CONSTRUCTION AND PROFILE STUDY

Part I

Tire Traction Data Measured by The HSRI Mobile Tire Tester

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Project 329180

Tire Traction Characteristics Affecting Vehicle Performance

Document 5

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DOCUMENT 5

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INTRODUCTION

This document contains the processed data measured by the HSRI mobile tire tester at Automotive Proving Grounds, Inc., Pecos, Texas during the time period May 8 to June 17, 1972. Eleven different tire designs (listed in Table 1) were tested on wet and dry asphalt and concrete. Surface and water depth information will be found in the TEST PROCEDURES and TEST DATA sections, respectively.

A primary objective of this test program was to acquire a large traction data base for use in tire model validation work. In addition, it is hoped that the analysis of this data, and similar data from previous test programs, will enable some definite statements to be made concerning the influence of carcass construction and meridian profile on the wet and dry traction fields of production tires. Such analytical evaluations will be the subject of Part II of the Construction and Profile Study.

TIRES TESTED

The tires tested were commercially available production tires selected for similarity of tread pattern and tire cord. As a tread pattern is designed and tire cord specified for optimum performance of a particular tire construction, it is impossible to obtain a sequence of production tires which vary only in aspect ratio and carcass construction (bias, belted-bias, radial). It is believed, however, that the two tire variables under study (carcass construction and meridian profile) do have a definite influence on the traction field of production tires which are similar in other respects. Because of the highly interactive nature of all tire variables which influence tire traction, information obtained from a sequence of experimental tires carefully constructed to show selected variations would be difficult to use in predicting the traction behavior of production tires. Both types of test programs are needed. Findings obtained during the course of analysis of the production tire data presented in this document should be confirmed with similar tests made on specially constructed tires.

Figure 1 presents the meridian profiles of the tires tested for this study. The dimensions (inches) indicated in Figure 1 are those specified by the 1972 Tire and Rim Association Yearbook for the mounted tire inflated to 24 psi. An attempt was made to have all three carcass constructions represented in all three aspect ratios. This proved to be impossible with production tires. Discussions with tire industry people revealed that several such combinations are impractical. For example, a low aspect ratio bias-ply tire requires a belt for tread stability. A 60-series belted-bias tire was included in the tire inventory. Unfortunately, the 60-series radial tire in a comparable tread pattern and tire cord intended for this test program was delayed in being certified for production and thus was unavailable for testing.

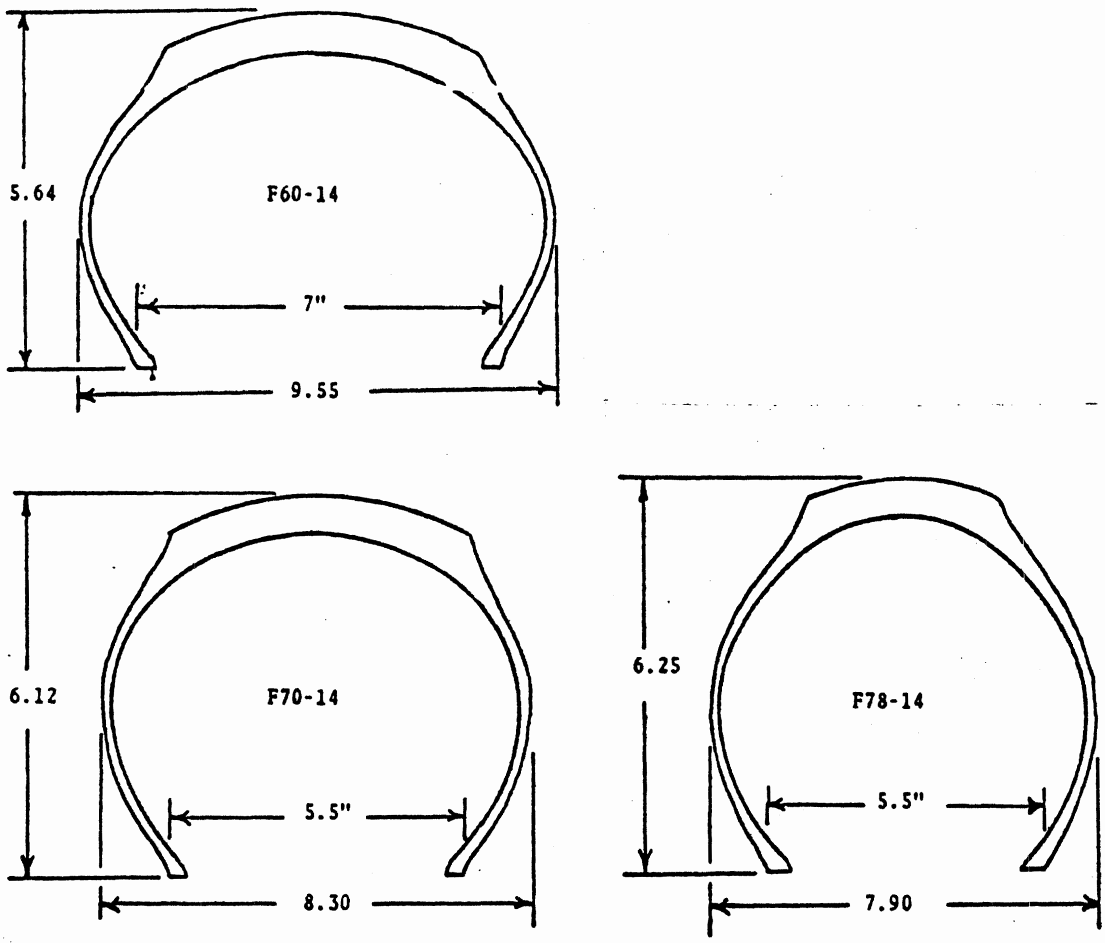

Figure 1. Meridian profiles of tires tested for the HSRI construction and profile study.

Table 1 gives construction and profile data for the tires tested. Tires from the five major U.S. manufacturers are represented in this tire inventory. A tire code (e.g., B178A) is used to avoid identifying the manufacturer. The tires are all load range B (4-ply rating).

TABLE 1

CARCASS CONSTRUCTION AND MERIDIAN PROFILE DATA

Code	Size	Rim	Carcass	Cord	H/W*	Periphery**
B178A	F78-14	5.5	Bias	Polyester	.80	16.15
B178B	F78-14	5.5	Bias	Polyester	.80	15.75
B170A	F70-14	5.5	Bias	Polyester	.74	16.75
B278A	F78-14	5.5	Belted-Bias	Polyester-Glass	.80	15.50
B278B	F78-14	5.5	Belted-Bias	Polyester-Glass	.80	15.75
B278C	F78-14	5.5	Belted-Bias	Polyester-Glass	.80	15.80
B270A	F70-14	5.5	Belted-Bias	Polyester-Glass	.74	16.00
B270B	F70-14	5.5	Belted-Bias	Polyester-Glass	.74	16.25
B260A	F60-14	7.0	Belted-Bias	Polyester-Glass	.59	17.25
R70A	FR70-14	6.0	Radial	Rayon-Rayon	.71	16.75
R70B	FR70-14	6.0	Radial	Rayon-Rayon	.71	17.00

*Inflated tire aspect ratio.

**Bead-to-bead meridian length (inches, uninflated).

Although an attempt was made to have a standard longitudinal groove, highway-type tread pattern on all tires, pattern variations are inevitable with production tires. The greatest pattern deviation on the tires tested is that of the radial tire R70A which came in a 5-rib moderately open (transverse grooving) tread. The other radial tire tested had a continuous rib pattern similar to the patterns on the bias and belted-bias tires. Except where noted, the tread pattern data given in Table 2 is for the inflated but unloaded tire. Tread compound information has not yet been obtained for these tires.

TABLE 2

TREAD PATTERN DATA

Code	Size	Tread Arc*	Ribs	Groove Depths (in)		Contact Print **	
				Shoulder	Crown	Void (%)	Length (in)
B178A	F78-14	6.00	7	.42	.36	45.0	6.80
B178B	F78-14	5.75	7	.41	.34	36.3	6.58
B170A	F70-14	6.50	7	.41	.35	31.4	6.30
B278A	F78-14	5.75	7	.42	.36	40.6	7.15
B278B	F78-14	5.70	7	.42	.36	39.3	7.08
B278C	F78-14	5.75	7	.42	.36	34.4	7.00
B270A	F70-14	6.30	7	.36	.32	37.4	6.70
B270B	F70-14	6.50	7	.40	.36	32.0	6.20
B260A	F60-14	8.00	9	.32	.30	42.7	5.60
R70A	FR70-14	6.50	5	.40	.36	47.0	7.12
R70B	FR70-14	6.50	7	.40	.34	37.0	7.08

*Shoulder-to-shoulder transverse arc length (inches, uninflated)

**At test load (1100 lb.) and 24 psi. The % void includes kerfing.

TEST PROCEDURES

The following specifications pertain to mobile tire tests performed on the tire inventory (Tables 1 and 2) for the HSRI construction and profile study.

Date:	May 8 to June 17, 1972
Site:	Automotive Proving Grounds, Inc., Pecos, Texas
Test:	Braking-Cornering Traction (dry and wet)
Load:	1100 lb., 28 psi
Slip:	-2, 0, 2, 4, 8, 12, 16 deg; -5 to 100% long.
Speed:	20, 40, 55 mph
Surface:	(1) asphalt, (2) concrete

(1) A coarse aggregate bituminous concrete with ASTM standard tire 40 mph wet friction coefficients .75 peak and .47 slide. Dry coefficients .85 peak and .73 slide at 40 mph. Slight macro and moderate microtexture. A.P.G.*designation: S

(2) Brushed concrete highway surface with ASTM standard tire 40 mph wet friction coefficients .72 peak and .46 slide. Dry coefficients .82 peak and .68 slide at 40 mph. Slight macro- and moderate microtexture. A.P.G. designation: L

(The preceding are A.P.G. surface specifications.)

All test tires are mounted on the rims specified (Table 1, Column 3) by the 1972 Tire and Rim Association Yearbook.

The specified tire load, 1100 lb., is 86% of the Tire and Rim Association design load (1280 lb.) for an F-size tire. All of the wet testing was performed at 1100 lb. The dry testing was performed at slightly lower loads (ranging from 800 to 1000 lb.) due to the inability of the mobile tire tester to lock the test wheel on a dry surface at 1100 lb. The actual test loads are indicated with the output data.

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*A.P.G. - Automotive Proving Grounds

The inflation pressure of 28 psi was set in the cold tire. As the test wheel contacts the pavement only during test surface transit (less than 600 ft.), pressure rise due to tire heating is not a problem. This procedure was adopted after observations of the tread surface temperature with an infrared radiometer showed a very rapid temperature decay when the test tire was lifted after test surface transit.* Considerable convection cooling apparently takes place as the unloaded tire moves along the approach road between tests. No pressure change was found during checks made immediately after a test transit.

Lateral tire slip is controlled by manually setting the test wheel at a specified slip angle. As the mobile tire tester enters the test surface, the test wheel is lowered to loaded contact at the specified slip angle. Longitudinal slip is then introduced by an independent hydraulic motor which drives (and brakes) the test wheel according to a preset program. For these tests, a ramp control input (Fig. 2) was used to slowly reduce the test wheel rotational velocity to zero (locked wheel) and then return it to the test transit velocity (free rolling). The actual test wheel

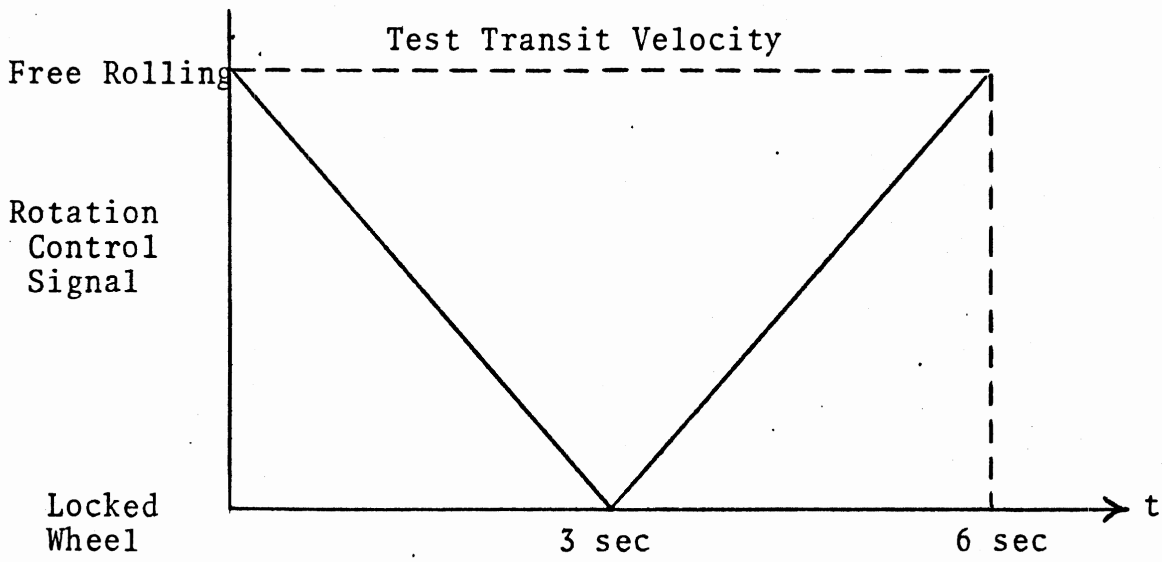

Figure 2. Test wheel rotation control signal vs. time.

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*An average tread temperature of 130°F was observed during dry testing. A localized hot spot at approximately 200°F occurs at high slip angle wheel lock.

rotational velocity is measured by a DC tachometer and recorded along with the output of the traction force transducers. Longitudinal wheel slip was computed by ratioing the test wheel tachometer signal between the free-rolling and locked-wheel values. It is believed that the lock-unlock cycle time is sufficiently long to consider the traction force versus longitudinal slip data as representative of steady-state conditions.

The test transit velocity is controlled by an engine governor which limits the diesel engine driving the mobile tire tester to 2100 rpm. The transit velocity is maintained by driving the engine up against the governor while in the transmission gear giving the desired velocity at 2100 rpm. Table 3 gives the truck velocities in each gear as recorded by a fifth wheel speedometer.

TABLE 3

MOBILE TIRE TESTER GEAR SELECTIONS
AND RESULTING VELOCITIES AT 2100 rpm

Gear	Truck Velocity (mph)
1	9.4
2	12.8
3	14.0
4	19.0
5	23.8
6	29.2
7	39.0
8	49.8
9	60.0

The fourth and seventh gears were used for the 20 and 40 mph tests. The hydraulic test wheel motor limited the maximum speed at which the test wheel could be locked to 55 mph. This velocity was obtained in ninth gear at 1600 rpm which was maintained by the truck driver.

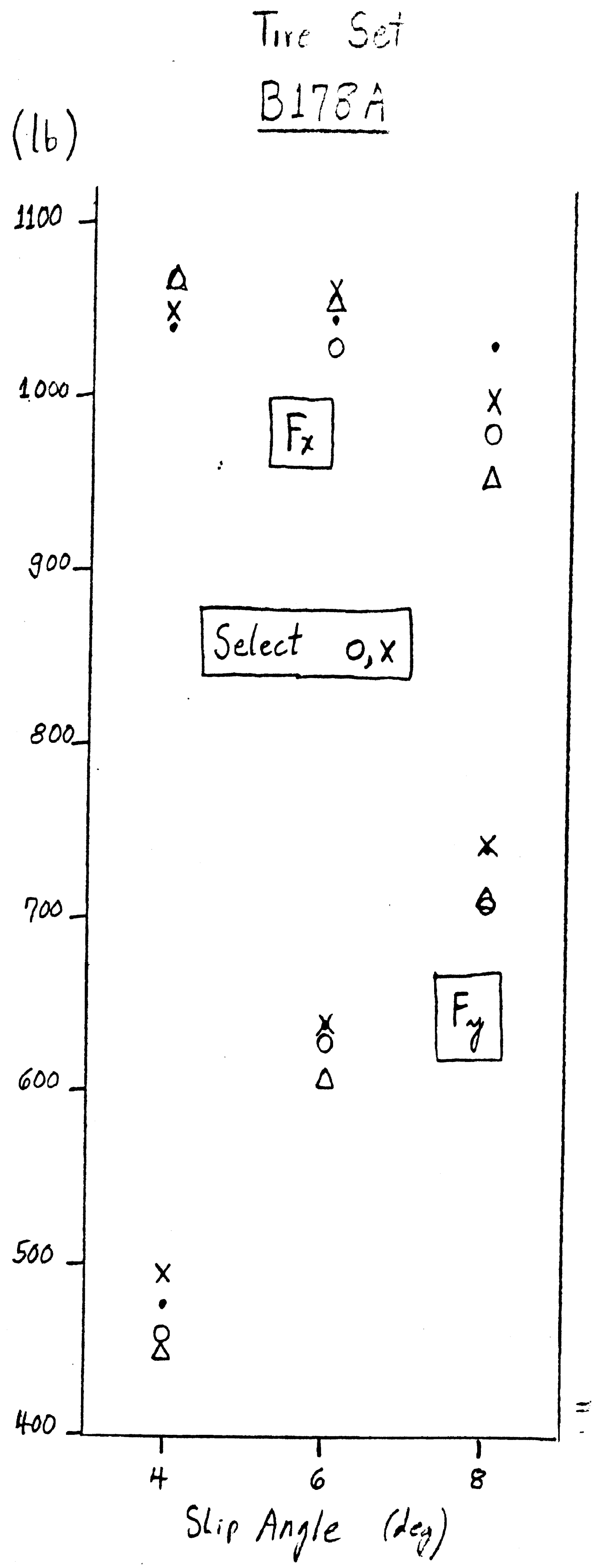
SCREENING PROGRAM

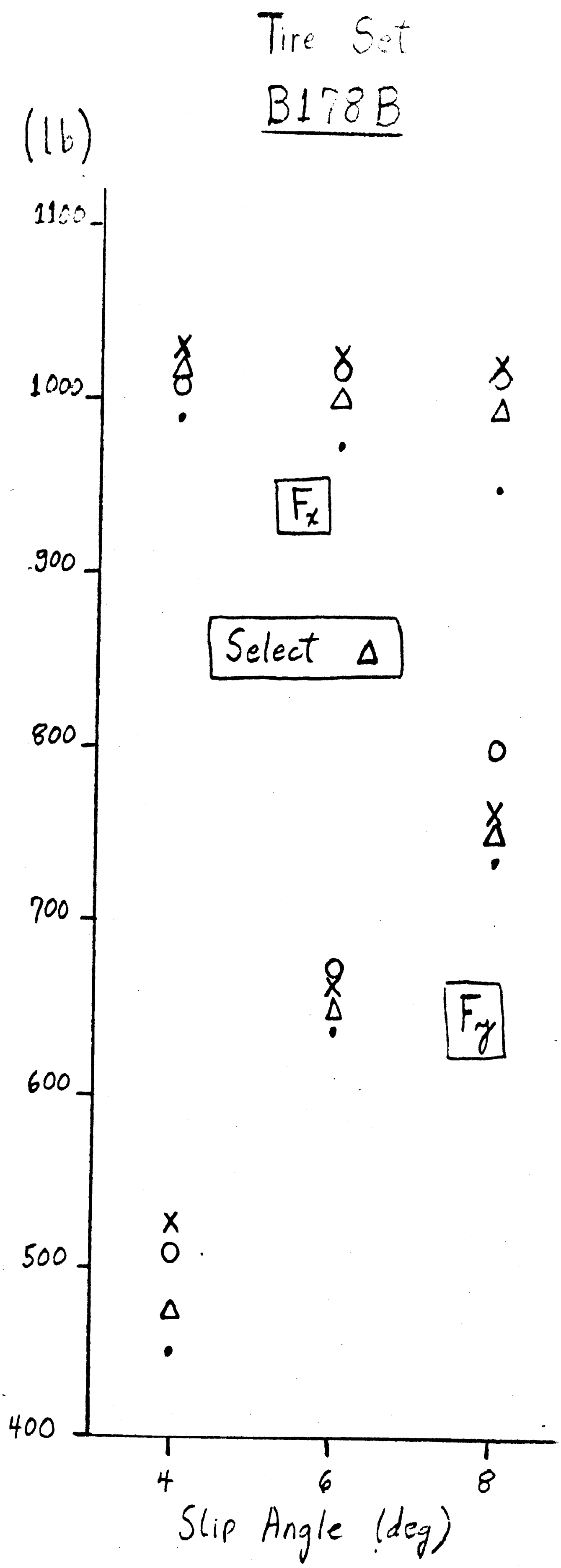
A set of four tires* was purchased for each of the eleven tire designs (Tables 1 and 2) tested. Each tire set was broken in with approximately 100 miles of highway driving using automobiles for which the tires were designed. In order to obtain a representative tire for each design, a low-speed screening program was conducted according to the following specifications.

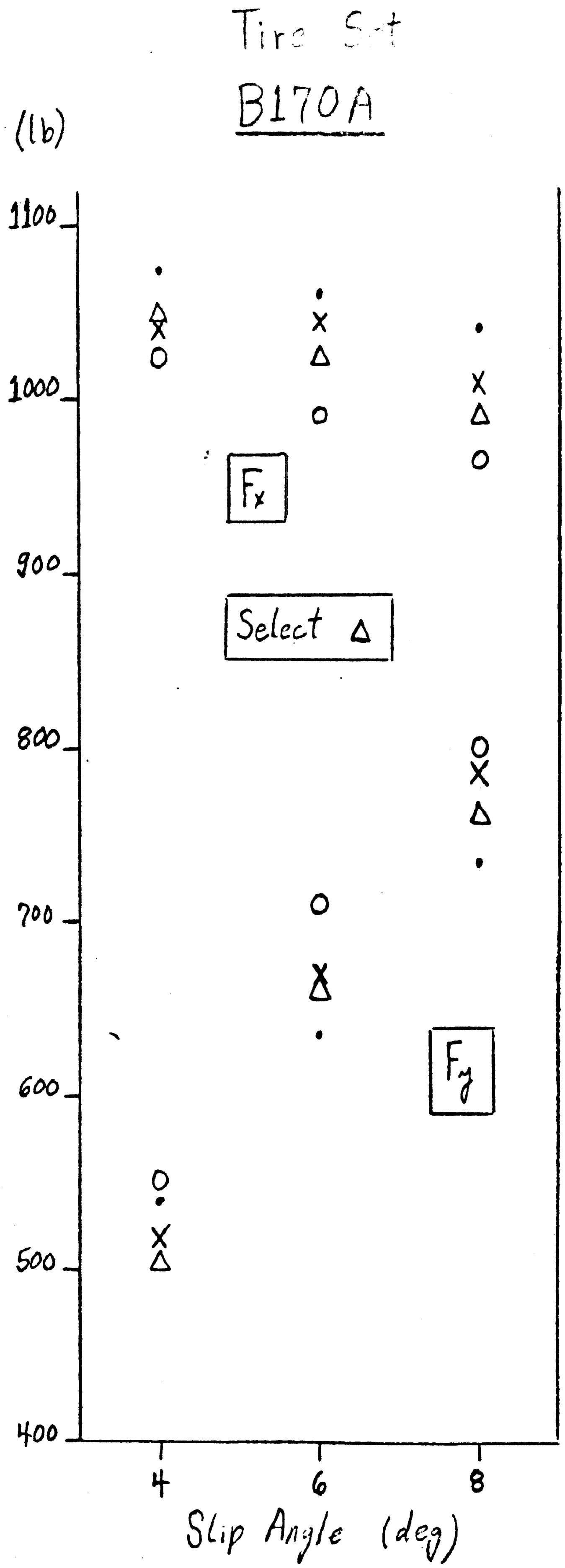
Site:	Automotive Proving Grounds, Inc., Pecos, Texas
Test:	Peak traction force generation; longitudinal (F_x) and lateral (F_y)
Load:	1100 lb., 28 psi
Slip:	4, 6, 8 deg.; 0-100% longitudinal slip
Speed:	20 mph
Surface:	Asphalt concrete approach road, dry

The peak longitudinal and lateral forces plotted as a function of slip angle were used to determine the representative tire of each set. These plots are given on the following pages. The tire(s) selected are indicated on each plot.

*The tires were primarily premium grade and all were from the five major U.S. tire manufacturers.


Tire Set
B178A
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select o,x
Fy
4
6
8
Slip Angle (deg)


Tire Set
B178B
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select Δ
Fy
4
6
8
Slip Angle (deg)


Tire Set
B170A
(lb)
1100
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900
800
700
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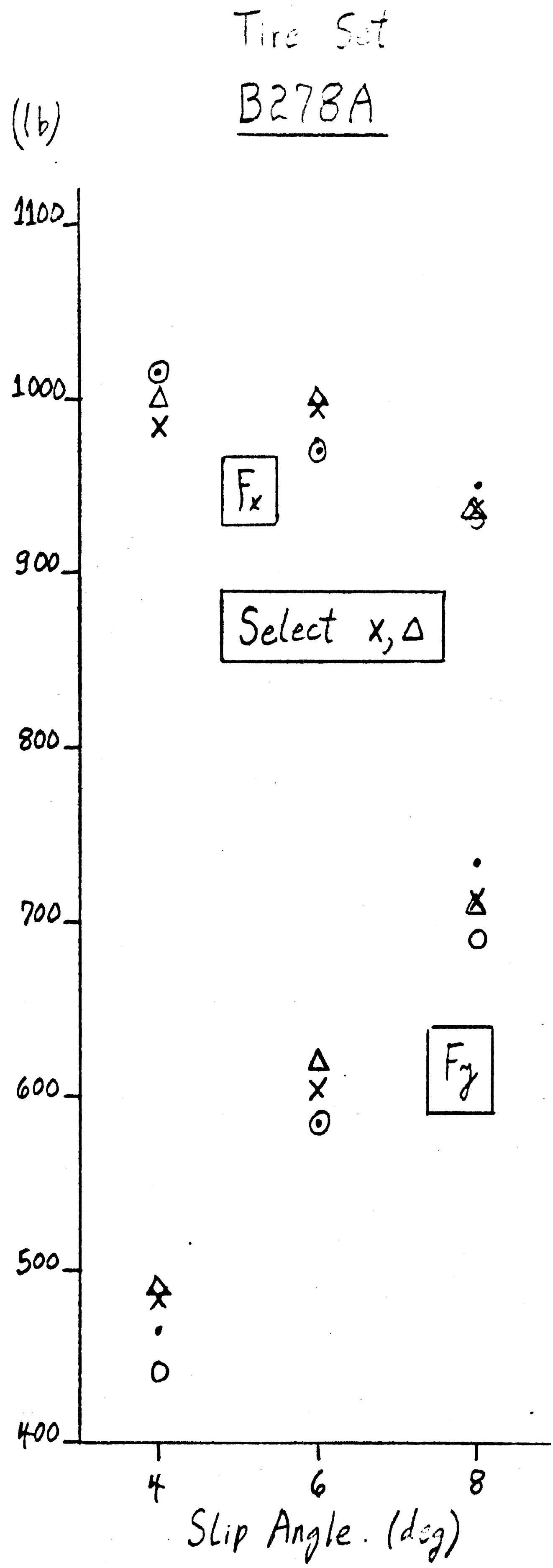
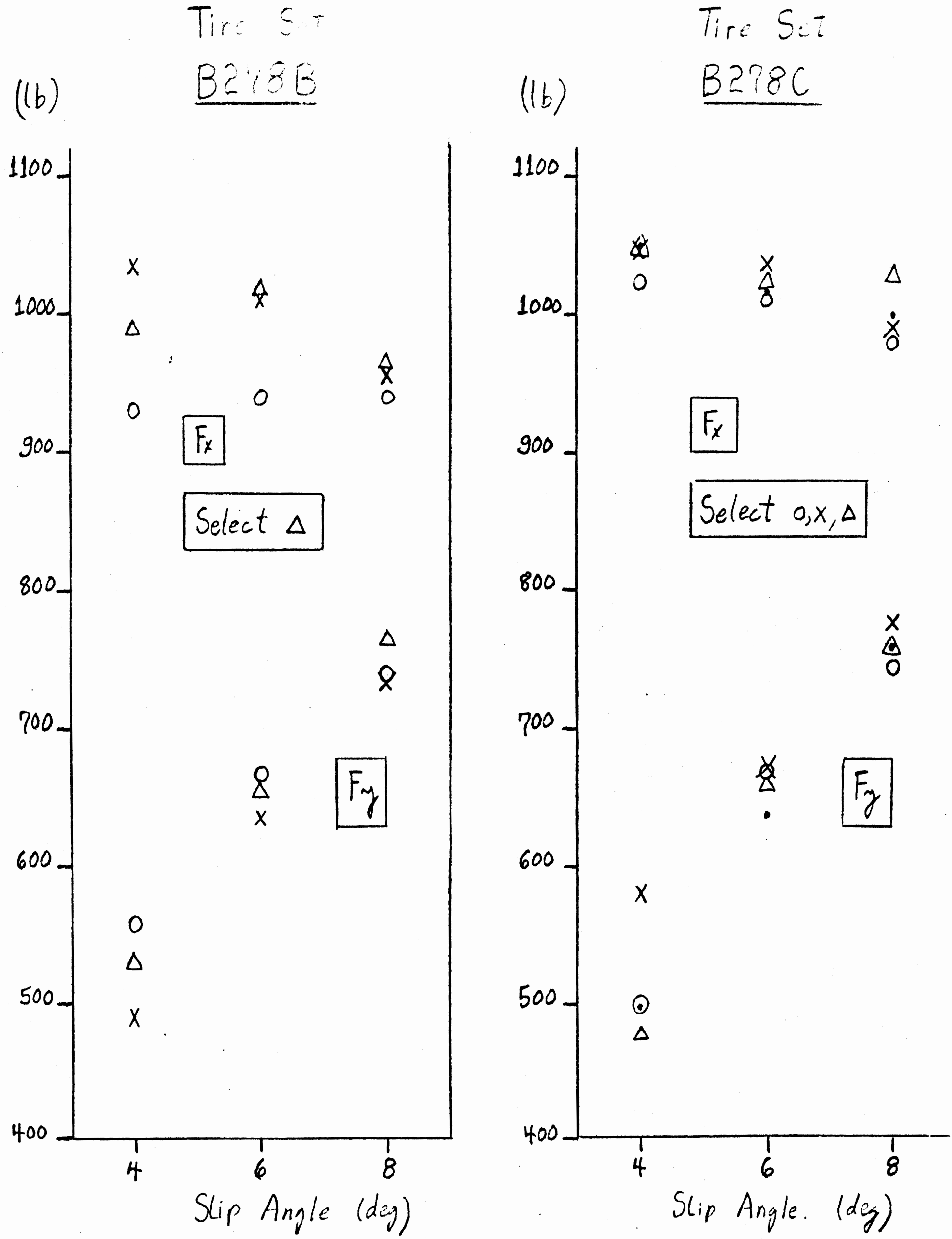
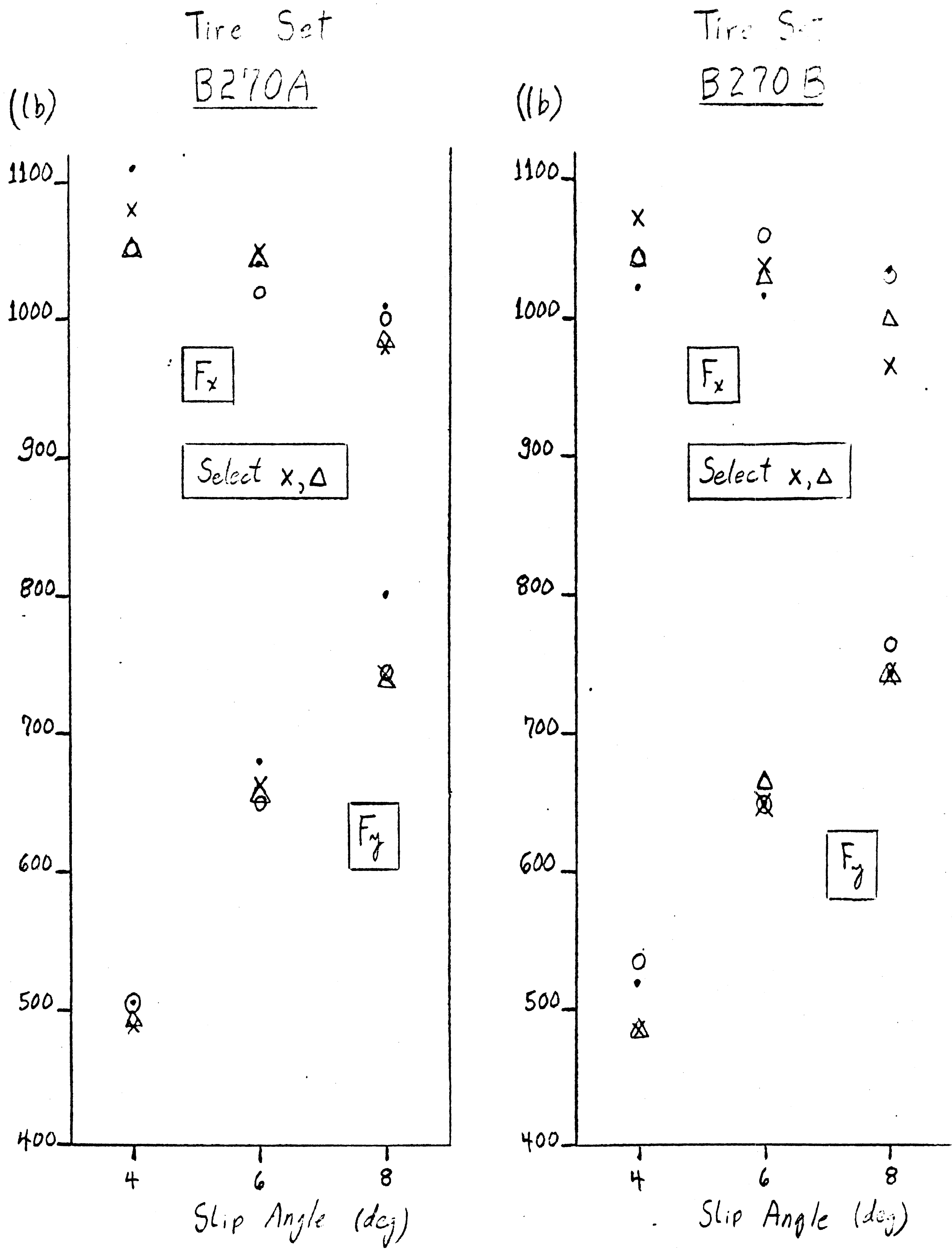
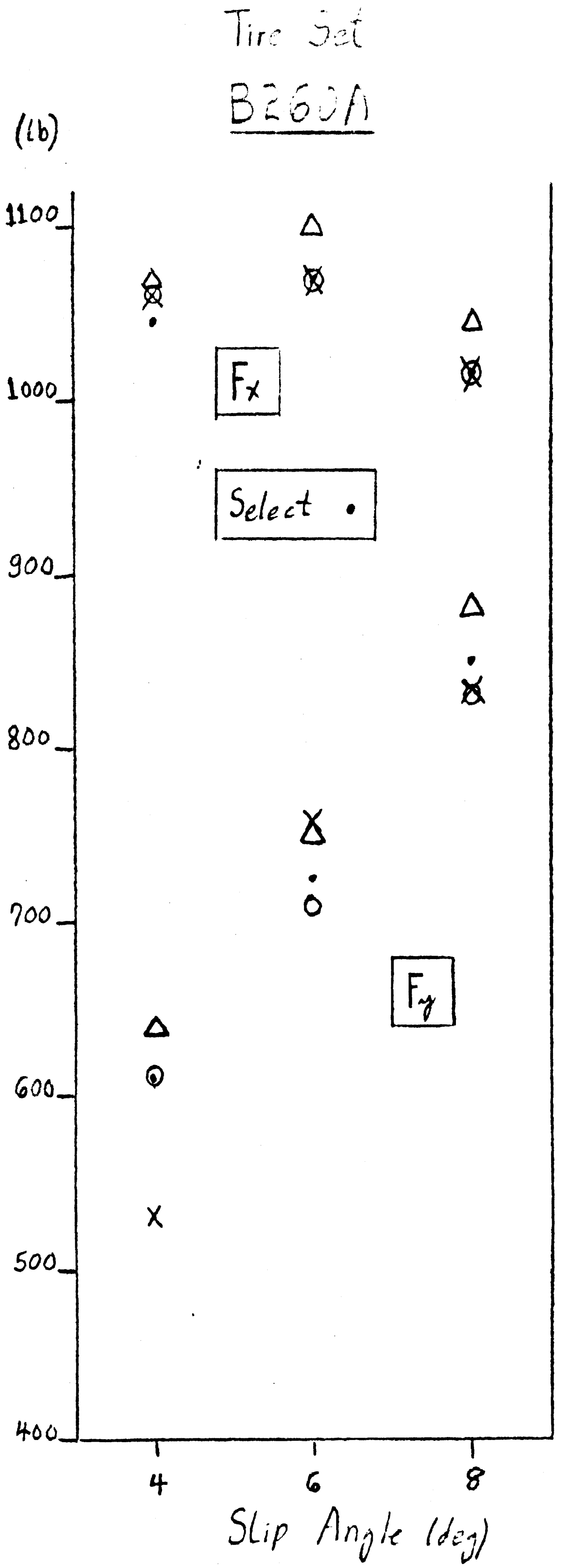
500
400
Fx
Select Δ
Fy
4
6
8
Slip Angle (deg)


Tire Set
B278A
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select X, Δ
Fy
4
6
8
Slip Angle (deg)



Tire Set
B278B
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select Δ
Fy
4
6
8
Slip Angle (deg)
Tire Set
B278C
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select o,x,Δ
Fy
4
6
8
Slip Angle (deg)


Tire Set
B270A
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select x, Δ
Fy
4
6
8
Slip Angle (deg)
Tire Set
B270B
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select x, Δ
Fy
4
6
8
Slip Angle (deg)


Tire Set
B260A
(lb)
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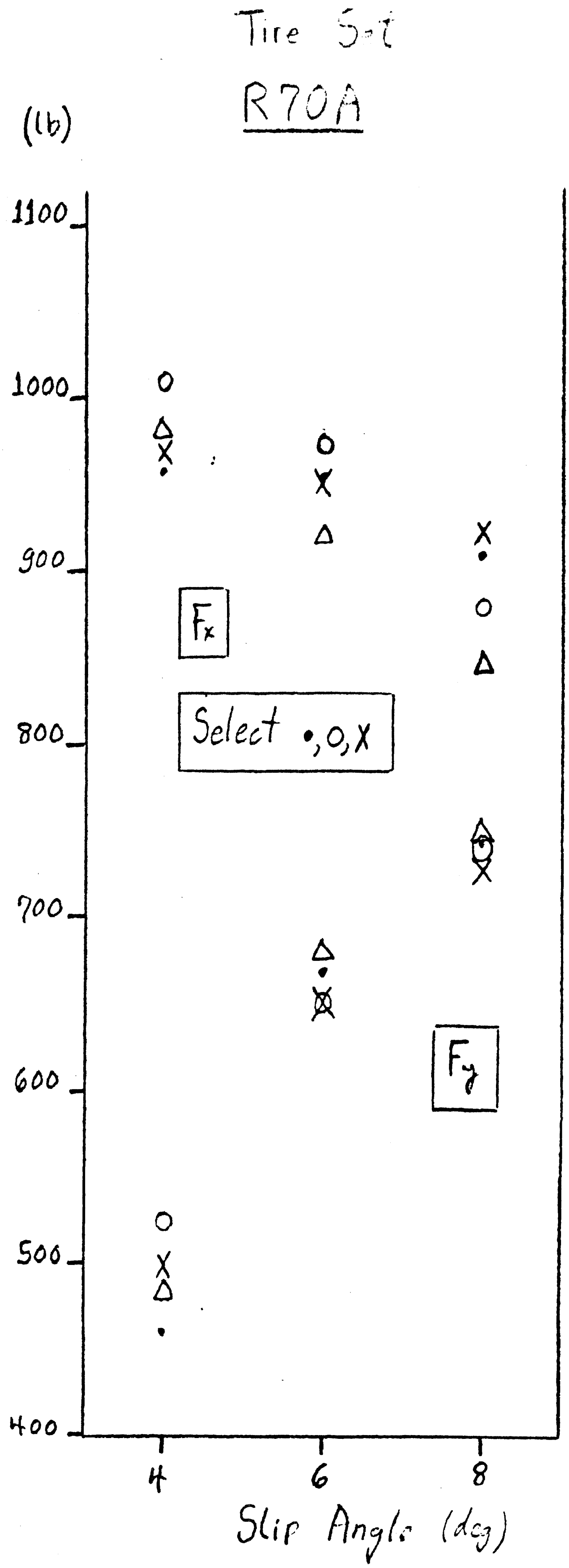
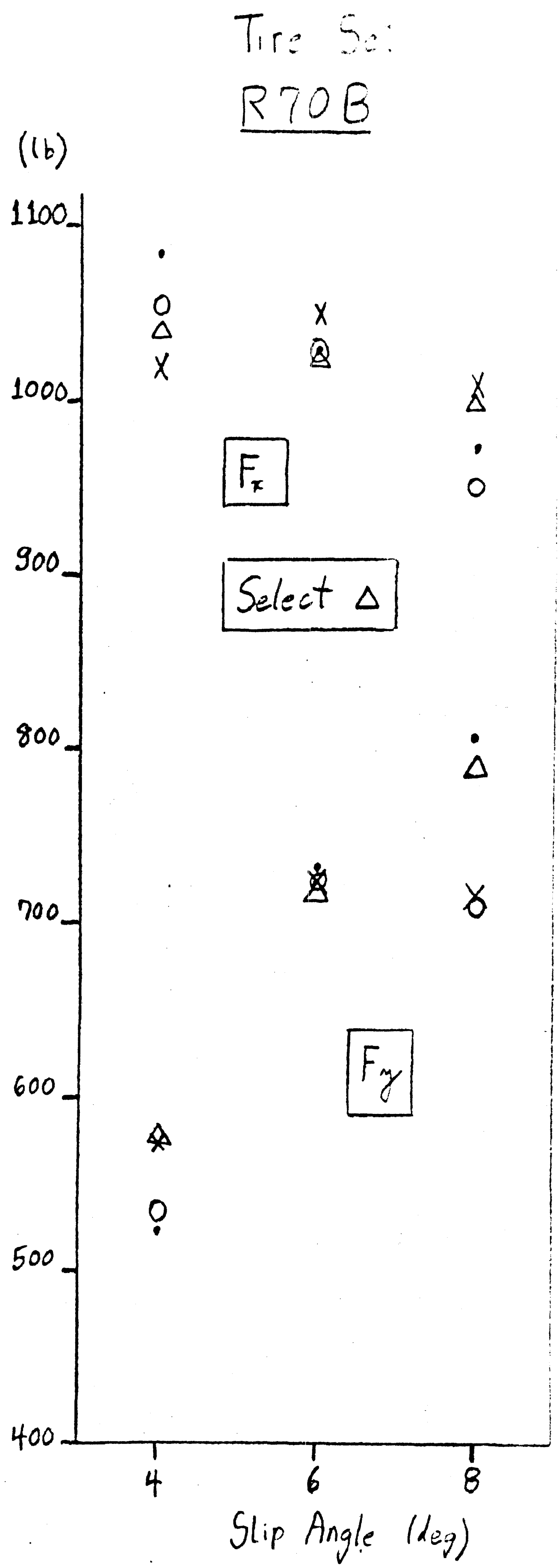
1000
900
800
700
600
500
400
Fx
Select •
Fy
4
6
8
Slip Angle (deg)



Tire Set
R70A
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select •, o, x
Fy
4
6
8
Slip Angle (deg)



Tire Set
R70B
(lb)
1100
1000
900
800
700
600
500
400
Fx
Select Δ
Fy
4
6
8
Slip Angle (deg)

TEST DATA

The following traction test data was obtained from the eleven tires determined by the previously described screening program as representative of their particular design.

Two data acquisition systems (analog tape and oscillograph paper) were used on-board the mobile tire tester. The magnetic analog tape records were processed entirely by computer. The traction data from the analog tape system appears as computer-produced plots which include aligning moment as well as longitudinal and lateral forces. The other acquisition system, oscillograph recording on chart paper, requires data processing by hand. The hand-processed oscillograph records appear as longitudinal and lateral force plots on separate ordinates. Most of the oscillograph records do not include aligning moment. Table 4 separates the computer-processed analog tape data from the hand-processed oscillograph data.

TABLE 4

CONSTRUCTION AND PROFILE STUDY
DATA ACQUISITION

Tire Code	Wet Tests	Dry Tests
B178A	Analog Tape	Analog Tape
B178B	Analog Tape	Analog Tape
B170A	Analog Tape	Analog Tape
B278A	Analog Tape	Analog Tape
B278B	Oscillograph	Analog Tape
B278C	Oscillograph	Oscillograph
B270A	Oscillograph	Analog Tape
B270B	Analog Tape	Analog Tape
B260A	Analog Tape	Analog Tape
R70A	Analog Tape	Analog Tape
R70B	Oscillograph	Analog Tape

A complete description of the data processing procedures followed will be given in a subsequent document devoted to analysis of this data.

The processed tire traction force and moment measurements are presented here as functions of longitudinal slip (braking) for selected slip angles. The complete body of tire data is stored on magnetic digital tape according to the format given later in this report. It was felt that the traction forces versus longitudinal slip data would be of greatest interest at this time. Many plotting combinations are possible.

The plots given designate the test surface as wet or dry. Table 5 gives the water depths and resulting ASTM skid numbers (40 mph, slide) measured with the HSRI mobile tire tester on each of the days when wet testing was conducted.

TABLE 5

WATER DEPTHS AND SKID NUMBERS* ON SURFACES USED FOR THE CONSTRUCTION AND PROFILE STUDY

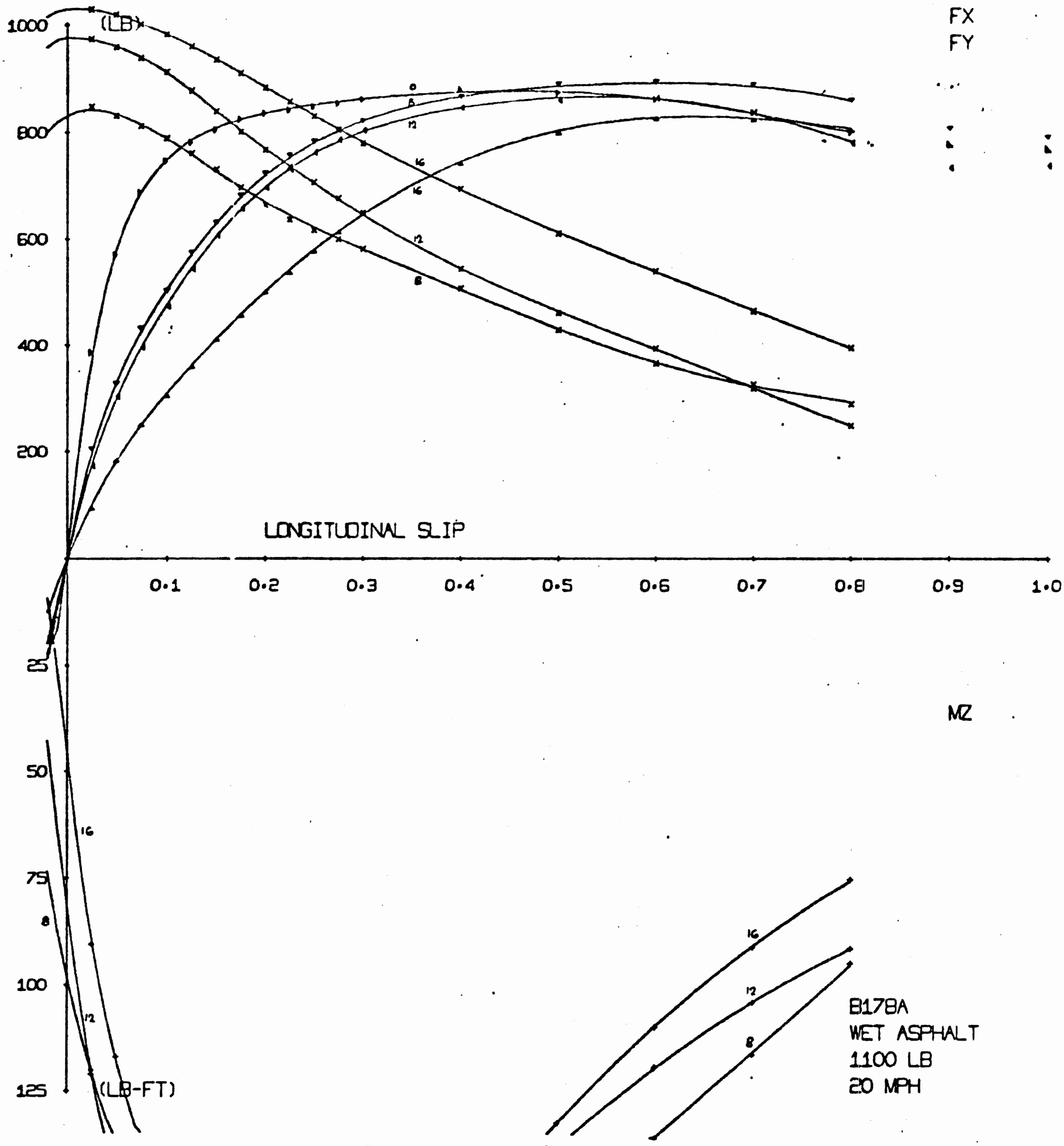
1972	Asphalt		Concrete	
Date	Depth	SN	Depth	SN
5/17	.020	.53	.015	.34
5/18	.015	.52	.015	.34
6/1	.015	.55	.010	.36
6/6	.015	.55	.010	.37
6/7	.015	.53	.010	.33
6/8	.020	.54	.015	.33
6/11	.020	.56	.015	.35

*40 mph locked wheel test according to ASTM E274-70.

The water depths were measured at noon on each of the indicated days with a B.F. Goodrich Water Film Depthmeter* made available by Automotive Proving Grounds.

Discrete points indicated on the plots by X, Δ, O, •, etc., are the averages of forces (or moment) measured during a number of replicate runs. The continuous curves which pass through most of the discrete points result from a least squares fit (in the case of computer processed data) or a flexible french curve fit (in the case of the hand-processed data).

*An electric probe-type depthmeter measuring water depth above surface asperities.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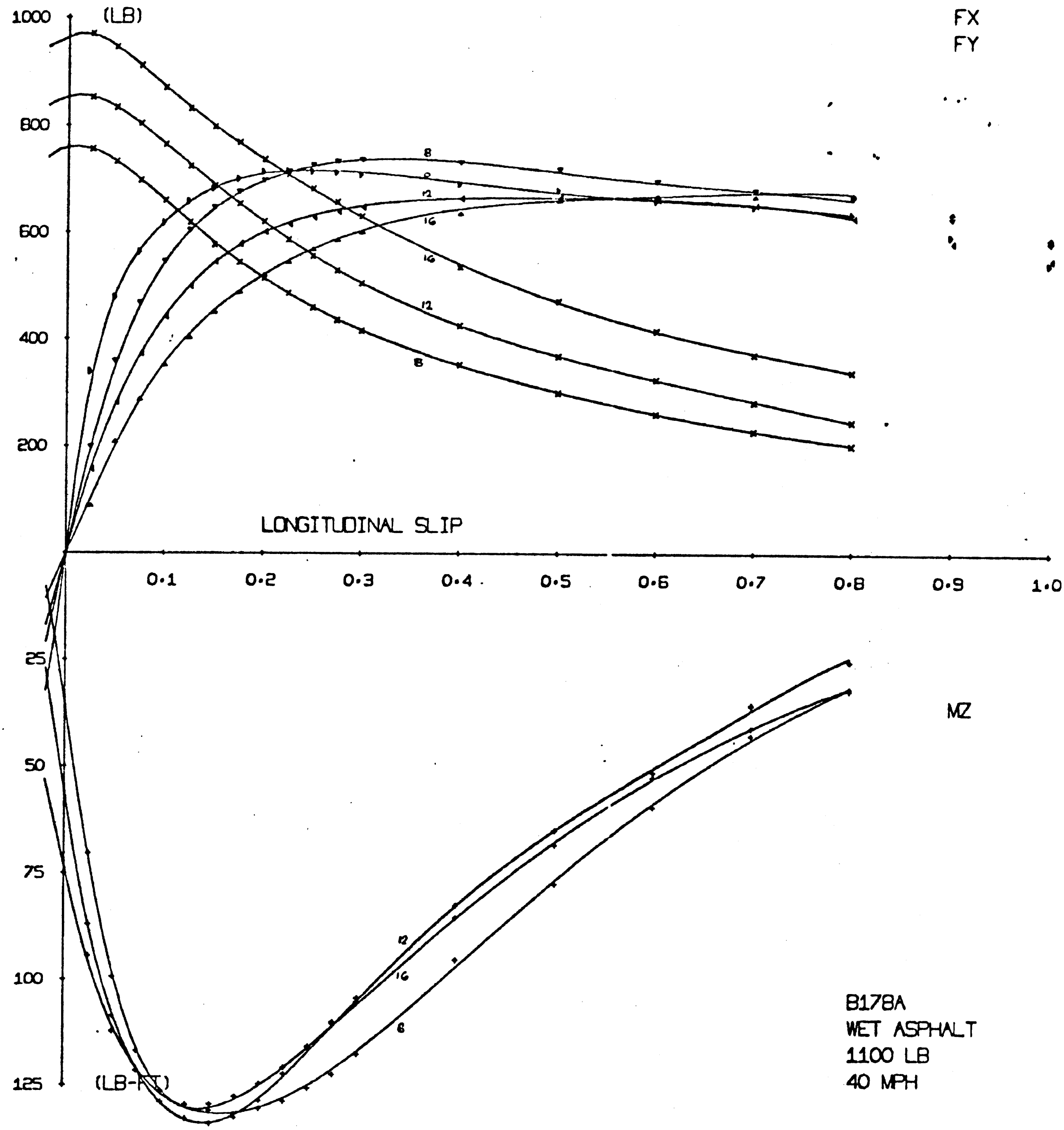
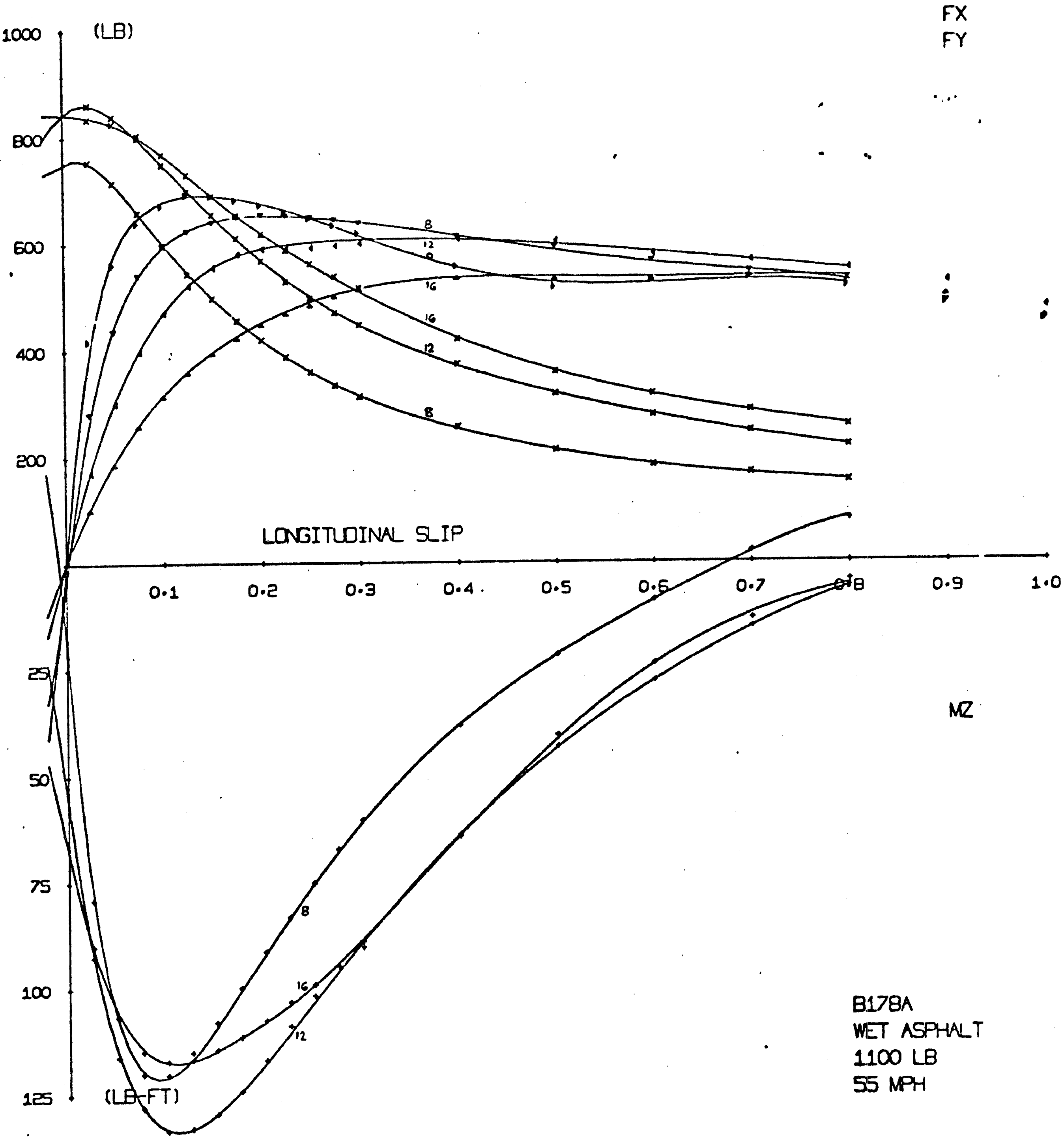
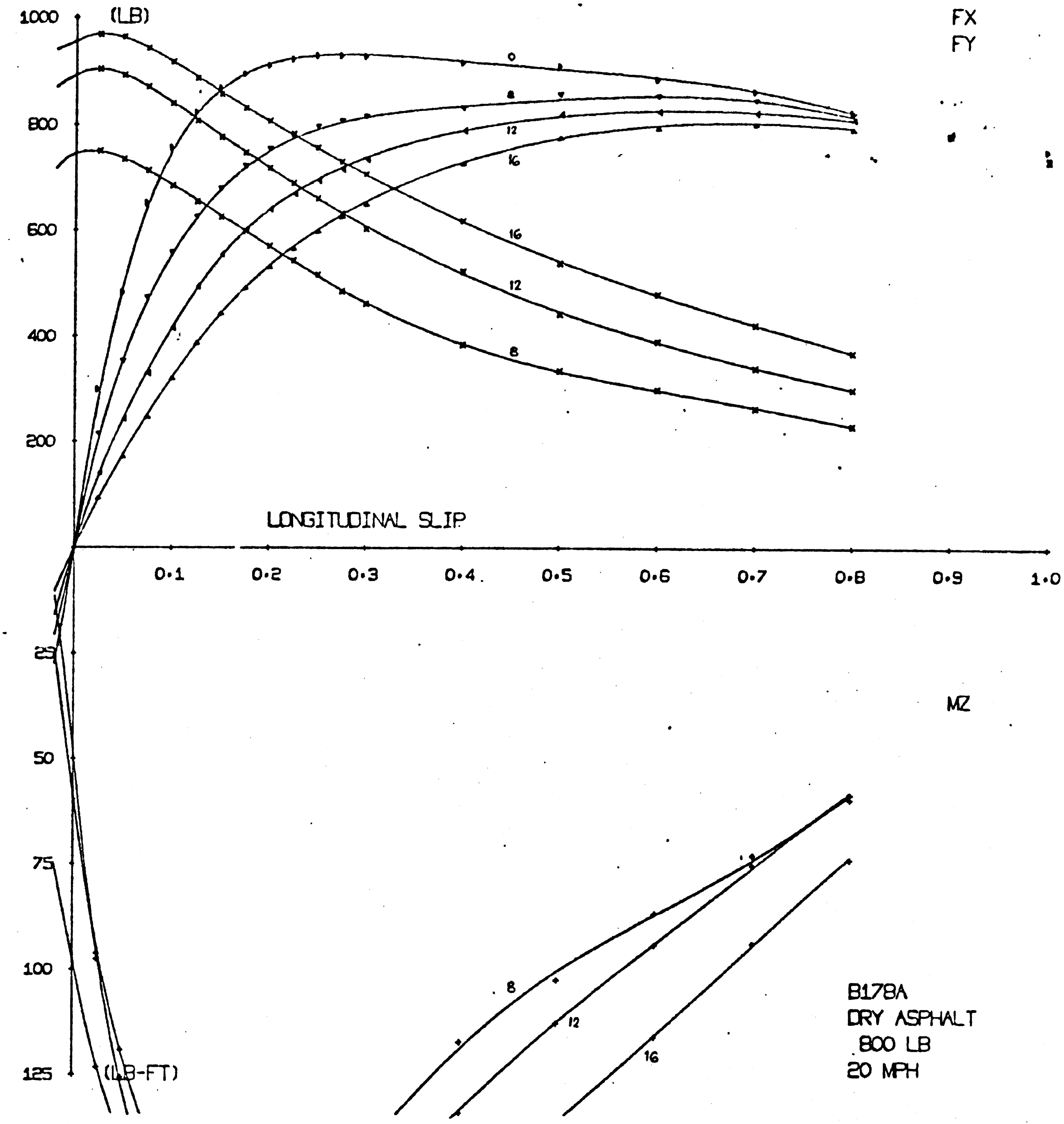
800
600
400
200
FX
FY
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
B178A
WET ASPHALT
1100 LB
20 MPH



1000
(LB)
800
600
400
200
FX
FY
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
12
16
8
B178A
WET ASPHALT
1100 LB
40 MPH



FX
FY
(LB)
1000
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
MZ
25
50
75
100
125
(LB-FT)
B178A
WET ASPHALT
1100 LB
55 MPH



1000
(LB)
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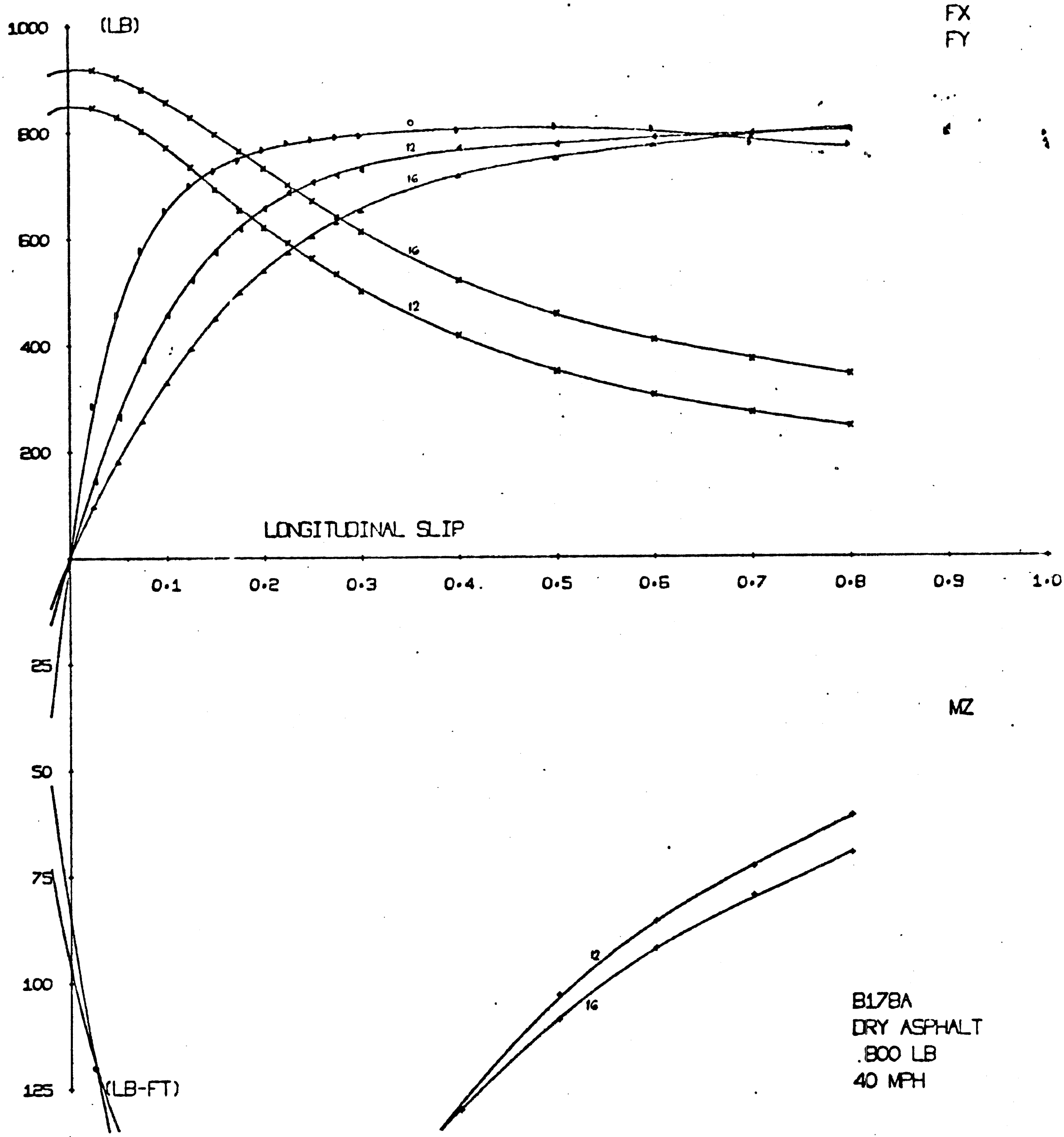
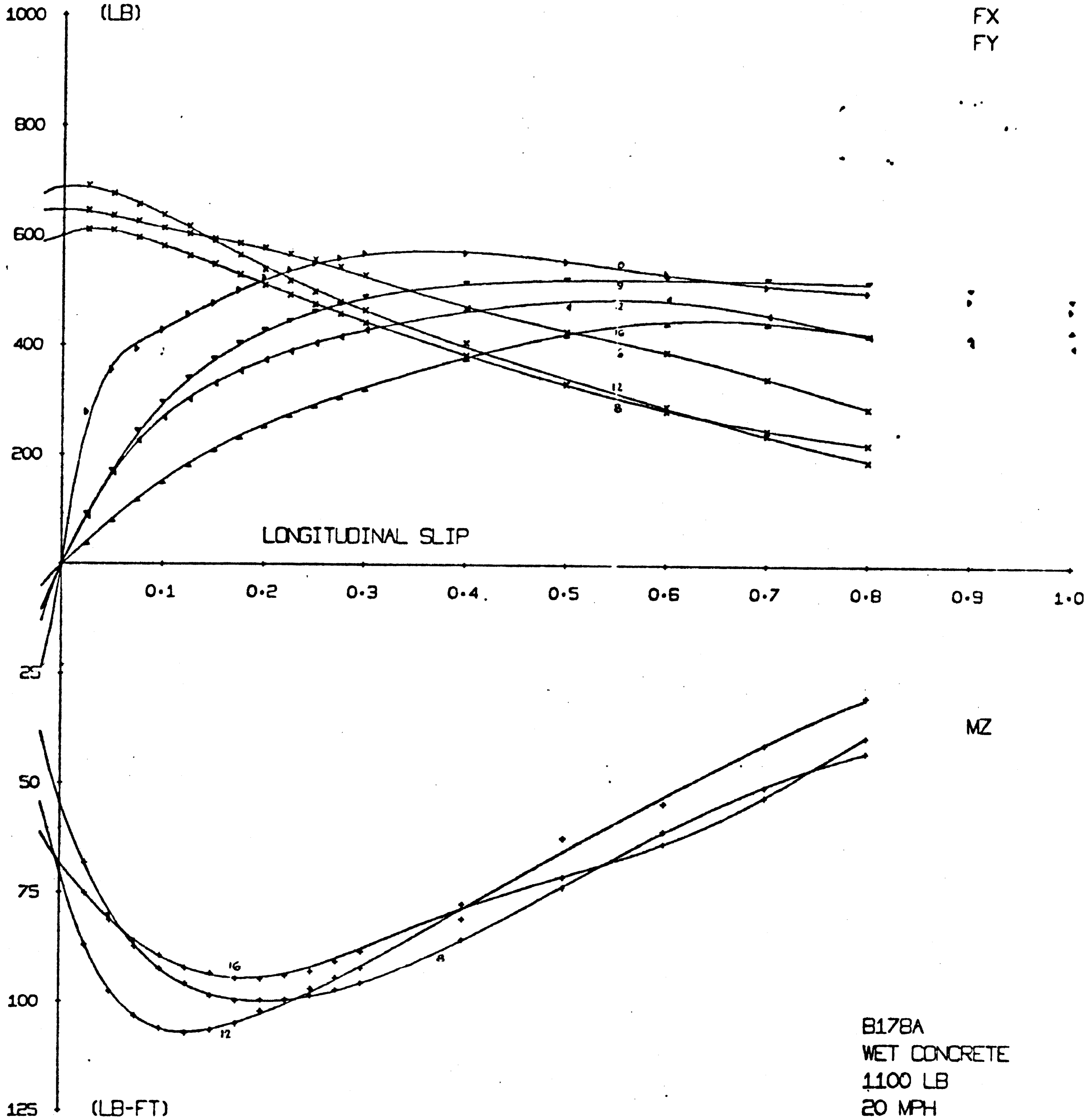
600
400
200
FX
FY
0
8
12
16
16
12
8
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
B178A
DRY ASPHALT
800 LB
20 MPH


