SOIL REACTION FORCES ON AGRICULTURAL DISC IMPLEMENTS

Volume II

by

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B. Sc. Agric. Engng. (BAU)

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for the degree of Doctor of Philosophy
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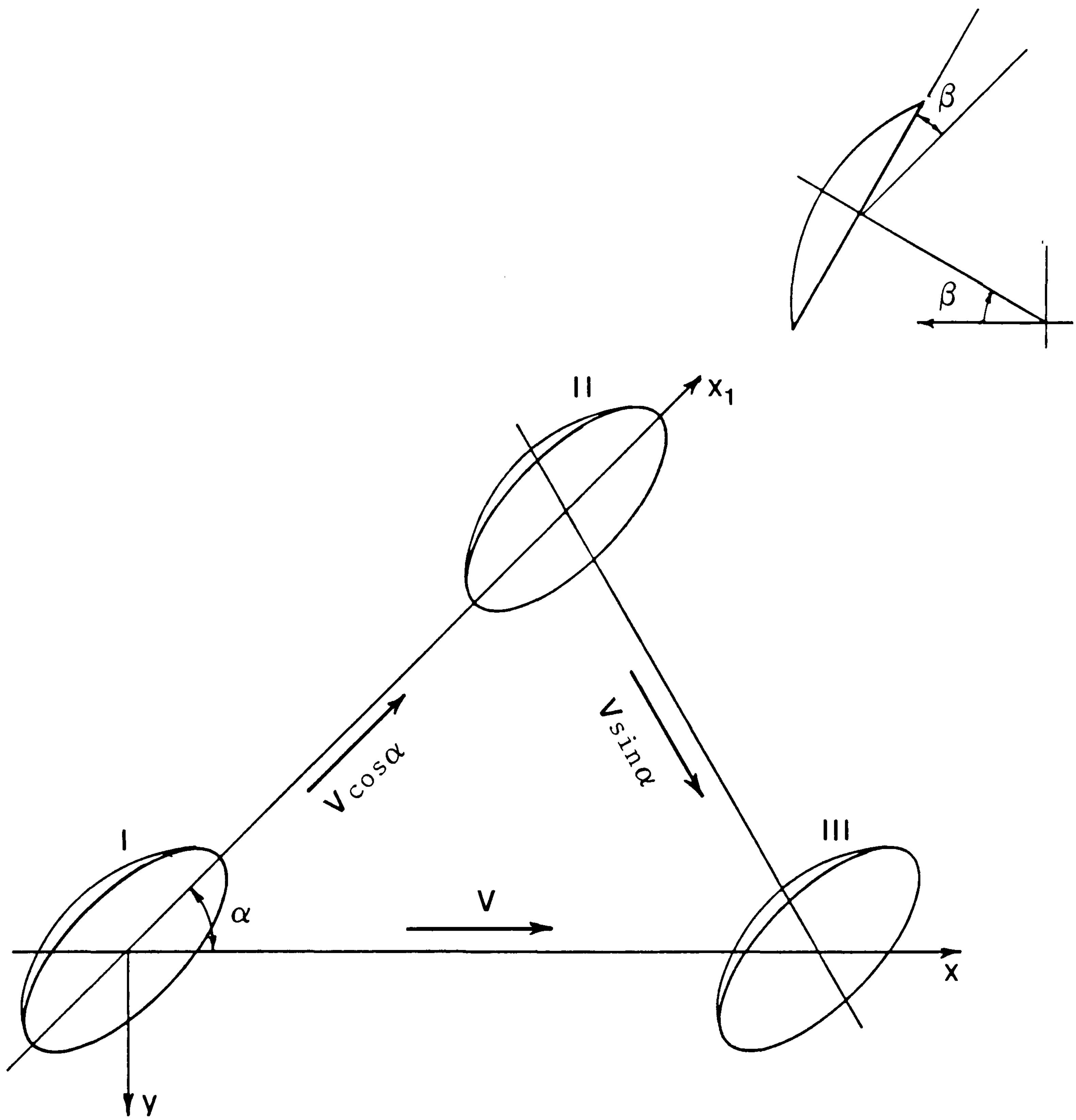


Fig. 2.1 Kinematics of the disc.

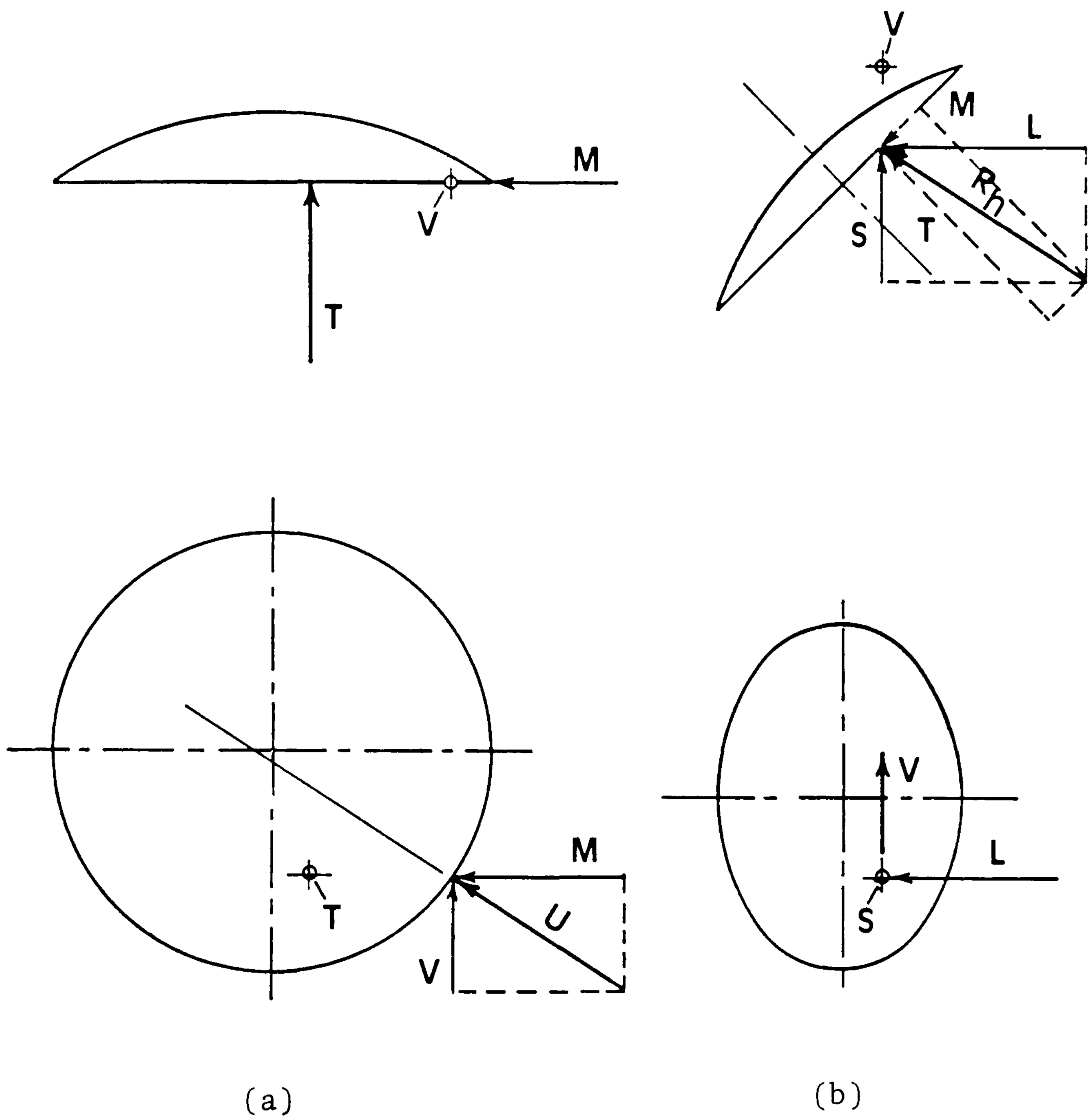
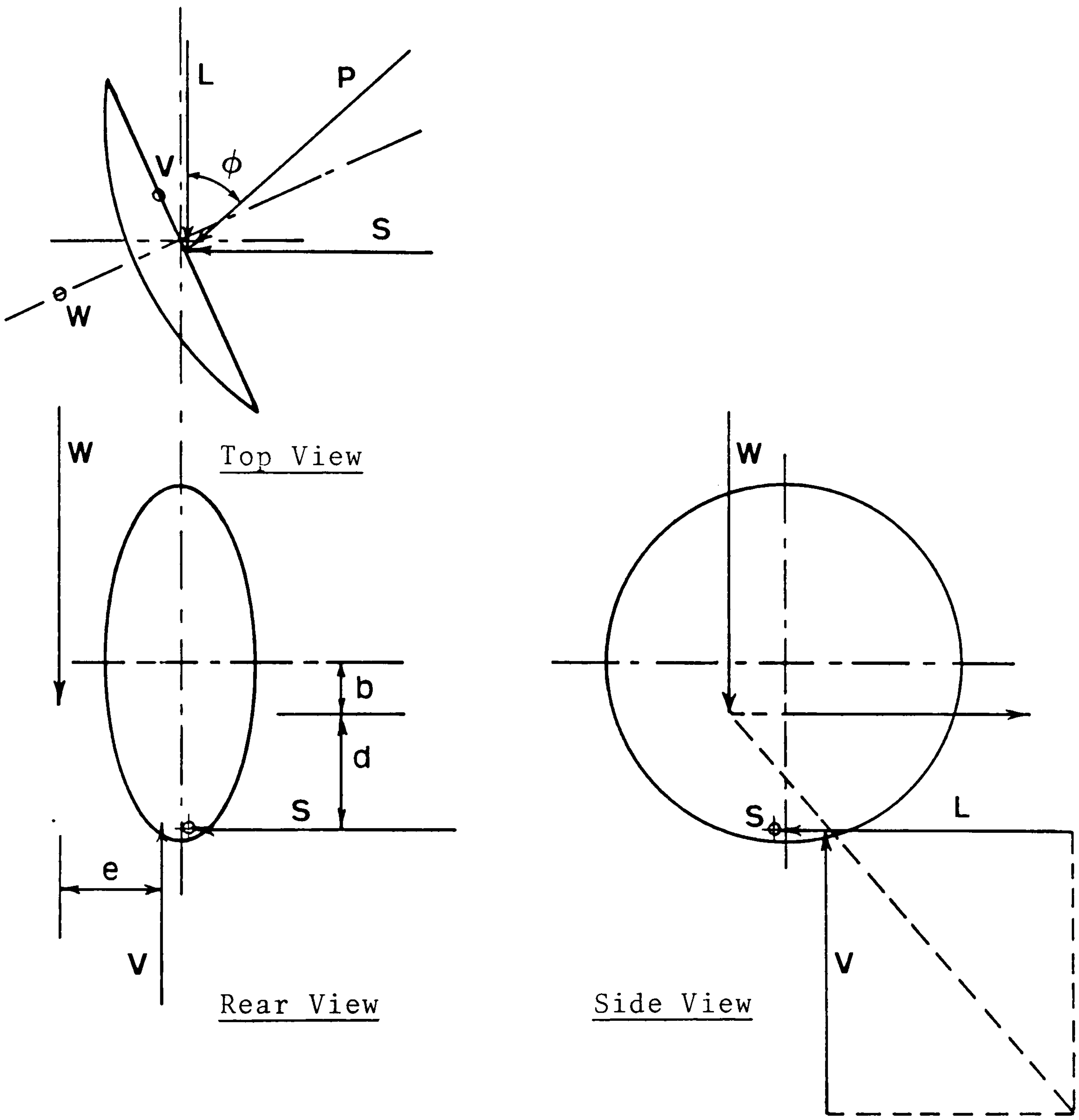


Fig. 2.2 Resultant soil reaction forces acting on a vertical disc. (a) A thrust force T, plus a radial force U and (b) a horizontal force R_h plus a vertical force V.



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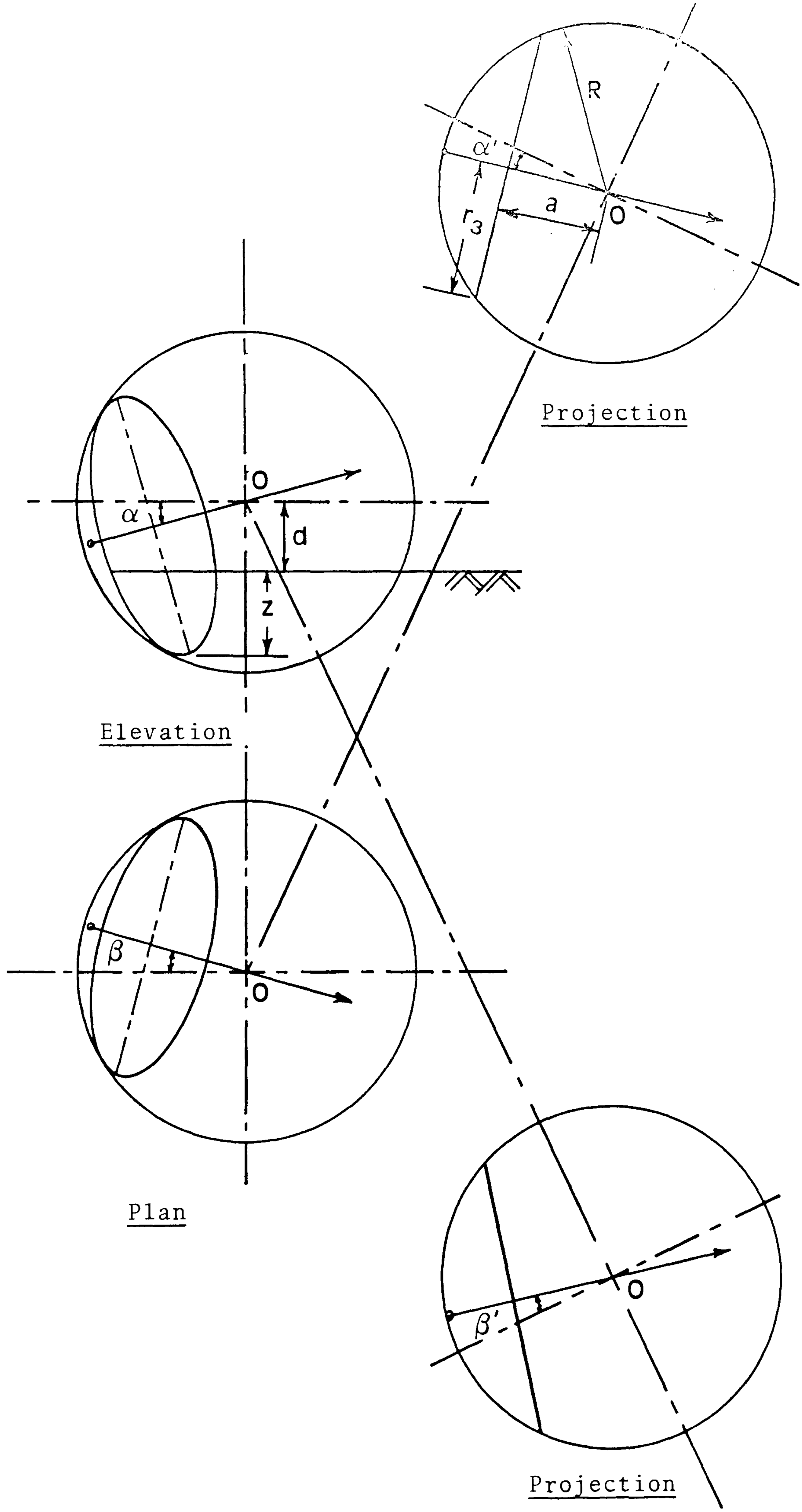
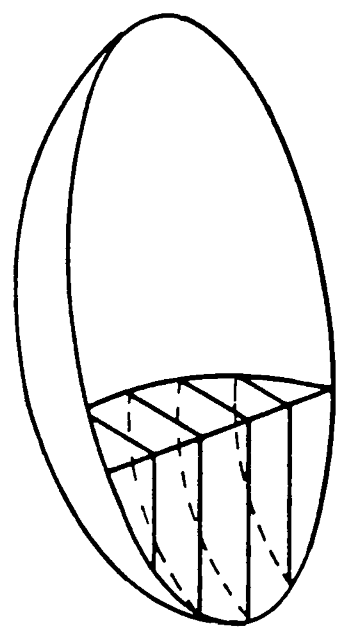
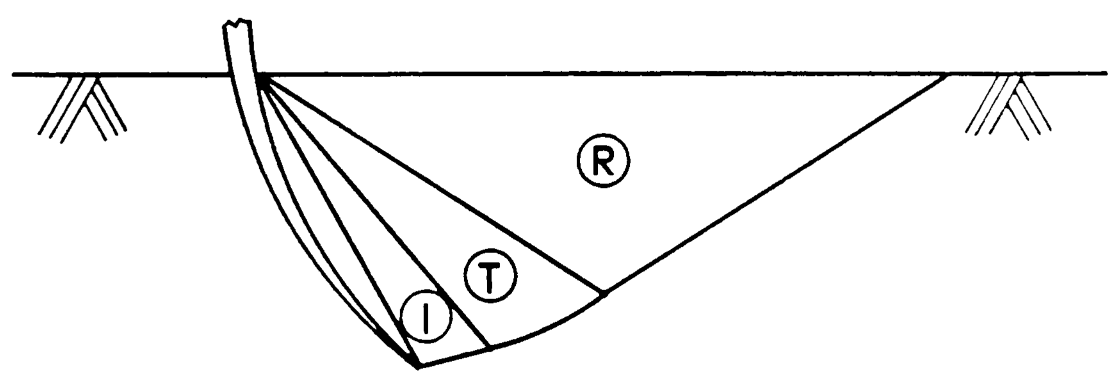


Fig. 3.1 Geometric parameters of the disc.



(a)



(b)

Fig. 3.2 (a) Disc interface divided into a finite number of narrow tines. (b) Disc interface with basic types of rupture boundary.

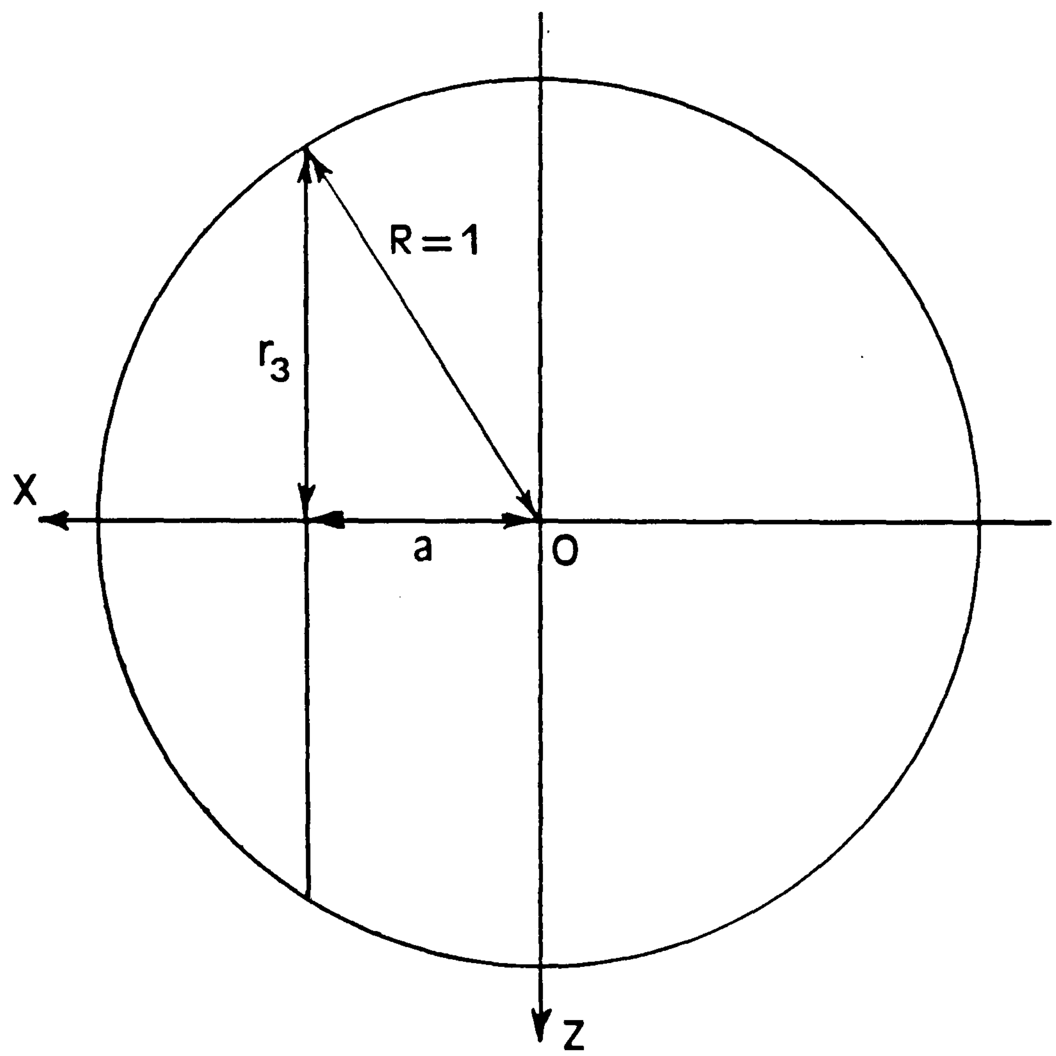
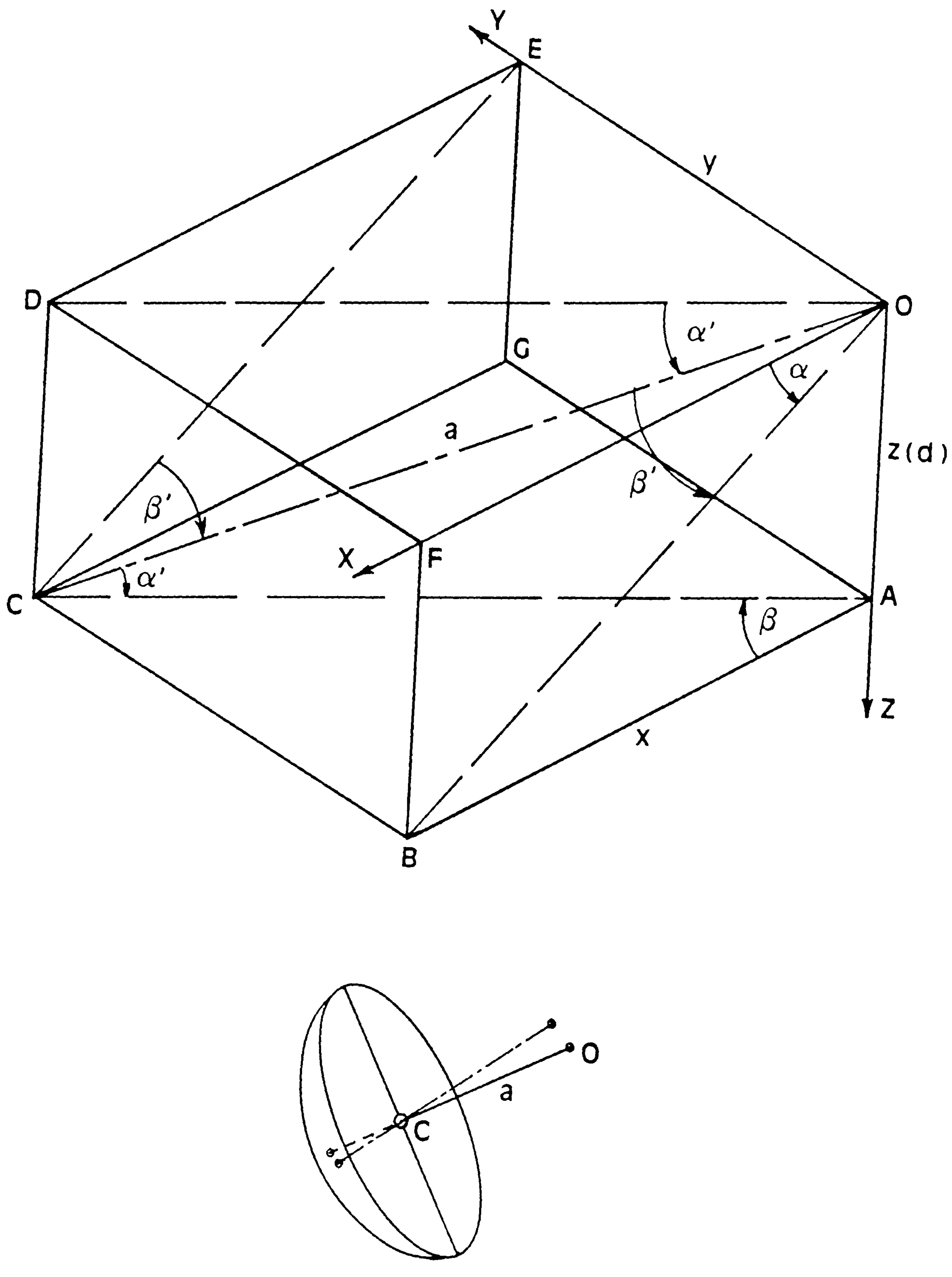


Fig. 3.3 Sphere of unit radius.



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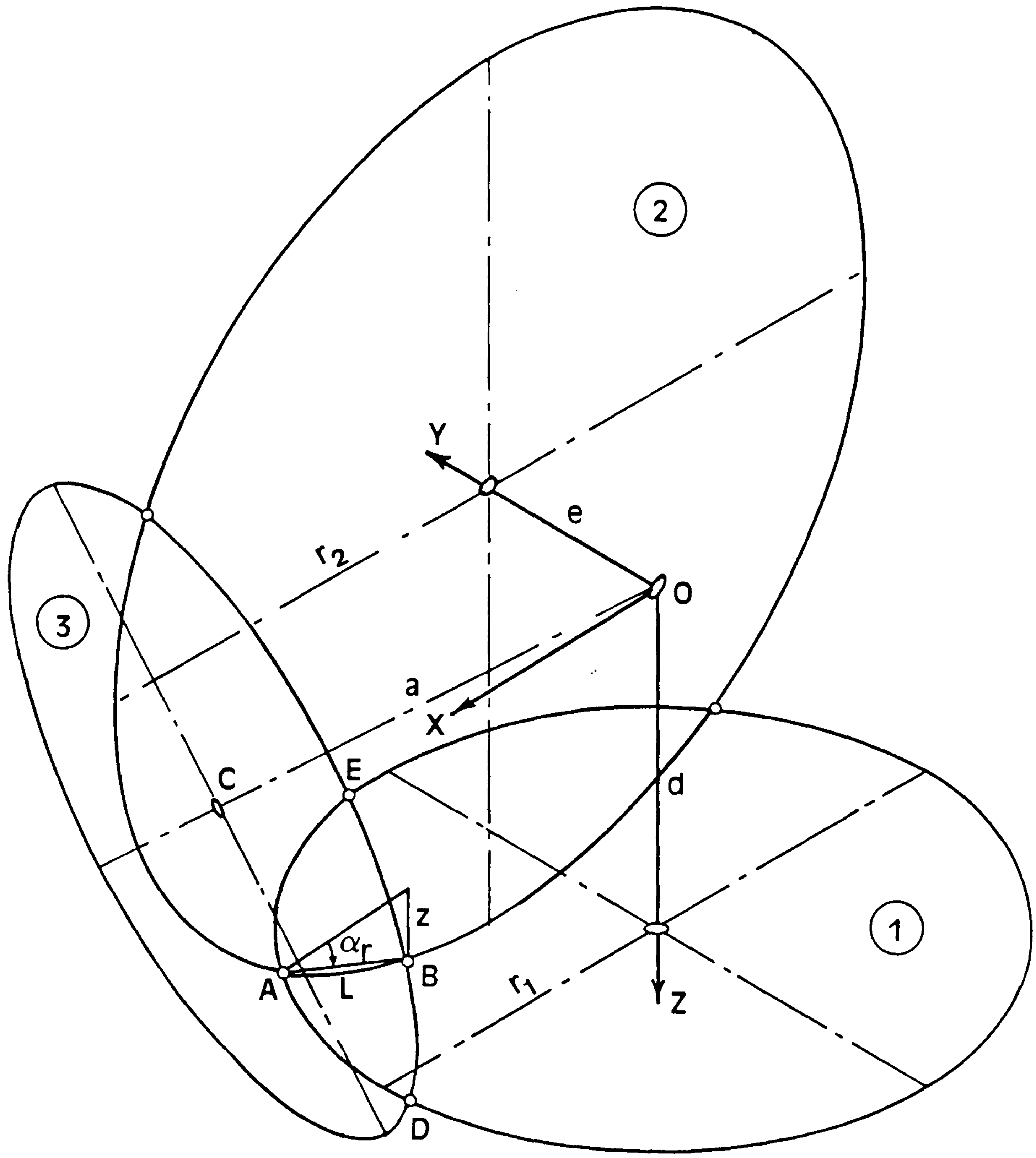

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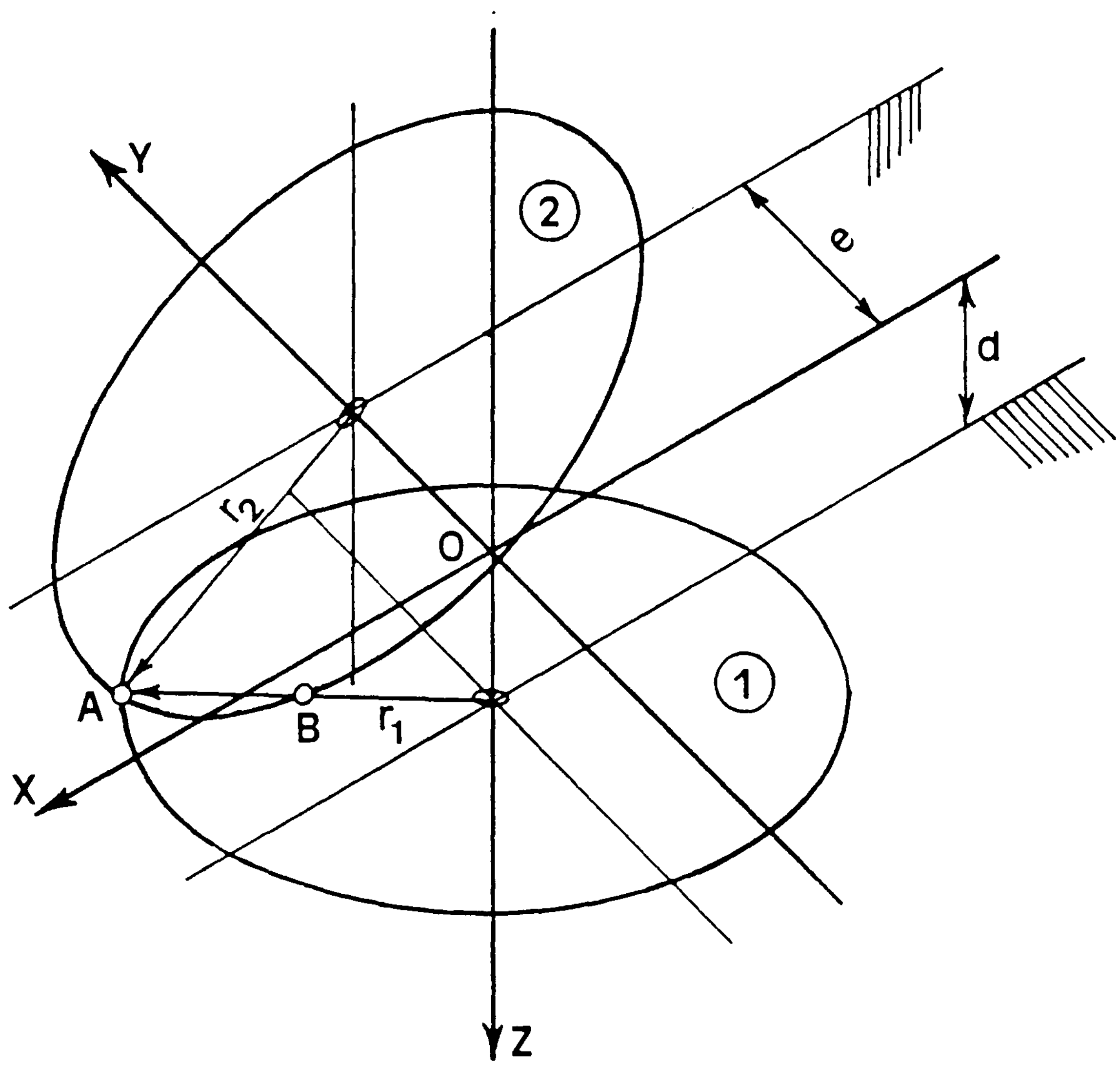

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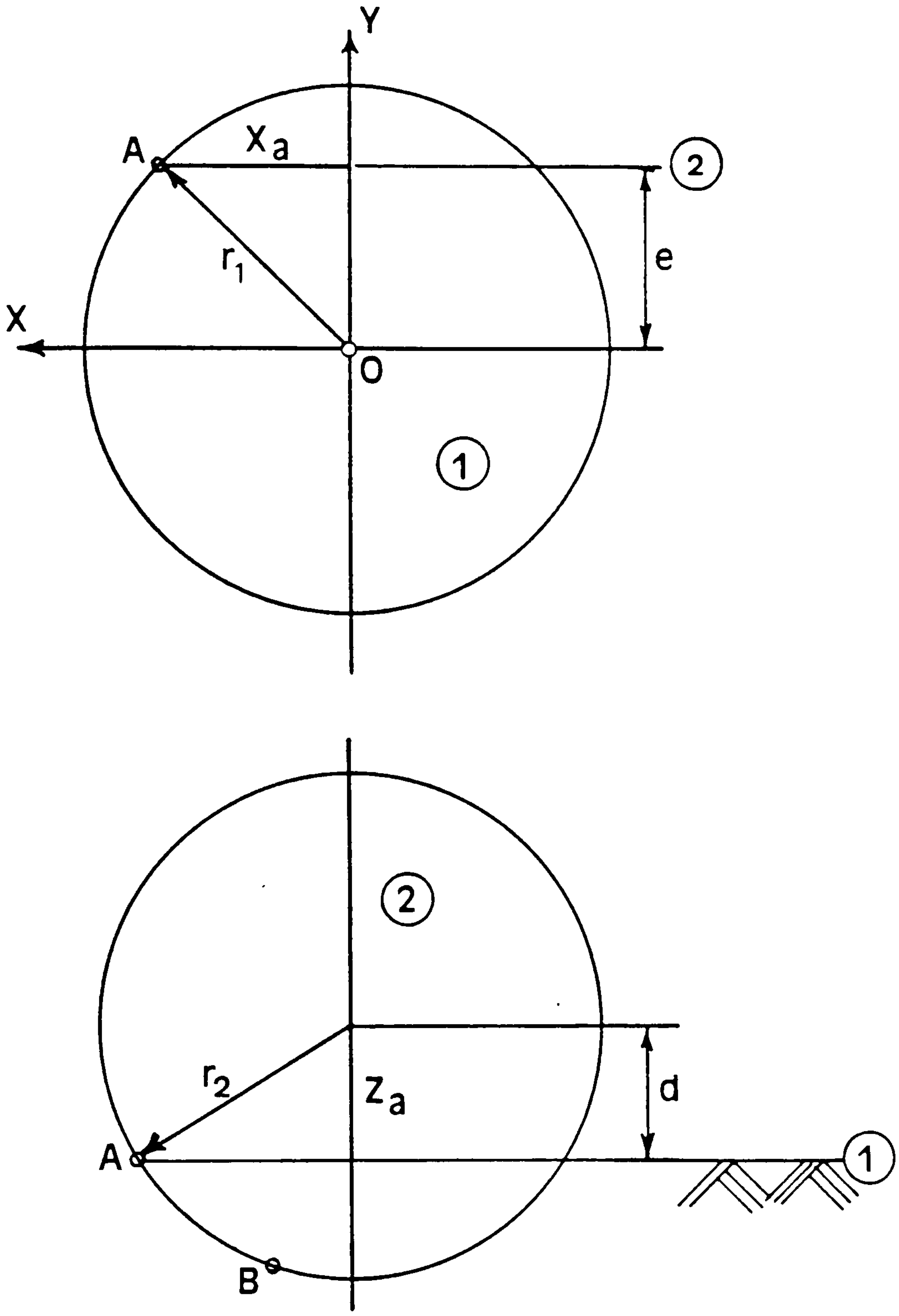

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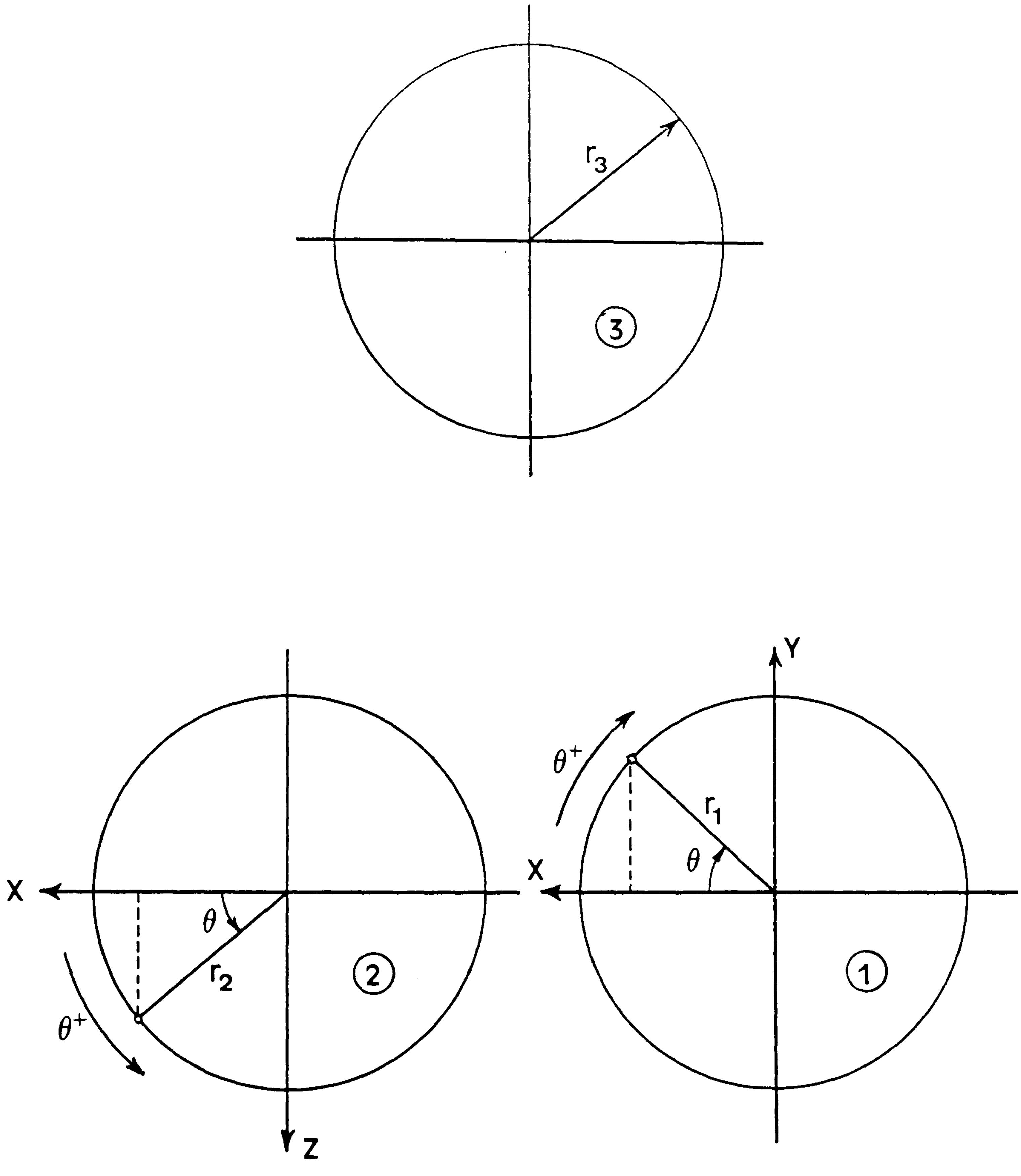
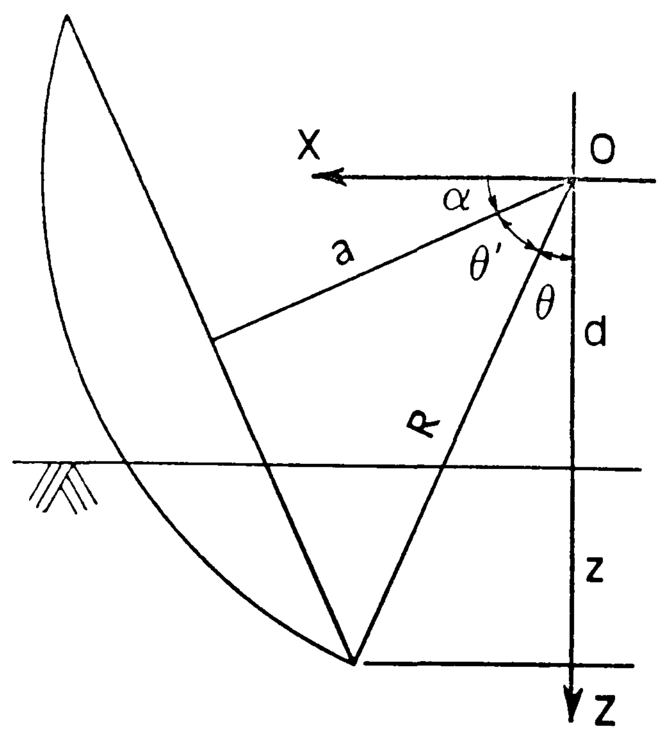


Fig. 3.8 Sign convention for θ



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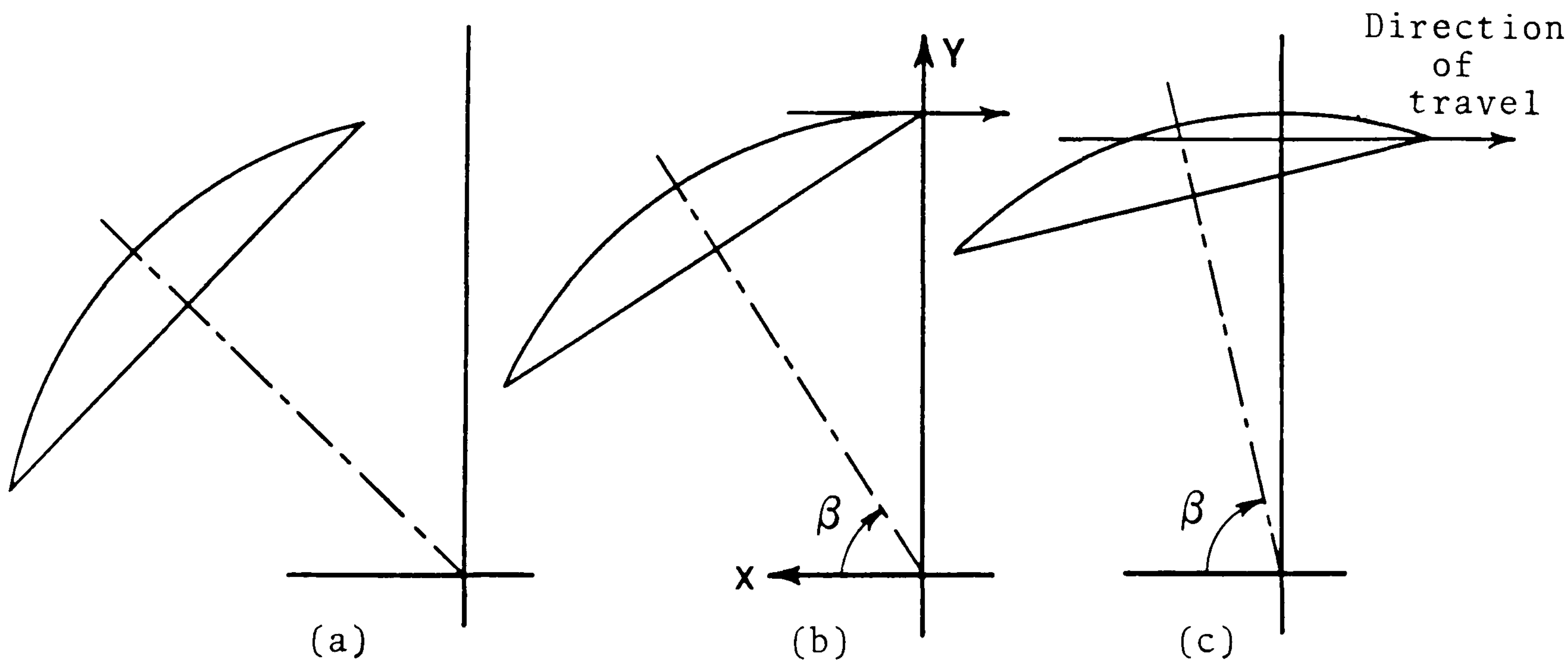

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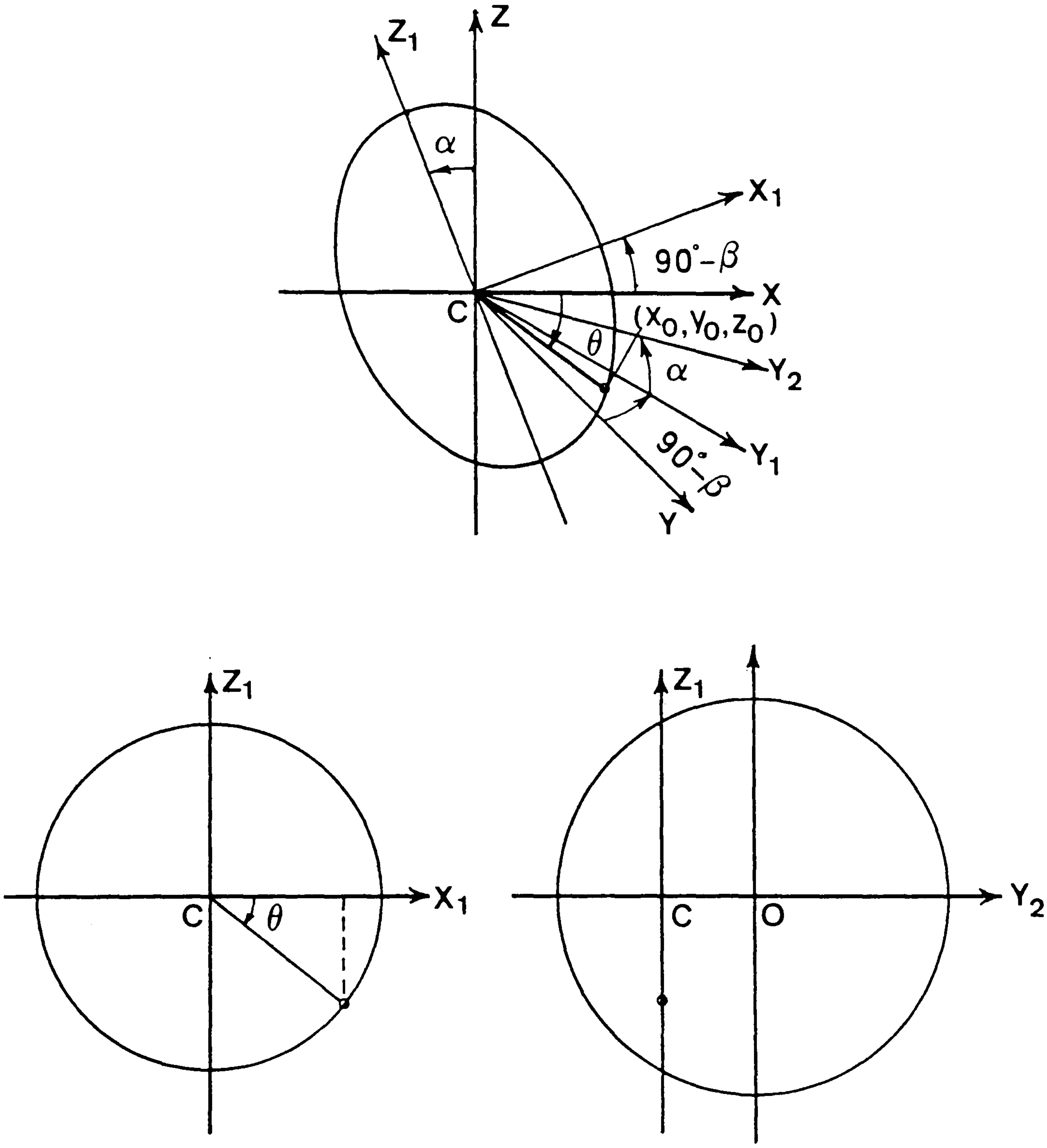

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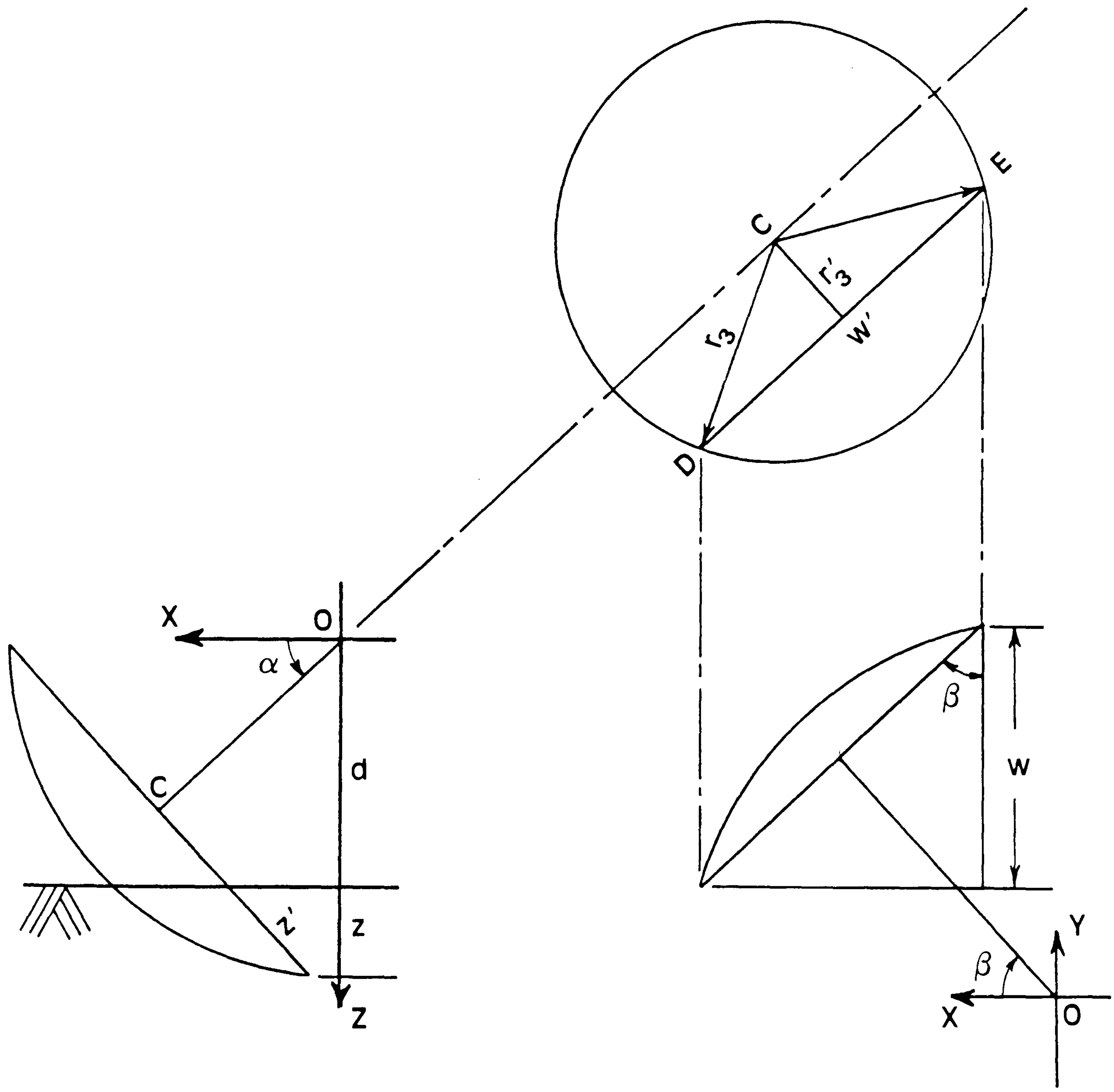

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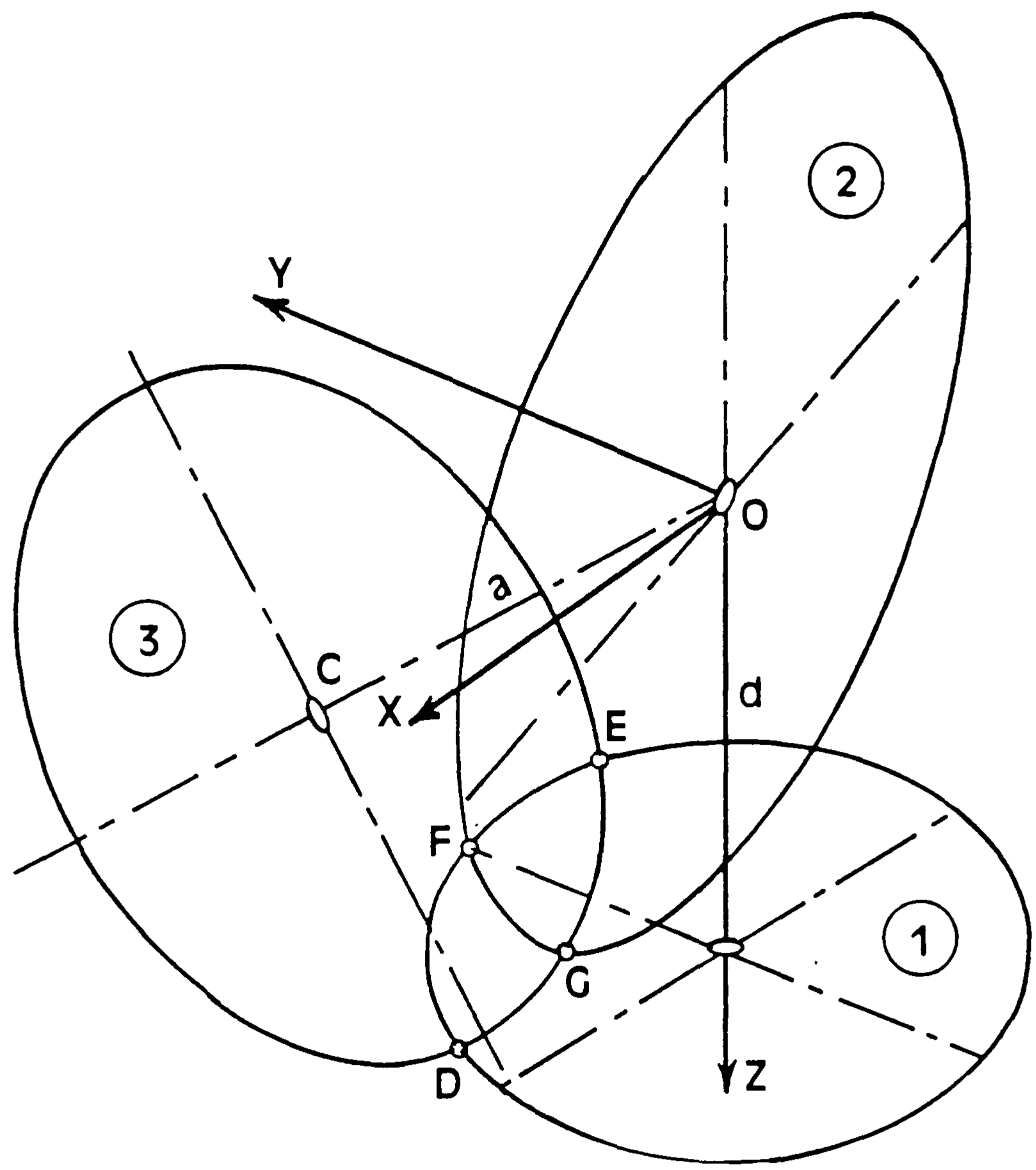
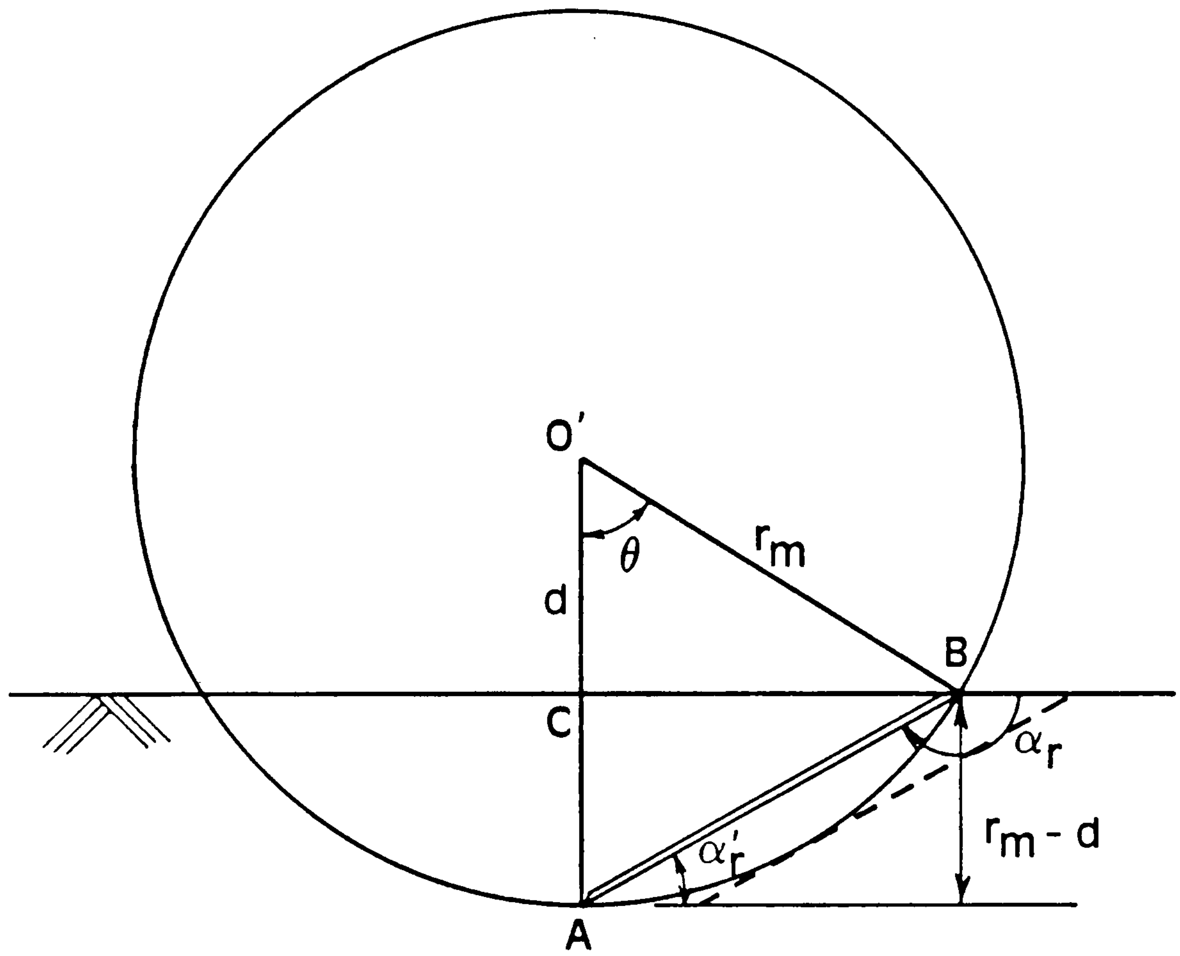


Fig. 3.13 Intersections of (1) horizontal soil surface plane, (2) vertical plane in Y-Z and (3) disc face plane defined by the disc sphere.



