# SHOCK ABSORPTION SYSTEMS FOR ARTIFICIAL TURF SURFACES

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February 13, 2008

The Grass and Yarn Tufters Forum 2008

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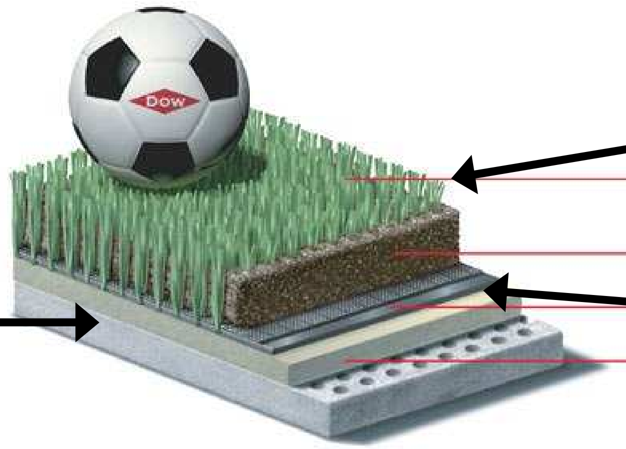
# Artificial Turf Surfaces

➢A typical artificial turf surface is made of several layers:

**Infill:**
- Surface interaction
- Traction, energy absorption

**Shock pad:**
- Safety
- Energy absorption




**Yarn:**
- Surface interaction
- Friction, ball roll

**Backing:**
- Method of construction
- Stability/durability of field

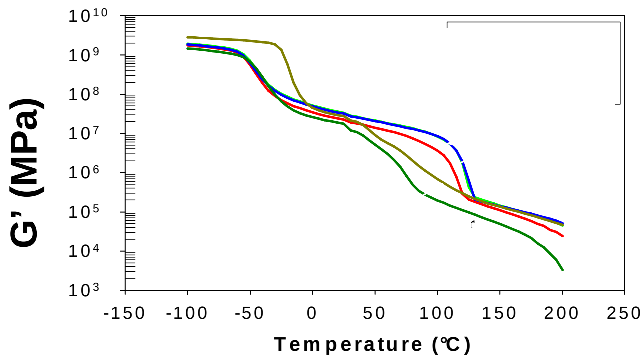
➢All layers are interlinked

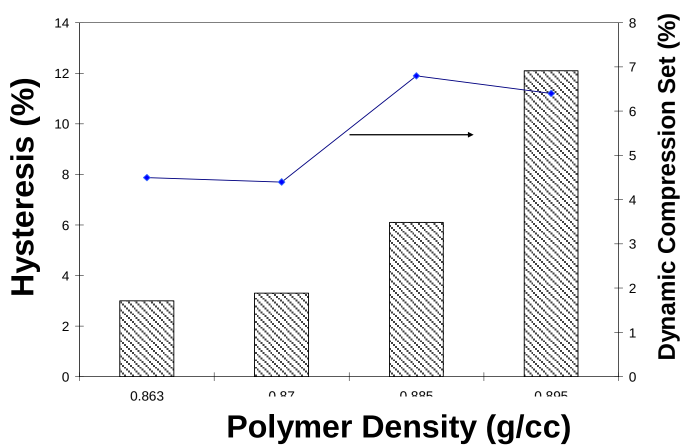
➢System is currently designed by experience with natural turf as performance target

# Can new products be differentiated in the lab?

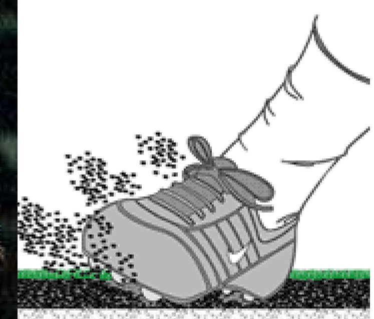
- Goal: Develop lab tests on components and systems to predict long-term performance
- Approach: Use test methods from elastomer product development and solids handling
  - Vary material compositions to determine if tests differentiate performance in manner analogous to accepted test standards
  - Focus on Infill and Shock Pad as primary shock absorption components

