FINAL REPORT

For the Florida Department of Transportation

Development of an Automated Procedure for Implementing Resilient Modulus Test for Design of Pavement Structures in Florida

FDOT Research Contract No.: BC-352-11

FSU Project No.: 6120-580-39

by

W. V. Ping, P.E.

Zenghai Yang

Department of Civil & Environmental Engineering

Florida A&M University – Florida State University

COLLEGE OF ENGINEERING

Tallahassee, FL 32310

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DISCLAIMER

"The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Department of transportation or the U.S. Department of Transportation. This report is prepared I cooperation with the State of Florida Department of Transportation and The U.S. Department of Transportation."

METRIC CONVERSIONS

inches = 25.4 millimeters

feet = 0.305 meters

square inches = 645.1 millimeters squared

square feet = 0.093 meters squared

cubic feet = 0.028 meters cubed

pounds = 0.454 kilograms

poundforce = 4.45 newtons

poundforce per square inch = 6.89 kilopascals

pound per cubic inch = 16.02 kilograms per meters cubed

Technical Report Documentation Page

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16. Abstract

The resilient modulus (MR) of pavement materials is an essential parameter for mechanistically based pavement design procedure. Conducting the MR test in a triaxial chamber is a time consuming task and calls for skill and carefulness. Besides running the test, the engineer needs to spend a lot of time in designing spreetsheets, entering data, consulting complementary protocols and eventually performing the statistical analysis and printing final reports. It is also inconvenient to maintain these Excel files and difficult to search the data from these files. The amount of time and effort in conducting the MR test and manipulating the test results could be significantly saved by using a computerized software program. The reliability of the test results could also be improved accordingly.

A resilient modulus database, Soil Lab Assistant (SLA) was developed to store the available MR test results and to facilitate soil resilient modulus evaluation and pavement design. The Soil Lab Assistant is a software application, written in Visual Basic 6, that was conceived as a way of assisting soil lab technicians to run the soil triaxial test, analyze the test data, store the final test results to the data base, retrieve data from data base, and produce final test reports. The development and application of the SLA were described and summarized in this report.

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The FDOT Research Center, through the assistance of Richard Long and his staff, provided financial and contractual support. David Horhota, State Geotechnical Materials Engineer with the State Materials Office, and his staff (Summer Hartley and others) provided strong support to this research study.

EXECUTIVE SUMMARY

The resilient modulus (MR) of pavement materials is an essential parameter for mechanistically based pavement design procedure. Conducting the MR test in a triaxial chamber is a time consuming task and calls for skill and carefulness. Besides running the test, the engineer needs to spend a lot of time in designing spreadsheets, entering data, consulting complementary protocols and eventually performing the statistical analysis and printing final reports. It is also inconvenient to maintain these Excel files and difficult to search the data from these files. The amount of time and effort in conducting the MR test and manipulating the test results could be significantly saved by using a computerized software program. The reliability of the test results could also be improved accordingly.

A resilient modulus database, Soil Lab Assistant (SLA) was developed to store the available MR test results and to facilitate soil resilient modulus evaluation and pavement design. The Soil Lab Assistant is a software application written in Visual Basic 6, that was intended as a way of assisting soil lab engineers to run the soil resilient modulus triaxial test, analyze the test data, store the final test results to a database, retrieve data from the database, and produce final test reports. The development and application of the SLA were described and summarized in this report.

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The 1993 AASHTO Guide for Design of Pavement Structures has incorporated the resilient modulus (MR) of component materials into the design process. Considerable attention has also been given to development of mechanistic-empirical approaches (AASHTO Pavement Design Guide) for design and evaluation of pavements. Both the 1993 Guide and all mechanistic based approaches use the resilient modulus of each layer in the design process.

Conducting the MR test in a triaxial chamber is a time consuming task and calls for skill and carefulness. Failure of doing the checks as specified in the protocol will result in unreliable MR data. Besides running the test, the engineer needs to spend a lot of time in designing spreadsheets, entering data, consulting complementary protocols and eventually performing the statistical analysis and printing final reports. The amount of time and effort in conducting the MR test could be significantly saved by using a computerized software program. The reliability of the test results could also be improved accordingly.

In Florida, several research projects in the past ten years have been conducted to study the resilient modulus characteristics of Florida pavement soils. The MR test procedure and the selection of an appropriate design M_R value for pavement materials have always been significantly complicated by the fact that the MR of the material is affected by many factors: soil type, test method, specimen moisture and density, specimen size, confining pressure, deviator stress, etc. One

soil specimen may have many different resilient modulus values depending on the states of stresses.

More than two hundred laboratory triaxial resilient modulus tests on Florida soils have been conducted in the previous studies. These test results with other basic physical properties such as optimum moisture, maximum density, plasticity, classification, (Limerock Bearing Ratio) LBR, permeability, etc. have been saved on the computers in Microsoft Excel table format. It is inconvenient to maintain these files and difficult to manipulate the data from these files. A database for these test results is needed.

In this study, a resilient modulus database, Soil Lab Assistant (SLA), was developed to store the available MR test results and to facilitate soil resilient modulus evaluation and pavement design. The Soil Lab Assistant (SLA) is a software application written in Visual Basic 6, that was intended as a way of assisting soil lab engineers to run the soil resilient modulus triaxial test, analyze the test data, store the final test results to a database, retrieve data from the database, and produce final MR test reports. The development and application of the SLA are described and summarized in this report.

Chapter 2. Database Development

2.1 General

This chapter describes the development of the database information system. The development process was started first to clarify the user requirements of the application. Then the entities and relationships were defined for the relational database model. The database was implemented using Microsoft Access.

2.2 Specifying Requirements

For an information system to be useful, it must record and manipulate information that is important to its users. The information must be accurate and complete. The ideas and opinions of the users must be converted into the working information system. Several research meetings were held with the professional engineers and application users of the Florida Department of Transportation (FDOT), the sponsor of this research project, to discuss what information must be stored and how that information is likely to be used. An important part of the discussion is determining the vocabulary that is used to describe the objects and operations. Adopting the user's vocabulary makes it much easier for the user to adopt and use the final system.

Documents about soil materials properties and different kinds of soil tests were evaluated. These documents include:

(1) FDOT sample transmittal card (Form 675-050-04) (Figure 2.1)

(2) Test report for Standard Method of Test for Determining the Resilient Modulus of Soils and Aggregate Materials. AASHTO Designation T 292 and T294 (Figure 2.2).

(3) Test report for Standard Method of Test for Determining the Resilient Modulus of Soils and Aggregate Materials. AASHTO Designation T 307-99 (Figure 2.3).

(4) Test report for Particle Size Analysis (Hydrometer), FM 1-T88, used by State Material Office, Soil Laboratory, Florida Department of Transportation (Figure 2.4).

(5) Test report for Liquid Limit/Plastic Index of Soils (T89/90), used by State Material Office, Soil Laboratory, Florida Department of Transportation (Figure 2.5).

(6) Test report for 6" standard and modified Proctor and LBR used by State Material Office, Soil Laboratory, Florida Department of Transportation (Figure 2.6).

(7) Test report for Flexible Wall Permeability (ASTM D 5084) (Figure 2.7).

Base on the above collected information, the information content of the database were specified and the following database model was established.

2.3 Relational Database Model

The relational database model is a conceptual model that describes data as entities, attributes, and relationships. It represents data in the form of two-dimension tables. Each table represents an entity about which information is collected, and is a set of

records, where a record in turn is a set of fields and each field is a paired field-name/field-value. All records in a particular table have the same number of fields with the same field-names. The characteristics of a relational model are as following.

Values are atomic.

Column values are of the same kind.

Each row is unique.

The sequence of columns is insignificant.

The sequence of rows is insignificant.

Each column must have a unique name.

All values in a column come from the same domain.

2.3.1 Entity and attribute

An entity is a distinguishable objective that exists. Entities are concepts, real or abstract, about which information is collected. Attributes are properties, which describe the entities. A particular instance of an attribute is a value. Each entity has associated with it a set of attributes describing it.

The investigation process that was described in section 2.2 identified specific objects that must be stored and managed in the Soil Laboratory database. The firs step in database modeling is to name and describe the classes of those objects. Figure 2.8 summarizes all of the entity classes and their attributes for this data base. Each attribute is characterized by a name, a data type, a field size, and a description.

2.3.2 Relationship and key

A relationship is an association between two or more tables. Relationships are expressed in the data values of the primary and foreign keys. A primary key is a column or columns in a table whose values uniquely identify each row in a table. A foreign key is a column or columns whose values are the same as the primary key of another table. A foreign key can be considered as a copy of the primary key from another relational table. The relationship is made between two relational tables by matching the values of the foreign key in one table with the values of the primary key in another. Keys are fundamental to the concept of relational databases because they enable tables in the database to be related with each other. Navigation around a relational database depends on the ability of the primary key to unambiguously identify specific rows of a table. Navigating between tables requires that the foreign key is able to correctly and consistently reference the values of the primary keys of a related table.

Figure 2.9 shows the entity-relationship model of this database information system that is implemented using Microsoft Access. This figure includes entities and their attributes, keys of each entity, and relationships between the entities. The attributes whose names are bold are the keys of their entities. The types of the relationships are represented in Figure 2.9 by the symbols ‘1’ and ‘∝’ that appear above the relationship line. Two basic relationships exit in this database, one to one relationship and one to many relationships.

One to one relationship is represented by the symbols ‘1’ appearing above the relationship line at both ends. In a one-to-one relationship, each record in Table

A can have only one matching record in Table B and each record in Table B can have only one matching record in Table A. For example, one kind of material can only have one modified Proctor test recorded in the database.

One to many relationships is represented by the symbol ‘1’ appearing above the relationship line at one end and the symbol ‘∝’ at the other end. In a one-to-many relationship, a record in Table A can have many matching records in Table B, but a record in Table B has only one matching record in Table A. For example, one modified Proctor test needs several compaction tests at different moisture contents.

2.3.3 Data integrity

Data integrity means, in part, that you can correctly and consistently navigate and manipulate the tables in the database. There are two basic rules to ensure data integrity: entity integrity and referential integrity.

The entity integrity rule states that the value of the primary key can never be a null value (a null value is one that has no value and is not the same as a blank). Because a primary key is used to identify a unique row in a relational table, its value must always be specified and should never be unknown. The integrity rule requires that insert, update, and delete operations maintain the uniqueness and existence of all primary keys.

The referential integrity rule states that if a relational table has a foreign key, then every value of the foreign key must either be null or match the values in the relational table in which that foreign key is a primary key.

In Microsoft Access, referential integrity is a system of rules to ensure that relationships between records in related tables are valid, and that you don't

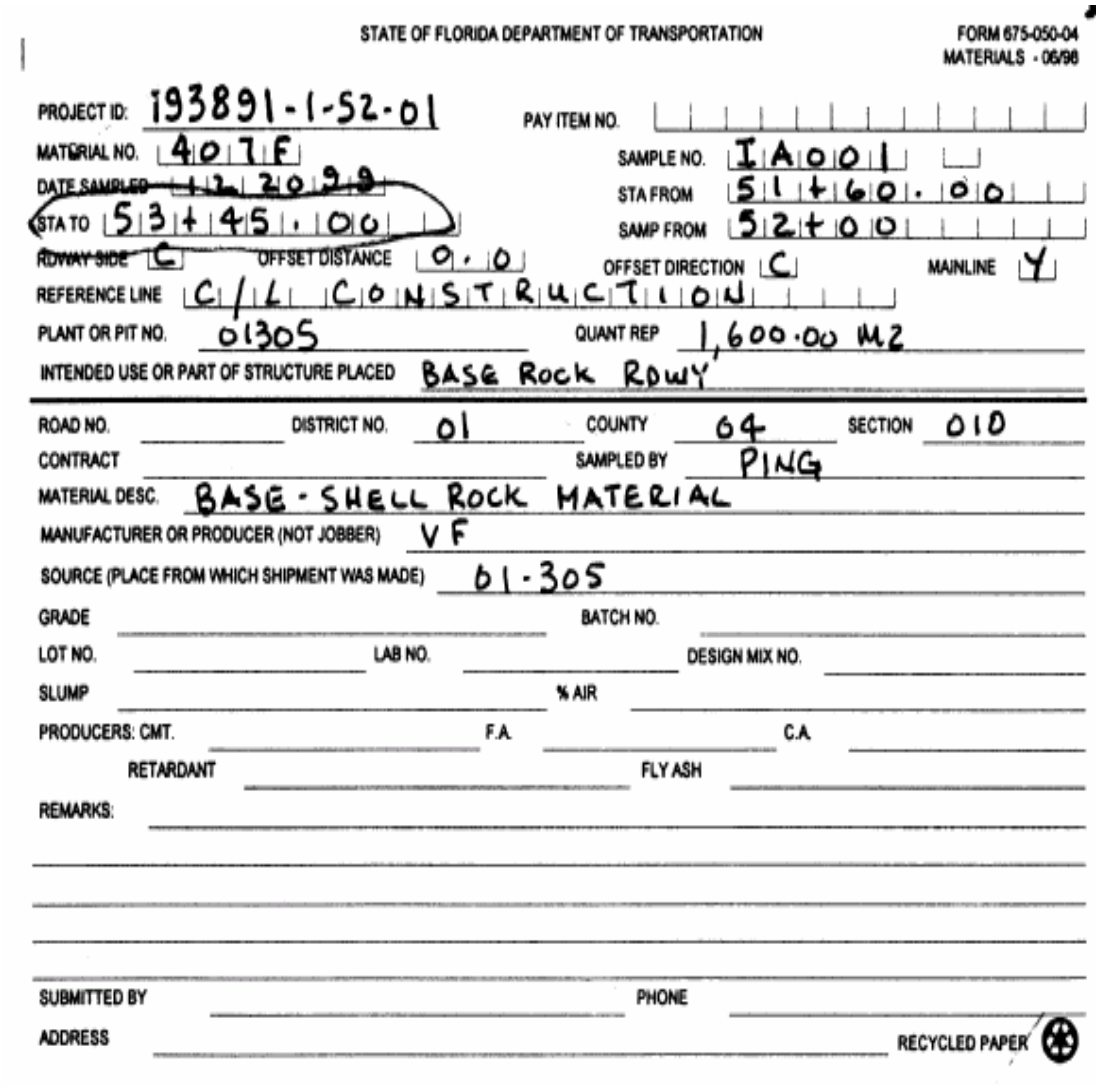
accidentally delete or change related data. When referential integrity is enforced, the following rules will be observed.

A value in the foreign key field of the related table cannot be entered if that value doesn't exist in the primary key of the primary table. However, you can enter a Null value in the foreign key, specifying that the records are unrelated. For example, a test cannot be done by a worker that doesn't exist in the worker table. But the WorkerID field in the test table can be Null value, which means the worker who did the test is not known.

A record from a primary table can't be deleted if matching records exist in a related table. For example, you can't delete a material record from the Material table if there are different tests of that material recorded in other tests table. This restriction can be overridden and referential integrity is still preserved by setting the Cascade Delete Related Records check boxes (Figure 2.10). When the Cascade Delete Related Records check box is set, deleting a record in the primary table deletes any related records in the related table.

A primary key value in the primary table can't be changed, if that record has related records. For example, you can't change a material's ID in the Material table if there are tests of that material recorded in other test tables. These restrictions can be overridden and referential integrity is still preserve by setting the Cascade Update Related Fields check boxes (Figure 2.10). When the Cascade Update Related Fields check box is set, changing a primary key value in the primary table automatically updates the matching value in all related records.

Figure 2.1 FDOT sample transmittal card (Form 675-050-04)



STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FORM 675-050-04
MATERIALS - 06/98

PROJECT ID: 193891-1-52-01 PAY ITEM NO.

MATERIAL NO. 407F SAMPLE NO. IA001

DATE SAMPLED 1-12-2009 STA FROM 51+60.00

STA TO 53+45.00 SAMP FROM 52+00

RDWAY SIDE C OFFSET DISTANCE 0.0 OFFSET DIRECTION C MAINLINE Y

REFERENCE LINE C/L CONSTRUCTION

PLANT OR PIT NO. 01305 QUANT REP 1,600.00 M2

INTENDED USE OR PART OF STRUCTURE PLACED BASE Rock RDWY

ROAD NO. DISTRICT NO. 01 COUNTY 04 SECTION 010

CONTRACT SAMPLED BY PING

MATERIAL DESC. BASE - SHELL ROCK MATERIAL

MANUFACTURER OR PRODUCER (NOT JOBBER) VF

SOURCE (PLACE FROM WHICH SHIPMENT WAS MADE) 01-305

GRADE BATCH NO.

LOT NO. LAB NO. DESIGN MIX NO.

SLUMP % AIR

PRODUCERS: CMT. F.A. C.A.

RETARDANT FLY ASH

REMARKS:

SUBMITTED BY PHONE

ADDRESS

RECYCLED PAPER

Figure 2.2 Test report for AASHTO T 292 and T294 Test Method for Determining the Resilient Modulus of Soils and Aggregate Materials

	Summary of Resilient Modulus Test Results						
Test Type	**T292-91I**				**Soil Identification**		
Date:	9/26/1995				Subgrade (Fine Sand)		
Sample:	2A1BSS1				S.R.884		
Mold:	# 1				Lee County, Site #1		
Lab.Moist:	12.0%				Opti. Moist	12.0%	
Lab.Den.	16.29	kN/m^3			Opti. Den.	16.35	kN/m^3
Compaction Effort:		30 blows/layer					
					Conditioning Information		
					Load Type	Dynamic	
					Dev. σ	82.74	kPa
					Conf. σ	103.42	kPa
					No. Reps.	1000	

Confining Pressure	Axial Load	Dev. Stress	Bulk Stress	Middle Strain	Total Strain	Middle Modulus	Full Length Modulus
kPa	kN	kPa	kPa			MPa	MPa
103.42	0.375	46.263	356.523	0.00016	0.00019	291.670	240.939
103.42	0.544	67.056	377.316	0.00024	0.00028	283.376	240.546
103.42	0.825	101.728	411.988	0.00035	0.00041	287.017	246.005
68.95	0.264	32.535	239.385	0.00013	0.00017	249.886	193.523
68.95	0.377	46.490	253.340	0.00019	0.00024	242.539	193.696
68.95	0.544	67.101	273.951	0.00028	0.00035	239.031	192.657
68.95	0.824	101.662	308.512	0.00041	0.00050	247.607	201.911
34.47	0.151	18.685	122.095	0.00009	0.00014	201.293	137.129
34.47	0.265	32.677	136.087	0.00017	0.00024	189.547	137.003
34.47	0.376	46.422	149.832	0.00025	0.00033	186.025	139.042
34.47	0.546	67.307	170.717	0.00035	0.00047	191.015	144.356
13.79	0.151	18.683	60.053	0.00013	0.00019	144.455	96.223
13.79	0.265	32.669	74.039	0.00023	0.00032	142.733	100.572
13.79	0.377	46.556	87.926	0.00031	0.00044	150.434	106.698

Figure 2.3 Test report for AASHTO T 307-99 Test Method for Determining the Resilient Modulus of Soils and Aggregate Materials

RESILIENT MODULUS TEST RESULTS

SOILS LABORATORY, FAMU-FSU COLLEGE OF ENGINEERING

SAMPLE ID:	365002	TEST NO:	2
PROJECT ID:		SPECIMEN PREPARATION DATE:	6/9/2004
LAB NO:	21391-S	SPECIMEN DIAMETER, TOP, (in):	4
SOIL CLASS:	A-3	SPECIMEN DIAMETER, MIDDLE, (in):	4
LBR	33	SPECIMEN DIAMETER, BOTTOM, (in):	4
MDF MAX DEN (pcf):	104.1	SPECIMEN HEIGHT (in):	8
MDF OPT MIS (%):	14.5	COMPACTION MC, (%):	14.3
% passing 200 sieve	6	COMPACTION DRY DEN, (pcf):	103.9
		MC AFTER TESTING, (%):	14.3
		TESTED BY:	Ginger Ling
		TEST DATE:	6/9/2004

PRECONDITION INFORMATION	
CONFINING STRESS (psi):	6
MAX. AXIAL STRESS (psi):	4
REPETITIONS:	500

REMARKS:

1. Water expels a lot during compaction.
2. Actual axial load waveform rings at peak for Seq. 1 ~ 5.

TEST SEQ. #	CONFINING STRESS	MAX. AXIAL STRESS	CONTACT STRESS	CYCLIC STRESS	BULK STRESS	RESILIENT STRAIN	RESILIENT MODULUS
	psi	psi	psi	psi	psi	in/in	psi
1	6	2.025382484	0.095035	1.930347	20.02538	9.2113E-05	20956.3829
2	6	4.011165159	0.1814808	3.829684	22.01117	0.00018205	21036.0526
3	6	6.042228392	0.4710055	5.571223	24.04223	0.00027289	20415.5706
4	6	8.02032707	0.6502089	7.370118	26.02033	0.00035337	20856.8156
5	6	10.00418901	0.9874846	9.016704	28.00419	0.00043082	20929.3629
6	4	1.998488185	0.1611729	1.837315	13.99849	0.0001188	15465.9911
7	4	4.001834459	0.3307713	3.671063	16.00183	0.00023286	15764.931
8	4	6.019999506	0.4959787	5.524021	18.02	0.00032326	17088.6414
9	4	8.022248089	0.641976	7.380272	20.02225	0.00040674	18144.8432
10	4	10.03519952	0.9833681	9.051831	22.0352	0.00047907	18894.6988
11	2	1.998213854	0.1705035	1.82771	7.998214	0.00015411	11859.4216
12	2	3.99497371	0.3491581	3.645816	9.994974	0.00027677	13172.5185
13	2	5.998594092	0.5327525	5.465842	11.99859	0.00038868	14062.5297
14	2	8.012093949	0.6680469	7.344047	14.01209	0.00048164	15248.0521
15	2	10.01626433	0.9866613	9.029603	16.01626	0.00058537	15425.3868

Figure 2.4 FDOT Test Report for Particle Size Analysis (Hydrometer), FM 1-T88

Foundation Laboratory	FM 1-T 88 Particle Size Analysis (Hydrometer)	Effective Date: March 19, 2001 By: SW Page 1 of 1

Sample No. : Ginger 1 Original Sample 289.20 GM LAB NO.: **21697-S**

Spec. Grav. : corrected 287.83 Minus #10 MAT. 289.20 GM 100.00 % passing

TESTED BY: AW DATE 10/5/2004 corrected 287.83

Liquid Limit: NP Plastic: NP Index: NP SOILCLASS: A-2-4

SIEVE ANALYSIS

Sieve Analysis	3/4"	1/2"	3/8"	#4	#10	#40	#60	#100	#200
Wt. Retained					0.00	18.37	49.06	80.25	96.53
% Retained	0.00	0.00	0.00	0.00	0.00	16.85	45.00	73.60	88.53
% Finer	100.00	100.00	100.00	100.00	100.00	83.15	55.00	26.40	11.47
% Finer (Total)	100	100	100	100	100	83	55	26	11

HYGROSCOPIC MOISTURE, W

Tare No.	60
Tare + Air Dry Soil	129.84
Tare + Oven Dry Soil	129.79
Wt. Water	0.05
Tare Wt.	119.27
Oven Dry Wt.	10.52
Hygroscopic Moisture, *W*	0.475
Correction Factor (100/(100+*W*)	0.9953

HYDROMETER ANALYSIS composite correction for hydrometer id# 89-20545

(For Hydrometer 152H) Time Start

Elapsed Time	2	5	15	30	60	250	1440	2880
Temperature (°f)								
Hydrometer Reading								
Composite Correction	0	0	0	0	0	0	0	0
Corrected Reading (Ra)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Grain Diameter (mm)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
% Finer = (Ra/Wx)100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Finer (Total)	0	0	0	0	0	0	0	0

MINUS #10 MATERIAL

Tare No.	65
Tare + Air Dry	229.43
Tare Wt.	119.88
Air Dry Wt.	109.55
Oven Dry Wt.(Wx)	109.03

<.002=clay, .002-.075=silt, >.075=sand .075-#200, .025-#60, .045-#40, 2.0-#10, 4.75-#4

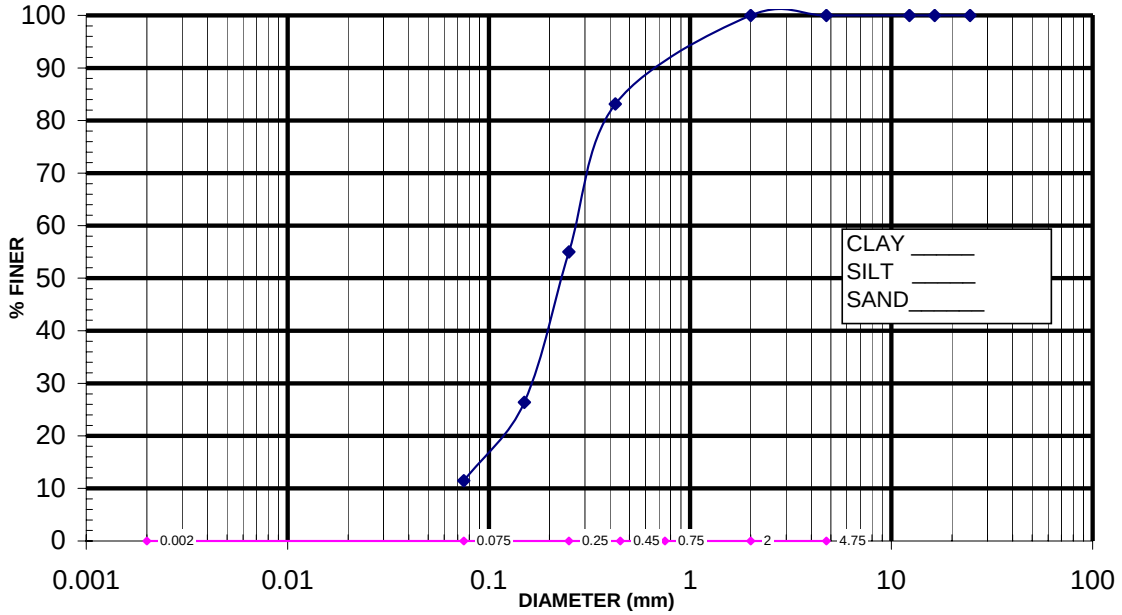


Figure 2.5 FDOT Test Report for Liquid Limit/Plastic Index of Soils (T89/90)

Foundations Laboratory	T-89/90 Liquid Limit/ Plastic Index of Soils	Effective Date:	4-Jan-01
		By: SW	Page 1 of 1

Project No.
Lab No. 21698-S
Sample No. Ginger 2
Location
Depth

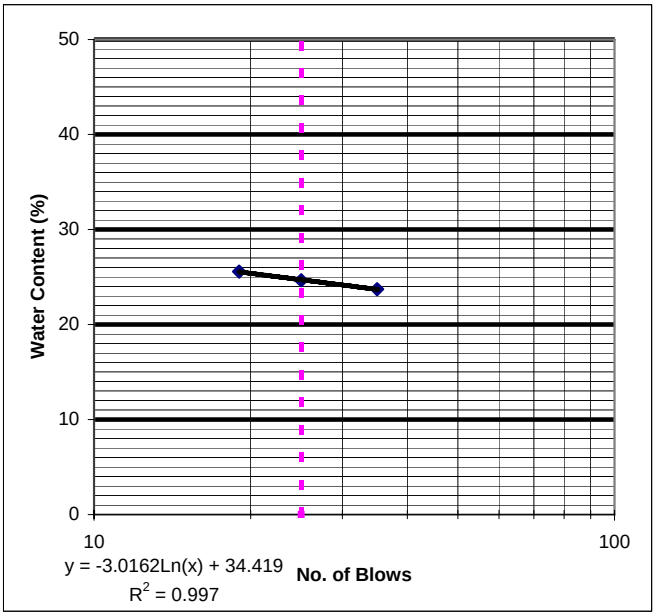
Date 10/5/2004
Tested By AW
Description light orange sand w/clay

Liquid Limit

Tare No.	Wet Weight + Tare (gm)	Dry Wt. + Tare (gm)	Wt. Water (gm)	Tare Wt. (gm)	Dry Wt. (gm)	Water Content (%)	No. of Blows
108	50.38	47.69	2.69	36.35	11.34	23.72	35
78	49.11	46.28	2.83	34.8	11.48	24.65	25
76	47.44	44.86	2.58	34.77	10.09	25.57	19

Plastic Limit

Tare No.	Wet Weight + Tare (gm)	Dry Wt. + Tare (gm)	Wt. Water (gm)	Tare Wt. (gm)	Dry Wt. (gm)	Water Content (%)
12	42.07	40.89	1.18	34.45	6.44	18.32



Summary

Liquid Limit, LL	25
Plastic Limit, PL	18
Plasticity Index, PI	6

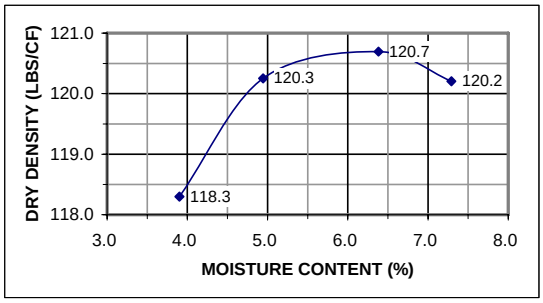
Remarks

Figure 2.6 FDOT Test report for 6” standard and modified Proctor and LBR

6" STD & 6" MOD PROCTOR AND LBR	FLORIDA DEPARTMENT OF TRANSPORTATION STATE MATERIALS OFFICE SOILS LABORATORY	EFFECTIVE BY:	6/10/2003 T.A.B.

