STATE OF FLORIDA

Survey of Current Practices of Using Falling Weight Deflectometers (FWD)

Research Report
FL/DOT/SMO/01-452

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STATE MATERIALS OFFICE

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EXECUTIVE SUMMARY

In May of 2001, the Florida Department of Transportation (FDOT) distributed a survey questionnaire to the 51 State Departments of Transportation (DOTs), and to 3 Canadian provinces including British Columbia, Ontario, and Quebec. The objective was to assess the current practices of using the Falling Weight Deflectometer (FWD) by these highway agencies, and to gather some related facts and figures of interest to FWD users. This report provides a summary of the survey results based on the responses received from the user agencies.

BACKGROUND

Because of the speed and ease of operation, deflection-based techniques are being widely used in the evaluation of the structural integrity and the estimation of the elastic moduli of in-place pavement systems. Deflections can be non-destructively induced and measured using different commercially available devices. The more commonly used devices are generally categorized into two types depending on how the load is applied to the pavement system. Vibratory devices, such as Dynaflect, apply a steady-state sinusoidal load, while those known as impact or falling weight devices apply an impulse load to the pavement. In recent years, the Falling Weight Deflectometer device, commonly known as the FWD, is gaining more acceptance among highway agencies because of its versatility, reliability, and ease of use. It is also believed that FWD loading better simulates the effects of traffic on pavement structures. It consists of a trailer mounted with a falling weight system capable of loading a pavement in a manner that simulates, in both magnitude and duration, actual wheel loads. An impulse load is generated by dropping a weight mass from a specified height. The mass is raised hydraulically, then released by an electrical signal and dropped with a buffer system on a 12-inch (300-mm) diameter rigid steel plate. A thin, hard rubber pad rests between the plate and the pavement surface to allow for an even load distribution. The resulting pavement deformations are picked up through a series of sensors located along the centerline of the trailer. The deflection measurements are recorded by the data acquisition system located in the tow vehicle. Figure 1 gives an illustration of such a device.

The present report summarizes the results of a survey of the current practices of FWD users.

Figure 1 Falling Weight Deflectometer, Dynatest 8000

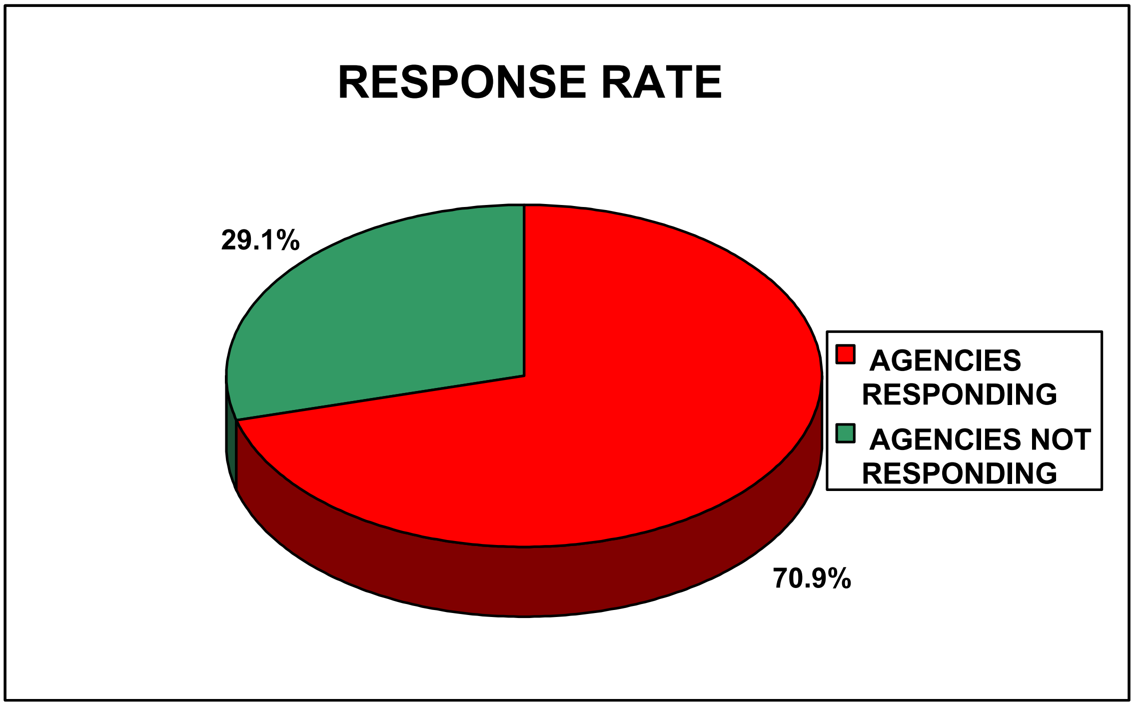
OBJECTIVE

The purpose of this study is to assess the current practices of using the FWD by governmental agencies, and to gather some related facts and figures of interest to FWD users.

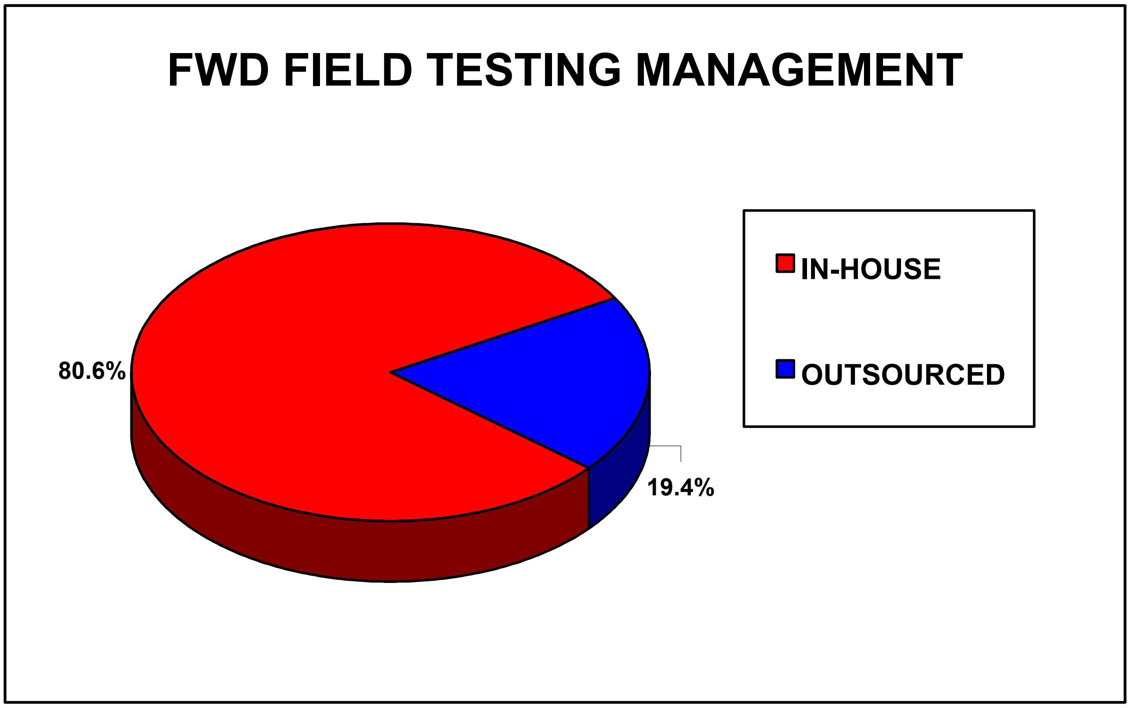
SURVEY DATA ANALYSIS

A total of 39 responses were received representing a 71% response rate. Of these 39 responses, 36 responses were received from State DOTs, two responses from British Columbia - representing the Northern region, BC (N), and the Southern region, BC (S)-, and one response from Ontario. The State of Connecticut has a proposed FWD program, which was not implemented at the time of this survey. Respondents from the States of Delaware and Hawaii indicated that they did not make use of the FWD. The results from this survey are based on the information provided by the responding user agencies, and are summarized in the following pages according to the three FWD program areas addressed in the survey, namely 1) FWD Program Management, 2) FWD Operation, and 3) Pavement Design Parameters.

