FAULTMETER - JOINTS

General Description

An electronic digital faultmeter used to measure transverse concrete joint faults. The transverse contraction joints in concrete pavement eventually wear out with repeated heavy vehicle loading. One symptom of this wear is the presence of "stepping" at the joints, also called "faulting."

COLLECTION FREQUENCY

Faulting measurements are taken 3 times per year with a modified Faultmeter per modified LTPP protocol.

Operation & Data Processing

Data is collected manually currently with the faultmeter device.

STEP BY STEP PROCESS: Measurements are taken at selected joints. The offset from the centerline is recorded. One measurement is made at each location. The representative value of the readings is recorded to the nearest millimeter. Faulting is assumed to be positive.

Specifications

LTPP Protocol

Database Tables

DISTRESS_PCC_FAULTS – Raw Data output from the data collection spreadsheet.

Name	Null?	Type
CELL	NOT NULL	NUMBER(3,0)
LANE	NOT NULL	VARCHAR2(20)
DAY	NOT NULL	DATE
SAMPLE_TIME		NUMBER(4,0)
JOINT_NUMBER	NOT NULL	NUMBER(6,0)
FAULT_DEPTH		NUMBER(6,2)
DATE_UPDATED		DATE
OFFSET_FROM_CENTERLINE	NOT NULL	NUMBER(10,2)
ID		NUMBER (19,0))

PCC Joint Faulting Measurements at the MnROAD Project

HISTORY OF THE FAULT MEASUREMENTS AT MnROAD

INTRODUCITON

This document outlines the history of transverse joint fault measurements taken on the PCC cells at the MnROAD project. It will describe both the current testing scheme and the history of changes.

FAULTING OF PCC PAVEMENT JOINTS

Portland cement concrete (PCC) pavements are constructed with transverse contraction joints to relieve stresses in the slabs caused by temperature and moisture. Over time, traffic loading and erosion of the soil layers under PCC slabs results in stepping or "faulting" of the transverse joints. Faulted joints have a direct impact on the ride quality of the pavement.
A review of the literature shows gaps in the availability of long-term field data on joint faulting of PCC pavements. Once long-term field data are available, trends in joint faulting can be established and modeled. This will lead to greatly improved pavement design procedures.

FAULT MEASUREMENTS AT MnROAD

Fault measurements are being taken at the MnROAD project to establish long-term trends that can be used to calibrate models in new mechanistic-empirical design methods. The wide range of variables built into the test sections will result in a fairly comprehensive set of data that can be used to develop new models, or calibrate existing ones.

Fault measurements at the MnROAD project are typically taken three times a year. The schedule depends on available access to the "mainline" test sections. Traffic must be temporarily switched to the old highway section to allow safe access to the test sections.

Fault measurements at the MnROAD project began in the fall of 1994, shortly after traffic was first placed on the test sections. Measurements continue to be taken, and are expected to be continued until each test section fails or is modified.

Measurements are taken using an electronic digital faultmeter. Mn/DOT uses a newly designed device patterned after the one developed by the Georgia Department of Transportation [1] which model is the standard device used in the data collection for the FHWA LTPP (Long-Term Pavement Performance) project.

Mn/DOT's faultmeter was originally constructed to Georgia DOT specifications by Mn/DOT's Maplewood Laboratory shop personnel. Modifications to the device were designed by the author and made by the shop in the winter of 2001-2002, to enhance the repeatability of the measurements. The principle change was the replacement of the four point "long feet" system, with a three point "bolt feet" system. Due to surface irregularities in the concrete pavement slabs, the four point long foot system commonly resulted in the operator having to move the device several times to avoid rocking of the base, which often led to non-repeatable measurements. By installing the three point "bolt head" feet, the device could simply be set down for a quick, stable and repeatable measurement.
Figures 1 and 2 show dimensions and layout of the new three point foot system. Also shown in the figures is the addition of an offset rod, used to increase the speed of measurements. The rod can be used as a guide to quickly place the device relative to the outside edge of the fogline painted on the test sections. Allen head anchor screws allow quick and easy adjustment, as well as removal, of the rod.

Measurements with the modified faultmeter began in the spring of 2002. During the winter of 2003, a comparison of the data from before and after the modifications revealed significant changes in the faulting trends of the test sections. Brief experimentation on the MnROAD PCC test sections in February 2003 revealed that, while the modified faultmeter is now more stable during measurements, the measurements are more susceptible to variation caused by the surface texture of the concrete. To reduce this variation in the future, the locations of the front two feet of the faultmeter were marked on the slab during the spring 2003 measurements. Once several measurements have been taken at these locations, it is hoped the trends can be fit to the trends established before faultmeter modifications were invoked.