# Link Materials Science to Performance



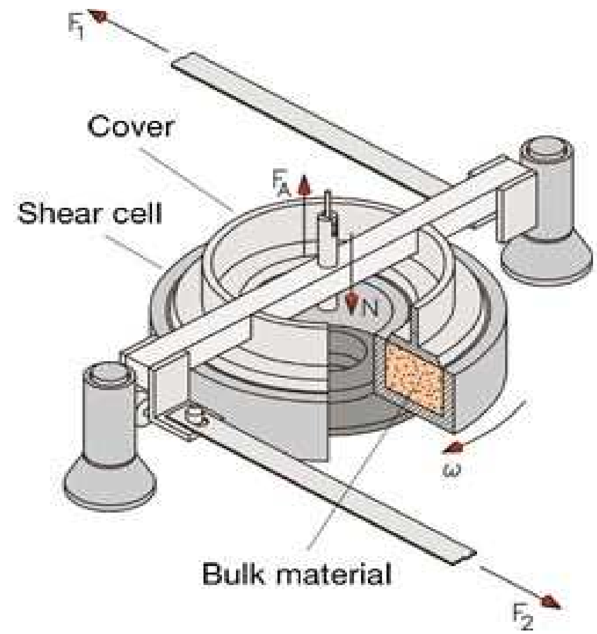




- Performance Attributes
  - Energy absorption
  - Migration
  - Heat resistance (blocking)
  - UV / Weathering
  - Skin friction (COF)
  - Odor



# Infill Test Method Development

- Ring Shear Tester (RST)
  - Flowability
  - Bulk density and compressibility
  - Attrition (measures durability)
  - Time consolidation (correlated to long-term shock absorbency)
- Microscopy
  - Particle shape and PSD
- Tests run at room temperature and 65℃



# Particle Size and Shape are Significantly Different

Crumb Rubber (Ambient)

Silica Sand-Uncoated

Thermoplastic Elastomer

Crumb Rubber (Cryogenic)

