Summary of recommended changes Consensus Forming Table

Version 2 September 2015

Notes from meeting on 2 September, 2015

Item 1. Move forward with alternatives to use sine or haversine (offset sine). Expect to get same or very similar fatigue results. Strain must be defined for either wave form as peak to peak. Test needs to report which wave form used.

Item 2. Full agreement

Item 3. Full agreement. Question of limits for friction drag and technical approach to achieve this and how to check (need information from manufacturers to prepare spec).

Item 4. Full agreement. Questions of what clamping stress range to specify and how to check it, and appropriate geometry of clamps (need information from manufacturers to prepare spec).

Item 5. Full agreement. (Need to come up with calculations for averaging logs.)

Item 6. Full agreement. (Need to bring in and review AASHTO TP62-07 language.)

Item 7. Full agreement. (Need precision and bias to specify replicates. Should be evaluated in log form.)

Item 8. Full agreement. (Need to provide detailed precise calculation).

Item 9. Full agreement.

Next Steps

1. Report back to FHWA Mix ETG in mid-September.
2. Get information to Texas A&M working on NCHRP 9-57.
3. Get from John Bukowski current TP 62 spec. Write draft language where needed as identified in this document and put in both AASHTO T 321 and ASTM D 7460.
4. Go to the manufacturers and get information where needed, and also review the draft specs.
5. Report to ETG with update.
6. Go to ASTM (get steps 1 through 5 done before February 2016 ballot) and AASHTO (get steps 1 through 5 done before June 2016) committee ballots. Inform CEN committee.

New recommendations since poll shown in yellow.

Change Item	Proposed Change	Matches current ASTM D7460 (10)?	Matches current AASHTO T 321 (14)?	Matches current prEN 12697-24 (13)?	Bill opinion	Geoff opinion	Phil opinion	John opinion
1 Wave form	a. Sine wave moving through fixed zero deformation location, not in one direction from zero deformation location. b. Strain level calculated as peak to peak of sine wave, not from zero deformation location.	a. No b. No, from zero deflection position	a. Yes b. Yes	a. Yes b. No, from zero deflection position	a.)**Disagree**, to move through zero forces healing on materials. b.)part 1: **Agree**, peak to peak calculations. part2: **Disagree**, one direction loading (Recommend opposite of gravitational pull).	Yes – this is consistent with the original specification	Agree since this is easier to explain and control by devices per IPC/Cooper. Main agreement from testing ease and control.	a. agree b. agree
2 LVDT reference location	a. Fixed location relative to clamps, not on beam b. From target glued on side of beam at neutral axis.	No. Alternatives of fixed and moving reference shown.	a. Yes b. Yes	a. specifies deflection must be measured at or between the interior clamps. b. No	a.) **Agree**, Fixed Reference LVDT b.) **Agree**, From target affixed to *neutral axis*	Agree	Agree to help reduce error/COV especially at higher strains	Agree
3 Rotational and lateral translation at clamping locations	Free rotation and horizontal translation at all clamps.	No. No free translation of inner clamps.	Yes	Yes	**Agree**	Must have.	Agree. Seems to make more impact as strain increases. Not sure if it matters much at lower strains. Again should reduce error/COV.	Agree

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4 Clamping stress	a. Fixed clamping stress, with lowest stress level possible to be determined after consultation with manufacturers b. Recommend a one inch contact surface with radius edges that extend beyond the 1" width of the clamp.	Not mentioned	Clamping procedure given, no prescribed stress range.	Not mentioned	**Agree**, Recommend using lowest pressure required to keep clamps engaged during tests.	Agree, need to ask manufacturers for input.	Agree but not strong on this. I could see where it make a difference with softer beams. Same as John said. For now maybe a note that says the beam much be held firm and not move. Caution to not over clamp the beam. Look for clamping indentions after test.	Agree but don't know what to put
5 Response sampling intervals and numbers (see attachment at bottom of table)	a. Use attached recommended schedule, which is based on decadal increments with sub-decadal increments as repetitions increase. b. Take initial stiffness at 50 cycles. c. Add information about changing gain settings to achieve good wave by 50 cycles. d. Averages should be calculcated on logs, need precise calculation method.	a. Suggested sampling given, example shown doesn't match. Replicates at sampling points not mentioned. b. Yes	a. 200 points within each log decade. b. Yes	a. "measured regularly" b. 100 cycles	a.) **Agree**, files can get very large. b.) **Agree**, equipment is capable of achieving amplitude deformation in ≤5 sec.	Agree, use table at end of memo	Agree	a. Agree b. Agree, but need proposed detailed method (now added in table)

