

CathCAD®

The Software for Designing your Next MicroCatheter

Ron Roth, Ph.D.
Roth Technologies, LLC

sales@cathcad.com

Background

- Education
 - Ph.D. – Georgia Tech (1992)
 - Controls, Dynamics and Vibration, and Mechanics of Materials
- HV Tech/MedSource/Accellent
 - VP of Engineering (1992 - 2004)
- EControls, LLC
 - VP of Manufacturing (2005 – 2011)
 - Advisory Engineering (2012 – Present)
- Roth Technologies (2012 – Present)
- Contact Info – Ron Roth
 - Email: sales@cathcad.com
 - Phone: 210-380-9890

CathCAD[®] Release History

- Product released August, 2012
- Current Software consists of three products
 - CathCAD[®] Standard (braid and nonbraid)
 - CathCAD[®] Advanced (multi-stranded braid, hybrid braid and spiral reinforced)
 - Multi Lumen (ML) CathCAD[®]
- All products use the SAME analytical computational engine.
- The front end (data input) of each product has been optimized for the particular application
- Software does NOT utilize empirical data or “rules of thumb”

CathCAD® Customer Base (2020)

- Fifty+ Licensed Companies (50% market)
- 150+ Active Users
- Worldwide User Base
 - USA, Australia, Germany, Ireland, UK, India, Japan
- 91,000+ model runs executed since 2013

- We believe the potential User base is around 100 Companies

CathCAD[®] FOUNDATIONS

- Basic Assumptions
 - Long ($L/R \gg 1$) and Thin Walled ($Wall/R \ll 1$)
 - Isotropic Materials (material behaves the same in all directions)
 - Linear Elastic Behavior (Small Deflections)
 - Perfect Concentricity and Lamination (no voids, ...)
- Classical Lamination Theory
 - Jones, R.M., *Mechanics of Composite Materials*, 1975.
 - Richardson, David, **The Fundamental Principles of Composite Material Stiffness Predictions**
 - Foundations used to calculate EA/ EI/GJ, and failure mode algorithms
- Tube Buckling (Kink Radius) governed by Brazier Effect
 - Brazier, L.G., "The Flexure of Thin Cylindrical Shells and Other Thin Sections," *Late of the Royal Aircraft Establishment*, Reports and Memo No. 1087 (M.49), May, 1926.
 - Used to calculate Buckling Kink Radius
- **ANSI/SCTE 51 2007 Method for Determining Drop Cable Braid Coverage Society of Cable Telecommunication Engineers**

CathCAD® Material Data

- CathCAD® includes a standard Materials and Braid Wire Databases which are hosted on a MySQL Server
- Materials include Polyimide, Polyurethanes, Nylon, LD/MD/HDPE, PeBax, and Fluoropolymers (FEP, PTFE, ETFE)
- Base material information comes from Vendor Datasheets
 - We have found over the last seven years that some vendors are “optimistic” with regards to material properties (especially w/ regards to the Nylons)
- The System can be easily updated with new materials
 - Each customer has their own (separate) database
 - Our CathACCESS® program allows the customer to directly to view, modify, add, subtract materials from the database
 - We also provide this service at no charge (24 hour turn around)
- Braid and Coil Wire sizes include flat and round braid wire sizes

CathCAD® Standard

- NonBraid
- Braid
- Up to Six Layers
- Exports to Excel
- Pick Count Macro

- Most commonly used by Users

CathCAD®: V2.3.0

STATUS BAR
 WAITING: Enter Composite Tubing Design

DIMENSIONS

Tubing ID (inches) Tubing OD (inches)
 Number of Layers Bend Radius (inches)

LAYER CONFIGURATIONS

Layer #	Config	Thick	Layer Material	Braid Wire Size	# of Wires	Pick Count	Braid Angle	SAC
Layer 1:	NonBraid	0.00100	PTFE					
Layer 2:	Braid	0.00200	PEBAX 72D	1 mil rd SS 304V ST	16 BW	80.0	46.89	0.207
Layer 3:	NonBraid	0.00150	PEBAX 72D					

MODEL OUTPUT

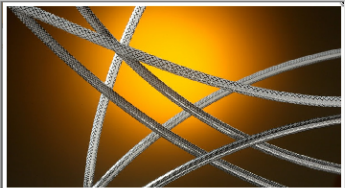
EI (lbs-inch**2)	0.01377	KR (inches)	0.230 / 0.175
EA (lb)	91.04	X ID (inches)	0.0300
GJ (lbs-inch**2)	0.04534	Y ID (inches)	0.0300
Burst (psi):	265 / 822	Tensile (lbs)	2.28 / 8.18
Ext Press (psi):	675.9	Torque (lbs-in)	0.6038

