Proposed Extension to Pooled Fund 1338

Improving Specifications to Resist Frost Damage in Modern Concrete Mixtures

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Task11 – Continued Development of the SAM

This task will aim to improve the usability and performance of the SAM. First the research team will continue to improve the design of the meter so that there are a lower number of leaks and maintenance. This will be done by improving the performance of the o-rings and components of the meter.

The existing seals match those of the traditional Type B meter as that is what the company that produces the air meter had in stock and were comfortable with. Since the SAM goes to higher pressures then these parts may need to be redesigned. The first o-ring to be modified is between the lid and the bucket of the meter. A custom o-ring will need to be made and distributed to the states for their usage. Next, the pump assembly in the meter will be investigated that will make the test faster. Preliminary work at Oklahoma State University shows that the right pump design may reduce the test time to 5 min and not require the use of the CAPE. This will require some modification to the top of the meter but this could be done on all existing SAMs. While both of these pieces of the meter work now, improvement in their performance will make the SAM a more usable tool.

The precision and bias statement for the SAM is still ongoing and an extension of the pooled fund would allow it to be finalized. This could then be added to the AASHTO TP 118 test method and also used to guide specification usage of the SAM. In addition, the various specifications that have been used to implement the SAM will be gathered and made available on a website. Specific conversations will be had with each state to determine their future plans for the SAM and if any assistance is needed. Finally, the AASHTO TP 118 test method will continue to be updated with the latest findings.

Task 12 – Investigate field construction practices and aid SAM adoption

In this task the research team will continue to work with different DOTs to investigate their interest in field usage of the SAM. A poll will be sent out to the states to find their interest in different field practices. These will be ranked and then focused efforts will be made by the research team in collaboration with the different states to investigate these construction procedures. One focus area is anticipated to be the pumping of concrete. Some preliminary data has already been collected that show great promise, but more work is needed to validate these efforts. These findings will be extended by visiting several construction sites in Oklahoma to support the preliminary work. Also, the team will investigate the usage of light weight aggregate in the SAM. Some work has been done on this but more is needed with a wider range of materials.

In addition, the research team will continue to support the states by testing samples that they want to send from the SAM field testing. This field data is very valuable as it provides important insights into how different combinations of materials perform in different environments. This shows the value of the

SAM and also allows DOTs and industry to realize what materials and construction combinations cause challenges with the air void system.

Task 13 – Standardizing a new rapid freeze thaw test

As part of the previous research on the pooled fund it was realized that critical degree of saturation has a significant impact on the freeze thaw resistance of concrete. This means that as the concrete becomes increasingly saturated that there will be a point when the concrete becomes critically saturated after which time a freezing cycle results in damage. While the current test method is based on placing samples in water and subjecting them to freezing cycles, it appears that it may be possible to extend this very economical and simple test to a more rapid test method. The proposed test method (the bucket test) is simple as the concrete mass is measured after demolding and then over time while the sample is in lime water or perhaps a simulated pore solution. While this test seems simple it shows great agreement with the ASTM C 666 data as shown in Fig. 1.

Work at Oregon State has shown that it may be possible to extend this approach to an even faster test method that could be used as an input into the service life prediction model. If successful this would imply that data from the SAM test and bucket test could be used to provide an indication for the service life of a concrete element exposed to freezing and thawing.

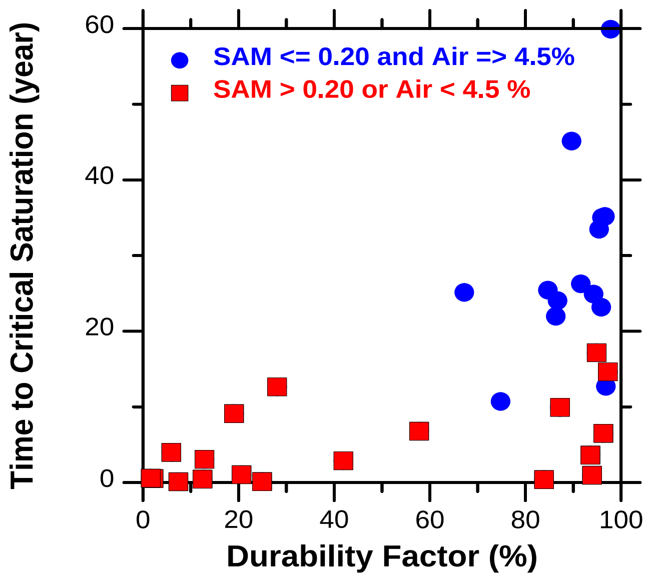


Figure 1 – Time to critical saturation as determined by the bucket test is shown versus the ASTM C 666 durability factor. Good agreement is shown between the two methods.

