20th Quarterly Progress Report to the FEDERAL HIGHWAY ADMINISTRATION (FHWA)

On the Project
THE IMPACT OF WIDE-BASE TIRES ON PAVEMENT DAMAGE
DTFH61-11-C-00025

For the Period
January 1st to March 31st, 2016

Submitted by
Illinois Center for Transportation
University of Illinois at Urbana-Champaign

FEDERAL HIGHWAY ADMINISTRATION
QUARTERLY PROGRESS REPORT

FHWA Project DTFH61-11-C-00025 FY: 2016 Quarter: 20 January-March
Research Agent Illinois Center for Transportation
Principal Investigator Imad L. Al-Qadi

PHASE	RESEARCH TASK	2011									2012												2013												2014												2015												2016				ESTIMATED % COMPLETION
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	
1	1.1. Comprehensive literature review and synthesis on past and current research	20	60	90	100																																																									100
	1.2. Experimental plan and modeling framework			50	60	80	100																																																								100
	1.3. Implementation and marketing plan		10	50	70	80	100																																																								100
	1.4. Phase I report			60	70	80	100																																																								100
	1.5. Conference call with panel	0	50			100																																																									100
	1.6. Presentations to relevant conferences and symposiums																																																														100
2	2.1. Prepare experimental equipment, test structures, and instrumentation					0	0	0	0	0	10	30	40	45	50	60	70	85	90	95	100																																										100
	2.2. Conduct experiments, including material characterization and accelerated loading						0	0	0	0	5	10	20	25	30	40	50	60	70	40	40	40	45	50	55	55	57	60	62	65	68	70	72	73	75	77	80	82	84	85	87	88	90	92	95	95	97	98	100														100
	2.3. Conduct modeling					0	0	0	0	0	1	2	5	6	8	10	20	25	30	30	35	35	40	45	50	50	53	55	56	57	59	60	61	62	65	68	70	85	90	95	96	97	97	97	97	97	98	99	100														100
	2.4. Development of analysis tool													0	0	0	0	5	5	10	15	15	20	25	35	40	42	45	46	48	49	51	52	52	55	58	60	62	65	70	75	77	80	85	90	90	92	93	95	97	98	100											100
	2.5. Delivery of draft Phase II report and analysis tool																												0	0	0	0	0	0	0	0	0	0	0	0	10	20	30	40	50	50	60	70	85	87	90	95	95	95	95	96	97	98	99	100	100		100
	2.6. Present to relevant conferences and symposiums																																																														100
	2.7. Prepare article, technical papers, user manuals, training, TAC meeting, and TRB webminar																																																														95
	Estimated Progress (%)	1	3	7	8	10	11	11	11	11	13	16	20	21	23	27	33	39	43	41	40	38	42	45	49	50	52	54	54	56	57	58	59	60	62	64	65	71	73	76	79	81	83	86	88	88	91	93	96	97	98	99	99	99	99	99	99	99	99	99	99		100
	Planned Progress (%)	1	3	7	10	13	17	21	25	29	33	36	40	44	47	51	55	59	61	63	64	66	68	70	71	73	75	77	81	85	89	93	97	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

QUARTERLY PROGRESS REPORT

QUARTER 20

The Impact of Wide-Base Tires on Pavement Damage – A National Study

1. Work Performed

The following tasks were accomplished during this quarter:

- The final report has been finalized and submitted
- Domain analysis approach was enhanced to capture the influence of differential tire inflation pressure (see appendix A)
- ICT-Wide Tool was fine-tuned to improve appearance and performance. See Appendix B for the final appearance of the tool