COMPUTE

EXPORT TO EXCEL

PICK COUNT MACRO

QUIT



CathCAD® Advanced

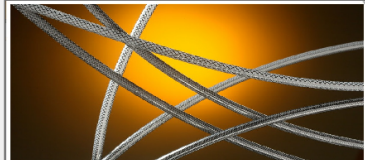
- NonBraid
- Braid
- Multi-stranded Braid
- Hybrid Braid
- Coil/Spiral Reinforced
- Up to Six Layers
- Export to Excel
- Pick Count Macro
- **Support for English/Metric units**
- Created to handle multi-stranded, hybrid, and coil reinforced designs

CathCAD®: V3.3.0

STATUS BAR
WAITING: Enter the Composite Tubing Design

DIMENSIONS

Tubing ID (inches) Tubing OD (inches)
 Number of Layers Bend Radius (inches)



LAYER CONFIGURATIONS

Layer #	Design	Thick	Layer Material	Braid/Coil Wire Size	Num of CW	Num of CCW	Num of Ends	PPI/WPI	Wire Angle	SAC
Layer 1:	NonBraid	0.00100	PTFE							
Layer 2:	Hybrid	0.002	PEBAX 72D	1 mil rd SS 304V ST	4 BW	4 BW	1 Strd	80.0	46.89	0.390
				0.5x3 mil SS 304V ST	4 BW	4 BW	1 Strd			
Layer 3:	NonBraid	0.0015	PEBAX 72D							

MODEL OUTPUT

EI (lbs-inch**2)	0.01465	KR (inches)	0.215 / 0.169
EA (lb)	96.79	X ID (inches)	0.0300
GJ (lbs-inch**2)	0.06336	Y ID (inches)	0.0300
Burst (psi):	263.4 / 893.8	Tensile (lbs)	2.42 / 8.99
Ext Press (psi):	823.5	Torque (lbs-in)	0.8436

COMPUTE

EXPORT TO EXCEL PICK COUNT MACRO

QUIT

MultiLumen (ML) CathCAD®

- MultiLumen Designer
 - Double D
 - Circle Crescent
 - Multiple Rd Lumens
 - User Entry
- NonBraid
- Braid
- Up to Three Layers
- Export to Excel

The screenshot displays the ML CathCAD® V1.2.5 Full ML software interface. The main window, titled "ML CathCAD® V1.2.5 Full ML", shows the "MultiLumen Designer" configuration. The "STATUS BAR" indicates "Enter MultiLumen Tubing Design". The "MULTILUMEN CONFIGURATION" section includes input fields for "Number of Layers" (3), "Overall OD (inches)" (0.05700), "IDx (inches) - ref" (0.03998), and "IDy (inches) - ref" (0.03818). The "CONFIGURATION" section shows "Base ML" as "MultiLumen Designer" and "MultiLumen Matl" as "PEBAX 72D". The "Layer 1" is "Double D ML". The "Secondary Configuration" table is as follows:

Layer	Configuration	Thickness (inches)	Layer Material
Layer 2:	Braid	0.00200	PEBAX 72D
Layer 3:	NonBraid	0.00150	PEBAX 72D

The "MODEL OUTPUT" section displays the following values:

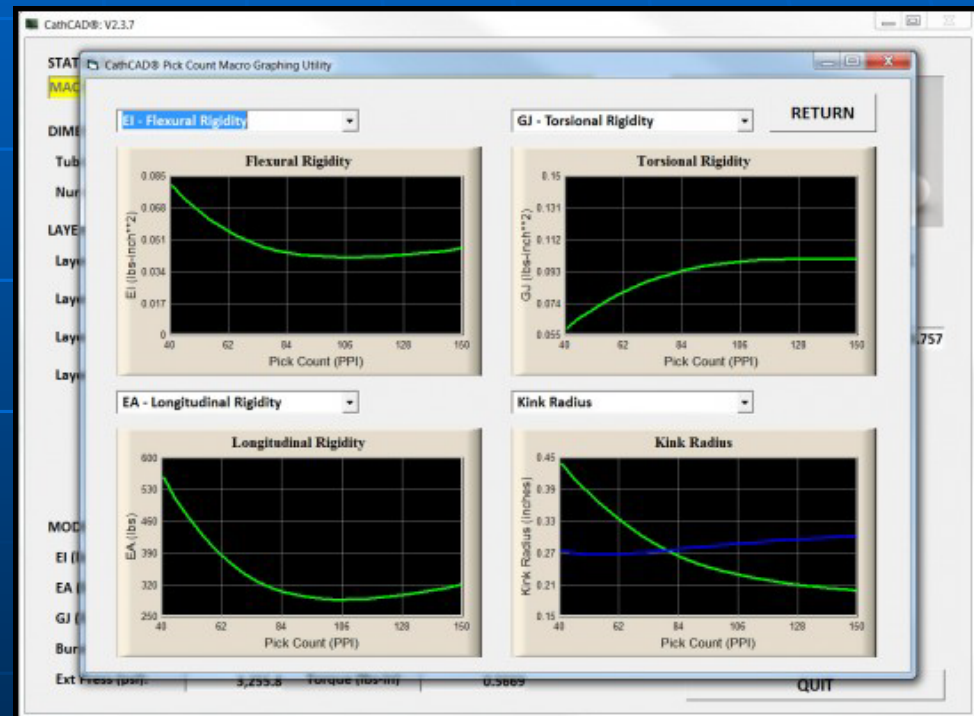
Elxx (lbs-inch**2)	0.04309	KR x-axis (inches)	0.155 / 0.232
Elyy (lbs-inch**2)	0.04356	KR y-axis (inches)	0.124 / 0.230
EA (lb)	159.64	Tensile (lbs)	3.99 / 19.96
GJzz (lbs-inch**2)	0.11308	Torque (lbs-inch)	1.4197
Ext Press (psi):	3,097		

An inset window titled "ML CathCAD® Double D Configurator" is overlaid on the main window. It shows the "STATUS BAR" with "Enter the parameters for a Double D Multilumen Design". The "INPUT FIELDS" section includes "OD (inches)" (0.0500), "ID (inches)" (0.0400), and "WALL (inches)" (0.0050). The "COMPUTED FIELDS" section includes "lxx (inches^4)" (1.8155E-7), "lyy (inches^4)" (2.078E-7), "Jzz (inches^4)" (3.8935E-7), and "Area (inches^2)" (9.0686E-4). A diagram of a double D lumen cross-section is shown with labels for OD, ID, and WALL. The "COMPUTE" button is highlighted.