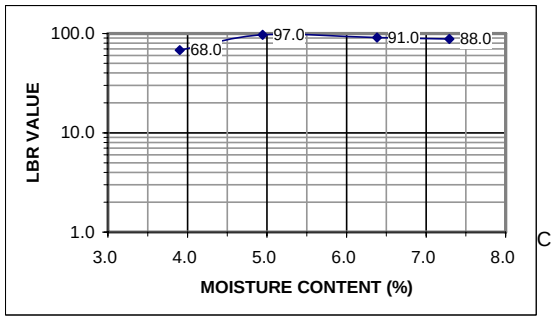
LAB. NR:	21697-S	**PROJECT**	LBR- FSU		
SAMPLE NR:		**DESCRIPTION:**	DR. PING		
SAMPLE DATE:					
MATERIAL NR:	020	**SOIL DESCRIPTION:**	RED/TAN SND/CL	**GRAD PASS #3 1/2:**	100
PIT NUMBER:		**SOIL CLASS:**	A-2-4	**GRAD PASS #4:**	100
DATE COMPACTED:	10/14/2004	**MAX. DENSITY:**	120.7	**LIQUID LIMIT:**	NP
DATE TESTED:		**OPT. MOISTURE %:**	6.4%	**PLASTIC INDEX:**	NP
TECHNICIAN:	MIKE DAVIS	**LBR VALUE:**	97 @ 4.9%	**CARB. CONTENT:**	

MOLD NR.	215	193	208	146
WATER (C.C)	4	5	6	7
W.W=M(GR.)	11295	11418	11478	11551
W.W+M(LBS)	24.90	25.17	25.30	25.47
MOLD WT. (LBS)	15.67	15.70	15.67	15.79
W.W (LBS)	9.23	9.47	9.63	9.68
W.U.WT.(LBS C/F)	123.0	126.2	128.4	129.0
D.U.WT (LBS C/F)	118.3	120.3	120.7	120.2
LBR	68.0	97.0	91.0	88.0
REC #	6	5	7	6



MOISTURE DETERMINATION

CAN NR.	21	26	70	G-2
CAN +W.S (GR)	610.1	587.3	637.1	646.9
CAN +D.S.(GR)	590.1	563.3	603.4	608.0
WT.WATER (GR)	20.0	24.0	33.7	38.9
WT. CAN(GR)	77.6	77.9	75.5	74.5
WT.D.S. (GR)	512.5	485.4	527.9	533.5
MOIST. CONT. (%)	3.9	4.9	6.4	7.3



C

Figure 2.7 Test report for Flexible Wall Permeability (ASTM D 5084)

FLEXIBLE WALL PERMEABILITY WORKSHEET

LAB # 21433

MATERIAL DESCRIPTION: 4" pore stones 24% -200

$w_{i=}$ _____ $wf_{=}$ _____

SAMPLE DIMENSIONS:

LENGTH(in.): 2.1

DIAMETER(in.): 4.0

AREA(in^2): 12.608717

Test Date	CHAMBER READINGS			INFLOW BURETTE			OUTFLOW BURETTE			TEST TIME (sec)	GRADIENT	PERMEABILITY (cm/sec.)
	CELL PRESSURE (psi)	BACK PRESSURE (psi)	B VALUE	PRESSURE (PSI)	Ht. H_2O INITIAL (cm)	Ht. H_2O FINAL (cm)	PRESSURE (psi)	Ht. H_2O INITIAL (cm)	Ht. H_2O FINAL (cm)			
11/19/2004	87	80	0.99	81	0.3	12.6	80	24.9	12.7	1320	15.67	7.34E-06
				81	12.6	16.0	80	12.7	9.2	520.00	12.69	6.43E-06
				81	0.5	13.4	80	24.9	11.9	1260	15.50	8.22E-06
				81	13.4	22.1	80	11.9	3.2	1260.00	11.39	7.50E-06
											average=	7.37E-06
11/22/2004	87	80		81	0.4	11.0	80	24.5	14.0	1080.00	15.89	7.60E-06
				81	11.0	20.8	80	14.0	4.2	1380.00	12.04	7.31E-06
				81	0.3	23.3	80	25.0	1.7	3420.00	13.62	6.33E-06
				81	0.2	6.8	80	24.9	18.2	720.00	16.75	6.79E-06
											average=	7.01E-06
11/29/2004	94	80		81	0.3	15.0	80	24.7	10.0	2460.00	15.16	4.90E-06
				81	15.0	21.0	80	10.0	4.9	3600.00	11.33	1.68E-06
				81	0.1	21.9	80	24.3	2.3	7680	13.76	2.63E-06
				81	0.7	16.7	80	24.5	8.5	4200	14.80	3.21E-06
											average=	3.10E-06
12/8/2004	101	80		81	0.3	12.2	80	25.1	13.1	4080	15.76	2.30E-06
				81	0.1	12.2	80	24.9	12.8	3960	15.73	2.40E-06
				81	0.3	17	80	25	8.2	6120	14.83	2.30E-06
				81	0.4	9.6	80	24.8	15.5	2820	16.20	2.50E-06
											average=	2.38E-06

Figure 2.8 Entities and their Attributes

Entities	Attributes	Data Type	Field Size	Constraints	Description
Material					
	SampleID	Text	50	Key	
	MaterialID	Text	50		
	SampleLevel	Text	50		Base, Subbase, Subgrade, or Embankment
	SampledByID	Text	50		Worker ID who sampled the material
	SampledDate	Text	50		Date when material are sampled
	LabNo	Text	50		Laboratory Number
	StationFrom	Text	50		Station No where the project begins
	StationTo	Text	50		Station No where the project ends
	SampleFrom	Text	50		Station No where the material is sampled
	RWSide	Text	50		North, South, East, or West
	OffsetDistance	Text	50		
	OffsetDirection	Text	50		
	MainLine	Text	50		Is the material on the Main Line (Yes / No)
	ReferenceLine	Text	50		
	PlantOrPitNo	Text	50		Plant or Borrow pit No
	QuantRep	Text	50		
	IntendedUse	Text	50		Intended Use
	RWID	Text	50		Road Way ID
	RWName	Text	50		Road Way Name
	County	Text	50		
	MP	Number	Double		Mile Post
	MaterialDesc	Text	50		Material Description
	Remarks	Text	50		
MRTest					MR Test from T292 and T294
	TestNo	Text	50	Key	
	SampleID	Text	50	Key	
	TestTime	Text	50		
	TestedByID	Text	50		Worker ID who run the MR test
	TestMethod	Text	50		T292, or T294
	SampleSize	Number	Single		Specimen Diameter
	TestMC	Number	Double		specimen moisture content under test
	TestDUW	Number	Double		specimen dry unit weight under test
MRTestData					
	SampleID	Text	50	Key	
	TestNo	Text	50	Key	
	ConfPressure	Number	Double	Key	Confining pressure
	AxialLoad	Number	Double	Key	Axial Laod
	DeviatorStress	Number	Double		Deviator Stress
	MiddleMR	Number	Double		MR from Middle LVDT
	FullMR	Number	Double		MR from full length LVDT

Figure 2.8 Entities and their Attributes (continued)

Entities	Attributes	Data Type	Field Size	Constraints	Description
MRTest307					MR test from T307 test procedure
	TestNo	Text	50	Key	
	SampleID	Text	50	Key	
	SpecimenPreparationDate	Text	50		
	SpecimenDiameterTop	Number	Single		Specimen Diameter at top
	SpecimenDiameterMiddle	Number	Single		
	SpecimentDiameterBottom	Number	Single		
	HeightOfSpecimen	Number	Single		
	CompactionMC	Number	Single		Compaction Moisture Content
	CompactionDUW	Number	Single		Compaction Dry Unit Weight
	MCAfterTesting	Number	Single		Moisture Content after Testing
	TestTime	Text	50		
	TestedByID	Text	50		
	TestMethod	Text	50		T307
	ConditioningRepetion	Number	Integer		Load cycles for the conditioning phase
	Remarks	Text	255		
MRTest307Data					
	SampleID	Text	50	Key	
	TestNo	Text	50	Key	
	ConfStess	Number	Double	Key	Confining Stress
	MaxAxiialStress	Number	Double	Key	Max. Axial Stress
	ContactStress	Number	Double		Contact Stress
	ResilientStrain	Number	Double		
	MR	Number	Double		Resilient Modulus
MdfProctor					Modified Proctor Test
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	MdfOMC	Number	Double		Modified Optimum Moisture Content
	MdfMDUW	Number	Double		Modified Max. Dry Unit Weight
MdfProctorData					
	SampleID	Text	50	Key	
	MC	Number	Double	Key	Moisture Content
	DUW	Number	Double		Dry Unit Weight
StdProctor					Standard Proctor Test
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	StdOMC	Number	Double		Standard Optimum Moisture Content
	StdMDUW	Number	Double		Standard Max. Dry Unit Weight
StdProctorData					
	SampleID	Text	50	Key	
	MC	Number	Double	Key	Moisture Content
	DUW	Number	Double		Dry Unit Weight
SieveAnalysisTest					Soil Sieve Analysis
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
SieveAnalysisData					
	SampleID	Text	50	Key	
	SieveNo	Text	50	Key	
	Opening	Number	Double		
	PassingPercentage	Number	Double		

Figure 2.8 Entities and their Attributes (continued)

Entities	Attributes	Data Type	Field Size	Constraints	Description
AtterbergTest					
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	LiquidLimit	Number	Double		
	PlasticLimit	Number	Double		
	ShrinkageLimit	Number	Double		
AASHTOClassification					
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	Classification	Text	50		
	SoilType	Text	50		
LBRTest					
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	LBRValue	Number	Double		
LBRTestData					
	SampleID	Text	50	Key	
	MC	Number	Double	Key	Moisture Content
	LBR	Number	Double		
PermeabilityTest					
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
	TestApproach	Text	50		Penel/Constant Head
	CompactedDUW	Number	Double		
	InitialDegreeOfSatuation	Number	Double		
	FinalDegreeOf Satuation	Number	Double		
	Permeability	Number	Double		
SuctionTest					
	SampleID	Text	50	Key	
	TestedByID	Text	50		
	TestDate	Text	50		
SuctionTestData					
	SampleID	Text	50	Key	
	MC	Number	Double	Key	Moisture Content
	SuctionValue	Number	Double		
Worker					Workers to get the material and do the test
	WorkerID	Text	50	Key	
	LastName	Text	50		
	FirstName	Text	50		
	MiddleName	Text	50		
	Title	Text	50		
User					Users of the this software
	UserName	Text	50		
	FirstName	Text	50		
	LastName	Text	50		
	PhoneNo	Text	50		
	Email	Text	50		
	Password	Text	50		

Figure 2.9 Entity-Relational Model

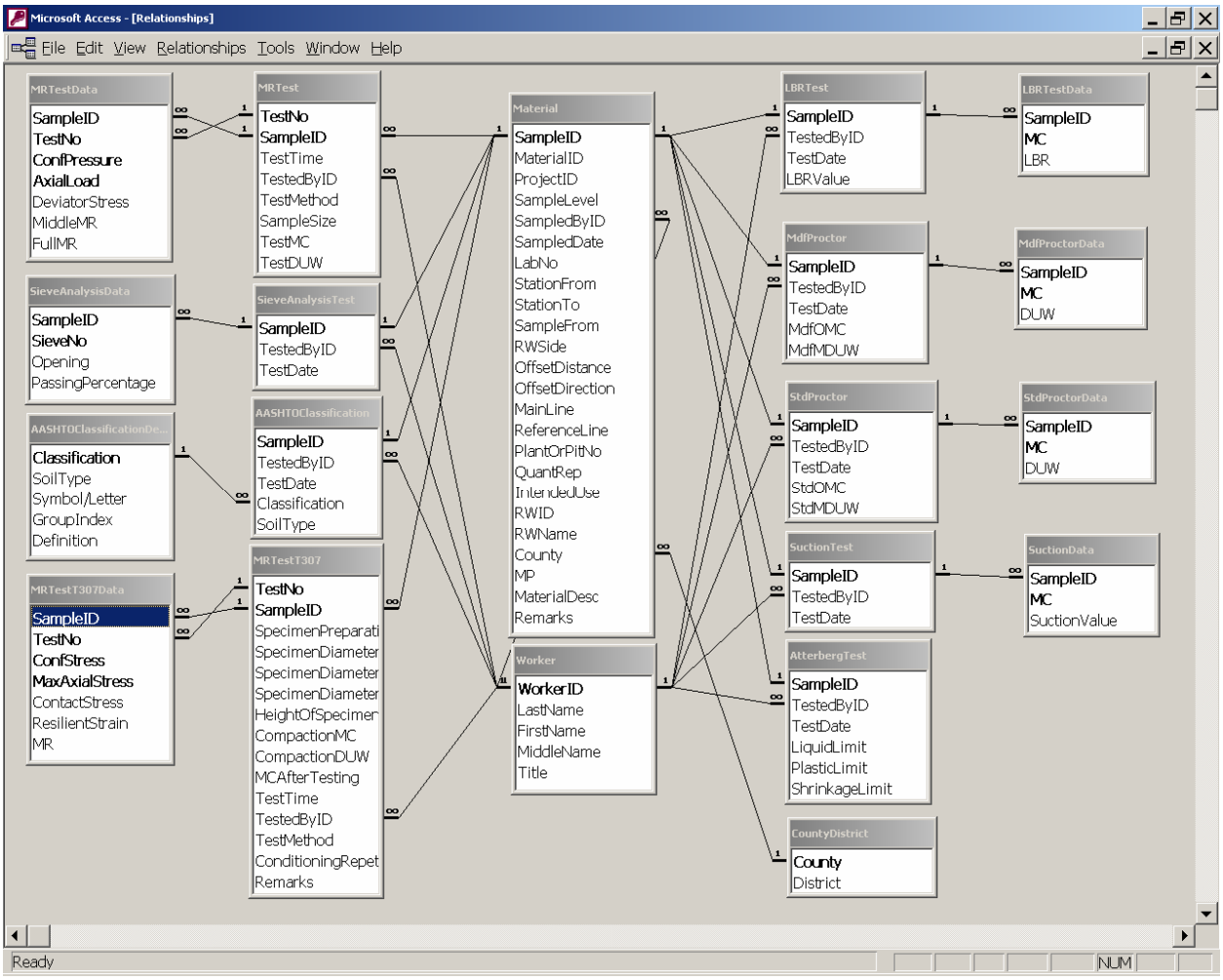
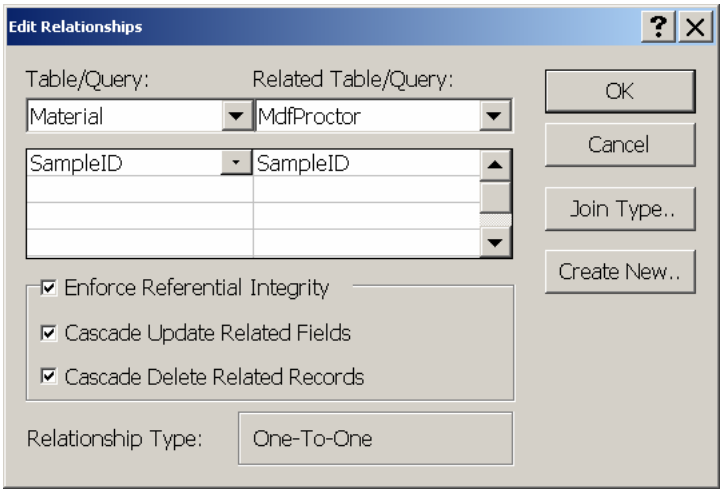


Figure 2.10 Enforced Referential Integrity



Chapter 3. Application Development

3.1 General

This software application was conceived as a way of assisting soil lab engineers to run soil tests, analyze the test data, store the final test results to the data base, retrieve data from data base, and produce final test reports. These soil tests include triaxial resilient modulus test, modified and standard Proctor tests, soil sieve analysis, Atterberg test, AASHTO classification, LBR test, permeability test, and soil suction test. To help the engineer to understand the resilient modulus concept and conduct the test, a comprehensive guideline on the resilient modulus test for soil and aggregate materials are provided using LTPP findings. The 1993 AASHTO Design Guide procedures for Design of Pavement Structures are implemented in this application. User logon is required to manipulate test results stored in the database.

The database system of this application is implemented using Microsoft Access. The application interfaces are developed using Microsoft Visual Basic 6.0. The test reports are produced using Microsoft Excel. The Visual Basic part of this application consists of a total of 41 forms/windows and about 6,000 lines of code. The guidelines on resilient modulus test are created using RoboHelp and Microsoft Frontpage. This documentation consists of more than one hundred of webpages and three video files and occupies about 430 Megabytes. The application is packaged to one exe file for easy installation using Wise Installation System 9.0. The entire system occupies 434 megabytes after compilation and packaging.

3.2 Main menu

The main menu of this application is shown in Figure 3.1. They include five items:

- System
- Database
- Pavement-Design
- MR-Test
- Help

Each main menu item contains a certain number of submenu items, as discussed below.

3.3 System

The submenu items of the System menu are shown in Figure 3.2, which include:

- Logon
- Change Password
- User Administration
- Database Backup
- Database Restore
- Exit

The Logon submenu is designed to protect the database from modification by unauthorized person. Logon is not required if the user just want browse the database or other information.

The Change Password submenu is designed to let the users change their password after they logon. The user passwords are encrypted and stored in the database.

The User Administration submenu is designed for the manager to administrate other users' accounts. A default account 'Manager' will be created when the program was run first time after installation. The user 'Manager' can create, delete user accounts and change password for the existing account.

The Database Backup and Database Restore submenu is designed to help the user to make a backup copy of the Microsoft Access Database file.

The Exit submenu is used to exit this application.

3.4 DATABASE

The submenu items of the Database menu are shown in Figure 3.3, which include:

- Material
- MR Test (T292, T294)
- MR Test (T307)
- Modified Proctor Test
- Standard Proctor Test
- Sieve Analysis Test
- Atterberg Test
- AASHTO Classification
- LBR Test
- Permeability Test
- Suction Test
- Worker
- Search

The flowing is a brief description of these submenus. The detail information about these submenus and how to use them can be found in the User's Guide.

Material This submenu is designed to input, browse, edit, and delete the information about the material. After the soil materials are brought to the laboratory, the first thing is to record the available information about the material, such as sample ID, project ID, location, material description, and the worker who sampled the material, etc. This submenu is corresponding to the 'Material' entity of the database.

MR Test (T292, T294) This submenu is designed to import, browse, edit and delete the previous resilient modulus test results which were conducted following AASHTO test protocol T292 and T294. This protocol is no longer used for testing the material and is substituted by the AASHTO test protocol T307. This submenu is corresponding to the MRTest and MRTestData entities of the database. An Excel summary report of each test can be produced from this submenu. The data can be browsed either in English unit system or in Metric unit system.

MR Test (T307) This submenu is designed to analyze the test results and input the resilient modulus data into the database after the resilient modulus test is finished based on the AASHTO test procedure T307. It is also used to browse and edit the resilient modulus test results. This submenu is corresponding to the MRTestT307 and MRTestT307Data entities of the database. An Excel summary report of each test can be produced from this submenu. The data can be browsed either in English unit system or in Metric unit system.

Modified Proctor Test, Standard Proctor Test, Sieve Analysis Test, Atterberg Test, AASHTO Classification, LBR Test, Permeability Test, Suction Test These submenus are used to input the respective test results into the database after each test is done. They are also used to browse and edit the respective test results. An Excel summary report of each test can be produced from these submenus.

Worker This submenu is used to store information about the workers who bring the materials into the laboratory or who did the test on the materials. This submenu is corresponding to the worker entity of the database.

Search This submenu is designed to find specific materials from the database based on different criteria. A search criterion can be any one or combination of the following: Sample ID, Project ID, Roadway, Roadway ID, District, County, Mile Post, Soil Type, AASHTO Classification, Test Date, Sample Size and Test Method.

3.5 Pavement Design

The 1993 AASHTO Guide for Design of Pavement Structures has incorporated the resilient modulus of component materials into the design process. This menu can be used to design pavement structures using the resilient modulus test result for a subgrade and base materials as per the AASHTO 1993 Guide recommendations. More information about the 1993 AASHTO Guide for Design of Pavement Structures can be found under the Help menu and then the MR Information submenu.

3.6 MR TEST

The MR TEST menu is designed to provide step by step information for running the resilient modulus test.

3.7 HELP

Two submenus are put under the Help menu. They are MR Information and Users Manual (Figure 3.4).

MR Information To help the laboratory engineer to understand the resilient modulus concept and conduct the resilient modulus test. The documents under this submenu provide comprehensive guidelines on the resilient modulus test for soil and aggregate materials using LTPP findings. This includes details on the usefulness of test results in pavement design, especially in a mechanistic context; the background and usefulness of the test procedure; and the techniques that can be used to reduce the within- and between-laboratory variability.

Users Manual The information about how to use this program is provided under this submenu.

Figure 3.1 Soil Lab Assistant Main Menu

Figure 3.2 System Menu

Figure 3.3 Database Menu

Figure 3.4 Help Menu

Chapter 4. Summary and Conclusion

4.1 Summary

The primary objective of this study was to develop an automation procedure for implementing resilient modulus test for design of pavement structures. To achieve the objective, a resilient modulus database software system, Soil Lab Assistant (SLA), was developed to store the available MR test results and to facilitate the soil resilient modulus evaluation and pavement design process.

For the development of the database, user requirements were collected and implemented into the database design process. The database system of this application was implemented using Microsoft Access. The application interfaces were developed using Microsoft Visual Basic 6.0. The test reports were produced using Microsoft Excel. The 1993 AASHTO Guide for Design of Pavement Structures was incorporated in this application for design of flexible pavements. A comprehensive guideline on the resilient modulus test for soil and aggregate materials was provided using the LTPP findings. The guidelines on the resilient modulus test were created using RoboHelp and Microsoft Frontpage. The SLA application was packaged to one EXT file for easy installation using Wise Installation System 9.0.

4.2 Conclusion

A resilient modulus database system, Soil Lab Assistant (SLA), was developed using Visual Basic 6.0 and Microsoft Access. The entities and relationships were defined for the relational database model. The SLA software application was

intended as a way of assisting soil lab engineers to run the soil resilient modulus and other tests, analyze the test data, store the final test results to the database, retrieve data from the database, and produce final test reports. A user's manual was provided for the Soil Lab Assistant (SLA) application.

The resilient modulus of component materials has been incorporated into the AASHTO pavement design process. The soil Lab Assistant can be used to design pavement structures using the resilient modulus test results for subgrade and base materials according to the AASHTO 1993 Guide for Design of Pavement Structures.

To help the laboratory engineers to understand the resilient modulus concept and conduct the resilient modulus test, comprehensive guidelines were provided on the resilient modulus test for soil and aggregate materials using the LTPP findings. The documents included details on the usefulness of test results in pavement design, especially in a mechanistic context; the background and usefulness of the test procedure; and the techniques that can be used to reduce the within – and between – laboratory variability.

Appendix A Users Manual

USER GUIDE TO

SOIL LAB ASSISTANT

Florida Department of Transportation

PAVEMENT DESIGN AND MANAGEMENT

TALLAHASSEE, FLORIDA

November 2005

CONTENTS

List of Figures

Chapter I: Introduction

The resilient modulus (M_R) of pavement materials is an essential parameter for mechanistically based pavement design procedure. The MR test procedure and the selection of an appropriate design M_R value for pavement materials have always been significantly complicated by the fact that the MR of the material is affected by many factors. Conducting the MR test in a triaxial chamber is a time consuming task and calls for skill and carefulness. Failure of doing the checks as specified in the protocol will result in unreliable MR data. Besides running the test, the engineer needs to spend a lot of time in designing spreadsheets, entering data, consulting complementary protocols and eventually performing the statistical analysis and printing final reports. The amount of time and effort in conducting the MR test could be significantly saved by using a computerized software program. The reliability of the test results could also be improved accordingly.

Soil Lab Assistant (SLA) is a software application written in Visual Basic 6, that was intended as a way of assisting soil lab engineers to run the soil resilient modulus triaxial test, analyze the test data, store the final test results to the database, retrieve data from the database, and produce final test reports.

Chapter II: Installation

It is easy to install the Soil Lab Assistant software. This software is packaged and distributed in only one executable file, SoilLabAssistantInstallation.EXE. This executable file installs all of the software files onto your computer hard-drive into the proper directories.

System Requirements

The following is a list of minimum computer equipment requirements that are required to run the Soil Lab Assistant software package:

Min. Processor: Intel Pentium or equivalent

Min. Operating System: Windows 9x, XP, 2000, 2003

Memory/Hard Disk: 64 Mb/800 Mb

Database: Microsoft Access

Applications: Microsoft Excel

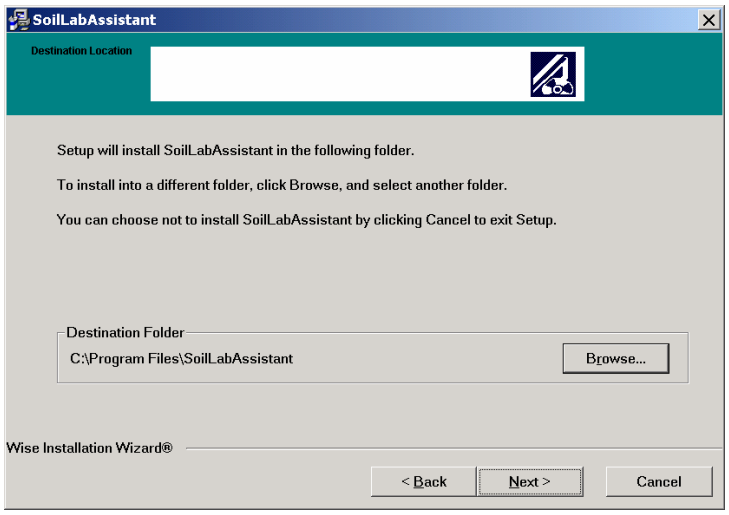
Installation steps

Very Important: Make sure that you have Windows 2000/2003/XP administrative permissions while installing the software.

Double click the file SoilLabAssistantInstallation.EXT on the CD. Then follow the instruction of the installation software.

When asked, input the directory or click the browse button to find the directory where you want the software installed. The default is C:\Program Files\SoilLabAssistant (Figure 1).

Figure 1. SoilLabAssistant Setup Window



Chapter III: Using Soil Lab Assistant

SYSTEM MANUAL

Logging On

If you just need to retrieve data from the database system, you do not need to logon. If you want to input new data into the database or modify the database, you need to logon to the system. Before logon, you need to have an account in the system.

When you try to logon to the system first time after the program was installed into the computer, the program will ask you to setup the password for the 'Manager' account. This account is a default account which will be used to administrate other user accounts on the system.

IMPORTANT: Keep the password of the Manager account in a safe place. Don't loose it.

To get a user account, contact the manager of this application.

Figure 2 is the first screen you will see when you start Soil Lab Assistant. To logon, click System, and then click Logon. Figure 3 will open. Select you user name, type your password. By clicking the <LogOn> button, Soil Lab Assistant will proceed to validate the username/password combination you've entered.

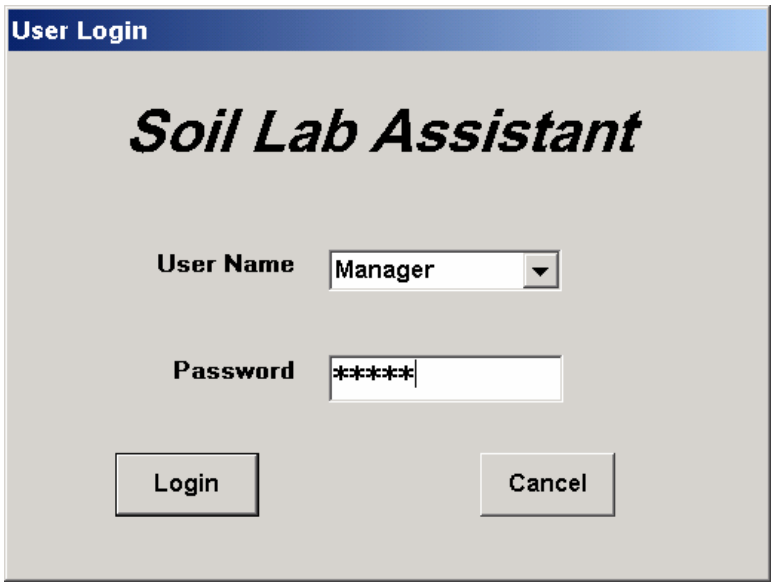
If the username and password you enter do not represent an authorized username/password combination, the software will display an error message. You are given three opportunities to re-enter the username and password before the application terminates.

Note: Your username **is not** case sensitive, but your password **is** case sensitive

Click the <Cancel> button to cancel the logon process of the application.

Figure 2. Soil Lab Assistant

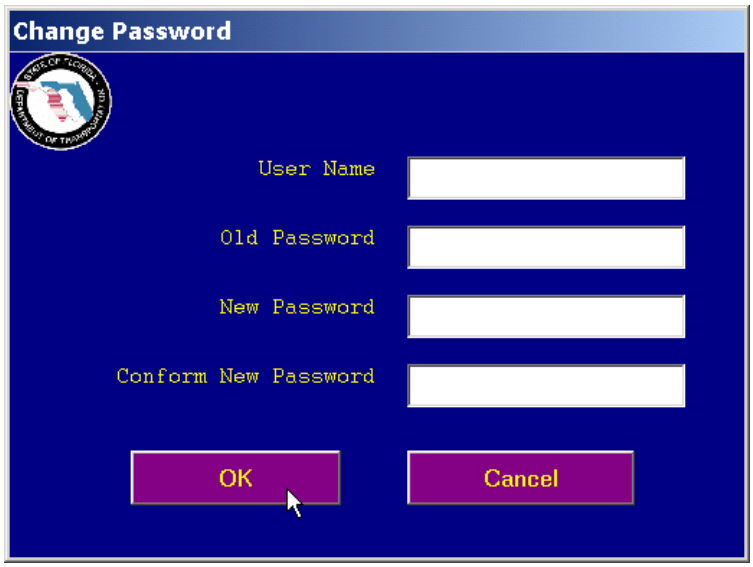
Figure 3. User Login



Change Password

Once you are logged in, you may change your password. Click System, then <Change Password>, Figure 4 opens. Filling out the fields accordingly, your password will be changed.

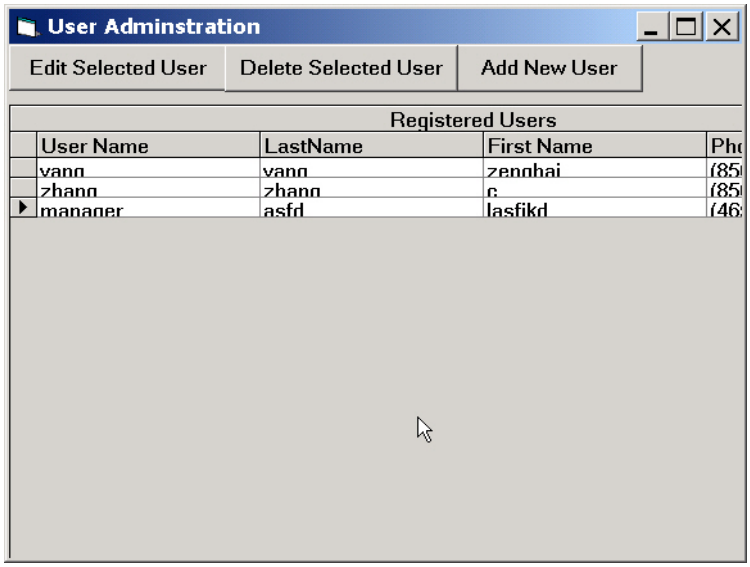
Figure 4. Change Password Window



User Administration

The manager, after logon, can add new users, delete users, and edit the users' information, including users' password. Clicking <System>, then <User Administration>, Figure 5 opens.

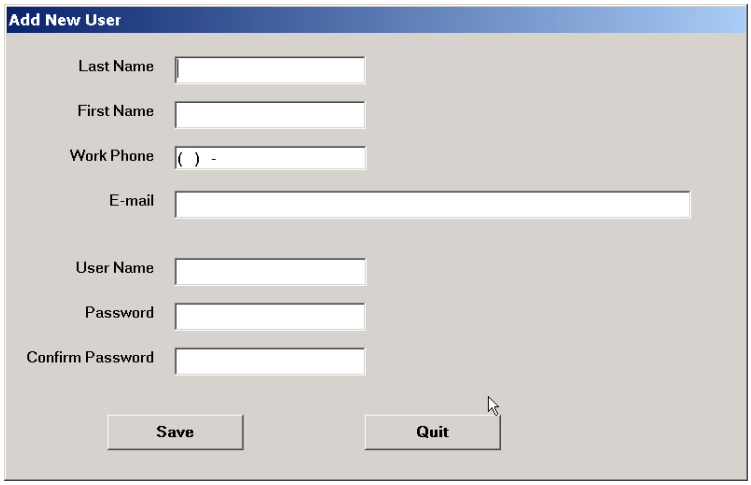
Figure 5. User Administration Window



❖ ***Add New User***

By clicking the <Add New User> button, Figure 6 shows up. Fill out the fields accordingly.

Figure 6. Add New User window



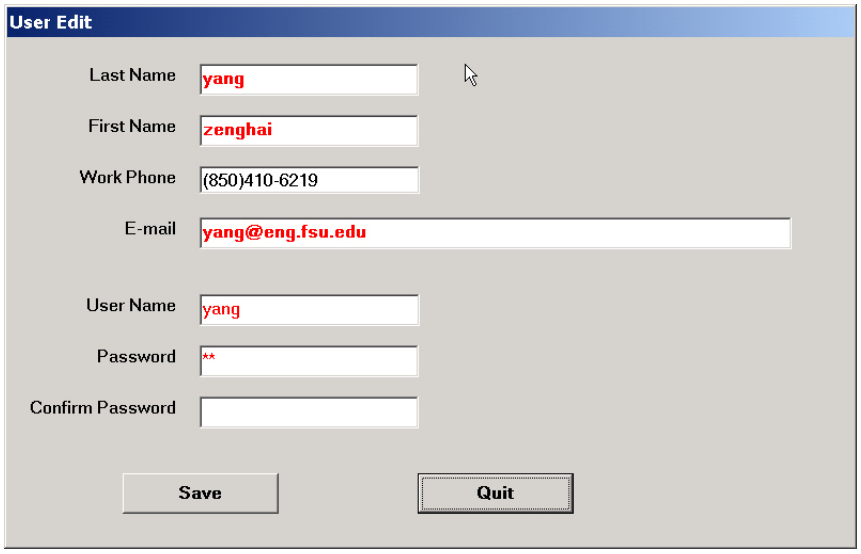
❖ ***Delete User***

By clicking the <Delete Selected User> button, the selected user will be deleted from the system.

❖ ***Edit User***

By clicking the <Edit Selected User> button, Figure 7 opens. The manager can edit the information about the user and can reset user's password.

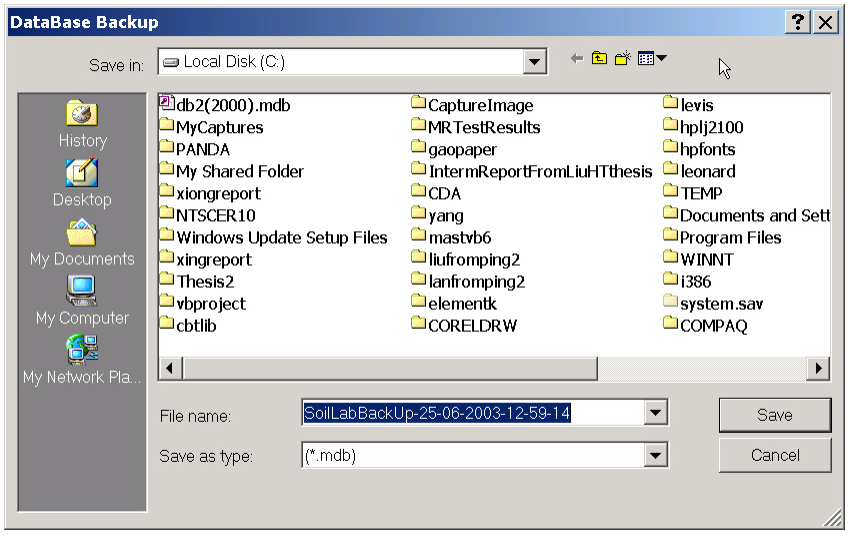
Figure 7. User Edit Screen



Database Backup

You can backup the database before you make any change to the database. Click <System>, then click <Database Backup>, Figure 8 shows up. You may backup the database to any location. Name the backup file and click <Save>. The default backup file name is defined by the backup time.