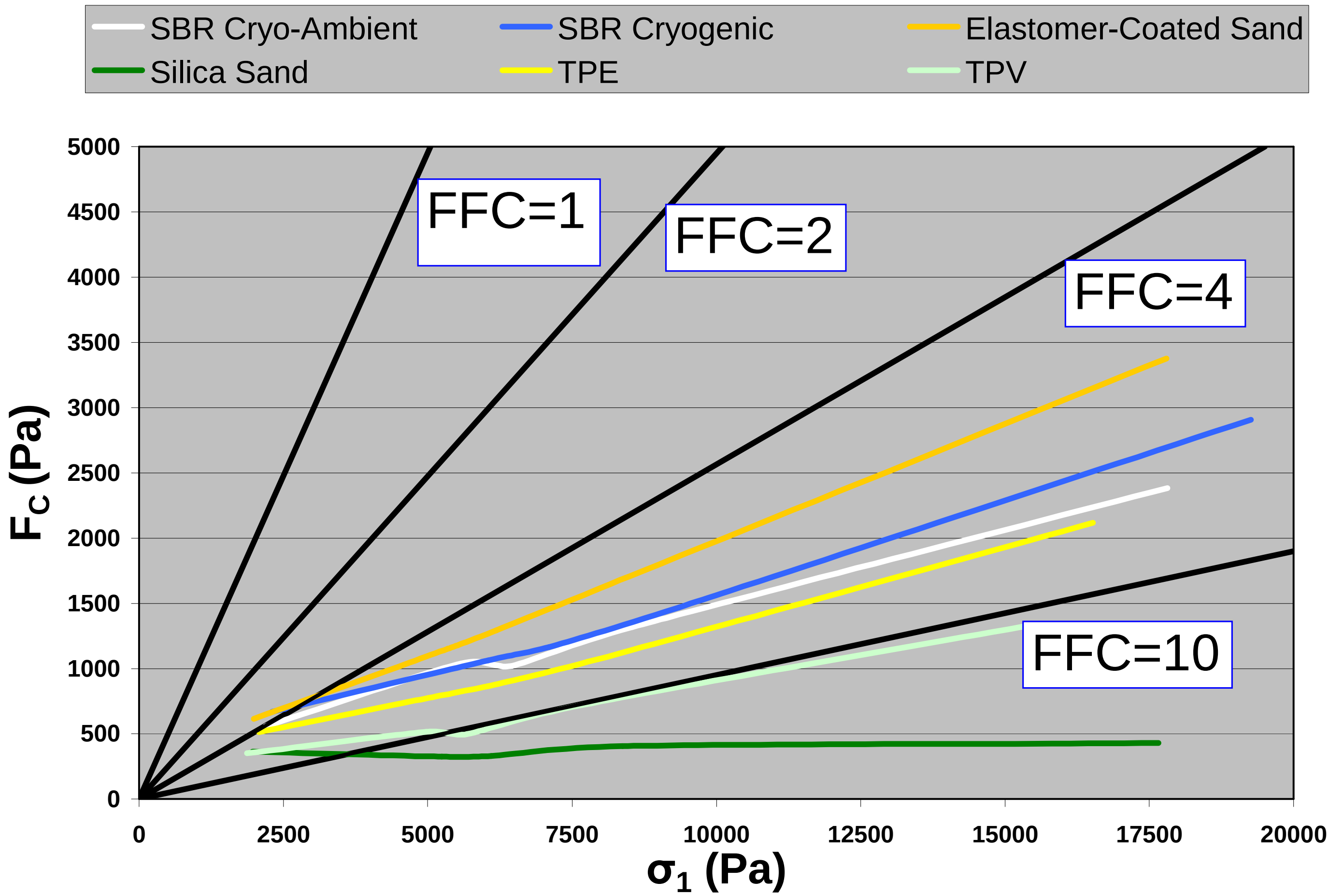
Elastomer-Coated Sand

Thermoplastic Vulcanizate

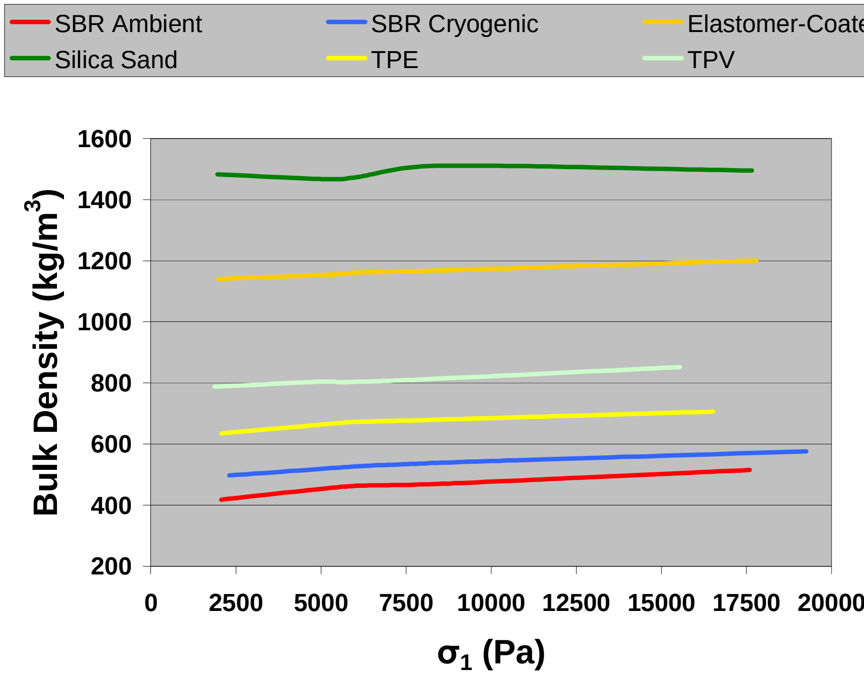
# Infill Consolidation Prediction via RST

| | |
|---|---|
| FFC<1 | – Consolidated |
| 1<FFC<2 | – Very cohesive |
| 2<FFC<4 | – Cohesive |
| 4<FFC<10 | – Easy flowing |
| 10<FFC | – Free flowing |

- FC = Unconfined yield stress
- FFC = Flow function indicator (σ1/FC)