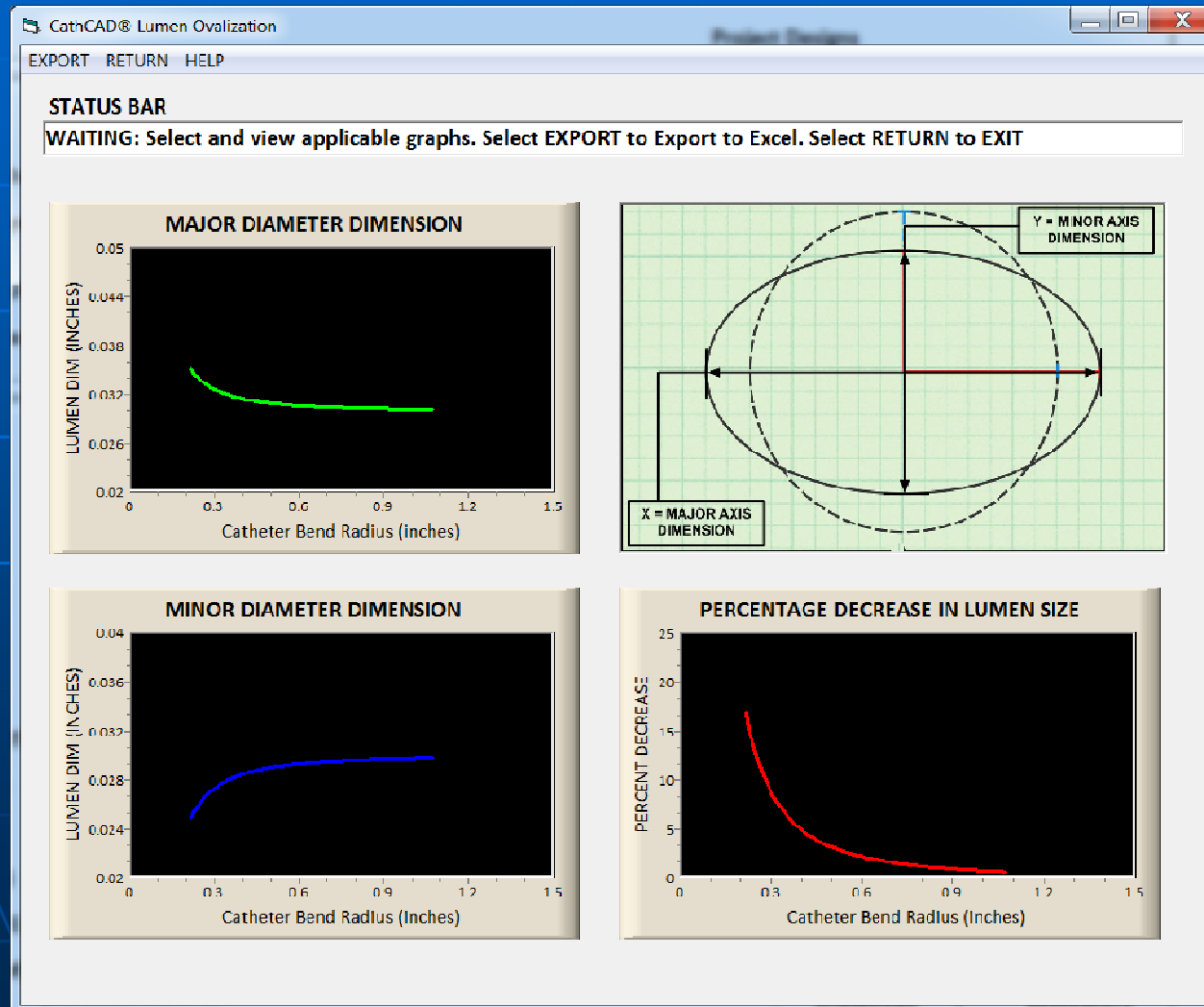
CathCAD® Pick Count Macro

- Enter pick count min, max, step size
- System computes automatically at each pick count
- Export results to Excel
- Built-in graphing of outputs

Saves you time and allows you to get a better feel for the design



CathCAD® Ovalization Model



CathCAD® Material Blending

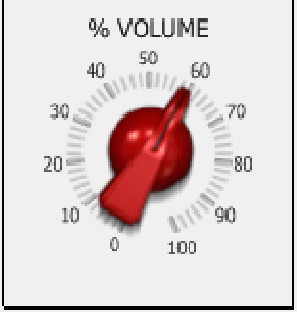
CathCAD(R) Matrix Material Blender Function

STATUS BAR
WAITING: Create your new material. Select SAVE/DISCARD when completed

Matrix Material 1: PEBAX 7233 SA01
MM1 Vol %: 60.0

Matrix Material 2: PEBAX 6333 SA01
MM2 Vol %: 40.0

% VOLUME



Blended Matl Name: New Mixed Material Name

Modulus of Elasticity: 58,566 psi

Tensile Strength: 7,512 psi

Poisson's Ratio: 0.300 unity

Validity:

DISCARD

SAVE

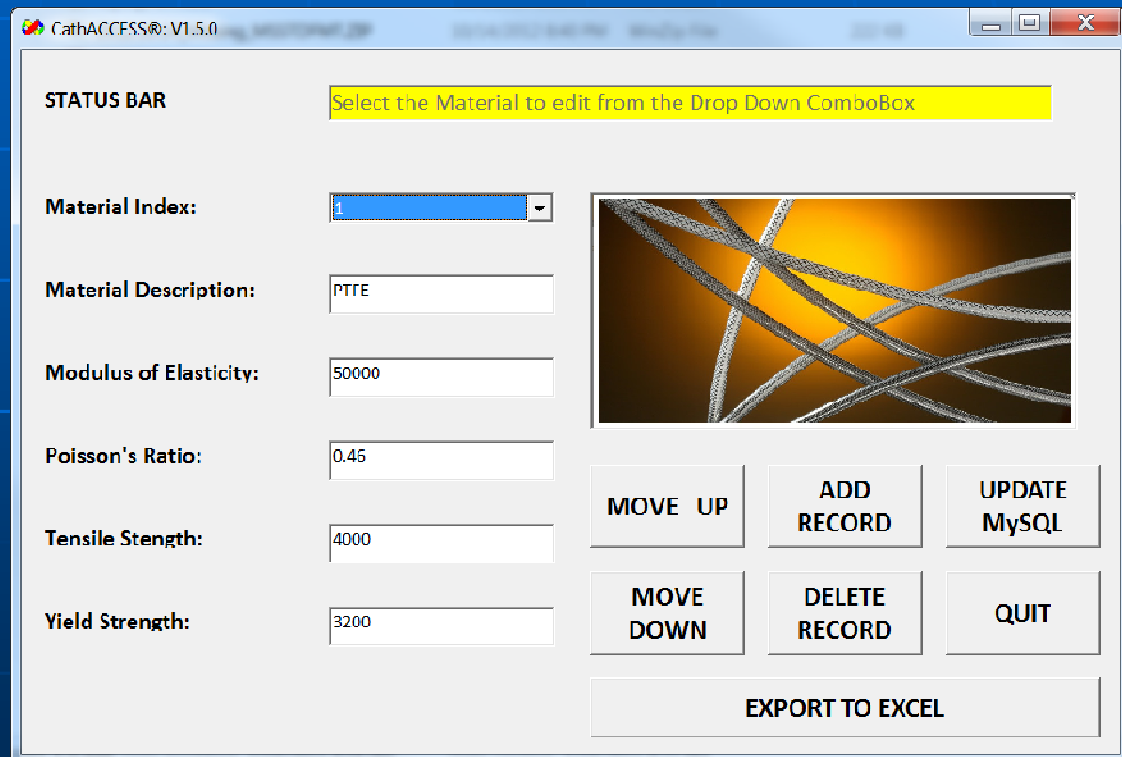
CathCAD® Exports Directly to Microsoft Excel

