METHOD TO ESTIMATE STANDARD PROCTOR MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT OF FINE GRAINED SOILS

1.0 SCOPE

1.1 This procedure is used for estimating the Standard Proctor maximum dry density and optimum moisture content of a fine grained soil sample from the Liquid Limit (LL) and Plasticity Index (PI) as determined by ASTM D4318.

1.2 Alberta Transportation has correlated the Atterberg Limits of fine-grained soils with the soils' Standard Proctor maximum dry density and optimum moisture content. Six hundred soil samples with varying composition, plasticity and classification were used. Soil samples with standard effort 5-point moisture-density relation tests, as determined by ASTM D698, were selected.

1.3 The PI of each soil was plotted vertically versus the LL of the soil horizontally. Each point was labelled with the soils' maximum dry density. Points of equal density were joined to form a straight line. The estimated maximum dry density of a soil is then interpolated from the graph, by plotting the LL and PI of the soil.

1.4 Another graph of PI (vertically) versus LL (horizontally) was also plotted for the optimum moisture content of each soil. Points of equal optimum moisture content were joined. The resulting straight lines were used to estimate the optimum moisture content of a soil of known LL and PI.

1.5 Interpolation is required when the plotted point does not directly fall on a moisture or density line.

2.0 APPLICABLE DOCUMENTS

2.1 Alberta Transportation charts titled "Estimated Standard Proctor Maximum Density in (lb/ft^3)" and "Estimated Standard Proctor Optimum Moisture Content in (%)".

3.0 PROCEDURE

3.1 Maximum Density Estimation

3.1.1 Test points (LL, PI) outside the limits of this model are invalid and estimates cannot be extrapolation.

3.1.2 The lower limits of this model are defined as:

PI = 0.73 X (LL-20) if $20 \leq LL \leq 62.5$
("A" line)

85.0 pcf line if LL > 62.5

The upper limits of this model are defined as:

125.0 pcf line if $15 \leq LL \leq 29.0$

PI =0.74 X (LL-2.2) if LL > 29.0

3.1.3 If the test point (LL, PI) falls directly on a line, then the maximum density of that line will be the estimated maximum density of the soil sample.

3.1.4 If the test point (LL, PI) does not fall on a line the estimated maximum density is calculated as follows:

3.1.4.1 Plot LL & PI on the estimated Standard Proctor Maximum Density Chart.

3.1.4.2 Identify the maximum densities corresponding to the lines immediately above and below this point.

3.1.4.3 Calculate PI above (A) and PI below (B) using the PI equations corresponding to the maximum densities from 3.1.4.2.

3.1.4.4 In order to convert the incremental difference in PI to the corresponding incremental differences in maximum densities, carry out the following calculations:

$$\Delta\ maximum\,density = \frac{PI - PI(B)}{PI(A) - PI(B)}\ x\ 2.5\ *$$

* NB 2.5 = maximum density (above) - maximum density (below)

3.1.4.5 Calculate estimated maximum density:

maximum density (below) + ? maximum density

3.1.4.6 Convert to metric units by multiplying the estimated maximum density in lb/ft^3 by 1000/62.4 and report to the nearest 10 kg/m^3.

3.1.5 Example:

3.1.5.1 PI = 35; LL = 60

3.1.5.2 maximum density (above) = 95.0 lb/ft^3

maximum density (below) = 92.5 lb/ft^3

3.1.5.3 Calculate:

PI(A) = (1.0300 X (60-24.4)) = 36.7

PI(B) = (1.00 X (60-26)) = 34

3.1.5.4 ? maximum density

$$\frac{35 - 34}{36.7 - 34} x\ 2.5 = 0.93\ lb/\ ft^3$$

3.1.5.5 Estimated maximum density

92.5 + 0.93 = 93.43 lb/ft^3

3.1.5.6 Converting to metric units

93.43 X (1000/62.4) = 1497 kg/m^3

Report estimated maximum density as: 1500 kg/m^3

3.2 Optimum Moisture Content Estimation

3.2.1 Test points (LL, PI) outside the limits of this model are invalid and estimates cannot be extrapolated.

3.2.2 The lower limits of this model are defined as:

PI = 0.73 X (LL-20) if $20 \leq LL \leq 52.6$
("A" line)

30% Line if LL > 52.6

The upper limits of this model are defined as:

10% Line if $15 \leq LL \leq 30$

PI =0.74 X (LL-2.2) if $30 < LL \leq 63$

20% Line if LL > 63

3.2.3 If the test point (LL, PI) falls directly on a line, then the optimum moisture content of that line will be the estimated optimum moisture content of the sample.

