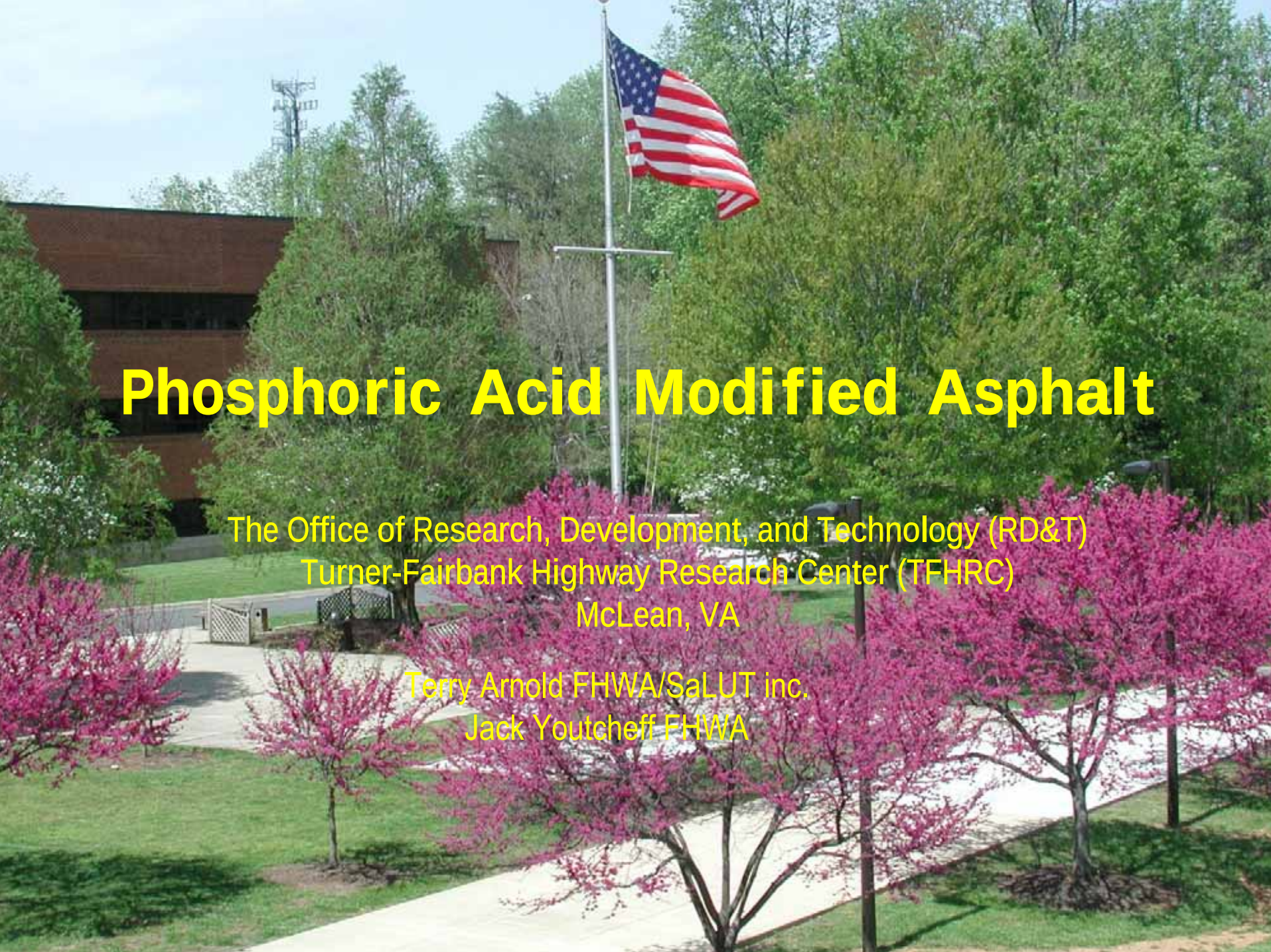


Phosphoric Acid Modified Asphalt

The Office of Research, Development, and Technology (RD&T)
Turner-Fairbank Highway Research Center (TFHRC)
McLean, VA

Terry Arnold FHWA/SaLUT inc.
Jack Youtcheff FHWA

Four SHRP Asphalts

	Origin	Grade	Asphaltene %	Polar Aromatics	Napthenic Aromatics	Saturates
AAD-1	CA Coastal	PG 58-28	20.5	41.3	25.1	8.6
AAK-1	Boscan	PG 64-22	20.1	41.8	30.0	5.1
AAM-1	West TX Int.	PG64-16	4.0	50.3	41.9	1.9
ABM-1	CA Valley	PG 58-10	7.1	52.4	29.6	9.0

Grades of Phosphoric Acid

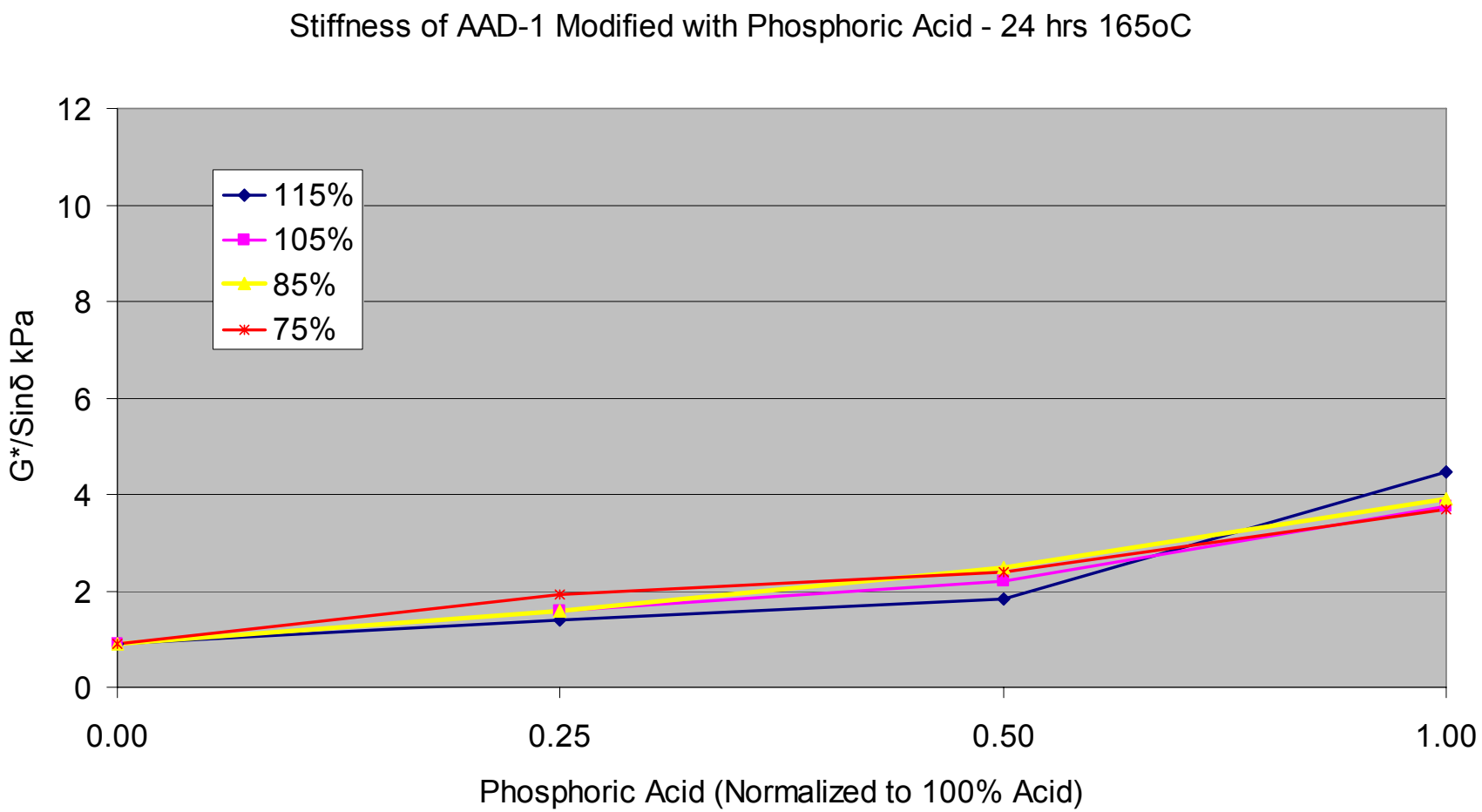
- 115%
- 105%
- 85%
- 75%
- 50% (Green Acid)
- Phosphorous Pentoxide

