. However, L-shaped and oval columns are also used.

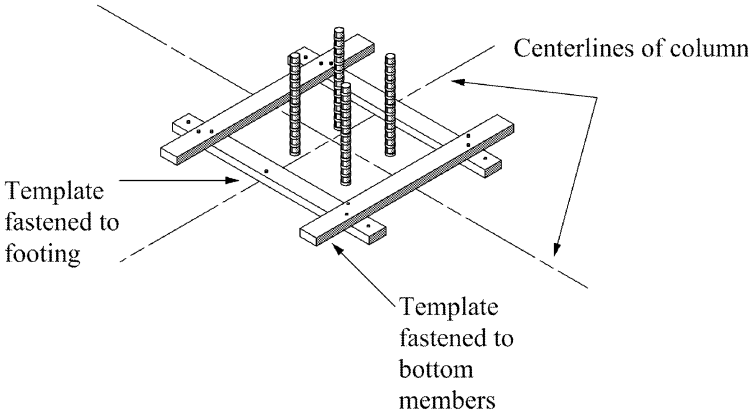
COLUMN FORMS

Forms for columns can be built out of a variety of materials, including wood, metal, fiberglass and tubular fiber forms. All column construction begins with a careful layout of the location of the column using grid lines given on the plans. Since the columns are structural members, they will have a cage of reinforcing steel installed in them to give adequate strength. There is reinforcing steel that projects out of the footing so that the rebar for the column can be connected to the slab or footing below.

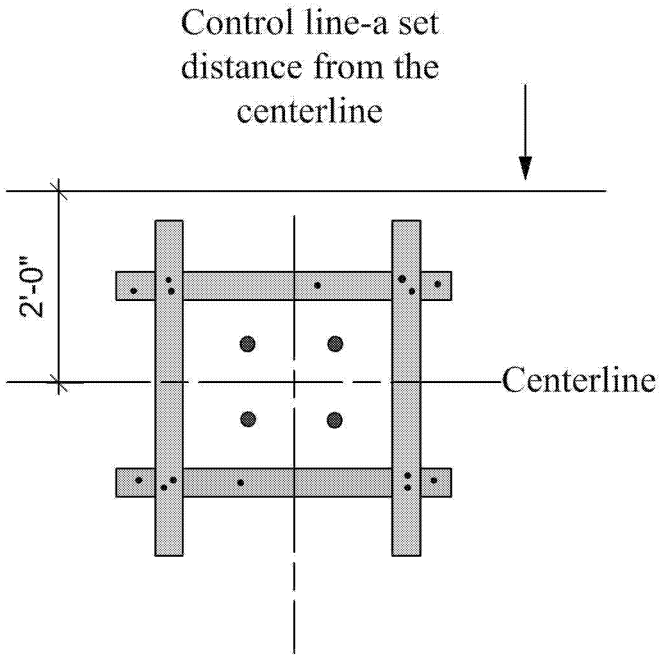


In multi-storied construction, the columns generally continue straight up from floor to floor, so the rebar extends above the floor slab. This way a new cage of steel can be attached to the existing rebar, thus giving a continuous tie from one floor to another.

After laying out where the column will go, the next step is to build a base template to hold the column in place. This is generally accomplished by securing two 2 x 4s to the footing or the slab and then nailing two more 2 x 4s on top of those in the opposite direction.

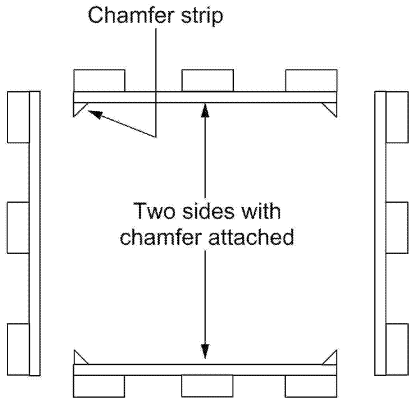


The placement of the base must be calculated to accommodate the form and any stiffeners that will be used. Since columns are generally laid out to their centerlines, this means that once the form is constructed, the layout lines will not be seen. Control lines should be established to ensure that the column remains on layout. A control line is a line that is offset a set amount (for instance, 1') from the original layout and it will remain visible after the form is in place. This way alignment can always be checked.



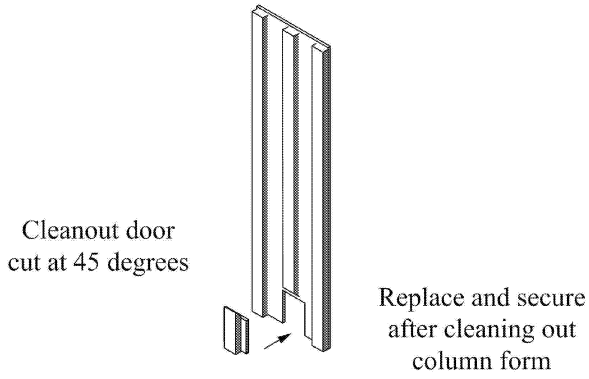
WOODEN COLUMN FORMS

Wooden column forms are made from plywood sides that are stiffened with vertical 2 x 4s that give the form strength. Two opposing sides of the form have chamfer strips nailed to them before assembly because there is limited space to do so once the sides are erected.



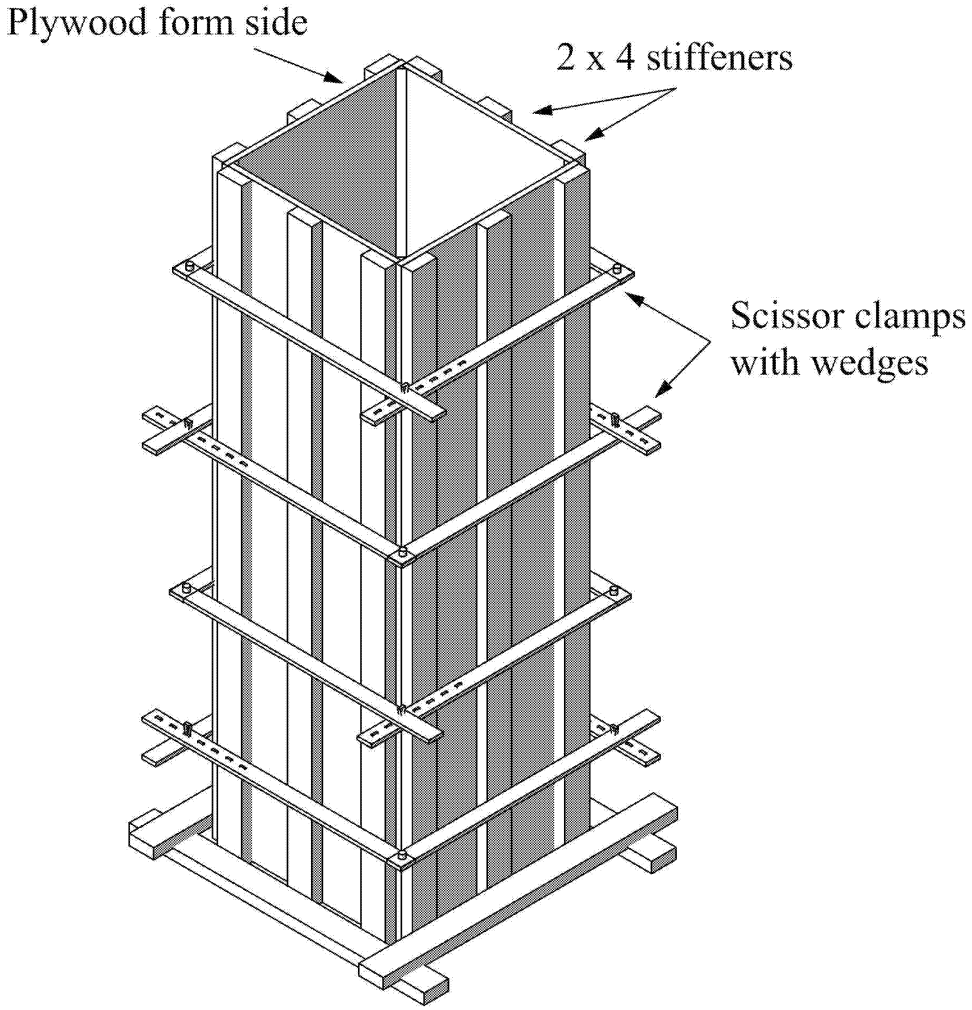
Since the reinforcing steel is usually installed before the form is installed, the form must be built around the rebar. Often, three sides are built, connected and put in place and then the last side is installed.

To ensure that the bottom surface of the column is clean and free of debris, a cleanout door is cut in one side of the form. The cleanout door should be cut at 45 degree angle. Once the form has been cleaned with compressed air, the door is put back in the opening and secured against blowout.



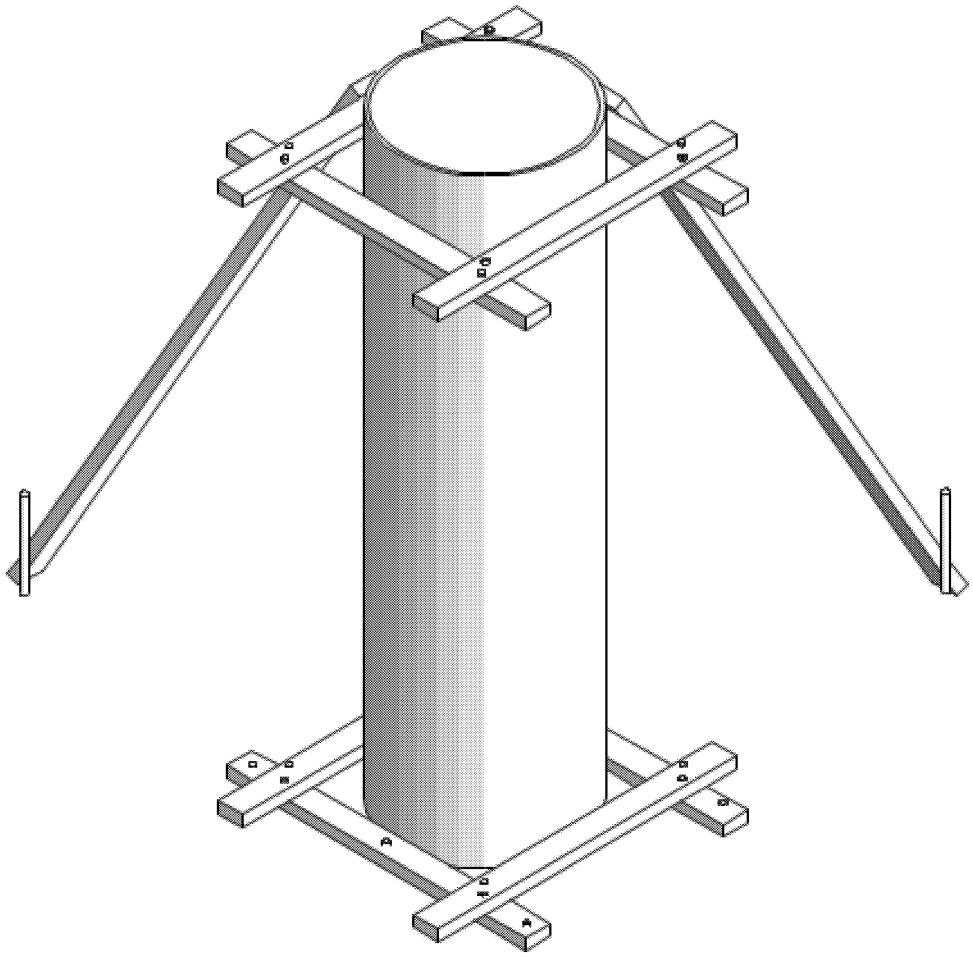
Tall columns are difficult to adequately vibrate, so an opening can be cut about half way up the column. The vibrator can be inserted in the opening to ensure proper consolidation of the bottom half of the column. The opening is then sealed and secured and the rest of the column is vibrated from the top.

Once the form is in place, there are several ways to tie the form together. Wooden collars, similar to the base, could be used and then laced with upright 2 x 4s. The most common way is to use an adjustable metal clamp system (such as scissor clamps) that wraps around the column. The column is plumbed and braced from two directions and then the column is clamped. If the clamps are installed before plumbing, it is difficult to plumb the column.



ROUND FIBER FORMS

Tubular fiber forms are used to form round columns from 6" up to 48" in diameter. The form is made of plies of fiber that are spiraled into layers. The inside has a waxy texture that helps in the stripping of the form. Since there is no opening in the form, rebar is installed before the form is in place; then the form is lowered over the top of the rebar. The bottom is held in place with a wooden base just the same as a wood form. The form is braced by placing a wood template around the top of the form and braces are secured to the template in two directions.

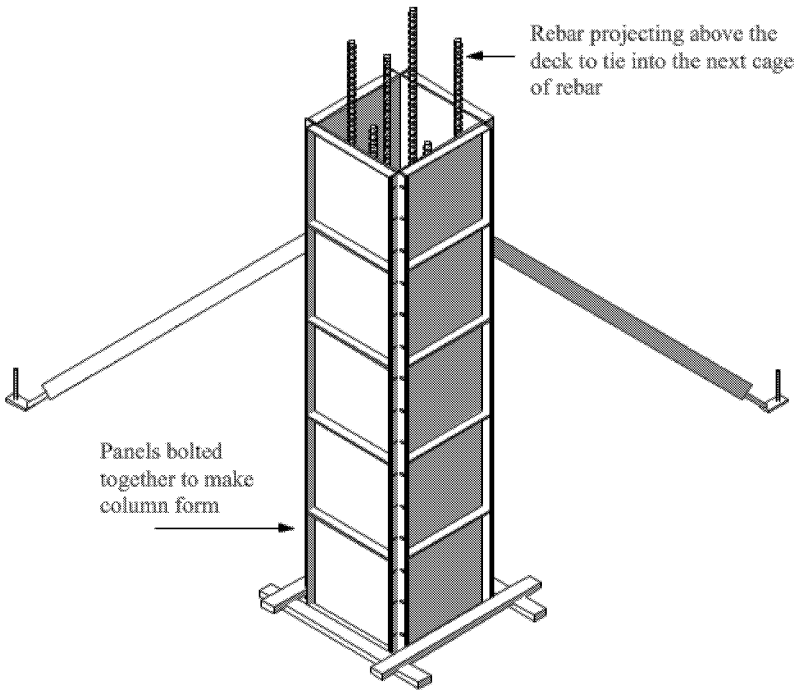


After the column is poured, if possible, the form should be left on for a few days and then removed. The fiber form can be stripped by cutting it with a saw or a knife. Care must be taken to not cut into or mar the surface of the concrete.

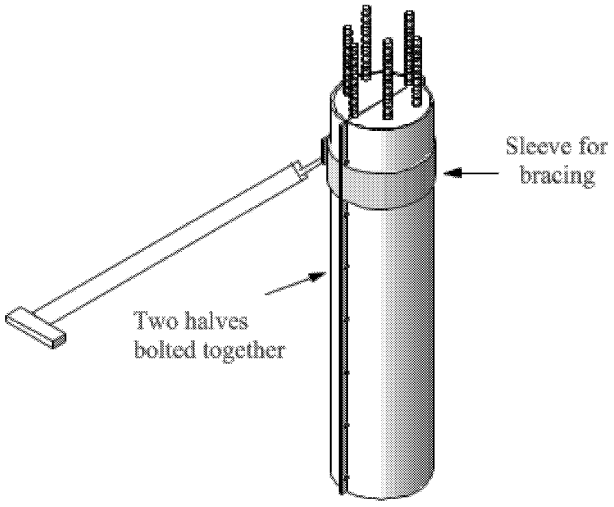
METAL COLUMN FORMS

Metal column forms are used throughout the industry for many reasons. Metal forms are extremely durable and are reusable for many years. Generally, metal forms strip easier and provide a smoother finish than wooden forms. On the other hand, metal forms are more expensive that wooden forms and the weight of the forms often requires them to be placed using a lift or a crane. In addition, metal forms are not as adaptable as wooden forms, which can be made to any dimensions needed. When metal forms are used, the columns for a job often will be all the same so the forms can be used over again from floor to floor.

Most metal column forms are modular units that are bolted or pinned together. There are usually brackets that allow for bracing to be attached.



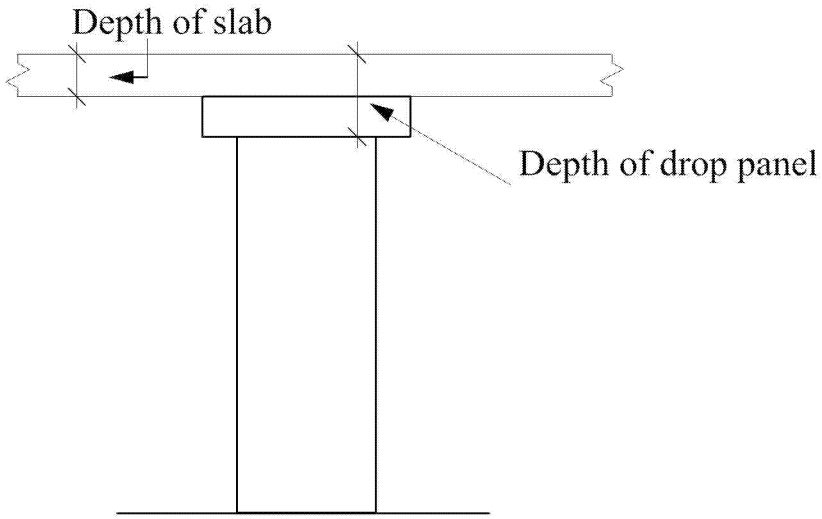
Metal forms are not only used to form square or rectangular columns; round forms can also be constructed. The forms usually have two halves that are placed around the reinforcing and are bolted together through flanges that are part of the form halves.



