NCAT Work Plan

Mechanistic Design Data from ODOT Instrumented Pavement Sites

Sponsoring Organization:
Oregon Department of Transportation Research Unit
555 13th St NE
Salem, OR 97301-6867

Submitted by:
Dr. David H. Timm, P.E.
Brasfield and Gorrie Professor of Civil Engineering
Principal Investigator

APPROVAL:

Dr. John M. Mason
Vice President for Research & Economic Development

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1. BACKGROUND

The Oregon DOT (ODOT) instrumented three pavement sites between 2004 and 2008 to support efforts toward implementing mechanistic-empirical (M-E) pavement design. Though data were collected as part of an earlier research project, data reduction and analysis was not conducted and the response measurements are still considered to be in raw format. There is a need to evaluate the usefulness of the data and assess whether it can be useful for M-E design. There is also a need to develop user-friendly tools for ODOT to continue collecting and analyzing data to support M-E design.

2. OBJECTIVES

The primary objective of this research is to process existing data sets and evaluate their usefulness toward implementation of M-E design. A secondary objective is to develop user-friendly processing schemes to facilitate future data processing and analysis.

3. WORK PLAN

The project will be completed in two phases, comprised of four tasks as enumerated below. Since the status of the raw data is unknown, the first phase will focus on preliminary assessment of the data. If the data sets are judged to be useful at the completion of Phase I, all the data will be processed and evaluated in Phase II. Otherwise, the project will be terminated. Figure 1 illustrates summarizes the proposed workplan.

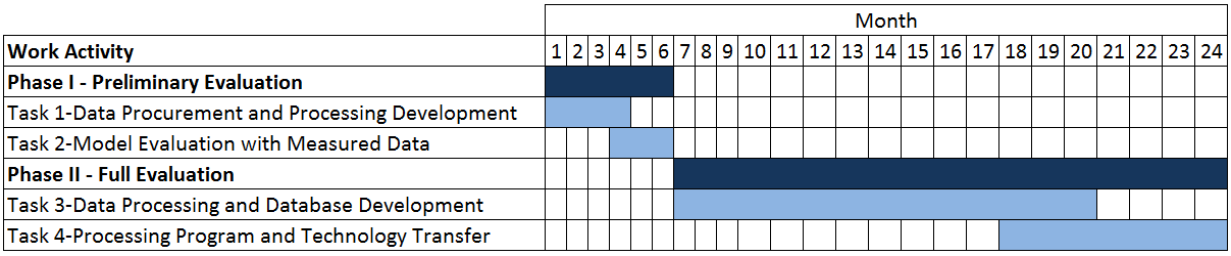


Figure 1. Proposed Workplan.

3.1 Phase I – Preliminary Evaluation

3.1.1 Task 1 – Data Procurement and Processing Development

This task will first focus on acquiring data from ODOT and developing a fundamental understanding of how the data are organized and formatted. Collaborative discussions will be held with ODOT regarding the important components of the raw data to extract and store. This will be conducted through a site visit to ODOT at a mutually-agreeable time. After the site visit, a customized scheme will be developed to process the data. Figure 2 illustrates one such processing scheme, in the form of a template, that NCAT developed for an instrumented pavement site on I-40 in New Mexico. The template requires minimal user interaction after the data have been uploaded and automatically detects peaks and creates a data table that stores key information. Figure 3 shows a

magnified raw strain signal, with peak strains automatically detected by the processing algorithms. Figure 4 shows the data table automatically generated for each axle hit over the gauge array. It is important to note that these figures represent one example of a processing scheme tailored specifically for the site conditions and research objectives of the I-40 project in New Mexico. A new processing scheme will be developed for the ODOT sites, through collaboration with ODOT, that will focus on extracting useful information from the raw data and compiling it into data tables in the most efficient manner possible.