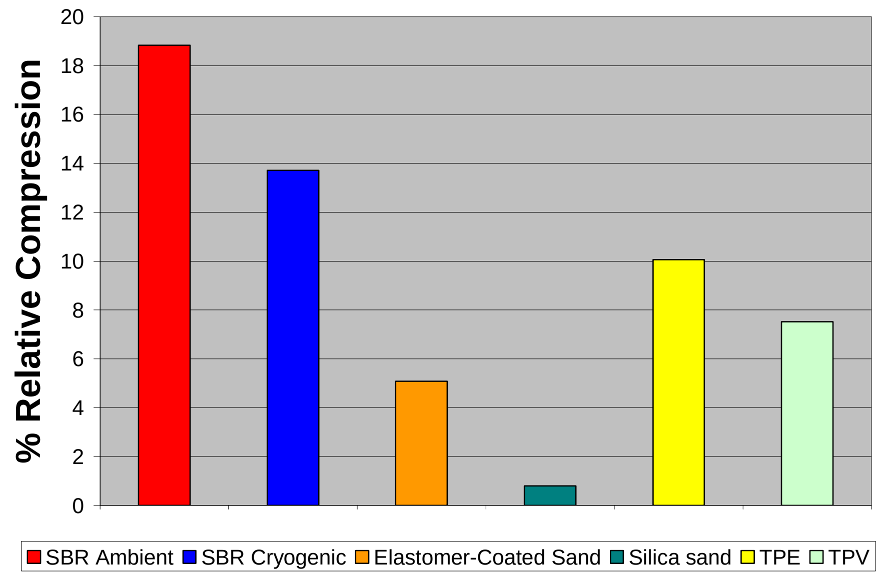


# Recovery and Density After Compression




Indicative of relative change in packing of particles over time

Recoverability
(Higher is Better)



# Summary of RST Information

- ✓ ➢Migration
- ✓ ➢Heat resistance (blocking)
- X ➢UV / Weathering
- ✓ ➢Elastic Recovery
- X ➢Low skin friction (COF)
- X ➢Minimal odor
- ✓ ➢Abrasion resistance

# Shock Pads for Artificial Turf

- Background:
  - Variety of shock pads available in the market based on different technologies
  - Comprehensive studies of long-term performance of new shock pads under extreme conditions has not been published
- Goal:
  - Analyze the influence of shock pad properties on the energy absorption of artificial turf surfaces
  - Develop correlations to industry standards to increase product development process

# Performance Requirements

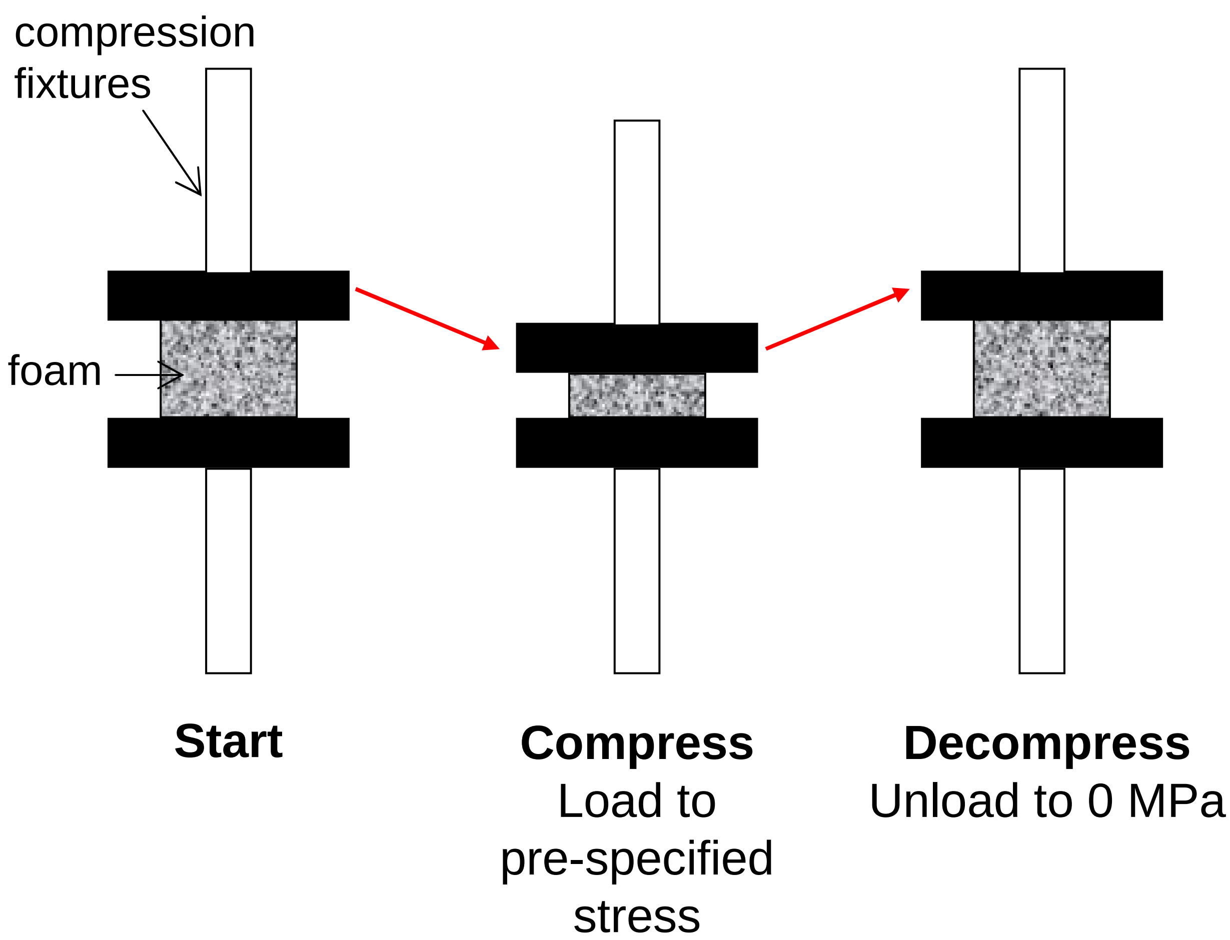
➢FIFA shock absorption performance measured via the following tests:

| Property | Equation | Range |
|---|---|---|
| Force Reduction | $FR = \left(1 - \frac{F_{max\,(test\ piece)}}{F_{max\,(concrete)}}\right) x\,100\ (\%)$ | 55-70% |
| Energy Restitution | $ER = \frac{(V_2)^2}{(V_1)^2} .100\%$ | 30-45% |

➢Lab test methods developed to simulate the following situations:

- Cyclic loading under compression to predict **recovery in use**
- Compressive strain at 0.16 MPa / 65 ℃ / 12 h for s imulating **short-term high load recovery**

# Compressive Hysteresis Behavior

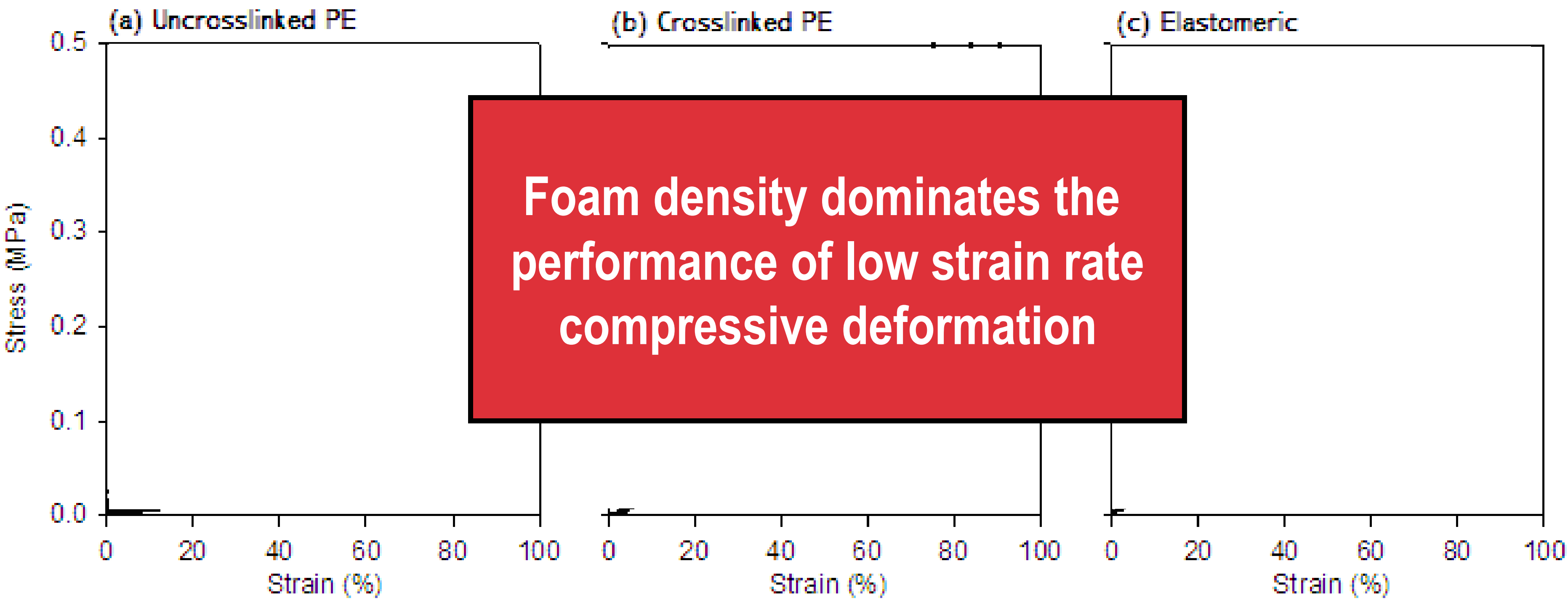



Background:

- Athletes exert cyclical loads on fields during play
- Hennig and Milani examined forces exerted on shoes during running at 3.3 m/s
- For a 72 kg runner, the maximum stress was estimated to be 0.9 MPa.

# Laboratory Analysis: Slow Deformation

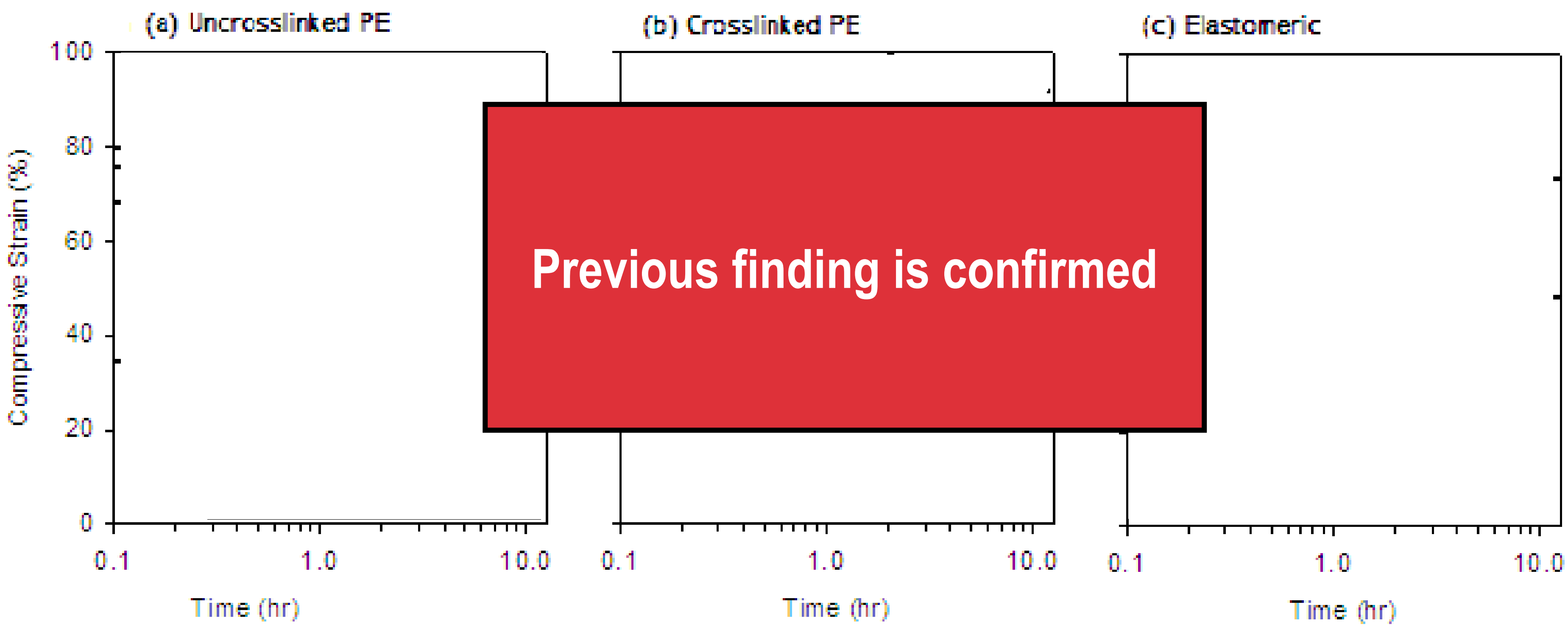
- Compressive stress maximum of 0.4 MPa applied at 1 $min^{-1}$