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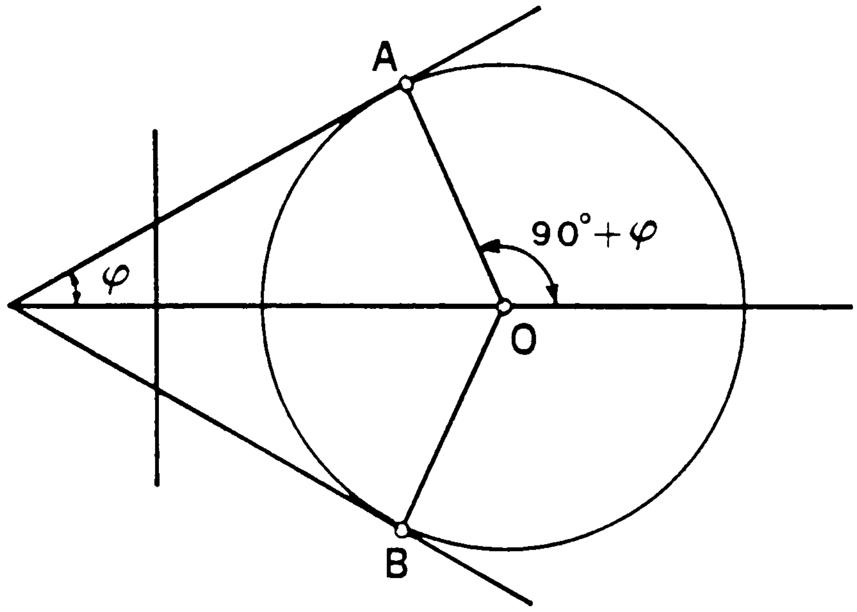
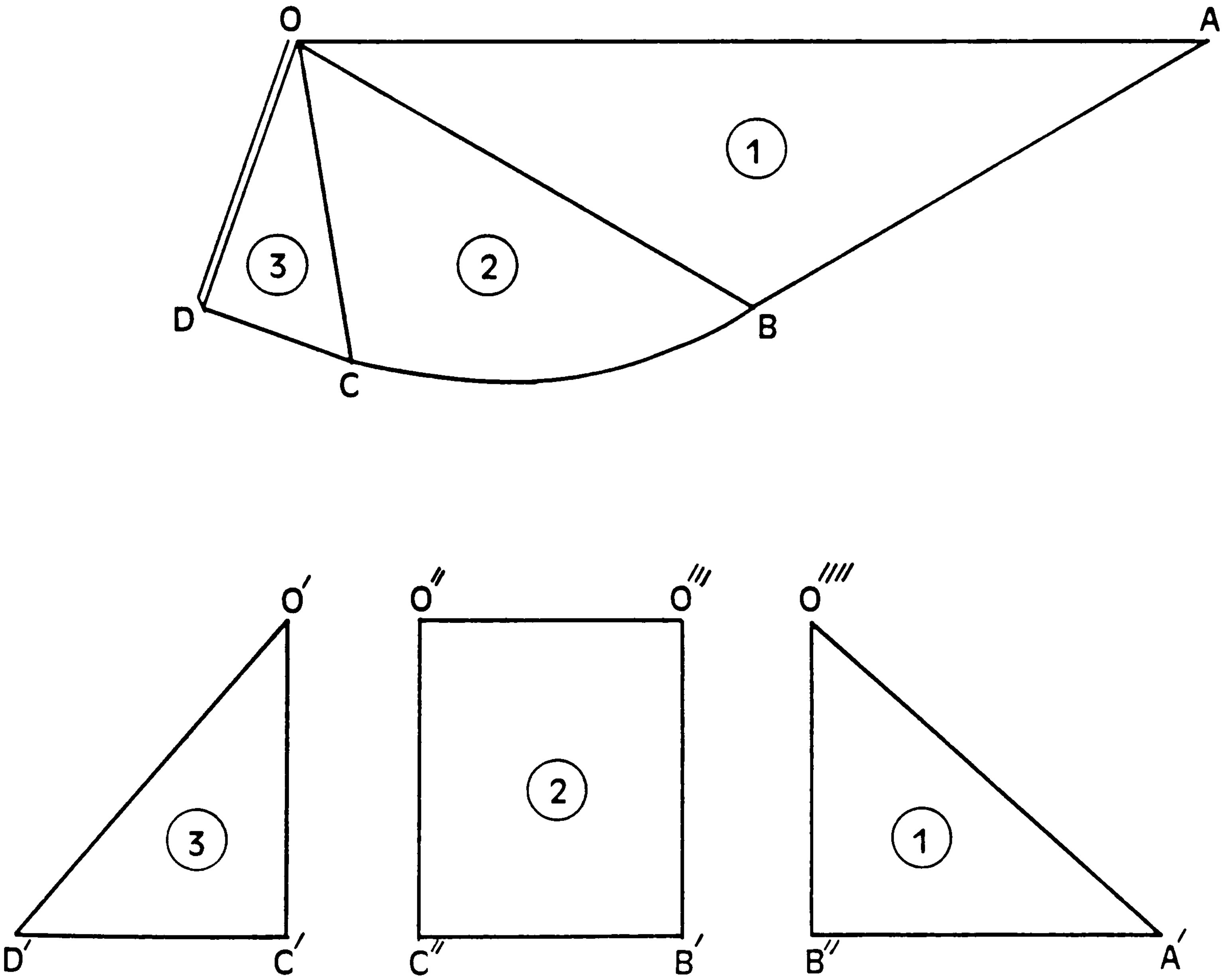


(a)



(b)

Fig. 4.1 (a) Mohr's circle illustrating the two planes of incipient failure; (b) Sokolovski's solution to earth pressure problem.

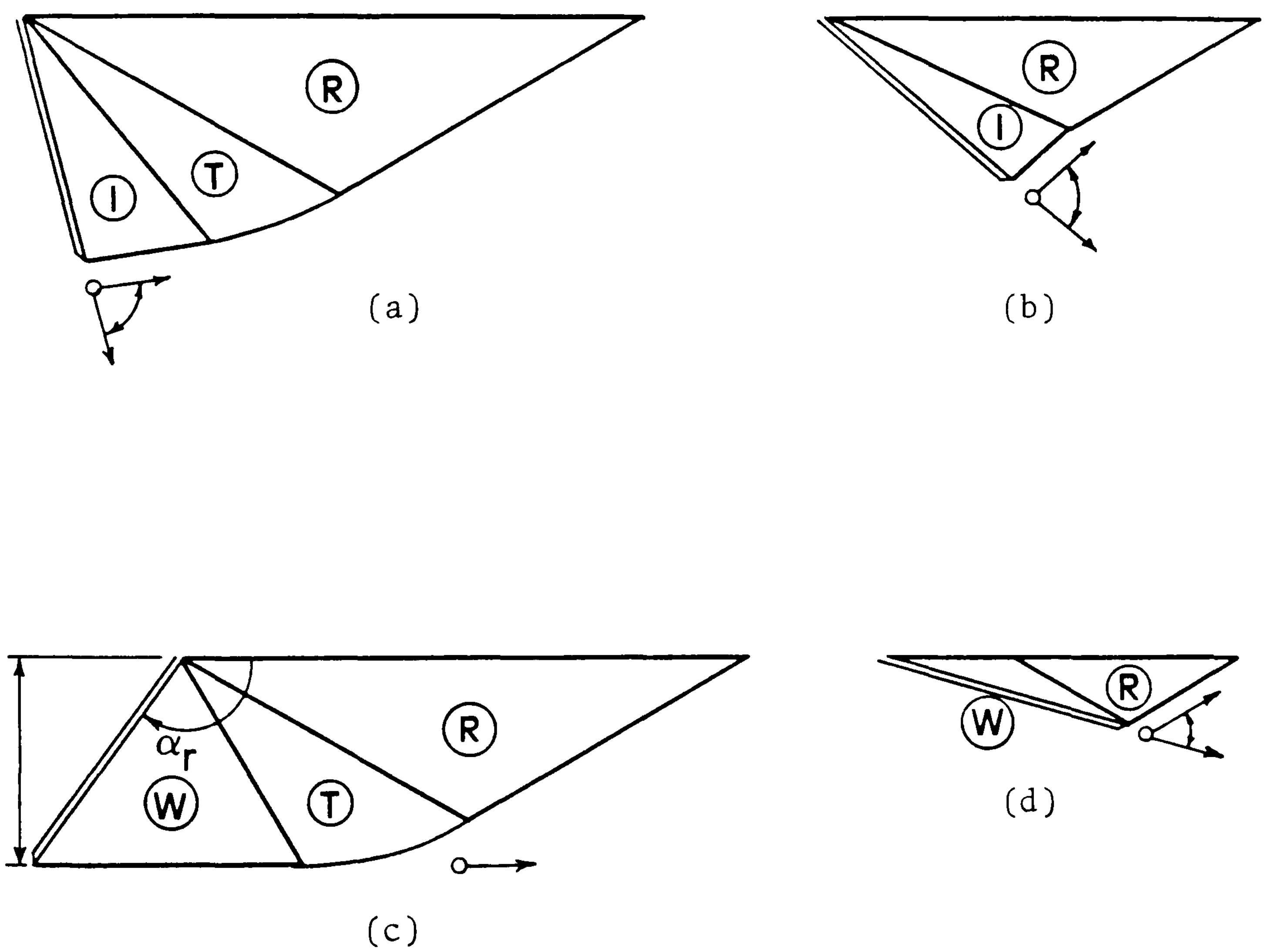
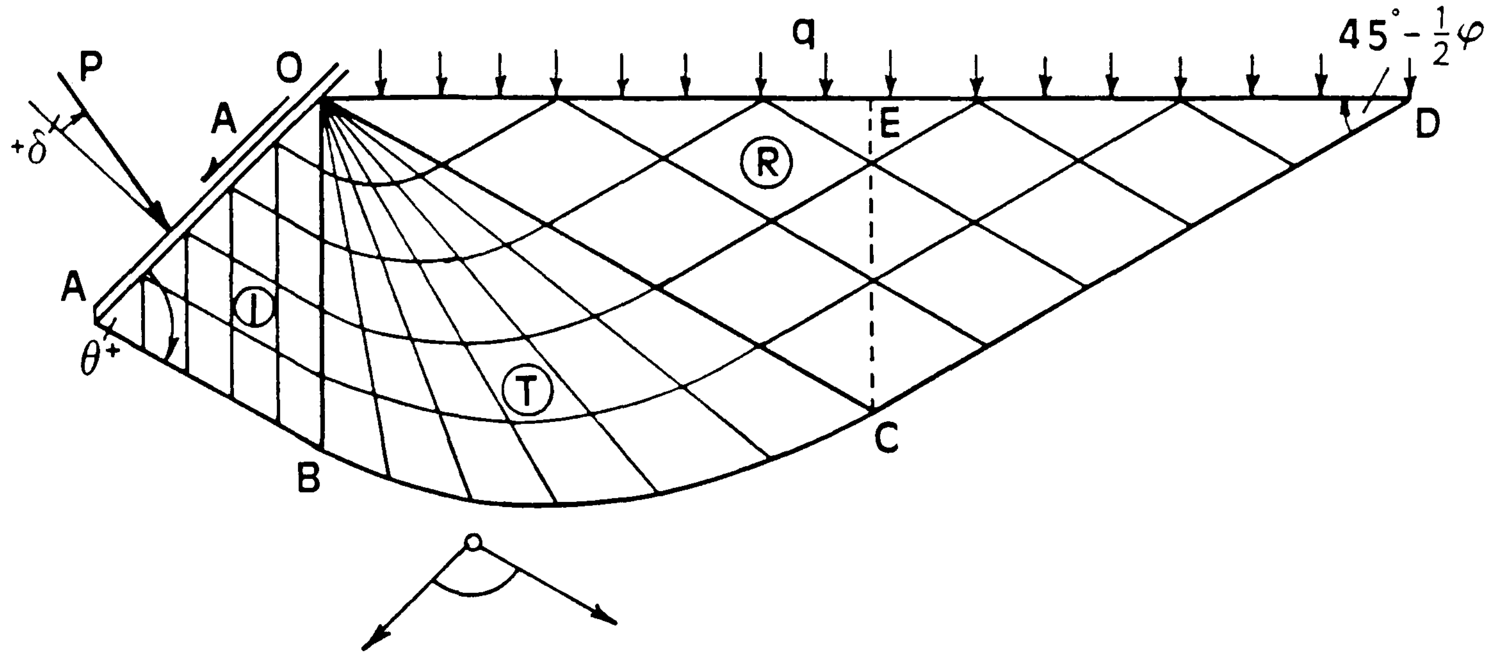
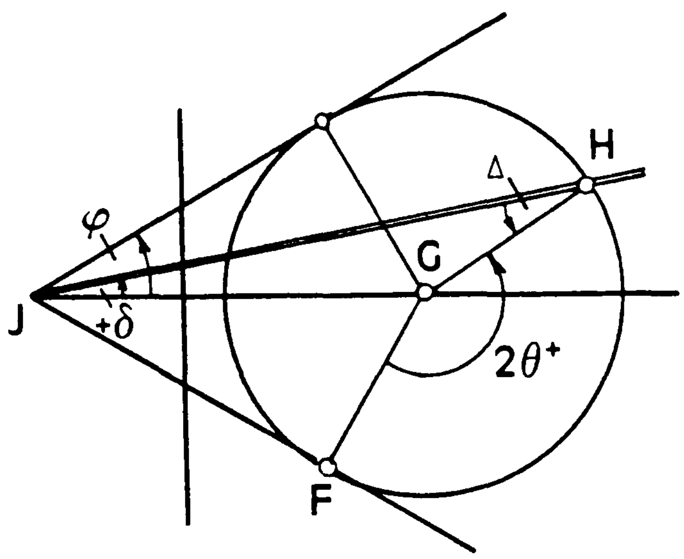


Fig. 4.2 Main types of slip-line fields; (a) Basic field comprising the Interface (I), Transition (T) and Rankine (R) zones. (b) Small rake angles inducing a stress discontinuity between (I) and (R). (c) Large rake angles with soil boundary wedge (W) fixed to interface. (d) Small rake angles with wedge or discontinuity for a fully rough interface.

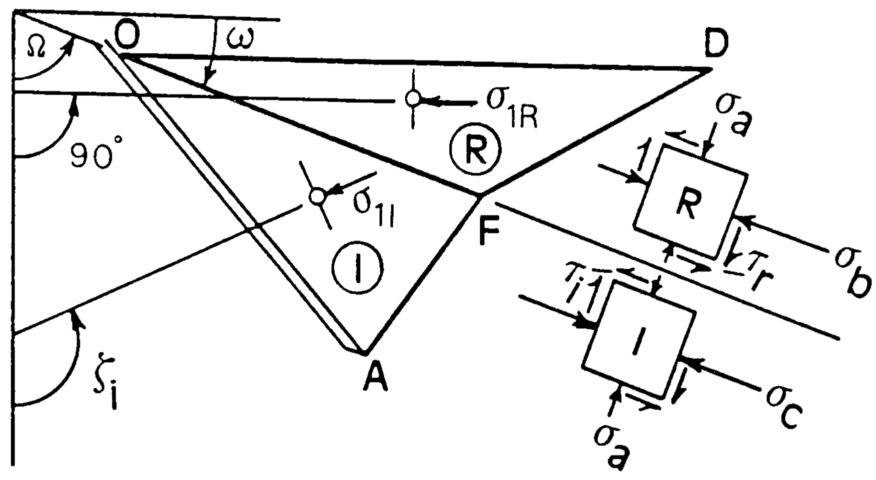


(a)



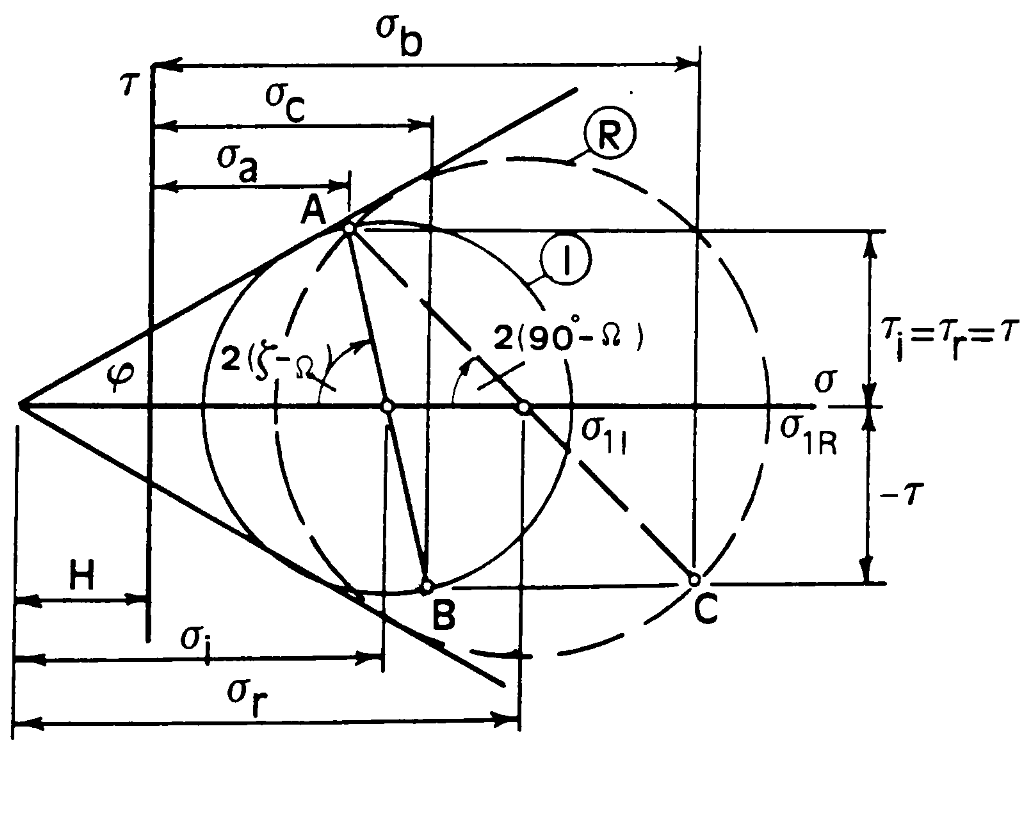
(b)

Fig. 4.3 (a) Basic slip-line field and rupture zone.
(b) Mohr's diagram.



(a) (b)

Fig. 4.4 (a) The plane of discontinuity OF separates the Interface and Rankine zones. (b) The stress conditions on either side of the discontinuity.



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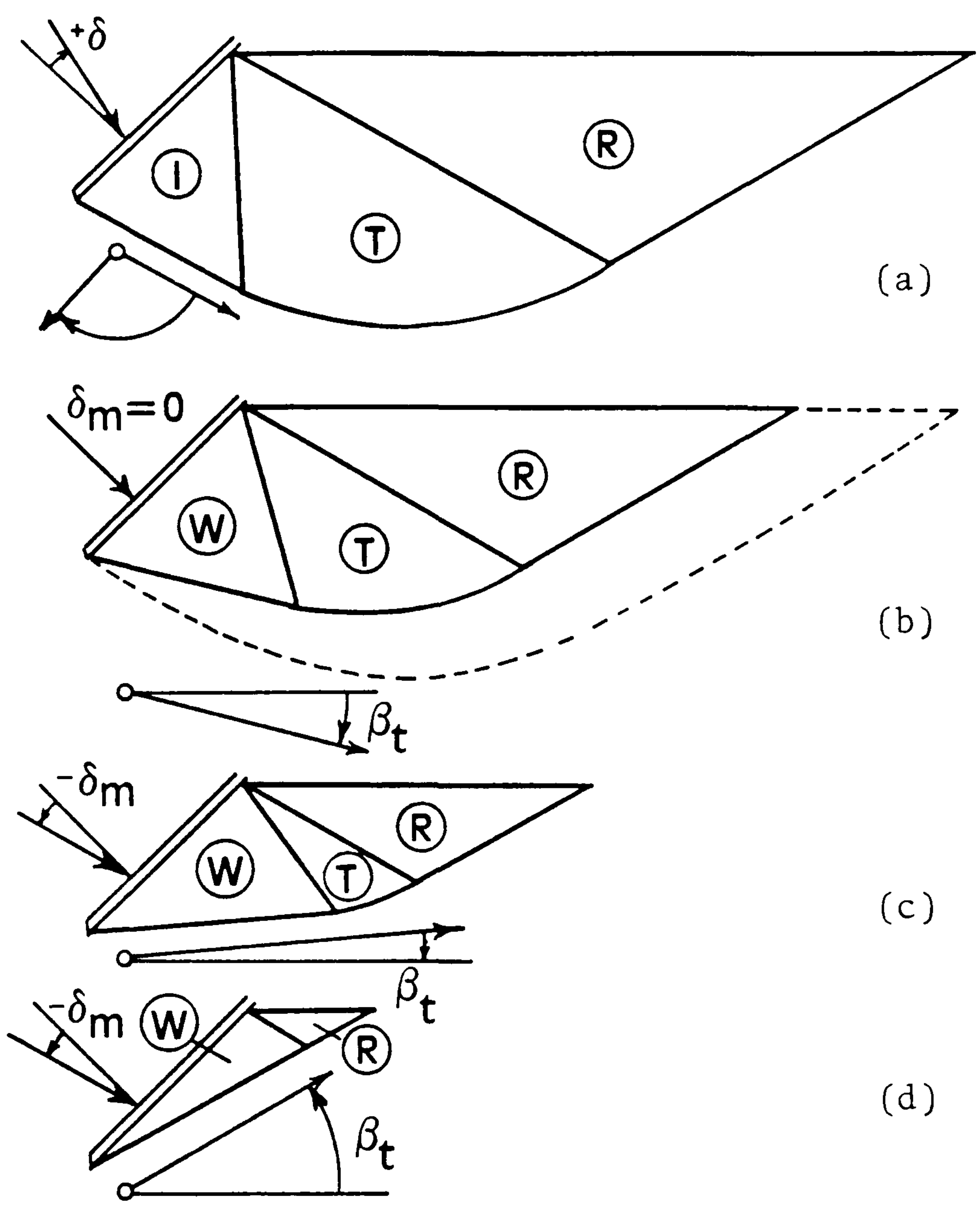
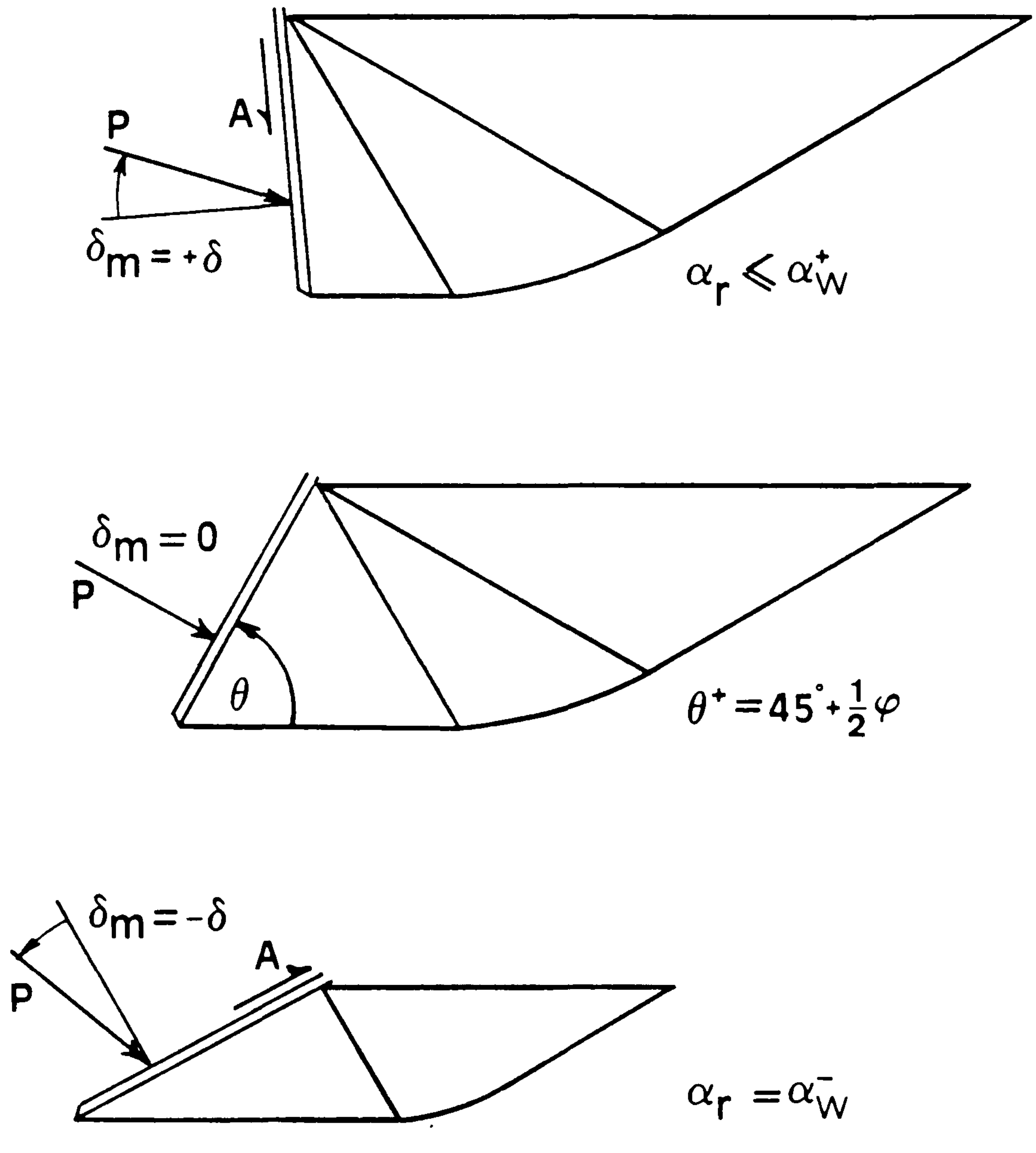


Fig. 4.6 Boundary wedge formation and influence of direction of motion on wedge geometry. (a) Basic slip-line field showing range of β_t for which it is valid. (b), (c) Boundary wedges when is outside range. (d) Limit of application of analysis when $\beta_t = (45° - \frac{1}{2}\varphi)$.



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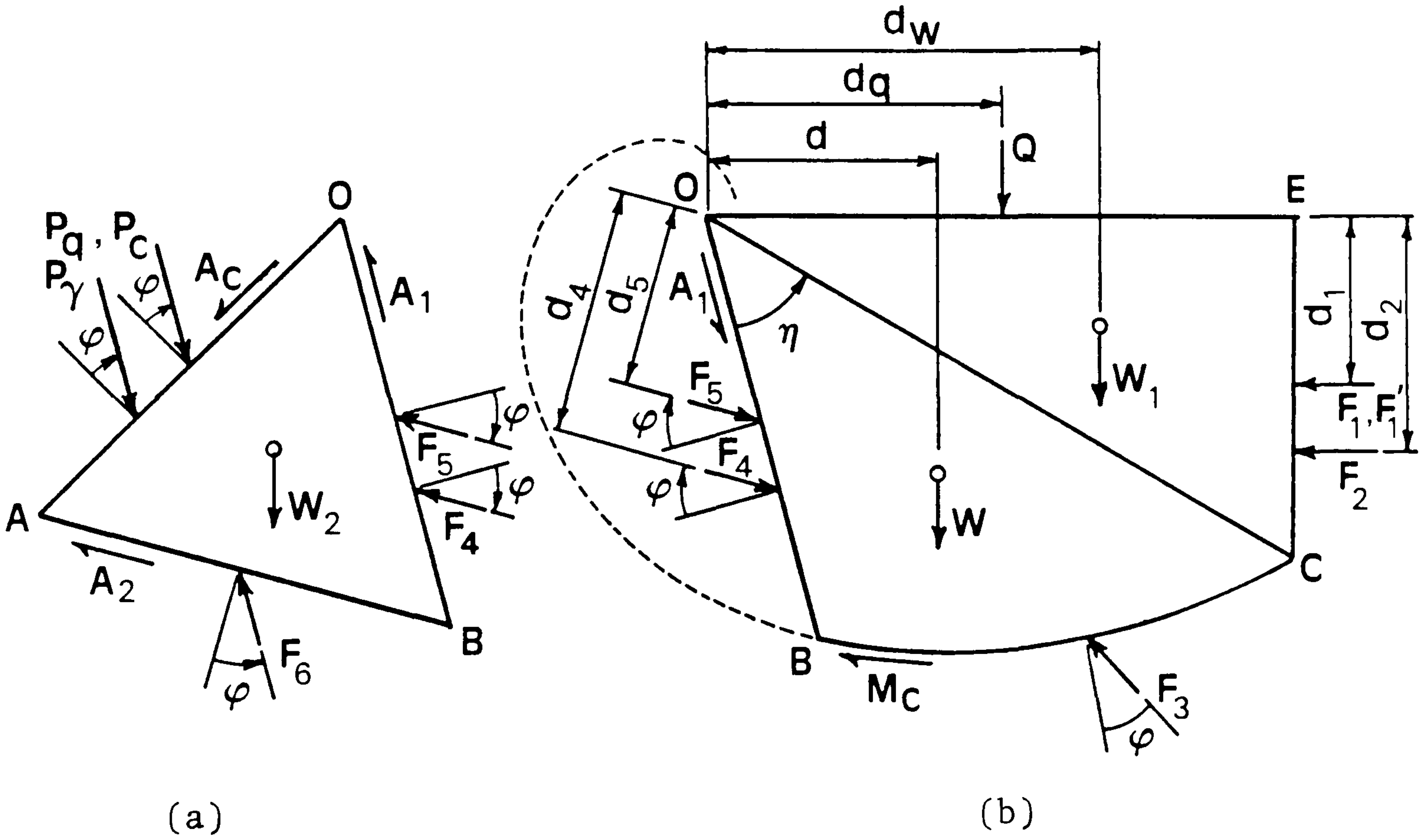


Fig. 5.1 Forces acting on the soil rupture block in basic passive failure (a) Interface zone (b) Transition zone and half the passive Rankine zone.

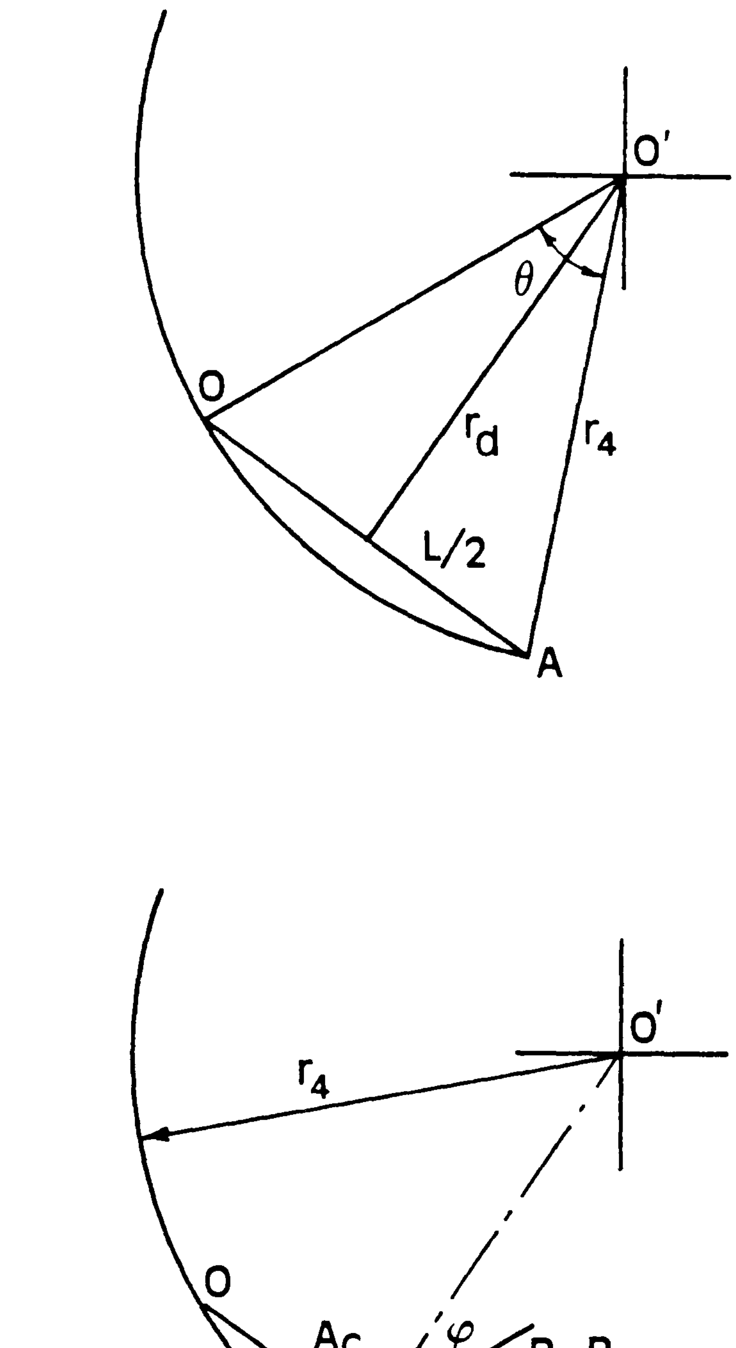


Fig. 5.2 Co-hesive and Adhesive forces on the soil block adjacent to the disc concave working surface.

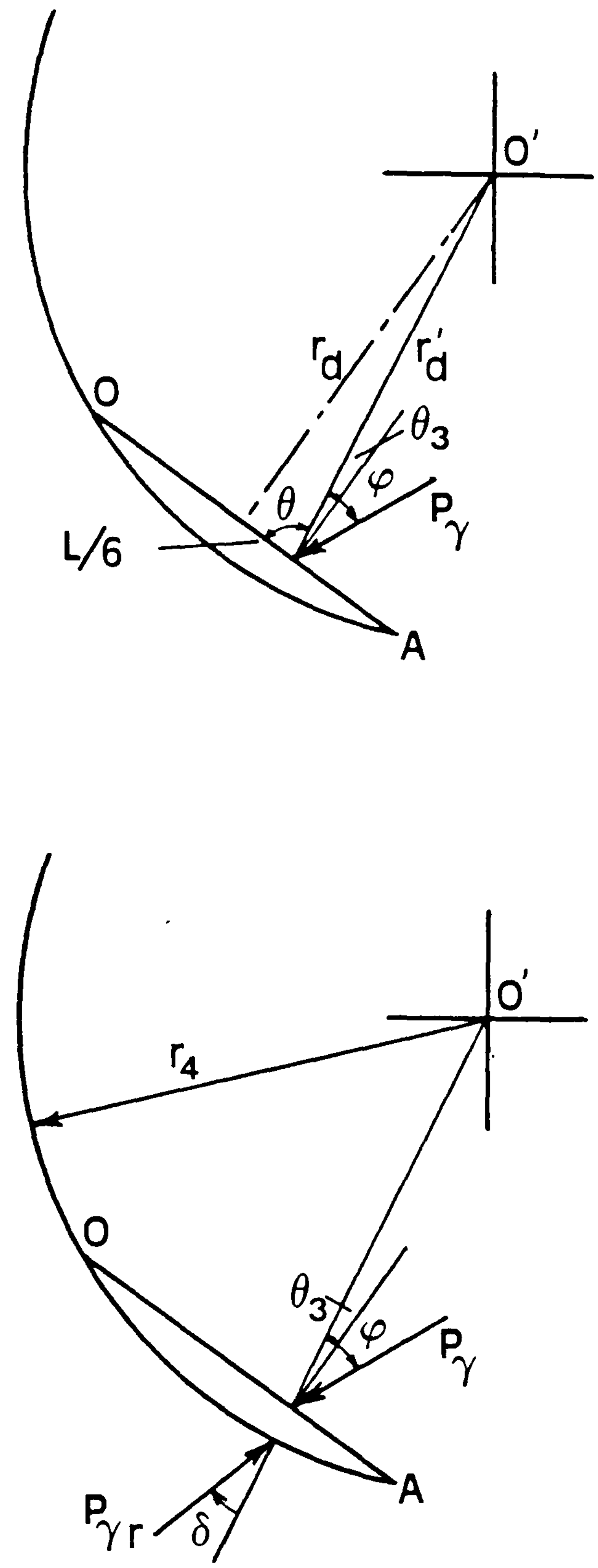


Fig. 5.3 Gravitational forces on the soil block adjacent to the disc concave working surface.

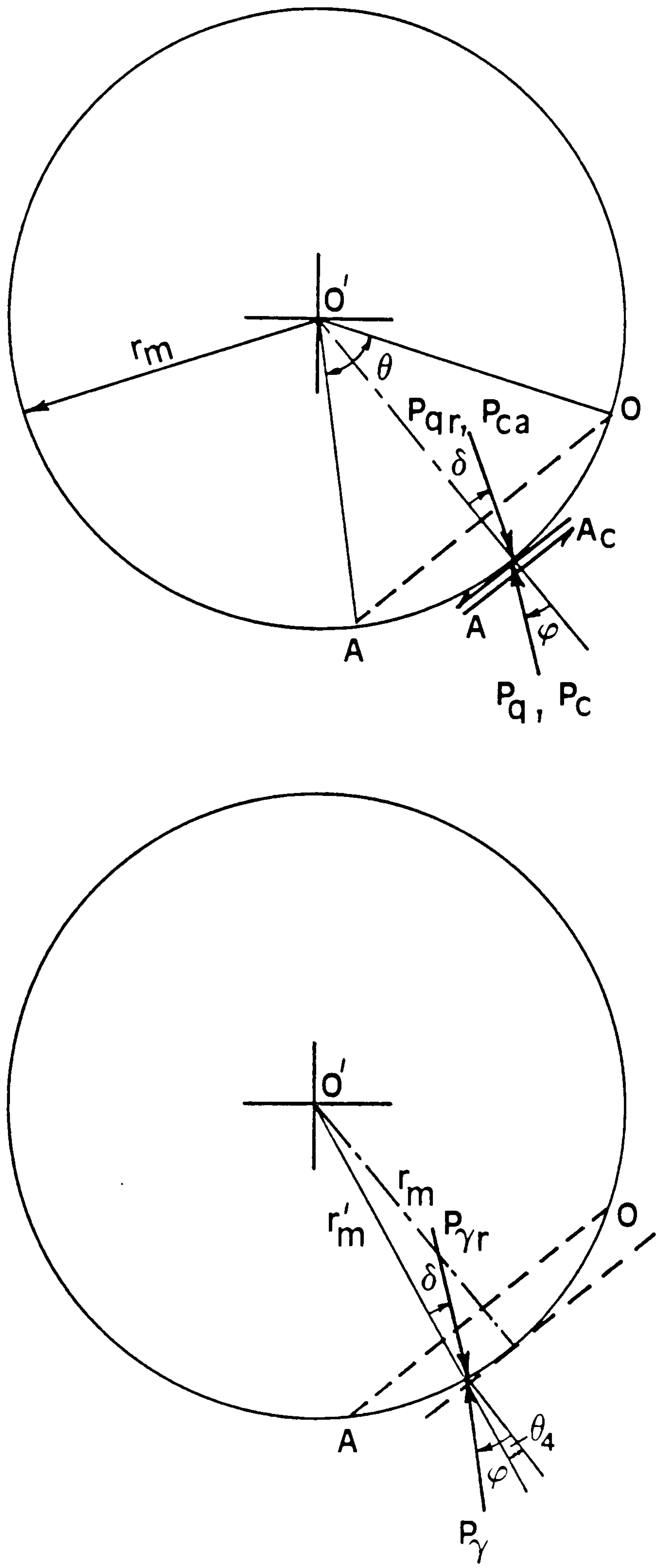


Fig. 5.4 Forces on the soil block adjacent to the disc convex (scrubbing) surface.

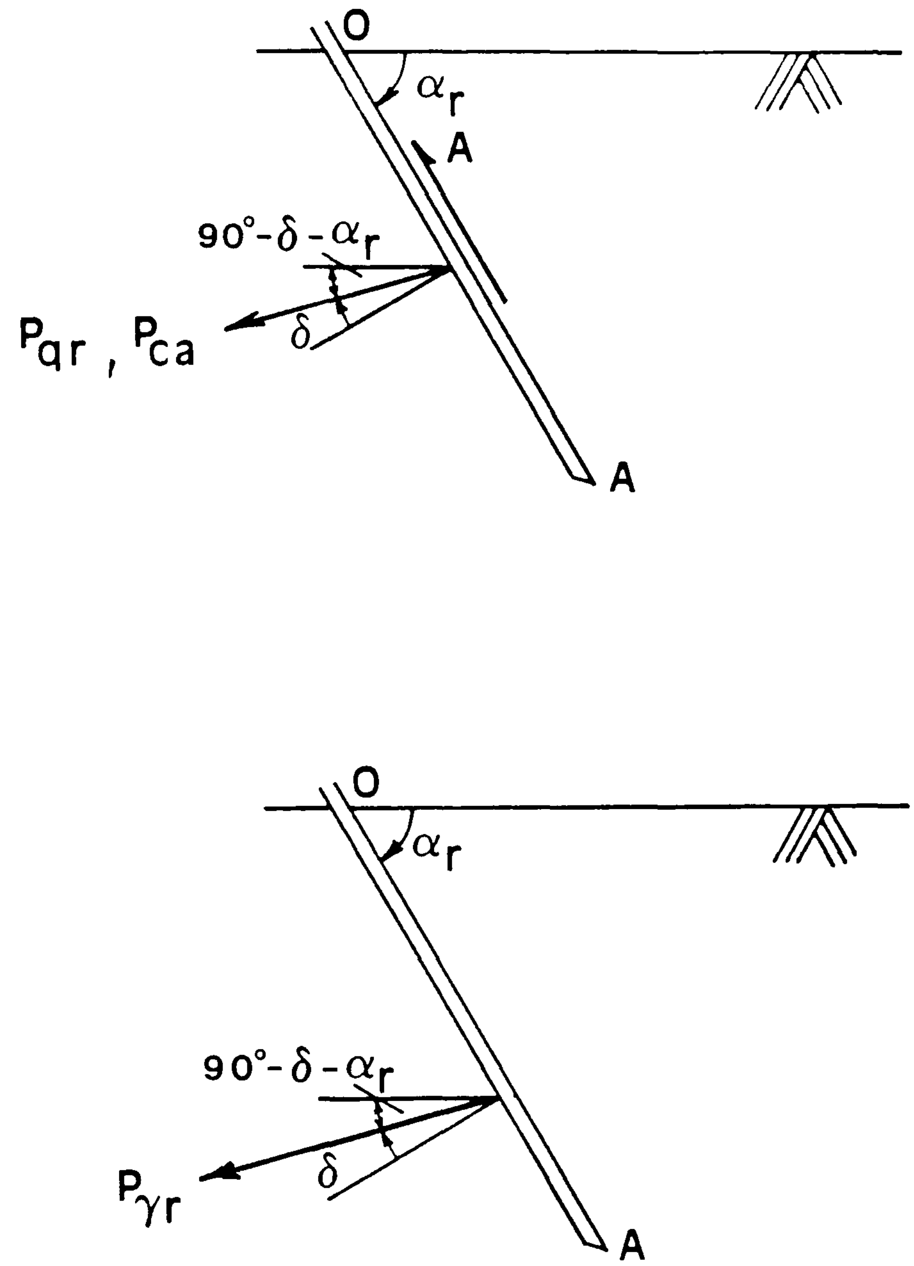


Fig. 5.5 Forces acting on the disc interface.

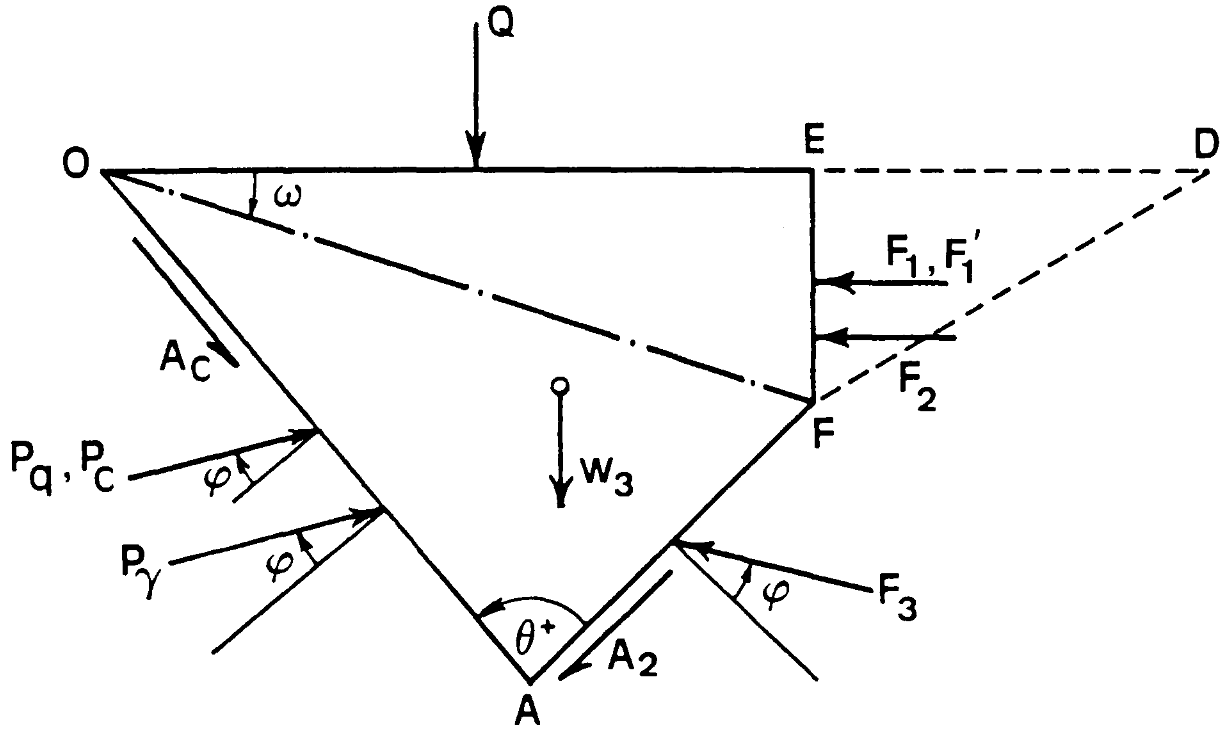


Fig. 5.6 Forces acting on rupture block with a discontinuity.

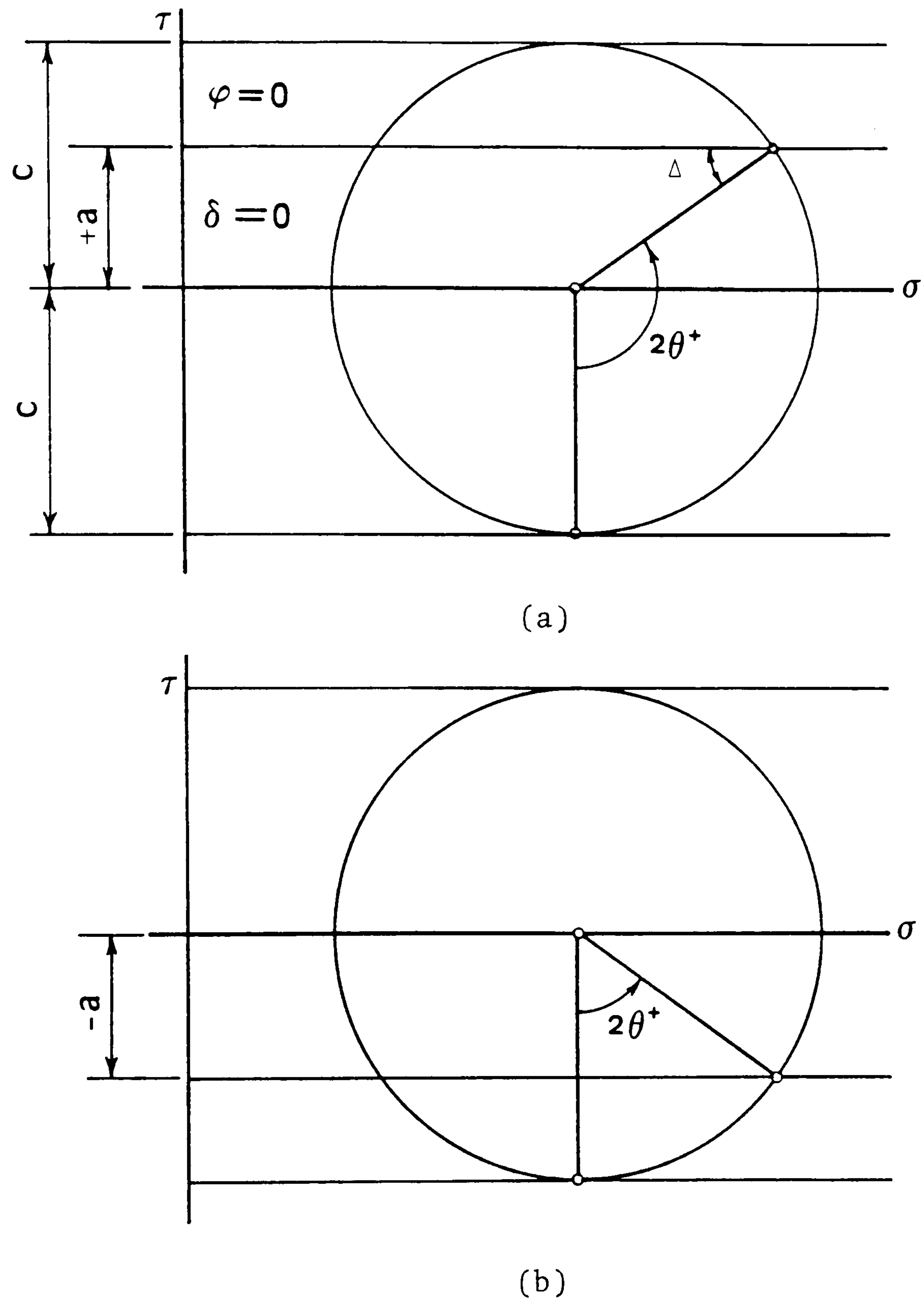


Fig. 5.7 Special case when $\varphi=0$. (a) Estimation of θ^+.
(b) Minimum value of θ^+.

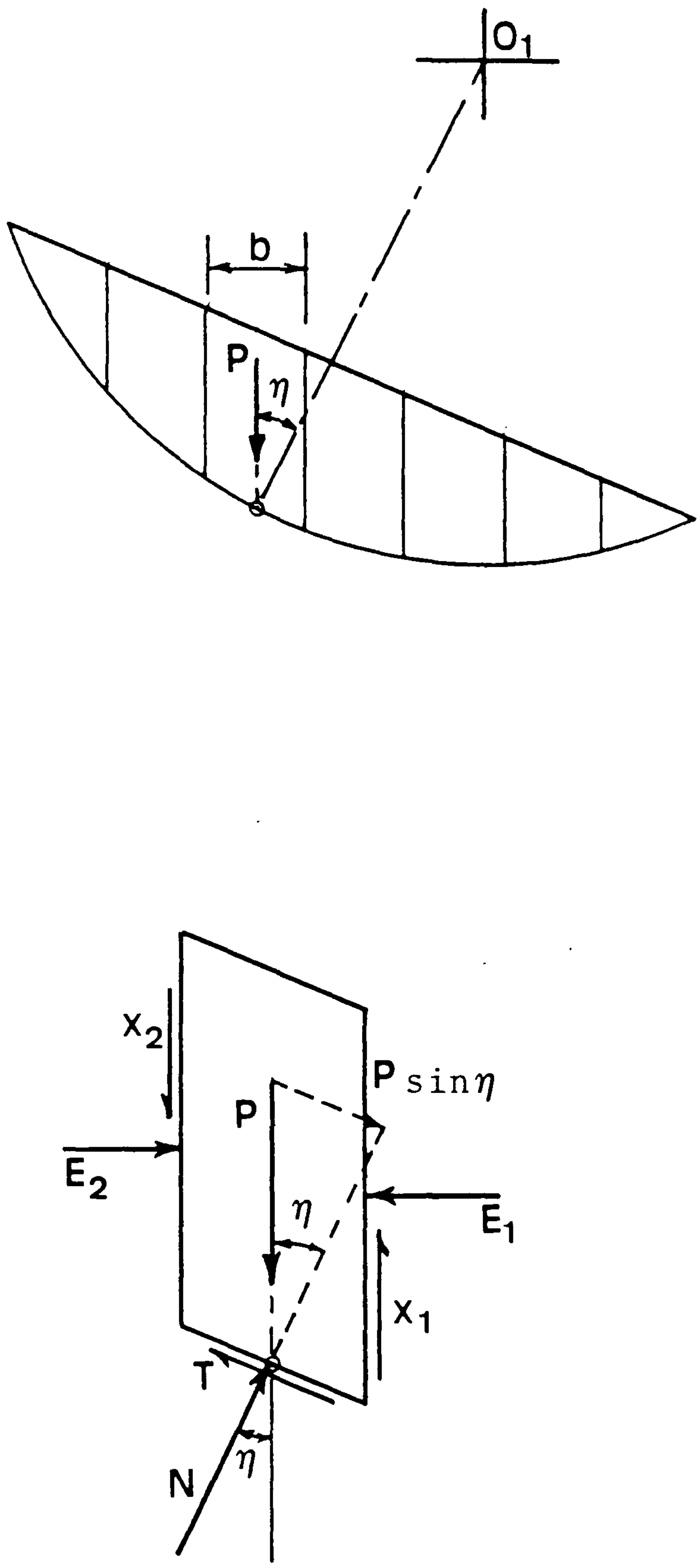


Fig. 5.8 Effective force calculation using method of slices.

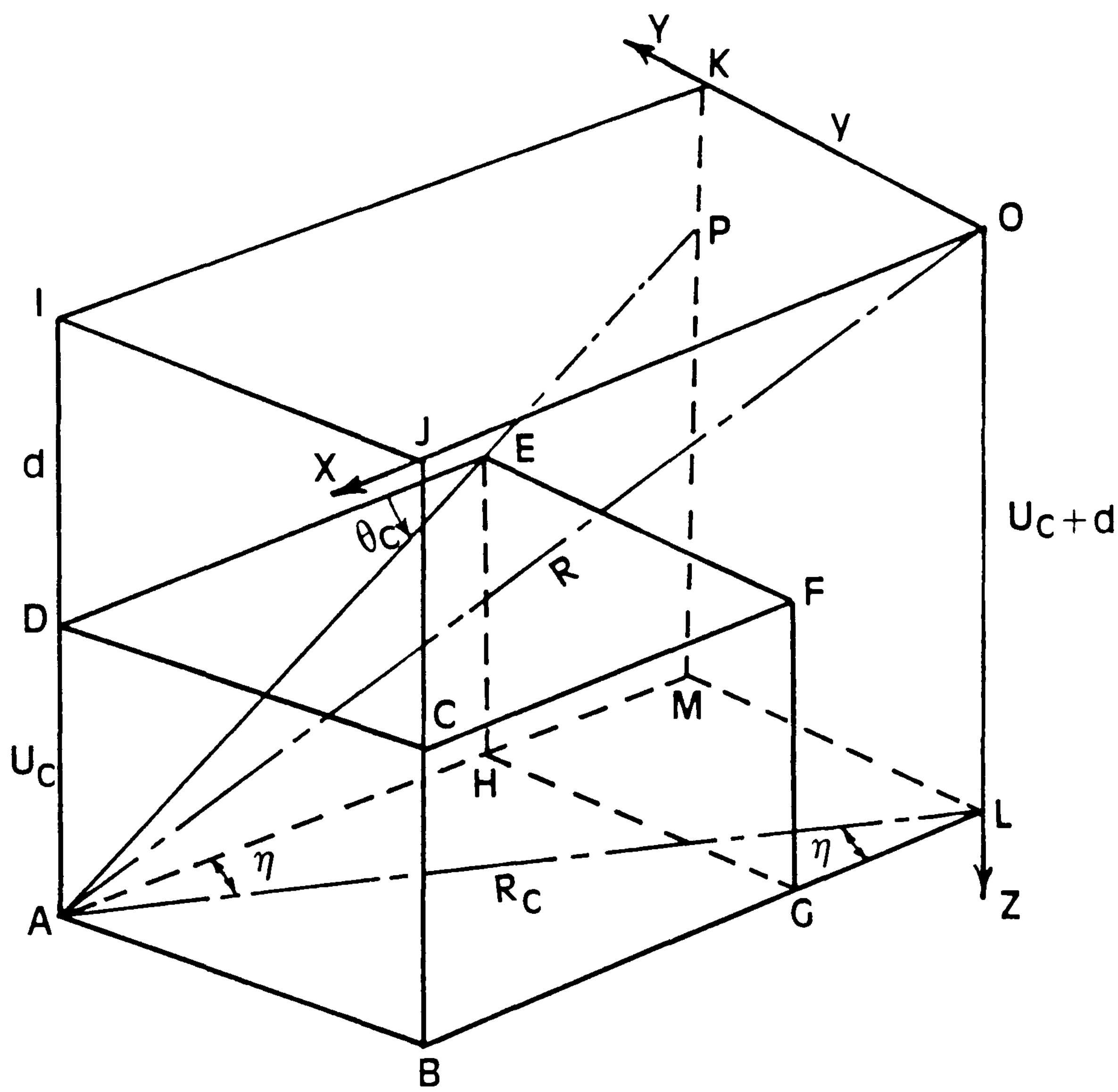


Fig. 5.9 Calculation of the angle η.

