Pervious Concrete

PHASE TWO

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Dr. Chun-Hsing Jun Ho
Department of Civil Engineering,
Construction Management, and
Environmental Engineering.

Dear Dr. Chun-Hsing Jun Ho,

Pervious Concrete Research Team has completed the project proposal for phase two of the pervious concrete research project. The project proposal consists of the project understanding, the scope of services, the cost of engineering services and the project scheduling.

Thank you for letting us to be part of your research and we hope that we have satisfied your requirements from this proposal. We look forward to working with you.

Sincerely,

Pervious Concrete Research Team

Fawaz Almutairi Fahad Aloqaili

Fawaz Almutairi *Fahad Aloqaili*

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Introduction

The purpose of this project is to help Dr. Chun-Hsing (Jun) Ho with his research in developing pervious concrete mix design formula. The pervious concrete mix design formula must withstand the cold climate conditions, especially in Flagstaff, Arizona. This is the second phase of this research project as the team continues with the project while having results and mix formulas created in phase one. This project includes producing specimens, laboratory testing, applying the mixtures created in phase one on the ARD (Applied Research and Development) parking lot on NAU campus and monitor the performance of the mixtures applied.

Project Understanding

The project understanding consists of several sections, which can help in understanding this research project. The sections include the project purpose, background, stakeholders, existing conditions, technical work and challenges.

Project Purpose

Pervious concrete is a mixture of concrete that specializes in high void ratio that allows water to pass through the pavement to the ground in a short amount of time without affecting the pavement. This helps in managing storm water by reducing flooding. The purpose of phase two of the pervious concrete project is to apply the mixtures created in phase one of the same in a parking lot near the Sky Dome building on NAU campus and another parking lot near the City Hall of Flagstaff. After the completion of the two pervious concrete paving projects, monitoring the performance of the mixtures is needed for this project. Another purpose for this project is to create a stronger mixture of the pervious concrete by adding an admixture, Silica-Fume, which helps in increasing the strength of concrete. The new mixture includes fiber, aggregate, cement, water and Silica-Fume. These mixtures will be expected to increase the strength and void ratio of specimens, which will advance the performance of pervious concrete.

Background

The US Environmental Protection Agency (EPA) recommends the pervious concrete pavement system to manage surface storm-water runoff and treat the storm-water. When looking at the mix materials and the mixing techniques, the conventional concrete mix is similar to the pervious concrete mix. The pervious concrete has a higher void ratio, which reduces its strength

when compared to the conventional concrete. A parking lot located in Applied Research and Development building (ARD) of the campus was made of pervious concrete in 2009. This parking lot failed after three years from the completion. A team from phase one was to develop pervious concrete mix formulas. Then, based on the formulas, the team produced specimens. While a few pervious concrete mixtures appeared to be a promising product, there is still a need to improve its performance in durability, strength, and air void. The information gathered from phase one is necessary for applying and monitoring part of this phase. Also, the information is important to know the mistakes made by the other team as well as the different mixtures created in the phase. This will help in avoiding the same mistakes and have more ideas in creating the stronger and more appropriate mixture for the parking lots. The city of Flagstaff winter climate is often below freezing and this affects mixtures due to freeze-thaw cycle. Also, the city of Flagstaff usually experience high frequency of freeze-thaw cycles, which will need to be considered which creating the mixtures.

Stakeholders

There are many stakeholders related to this project. One of these stakeholders is the client, Dr. Chun-Hsing (Jun) Ho, who has provided the team with instructions and information to make a better mixture for the parking lot. In addition, faculty, staff, and students, who commute to Northern Arizona University, will park on campus and are part of stakeholders. Moreover, residents visiting the City of Flagstaff will need to park in front of the building. Lastly, the practicing engineers in the area of the project are one of the stakeholders. This project helps in achieving such goal as it will consider these people as part of the stakeholders.

Existing Conditions

The mixtures created will need to withstand the weather conditions in the project. The conditions include the cold weather experienced by Flagstaff in the period between December and March. The average temperature in Flagstaff is 46^{o}F/8^{o}C while the temperature in the period mentioned is 32^{o}F/0^{o}C. Moreover, Flagstaff experiences around two hundred freeze-thaw cycles around the year. This change in cycles can have different effects on the concrete and its strength. The parking lot near the ARD building located on NAU campus was made out of pervious concrete. But, three years after the completion of the concrete, failure occurred and cracks appeared in the pavement. This happened due to the clogging within the pavement. When the water

stays in the pavement and freezes, the pavement expands. Moreover, when the water stays in the pavement and thaws after freezing, the pavement shrinks. After many Freeze-Thaw cycles, the pavements experiences many cracks. In addition, the water stayed inside the concrete creating significant pressure to deteriorate the pavement system.

Technical Work

The second phase of this project consists of two main components. The first one is to apply the mixtures created in phase one to two parking lots around Flagstaff which include the parking lot near the City Hall of Flagstaff and the parking lot near the Sky Dome located on NAU campus. After completion, the team is planned to monitor the performance of pervious concrete parking lots and collect water samples from the bottom of the pavement. The second objective is to evaluate the strength and void changes of pervious concrete mixtures with the addition of Silica-Fume.