3.2.4 If the test point (LL, PI) does not fall on a line the estimated optimum moisture content is calculated as follows:

3.2.4.1 Plot LL & PI on the Estimated Standard Proctor Optimum Moisture Content Chart.

3.2.4.2 Identify the optimum moisture content corresponding to the lines immediately above and below this point.

3.2.4.3 Calculate PI above (A) and PI below (B) using the PI equations corresponding to the optimum moisture contents from 3.2.4.2.

3.2.4.4 In order to convert the incremental differences in PI to the corresponding incremental difference in moisture content, carry out the following calculation:

$$\Delta\ optimum\ moisture\ content = \frac{PI - PI(B)}{PI(A) - PI(B)}\ x\ 2.0*$$

* NB 2.0 = optimum moisture content (below) - optimum moisture content (above)

3.2.4.5 Calculate estimated optimum moisture content:

optimum moisture content (below) - ? optimum moisture content

3.2.4.6 Round off to the nearest 1% and report as estimated optimum moisture content.

3.2.5 Example:

3.2.5.1 PI = 51; LL = 70

3.2.5.2 Optimum moisture content (above) = 20%

Optimum moisture content (below) = 22%

3.2.5.3 Calculate:

PI(A) = (1.0628 X (70-20.8)) = 52.3

PI(B) = (1.0406 X (70-22.4)) = 49.5

3.2.5.4

$$\Delta\ optimum\ moisture\ content = \frac{51.0 - 49.5}{52.3 - 49.5}\ x\ 2.0 = 1.07$$

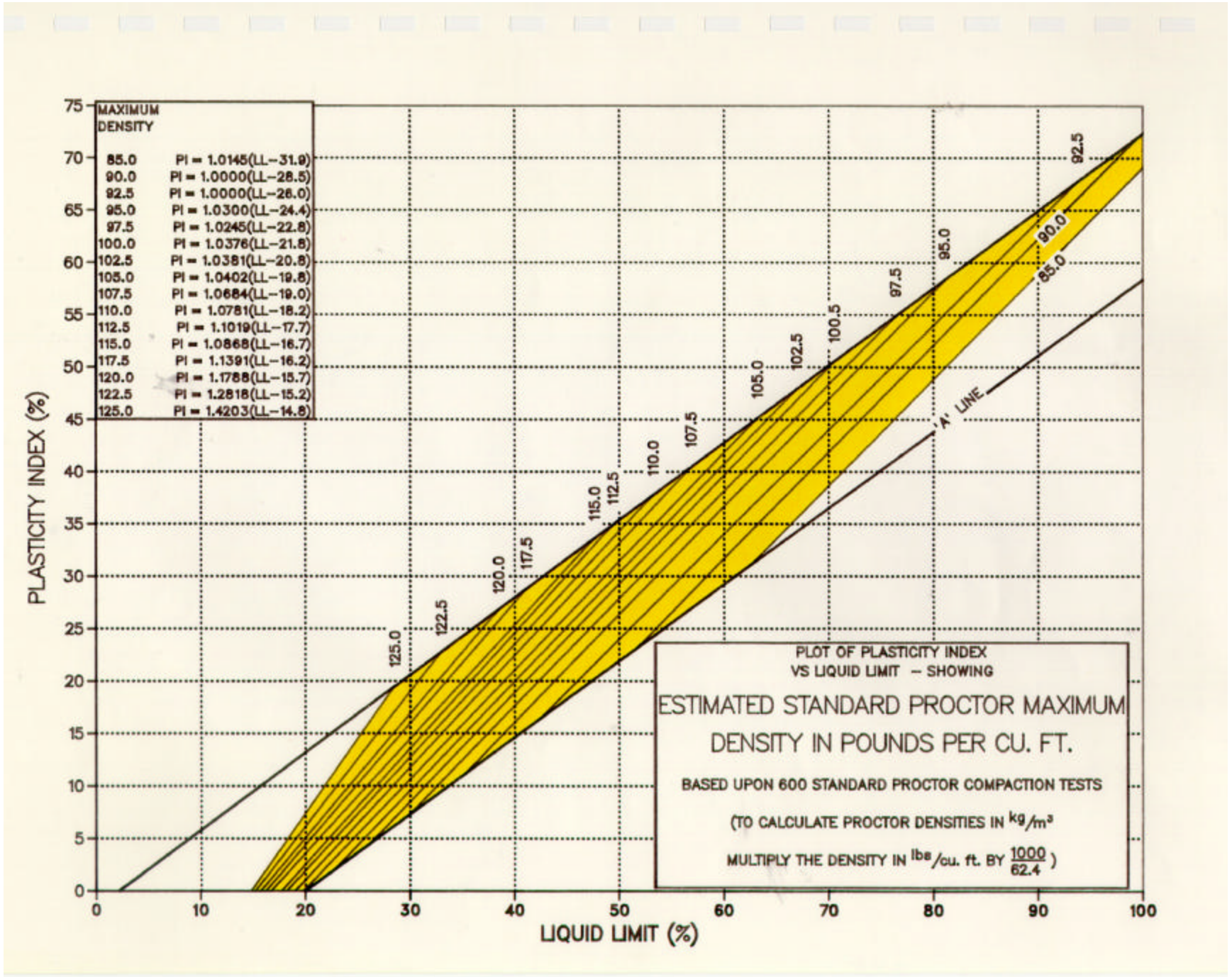
3.2.5.5 Estimated optimum moisture content

