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APPENDIX D

Roadway Thickness Calculations And Design Charts

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SHEET_____ OF_____

PROJECT NO. 89241

PROJECT Piñon Ridge Mill REVIEWED BY [illegible] DATE 9/27/08

SUBJECT Roadway Design BY Nate Picker DATE 9/24/2008

(1) R-values of 14 & 28 were obtained from laboratory testing

- R-value of 14 used in design

Conversion to M_R

$$S_1 = [(R-5)/11.29] + 3$$

$$M_R = 10^{[(S_1 + 18.72)/6.24]}$$

← Equations obtained from AASHTO pavement design manual

$S = \cancel{3.97}$ 3.99

$M_R = 4060$ psi

$M_R = 1500 \cdot CBR$ ← From AASHTO pavement design manual

$CBR = 2.7$

(2) Maximum Wheel Load

$$\frac{\text{weight of axle}}{\text{\# of wheels}} = \frac{36{,}000 \text{ lbs}}{8} = 4500 \text{ lbs} = \text{max wheel load}$$

- increase wheel load by 20% per DOT manual

$4500 + (1.20) \cdot 4500 = 5400$ lbs ← max wheel load used in design

KLEINFELDER

SHEET_____ OF_____

PROJECT NO. 89241

PROJECT Piñon Ridge Mill REVIEWED BY DR DATE 9/27/08

SUBJECT Roadway Design (cont.) BY Nate Zilcher DATE 9/24/2008

(3) Use Nomograph (Figure 18 of DOI manual-attached)

with CBR = 2.7 & max wheel load = 5400 lbs

Total thickness = 17 inches

- Thickness of upper layer - Class 1 Subase

Class 1 Subase CBR = 55 & max wheel load = 5400 lbs

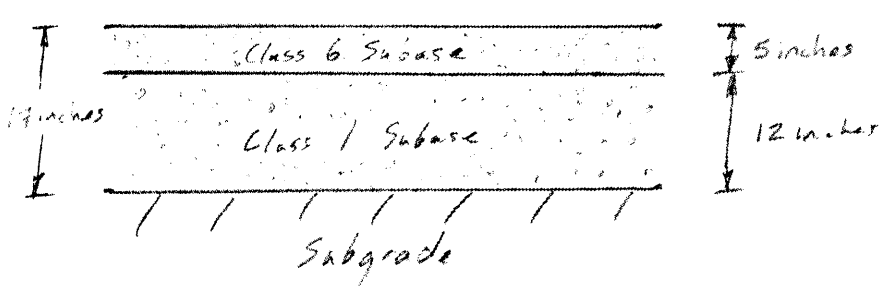
Thickness of upper layer = 5 inches

- Thickness of lower layer - Class 6 Subase

Class 6 Subase CBR = 60 & max wheel load = 5400 lbs

Thickness of lower layer minimum = 4 inches

Example Section: applies to all roadways that will be accessed by large mine haul trucks



(17" - 5" = 12")

