Table 3 Properties of discontinuous fibers used in experimental study.

Fiber Type	*Diameter mm*	*Length mm*	*Density g/cc*	*Tensile Strength MPa (ksi)*	*Elastic Modulus GPa (ksi)*
PVA* f1	0.19	12	1.31	900 (130)	29 (4,200)
PVA* f2	0.014	6	1.31	900 (130)	29 (4,200)
Carbon f3	0.0095	6.35	1.80	2800 (405)	240 (35,000)

* Poly Vinyl Alcohol.

Table 4 Volume of reinforcement

ID of the Test Series	Type of Mesh	Volume of Mesh* V_r	Fiber Type	Volume of Fibers V_f	Total Volume Fraction of Reinforce-ment
K0%	Kevlar	1.15%	----	----	1.15%
K1%f1	Kevlar	1.15%	PVA 12 mm	1%	2.15%
K1%f2	Kevlar	1.15%	PVA 6mm	1%	2.15%
K1%f3	Kevlar	1.15%	Carbon	1%	2.15%
K2%f1	Kevlar	1.15%	PVA 12 mm	2%	3.15%
S0%	Spectra	1.67%	---	---	1.67%
S1%f1	Spectra	1.67%	PVA 12 mm	1%	2.67%
S1%f2	Spectra	1.67%	PVA 6mm	1%	2.67%
S1%f3	Spectra	1.67%	Carbon	1%	2.67%
S2%f1	Spectra	1.67%	PVA 12 mm	2%	3.67%
C0%	Carbon	1.40%	---	---	1.40%
C1%f1	Carbon	1.40%	PVA 12 mm	1%	2.40%
C1%f2	Carbon	1.40%	PVA 6mm	1%	2.40%
C1%f3	Carbon	1.40%	Carbon	1%	2.40%
C2%f1	Carbon	1.40%	PVA 12 mm	2%	3.40%

* For two layers of mesh
K : Kevlar mesh: leno weave in longitudinal direction; V_{rL} = 0.72%
S : Spectra mesh
C : Carbon mesh
f1 : PVA 12mm-long fibers
f2 : PVA 6mm-long fibers
f3 : Carbon 6 mm-long fibers

Table 5. Summary of the average test results.

ID	f_{cr} MPa (psi)	d_{cr} mm (in)	f_{pc} MPa (psi)	d_{pc} mm (in)	d_{max} mm (in)	Toughness Index I_{10}	Toughness Index I_{30}
K0%	5.31 (770)	0.305 (0.012)	26.89 (3900)	16.51 (0.65)	16.51 (0.65)	8	25
K1%f2	7.58 (1100)	0.305 (0.012)	35.85 (5200)	15.24 (0.60)	20.32 (0.8)	11	34
K1%f1	6.90 (1000)	0.254 (0.010)	38.61 (5600)	14.73 (0.58)	>30.48 (>1.2)	8.5	32
K2%f1	7.72 (1120)	0.457 (0.018)	39.99 (5800)	16.51 (0.65)	>30.48 (>1.2)	12	36
K1%f3	8.62 (1250)	0.483 (0.019)	31.03 (4500)	13.97 (0.55)	17.78 (0.7)	8	38
S0%	4.83, (700)	0.254 (0.010)	26.20 (3800)	17.78 (0.70)	17.78 (0.7)	9	30
S1%f2	9.65 (1400)	0.356 (0.014)	36.54 (5300)	19.05 (0.75)	24.13 (0.95)	12	43
S1%f1	7.24 (1050)	0.254 (0.010)	37.23 (5400)	21.59 (0.85)	>30.48 (>1.2)	10	36
S2%f1	8.62 (1250)	0.305 (0.012)	37.23 (5400)	22.86 (0.90)	>30.48 (>1.2)	10	36
C0%	5.86, (850)	0.381 (0.015)	25.51 (3700)	6.35 (0.25)	6.35 (0.25)	13	42
C1%f2	7.58 (1100)	0.381 (0.015)	25.51 (3700)	7.11 (0.28)	7.11 (0.28)	14	42
C1%f1	6.90 (1000)	0.254 (0.010)	26.89 (3900)	5.84 (0.23)	15.24 (0.60)	14	43
C2%f1	9.65 (1400)	0.305 (0.012)	26.20 (3800)	5.08 (0.20)	25.4 (1.0)	16	43