As part of the extension to the pooled fund we would like to work to improve the test procedure, to author a test method for AASHTO, and to start a round robin with the pooled fund members. At the conclusion of the extension the standard language would be in existence as well as a method to utilize this in mixture qualification or even mixture acceptance.

Task 14 – Measuring different FT exposure conditions

It is widely realized that different freeze thaw environments are different across the US. However, all of the freeze thaw specifications treat each environment the same. As part of this task the research team aims to create large batches of concrete prisms in the laboratory with carefully controlled air void quality, w/cm, and a known desorption isotherm. A certain number of beams from the mixture will be investigated in the laboratory rapid freeze thaw test (ASTM C 666). The concrete will also be characterized in a number of test methods that measure porosity and the rate of penetration of water into the concrete. From the same concrete mixture prisms will be made with embedded gauges in them to measure moisture (degree of saturation), freeze-thaw damage, and temperature of the concrete in service. These beams will then be sent to each pooled fund state and a few other locations with distinctly different environmental conditions. At each location the prisms should be placed in areas where they are protected from the weather, on a drainable base, on an undrainable base, and locations then a set should be salted. A tentative location for each set of prisms is shown in Fig. 2. These beams will be placed outside and monitored by small data loggers developed at Oklahoma State University with newly developed gages from the research team. These data loggers are solar powered and will be used to monitor the beams. The states will need to visit the data logger every three months and remove an SD card and add a blank one. The data will then be uploaded to a website.

Figure 2 – Current estimate of freeze thaw exposure conditions to be measured.

These beams will be designed so that some fail while some perform well based on our previous lab experiments and so results should be obtained quickly. However, because the beams are in different environments this will give the users great insight into how their particular environment compares to others and to the standard freeze thaw testing. The data loggers will be designed so that new beams could be added to the states in the future and they can be continue to be used. These same samples will also be evaluated in Task 16 to enable the gages to be compared to the very precise laboratory measurements. These data loggers have been tested heavily at Oklahoma State for robustness and have survived heavy rainstorms, tornados, and earthquakes.

