Beyond the Clock: Sustainable Solutions for Returned Ready-Mix Concrete

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Research Objectives

Three different mixes were evaluated

- Mix 1 - 100% Cement
- Mix 2 - 60% Cement + 40% Slag
- Mix 3 - 75% Cement + 25% Flyash

One batch of each of the mixes were made with and without the use of hydration stabilizer. The mixes were poured twice, during hot weather and moderate conditions.

Mix designs Emphasis on locally available materials.

Ready mix concrete supplied by Silvi Concrete - Fairless Hills, P.A

SILVI Batching Plant

SILVI Batching Plant

Test Parameters

Per applicable standards, the following tests were performed on concrete batches at these time lapses: 60 (control sample), 90, 120, 150 and 180 minutes

- Slump Test – Before and after re-dosing admixtures.
- Air Entrainment – Before and after re-dosing admixtures.
- Concrete Temperature – Before and after re-dosing admixtures.
- Microwave water content – Before and after re-dosing admixtures.
- Compressive strength at 3, 7, 28 and 56 days.
- Flexural Test at 28 days and 56 days.
- Concrete Permeability – Coulomb Test at 90 days.

Target Properties

- Target 28 day compressive strength - 6000 psi
- Max. size of aggregate = 1 inch
- Target slump = 6 inch, ± 1 inch
- Target air content = 6% ± 1.5%
- Hot weather when ambient temperature is greater than 90°F - ACI 305.

  Moderate weather when ambient temperature is between 68°F and 80°F.
- Specimen size :
  - 4"x 8" cylinders for compressive strength
  - 6"x 6"x 18” and 4”x 4”x12” beams for flexural strength

Concrete Molds

Quality Control

- Only HRWR and AEA were added to meet target properties at required intervals. Microwave water content check. Water addition prohibited.
- QC from Silvi Concrete and Sika admixtures were present at all times with temperature charts and advised on dosage and mixing
- 11 cubic yard RMC mixer utilized. Batched 5 cubic yard per mix
- ACI Concrete Field Testing Tech 1 certified students / staff performed slump, air and other tests.

Fresh Concrete Testing

Fresh Concrete Testing

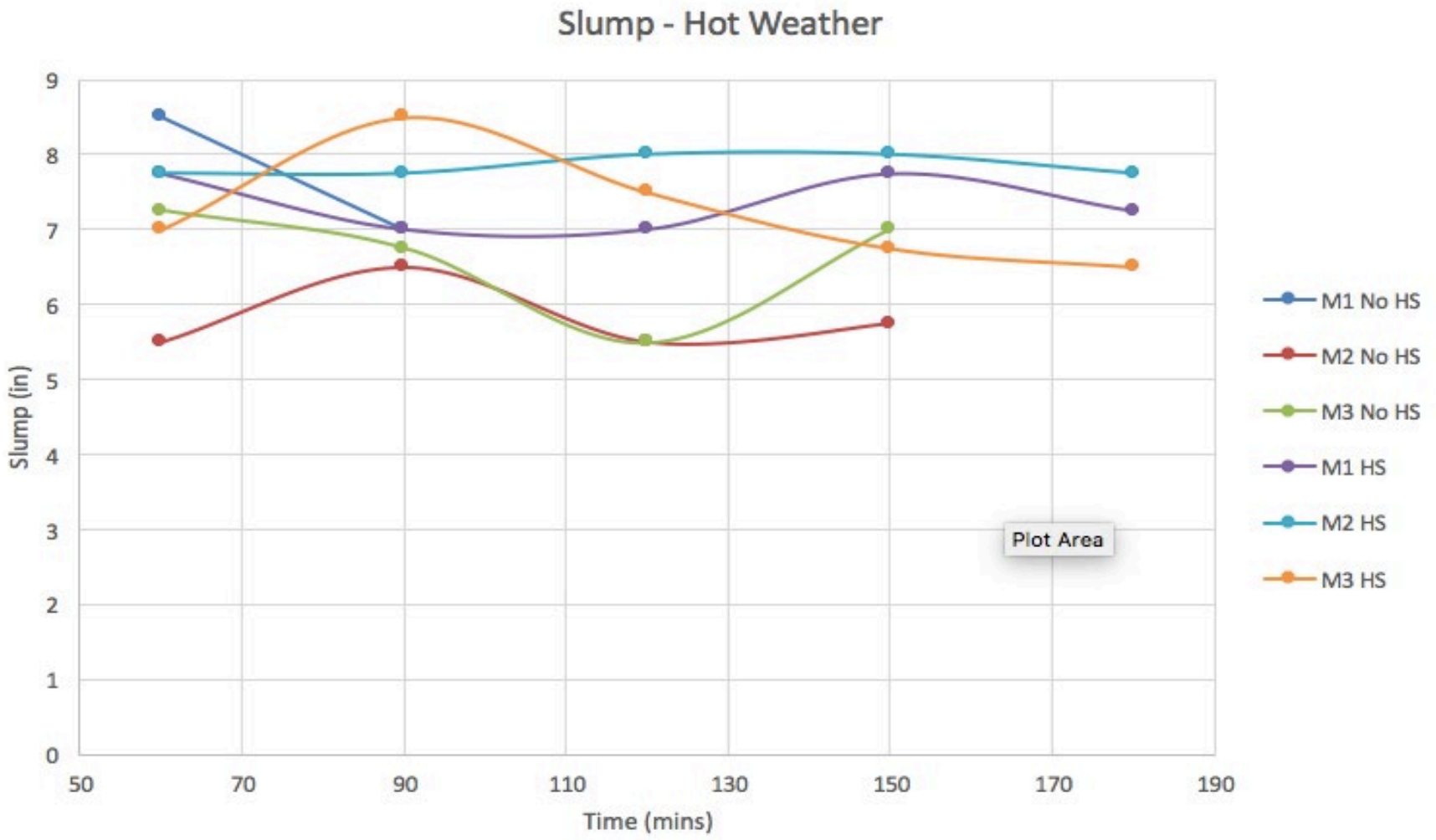
Expected Research Outcome

- Quantify the loss in performance, if any, beyond the 90 minute specified limit for concrete mixes without hydration stabilizer / retarder.
- Report the performance of concrete mixes with hydration stabilizer over extended discharge time of up to 180 minutes in 30 minute increments.
- Finally, evaluate the feasibility of the 90 minute guideline with regards to current concrete mix design technology and mix constituents.

