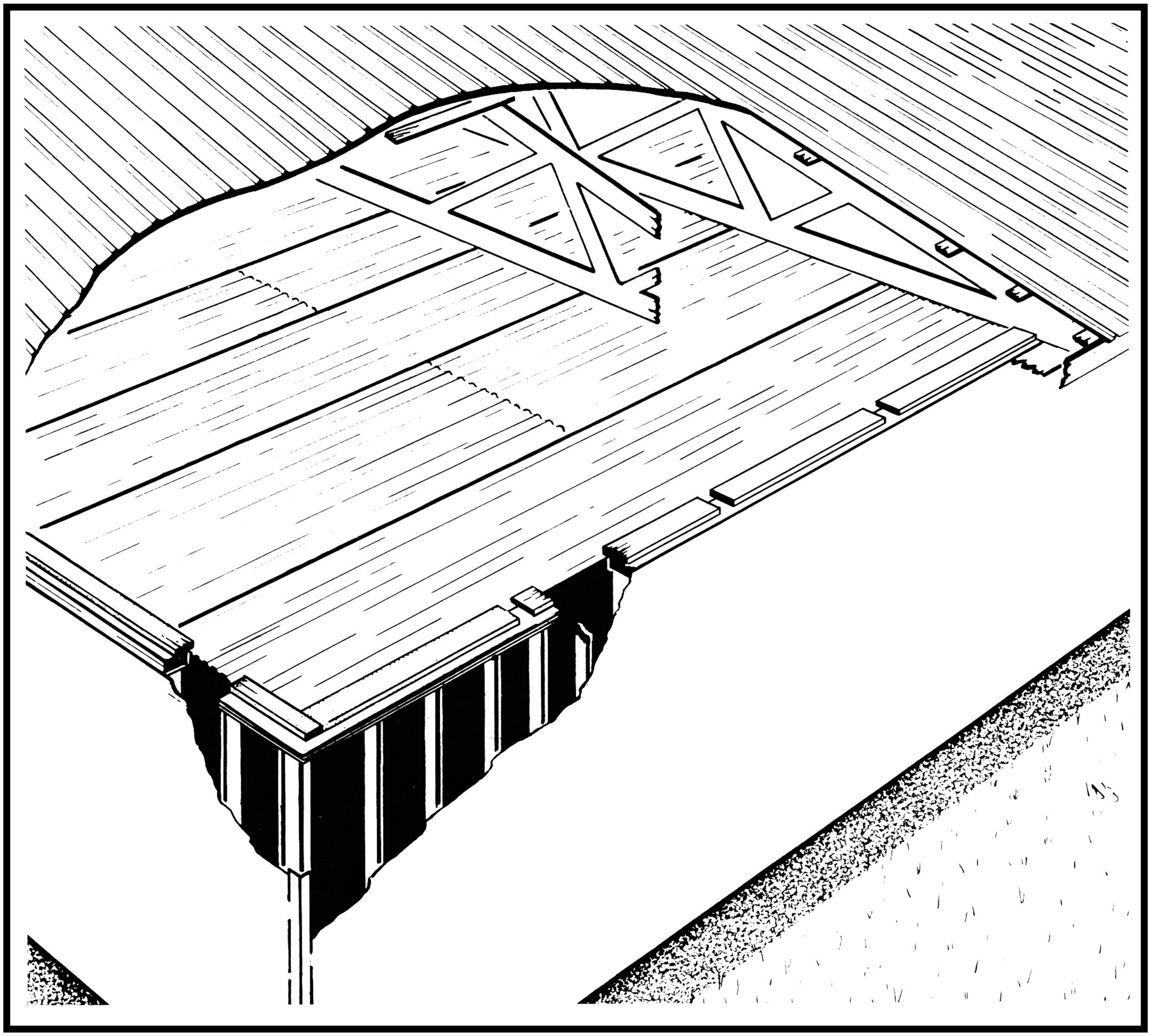
STEEL CEILING DIAPHRAGM FOR BULK VEGETABLE STORAGES



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STEEL CEILING DIAPHRAGM FOR BULK VEGETABLE STORAGES

CPS
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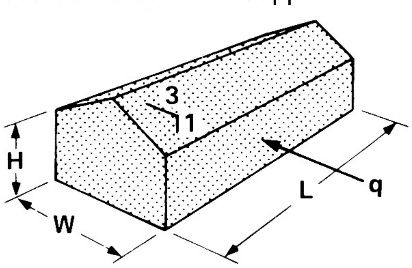
This leaflet and the corresponding plan shows how to build a galvanized sheet steel ceiling in combination with wood roof trusses and wood stud walls. This diaphragm ceiling combines three essential functions: It supports the vapor barrier and attic insulation, provides horizontal wind bracing, and holds the top of the endwalls against the pressure of the stored produce (potatoes, etc,). The pressure of the product piled against the sidewalls is usually resisted at the top by increasing the size of the truss lower chords and by providing a secure wall-to-truss strap connection (see Plan **331-01** Bulk Vegetable Storage Wall, for example).