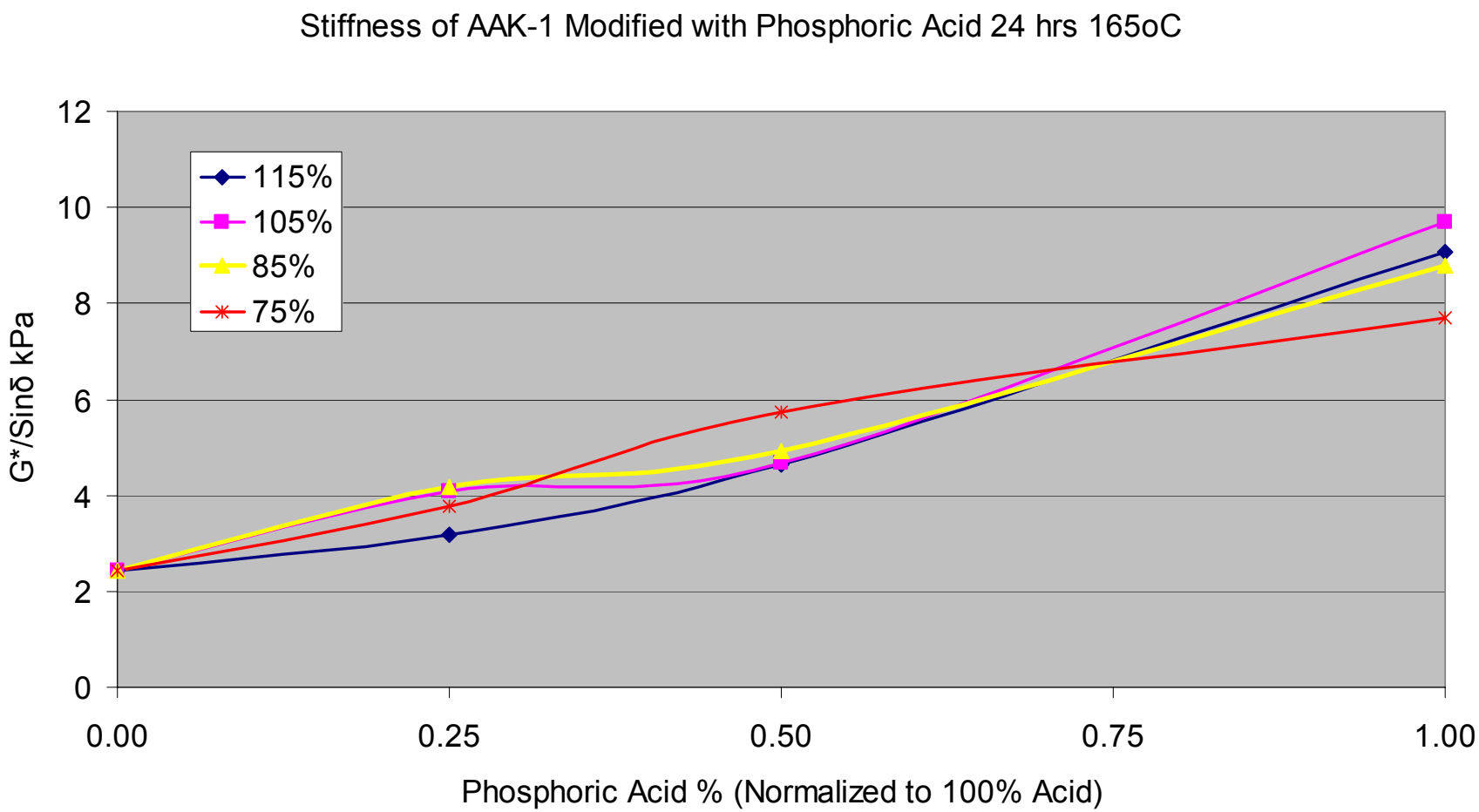
Three Addition Levels

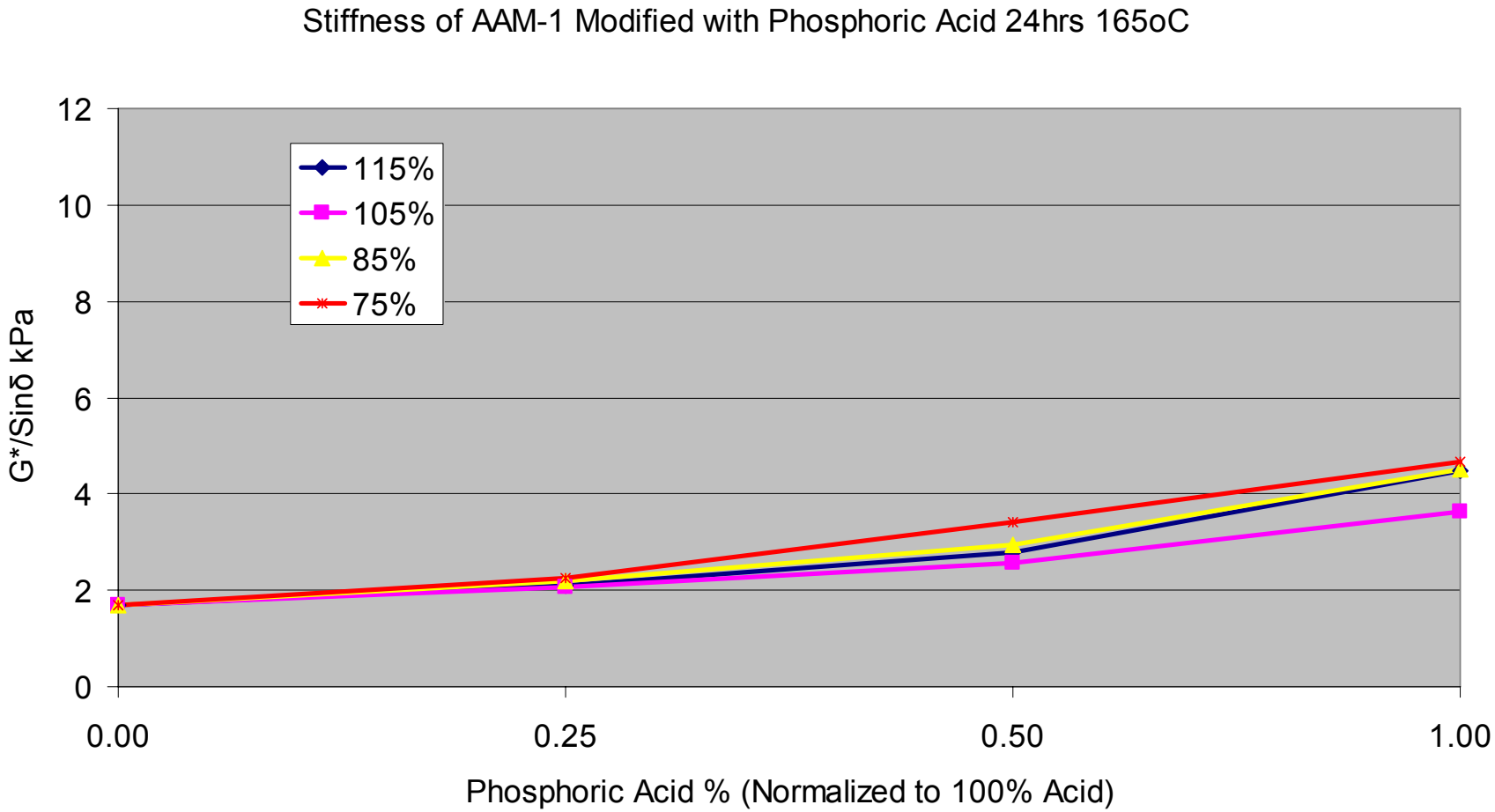
- 0.25%
- 0.5%
- 1.0%

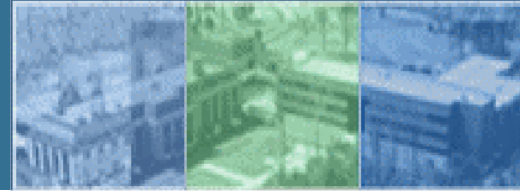
Effect of Acid Type on Stiffness (G*/Sinδ 64°C)