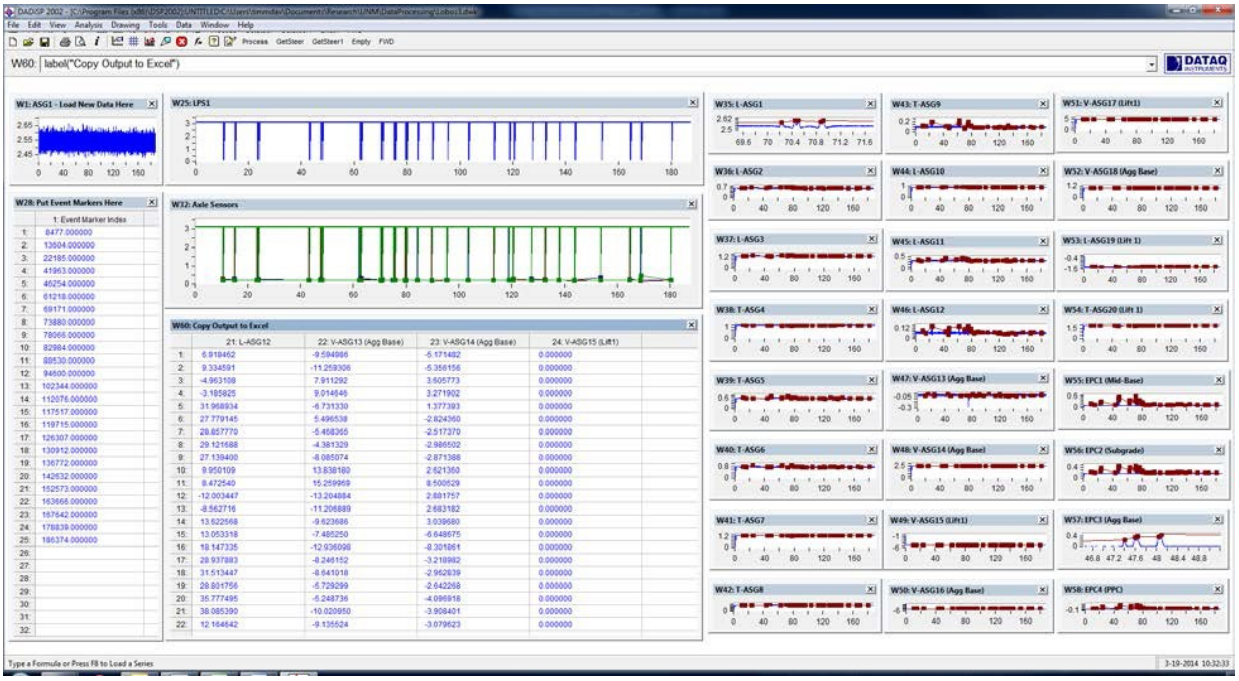


Figure 2. I-40 Processing Template.

