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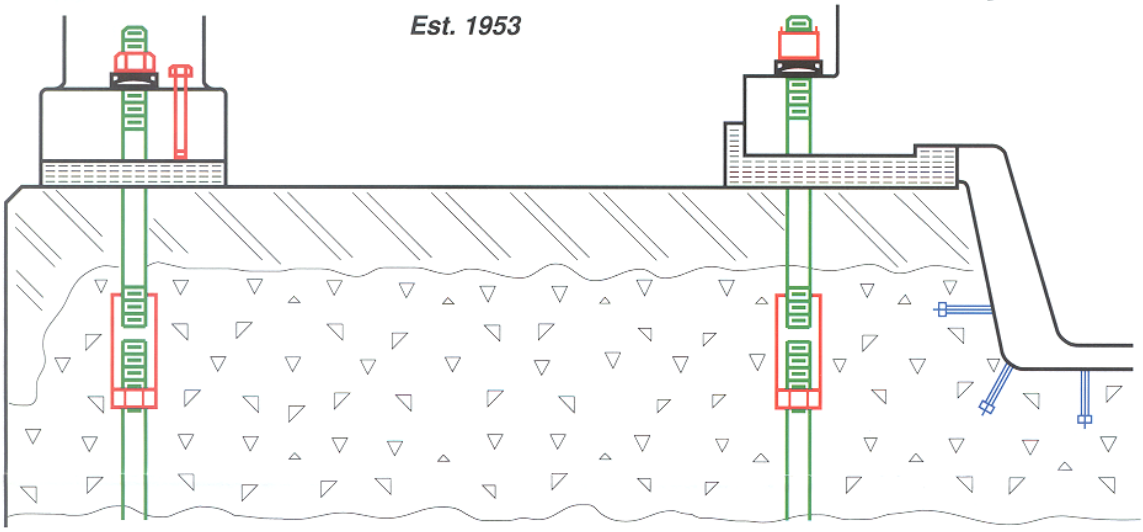

Grouting Technology Newsletter

Reinforcing Deep Epoxy Grout Pours*

Epoxy machinery grouts were originally designed for critical machinery, such as large compressors, engines and turbines. With such applications, typical grout pour depths were 1-1/2" to 2" and on new concrete.

Once the excellent physical properties and long service life of epoxy grouts became known, it was not long until epoxy grouts were being used in much deeper thicknesses of 6" to 14". This is often found when regrouting old equipment. Pour depths of 24" to 30" in case of concrete structural repair have been seen.

These applications meant that the epoxy grout was being used to replace concrete in a part of the foundation containing reinforcing steel. As a result, the first steel reinforced deep epoxy grout pours were patterned after steel reinforced concrete. While these deep pours were successful, field experience has indicated that some additional guidelines on the use of steel to reinforce deep epoxy grout pours are necessary.

Before touching on what these guidelines are, let us discuss when steel reinforcing should be added to an epoxy pour and the benefits that steel can provide.

Benefits From Using Steel Reinforcing In Deep Epoxy Grout Pours

- Increase the tensile load carrying capacity
- Helps bridge a fracture in the concrete below