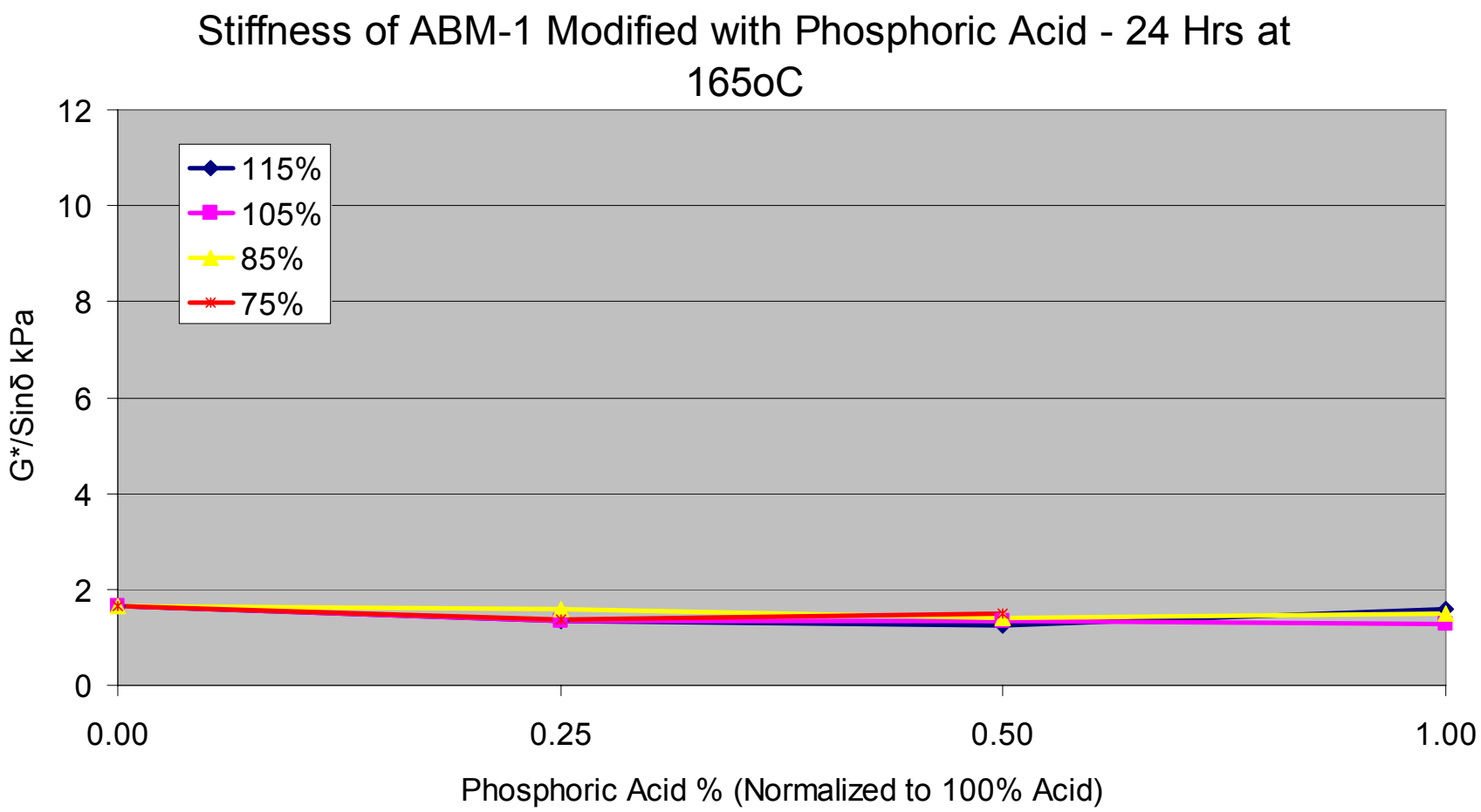
24 Hours Storage 165°C


Stiffness of AAD-1 Modified with Phosphoric Acid - 24 hrs 165oC
G*/Sinδ kPa
12
10
8
6
4
2
0
115%
105%
85%
75%
0.00
0.25
0.50
1.00
Phosphoric Acid (Normalized to 100% Acid)


Stiffness of AAK-1 Modified with Phosphoric Acid 24 hrs 165oC
G*/Sinδ kPa
12
10
8
6
4
2
0
115%
105%
85%
75%
0.00
0.25
0.50
0.75
1.00
Phosphoric Acid % (Normalized to 100% Acid)


Stiffness of AAM-1 Modified with Phosphoric Acid 24hrs 165oC
G*/Sinδ kPa
12
10
8
6
4
2
0
115%
105%
85%
75%
0.00
0.25
0.50
1.00
Phosphoric Acid % (Normalized to 100% Acid)



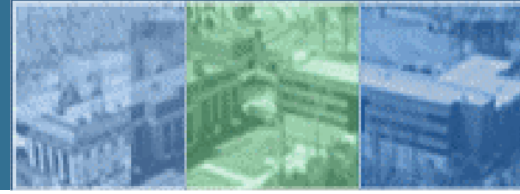

Stiffness of ABM-1 Modified with Phosphoric Acid - 24 Hrs at 165oC
G*/Sinδ kPa
12
10
8
6
4
2
0
115%
105%
85%
75%
0.00
0.25
0.50
1.00
Phosphoric Acid % (Normalized to 100% Acid)

Conclusion – Based on 24 Hour Stiffness

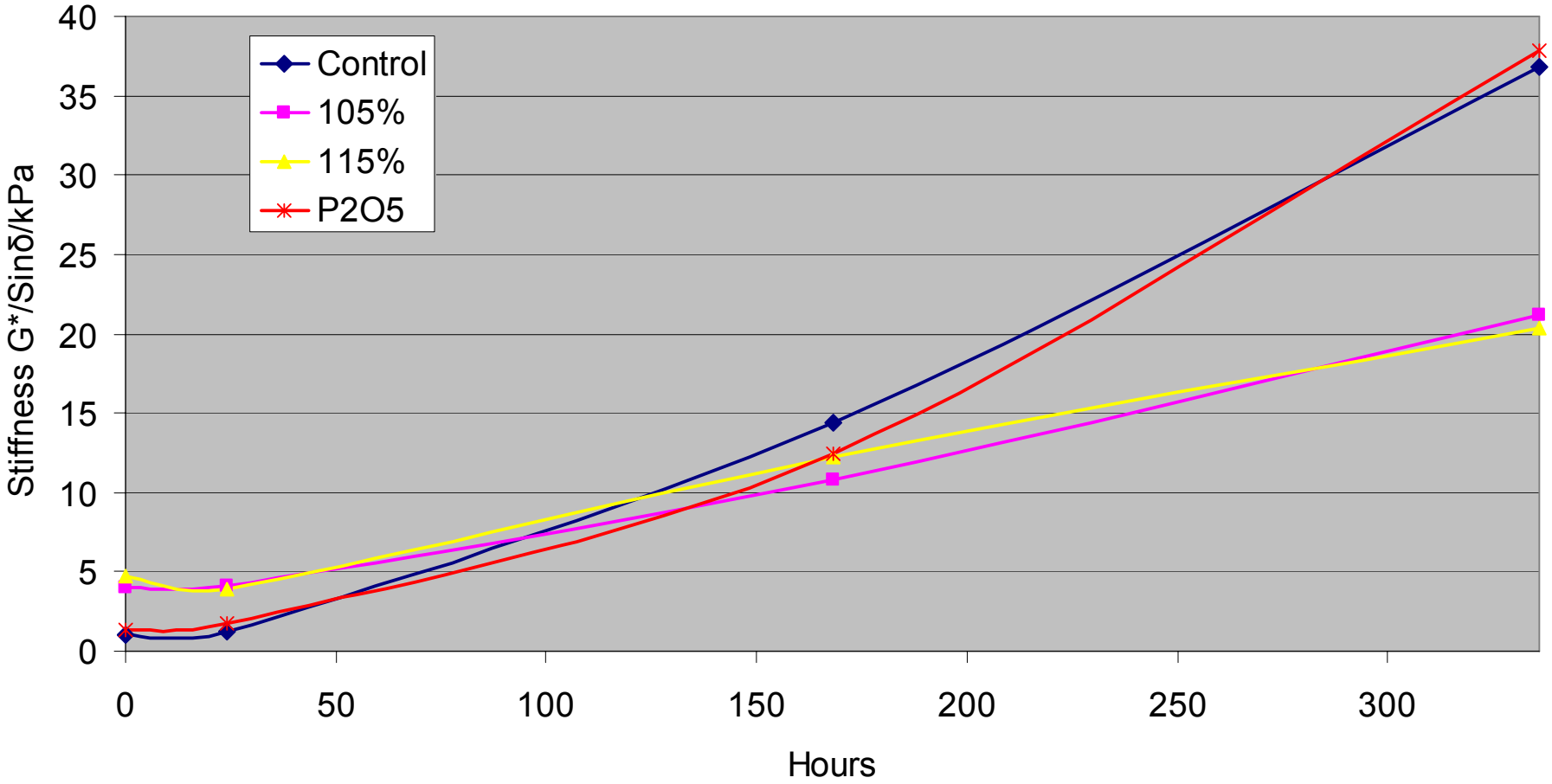
- Any of the Phosphoric Acid Grades can be used
- Acids Containing Water Cause Foaming
- Green Acid is Likely to Cause Corrosion
- Stiffness is Asphalt Dependant
- AAK-1 (Boscan) is the Most Responsive
- ABM-1 (CA Valley) Showed No Stiffness Increase

