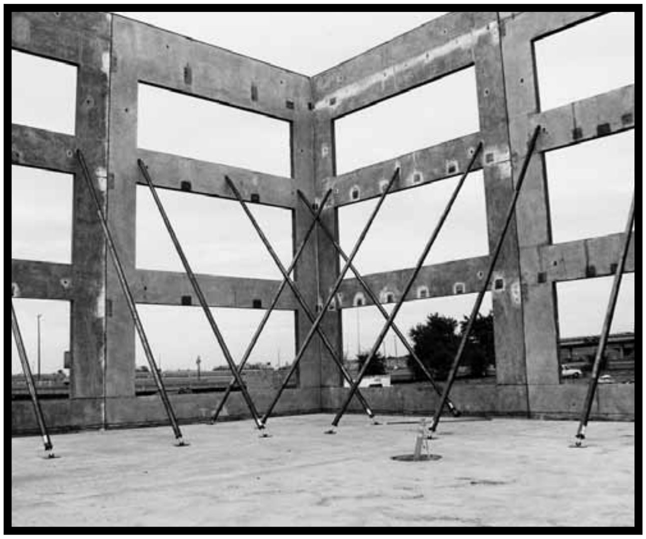
General and Technical Information

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.

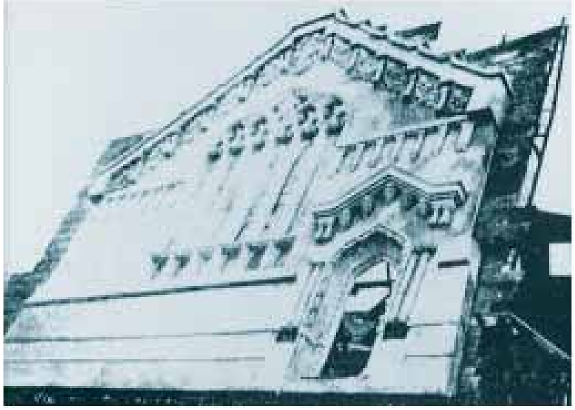
Mr. Aiken is recognized by many as being the father of what is now known as tilt-up construction. In addition, Mr. Aiken developed the first insulated tilt-up wall panels, which consisted of 2” of concrete, 2” of sand and 2” of concrete. As the panels were tipped into position, workers washed the sand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

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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.

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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.

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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.

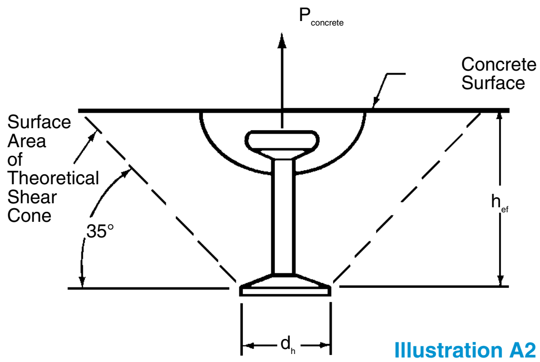


Illustration A2

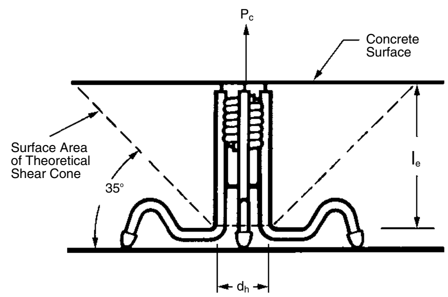
Combined Shear and Tension Interaction

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



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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.