Challenges

There are many challenges that can influence the project. One of these challenges is high frequency of freeze-thaw cycles. It will be difficult to produce pervious specimens and let them sit in the field to go through the freezing and thawing conditions. Therefore, a freeze-thaw device is available in the construction materials lab to be used to shorten the time need for testing the samples.

Scope of Services

The scope of services sections consists of the tasks in phase two of the pervious concrete research project. There are a total of ten major tasks for this phase of the research project and each task consists of subtasks which help explain what need to be done in order to finish phase two of the research project.

Task 1- Team Management

1.1 Meetings

Meetings are held weekly to discuss the project and add any updates presented by the client. The persons attending the meeting will be the client/technical advisor, Dr. Jun Ho, and the assistants, Fawaz Almutairi and Fahad Aloqaili. The duration of the meeting will be between 30-60 minutes.

Deliverable: meeting notice, meeting agenda, meeting minutes, and the meeting outcome.

Task 2- Project Development

2.1 Project description

The team will prepare a comprehensive description of the proposed project, which includes the purpose of the project, the need of the project and the technical background.

Deliverable: Section of Introduction, Understanding and Approach, and Project Management for the project proposal

2.2 Task Breakdown

The team will prepare a list of tasks for the project, which includes a deliverable for each subtask.

Deliverable: Section of Scope of Service for project proposal.

2.3 Timeline, Staff Plan and Budget

The project proposal will include each of the sections: Timeline, Staff Plan and Budget.

Deliverable: Section of Timeline, Staff Plan and Budget in the project proposal.

2.4 Final Project Proposal

The team will prepare the final project proposal, which includes all the necessary information for the client to know about the project.

Deliverable: The Final Project Proposal

Task 3- State of the Art Literature Review

3.1 Previous Work

The team will research the previous work related to the project, especially the phase one of the same project.

Deliverable: Section of Literature Review

3.2 Aggregate Gradation

The team will research the aggregate gradation for pervious concrete.

Deliverable: Section of Literature Review

3.3 Mix design

The team will research the different pervious concrete mixtures, which include cement, water, aggregates, and admixtures.

Deliverable: Section of Literature Review

3.4 Admixtures

The team will research the different admixtures that can help improve the performance of the pervious concrete mixtures.

Deliverable: Section of Literature Review

Task 4- Material Preparation

4.1 Material Preparation

Material preparation includes purchasing the material and delivering them to the lab in the Engineering building on NAU campus.

Deliverable: Pictures of the materials purchased in the final proposal.

4.2 Testing Equipment Preparation

The equipment and the concrete test machines used for the project are located in the Engineering Building on NAU campus.

Deliverable: Pictures of the equipment and the machines in the final proposal.

4.3 Sieve Analysis

The team will apply a series of sieve analyses for the aggregates.

Deliverable: Table showing the aggregates and their sizes.

Task 5- Application

5.1 Applying Mixes

The team will apply the mixtures created in the first phase of the project in the field for testing purposes.

Deliverable: Pictures of the applying the mixtures in the field.

5.2 Monitoring

The team will monitor the performance of the mixtures and record any observations associated to the mixtures.

Deliverable: Table showing the performance of the mixtures.

Task 6- Mix Formula Development

6.1 Proportions Calculation

The team will calculate the weight of different sizes of aggregate and other materials used in different mixtures. Each mix design will have different amounts of materials.

Deliverable: Table showing the information of each material used in each mixture.

6.2 Sieve Analysis

The team will perform sieve analysis for the mix design consisting of various aggregate gradations.

Deliverable: Table of aggregate gradation and gradation chart for each mixture.

6.3 Add new Admixture.

The team will be adding the new admixture, Silica Fume, to the mixtures. The admixture is expected to improve the performance of the pervious concrete mixtures in the compressive strength and the permeability.

Deliverable: Table showing the performance of the mixture with the new admixture added.

Task 7- Specimen Production

7.1 Specimen Production

The team will create different specimens using the different mixtures. The molds will be either rectangular or cylindrical depending on the lab test requirement. The team will create 3-5 specimens for each mixture formula.

Deliverable: Specimen log associate with pictures.

Task 8- Lab Testing

8.1 Void ratio Test

The team will perform a test to calculate the void ratio of the mixtures. The void ratio should be greater than the void ratio calculated in the first phase of the project.

Deliverable: Data sheet has test results for the different specimens.

8.2 Compression Strength Test

The team will perform the compression strength test to the different mixtures using the compression-testing machine located in the Engineering Building on NAU campus.

Deliverable: Data sheet has test results for the different mixtures.

8.3 Permeability Test

The team will perform the permeability test, which is evaluating how fast the liquids penetrate into the pervious concrete specimens.

Deliverable: Data sheet has test results for the different mixtures.

