NATURAL RESOURCES CONSERVATION BOARD

Technical Guideline

TG 2004-02: Concrete Manure Liner Guidelines

November 29, 2004

To: All Confined Feeding Operation (CFO) Owners
All Livestock Owners

MANURE LINERS FOR LIQUID AND SOLID MANURE: RULES UNDER AOPA

This Natural Resources Conservation Board (NRCB) technical guideline describes minimum requirements for concrete manure liners when constructed in an area that does not provide a natural barrier to an aquifer.

Section 9 of the *Agricultural Operation Practices Act* (*AOPA) Standards and Administration Regulation* (AR 267/2001) requires an owner or operator of a manure storage facility or manure collection area to have a liner that lies above the uppermost aquifer of the site.

Liquid manure storage facilities made of non-compacted naturally occurring material must not have less than 10 metres of naturally occurring material with a hydraulic conductivity of not more than 1×10^{-6} centimetres per second.

Solid manure storage facilities made of non-compacted naturally occurring material must not have less than 2 metres of naturally occurring material with a hydraulic conductivity of not more than 1×10^{-6} centimetres per second.

Section 9(9) of the Standards and Administration Regulation states that alternative liner systems that are constructed and maintained to provide the same or greater protection than that provided by the above, may be considered by the Board.

MEETING AOPA RULES WITH CONCRETE MANURE LINERS

Concrete manure liners for a liquid manure storage facility must be constructed and maintained to provide equal or greater protection than 10 metres of naturally occurring material with a hydraulic conductivity of not more than 1×10^{-6} centimetres per second. Concrete manure liners for solid manure storage facilities must be constructed and maintained to provide equal or greater protection than 2 metres of naturally occurring material with a hydraulic conductivity of not more than 1×10^{-6} centimetres per second.

PROFESSIONALLY ENGINEERED CONCRETE DESIGNS

The requirements set out in Section 9 of the *AOPA Standards and Administration Regulation* may be achieved through numerous different professionally engineered concrete designs. Although a concrete design may differ from the technical guideline, it is considered acceptable if it is developed under the direction of a professional engineer, provides complete details of the design, and provides justification for compliance with *AOPA* requirements. Details with regard to cement type, water-to-cementing materials ratio, air entrainment, crack control, compressive strength, durability, protective treatments, and any other pertinent information may be necessary to justify that the proposed design provides the same or greater protection as outlined in Section 9(9).

NON-ENGINEERED CONCRETE DESIGNS

To ensure compliance with *AOPA* regulations and develop consistency throughout the province, the NRCB technical guideline on concrete manure liners describes the minimum requirements for non-engineered concrete manure liners when constructed in an area that does not provide a natural barrier to an aquifer. The following elements must be considered when constructing a concrete manure liner to meet these conditions.

CONCRETE STRENGTH

LIQUID MANURE STORAGE SYSTEMS

Exposure Condition
It is assumed that liquid hog manure and liquid dairy manure contains a sulphate (SO_4) concentration of 1,500 to 2,500 mg/L, which is an S-2 (Severe) class of exposure. Manure with other sulphate concentrations or attacking agents may dictate other exposure conditions, which may have to be taken into account.

Other Considerations
The water-soluble sulphate in soil or groundwater may indicate a more severe degree of exposure, which would become the governing condition.

Type 50 Cementing Materials
For liquid manure liners made of concrete, Type 50 (sulphate resistant) cementing materials should be used. Other products for concrete mix enhancement such as high-performance concrete, silica fume, fly ash, other pozzolanic materials, and special additives may be used to improve the structure's performance.

Liquid Manure Storage System

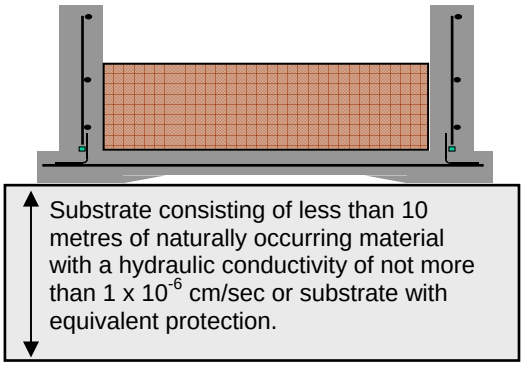


Table 1. Concrete strength required for liquid manure system using W/CM ratio of .45 and air entrainment