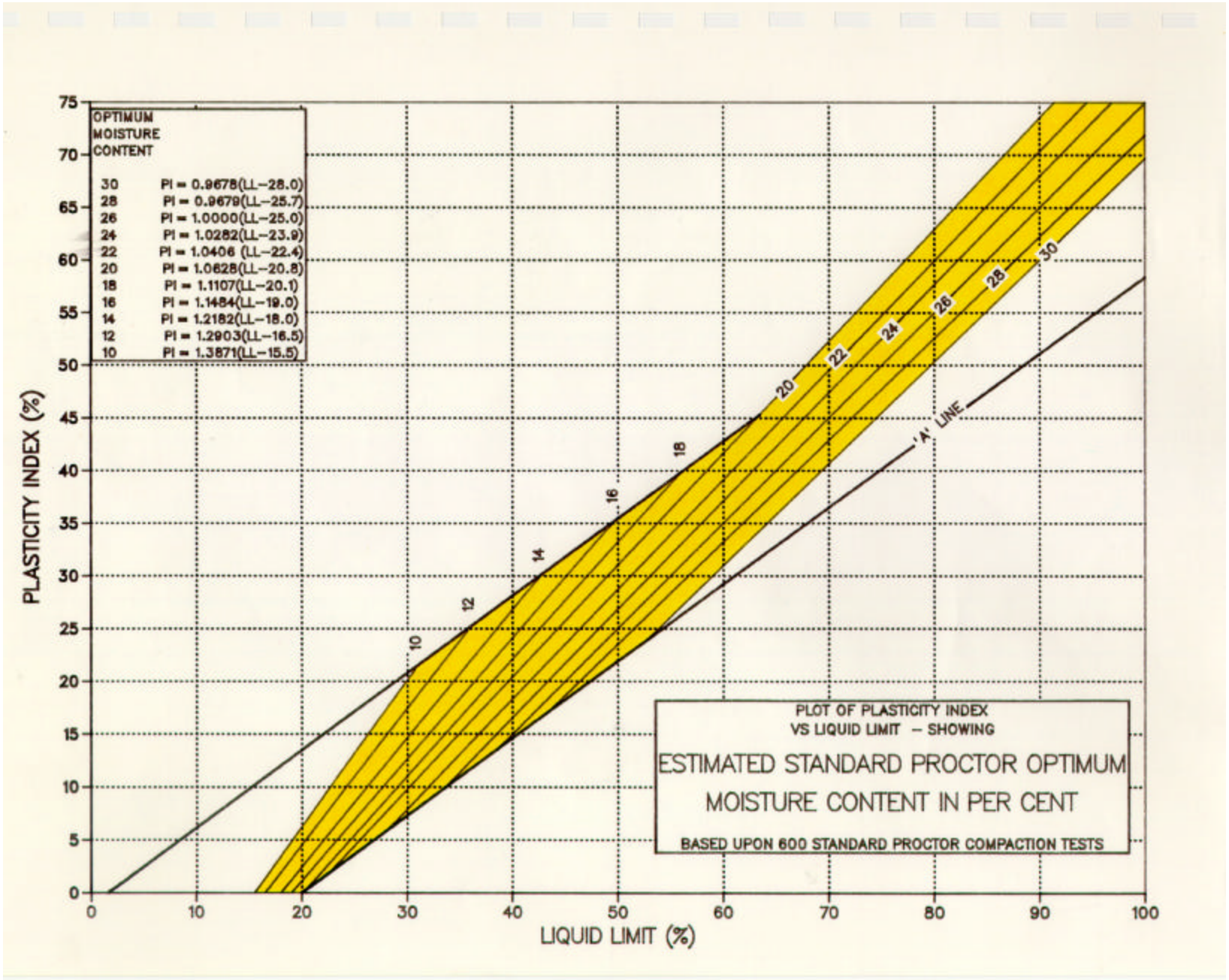
22 - 1.07 = 20.93

3.2.5.6 Report estimated optimum moisture content as: 21%

4.0 REPORT

4.1 Record results and report along with Atterberg limits, sieve analysis and other soil survey test results.


MAXIMUM DENSITY
85.0 PI = 1.0145(LL−31.9)
90.0 PI = 1.0000(LL−28.5)
92.5 PI = 1.0000(LL−26.0)
95.0 PI = 1.0300(LL−24.4)
97.5 PI = 1.0245(LL−22.8)
100.0 PI = 1.0376(LL−21.8)
102.5 PI = 1.0381(LL−20.8)
105.0 PI = 1.0402(LL−19.8)
107.5 PI = 1.0684(LL−19.0)
110.0 PI = 1.0781(LL−18.2)
112.5 PI = 1.1019(LL−17.7)
115.0 PI = 1.0868(LL−16.7)
117.5 PI = 1.1391(LL−16.2)
120.0 PI = 1.1788(LL−15.7)
122.5 PI = 1.2818(LL−15.2)
125.0 PI = 1.4203(LL−14.8)
PLASTICITY INDEX (%)
LIQUID LIMIT (%)
'A' LINE
PLOT OF PLASTICITY INDEX
VS LIQUID LIMIT – SHOWING
