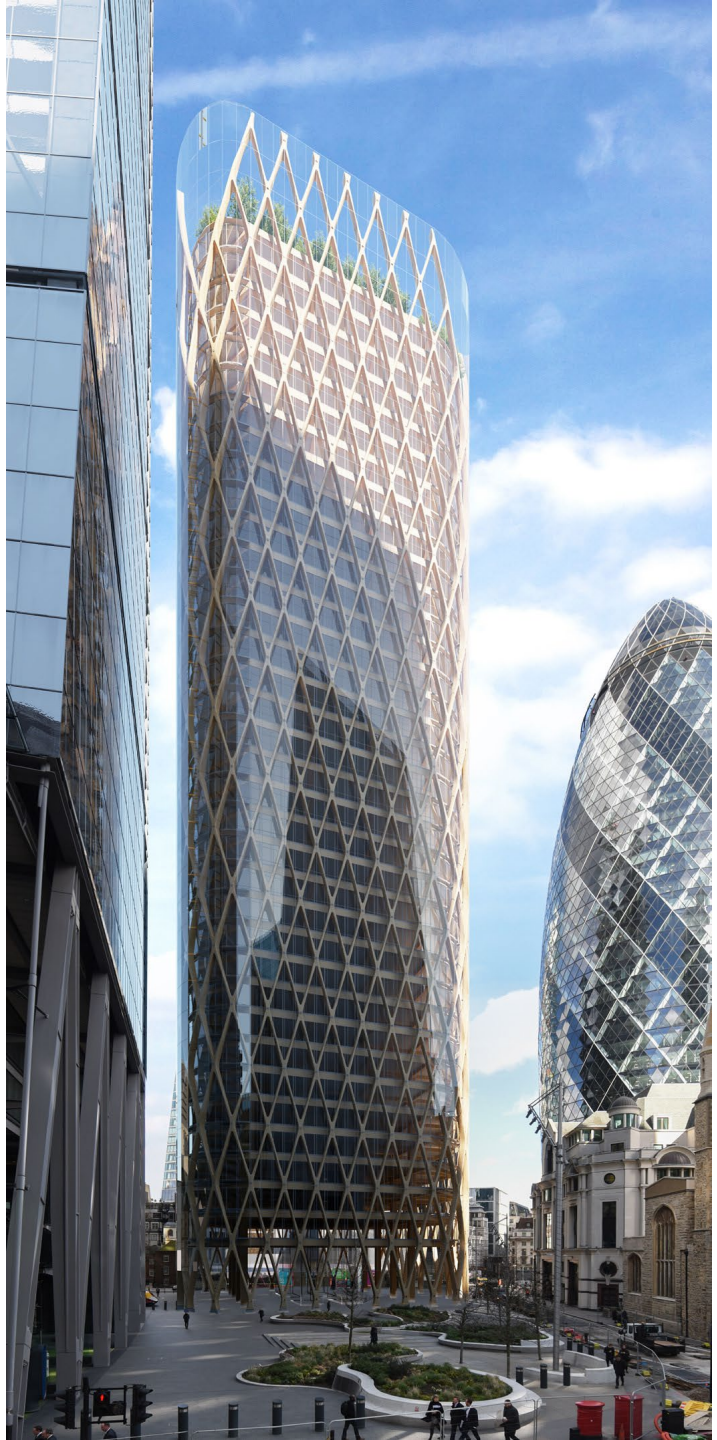
Bamboo Engineering

Neil Thomas

atelier one

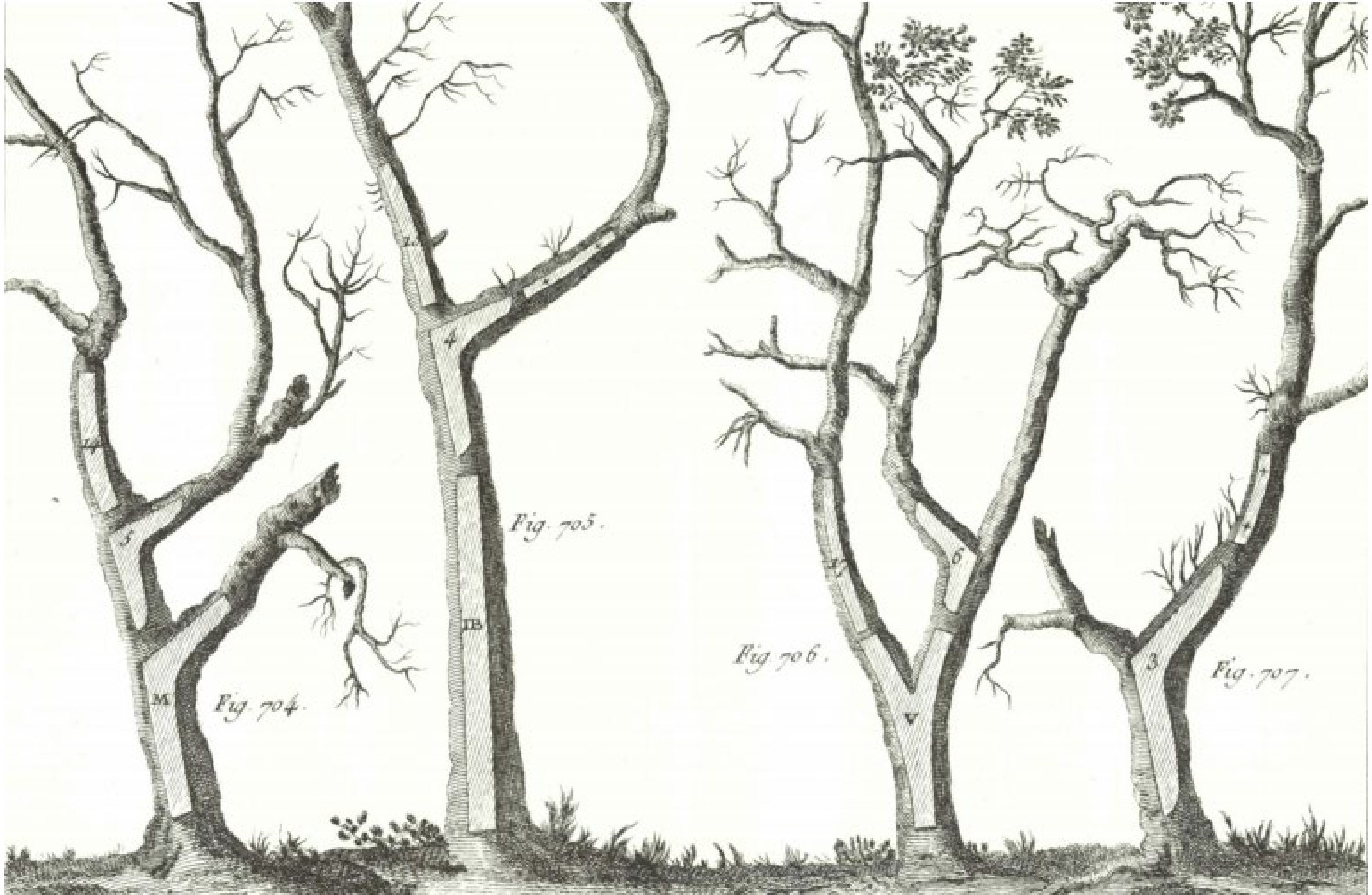
Tall Timber



Woodland Trust


IT NOW APPEARS
THAT MOST STARS
HABITABLE ZONE
WHERE THE
WORLDS
IN OUR GALAXY
ALONE, AND WITH INTELLIGENCE
FINDING OUT IF ANY
OF THESE PLANETS ARE
THERE HAS
NEVER
INTERNATIONAL
CIVILIZATION, WE
PICK OUT PLANETS
ACROSS THOUSANDS OF LIGHT
MAGNITUDE
FASTER
THE LAST
FEW YEARS,
ASTRONOMERS HAVE
ONLY CHILD.
AS ARTHUR
C. CLARKE SAID, "IN
ENDEAVOR, ALL WE
MAKE
SCIENCE OR SCIENCE FICTION
OUR THOUGHTS IN
MEET THEM IN
PRIMATES, AND THAT
OF THE MILKY WAY,
OF
THE VAST
THE ONLY
OF WATER, LIFE, AND
"GOT - AN
OFFERED TO


THE WAVES HAVE A JOY OF BLUE
AND GOLD, AND THE AIR IS GREEN WITH
RECYCLING OF THE TREES. A YELLOW LEAF
TREMBLES IN THE AUTUMN WIND, AND A VOICE IS HEARD THAT IS THE
OCTOBER WIND'S AGLOW. AND IN THAT LEAF THE VOICE IS ORGANISED,
AND IN THAT FIELD THE VOICES ARE THE SAME. HE HAD THE FIRST
TRANSFO- RMATIVE WINTER. I HAVE BEEN SO COLD MYSELF I THOUGHT
THE STR- EETS WOULD NOT REMEMBER ME. TRIUMPHS FROM THE AIR (I WILL ADMIT I DID
NOT AIM AS FAR AS THE EYE COULD SEE) WERE ALL THE JOY OF IT, AND I THO- UGHT THE
CAR WILL END AND THE WORLD TURN ON. INCALCULABLY THE SUN IS AT MY BACK BEHIND AN
ASTONISHING AND FASCI- NATING CLOUD. THIS WALK IS MY SYMBOLIC CASTING, THIS
ENDLESS COLLAB- ORATION WITH THE LEAVES, THESE GREEN HARVESTS OF MY SHADOW
THAT WILL GO ON FOR A LONG TIME BEFORE THE GREAT ECLI- PSE, THOUGH I HAVE TRIED
I COULD BELIEVE IN WHAT THE LIGHT WAS YING, THAT IT WAS GOOD, THAT IT
WAS LONGED- FOR, THOUGH I THOUGHT IT MARVE- LLOUS, WHILE
I WATCHED THE SEA AND THE SKY; I RESP- ECTED THE LILIES THAT
GROW IN MY GARDEN, AND MOON. THE LILIES MADE
GROUP ABOUT THE AND STARED
UK PAVILION
جناح المملكة المتح


4
5
M
Fig. 704.
4
IB
Fig. 705.
6
V
Fig. 706.
3
Fig. 707.


Date & Time: Thu May 7 19:40:09 BST 2015
Position: +050.79502° / -002.67711°
Altitude: 604ft
Azimuth/Bearing: 064° N64E 1138mils (True)
Elevation Angle: +26.5°
Horizon Angle: -00.3°
Zoom: 1X