12" > 4" ∴ OK

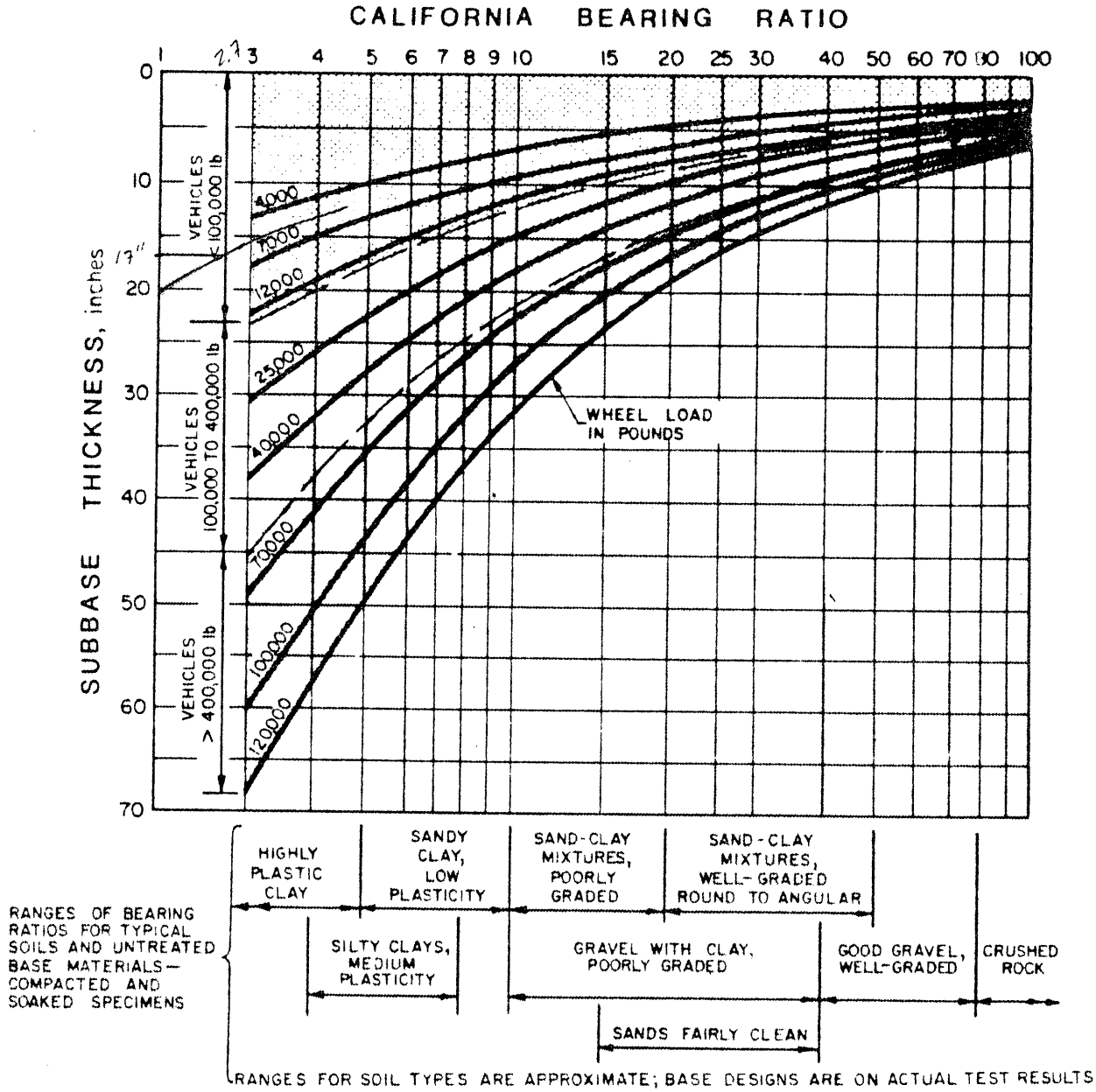


FIGURE 18. - CBR curves.

KLEINFELDER

SHEET ____ OF ____

PROJECT NO. 89241

PROJECT Piñon Ridge Mill REVIEWED BY [illegible] DATE [illegible]

SUBJECT Roadway Design (cont) BY Nate Pilcher DATE 9/24/2008

(4) Design for light duty roadways: traffic is limited to passenger cars, light trucks, & chemical & delivery trucks

- AASHTO Low Volume Roadway Design Manual was used for design of parking & drive areas

Design Serviceability Loss = 2.5

Allowable Rutting = 2.0 inches

ESAL Calculation

Vehicle Type	ADT	Traffic Mix	LEF	20 years	ESAL
3S2	3	3%	1.788	7300 Days	39,157
passenger cars	88	97%	.0002	7300 Days	130

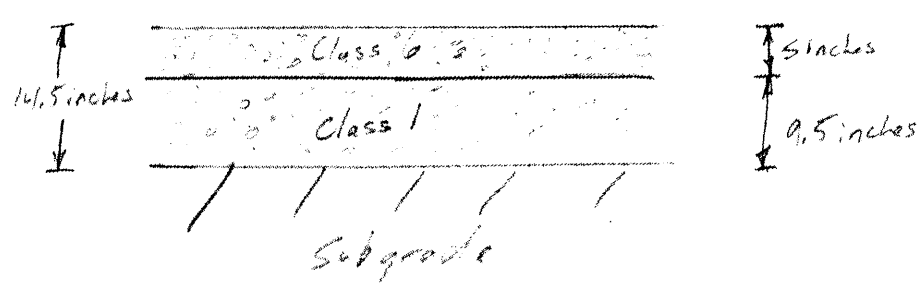
ESAL = 40,000

From Chart which is based on Nomographs (Attached):

Rutting controls Thickness - 14.5 inches

use 14.5 inches of base course for light duty roadways

Example Section:



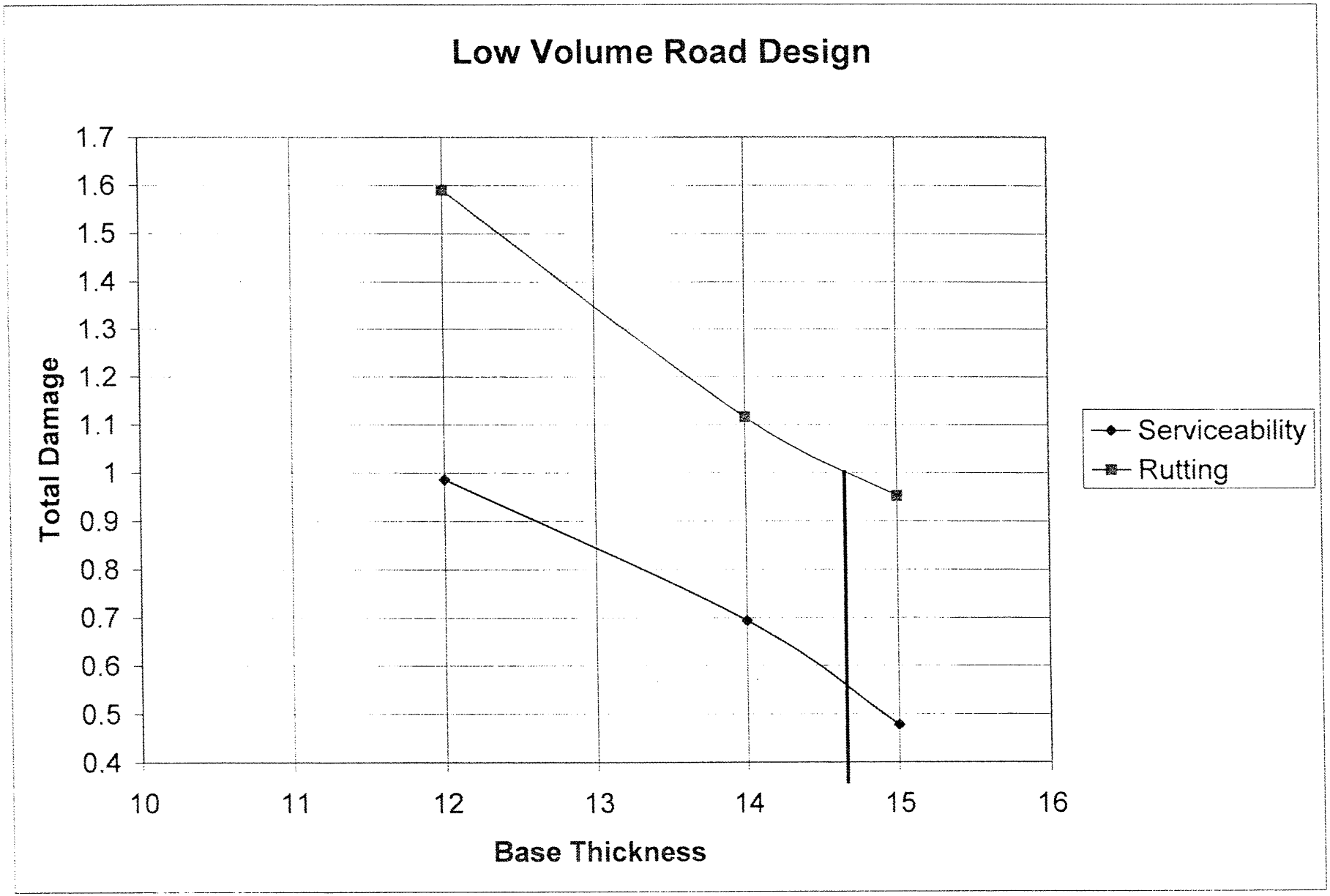

Low Volume Road Design
Total Damage
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
10
11
12
13
14
15
16
Base Thickness
Serviceability
Rutting

Table 4.4. **Chart for computing total pavement damage (for both serviceability and rutting criteria) based on a trial aggregate base thickness.**

ESAL = 40,000

TRIAL BASE THICKNESS, D_{BS} (Inches) 12

Serviceability Criteria ΔPSI = 2.5

Rutting Criteria RD(inches) = 2.0

(1) Season (Roadbed Moisture Condition)	(2) Roadbed Resilient Modulus, M_R(psi)	(3) Base Elastic Modulus, E_{BS}(psi)	(4) Projected 18-kip ESAL Traffic, w_{18}	(5) Allowable 18-kip ESAL Traffic, $(W_{18})_{PSI}$	(6) Seasonal Damage, $\frac{w_{18}}{(W_{18})_{PSI}}$	(7) Allowable 18-kip ESAL Traffic, $(W_{18})_{RUT}$	(8) Seasonal Damage $\frac{w_{18}}{(W_{18})_{RUT}}$
Winter (Frozen)	20,000	25,000	25% 10,000	500,000	0.02	100,000	0.1
Spring/Thaw (Saturated)	2,000		12.5% 5,000	15,000	0.333	9,500	0.526
Spring/Fall (Wet)	4,500		25% 10,000	30,000	0.333	20,000	0.5
Summer (Dry)	6,500		37.5% 15,000	50,000	0.3	32,000	0.467
		Total Traffic =		Total Damage =	0.986	Total Damage =	1.59