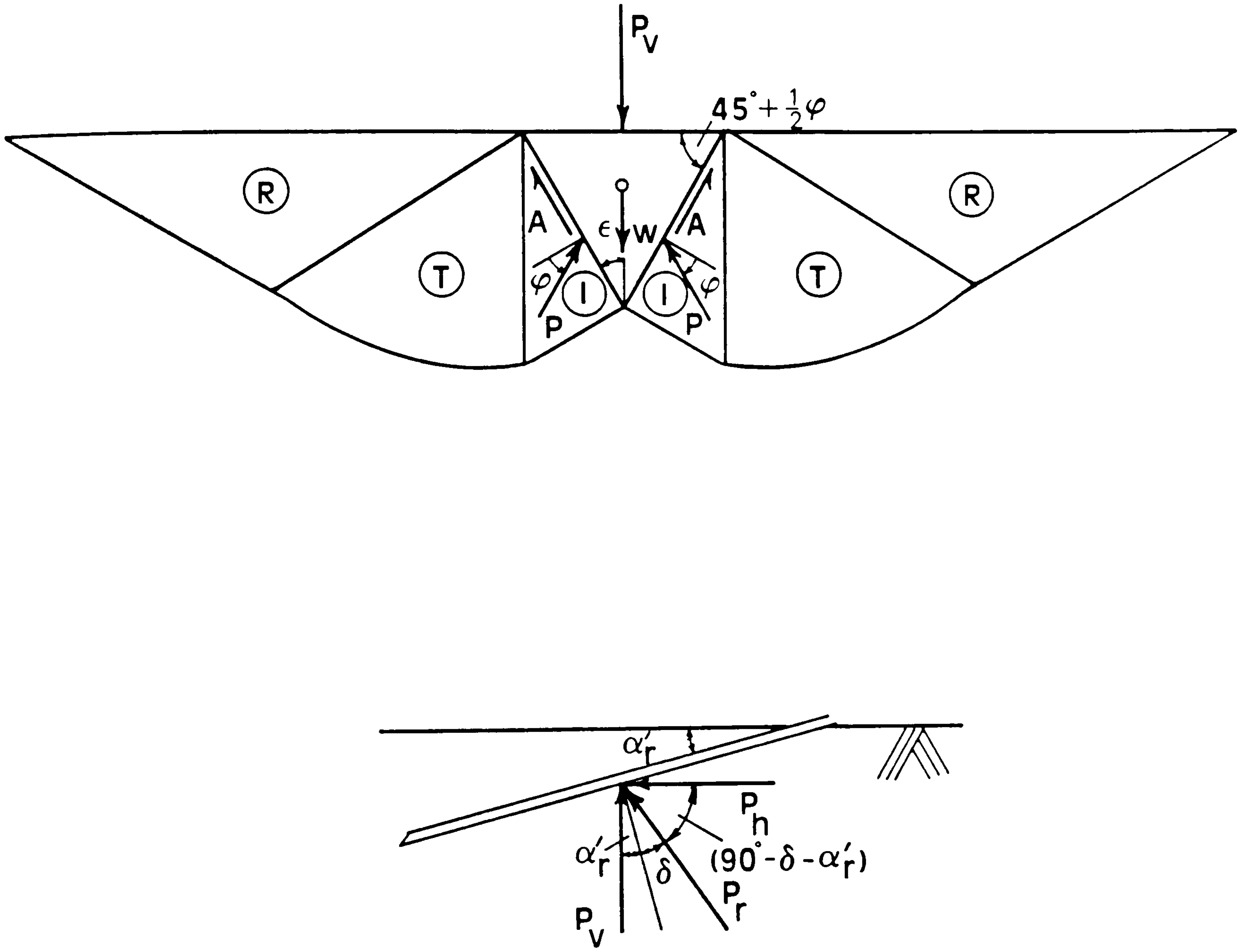


Fig. 5.10 Modified rupture block in the vicinity of the bearing capacity conception.

Fig. 6.1 Recording unit comprises of an Oscillograph recorder, amplifiers and an event marker regulator.

Fig. 6.2 Complete test rig.

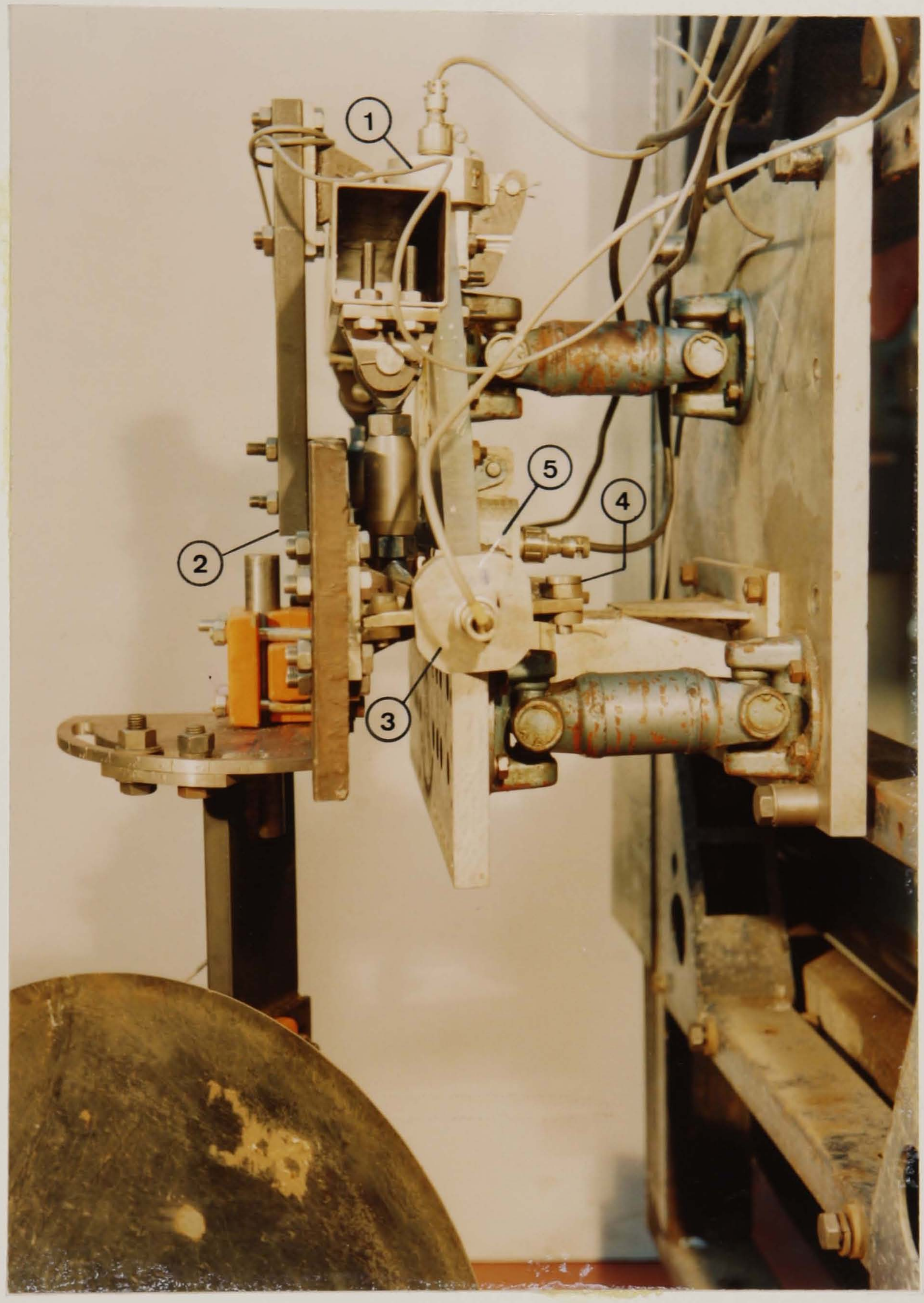


Fig. 6.3 Dynamometer arrangements between parallel plates.

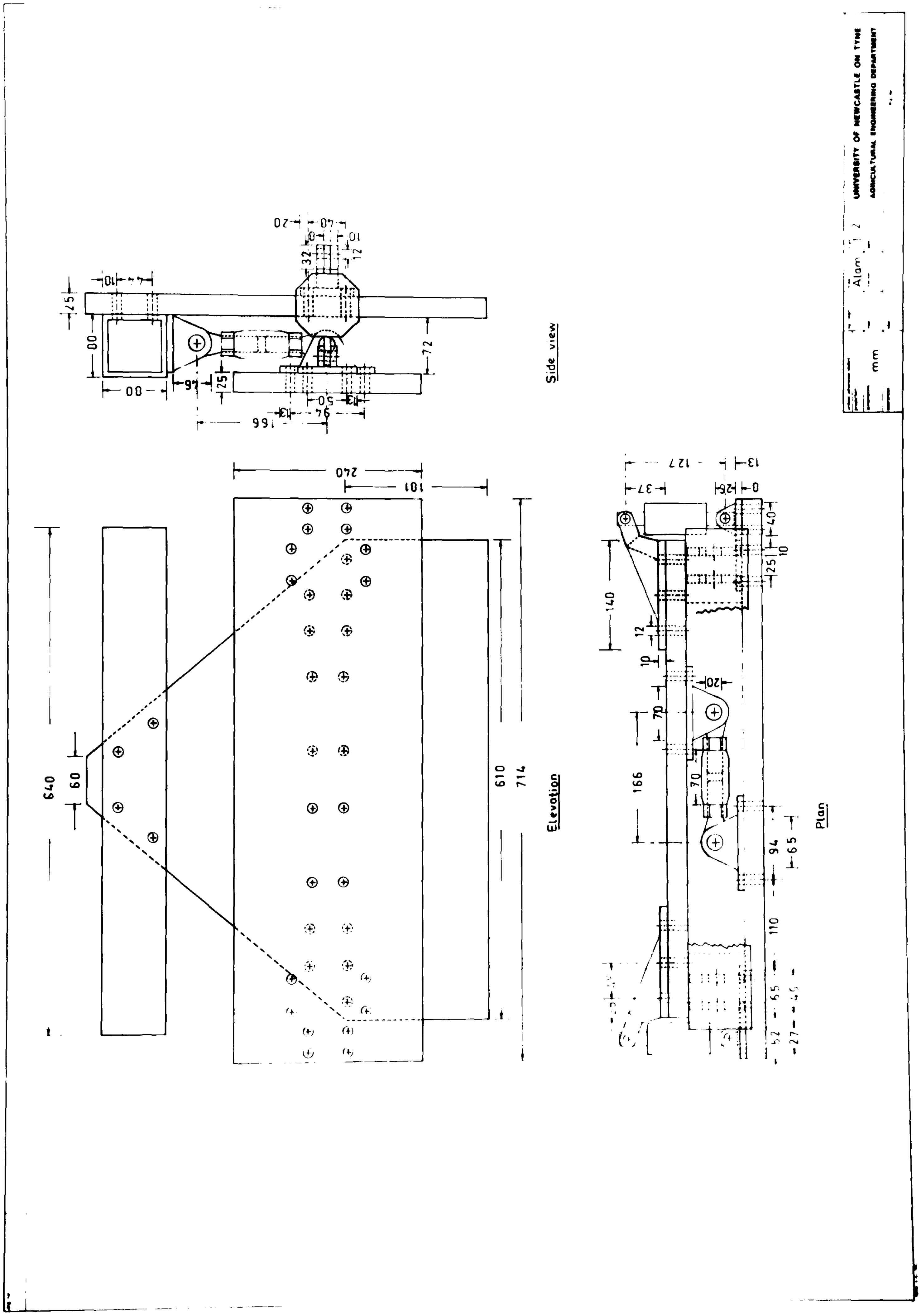


Fig. 6.4 Design of the test rig extension.

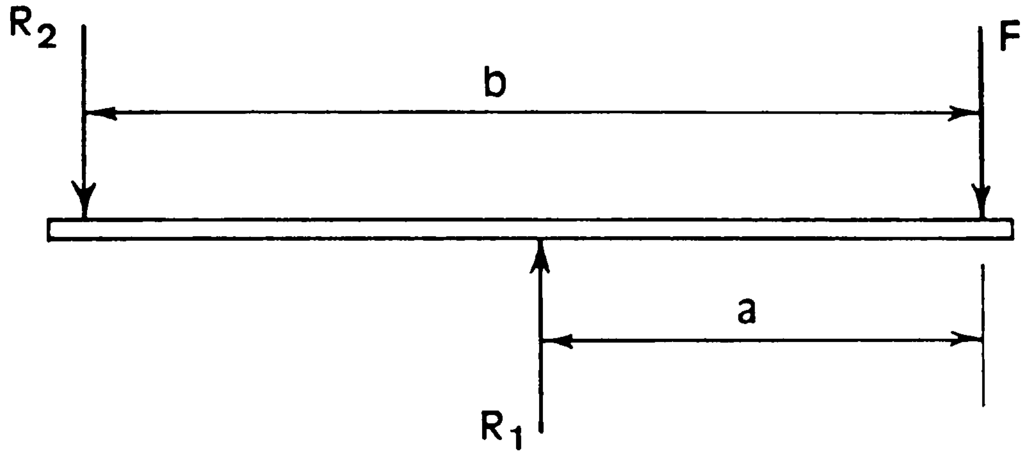


Fig. 6.5 Reaction forces on the side-way positioned dynamometers with respect to the lateral force on the disc.

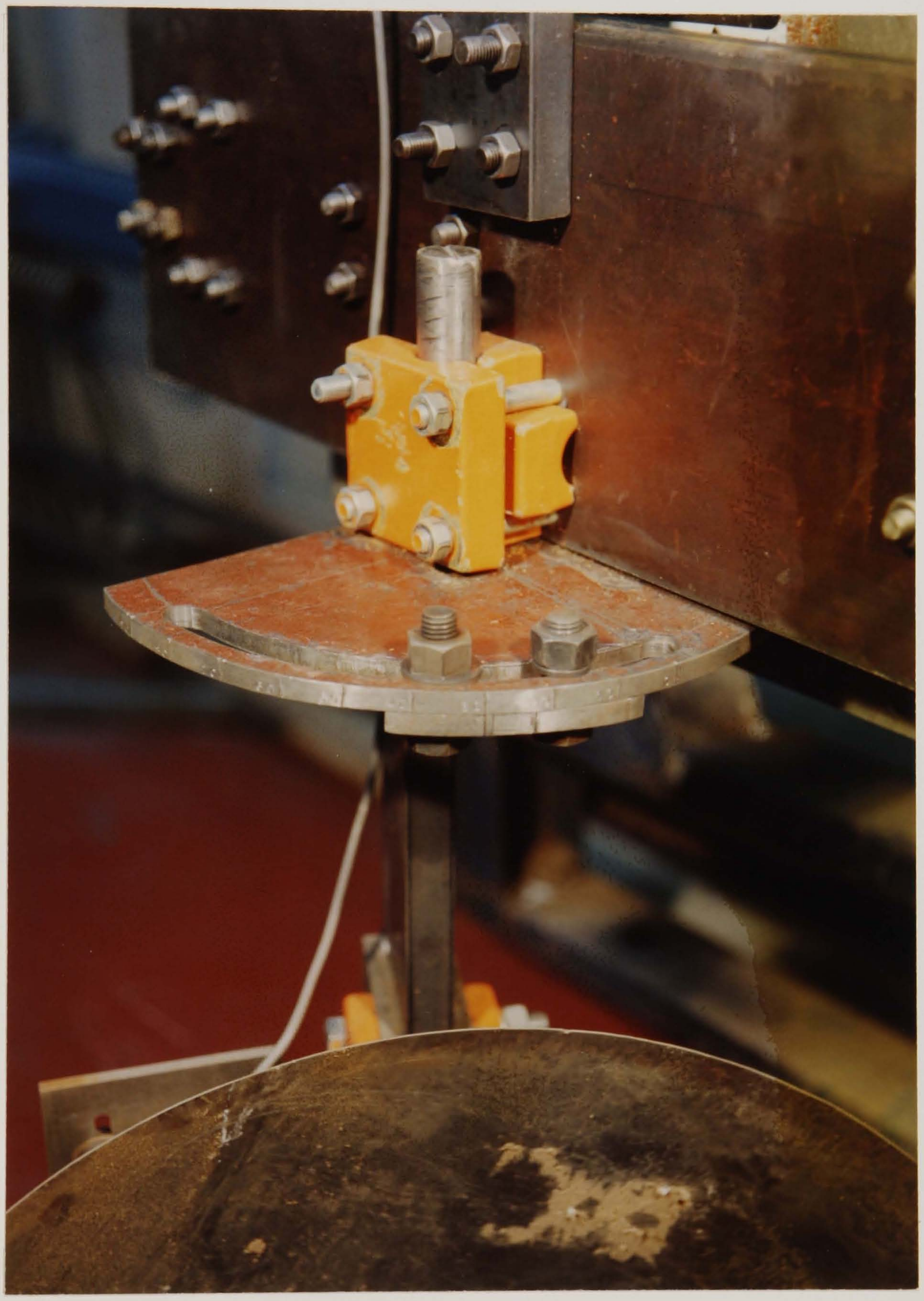


Fig. 6.6 Disc angle selector.

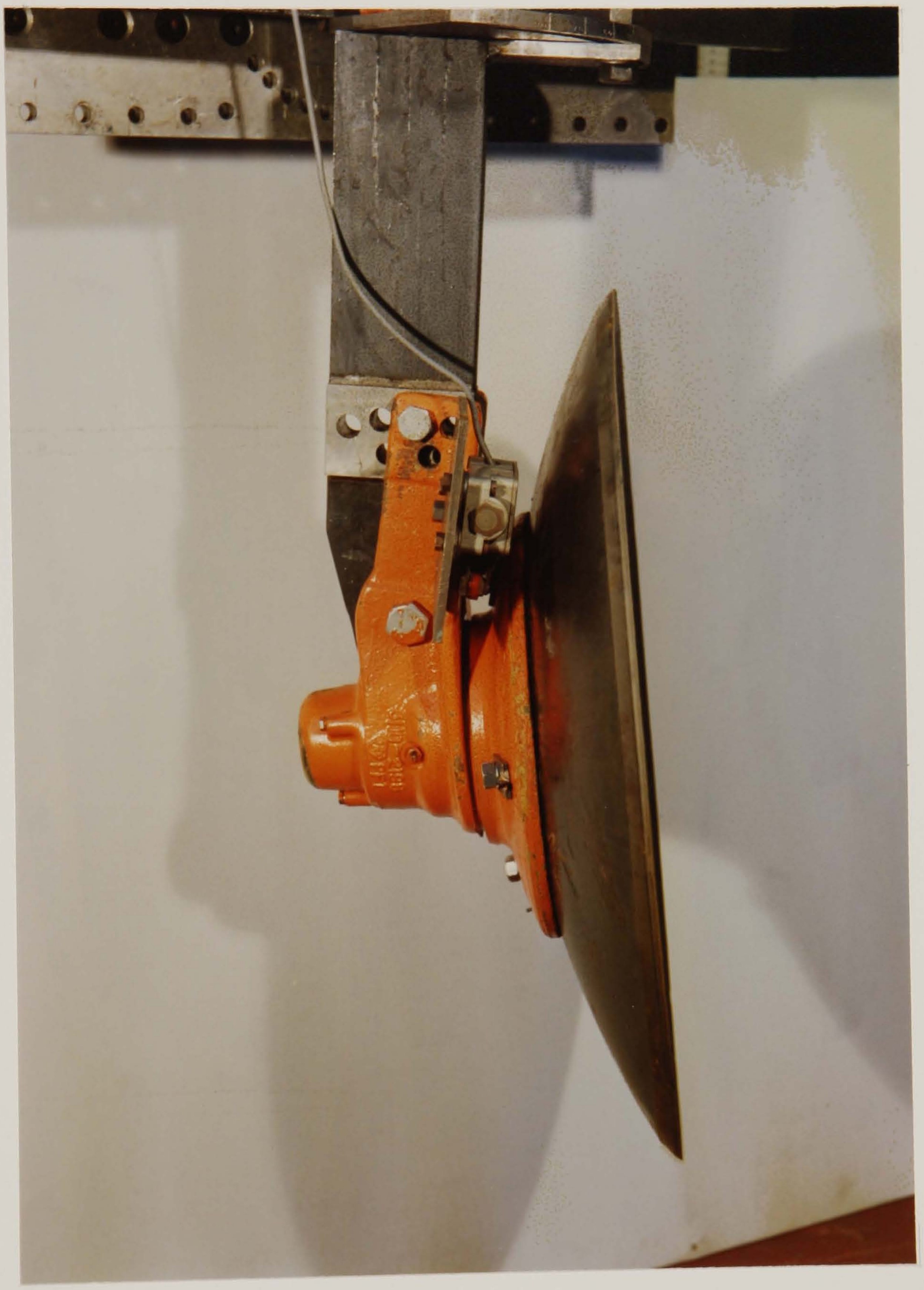


Fig.6.7 Disc inclination angle selector.

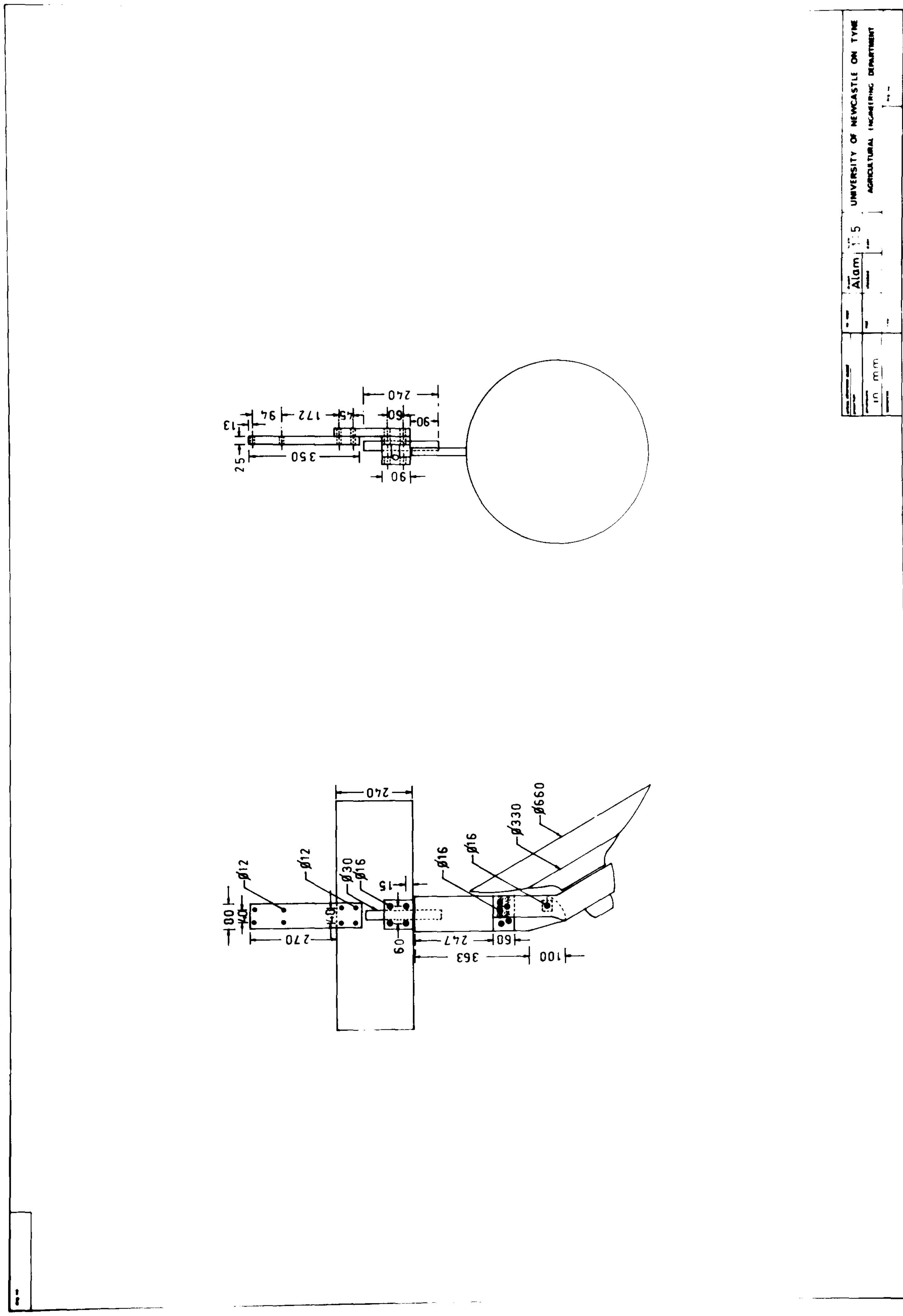


Fig. 6.8. Disc leg assembly.

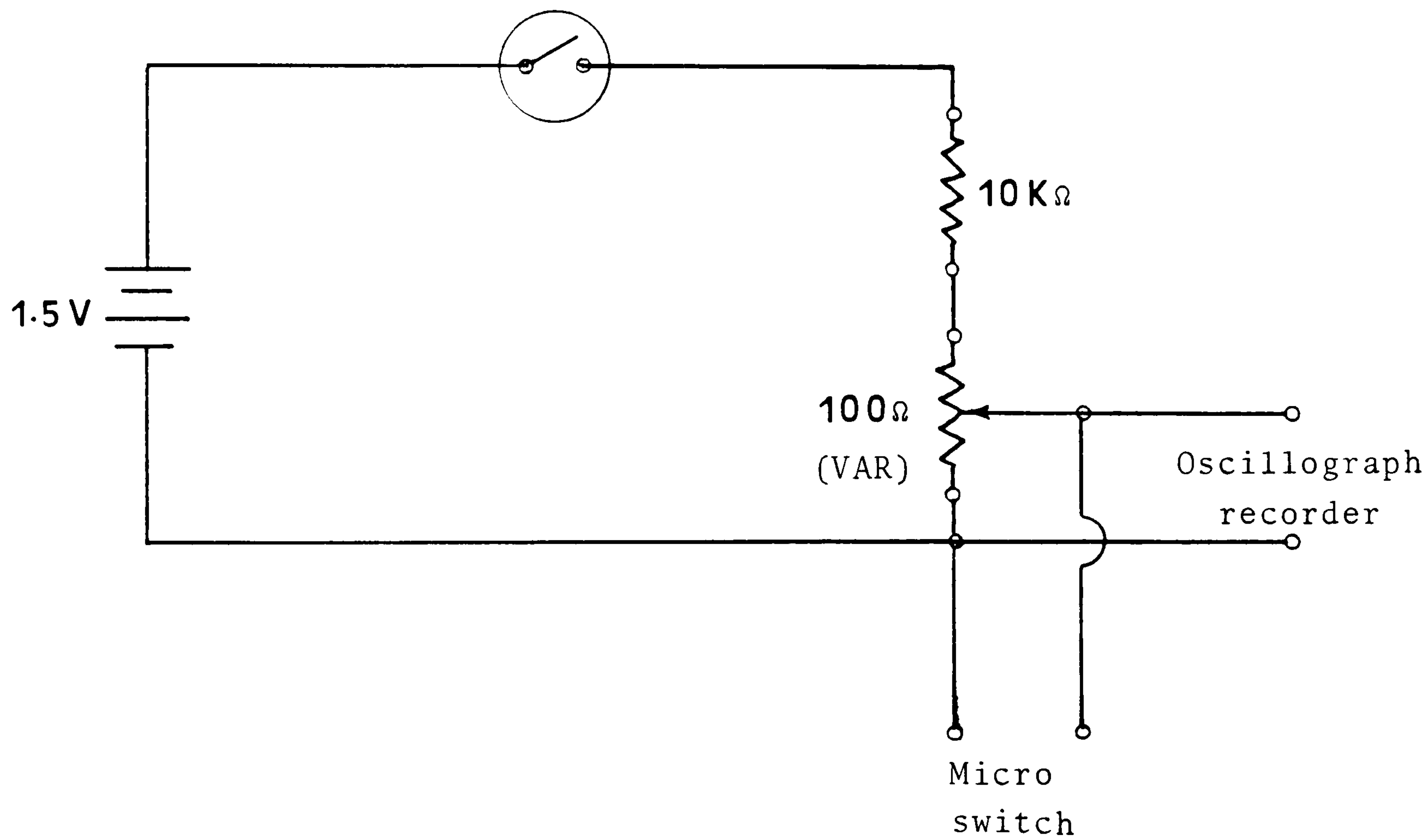


Fig. 6.9 Circuit diagram of the event marker regulator.

Fig. 6.10 Nature of the surcharge during disc is in operation.

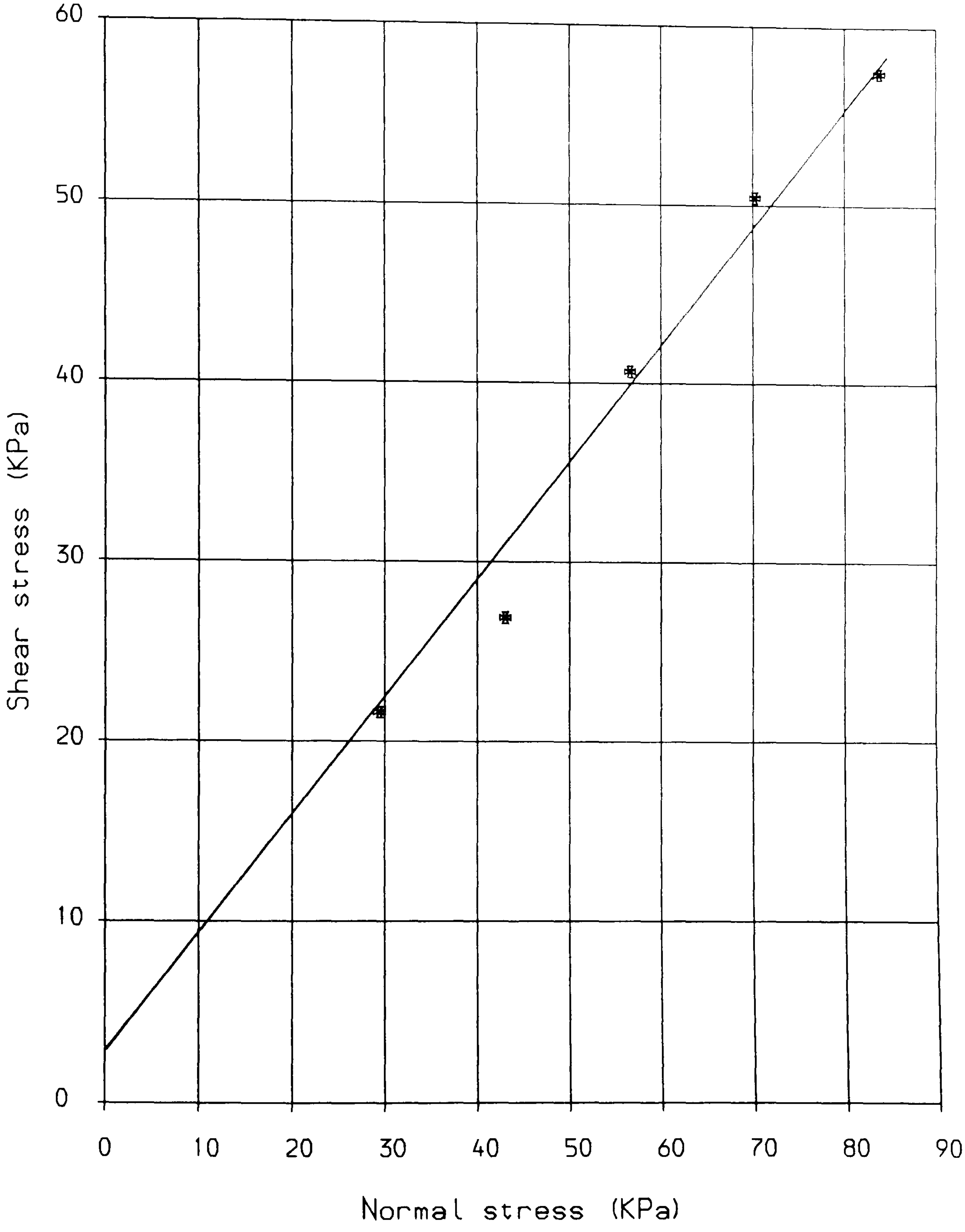


Fig. 6.11 Computation of Cohesion and Soil internal friction angle from Shear-Box test.

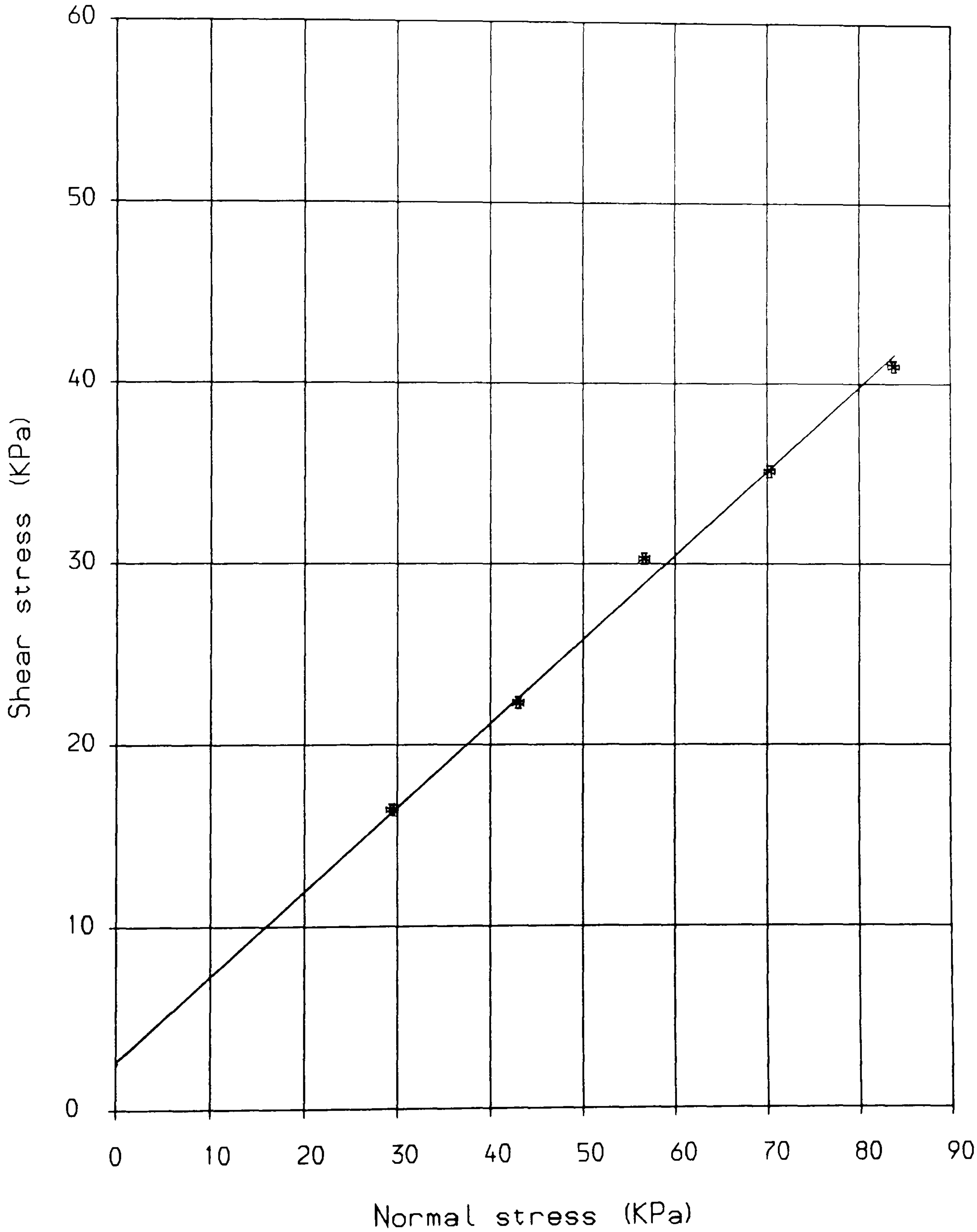


Fig. 6.12 Computation of Aohesion and Soil-Metal friction angle from Shear-Box test.

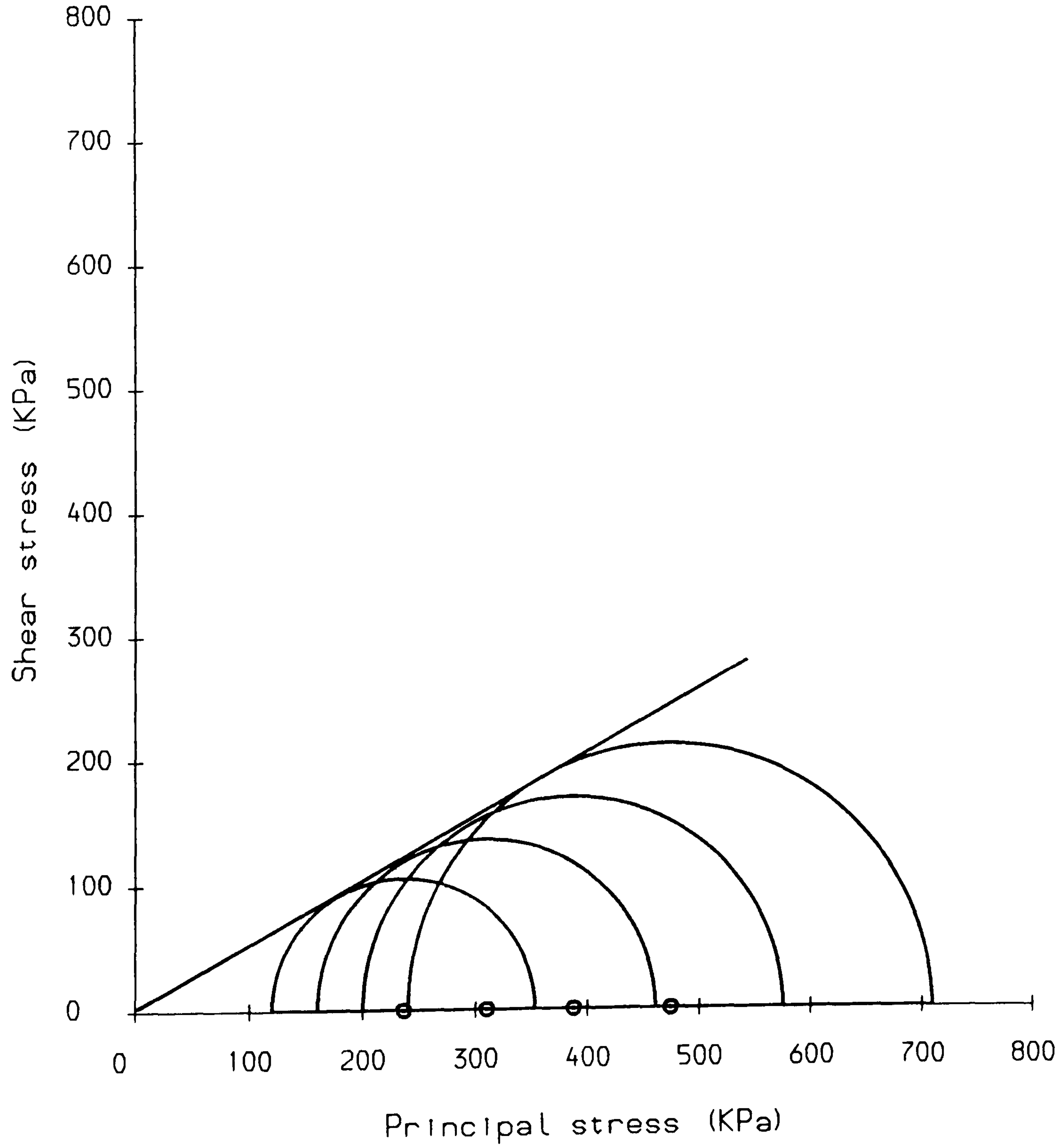


Fig. 6.13 Computation of Cohesion and Soil internal friction angle from Tri-axial test.

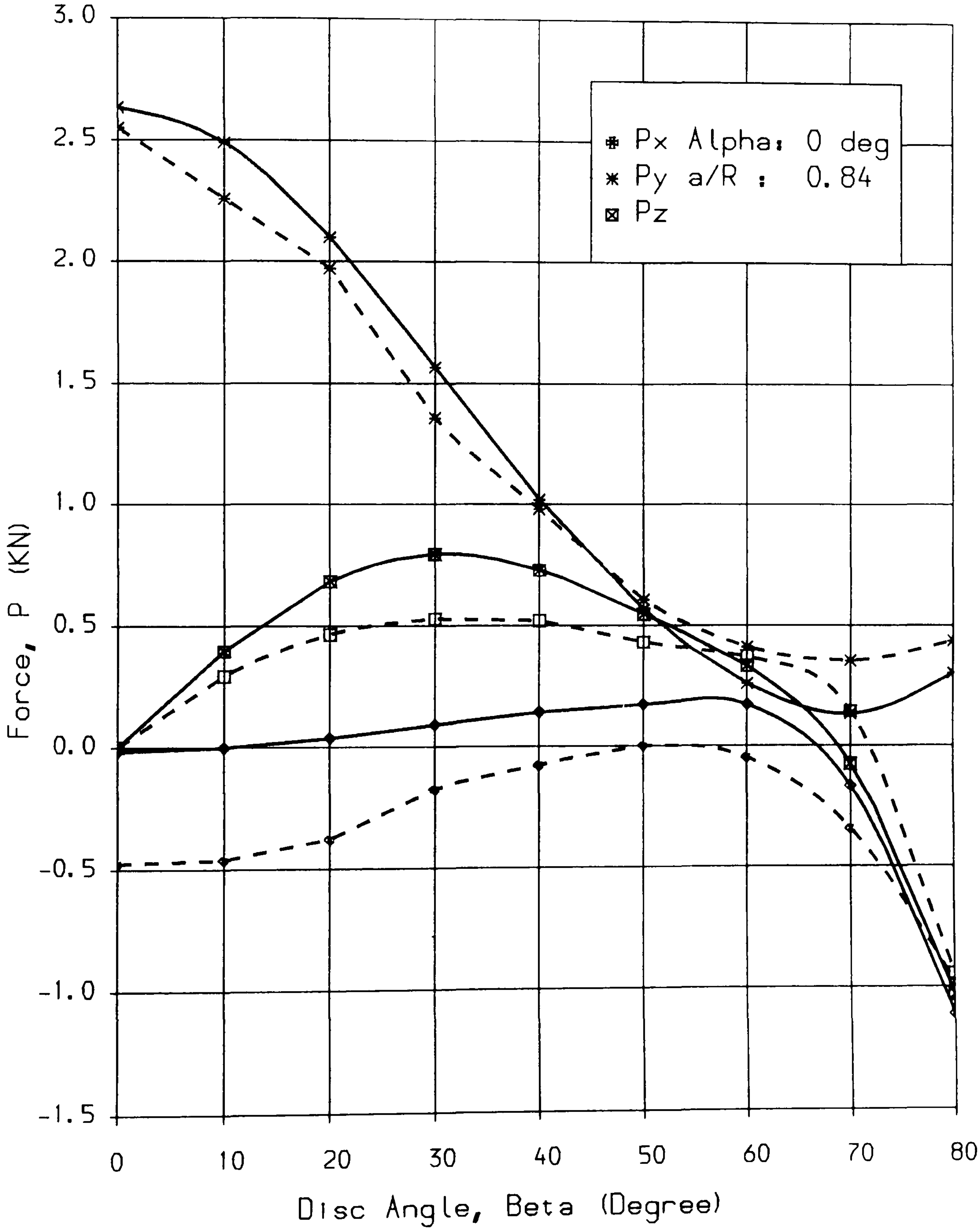


Fig. 6.14 Comparison between the predicted (solid line) and experimental (broken line) results.

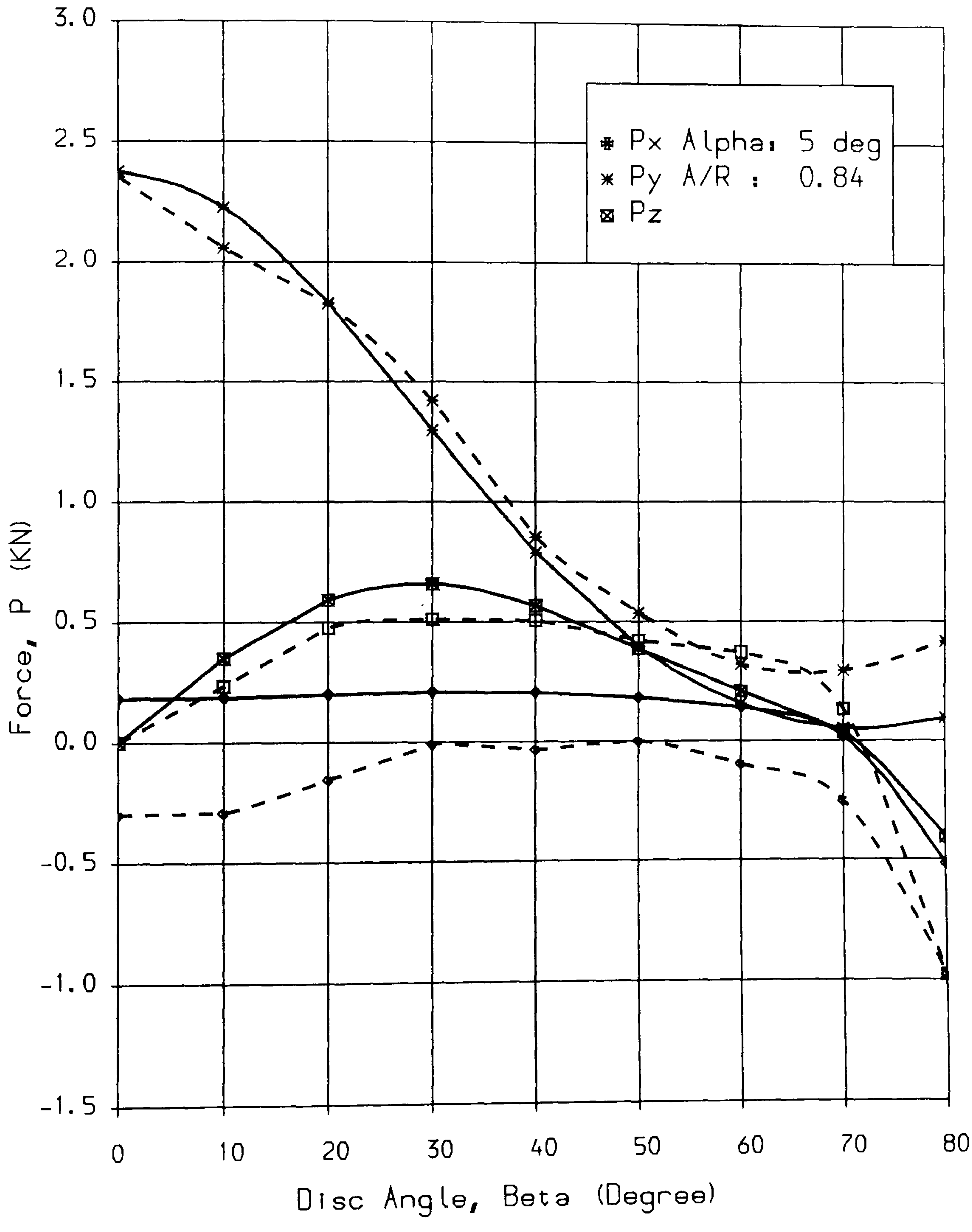


Fig. 6.15 Comparison between the predicted (solid line) and experimental (broken line) results.

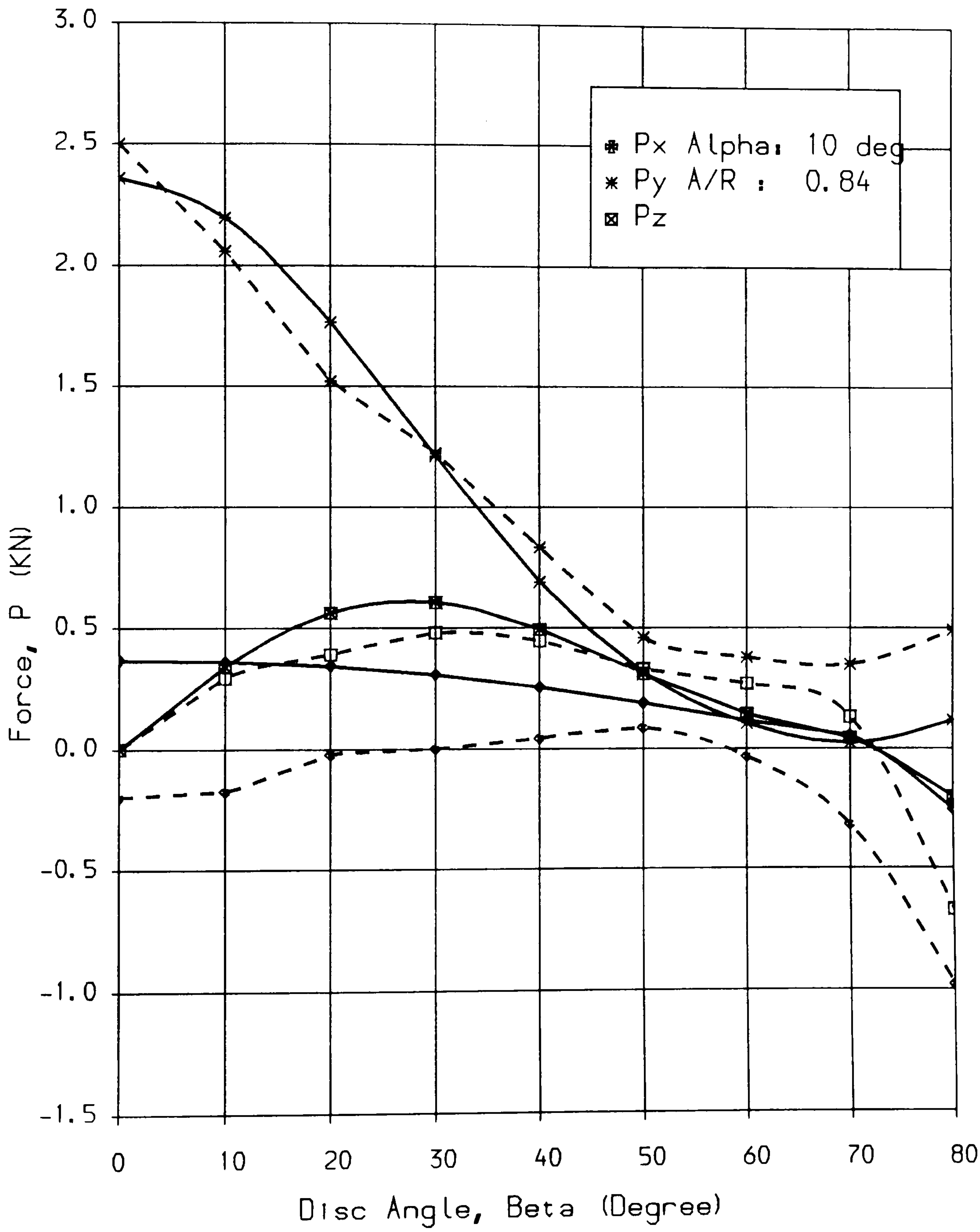


Fig. 6.16 Comparison between the predicted (solid line) and experimental (broken line) results.

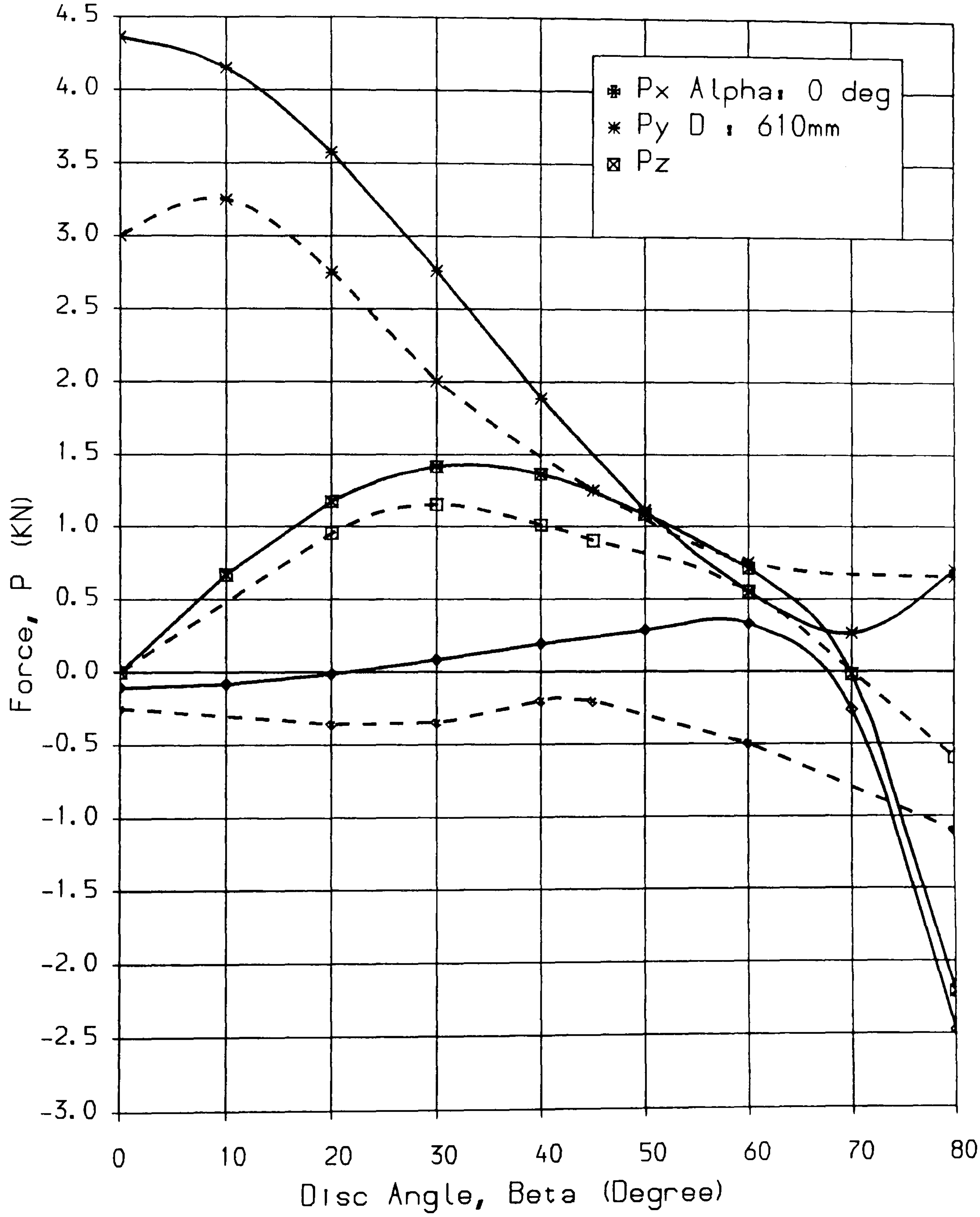


Fig. 6.17 Comparison between the predicted (solid line) and Godwins (1985) experimental (broken line) results.