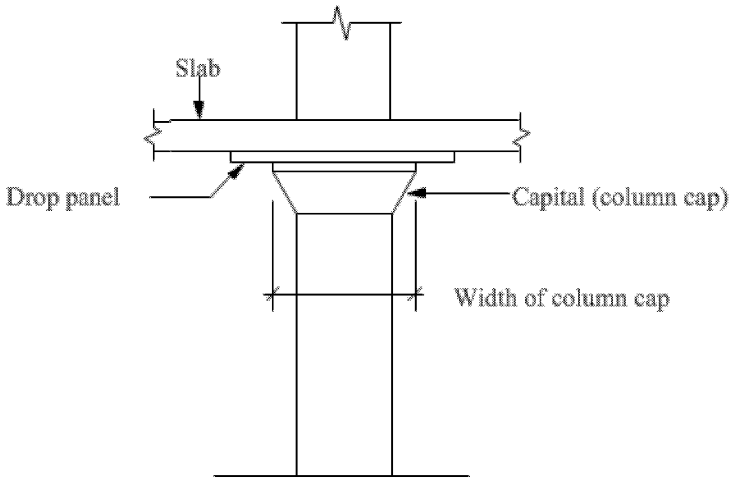
Round columns can also be made of fiberglass, which weighs less than the metal form. Fiberglass leaves a smooth architectural finish and strips easily.

DROP PANELS

To help distribute the weight of the slab, it is often necessary to thicken the slab area above a column. This thickened section at the top of the column is known as a drop panel, since it drops down from the bottom of the deck slab. An engineer calculates the size and thickness of the drop panel.



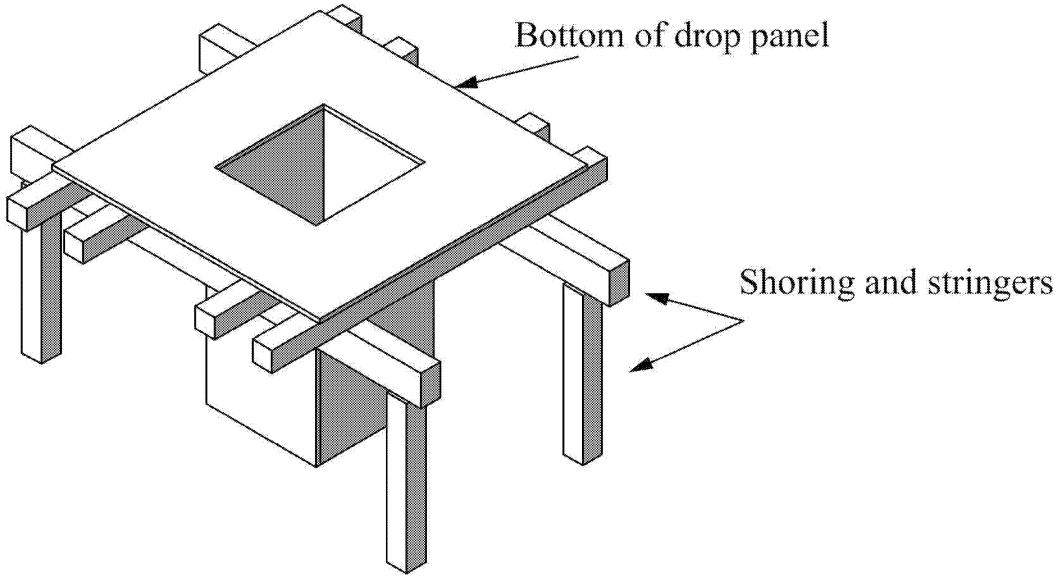
A wider section of form can be added to the top of the column form to give the column a flanged area at the top. This is known as a capital or column cap, and it is used to provide a larger area at the top of the column to help carry the load from above.



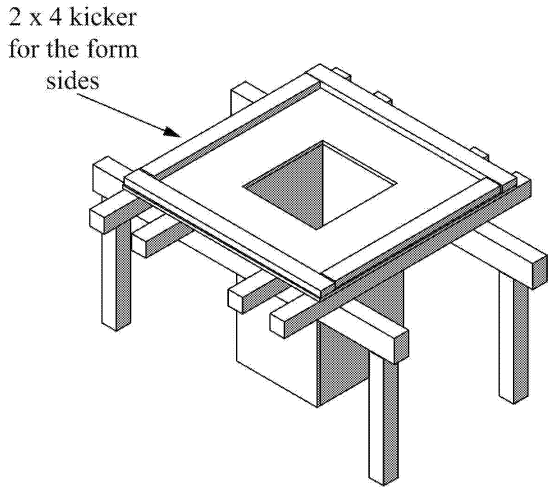
FORMING A DROP PANEL

When a drop panel is called for, the form is built in the following steps:

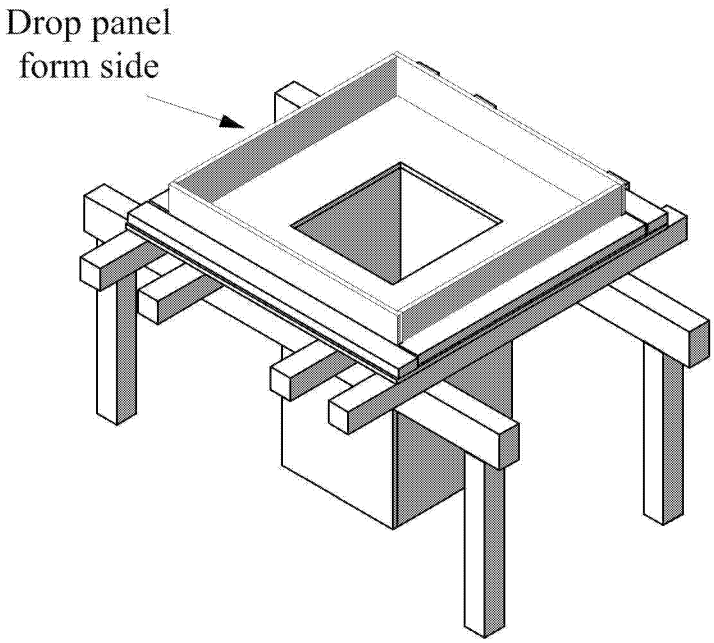
1. Using shores and stringers, set up a deck for the bottom of the drop panel that opens on to the top of the column.



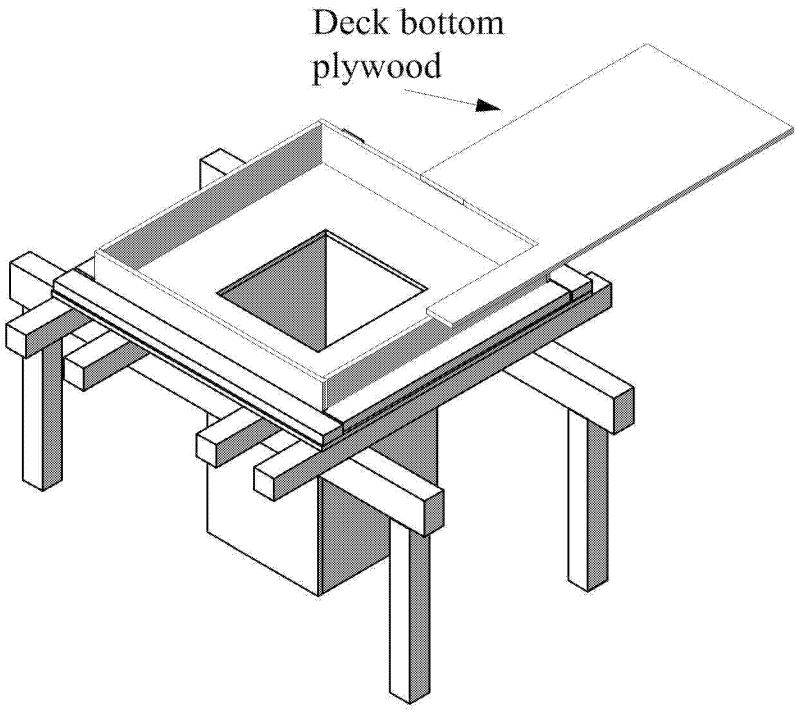
2. On the bottom ply of the drop panel, layout the location of the sides of the panel. Nail kickers down on the ply to brace the sides.



3. Nail the side pieces of ply to the kickers and brace off the sides.



4. Extend the plywood of the upper deck around the ply of the drop panel.



SUMMARY

In multistory concrete construction, columns are the structural support for the floors. They must be laid out carefully and built soundly to make sure that the engineered load is transferred as intended. Columns can be a variety of shapes; most commonly, square, rectangular and round. Column forms can be constructed of wood, metal, tubular fiber and fiberglass. All columns must be adequately secured and braced to ensure that they are plumb. Drop panels are thickened sections of concrete above columns that distribute the weight of the slab over a wider area. Drop panels can be further strengthened through the use of capitals, which are flared areas at the top of columns that help support the drop panel.

Lesson 2 Setting Column Forms

INTRODUCTION

In this lesson you will lay out, construct and brace wooden column forms and round fiber form columns

LESSON OBJECTIVES

At the end of the lesson, the student will be able to correctly lay out, build and brace a square or round column form from the information supplied on the plans.

SPECIFIC OBJECTIVES

On completion of the lesson, the student will be able to:

1. Read a set of plans to locate the grid lines of the column to be placed.

2. Use the information given to lay out the size and shape of the column.

3. Construct the wood column and place the scissor clamps.

4. Set the round column and properly secure and brace all the columns plumb.

APPLICATION IN THE FIELD

Concrete columns are an integral part of the structural integrity of many multi-storied buildings. As has been discussed, many concrete columns continue from level to level, sometimes for tens of stories. The ability to lay out and construct columns is an essential tool of the concrete carpenter. The need for accuracy is primary, a column that is not in the right location may effect the structural stability of the building. Likewise, columns must be set and plumbed accurately since many columns are placed in rows and any column misplaced or out of plumb will be highly visible. There are many types of forms for columns beside the two presented here, and the carpenter needs to be able to adapt to whatever form is being used. On some multi-storied jobs, the schedule calls for placing a new concrete deck in as little time as a week, so the carpenter who can efficiently build and place columns will be in demand.

EVALUATION

Each student will be evaluated on their participation in the constructing of the square and round columns, and the quality and accuracy of their work. In addition, a post test will be administered.

INTRODUCTION

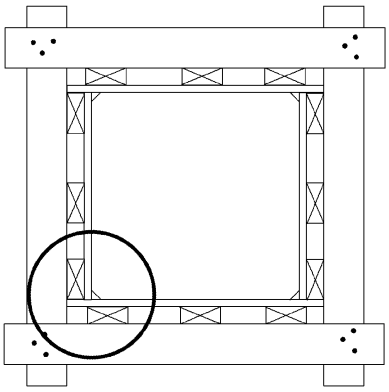
In this lesson, the students will work together to build two square columns out of wood, and one round column out of a fiber form. The forms will be secured in the correct location and braced in both directions.

PROCEDURES

1. Using the plan labeled Plan View, the students will build the columns at A1, A2 and A3 or B1, B2 and B3. This will mean building two square columns and one round column.

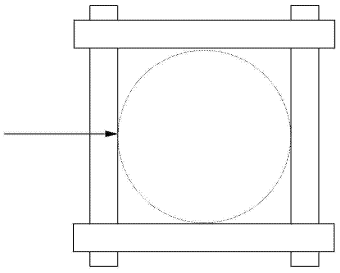
2. Lay out the grid lines for the project.

3. Use the square column details to calculate the four side pieces of 5/8" plywood for each of the square columns. The grain of the plywood should run vertically for the maximum strength. Chamfer the edges before putting the sides together. Note that two of the pieces run past to line up with the outer stiffener.



4. Cut the fiber form at the correct height.

5. Lay out exactly where the columns are to go and make sure that the layout is square. Since it is difficult to see whether the inside of the column is on the layout, snap control lines to the outside of the form so that alignment can be maintained with the form in place. Secure a 2 x 4 collar as shown, in the field the bottom 2 x 4 would be shot down or drilled and pinned down. On the round column, the collar will just touch at one point on each side, as seen below.



The form is strong enough to hold its shape. Another collar is placed at ¼ of the height of the column below the top of the round form and nailed from the inside of the form into the 2 x 4s. This upper collar will be used to brace off the column.

6. Add wood braces in two directions and plumb the column both ways. This is an important step.

7. The elevation view of the square columns show that they are to be secured with the use of scissor clamps. There are many types of these clamps available, however, they are all similar. Place the clamps as shown and tighten them.

8. Remember that in the field, there is a cage of rebar inside the column. When putting up the form it is important to make sure that there is sufficient clearance between the rebar and the inside of the form. It may be necessary to use dobies or chairs to get the clearance needed.

Chapter 3 Wall Gang Forms

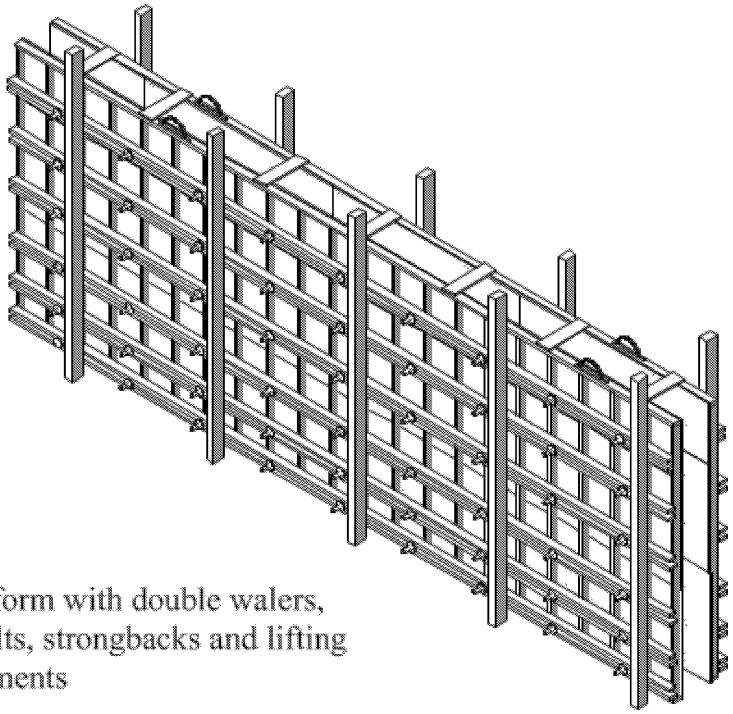
THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **What are gang forms?**
- **How are wood gang forms constructed?**
- **What is the purpose of a taper tie?**
- **What type of metal gang forms are used, and how are they used?**

Heavy concrete construction often uses panel forms or gang forms to form the exterior concrete walls for a building. Many of these forms are climbing forms, which means that as the building progresses, the forms are moved from one level up to the next level. This allows the same forms to be used over and over again, which is efficient and economical. These large sections of formwork are made of wood or metal, and the weight and size of the panels means that they must be moved and placed mechanically, usually with a crane. This chapter will examine several types of these gang forms.

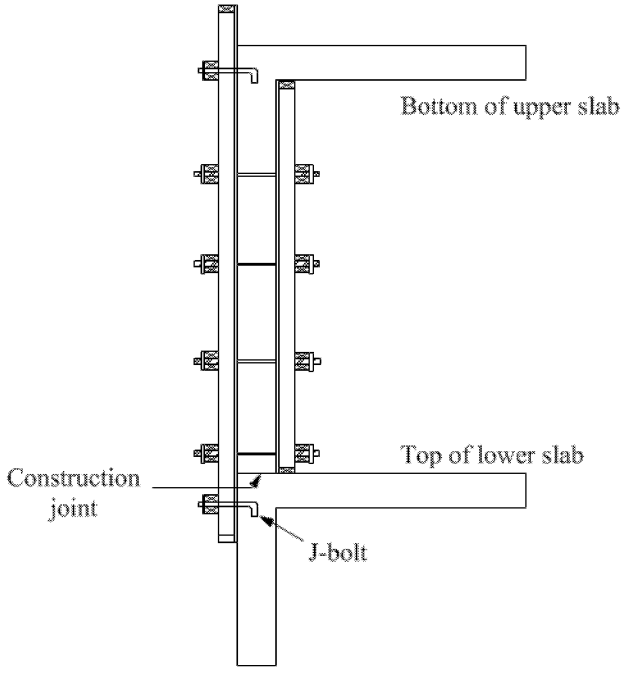
WOODEN PANEL FORMS

Panel forms are large sections of wooden forms that can be reused many times. These forms are built on the job site. They are usually constructed with a 2 x 4 frame that consists of two plates and studs. The frame is sheathed with form plywood. The walls are held together using she-bolts, taper ties, or occasionally, snapties. These forms can be reused, however they will not stand up to as many repeated pours as forms built of composite materials or metal.

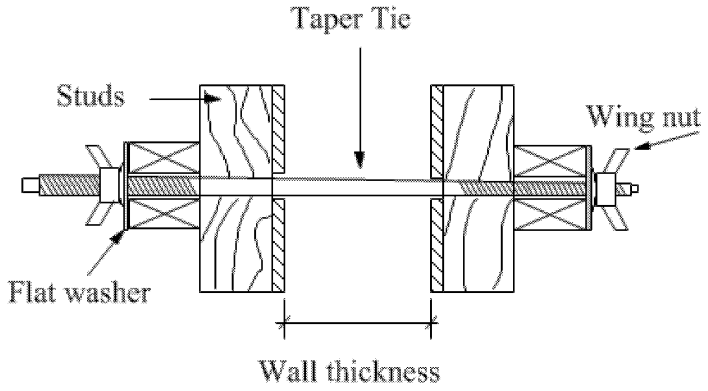


Panel form with double walers, she bolts, strongbacks and lifting attachments

When the panel form is used on the first floor, it is fastened to the wall footing. When the panel is raised to subsequent floors, the wall usually is attached to the building with the use of J-bolts that are embedded in the previously poured wall. The bottom of the form is secured on the bolt and a new bolt is inserted at the top of wall.