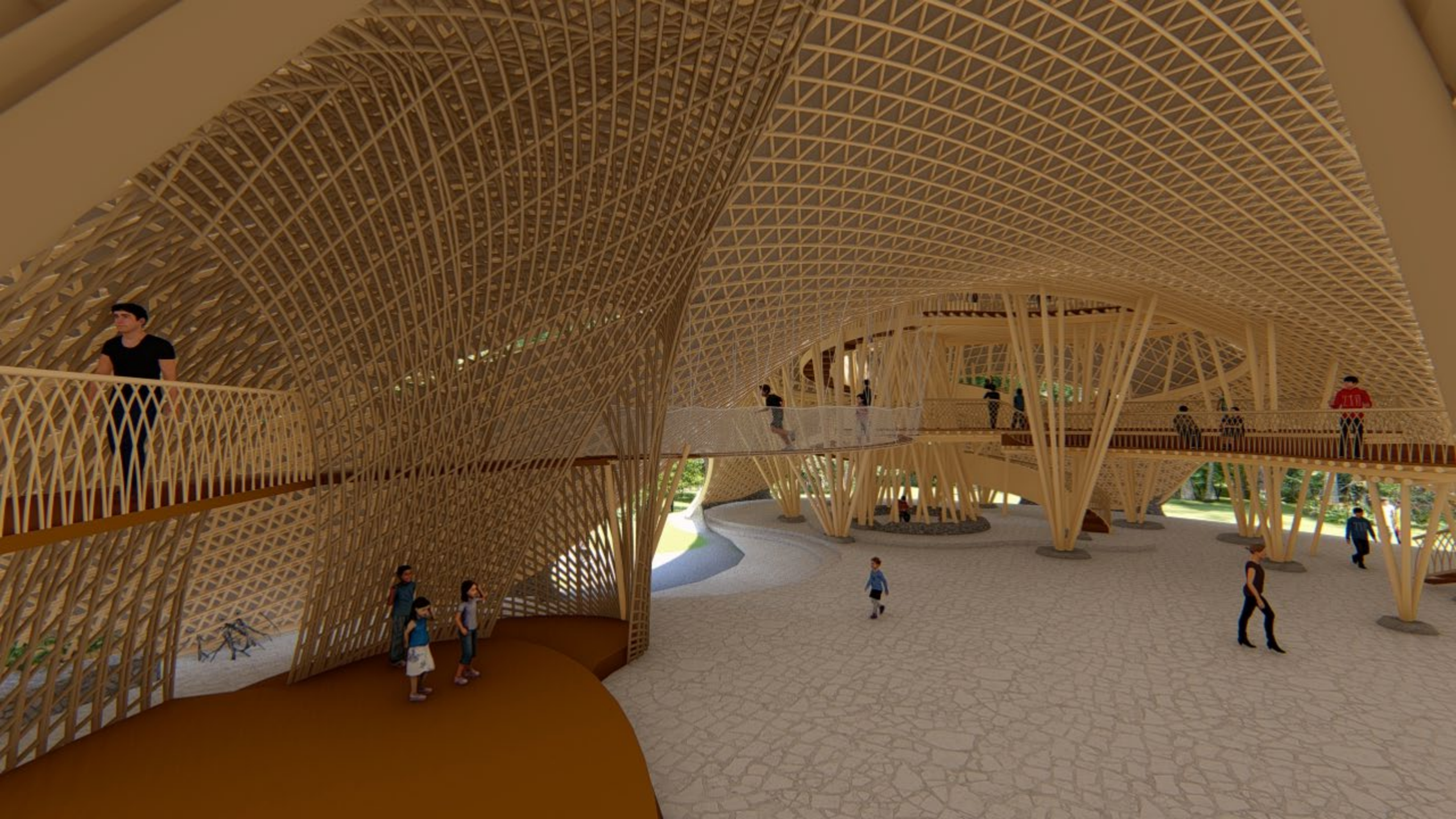

KUKA
KUKA

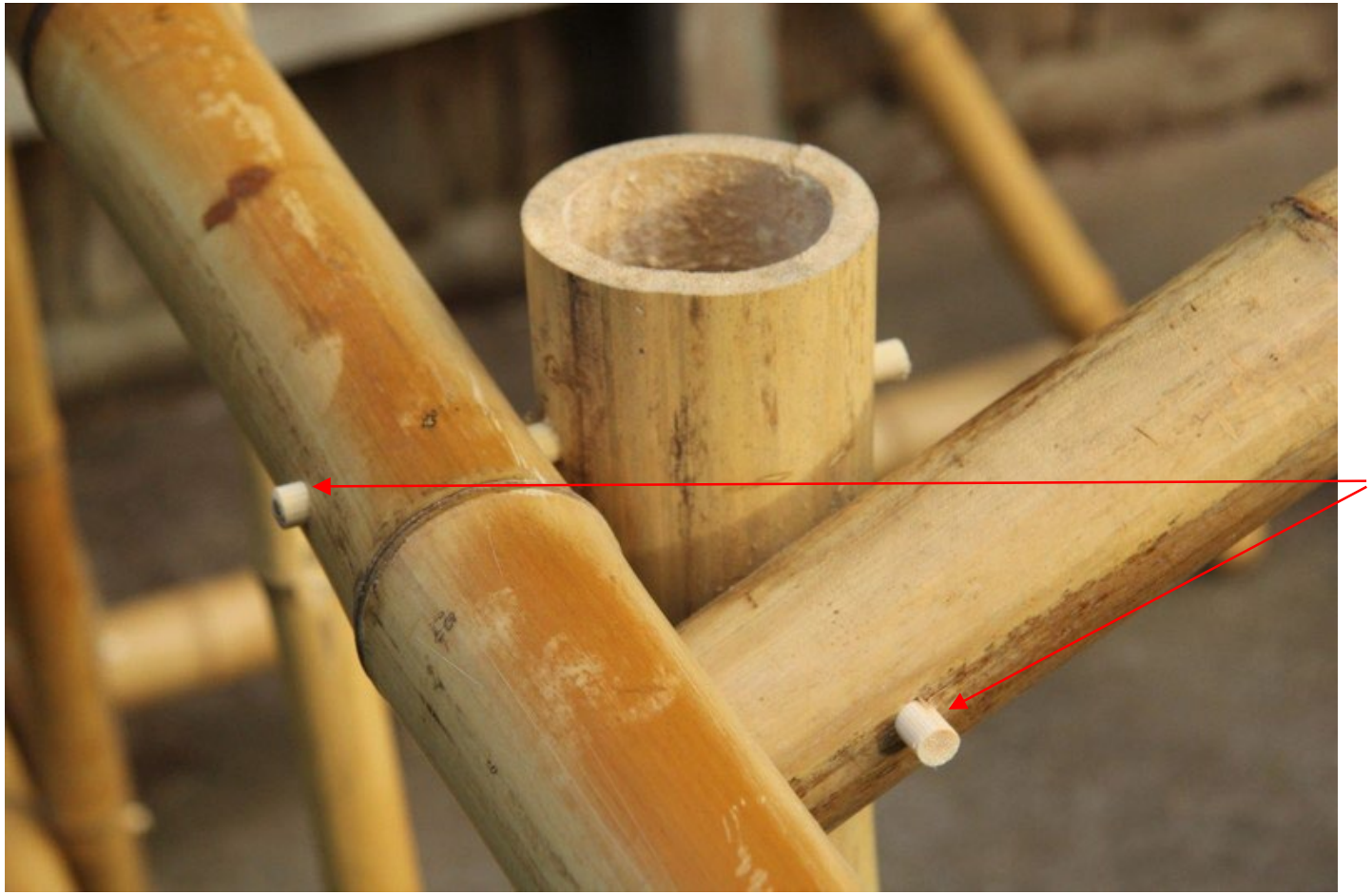
Bamboo

Green School Bali

Sharma Spring

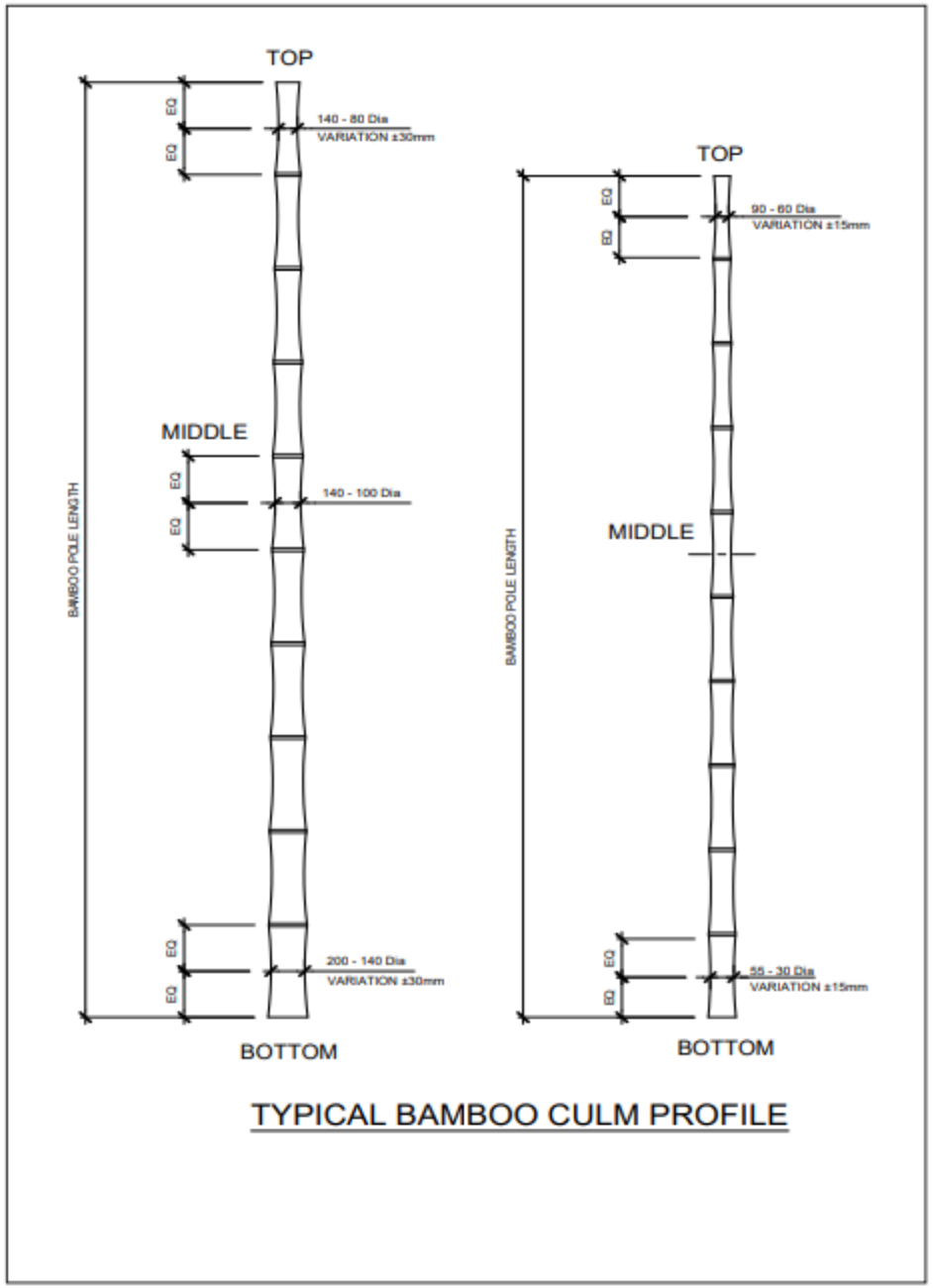
Moon House



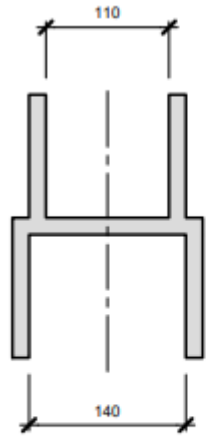


Traditional dowelled connections rely on loading a small area of bamboo in shear. This significantly restricts the force that can be transferred.

