Timber storage building in Oshawa (Ontario)

10. Timber Storage Building in Oshawa (Ontario)

Owner: *Westcane Sugar Limited*
Consulting Engineers: *Morrison Hershfield Limited*
General Contractor: *Sub-Con Industries Ltd.*
Dome Fabricator: *Bulk-Store Structures Ltd.*
Work Duration: *15 weeks*
Service Date: *October 1981*

Westcane Sugar Ltd. refinery's production had grown such that by the mid-1970's the capacity of their storage shed for raw sugar was inadequate. A 60 m by 100 m asphalt pad was constructed adjacent to this shed, on which raw sugar was placed until the summer of 1981, when a 5400 m^2 clear span timber barrel building was erected.

Building Selection

Westcane selected a barrel structure for its new storage facility because of the building's low price, fast erection, ease of future expansion and natural resistance to the corrosive acids created by fermentation of stored sugar. The barrel structure was more economical than competing wood or steel structures, primarily due to the self-supporting dome ends which require no other structural support members except for the panels themselves; dome end storage accounts for some 28% of this building's total capacity of 35000tonnes (Fig. 1). This system also offers the possibility of future expansion at reasonable cost through dismantling of the dome end, erection of additional barrel sections and re-assembly of the dome ends.

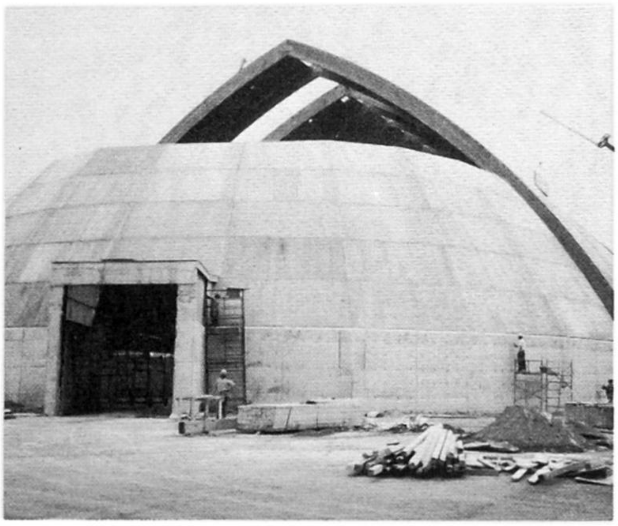

Fig. 1 Dome end

Building Description

Conceptually the barrel building is formed by slicing a 45 m diameter dome down the middle, moving the two halves apart to become "dome ends" and inserting an arched barrel section of matching geometry. The 45 m dome is the largest of the "off-the-shelf", completely panelized beehive-shaped storage domes for which factory-built trapezoidal panels are bolted together to form a selfsupporting shell.

In addition to the 45 m diameter dome ends, this building has a 73 m centre barrel section consisting of fifteen 5 m bays. The structure is supported atop a 3.6 m concrete retaining wall giving an overall building height to the apex of 26.5 m.

Dome Ends

The standard 45 m dome consists of thirteen horizontal rings, with each ring containing twenty-four 2.4 m wide panels. Individual panel length varies from a maximum of approximately 6 m at the dome's base, to approximately 0.6 m in the top most ring. When a standard dome is used as dome ends for a barrel building, two of the sectors of standard panels are deleted and replaced by four sections of special transition panels to abut the outer arches of the barrel.

The panels consist of 12.5 mm sheathing grade Douglas fir plywood bonded with a waterproof adhesive to the horizontal and vertical panel stringers. All stringers are cut and planed to the requisite angles to ensure positive bearing all around between stringer and plywood and between adjacent stringers. Horizontal stringers are for the most part 38 × 140 mm, but increase to a maximum of 38 × 235 mm for the edge rails of the lower panels. Vertical stringers are 89 × 89 mm, or single, double or triple 38 × 140 mm that are glued-laminated prior to panel assembly. Vertical stringers are located at the panels' outer edges and at the vertical joints between sheets of plywood. Their width is varied to accommodate the different glueline widths that are needed to resist the within-panel hoop tension forces without exceeding the plywood's allowable rolling shear stress. All stringers are No. 1 spruce-pine-fir.

Barrel Section

The barrel section consists of stressed skin plywood panels placed over 1140 mm deep glulam arches (Fig. 2). The standard arches are 220 mm wide; those adjacent to the dome ends are 170 mm wide, while those which support the inclined conveyor gallery that enters the centre bay of the building are 310 mm wide. Pairs of glulam collar-ties run between the arches at the 21 m level above the finished floor; the collar-ties carry the shuttle conveyor that runs the length of the barrel section.

