

# *Evaluating Binder Properties in RAP*

*Goal: How to select PG grade of fresh  
binder for Recycled HMA*

**Update on element E2b-1.b  
October 28-29, 2008 – Phoenix, Arizona**

*S. Mangiafico, E. Bautista, & Bahia*





# Progress

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- Review Literature / background
  - Properties of binders in RAP
  - Changes in rheology & failure properties due to aging
  - Blending Charts for determination of properties of blended bitumen
- **Development of new BBR protocol for evaluating RAP binders without solvent extraction**
  - Stiffness (S) and Creep rate (m)
  - Fracture properties



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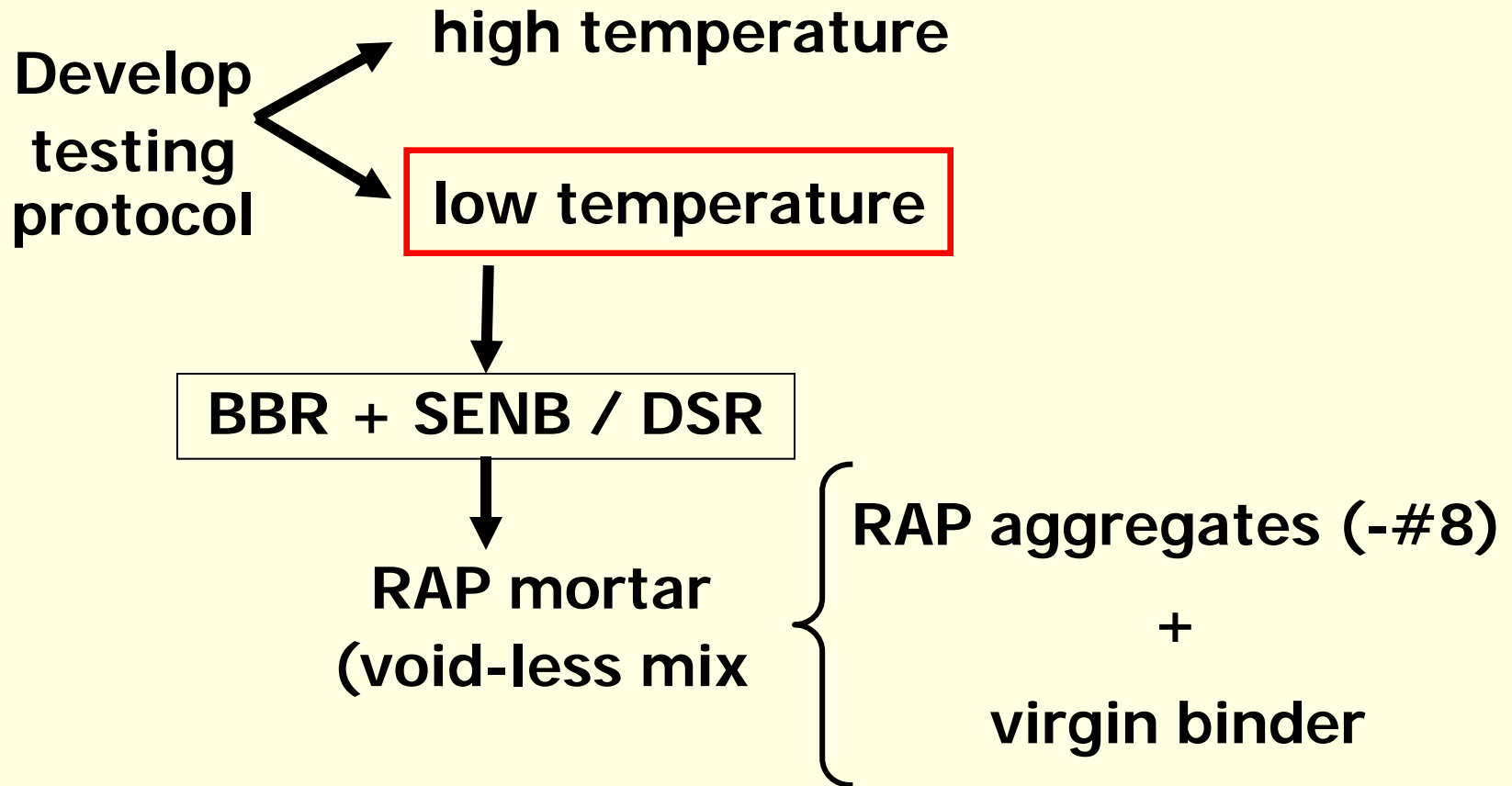
# What is needed to reduce RAP use barriers?

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- A method to measure / estimate  $S(60)$  and  $m(60)$  **without extraction and recovery.**
- Method should represent mixing of fresh binders with binder in RAP in practice
  
- ***ARC work element: E2b***
  - *One of the best alternatives:*
  - *Test RAP mortars*

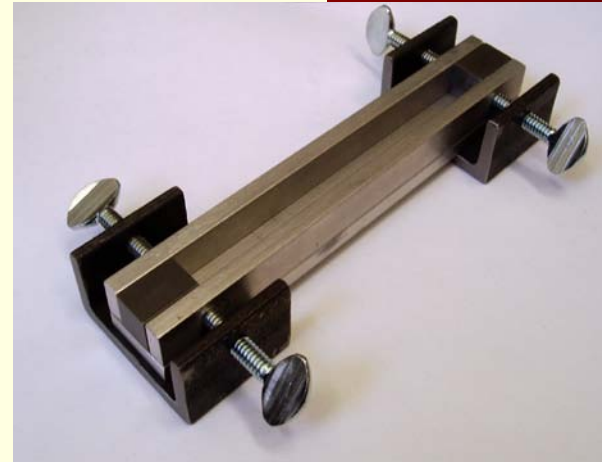


# Current Approach for Testing



# Measuring Properties of RAP Binder

- Rap Mortar :
  - Voidless mix of 15 % binder + P# 8 RAP



# Development of RAP Mortar Testing Protocol

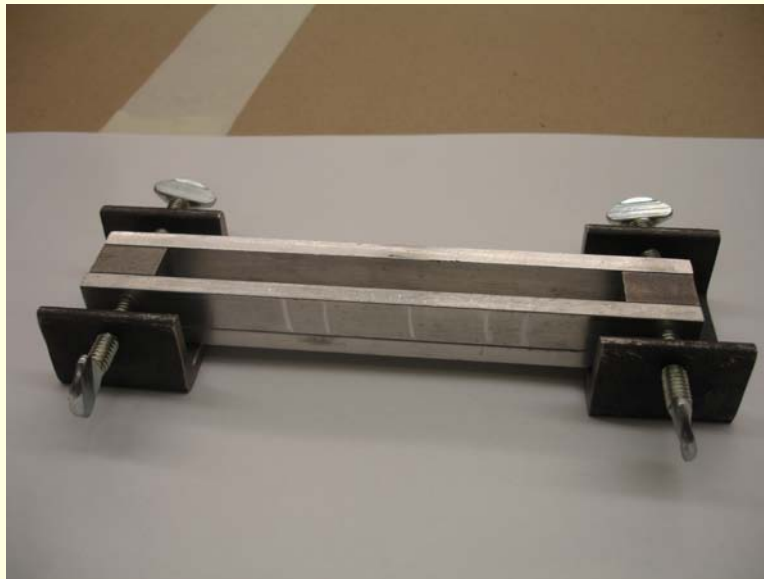
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- ✓ **Modify BBR testing procedure:**
  - **molds**
  - **testing parameters**
  
