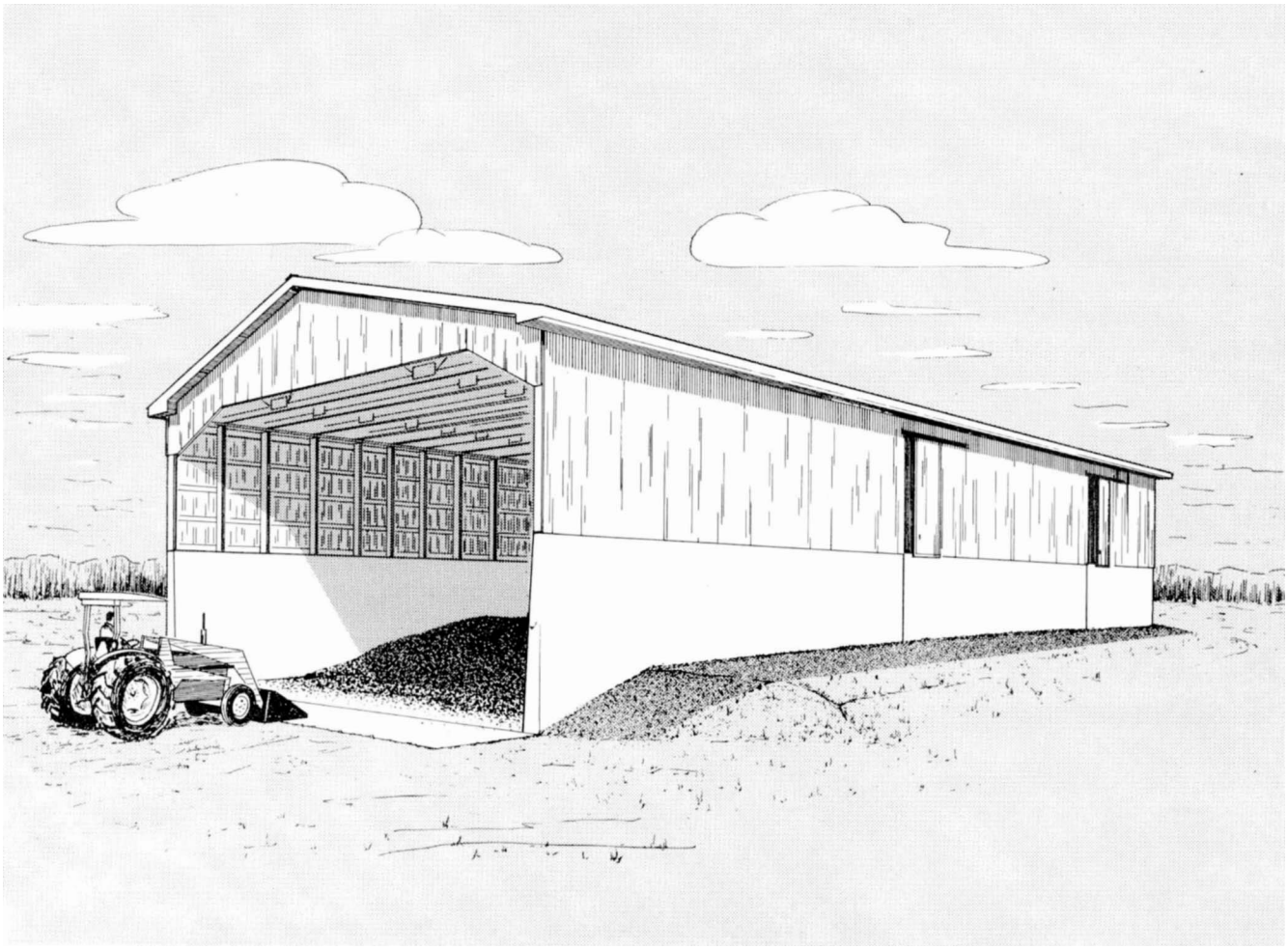
COVERED TIMBER / CONCRETE WALL BUNKER SILO



PLAN M-7436 **REV. 87:11**

This plan gives structural details for building a cast-in-place concrete horizontal silo with a wood stud-frame superstructure and a clear-span trussed roof. You may adjust silo length and width within the limitations of available roof trusses designed for the expected roof snow load in your area. An optional concrete divider wall can be added in case two silages are to be harvested and fed out at different times. As another option, you can build the concrete walls and floor without the wood frame walls and roof.

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The concrete base walls are 3 m (10 ft) high and the stud-frame walls above add another 3 m, so a low-profile tractor can spread and pack the silage.

