BUILDING STRENGTH™

DELTA TIE

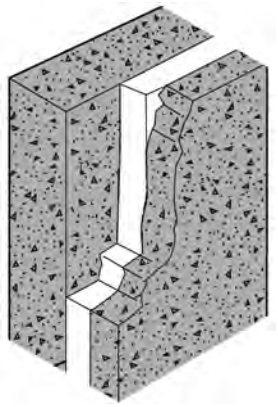
INSULATED CONCRETE SANDWICH PANEL TIE

APPLICATION GUIDE

DAYTON SUPERIOR®

Concrete Sandwich Panels

Generally speaking, sandwich panels are comprised of two layers of concrete (called wythes), separated by a thickness of insulating material and held together by some means of mechanical connection.



Insulated concrete panels can be utilized as exterior load bearing walls or interior partitions. They are used in virtually any building application such as: industrial buildings, correctional institutions, schools, warehouses, offices, buildings requiring atmospheric controls and residential buildings. The concrete surfaces of an insulated panel will accept all of the architectural surface treatments available to standard precast or site cast concrete panels.

Internally Insulated Wall Panels

One of the largest contributors to energy waste in a building is heat loss and/or gain through walls, roofs, doors and windows. The energy efficiency of the building envelope is a major consideration in an analysis of its life cycle costs.

The mass of an internally insulated concrete wall panel makes it a significant thermal reservoir having the ability to store a large amount of heat energy. During the heating season, an internally insulated concrete wall panel will absorb interior heat during the day, radiating the warmth back into the building's interior during the night. This same principle in reverse holds true during the cooling season.

An internally insulated concrete wall panel, by storing and later releasing the energy needed for heating or cooling, delivers year round energy benefits. It also offers the most effective solution for reducing waste and conserving energy by maintaining the building with a relatively steady interior temperature. Working together, the rigid foam insulation and concrete contribute to a highly energy-efficient building and reduce the peak energy demands, potentially allowing the use of smaller capacity cooling and heating units.

Delta Tie

To maintain the thermal efficiencies achieved by the use of internally insulated concrete wall panels and to improve the panel's strength and deflection properties, Dayton Superior developed the Delta Tie for connecting the two wythes of internally insulated wall panels. The Delta Tie is a discrete truss, fabricated entirely from continuous wound alkali resistant fiberglass rovings and alkali-resistant epoxy vinyl ester resins. This design greatly reduces thermal bridges.

Production of the Dayton Superior Delta Tie is with a proprietary process using an alkali-resistant (AK) vinyl ester resin and individual AK fiberglass rovings set in a particular and continuous pattern for developing the maximum load carrying capacity.

The AK resin is heated in a temperature-controlled die to induce a chemical reaction that bonds the AK glass fibers and AK resin into a strong, durable composite material. Upon completion, the load- carrying struts of the Delta Tie contain an average of 77% AK glass fibers and 23% AR resin.

A non-composite internally insulated panel takes into account the strength of the interior wythe ONLY. It does not take advantage of any additional strength that the exterior wythe has to offer.

In order to take advantage of the additional strength, the wall panel must be fabricated so that it will function as a partially composite panel. Depending on the tie spacing selected for use, the Delta Ties increase the composite action. For the same height and width panel, a thinner structural wythe can be achieved when using the Delta Tie.

The Delta Tie is designed so that it can be oriented in the panel either on end or on its side, depending on the thickness of insulation specified. This versatile dual-use feature adds to the Delta Tie's application compatibility and at the same time reduces inventory and storage requirements.

Typical construction details drawings are available upon request.

Delta Tie Advantages

The Delta Tie has exhibited excellent loading behavior and load capacities in tests conducted on individual test specimens as well as in full-scale panel tests.

The Dayton Superior Delta Tie offers the owner, specifier and contractor the following advantages:

Use With Any Rigid Foam Insulation

The Delta Tie can be used with any type of rigid foam insulation.

Easy Learning Curve

Users have reported that it takes just a short length of time to get their employees "up to speed" on installing the Delta Tie.

Labor and Material Savings

The Dayton Superior P24 Delta Tie uses up to 75% fewer ties versus comparable systems.

Typical total savings range between 20-30% over any composite product.

Design Flexibility

The capabilities of the Delta Tie's truss design can greatly increases the stiffness of the panel.

Partial Composite Action

Due to the partial composite action that is gained by using the Delta Tie, thinner panels can be designed, braced and erected.

Minimum Thermal Bridges

Insulation is not interrupted by block-outs for connectors, allowing for insulation to be placed from panel edge to panel edge and from top of panel to bottom of panel.

Increased Composite Moment of Inertia

Depending on the selected tie spacing, the composite moment of inertia of the tilt-up panel can be increased, which may result in a thinner overall panel thickness.

