Assessing Baseball Bat Performance

SGMA Baseball and Softball Council Meeting

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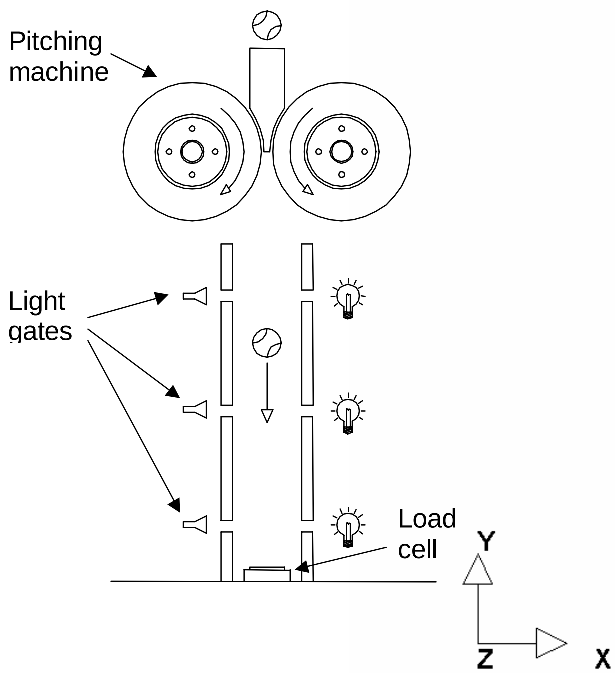
Objectives

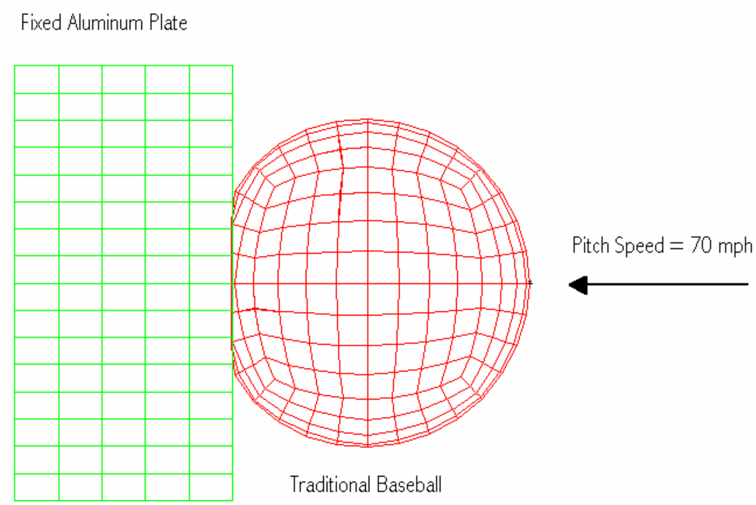
- Develop and verify a computational model to predict bat performance
- Compare the relative performance of wood and metal bats using current test methodologies
- Consider improvements in assessing baseball bat performance

Methodology

- Characterize the dynamic response of baseballs
- Experimentally verify the bat-ball model
- Consider the effect of test method and performance measure on bat performance