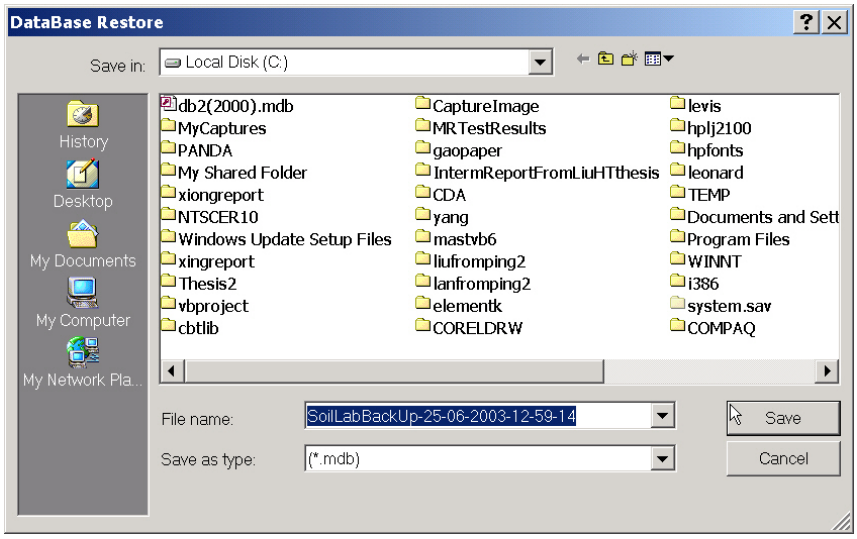
Figure 8. Backup Window



Database Restore

You can restore the backup database. Click <System>, then click <Database Backup>, Figure 9 shows up. Locate your backup database and click <Save>.

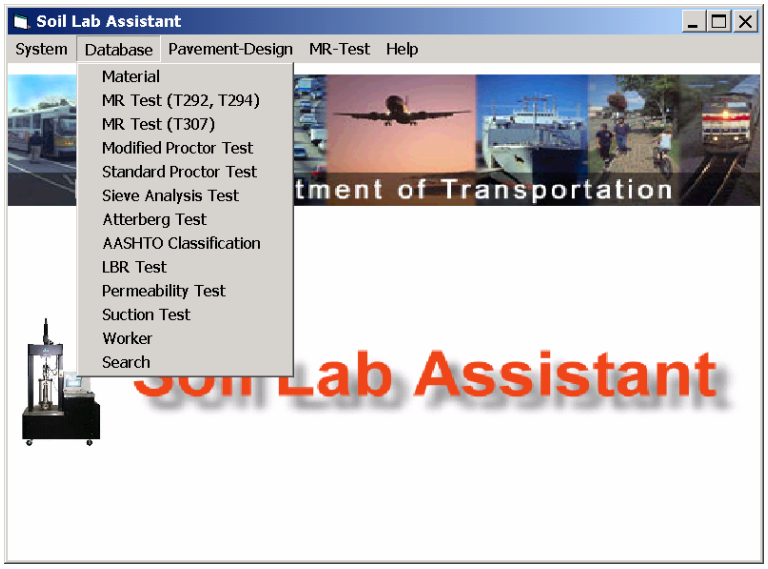
Figure 9. Database Restore Window



DATABASE MANUAL

You may browse the database or modify the database through this pull down menu. Figure 10 shows the sub-menus under this menu. Each of the submenus is explained in the following sections.

Figure 10. Database Manual



Material

By clicking the <Material> sub-manual under the <Database> manual, if you are logged on, Figure 11 shows up. If you are not logged on, Figure 12 shows up. Under this situation, you can not modify the database. The information shown on this window is about the material's location, sample date, project ID, material description, and the worker who took the sample, etc.

Figure 11: Material Window (logged on)

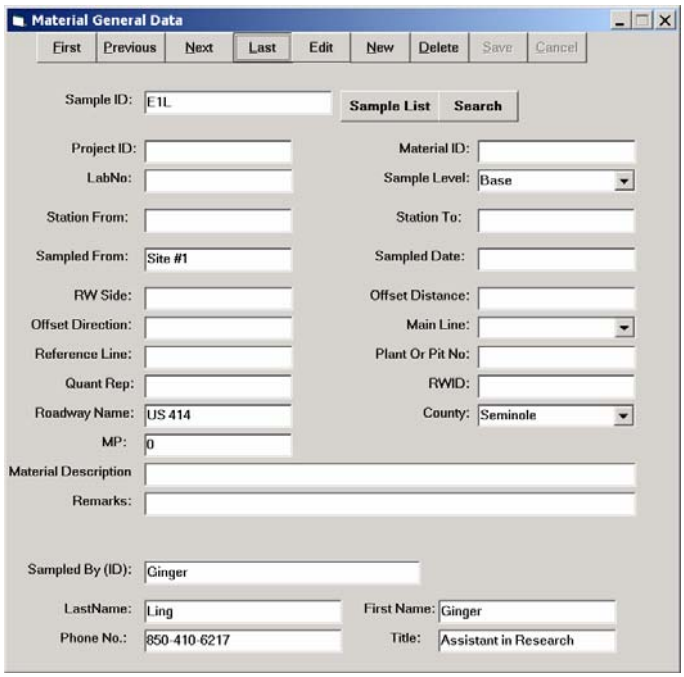
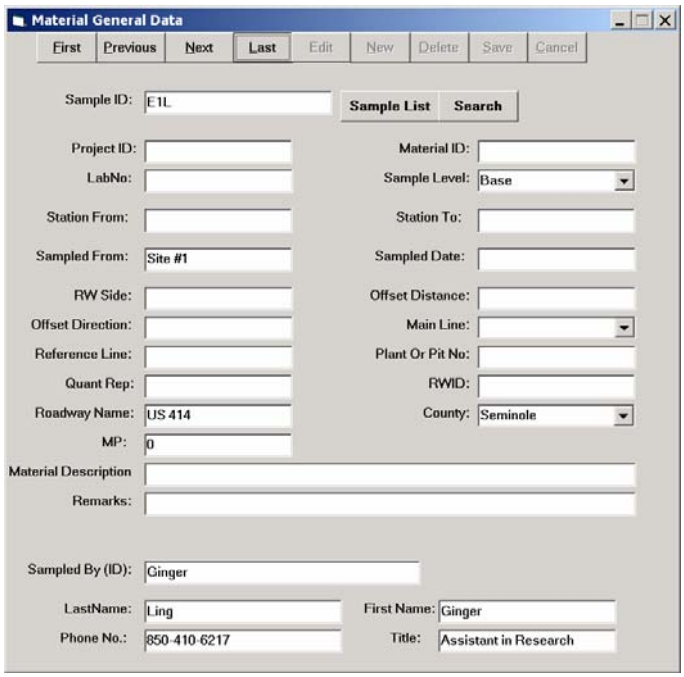


Figure 12: Material Window (not logged on)



❖ *Navigation*

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the data base.

By clicking<Sample List> button, all of the materials in the database are listed out in data sheet format (Figure 13). You may sort the data by one field when you click the corresponding column title. This is useful to help you locate the specific data.

By clicking <Search> button, Figure 14 shows up. You may use this tool to find specific data from the database if you know the “Sample ID”.

Figure 13. Material List Window

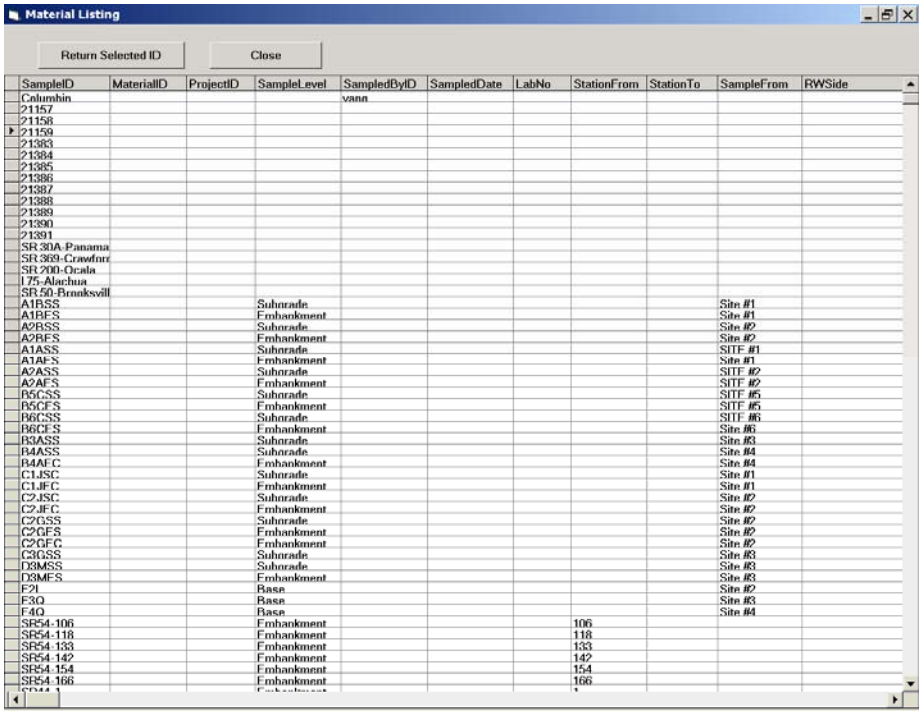
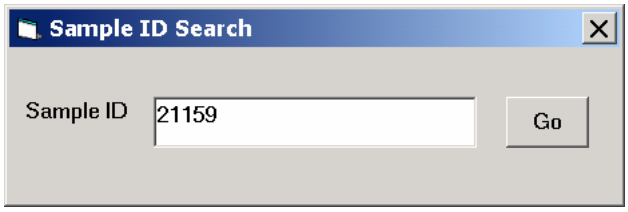


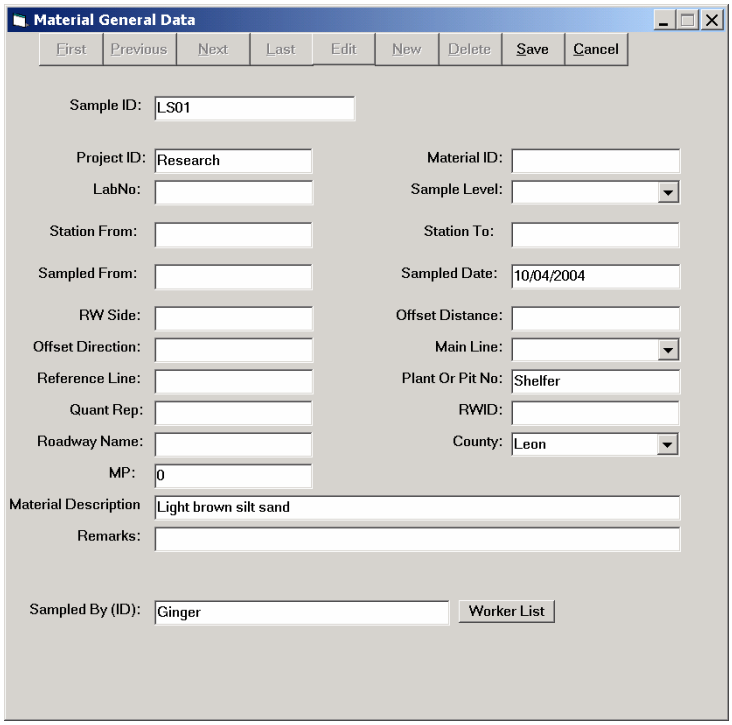
Figure 14. Material Search Window



❖ *Edit*

If you want to edit a specific set of data, after locating that data, click the <edit> button and Figure 15 shows up. After modifying the data fields, click the <Save> button to save the modified data, or click <Cancel> button to cancel the modification.

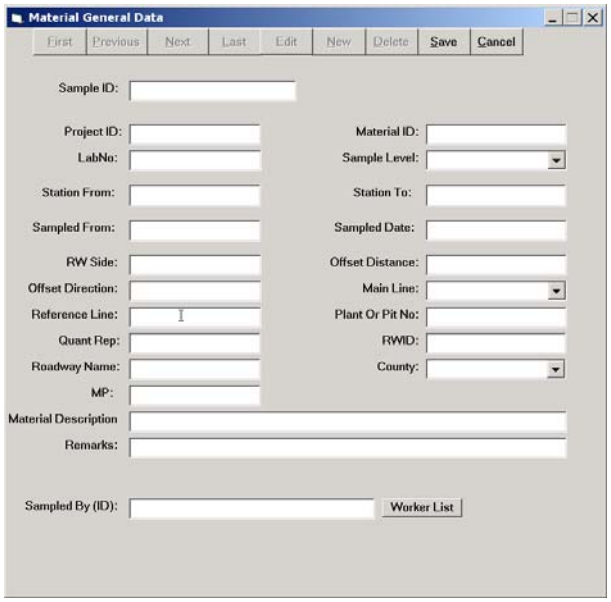
Figure 15. Data Entry Edit Window



❖ *New Data Entry*

To input new data entry, click the <New> button on Figure 11. Figure 16 shows up. Fill out the fields, then click the <Save> button to save the new data entry. To cancel the new data entry process, click the <Cancel> button.

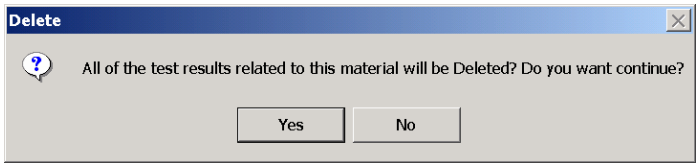
Figure 16. Input New Data Entry Window



❖ ***Delete Data Entry***

If you want to delete a specific set of data, after locating that data, click the <Delete> button, Figure 17 shows up and gives you a warning to your action. Click <Yes> to delete the data entry. Click <Cancel> to cancel your delete action and return to your previous screen, Figure 11.

Figure 17. Material Data Entry Delete Warning Window

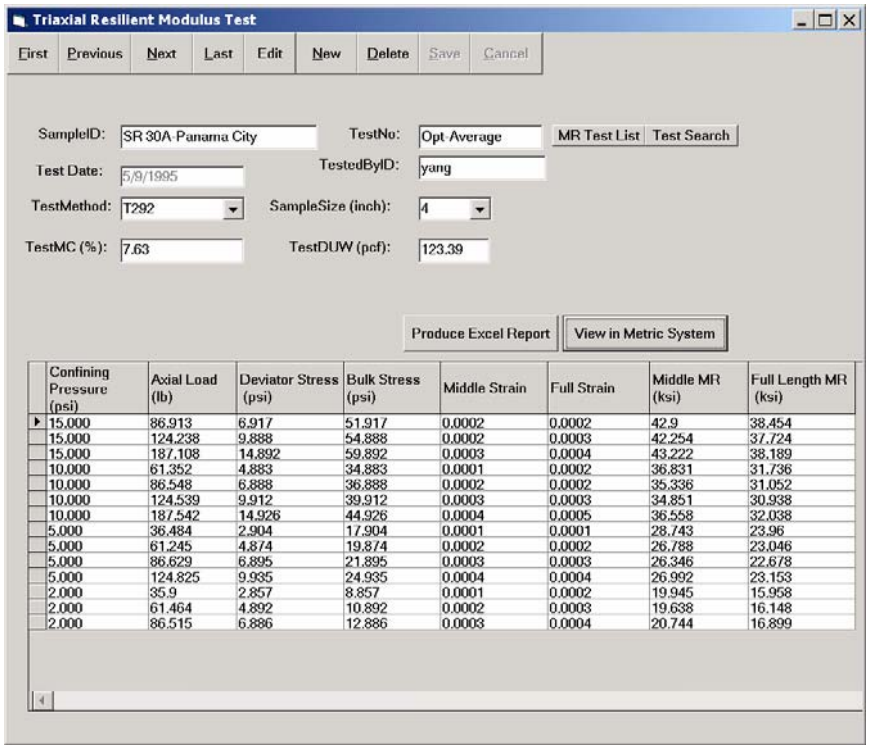


MR Test (T292, T294)

This <MR Test (T292, T294)> sub-manual lets you import, browse or edit the resilient modulus test data of the testing materials from previous resilient modulus testing protocols, T292 and T294. These two testing protocols are no longer used for the soil test.

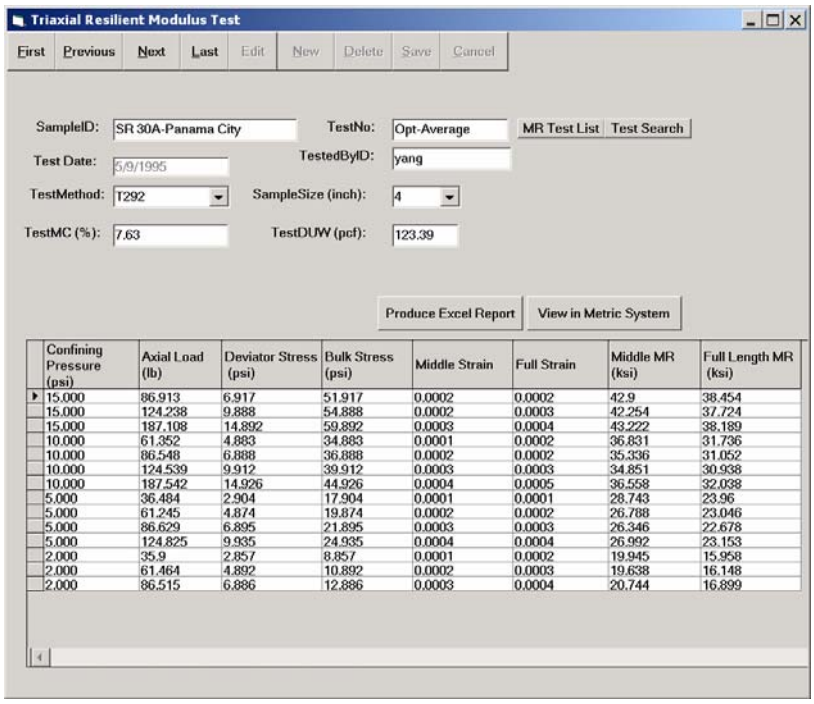
If you are logged on, after clicking <MR Test (T292, T294)> Sub-Manual, Figure 18 shows up. This window lets you edit database or import previous test results. If you are not logged on, Figure 19 shows up. This window only let you browse the data.

Figure 18. MR test data window (logged on)



Confining Pressure (psi)	Axial Load (lb)	Deviator Stress (psi)	Bulk Stress (psi)	Middle Strain	Full Strain	Middle MR (ksi)	Full Length MR (ksi)
15.000	86.913	6.917	51.917	0.0002	0.0002	42.9	38.454
15.000	124.238	9.888	54.888	0.0002	0.0003	42.254	37.724
15.000	187.108	14.892	59.892	0.0003	0.0004	43.222	38.189
10.000	61.352	4.883	34.883	0.0001	0.0002	36.831	31.736
10.000	86.548	6.888	36.888	0.0002	0.0002	35.336	31.052
10.000	124.539	9.912	39.912	0.0003	0.0003	34.851	30.938
10.000	187.542	14.926	44.926	0.0004	0.0005	36.558	32.038
5.000	36.484	2.904	17.904	0.0001	0.0001	28.743	23.96
5.000	61.245	4.874	19.874	0.0002	0.0002	26.788	23.046
5.000	86.629	6.895	21.895	0.0003	0.0003	26.346	22.678
5.000	124.825	9.935	24.935	0.0004	0.0004	26.992	23.153
2.000	35.9	2.857	8.857	0.0001	0.0002	19.945	15.958
2.000	61.464	4.892	10.892	0.0002	0.0003	19.638	16.148
2.000	86.515	6.886	12.886	0.0003	0.0004	20.744	16.899

Figure 19. MR Test Data Window (not login)



Confining Pressure (psi)	Axial Load (lb)	Deviator Stress (psi)	Bulk Stress (psi)	Middle Strain	Full Strain	Middle MR (ksi)	Full Length MR (ksi)
15.000	86.913	6.917	51.917	0.0002	0.0002	42.9	38.454
15.000	124.238	9.888	54.888	0.0002	0.0003	42.254	37.724
15.000	187.108	14.892	59.892	0.0003	0.0004	43.222	38.189
10.000	61.352	4.883	34.883	0.0001	0.0002	36.831	31.736
10.000	86.548	6.888	36.888	0.0002	0.0002	35.336	31.052
10.000	124.539	9.912	39.912	0.0003	0.0003	34.851	30.938
10.000	187.542	14.926	44.926	0.0004	0.0005	36.558	32.038
5.000	36.484	2.904	17.904	0.0001	0.0001	28.743	23.96
5.000	61.245	4.874	19.874	0.0002	0.0002	26.788	23.046
5.000	86.629	6.895	21.895	0.0003	0.0003	26.346	22.678
5.000	124.825	9.935	24.935	0.0004	0.0004	26.992	23.153
2.000	35.9	2.857	8.857	0.0001	0.0002	19.945	15.958
2.000	61.464	4.892	10.892	0.0002	0.0003	19.638	16.148
2.000	86.515	6.886	12.886	0.0003	0.0004	20.744	16.899

❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the data base.

Clicking the <MR Test List> button will list all of the materials in the MR test database in data sheet format. You may sort the data by the one field when you click the corresponding column title. This is useful to help you locate data.

By clicking the <Search> button, Figure 20 shows up. You may use this tool to find specific data from the database, if you know the “Sample ID”.

Clicking the <View in Metric System> button converts the test data into Metric Units as shown in Figure 21. Clicking the <View in Custom System> button returns the test data into English units as shown in Figure 18.

Figure 20. MR Test (T292, T294) Search Window

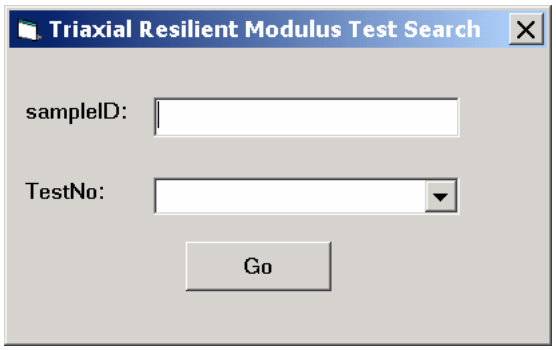
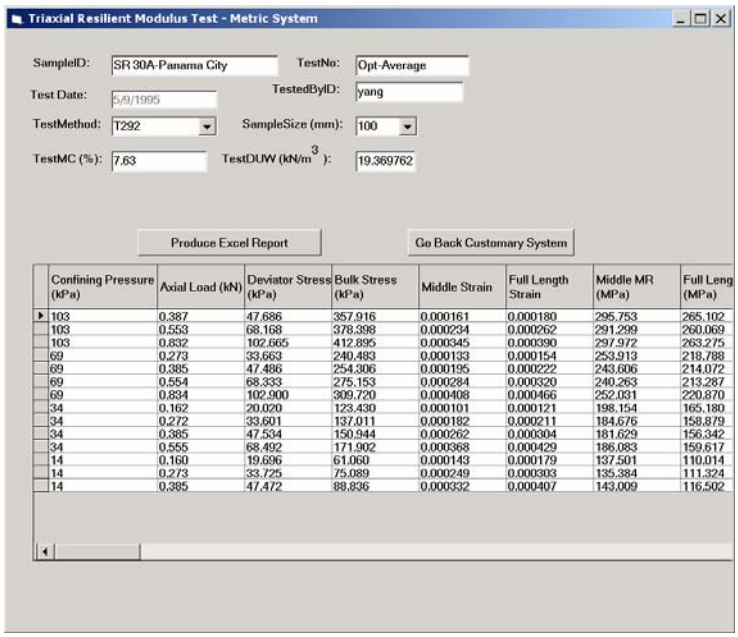


Figure 21. MR Test Data in Metric Units Format



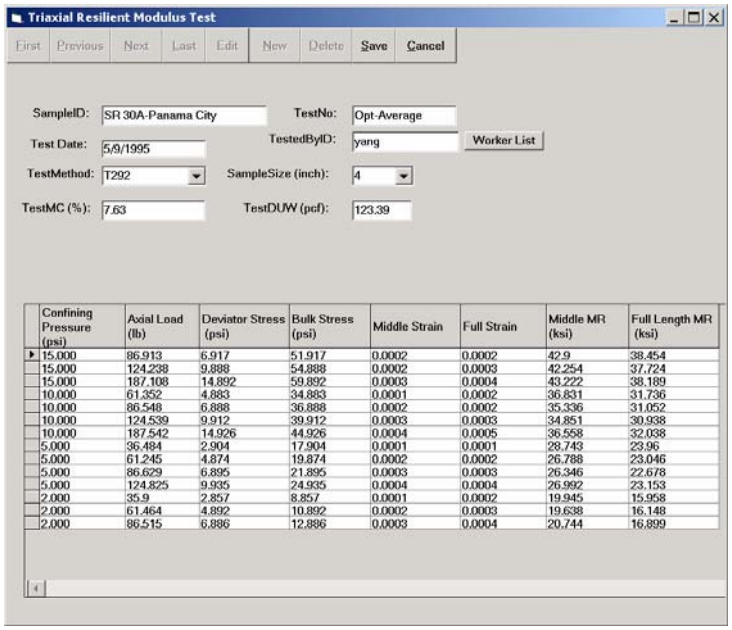
Confining Pressure (kPa)	Axial Load (kN)	Deviator Stress (kPa)	Bulk Stress (kPa)	Middle Strain	Full Length Strain	Middle MR (MPa)	Full Leng (MPa)
103	0.387	47.686	357.916	0.000161	0.000180	295.753	265.102
103	0.553	68.168	378.398	0.000234	0.000262	291.299	260.069
103	0.832	102.665	412.895	0.000345	0.000390	297.972	263.275
69	0.273	33.663	240.483	0.000133	0.000154	253.913	218.788
69	0.385	47.486	254.306	0.000195	0.000222	243.606	214.072
69	0.554	68.333	275.153	0.000284	0.000320	240.263	213.287
69	0.834	102.900	309.720	0.000408	0.000466	252.031	220.870
34	0.162	20.020	123.430	0.000101	0.000121	198.154	165.180
34	0.272	33.601	137.011	0.000182	0.000211	184.676	158.879
34	0.385	47.534	150.944	0.000262	0.000304	181.629	156.342
34	0.555	68.492	171.902	0.000368	0.000429	186.083	159.617
14	0.160	19.696	61.060	0.000143	0.000179	137.501	110.014
14	0.273	33.725	75.089	0.000249	0.000303	135.384	111.324
14	0.385	47.472	88.836	0.000332	0.000407	143.009	116.502

❖ ***Edit***

If you want to edit a specific set of data, after you locate that data, click the <Edit> button, Figure 22 shows up. Here you can only edit the entries of the fields “Test Date”, “TestedByID”, “Test Method”, “TestMC”, and “TestDUW”. Then you can click the <Save> button to save the modified data, or click the <Cancel> button to cancel the modified data.

If you want to edit other data, you need to delete the whole entry and input the whole sample as a new entry with the original test data.

Figure 22. MR Test Data Edit Window



Confining Pressure (psi)	Axial Load (lb)	Deviator Stress (psi)	Bulk Stress (psi)	Middle Strain	Full Strain	Middle MR (ksi)	Full Length MR (ksi)
15.000	86.913	6.917	51.917	0.0002	0.0002	42.9	38.454
15.000	124.238	9.888	54.888	0.0002	0.0003	42.254	37.724
15.000	187.108	14.892	59.892	0.0003	0.0004	43.222	38.189
10.000	61.352	4.883	34.883	0.0001	0.0002	36.831	31.736
10.000	86.548	6.888	36.888	0.0002	0.0002	35.336	31.052
10.000	124.539	9.912	39.912	0.0003	0.0003	34.851	30.938
10.000	187.542	14.926	44.926	0.0004	0.0005	36.558	32.038
5.000	36.484	2.904	17.904	0.0001	0.0001	28.743	23.96
5.000	61.245	4.874	19.874	0.0002	0.0002	26.788	23.046
5.000	86.629	6.895	21.895	0.0003	0.0003	26.346	22.678
5.000	124.825	9.935	24.935	0.0004	0.0004	26.992	23.153
2.000	35.9	2.857	8.857	0.0001	0.0002	19.945	15.958
2.000	61.464	4.892	10.892	0.0002	0.0003	19.638	16.148
2.000	86.515	6.886	12.886	0.0003	0.0004	20.744	16.899

❖ *New Data Entry*

To import new MR test data entry from previous T292 and T294 test results, click <New> button on Figure 18. Figure 23 shows up. Fill out the fields. The data of “SampleID” and “TestNo” are used as the keys in the database. The combination of the two fields must be unique in the database and are required data. The data of “Sample Size” is the sample diameter, which is used to calculate the resilient modulus. So, this data is required.

Clicking the <Previous MR Test Data Format Setup> button, Figure 24 opens. The previous MR tests were conducted and analyzed by different technicians and graduate students. So the final test data were formatted differently in Excel files. You need to find out the data sheet name and the data location in the Excel file (Figure 25) and input the information into Figure 24. You can click the <Save> button to save the information to the program.

Clicking the <Open Previous MR Test Data> button, Figure 26 will show up. Select the previous analyzed data file. Click the <Open>. The program will read the resilient modulus test data from the Excel file to the database (Figure 27). You may either save the data to database by clicking the <Save> button or cancel the new data entry process by clicking the <Cancel> button after you check the data.