Tested Performance

Passed ASTME-119 (4 hour) and NFPA 285 fire testing.

Tensile and Shear Strength

Based on results from tensile testing, the P24 Delta Tie has an average ultimate tensile capacity of over 3,400 lbs. per tie, in its narrow orientation.

In a typical wall panel, the Delta Ties may be subjected to approximately 500 lbs. of tensile force during the erection process. Assuming a 3" exterior wythe, that force can be calculated as follows:

Face Weight (150 pcf normal weight concrete)	**= 37.5 psf**
Suction	**= 20 psf**
Total	**= 57.5 psf**
Tributary area per Delta Tie	**= 8.0 sq.ft.**
Tensile force per Delta Tie	**= 460 lbs.**
Safety Factor	**= 7:1**

The average ultimate shear capacity of the P24 Delta Tie varies based on insulation thickness and the orientation. In its narrow orientation, the Delta Tie has an average ultimate capacity of over 3,600 lbs. per tie.

In a typical panel, the Delta Ties will be subjected to approximately 300 lbs. of shear force during the erection process. Again, assuming a 3" exterior wythe, that force can be calculated as follows:

Face Weight (150 pcf normal weight concrete)	**= 37.5 psf**
Tributary area per Delta Tie	**= 8.0 sq.ft.**
Tensile force per Delta Tie	**= 300 lbs.**
Safety factor	**= 12:1**

Even though it appears that the tie spacing could be increased, Dayton Superior does not recommend it. The maximum recommended tributary area for either tensile or shear loading conditions is **8.0 sq.ft. per tie**.

Insulation Materials

Although insulation can be made from a variety of materials, it usually comes in five typical forms: blankets, blown-in, loose-fill, reflective film or rigid foam board. Each type of insulation is made to work in a particular part of a building. Closed-cell foams, such as polystyrene, in which the air is trapped in bubbles are an excellent insulator and are generally used for internally insulating concrete tilt-up wall panels.

The type and brand that is most readily available, meeting the project's specified R-value, is generally accepted The thickness of insulation needed depends on the climate, type of heating used and building use.

The following four types of rigid foam insulation, having initial R-values ranging from R-4 to R-8 per inch of thickness, are used in internally insulated concrete wall panels:

- EPS (molded expanded polystyrene)
- XPS (extruded polystyrene)
- PUR (polyurethane)
- PIR (polyisocyanurate)

EPS foam is a closed-cell insulation that's manufactured by"expanding" a polystyrene polymer; the appearance is typically a white foam plastic insulation.

EPS insulation will bond to the concrete and is often referred to as "bead board." When used in an internally insulated concrete wall panel, it must have sufficient density so that workers can walk on it without causing any damage. EPS foam is susceptible to absorbing moisture resulting in a reduced R-value. A plastic vapor retarder should be considered when using this type of insulation.

XPS foam is a closed-cell material that is manufactured using an extrusion process, is more consistent in density, does not bond to concrete and has a higher compressive strength. It also has a reputation for long-term reliability and superior resistance to time, water, cold, heat, and pressure.

Both the PUR and PIR foams are closed-cell foams that contain a low conductivity gas in their cells. The thermal resistance of the gas gives these foams a higher R-value than either EPS or XPS foams. However, due to a phenomenon known as "thermal drift," the R-value of these two foams drops over time as the insulation ages and some of the gas escapes and is replaced by air.

Dayton Superior Insulated Concrete Panel Tie

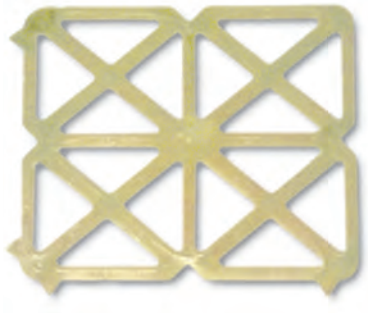
The Dayton Superior P24 Delta Ties are unique in concept and design. This versatile tie allows insulation from panel-edge to panel-edge reducing thermal bridges and the resulting energy loss. The Delta Tie is a non-metallic, geometrically configured, two-dimensional truss manufactured from continuous wound fiberglass embedded in an alkali resistant resin. The non-metallic design of the Delta Tie greatly reduces thermal transfer through the panel, increasing the insulating efficiency.

The P24 and P24XL Delta Tie dimensions are shown in the accompanying detail.

The tie is designed so that it can be oriented in the panel either on end or side depending on the thickness of the insulation. For example, the 5" x 7" (127mm x 178mm) size can be used on its side in a panel with 2" insulation or on end for thicker 3" and up insulation. This versatile, dual-use feature adds to the Delta Tie's effective application compatibility and, at the same time, reduces inventory and storage requirements.

