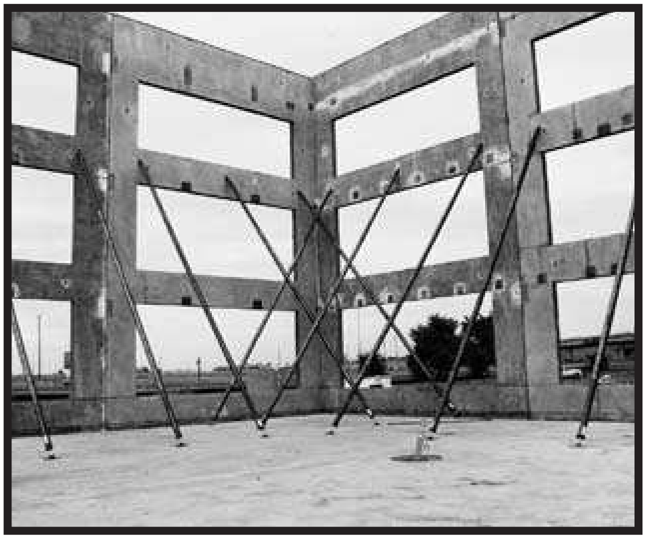
Tilt-Up Construction

Tilt-up is a job-site form of precast concrete construction. It involves prefabricating concrete wall sections (panels) flat on either the building floor slab or on a temporary casting slab, then lifting or tilting them up and carrying them to their final position with a mobile crane. Once they are in position, the panels are temporarily braced until they are tied into the roof and floor system and become an integral part of the completed structure.

It is a fast, simple, and economical method of construction, which has been used extensively for one-story buildings and has most recently been adapted successfully to multi-story structures. Today, walls of up to four stories in height are being cast and tilted into position. Currently there have been several instances of wall panels as high as six stories being cast and erected as a unit by the tilt-up method of construction.

The economy of tilt-up lies in its simplicity of construction. The critical factors in this method of construction are handled in the pre-construction planning stage. Skill in laying out panel erection sequences and designing safe lifting elements which fully utilize crane time will provide for the fast and safe completion of the job.



Early History of Tilt-Up

Robert Hunter Aiken erected the earliest know tilt-up building around 1893, at Camp Logan, IL located just north of the town of Zion. As mobile cranes were not available during this time-period, Mr. Aiken used a specially designed tipping table on which to cast and erect the wall panels.

Mr. Aiken is recognized by many as being the father of what is now known as tilt-up construction. In addition, Mr. Aiken developed the first insulated tilt-up wall panels, which consisted of 2” of concrete, 2” of sand and 2” of concrete. As the panels were tipped into position, workers washed the sand from between the concrete wythes, leaving an insulating center air space.

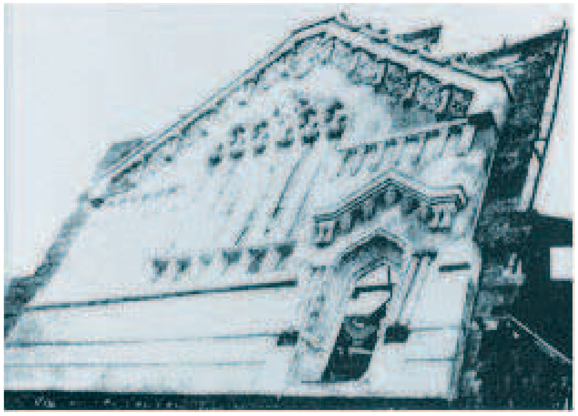
In an article published around 1910, Mr. Aiken reported that two men were able to erect a wall, in one hour, that was 76 feet long by 27 feet tall and weighed 76 tons. In this same article, Mr Aiken stated he had used his tipping table method of construction to erect fifteen structures in five different states. His method of construction was known as the “Aiken method of house building.”

Only two mid-western buildings constructed using Mr. Aiken’s “method of house building” are known to survive. They are the Memorial United Methodist Church of Zion, IL and the Camp Perry Commissary Building 2009 located near Port Clinton, OH. The Zion church was erected in 1906 and the Commissary in 1908. Both buildings stand today as monument to the longevity of tilt-up construction.

In 1911, Robert Aiken and his Aiken Reinforced Concrete Company, Inc. used his innovative construction method to erect 111-foot x 644-foot Paint Shop building, containing 36 rail car bays, for the Los Angeles Railway Company. The building’s 106-foot long, 100-ton wall sections were cast horizontally and then tipped into position. This building is undoubtedly the largest of its era to employ tilt-up construction.

Also in Los Angeles, Mr. Thomas Fellows, developed a variation of the Aiken system in 1910 and used it to construct a low-cost demonstration house. Mr. Fellows cast the modular wall units horizontally on the ground and later lifted them into place using a mechanical crane.

In 1912, a San Diego based architect, Mr. Irving Gill used the Aiken tipping wall technology in the Banning House in Los Angeles and in the large La Jolla Women’s Club building of 1913. In 1912, Mr. Gill purchased the patent rights of the bankrupt Aiken Reinforced Concrete Company and formed his own Concrete Building and Investment Company. However, the Aiken method was determined not to be very useful in concrete construction and Gill did not employ it much after 1913.



Although Mr. Aiken, Mr Fellows and Mr. Gill pioneered tilt-up construction, modern day tilt-up’s popularity is based on two WW II era developments, the introduction of the ready-mix concrete batch plant and mobile cranes.

General and Technical Information

Dayton Superior's Role in the Development of Tilt-Up

Since the beginning of tilt-up construction, Dayton Superior has been instrumental in developing and manufacturing the hardware necessary to safely and economy in the most critical steps for this method of construction -- that of lifting the wall panel and placing it in place without damage. The embedded coil insert pioneered by Dayton Superior was an important development in tilt-up techniques. A major breakthrough resulted in the mid-sixties with the design of the Twist-Lift insert and lifting hardware. The Twist-Lift System was one of the simplest and most economical lifting systems on the market for many years. The Twist-Lift System was a quick connect-release system and was the forerunner of today's ground release systems

Further innovations have been made through research and development of the Ground Release Swift Lift System for tilt-up construction. This system offer tilt-up contractors the advantage of being able to release of the lifting hardware from the ground with a simple pull on a release line. Worker safety was greatly improved as the Ground Release Swift Lift System eliminated the need for workers to climb a ladder to remove the lifting hardware from the panel.

Dayton Superior has continued to strive to provide the contractor with a variety of options for lifting panels, developing the Gyro Tilt Plus System, the Tilt-Up 3 Lifting System and recently introduced the Superior Lift Tilt-Up System. Our product development team continues to strive to provide a complete package for economical and safe construction of tilt-up buildings.

Technical Services

Dayton Superior maintains two strategically located Technical Services Department, located in Ohio and California. Dayton Superior Technical service is based on approximately 50 years experience involved in detailing several million panels of all shapes, sizes and degree of difficulty. Using computer aided design, the following services are provided to serve the needs of the Tilt-Up Construction Industry. Services include:

- Consultation/recommendations
- Panel erection details
- Wind bracing requirements
- Additional reinforcement, if necessary
- Strongback requirements, if necessary
- Rigging methods
- Material takeoffs

General Tilt-Up Considerations

Tilt-up construction involves the following considerations:

- The tilt-up concrete panel is partially supported by the ground or slab during tilting.
- The concrete panel is usually handled only once.
- After tilting, the panel is only raised two to three feet and is generally not moved very far by the crane.

At the time of initial lift, the face lift inserts and bolts/hardware are in tension or in a combination of tension and shear. As the panel is rotated and raised, tension decreases and shear increases as the entire load is transferred to the inserts (when the panel is in a vertical position).

Tilt-up panels must be reinforced with no less than the minimum steel required by the latest edition of the American Concrete Institute, *Building Code Requirements for Reinforced Concrete* (ACI 318). As a general rule, #4 bars at 12" O.C. in both directions will satisfy the requirement. If flexural stress limits will be exceeded during lifting, additional reinforcing steel, or strongbacks must be added to the panel.

Definitions

Rated Load — The maximum load that should be applied to an anchor, insert, coil bolt, brace or lifting hardware unit. Safe Working Load, Safe Load Carrying Capacity or SWL are other terms used in this handbook for the term Rated Load.

Ultimate Load — The average load or force at which the item fails or no longer will support or carry a load.

Dynamic Load — A resulting load from the rapid change of movement, such as the sudden stopping, jerking or impacting a static load. A dynamic load may be several times a static load.

Safety Factor — A term denoting theoretical reserve capability which has been determined by dividing the ultimate load of the product by its rated load. This is expressed as a ratio; for example, 2 to 1.

Safety Notes and Product Application

Dayton Superior publishes the safe working loads and the associated minimum safety factors of its products and strongly advises that the minimum safety factors displayed not be exceeded. When there are unusual job conditions, minimum safety factors must be increased to accommodate unusual conditions. Refer to the provisions of the American National Standards Institute (ANSI A 10.9). Occupational Safety and Health Administration (OSHA) Act, Part 1910, the American Concrete Institute (ACI) *Tilt-Up Concrete Structures (ACI 551)* and *Recommended Practice for Concrete Formwork* (ACI 347) and the *Tilt-up Concrete Association's Guideline for Temporary Wind Bracing of Tilt-Up Concrete During Construction,* when considering safety factors.

Warning: Dayton Superior strives to ensure that all products it supplies meet or exceed all safety requirements. However, the performance of a product may be affected by the manner in which the product is used. It is imperative that the user be familiar with the proper installation and use of the products displayed in this publication prior to job application. Failure to properly install and use the products displayed in this publication may lead to serious accidents and/or deaths.

Safety Notes and Product Application:

All safe working loads shown in this publication were established with the following factors considered:

1. All products are in new or "as new" condition. The safe working load is considered the greatest load that will be applied to a product.
2. Inserts are correctly embedded in sound concrete and are firmly bolted or wired in place so that the vertical axis of the inserts is perpendicular to the lifting surface.
3. Concrete compressive strength (f'c) at time of initial lift is at least the strength listed in the insert selection chart for the insert being used.
4. Bolted hardware has full bearing on the concrete surface, and attachment bolts bear fully on the hardware.
5. Caution must be taken so that the hardware is not subjected to a side loading that will cause an additional, unintended loading.
6. Erection and attachment bolts are the proper length and are well tightened to prevent hardware slippage and bolt bending.
7. Coil bolts have minimum coil penetration through the insert coil, but are not bearing on concrete at the bottom of the void.
8. Inserts are properly located in relation to edges, corners and openings, and are at distances that permit the development of a full shear cone. Minimum edge distances are noted throughout this publication.
9. The applied load on an insert is calculated to include the effect of both axial and transverse loads.
10. Electroplated inserts have been properly baked to relieve brittleness. Failure to do so may result in premature failure.
11. No field welding to the lifting inserts or lifting hardware has taken place. Welding may cause brittleness and result in premature failure. Since Dayton Superior cannot control field conditions or field workmanship, Dayton Superior does not guarantee any product altered in any way after leaving the factory.

Safety Factors

Dayton Superior recommends the following minimum safety factors identified by Occupational Safety and Health Administration (OSHA), Act Part 1910 and American National Standards Institute (ANSI 10.9). Tilt-up construction may require additional safety considerations. Many field conditions may warrant higher safety factors, i.e., adhesion of the panel to the casting surface, jerking the crane during lift, inadequate crane size, improper handling of an erected panel, transporting an erected panel over rough surfaces, exceeding boom capacity, etc. The minimum safety factors listed below should be adjusted accordingly when any of the above conditions are known to exist.