1000
(LB)
FX
FY
800
600
400
200
o
12
16
16
12
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
12
16
B178A
DRY ASPHALT
.800 LB
40 MPH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FY
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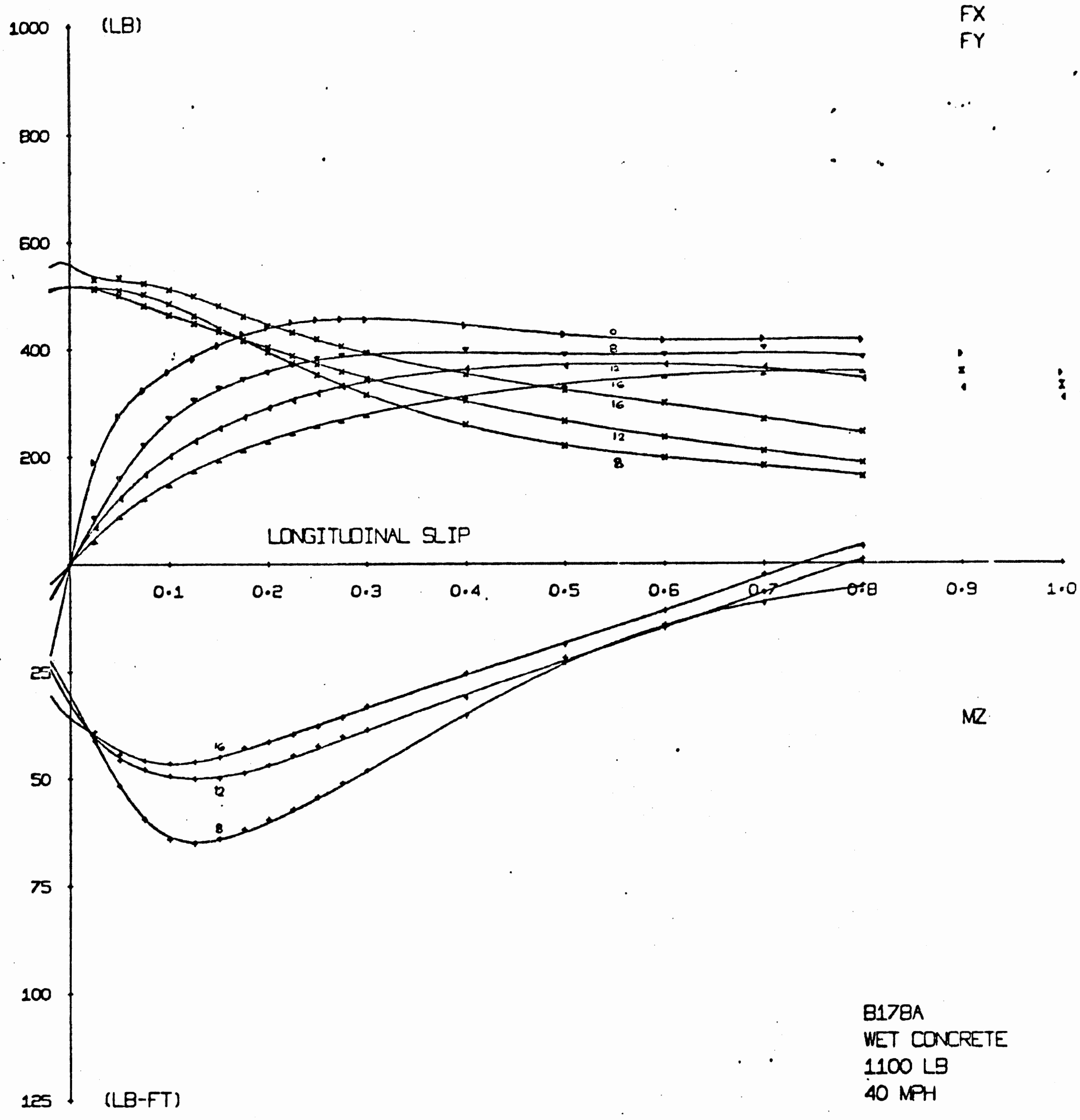
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
MZ
50
75
100
125
(LB-FT)
B178A
WET CONCRETE
1100 LB
20 MPH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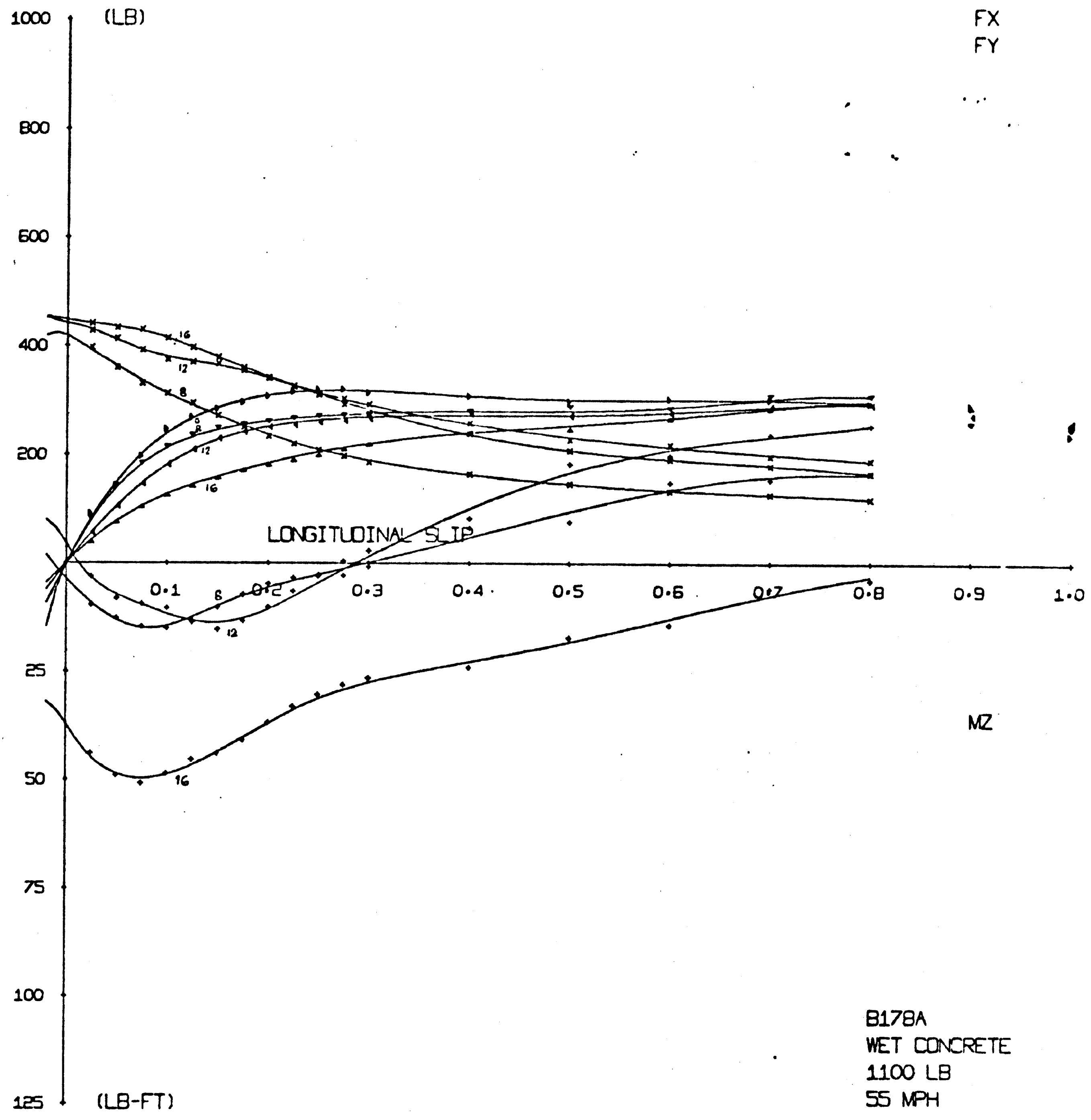
(LB)
800
600
400
200
FX
FY
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
B178A
WET CONCRETE
1100 LB
40 MPH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(LB)
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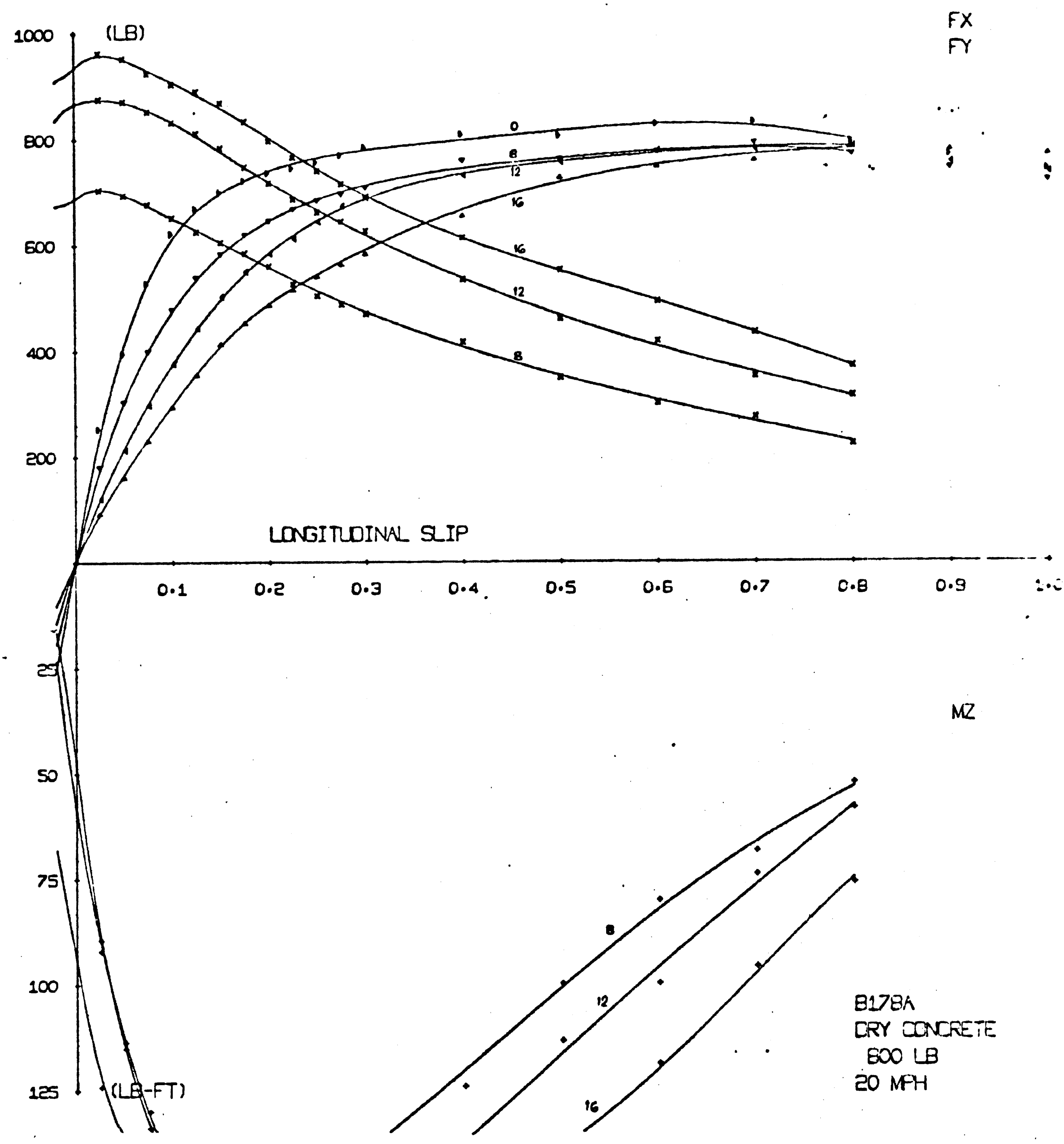
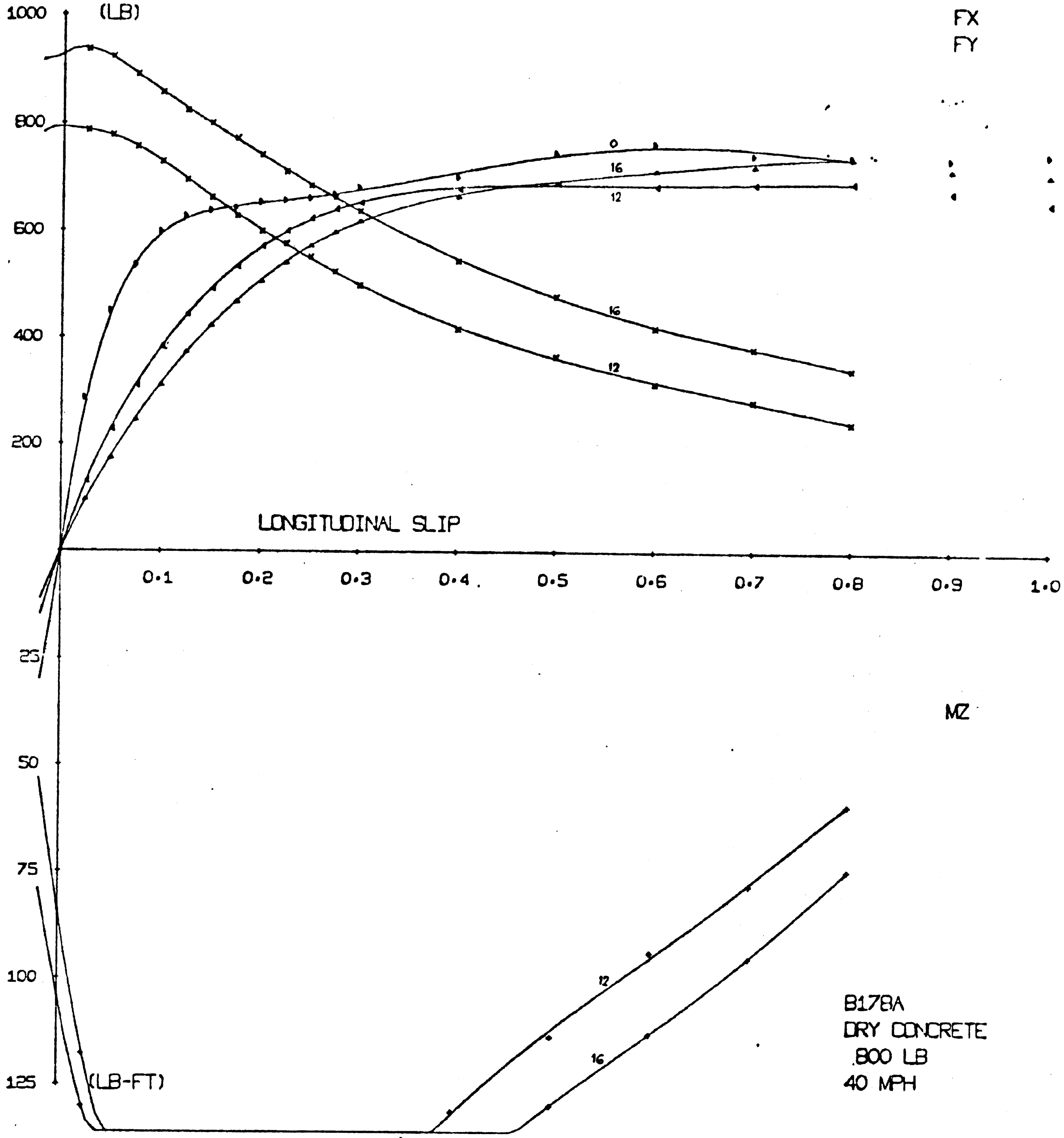
600
400
200
FX
FY
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
16
12
8
B178A
WET CONCRETE
1100 LB
55 MPH



FX
FY
1000
800
600
400
200
(LB)
0
8
12
16
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
25
50
75
100
125
(LB-FT)
MZ
B178A
DRY CONCRETE
600 LB
20 MPH



1000
(LB)
800
600
400
200
FX
FY
0
16
12
16
12
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
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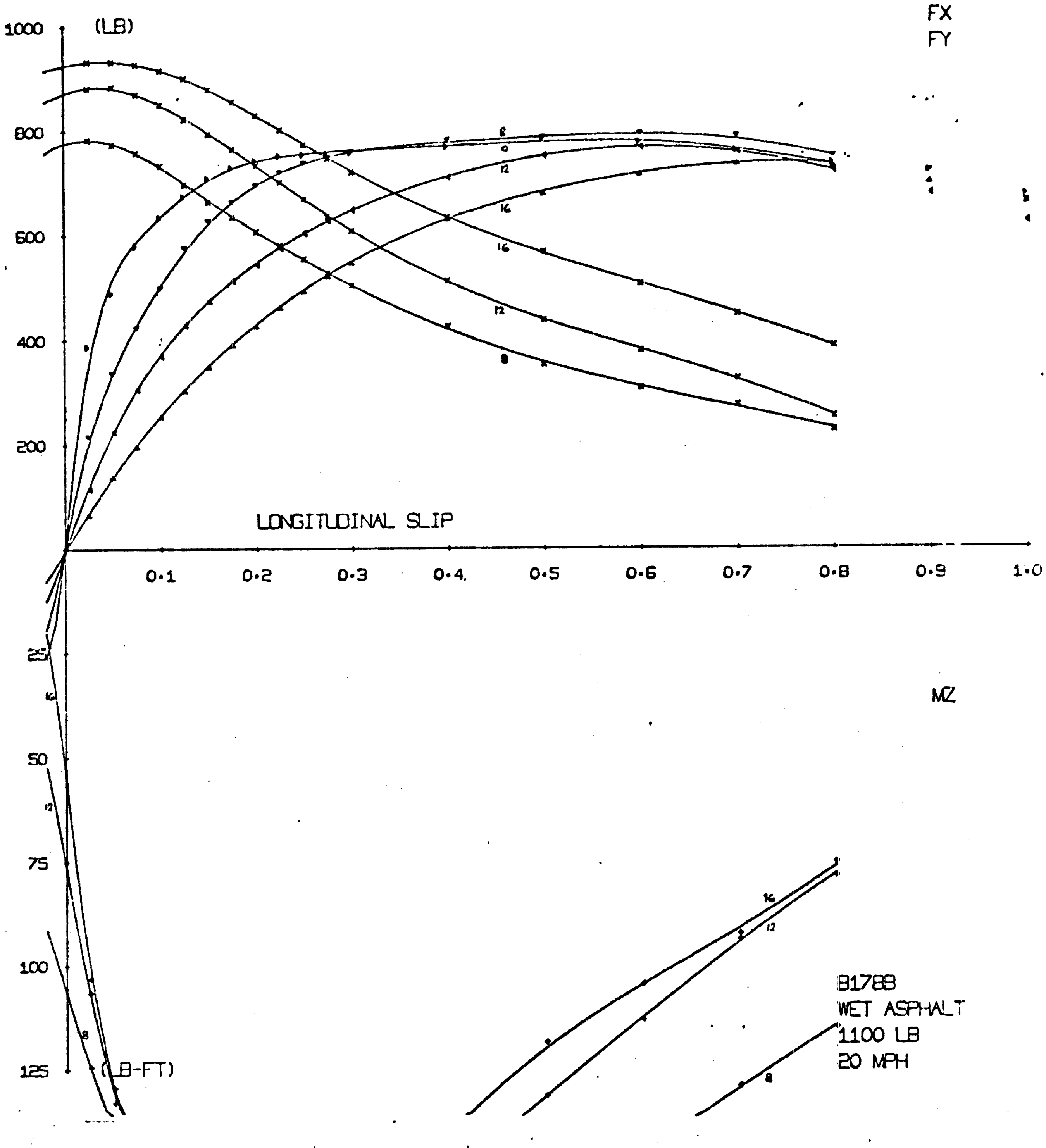
16
B178A
DRY CONCRETE
800 LB
40 MPH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0·6
0·7
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0·9
1·0
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25
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75
100
125
(LB-FT)
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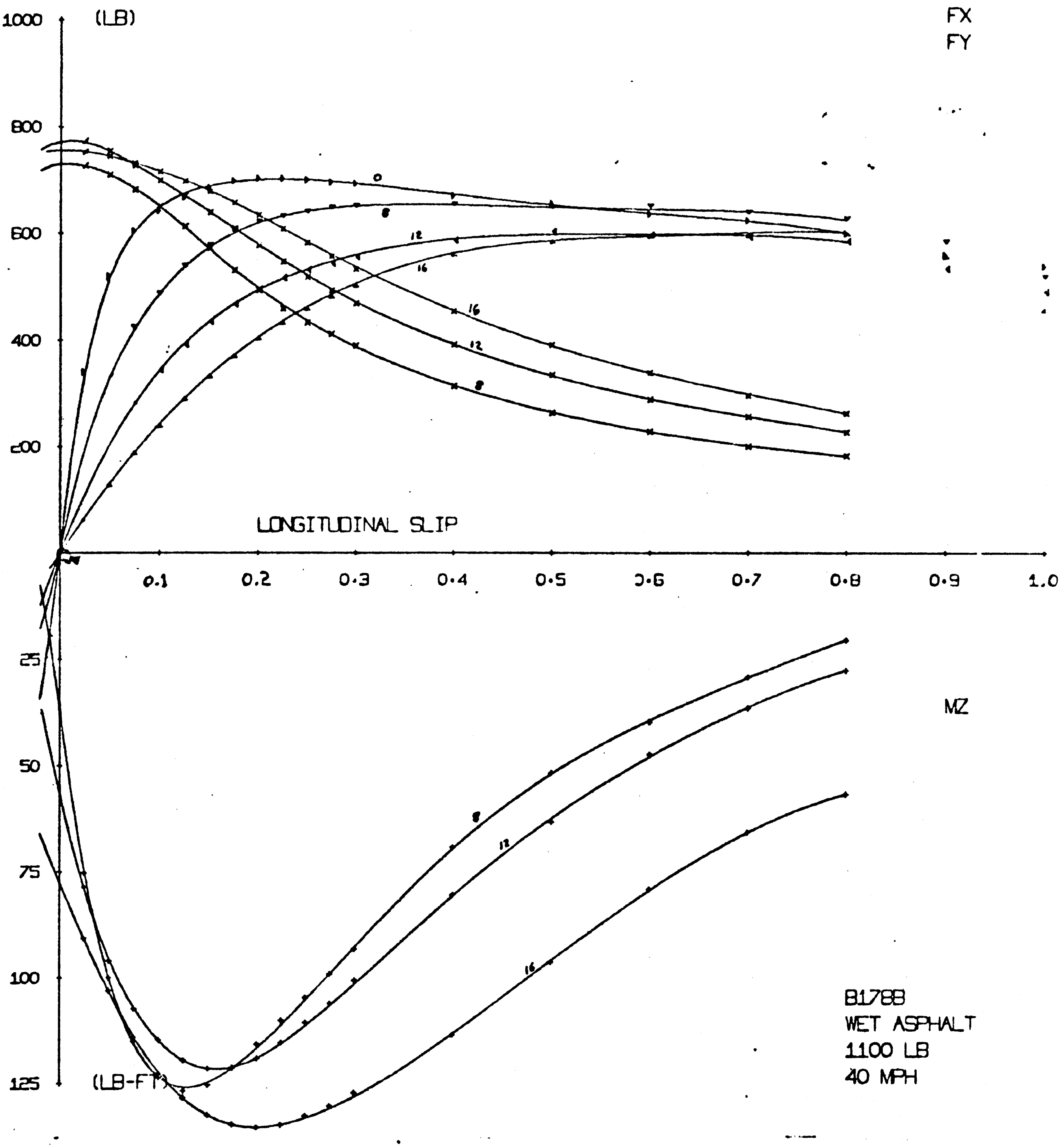
WET ASPHALT
1100 LB
20 MPH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0.6
0.7
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75
100
125
(LB-FT)
MZ
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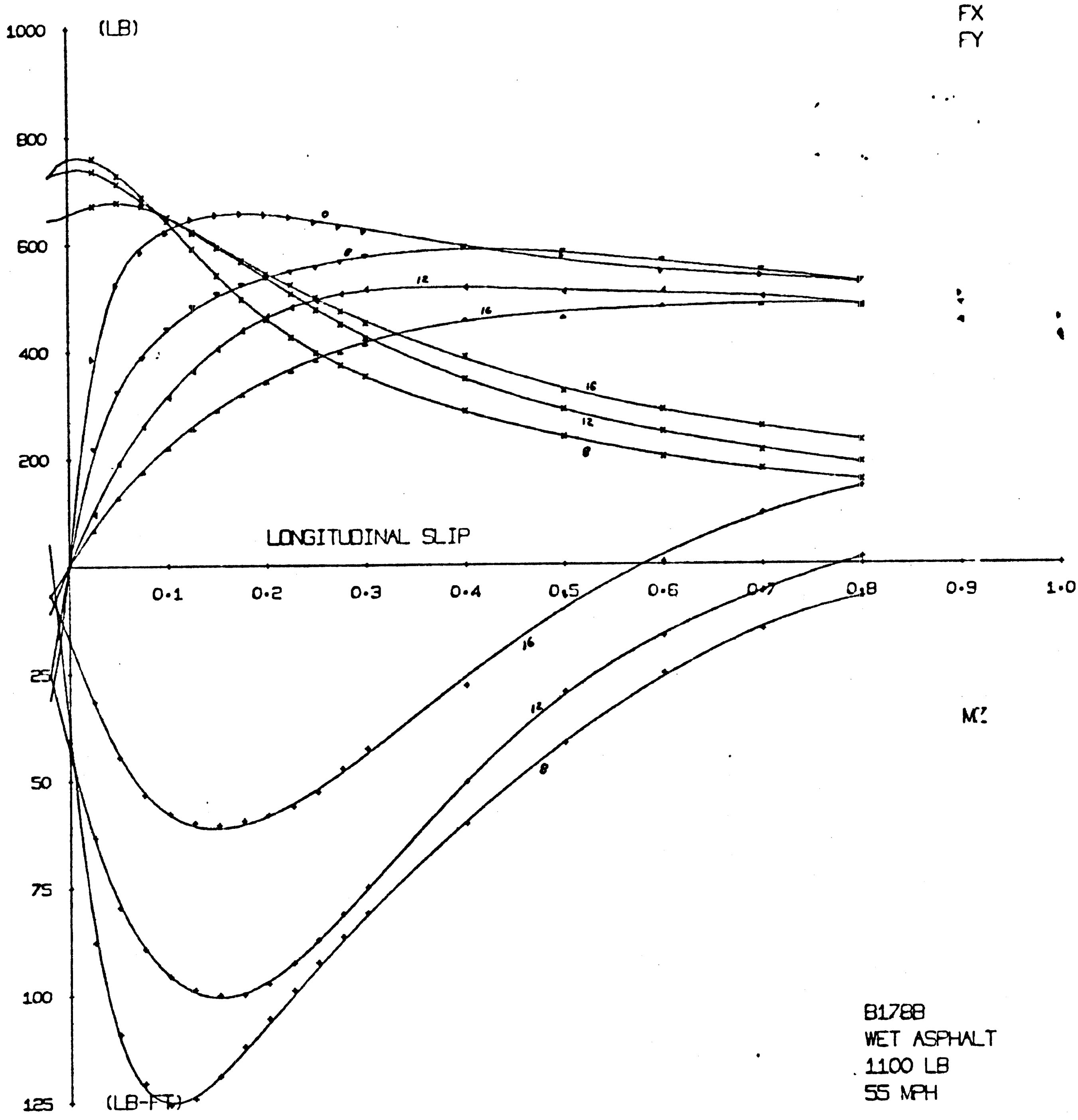
40 MPH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0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
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125
(LB-FT)
MZ
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8
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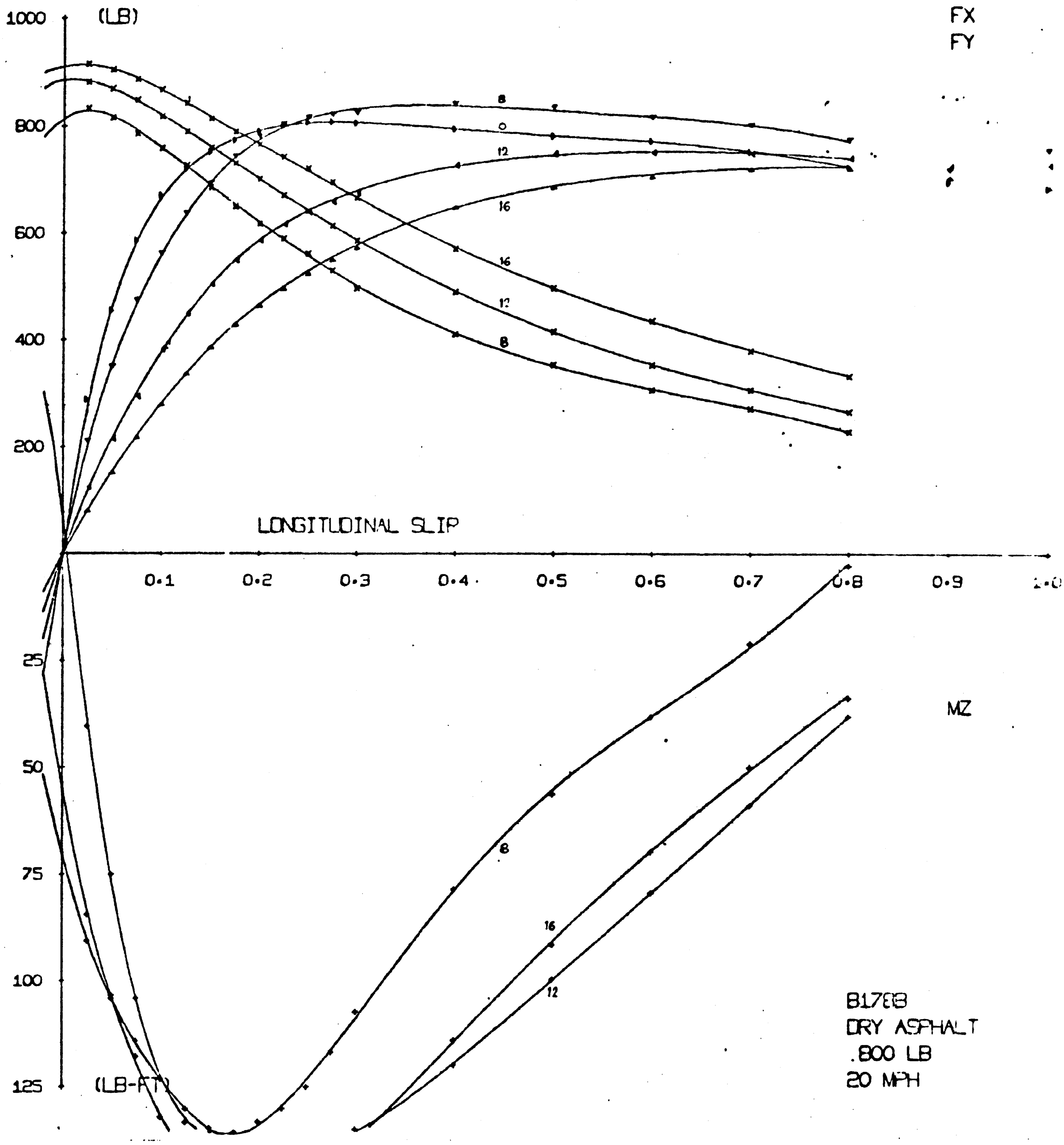
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0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
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100
125
(LB-FT)
MZ
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12
B178B
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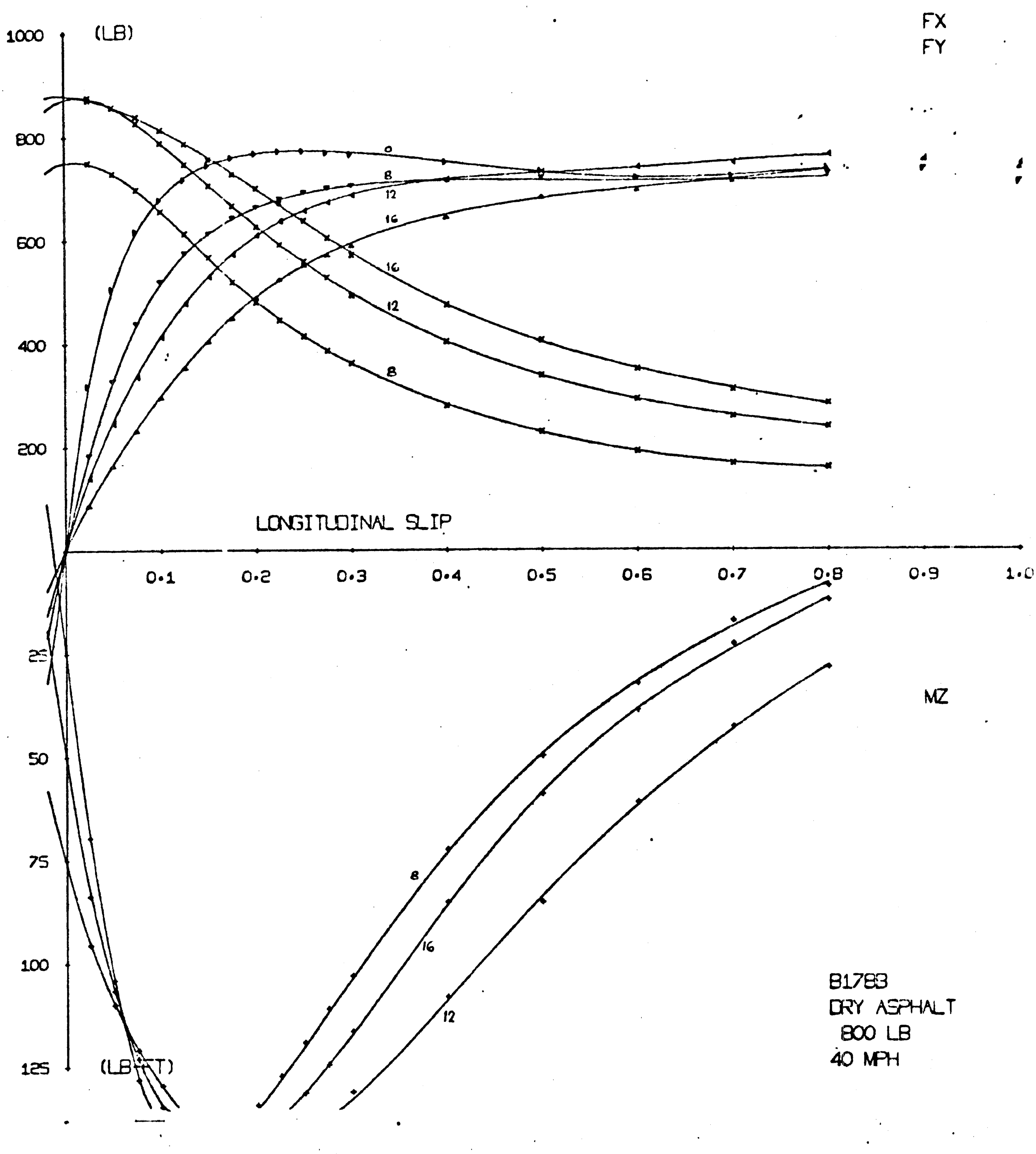
.800 LB
20 MPH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0·6
0·7
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100
125
(LB-FT)
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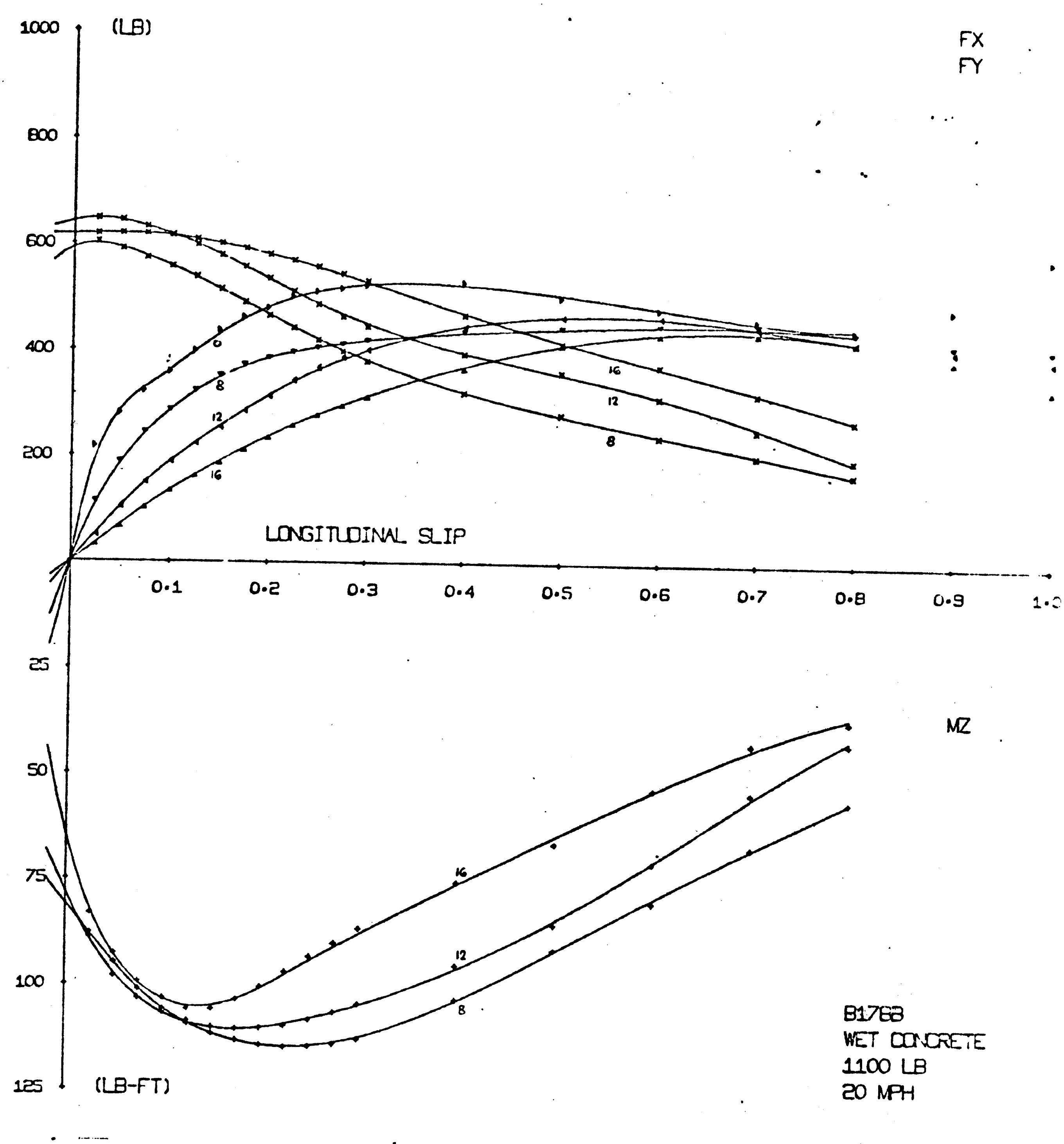
40 MPH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0·6
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100
125
(LB-FT)
MZ
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WET CONCRETE
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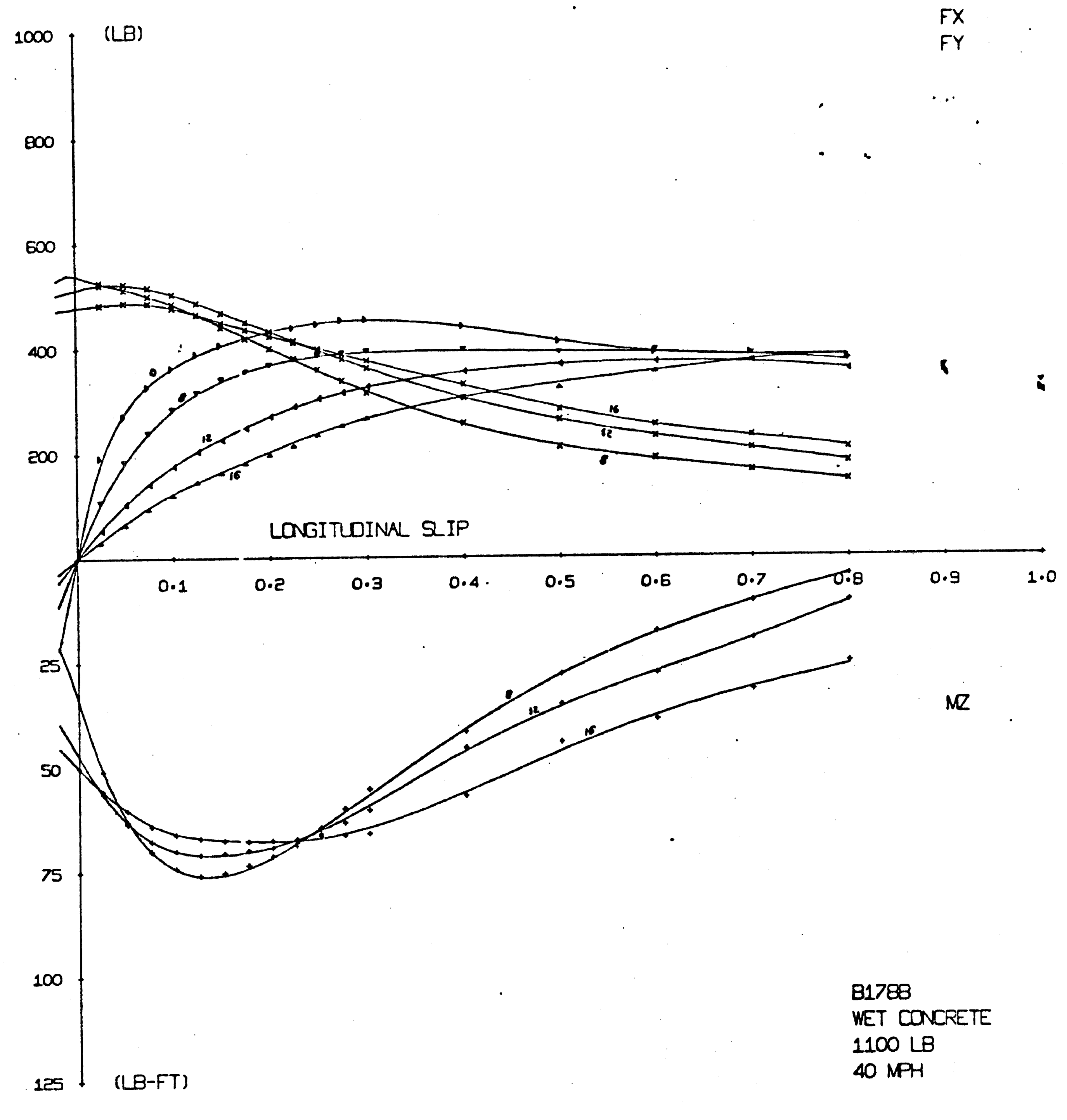
20 MPH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(LB)
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0·6
0·7
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1·0
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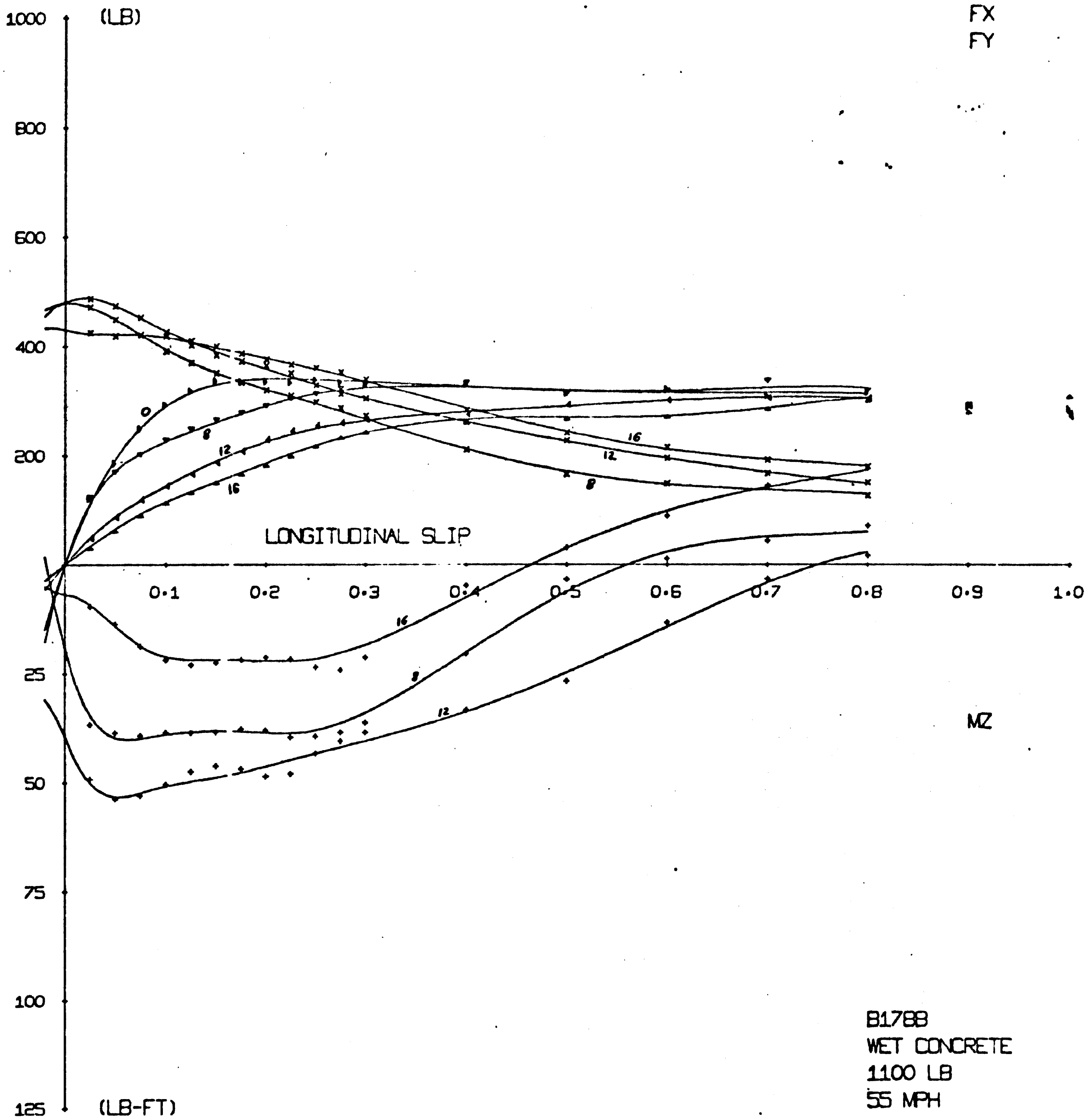
50
75
100
125
(LB-FT)
MZ
B1788
WET CONCRETE
1100 LB
40 MPH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FY
LONGITUDINAL SLIP
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0·5
0·6
0·7
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1·0
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50
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100
125
(LB-FT)
MZ
B17BB
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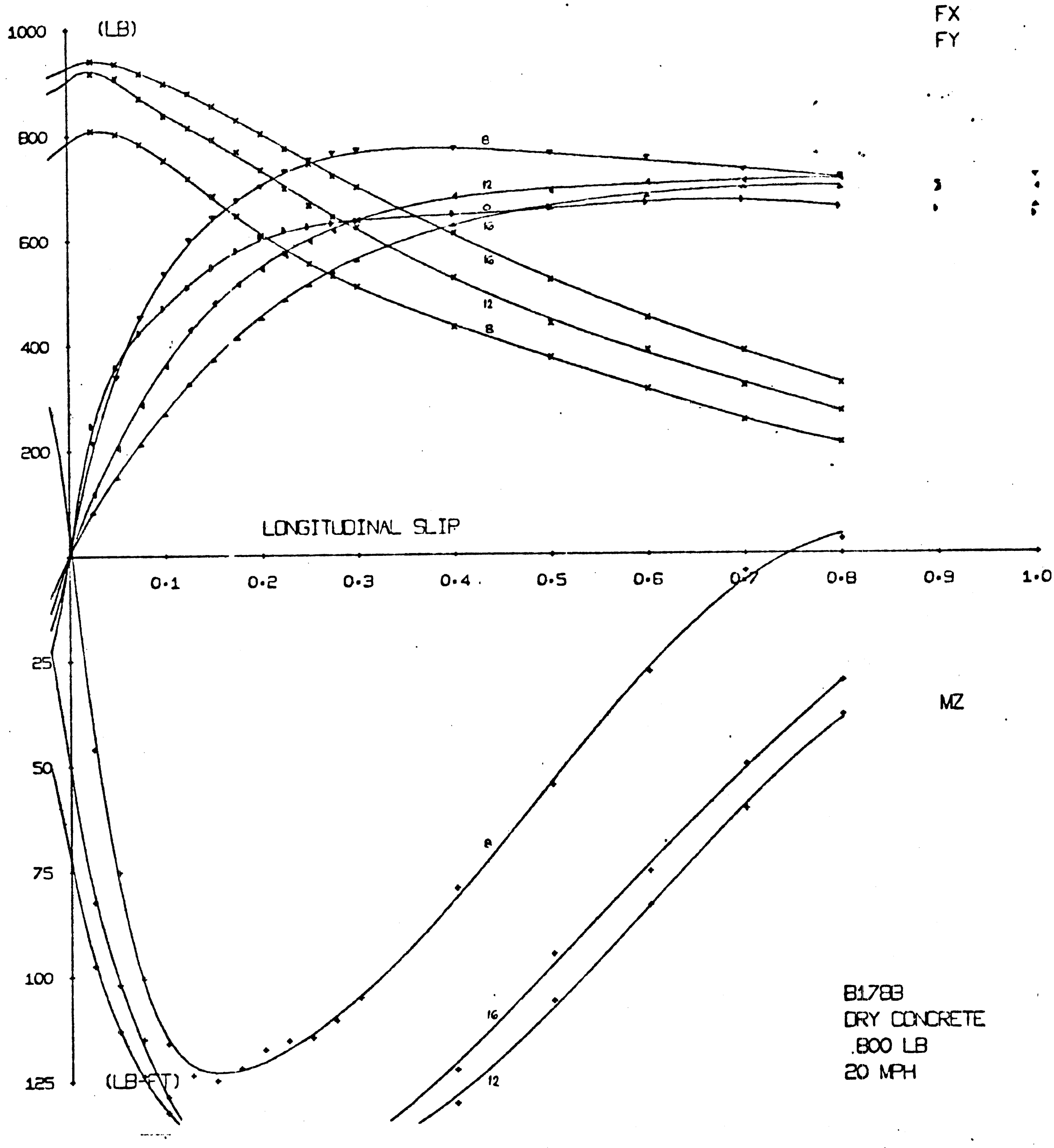
1100 LB
55 MPH



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(LB)
FX
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16
LONGITUDINAL SLIP
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0.3
0.4
0.5
0.6
0.7
0.8
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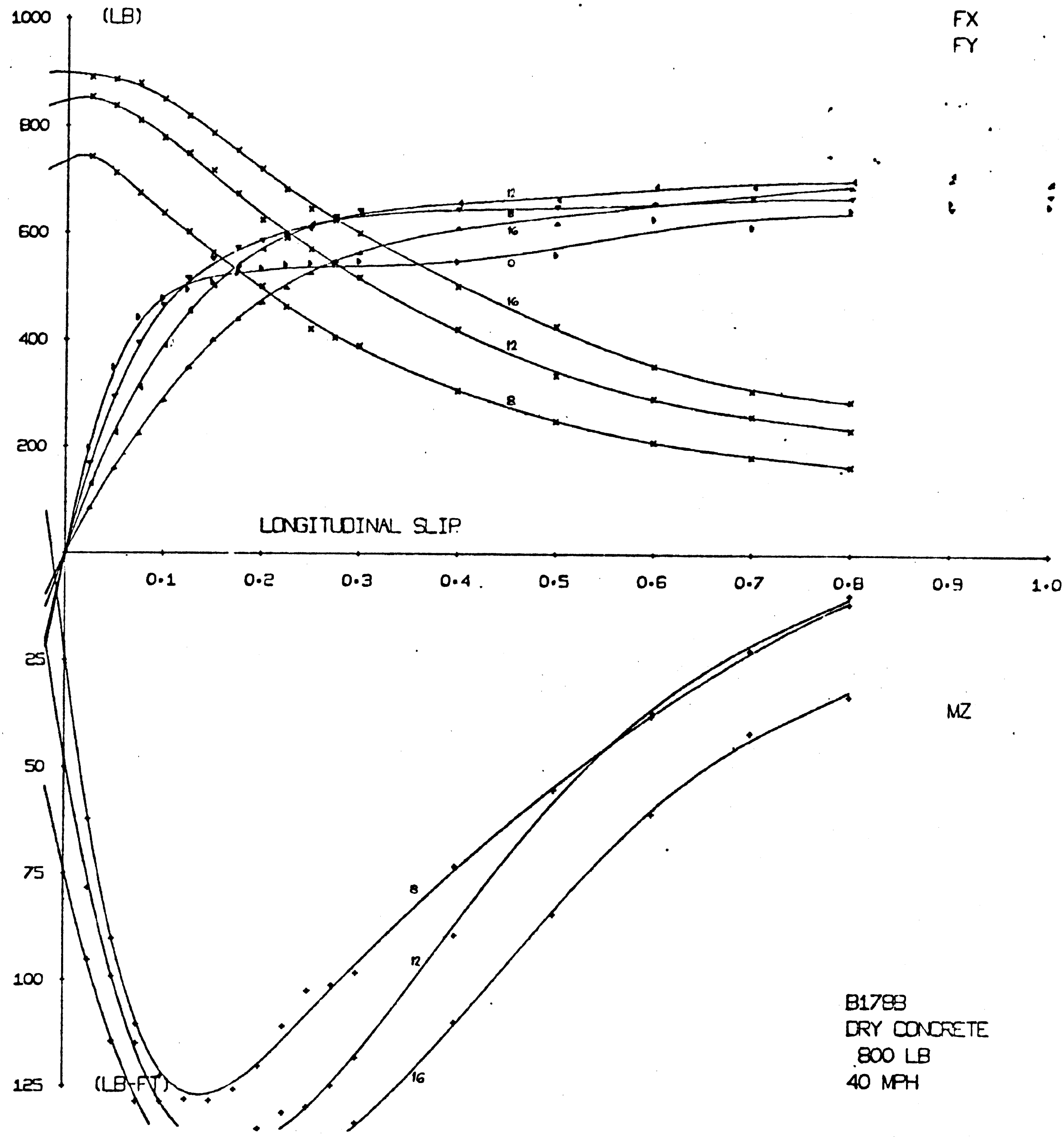
1.0
25
50
75
100
125
(LB-FT)
MZ
B1783
DRY CONCRETE
.800 LB
20 MPH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(LB)
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FX
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LONGITUDINAL SLIP
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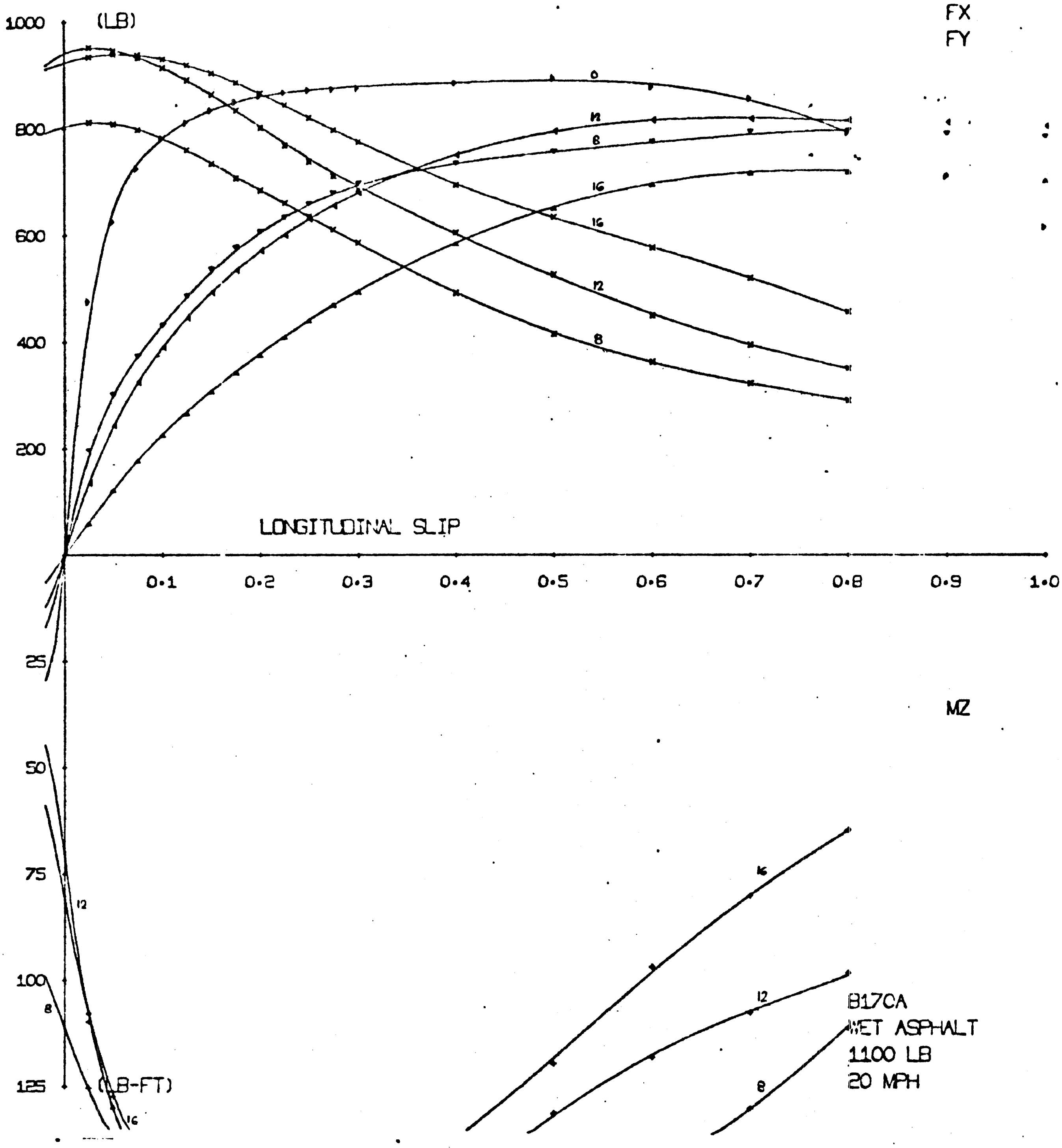
100
125
(LB-FT)
MZ
B1783
DRY CONCRETE
800 LB
40 MPH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(LB)
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MZ
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75
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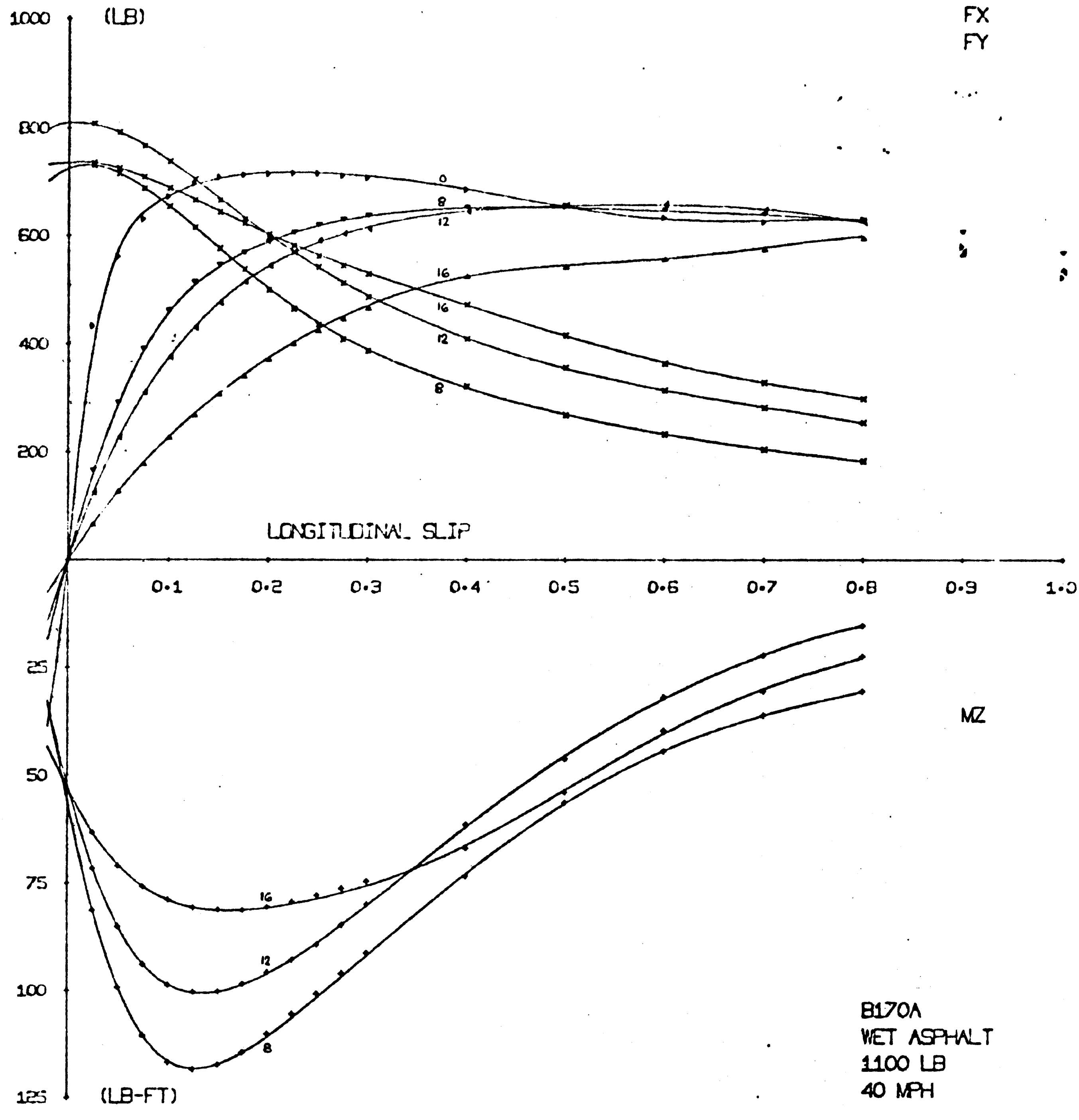
125
(LB-FT)
B17CA
WET ASPHALT
1100 LB
20 MPH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(LB)
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8
LONGITUDINAL SLIP
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MZ
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(LB-FT)
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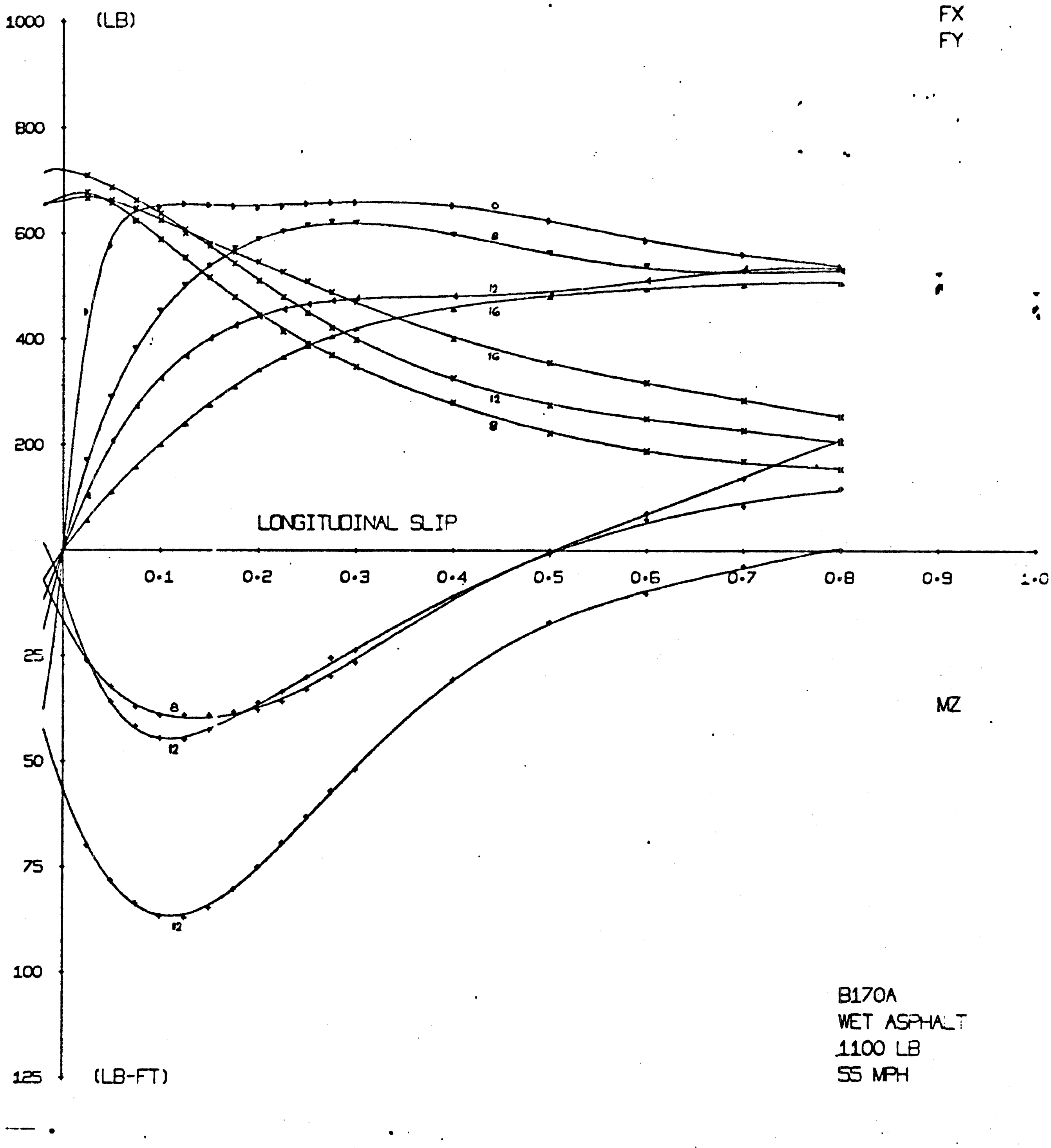
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MZ
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(LB-FT)
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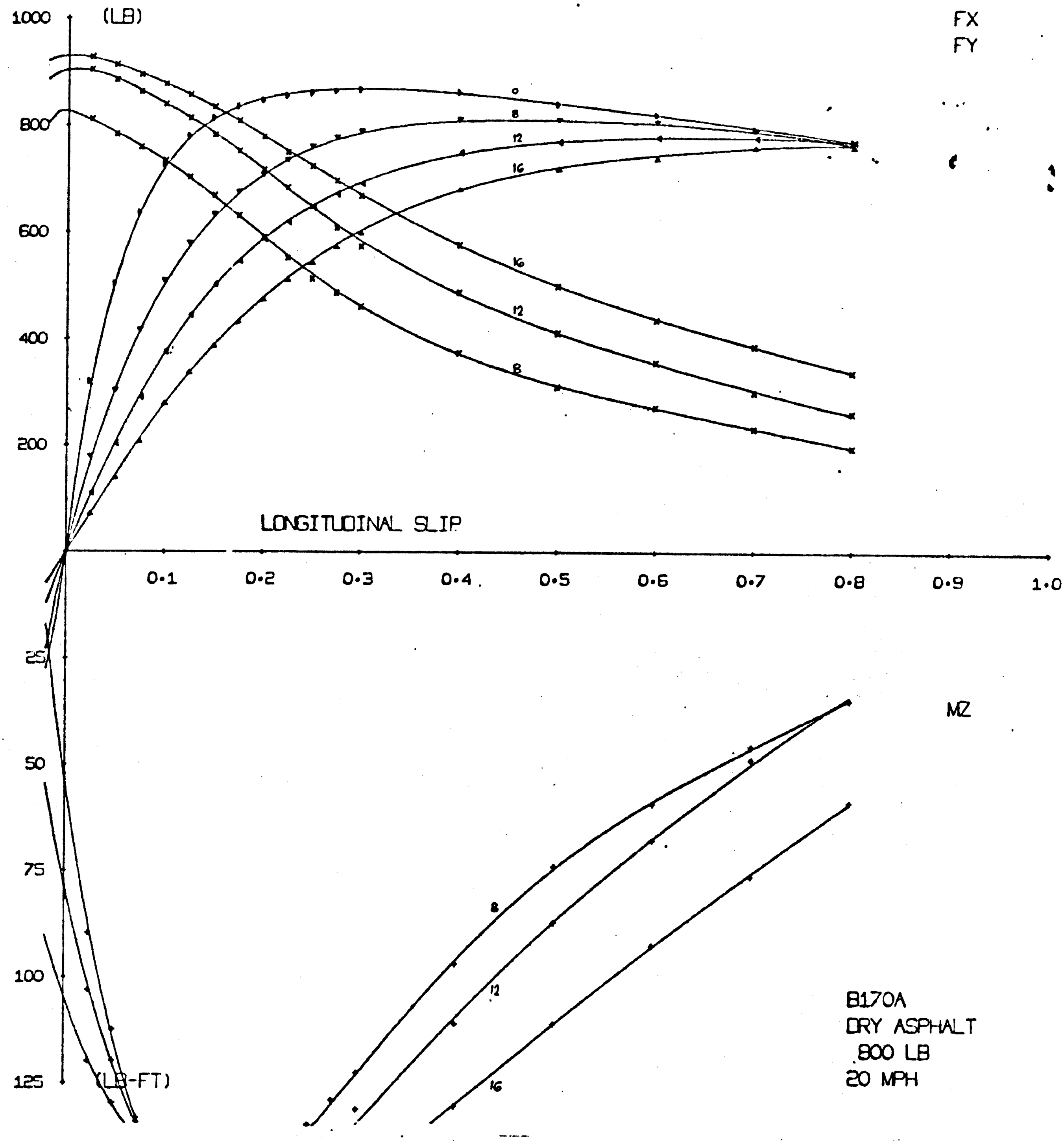
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LONGITUDINAL SLIP
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(LB-FT)
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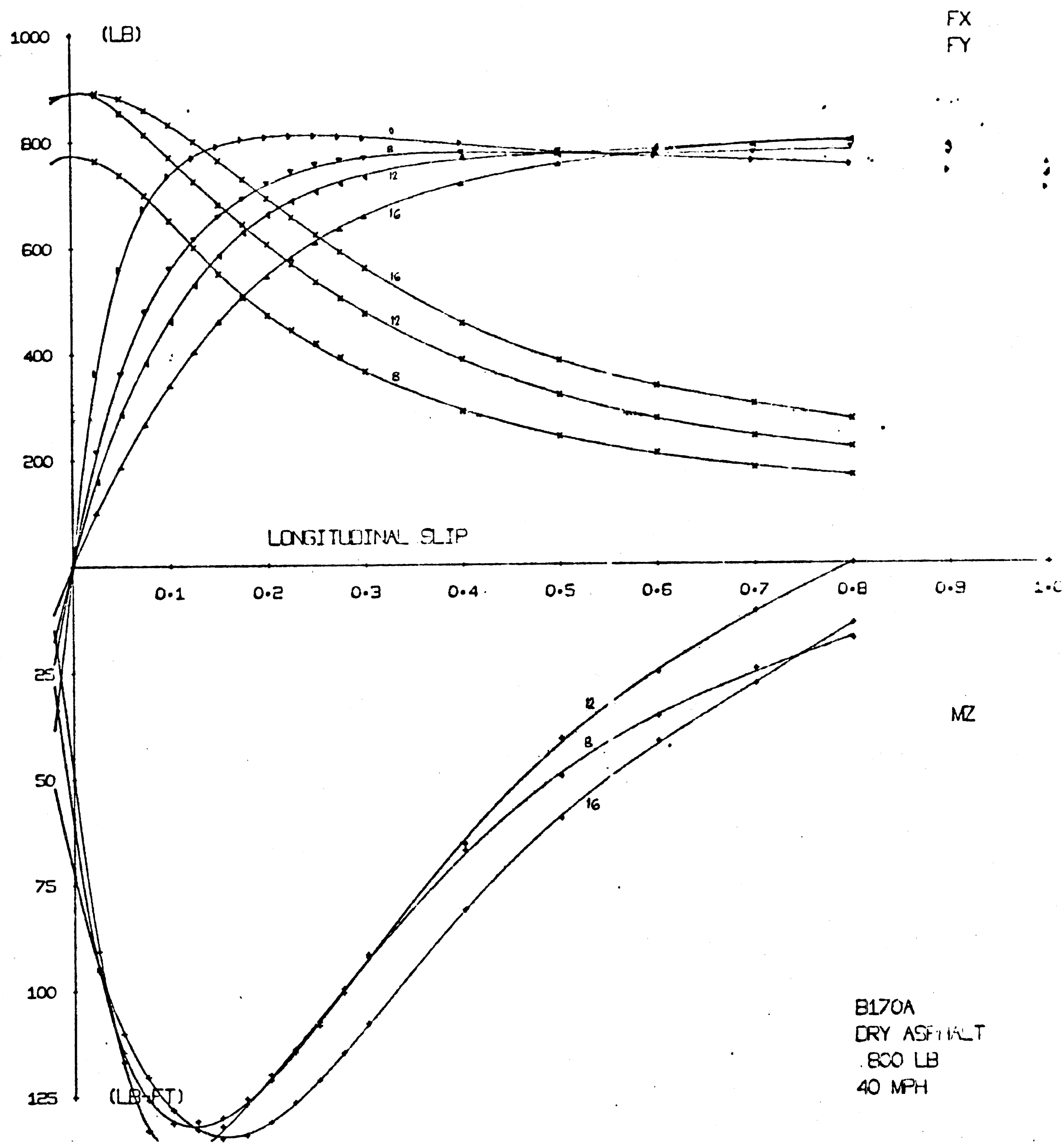

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(LB-FT)
MZ
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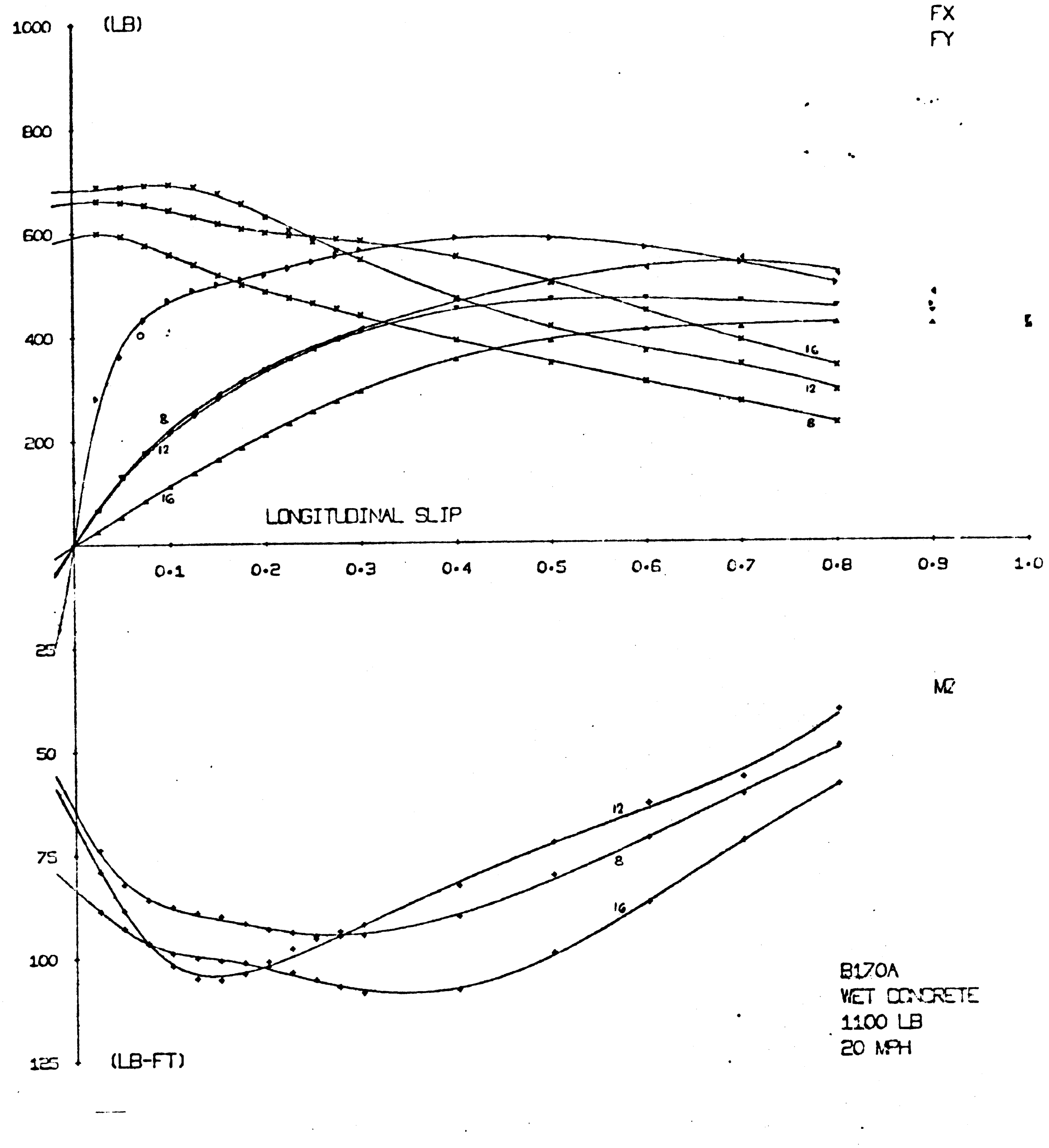