In individual tie specimen and full size panel tests, the Delta Tie has exhibited excellent loading behavior and load capacities.

Product Code	Size
100654	5" X 7" Tie
143984	9" X 11" Tie



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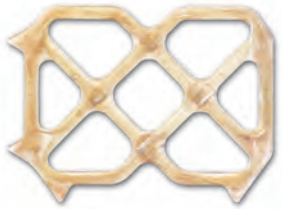

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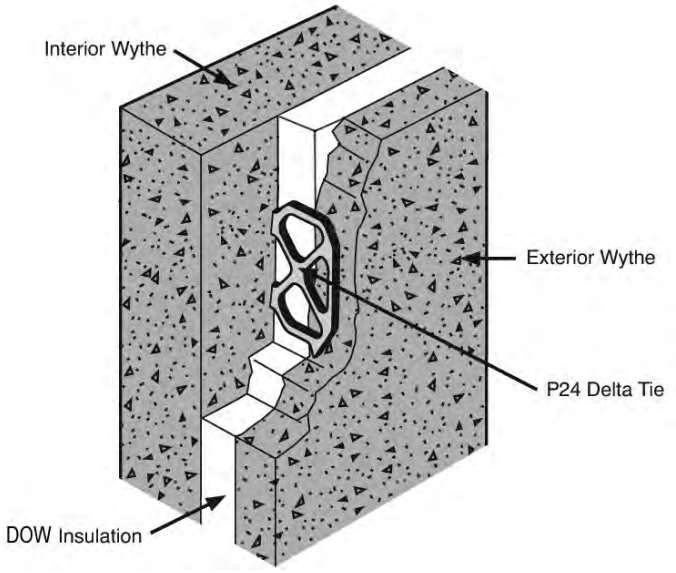
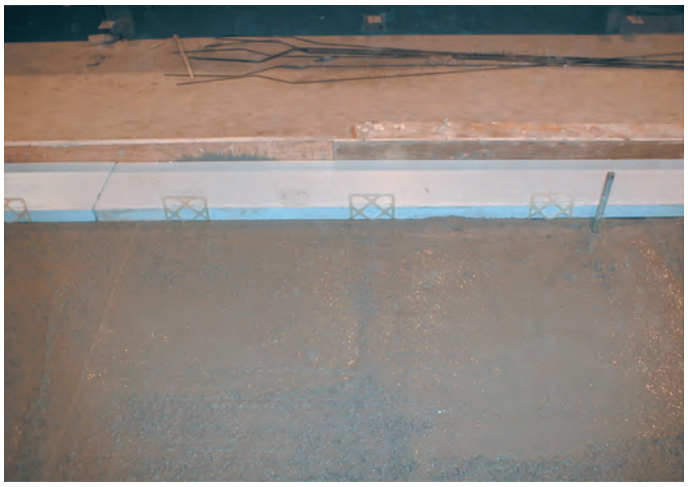
Insulated Panel Components

Internally insulated concrete wall panels are made up of three different wythes:



- The EXTERIOR WYTHE acts as a barrier against the environment, protecting the foam insulation from exterior damage, and depending on design requirements and architectural treatments, may be as thin as 2". It can have any architectural treatment, such as those created with formliners, an exposed aggregate surface, a thin brick surface or a simple textured coating.
- The INSULATION wythe provides an excellent thermal barrier that works to reduce heat loss as well as the building's energy costs.
- The INTERIOR WYTHE is normally the structural wythe, which supports the wind, roof, as well as any upper floor loads. It also protects the insulation from damage. Depending on the spacing of the Delta Tie, the interior wythe can work with the exterior wythe providing partial composite action for the wall panel. Having a thicker or structural wythe on the interior side of the building also acts to maximize the thermal mass effect of the wall, stabilizing the interior temperature, resulting in lower energy costs.

Concrete, because of its density, has the capacity to absorb and store large quantities of heat. This thermal effect causes concrete to react very slowly to changes in outside temperature. This characteristic reduces peak heating and cooling loads and delays the time at which these peak loads occur. This delay improves the performance of heating and cooling equipment, since the peak cooling loads are delayed until nighttime, when the outside temperature has dropped.



Delta Ties inserted into the first wythe — the exterior wythe — along the edge of the second wythe — the rigid insulation.

The third wythe — the interior wythe — being installed over the insulation, incorporating the Delta Tie and rebar.

Insulated Wall R-Values

Internally insulated concrete wall panels are designed to resist the flow of heat energy through the wall. In most buildings, internally insulated concrete wall panels are used to keep the heat inside the building. However, in special cases, such as a freezer application, internally insulated wall panels are designed to keep cold in and heat out.

