Hay Storage - Planning and Design Guidelines

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Highest quality hay requires good weather-tight storage to maintain the desired quality. Both structural and functional design are essential to a quality hay storage.

Structurally, the hay storage building must resist the forces of nature; wind loads that tend to blow the building over, or remove the roof, and snow loads. Functional design implies weather tightness, convenience of access and hay handling, and the proper type of base to prevent spoilage of hay at the floor.

PLANNING THE STORAGE

Size and Shape

Capacity of a hay storage building can be estimated by allowing 160 - 190 kg/m^3 (10 - 12 lb/ft^3) for "regular" density bales, and 1.5 to 1.7 times this amount for high density bales. On this basis, allow 1.1 - 1.25 m2/t (11- 12 ft2/ton) for most mechanical stacking systems. Building dimensions should be based on multiples of the width of the stacking equipment. A "stack and retrieve" bale handling system requires about 3.3 m (11 ft) per stack unit to allow space for retrieval, plus 0.6 m (2 ft) at each outside wall.

There should be adequate clearance to the bottom of the roof trusses or other structural members to allow for tilting of the fully loaded bale wagon. For most applications this means a minimum of 5.4 m (18 ft). For storing large round bales the width module is not as critical; however, designing for bale wagons makes the storage more versatile.

Site Selection and Preparation

Site selection is critical to the success of a storage. The two main considerations are drainage and access. Drainage of rain and melt water from both the roof and surrounding area is essential. The storage floor should be crowned about 300 mm (12") above surrounding ground level.

Consider the effects of building expansion, and runoff from multiple adjacent storages. Also assure that roadways and snow drifting do not cause water accumulation problems. Installation of culverts and some extra earthwork at the time of site preparation will pay dividends over the long term.

Access

Convenient access for both the storage loading and marketing phases of the haying operation must be accommodated. Hay storage associated with hay processing plants probably need to accommodate fork lifts, grapple forks and similar site operations.

Site selection for farm storage sometimes involves compromise between convenience for road access, and security from theft and fire. Roadways and turning areas in the yard should allow ample space for transport trailers and bale wagons.

Fire Separation

Spacing storages at least 15 m (50 ft) apart reduces the risk of fire spread, and increases chances for fire fighters to control a blaze. Often spacing of buildings is a compromise between safety and practicality. For operations that store several thousand tonnes of hay, the economy of large scale structures must be weighed against the risk of a potentially large fire loss. Insurance considerations should be determined before deciding on a final storage plan.

The space available and the proximity to the processing plant for convenience of materials handling also have to be considered. Proximity to public roads, farm buildings and process equipment increases both the risk and magnitude of fire losses. Availability of water for fire fighting is desirable, but not always attainable.

BUILDING DESIGN

Types of Buildings

There are two classes of hay storages: fully enclosed and "roof only" structures. Markets that demand top quality hay will also require hay sheds that offer full protection from weather, including wind-driven rain and snow, and bleaching from sunlight. These structures can be open at one end for ease of filling, but are otherwise totally enclosed. As a result they are more expensive, and may have more restrictive structural requirements than open-walled buildings. It may be desirable to cover end bales of open-ended buildings with tarps or cloth, or to install doors, to prevent sun bleaching.

Examples of totally enclosed structures are:

- Closed pole frame buildings
- Stud wall wood frame
- Arch structures of either frameless steel or laminated wood
- Rigid frame pre-engineered steel frame
- Column-and-beam type steel frame

(See Figure 1. next page)

Open-walled pole frame storages, or umbrella structures, cost less and require less critical structural design. While they do not provide the complete protection and the storage may be quite acceptable for an individual use.

Round or arched buildings will probably have restricted clearance for bale wagons near the sides, which reduces their effective capacity. They are excellent, however, for storage of large round bales.

Base Materials

Proper base material is important to the keeping quality of baled hay. Several options are available:

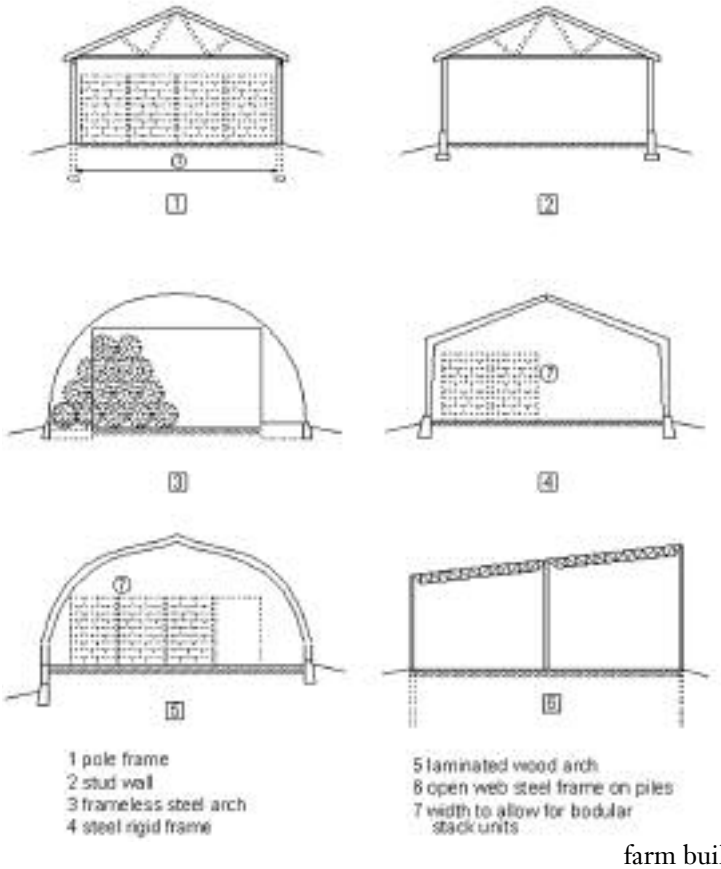
- Compacted granular material (very coarse gravel or small rock)
- Compacted gravel with rough boards or planks
- Layer of loose hay

The best base for hay storage is a compacted granular material for good drainage. Experience has shown that larger rocks, up to baseball size, provide the best aeration and separation of the hay from damp earth or sub-base material. (See figure 2, below)

Polyethylene vapour barrier material under a stack is not recommended; it can do more harm than good by not allowing drainage if snow enters the storage, and it encourages formation of condensation at the bottom of the stack. Likewise, concrete floors can cause spoilage from condensation, depending on the condition of the hay. Concrete overlaid with rough boards is a good system, but more costly than other options.

The bottom layer of hay must be free of contamination from earth, rocks or stain. One solution is to provide a layer of old hay, broken bales or loose new hay, below the main stack. Do not allow rotted or mouldy hay in the base material if there is a chance it can contaminate the high quality market hay. Straw is not a suitable base material for hay destined for export, since it can harbour the hessian fly larvae, the presence of which can result in rejection of a hay shipment. Other suitable base materials to protect bottom bales are horticultural cloths or similar porous plastic meshes.

Figure 1. Types of buildings for hay storage.



Ventilation and Condensation Control

The storage must allow for air exchange, either by natural ventilation, or a fan system. This is desirable in order to remove moisture from several sources:

- Hay that is not perfectly dry
- Moisture that accumulates due to "moisture migration" from warmer to cooler areas of a stack
- Condensation that forms on the underside of steel roofs

Buildings open at one end will experience adequate natural ventilation if the opposite end wall or gable is equipped with louvres or similar vents. Soffits of gable roofed buildings should also be of open design for maximum ventilation.

Forced aeration, with a fan and duct system, for the purpose of drying hay that is stored at too high a moisture content (over 15%) is of questionable value. This aspect of storage management requires more research and evaluation.

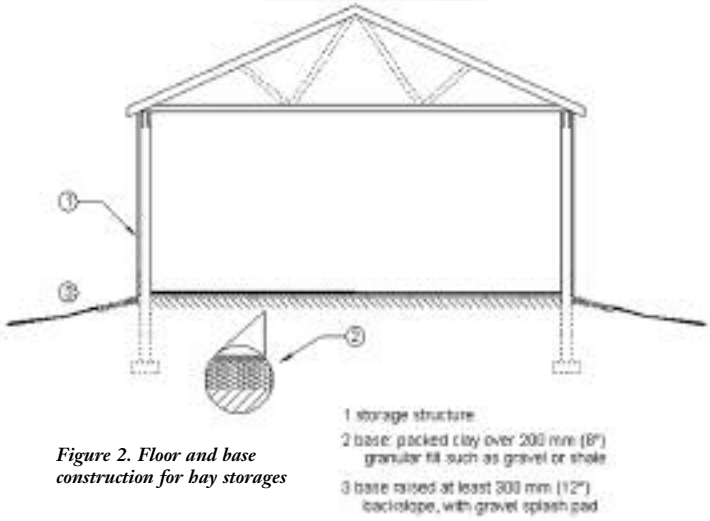


Figure 2. Floor and base construction for hay storages

STRUCTURAL DESIGN

Basic Criteria

Buildings for storage of hay have relatively simple structural needs. The main structural requirement is to withstand the climatic loads of wind and snow. The building should be built square, true and level, and have a weather-tight roof.

Snow and wind loads for farm buildings are defined in the Alberta Building Code, modified slightly for farm buildings by the Canadian Farm Building Code. Though the latter document is not enforced in Alberta, it is a valid and valuable reference for the design of farm buildings.

For many locations, and particularly for high-walled open-ended structures, the wind load may be more critical to the building design than snow loading. Pole frame and stud wall buildings are most susceptible. The wind force on the side walls, and the overturning forces, are much greater for fully enclosed buildings of this type than for similar buildings with open sides.

