1986

Wim + response systems user's guide, March 1986

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Prepared For
U. S. Department of Transportation
Federal Highway Administration
Office of Research and Technology
Washington, D. C., 20590

WIM+RESPONSE SYSTEM USER'S GUIDE

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March 1986

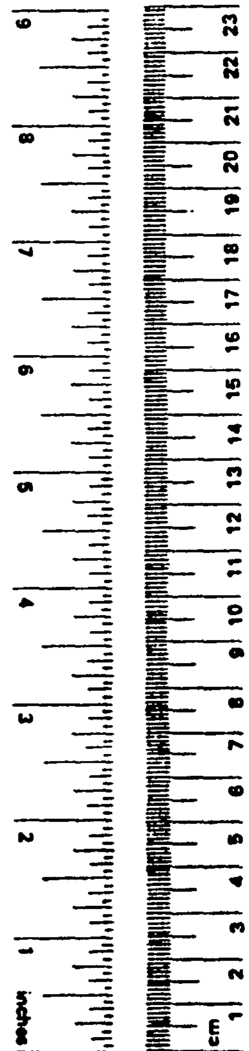
Fritz Engineering Laboratory Report No. 490.6

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

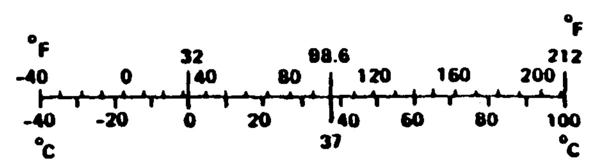
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ACKNOWLEDGEMENTS

This research was performed by personnel at Fritz Engineering Laboratory, Department of Civil Engineering, Lehigh University, Bethlehem, Pennsylvania. Dr. Irwin Kugelman is Chairman of the Department of Civil Engineering.

The research reported herein is part of an investigation entitled "Structural Evaluation of In-Service Bridges Using WIM Technology, sponsored by the Federal Highway Administration (FHWA), Washington, D.C. The project supervisor and contracting officer's administrative representative (COTR) for the FHWA is Mr. Hal Bosch.

The field studies would not have been possible without the excellent cooperation and expert assistance of personnel from the Pennsylvania Department of Transportation (PADOT), District 5-0. Special thanks are due Mr. Jim Hoegg, Maintenance Inspector, whose presence and assistance provided vital liaison between PADOT, District 5-0 and the Lehigh University research team.

TABLE OF CONTENTS

SYSTEM USERS GUIDE

1. Introduction

The WIM+RESPONSE system is a portable system which utilizes an existing bridge to serve as an equivalent static weigh scale to obtain gross vehicle weight (GVW), axle weights and spacings, as well as speeds of vehicles crossing the bridge at normal highway speeds. Also, strains in the bridge components can be obtained at the same time the loading data is being collected and can be used for bridge response investigations.

Since the weighing operation cannot easily be detected by truck drivers, the results are not subjected to the usual bias associated with traditional truck weighing methods. The relatively unbiased statistical data on truck information can be used to update the live load patterns on highways and more rational "standard design trucks for use in bridge design and rating procedures can be determined.

For an evaluation of bridge response, the primary information required is the magnitude and variation of stress in bridge components during passage of vehicles over the bridge. The system can simultaneously acquire and process load and response data from in-service bridges. Therefore, the correlation of loading and response can now be investigated.

2. Methodology

The integrated WIM+RESPONSE system is designed* in such way that load and response data are stored simultaneously on the same mass storage device (floppy disk). The data can then be processed to obtain simultaneous load and response information. The load information obtained includes: axle weights, axle spacings, truck speed, gross vehicle weight and truck configuration. The computer software developed for this system can process the response data in a laboratory to obtain stress range histograms, strain rate histograms, and maximum stresses for each strain gage (transducer) from which the strain data is collected. The load and response information can also be incorporated into one plot to show the relationship between both, e.g. GVW vs. max. stress.

The load and response data is acquired from four sources during acquisition: analog signals from both the strain transducers and strain gages, "digital" signals from the tapeswitches and the optional keypad. As a vehicle approaches the instrumented span the appropriate hauling category (box, auto carrier, etc.) may be input via the keypad by the observer. The system then operates automatically as if the observer were not present. When the steering axle arrives at the first tapeswitch, which is located approximately 4-7 feet before the beginning of the bridge, the computer begins acquiring strain data from the strain transducers and strain gages. The strain data is acquired at the rate of 40 to 80 samples per second per channel

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* A more detailed discussion on the theoretical considerations is found in the "WIM+RESPONSE STUDY OF FOUR IN-SERVICE BRIDGES" - Final Report.

as selected by the operator during the input of the site parameters when loading the data acquisition program. The second tapeswitch is set approximately 3-6 feet from the first tape switch (approximately 1 foot before the beginning of the weigh span). The MINC system checks the tapeswitches several thousand times per second for axle pulses. Whenever a plus is detected from either tapeswitch, the clock is read and the time (time stamp) is stored. The precise distance between tapeswitches can be changed at the beginning of the data acquisition program.