- ✓ **Set up experimental plan**
  
- ✓ **Data acquisition**
  - **RAP mixture**
  - **virgin binder**
  
- ✓ **Blending charts → influence of binder on RAP**

# BBR test modification

**Modified mold (12.7 mm x 12.7 mm cross section)**



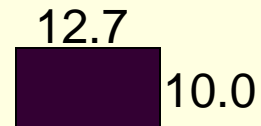
**Allow for at least 4 times maximum aggregate size**



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# BBR test modification

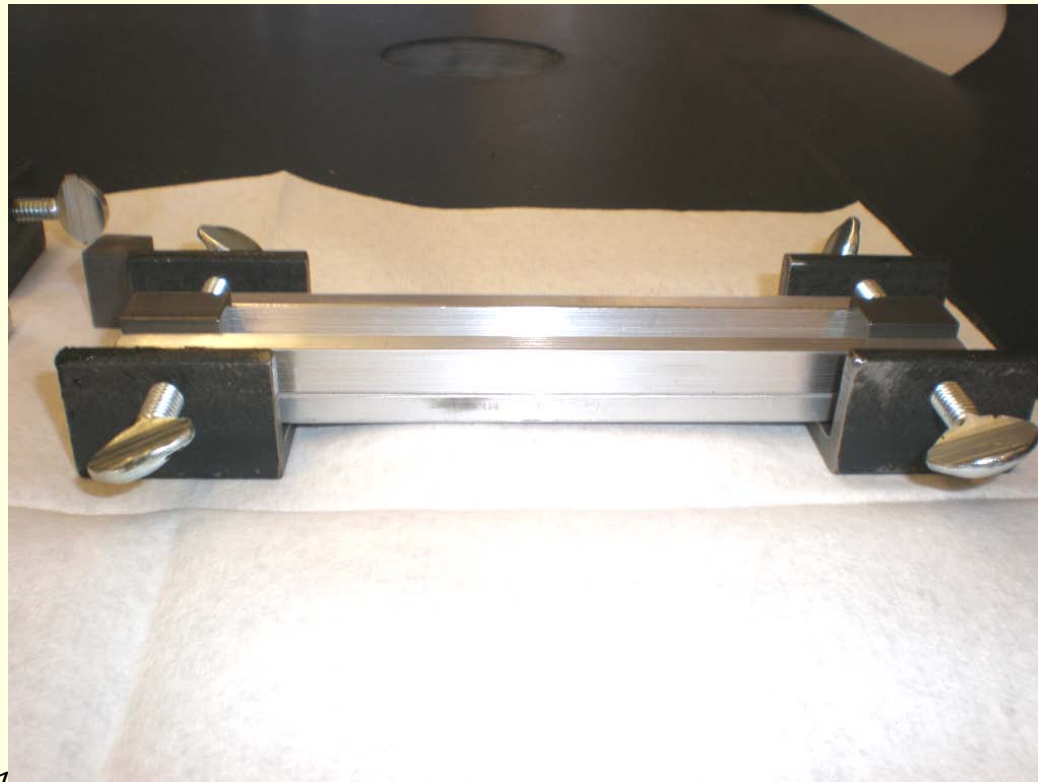
- ✓ **LVDT Position:**
  - ✓ Excessive thickness, LVDT → raised
- ✓ **Load:**
  - ✓ 2000 mN → deflections not significant
  - ✓ 3000 mN → deflections close to LVDT resolution
  - ✓ 4000 mN → better, used for current BBR
- ✓ **Temperature**
  - ✓ -6.0 °C
  - ✓ 0.0 °C (selected for current BBR)
- ✓ **Specimen Thickness**
  - ✓ 12.7 mm changed to 10.0 mm