R-value is a rating or measure of resistance of an insulation's ability to retard the flow of heat. Generally, the higher the R-value, the better insulator it is. Foam insulation's long-term R-value will vary depending upon the characteristics of its manufacture. It is suggested that the specifier consult the insulation manufacturer for this information.

Insulated Wall U-Factors

Another measure of how well a material or a combination of materials conducts heat is the U-factor, which is the reciprocal of the R-value. The lower the U-factor, the better.

Internally insulated concrete wall panels, with their high thermal storage properties, have an advantage over many other building materials. However, a solid concrete wall panel, by itself, is not very effective as an insulator. For example, a 6" solid concrete wall has an R-value of 1.27 and a U-factor of 0.787. By adding only 1" of extruded foam insulation to the middle of the 6" wall, the R-value of the wall will increase to 6.27 and the U-factor will drop to 0.159.

The use of internally insulated walls having higher R-value would seem to be more efficient. However, the U-factor is a better number for use in determining the effectiveness of an insulated wall. As additional insulation is added to the wall, the wall's R-value continues to increase at a uniform rate, but the U-factor drops more slowly as more insulation is added. The following chart illustrates this principle.

Exterior Wythe	XPS Insulation	Interior Wythe	Total Wall Thickness	R-Value	U-Factor
3	2	2	7	11.20	0.0892
3	2	3	8	11.27	0.0887
3	2	4	9	11.34	0.0881
3	2	5	10	11.40	0.0877
3	2	6	11	11.47	0.0871
3	2	7	12	11.54	0.0866
3	3	2	8	16.20	0.0617
3	3	3	9	16.27	0.0614
3	3	4	10	16.34	0.0611
3	3	5	11	16.40	0.0609
3	3	6	12	16.47	0.0607
3	3	7	13	16.54	0.0604
3	4	2	9	21.20	0.0471
3	4	3	10	21.27	0.0470
3	4	4	11	21.34	0.0468
3	4	5	12	21.40	0.0467
3	4	6	13	21.47	0.0465
3	4	7	14	21.54	0.0464
3	5	2	10	26.20	0.0381
3	5	3	11	26.27	0.0380
3	5	4	12	26.34	0.0379
3	5	5	13	26.40	0.0378
3	5	6	14	26.47	0.0377
3	5	7	15	26.54	0.0376

Exterior Wythe	PolyIso Insulation	Interior Wythe	Total Wall Thickness	R-Value	U-Factor
3	2	2	7	14.20	0.0704
3	2	3	8	14.27	0.0700
3	2	4	9	14.34	0.0697
3	2	5	10	14.40	0.0694
3	2	6	11	14.47	0.0691
3	2	7	12	14.54	0.0687
3	3	2	8	20.70	0.0483
3	3	3	9	20.77	0.0481
3	3	4	10	20.84	0.0479
3	3	5	11	20.90	0.0478
3	3	6	12	20.97	0.0476
3	3	7	13	21.04	0.0475
3	4	2	9	27.20	0.0368
3	4	3	10	27.27	0.0367
3	4	4	11	27.34	0.0366
3	4	5	12	27.40	0.0365
3	4	6	13	27.47	0.0364
3	4	7	14	27.54	0.0363
3	5	2	10	33.70	0.0297
3	5	3	11	33.77	0.0296
3	5	4	12	33.84	0.0295
3	5	5	13	33.90	0.0295
3	5	6	14	33.97	0.0294
3	5	7	15	34.04	0.0293

The total R-value of an internally insulated concrete wall panel is a summation of the individual items that make up the wall. The above chart is based on the following individual R-values.

- An R-value of 0.0693 per inch of concrete.
- An R-value of 5.00 per inch of insulation.
- An R-value of 0.68 for the inside air film.
- An R-value of 0.17 for the outside air film.

Insulated Panels Provide Energy Savings

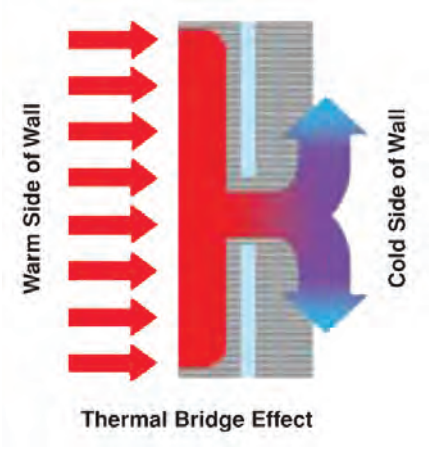
Thermal Bridges/Cold Spots

Thermal bridges are formed in internally insulated concrete wall panels when concrete ribs and/or metal ties, which are used to connect the wythes together, interrupt the foam insulation layer.

