



## **Busting 90 Minutes**



# **Evaluation of the 90 Minute Rule as an Acceptance Criteria**

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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 (pic 1)



**Slide 3**

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**wr1**

wayne rawlins, 10/14/2018

SILVI Batching Plant (Pic II)



# 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,  $\pm 1$  inch
- Target air content =  $6\% \pm 1.5\%$
- Hot weather when ambient temperature is greater than  $90^{\circ}\text{F}$  - ACI 305.  
Moderate weather when ambient temperature is between  $68^{\circ}\text{F}$  and  $80^{\circ}\text{F}$ .
- 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 (Pic I)



## Fresh Concrete Testing (Pic II)



# 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.



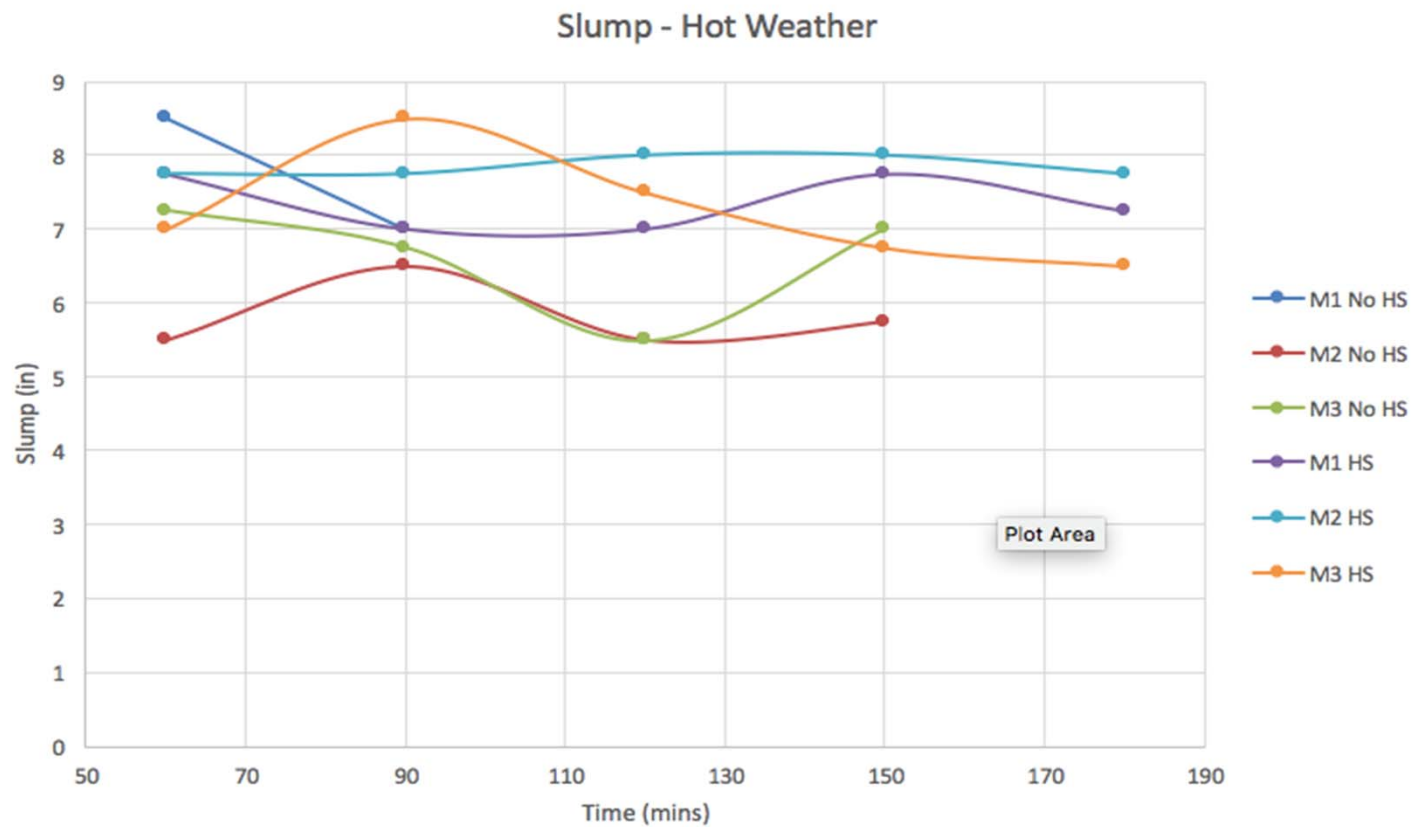
