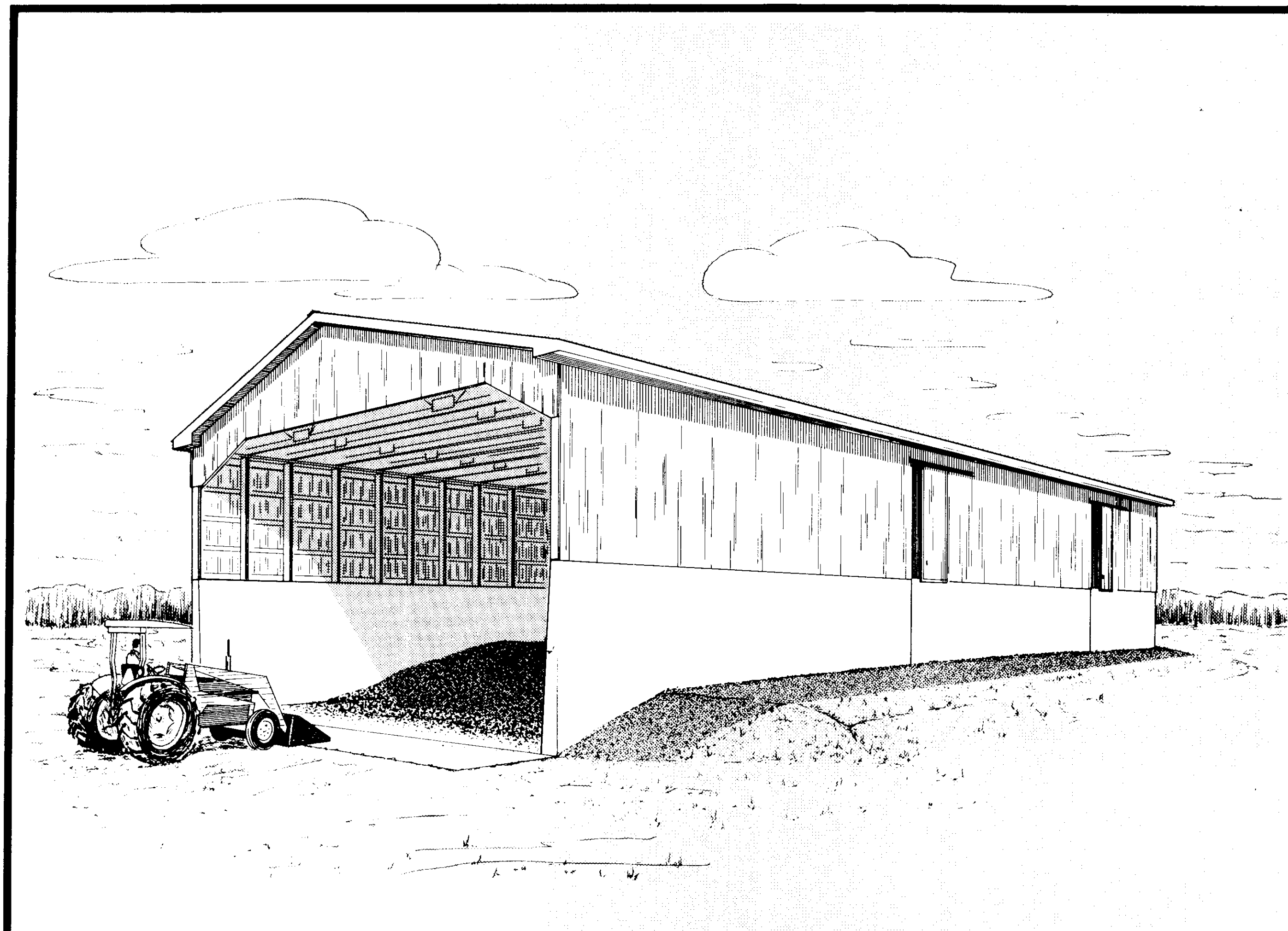
PLAN
M-7436

ROOFED HORIZONTAL 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.

CANADA
PLAN SERVICE

The Canada Plan Service prepares detailed plans showing how to construct modern farm buildings, livestock housing systems, storages and equipment for Canadian Agriculture.

This leaflet gives management information and describes one of these detailed plans. To obtain a copy of the Canada Plan Service detailed plan, contact your local provincial agricultural engineer or extension advisor.

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/m³ (14 Ib/cu ft) if tractor-packed, or 160 kg/m³ (10 Ib/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 Ib/ft²). 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! This 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 form work.

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 superstructure. 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".

TABLE 1 DRY MATTER CAPACITY OF PACKED HORIZONTAL SILOS

Silo width,	Wall height	Dry matter storage capacity (tonnes) Silo length (m)							
(m)	(m)	19.2	24.0	28.8	33.6	38.4	43.2	48.0	52.8
9.6	2.4	84	108	131	155	180	202	225	249
	3.6	124	161	198	234	274	308	345	382
12.0	2.4	105	134	163	192	223	250	279	308
	3.6	153	198	244	289	338	380	425	471
	4.8	196	258	320	383	450	507	569	632
14.4	3.6		236	290	344	402	452	506	560
	4.8		306	380	454	534	602	675	749
	6.0		370	465	559	661	747	842	936
19.2	3.6			382	453	530	596	667	738
	4.8			499	596	701	790	887	984
	6.0			608	732	865	978	1102	1225
24.0	3.6				563	658	739	828	916
	4.8				739	869	979	1099	1219
	6.0				904	1069	1209	1361	1514
		Dry matter storage capacity (tons) Silo length (ft)							
(ft)	(ft)	64	80	96	116	128	144	160	176
32	8	93	119	144	171	198	223	248	274
	12	137	177	218	258	302	339	380	421
40	8	116	148	180	212	246	276	308	339
	12	169	218	269	319	373	419	468	519
	16	216	284	353	422	496	559	627	697
48	12		260	320	379	443	498	558	617
	16		337	419	500	589	663	744	825
	20		408	512	616	728	823	928	1032
64	12			421	499	584	657	735	813
	16			550	657	773	871	978	1084
	20			670	807	953	1078	1214	1350
80	12			-	620	725	814	912	1009
	16				814	958	1079	1211	1343
	20				996	1178	1332	1500	1668

* For unpacked capacities, multiply above capacities by 0.7.