All axles of the vehicle have been received when one of the following two constraints have been met: 1) a default value of 37 feet (11.28m) between any two consecutive axles, and/or, 2) a default value of 65 feet (19.81m) between the first and the last axle. These default values can be changed during the set up phase. These distances are changed to equivalent time constraints by dividing by the vehicle velocity. The velocity is obtained from the arrival times of the first axle on each tapeswitch and the distance between tapeswitches. Axle spacing is obtained in a similar manner. These constraints can be easily changed at the start of the data acquisition program.

Once the last axle of the vehicle has been timestamped, the program classifies the vehicle as a car or a truck based on the number of axles and the peak strain value during the crossing of the weigh span. A car is arbitrarily defined as any two axle vehicle with an axle spacing less than 12.1 feet (3.69m) or any vehicle causing a peak girder strain less than a preset value. The preset strain level is site dependent and on the order of 10 microstrain. The purpose of this constraint is to prevent a car pulling a trailer to be classified as a truck. These constraints are also easily changed at the start of the data acquisition program.

If a vehicle is classified as a car, strain sampling is discontinued. However, the car velocity is stored in a separate file (FILE 16) which can be used for velocity statistics if desired.

If the vehicle is classified as a truck, strain acquisition is continued for a predetermined length of time. At the end of this time velocity and axle spacing are then displayed on the CRT and the strain data, tape switch activation times, and site information are recorded on a floppy disk. The recording process is programmed to allow the computer to perform other on-site tasks (at the operator's option) such as determining axle weights and gross vehicle weights and simultaneously displaying this information on the CRT.

The length of time that strains are acquired is predetermined at the beginning of the program by designating a "span length". This length is not necessarily the length of the weigh span or the bridge length. The designated "span length" is converted to time by dividing by truck speed. Strain acquisition time will be longer for slower moving trucks and shorter for fast moving trucks. The "span length" selected is a function of the sampling rate and the disk space (buffer length) per truck weighing event.

$$\text{Sampling Time} = \frac{\text{(TS1 DIST + SPAN + TRUCK LENGTH)}}{\text{VELOCITY}} + 1.0 \text{ sec}$$

The weigh-in-motion concept is an "inverse" type problem in that the bending moment is measured (input from the strain transducers), but the live loads causing this moment must be calculated. Since data are recorded continuously during truck passage, the axles are "weighed" many times. The axle weights are found by minimizing the least squares difference between the measured strains and the values calculated by the data acquisition program from the vehicle dimensions and the influence line for the weigh span (simple span) or bridge (continuous spans). The influence line can be calculated using a suitable structural analysis program or determined in the field using a calibration truck with known axle weights and spacing. The calibration truck can travel over the bridge at normal highway speed a sufficient number of times to ensure a reasonably accurate estimate of the influence line.

The WIM+RESPONSE system is capable of acquiring and storing up to 16 channels of simultaneous load and response data. Up to 6 of these channels are dedicated to WIM data coming from the strain transducers clamped to the main griders of the weigh span. These channels employ the existing 6 channel WIM strain conditioning center which is part of the FHWA WIM system. These same 6 channels can provide RESPONSE data from the strain transducers used for the weighing operation plus additional strain transducers mounted elsewhere on the bridge, if less than 6 are used in the weighing operation. A new 10 channel strain conditioning center is provided to simultaneously obtain additional channels of RESPONSE data from up to 10 strain gages mounted anywhere on the bridge. The strain conditioning centers used both the WIM and RESPONSE data require continuous manual balancing during field studies to ensure close to zero strain at all gages prior to a truck crossing the bridge.

The system was designed to store 110 truck "weight plus response" events per floppy disk. A buffer length of 2,000 strain data samples was also selected. At a sampling rate of 40 samples per second per channel, a truck speed of 55 mph (88 kph) and allowing one second for residual vibrations to dissipate, a maximum bridge length of about 170 feet (51.8m) can be accommodated. For example, one simple span up to 170 feet (51.8m) can be used to obtain both weight and response data. Two consecutive simple spans with a total length up to 170 feet (51.8m) can be used with one span providing weight data and both spans providing response data. A series of continuous spans or a combination of simple and continuous spans with a total length up to 170 ft. (51.8m) can also be used. In this case, one span will be used for weight data, while response data can be obtained from all spans.

The original WIM system does not provide for the following:

a) separate identification and separate weighing of individual trucks when they are closely spaced; or

b) separate identification and separate weighing of individual trucks when they are side-by-side.

The WIM+RESPONSE system treats either of the above two situations as a "super truck" for load and response calculations.

