

LSAA 2016 WORKSHOP :

FEASIBLE BASIC SHAPES FOR TENT-TYPE (MECHANICALLY STRESSED) MEMBRANE STRUCTURES

OBJECTIVE

The objective is to provide a guide to simple model methods for the preliminary design (formfinding) of mechanically stressed membrane structures (tents) for further development of structural shape (by experimental and/or digital means).

REQUIRED MATERIALS AND TOOLS

Materials:

XPS rigid foam panel (30mm):

(Bunnings uncut: XPS Knauf Insulation board 1200x600x30mm @\$12.50; uncut with cutting service available at extra cost: Foamex Bayswater XPS board 2440x1220x30mm @ 21.60)

approx 2m white brickline for cable support and/or cable boundaries (comes in 50m spools-can be shared)

(Bunnings/Hardware shops)

Sataysticks or wood dowel 10mm diameter for point supports (mast)

4-5x (sticks), 1m (dowel)

(Supermarket/Bunnings Hardware)

Ladies pantihose XL (white colour) 1x

(Kmart/Supermarket)

Mild steel wire coathangers for arch or frame supports and as edge cable template

(Kmart or second-hand at Laundry and Dry-Cleaning shops)

about 50 push-pins with large head and 50 map-pins

(Officeworks-Stationery shops)

Superglue 1x

(Officeworks-Stationery shops)

Cardboard or cutting board underlay for cutting materials

(Officeworks)

Transparent drafting paper

(Officeworks)

10 Sheets of A4 white paper

Tools:

Pencils, thin permanent OH-Marker 0.5mm black, scissors, small modelknife (sharp blades), larger modelknife (Stanley), set of pliers, set square, compasses, measuring tape, cutting edge

FOR SPECIAL ATTENTION:

MATERIALS AS LISTED HAVE BEEN PROVEN AS MOST SUCCESSFUL AND SHOULD NOT BE REPLACED WITHOUT RISKING AN ADVERSE IMPACT ON CONSTRUCTION TIME REQUIRED AND MODEL QUALITY.

GUIDE FOR MODEL CONSTRUCTION

1.1. Select a model from the matrix of possible shapes. The shapes are defined by their support (single surface, mast, arch or frame, mast and cable) and edge condition (rigid edge such as beam or frame, flexible cable edge).

MATRIX MOEGLICHER VARIATIONEN: UNTERSTUETZUNG UND RAND

		POINT SUPPORTS				POINT & LINE SUPPORTS	LINE SUPPORTS [FRAMES]					
		Pa point	Pb ring	Pc hump	Pd batten	PL point cable	La portal	Lb inclined	Lc arch			
Rigid boundary										1	Rigid boundary	
Cable boundary										2	Rigid boundary	
										3		
										4		
		POINT SUPPORTS									5	
		Pf single loop	Pf dual loop	Pg rosette						6		
Rigid boundary										7	Cable/rigid boundary	
Cable boundary										8		

**MATRIX OF POSSIBLE SHAPE VARIATIONS IN PLAN VIEW:
SUPPORT AND BOUNDARY**

PROCESS:

-prepare base-board for the model

having determined the outline of the membrane surface in plan cut a scaled version of this plan from the foam panel (approx dimensions not to exceed 20 cm in width and 40cm in length)

-prepare (panti-hose) stretch-fabric:

Cut a piece corresponding to the length of the plan (max 40cm) from the upper leg-part of the pantihose (do not use the hose or the reinforced section of the leg!!), then cut it open lengthwise to obtain a piece approx 20cm – 25cm wide and max.40cm long

-prepare supports:

dependig on the type of chosen support (mast, arch, mast and cable):

a. Mast:

Determine position (centre) and mastheight (max 10cm) and cut a corresponding piece of dowel or stick (+thickness of board), push the mast into the board and fix a suitable support for the fabric-membrane on top (circle of cardboard, styrofoam sphere, table tennis ball etc).

b. Arch:

When cutting the base board allow an additional 3cm on each side for positioning of arch supports.

Determine the position of support points (e.g.at diagonal corners) and rise (max height=10cm) of the arch and draw a section through the arch onto a A3 sheet of paper. Then draw a semi-circle through these 3 points, place this paper onto the base-board, determine the length of the arc (add twice the board thickness at each end for supports) and cut a piece of straight wire of the same length from a wire cloth hanger.

Place the wire on the board over the shape of the arc and bend it gently until the correct arch-shape is achieved. Then push the ends of the arch into the base-board.

c. Mast and cable:

Determine the curve (length) of cable using a piece of jewellery chain by suspending it between cable anchorage points and the mast-top (mast construction as in a.). Cut a corresponding piece of plumb-line (+8cm!!!) and fasten it centrally from the masttop to the anchorage on the baseboard (4cm of line should extend over each of the achorages at both ends!!)

-attach the stocking-material to the prepared support-system:

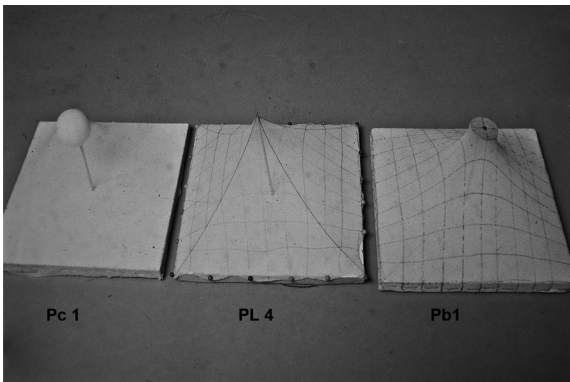
Take the fabric and place it centrally over the support-system. Observe symmetry. Now stretch the fabric carefully, first centrally and then progressively towards the corners of the baseboard and fix it to the edges of the base-board using map-pins. Control even stretching by feel of tension in the fabric. Cut-off excess fabric below the edge.