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MZ
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125
(LB-FT)
B170A
WET CONCRETE
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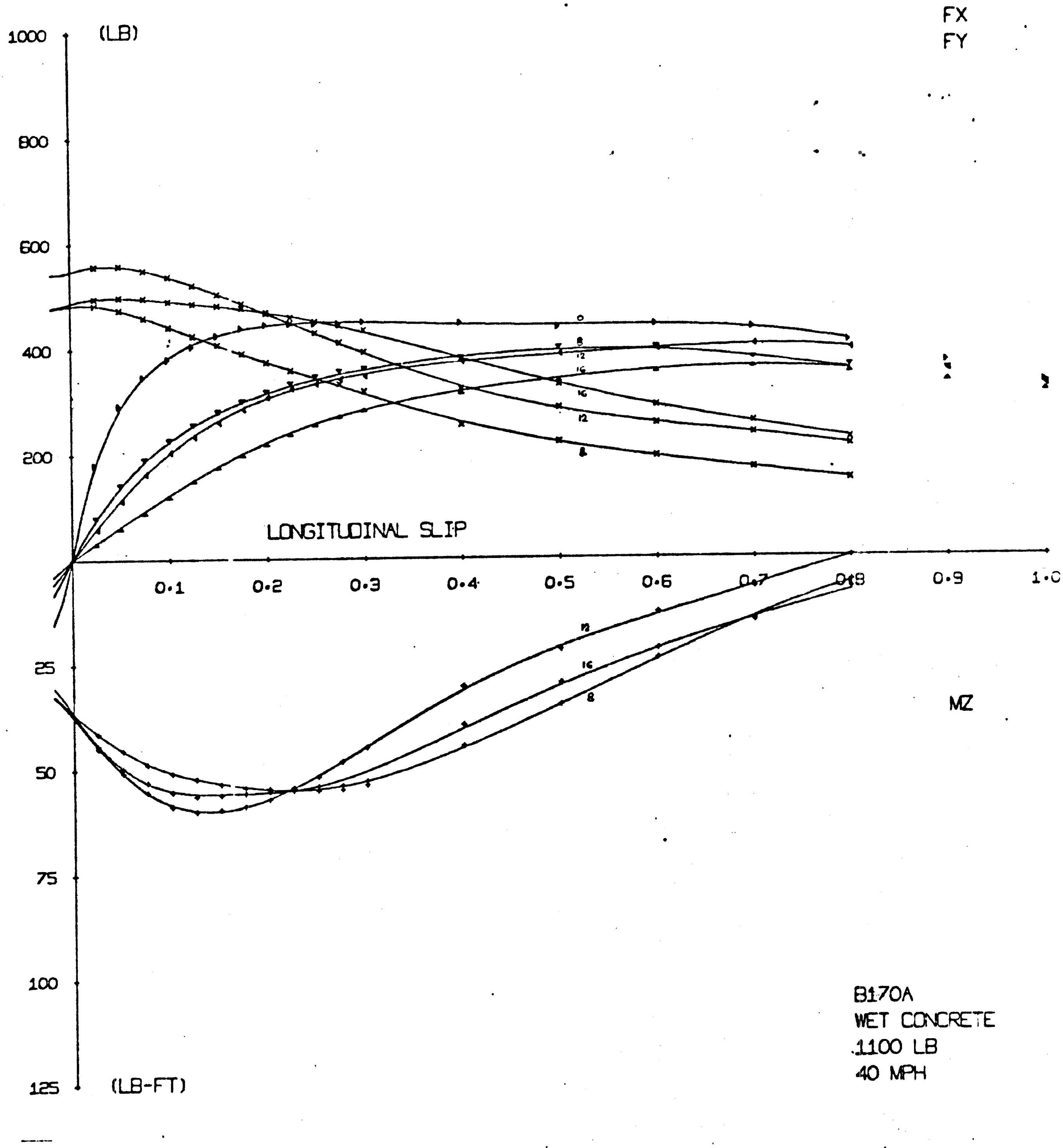

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(LB)
LONGITUDINAL SLIP
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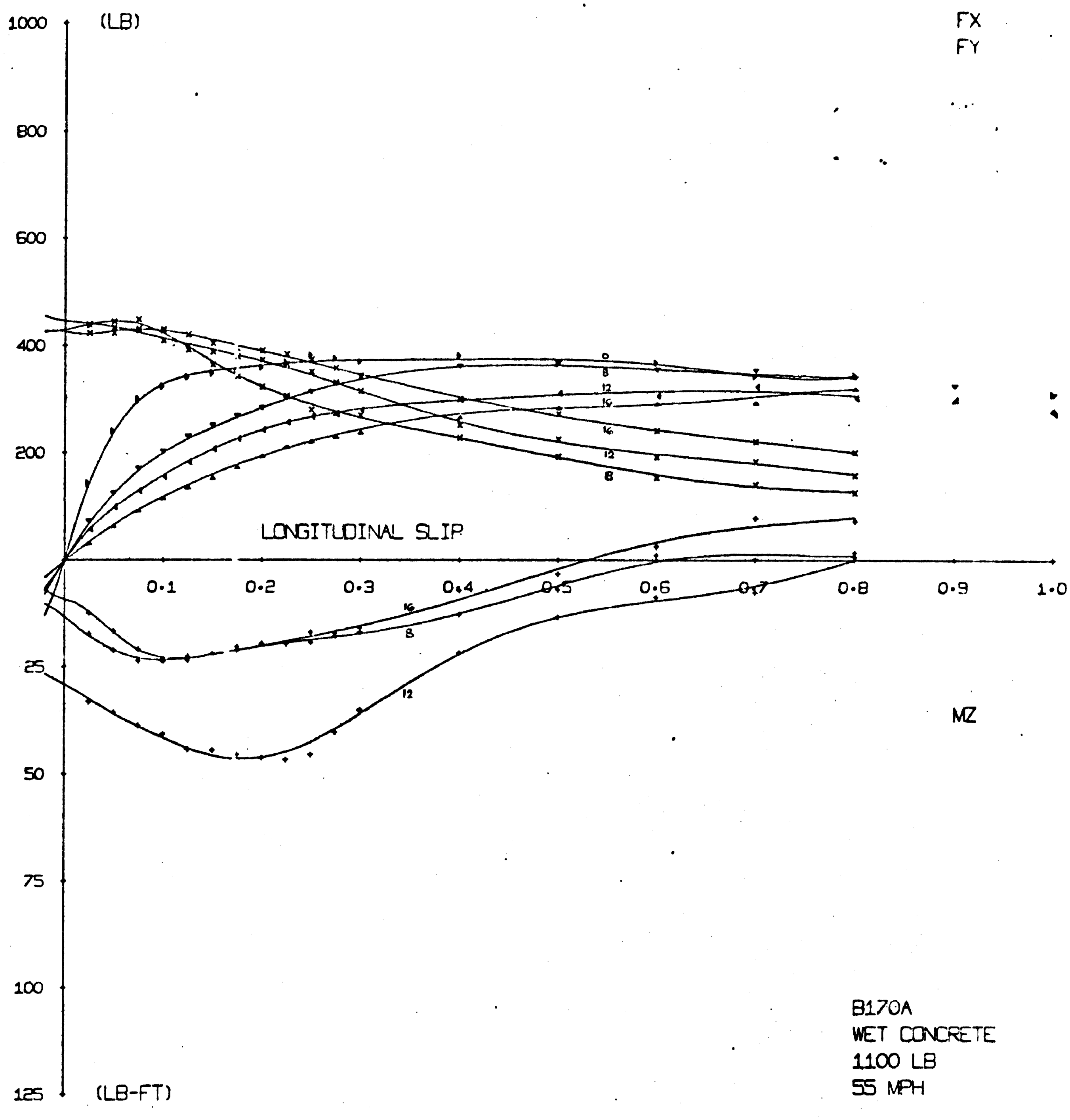
(LB-FT)
MZ
B170A
WET CONCRETE
1100 LB
40 MPH



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800
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125
(LB)
(LB-FT)
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FY
MZ
LONGITUDINAL SLIP
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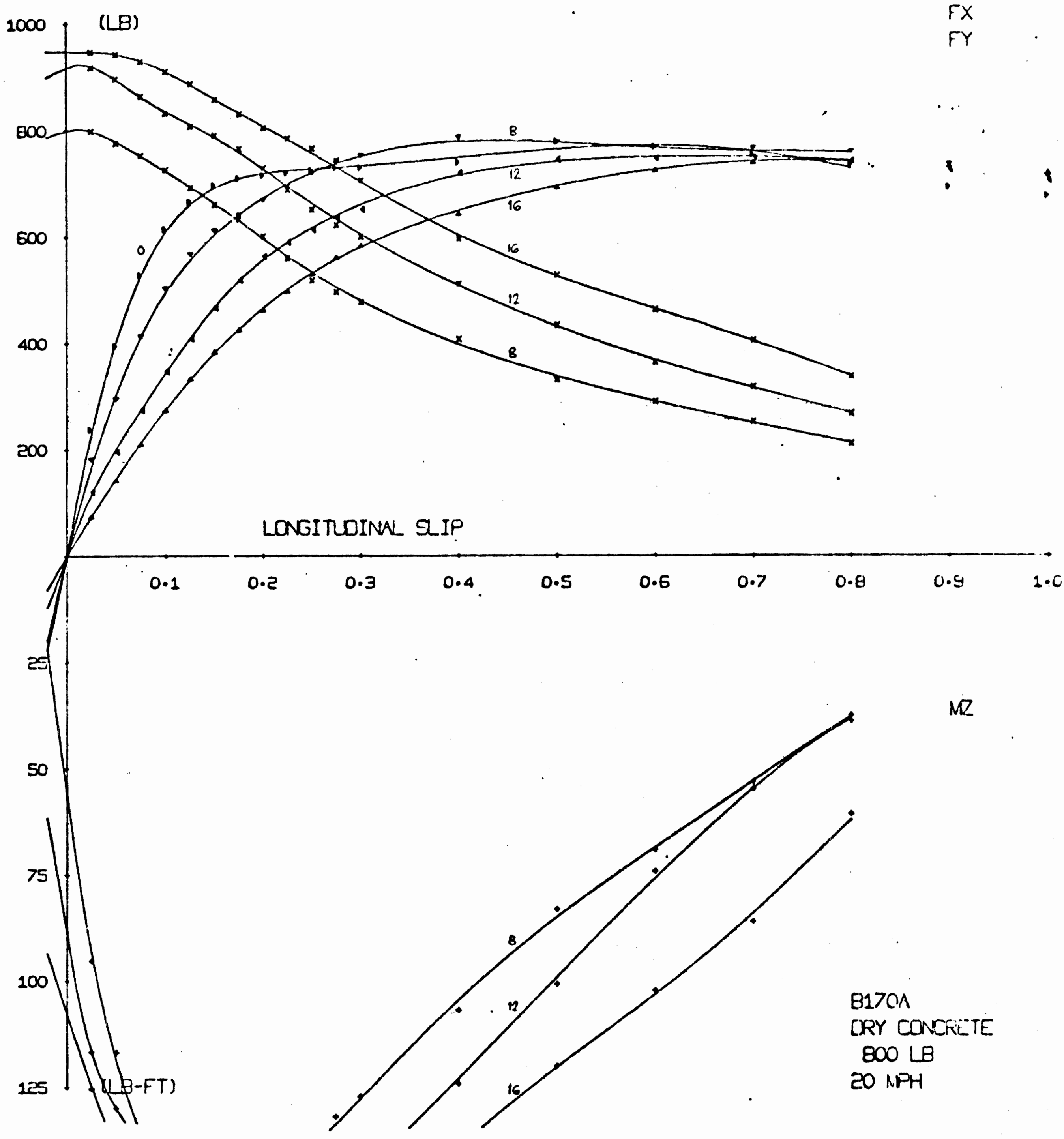
WET CONCRETE
1100 LB
55 MPH



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LONGITUDINAL SLIP
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(LB-FT)
MZ
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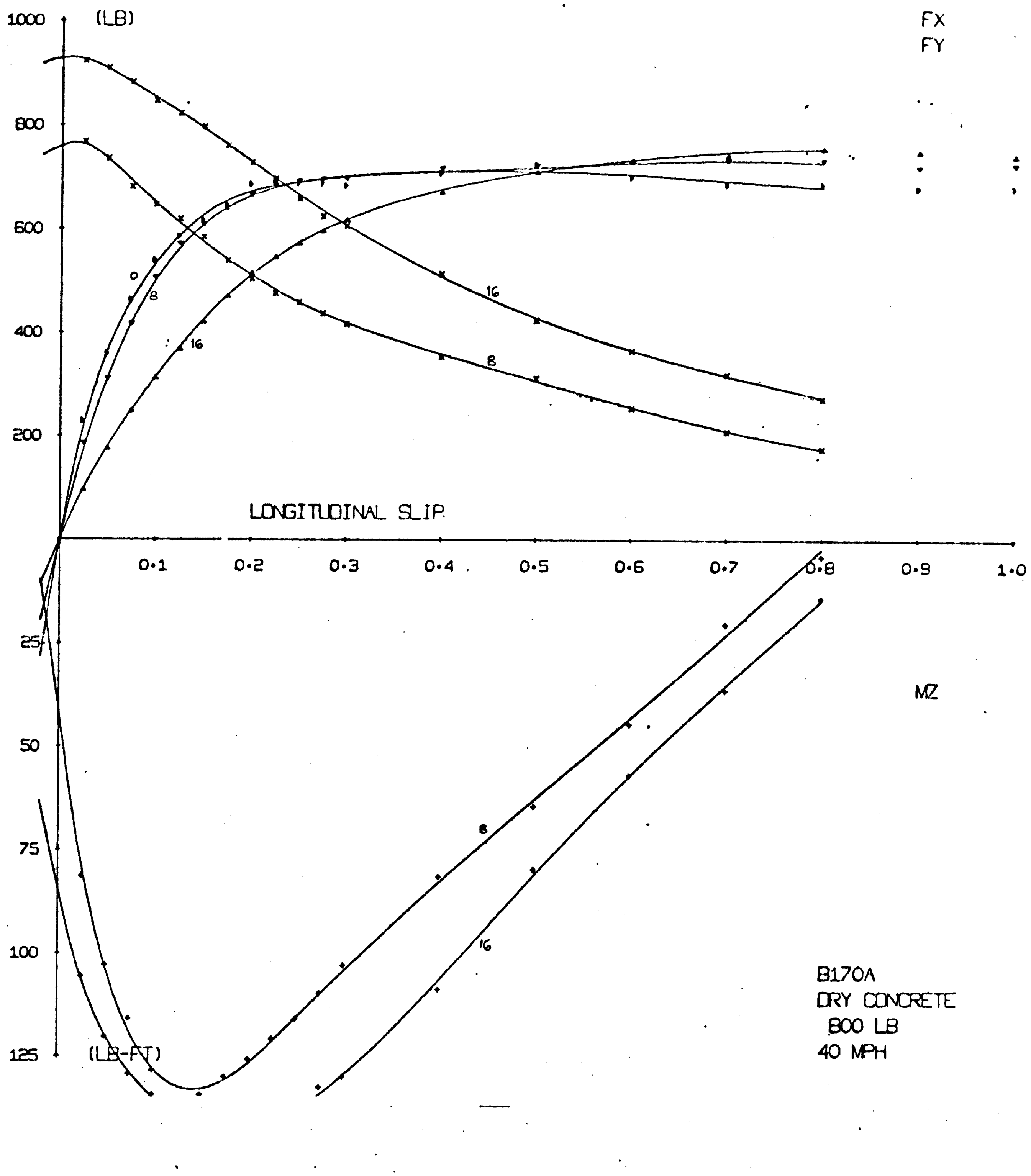

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(LB-FT)
MZ
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B170A
DRY CONCRETE
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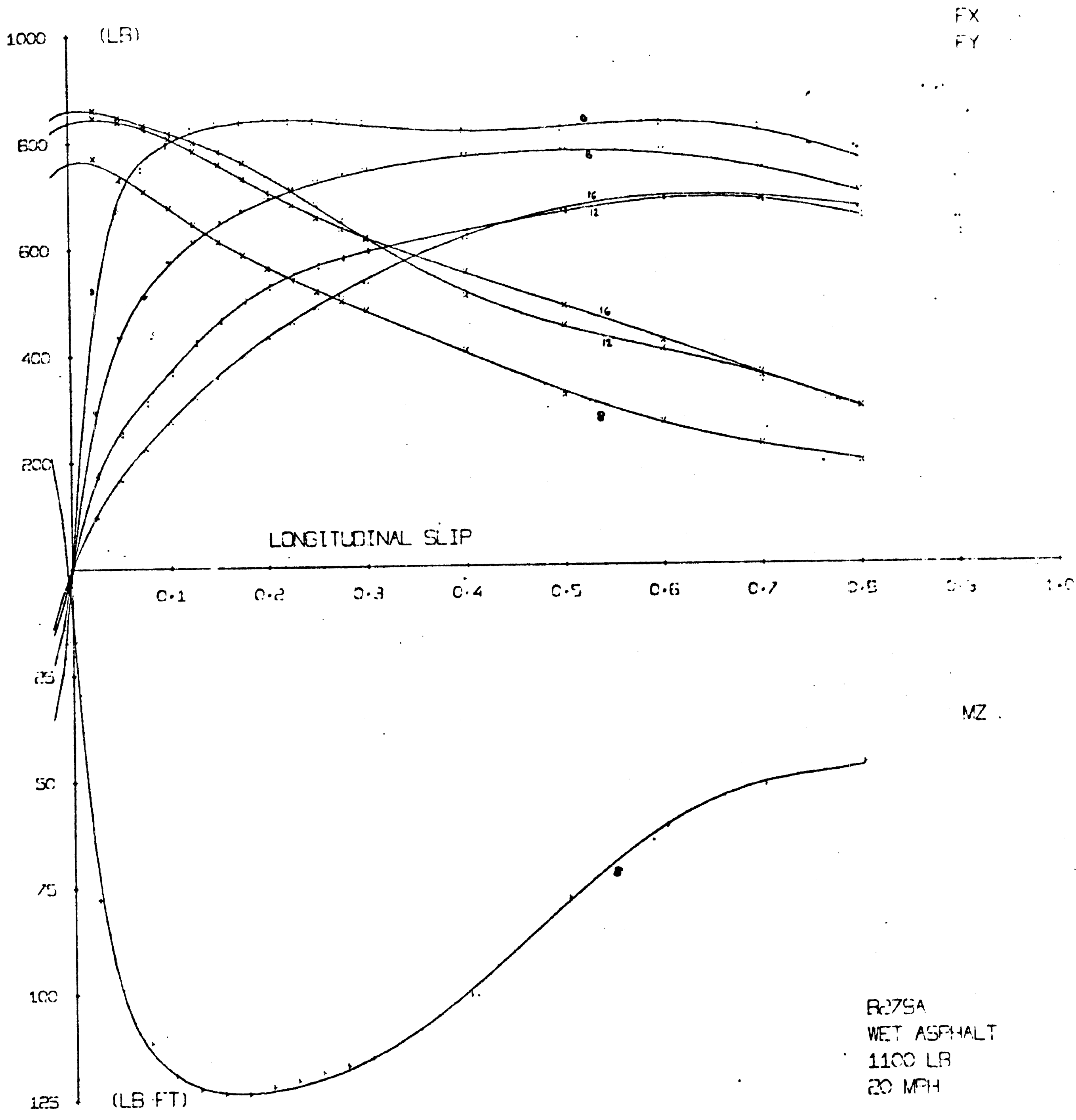

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MZ
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125
(LB FT)
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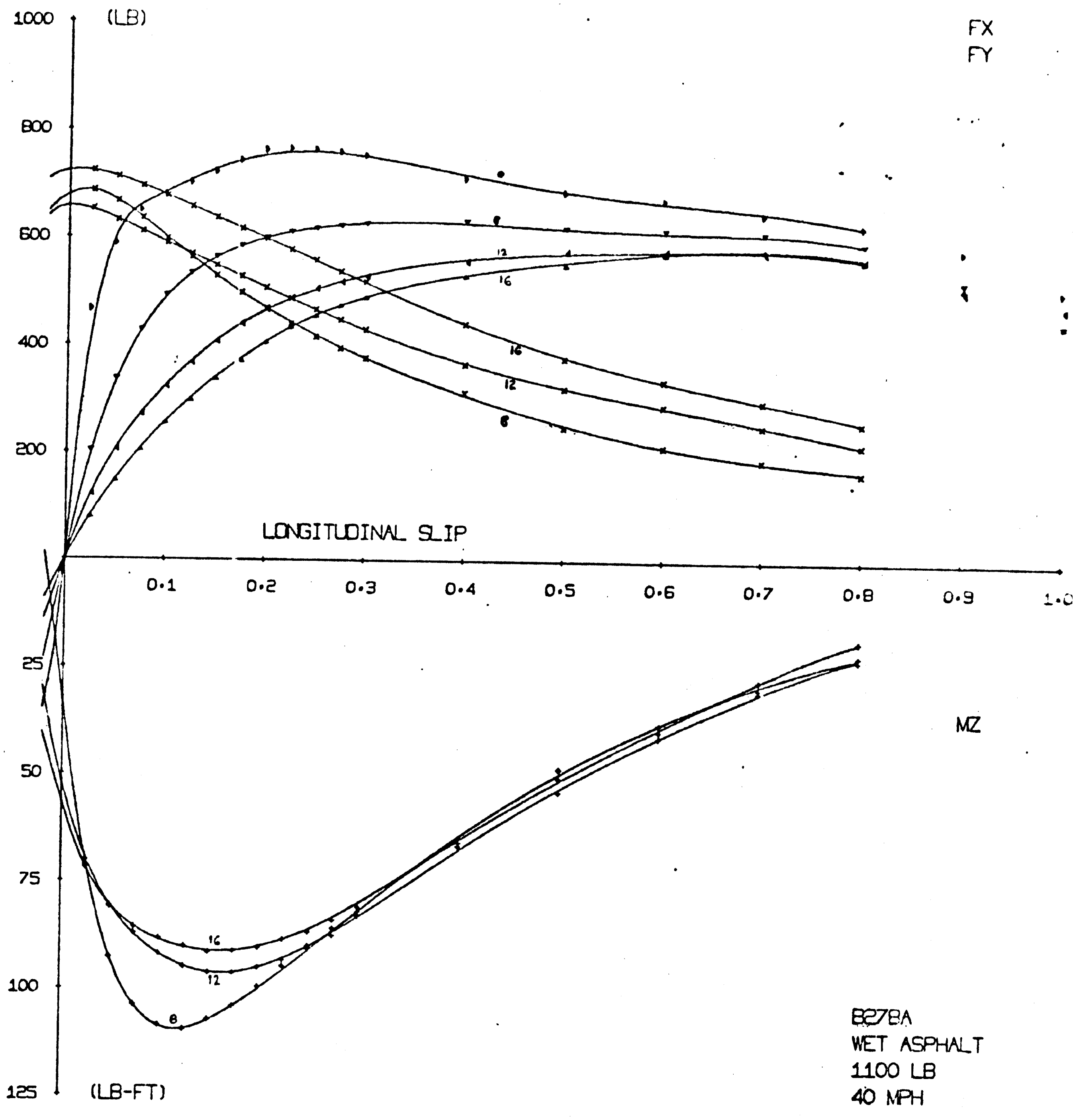
1100 LB
20 MPH



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FX
FY
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0.6
0.7
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100
125
(LB-FT)
MZ
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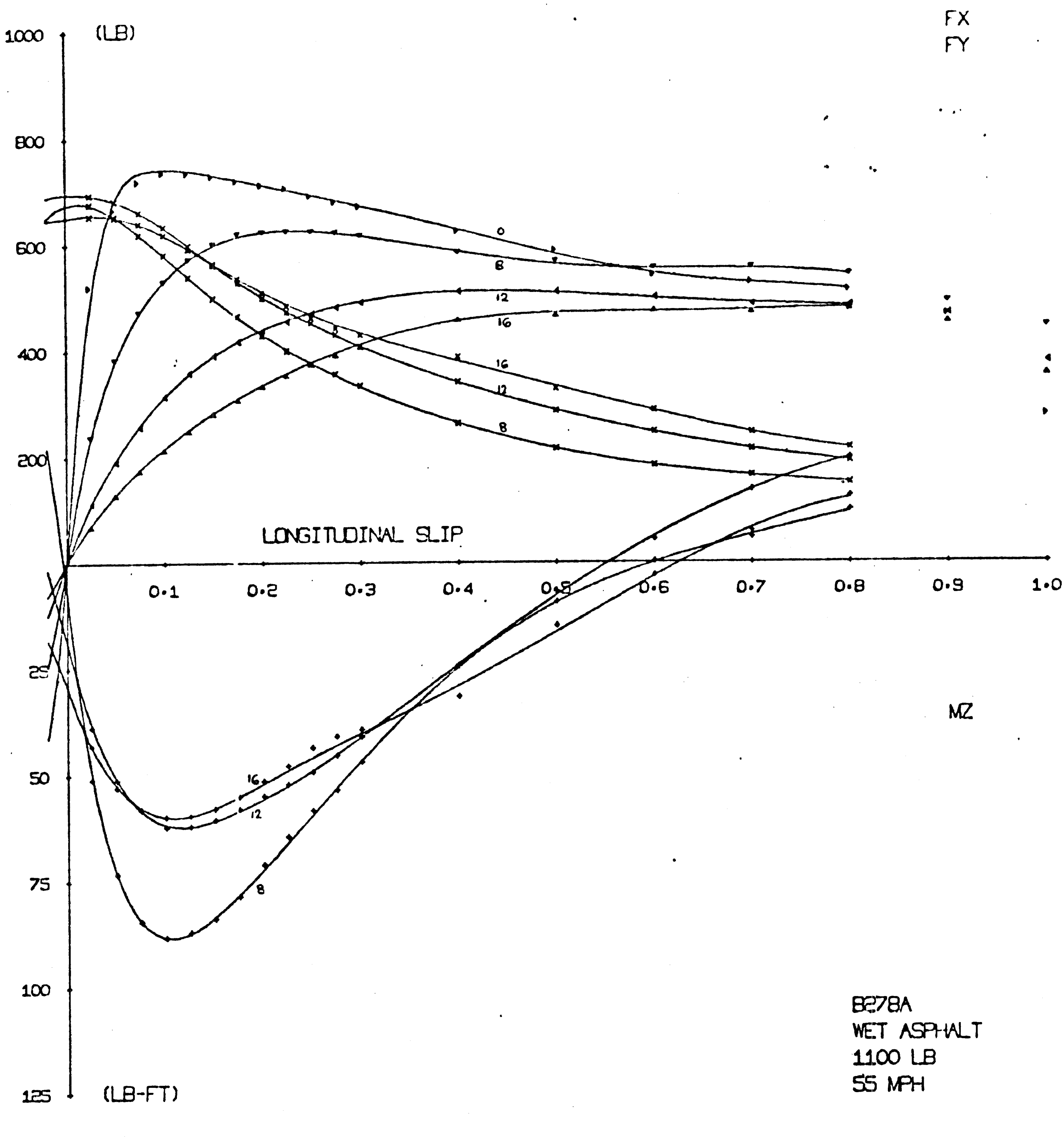

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LONGITUDINAL SLIP
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1·0
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MZ
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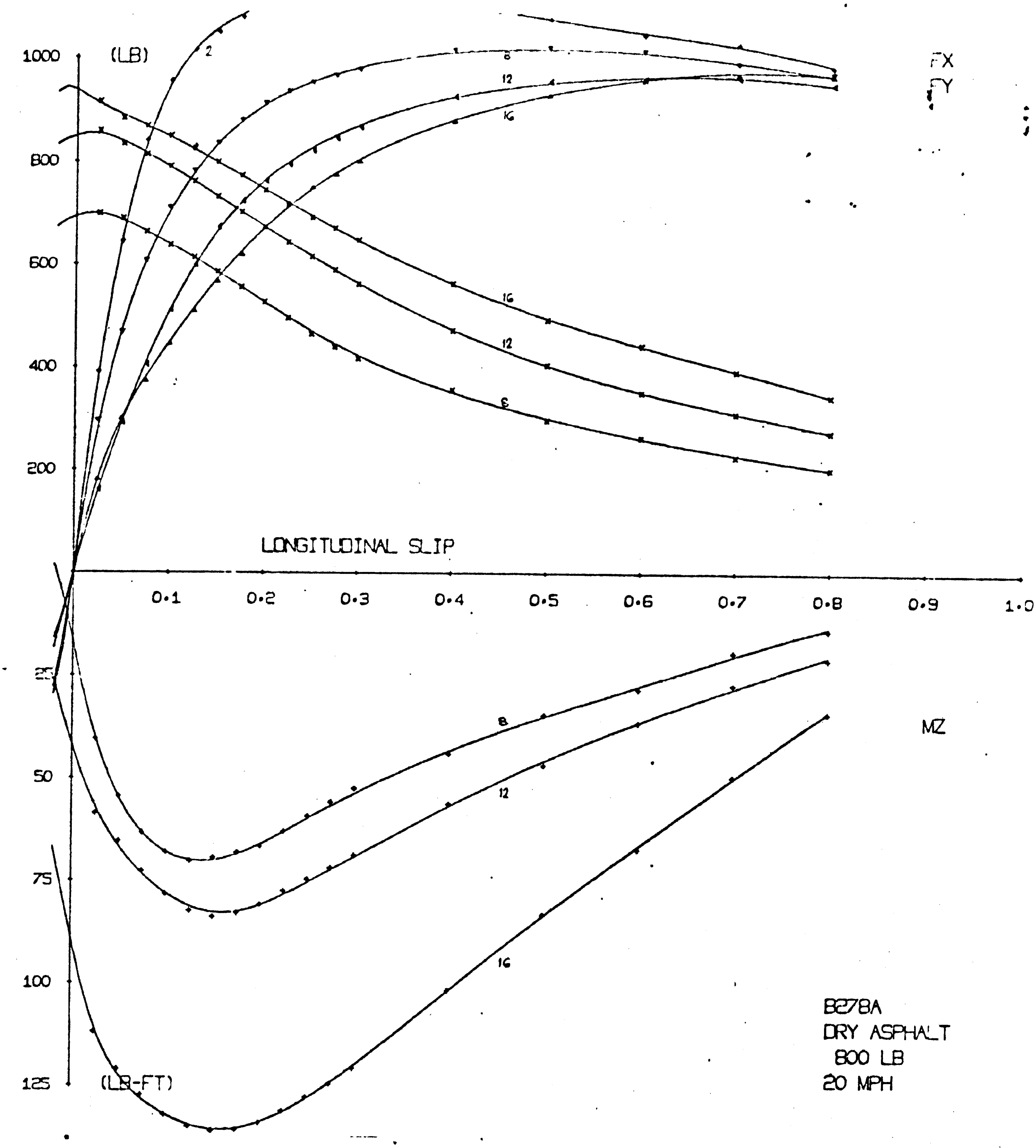
100
125
(LB-FT)
B278A
WET ASPHALT
1100 LB
55 MPH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(LB)
FX
FY
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0.6
0.7
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0.9
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MZ
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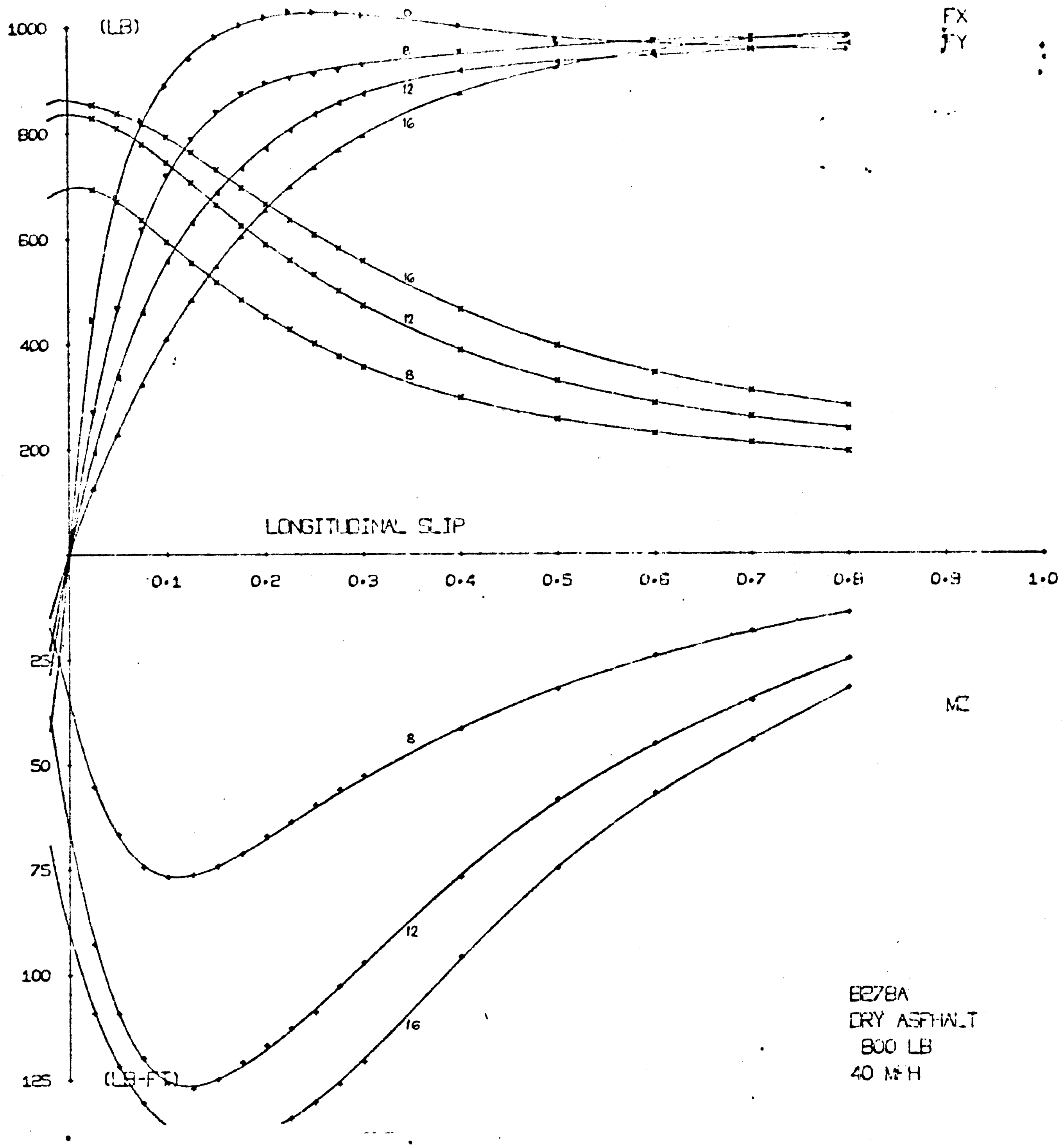
75
100
125
(LB-FT)
B278A
DRY ASPHALT
800 LB
20 MPH



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200
(LB)
FX
FY
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12
16
LONGITUDINAL SLIP
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0.4
0.5
0.6
0.7
0.8
0.9
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100
125
(LB-FT)
MZ
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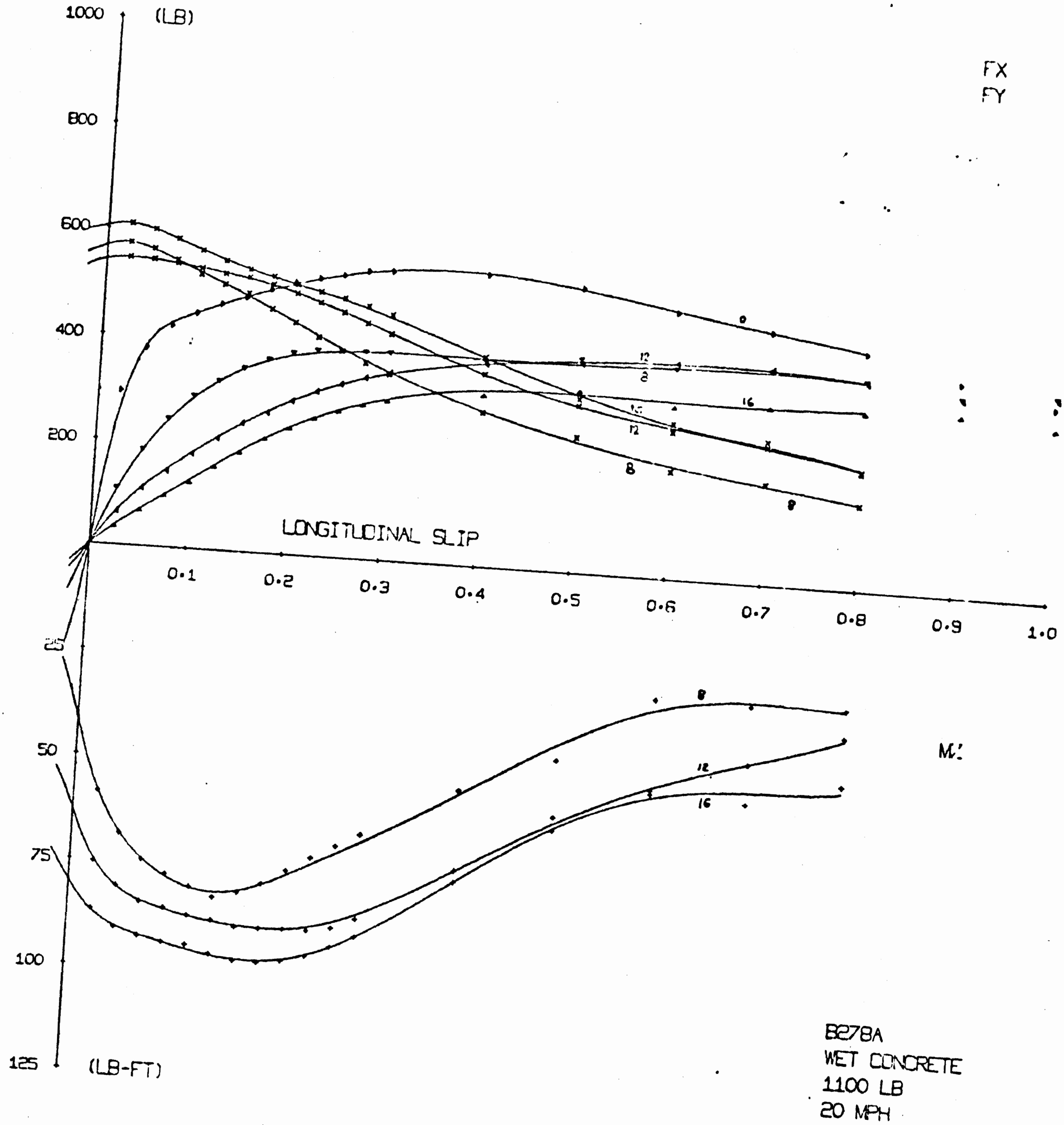
800 LB
40 MPH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FX
FY
LONGITUDINAL SLIP
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0·9
1·0
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100
125
(LB-FT)
MZ
8
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16
B278A
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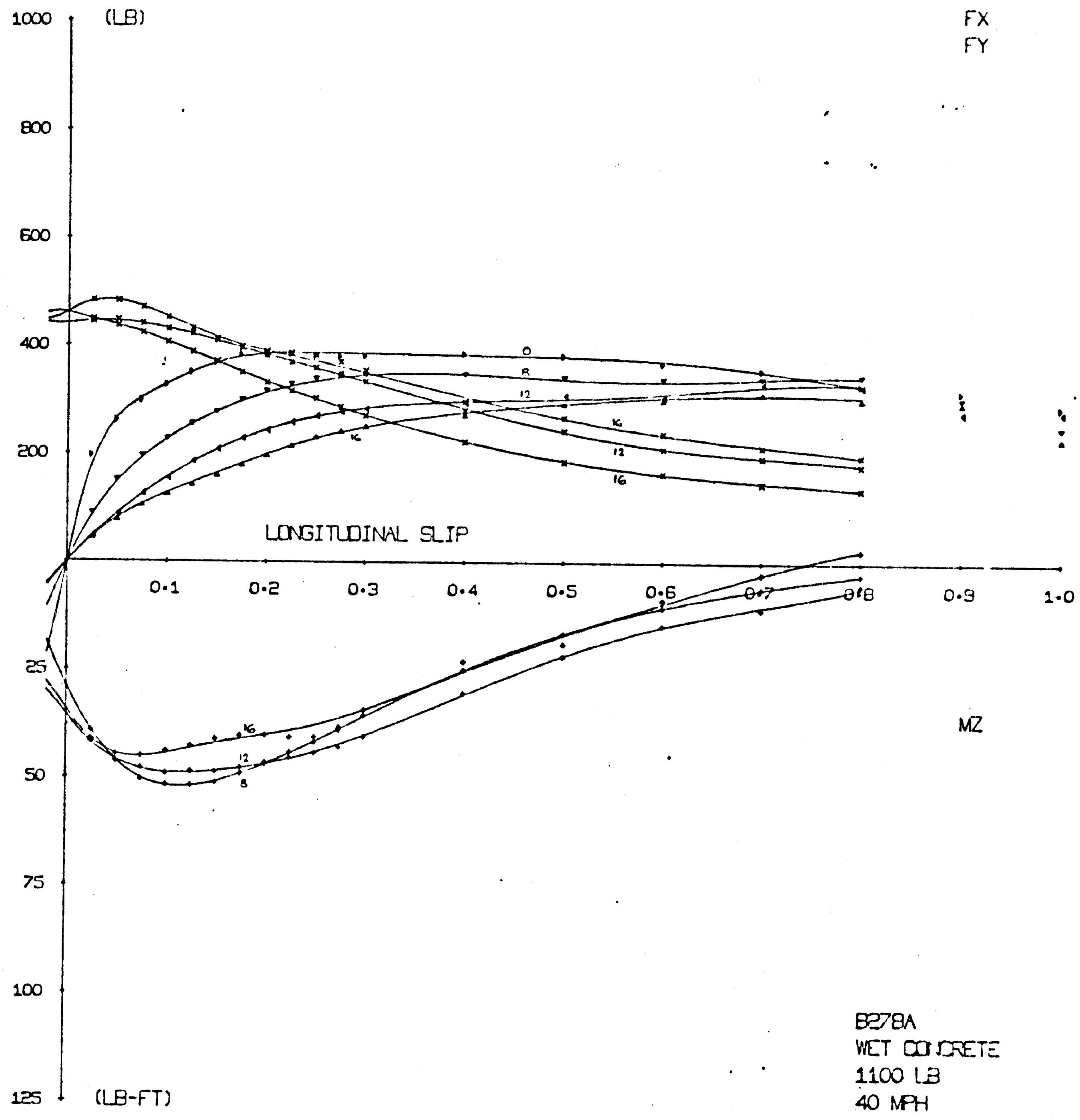
1100 LB
20 MPH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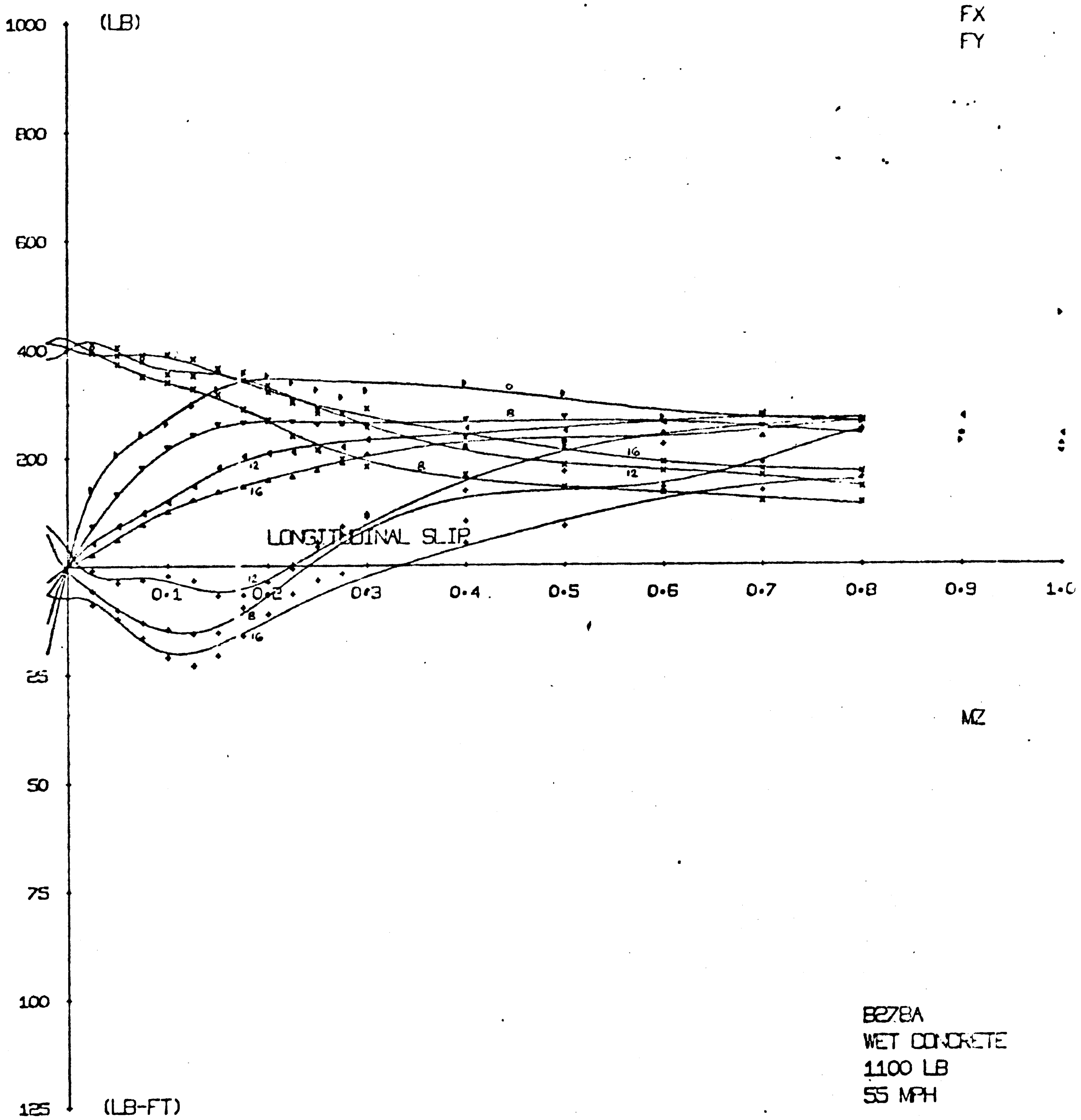
1·0
25
50
75
100
125
(LB-FT)
MZ
B278A
WET CONCRETE
1100 LB
40 MPH



FX
FY
(LB)
1000
800
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200
25
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75
100
125
(LB-FT)
LONGITUDINAL SLIP
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0·2
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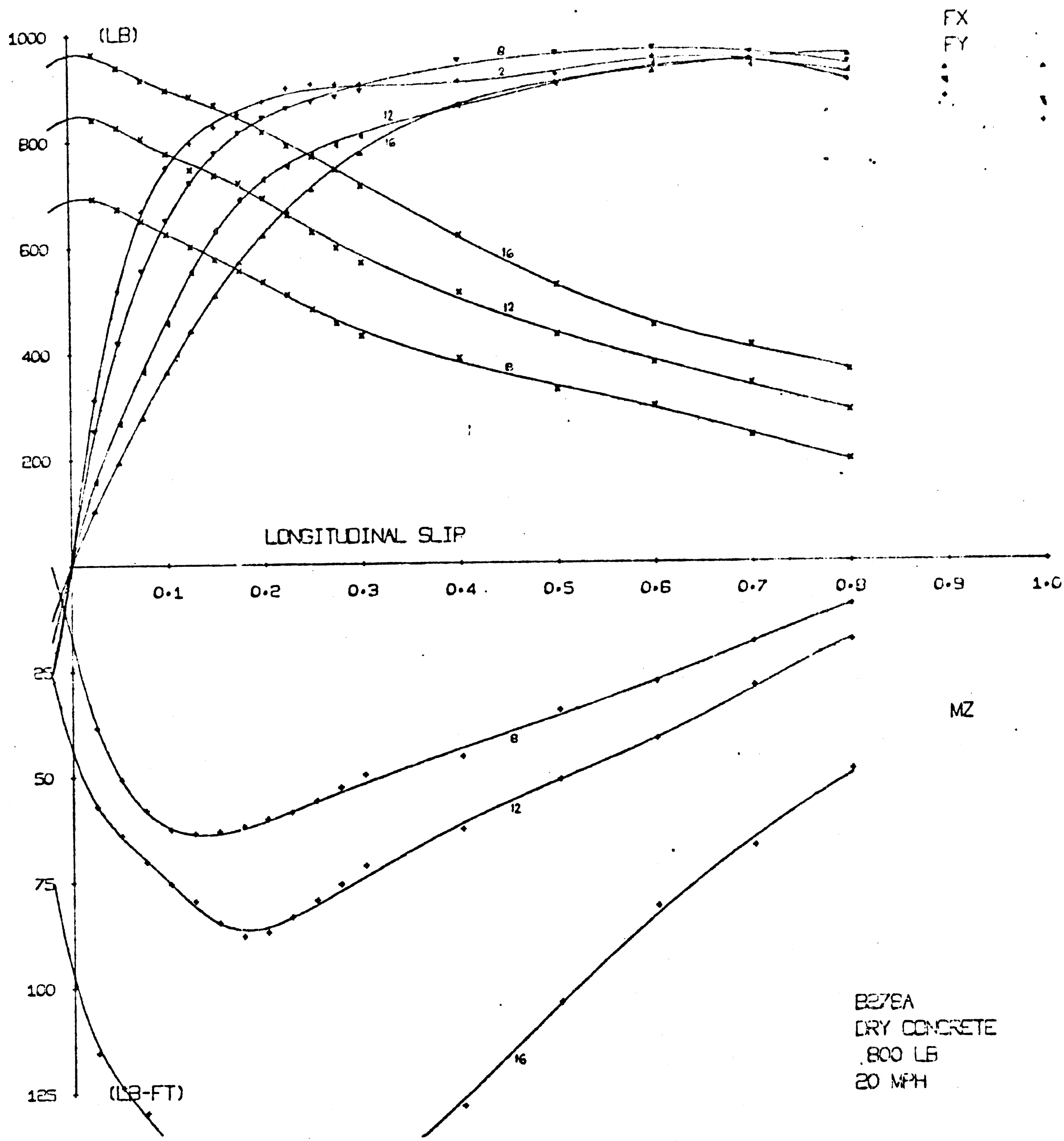
0·9
1·0
MZ
B278A
WET CONCRETE
1100 LB
55 MPH


FX
FY
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(LB)
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600
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2
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12
8
LONGITUDINAL SLIP
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0.2
0.3
0.4
0.5
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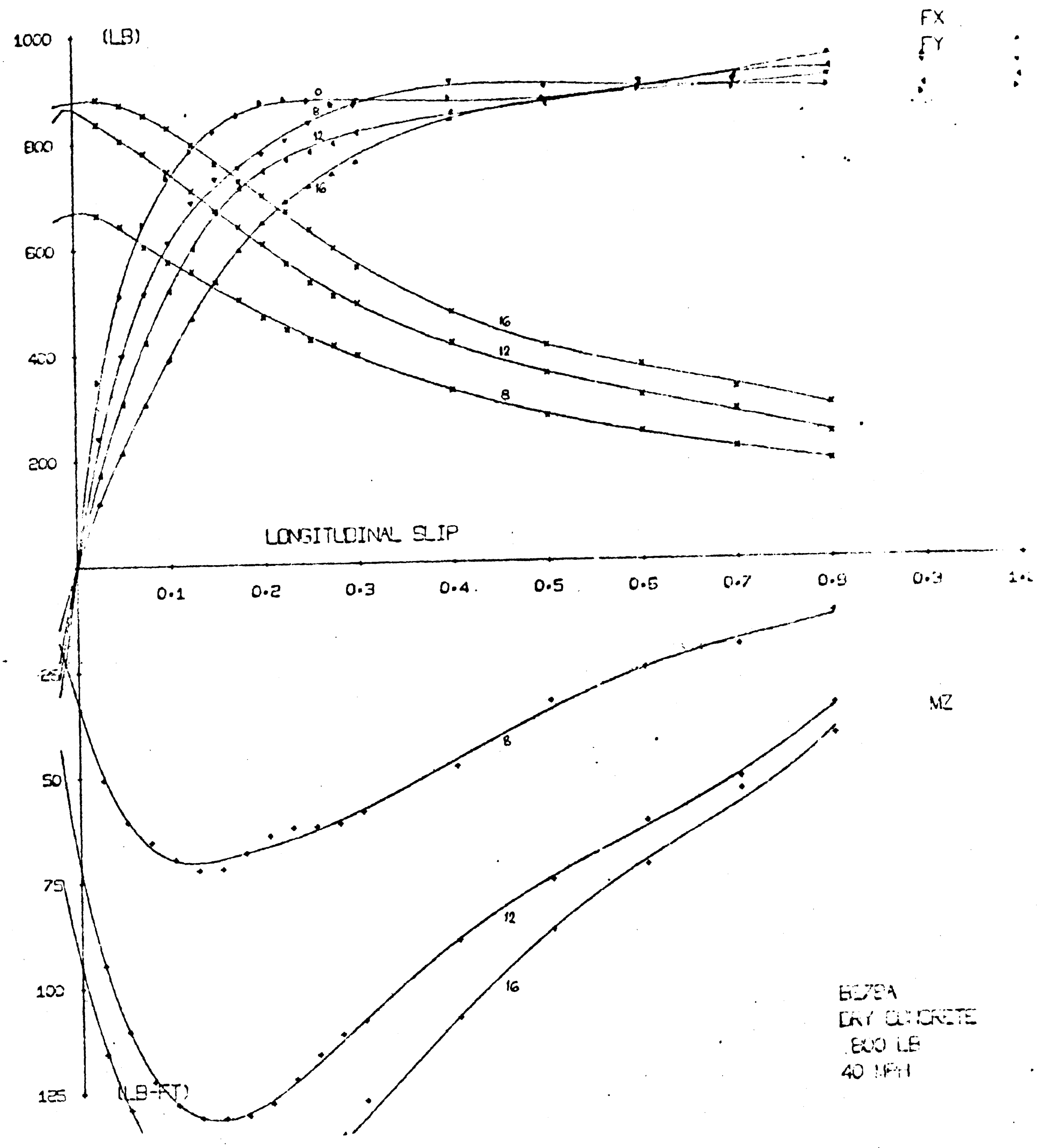
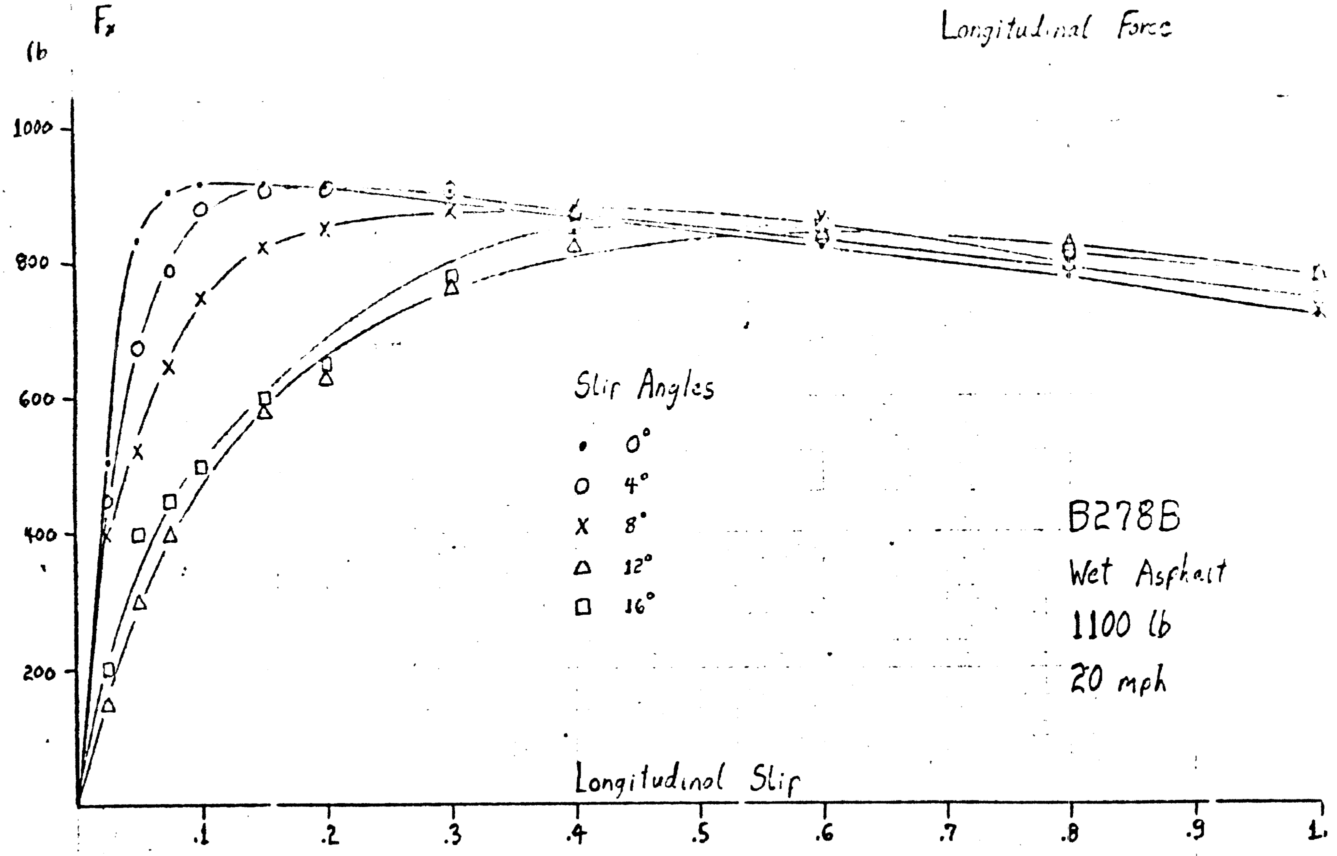
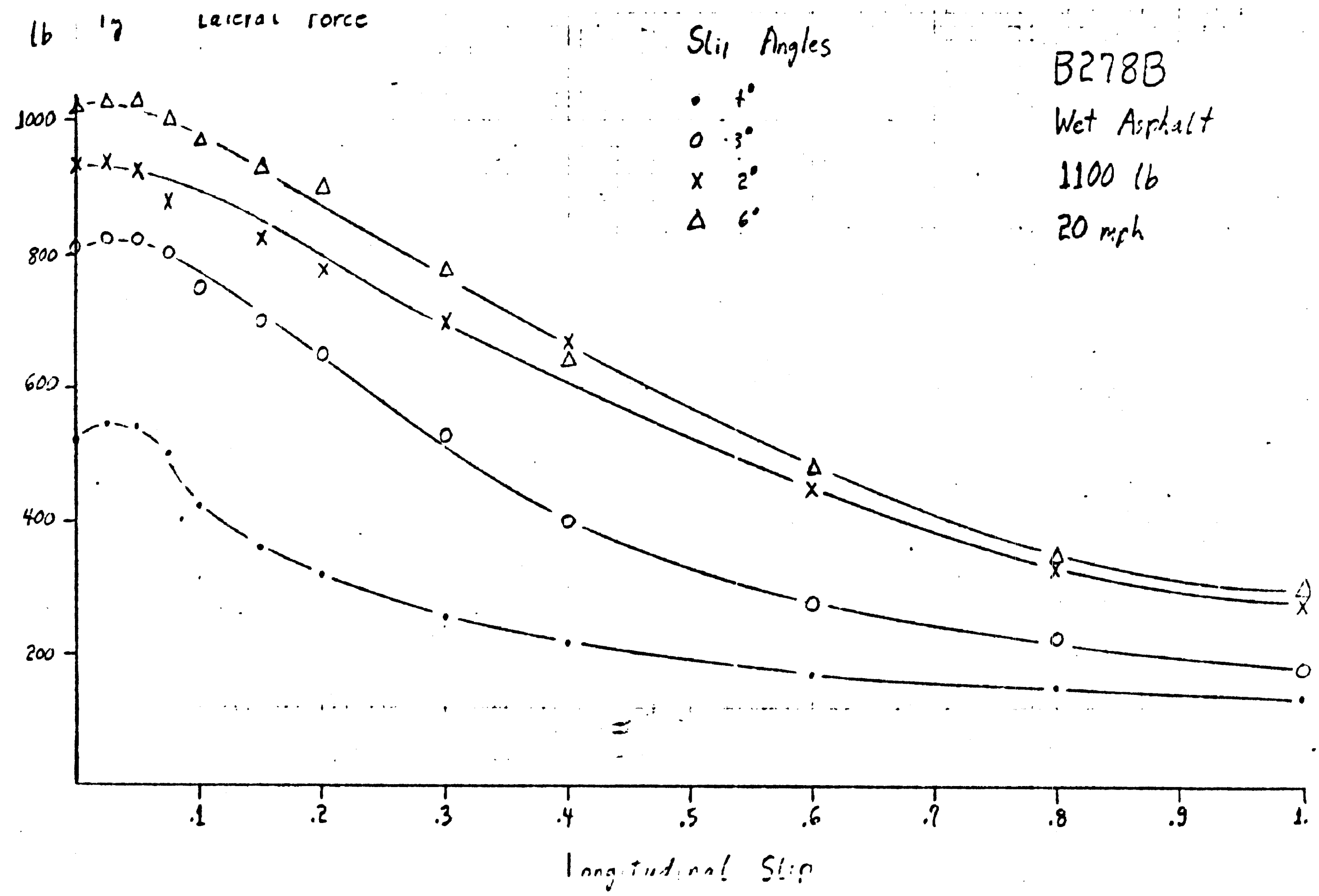
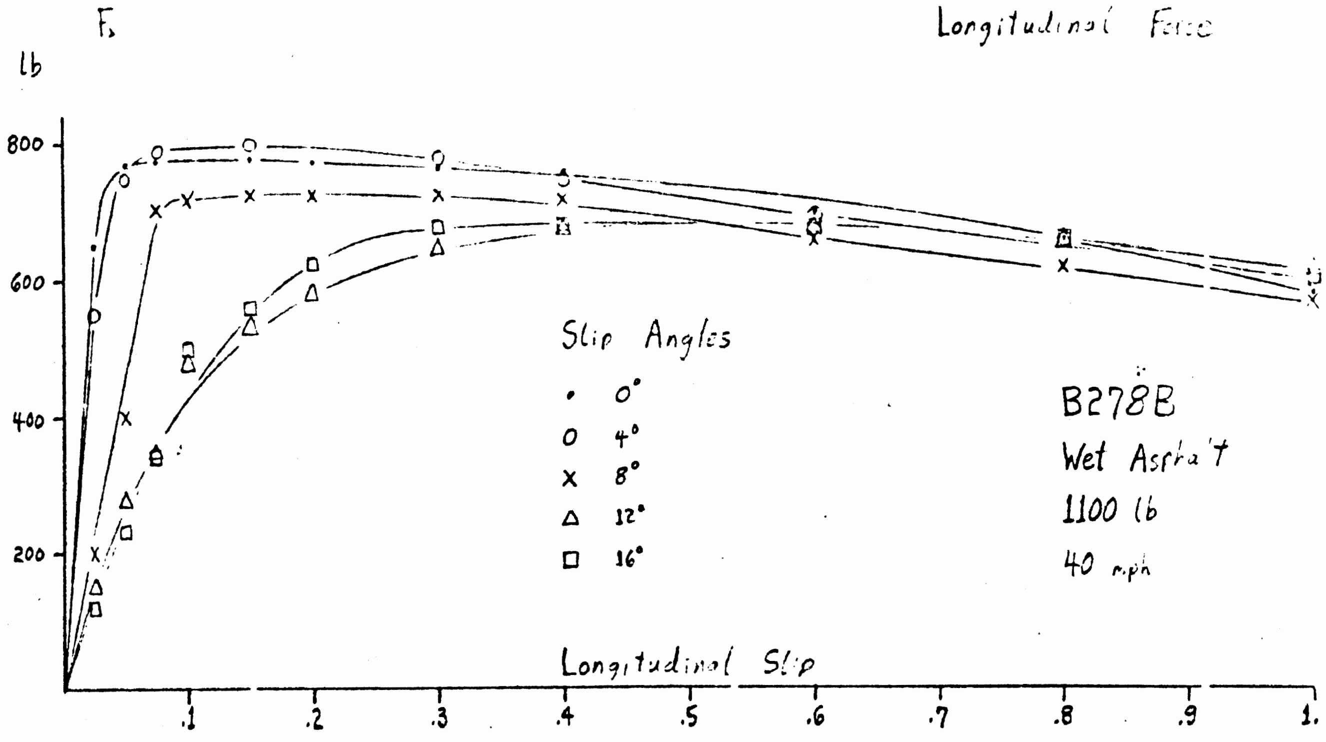
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
B278A
DRY CONCRETE
800 LB
20 MPH



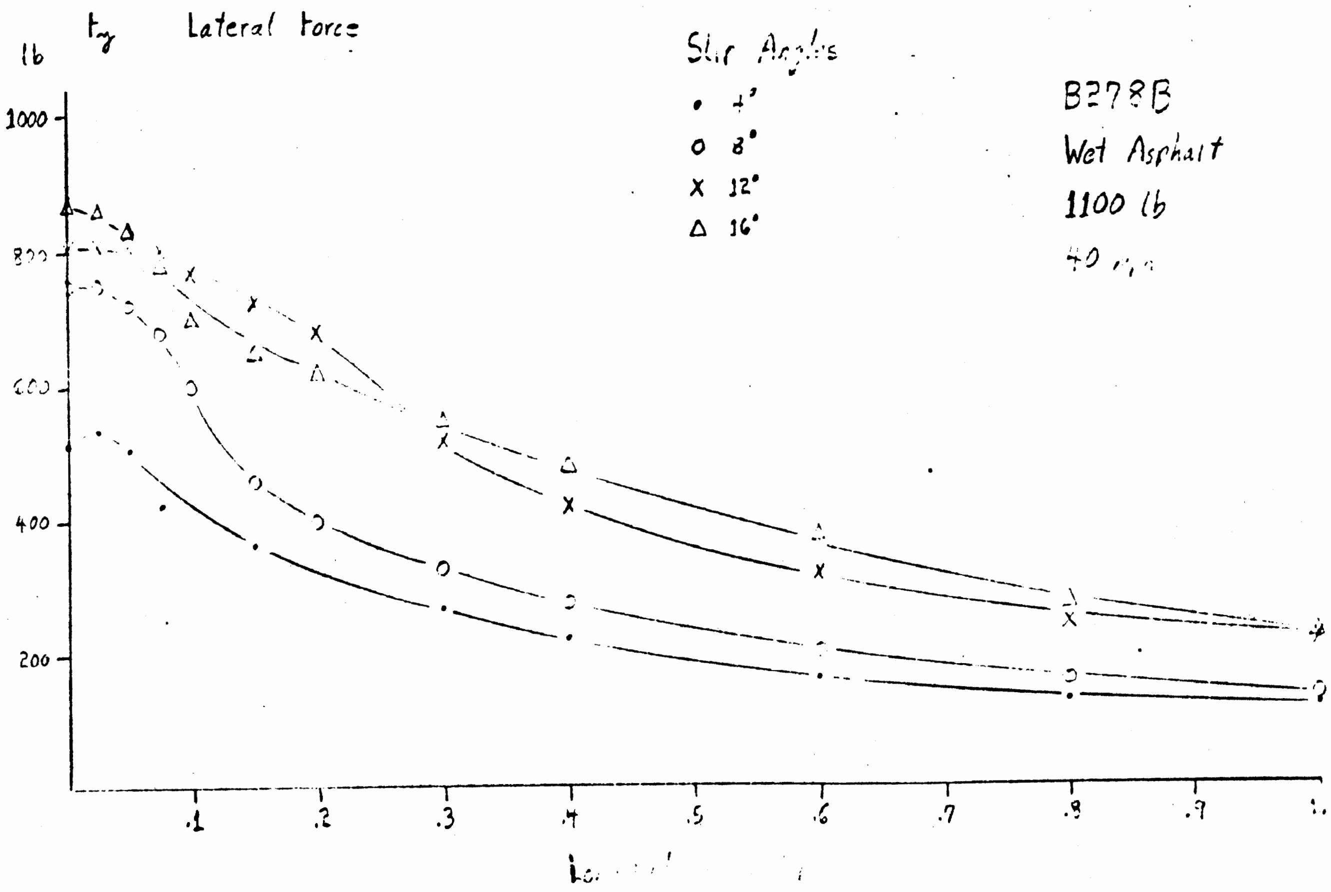
FX
FY
(LB)
1000
800
600
400
200
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
8
12
16
MZ
25
50
75
100
125
(LB-FT)
DRY CONCRETE
800 LB
40 MPH


Fx
lb
Longitudinal Force
1000
800
600
400
200
Slip Angles
0°
4°
8°
12°
16°
B278B
Wet Asphalt
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

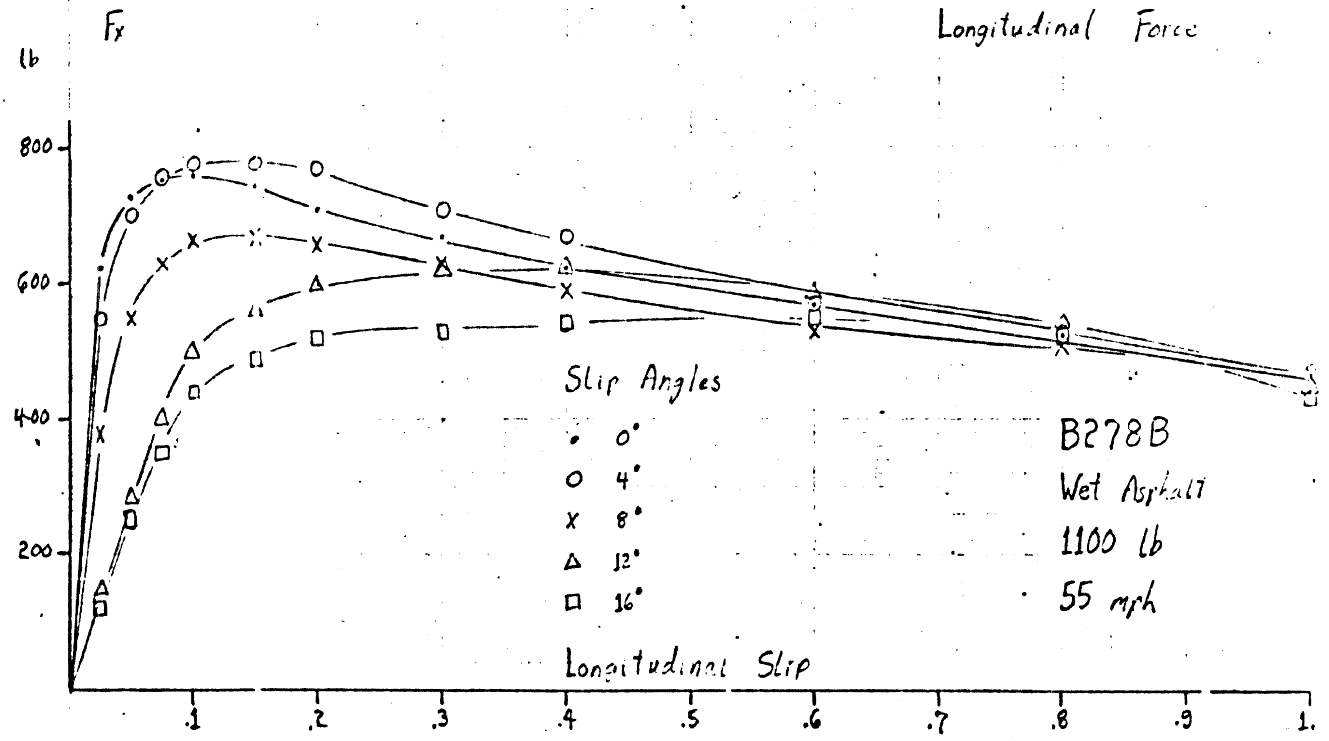

lb
Lateral Force
Slip Angles
B278B
Wet Asphalt
1100 lb
20 mph
1000
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip

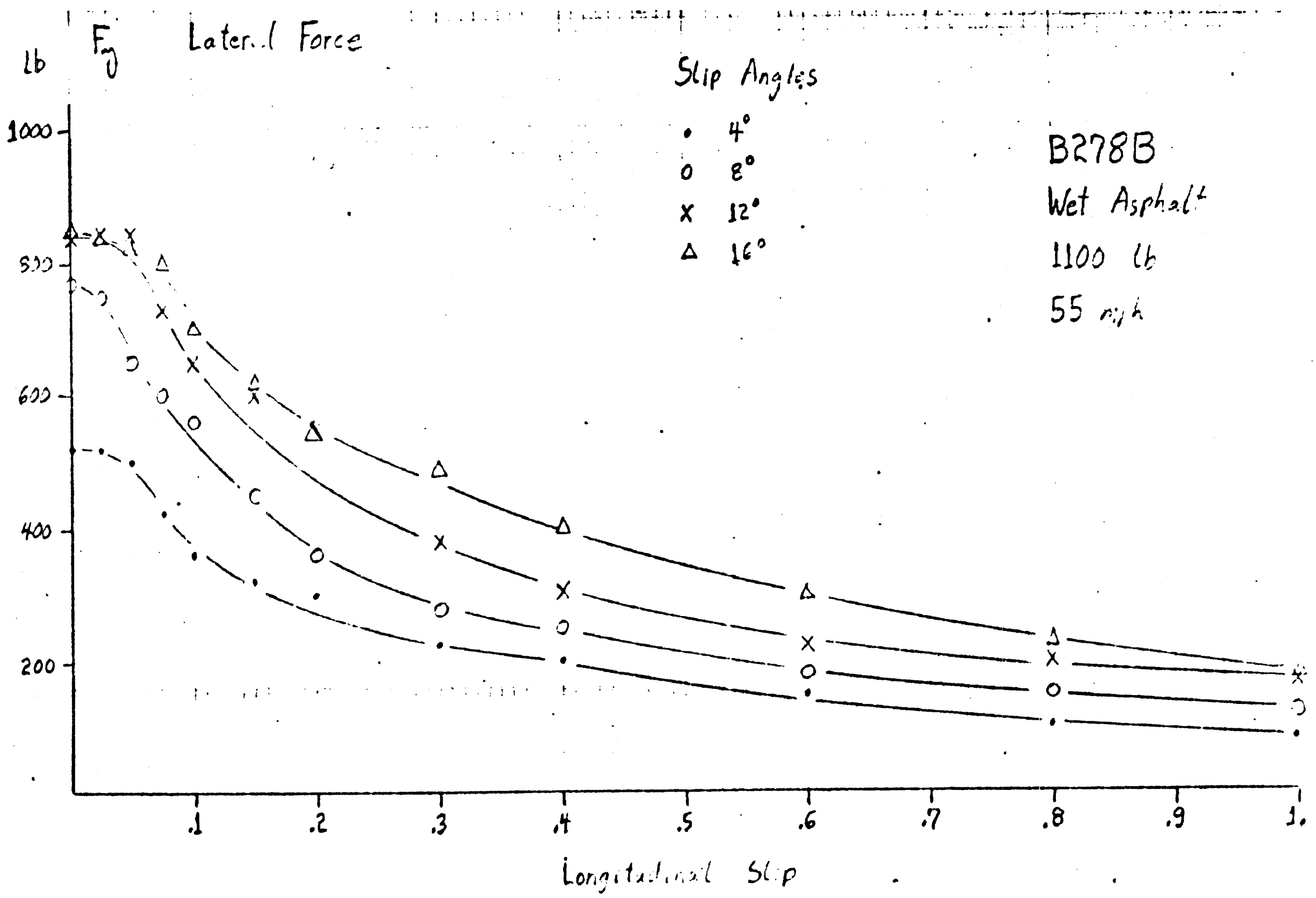


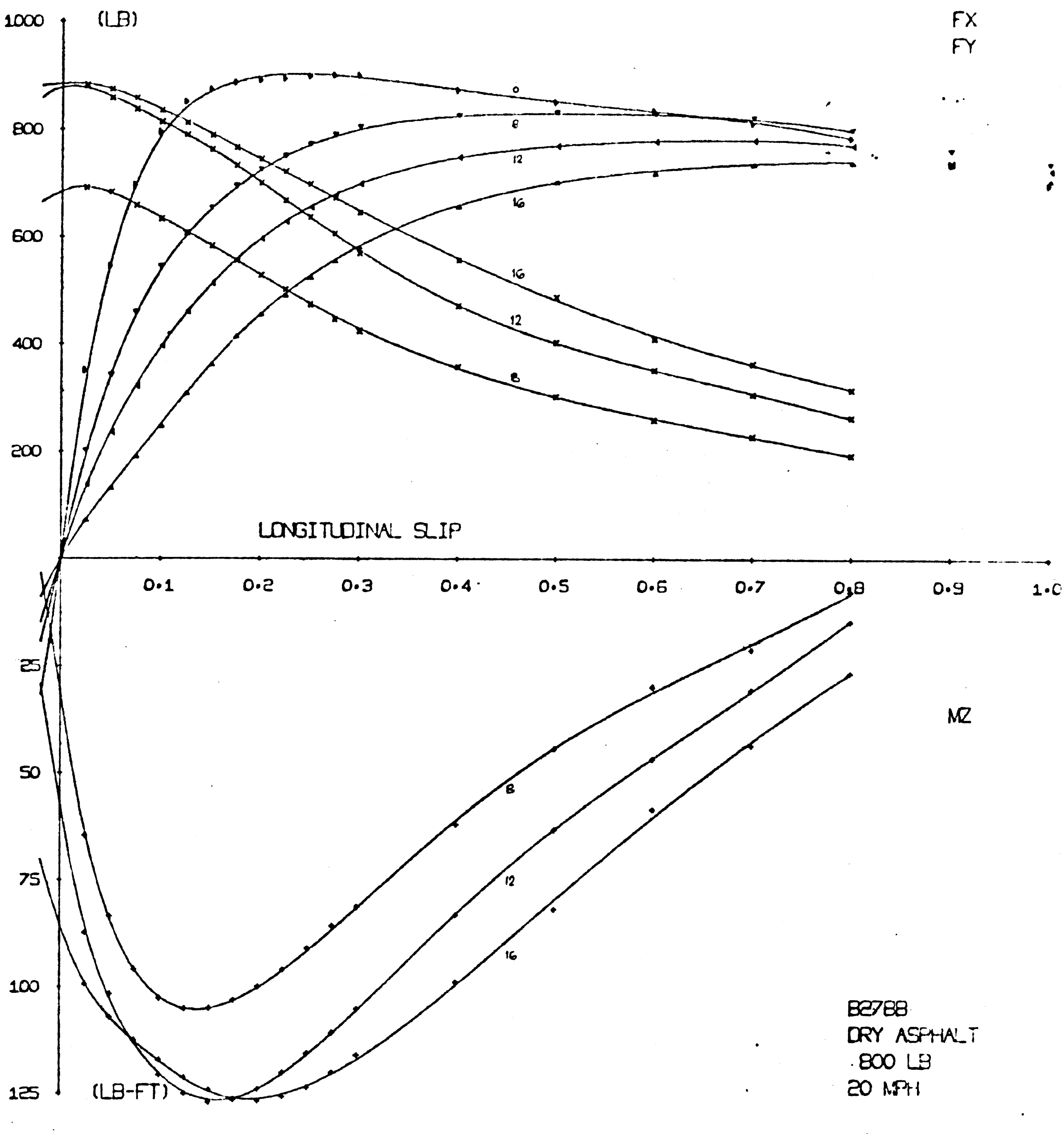
Fx
lb
Longitudinal Force
800
600
400
200
Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278B
Wet Asphalt
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

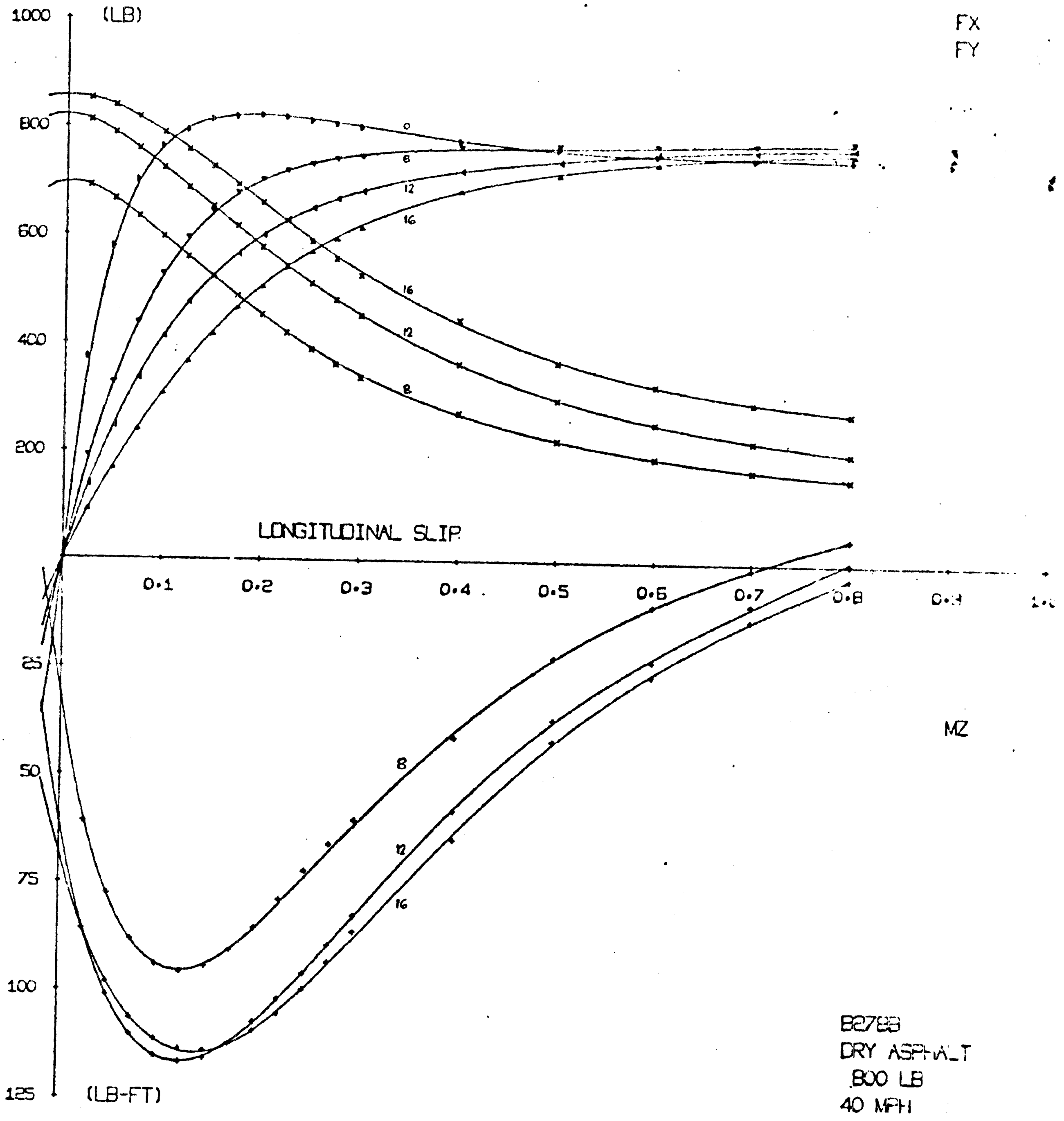


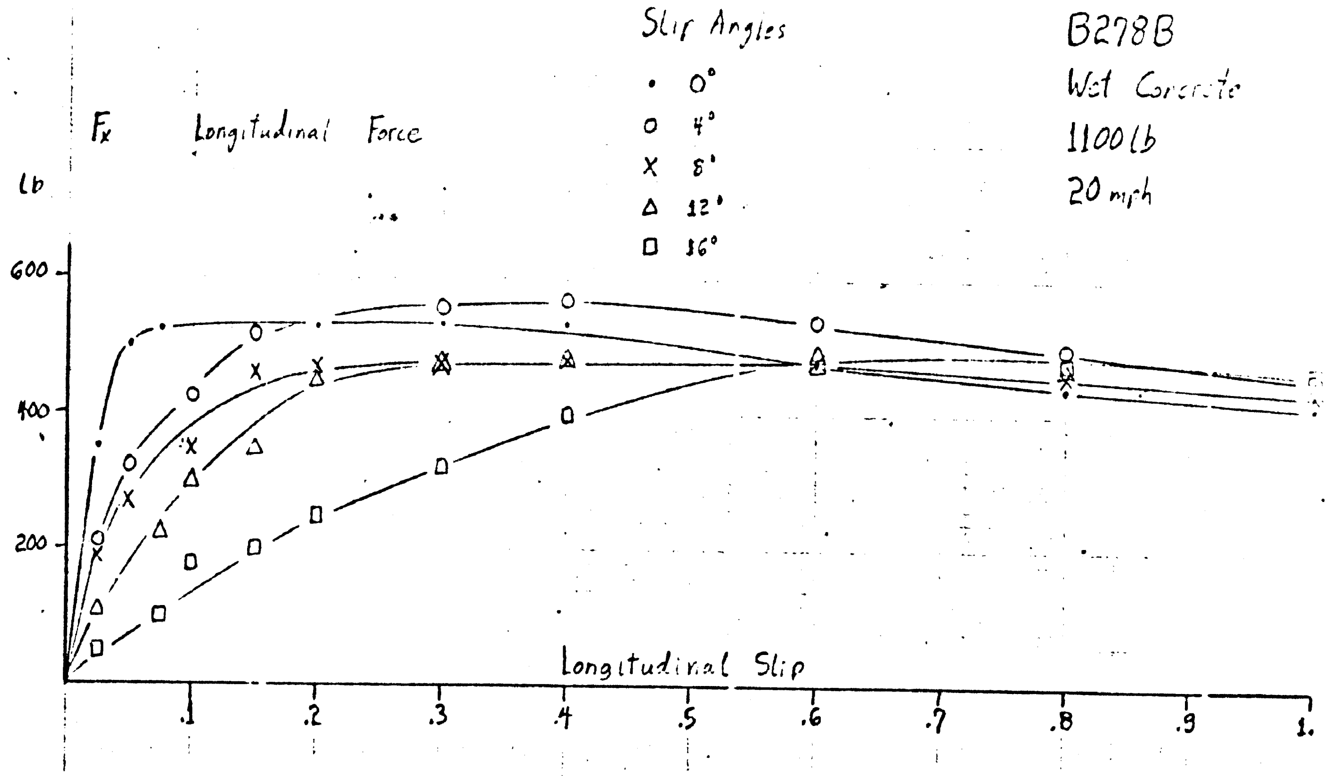
Fy
Lateral Force
lb
1000
400
200
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278B
Wet Asphalt
1100 lb
.1
.2
.3
.4
.5
.6
.7
.8
.9

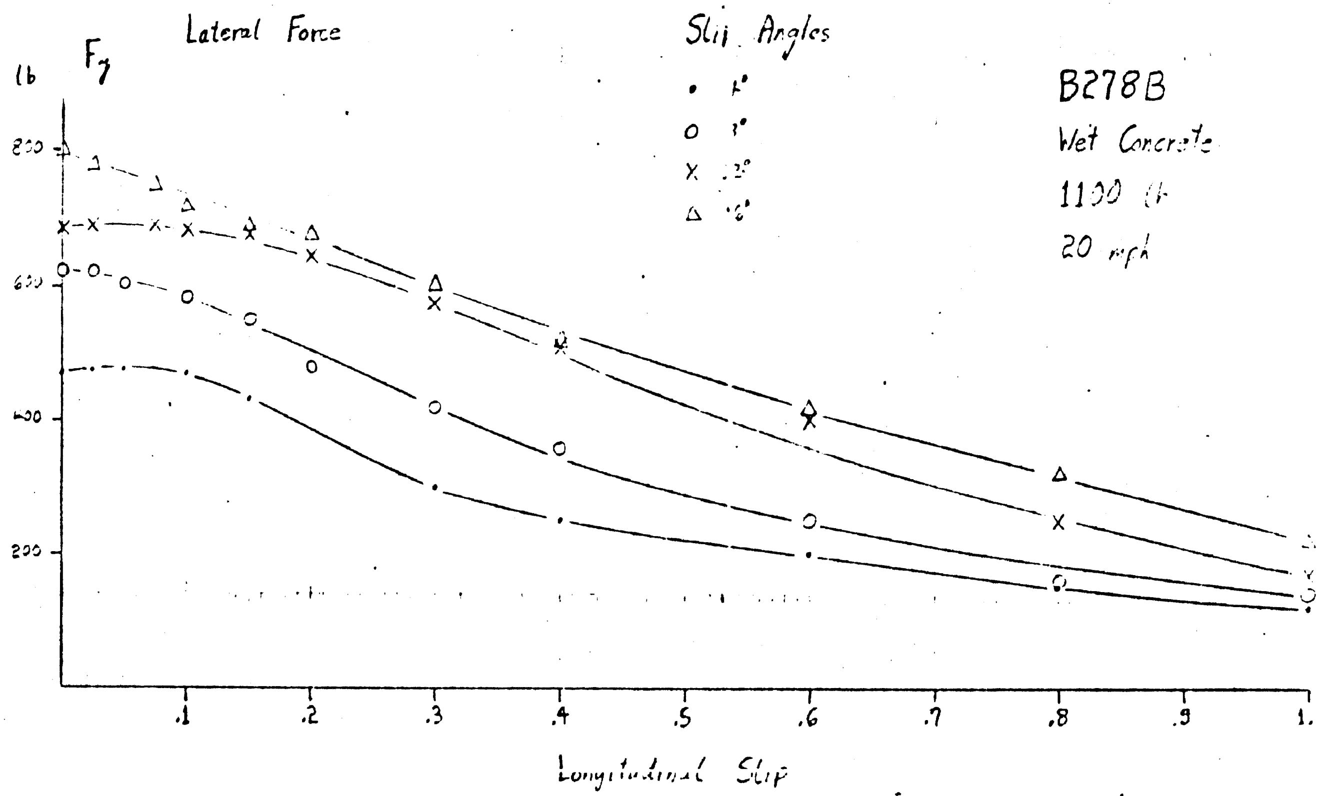

Fx
lb
Longitudinal Force
800
600
400
200
Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278B
Wet Asphalt
1100 lb
55 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

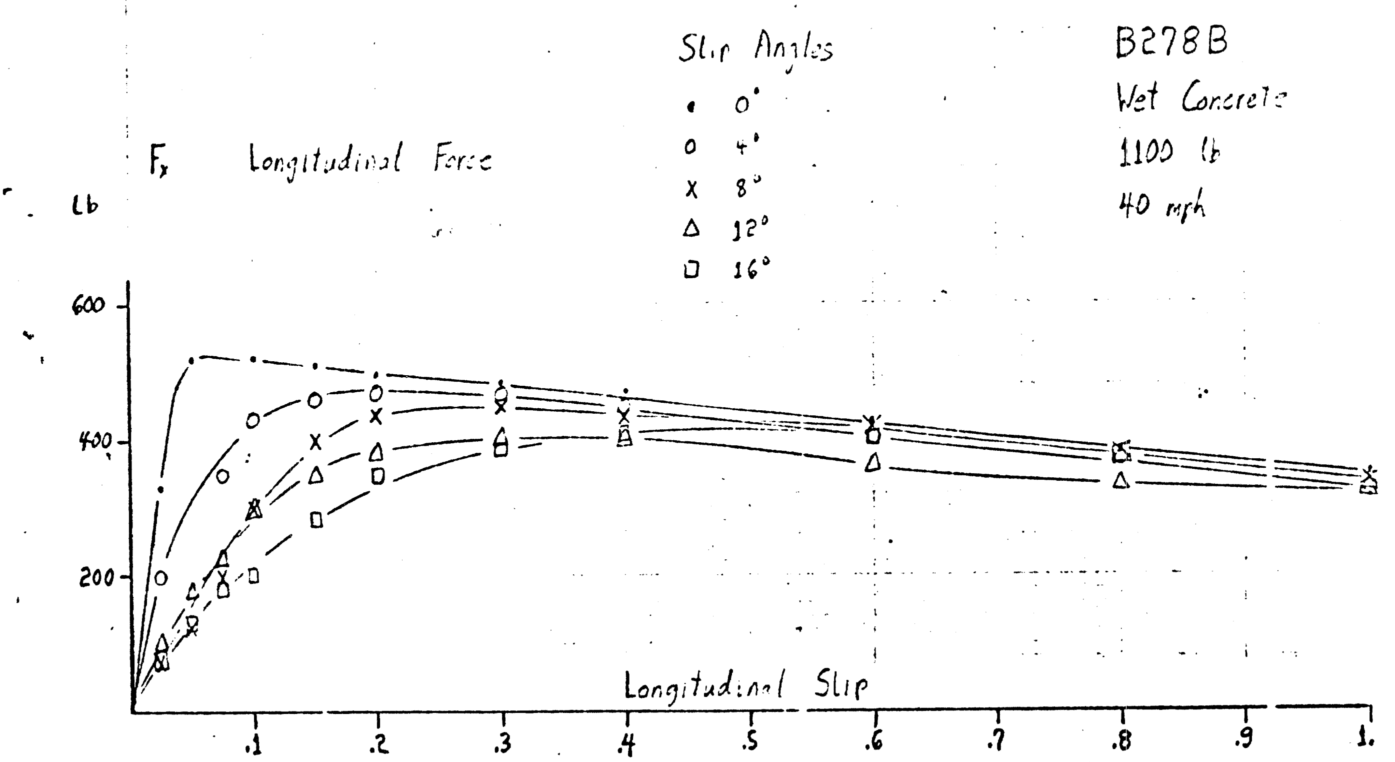

lb
Fy
Lateral Force
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278B
Wet Asphalt
1100 lb
55 mph
1000
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip

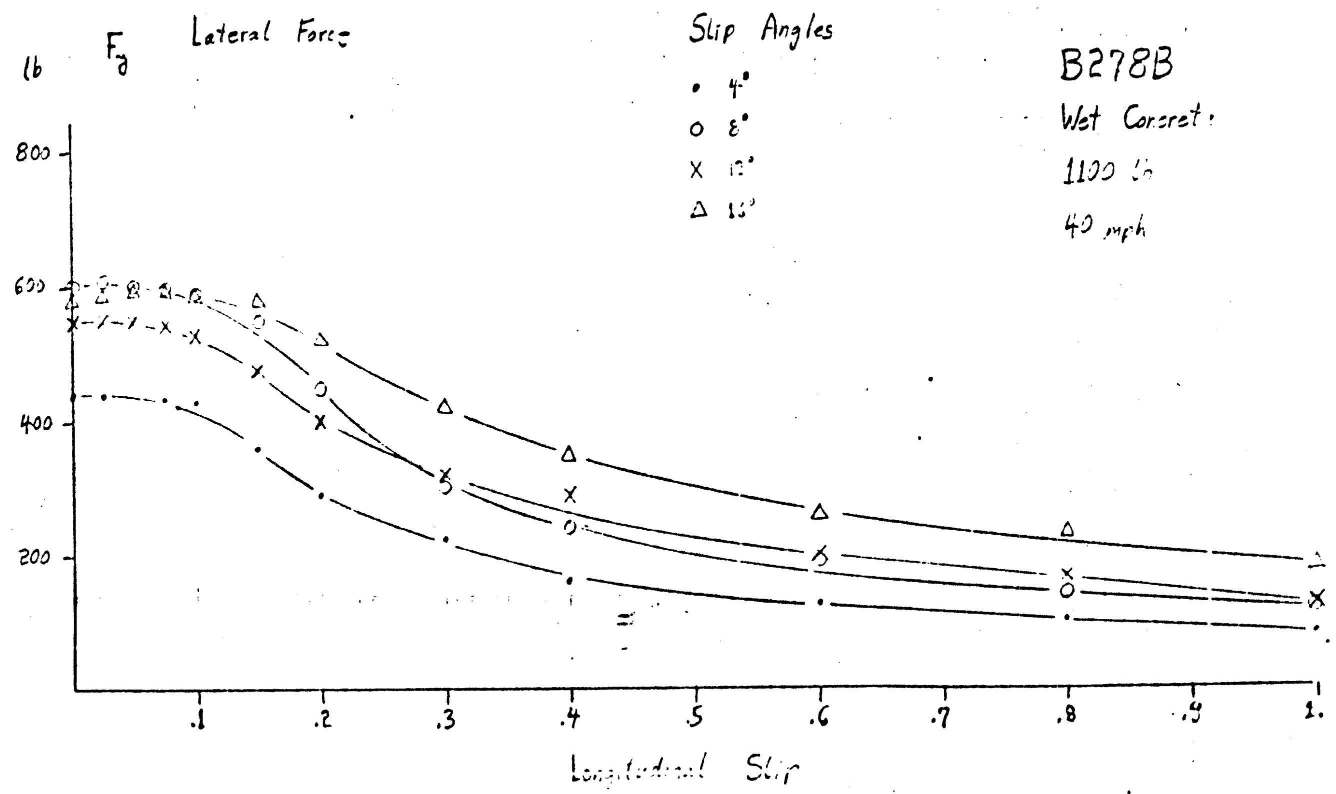

1000
800
600
400
200
(LB)
FX
FY
o
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
B27BB
DRY ASPHALT
800 LB
20 MPH

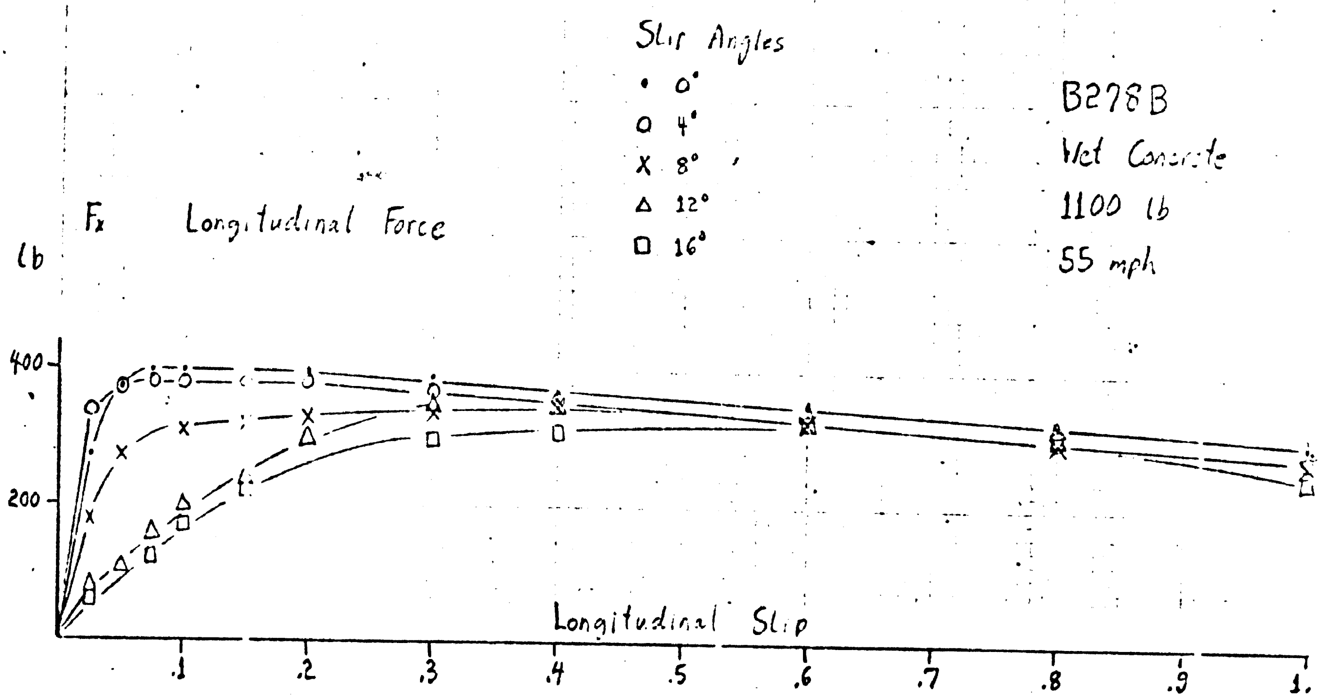

1000
(LB)
FX
FY
800
600
400
200
0
8
12
16
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
25
50
75
100
125
(LB-FT)
MZ
B278B
DRY ASPHALT
800 LB
40 MPH

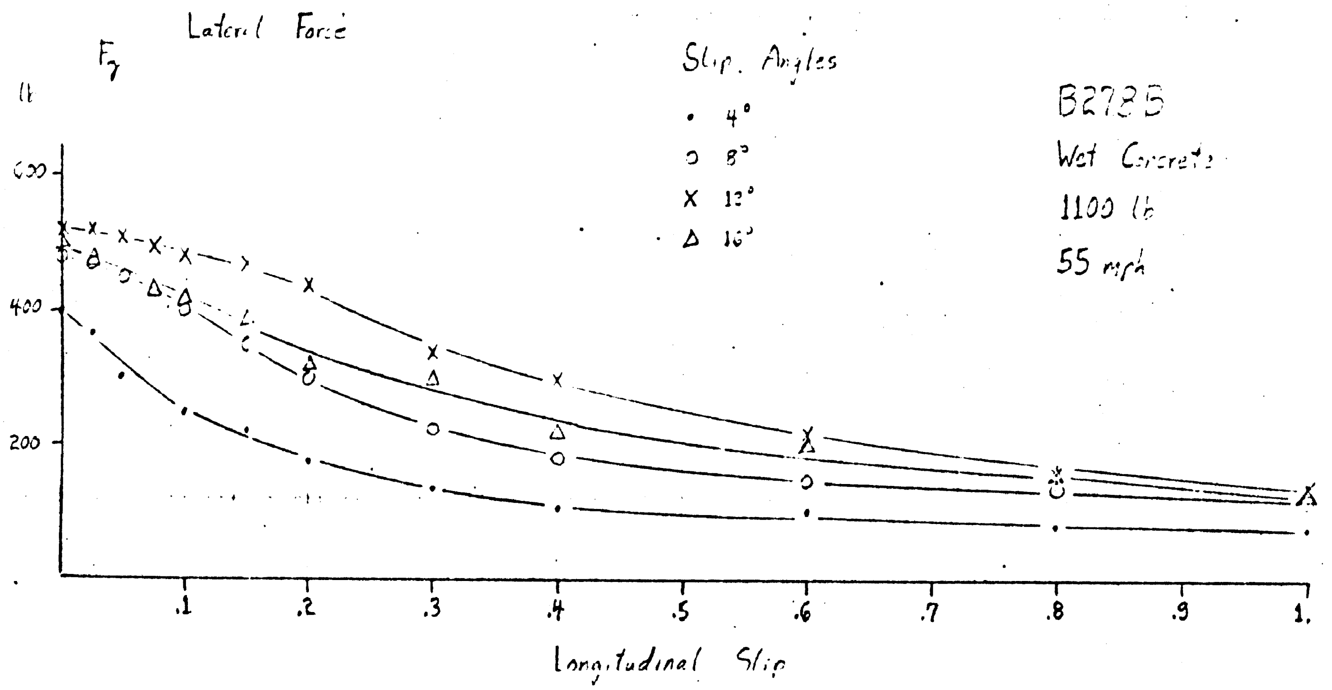

Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278B
Wet Concrete
1100 lb
20 mph
Fx
Longitudinal Force
lb
600
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

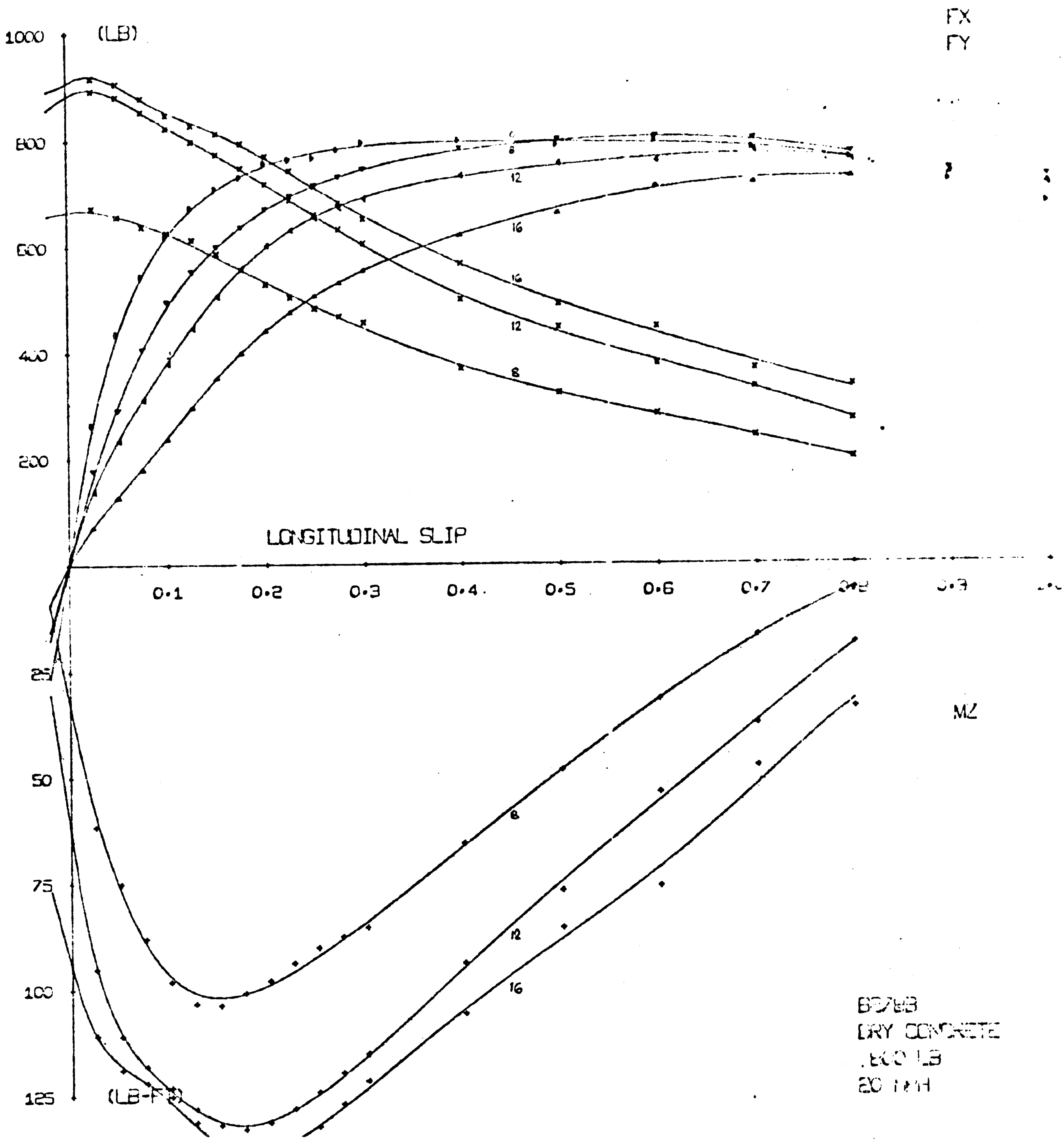

Lateral Force
Fy
lb
Slip Angles
B278B
Wet Concrete
20 mph
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip

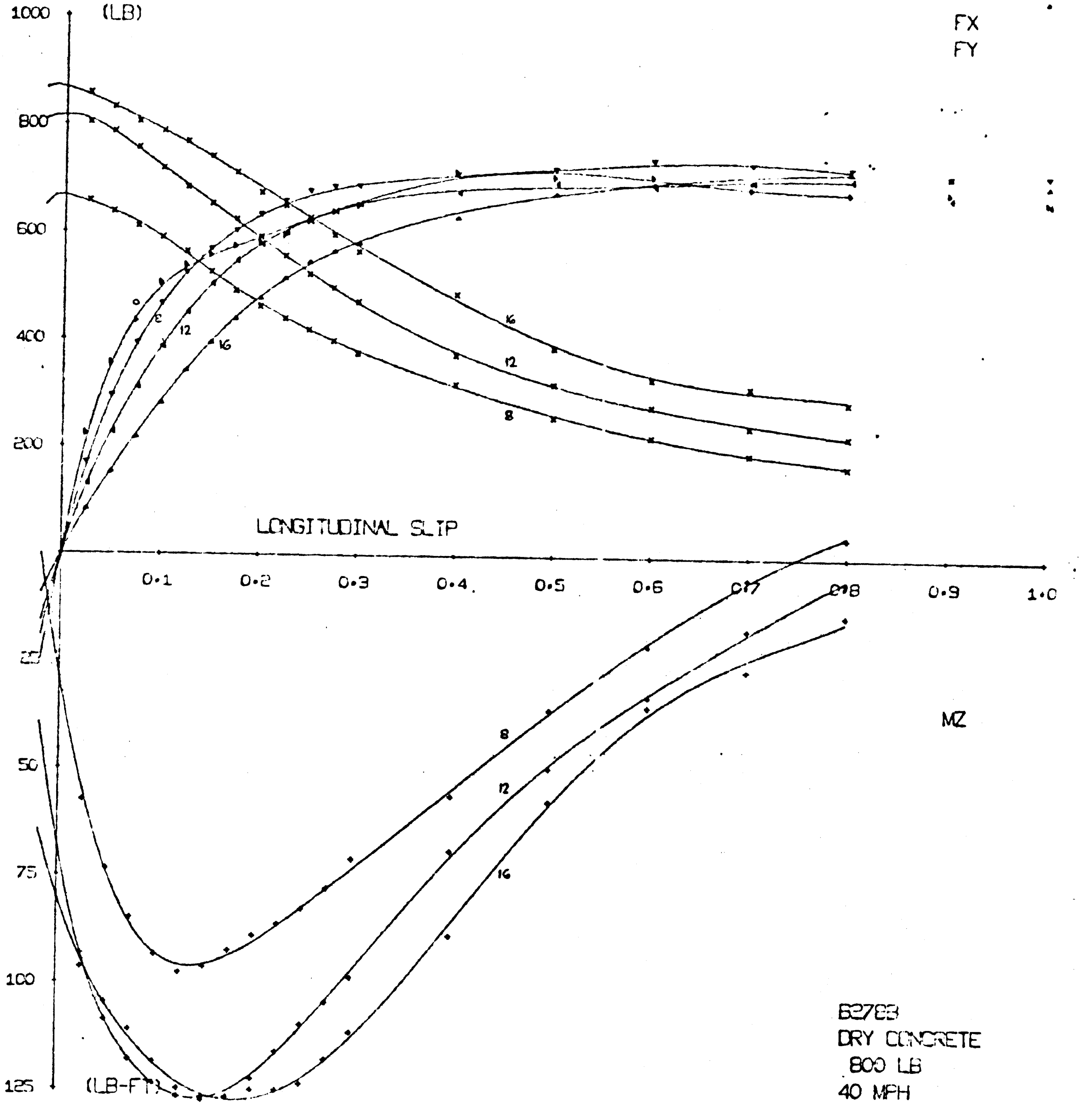

Fx Longitudinal Force
lb
Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278B
Wet Concrete
1100 lb
40 mph
600
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

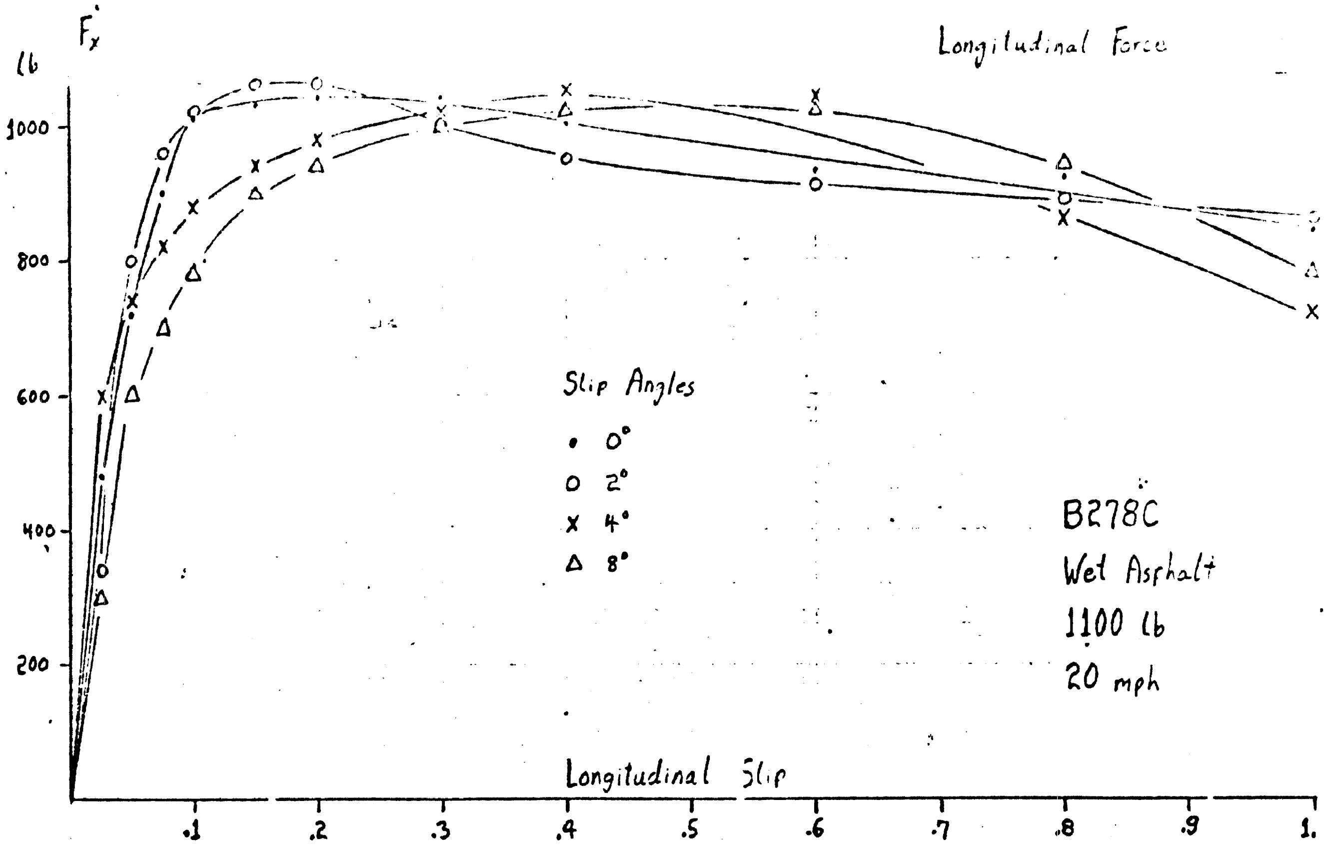

Fy Lateral Force
lb
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278B
Wet Concrete
40 mph
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278B
Wet Concrete
1100 lb
55 mph
Fx Longitudinal Force
lb
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

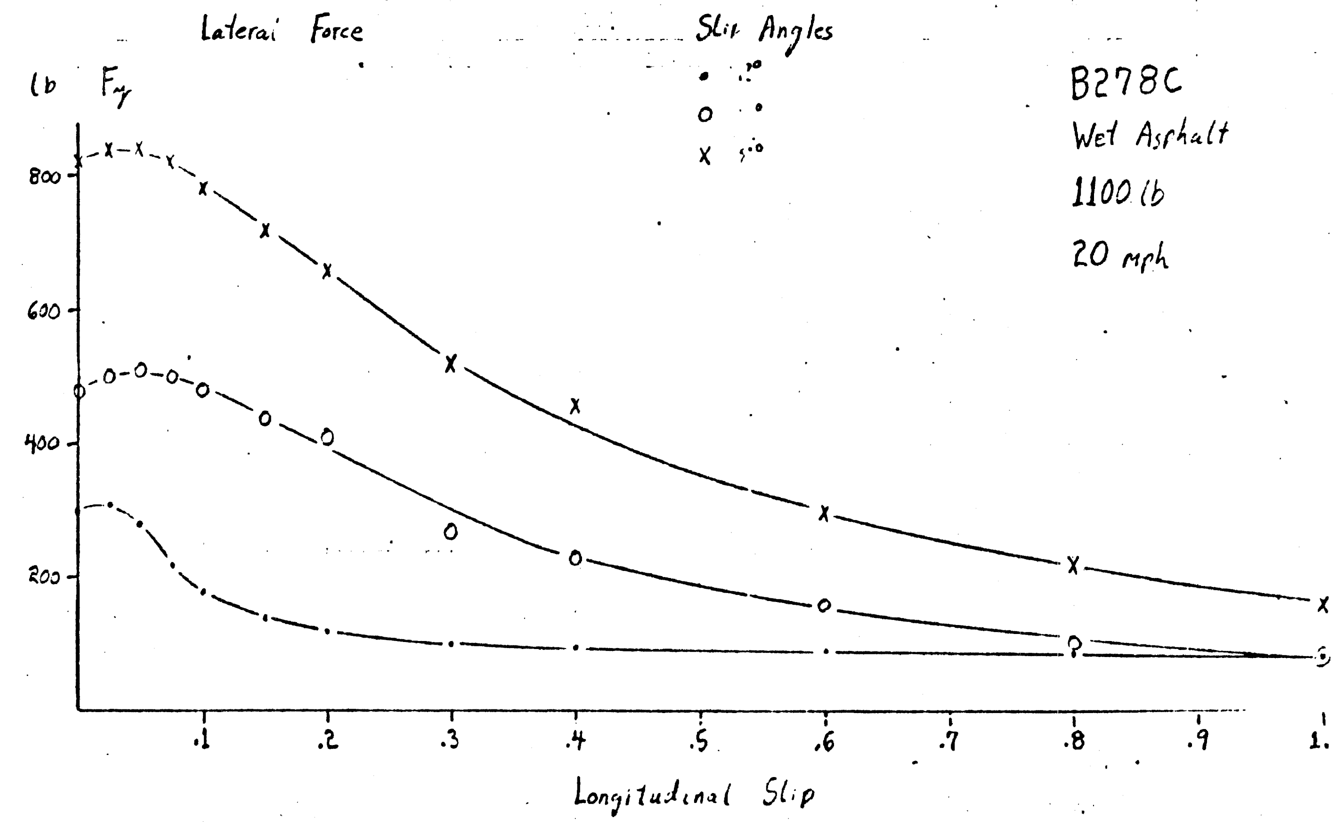

Lateral Force
Fy
lb
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278B
Wet Concrete
1100 lb
55 mph
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


FX
FY
1000
(LB)
800
600
400
200
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
25
50
75
100
125
MZ
8
12
16

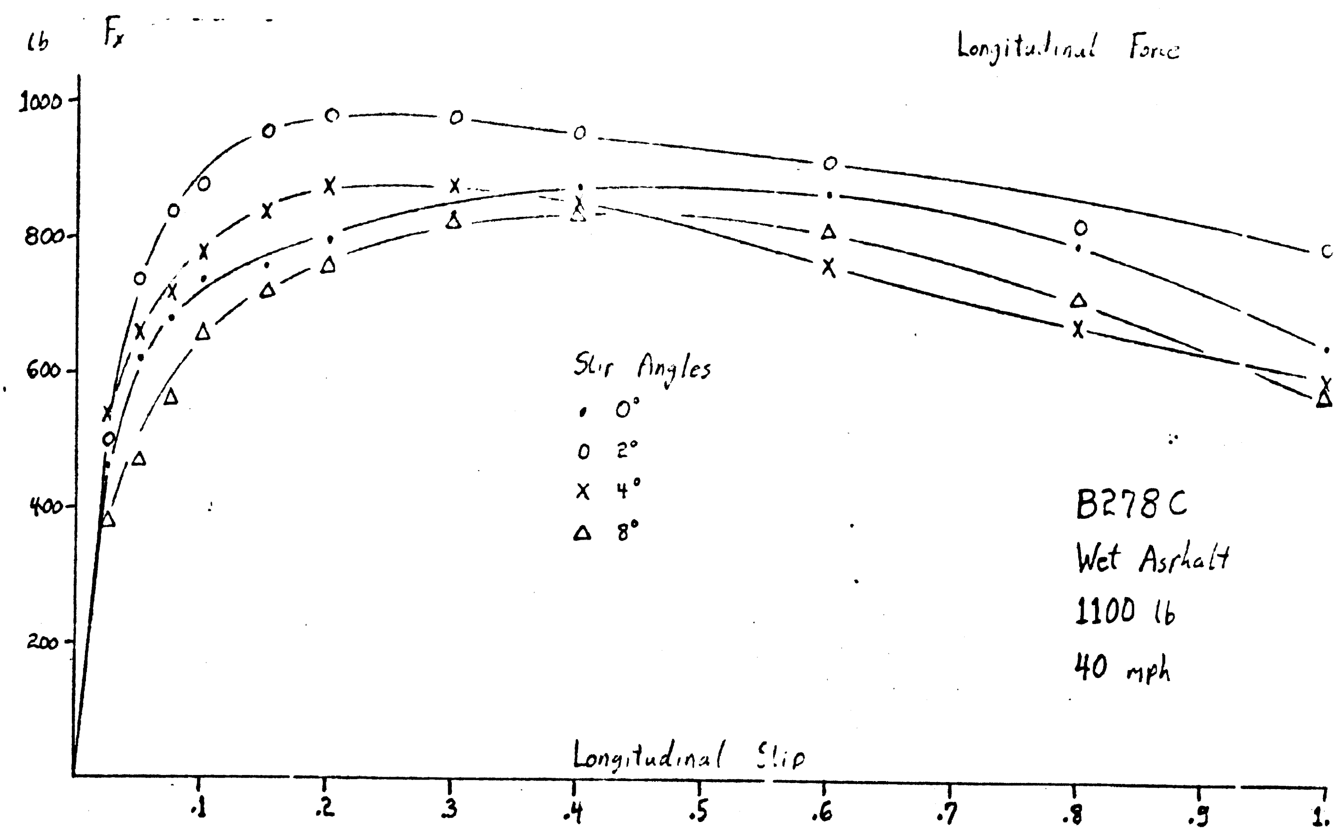

1000
(LB)
FX
FY
800
600
400
200
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
16
12
8
25
50
75
100
125
(LB-FT)
MZ
B278B
DRY CONCRETE
800 LB
40 MPH

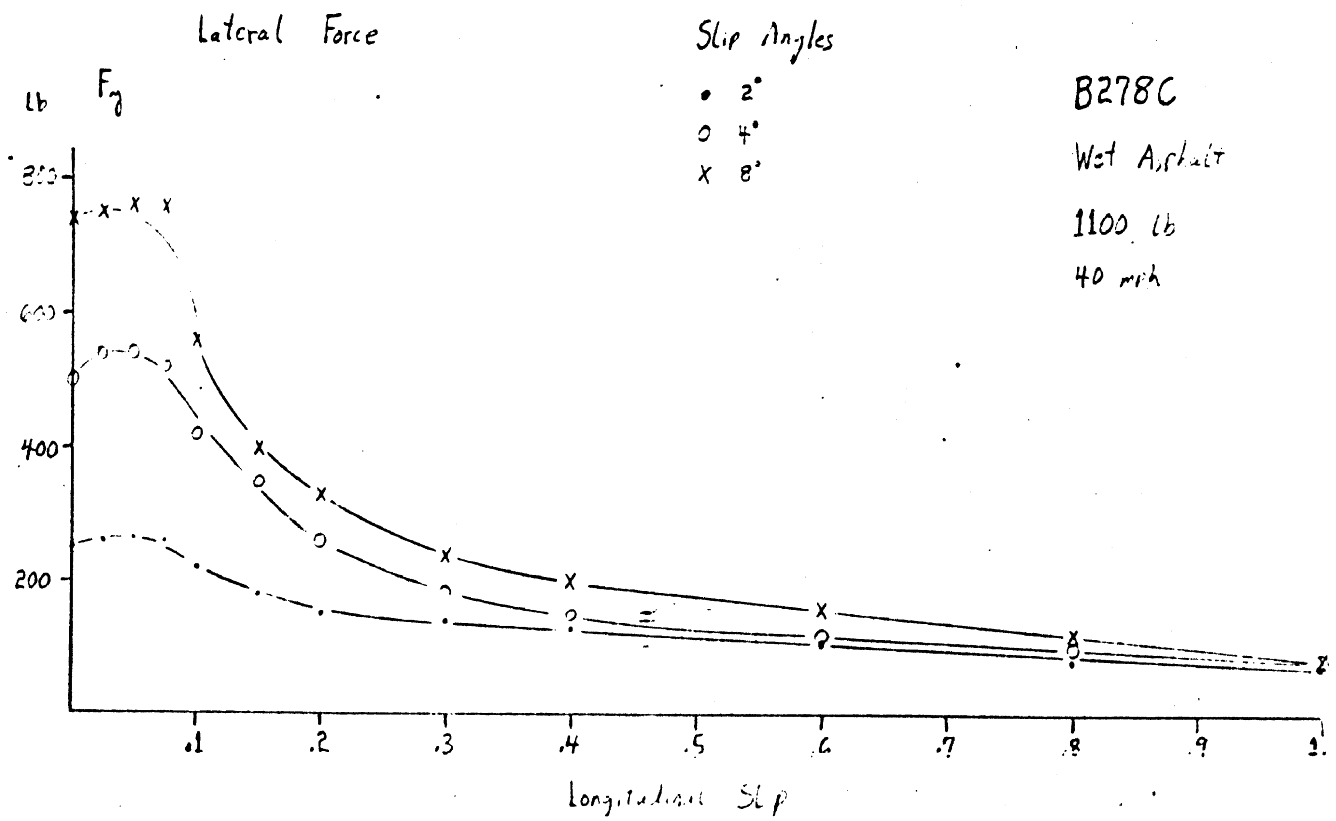


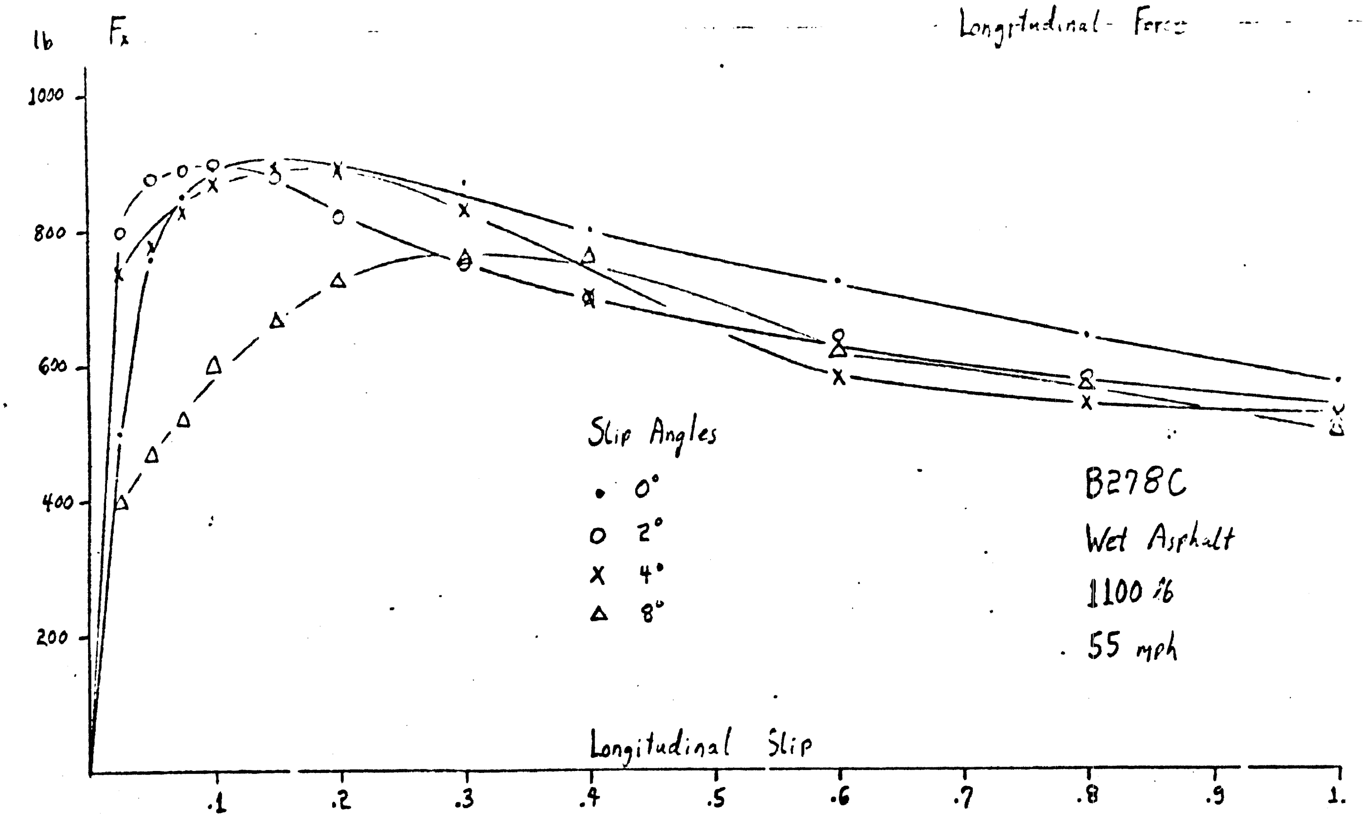
F_x
lb
Longitudinal Force
1000
800
600
400
200
Slip Angles
• 0°
o 2°
x 4°
Δ 8°
B278C
Wet Asphalt
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

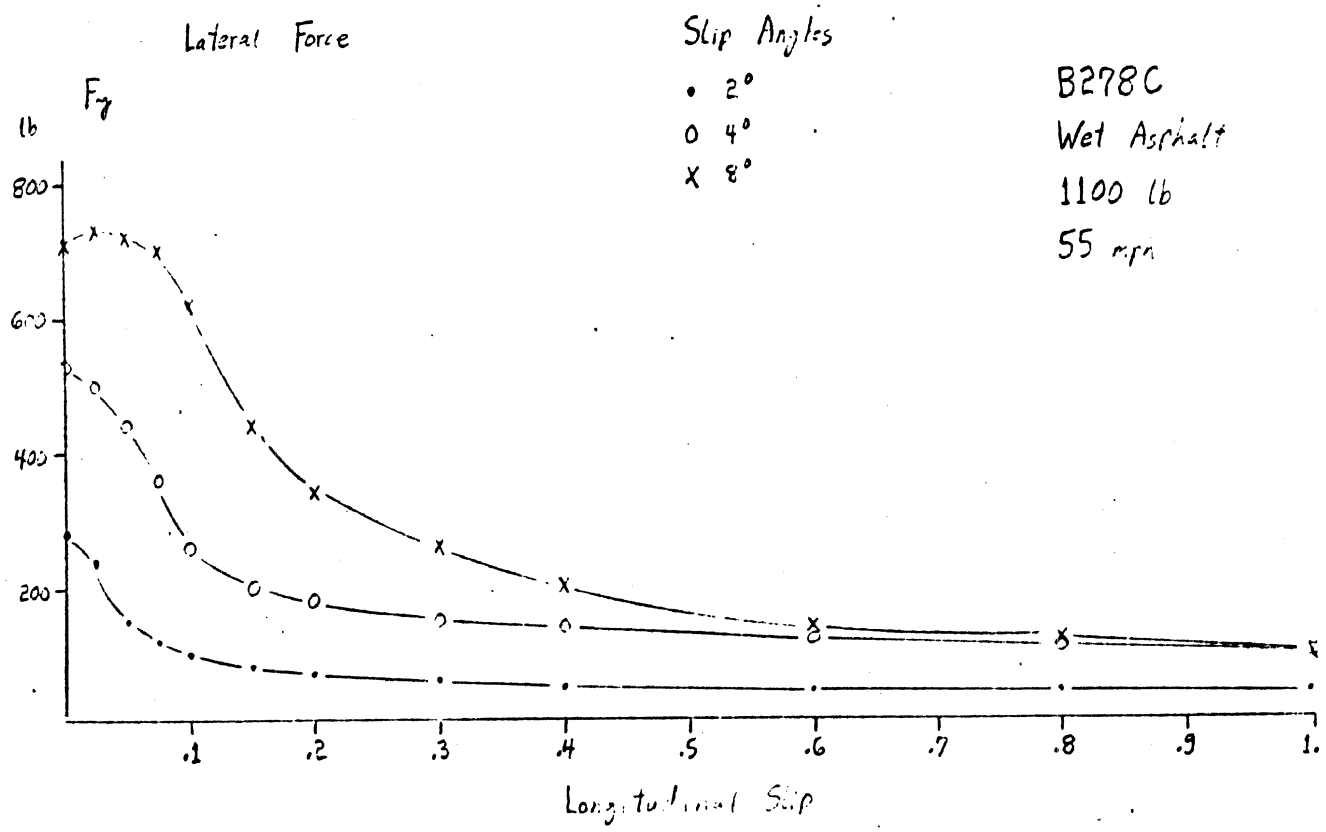


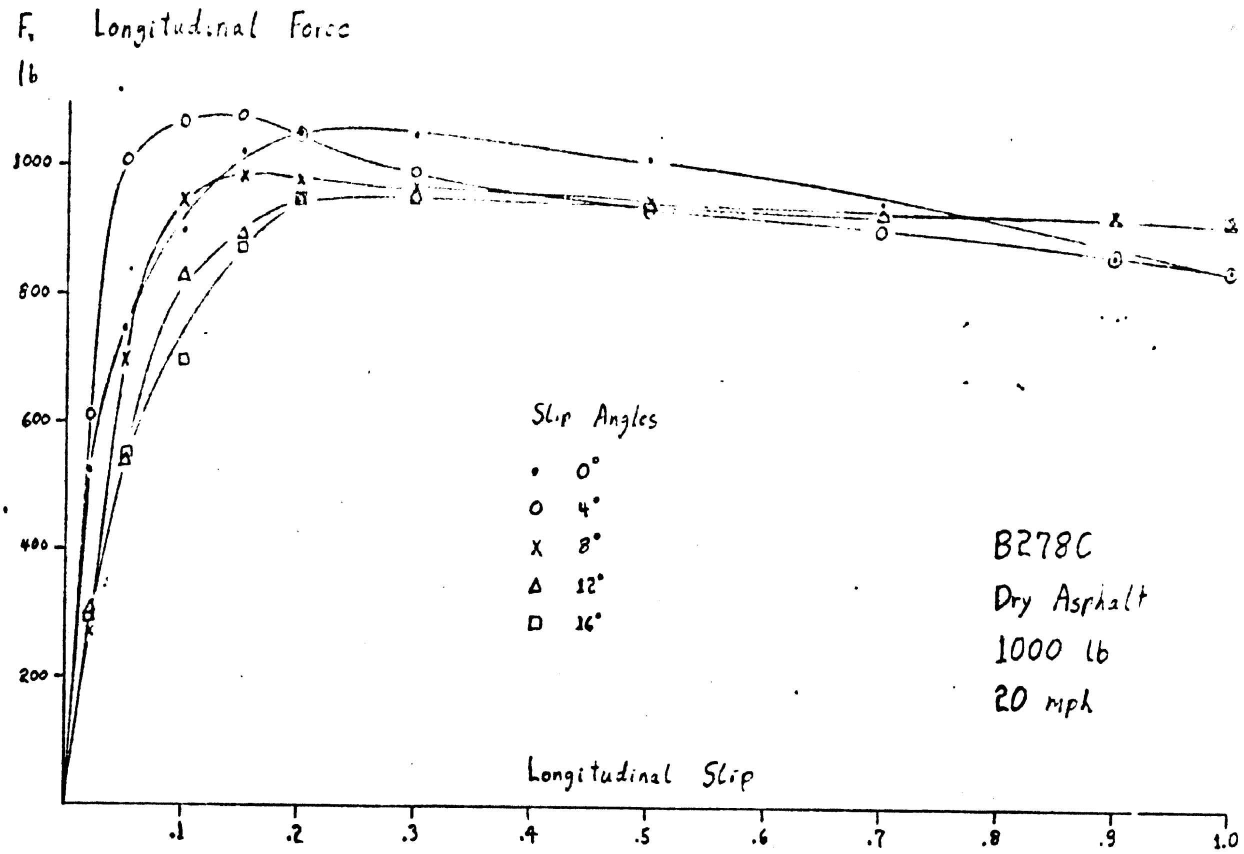
Lateral Force
Slip Angles
lb
F_y
B278C
Wet Asphalt
1100 lb
20 mph
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


lb F_x
Longitudinal Force
1000
800
600
400
200
Slip Angles
0°
2°
4°
8°
B278C
Wet Asphalt
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

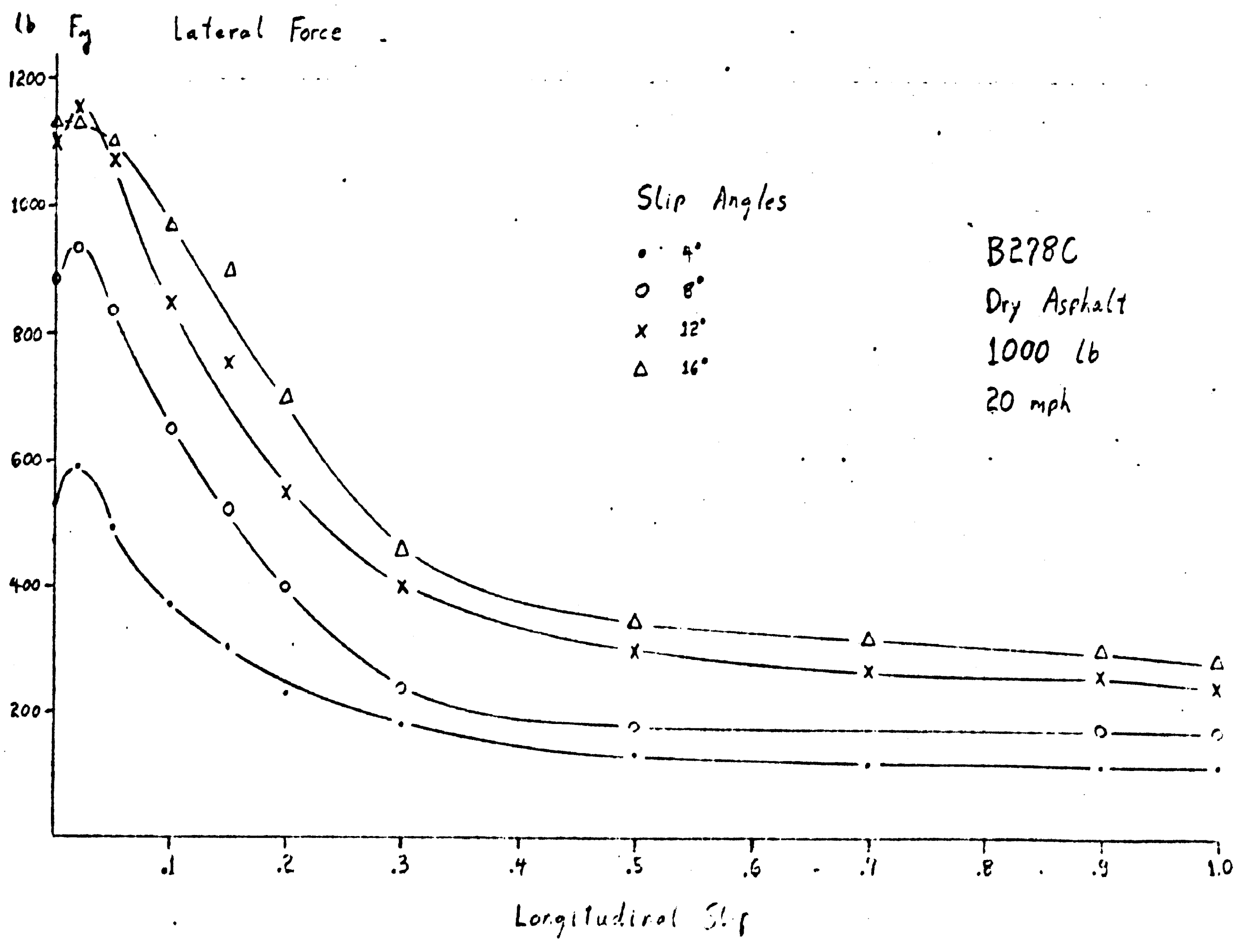

Lateral Force
lb F_y
Slip Angles
2°
4°
8°
B278C
Wet Asphalt
1100 lb
40 mph
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


Longitudinal Force
lb
F_x
1000
800
600
400
200
Slip Angles
• 0°
o 2°
x 4°
Δ 8°
B278C
Wet Asphalt
1100 lb
55 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

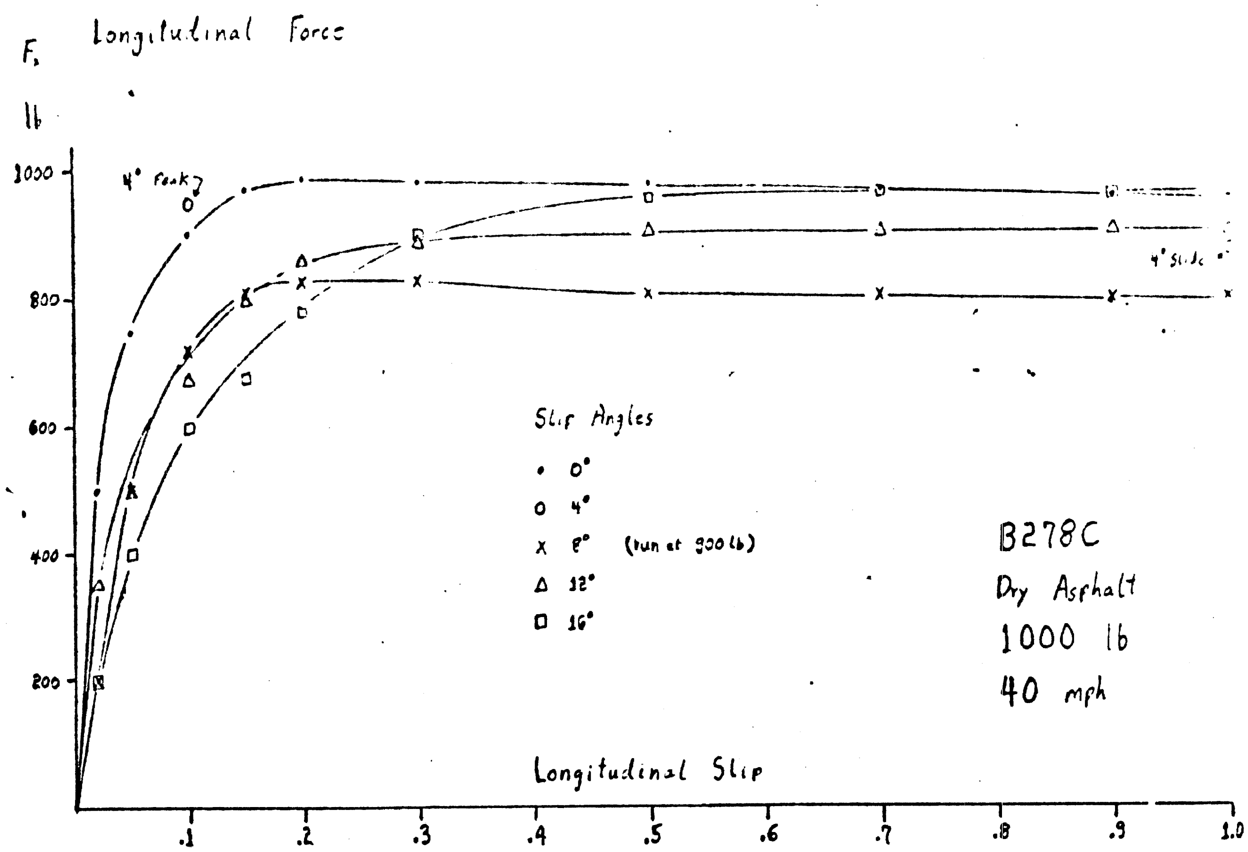

Lateral Force
Slip Angles
• 2°
o 4°
x 8°
F_y
lb
B278C
Wet Asphalt
1100 lb
55 mph
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip



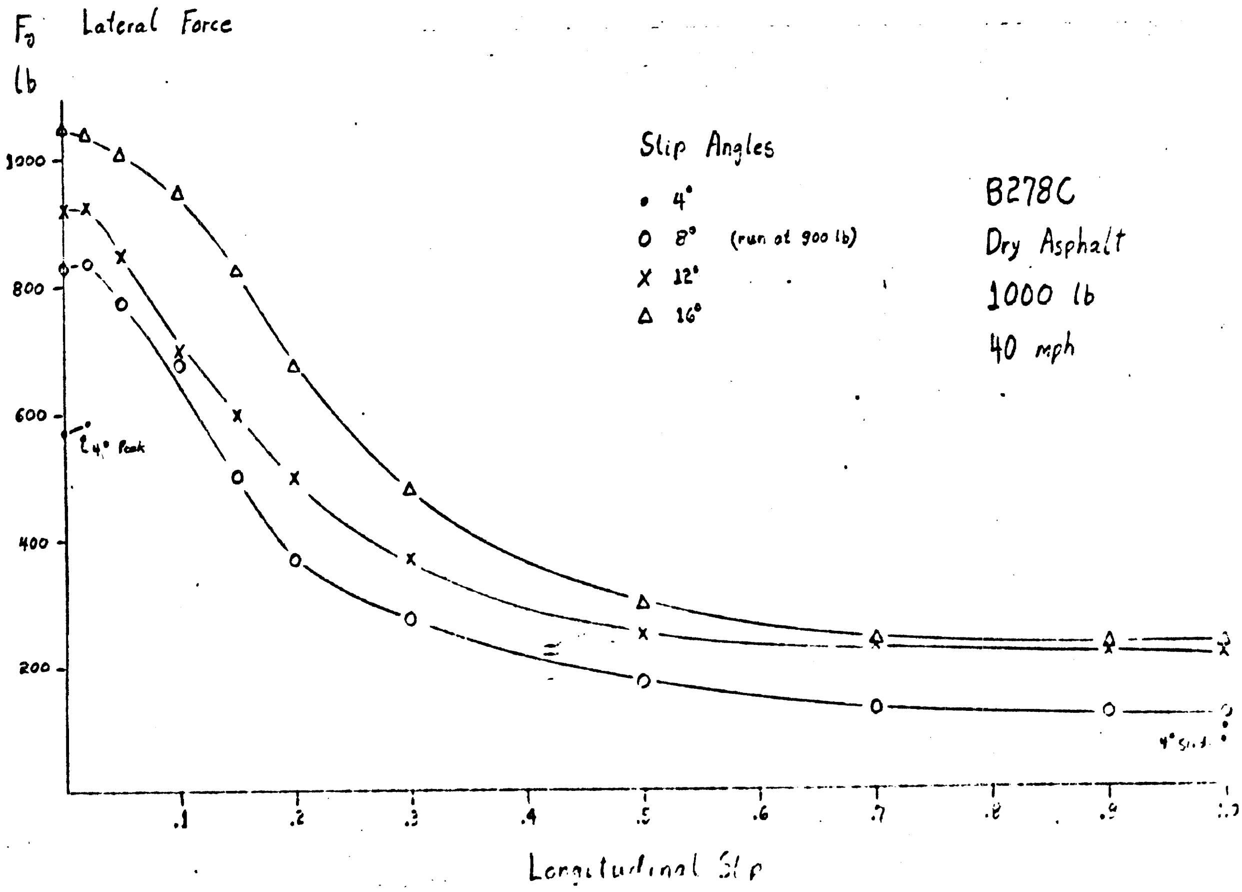
F_x Longitudinal Force
lb
1000
800
600
400
200
Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278C
Dry Asphalt
1000 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0



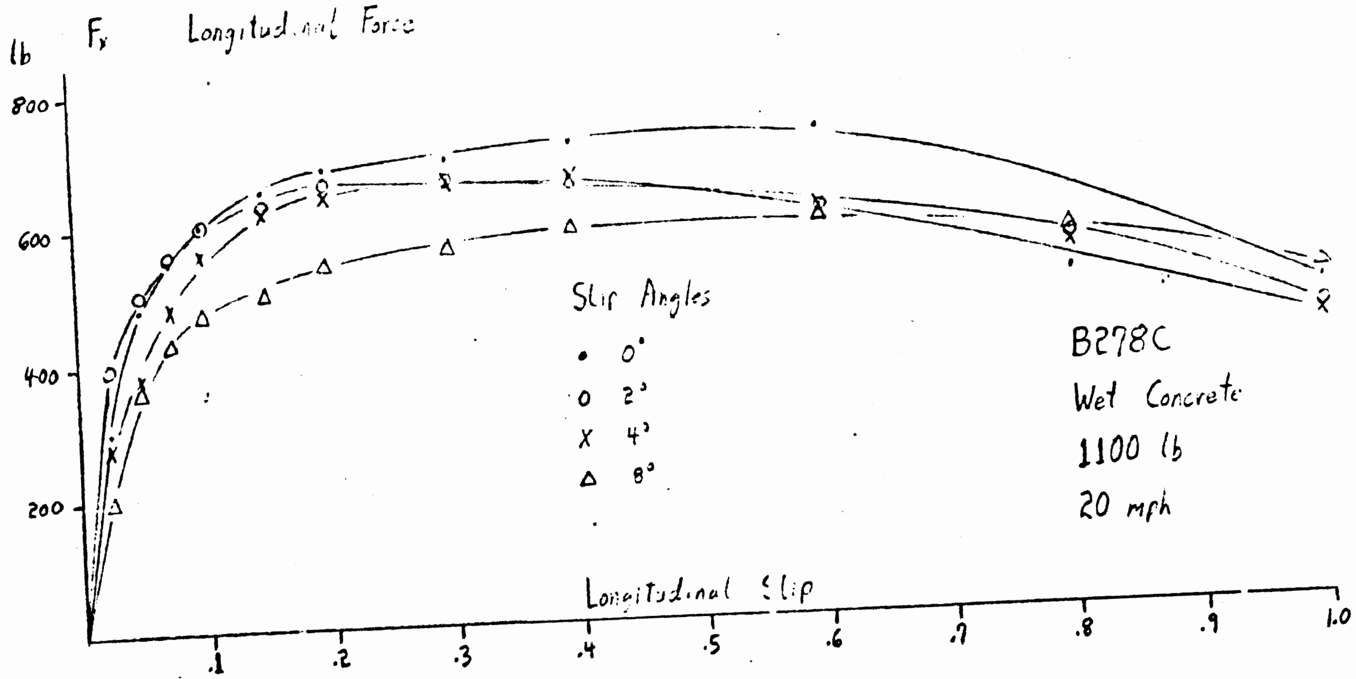
lb F_y Lateral Force
1200
1000
800
600
400
200
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278C
Dry Asphalt
1000 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip



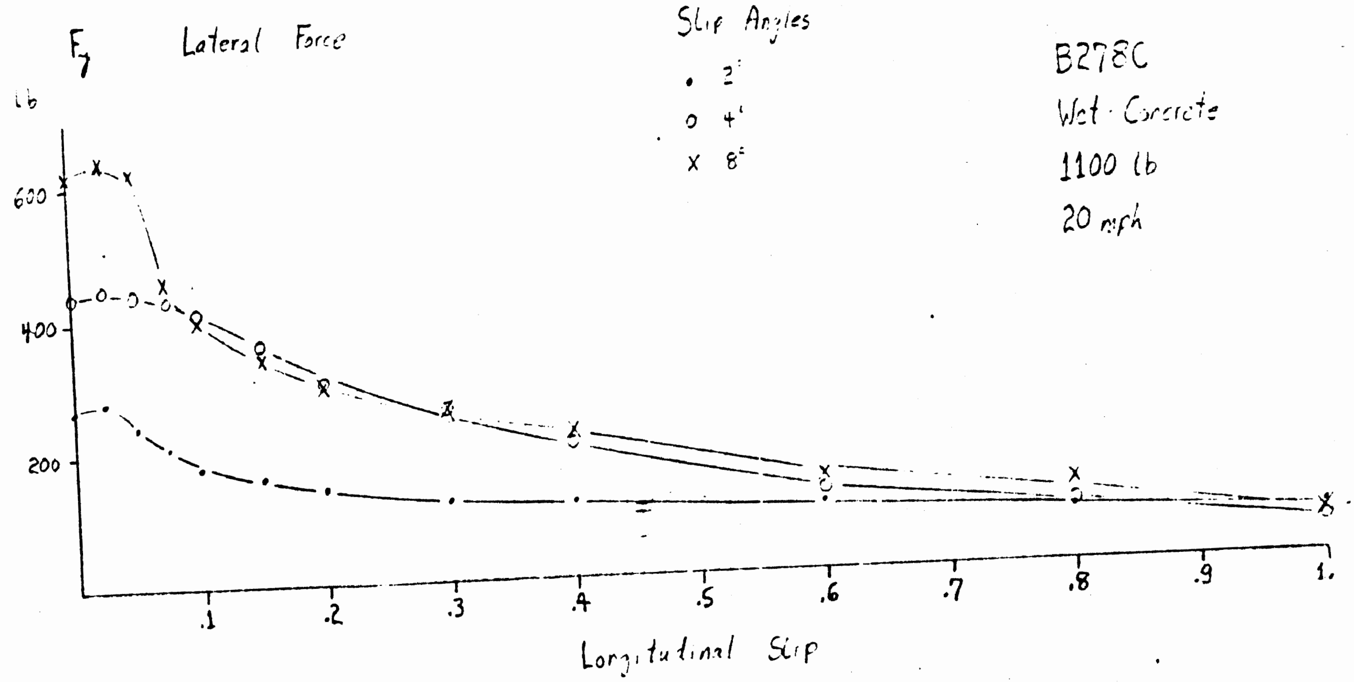
F_x Longitudinal Force
lb
1000
800
600
400
200
4° Peak
4° Slide
Slip Angles
• 0°
o 4°
x 8° (run at 900 lb)
Δ 12°
□ 16°
B278C
Dry Asphalt
1000 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0



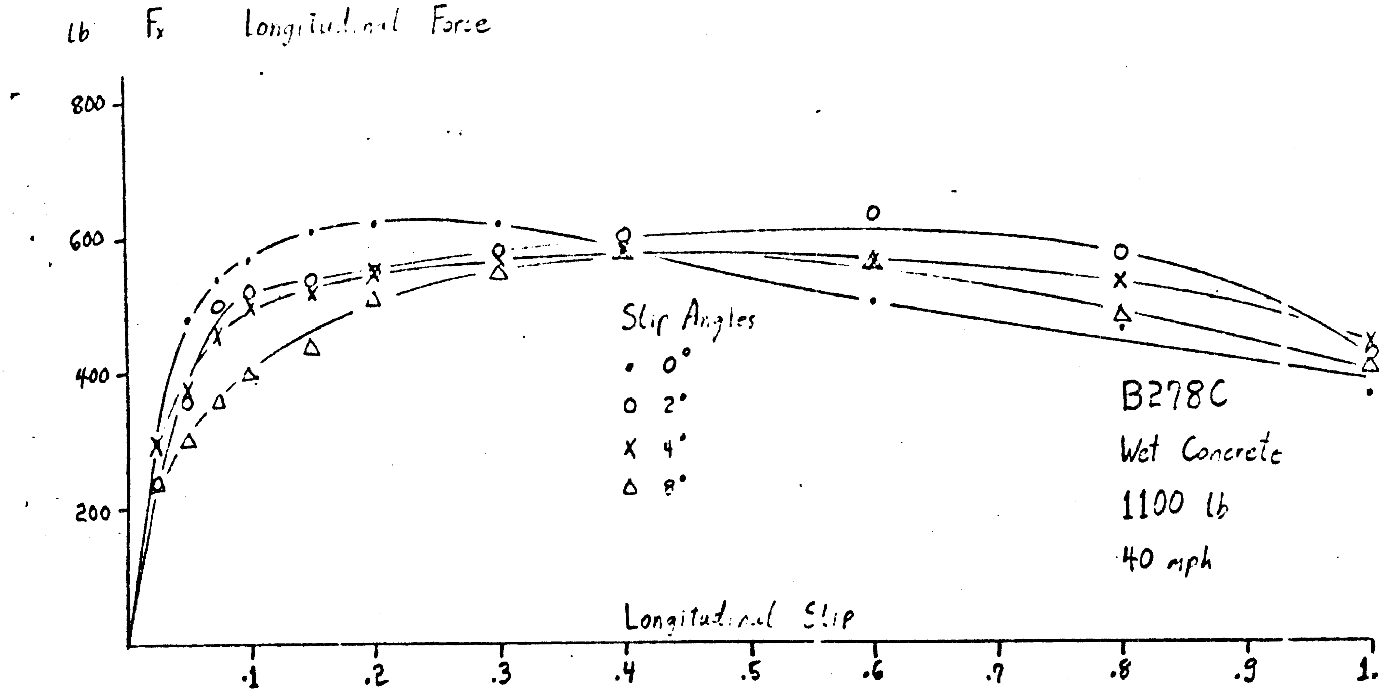
F_y Lateral Force
lb
1000
800
600
400
200
4° Peak
4° Slide
Slip Angles
• 4°
o 8° (run at 900 lb)
x 12°
Δ 16°
B278C
Dry Asphalt
1000 lb
40 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
Longitudinal Slip

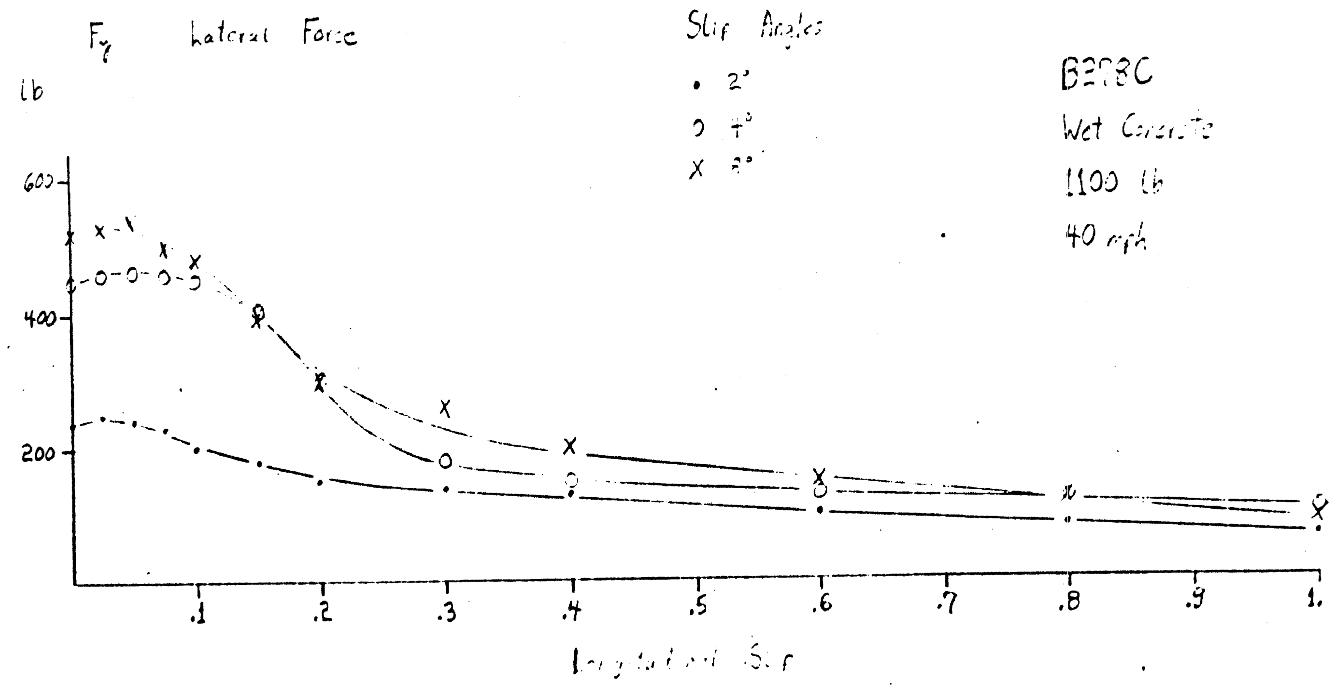


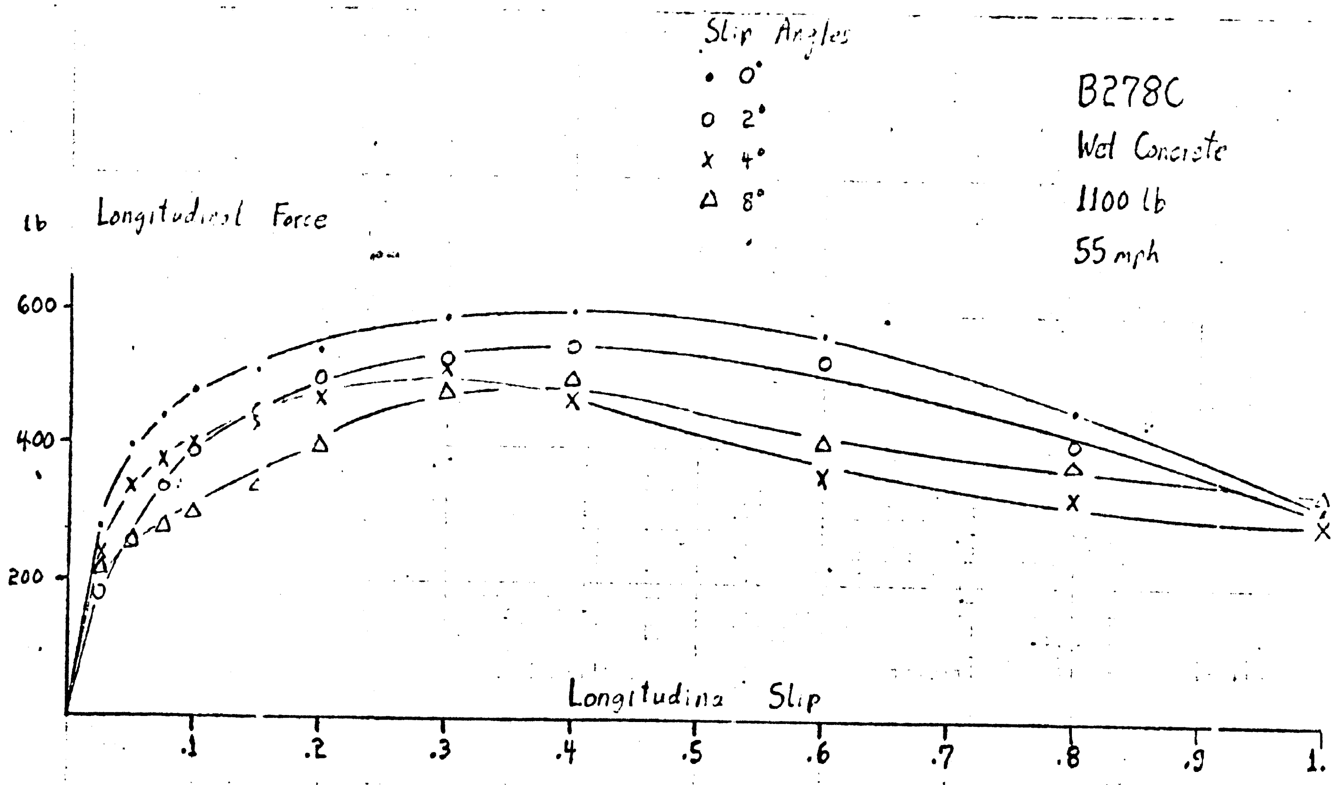
lb
F_x Longitudinal Force
800
600
400
200
Slip Angles
• 0°
o 2°
x 4°
Δ 8°
B278C
Wet Concrete
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0



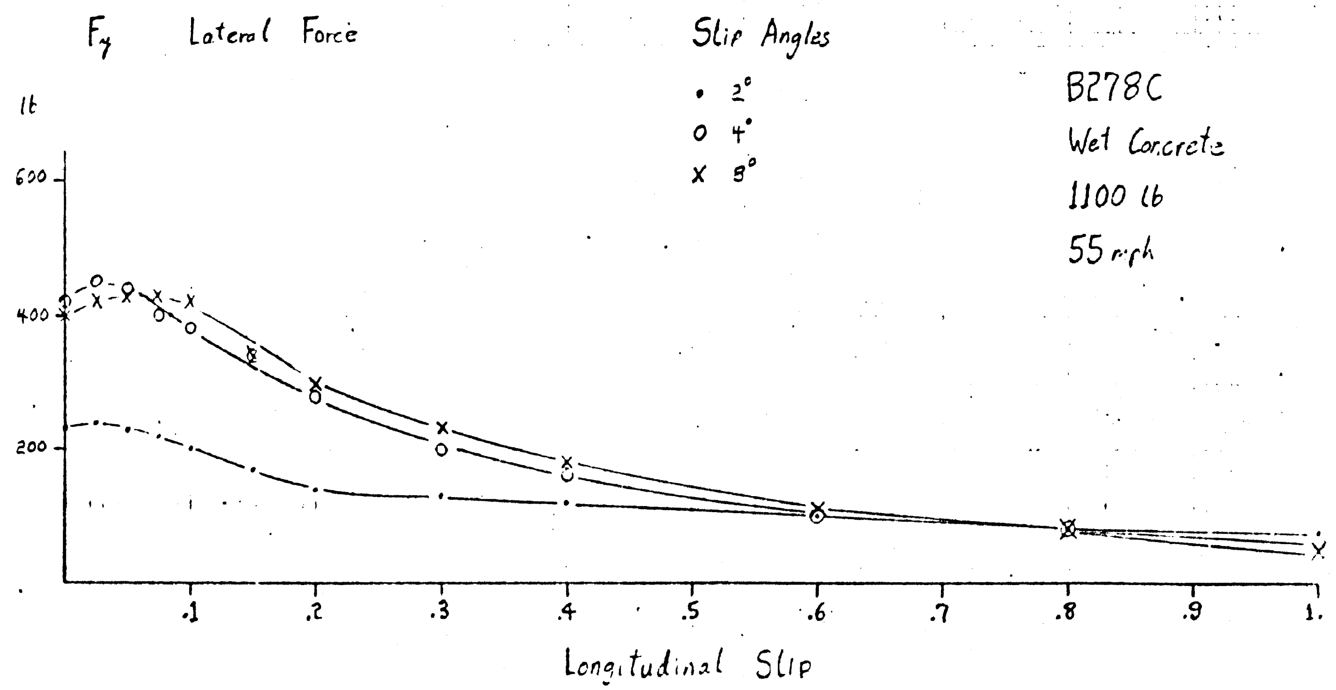
F_y Lateral Force
lb
600
400
200
Slip Angles
• 2°
o 4°
x 8°
B278C
Wet Concrete
1100 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


lb
F_x Longitudinal Force
800
600
400
200
Slip Angles
0°
2°
4°
8°
B278C
Wet Concrete
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

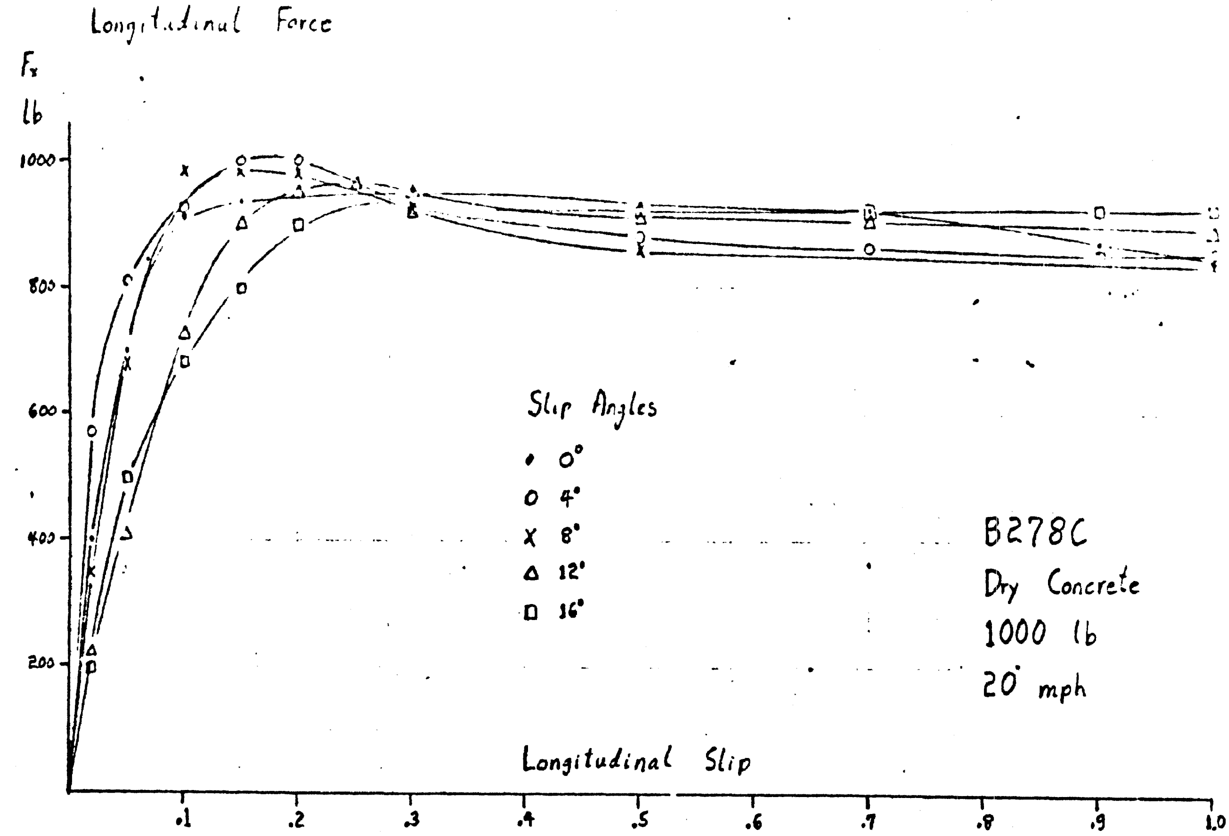

F_y Lateral Force
lb
Slip Angles
2°
B278C
Wet Concrete
1100 lb
40 mph
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.

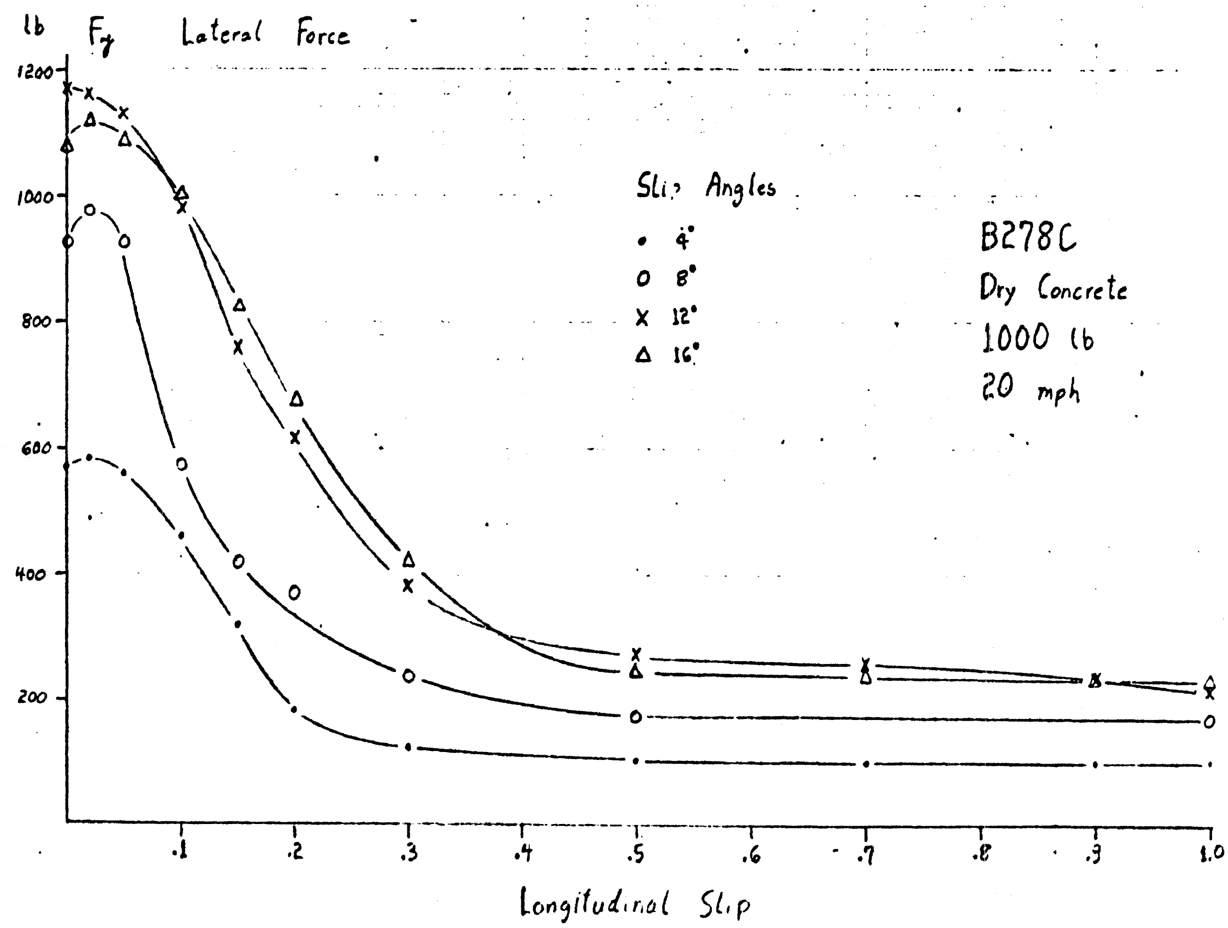


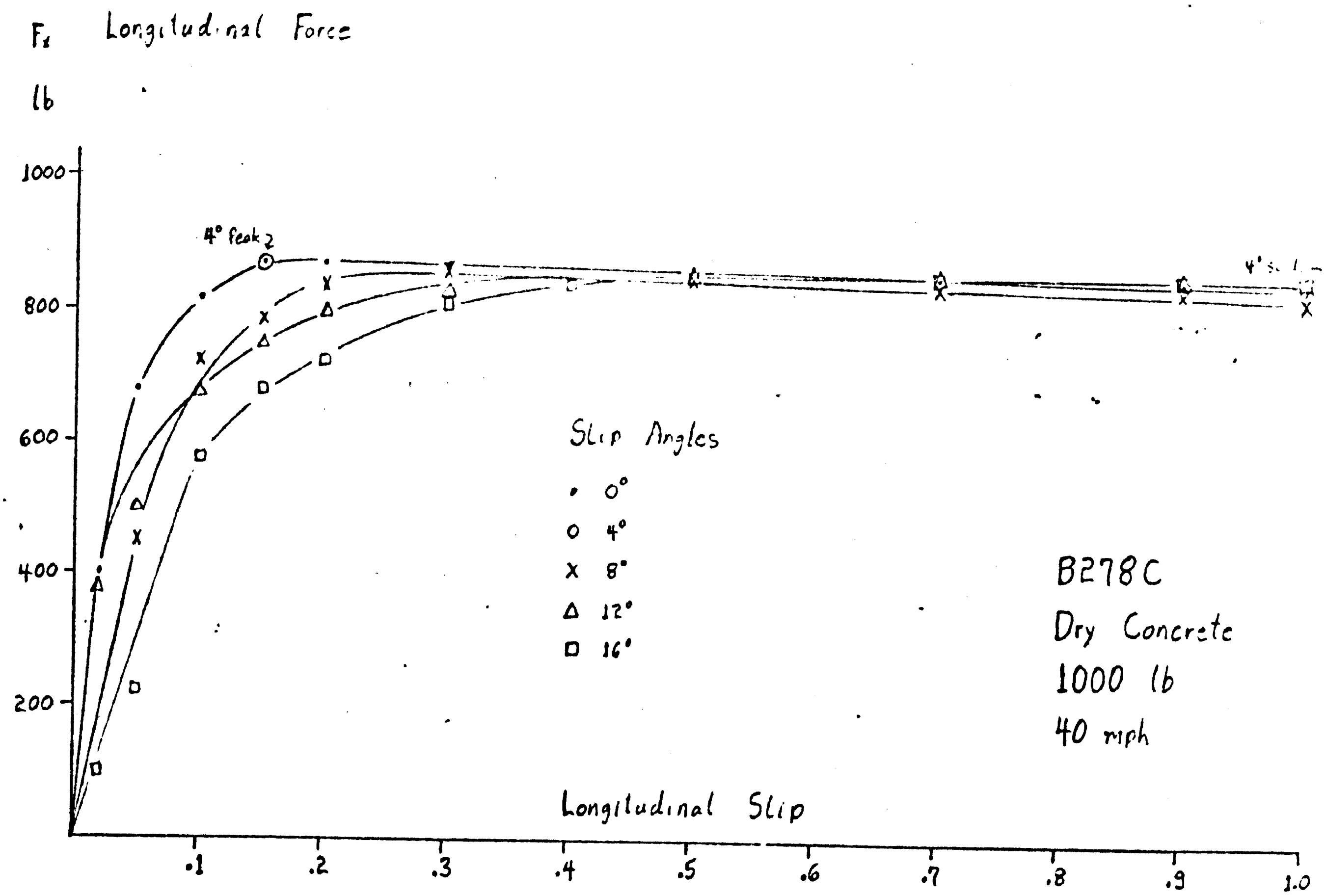
Slip Angles
• 0°
o 2°
x 4°
Δ 8°
B278C
Wet Concrete
1100 lb
55 mph
lb Longitudinal Force
600
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.



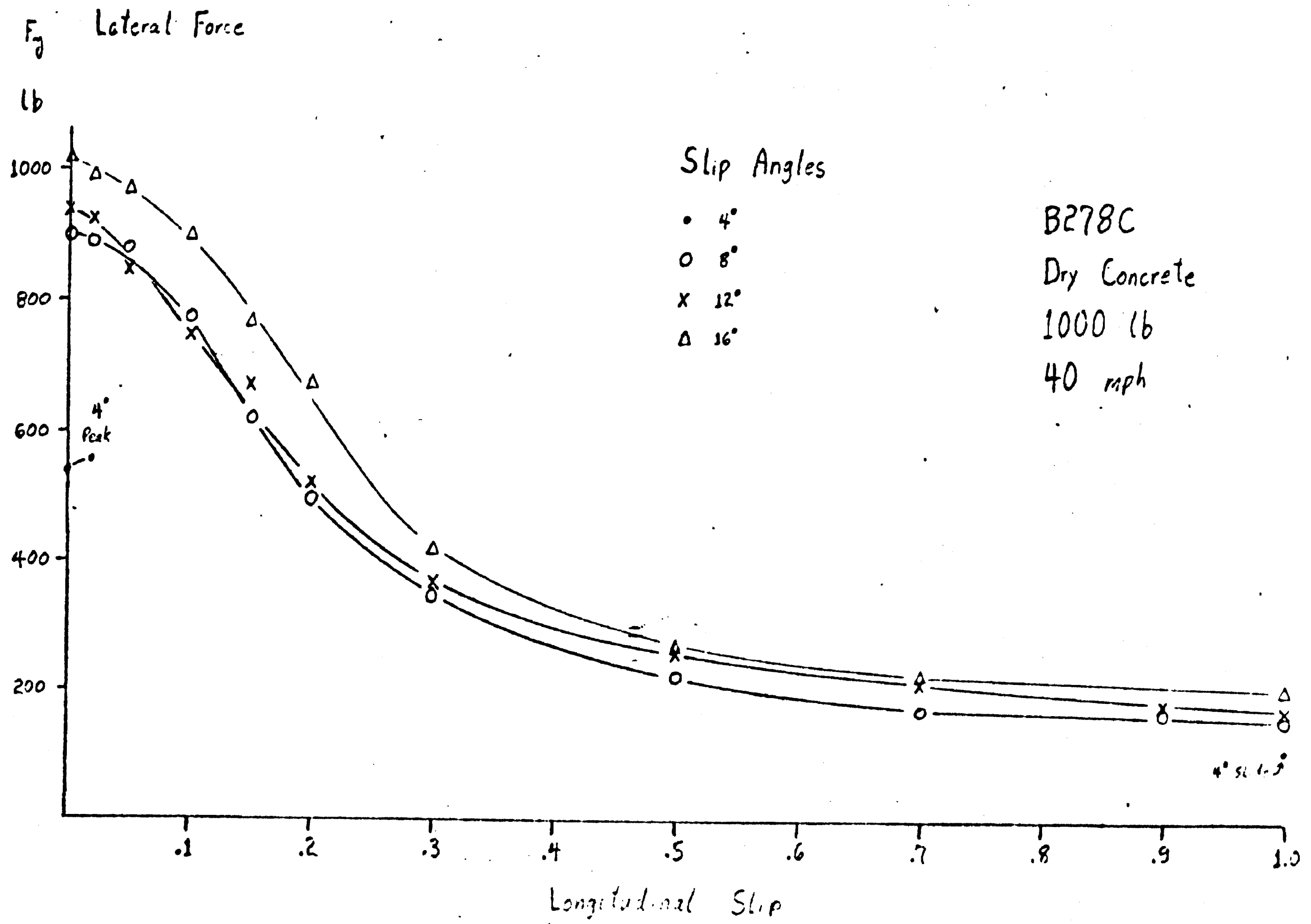
F_y Lateral Force
Slip Angles
• 2°
o 4°
x 8°
B278C
Wet Concrete
1100 lb
55 mph
lb
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.
Longitudinal Slip


Longitudinal Force
Fx
lb
1000
800
600
400
200
Slip Angles
0°
4°
8°
12°
16°
B278C
Dry Concrete
1000 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

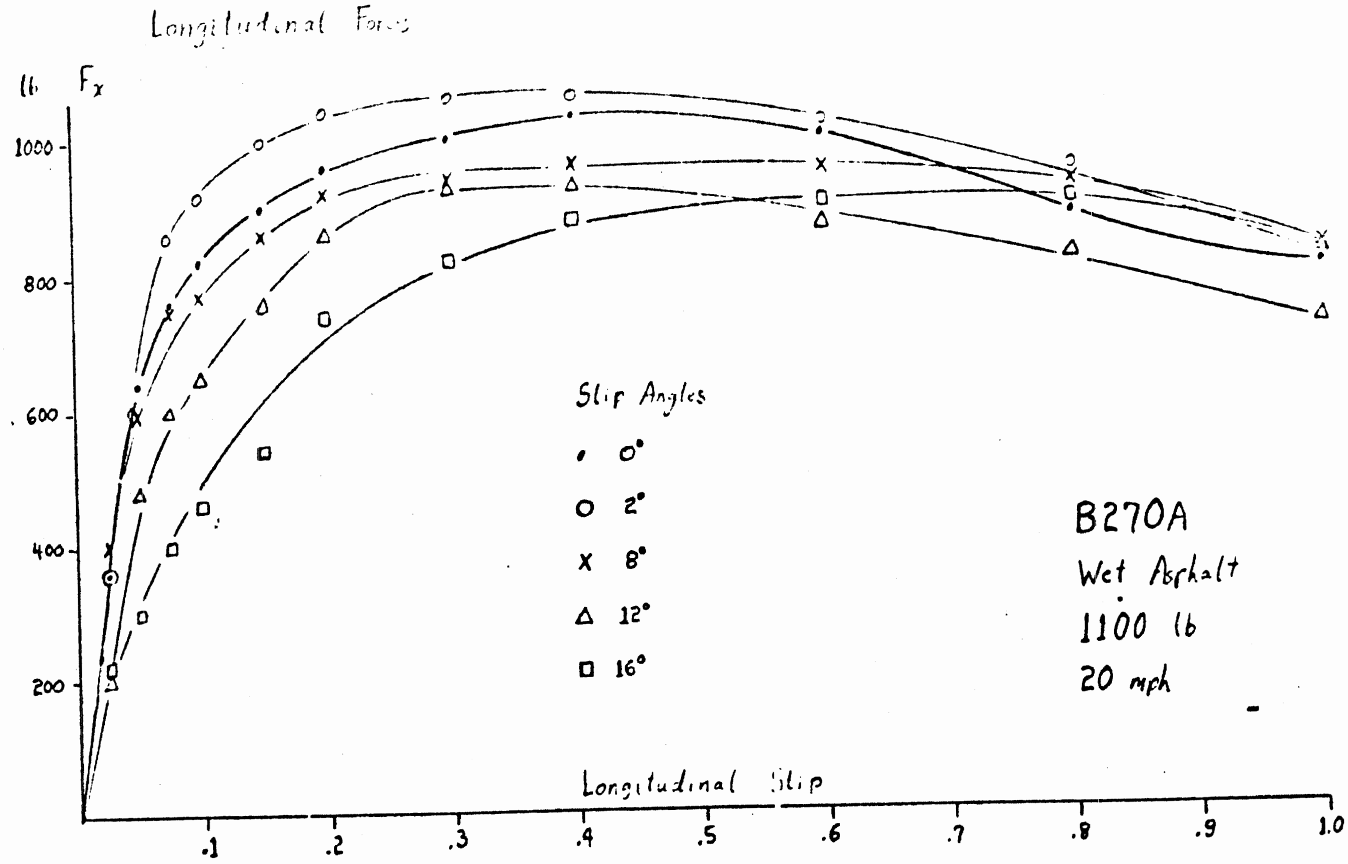

lb
Fy
Lateral Force
1200
1000
800
600
400
200
Slip Angles
4°
8°
12°
16°
B278C
Dry Concrete
1000 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip

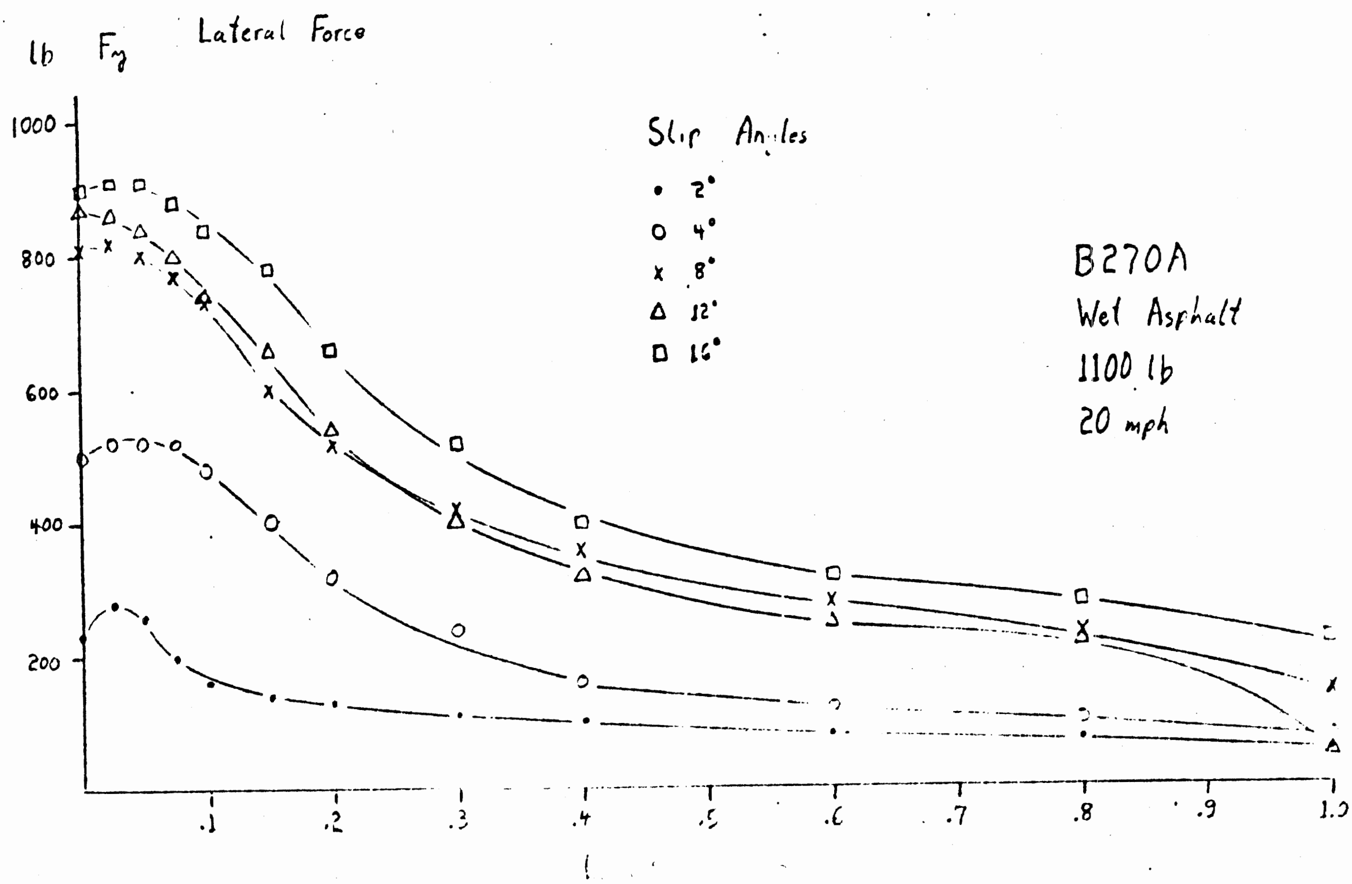


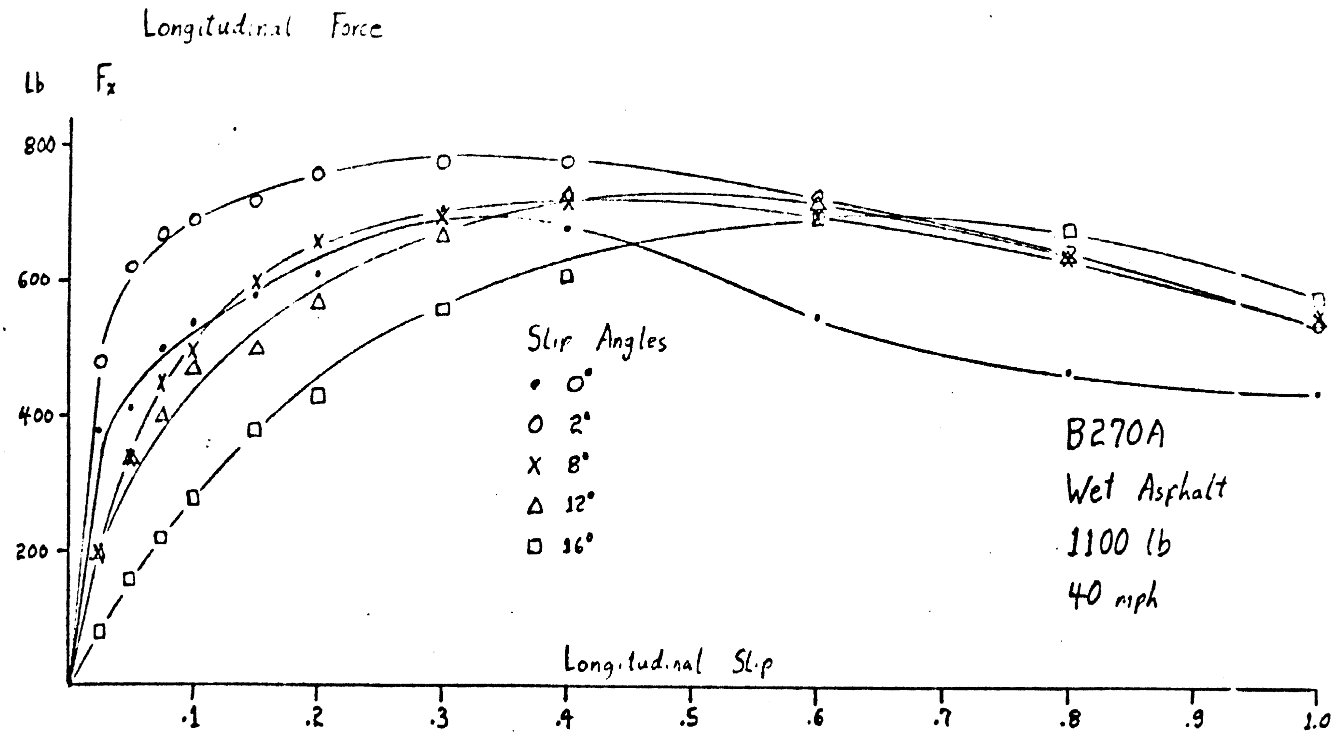
F_x Longitudinal Force
lb
1000
800
600
400
200
4° Peak
Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
B278C
Dry Concrete
1000 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

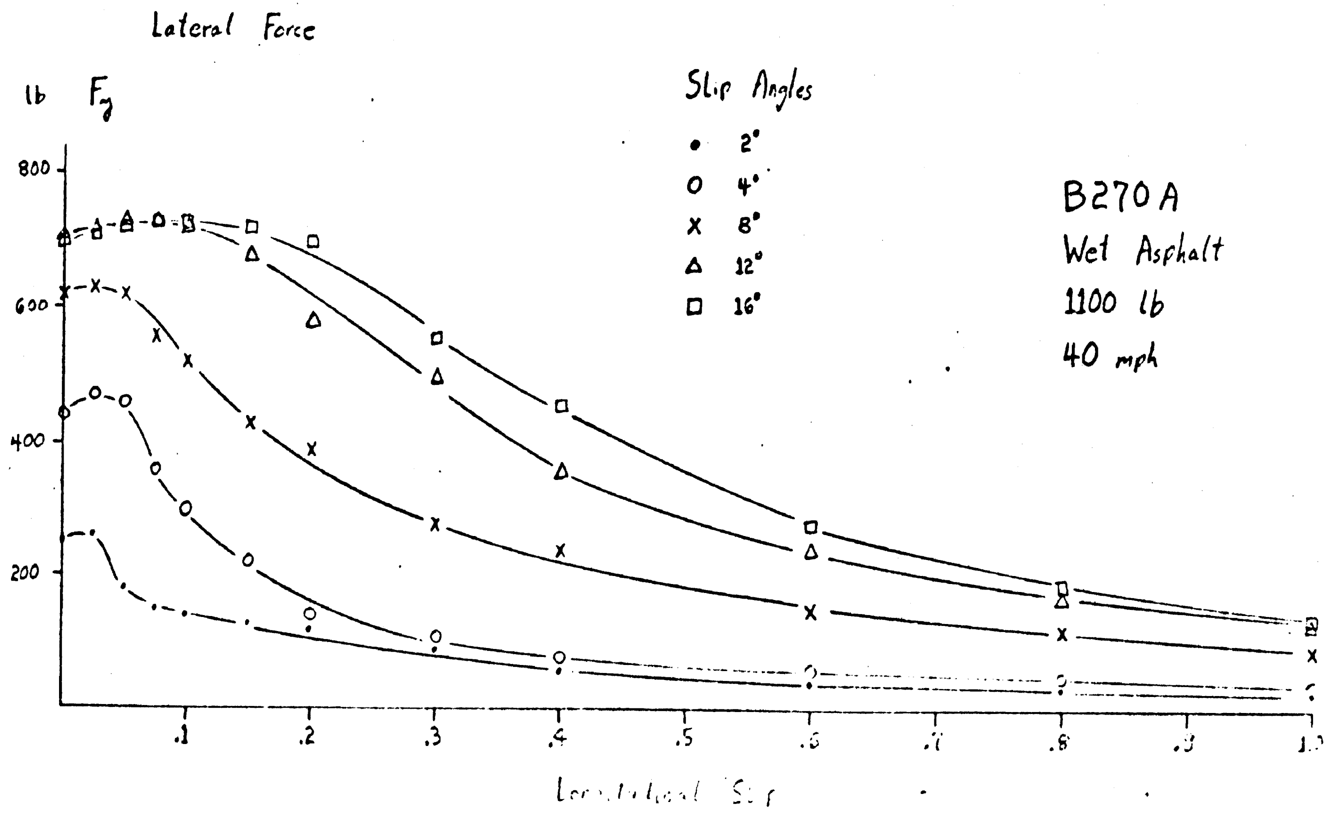


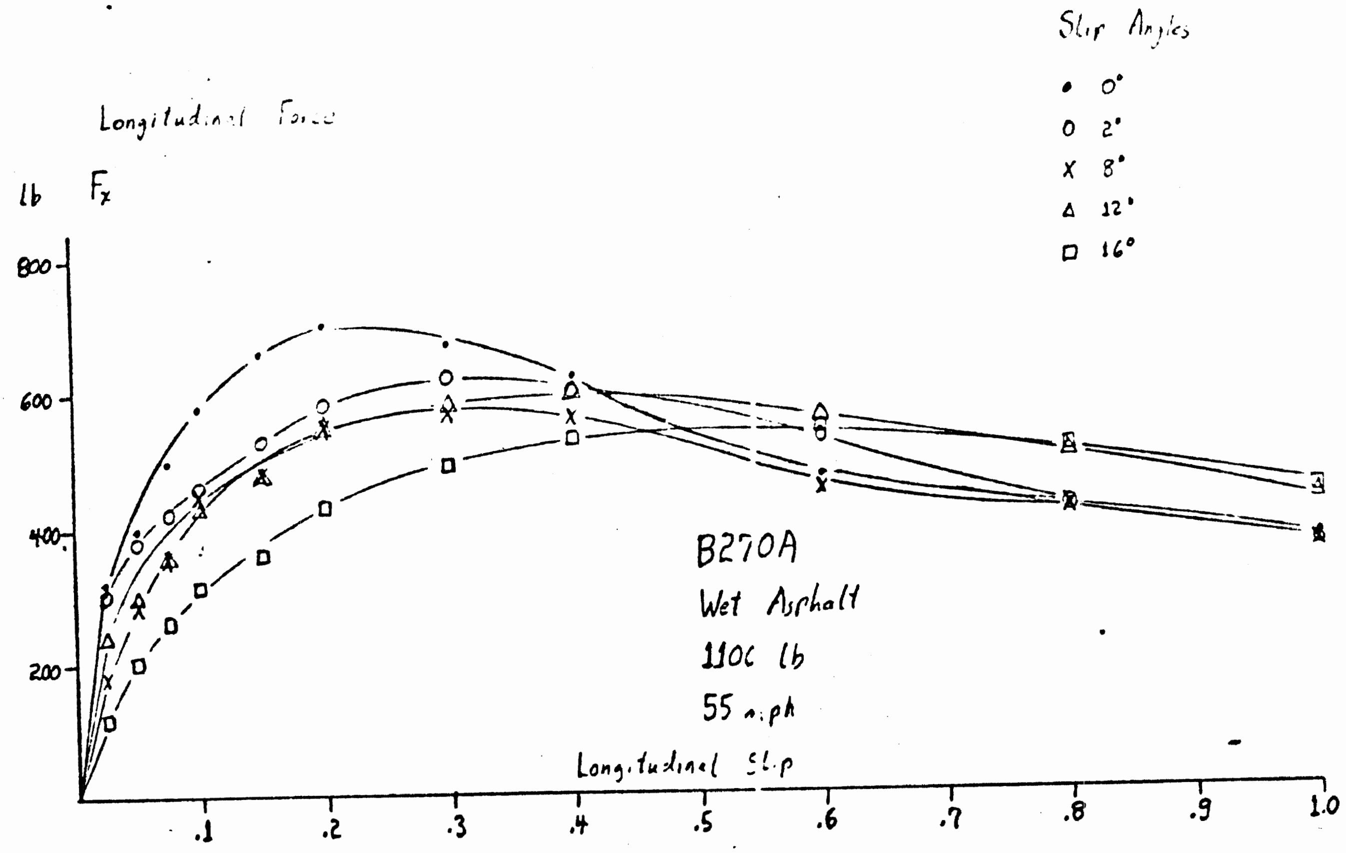
F_y Lateral Force
lb
1000
800
600
400
200
4° Peak
Slip Angles
• 4°
o 8°
x 12°
Δ 16°
B278C
Dry Concrete
1000 lb
40 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip


Longitudinal Force
lb Fx
1000
800
600
400
200
Slip Angles
0°
2°
8°
12°
16°
B270A
Wet Asphalt
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


lb Fy
Lateral Force
1000
800
600
400
200
Slip Angles
2°
4°
8°
12°
16°
B270A
Wet Asphalt
1100 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


Longitudinal Force
lb F_x
800
600
400
200
Slip Angles
• 0°
○ 2°
x 8°
△ 12°
□ 16°
B270A
Wet Asphalt
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


Lateral Force
lb F_y
800
600
400
200
Slip Angles
• 2°
○ 4°
x 8°
△ 12°
□ 16°
B270A
Wet Asphalt
1100 lb
40 mph
.1
.2
.3
.4
.5
.8
1.0


Slip Angles
• 0°
o 2°
x 8°
Δ 12°
□ 16°
Longitudinal Force
lb F_x
800
600
400
200
B270A
Wet Asphalt
1100 lb
55 mph
Longitudinal Slip
.1
.2
.3
.4
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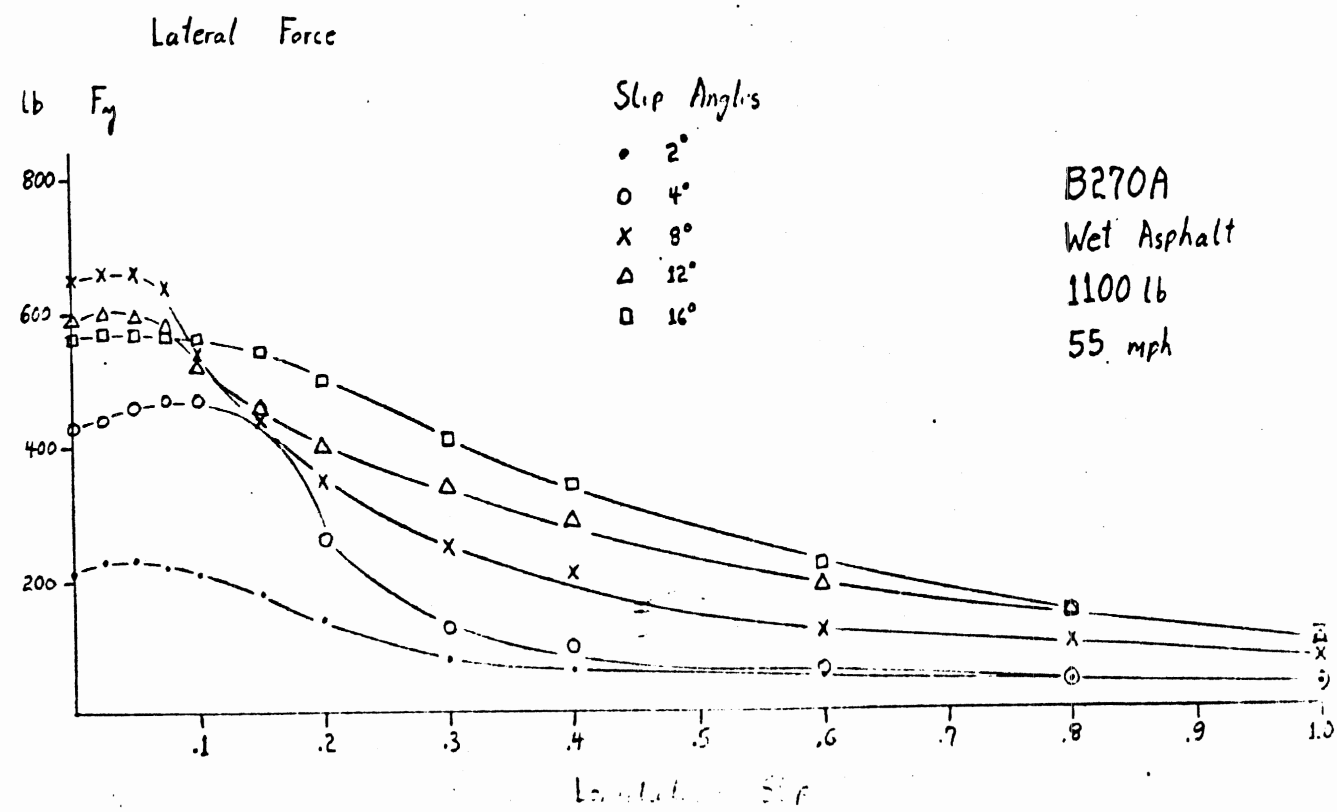
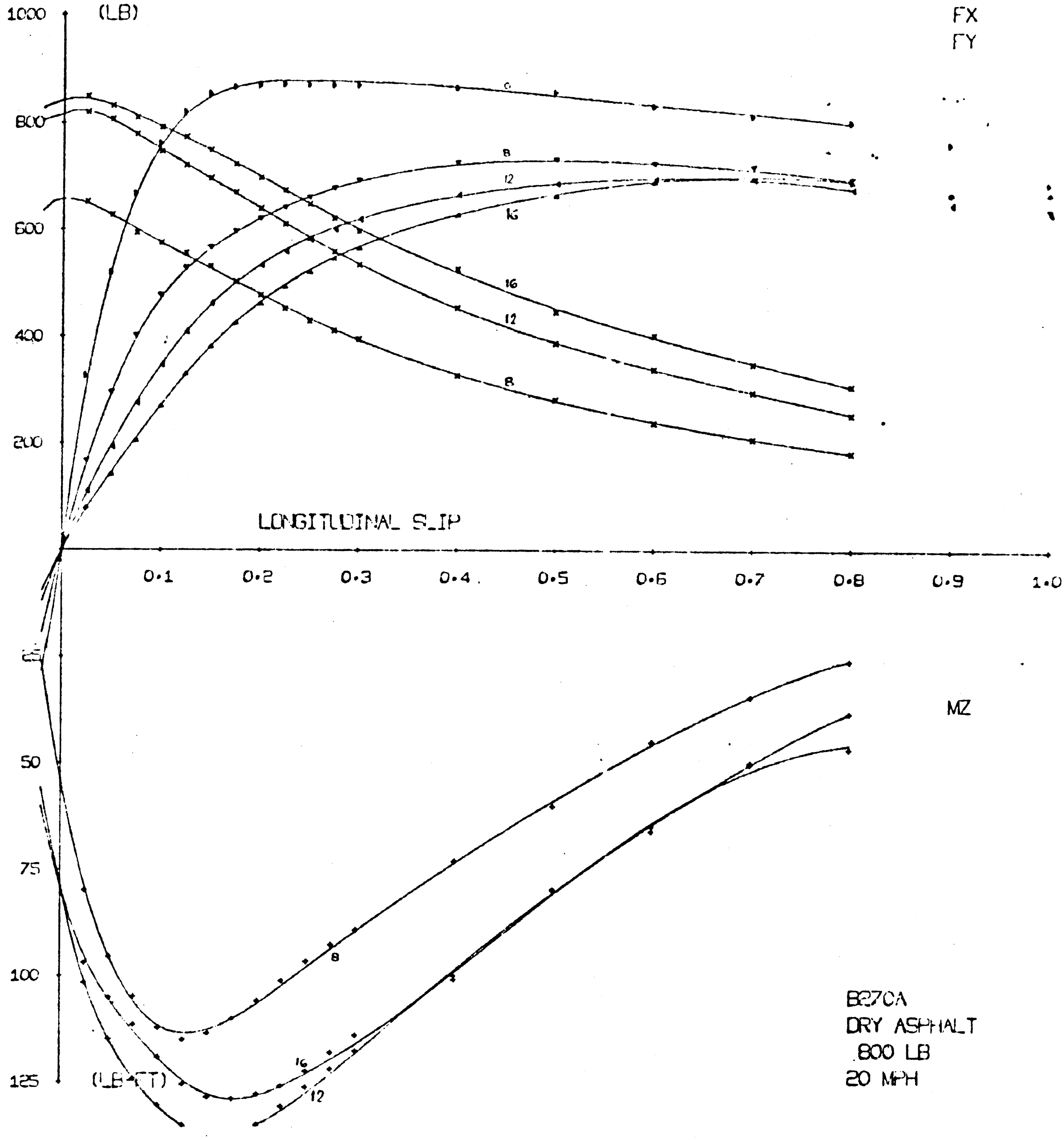
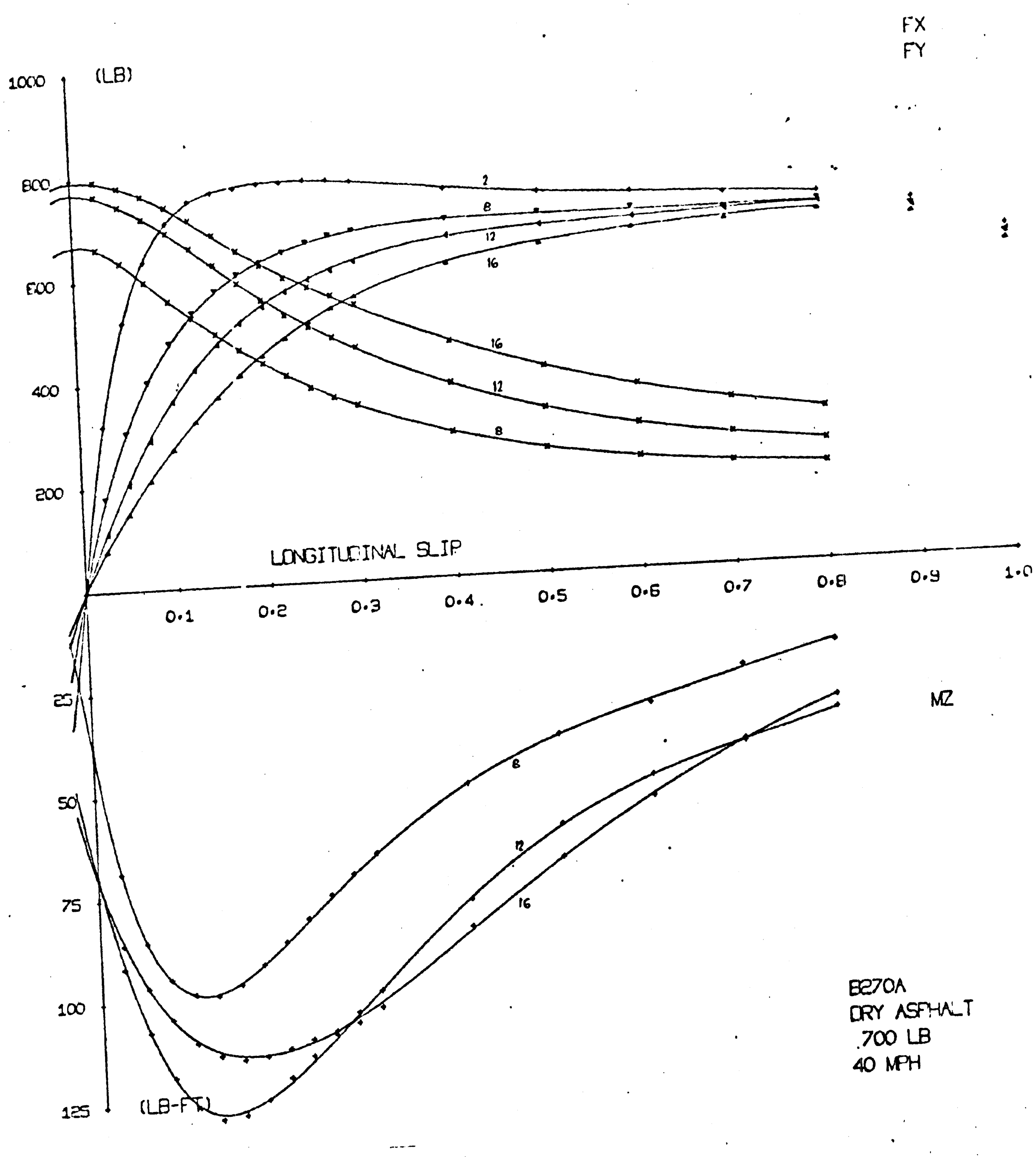
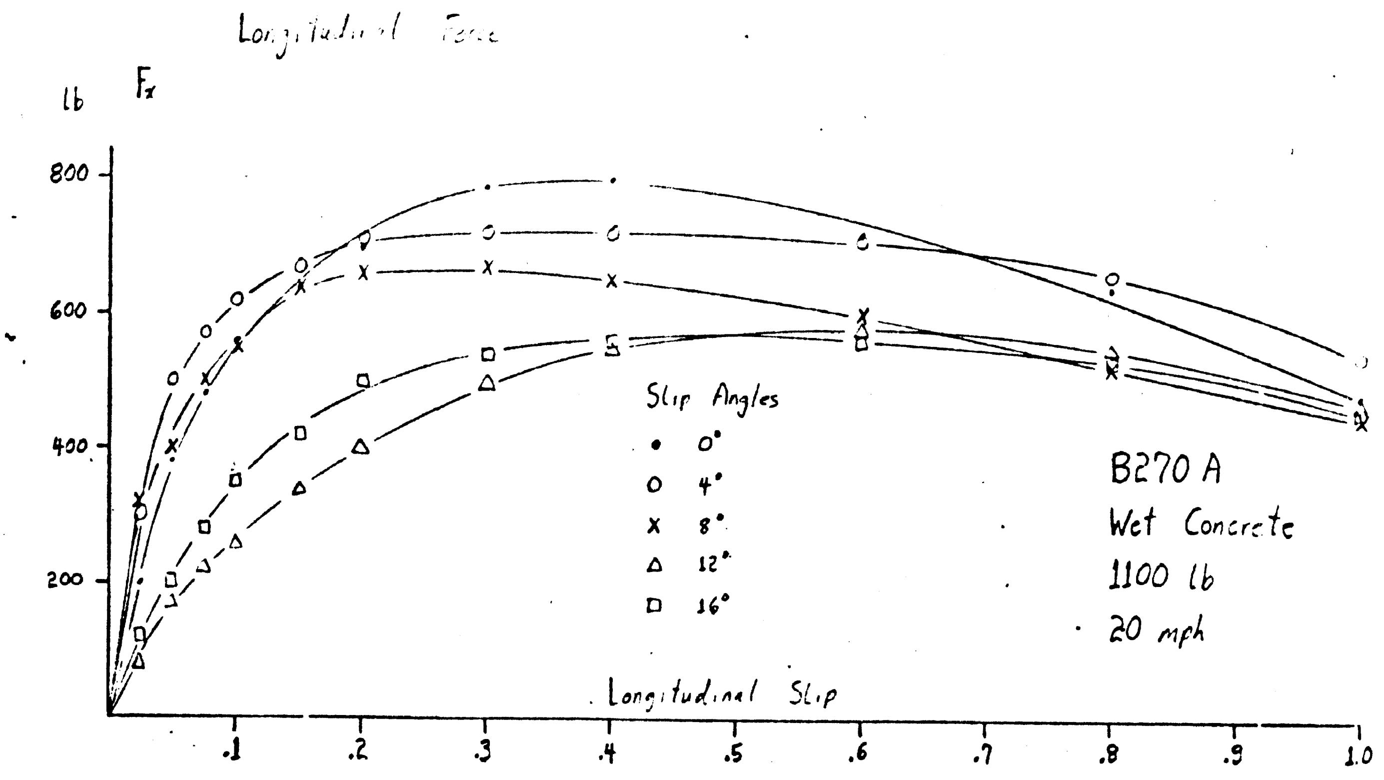
.9
1.0

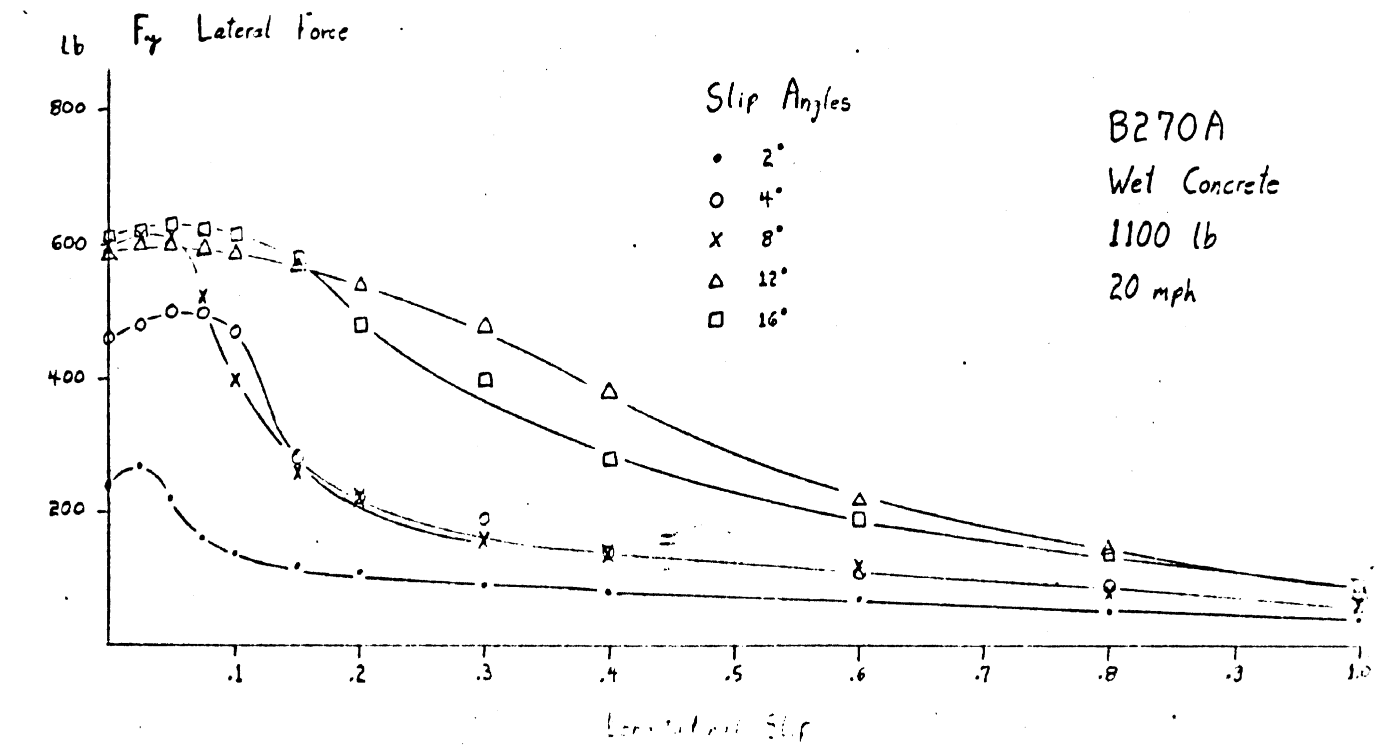

Lateral Force
lb F_y
Slip Angles
• 2°
o 4°
x 8°
Δ 12°
□ 16°
B270A
Wet Asphalt
1100 lb
55 mph
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

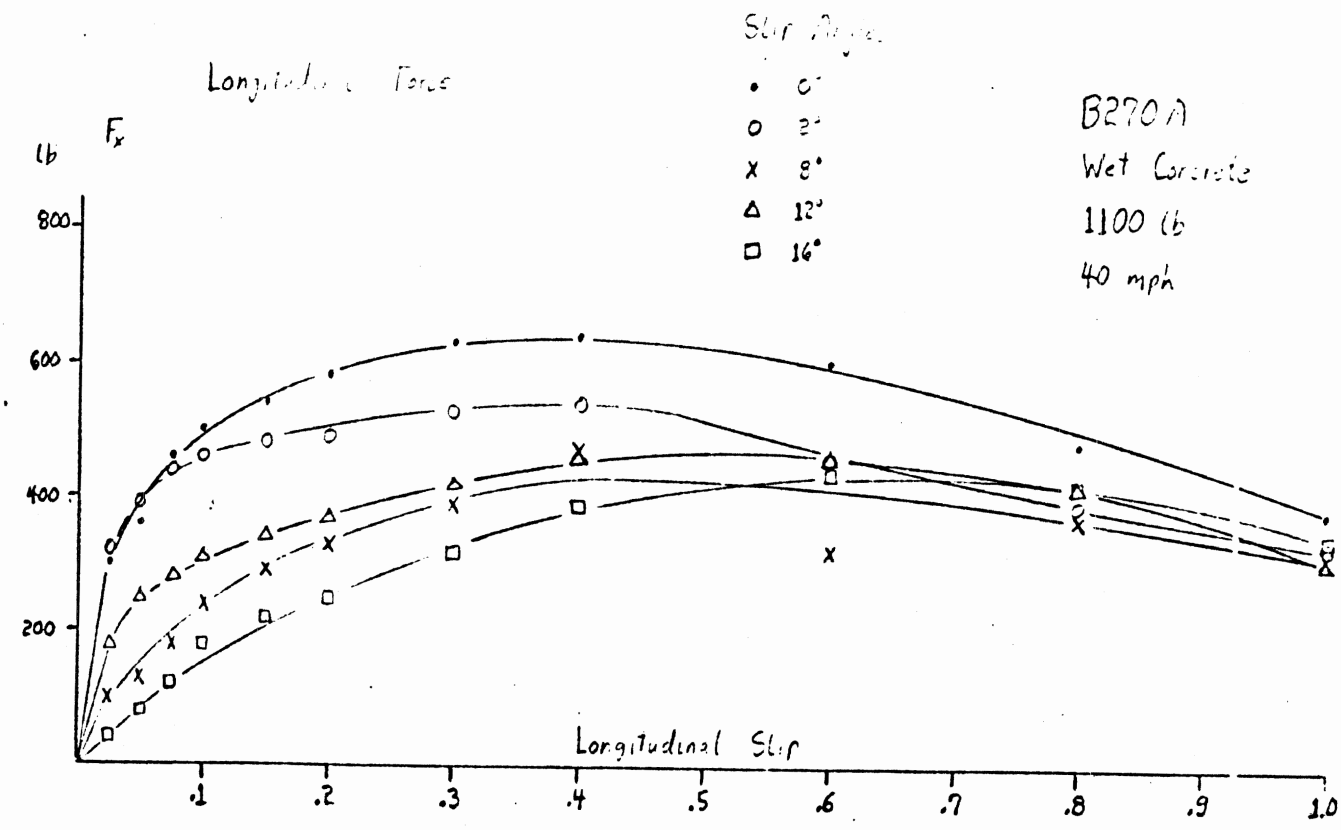


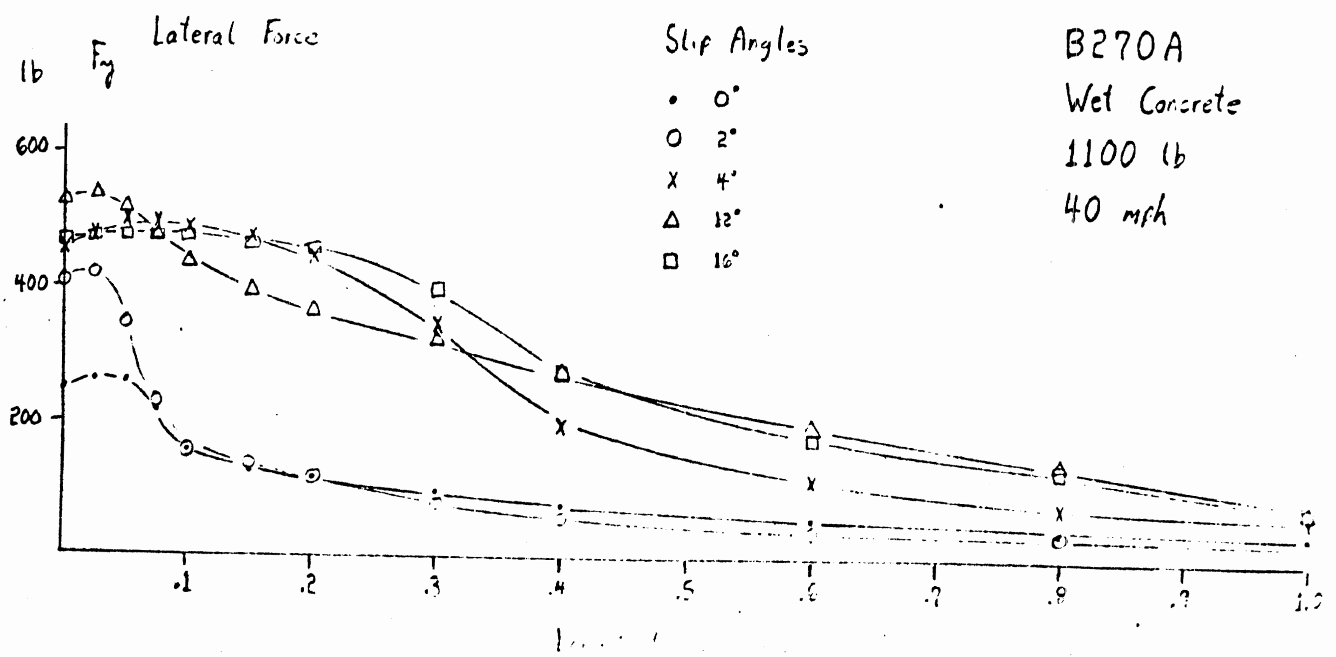
1000
(LB)
FX
FY
800
600
400
200
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
8
16
12
B270A
DRY ASPHALT
800 LB
20 MPH

