

## Summary of Key Points from Kansas City Demonstration

### Foundation Inspection / Anchoring Types and Practices

#### FOUNDATION INSPECTION- NSSA/ICC 500, Section 308.

1. Minimum slab thickness must be an average 3 ½ inches.
  - To test for thickness drill several holes (3/4" or larger) concentrated around area of installation. Take a piece of stiff wire, bend a hook on the end to insert into hole. Lift up and engage hook, several times, to get good average thickness. Measure depth of hole with tape measure.
  - If there is any doubt that the average thickness is less than 3 ½ inches, a plan should be put into place to cut out existing section of concrete and re-pour with proper reinforcement.
2. Minimum steel reinforcement- No. 4 bars at a maximum spacing of 18" on center, in two perpendicular directions or 6" x 6"- W1.4 x W1.4 welded wire reinforcement over entire area on installation.
  - The best device to assure this is GPR (ground penetrating radar). These devices can detect both ferrous and non-ferrous materials, they can also detect voids in concrete and thickness. They can be cost effective to own even for companies not in the concrete business, because of the reduction in liability from installing a shelter on an inadequate foundation.
3. Foundation surface condition and compressive strength of concrete - The minimum standard for concrete strength is 2500 psi.
  - A good way to check the compressive strength of the foundation is with a rebound hammer (calibrated nail gun). It is recommended to take as many as 12 hits on the surface of the foundation in the area around installation site. The readings on the hammer scale can be converted into psi.
  - Another quick test, is to scrape the surface of the foundation with a small flat head screwdriver. If the surface is easily scratched with deep grooves, you must reconsider the quality of the concrete to hold anchors.
  - A slab which contains numerous large cracks caused by settlement of the support of the supporting subgrade, prior extreme loading, or improper finishing or curing should not be considered adequate for shelter anchorage. Small cracks are acceptable, 1/32" or smaller.
  - It is important to determine the location of any construction joints where the reinforcing may be discontinuous, this would make the slab inadequate for shelter anchorage. Sawn control joints will be acceptable, provided reinforcing has not been cut.

#### ANCHOR INSPECTION – NSSA/ICC 500, Section 106.3 and 3.1.

1. Special inspections shall be provided for “anchors” post installed in hardened concrete, when used for anchorage of shelter components forming a part of the shelter enclosure (floor) or for anchorage of the shelter structure to foundations.
2. NSSA/ICC 500, Section 106.3.1 requires a special inspection to verify the post installed anchor installation and capacity in accordance with Section 107.2.1, which should be the same as the recommendation by the design engineer. **Exception:** For residential shelters, where the authority having jurisdiction verifies that the anchorage meets ICC 500 Section 107.2.1, the special inspection is permitted to be waived.

*The NSSA recommends following engineering specifications for anchor type, size, and capacity. NSSA also recommends following manufacturers installation procedures and use of adhesives. The NSSA conducted a practical demonstration for proper anchor installations and tried to also demonstrate improper practices. SEE RESULTS BELOW*

### **TEST RESULTS FOR DIFFERENT ANCHORS INSTALLED PROPERLY AND IMPROPERLY!**

- ❖ **All three anchor types; expansion, screw, and adhesive** were tested for pull-out strength. They were all very close to manufacturer’s specifications when installed properly. (Note: the test slab quality was not ideal or uniform, because we attempted to meet minimum compressive strength requirements and thickness).
- ❖ The **properly installed expansion anchors and screw anchors**, when tested to failure, pulled cone shaped plugs of concrete from the slab, which was expected. Demonstrating the depth of embedment of the anchor and compressive strength of the concrete are the main determining factors to the ultimate pull-out strength of these type anchors, because the concrete will fail first.
- ❖ Test results for **expansion anchors improperly installed** showed the following results:
  - When the drill hole was located 2” from the edge of the slab, the expansion anchor cracked the slab (anchorage) and were ineffective.
  - If the expansion anchors were over torqued, the anchor began to spin in the hole and would have to be replaced, most likely with an adhesive anchor if trying to utilize same hole.
- ❖ Test results for **screw anchors improperly installed** showed the following results:
  - If the drill hole size was oversized the screw anchor would either not tighten or would yield a lesser pull-out strength. Both conditions should warrant replacing screw type anchor or squirting acrylic adhesive in hole to secure screw anchor.
- ❖ Test results for **properly installed adhesive anchors** yielded higher pull-out strengths, as would be expected. When tested to failure the anchor puller a uniform cylindrical

shaped plug slightly larger than the drill hole size and depth. The concrete failed uniformly around the bond between concrete and adhesive. Adhesive anchors are highly recommended for shelter installations.

- ❖ Test results for **adhesive anchors improperly installed** showed the following results:
  - If the drill hole was not cleaned out properly, blow-brush-blow, the results showed much lower and unacceptable pull-out strengths.
  - If the drill hole was  $\frac{1}{4}$ " oversized the results showed the pull-out strengths to be similar to properly installed anchors. This would probably hold true unless the hole was too oversized and it would also be harder to place anchor straight up in hole. Proper hole size is recommended.