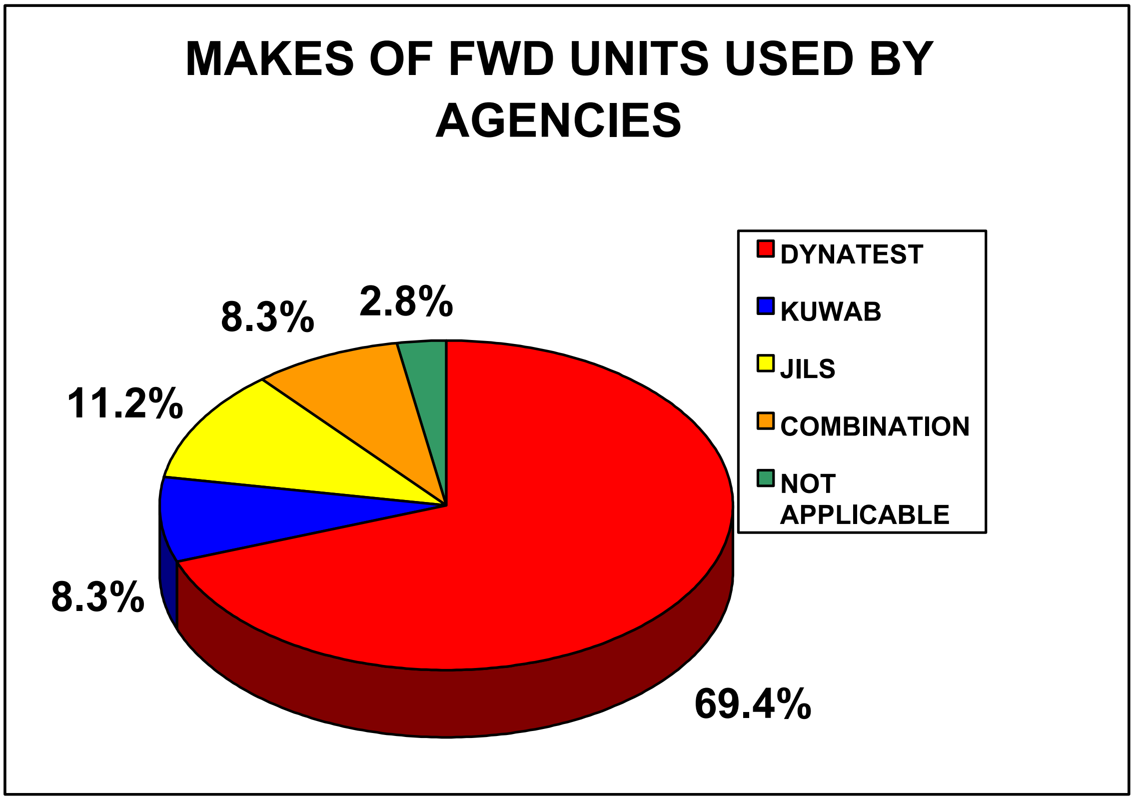
PART I: FWD Program Management



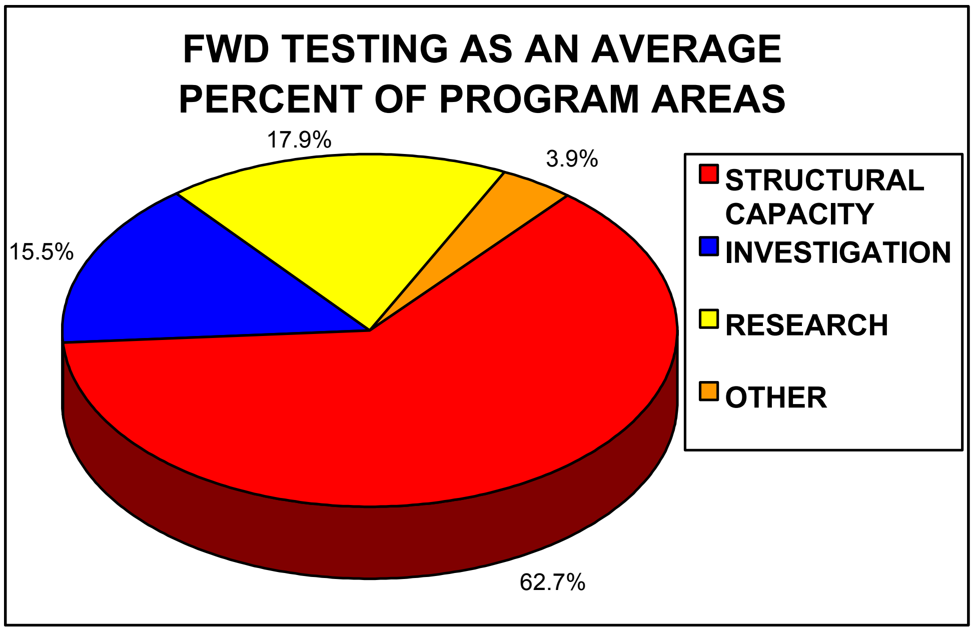
AGENCIES RESPONDING			AGENCIES NOT RESPONDING	
AZ	KY	ON	AL	NH
BC(N)	ME	PA	AK	NM
BC(S)	MN	PR	AR	OH
CT	MD	SC	CA	OK
DE	MI	SD	CO	OR
FL	MS	TN	LA	RI
GA	MO	TX	MA	WY
HI	MT	UT	NE	
ID	NV	VA		
IL	NJ	VT		
IN	NY	WA		
IA	NC	WV		
KS	ND	WI		
39			**16**	



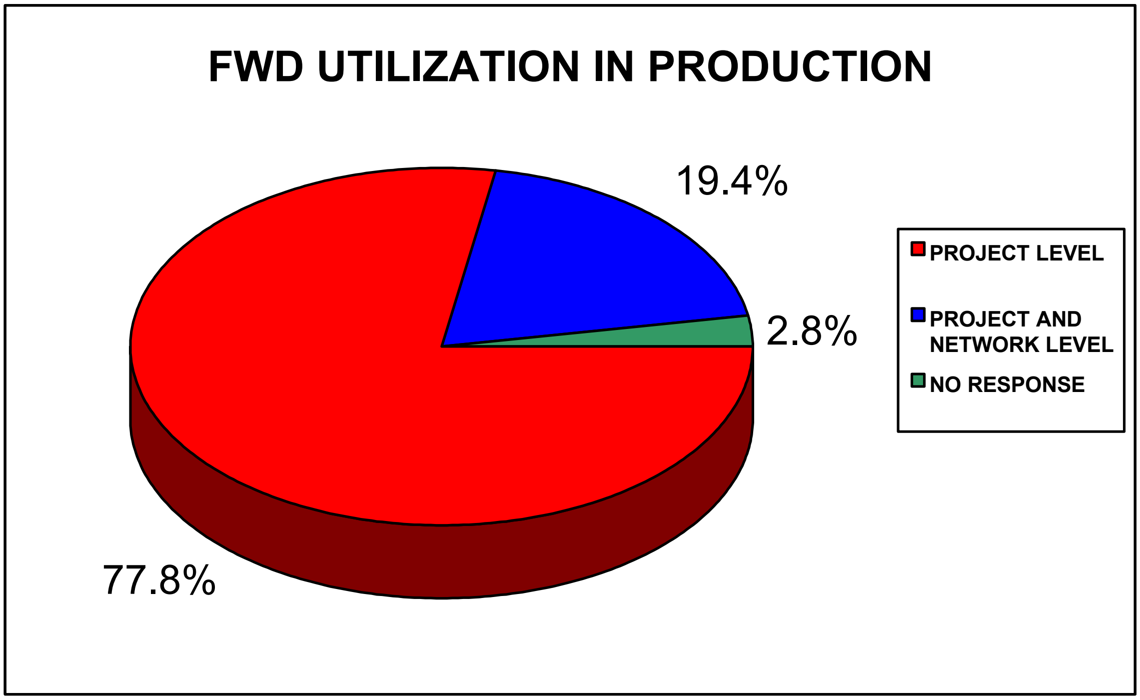
IN-HOUSE		OUTSOURCED (%)
AZ	MT	ID (5)
BC(N)	NV	MD (5)
BC(S)	NY	NJ (90)
FL	NC	ON (100)
GA	ND	TX (2)
IL	PA	UT (2)
IN	PR	WI (10)
IA	SC	
KS	SD	
KY	TN	
ME	VA	
MN	VT	
MI	WA	
MS	WV	
MO		
29		**7**



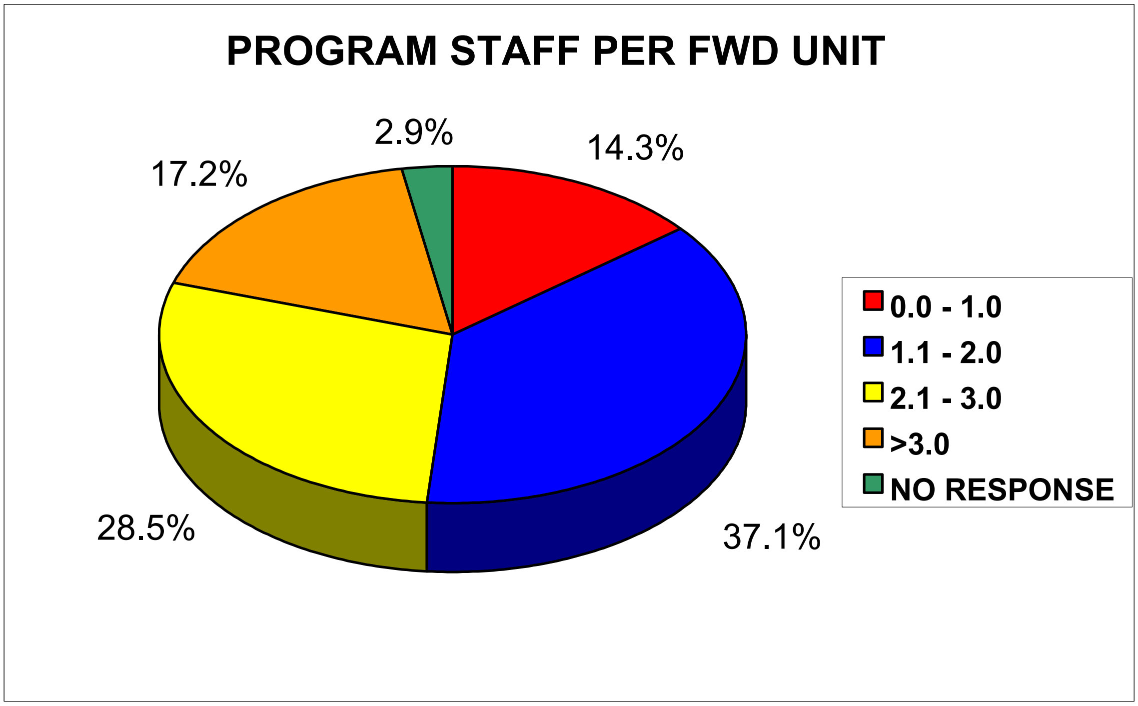
DYNATEST		KUWAB	JILS	COMBINATION	NOT APPLICABLE
BC(N)	NJ	MI	IA	AZ	ON
BC(S)	ND	PA	KY	NY	
FL	PR	WI	ME	NC	
GA	SC		MT		
ID	SD				
IL	TN				
IN	TX				
KS	UT				
MD	VA				
MN	VT				
MS	WA				
MO	WV				
NV					
25		3	4	3	1



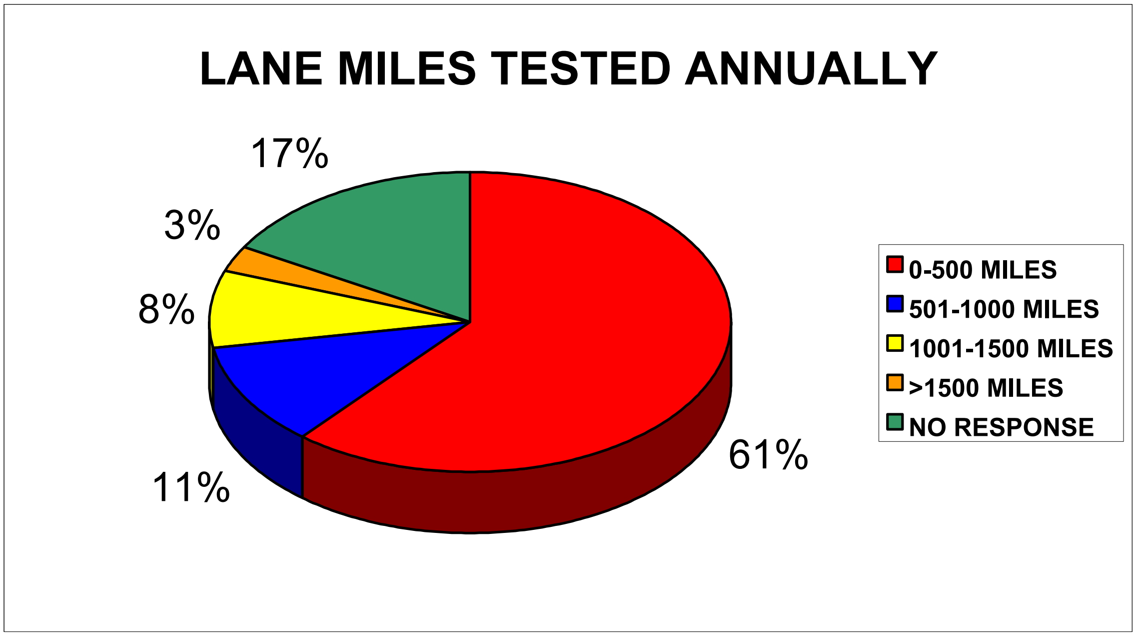
PERCENT OF PROGRAM AREAS				
AGENCY	**STRUCTURAL CAPACITY**	**INVESTIGATION**	**RESEARCH**	**OTHER**
AZ	85	10	5	0
BC(N)	90	0	5	5
BC(S)	90	10	0	0
FL	75	10	10	5
GA	30	50	20	0
ID	95	0	0	5
IL	45	5	50	0
IN	30	20	20	30
IA	75	0	25	0
KS	95	2	3	0
KY	25	25	50	0
ME	80	20	0	0
MD	85	10	5	0
MI	25	10	65	0
MN	25	25	50	0
MS	75	5	20	0
MO	35	65	0	0
MT	90	5	5	0
NV	70	10	10	10
NJ	10	0	10	80
NY	10	10	80	0
NC	75	20	5	0
ND	70	10	20	0
ON	90	10	0	0
PA	89	0	10	1
PR	95	0	5	0
SC	80	10	10	0
SD	80	10	10	0
TN	30	30	40	0
TX	65	15	10	5
UT	80	5	15	0
VA	50	25	25	0
VT	60	10	30	0
WA	90	5	5	0
WV	90	0	10	0
WI	0	100	0	0