Figure 23. MR Test Data Entry Input Window

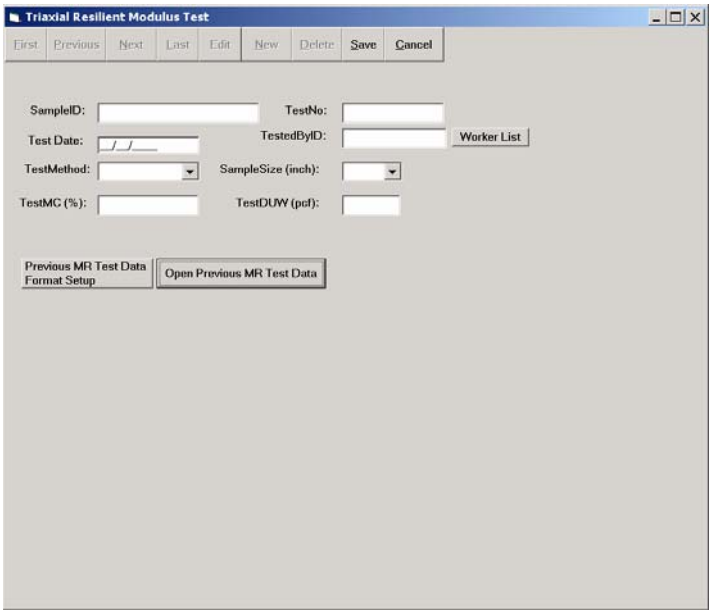


Figure 24. MR Test Data Import Setup Window

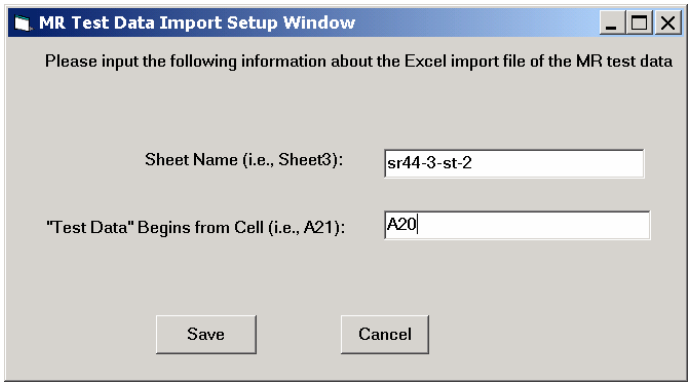


Figure 25. Previous MR Test Results Format Sample

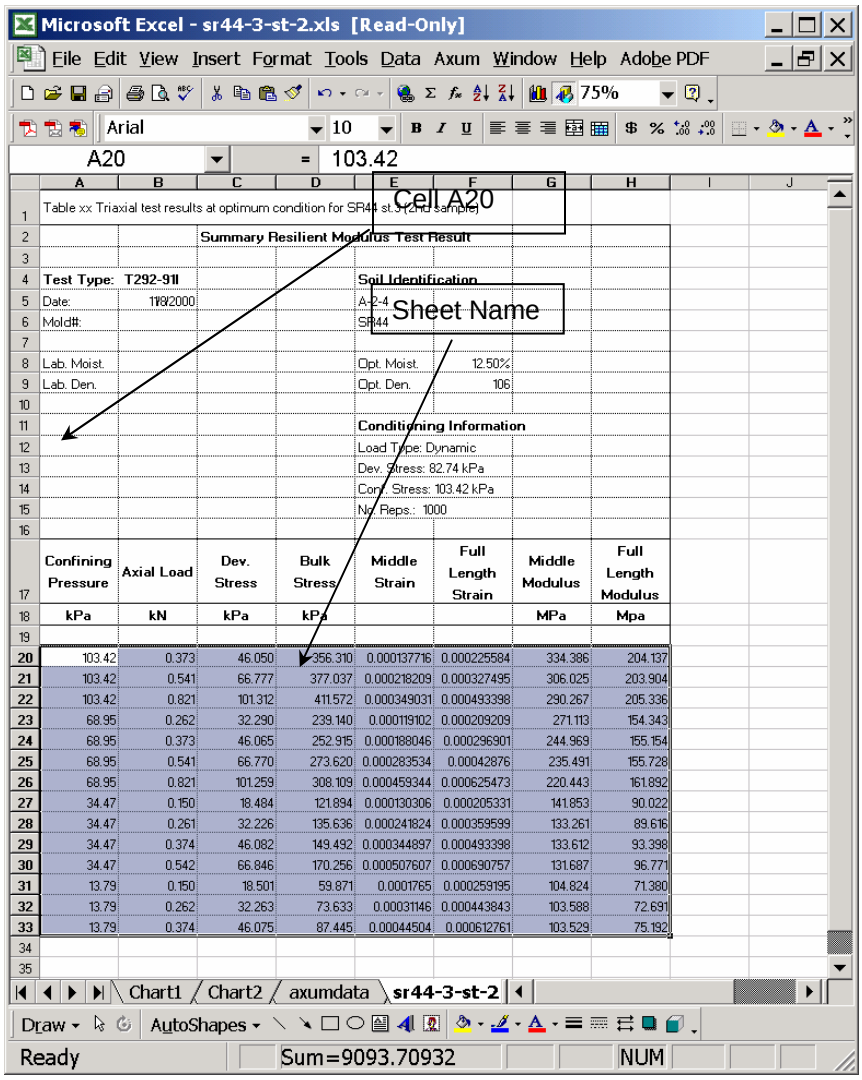


Figure 26. Open File Dialog Window for MR Test Data Input

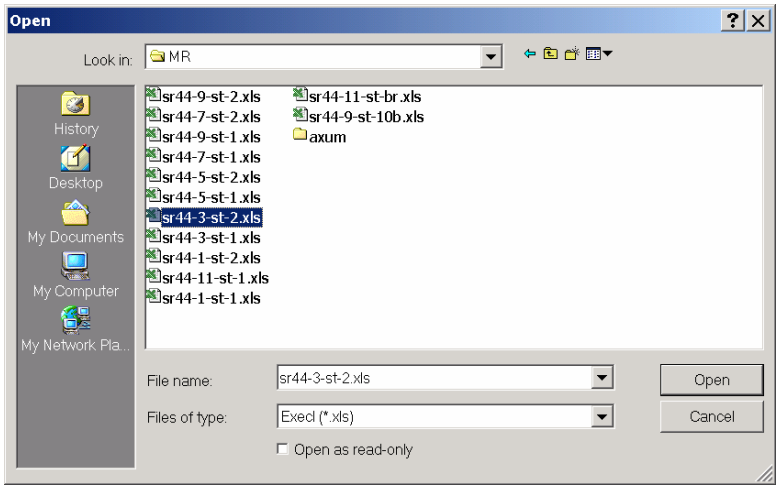
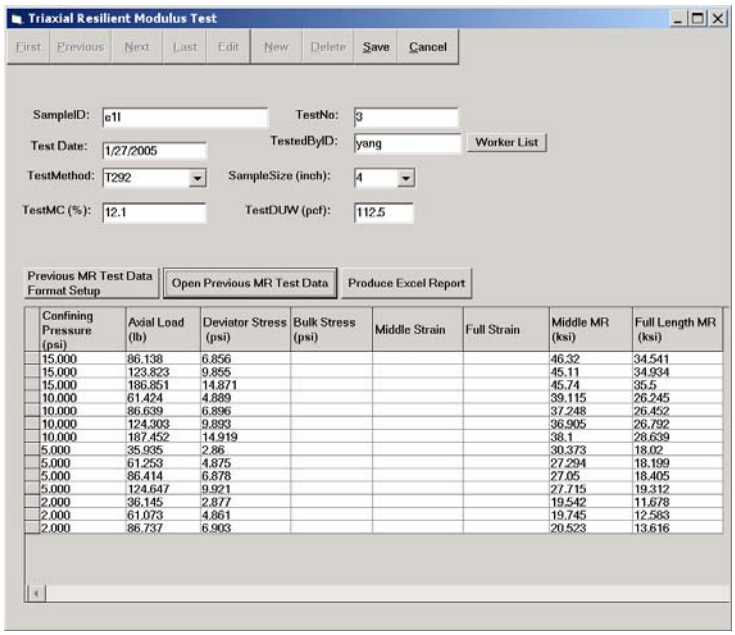


Figure 27. MR Data Imported from Previous MR Test

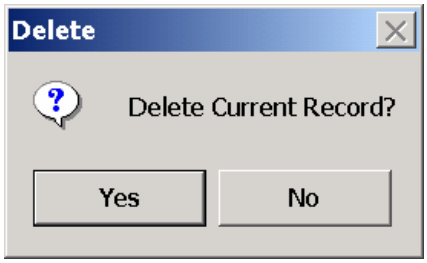


Confining Pressure (psi)	Axial Load (lb)	Deviator Stress (psi)	Bulk Stress (psi)	Middle Strain	Full Strain	Middle MR (ksi)	Full Length MR (ksi)
15.000	86.138	6.856				46.32	34.541
15.000	123.823	9.855				45.11	34.934
15.000	186.851	14.871				45.74	35.5
10.000	61.424	4.889				39.115	26.245
10.000	86.639	6.896				37.248	26.452
10.000	124.303	9.893				36.905	26.792
10.000	187.452	14.919				38.1	28.639
5.000	35.935	2.86				30.373	18.02
5.000	61.253	4.875				27.294	18.199
5.000	86.414	6.878				27.05	18.405
5.000	124.647	9.921				27.715	19.312
2.000	36.145	2.877				19.542	11.678
2.000	61.073	4.861				19.745	12.583
2.000	86.737	6.903				20.523	13.616

❖ ***Delete MR Data Entry***

If you want to delete a specific set of data, select that data, click the <delete> button, and Figure 28 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

Figure 28 . MR test data record delete warning window



❖ ***MR Test Report***

If you want to produce an MR test report in Excel format, select the data entry, and click the <Produce Excel Report> button. The program will collect all of the data related to the material and MR test from the database, input them to the Microsoft Excel program, and produce a report including data sheet and regression diagrams. The report can be either custom unit system format or metric unit system format. Before you press the <Produce Excel Report> button, select the right units system by clicking the <Metric System> button or the <Custom System> button (Figure 29, Figure 30, Figure 31, Figure 32, Figure 33, and Figure 34). You can save this report and print this report using Excel program.

Figure 29. MR Test Excel Report, Custom Units

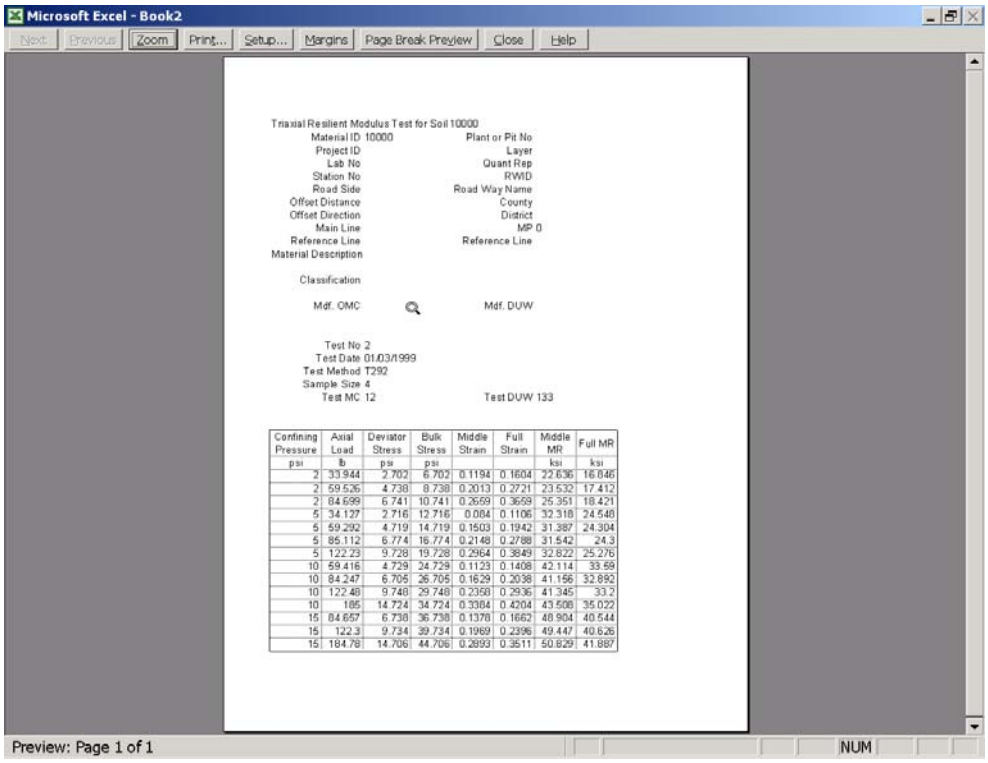


Figure 30. MR test Regression Chart, Custom Units

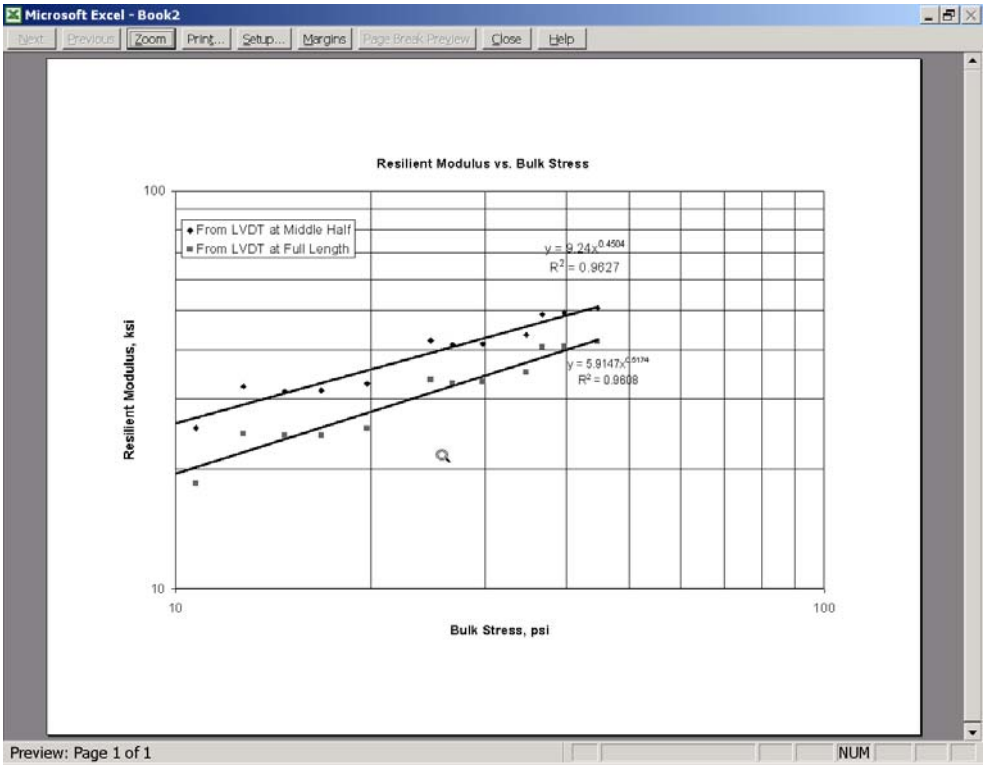


Figure 31. MR test Regression Chart II, Custom Units

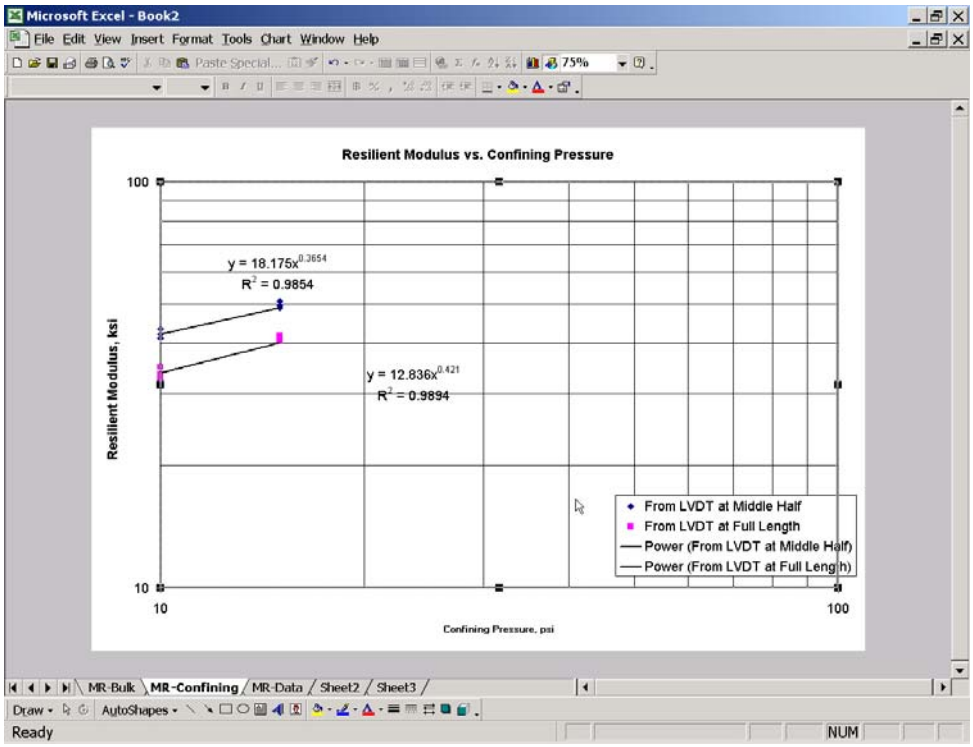
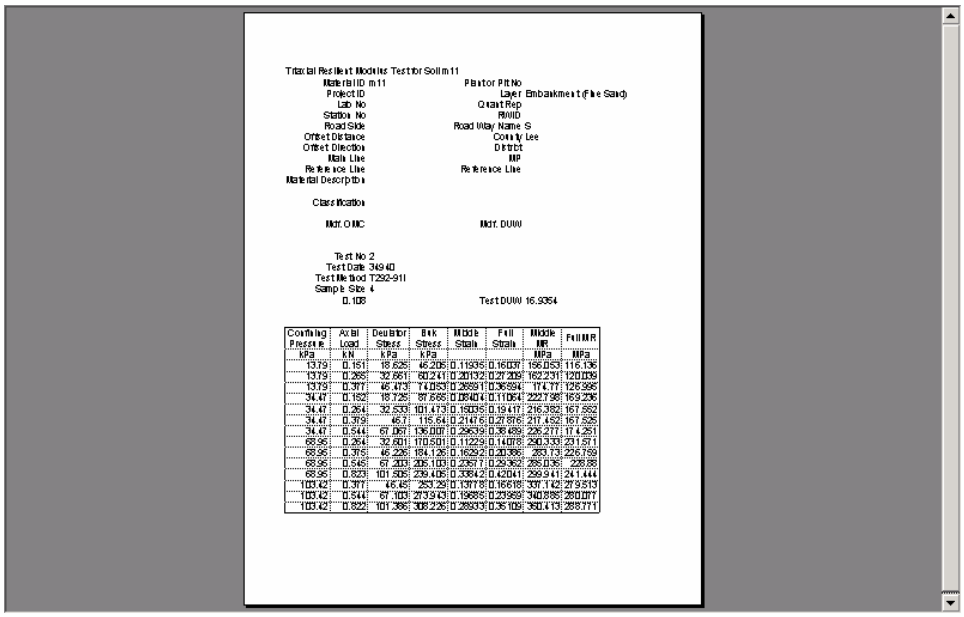


Figure 32. MR Test Excel Report, Metric Units



Triaxial Resilient Modulus Test for Soil m11

Material ID	m11	Pit or Pit No	
Project ID		Layer	Embankment (Fine Sand)
Lab No		Operator Rep	
Station No		RWID	
Road Side		Road Way Name	S
Offset Distance		County	Lee
Offset Direction		District	
Main Line		MP	
Reference Line		Reference Line	

Material Description

Classification

Mdr. OMC		Mdr. DUW	

Test No 2
Test Date 3/4/40
Test Method T292-91I
Sample Size 4
0.108

Test DUW 16.9364

Confining Pressure kPa	Axial Load kN	Deviator Stress kPa	Bulk Stress kPa	Middle Strain	Full Strain	Middle MR MPa	Full MR MPa
13.79	0.151	18.626	46.205	0.11935	0.16037	156.053	116.136
13.79	0.265	32.661	60.241	0.20132	0.27285	162.231	120.209
13.79	0.371	45.473	74.053	0.26891	0.36894	174.77	126.995
34.47	0.152	18.725	87.668	0.08404	0.11064	222.798	169.236
34.47	0.264	32.539	101.473	0.16035	0.19417	216.382	167.562
34.47	0.378	46.1	115.64	0.21476	0.27876	217.452	167.525
34.47	0.544	67.067	136.607	0.29639	0.39489	226.277	174.251
68.96	0.264	32.601	170.501	0.11229	0.14078	290.303	231.571
68.96	0.375	46.226	184.126	0.16292	0.20386	283.73	226.759
68.96	0.545	67.203	205.103	0.2357	0.29302	285.035	228.88
68.96	0.823	101.585	239.485	0.35842	0.42041	299.941	241.444
103.42	0.377	46.45	253.29	0.13778	0.16618	337.142	279.513
103.42	0.544	67.103	273.943	0.19688	0.23989	340.886	280.077
103.42	0.822	101.366	308.226	0.28933	0.35109	350.413	288.771

Figure 33. MR Test Regression Chart, Metric Units

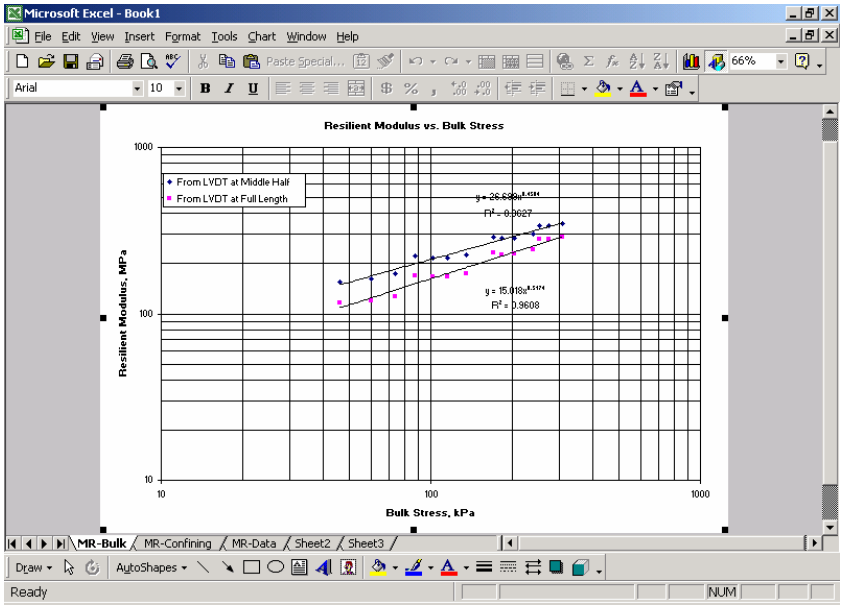
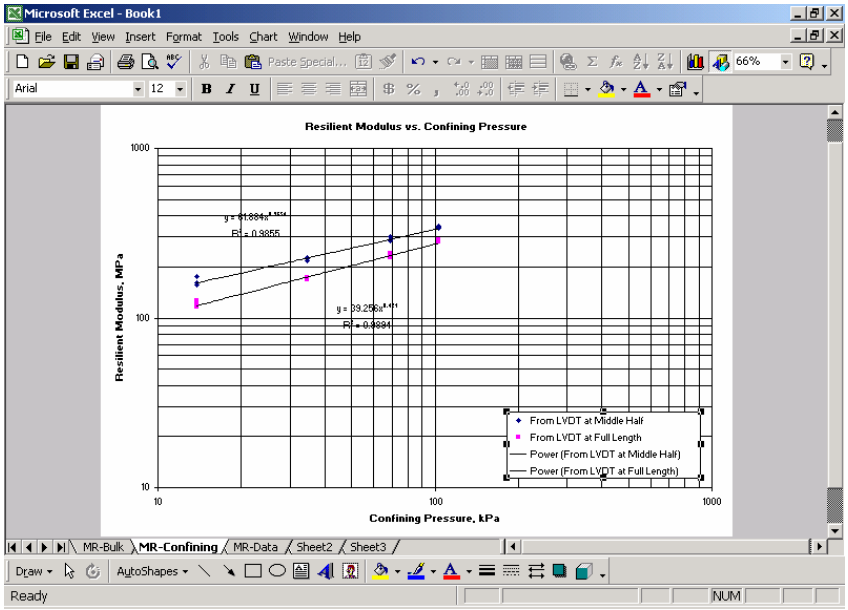


Figure 34. MR Test Regression Chart II, Metric Units



Modified Proctor Test

The <Modified Proctor Test>submenu lets you browse or edit the Modified Proctor test data of the testing materials. If you are logged on, after clicking the <Modified Proctor Test> Submenu, Figure 35 shows up. This window lets you edit the database. If you are not logged on, Figure 36 shows up. This window only lets you browse the data.

❖ ***Navigation***

Use the navigation buttons <First>, <Previous>, <Next>, and <Last> to browse the database.

Clicking the <Test List> button will list all of the materials in the Modified Proctor test database in data sheet format. You may sort the data by one field when you click the corresponding column title. This is useful to help you locate specific data (Figure 37).

Clicking the <Search> button, Figure 38 shows up. Type the sample ID and press the <Go> button. The data entries with your specified sample ID will be the current data and will be shown in the window.

Figure 35. Modified Proctor test data window (logged on)

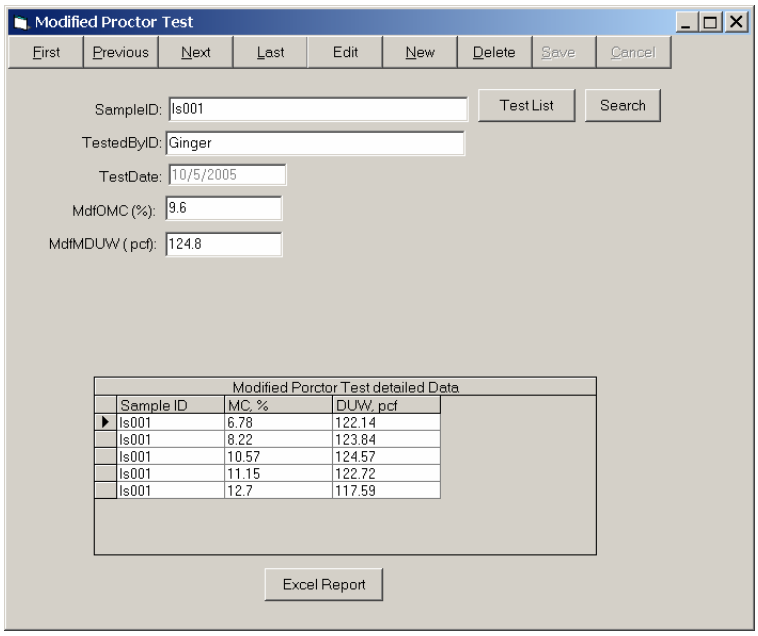


Figure 36. Modified Proctor Test Data Window (browse only)

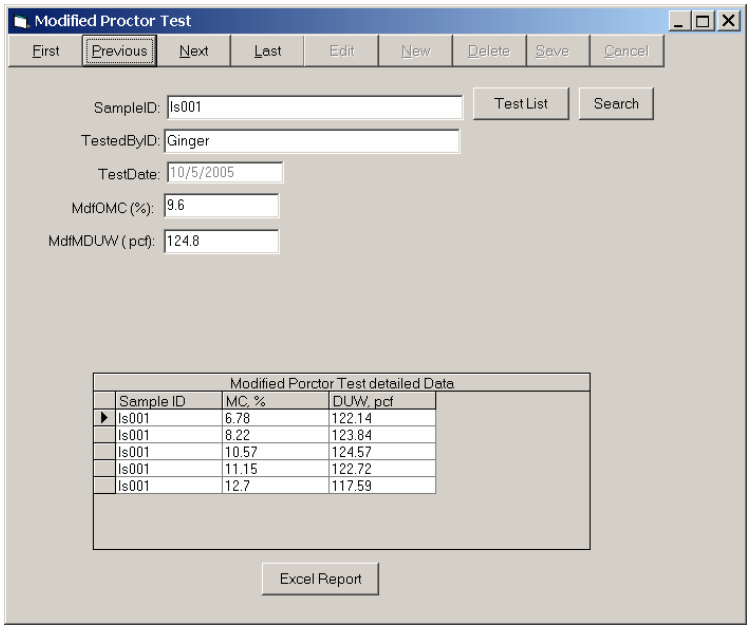
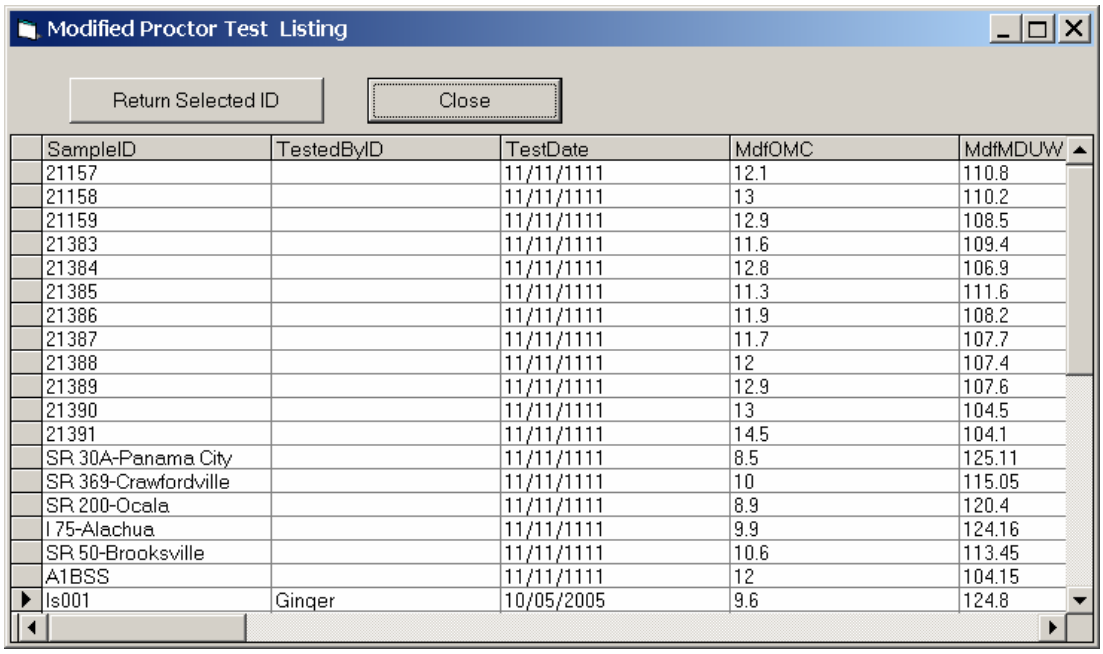
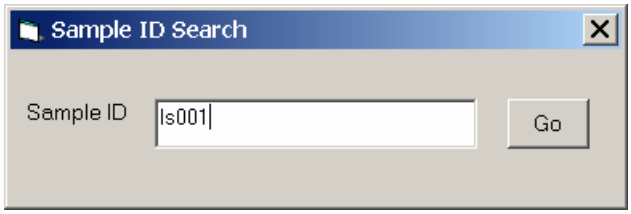


Figure 37. Modified Proctor Test Data List



SampleID	TestedByID	TestDate	MdfOMC	MdfMDUW
21157		11/11/1111	12.1	110.8
21158		11/11/1111	13	110.2
21159		11/11/1111	12.9	108.5
21383		11/11/1111	11.6	109.4
21384		11/11/1111	12.8	106.9
21385		11/11/1111	11.3	111.6
21386		11/11/1111	11.9	108.2
21387		11/11/1111	11.7	107.7
21388		11/11/1111	12	107.4
21389		11/11/1111	12.9	107.6
21390		11/11/1111	13	104.5
21391		11/11/1111	14.5	104.1
SR 30A-Panama City		11/11/1111	8.5	125.11
SR 369-Crawfordville		11/11/1111	10	115.05
SR 200-Ocala		11/11/1111	8.9	120.4
I 75-Alachua		11/11/1111	9.9	124.16
SR 50-Brooksville		11/11/1111	10.6	113.45
A1BSS		11/11/1111	12	104.15
ls001	Ginger	10/05/2005	9.6	124.8

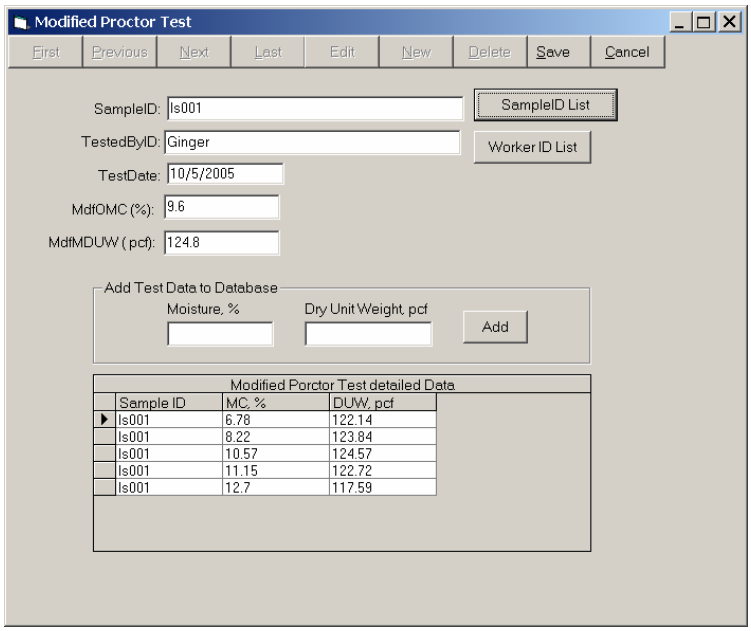
Figure 38. Modified Proctor Test Data Search Window



❖ ***Edit***

If you want to edit a set of data, after you locate that data, click the <edit> button, Figure 39 shows up. You can edit the value on fields “Test Date”, “TestedByID”, “Test Method”, “MdfOMC”, and “MdfMDUW”. You can not modify the sample ID, which is a foreign key in the database. If you want to modify the sample ID, you have to go to the Material submenu and change the sample ID over there. You can click the <Save> button to save the modified data, or click the <Cancel> button to cancel the modification.

Figure 39. Modified Proctor Test Data Edit Window



❖ ***New Data Entry***

To input new Modified Proctor test results, click the <New> button on Figure 35. Figure 40 shows up. The data of "SampleID" is a foreign key in the database and must have been input in the Material submenu. Input the worker's ID who did the test and the test date. Leave the MdfOMC and MdfMDUW fields blank and update them at a later time. First, input the Moisture, Dry Unit Weight data and click the <Add> button to save the data to the database. Click <Save> button to save the data to the data base and return to Figure 35. Click the <Excel Report> button. Figure 41 will be produced. You may read the modified OMC value and Modified Max. DUW value from this graph. Then you use the Edit Button to enter these two values to the database.