Safety Factor	Intended Use of Product
1.5 to 1	Tilt-up Wall Braces
2 to 1	Floor and Wall Brace Anchors
2 to 1	Lifting Inserts
3 to 1	Permanent Panel Connections
4 to 1	Handling Panels Multiple Times
5 to 1	Lifting Hardware and/or Reusable Hardware

If a different safety factor is required for any reason, the published safe working load must be adjusted. The following equation is used to adjust a safe working load:

$$\text{New Safe Working Load} = \frac{\text{Old Safe Working Load x Old Safety Factor}}{\text{New Safety Factor}}$$

Warning: New Safe Working Load must not exceed the product's Mechanical Capacity — New Safety Factor. Contact the closest Dayton Superior technical service center for assistance in determining a products mechanical capacity.

General and Technical Information

DAYTON SUPERIOR

Lifting Stresses and Concrete Design

Lifting and rotating a wall panel creates high stresses that may exceed in-place construction values. A tilt-up wall panel with low concrete compressive strength is more susceptible to failure by erection stresses.

The maximum erection stress occurs as the horizontal panel is tilted into a vertical position. These applied stresses happen early in the construction sequence, before the concrete has attained full strength.

As the panel is tilted, the dead weight of the panel induces a flexural moment with associated stresses. The stress level is dependent on the size and weight of the panel, the number of openings, the number of lifting inserts and locations, and the type of rigging and cable lengths used. The lifting stresses are controlled with proper insert design and placement, strongback options, various reinforcing techniques and/or by increasing the compressive strength of the concrete at the time of lift.

Concrete is weak in tension, therefore induced tensile stresses are limited to values below the tensile resistance of the concrete. The table below lists various safe tensile stress limits.

Concrete Weight	Allowable Tensile Stress
150 PCF	$6\sqrt{f'_c}$
Greater Than 110 PCF and less than 150 PCF	$.85 \times 6\sqrt{f'_c}$
110 PCF	$.75 \times 6\sqrt{f'_c}$

Note: f'_c refers to the actual concrete compressive strength at time of lift.

Safe Working Load Reduction Factors for Lightweight Concrete

Safe working loads for the products shown in this publication were derived from analysis and testing using reinforced normal weight concrete (150 pcf). The safe working load of an insert is dependent on the compressive strength and density of the concrete in which it is embedded. Therefore, when Dayton Superior tilt-up inserts are used in “lightweight” concrete tilt-up panels, the safe working load must be recalculated to compensate for the reduction in concrete density. Multiply the published safe working load by the reduction factor shown in the table to obtain the corrected safe working load.

Concrete Type	SWL Reduction Factor
Normal Weight	1.0
Sand-lightweight Concrete	0.70
All-lightweight concrete	0.60
For all-lightweight concrete with a weight of 110 pcf or less	0.60

Interested readers are referred to section 11.2 of the American Concrete Institute’s “Building Code Requirements for Reinforced Concrete (ACI 318)” for additional information.

Anchor/Insert Capacity

Anchors/Inserts are designed to resist loads applied as direct tension, shear or a combination of the two. The following equations have been developed to predict concrete capacity of anchors/inserts and are applicable to anchors/inserts that are properly embedded in unconfined concrete. Confinement of the concrete, either from an applied compressive force or reinforcement is known to increase the load carrying capacity of concrete. At this time, design equations for anchors/inserts, which include reinforcement confinement, have not been developed.

The Strength of the Concrete

When a load is applied to an insert embedded in concrete, it induces a corresponding resistive force in the concrete. Insert failures can be predicted with a reasonable degree of accuracy by using the following equation for concrete breakout from ACI 318 Appendix D.

f'_c = Compressive strength of the concrete at time of lift

$P_{concrete} = 0.75 \times \varphi_{c,N} \times \lambda \times 24 \times \sqrt{f'_c}\, h_{ef}^{1.5}$

$P_{concrete}$ = Maximum tension load carried by concrete and;

λ = Reduction factor for use with lightweight concrete, see page 6;

$\varphi_{c,N}$ = Factor for cracked concrete: 1.0 if cracked and 1.25 if uncracked.

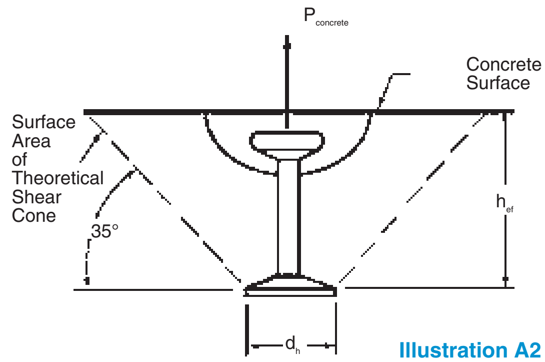


Illustration A2

Combined Shear and Tension Interaction

Anchors/inserts and bolts that are subjected to combined shear and tension loading should satisfy the following equation:

$$\left(\frac{f_v}{F_v}\right)^{5/3} + \left(\frac{f_t}{F_t}\right)^{5/3} \leq 1.0$$

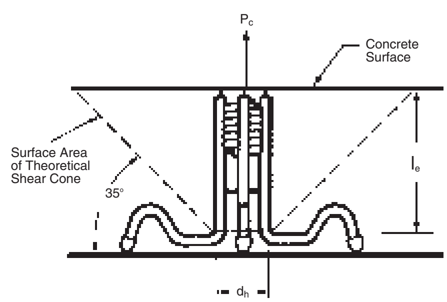
Where:

f_v = applied shear load

F_v = shear safe working load

f_t = applied tension load

F_t = tension safe working load



General and Technical Information

Edge and Shear Loading

Another condition frequently encountered is an insert embedded near a free edge or corner and loaded in a direction transverse to the axis of the bolt, toward the free edge. Edge lift panels are examples of this condition.

Many tests have shown that edge inserts loaded transversely to destruction (see Illustration L) finally fail because of an initial failure of the concrete over the coil. This initial failure transfers the entire load to the insert struts. If the load is large enough, the struts will fail in bending or shear or both.

An analysis of tests indicates that the ultimate load on edge inserts loaded in the direction of the free edge is a function of the distance from the insert to the free edge. The effect of bolt diameter and insert configuration appears to be of secondary and negligible importance. For conditions where shear loading must be considered, it is appropriate to use the following equation from ACI 318 Appendix D:

$$\text{Shear Safe Working Load (lbs.)} = \frac{\psi_c \cdot \lambda \cdot 8 \left(\frac{l_e}{n \cdot d_o}\right)^{0.2} \cdot \sqrt{n \cdot d_o} \cdot \sqrt{f'_c} \cdot \left(c_{a1}\right)^{1.5}}{\text{Appropriate Safety Factor}}$$

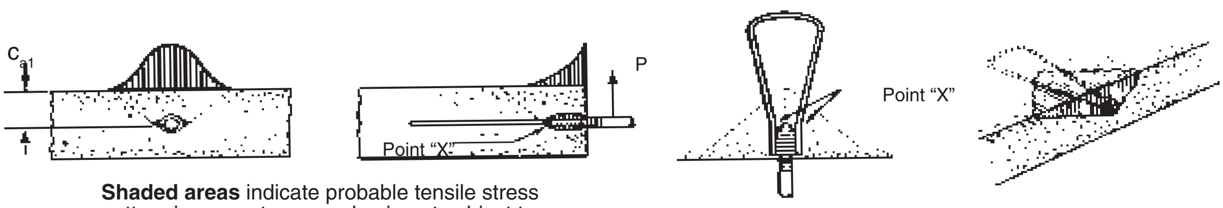
With the maximum shear safe working load equal to, or less than, the insert's tension Safe Working Load.
Where:

- φ_c = Cracked concrete factor: 1.0 for cracked concrete and 1.4 if uncracked.
- λ = Reduction factor for lightweight concrete, see page 6.
- l_e = Minimum of embedment length or 8 x (n x d_o).
- n = Number of struts on the insert.
- d_o = Diameter of the insert struts.
- f'_c = Specified concrete compressive strength.
- c_{a1} = Distance from centerline of the insert to the edge.

For conditions where a corner or thickness in direction of embedment is less than 1.5 x c_{a1} or an adjacent insert is closer than 3 x c_{a1} contact Dayton Superior Technical Services Department for insert capacities.

For cases where increased shear capacity is required, the addition of pre-formed shear bars over the top of the insert will greatly increase the distribution of the load. Shear bars, when used, must be in solid contact with the insert to be effective.

If accurate capacities of inserts are desired, several inserts with shear bars should be tested in job size panels.



Shaded areas indicate probable tensile stress pattern in concrete near edge insert subject to load **"P."**

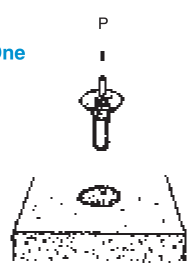
Illustration L

Dotted line indicates line of probable concrete failure
Point "X"– point of possible strut fracture.

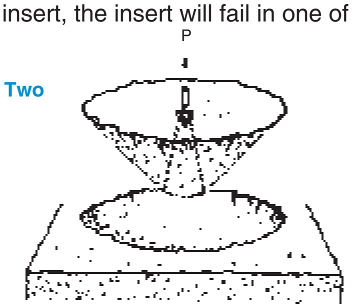
Anchor/Insert Failure

When the applied load P exceeds the pullout capacity of the insert, the insert will fail in one of four ways.

One



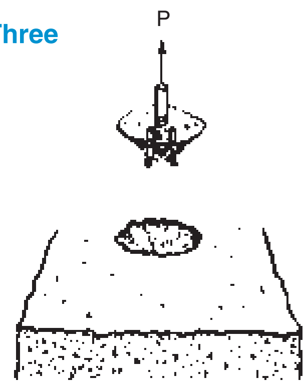
Two



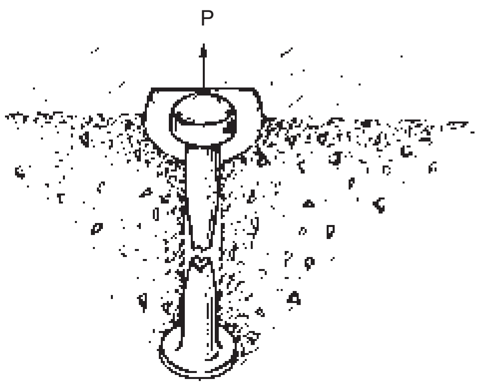
The entire insert may pull out of the concrete, with little apparent damage to the concrete. Such failures are rare and when they do occur, are the result of bond failure between the concrete and insert. These failures usually occur in green, or low strength concrete.

The entire insert may pull out of the concrete bringing with it a cone of concrete having its apex slightly above the most deeply embedded part of the insert. Such failures usually occur when the tensile strength of the shear cone surrounding the insert is not as great as the mechanical strength of the insert itself.

Three



Four



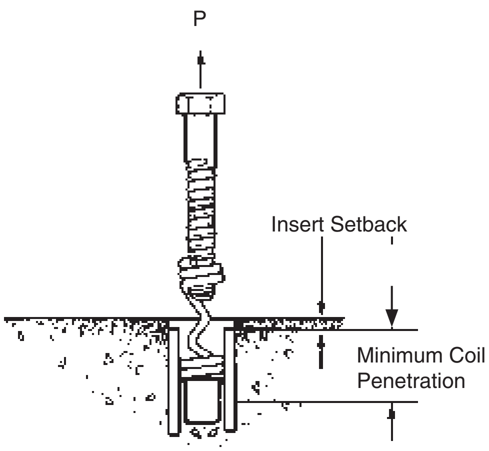
A ductile failure may occur in the insert. Coil type inserts will usually fail at a point just below the helically wound wire coil. A small cone of concrete will usually be pulled out of the concrete surface. This cone will have its apex at a point just below the coil. Its base diameter will be approximately twice its cone height.