3. WIM+RESPONSE System Components

The following tabular information shows the complete list of WIM+RESPONSE components and their purposes for data acquisition and processing.

ITEM	COMPONENTS	PURPOSE
1.	MINC 11/23	The control processor used to control data acquisition and perform data reduction.
2.	VT125 Terminal	Used as a input media and as a graphics monitor to display results.
3.	WIM - Conditioner	Used to amplify the strain signals from transducers and the digital signals from the tapeswitches and the keypad.
4.	Response Conditioner	Used to amplify the strain signals from strain gages.
5.	PRINTER - LA50	Used to obtain a hard copy of information displayed on the CRT.
6.	Tapeswitches	Used to detect the arrival of vehicle axles.
7.	Transducers	Used to measure and amplify the strain signals associated with truck weights and response data.
8.	Strain Gages	Used to measure the strain signals for response analyses.
9.	Cables (Analog) Gray Colored	Used for connecting the WIM system, ie. connecting transducers, tapeswitches and keypad to the WIM conditioner. (5 pin and 19 pin variety.)
10.	Cables (Analog) White Colored	Used for connecting strain gages to the Response conditioner.
11.	Frequency Meter	Used to measure the electric power frequency to avoid possible electrical damage to the system.
12.	C-Clamps	Used to mount the transducers on steel girder flanges.
13.	Door Clamps	Used to mount the transducers on concrete girders.
14.	K Box (keypad)	Used to identify the traffic lane and the truck type category (digital input).

15.	S Box	Used as a inter-connection between the transducers and the WIM conditioner.
16.	D Box	Used for inter-connection between the keypad, tapeswitches and the WIM conditioner.
17.	T Box	Used to connect tapeswitches and a K-Box or a D-Box.
18.	Floppy Disks	Used as a mass storage media for programs and data (8 inch).
19.	Traffic Tape (4"-6")	Used to secure tapeswitches to roadway in heavily trafficed areas.
20.	Silver Duct Tape (2")	Used to secure tapeswitches to roadway in lightly trafficed areas.
21.	Double Sided Tape (2")	Used with tapeswitches.
22.	Intercom	Used for communications between personnel in van and those on roadway.
23.	Generator	Used as portable power supply.
24.	Oscilloscope	Used for viewing of electrical signals from gages.

Additional information and more detail on these items can be found in the "WIM+RESPONSE Training Guide", FHWA/RD-86/047, and in the "WIM+RESPONSE Hardware Reference Manual", FHWA/RD-86/049.

4) Data Acquisition Programs - Illustrative Procedure DP8

The data acquisition software is used to collect and store raw data in the MINC computer. It also permits a preliminary examination of the validity of the data as it is being collected.

Prior to data acquisition, the prototype WIM+RESPONSE system must be set up. This includes the following:

a) Blank data file numbered 14 (FTN14.DAT) be generated on floppy disks for storing raw data. This procedure is usually done in the laboratory before going out to the field (FILE 15 is usually done at the same time).

b) Tapeswitches mounted on the road surface of the bridge approach and connected to the WIM conditioner.

c) Transducers mounted and connected to the WIM conditioner.

d) Strain gages mounted and connected to the RESPONSE conditioner.

e) Keypad connected to the WIM conditioner. This is necessary only when truck selection is to be performed manually.

f) Conditioners properly grounded and balanced; and

g) All cables between conditioners and MINC as well as CRT and MINC properly connected.

The data acquisition software group contains the following computer programs:

1)	FICRE8.COM	This command program first formats and initializes a blank disk and then executes the CREAT8.SAV program.
2)	CREAT8.SAV	This program generates data files FTN14.DAT and FTN15.DAT on a blank disk.
3)	SIMPLE.SAV	This program generates an influence line for a simple span beam structure.
4)	BILIN8.SAV	This program generates an influence line for either a continuous statically indeterminate beam or single span structure.
5)	PLINF8.SAV	This program plots the influence line of the beam structure on the graphics CRT.
6)	DP8.SAV	This program performs the data collection and optionally does weight calculations.

7) FIND8.SAV — This program performs a search on FTN14.DAT to determine the number of the last truck written to this file.

8) PLDAT8.SAV — This program plots the strain data obtained from transducers and strain gages on the graphics CRT.

To illustrate the use of one of the data acquistion programs, the following sample session for DP8 is included. It is highly recommended that the user become familiar with the parameters in this program before attempting to execute it in the field. For a description of the FICREA.COM program which formats, initializes a disk and executes the CREAT8.SAV program to create data files - FTN14.DAT and FTN15.DAT, see section 1.3.1 of the WIM+RESPONSE SOFTWARE REFERENCE MANUAL, FHWA/RD-86/050.

Program DP8.SAV

NAME: DP8.SAV. The major function of this program is to collect raw data in the field and optionally perform truck weight calculations.

