1982

G82-630 Concrete Construction: Obtaining Quality Results

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G82-630-A

NebGuide

Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Concrete Construction

Obtaining Quality Results

This NebGuide describes the prior planning, site preparation, forming, ordering, placing, finishing, jointing and curing needed for successful concrete construction projects, especially slabs or flatwork.

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Concrete is an excellent construction material for many agricultural applications. By paying careful attention to some major considerations, quality concrete construction can be achieved. The result can be years of reliable service.

Planning

Planning and actual construction are equally important. Poor decisions are often made when the ready-mix truck is waiting in the driveway as the builder hurries to finish formwork or find enough shovels, wheelbarrows and help to handle the task ahead.

The expected use of the concrete must be known in order to determine the required thickness and any special properties. The load carrying capacity of a slab is primarily dependent on thickness. A 4-inch thick slab will handle light duty loads such as cars, pickups, light tractors and livestock. A 6-inch slab will handle most medium duty farm loads, including straight trucks, feed wagons and most other equipment. Unusually heavy vehicles or high volume traffic require special design consideration.

Site Preparation

The construction site should be well-drained and free of standing or flowing water. Access to the site by ready-mix trucks must be considered.

Depending on site conditions and the intended use of the slab, varying amounts of preparation may be required. In many cases the slab can be placed directly on undisturbed soil. Compacted subgrades can be used to raise the final elevation of the slab, while subbases are often used to control moisture. The key is to have uniform conditions below the slab.

Subgrades should be placed on undisturbed soil and built up in 6-inch thick layers. Each layer should be compacted to as high a density as practical, paying careful attention to uniformity of density, moisture content and soil type. Overbuild the subgrade about 1 to 2 inches, and then trim off the excess to final grade. Loosen areas between cut and fill zones for a distance of 3 to 5 feet and then compact them so a transition area is formed and abrupt changes in density are avoided.

For soils with questionable drainage, such as clays, silts and high organic matter soils, use a 4- to 8-inch thick subbase of compacted sand or fine gravel. This subbase will help break the capillary action of water. Subbases can also be used to improve the accuracy of final grading.

Soil compaction methods should minimize variations in density. A sheepsfoot or rubber tired roller works well on cohesive soils like clay. Vibrating rubber tired and sheepsfoot rollers are best for sandy cohesionless soils. Portable vibrating packers can be used for small jobs.

Uniform density of the area below the slab is a key to good performance. Hard and soft spots must be avoided to eliminate differential settlement and resultant concrete cracking. Remove all organic matter, such as grass, weeds, wood and manure, as well as pockets of soft or muddy soil. Never place concrete on frozen or muddy ground. This is a non-uniform condition and a common mistake. To help assure good drainage, slope the subgrade away from any structures.

Forming

Generally, 2 × 4 or 2 × 6 inch lumber is used for forms. Steel paving or other special forms are also available. Forms need to be set to the final desired grade of the slab.

Lumber should be straight and staked at 2-foot intervals to minimize form bowing. Drive or cut off stakes flush with the top of the forms for strike-off convenience. Forms will last longer and strip more easily if form oil is applied.

After forming is completed, check the slab thickness. One method is to place a stringline or straightedge across the top of the forms and measure the depth to the subbase. This final check assures correct slab thickness, and may save some concrete. As an example, if a 4-inch slab has 1 inch extra thickness, 25 percent more concrete will be required.

Provide thickened edges at locations where vehicles will be driven on and off the finished slab (*Figure 1*). Thickened edges reduce stresses in the concrete, minimizing crumbling and breakage. Make these edges 1 1/2 to 2 times thicker

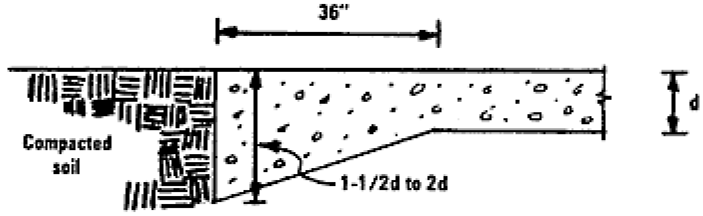


Figure 1. Thickened slab edge in vehicle traffic area.

than the rest of the slab, and taper them
back into the body of the slab for a distance of 36 inches.