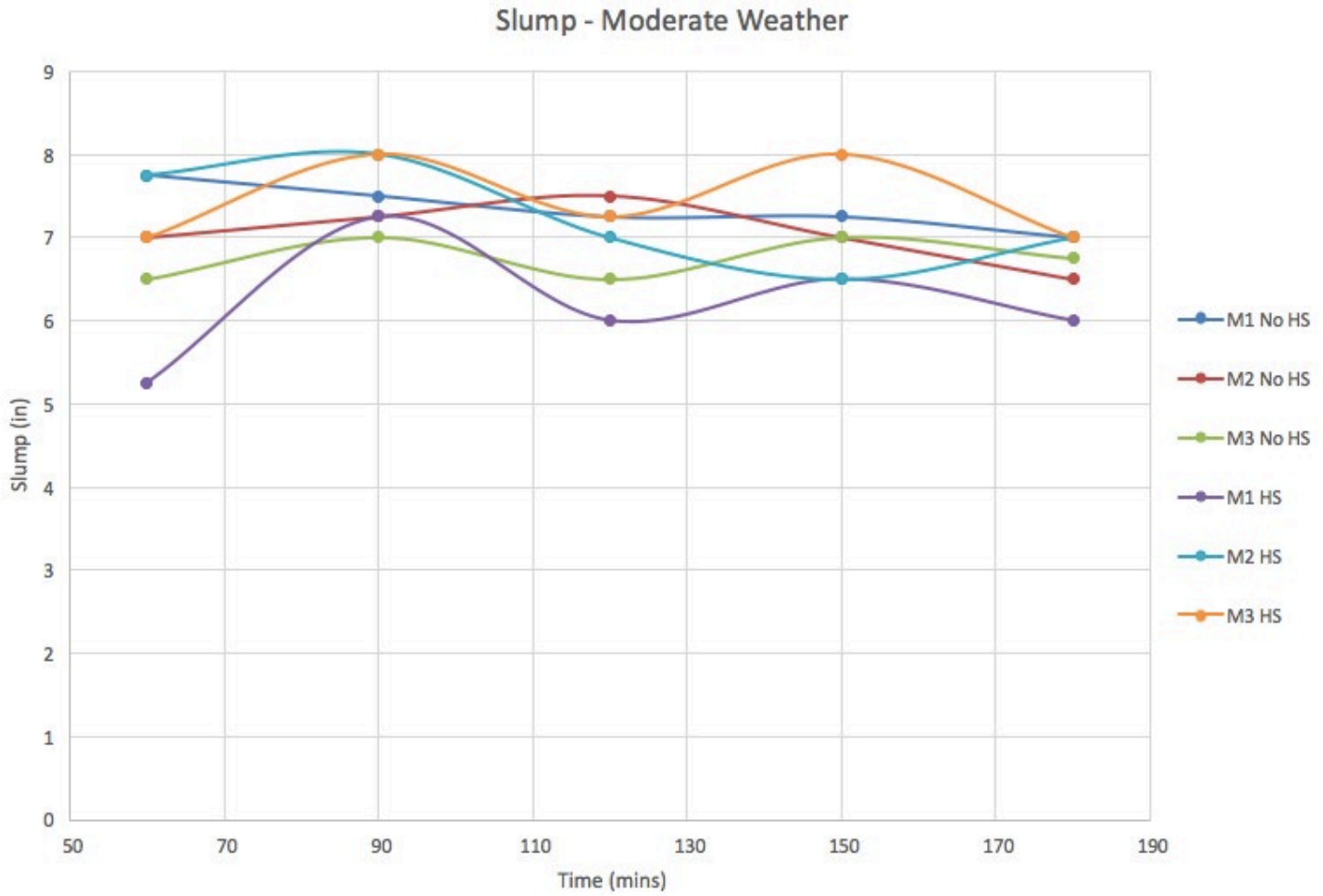
Transporting Samples Back to NJIT

NJIT Curing Room

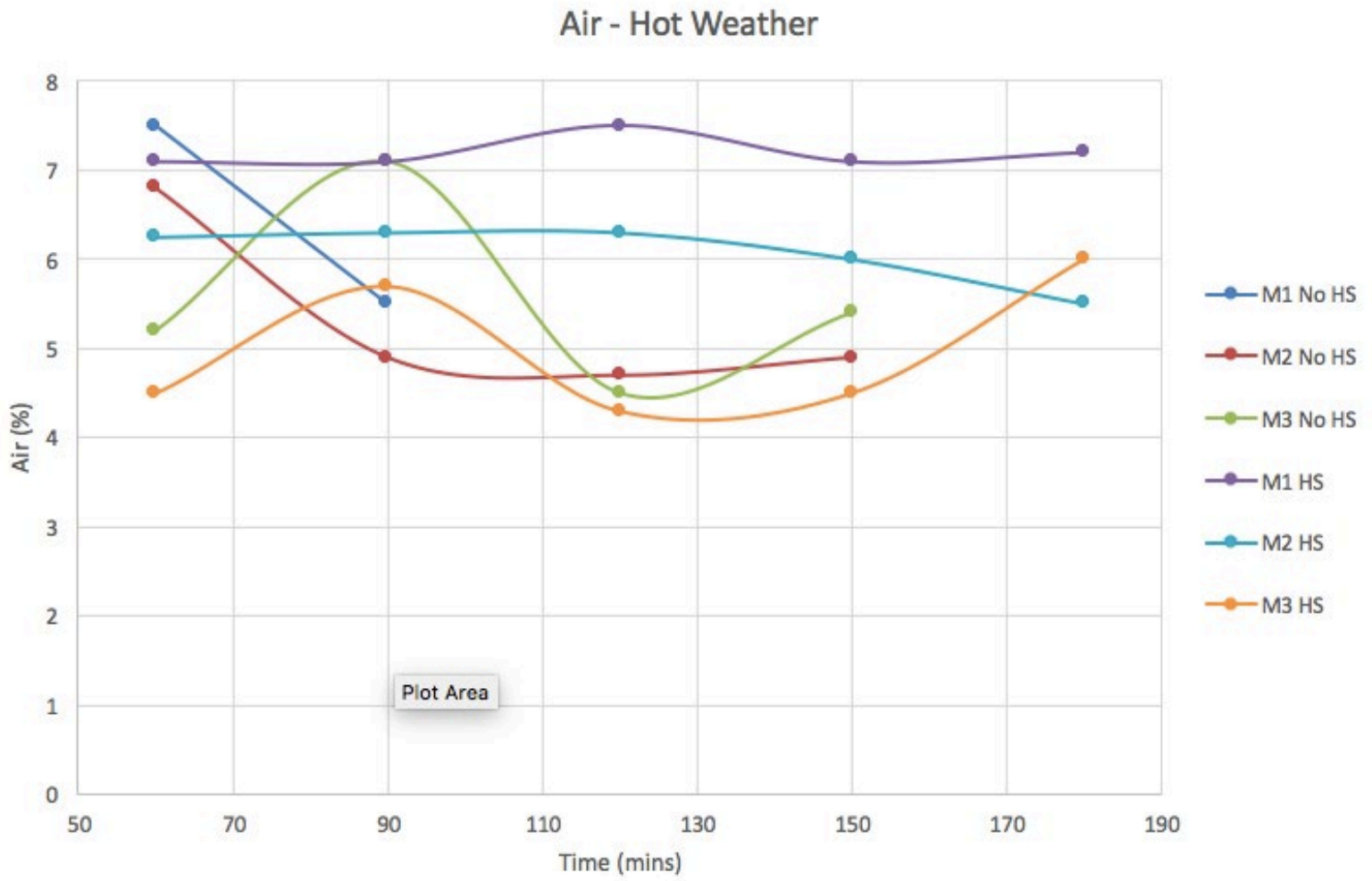
Field Test Results – Slump



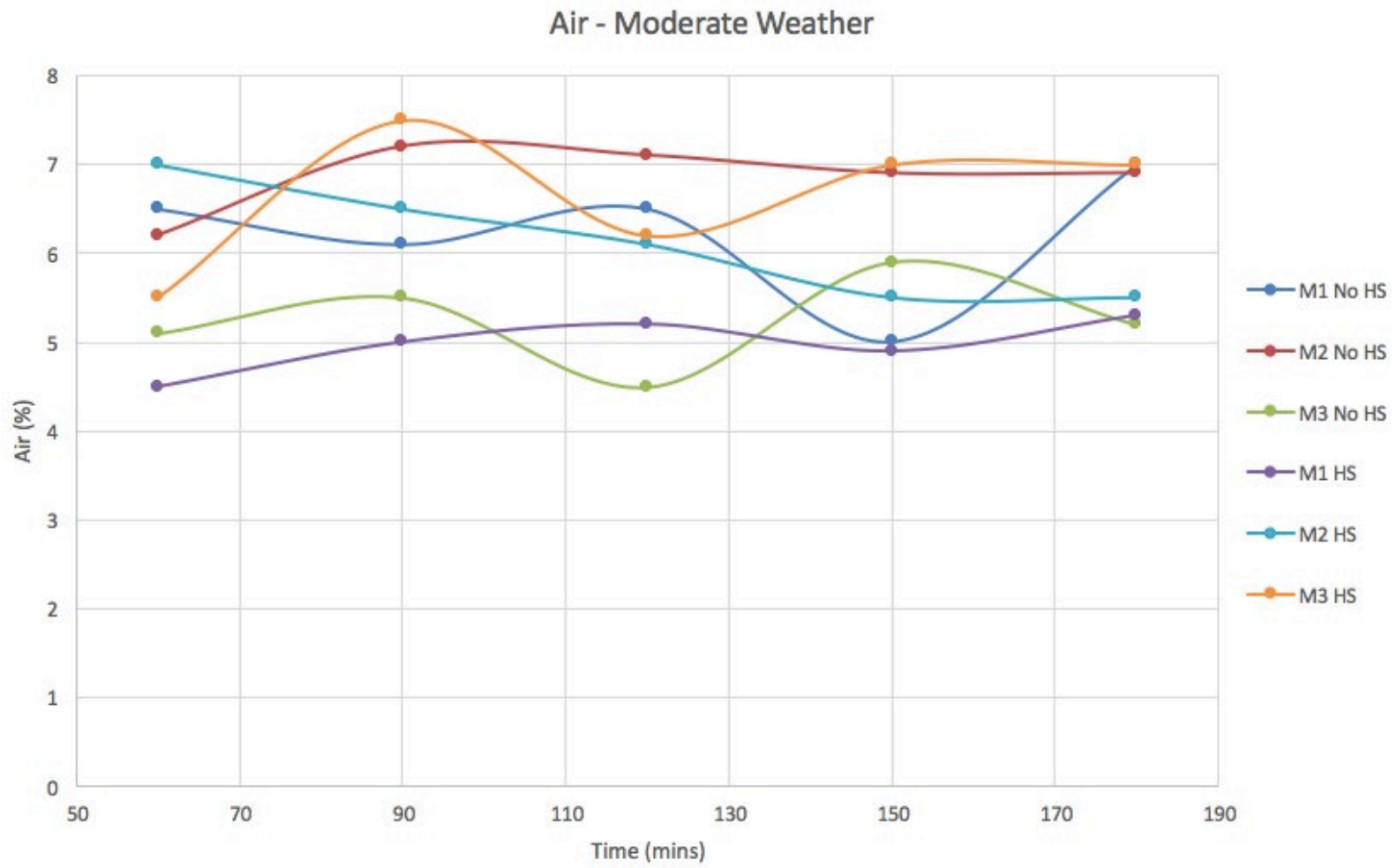
Field Test Results - Slump