	A	B	C	D	E
1	MODEL RUN ID	UNITS	RT100108-01	RT100108-02	RT100108-03
2	ID	inches	0.0200	0.0200	0.0200
3	OD	inches	0.0260	0.0260	0.0260
4	WALL	N/A	3.0 mils	3.0 mils	3.0 mils
5	COMPOSITE LAYERED DESIGN Layer 1 = Inside Layer BA = Braid Angle SAC = Surface Area Coverage BM = Braid Matrix Material	Layer 1	1.0 mils Polyimide	3.0 mils Polyimide	3.0 mils PeBax 72D
6		Layer 2	0.5x3 mil SS 304V ST, 16 BW, 60.0 PPI, BA=28.5 DEG, SAC=61.3%, BM = Polyimide	N/A	N/A
7		Layer 3	1.0 mils Polyimide	N/A	N/A
8		Layer 4	N/A	N/A	N/A
9		Layer 5	N/A	N/A	N/A
10		Layer 6	N/A	N/A	N/A
11	CathCAD® OUTPUTS				
12	EI FLEXURAL STIFFNESS	lbs-inch**2	0.0354	0.0073	0.0009
13	EA LONGITUDINAL STIFFNESS	lbs	526.18	108.38	13.66
14	GJ TORSIONAL STIFFNESS	lbs-inch**2	0.0281	0.0056	0.0007
15	KINK RADIUS	inches	0.260 / 0.307	0.110 / 0.334	0.110 / 0.134
16	BEND RADIUS	inches	2.0000	2.0000	2.0000
17	X_DIM @ BEND RADIUS	inches	0.0200	0.0200	0.0200
18	Y_DIM @ BEND RADIUS	inches	0.0200	0.0200	0.0200
19					
20	TENSILE STRENGTH SF = 1	lbs	2.1883	4.3354	1.3657
21	MAXIMUM TORQUE SF = 1	lbs/inch**2	0.0184	0.0499	0.0157
22	BURST PRESSURE SF = 2	psi	1,260 / 6,656	2,609 / 3,000	378 / 822

Allows the User to spend more time running models rather than writing down the answers...

CathACCESS® Utility Program

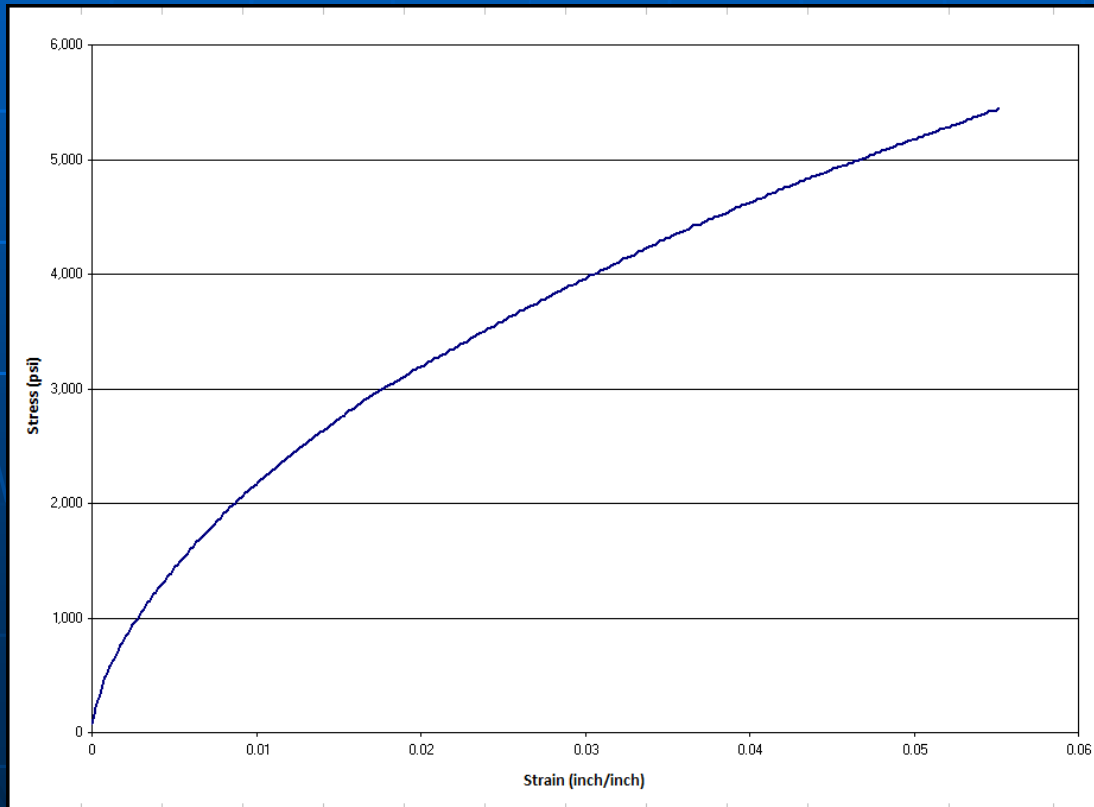
- Direct Access to the Materials (Matrix) Library
- Add/Subtract/Modify/Reorder