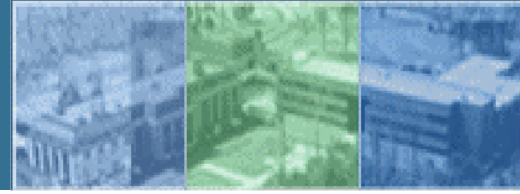
Environmental Considerations

Effect of Air – PAV Aging

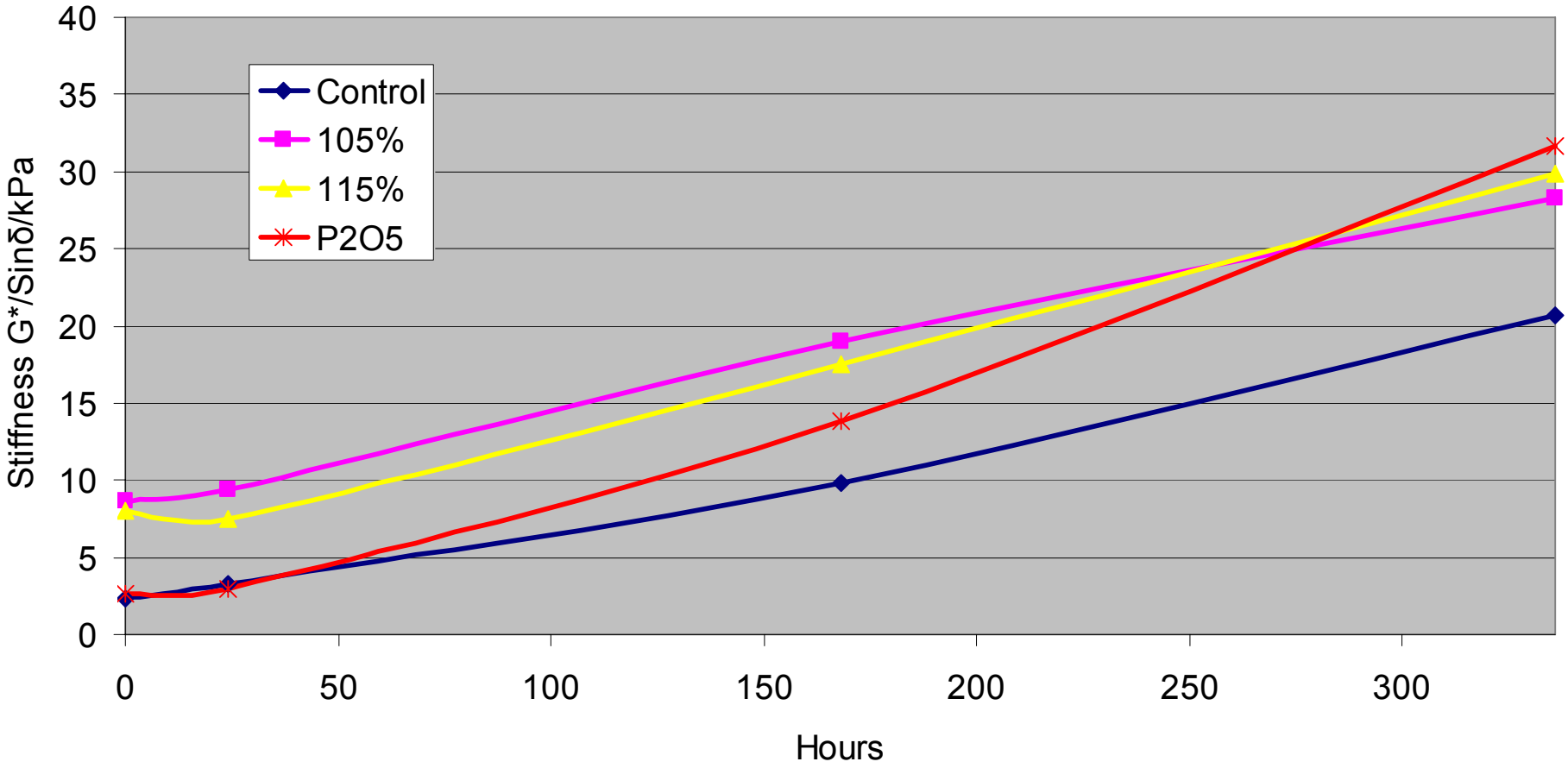


PAV Aging 100oC, AAD-1 Under Air 1% Phosphoric Acid

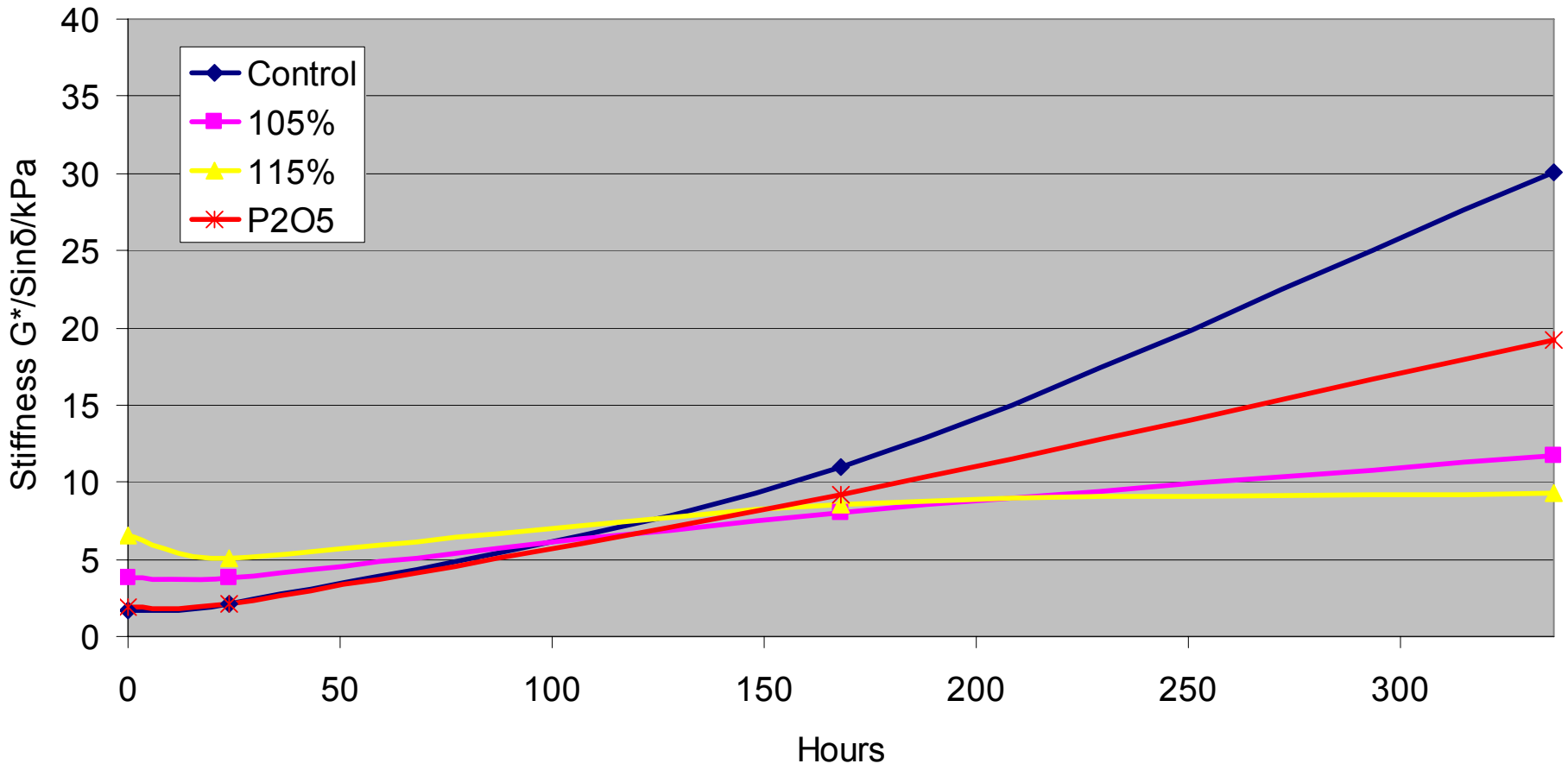




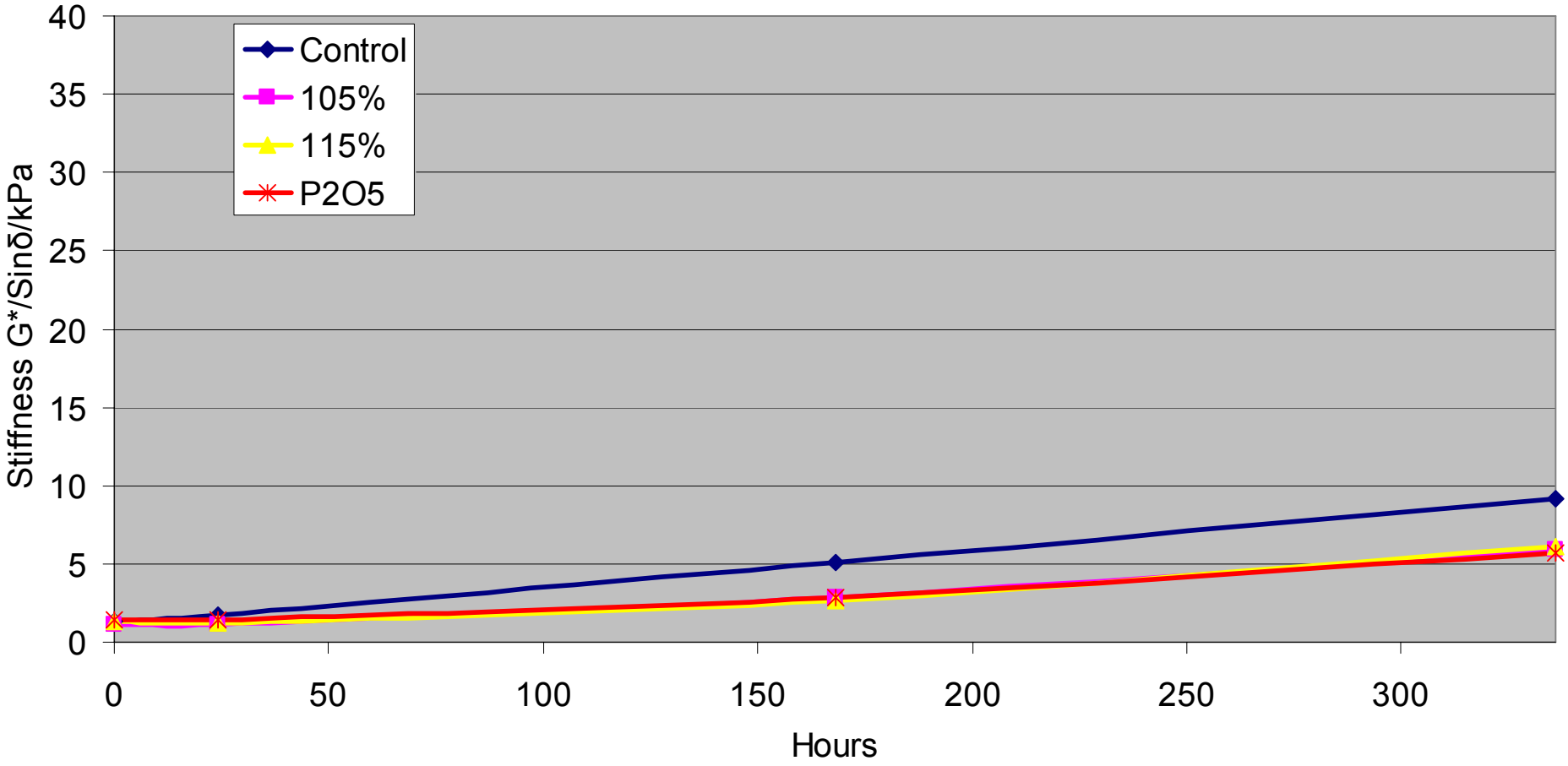
PAV Aging 100oC, AAK-1 Under Air 1% Phosphoric Acid