f_{cr} : Cracking Stress
d_{cr} : Deflection at cracking
f_{pc} : Maximum post-cracking stress
dpc : Deflection at post-cracking stress
d_{max} : Maximum deflection
f1 : PVA#12mm-long fibers
f2 : PVA 6mm-long fibers

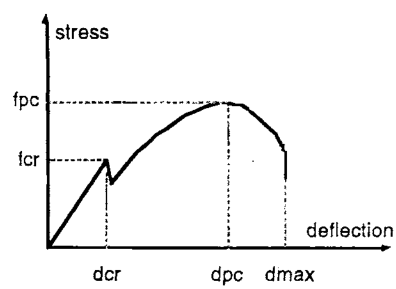


Table 6. Cracking observation after testing

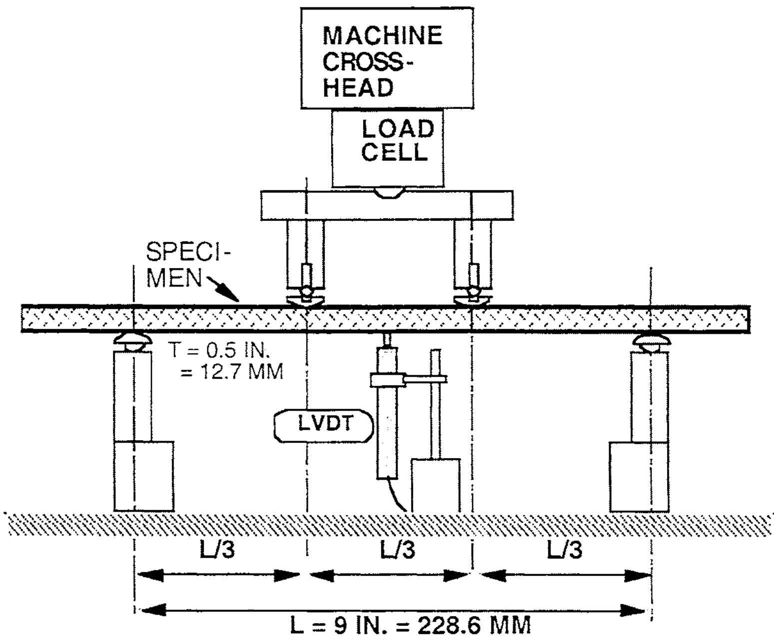
Specimen ID	Total no. of cracks visible to the naked eye	Crack spacing mm (in.)	Comments
K0%	7	19.05 (0.75)	cracks occurred in the middle portion of specimen.
K1%f2	11	15.24 (0.60)	cracks occurred in the middle portion of specimen
K1%f1	18	10.67 (0.42)	cracks occurred first under the load points and then over the middle portion of the specimen
K2%f1	20	8.89 (0.35)	cracks occurred first under the load points and then over the middle portion of the specimen
K1%f3	9	17.02 (0.67)	cracks occurred in the middle portion of specimen
S0%	6	19.05 (0.75)	cracks occurred in the middle portion of specimen
S1%f2	13	13.97 (0.55)	cracks occurred in the middle portion of specimen
S1%f1	17	10.41 (0.41)	cracks occurred first under the load points and then over the middle portion of the specimen
S2%f1	19	9.14 (0.36)	cracks occurred first under the load points and then over the middle portion of the specimen
C0%	1 major crack and 1 very fine crack	-	a major crack occurred near one of the load points
C1%f2	1 major crack and 1 very fine crack	-	a major crack occurred near one of the load points
C1%f1	1 major crack and 2 very fine cracks	-	a major crack occurred near one of the load points
C2%f1	1 major crack and 2 very fine cracks	-	a major crack occurred near one of the load points

K : Kevlar mesh
S : Spectra mesh
C : Carbon mesh
f1 : PVA 12 mm-long fibers
f2 : PVA 6 mm-long fibers
f3 : Carbon fibers

Table 7. Failure modes for each series of tests.