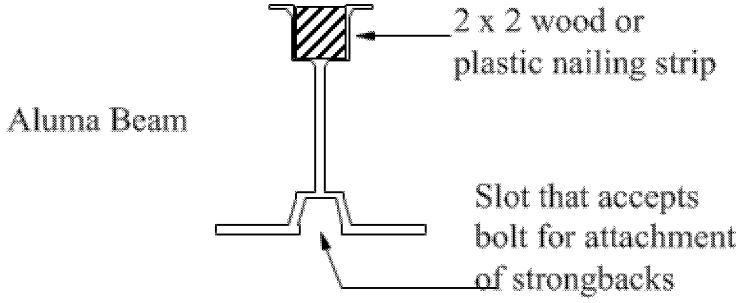
There will be a construction joint where the fresh concrete from above contacts the hardened concrete below. This procedure can be repeated for many stories. The panel form usually will include double walers and strongbacks to give it strength. As stated above, she bolts or taper ties are commonly used to contain the concrete. A taper tie is a one-piece tie that is narrower at one end and has threads on each end. The tie passes through the inside and outside forms and is held on each side with a washer and a wing nut. The fact that it is tapered means that it should be easily removed from the thicker end during the stripping process.



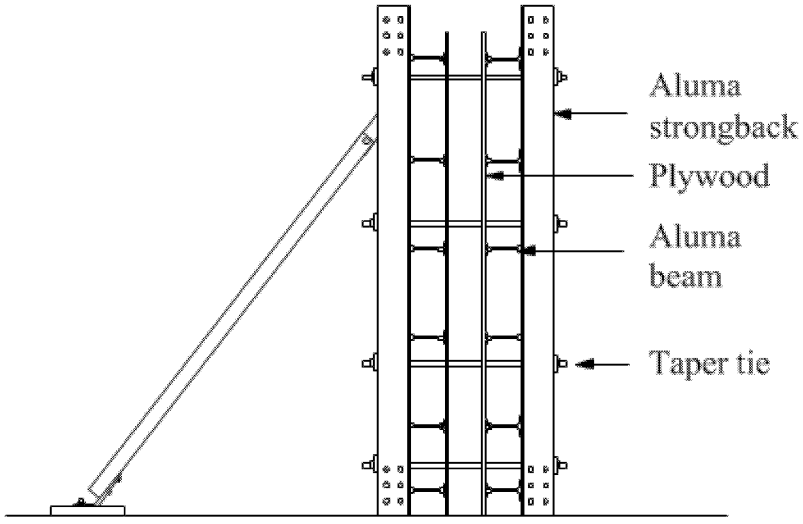
Because of their great strength, taper ties can be used for thick (up to 3' wide), high walls. The taper tie can be set to the proper wall thickness prior to installation. Once set, the wing nut and washer on the large end can be left untouched: when the wall is stripped, the wing nut and washer on the smaller end are removed and the tie is driven towards the concrete. Stripping can be aided by greasing the taper tie prior to placing the concrete. On the subsequent lift, the large end is inserted through the form until it is tight against the walers and the smaller end is tightened until the desired width is achieved.

METAL GANG FORMS

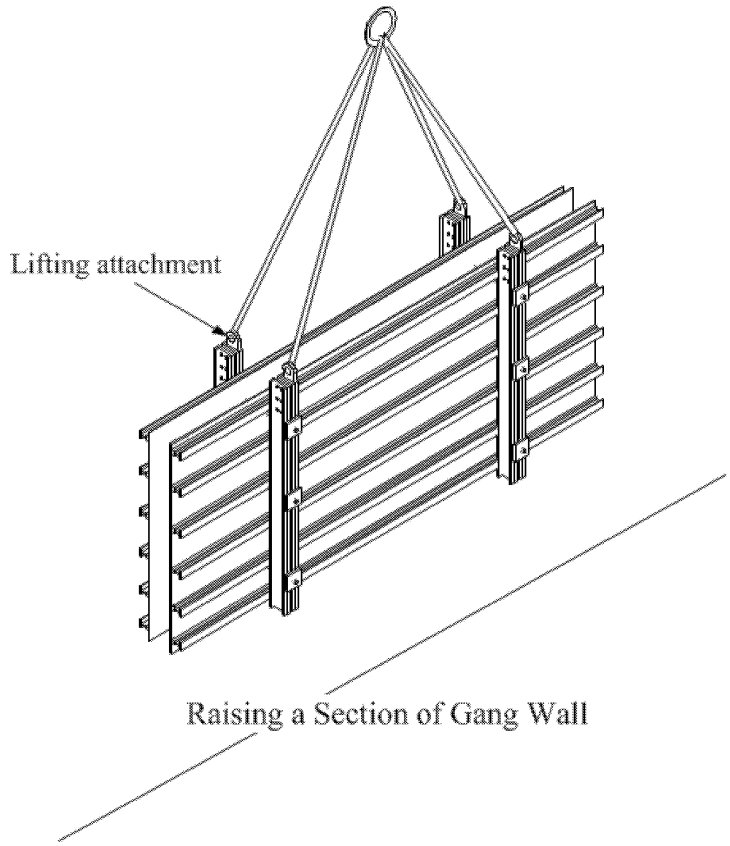
The majority of gang panels are made of metal. The advantage of metal is that is strong and can be used almost indefinitely. Metal forms are especially useful when the same design is repeated over and over again, such as a multi-storied building with each floor being the same layout. Because their weight, metal forms are usually set by crane. "Flying the forms" occurs when the forms are stripped and then lifted to the next level. There are many types of metal forms available and they all have similar designs. One design we will discuss here is the Aluma wall. The components of the Aluma wall are made of aluminum rather than steel, which reduces the weight of the wall. The Aluma wall is a system that uses Aluma Beams that act as walers to which you attach the plywood. The Aluma Beam is a light weight, high strength I shaped beam. There is a piece of wood or plastic that is inserted into the top flange of the beam that allows for plywood sheathing to be secured to the beam. This strip can be replaced when needed.



The beams are usually run horizontally, but sometimes they are run vertically. The plywood sheathing is run at a 90° to the beam and is nailed or screwed on. Strongbacks are added and the panel is stood up. Braces are then added and secured.

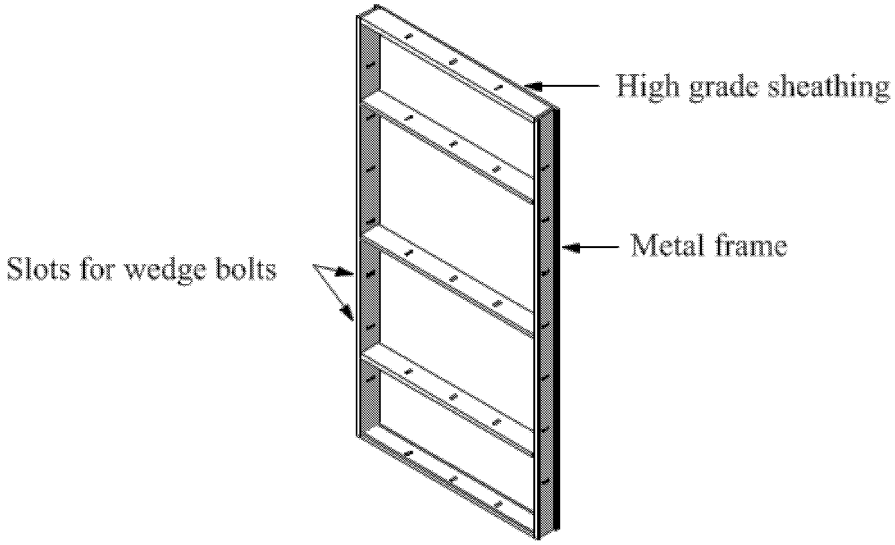


The beams come in various lengths from 9 to 21 feet. A wall can be assembled to any height or length required. A strongback is attached to the backs of the walers with bolts and then ties are inserted where necessary. Braces, guardrails, lifting attachments and other accessories can be added using the same bolts.

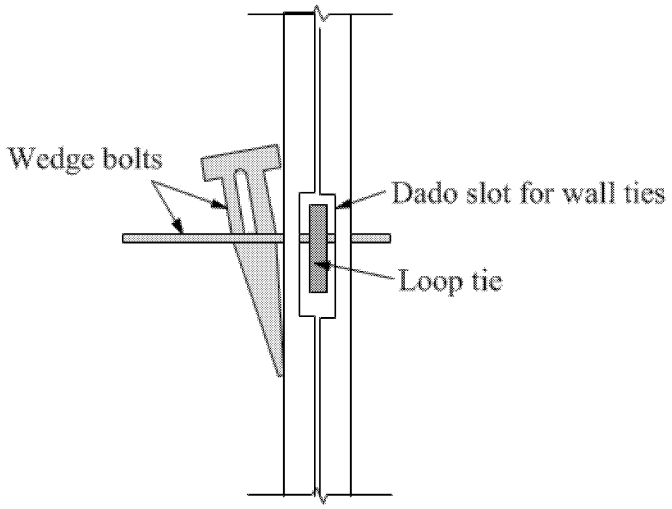


Raising a Section of Gang Wall

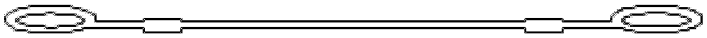
Another type of gang wall can be assembled by pinning together panels that have a steel frame and are covered with a high density overlay (HDO) sheathing. The panels come in modular widths of 2' and vary in heights from 3' to 10'. There are filler panels to make the walls adaptable to the length of wall needed.



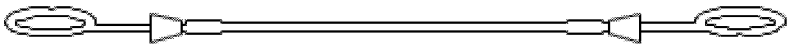
The panels have slots in the metal frame at 6" o.c. increments. These slots are found on all fours sides and are used to connect the panel with another panel. Panels can be stacked on top of one another to make higher walls. The panels are pinned together using a metal wedge known as a wedge bolt.



There is a slot in the wedge bolt that accepts the narrow end of another bolt and clamps the two panels together. There are several types of wall ties that can be used, however walls are often held together with a tie that has a loop.



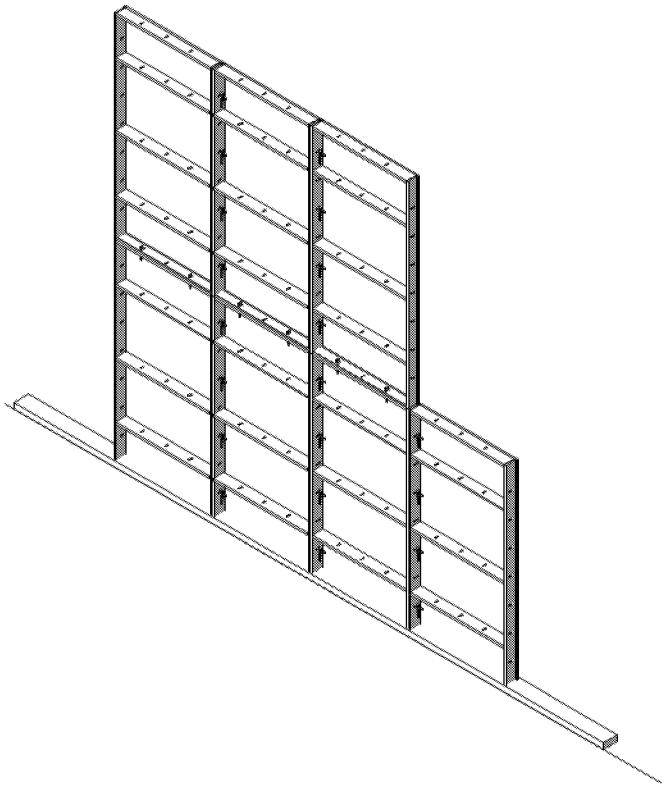
Loop tie



Loop tie with cones

The ties fits through the dado in the edge of each panel and the wedge bolt is laced through the loop and pinned in place with another wedge bolt.

In addition there are other brackets that allow for walers, strongbacks and scaffolding to be installed. Corners can also be connected to the walls. A 2x kicker is fastened to the footing or the slab to hold the bottom of the form in place.



SUMMARY

Large sections of concrete walls are most effectively formed and placed with the use of panel or gang forms. One type of gang form, panel forms, are generally large wooden forms that are built to be used multiple times. Other gang forms are generally metal forms that are assembled into larger units that can range up to 30' x 50' in size. There are many different gang panels available which are similar in design and use. Discussed here was an Aluma wall composed of I-shaped aluminum beams, plywood sheathing and aluminum strongbacks. This system is bolted together with a patented bolt design. Also covered is a panel system that features a metal framed, high grade plywood sheathed panel that is pinned together with a pin known as a wedge bolt. The forms are held together with she-bolts, taper ties, loop ties or some other type of ties.

These forms are particularly useful when they are used, stripped and reset for the same pour on another level or location. Movement of gang forms is done by crane or other lifting device. Safety must be a constant concern when flying large sections of formwork, an accident could result in damage to the forms or injury to the workers. The carpenter should be familiar with the components of these systems and then adapt that knowledge to similar systems that are encountered.

Lesson 3 Gang Forms

INTRODUCTION

In this lesson you will lay out, assemble and brace two types of gang forms.

LESSON OBJECTIVES

At the end of the lesson, the student will be able to correctly lay out, build and brace a gang panel wall made of Symons forms. The student will also be able to lay out, build and brace a section of Aluma Wall gang form.

SPECIFIC OBJECTIVES

On completion of the lesson, the student will be able to:

1. Read a set of plans to locate where the gang form wall is to go in the project.

2. Identify the components of a Symons form wall, including the panels, the wedge bolts and loop ties.

3. Identify the components of an Aluma form wall, including the Aluma beams, clamp and bolt assemblies, strongbacks, tie plates and taper ties.

4. Properly assemble and brace a gang form comprised of Symons forms.

5. Properly assemble and brace a section of an Aluma wall gang form.

APPLICATION IN THE FIELD

In multi-storied concrete construction, the need for efficiency is foremost. It is not efficient to construct forms piece by piece, place the concrete, strip the forms and then reassemble the form piece by piece again on the next level. Contractors have moved to using gang forms, which essentially are large sections of forms that are used and then moved intact to the next level. These forms could be made of plywood, with wood frames and walers, or, more commonly, some type of metal or fiberglass form is used. The fact that these are large sections of forms, some as big as 30' x 50', they need to be lifted mechanically, usually by a crane. The carpenter must be adaptable to the different kinds of gang forms and the special designs of each. Once mastered, the carpenter must then work to increase the efficiency in moving, placing and then stripping the forms. On many jobs, the whole process may be repeated in a week or less and oftentimes, this time can be reduced as the crew becomes more familiar with the system. This kind of gang form work can sometimes last for many months on one building and often, the company will use the same forms on similar jobs. The carpenter should always be aware of the danger involved in working with heavy forms and particularly being involved in the "flying" or hoisting of large sections of forms, often many stories off the ground.

EVALUATION

Each student will be evaluated on their participation in the constructing of each of the two gang forms. The quality and accuracy of the work will also be included in the evaluation. In addition, a post test will be administered.

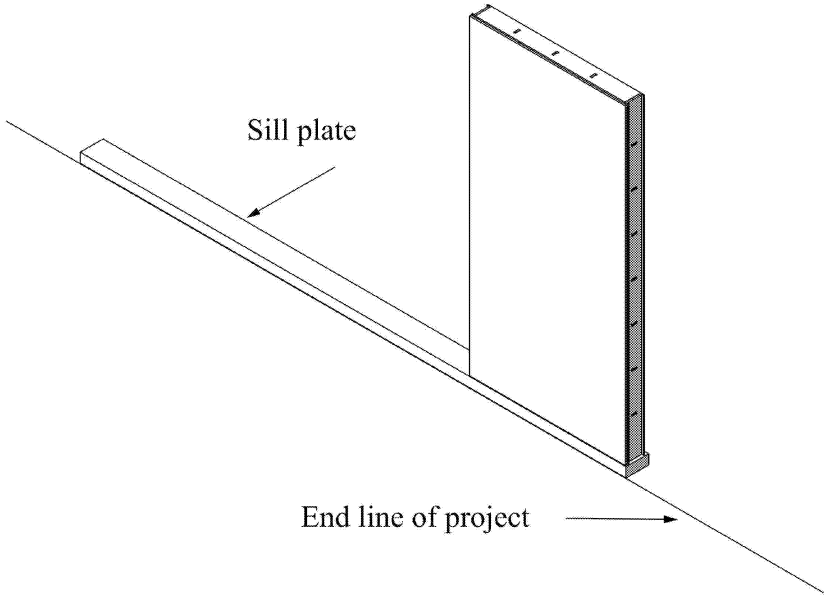
INTRODUCTION

In this lesson, the students will work together to assemble a 30' x 8' wall section of Symons forms. In addition, groups will construct an 8'-0" x 8'-0" section of an Aluma wall.

PROCEDURES

Symons wall

1. Locate the end wall line of the project on A2.



2. Nail a 2 x 4 plate on the end line, place the first Symons form on the sill and nail it through the holes in the bottom of the frame.

3. Continue by nailing down the next panel and then secure it to the next panel with two sets of wedge bolts.

4. Continue in this manner until the whole row is complete, inserting the loop ties as shown on A5. The space of the ties horizontally is every two feet (2').

5. After the bottom row is complete, place the next panel on top of the first panel and secure it to the form below with two sets of wedge bolts.

6. Add the double walers and strongbacks as seen on sheets A4 and A5. Install braces and line the wall.

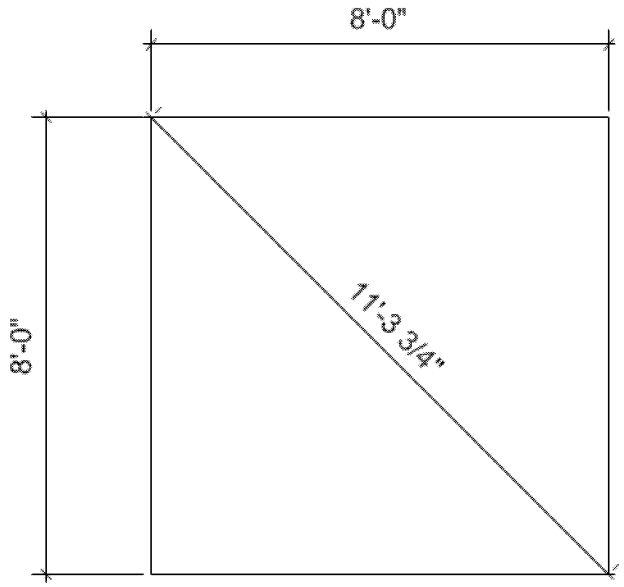
7. Install the scaffold bracket and the handrail.