PURPOSE: This program is used to collect truck information and strain data at the field and store it in FTN14.DAT. Truck weights can also be calculated and stored in FTN14.DAT at the same time.

OPERATIONAL DESCRIPTION: The procedure required to initiate and execute this program is as follows:

1) The date and time must have been keyed in and file 14 assigned to disc drive 1. This can be done by entering:

```
DATE  xx-%%%-yy
TIME  hh:mm:ss
ASS DY1: 14
```

where xx is the date, %%% is the month and yy is the year; hh is the hour, mm is the minutes and ss is seconds.

For instance, November 1, 1985, 2:30 pm should be entered as:

```
DATE  1-Nov-85
TIME  14:30:30
```

2) A blank, formatted disc with FTN14.DAT and FTN15.DAT on it must reside in drive 1.

3) After this has been accomplished, the user should enter:

RUN DP8 or R DP8

4) The system will respond with:

DATE MMDDY

5) The user should enter the date following the above format, i.e. 11015 for November 1, 1985.

6) The system then responds with:

ICHANGE, SPACING, TS1-BRIDGE, MIN STRAIN, TRUCK, SPAN

7) The user should respond according to the following: ICHANGE, integer (I), is the index for the user's option of changing the following default parameters:

max axle spacing, max car length, max truck length and no. of lanes for collecting data.

ICHANGE = 0, all parameters kept as default values and data collected for trucks in one lane only. The default values are 37.0 feet, 12.1 feet and 65.0 feet for max. axle spacing, max. car length and max truck length respectively. 16 channels of data will be collected.

ICHANGE = 1, all parameters kept as default values and the no. of lanes and channels for collecting data will be determined by the user interactively.

ICHANGE = -1, all parameters will be entered interactively via the keyboard.

SPACING (R) is the distance in feet, real (R), between tapeswitches 1 and 2.

TS1-BRIDGE (R) is the distance between tapeswitch 1 and the first bearing of the bridge, in feet.

MIN STRAIN (R) is the value which the max. strain on any channel must be greater than so that the vehicle being weighed is considered to be a truck. Enter the value in volts. A typical range is .15 to .50 volts.

TRUCK (I) is the truck identification (record) number on disk file FTN14.DAT.

SPAN (R) is the length (divided by velocity of truck to obtain time period for collecting data) over which strain data is acquired.

Please note that (I) represents an integer, (R) represents a real number.

8) The system then responds with:

PROCESS, KEYPAD, SAMPLING RATE

9) The user must respond according to the following:

PROCESS (I) is the index to determine if the truck weight to be calculated.
PROCESS = 0, truck weights are not to be processed
1, truck weights are to be processed
KEYPAD (I) is the index to determine if the keypad is to be used for vehicle selection
KEYPAD = 0, keypad input will be accepted but is not mandatory
= 1, keypad input is mandatory

Note: If two-lane data acquisition is to be performed, the keypad must be used for lane 2 data collection.

SAMPLING RATE (I) is the number of strain samples per second per channel for strain data acquisition. A recommended range is 40 hz for long bridges to 60 hz for short bridges.

10) If the user entered ICHANGE = -1 at step (7), the system will now respond with:

MAX AXLE SPACING, MAX CAR LENGTH, MAX TRUCK LENGTH

The user should make entries according to the following to change the default values:

MAX AXLE SPACING (R): Max spacing between two adjacent axles. If the axle spacing is greater than this value, the latter axle is regarded as belonging to the second vehicle. Default is 37.0 feet.

MAX CAR LENGTH (R): The maximum distance between axles of cars. If the length of a vehicle is less than this value, it is regarded as a car and data acquisition will not be performed. Default is 12.1 feet.

MAX TRUCK LENGTH (R): The maximum distance between the first axle and the last axle of trucks. If the length of a truck is larger than this value, the axles beyond this length measured from the first axle will be ignored. The default value is 65.0 feet.

11) If the user entered ICHANGE = -1 or 1 at step (7) the system will respond with:

LANES, NCHAN

The user should make entries according to the following:

LANES (I): Number of lanes instrumented for data acquisition, 1 or 2. Default is 1.

NCHAN (I): Number of channels of strain data. Default is 16.

If the no. of channels is less than 0 or greater than 16, the system will go back to step (11).

12) The system then responds with:

NO. OF TRANSDUCERS AND STRAIN GAGES

13) The user should enter:

NO OF TRANSDUCERS (I): The no of channels used for truck weight calculations.

NO OF STRAIN GAGES(I): The no. of channels not used for truck weight calculation. These may include the channels connected to the WIM conditioner.

The total number of transducers and strain gages must be equal to the no. of channels. If they are not equal, the system will go back to step (13) again.

14) If the user entered LANES = 2 in step (11), the system will respond with:

LANE 2 TS SPACING, TS3-BRIDGE

The user should input as follows:

LANE 2 TS SPACING (R): Spacing between tapeswitches 3 and 4 in lane 2.