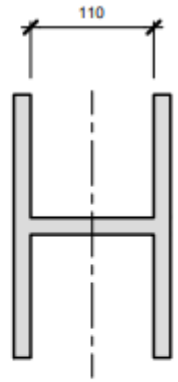
natural
bamboo



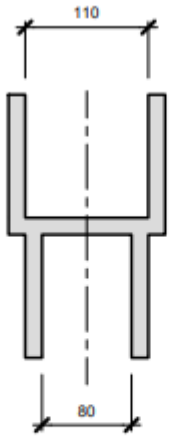
TYPICAL BAMBOO CULM PROFILE



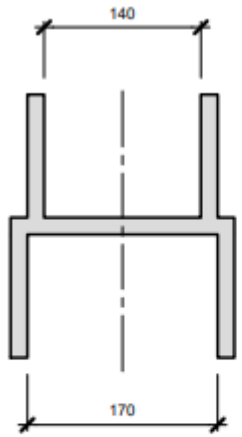
140 / 110
STEPPED



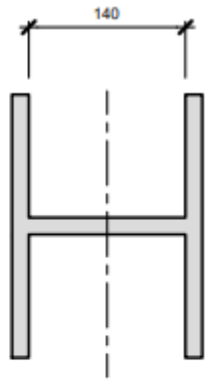
110 / 110
PARALLEL



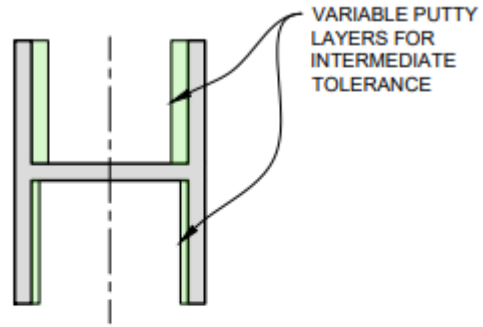
110 / 80
STEPPED



170 / 140
STEPPED

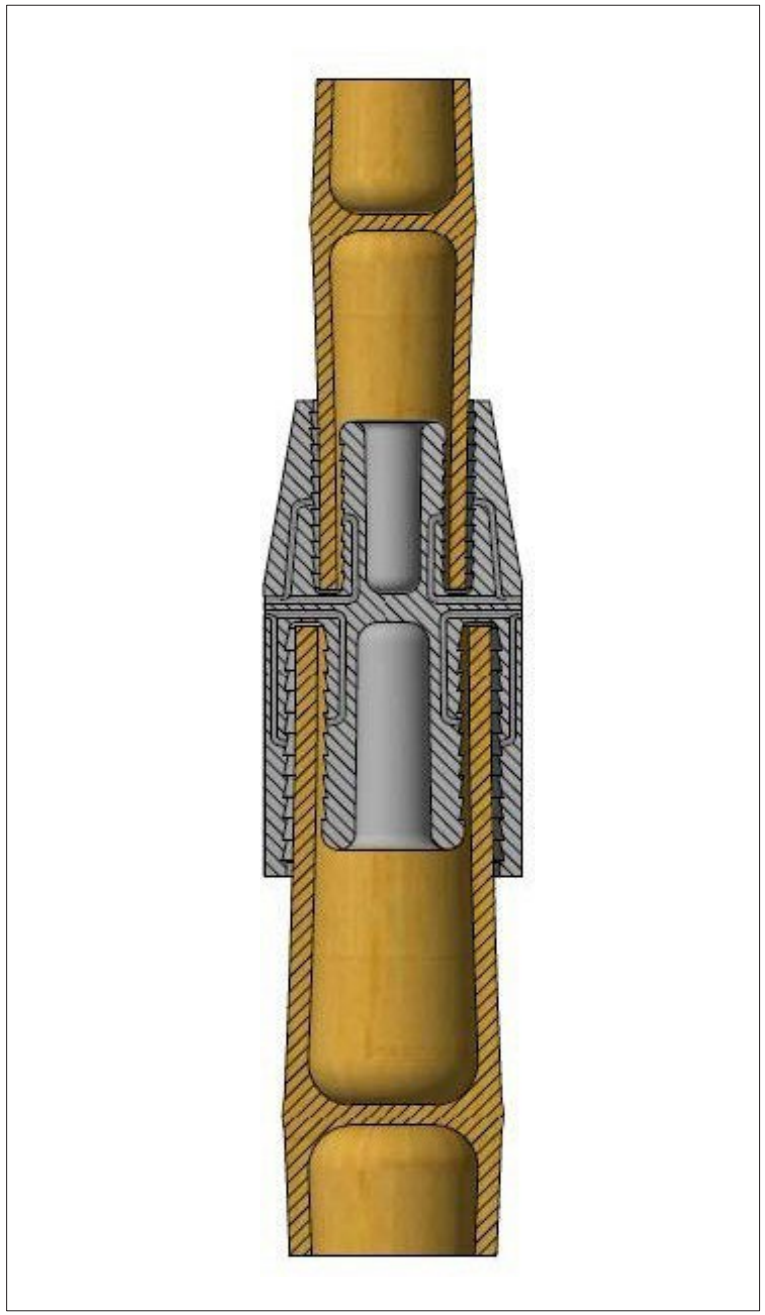


140/140
PARALLEL

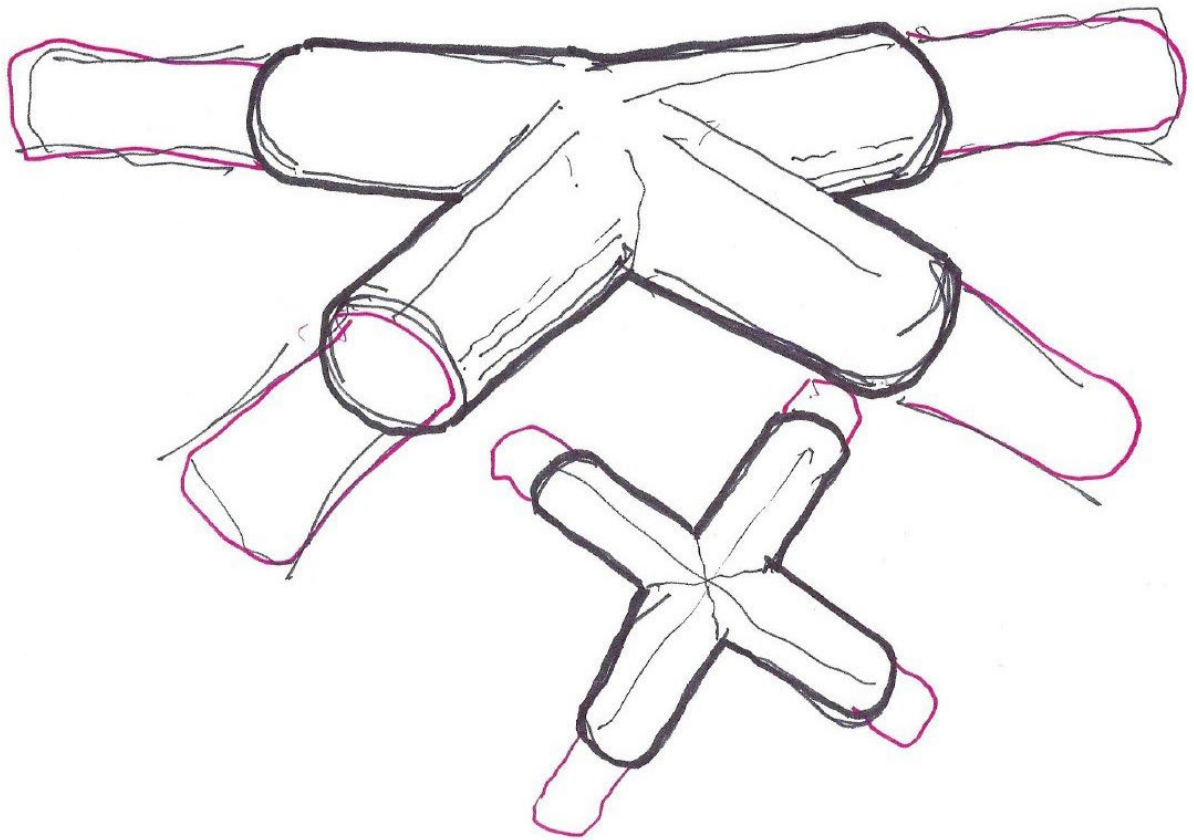


CONNECTION NODE VARIANTS

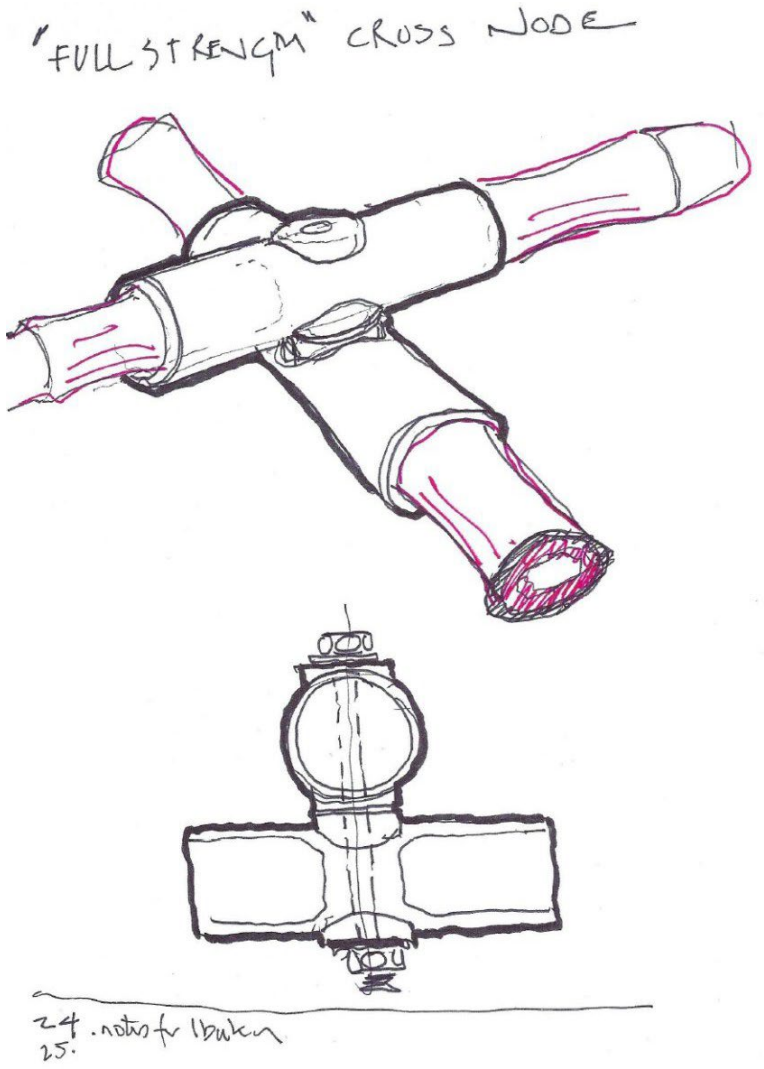

Juniordentist.co



3D printed coupler



“Full strength” cross node



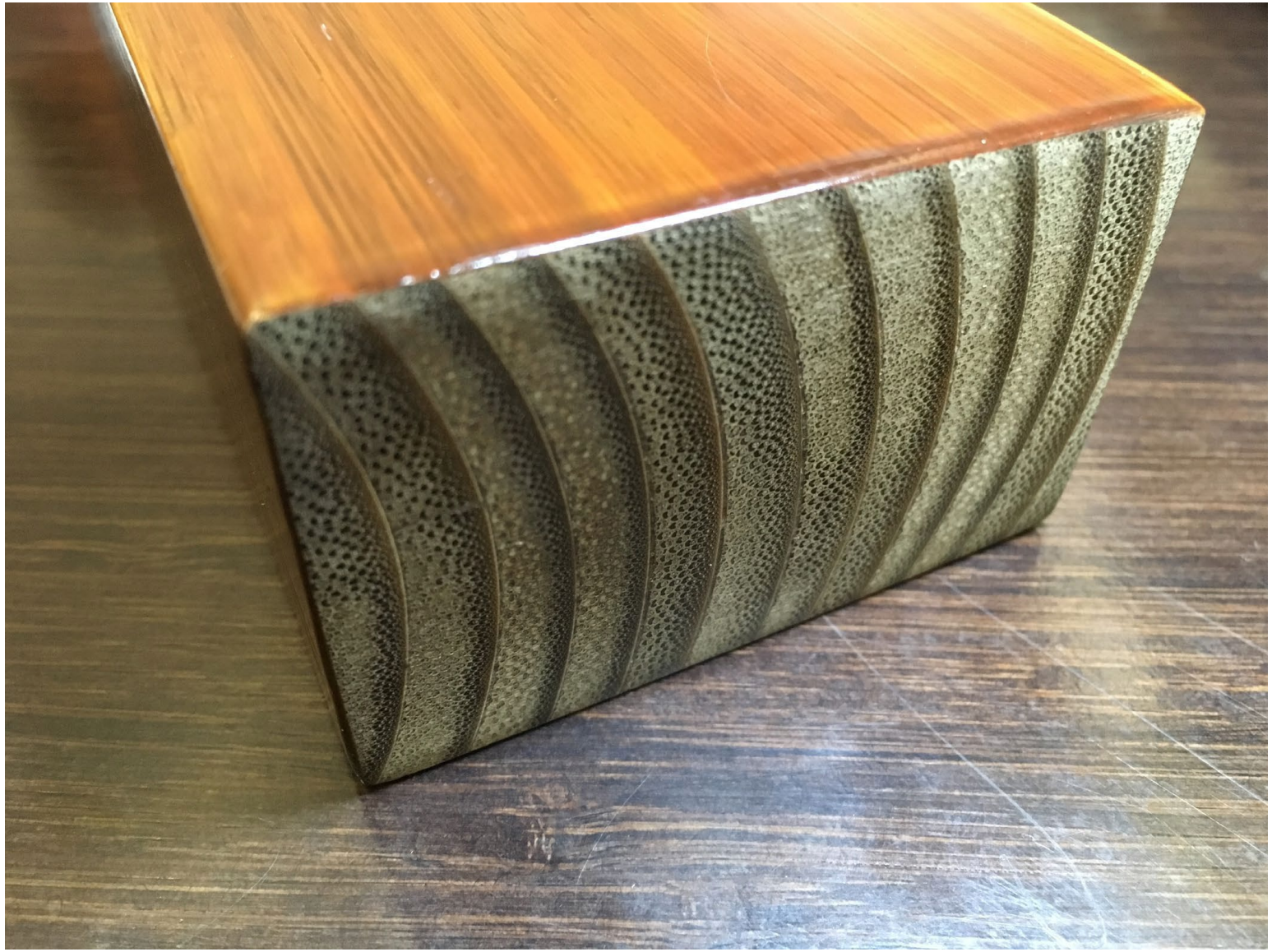
Concept design for an anticlastic bamboo gridshell, using principles inspired by Frei Otto, to form a great hall.