# BBR test – new mold

**New mold  
(10 mm Thick x 12.7 mm Wide)**

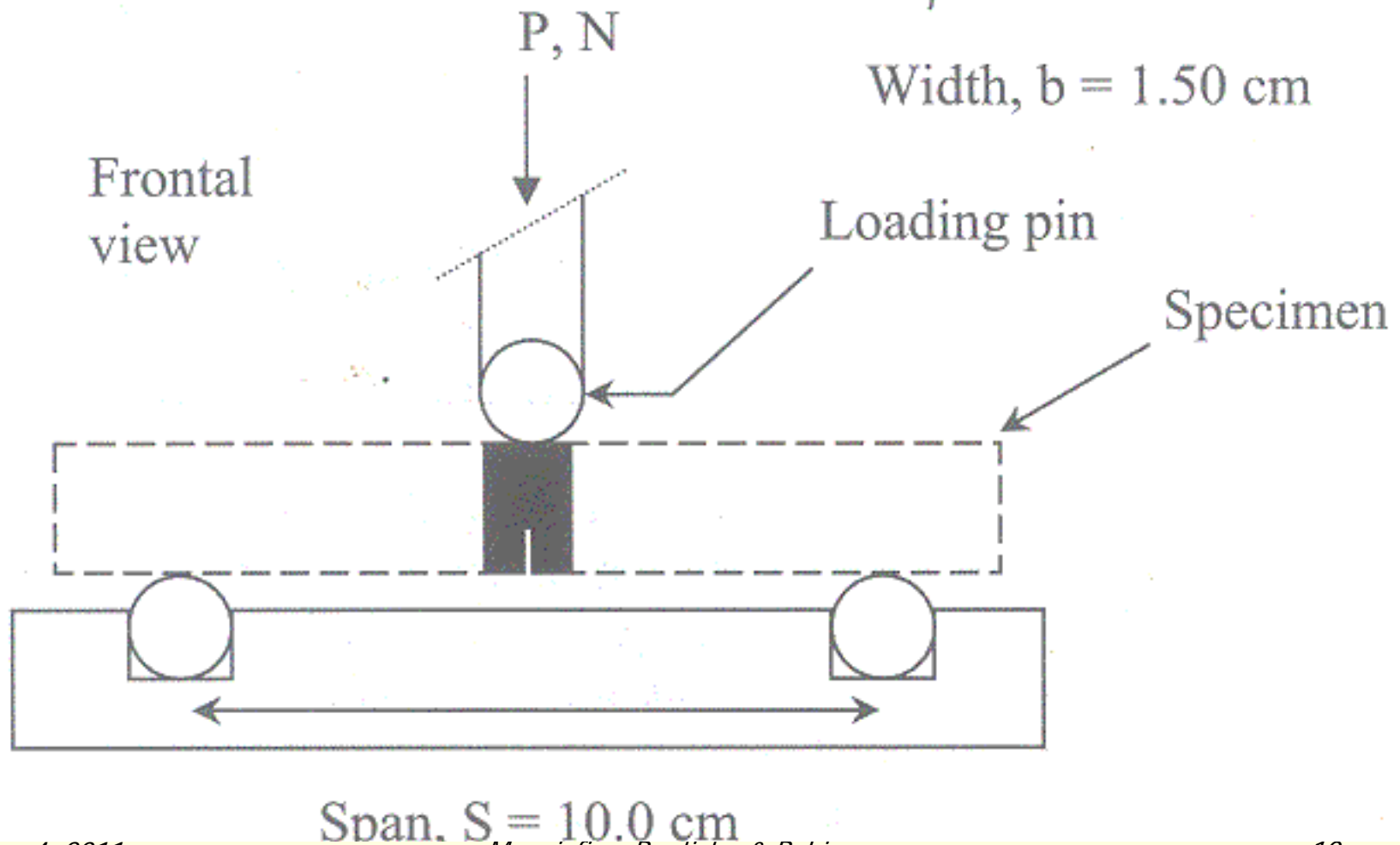




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# Single Edge Notched Beam Test

Hesp et al. 2000,.....



# Design Mold for Fracture Testing

*Work in collaboration with G. Reinke (2008)*

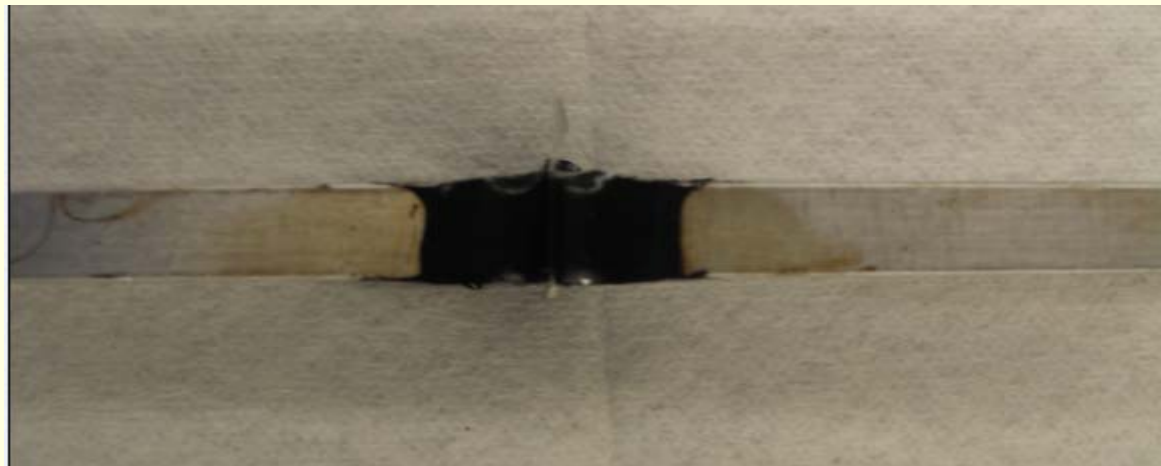




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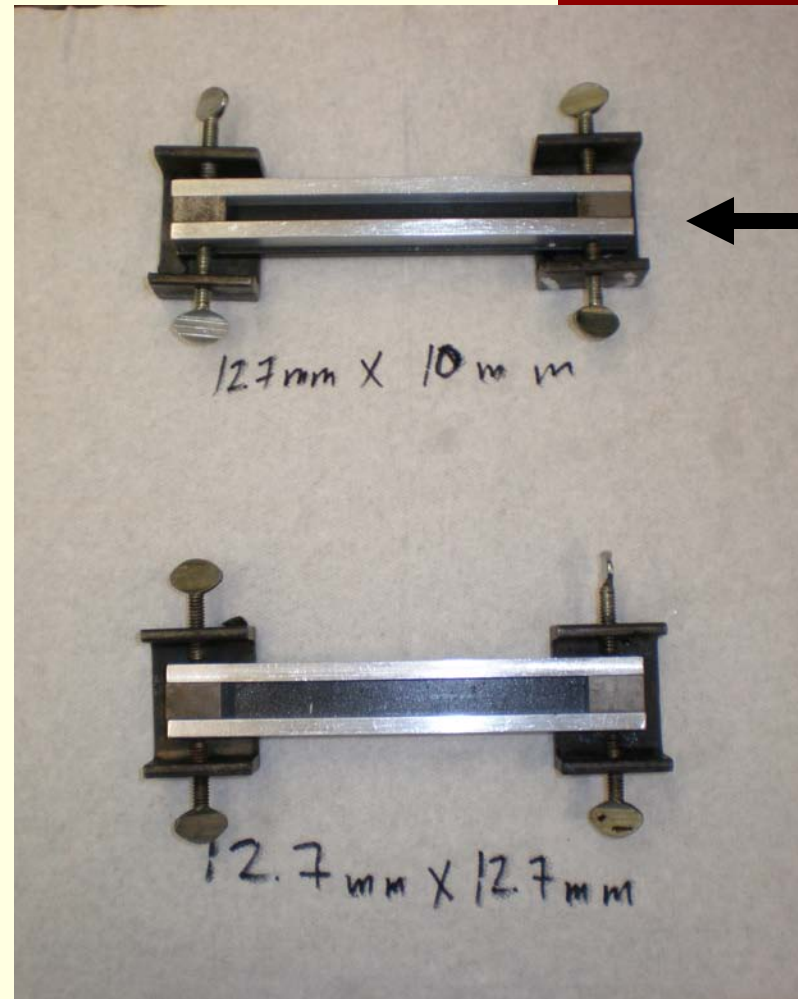
# SENB Sample