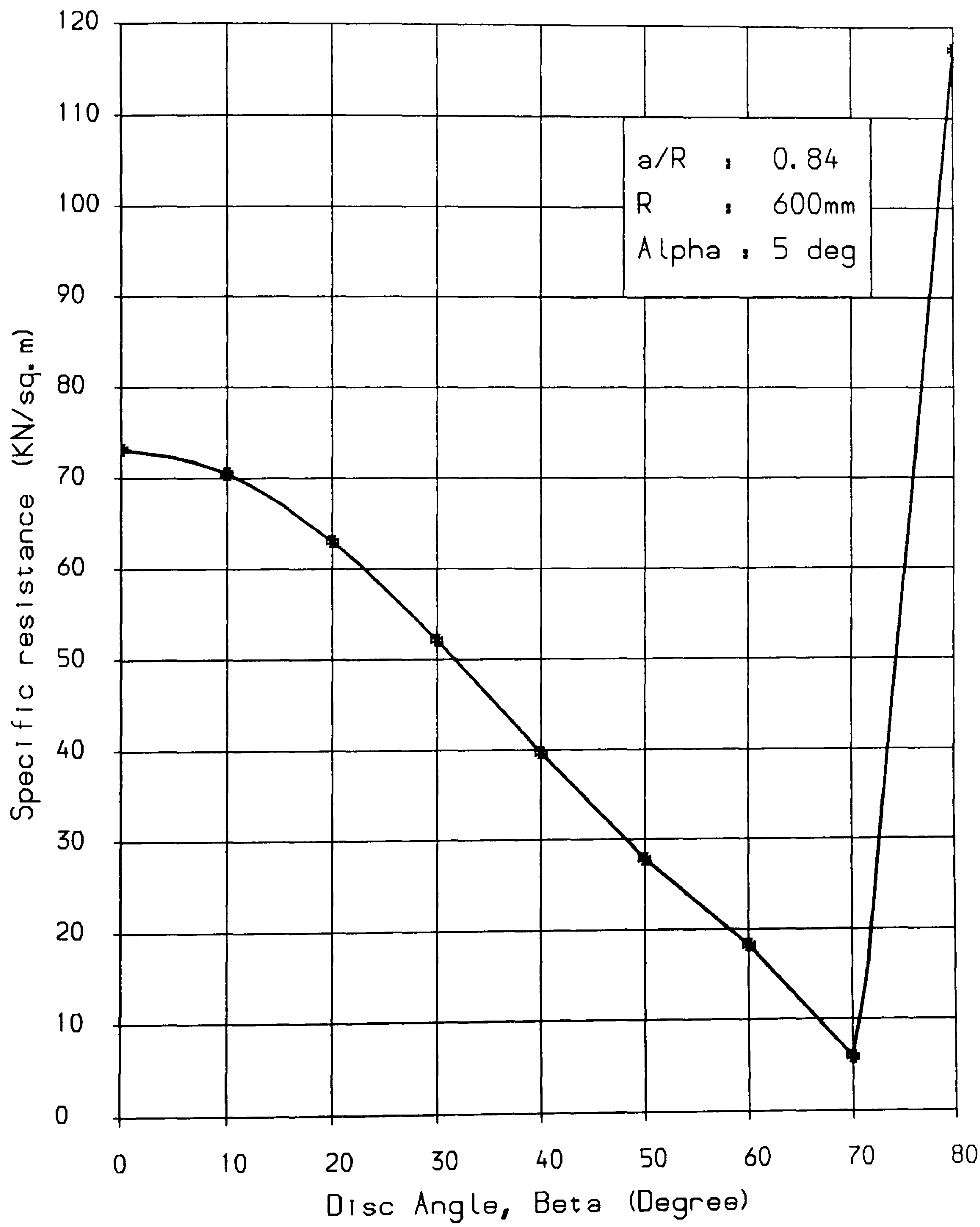


Fig. 6.18 Variation in Specific resistance with Disc angle

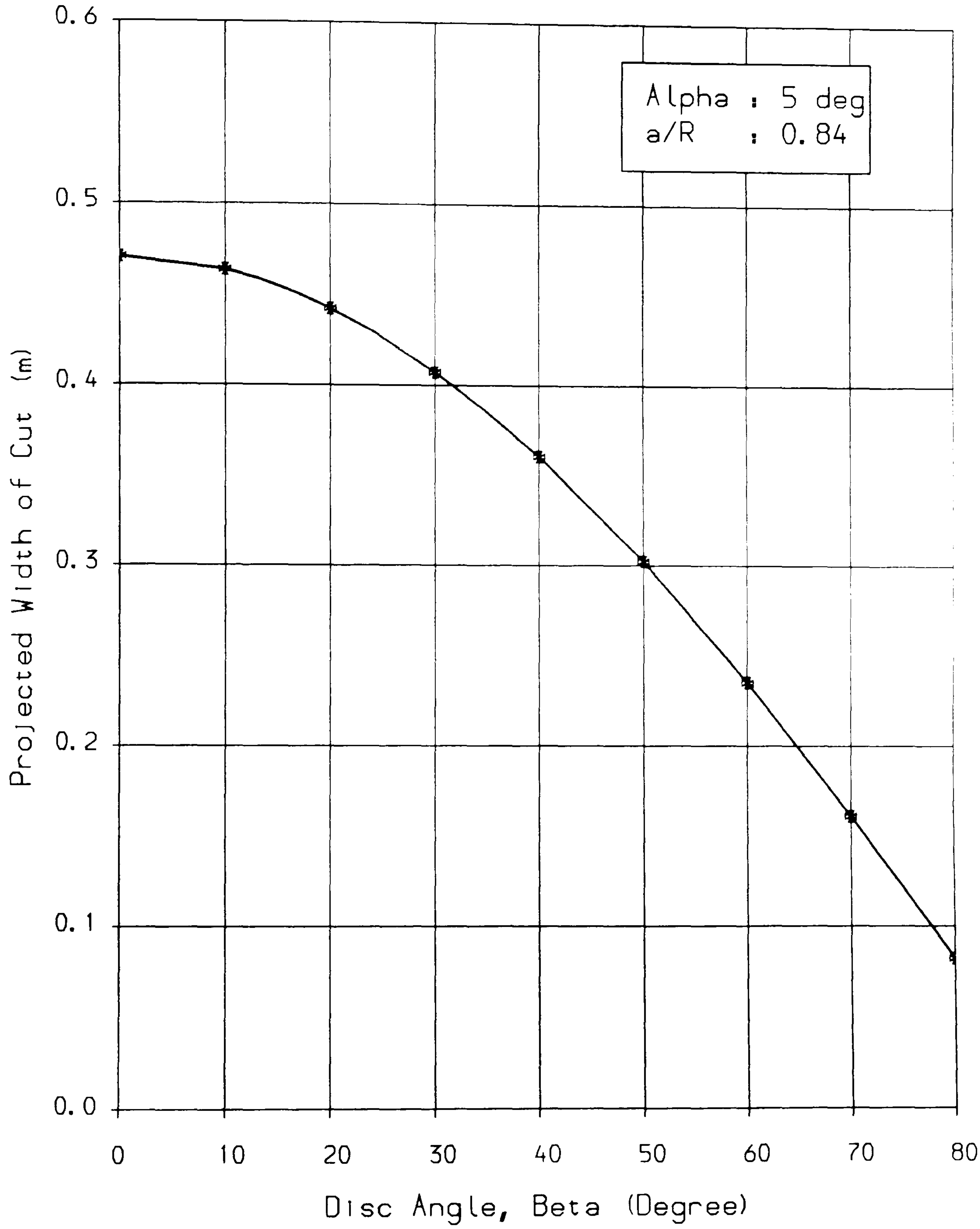


Fig. 6.19 Variation in Projected Width of cut with Disc angle

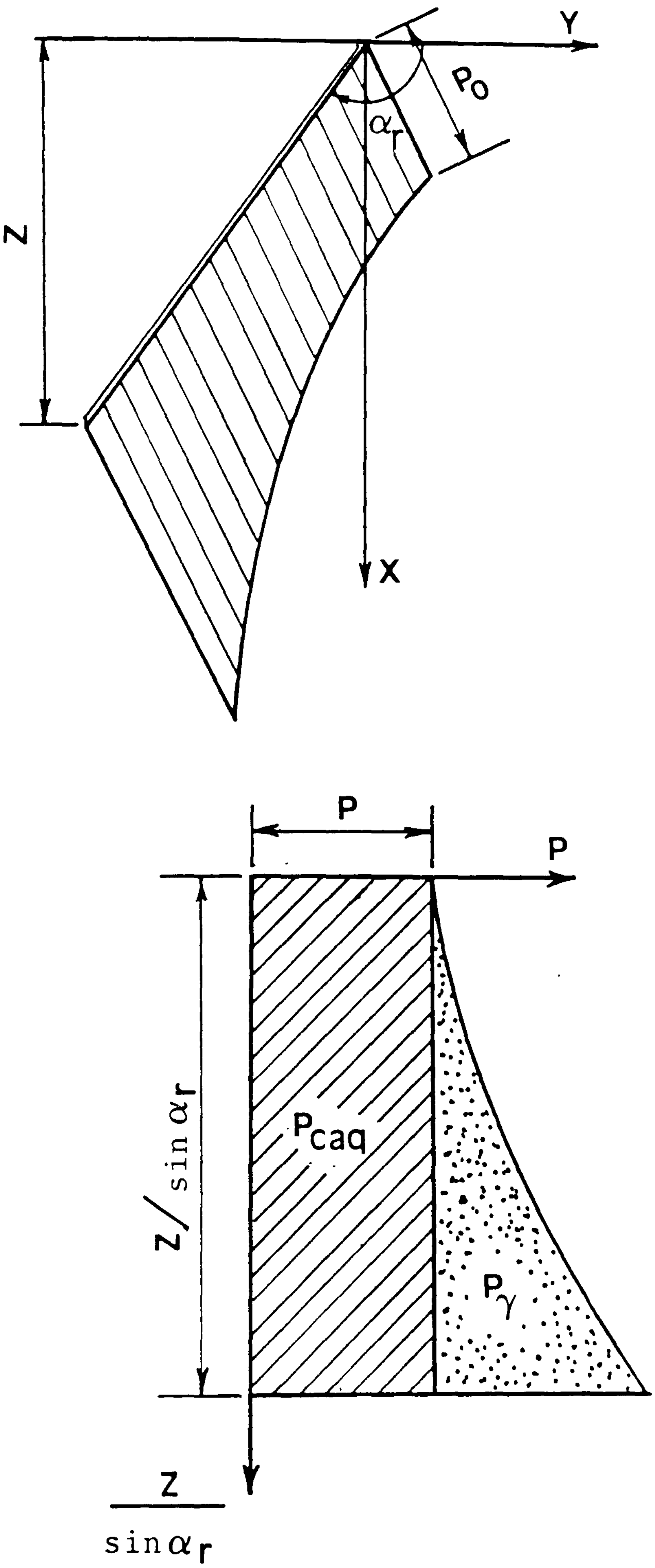


Fig. 7.1 Force component at interface.

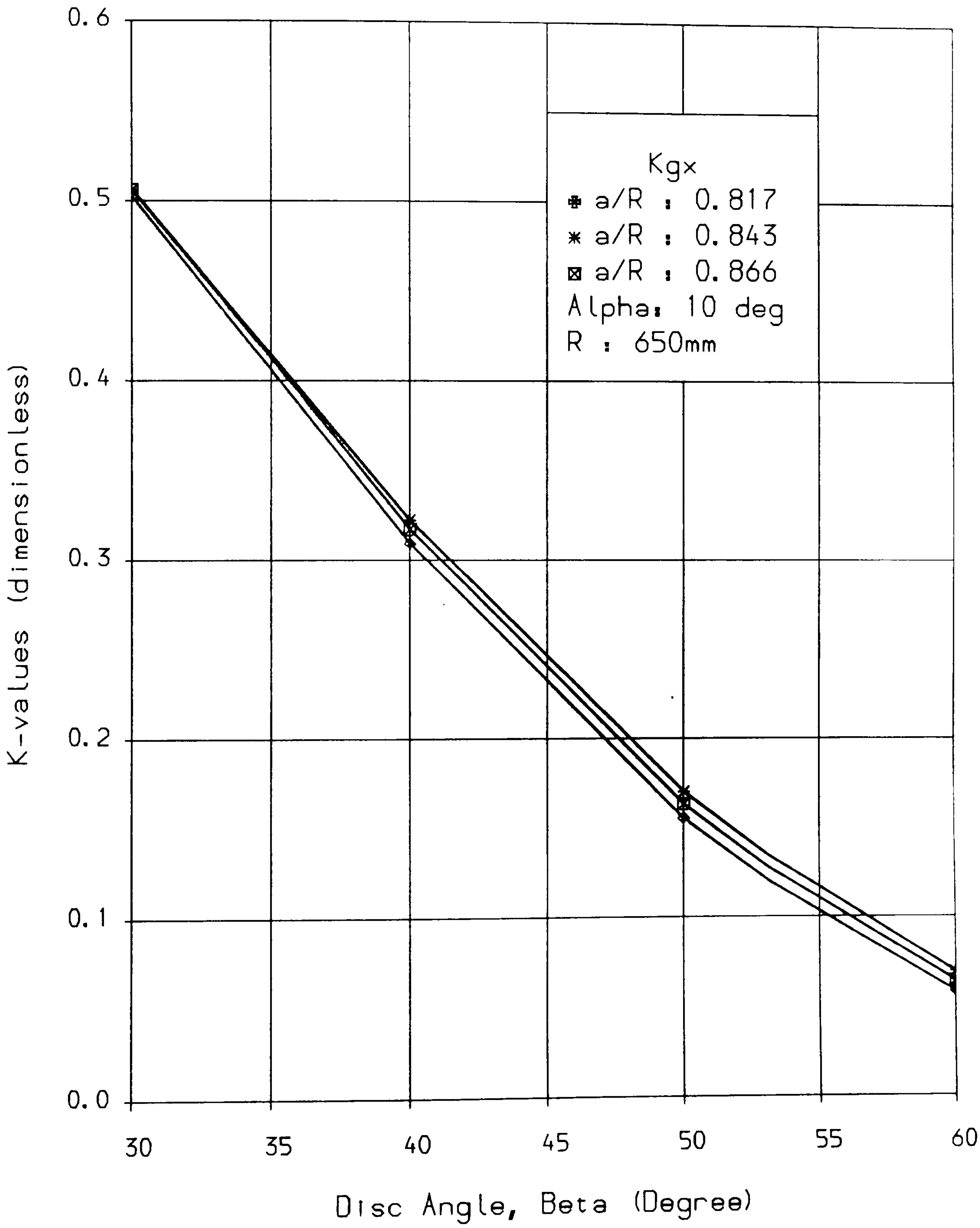


Fig. 7.2 Comparison between K-values for different a/R.

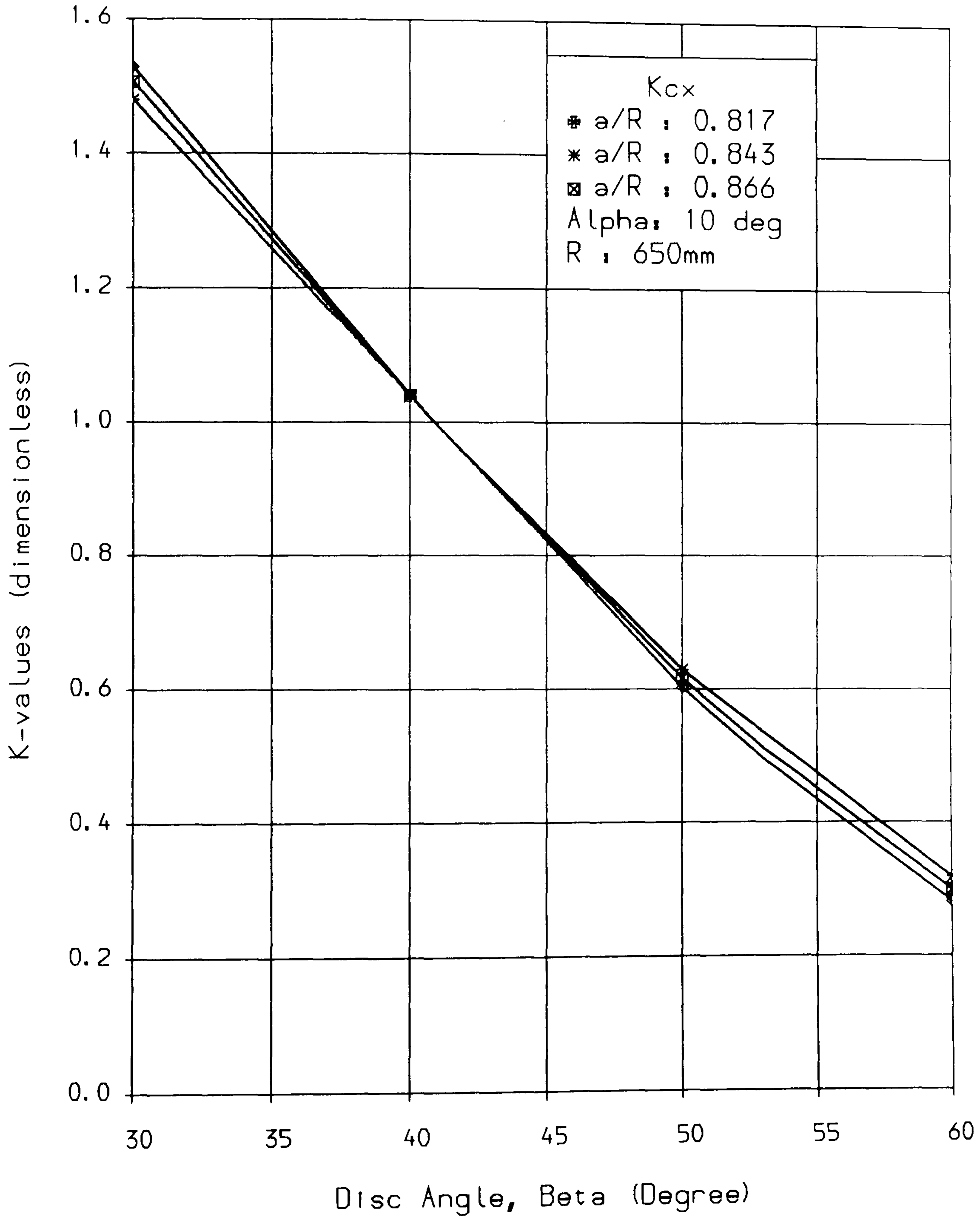


Fig. 7.3 Comparison between K-values for different a/R.

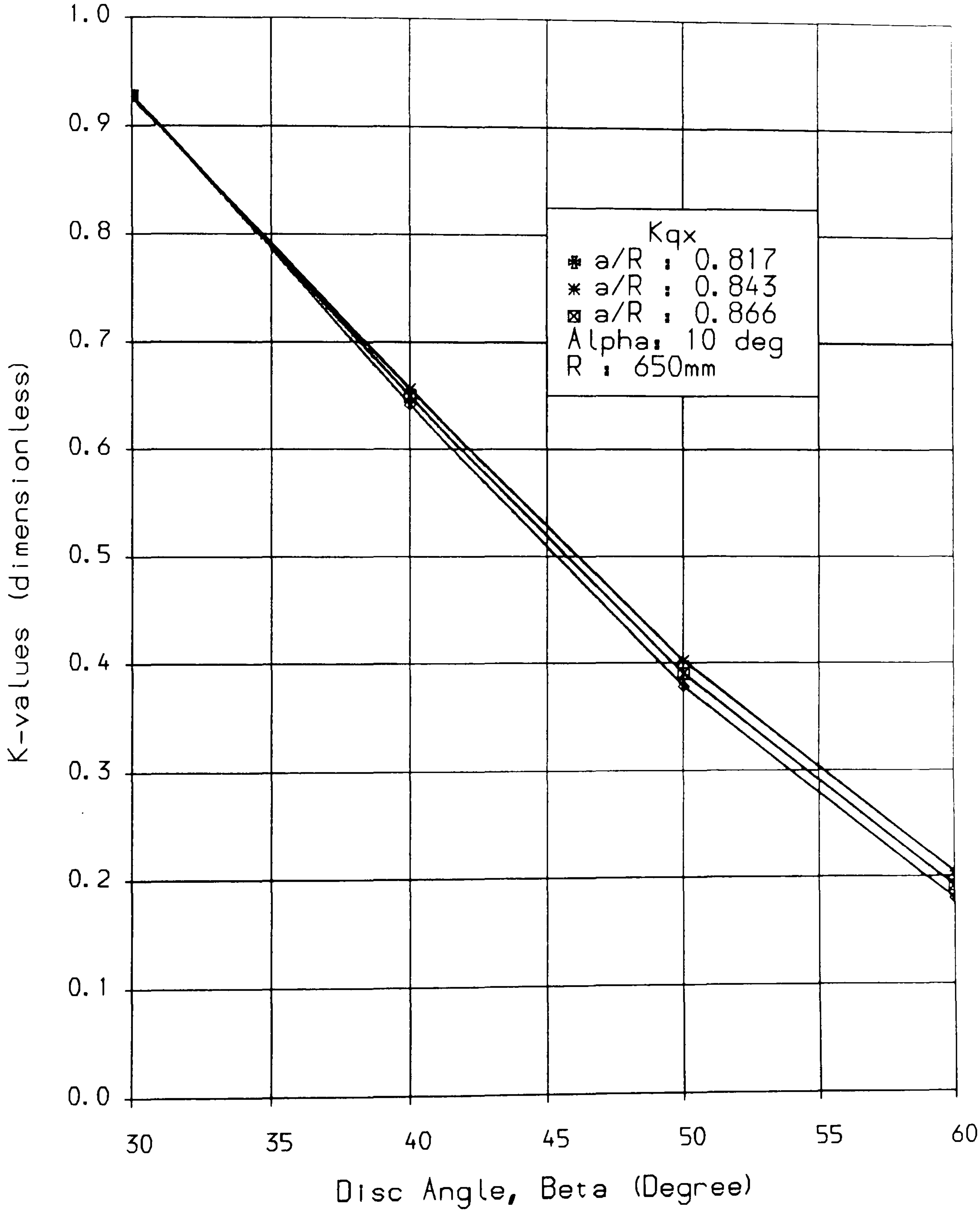


Fig. 7.4 Comparison between K-values for different a/R.

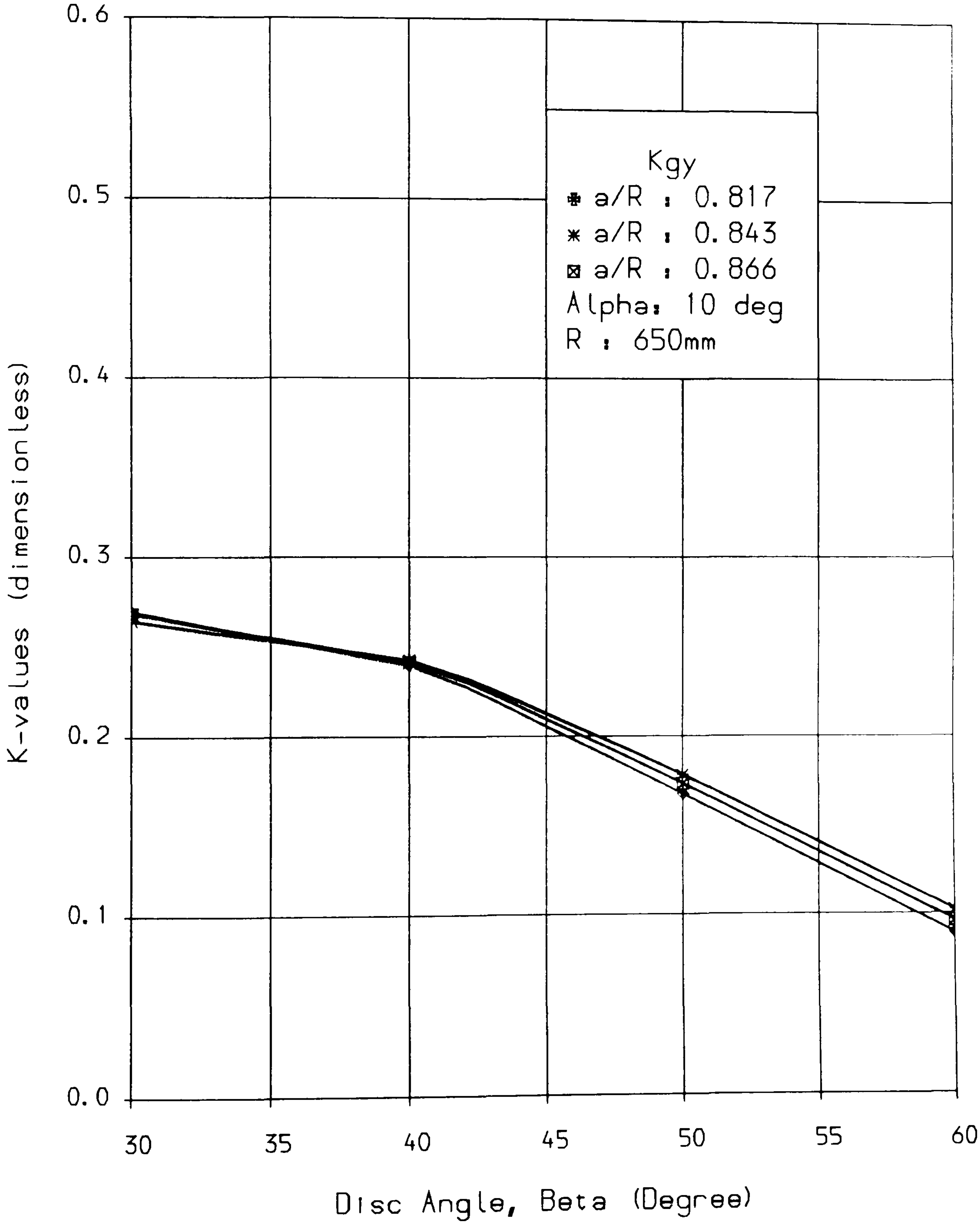


Fig. 7.5 Comparison between K-values for different a/R.

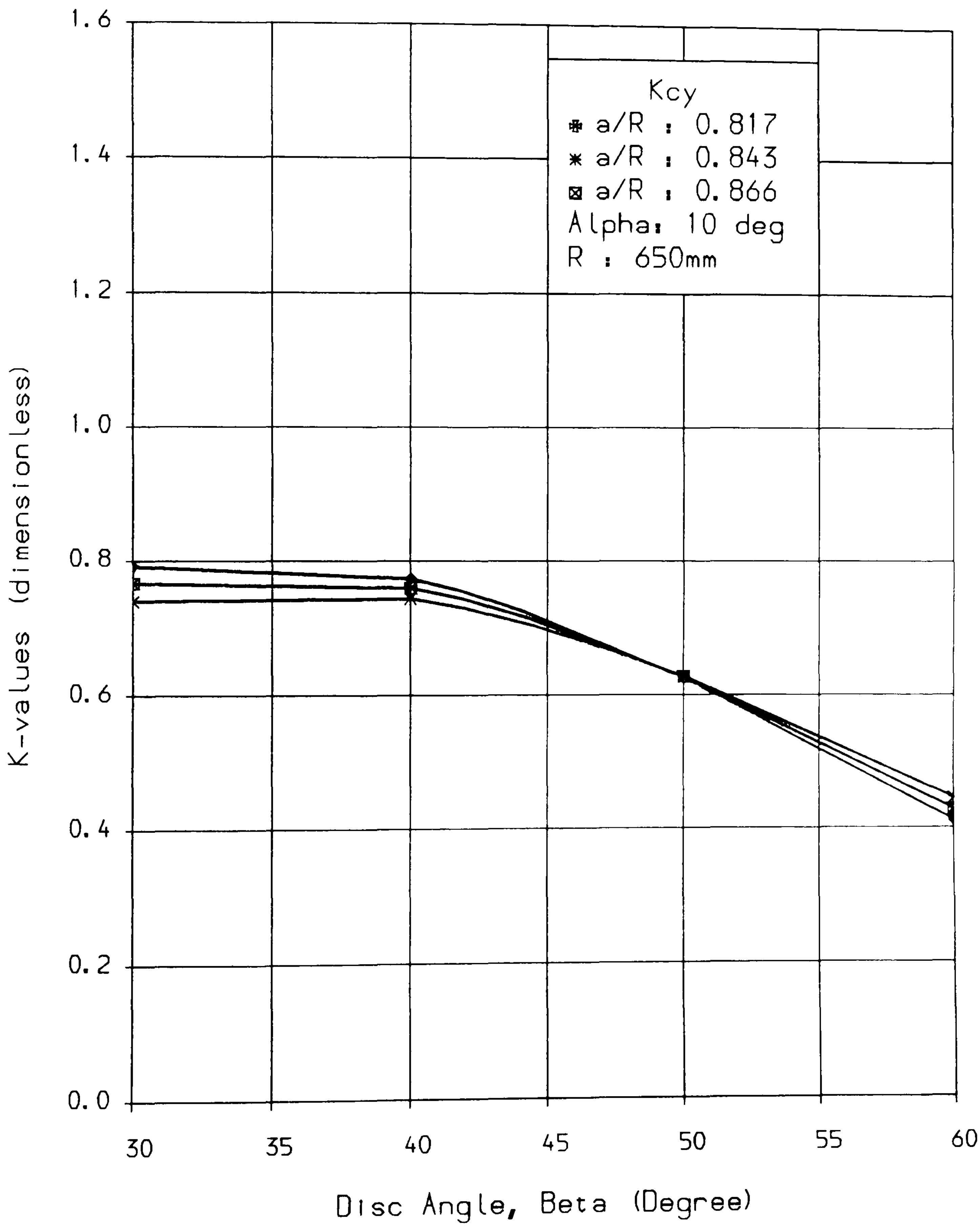


Fig. 7.6 Comparison between K-values for different a/R.

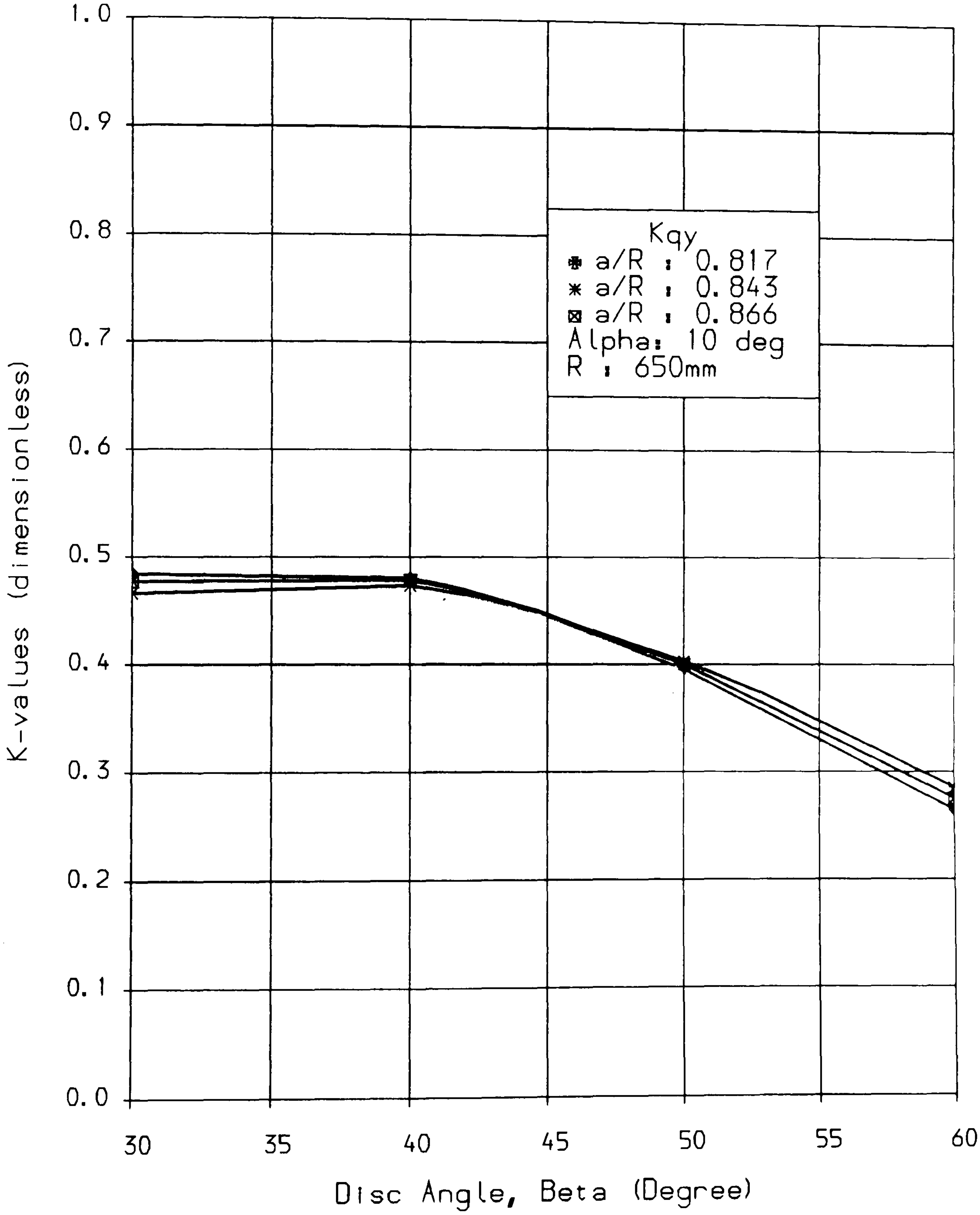


Fig. 7.7 Comparison between K-values for different a/R.

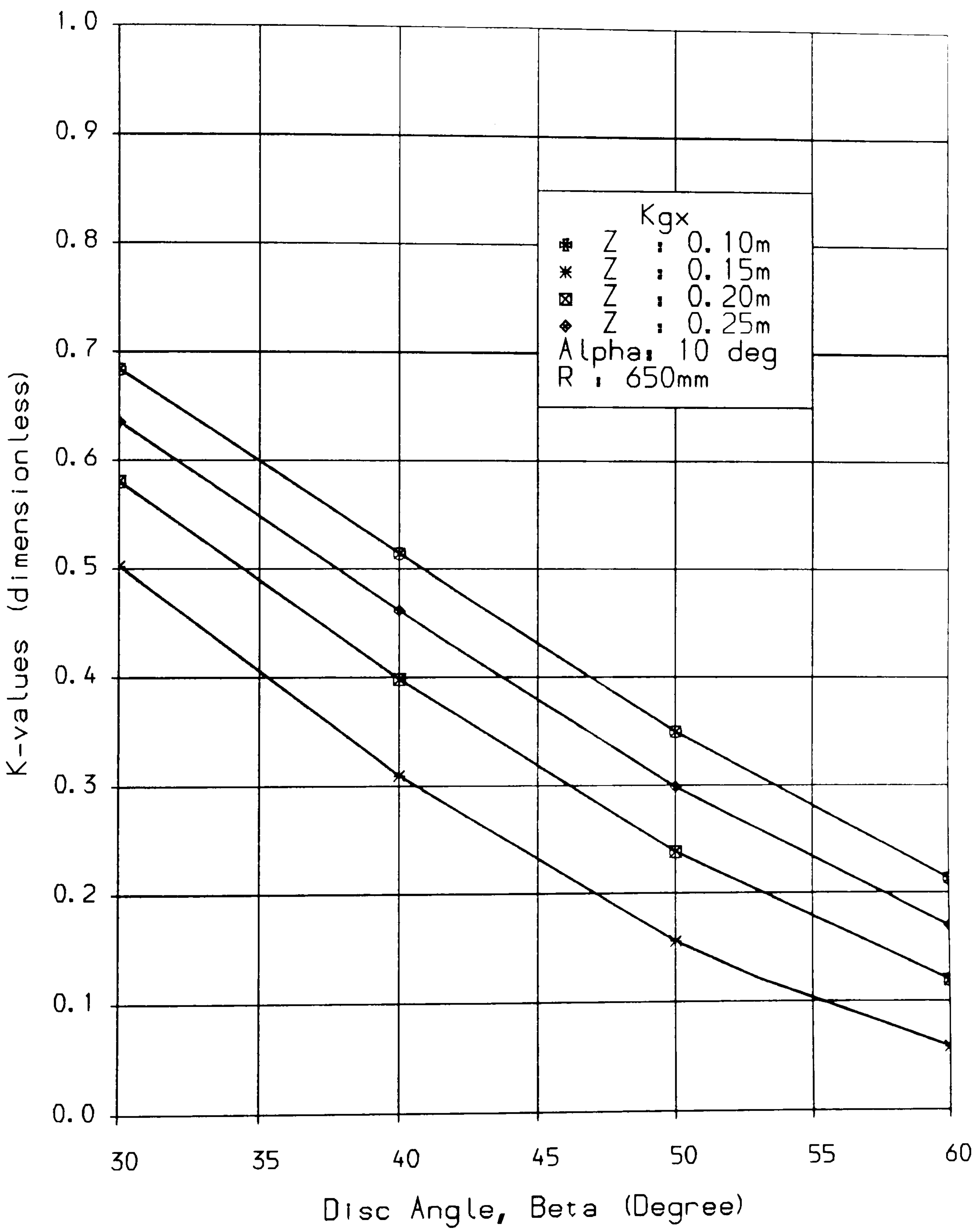


Fig. 7.8 Comparison between K-values for different Depth of Cut.

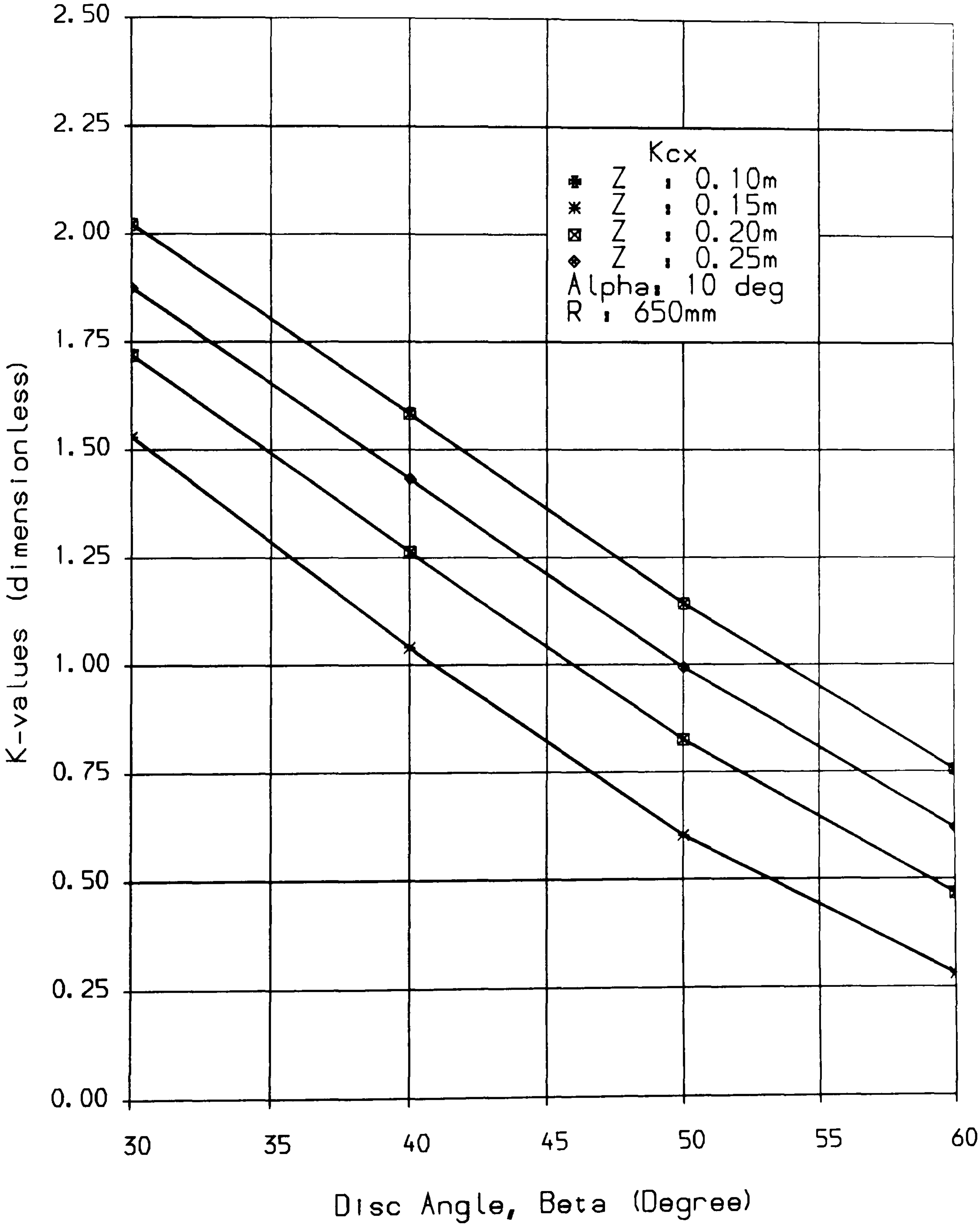


Fig. 7.9 Comparison between K-values for different Depth of Cut.

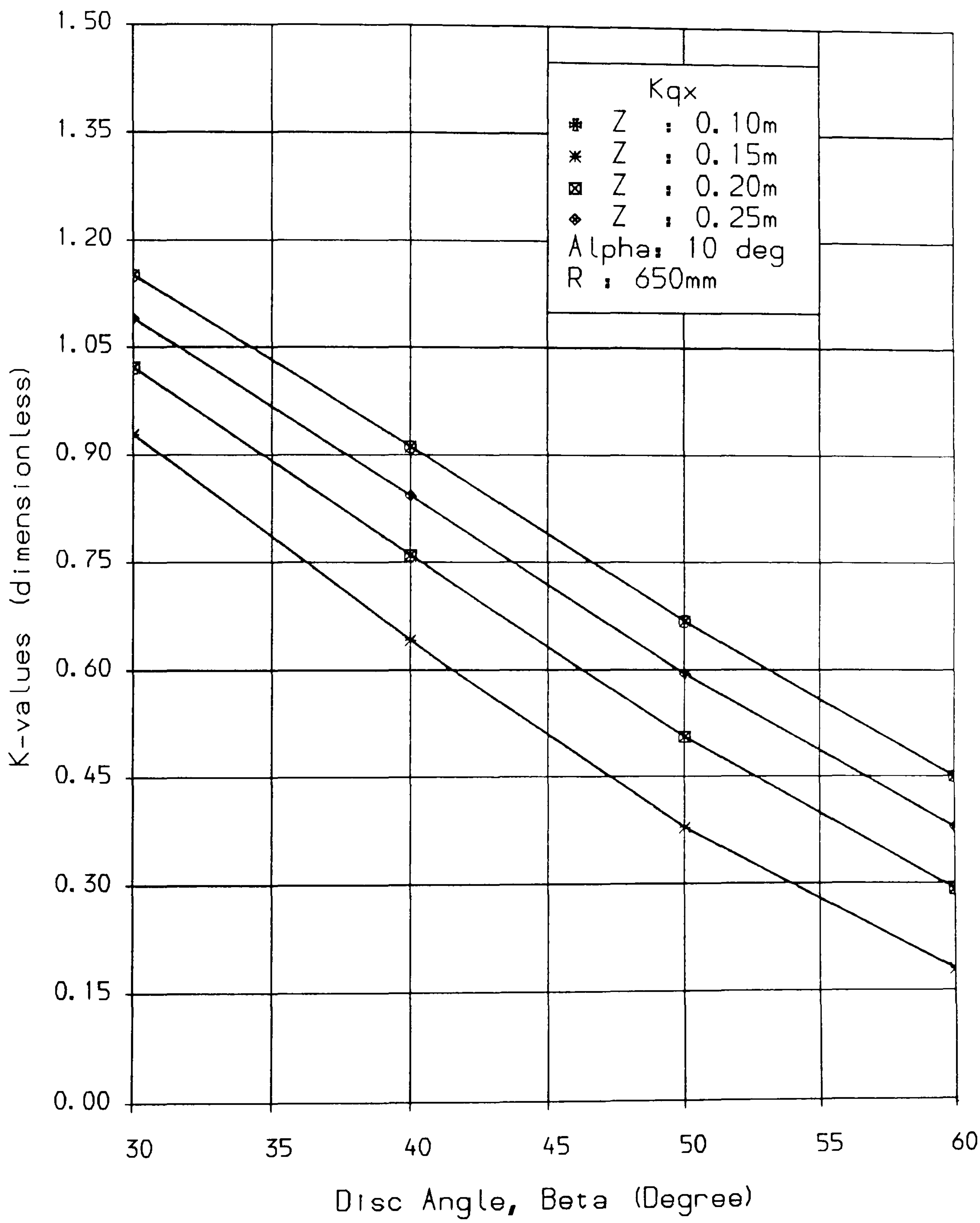


Fig. 7.10 Comparison between K-values for different Depth of Cut.

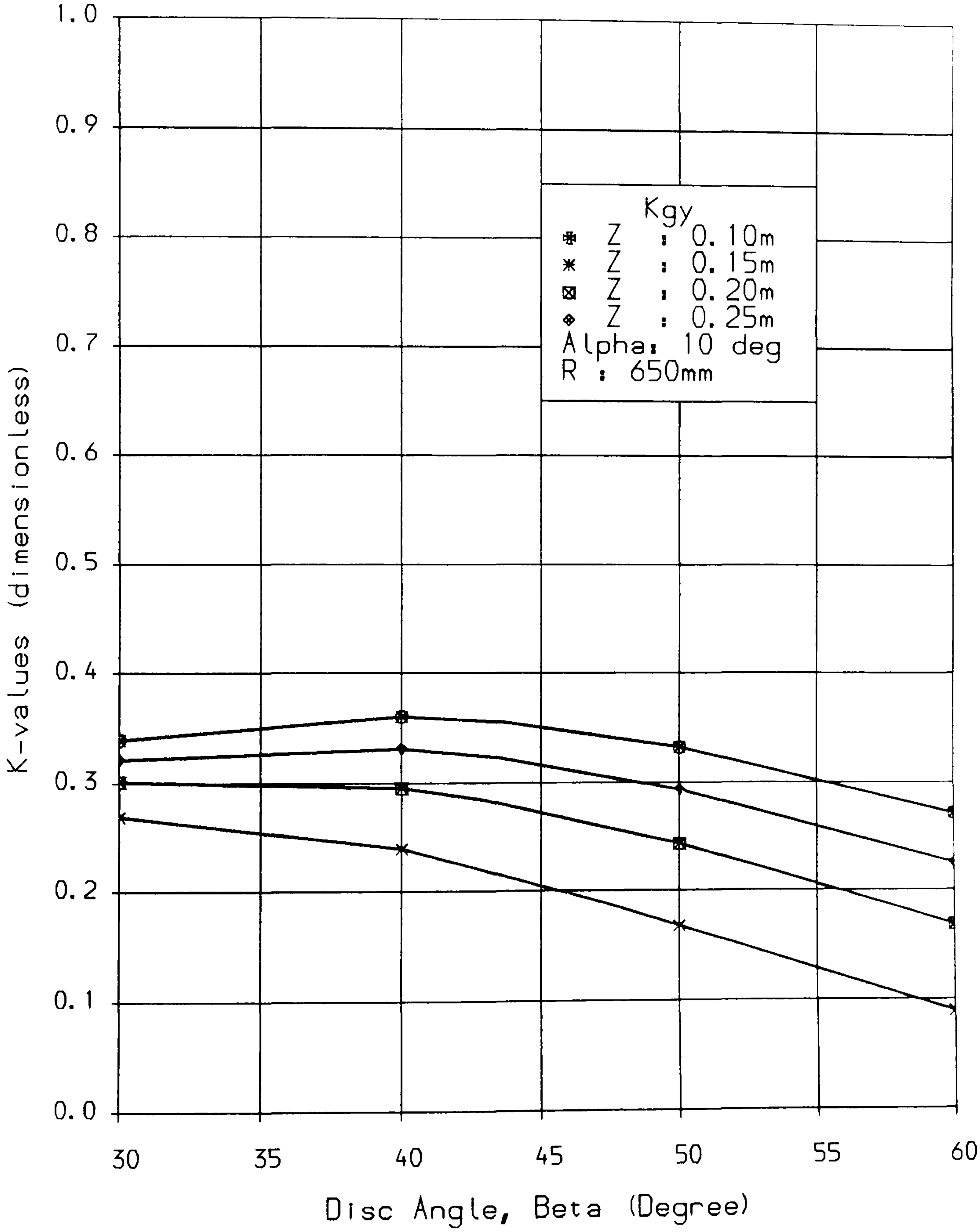


Fig. 7.11 Comparison between K-values for different Depth of Cut.

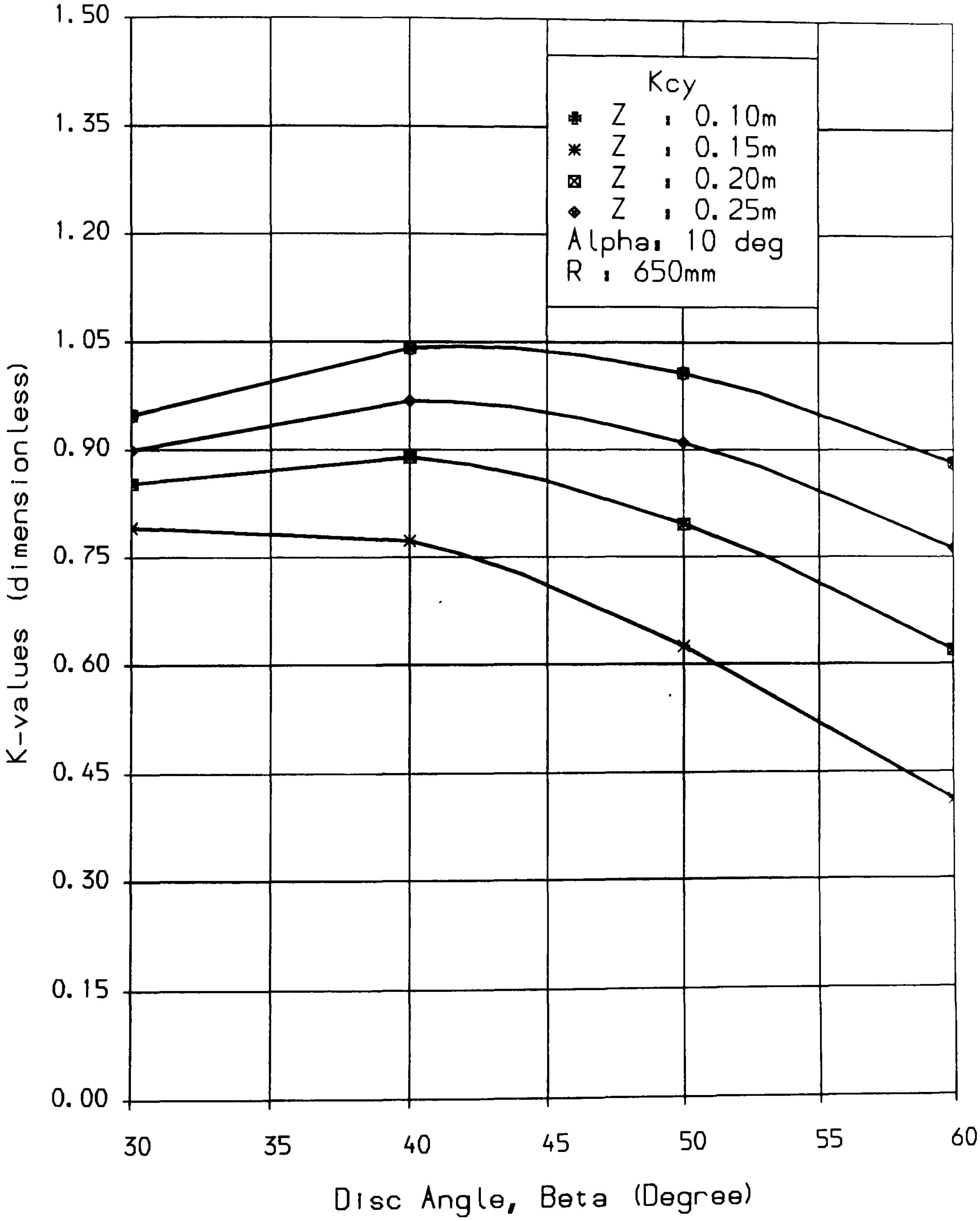


Fig. 7.12 Comparison between K-values for different Depth of Cut.

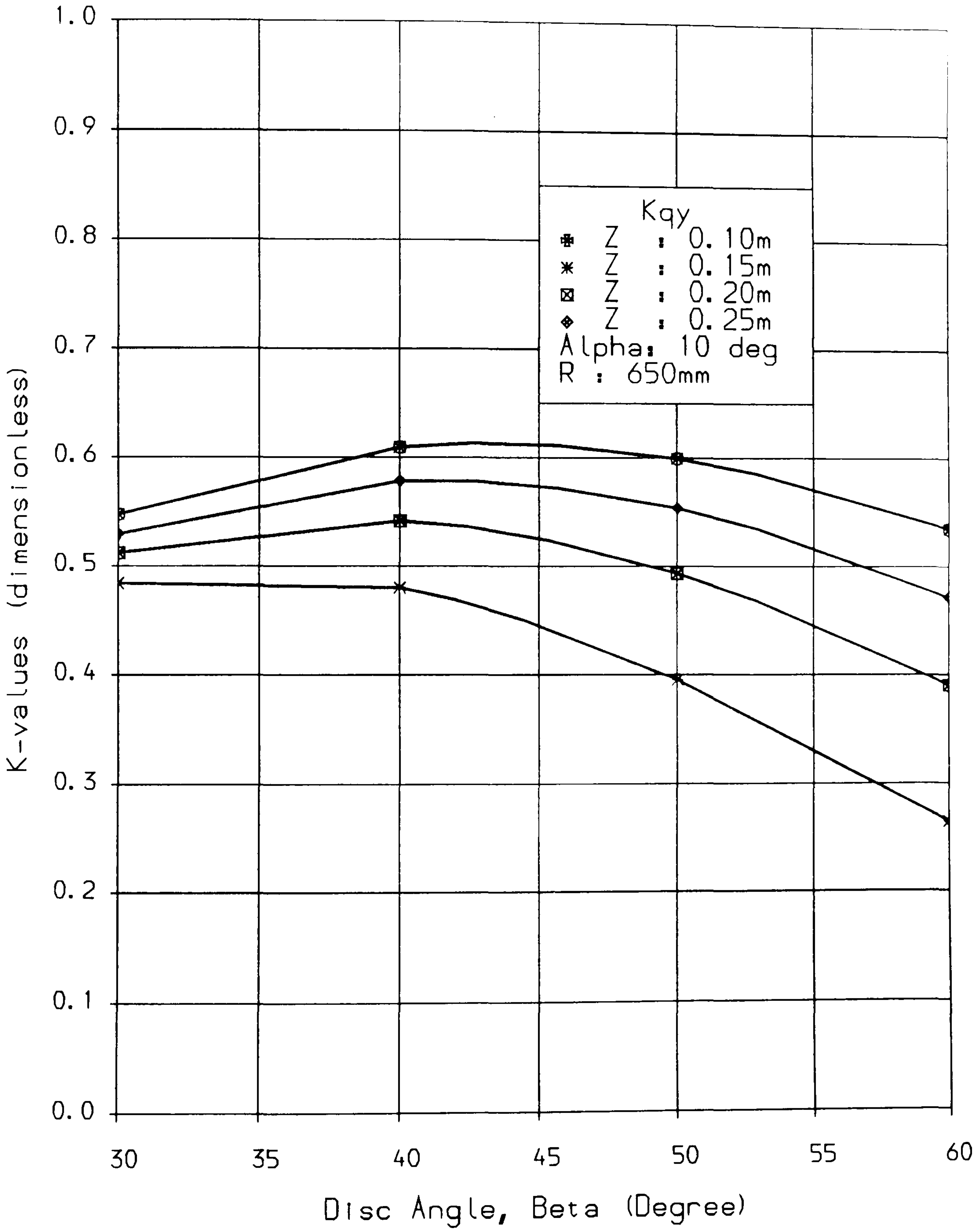


Fig. 7.13 Comparison between K-values for different Depth of Cut.

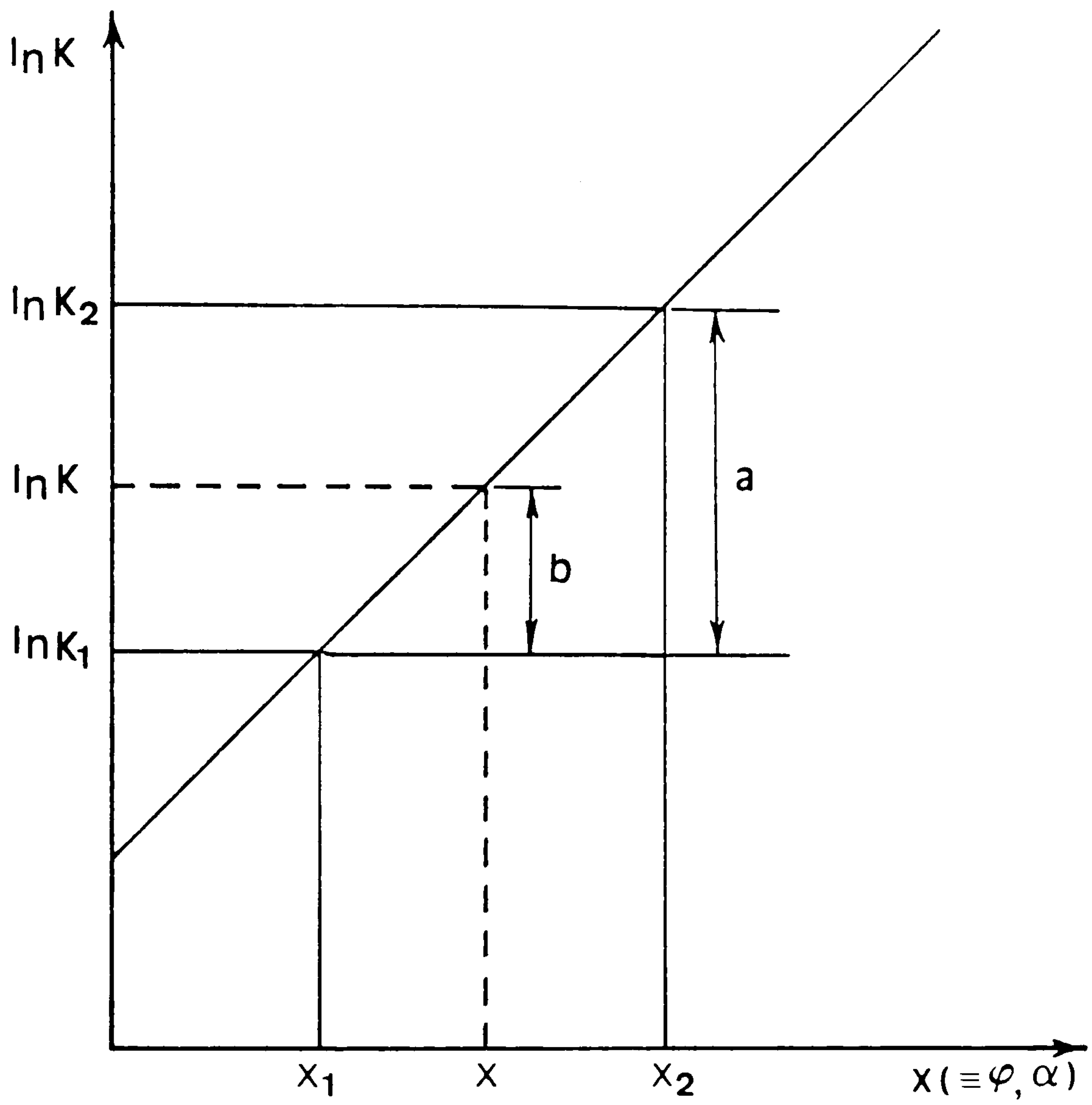


Fig. 7.14 Logarithmic interpolation.