Robt. L. Rowan & Assoc., Inc. • 3816 Dacoma • P.O. Box 920760 • Houston, Texas 77292-0760
Tel (713) 681-5811 • Toll Free (800) 231-2908 • Fax (713) 681-5815
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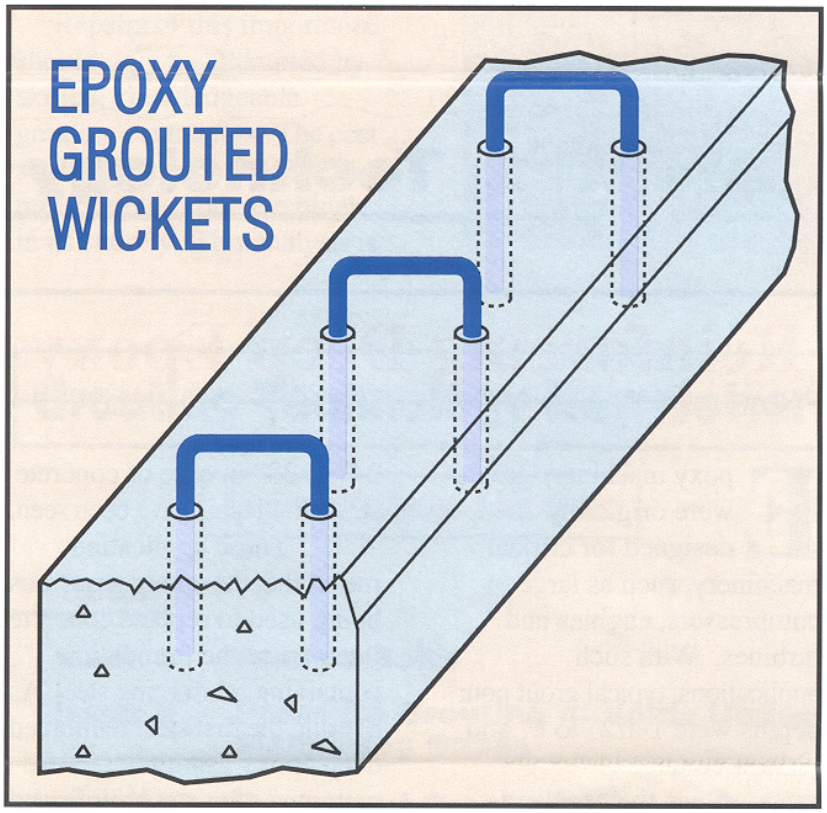
- ➢ Increases the uplift capacity between a concrete block and thick grout pour *(enhances the bond)*

- ➢ Reduces "edge-lifting" type cracks around the block perimeter adjacent to the grout/concrete interface

Before discussing the above applications, it is only fair to call attention to a misconception not listed: that steel reinforcing will reduce cracking in deep epoxy grout compressor block pours. While steel reinforcing in some cases can minimize cracking, it also can contribute to cracks as well. Because of this, it is better to control vertical cracking in deep epoxy grout pours by the use of expansion joints, as discussed in the last newsletter. This does not mean you should not use steel reinforcing. You should add it when it is called for, as listed above. Take care, as will be explained further, so as not to increase the possibility of cracking when using steel reinforcing.

1) Through the use of additional steel reinforcing in a deep epoxy grout pour that is replacing some of the original concrete, additional tensile load carrying capacity can be developed.

This technique was used very successfully in the late 1950s to upgrade concrete compressor foundations poured during World War II with too little steel because of shortages. Later this tensile-enhancing technique was used in plant modernizations, when larger capacity machines were retrofitted to old foundations.*



2) Steel added to a deep epoxy grout pour can help bridge hairline cracks in the old foundation below.

In addition, fiberglass cloth reinforcing can also be used to keep a hairline crack in the foundation from "reflecting" up into the epoxy grout pour. If the concrete block has a structural crack that is moving, additional steps should be taken to correct that problem, as pointed out in our Volume 1, Issue 3.

3) Steel reinforcing in the form of rebar wickets and dowels can substantially increase the bond between the epoxy cap and the concrete block and can increase the uplift capacity in the vicinity of the anchor bolts.

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This can also be particularly helpful when the bond of the grout cap to the block is questionable because of oil contamination.

4) "Edge-lifting" type cracks around the perimeter of the block, either at the grout/concrete interface or 1" to 2" below, can occur even in epoxy grout pours of 1-1/2" thickness poured on a new concrete block.

These are caused by the higher coefficient of expansion of epoxy materials compared to concrete. The weaker (in tensile strength) concrete below fails in tension as the epoxy grout expands and contracts at a greater rate from temperature changes.

If #3 bars, either as dowels or wickets, are set in the edge of the concrete before pouring the grout cap, "edge-lifting" can be controlled. Drill 5" deep, 7/8" holes at a 45° angle, on 12" to 14" centers, and pre-bend the dowels so they are vertical and just inside the form. They will be bonded in place as the grout is poured. Breaking the top edge of the concrete block with a chipped, 2" to 3" chamfer makes drilling the dowel holes easier, and the chamfer itself also helps control "edge-lifting" (See Figure 1).