PAV Aging 100oC, AAM-1 Under Air 1% Phosphoric Acid



PAV Aging 100oC, ABM-1 Under Air 1% Phosphoric Acid



Findings and Conclusions PAV Aging Air

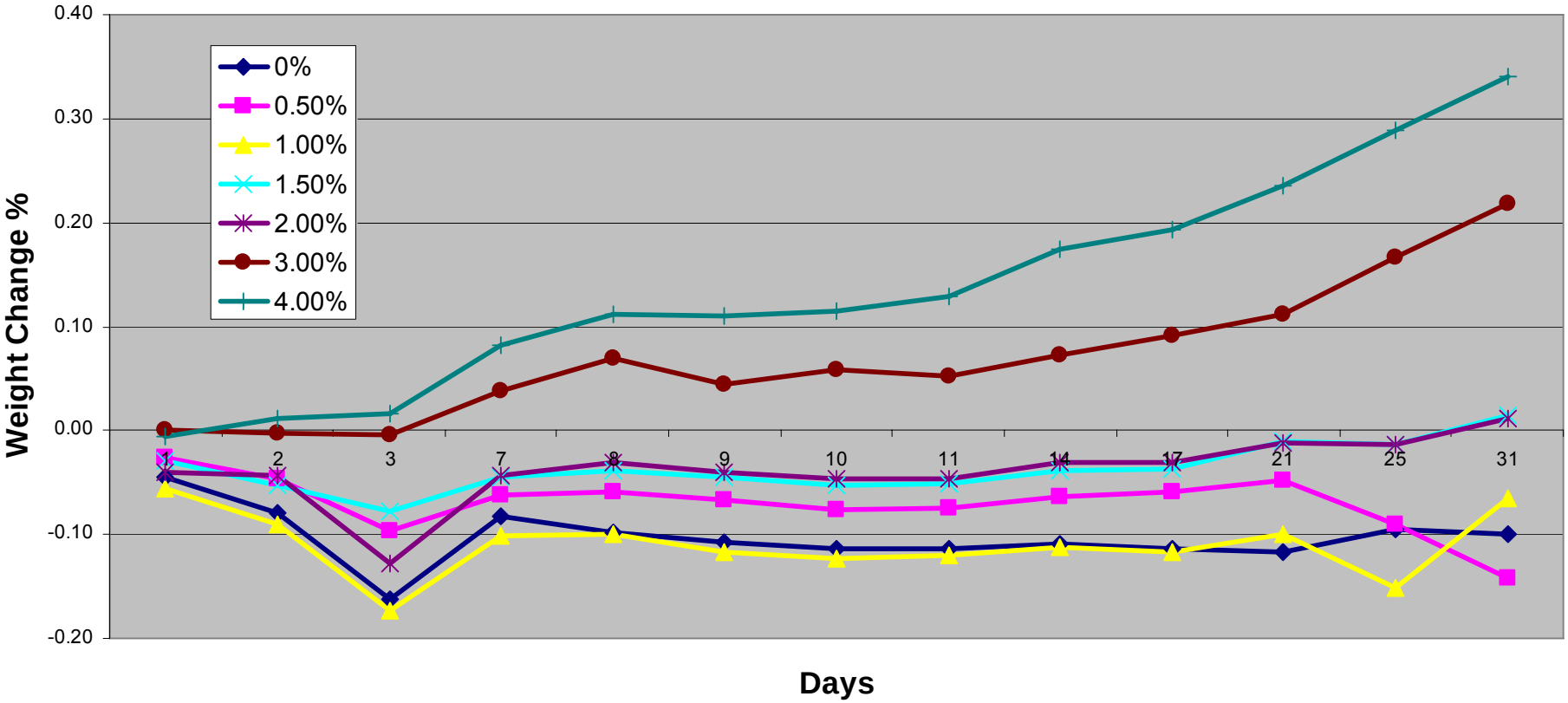
- Aging Rate is Asphalt Dependant
- AAK-1 (Boscan) – All acid modified samples were worse than the control
- AAM-1 (West TX Int.) and ABM-1 acid modified samples were better than the control

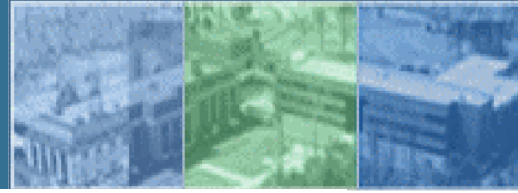
Environmental Effects - Water

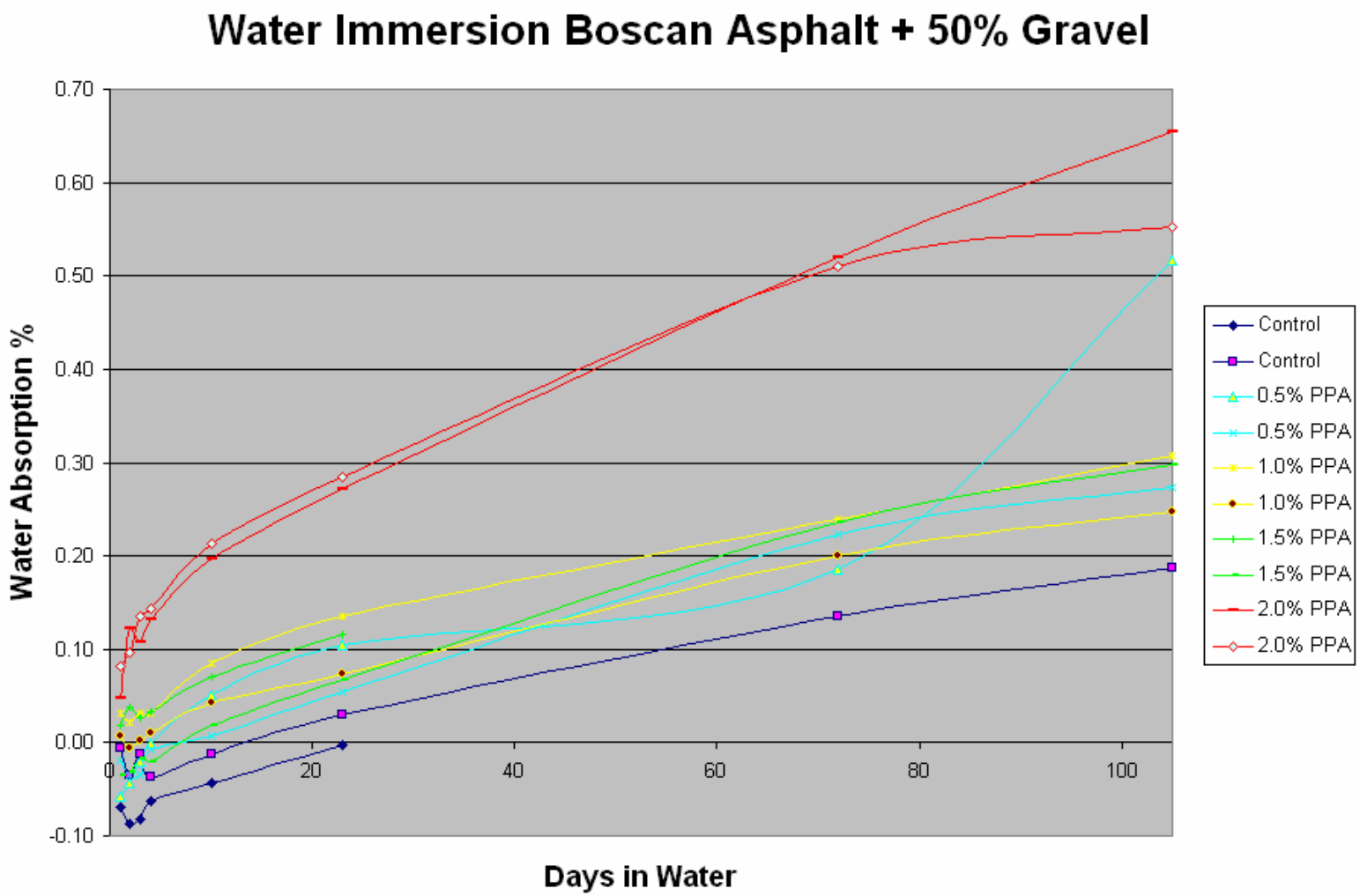
Asphalt and 50% Mastics

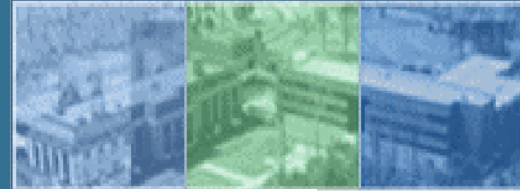
Asphalt is 60% Bachequero, 40% Menemota 21