8. Measure in 12" from the end line and snap another line. Place another sill on this line.

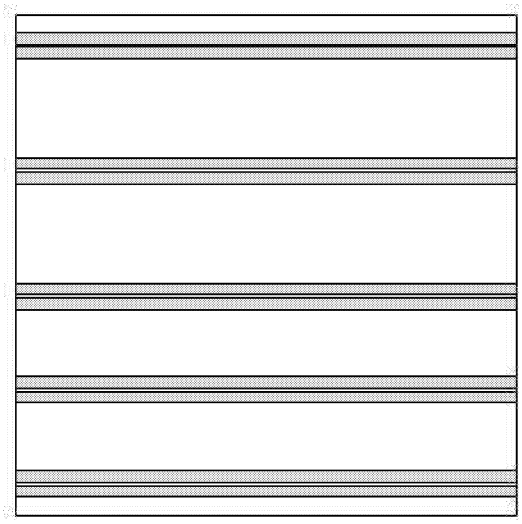
9. Double up the inside forms.

Aluma wall

1. Begin by snapping an 8'-0" x 8'-0" square on the floor.

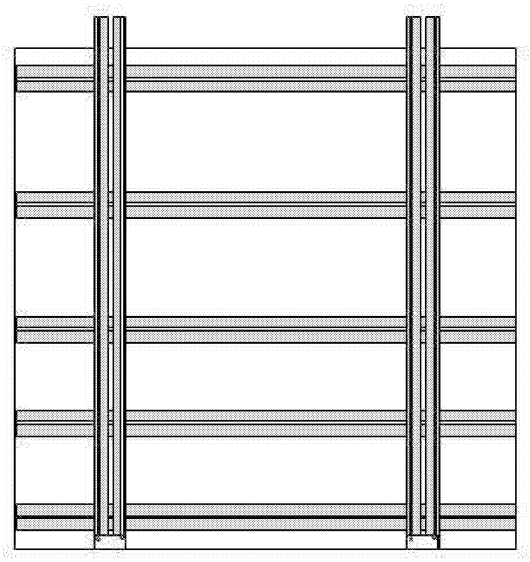


2. Place the Aluma beams on the layout with the vertical spacing shown on A5.

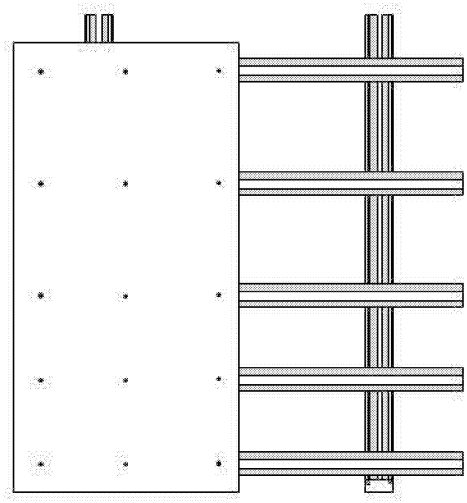


Check from corner to corner to make sure that the joists are square.

3. Attach the strongback shoes to the bottom of the strongbacks. Position the strongbacks as shown on the plan. Make sure to square up from the bottom layout line to make sure the strongbacks are not below where the sheathing will be. Use the Aluma bolts to clamp the strongbacks into position.



4. Flip the entire assembly over and square off of the layout lines to align the assembly with the layout. Position 2 pieces of 5/8" plywood on the beams and screw them on.



5. Carefully lay out the location of the two taper ties and drill 1 ½" holes. These should center between the strongbacks.

6. Attach the lifting hardware so that it is facing the inside of the wall.

7. Fasten a 2 x 6 sill 5/8" behind the concrete line. Stand and position the assembled form and tack it to the mudsill.

8. Construct and drill the other 8' x 8' panel and position it 12" across from the first side. Use a 12" wood spreader in the bottom of the form to keep the proper distance.

9. Build a bulkhead and install it in one end of the form.

10. Attach the braces and plumb the form.

11. Insert the tie plates and taper ties and use a spreader at the top to keep the proper distance. Tighten the nut wings.

Chapter 4 Traditional Decking

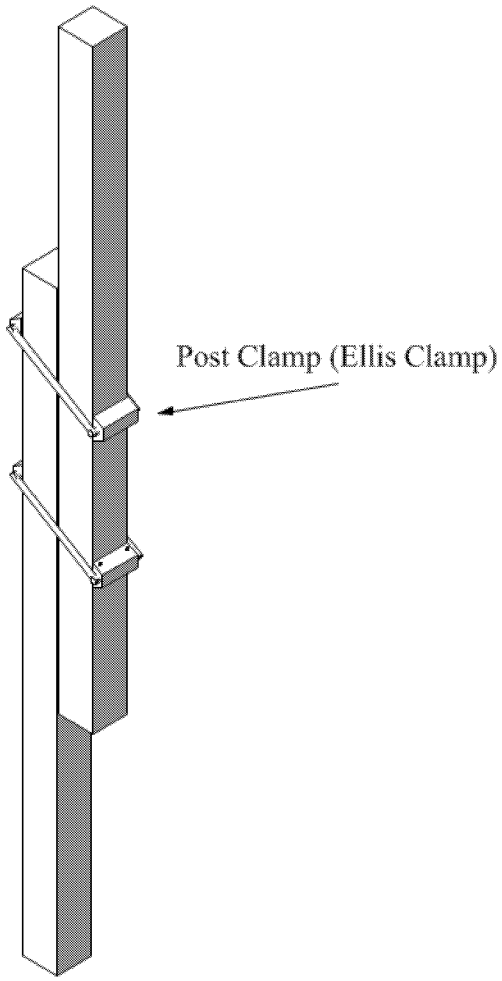
THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **What is the traditional method of decking?**
- **How is an Ellis clamp used?**
- **What are the components of the wooden system?**
- **What is the purpose of reshores?**

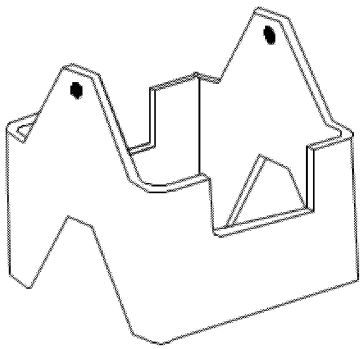
When a concrete slab is placed on the soil, it is known as a slab on grade. When a slab is raised off the ground, it is known as a deck. In order to place a deck slab, there needs to be an underlying structure to support the concrete deck until it is strong enough to carry its own weight. This is achieved with shoring, known as falsework, since it is not a permanent part of the building. The shoring can be made of wood or it may be a metal shoring system.

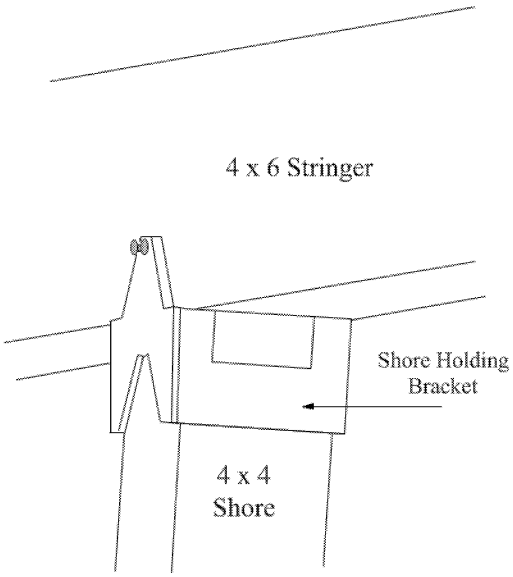
Traditionally, decking has been done using wood members for the posts and girders. The most common members used are 4 x 4 posts and 4 x 6 girders. We will cover the steps involved in erecting this system.

The shoring posts are two pieces of 4 x 4s that are joined together with the use of a post clamp, commonly referred to as an Ellis clamp. The clamps are attached to the lower of the two posts. Clamps can be loosened to allow for up and down adjustment. Once they are set to grade, the clamps are tightened down and held in place with a nail. To remove the falsework, the clamps are loosened and the decking material can be lowered. If a single post is used instead, the post should to be wedged up to the proper elevation. By removing the wedges the post can then be removed. A single post should not be cut to the exact elevation needed, since it would be difficult to strip and would result in damage to the materials.

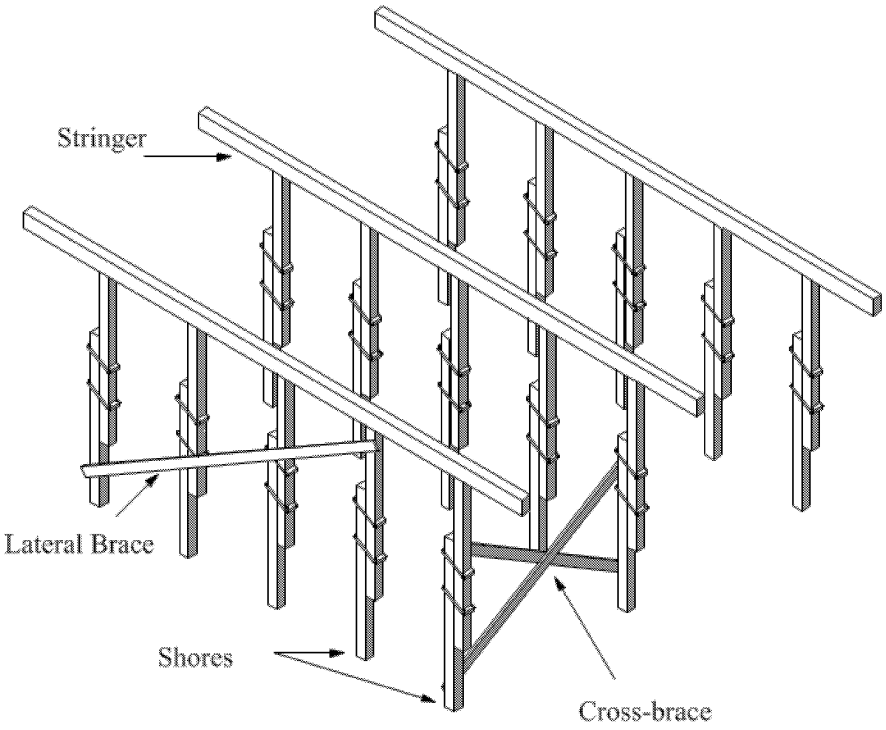


The clamped posts, sometimes called “slip shores” are attached to a horizontal girder (stringer) that carries the weight from above. Shore cups, seen below, are nailed to the underside of the 4 x 6 girder at a specified interval. The shore is inserted into the cup and tightened.

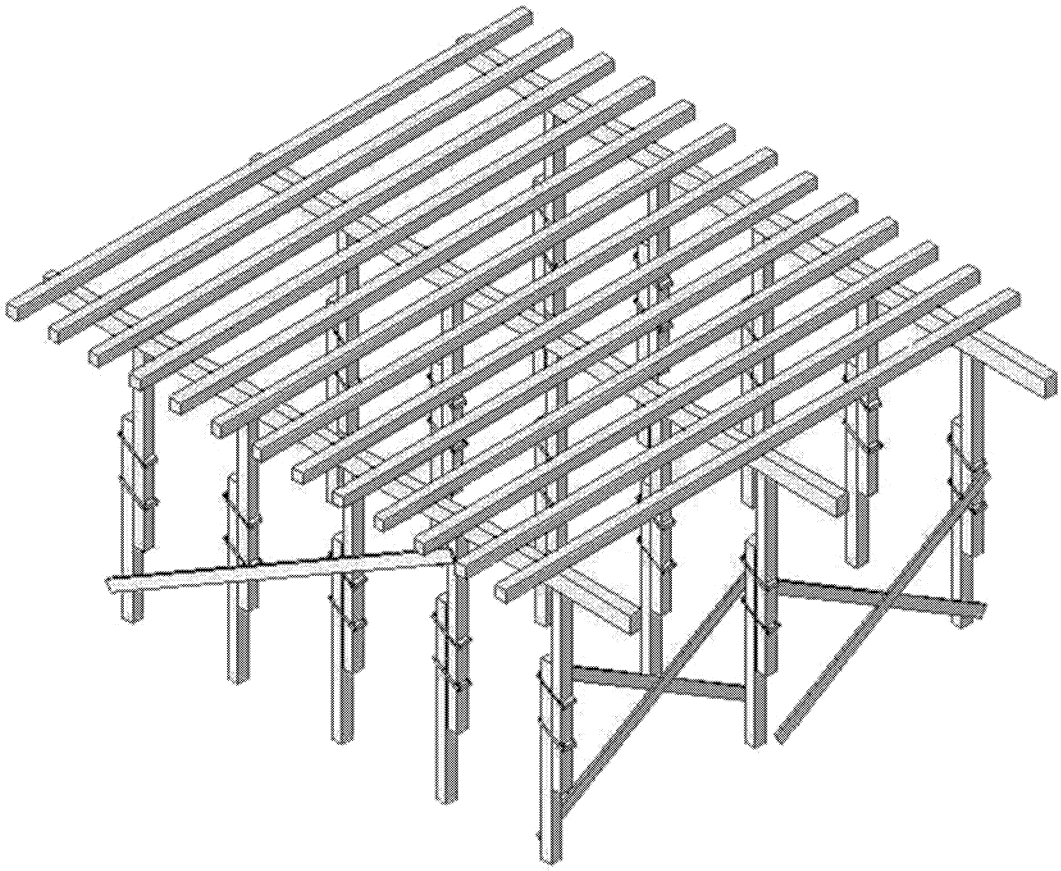




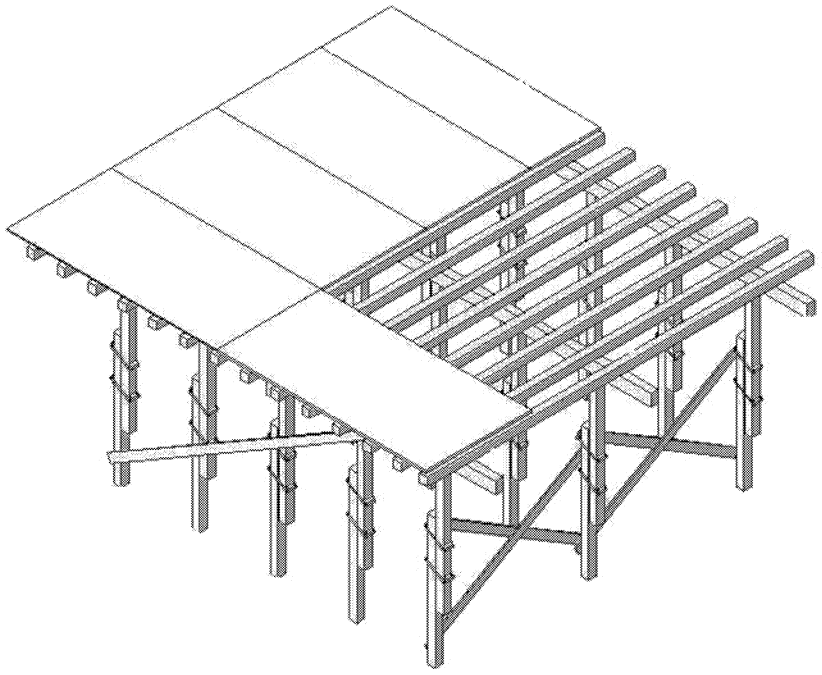
A post is installed at each end of the stringer and the assembly is stood in place. Another row is then set up next to the first row and cross-braced to each other. The intermediate shores are then installed and more rows are added until the entire area is shored.



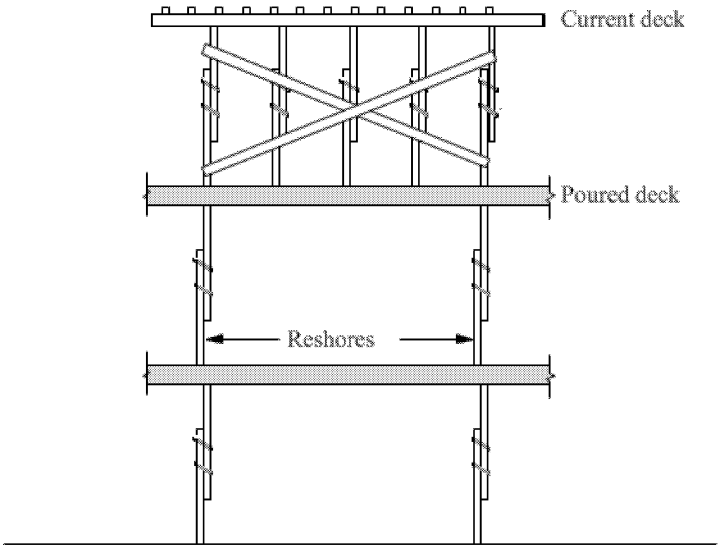
Once the rows are assembled and secured, joisting is then placed across the stringers to create a platform for the soffit plywood. The joists are usually 4 x 4s that are placed at roughly one foot centers. A minimum of nails is used since all of the nails must be pulled when they are stripped. The dead load of the concrete will hold the joists in position. The joists often overlap by running one next to the other.