TS3 - BRIDGE (R): Distance from tapeswitch 3 to the first bearing of the bridge.

15) If the user entered PROCESS = 1 in step (9), the system will respond with:

NAME OF FILE WITH INFLUENCE LINE

The user should enter the influence line file name as:

DY_: xxxxxx.yyy

where: the underscore character (_) represents the number of the disc drive, either 0 or 1, containing the influence line file.

xxxxxx.yyy is the influence file name of the bridge previously generated from SIMPLE.SAV (Section 1.3.3) or BILIN8.SAV (Section 1.3.4).

16) If the user entered PROCESS = 1 in step (9), the system will respond with:

LENGTH OF INFLUENCE LINE, CALIBRATION, SAMPLES

The user should input as follows:

LENGTH OF INFLUENCE LINE (I): Length of influence line to the nearest foot.

CALIBRATION (R): Factor obtained from the calibration vehicle to calculate real truck weights.

SAMPLES (I): number of data points to be ignored at the beginning of strain record when calculating truck weights. The purpose is to consider the skewness of the bridge; 0 for a right bridge and 1,2 for a skew bridge.

At this point, the input is complete and the system is ready to collect data.

17) If any parameter previously entered needs to be changed, push the "data" button twice on "digital in" module of the MINC computer. The following message will appear on the screen:

NEXT TRUCK NUMBER IS XXX
CHANGES? -1 START OVER 0 STOP 1 MINOR CHANGES

18) The user should select one of the following three options:

-1: Reenter the input sequence starting from step (7)
0: Stops execution of the program
1: Only some parameters need modification

19) If the user enters "1" in step (18), the system will respond with the following message:

PROCESS, KEYPAD, # SAMPLES, CALIBRATION

The user should input the parameters following the explanation described in the previous steps.

At this point, the system will be ready again for data collection.

20) When the truck no. reaches 110, the system will respond with the following message:

THE TRUCK NUMBER HAS EXCEEDED THE LIMIT OF 110.
DO YOU WISH TO: 1 STOP, 0 CHANGE DISKS, -1 CHANGE TRUCK NUMBER

21) The user should select one of the following three options:

1: Stops the execution of the program
0: A new disk will be inserted for data collection
-1: A new truck number will be started for data collection.

22) If the user responds with "0" in step (21), the system will respond with the following message:

CHANGE DISKS AND THEN TYPE THE STARTING TRUCK NUMBER

The user should change disks and then enter the starting truck number (I). At this point, the system is ready for data collection again.

23) If the user responds with "-1" in step (21), the system will respond with:

TRUCK NUMBER

The user should enter the starting truck number (record number)and the system will be ready for data collection again.

Note: To collect data for trucks in lane 2, the keypad must be used. "LANE 2" button must be pushed followed by another button indicating the truck type before the truck reaches tapeswitch 3. The "LANE 2" button will produce the message "LANE 2" on the CRT. The button indicating the truck type will produce an input number on the CRT as "INPUT xxx". where xxx is an integer number.

The equivalent input number and truck type are as follows:

18	SPECIAL
20	OTHER
24	TEST
33	CHEMICAL
34	FUEL
36	CONCRETE
40	TANK
65	OPEN HAULER
66	MACHINERY
68	STEEL
72	FLAT
123	DUMP
130	BUS
132	CAR CARRY
136	BOX

PROGRAM OPTIONS: The user has the following options via the keyboard during data acquisition.

a) max. axle spacing, max. car length, max. truck length and minimum strain for distinguishing truck and car (see the OPERATIONAL DESCRIPTION, step 7).

b) Calculating truck weight during the data acquisition or not (see OPERATIONAL DESCRIPTION, step 9).

c) Keypad mandatory or not (OPERATION DESCRIPTION, step 9).

d) SAMPLING RATE for data acquisition. The rate depends on the length of the bridge, the buffer size, and the bridge dynamics. (OPERATIONAL DESCRIPTION, step 9).

e) No. of lanes and channels for data acquisition (OPERATIONAL DESCRIPTION, step 11).

f) Number of data points to be ignored (SAMPLES) (OPERATION DESCRIPTION, step 16).

This program is set in such a way that each data disc will contain up to 110 trucks information and each truck can have up to 2060 samples/words (60 for truck header block and 2000 for strain data). This is consistent with the size of FTN14.DAT. If the user wants to change the size of FTN14.DAT, source code of programs CREAT8 and DP8 must be modified to be consistent with each other.

