Systems for Protection Against Terror Attack

- Blast
- Fire
- Cutting
- Vulnerable areas: cables, connections, supports
- Panels (sheets) for protecting control rooms, target buildings such embassies

Blast

- Interaction of blast waves with structures
- Functionally graded layers of matrix and fibers
- Self destructing panels made of alternative high and low modulus layers (epoxy vs high modulus carbon)
- Aesthetically pleasing

High Temperature

- Matrix with resistance up to 3000 F
- Compatible with carbon. glass., steel, alumina, polymeric, ..
- Protection of cables and other vulnerable structural components for up to 3 hours
- Structural fire protection layers

Background

- High temperature
- Abrasion resistance
- Use of fibers at various scales from nano to macro to protect against blast

Typical Sample Prior to Test

- Balsa wood core with inorganic carbon fiber facings
- Smooth & glossy
- Sample dimensions:
  - 4 inches wide
  - 4 inches long
  - ¼” inch thick

Sample After Fire Testing

- Facings visibly charred from intense heat
- Rough surface with minor cracking
- Sample dimensions change, including weight

Plain Balsa Wood – Prior to Test

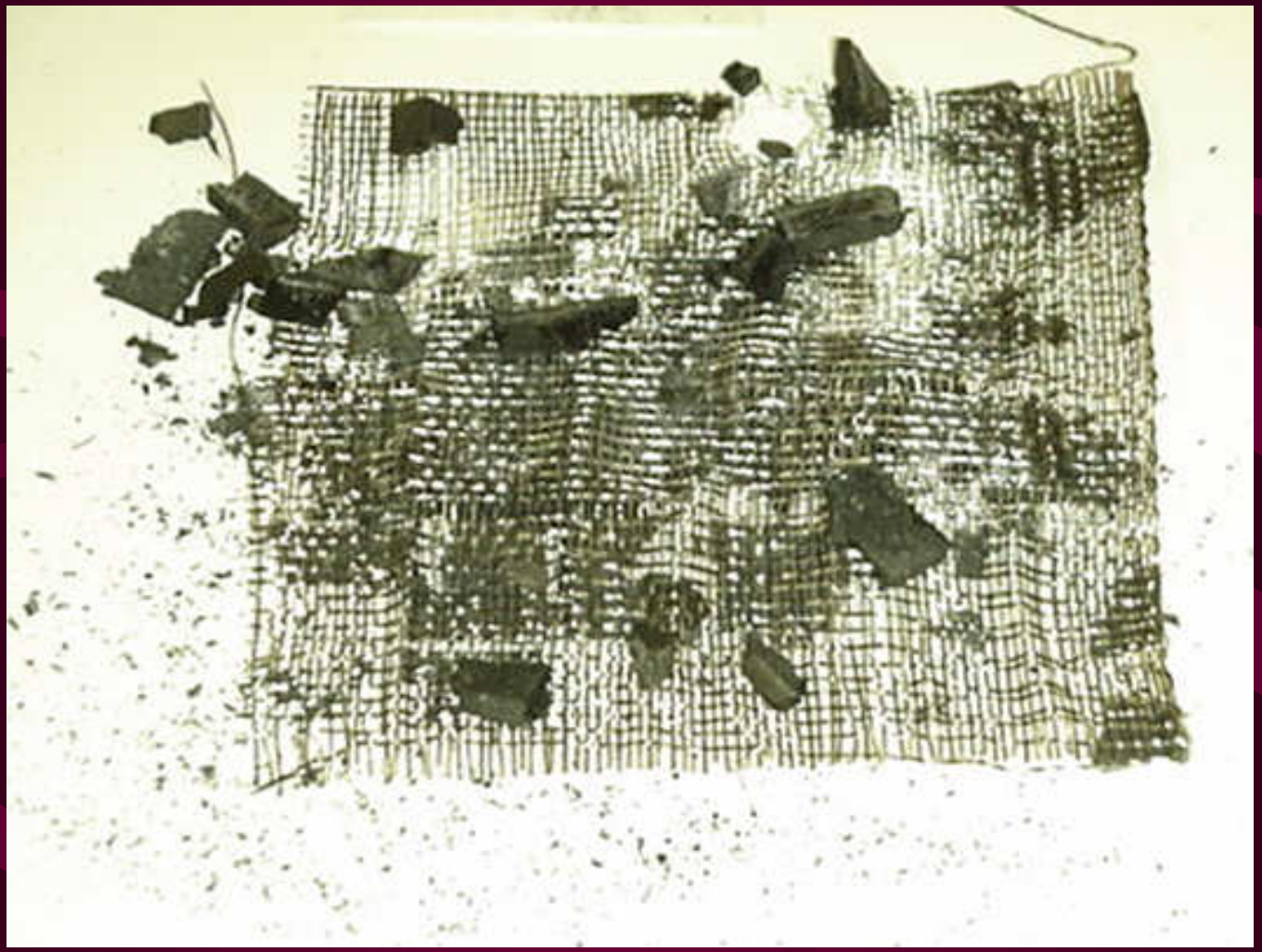
- Individual blocks of balsa wood
- Dimensions:

  6” x 6” x 0.5”

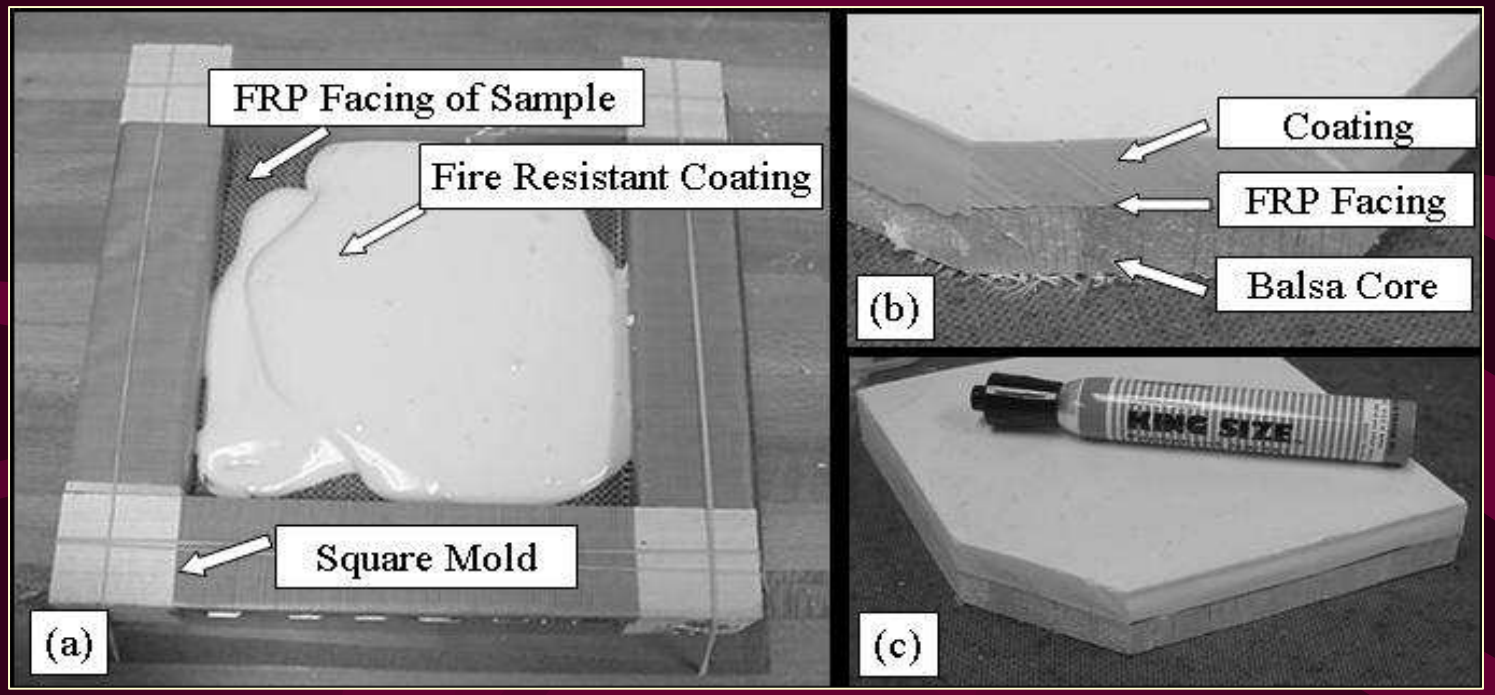
Plain Balsa Wood – During Test

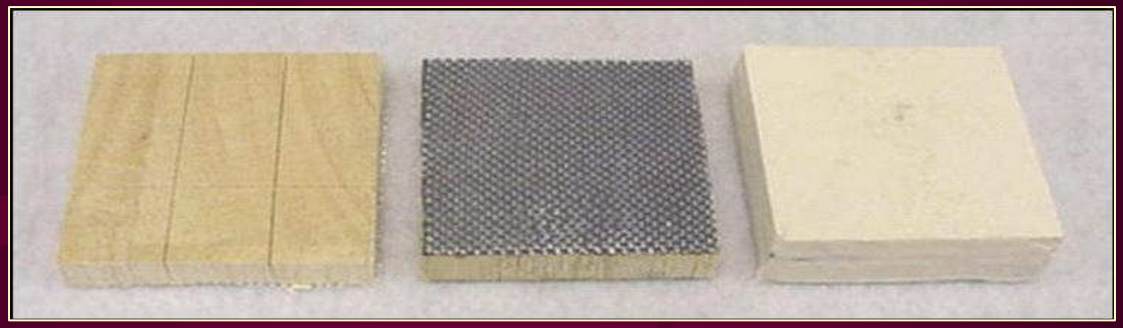
Plain Balsa Video.MPG

Plain Balsa Wood – After Test



Application of Fireproofing





Balsa With Fireproofing

OSU Heat Release Rate Results

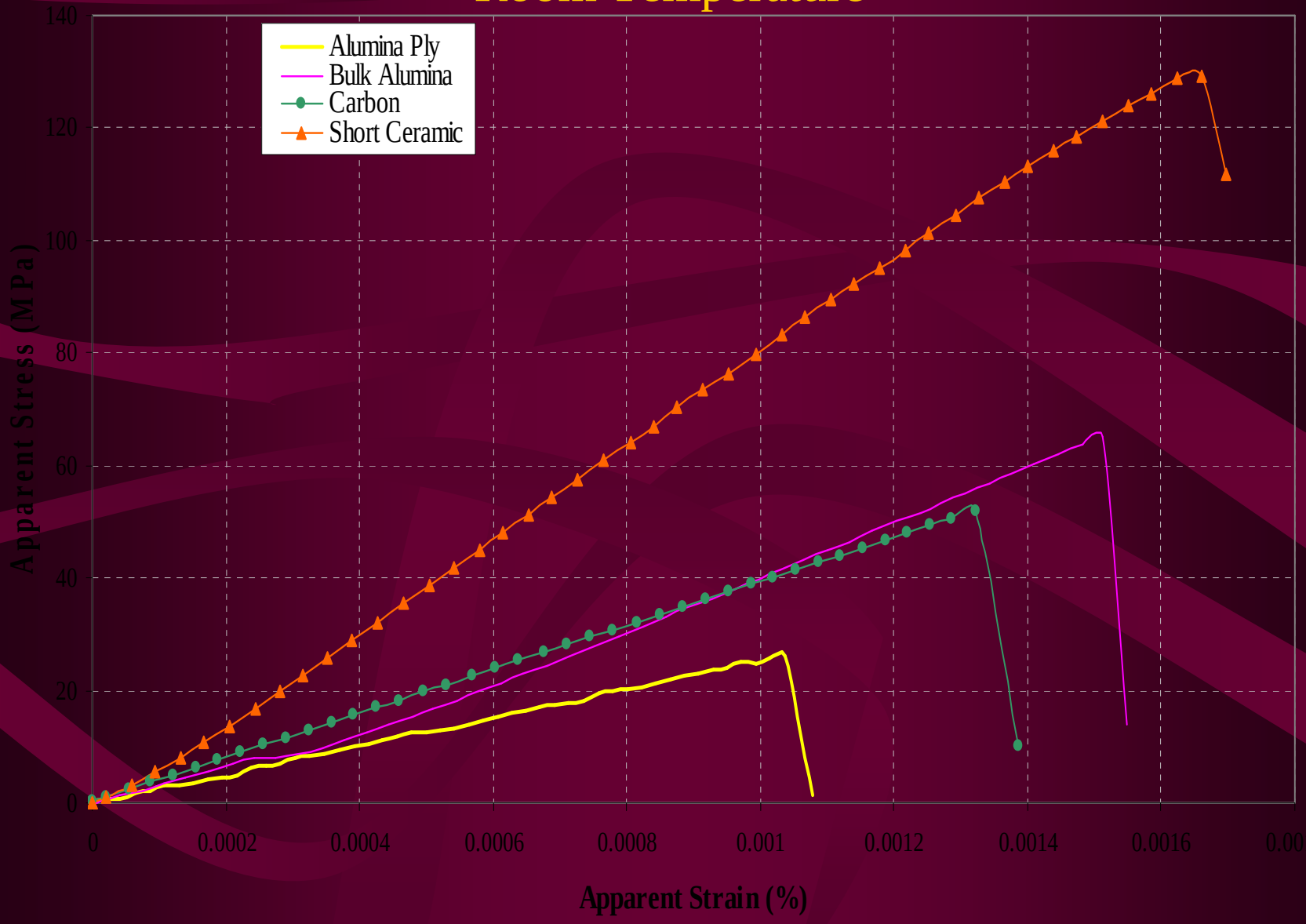
Sample ID	Peak *HRR*	t_{PHRR}	Heat Release		FAA Test Result (65·65)
			2 Minutes	5 Minutes	
	(kW/m^2)	(sec)	($kW \cdot min/m^2$)		(Pass / Fail)
OSU Balsa 1*	165	176	166	438	Fail
OSU Balsa 2*	163	9	169	290	Fail
OSU Balsa 3*	184	11	177	272	Fail
Average	*171*	*65*	*171*	*333*	*All Failed*
St. Deviation	*11.22*	*95.85*	*5.64*	*91.43*	
OSU Reinf.†	104	214	70	275	Fail
OSU 2	53	106	21	130	Pass
OSU 4	28	292	4	36	Pass
OSU 5	11	518	-8	-7	Pass
OSU 7	4	94	-10	-16	Pass
OSU 11	3	605	-14	-23	Pass
Balsa (core only)[G]	125	125	-	40	Fail
GRP (no core)[G]	132	105	-	77	Fail
GRP/Balsa Core[G]	157	220	-	103	Fail

