Module 3 – Framing

Chapter 1

During this module on framing we will take a look at the process and procedures for metal building framing, the tools you will need for this task, and the safety considerations involved with this building erection phase.

The first thing an erector should do prior to beginning the framing process is to familiarize his self with the building drawings and specs. Regardless of how many buildings they have worked on in the past this step is vital. A key to understanding the framing process is to become familiar with the primary structural components of a typical metal building.

The large vertical beams are most commonly called columns. There are four types of columns: mainframe columns which always stand along the side walls, end wall columns, corner columns, and finally interior columns which are used as an intermediate support for the rafter frame.

Next are the rafters. They run across the building and are bolted to the columns. There are two types: the mainframe rafters which run between the mainframe columns and the end wall rafters that are bolted between the corner columns and also bolted on top of the end wall columns.

Attached to the columns and extending from the front of the building and creating a roof overhang are canopy beams.

The light gauge horizontal substructure members are known as girts. There are two types: A bypass girt is bolted on the outside of the column and a flush girt is attached with a clip to the web of a column.

On the very top of the columns at the intersection of the side wall and roof are eave struts.

Attached to the rafters for roof support are purlins.

Chapter 2

Before beginning the framing process on any building, the erection foreman or supervisor should develop a site-specific erection plan that will establish the sequence for framing. He must also determine if there are any critical lifts. These are lifts that require more than 75% of a crane's capacity or require multiple cranes to accomplish. The erection plan will also be used to determine the lifting equipment required for both material and personnel.

It is important to perform an inspection of your personnel lift equipment daily. Remember to check fuel levels or battery strength, as well as the tires, fall protection provisions, as well as cables or hoses. Make sure you are familiar with all the operational warnings posted on the

equipment. When you turn the equipment on, look at all the gauges to confirm proper functioning. Check your indicator lights as well. Check horns and alarms for proper function.

Finally, make sure that all refuse and unneeded tools are picked up off of the walking surface and it is free from oil. Material lifting equipment should also be inspected prior to operation to make sure that all are in good working condition. Check the tires, the forks, the boom cable, and hook. Check to assure that the radiator is not leaking. Also, check the hydraulic hoses for possible leaks.

When it comes to moving components on the job site there are three key positions that you need to be familiar with. First is the material lift operator. He is the person responsible for the operation of the crane boom truck or forklift. Next is a signalman. They are designated to give the lifting direction to the material handling equipment operator for maneuvering components. In some instances the rigger will be giving the signals picking up the load and then a second person will be giving the signals for the connection. Remember that both the signalman and the material lifting equipment operator are responsible for the safety of everyone working in the vicinity of that lifting equipment. The third position is a connector. They will normally make the connection of the major components in the air while the material lifting equipment is in use. On a small job, a connector will often be the signalman as well.

When operating a piece of equipment that is powered by a combustible fuel you should never smoke while operating. Remember that only qualified personnel should ever operate this equipment and never under the influence of alcohol or drugs.

Chapter 3

Let's review the hand signals that should be used to communicate between the signalman and the material lifting equipment operator.

To signal a normal stop, extend your arm with your palm facing down and hold that position rigidly.

To signal emergency stop extend your arm palm facing down and move your hand rapidly right and left.

To signal to raise the load extend your forearm vertical with your forefinger pointing up. Now move your hand in a horizontal circle.

To increase the hoist speed, speed up the circling motion.

To signal to lower the load, extend your forearm downward with your forefinger pointing down. Move your hand in a horizontal circle.

To slow down the lowering speed, slow down the circling motion.

To signal to raise the boom extend your arm with your fingers closed and your thumb pointing upward.

To signal to lower the boom, extend your arm with your fingers closed and your thumb pointing downward.

To signal dog everything which means stop everything clasp your hands in front of your body.

To signal to extend the boom while using a telescoping boom, with both fists in front of your body extend your thumbs pointing outward.

To signal to retract the boom while using a telescoping boom, with both fists in front of your body extend your thumbs pointing toward each other. This is the signal to use the main hoist. You can also tap your head with your hand. This is the signal to use the whip line. You can also tap your elbow with your hand.

To signal to raise the boom and lower the load, extend your arm with your thumb pointing up. Flex your fingers in and out as long as the load movement is desired.

To signal to lower the boom and raise the load, extend your arm with your thumb pointing down. Flex your fingers in and out as long as the load movement is desired.