Dynamic Ball Response





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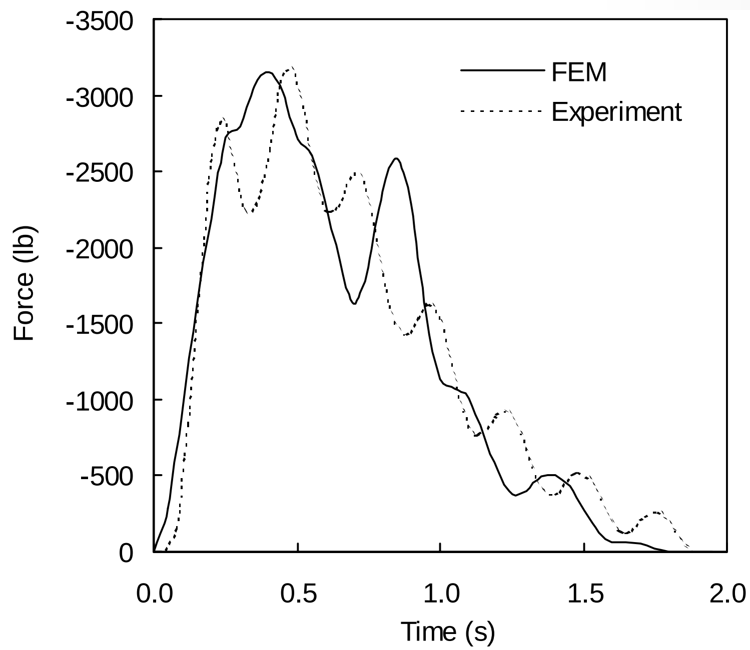
Dynamic Ball Properties



Viscoelastic material model

$$G(t) = G_\infty + (G_o - G_\infty)e^{-\beta t}$$

Ball Type	G_0 (ksi)	G_∞ (ksi)	β	k (ksi)
traditional	4.5	1.5	11000	13.5
synthetic	0.3	0.15	1250	2.75

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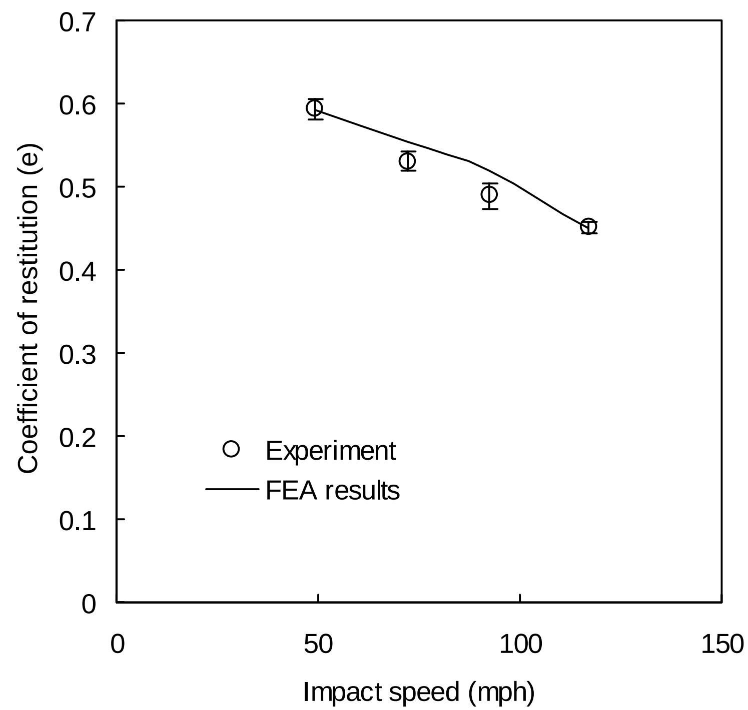
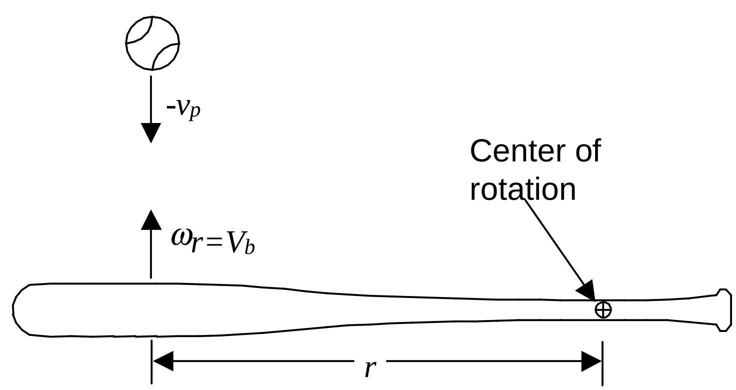
Coefficient of Restitution