Type of Manure System	Condition (Sulphate Content of Liquid Manure is Assumed to be 1,500 to 2,500 mg/L)	Maximum W/CM Ratio	Typical Minimum Compressive Strength of Type 50 Concrete at 56 days	Air Entrainment Required
Liquid	Outside – Subject to Freezing	0.45	32 Mpa	Yes
Liquid	Inside – Not Subject to Freezing	0.45	32 Mpa	Yes

Source: *CSA A23.1-00, Table 12, Requirements for Concrete Subjected to Sulphate Attack*

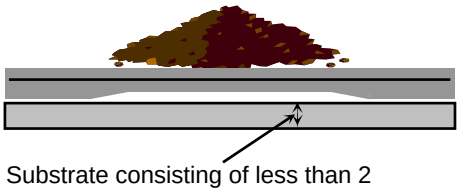
SOLID MANURE STORAGE SYSTEMS

Exposure Condition
It is assumed that solid manure contains a sulphate concentration of 0.075%, which is an S-3 (Moderate) class of exposure. Manure with other sulphate concentrations or attacking agents may dictate other exposure conditions, which may have to be considered.

Other Considerations
The water-soluble sulphate in soil or groundwater may indicate a more severe degree of exposure, which would become the governing condition.

Type 50 Cementing Materials
Type 50 cementing materials should be used for solid manure liners made of concrete. Other products for concrete mix enhancement such as high-performance concrete, silica fume, fly ash, other pozzolanic materials, and special additives may be used to improve the structure's performance.

Solid Manure Storage System



Substrate consisting of less than 2 metres of naturally occurring material with a hydraulic conductivity of not more than 1 x 10^{-6} cm/sec or substrate with equivalent protection.

Table 2. Concrete strength required for solid manure system using W/CM ratio of .50 and air entrainment

Type of Manure System	Condition (Water-Soluble Sulphate Content of Solid Manure is Assumed to be 0.075%)	Maximum W/CM Ratio	Typical Minimum Compressive Strength of Type 50 Concrete at 56 days	Air Entrainment Required
Solid	Outside – Subject to Freezing	0.50	30 MPa	Yes
Solid	Inside – Not Subject to Freezing	0.50	30 MPa	Yes

Source: *CSA A23.1-00, Table 12, Requirements for Concrete Subjected to Sulphate Attack*

CONCRETE SPECIFICATIONS

Other Cements
Concrete may be made of other cement and cementing materials provided it meets the requirements for sulphate exposure. Type 10 concrete with 20 to 25% fly ash may be able to meet the requirements for concrete exposed to an S-3 (Moderate) class of exposure or even an S-2 (Severe) class of exposure. Concrete suppliers can advise if this is possible.

Air Entrainment
Air entraining admixtures (AEA) are used to entrain microscopic air bubbles in concrete. Concrete with air entrainment is less permeable and more durable than plain concrete. For those reasons it is required for water-tightness and resistance to sulphate attack.

Placement and Curing
Placement and curing of concrete are important to ensure the desired result is obtained. Place in forms with the aid of a vibrator for high density, water tightness, no "honeycombs", and excellent bondage with both reinforcing and floor joints. Proper curing is required to ensure the concrete obtains its potential design strength and durability.

Cold Weather Protection
CAN/CSA A23-00 requires cold weather protection measures be taken when the air temperature is at or below 5°C or when there is a probability of it falling below 5°C within 24 hours of placing concrete and requires that all materials and equipment be on hand before placing concrete. Protection shall be provided by means of heated enclosures, coverings, insulation, or a suitable combination of these methods. The protective measures are to be maintained until a minimum temperature differential between the concrete surface and ambient conditions occur.