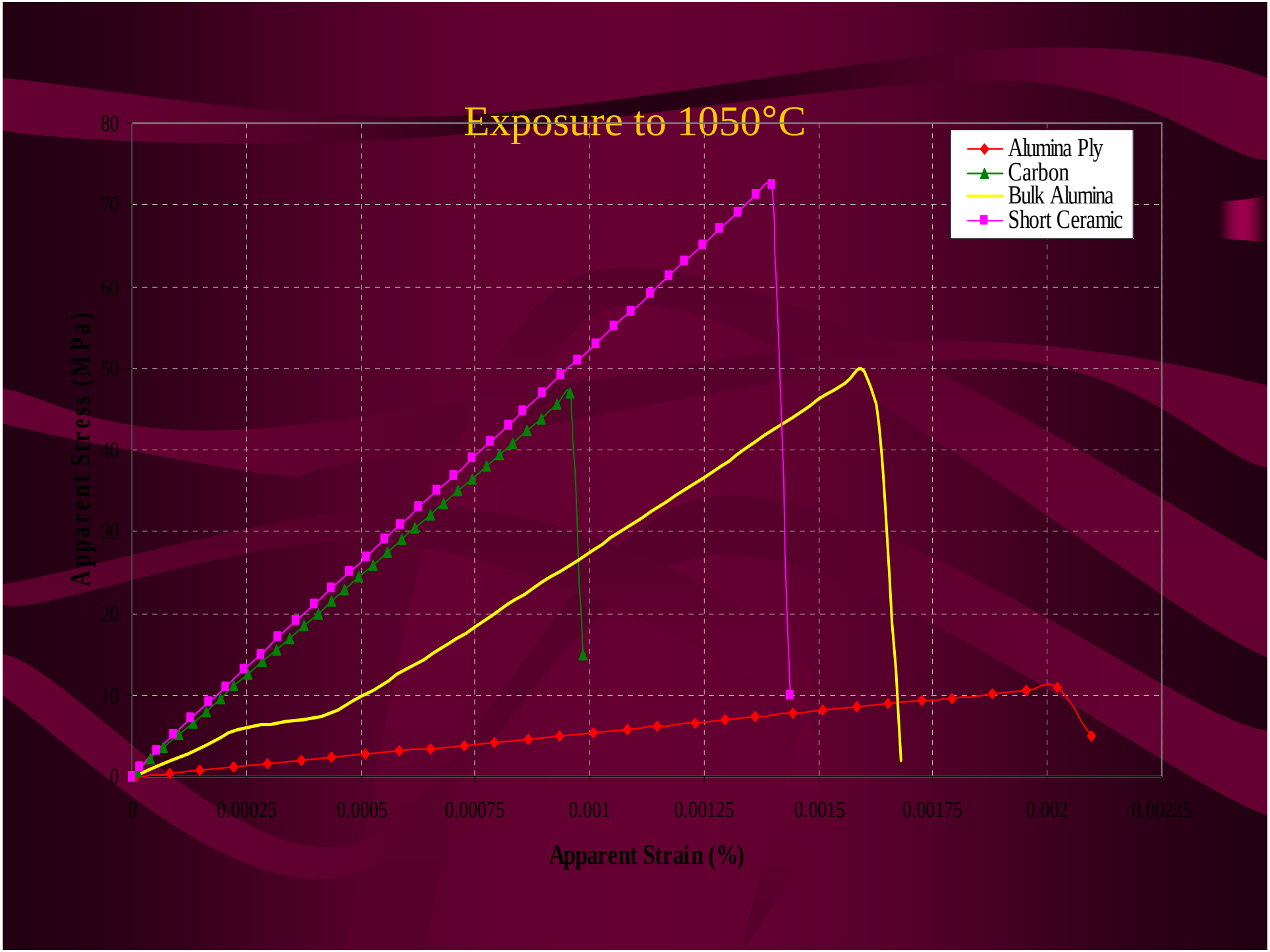
Conclusions – Sandwich Panels (Fire)

- All balsa wood composites passed FAA requirements for both heat release and smoke generation
- 2 mm thick layer of fireproofing is sufficient in providing adequate heat release protection and easily satisfies the FAA smoke requirements, while increasing the mass of the sandwich plate by 8%.
- The type of reinforcement on the facings plays a significant role in determining the amount of smoke generated. Fabrics with only carbon fiber generate much less smoke than the fabrics that had glass fibers in the fill direction
- A strong relationship exists between the thickness of the fireproofing and the sandwich plate density. For any given thickness of fireproofing, the resulting density of the sandwich structure can be estimated accurately.