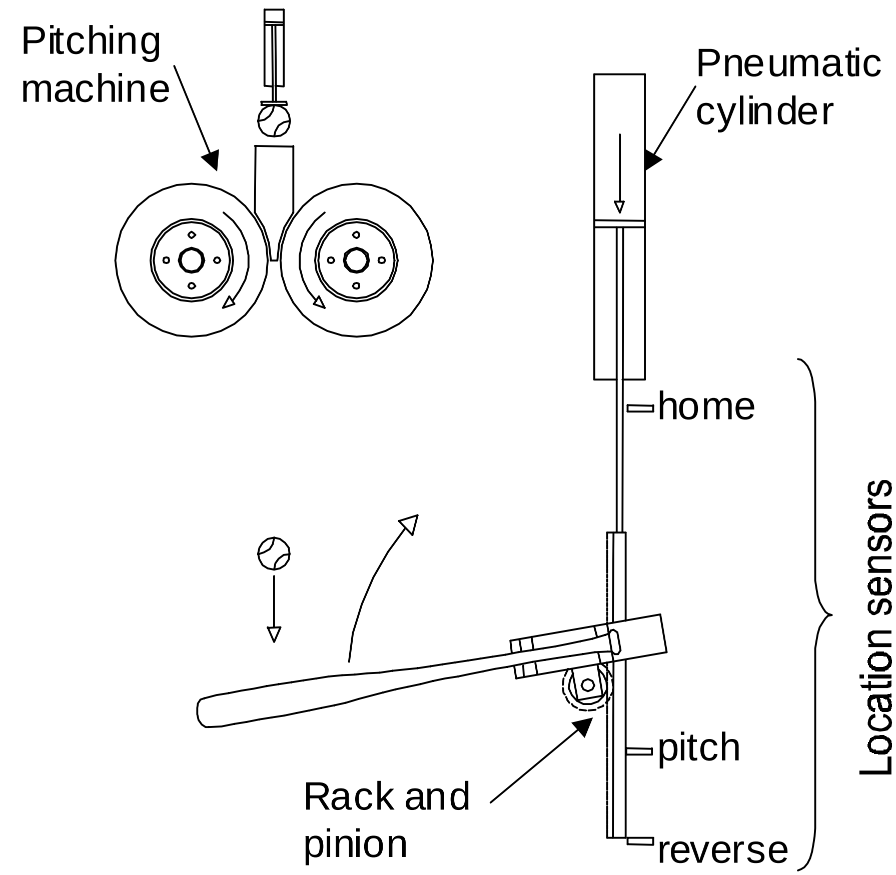


Bat-Ball Motion

- Maximum bat speed ~72 mph
- Maximum ball speed ~90 mph
- Center of rotation ~x=3 in, ~y=1.3 in



Dynamic Bat Testing



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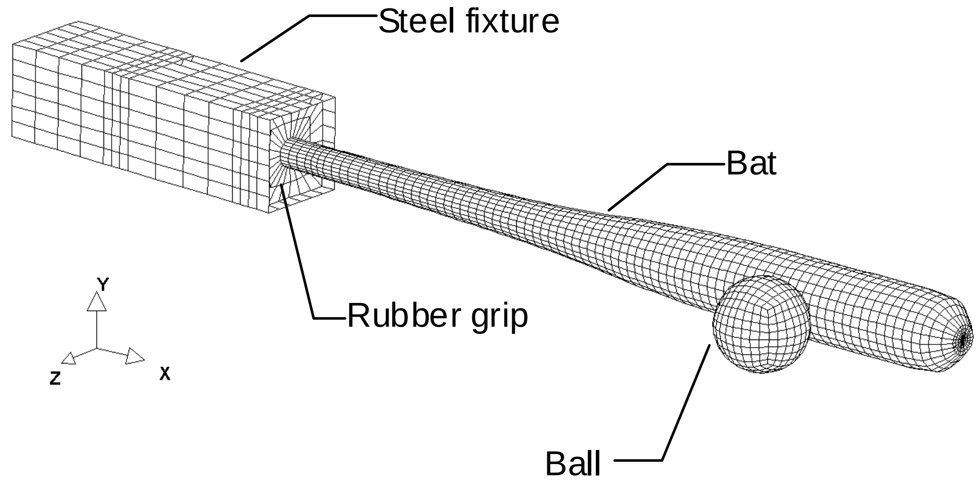
Dynamic FEA Model