With the original design by the Georgia DOT came some inherent flaws. The design required the operator to pick up the device between each measurement. While it is not heavy, the repetition of the movement caused some back pain in the operators. Also since there was no storage memory on the device, the operator would have to handwrite each output of the meter on a spreadsheet. This could cause some human error into the process. Since the data was collected manually, it also would have to be entered into the data flow process by hand. That provided another opportunity for human error.

With these factors in mind, it was decided to try and find an alternative. The two main objectives being to reduce the ergonomic flaws and eliminate the possible human error in the data flow.

The solution came in the form of a new format for the device. The measurement is made in principally the same way by setting the base of the device on one side of the joint and the measuring device on the other. However, the device measuring the fault distance was changed from an LVDT to a laser displacement sensor. A tablet computer is added to control the laser and store the data. All of this was mounted on a base that still has the three bolt feet but the operator simply tips the device backwards onto a set of wheels and rolls it around.

Figure 3 Figure 4

Figure 3 above shows the device in working mode. The handle is adjustable to accommodate someone of average height. The handle can also be turned and lowered for a more compact unit for transporting as seen in figure 4.

The first version of the unit was design to have the exact footprint of the original faultmeter. After initial testing to verify the accuracy and reliability some modifications were made. First the width of the front bolt feet was increased for more stability. Second an enclosed channel around the path of the laser was installed to reduce the ambient light reflecting off of the aluminum base material. Thirdly a handle grip was added for more operator comfort.

MEASUREMENT LOCATIONS AND QUANTITIES

Fault measurements at the MnROAD project follow the criteria established by the FHWA LTPP project. Measurements were taken at each joint, in the direction opposite traffic flow, at offsets of 1 and 2.5 feet from the outside edge of the fogline (see update note below). This is done for both the driving and passing lanes of the mainline sections, and the 80k and 102k lanes of the low volume road sections.

Since 1994, fault measurements have been taken at every joint (except in transition areas between test sections) in the original PCC test sections. Measurements have also been taken at every joint in the ultrathin whitetopping sections and new PCC test sections 32, 52 and 53 since 2001. The data can be found in the MnROAD database in a table called “MNR_DISTRESS_PCC_FAULTS”.

Due to reduced personnel and resources in 2003, it was determined that fewer joints can be measured in the future. By examining the faulting trends from 1994-2003 at each of the transverse joints in the test sections, approximately 50 percent of the joints were chosen for future monitoring. Tables in Appendix A list the joints to be measured for faulting after the fall of 2002. Selection criteria were based on a smooth historical trend and whether the slope of a linear best-fit line through the data was typical for each test section. Most joints do not exhibit a linear trend in faulting during their early age, however most follow a linear type trend later in life.

Update note: In January 2009, several new MnROAD test sections were added to the fault measurement schedule. The location of the measurement points was also revised. The measurement points were moved to standard offset distances of 3 feet and 10 feet from the centerline of the pavement for both lanes. It was believed that enough measurements had been taken at 1 foot and 2.5 feet from the fogline for comparison, and that more interesting trends may be observed by comparing faulting in the two wheelpaths of each lane. Due to centerline tie-bars, many pavements tend to fault more in the wheelpath nearest the shoulder. These new testing locations should provide valuable data toward characterizing this phenomenon.

The data collection process using the new meter is handled primarily by the program on the tablet computer. It is based on the Crandun Technologies library of commands for the laser and Visual Basic for Application and runs in Microsoft Excel. Once the operator opens the program for the specific cell they are in, the program instructs them through the collection process by displaying both the joint and offset for each measurement. There is also an option to accept or reject the data collected. If the operator feels the data displayed is incorrect they can redo the reading . Upon finishing the collection process for the cell the operator presses one more button to save the data to the tablet hard drive. From there the data can be transferred via a network connection.

Calibration During Operation

Since the faultmeter can measure down to tenths of a millimeter, it is important to check the calibration of the device periodically before use. A calibration and storage base was constructed in conjunction with the faultmeter. It contains a built-in aluminum block 10 millimeters high. By placing the device on the base and running the collection program, the operator should get a reading of 10 millimeters, $\pm$ 0.1 millimeters. The device should also be calibrated to a “zero” reading by moving it behind the 10 millimeter block on the base. If adjustment is necessary, the “bolt” feet can adjusted to bring the device into calibration. It is recommended to monitor wearable parts, like the new “bolt” feet, since it can affect the calibration of the device.