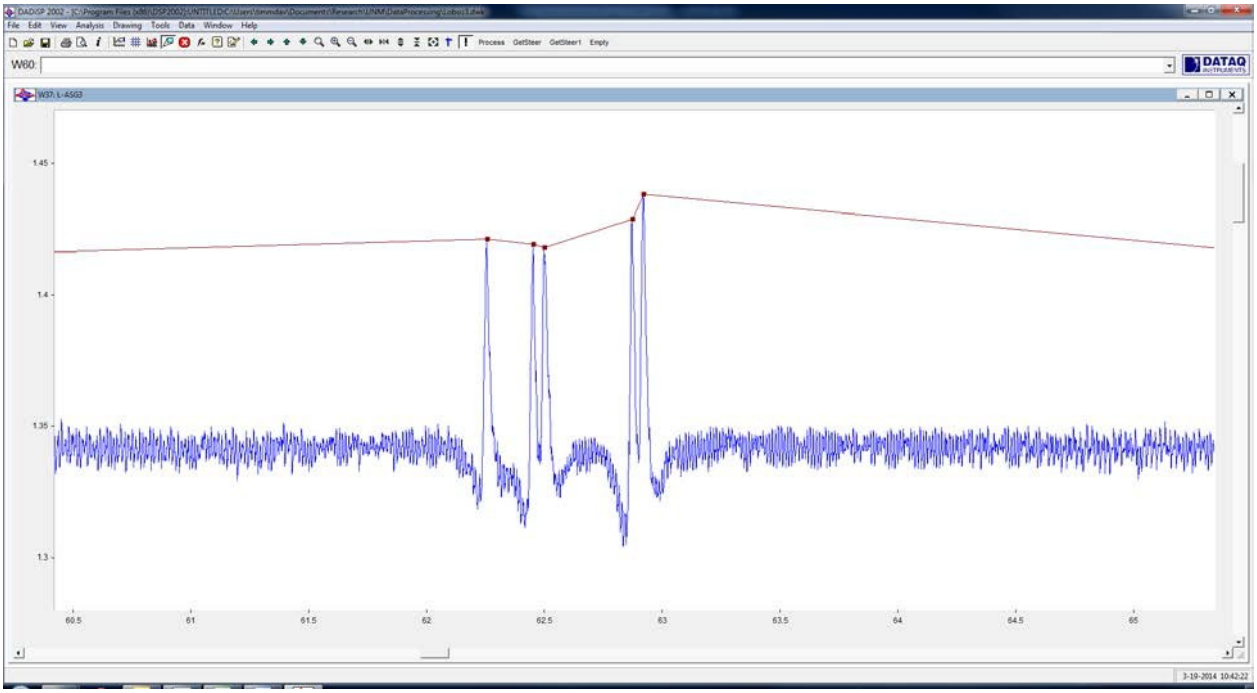
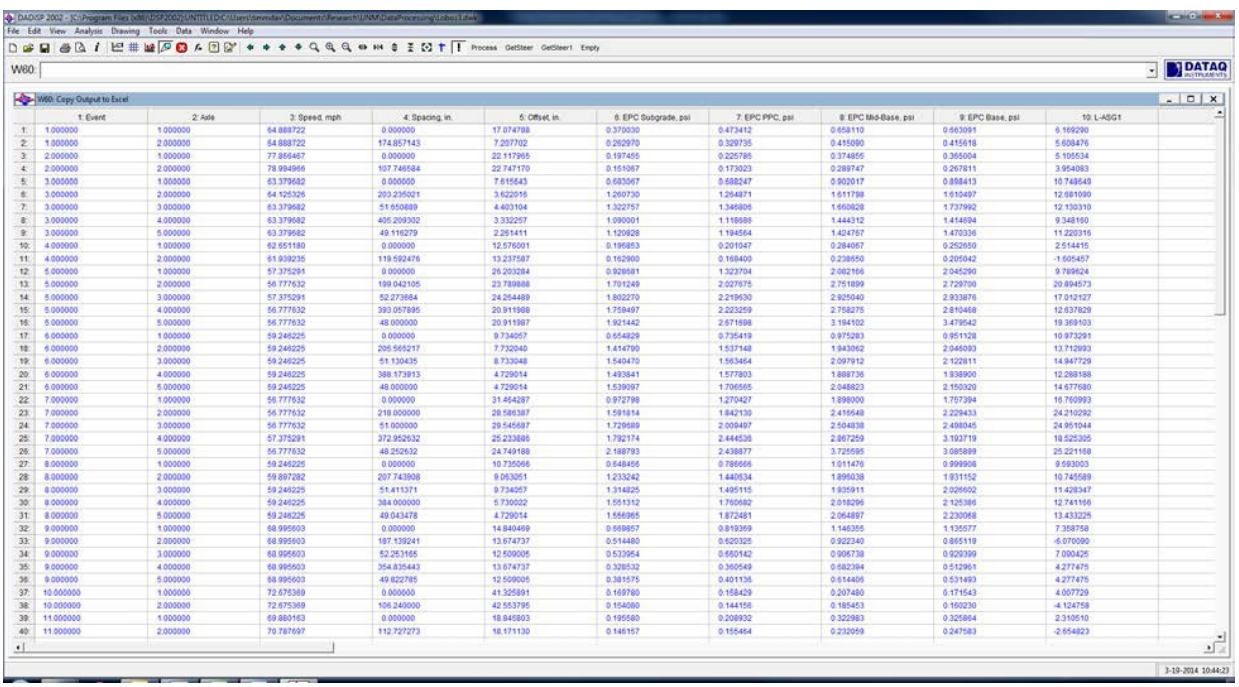


Figure 3. I-40 Peak Strains Detected.