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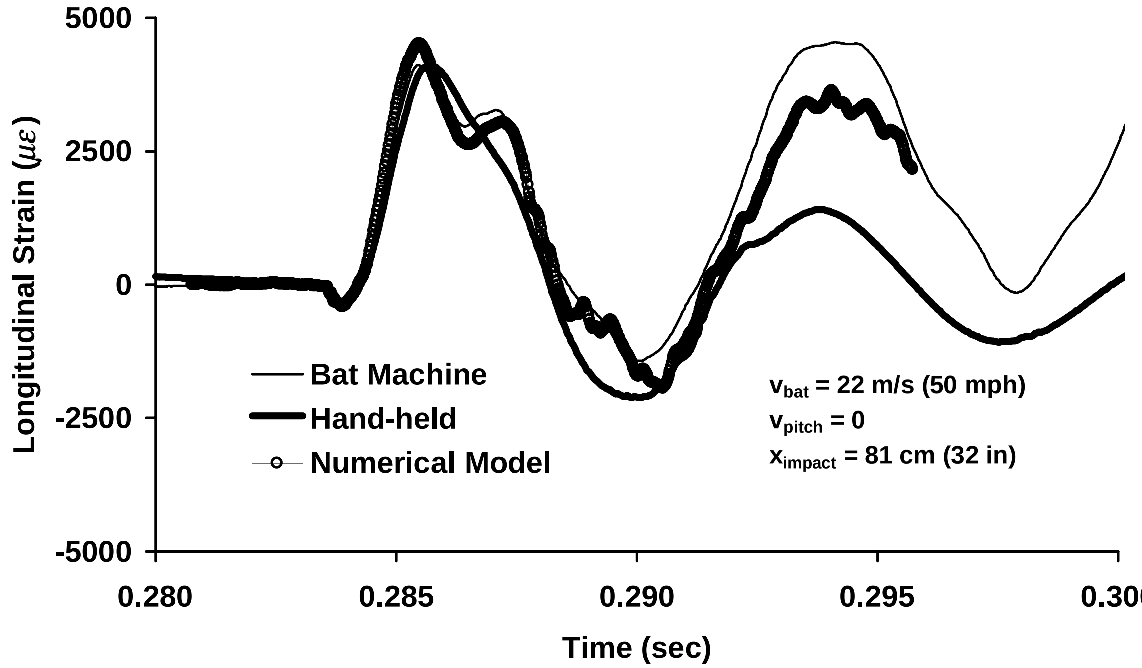
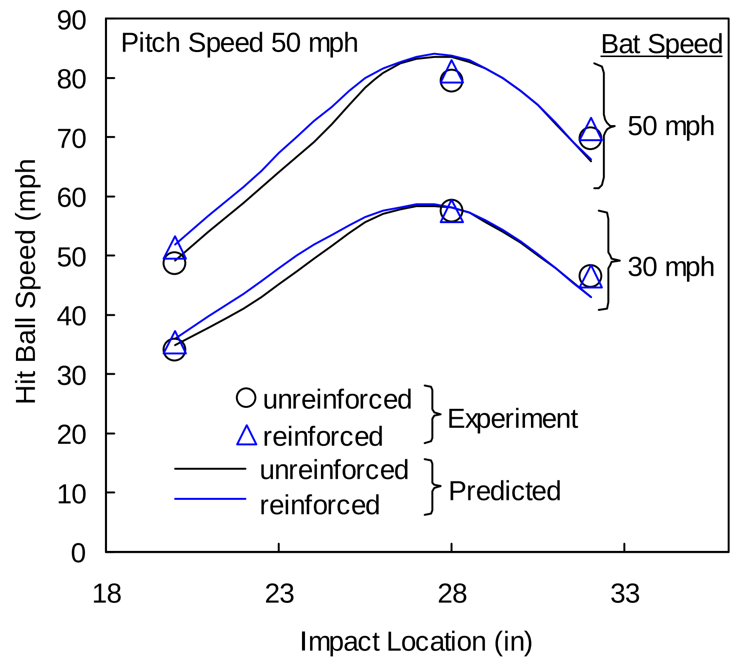
Strain Comparison