To signal to travel while on the ground if using a hoist, use both hands or your fists in front of your body making a circular motion around each other.

To signal to travel during driving, extend your arm forward with your hand open and slightly raised making a pushing motion in the direction of travel intended.

To signal to move slowly, use one hand to give the motion signal and place the other hand motionless over that hand. This example is to lower slowly.

To signal to retract the boom using only one hand raise your fist in front of your chest with your thumb pointing outward and the heel of your fist tapping your chest.

To signal to extend the boom using only one hand, raise your fist in front of chest with thumb tapping chest.

To signal to swing crane right extend your arm with fingers and thumb flat to the right.

To signal to swing crane left extend your arm with fingers and thumb flat to the left.

When you are giving signals to a forklift operator there are four additional hand signals that you will need to learn. They include: If you need the operator to extend the forks, point two fingers on one hand towards yourself.

The signal to retract the forks is pointing two fingers with one hand towards the operator.

The signal to tilt the forks up is to extend your arm with your fingers closed and your thumb pointing outward rotating your wrist from the 9 o'clock position to the 12 o'clock position.

The signal to tilt the forks down is to extend your arm with your fingers closed and your thumb pointing outward rotating your wrist from the 9 o'clock position to the six o'clock position.

Chapter 4

The erection plan will also help you determine the type and quantities of tools needed for the particular building erection. Remember to always use the right tool for the particular task. Using an improper tool for a task can cause damage to components or even personal injury. Be sure your tools meet OSHA requirements for commercial construction use. The tools we will use in this framing module include spud wrenches, a bull pin, wrenches, a thread chaser for the anchor bolts, oil can or metal lubricant spray, ratchets and sockets, a connecting bar, bolt pouches, a tension control or TC gun, an impact wrench, a five-pound sledge hammer, a power supply with GFI, and extension cords.

Chapter 5

Finally, the erection plan will also be used to determine the needed crew configuration. The importance of good communication among your erection team members cannot be over-emphasized. Your supervisor should call a crew meeting to discuss the safety plan as well as the erection plan just prior to beginning the framing process. Remember safety is your number one concern. If you are uncertain of any aspect of the erection plan or safety plan let your supervisor know immediately.

While are there are many variations of metal buildings you must always choose the installation operation to fit your requirements and particular conditions. There are however certain installation rules for structural members that are widely used and have worked well in the past. These are general practices and may not apply to all buildings and all conditions. But we will take a look at the ones most commonly used since in most cases you will find these to be most relevant.

Primary support members are designed for specific structural strength. If you think you need to alter any of these members you should contact your supervisor who must consult the manufacturer prior to doing so. Cutting a primary member such as a column or rafter could cause a major structural failure with severe damage, injury, or even death. Let's look at some guidelines for considering during the process of raising major structural components.

Remember that when the roof span consists of several rafter sections as with wide buildings a safe procedure for raising by sections and supporting the free end must be followed

regardless of equipment available. In most cases you will proceed from the outside columns inward toward the peak until the entire frame is bolted into place. These general procedures apply to either clear span or multiple span frames.

There are two words of caution concerning installation of rigid frames. First, rigid frames especially free ends or cantilevered sections should never be left unsupported. The frames could fall down and cause injury or death so you want to make sure your frames have adequate support. Second, additional care is required for installing multiple span frames compared to clear span frames. Frames with interior columns are lighter and can buckle during installation more so than clear span frames so you need to use extra care during rigging and also when you are handling interior column frames.

The safety of yourself and others depends on proper installation techniques so make sure you follow the correct procedures during installation.

Chapter 6

OSHA regulations require that prior to beginning erection of structural components, written authorization from the controlling contractor must be provided to the erector indicating the concrete slab and anchor bolts are sufficiently strong enough to support the required building loads. Remember you should never begin installation without written authorization from the controlling contractor. If you were to use uncured concrete, anchor bolts might pull loose and the slab could chip and cause building components to fall and crush or crack the slab. Obviously this could also result in injury or death to you or your crew.

After your supervisor has received the written authorization from the controlling contractor to begin framing and prior to beginning to erect the major structural components, one person should be responsible for confirming that all the column anchor bolts are ready for installation of the columns. The first step in this process is to check the anchor bolts to confirm that they are properly installed as designated by the anchor bolt plan. This includes location, pattern, projection, and elevation. On very large jobs often a civil engineer will be brought in to perform this task. In some installations you may be required to shim up the column to compensate for elevation variances in the concrete, or as otherwise required by the architect. An engineer should always specify how this should be properly done to limit liability to the erectors. If the anchor bolts are bent just slightly they should first be straightened using a small sledgehammer tapping against the nut, being careful not to hit the threads. If the anchor bolts have been bent to the point where they may have been stressed severely you must check with your supervisor to determine if the bolt can be adjusted or must be replaced using approved methods.