Water Absorption Citgo Asphalt BBR Beams 115% Polyphosphoric Acid

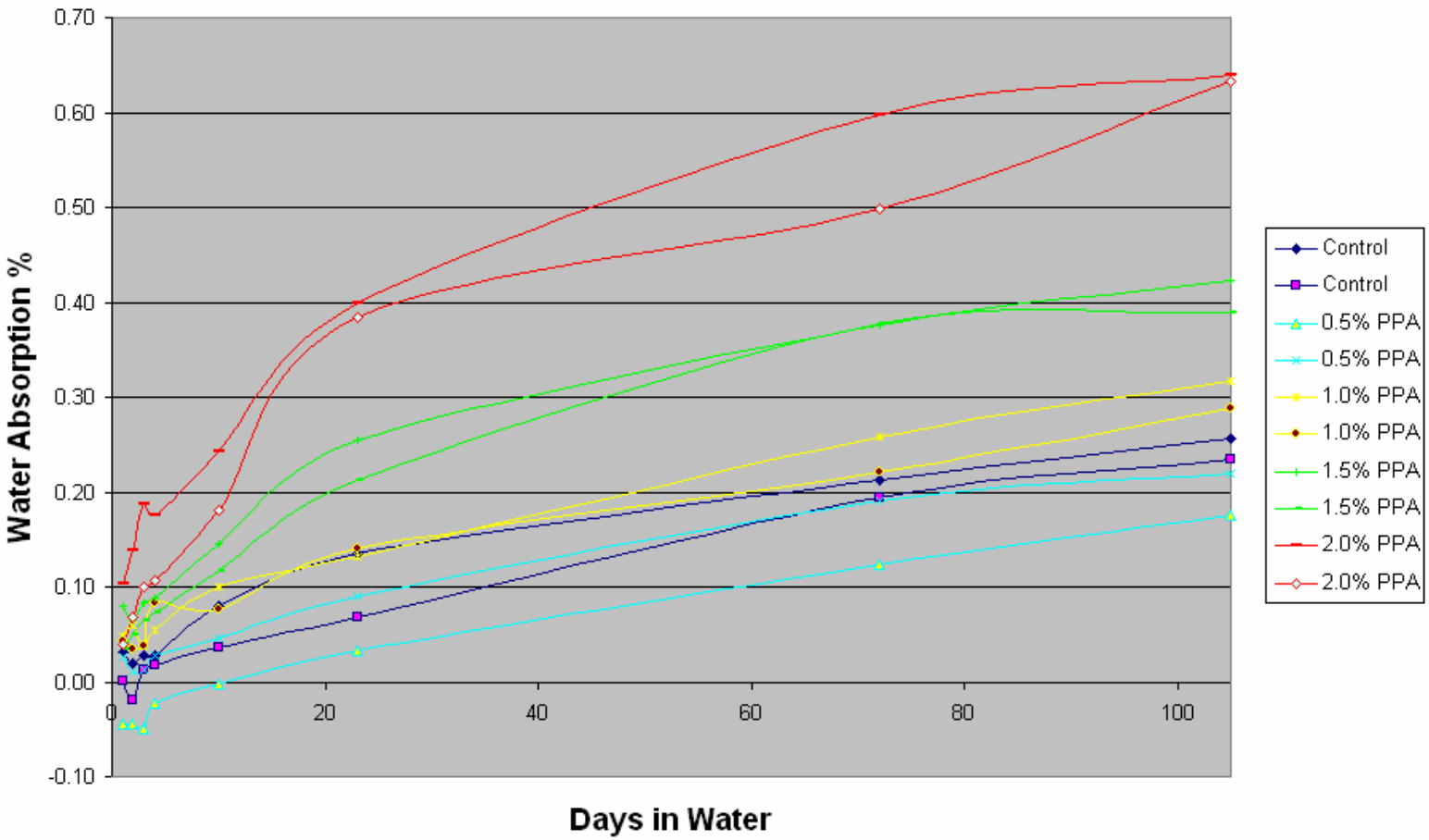


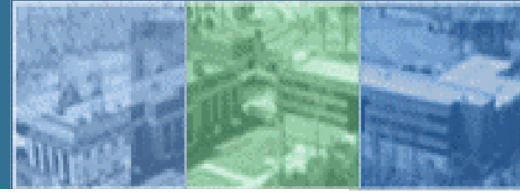



Water Immersion Boscan Asphalt + 50% Gravel
Water Absorption %
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
20
40
60
80
100
Days in Water
Control
Control
0.5% PPA
0.5% PPA
1.0% PPA
1.0% PPA
1.5% PPA
1.5% PPA
2.0% PPA
2.0% PPA