"Headed" type inserts will exhibit a ductile failure through the shaft diameter of the insert.

These failures usually occur in higher strength concrete or adequate embedments when the concrete resistance is greater than the mechanical strength.

Failures of this type are due to a definite overload being applied to the inserts. Such failures can be prevented by choosing inserts of capacity suitable to job conditions or by increasing the number of inserts used to lift the tilt-up panel.

COIL BOLT/COIL INSERT FAILURE



Warning! When bolting coil type inserts, the bolt should always extend at least the proper amount beyond the bottom of the insert coil. Failure to do this causes the entire bolt load to be transferred to fewer turns of the coil, causing an increased load per weld contact point. The coil will then unwind much like a corkscrew, resulting in a premature failure.

Bolt Diameter	Minimum Coil Penetration
3/4"	2-1/4"
1"	2-1/2"
1-1/4"	2-1/2"
1-1/2"	3"

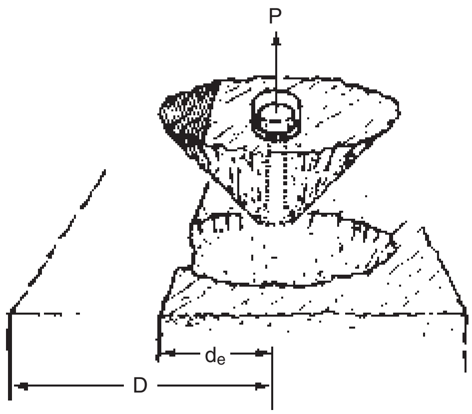
See page 29 for proper method of determining bolt lengths.

Insert Placement

Tilt-up lifting inserts are generally categorized in two types, FACE lift and EDGE lift. Both types of inserts must be placed accurately and positioned properly. Safe working load of the insert may decrease considerably if the insert is not positioned perpendicular to the bearing surface. All Dayton Superior lifting inserts are designed for easy positioning and securing to the reinforcement steel.

It is also important that all coil style lifting inserts be placed so the depth of thread is constant throughout the job, minimizing improper bolt engagement. Keep all lifting inserts free of dirt, ice and other debris that may interfere with hardware engagement.

Insert Edge Distances

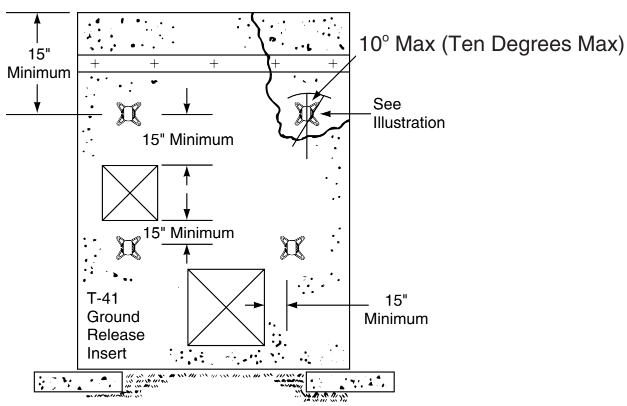


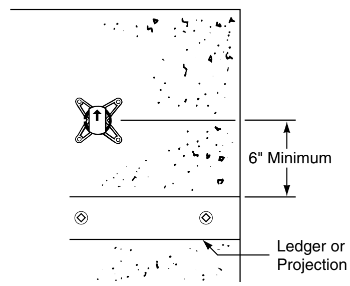
Embedment of inserts closer to any edge; construction joint; window or door opening than the minimum edge distances shown in this handbook will greatly reduce the effective area of the resisting concrete shear cone and thus reduce the insert's tension safe working load. The shaded area of the shear cone indicates the extent to which this area is reduced. Tension safe working loads of inserts near a free edge or corner must therefore be reduced in proportion to the reduction in effective shear cone area.

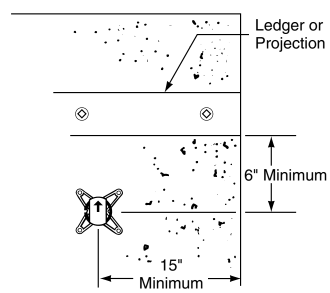
d_e = Actual edge distance

D = Minimum edge distance required to develop insert's SWL

Minimum Insert Distances







Warning! All Lifting Inserts must be properly located in relation to the center of gravity of the panel. As shown on the Dayton Superior Technical Service panel drawings.

Loadings Conditions

Safe working loads shown in this publication are for static load conditions and must never be exceeded. If dynamic forces or impact load conditions are anticipated, the safe working loads must be reduced accordingly.

Care must be exercised to ensure that all inserts and hardware are properly aligned, all lifting plates and bolts are properly secured, all rigging is equalized and that proper size crane cables are used. The centerline of the spreader bar and hook must be on the centerline of the panel and the crane cables must be of proper size and length.

Warning! Users of Dayton Superior products must evaluate the product application, determine the appropriate safety factor, calculate the applied loads and control all field conditions to prevent excessive product loading.
When uncertain about proper installation or use of a Dayton Superior product, contact Dayton Superior for clarification. Failure to do so may expose workers to hazards which could result in serious injury or death.

Tilt-Up Problem Areas

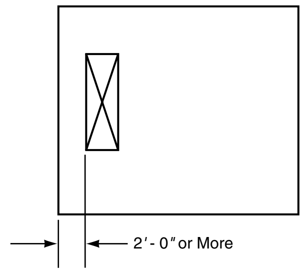
Field Conditions, Equipment and Panel Sizes

Become familiar with field conditions and equipment available for the tilt-up project. As a rule of thumb, crane capacity should be 2 to 3 times the maximum panel weight. Actual crane capacity depends on crane location and the panel's center of lift.

For rigging and lifting efficiency, Dayton Superior recommends the following: Panel heights up to 24'-0", width should be 36'-0" or less. Panel heights up to 36'-0", width should be 24'-0" or less.

Panel Openings

Position openings in the center of the panel. If this is not possible, maintain a 2'-0" leg of concrete. Less than 2'-0" of concrete will usually require strongbacks or additional reinforcing.



Pier Heights

When pier heights vary, always keep the bottom of the panel parallel to the horizon (see Fig. 1). Avoid panel designs similar to Figures 2 and 3. Designs such as these will require strongbacks and/or special handling to prevent panel twisting and spalling.

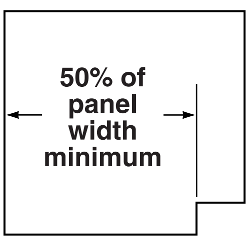


Fig. 1

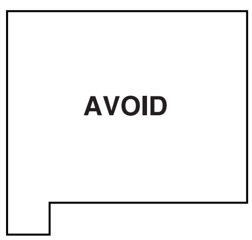


Fig. 2

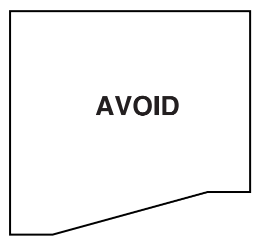
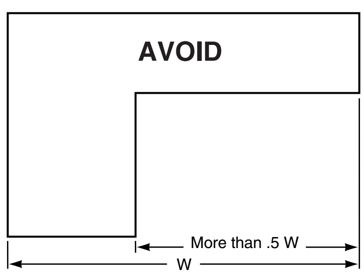
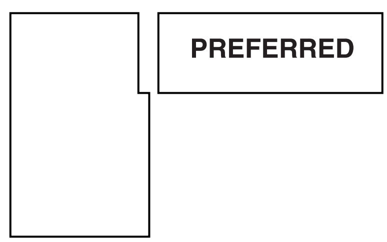


Fig. 3

Headers

Avoid panel designs that have large center of gravity shifts. If a header is required, the example on the right is the preferred design.





Hardware Inspection

All reusable products supplied by Dayton Superior are subject to wear, misuse, corrosion, alteration and other factors which may affect product safe working loads. Dayton Superior recommends that all users of Dayton Superior tilt-up hardware establish a quality control program to monitor and inspect their tilt-up hardware.
The frequency of inspections is best determined by the user and is dependent on the frequency of use, duration of use and the environmental conditions during use.

General and Technical Information

Tilt-Up Construction Sequence

General

The nature of tilt-up construction dictates the need for thorough preplanning. The economy and success of tilt-up construction is realized by efficient on-site production operation and careful planning with each step of the construction sequence building on the previous step. The following sequence is offered as a planning aid for a typical tilt-up project.

Site Access and Job Conditions

It is advisable to investigate regulations on daily start up times, noise and dust control and job site perimeter fencing. Check job site restriction on tonnage or limitations on access to the site. As an example, special permits are common requirement for schools and churchs.

Scheduling

The construction sequence and scheduling must be constantly monitored and controlled. A function performed out of sequence usually prevents the next scheduled function from proceeding.

The following is a construction sequence for a typical tilt-up project:

1. Complete the site preparation.
2. Install underslab plumbing and electrical.
3. Cast and cure interior column footings.
4. Cast and cure interior floor slab.
5. Form, cast and cure exterior footings.
6. Form, cast and cure tilt-up panels.
7. Erect and brace panels.
8. Construct the roof structure/diaphragm.
9. Cast and cure the "leave out" strip between the floor slab and the panels.
10. Remove the braces.
11. Schedule other trades for painting, landscaping, interior framing and interior finish.

This sequence is only meant as a guide and may vary from job to job.

Slab as a Work Platform

Initial grading of the site should include completion of all subgrade work for the building floor, and parking and truck areas. A roadbed and an accessibility ramp to the subgrade should also be completed at this time. Emphasis must be placed on having a strong, well compacted subgrade. Regardless of how much effort goes into producing a good slab, the slab will only be as good as its subbase.

The panel contractor should make plans for stubbing all electrical and plumbing items below the finished floor level. This provides additional floor space for casting panels, and provides an obstacle free area for crane movement.

The quality of the floor slab in a tilt-up constructed building is extremely important. The tilt-up panels are normally cast on the floor slab of the building and any imperfection in the floor slab will be mirrored in the panel. For best results, the floor slab should have a hard, dense, steel trowel surface.

The panel contractor should try to layout the panel forms so that no panels are cast over a floor slab construction or control joint. Should a panel have to be cast over a joint, there are several ways to minimize the transfer of the joint image to the panel. The most popular is to fill the joint with drywall compound. Drywall compound readily disintegrates after the panel is lifted and leaves a relatively clean joint that can be blown free of residue, if joint sealing is required. An effective method for eliminating a control joint image from a panel is to utilize the Dayton Superior T Strip. The T Strip is inserted into the control joint at the time the joint is saw cut. It provides spalling protection for the joint and will leave only a small rounded depression in the tilt-up panel. The small rounded depression is then easily eliminated with a later skim coating of Dayton Superior Sure finish.

The floor area at a column block-out can be made available for casting by filling the block-out with sand to about three inches from the floor surface and then finish filling it with concrete. The block-out image will be transferred to the panel, so choose a panel to cast over the block-out that is not critical to the building's aesthetics.

Bondbreaker and Curing Compounds

Bondbreakers and curing compounds are among the most critical materials used on a tilt-up project. These products should have their performance criteria carefully evaluated. The application of the curing compound on the floor slab is the most critical step in the preparation process. The application should begin immediately after the hard steel troweling and the dissipation of the excess bleed water. A cure coat applied too late may render the slab highly permeable, leading to bondbreaker absorption and poor parting characteristics.