	1: Event	2: Axle	3: Speed, mph	4: Spacing, in.	5: Offset, in.	6: EPC Subgrade, psi	7: EPC PPC, psi	8: EPC Mid-Base, psi	9: EPC Base, psi	10: L-ASG1
1:	1.000000	1.000000	64.888722	0.000000	17.074788	0.370030	0.473412	0.658110	0.563091	6.169290
2:	1.000000	2.000000	64.888722	174.857143	7.207702	0.262970	0.329735	0.415090	0.415618	5.608476
3:	2.000000	1.000000	77.866467	0.000000	22.117965	0.197455	0.225785	0.374855	0.365004	5.105534
4:	2.000000	2.000000	78.994966	107.746584	22.747170	0.151067	0.173023	0.289747	0.267811	3.954083
5:	3.000000	1.000000	63.379682	0.000000	7.615543	0.683067	0.688247	0.902017	0.898413	10.749649
6:	3.000000	2.000000	64.125326	203.235021	3.622016	1.260730	1.264871	1.611798	1.610497	12.681090
7:	3.000000	3.000000	63.379682	51.650889	4.403104	1.322757	1.346806	1.660829	1.737992	12.130310
8:	3.000000	4.000000	63.379682	405.209302	3.332257	1.090001	1.118685	1.444312	1.414694	9.348160
9:	3.000000	5.000000	63.379682	49.116279	2.251411	1.120828	1.194564	1.424767	1.470336	11.220316
10:	4.000000	1.000000	62.651180	0.000000	12.576001	0.196853	0.201047	0.284067	0.252650	2.514415
11:	4.000000	2.000000	61.939235	119.592476	13.237587	0.162900	0.168400	0.238650	0.205042	-1.605457
12:	5.000000	1.000000	57.375291	0.000000	26.203284	0.928681	1.323704	2.082166	2.045290	9.789624
13:	5.000000	2.000000	56.777632	199.042105	23.789888	1.701249	2.027675	2.751899	2.729700	20.894573
14:	5.000000	3.000000	57.375291	52.273684	24.264489	1.802270	2.219530	2.925040	2.933876	17.012127
15:	5.000000	4.000000	56.777632	393.057895	20.911988	1.759497	2.223259	2.758275	2.810468	12.637829
16:	5.000000	5.000000	56.777632	48.000000	20.911987	1.921442	2.571598	3.194102	3.479542	19.369103
17:	6.000000	1.000000	59.246225	0.000000	9.734057	0.554829	0.735419	0.975283	0.951128	10.973291
18:	6.000000	2.000000	59.246225	205.565217	7.732040	1.414790	1.537148	1.943062	2.045093	13.712893
19:	6.000000	3.000000	59.246225	51.130435	8.733048	1.540470	1.563464	2.097912	2.122811	14.947729
20:	6.000000	4.000000	59.246225	388.173913	4.729014	1.493841	1.577803	1.888735	1.938900	12.268188
21:	6.000000	5.000000	59.246225	48.000000	4.729014	1.539097	1.706565	2.048823	2.150320	14.677680
22:	7.000000	1.000000	56.777632	0.000000	31.464287	0.972798	1.270427	1.898000	1.757394	16.760993
23:	7.000000	2.000000	56.777632	218.000000	28.586387	1.591814	1.842130	2.416548	2.229433	24.210292
24:	7.000000	3.000000	56.777632	51.000000	29.545687	1.729589	2.009497	2.504838	2.498045	24.951044
25:	7.000000	4.000000	57.375291	372.952632	25.233886	1.792174	2.444536	2.867259	3.193719	19.525305
26:	7.000000	5.000000	56.777632	48.252632	24.749188	2.188793	2.438877	3.725595	3.085899	25.221158
27:	8.000000	1.000000	59.246225	0.000000	10.735066	0.648456	0.786666	1.011476	0.999908	9.593003
28:	8.000000	2.000000	59.897282	207.743908	9.053051	1.233242	1.440634	1.895038	1.931152	10.745589
29:	8.000000	3.000000	59.246225	51.411371	9.734057	1.314825	1.495115	1.935911	2.026602	11.428347
30:	8.000000	4.000000	59.246225	384.000000	5.730022	1.551312	1.765682	2.018296	2.125386	12.741166
31:	8.000000	5.000000	59.246225	49.043478	4.729014	1.556965	1.872481	2.064897	2.230068	13.433225
32:	9.000000	1.000000	58.995603	0.000000	14.840469	0.569857	0.819369	1.146355	1.135577	7.358758
33:	9.000000	2.000000	58.995603	187.139241	13.674737	0.514480	0.620325	0.922340	0.865119	-6.070090
34:	9.000000	3.000000	58.995603	52.253165	12.509005	0.533954	0.660142	0.906738	0.929399	7.090425
35:	9.000000	4.000000	58.995603	354.835443	13.674737	0.328532	0.360549	0.582394	0.512961	4.277475
36:	9.000000	5.000000	58.995603	49.822785	12.509005	0.381575	0.401136	0.614406	0.531493	4.277475
37:	10.000000	1.000000	72.675369	0.000000	41.325891	0.169780	0.158429	0.207480	0.171543	4.007729
38:	10.000000	2.000000	72.675369	106.249000	42.553795	0.154080	0.144156	0.185453	0.160230	-4.124758
39:	11.000000	1.000000	69.880163	0.000000	18.846803	0.195580	0.208932	0.322983	0.325864	2.310510
40:	11.000000	2.000000	70.787697	112.727273	18.171130	0.146157	0.155464	0.232059	0.247583	-2.654823