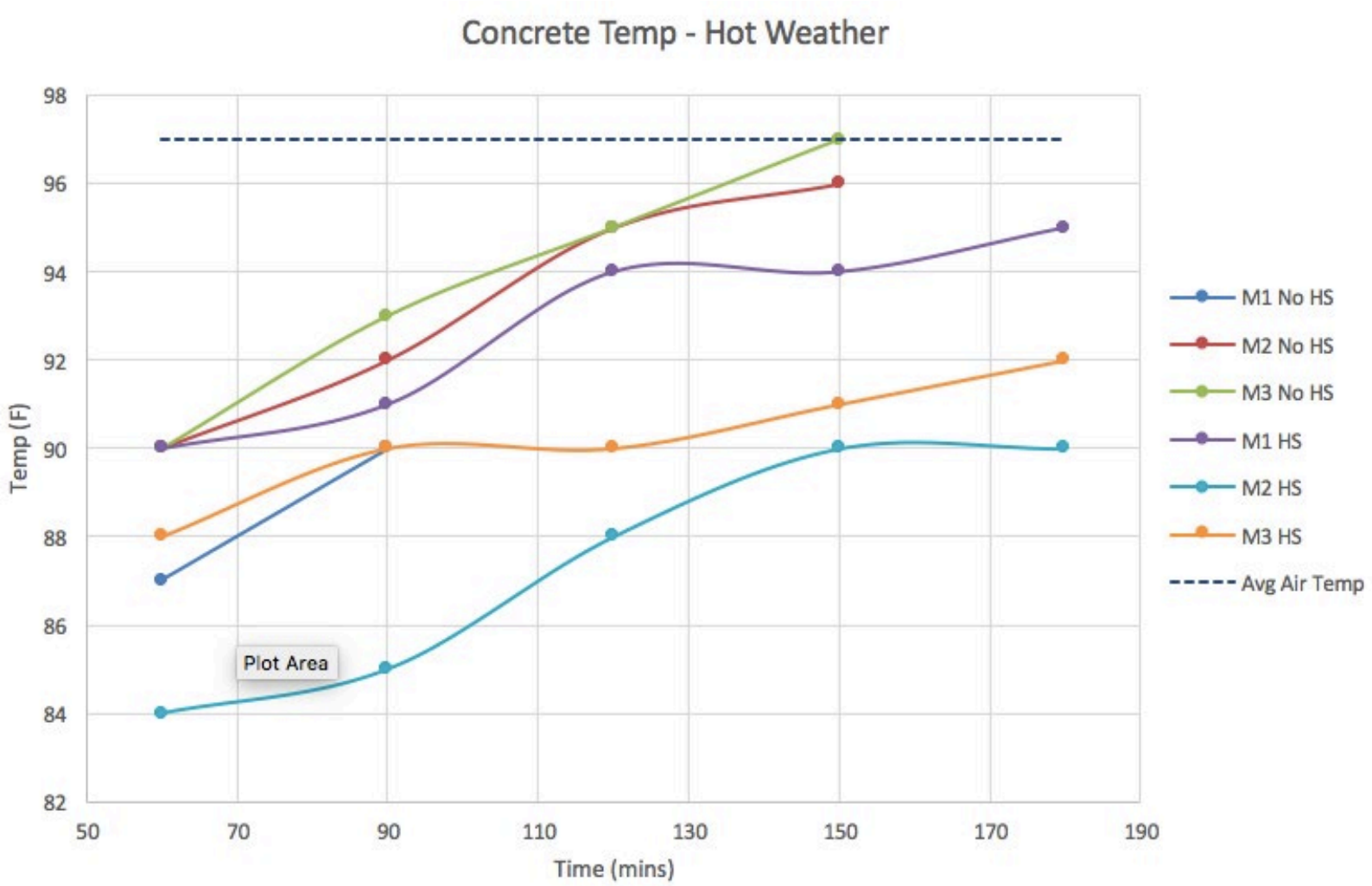
Field Test Results - Air



Field Test Results - Air



Field Test Results – Concrete Temp



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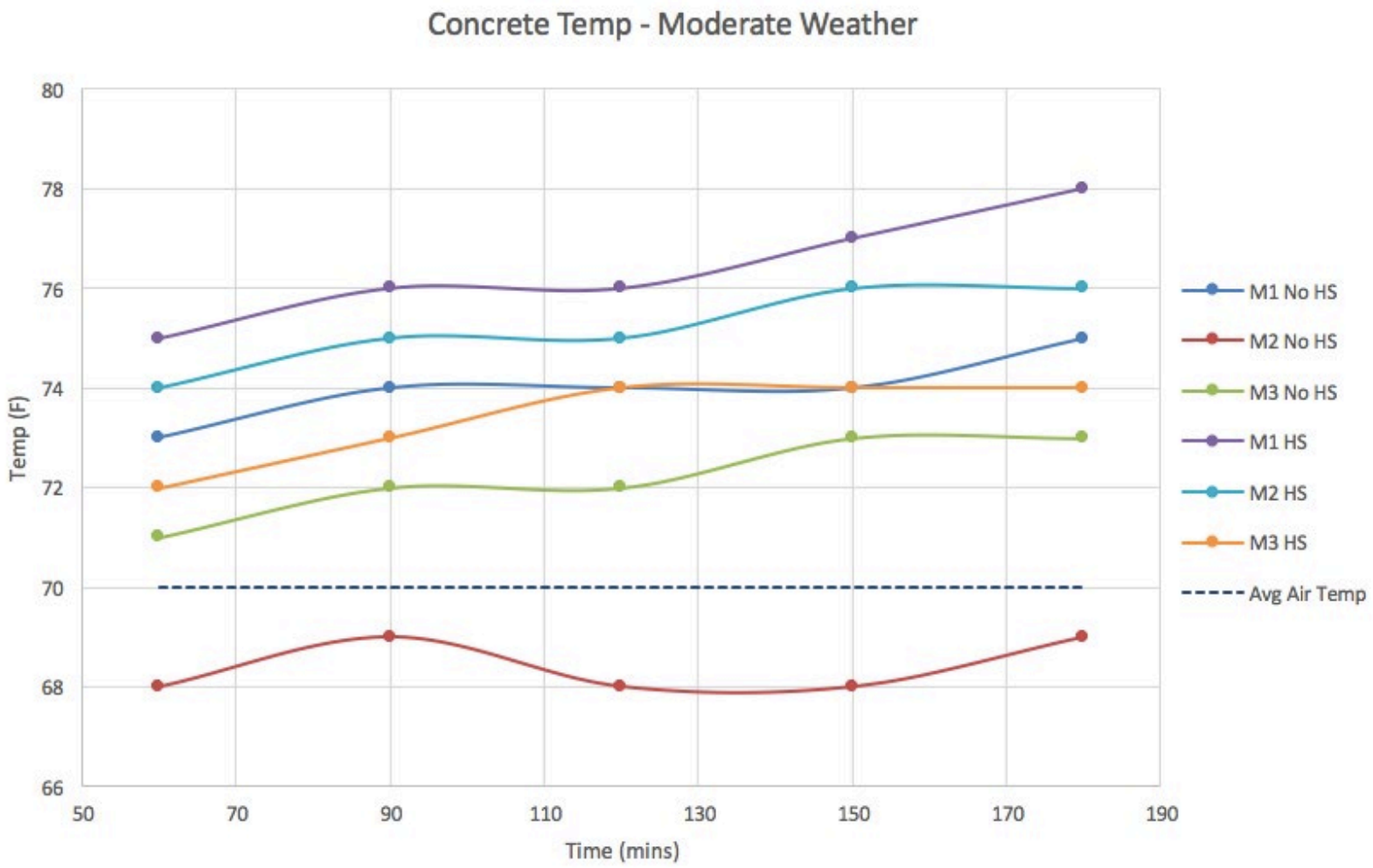
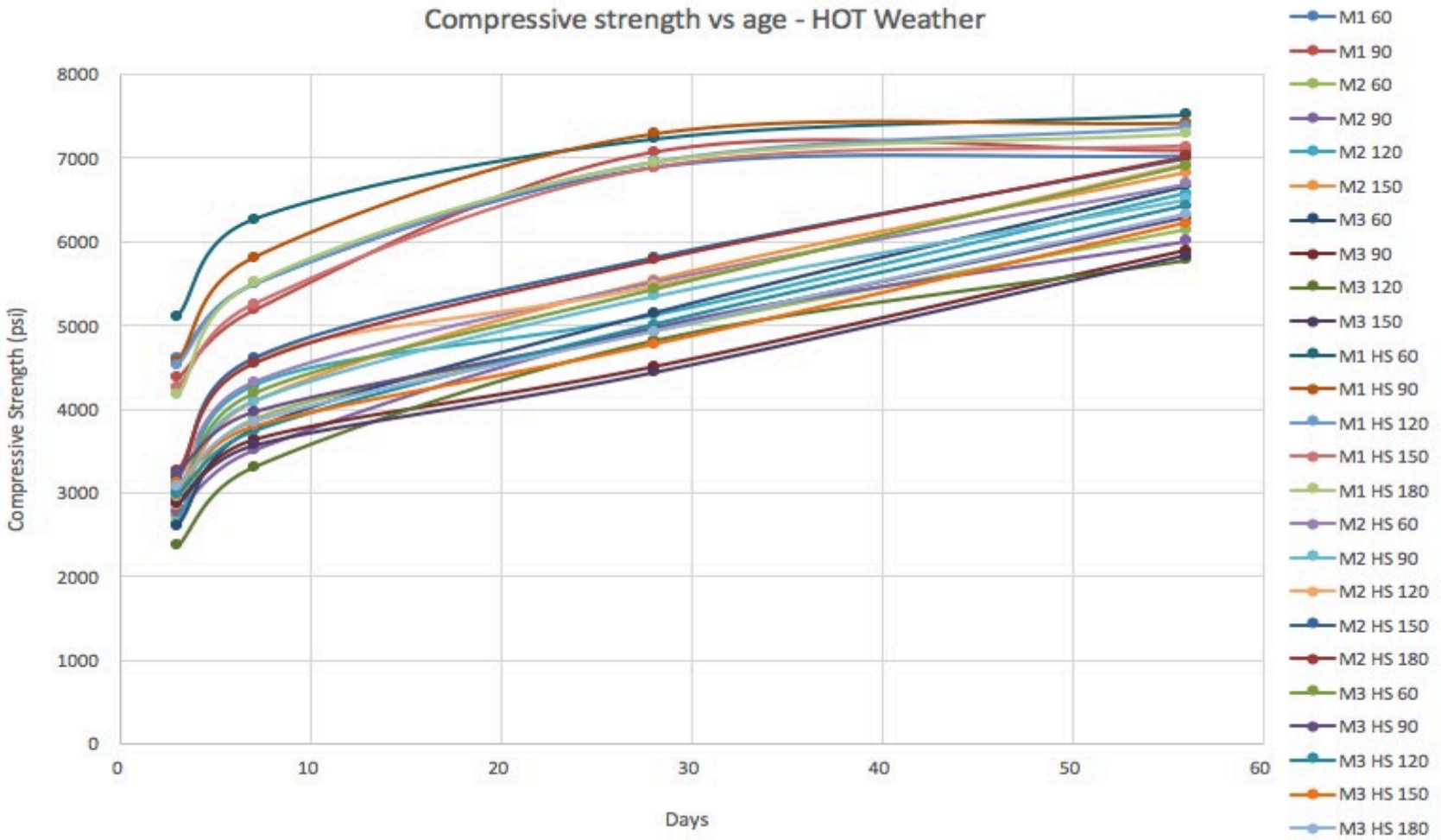