Typically, look for the following cure characteristics:
1. A well cured casting slab.
2. Excellent parting characteristics of the bondbreaker.
3. Good drying characteristics of the bondbreaker.
4. Clean appearance of the finished panel and floor slab.
5. Good compatibility with subsequent floor treatments and/or floor coverings.
6. Good compatibility with wall finishes such as paint, elastomeric coatings, sealants, adhesives, etc.

There are three basic types of bondbreakers:
1. Membrane forming.
2. Non-membrane forming — reactive.
3. Combinations of membrane forming and reactive.

Since the membrane forming materials rely on crude petroleum resins and waxes to form a water insoluble barrier between the freshly cast wall panel and the casting slab, they are prone to leave residue on both the panel and the slab. Under optimum conditions of temperature and sunlight, they will usually dissipate in approximately 90 days. Varying environmental and/or application conditions may result in residue being present much longer. Residue may discolor the concrete and interfere with subsequent surface treatments.

Reactive materials work with the excess lime available to create crude soaps. These soaps provide a moisture barrier to prevent the migration of the cement matrix into the casting slab.

A final note: whenever there is doubt about sufficient bondbreaker on the casting slab, always apply more. It is the cheapest insurance available for a successful tilt-up job. Refer to the Dayton Superior brochure *“Use and Application of Bondbreakers”* for more information.

Shop Drawings

A complete set of detailed panel drawings is required for every tilt-up project. If the drawings are not part of the plans prepared by the engineer of record, then the panel contractor should prepare the set and submit them to the engineer for approval. The detailed panel drawings should contain the following information:

1. Panel identification.
2. All pertinent dimensions.
3. All physical characteristics, including weight.
4. All reinforcing steel.
5. Location and identification of all embedded items.
6. Finishes and textures.
7. Rigging and bracing information.

Panel Casting Layout

The panel contractor should consult with the erection contractor in the development of a good casting layout. For a smooth construction sequence, two important criteria must be met:

1. The panels must be located for efficient casting.
2. The panels must be located for safe and efficient erection.

The panel layout should provide accessibility to the panel forms for the ready mix trucks and crane.

Tilt-up panels should be cast as near as possible to their final location in the structure. An effort should be made to place as many side by side as possible. If a panel must be “walked” to its final position, try to keep the distance as short as possible. “Walking” the panels should be avoided, if possible.

General and Technical Information

DAYTON SUPERIOR

Panel Construction

After the floor slab has been cleaned, the tilt-up panels are outlined directly on the floor slab with chalk. The chalk lines can be sprayed with a coat of bondbreaker to prevent rain from washing them away. The panel edge forms, and any opening forms can then be set in place.

Fog the casting area with clean, potable water prior to application of the bondbreaker. The fogging should saturate the slab, but any standing water must be removed before the bondbreaker is applied. The bondbreaker should be applied in a two-coat application; the first coat of the material sprayed in one direction and the second coat sprayed perpendicular to the first. Be sure to let the first coat dry before applying the second coat. Applying the bondbreaker in this manner will help ensure a smooth, uniform coating.

Check the slab and bondbreaker before pouring any concrete. The slab should have a slightly tacky, soapy feeling. Bondbreaker can be tested by dropping a small amount of water on the casting bed, from a height of about 24” above to allow it to splatter. If the bondbreaker is applied correctly, the water will bead into small droplets as it would on a freshly waxed automobile. If the water does not bead, respray all of the suspected areas of the casting slab.

When all of the panel preparations are complete and the panel is ready for placement of the concrete, the entire panel area should be fogged with potable water to be certain that the pores of the concrete slab have been properly saturated. Make sure there is no standing water, and proceed with the concrete placement.

The panel concrete must be properly consolidated using an appropriate concrete vibrator. It is preferable to use the vibrator in an up and down motion. Laying the vibrator horizontal and dragging it along the reinforcing steel will often leave the pattern of the rebar visible on the down side face of the panel. Avoid over vibration; it may cause segregation of the aggregate and bring excess water to the surface.

Preparation for Lifting

Clean the panel and the surrounding floor slab area. Locate and prepare all pertinent embedded devices that are accessible. Do any dressing or patching that can be accomplished on the ground. Attach all pipe braces and strongbacks as required.

Each panel should be numbered and clearly identified according to the panel layout/erection sequence plan. Place the identifying mark in a position that will not be exposed when the structure is completed. The structure footing should also be marked with the corresponding identifying numbers to give the erection crew clear indication where each panel goes. The footing should be appropriately marked to show the proper position of each panel on the footing.

All lifting inserts should be uncovered, cleaned out and tested with a hardware unit several days prior to erection day. Rotary hammers, drills, leveling shims, cutting torch, steel wedges, pry bars, level and plumb bob and a full set of hand tools should be available at the job site.

Panel Erection Techniques

The following panel erection techniques are suggested as an aid for the safe and efficient erection of tilt-up wall panels.

- **Layout —** Prior to the day of erection, the panels should be laid out on the exterior foundations and the exterior wall line established.
- **Alignment —** One method of alignment is to mark the limits of each panel, then drill 3/4” holes into the foundation approximately 5” deep. Install two #5 rebars (approximately 10” long) on each side of each panel.
- **Leveling —** Prior to day of erection, install leveling shims with a level so that the top of all panels are in line. Grout should be installed around the shims to hold them in position.
- **Grout —** After panels are erected and aligned, grout as specified should be placed under each panel. Grouting should be accomplished as early as possible after panel erection. Care should be taken to make certain the grout fills the void between bottom of panel and top of footing.

After the Lift

When constructing the floor slab, a perimeter strip, generally three to five feet wide is often open to facilitate the footing excavation. This excavated area can be up to five or six feet deep, depending on the building design, and won’t be backfilled until after the wall panels have been erected. The perimeter strip must be backfilled and compacted very carefully to avoid movement or bending of the panels.

Usually there are reinforcing steel bars projecting from the slab into the perimeter area which will overlap the bars that project from the panels. If the panel is a “dock-high” panel, it may be best to weld the floor rebar to the panel rebar. After the backfill is in place and properly compacted, concrete is placed into the perimeter strip to connect the floor slab to the wall panels.

Wall braces should **NEVER** be removed until all structural connections are complete. Note that the perimeter strip between the floor slab and the wall panels is considered a structural connection.

If the building’s structural drawings do not indicate when the braces can be removed, the engineer of record should be consulted.

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Panel Analysis

As the tilt-up panel is rotated from the horizontal to the vertical, the panel is subjected to bending that causes both compressive and tensile stresses that must be resisted by the concrete, reinforcing steel, or a method of strongbacking that prevents the initial bending.

The lifting inserts are normally located so that the overhanging portions of the panel sides or top will reduce the bending moments between pickup points, thereby reducing the compressive and tensile stresses in the concrete.

Tilt-up panels are usually thin and very seldom do they contain two layers of reinforcing steel. It is, therefore, necessary to allow some tensile stress in the concrete to be introduced in the tension areas. The value of allowable tensile stress in the concrete is a function of the modulus of rupture and the safety factor used. A conservative value appears to be approximately $6\sqrt{f'_c}$.

Since the typical reinforcing in a panel is #4 bars at 12 in. o.c., both horizontally and vertically, it is important to be sure of the compressive strength of the concrete at the time of erection. In turn, the concrete must have sufficient tensile strength to provide the resisting strength necessary to erect the panels without cracking. This concrete quality can be obtained by having a proper mix proportion and a curing process that minimizes moisture loss. Strength tests using compression cylinders, Test Beam Break (modulus of rupture), or a Split Cylinder Test are methods of determining the value of the concrete strength and/or tensile strength of the concrete at the time of erection.

It is normal to have a minimum concrete compressive strength of 2,500 psi before the tilting operation commences. Generally, the ultimate tensile stress would be 375 psi or greater with an allowable stress of 300 psi. This assures a good tilting sequence with no cracking from tilting although some shrinkage cracks may appear.

Depending upon the quality of bond breaker used and the care taken in application, the amount of “bond” between the panel and the base slab can be from negligible to significant. Initially, a suction force must be overcome at the time of release from the base slab and estimates of this force vary considerably. Panel size, interface texture, and water between the panel face and the base slab all contribute to this additional load that is applied to the inserts and the surrounding concrete. Estimates vary from negligible to 20 psf of panel area. Experience has shown that the safety factor between the design stress and the ultimate tensile stress is sufficient to absorb the additional stresses without cracking the panels.

Minor impact loads that occur during the tilting sequence do not create bending stresses in excess of the safety factor. However, if a panel suddenly drops and is caught by the slings, or hits the crane boom or some other obstruction, an increased load will be applied to the pickup inserts.

Panels are analyzed for stresses at 0 degrees and at various angles during the tilting sequence. They are analyzed at 0 degrees because of the added loads from suction, impact, bond, and because the spans are the longest. Panels with more than one horizontal row of pickup points are analyzed at angles of rotation due to the cable configuration changing the loads to the pickup points and therefore, changing the bending moments. The resultant stresses are compared to the allowable and if exceeded, additional reinforcing or strongbacks are added depending upon the contractor’s preference.

After the tilt-up panels are analyzed vertically, they are examined horizontally. The procedure for horizontal analysis is similar to the vertical examination, except that a portion of the panel resting on the ground is not considered because of continuous support.

Erection Details

The engineering service (Erection Details) which is provided by Dayton Superior is a very important part of our total tilt-up package. The location and selection of the proper lifting insert, brace type and brace anchor location, as well as the calculation of additional reinforcing steel or strongback size and location is critical for a safe and efficient panel erection.

Dayton Superior uses computers to provide fast and accurate analysis of the stresses involved in tilting a panel into position. Erection detail booklets are furnished to the contractor showing pickup locations, wall brace insert locations, crane riggings and cable lengths, reinforcing or strongback details, and specific assumptions relating to concrete strength and wind loads used in the brace design. These details are furnished at a nominal charge and are as important to the success of the operation as are the contract drawings. In order to provide these erection details to the tilt-up contractor, Dayton Superior needs the following information:

- Name of our dealer where you will purchase accessories.
- Name and address of project.
- Name of contractor.
- Job phone number.
- Name of job superintendent.
- Crane operator.
- Project plans with panel drawings.
- Number of buildings.
- Approximate number of panels.
- Number of detail booklets required.
- Date erection details required.
- Are copies of calculations required?
- Is engineer’s stamp required?
- Type of inserts preferred for tilting, bracing and strongbacking.
- Rigging type preferred for tilting.
- Are braces required? If so, what is the specified maximum wind load (psf)? Are panels to be braced to inside or outside of the building?
- Are panels cast inside face up or outside face up?
- Type and unit weight of concrete.
- Compressive strength of concrete at *lift.*
- Type and details of surface treatment.
- Special instructions not covered by the above items.