For slabs that are to be used as part of a livestock housing facility or for grain storage, provide a means to prevent entrance of moisture through the floor. This can be done by using a 3-inch thick layer of coarse sand and a polyethylene vapor barrier. Place the sand over the vapor barrier and compact the sand. The sand should be moist but free of drainable water at the time of concrete placement. When using polyethylene, avoid excess water in the mix and excess working of the concrete. Failure to do so can lead to blistering and cracking of the slab surface. Take care not to damage the plastic during construction.

Ordering

Check the weather forecast before ordering concrete. This information will help you decide if hot or cold weather precautions need to be made. Ideal temperatures for placing concrete are between 50 and 90°F. As concrete temperatures increase, setting time shortens, leaving less time to complete the job. Reduced temperatures lengthen setting time. The temperature of newly placed concrete should not drop below 40°F for at least a week.

Concrete is ordered by the cubic yard. Errors are common when calculating the quantity required. To calculate the required volume, an irregularly shaped slab may be broken down into recognizable geometric shapes. These shapes are generally the rectangle, circle and triangle. Calculate the square feet of surface area for each individual section, and then add them to determine total surface area. Multiply the surface area by the thickness in feet to determine the total volume in cubic feet. Divide this value by 27 to obtain the volume in cubic yards. A common practice is to increase the calculated volume by five or ten percent, called over-run, to help account for slight deviations in slab thickness, thickened edges, etc.

The ready-mix supplier can provide guidance on the proper amount of cement per cubic yard, water-to-cement ratio, and air entrainment required to obtain the desired strength, consistency, workability, and other properties such as resistance to freeze/thaw action, resistance to abrasion from frequent scraping, and resistance to manure and silage acids.

A high water-to-cement ratio generally means a weaker, less durable and less water-tight concrete. Avoid adding water in excess of the amount necessary for good workability. Air entrainment is recommended for all agricultural concrete to increase durability and freeze/thaw resistance.

Give the ready-mix supplier detailed directions to the jobsite. If the driver is lost, valuable working time is lost and concrete quality may be reduced. Indicate any special restrictions such as low load limit bridges and underpasses that must be avoided. Describe the jobsite conditions as to any height, weight or width restrictions, as well as ground conditions and any other important factors. Indicate the desired time interval between loads.

Placing

The subbase needs to be moistened to a depth of 4 to 5 inches about an hour before placing concrete. The soil should form a ball when squeezed, but break apart readily and not leave a wet outline on your hand. This serves to cool the ground and minimize the loss of workability through moisture loss. Manpower and tools need to be available before the ready-mix truck arrives. Concrete should be in place about 90 minutes after batching at the ready-mix plant.

Concreting tools commonly required are:

- wheelbarrows,
- square nose shovels,
- straight strike-off board (screed),
- bull float,
- wood float,
- edger,
- groover or jointer,
- steel trowel,
- broom.

Place concrete as close to its final position as possible, not in large piles. Avoid excess movement and raking of fresh concrete, since separation of the aggregate and cement paste can occur.

Using a sawing action, a screed board moved along the forms strikes the concrete to the top of the forms. For reduced labor, mechanically vibrated screeds can be used. Always maintain a small amount of concrete ahead of the screed.

One of the most common mistakes at the jobsite is adding water to the concrete mix. This is done to change the consistency of the concrete, but should be avoided. The extra water increases the water-to-cement ratio which substantially reduces strength and durability. The excess water must also evaporate from the concrete, leading to the formation of shrinkage cracks. Concrete which flows readily or "pours" probably has too much water.

Bullfloating is the last step in placement. Large aggregates are pushed below the surface and major surface irregularities are removed. *NEVER* bullfloat when free water is present on the surface. This changes the water-to-cement ratio at the surface and creates a weak layer where strength and durability are needed most.