Transporting Samples Back to NJIT



NJIT Curing Room



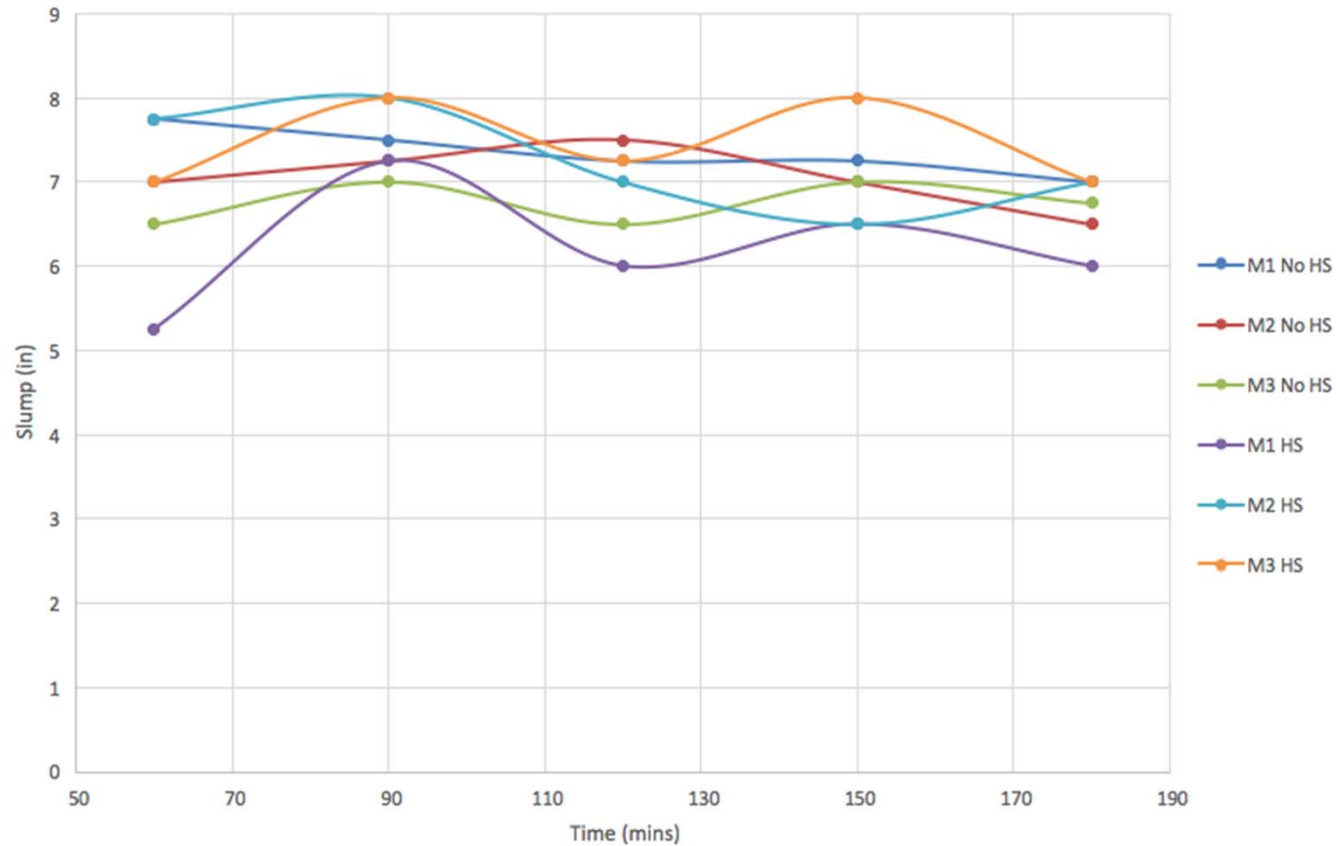
# Field Test Results – Slump



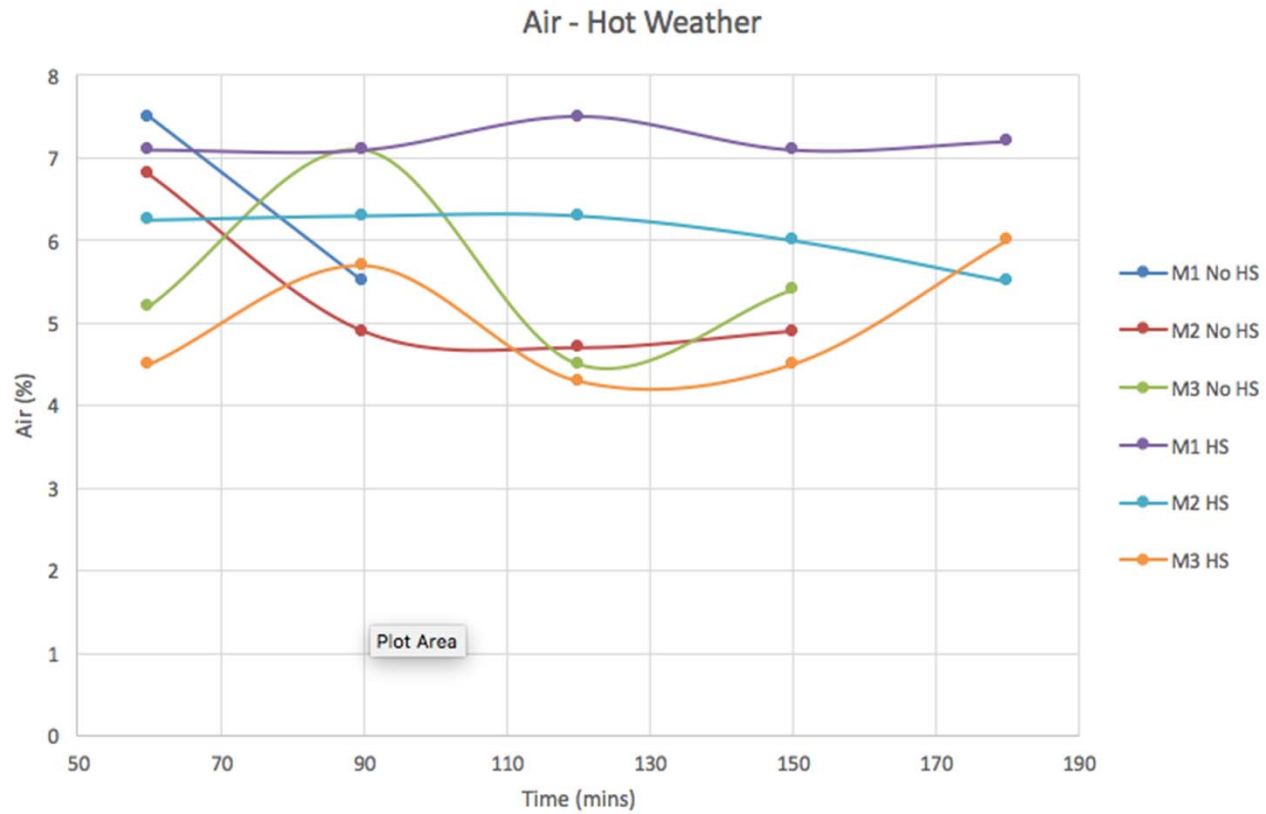


# Field Test Results - Slump

Slump - Moderate Weather

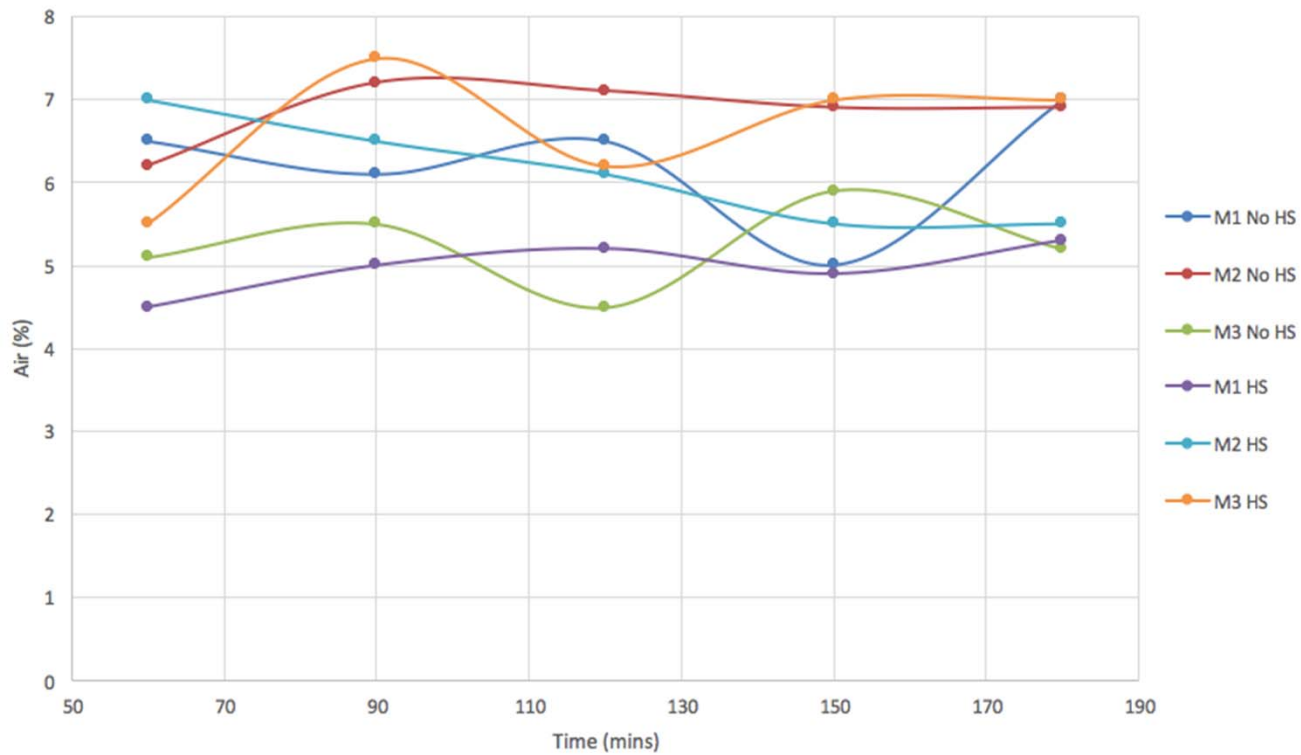


# Field Test Results - Air



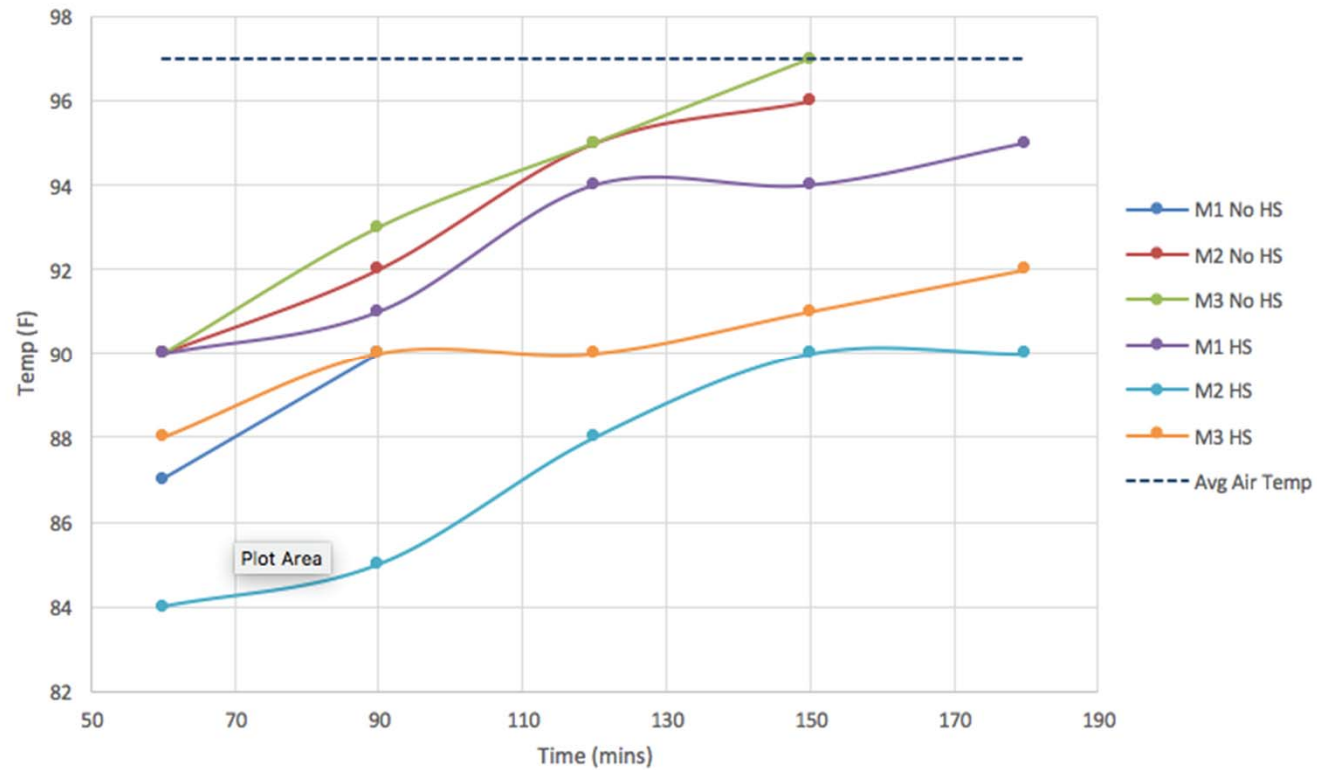
# Field Test Results - Air

Air - Moderate Weather