Performance Comparison



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Test Methods

- Initially stationary bat (ASTM)
- Initially stationary ball
- Initially moving bat and ball (NCAA)

Performance Measure

- Coefficient of Restitution

$$e = \frac{\omega_2 r_i - v_h}{v_p - \omega_1 r_i}$$

- Bat Performance Factor (ASTM)

$$BPF = \frac{e}{e_b}$$

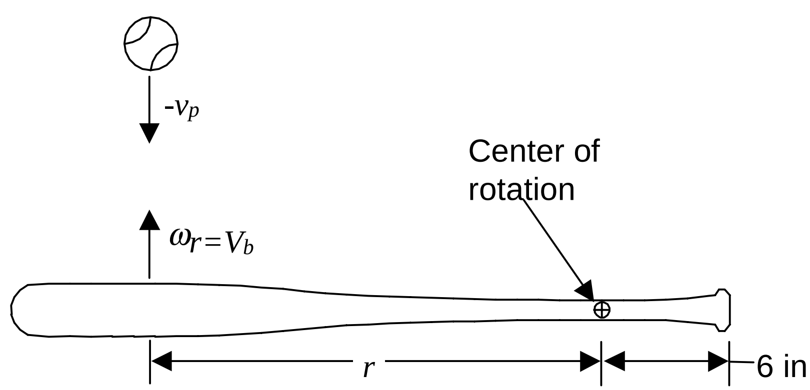
- Ball Exit Speed Ratio (NCAA)

$$BESR = \frac{v_h - \frac{1}{2}\left(\omega_1 r_i + v_p\right)}{\omega_1 r - v_p}$$

- Hit Ball Speed (v_h)

Impact Location

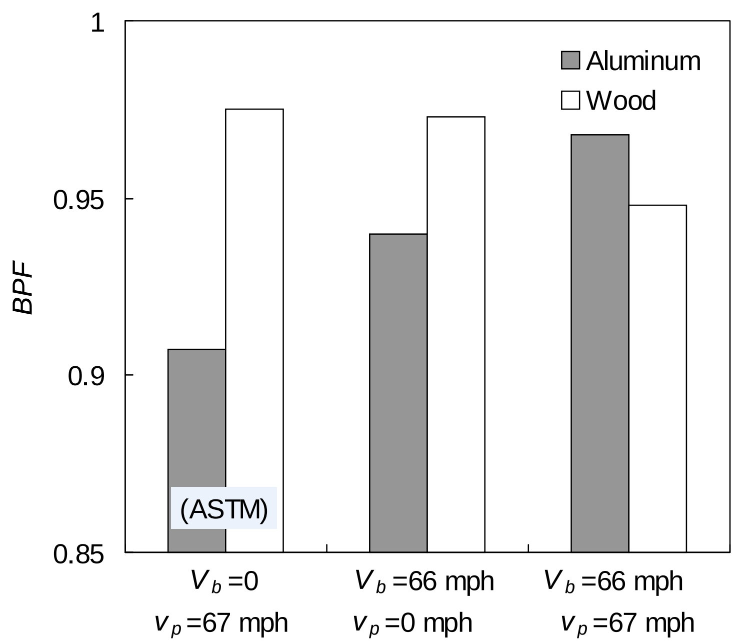
- Fixed locations (6 in from end of bat)
- Center of percussion (ASTM)
- Sweet spot (NCAA)