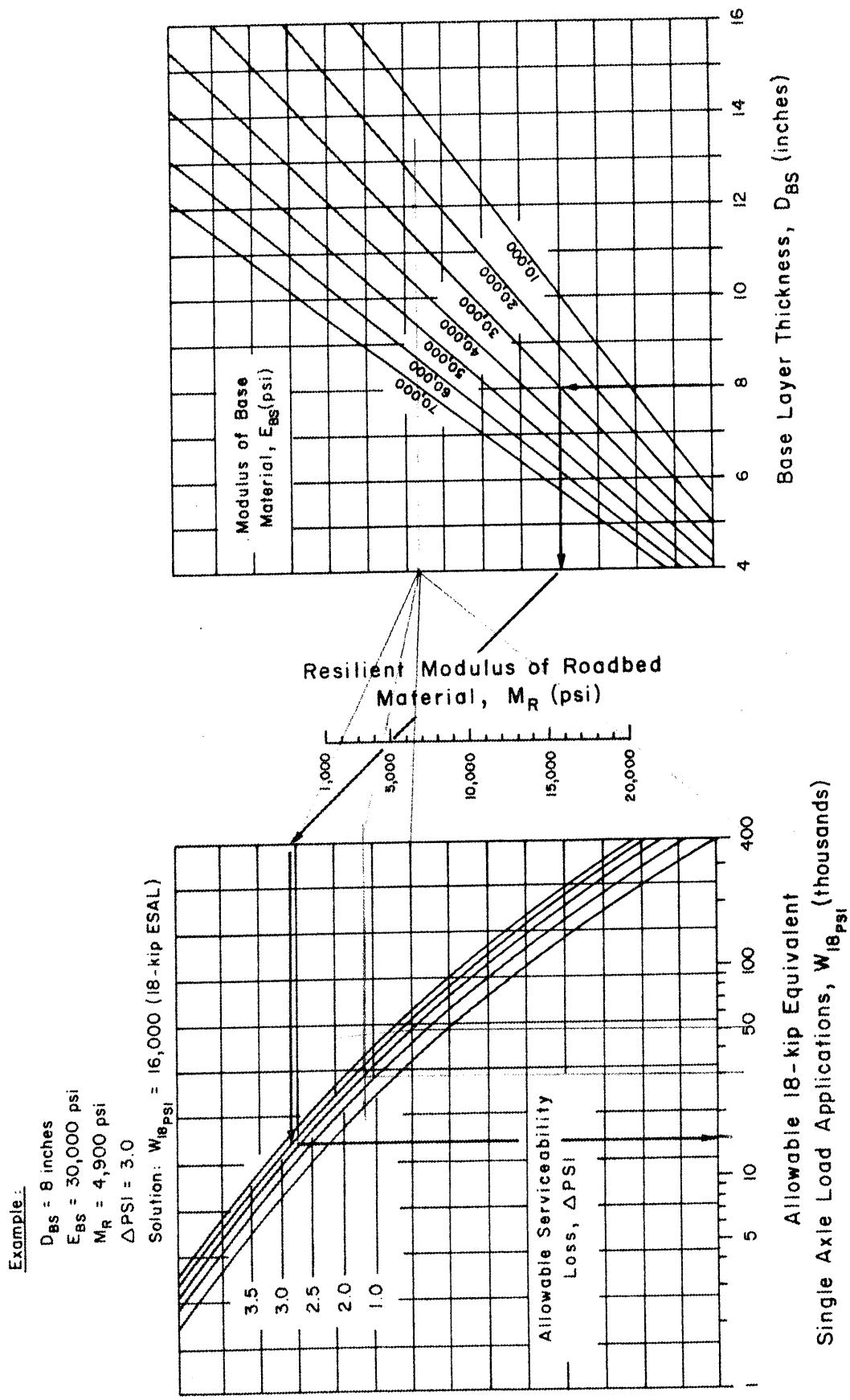


Figure 4.2. Design chart for aggregate-surfaced roads considering allowable serviceability loss.