Pole Buildings

Wind bracing and adequate plate beam connections are the main concerns for the design of these structures. For most buildings the end walls, combined with a strong structural roof system, provide adequate wind resistance. Canada Plan Service leaflet 9310 - Steel Roof Diaphragm Wind Bracing describes this aspect of structural design.

This is not the case for buildings having fully closed side walls and at least one open end. For these, the pole walls and bracing system have to provide all the wind resistance.

Wind Bracing

Wind resistance for open-end buildings can be provided by the following three methods, or a combination thereof:

- Structural knee braces combined with the pole frame
- Over-sized poles alone, of sufficient strength
- An external bracing system

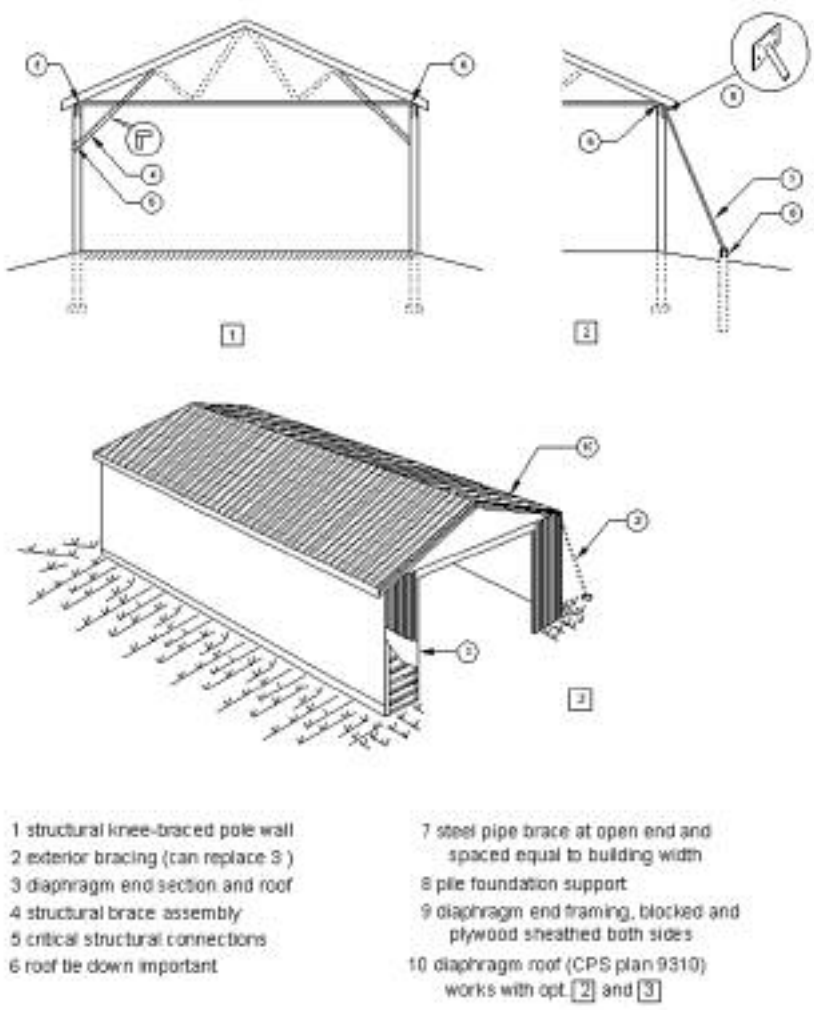
For pole-type hay storage structures, the option of knee bracing may not be a good alternative if the knee braces interfere with the clearance needed for bale wagon operation. Otherwise, the most critical design of an effective knee brace system is to provide the substantial fastening needed to take the high forces imposed on the brace connections. (See Figure 3.)

Over-sizing of poles is another method of providing walls with adequate wind resistance. External braces, though not as neat and tidy, are very effective at wind resistance. A brace of this type at one side of the building every 12 - 20 m (40 - 60 ft) is adequate for most buildings.

Where building length is up to twice the width, and both ends either closed or rigidly braced with a structural wall or external brace, the roof can be built as a structural diaphragm for adequate wind resistance, as explained earlier.

Uplift forces from wind on high exposed buildings is substantial; and for open-fronted or open-ended structures the uplift force is nearly doubled. All systems require extra strong steel strap connections of trusses to the support beams.

Figure 3. Methods for wind bracing open-end frame builings.



Commercial Pre-engineered Structures

A variety of commercially manufactured arch, pole and rigid frame structures make excellent and economical hay storages. Owners should assure that the building considered meets appropriate wind and snow loading for the locality, and that site and base preparation is specified for the storage of hay.

Most arch or rigid frame structures do not have the problem of wind bracing that affects tall straight-wall buildings; however, the supplier/designer should be made aware if the end wall is intended to be left open. Round-roofed structures have special unbalanced snow loading requirements, as defined in building codes.

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