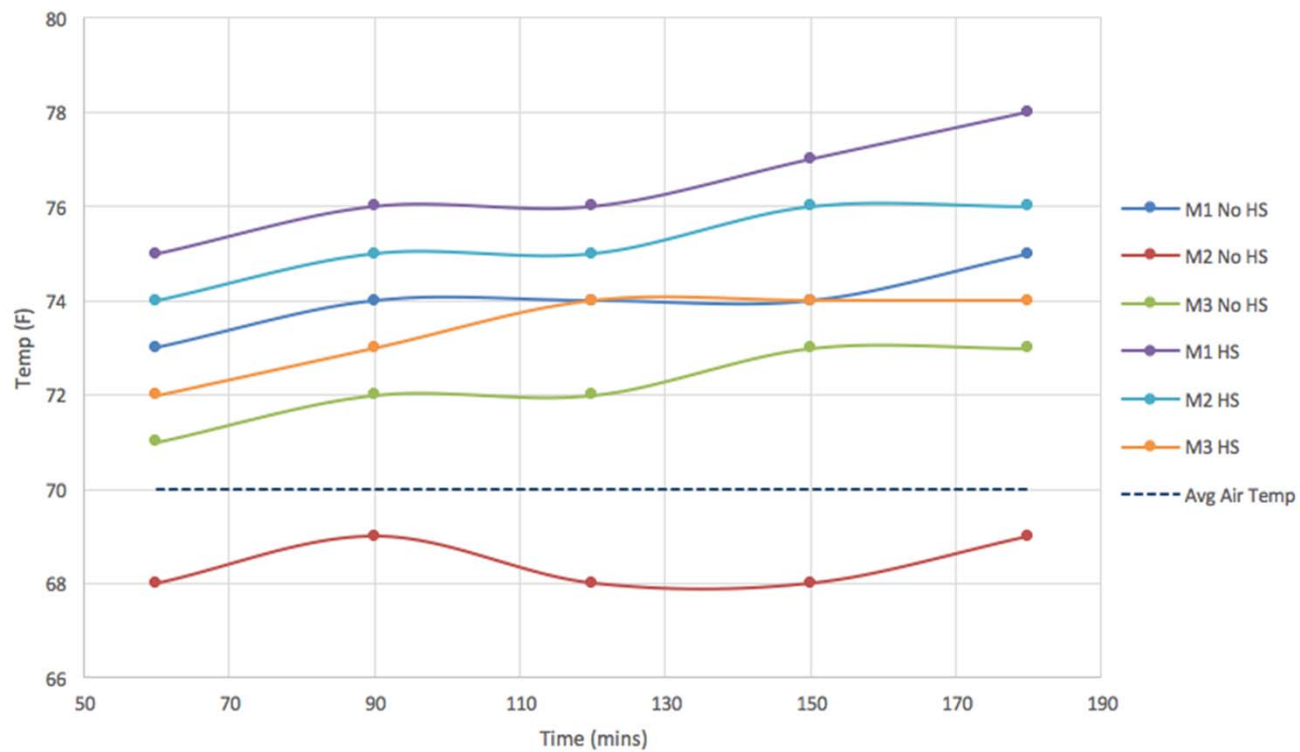
# Field Test Results – Concrete Temp

Concrete Temp - Hot Weather

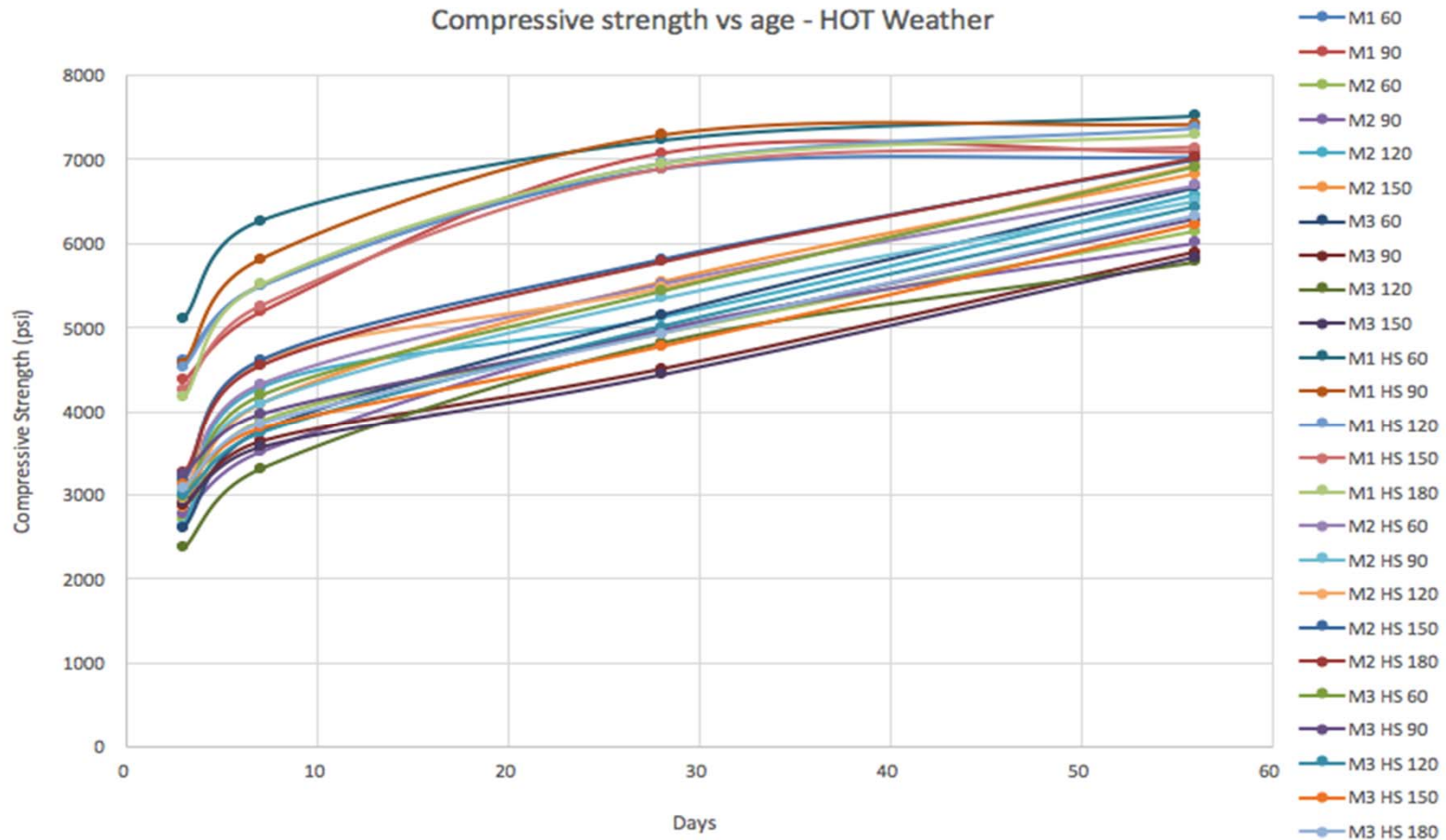


# Field Test Results – Concrete Temp

Concrete Temp - Moderate Weather

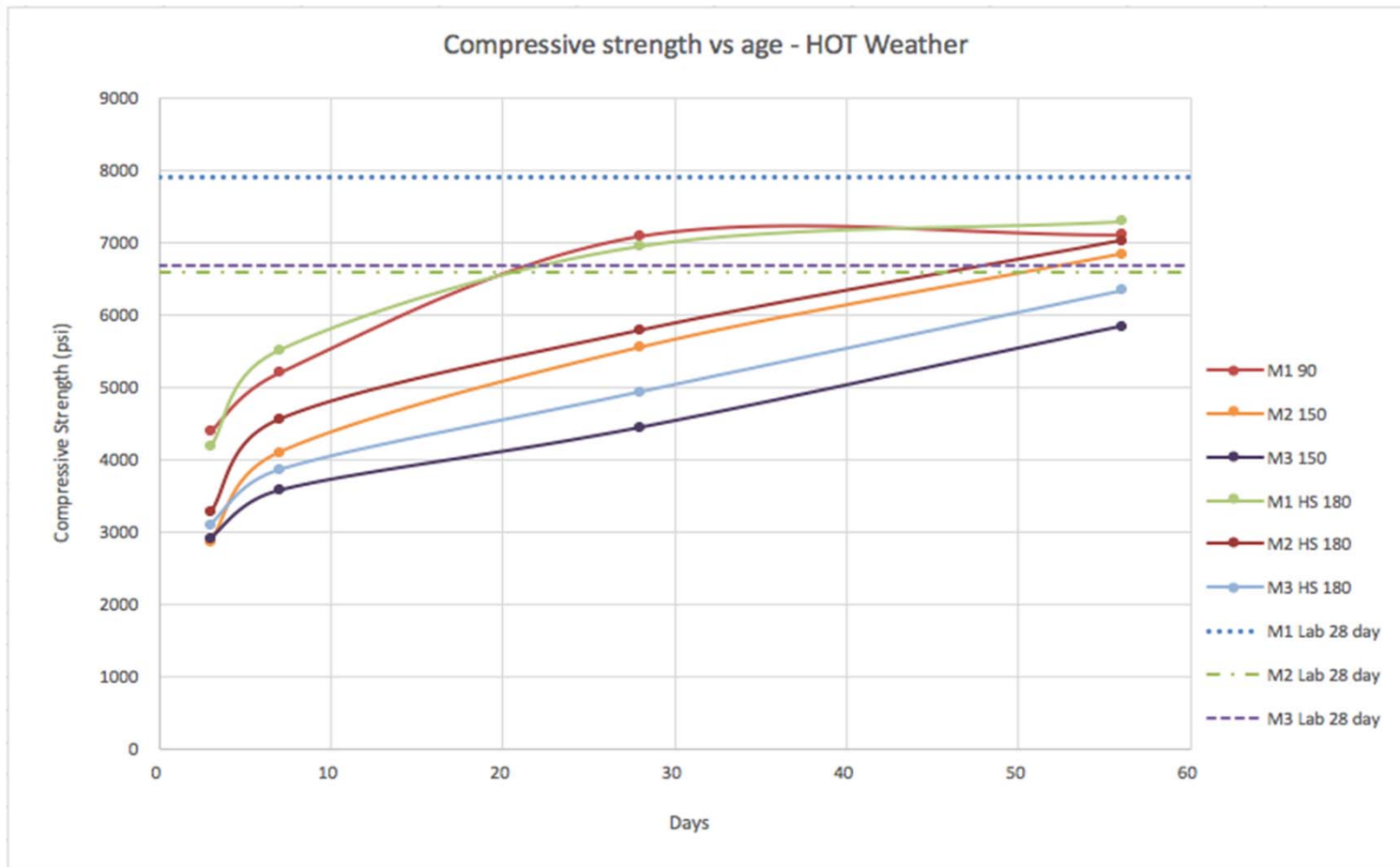


## Test Results – Compression Test (ASTM C39)





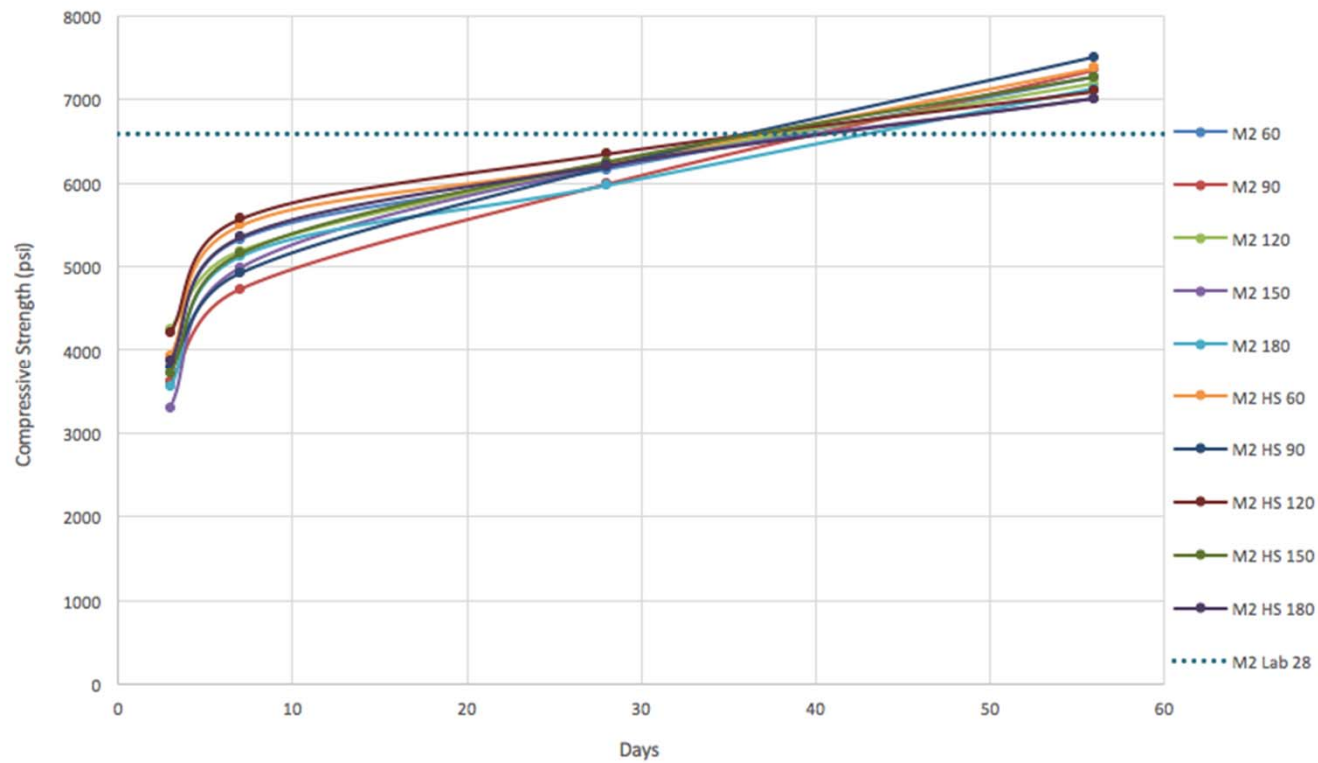
## Test Results – Compression Test (ASTM C39)