2. Work to Be Accomplished in the Next Quarter

- Address final comments/reviews from the panel regarding the final report

3. Problems Encountered

- No issues were found in this quarter

4. Current and Cumulative Expenditures

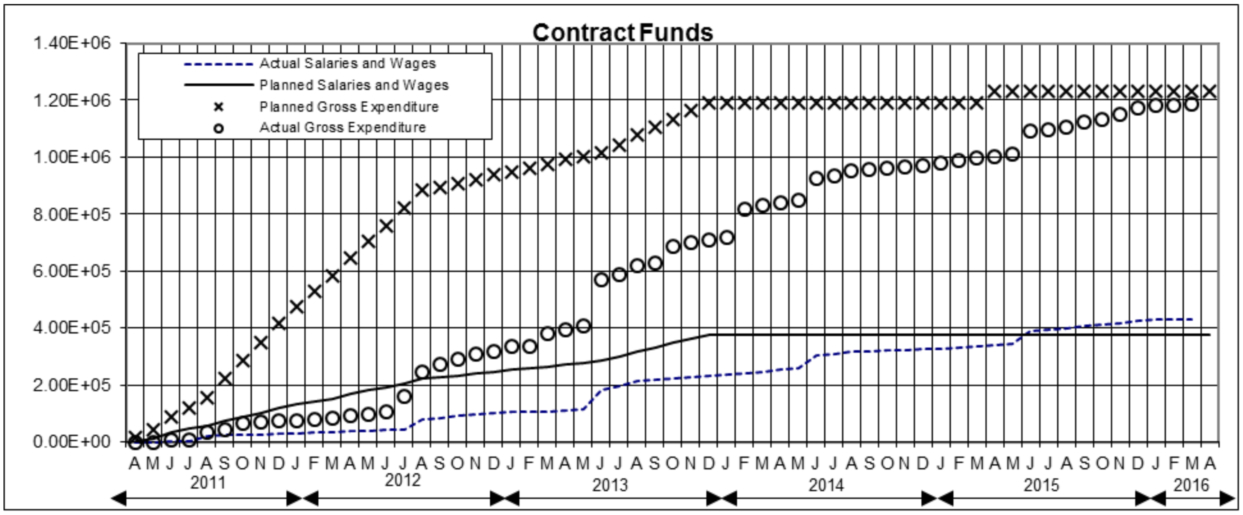

Figure 1. Project's expenditure (based on current plan including amendments).

5. Planned, Actual, and Cumulative Percentage of Effort

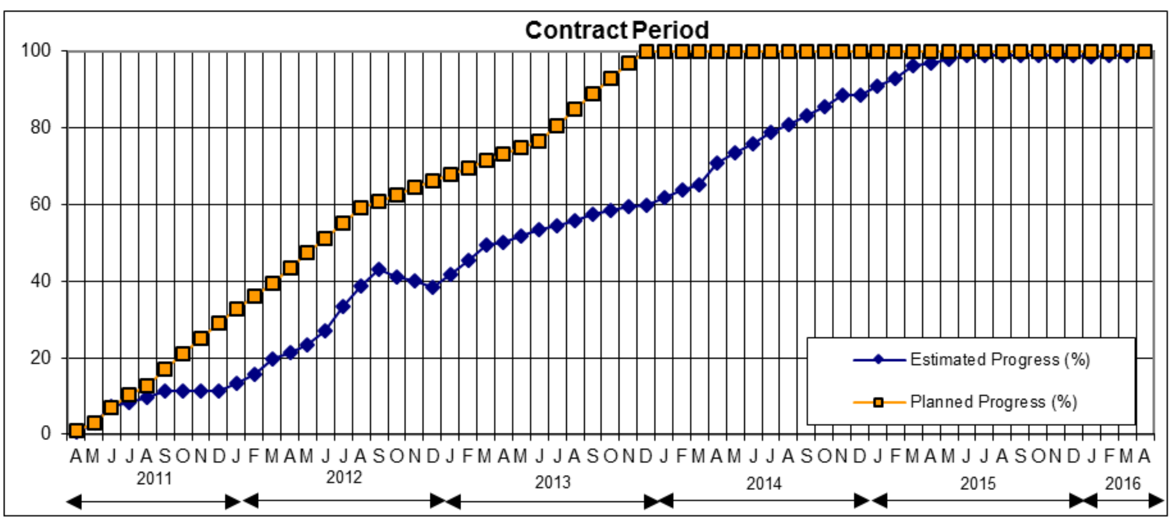

Figure 2. Project's progress (based on current plan including amendments).

Appendix A Domain Analysis Enhancement

When NG-WBT is compared to the uniformly inflated DTA and steer tire, a clear distinction of the cumulative stress/strain ratio is observed. However, for the case of the differentially inflated DTA, the comparison of the zone close to the surface underneath the tires (zone 2) did not reveal significant difference. There are two main factors for this finding:

- The domain method averages the high values under the tire carrying more load (or with higher inflation pressure) with the low values under the tire carrying less load (or with low inflation pressure).
- The influence of the contact stresses surpasses the designated zone 2 (note that this is kept constant for all cases considered) and it may be noticed that the distribution extends to zone 5. In contrast to other three cases (WBT, uniformly inflated DTA, and steer), zone 5 values tend to zero.

Consequently, and in order to identify the impact of the two tires, zone 2 was divided into two. Defining the nine zones from the figure below provides critical regions where typical pavement distresses nucleate or highly impact. For example, zone 2 not only relates to near-surface distresses, but it is also highly governed by the distribution of the contact stresses.