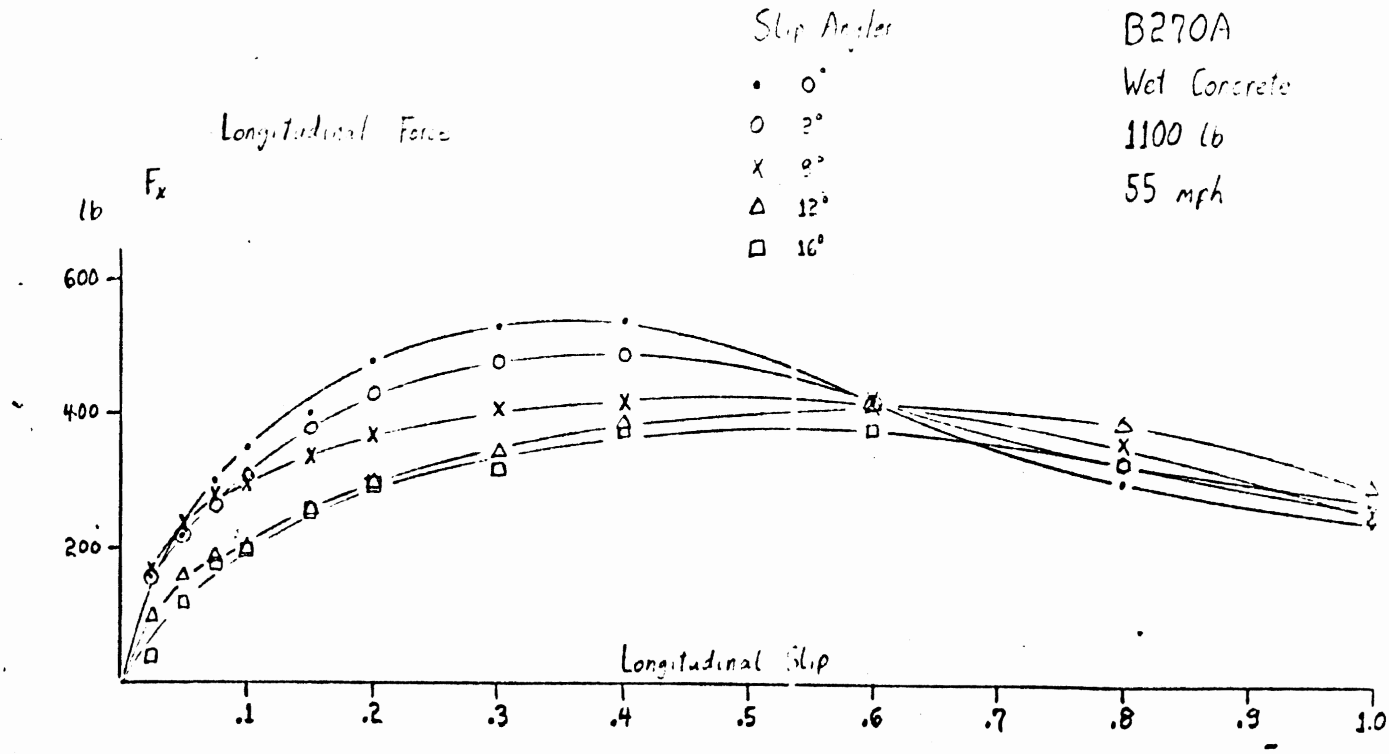

FX
FY
1000
(LB)
800
600
400
200
2
8
12
16
16
12
8
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
MZ
25
50
75
100
125
(LB-FT)
8
12
16
B270A
DRY ASPHALT
700 LB
40 MPH

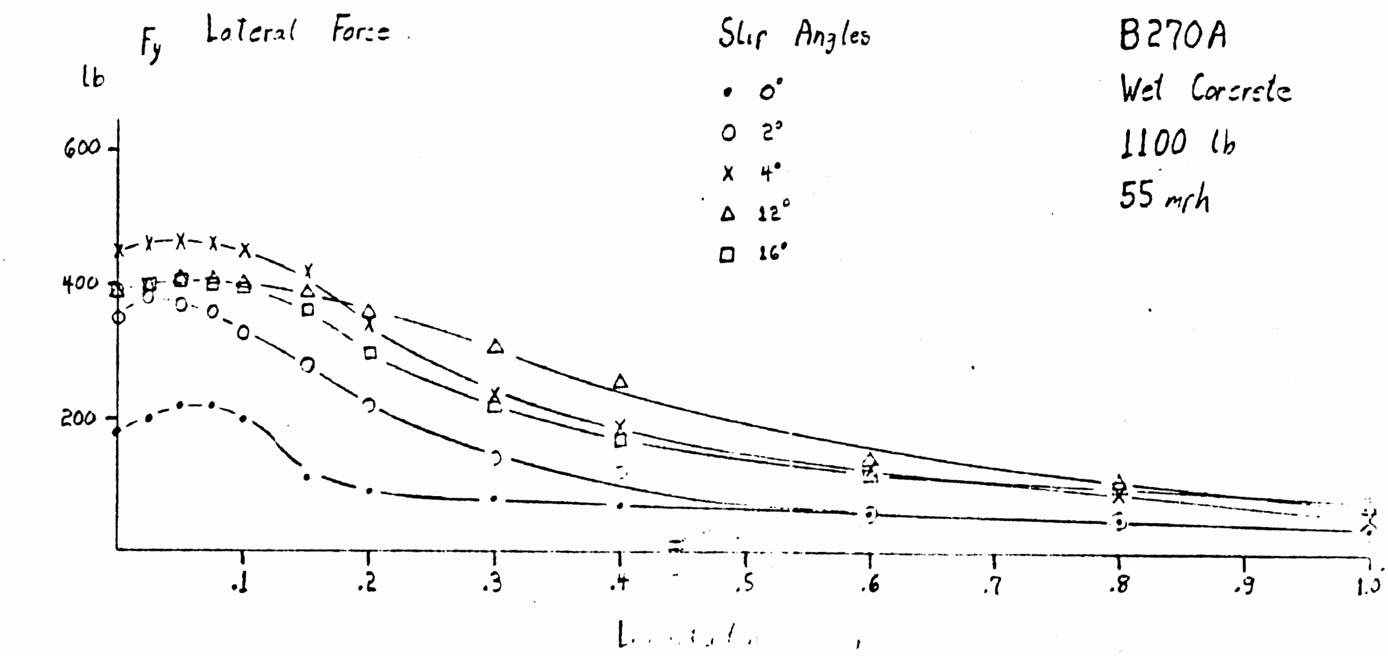

Longitudinal Force
lb
F_x
800
600
400
200
Slip Angles
0°
4°
8°
12°
16°
B270 A
Wet Concrete
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

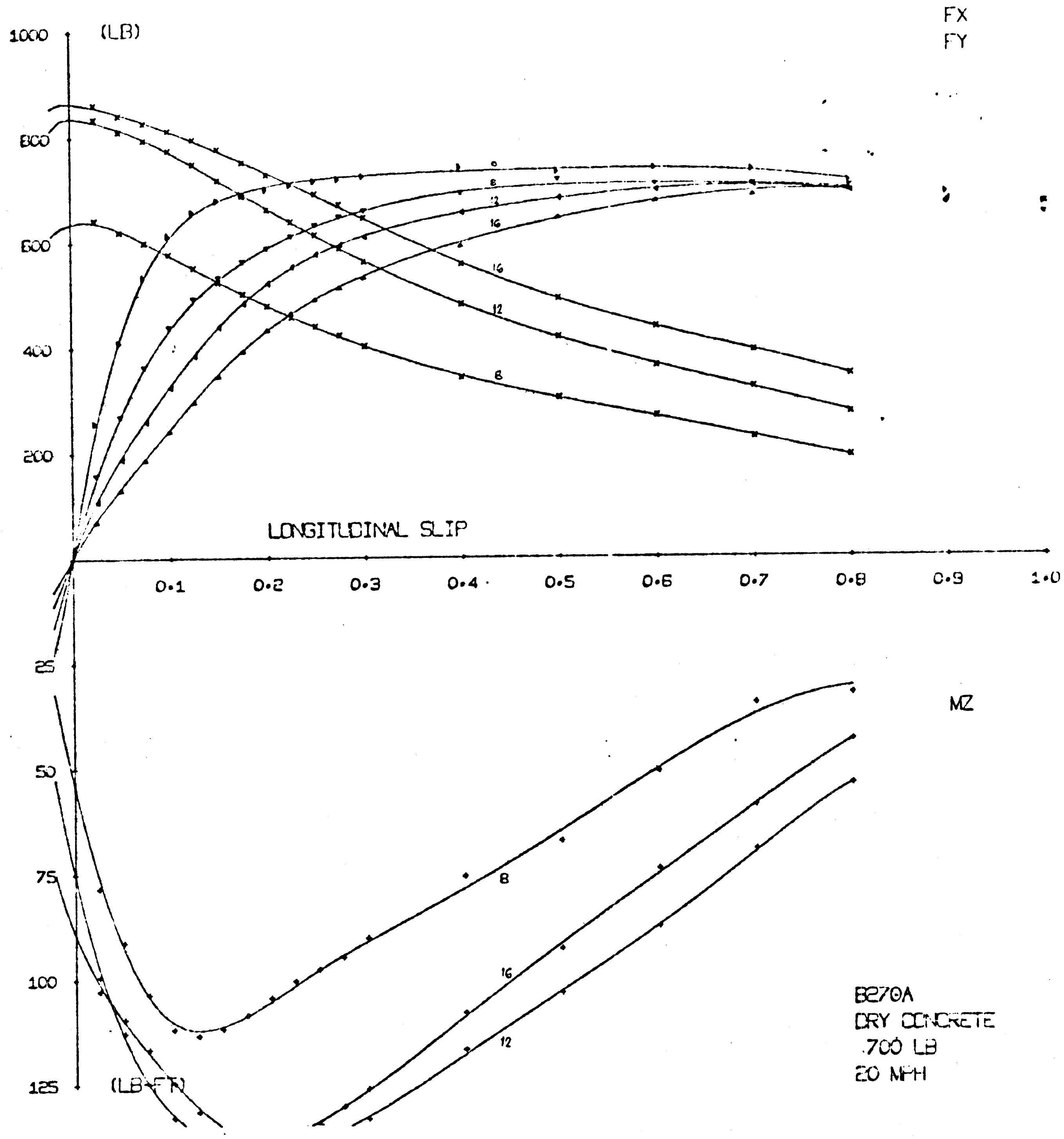

lb
F_y Lateral Force
800
600
400
200
Slip Angles
2°
4°
8°
12°
16°
B270A
Wet Concrete
1100 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

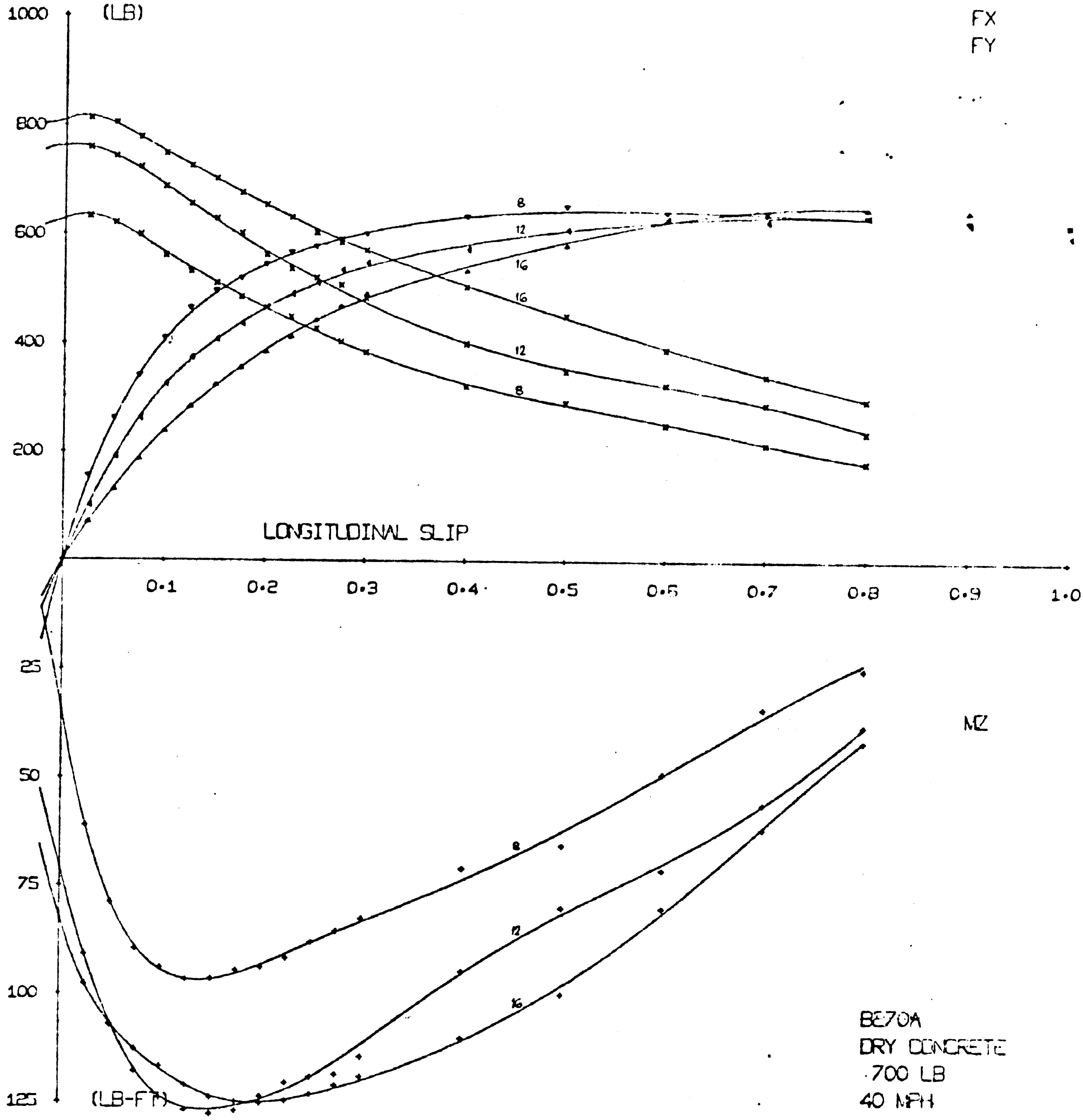

Longitudinal Force
F_x
lb
Slip Angles
• 0°
o 2°
x 8°
Δ 12°
□ 16°
B270A
Wet Concrete
1100 lb
40 mph
800
600
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

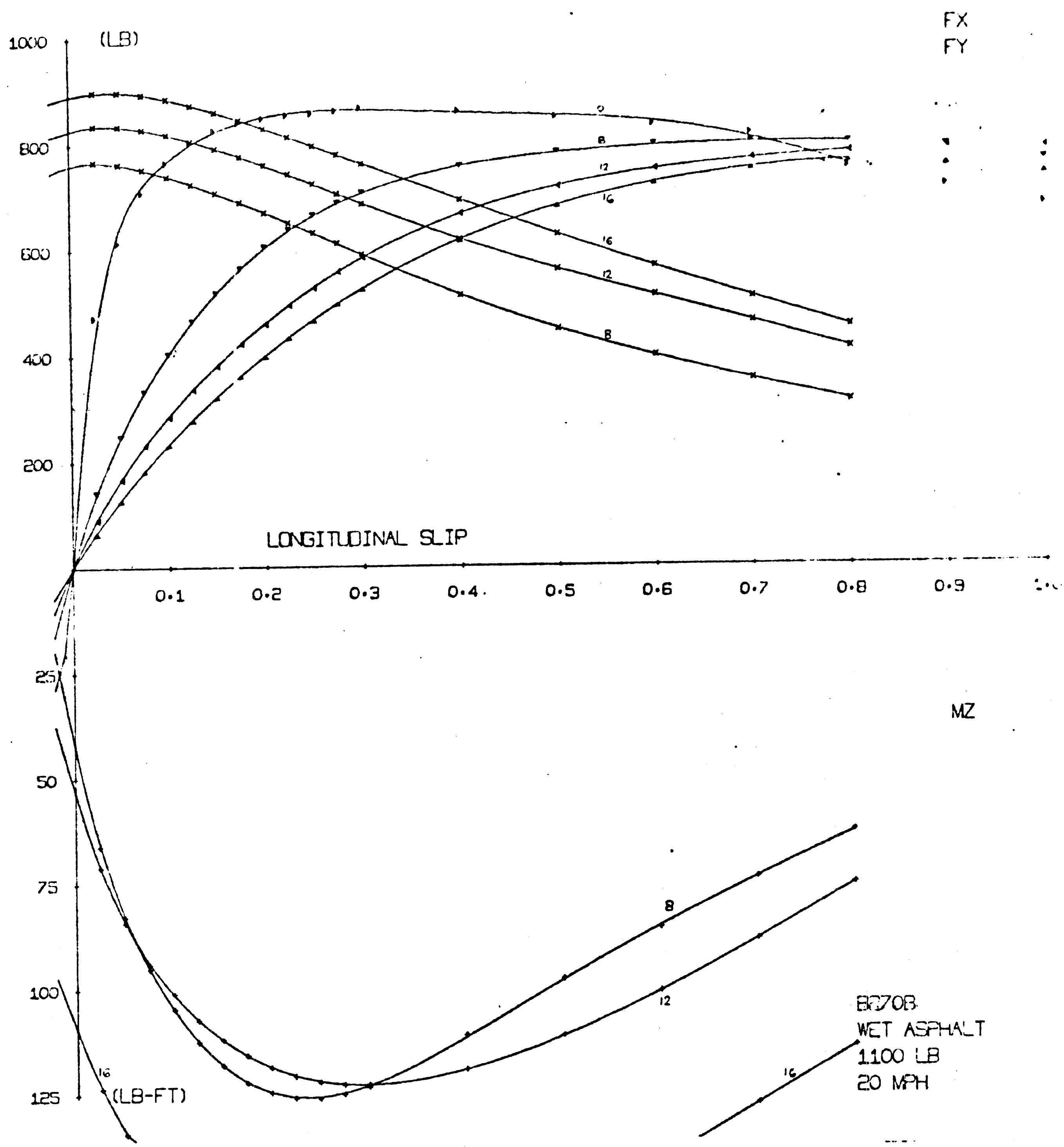

Lateral Force
F_y
lb
Slip Angles
• 0°
o 2°
x 4°
Δ 12°
□ 16°
B270A
Wet Concrete
1100 lb
40 mph
600
400
200
.1
.2
.3
.4
.5
.8


Slip Angles
• 0°
o 2°
x 8°
Δ 12°
□ 16°
B270A
Wet Concrete
1100 lb
55 mph
Longitudinal Force
F_x
lb
600
400
200
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


F_y
Lateral Force
Slip Angles
• 0°
o 2°
x 4°
Δ 12°
□ 16°
B270A
Wet Concrete
1100 lb
55 mph
lb
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


1000
(LB)
800
600
400
200
FX
FY
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
B270A
DRY CONCRETE
700 LB
20 MPH


1000
(LB)
FX
FY
800
600
400
200
8
12
16
16
12
8
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
BE70A
DRY CONCRETE
700 LB
40 MPH


FX
FY
1000
(LB)
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
MZ
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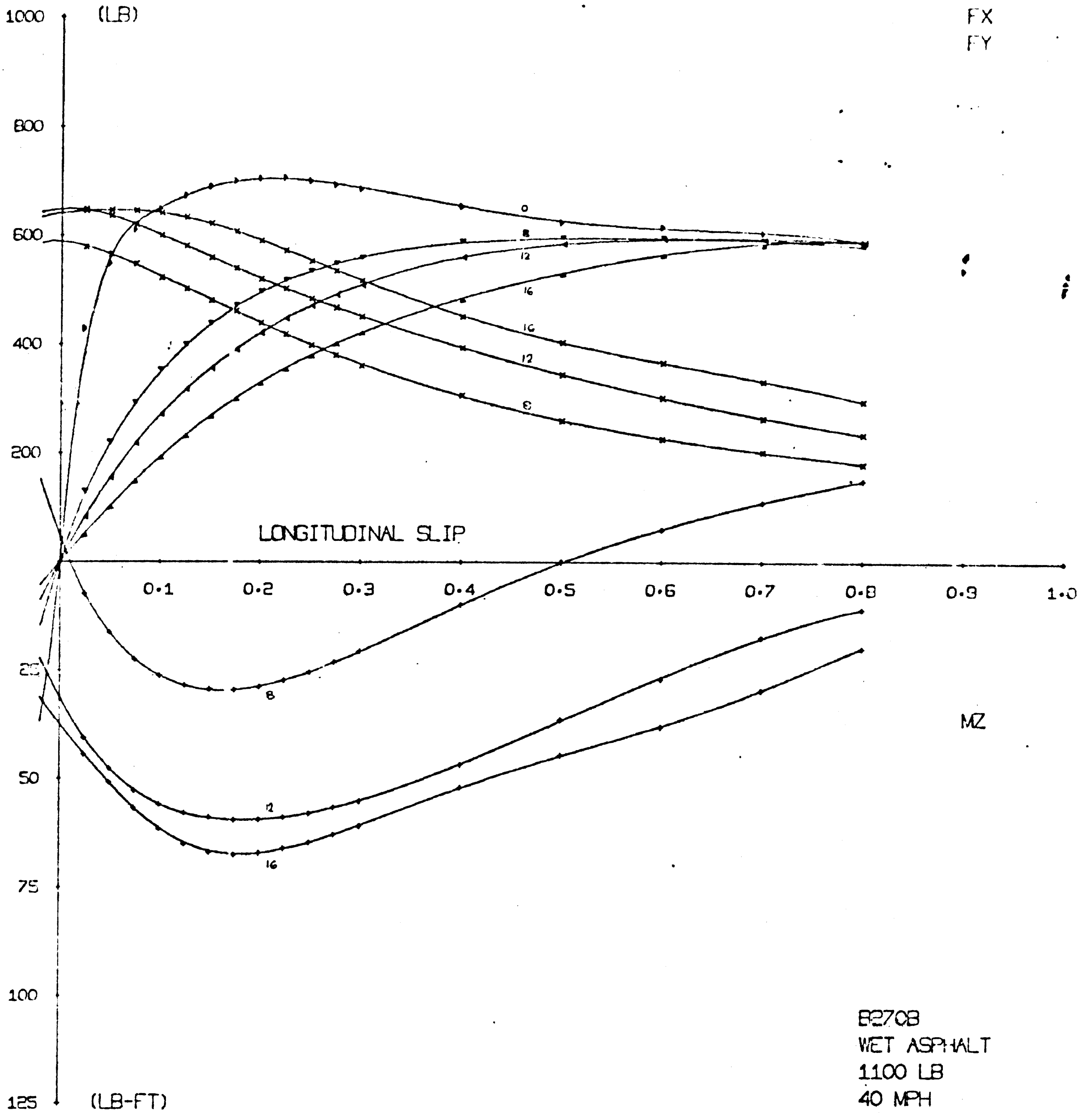
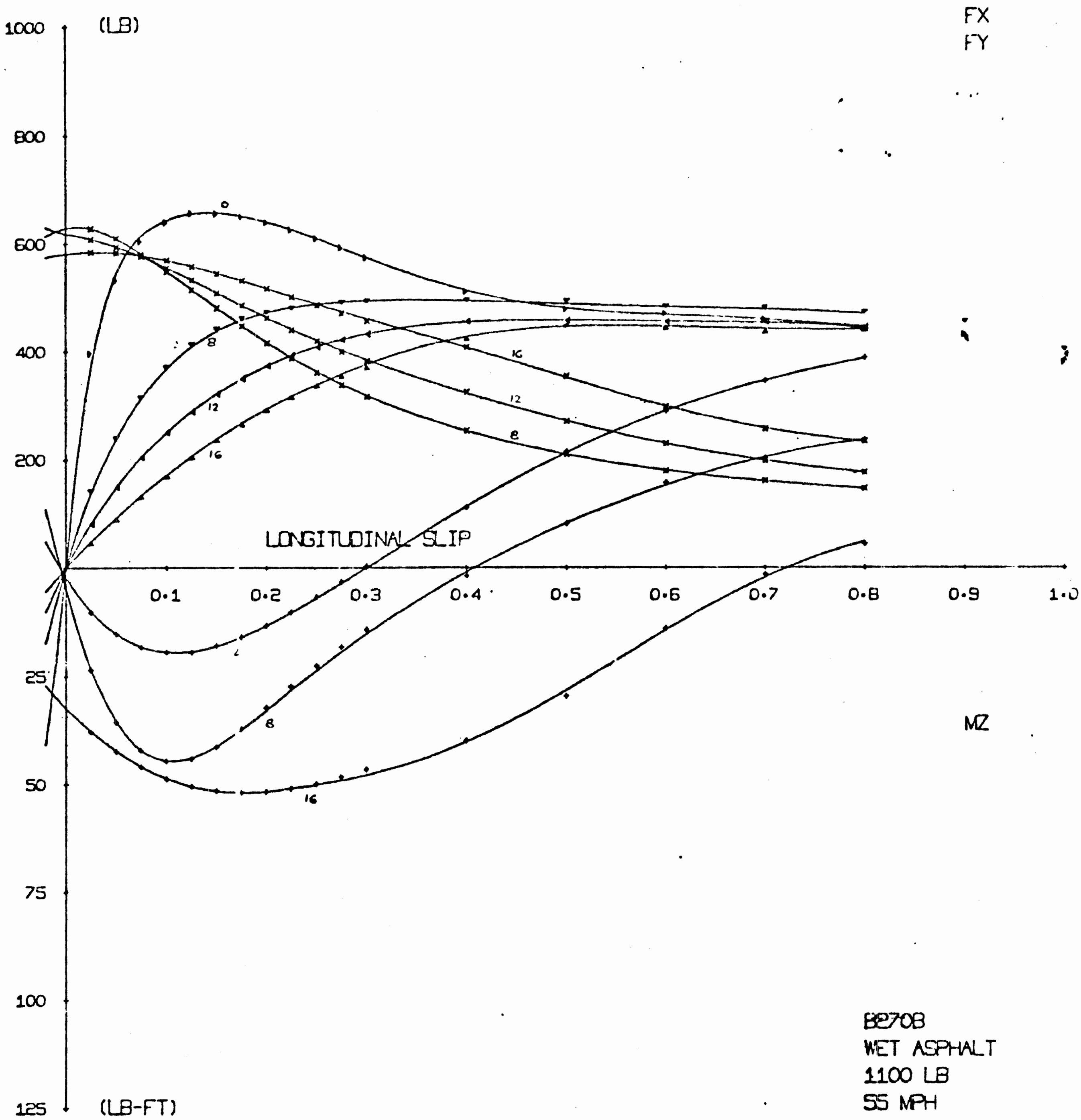
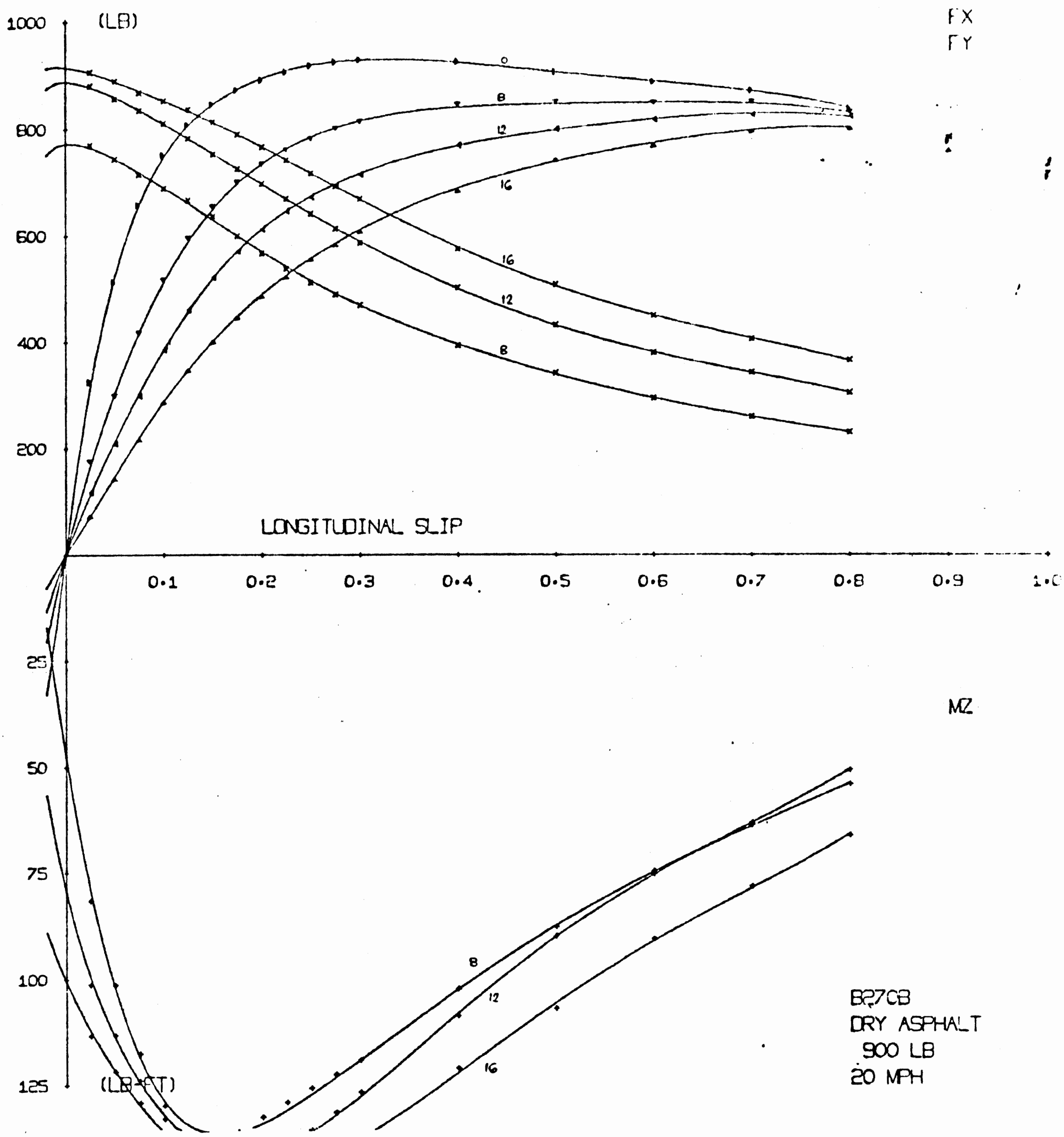
50
75
100
125
(LB-FT)
8
12
16
B770B
WET ASPHALT
1100 LB
20 MPH


1000
(LB)
FX
FY
800
600
400
200
0
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
8
MZ
50
12
16
75
100
125
(LB-FT)
B270B
WET ASPHALT
1100 LB
40 MPH



1000
800
600
400
200
25
50
75
100
125
(LB)
(LB-FT)
FX
FY
MZ
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
B270B
WET ASPHALT
1100 LB
55 MPH



1000
(LB)
FX
FY
800
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200
LONGITUDINAL SLIP
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0·2
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0·4
0·5
0·6
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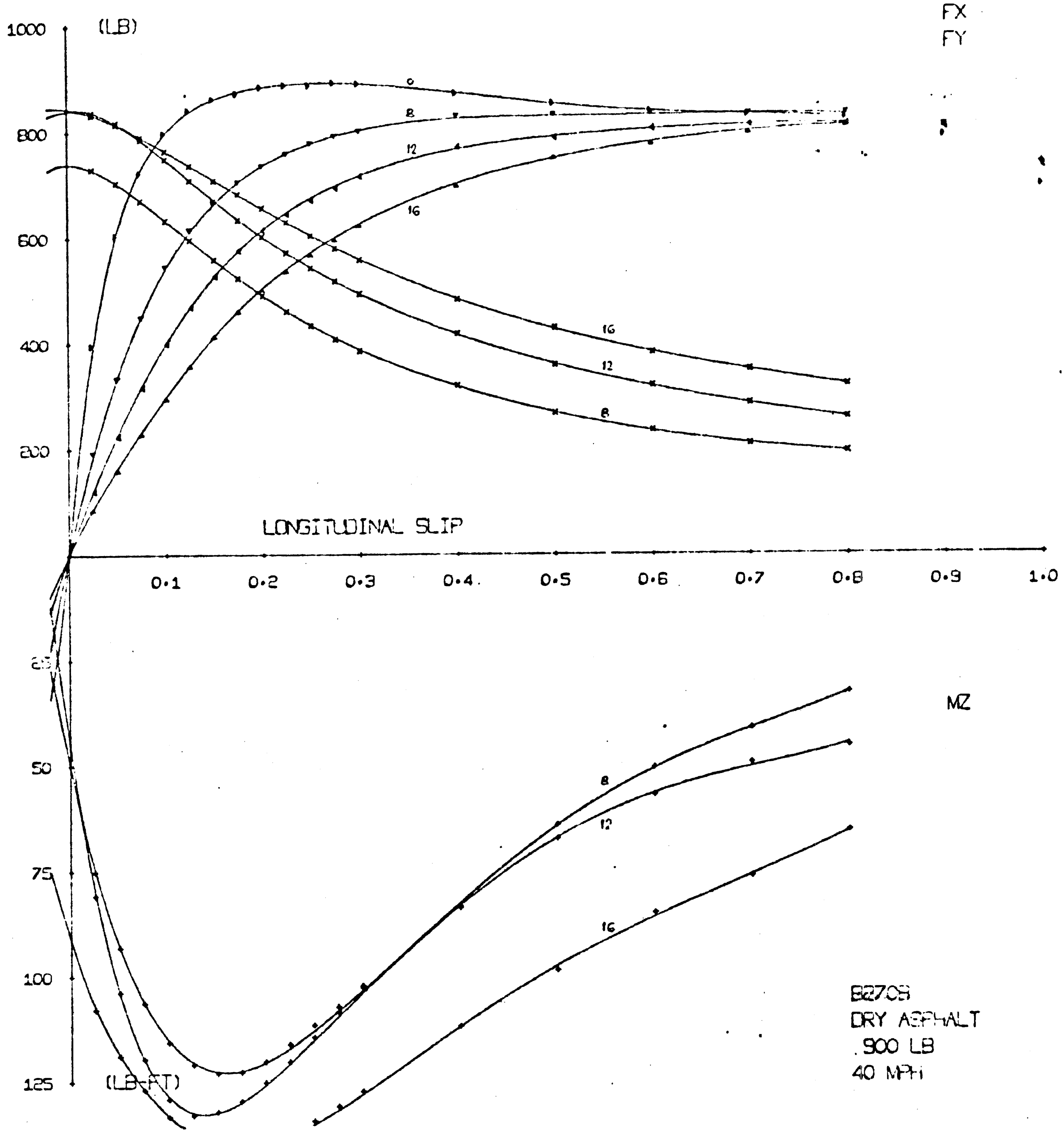
0·8
0·9
25
50
75
100
125
(LB-FT)
MZ
B27CB
DRY ASPHALT
900 LB
20 MPH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(LB)
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FY
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200
LONGITUDINAL SLIP
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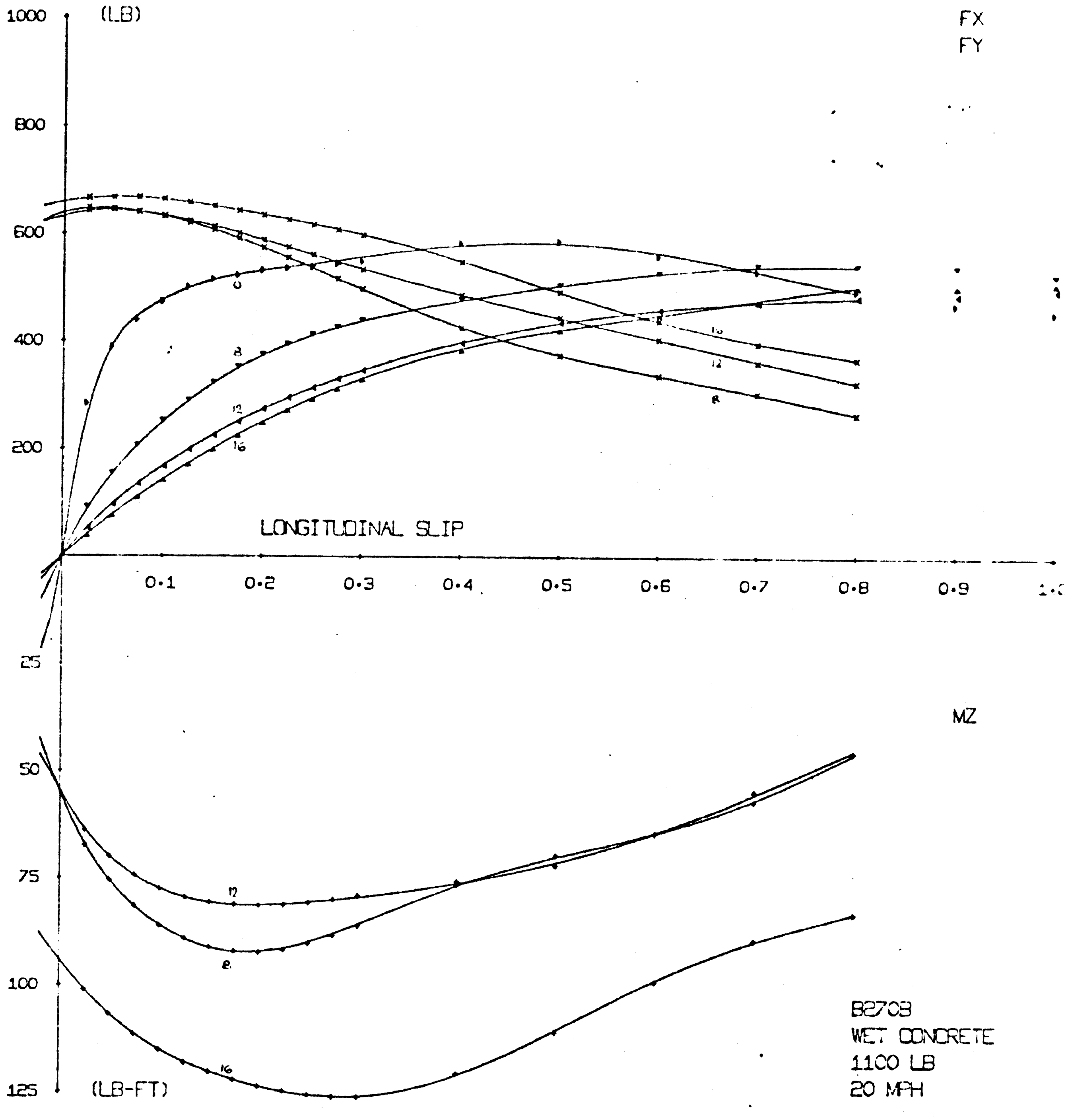
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
B270S
DRY ASPHALT
900 LB
40 MPH



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(LB)
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FY
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400
200
LONGITUDINAL SLIP
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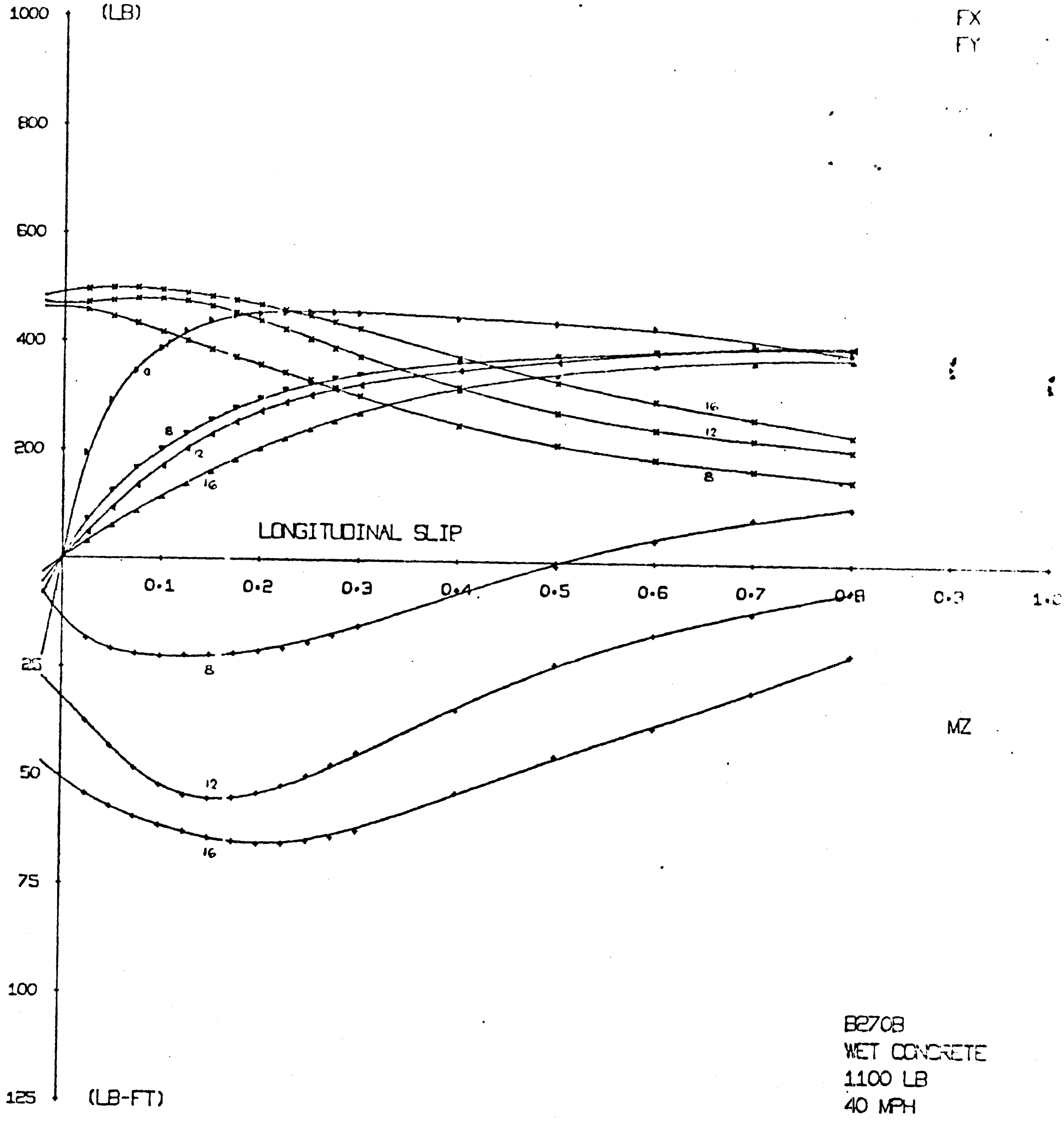
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
25
MZ
50
75
100
125
(LB-FT)
B270B
WET CONCRETE
1100 LB
20 MPH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200
(LB)
FX
FY
LONGITUDINAL SLIP
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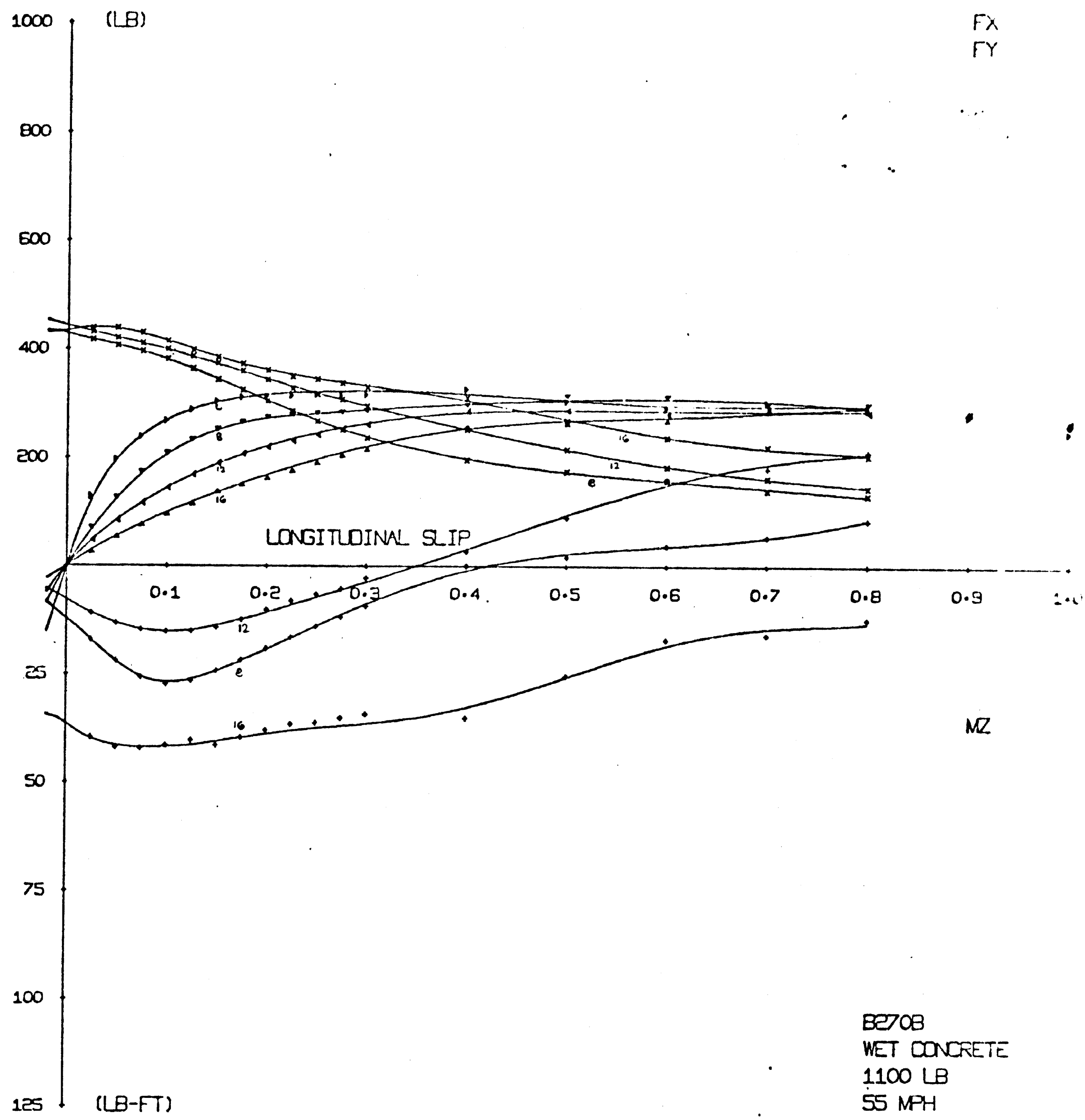
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.0
25
50
75
100
125
(LB-FT)
MZ
B270B
WET CONCRETE
1100 LB
40 MPH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(LB)
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FX
FY
LONGITUDINAL SLIP
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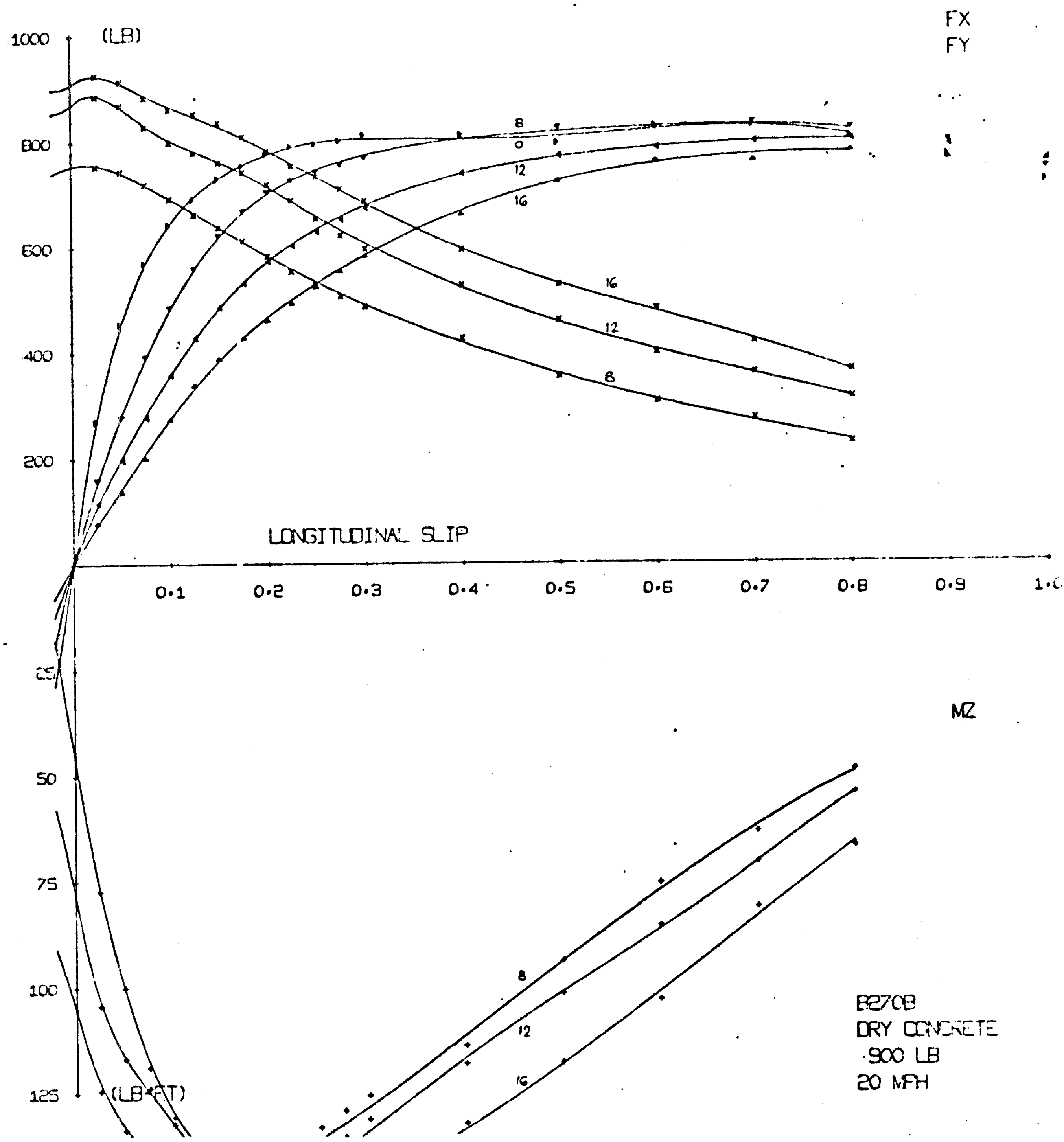
25
50
75
100
125
(LB-FT)
MZ
B270B
WET CONCRETE
1100 LB
55 MPH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FY
(LB)
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600
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16
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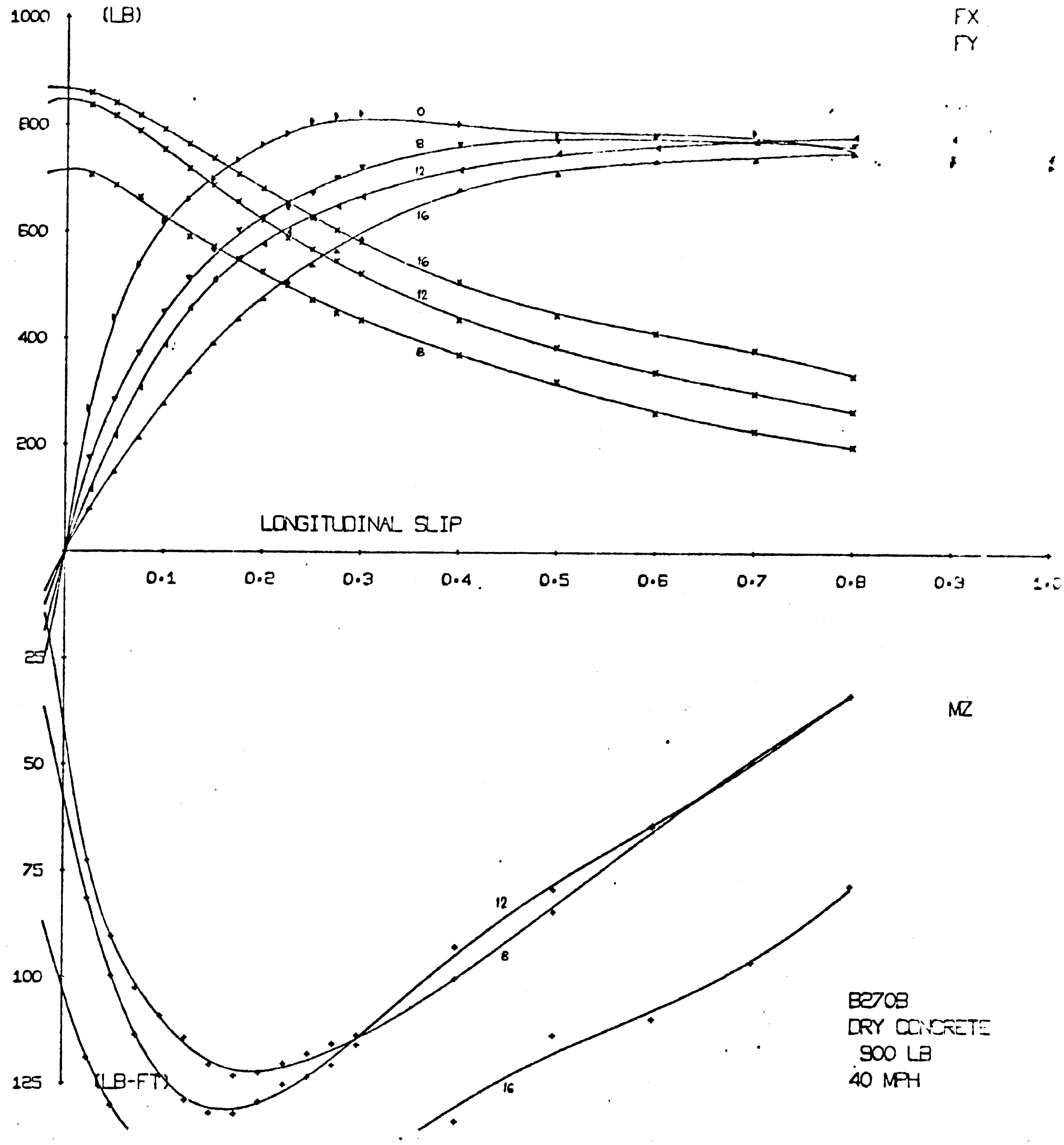
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
25
MZ
50
75
100
125
(LB-FT)
8
12
16
B270B
DRY CONCRETE
900 LB
20 MPH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(LB)
FX
FY
800
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200
LONGITUDINAL SLIP
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0.3
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0.5
0.6
0.7
0.8
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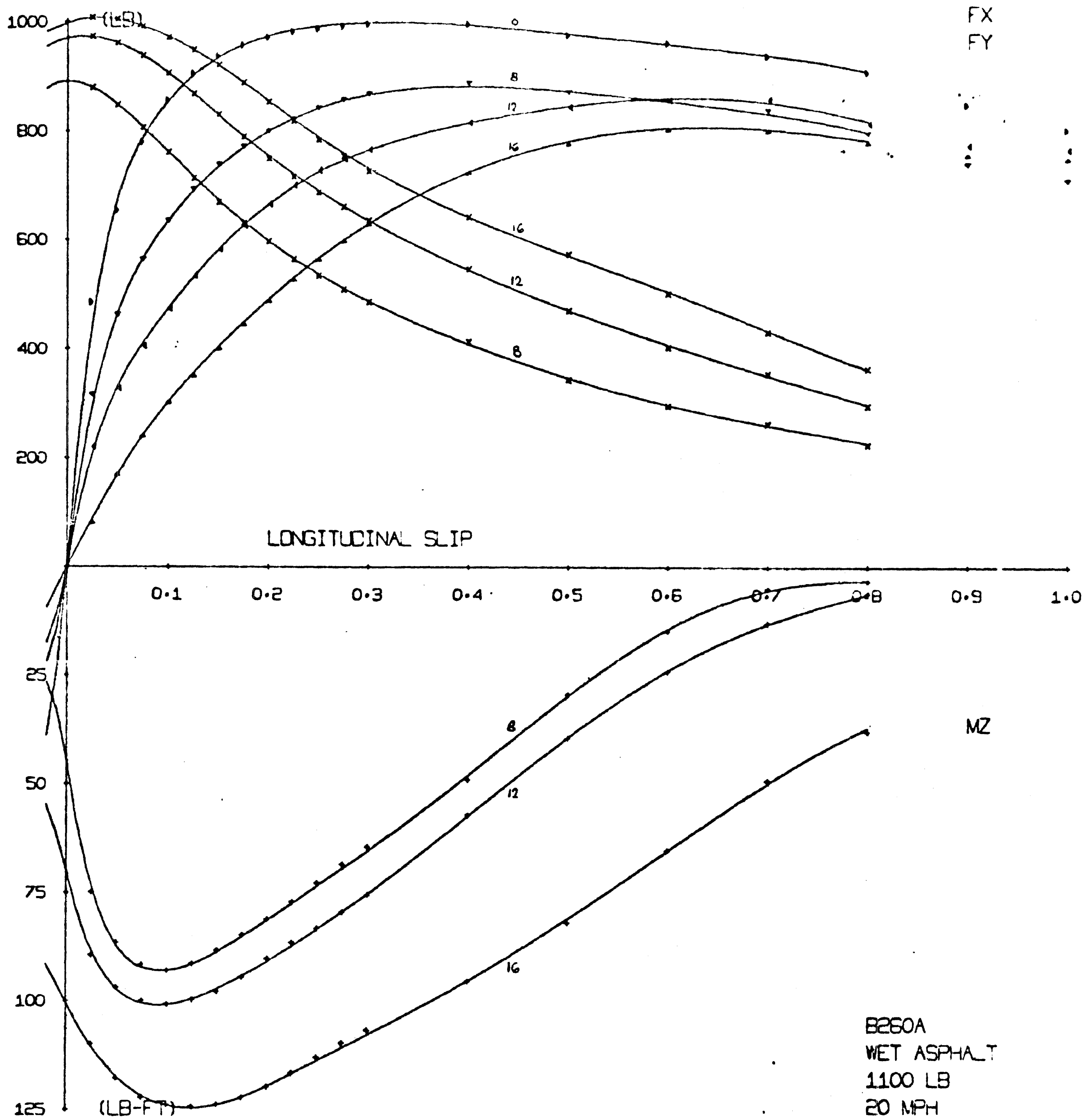
1.0
25
50
75
100
125
(LB-FT)
MZ
B270B
DRY CONCRETE
900 LB
40 MPH



FX
FY
MZ
1000
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200
(LB)
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
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0·7
0·8
0·9
1·0
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75
100
125
(LB-FT)
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12
16
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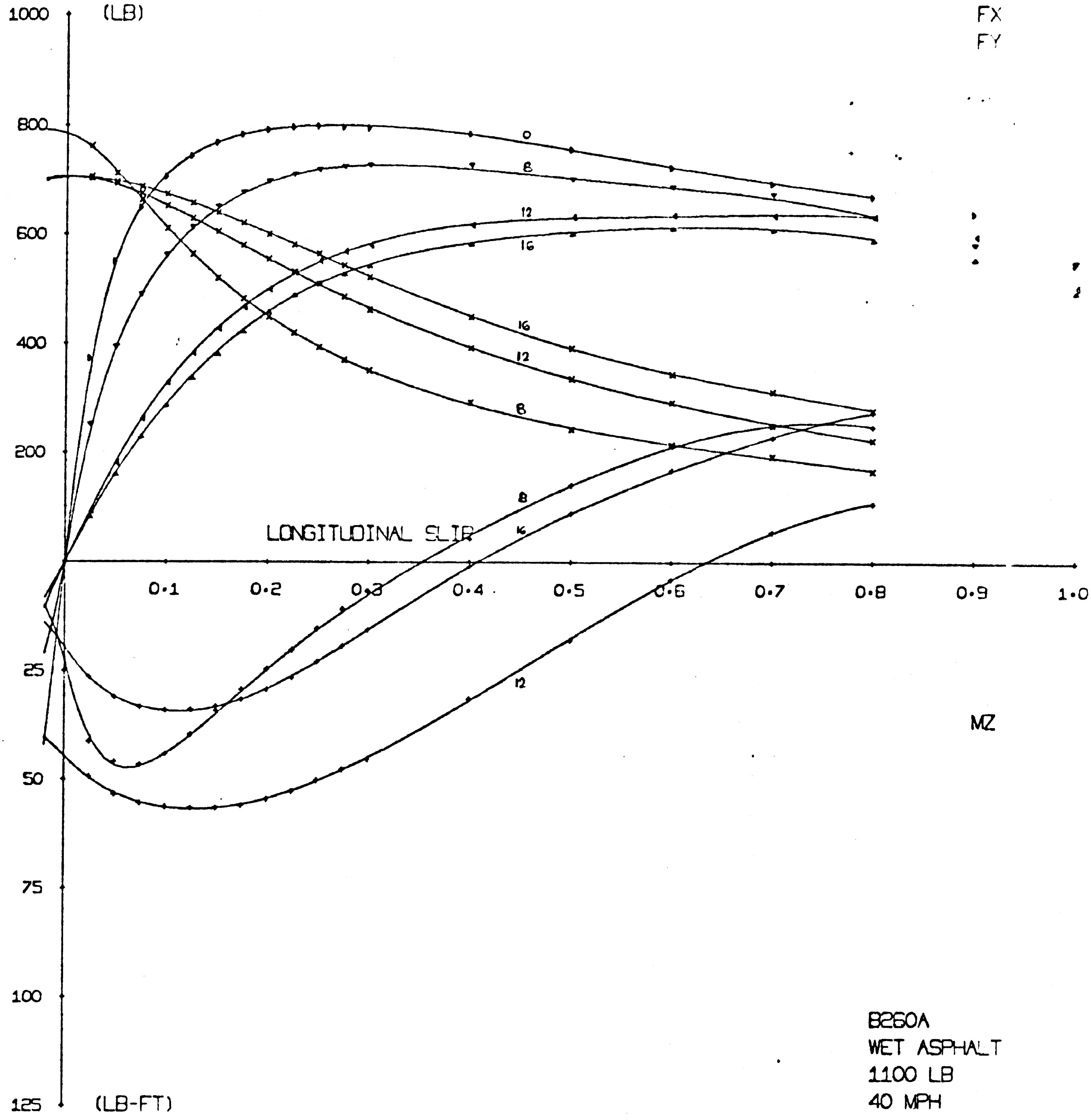

1000
(LB)
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400
200
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50
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100
125
(LB-FT)
FX
FY
0
8
12
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16
12
8
8
16
12
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
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0·7
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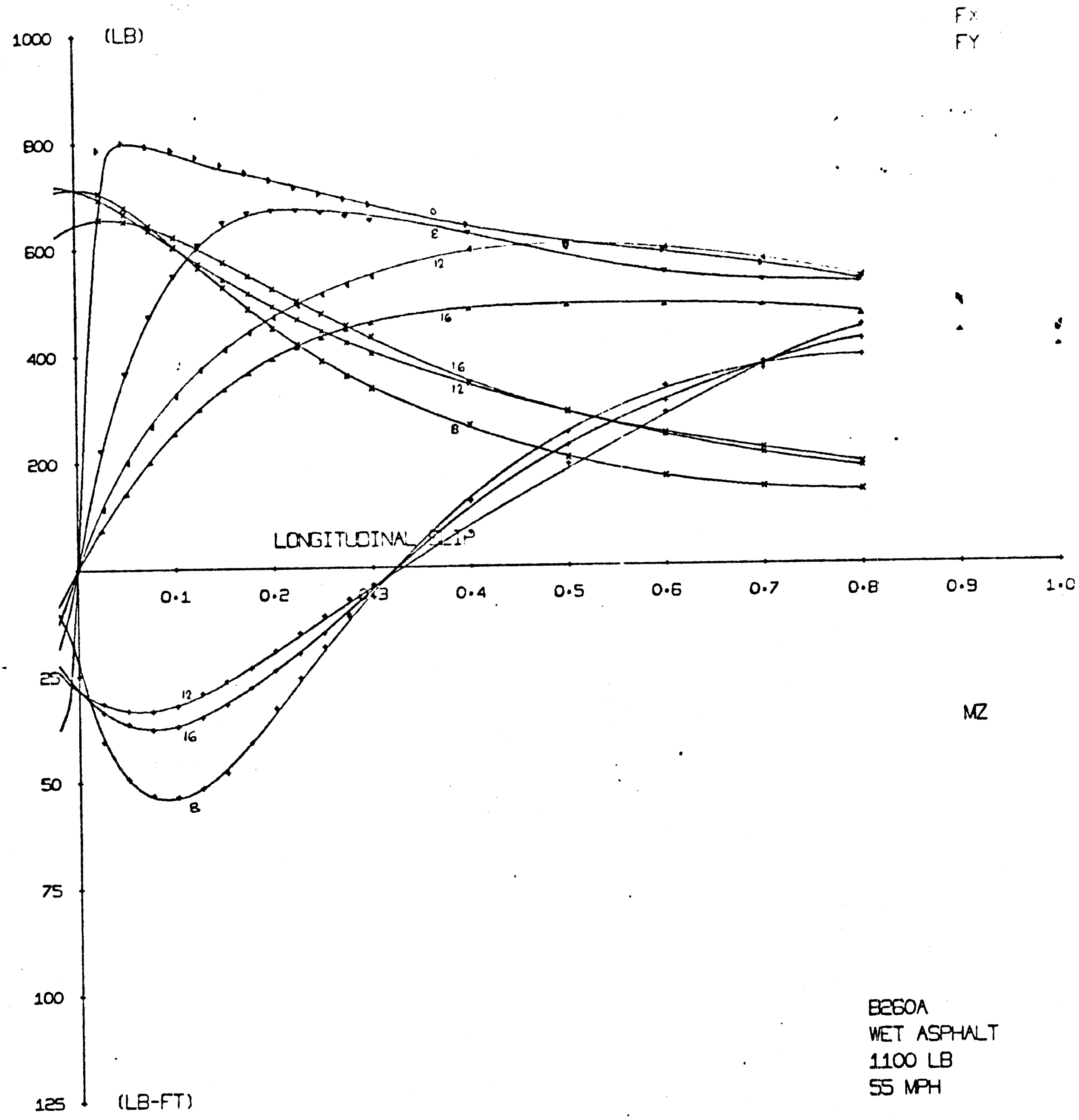
0·9
1·0
MZ
B260A
WET ASPHALT
1100 LB
40 MPH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FY
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200
(LB)
LONGITUDINAL SLIP
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0·9
1·0
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50
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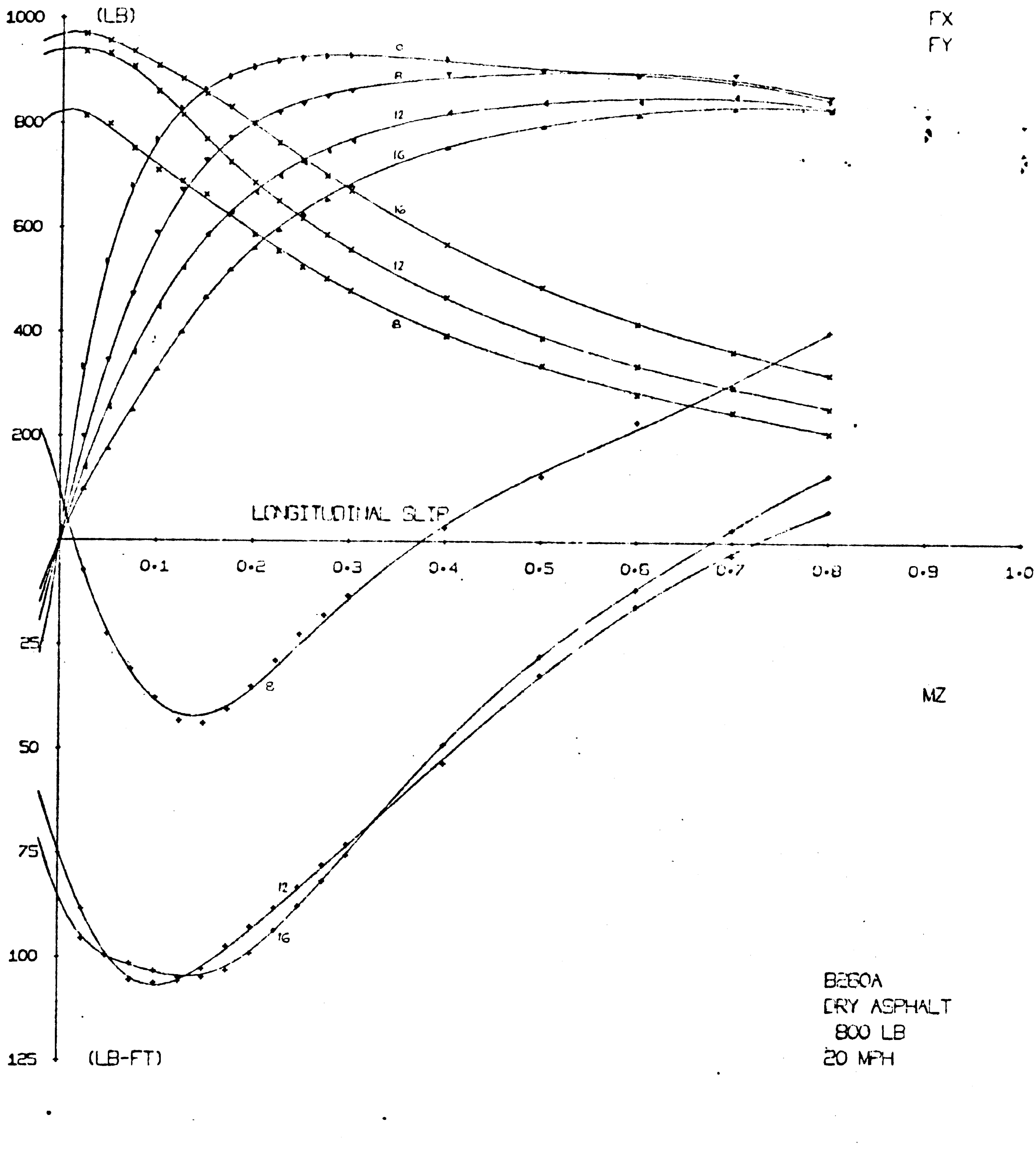
100
125
(LB-FT)
MZ
B260A
WET ASPHALT
1100 LB
55 MPH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(LB)
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200
FX
FY
LONGITUDINAL SLIP
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0·6
0·7
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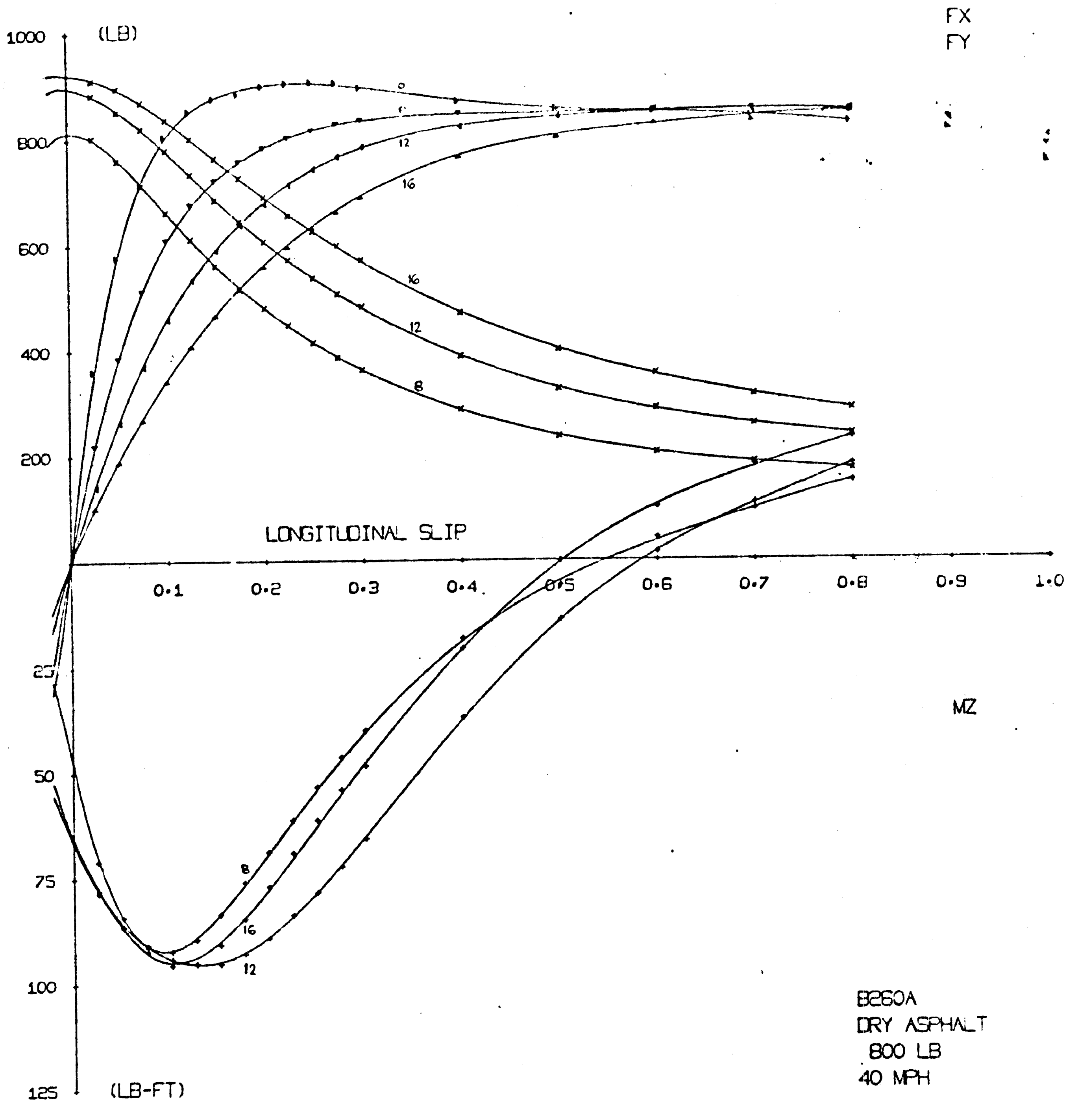
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
B260A
DRY ASPHALT
800 LB
20 MPH