Calculate storage capacity on a settled dry-matter density of 220 kg/m^3 (14 lb/cu ft) if tractor-packed, or 160 kg/m^3 (10 lb/cu ft) if unpacked. Based on typical whole-plant silage at 67% moisture content, wet densities of silage will be about three times the dry densities given.

The silo may be filled by forage blower, or by dumping silage on the paved front apron and bulldozing it back with the packing tractor. Small sliding doors are spaced at 12 m (40 ft) along one or both walls for filling by blower.

FOOTINGS, WALLS AND DESIGN PRESSURES The concrete walls and footings will handle the silage and compaction pressures to be published in the Canadian Farm Building Code. Wall pressures are based on a maximum tractor one-wheel load of 1600 kg (3500 lb) or a total four-wheel load of 4600 kg (10 000 lb).

Footings and walls work together as a structural unit; that is, the 'toe' of the footing extends far enough under the silage so that the silage mass bearing down on it prevents the wall from tipping out. This is a simple and economical design using traditional engineering principles developed for retaining walls. Overturning forces from silage acting on the walls place the highest vertical pressures on soil under the 'heel' (the outside edge of the footings). Walls and footings are proportioned to give a maximum soil-bearing pressure of 106 kPa (2200 lb/ft^2). Do not build this structure on soils with a history of foundation problems such as poor drainage or uneven and excessive settlement.

FROST HEAVE Frost poses another potential problem. It can penetrate under the exposed floor after the silage has been removed. Wherever there is soil containing silt or clay and a groundwater supply, frost heave can lift the footings and walls with an irresistible force! The silo design includes several ideas to minimize (if not prevent) the destructive effects of frost heave.

First, the footings and floors are all laid on a flat bed of compacted gravel. Gravel improves drainage and also provides some additional non-heaving cover over the frost-sensitive subsoil below. Floors and footings are placed as unconnected slabs so that floor movements will show up as straight-line cracks along the footing edge, not as random cracks. Wall-and-footing units are divided into sections 12 m (40 ft) long, again so that wall cracks will show at predictable vertical lines, each at the edge of the filling doorways in the superstructure.

On soils with a reputation for severe frost heave, extruded polystyrene insulation board can be laid flat under the footings. This extra insulation reduces the loss of heat from the soil into the unheated silo space above, thus reducing the depth of frost penetration. To be effective, the insulation board must be wider than the footing. A perimeter tile drain under the gravel bed also helps by removing some excess water before it can penetrate under the floor. As well, a raised, outward-sloping backfill of soil around the three closed walls improves surface drainage away from the footings, and adds insulation to reduce the depth of frost penetration each winter.

CONCRETE FOOTINGS AND WALLS The footings are reinforced with steel rebars to resist bending where the walls connect from above. Steel L-hooks are prebent and wired in place within the footing forms so that they extend up into the wall forms after the concrete is placed. Vertical and horizontal wall rebars are then wired in place while setting up the wall forms. The wall thickness is tapered, starting with 300 mm (12 in.) form ties for the bottom row and decreasing to 275, 250, 225, 200 and 175 mm (11, 10, 9, 8 and 7 in.) ties with each 600 mm (24 in.) vertical rise. This gives a uniform taper that saves a significant volume of concrete (20% of the wall), yet results in extra bending and shear strength at the bottom where most needed. Some builders may prefer to build the walls a uniform 300 mm (12 in.) thick, using more concrete but simplifying the formwork.

WOOD-FRAMED STUD WALLS AND ROOF This covered silo is a very tall structure. With one end open to the weather, it is particularly vulnerable to uplift or overturning by wind. Several innovative anchoring details provide exceptional wind resistance. The design is based on a 1/10 hourly wind force up to 0.5 kPa, which is safe for most parts of Canada where covered silos would be used. Anchor bolts, galvanized steel strapping and concrete nails are used in a variety of easy ways, to secure the studs to the sill, to tie the trusses to the top wall plate, etc. Doubled studs and doubled knee-bracing are used at each truss (at one long wall only); this is done so that any wall movements due to frost heave or silage pressures will not transmit damaging stresses into the wood super-structure. Do not stack silage above the concrete wall. Neither the concrete nor the wood parts of the walls are designed for the extra forces resulting from such overfill.

DRAINAGE FOR SILAGE JUICE As every site condition is a little different, the floor is shown flat. However, it is probably better to slope the floor, walls and roof structure at 1 to 2% towards one front corner. At this point, add a collection sump and a drain leading to a nearby liquid manure storage. To prevent pollution, do not connect this effluent drain to any ditch or field drainage tile, including the clean groundwater drainage system mentioned above under "Frost Heave".