The time period for data collection is set in the program as:

$$\frac{\text{(TS1 DIST + SPAN + TRUCK LENGTH)}}{\text{TRUCK VELOCITY}} + 1.0 \text{ sec.}$$

where 1.0 sec is used for measuring residual vibration of the bridge after the truck leaves the bridge. If 16 channels are used for data collection, each channel can only contain up to 125 strain data points. Therefore, the sampling rate must be properly assigned in order that all the strain data can be recorded. If another truck comes along during this time period, its data will be recorded and therefore a second peak can be observed in this sampling time period.

ERROR/RECOVERY PROCEDURES: Possible errors may include:

1) ILLEGAL MEMORY REFERENCE
   This may happen only when the truck weight calculation is performed and the truck speed is too low (say below 30 mph)

   To remedy this situation, simply rerun the program.

2) Incorrect typing of any of the keyboard inputs.

   To remedy this situation, the easiest way is to use "data" button to start the input again. (SEE OPERATIONAL DESCRIPTION).

5. Field Data Processing Programs - Illustrative Procedure PLDAT8

This software group is used in the field data processing phase of the operation of the WIM+RESPONSE system. It also permits a preliminary examination and display of the data which have been collected. Prior to this field data processing phase, there must be some collected data which is stored in FILE 14.

This software group contains the following computer programs:

1) FIX8.SAV — This program inspects and corrects raw data stored in File 14.

2) PLDAT8.SAV — This program plots the strain data stored on File 14 on the graphic CRT.

To illustrate the use of one of the two programs in the field data processing group, the following sample session for PLDAT8 is included.

Program PLDAT8.SAV

NAME: PLDAT8. The major function of this program is to plot the strain data from each channel on the graphics display screen (CRT).

PURPOSE: This program is used to inspect the data for errors, incorrect zero shifts, the influence of possible other vehicles on the bridge, or to assess what lane weighing factors should be assigned.

OPERATIONAL DESCRIPTION: The procedure required to initiate and execute this program is as follows:

1) File 14 must be assigned to the disk drive 1 prior to execution of this program. To do this, type in the following:

```
.ASS DY1: 14
```

Please note that the data disk should be in disk drive 1.

2) After this has been accomplished, the user should enter:

```
.RUN  PLDAT8 or R PLDAT8
```

3) The program will respond with the following:

DO YOU WANT A HARD COPY OF PLOT?
1 = YES, 0 = NO

4) The user should then input either 1 or 0.

5) The program will then ask for a channel number to be displayed.

WHICH CHANNEL (0-15)

6) The user should then input the channel number that the strain plot is required for.

7) The program will then display TRUCK NUMBER ...?

8) The user should then input an integer number which represents the Truck No. (normally 110) e.g.

28

9) The program will then display the plot of strain data.

10) After the plotting of the data is finished, the program will display the Truck No. and the Channel No. that was plotted. Then it will respond with

TO CONTINUE: (1), STOP: (0)

11) The user should then input the desired numbers. If (1) is input, the program followst step (3) and after, otherwise it will halt the execution.

PROGRAM OPTIONS: No options regarding display format are available to the interactive user. Desired changes must be made to the source code as contained in the Master Program Library (MPL) for the system.

ERROR/RECOVERY PROCEDURES: Possible errors may include:

Incorrect specification of either the disc drive, channel number or truck number.

To remedy this situation, simply reenter the correct entries in the format specified earlier in this section.

6. Data Reduction Programs - Illustrative Procedure PROCE8

The data reduction software is normally used after the field study has been completed. It can be used to produce stress range histograms, strain rate histograms, GVW histograms, or other data reductions.

The data reduction is usually performed in the laboratory after data acquisition has been finished. Only the MINC computer, terminal and line printer need to be connected to use the data reduction programs.

The data reduction software contains the following computer programs:

1) PROCE8.SAV — This program processes the raw data on File 14 and stores the results on File 15. The results include truck speed, truck weight, axle spacings, axle weights and the max strains for each channel in terms of minivolts.

2) READ15.SAV — This program reads the processed data stored on File 15 (FTN15.DAT).

3) STREN8.SAV — This program processes the raw strain data stored on File 14 to obtain a stress range histogram in tabular form. The stress range counting method can be either ascending, descending, or reservoir.

4) SRAT8.SAV — This program processes the raw data stored on File 14 to obtain a strain rate histogram in tabular form.

5) SUMAR8.SAV — This program optionally lists the individual truck information or summarizes the total truck information stored on File 15.

6) MXTRE8.SAV — This program reads the processed data on File 15 and plots out GVW vs maximum stress for each channel. The statistical relationship between GVW and maximum stress is also computed for each channel.

7) PLOT8.SAV — This program optionally plots a histogram for either stress range, GVW distribution or strain rate.

To illustrate the use of one of the data reduction programs, the following session for PROCE8 is included.

Program PROCE8.SAV

NAME: PROCE8.SAV The major function of this program is (1) to compute the axle weights for each truck using the strain records collected in the field along with the truck speed and axle configuration, (2) to compute the max. strain for each channel per truck using the strain records collected in the field.