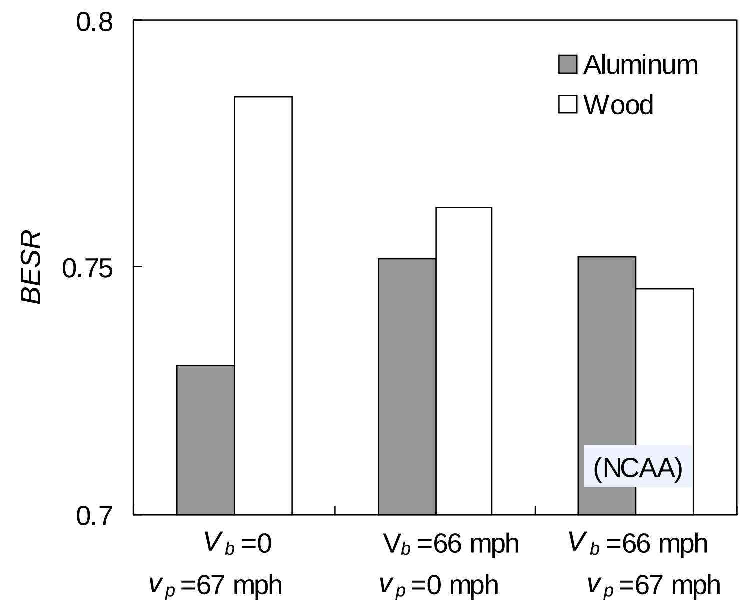
Bat Comparison

Bat	Mass (oz)	C.G. (in)	MOI (oz in^2)
wood	32	16.9	11,403
aluminum	30	16.5	10,803

Bat Performance Comparisons



(impact at center of percussion)



(impact at sweet spot)

