DEPARTMENT OF BIOLOGICAL
AND AGRICULTURAL ENGINEERING

Temporary Grain Storage Considerations

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Grain storage in temporary structures must be considered when permanent commercial and on-farm grain storage structures are filled. The primary problems in adapting existing farm shelters and machine sheds or using alternative structures for temporary grain storage include:
1) structural strength;
2) floor surface;
3) grain handling; and
4) grain management.

Existing Farm Buildings - Structural Strength

Stored in a building, grain pushes out against the walls, so the building frame and lining materials must withstand heavy horizontal loads. Shallow grain piles are easier to contain than deep ones. The total lateral load from a 10-foot-deep pile is 6.25 times the load from a 4-foot-deep pile. The load from a level pile is only about three quarters as much as from a pile heaped at the filling angle of repose.

Under the lateral pressure of grain, a building wall may fail or be permanently damaged. The damage is caused by tipping the foundation wall outward; shearing or tearing out the anchor bolts in the sill; bowing the sill or wall sections between the anchor bolts; or structural failure in the wall sections above the foundation wall.

The wall attachments are especially critical in grain storage structures. The foundation wall must be tied to the floor either by casting them in one piece, or by lacing reinforcing rods through the joint to make them act as one unit. Since the load from the wall is transferred into the foundation wall and floor through the anchor bolts or stud attachments, both the floor and the anchors have to be adequate for heavy loads.

The side and end walls of most farm structures are not built to withstand lateral loads other than those normally sustained from wind pressure. The exception is if the building was constructed with a grain package. Most building firms offer a grain package as an option during preliminary planning. Although diagonal props or braces along the outside of the wall, or diagonal floor ties to the inside floor may be used, their cost, maintenance, and inconvenience usually rule them out.

Lining an existing pole building to 4 feet high is fairly economical and does not interfere with other uses of the building. (Figure 1.) The poles should be 8 feet on center, 4 feet in the ground and no more than 14 feet above the ground. Each pole should be cabled to the opposite side post with a minimum $^{3}/_{8}$-inch-diameter steel cable. The plywood liner is supported by 2×6 lumber, which is positioned horizontally on 12-inch centers.

Installing new framing on the inside of the poles or posts is recommended. The sill and plate can be continuous across one or more posts. In either case, anchor the sill to the floor with angle iron and anchor bolts or with power-driven nails. The fasteners should be able to withstand 300 pounds of pressure per running foot of wall based on a grain depth of 4 feet or less. A freestanding bulkhead is placed across doorways greater than 8 feet wide. These should be purchased from a manufacturer rather than fabricated on site.

Grain should not be piled higher than the lower cord of a truss. The lower cord is design to help carry the roof load and not the grain load. Loading equipment cannot be suspended from the lower cord due to weight problems.

Floor Surface

Existing buildings frequently have irregular and cracked concrete floors or earth floors. Without a vapor barrier, grain should be stored only 1 to 3 months on these floors. There may be some quality reduction due to spoilage and dirt contamination. A 4 to 6 mil plastic sheet can be installed as a vapor barrier on top of the floor surface. Care must be taken to keep the vapor barrier intact and out of the way while filling and unloading the storage. Generally, if the floor is well