Joints Measured for Faulting (Fall 2002 – Fall 2008)

Note: All PCC test section joints (except in transition areas between sections) were measured for faulting from fall 1994 through fall 2002.* The joints listed below were measured for faulting until 2008.
* Measurements for test sections 32, 52-53 and UTW test sections 92-97 began in 2001.

MAINLINE TEST SECTIONS

Cell	Joint Numbers
5	3, 4, 5, 8, 10, 14, 17, 18, 22, 24, 25
6	32, 35, 36, 40, 41, 42, 48-51, 54, 57-59, 61, 62
7	68-70, 73, 77, 78, 81, 82, 84, 86, 87, 89, 91
8	97-101, 104-106, 109-116, 125
9	132, 134, 139, 141-143, 145, 147-154, 157, 164
10	167, 169, 170, 172, 174, 175, 178, 182, 186-190
11	194-196, 198, 199, 207-211, 214
12	217, 219, 221-222, 224, 226-227, 232, 234, 236-237, 241-244, 247
13	251-252, 254, 256, 258-259, 262, 265-266, 269-270, 272-273

LOW VOLUME ROAD TEST SECTIONS

Cell	Joint Numbers
32	1202, 1205, 1209-1210, 1215-1219, 1221-1222, 1228, 1230-1232, 1236-1237, 1239, 1241-1243, 1245
36	1003, 1005, 1008, 1012, 1015-1016, 1020-1022, 1024, 1026-1028, 1030, 1033
37	1038-1040, 1042, 1045, 1047-1049, 1053, 1055, 1059, 1061, 1064-1066, 1068, 1070, 1072, 1074, 1076
38	1081-1082, 1084, 1088-1090, 1092, 1100-1101, 1103-1106, 1109,1112-1113
39	1115, 1118-1119, 1121, 1126-1129, 1131-1132, 1136, 1138, 1140
40	1144-1146, 1149-1150, 1154, 1156-1157, 1159, 1162-1163, 1165, 1167-1168, 1170, 1172
52	1248, 1253, 1255-1257, 1259-1260, 1262-1264
53	1267, 1270-1273

ULTRATHIN WHITETOPPING TEST SECTIONS (MAINLINE)

Cell	Joint Numbers
92	2264-2265, 2267, 2269, 2273-2275, 2278-2280
93	2005, 2008, 2011, 2015, 2017, 2020, 2022, 2025, 2029-2030, 2036, 2040-2041, 2043, 2049, 2058-2061, 2065, 2074
94	2089, 2093-2094, 2097, 2101-2102, 2106-2107, 2109, 2112, 2121, 2124, 2132, 2141-2142, 2147
95	2153, 2158-2159, 2161, 2164, 2167, 2176, 2178, 2181-2182, 2186, 2191, 2195, 2198, 2199, 2202-2203, 2207
96	2213-2215, 2219, 2225, 2228, 2230-2231, 2237, 2239, 2244-2245
97	2248-2250, 2254-2255, 2257-2261