Specimen ID	Type of failure	Comments
K0%	Delamination of the mesh	The tensile (bottom) mesh delaminated near the load point leading to a sudden drop in resistance and failure
K1%f2	Shear type failure	At failure, a loud noise occurred and the load suddenly dropped.
K1%f1	Shear type failure	After failure, the specimens could still take some load. Even at very large deflections, the mesh did not break.
K2%f1	Shear type failure	After failure, the specimens could still take some load. Even at very large deflections, the mesh did not break.
K1%f3	Shear type failure	At failure, a loud noise occurred and the load suddenly dropped.
S0%	Delamination of the mesh	The tensile (bottom) mesh delaminated near the load point.
S1%f2	Shear type failure	At failure, a loud noise occurred and the load suddenly dropped.
S1%f1	Shear type failure	After failure, the specimens could still take some load. Even at very large deflections, the mesh did not break.
S2%f1	Shear type failure	After failure, the specimens could still take some load. Even at very large deflections, the mesh did not break.
C0%	Tensile failure of the mesh	The main crack kept opening under increased load, then the mesh suddenly failed.
C1%f2	Tensile failure of the mesh	The main crack kept opening under increased load, then the mesh suddenly failed.
C1%f1	Tensile failure of the mesh	The main crack kept opening under increased load, then the mesh suddenly failed. After failure, the specimens could still take some load.
C2%f1	Tensile failure of the mesh	The main crack kept opening under increased load, then the mesh suddenly failed. After failure, the specimens could still take some load.

(a)



(b)

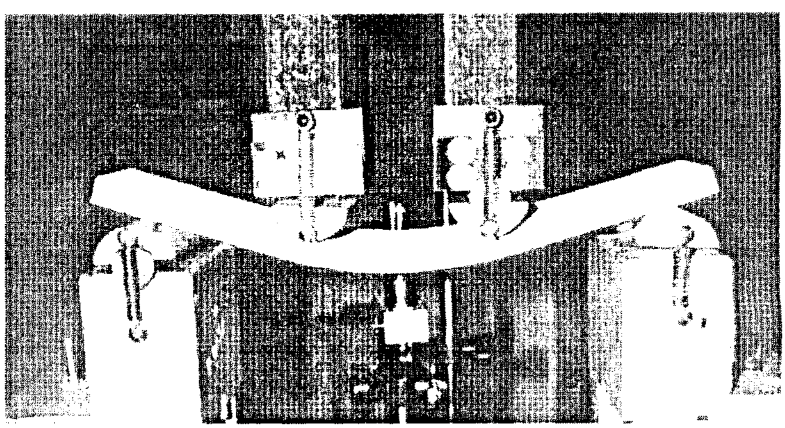
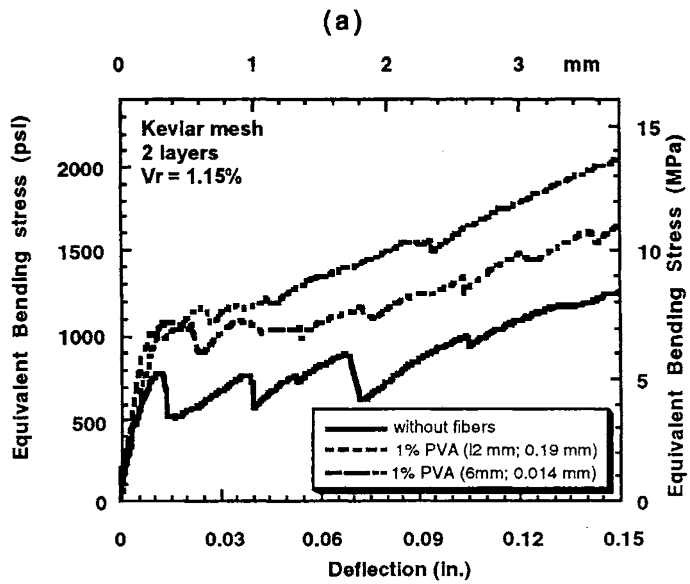


Figure 1 a) Loading arrangement, and b) photo of test set-up with bent specimen.