*Work in collaboration with G. Reinke (2008)*



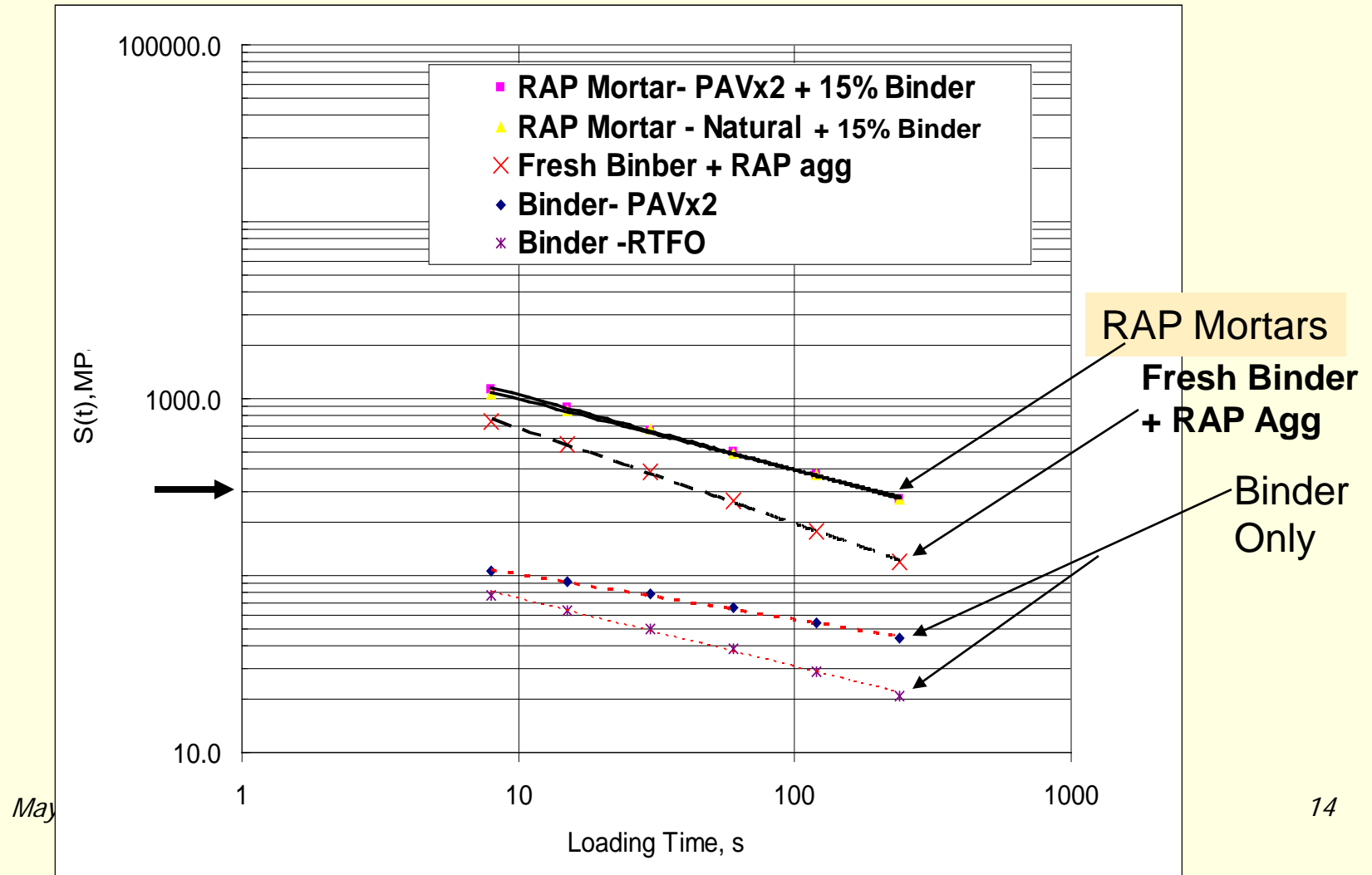
# New Geometry:

- Better consistency
- No plastic strips
- Teflon coated molds
  
- Results are more repeatable



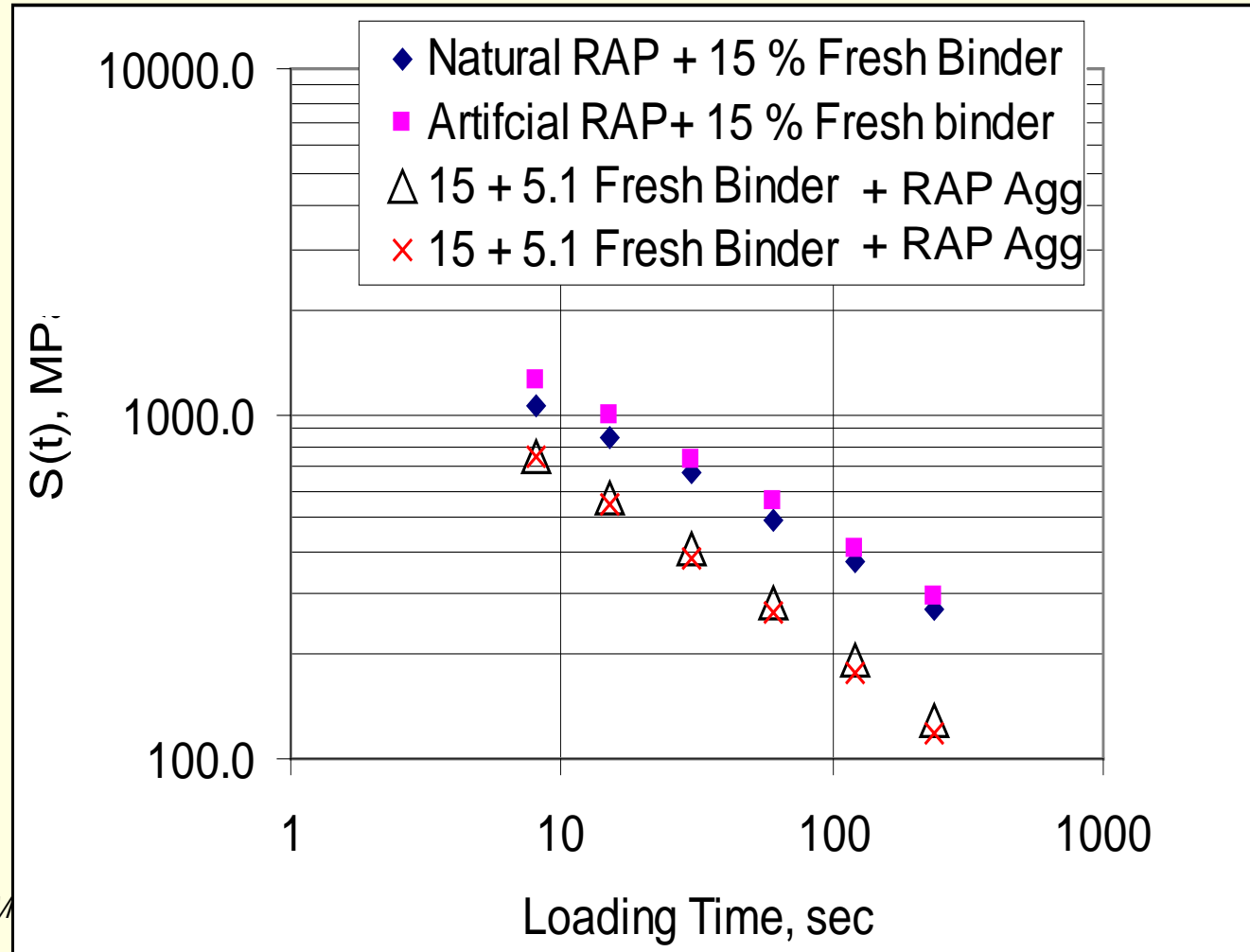


# Effect of RAP Binder Aging On *RAP Mortar BBR Stiffness*



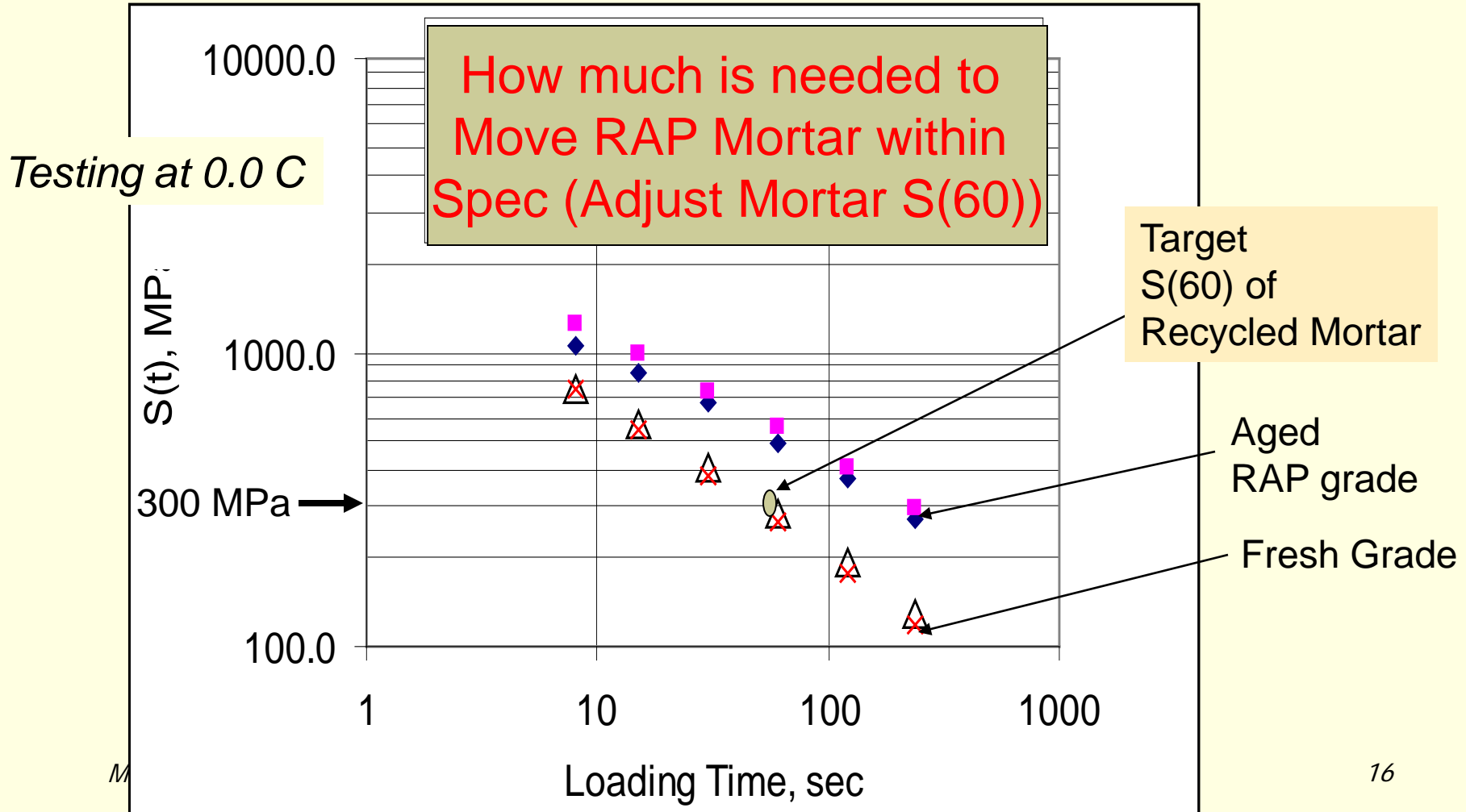


# Repeatability of BBR Test RAP Mortar Samples





# Concept of need to change PG grade







# Proposed Testing Protocol

Sieve RAP on #8 and split

Burn in Ignition Oven To get aggregate & estimate AC%

Mix aggregate with fresh binder at RAP ac% + 15 %

Prepare 2 BBR mortar beams

Test 2 BBR mortar beams at 0.0 C (B)  
RAP agg + ac%+ 15%

Mix with 15 % fresh binder of required PG grade

Prepare 2 BBR mortar beams

Test 2 BBR 2 BBR mortar with P#8 RAP beams at 0.0 C (A)

Compare A and B, No difference (Stop)  
Significant difference Proceed to ( C )