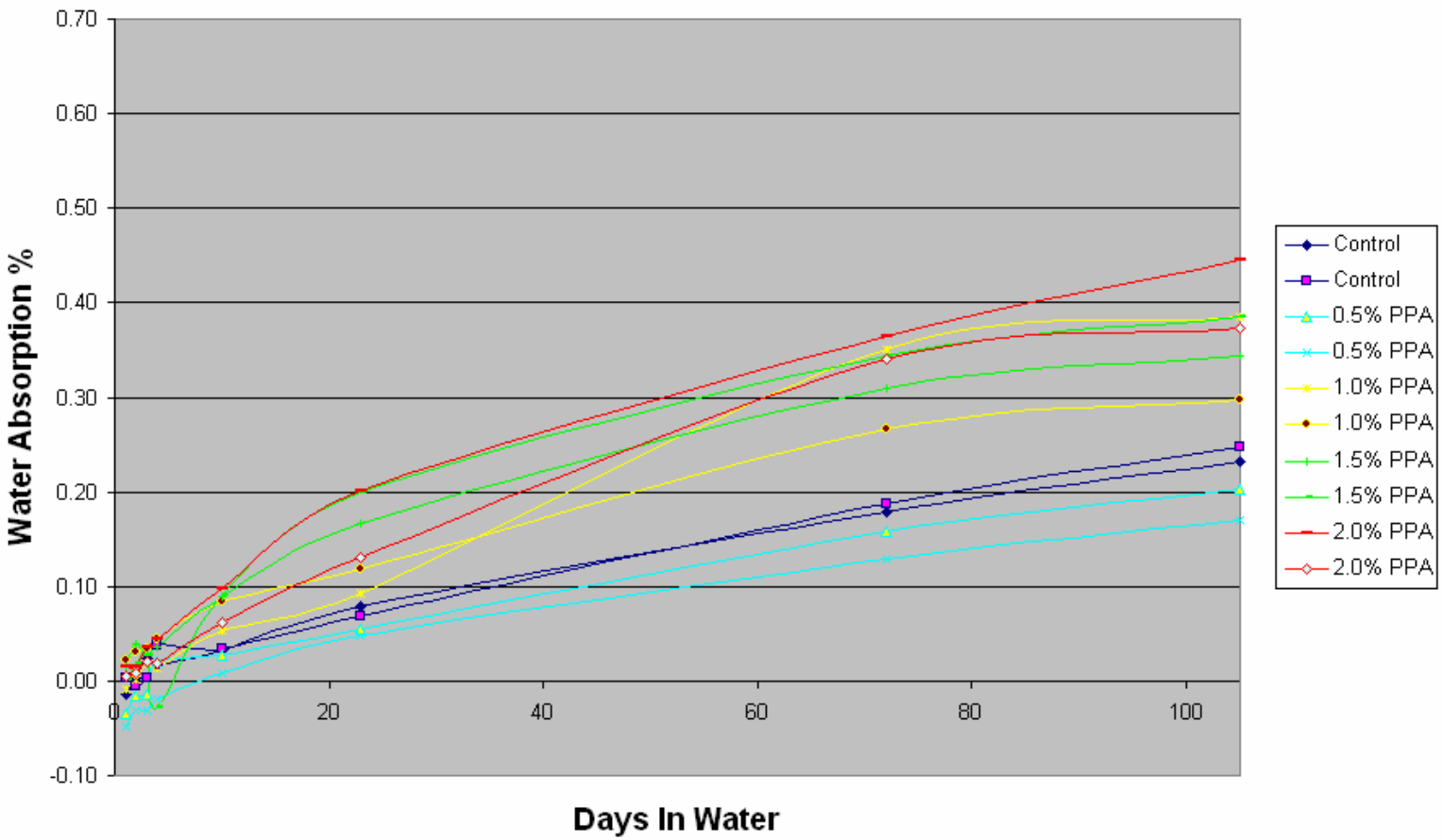


Water Immersion Boscan Asphalt + 50% Diabase





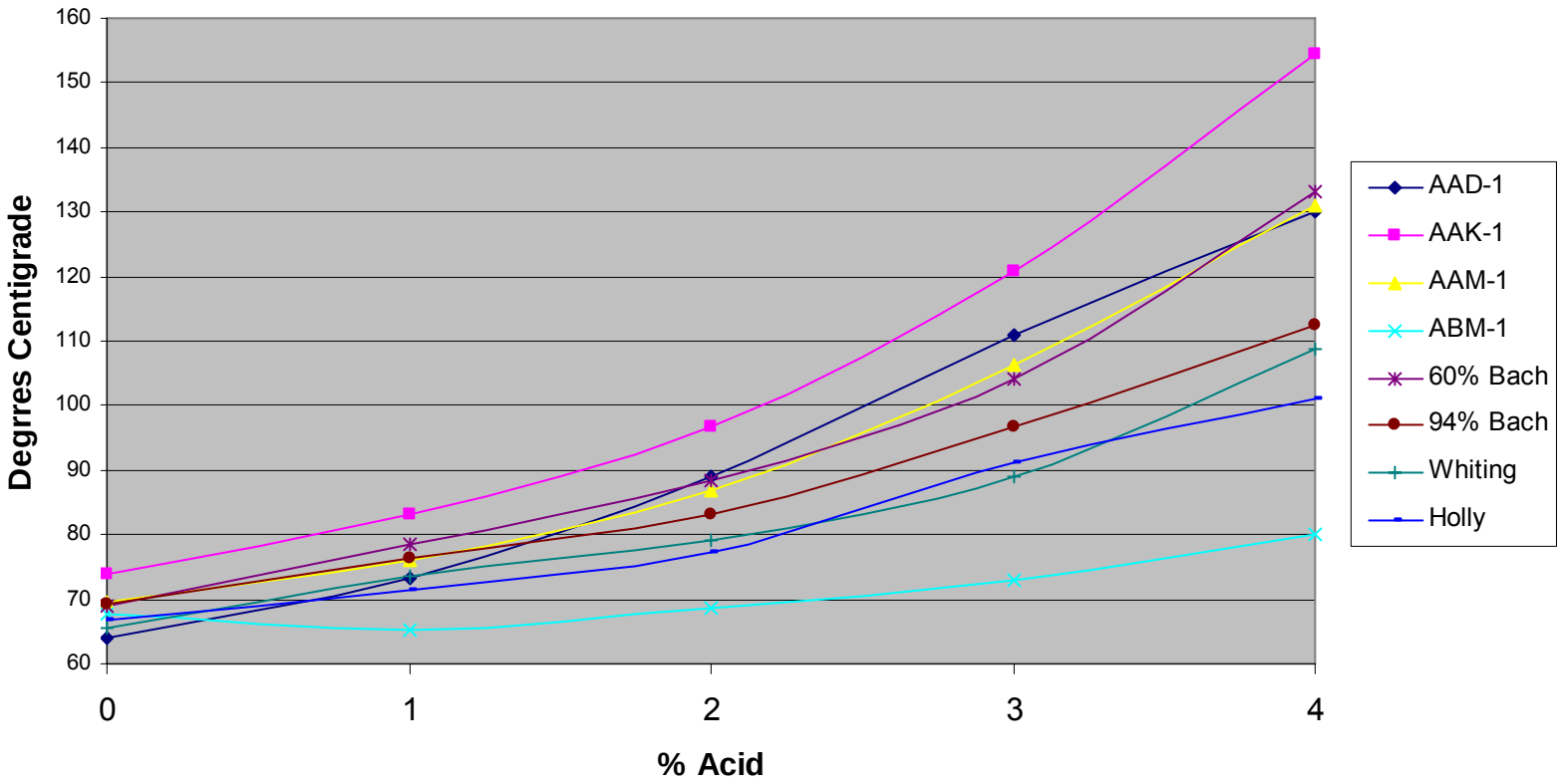
Water Immersion Boscan Asphalt + 50% Sand



Proposed Work Plan

- Three binders with different sensitivities to PPA
- Two aggregates, non stripping and stripping;
- Amine anti- strip additives and lime
- Four stripping tests
- Effect of Polymer Modification with SBS

Effect of 115% PPA Acid Modification on Original PG Grade



Binders

- Citgo
- BP Whiting
- Lion Oil

Aggregate

- Non Stripping Aggregate:
  - Limestone from H. B. Mellot MD
- Stripping Aggregate
  - Sandstone from Keystone MD

Performance Testing - Anti-strip Additives at 0.5%