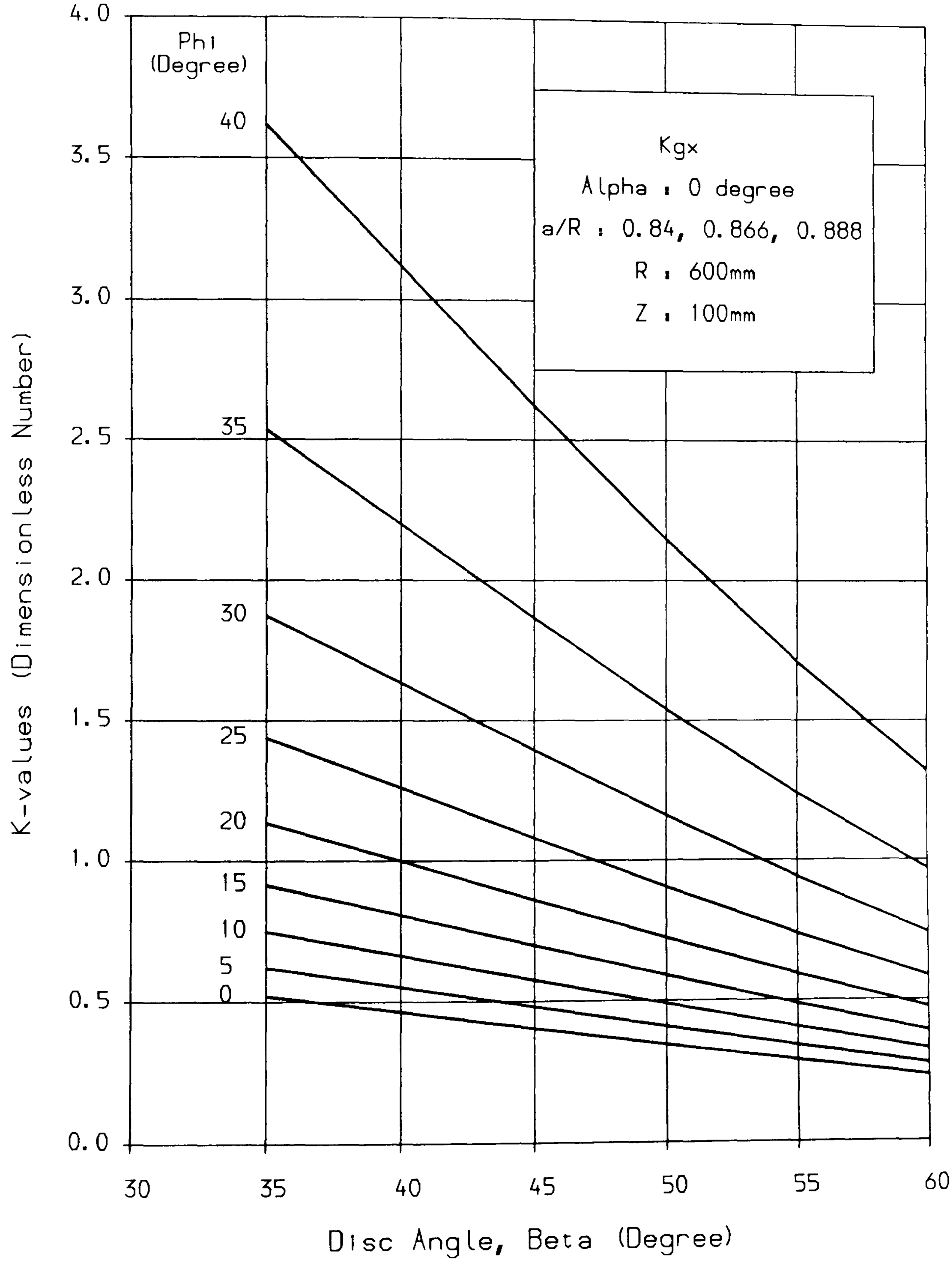


Chart 1. K-factor for Longitudinal-Gravitation Force

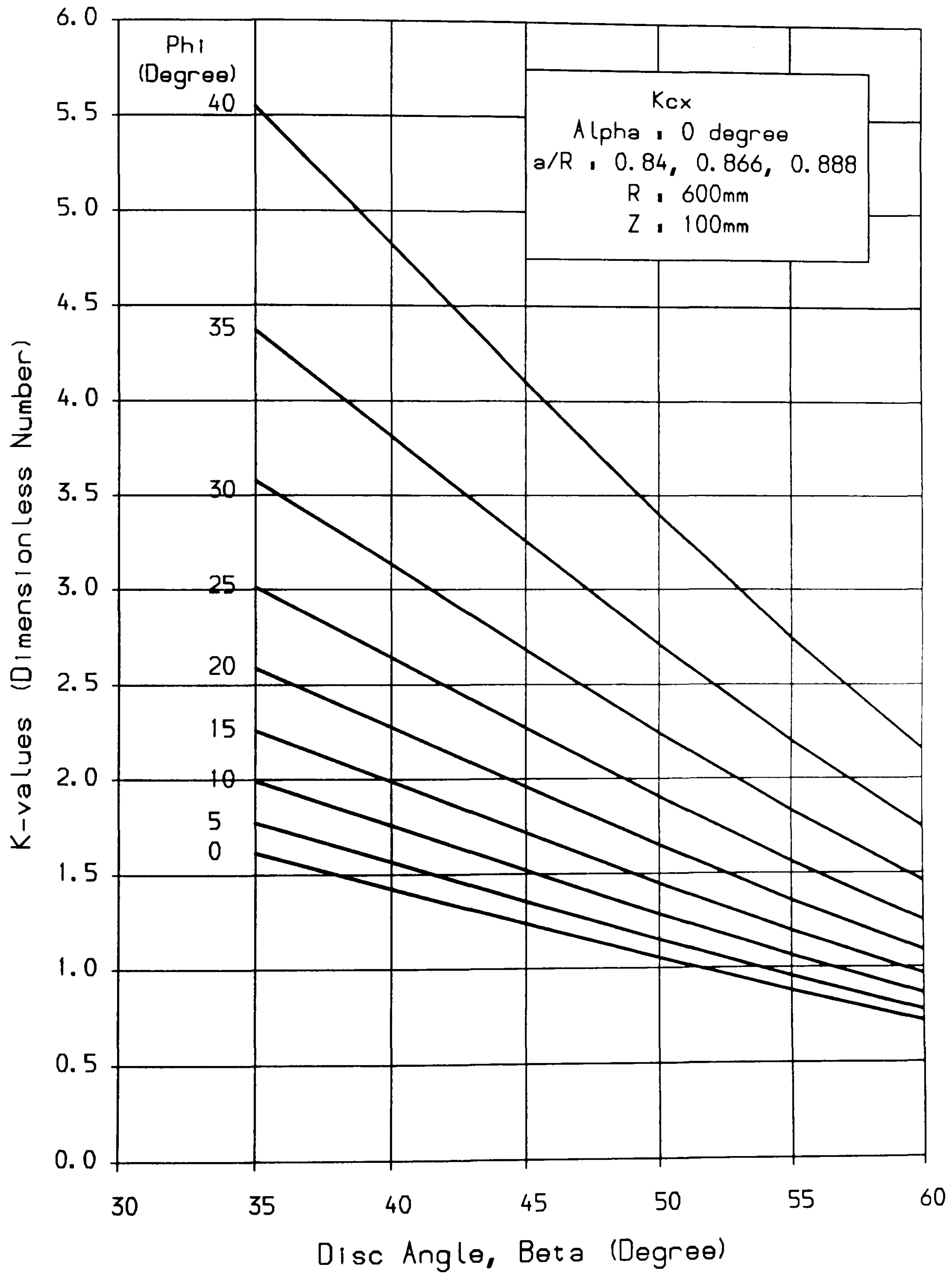


Chart 2. K-factor for Longitudinal Cohesive-Adhesive Force

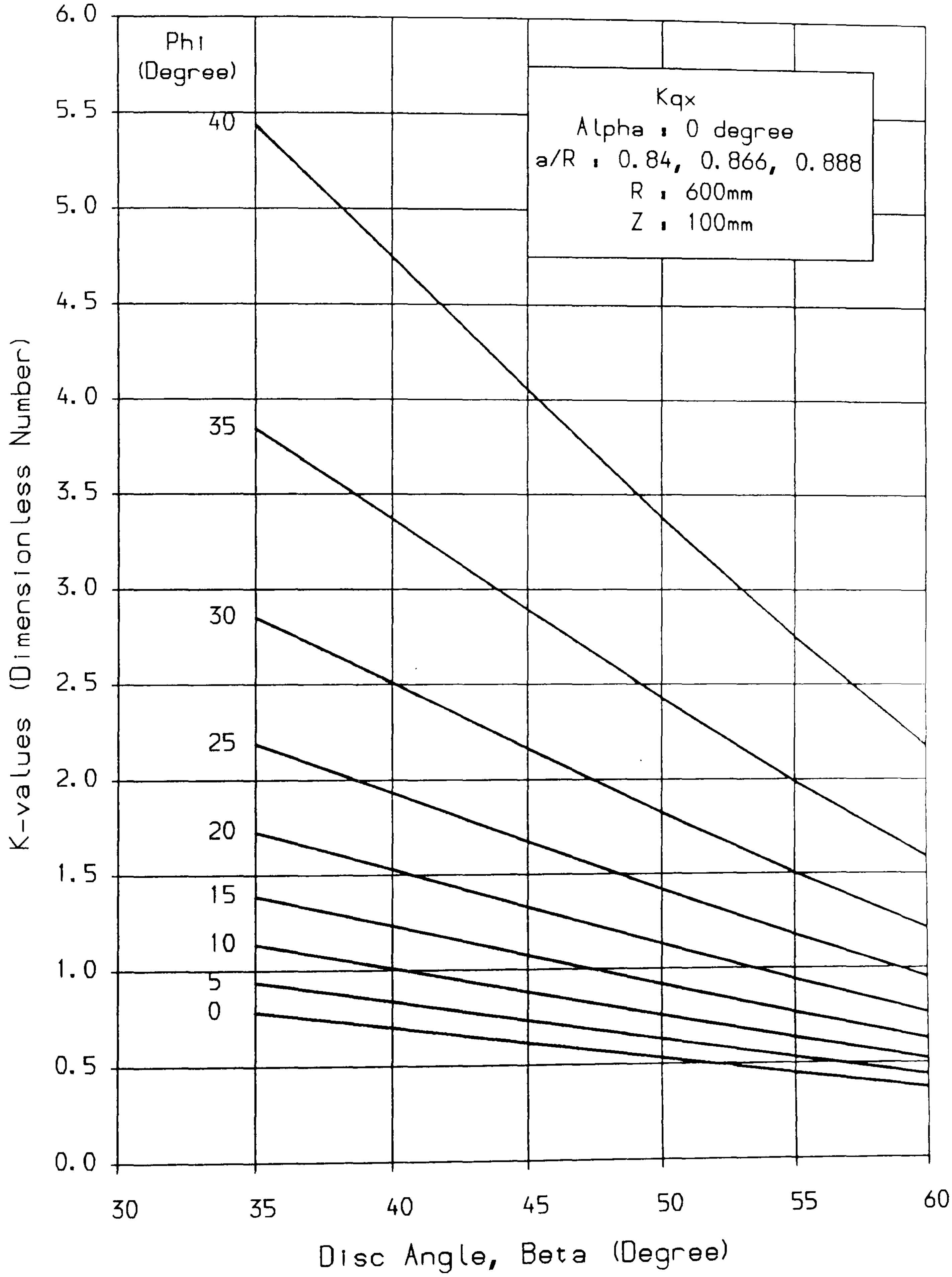


Chart 3. K-factor for Longitudinal Surcharge Force

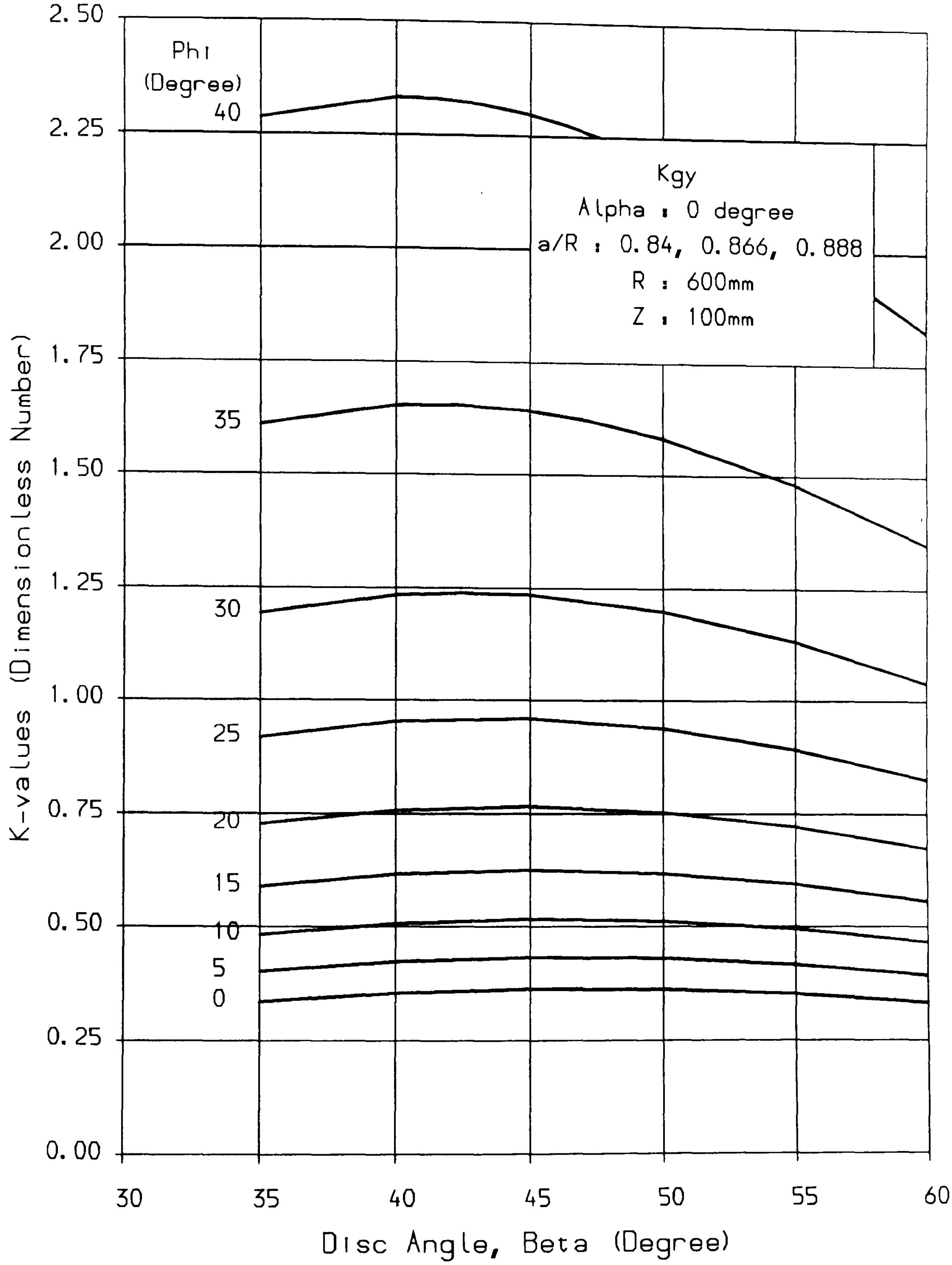


Chart 4. K-factor for Lateral Gravitation Force.

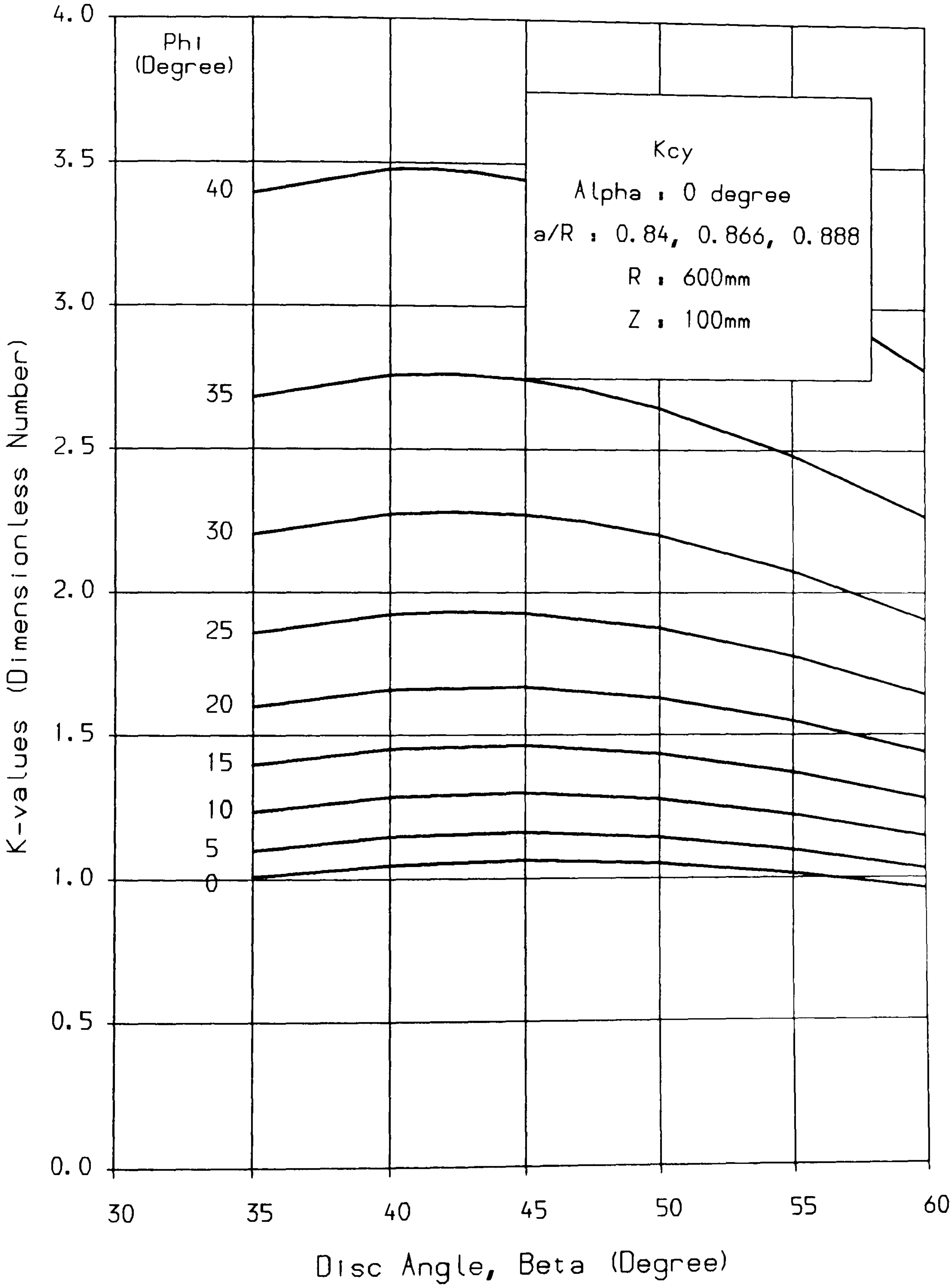


Chart 5. K-factor for Lateral Cohesice-Adhesive Force

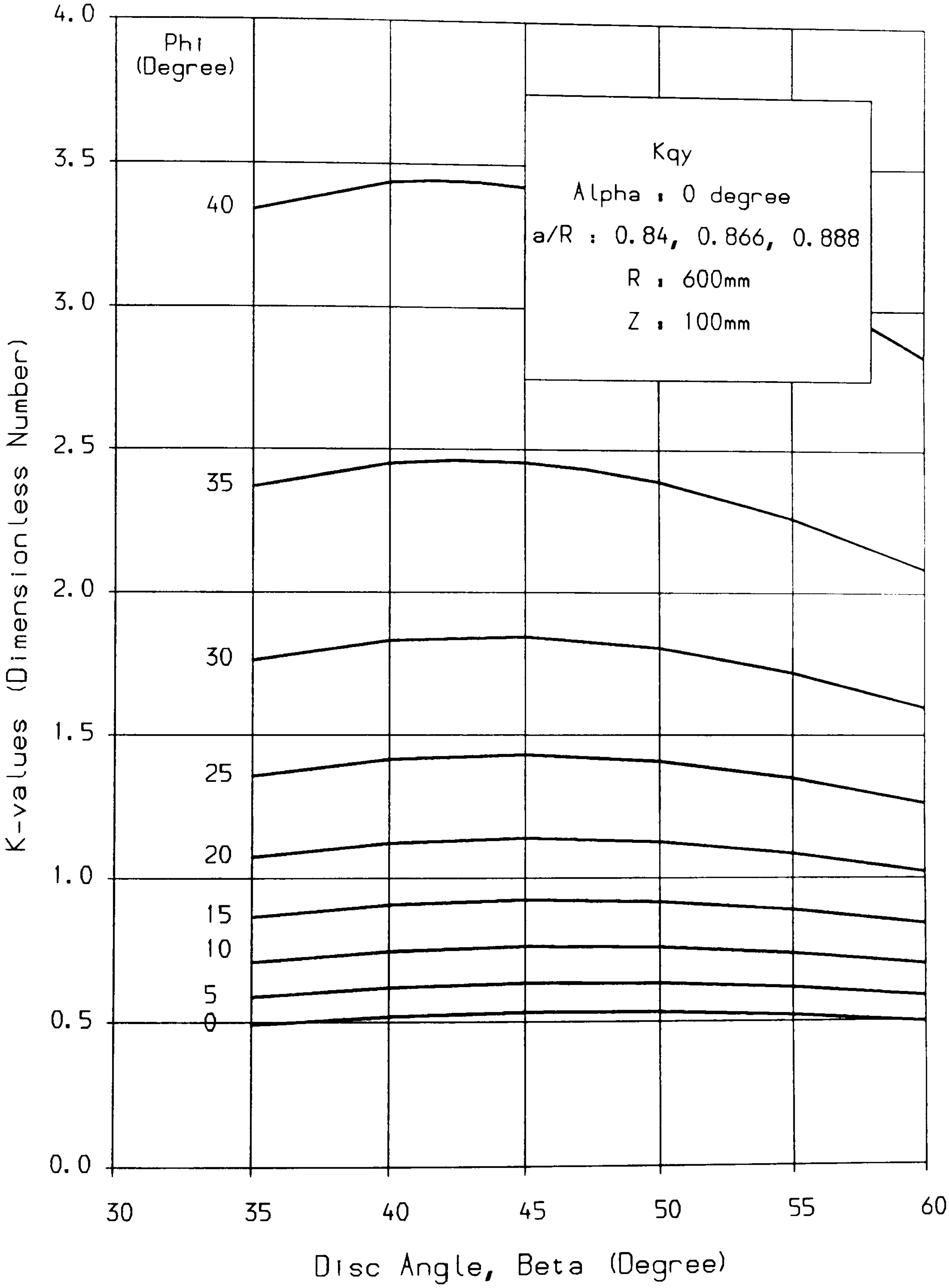


Chart 6. K-factor for Lateral Surcharge Force

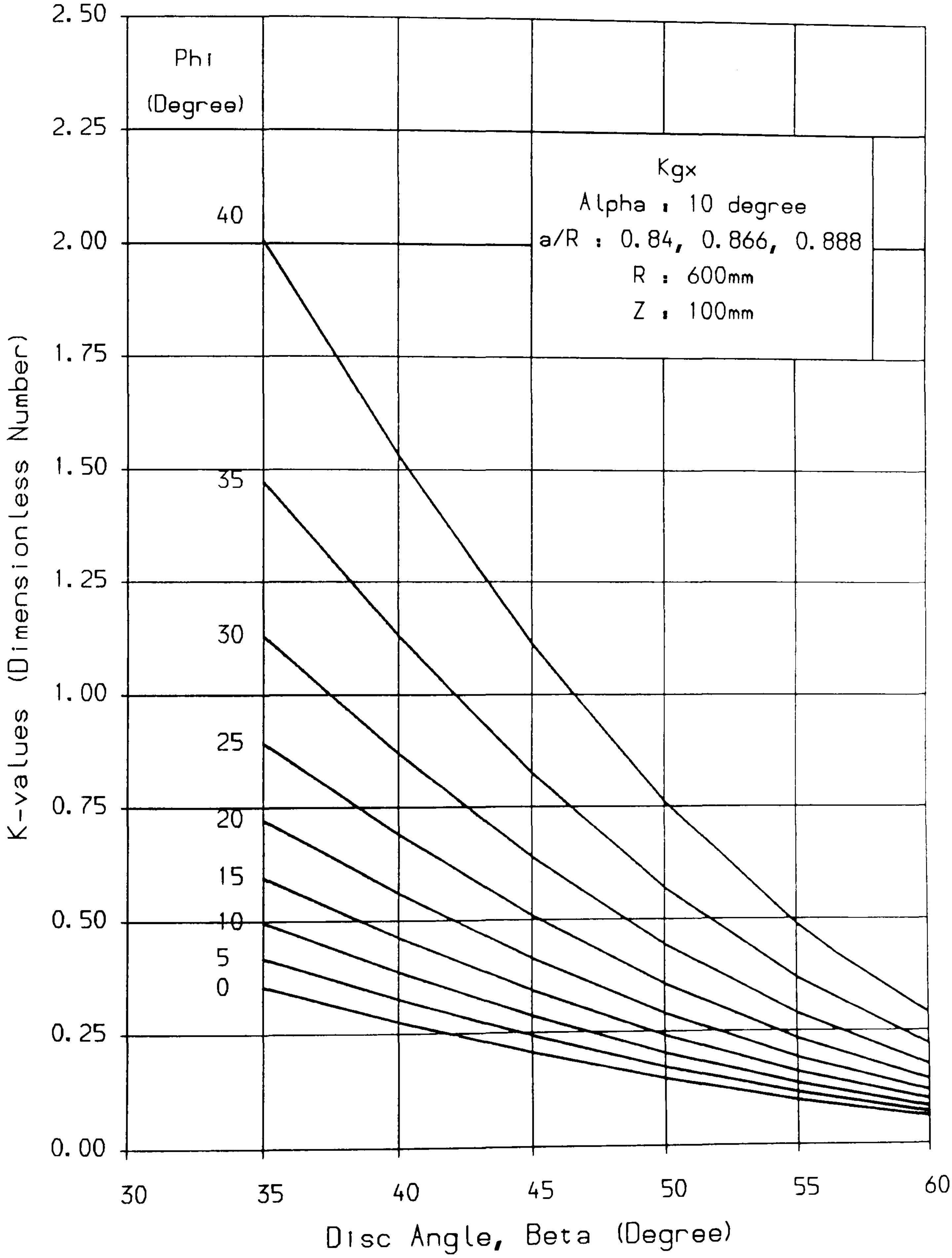


Chart 7. K-factor for Longitudinal-Gravitation Force

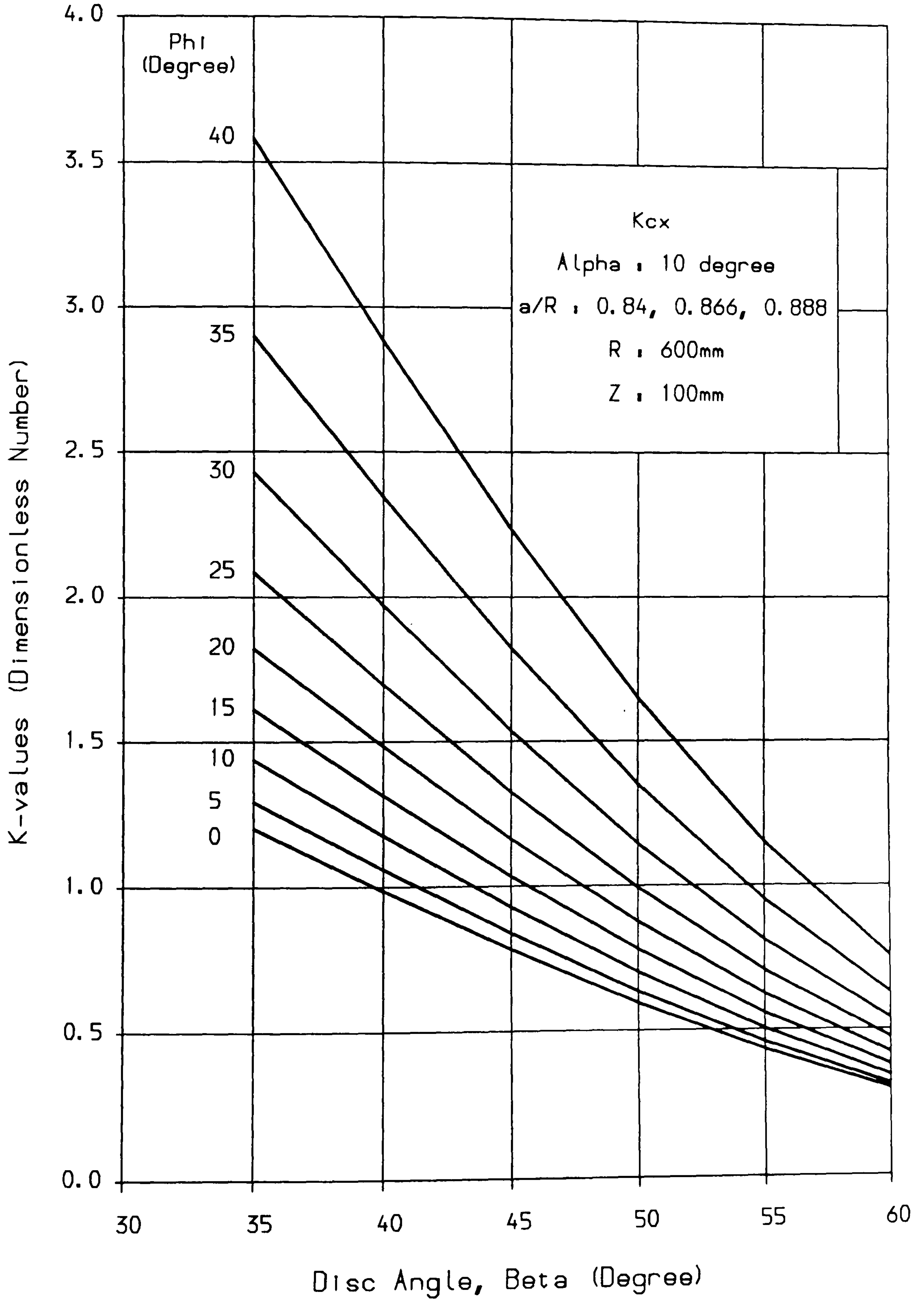


Chart 8. K-factor for Longitudinal Cohesive-Adhesive Force

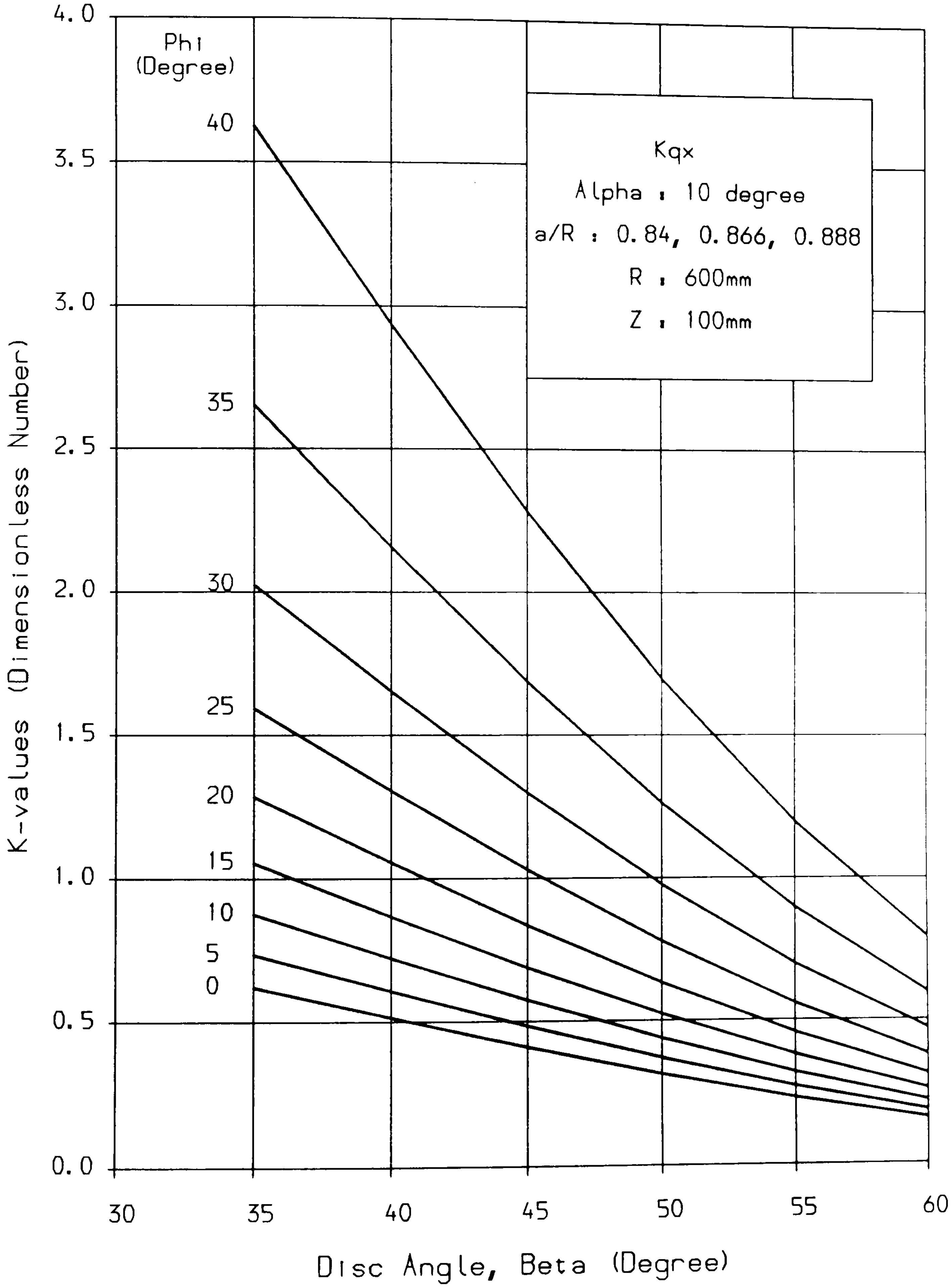


Chart 9. K-factor for Longitudinal Surcharge Force

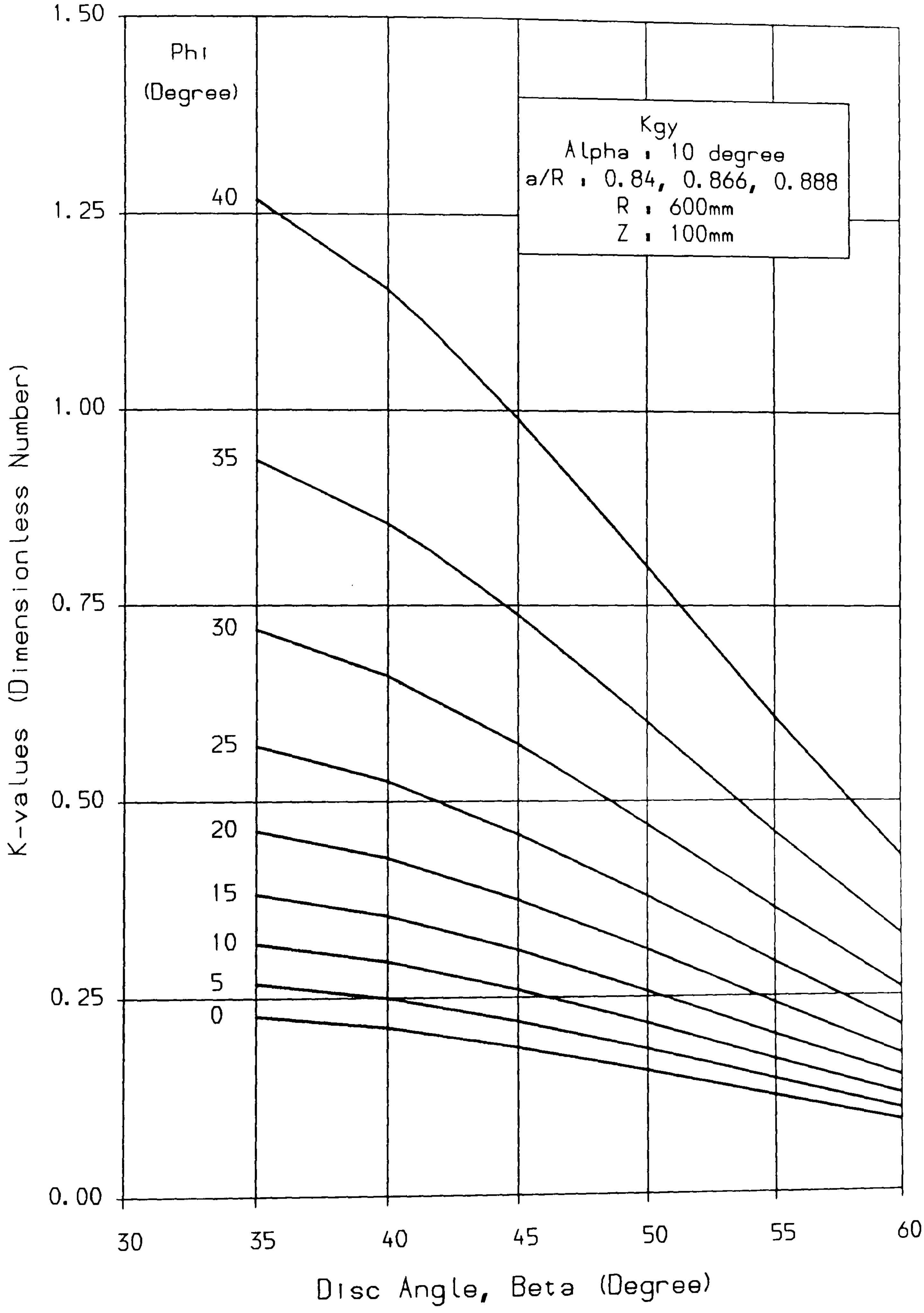


Chart 10. K-factor for Lateral Gravitation Force.

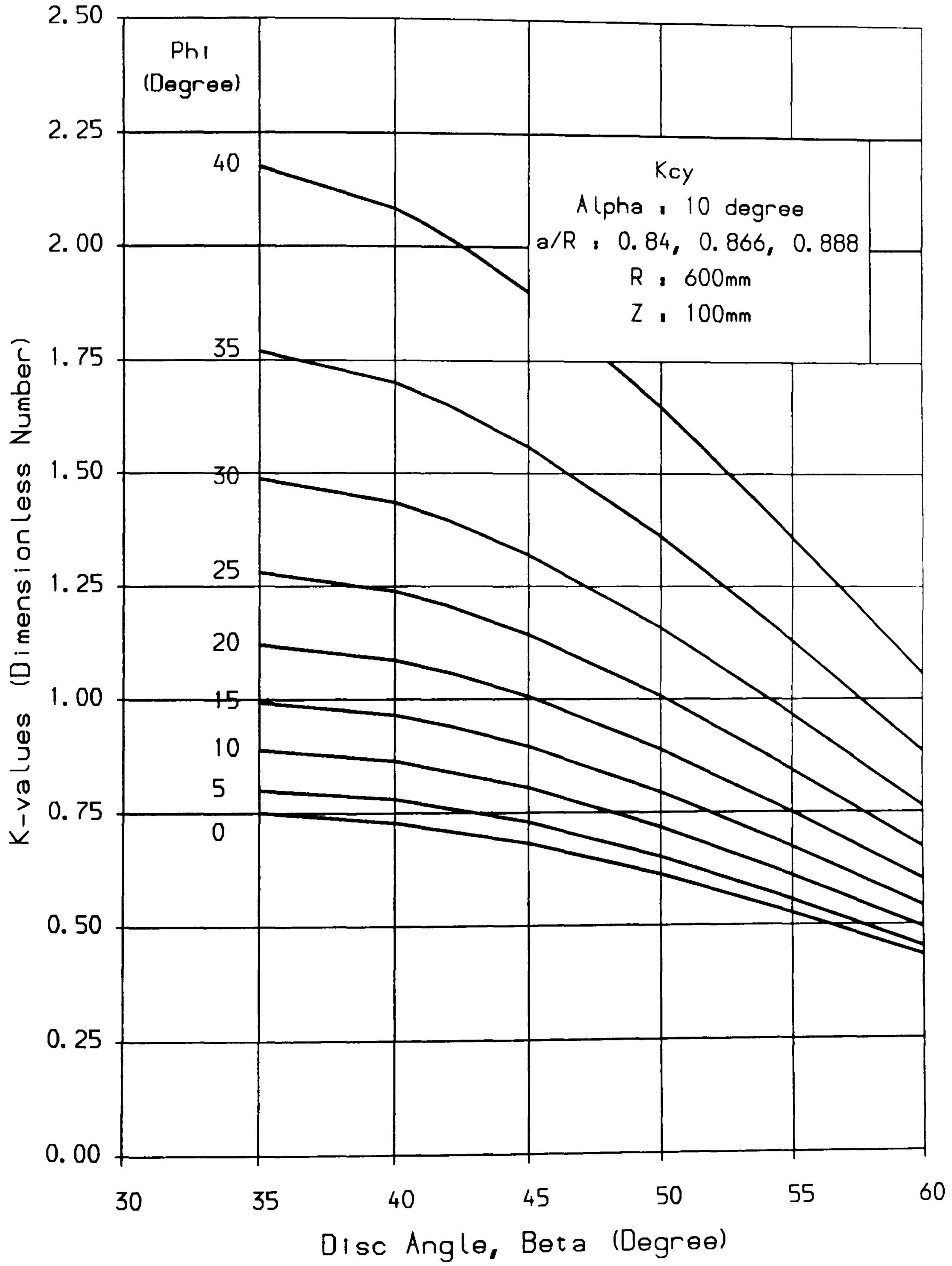


Chart 11. K-factor for Lateral Cohesive-Adhesive Force.

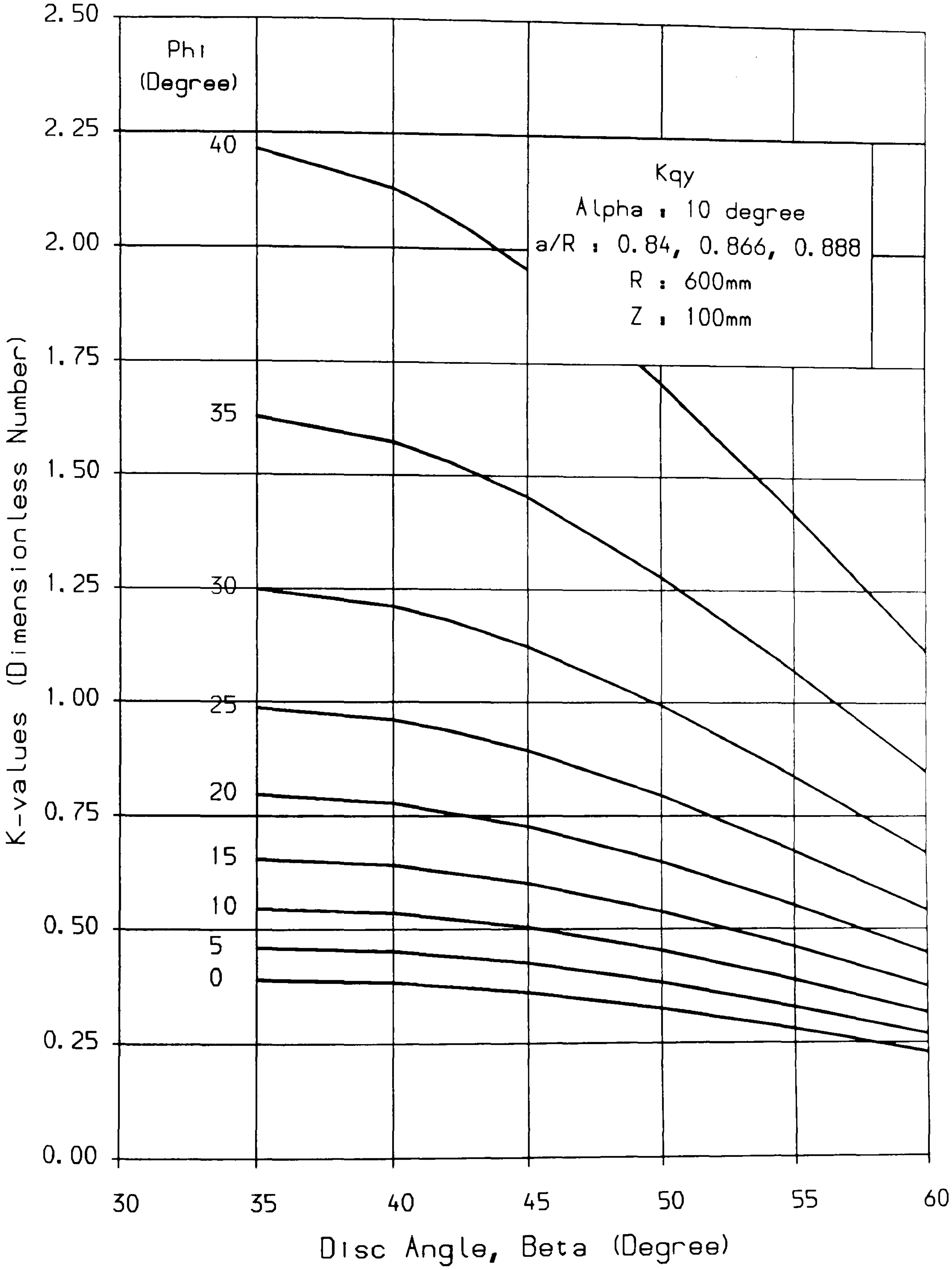


Chart 12. K-factor for Lateral Surcharge Force.

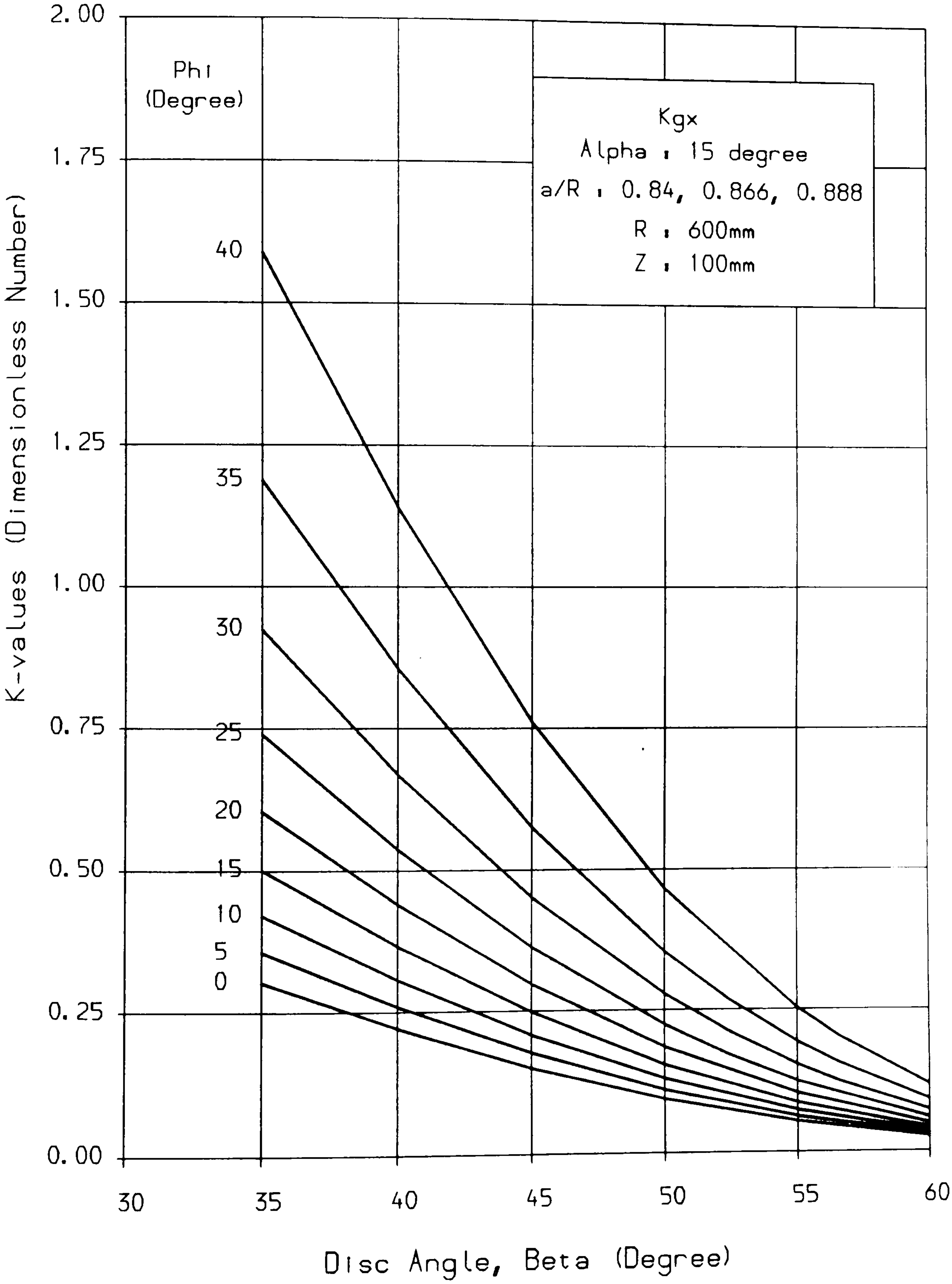


Chart 13. K-factor for Longitudinal-Gravitation Force

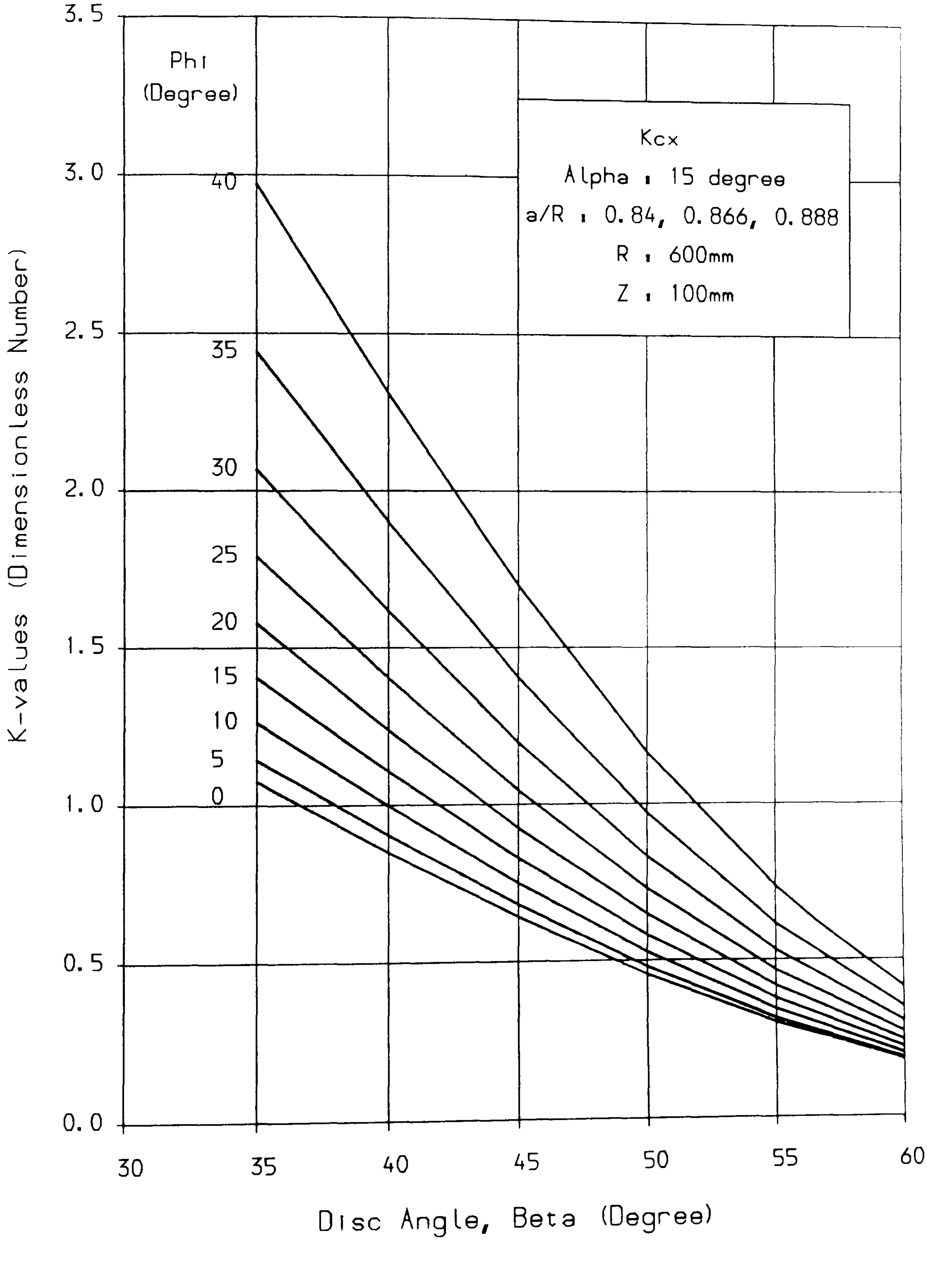


Chart 14. K-factor for Longitudinal Cohesive-Adhesive Force

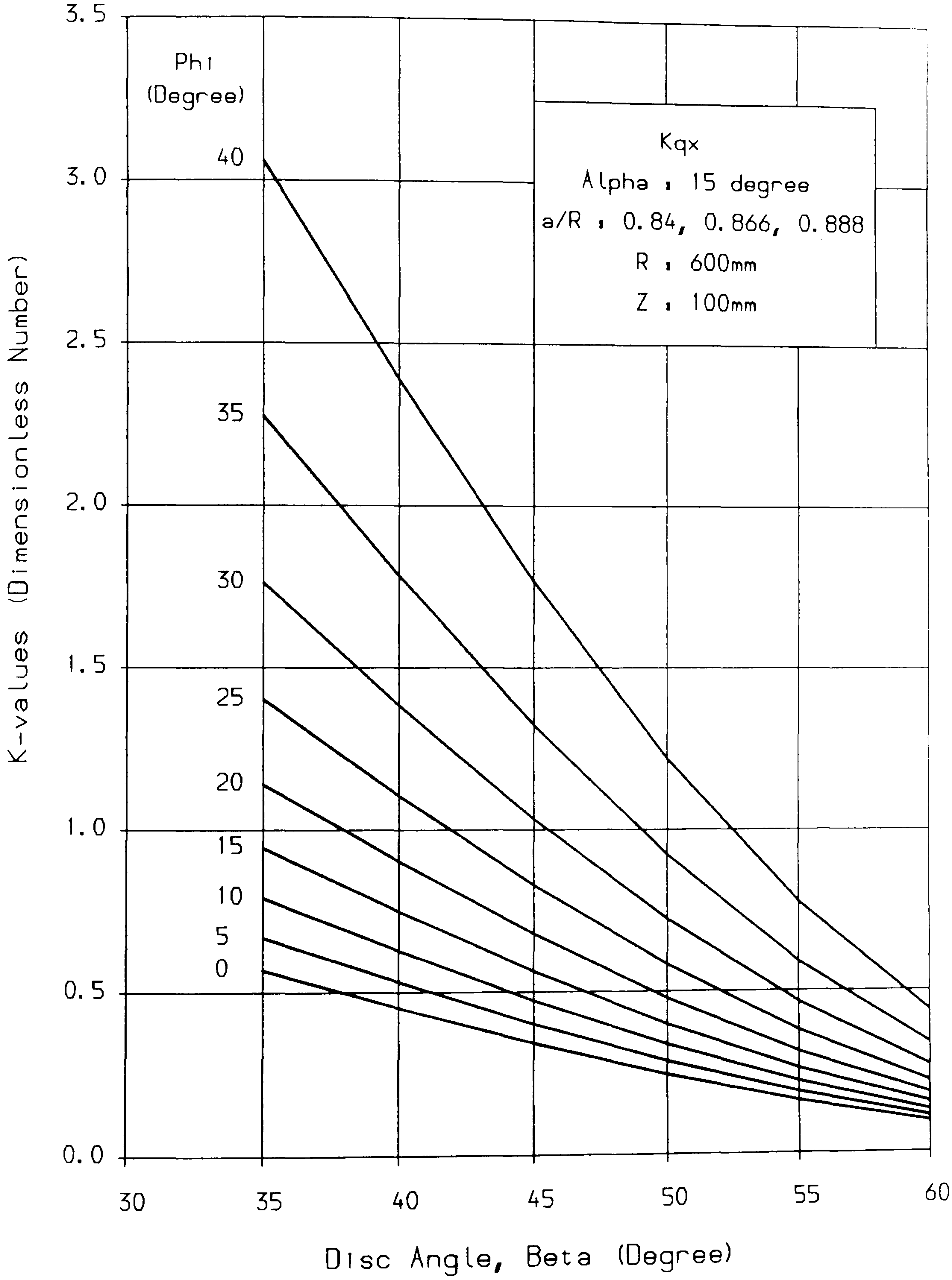


Chart 15. K-factor for Longitudinal Surcharge Force

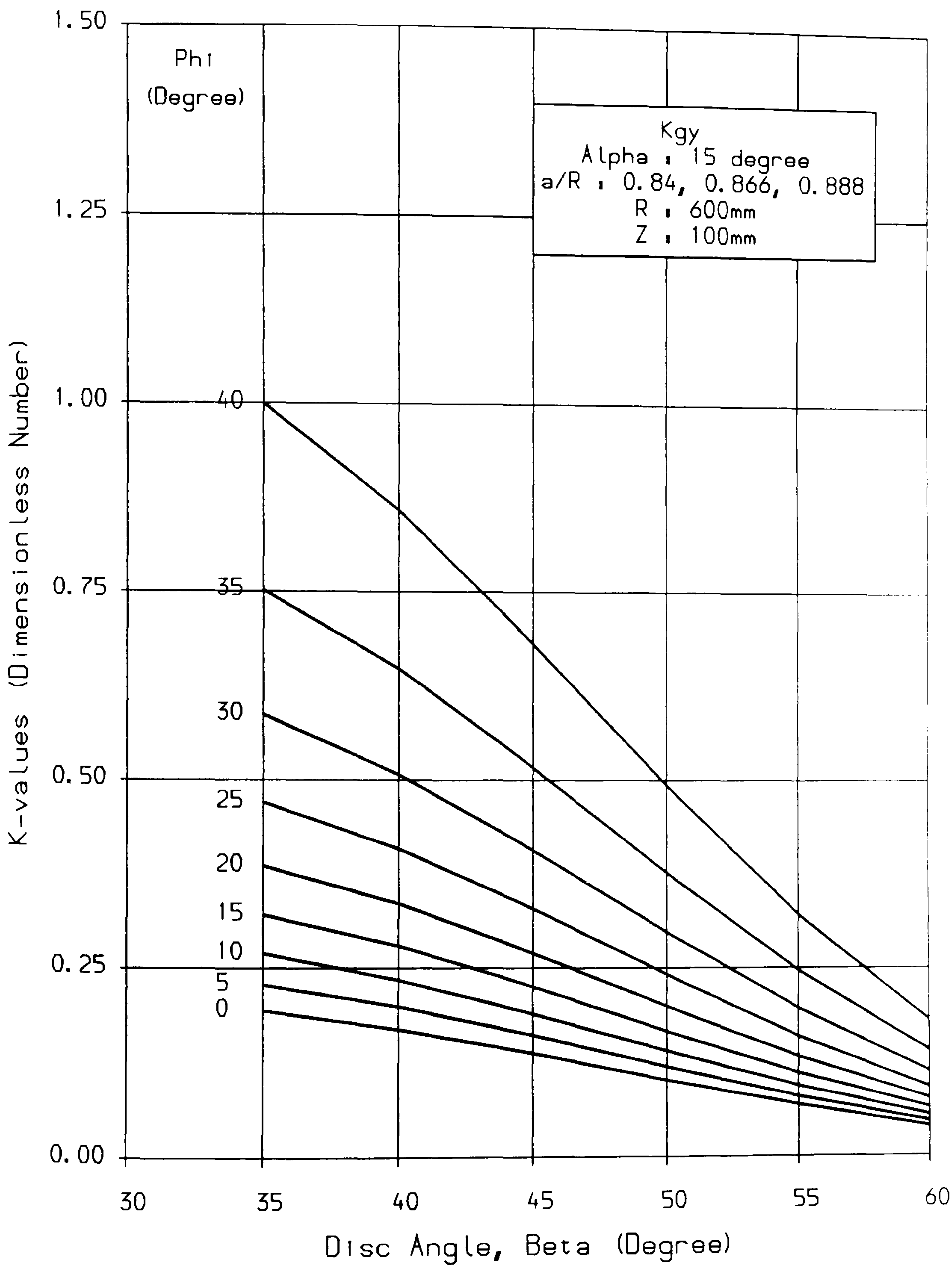


Chart 16. K-factor for Lateral Gravitation Force.