Test 2 BBR beams of fresh binder (C)  
Conduct Analysis

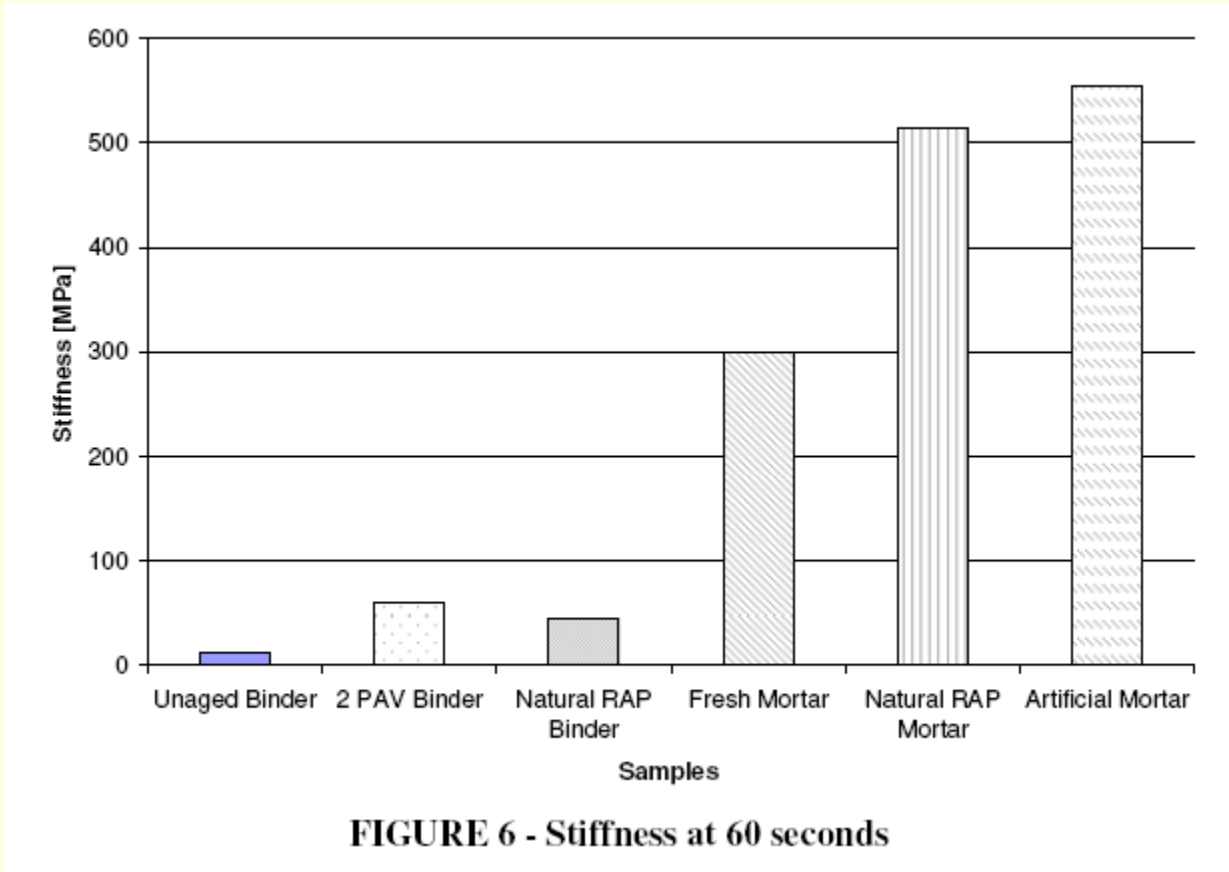


# Proposed Procedure

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- 3. Analysis (When needed)
  - Establish binder to mortar relationship
  - Convert mortars stiffness values to binder values
  - Use blending chart to estimate the stiffness of
  - the aged binder in the natural RAP.
- Based on the known stiffness of the aged binder, **calculate how much RAP can be used** without exceeding the 300 MPa limit.
- Conversely, **estimate the grade of the fresh binder needed** to bring back the stiffness of the blended binder within the PG limits, at the intended RAP concentration.

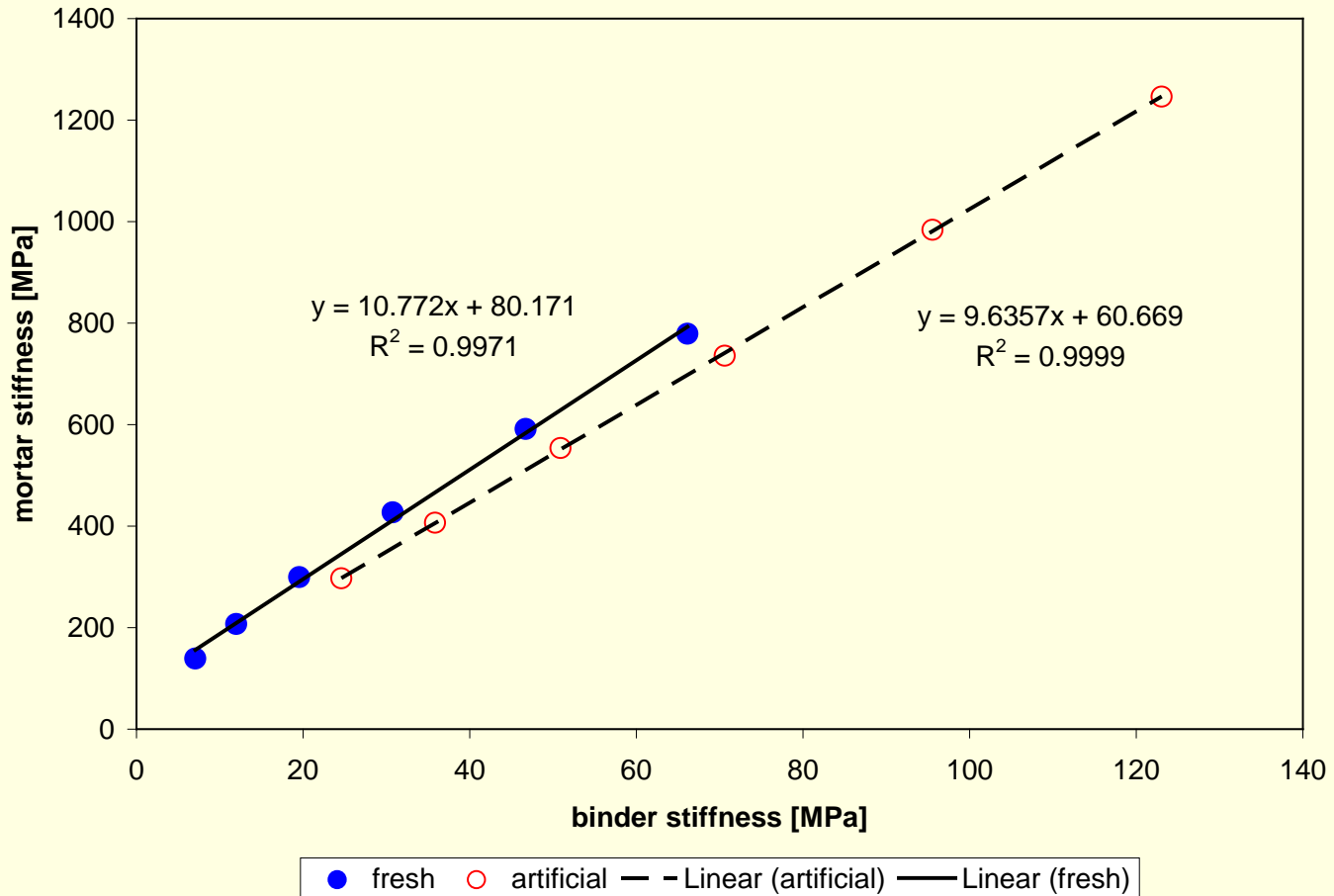
# Effect of aging on binder and mortar stiffness values





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# Relationship between binder and mortar stiffness values