Joint Faulting Update: Spring 2011

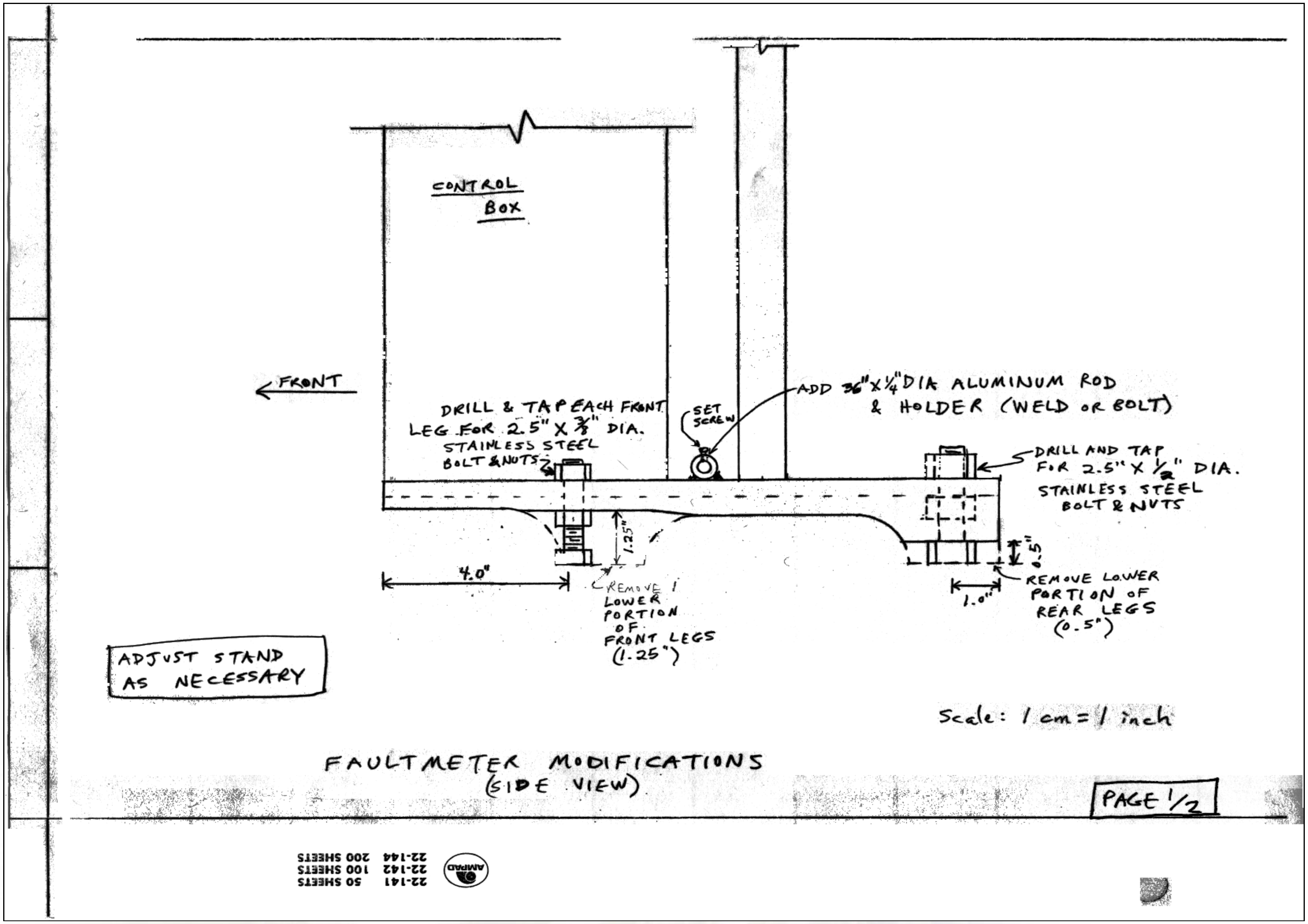
Transverse joint faulting measurements are taken at select locations throughout the MnROAD concrete test cells. Beginning in April 2009, measurements will be taken across the selected joints in each of the wheelpaths: Outer wheelpath, Inner wheelpath (10 feet and 3 feet offsets from the centerline in both lanes).