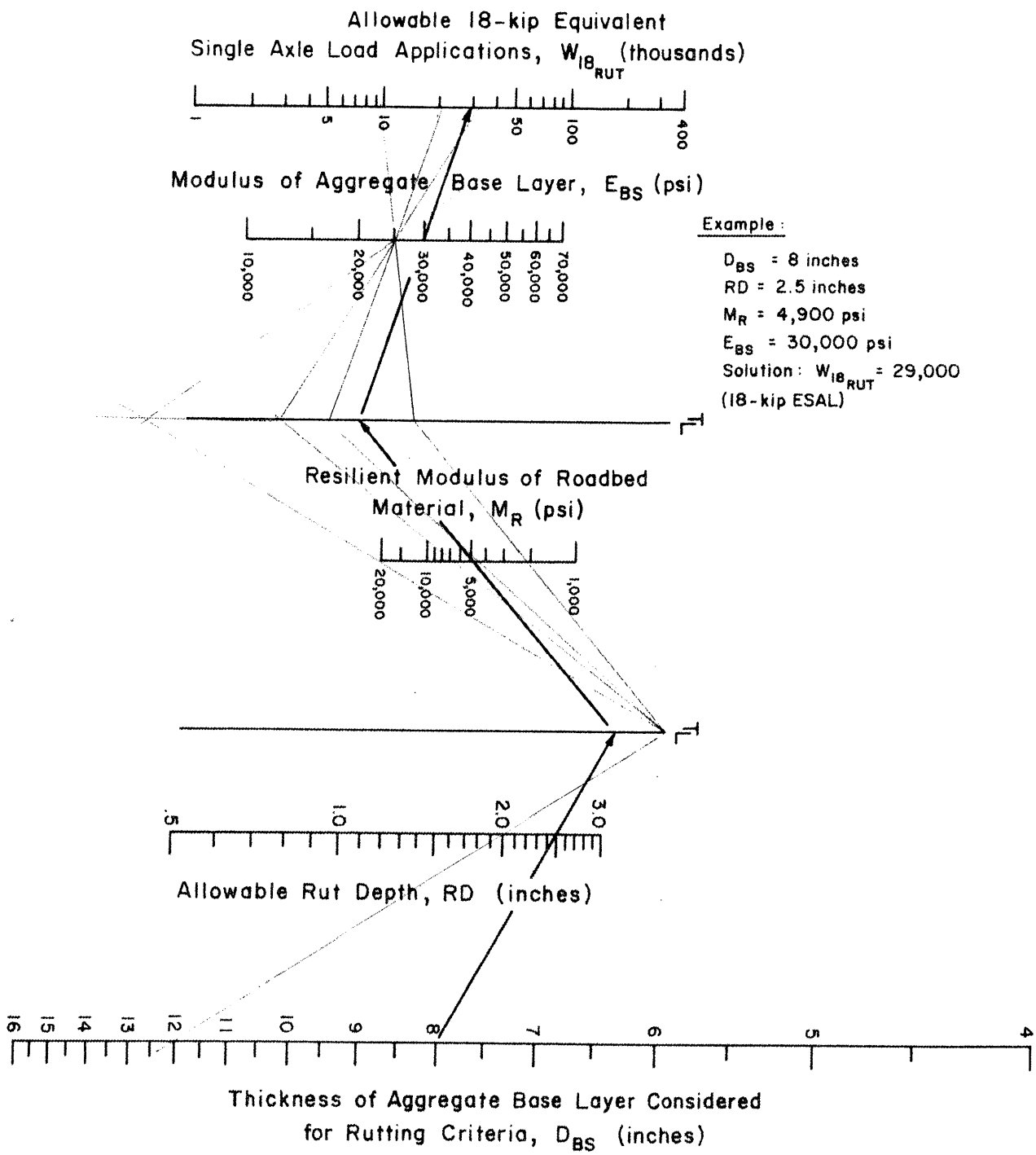


Figure 4.3. Design chart for aggregate-surfaced roads considering allowable rutting.

Table 4.4. Chart for computing total pavement damage (for both serviceability and rutting criteria) based on a trial aggregate base thickness.

ESAL = 44,000

TRIAL BASE THICKNESS, D_{BS} (Inches) 14

Serviceability Criteria, Δ PSI = 2.5

Rutting Criteria RD(inches) = 2.0

(1) Season (Roadbed Moisture Condition)	(2) Roadbed Resilient Modulus, M_R(psi)	(3) Base Elastic Modulus, E_{BS}(psi)	(4) Projected 18-kip ESAL Traffic, w_{18}	(5) Allowable 18-kip ESAL Traffic, $(W_{18})_{PSI}$	(6) Seasonal Damage, $\frac{w_{18}}{(W_{18})_{PSI}}$	(7) Allowable 18-kip ESAL Traffic, $(W_{18})_{RUT}$	(8) Seasonal Damage $\frac{w_{18}}{(W_{18})_{RUT}}$
Winter (Frozen)	20	25	10	500	0.02	500	0.02
Spring/Thaw (Saturated)	2		5	25	0.25	13	0.385
Spring/Fall (Wet)	4.5		10	47	0.213	29	0.345
Summer (Dry)	6.5		15	71	0.211	41	0.366
		Total Traffic =		Total Damage =	0.694	Total Damage =	1.116