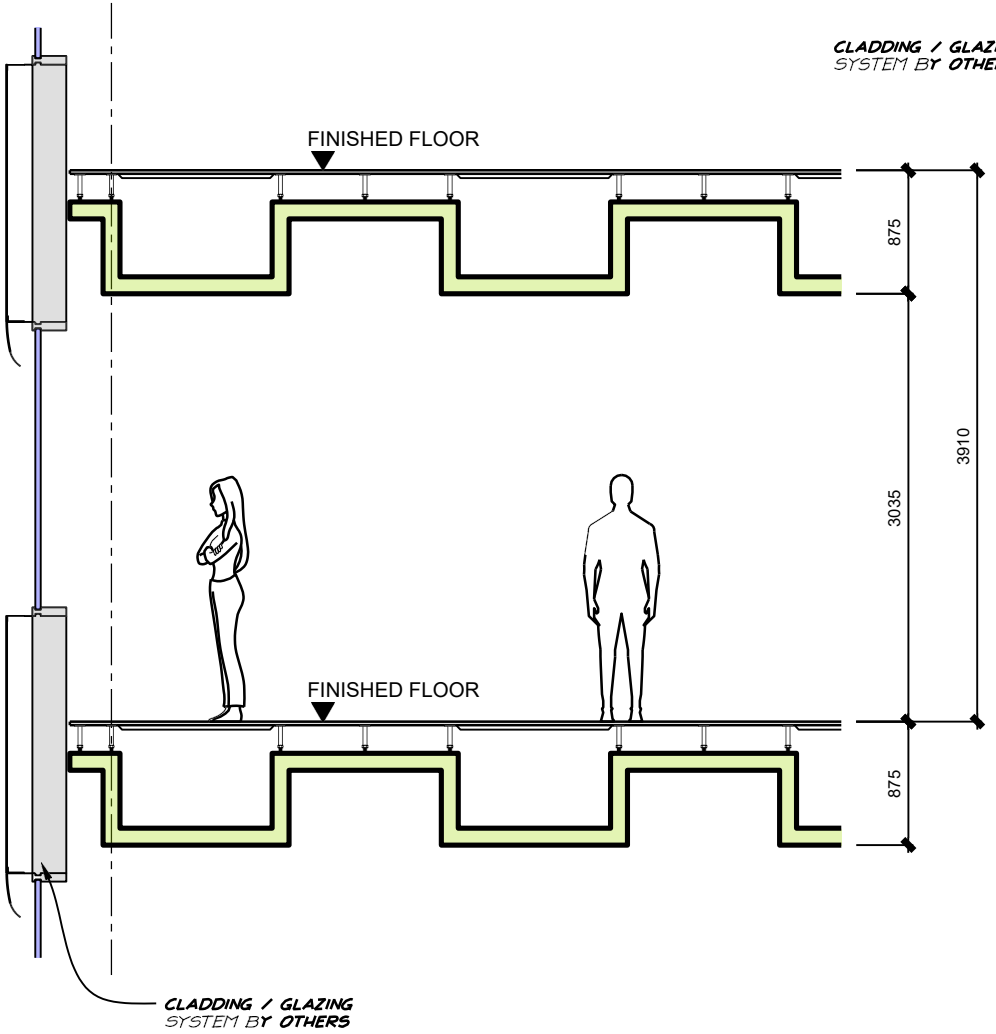
Green School Great Hall

Engineered Bamboo

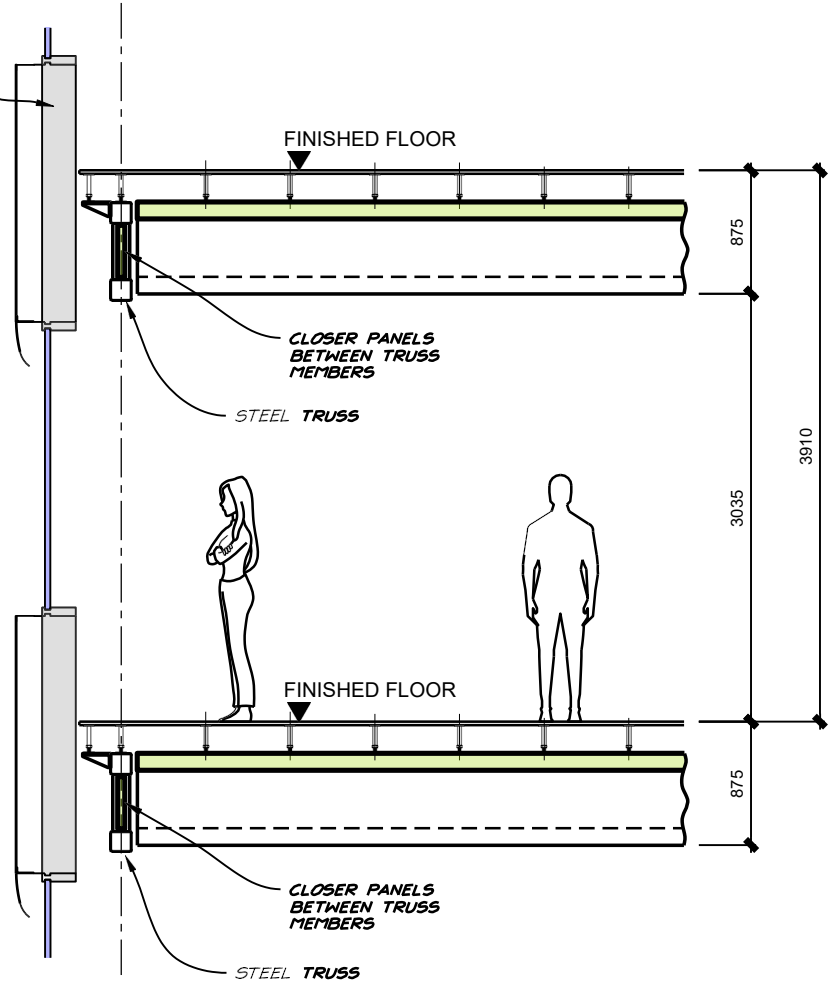
Mechanical Properties - Engineered Bamboo Products

		Lamboo LVB 	MOSO Bamboo N-finity 	GL 24c 	BauBuche 	ReNuTeq VereLam 
Density [kg/m³]		705	650-700	365	800	673
Young's Modulus (MOE) [GPa]		9.0	9.7	11	16.8	20.0
Flexural Strength (MOR) [MPa]		77.2	56.7	24	75	88.3
Compressive Strength [MPa]	Parallel	56.9	34.4	21.5	59.4	93.0
	Perpendicular	19.8	9.9	2.5	14.8	20.9
Tensile Strength [MPa]	Parallel	60.7	39.9	17	60.0	147.9
	Perpendicular	4.6	1.9 Edgewise 2.8 Flatwise	0.5	0.6	3.7
Shear Strength [Mpa]		20.0	4.6 Edgewise 6.5 Flatwise	3.5	4.5	20.0

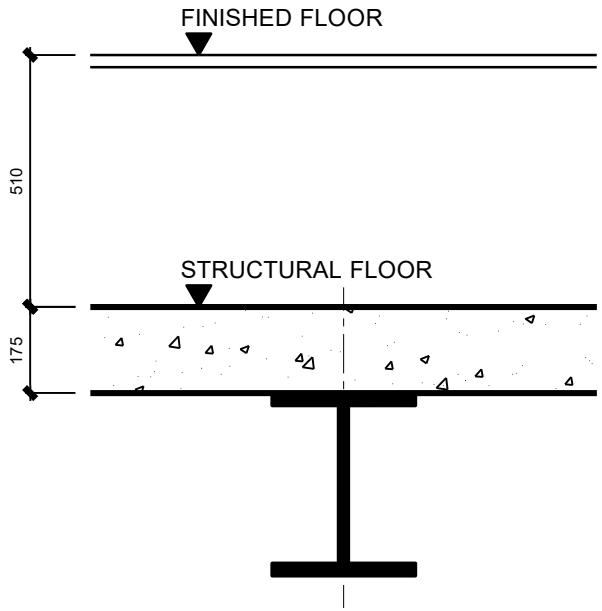




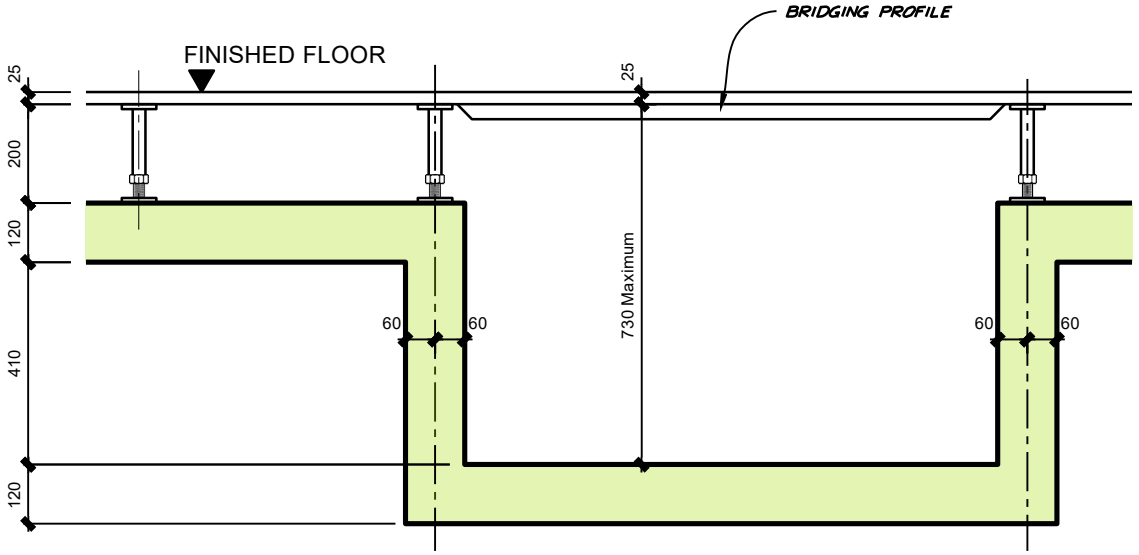
PROPOSED EDGE SECTION
PERPENDICULAR TO TIMBER SPAN
(OPTION 1)



PROPOSED EDGE SECTION
PARALLEL TO TIMBER SPAN
(OPTION 1)