Where storage buildings are clad inside with wide panels like sheet steel or plywood, the external wind pressures and the internal storage loads can often be handled by the diaphragm action of the ceiling cladding, working in combination with endwall and sidewall cladding like a closed "box". For effective diaphragm action, each panel of ceiling and wall cladding is nailed or screwed to adjacent framing and cladding along all four edges.

DESIGN Wind pressures for locations in Canada, and the rules for determining wind forces on various building surfaces, are found in the Supplement to the National Building Code of Canada, 1980. For "low human occupancy" farm buildings as defined in the Canadian Farm Building Code, use the 1/10 hourly wind pressures tabled in the Supplement.



For rectangular farm storage buildings with stud walls and gable truss roofs as above, the maximum hourly wind pressure is:

$$q = 2.22 \frac{SW}{HL}$$

where
q = 1/10 hourly wind pressure, kN/m^2
S = ceiling shear strength, kN/m of span
W = ceiling span, m
L = ceiling (or room) length, m
H = stud wall height, m

The ceiling shear strength S may be limited by either the shear strength of the ribbed galvanized steel, or by the spacing of the screws driven around the perimeter and across each sheet. The customary steel thickness and profile for diaphragm ceilings is 0.3 mm (30 gauge, before galvanizing), diamond rib, with ribs spaced at about 150 mm. This profile gives adequate longitudinal stiffness for a ceiling screwed to the underside of wood roof trusses spaced at up to 1200 mm. Joints between adjacent panels should lap one full rib at the sides and at least 75 mm at the ends. Therefore order the sheets cut 4875 mm long, for trusses spaced at 1200 mm (four truss spaces, plus 75 mm for the laps). Using special self-drilling roofing screws 4 x 19 mm (No. 8 x 3/4"), the ceiling shear strength is:

Screw spacing to trusses (beside each rib) mm	Stitch-screw spacing at lapped ribs mm	Ceiling shear strength S kN/m
150	100	3.15
150	150	2.71
150	200	2.25
150	300	1.50

With bulk vegetables, there is considerable storage pressure against the side and end walls, and the diaphragm ceiling is the most convenient way to hold the top of the end stud walls against this pressure. This principle uses tension developed parallel to the ribs of the ceiling steel to handle endwall storage pressure (obviously the corrugated steel cannot do the same task for the sidewalls, as the ribs run the wrong way). The plan shows ceiling sheets installed with lapped end-joints staggered 2.4 m, so that the entire ceiling is dovetailed together as an effective continuous tension member extending from one endwall to the other. A special screwed connection from the ceiling to a plywood strip is in turn spiked to the top of the endwall plates. This connection is designed to handle the storage pressure in combination with the tranverse shear due to wind. Using the same 4 x 19 mm screws as in the rest of the ceiling, the screw spacing is:

$$s = \frac{0.45\,(1000)}{\sqrt{\left[\frac{0.45qHL}{W}\right]^2 + \left[\frac{(H-a)^3}{3H}\right]^2}}$$

where s = screw spacing, mm
a = clear height, top of potato pile to ceiling, m (usually assumed 0.6 m)

EXAMPLE PROBLEM For a gable-roofed bulk potato storage building 15 x 36m with studwalls 4.8 m high, find the steel diaphragm ceiling screw spacings for Morden, Manitoba (1/10 hourly wind pressure q = 0.40 kN/m^2).

Try ceiling stitch-screws spaced at 200 mm. From the table above, ceiling shear strength S = 2.25 kN/m, and the 1/10 hourly wind pressure is:

$$q = 2.22\frac{SW}{HL} = 2.22\frac{(2.25)(15)}{(4.8)(36)} = 0.43 \text{ kN/m}^2$$

which is greater than q = 0.40, and therefore safe.

Spacing of ceiling-to-endwall screws for storage pressure at the top of the wall is:

$$s = \frac{0.45\,(1000)}{\sqrt{\left[\frac{0.45qHL}{W}\right]^2 + \left[\frac{(H-a)^3}{3H}\right]^2}}$$

$$s = \frac{0.45\,(1000)}{\sqrt{\left[\frac{(0.45)(0.4)(4.8)(36)}{15}\right]^2 + \left[\frac{(4.8-0.6)^3}{3\,(4.8)}\right]^2}}$$

= 81 mm, therefore use 2 screws per rib-space of 150 mm, equivalent to a screw spacing of 75 mm.

The 18.5 mm plywood connection plates to which the ceiling is screwed must in turn be nailed to the endwall top plates with 4.5 x 102 mm spiral nails, at the same 75 mm spacing. It is a good idea to drive these nails in a staggered row to avoid splitting the top wall plate.

A table on the plan sheet gives ceiling screw spacings for typical bulk vegetable storage dimensions. Use the above formula for situations not covered by the table.