PERVIOUS CONCRETE RESEARCH PROJECT: PHASE II

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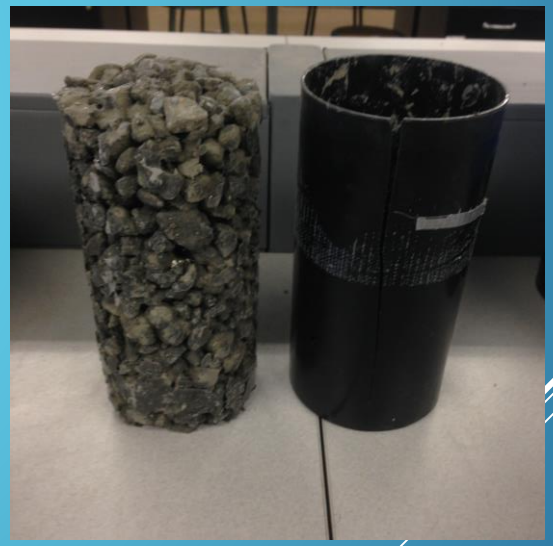
CENE 486: Senior Design

PRESENTATION OVERVIEW

- Project Background
- Project Objective
- Project Management
- Material Preparation
- Mix Design Formulas
- Results
- Summary of Project Cost
- Future Research Suggestions and Conclusions



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PROJECT BACKGROUND

- Applied Research Development (ARD) building parking lot made of pervious concrete has **failed** after three years of completion (2007).
- Flagstaff experiences **250** freeze-thaw cycles in one year.
- Project Client/Technical Advisor: **Dr. Chun-Hsing Jun Ho.**
- Junyi Shan and Darius Ishaku finished Phase I in Dec 2013.
- EPA recommends pervious concrete pavement to reduce surface storm water runoff and treat the storm-water on-site.
- Records show that 25% of the pervious concrete pavement installations have failed.

http://nau.edu/CEFNS/NatSci/SESES/Climate-Science-Solutions/

https://sites.google.com/site/junhonau/

PROJECT OBJECTIVE

- Develop pervious concrete mix design which can withstand the cold climate and high frequency of freeze-thaw cycles of at least **300**.
- Minimum compressive strength of **2500 psi** and a minimum void ratio of **17%**.
- Apply the **best** mix design formula to the ARD parking lot.
- Compare the impacts of **fiber** and **silica fume** on the mix design formulas.

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PROJECT MANAGEMENT (TASK LIST)

- Task 1- Team Management
- Task 2- Project Development
- Task 3- State of the Art Literature Review
- Task 4- Material Preparation
- Task 5- Mix Formula Development
- Task 6- Specimen Production
- Task 7- Lab Testing
- Task 8- Data Analysis
- Task 9- Final Deliverable

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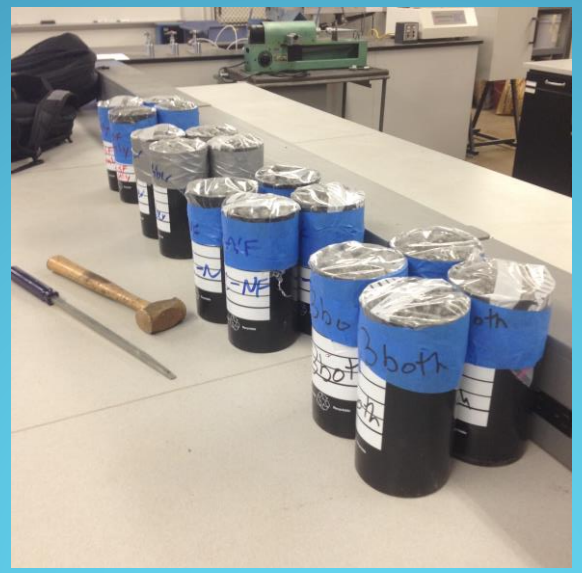
MATERIAL PREPARATION

- Portland cement type II
- Water
- Coarse aggregate:
  - Prescott:
    - Basalt only
  - Camp Verde
    - Basalt, Limestone, Quartzite, and Granite
  - #4(0.187"),1/2", 3/8", and 3/4"
- Fine aggregate (nature sand)
- Fiber (Fibermesh@150)
- Silica fume
- Admixtures
  - Hydration Stabilizer
  - Mid-range Water Reducer
  - Viscosity Modifier
  - Air Entrainment