Often times when the slab is being poured concrete will splash on the bolts or they may even have damaged threads. A messed up thread will surely delay the crew when it comes time to install the columns. So the person responsible for checking all the anchor bolts should use a thread chaser to run over every bolt to assure the nuts will go on smoothly when the time comes to set the columns. This will save the company substantial money.

This is done by first removing the nut from the bolt with a wrench. Then, lubricate the bolt with oil or commercial lubricant spray. Next, place the correct side of the thread chaser over the top of the bolt and carefully turn the thread chaser by hand to be sure that you start the thread chaser on the factory threads. If you cross thread the bolt the thread chaser will cut a new set of threads in the bolt and you risk the possibility of damaging the bolt to the point it would have to be replaced by another at significant cost and delay. Now, run the thread chaser all the way to the base of the slab. Continue to lubricate it as needed. Finally, remove the thread chaser and replace the nut on the bolt.

Chapter 7

Another thing that is important to do before the framing crew arrives is to confirm the inventory of building components to be sure all of them are at the site. Go to the storage area and open the hardware crates and containers and organize all the required bolts and fasteners by size and grade. If possible all of the bolts and nuts should be made up prior to erection. This will save time in the air and on the ground connecting components.

During the module on unloading and material handling you learned that in most cases, you should lay out all your columns and rafters on the slab as they are unloaded from the truck. This saves both time and money for unnecessary restaging of your components.

Let's look at the final material staging process now that happens prior to beginning the framing sequence. The corner columns are staged at each corner of the slab. The end wall columns and end wall rafters are positioned along the end walls. The mainframe columns should be positioned with a base near each designated anchor bolt location. The eave struts are positioned along the sidewalls.

The erection drawings indicate that on this building flush girts will be installed in the front of the building and on the side walls. So the flush girts should be staged just off the front and sides of the slab. The plans also call for bypass girts on the back wall so they should be staged off the slab there. Be sure to leave room for the personnel lifting equipment to maneuver on the slab.

Chapter 8

Now with our components staged properly for beginning the framing sequence we are ready to maneuver the first two mainframe rafter sections together on the slab. To align the holes, use the pointed end of a spud wrench or bull pin.

Now let's look at the correct way to tighten bolts used for connecting your components. Since there is a specific sequence to getting the bolts tightened you will want to pay close attention to ensure the correct order of bolt tightening is followed according to your manufacturer's recommendations. The normal sequence is to first insert all the bolts in your connection. Begin at the rigid point in the connection where there is no gap and spend time in each row of bolts progressing toward the edge of the connection with the gap. Snug tight bolts from the most rigid part of the connections to the free edges. Repeat this until all plies of the connection are completely pulled together with no gaps and all bolts are snug tight. You can do this with a few impacts of an impact wrench or by using your full effort with an ordinary spud wrench. A tension control or TC gun with special tension control bolts can also be used to connect primary structural components. When a TC bolt is tightened to the correct tension, the end will snap off. Then the end is ejected from the TC gun and you are ready for the next bolt.

The advantage of using TC bolts is that they can be easily inspected from the ground to confirm proper installation. These bolts do cost more than regular bolts and need to be specially ordered from the manufacturer if desired for a particular project. Remember it is each erector’s responsibility to make sure the bolts are properly tightened.

Now let's get back to the framing crew. This building has been designed to have a covered area extending from the rafters at the front of the building cantilevered over the four overhead doors. So the next step is to attach the canopy beams to each of the specific columns. Now on each column, install the girt clips. Flush clips are bolted to the web of a column. This is an end wall rafter bolted together with the specified parts. Remember that these rafters will be bolted to the corner columns and also connected on top of the end wall columns. While the rafters are still on the slab you will also want to install the flange braces snug tight as specified by the manufacturer. After they are erected the other ends will be bolted to the purlins.

Chapter 9

After all of the girt clips have been bolted to the columns and all of the flange braces have been bolted to the rafters we are ready to rig the first column of a braced bay for lifting. A braced bay is one in which the manufacturer has designed cross bracing between the columns or the rafters.