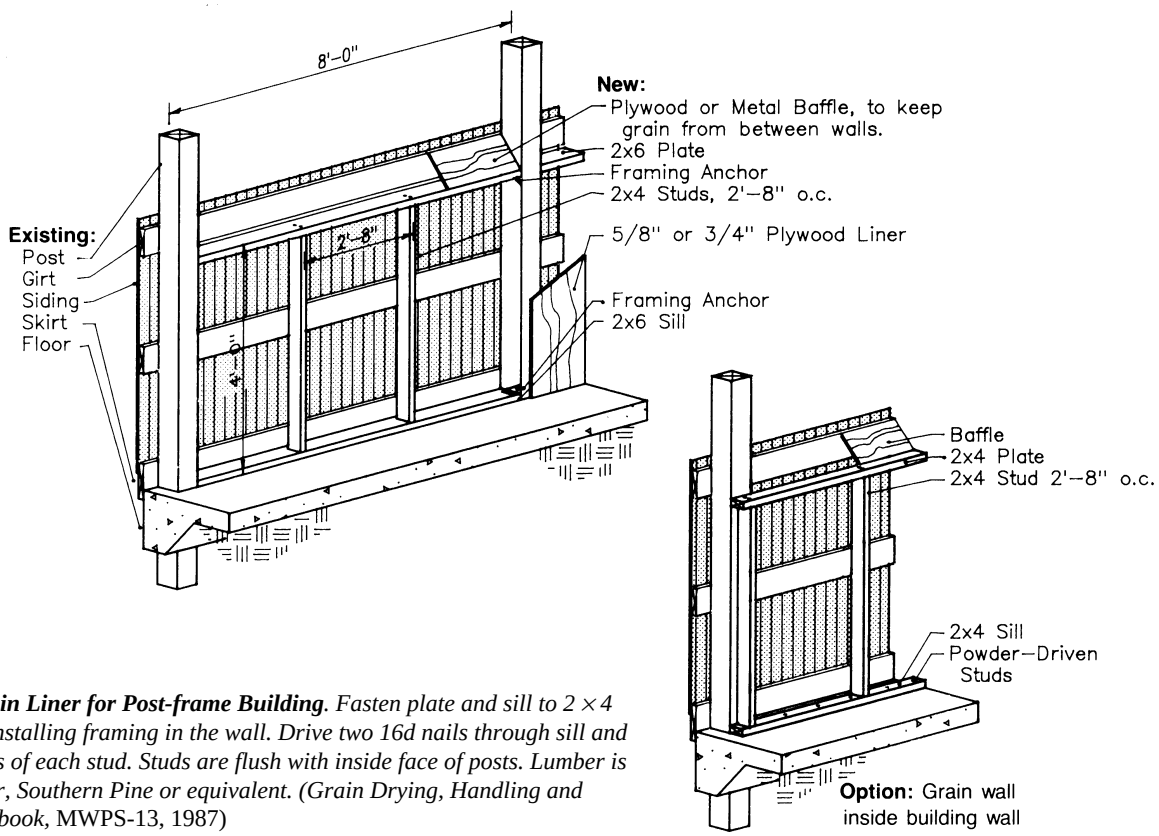

Figure 1. Grain Liner for Post-frame Building*. Fasten plate and sill to 2 × 4 studs before installing framing in the wall. Drive two 16d nails through sill and plate into ends of each stud. Studs are flush with inside face of posts. Lumber is No. 2 or better, Southern Pine or equivalent. (Grain Drying, Handling and Storage Handbook,* MWPS-13, 1987)

drained and water does not drain into the building, the plastic liner is not placed on the floor because of unloading problems.

Grain Handling

Filling and unloading of temporary storage are usually accomplished with a portable auger or other inclined conveyor. The auger can be easily shifted to shape the pile. Although fines distribution will be a problem, this will usually not be a big factor in 3 months or less storage of cool, dry grain, unless the grain quality is very bad. Access to the grain should be planned for emptying. Unloading alternatives are inclined augers plus scoop shovels, a tractor with a front end loader, or pneumatic vacuum conveyor. Care must be taken during filling not to encompass the undercarriage of the conveyor with grain. This causes difficulties during conveyor movement and may damage the undercarriage.

Round Metal Bin Rings

Round metal bin rings without a roof structure have occasionally been installed inside buildings to obtain sidewalls capable of sustaining grain loads. Buildings that can be used are shops, machine sheds, or hay sheds. A 36-foot-diameter round metal bin inside a 40 foot wide shop has a capacity of 800 bushels per vertical foot. Four rings, each ring is 32 inches, would be used in a building with 12 foot sidewalls. The bin would have a capacity of 8,500 bushels. If the shop or machine shed would allow for multiple bins to be installed, the rings purchased should be sized to allow the construction of a 36 foot bin at a later date. Purchase of just rings, excluding the cost of the roof, ladders, etc., will cost $0.25 to $0.35 per bushel of capacity. If this option is used, the aeration system should be similar to the manufacturer's recommendations for conventional storage structures.