-quick and dirty method for flexible (cable) edge:

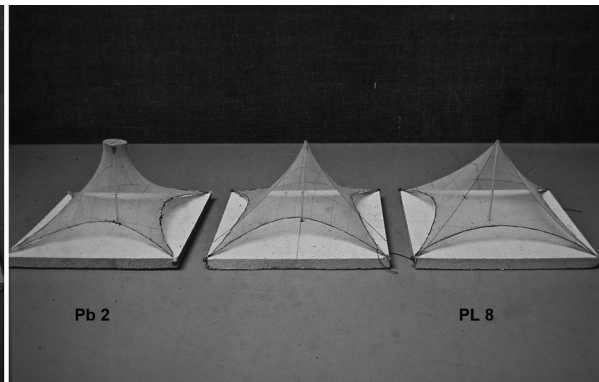
(not suitable for actual formfinding only for very preliminary appreciation of approximate shape)

confirm that anchorage points are firmly fixed to the board (extra pins), then release the stretch-fabric between anchorage points to produce a flexible (cable) edge.

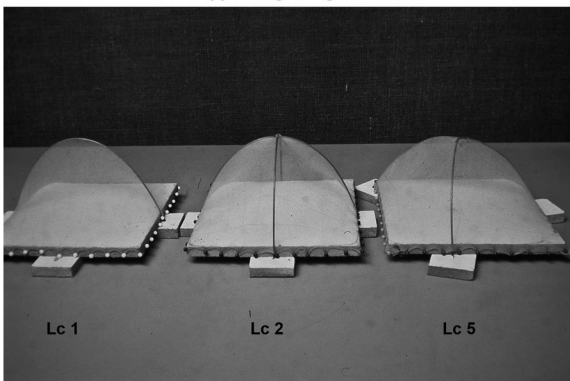
1.2 Photograph the model in simulated parallel light condition to obtain principal sections (approximate section curves) and a plan for the modelshape and document all this digitally. If there is access to a shapefinding program such as "Formfinder" develop the chosen shape digitally and compare the outcome.



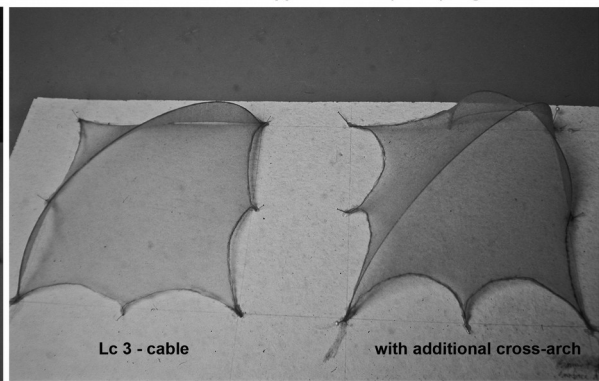
Mast and Mast-Cable Support Rigid Edge



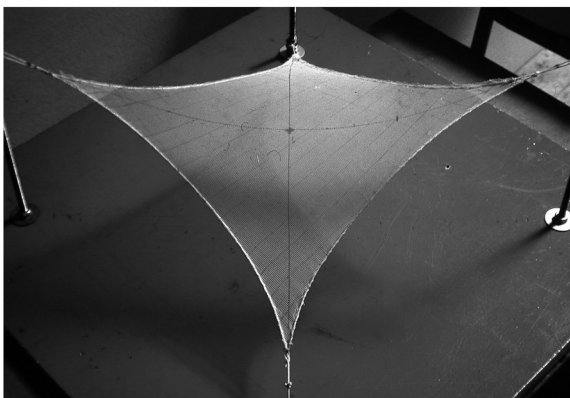
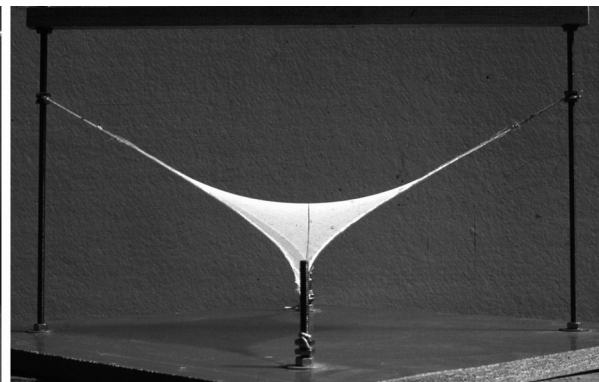
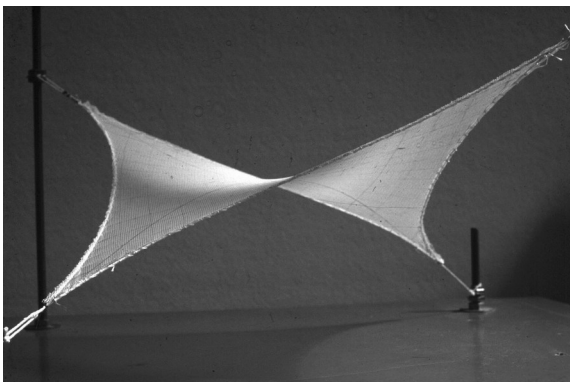
Mast and Mast-Cable Support Flexible (Cable) Edge



Arch Support Rigid Edge



Arch Support Flexible (Cable) Edge



Example of accurately constructed Formfinding model of a 4-point sail ("Hypar") with flexible (cable edges)