Finishing

After bullfloating, allow concrete to stiffen and the water sheen to disappear from the surface. This is usually in about 15 minutes to an hour. A simple test is to step on the concrete. Footprints more than 1/4 inch deep indicate more setting time is required. At this point, finish floating can begin, and joints and edges can be tooled.

Finish floating uses a wooden or metal float to remove slight imperfections. Floating is frequently used as a final finish. It provides a good slip resistant texture. Floating also prepares the surface for subsequent finishing operations.

Troweling follows floating when a smooth, dense surface is desired. Timing is important in this operation. If delayed too long, the surface becomes too hard to trowel. Early troweling will produce a nondurable surface. Several trowelings may be desirable, but never trowel enough to produce free water at the surface. The surface stiffens with each successive troweling, so smaller trowels and increased tilt of blade are necessary.

Transverse brooming following floating is a finishing operation that produces a gritty, slip resistant surface. It should be timed so the concrete is sufficiently hard to maintain the rough scoring. Special brooms are available for this operation. Burlap, tined and grooved finishes can also be used to provide slip resistant surfaces.

Jointing

Incorrect jointing practices are a major problem in flatwork or slab construction. This leads to uncontrolled or random cracking, and a poor quality job. Three types of joints are commonly used--isolation, control, and construction (*Figure 2*).

Isolation joints are used to separate slabs from fixed objects such as walls or posts. This allows movement of the slab with relation to the fixed object. The joint is formed by putting isolation joint material around the object and casting the concrete to it. Asphaltic or expanded PVC materials are commonly used.

Concrete shrinks slightly as it loses moisture. After hardening, changes in temperature and moisture cause expansion and contraction which can lead to cracking. Control joints are purposely placed in the concrete to allow for these dimensional changes and to encourage cracks to develop in predetermined locations, rather than in a random manner. To help assure that cracks develop at the joints, tool or cut the slab to a depth of one-quarter of its thickness (1 inch for a 4-inch slab, 1 1/2 inches for a 6-inch slab). Jointing tools and saws are available for this purpose. Don't cut all the way through the slab as this will destroy the aggregate interlock, interrupting load transfer between adjacent panels.

Determine control joint spacing using the "2d rule." The thickness of the slab in inches is doubled to determine the maximum joint spacing in feet. For example, a 4-inch thick slab requires a joint spacing of 8 feet. A 6-inch slab requires a 12 foot spacing. Joint spacing should not exceed 15 feet. A slab should appear to be made up of panels. Further, the larger dimension of the panel should not be more than 1 1/2 times the smaller dimension. Mark joint locations directly on the forms.

When control joints cannot be tolerated, reinforcing steel mesh can be used as a substitute. The mesh does not eliminate cracking, and frequent random cracks may develop. However, the mesh helps hold the cracks together and the individual segments in position.

Extra care is needed when using reinforcing mesh as it should be located uniformly at the center of the slab. Mesh in flat sheets, rather than roll form, is easier to position properly and is recommended. The mesh is held in position by using special supports called chairs. Once in place, do not walk on the mesh to avoid pushing it out of position. Avoid pulling or pushing the mesh into position through the concrete as this can disturb positioning of the aggregate and create a weak area where cracks may form.

Construction joints are used where work is to be terminated for a period of time. If possible make construction joints coincide with control joints. The ideal construction joint consists of both a thickened slab edge and a keyway cast into the edge, although either one technique or the other is usually sufficient. The purpose of the joint is to minimize movement between adjacent slab sections. Construction joints should conform to the dimensions given in *Figure 2*.

An edger, which is like a short steel trowel with a rounded side and, somewhat similar to a jointing tool, can be used adjacent to the forms. Edging increases the consolidation and strength of the slab edges, and aids in form removal. When correctly used, an edger produces a more attractive rounded edge, which is less severe on tires and livestock, and can reduce concrete crumbling.