Figure 40. Modified Proctor Test Data Record Input Window

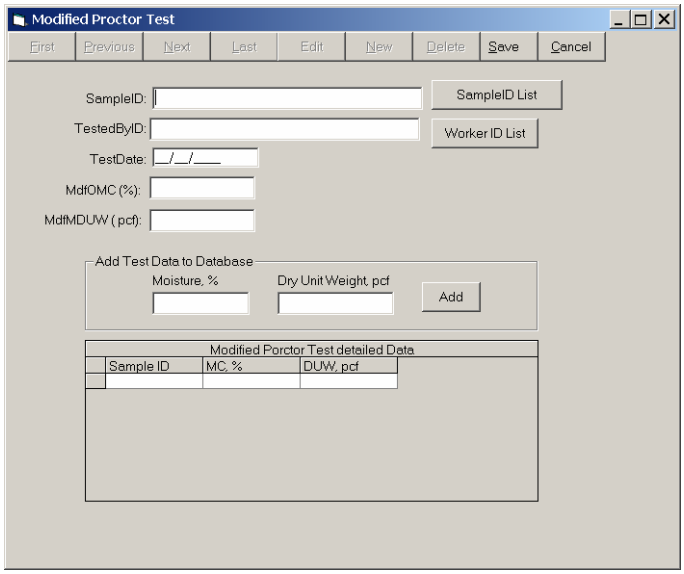
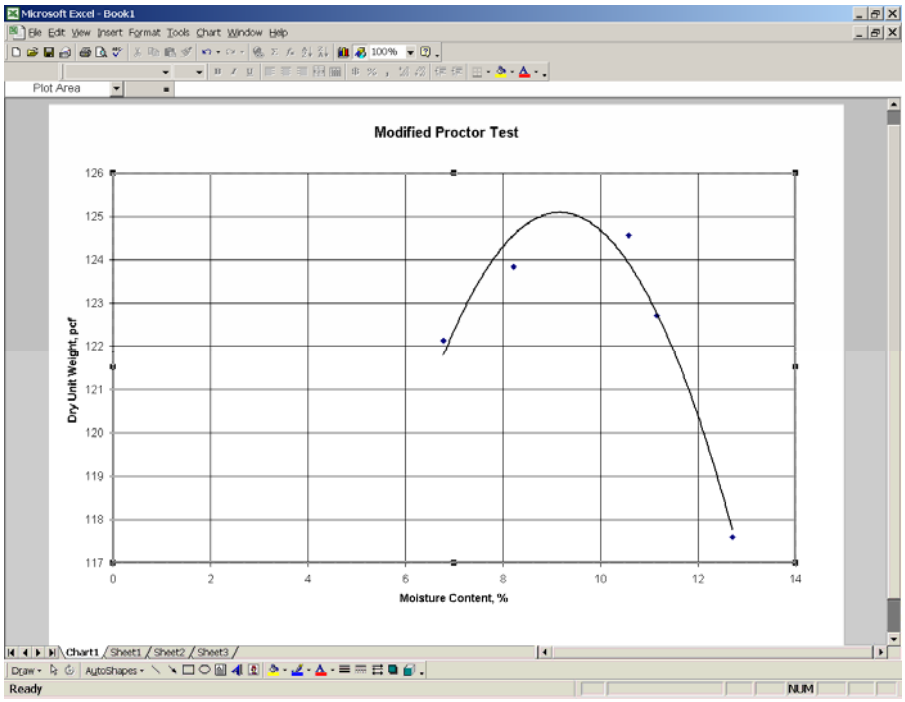


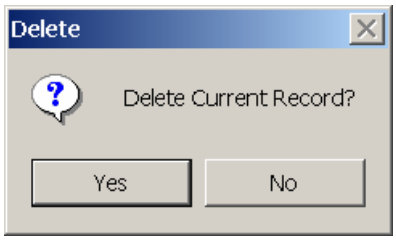
Figure 41. Modified Proctor Test Curve



❖ ***Delete MR Data Entry***

If you want to delete a set of data, select the data and click the <delete> button, Figure 42 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

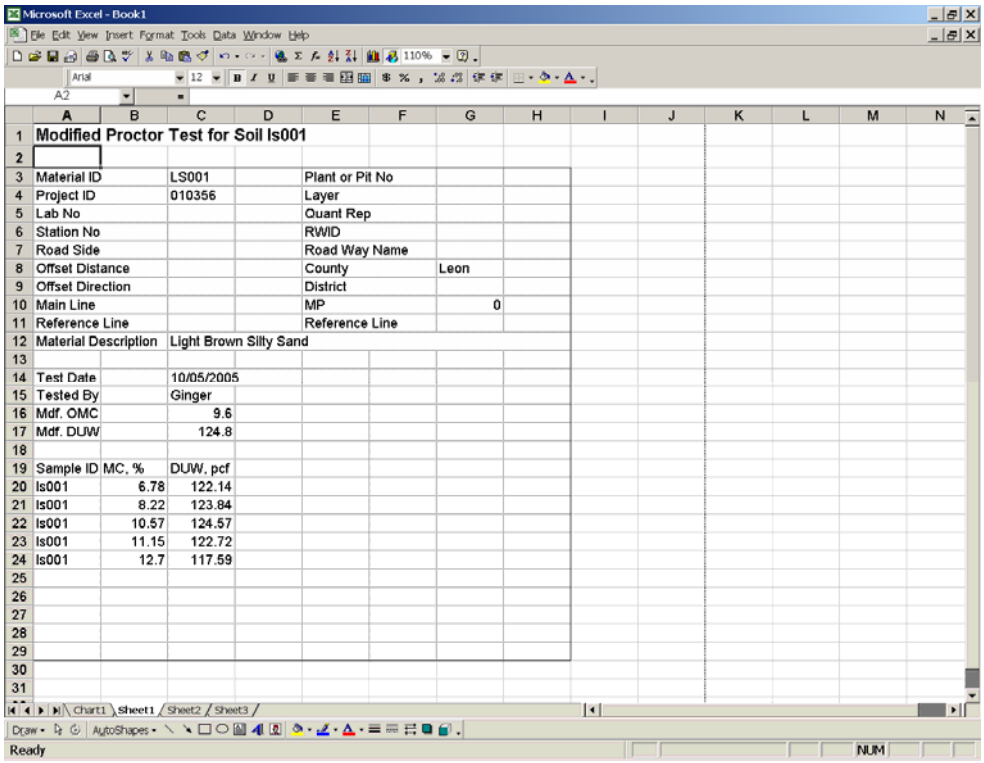
Figure 42. Modified Proctor Test Data Record Delete Warning Window



❖ ***Modified Proctor Test Excel Report***

If you want to produce a Modified Proctor test report in Excel format, locate the data and click the <Excel Report> button. The program will collect all of the data related to the material and Modified Proctor test from the database, input them to the Microsoft Excel program, and produce a report including data sheet and diagrams. You may save this report and print this report through the Excel program (Figures 38, 39).

Figure 43. Modified Proctor Test Report



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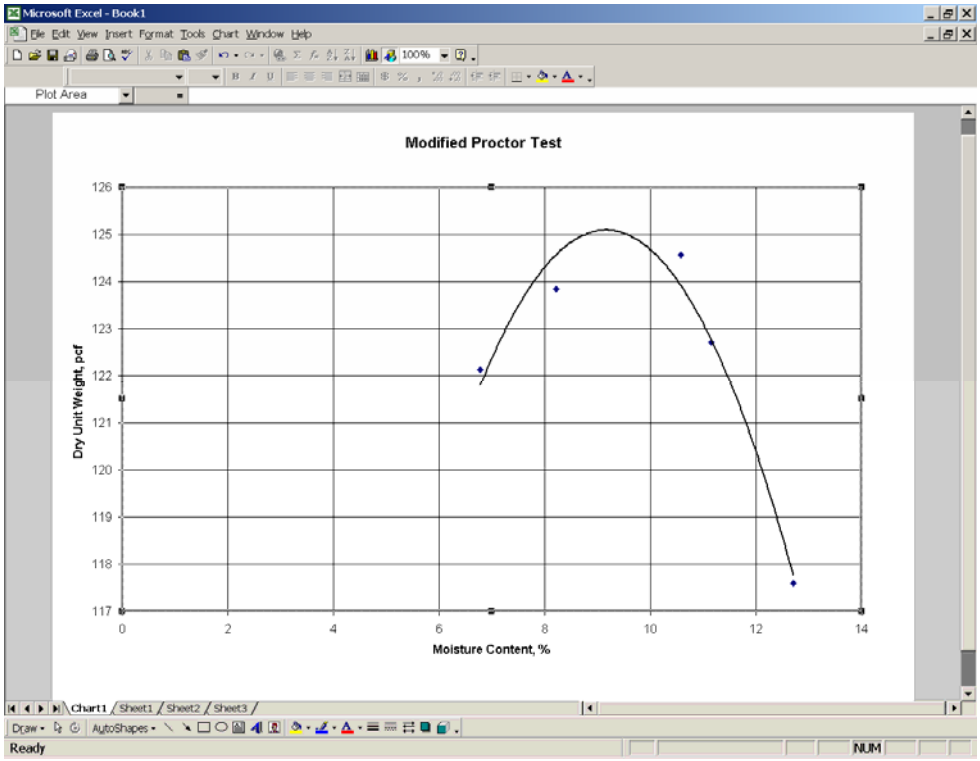
	A	B	C	D	E	F	G	H
1	Modified Proctor Test for Soil ls001							
2								
3	Material ID		LS001		Plant or Pit No			
4	Project ID		010356		Layer			
5	Lab No				Quant Rep			
6	Station No				RWID			
7	Road Side				Road Way Name			
8	Offset Distance				County		Leon	
9	Offset Direction				District			
10	Main Line				MP		0	
11	Reference Line				Reference Line			
12	Material Description		Light Brown Silty Sand					
13								
14	Test Date		10/05/2005					
15	Tested By		Ginger					
16	Mdf. OMC		9.6					
17	Mdf. DUW		124.8					
18								
19	Sample ID	MC, %	DUW, pcf					
20	ls001	6.78	122.14					
21	ls001	8.22	123.84					
22	ls001	10.57	124.57					
23	ls001	11.15	122.72					
24	ls001	12.7	117.59					
25								
26								
27								
28								
29								
30								
31								

Chart1 Sheet1 Sheet2 Sheet3

Ready

Figure 44. Modified Proctor Test Chart



Standard Proctor Test

The <Standard Proctor Test> submenu lets you browse or edit the standard Proctor test data of the testing materials. If you are logged on, after clicking the <Standard Proctor Test> Submenu, Figure 45 shows up. This window lets you edit the database. If you are not logged on, Figure 46 shows up. This window only let you browse the data.

❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the data base.

Clicking the <Test List> button lists all of the materials in the Standard Proctor test database in data sheet format. You may sort the data by one field when you click the corresponding column title. This is useful to help you locate specific data (Figure 47)

Clicking the <Search> button,
Figure 48 shows up. Type the sample ID, then press the <Go> button. The data entries with your specified sample ID will be current data and list in the window.

Figure 45. Standard Proctor Test Data Window (logged on)

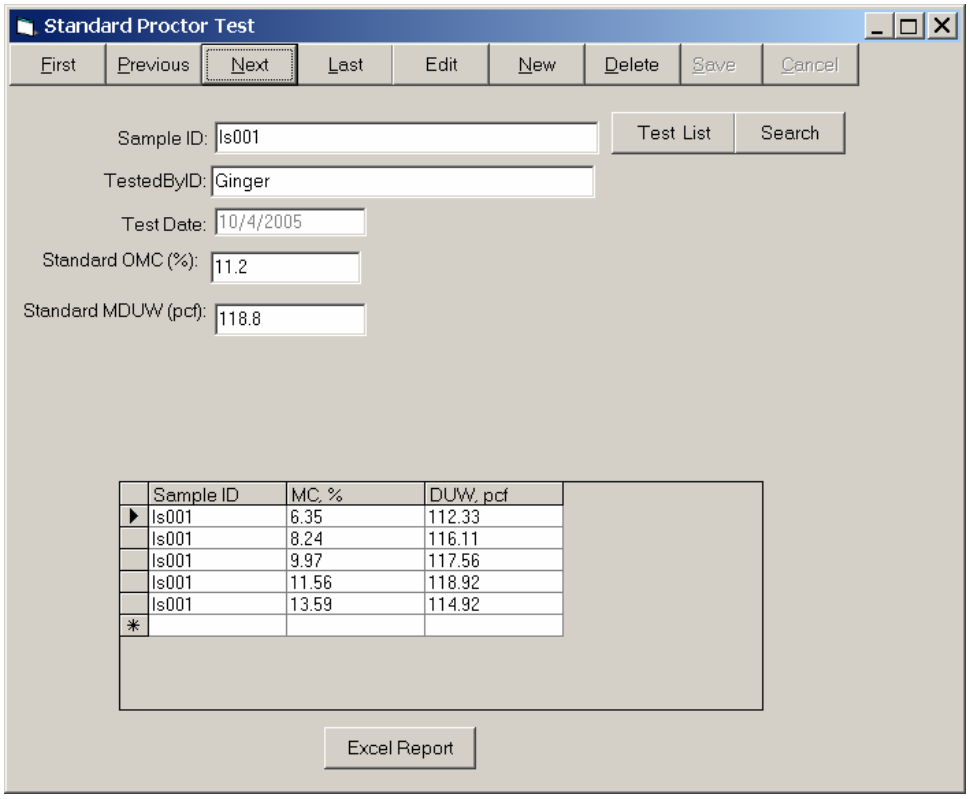


Figure 46. Standard Proctor Test Data Window (not logged on)

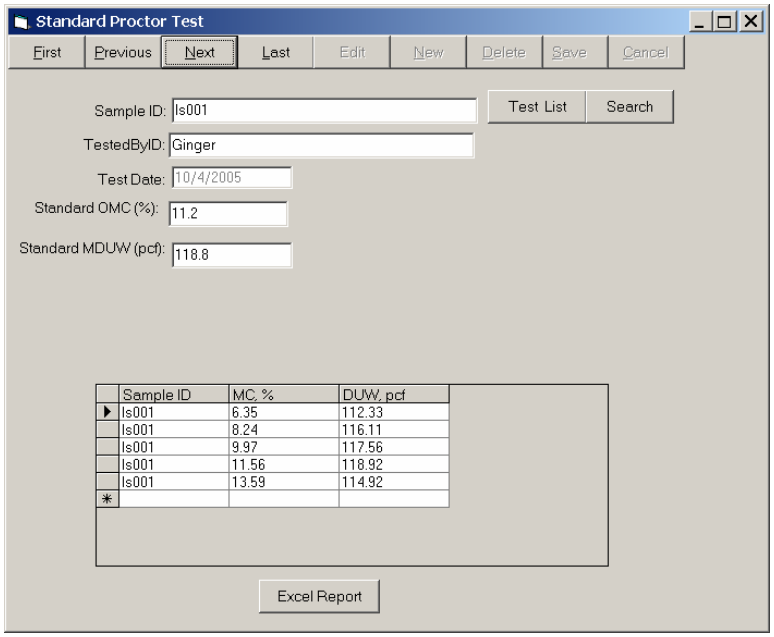


Figure 47. Standard Proctor Test Data List

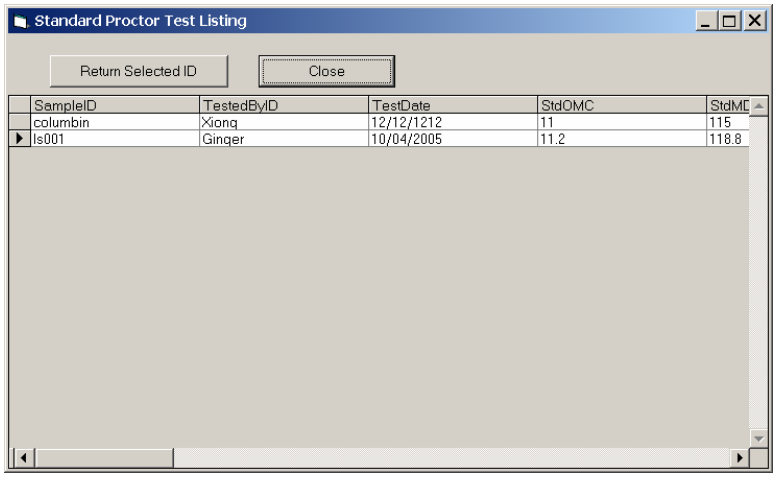
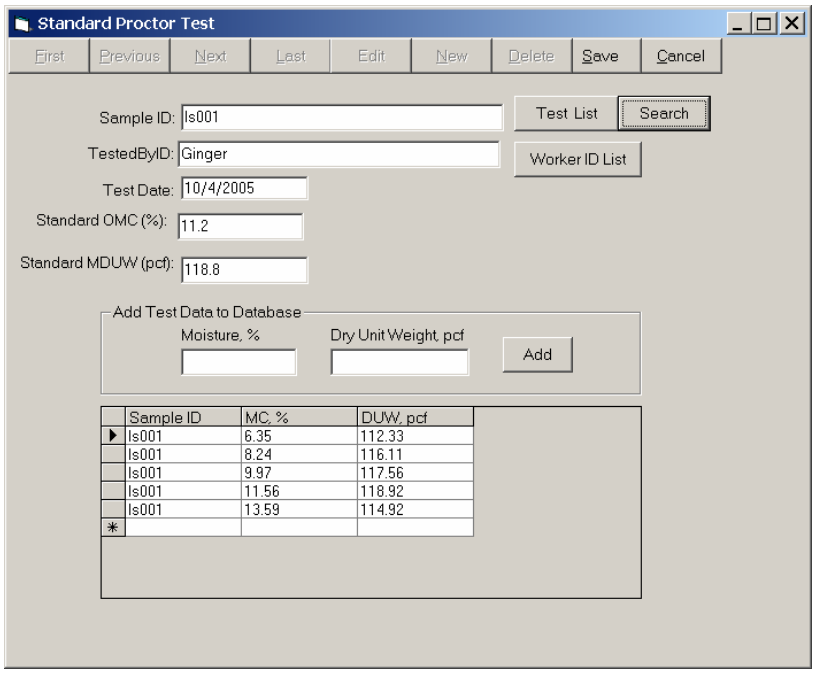


Figure 48. Standard Proctor Test Data Search Window

❖ ***Edit***

To edit a data record, locate that data and click the <edit> button, Figure 49 shows up. You can edit the value on fields “Test Date”, “TestedByID”, “Test Method”, “StdOMC”, and “StdMDUW”. You cannot modify the sample ID, which is a foreign key in the database. If you want to modify the sample ID, you have to go to the Material submenu and change the sample ID over there. You can click the <Save> button to save the modified data, or click <Cancel> button to cancel the modification.

Figure 49. Standard Proctor Test Data Edit Window



❖ ***New Data Entry***

To input new standard Proctor test results, click the <New> button on Figure 45. Figure 50 shows up. The data of “SampleID” is a foreign key in the database and must have been input in the Material submenu. Input the worker’s ID who did the test and the test date. Leave the StdOMC and StdMDUW fields blank and update them at a later time. First, input the Moisture, Dry Unit Weight data and click the <Add> button to save the data to the database. After finish the data input Click <Save> button to save the data to the database and return to Figure 45. Click the <Excel Report> button. Figure 51 will be produced. You may read the Standard OMC value and Standard Max. DUW value from this plot. Then you use the Edit Button to enter these two values to the database.

Figure 50. Standard Proctor Test Data Record Input Window

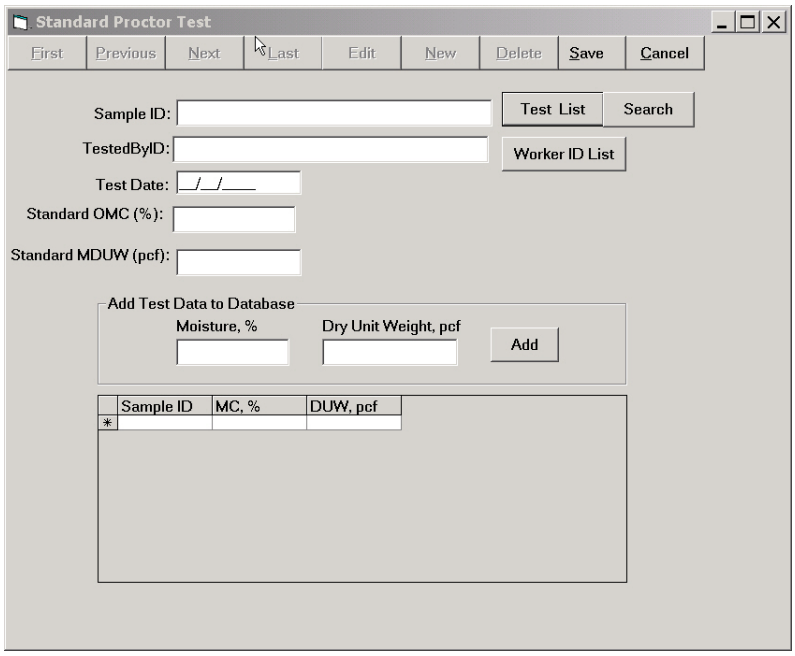
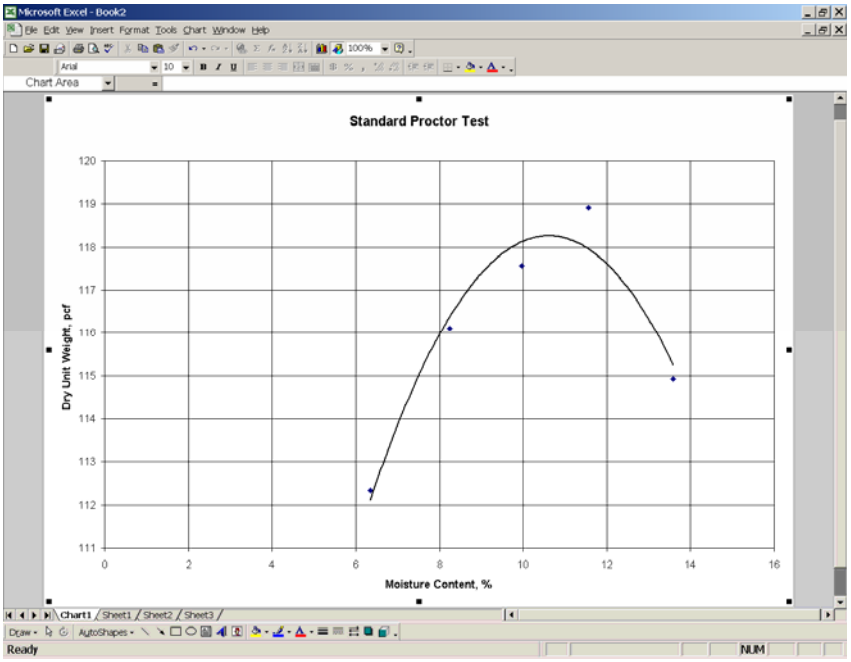


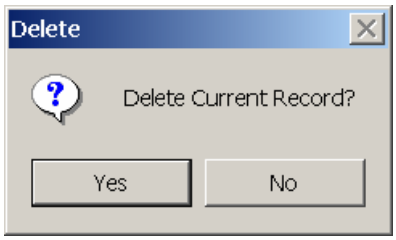
Figure 51. Standard Proctor Test Curve



❖ *Delete Standard Proctor Data Entry*

To delete a set of data, locate that data and click the <delete> button. Figure 52 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

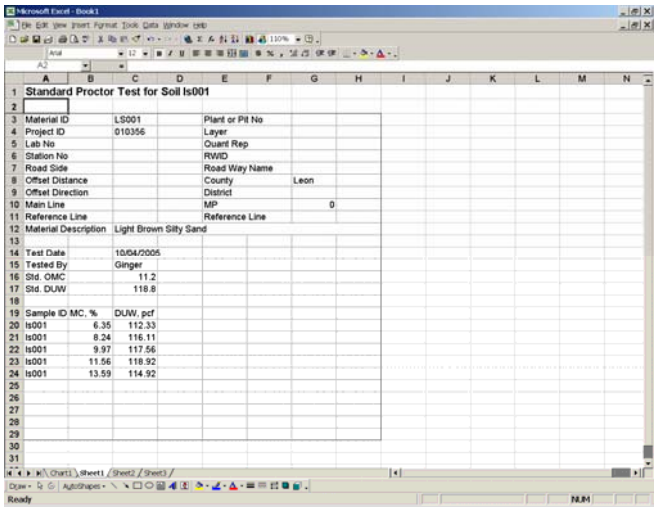
Figure 52 . Modified Proctor Test Data Record Delete Warning Window



❖ ***Standard Proctor Test Excel Report***

To produce a Standard Proctor test report in Excel format, locate that data and click the <Excel Report> button. The program will collect all of the data related to the material and Standard Proctor test from the database, input them to the Microsoft Excel program and produce a report including data sheet and diagrams. You may save this report and print this report through Excel program (Figures 38, 39).

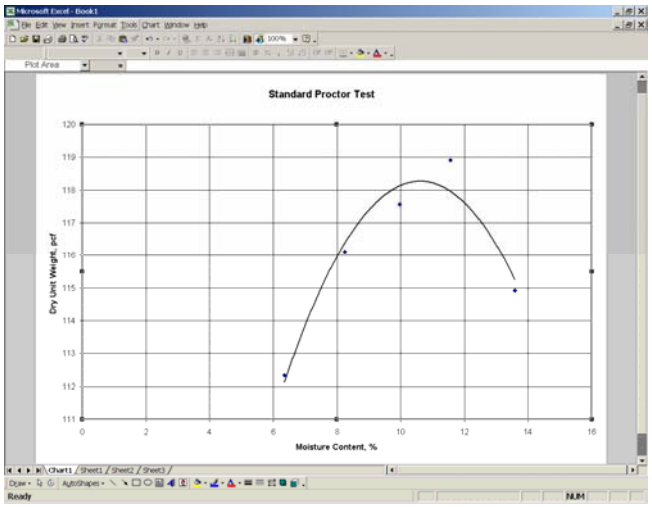
Figure 53. Standard Proctor Test Report



Standard Proctor Test for Soil ls001

Material ID		LS001	Plant or Pit No	
Project ID		010356	Layer	
Lab No			Quant Rep	
Station No			RWID	
Road Side			Road Way Name	
Offset Distance			County	Leon
Offset Direction			District	
Main Line			MP	0
Reference Line			Reference Line	
Material Description		Light Brown Silty Sand		
Test Date		10/04/2005		
Tested By		Ginger		
Std. OMC		11.2		
Std. DUW		118.8		
Sample ID	MC, %	DUW, pcf		
ls001	6.35	112.33		
ls001	8.24	116.11		
ls001	9.97	117.56		
ls001	11.56	118.92		
ls001	13.59	114.92		

Figure 54. Standard Proctor Test Graph



Sieve Analysis Test

The <Sieve Analysis Test> submenu lets you browse or edit the Sieve Analysis test data of the testing materials. If you are logged on, after clicking <Sieve Analysis Test> Sub-Manual, Figure 55 shows up. This window lets you edit the database. If you are not logged on, Figure 56 shows up. This window only lets you browse the data.

Figure 55. Sieve Analysis Test Data Window (logged on)

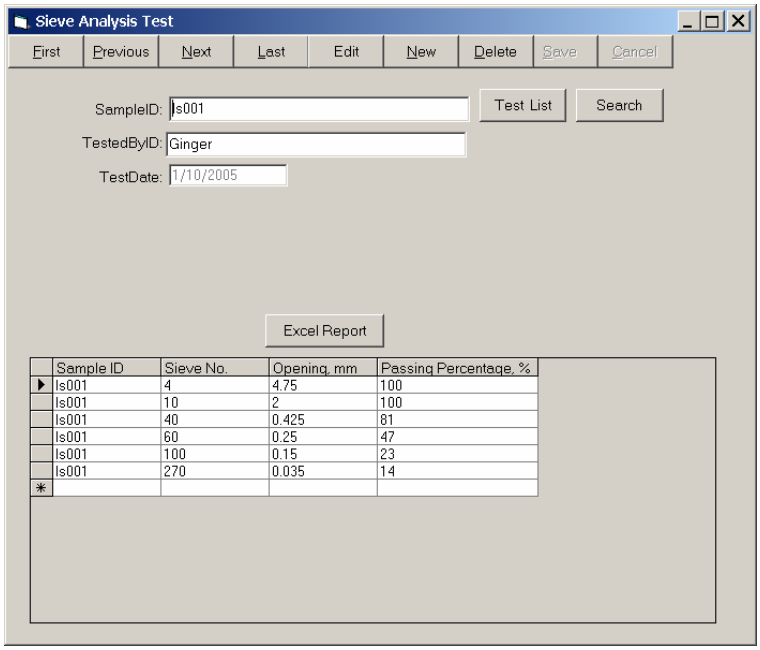
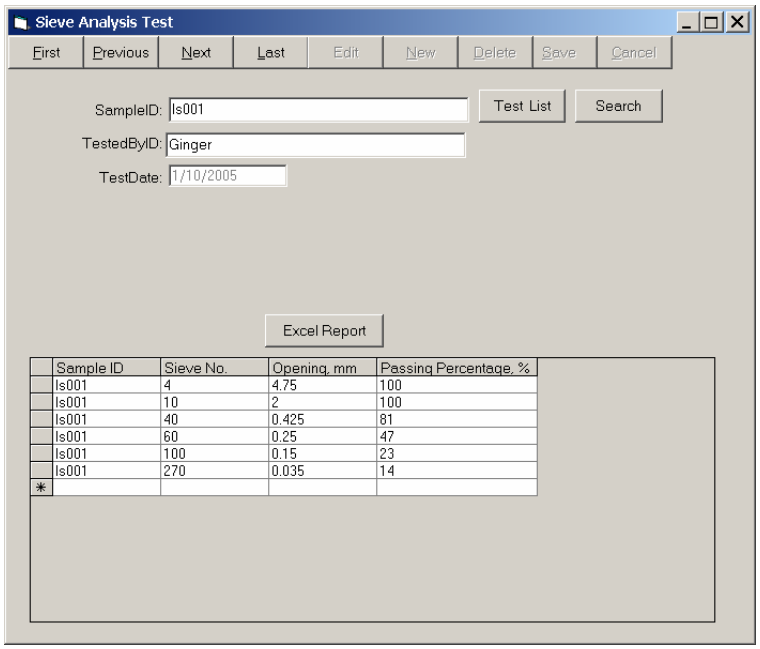


Figure 56. Sieve Analysis Test Data Window (not logged on)



❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the database.

Click the <Test List> button and all of the materials in the Sieve Analysis test database will be listed out in data sheet format. You may sort the data by one field when you click the corresponding column title. This is useful to help you locate specific data (Figure 57)

Click the <Search> button and
Figure 58 shows up. Type the sample ID, then press the <Go> button. The data entries with your specified sample ID will be current and shown in the window.

Figure 57. Sieve Analysis Test Data List

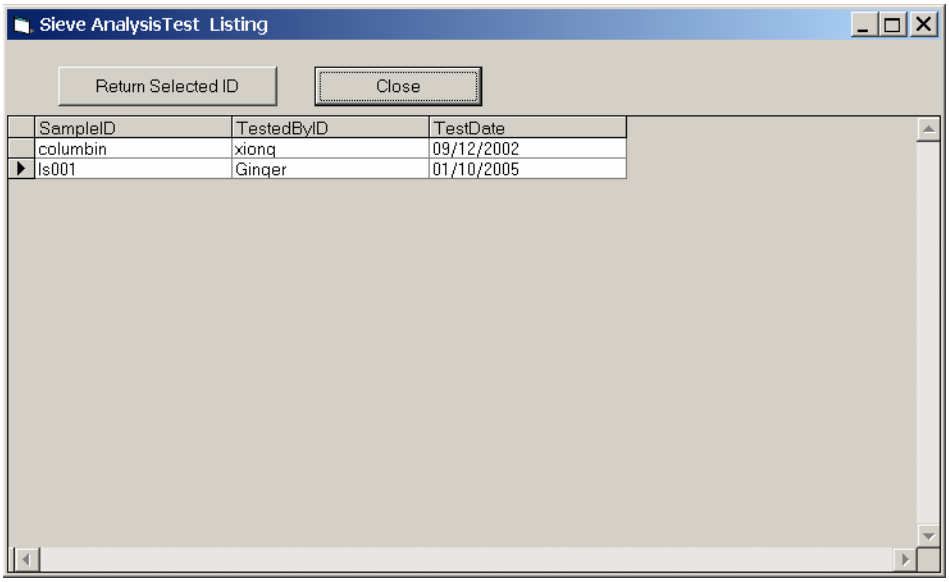


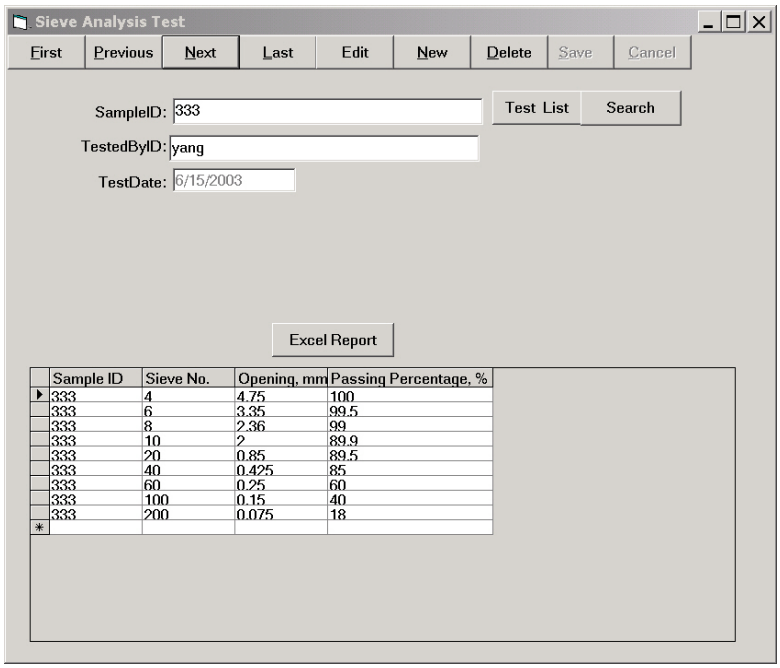
Figure 58. Sieve Analysis Test Data Search Window

❖ ***Edit***

If you want to edit a data record, after you locate that data, click the <edit> button and

Figure 59 shows up. You can edit the value on fields “Test Date”, “TestedByID”, “Test Method”. You cannot modify the sample ID, which is a foreign key in the database. If you want to modify the sample ID, you have to do it in the Material submenu. You can click the <Save> button to save the modified data, or click <Cancel> button to cancel the modification.