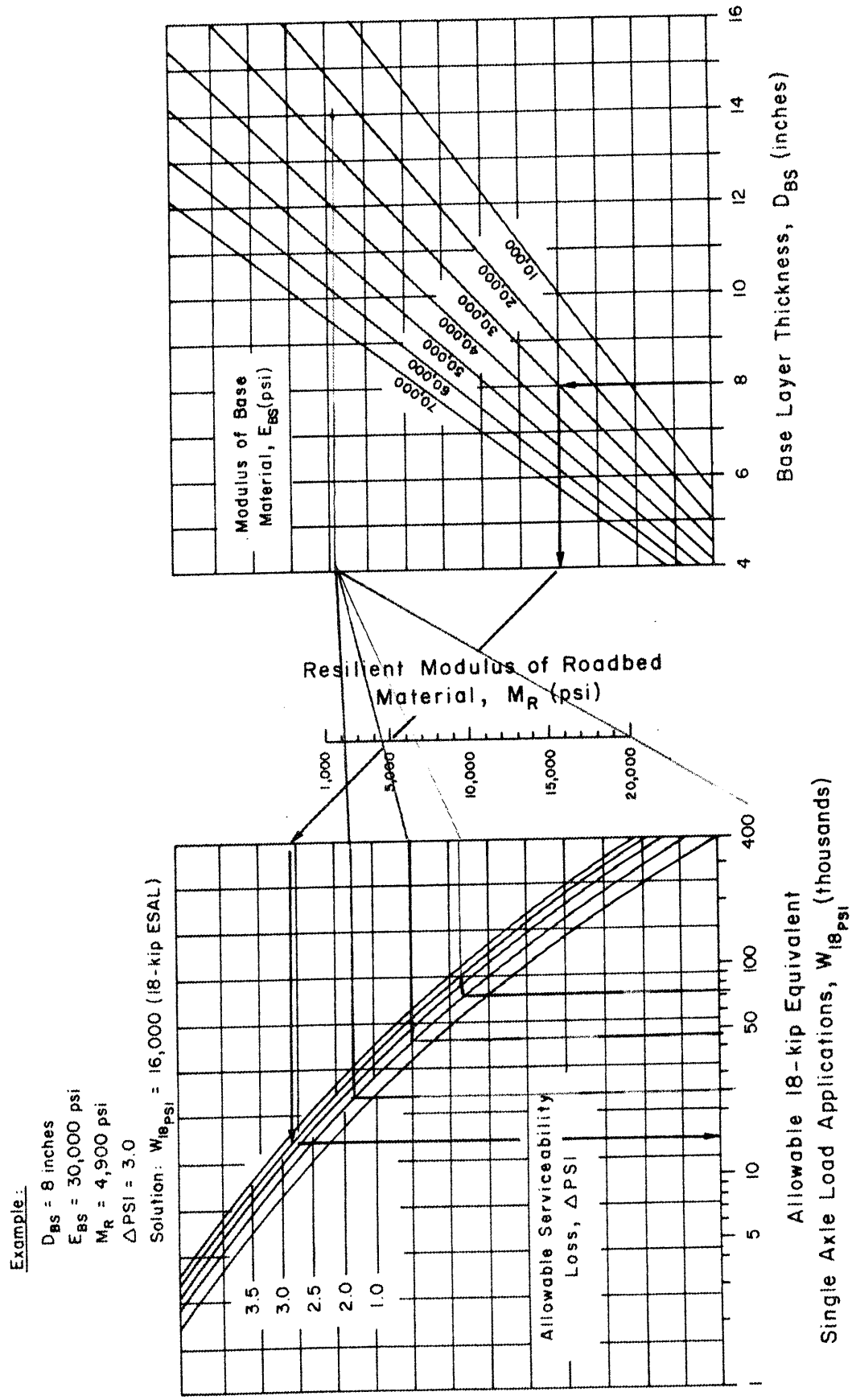


Figure 4.2. Design chart for aggregate-surfaced roads considering allowable serviceability loss.