Test Results – Compression Test (ASTM C39)



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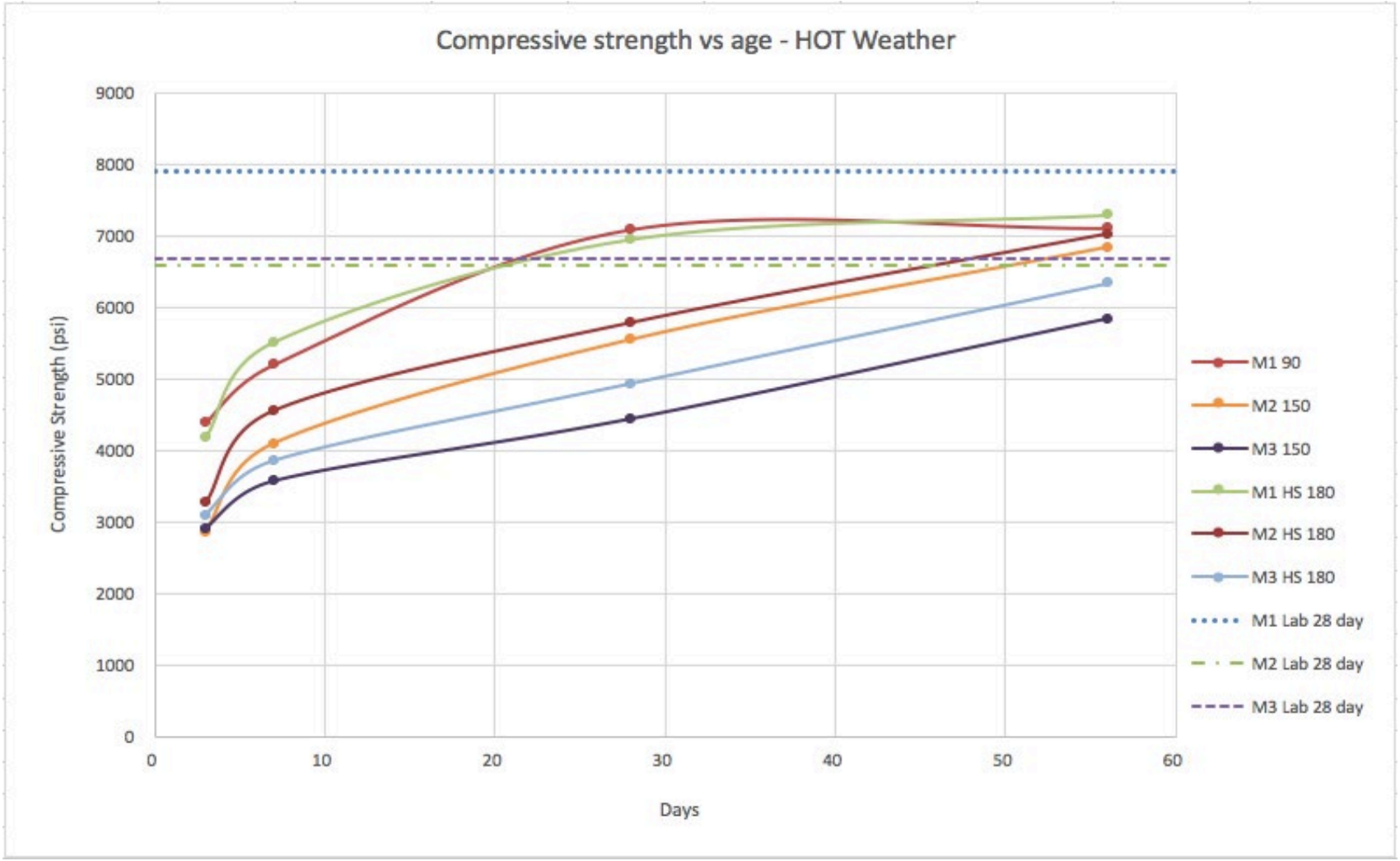

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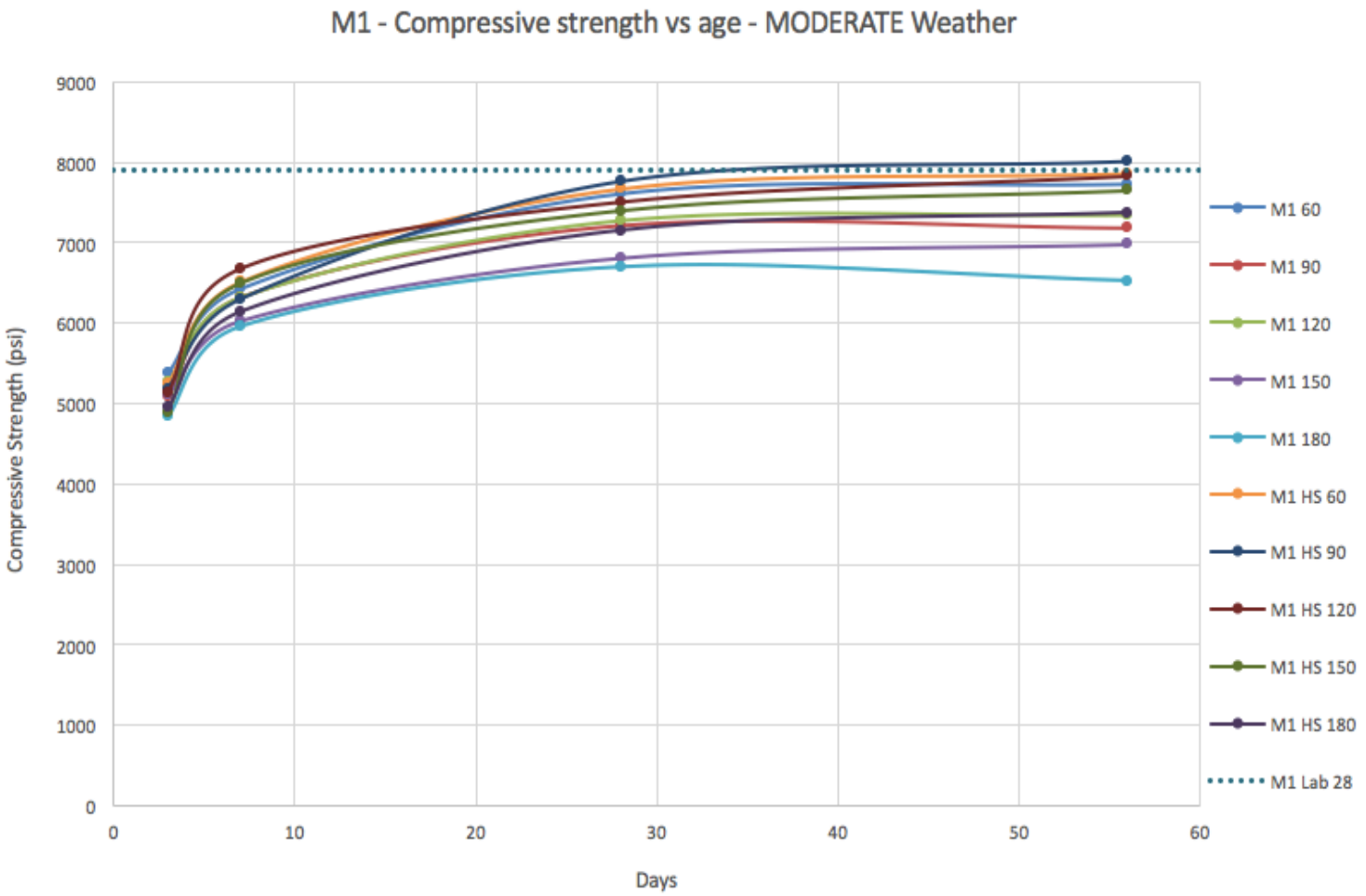

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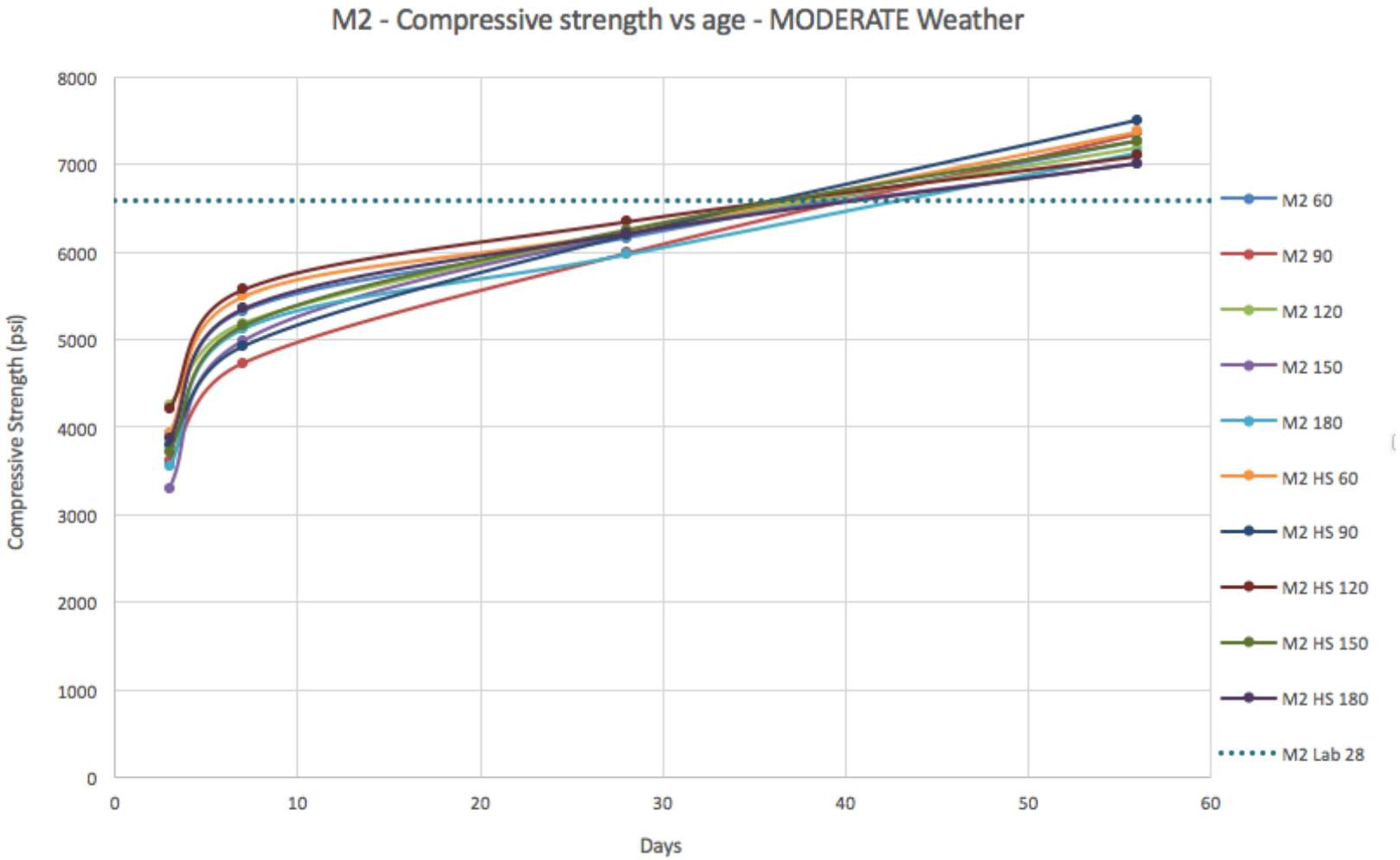