**Foam density dominates the performance of low strain rate compressive deformation**

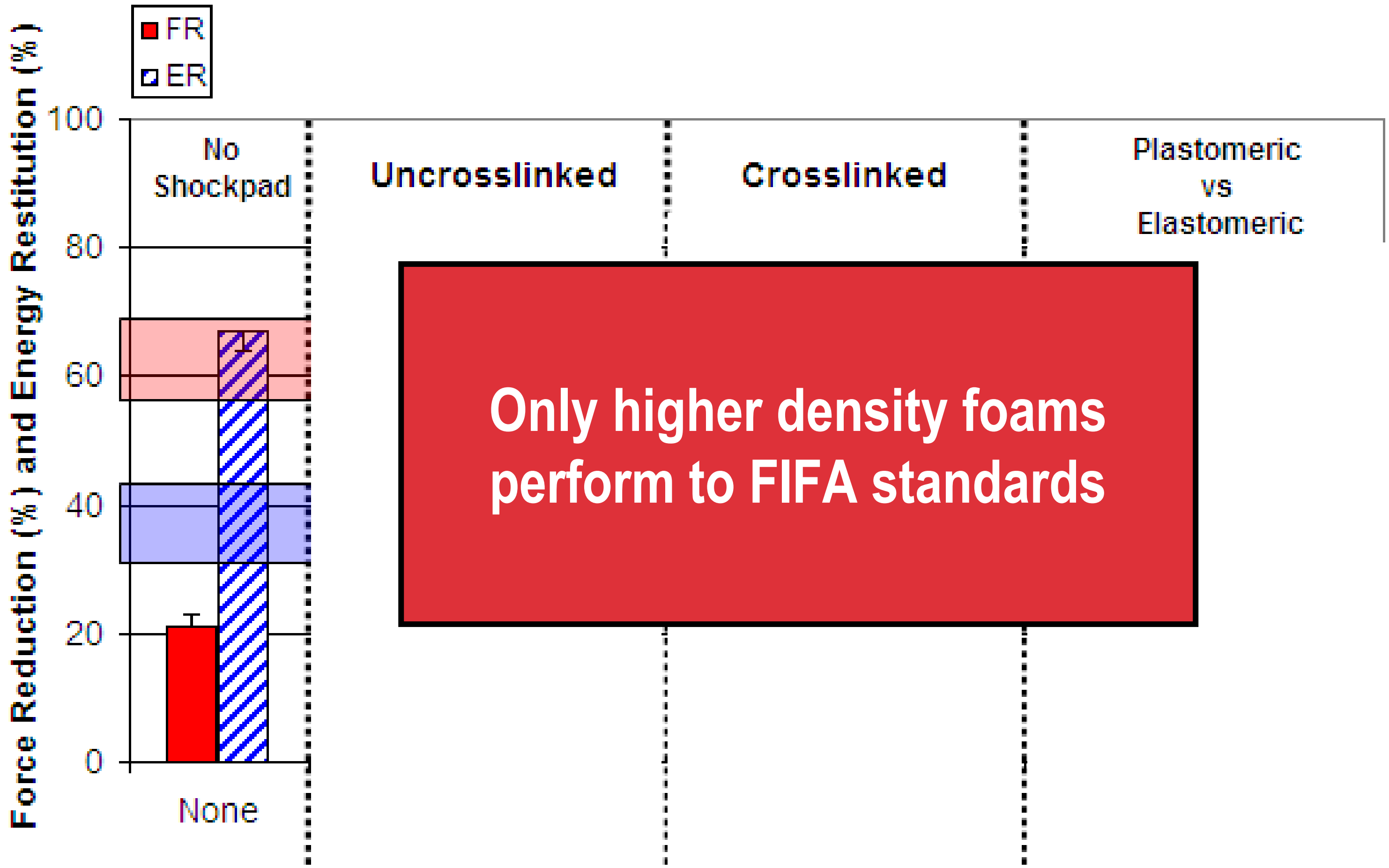
# Laboratory Analysis: Extreme Conditions

- Compressive strain at 0.16 MPa (static load simulating a light vehicle on the field) and high temperature (65 ℃) for 12 hours