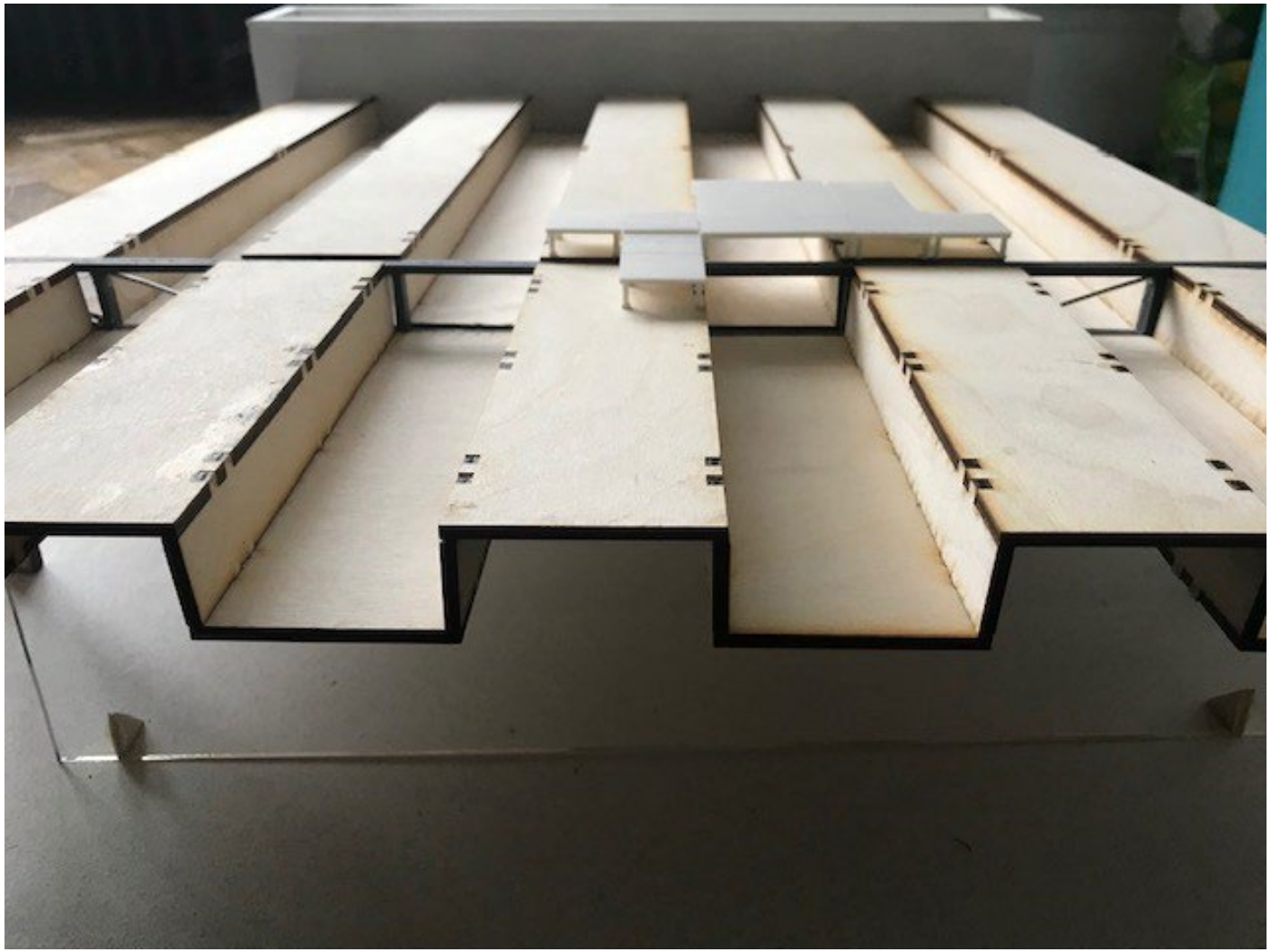


CURRENT FLOOR SYSTEM

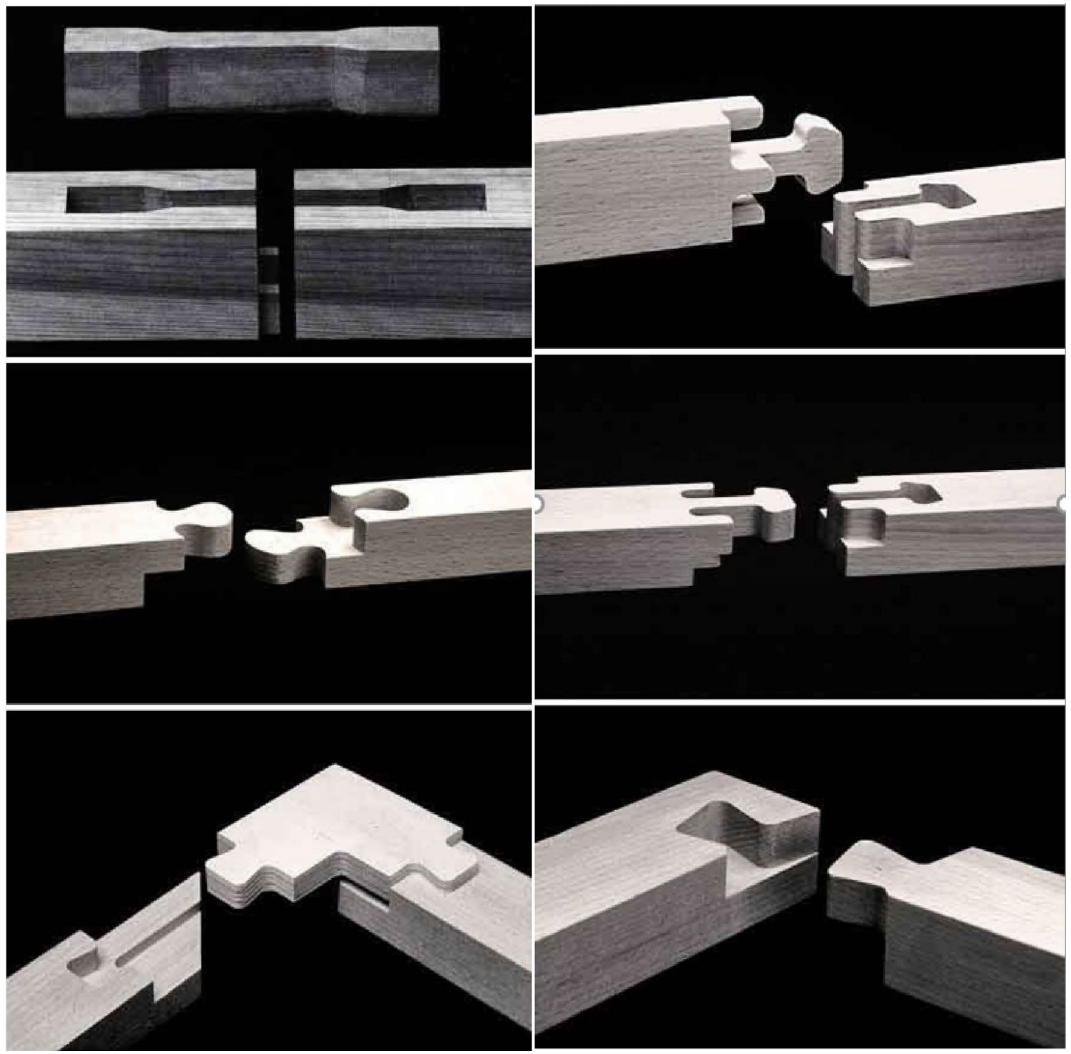


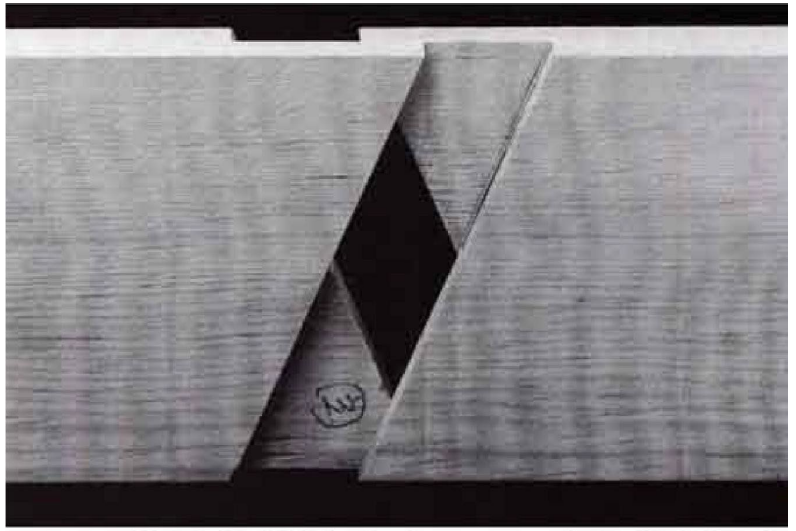
PROPOSED FLOOR SYSTEM

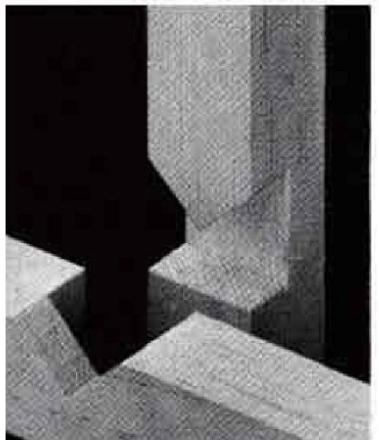
(OPTION 1)



Japanese Joinery Examples





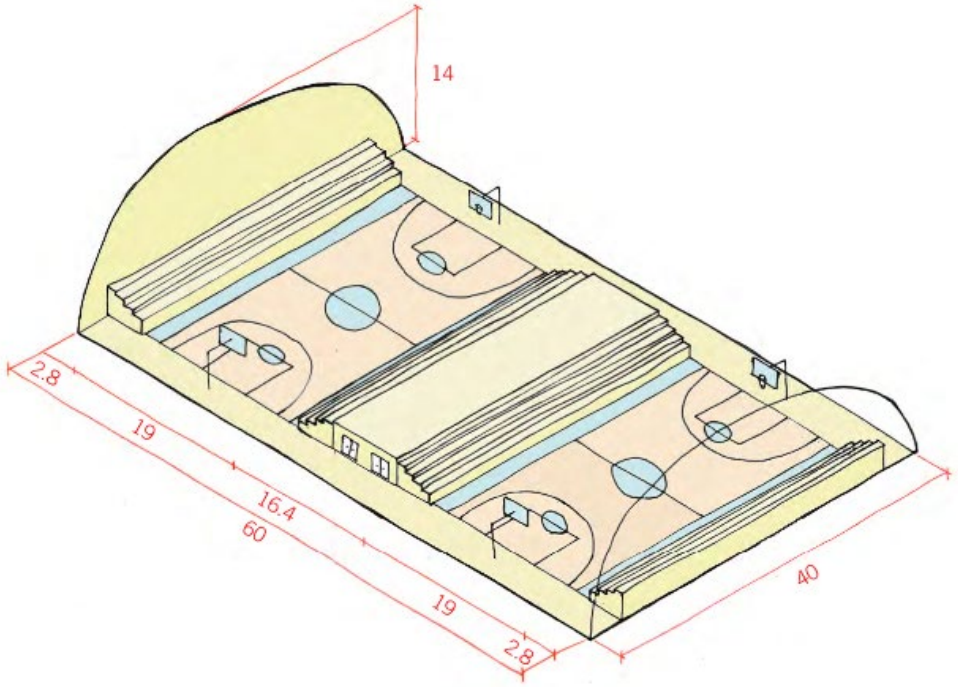


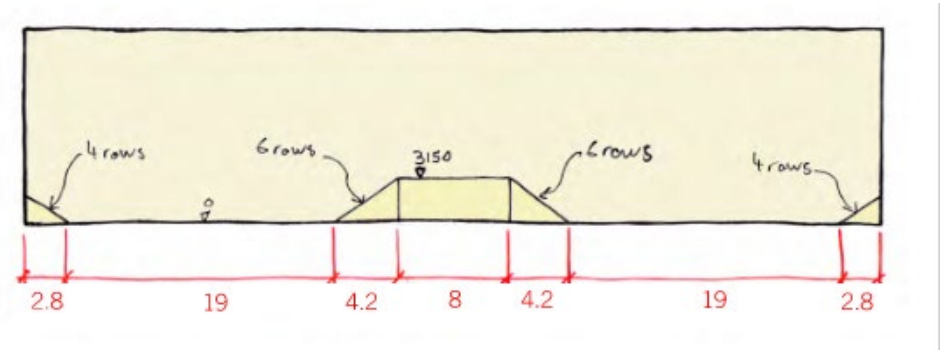
2. Design Parameters

The following design parameters have been established for the purposes of the cross-comparison exercise.