PURPOSE: This program is used to reduce the raw data stored on File 14 to obtain the truck characteristics and to compute maximum stress at each channel for each truck event. All the reduced data will be stored on File 15 for future use.

OPERATIONAL DESCRIPTION: The procedure required to initiate and execute this program is as follows:

1) FILE 14 and FILE 15 must be assigned to the disk drive 1 prior to this program and the data disk which contains FILE 14 and FILE 15 must reside in drive #1.

```
ASS  DY1: 14
ASS  DY1: 15
```

2) After this has been accomplished, the user should enter:

```
RUN PROCE8  or R PROCE8
```

3) The system will respond with:

```
NAME OF INFLUENCE LINE FILE?
```

4) The user should then enter the disk drive where the influence line file is located and the influence line file name in the following format:

```
DY_: FILENAME
```

where the underscore character (_) represents the number of the disk drive, either 0 or 1, containing the influence line file.

5) The system will then respond with:

```
HOW MANY LANES?
```

6) The user should enter the number of traffic lanes at the site for data acquisition, e.g.

```
1
```

for one lane data acquisition.

7) The system will respond with:

   HOW MANY CHANNELS WERE RECORDED?

8) The user should enter the total number of channels used for collecting data (1-16).

   42

9) The system will then respond with:

   NUMBER OF TRANSDUCERS FOR WEIGHT

10) The user should enter the number of transducers used for weight computation (1-16), for example:

    4

    The strain data acquired from other transducers and strain gages will be used for response analysis only. Note: The transducers used for truck weight computation can also be used for response analysis.

11) The system will then respond with:

    ENTER THE WEIGHTING FACTOR FOR LANE #1

12) The user should enter the girder weighting factors for lane #1. For a single truck event, uniform distribution factors (1.0 for all instrumented girders) should be used. Modified distribution factors can be used to reduce the effect of side by side trucks on the truck being weighed. An example of modified distribution factors for a bridge using four girders to weigh truck would be REAL numbers, e.g.

    1.0, 1.0, 0.5, 0.1

    which corresponds to the girders numbered in such a way that the first two girders are right under lane 1.

13) If the input in (6) is 2, which means that 2 lane data acquisition was performed at the site, the system will respond with:

    ENTER THE WEIGHTING FACTOR FOR LANE #2

14) The user should enter the girder weighting factors for lane #2 following the rules described in (12). An example of modified distribution factors for a

bridge using four girders to weigh trucks would be REAL numbers, e.g.

0.1, 0.5, 1.0, 1.0

15) The system will then respond with:

LENGTH OF INFL. LINE, SAMPLES, SPAN

16) The user should first enter:

a) the length of influence line in feet, rounded down to the nearest foot (INTEGER).

b) the number of samples to delay the analysis The time of each sample is equal to the inverse of the sampling rate (INTEGER). This is used to account for skewness of a bridge.

c) the length of the span in feet (INTEGER).

An example of input would be:

41, 0, 41

17) The system will then respond with:

DISPLAY RESULTS? 1=YES, 0=NO

18) The user should enter 1 or 0 to specify the format for displaying results.

If 1 is entered, the axle weights, axle spacings, truck speed, truck configuration, truck identification, number of axles detected by the first and the second tapeswitch, the lane in which the truck is on, and the method used to compute front axle, all will be displayed on the CRT.

If 0 is entered, only the front axle weight will be displayed on the CRT.

19) The system will then respond with:

CALIBRATION TRUCK USED? 1=YES, 0=NO

20) The user should enter 1 or 0 to specify the calibration truck information.

If 1 is entered, the calibration factors for weight computation will be computed (average for each lane) by the program using the known weight calibration truck run. The system will next respond with (23).

If 0 is entered, the calibration factors for weight computation should have been computed prior to the program. The calibration factors will be entered later.

21) If 0 was entered in (20), the system will respond with:

WHAT IS/ARE CALIBRATION FACTOR(S)?

22) The user should enter calibration factor for lane 1, and lane 2 if 2 lane data acquisition was performed. At this point, the system will display the value of calibration factor(s),(REAL), on the CRT as following:

CALIBRATION FACTOR # 1 = XXXXX
CALIBRATION FACTOR # 2 = XXXXX

where xxxxx are the calibration factors entered by the user.

The system will next respond with (29)

23) If 1 was entered in (20), the system will respond with:

WHAT IS THE ACTUAL TEST TRUCK WEIGHT?

24) The user should enter the actual weight of the calibration truck in Kips, (REAL), for example:

72.8

25) The system will respond with:

HOW MANY PASSES OF TEST TRUCK?

If one lane data acquisition was performed, or

HOW MANY PASSES OF TEST TRUCK IN LANE 1, LANE 2?

If two lane data acquisition was performed.

