Bio-Bridge Built with Hemp and Nomex

Erik Larson ▪ Ingram School of Engineering ▪ Texas State University – San Marcos

Advisors: Dr. Jitendra Tate and Shane Arabie

This bridge won 3rd prize at SAMPE (Society for Advancement of Materials and Process Engineering) Lightweight Bridge Building Contest at Annual Conference, Long Beach on May 20, 08.

Benefits of Natural Fiber Composites

With increasing environmental awareness in a society striving toward a "greener" future, it is easy to see the pragmatic use for such materials. Natural fibers can be relatively inexpensive, have low densities, be easily recycled, give off just as much carbon dioxide when burned as they absorb while growing, and most importantly, can be grown from the earth. Being organic, natural fiber does have some limitations that make it take a back seat to other man-made fibers such as glass, carbon, and boron.

Limitations of Natural Fiber Composites

Natural fiber, compared to other matrix materials, is less durable, contains a lower strength, and is not available in a variety of different weaves.

Why Hemp?

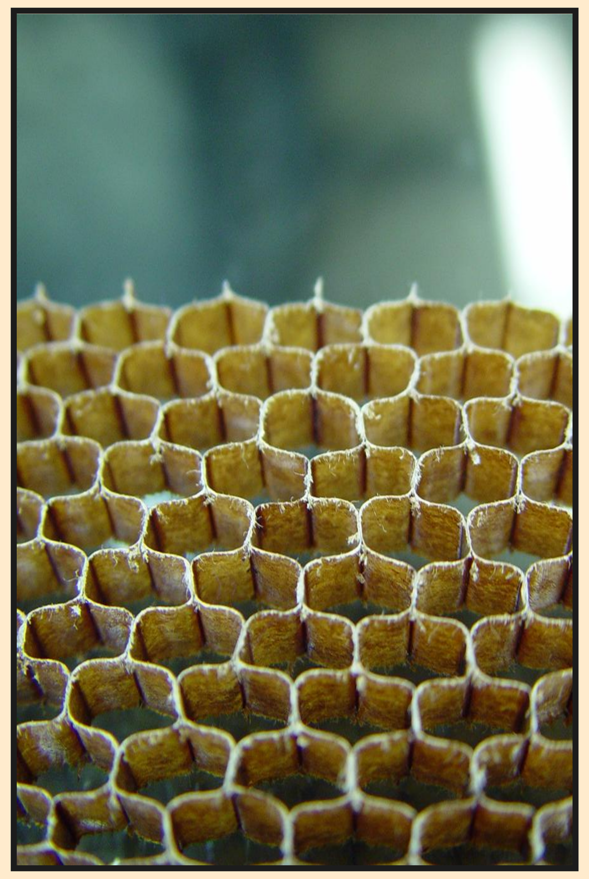
Hemp was chosen as a reinforcement material because of its high strength compared to other natural fibers. A local shop in town called The Hemp Store sold a woven fabric that was used for the roadway, trusses, and cross-members. The original design was to include coconut coir but was later changed.

Why Nomex?

If Nomex was not supplied in the kit, buying some would not have been an option due to its extremely high price. However, the honeycomb sandwich structure using two flat panels of hemp as the skins make for an extremely strong and lightweight roadway.

Hemp Fabric

Nomex



More about Hemp and Nomex

Hemp has a very good balance of tensile strength and tensile modulus which makes it a great natural fiber for construction of a load bearing structures. Also, hemp has a relatively high specific strength which gives it lighter and stronger characteristics.