Panel Erection Information

Computer Service

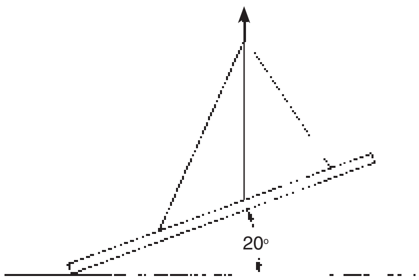


Fig. 1

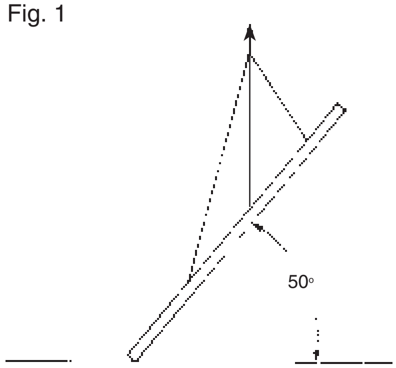


Fig. 2

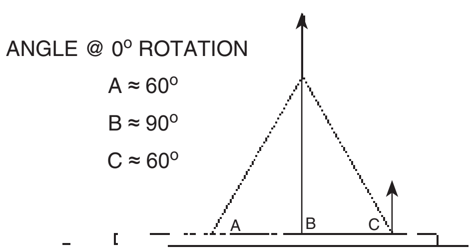


Fig. 3

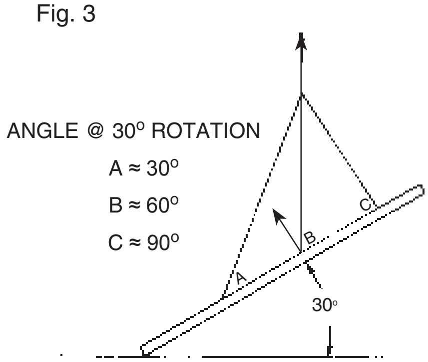


Fig.4

- All panels with openings are entered in the computer for analysis.
- Inserts are then positioned relative to the center of gravity.
- Panel dimensions and insert locations are checked by the computer for exact insert loading and flexural stress analysis.
- The bending moments and stresses in a panel are constantly changing as the panel rotates from 0° (horizontal) to approximately 90° (vertical).
- Stresses are checked at various degrees of rotation with respect to the horizontal.
- The most critical stress during lifting will normally occur somewhere between 20° and 50° rotation. The reason for this range is the different geometric shapes of the panels and number of inserts required.
- The calculations for determining the stresses at varying angles of rotation are extremely complex due to the cable geometry and the method of structural analysis required, and can only be accomplished efficiently by utilizing the accuracy and speed of the computer.
- As the cable, attached to the lifting plate, changes its angle during rotation, the force components on the lifting plate will vary causing the **tension** load on the insert to vary.
- When one insert's **tension** load increases, another insert's **tension** load may decrease. This is what causes the bending moments and stresses to vary throughout rotation of the panel.
- For example: the tension load at "B" in Fig. 3 is 100% tension and the tension load at "C" is 85% tension, but when rotated to 30° in Fig. 4, the tension load at "B" has decreased to 80% and the tension load at "C" has increased to 100%.
- To provide uniformity in panel detailing, Dayton Superior provides computerized or computer aided drafting graphics in addition to the stress analysis.

Panel Erection Information

DAYTON SUPERIOR

Stress Tables and Rigging Patterns

Note: The accompanying stress tables and rigging configurations are intended for estimating purposes only and are not to be used for designing purposes.

The stress tables are valid for solid, uniformly thick panels without exposed aggregate or formliners. For panel shapes that vary from these criteria, contact a Dayton Superior Technical Services Department for assistance. A flexure (bending) stress analysis will be required.

The following tables show the actual bending stresses in pounds per square inch (psi) according to panel thickness, height and rigging configuration and are based on dead load only. Additional safety factors must be applied for any anticipated impact or dynamic loads.

Panel Thickness	Maximum Panel Width	
	2 Wide Rigging	4 Wide Rigging
4”	21”-0”	34’-0”
5”	24’-0”	38’-0”
5-1/2”	25’-0”	40’-0”
6”	26’-0”	41’-0”
6-1/2”	27’-0”	43’-0”
7”	28’-0”	45’-0”
7-1/2”	29’-0”	46’-0”
8”	30’-0”	48’-0”
8-1/2”	31’-0”	49’-0”
9”	32’-0”	51’-0”
9-1/2”	33’-0”	52’-0”
10”	33’-0”	54’-0”
10-1/2”	34’-0”	55’-0”
11”	35’-0”	56’-0”
11-1/2”	36’-0”	57’-0”
12”	37’-0”	59’-0”

When choosing a desired rigging configuration, always make certain the panel total weight divided by the number of lifting inserts does not exceed the following:

1. Face lift insert safe working load.
2. Edge lift inserts tension safe working load.
3. 65% of the panel weight divided by the number of inserts does not exceed edge lift insert shear safe working load.

Calculate normal weight concrete at 150 pounds per cubic foot.

Panels may be safely tilted when the calculated bending stress is equal to, or lower than the allowable bending stress for the compressive strength at the time of lifting. When the calculated bending stress exceeds the allowable, the panel can be tilted only if the bending stress is reduced by:

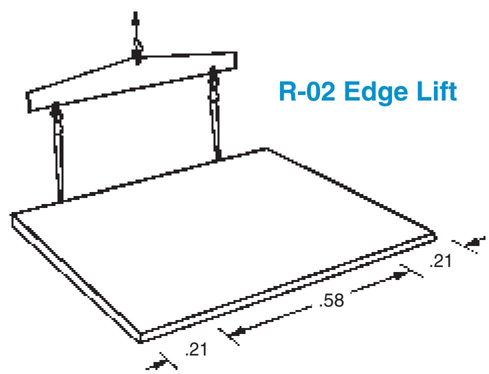
1. Increasing the number of lifting inserts;
2. Using additional, properly placed reinforcing steel;
3. Using external stiffening devices, such as strongbacks or
4. Possibly changing the concrete mix to a stronger compressive strength.

Table of Allowable Concrete Stresses (psi)							
f'_c	2,000	2,300	2,500	2,700	3,000	3,500	4,000
Allowable Bending Stress	268	287	300	311	328	354	379

f'_c = Normal weight concrete compressive strength at time of lift.

Note: See page 4 before using these charts for estimating lightweight concrete panels

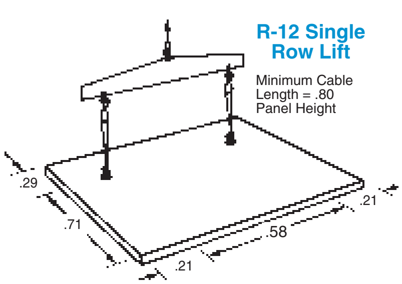
Edge Lift Panel Stress (psi)													
Panel Thickness	Panel Height												
	9’	10’	11’	12’	13’	14’	15’	16’	17’	18’	19’	20’	21’
4”	190	234	284	338	396								
5”	152	188	227	270	317	368	422						
5-1/2”	138	170	206	245	288	334	384						
6”	127	156	189	225	264	306	352	400					
6-1/2”	117	144	175	208	244	283	325	369	417				
7”	108	134	162	193	226	263	301	343	387				
7-1/2”	101	125	151	180	211	245	281	320	361	405			
8”	95	117	142	169	198	230	264	300	339	380	423		
8-1/2	89	110	133	159	186	216	248	282	319	357	398		
9”	84	104	126	150	176	204	234	267	301	338	376	417	
9-1/2”	80	99	119	142	167	193	222	253	285	320	356	395	
10”	76	94	113	135	158	184	211	240	271	304	338	375	413
10-1/2”	72	89	108	129	151	175	201	229	258	289	322	357	394
11”	69	85	103	123	144	167	192	218	246	276	308	341	376
11-1/2”	66	82	99	117	138	160	183	209	236	264	294	326	360
12”	63	78	95	113	132	153	176	200	226	253	282	313	345



R-02 Edge Lift

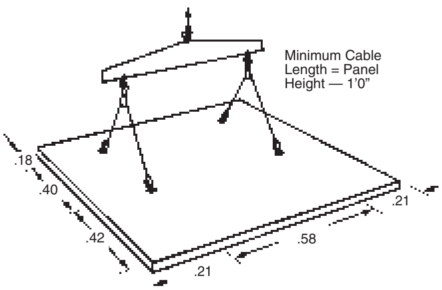
R-12 Single Row Lift

Minimum Cable Length = .80 Panel Height

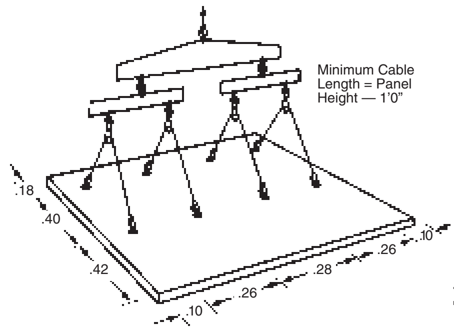


Single Row Lift Panel Stress (psi)																						
Panel Thickness	Panel Height																					
	13’	14’	15’	16’	17’	18’	19’	20’	21’	22’	23’	24’	25’	26”	27’	28’	29’	30’	31’	32’	33’	34’
4”	139	161	185	210	237	266	296	328	362	397												
5”	111	129	148	168	190	213	237	262	289	318	347	378	410									
5-1/2”	101	117	134	153	172	193	215	239	263	289	316	344	373	403								
6”	92	107	123	140	158	177	197	219	241	265	289	315	342	370	399							
6-1/2”	85	99	114	129	146	164	182	202	223	244	267	291	315	341	368	396						
7”	79	92	105	120	135	152	169	187	207	227	248	270	293	317	342	367	394	422				
7-1/2”	74	86	98	112	126	142	158	175	193	212	231	252	273	296	319	343	368	394	420			
8”	69	80	92	105	119	133	148	164	181	198	217	236	256	277	299	321	345	369	394	420		
8-1/2”	65	76	87	99	112	125	139	154	170	187	204	222	241	261	281	303	325	347	371	395	420	
9”	62	71	82	93	105	118	132	146	161	176	193	210	228	246	266	286	307	328	350	373	397	421
9-1/2”	58	68	78	88	100	112	125	138	152	167	183	199	216	233	252	271	290	311	332	354	376	399
10”	55	64	74	84	95	106	118	131	145	159	174	189	205	222	239	257	276	295	315	336	357	379
10-1/2”	53	61	70	80	90	101	113	125	138	151	165	180	195	211	228	245	263	281	300	320	340	361
11”	50	58	67	76	86	97	108	119	132	144	158	172	186	202	217	234	251	268	287	305	325	345
11-1/2”	48	56	64	73	82	92	103	114	126	138	151	164	178	193	208	224	240	257	274	292	311	330
12”	46	54	62	70	79	89	99	109	121	132	145	157	171	185	199	214	230	246	263	280	298	316

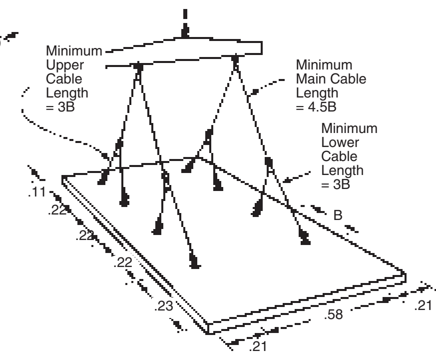
Panel Erection Information



R-22 Double Row Lift



R-24 Double Row Lift



R-42 Four Row Lift

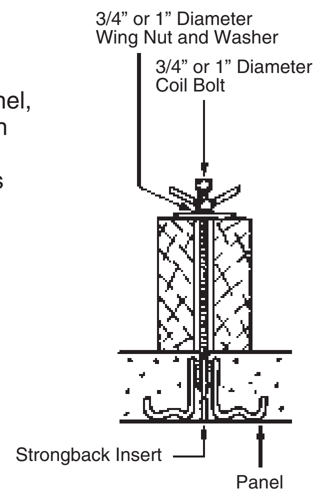
R-22 & R-24 Double Row Lift Panel Stress (psi)																								
Panel Thickness	Panel Height																							
	20'	21'	22'	23'	24'	25'	26'	27'	28'	29'	30'	31'	32'	33'	34'	35'	36'	37'	38'	39'	40'	41'	42'	43'
4"	205	226	248	271	295	320	346	373	401															
5"	163	180	197	216	235	255	276	297	320	343	367	392	418											
5-1/2"	148	164	180	196	214	232	251	271	291	312	334	357	380	404										
6"	136	150	165	180	196	213	230	248	267	287	307	328	349	371	394	417								
6-1/2"	125	138	152	166	181	196	212	229	246	264	282	301	321	342	363	384	406							
7"	117	129	141	155	168	183	198	213	229	246	263	281	299	318	338	358	379	400	422					
7-1/2"	109	120	132	144	157	170	184	198	213	229	245	262	279	296	315	333	353	373	393	414				
8"	102	113	124	135	147	160	173	186	200	215	230	246	262	278	295	313	331	350	369	389	409			
8-1/2"	96	106	116	127	138	150	162	175	188	202	216	231	246	261	277	294	311	329	347	365	384	403	423	
9"	91	100	110	120	131	142	154	166	178	191	205	219	233	248	263	279	295	311	329	347	364	382	401	421
9-1/2"	86	95	104	114	124	134	145	157	169	181	194	207	220	234	249	263	279	294	310	329	344	361	379	398
10"	82	90	99	108	118	128	138	149	160	172	184	196	209	223	236	250	265	280	295	311	327	344	361	378
10-1/2"	78	86	94	103	112	122	132	142	153	164	176	187	200	212	225	239	253	267	282	295	312	328	344	361
11"	74	82	90	98	107	116	125	135	146	156	167	178	190	202	215	227	241	254	268	282	297	312	328	343
11-1/2"	71	78	86	94	102	111	120	129	139	149	160	171	182	193	205	217	230	243	256	270	284	298	313	328
12"	68	75	82	90	98	106	115	124	133	143	153	163	174	185	197	208	220	233	245	259	272	286	300	314