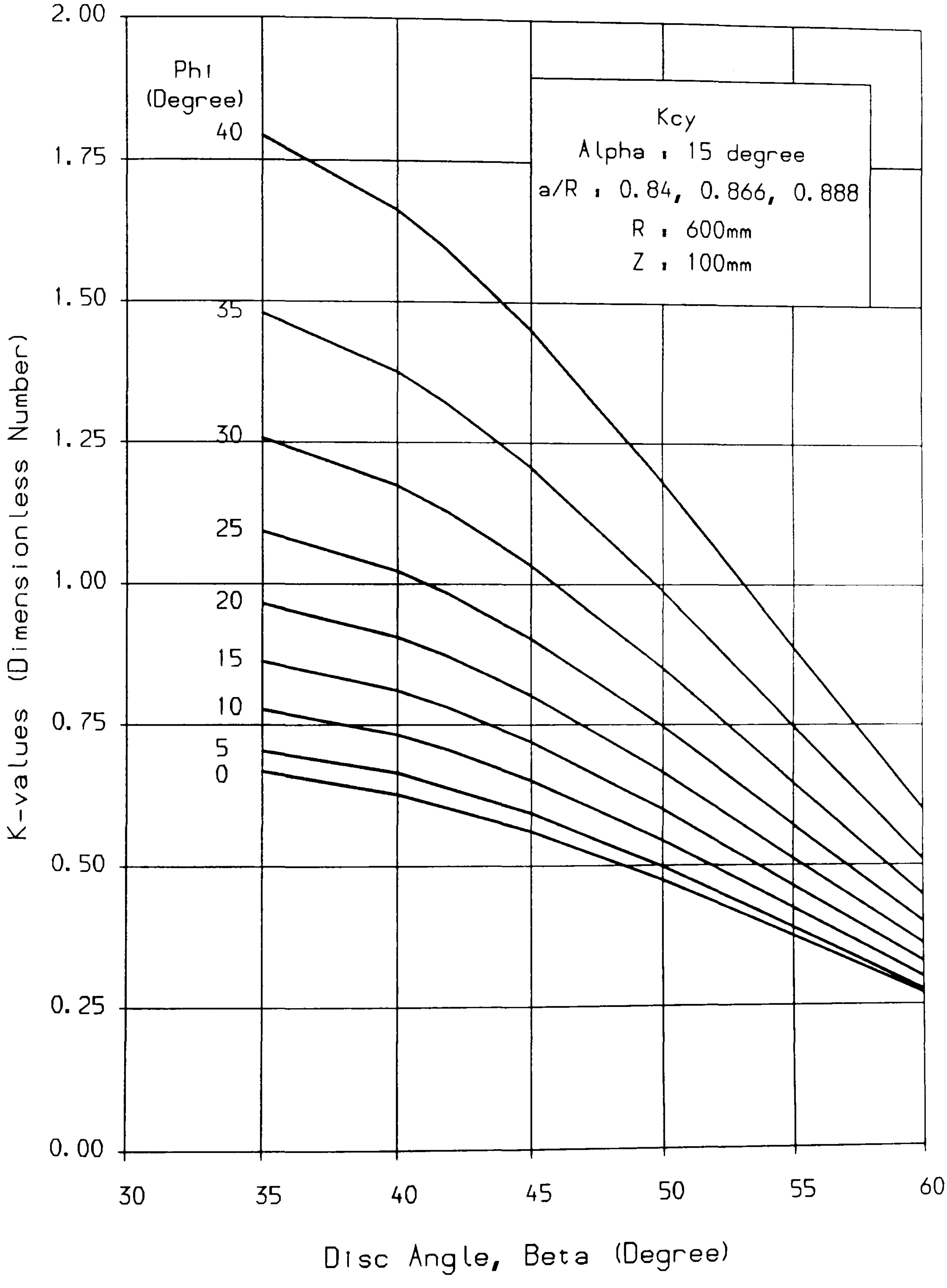


Chart 17. K-factor for Lateral Cohesive-Adhesive Force.

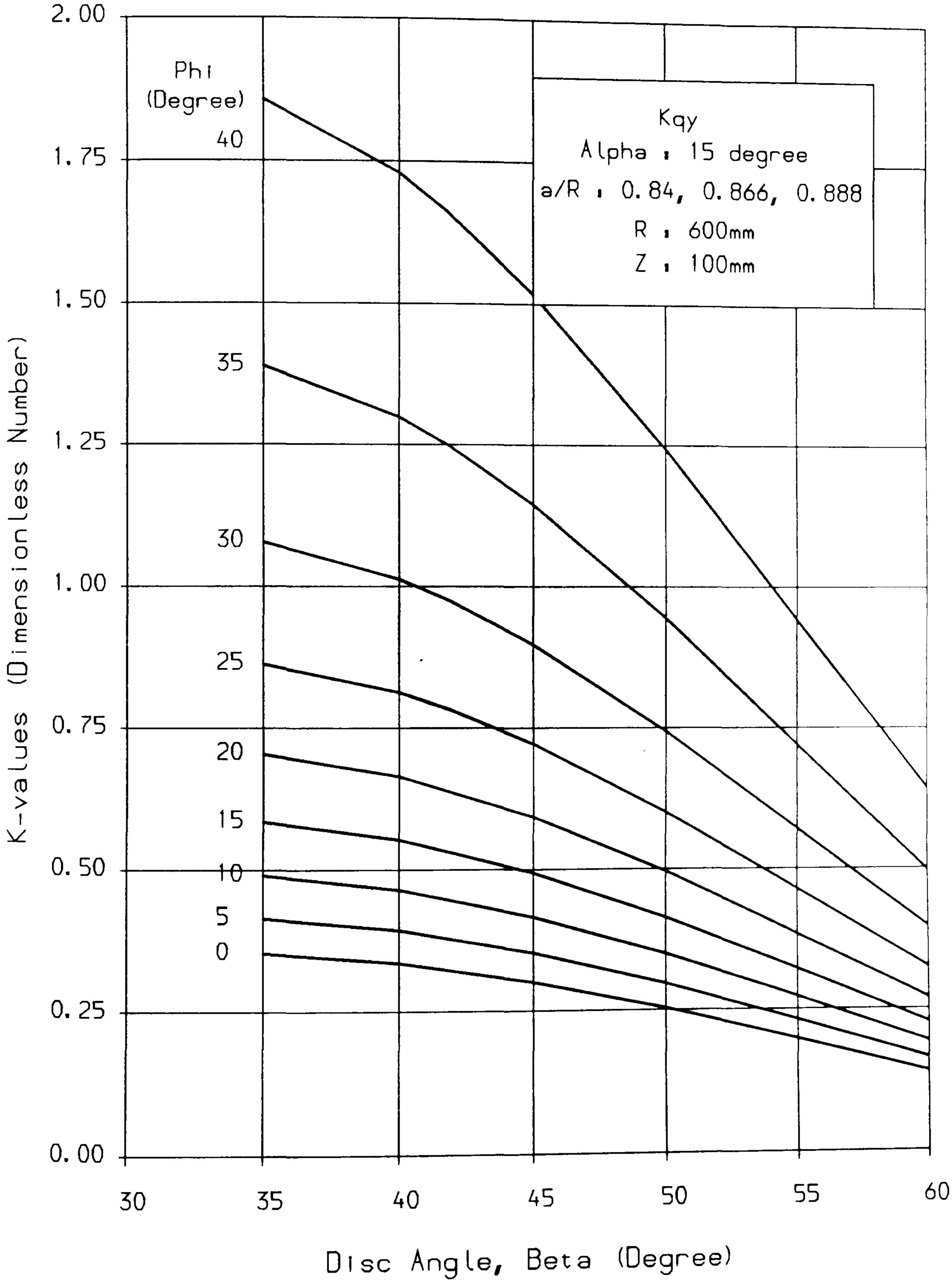


Chart 18. K-factor for Lateral Surcharge Force.

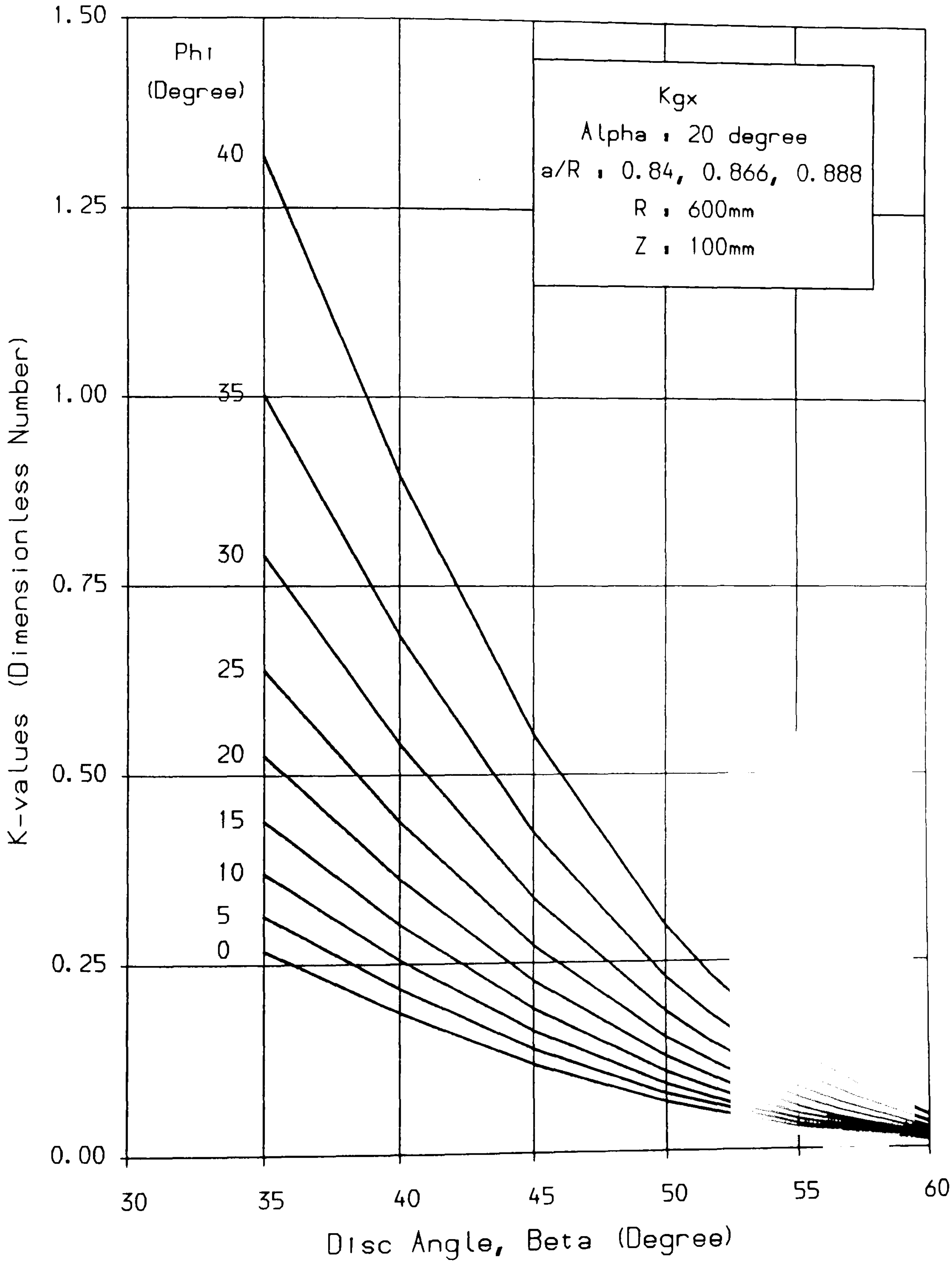


Chart 19. K-factor for Longitudinal Gravitation Force.

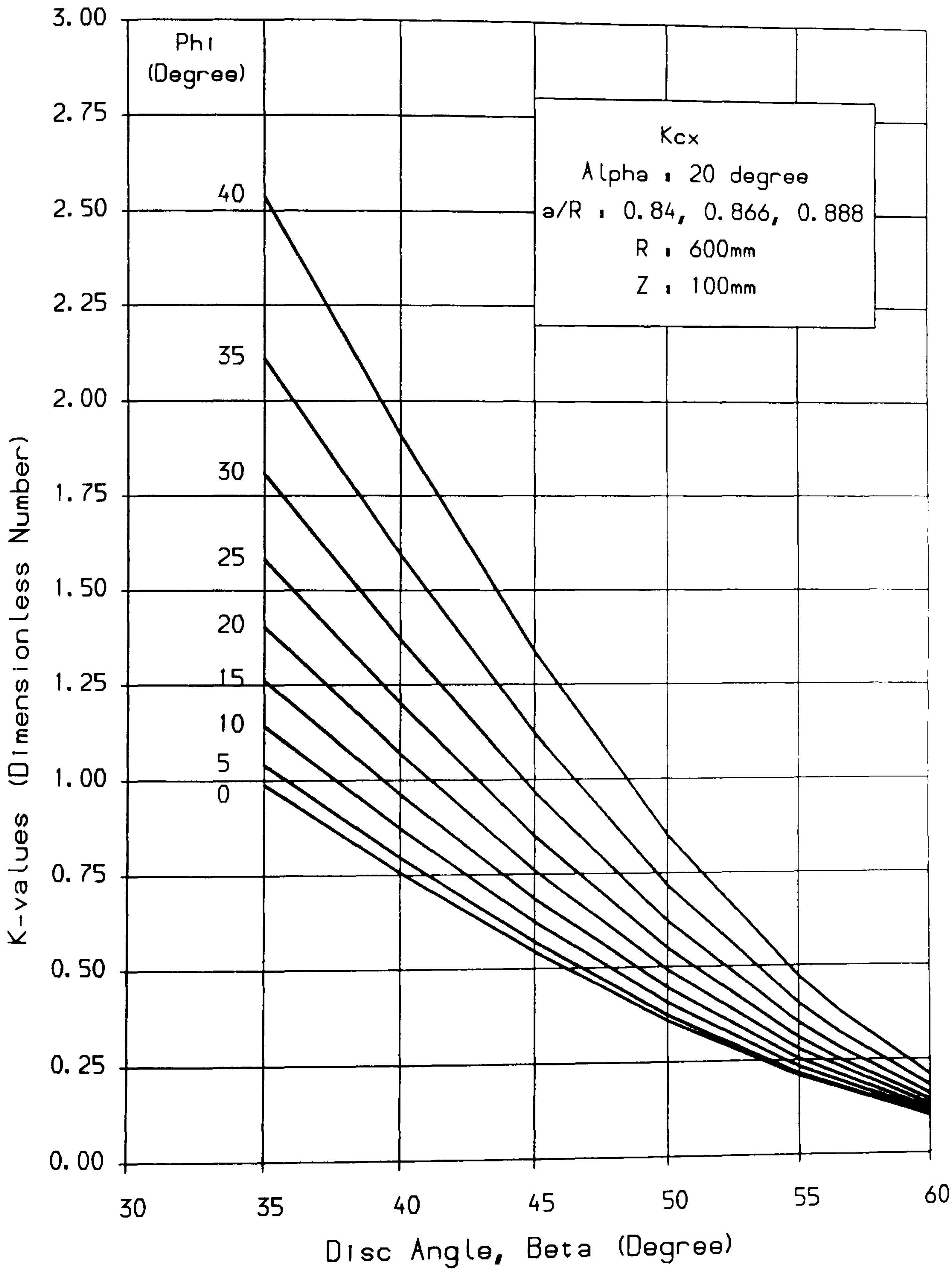
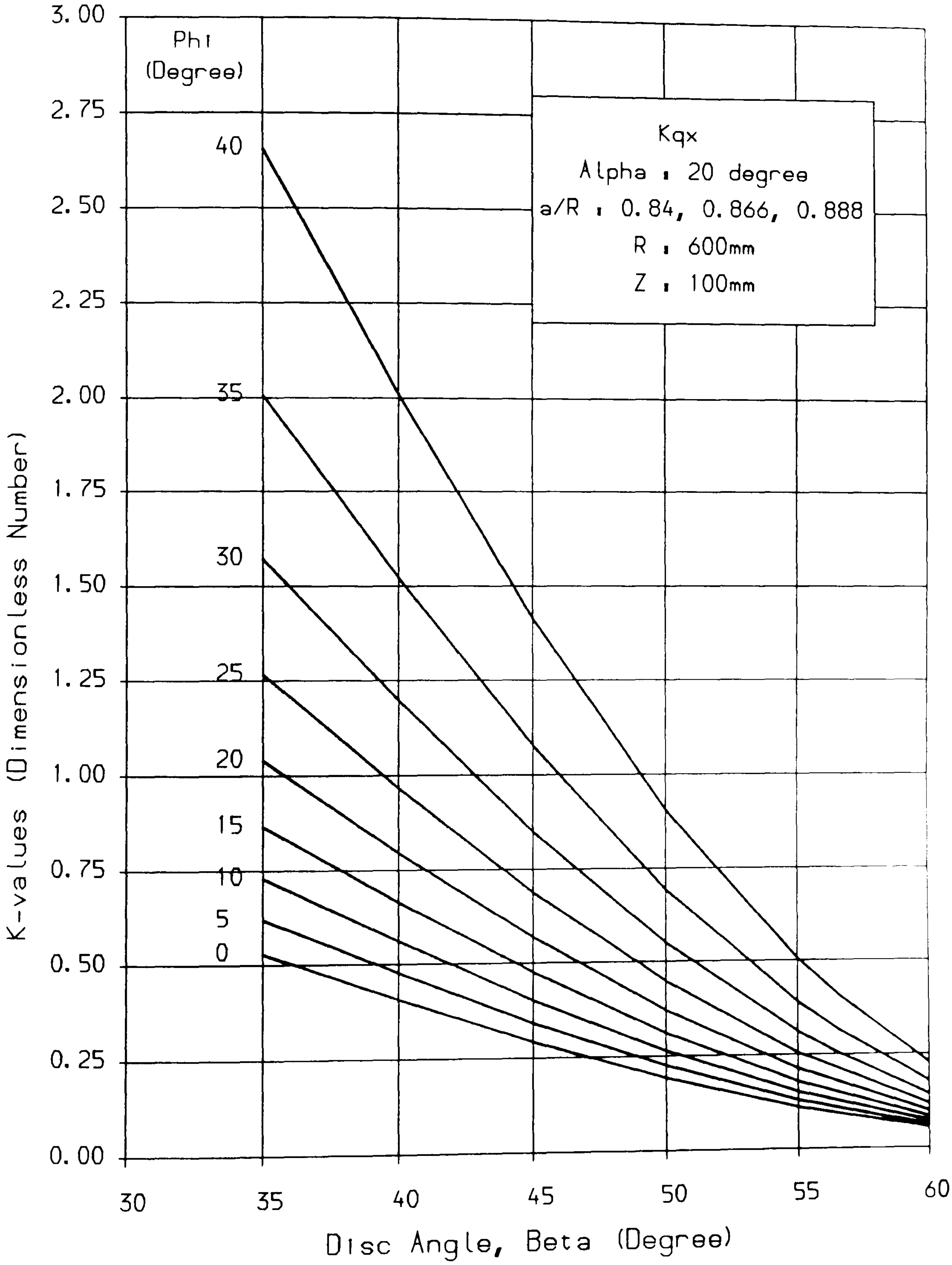


Chart 20. K-factor for Longitudinal Cohesive-Adhesive Force.



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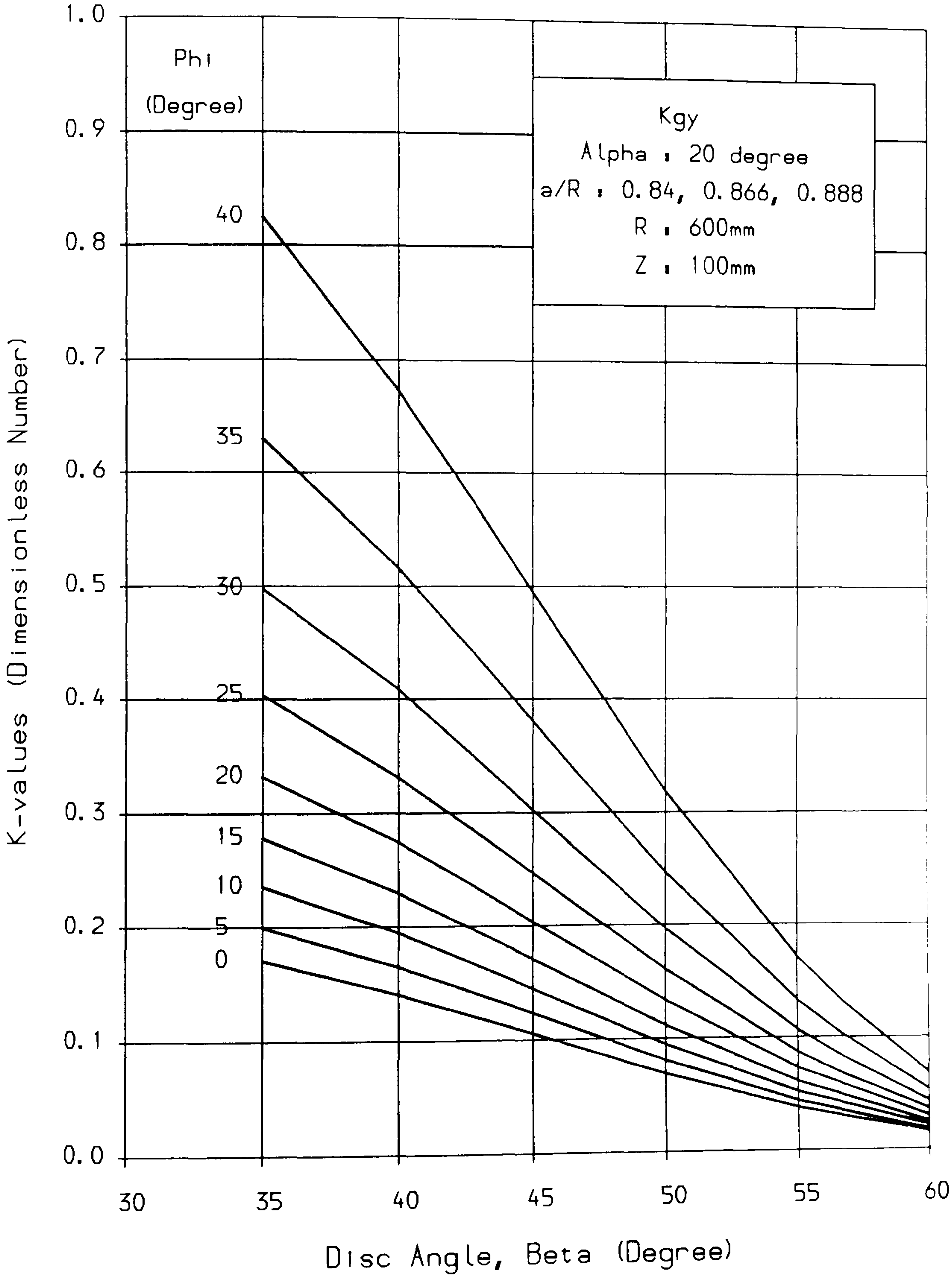
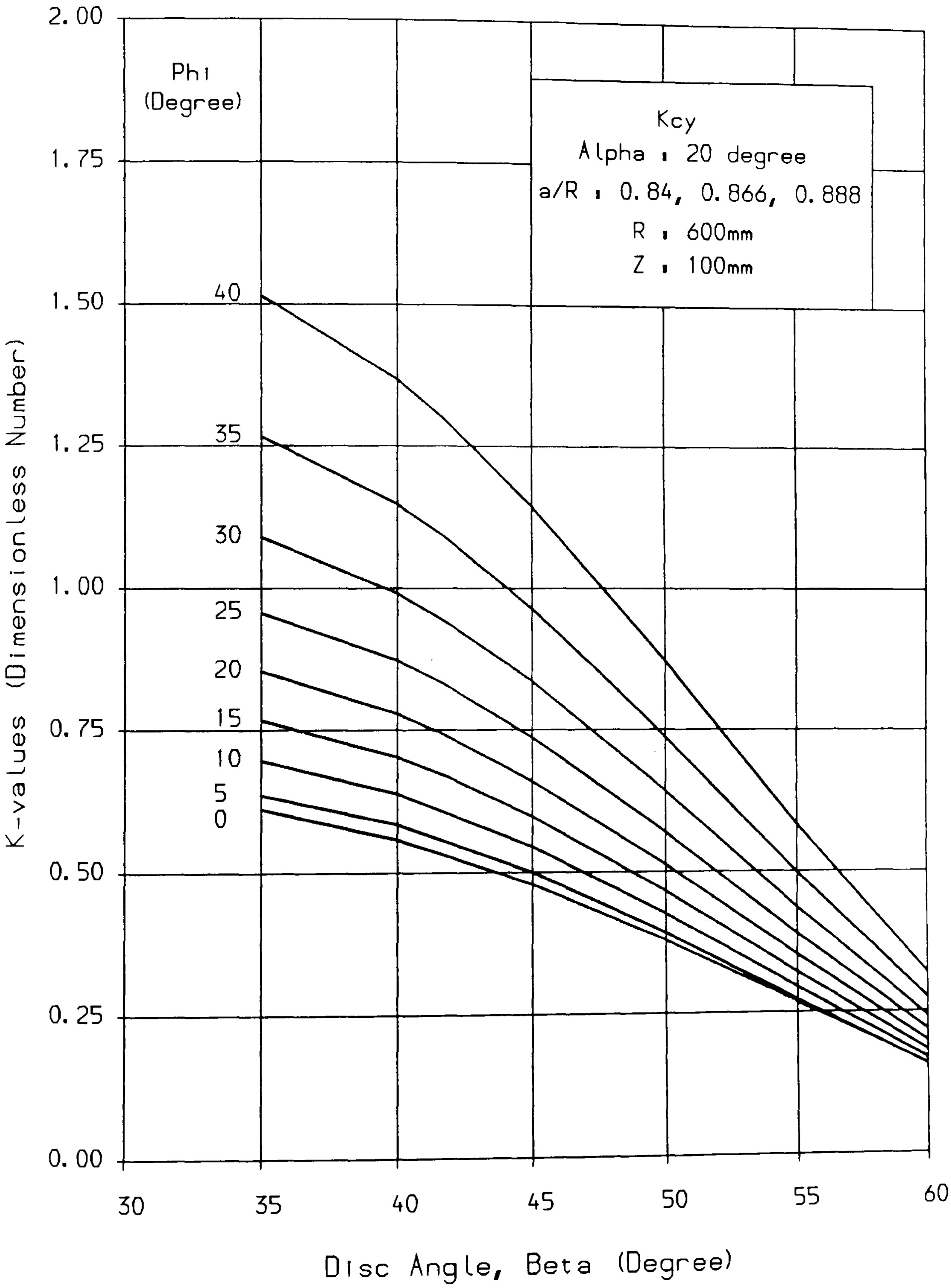


Chart 22. K-factor for Lateral Gravitation Force.



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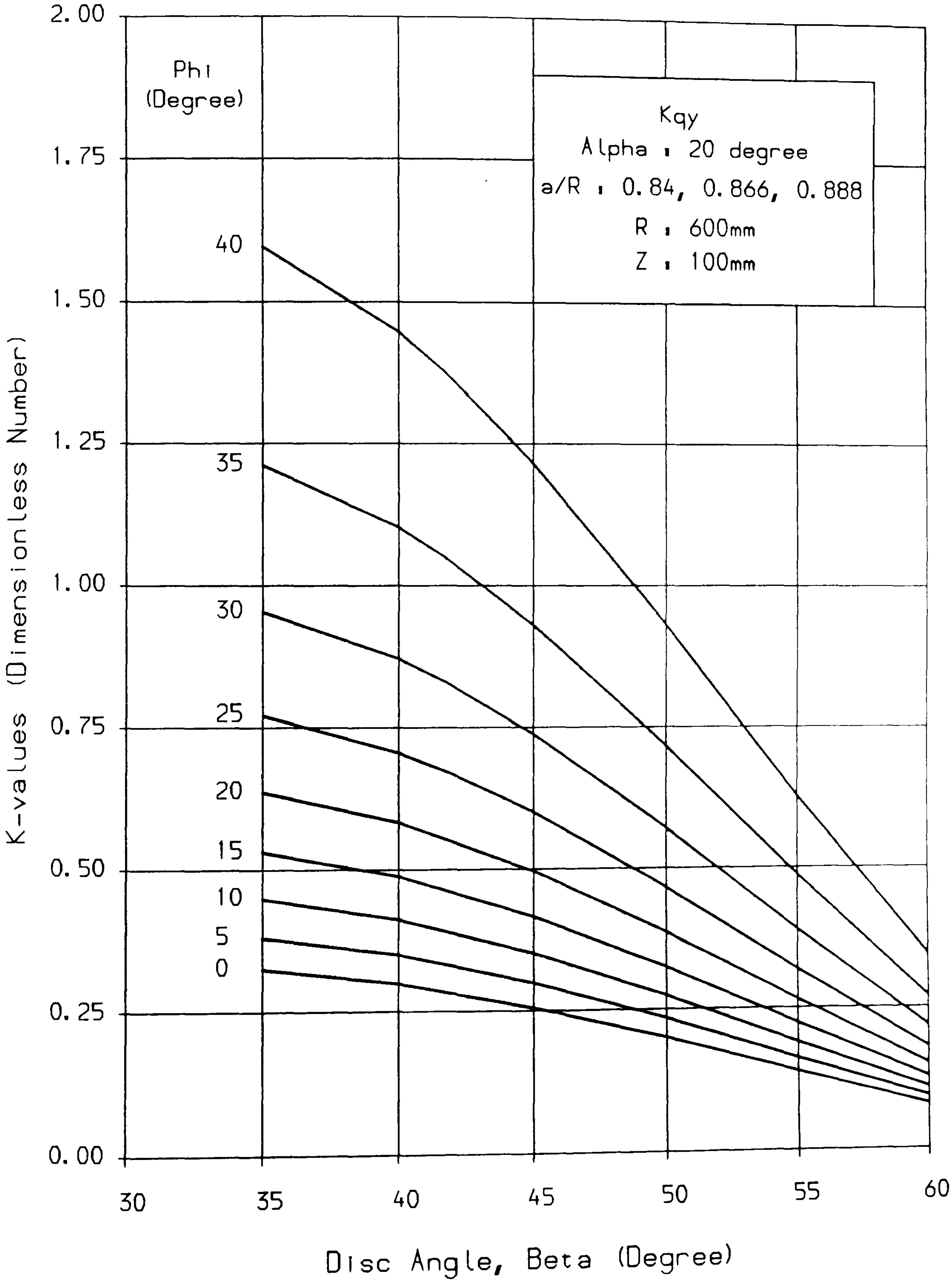

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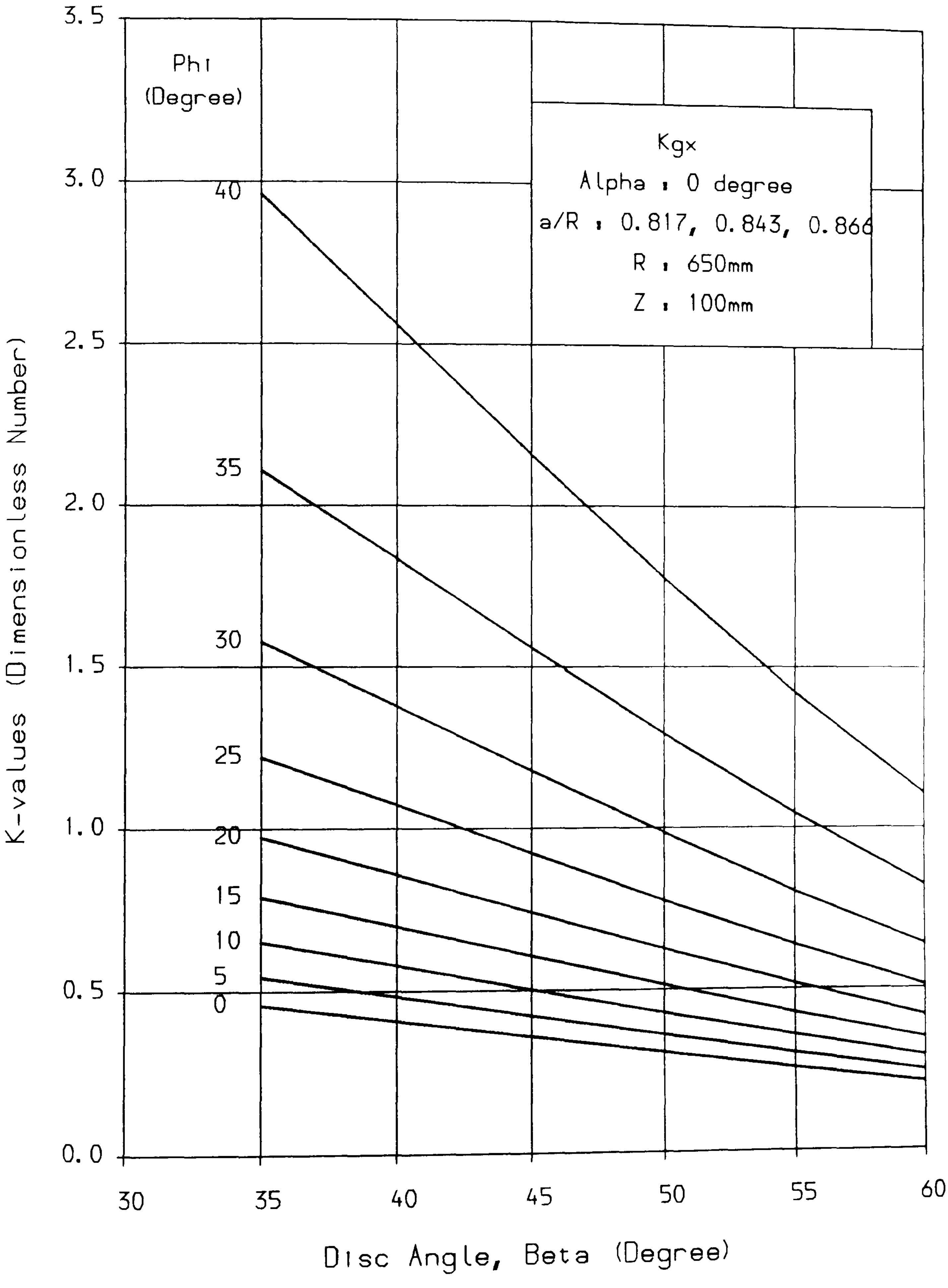

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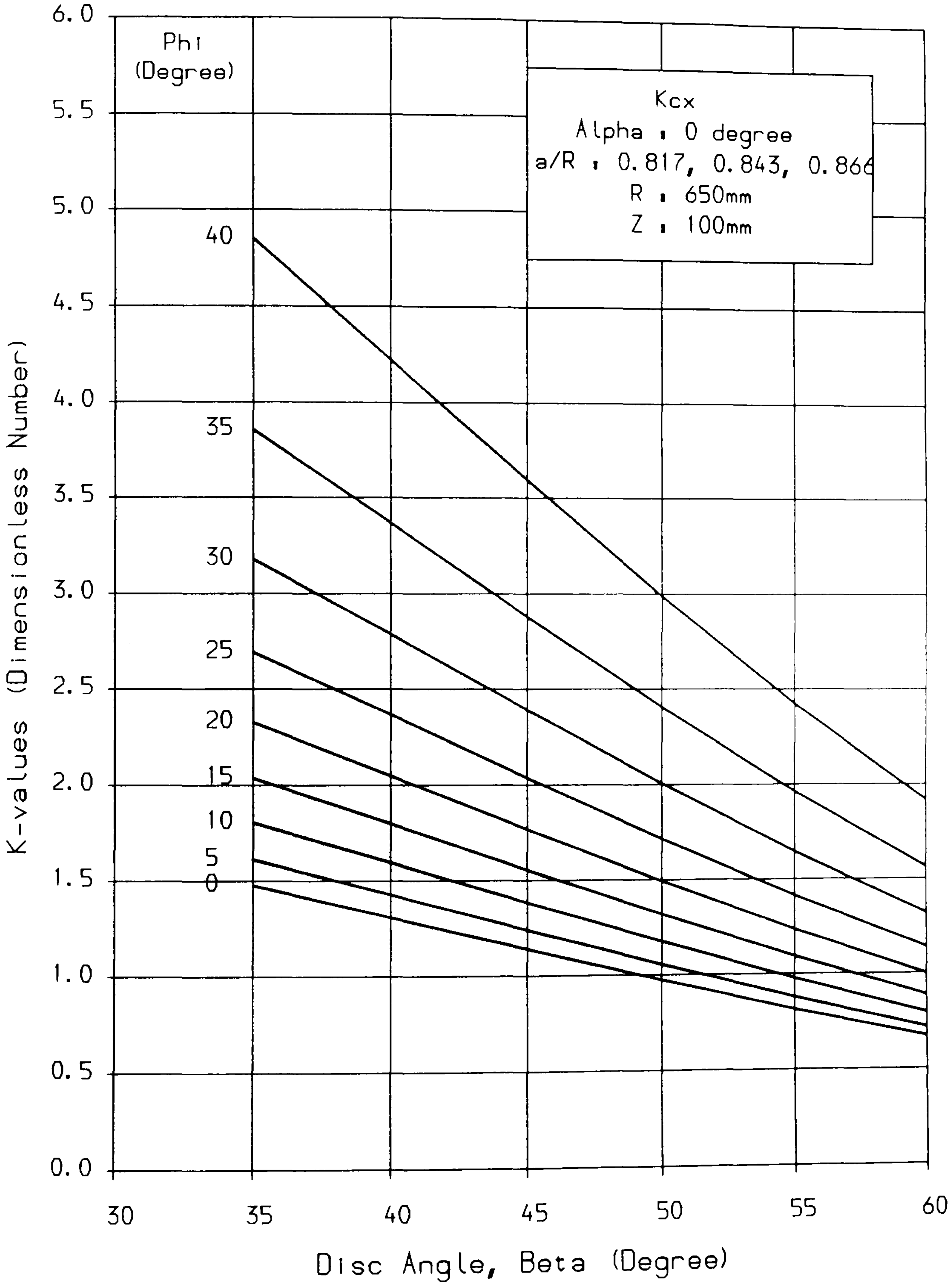

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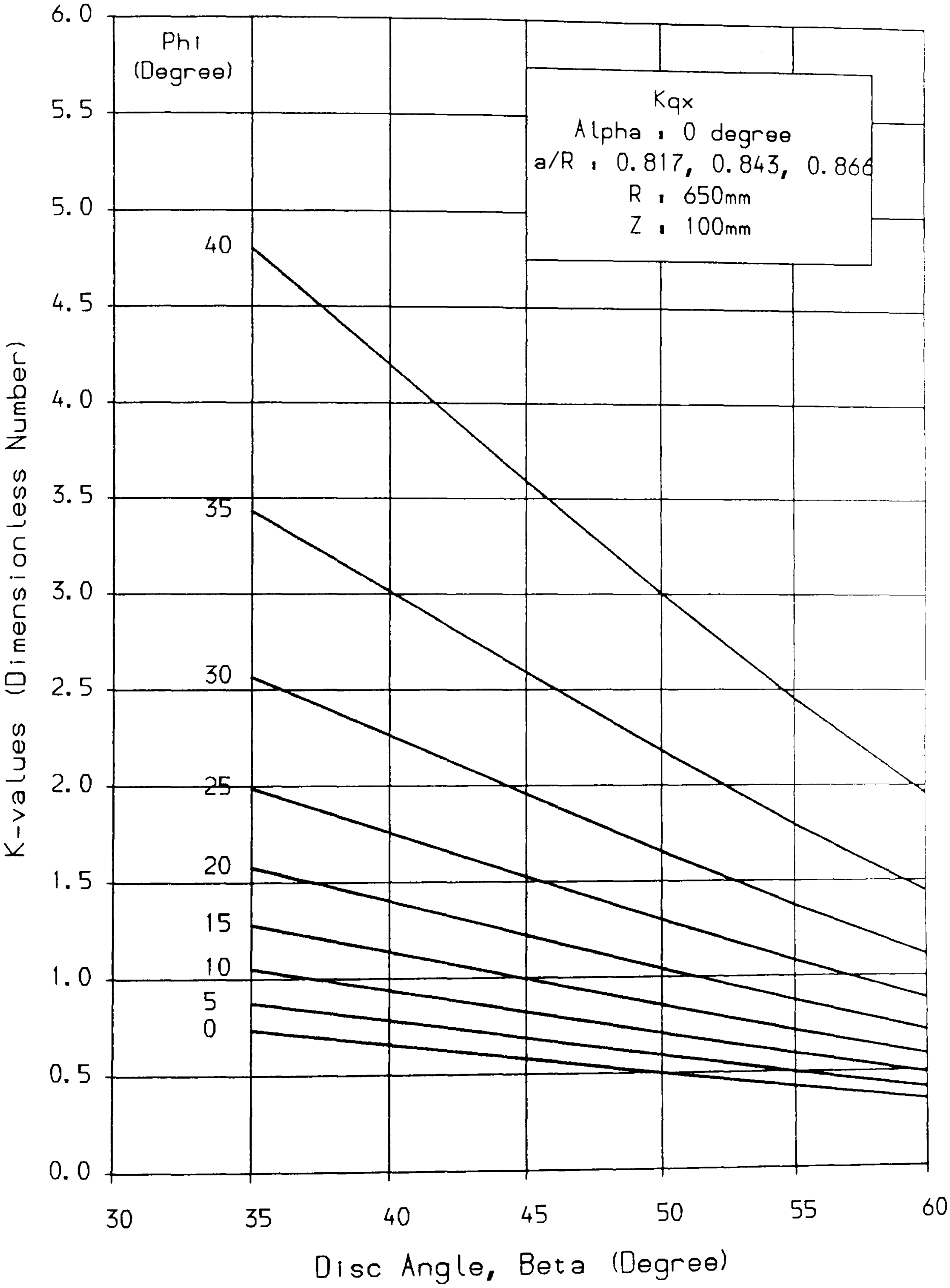

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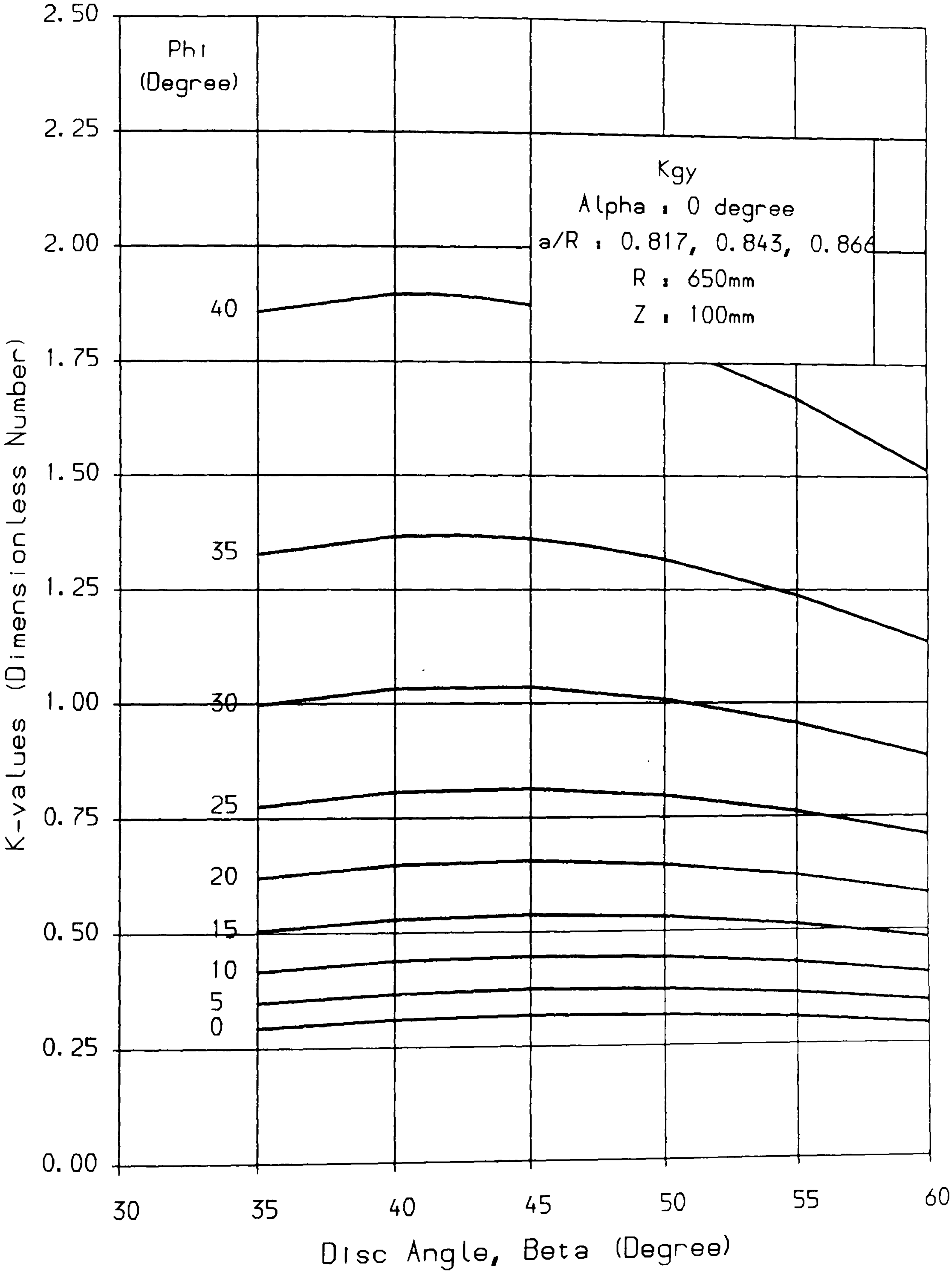

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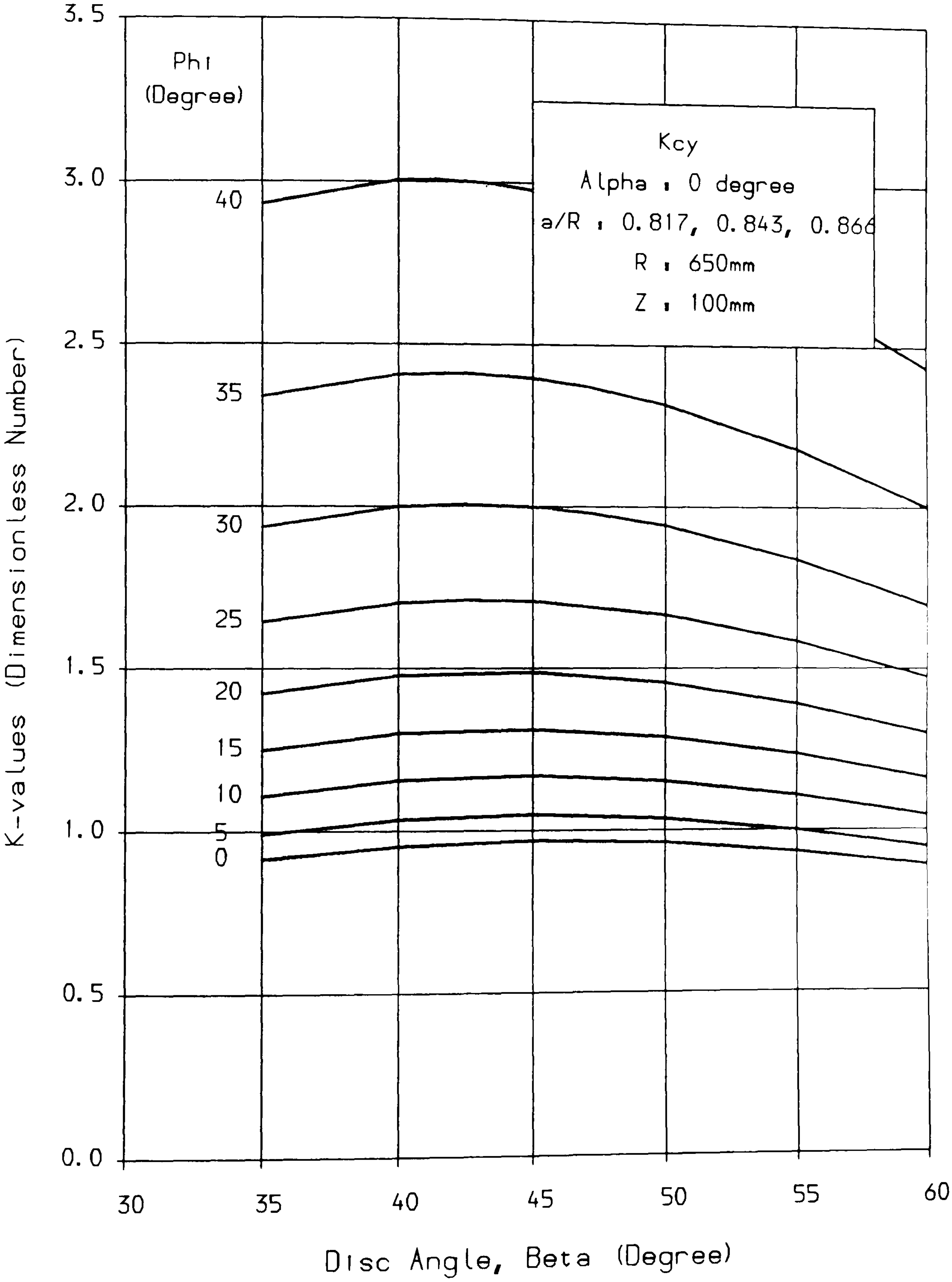

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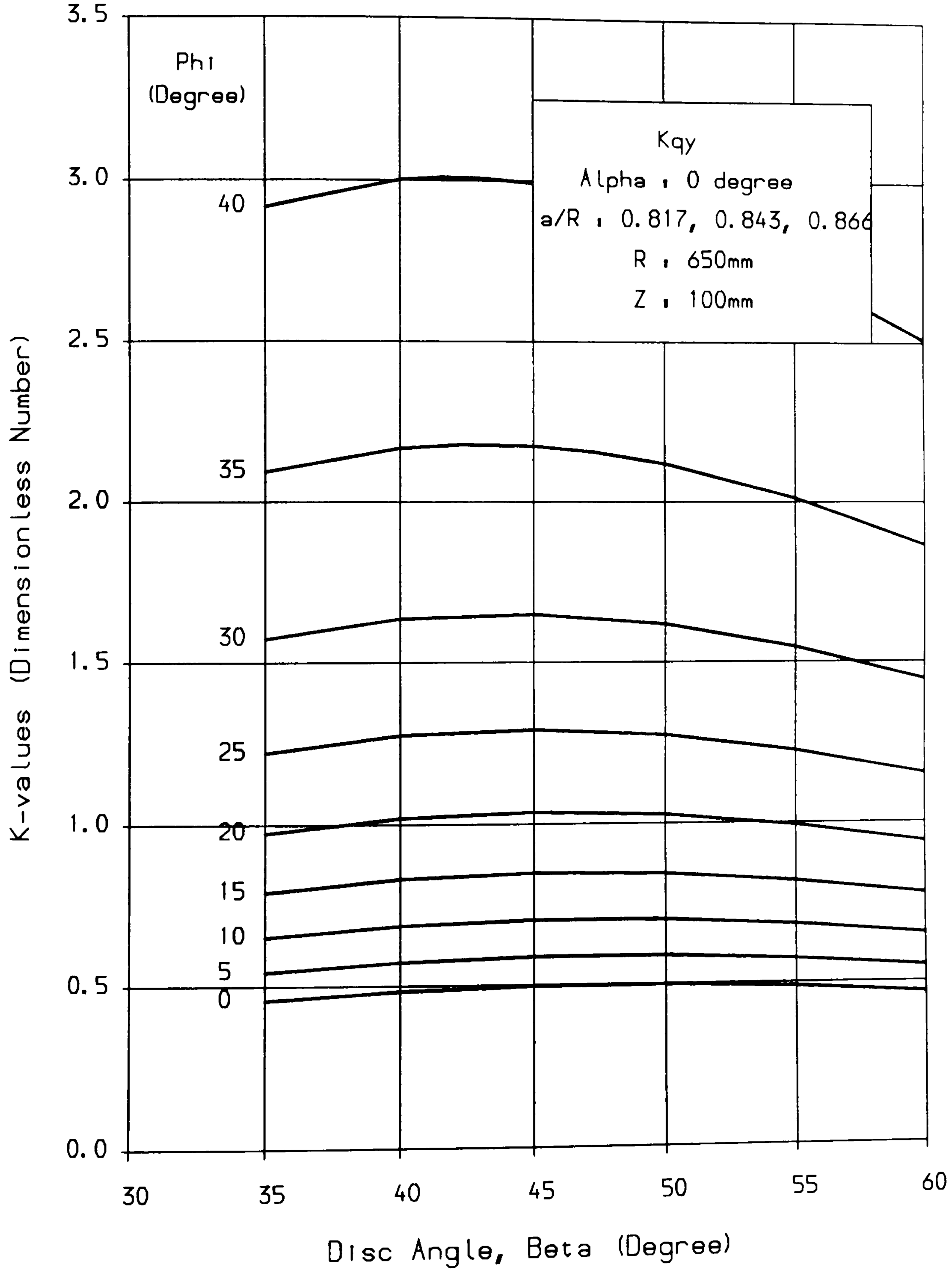

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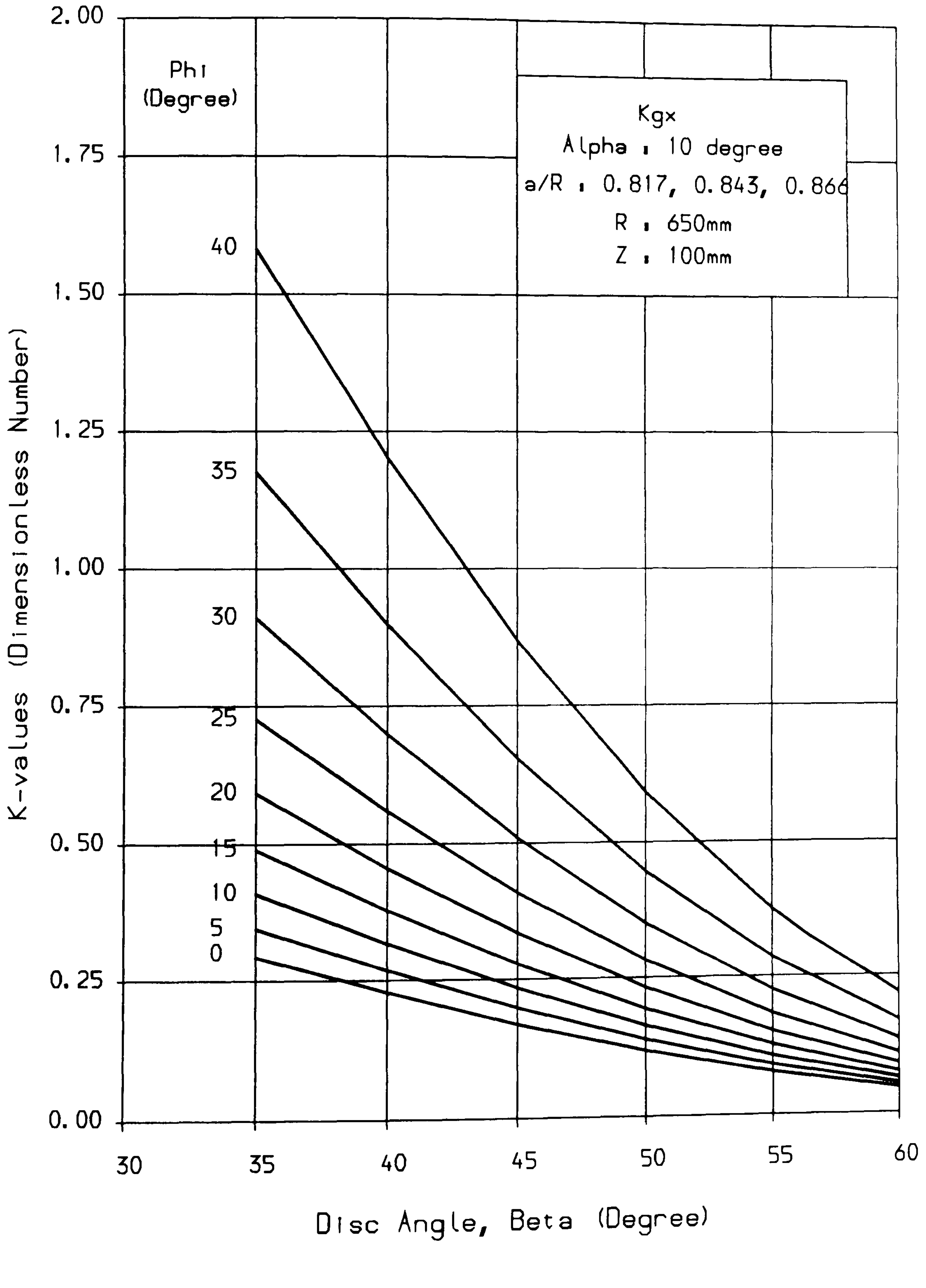