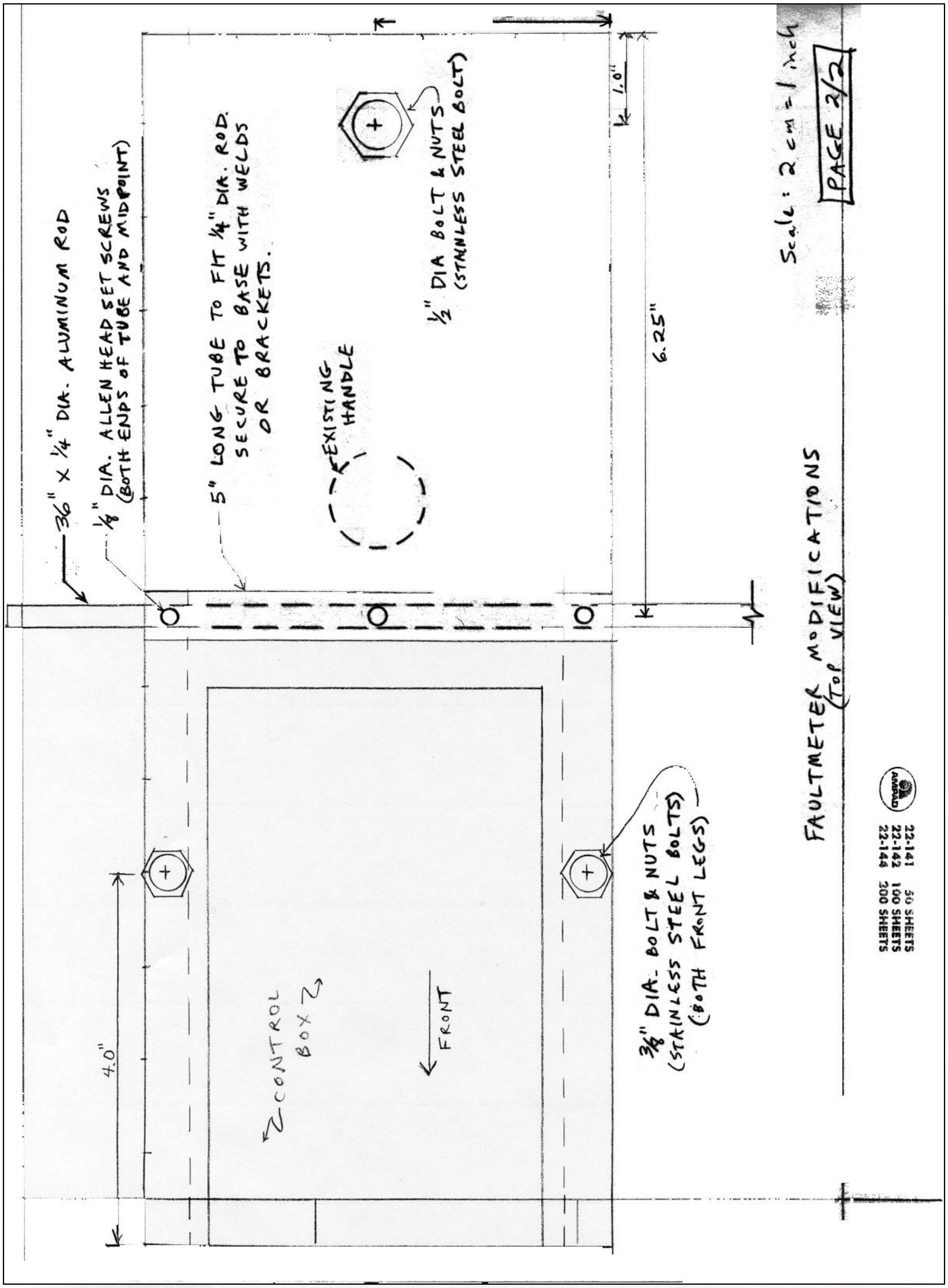
The following table lists the MnROAD cells to be tested in the months of April and July.

Concrete Test Cells Measured for Transverse Joint Faulting
Mainline: 1 (future), 5, 6, 7, 8, 9, 60, 61, 62, 63, 96, 97, 92, 70, 71, 72, 10, 11, 12, 13, 14
LVR: 32, 52, 53, 54, 36, 37, 38, 40

FIELD CONDITION SHEETS AT: R:\MnROAD\Data - Collection\Faultmeter\Documents\Faulting Data Collection Sheets.xls

AFTER DATA HAS BEEN COLLECTED, MAKE A COPY OF THE *FAULTING DATABASE TEMPLATE* AT: R:\MnROAD\Data - Collection\Faultmeter\Data\Joint Faulting Database Template.xls


CONTROL BOX
FRONT
DRILL & TAP EACH FRONT LEG FOR 2.5" X 3/8" DIA. STAINLESS STEEL BOLT & NUTS
SET SCREW
ADD 36" X 1/4" DIA ALUMINUM ROD & HOLDER (WELD OR BOLT)
DRILL AND TAP FOR 2.5" X 1/2" DIA. STAINLESS STEEL BOLT & NUTS
1.25"
4.0"
REMOVE LOWER PORTION OF FRONT LEGS (1.25")
0.5"
1.0"
REMOVE LOWER PORTION OF REAR LEGS (0.5")
ADJUST STAND AS NECESSARY
Scale: 1 cm = 1 inch
FAULTMETER MODIFICATIONS (SIDE VIEW)
PAGE 1/2
AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS


36" x 1/4" DIA. ALUMINUM ROD
1/8" DIA. ALLEN HEAD SET SCREWS
(BOTH ENDS OF TUBE AND MIDPOINT)
5" LONG TUBE TO FIT 1/4" DIA. ROD.
SECURE TO BASE WITH WELDS
OR BRACKETS.
EXISTING HANDLE
1/2" DIA BOLT & NUTS
(STAINLESS STEEL BOLT)
1.0"
6.25"
Scale: 2 cm = 1 inch
PAGE 2/2
FAULTMETER MODIFICATIONS
(TOP VIEW)
AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
3/8" DIA. BOLT & NUTS
(STAINLESS STEEL BOLTS)
(BOTH FRONT LEGS)
CONTROL BOX
FRONT
4.0"

For more information:

For more information about MnROAD and the Road Research program at Mn/DOT:

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