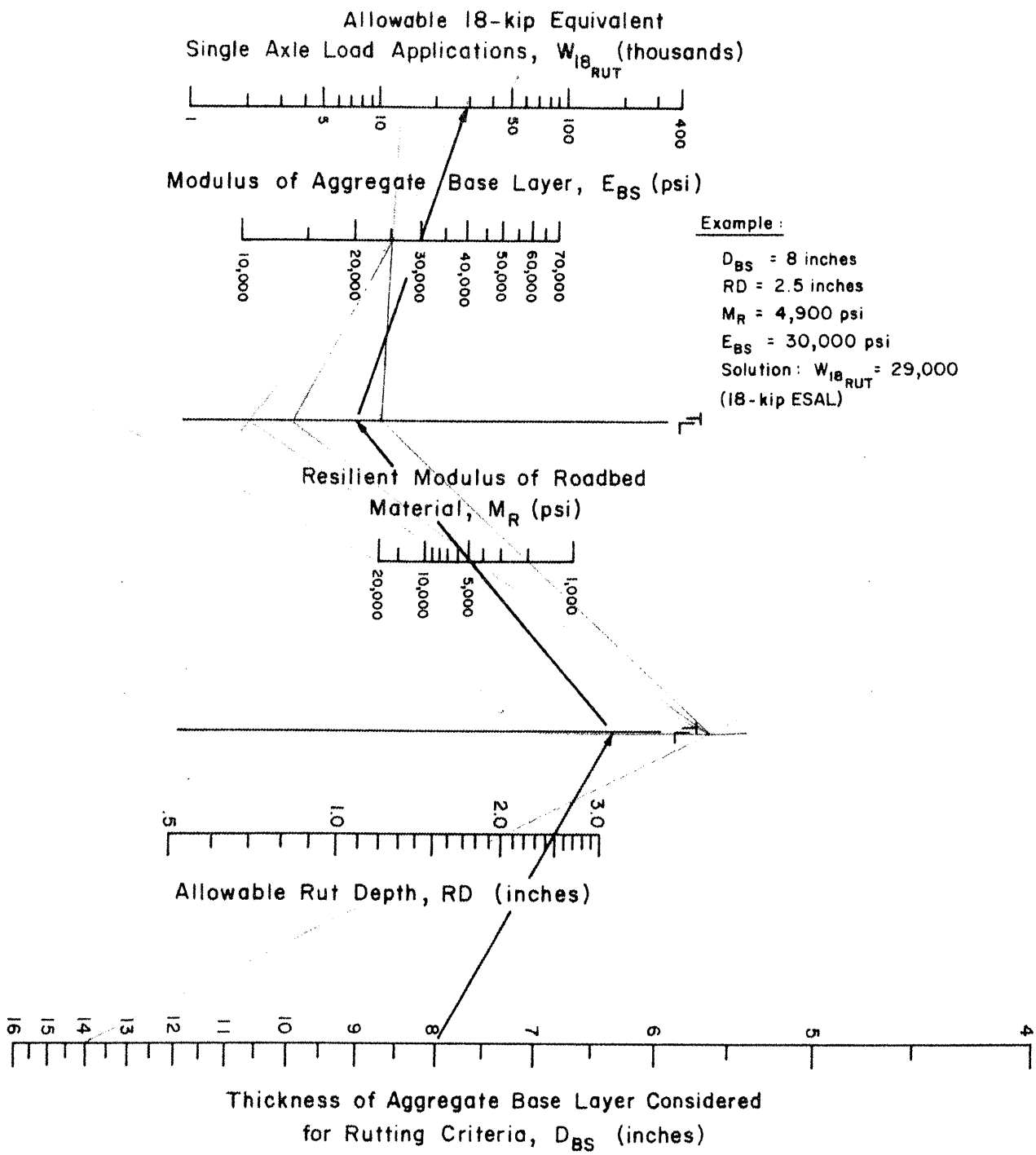


Figure 4.3. Design chart for aggregate-surfaced roads considering allowable rutting.

Table 4.4. Chart for computing total pavement damage (for both serviceability and rutting criteria) based on a trial aggregate base thickness.

TRIAL BASE THICKNESS, D_{BS} (Inches) 15

Serviceability Criteria ✓ ΔPSI = 2.5

Rutting Criteria RD(inches) = 2.0

(1) Season (Roadbed Moisture Condition)	(2) Roadbed Resilient Modulus, M_R(psi)	(3) Base Elastic Modulus, E_{BS}(psi)	(4) Projected 18-kip ESAL Traffic, w_{18}	(5) Allowable 18-kip ESAL Traffic, $(W_{18})_{PSI}$	(6) Seasonal Damage, $\frac{w_{18}}{(W_{18})_{PSI}}$	(7) Allowable 18-kip ESAL Traffic, $(W_{18})_{RUT}$	(8) Seasonal Damage $\frac{w_{18}}{(W_{18})_{RUT}}$
Winter (Frozen)	20	25	10	500	0.02	500	0.02
Spring/Thaw (Saturated)	2	1	5	34	0.147	16	0.313
Spring/Fall (Wet)	4.5	1	10	62	0.161	32	0.313
Summer (Dry)	6.5	1	15	100	0.15	49	0.306
		Total Traffic =		Total Damage =	0.478	Total Damage =	0.952