Plywood Bins

Plywood bins, 4 or 8 feet deep and 10 to 37 feet in diameter, can be made by nailing plywood sheets and 2 × 4 nailers into a long strip and bending to form a circle (Figure 2.). Fasteners and nails are critical to keep the bin from bursting.

Use at least 3/8-inch plywood with at least a 24/0 span rating. Usually it is a joint that fails, not the plywood sheet itself. If in doubt about plywood strength, wrap the bin with cable, hoops, or at least No. 9 wire.

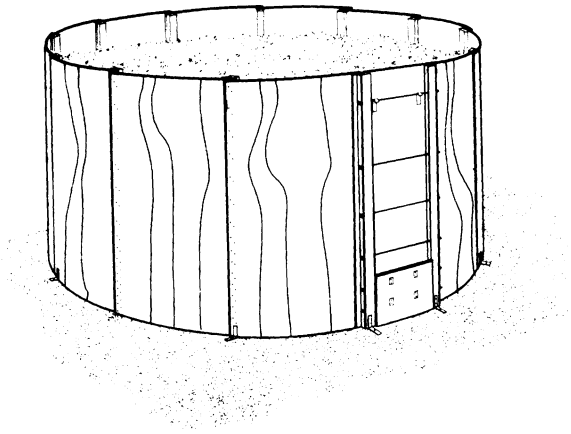

Figure 2. *Round Plywood Bin*

Hay Bales

Big square or round hay bales are an option for creating a low-cost temporary structure. Grain depth should be limited at the sidewalls to 4 feet. After the ground has been prepared, a circle with a diameter of 60 feet or more should be draw on the ground. The bales are then placed around the perimeter to form the sidewalls. The end of the bales are placed perpendicular to the perimeter of the circle. A 60 foot diameter pile will store about 12,000 bushels of grain. Normally, one large pile is better than multiple smaller piles since the total surface area is less. Three 3/8- to 1/2-inch cables should be wrapped around the perimeter of the bales and securely fastened. It is advisable to set the bales on 24 to 36 inches of 6 mil plastic and then bring the plastic up the inside of the bales and over the top. The plastic is used to prevent moisture from wicking from the bales into the grain. Peaking the grain so it flows on top of the bales aids in pile construction. The covering or tarp should cover the pile and bales.

Silage Bags

Silage bags are better suited for cracked or rolled high-moisture grain than dry grain. Manufacturers should be consulted on their experience using the bags to store grain. A 10-foot diameter bag will store about 60 bushels per foot. If grain is placed in a bag, then it should be dry and cool. The heat transfer from the surface of a bag to the grain will cause moisture movement. The heat buildup along with moisture creates an optimum environment for molds. If silage bags are used with dry grain, an aeration system is needed. A 8-inch corrugated drain pipe should be placed in the top of the bag and a 12-inch corrugated pipe along the bottom. The 8-inch pipe is used as an inlet for the aeration system and the 12-inch pipe as the return pipe. The air is pulled from the top of the bag to the bottom using a 12- or 14-inch fan. The bags should be limited to 100 feet in length.

Commercially Available Temporary Grain Storage

Units are available through some farm supply stores and grain equipment suppliers. These units vary in construction. Polyethylene sheeting, reinforced-fiber sheeting, wire mesh, wood, or metal panels for holding the grain are usually used. Repairs, freight, erection, and site costs need to be included when getting estimates. Some units are reusable.

Various forms of plastic sheeting are available to be used with grain piled on the ground to prevent rain and wind loss. Usually the covering will need repair or replacement after one season of use. Rodents, birds, chewing insects, sharp hooves or claws, and gunshot can cause leak problems. Some suppliers have a mesh fishnet type of fabric draped over the plastic covering to help hold the plastic sheeting in place.