Mixing



Molding

De-Molding

Curing Samples

Specimen Without Fiber

Specimen with Fiber

Pictures Taken By Fahad and Fawaz

MIX DESIGN FORMULAS

ASTM C 192/C 192M-02 Specimen Preparation Procedure

Mix ID#	Material Proportion (lb./yd³)			
	Aggregate Gradation			
	#4	3/8"	1/2"	3/4"
#25 CV	250	400	1850	-
#26 CV	500	500	1500	-
#27 CV	250	750	1500	-
#26 PR	500	500	1500	-
#27 PR	250	750	1500	-
#30 PR	500	500	1250	250
#31 PR	-	1000	1500	-
#32 PR	750	200	1550	-
#33 PR	750	350	1400	-
#16 PR	1000	1500	-	-
#34 PR	850	450	1200	-

Material Proportion (lb./yd³)			
Cement	Water	w/c ratio	Sand
616	169.4	0.275	200

Admixture(oz.)				Fiber (lb./yd³)
Delvo	P900	Micro Air	vma	
105	36	12	20	1.1

COMPRESSIVE STRENGTH AND VOID RATIO RESULTS

ASTM C39 Compressive Strength Test Procedure

ASTM C127 Void Ratio Test Procedure

Mix Number	Compressive Strength				Void Ratio	
	7-day Comp.(psi)		28-day Comp.(psi)		Sample 1	Sample 2
#25 CV	1107	955	N/A	1115	24.5	26.7
#26 CV	1300	1354	1415	1354	23.6	22.6
#27 CV	1115	1258	1369	1831	18.7	23.8
#26 PR	2548	2189	2651	N/A	22.2	20.4
#27 PR	1871	N/A	2014	2309	19.2	17
#30 PR	1433	1690	1823	1779	20.1	20.5
#31 PR	2699	2879	2946	2923	17.5	17.1
#32 PR	2538	1982	2787	2548	20.6	18.8
#33 PR	2502	1911	2946	2962	17.2	17
#16 PR	2866	2906	3177	2986	21.2	23
#34 PR	1831	1672	2070	N/A	17.3	17.2

N/A: not reasonable result

COMPRESSIVE STRENGTH AND VOID RATIO RESULTS

ASTM C39 Compressive Strength Test Procedure ASTM C127 Void Ratio Test Procedure

Mix Number	Compressive Strength				Void Ratio (%)			
	7-day Comp.(psi)		28-day Comp.(psi)		Sample 1	Sample 2	Sample 3	Sample 4
31 No Fiber/SF	2150	2229	2389	2477	20.8	20.9	20.4	21.8
31 Fiber	2492	2548	2673	2708	21.6	21	19.3	21.9
31 SF	3362	3424	3495	3554	18	19.2	18.3	18.8
31 Fiber/SF	3838	3933	4154	4033	20	19.1	19.4	18.8

FINAL MIX DESIGN FORMULA

Mix ID#	Material Proportion (lb./yd³)								Admixture(oz.)				Fiber (lb./yd³)	Silica Fume (lb)
	Cement	Water	w/c ratio	Sand	Aggregate gradation				Delvo	P900	Micro air	vma		
					#4	3/8"	1/2"	3/4"						
#31 SF	585.2	166.3	0.27	200	1000	-	1500	-	105	36	12	20	-	0.068
#31 SF/Fiber	585.2	166.3	0.27	200	1000	-	1500	-	105	36	12	20	Fiber 150, 1.1	0.068

- Based on Freeze-Thaw Cycle Results, the best of the two formulas will be chosen as the FINAL Mix Design Formula.
- Freeze-thaw Cycle test is in progress as it will be done by the end of the year. (Currently at 90th cycle)

SUMMARY OF PROJECT COST

Type of Worker	Rate $/Hr
1. Senior Engineer	140
2. Project Engineer	110
3. Engineer in training	75
4. Intern/Technician	60

Cost of Phase II			
Total Hours	380	$	35,161.67
Equipment Cost Total		$	3,717.39
Total Cost of Project		**$**	**38,879.06**

Initial cost estimation: 30,750.00$
Final cost estimation: 38,879.06$

CONCLUSIONS

- #31 is the final mix design formula which had the highest compressive strength results with an acceptable void ratio.
- Fiber connects aggregate particles together and increase the compressive strength.
- Silica fume has a significant impact on the performance of pervious concrete.
- Aggregate from Prescott, AZ has better performance than Camp Verde, AZ aggregate.