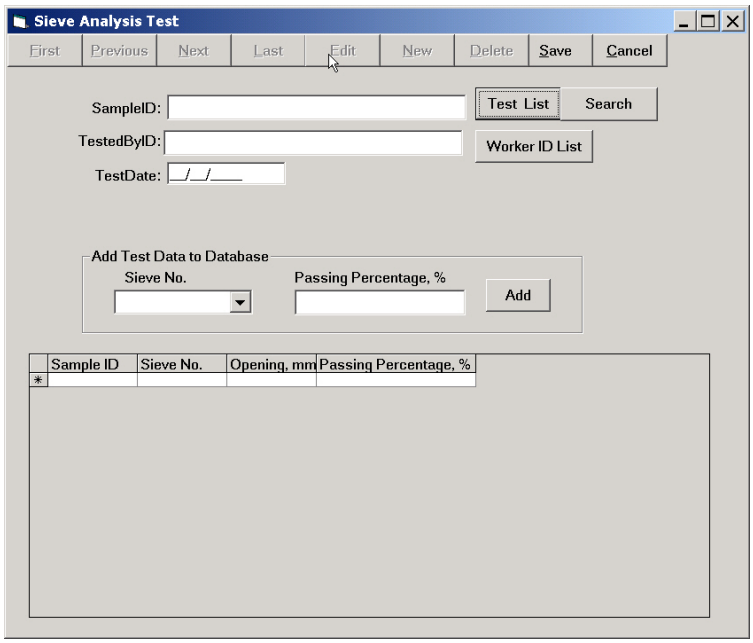
Figure 59. Sieve Analysis Test Data Edit Window



❖ ***New Data Entry***

To input new Sieve Analysis test results, click the <New> button on Figure 55. Figure 60 shows up. The data of "SampleID" is a foreign key in the database and must have been input in the Material submenu. Input the worker's ID who did the test and the test date. Select the Sieve Number input the Passing Percentage and click the <Add> button to save the data to the database. After finishing input the data, you can click the <Save> button to save the data to the database and return to Figure 55. You can press <Cancel> button to cancel this new data entry process.

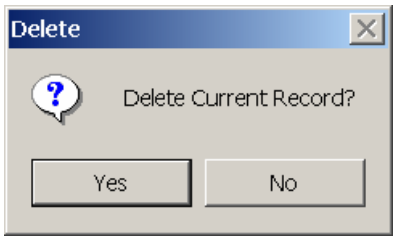
Figure 60. Sieve Analysis Test Data Record Input Window



❖ ***Delete Sieve Analysis Data Entry***

If you want to delete a set of data, after you locate that data, click the <delete> button and Figure 61 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

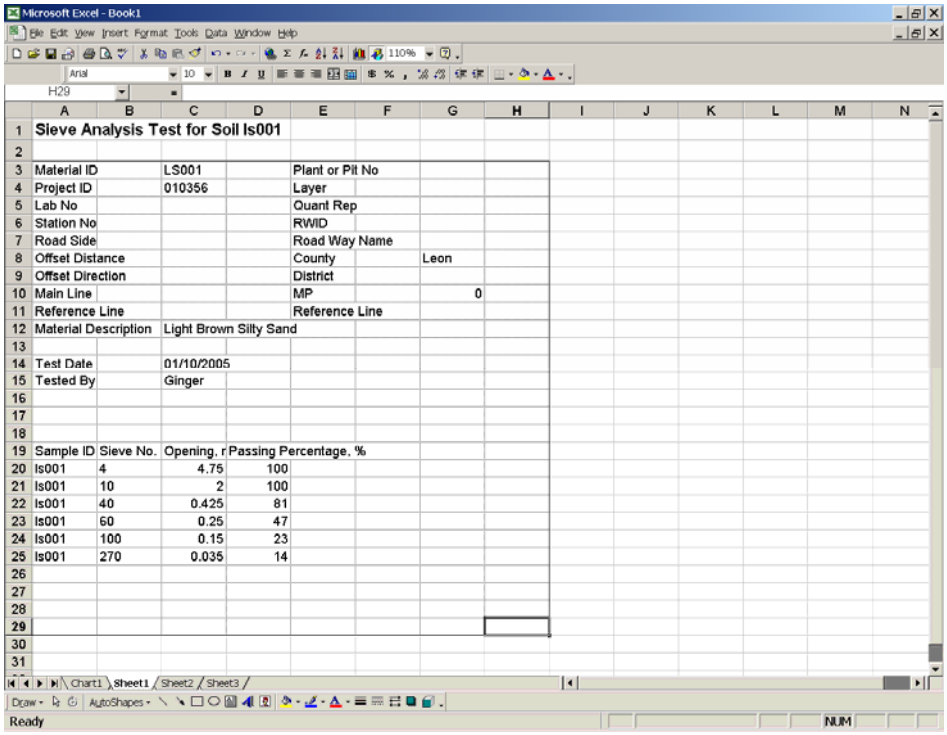
Figure 61. Sieve Analysis Test Data Record Delete Warning Window



❖ ***Sieve Analysis Test Excel Report***

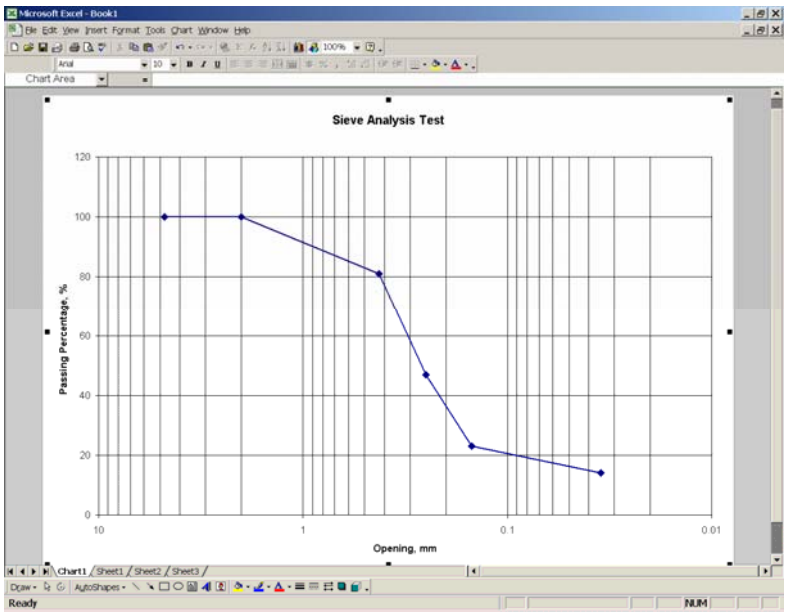
If you want to produce a Sieve Analysis test report in Excel format, select a data entry and click the <Excel Report> button. The program will collect all of the data related to the material and Sieve Analysis test from the database, input them to the Microsoft Excel program, and produce a report including data sheets and diagrams. You may save this report and print this report through the Excel program (Figures 56, 57).

Figure 62. Sieve Analysis Test Report



	A	B	C	D	E	F	G	H
1	Sieve Analysis Test for Soil ls001							
2								
3	Material ID		LS001		Plant or Pit No			
4	Project ID		010356		Layer			
5	Lab No				Quant Rep			
6	Station No				RWID			
7	Road Side				Road Way Name			
8	Offset Distance				County		Leon	
9	Offset Direction				District			
10	Main Line				MP		0	
11	Reference Line				Reference Line			
12	Material Description		Light Brown Silty Sand					
13								
14	Test Date		01/10/2005					
15	Tested By		Ginger					
16								
17								
18								
19	Sample ID	Sieve No.	Opening, r	Passing Percentage, %				
20	ls001	4	4.75	100				
21	ls001	10	2	100				
22	ls001	40	0.425	81				
23	ls001	60	0.25	47				
24	ls001	100	0.15	23				
25	ls001	270	0.035	14				
26								
27								
28								
29								
30								
31								

Figure 63. Sieve Analysis Test Chart



Atterberg Test

This <Atterberg Test> submenu lets you browse or edit the Atterberg test data of the materials tested. If you are a logged on, after clicking <Atterberg Test> submenu, Figure 64 shows up. This window lets you edit the database. If you are not logged on, Figure 65 shows up. This window only lets you browse the data.

Figure 64. Atterberg Test Data Window (logged on)

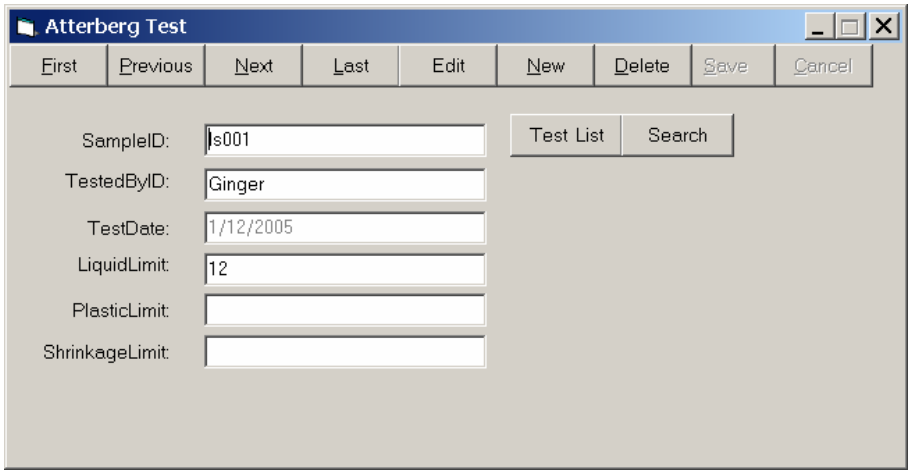
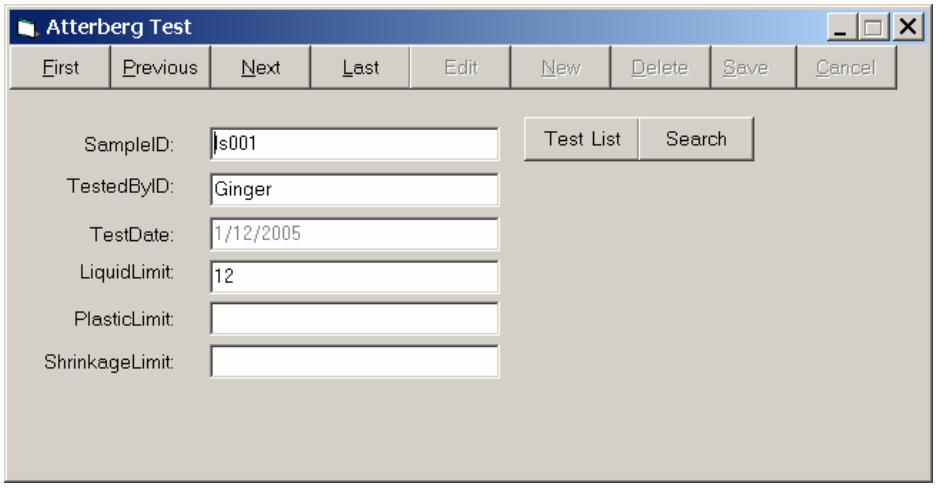


Figure 65. Atterberg Test Data Window (browse only)

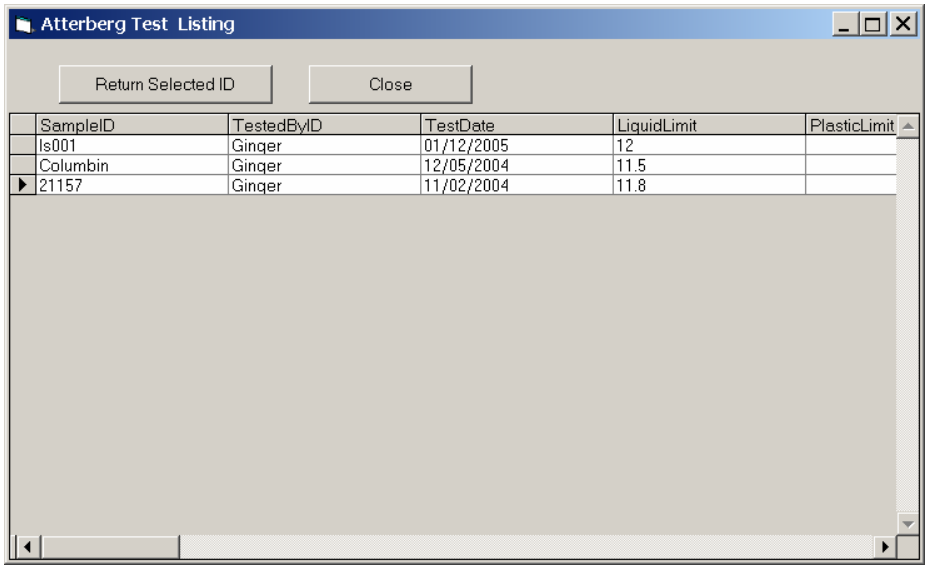


❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the database.

Clicking the <Test List> button, all of the materials in the Atterberg test database will be listed out in a data sheet format. You may sort the data by one field when you click the corresponding column title. This is useful to help you locate specific data (Figure 66).

Figure 66. Atterberg Test Data List



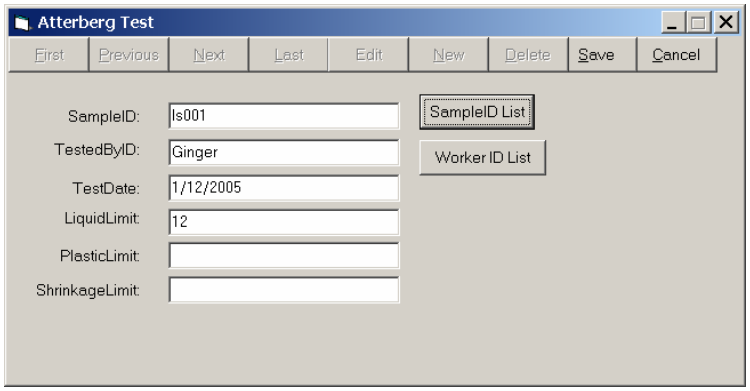
Clicking the <Search> button, Figure 67 shows up. Type the sample ID, then press the <Go> button. The data entries with your specified sample ID will be current and shown in the window.

Figure 67. Atterberg Test Data Search Window

❖ ***Edit***

If you want to edit data, after you locate that data, click the <edit> button and Figure 68 shows up. You can edit any field but sample ID, which is the foreign key in the database. If you want to modify the sample ID, you have to go to the Material submenu to modify it. Click <Save> button to save the modified data or click <Cancel> button to cancel the modification.

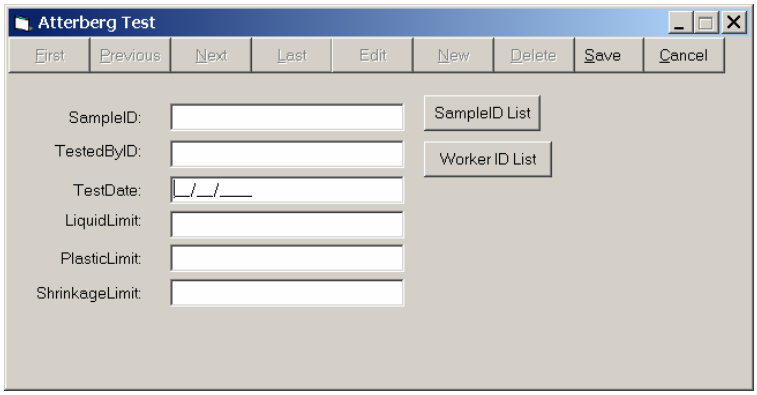
Figure 68. Atterberg Test Data Edit Window



❖ ***New Data Entry***

To input new Atterberg test data, click the <New> button on Figure 64. Figure 69 shows up. The data of "SampleID" is a foreign key in the database and must have been input in the Material submenu. Fill out the other fields, then click the <Save> button to save the data to the database. Press <Cancel> button to cancel this new data entry process.

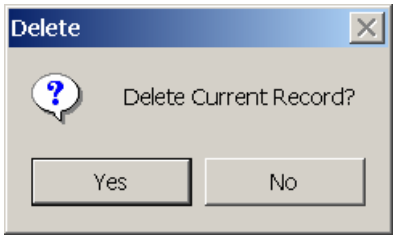
Figure 69. Atterberg Test Data Record Input Window



❖ ***Delete Atterberg Data Entry***

If you want to delete a set of data, after you locate that data, click the <delete> button and Figure 70 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

Figure 70. Atterberg Test Data Record Delete Warning Window



AASHTO Classification

The <AASHTO Classification> submenu lets you browse or edit the AASHTO Classification data of the materials tested. If you are logged on, after clicking the <AASHTO Classification> submenu, Figure 71 shows up. This window lets you edit database. If you are not logged on, Figure 72 shows up. This window only lets you browse the data.

Figure 71. AASHTO Classification Data Window (logged on)

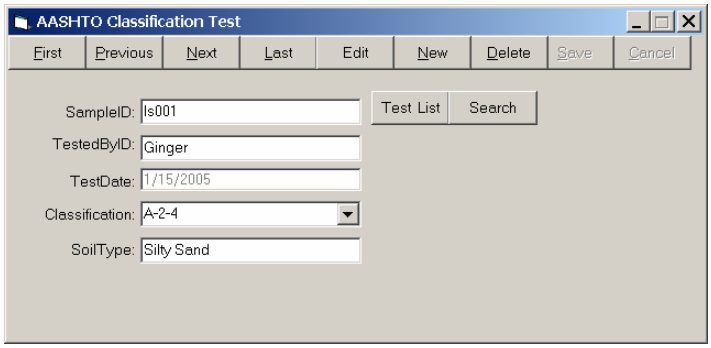
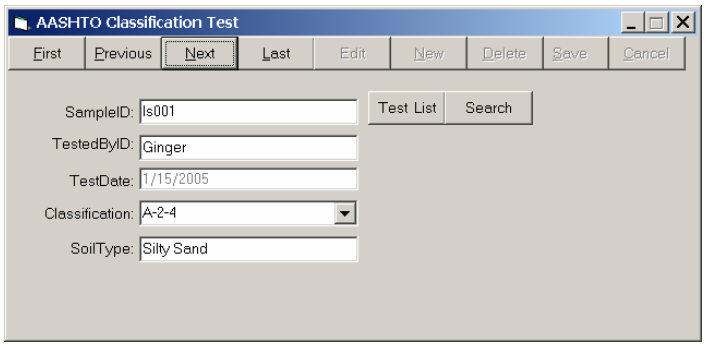


Figure 72. AASHTO Classification Data Window (browse only)



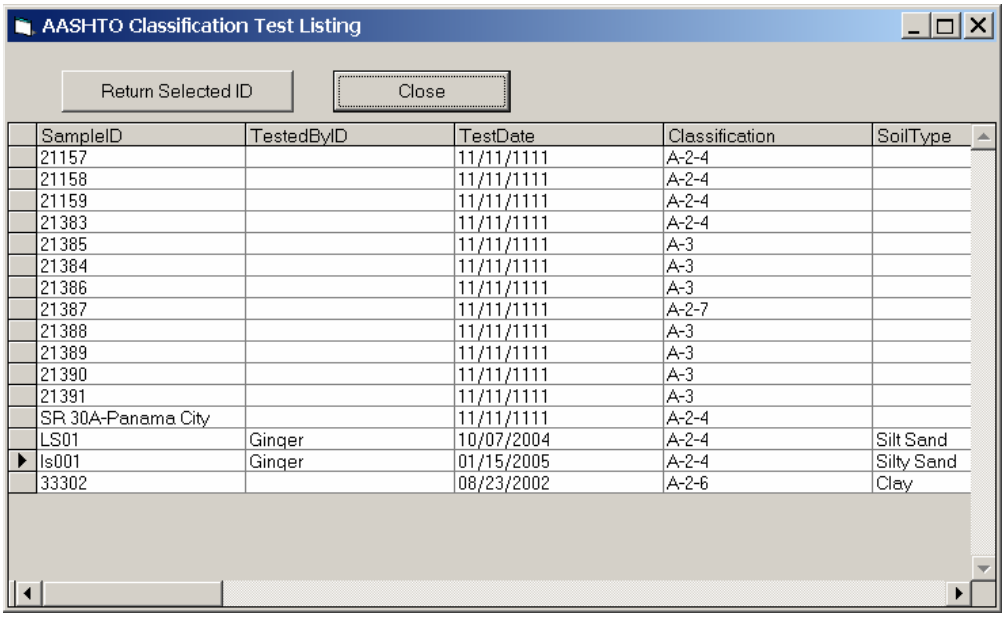
❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the database.

By clicking the <Test List> button, all of the materials in the AASHTO Classification database will be listed out in data sheet format. You may sort the data by the one field when you click the corresponding column title. This is useful to help you locate specific data entry (Figure 73)

By clicking the <Search> button,
Figure 74 shows up. Type the sample ID and press the <Go> button. The data entries with the sample ID you specified will be current and shown in the window.

Figure 73. AASHTO Classification Data List



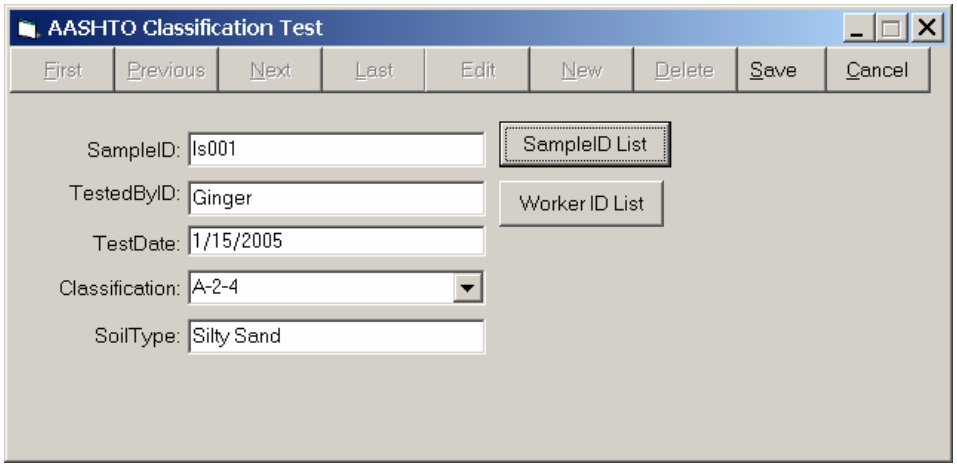
SampleID	TestedByID	TestDate	Classification	SoilType
21157		11/11/1111	A-2-4	
21158		11/11/1111	A-2-4	
21159		11/11/1111	A-2-4	
21383		11/11/1111	A-2-4	
21385		11/11/1111	A-3	
21384		11/11/1111	A-3	
21386		11/11/1111	A-3	
21387		11/11/1111	A-2-7	
21388		11/11/1111	A-3	
21389		11/11/1111	A-3	
21390		11/11/1111	A-3	
21391		11/11/1111	A-3	
SR 30A-Panama City		11/11/1111	A-2-4	
LS01	Ginger	10/07/2004	A-2-4	Silt Sand
ls001	Ginger	01/15/2005	A-2-4	Silty Sand
33302		08/23/2002	A-2-6	Clay

Figure 74. AASHTO Classification Data Search Window

❖ ***Edit***

If you want to edit data, after you locate that data, click the <edit> button and Figure 75 shows up. You can edit any field but sample ID, which is a foreign key in the database. You have to modify the Sample ID through the Material submenu. You can click the <Save> button to save the modified data or click the <Cancel> button to cancel the modification.

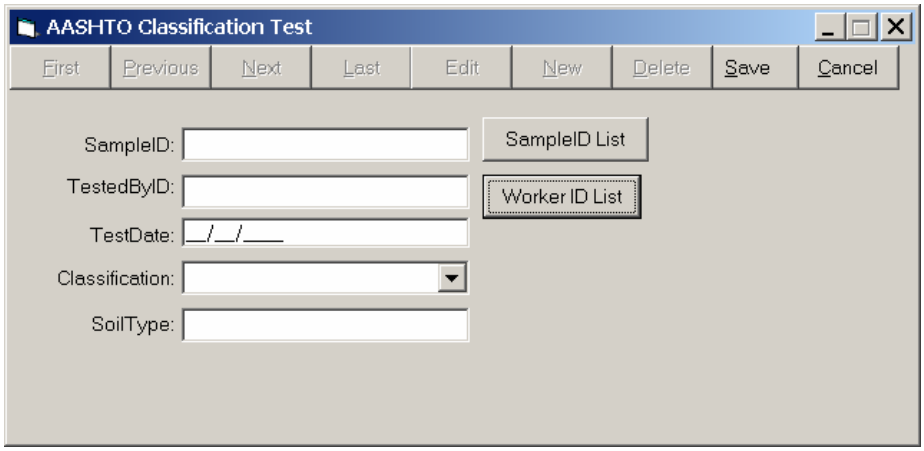
Figure 75. AASHTO Classification Data Edit Window



❖ ***New Data Entry***

To input new AASHTO Classification data, click the <New> button on Figure 71. Figure 76 shows up. The data of "SampleID" is used as a foreign key in the database and must have existed in the database. Fill out the fields, then click the <Save> button to save the data to the database. Press the <Cancel> button to cancel this new data entry process.

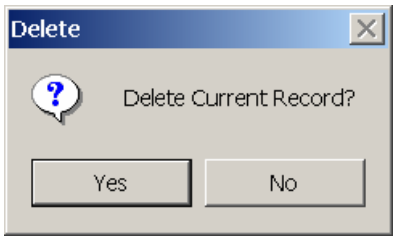
Figure 76. AASHTO Classification Data Record Input Window



❖ ***Delete AASHTO Classification Data Entry***

If you want to delete a set of data, after you locate that data, click the <delete> button,
Figure 77 shows up and give you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

Figure 77. AASHTO Classification Data Record Delete Warning Window



LBR Test

The <LBR Test> submenu lets you browse or edit the LBR test data of the testing materials. If you are logged on, after clicking the <LBR Test> submenu, Figure 78 shows up. This window lets you edit the database. If you are not logged on, Figure 79 shows up. This window only lets you browse the data.

Figure 78. LBR Test Data Window (logged on)

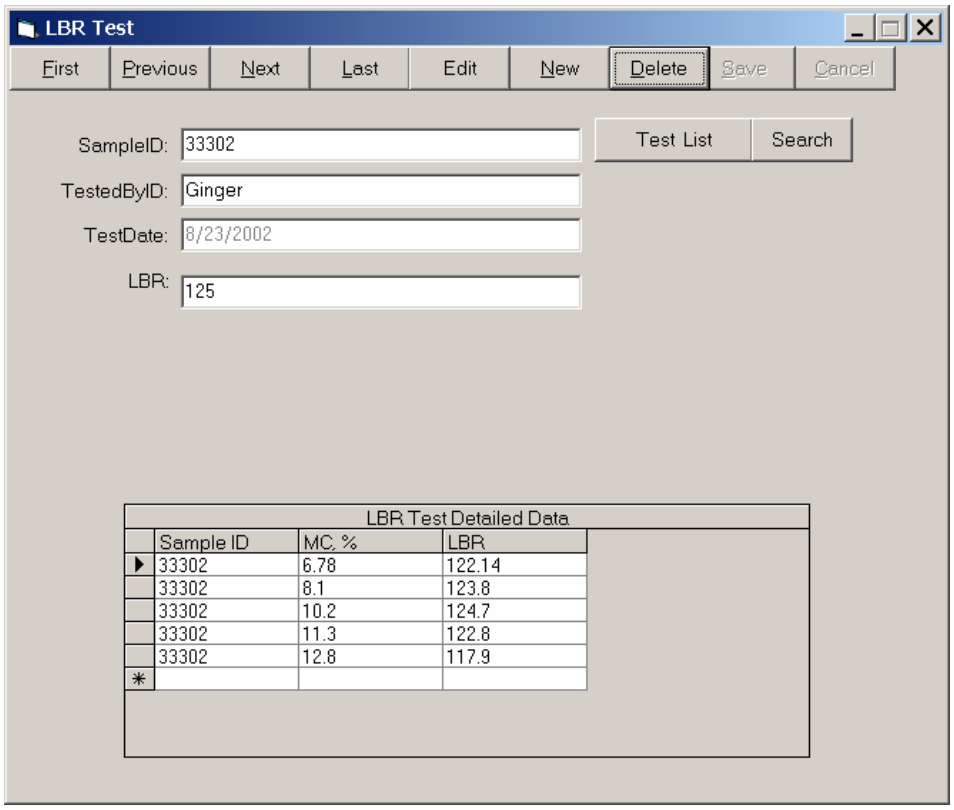
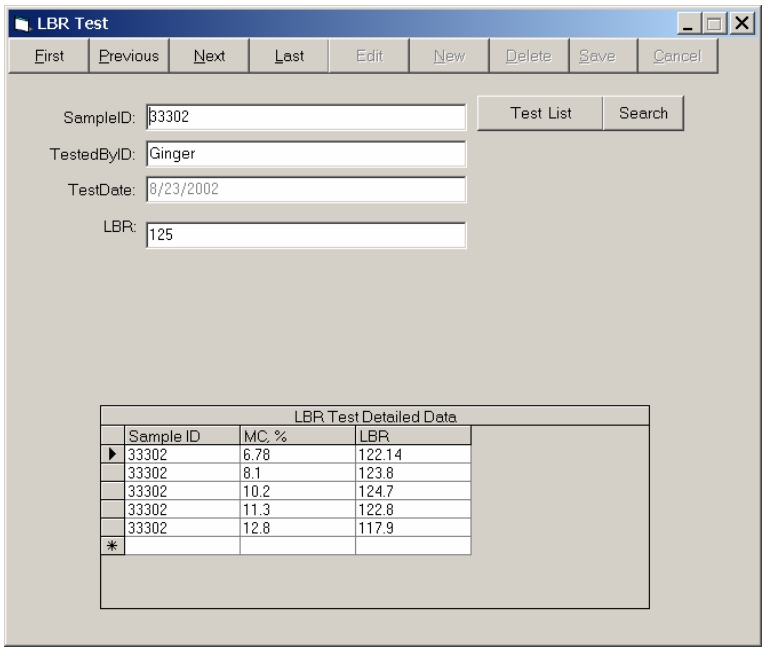


Figure 79. LBR Test Data Window (browse only)



❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the data base.

By clicking the <Test List> button, all of the materials in the LBR test database will be listed out in data sheet format. You may sort the data by one field when you click the corresponding column title. This is useful to help you locate specific data (Figure 80)

By clicking the <Search> button, Figure 81 shows up. Type the sample ID and press the <Go> button. The data entries with your specified sample ID will be current and shown in the window.

Figure 80. LBR Test Data List

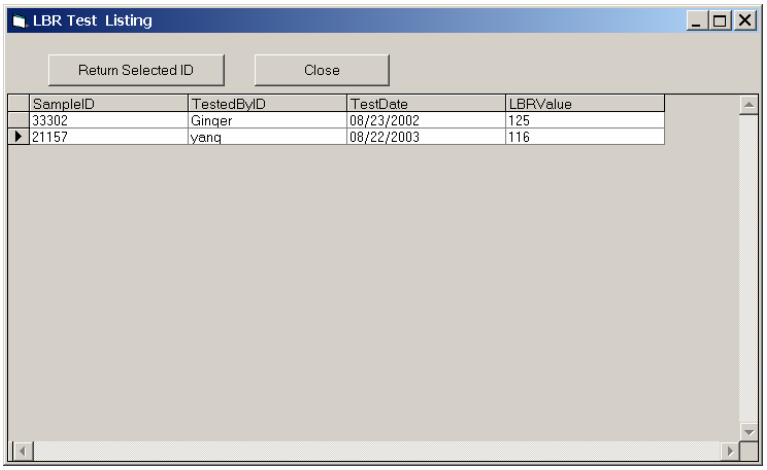
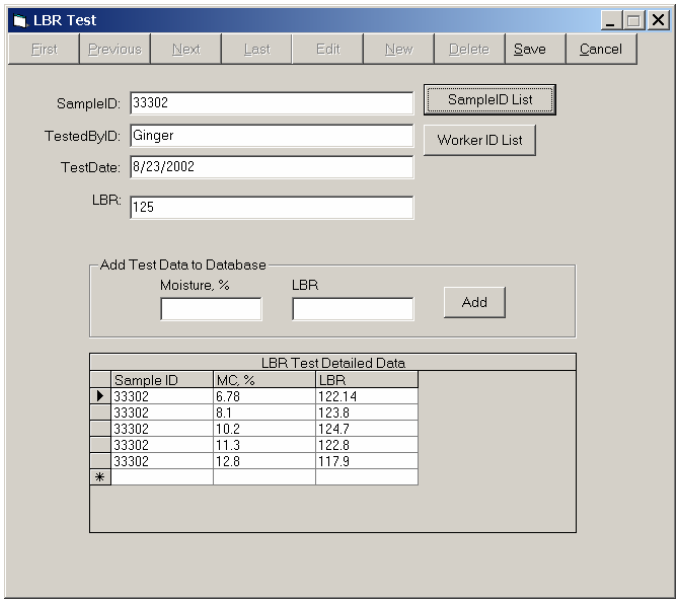


Figure 81. LBR Test Data Search Window

❖ ***Edit***

If you want to edit a set of data, after you locate that data, click the <edit> button, Figure 82 shows up. You can edit the value on fields “Test Date”, “TestedByID”, “LBR”. You cannot modify the sample ID, which is a foreign key in the database. If you want modify the sample ID, you have to go to the Material submenu and change the sample ID over there. You can click the <Save> button to save the modified data or click the <Cancel> button to cancel the modification.

Figure 82. LBR Test Data Edit Window



❖ ***New Data Entry***

To input new LBR test results, click the <New> button on Figure 78. Figure 83 shows up. The data of "SampleID" is a foreign key in the database and must have been input in the Material submenu. Input the worker's ID who did the test and the test date. The LBR value is taken from the test data graph. You may first leave the LBR field blank and just input the test points into the database. Input the Moisture and individual LBR data and click the <Add> button to save the data point to the database. After finishing input the data, click <Save> button to save the data to the database and return to Figure 78. Click the <Excel Report> button, Figure 84 will be produced. You may read the LBR value from this graph. Then you can use the Edit Button to enter the LBR value to the database.