The screenshot shows the CathACCESS V1.5.0 utility program window. The title bar reads "CathACCESS®: V1.5.0". The interface includes a status bar at the top with the text "Select the Material to edit from the Drop Down ComboBox". Below this, there are several input fields for material properties: "Material Index" (a dropdown menu showing "1"), "Material Description" (text box with "PTFE"), "Modulus of Elasticity" (text box with "50000"), "Poisson's Ratio" (text box with "0.45"), "Tensile Strength" (text box with "4000"), and "Yield Strength" (text box with "3200"). To the right of these fields is a small image showing a network of fibers. At the bottom right, there are six buttons: "MOVE UP", "ADD RECORD", "UPDATE MySQL", "MOVE DOWN", "DELETE RECORD", and "QUIT". A large button labeled "EXPORT TO EXCEL" is located at the bottom center of the window.

0.0165x0.0220 Braided Composite Tube

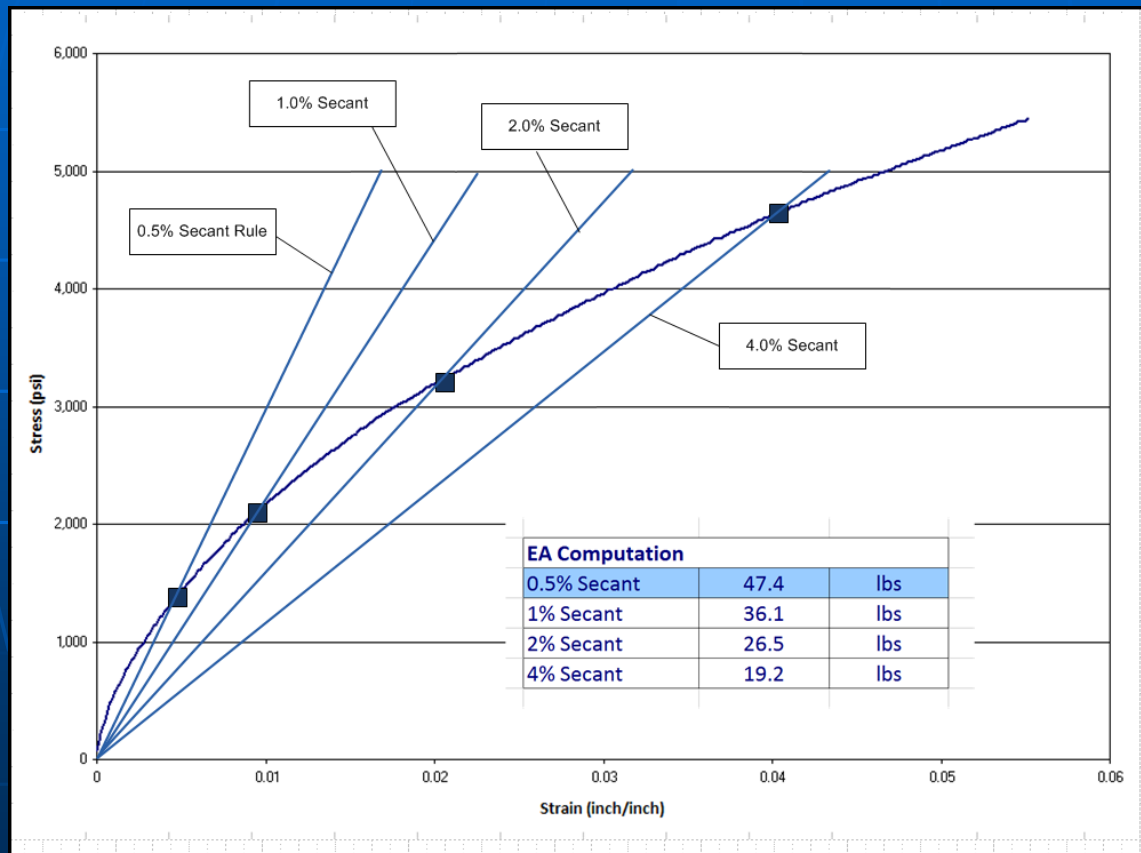
- 0.0165"x0.0220" Braided Composite Tube Design
- CathCAD® Model EA = 54 lbs
- Question: What is the Modulus of Elasticity?