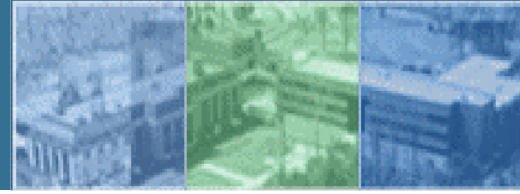
• Innovalt W	Innophos
• Adhere LOF 65-00	Arr Maz
• Adhere LA-2	Arr Maz
• Gripper X-2	Kao

Performance Testing - Binders

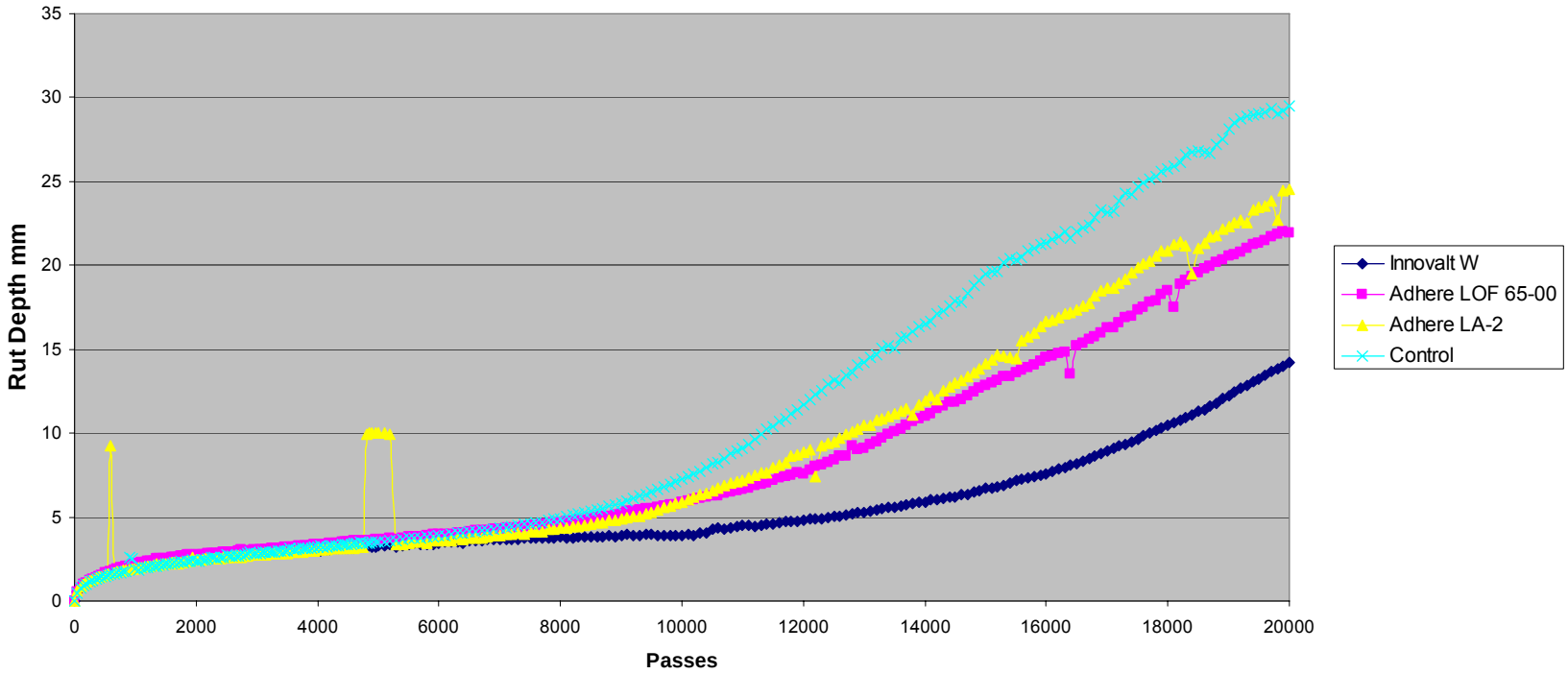
1. Determine how much PPA is needed to increase Superpave PG grade by one and two steps.
2. Determine how much SBS Polymer is needed to increase PG grade by one step then how much PPA to increase by another.
3. 3% PPA Regardless of PG Grade
4. Use these two levels of modification to investigate effect of PPA on stripping and antistrip additives

Performance Testing - Anti-strip Tests

- Hamburg
- TSRT



Hamburg 50degC Citgo Asphalt Sandstone Aggregate



Questions?