8.4 Freeze-thaw Cycle Test

The team will perform the Freeze-Thaw cycle test using the HM-120 Automatic Freeze-Thaw equipment to evaluate the durability of the different specimens.

Deliverable: Data sheet has test results for the different mixtures.

Task 9- Data Analysis

9.1 Final Data Sheet

The team will gather the data sheets for this project and create the final data sheet that is neat and organized showing the necessary data to evaluate the performance of each specimen.

Deliverable: Final data sheet

9.2 Final mixture Formula

The team will analyze the different mixtures depending their performance in the tests

explained in task 8. After that, the team will decide which mixture formula will be the suitable one for the current condition and it will be declared as the final mixture formula is the best.

Deliverable: Section Discussion explaining the performance of the final mixture formula and the decision process.

Task 10- Final Deliverable

10.1 Research Paper

The research paper will include the sections in task 3. Furthermore, it will include the process and the development of the project.

Deliverable: Research paper

10.2 Presentation

The team will perform an oral presentation explaining the different sections in the project by the end of the spring semester in 2014.

Deliverable: Oral presentation

10.3 Website

The team will design and upload a website to the public, which has the team's project and the information associated with it.

Deliverable: the website

Cost of Engineering Services

Phase two of the Pervious Concrete Research Project has ten major tasks and 27 subtasks within them. Two engineers, Fawaz Almutairi and Fahad Aloqaili, will work on the project as a team while assigning one of them in charge of a certain major task as the other becomes the assistant in that task. Both engineers are in charge of five major tasks. The task hours for the main tasks are listed in Table 1. As shown in Table 2, the total hours for each engineers is 205 hours with a total of 410 hours for both engineers to finish this phase of the project. The engineer fee for each engineer working in this project is $75/hour. Therefore, the total fee for each engineer to finish the project is $30,750.00. Table 2 shows the subtasks under each major task as well as the hours they need to finish with the engineer fee.

Table 1: Estimated Hours and Engineers In-charge

Task	*Estimated Hour*	*Engineer In charge*	*Assistant Engineer*
Task 1: Team Management	36	Fawaz	Fahad
Task 2: Project Development	36	Fahad	Fawaz
Task 3: Literature Review	60	Fawaz	Fahad
Task 4: Material Preparation	24	Fahad	Fawaz
Task 5: Application	16	Fawaz	Fahad
Task 6: Mix Formula Development	40	Fahad	Fawaz
Task 7: Specimen Production	26	Fawaz	Fahad
Task 8: Lab Testing	80	Fahad	Fawaz
Task 9: Data Analysis	32	Fawaz	Fahad
Task 10: Final Deliverable	60	Fahad	Fawaz
Total Hours	410		

Table 2: Estimated Hours and Total Charges for Subtasks

		Hours		Engineer Fee	
Major Task	**Subtask**	**Fawaz**	**Fahad**	**Fawaz ($75/hr.)**	**Fahad ($75/hr.)**
Task 1	1.1 Meetings	18	18	1350	1350
Task 2	2.1 Project Description	4	4	300	300
	2.2 Task Breakdown	4	4	300	300
	2.3 Timeline, Staff Plan and Budget	4	4	300	300
	2.4 Final Project Proposal	6	6	450	450
Task 3	3.1 Previous Work	8	8	600	600
	3.2 Aggregate Gradation	8	8	600	600
	3.3 Mix Design	8	8	600	600
	3.4 Admixtures	6	6	450	450
Task 4	4.1 Material Preparation	4	4	300	300
	4.2 Testing Equipment Preparation	4	4	300	300
	4.3 Sieve Analysis	4	4	300	300
Task 5	5.1 Applying Mixes	4	4	300	300
	5.2 Monitoring	4	4	300	300
Task 6	6.1 Proportions Calculation	5	5	375	375
	6.2 Sieve Analysis	8	8	600	600
	6.3 Add new Admixture	7	7	525	525
Task 7	7.1 Specimen Production	13	13	975	975
Task 8	8.1 Void Ratio Test	10	10	750	750
	8.2 Compression Strength Test	10	10	750	750
	8.3 Permeability Test	10	10	750	750
	8.4 Freeze-thaw Cycle Test	10	10	750	750
Task 9	9.1 Final Data Sheet	8	8	600	600
	9.2 Final Mixture Formula	8	8	600	600
Task 10	10.1 Research Paper	12	12	900	900
	10.2 Presentation	8	8	600	600
	10.3 Website	10	10	750	750
	Total per Engineer	**205**	**205**	**$ 15,375.00**	**$ 15,375.00**
	Total for Both	**410**		**$**	**30,750.00**

Project Scheduling

The project schedule has all the tasks associated with the project as well as the dates for each of them. It also includes the deliverables in this project. Microsoft Project was used to construct the project schedule. The project schedule also shows the start and end dates of each task in the project as well as the duration of each task. Phase two of this project requires 11 months to finish starting from January 2014 till December 2014. The project schedule is provided in the appendix.