FUTURE RESEARCH PLAN

- The Freeze-Thaw Cycle Test will continue until the samples have completed at least 300 cycles or have failed.
- Apply the Final Mix Design Formula to the ARD parking lot and monitor its performance.
- Continue with developing mix design formulas to find better results in Compressive Strength and Void Ratio.

Pictures Taken By Fahad and Fawaz

ACCOMPLISHMENTS

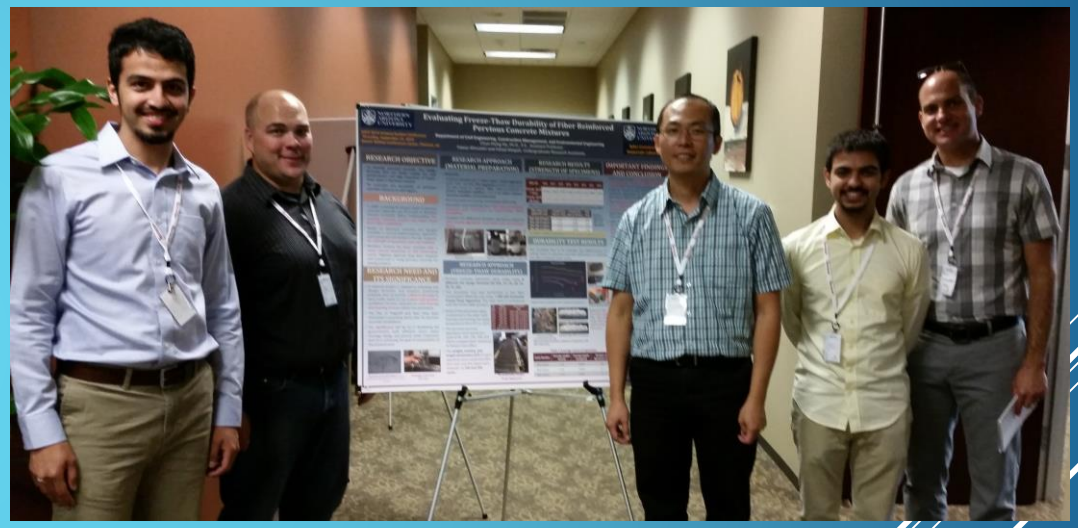
Won 1st Place for Arizona Pavement/Materials Conference 2014 (Picture with Dr. Rita Cheng, NAU President)

Won 2nd Place for ASCE Arizona Conference 2014 (Picture with Brent Borchers, P.E., AzSCE President)

Pictures Taken by Junyi Shan

ACKNOWLEDGEMENTS

- Dr. Chun-Hsing Jun Ho (Technical Advisor and Client)
- Junyi Shan, Darius Ishaku and Mengxi Du (Phase I Team)
- Professor Wilbert Odem (CENE 476 Instructor)
- Professor Bridget Bero, Dr. Charles Schlinger, and Mr. Mark Lamer (CENE 486C Instructors)
- Mr. Vere Harris, Quality Control Manager, CEMEX at Prescott, AZ.



Picture Taken by Junyi Shan

REFERENCES

- National Ready Mixed Concrete Association (NRMCA). *Freeze-Thaw Resistance of Pervious Concrete*, NRMCA, Silver Springs, MD, 2004.
- http://nau.edu/CEFNS/NatSci/SESES/Climate-Science-Solutions/
- https://sites.google.com/site/junhonau/home
- http://www.cemexusa.com/
- http://www.astm.org/Standard/
- http://water.epa.gov/polwaste/npdes/swbmp/Pervious-Concrete-Pavement.cfm

QUESTION ??