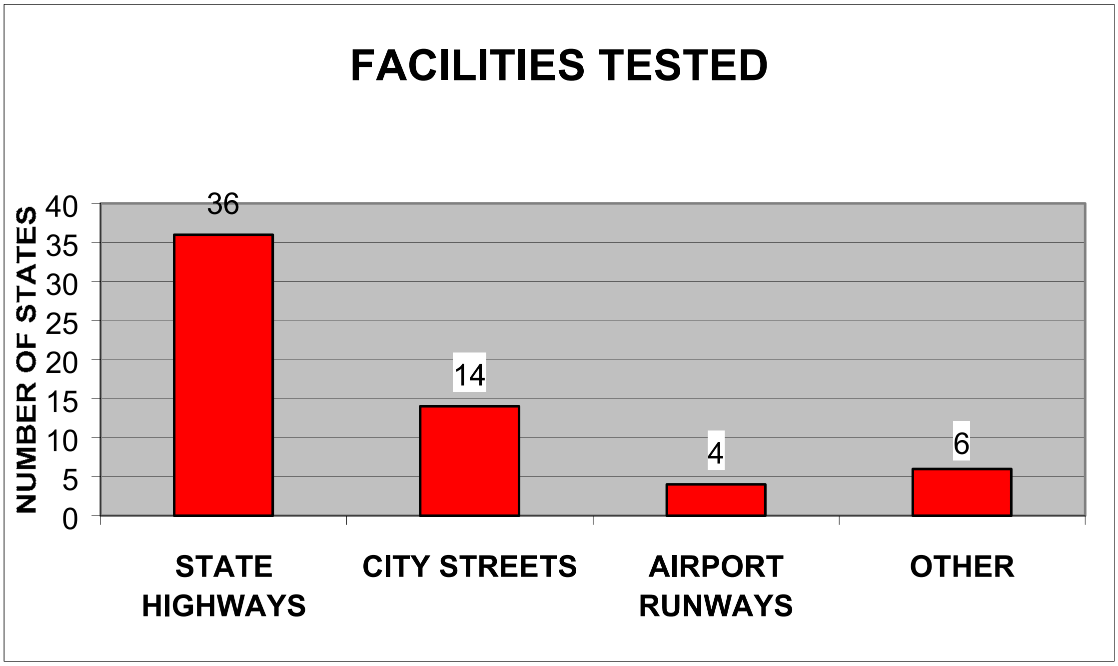
PROJECT LEVEL				PROJECT AND NETWORK LEVEL	NO RESPONSE
BC(N)	KY	NV	SC	AZ	
BC(S)	ME	NY	TN	IL	
FL	MD	NC	VA	MT	
ID	MN	ND	VT	NJ	
IN	MI	ON	WA	SD	
IA	MS	PA	WV	TX	
KS	MO	PR	WI	UT	
28				**7**	**1**



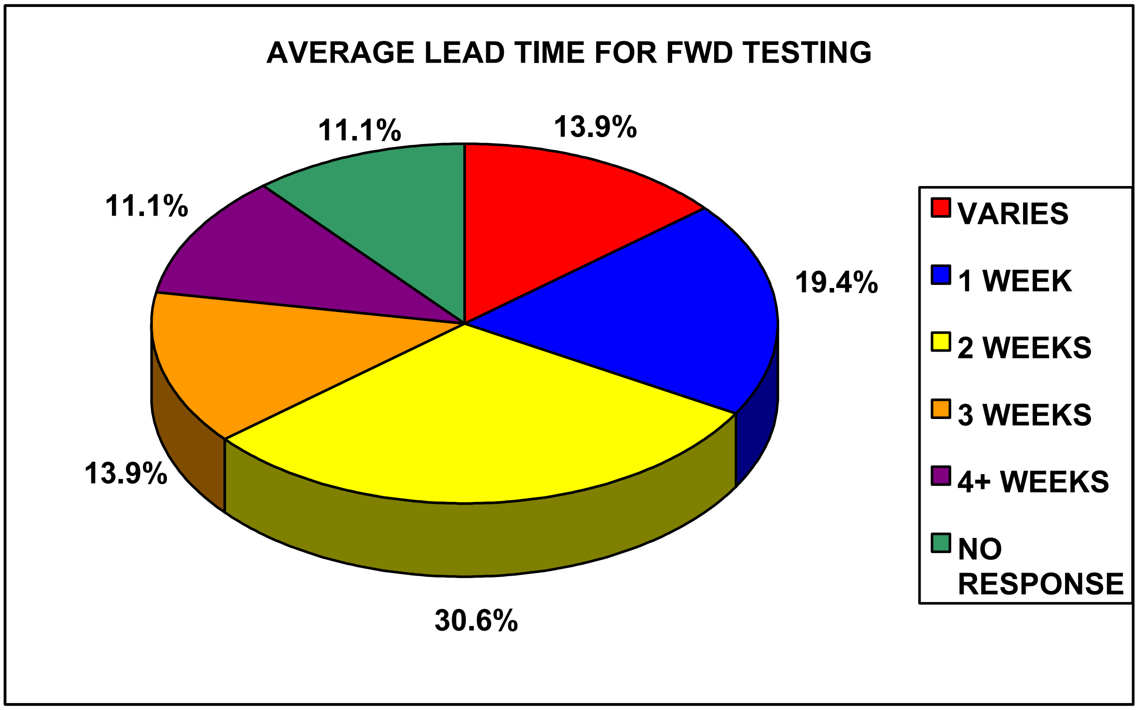
NOTE: Program Staff includes FWD operators, Engineers, In-house Consultants, and other Assistants.



0-500 MILES		501-1000 MILES	1001-1500 MILES	>1500 MILES	NO RESPONSE
AZ	NY	AZ	FL	TX	
BC(N)	NC	ID	KS		
BC(S)	ND	IN	SD		
IL	PR	UT			
IA	SC				
ME	TN				
MD	VA				
MI	VT				
MS	WA				
MT	WV				
NV	WI				
22		**4**	**3**	**1**	**6**



AGENCY	STATE HIGHWAYS	CITY STREETS	AIRPORT RUNWAYS	OTHER	AGENCY	STATE HIGHWAYS	CITY STREETS	AIRPORT RUNWAYS	OTHER
AZ	X				NV	X	X		
BC(N)	X				NJ	X	X		X
BC(S)	X				NY	X			
FL	X				NC	X		X	
GA	X				ND	X	X		
ID	X	X			ON	X			
IL	X	X	X	X	PA	X	X		
IN	X	X		X	PR	X	X		
IA	X				SC	X	X		
KS	X				SD	X	X	X	
KY	X	X			TN	X			X
ME	X	X			TX	X		X	
MD	X	X			UT	X			
MN	X				VA	X			
MI	X	X			VT	X			X
MS	X				WA	X			X
MO	X				WV	X			
MT	X				WI	X			


AVERAGE LEAD TIME FOR FWD TESTING
11.1%
13.9%
11.1%
19.4%
13.9%
30.6%
VARIES
1 WEEK
2 WEEKS
3 WEEKS
4+ WEEKS
NO RESPONSE

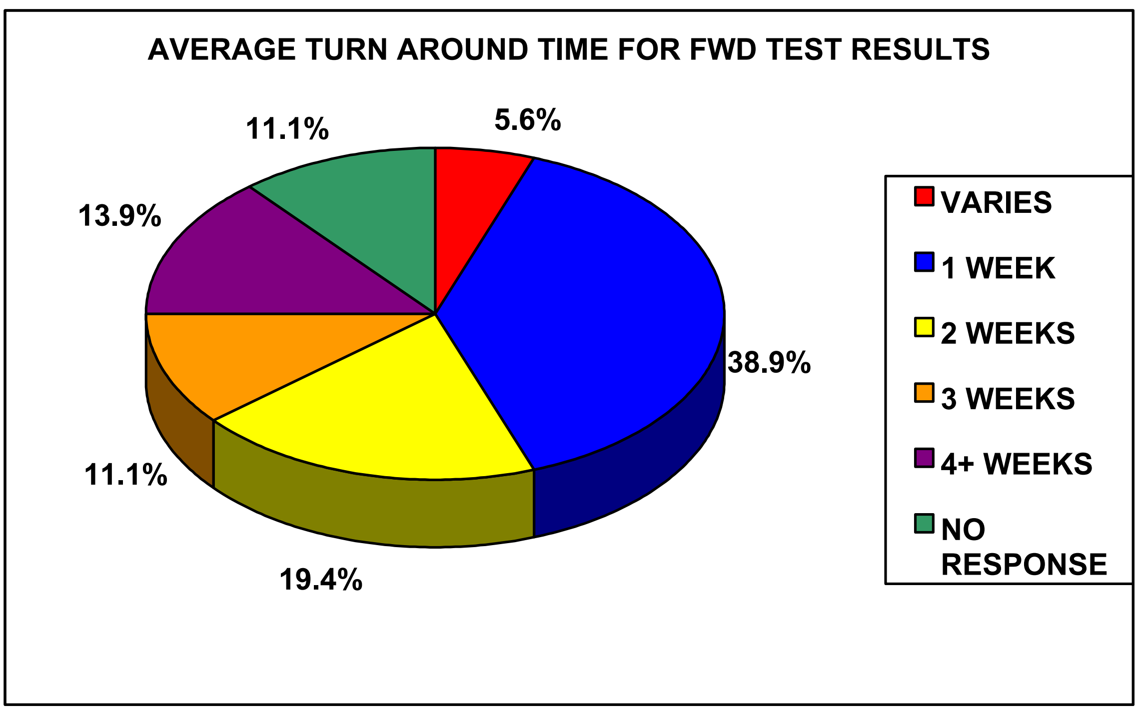

AVERAGE TURN AROUND TIME FOR FWD TEST RESULTS
11.1%
5.6%
13.9%
38.9%
11.1%
19.4%
VARIES
1 WEEK
2 WEEKS
3 WEEKS
4+ WEEKS
NO RESPONSE