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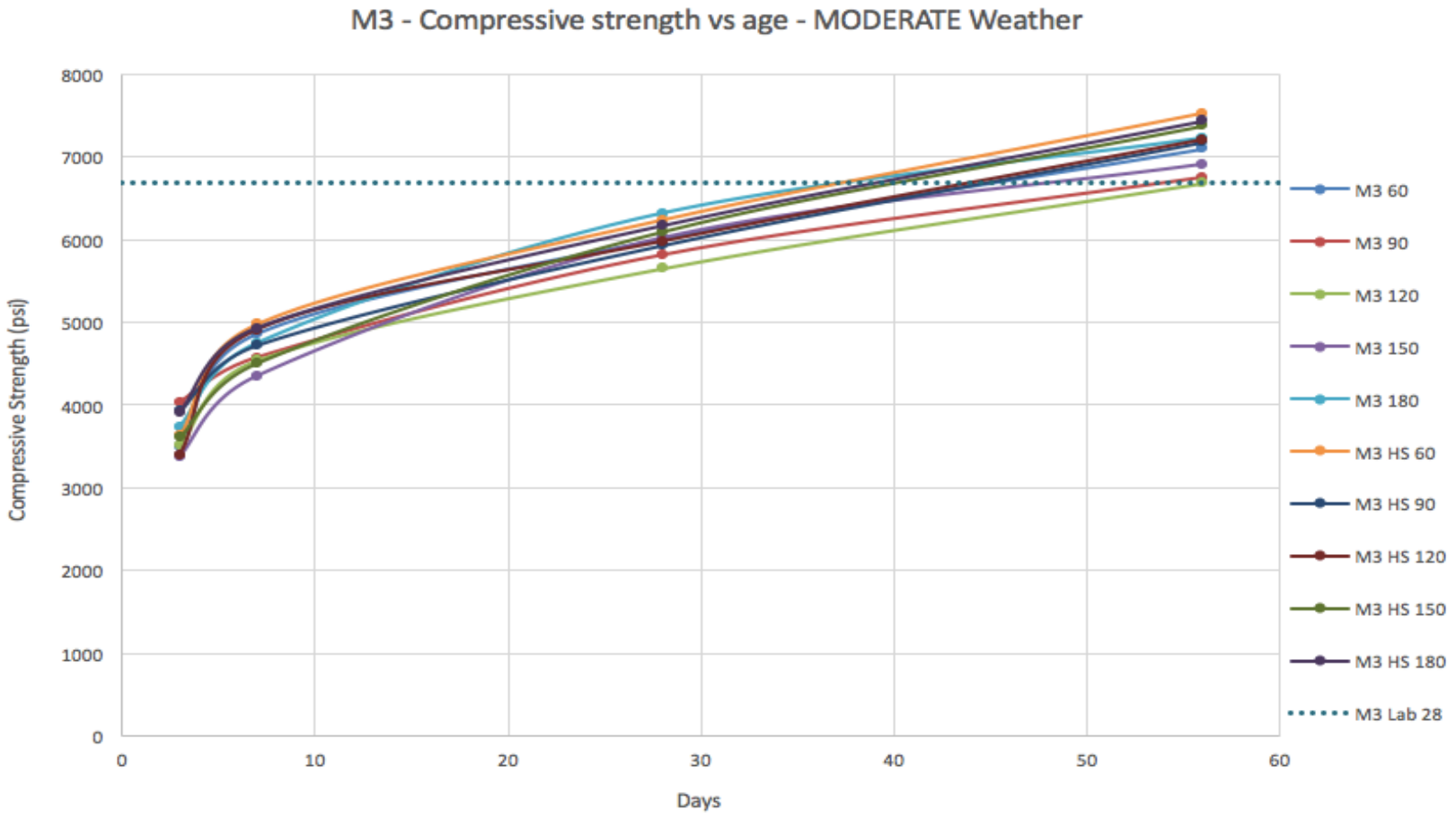
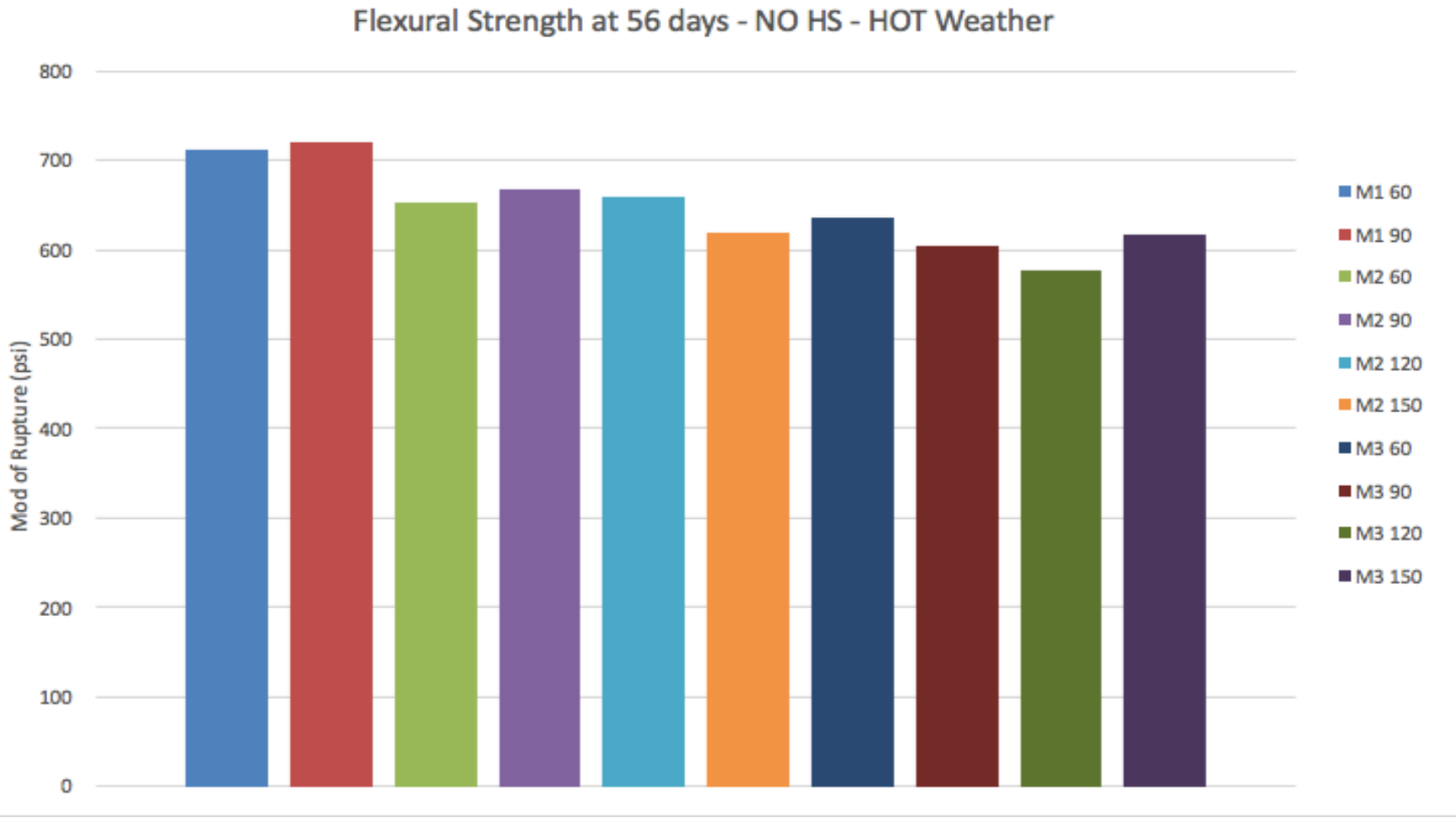


Test Results – Flexure Test - (ASTM C78)