Curing

Concrete does not "dry"--it hardens by a chemical reaction (called hydration) between the water and cement. Extra water should be avoided before concrete sets (initial hardening). After setting, water is beneficial to the completion of the hydration process which, under the right conditions, will continue for a year or more. Curing is the process of maintaining the proper conditions of moisture and temperature of newly cast concrete. The extent to which this process is carried out affects the durability, strength, water tightness, wear resistance, volume stability and freeze/thaw resistance of the concrete.

Commercial curing compounds, polyethylene plastic sheets and water-proof building paper are ways of sealing in mixing water to enhance proper curing. Water mist, dampened burlap, dampened straw and flooding are methods that enhance curing by supplying additional water. Keep the concrete continually moist. Avoid alternate wetting and drying.

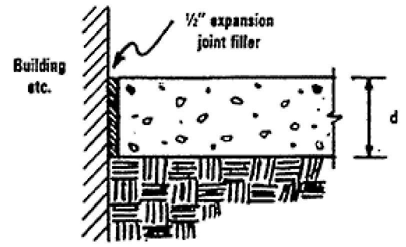
Temperature is also a requirement for proper curing, with 73°F being ideal. Between 50 and 90°F is a practical temperature range. Insulating blankets and straw are used in the winter, and sun shades and white-pigmented curing compound hold down temperatures in the summer. Avoid putting cold water on a hot slab as the thermal shock can induce cracks in the new concrete which has not had sufficient time to develop much strength.

Curing is overlooked by most builders and even by many professionals. It costs very little and is a key to long lasting concrete. Curing times should be as long as possible as concrete continues to gain strength during this time. However, for most agricultural applications, curing times of three to seven days are usually practical limits. For more information on the curing process, see NebGuide *G82-625, Concrete Construction: Curing*, which is available from the Cooperative Extension Service office in your county.

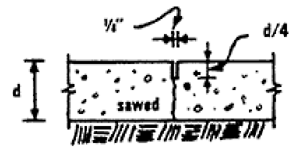
Summary

Concrete is an excellent construction material for many agricultural applications. A successful project is usually assured by paying careful attention to prior planning, site preparation, formwork, concrete ordering, placing, finishing, jointing and curing. If these details are neglected, it is possible to end up with a "monument" which can cause problems for many years to come.

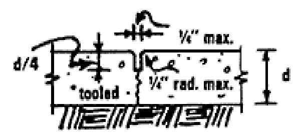
Figure 2. Types of concrete slab joints.



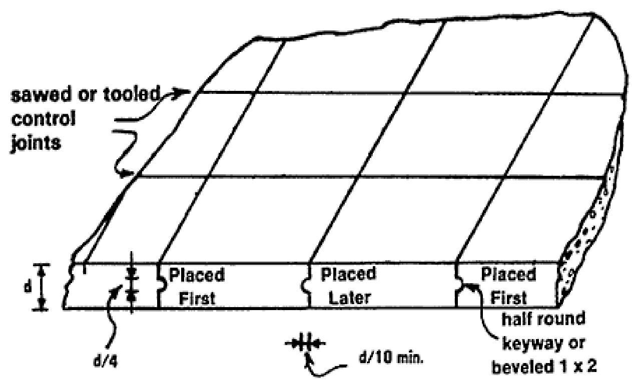
a) Isolation joint



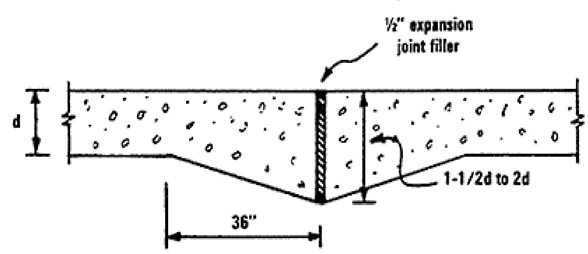
b) Sawed control joint



c) Tooled control joint



d) Keyway construction joint



e) Thickened edge construction joint

File G630 under: FARM BUILDINGS
E-3, Construction Materials
Issued February 1983; 12,000 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.