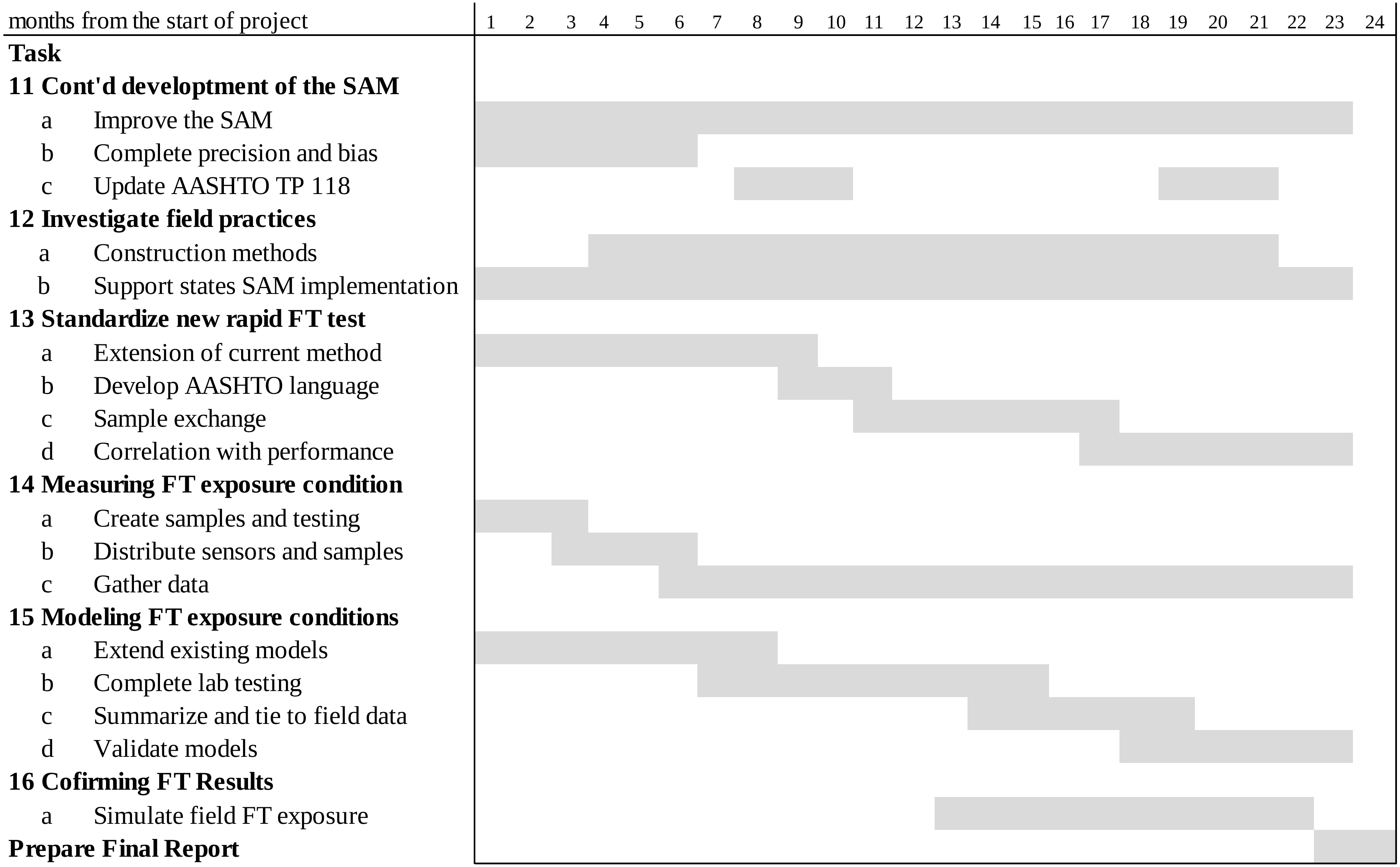
Task 15 – Modeling different FT exposure conditions

The data from the field monitoring (Task 14) will be essential in establishing models to simulate how different exposure conditions impact FT prediction. These models will aim to incorporate drying, wetting, salts, temperature ranges, etc. in making the ultimate prediction of FT field performance of concrete. The previous work on this pooled fund has used well known exposure conditions to better understand the freeze thaw performance of concrete. This has allowed us to build a new level of understanding of FT performance. In this task we aim to extend this knowledge to much more variable exposure conditions of the concrete. This may require some additional laboratory testing to look at how wetting and drying cycles impact the moisture penetration. It also may require completing some previous testing under the influence of salt solution. The ultimate goal of this work is to build a numerical model that will help DOTs design their concrete based on their local conditions and exposure levels. This tool could also be used to forecast the life of concrete of different qualities into the future. This would aid in the design, repair, and service life prediction of existing structures to predict differences in designed and provided life expectancy of structures.

Task 16 - Confirmation of FT results with X-ray and neutron imaging

Both research groups on this project have been studying the movement of water with both X-ray and neutron tomography and radiography. These techniques lend themselves well to the study of freeze thaw damage within concrete as they can be used to evaluate structure, fluid movement, and damage. These methods will be a useful tool to validate the findings from this work and provide deeper insights to critical questions. These tools will not be extensively used in the research; however, they will be able to provide measurements that are not possible with any other method. It is anticipated that a freezing stage will be constructed for usage for neutron and X-ray imaging. This will allow in-situ imaging to be complete of materials as they are freezing.

Schedule


months from the start of project
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Task
11 Cont'd developtment of the SAM
a Improve the SAM
b Complete precision and bias
c Update AASHTO TP 118
12 Investigate field practices
a Construction methods
b Support states SAM implementation
13 Standardize new rapid FT test
a Extension of current method
b Develop AASHTO language
c Sample exchange
d Correlation with performance
14 Measuring FT exposure condition
a Create samples and testing
b Distribute sensors and samples
c Gather data
15 Modeling FT exposure conditions
a Extend existing models
b Complete lab testing
c Summarize and tie to field data
d Validate models
16 Cofirming FT Results
a Simulate field FT exposure
Prepare Final Report