



## Tensile Fabric Structure Design Terminology

**Anticlastic** – A surface with positive (Gaussian) curvature in one principal direction and negative (Gaussian) curvature in the other. A saddle shape or potato chip.

**Bias** – Oriented at 45-degrees to the warp and fill directions of the fabric.

**Biaxial** – Taken along two concurrent orthogonal directions, usually principal directions.

**Cable Cuff** – Edge treatment in which the fabric is folded over on itself to form a pocket in which a catenary cable can be installed.

**Cable Fitting** – Device attached to the end of a cable to allow a connection to another member. Fittings can be swaged, speltered or compression type.

**Catenary** – The curve theoretically formed by a perfectly flexible, uniformly dense, inextensible “cable” suspended from each of two end points. In fabric structures, this shape is probably not ever truly developed, but is commonly used to describe the shape developed at the boundary of a uniformly stressed fabric structure attached to a cable which is restrained only at its end points.

**Catenary Cable** - Steel cables that run through the pockets on the perimeter of a tension structure fabric. The shape of the cable follows that of the pocket, which is typically curved with a ratio of 1:10. The length and thickness of the cable is to be determined by the engineer supplying the modeling and reaction loads.

**Clevis** – Device used with a cable stud end or a threaded rod to form a pinned connection that is somewhat adjustable.

**Coating** – A material applied to a fabric for waterproofing and protection of the fabric yarns.

**Compensation** – The allowance in the design of material in the unstressed condition that will account for the tension and stretch in membrane or cables.

**Elongation** – The change in material lengths. Normally this is associated with a load or force acting on the material. In membrane, this elongation does not refer to true strain of the fiber elements but refers to the “apparent” strain resulting from tension on the material.

**Fill & Warp Yarns** – The shorter yarns of a fabric, which usually run at right angles to the warp yarns (also known as weft yarns). **Warp Yarn** – The yarns in the long, straight direction of a piece of fabric.

**Form Finding** (AKA "Form Generation") – The process of determining the equilibrium shape of a tensioned membrane structure.

**Guy Cable** - This steel cable is used to support the structural integrity of the steel frame. It may be attached at the ends of the steel struts (or “arms”) to hold them together and resist them from movement relative to each other. Unlike catenary cables, the lengths are calculated by a straight point-to-point dimension.

**Hysteresis** – The failure of fabric to return to its original geometry after the strain-inducing force has been removed.

**Keder Cord** – A solid pieces PVC cord used at a “rope edge”. Rope edges provide strength and a surface to evenly distribute fabric tension forces.

**Light Transmission** – A measure of the portion of light striking a fabric surface that passes through the fabric and into the space.

**Mast** – The principal upright in a tension membrane structure.

**Membrane** – The fabric panels used in tension structures. PTFE, PVDF, VCP and HDPE are widely used. They are available totally opaque where not light penetrates to varying degrees of translucency allowing natural or artificial light to filter through. The membranes are available with a wide range of top finishes (think a Teflon coated pan) which are used on fabric for greater protection against UV degradation and for the ease and natural cleaning purposes. Some brand names are Ferrari’s PVDF named “T2®” or Dupont’s PVF named “Tedlar®” or “Kynar®”.

**GOOD** - VCP or “Polyvinylchloride”, properly mixed with plasticizers for flexibility and applied to a polyester scrim substrate provides a high strength and popular material used in tension structures. The life expectancy ranges from 15 to 25 years with premium top coatings like Kynar™ available. Costs are proportionally lower than PVDF and PTFE. Material weight will range from 22 to 32 ounces per square yard.

**BETTER** - PVDF or Polyvinylidene fluoride is a highly non-reactive and pure thermoplastic fluoropolymer produced by the polymerization of vinylidene difluoride. PVDF is a specialty material in the and is used generally in applications requiring the highest purity, strength, and resistance to solvents, UV and low smoke generation during a fire event. Weight will range from 28 to 39 ounces per square yard.

**BEST** - PTFE or “Polytetrafluoroethylene”, commonly known by its trademark name Teflon™. This coating is applied to a fiberglass scrim to produce a high strength tension structure fabric membrane with a life expectancy of thirty five or more years. Weight will range from 29 to 45 ounces per square yard.

**PREMIUM** – Tenara™ is the most expensive membrane used in fabric architecture. Tenara is a fully woven fabric that drapes smoothly allowing full movement in retractable roof structures and sun shades. Highly translucent it captures and filters more light than other membranes. It is unaffected by damaging UV rays, acid rain, salt water and other environmental challenges. Made of high-strength fibers, it will flex and fold countless times without cracking or losing strength. It’s easy to clean and naturally resistant to stains, mold and mildew.

**ETFE** or “Ethylenetetrafluoroethylene”. This is a very high tech material that was originally developed for the space industry and is unique in that it does not degrade under ultraviolet light or atmospheric pollution. ETFE foil can be supplied as a single layer membrane supported by a cable net or as a series of pneumatic cushions made up of two or three layers supported by an aluminum frame system. The ETFE copolymer is extruded into thin films (or foils) which are used to form these single layer or multi-layer cushions.

ETFE foil is extremely long lasting with an estimated life of 50 years and it can be used as part of any permanent building envelope. The surface is very smooth and has anti-adhesive properties enabling the envelope to self clean with natural rainfall.

ETFE combines exceptional light transmission with high insulation. Each layer can incorporate different types of solar shading enabling the designer to optimize the aesthetic and environmental performance of the building.

**HDPE** – or High Density Polyethylene is the most affordable fabric of heavy duty woven open mesh that blocks up to 95% of harmful UV rays. This superior Fire Rated Knitted shade fabric is designed for use in modular shade structures and shade sails. Weight will range from 12 to 14 ounces per square yard.

**Membrane Plate & Clamp** – Metal plates attached to the membrane corners used for securing the membrane to the frame. **Membrane Clamp** – Device for clamping the edge of a membrane panel, usually a bar or channel shape and made of aluminum or steel.

**Node Points** – Intersection points of the elements used to define the fabric shape in the structural analysis; these are normally given in terms of a three-dimensional co-ordinate system.

**Patterning** – The process of defining two-dimensional pieces of fabric, which are welded together to form a three-dimensional shape. M-Panel and AutoCAD software assist in the process of patterning.

**Radius of Curvature** – The inverse of the magnitude of (Gaussian) curvature at a location on a membrane surface. The magnitude is typically considered in two principal directions. The orientation of the principal directions and their magnitude may vary continuously over the surface.

**Sectionalizing** – Method of field joining large fabric panels utilizing engineered clamping hardware.

**Spelter** – Type of cable fitting in which the strands of the cable are opened inside the fitting and molten lead is poured into the fitting to secure the cable.

**Stay Cable** – A steel cable that is used to stabilize the mast in response to the forces created by wind loads. The stay cables are used to resist movement of the structure relative to the earth. One end of the cable will typically connect to the end of the steel frame near the fabric connection. The other end will terminate to a sturdy section of the mast or a footing in the ground.

**Swage** – Type of cable fitting in which a sleeve fits over the outside of the cable and the sleeve is compressed around the cable to form a tight fit.

**Synclastic** – A surface with positive (Gaussian) curvature in both principal directions. A bubble or dome shaped surface.

**Uniaxial** – Taken along one direction, usually a principal direction.