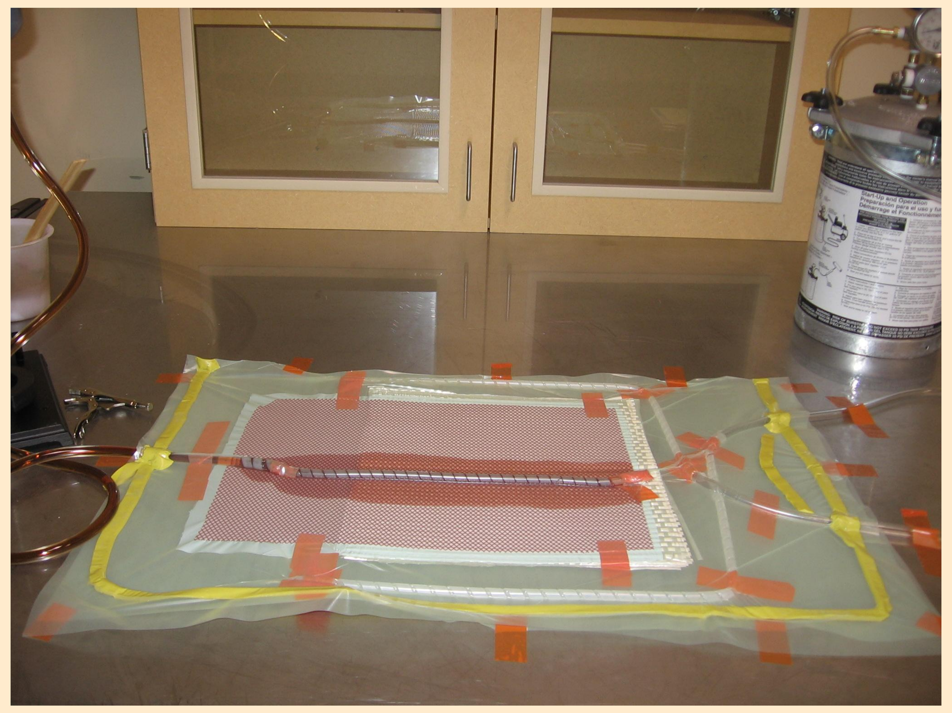
Honeycomb Nomex, which is actually made from Kevlar paper, is usually dipped in a phenolic resin to produce a honeycomb core with high strength and very good fire resistance.

The Future of Natural Fiber Composites

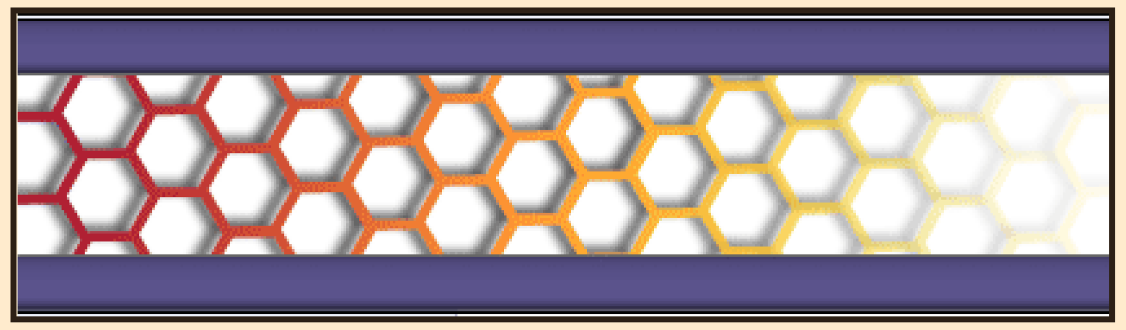
As written in the May/June 2008 edition of the SAMPE Journal, natural fibers are rapidly emerging in composites applications where glass fibers (predominantly E-glass) have been traditionally used. With many consumer products stressing environmental impact, the use of natural fibers should grow tremendously in the near future.

Manufacturing

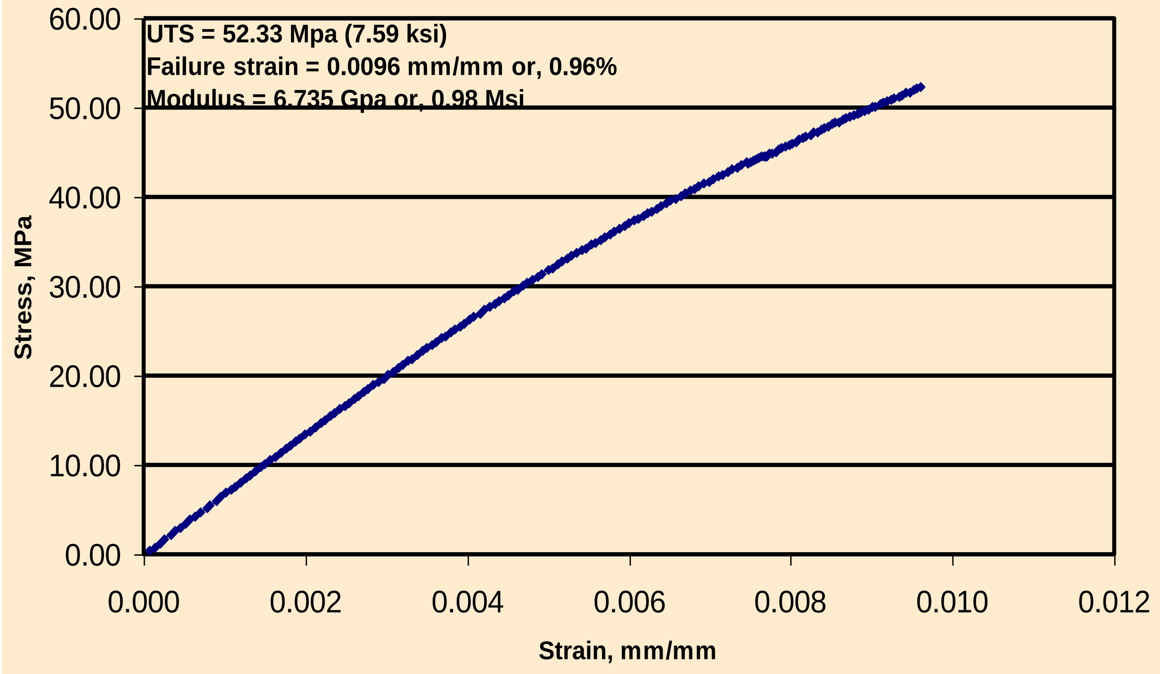
This bridge was built with simple hand lay-up and vacuum bagging. All of the panels, trusses, and cross-members were created and later assembled.