TABLE 1A FWD OPERATING BUDGET AND MAINTENANCE OF TRAFFIC

AGENCY	PROJECT INFORMATION		AVERAGE OPERATING BUDGET PER LANE MILE	MAINTENANCE OF TRAFFIC		
	NUMBER OF PROJECTS	NUMBER OF LANE MILES		IN-HOUSE STAFF	DOT MAINTENANCE	CONSULTANT/ CONTRACTOR
AZ	25	500	do not separate costs	X	X	X
BC(N)	12	250	$286	X		X
BC(S)	20	400	$550	X		X
FL	165	1135	$203		X	
GA	no information given		no information given		X	
ID	40	600-700	$385	X		
IL	50~60	100-125	$478		X	
IN	50	700	$171	X	X	
IA	new unit - no testing done yet		unknown	X	X	
KS	70	1400	$71	X		
KY	15		$50,000, 15 projects tested		X	
ME	50	120	no information given	X	X	
MD	150	300	charged to design project budget		X	X
MI	12	70	no information given	X	X	X
MN	233	975	not available		X	
MS	25	500			X	
MO			$50,000, no project info given	X		
MT	40	350	$429	X		
NV	20	400	$75	X		
NJ	no information given				X	X
NY	100	18	$269		X	
NC	70	280	unknown		X	X (infrequent)
ND	0	300	$267	X		
ON	4-5					X
PA	250				X	
PR	34	400	$160	X		
SC	25	300	not specifically budgeted		X	
SD	60	1500	$27	X		
TN	20	120	not yet established		X	
TX	250-500	5,000-15,000	$28		X	
UT	10~20	1000	$130	X	X	X
VA	20	250	no information given		X	
VT		60	$2,500		X	
WA	30	200	$61		X	
WV	50	200	no information given	X	X	
WI	10	100	$300			X

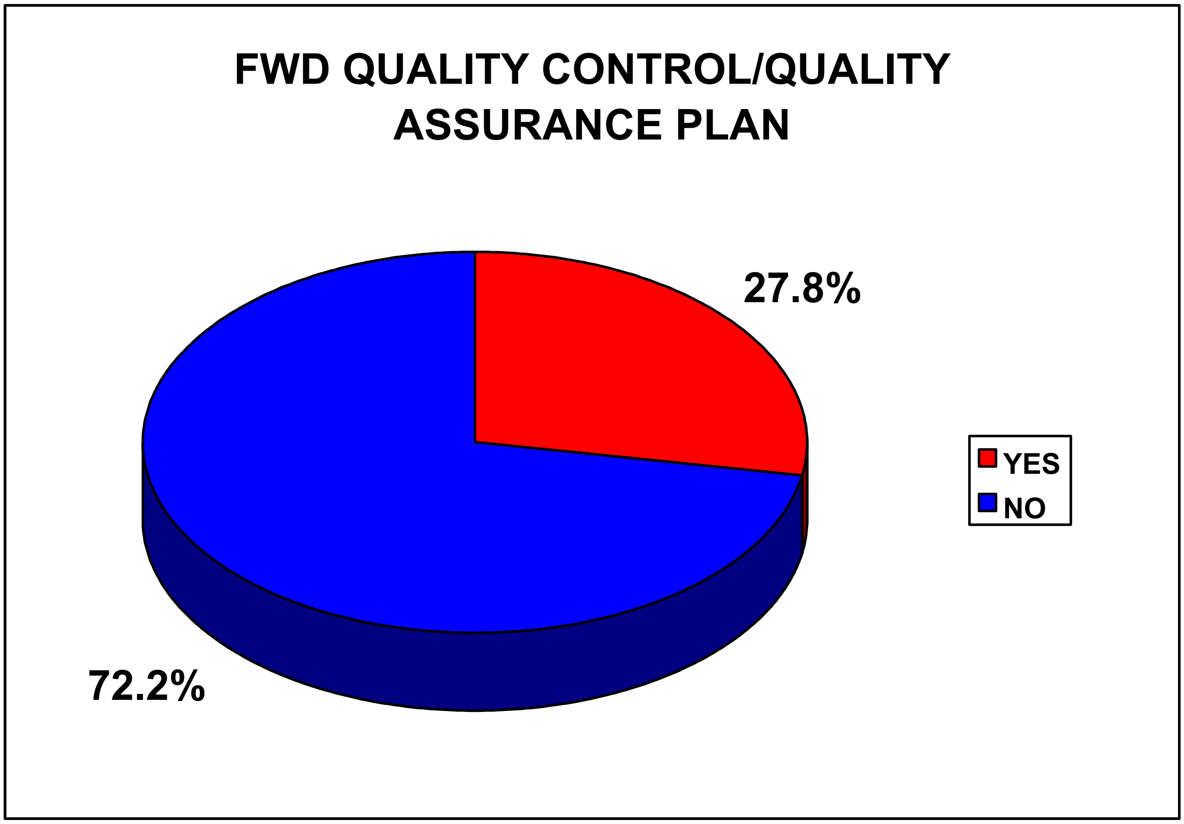
TABLE 1B FWD CUSTOMERS AND SERVICES PROVIDED

	FWD PROGRAM MANAGEMENT CUSTOMERS AND INFORMATION/SERVICES PROVIDED			
AGENCY	DESIGN	MAINTENANCE	CONSTRUCTION	OTHER
AZ	FWD results			FWD results
BC	overlay requirements and rehab		quality control	
BC	new construction	surface rehab designs	quality control	
FL	subgrade resilient modulus		investigation	research, testing support, pavement performance
GA			investigation and analysis	
ID	pavement evaluation, design information	deflection data		
IL	design overlays			research data collection
IN	rehab strategy, subgrade stiffness, pavement stiffness	undersealing locations, load transfer across joints and cracks	effectiveness of rubblization	data for research
IA	not determined yet			
KS	pavement design for project level rehab. information			pavement management system for project optimization of substantial maintenance projects
KY	structural evaluations and overlay design			
ME	subgrade modulus and overlay thickness	check subgrade moduli when desired density not reached		
MD	pavement recommendation. - new and rehab	pavement recommendation - emergency repair	pavement recommended - construction related	research or material investigation
MN	no specific information provided			research, seasonal, and annual deflections for MnRoad
MI	subgrade resilient modulus			University - variety of FWD data, deflection basin, time/history, joint/crack efficiencies
MS	overlay thickness design	joint load transfer efficiency analysis		University researchers as needed
MO	load transfer checks on pavement and bridge approach slabs			
MT	resilient modulus values			pavement management
NV	pavement condition, cores, with overview of condition of project at the time of testing			
NJ				capital investment strategies
NY	subgrade evaluation		QA/QC, rubblization and crack and seat	performance monitoring projects

