UPDATING THE VKELLY TEST

INTRODUCTION

The VKelly test was developed to provide agencies and contractors a tool that reports how a slipform paving mixture responds to vibration. It has been noted in the past that the slump test was useful, but did not provide a complete picture of the workability of a mixture. Increased complexity of mixtures including the use of supplementary cementitious materials and chemical admixtures has reduced the usefulness of the information provided by the slump test. In addition, current construction tools call for more information about all of the rheological properties of a mixture that are not fully described by the slump test.

Initial evaluation by agencies has shown that the VKelly does provide useful, numerical and repeatable data on how a mixture will perform in a paving machine and that it could distinguish between workability of mixtures with similar slumps. It has also been used by contractors to develop mixture proportions that were reported to be successful in the field. They were able to reduce the amount of cementitious materials in a mixture while improving workability without compromising engineering properties.

A number of rigs were sent to agencies around the country for them to evaluate. Feedback indicated that while seemingly technically sound, the test was challenging to operate.

The aim of the work proposed here is threefold:

- Make the test more user friendly and portable
- Understand the science behind the method to guide mixture proportioning and field operations based on test results
- Broaden the applicability to include structural and pumping mixtures

The long-term vision of this work is to develop an understanding of how mixtures can be proportioned that are relatively insensitive to vibration abuse or are ideal for the vibration system planned for use on a given site. In addition, it is desirable that a real-time test be available on a site so that as a mixture is delivered, it can be tested for workability variances due to batching or transport, thus providing the operator with guidance on how to tune the placing equipment for a truckload for a given workability. Data can also be provided to the batch plant to guide proportions for the next truck to maintain uniformity.

TEST OPERATION

The following challenges have been reported with using the equipment currently available:

- Two people are required to take readings, or a video recording has to be used to extract the data after the test is over
- Results should be immediately reported without having to enter data into a spreadsheet
- The need to be connected to a 110 V power source makes field testing a challenge
- The cost of the ball is high
- Having the vibrator as separate unit to the ball makes the equipment hard to handle
- The equipment cannot be used for higher slump mixtures

Work is ongoing with a commercial manufacturer to build a device that is battery powered, with single person operation and instant readout. This will address many of the concerns received, as well as remove the variability inherent in users using the variety of vibrators in labs around the country.

TEST APPLICATION

The current test system is only appropriate for mixtures with slumps less than 3". On the other hand, standard rheology test systems such as the ICAR Rheometer do not provide meaningful results in such low workability mixtures. It is envisioned that modifications to the system will expand the VKelly test to be valid for structural, pumpable, and even SCC mixtures.

TEST OUTPUT

At present, the output from the method is a so-called VKelly Index that has been tested in the field to assess upper and lower limits for slipform paving. Initial laboratory test data using a smart vibrator that also reports the voltage required to maintain a constant vibration frequency also indicates the potential to assess a number of other mixture properties. Based on this information there is a need to fully understand the mixture and equipment factors that influence the rate at which the ball sinks under vibration and how it can be used to guide mixture proportioning and construction processes.

WORK PLAN

Device Variables

Parameters that can be adjusted in the VKelly test include:

- Amplitude of the vibrator head. In reality, this is not true, because most commercial vibrators operate with a fixed weight offset leading to amplitudes of around 2 mm. Adjusting the equipment to vary this would be expensive.
- Vibrator frequency can be controlled using commercial devices. It is desirable to stay within the range of recommended practice, although tests should be conducted over a range of frequencies to ascertain recommended limits.
- Duration of the test is currently set to 36 seconds but this can likely be modified.

- The number of readings is currently set as 6 readings every 6 seconds. Results are showing this can likely be reduced to 2 readings.
- The size of the ball in use at present is 6" in diameter. It is envisioned that using a variety of sizes will broaden the applicability of the method
- The ball currently in use is machined aluminum, and the cost of this has proven to be challenging. There would be value in investigating the feasibility of using semi-disposable approaches like 3-D printed heads, possibly with different shapes.
- The weight of the ball is currently ~30 lb. Again, adjusting this may facilitate a broader application of the test

These parameters will be investigated as part of the work under this pooled fund.

Mixture variables:

A wide range of mixture variables needs to be tested to understand this method, and how a mixture response to vibration is affected by ingredients and proportions:

- Use of added water or WRA to adjust a mixture between the batch plant and the point of delivery
- The quality of the air void system including total air volume along with bubble size, spacing and stability
- The type and dosage of supplementary cementitious materials
- The size and shape of the aggregate particles
- The gradation of the aggregate system
- The time after batching as a function of evaporation and chemical reactions.
- Workability targets

Tests

It is proposed that the following tests be conducted on the various mixtures prepared using the various device parameters discussed above:

- Initial sink vs slump
- Rate of sink of VKelly balls under vibration
- ICAR rheology for structural mixtures
- Voltage curve of vibrator
- Standard fresh concrete characterization tests such as slump, SAM, bleed, segregation, and calorimetry

Analysis

All of the data collected will be cross-correlated to look for trends and relationships to understand how vibration affects a mixture, how mixture proportions influence responses, and which tests methods provide the necessary information to be useful.

WHAT DO WE NEED TO CONDUCT THE RESEARCH

The biggest need initially is a VKelly device than can be adjusted and modified to control the variables discussed above. This is being developed by a manufacturer.

After that, it is a matter of time, materials, lab access and a smart student to do the number crunching.

BENEFITS

At the end of the day, it is planned to refine the VKelly method and provide a cost effective, useful, operator friendly, portable, device that delivers a wealth of information about the fresh properties of a mixture before it is even unloaded from a dump truck. It is the goal to extend the applicability of the method to be useful for structural concrete.

In addition, it is planned to use the VKelly test to provide guidance to assist design laboratories:

- Proportion mixtures that are workable, meet specified performance limits while optimizing cementitious content
- Understand the effects of ingredient variability
- Design concrete mixtures that are pumpable for high slump concrete

During construction, the test should also be useful for providing reliable data that will allow contractors to optimize their process controls around the mixtures being delivered.

DELIVERABLES

The following deliverables are planned:

- A device that can be used by one person in the lab or the field that will report data to a phone or tablet.
- Guidance on how to use it in the form of a tech brief and a video. This guidance will include how to improve mixtures in the lab, and how to respond to variability in the field.
- A revision to AASHTO TP 129
- A report and webinar that details the work conducted and findings developed

TIME AND MONEY

It is envisioned that this work will take two years to complete at an estimated cost of $200,000 = 10 states at $10,000 per year