Now refer to the erector's drawings to determine which bay or bays are braced bays. You should always set braced bay columns first. The reason you will do this is that a braced bay can stand more securely than an unbraced bay without wall sheeting installed. Once the braced bay is up the adjacent structural members will be connected to it. There may be many braced bays in a building and in large buildings, most erectors like to start from a braced bay toward the center of the building.

Chapter 10

This being a small metal building our crew will begin with the first bay from the left. It is a braced bay. The next step is to position the crane, or in this case a boom truck for our first pick. Here the corner column is rigged with a super clamp.

Super clamps come in various sizes depending on the particular load requirement. Be sure to confirm that the structural point at which you are clamping to is sufficiently strong enough to support the weight of the component. If in doubt check with the structural engineer prior to making the pick. Super clamps offer a much better rigging solution than chokers on columns. They will save you time and money.

Now the boom truck cable hook is attached to the super clamp. Then the column is hoisted and positioned over the anchor bolts. The boom truck operator carefully follows the signals of the connector. Once again communication is vital to the safety of your team during this procedure.

Now the nuts are attached and tightened securely. In this case the column is securely bolted and the connector releases the pick. If needed you should be prepared to temporarily brace the column prior to releasing the pick.

Now the connector can remove the super clamp for rigging the next column. Now in the braced bay the first mainframe column is rigged with a super clamp and hoisted into position. It is bolted securely into place. After at least two columns in the braced bay are stood up side-by-side you can attach the first grits. Just snug tighten the bolts for now.

Now install the rest of your columns in the braced bay using the same procedures. Be particularly careful when you are raising columns that are cantilevered like this for a roof overhang. A tagline should be attached to prevent the structural component from swinging and injuring someone or damaging materials or equipment. Continue to install the bypass girts around the building. At the girt laps be sure you follow the OSHA guidelines carefully to assure that no one is injured by a loose girt.

Now we are ready to rig the end wall rafter for hoisting. Here we are using a super clamp for the pick. An erector with a guide rope helps to control the iron in the air. The connector maneuvers his lift into position to make the connection at the corner column. The signalman directs the boom operator to maneuver the end wall rafter into position. After aligning the holes with the spud wrench insert the bolts and attach the nuts specified in the erection plans. Then tighten the bolt securely. Now the connector can maneuver his lift along the end wall rafter and make each connection at the end wall columns bolting each of them securely. Next the connector bolts the end wall rafter to the other corner column.

Now we are ready to prepare the first mainframe rafter to be hoisted. This rafter is part of the braced bay. Here two chokers are rigged for the pick. Remember to carefully place them so the load is raised in a balanced manner. You should attach a tag line to control the iron during maneuvering. Before lifting the first mainframe rafter, the connector needs to maneuver the scissor lift into a position that will allow him to make the connection without interfering with

the pick. Now insert the bolts and attach the nuts specified in the erection plans. Tighten the bolt securely. Now the bolts on the other end of the rafter need to be securely attached to the other mainframe column.

Some manufacturers require a turn of the nut method when bolting mainframe components. This process is a National Industry standard that mandates a certain method of tightening the bolts to achieve the required torque value. The bolt is first snug up until the plates are pulled together. Then a mark is made on the nut and the plate indicating the starting position. Depending on the size and type of the bolt the specifications will call for an additional turn of the nut. This will generally range from a half turn to 3/4 of a turn. Many jurisdictions will call for an inspector to be present during this process. You should consult with this inspector prior to beginning the turn of the nut method.

During the framing process, particular caution needs to be used when a cantilevered framing section is partially installed like this one. At this stage you may need to put up temporary installation bracing until the structure is complete, particularly if these components will be left standing overnight. That decision is made by the competent person on the erection crew prior to releasing the pick. Use as much temporary bracing as necessary to make sure your structure is secure during installation. Remember the erector is responsible for adequate temporary bracing. It is not supplied by the manufacturer so it is up to you to ensure there is enough to support your structure as needed. Your bracing should be installed to a taut condition removing all slack. Make sure not to over tighten these.

Chapter 11

At this point we are ready to raise and install the eave struts on both side walls of the braced bay. Using the specified bolts and nuts, bolt them securely.

Now we are ready to stage purlins for installation in the braced bay. Here two scissor lifts are used to lift and connect the purlins between the first two rafters in the braced bay. This will provide a great deal of stability to the partially standing structure.