# Blending chart of fresh and RAP Binder

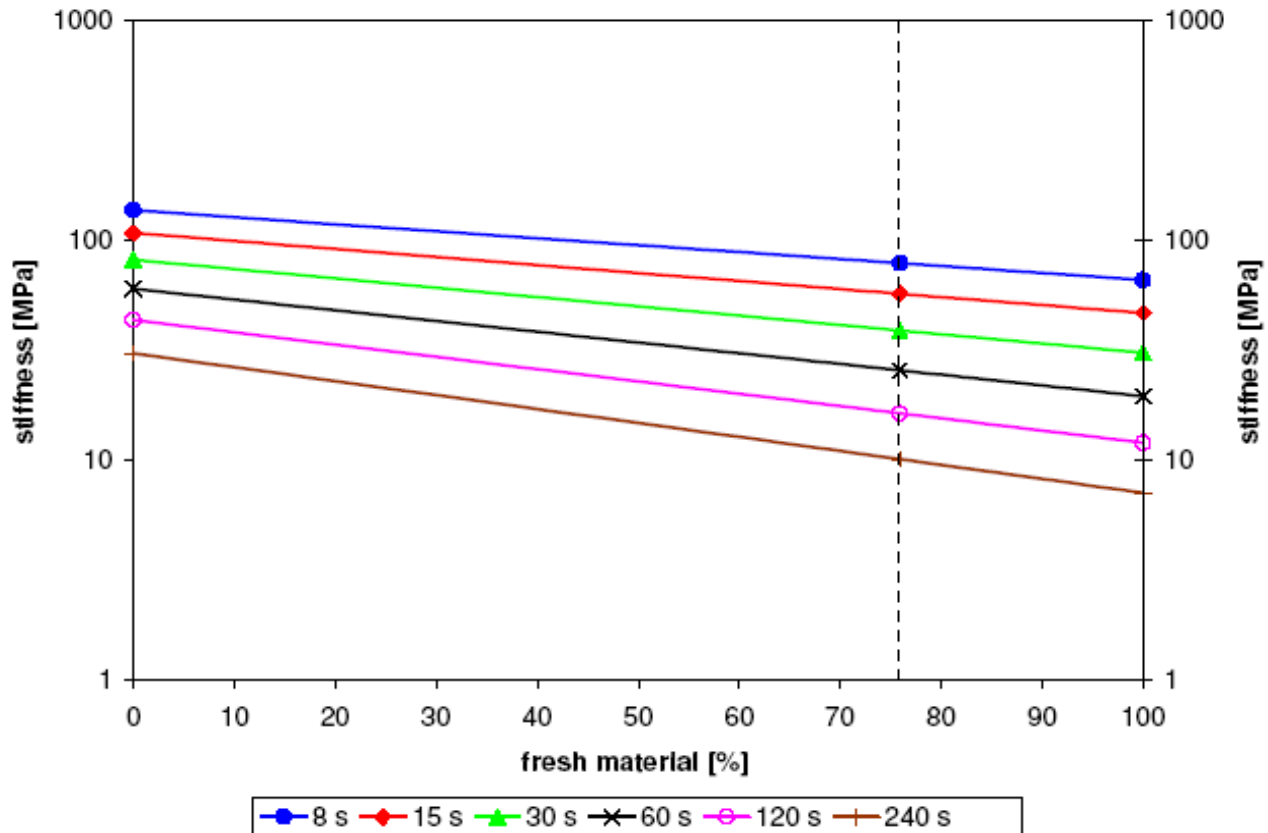
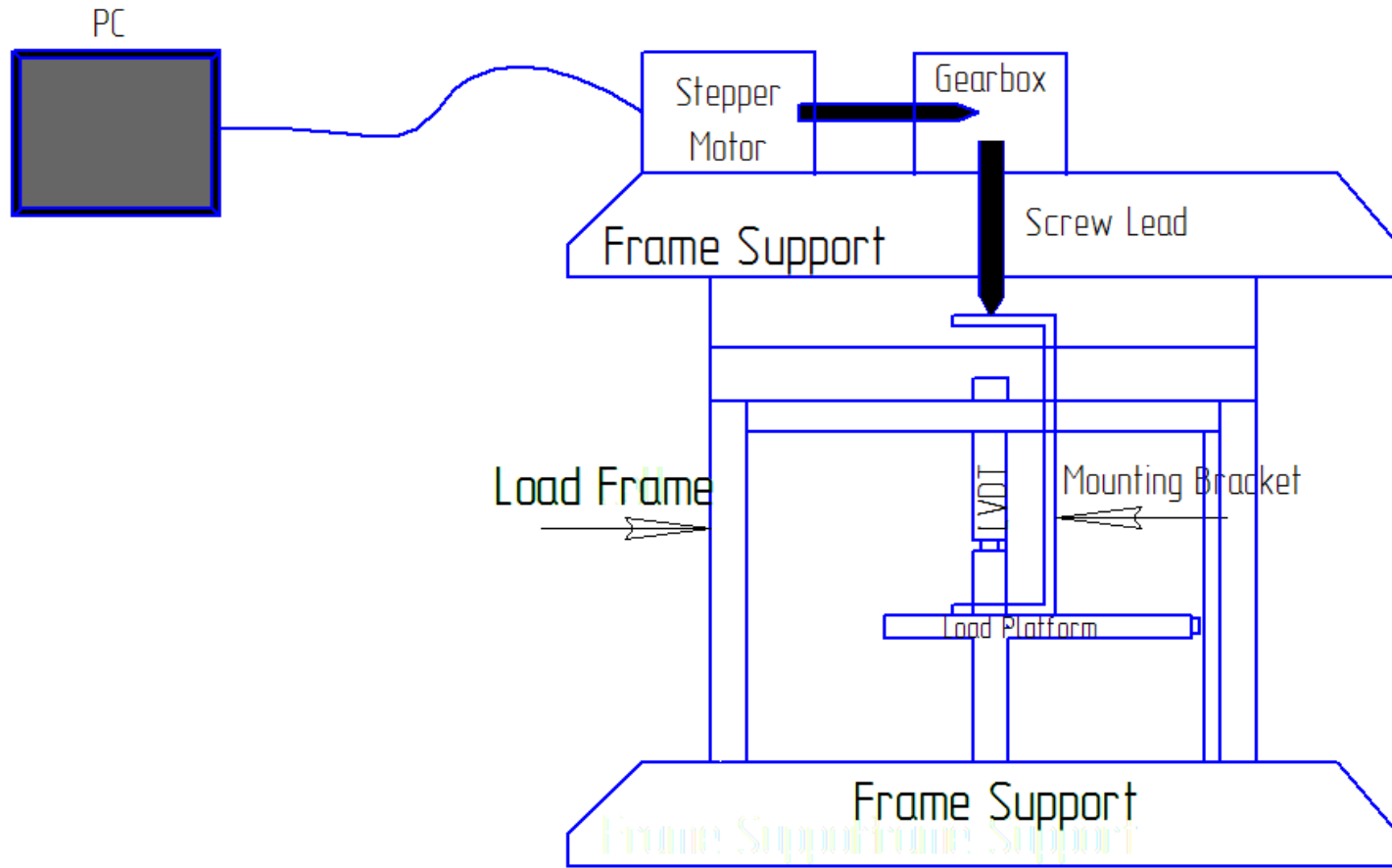


FIGURE 5 - Blending chart to Estimate Stiffness of Blended Binder in the artificial RAP