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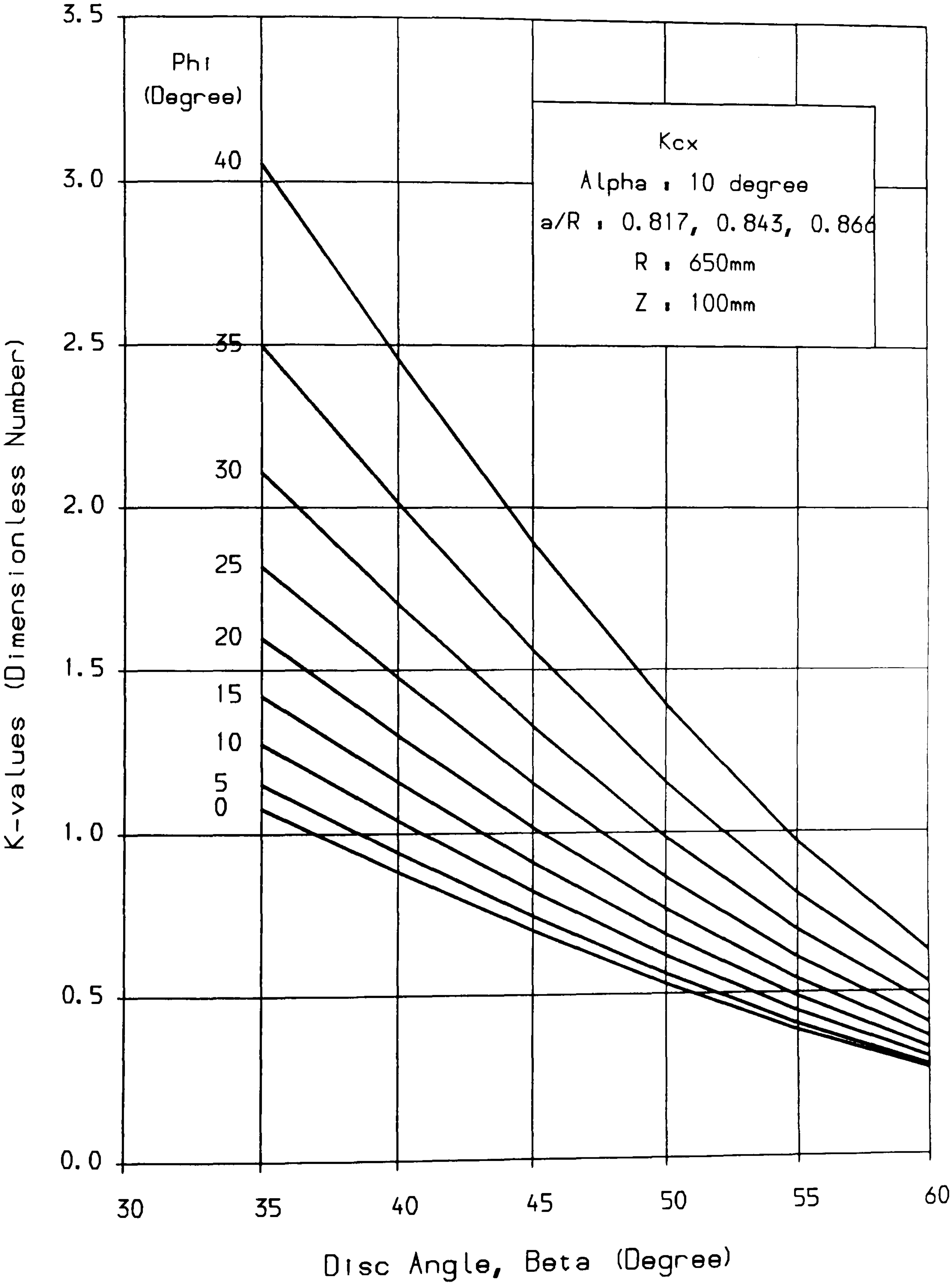

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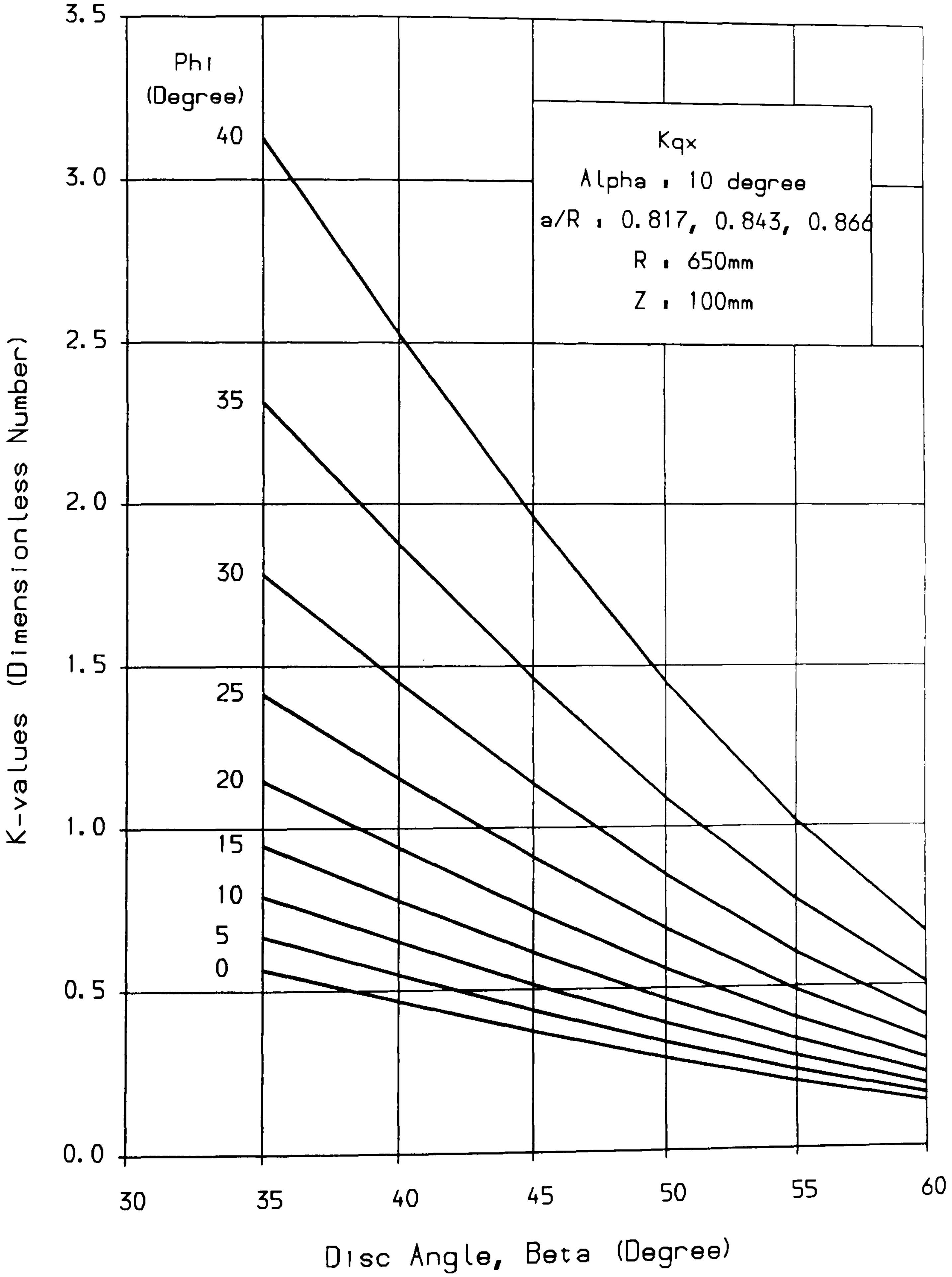

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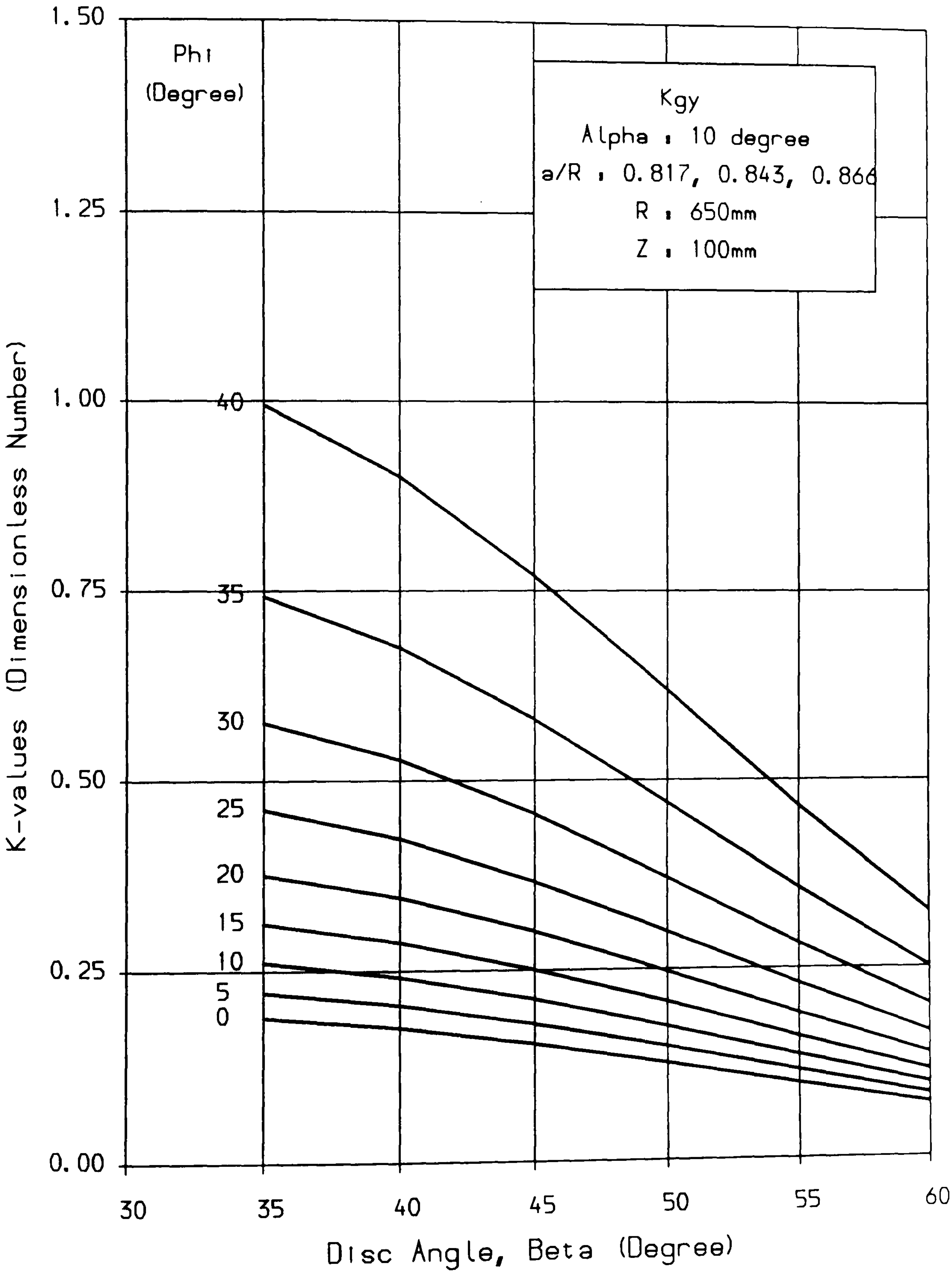

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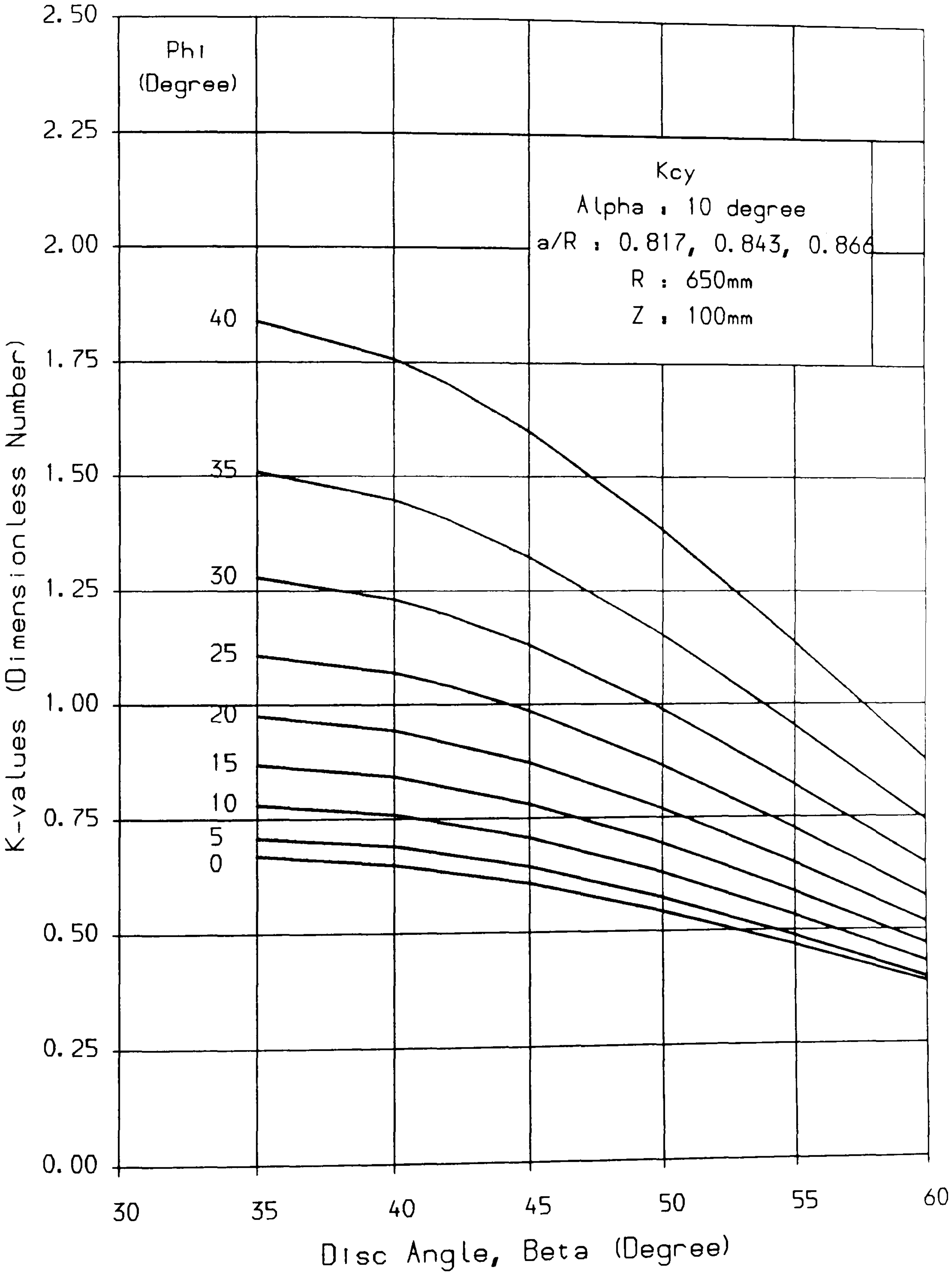

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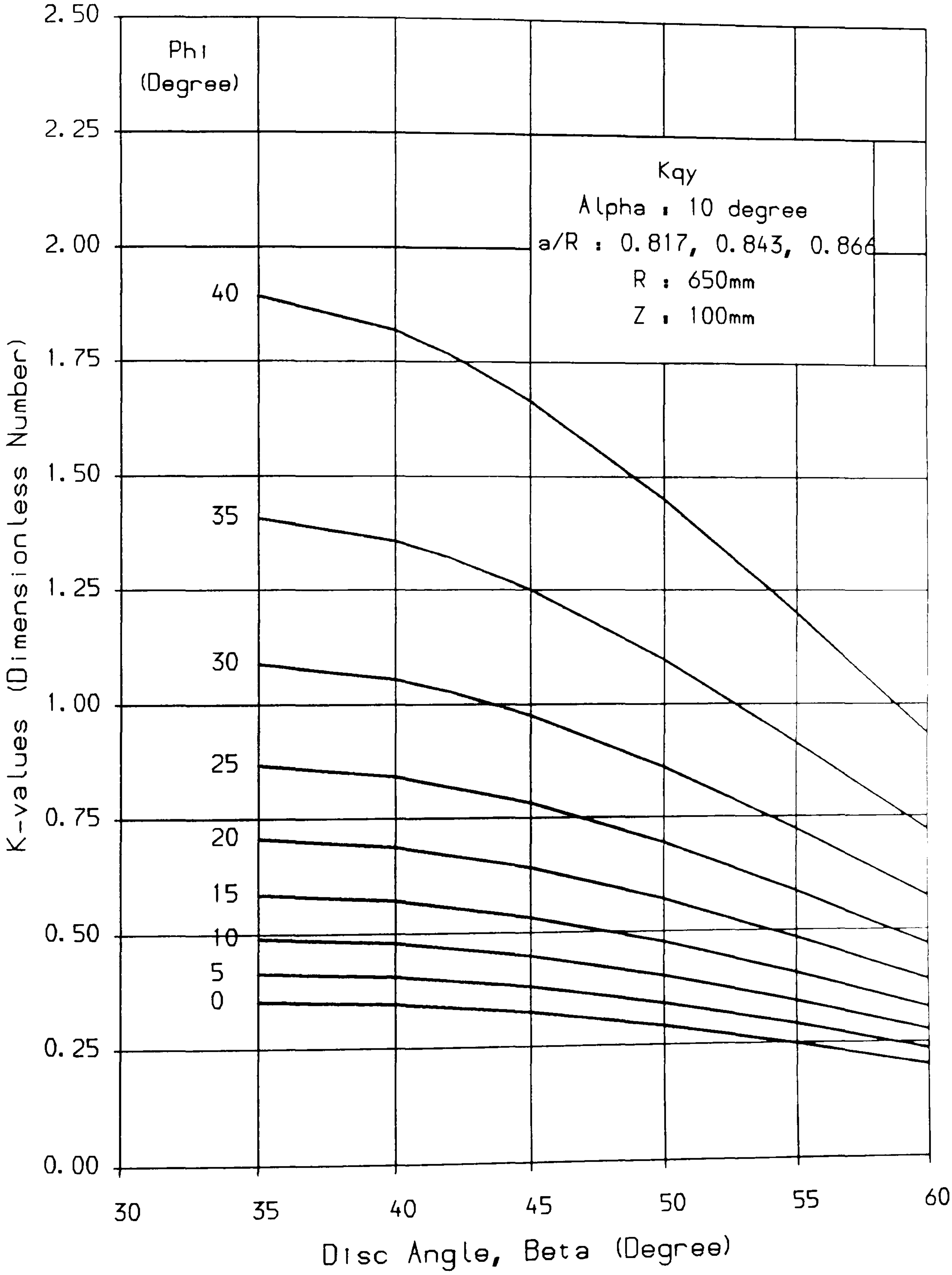

Chart 36. K-factor for Lateral Surcharge Force.

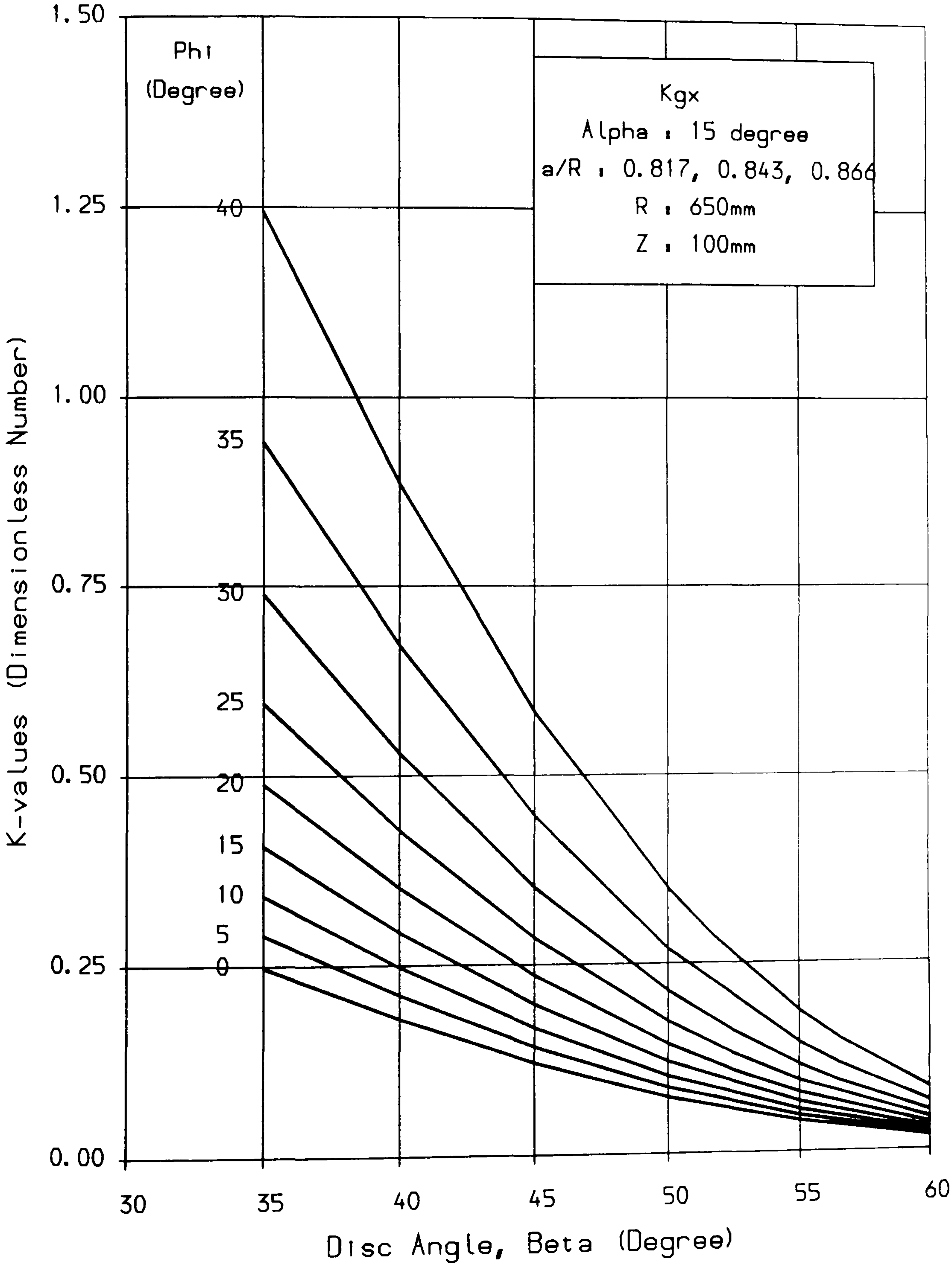

Chart 37. K-factor for Longitudinal Gravitation Force.

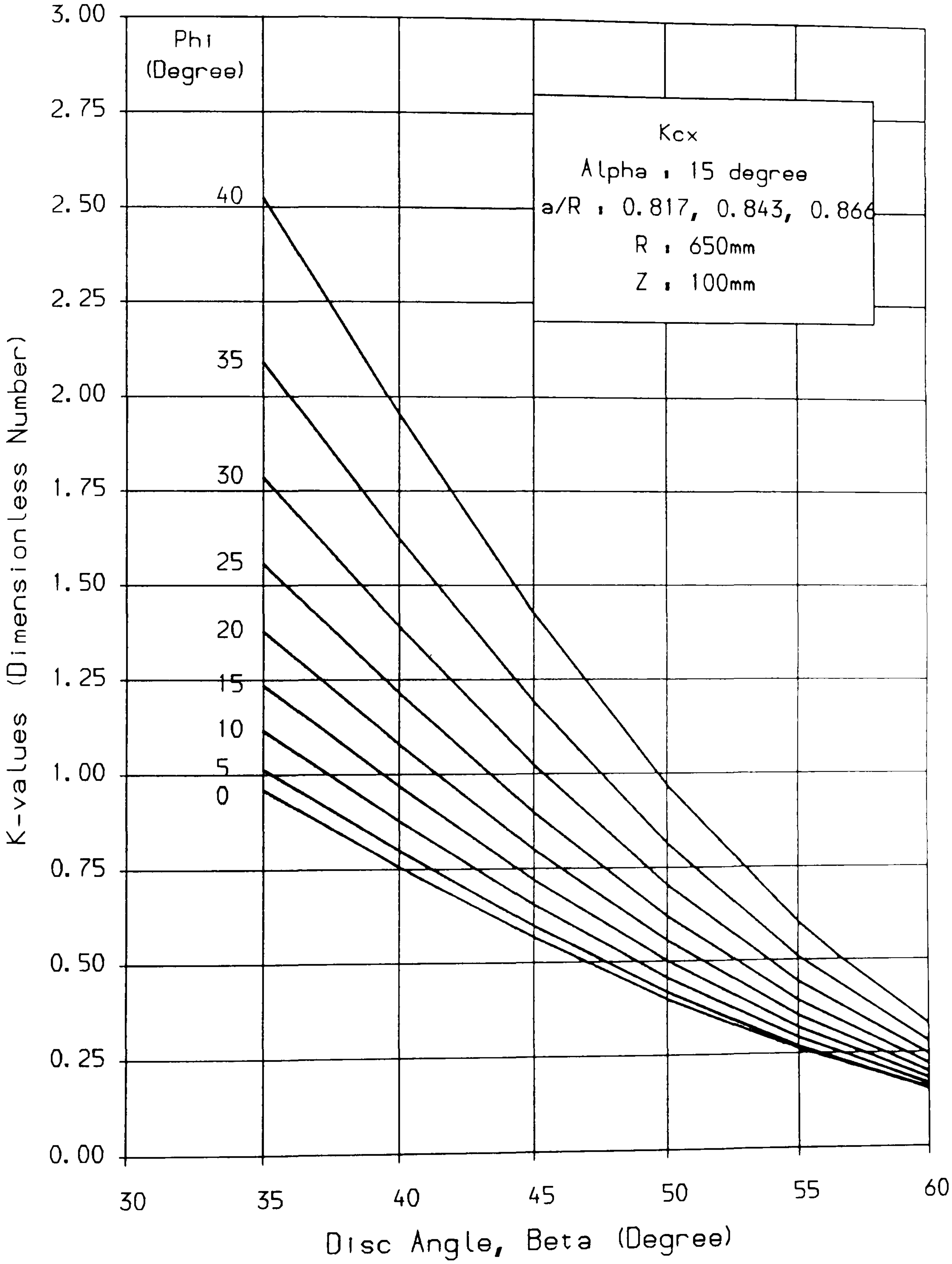

Chart 38. K-factor for Longitudinal Cohesive-Adhesive Force.

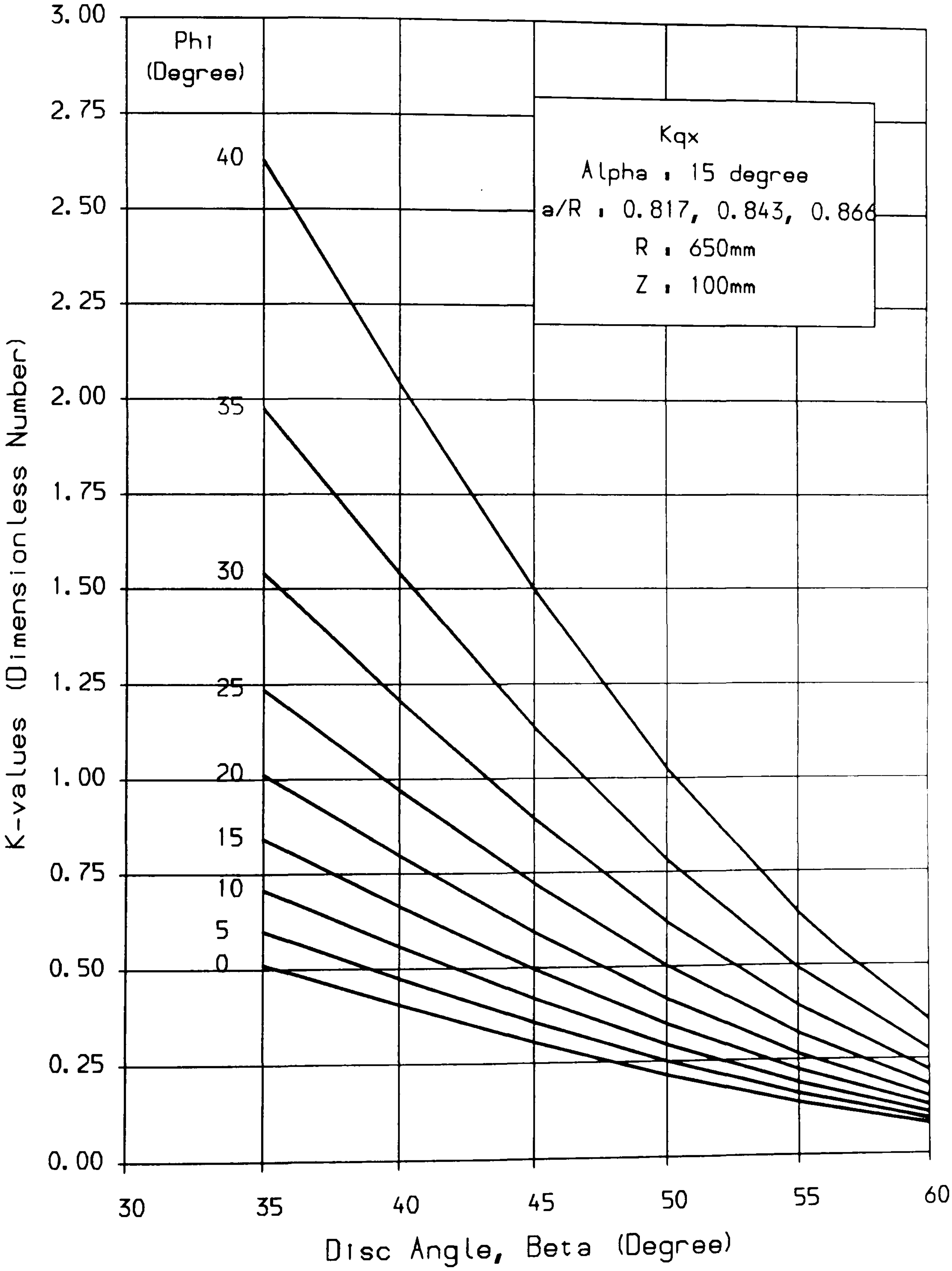

Chart 39. K-factor for Longitudinal Surcharge Force.

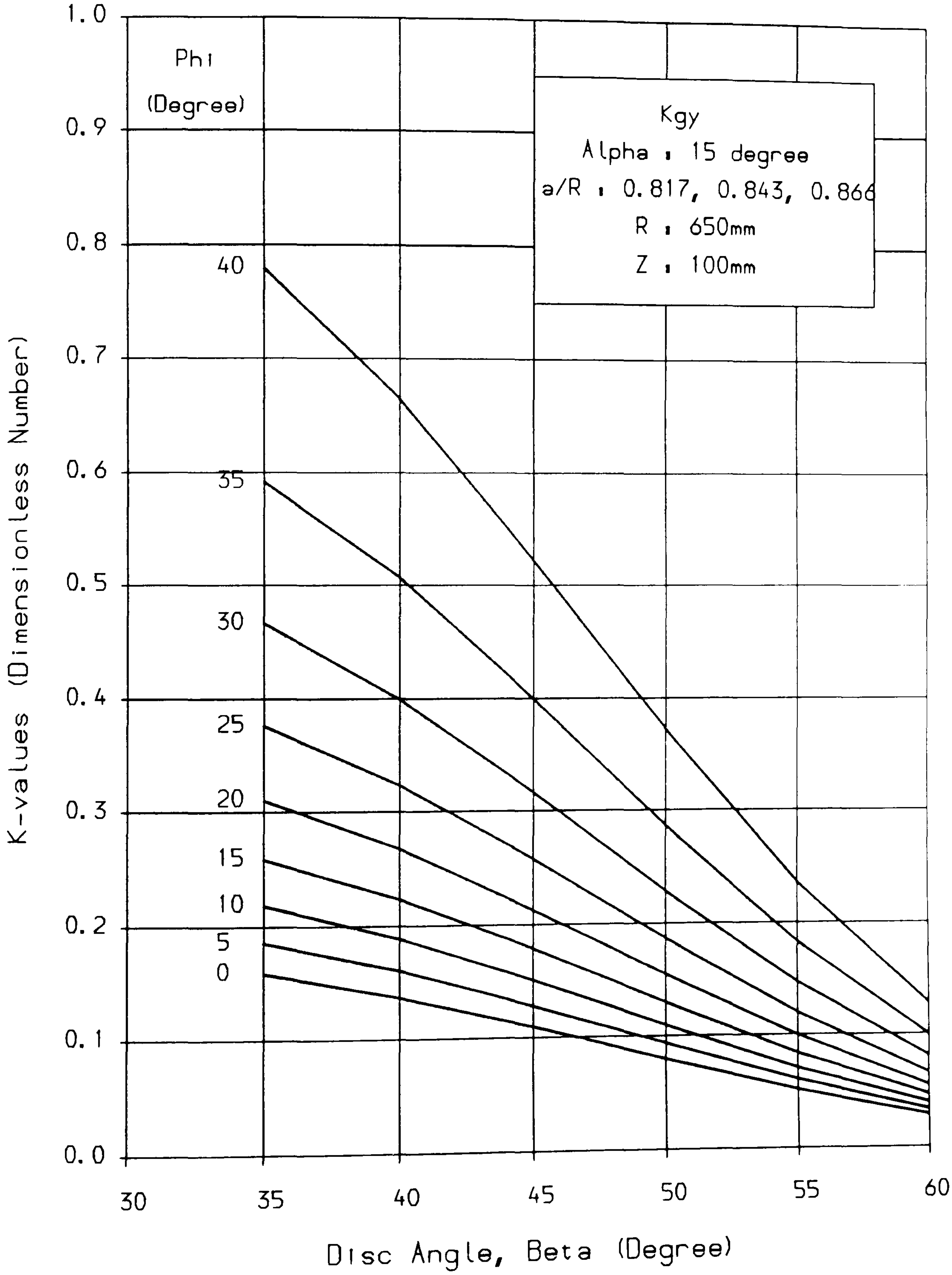

Chart 40. K-factor for Lateral Gravitation Force.

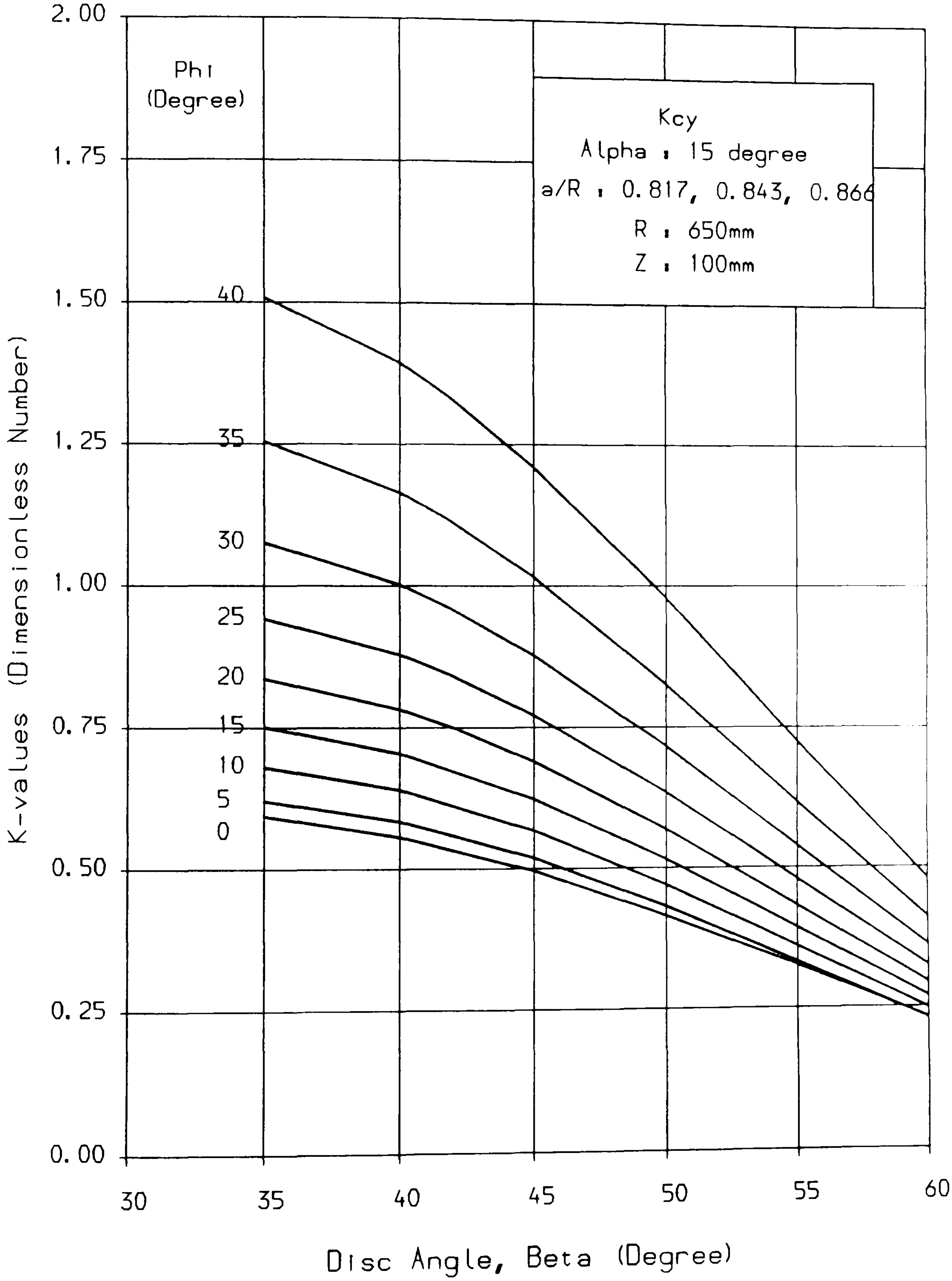

Chart 41. K-factor for Lateral Cohesive-Adhesive Force.

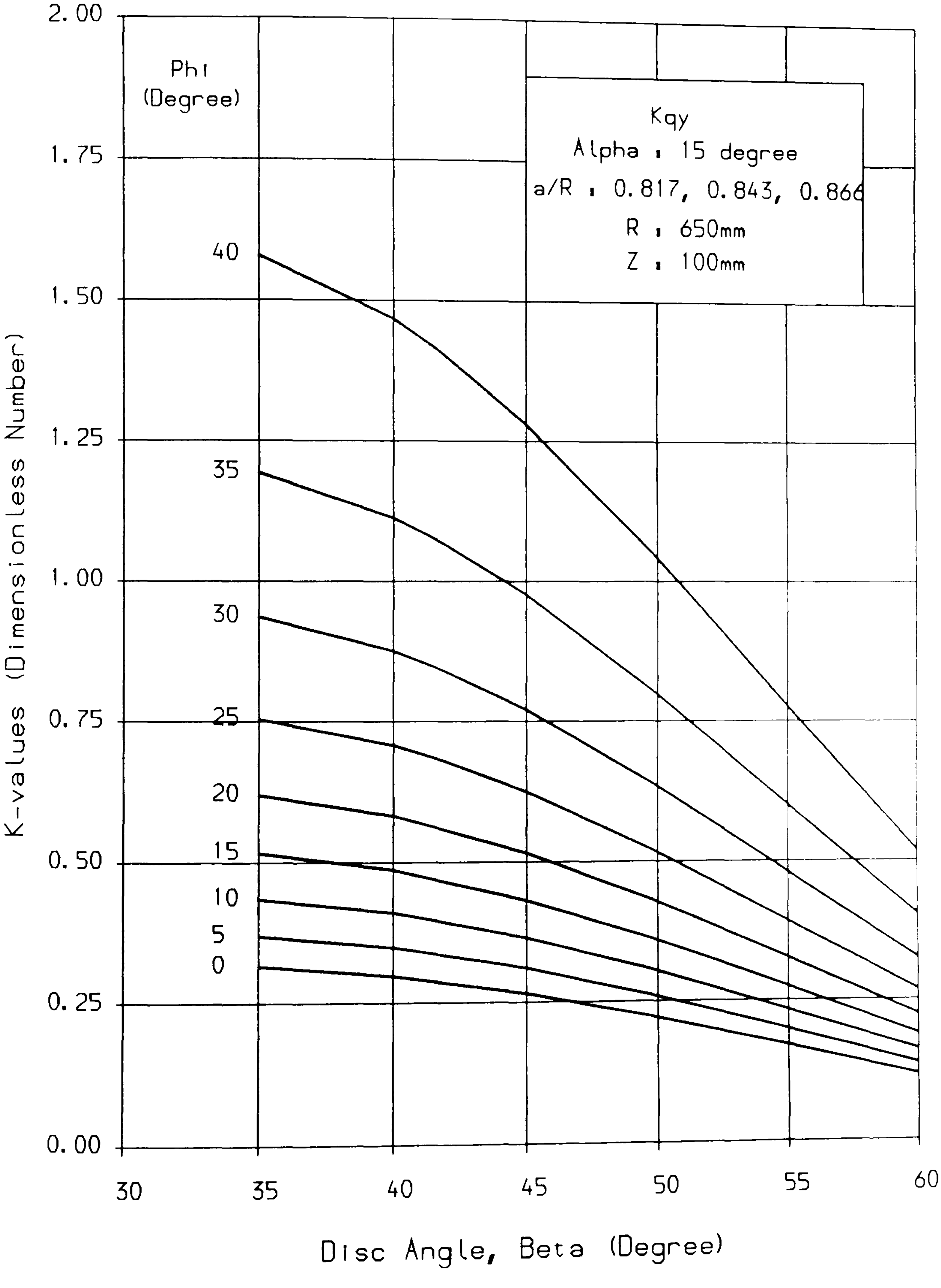

Chart 42. K-factor for Lateral Surcharge Force.

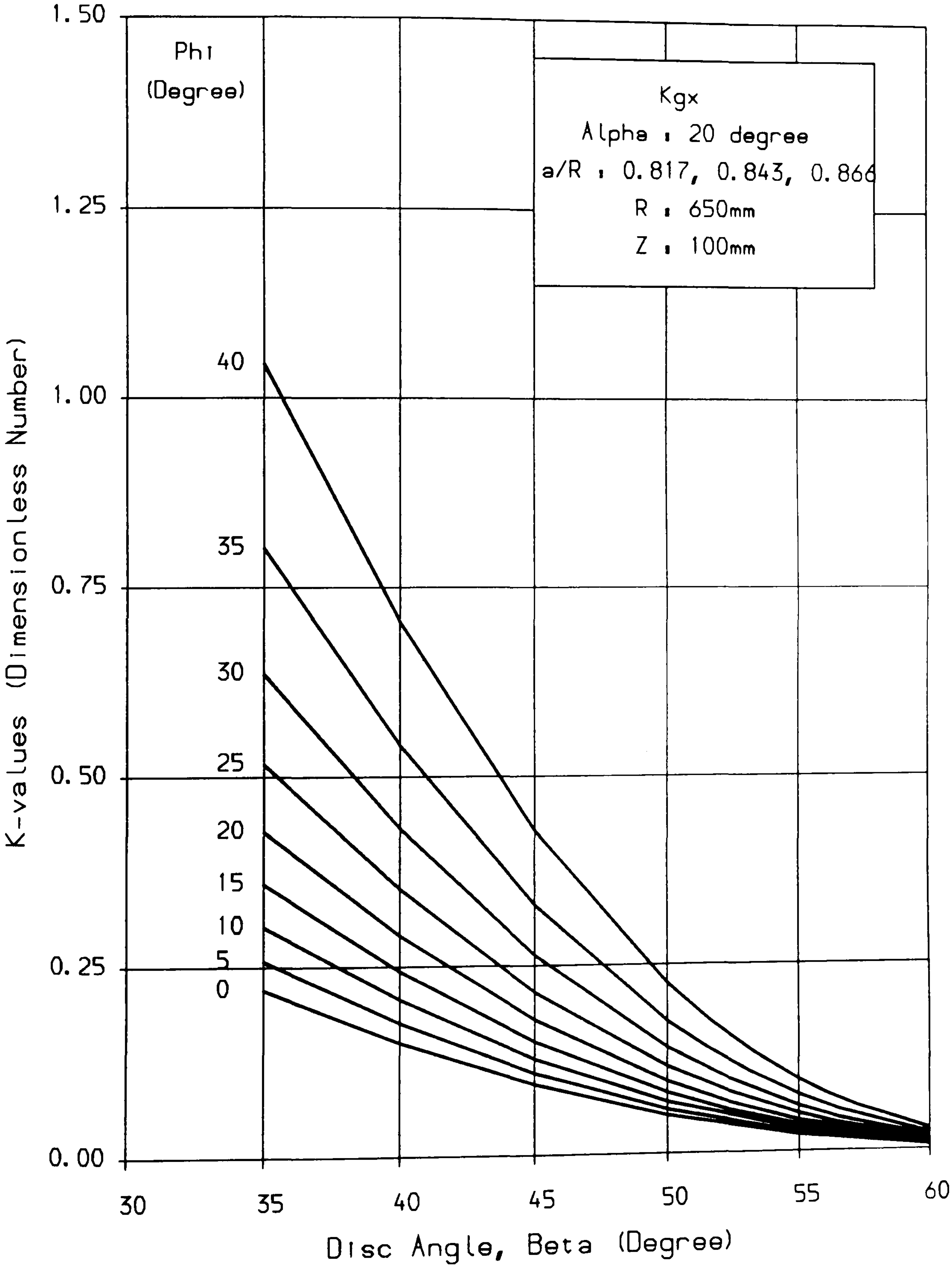

Chart 43. K-factor for Longitudinal Gravitation Force.

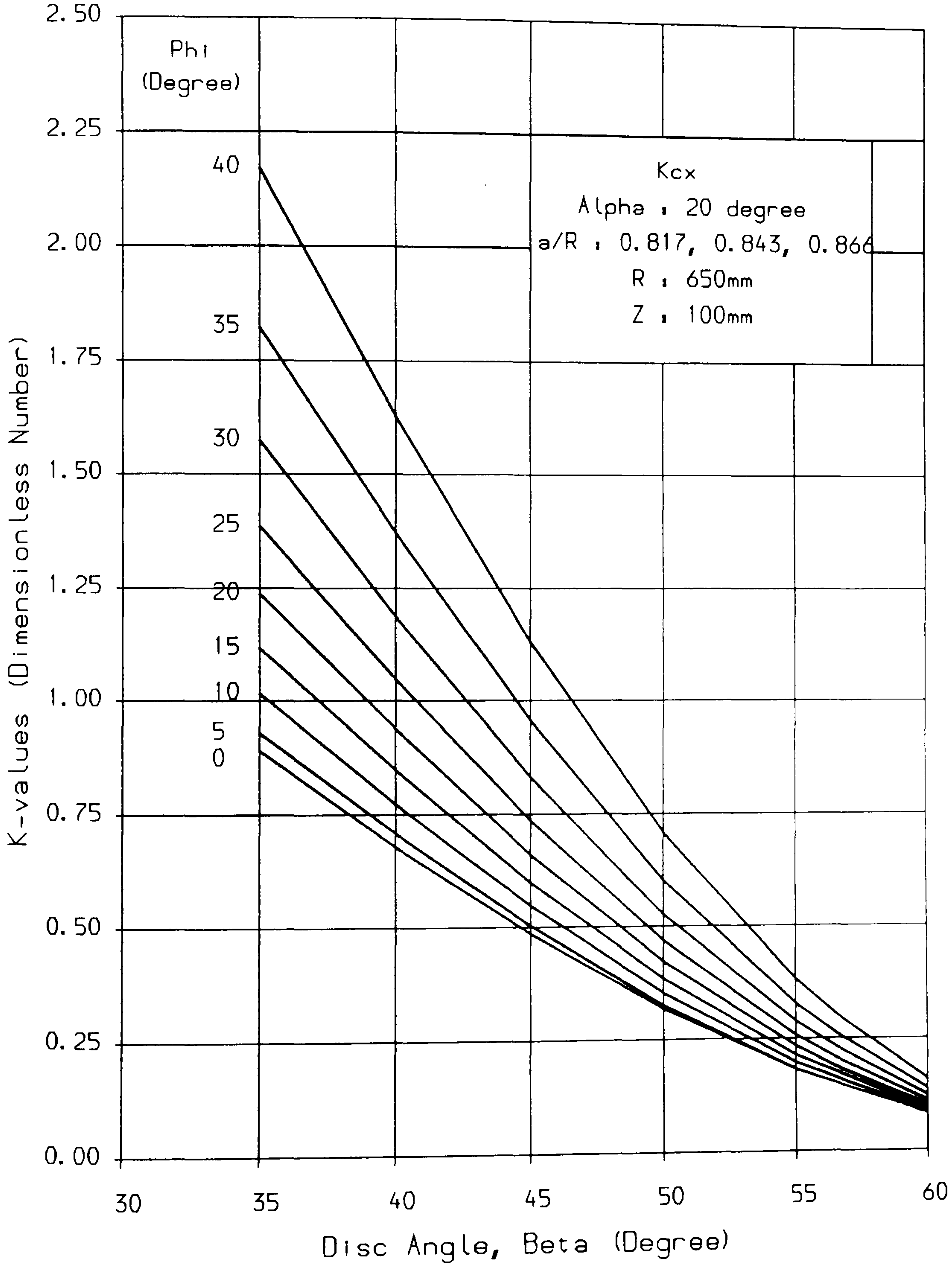

Chart 44. K-factor for Longitudinal Cohesive-Adhesive Force.

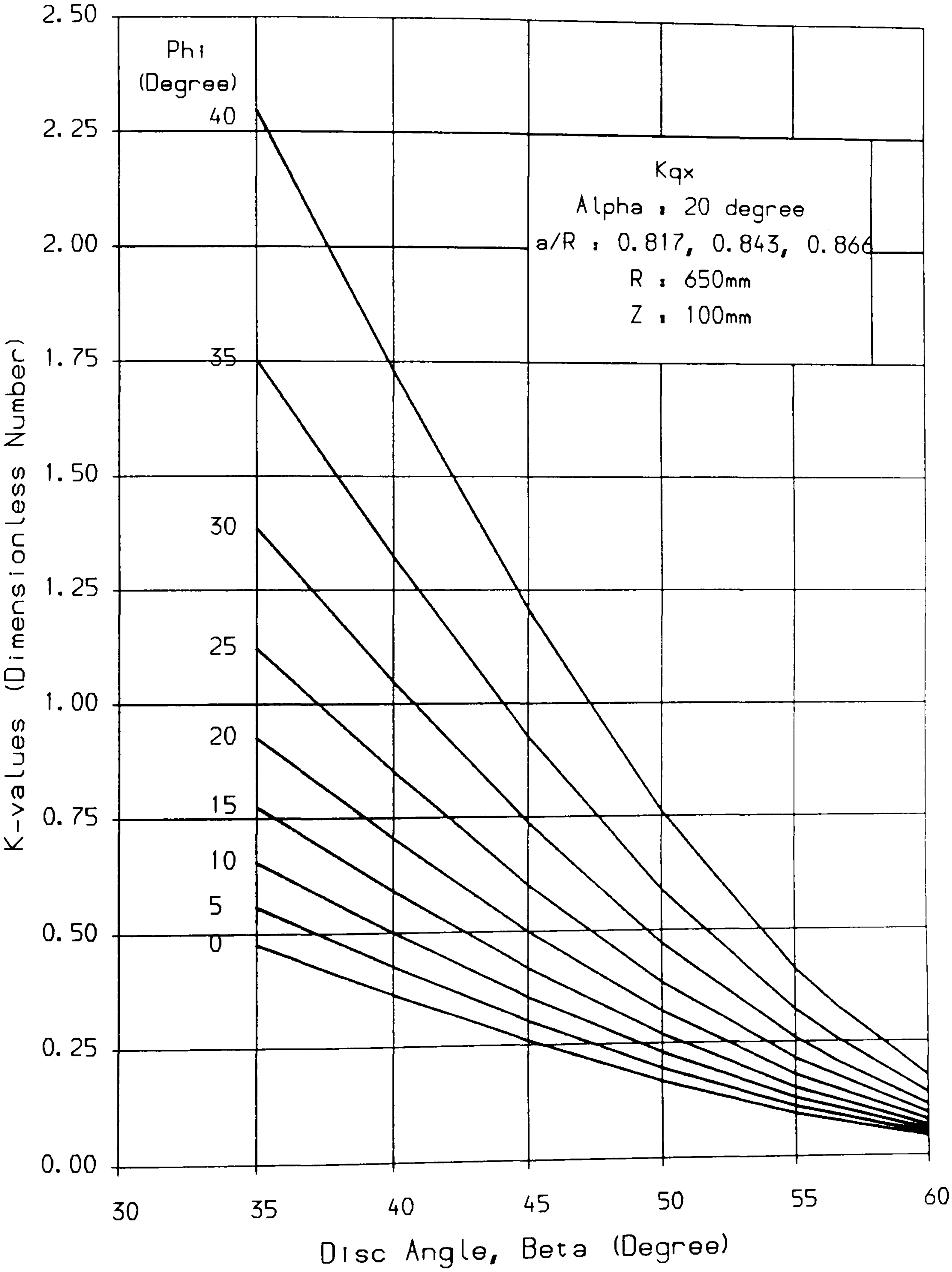

Chart 45. K-factor for Longitudinal Surcharge Force.

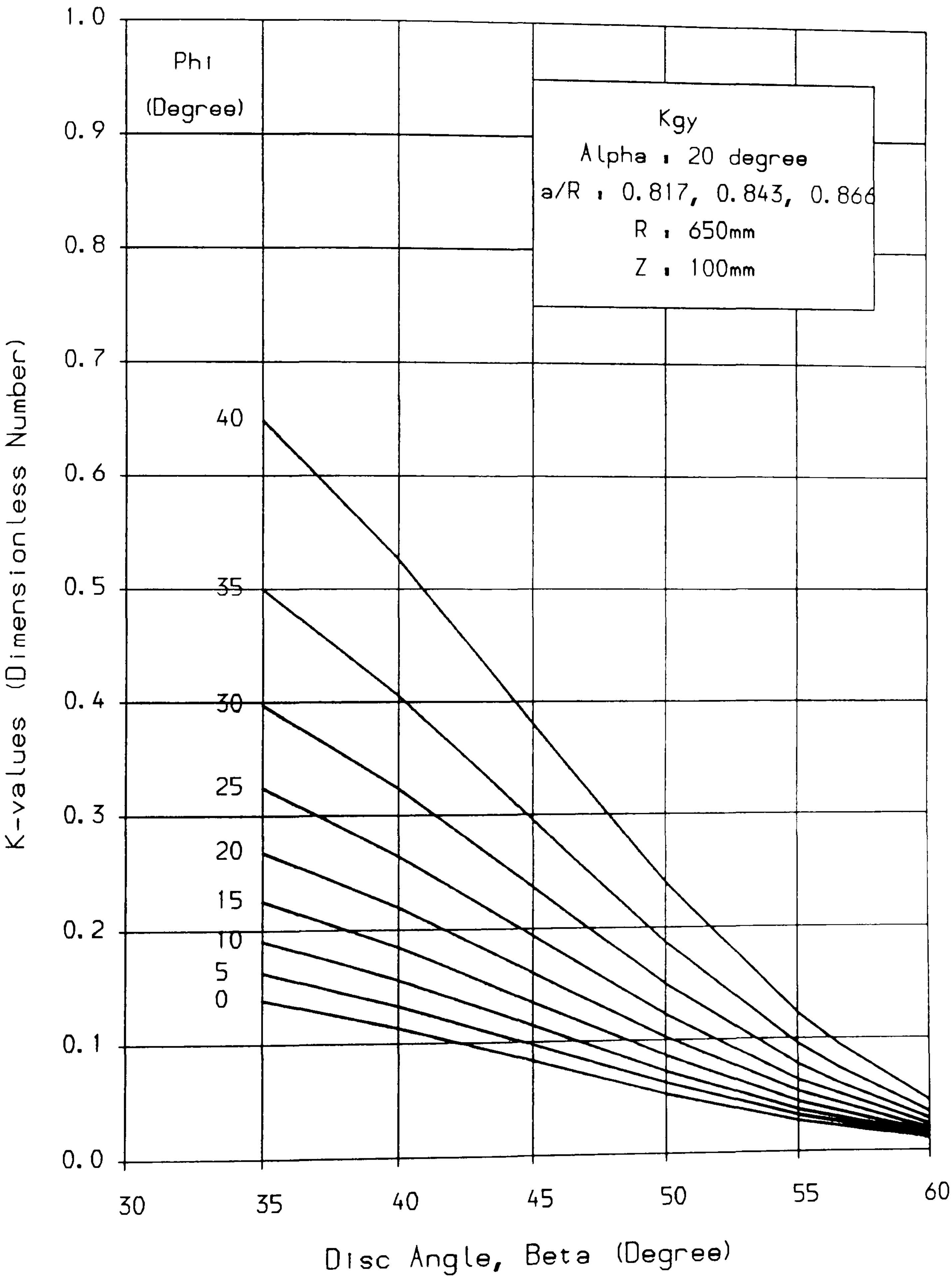

Chart 46. K-factor for Lateral Gravitation Force.

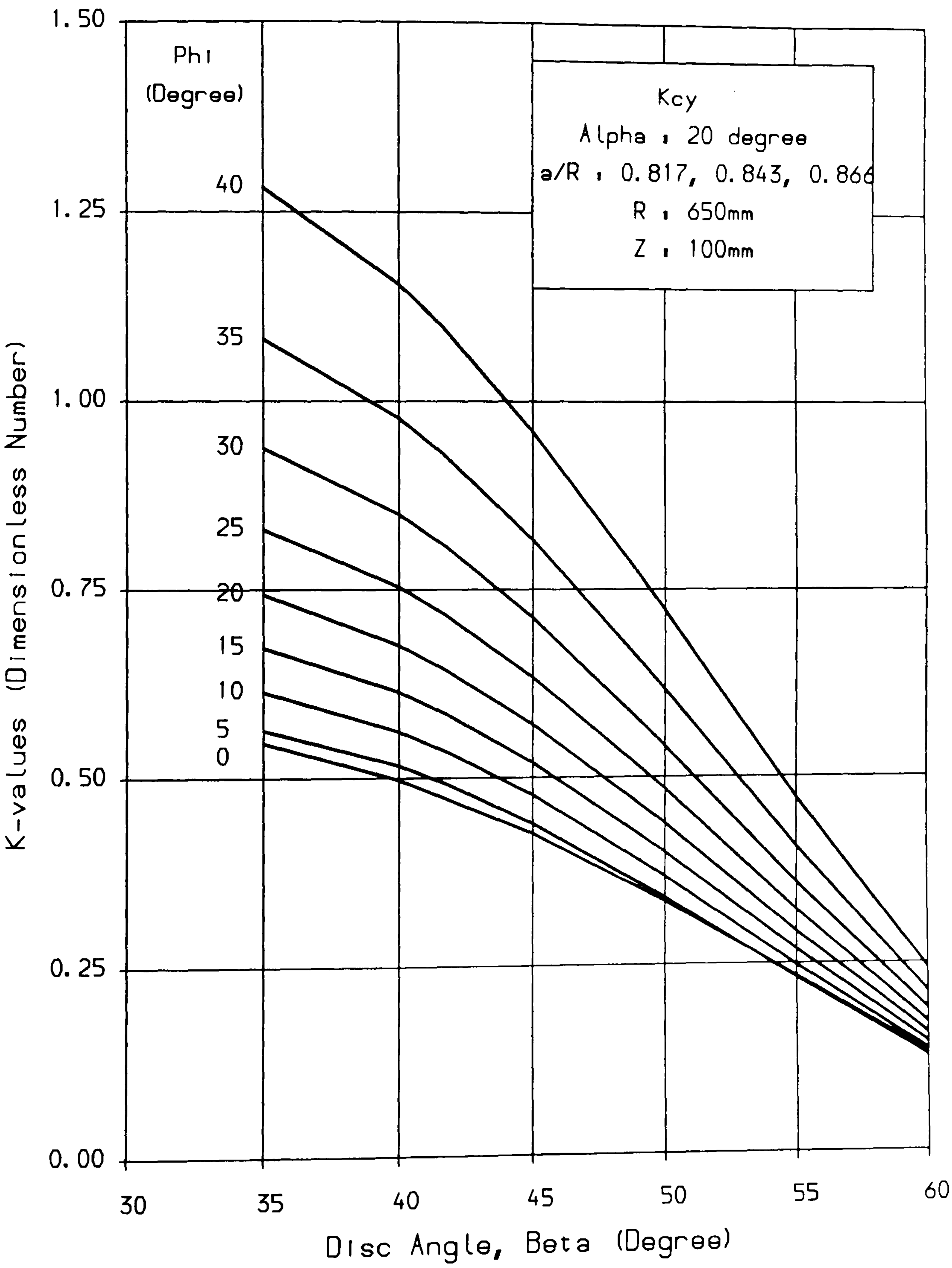

Chart 47. K-factor for Lateral Cohesive-Adhesive Force.