The final step is to cover the joists with 4 x 8 sheets of plywood that become the soffit (underside) for the deck. When laying plywood for floor or roof sheathing, the joints of the plywood sheets are staggered to provide strength. In decking the sheets are laid so that the joints line up. Since the deck is temporary and the plywood will be stripped, the seams should be symmetrical (lined-up) so that they are aesthetically pleasing. A minimum number of nails are used to nail the ply, again, because all the nails must by pulled in the stripping processs.



Once the concrete is placed and allowed to cure, the shores are lowered and the stringers, joists and plywood are removed. This can be a dangerous job and care must be taken for the safety of the workers and the preservation of the materials. Often the decking materials are then moved to the next level and the process begins all over again. Since the concrete is still attaining its design strength, it may be necessary to place shores beneath the concrete at locations where there are heavy loads above. These shores are known as reshores and sometimes they may be placed at several levels until the concrete has cured to the proper strength.



SUMMARY

When a slab is poured above grade, the formwork below must support the concrete until it achieves its proper strength. This formwork is called falsework and it must be constructed soundly enough to carry the weight of the deck, the workers and all of the equipment. The traditional method of shoring up the deck is through the use of wooden shores that support wooden girders. Joisting material is placed across the girders and then the joists are covered with plywood that forms the bottom of the deck. After the deck is poured and can support itself, the formwork is removed and reused. At this time, reshores will be installed at key structural points until the slab (or slabs) above has reached its design streng

Lesson 4 Building and Using an Ellis Shore

Step 1. Get two 4 x 4s, one between 5'-0" and 7'-0", this will be the lower shore member. The upper shore needs to be long enough to reach the desired height and have a 24" overlap.

Step 2. Attach an Ellis clamp to the lower shore 2" down from the top of the shore. Attach a second clamp to the shore 12" below the first shore. Secure both clamps with 4 duplex nails through the holes in the clamp

Step 3. Slide the upper shore member alongside the lower shore until the proper elevation is reached.

Step 4. Hammer the clamps down so that they bite the wood. Tack a nail above the clamp to keep it from vibrating loose. Bend the nail over so it is not a safety hazard.

Step 5. When lowering an Ellis shore, remove the tacked nail, then loosen the clamp by tapping the clamp upward. This should lower the shore slightly. For faster lowering, raise both clamps at the same time. One method of doing this is to turn your hammer upside down and lift both clamps simultaneously.

NOTE: This method can result in the upper shore dropping quickly, so keep your feet clear!

Lesson 4a Traditional Decking

INTRODUCTION

In this lesson you will be building a wooden shored deck and column drop panels.

LESSON OBJECTIVES

At the end of the lesson, the student will be able to correctly lay out, construct, sheath and secure a section of a traditional shored deck. The student will also be able to lay out and build a column drop panel.

SPECIFIC OBJECTIVES

On completion of the lesson, the student will be able to:

1. Read a set of plans to locate where the decking is to be installed.

2. Identify the components a wooden shoring system, including Ellis shores, stringers, joists and sheathing.

3. Identify the components of a drop panel, including shoring and bracing.

4. Properly assemble a section of a wooden shored deck.

5. Properly assemble a drop panel at the top of a column.

APPLICATION IN THE FIELD

In concrete deck construction, what we are calling the traditional method, is one that uses wood shores and stringers to form sections of deck. This method is tried and true and has been used for many years. In terms of cost, using wood shoring and decking is cheaper than metal shoring and forms, however, it is usually not as efficient as some of the metal systems of decking where entire sections can be left intact and lifted to the next level. The wooden shoring system is built piece by piece, stripped and rebuilt again. However, the components of the system, like the slipshores, can be used over and over again. This reuse factor makes wooden shoring competitive and it is still used on many projects. In cases where other decking systems are used, there are often sections that can't be formed with other means, and these are then "filled in" with wood shoring. The traditional shoring method is not complicated, all concrete carpenters should understand and be able to do the work. It is hard work as the components are heavy and the pace is quick. Stripping the forms can be dangerous. The process involves taking out all the intermediate shores, and when the last shores are removed, the stringers, joists and sheathing all collapse. The materials are then sorted and stacked and loaded up for the next use. Decking done with the traditional method is still used by many companies and it is a valuable skill.

EVALUATION

Each student will be evaluated on their participation in the constructing of the falsework and deck forms. The quality and accuracy of the work will also be included in the evaluation. In addition, a post test will be administered.

INTRODUCTION

In this lesson, the students will divide into two groups which will begin on opposite sides of the project and erect the shores and stringers in rows working toward the center of the project. In addition, each side will shore and construct a drop panel around either column A1 or B3. The project will include joisting and sheathing the entire area.

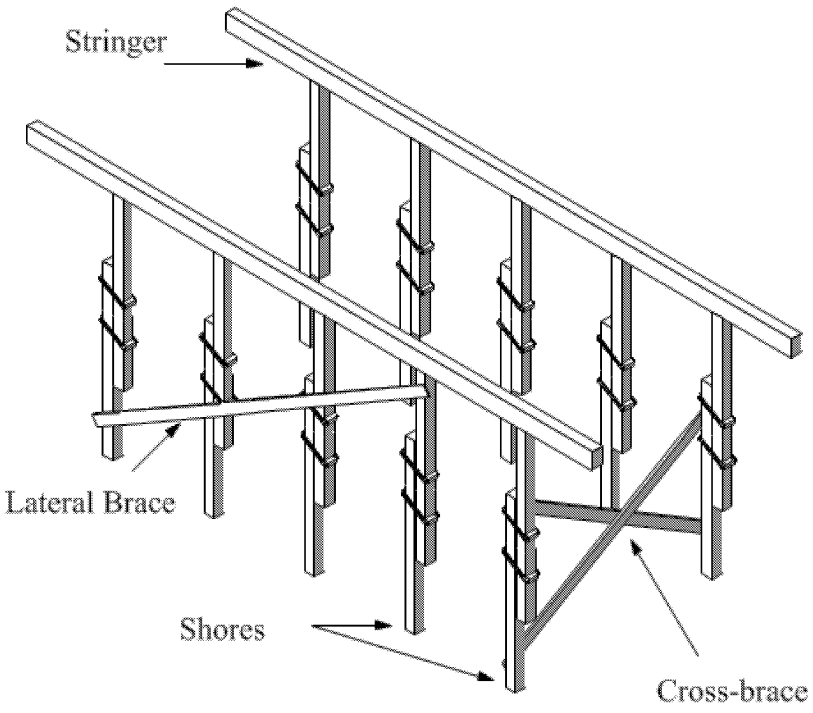
PROCEDURES

1. Using the "Plan View of Wood Shoring", the details, and the sectional views of the shoring and the drop cap, lay out the location and direction of the stringers.

2. Attach the shore holder cups to the bottom of the stringers at the proper layout.

3. Stand the stringer by installing one Ellis shore at each end of the stringer. Temporarily brace the stringer to the project wall. Check the stringer elevation and raise or lower the shores accordingly. Continue the second section of stringer in the same manner.

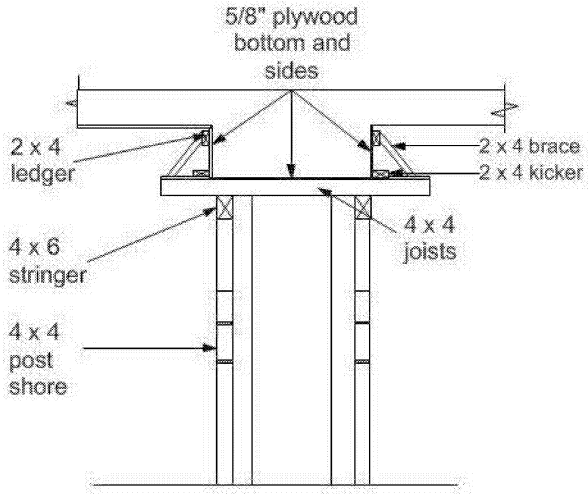
4. At the distance shown on the plan, complete the second row of stringers. At this point, 1 x 4 bracing should be installed to the first two rows to stabilize them. The bracing needs to be only attached to the lower post of the Ellis shores.



5. Fill in the remaining shores in the first two rows.

6. Using the plan, erect the other rows in the same manner, bracing as you go.

7. Working on either A1 or B3, whichever is in your section, build the bottom of the drop cap and shore underneath according to the details shown. Then build the side panels and brace them.



8. Raise or lower the posts until the deck is level and secure the Ellis brackets with a nail.

9. Next, roll the 4 x 4 joists at 2'-0" on center. The joists do not have to be laid out exactly, a 2' mark on your hammer handle can act as a template for the layout. Only nail the joists that will be supporting the ends of the plywood, the other joists will not move when the weight of the concrete is on them. Since this is falsework and will be removed later, any nails that are used will need to be pulled when the falsework is stripped, so the minimum amount of nails is called for.

10. Erect guardrails around the perimeter of the project using the CALOSHA regulations of the top rail at 42" to 45", a midrail and toe boards. (This step is only necessary if sheathing the project)

11. **Optional**: Working from the center of the project out toward the walls, lay the 5/8" plywood sheathing. Remember that the joints should be lined up rather than staggered. This is because the sheathing is not a permanent part of the structure, unlike a subfloor, and the joints need to be aligned so the concrete will look aesthetically pleasing.

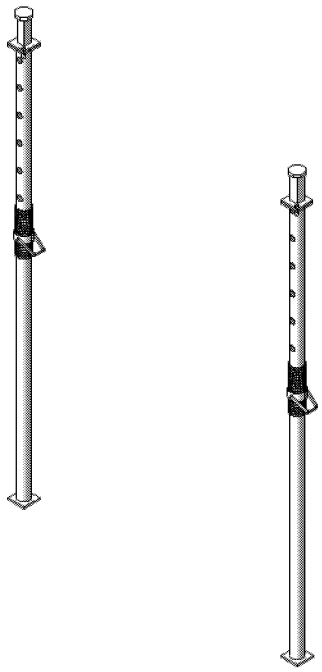
Chapter 5 Metal Shoring

THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

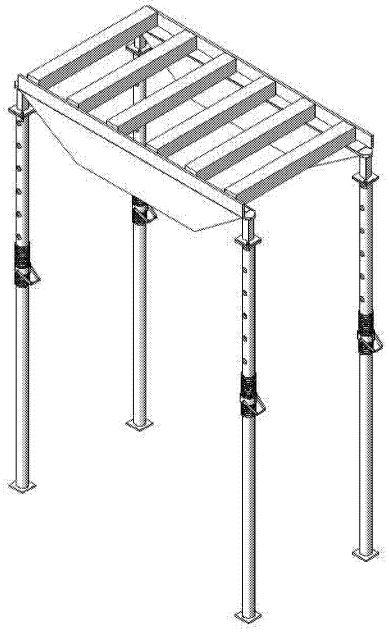
- **What are the advantages of metal shoring?**
- **What are metal adjustable shores and how are they used?**
- **What is metal frame shoring, and how is it used?**

In the previous chapter we saw the traditional wooden shoring system used to support a concrete deck. This chapter will cover another type of shoring, one that uses metal rather than wood. As with metal wall forms, there are advantages to using metal shoring: they are durable and they can be reused many times. In addition, the strength of metal shoring means that the supports can span greater distances than with wood shoring. We will discuss several different types of metal shoring including metal adjustable shores, metal-framed shoring, steel tower frames and flying forms.

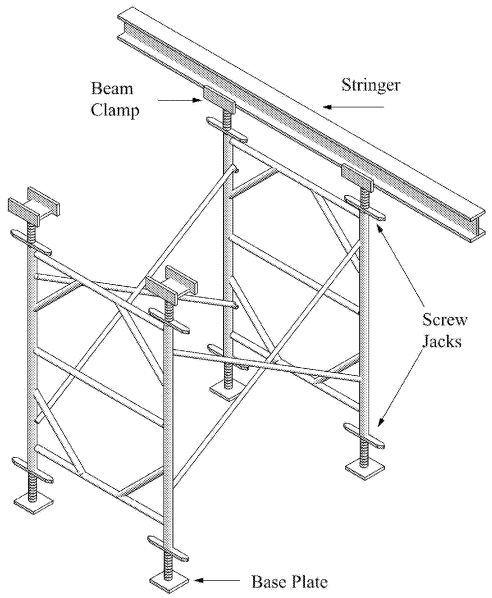
Metal adjustable shores are manufactured by many different companies, but they all operate in the same manner. The shores are constructed with tubular steel that is open to allow water to escape. The shores are adjustable, with holes or notches to raise the shore to a rough height and then threaded areas for fine tuning the elevation. In addition, most of the shores have a special head that allows for easy stripping. When struck, the head drops down several inches, which creates room to strip the falsework. The size of the shore will be determined by the load it must carry.



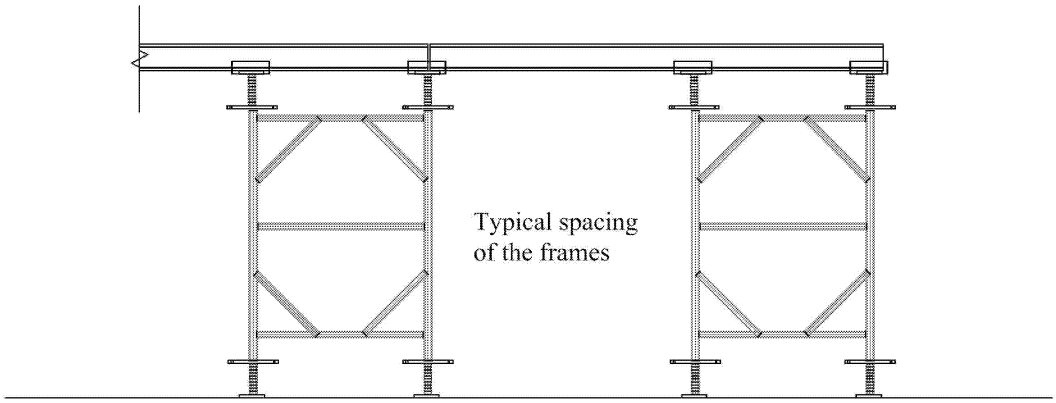
There are a number of types of stringers and joists that attach to the shores and then the sheathing can be laid.



Another type of metal shoring is metal frame shoring. This consists of welded scaffold frames that have screw jacks with base plates inserted into the bottom of the frame. There are also screw jacks that are added to the top of the frame. The upper jack usually has a bucket attached to it, the stringer (often a metal beam) sits in the bucket and is clamped in place. If the legs are resting on soil, the frames need to have mudsills under the base plates to spread the load.

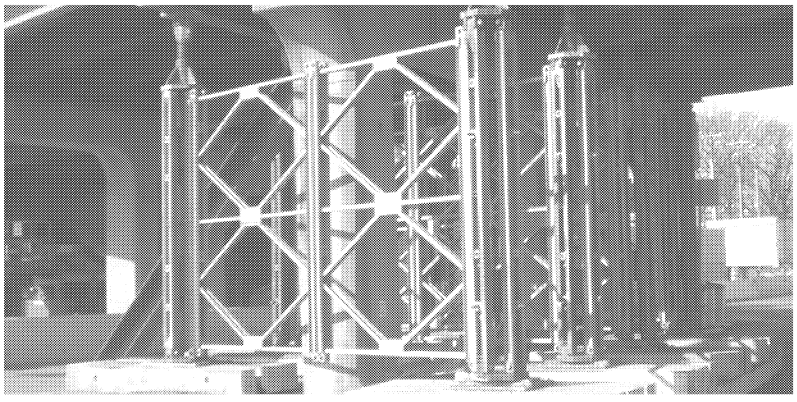


The spacing of the frames is determined for the load. Oftentimes there will be a set of frames and then an equal space and then the next set of frames.



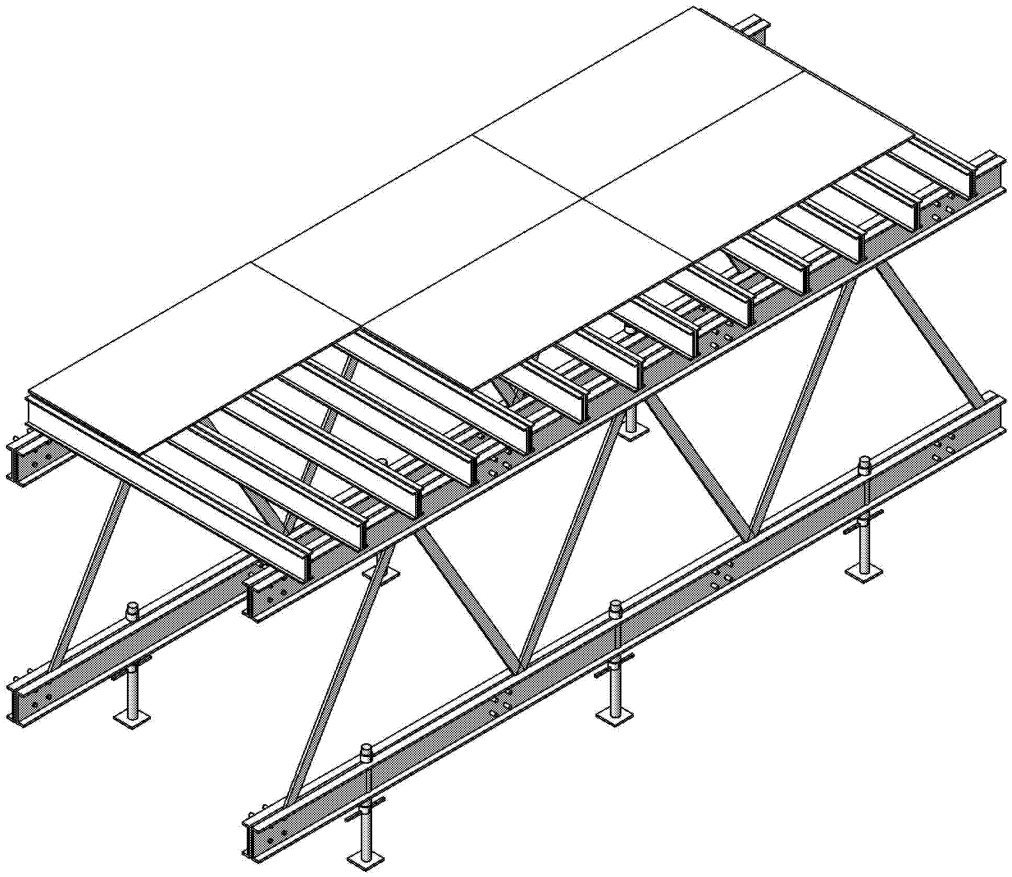
The frames are set up to a rough elevation and then raised or lowered to the correct elevation. Sometimes the stringer will be similar to an Aluma beam with the nailing strip, in which case wooden joists can be used. Other times, metal joists are used and clamped to the stringer.