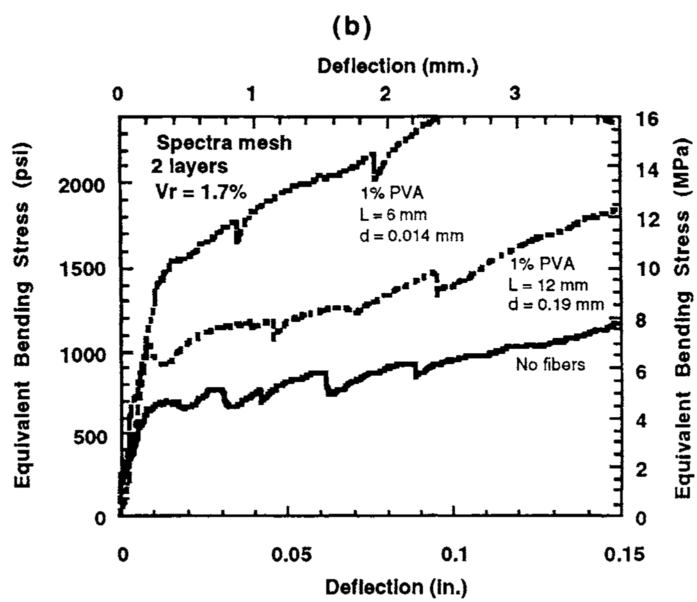


Figure 2 Typical effect of fiber addition on first crack strength and initial portion of bending stress versus deflection curve for LCC plates with a) Kevlar meshes and b) Spectra meshes.

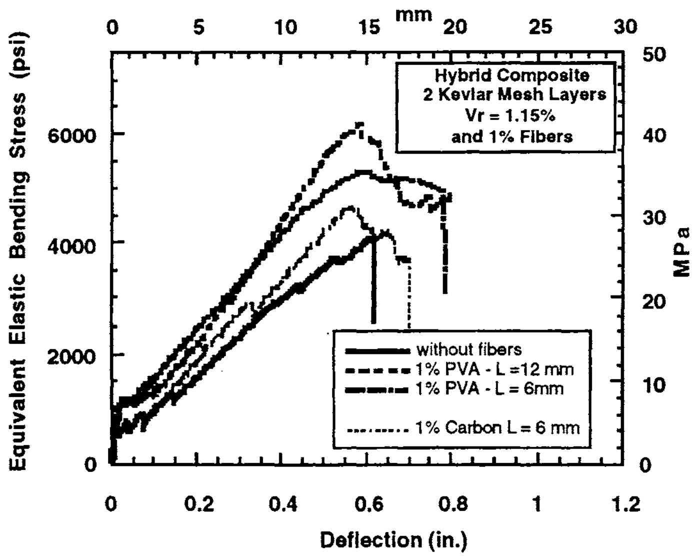


Figure 3 Effect of adding 1% fibers by volume on bending stress versus deflection response of LCC plates with Kevlar meshes