1000
(LB)
800
600
400
200
FX
FY
16
12
8
LONGITUDINAL SLIP
0·1
0·2
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0·4
0·5
0·6
0·7
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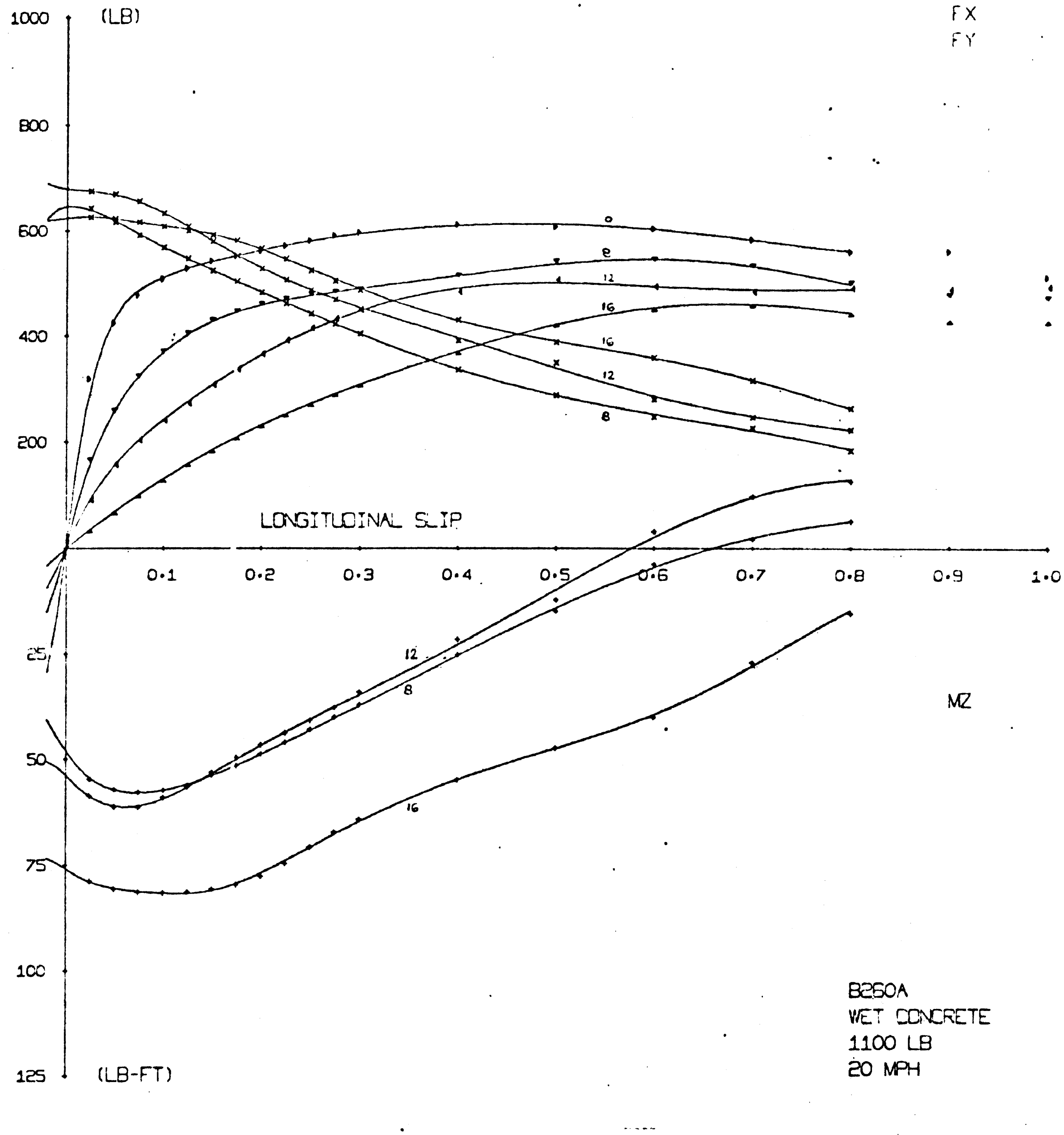
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
B260A
DRY ASPHALT
800 LB
40 MPH



1000
(LB)
FX
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200
LONGITUDINAL SLIP
0·1
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0·6
0·7
0·8
0·9
1·0
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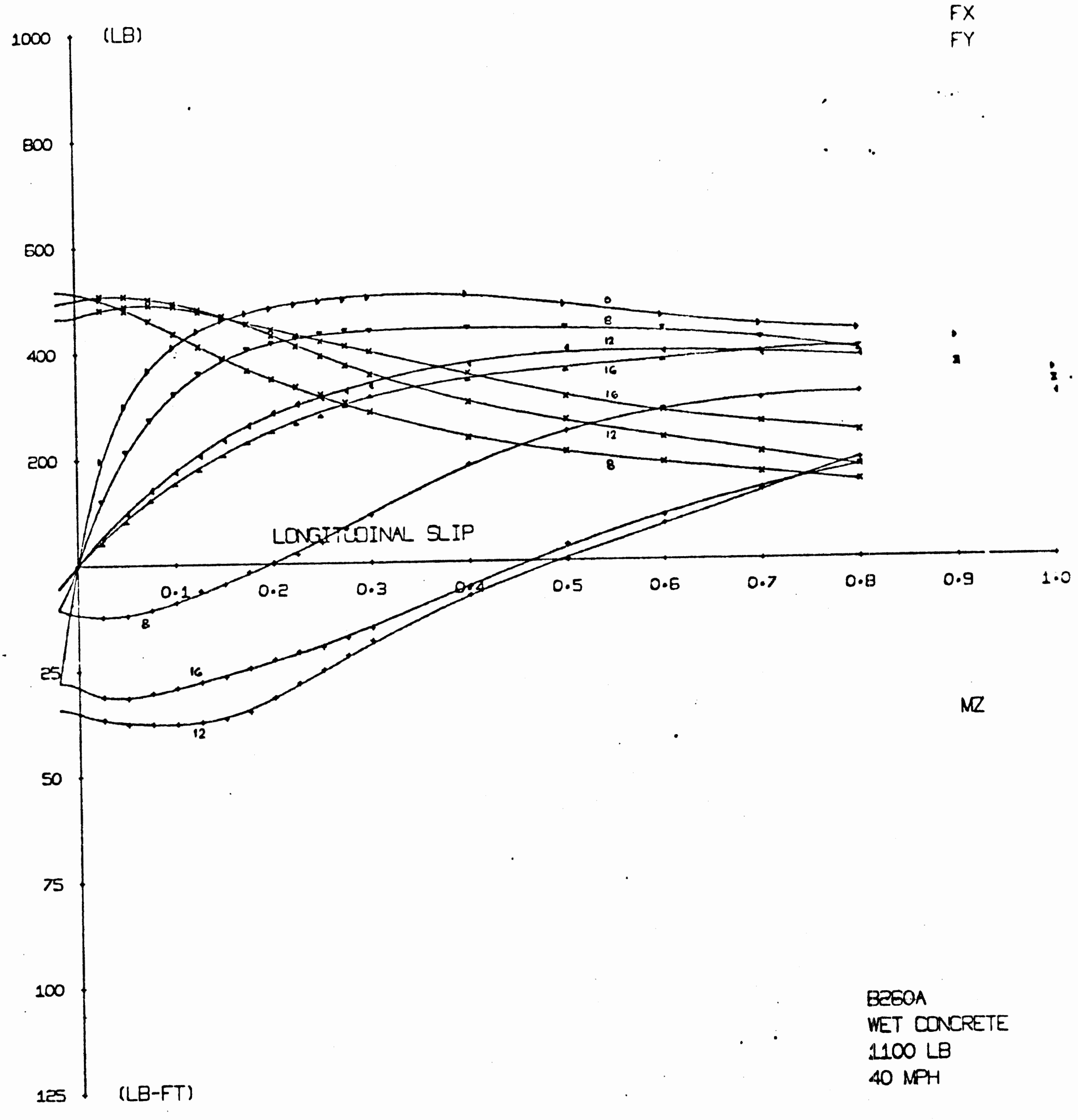
50
75
100
125
(LB-FT)
MZ
B260A
WET CONCRETE
1100 LB
20 MPH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FY
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200
(LB)
LONGITUDINAL SLIP
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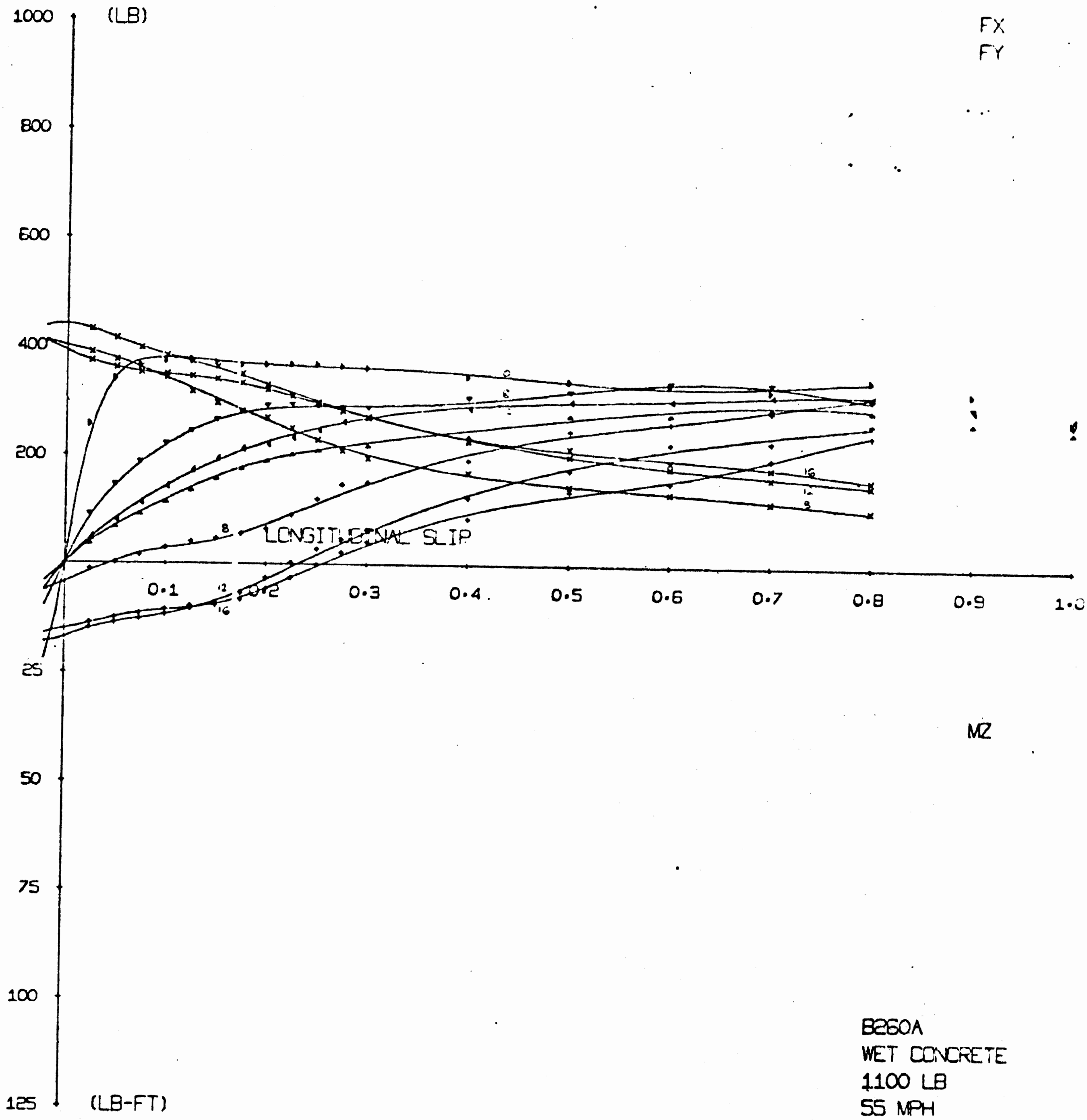
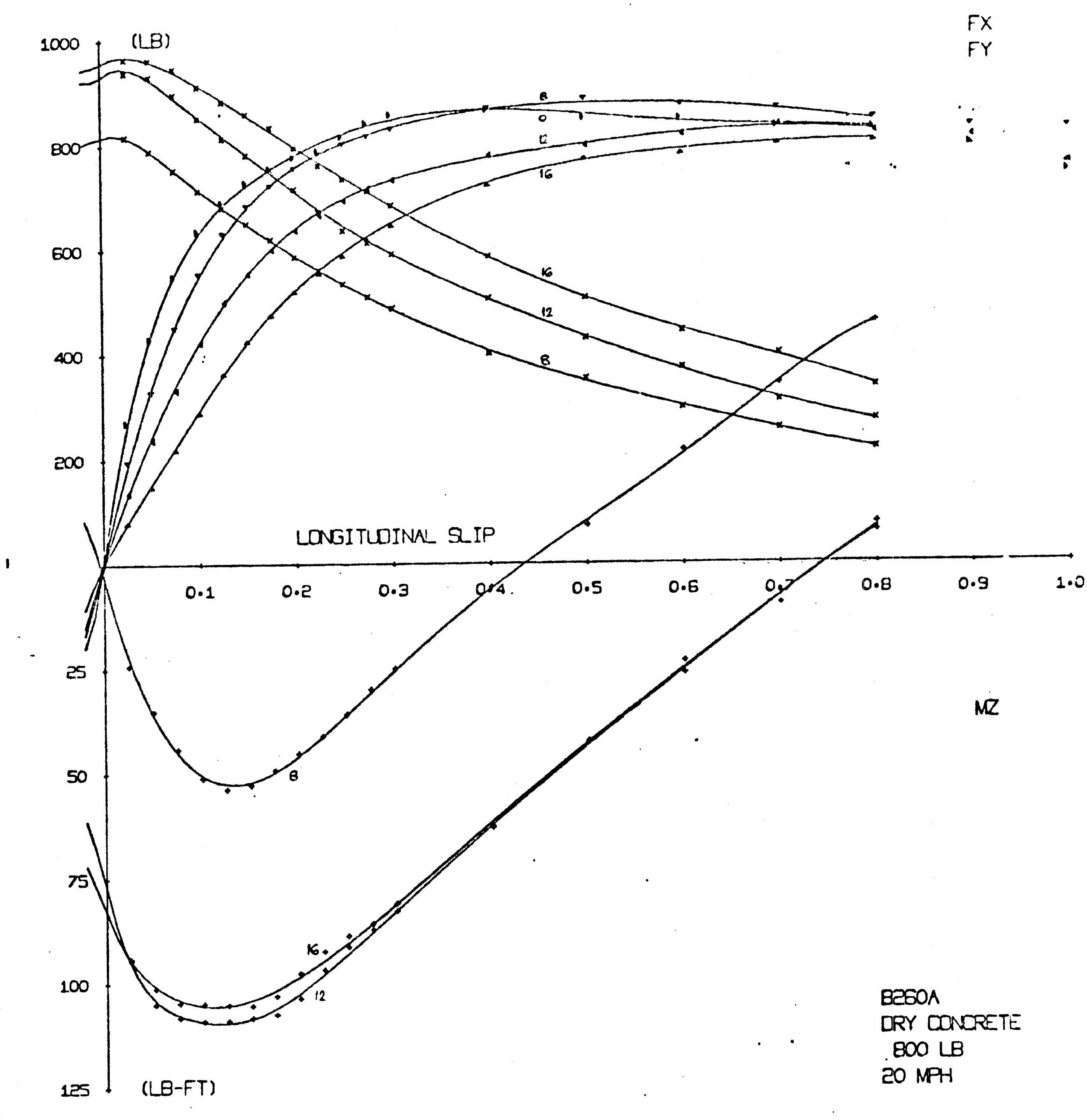
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
B260A
WET CONCRETE
1100 LB
40 MPH



1000
(LB)
FX
FY
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
MZ
50
75
100
125
(LB-FT)
B260A
WET CONCRETE
1100 LB
55 MPH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FY
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(LB)
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600
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200
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0·6
0·7
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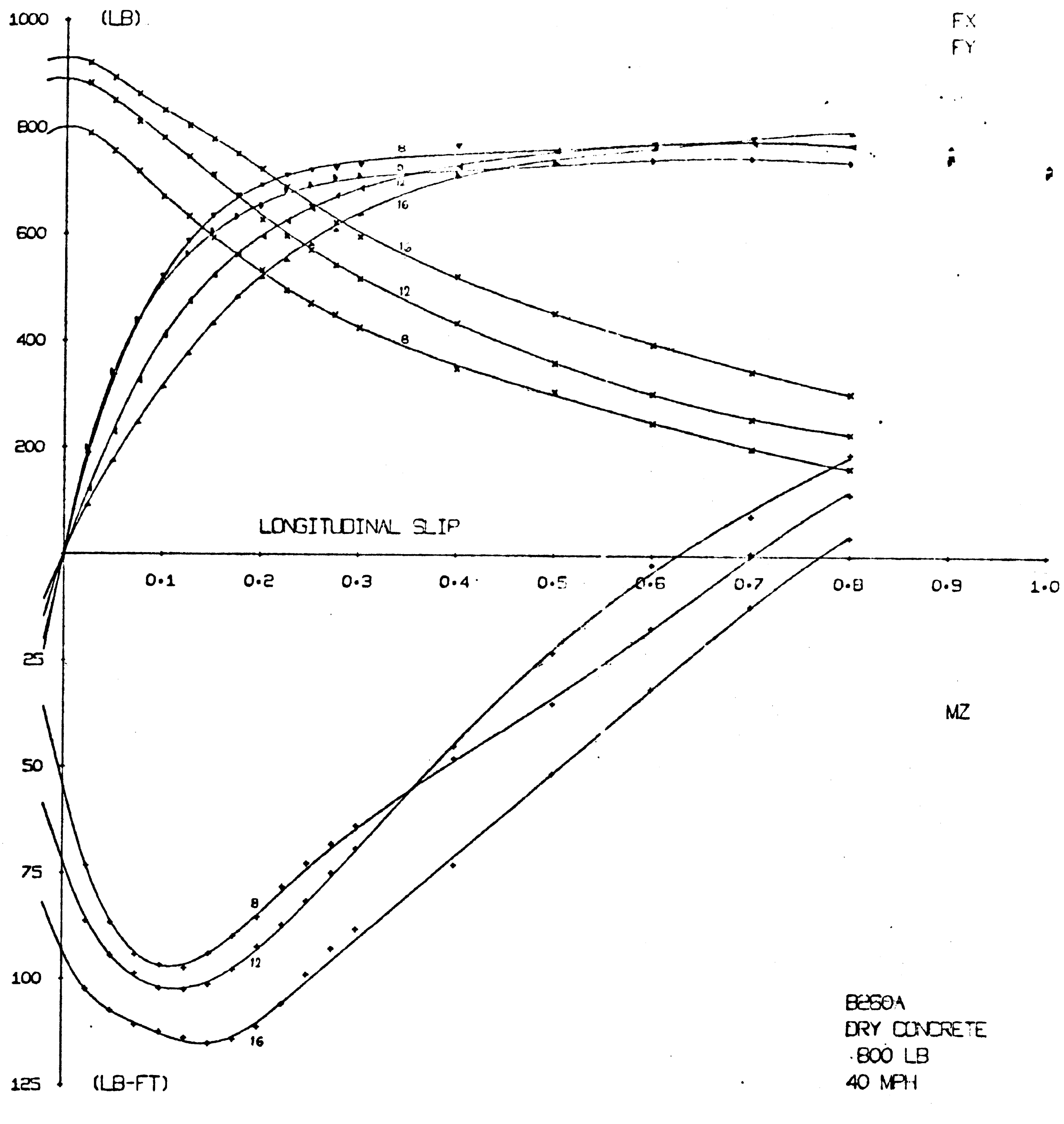
1·0
25
50
75
100
125
(LB-FT)
MZ
B260A
DRY CONCRETE
800 LB
20 MPH



1000
(LB)
FX
FY
800
600
400
200
8
12
16
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
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75
100
125
MZ
(LB-FT)
B8260A
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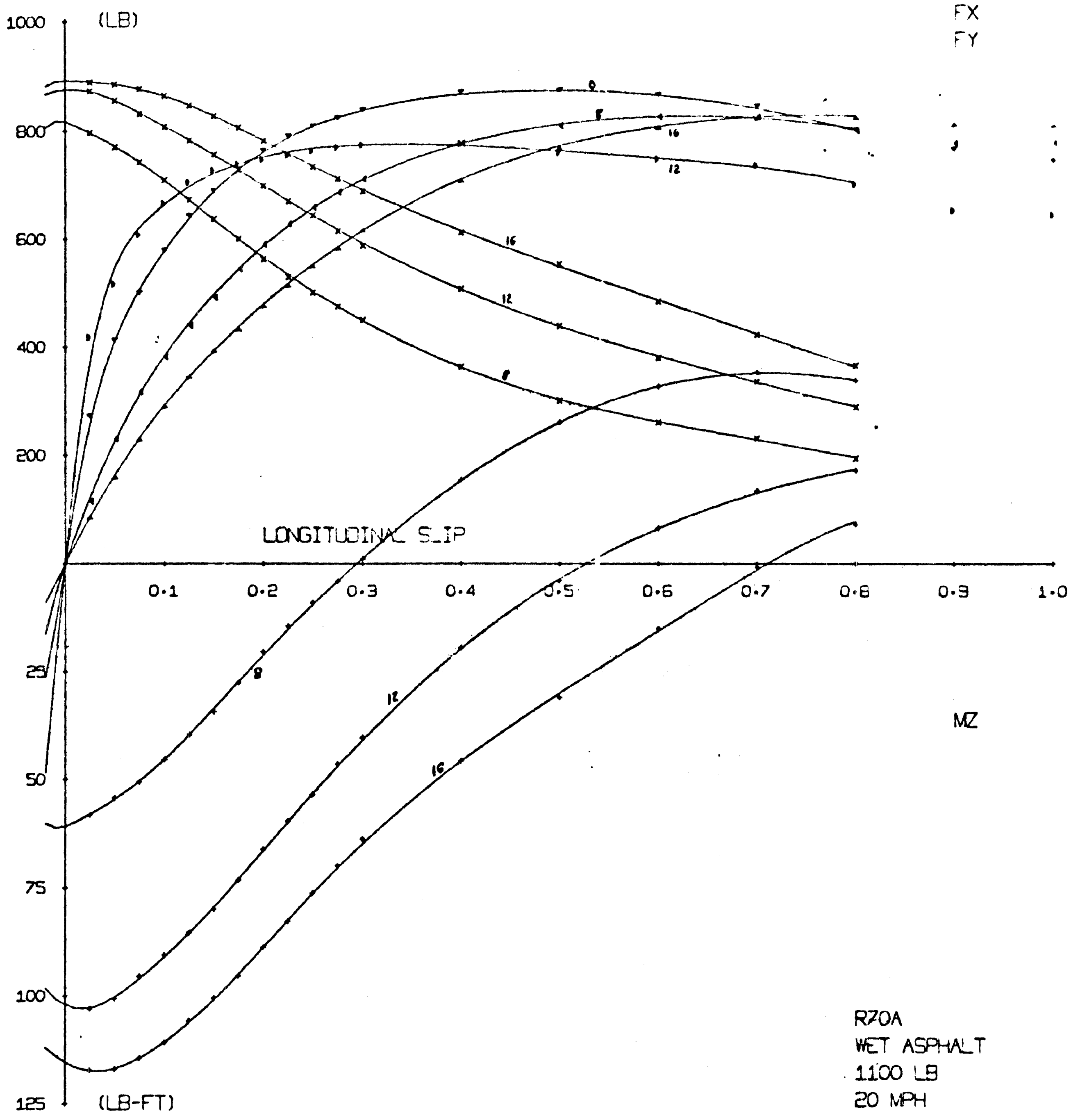
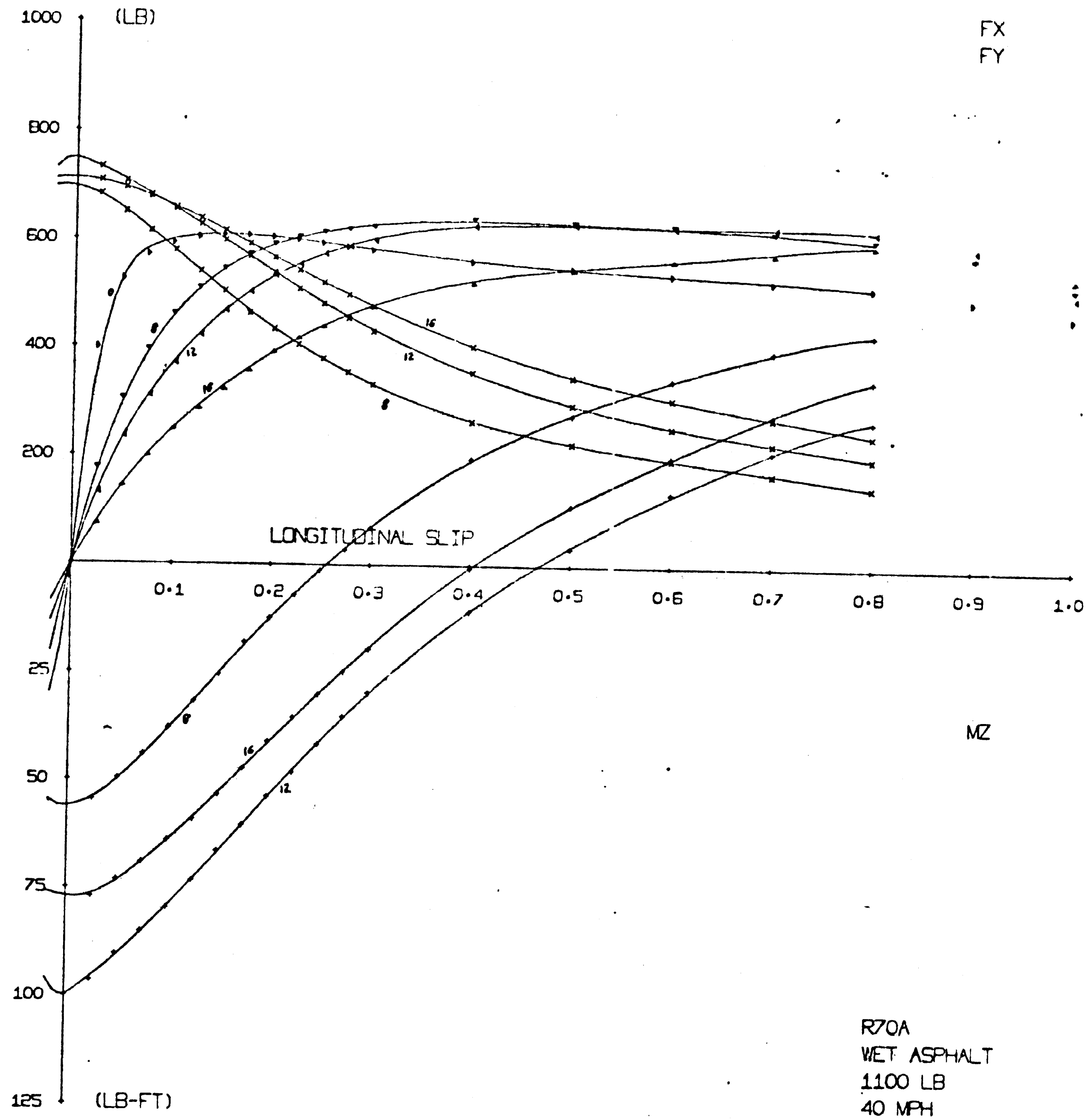
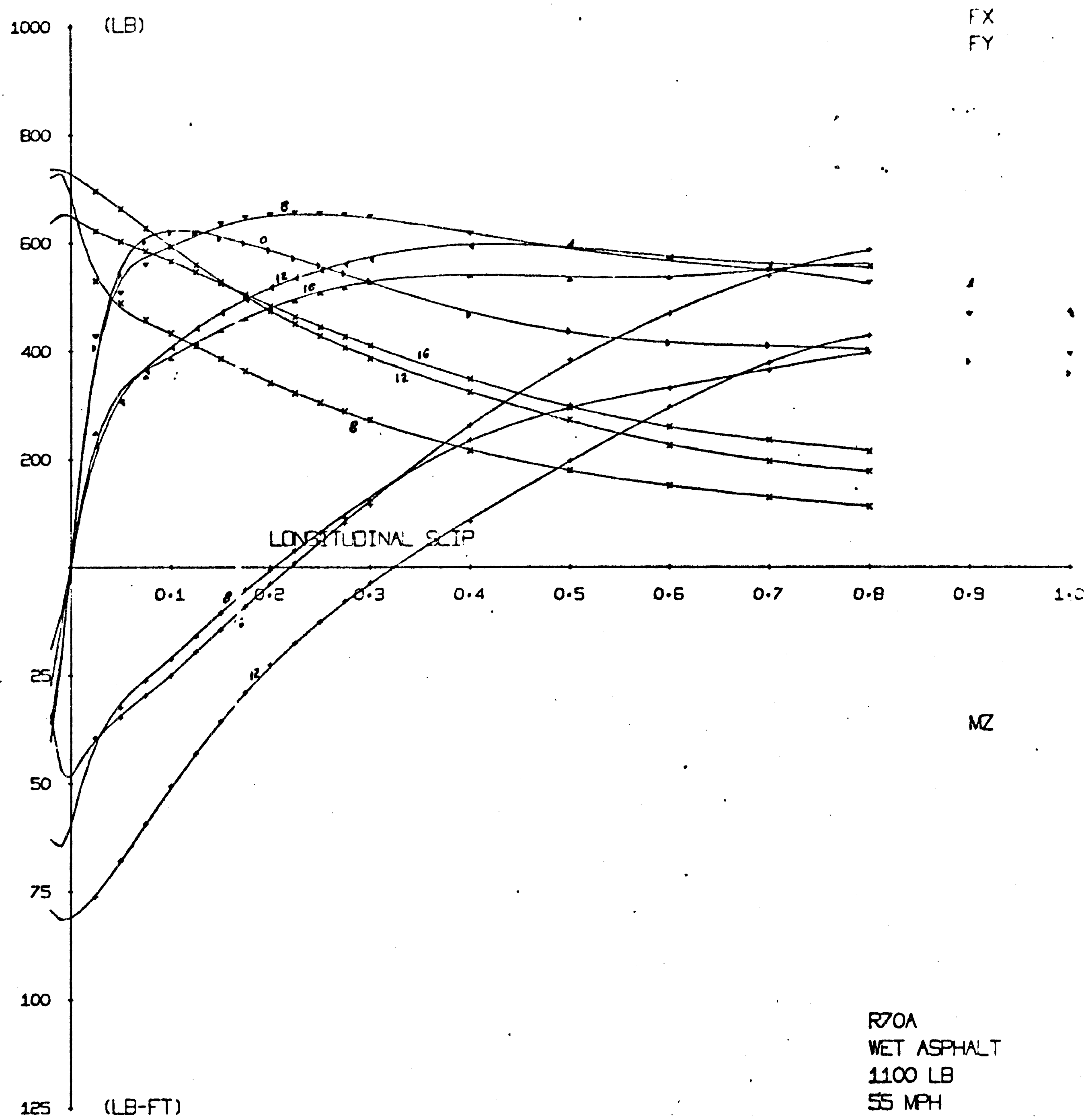
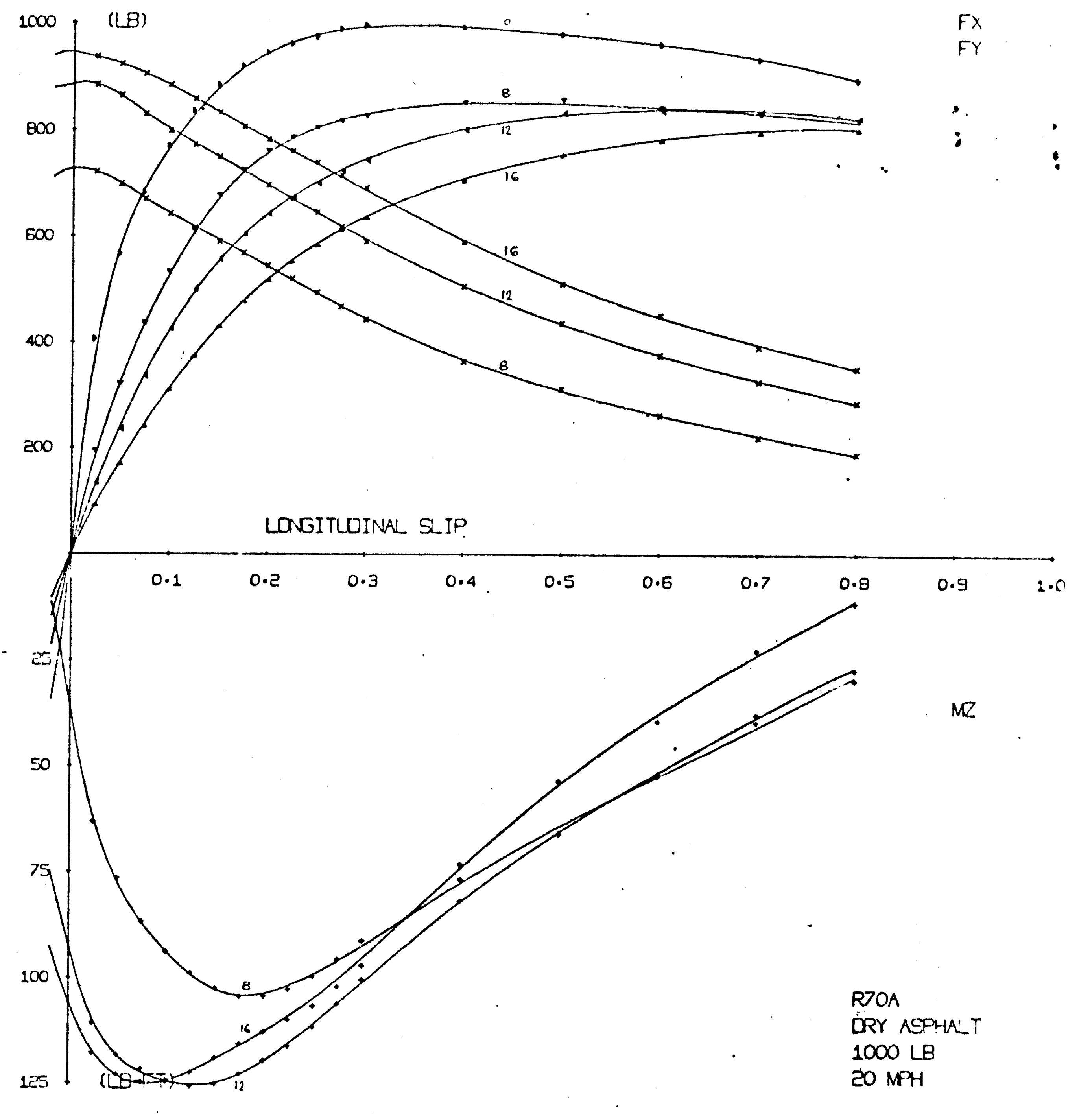
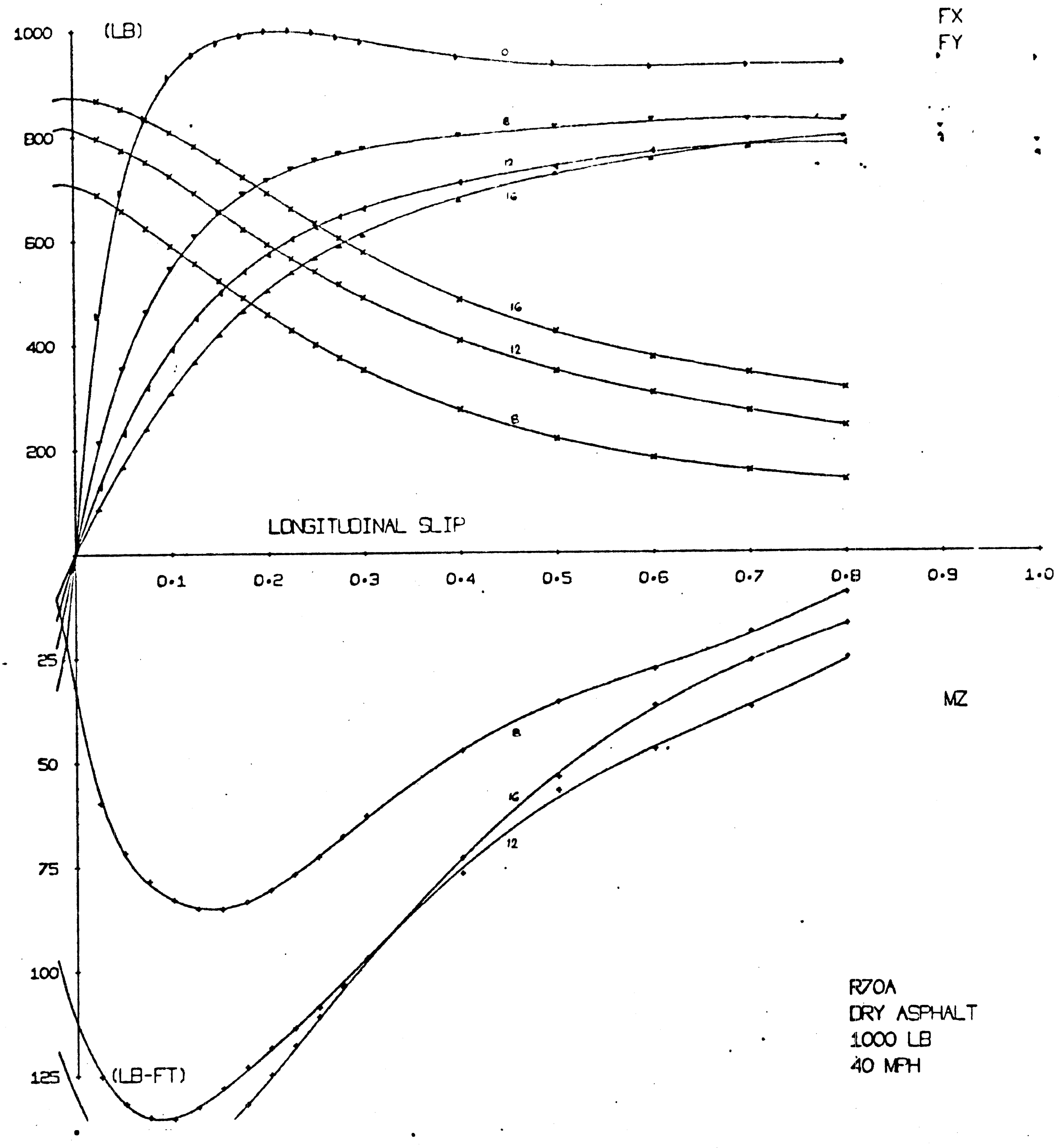
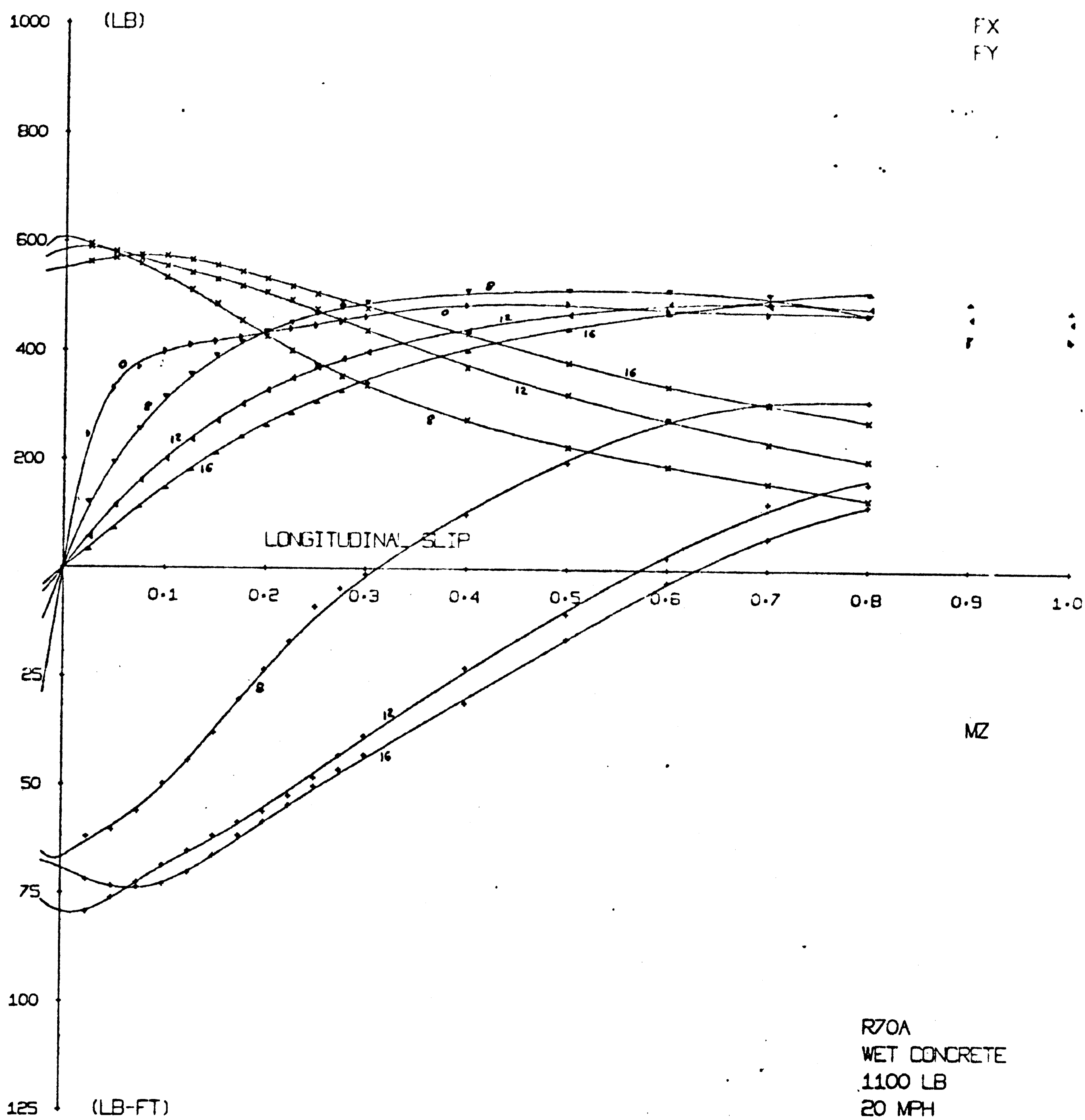

(LB)
FX
FY
1000
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
R70A
WET ASPHALT
1100 LB
20 MPH


1000
(LB)
800
600
400
200
FX
FY
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
R70A
WET ASPHALT
1100 LB
40 MPH

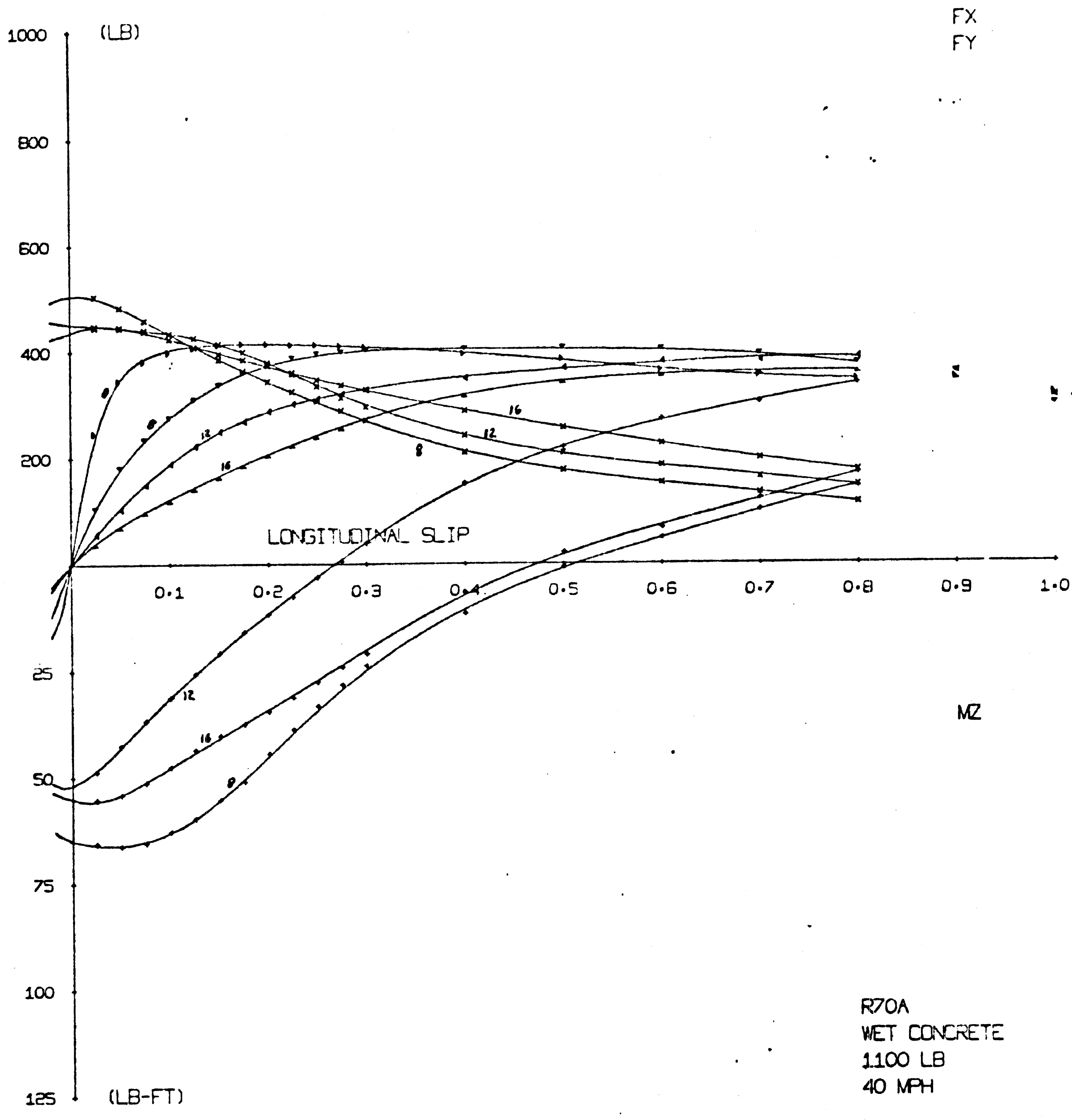

(LB)
FX
FY
1000
800
600
400
200
25
50
75
100
125
(LB-FT)
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
LONGITUDINAL SLIP
MZ
R70A
WET ASPHALT
1100 LB
55 MPH


1000
800
600
400
200
(LB)
FX
FY
8
12
16
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
MZ
R70A
DRY ASPHALT
1000 LB
20 MPH

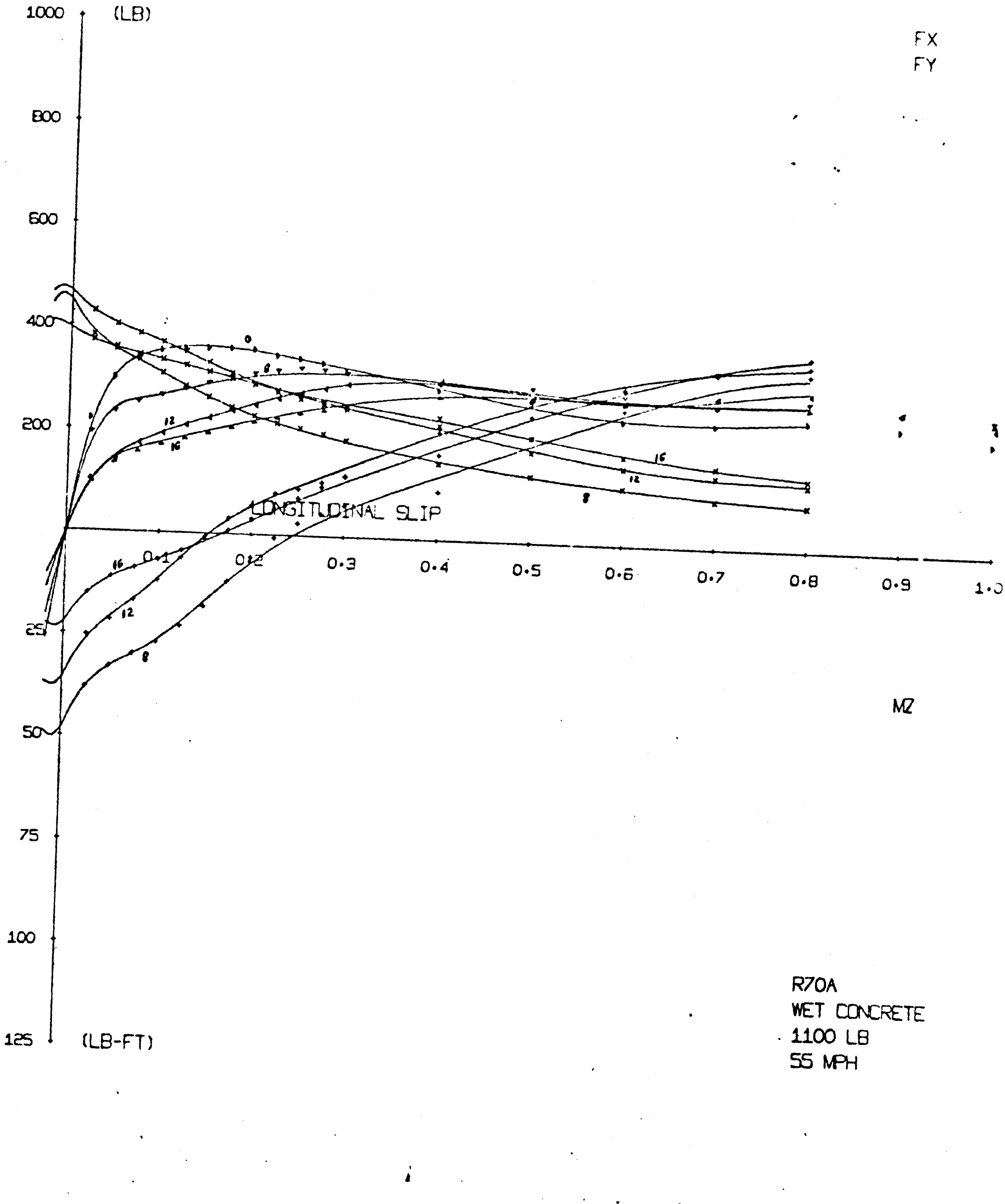

1000
800
600
400
200
(LB)
FX
FY
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
R70A
DRY ASPHALT
1000 LB
40 MPH

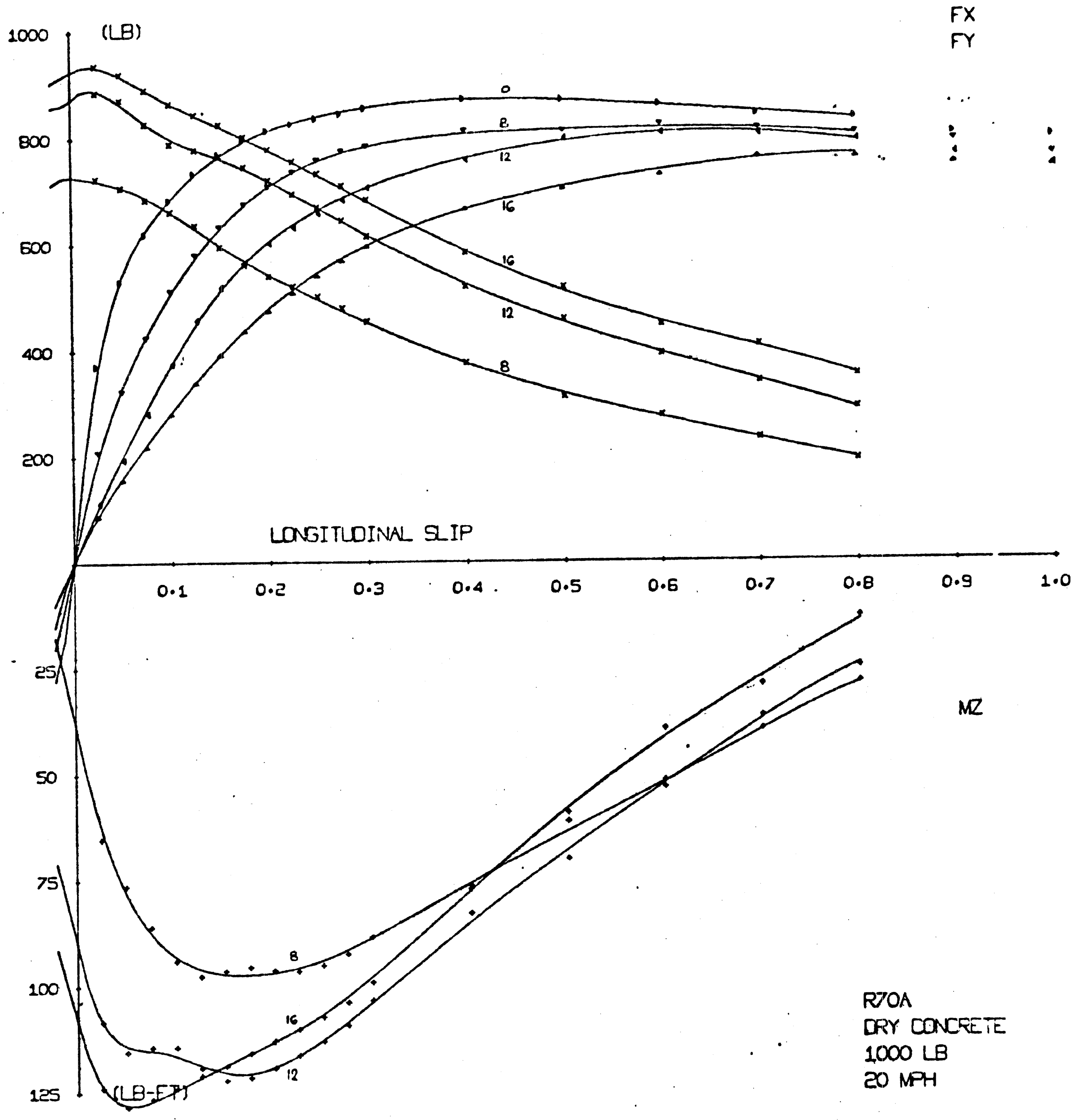


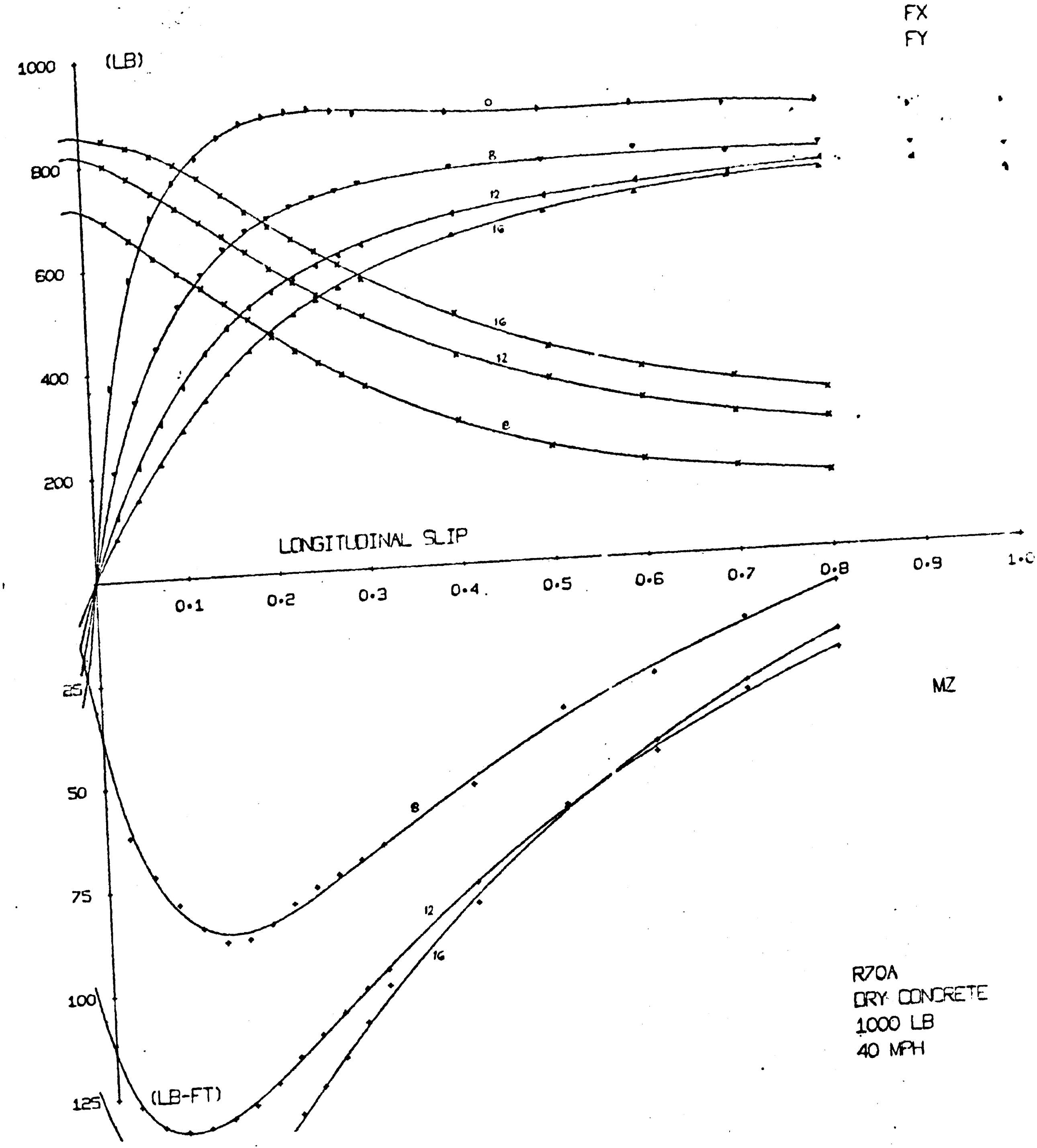
1000
(LB)
FX
FY
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
MZ
50
75
100
R70A
WET CONCRETE
1100 LB
20 MPH
125
(LB-FT)

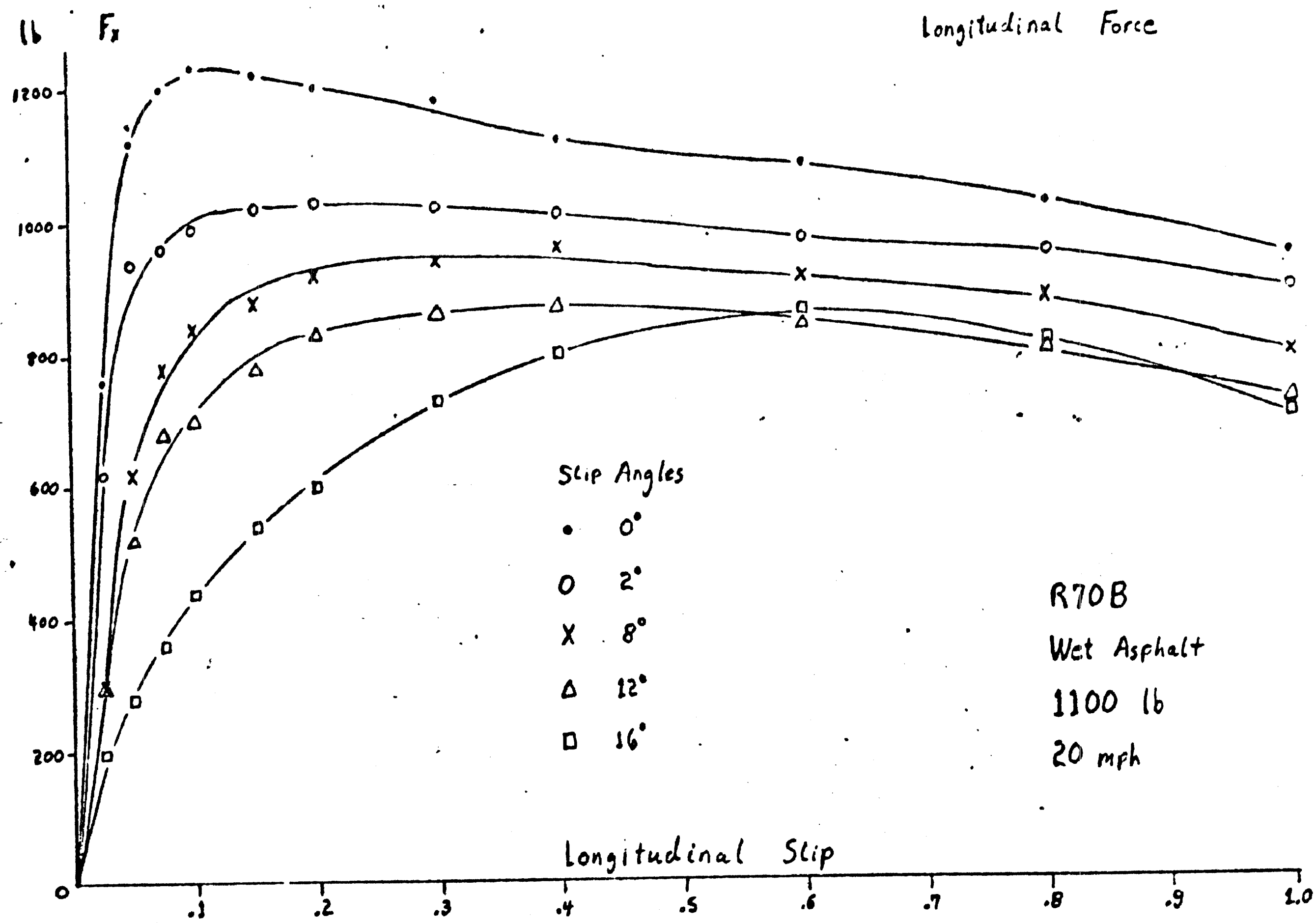


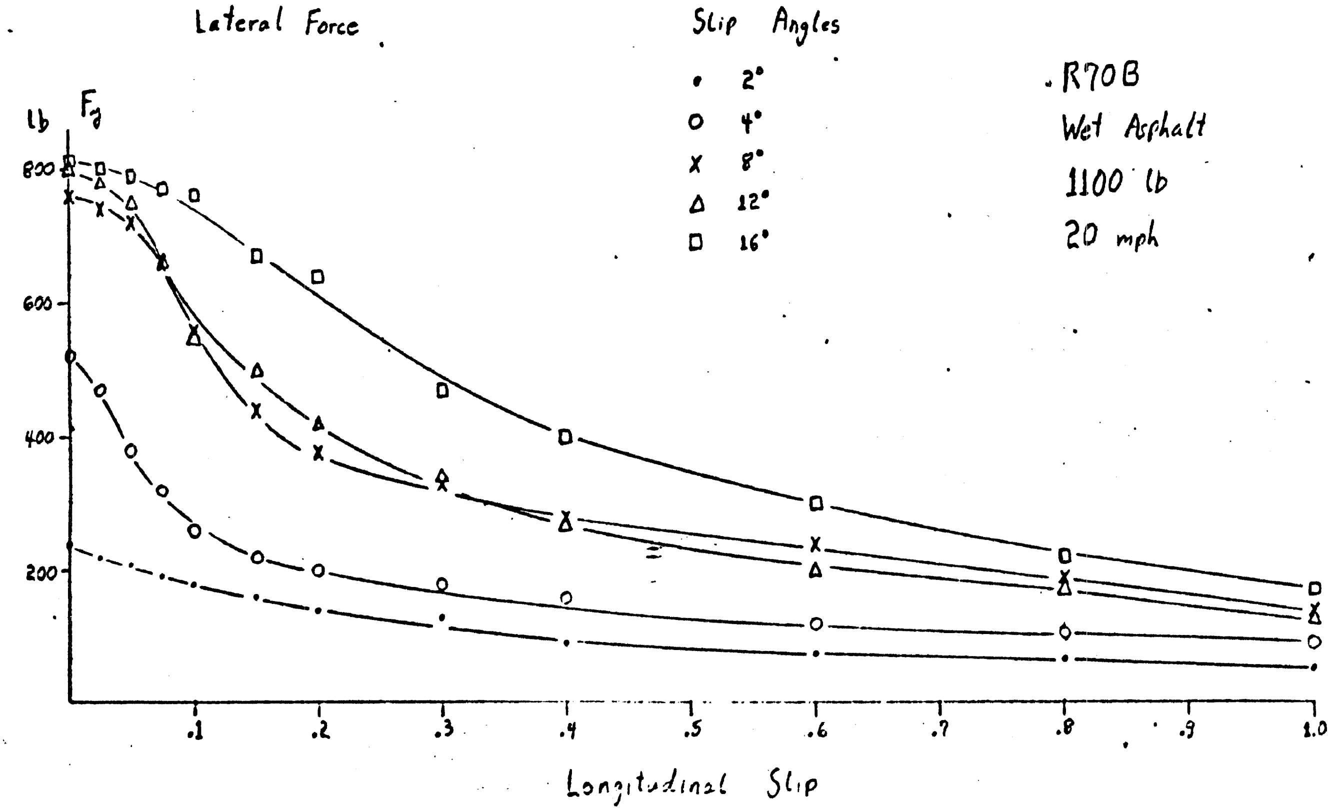
FX
FY
1000
800
600
400
200
(LB)
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
R70A
WET CONCRETE
1100 LB
40 MPH

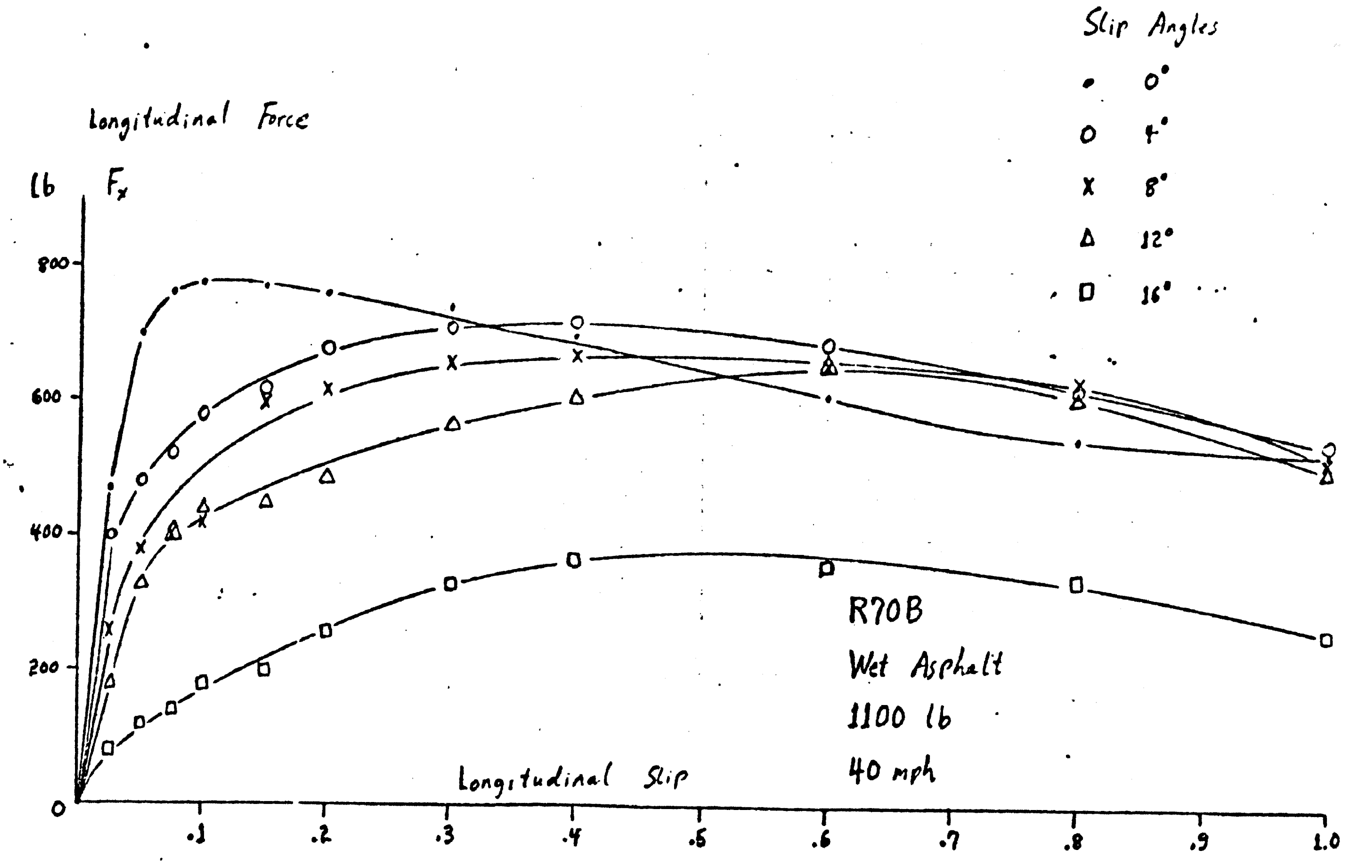

1000
(LB)
800
600
400
200
FX
FY
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
R70A
WET CONCRETE
1100 LB
55 MPH

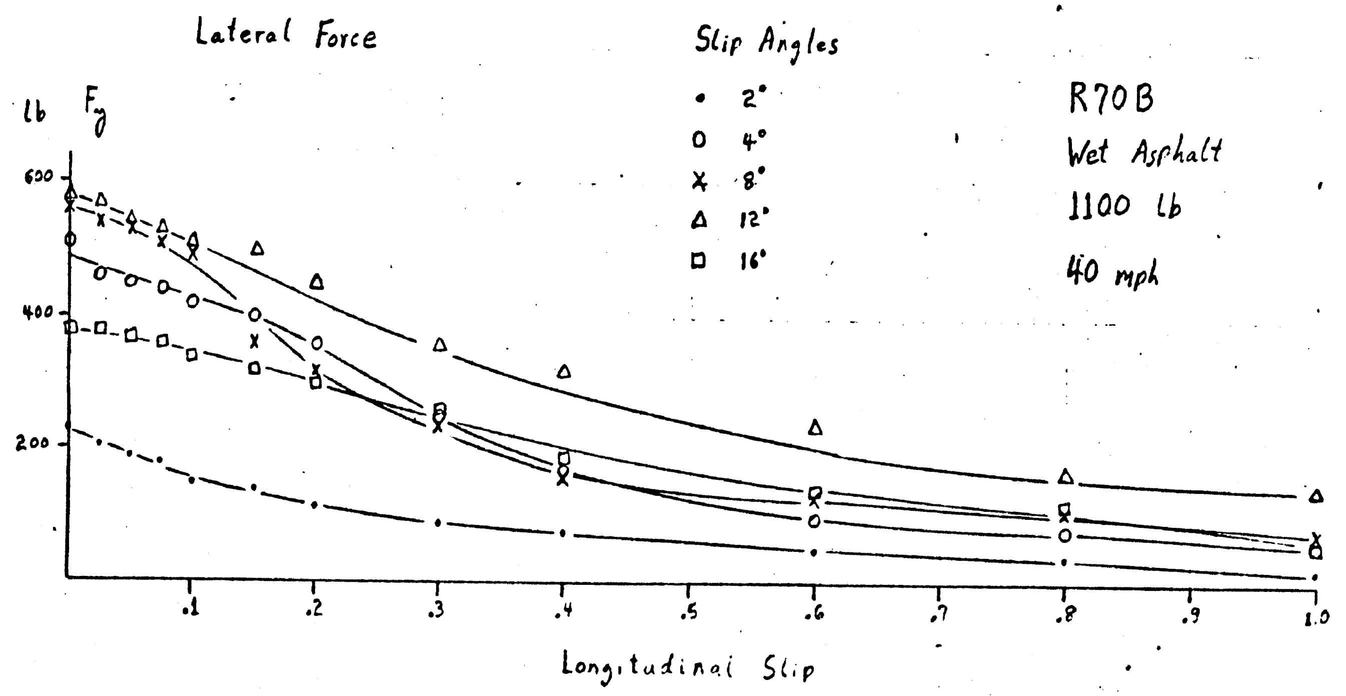

FX
FY
1000
800
600
400
200
(LB)
0
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
MZ
8
16
12
R70A
DRY CONCRETE
1,000 LB
20 MPH