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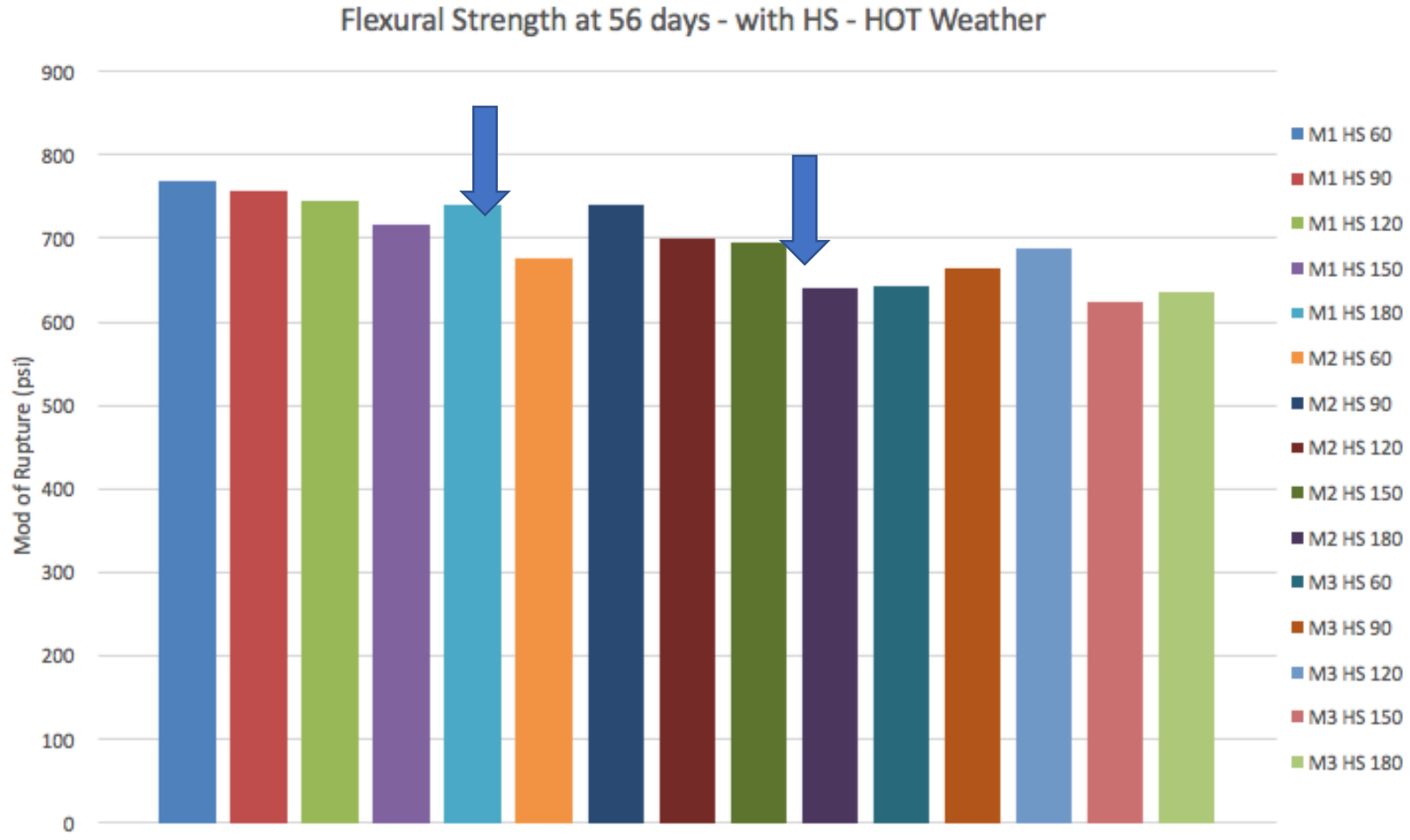

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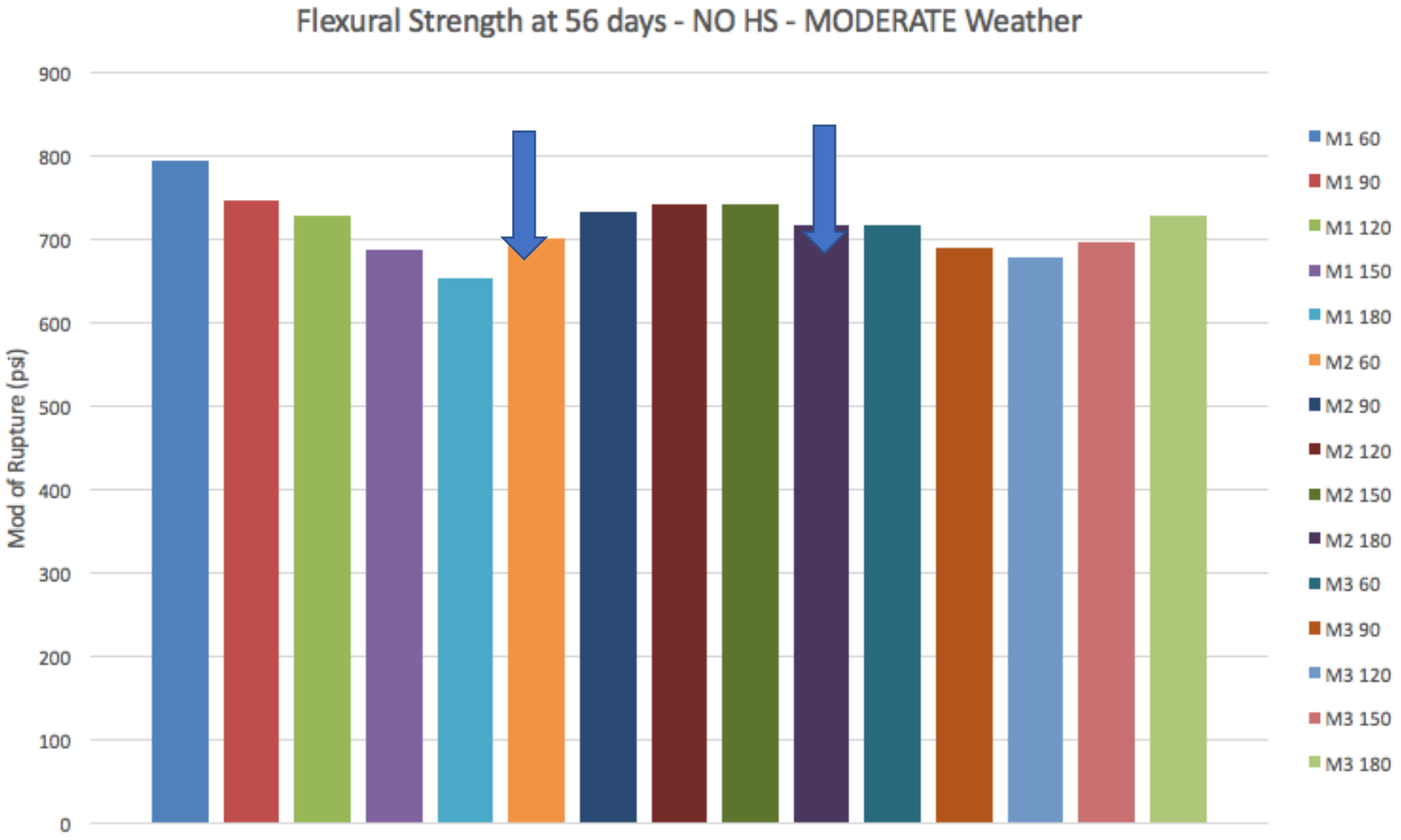

