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Structural Design for a Wide Span Roof Structure made from small to medium cross sectional structural wood components

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Abstract

The Oita Prefecture's Martial Arts Sports Center (Draft Title) is an indoor sports facility being constructed within the expansive grounds of the Oita Sports (Athletic) Park. The structure incorporates a 70m x 100m vaulted ceiling open space for Multi-purposes Sports and a 30m x 100m open spaced, devoid of upright columns for Martial Arts in a 16,000m2 total floor space spread over 3 stories above ground and 1 under ground level. There is a grand total of some 1,000 m3 of Japanese "Sugi" cedar structural lumber used in the roof's wood frame structure over the Multi-Purpose Sports Stadium and the Martial Arts Sports Center. Structural design details of the wood frame vaulted roof structure of the Multi-Purpose Sports Stadium is herein outlined.

The Roof Structure is designed from 3 in-plane arched surface section of cylinders shapes on 3 separate vertical load axis and as such the shape or contour of the joint cut surfaces (of the pieces) of all structural wood beams are trapezoidal in shape. Detailed discussions were held with the Oita Prefecture's Wood Products Cooperative (Association) in order to determine the type and sizes of structural lumber to be utilized for the project. 120mm thick x 240mm wide x 4,000mm long Solid Structural "Sugi" cedar Lumber was determined to be the most desirable and most readily available base lumber for the project. As herein described, in order to create a large covered open space with the available small dimension lumber components, special webbed arched trusses that distributed the vertical and horizontal stress loads evenly were designed. The Arched Truss framework was designed as follows:

1. The majority of vertical loads were supported by Arched Structural Assemblies (trusses) 2. When horizontal loads are applied to the components of the arched structure, inverse moments are distributed along the center axis of the span; arched components become the bottom chord and the trusses are spaced according to the degree (size) of the bearing moment. 3. The Rise to Run ratio is set at 1:8. At each grid line, the Sugi structural components are jointed (spliced) in place to form arched structural assemblies (trusses). It is mechanically preferred to configure the arch on a quadratic curve but by doing so, all the joint angles of the components need to be different, so a circular curvilinear was line chosen as the base or reference line for the Arch. 4. In order to make all the cut angles for all the joints of the different spans per grid line the same, the fracture line of the circular geometric shape of the bottom chord was chosen as the central angle in a radial direction for each diffraction point. 5. As the diagonal bracings required in each of the trapezoidal cells in the fundamental frame needed to be longer than 4 m, Tensile Stresses Steel Rods were employed on an cross bracing pattern instead of Lumber and relied strictly on Tension loading to stabilize the assembly. 6. In order to prevent sideways buckling of the Upper Chord of the Arched Trusses, and to insure sufficient horizontal plane strength (diaphragm) of the entire roof structure, strapping was secured perpendicular to the direction of the trusses at 910mm on center spacing and covered with a layer of structural plywood.