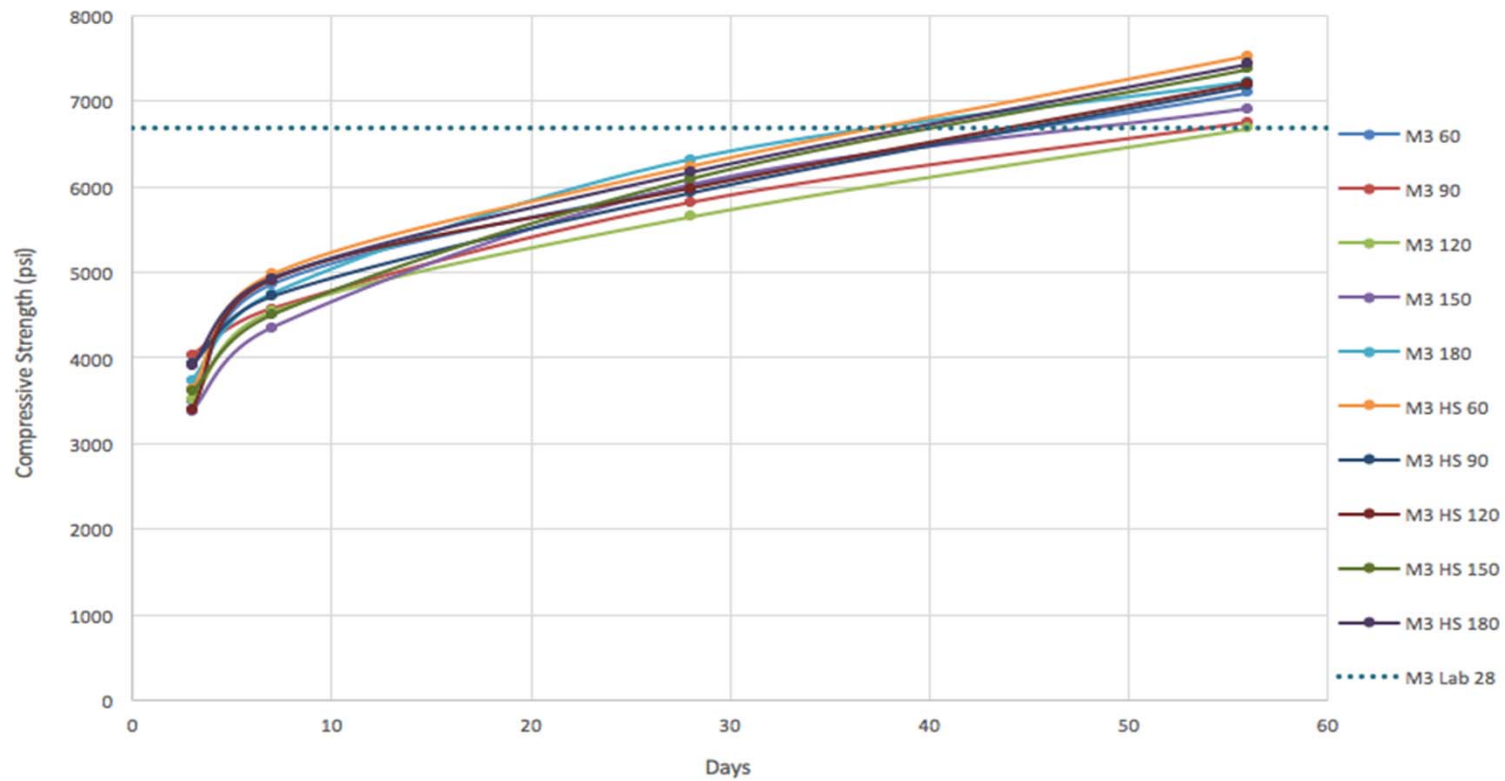
## Test Results – Compression Test (ASTM C39)

M2 - Compressive strength vs age - MODERATE Weather



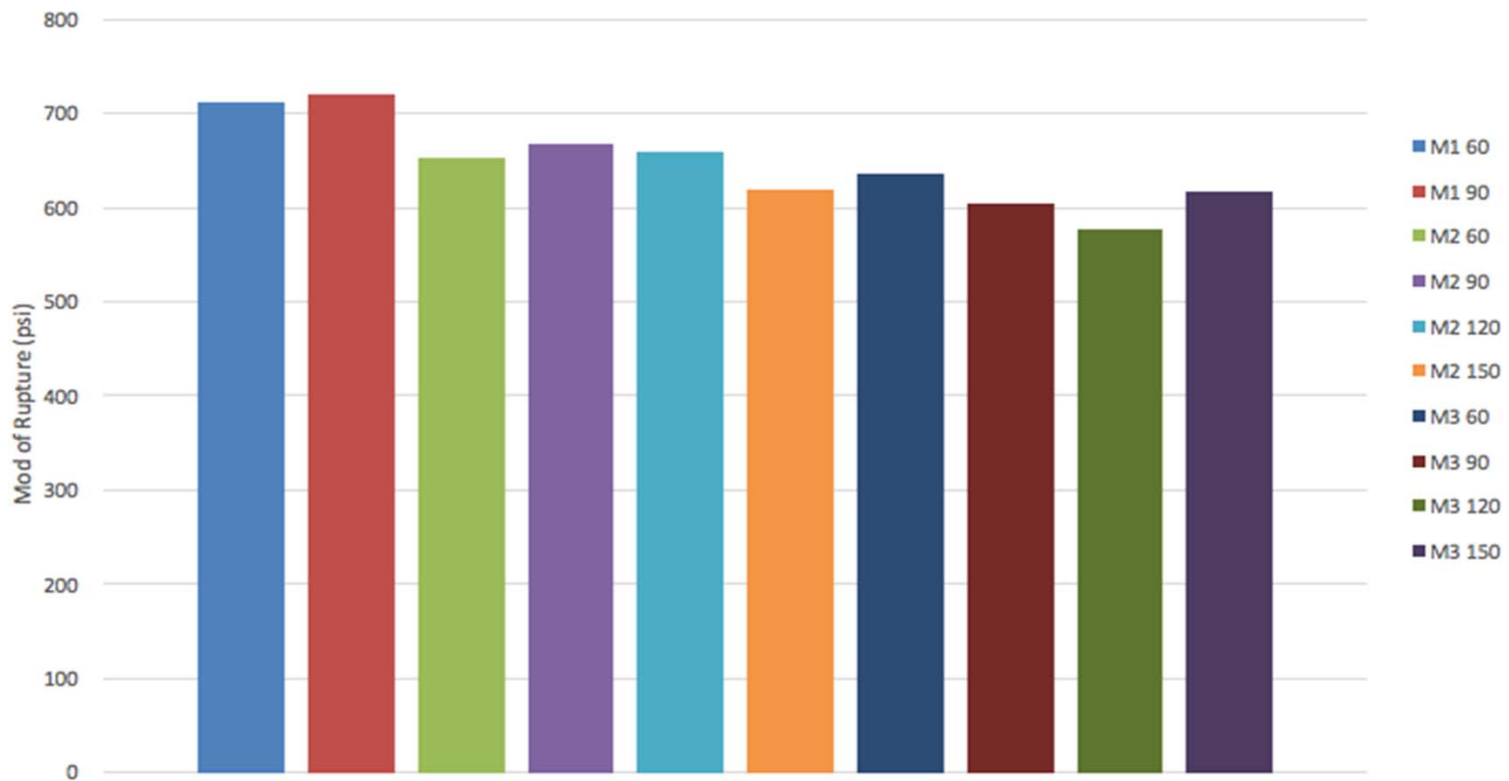
# Test Results – Compression Test (ASTM C39)