R-42 & R-44 Four Row Lift Panel Stress (psi)																								
Panel Thickness	Panel Height																							
	32'	33'	34'	35'	36'	37'	38'	39'	40'	41'	42'	43'	44'	45'	46'	47'	48'	49'	50'	51'	52'	53'	54'	55'
4"	313	333	353	374	396	418																		
5"	250	266	282	299	316	334	353	371	391	410														
5-1/2"	227	241	256	272	287	303	320	337	355	373	291	410												
6"	208	221	235	249	263	278	293	309	325	341	358	376	393	411										
6-1/2"	192	204	217	230	243	257	271	285	300	315	331	347	363	380	397	414								
7"	178	189	201	213	225	238	251	264	278	292	307	321	337	352	368	384	400	417						
7-1/2"	166	176	187	198	210	222	234	246	259	272	286	299	314	328	343	358	373	389	405	421				
8"	156	166	176	186	197	208	220	231	243	256	268	281	294	308	322	336	350	365	380	396	411			
8-1/2"	146	155	165	175	185	195	206	217	228	240	252	264	276	289	302	315	329	343	357	371	386	401	416	
9"	139	148	157	166	176	186	196	206	217	228	239	251	263	275	287	300	312	326	339	353	367	381	395	410
9-1/2"	131	140	148	157	166	176	185	195	205	216	226	237	249	260	272	284	296	308	321	334	347	361	374	388
10"	125	133	141	149	158	167	176	186	195	205	215	226	236	247	258	269	281	293	305	317	330	343	356	369
10-1/2"	119	126	134	142	150	159	168	176	186	195	205	214	225	235	245	256	267	279	290	302	314	326	338	351
11"	113	121	128	136	144	152	160	169	177	186	195	205	215	224	234	245	255	266	277	288	300	311	323	335
11-1/2"	109	115	123	130	137	145	153	161	170	178	187	196	205	215	224	234	244	255	265	276	287	298	309	321
12"	104	111	117	124	132	139	147	155	163	171	179	188	197	206	215	224	234	244	254	264	275	285	296	307

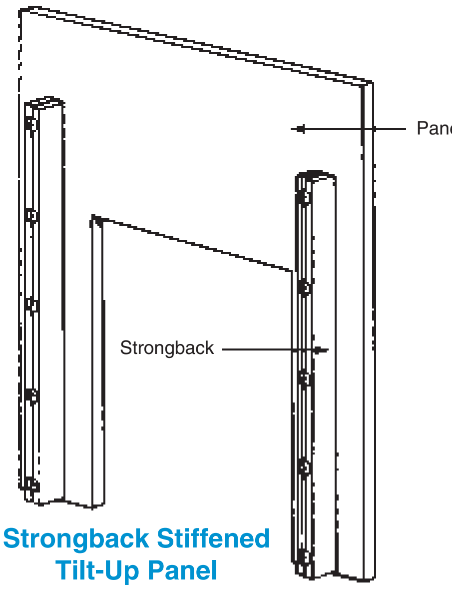
Panel Erection Information

Strongbacks

When openings are required in a tilt-up panel, they often create extreme bending stresses in the remaining concrete sections. If additional reinforcing steel is not an option, strongbacks can be used effectively to stiffen the panel. Strongbacks may be fabricated from lumber, aluminum or steel and are usually reusable.

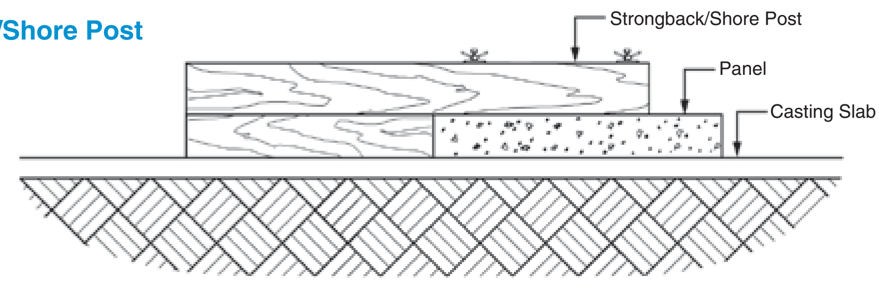


Section Through Strongback

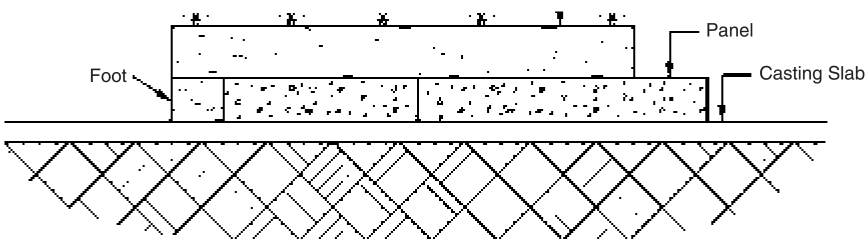


Strongback Stiffened Tilt-Up Panel

Strongback/Shore Post



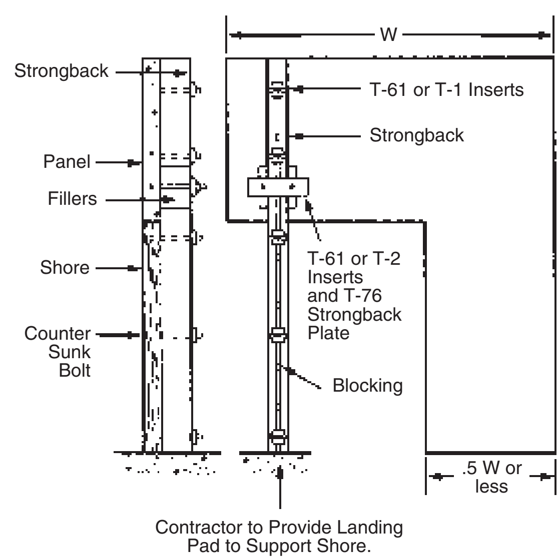
Strongback With Foot



Strongback-Shore

The strongback-shore system is used to reduce stresses during the lifting process and stabilize the panel during and after erection. Generally, this system should be utilized on panels where an offset opening is equal to or greater than 1/2 the panel width. The concrete leg section must be checked for stresses to determine if additional reinforcing steel or strongbacks are needed.

Strongback size should be of sufficient width and depth to carry erection loads and consist of material strong enough to withstand repeated use. The shore depth should be the same nominal size as the panel thickness, i.e., a 6” panel would require a 4x6 or 6x6 shore.



Panel Erection Information

Rigging and the Crane

General

The most important phase during the construction of a tilt-up building is the erection of the wall panels. It is extremely important for the designers and contractors to plan and re-plan this portion of the job. They should direct their efforts to ensure that this important phase of construction is performed safely and efficiently.

Since there must be a close, cooperative relationship between the panel contractor and the erection subcontractor, it is advisable to select an erection sub-contractor during the early days of the project. The erection sub-contractor and crew should be well experienced in tilt-up, as panel tilting and handling is a very specialized skill.

Prior to Construction

Prior to the actual start of construction, an inspection of the site should be made by the contractor. The location of the jobsite may be such that special permits will be required to gain access to the site for heavy equipment such as the crane. As an example, permits are a common requirement for schools and church projects. These projects are usually built in residential areas where weight and size restrictions may exist.

It is advisable for the contractor to investigate restrictions on early daily start-up times. Many areas have noise abatement and dust control regulations. Also, the panel contractor and erection contractor should walk the site and determine a suitable location for the crane assembly and rigging make-up. Some local governments will not allow this activity on public streets.

It is also advisable that any problems with uneven terrain be noted at this time and dealt with prior to bringing the crane onto the jobsite.

The panel contractor and the erection contractor should always agree on a location for both the crane entrance onto the floor slab as well as the exit ramp off the floor slab. If necessary, plans should be made to thicken the floor slab at these ramp locations so the crane weight will not damage the edge of the slab.

Underground tunnels, trenches and sewer lines are a very common occurrence and can create problems. It is necessary to know the location of these underground hazards and to avoid those that may need strengthening in order to support the crane's weight. We have often found that the location of these underground hazards is not always noted on the architect/engineer's plans. Further investigation by the panel contractor should be made in an effort to discover these types of unknown hazards.

Overhead electric or telephone wires can be a common problem on both urban and rural job sites. It may be necessary to shut off the power in some overhead wires in order to safely operate the crane during panel erection. Most safety regulations dictate that cranes will not be allowed to work closer than ten feet to power lines.

The quality of the floor slab on a tilt-up project cannot be over emphasized due to the heavy weights that the slab will be expected to support early in its life. Equally as important as the slab, is the sub-base under the floor slab. When it comes to supporting the combined weight of the crane and tilted panel, the floor slab is no better than its sub-base. Even a thick, properly engineered floor slab with two curtains of reinforcing steel will not support the weight of the crane if the sub-base is unstable.

To insure an efficient construction procedure, careful consideration must be given to the casting location of the panels. The following two important criteria must be met if the contractor expects to have a successful project:

- Panels must be located for efficient CASTING.
- Panels must be located for efficient LIFTING.

The panel contractor should work with the erection subcontractor in developing the panel casting layout. The erector's advice should be sought so that the panels are cast in such a position that a properly sized crane can safely reach and erect them.

Crane selection should not be looked on as merely routine. General rules for sizing the crane state that the crane capacity should be a minimum of two to three times that of the heaviest panel including the weight of the rigging gear. However, in the final analysis not only the panel weight, but also the crane's position relative to the panel must be considered: The following questions must be answered before final determination of crane size can be established:

- How far must the crane reach to lift the panel?
- How far will the crane have to travel with the panel?
- How far will the crane have to reach to set the panel?

Crane Certification

The crane that is finally selected for the project should be properly certified. Many, if not all states have standards with which erection sub-contractors must comply. Prudent contractors make certain they have available at the jobsite documentation attesting to the crane's certification. The contractor should also obtain a certificate of liability insurance from the erection sub-contractor.

Prior to Erection

Site Inspection

After the panels are cast and curing, the panel contractor, erection sub-contractor, and the accessory supplier should again walk the site. The terrain upon which the crane will travel should be inspected and any further corrections noted. Corrective actions shall be taken prior to erection of the panels.