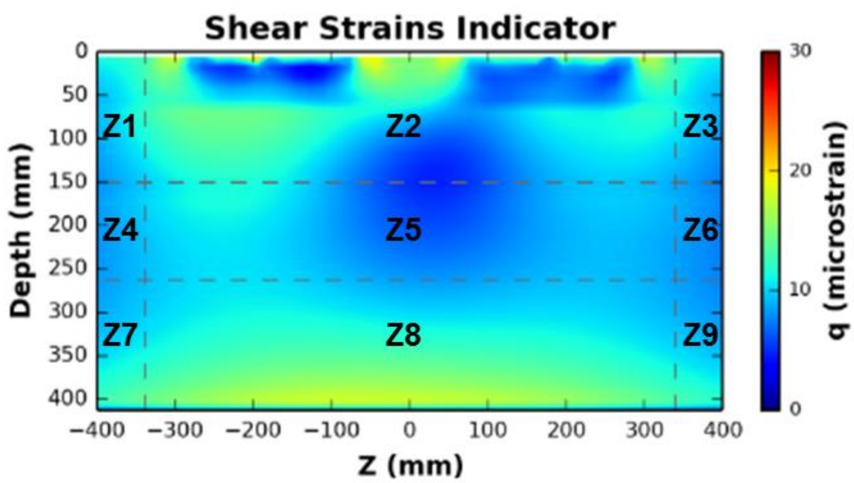

Figure 3. Nine zones are defined for each pavement layer to localize areas with high stress magnitudes.

The nine zones were then modified by introducing another partition within zones 2 and 5. Two cases were considered: i) vertically cut zones 2 and 5 along the middle of the tire width to isolate each of the DTA tires; and ii) maintain the aforementioned vertical cut and add another partition horizontally along the depth of 3 in. The second case is introduced to focus the resolution of the ratios within the top and bottom sections of zone 2.

For the first case, the cumulative ratios considered the combination of zones 2 and 5 for each tire, wherein one tire has a higher tire inflation pressure than the other. The resulting cumulative strain ratios for each zone combination were 1.172 and 0.997. In particular, the higher cumulative ratio of 1.172 belonged to the tire with a higher tire inflation pressure, which indicated that this individual tire could induce a damage potential of 17.2% greater than its counterpart from the L12B case.

The new zones were further discretized, as noted in the second case, by adding a horizontal cut along 3 in. The intent was to further isolate the near-surface behavior within the top section of zone 2 from the bottom; therefore, the resulting ratios included three new zones: top and bottom sections within zone 2, and zone 5.

The resulting cumulative ratios revealed a slight difference of up to 1% for both tires. This was anticipated as within each of the nine zones, the proposed method effectively magnifies the areas with higher shear and normal values using the polar sector weights (recall that the closer the stress/strain state to the failure plane, the more it is penalized).

It worth noting that further discretization of the nine zones do not change the cumulative ratios significantly. In addition, combining zones 2 and 5 (along with isolating each of the tires) not only provided an effective way to isolate the impact of the differential tire inflation pressures, but also captured the impact of the higher inflation pressure at a greater depth. Therefore, with the proposed domain analysis method:

- The three-dimensional pavement stress and strain states were effectively quantified using a scalar parameter
- Load cases could be conveniently compared using the scalar parameter in both stress and strain domains
- The nine zone could be effectively related to regions of critical pavement distresses
- Modifications of the zones captured the influence of differential tire inflation pressures.

Finally, it is worth to note that the “Domain Analysis Enhancement” is presented as an additional method to evaluate pavement responses. In lieu of using the critical point response, the method utilizes stress and strain states in three dimensions that coincides with the realistic contact stress input. In addition, the aim of this new method is to quantify the damage potential of a load case relative to the reference DTA case using the results from finite element modeling. With respect to the ICT-Wide tool, the new analysis method has not been implemented and does not impact any of the damage analysis presented in the report.