Figure 4. I-40 Data Table.

3.1.2 Task 2 – Model Evaluation with Measured Data

Task 2 will focus on evaluating the quality of the measured data with respect to pavement responses predicted through mechanistic modeling. At least one load application will be simulated in a computer-based modeling program and the results will be compared

against the measured pavement response. It is anticipated that the simulation will utilize layered elastic analysis which is the current standard-of-practice for flexible M-E design. A key component to this activity will be the determination of the in-place material properties (i.e., modulus and Poisson ratio) and thicknesses as primary inputs to the mechanistic model. It is assumed that ODOT will make these data available from existing data sets.

A Phase I report will be developed that details the work in Tasks 1 and 2. It is proposed that the contents of the report be presented through another site visit to ODOT, at a mutually agreeable time. The site visit will result in an official decision from ODOT whether to proceed to Phase II or terminate the project and allow for further discussion and possible revisions to the proposed work in Tasks 3 and 4, as needed. Furthermore, a separate half-day meeting will be conducted during the site visit to discuss ODOT's implementation of mechanistic-empirical design strategies.

3.2 Phase II – Full Evaluation

3.2.1 Task 3 – Data Processing and Database Development

With approval to proceed, the primary goal of Task 3 is to build a comprehensive database from all previously-collected data. The data processing scheme developed in Task 1, with possible further refinements, will be the primary tool from which a Microsoft Access© database will be created. The database will provide flexibility in generating a variety of summary and detailed reports from the measured pavement responses. The database will also be used as a basis of comparison with predicted pavement responses through mechanistic modeling. Figure 5 shows one such example from the NCAT Test Track (Barrett and Timm, 2005).