A variation of the tubular scaffold shoring system is the steel tower frames. While similar in design to the frame scaffold, the steel towers are larger and far stronger. The frames are welded and braced as a unit, usually about 8'-0" to 10'-0" in height. The towers can be stacked on top of each other to form higher decks. This type of metal shoring is generally used when the deck is high and the load is great, like a bridge or a pier cap. Due to the heavy load (up to 100,000 lbs. per leg), the bottom legs are often resting on sandjacks which will aid in lowering the towers and removing the falsework.



Another type of metal form system is the flying form. It consists of large aluminum sections that support a wooden deck. These forms are usually built in prefabricated modules to fit the size of the area to be decked. There are aluminum trusses on each side of the form with beams sitting on top of the trusses to act as joisting. The plywood deck is then added to the structure. Adjustable jacks are used to raise the form to the correct

elevation and, once the concrete has cured, to allow for stripping. The forms are usually rolled out to the edge of the building where the rigging is attached and the crane lifts (flys) the whole assembly up to the next level. In order to safely rig the form, a hole (called a knockout) is opened in the deck so the crane can have another pick point as the form is rolled outside of the building.



It will be necessary to fill in any areas of deck not covered by the form, and wooden shoring is often used for this purpose. These types of forms can be very efficient when used on multistory buildings where all of the levels are the same. The walls and columns are already poured before positioning the flying forms. The goal is to get the form as close to its position on the previous level, this way much of the filler material can be reused. There will be some leakage of concrete at the intersection between the deck form and the walls and columns, oftentimes the leakage will be washed off with a hose before it set up.

There are many other types of metal forms not discussed here, however, there are similarities between all to them. The majority of concrete decking is done using metal forms, so the carpenter would do well to become familiar with the characteristics of metal formwork.

Lesson 5 Metal Shoring

INTRODUCTION

In this lesson you will lay out and assemble a Pro-Shore (Harsco brand) metal shoring system.

LESSON OBJECTIVES

At the end of the lesson, the student will be able to correctly lay out and safely assemble a Pro-Shore deck and set it to grade.

SPECIFIC OBJECTIVES

Upon completion of the lesson, the student will be able to:

1. Read a set of plans to locate where the Pro-Shore deck is to go in the project.

2. Identify the components of the Pro-Shore metal shoring system, including the post shores, the dropheads, the ledgers and the joists.

3. Safely erect a fully braced section of shoring as a starting point for the project.

4. Progressively assemble the remaining shoring and joisting.

5. Set the deck to the proper elevation.

APPLICATION IN THE FIELD

As we have seen, deck shoring can take many forms, including the wooden shoring in the past lesson. Metal shoring has advantages over wood; durability and strength. Many of the suppliers of metal form systems have a metal shore system similar to the Pro-Shore system. This type of system is being used more and more in the field, particularly when large sections of decks are to be formed over and over. The concrete carpenter should be familiar with this type of system and be efficient in its erection.

EVALUATION

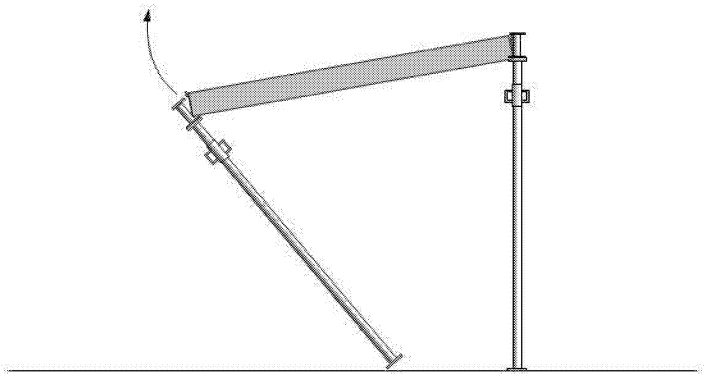
Each student will be evaluated on their participation in the constructing the metal shore deck. The quality and accuracy of the work will also be included in the evaluation. In addition, a post test will be administered.

INTRODUCTION

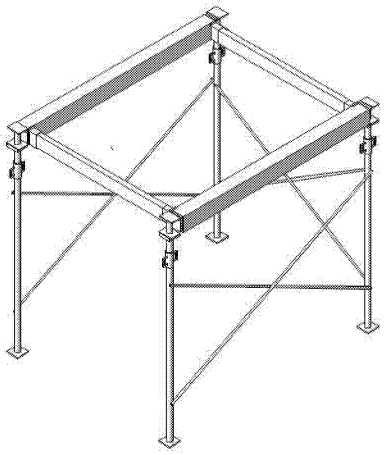
In this lesson, the students will work from the plans and install the Pro-Shore deck. Once the first, fully braced, section is complete, two groups will branch out to set up the remaining sections.

PROCEDURES

1. Using sheet A-8 of the plans, layout the location of the first section of Pro-Shore. Set the first post where indicated and attach the ledger to it. Then hook the other end of the ledger into another post and raise the assembly into position.

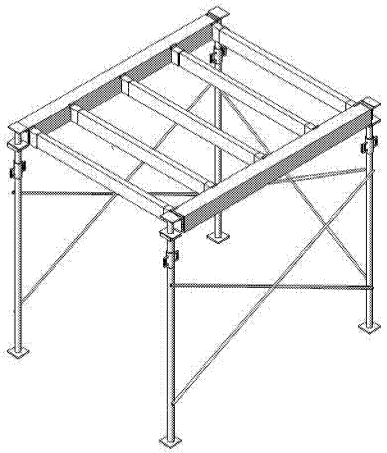


2. Raise another section approximately 6 feet from the first. Drop in a joist at each end of the section and brace it in all four directions.

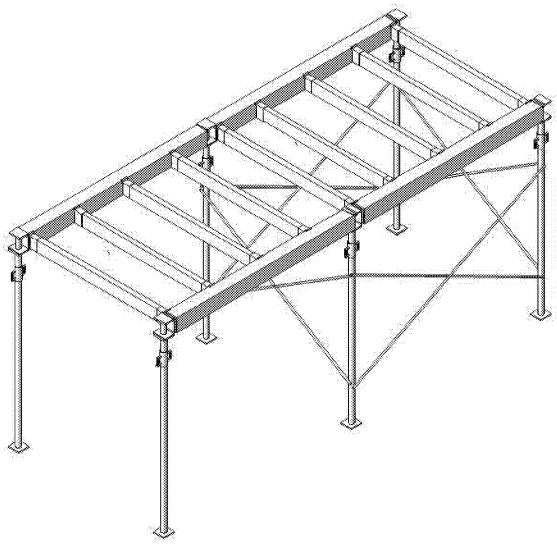


This gives stability for the next sections of the system.

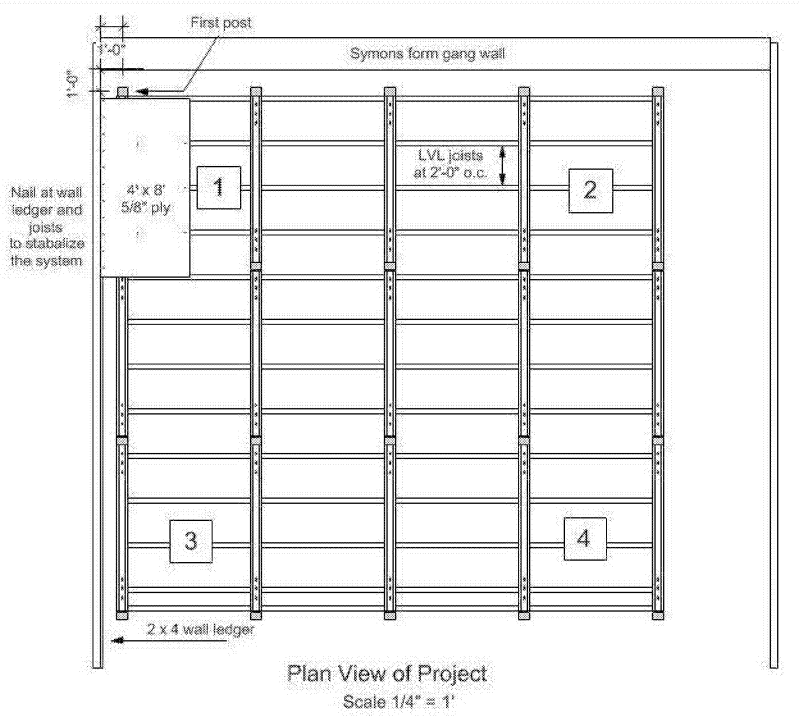
3. Fill in the remaining joists at 2' o.c.



4. Connect two more ledgers to the existing posts and raise two more posts at the other end.



5. Continue to expand in both directions until the shoring is completed. The staging in each corner will be fully braced.



6. Set the project to grade using the elevation view on A8.

Chapter 6 Floor Forms

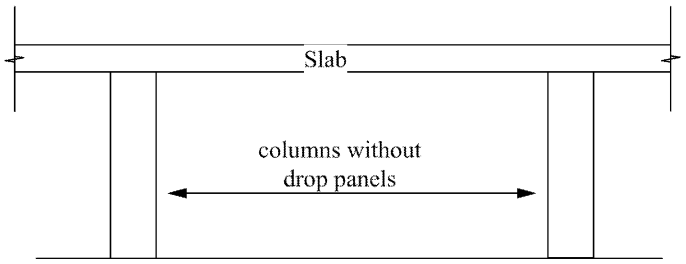
THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **What are the various floor form designs?**
- **How do the systems vary?**
- **What are girders and beams?**
- **How do one-way and two-way systems work?**

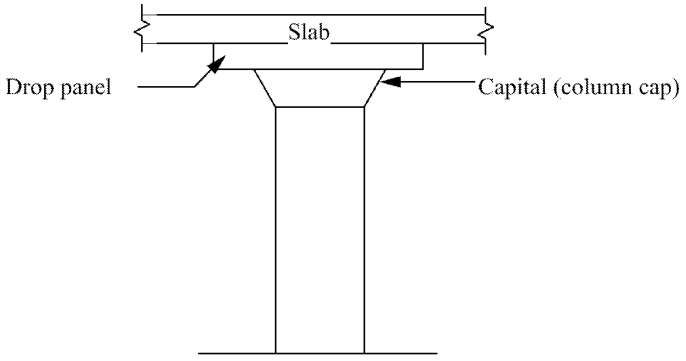
There are various floor form designs used in concrete floor construction. The system chosen must be sufficient to support the deck and successive floors. The systems include a flat plate, flat slab, one-way joist and two-way joist systems. Girders and beams are often used to help carry the weight of the deck without having the dead weight of a thick, or deep, slab.

Flat plate slabs are uniformly thick slabs that are supported by the columns without any drop panels or capitals. This system can only support lighter loads or limited spans.

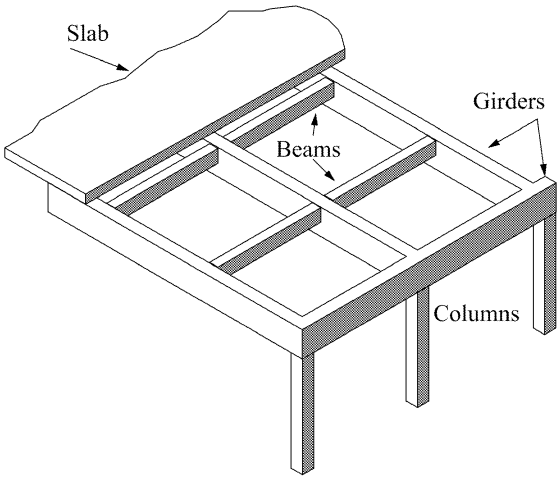
Flat Plate System



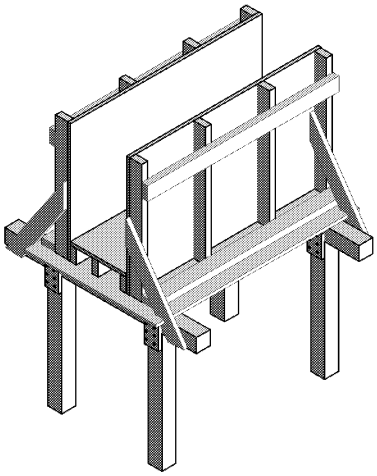
A flat slab is similar to the flat plate slab; however, the weight of the slab or the span between supports is such that the columns need a drop panel, and sometimes capitals, to carry the load. The drop panel makes a thickened section of concrete to be carried by the column and the flare of the capital transfers the weight onto the column.

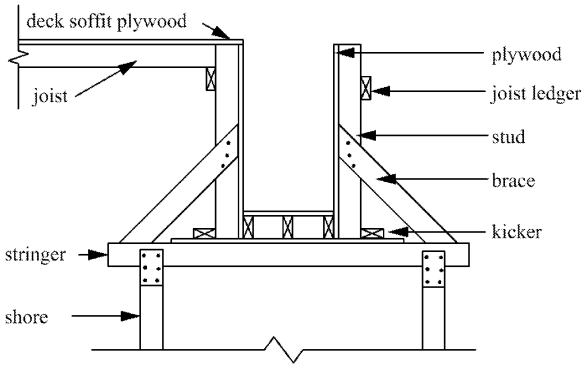


When the loads are greater and the spans are increased, girders and beams may be used to give additional support, which allows for a thinner slab. Girders are heavy horizontal members that support beams from a bending load. Beams are also horizontal members that carry the weight over a span such as from column to column.



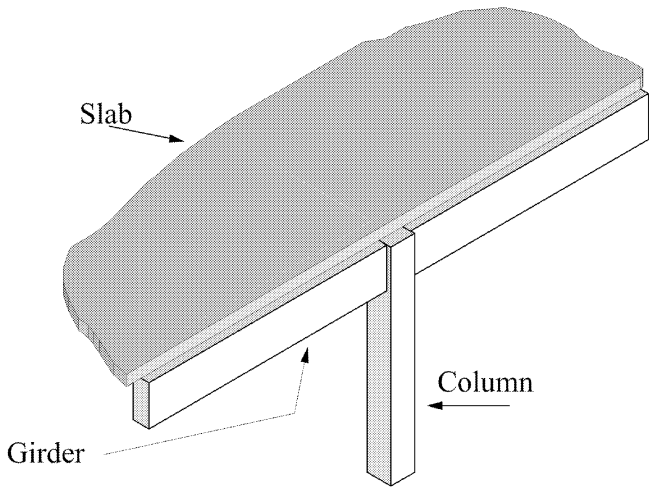
Girders can be constructed by using plywood for the sides and the bottom of the girder. The plywood is backed by studs that are braced and kicked off. The girder must be supported with shoring. The plywood for the bottom of the deck usually laps over the top of the sides of the girder. Here are two views of the components of a girder form.





If wooden girder forms are not used, there are many manufactured metal girder forms that can be assembled to the desired size and length. Shown below is an example of a manufactured girder form supported with shoring.

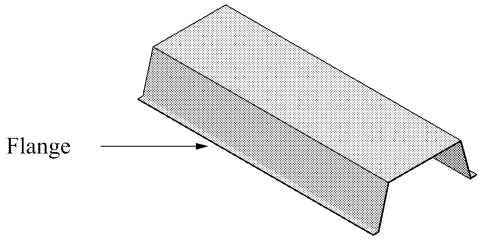
The end result of either wooden girder forms or manufactured forms is a concrete girder that carries much of the dead load of the deck. The size and depth of the girder is engineered to safely span from column to column. Generally beams are smaller horizontal members that connect at right angles to the girders. They add further strength to the system.



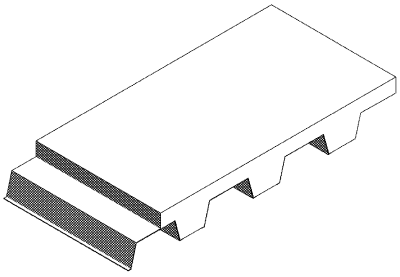
ONE-WAY AND TWO-WAY JOIST SYSTEMS

Concrete joist systems connect concrete joists with a concrete slab. The joists are formed with prefabricated pans that can be used over and over again. The pans are made of steel or fiberglass and can be nailed to the soffit.

One-way joists are made with pans that come in dimensions of 20", 30" and 40" with depths of 8" to 20". The slabs that are combined with joist systems are normally only 2 ½" to 4 ½" thick. The pans can be joined together to form long joists or adjustable pans can be used to achieve the same results. The illustration below shows a long pan and the resulting slab.

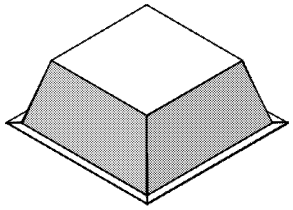


long pan



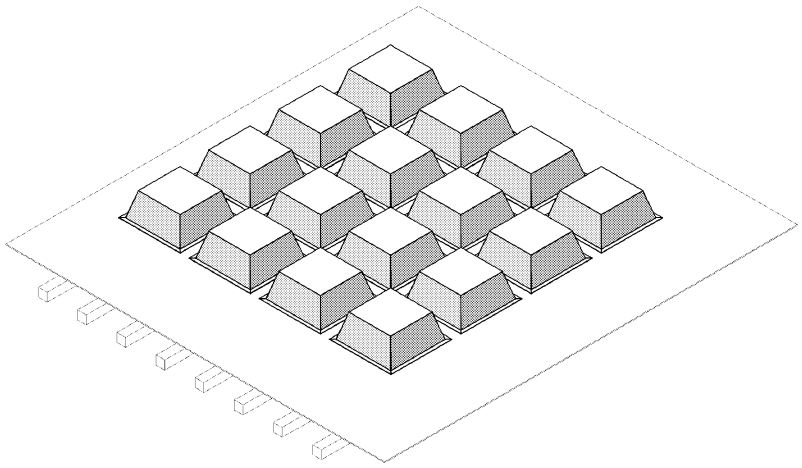
one-way slab

The two-way joist system forms joists running in both directions. These pans are known as dome pans. They are square forms nailed in place through the flanges.