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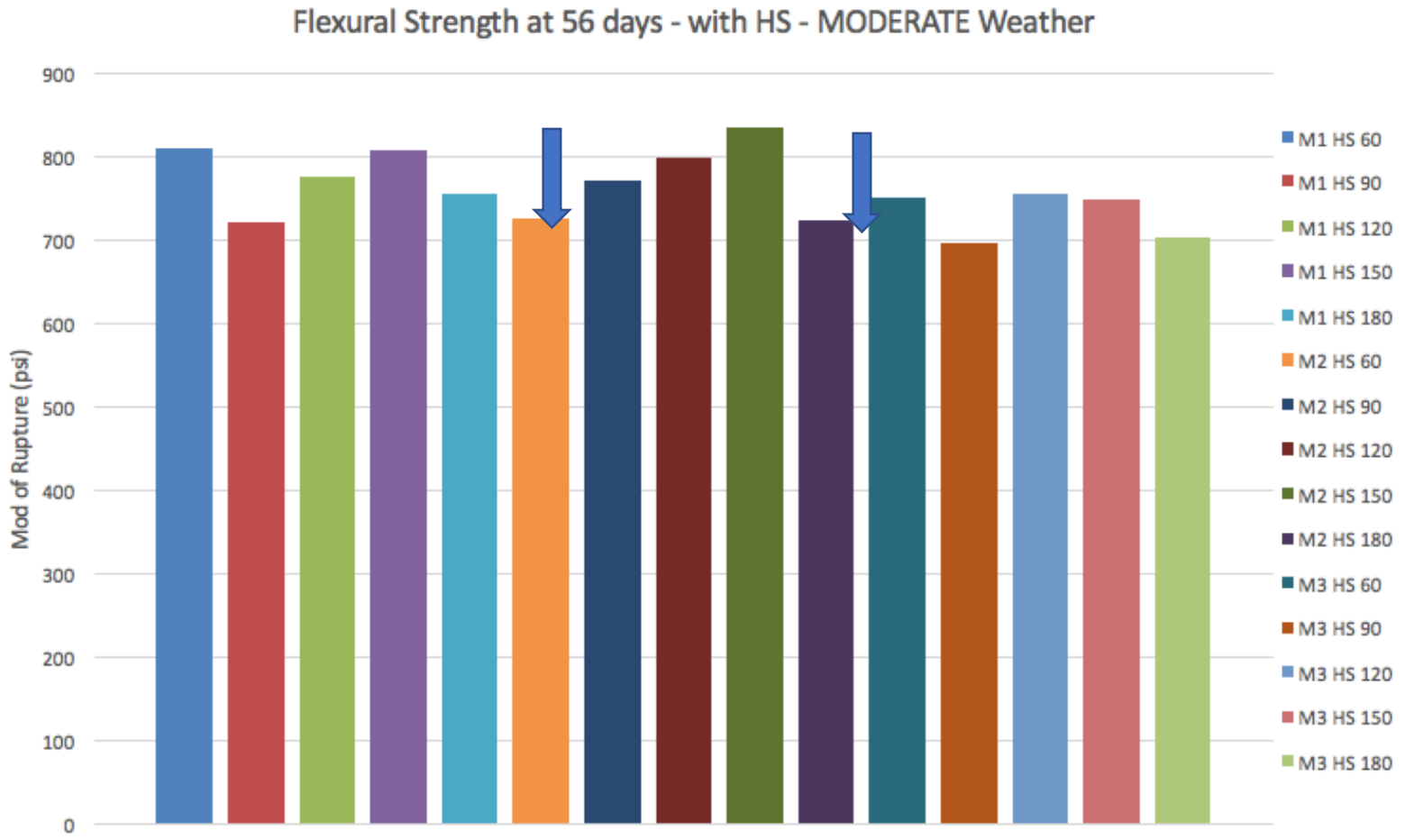
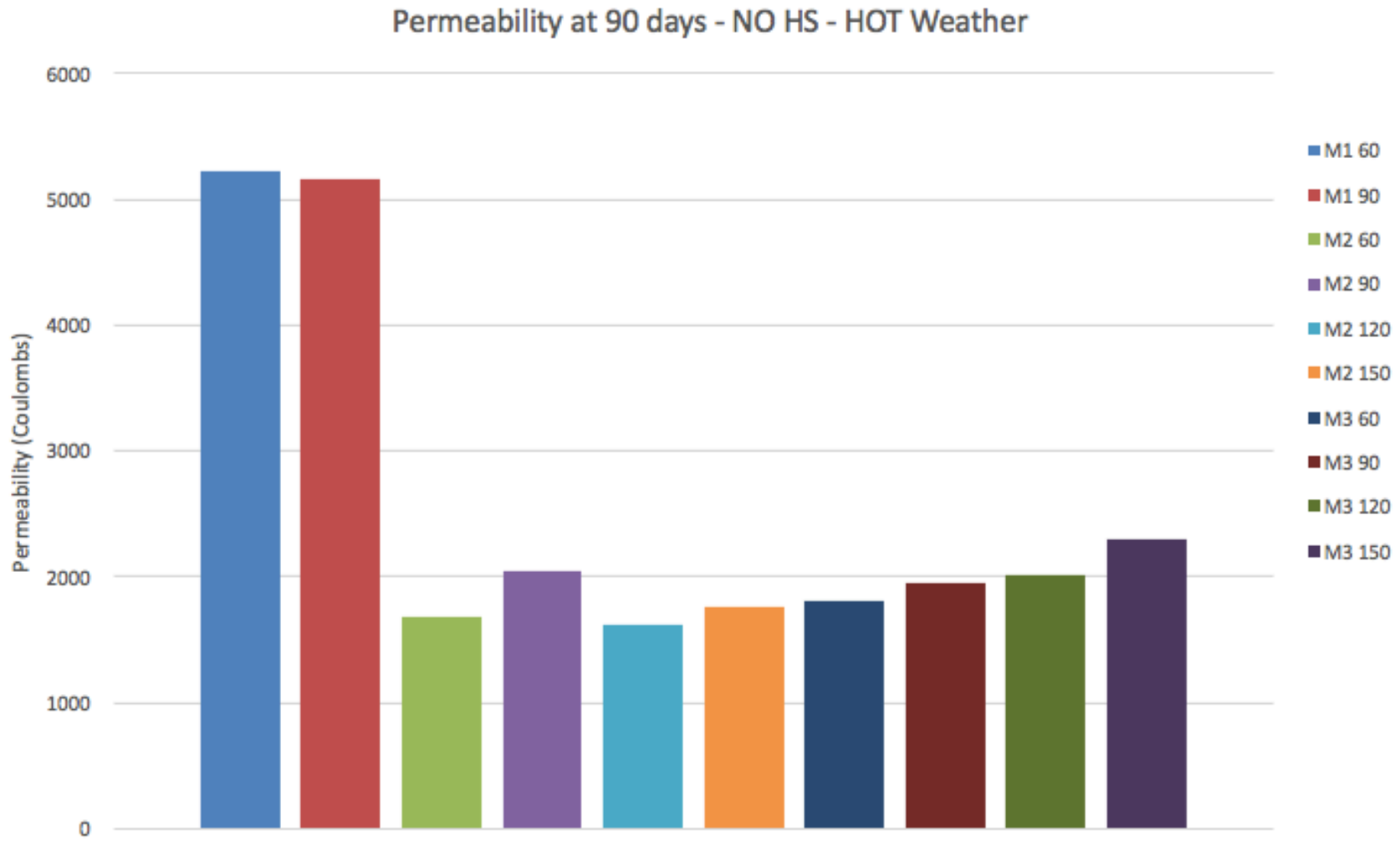


Coulomb Permeability Test



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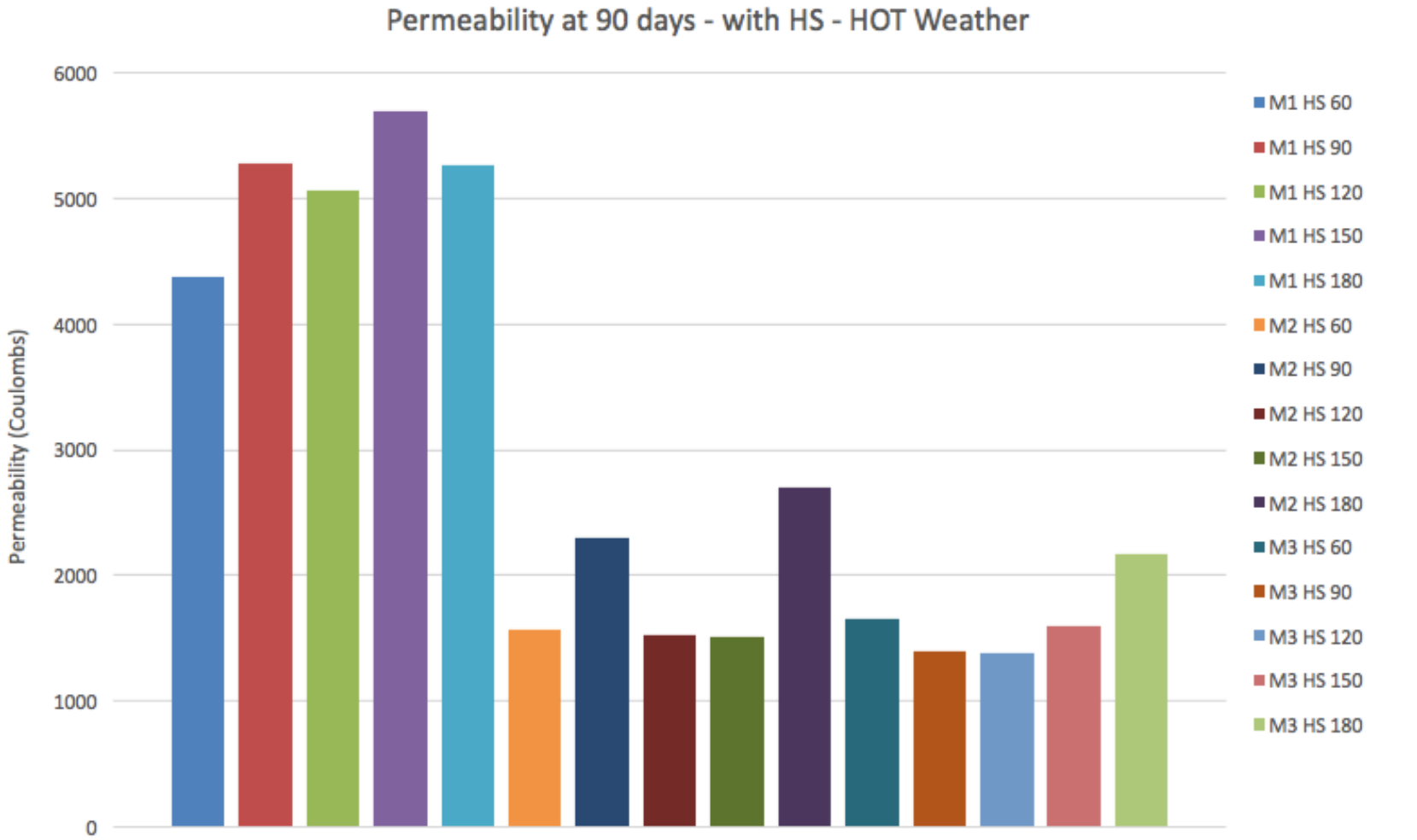