2.1 Court Layout

The structure is to accommodate 2 basketball courts. The arrangement of these courts is still undecided. The below arrangement has been selected for the



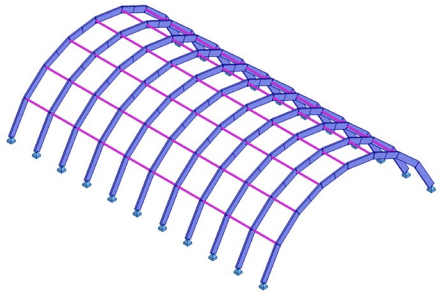


1. INTRODUCTION

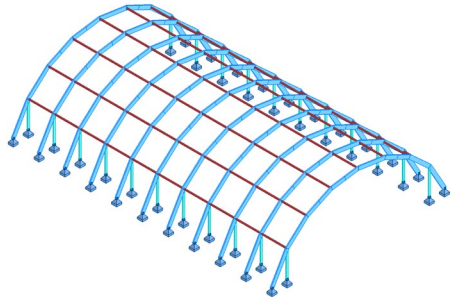
This document compares various structural forms proposed for the project - Fort Erie Basketball Court.

Stability in lengthwise direction is not yet addressed and thus will require further bracing.

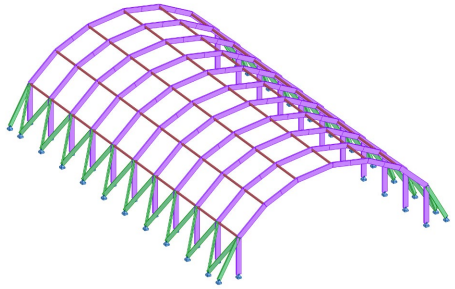
Barrel Arch Without Props



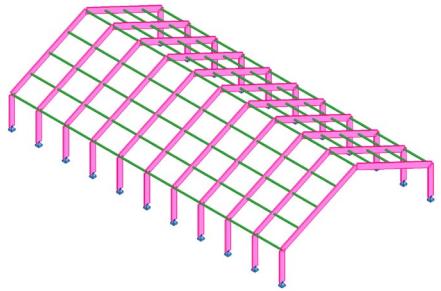
Barrel Arch With Props



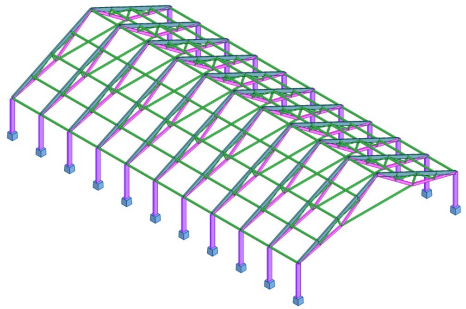
Barrel Arch With Props and Releases



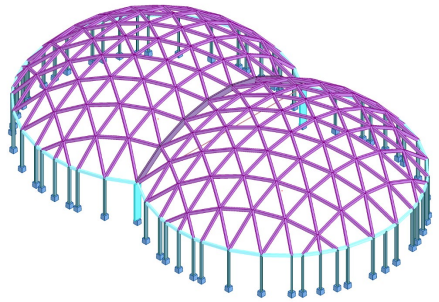
Portal Frame



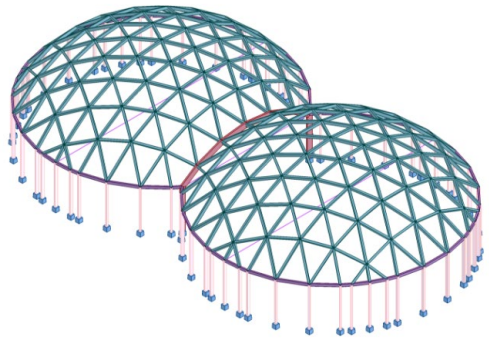
Pitched Roof



Dome Arrangement A



Dome Arrangement B

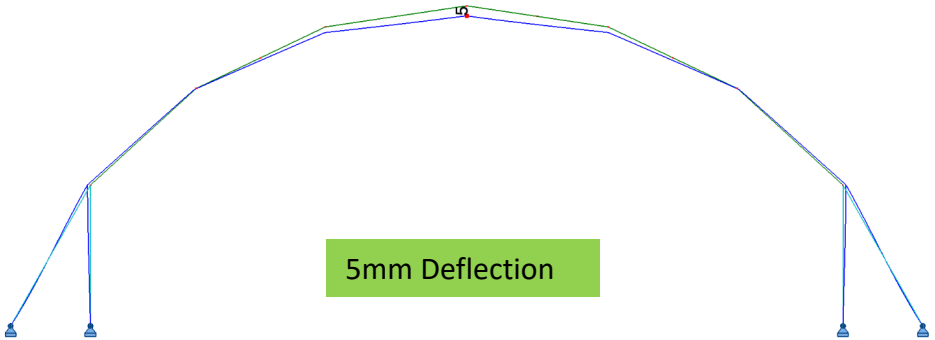


3. Comparison Exercise

3.3 Barrel Arch – Propped and Released

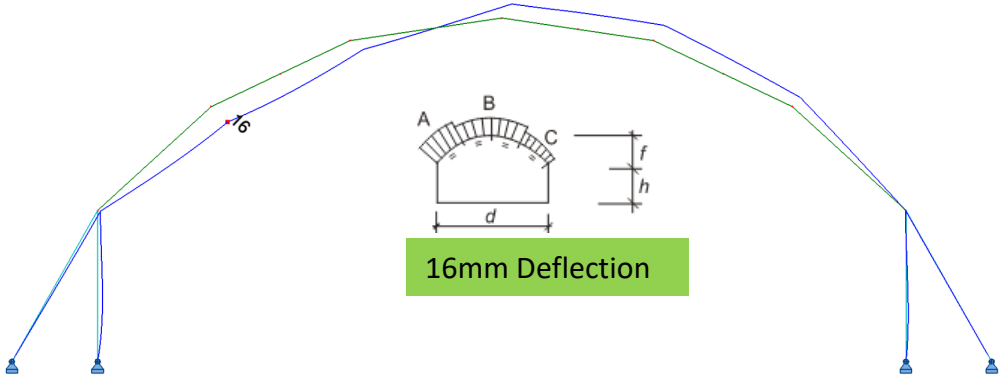
3.3.4.2 Deflection cases

DEAD LOAD



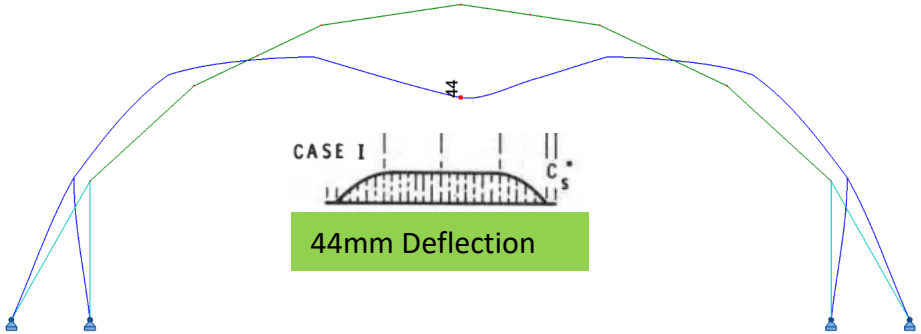
5mm Deflection

WIND LOAD



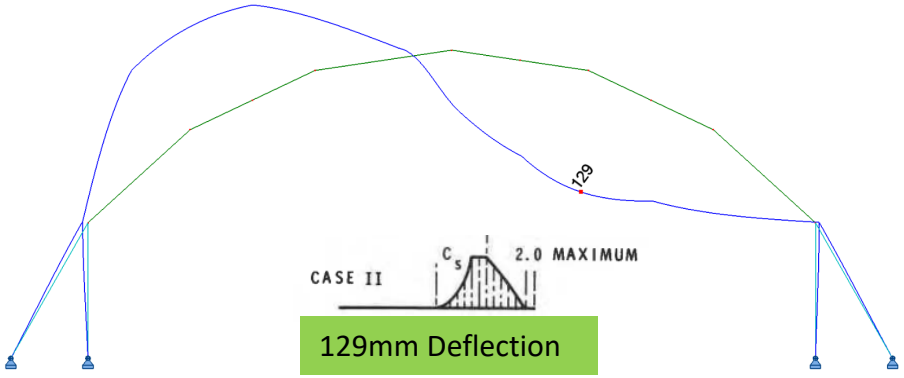
16mm Deflection

SNOW LOAD -1



44mm Deflection

SNOW LOAD -2

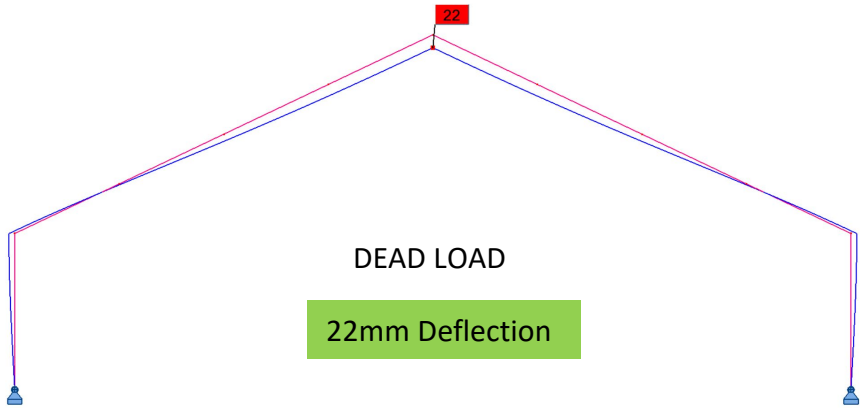


129mm Deflection