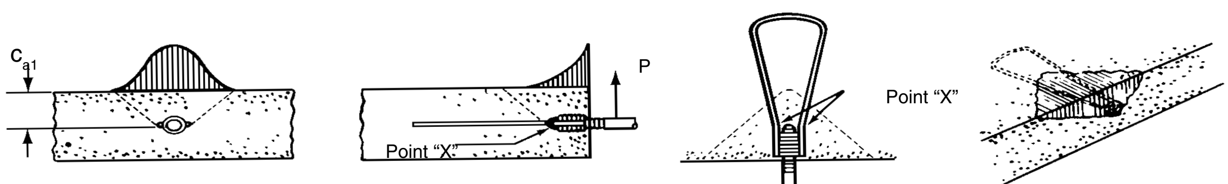
f'_c = Specified concrete compressive strength.

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."**

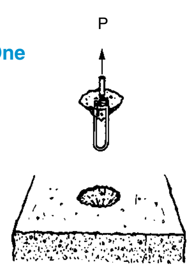
Illustration L

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

Anchor/Insert Failure

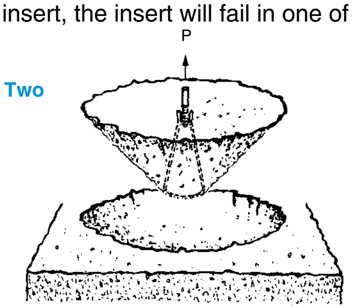
When the applied load P exceeds the pullout capacity of the insert, the insert will fail in one of four ways.

One



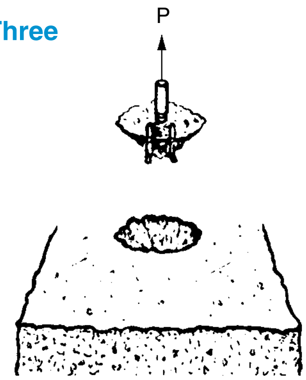
The entire insert may pull out of the concrete, with little apparent damage to the concrete. Such failures are rare and when they do occur, are the result of bond failure between the concrete and insert. These failures usually occur in green, or low strength concrete.

Two

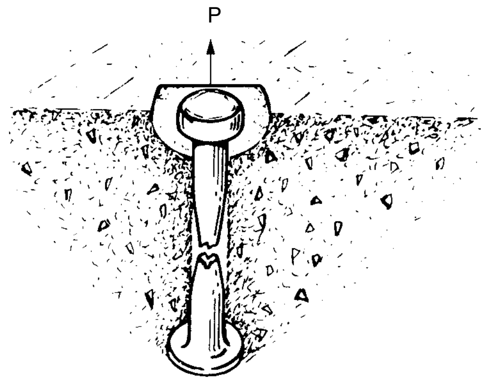


The entire insert may pull out of the concrete bringing with it a cone of concrete having its apex slightly above the most deeply embedded part of the insert. Such failures usually occur when the tensile strength of the shear cone surrounding the insert is not as great as the mechanical strength of the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

Three



Four



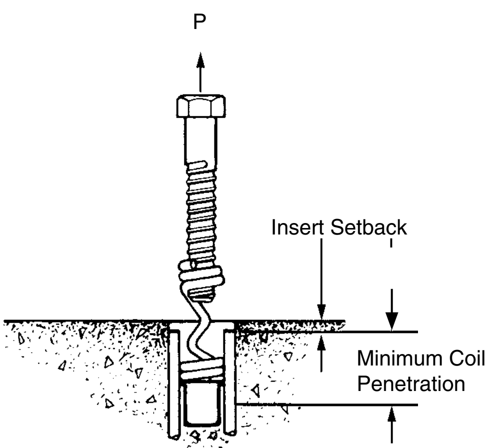
A ductile failure may occur in the insert. Coil type inserts will usually fail at a point just below the helically wound wire coil. A small cone of concrete will usually be pulled out of the concrete surface. This cone will have its apex at a point just below the coil. Its base diameter will be approximately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

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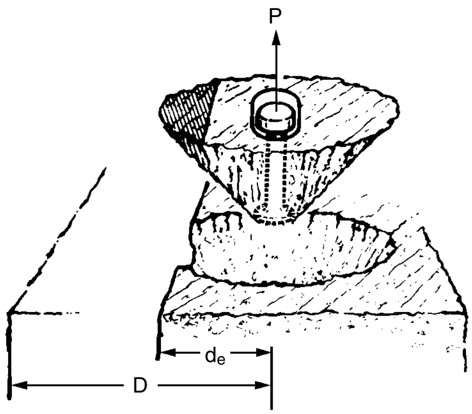
Insert Edge Distances