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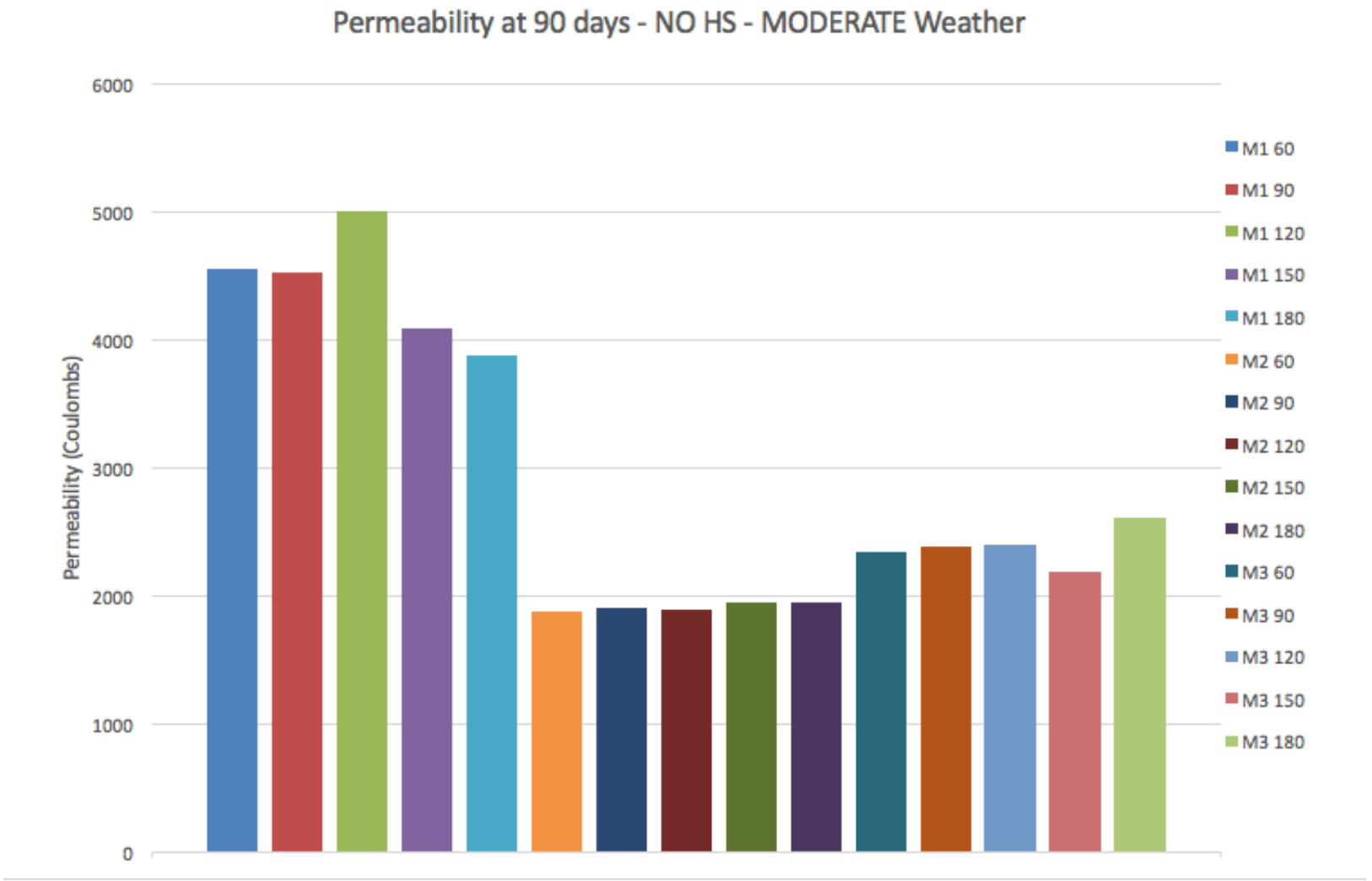

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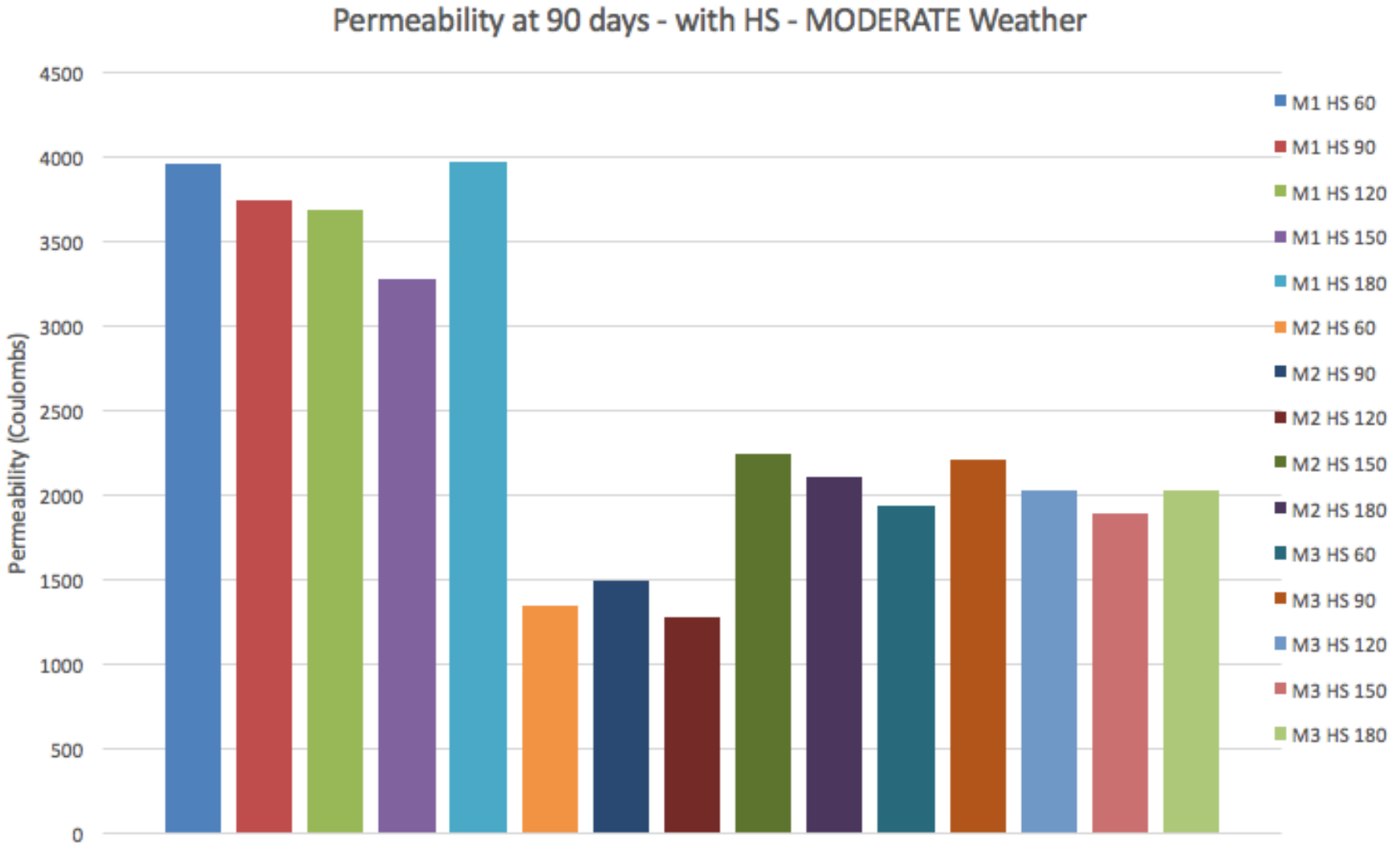

Summary of research findings

- Summer pour without Hydration Stabilizer
  - 100% cement mix workable up to 100 mins.
  - 100% cement mix was repeated twice on different days, when temperature averaged 98F, to affirm longevity of mix
  - Slag mix and Fly ash mix workable up to 150 mins.

- Summer pour with Hydration Stablilizer
  - All mixes workable up to 180 mins

In hot weather, for 100% cement mix, redosing had to be done every half hour to meet target properties.

Slag mix and Fly ash mix had to be redosed once every hour.

Summary of research findings

- Fall pour without Hydration Stabilizer
  - 100% cement mix workable up to 180 mins.
  - Slag mix and Fly ash mix workable up to 180 mins.

- Fall pour with Hydration Stablilizer
  - All mixes workable up to 180 mins

In moderate weather, for 100% cement mix, redosing still had to be done every half hour to meet target properties.

Slag mix and Fly ash mix had to be redosed once every 90 mins.

Summary of research findings

Compression Test

- Compressive strength test data indicates moderate weather pour concrete mixes were comparatively stronger to hot weather concrete pour concrete mixes. This is because the moderate weather mixes required less redosing efforts to maintain required workability conditions.
- Concrete mixes with Hydration stabilizer yielded higher compressive strength compared to control mix (without hydration stabilizer) for both hot and moderate weather pour conditions. It should be noted that the dosage of hydration stabilizer was maintained same for both weather conditions.
- 28 day compressive strength of concrete met the 6000 psi requirement even for mixes that lasted beyond 90 mins. Any relative drop in strength for extended discharge mix compared to control mix (60 min pour) can be attributed to redosing efforts required for maintaining air.

Summary of research findings

Flexure Test

- Flexure strength test data indicates moderate weather pour concrete mixes were comparatively stronger to hot weather concrete pour concrete mixes. This is because the moderate weather mixes required less redosing efforts to maintain required workability conditions.

- Concrete mixes with Hydration stabilizer yielded higher modulus of rupture compared to control mix (without hydration stabilizer) for both hot and moderate weather pour conditions. It should be noted that the dosage of hydration stabilizer was maintained same for both weather conditions.

- Flexural strength of concrete averaged about 11% of compressive strength even at extended discharge times.

Coulomb Permeability Test

- There was no considerable change in permeability of concrete at extended discharge times compared to control mix (at 60 min) despite the redosing efforts for maintaining air. This was true for both hot and moderate weather pours.

- Mixes with hydration stabilizer had relatively low permeability compared to mixes without it.

Summary of research findings

- For best results hydration stabilizer had to be introduced early with water line unlike water reducer and air entrainer.

- Concrete began to exhibit flash setting outside the mixer at 97F when no hydration stabilizer was used. Hydration stabilizer kept concrete temperature relatively cooler around 85F during hot weather pour.

- Excess air in concrete mix directly correlates to reduction in compressive and flexural strength.

Thank you

We are very grateful to all who have supported this first phase of the research and to those who have committed to supporting its continuation.

Questions / Suggestions / Recommendations

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