M3 - Compressive strength vs age - MODERATE Weather

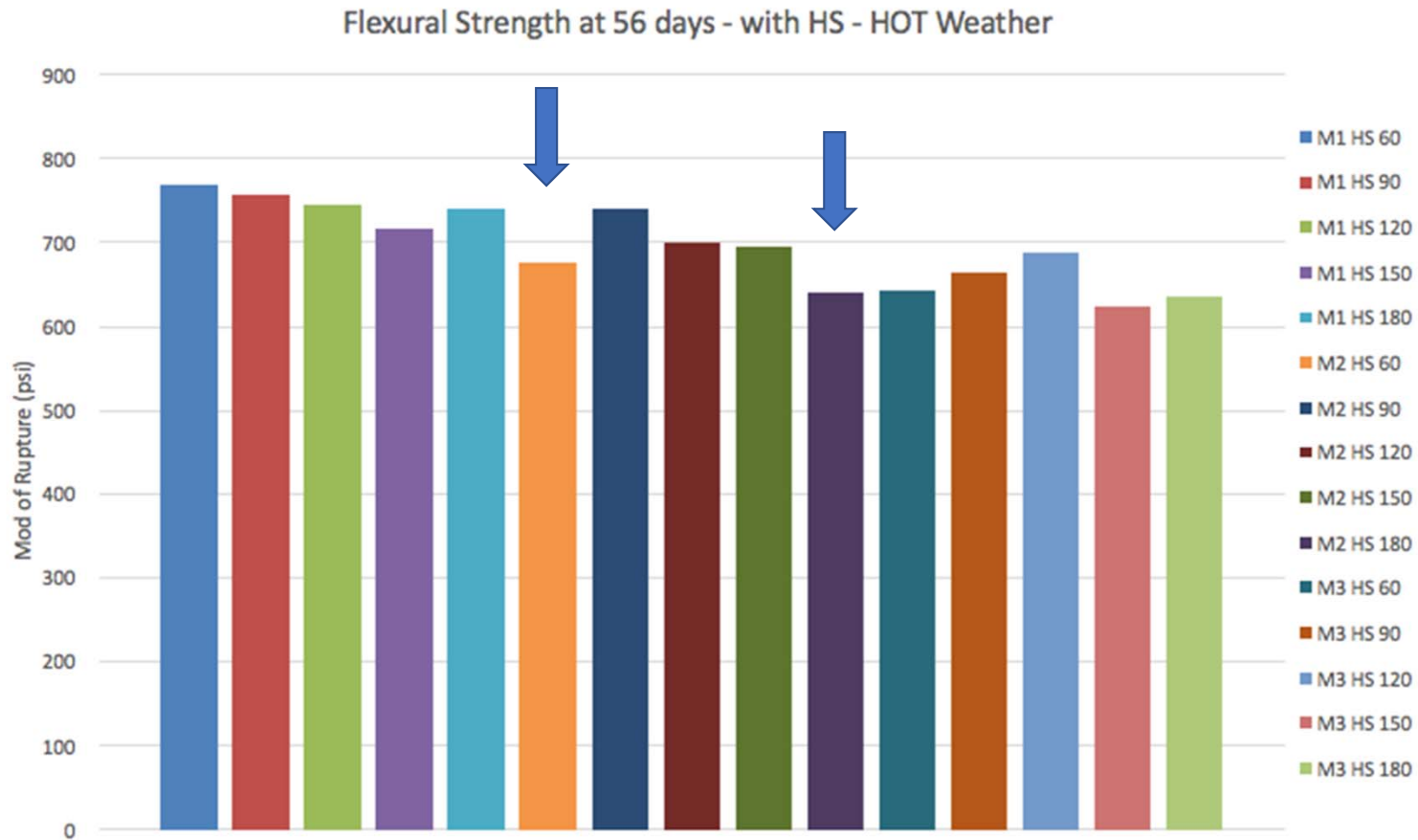


# Test Results – Flexure Test - (ASTM C78)

Flexural Strength at 56 days - NO HS - HOT Weather



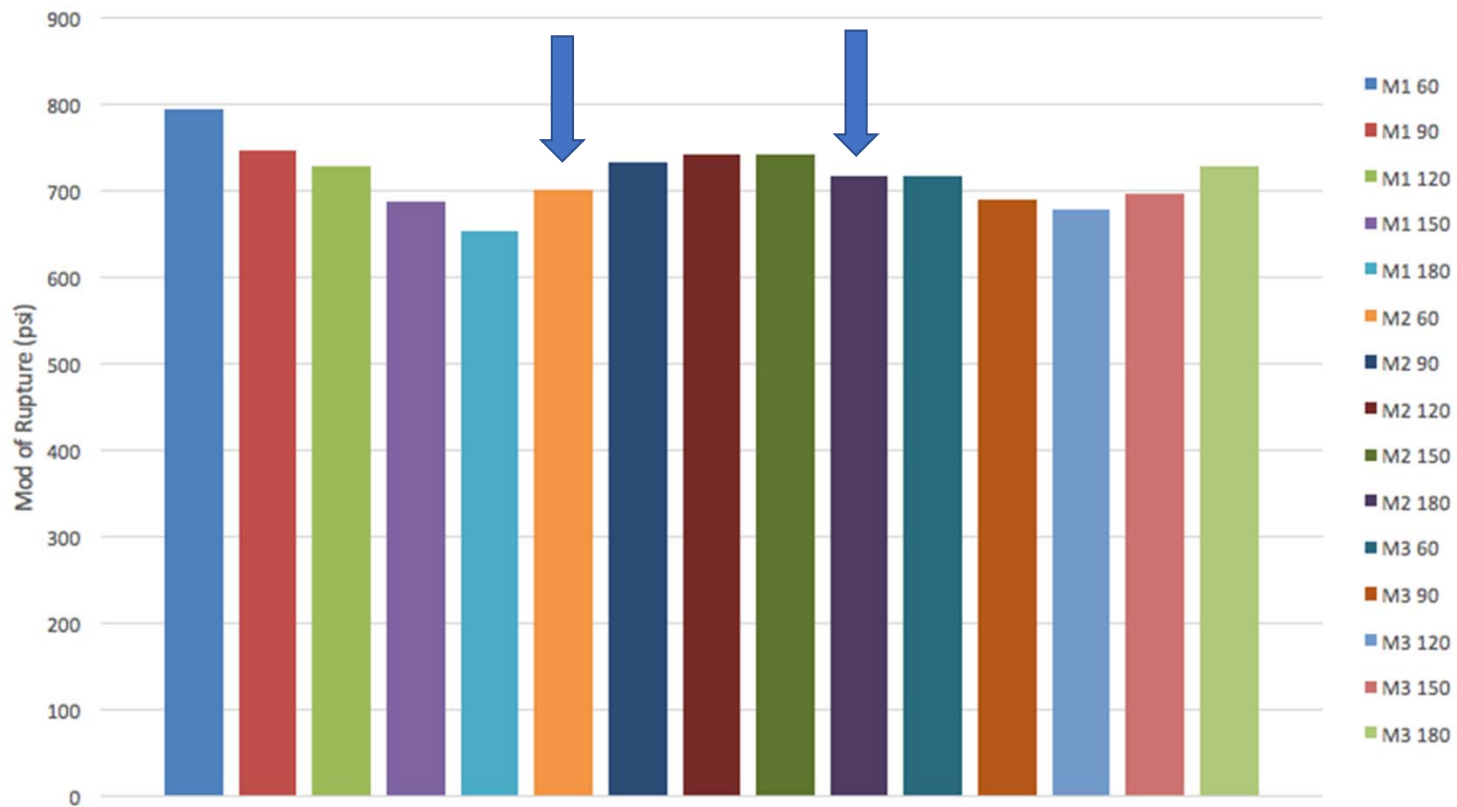
# Test Results – Flexure Test - (ASTM C78)