3. Comparison Exercise

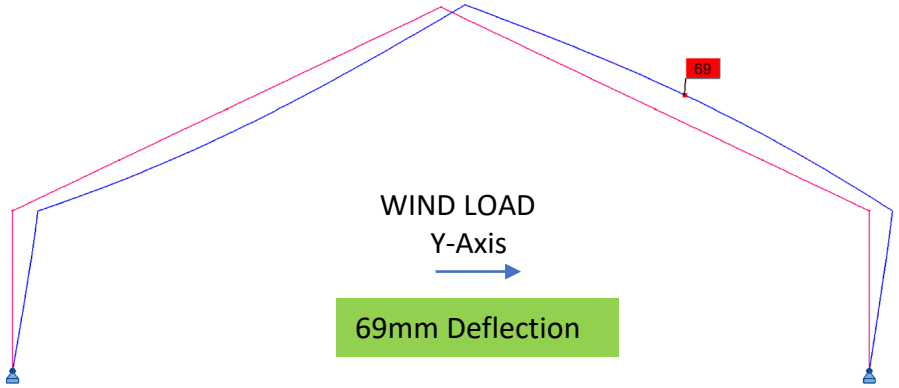
3.4 Portal

3.4.4.2 Deflection Cases



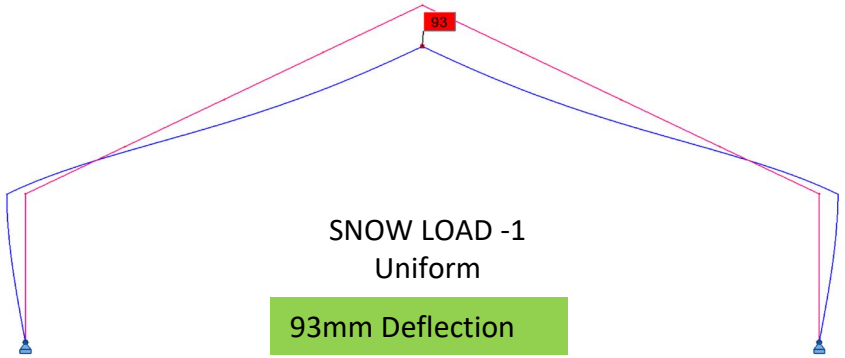
DEAD LOAD

22mm Deflection



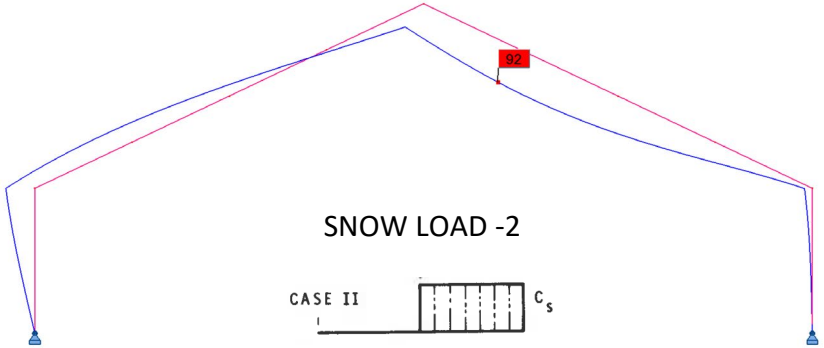
WIND LOAD
Y-Axis

69mm Deflection



SNOW LOAD -1
Uniform

93mm Deflection



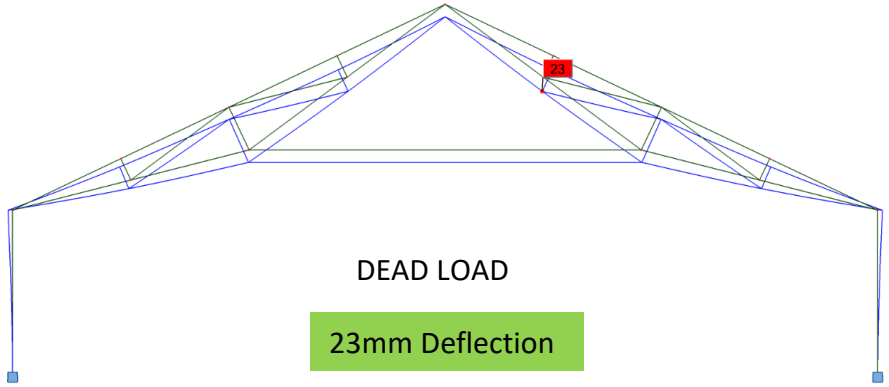
SNOW LOAD -2

92mm Deflection

3. Comparison Exercise

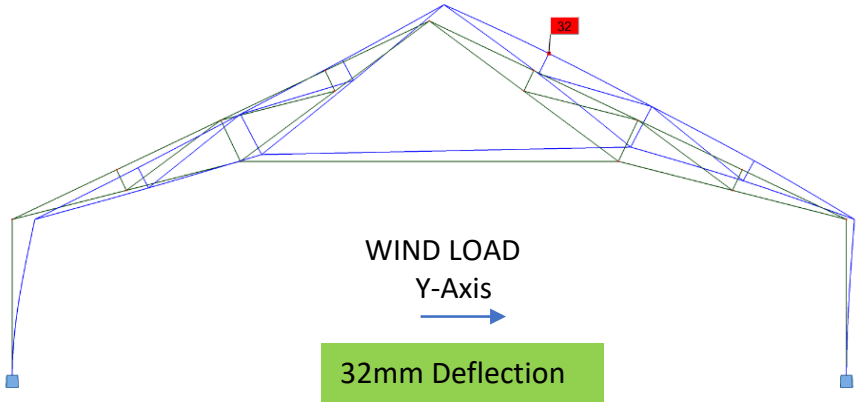
3.5 Pitched Roof

3.5.4.2 Deflection Cases



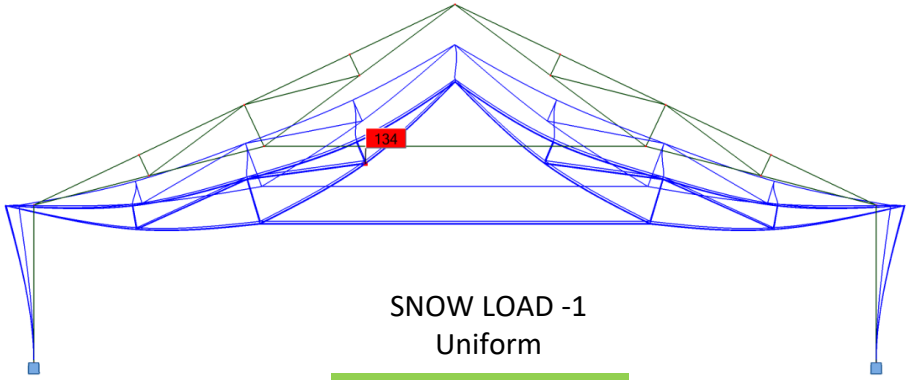
DEAD LOAD

23mm Deflection



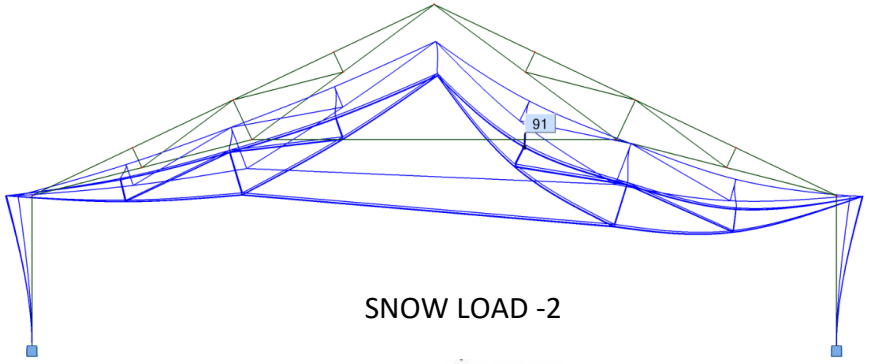
WIND LOAD
Y-Axis

32mm Deflection



SNOW LOAD -1
Uniform

134mm Deflection



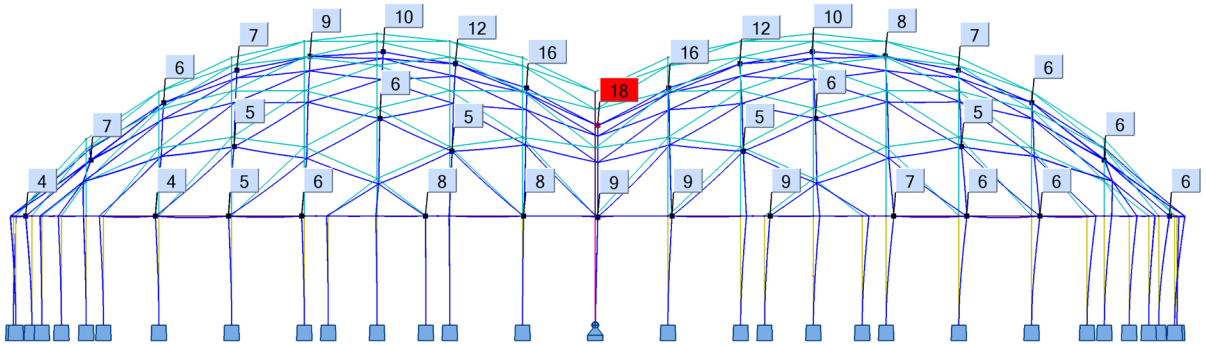
SNOW LOAD -2

91mm Deflection

3. Comparison Exercise

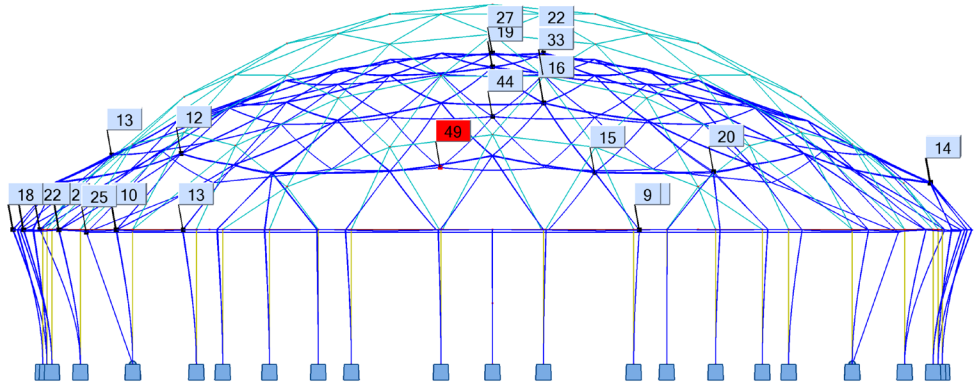
3.6 Domed Roof – Pinned Internal Dome A

3.6.4.2 Deflection Cases



DEAD LOAD

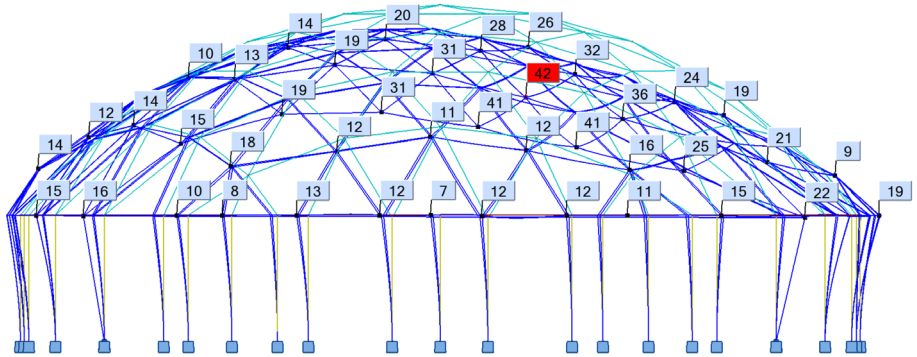
18mm



SNOW LOAD -1

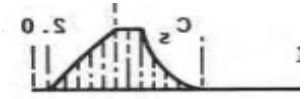
Uniform

49mm



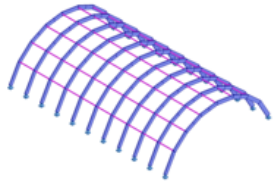
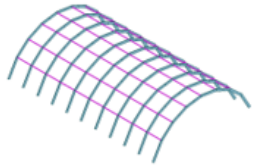
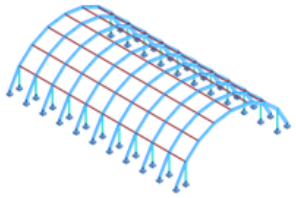
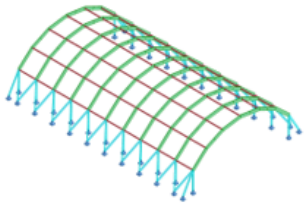
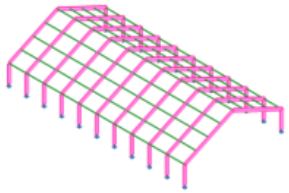
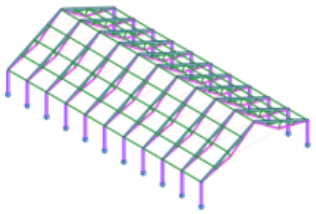
SNOW LOAD -2