ESTIMATED STANDARD PROCTOR MAXIMUM
DENSITY IN POUNDS PER CU. FT.
BASED UPON 600 STANDARD PROCTOR COMPACTION TESTS
(TO CALCULATE PROCTOR DENSITIES IN kg/m³
MULTIPLY THE DENSITY IN lbs/cu. ft. BY 1000/62.4)


OPTIMUM
MOISTURE
CONTENT
30 PI = 0.9678(LL-28.0)
28 PI = 0.9679(LL-25.7)
26 PI = 1.0000(LL-25.0)
24 PI = 1.0282(LL-23.9)
22 PI = 1.0406 (LL-22.4)
20 PI = 1.0628(LL-20.8)
18 PI = 1.1107(LL-20.1)
16 PI = 1.1484(LL-19.0)
14 PI = 1.2182(LL-18.0)
12 PI = 1.2903(LL-16.5)
10 PI = 1.3871(LL-15.5)
'A' LINE
PLOT OF PLASTICITY INDEX
VS LIQUID LIMIT - SHOWING
ESTIMATED STANDARD PROCTOR OPTIMUM
MOISTURE CONTENT IN PER CENT
BASED UPON 600 STANDARD PROCTOR COMPACTION TESTS
PLASTICITY INDEX (%)
LIQUID LIMIT (%)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
0
10
20
30
40
50
60
70
80
90
100