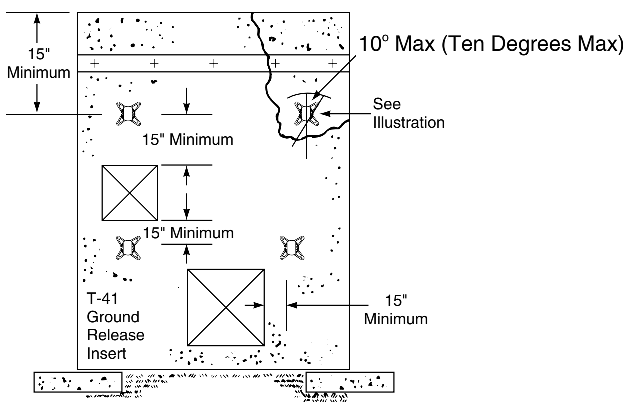


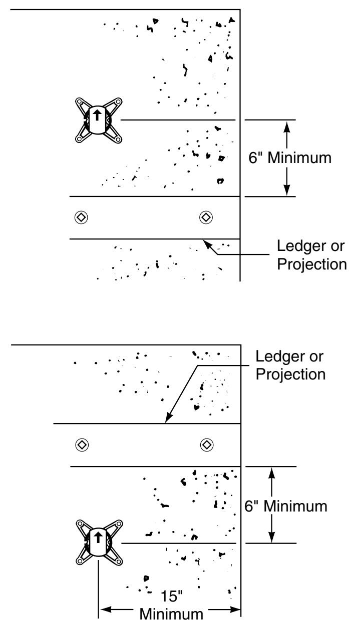
Embedment of inserts closer to any edge; construction joint; window or door opening than the minimum edge distances shown in this handbook will greatly reduce the effective area of the resisting concrete shear cone and thus reduce the insert's tension safe working load. The shaded area of the shear cone 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

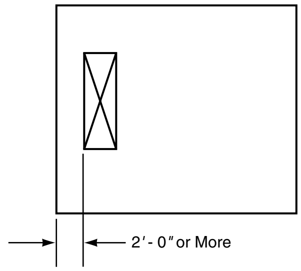
Field Conditions, Equipment and Panel Sizes

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.

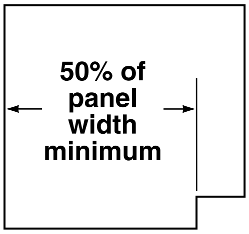


Fig. 1

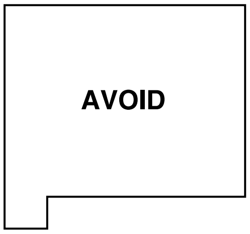


Fig. 2

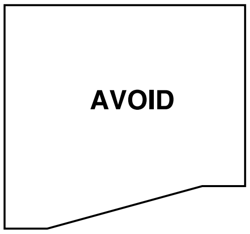
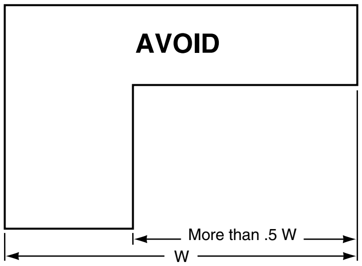
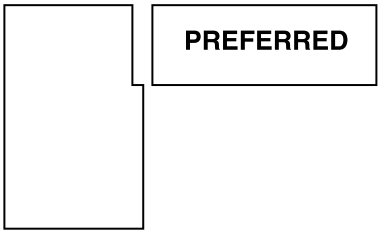


Fig. 3

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

DAYTON SUPERIOR

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

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.