Thermal bridges allow heat energy (thermal conductivity) to escape through the wall at a faster rate. Heat energy will always travel from a higher temperature to a lower temperature. The greater the difference in temperature, the faster the heat energy will travel.

When the transfer of heat energy occurs in a wall, it will create a cold spot. Cold spots are not only unsightly, they also allow condensation and freeze thaw areas to form. Thermal bridges will also lead to damage of the building's walls and greatly reduce the insulating properties of the building.

To prevent the forming of concrete thermal bridges and/or infiltration of air, the rigid foam insulation should not be interrupted by block-outs for inserts or other embedment. The sheets should be placed tightly together with any gaps between the rigid foam sheets that are wider than 1/8", sealed with foam caulk or foam insulation sealing tape.



Thermal Bridge Effect


Cold Spots at Insert Blockouts

Condensation

As the insulation in any internally insulated concrete wall panel is subjected to a significant amount of moisture condensation, due to the insulation being enclosed in concrete, the "dew point" of the wall will usually occur inside the insulation layer. The "dew point" is a measure of the amount of moisture inside the wall. When metal ties are used to connect the wythes, the moisture hidden inside the wall will condense on the ties, causing the metal ties to fail due to corrosion (rust). If a sufficient number of metal ties fail, the outer wythe may delaminate from the wall.

The non-metallic design of the Delta Tie and high resistance to alkalai make them extremely durable when used to create internally insulated concrete wall panels.

Delta Tie Design

For any given internally insulated concrete wall panel, the load, shear and moment diagrams are used to calculate the number of Delta Ties to resist permanent in-place loads and temporary loads imposed during the erection process.

By using the Delta Tie, the engineer is able to keep the thermal benefits of a fully insulated non-composite concrete wall panel, and yet increase the panel's stiffness. By selecting the appropriate Delta Tie spacing, a panel can now be designed to act in a partially composite manner. This design will allow both wythes to support a portion of the imposed loads, resulting in a more economical design.

Load Capacities

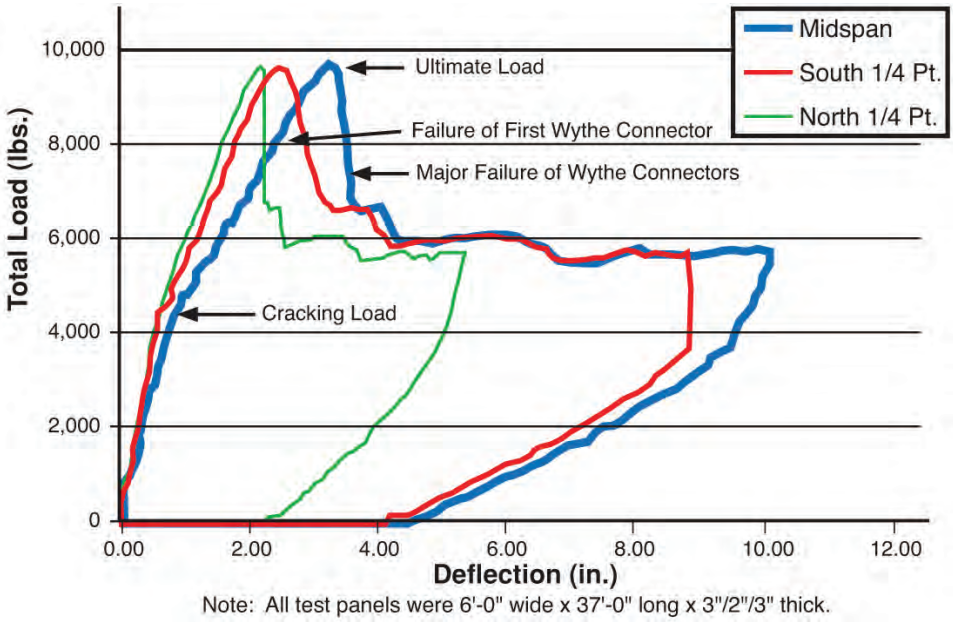
Delta Tie Type	Insulation Thickness (inches)	Tension Capacity * (lbs)	Shear Capacity * (lbs)
P24 (5"x7")	1"- 2"	3407	3612
P24 (5"x7")	3"	2546	1787
P24 (5"x7")	4"	2136	1360
P24XL (9"x11")	1" - 5"	5800	3700
P24XL (9"x11")	6"	3400	3075
P24XL (9"x11")	7"	4000	2800
P24XL (9"x11")	8"	3200	1650

*Ultimate Strength Per Tie. Factor Of Safety is variable based on the panel configuration.