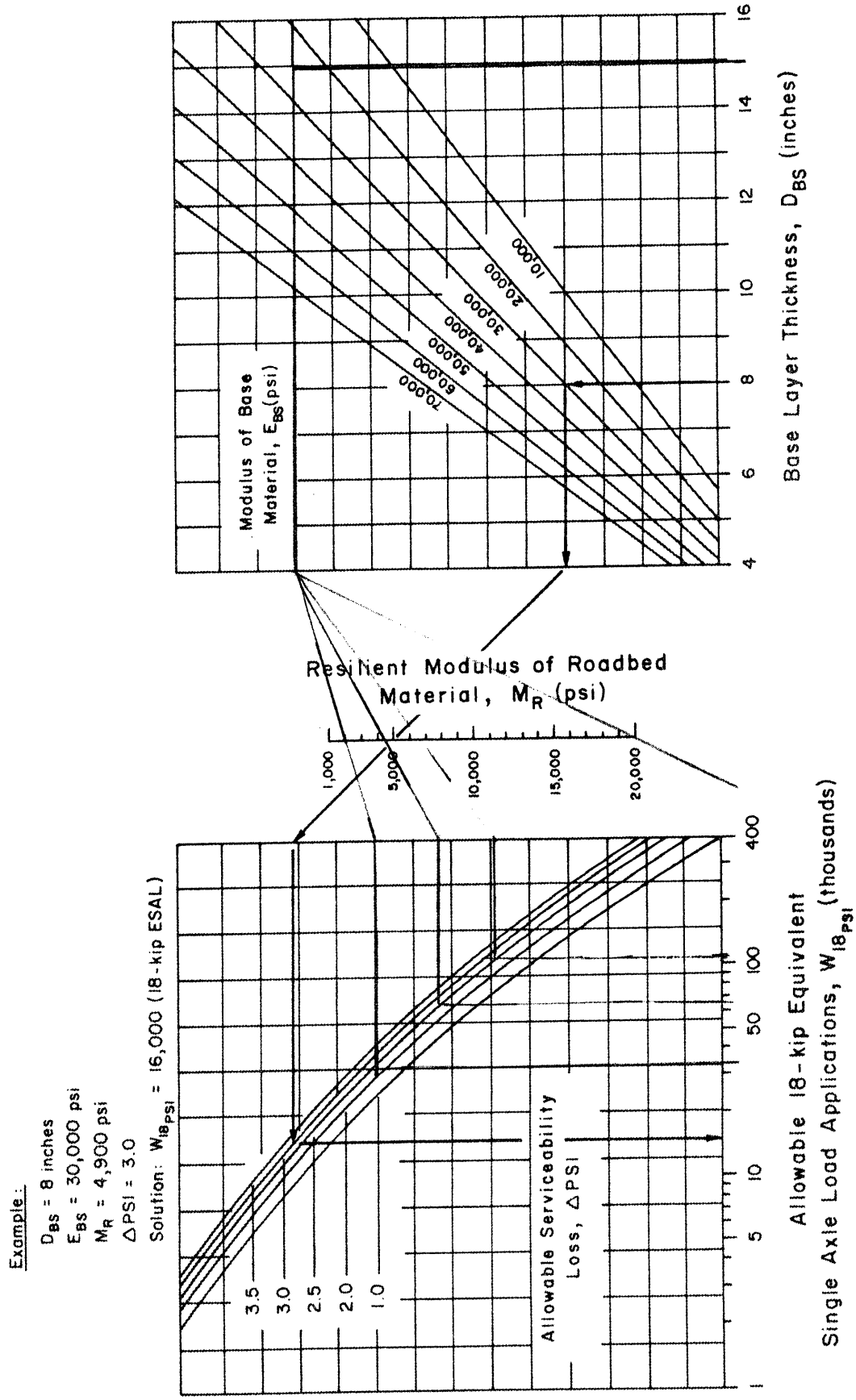


Figure 4.2. Design chart for aggregate-surfaced roads considering allowable serviceability loss.

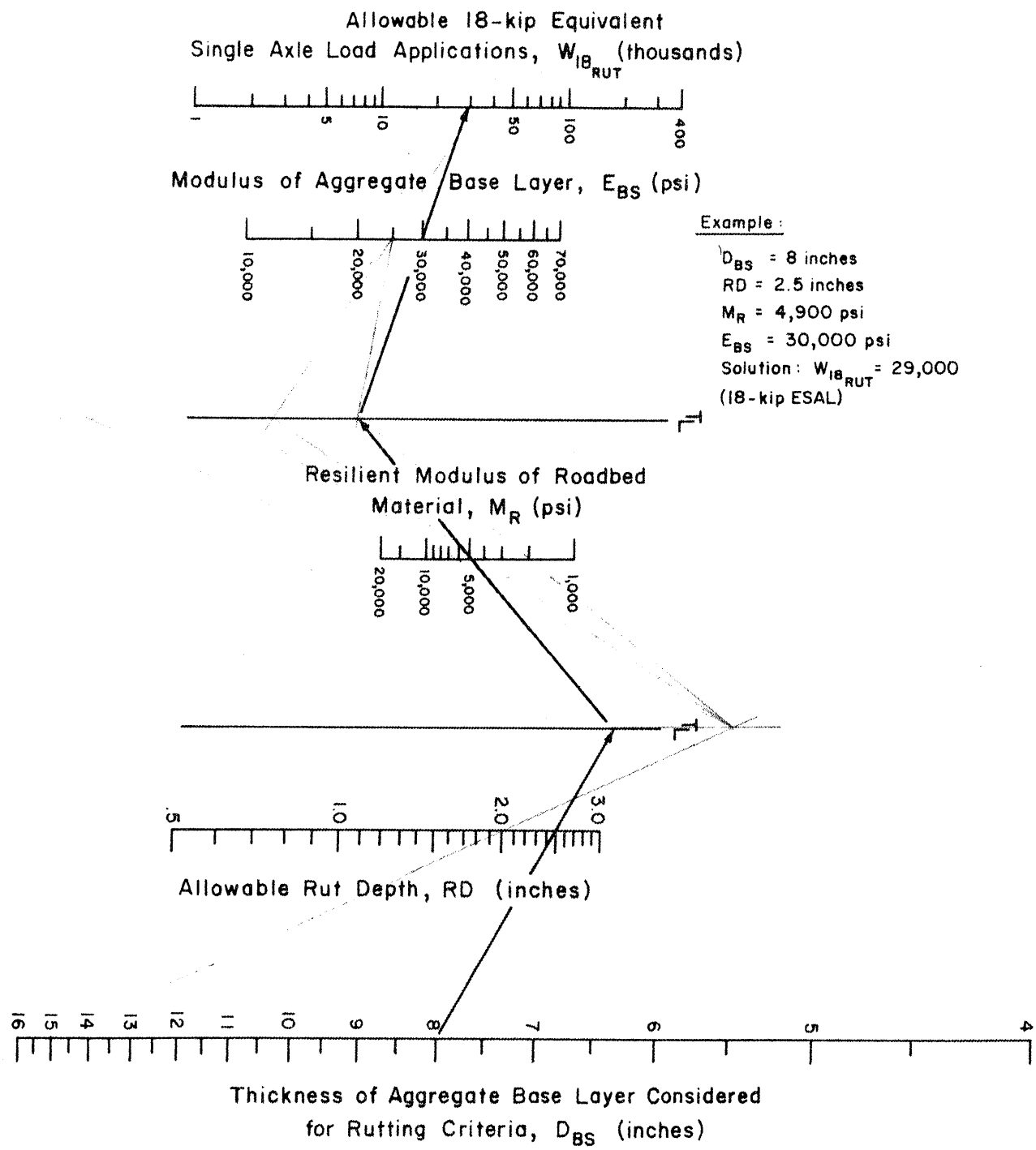


Figure 4.3. Design chart for aggregate-surfaced roads considering allowable rutting.