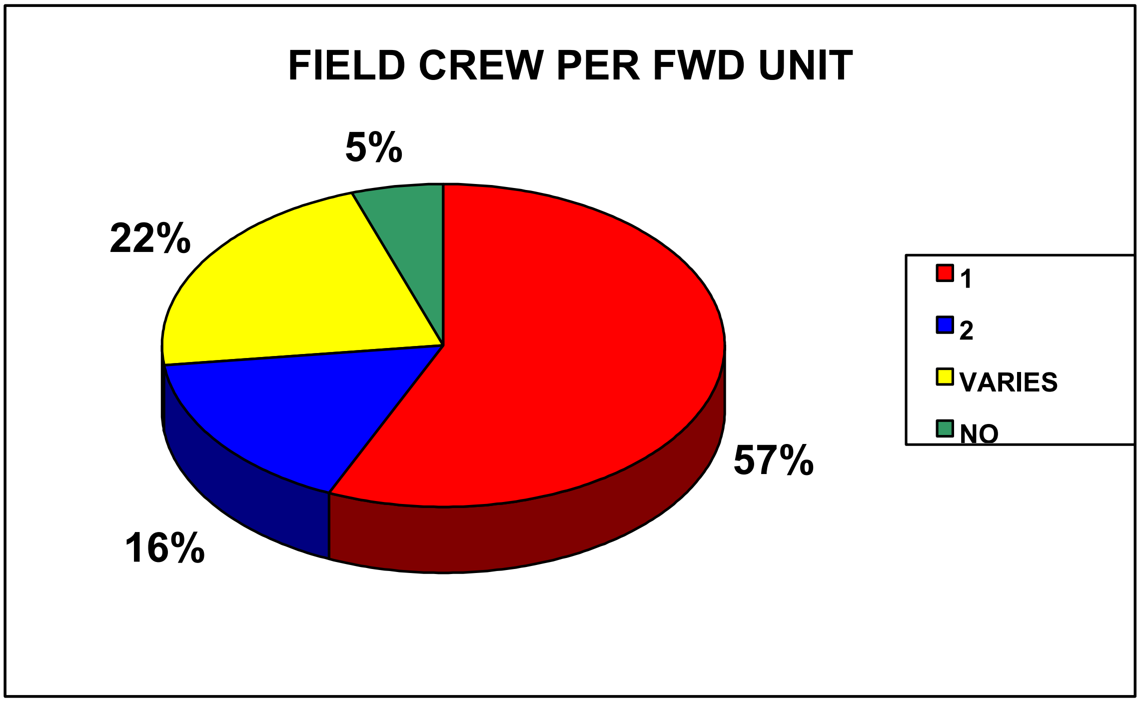
TABLE 1B FWD CUSTOMERS AND SERVICES PROVIDED

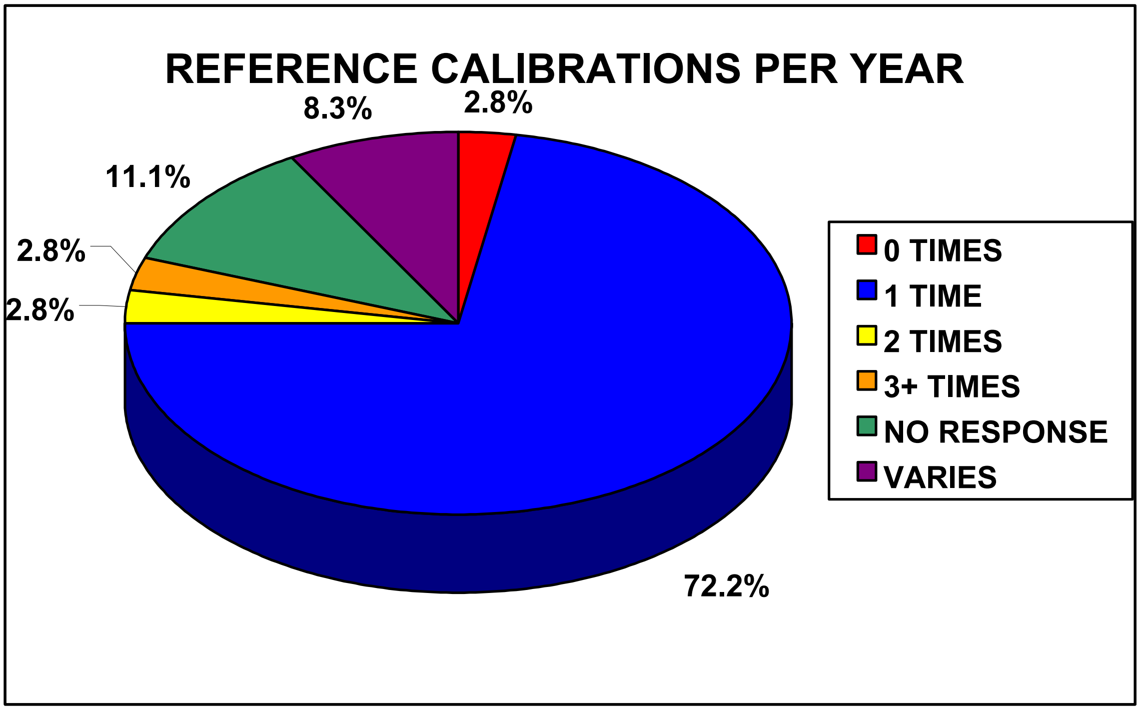
	FWD PROGRAM MANAGEMENT CUSTOMERS AND INFORMATION/SERVICES PROVIDED			
AGENCY	**DESIGN**	**MAINTENANCE**	**CONSTRUCTION**	**OTHER**
NC	overlay designs, recommended repairs to existing roadways	weight restrictions for posted roads, evaluation of roadways regarding hauling, overweight permit applications, forensic studies	suitability of roadways for rubblization uniformity of construction activities	
ND	structural analysis/pavement design	seasonal subgrade modulus		
ON			no specific information provided	
PA	deflection and resilient modulus data		location of concrete joints with poor load transfer	
PR	overlay thickness and areas to be removed	overlay thickness and areas to be removed	structural capacity	University and FHWA-SHRP
SC	overlay recommendations, pavement design		forensic analysis for early failure	evaluation of new materials
SD	elastic modulus of each layer, soft spots, overlay design	elastic modulus of each layer, soft spots	elastic modulus of each layer, soft spots, road limits	
TN	raw data - computed results in the future			
TX	procedure/analysis/collection support	analysis/collection support	analysis/collection support	Universities - analysis/collection support
UT	all groups get an annual report for pavement condition with FWD test results, modulus, summaries, years to fatigue failure, pavement design project level or special requests to get the test results and five day temperatures			
VA	existing structural condition for use in AASHTO pavement design		identification of weak areas	research - information for specialized projects
VT	structural design			pavement design committee, deflection data
WA	overlay thickness using mechanistic-empirical overlay design procedure developed by WSDOT and the University of Washington		existing pavement strength and determine if pavement removal is necessary	
WV	resilient modulus values			
WI	load transfer, structural strengths	load transfer, structural strength	load transfer structural strength	

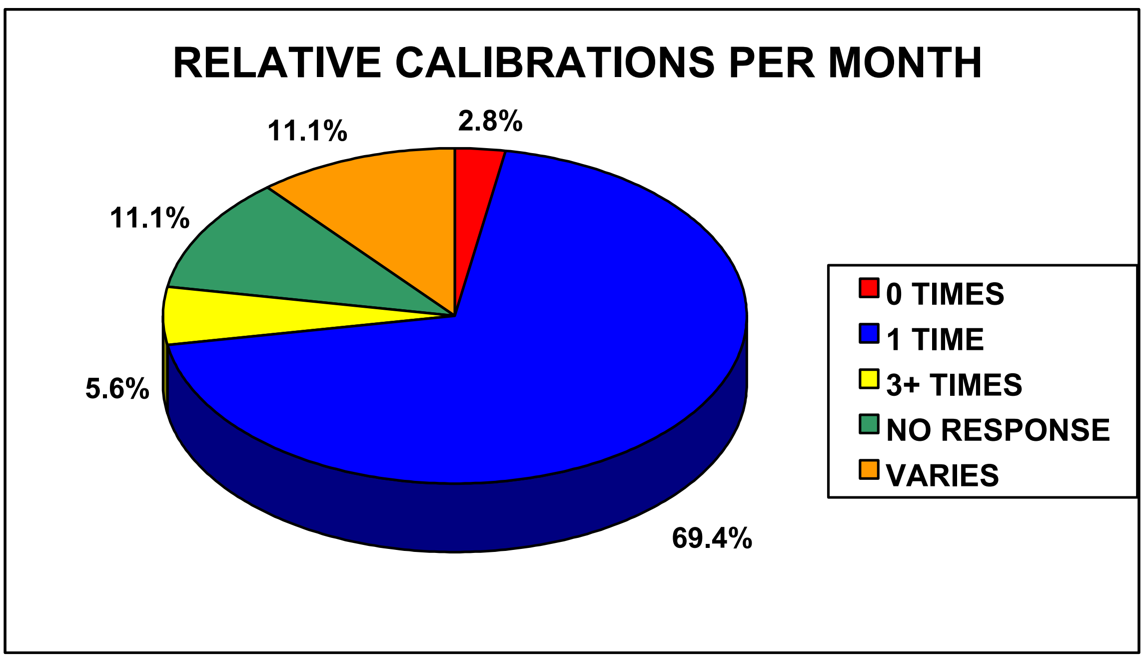
PART II: FWD Operation



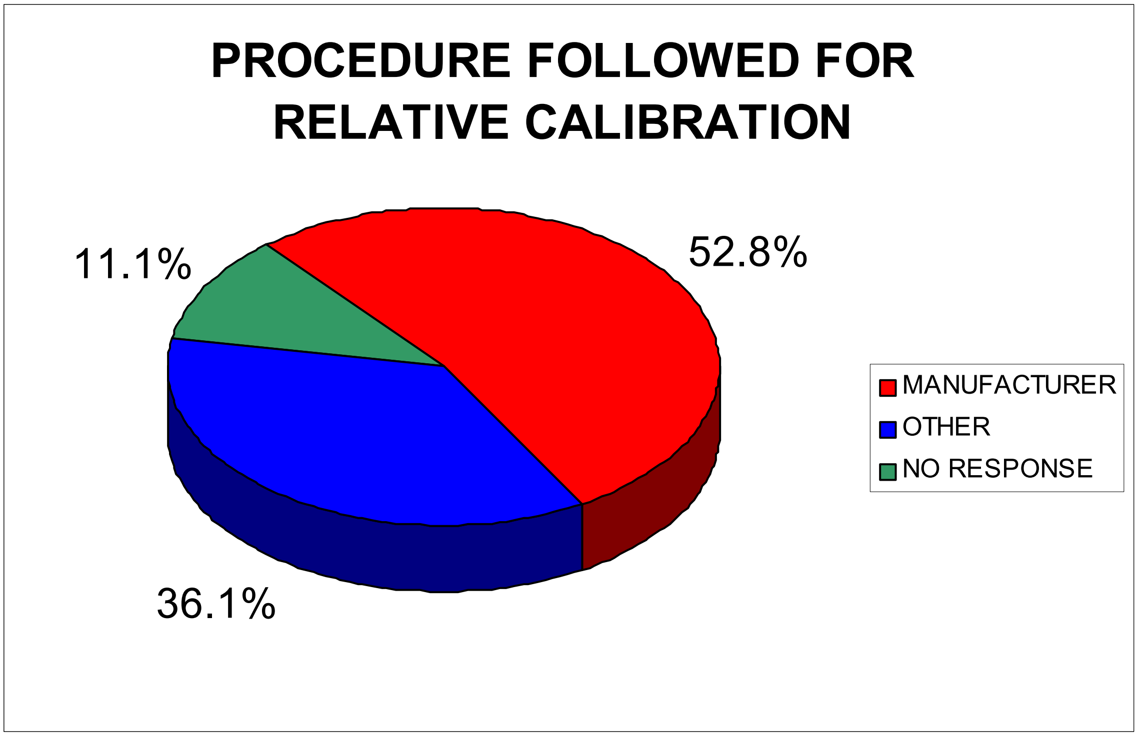
STATES WITH QUALITY ASSURANCE/QUALITY CONTROL PLANS	
AZ	monthly calibration and fixed concrete test pad; generally at annual SHRP center calibration; data collection and import programs of anomalous readings
FL	monthly and annual calibrations; field and office checks; standard testing procedure and project specific instructions
ID	calibration procedures outlined in Operator's manual; calibrated at the Nevada center annually; SHRP quality software, but data quality is checked by the Operator and Pavement Design Eng. Written plans not available
IN	SHRP FWD Calibration Protocol for reference and relative calibration; INDOT has its own calibration center
MD	no information provided
MN	no information provided
NV	detailed set of instructions applicable to every project plus project specific information
SD	SHRP
TX	LTPP calibration protocol
VA	document still in development and not ready for release outside of the agency