Concrete Blocks or Road Barriers

Most concrete plants have 2-foot by 2-foot by 8-foot concrete blocks cast from concrete remaining in trucks. The cost of the blocks can range from $3 to $10 per foot. These can be used to form the sidewalls of a trench-type silo of a grain storage structure. Grain depth is limited to 4 to 6 feet. The site selected should allow the blocks to be backfilled with earth to prevent movement. Concrete road barriers are normally 30 to 36 inches tall and cost $30 to $40 per foot. Concrete road barriers are better suited for wider storage piles.

Concrete Silos

Concrete silos generally need to be reinforced and weather proofed to hold grain. A weather-tight chute and roof, along with foundation drainage are essential. Consult with the manufacturer about the structural strength and reinforcing required. In older silos, the number of hoops generally has to be doubled when storing dry grain.

Silos also present loading problems since silage blowers cause grain damage and cannot be used. They must be unloaded from the center to avoid damage to the silo and foundation.

Storage Considerations

Grain entering a temporary storage structure should be cool and dry. Grain harvested later in the season during cool weather will store longer. In addition, grain tem-

peratures will vary 20 to 40 degrees Fahrenheit throughout the day. Temperatures of grain placed into storage should within 10 to 15 degrees Fahrenheit for each load to prevent moisture movement due to temperature gradients. If at all possible cool the grain to 50 degrees Fahrenheit or below before placing in storage.

The maximum moisture content of any load should not exceed the recommended safe storage moisture content for a particular grain. Normally, these values are 13, 14 and 15.5 percent moisture (wet basis) for soybeans, grain sorghum, and corn, respectively. The grain should be placed in the storage at less than 14 percent moisture, wet basis, and preferably 13 percent for greater safety. It is important to remember the moisture content is based on the maximum of any one load rather than the average of all loads. The average moisture content of the pile should be 1/2 to 1 percent less than the safe storage moisture content.

Grain of poor quality should be dried 1 percent more than required for good quality grain. Weedy fields or fields with varying grain maturity should not be placed into a temporary storage structure. Weeds and immature grain tend to be at higher moisture contents than mature grain kernels. Pockets of wet grain or trash can cause spoilage. If storage is to be for longer than 6 months, consult your Extension entomologist or county K-State Research and Extension agent about possible insecticide treatment. Since a large surface of the grain is exposed, rodent, bird, and insect damage need to be monitored.

Grain Aeration

Install aeration if more than 1,000 bushels are stored for longer than 2 months. Aeration rates of at least 1/10 cubic feet of air per minute per bushel should be provided. The uniformity of aeration is as important as providing the correct total amount of air. Generally, it is necessary to have two or three smaller fans and ducts to obtain proper air distribution in flat storage structures. Many setups use 12 inch or larger corrugated drain pile for aeration ducts in temporary structures. The drain pipe is covered with cloth to prevent grain from plugging the openings. The number of fans and aeration ducts is dependent on the grain type and dimensions of the grain pile. A useful publication for designing the aeration system is *Dry Grain Aeration Systems Design Handbook*. This is available from K-State Research and Extension Department of Biological and Agricultural Engineering, information about purchasing a copy can obtained by calling (785) 532-5813.

Summary

Existing agricultural farm buildings can be used to store grain for 3 months if the grain is **not** piled against the outside walls. With modifications, grain may be piled up to 4 feet deep along the walls for temporary storage.

In the final analysis, the most economical answer for strictly short-term storage is to pile grain on the floor and peak the pile as much as possible or allow the grain to remain in the field. Any construction more than this must be viewed in terms of its long-term performance and cost in relation to other permanent storage systems. Temporary storage is generally less than 8 to 12 weeks since investment in equipment and facilities to properly store the grain is held to a minimum. Increases in grain prices during the 8 to 12 weeks following harvest must cover the investment in temporary storage facility and losses incurred during storage. Losses or discounts of 10 percent should be used with initial feasibility analysis of a temporary structure.

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