Figure 83. LBR Test Data Record Input Window

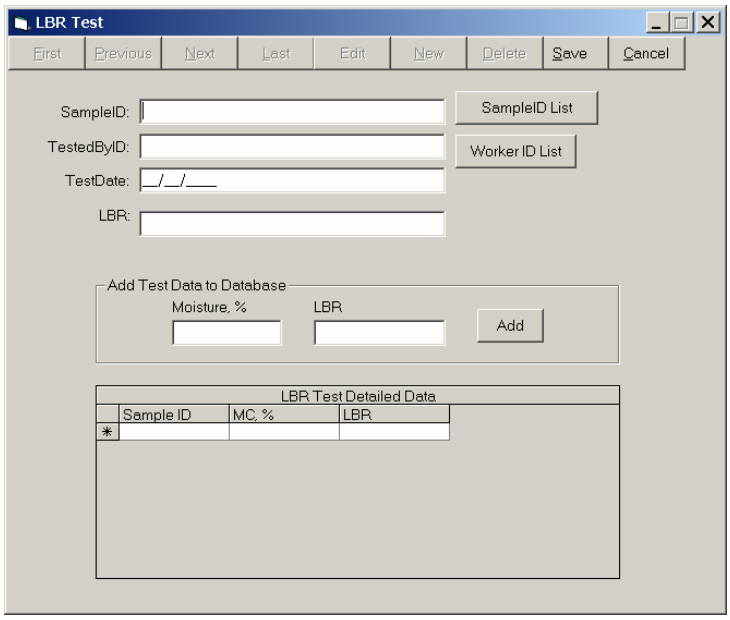
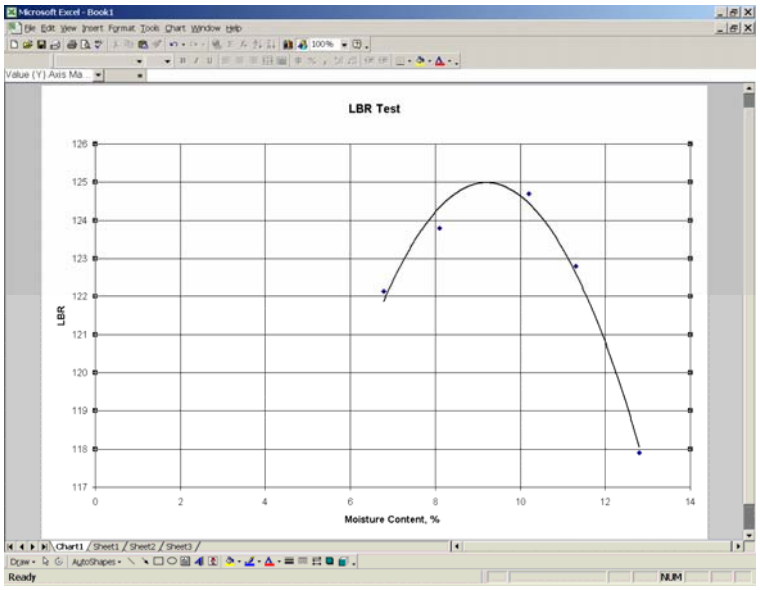


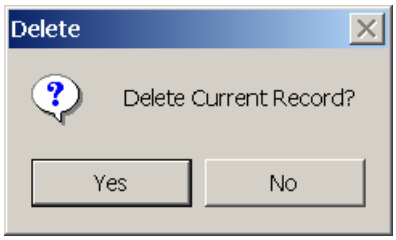
Figure 84. LBR Test Graph



❖ ***Delete LBR Data Entry***

If you want to delete a set of data, after you locate that data, click the <delete> button, Figure 85 shows up and give you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

Figure 85. LBR Test Data Record Delete Warning Window



❖ ***LBR Test Excel Report***

If you want to produce an LBR test report in Excel format, after you locate the data entry, click the <Excel Report> button. The program will collect all of the data related to the material and LBR test from the database, input them to the Microsoft Excel program and produce a report including data sheet and graphs. You may save this report and print this report through Excel (Figure 86,

Figure 87).

Figure 86. LBR Test Report

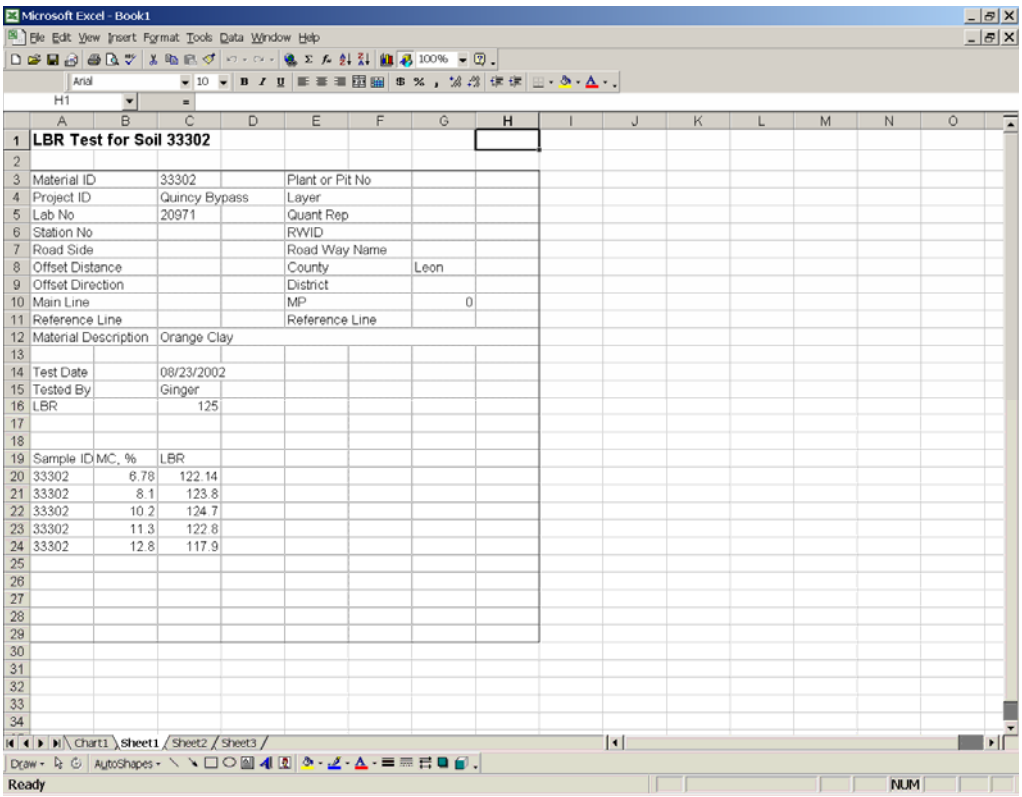
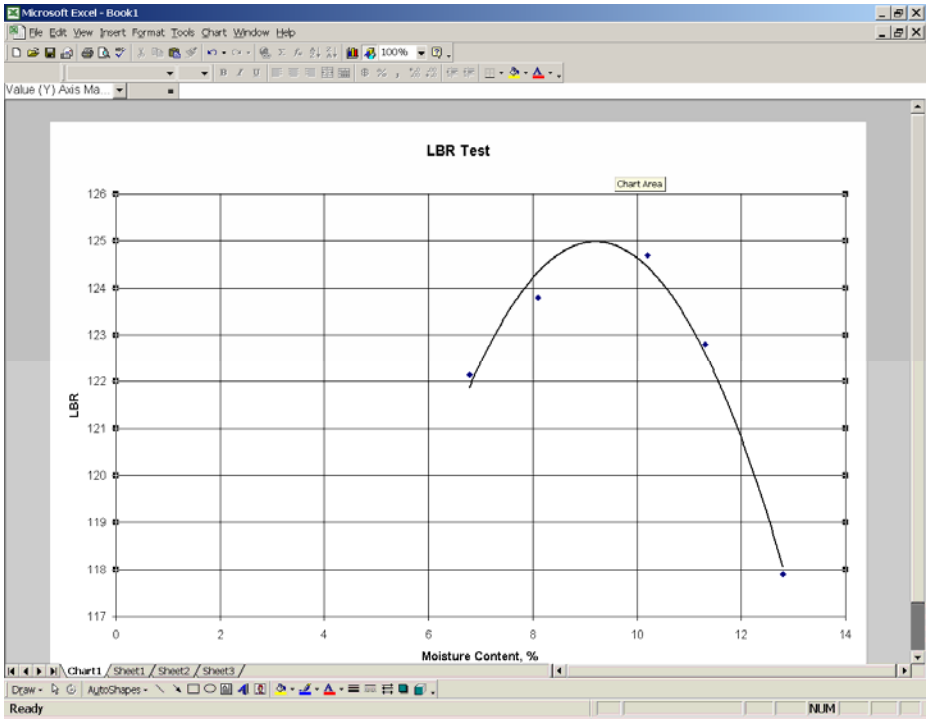


Figure 87. LBR Test Graph



Worker

The <Worker> submenu lets you browse or edit the Workers' data. Workers are the people who run the soil tests or bring the materials to the Lab. If you are logged on, after clicking the <Worker> submenu, Figure 88 shows up. This window lets you edit the database. If you are not logged on, Figure 89 shows up. This window only let you browse the data.

Figure 88. Worker Data Window (logged on)

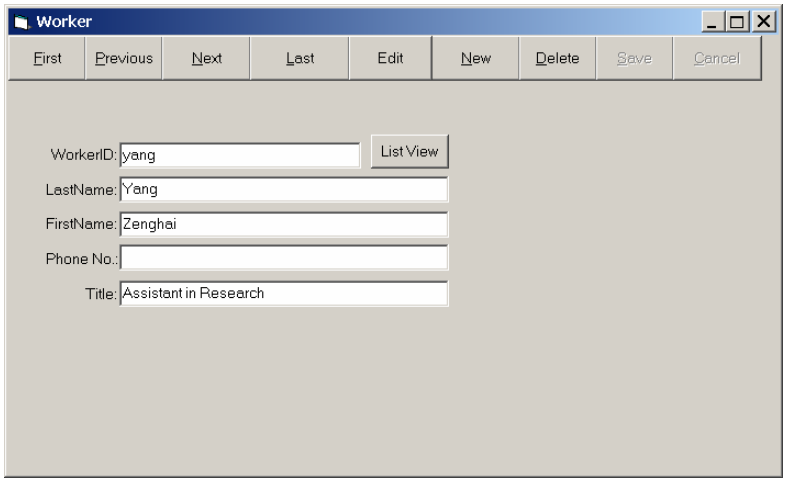
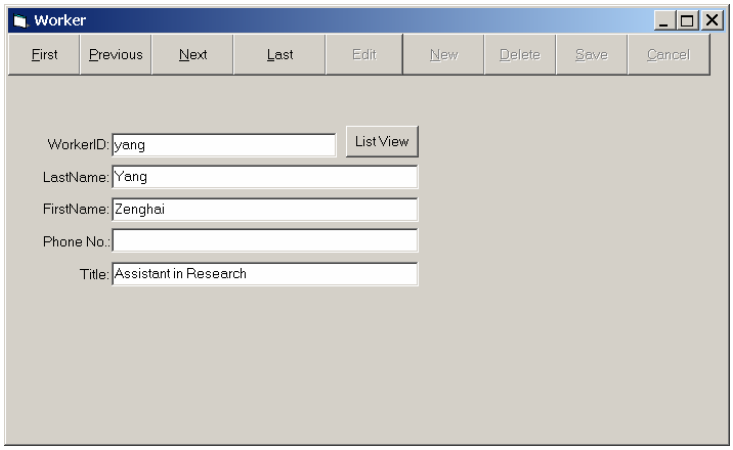


Figure 89. Worker Data Window (browse only)

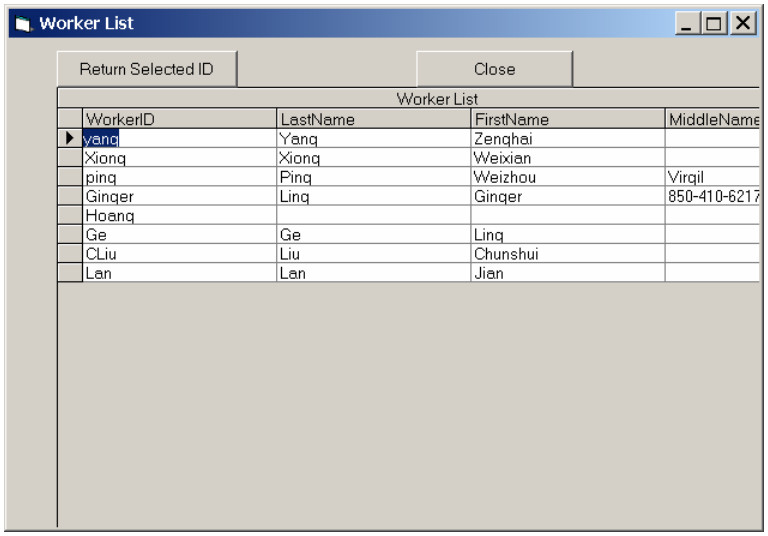


❖ ***Navigation***

You may use the navigation buttons <First>, <Previous>, <Next> and <Last> to browse the database.

By clicking the <List View> button, all of the workers in the database will be listed out in data sheet format. You may sort the data by the one field when you click the corresponding column title. This is useful to help you locate the data (Figure 90).

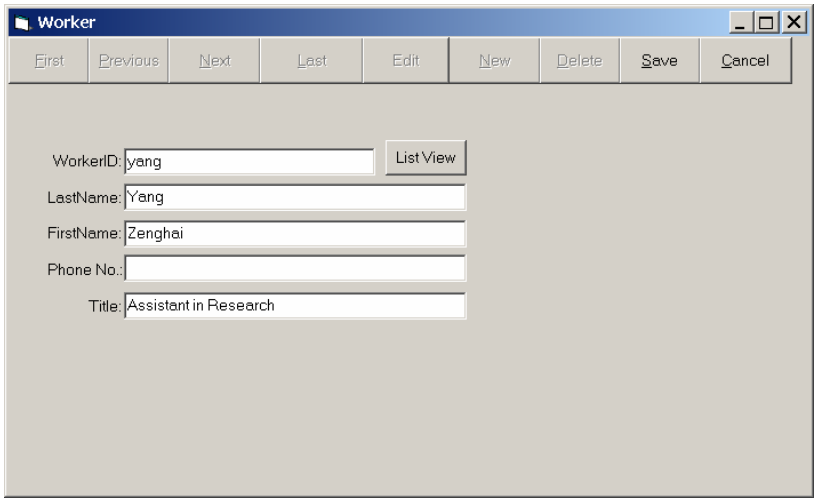
Figure 90. Worker Data List



❖ ***Edit***

If you want to edit the data, after you locate that data, click the <edit> button and Figure 91 shows up. You can edit any field. Click <Save> button to save the modified data. Or click <Cancel> button to cancel the modification.

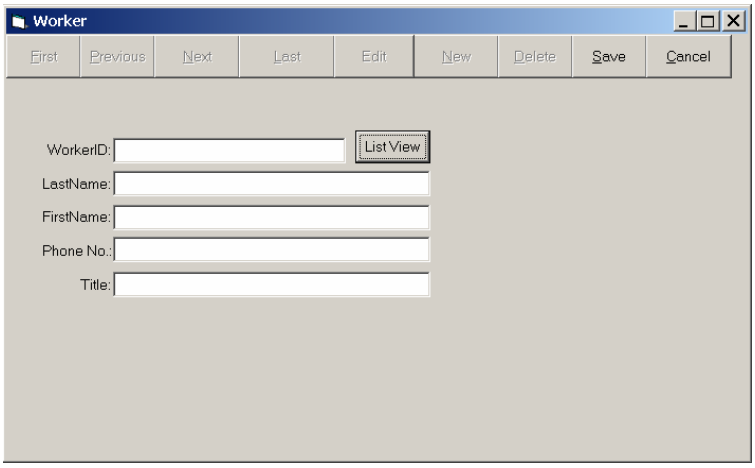
Figure 91: Worker Data Edit Window



❖ ***New Data Entry***

To input new Worker data, click the <New> button on Figure 88 and Figure 92 shows up. The data of "WorkerID" is used as the primary key in the database and must be unique in the database. Fill out the fields, then click the <Save> button to save the data to the database. Press the <Cancel> button to cancel this new data entry process.

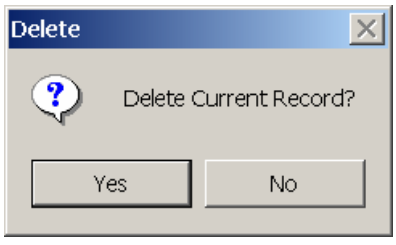
Figure 92. Worker Data Record Input Window



❖ ***Delete Worker Data Entry***

If you want to delete a set of data, after you locate that data, click the <delete> button and Figure 93 shows up and gives you a warning to your action. Click <Yes> to delete the current record. Click <Cancel> to cancel your delete action and return to your previous screen.

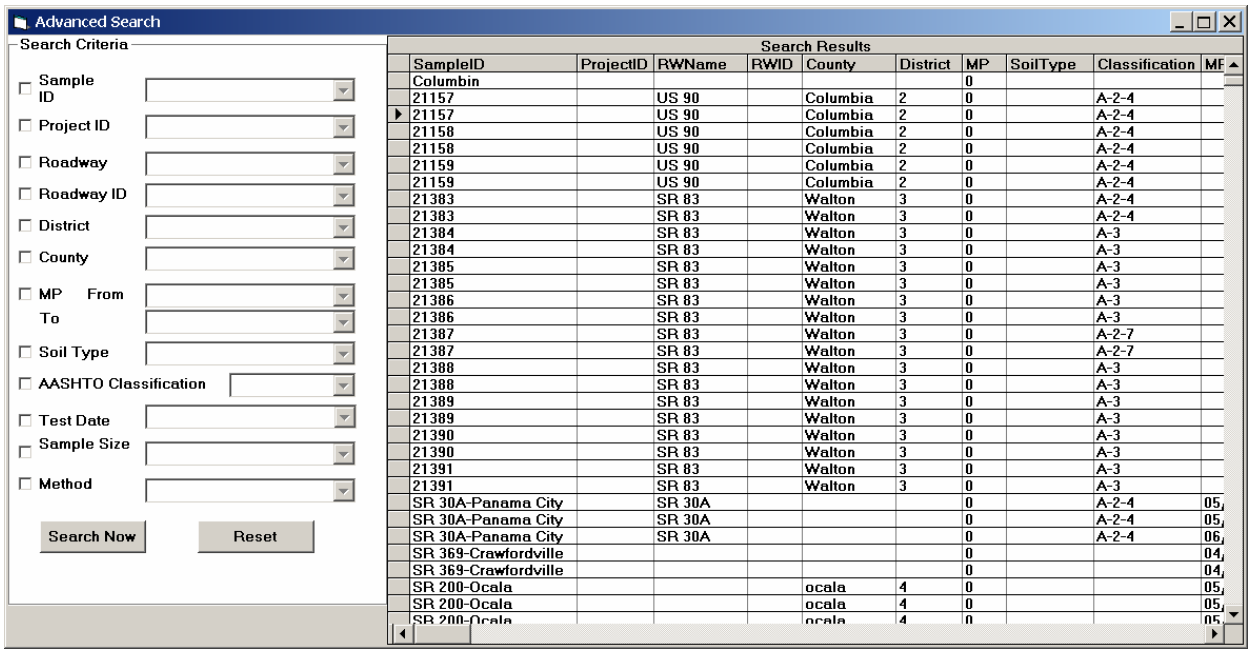
Figure 93. Worker Data Record Delete Warning Window



Search

Clicking the <Search> button opens the Material Search Window (Figure 94). You may use this tool to find the “MaterialID” from the database. Click the check box and select an available data in the drop box as your search criteria. Click the <Search Now> button. All of the data entries which meet your search criteria will be listed in the right window.

Figure 94. Material Search Window



PAVEMENT DESIGN

To do the pavement design, click the <Pavement Design> menu. Figure 95 will show up. The definition for each field will show up when you put the computer cursor on the field. Each field on this window is defined as following.

W18 – the cumulative two-directional 18-kip ESAL units predicted for a specific section of highway during the analysis period (from the planning group)

Lane Distribution Factor, Lf – lane distribution factor, expressed as a ratio that accounts for distribution of traffic in one direction, one lane: 1, two lanes: 0.8-1, three lanes: 0.6-0.8, four lanes: 0.5-0.75.

Directional Distribution Factor, Df - directional distribution factor; 1 for one way, 0.5 for most two way roadways, may vary from 0.3 to 0.7 depending on which direction is loaded and which is unloaded.

W18 in design lane is the cumulative 18-kip ESAL traffic during the design period. After you fill out the above fields, click this button, the program will calculate and fills out this field for you.

Reliability, R – the level of reliability for design

Standard Deviation, S -- Standard Deviation: 0.35 for rigid pavements, 0.45 for flexible pavements

Δ PSI - Design Serviceability Loss

Base MR (psi) – You may type the number in the field if you know it or you can get it from the database. Click the <double arrow> button next to the field. Figure 96 shows up. Type the SampleID and click the <Get MR> button. The program will get MR value and fills out the filed. If you do not know the SampleID, click the <Database> menu and use the search submenu to find the SampleID.

Subgrade MR (psi) – You may type the number in the field if you know it or you can get it from the database. Click the <double arrow> button next to the field. Figure 96 shows up. Type the SampleID and click the <Get MR> button. The program will get MR value and fills out the filed. If you do not know the SampleID, click the <Database> menu and use the search submenu to find the SampleID.

Embankment MR (psi) – You may type the number in the field if you know it or you can get it from the data base. Click the <double arrow> button next to the field. Figure 96 shows up. Type the SampleID and click the <Get MR> button. The program will get MR value and fills out the filed. If you do not know the SampleID, click the <Database> menu and use the search function to find the SampleID.

AC Coefficient – Type the AC coefficient here. A typical value is 0.44.

Base Coefficient – After you fill out the base MR, the program can calculate the base coefficient value for you by clicking the <Base Coefficient> button.

Subgrade Coefficient – After you fill out the subgrade MR, the program can calculate the subgrade coefficient value for you by clicking the <Subgrade Coefficient> button.

SN (Structural Number) -- After you fill out the traffic data, reliability and serviceability data, and coefficient data, the program will calculate the required structural number when you click the <SN> button. If you have not filled out the above data, the program will let you know which data is required for the calculation.

Layer thickness of Stabilized Subgrade, Base, and AC – Fill out any two fields of the three fields, the program will calculate the third one.

Figure 95. Pavement Design Window

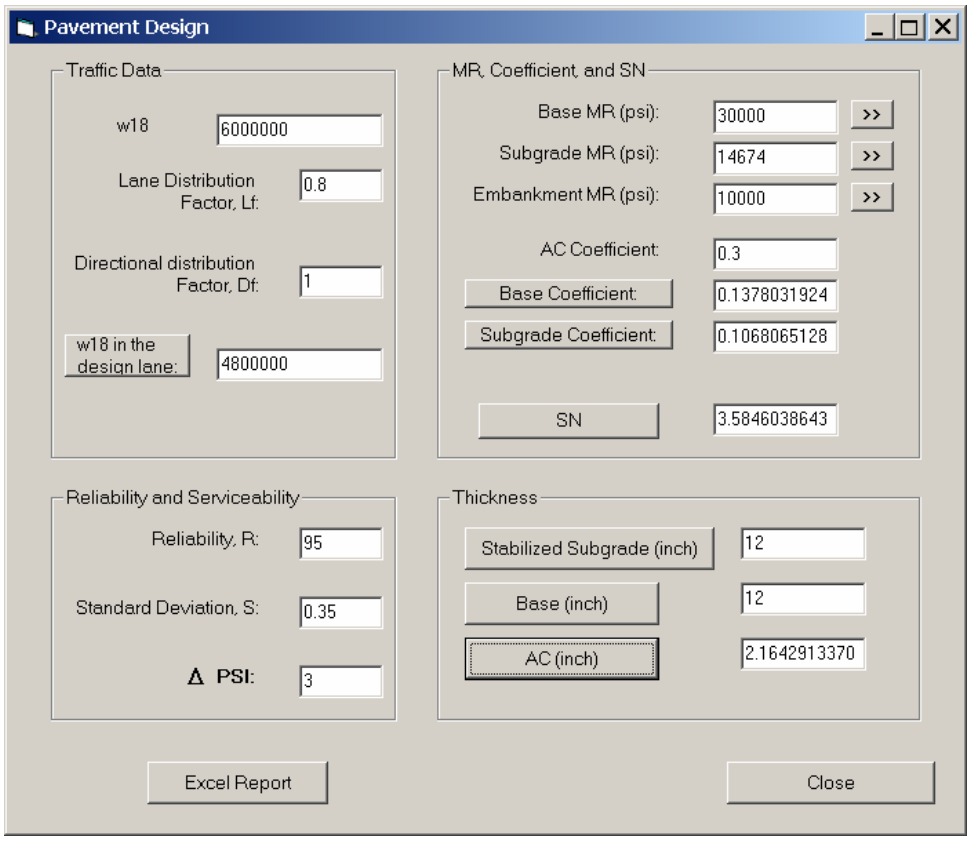
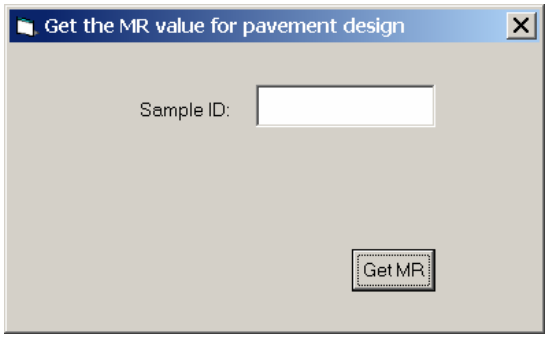
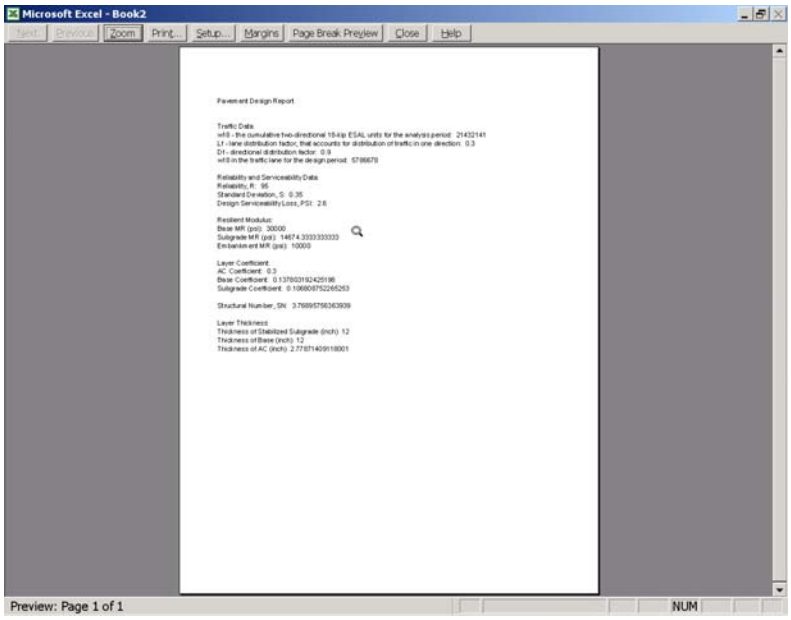


Figure 96. Get the MR Value for Pavement Design



Excel Report – After you finish the design, if you want to print out the design, click the <Excel Report> button. The program will put the design into the Excel Data sheet and you can print the data from Excel (Figure 97).

Figure 97. Pavement Design Report



HELP

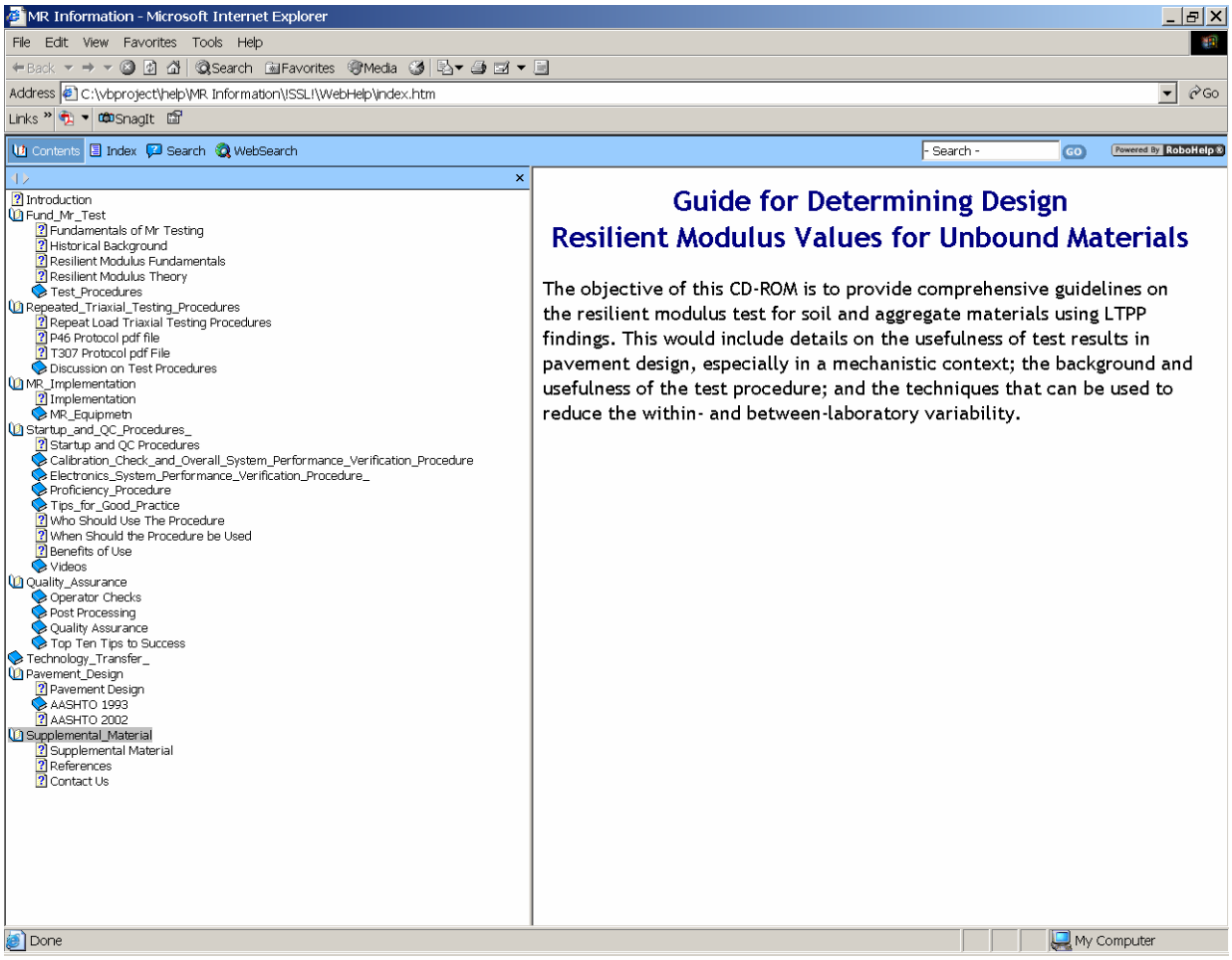
Two submenus are under the <Help> menu (Figure 98).

Figure 98. Help Menu

MR Information

By clicking the <MR Information> submenu, the following web page (Figure 99) shows up. This web page provides comprehensive guidelines on the resilient modulus test for soil and aggregate materials using LTPP findings. This would include details on the usefulness of test results in pavement design, especially in a mechanistic context; the background and usefulness of the test procedure; and the techniques that can be used to reduce the within- and between-laboratory variability. You may find the information you need by clicking the <contents>, <Index> or <Search> tab on the left side of the window.