Displacement

The results from one full-scale panel test show the load deflection responses of the panel. All full-scale test panels exhibited a similar failure mode. After first cracking, the load deflection behavior was linear until the load at which the highly stressed Delta Ties begin to fail.

Composite designs should use sufficient Delta Ties to assure stresses are maintained below the ultimate value of the Delta Tie and shall conform to local Building Code requirements.



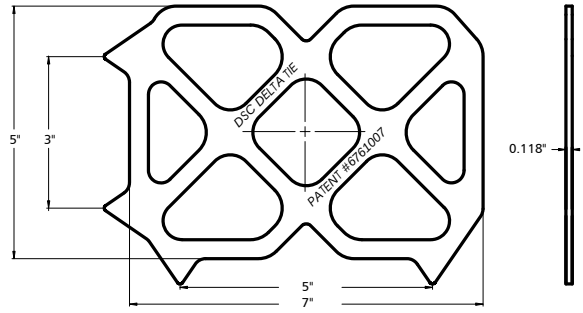
Note: All test panels were 6'-0" wide x 37'-0" long x 3"/2"/3" thick.

Minimum Wythe Thickness

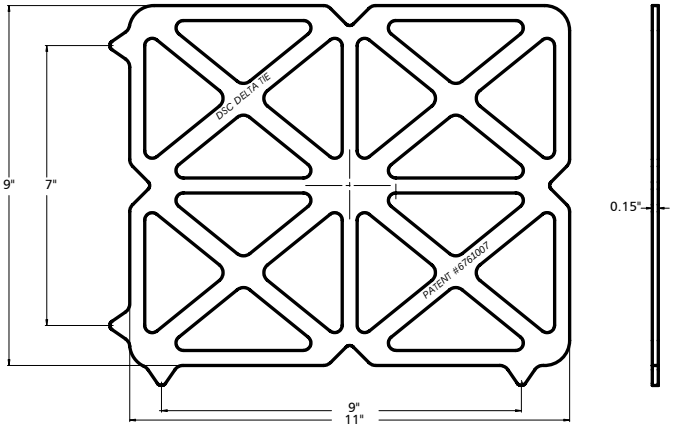
A minimum external wythe thickness of 2" is recommended. If architectural features, such as reveals, a formliner or exposed aggregate, are present in the exterior wythe, then the minimum thickness would be 2" plus the thickness of the architectural feature.

EXAMPLE: For a wythe having a ¾" reveal, the minimum thickness would be ¾" + 2" or 2¾" minimum.

The structural wythe thickness will vary depending on application of the panel (cladding or load bearing) and the imposed loads to which the panel will be subjected. The Engineer of Record for the building project must determine the actual thicknesses of the external and internal wythes.



P24



P24XL

Concrete/Reinforcing Steel

Normally, a high quality, normal weight concrete having a minimum 28-day compressive strength of at least 4,000 psi is specified. Care should be taken when using self-consolidating concrete (SCC) in the thin exterior wythe, as workers must walk on top of the foam insulation during installation of the P24 Delta Ties and the SCC might not support the weight of the workers.

The concrete mix design for the exterior wythe should specify a maximum aggregate size of ¾". The use of a larger size aggregate will interfere with the installation of the Delta Tie.

The design-mix usually specifies a slump of between 4" and 6".

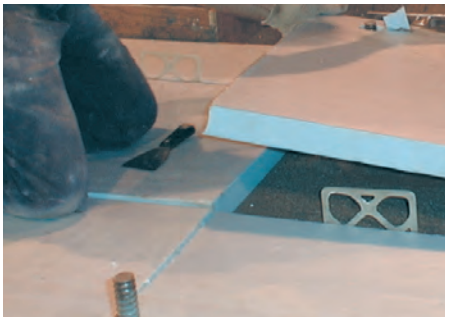
The exterior and interior wythes should be reinforced per the American Concrete Institute's Building Code Requirements for Structural Concrete, ACI 318 Latest Revision.

Composite Moment Capacity

For any given sandwich panel, the shear and moment diagrams define the panel stiffness required for lifting and installation. The composite panel stiffness may be tuned by adjusting the overall tie density, and a targeted adjustment can be realized by the addition of extra ties placed in the zones of maximum shear flow.

Standard Installation

1. After installing the required exterior wythe's reinforcement, place and screed the concrete to the specified thickness.
2. Cut the first strip of foam to the required width (4"-12" max) per placement drawings and place it tightly against the side of the form.
3. Add full sheets of insulation to within 4"-12" of opposite edge; place filler piece to edge.
4. Insert Delta Tie vertically per placement drawings between insulation sheets. If the tie hits the reinforcing mesh, prior to reaching its minimum embedment depth, move the tie slightly so that the reinforcing mesh sits in the depressed "V" section of the tie. NOTE: The minimum Delta Tie embedment into the fresh concrete is 1½". ***Alternative Method:*** Cut the first strip of insulation, then insert the first row of Delta Ties spaced vertically as required. Add the remaining courses of insulation and connectors. Foam-back tape is available for sealing the insulation joints, if necessary.