Hot Weather Protection

When the air temperature is at or above 27°C, or when there is a probability of it rising to 27°C during the placing period, facilities shall be provided for the protection of the concrete in place from the effects of hot and/or drying weather conditions. The determination of moderate and severe drying conditions is given in Appendix D of *CAN/CSA A23.1.*

Severe drying conditions require additional measures be taken to prevent the rapid loss of moisture from the concrete surface. Such measures include one or more of the following:

a. Dampening the subgrade prior to placing the concrete;
b. Erecting sunshades over the concrete during finishing operations;
c. Lowering the concrete temperature;
d. Covering the concrete surface with white polyethylene sheeting between the various finishing operations;
e. Applying a fog spray immediately after placement and before finishing. Care shall be taken to prevent an accumulation of water that may reduce the quality of the cement paste;
f. Beginning the concrete curing immediately after trowelling; or
g. Placing the concrete at night.

CRACK CONTROL - REINFORCEMENT

Liquid Manure Storage Systems (less than 2.4 metres high)

Adequate rebar[1] must be provided to control cracks when a liner is constructed in an area that does not provide a barrier, consisting of 10 metres of natural material with a hydraulic conductivity of less than 1×10^{-6} cm/sec or equivalent, to an aquifer.

Solid Manure Storage Systems

Adequate rebar[1] must be provided to control cracks when a liner is constructed in an area that does not provide a barrier, consisting of 2 metres of natural material with a hydraulic conductivity of less than 1×10^{-6} cm/sec or equivalent, to an aquifer.

Protection of Rebar

Adequate protection of rebar[2] must be provided to reduce corrosion due to the exposure conditions.

Concrete Thickness

Concrete must be of adequate thickness[1] to provide adequate cover of rebar.

LEAK CONTROL METHODS – wall to floor, wall to wall, and floor to floor joints

The joint between liquid manure pit walls and the pit floor should be tight and not allow movement. This requires vertical reinforcement from walls into the floor.

Watertight joint construction can be achieved by one of the following three methods or any other approved method:

a. **Figure 1** (page 5) shows a gasketed joint, using a device known as a **water stop**. These are commonly used in water storage structures.
b. **Figure 2** (page 5) shows a 10 mm wide full-length **caulked joint** consisting of an expanding sealer compatible with manure.
c. **Figure 3** (page 5) shows the use of an **expanding caulked joint** in the middle of the wall between the pit wall or floor and the adjacent pit wall or floor. The caulk contains sodium bentonite.

---

[1] *Canadian Standards Association A23.3 "Concrete Design Handbook"*

[2] *Canadian Standards Association A23.1 "Concrete Materials and Methods of Concrete Construction"*