Entrance and exit ramps should be checked. The entrance ramp should be built up so the crane descends slightly down onto the slab instead of crawling up onto it. The exit ramp should be built in the same manner. On some buildings, architectural openings are large enough for the crane to exit. In any case, do not let the crane's weight bear at the extreme edge of the slab. This is of particular importance if the crane is walking out with the added weight of the closure panel.

Equipment and Crew

The panel contractor and the erection contractor must itemize the rigging and equipment that will be needed for a proper and safe lift. The instruction manual that is supplied by Dayton Superior will specify all the types of rigging configuration and cable lengths for the project. These details should be rigidly adhered to, since they are an integral part of the erection stress calculations.

DAYTON SUPERIOR DOES NOT SPECIFY THE DIAMETER OR SAFE WORKING LOAD OF THE CABLE as this is the responsibility of the erection contractor. The panel contractor should also make a list of required tools. The list should include, but not be limited to, a compressor, drills, wrenches, a bolt-on lift plate along with extra T-13 post drilled anchors, ladders and miscellaneous hand tools. A minimum of two extra lifting hardware units should be on the job.

It is also prudent to anticipate material needs for last minute repairs. If a delay is caused for any reason, down time can add up rapidly.

The panel contractor should provide a clean working area with all obstacles removed. Members of the erection crew will be guiding a panel while it is being moved from the casting location to its position in the structure. Most of the time these crew members will be looking up at the rigging and inserts. They should not be tripping over loose debris and tools.

The erection contractor's minimum crew should consist of the crane operator, oiler (driver), rigger foreman, and two journeyman riggers. This crew should be augmented, as required, by carpenters and laborers from the panel contractor's work force, primarily to handle braces. In areas of the country where no erection contractors are available, the minimum crew should consist of crane operator, oiler, foreman and four to five laborers. An exception to this would be with stacked panels which require an additional two to three laborers. Consideration should also be given to having a welder standing by. A properly staffed and well coordinated erection crew is the key to successful lifting.

The crane operator must be a skilled journeyman, experienced in handling tilt-up panels. He must be able to control three motions of his crane: hoist, swing and boom hoist. It is quite normal to use all three of these functions simultaneously.

Panel Preparation

All standing water should be blown away from around the perimeter of the panel. Also, remove all water that might be pooled in panel openings. Standing water prevents air from entering under the panel and creates an additional load that must be overcome. These suction loads can be of such strength, that the additional load causes the lifting inserts to be overloaded.

Panel preparations should also include checking the inserts for proper location, as shown in the erection instructions. It also includes removing the void former from the insert. All inserts should be checked with a lift hardware to make certain that the hardware can be properly attached to the lifting insert. Strongbacks should also be properly installed at this time.

The required compression strength of the concrete must be attained. The strength of concrete, noted in the erection instructions, refers to the concrete compressive strength at the time of lifting and not the ultimate or 28 day strength . This should be checked by an independent test lab using beam or cylinder tests.

Blockouts over interior footings should not be broken out prior to the lift, particularly in rainy weather. Water under the slab could make the subgrade weak. Projecting ledgers and reinforcing steel must be brought to the attention of all concerned. All bracing that is attached to the panel prior to the lift must be inspected for proper length and type.

Day of Erection - Safety Meeting

A safety meeting with full crew should be held before any lifting starts and the accessory supplier should also be present for this meeting. Personnel should be told to never place themselves under the panel while it is being tilted or on the blind side of the panel when the crane is traveling with it. The crew should be told to never get between the crane and the panel. A conscientious erection contractor will always advise his crew that horseplay or unnecessary talking will not be allowed.

A standard part of the safety meeting, which is normally conducted by the rigger foreman, should contain comments about the need to remain alert. Each person's safety depends on the safe practices of others. The crew should be reminded that safety is everyone's responsibility and that hard hats are required. It is advisable for the erection contractor to create a safety check list and have the crew members sign it at the end of the safety meeting.

The rigger foreman should be clearly identified at the safety meeting. This individual will be the one the crane operator will be looking to for all signals. The rigger foreman must be experienced with handling panels and be totally familiar with the precise set of hand and arm signals. This will safely communicate his desires to the crane operator. Verbal instructions are all but impossible due to the noise level in the operator's cab.

A competent rigger foreman will create and maintain a confident atmosphere during the lift. He will always remain alert to guard against overconfidence, and will not allow the crew to become careless.

During the safety meeting the rigger foreman should demonstrate the proper use of the lifting hardware, bracing hardware and the proper way to hold a brace and how to use any necessary tools and equipment. If the crane is using rolling outriggers a warning to the crew to stay clear is in order.

The crew should be broken up into teams for handling bracing, rigging, and hardware attachment. Each individual's function and responsibility should be clearly defined. The panel contractor should furnish an individual whose responsibility it is to clean the floor slab casting location as soon as the crane has lifted a panel and cleared the area. Regardless of how good a contractor's housekeeping is prior to the lift, there is always a certain amount of debris left behind. This individual should also make certain that all left-over forming nails are pulled from the slab.

The rigging details furnished by Dayton Superior in the erection instructions are not merely simple guidelines from which the erector can stray. THE RIGGING DETAILS DEFINE THE PROPER RIGGING FOR EACH PANEL FOR THE ERECTOR. Spreader bar widths and cable angles are integral parts of the erection stress analysis.

Proper cable lengths are important to the success of the lift.

The use of cables that are shorter than the prescribed length will increase stresses in the panel and could cause the panel to crack. If an erector has a problem with rigging details or cable lengths, as they are shown in the erection instructions, he should not take it upon himself to change them. Instead, a call should be made to the technical service center from which the erection instructions originated. An alternate solution may be worked out depending on the individual situation.

Extra precautions should be taken when lifting panels with special shapes or special rigging. The erection instructions should be consulted for CAUTIONARY NOTES as to how a panel might act during lifting, and to again verify the rigging and the insert locations.

During the Lift Precautions

Wind conditions must be considered prior to lifting a panel. A 40-ton panel will easily move in a slight breeze when hanging from a crane. All spectators should be kept well away from the lift and not allowed to interfere with the proceedings.

Panels should be inspected prior to lifting for any reinforcing steel and/or ledgers that may be projecting beyond the panel edges that will create interference when the panel is being plumbed next to a previously erected panel. This happens most often at corners.

After all attachments are made to the panel, and as the rigging is being raised to take the slack out of the cables, but prior to initial loading of the inserts, all rigging gear must be inspected for proper alignment and be free of snags. If non-swivel type sheaves are used, make certain the sheaves are properly aligned. As cables are being tensioned, they invariably tend to twist and possibly rotate the lifting hardware causing side loading on the hardware. The rigger foreman should be alert for this condition and if it does happen, SHOULD HALT THE LIFT AND REALIGN THE HARDWARE.

It is the rigger foreman's responsibility to be alert to all obstacles in the path of the crane and crew. He should be alert for panels that may be stuck to the casting surface. Under such conditions, loads transferred to the lifting inserts could be more than doubled causing possible insert failure. Carefully positioned, pry bars and wedges can often be successful in helping the crane release the panel from the casting surface. Any wedges that are applied to help release the panel should be positioned at the insert lines.

Braces are almost always attached to the panel prior to lifting. Caution must be taken to be certain the braces will not be trapped by the rigging when the panel is in the upright position.

Plumbing Panels Precautions

Be alert when plumbing panels to their final upright position. Caution must be taken to make certain the panel being plumbed does not strike a previously erected panel. All personnel should be cleared of those critical areas around a panel when plumbing is being done. If the panel being plumbed is a closure panel, measurements should be taken prior to lifting to make certain the panel will fit.

Tilt-up panels should be as plumb as possible prior to attaching the brace to the floor attachment anchor. Temporary out-of-plumb-ness SHOULD NOT EXCEED 4" measured at the top of the panel. It is generally more practical to "fine tune" the panel plumb-ness with the pipe braces after the lift is completed.

There are two commonly occurring conditions that dictate that the panels be braced perfectly plumb prior to releasing the crane:

1) If the panel is going to support an adjacent spandrel or lintel panel, the supporting panel should be in an accurate final position to prevent having to adjust it later when it is supporting another panel.

2) If the bracing design calls for a subsupport system of knee, lateral, and end or cross bracing, then the panel should be accurately plumbed prior to attaching the subsupport system. Panels requiring subsupport systems must not be plumbed later as the brace subsupport system, if not removed, must be at least loosened in order to adjust the main brace, thus placing the panel in a dangerous position.

Bracing General

Do not release the crane load if, for any reason, the bracing does not appear adequate. Crane loads should always be released slowly, keeping an eye on the panel and bracing for any unusual activity. It is desirable that all bracing be complete before releasing the crane. That is, all knee, lateral, and end or cross bracing, if required, be in place. However, this is not always possible. You should always be able to install the knee bracing, however, the crane's position near the panel may prevent the lateral bracing from being attached.

Once the crane is clear of the area, the panel contractor must complete the lateral and end or cross bracing. He must complete this phase of the bracing while remaining no more than one panel behind the erection crew. All bracing should be completed on all erected panels at the end of the work day.

Standard Rigging Details

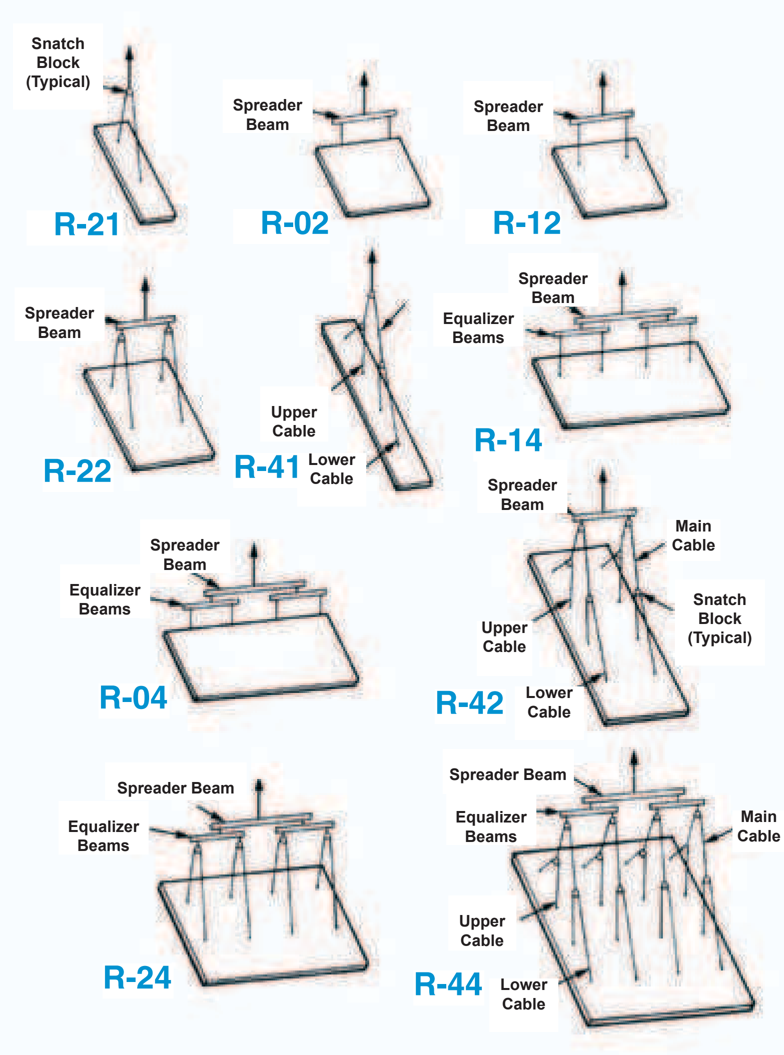
Rigging is an integral factor in Dayton Superior erection stress analysis. Rigging used on this project must conform to the rigging pattern specified and shown on the panel layout sheet for that individual panel.