5. When all of the sheets of insulation and connectors have been placed in the panel, the top reinforced concrete wythe is cast and screeded as necessary.
6. After proper concrete set, the panel may be removed from the form and the process repeated.

Post Placement Inspection of Ties

- Usually done the next day
- Check all ties for looseness and placement
- Identify any that require retrofitting

Delta Tie Retrofit

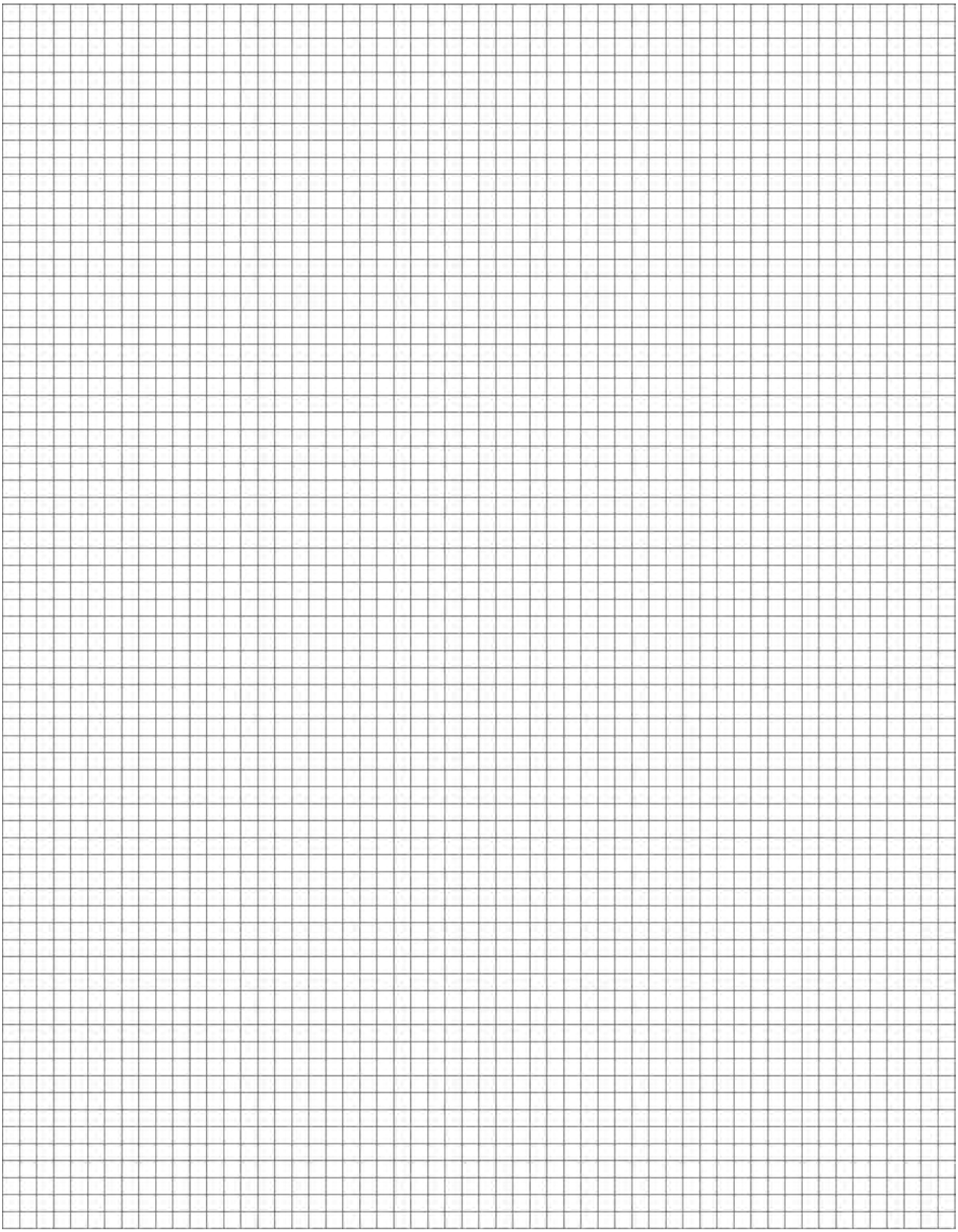
1. Cut insulation around tie
2. Use a quick cut saw to cut away old Delta Tie and create a replacement slot 1-1/2" deep
3. Clean out slot
4. Fill slot with J58 Resi-Bond epoxy (follow J58 Technical Data Sheet instructions)
5. Place new Delta Tie into slot
6. Replace insulation around new tie