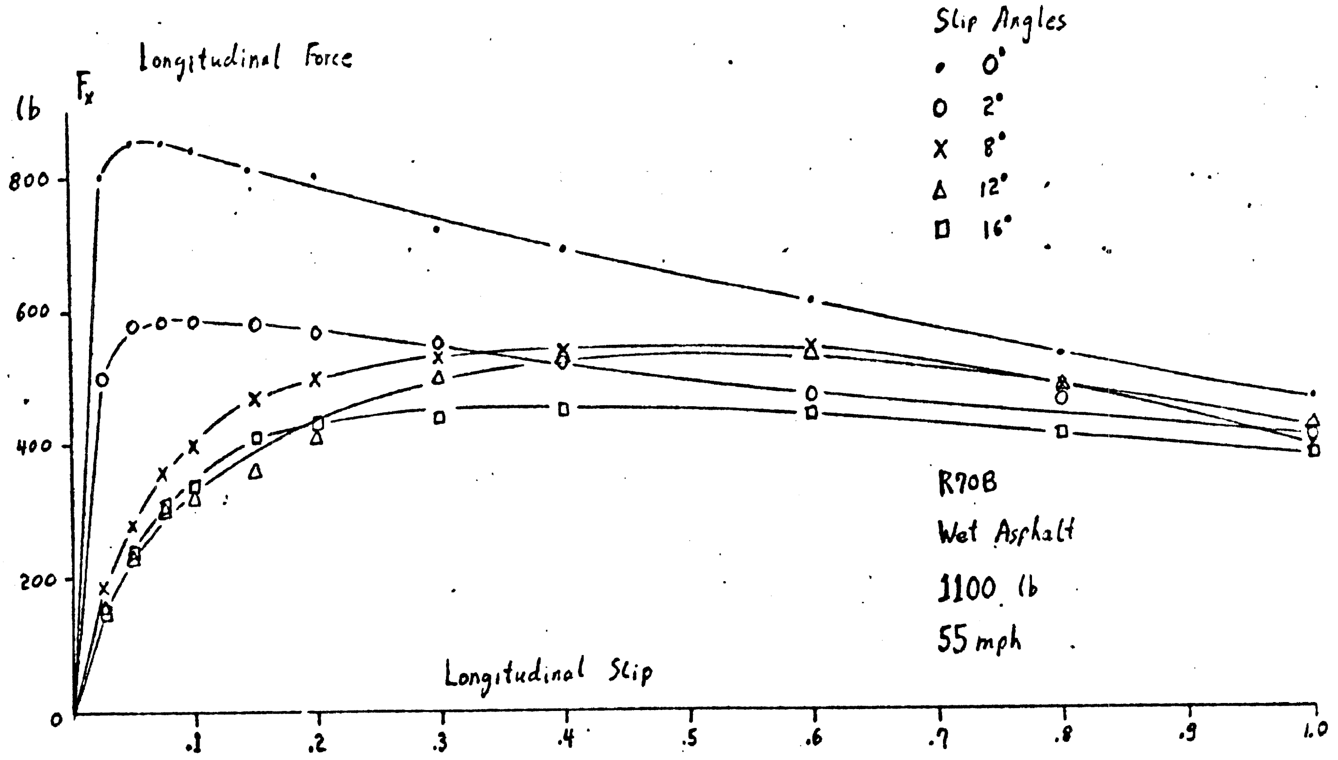

FX
FY
(LB)
1000
800
600
400
200
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
MZ
25
50
75
100
125
(LB-FT)
R70A
DRY CONCRETE
1000 LB
40 MPH

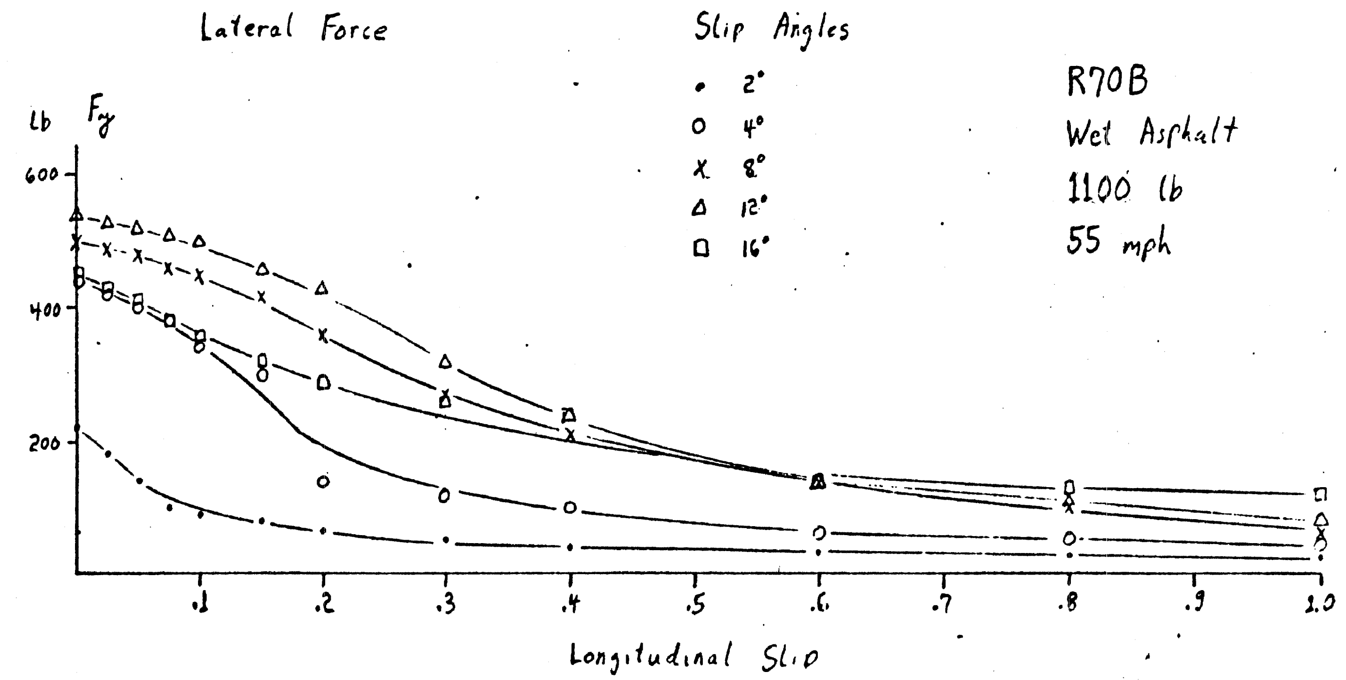

lb F_x
Longitudinal Force
1200
1000
800
600
400
200
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip
Slip Angles
• 0°
o 2°
x 8°
Δ 12°
□ 16°
R70B
Wet Asphalt
1100 lb
20 mph

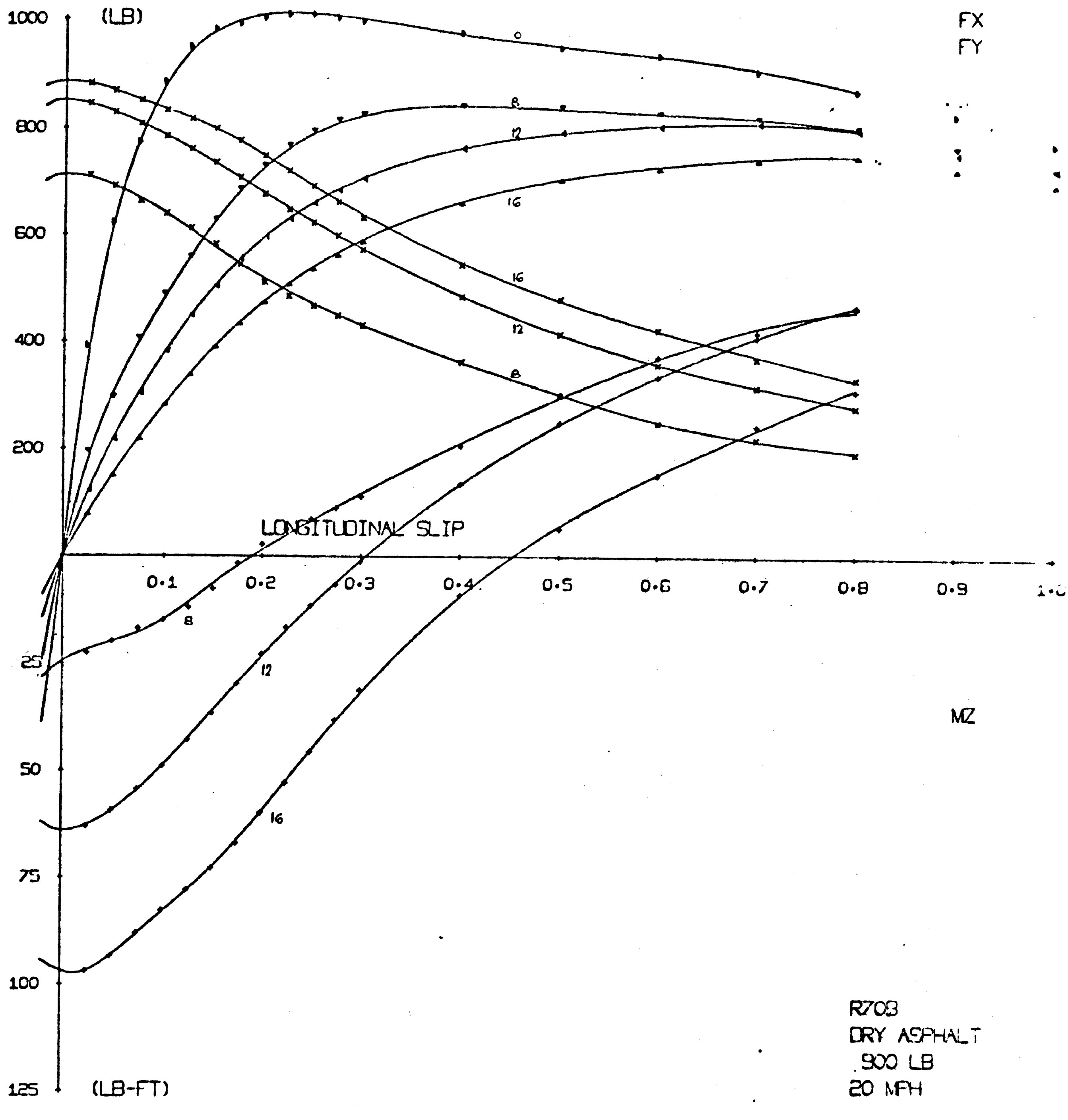

Lateral Force
Slip Angles
• 2°
o 4°
x 8°
Δ 12°
□ 16°
R70B
Wet Asphalt
1100 lb
20 mph
lb F_y
800
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip


Slip Angles
• 0°
o 4°
x 8°
Δ 12°
□ 16°
Longitudinal Force
lb F_x
800
600
400
200
0
R70B
Wet Asphalt
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

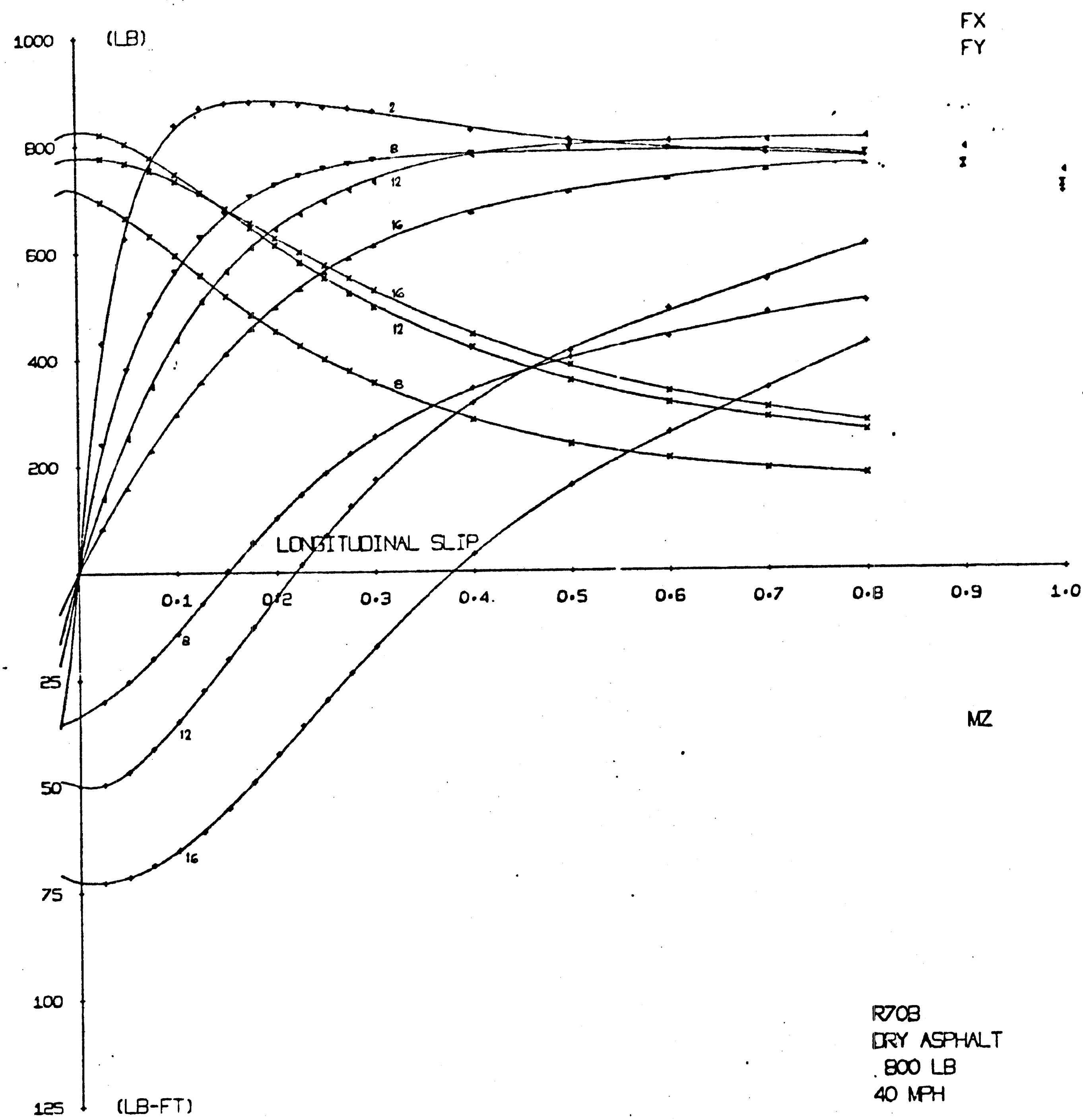

Lateral Force
lb F_y
Slip Angles
• 2°
o 4°
x 8°
Δ 12°
□ 16°
R70B
Wet Asphalt
1100 lb
40 mph
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip


Longitudinal Force
F_x
lb
800
600
400
200
0
Slip Angles
• 0°
o 2°
x 8°
Δ 12°
□ 16°
R70B
Wet Asphalt
1100 lb
55 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

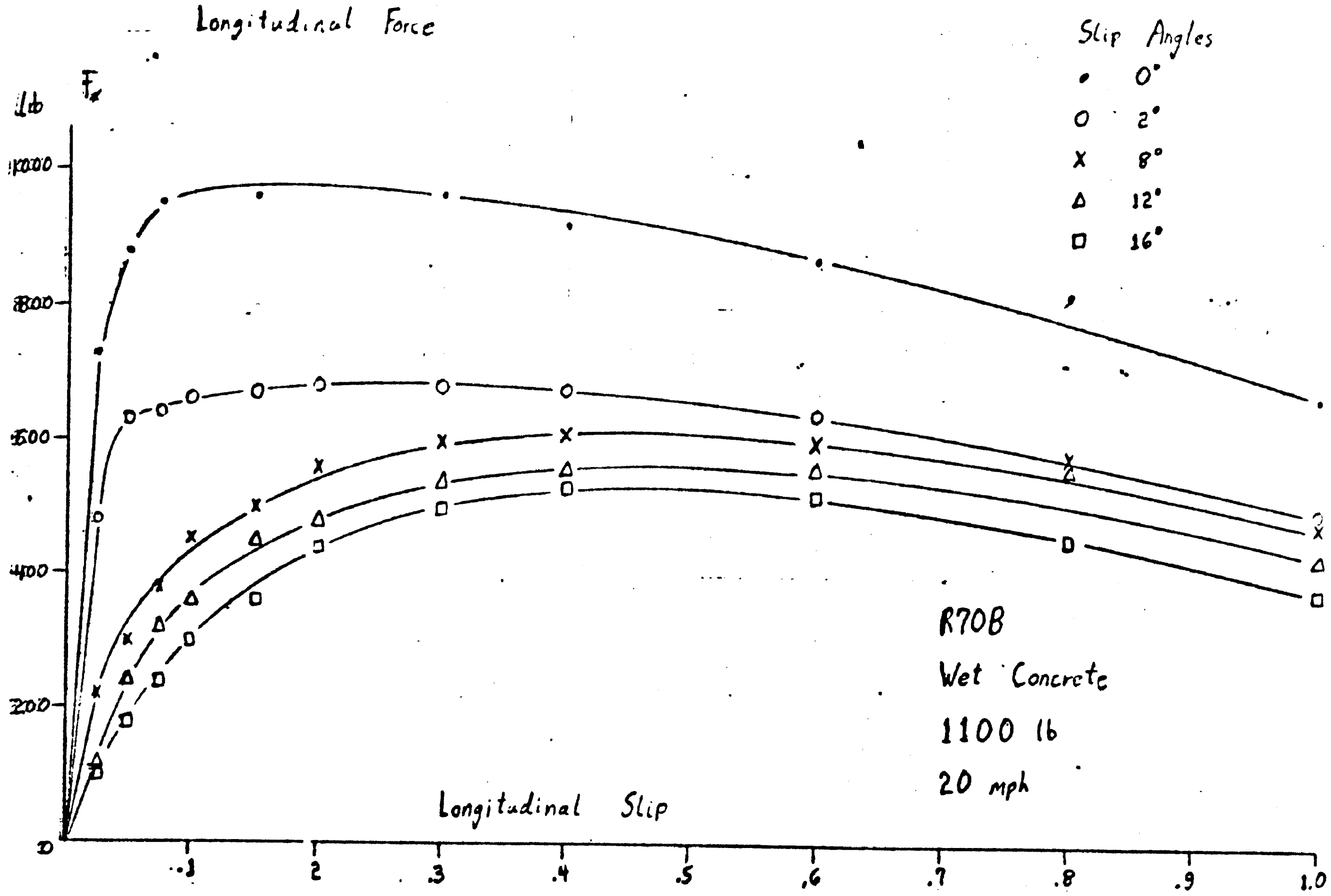

Lateral Force
Slip Angles
• 2°
o 4°
x 8°
Δ 12°
□ 16°
R70B
Wet Asphalt
1100 lb
55 mph
lb
F_y
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip

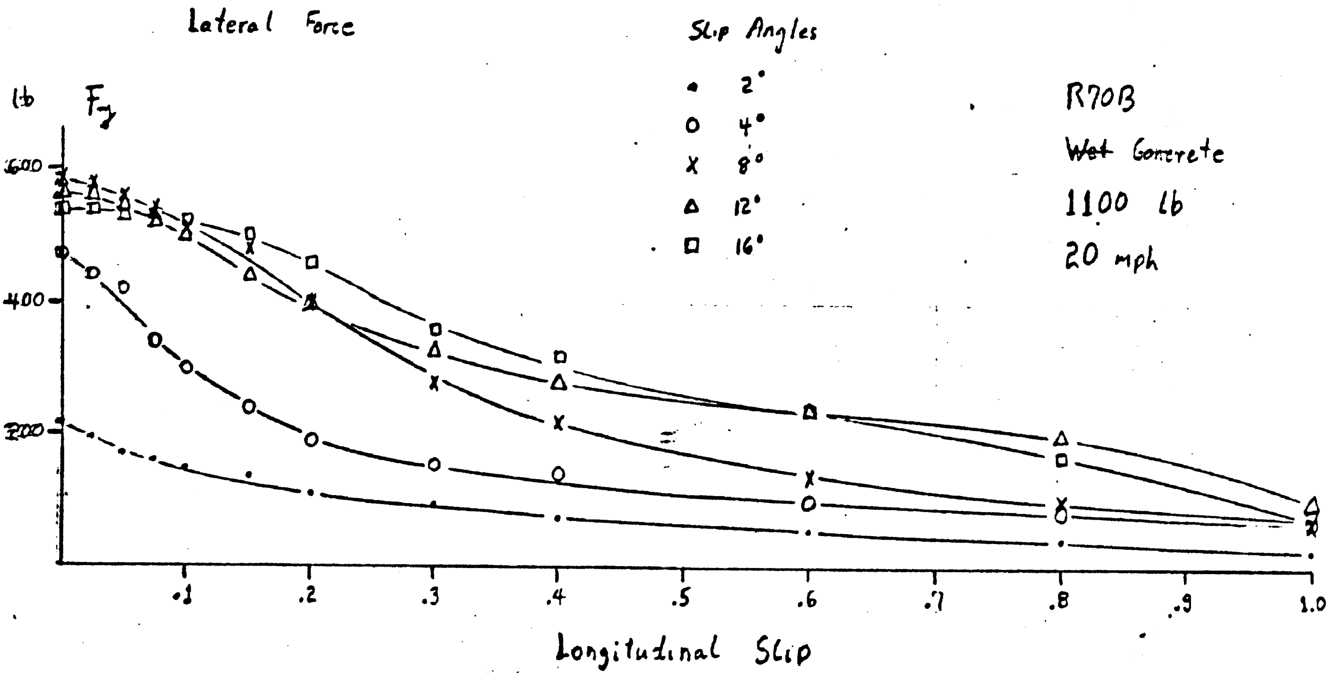


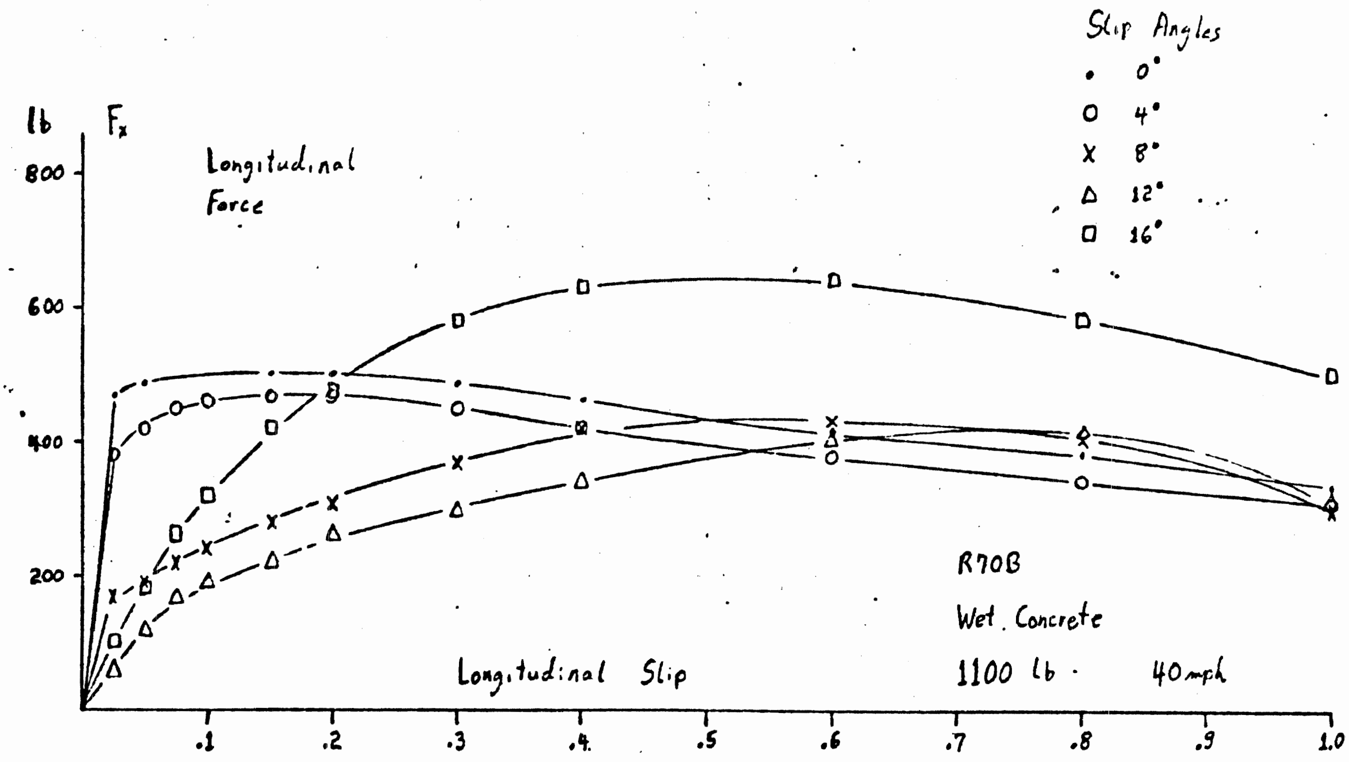
1000
(LB)
800
600
400
200
FX
FY
o
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
8
12
16
25
50
75
100
125
(LB-FT)
MZ
R703
DRY ASPHALT
900 LB
20 MPH



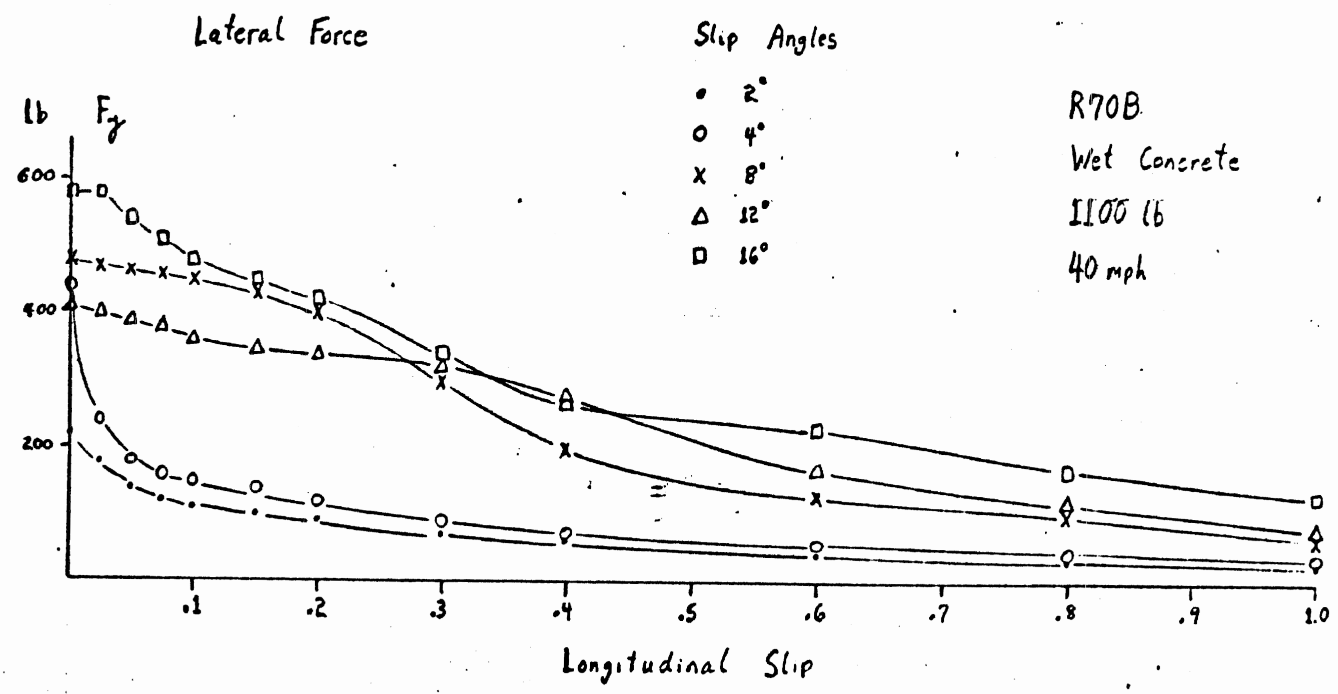
1000
(LB)
FX
FY
800
600
400
200
2
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4.
0·5
0·6
0·7
0·8
0·9
1·0
8
12
16
25
50
75
100
125
(LB-FT)
MZ
R70B
DRY ASPHALT
800 LB
40 MPH


Longitudinal Force
F_x
lb
1000
800
600
400
200
0
Slip Angles
0°
2°
8°
12°
16°
R70B
Wet Concrete
1100 lb
20 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

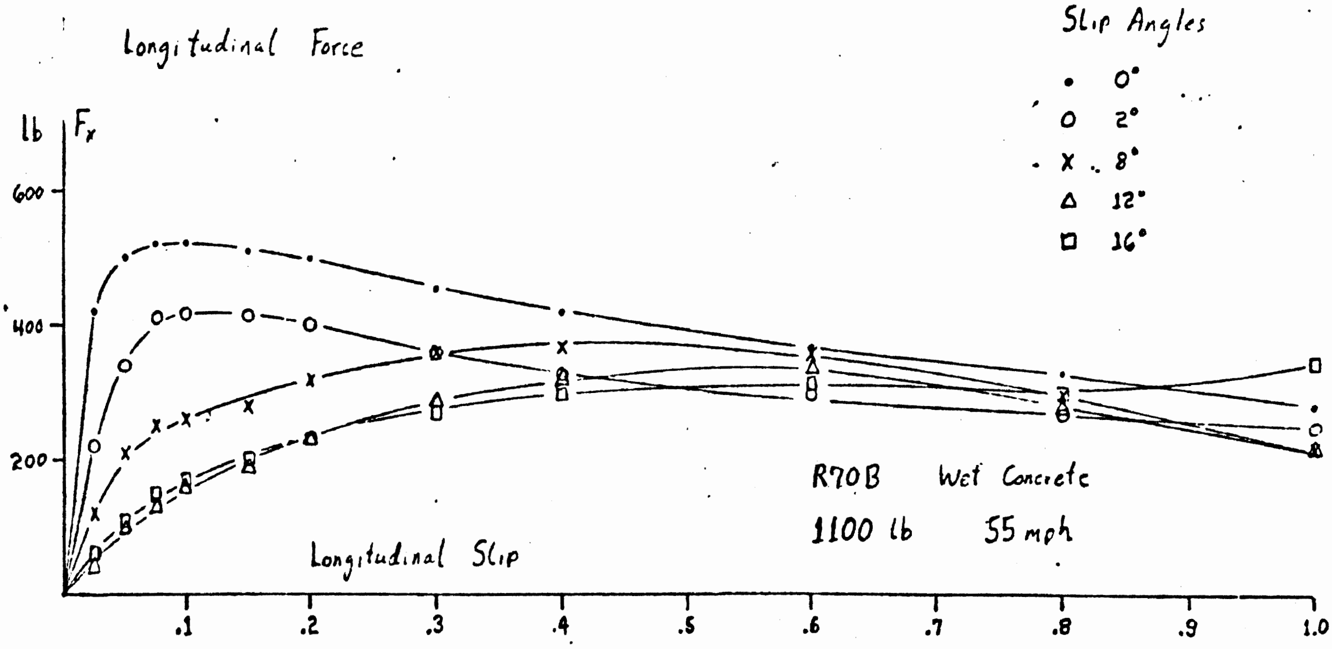

Lateral Force
lb
F_y
600
400
200
Slip Angles
2°
4°
8°
12°
16°
R70B
Wet Concrete
1100 lb
20 mph
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip

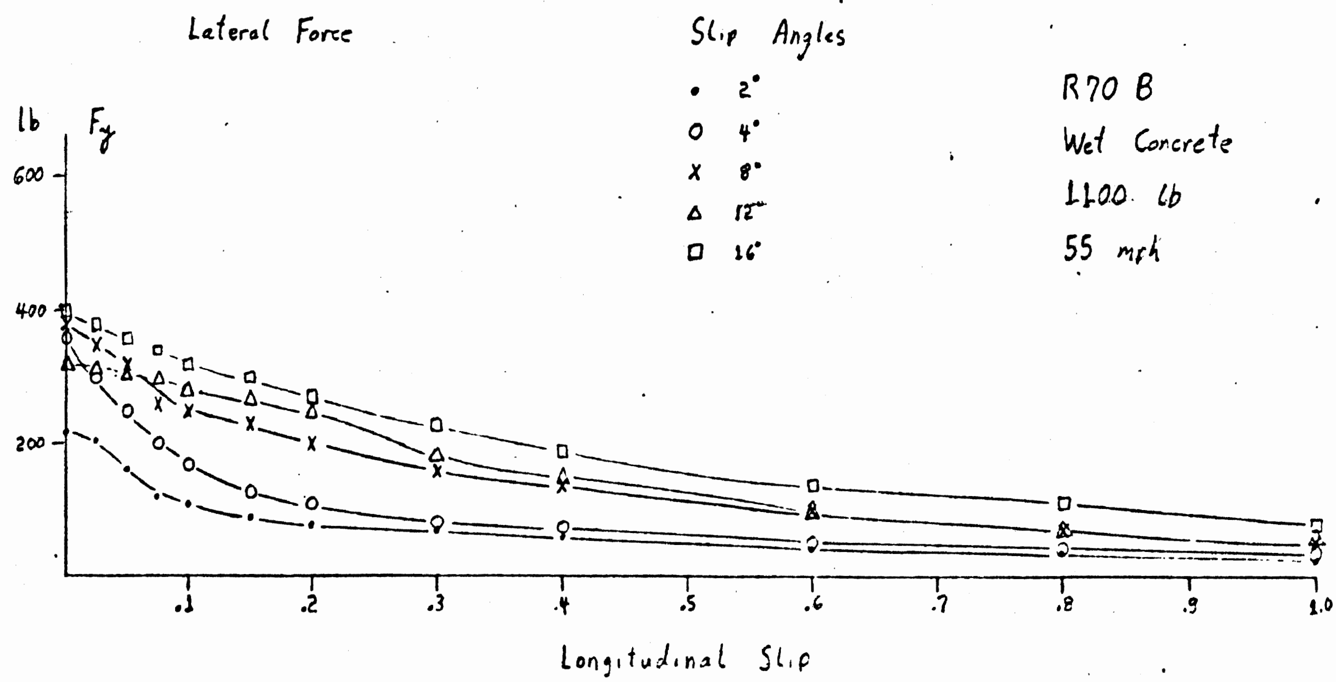


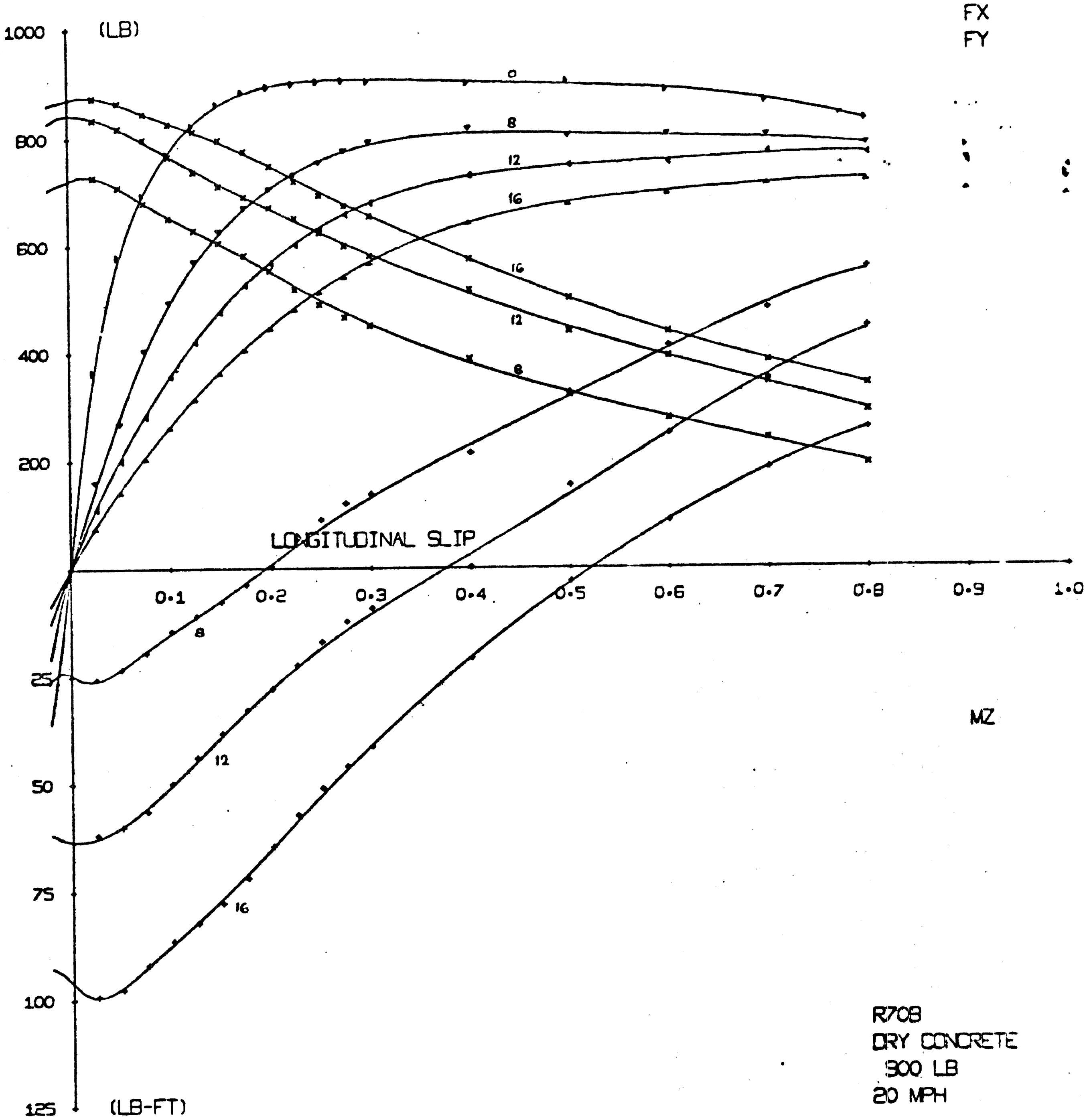
lb
F_x
Longitudinal Force
Slip Angles
0°
4°
8°
12°
16°
800
600
400
200
R70B
Wet Concrete
1100 lb
40 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

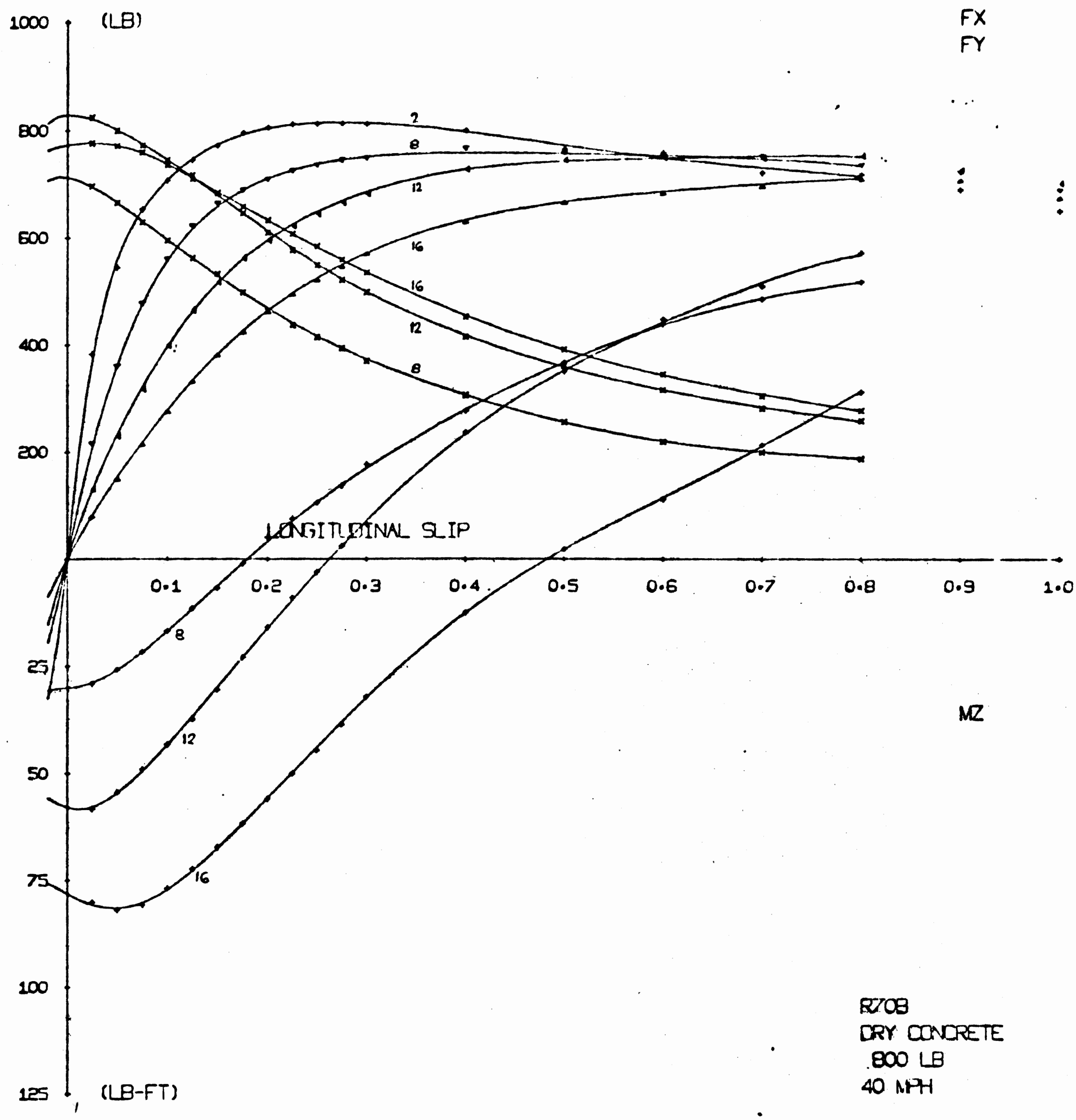


Lateral Force
Slip Angles
2°
4°
8°
12°
16°
R70B
Wet Concrete
1100 lb
40 mph
lb
F_y
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip


Longitudinal Force
Slip Angles
0°
2°
8°
12°
16°
lb
F_x
600
400
200
R70B Wet Concrete
1100 lb 55 mph
Longitudinal Slip
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0


Lateral Force
Slip Angles
2°
4°
8°
12°
16°
R70 B
Wet Concrete
1100 lb
55 mph
lb
F_y
600
400
200
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Longitudinal Slip


FX
FY
(LB)
1000
800
600
400
200
0
8
12
16
16
12
8
LONGITUDINAL SLIP
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
25
50
75
100
125
(LB-FT)
MZ
8
12
16
R70B
DRY CONCRETE
900 LB
20 MPH


1000
(LB)
800
600
400
200
FX
FY
2
8
12
16
16
12
8
LONGITUDINAL SLIP
0·1
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
25
50
75
100
125
(LB-FT)
8
12
16
MZ
R70B
DRY CONCRETE
800 LB
40 MPH

DIGITAL TAPE STORAGE

Many of the preceding tire data plots were drawn by a Calcomp 565 digital plotter driven on-line by an IBM 1800 computer. This data was processed entirely by computer from analog tape recordings (Table 4) made on-board the mobile tire tester.

The entire collection of computer-processed data, with test particulars, has been stored on magnetic digital tape. The format used for the storage is very close to the format conceived by Mr. W. T. Wells* of Chrysler.

Each data point** is represented by three 80-column cards, or card images stored on tape. Figure 3, on the next page, illustrates the three card image formats with a representative data point. The first column of each card identifies the type of card; test description, tire description, or the test input/output. The tire code (Cols. 10-21 on the description card) is that of the tire designs listed in Tables 1 and 2. The tire code is preceded by a tire number (1-4) indicating which tire of the four-tire set was tested.

The read formats for the card images illustrated in Figure 3 are

Card 1

(I1, 8X, A4, A2, I2, 3X, 2A4, A3, 2PF2.0, 3PF2.0, 40X, I5)

*"Tire Cornering-Braking Data," by William T. Wells, Akron Rubber Group Tire Mathematics Symposium, April 23, 1971, Akron, Ohio.

**The tire traction forces and moment at a specific set of operating conditions (velocity, slip angle, longitudinal slip, etc.).

TEST DESCRIPTION CARD

	Card ID	Date	Pressure			SN_{40}	Water Depth	Card Sequence
	1	060172	28	CONCRETE	DRY	73		4095
Columns	1	10-15	16-17	21-28	29-31		34-35	76-80

TIRE DESCRIPTION CARD

	Card ID	Tire No	Tire Code	Tire Type	Size	Aspect Ratio	Rim	Fabric	Ribs	Card Sequence
	2	3	R70A	RADIAL	FR70-14	70	6.0	RAYON-RAYON	5	4096
Columns	1	8-9	10-21	22-32	33-40		43-48	56-70	71	76-80

TEST I/O CARD

	Card ID	Tire No.	Velocity	Load	Inclination	Slip Angle	Wheel Slip	Lateral Force	Aligning Moment	Longitudinal Force	Card Sequence
	3	3	40	900	0	12	-25	8163	-917	-1549	4097
Columns	1	8-9		13-16		20-22	28-33	34-39	40-45	58-63	76-80

Figure 3. HSRI braking-cornering data: card image formats

Card 2

(I1, 6X, I2, 2A4, 4X, 2A4, A3, 2A4, I2, 3X, A3, 7X, 3A4, A3, I1, 4X, I5

Card 3

(I1, 6X, I2, F3.0, F4.0, 2F3.0, 6X, F5.1, 2F6.1, 12X, F6.1, 12X, I5)

The SN40 skid number punched in card 1 (Cols. 32-33) is read with a scale factor of 2 to obtain the friction coefficient. The water depth (Cols. 34-35) is read with a scale factor of 3 to obtain the depth in inches.

The force and moment data points in card 3 are the average values derived from a number (usually 10) of replicate force and moment versus longitudinal slip curves obtained by repeated testing at the same operating conditions. As unbiased measurement errors are minimized by data averaging, it is reasonable to expect the averaged data points to be more accurate than those of a single measurement. For this reason, the averaged data points are recorded to .1 lb. (a greater accuracy than can be expected from a single mobile tire tester measurement) in order to more accurately determine such parameters as the longitudinal slip stiffness, C_s.

Figure 4 illustrates a segment of the 80-column card image records stored on digital tape. It is seen that cards 1 and 2 need not be repeated for variations in slip angle and longitudinal slip.

The digital tape is 9-track in IBM EBCDIC code at 800 bpi. The 80-column records are unblocked and have a record sequence number in the last 5 columns. Two file marks signal the end of the tape.

3	11 551100	0	4	500	1078	481	5402	1996
3	11 551100	0	4	600	939	521	5224	1997
3	11 551100	0	4	700	863	521	5232	1998
3	11 551100	0	4	800	820	505	5176	1999
3	11 551100	0	4	900	871	453	4843	2000
3	11 551100	0	4	1000	809	294	4141	2001
1	06017228		ASPHALT WET5315					2002
2	11B260A		BIAS-BELTEDF60-14			60 7.0	POLYESTER-GLASS9	2003
3	11 551100	0	8	-25	7081	-88	-1686	2004
3	11 551100	0	8	0	7130	-221	0	2005
3	11 551100	0	8	25	7062	-405	2202	2006
3	11 551100	0	8	50	6784	-493	3645	2007
3	11 551100	0	8	75	6445	-532	4700	2008
3	11 551100	0	8	100	6041	-535	5464	2009
3	11 551100	0	8	125	5639	-515	6040	2010
3	11 551100	0	8	150	5274	-479	6452	2011
3	11 551100	0	8	175	4862	-408	6628	2012
3	11 551100	0	8	200	4494	-328	6668	2013
3	11 551100	0	8	225	4179	-258	6666	2014
3	11 551100	0	8	250	3867	-185	6416	2015
3	11 551100	0	8	275	3587	-109	6550	2016
3	11 551100	0	8	300	3347	-41	6472	2017
3	11 551100	0	8	400	2636	153	6214	2018
3	11 551100	0	8	500	2024	311	5892	2019
3	11 551100	0	8	600	1660	417	5440	2020
3	11 551100	0	8	700	1436	462	5270	2021
3	11 551100	0	8	800	1365	485	5266	2022
3	11 551100	0	8	900	1237	445	4845	2023
3	11 551100	0	8	1000	1156	312	4268	2024
1	06017228		ASPHALT WET5315					2025
2	11B260A		BIAS-BELTEDF60-14			60 7.0	POLYESTER-GLASS9	2026
3	11 551100	0	12	-25	7209	-225	-1239	2027
3	11 551100	0	12	0	7119	-285	0	2028
3	11 551100	0	12	25	6935	-315	1141	2029
3	11 551100	0	12	50	6661	-333	2011	2030
3	11 551100	0	12	75	6353	-335	2679	2031
3	11 551100	0	12	100	6021	-322	3246	2032
3	11 551100	0	12	125	5707	-292	3726	2033
3	11 551100	0	12	150	5408	-264	4112	2034
3	11 551100	0	12	175	5153	-234	4424	2035
3	11 551100	0	12	200	4901	-194	4699	2036
3	11 551100	0	12	225	4655	-153	4922	2037
3	11 551100	0	12	250	4428	-113	5120	2038
3	11 551100	0	12	275	4213	-74	5299	2039

Figure 4. Card image tape dump.

DATA TABLES

The digital tape storage described in the previous section is used for the data processed by computer from analog tape records. Force and moment data for 21 longitudinal slip values (spaced between free-rolling and locked wheel) at each set of operating conditions are stored on the digital tape.

The oscillograph record data was hand-processed for only 12 values of longitudinal slip. This data, which is not included* in the digital tape storage, is given in the following tables of longitudinal slip (s_x) and traction forces (F_x, F_y) in pounds.

*Table 4 on page 16 indicates which tires have test data by analog tape acquisition. This data is subsequently stored on digital tape.

B278B
1100 lb
Wet Asphalt

0°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	–	0	–	0	–
.025	505	–	650	–	625	–
.05	835	–	770	–	730	–
.075	905	–	775	–	755	–
.10	915	–	×	–	760	–
.15	915	–	780	–	745	–
.20	910	–	775	–	710	–
.30	905	–	770	–	670	–
.40	845	–	760	–	625	–
.60	820	–	700	–	570	–
.80	775	–	660	–	520	–
1.00	720	–	580	–	440	–

B278B
1100 lb
Wet Asphalt

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	520	0	515	0	520
.025	450	545	550	535	550	520
.05	675	540	750	505	700	500
.075	790	500	790	425	760	425
.10	880	425	×	×	775	360
.15	905	360	800	365	775	320
.20	905	320	×	×	770	300
.30	905	255	785	270	710	225
.40	870	215	750	225	670	200
.60	830	170	695	165	575	150
.80	790	150	660	130	525	100
1.00	745	135	600	120	470	80

B278B
1100 lb
Wet Asphalt

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	935	0	805	0	835
.025	150	940	150	810	150	845
.05	300	925	275	810	285	845
.075	400	880	350	805	400	730
.10	×	×	475	770	500	650
.15	580	825	530	720	575	600
.20	630	775	580	680	600	550
.30	765	700	650	520	625	380
.40	825	670	675	420	625	305
.60	835	450	680	320	590	225
.80	815	330	660	245	540	200
1.00	775	275	620	220	450	170

B278B
1100 lb
Wet Asphalt

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	1020	0	870	0	850
.025	200	1030	120	865	125	845
.05	400	1030	230	830	250	825
.075	450	1000	360	775	350	800
.10	500	970	500	700	440	705
.15	600	930	560	650	490	620
.20	650	900	625	620	520	550
.30	780	775	675	550	530	490
.40	850	640	685	480	545	400
.60	850	475	680	375	550	300
.80	805	350	665	275	525	230
1.00	775	300	600	230	430	175

B278B
1100 lb
Wet Concrete

0°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	-	0	-	0	-
.025	350	-	330	-	275	-
.05	500	-	520	-	375	-
.075	525	-	×	-	400	-
.10	×	-	520	-	400	-
.15	×	-	512	-	400	-
.20	530	-	500	-	400	-
.30	535	-	485	-	390	-
.40	535	-	470	-	370	-
.60	475	-	425	-	350	-
.80	440	-	385	-	325	-
1.00	415	-	350	-	300	-

B278B
1100 lb
Wet Concrete

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	470	0	440	0	400
.025	210	475	200	440	340	365
.05	325	475	×	×	375	305
.075	×	×	350	435	380	×
.10	425	470	430	430	380	250
.15	515	430	465	360	380	220
.20	×	×	470	290	380	175
.30	560	300	470	225	370	135
.40	570	250	450	160	360	125
.60	540	200	405	125	330	100
.80	500	150	370	100	305	80
1.00	460	120	325	80	285	75

B278B
1100 lb
Wet Concrete
8°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	620	0	605	0	480
.025	190	620	75	610	180	470
.05	270	605	125	605	275	450
.075	×	×	200	600	×	×
.10	350	585	300	590	310	400
.15	460	550	400	550	320	350
.20	470	480	435	450	330	300
.30	475	420	450	305	340	225
.40	480	360	435	240	350	180
.60	480	250	420	190	325	150
.80	460	160	380	140	300	135
1.00	440	140	340	120	275	120

B278B
1100 lb
Wet Concrete

12°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	685	0	550	0	525
.025	110	690	100	550	80	520
.05	×	×	175	550	110	510
.075	225	690	225	545	160	495
.10	300	685	300	530	200	480
.15	350	675	350	475	240	470
.20	450	645	380	400	300	440
.30	480	575	405	320	350	340
.40	485	510	400	290	350	300
.60	490	400	360	200	345	220
.80	470	250	335	165	325	160
1.00	445	170	320	125	305	140

B278B
1100 lb
Wet Concrete

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	800	0	585	0	495
.025	50	775	75	590	60	475
.05	×	×	130	595	×	×
.075	100	750	180	595	125	430
.10	175	715	205	590	170	420
.15	200	690	285	580	225	325
.20	250	675	350	525	×	325
.30	325	600	390	425	300	300
.40	400	515	410	350	310	220
.60	480	420	405	260	325	205
.80	480	325	380	230	310	160
1.00	470	225	335	180	250	125

B278C
1100 lb
Wet Asphalt

0°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	–	0	–	0	–
.025	480	–	460	–	500	–
.05	720	–	620	–	760	–
.075	900	–	680	–	850	–
.10	1010	–	740	–	890	–
.15	1030	–	760	–	900	–
.20	1040	–	800	–	890	–
.30	1040	–	840	–	870	–
.40	1000	–	880	–	800	–
.60	930	–	870	–	720	–
.80	920	–	800	–	640	–
1.00	840	–	650	–	570	–

B278C
1100 lb
Wet Asphalt

2°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	300	0	250	0	280
.025	340	310	500	260	800	240
.05	800	280	740	265	880	150
.075	960	220	840	260	890	120
.10	1020	180	880	220	900	100
.15	1060	140	960	180	880	80
.20	1060	120	980	150	820	70
.30	1000	100	980	140	750	60
.40	950	95	960	130	700	50
.60	910	90	920	110	640	45
.80	890	85	830	80	580	40
1.00	860	80	800	70	530	40

B278C
1100 lb
Wet Asphalt

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	480	0	500	0	530
.025	600	500	540	540	740	500
.05	740	510	660	540	780	440
.075	820	500	720	520	830	360
.10	880	480	780	420	870	260
.15	940	440	840	350	890	200
.20	980	410	880	260	890	180
.30	1020	270	880	180	830	150
.40	1050	230	860	150	700	140
.60	1040	160	770	120	580	120
.80	860	100	680	100	540	110
1.00	720	80	600	80	520	100

B278C
1100 lb
Wet Asphalt

8°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	820	0	740	0	710
.025	300	840	380	750	400	730
.05	600	840	470	760	470	720
.075	700	820	560	760	520	700
.10	780	780	660	560	600	620
.15	900	720	720	400	670	440
.20	940	660	760	330	730	340
.30	1000	520	830	240	760	260
.40	1020	460	840	200	760	200
.60	1020	300	820	160	620	140
.80	940	220	720	120	570	120
1.00	780	160	580	80	500	100

B278C
1000 lb
Dry Asphalt

0°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	-	0	-		
.02	525	-	400	-		
.05	750	-	750	-		
.10	900	-	900	-		
.15	1025	-	970	-		
.20	1050	-	985	-		
.30	1050	-	980	-		
.50	1015	-	975	-		
.70	950	-	965	-		
.90	870	-	955	-		
1.00	850	-	950	-		

B278C
1000 lb
Dry Asphalt

4°

S_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	531				
.02	610	589				
.05	1012	491				
.10	1070	376				
.15	1080	301				
.20	1050	230				
.30	991	181				
.50	936	138				
.70	909	120				
.90	866	115				
1.00	850	115	870	92		

oscillograph record
almost unreadable

B278C
1000 lb
Dry Asphalt

8°

S_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	885	0	830		
.02	275	935	200	835		
.05	700	835	500	775		
.10	950	650	720	675		
.15	987	525	810	500		
.20	980	400	825	370		
.30	970	240	825	275		
.50	950	180	805	175		
.70	×	×	800	130		
.90	935	175	795	120		
1.00	925	170	795	115		

B278C
1000 lb
Dry Asphalt

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	1100	0	920		
.02	310	1155	350	925		
.05	540	1070	500	850		
.10	830	845	675	700		
.15	895	755	800	600		
.20	950	550	860	500		
.30	955	400	890	370		
.50	940	300	900	250		
.70	935	270	900	230		
.90	930	260	900	220		
1.00	925	240	900	215		

B278C
1000 lb
Dry Asphalt

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	1130	0	1050		
.02	300	1130	200	1040		
.05	550	1100	400	1030		
.10	700	975	600	950		
.15	875	850	675	825		
.20	950	700	780	675		
.30	950	465	900	480		
.50	940	350	955	300		
.70	×	320	960	240		
.90	×	300	960	235		
1.00	930	285	960	230		

B278C
1100 lb
Wet Concrete

0°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	–	0	–	0	–
.025	300	–	300	–	280	–
.05	480	–	480	–	400	–
.075	550	–	540	–	440	–
.10	600	–	570	–	480	–
.15	650	–	610	–	510	–
.20	680	–	620	–	540	–
.30	690	–	620	–	590	–
.40	710	–	580	–	600	–
.60	720	–	500	–	570	–
.80	500	–	460	–	460	–
1.00	470	–	360	–	320	–

B 278 C
1100 lb
Wet Concrete

2°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	270	0	240	0	230
.025	400	280	240	250	180	240
.05	500	240	360	240	260	230
.075	560	210	500	230	340	220
.10	600	180	520	200	390	200
.15	630	160	540	180	450	170
.20	660	140	550	150	500	140
.30	660	120	580	140	530	130
.40	650	115	600	130	550	120
.60	600	100	630	100	530	100
.80	550	80	570	80	410	80
1.00	430	70	420	60	310	75

B278C
1100 lb
Wet Concrete

4°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	440	0	450	0	420
.025	280	450	300	460	240	450
.05	380	440	380	465	340	440
.075	480	430	460	460	380	400
.10	560	410	500	450	400	380
.15	620	360	520	400	430	340
.20	640	300	550	300	470	280
.30	660	260	570	180	520	200
.40	660	200	580	150	470	160
.60	600	120	560	130	360	100
.80	540	90	530	120	330	80
1.00	420	50	420	100	300	60

B278C
1100 lb
Wet Concrete

8°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	620	0	520	0	400
.025	200	640	240	530	220	420
.05	360	620	300	540	260	430
.075	430	460	360	500	280	430
.10	470	400	400	480	300	420
.15	500	360	440	400	340	340
.20	540	300	510	300	400	300
.30	560	260	550	260	480	230
.40	580	220	580	200	500	180
.60	590	140	560	150	410	110
.80	560	120	480	120	380	80
1.00	490	60	400	90	340	50

B278C
1000 lb
Dry Concrete

0°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	-	0	-		
.02	400	-	400	-		
.05	700	-	680	-		
.10	910	-	815	-		
.15	935	-	870	-		
.20	×	-	870	-		
.30	950	-	870	-		
.50	930	-	865	-		
.70	920	-	857	-		
.90	870	-	850	-		
1.00	840	-	845=	-		

B278C
1000 lb
Dry Concrete

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	570	0	540		
.02	575	585	×	556		
.05	810	560				
.10	925	460				
.15	1000	320	870			
.20	1000	185				
.30	925	125				
.50	880	105				
.70	865	100				
.90	850	100				
1.00	850	100	840	115		

oscillograph record almost unreadable

B278C
1000 lb
Dry Concrete

8°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	925	0	900		
.02	350	975	×	890		
.05	680	925	450	880		
.10	985	575	725	775		
.15	985	420	785	620		
.20	980	370	840	500		
.30	925	240	860	350		
.50	860	175	850	225		
.70	850	175	840	175		
.90	840	170	835	170		
1.00	835	170	830	160		

B278C
1000 lb
Dry Concrete

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	1170	0	940		
.02	225	1160	380	925		
.05	410	1130	500	850		
.10	730	980	675	750		
.15	900	760	750	675		
.20	950	615	795	525		
.30	950	385	830	370		
.50	910	275	850	260		
.70	905	260	860	215		
.90	×	235	860	185		
1.00	885	215	860	175		

B278C
1000 lb
Dry Concrete

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	1080	0	1015		
.02	200	1115	100	990		
.05	500	1090	225	970		
.10	685	1000	575	900		
.15	800	825	680	770		
.20	900	675	725	675		
.30	920	475	810	420		
.50	920	250	840	275		
.70	920	240	860	225		
.90	920	235	860	220		
1.00	920	230	860	210		

B270A
1100 lb
Wet Asphalt
0°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	-	0	-	0	-
.025	360	-	380	-	320	-
.05	640	-	410	-	400	-
.075	760	-	500	-	500	-
.10	820	-	540	-	580	-
.15	900	-	580	-	660	-
.20	960	-	610	-	700	-
.30	1000	-	710	-	670	-
.40	1030	-	680	-	620	-
.60	1000	-	550	-	470	-
.80	880	-	470	-	420	-
1.00	800	-	440	-	370	-

B270A
1100 lb
Wet Asphalt
2°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	230	0	250	0	210
.025	360	280	480	260	300	230
.05	600	260	620	180	380	230
.075	860	200	670	150	420	220
.10	920	160	690	140	460	210
.15	1000	140	720	130	530	180
.20	1040	130	760	120	580	140
.30	1060	110	780	90	620	80
.40	1060	100	780	60	600	60
.60	1020	80	730	40	510	50
.80	950	70	650	35	420	40
1.00	810	50	540	25	360	30

B270A
1100 lb
Wet Asphalt

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	500	0	440	0	430
.025	400	520	470	470	120	440
.05	520	525	610	460	260	460
.075	680	520	670	360	370	470
.10	820	480	730	300	440	470
.15	920	400	780	220	480	460
.20	970	320	790	140	550	260
.30	1000	240	780	110	590	130
.40	1020	160	720	80	590	100
.60	960	120	600	60	500	60
.80	840	100	520	50	400	40
1.00	740	70	470	40	330	30

B270A
1100 lb.
Wet Asphalt

8°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	~~4~~00	810	0	620	0	650
.025	400	820	200	630	180	660
.05	600	800	340	620	290	660
.075	750	770	450	560	360	640
.10	770	730	500	520	450	540
.15	860	600	600	430	480	440
.20	920	520	660	390	550	350
.30	940	420	700	280	570	250
.40	960	360	720	240	560	210
.60	950	280	700	150	450	120
.80	930	230	640	120	420	100
1.00	830	140	550	90	360	70

B270A
1100 lb
Wet Asphalt

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	870	0	710	0	590
.025	200	860	200	720	240	600
.05	480	840	340	730	300	595
.075	600	800	400	730	360	580
.10	650	740	470	720	430	520
.15	760	660	500	680	480	460
.20	860	540	570	580	550	400
.30	930	400	670	500	580	340
.40	930	320	730	360	600	290
.60	870	250	720	240	560	190
.80	820	220	640	170	500	150
1.00	720	150	550	130	430	100

B270A
1100 lb
Wet Asphalt
16°

S_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	900	0	700	0	565
.025	220	910	80	710	120	570
.05	300	910	160	720	200	570
.075	400	880	220	730	260	565
.10	460	840	280	730	310	560
.15	540	780	380	720	360	540
.20	740	660	430	700	430	500
.30	820	520	560	560	490	410
.40	880	400	610	460	530	340
.60	900	320	700	280	540	220
.80	900	280	680	190	510	150
1.00	820	220	580	140	420	110

B270A
1100 lb
Wet Concrete

0°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0		0		0	
.025	200		300		160	
.05	380		360		220	
.075	480		460		300	
.10	560		500		350	
.15	640		540		400	
.20	700		580		480	
.30	790		630		530	
.40	800		640		540	
.60	720		600		420	
.80	620		480		300	
1.00	480		380		240	

B270A
1100 lb
Wet Concrete

2°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	240	0	250	0	180
.025	580	270	320	260	160	200
.05	680	220	390	260	220	220
.075	710	160	440	220	260	220
.10	715	140	460	160	310	200
.15	715	120	480	130	380	110
.20	710	110	490	120	430	90
.30	705	90	530	100	480	80
.40	700	80	540	80	490	70
.60	660	70	460	60	420	60
.80	600	50	390	45	330	50
1.00	460	40	330	40	250	35

B270A
1100 lb
Wet Concrete
4°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	460	0	410	0	350
.025	300	480	420	420	320	380
.05	500	500	460	350	380	370
.075	570	500	470	230	410	360
.10	620	470	490	160	440	330
.15	670	280	500	140	450	280
.20	710	220	510	120	455	220
.30	720	190	510	80	440	140
.40	720	140	460	60	430	120
.60	710	110	360	40	330	60
.80	660	90	310	35	290	50
1.00	540	60	290	30	250	40

B270,A
1100 lb
Wet Concrete

8°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	600	0	460	0	450
.025	320	610	100	480	170	460
.05	400	610	130	500	240	465
.075	500	520	180	500	280	460
.10	550	400	220	490	300	450
.15	640	260	290	480	340	420
.20	660	220	330	450	370	340
.30	670	160	390	350	410	240
.40	650	140	470	200	420	190
.60	600	120	420	120	420	130
.80	520	80	370	80	360	90
1.00	450	60	320	60	260	50

B270/1
1100 lb
Wet Concrete

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	590	0	530	0	390
.025	80	600	180	540	100	400
.05	170	605	250	520	160	410
.075	220	595	280	480	190	410
.10	260	590	310	440	200	405
.15	340	570	340	400	260	390
.20	400	540	370	370	300	360
.30	500	480	420	330	350	310
.40	550	380	460	280	390	260
.60	580	220	460	200	420	140
.80	550	150	420	150	390	110
1.00	470	80	310	80	300	70

B270A
1100 lb
Wet Concrete

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	610	0	470	0	390
.025	120	620	40	475	40	400
.05	200	630	80	475	120	405
.075	280	625	120	480	180	400
.10	350	~~580~~ 615	180	475	200	395
.15	420	580	220	470	260	360
.20	500	480	250	460	300	300
.30	540	400	320	400	320	220
.40	560	280	390	280	375	170
.60	560	190	435	180	380	120
.80	530	140	420	140	330	95
1.00	460	90	340	80	280	80

R70B
1100 lb.
Wet Asphalt

0°

	20 mph		40 mph		55 mph	
s_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	–	0	–	0	–
.025	760	–	470	–	800	–
.05	1120	–	700	–	855	–
.075	1200	–	760	–	855	–
.10	1230	–	775	–	840	–
.15	1220	–	770	–	810	–
.20	1200	–	760	–	800	–
.30	1180	–	740	–	720	–
.40	1120	–	700	–	690	–
.60	1080	–	610	–	610	–
.80	1020	–	550	–	530	–
1.00	940	–	530	–	460	–

R70B
1100 lb.
Wet Asphalt

2°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	240	0	230	0	220
.025	620	220	350	205	500	180
.05	940	210	600	190	580	140
.075	960	190	680	180	582	100
.10	990	180	720	150	585	90
.15	1020	160	740	140	580	80
.20	1030	140	740	115	570	65
.30	1020	115	730	90	555	50
.40	1010	90	720	75	520	40
.60	970	75	680	50	470	30
.80	950	65	620	40	460	25
1.00	890	50	540	20	405	20

R70B
1100 lb
Wet Asphalt

4°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	520	0	510	0	440
.025	750	470	400	460	300	420
.05	900	380	480	450	380	400
.075	970	320	520	440	420	380
.10	1000	260	580	420	500	340
.15	1100	220	620	400	550	200
.20	1050	200	680	360	560	140
.30	950	180	710	250	550	120
.40	920	160	720	170	540	100
.60	830	120	690	100	450	60
.80	810	105	620	80	420	50
1.00	760	90	540	60	400	40

R70B
1100 lb
Wet Asphalt

8°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	760	0	560	0	500
.025	300	740	260	540	190	490
.05	620	720	380	530	280	480
.075	780	660	400	510	360	460
.10	840	560	420	490	400	450
.15	880	440	600	360	470	420
.20	920	380	620	320	500	360
.30	940	330	660	240	530	270
.40	960	280	670	180	540	210
.60	910	240	660	130	540	140
.80	880	190	630	110	480	100
1.00	790	140	520	80	390	60

R70B
1100 lb
Wet Asphalt

12°

α_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	800	0	580	0	540
.025	300	780	180	570	160	530
.05	520	750	330	540	230	520
.075	680	660	400	530	300	510
.10	700	550	420	510	320	500
.15	780	500	450	500	360	460
.20	830	420	490	450	410	430
.30	860	340	570	360	500	320
.40	870	270	610	320	530	240
.60	840	200	660	240	535	150
.80	800	170	610	170	480	110
1.00	720	130	520	140	420	80

R70B
1100 lb
Wet Asph lt

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0.	0	810	0	380	0	450
.025	200	800	80	380	160	430
.05	280	790	120	370	240	410
.075	360	770	140	360	310	380
.10	440	760	180	340	340	360
.15	540	700	200	320	405	320
.20	600	640	260	300	430	290
.30	730	470	330	260	440	260
.40	800	400	370	190	450	220
.60	860	300	360	140	440	160
.80	810	220	340	120	410	130
1.00	710	170	260	60	380	120

R7C6
1100 lb
Wet Concrete

0°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	-	0	-	0	-
.025	730	-	470	-	420	-
.05	880	-	490	-	500	-
.075	950	-	-	-	520	-
.10	-	-	-	-	520	-
.15	960	-	500	-	510	-
.20	-	-	500	-	500	-
.30	965	-	490	-	455	-
.40	920	-	460	-	420	-
.60	870	-	410	-	370	-
.80	820	-	380	-	330	-
1.00	670	-	330	-	280	-

R70B
1100 lb
Wet Concrete

2°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	215	0	220	0	220
.025	480	195	490	180	220	205
.05	630	170	510	140	340	160
.075	640	160	515	120	410	120
.10	660	150	510	110	415	110
.15	670	135	505	100	415	90
.20	680	110	500	90	400	80
.30	680	95	470	70	360	70
.40	675	75	450	60	330	60
.60	640	55	400	40	300	40
.80	–	40	365	30	270	35
1.00	500	25	340	25	250	25

R70B
1100 lb
Wet Concrete

4°

	20 mph		40 mph		55 mph	
Δ_x	F_x	F_y	F_x	F_y	F_x	F_y
0	0	475	0	440	0	360
.025	400	440	380	240	240	300
.05	500	420	420	180	250	250
.075	650	340	450	160	290	200
.10	680	300	460	150	320	170
.15	685	240	465	140	360	130
.20	680	190	465	120	380	110
.30	670	155	450	90	385	80
.40	620	140	420	65	380	75
.60	550	100	380	55	300	50
.80	520	85	340	40	240	40
1.00	470	70	310	35	210	35

R70B
1100 [illegible]
Wet Concrete

8°

Δ_x	20 mph F_x	20 mph F_y	40 mph F_x	40 mph F_y	55 mph F_x	55 mph F_y
0	0	590	0	480	0	380
.025	220	580	170	470	120	350
.05	300	560	190	465	210	320
.075	380	540	220	460	250	260
.10	450	510	240	450	260	250
.15	500	480	280	430	280	230
.20	560	400	310	400	320	200
.30	600	280	370	300	360	160
.40	610	220	420	200	370	140
.60	600	140	430	130	360	100
.80	580	100	400	100	300	70
1.00	480	70	300	65	220	50

R70B
1100 #
Wet Concrete

12°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	570	0	410	0	320
.025	120	560	60	400	20	315
.05	240	550	120	390	100	310
.075	320	520	170	380	130	300
.10	360	500	190	360	160	280
.15	450	440	220	350	190	270
.20	480	400	260	340	230	250
.30	540	330	300	320	290	180
.40	560	280	340	280	320	150
.60	560	240	400	170	340	100
.80	560	200	405	120	280	75
1.00	430	100	310	80	220	60

R70B
1100
Wet Concrete

16°

Δ_x	20 mph		40 mph		55 mph	
	F_x	F_y	F_x	F_y	F_x	F_y
0	0	540	0	580	0	400
.025	100	540	100	580	60	380
.05	180	535	180	540	110	360
.075	240	530	260	510	150	340
.10	300	520	320	480	170	320
.15	360	500	420	450	200	300
.20	440	460	470	420	230	270
.30	500	360	580	340	270	230
.40	530	320	630	270	295	190
.60	520	240	640	230	315	140
.80	460	170	580	170	300	110
1.00	380	80	500	130	345	80

APPENDIX

TREAD WEAR

Tread depth was measured in the shoulder and crown rib grooves before and after testing with a dial-type runout gage.* Table 6 lists the average reduction in tread depth (wear) measured after completion of the wet and dry tests. The wet wear values are averages of both shoulder grooves measured at 4 points around the tire circumference. The dry wear values are averages of both shoulder and crown rib grooves measured at 6 points around the circumference. The new tire groove depths are the averages of the crown and shoulder depths given in Table 2. All measurements are in inches.

TABLE 6

TREAD WEAR DATA

Code	Size	New Depth	Wet Wear	Dry Wear
B178A	F78-14	.39	.010	.127
B178B	F78-14	.37	.005	.101
B170A	F70-14	.38	.008	.095
B278A	F78-14	.39	.003	.090
B278B	F78-14	.39	.010	.063
B278C	F78-14	.39	.012	.113
B270A	F70-14	.34	.011	.090
B270B	F70-14	.38	.005	.146
B260A	F60-14	.31	.015	.090
R70A	FR70-14	.38	.018	.161
R70B	FR70-14	.36	.010	.126

*A modified machinist's gage calibrated to .001 inch.