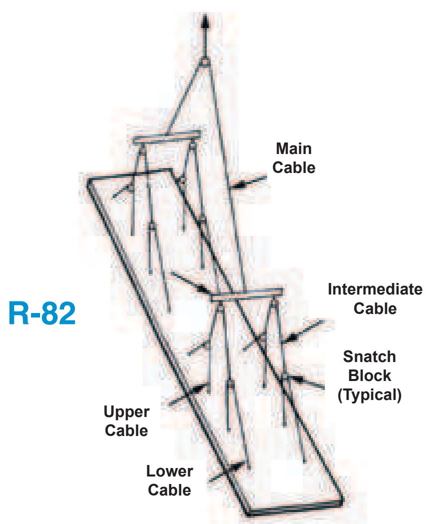
Use spreader and equalizer beams of such length that rigging cables are at a 90 ± 5 degree angle with the equalizer beams, unless otherwise shown or noted on the panel layout sheet.

The contractor must refer to the special information sheet for the minimum cable length to be used for each type of rigging specified in these erection details. Using shorter cables than specified may overload inserts or crack panels.

WARNING
Use of shorter cables or rigging patterns other than specified can cause insert failure, cracked panels, property damage, serious injury or death.

Cables must be of sufficient diameter to minimize stretch under load. Small diameter cables may have sufficient strength, but may stretch and cause the panel to bounce and result in increased insert loads.





WARNING
The factor of safety used in the lifting design for these tilt-up panels is based on the panel being handled one time. Lifting and/or handling a panel more than one time could lead to property damage, serious injury or death.

WARNING
Contact Dayton Superior Technical Service Center for proper rigging details before attempting to use two cranes dual-rigged to lift one panel. Improper dual-rigged cranes may overload inserts resulting in property damage, serious injury or death

Panel Erection Information

DAYTON SUPERIOR

Boom Positioning

To safely erect a tilt-up panel, the crane boom must be directly over the panel's center of lift. If the boom is not correctly positioned the inserts have different loads than calculated in the erection analysis and the stresses in the panel will be greater than anticipated. If insert loads or panel stresses become too large, an insert will pull out of the concrete or the panel will crack.

When the crane boom is set toward the bottom of the panel (under-booming) as the panel is erected, the panel will slide backwards. When the crane boom is set toward the top of the panel (over-booming) as the panel is erected, the panel will slide forward.

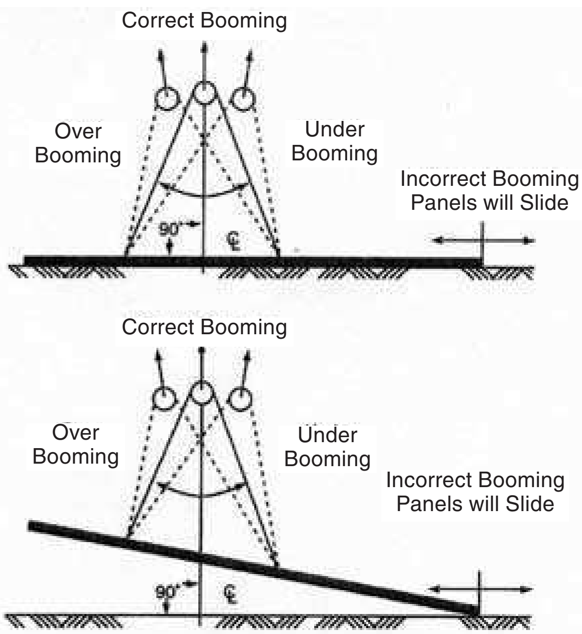
When a panel slides due to excessive under-booming or over-booming, it is possible for someone to be trapped between panels, between the panel and the crane, between panel braces, etc.

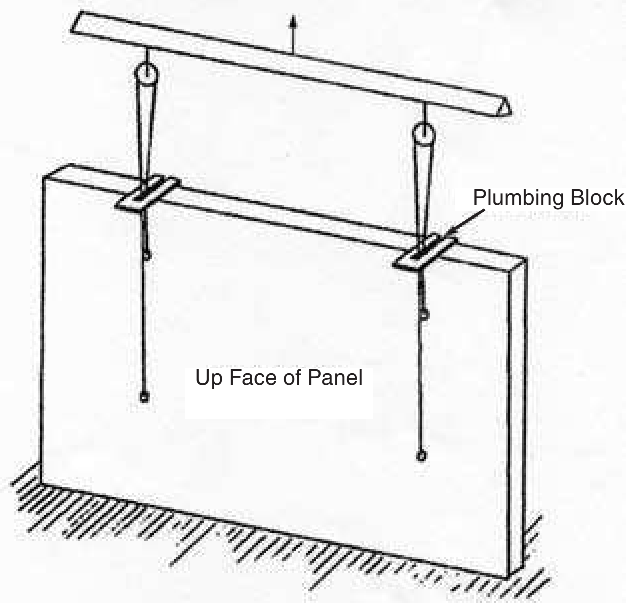
Plumbing Face-Lifted Panels

When a tilt-up panel is too tall to erect using edge lift inserts and the panel must hang as plumb as possible for setting, there are three standard methods available for use. One is the "plumbing block" method, the second is the "brace and re-rig" method and the third is the "transfer" method.

Plumbing Block Method

After erecting the panel to a vertical position, set the panel on the ground and tip the panel so that the panel's top edge rests against the rigging cables. Next, plumbing blocks supplied by others are placed around the cables and hooked over the top of the panel as shown below. The tendency of the cables to pull away from the panel will keep the plumbing blocks tight as the crane lifts the panel into position.

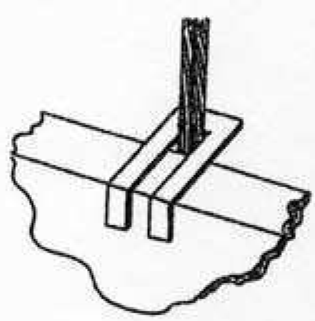




NOTE: Rigging may vary from that shown.

WARNING

Incorrect placement of the crane boom can cause over-stressing of the panel/inserts and possible sliding of the panel. Failure to correctly position the crane boom can cause property damage, serious injury or death



Plumbing blocks must be fabricated for each particular situation depending on the panel thickness and the number and diameter of cables. The plumbing blocks must fit securely over the thickness of the panel an the cables as shown.

Down Face of Panel

Brace and Re-rig Method

The "brace and re-rig" method is used when a crane does not have a second line that can safely carry the required panel weight. This method requires you to:

1) Erect the panel using the face lift inserts only.

2) Brace the panel as required.

3) Release the face lift hardware and rigging.

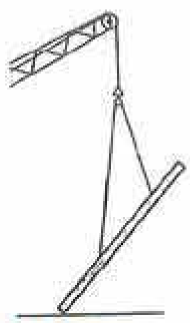
4) Reinstall the proper hardware and rigging onto the final set inserts.

5) With the rigging tight, remove the bracing.

6) Lift and set the panel into its final position.

7) Brace the panel as detailed.

8) Remove the final set lifting hardware and rigging.



1) Lift Panel With Face Lift Inserts

2) Brace Panel
3) Release Hardware

4) Re-Rig Panel
5) Remove Bracing
6) Lift and Set Panel

7) Set and Brace
8) Remove Hardware

WARNING

Failure to properly brace panels before releasing lifting hardware may cause failures resulting in injury or death.

Transfer Method

The "transfer" method is generally used when the crane has a second line that can safely carry the total panel weight. Using the transfer method requires:

1 That the panels be lifted to the vertical position using the face lift inserts and rigging only.

2) Keeping the rigging attached to the final set inserts slack with the final set hardware properly aligned with the cables.

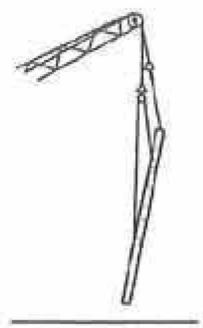
3) After the panel is vertical and completely in the air, transfer the total panel load to the crane line and rigging attached to the final set inserts.

4) The panel is then set into its final position.

5) Brace the panel as detailed.

6) Release both the face lift and final set lifting hardware and rigging.

1) Lift Panel Using Face Inserts
2) Edge Lift Rigging Remains Slack



3) Transferring Load To Edge Lift Inserts

4) Load Transfered and Panel Set In Place

5) Brace As Required
6) Release Hardware

NOTE: Rigging may vary from that shown.

Dayton Superior manufactures several lifting systems for Tilt-Up Construction. These systems are made to meet the many designs and job requirements found in the market. The project requirements along with the contractor's preference dictate which system is utilized on a project. Listed below is a brief description of the various options available to the contractor.

Superior Lifting System

This system features the T-110 Superior Lift Insert capable of lifting 24,000 # SWL per insert for face lifting and the T120 Superior Lifting Hardware for erection of the panels. The system is a ground release system typically used on larger, heavier panels with concrete thickness over 8". The insert is composed of a forged anchor with wire leg assembly for support and a plastic disposable void former. The insert is a directional insert used parallel to the height of the panel. For edge lifts, the Dayton P-92P Erection Anchor with shear plate is utilized. This utilizes the same T-110 Superior Lifting Hardware.

Ground Release Lifting System

This system features the T-41 Ground Release Insert capable of lifting 15,000 # SWL per insert for face lifting and the T-43L Ground Release Lifting Hardware for erection of the panels. This system is a ground release system typically used for panels up to 8" in thickness. The insert is a forged "dog bone" style insert with a plastic star base or wire base and a plastic disposable void former. The insert is a directional insert used parallel to the height of the panel. For edge lifts, the Dayton P-52 Swift Lift Anchor with shear bar is utilized. This anchor can utilize the same T-43L hardware during the erection. This system is available in a 22,800 # SWL System. See T-81 Heavy Ground Release Insert.

Gyro Tilt Plus System

This system features the T49 Gyro Tilt Plus Face Insert capable of lifting 15,000 # SWL per insert for face lifting and the T-50 Gyro Tilt Plus Lifting Hardware for erection of the panels. This system is a ground release system typically used for panels up to 8" in thickness. The insert is a forged "dog bone" style insert with a wire leg assembly or plastic star base and a plastic disposable void former. This insert is a non-directional insert allowing complete rotation of the lifting hardware. For edge lifts, this system also uses the T-49E Anchor (no base) with shear bar and the T-50 Gyro Hardware during erection. This system is available in a 22,800 # SWL System. See T-52 Heavy Gyro Insert.

Tilt-Up 3 Lifting System

This system features the T-90-F Face Lift Insert capable of lifting 15,000 # SWL per insert for face lifting and the T-92 Tilt-Up 3 Lifting Hardware for erection of the panels. This system is a ground release system typically used for panels up to 8" in thickness. The insert is a forged rectangular style insert with a plastic star base and a plastic disposable void former. The insert is a directional insert used parallel to the height of the panel. For edge lifts, the Dayton P92P Erection Anchor with shear plate is utilized. This anchor can utilize the same T-92 Lifting Hardware.

Coil Lifting System

This is the basic system employed during the original development years of tilt construction. This system uses the Dayton Superior T-1 Pick Up Insert along with B14 Coil Bolts and a variety of lifting hardware. The T-1 Insert is available in 3/4" to 1-1/2" diameters, capable of lifting 14,000 # SWL per insert. This system is utilized today with smaller buildings and unique