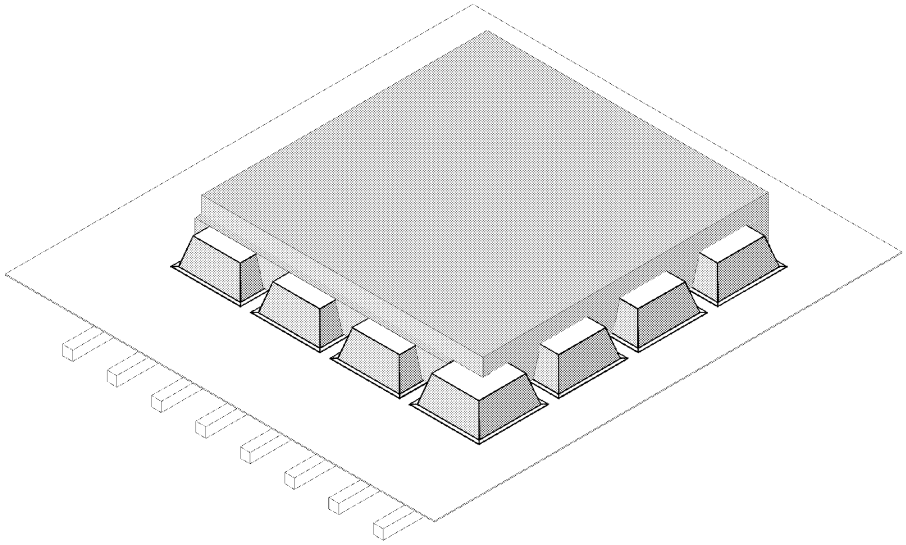


Dome pan for a two-way system

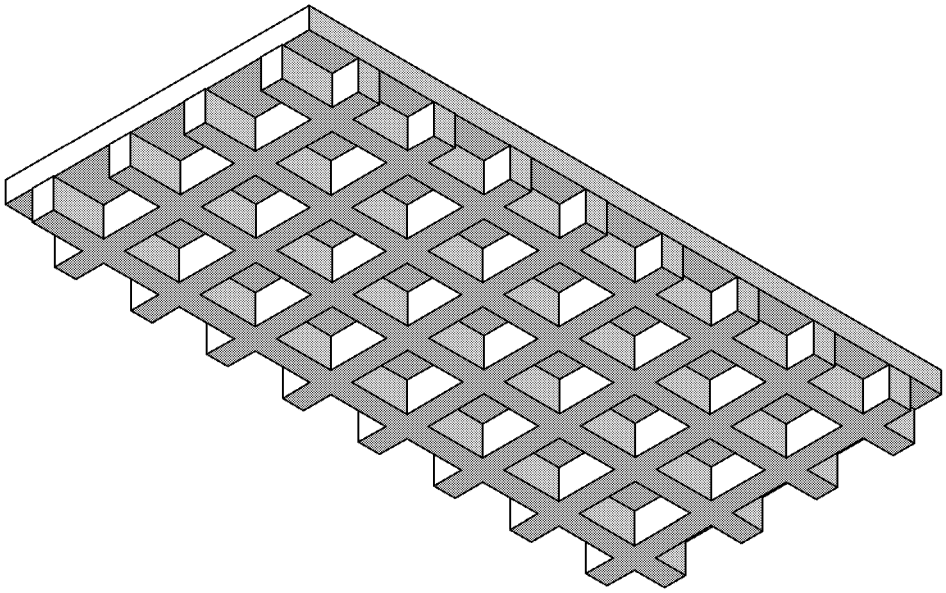
The domes are laid in rows with the desired spacing between them and the slab is poured monolithically between the rows and on top of the domes. Shown below is what the pans would look like before the placing of the concrete.



Seen next is the pans with the deck concrete in place.



Once the slab has been poured and allowed to cure to the proper strength, the falsework is then stripped. If the dome pans are made of steel, they have been oiled prior to placing the concrete. Some of the fiberglass pans have valves that can be connected to compressed air; the pans are then popped loose with the pressure of the air. The finished result is a deck that looks waffle shaped.



Two-way slab seen from underneath

Whichever system is used in forming a deck, once the forms are stripped they are usually moved to the next level and the whole procedure begins again. This repetition allows the crew to refine the process and production is increased.

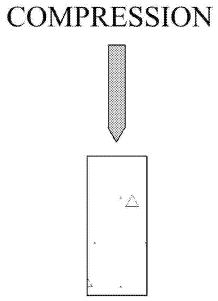
The concrete carpenter should be adaptable to whatever system is being used; there are similarities with all of them. In all cases, the work is heavy and can be dangerous, and all safety procedures should be followed.

Chapter 7 Prestressed Concrete

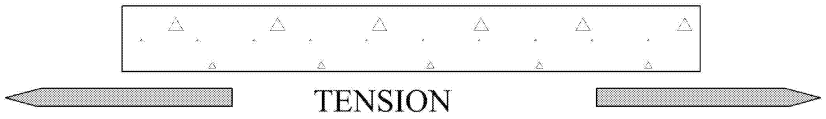
THIS CHAPTER WILL PROVIDE ANSWERS TO THE FOLLOWING QUESTIONS:

- **What is prestressed concrete?**
- **What is the principle of prestressing?**
- **What are the benefits of prestressing?**
- **What are pre-tensioning and post-tensioning?**

We have discussed the elements of building a deck including the column forms, the shoring and the types of floor systems. The design of a deck and the type of floor system used may be affected by whether or not the deck will be a post-tensioned slab. In this chapter we will discuss the principle of prestressed concrete, which is used by architects and engineers throughout the industry. Concrete is tremendously strong in compression, which is the force caused by a crushing load.



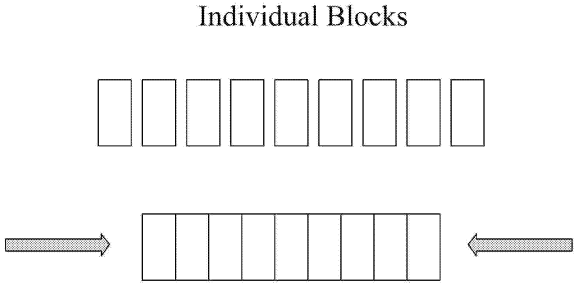
Because of this, concrete is ideal for columns and other areas that are subject to vertical, or compressive loads. However, concrete has very little strength in tension, which is the pulling force that is placed on a horizontal beam. The bottom of the beam is in tension and, when loaded, it will fail if it is made only of plain concrete. This is because plain concrete lacks tensile strength.



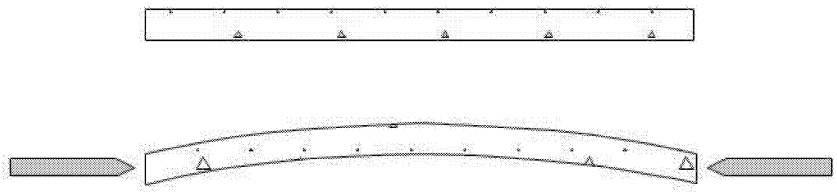
To make concrete a more complete building material, one that can withstand compressive and tensile loads, rebar is added to the concrete. Reinforcing steel has great tensile strength and it adds this strength to the plain concrete. Therefore, almost all concrete used in construction today is reinforced concrete. The amount, the size and the placement of the rebar is usually specified by the engineer and it is calculated to adequately carry the load imposed on the concrete.

Even reinforced concrete has its limitations, and engineers looked for ways to increase the strength of concrete. As early as the 1920s, designers were attempting to add compression to the ends of beams to make the beam stronger.

In the illustration seen below, the individual blocks have no collective strength. However, when force is applied to the ends, the blocks are compressed and act as one piece.



This is the idea of prestressed concrete, by adding compression to the ends of a beam, or a slab, it adds strength to the entire beam or slab. Concrete that is prestressed is stronger than reinforced concrete and, as such, can span longer distances. In addition, prestressing can create uplift in the middle of a beam that helps to counteract the deflection caused by the weight applied. This principle can be seen if one imagines applying pressure to both ends of a thin strip of wood; when the pressure is applied, the middle will rise.

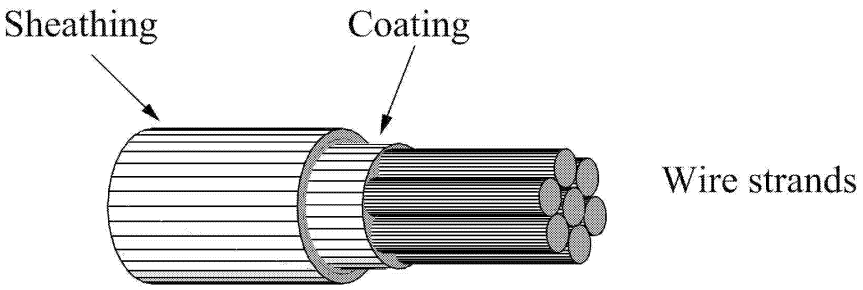


Engineers use this idea to span longer distances with fewer columns. In addition, a prestressed concrete slab can be thinner. This reduces the weight of the slab, uses less concrete and also makes for a lower building height. All of these features make prestressed concrete desirable for slabs and decks, including multi-storied buildings and parking garages.

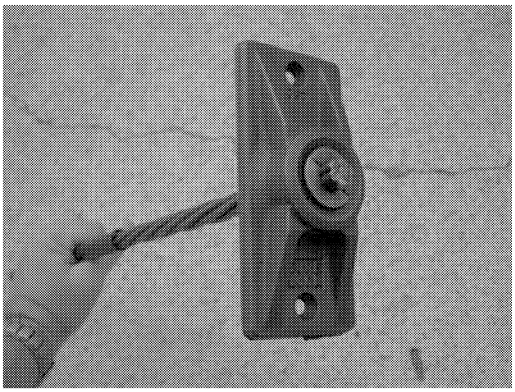
PRE-TENSIONING AND POST-TENSIONING

Prestressed concrete is divided into two types. The difference in the two types is determined by whether the compression is applied before or after the concrete is placed. In pre-tensioned concrete, high strength steel cables, known as tendons, are placed in the forms and the ends are stretched to the prescribed tension. Once the concrete is placed and has reached its proper strength, the tension on the tendons is released and this compresses the member. Pre-tensioning is usually done in a casting yard that is set up

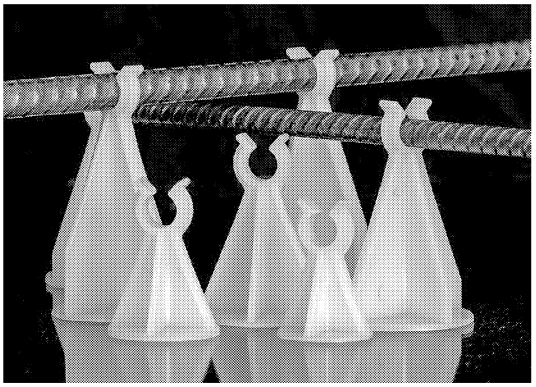
with the jacks and the other equipment needed to pre-tension members. Since this is generally done away from the job site, we will concentrate on post-tensioning.
Post tensioning is a common element in many commercial concrete jobs including bridges and deck slabs. The tendons are made up of one or more strands of steel that have a protective coating and are placed in sheathing or, in cases of large tendons, ducts. The steel used for post-tensioning is very strong, a typical strand will yield at about 243,000 psi., whereas rebar will typically yield at about 60,000 psi.
The tendons are placed in a sheathing that allows for the movement of the tendon inside. The strands are covered with a coating of grease that serves as a corrosion protection.



The tendons are color coded to simplify the installation by the ironworkers. The tendons usually run the entire length of the pour, however, some tendons terminate at a point inside the slab. One end of the tendon is secured and the other end of the tendon passes through a housing that is attached to the inside of the edge form.



The tendons are supported on rebar chairs. The tendons are often draped, meaning that the tendon is installed at a high point over the slab's supports, such as columns and at a low point in the unsupported areas. This draping is achieved by using different chair heights, seen below. The draping provides uplift to areas subject to deflection.



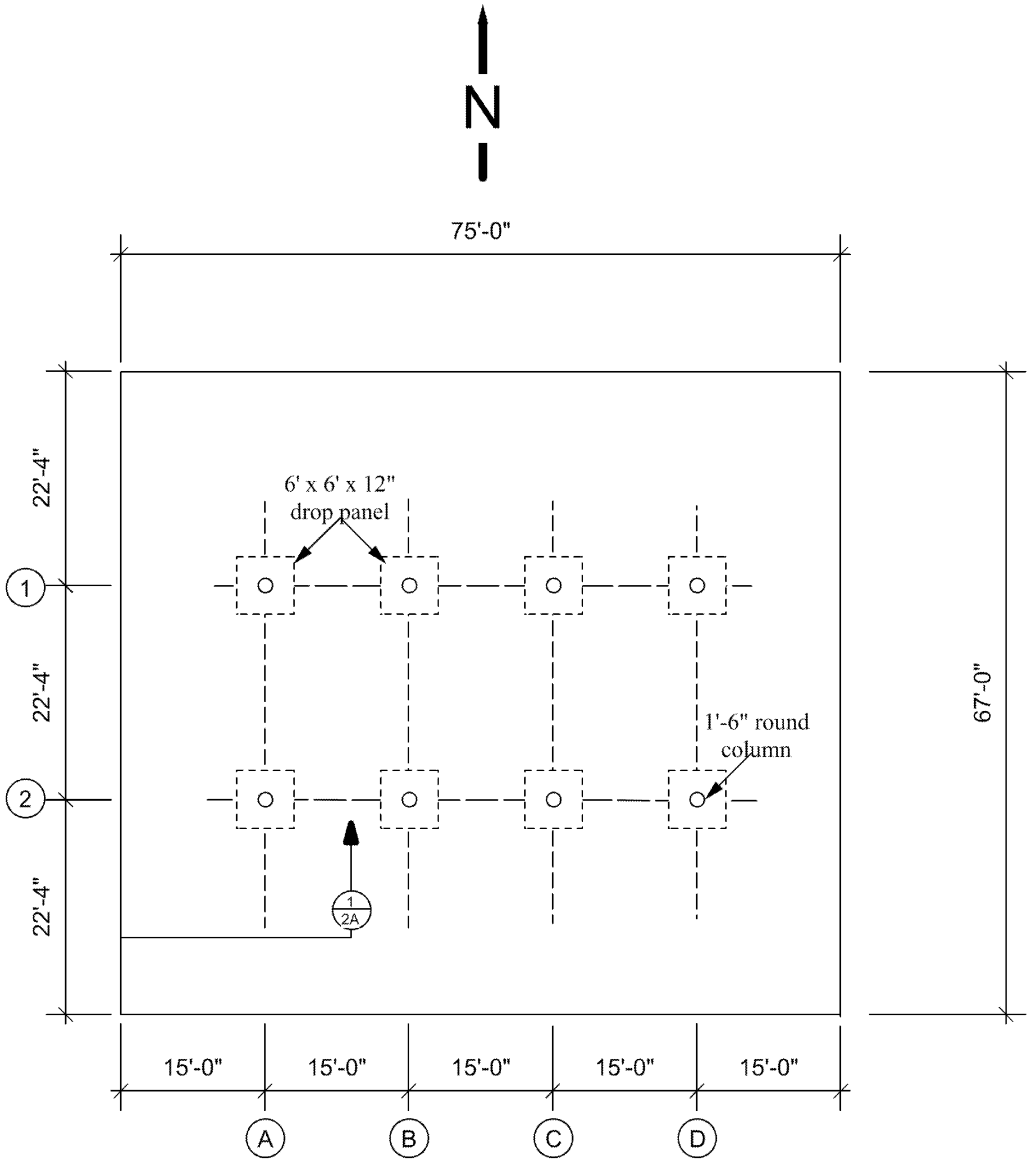
There is a plastic sleeve that protects the tendon at the edge of the pour. Once the concrete is placed, it must be cured long enough for the proper stength to be achieved for stressing. The sleeve is removed from the concrete and a hydralic jack is attached to the exposed end of the cable. A typical stressing force of 27,000 psi. is applied. A cone shaped wedge is used to grip the tendon as it is stretched and prevent the tendon from slipping back after the jack is removed. The shape of the gripper insures that the more tension that is applied, the tighter the cone grips the tendon.
It is important to stress that no workers be allowed to work in an area where stressing is taking place, as it is quite dangerous. Given the extreme force being used, a broken tendon can break through the slab and cause injury to anyone near it. In addtion, care must be used when drilling or shooting pins into a post-tensioned slab to avoid damaging the tendons.

SUMMARY

Prestressing concrete is a method that gives added strength to concrete. By subjecting the concrete to compression, the concrete will be stronger and able to resist deflection under heavy loads. The stressing is done using steel strands that are placed under tension. When the tensioning is done prior to placing the concrete, that is known as pre-tensioning. When the tensioning is done after concrete is placed, it is known as post-tensioning. Post-tensioned slabs are common in comercial concrete, including many garages, bridges and deck slabs.