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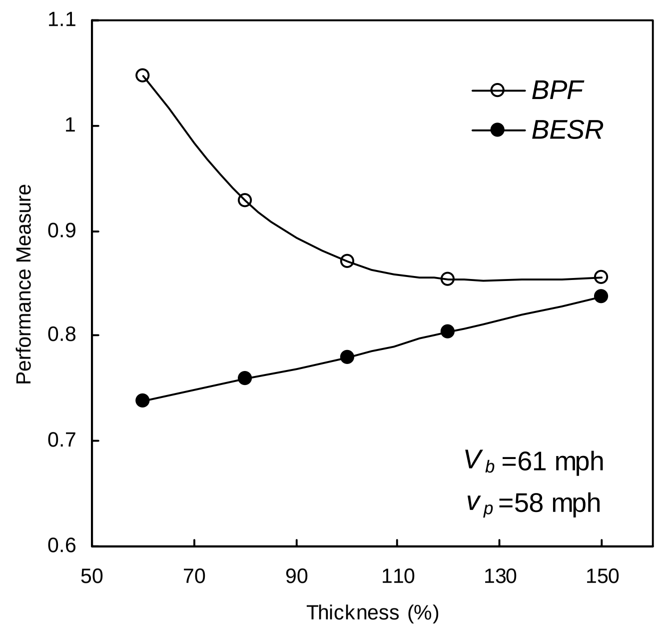
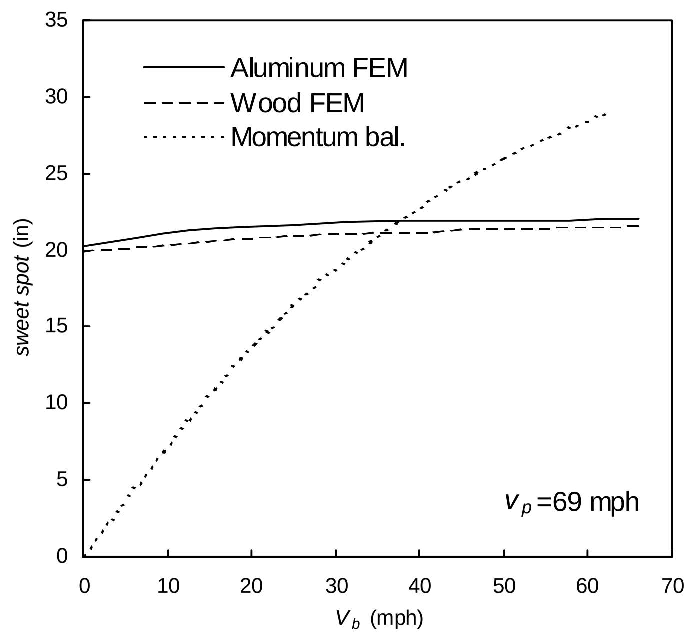
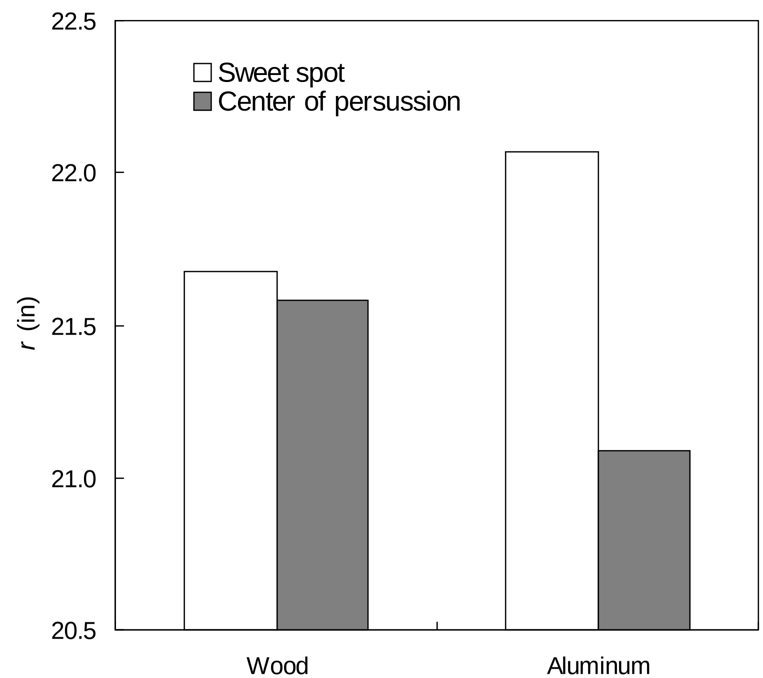
Effect of Bat Wall Thickness



Impact Location





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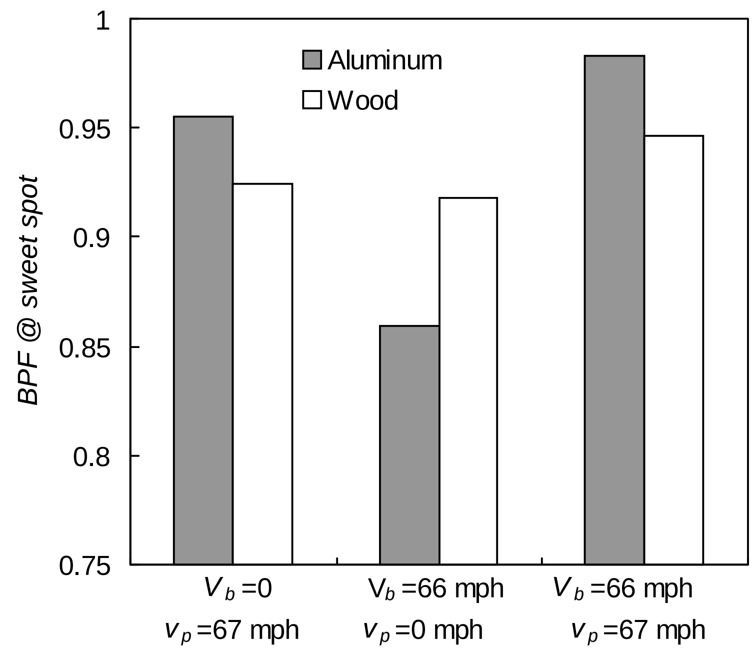
Impact at Sweet Spot