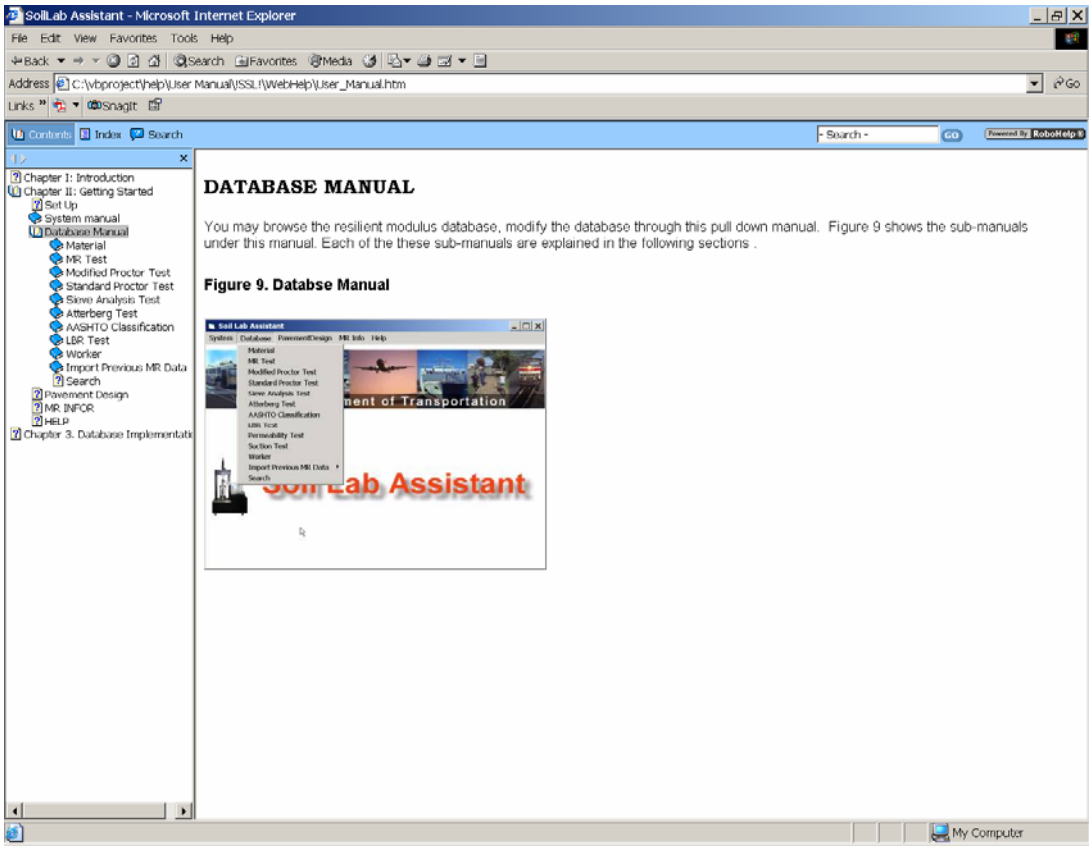
Figure 99. MR Information Web Page



Users Manual

Clicking the <Users Manual> submenu opens the Users Manual (Figure 100). Find the information you need by clicking the <contents>, <Index> or <Search> tab on the left side of the window.

Figure 100. Users Manual



MR Test Check List

❖ *Testing System Calibration*

1. The load cell should be monitored and checked once every two weeks or after every 50 resilient modulus tests with a calibrated proving ring to assure that the load cell is operating properly. An alternative to using a proving ring is to insert an additional calibrated load cell and independently measure the load applied by the original load cell to ensure accurate loadings. Resilient modulus testing shall not be conducted if the testing system is found to be out of calibration or if the load cell does not meet the manufacture's tolerance requirements stated below for accuracy, whichever of the two is of the higher accuracy.

2. The LVDTs shall be calibrated every two weeks, or after every 50 resilient modulus tests, whichever comes first, using a micrometer with compatible resolution. Resilient modulus testing shall not be conducted if the LVDTs do not meet the manufacture's tolerance requirements stated below for accuracy.

❖ *Specimen Preparation*

1. Material Type I includes all untreated granular base and subbase material and all untreated subgrade soils which meet the criteria of less than 70 percent passing the 2.00-mm (No. 10) sieve and less than 20 percent passing the 75-mm (No. 200) sieve, and which have a plasticity index of 10 or less. Soils classified as Type I will be molded in a 150-mm diameter mold.

2. Material Type 2 includes all untreated granular base/subbase and untreated subgrade soils not meeting the criteria for material Type I. Thin-walled tube samples of untreated subgrade soils fall in this Type 2 category.

3. The moisture content of the laboratory-compacted specimen shall not vary by more than +-1.0 percent for Type 1 materials or +-0.5 percent for Type 2 materials from target moisture content.

4. The wet density of the laboratory-compacted specimen shall not vary by more than +-2 percent of the target wet density.

5. The prepared specimens shall be protected from moisture change by applying the triaxial membrane and testing within 5 days of completion. Prior to storage, and directly after removal from storage, weigh the specimen to determine if there was any moisture loss. If the moisture loss exceeds 1 percent for type 1 materials or 0.5 percent for Type 2 materials, then the prepared specimen will not be tested.

6. In Florida, most soil materials are sand. It is difficult to move or handle the specimen after it is extruded out from the mold. So, place a moist paper filter and a moist porous stone on both ends of the specimen before it is extruded out and extrude them together out of the mold.

7. Place a membrane on the specimen immediately after the sample was extruded out from the mold using a membrane expander.

❖ ***Specimen Setup***

1. Carefully place the specimen with the porous stone on the top of the specimen base of the triaxial chamber. Carefully clean the surface of the top and bottom platen (the most possible cause for air leakage). Fold up the membrane and seal it to the top and bottom platen with an O-ring. Align the specimen with the piston rod of the loading system.

2. Connect the drainage line to the top platen. Connect the load cell, connect the LVDTs and adjust the LVDT readings to –0.19 inch for the vertical LVDTs –0.09 inch for the horizontal LVDTs.

3. Misalignment or dirt on the shaft of the transducer can cause the “sticking” of the shafts of the LVDT. Depress and release each LVDT prior to each test to assure that there is no sticking. An acceptable cleaner/lubricant (as specified by the manufacturer) shall be applied to the transducer shafts on a regular basis.

4. Close the chamber, connect the air pressure line, and apply 6 psi air confining pressure to the specimen.

5. Connect the drainage line from the chamber to water and open the valve. If bubbles are present, check for leakage caused by poor connections, holes in the membrane, or imperfect seals at the cap and base (most possible reason). Leakage through holes in the membrane can frequently be eliminated by coating the surface of the membrane with liquid rubber latex or by using a second membrane.

6. When leakage has been eliminated, close the chamber. Open all drainage valves leading into the specimen to atmospheric pressure.

7. Apply the specified pre-conditioning confining pressure to the specimen.

❖ ***MTS Machine Setup***

1. Click the <MTS Start Station Manager> button (Figure 101) on the computer desktop

2. Open Configuration file and Parameter sets (Figure 102)

3. Click the interlock and program reset button if necessary (Figure 103)

4. Start the hydraulic pump (Figure 104)

5. Run the Function Generator program to warm up the machine for about 5 minutes (Figure 105)

6. Stop the Function Generator program

7. Lower down the cross head of testing system (Figure 106) using the cross head control (Figure 107)

8. Move the MTS actuator down to the chamber rod as close as possible (Figure 108) using MTS remote control (Figure 109). But do not let them touch each other

9. Turn off the MTS remote control

Figure 101. Starting Station Manager

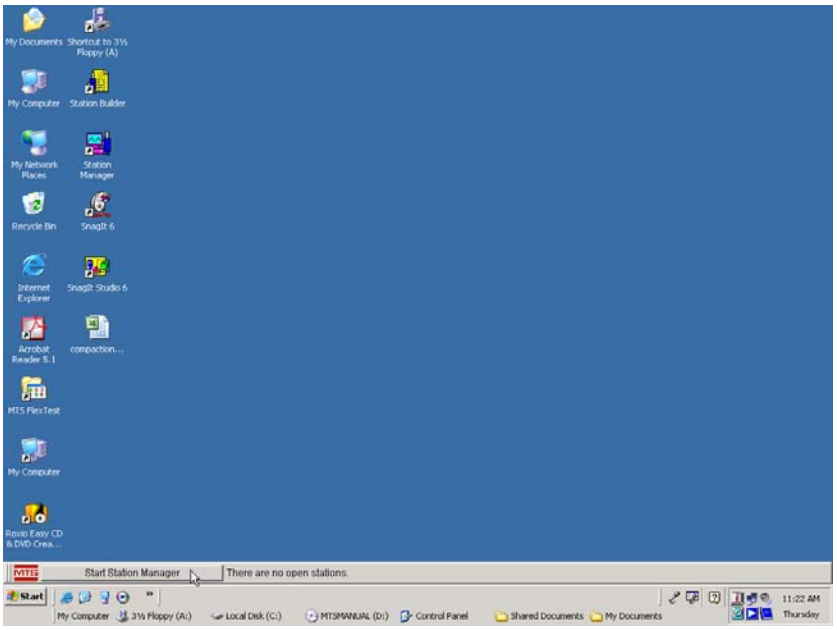


Figure 102. Opening Configuration File and Parameter Sets

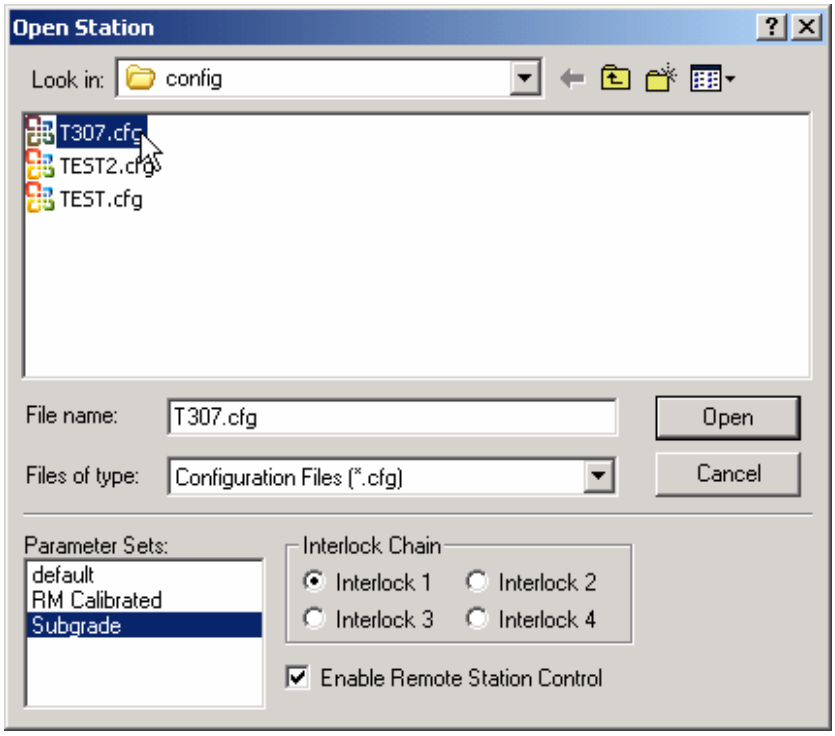


Figure 103. Interlock Reset

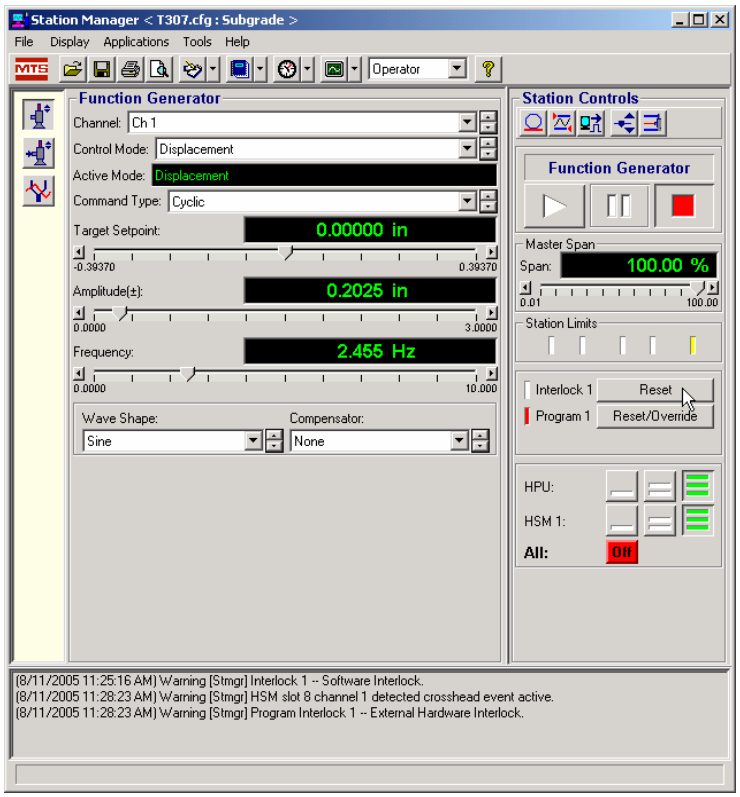


Figure 104. Starting the Hydraulic Pump

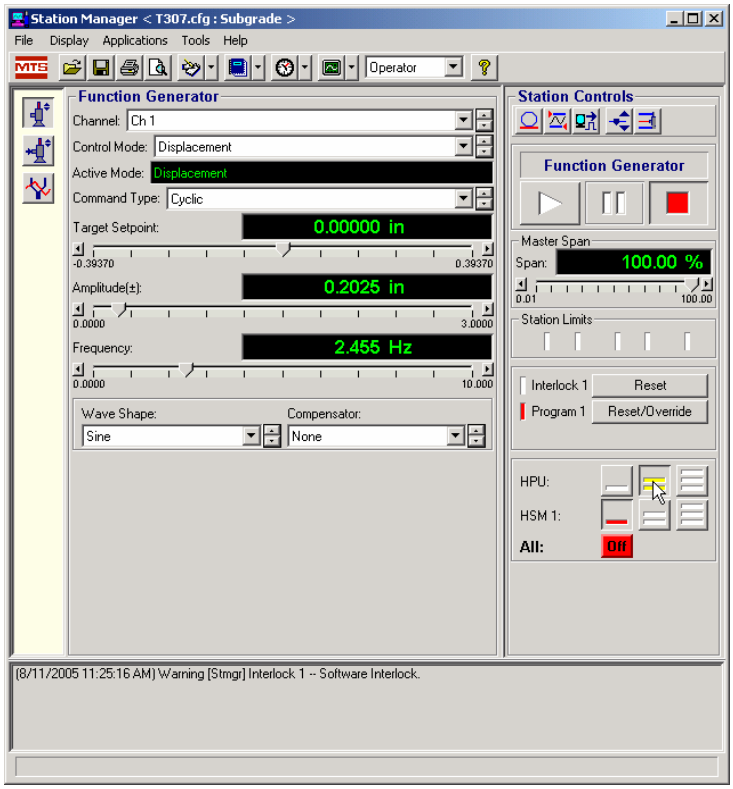


Figure 105. Running Function Generator

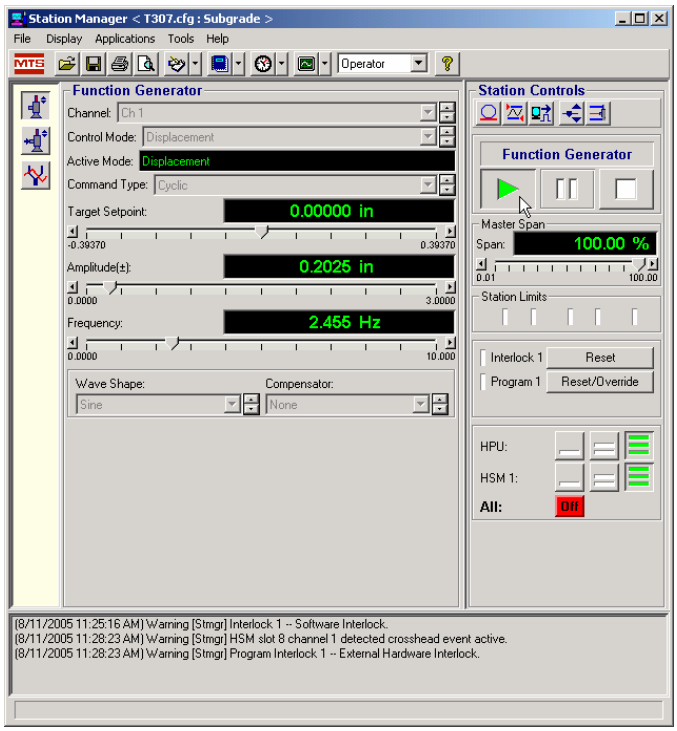


Figure 106. Lowering Down the Cross Head of Testing System

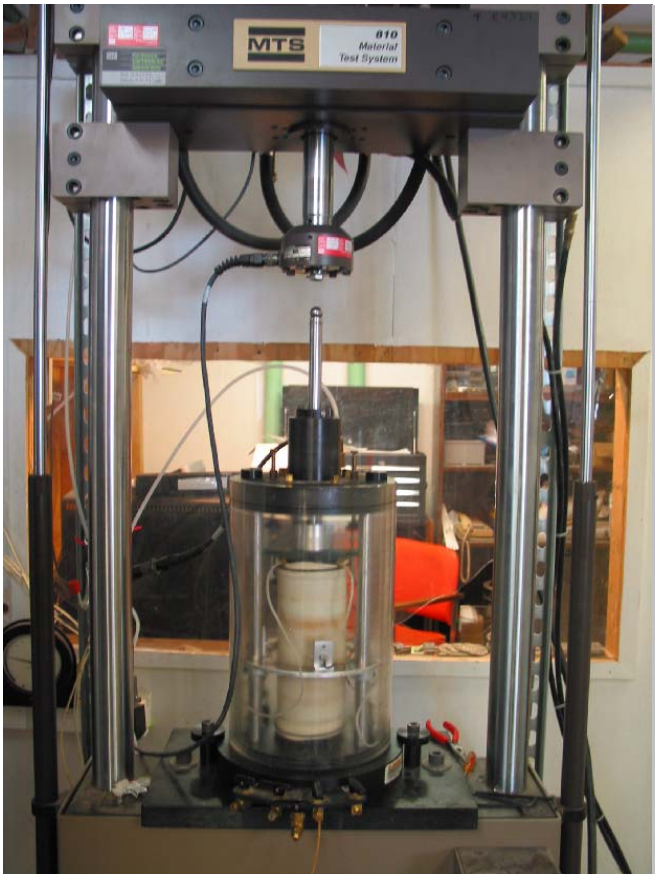


Figure 107. Cross Head Control

Figure 108. Lowering the Actuator Close to the Chamber Rod

Figure 109. MTS System Remote Control

❖ ***Run T307 Test***

1. Open the MultiPurpose TestWare program (Figure 110)
2. Open the T307 Test procedure (Figures 111 and 112)
3. Create a specimen folder (Figure 113)
4. Click the program reset button if necessary (Figure 114)
5. Offset the Force 2 load cell (Figure 115)
6. Run the test procedure (Figure 116)
7. Follow the instruction (Figure 117)
8. Check the LVDT responses (Figure 118).The technician shall conduct appropriate comparative checks of the individual deformation output from the two vertical LVDTs during the conditioning phase of each resilient modulus test in order to recognize specimen misplacement and misalignment. During the preconditioning phase, the two vertical deformation curves shall be viewed to ensure that acceptable vertical deformation ratios are being measured. The vertical deformation ratio (Rv) is defined as Rv = Ymax/Ymin, where Ymax equals the larger on the two vertical deformation and Ymin equals the smaller of the two vertical deformations. Every effort shall be made to achieve Rv values of 1.1 or less. Acceptable Rv values are 1.3 or less. If unacceptable vertical deformations are obtained (i.e., Rv is greater than 1.3), then the test shall be discontinued and specimen placement/alignment difficulties alleviated. Once acceptable vertical deformation values are obtained, and then the test shall be continued to completion. It is emphasized that the specimen alignment is critical for proper resilient modulus results.

9. If the total vertical permanent strain reaches 5 percent during conditioning, the conditioning process shall be terminated. For recompacted samples, a review shall be conducted of the compaction process to identify any reason(s) why the sample did not attain adequate compaction. If this review does not provide an explanation, the material shall be refabricated and tested a second time. If the sample again reaches 5 percent total vertical permanent strain during preconditioning, then the test shall be terminated and a notation added to the report form.

10. After completion of the resilient modulus test procedure, reduce the confining pressure to zero, remove the sample from the triaxial chamber, remove the membrane from the specimen and use the entire specimen to determine moisture content in accordance with T265.

11. Use the SoilLabAssistant (SLA) program to analyze the test data.

Figure 110. Opening MultiPurpose TestWare

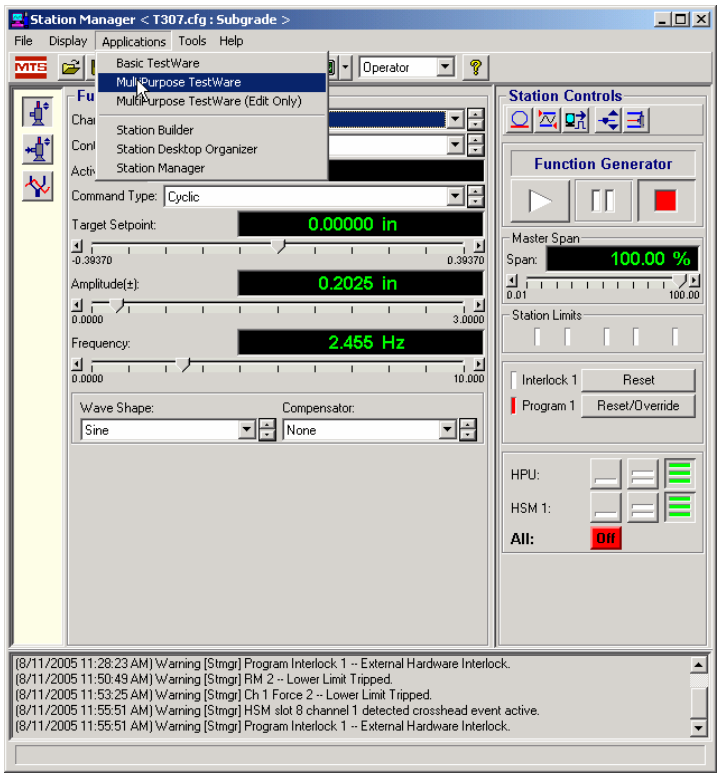


Figure 111. Opening Test Procedure File

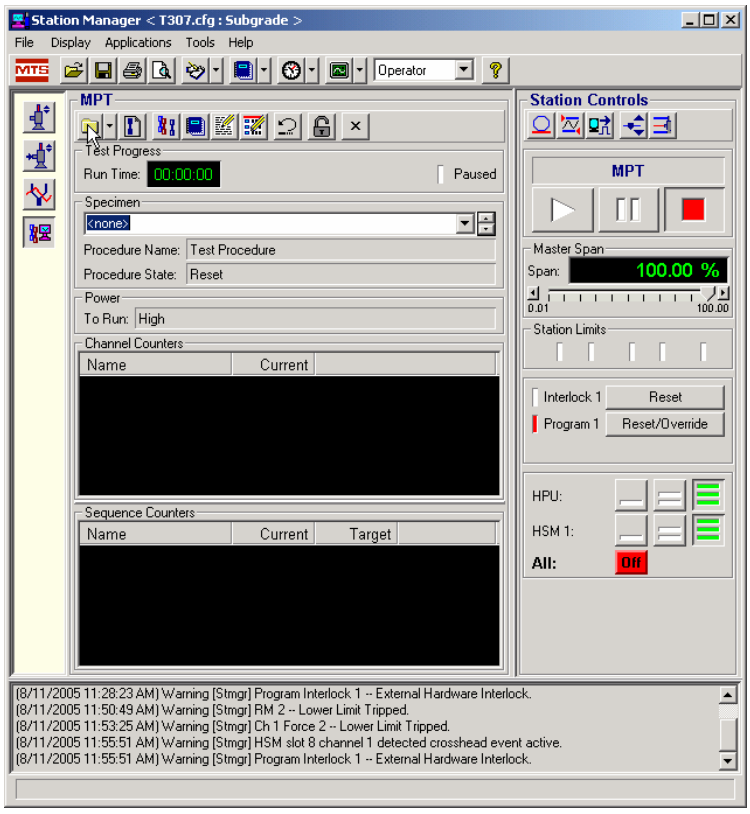


Figure 112. Selecting T307 Test Procedure

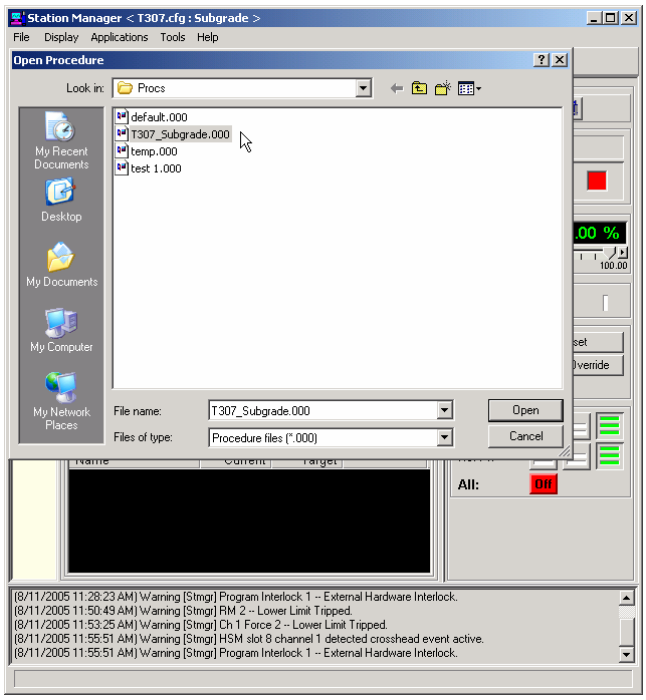


Figure 113. Creating a Specimen Folder

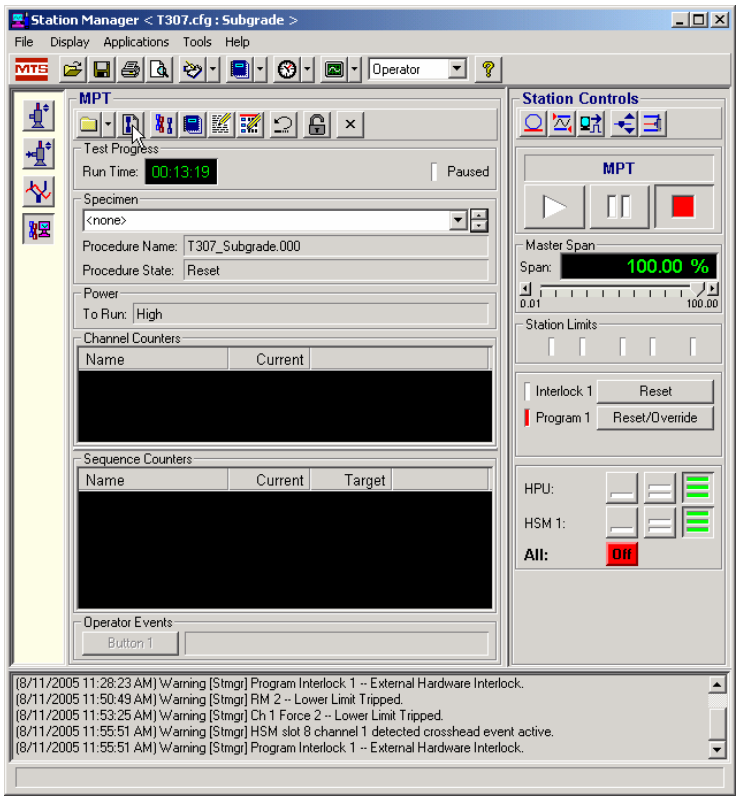


Figure 114. Clicking Program Reset Button

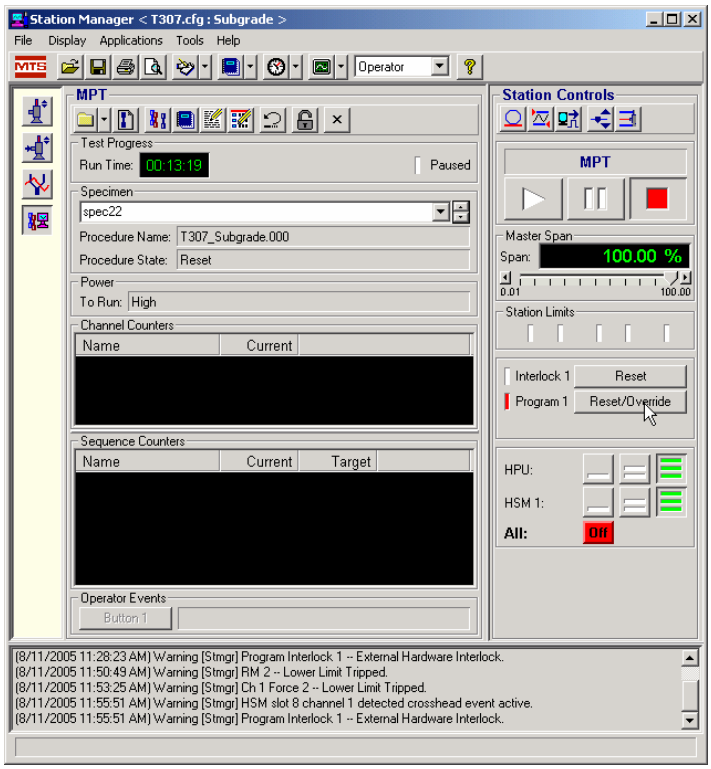


Figure 115. Offsetting the Force 2 Load Cell

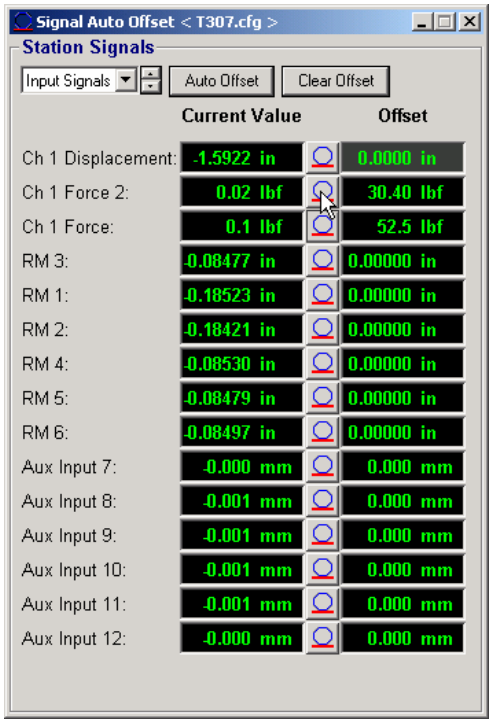


Figure 116. Running the Test Procedure

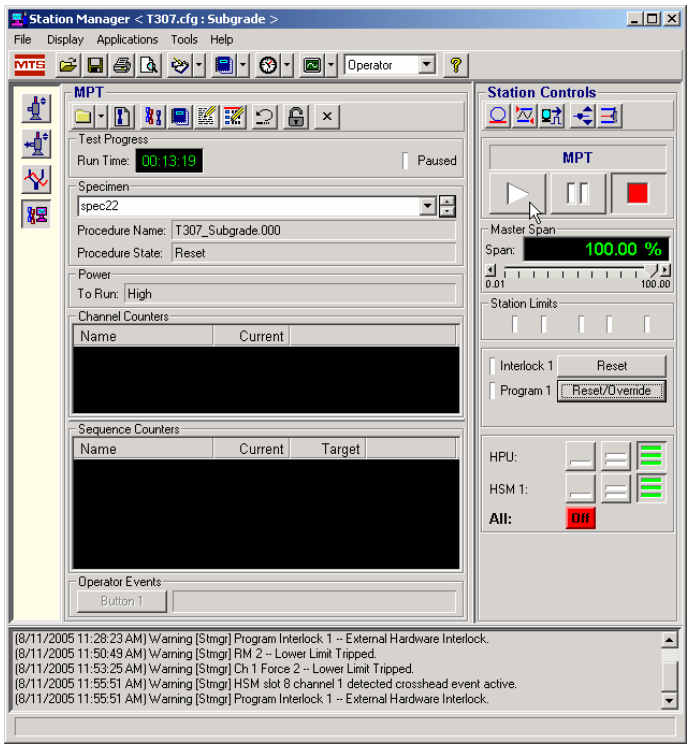


Figure 117. Following the Instruction

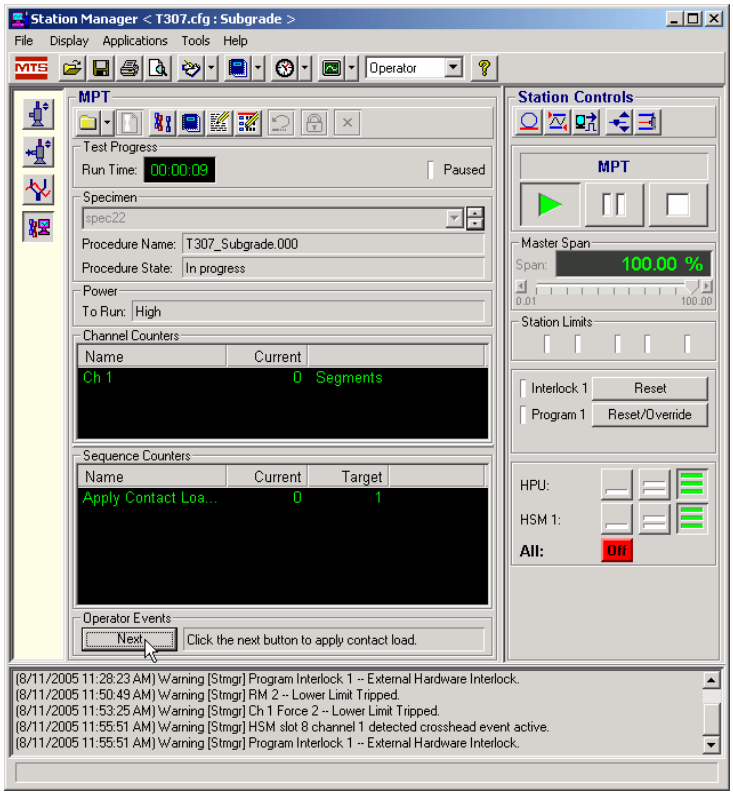


Figure 118. Checking the LVDT Responses