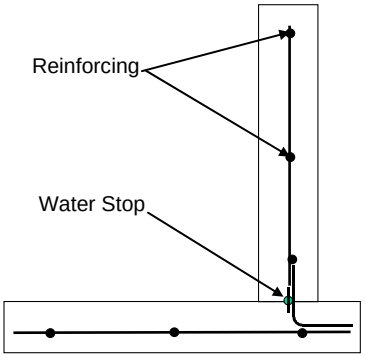


Figure 1: Water Stop

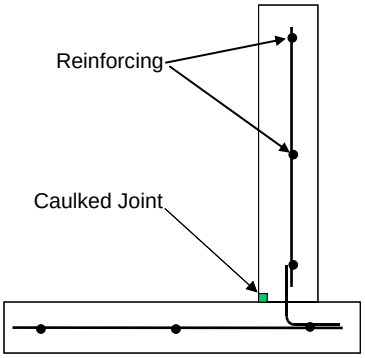


Figure 2: Caulked Joint

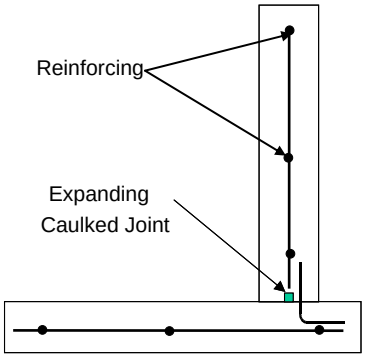
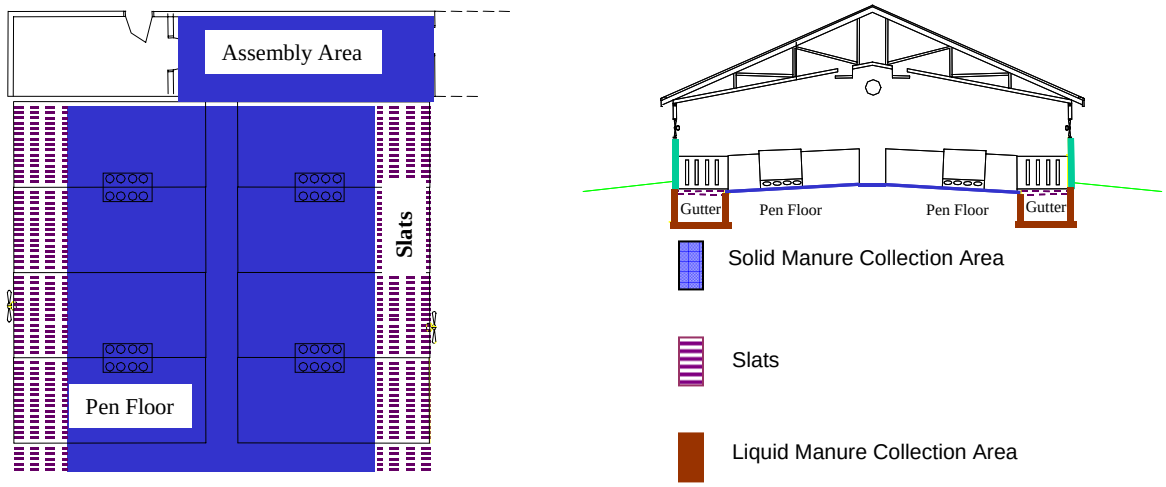


Figure 3: Expanding Caulked Joint

SWINE FEEDER BARN

Components Considered to be a Liner or Manure Collection System

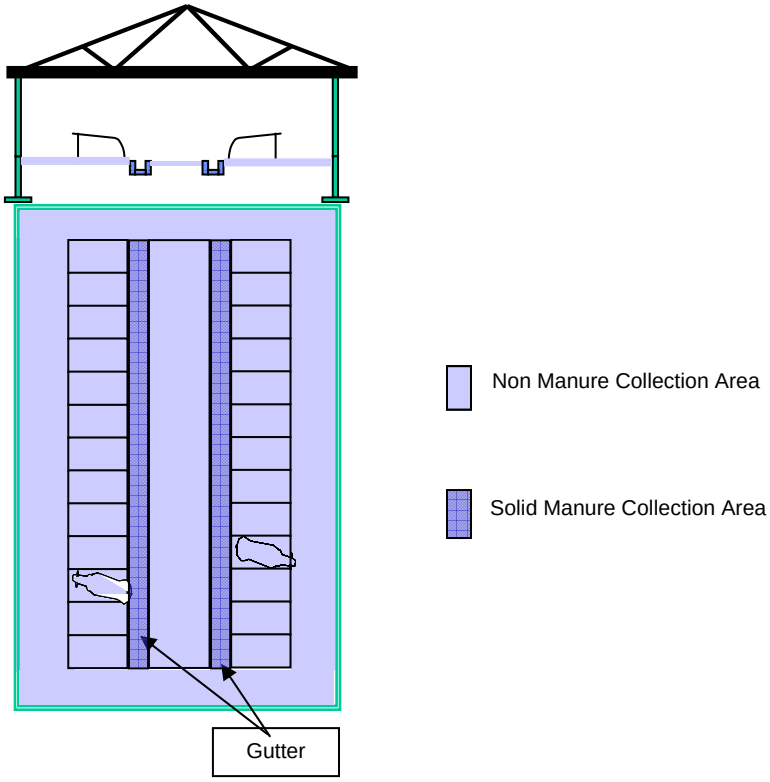
The following diagram illustrates the portions of a swine-feeder barn that are considered to be parts of a "liner" or "manure collection area" as interpreted from the Standards and Administration Regulation. It also shows which parts are considered to be solid manure collection areas and which parts are considered to be liquid manure collection areas.



DAIRY TIE STALL BARN

Components Considered to be a Liner or Manure Collection System

The following diagram illustrates the portions of a tie stall dairy barn that are considered to be parts of a "liner" or "manure collection area" as interpreted from the Standards and Administration Regulation.



DAIRY FREE STALL BARN

Components Considered to be a Liner or Manure Collection System

The following diagram illustrates the portions of a free stall dairy barn that are considered to be parts of a liner or manure collection area as interpreted from the Standards and Administration Regulation.