Important Information:

- It is critical that Steps #1 through #4 be completed immediately after the bottom wythe has been consolidated and leveled to its required thickness, no later than 15-20 minutes after placement of the concrete to ensure it is still plastic. If the Delta Tie is not embedded into the concrete while the concrete is still plastic, the concrete will not properly engage the Delta Tie.
- Care must be taken to ensure that Delta Ties are installed in their intended orientation in the panel.
- When using the Dayton Superior P24 and P24XL Delta Tie, lifting inserts and brace anchors are to be installed in the structural wythe ONLY.
- Dayton Superior recommends the use of 24" wide sheets of insulation.

A simple setting block.

Notes and Sketches



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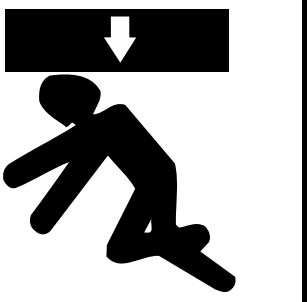
Safety Information



⚠WARNING

Improper Use of Concrete Accessories Can Cause Severe Injury or Death

Read, understand and follow the information and instructions in this publication before using any of the Dayton Superior concrete accessories displayed herein. When in doubt about the proper use or installation of any Dayton Superior concrete accessory, immediately contact the nearest Dayton Superior Service Center or Technical Service Department for clarification. See back cover for your nearest location.

Dayton Superior products are intended for use by trained, qualified and experienced workmen only. Misuse or lack of supervision and/or inspection can contribute to serious accidents or deaths. Any application other than those shown in this publication should be carefully tested before use.

The user of Dayton Superior products must evaluate the product application, determine the safe working load and control all field conditions to prevent applications of loads in excess of a product's safe working load. Safety factors shown in this publication are approximate minimum values. The data used to develop safe working loads for products displayed in this publication are a combination of actual testing and/or other industry sources. Recommended safe working loads given for the products in this publication must never be exceeded.

Worn Working Parts

For safety, concrete accessories must be properly used and maintained. Concrete accessories shown in this publication may be subject to wear, overloading, corrosion, deformation, intentional alteration and other factors that may affect the device's performance. All reusable accessories must be inspected regularly by the user to determine if they may be used at the rated safe working load or should be removed from service. The frequency of inspections depends upon factors such as (but not limited to) the amount of use, period of service and environment. It is the responsibility of the user to schedule accessory hardware inspections for wear and remove the hardware from service when wear is noted.

Shop or Field Modification

Welding can compromise a product's safe working load value and cause hazardous situations. Knowledge of materials, heat treating and welding procedures is necessary for proper welding. Consult a local welding supply dealer for assistance in determining required welding procedures.

Since Dayton Superior cannot control workmanship or conditions in which modifications are done, Dayton Superior cannot be responsible for

Interchangeability

Many concrete accessory products that Dayton Superior manufactures are designed as part of a system. Dayton Superior strongly discourages efforts to interchange products supplied by other manufacturers with components supplied by Dayton Superior. When used properly, and in accordance with published instructions, Dayton Superior products have proven to be among the best designed and safest in the industry. Used improperly or with incompatible components supplied by other manufacturers, Dayton Superior products or systems may be rendered unsafe.

Installation

WARNING

1. Dayton Superior Corporation products shall be installed and used only as indicated on the Dayton Superior Corporation installation guidelines and training materials.
2. Dayton Superior Corporation products must never be used for a purpose other than the purpose for which they were designed or in a manner that exceeds specific load ratings.
3. All instructions are to be completely followed to ensure proper and safe installation and performance
4. Any improper misuse, misapplication, installation, or other failure to follow Dayton Superior Corporation's instruction may cause product malfunction, property damage, serious bodily injury and death.

THE CUSTOMER IS RESPONSIBLE FOR THE FOLLOWING:

1. Conformance to all governing codes
2. Use of appropriate industry standard hardware
3. The integrity of structures to which the products are attached, including their capability to safely accept the loads imposed, as evaluated by a qualified engineer.

SAFETY INSTRUCTIONS:

All governing codes and regulations and those required by the job site must be observed. Always use appropriate safety equipment

Design Changes

Dayton Superior reserves the right to change product designs, rated loads and product dimensions at any time without prior notice.

Note: See Safety Notes and Safety Factor Information.

DAYTON® SUPERIOR®

1125 Byers Road
Miamisburg, OH 45342
937-866-0711
888-977-9600

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