Actual derived stress-strain curve derived from tensile test (elongation) of prototypes (qty = 5X)

0.0165x0.0220 Braided Composite Tube

Answer: It depends on what slope curve you use....



Use 0.5% Secant rule as the design is a braided design and the model assumes small deflections.

EA Measured = 47.4 lbs

Model = 54 lbs

Error = 14.8 percent

CathCAD® Validation Results

MODEL RUN ID NUMBER	UNITS	RT100052-01	RT100052-02	RT100052-03	RT100052-04
ID	(inches)	0.0298	0.0298	0.0300	0.0301
OD	(inches)	0.0380	0.0381	0.0385	0.0392
WALL	N/A	4.1 mils	4.2 mils	4.3 mils	4.6 mils
COMPOSITE LAYERED DESIGN	N/A	0.5 mils Polyimide / 1.5 mil rd SS 304V ST, 16 BW, 36.0 PPI, BA=25.5 DEG, SAC=23.3%, BM = FEP / 0.6 mils FEP	0.5 mils Polyimide / 1.5 mil rd SS 304V ST, 16 BW, 46.0 PPI, BA=31.4 DEG, SAC=24.6%, BM = FEP / 0.65 mils FEP	0.5 mils Polyimide / 1.5 mil rd SS 304V ST, 16 BW, 68.0 PPI, BA=42.2 DEG, SAC=28%, BM = FEP / 0.75 mils FEP	0.5 mils Polyimide / 1.5 mil rd SS 304V ST, 16 BW, 144.0 PPI, BA=62.6 DEG, SAC=42.7%, BM = FEP / 1.05 mils FEP
CathCAD(R) OUTPUTS					
EI FLEXURAL STIFFNESS	(lbs-inch**2)	0.0690	0.0478	0.0236	0.0170
EA LONGITUDINAL STIFFNESS	(lbs)	473	327	159	112
GJ TORSIONAL STIFFNESS	(lbs-inch**2)	0.0475	0.0620	0.0872	0.0990
PREDICTED KINK RADIUS	(inches)	0.444	0.340	0.191	0.094
PUBLISHED KR	(inches)	0.500	0.313	0.200	0.100
ERROR IN KR	N/A	-12.6%	8.1%	-4.7%	-6.4%
REQUIREMENT	N/A	<= 50%	<= 50%	<= 50%	<= 50%
PASS/FAIL	N/A	PASS	PASS	PASS	PASS
COMPUTED E (CathCAD®)	(lbs/inch**2)	1,083,248	738,771	347,694	225,320
PUBLISHED E	(lbs/inch**2)	1,078,650	741,010	322,713	178,388
ERROR	N/A	0.43%	-0.30%	7.74%	26.31%
REQUIREMENT	N/A	<= 30%	<= 30%	<= 30%	<= 30%
PASS/FAIL	N/A	PASS	PASS	PASS	PASS