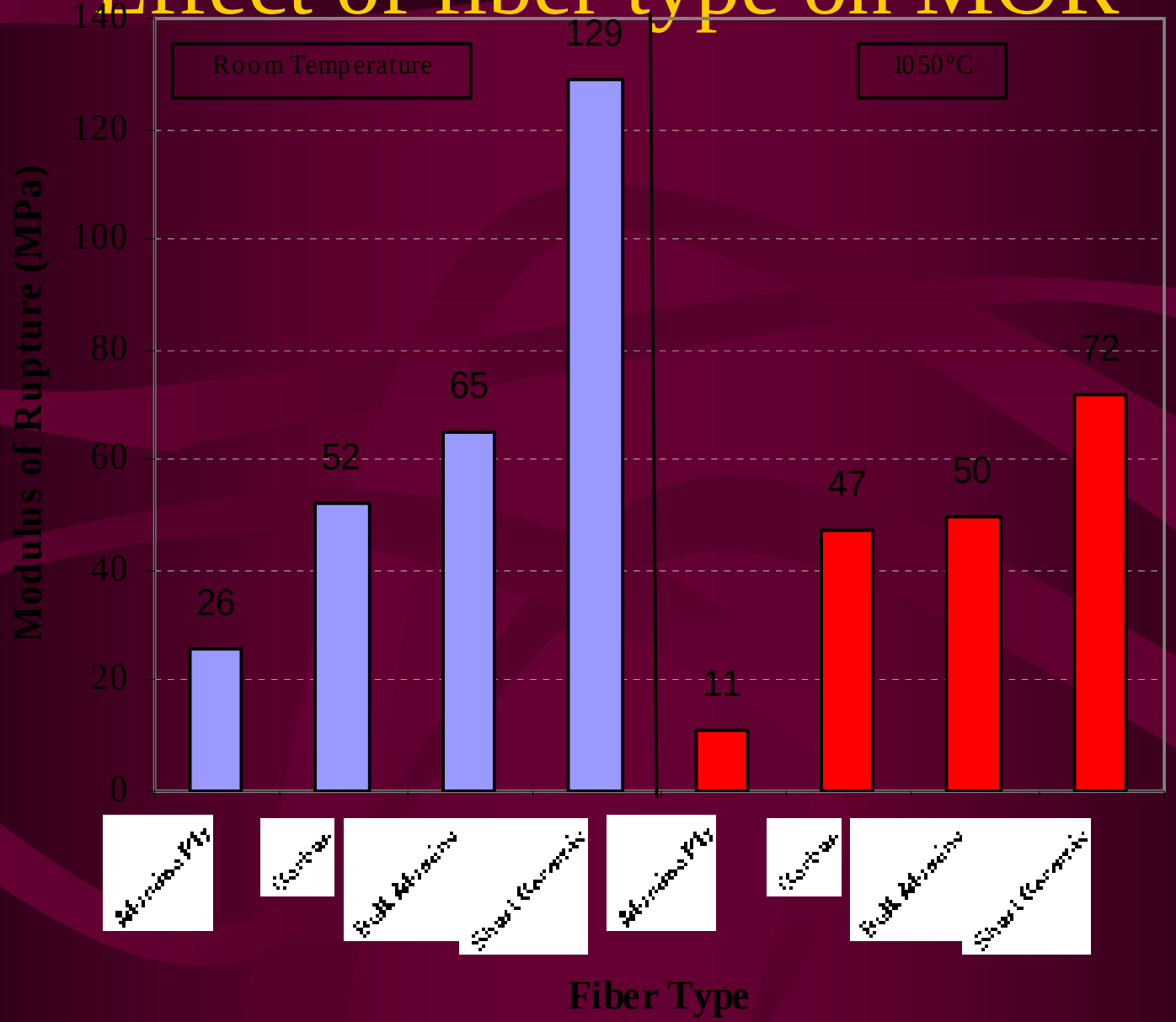
Samples

Room Temperature

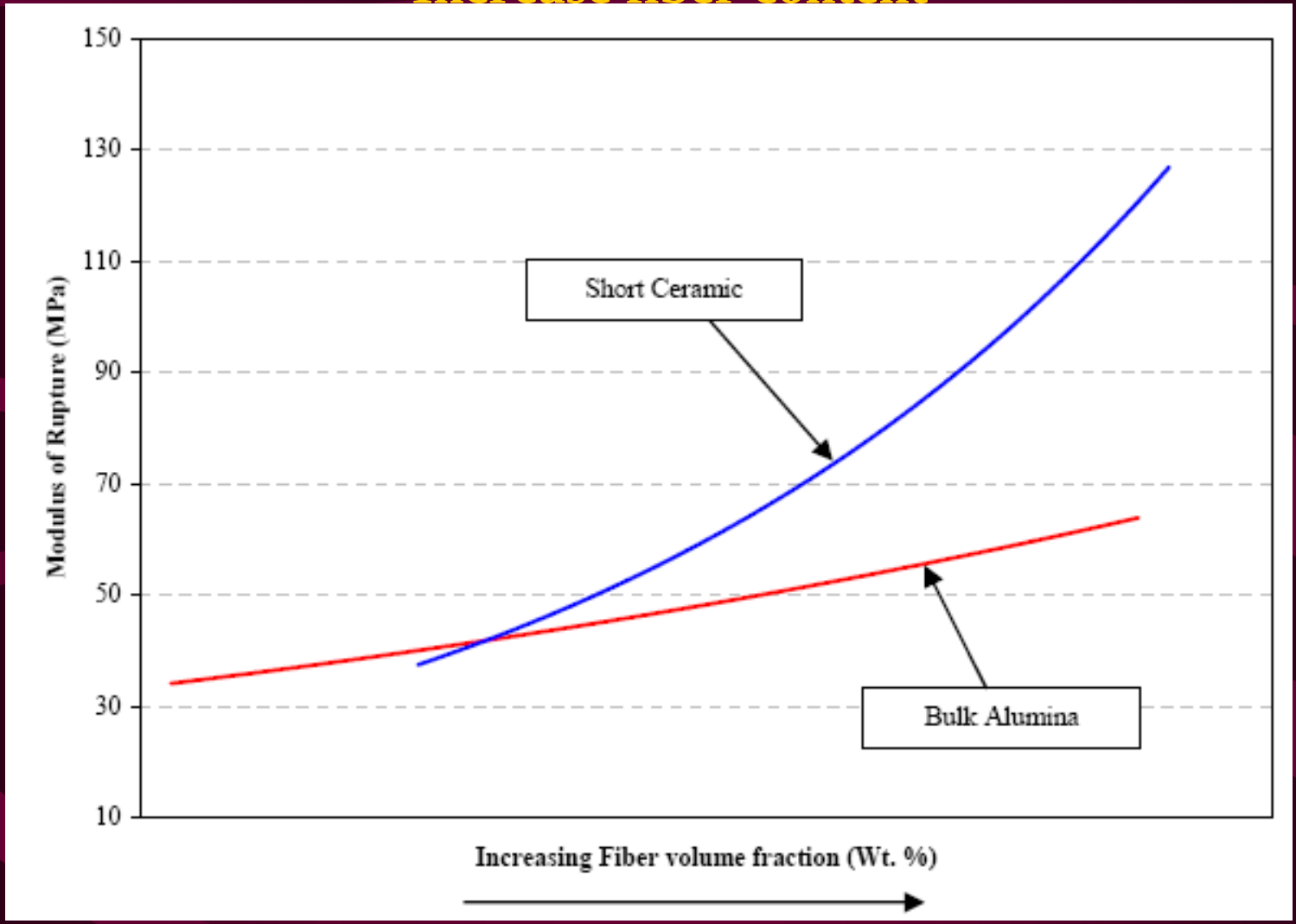



Exposure to 1050°C
Alumina Ply
Carbon
Bulk Alumina
Short Ceramic
Apparent Stress (MPa)
Apparent Strain (%)
0
10
20
30
40
50
60
70
80
0
0.00025
0.0005
0.00075
0.001
0.00125
0.0015
0.00175
0.002
0.00225

Effect of fiber type on MOR



Increase fiber content



RT	Weight	1500C/30min		
		Weight change	Percentage (%)	
1	3.0436	3.0337	-0.0099	-0.325
2	3.2544	3.2449	-0.0095	-0.291

Needed Research

- Characterization of thermal insulation properties
- Tests using actual structural components
- Manufacturing issues with functionally graded layers
- Manufacture of plates using the existing methods

Customers

- Port authority
- HMS
- State Department