# General Design for BBR Modification

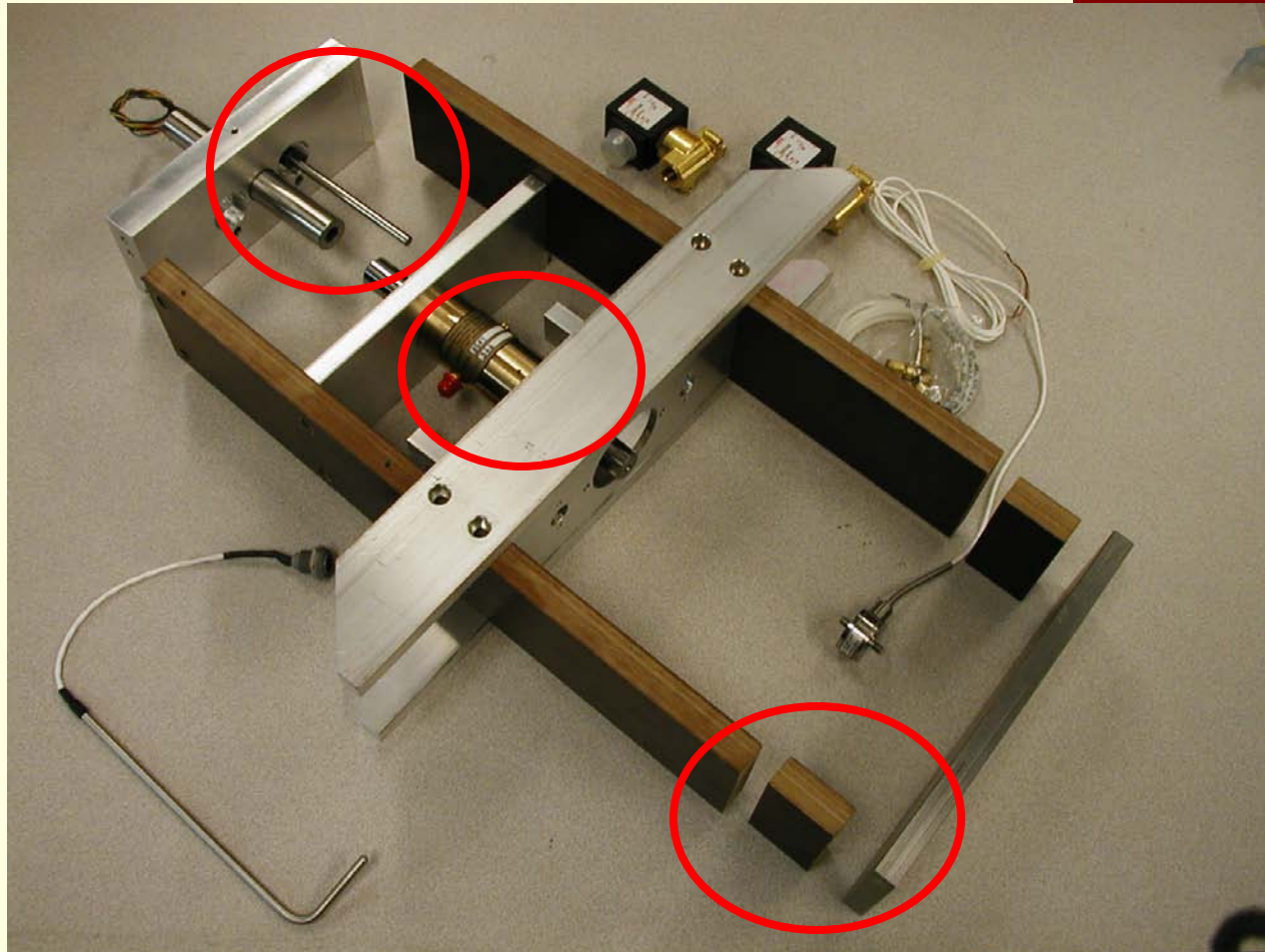




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# New BBR set-up

## Several up-grades



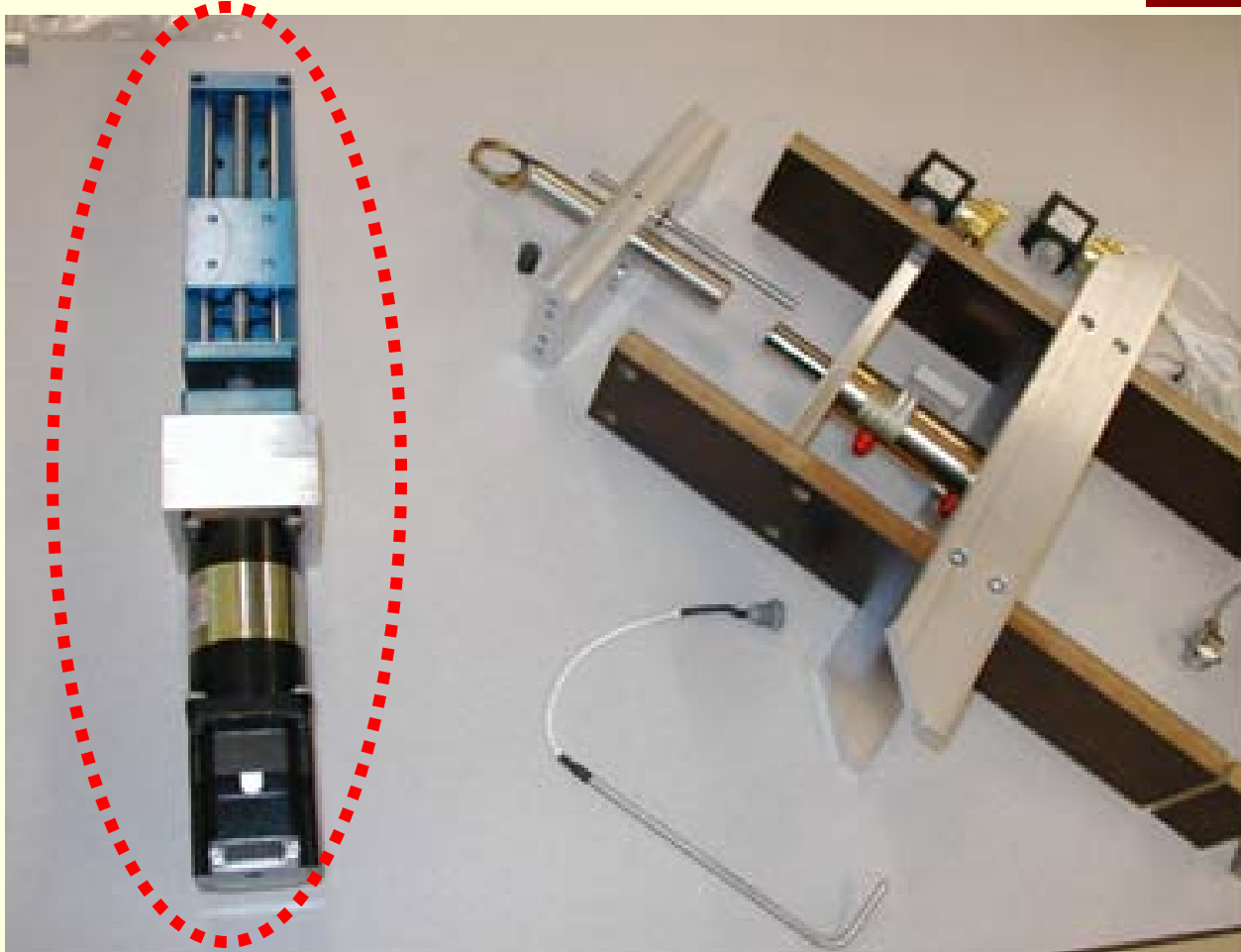
May 4, 2011

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# Next steps: Fracture Properties

## SENB – Hesp et al. - Manitoba







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## BBR Prototype for Mortars + SENB

- Load cell upgrade
- Motor for CDR
- Longer frame

# Interim Findings

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- A method for measuring/estimating the need for changing PG grade is under development
- It is based on the BBR
- Initial data is promising
- Challenges:
  - Sample preparation
  - Modification of BBR
  - Acceptance limits



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# Thank you for you time!

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## ➤ Acknowledgments

- Work is part of ARC, FHWA and WRI support is greatly appreciated
- Guidance and support of University of Nevada- Reno group is greatly appreciated.
  - Jon Epps
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## ➤ Questions?