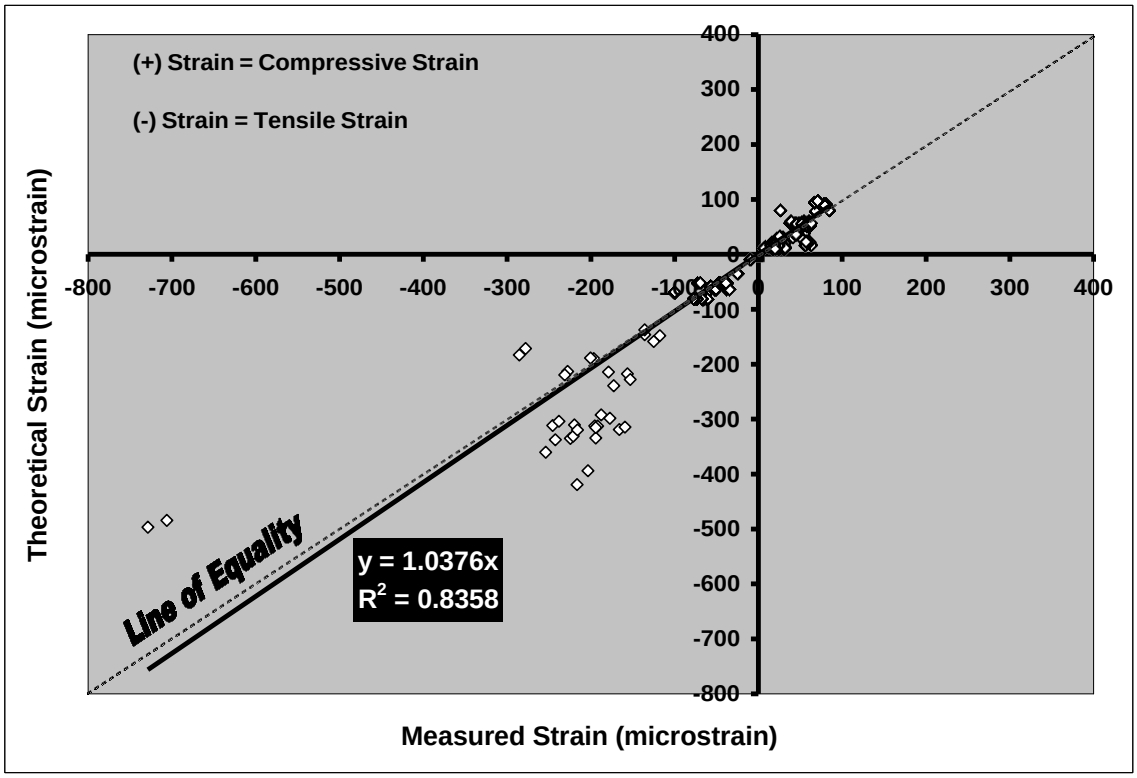


Figure 5. Measured vs. Predicted Strain Responses (Barrett and Timm, 2005).

3.2.2 Task 4 – Processing Program and Technology Transfer

The final task focuses on technology transfer that will enable ODOT to collect, process, store and analyze data collected in the future. The processing scheme developed in Task 1 and refined in Task 3 will go through further improvements to maximize usability and efficiency. A user's guide will be developed to accompany the scheme in addition to describing how to populate and update the Access database.

A Phase II report, in addition to the processing scheme and manual described above, will be developed. The report will detail the results of Tasks 3 and 4. It is proposed that a final site visit be conducted to present the report and include a processing/analysis workshop. The workshop will also include discussion regarding integrating data collected from the ODOT sites in M-E design implementation strategies.

4. BUDGET

To accomplish the work, Dr. Timm will serve as principal investigator with graduate student support. The detailed budget provided in Table 1 includes personnel time in addition to travel support for an initial site visit, a visit at the conclusion of Phase I and a final visit at the conclusion of Phase II. It is anticipated the first two visits will be made only by Dr. Timm while the final visit, which includes a workshop, will be made by Dr. Timm and the graduate

research assistant. The official Auburn University direct, fringe, indirect and graduate student tuition rates have been applied to each budget item.

