Iowa State University
Digital Repository

Agriculture and Environment Extension Publications

Agriculture and Natural Resources

11-2009

Livestock Industry Facilities and Environment: Concrete Specifications for Agriculture

Dwaine S. Bundy
Iowa State University

Jay D. Harmon
Iowa State University, jharmon@iastate.edu

Follow this and additional works at: http://lib.dr.iastate.edu/extension_ag_pubs

Part of the Agricultural Education Commons, and the Bioresource and Agricultural Engineering Commons

Recommended Citation
Bundy, Dwaine S. and Harmon, Jay D., "Livestock Industry Facilities and Environment: Concrete Specifications for Agriculture" (2009). *Agriculture and Environment Extension Publications*. 39.
http://lib.dr.iastate.edu/extension_ag_pubs/39

Iowa State University Extension and Outreach publications in the Iowa State University Digital Repository are made available for historical purposes only. Users are hereby notified that the content may be inaccurate, out of date, incomplete and/or may not meet the needs and requirements of the user. Users should make their own assessment of the information and whether it is suitable for their intended purpose. For current publications and information from Iowa State University Extension and Outreach, please visit http://www.extension.iastate.edu.

Concrete Specifications for Agriculture

Livestock Industry Facilities & Environment

Concrete is a mixture of Portland cement, water, air, and aggregates. Aggregates provide volume at low cost, comprising 66 percent to 78 percent of the concrete. Cement and water form a paste that hardens and glues the aggregates together. The quality of cement is directly related to the binding qualities of this cement paste.

Selection of concrete properties

Concrete is very durable and resists attack by water, animal manures, and chemicals such as fertilizers and fire. High quality concrete should be used around milk, silage, and animal manure. Portland cement concrete is a common building material with many advantages in agriculture. Concrete is versatile, strong, and economical. Most farm applications require the ability to withstand weathering, wetting, temperature changes, and abrasive uses. Durability is usually the main reason for selecting concrete as the construction material.

The durability and strength of concrete are highly dependent on the water-cement ratio. Sometimes fly ash, a waste product of coal-powered power plants, is used to modify certain properties or replace some of the cement.

Concrete is weak in tension. Its strength in compression depends on the proportions of the mix. The compressive strength is two to five times that of wood. Most structural uses depend on concrete strength in compression and steel in tension.

Portland cement

Several kinds of Portland cement have been developed for special purposes, including:

- TYPE I, normal Portland cement, is the general purpose type and usually is furnished unless an alternative is specified.
- TYPE II, is modified to release less heat during curing and is therefore suitable in mass concrete. It is moderately high in resistance to sulfates.
- TYPE III, is high-early strength. It is very finely ground and sets very rapidly. It is useful for slip-form construction and for cold weather jobs.
- TYPES I, II, and III are available as Types IA, IIA, and IIIA. These are air-entrained Portland cement formulated with a compound that releases many tiny bubbles of air during curing. They are recommended for agricultural applications even though they are slightly weaker than standard cement.

Factors affecting the quality of concrete

Air-entrainment

An air-entrainment agent to the cement produces millions of tiny bubbles in the concrete, giving the concrete greater weathering resistance. Air entrainment reduces the strength but increases the workability. Therefore, all concrete used for agricultural applications should be air entrained.

Maximum aggregate size

The maximum size of coarse aggregate that can be used depends on the sizes and shapes of concrete members, and the amounts and distribution of reinforcing steel. Generally, the maximum size should not exceed $1/5$ the minimum dimension of the member, or $3/4$ the clear space between reinforcing bars or between reinforcement and forms. For unreinforced slab on ground, the maximum size should not exceed $1/3$ the slab thickness. Smaller sizes may be used when availability or considerations of economy require them. The larger the aggregate, the less air-entrainment is necessary.

Workability

The workability of concrete is another quality to consider. The concrete should be placed with the stiffest consistency possible but still be reasonable to finish. A measure of concrete workability is slump. Table 1 shows suggested slump ranges for various types of construction. High slump, or flowing concrete, usually contains excess water that dilutes the water-cement paste and makes it weaker. Enough water is needed for full curing, but excess

IOWA STATE UNIVERSITY
University Extension

Pm-1589 Reviewed November 2009

water leaves voids when it evaporates. If a mix is too stiff to handle well, do not add water; reject the batch, or add cement and water. Adding only $\frac{1}{2}$ gal/bag of Portland cement lowers strength more than roughly 10 percent (500 psi). Concrete made with excess water also experiences greater shrinkage, which typically adds to more cracking. If high slump concrete is essential to the success of the project, produce it by using one of the high range water-reducer admixtures, also called super-plasticizer. These admixtures greatly increase the workability of the concrete for as much as 30 minutes, after which the concrete returns to its original form.

Table 1. Recommended maximum slump

Type of Construction	Slump (inches) Hand	Slump (inches) Mechanical
Mass concrete	3	2
Pavements, slabs, footings, reinforced foundation walls	4	3
Beams, columns, reinforced walls	5	4

Hand consolidating includes rodding and spading. Mechanical vibration permits stiffer mixes. Mass concrete has little or no reinforcing and is in a relatively large section (for example, a block of two steps and a small porch).