Appendix B: Final Appearance of ICT-Wide Tool

Final appearance changes were made on the ICT-Wide tool. Figures 1 and 2 show the snapshots of the first draft of final version (0.92) of the tool

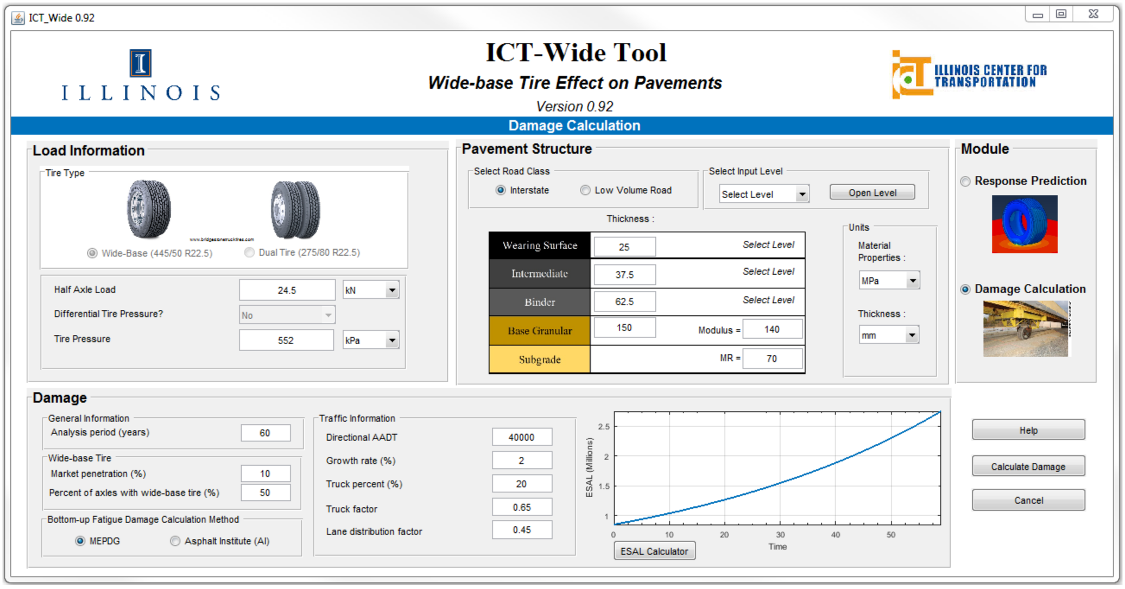

Figure 4 - ICT-Wide tool main menu with damage calculation module selected

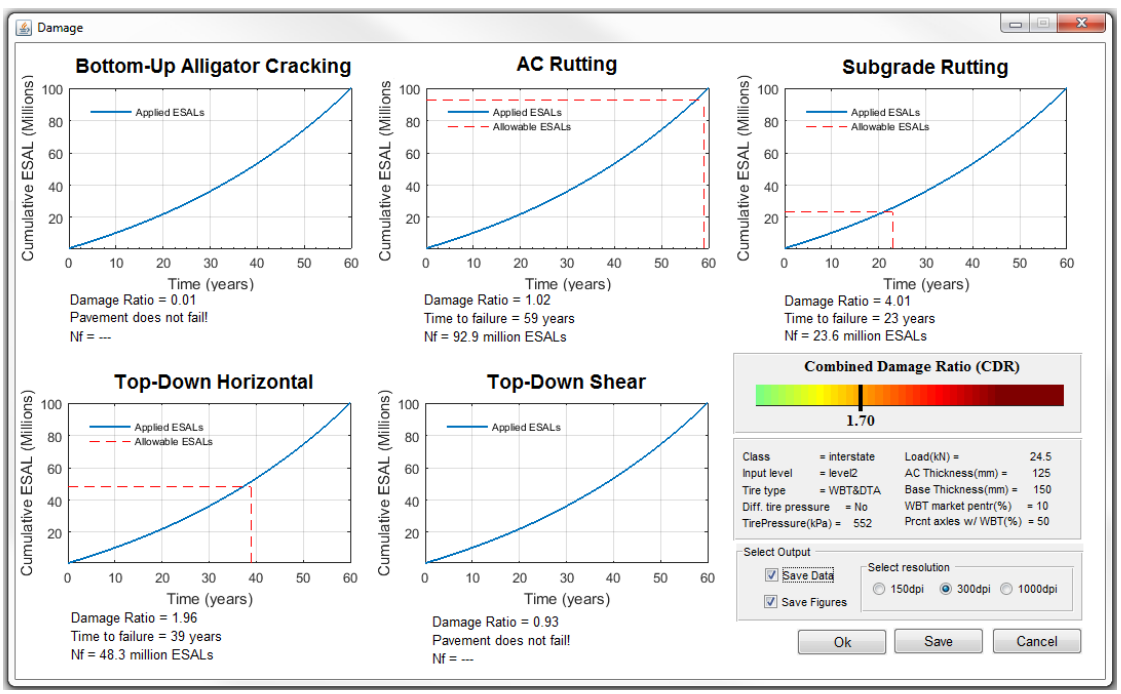

Figure 5 - Pavement damage results window from ICT-Wide tool