FIELD CREW PER FWD UNIT
5%
22%
57%
16%
1
2
VARIES
NO

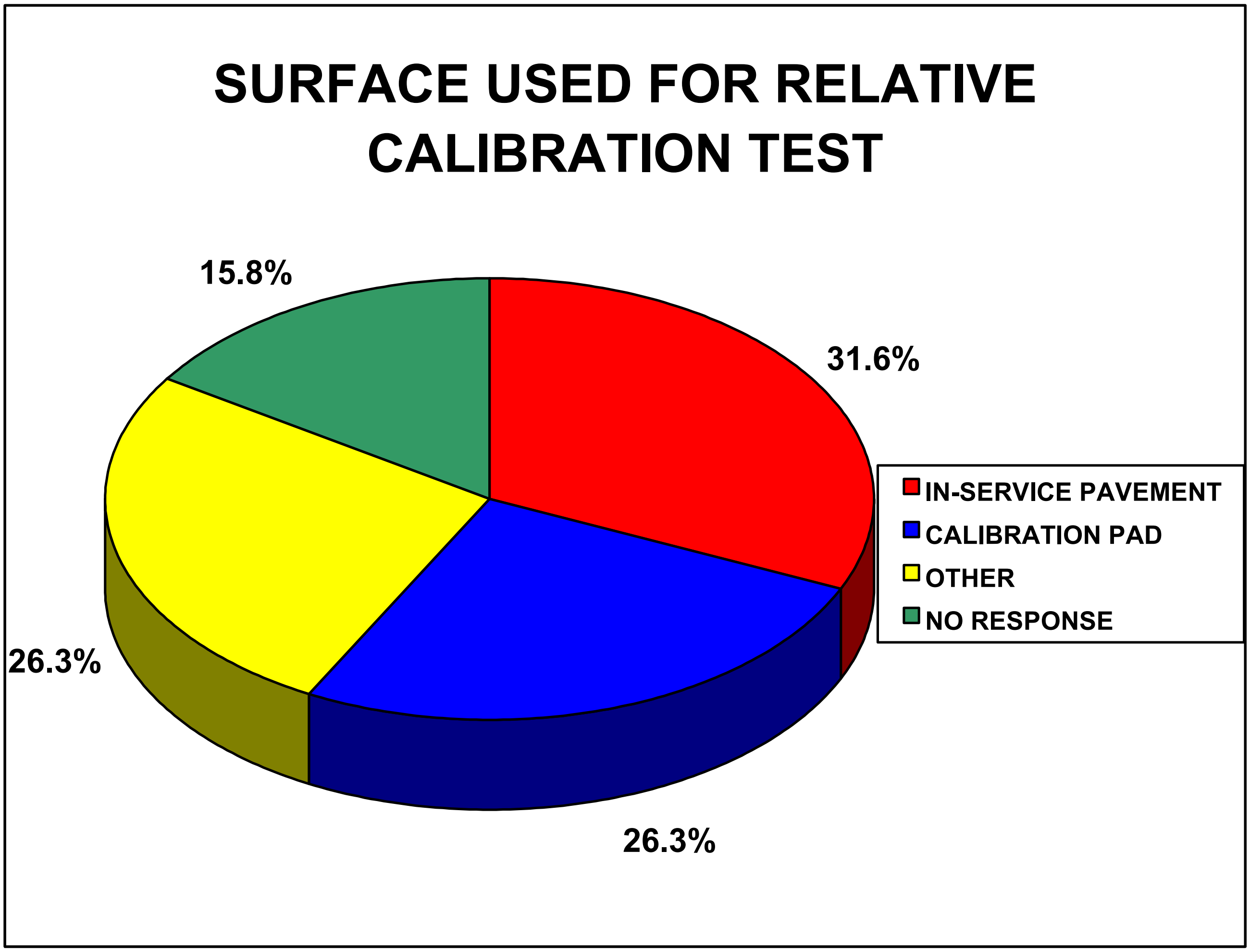




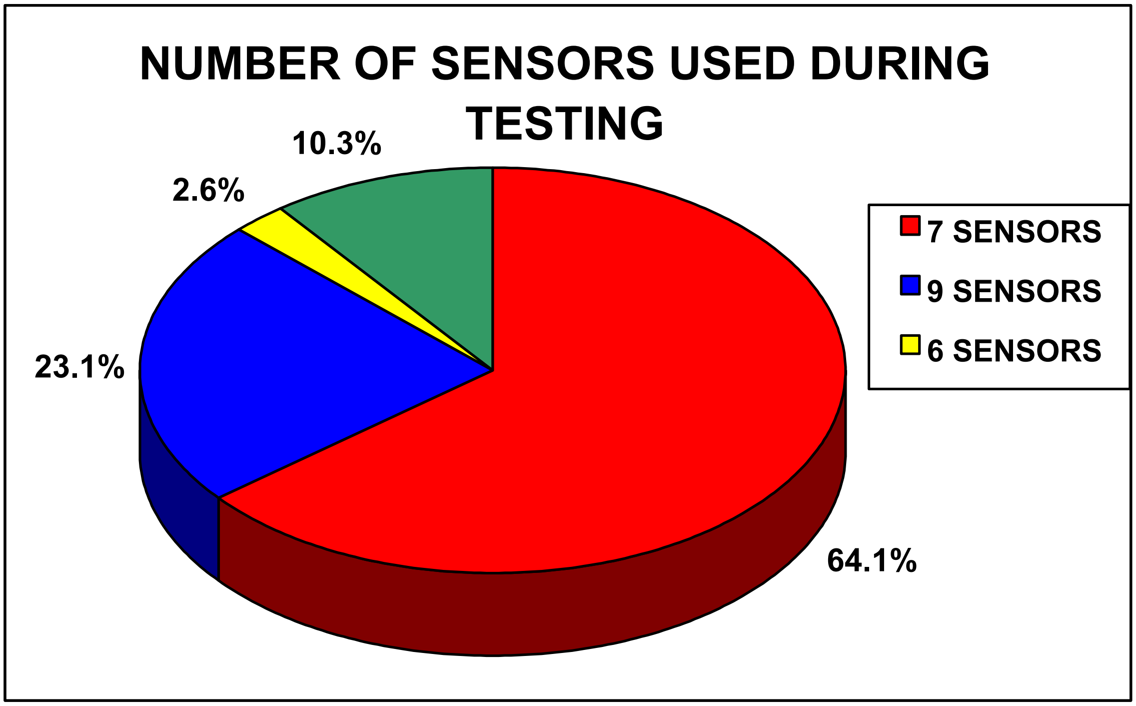
NOTE: Reference Calibration is the calibration of the FWD unit to known reference standards.
Relative Calibration is the comparison of FWD deflection sensors to one another.



MANUFACTURER		OTHER		NO RESPONSE
AZ	MS	ID	SHRP Relative Calibration program FWDCAL	
BC(N)	MO	IN	SHRP Calibration procedure	
BC(S)	NC	KS	SHRP/LTPP FWD Calibration Protocol	
FL	ND	MN	SHRP, MN is Central Region Calibration Center	
IL	SC	MI	only performed relative calibration at SHRP Calibration Center at PennDOT	
IA	TN	MT	same procedure as SHRP Center in Reno	
KY	UT	NV	LTPP	
ME	VT	NY	SHRP	
MD	WV	PA	SHRP Protocols	
	WI	PR	SHRP Protocols	
		SD	SHRP Calibration Center at MN DOT	
		VA	SHRP Calibration Procedure	
		WA	LTPP calibration procedures	
19		**13**		**4**

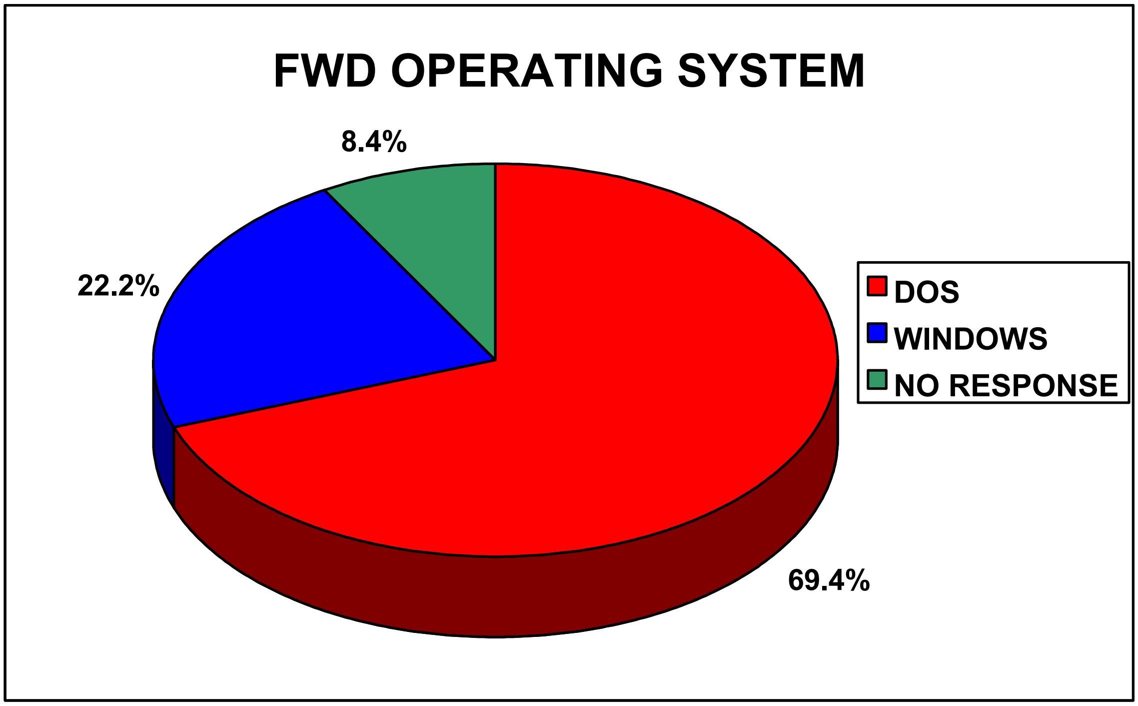


IN-SERVICE PAVEMENT	CALIBRATION PAD	OTHER		NO RESPONSE
BC(S)	AZ	BC(N)	parking lot (AC)	
ID	FL	KS	parking lot (weak asphalt pavement)	
IL	IN	ME	concrete entrance pad to garage	
KY	IA	MI	PennDOT SHRP Calibration Center	
MD	MN	NV	anywhere minimum requirements can be met	
MS	MT	NC	DOT facility lot	
MO	PA	PR	isolated flexible pavement	
MY	PR	SC	shop floor	
ND	SD	VA	garage floor concrete slab	
TN	WV	VT	concrete floor	
VA				
WA				
12	**10**	**10**		**6**



7 SENSORS		9 SENSORS	6 SENSORS	NO RESPONSE
AZ	NV	BC(N)	WA (6)	
FL	NC	BC(S)		
GA	PR	IN		
ID	SC	IA		
IL	SD	MN		
IN	TN	MO		
KS	TX	NY		
KY	UT	VA		
MD	VT			
ME	WA			
MI	WV			
MS	WI			
MT				
25		**8**	**1**	**4**

NOTE: Some agencies have more than one FWD with different numbers of sensors



DOS		WINDOWS	NO RESPONSE
AZ	NC	BC(S) (Version 3.1)	
BC(N)	PA	GA (Windows 98)	
FL	PR	IN	
ID	SC	KY (Windows 98)	
IL	TN	MO (WindowsNT 4.0)	
KS	TX	MT (Version 3.1)	
ME	UT	ND	
MD	VA	SD (Windows 98)	
MN	VT		
MI	WA		
MS	WV		
NV	WI		
NY			
25		**8**	**3**