Helpful Hints On Installing Rebar

While the size of steel and spacing is the province of the structural engineer, these hints on location and sizing can be used as long as the amount of steel is not reduced.

1) Always have at least 2" of grout covering horizontal rebar runs.

This applies to intermediate grout pours if multiple grout pours are being made. If a horizontal rebar run lies just under the grout surface even when later additional grout depth will be added, more than likely a crack will develop over the rebar.

Why it happens is a function of the heat transferred into the steel as the grout cures. This can be avoided by either stopping the pour at a lower level or by pouring to a greater height. Such cracks, if not filled with a liquid epoxy mixture (no aggregate) before pouring the next epoxy grout pour on top will probably cause the next pour to crack as well.

The solution is simple: either decrease the vertical distance of multiple rebar reinforcing layers or adjust the depth of grout poured at any one time to stay within these guidelines. Rebar, whether horizontal or vertical, as a matter of good practice, should not be in the top 2" of an epoxy grout pour.

2) When adding additional steel rebar beyond what is left in place after concrete removal, it is a good idea to use multiple pieces of small cross-section rebar rather than the large cross-section steel as called for in the original design.

The reasons are twofold:

A. Epoxy grouts have a modulus of elasticity considerably lower than steel (30×10^6 for steel vs. $.5$ to 3×10^6 for epoxy grouts).

This means that for the same unit load, the epoxy grout will stretch or compress much more than steel. Since steel rebar is only able to accept a tensile load applied to it by stretching, it makes sense that multiple, thinner cross-sections of rebar in a pour are a better means of increasing the total tensile load carrying capacity.

If conventional concrete design would suggest #7 or #9 bar on 12" centers, you might want to consider an equivalent total cross-section of steel, but use #5 bar on much closer centers, vertically and horizontally.

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B. Heat from the epoxy curing reaction concentrates in the rebar.

Without adequate grout covering it, the use of steel contributes to cracking in a thick epoxy cap. Smaller size steel, even relatively close together, is not as prone to induce cracking in the epoxy grout.

Other Uses Of Rebar With Epoxies

While too important a subject to cover in detail at the end of this newsletter, we would like to mention that epoxy injection grouts work well with rebar steel or higher strength B7 all-thread rods when used in the structural repairs of cracks in concrete blocks.

This technique was developed from field experience, when it was found that simply pumping a crack in a concrete block full of liquid epoxy injection grout did not give a permanent repair. The proper amount of steel must be used to add enough tensile-carrying capacity to keep the crack from "working." The epoxy injection grout must fill the crack and bond the steel in place.

These repairs have been quite successful. This technique can be used to stitch back a large compressor block fractured in two or more pieces. It can also eliminate a working cold joint at the block/mat interface. With major cracking, it is not uncommon to see 8 to 10 through bolts or resin anchored bolts measuring 1" to 1 -1/2" in diameter x 30' long used.

Repairs of this importance should only be attempted by skilled, knowledgeable grouting contractors. The cost should then be compared to replacing the concrete block in its entirety. This analysis is particularly important if the crack is a result of an improperly sized block or foundation mat. ■

**The above mentioned comments are valid if a decision has been made to utilize deep epoxy pours. However, before making that decision, consideration should be given to more recent evaluations of the long-term effectiveness of deep epoxy pours. Please see Volume 1, Issue 5, Revised.*

Grouting Technology Newsletter

Upcoming Issues

Volume I

Issue 8	**Anchor Bolts**
Issue 9	**Pressure Grouting of Voids Under Machinery Bases**
Issue 10	**Repairs of Cracks in Epoxy Grouts**
Issue 11	**Pump Grouting**
Issue 12	**Re-Grouting Reciprocating Gas Compressors 5 Year Repairs vs. 20 Year Reliability Criteria**

Volume II

Issue 1	**Gas Compressor Support Systems**

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