At this point the erector will install the first cross brace cable between the corner columns and the next mainframe column as specified by the manufacturer. When attaching the brace cable to a rafter or column, be sure the ear of the hillside washer is locked into the slot. Remember that any needed modifications to cross-bracing shown on the drawing must be approved by the manufacturer prior to modifying. After the cross-bracing is installed between the columns we can now bring the bay in to plumb using a level. You can tighten the vertical cables running between columns to bring the columns plumb. Keep in mind that after all the columns and rafters are installed you will need to confirm the entire building is square and plumb.

Now that the braced bay is plumbed and the major structural components are installed properly we will rig, raise, and install all of the rest of the additional rafters the same way, moving out from the braced bay.

Installing personnel doors, windows and framed openings will be covered in detail during the next DVD module in this Quality and Craftsmanship series entitled Windows and Doors. For now, you should check your drawings carefully to verify if the types of doors, windows or framed openings are to be installed before or after wall sheeting. Girts could interfere with the installation of these building components. This building calls for four overhead door frames to be installed. After they are assembled on the slab, flush girt hanger clips are attached. Then the frame is raised into place using a forklift. The frame is then anchored to the concrete using the specified fasteners and then plumbed. Now flush girts are attached between the overhead door frame and the mainframe columns as specified in the erection drawings. Now install remaining eave struts, install the bolts and nuts required, and then tighten them securely.

Next as you install the remaining purlins you will need to remove the bolts on the rafter to purlin connection. After you have lapped the purlins install the bolts and nuts and tighten

securely. At the purlin to purlin lap, install the bolts and nuts and connect the purlins together at the end of the laps as detailed in the specifications.

Now look at your roof architectural drawings to determine what roof penetrations are called for. Determine if any of these will require subframing to be installed at this stage in the framing sequence. If they do, then install them at this time according to the manufacturer's details. You can refer to the module in this Quality and Craftsmanship DVD series on roof penetrations for installation details of these various components.

Next install the cross-bracing cables or rods that run between the rafters or columns in between the remaining bays. Now an erector can align the other end of the flange braces bolted to the rafters and attach them to the purlins as required. Now tighten both the flange brace bolts securely.

Now that all of the framing components are in place take some time and go around the structure double checking to see that the correct bolts and nuts are in place. Also check to see if they are tightened the correct tension.

Chapter 12

Finally we are ready to plumb and square the building. The first step is to plumb the columns using a level, laser, or transit.

Now let's take a look at the proper setup and use of your transit. First set up your transit on the tripod and make sure it's level. Next rotate the transit until your tape reads the same at points A and B at the top of the column and at the base of the column. Make sure you measure flush with the web of the column. Lock the horizontal rotation of your transit and adjust the cable rod until the tape is reading the same at all points indicated as shown.

Next you will need to bring the bay into square by cross measuring. Bolt dimension should be the same forming the 90-degree corner. Be sure you are in compliance with OSHA fall protection requirements at all times.

Chapter 13

The next process in the framing sequence is referred to as “detailing the iron.” The first step in that is to install the rake angle using tek screws and a screw gun or bolts as specified. The rake angle is fastened to the purlins for secure attachment of the wall sheeting at the top of the wall. Check your manufacturer’s details to see if bridging or bracing is required between girts for wind loads.

Bridging or bracing may also be required in your roof between purlins. This is to prevent rolling of the purlins due to roof loading from snow; for example, collateral loads such as sprinklers, HVAC, and electrical or dead loads such as drop ceilings. Keep in mind that the overall strength of the building depends on the rest of the required components being installed including wall sheeting, roof panels, flashing, and trim. Temporary bracing should only be removed when a competent person has determined that it is safe to do so.

Chapter 14

Now that the framing is complete take the time needed to walk the site and visually inspect the building to verify that all the components are installed correctly. Now double check to verify the building is square and plumb prior to beginning the wall sheeting phase that will be covered in the Wall Sheeting module in the Quality and Craftsmanship series.

You are now ready for a framing inspection for compliance with local codes. Any excess framing components should be inventoried. Check with your supervisor to determine if they were overlooked or should be returned to the manufacturer or put into the company inventory for future use.

You have now completed the module on framing. This presentation was created by the Metal Buildings Institute and is one of several training modules available to metal building

erectors. We hope that it has helped you with understanding the basic procedures for framing. Continue on to the review section of this DVD to complete this module.