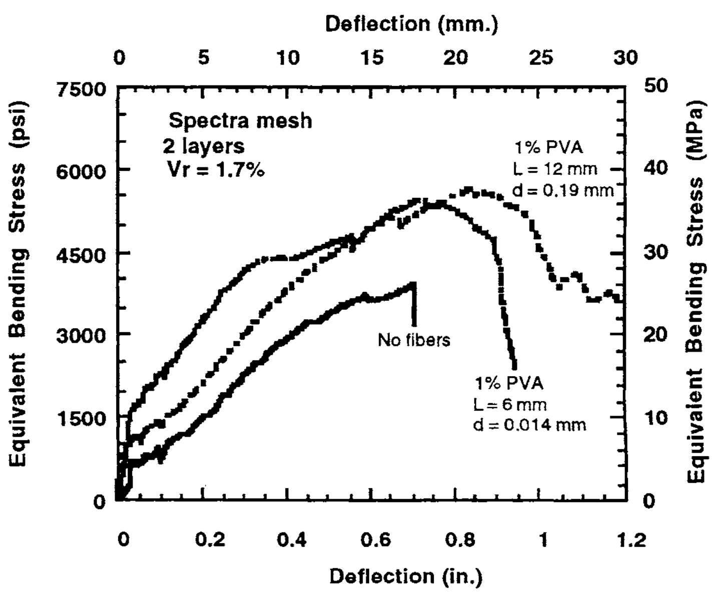


Figure 4 Effect of adding 1% fibers by volume on bending stress versus deflection response of LCC plates with Spectra meshes

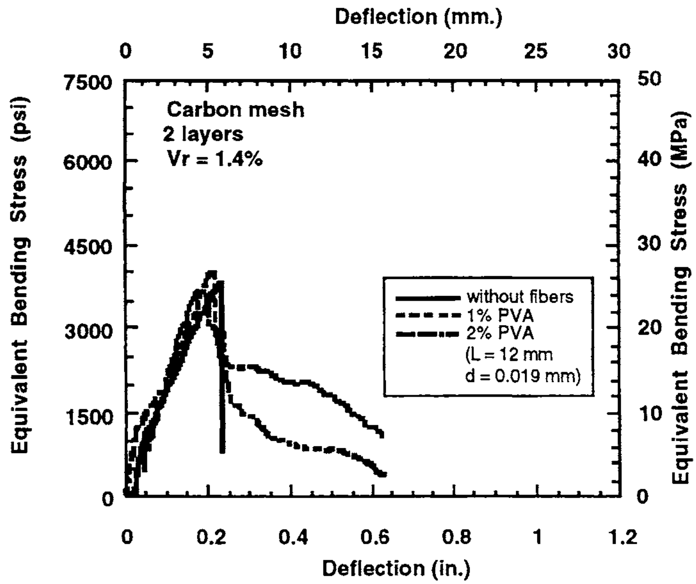


Figure 5 Effect of adding 1% and 2% fibers by volume on bending stress versus deflection response of LCC plates with carbon meshes

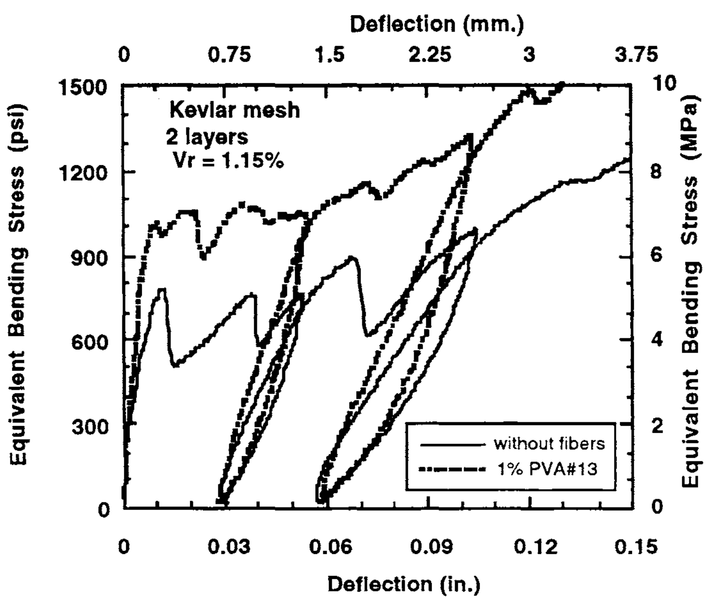


Figure 7 Typical hysteretic bending response curves of LCC plates with Kevlar meshes