0.075" x 0.108 Vestamid Braided Design

MODEL RUN ID	UNITS	DF100006-03	Experimental
ID	inches	0.0750	0.0750
OD	inches	0.1080	0.1080
WALL	N/A	16.5 mils	16.5 mils
COMPOSITE LAYERED DESIGN Layer 1 = Inside Layer BA = Braid Angle SAC = Surface Area Coverage BM = Braid Matrix Material	Layer 1	4.0 mils Vestamid L2101F (Secant Modulus)	4.0 mils Vestamid L2101F
	Layer 2	3x5 mil SS 304V ST, 16 BW, 30.0 PPI, BA=46.4 DEG, SAC=37.2%, BM = Vestamid L2101F (Secant Modulus)	3x5 mil SS 304V ST, 16 BW, 30.0 PPI, BA=46.4 DEG, SAC=37.2%, BM = Vestamid L2101F
	Layer 3	6.5 mils Vestamid L2101F (Secant Modulus)	6.5 mils Vestamid L2101F
	Layer 4	N/A	N/A
	Layer 5	N/A	N/A
	Layer 6	N/A	N/A
CathCAD® OUTPUTS			
EI FLEXURAL STIFFNESS	lbs-inch**2	1.6193	
EA LONGITUDINAL STIFFNESS	lbs	1498.58	1418.00
GJ TORSIONAL STIFFNESS	lbs-inch**2	6.0737	
KINK/MATL FAILURE RADIUS	inches	0.372 / 0.785	0.7500
BEND RADIUS	inches	2.0000	
X_DIM @ BEND RADIUS	inches	0.0755	
Y_DIM @ BEND RADIUS	inches	0.0745	
TENSILE STRENGTH SF = 1	lbs	37.465 / 110.759	
MAXIMUM TORQUE SF = 1	lbs-inch	21.5072	
INT BURST PRESSURE SF = 2	psi	410 / 1,970	
EXTERNAL COLLAPSE PRESSURE	psi	410	

MCerebus® Equipment Monitoring

- Equipment "Watchdog"
- 6"x4"x4" Form Factor
- WIFI Network required

A screenshot of the MCerebus mobile application interface. The status is displayed as follows:

MAC ID	5C:CF:7F:1A:2C:FC
Description	Subzero 400
Switch Setting	ON
Operating State	RUNNING
Box Temp	70.1 °F
WiFi Strength	-73.0 dBm

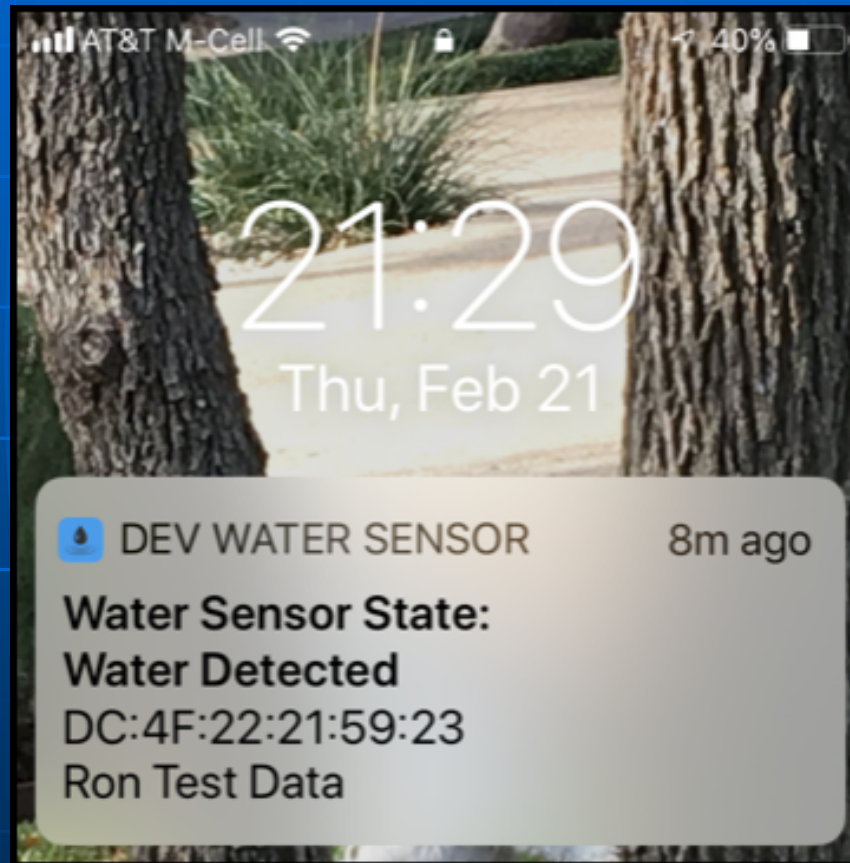
Last Time Record

2019-02-14 21:37:25

Status

Monitoring Summary

iPhone PUSH Notification



Ron Roth, Ph.D.
Roth Technologies, LLC
sales@cathcad.com
210-380-9890

CathCAD®, ML CathCAD®, CathACCESS®, and MCerberus® are
Registered Trademarks owned by Roth Technologies, LLC