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6 Details of calculations at each reporting interval	Defined approach for performing calculations. Fit sine wave to the strain and stress data and use those results for reporting stiffness and energy and other parameters. Use procedure in AASHTO TP 62-07 Section 12.	Defined equations given. Fitting of sine wave to strain and stress data not prescribed.	Defined equations given. Fitting of sine wave to strain and stress data not prescribed.	Defined equations given. Stiffness and phase angle include system as well as material damping. Stress calculated form stiffness. Fitting of sine wave to strain and stress data not prescribed.	**Agree**	This is an issue – need to consider if drift is an issue. Really we should discuss with manufactures how they are doing. Several acceptable methods exist. Look at AASHTO TP 62-07 (calculation of E* and ph. angle).	Agree. We can still use other calcs but need to have one agreed upon method.	Agree. Look at mix modulus approach and calculation of RMS for load and deformation. Check with manufacturers how they are doing it, and need standardization.
7 Strain level selection for testing	I. Provide non-mandatory alternatives for standard testing and reporting use the defined approach. Provide some guidance for different mix types at different strain ranges. 1. Approach shown in figure at end of table (select strain for minimum about 10,000 and max of about 1.5 M) a. use strain v Nf for design b. interpolate to specify strain that gives Nf of 1M or some other chosen Nf. c. interpolate to specify strain that gives other Nf 2. a. Freely select strains for intended purpose to define relationship of strain v Nf. b. Freely select strain to check whether materials reaches Nf or not. 3. Specify min repetitions repetitions to Nf for a selected strain level II. Provide recommendations for replicates after precision and bias completed.	Examples given for types of materials, no procedure for definition of strain/fatigue curve given.	Does not prescribe details of selection. Minimum of 10,000, suggested maximum of 1 million, the latter a little lower than the recommendation in this white paper.	Repetitions to Nf should be between 10,000 and 2 million, a the latter a little higher recommendation of this white paper	**Agree** to the 10,000 minimum. **Disagree** about a maximum if the operator wants to tie their machine up. I don't see an issue with runs longer than 1.5 or 2 million.	My view is that we should be trying to select a stra level to give certain life rather than determining life for a strain level. This controls the test time better.	50/50. I like defining 10,000 to 1.5 [illegible] research. Allow alternate for production. (I maybe misunderstanding) Specs in NJ, KY, KS, NY, state one strain for production.	Agree, but think need 3, and keep 1 [illegible] must include strain at 1 million cycles.

Comment [WC1]: Previous experience has shown that different materials run longer than others at the same με and that does not make the material perform worse or that the test has skewed results at elevated cycles. If you put a cap on the testing you will hinder products that perform well in the field. Question back would be what evidentiary results show that testing exceeding 1-2 million makes any significant difference?

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8. Add discussion about test termination and fatigue life where Nf is desired outcome. Run test to E*n with at least reduction of 15 % beyond failure defined as E*n peak. Currently in AASHTO and ASTM.	Include a discussion about test termination criteria and fatigue life? . Includes definition of when to stop the test for Nf and incremental-recursive uses, and fitting of sine wave to results at increments, and calculation of values from fitted sine wave rather than raw measurements (JH: pros and cons not completely sorted out).	Stiffness reduces to 40% initial value. Failure is defined as maximum E*n	E*n reduces 15% from peak value. Failure is defined as maximum E*n	Not specified. Uses 50% stiffness reduction as reference.	**Agree,** need discussion Not impressed with extrapolation models on beam fatigue. Extrapolations have issues with polymer modified asphalt mixtures.	Easy to track E*.n. Needs to be built in. Include ability to report no failure at a given strain level	Agree Even Cycles x Modulus has interpretation for the cutoff. Maybe define the cutoff once the curves drops 15 % over peak. Also what about some beams that do not show clear failure? This is a problem with some formulations with RAP /RAS and softer binder. They just seem to "flow". (see below in termination item)	Agree, need detailed definition
9. Add note about NMAS min and max and variability	Include a discussion related to maximum nmas of the mixes ?				50/50	Agree but need note about more outliers and variability as NMAS increases. Poorly investigated.	Maybe a note that explains that fatigue life and repeatability decrease generally with larger NMAS	Agree suggest that add a note
10. Specify minimum results that must be reported.	Repetitions, load, deformation, strain, stress, phase angle (need calculation from TP 62) and error on strain sine wave and load.				Agree	Agree	Agree	Agree

Note for Item 5.

repetitions	Intervals (space equally within each range)	Cycles at each collection points included in average reported
0 to 100	1-10, then every 10 to 100	5 (except for 1-10, report individual cycle)
100 to 1000	10	5
1000 to 10,000	40 equally spaced data points	5
10,000 to 100,000	At least one every 1,000 repetitions	5
100,000 to end of test	At least one every 10,000 repetitions	5

Note for Item 7