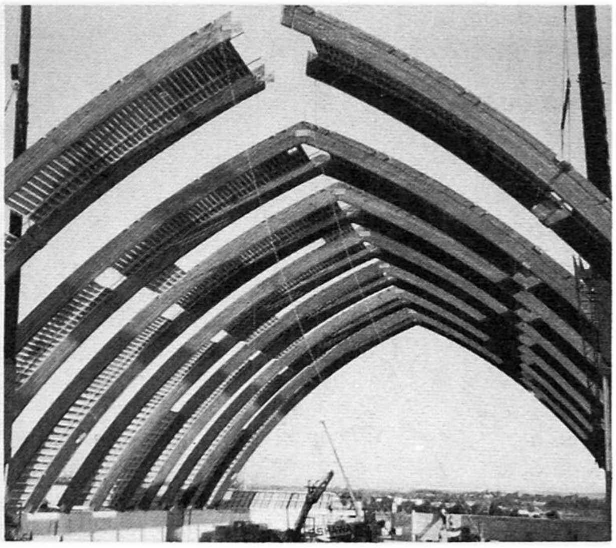

Fig. 2 Glulam arches form centre barrel section

The 1.2 × 5 m stressed skin panels consist of a 12.5 mm sheathing grade Douglas fir plywood compression skin factory-glued using a waterproof adhesive to 38 × 184 mm No. 1 spruce-pine-fir stringers; there is no tension skin. Plywood face grain is oriented parallel to the panel's span. Panel stringers are spaced at 300, 400 or 600 mm depending upon the design (drift) snow load stipulated for the panel's particular location within the roof. The Plywood skin extends beyond the panel end rails for a distance equal to one half of the arch width so that the panels can be installed by inserting the end rails between arches. Panels are bolted to the arches with two 16 mm bolts each end, plus the plywood lip is face-nailed to the arches with the equivalent of 89 mm nails spaced at 38 mm centres (Fig. 3).

The glued-laminated arches are designed as three-hinged members with the collar-ties acting as an integral part of the structural system. All glulam was Douglas fir; stress grade, 20 f-Ex; service grade, Exterior; and appearance grade, industrial. Each arch half was supplied at its full 32 m length so moment splices were not required. Galvanized weldments complete with bolts and 100 mm diameter shear plates at the peak and at the base connect the arch halves together and the arch halves to the foundation. The arch top face is laterally supported through its connection to the panels; lateral support of the bottom face is achieved by tie-rod bracing at mid-height that is periodically carried up to the level of the panels by tie-rod cross-bracing.

Foundation Wall

The building's superstructure is supported atop a 3.6 m high reinforced concrete wall designed to retain material on one or both sides of the building to a maximum depth of 3 m. In addition, the foundation wall is designed to resist local wind loads plus the loads imparted to it by the superstructure. The 300 mm thick wall runs around the full perimeter of the building. Within the barrel section, 450 mm thick concrete buttresses at 5 m centres support the arches above. The back face of the buttress is at 60° to the horizontal and so is continuous with the tangent to the arch base. The buttresses are integral to the 300 mm barrel wall and are located so that a flush face is provided on the building's interior to ease loader operations in the finished building. Thrust at the base of the buttresses is resisted by 32 mm diameter steel bars running below grade across the width of the building and protected against corrosion by an epoxy coal-tar wrapping. All walls and buttresses are carried below grade to spread footings founded below frost depth.

(A. Thomas Moryto)

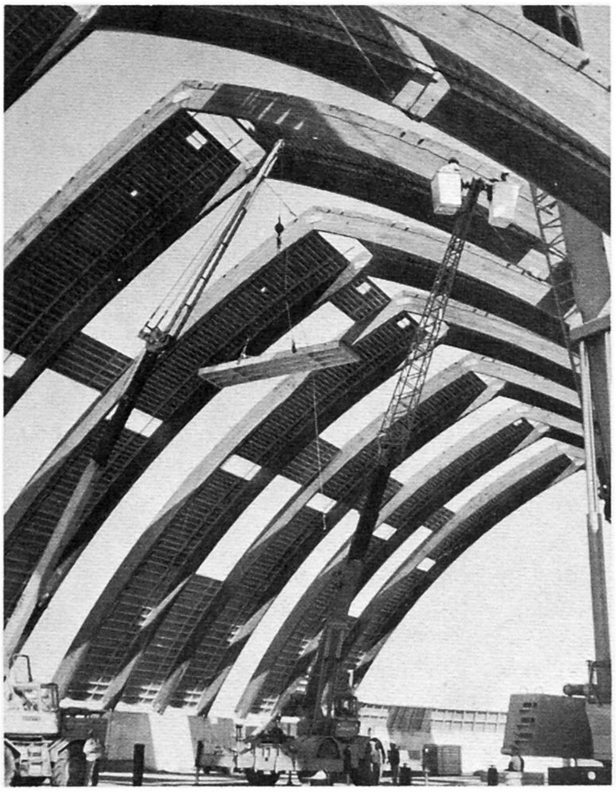

Fig. 3 Stressed skin panels lifted into place