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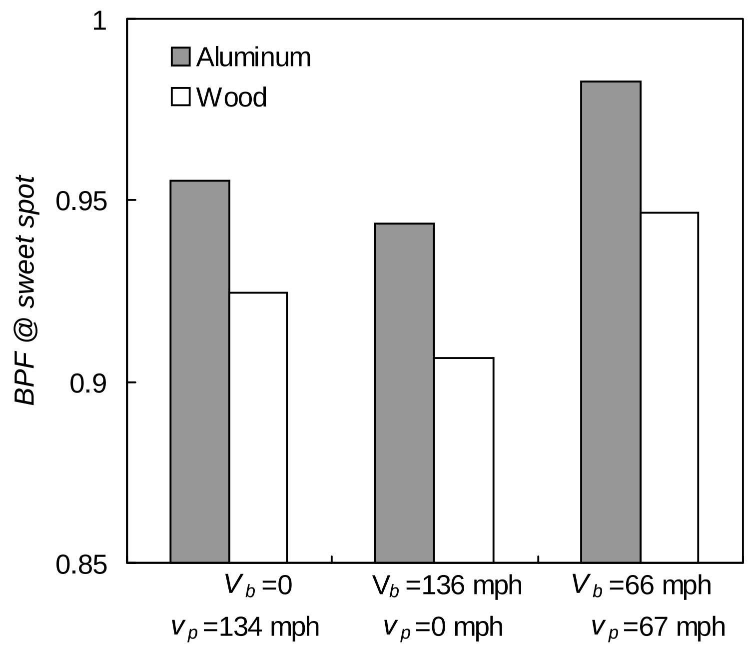
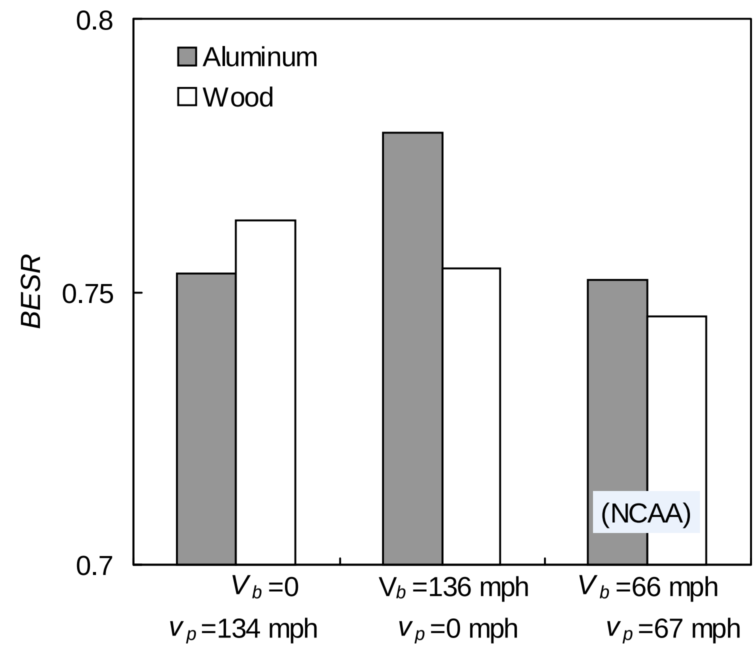
Constant Relative Speed





Summary

- Bats should be impacted at their experimentally determined sweet spot
- Bats should be impacted at relative speeds representative of play conditions
- Performance measures should include the MOI of the bat
- Tests employing an initially stationary ball or bat can represent performance accurately

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