TABLE 2 FWD LOADING SEQUENCE AND SENSOR SPACING

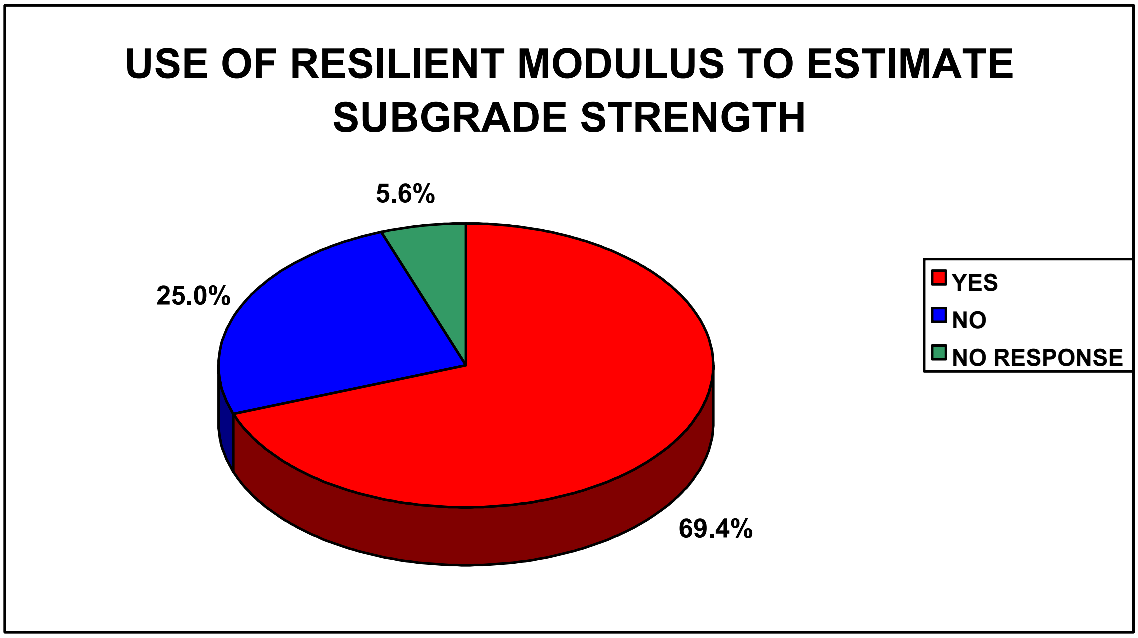
FWD OPERATION												
			TYPICAL SENSOR SPACING (in/mm)									
AGENCY	LOADING SEQUENCE AND MAGNITUDE	**AGENCY**	**D0**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
AZ	7 repetitions of 5 drops each at 12 kip	AZ	0	12	24	36	48	60	72		
BC(N)		BC	0	200	300	450	600	900	1200	1500	1800
BC(S)	3 seating loads @13 kip; 5 replicate loads @13 kip	BC									
FL	1 seating load @ 9 kip; 2 replicate loads @ 9 kip	FL	0	8	12	18	24	36	60		
GA		GA									
ID	5 drops per set, 7 sets, load level to develop 20 mil deflection	ID	0	8	12	18	24	36	48	60	72
IL	replicate loads @ 9 kip	IL	0	12	24	36	-12	12R	12L		
IN		IN	0	8	12	18	24	36	48	60	72
IA	not determined	IA	0	8	12	18	24	36	48	60	
KS	2 seating loads @ 6 kip; 5 replicate loads @14 kip	KS	0	8	12	18	24	36	60		
KY	X seating loads @15 kip; 4 replicate loads @15 kip	KY	0	8	12	18	24	36	60		
ME	2 seating loads @14 kip; 5 replicate loads @14 kip	ME	0	12	18	24	36	48	60		
MD	2 drops at each load level	MD	0	8	12	24	36	48	60		
MN		MN	0	8	12	18	24	36	48	60	72
MI		MI	0	12	12	8	12	18	24	36	60
MS	2 seating loads @ 16 kip; 5 replicate loads @ 16 kip	MS	0	12	24	36	48	60	72		
MO	2 seating loads @ 9000; 5 replicate loads @ 9000	MO	0	8	12	18	24	36	48	60	-12
MT	35 replicate loads @ 16 kip;	MT	0	8	12	18	24	36	48		
NV	1 seating load w/3 replicate loads @t 11 kips or 1 seating load w/4 drops from heights 1, 2, 3, 4	NV	0	12	24	36	48	60	72		
NJ	to be determined	NJ									
NY	3 seating loads @ 16 kip; 5 replicate loads @ 16 kip	NY	0	8	12	18	24	36	48	60	72
NC	1 seating load @ 9 kip; 3 replicate loads @ 9 kip	NC	0	8	12	18	24	36	48	60	
ND	3 seating loads @ 12 kip; 5 replicate loads @12-16 kip	ND	0	8	12	18	24	30	36	48	60

TABLE 2 FWD LOADING SEQUENCE AND SENSOR SPACING

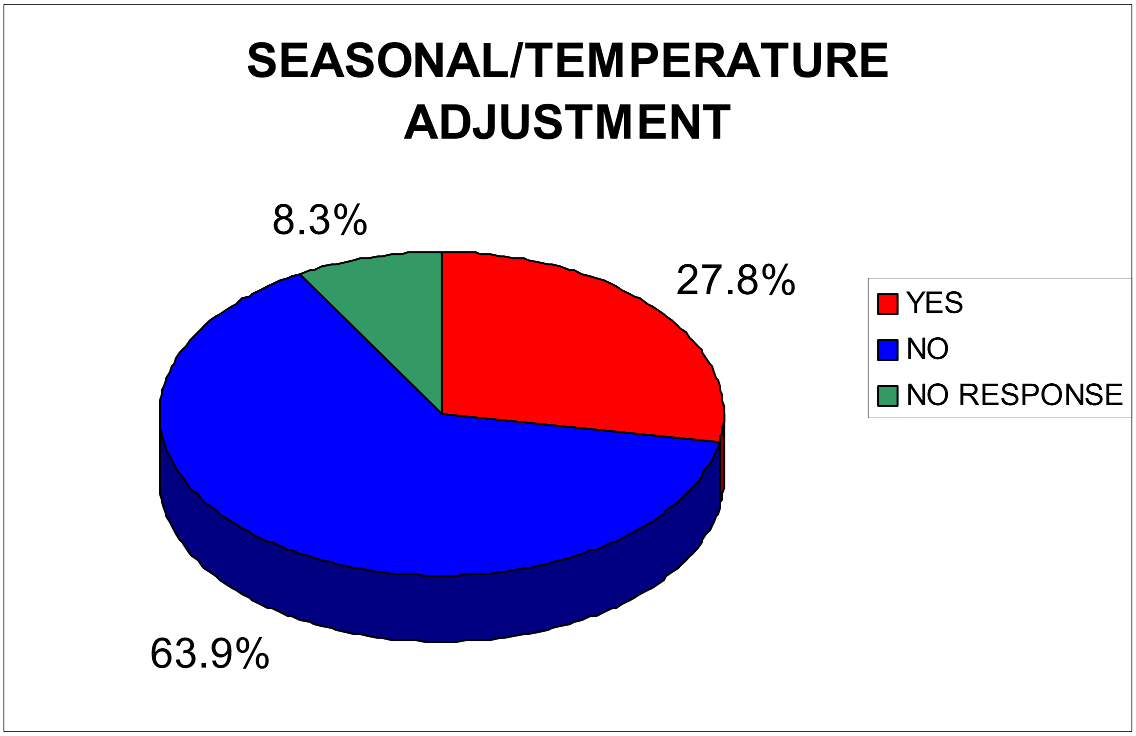
FWD OPERATION

		TYPICAL SENSOR SPACING (in/mm)									
AGENCY	LOADING SEQUENCE AND MAGNITUDE	**AGENCY**	**D0**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
ON		ON									
PA	2 seating loads @ 12 kip; 5 replicate loads @12 kip	PA	0	12	24	36	48	60			
PR	4 seating loads @ 6-16 kip; 1 replicate load @ 9 kip	PR	0	7.87	11.81	17.72	23.62	35.43	47.24	59.06	70.87
SC	2 seating loads @ 6 kip; 5 replicate loads @16 kip	SC	0	200	300	600	900	1350	1800		
SD	1 seating load @ 6 kip; 3 replicate loads @ 9, 12, 14 kip	SD	0	8	12	18	24	36	48		
TN		TN	0	12	24	36	48	60	72		
TX		TX	0	12	24	36	48	60	72		
UT		UT	0	12	24	36	48	60	72		
VA	load level to produce a minimum 16 mils deflection	VA	0	8	12	18	24	36	48	60	72
VT	2 seating loads (1-2 mils); replicate loads (20-40 mils)	VT	0	12	24	30	36	42	48	60	72
WA	2 seating loads @ 8 kip; loading sequence of 8, 6, 4.5, and 3 kip	WA	0	8 -12	12 8	24 12	36 24	48 36	 48		
WV	X replicate loads @12 kip	WV	0	8	12	18	24	36	48	60	72
WI	1 seating load @ 4.5 kip; 3 replicate loads @ 12.5 kip	WI	0		12	18	24	36	48	60	

PART III: Pavement Design Parameters



STATES AND PROCEDURES USED	
BC(N)	ELMOD Design
BC(S)	ELMOD 4
FL	modified AASHTO Guide
ID	backcalculation
IL	procedure developed by the University of Illinois
IN	no information provided
KS	AASHTO backcalculation procedure
ME	Darwin 3.01, using computed Mr for design purposes
MD	AASHTO Pavement Design Guide Protocol and other backcalculation analysis tools
MN	transitioning from R-value to Mr, EVERCALC and ELMOD and modified laboratory LTPP P-46 protocol
MI	AASHTO Pavement Design
MT	new AASHTO Darwin
NV	no information provided
NY	no information provided
ND	no information provided
ON	backcalculation
PA	AASHTO 1993 Guide
PR	no information provided
SC	no information provided
SD	estimate resilient modulus base on the liquid limit of the soils
UT	AASHTO, Evercalc, CBR correlation
VA	backcalculation according to 1993 AASHTO
VT	Darwin
WA	procedure developed in-house and software developed to read data*
WV	no information provided
WI	standard AASHTO procedures
	* Software can be downloaded at http://www.wsdot.wa.gov/fossc/mats/pavement/fwd.htm



STATES AND ADJUSTMENT FACTORS USED	
BC(N)	Benkelman Beam adjustment factor until a database of seasonal FWD data has been built
BC(S)	no information provided
ID	factors are location dependant depending on freezing of subgrade and spring thaw or on increased winter and spring moisture
IN	no information provided
MN	use temperature to normalize pavement surface deflections
KY	no information provided
NV	no information provided
VT	30% reduction
WA	description in users' manual already mentioned

FINDINGS

Following are the general findings on the current practices by the surveyed agencies in three FWD program areas.