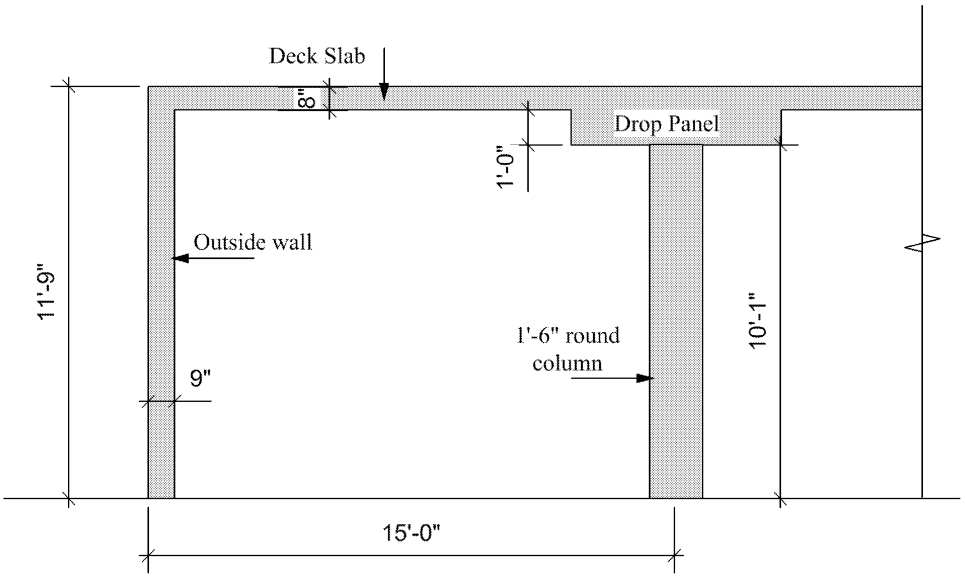
UNIT 018 – COMMERCIAL CONCRETE
TAKEOFF EXERCISE

The following blueprint shows a concrete deck supported by round columns. Use the blueprint to answer the questions below:



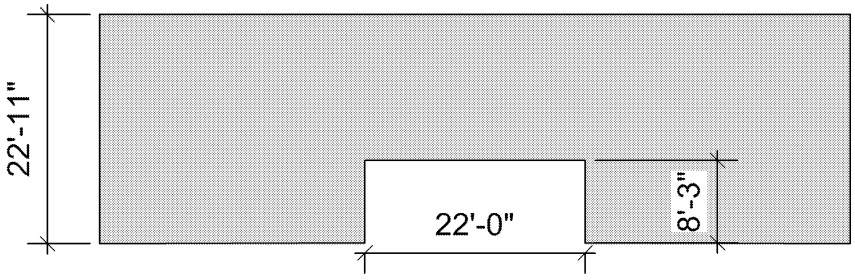
Plan View

Scale 1/16" = 1'

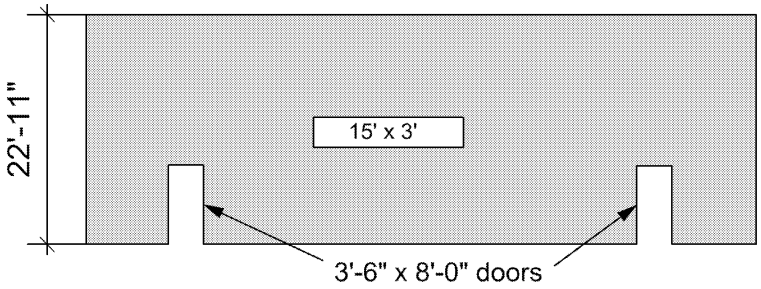


1
2A

Section View
Scale 1/4" = 1'-0"



North Elevation
Scale 1/16" = 1'-0"



East Elevation
Scale 1/16" = 1'-0"

1. How many columns are needed?	
2. How far is gridline A from gridline D?	
3. How thick are the walls?	
4. What is the total square footage (area) of all three openings on the east side of the building?	
5. What is the thickness of the deck slab?	
6. What are the dimensions of the north side opening?	
7. What is the thickness and the height of the columns?	
8. Give the length, width and thickness of the drop panels.	
9. What is the interior dimension between the inside of the west wall and the inside of the column on gridline A?	
10. Calculate the amount of cubic yards of concrete needed to pour the columns and the drop panels. (To find the volume of the round column, multiply Pi (3.14) x the radius x radius x the height of the column, or $\pi \times R^2 \times$ height of column = cubic feet/column.) Cubic feet in 1 column Number of columns Cubic feet in 1 drop panel Number of drop panels Total cubic yards	_____ _____ _____ _____ _____
11. Calculate the amount of cubic yards of concrete needed to pour the deck slab.	

UNIT 018 - COMMERCIAL CONCRETE

UBC CHAPTER 2 – GANG FORMS

Instructions: For each question, indicate which one of the four answers is correct or most nearly correct.

1. A gang form is constructed by:

   a. Driving pile
   b. Inserting a series of wedges
   c. Fastening a series of panels together
   d. Fastening a series of walers together

2. When moved up for successive lifts of a high wall, gang panels are used as:

   a. Climbing forms
   b. Flying forms
   c. Footing forms
   d. Ladder forms

3. Advantages of using gang forms **do not** include:

   a. Lower labor costs
   b. Reduced construction time
   c. Large sections of concrete may be formed at one time
   d. A crane is required

4. Gang form panels are fastened together and reinforced with:

   a. Wedges and anchors
   b. Walers and strongbacks
   c. Tag lines and rigging
   d. Braces and scaffolds

5. Which of the following materials are used to make composite forms of the desired shape or dimension?

   a. Metal
   b. Wood
   c. Fiberglass
   d. All of the above

6. Which type of tie has the greatest tensile strength?

   a. Snap ties
   b. Loop ties
   c. Taper ties
   d. Flat strap ties

7. Walers are fastened to panels, and strongbacks are fastened to:

   a. Panels
   b. Walers
   c. Sleepers
   d. Brackets

8. Excess form release agent on panel surfaces can:

   a. Stain the surface and interfere with concrete bonding
   b. Increase moisture penetration from uncured concrete
   c. Facilitate stripping of the forms
   d. Reduce the cost of forms

9. One method of communication between the ground crew and the crane operator is:

   a. Cell phone
   b. Morse code
   c. Hand signals
   d. Yelling

10. Some types of wall ties incorporate:

   a. Internal spreading devices
   b. Chamfer strips
   c. Lifting brackets
   d. Keyways

11. Bulkheads are used:

a. To create horizontal construction joints
b. To create framed openings in walls
c. To create vertical construction joints
d. To limit the height of a concrete pour

12. Thin pieces of rubber or plastic that are placed across a construction joint to prevent water leakage are known as:

a. Gaskets
b. Waterstops
c. No-leakers
d. Thermal barriers

13. For tight radii on curved wall:

a. Plywood cannot be used
b. Only plastic is suitable for a form material
c. Two thin sheets of sheathing may be used instead of one thick sheet
d. Framing is not necessary

14. The two most important things to consider when designing formwork are:

a. Depth and rate of concrete placement
b. Temperature and curing time of concrete
c. Design strength of concrete and curing method
d. Curing method and time of year

15. Stripping bars are used for:

a. Plumbing wall forms
b. Adjusting the tightness of ties
c. Prying forms away from concrete
d. Consolidating concrete

16. When should safety glasses be worn on a jobsite?

a. When using a power saw
b. When stripping forms
c. When assembling forms
d. At all times

17. Gang forms are used to build:

a. Walls
b. Columns
c. Abutments
d. All of the above

UNIT 018 - COMMERCIAL CONCRETE

UBC CHAPTER 3 – FLATWORK: DECKS

Instructions: For each question, indicate which one of the four answers is correct or most nearly correct.

1. What type of wooden shore splice uses four solid lumber or plywood cleats to secure the splice?

   a. Lap splicing
   b. Engineer splicing
   c. Butt splicing
   d. Top splicing

2. When a deck is supported by structural steel beams or girders, the deckforms that are used are known as:

   a. Gang forms
   b. Suspended forms
   c. Hanging forms
   d. Slipdeck forms

3. Horizontal shoring members are usually built in the shape of a:

   a. Truss
   b. Square
   c. Tube
   d. I beam

4. The formwork engineer does which of the following?

   a. Determines the live and dead load on the formwork
   b. Determines the spacing of the shores
   c. Determines the spacing of the stringers
   d. All of the above

5. What type of vertical shoring system would be used to support a very high and heavy deck, such as a bridge?

   a. Wood post shoring
   b. Adjustable metal shores
   c. Steel tower frames
   d. Tubular steel scaffolding

6. Which of the following is not a component of elevated deck formwork?

   a. A pry bar
   b. A stringer
   c. A mudsill
   d. A shore

7. A 10" thick deck that measures 33'-6" x 42' will require how many yards of concrete? (Round up to the next whole yard)

   a. 11,173 cubic yards
   b. 5 cubic yards
   c. 44 cubic yards
   d. 523 cubic yards

8. Which of the following is not a grade of plyform?

   a. BB plyform
   b. HDO plyform
   c. Structural plyform
   d. ¾" MDF

9. Which of the following are common shapes for job built shores?

   a. T-head
   b. L-head
   c. Two-piece adjustable
   d. All of the above

10. The type of joint that is placed between concrete and other structures is known as a (an):

a. Isolation joint
b. Construction joint
c. Cold joint
d. Control joint

11. What can be used to strip deck forms?

a. Pry bar
b. Wooden wedges
c. Compressed air
d. All of the above

KOEL UNIT 67 – FOUNDATION DESIGN FOR HEAVY CONSTRUCTION

Instructions: For each question, indicate which one of the four answers is correct or most nearly correct.

1. A cylindrical or rectangular casing that is placed in the ground and filled with concrete is a:

   a. Sheet pile
   b. Caisson
   c. Friction pile
   d. Bearing pile

2. When soil cannot be excavated, what may be driven to support tall buildings?

   a. Piles
   b. Spikes
   c. Columns
   d. Cheaters

3. Sheet piles are used primarily to resist what kind of pressure?

   a. Vertical pressure
   b. Static pressure
   c. Horizontal pressure
   d. Compressive pressure

4. What type of piles are often used in the construction of wharves and docks?

   a. Friction piles
   b. Bearing piles
   c. Sheet piles
   d. Wood piles

5. Which type of pile does not have to penetrate to load-bearing soil?

   a. Bearing piles
   b. Friction piles
   c. Wood piles
   d. Sheet piles

6. Which of the following **is not** a typical pile shape?

   a. Rectangular
   b. Round
   c. Square
   d. Octagonal

7. When soils are of low load-bearing strength, this type of foundation is used under the entire building area.

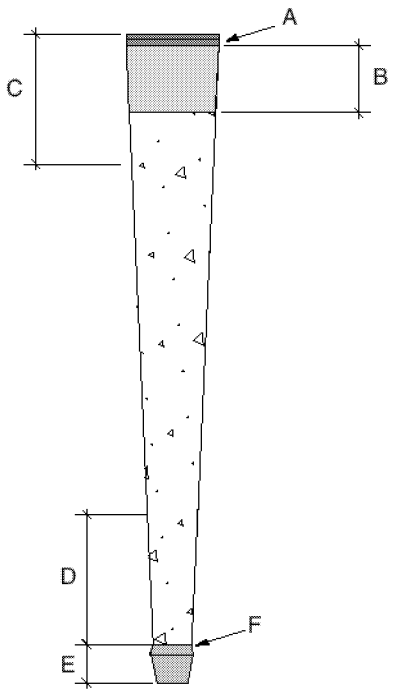
   a. Spread foundation
   b. Matt foundation
   c. Floating foundation
   d. Continuous foundation

8. What is the most common type of pile used for heavy construction?

   a. Friction piles
   b. Wood piles
   c. Sheet piles
   d. Bearing piles

Identify the parts of the pile:

9. Pile shoe	
10. Pile cutoff	
11. Foot	
12. Driving head	
13. Tip	
14. Butt	



UNIT 018 - COMMERCIAL CONCRETE

KOEL UNIT 68 – HEAVY CONCRETE CONSTRUCTION FORMWORK

Instructions: For each question, indicate which one of the four answers is correct or most nearly correct.

1. Most wood forms today are constructed with _____ backed by studs, walers, strongbacks and some bracing.

   a. OSB
   b. Plywood
   c. Solid wood
   d. Hardboard

2. Which of the following sheathings is made specifically for concrete formwork?

   a. Hardboard
   b. OSB
   c. Medium-density overlay (MDO)
   d. Utility-grade plywood

3. When are reinforcing steel bars placed in wall forms?

   a. After the inside forms are set
   b. After the inside and outside forms are set
   c. Before the outside forms are set
   d. After the outside forms are set

4. In order to make forms easier to strip, they should be coated with:

   a. Form release
   b. Paint
   c. Bond breaker
   d. Water

5. When positioning a wood column form, how should the form be secured to the footing?

   a. With anchor bolts
   b. With a wooden template that is attached to the footing
   c. With scissor clamps
   d. With snap ties

6. A form tie that consists of a single rod with a hex nut washer at one end and a bracket and wing nut at the other end is known as a:

   a. Taper tie
   b. She-bolt
   c. Snap tie
   d. Coil tie

7. Turnbuckle braces are installed at what height above the bottom of the form?

   a. 1/2 the height of the form
   b. 3/4 the height of the form
   c. 2/3 the height of the form
   d. At the top of the form

8. Light form ties have safe working load values of how many pounds?

   a. 7,350 lbs. or less
   b. 3,750 lbs. or less
   c. 375 lbs. or less
   d. 5,000 lbs. or less

9. Snap ties are generally available for wall thicknesses ranging from:

   a. 6" to 26"
   b. 6" to 24"
   c. 6" to 2'-6"
   d. 4" to 36"

10. A concrete horizontal member that supports a bending load over an opening, such as from column to column, is a:

    a. Girder
    b. Shore
    c. Joist
    d. Beam

11. Round concrete columns are often formed with the use of:

    a. Plywood forms
    b. Masonite forms
    c. Fiber forms
    d. Pipe forms

12. Which of the following **is not** a common reason for form failure?

    a. Use of undersized material
    b. Securely tightened form ties
    c. Shoring not plumbed
    d. Inadequate diagonal bracing

13. When bolts pass through double walers and screw into a helical coil welded to two or four rods, it is a:

    a. Taper tie
    b. Snap tie
    c. Waler rod
    d. Coil tie

14. A flat slab floor system is supported by columns and thickened sections over the column known as:

    a. Drop panels
    b. Girder panels
    c. Pier panels
    d. Beam panels

15. When a large panel form is made from a series of smaller panels joined together and is lifted into position with a crane, it is called a:

    a. Composite panel
    b. Assembly panel
    c. Gang panel
    d. Drop panel

16. A form system made of prefabricated components, usually including a wooden deck and a metal support system that is moved upward from floor to floor is known as a:

    a. Prefab form
    b. Flying form
    c. Aluma form
    d. Slip form

17. How many yards of concrete are required to fill 8 columns that measure 1'-6" x 1'-6" x 7'-9" high? (round up to the nearest 1/2 cubic yard)

    a. 140 cubic yards
    b. 5 ½ cubic yards
    c. 6 cubic yards
    d. 5 cubic yards

18. Which of these are used with wooden shores to adjust the height of the shore and provide space to remove the shore after the deck is placed?

    a. Wedges
    b. Fillers
    c. Clamps
    d. Gappers

19. A form that is raised electrically or hydraulically as the concrete is being placed at a rate of 2" to 70" per hour is a:

    a. Flying form
    b. Pan form
    c. Jack form
    d. Slip form

20. What type of pan should be used to form a two-way joist system?

a. Long pan
b. Dish pan
c. Dome pan
d. Adjustable pan

UNIT 018 - COMMERCIAL CONCRETE

KOEL UNIT 70 – PRECAST CONCRETE SYSTEMS

Instructions: For each question, indicate which one of the four answers is correct or most nearly correct.

1. When a concrete member has been prefabricated before being used, it is known as what?

   a. Cast-in-place concrete
   b. Precast concrete
   c. Postcast concrete
   d. Pretensioned concrete

2. Which of the following **is not** a type of precast structural member?

   a. Double-T
   b. Hollow-core slab
   c. Channel slab
   d. Slab-on-grade

3. The process of placing high-tensile steel cables in concrete and putting them under great tension to achieve greater resistance to lateral pressure is called:

   a. Prestressed concrete
   b. Post-tensioned concrete
   c. Pre-tensioned concrete
   d. Poststressed concrete

4. Which of the following is a method of connecting precast beams and columns?

   a. Clip connection
   b. Anchored connection
   c. Doweled connection
   d. Plate connection

5. Tilt-ups are generally used for:

   a. One story buildings
   b. One and two story buildings
   c. High rise buildings
   d. Three or more stories

6. If the high strength steel prestressing cables are put under tension before the concrete is placed, then it is called:

   a. Post-tensioned
   b. Casted concrete
   c. Lightweight concrete
   d. Pre-tensioned

7. If the high strength steel prestressing cables are put under tension after the concrete is placed, then it is called:

   a. Post-tenstioned
   b. Casted concrete
   c. Lightweight concrete
   d. Pre-tensioned

8. In tilt-up construction, what is used to fill the space between the bottom of the wall and the top of the footing?

   a. Grout
   b. Concrete
   c. It is left unfilled
   d. epoxy

9. What is the purpose of chord bars in tilt-up construction?

   a. Connects the footings to the walls
   b. Brace the walls
   c. Connects two panels together
   d. Connects the pilaster to the wall

10. When the floor slabs of a lift slab building are cast on top of each other, this is called:

    a. Multi casting
    b. Stack casting
    c. Deck casting
    d. Lift casting

11. In the lift slab method of construction, one way to secure the floor slab in proper position, is with the use of:

    a. Chord bars
    b. Nelson studs
    c. Lifting inserts
    d. Shear bars

12. The precast wall panels that cover the outside of a steel framed building are known as:

    a. Cladding walls
    b. Closet walls
    c. Curtain walls
    d. Shear walls

13. What is used to prevent tilt-up panels from sticking to the slab they are formed on?

    a. Bond breaker
    b. Water
    c. Form release
    d. Sand

14. The principle of prestressing puts the concrete member under what force?

    a. Tension
    b. Compression
    c. Shear
    d. Friction

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