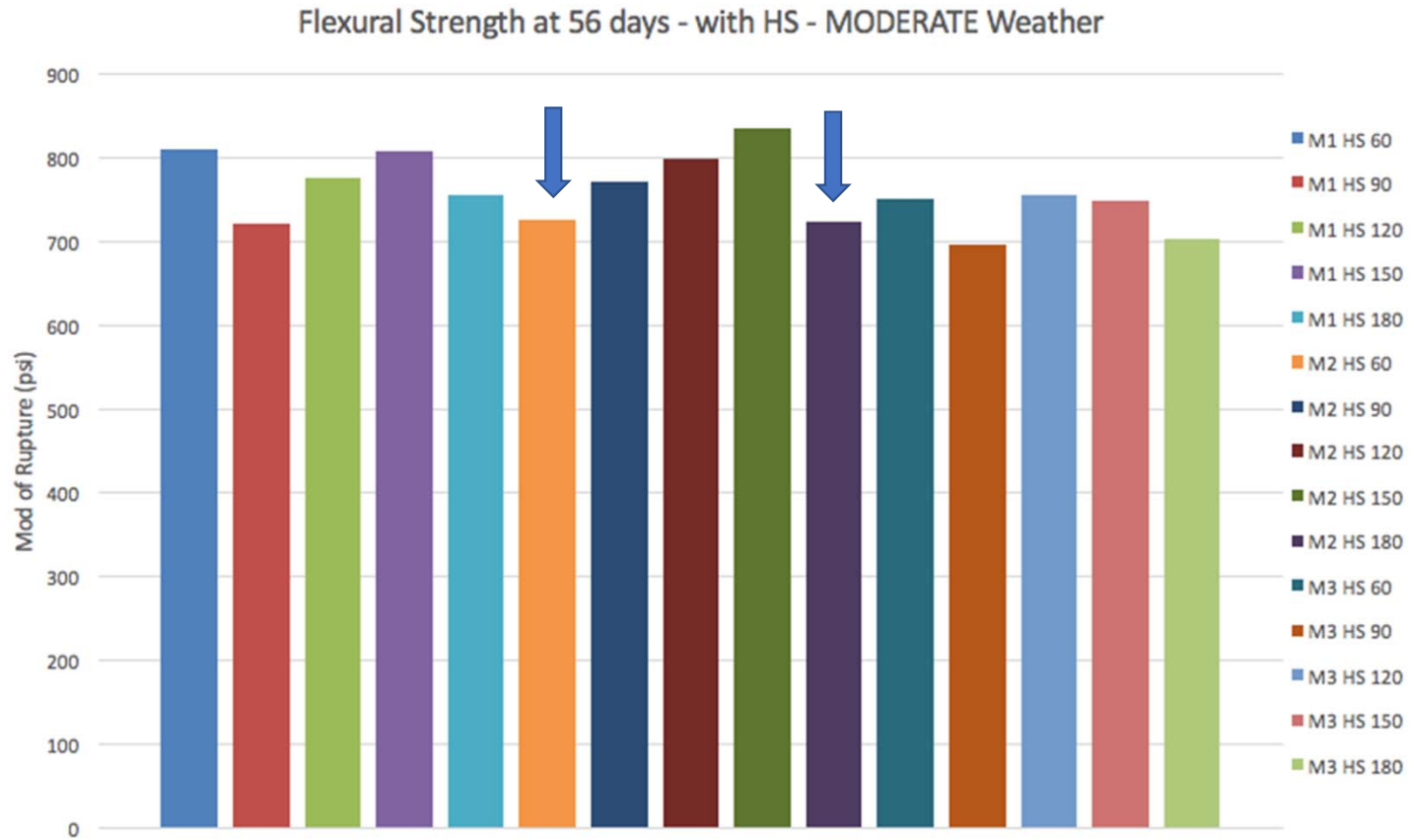


# Test Results – Flexure Test - (ASTM C78)

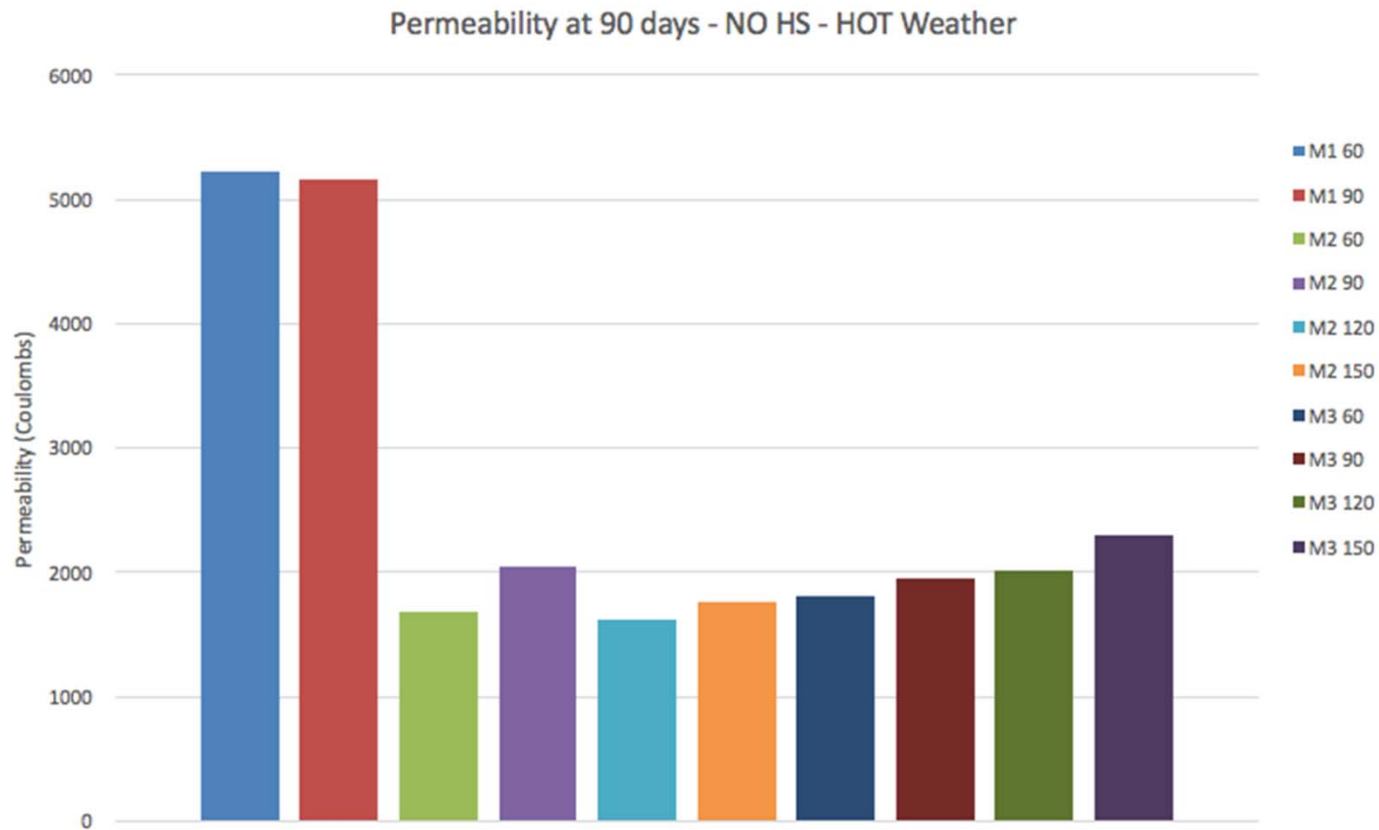
Flexural Strength at 56 days - NO HS - MODERATE Weather