FWD Program Management

- Twenty-nine agencies (81%) manage the field-testing in-house, while the other 7 agencies outsource the work.
- Twenty-five agencies (70%) own and operate Dynatest units, four agencies (11%) own and operate JILS units, three agencies (8%) own and operate KUWAB units, and three agencies (8%) own and operate a combination of Dynatest, KUWAB, and/or Jils units.
- The average use of the FWD according to program areas is 63% for structural capacity evaluation, 18% for research, 15 % for pavement investigation, and 4% for other pavement evaluation activities.
- Twenty-eight agencies (78%) use the FWD at the project level, while seven agencies (19%) use it at both project and network levels.
- Fourteen agencies (37%) use a total of two full time staff per FWD unit.
- Twenty-two agencies (61%) test between 0 to 500 roadway lane miles annually.
- The average annual FWD operating budget varies among agencies depending on the number of projects, project length, and individual costs involved.
- In addition to testing State highways, 14 agencies (39%) use the FWD to test city streets, four agencies (11%) test airport runways, and six agencies (17%) test some other type of facilities.
- Nineteen agencies (53%) use their maintenance units and/or own staff to provide maintenance of traffic during testing.
- Thirty-three agencies (92%) provide FWD testing services to the Design group.
- Most of the agencies require an average of one to two weeks lead-time for FWD testing.
- Most of the agencies require one to two weeks turn around time for the test results.

FWD Operation

- Seventy two percent of agencies have a Quality Control/Quality Assurance plan in effect.
- Twenty-one agencies (57 %) typically use one crewmember per FWD unit.
- Twenty-six agencies (72 %) have an annual reference calibration performed on their FWD unit(s).
- Over 69% perform a monthly relative calibration on their FWD unit(s).

- About 53% follow the manufacturer's relative calibration procedure while 36 % follow some other procedures.
- Over 31% use in-service pavements to perform a relative calibration.
- Sixty four percent use seven sensors when testing for a typical pavement rehabilitation project.
- Nearly 70 % of the FWD units owned by these agencies operate under the DOS environment.

Pavement Design Parameters

- Close to 70% of the agencies use the Resilient Modulus value to estimate subgrade strength.
- Only 28% of the agencies use a seasonal and/or temperature adjustment factor(s) for determining the effective subgrade modulus.

Appendix A

FLORIDA DEPARTMENT OF TRANSPORTATION
FALLING WEIGHT DEFLECTOMETER (FWD) QUESTIONNAIRE

Contact Information

Agency: ____

*Responden*t: ____

Title: ____

Phone: (   ) ______________ Fax*:* (   )______________ E-mail ________________

I - **FWD Program Management**

1) How is the FWD field-testing managed?

_____ % In-house _____ % Outsourced

2) How many FWD units do you own and operate?

___ Dynatest, ___ Kuwab, ____ Phonix, ____ Other (Describe) ____________

3) What percentage of your program is dedicated to each of the following areas?

____ Structural Capacity ___ Investigation ____ Research ____ Other

4) At what production level do you use your FWD?

____ Project ____ Network

5) How many full-time staff are involved with the FWD Program?

____ Operators ____ Engineer(s) ____ Consultants (in-house) ____ Other

6) How many statewide projects and average lane-miles are tested annually?

_____ Projects _____ Lane-miles

7) What is the average annual operating budget for your FWD testing program?

$ ________

8) What facilities do you test with the FWD?

__ State Highways, __ City Streets, __ Airport Runways, __ Other ___________
____

9) Who provides the Maintenance of Traffic during the deflection testing operation?

___ In-house Staff, ___ DOT Maintenance, ____ Consultant/Contractor

10) Which of the following groups are your customers and what service(s) or product(s) do you provide them with the FWD?

___ Design ____

___ Maintenance ____

___ Construction ____

___ Other ____

11) What is the average lead-time from the date you receive a request to the date of testing?

____ Weeks

12) What is the average turn-around time from the date of testing to the date the results are submitted to your customer?

____ Weeks

II - <u>FWD Operations</u>

13) Does your agency have an FWD Quality Control and/or Quality Assurance plan(s) in effect?

___ Yes (please provide a copy), ___ No

14) How many crewmembers do you use to operate an FWD unit on a typical pavement rehabilitation project?
___1, ____2, ___Varies

15) How often do you have your unit(s) calibrated?

a) Reference Calibration(s) per year: ___ 1 ___ 2 ____ 3 or more

b) Relative Calibration(s) per month: ___ 1 ___ 2 ____ 3 or more

16) What loading sequence and magnitude do you use for relative calibration?

___ Seating Load(s) @ ___ Kip, ___ Replicate Load(s) @ ___ Kip

17) What procedure do you follow to perform a relative calibration?

____ Manufacturer, ____ Other (please explain and/or provide a copy)
____
____
____

18) What surface do you use to conduct a periodic relative calibration test?

___ In-service Pavement, ___Calibration Pad, Other (describe) _____________
____

19) How many sensors do you use when testing deflection for a typical pavement rehabilitation project?

___ 7 ___ 9 Other (specify) ___

20) At what spacing (in. or mm) from the center of load do you set your sensors when testing deflection on a typical pavement rehabilitation project?

___D0 ___ D1 ____ D2 ___ D3 ___ D4 ___ D5 ___ D6 ___ D7 ___ D8

21) What operating system does your FWD unit(s) operate on?

___ DOS ____Windows ____ (Version) Other (describe) _________________

III **Pavement Design Parameters**

22) Does your agency use the Resilient Modulus to estimate sub-grade strength?

___ Yes ___ No If yes, please provide the procedure used

23) Does your agency use a seasonal and/or temperature adjustment factor(s) in determining the effective sub-grade modulus?

___ Yes ___ No

If yes, please provide the modified equation with the correction factor(s)

Please provide any additional information or input you would like to share in the space below. This includes comments based on your experience with the FWD which may not have been addressed in this questionnaire

FWD Field Operation

____

____

____

Pavement Design Parameters

____

____

____

Program Management

____

____

____

Other Comments

____

____

____

Do you want to receive a copy of the findings? _____ Yes _____ No

Thank you for your time and effort in answering this questionnaire.

Appendix B

Additional Comments

FWD Field Operation

The FWD User Group has been a big help and Dynatest has been very good too. –BC

ITD provides traffic control (two pick-ups and one attenuator truck) with hourly employees hired by HQ Materials Section. Since the crews work 9 or 10-hour days, utilization of District Maintenance for traffic control is difficult. –ID

FWD operators and pavement design engineers must have good communication and understand the needs and difficulties each face in their work environment to ensure quality data is achieved to develop pavement recommendations. –MD

We do not routinely perform multi-layer backcalculation analyses because of our previous experience with this method. Because we use a two-layer closed-form analysis, our sensitivity study indicates that the calibration precision is not as critical as with multi-layer methods. This is why we do not calibrate our units as frequently as some states or SHRP. In 13 years of operation, we have only once found a significant loss of accuracy due to a sensor problem, and this was quite obvious from the analysis. However, I understand that the LVDT-based FWD's suffer significantly greater loss of calibration with time than the accelerator-based units. –SC

We have questioned the value of project level testing, it's expensive and dangerous and not frequent enough to be of much value, except when you need to determine the effects of a proposed truck haul or something.
Safety is a real concern for the field crews, especially in the urban area with a lot of traffic. –UT

The FWD program has previously been housed in the Design Division, but has recently been transferred to the Division of Materials and Tests. We are in the development stages of a FWD program, and therefore, many of these specifics have not been addressed. – TN

We have our 15 FWDs stationed in the districts all over the state. They are operated mainly by district personnel, but are calibrated, rehabbed and maintained by division personnel located in Austin, TX. We do not have a database that tracks the workload or expenses for the FWDs, hence the wide ranges of numbers in the questionnaire. –TX

We operate with a technician operator and an engineer in the FWD tow vehicle, followed by a coring unit. In this way, we gather condition, DCP data, layer types/thickness/condition and detailed physical features at the same time as the FWD testing**.** –NC

Only equipment with a certificate of calibration issued within the past two years shall be used for FWD Testing. Maintenance and calibration checks shall be as per manufacturer's instructions. –ON

Pavement Design Parameters

Subgrade Modulus, as well as Moduli of base and surfacing, are developed by backcalculation using MODULUS or EVERCALC. The backcalculated moduli are not reduced to match laboratory results. Seasonal correction factors are used in design based on the location, climate, and temperature data. The University of Idaho developed program WINFLEX is the current standard for rehabilitation design. We do not use AASHTO for flexible pavement. –ID

FWD data collection for load transfer performance of joints in rigid and composite pavement is useful design criteria used to develop pavement rehabilitation recommendations at MDSHA. –MD

Regarding seasonal subgrade adjustment factors, we have tried to discern a seasonal pattern in subgrade modulus. While we found that calculated subgrade modulus does apparently vary by about 20% over time, we also found that the peak subgrade moduli at different sites occurred at different times throughout the year. Since SC does not have specifically dry or wet seasons, (average monthly precipitation throughout the year ranges from a low of 3 to a high of 6 inches) or a spring thaw typical of northern climates, we do not feel that an adjustment is meaningful in our climate. -SC

Most confidence for subgrade modulus. Questionable use of AASHTO 0.33 subgrade adjustment factor when both asphalt and concrete are part of pavement section. –UT

Effective thickness and effective structural number used for overlay design. –KY

With FWD testing results, a relationship between distresses seen on the surface and the need to do slab repairs should be established region by region. Based on this the Specialist shall select and test a range of joints, transverse cracks and Vermeer sawn joints with varying degrees of distress so that repairs can be predicted on a visual basis with confidence. –ON

Program Management

Each district and HQ Materials Sections develop their deflection testing needs in March of each year. Their requests are forwarded to HQ Materials, Pavement Design Engineer, and the Pavement Testing Unit Manager. The schedule for the year is developed from these requests and priority assigned to each project. The sequence of project priorities usually requires more than one trip through each District. The field season typically starts in Late April and extends through October. The Pavement Design Engineer and District Materials Engineer receive the field data within a week of the testing. The turn around time for the recommendations will depend on the position of the project on the priority list. The timing for Design to receive recommended pavement design data varies from 2-3 weeks to 2-3 months. –ID

Recommend having an operational budget for FWD for calibrations and other testing not associated with a specific design project. –MD

We have our system level testing scheduled on a 4 year or 6 year cycle, based on AADT. –UT

A report on FWD field tests should be submitted within 3 calendar days after completion of the field work. Measures on quality assurance and calibration of equipment should be provided. –ON

Other Comments

We follow the SHRP procedure for relative calibration (i.e. 5 drops per set, 7 sets). The load level used is as needed to develop the 20 mil deflection specified. –ID

Looking for criteria for AASHTO deflection analysis to include embankment in total pavement thickness when embankment modulus is much higher than soils (i.e. 3 times). -UT