Table 2. Durability and strength for air-entrained concrete

Application	Approximate Strength (psi)	Water-Cement Ratio (lb. water/lb. cement)
Feed bunks, slats, above ground bunkers	4,500	0.44
Manure tanks, parking lots	4,000	0.49
Feedlot floors, walls, drives, reinforced concrete walls, beams and columns	3,500	0.53
Footings, foundation walls, gravity retainer walls	3,000	0.62

Durability (weathering and chemical resistance) and strength depend primarily on water-cement ratio. Adding extra water rapidly lowers durability and strength.

Placing of concrete

A concrete slab on grade starts with a properly prepared site. Concrete requires no special soil as long as the soil is homogeneous and provides uniform support for the slab. A moist subgrade is especially important to prevent too rapid extraction of water from floors and similar slabs that are placed in hot weather. All hard and soft spots should be removed and recompacted so they are consistent with the rest of the soil. Reinforcement rods may help bridge small soft spots below the poured concrete. Care should be taken to see that debris are removed from the spaces of the concrete.

Concrete should be placed as nearly as possible in its final position. It should not be placed in large quantities at a given point and allowed to run or to be worked over a long distance in the form. This practice results in segregation, because the mortar tends to flow out ahead of the coarser material. Position the truck, and use a movable chute to place concrete as nearly as possible to its final position to reduce the tendency of over working.

Strike off the concrete with a vibrating screed. Some are effective to a concrete depth of about 12 inches. Additional consolidation of concrete along bulkheads often is achieved with internal vibrators. Avoid allowing screeds to vibrate after the concrete has been consolidated because this tends to bring excessive fine material to the surface.

If you don't have a screed, you can use a straight 2 × 4 board, working it side-to-side to work the concrete while moving it forward. Keep a small amount of concrete ahead of the screed to prevent low spots. Avoid starting and stopping the vibrating screed frequently because the accompanying movement removes entrained air. Immediately after screeding, work a bullfloat over the slab at right angles to the direction of screeding. The bullfloat removes small ridges left by the screed and slightly depresses the larger aggregates.

Outdoor slabs and those with livestock traffic should not be troweled smooth. Outdoor slabs normally should be finished with a broom. Various finishes may be desired for different ages and species of livestock. For breeding surfaces for swine, a 4- to 6-inch diamond pattern made with grooved saw cuts may be desirable. Cuts should be $^{1}/_{4}$- to $^{3}/_{8}$-inch deep and $^{1}/_{4}$- to $^{1}/_{2}$-inch wide.

The choice of floor finishes often is the most difficult challenge for a concrete contractor. The desired finish on floors varies even within the same type of described finish. Different types of brooms will result in different textures of floor surfaces.

Concrete placed in forms

Place concrete in lifts of up to 24 inches. Place consecutive lifts while the previous lift is still plastic. Vibrate, rod, or otherwise consolidate each lift. Penetrate the previous lift about one-fourth of the depth. Immersion-type vibrators are commonly used to consolidate concrete in walls, columns, beams, and slabs. Immersion spud vibrators are available in sizes of less than 1 inch to about 7 inches in diameter and with frequencies of 3,600 to 13,000 vpm. Vibrators consolidate concrete by pushing the coarse aggregate down and away from the points of vibration.

Form vibrators may be attached to the exterior of forms. They are especially useful for consolidating concrete in thin-walled members and with metal forms.

Curing

Concrete does not dry. Instead, it cures, or hardens, due to the hydration reaction between the cement and water. Curing is the process of keeping water in the concrete. Begin the curing process as soon as the surface is hard enough to prevent damage. On hot days with low humidity and/or windy conditions, be sure to cover the concrete to prevent rapid evaporation of the water. Other conditions can contribute to rapid evaporation. Covering the concrete usually affords adequate protection.

Commonly used methods for curing include:

- covering the concrete with a polyethylene sheet,
- spraying a liquid curing membrane on the concrete, and
- continually wetting the concrete with a soaker hose.

Walls usually are cured by covering them with polyethylene sheets. Exposed to typical summer temperatures, concrete will cure in three to seven days. Cooler weather may require more time. Little curing occurs when the concrete temperature is below 40 degrees F. Concrete must be maintained at 70 degrees for three days or 50 degrees for five days to cure properly. Do not allow it to freeze for the first four days to prevent damage.

Joints

There are three types of joints used in concrete construction: isolation, construction, and control. Isolation joints are used to separate structures that are expected to move separately (figure 1). The movement of a floor slab usually differs from that of abutting building elements, such as walls, columns, foundations, and footings. To be effective, an isolation joint must allow horizontal and vertical differential movement. In general, an isolation joint uses $^{1}/_{2}$- or $^{3}/_{4}$-inch thick asphalt impregnated fiberboard, which may be termed an expansion joint. To isolate columns on separate footings from a floor slab, use a round or square blockout.