# FIFA Quality Concept Analysis

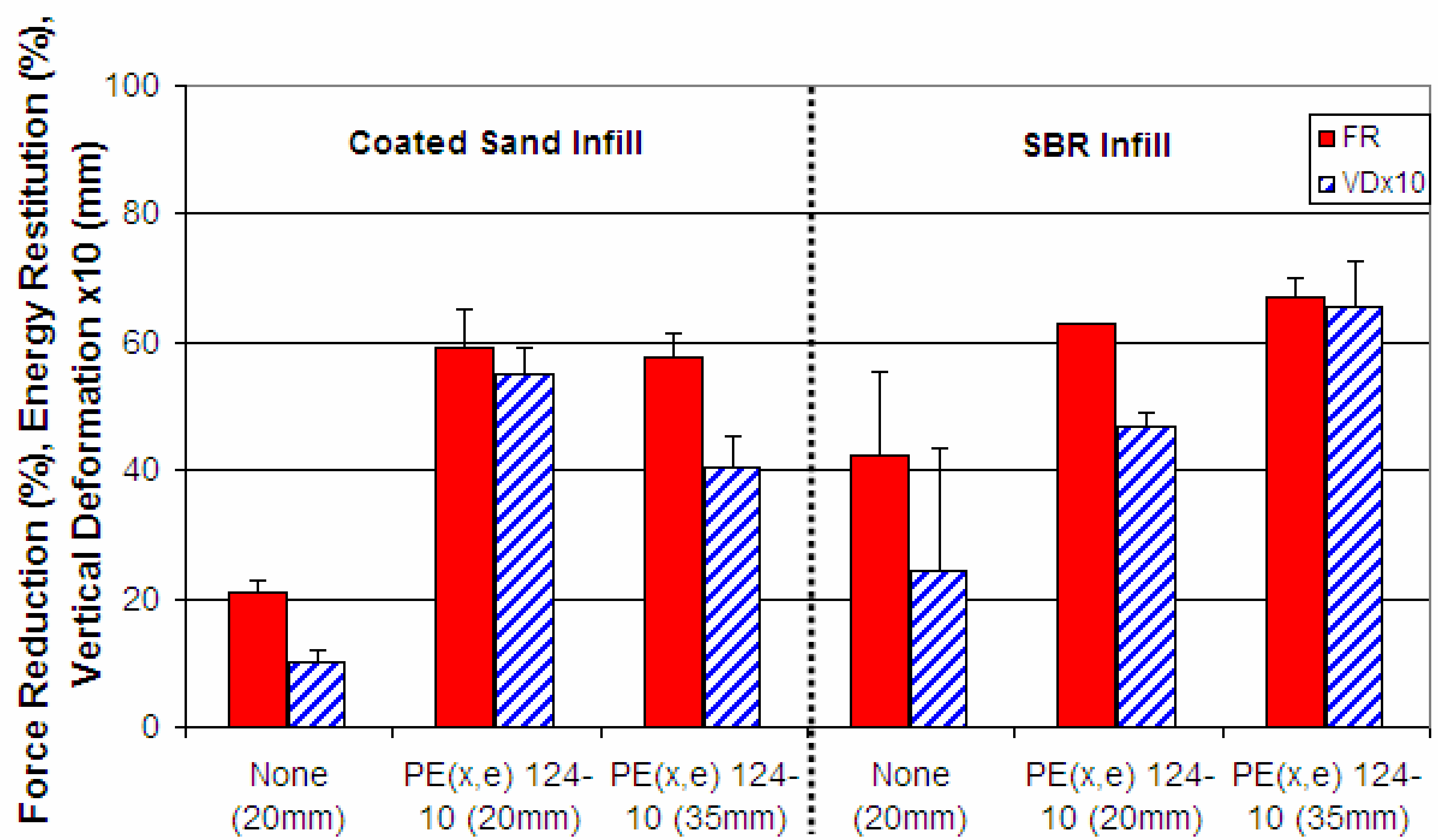
- Results on selected shock pads tested as part of a system according to FIFA:




Only higher density foams perform to FIFA standards

# FIFA Quality Concept Analysis

➢Results on selected shock pads tested as part of a system with different infill heights (indicated in brackets) according to FIFA testing:



# Summary of Results

- Recovery and migration of infill can be qualitatively predicted via ring-shear testing
  - Additional work with different backing systems in progress
- Lab scale tests on compressive performance of foams differentiates based on key design parameters
  - Foam density is the main parameter driving the energy absorption performance
  - Lower density PE foams do not appear suitable for applications defined by FIFA standards
- Further studies are being done to predict the long-term performance under ambient, wet, and higher temperature conditions