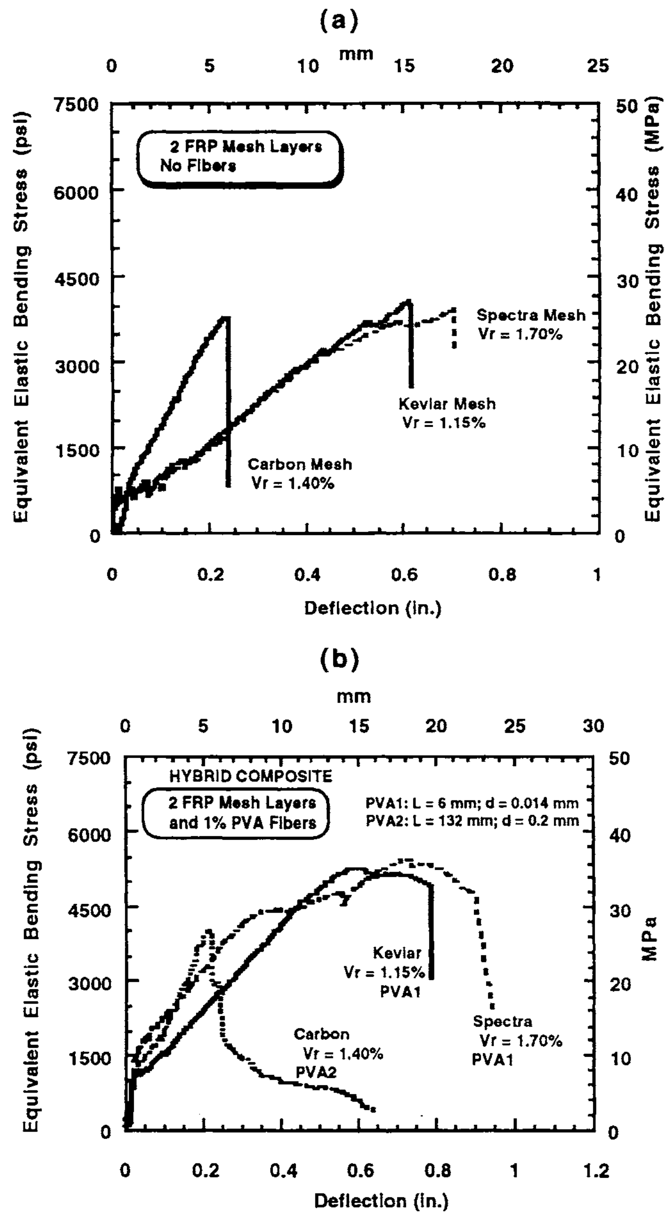


Figure 6 Typical stress deflection curves of LCC plates: a) reinforced with two layers of FRP mesh (no fibers), and b) same with 1% PVA fibers by volume.

Durability of Glass/Polymer Fibrous Mesh-Reinforced Thin Cementitious Composites

by G. J. Venta and J. F. Porter

Synopsis:

Composite cement boards emerged as some of the more innovative and highly promising engineered building materials. Such materials found their use in construction applications such as tile backerboard or EIFS substrate, where exposure to elements, water or high moisture, prevents the use of conventional gypsum or wood-based products. These cementitious boards, typically 12.7 mm thick, usually consist of an aggregated portland cement-based core matrix, reinforced with glass fiber materials. Virtually all boards developed and manufuactured in North America employ two layers of glass-fiber scrim embedded on both sides of the board, just under the surface. To prevent alkali attack on the glass in the high pH environment of the cementitious matrix, the scrim is coated during manufacture using specially formulated PVC plastisols.

This paper discusses the long-term performance aspects and the comparative assessment of various woven and non-woven plastisol-coated glass fiber fabrics in thin cementitious products. The importance of proper plastisol coating, its formulation, and application, is shown as well. Potential next generation of alternative reinforcements of fabric-faced cementitious boards, such as resistant AR-glass-based scrims and promising, patent pending developments of composite glass/polymer fibrous mesh reinforcement grids in reviewed as well.

Keywords: cement board; glass fiber scrim reinforcement; functional requirements; durability; simulated aging; non-woven scrim; woven scrim