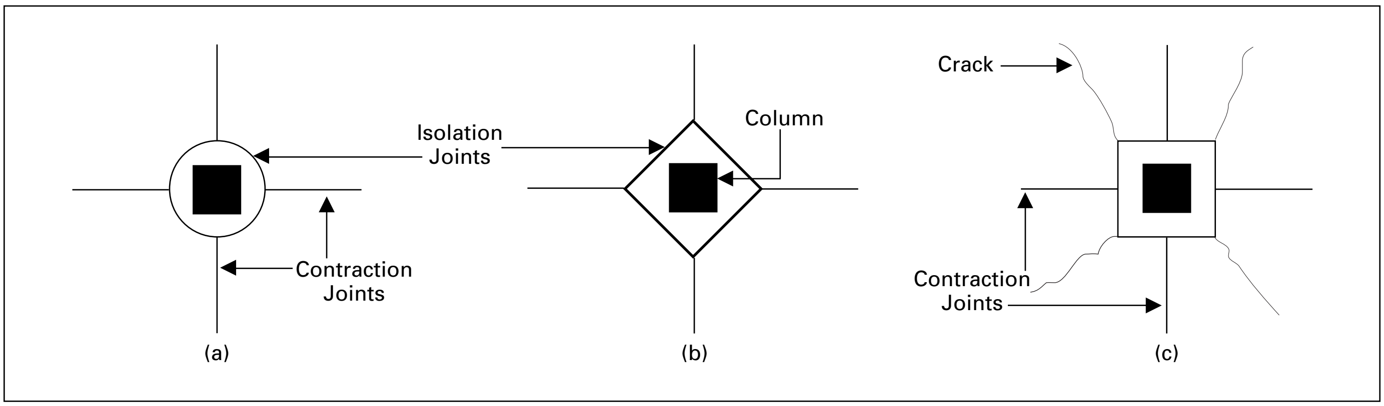

Figure 1. Isolation joints around columns can be circular (a) or square (b). If no isolation joints are used around columns or if the corners of the isolation joint do not meet contraction joints, radial cracking (c) can occur.

Construction joints, used as an aid during construction, allow concrete to be poured in sections of manageable size. They also can act as contraction joints, providing stress relief by allowing horizontal movement of the slab. Construction joints are used at the edge of each strip of a large slab. The joint often consists of a tongue and groove key formed by attaching a half round or beveled 1 × 2 piece of wood to the form and then casting the next concrete strip to complete the key.

As concrete dries, it usually shrinks about $\frac{1}{8}$ inch in 20 feet. Contraction joints (also called control joints) are used to control the cracking that can result from shrinkage, temperature changes, and repeated wetting and drying. Most contraction joints are induced. Joints are formed by cutting through the slab or wall to a depth equal to 25 percent of the thickness of the slab. Commercially available plastic strips also may be used and are placed during concrete placement. The cut establishes a weakened plane that dictates the crack location if stress exceeds the tensile strength of the concrete. As a rule, a 4-inch slab is jointed at 8-foot intervals, and a 5-inch slab is jointed at 10-foot intervals. You should not exceed a joint spacing of 15 feet.

Use of synthetic fibers

Synthetic fibers are no substitute for structural (primary) reinforcement in concrete because they add little or no strength. However, structural reinforcement doesn't provide its benefits until concrete hardens. Unlike structural reinforcement, synthetic fibers provide benefits while concrete still is plastic. They also enhance some of the properties of hardened concrete. Synthetic fibers are most commonly added to concrete for slab-on-grade construction to reduce early plastic shrinkage cracking and increase impact- and abrasion-resistance and toughness. The fibers also can be added to precast concrete to improve resistance to handling stress; to pumped concrete to improve cohesiveness; and to shotcrete to reduce rebound and material waste.

Both synthetic fibers and wire mesh used as a secondary reinforcement can help control cracking in cast-in-place concrete. The primary difference is when and how they work. Fibers are most beneficial soon after concrete placement by controlling the formation of plastic shrinkage cracks. Wire mesh, on the other hand, does not prevent crack formation. Instead, the mesh holds cracks together after they have formed. From an economic standpoint, using fibers eliminates the costs of handling and placing wire mesh. Also, wire mesh must be placed properly to be effective. This is not a concern with fibers, which disperse evenly throughout the concrete during mixing. And unlike wire mesh, synthetic fibers are noncorrosive and won't rust.

Joint sealing

There are several reasons to seal joints in floors:

- to keep out debris, making floors easier to clean;
- to prevent entry of water, chemicals, or bacteria; and
- to improve joint appearance.

But sealing can be expensive and time-consuming, so don't seal a joint unless necessary. In some floors, joint sealing is essential. In food-processing plants, strict hygiene requirements often demand sealing of every joint.

File: Engineering 1-1

Reviewed by Jay Harmon. Prepared by Dwaine Bundy, professor, and Jay D. Harmon, professor and extension agricultural and biosystems engineer, Department of Agricultural and Biosystems Engineering.

. . and justice for all
The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital or family status. (Not all prohibited bases apply to all programs.) Many materials can be made available in alternative formats for ADA clients. To file a complaint of discrimination, write USDA, Office of Civil Rights, Room 326-W, Whitten Building, 14th and Independence Avenue, SW, Washington, DC 20250-9410 or call 202-720-5964.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Jack M. Payne, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.