### INSTRUCTION TIPS FOR ANCHOR INSTALLATION

#### ANCHORS – EXPANSION / WEDGE TYPE

1. Selection: Select anchor size and grade based on engineering recommendations. Make sure the length of the anchor is set to a maximum depth based on the average thickness of the foundation (minus at least  $\frac{1}{2}$ " - you do not want to drill to close to bottom of slab). Example: would be a  $2\frac{3}{4}$  "to 3" inch screw is appropriate for a slab  $3\frac{1}{2}$ " thick. You must also compensate for the plate thickness of the shelter base. If this is  $\frac{1}{4}$  "thick, you must add this length to bolt size.
2. Drill hole: You must precisely mark the installation points with a template or the actual shelter can be set in place first. The hole size to be drilled will be given by manufacturer based on diameter of anchor. Once the correct bit size is selected and fixed in drill chuck, mark the depth of the anchor to be installed using a tape measure and piece of tape to mark maximum depth. Drill hole to bottom of tape on drill bit. Vacuum hole or blow out dust with air.
3. Install Anchor: Set shelter in place, if not already done and check hole alignment. Place nut on top of anchor, tap anchor in hole with a hammer to maximum depth. Hand tighten top nut and then use torque wrench to expand bottom wedge. Torque settings will be supplied by manufacturer. If no torque wrench available tighten nut 2 to 3 turns past hand tight.
4. Precautions: Never try and set wedge anchor to close to the edge of the slab. You should be at least 4-6" from the edge, where hole is drilled. Do not over tighten anchor, if anchor begins to spin (even with proper torque) this anchor will not work properly. You must have a back-up plan to reset another anchor, most likely an epoxy anchor.

#### ANCHORS – SCREW TYPE

1. Selection: Select anchor size and grade based on engineering recommendations. Make sure the length of the anchor is set to a maximum depth based on the average thickness of the foundation. It is not critically important if the screw penetrates through slab, however, it is not recommended. You must also compensate for the plate size of the shelter base. If this is  $\frac{1}{4}$ " thick, you must add this length to bolt size.
2. Drill hole: You must precisely mark the installation points with a template or the actual shelter can be set in place first. The hole size to be drilled will be given by manufacturer, normally you will drill a  $\frac{3}{8}$ " hole for a  $\frac{3}{8}$ " screw. Once the correct bit size is selected and the bit marked to the depth of the screw length, drill hole. Always vacuum hole or blow out dust with air.
3. Install Anchor: Set shelter in place, if not already done and check holes for alignment. Install screw with impact wrench, don't over tighten once it has reached the head of the screw.
4. Benefits: The screw type anchors will have a higher pull-out strength over expansion anchors (with same size), due to having a larger contact area with the concrete. The screw anchor can be set as close as 2" from a slab edge. You can also put some epoxy in the hole or on the screw threads for extra strength. You can remove screw from the hole and re-install later in same hole.
5. Precautions: It is important that all holes be drilled so as not to encounter rebar or tensioning cables. This is why scoping (GPR) the slab ahead of time can help you avoid this problem and pre-mark drill holes. If you can't avoid tensioning cables, you should consult with an engineer for advice

#### ANCHORS – ADHESIVE / EPOXY TYPE

1. Selection: Select anchor size and grade based on engineering recommendations. Make sure the length of the anchor is set to a maximum depth based on the average thickness of the foundation. It is not critically important if the drilled hole penetrates through the slab, however, it is not recommended. You must also compensate for the plate size of the shelter base. If this is  $\frac{1}{4}$ " thick, you must add this length to bolt size.
2. Drill hole: You must precisely mark the installation points with a template or the actual shelter can be set in place first. The hole size to be drilled will be given by manufacturer, normally epoxy set anchors are  $\frac{1}{8}$ " oversized and acrylic set anchors are  $\frac{1}{16}$ " oversized. Once the correct bit size is selected and the bit marked to the depth of the anchor length, drill hole. Always vacuum hole or blow out dust with air, then brush hole with nylon hand brush, then re-vacuum or blow out hole. Remember always: *Blow-Brush-Blow*
3. Install Anchor: Set shelter in place, if not already done and check holes for alignment. Install anchor by slowly hand rotating it in the center of the hole until it has reached the desired set depth. The top nut cap will not be tightened until the adhesive has been set

per manufacturers specifications. Normally an epoxy adhesive will require 24 hours to cure and an acrylic adhesive 1-3 hours to set up. Check anchors after they have set up and make sure they are set and no movement is detected. Tighten top nut to manufactures recommended torque, if possible, otherwise tighten until shelter is secure.

4. Benefits: Adhesive anchors will give you the highest pull out strength of any comparable sized anchor type. If you over size the drill hole slightly it will not affect performance. You can store excess adhesive for later projects if stored at correct temperature. Leave nozzle on tube and when you want to re-use later put on new nozzle; they are cheap.
5. Precautions: Remember always: **Blow-Brush-Blow** hole before installation. Make sure the adhesive is mixing properly before squirting into hole. It is always a good idea to squirt out some adhesive onto a piece of cardboard, until you are sure it has mixed and the color is consistent.