26) The user should enter the number of passes (INTEGER) of the calibration trucks in lane 1, and lane 2 if 2 lane date acquisition was performed.

27) The system will then respond with:

WHAT ARE THEIR ID'S?

If one lane data acquisition was performed, or

ID'S OF LANE 1 TEST TRUCK
ID'S OF LANE 2 TEST TRUCK

If 2 lane data acquisition was performed.

28) The user should give the truck ID numbers (INTEGER) corresponding to the test truck passes in each lane, e.g.

    2, 15, 27, 75

At this point, the system will start to compute the calibration factors for each lane based on the known static calibration truck weight and the collected strain data. Average values are computed. The results will be displayed on the CRT, for example:

CALCULATED ALONE, FRONT AXLE = 15.81442
CALCULATED ALONE, FRONT AXLE = 15.10041

CALIBRATION FACTOR #1 = 0.2484333
CALIBRATION FACTOR #2 = 0.3285436

where the calibration factors will be used later for computing the weights of all the other trucks. These factors should be recorded for future use.

29) The system will next respond with:

PROCESS TRUCKS-THROUGH-(-KSTART=START OVER;
0 = STOP)

30) The user should enter the starting and ending ID's of the trucks to be processed. The maximum number of trucks contained on a disk is 110. If a negative starting ID value is given, the program will return to (1) and input can be started over. If a 0 response is given, program terminates.

At this point, the system will start to compute the axle weights and max strain for each truck, and all the results will be stored in FILE 15, FTN15.DAT.

Depending on the display format specified in (18), the results displayed on the CRT will be different. If 0 was entered in (18), only the front axle weight for each truck will be displayed, for example:

CALCULATED ALONE, FRONT AXLE = 3.928829
CALCULATED ALONE, FRONT AXLE = 4.242358

If 1 was entered in (18), the truck information displayed on the CRT will be as follows:

```
CALCULATED ALONE, FRONT AXLE = 3.637317

TRUCK NUMBER       10         5 AXLES CONFIG    8
              80.0 FPS      54.5 MPH   5    5    1
     SPACING       10.24    3.92   24.40  3.68
WEIGHTS    9.3   10.7   10.7  11.4    11.4

FRONT AXLE BY   2                          GROSS  53.6
```

The method used in this program to compute axle weights is the statistical smoothing algorithm. The axle weights are computed which minimize the least square difference between the measured strain and the value calculated from the vehicle dimensions, velocity, and bridge influence line. The result is usually biased towards the accuracy of the heavier axles. The front axle, which is usually light relative to the other axles, is sensitive to small errors in timing. Therefore, two other methods are included in the program to compute the front axle weight and the most reasonable front axle weight will be used. The three methods are described as follows:

a) Method 0: statistical smoothing algorithm

b) Method 1: front axle weight is calculated alone using the initial portion of strain the record when the front axle only is on the instrumented span.

c) Method 2: front axle weight is calculated based on axle configuration and gross vehicle weight.

The results displayed on the CRT give the following information.

a) The front axle weight if calculated alone (method 1) is 3.637317 kips

b) The truck ID number is 10 on the current disk.

c) The truck has 5 axles

d) The truck configuration is classified as 3S-2 according to axle spacings designated as code 8.

The equivalencies between code and configuration are shown as follows:

1	2 single
2	3 single
3	25-1
4	4 single
5	3S-1
6	2S-2
7	2S-2 SPLIT
8	3S-2
9	3S-2 SPLIT
10	2S-3
11	2S-3 SPLIT
12	2S-1-2
13	3S-3
14	3S-3 SPLIT
15	3S-1-2
16	OTHER/BAD SPACING

e) The truck speed is 80.0 feet per second or 54.5 miles per hour.

f) The number of axles detected by the first tapeswitch is 5 the number of axles detected by the second tapeswitch is 5.

g) The truck was travelling in lane 1.

h) The axle spacings are 10.24, 3.92, 24.40, 3.68 (all in feet.)

i) The axle weights are computed as 9.3, 10.7, 10.7, 11.4, 11.4 (all in Kips.)

j) The final front axle weight is determined by method 2.

k) The truck gross weight is 53.6 Kips.

PROGRAM OPTIONS:

1) The interactive user can select the format of displaying results on the CRT.

2) The calibration factors for weighing trucks can be calculated by the program or entered from a previous calculation.

3) The weighting factors for each girder for each lane can be determined by the interactive user, but different calibration factors must be used corresponding to the each set of weighting factors.

ERROR/RECOVERY PROCEDURES: Possible errors may include:

1) Incorrect specification of either the disc drive, the filename, or the bridge length.

   To remedy this situation, simply re-enter the correct entries in the format specified earlier in this section.

2) Incorrect specification of the test truck ID and the lane no. in which the test trucks pass if calibration factors are to be computed using the program.

   The system terminates. To remedy this situation the program must be re-executed.