The flat panels and piece of honeycomb Nomex were bonded together with 3M 460 DP epoxy to make a sandwich structure.

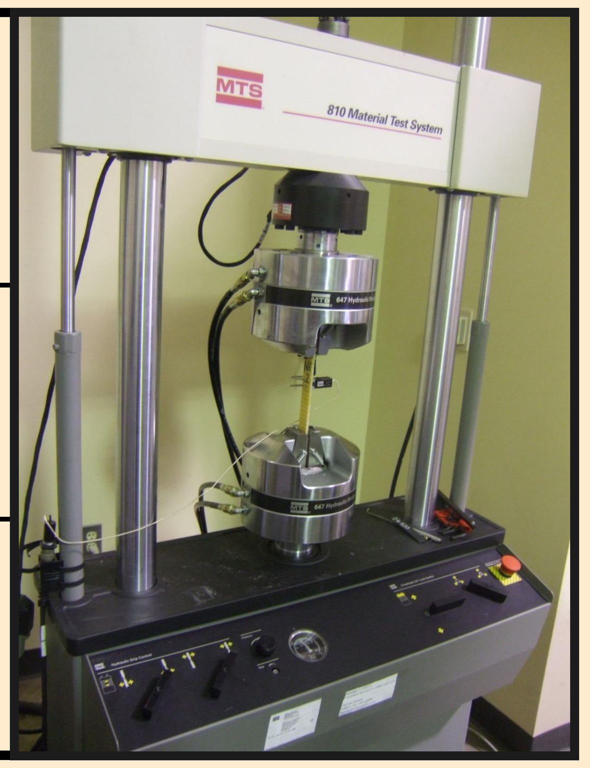


Stress vs Strain: Hemp/Epoxy Composites



Testing: Tension, Compression, and Bend

Vf, fiber volume fraction	0.6
UTS (MPa), Ultimate	52.33
E (Gpa), Tensile Modulus	6.735



Mechanical and Physical Properties of Natural Fibers

Fiber	*Density (gm/cm²)*	*Tensile Strength (ksi)*	*Tensile Modulus (msi)*	*Range of Elongation (%)*
Flax	1.50	75 - 215	4	2.7 - 3.2
Hemp	1.47	100	10	2.0 - 4.0
Kenaf	1.45	135	7.7	1.60
Jute	1.30	55 - 110	3.8	1.5 - 1.8
Ramie	1.50	60 - 135	8.9 - 18.6	3.6 - 3.8
Sisal	1.50	75 - 90	1.4 - 3.2	2.0 - 2.5
Coir	1.20	85	0.6 - 0.9	~30
Cotton	1.55	60	0.8 - 1.8	3.0 - 10.0
E-Glass	2.56	290 - 350	10	3.00
S-Glass	2.57	665	12.5	2.80
Aramid(Commercial)	1.44	435 - 455	9.0 - 10.0	3.3 - 3.7
Carbon (PAN Std. Mod.)	1.67	580	33 - 35	1.4 - 1.8

Ref # SAMPE Journal, Volume 44, No. 3, May/June 2008, pp 64

Special thanks to:

Hexcel

Dr. Hans Kual (Huntsman Advanced Materials)

The Hemp Store