Asymmetric

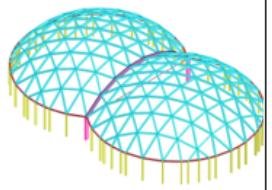
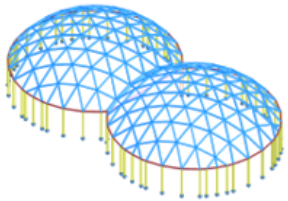
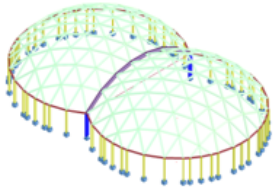
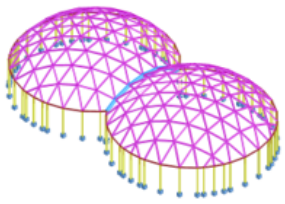
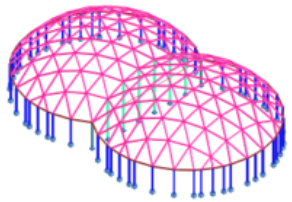
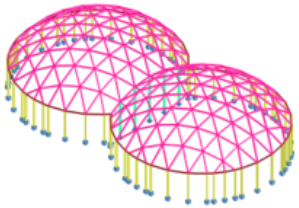


42mm

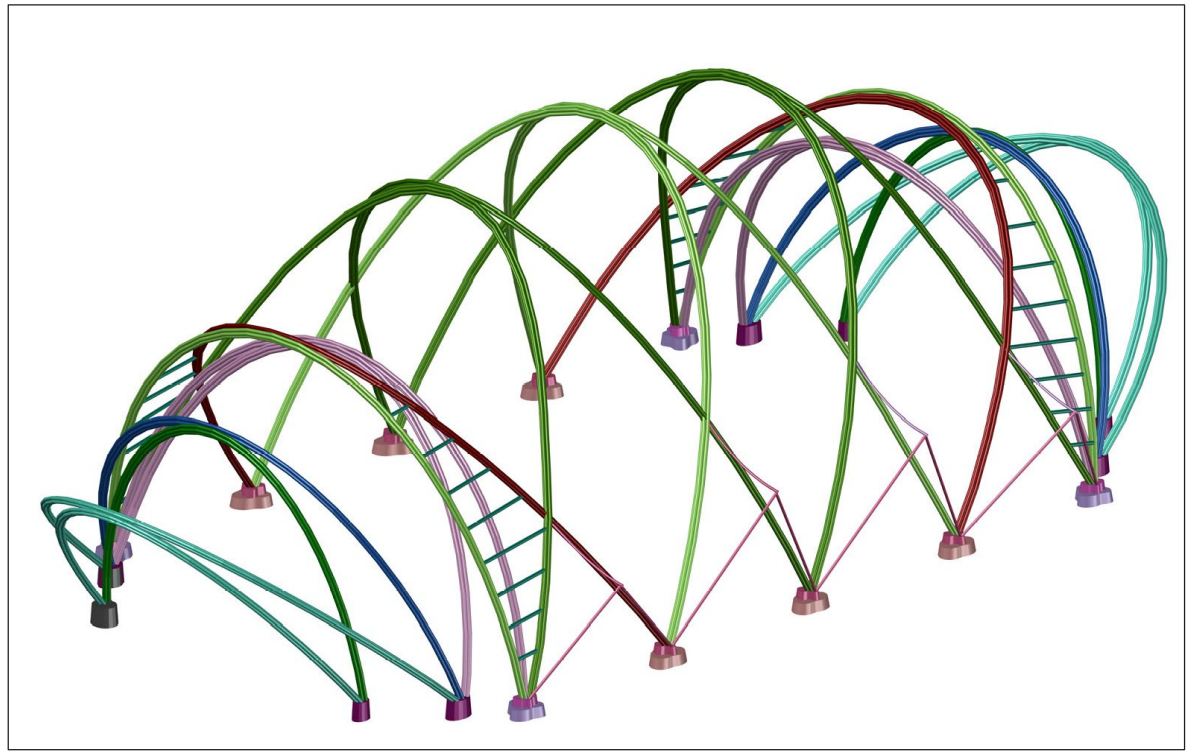
4. Comparison Summary

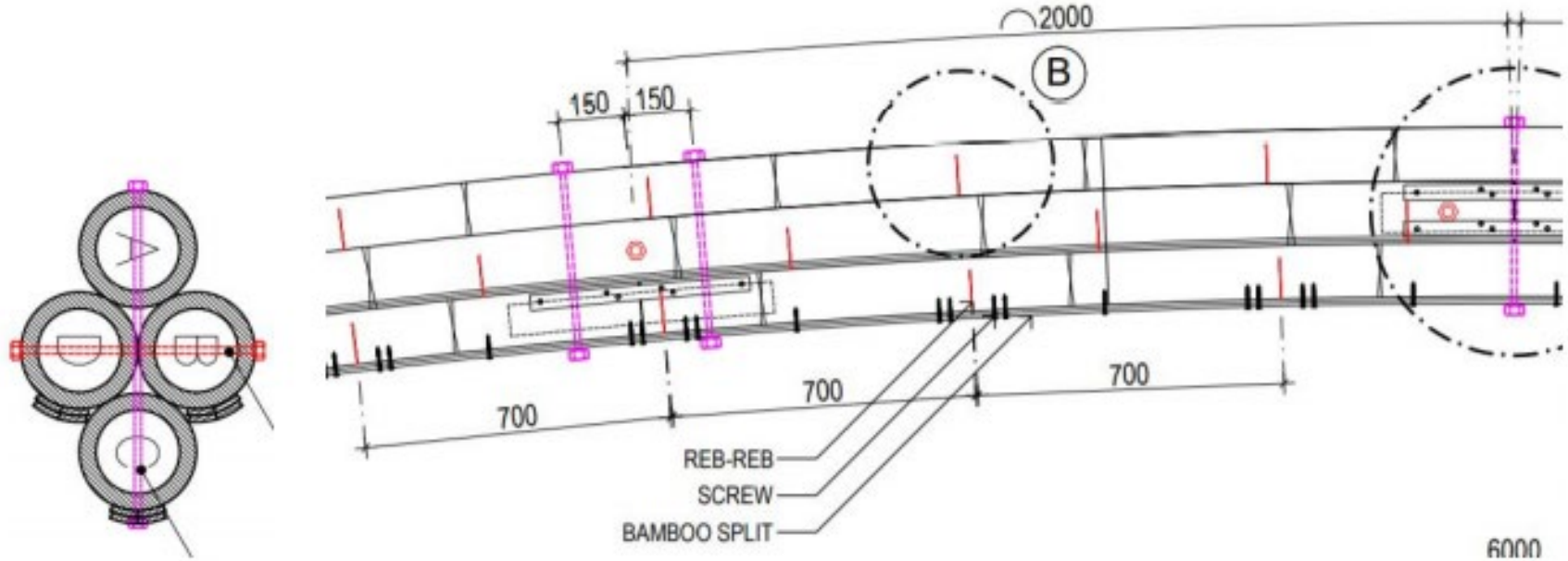
Scenario	1. Barrel Arch – No Prop						2. Barrel Arch – Prop			3. Barrel Arch – Propped and Released			4. Portal			5. Pitched Roof		
	1a. Deflection Limit: L/200			1b. Deflection Limit: None														
																		
Section Sizes	Arch	1000 x 300	U: 0.54	Arch	800 x 200	U: 0.98	Arch	800 x 200	U:0.97	Arch	850 x 200	U:0.93	Beams	1100 x 200	U: 0.79	Top Chord	600 x 200	U: 0.76
							Column	400 x 200	U:0.38	Column	400 x 200	U:0.98	Columns	1100 x 200	U:0.98	Bottom Chord	400 x 200	U: 0.98
										Back Props	400 x 200	U:0.95				Truss Members	200 x 200	U: 0.24
																Tie	89.3 CHS	U: 0.86
																Columns	800 x 200	U: 0.96
Total Volume	231 m^3			117 m^3			128 m^3			133 m^3			144 m^3			173 m^3		
Deflection Envelope	85mm L/211			309mm L/58.25			104mm L/200			129mm L/162			93mm L/354			132mm L/250		
Additional notes	• Effective length = 0.85L • All joints fixed			• Effective length = 0.85L • All joints fixed			• Effective length = 0.85L • Arch joints fixed; column joint pinned			• Effective length = 0.85L • Arch joints fixed; column joint pinned, back prop joint pinned			• Effective length = 0.85L • Lateral restraints taken at 2.3m centres • All joints fixed			• Effective length = L • All joints pinned • Lateral restraints for top chord taken at 2.3m centres		

4. Comparison Summary

Scenario	6. Pinned Domes						7. Fixed Domes						8. Fixed Domed – Internal Props					
	6a. Arrangement A			6b. Arrangement B			7a. Arrangement A			7b. Arrangement B			8a. Arrangement A			8b. Arrangement B		
																		
Section Sizes	CENTRAL ARCH	800 X 200	U:0.82	CENTRAL ARCH	950 X 250	U:0.91	CENTRAL ARCH	900 x 250	U:0.79	CENTRAL ARCH	900 x 250	0.88	CENTRAL ARCH	250 X 200	0.33	CENTRAL ARCH	250 X 200	0.24
	INTERNAL DOME STRUCTURE	350 X 250	U:0.93	INTERNAL DOME STRUCTURE	300 x 250	U:0.93	INTERNAL DOME STRUCTURE	250 X 250	U:0.75	INTERNAL DOME STRUCTURE	250 X 250	0.98	INTERNAL DOME STRUCTURE	250 X 200	0.75	INTERNAL DOME STRUCTURE	250 X 200	0.74
	RING BEAM	200 X 200	U:0.43	RING BEAM	200 x 200	U:0.49	RING BEAM	200 X 200	U:0.23	RING BEAM	200 X 200	0.49	RING BEAM	200 X 200	0.23	RING BEAM	200 X 200	0.24
	CENTRAL COLUMN	800 X 250	U:0.81	CENTRAL COLUMN	600 x 200	U:0.83	CENTRAL COLUMN	600 x 200	U:0.74	CENTRAL COLUMN	600 x 200	0.9	CENTRAL COLUMN	300 X 300	0.28	CENTRAL COLUMN	300 X 300	0.40
	PERIMETER COLUMNS	400 X 200	U:0.34	PERIMETER COLUMNS	400 x 200	U:0.4	PERIMETER COLUMNS	400 x 200	U:0.32	PERIMETER COLUMNS	400 x 200	0.38	PERIMETER COLUMNS	400 X 200	0.98	PERIMETER COLUMNS	400 X 200	0.82
Total Volume	Internal Dome – 133 m^3 Central Arch – 5 m^3 Ring Beam – 6.25 m^3 Columns - 27 m^3			Internal Dome - 127 m^3 Central Arch - 5 m^3 Ring Beam - 7 m^3 Columns - 34 m^3			Internal Dome – 95 m^3 Central Arch - 5m^3 Ring Beam – 6.25 m^3 Columns – 29.5 m^3			Internal Dome - 105 m^3 Central Arch - 5 m^3 Ring Beam - 7 m^3 Columns - 34 m^3			Internal Dome - 78 m^3 Ring Beam – 6.25 m^3 Columns - 31 m^3			Internal Dome – 92.7 m^3 Ring Beam - 7 m^3 Columns - 38 m^3		
Deflection Envelope	53mm L/530			54mm L/518			53mm L/530			42mm L/666			42mm L/666			47mm L/595		
Additional notes	• Effective length = L • Internal dome joints are pinned			• Effective length = L Internal dome joints are pinned			• Effective length = 0.7L • All internal dome joints fixed • Connection to central arch pinned • Connection to ring beam pinned			• Effective length = 0.7L • All internal dome joints fixed • Connection to central arch pinned • Connection to ring beam pinned			• Effective length = 0.7L • All internal dome joints fixed • Connection to columns fixed • Connection to ring beam pinned •			• Effective length = 0.7L • All internal dome joints fixed • Connection to columns fixed • Connection to ring beam pinned		


SOCCER FIELD




2000
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REB-REB
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