Table 1. Proposed Budget

	Hours		Direct Cost		Fringe		Personnel Indirect		Tuition	Travel		
Work Activity	**Timm**	**Grad Student**	**Timm**	**Grad Student**	**Timm**	**Grad Student**	**Timm**	**Grad Student**	**Grad Student**	**Direct**	**Indirect**	**Subtotal**
Phase I - Preliminary Evaluation												
1-Data Procurement and Processing Development	265	200	$17,535.05	$ 3,462.00	$ 5,435.87	$ 83.09	$11,026.04	$ 1,701.64	$ 346.20	$2,000.00	$ 960.00	$ 42,549.89
2-Model Evaluation with Measured Data	50	90	$ 3,308.50	$ 1,557.90	$ 1,025.64	$ 37.39	$ 2,080.39	$ 765.74	$ 155.79	$2,000.00	$ 960.00	$ 11,891.35
Phase I - Subtotal	315	290	$20,843.55	$ 5,019.90	$ 6,461.51	$ 120.48	$13,106.43	$ 2,467.38	$ 501.99	$4,000.00	$1,920.00	$ 54,441.24
Phase II - Full Evaluation												
3-Data Processing and Database Development	280	1250	$18,527.60	$ 21,637.50	$ 5,743.56	$ 519.30	$11,650.16	$ 10,635.26	$ 2,163.75	$ -	$ -	$ 70,877.13
4-Processing Program and Technology Transfer	190	310	$12,572.30	$ 5,366.10	$ 3,897.41	$ 128.79	$ 7,905.46	$ 2,637.55	$ 536.61	$4,000.00	$1,920.00	$ 38,964.22
Phase II - Subtotal	470	1560	$31,099.90	$ 27,003.60	$ 9,640.97	$ 648.09	$19,555.62	$ 13,272.81	$ 2,700.36	$4,000.00	$1,920.00	$109,841.35
Phase I & II												
Total	785	1850	$51,943.45	$ 32,023.50	$16,102.48	$ 768.57	$32,662.05	$ 15,740.19	$ 3,202.35	$8,000.00	$3,840.00	$164,282.59

5. BIOGRAPHICAL INFORMATION

Dr. Timm holds the Brasfield & Gorrie Chair of Civil Engineering at Auburn University where he has been a faculty member since 2001. He has been engaged in asphalt pavement research for the past twenty years and has authored and co-authored 120 technical documents that include journal articles, conference papers, invited trade magazine articles and technical reports. His primary areas of research emphasis are mechanistic-empirical (M-E) analysis and design achieved primarily through full-scale accelerated pavement testing. Much of his research is executed in cooperation with the National Center for Asphalt Technology (NCAT). Since joining the Auburn University faculty, Dr. Timm has successfully completed 33 funded research projects exceeding $28 million in the capacity of Principal Investigator (PI) or Co-Principal Investigator (Co-PI). His research sponsors have included numerous state departments of transportation, the Federal Highway Administration (FHWA), the National Asphalt Pavement Association (NAPA) and private corporations. His research projects have featured numerous instrumentation installations at the NCAT Test Track, in China, Oklahoma and New Mexico. A central theme to his research program is developing useful tools for use by practitioners. To that end, he has also been engaged in the asphalt industry as a private consultant to both the NAPA and Asphalt Pavement Alliance (APA). Key aspects of the consultancy have been the development of pavement design and analysis computer programs dealing with perpetual pavements, life cycle cost analysis and pavement cooling simulation software. Dr. Timm also strives to disseminate research results beyond technical publications through the development and delivery of short courses, webinars and active participation in research conferences, state asphalt pavement association meetings and national level meetings. He is also active in the profession through membership on Transportation Research Board (TRB) committees, both past (AFD60) and present (AFD40), serves on the APA Field Resource Team and is a member of the Association of Asphalt Paving Technologists (AAPT). Dr. Timm is a registered professional engineer in Alabama.

6. REFERENCES

Barrett, W.E. and D.H. Timm, “Theoretical vs Measured Pavement Responses Under Dynamic Loading,” 7th International Conference on the Bearing Capacity of Roads, Railways and Airfields, Trondheim, Norway, 2005.