# Test Results – Flexure Test - (ASTM C78)

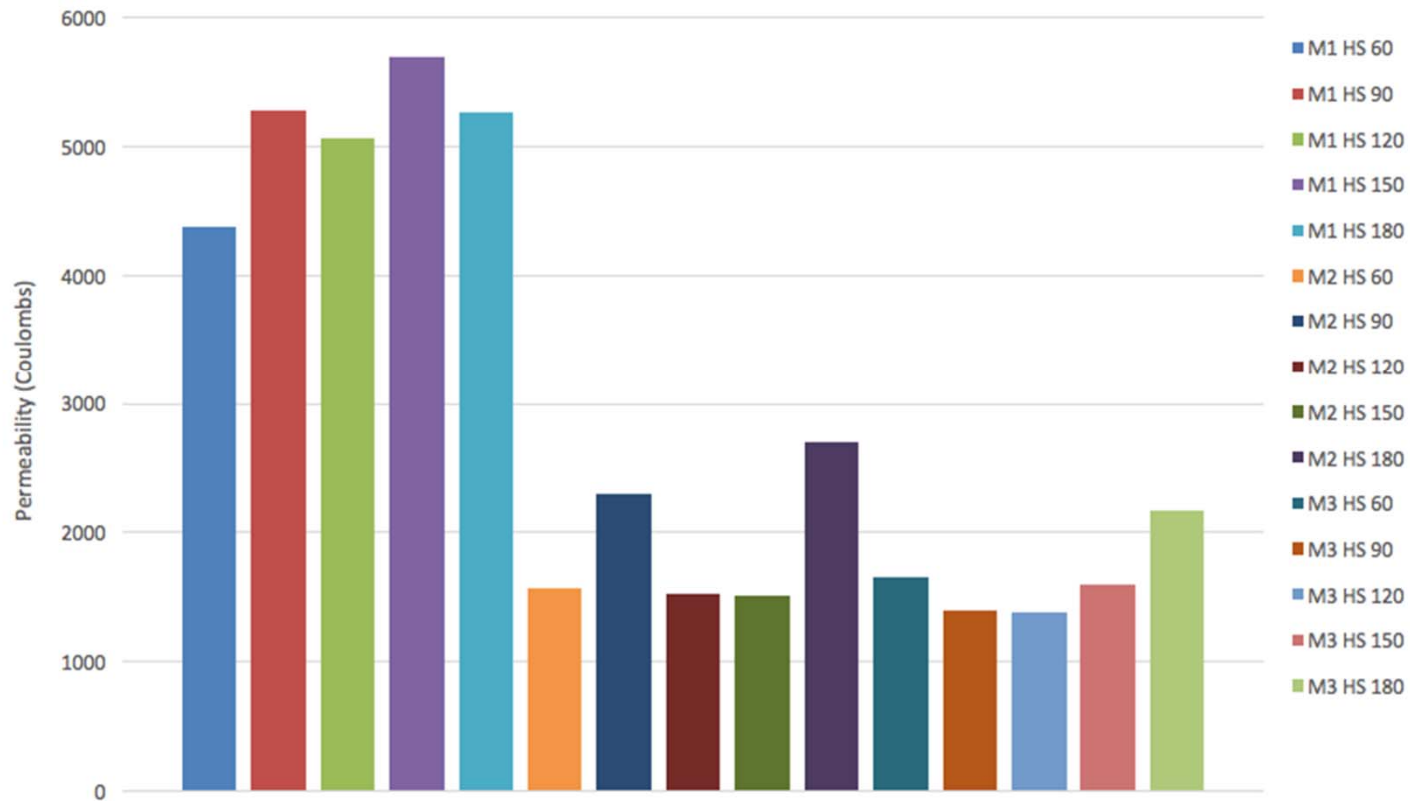


# Coulomb Permeability Test



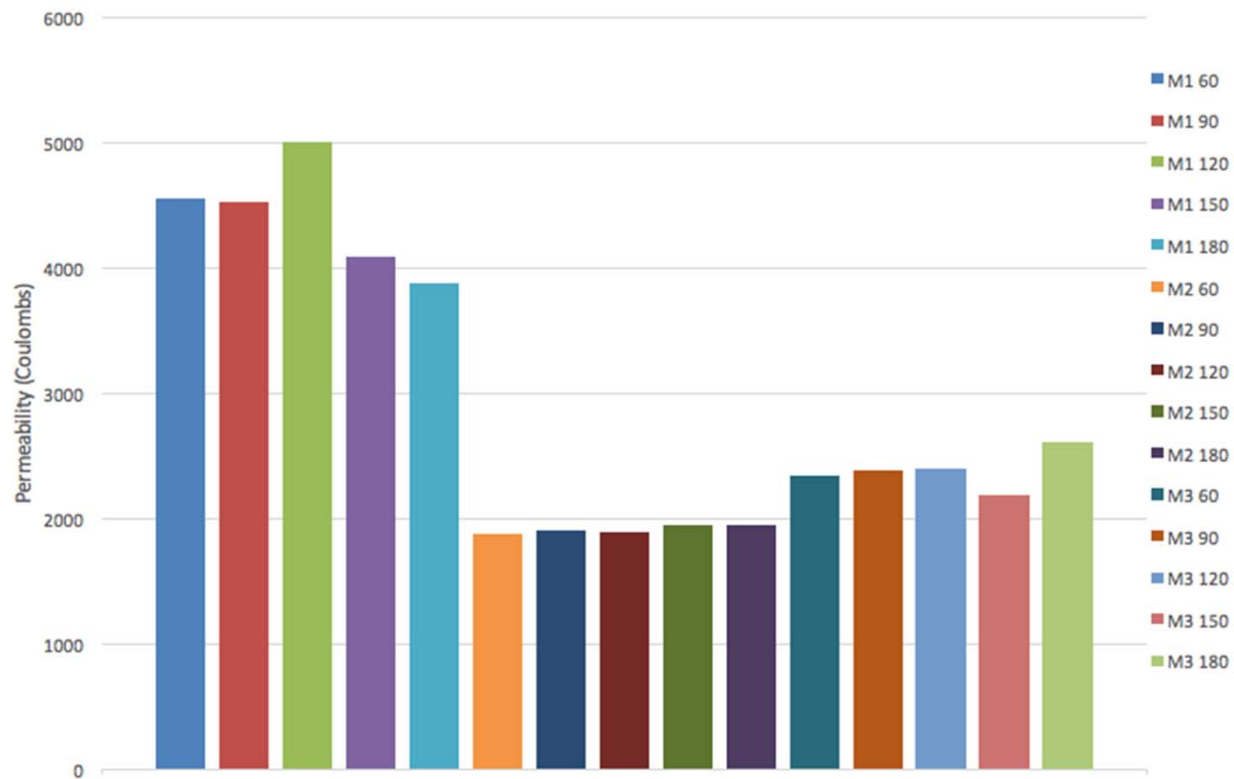
# Coulomb Permeability Test

Permeability at 90 days - with HS - HOT Weather



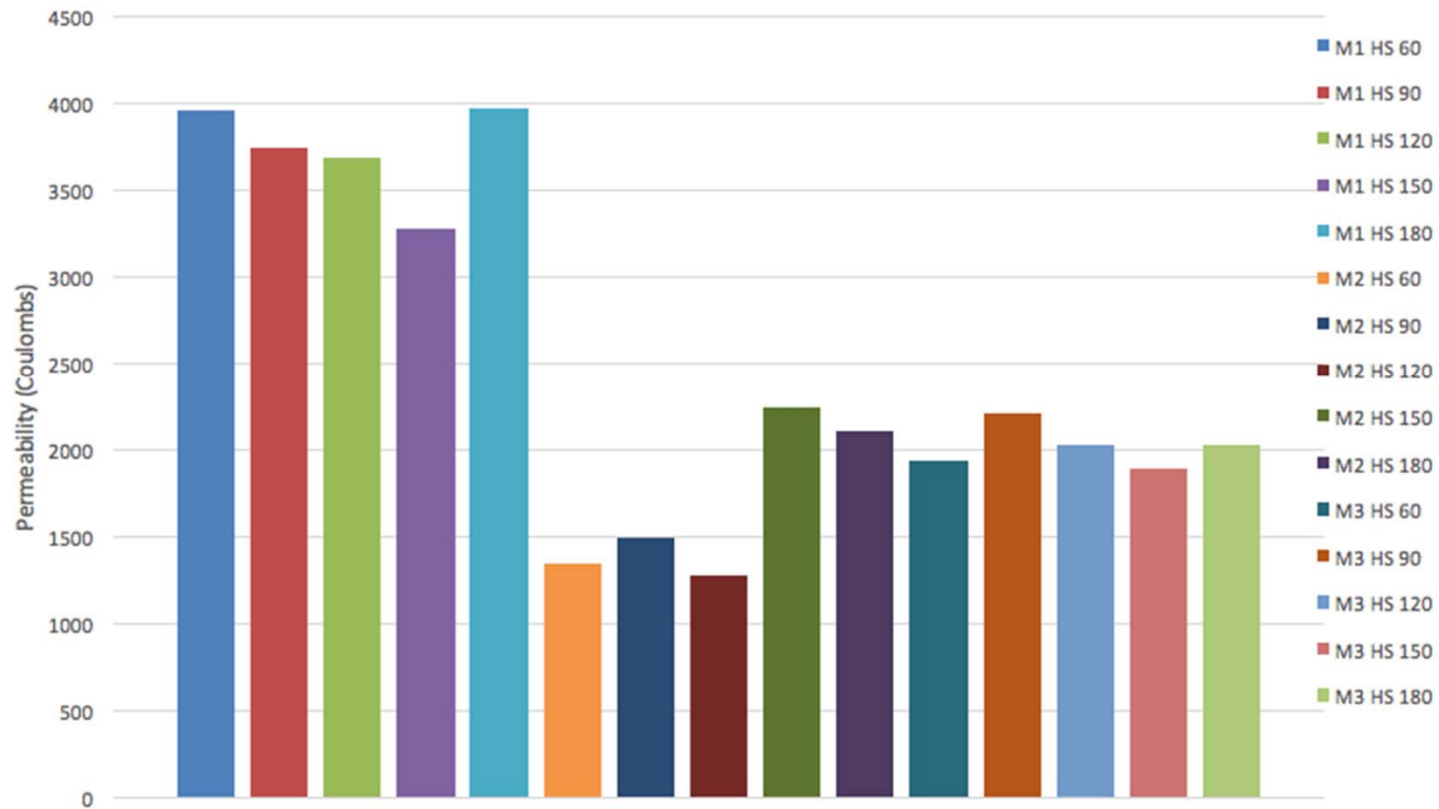
# Coulomb Permeability Test

Permeability at 90 days - NO HS - MODERATE Weather



# Coulomb Permeability Test

Permeability at 90 days - with HS - MODERATE Weather



## 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 Stabilizer
  - 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 Stabilizer
  - 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