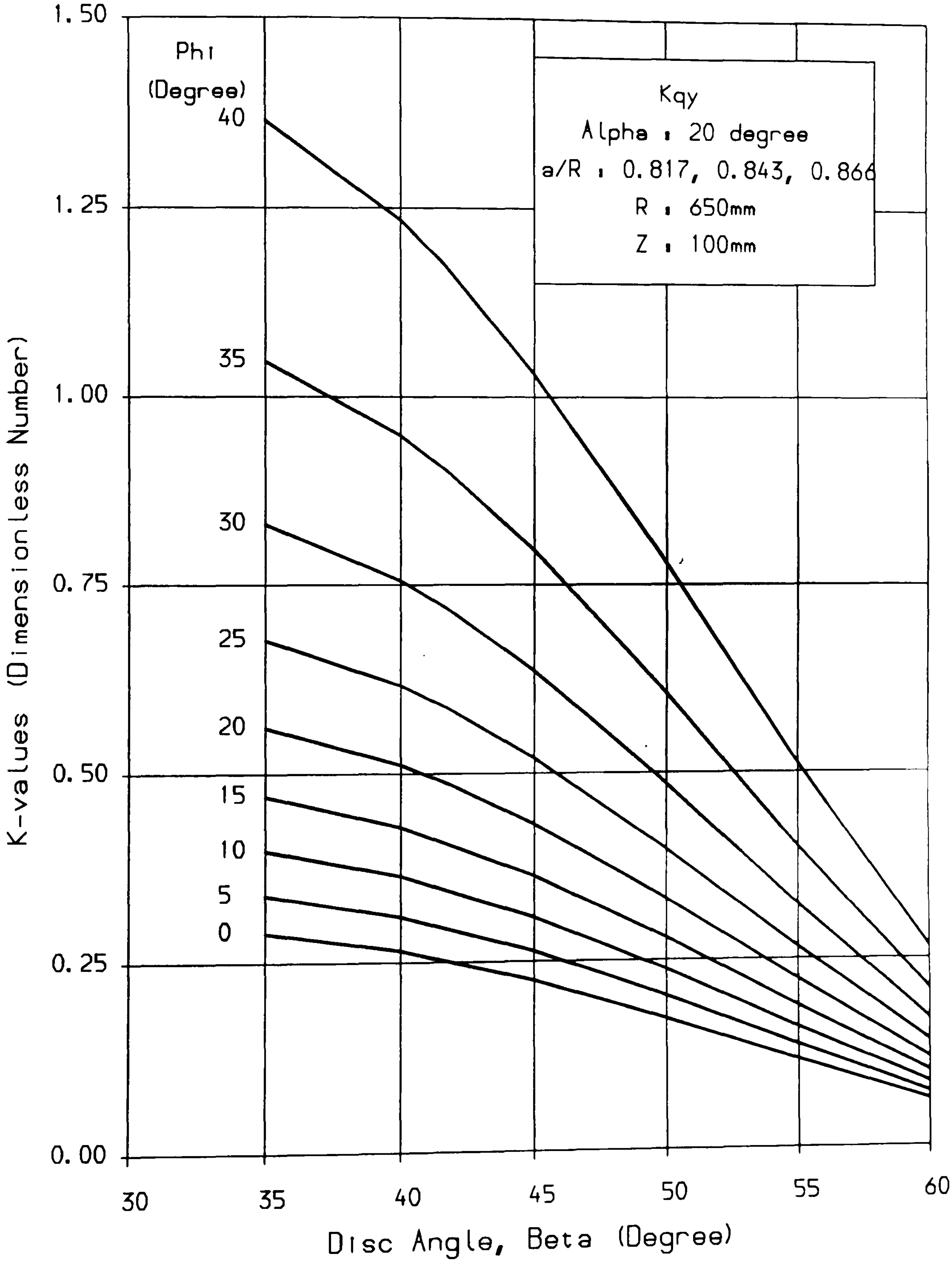

Chart 48. K-factor for Lateral Surcharge Force.

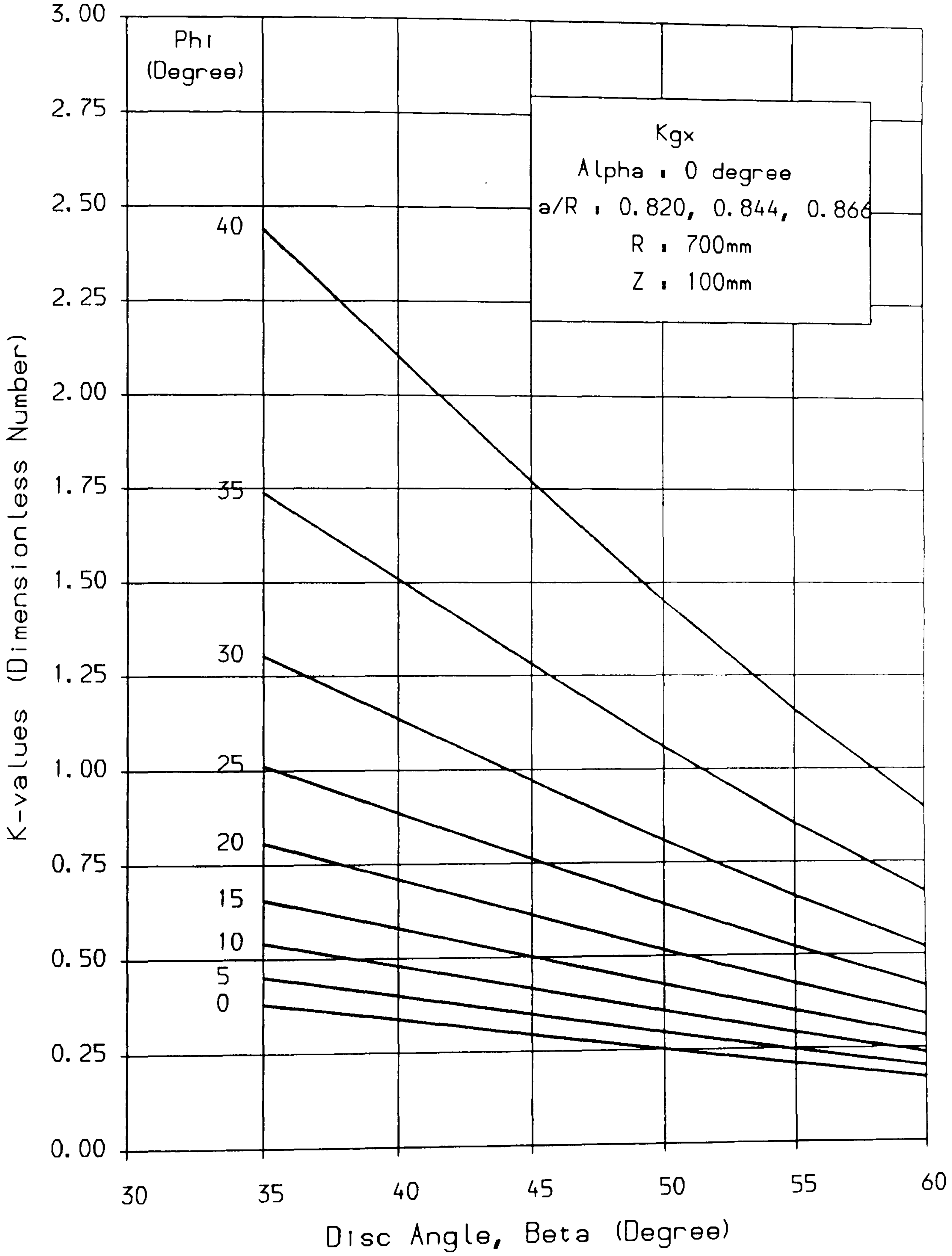

Chart 49. K-factor for Longitudinal Gravitation Force.

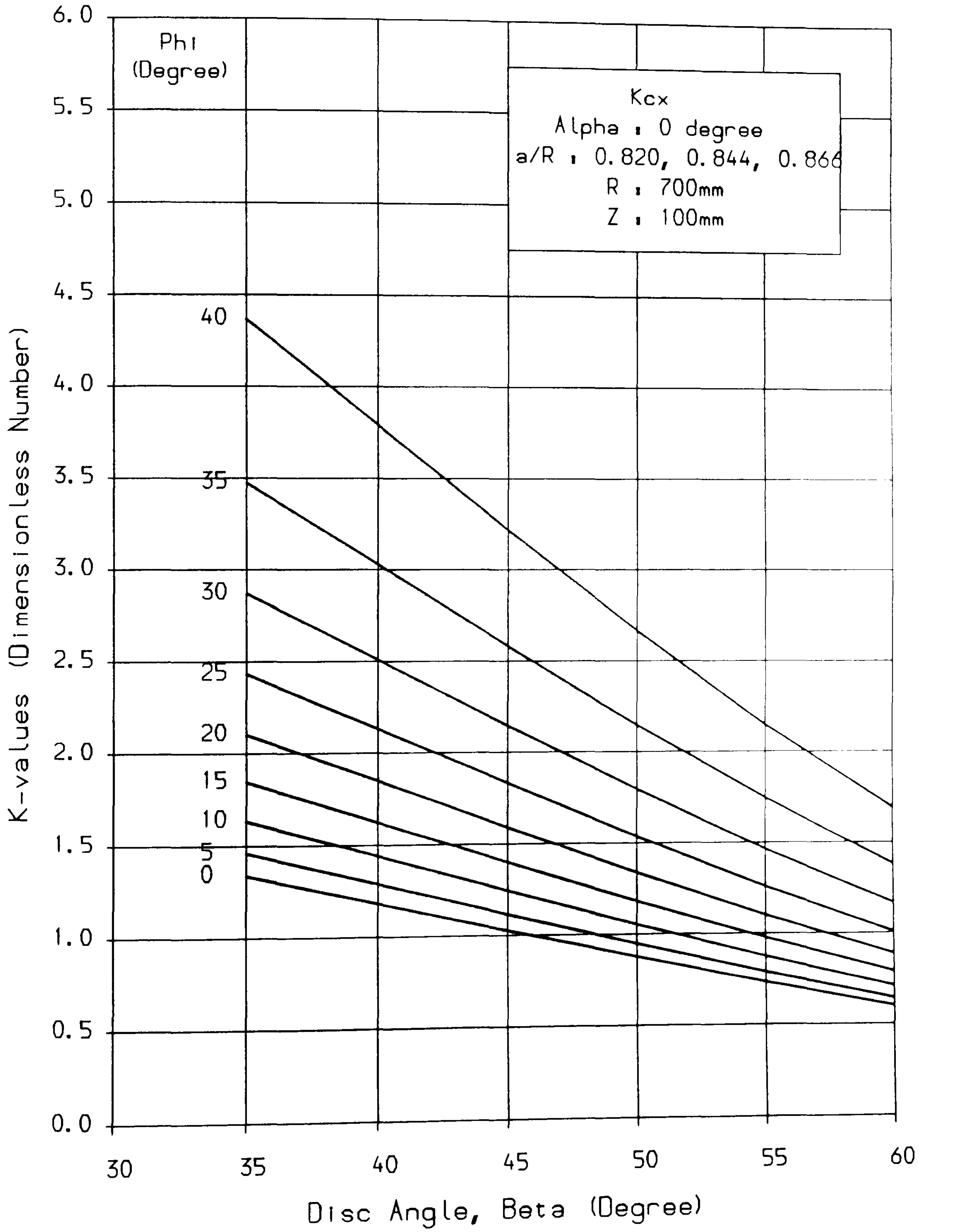

Chart 50. K-factor for Longitudinal Cohesive-Adhesive Force.

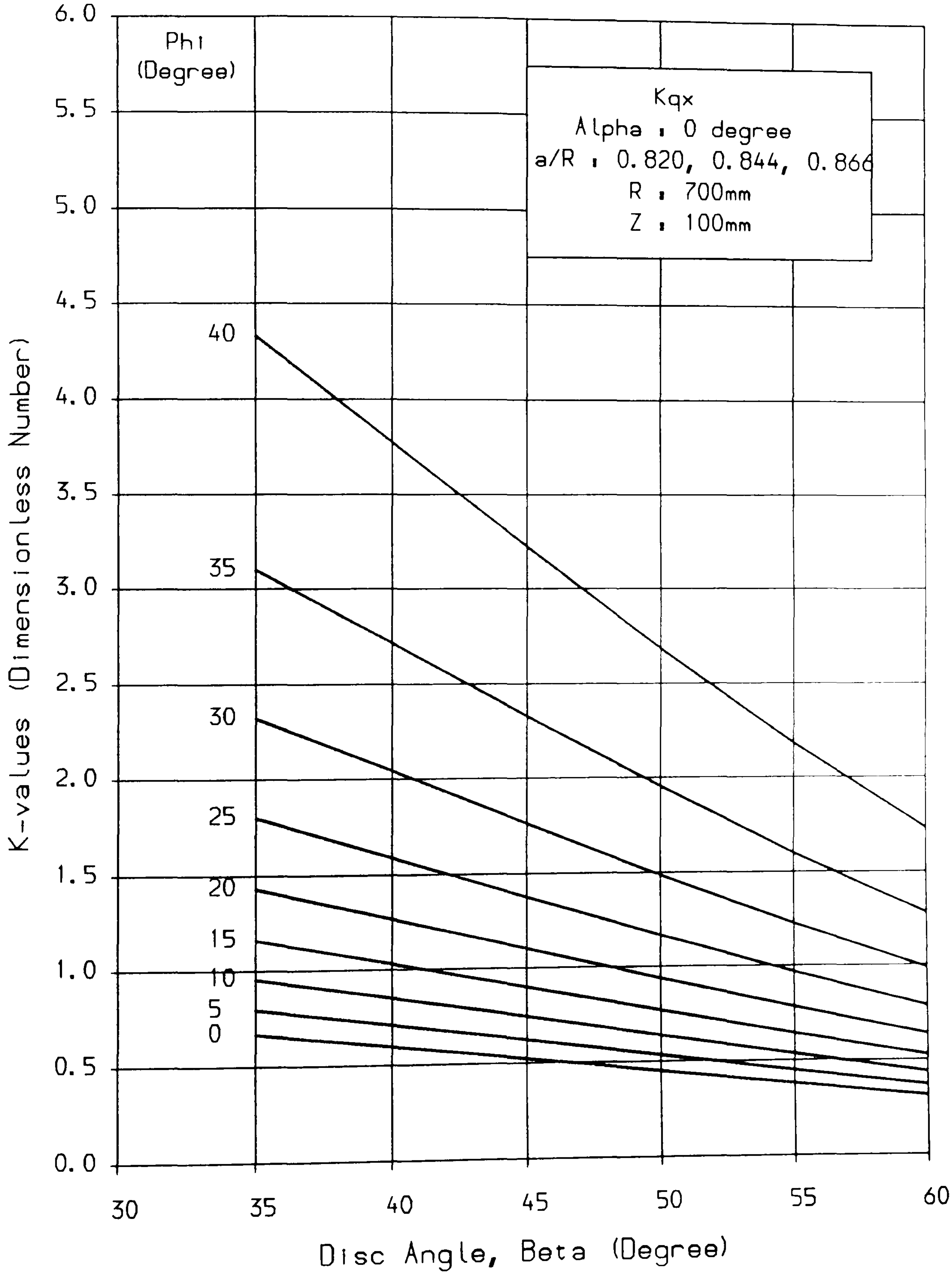

Chart 51. K-factor for Longitudinal Surcharge Force.

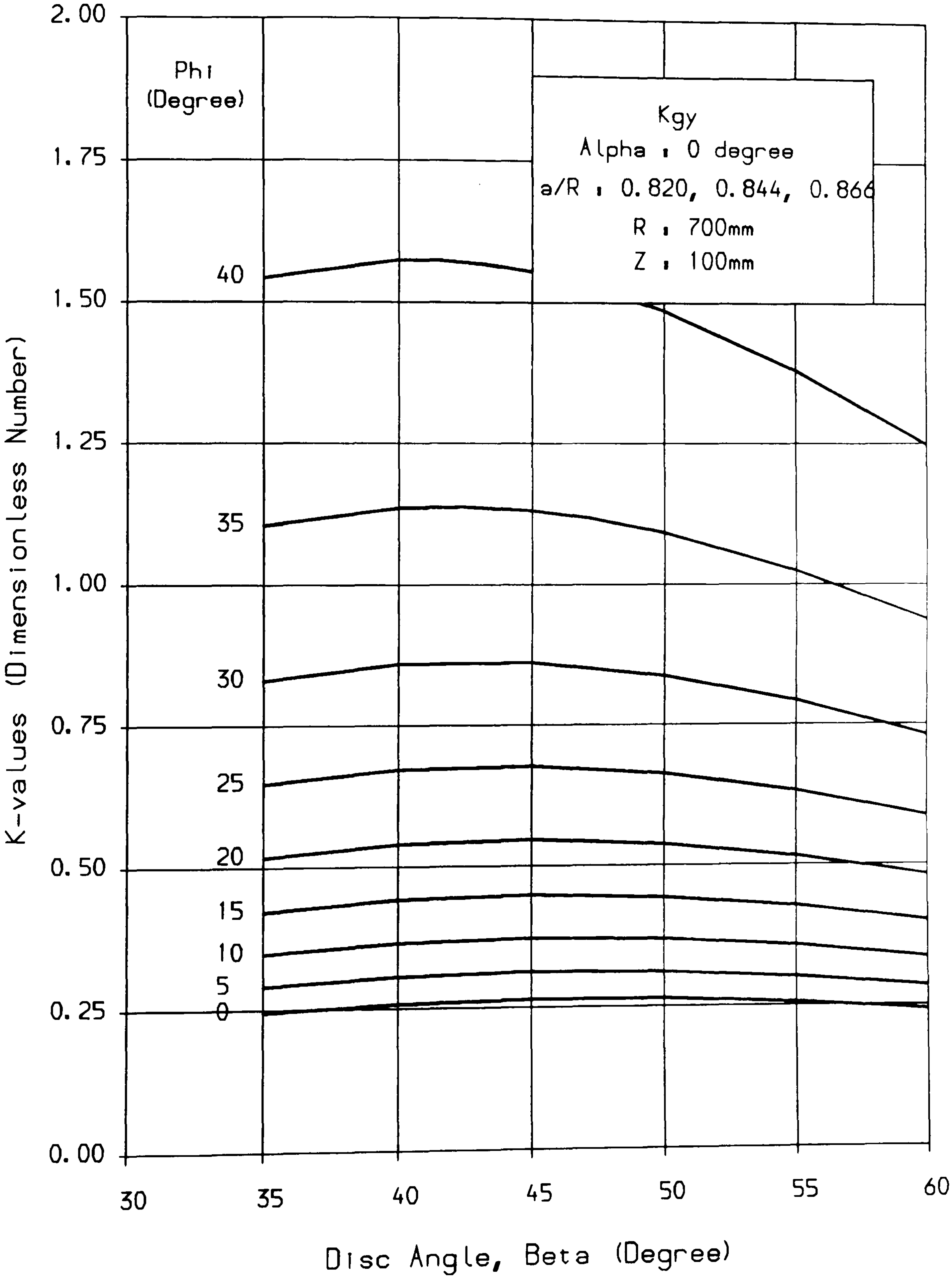

Chart 52. K-factor for Lateral Gravitation Force.

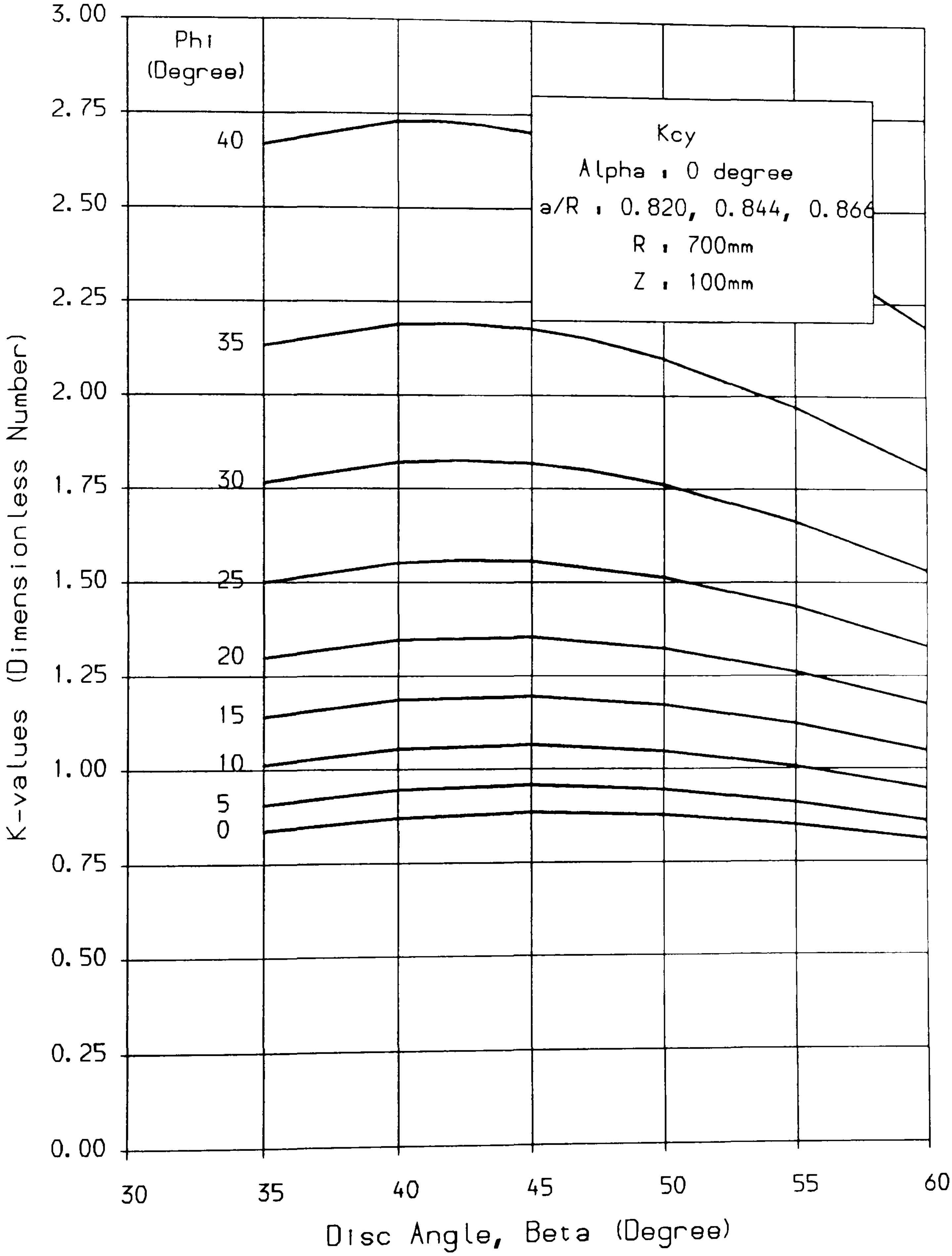

Chart 53. K-factor for Lateral Cohesive-Adhesive Force.

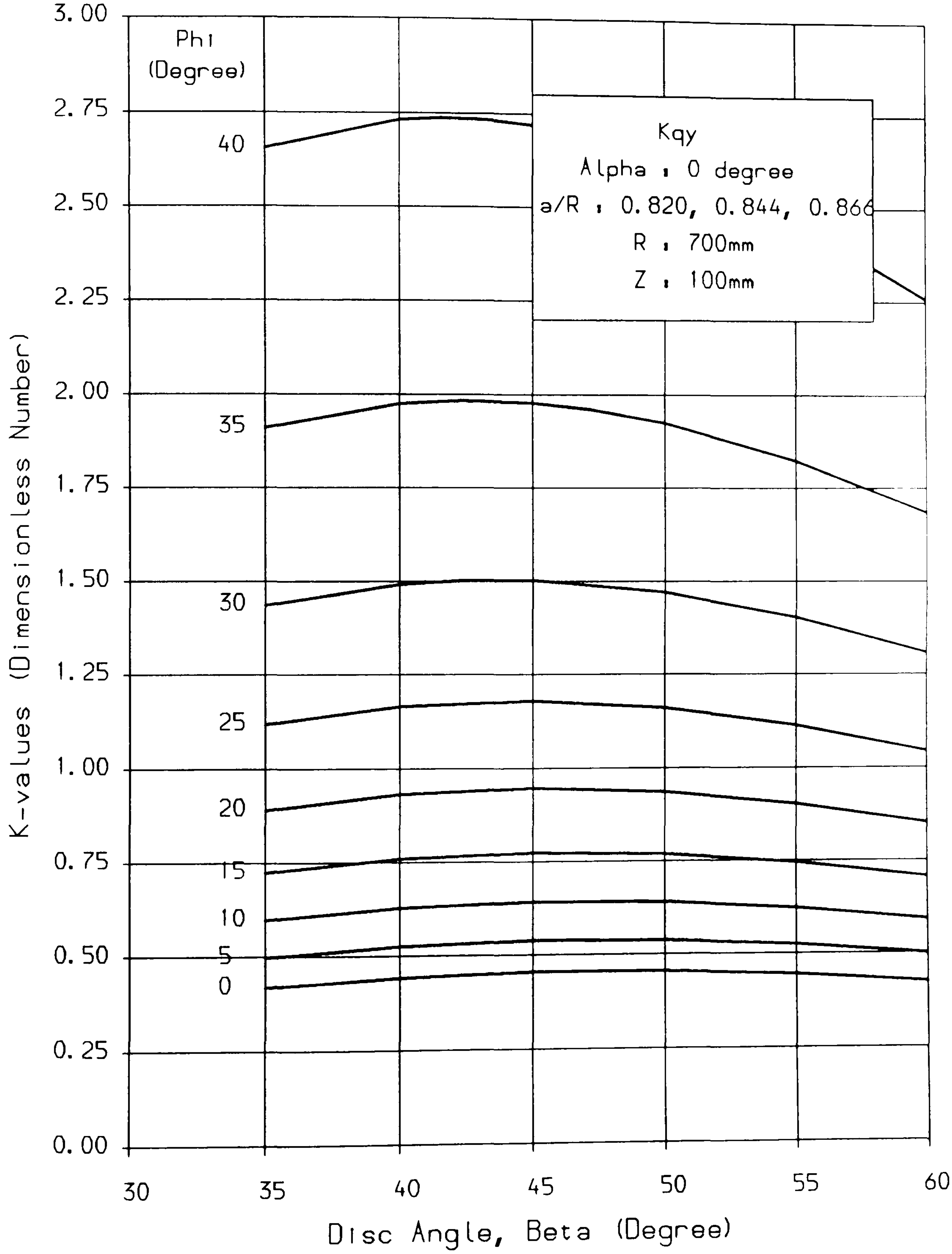

Chart 54. K-factor for Lateral Surcharge Force.

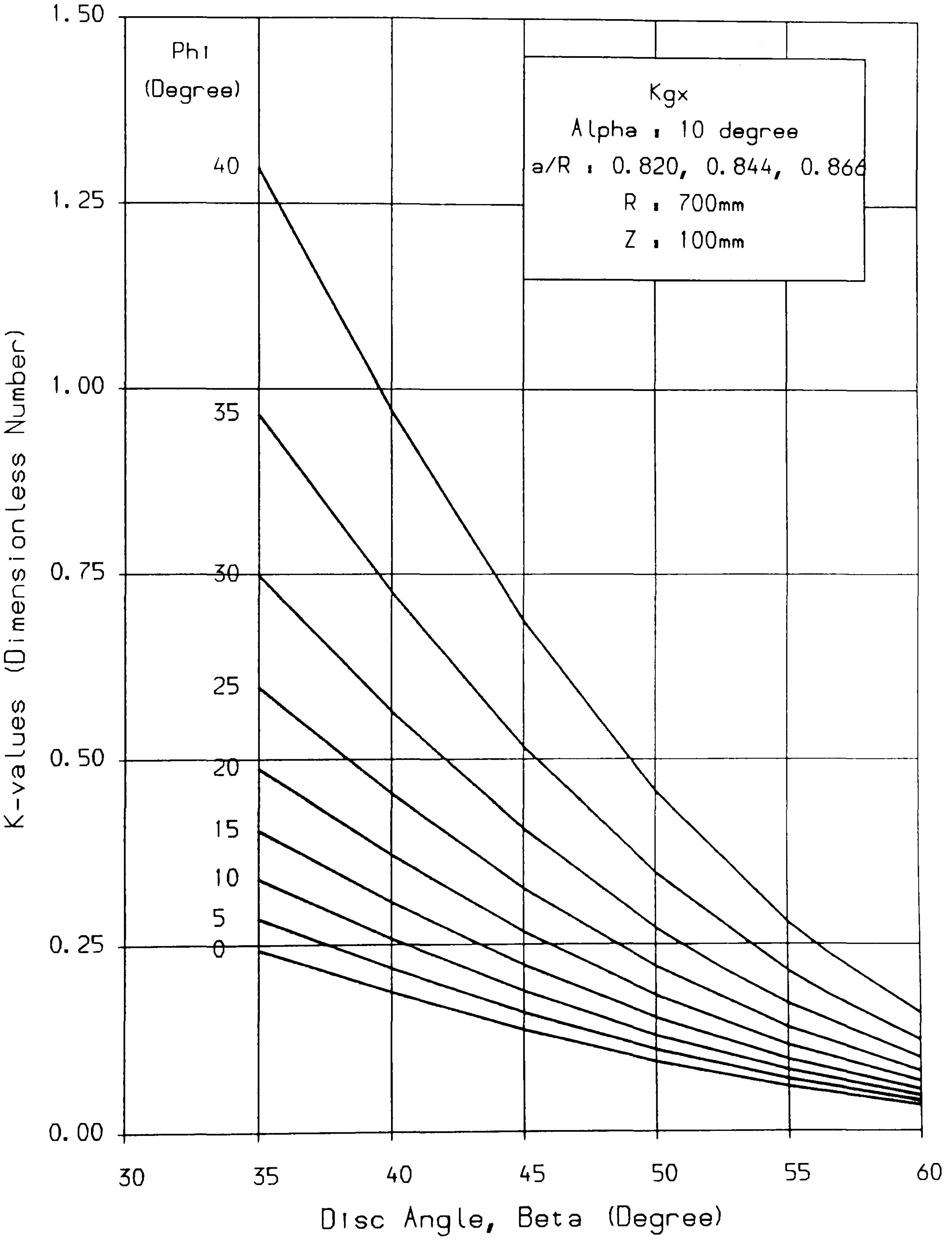

Chart 55. K-factor for Longitudinal Gravitation Force.

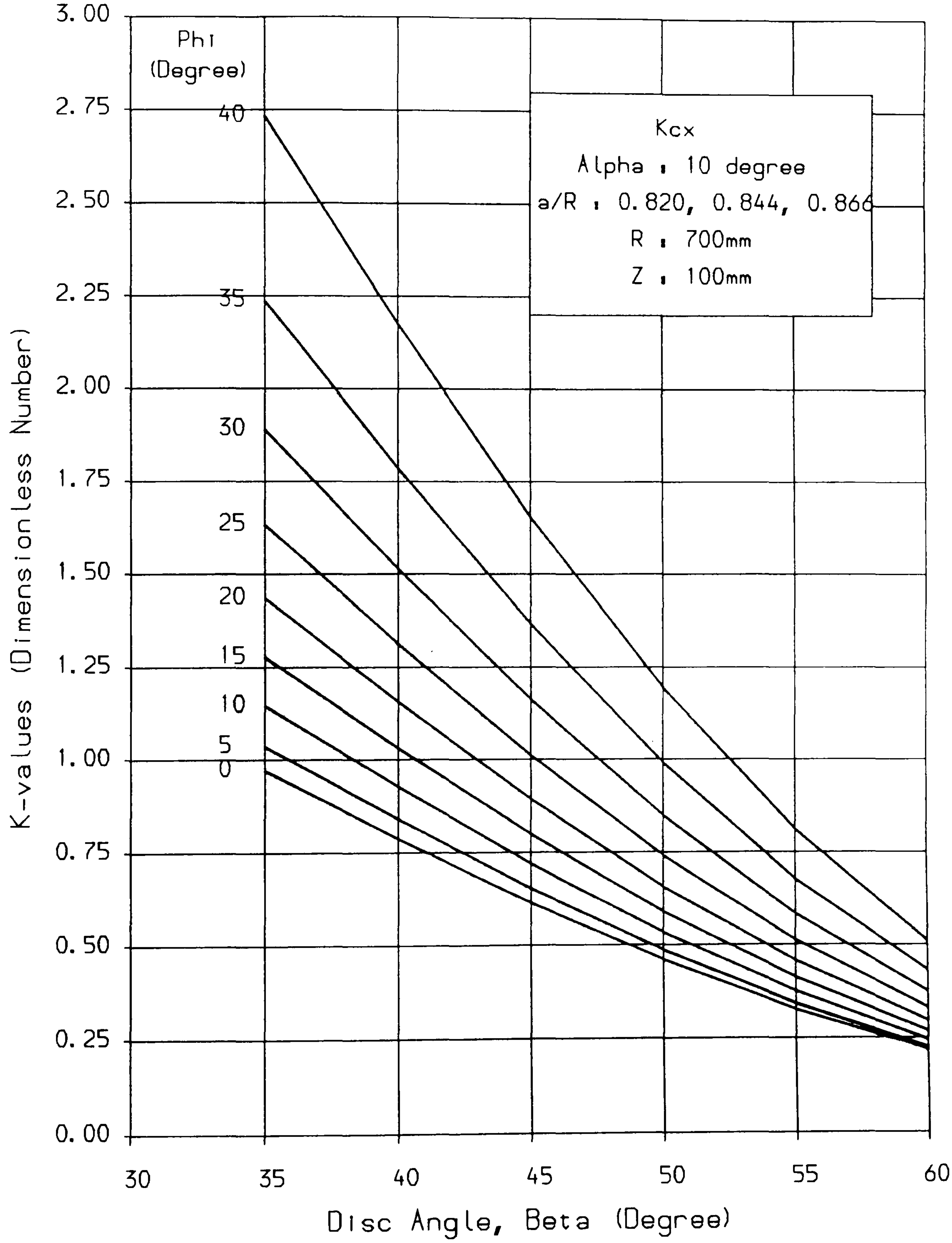

Chart 56. K-factor for Longitudinal Cohesive-Adhesive Force.

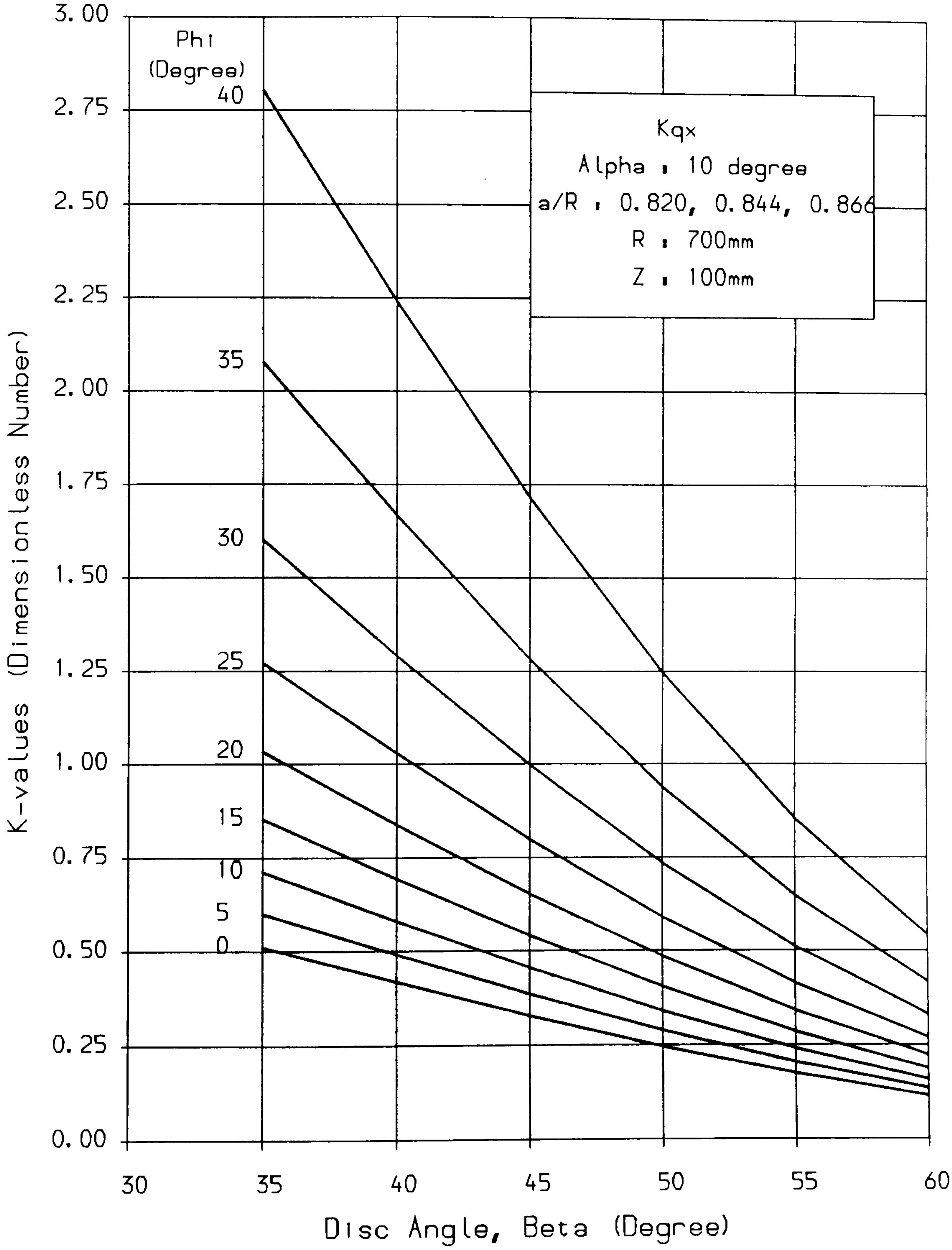

Chart 57. K-factor for Longitudinal Surcharge Force.

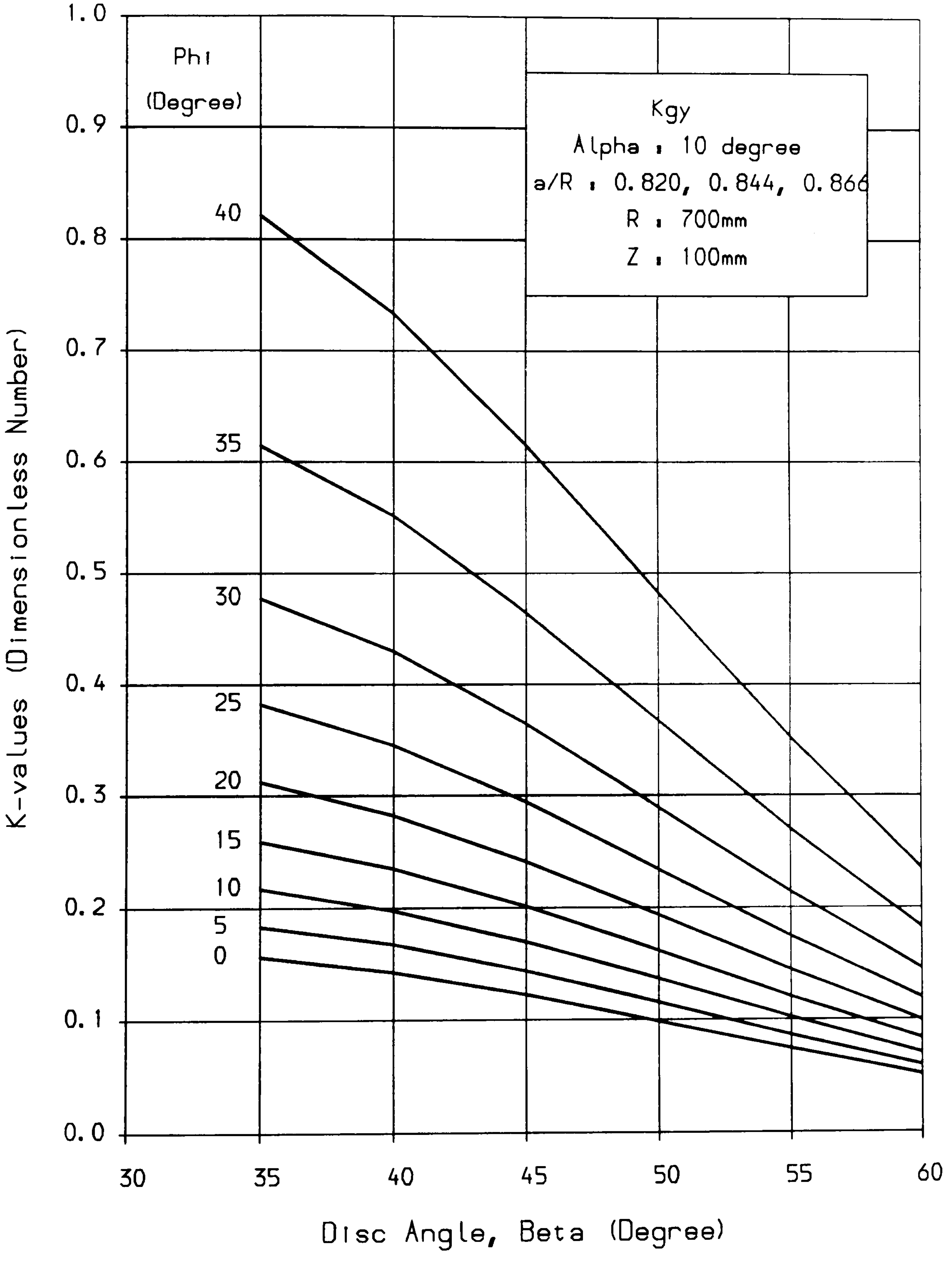

Chart 58. K-factor for Lateral Gravitation Force.

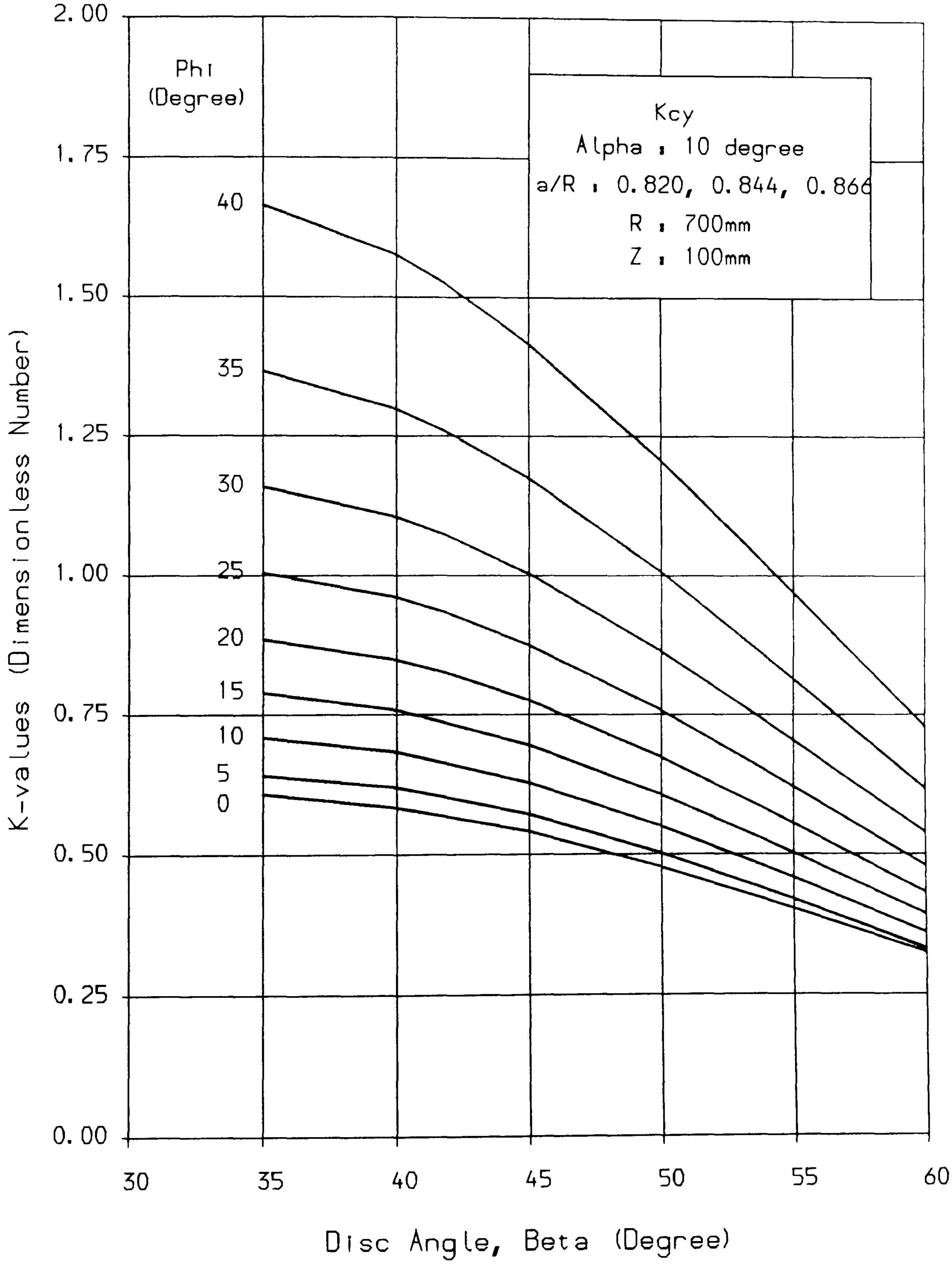

Chart 59. K-factor for Lateral Cohesive-Adhesive Force.

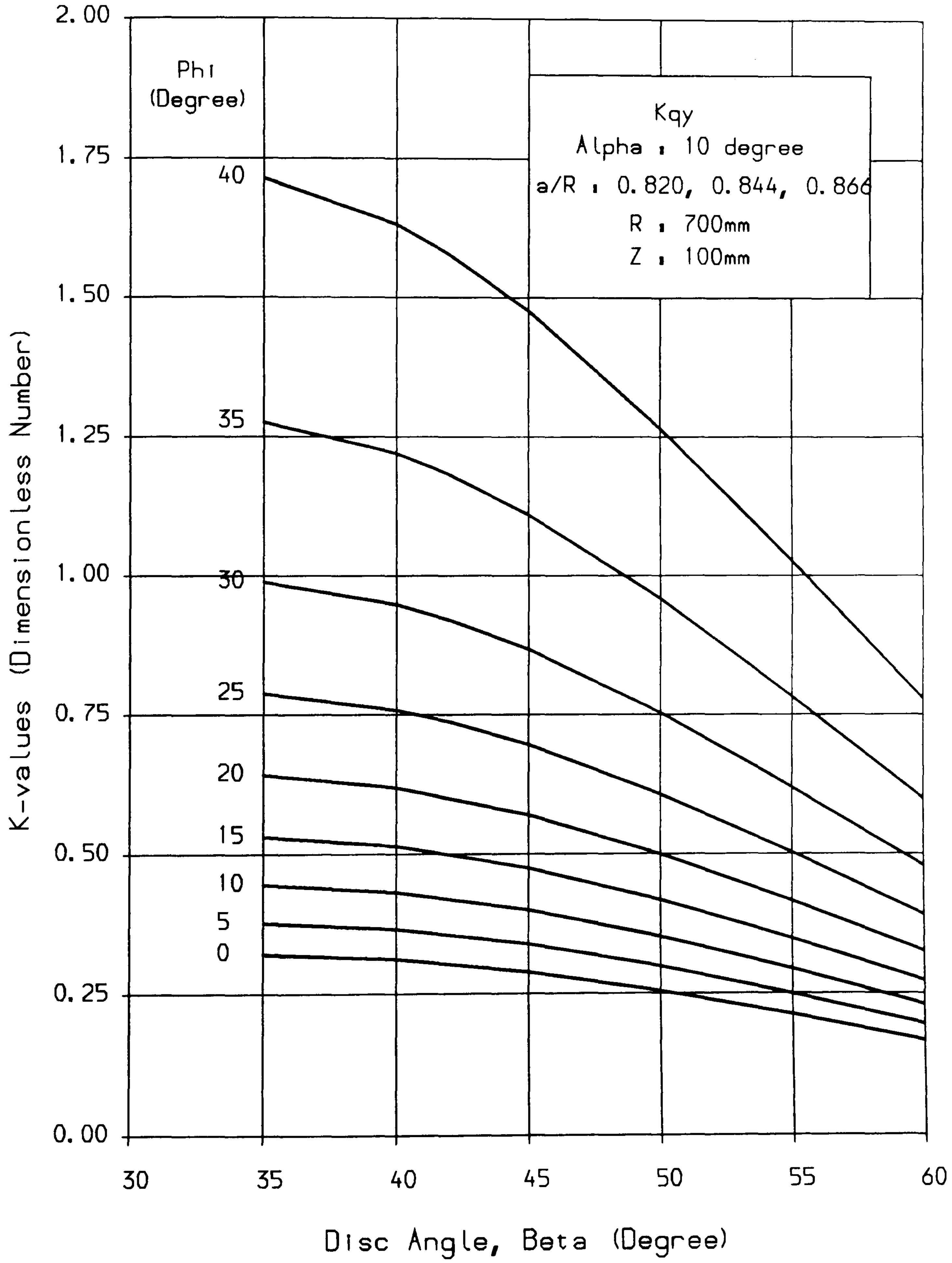

Chart 60. K-factor for Lateral Surcharge Force.

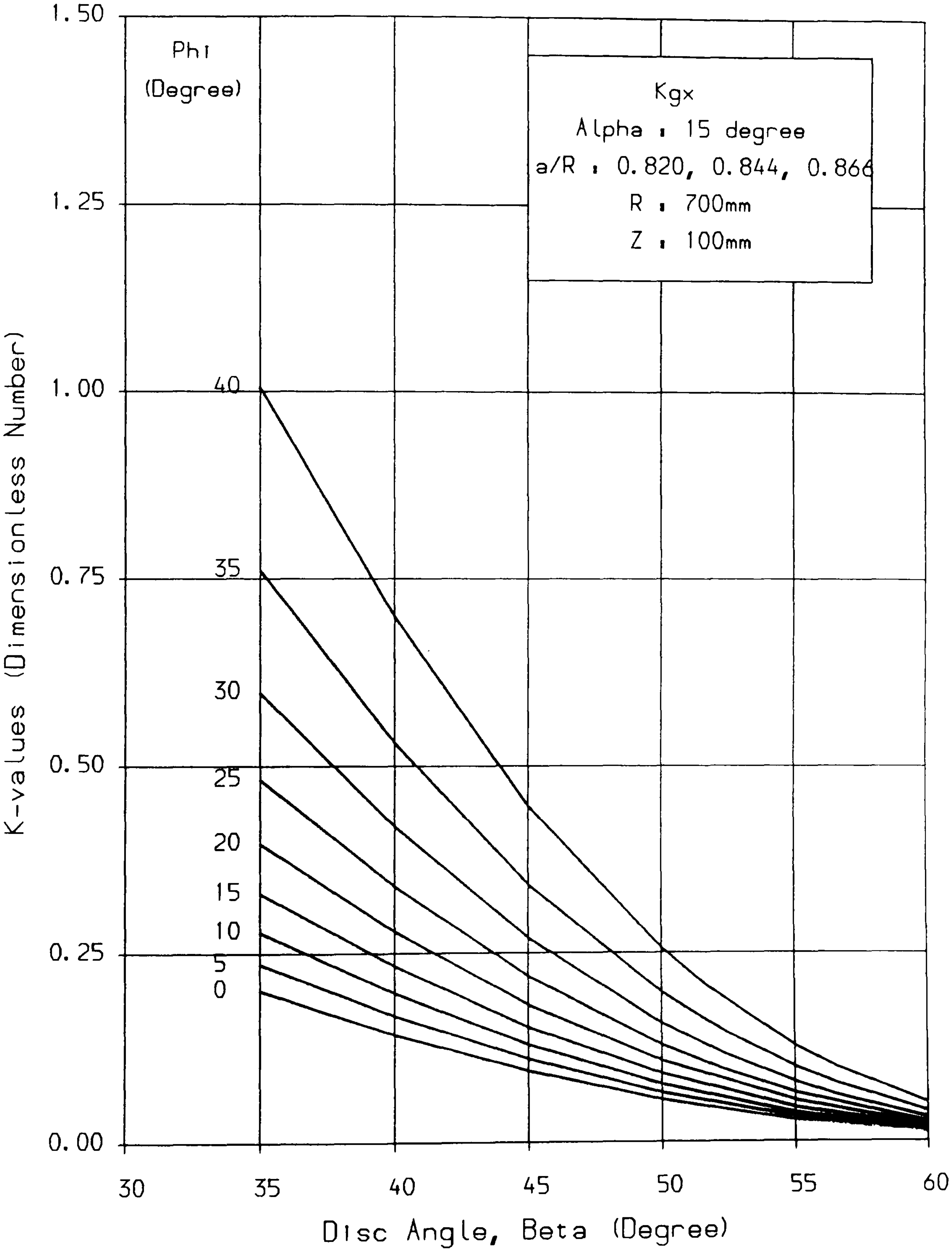

Chart 61. K-factor for Longitudinal Gravitation Force.

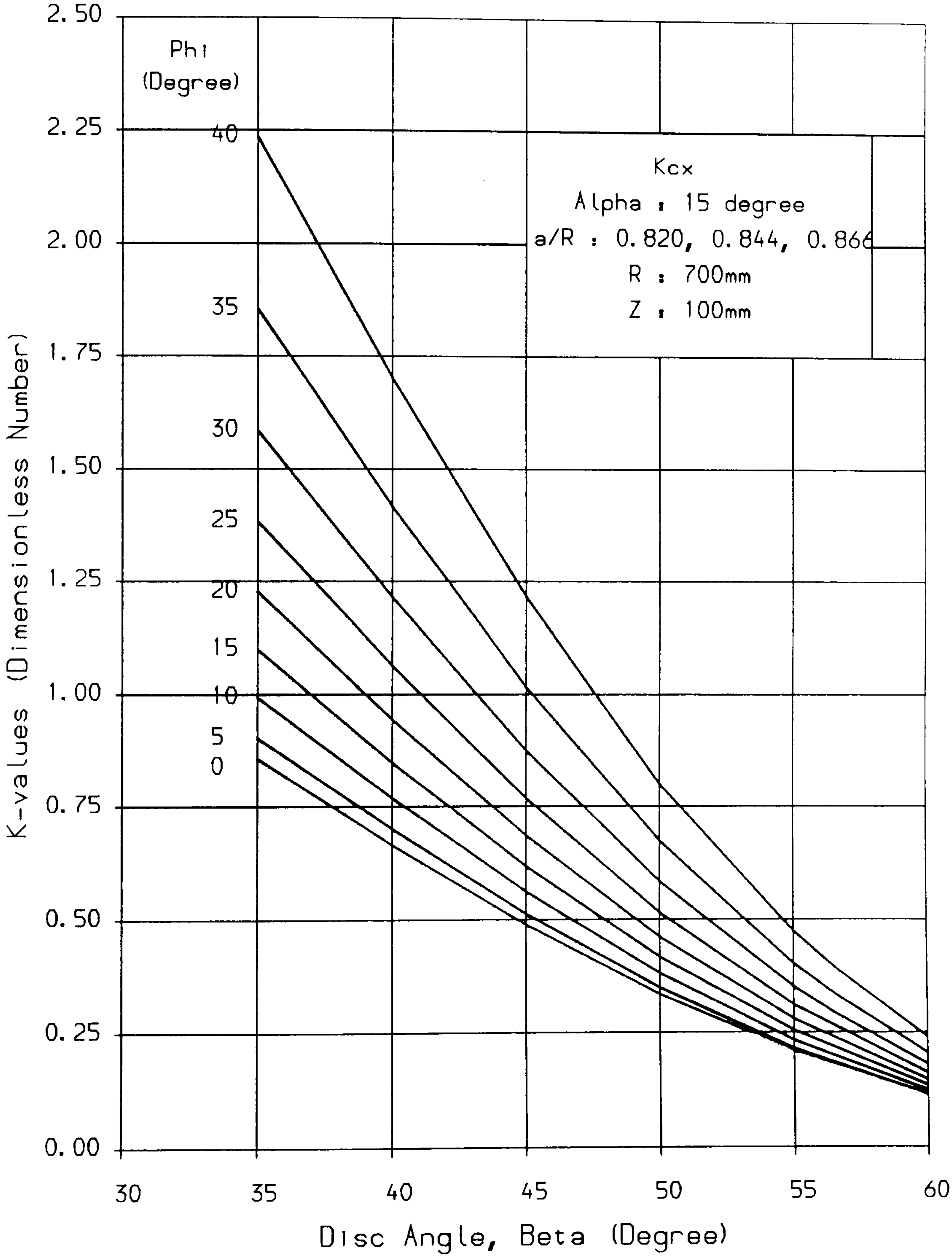

Chart 62. K-factor for Longitudinal Cohesive-Adhesive Force.

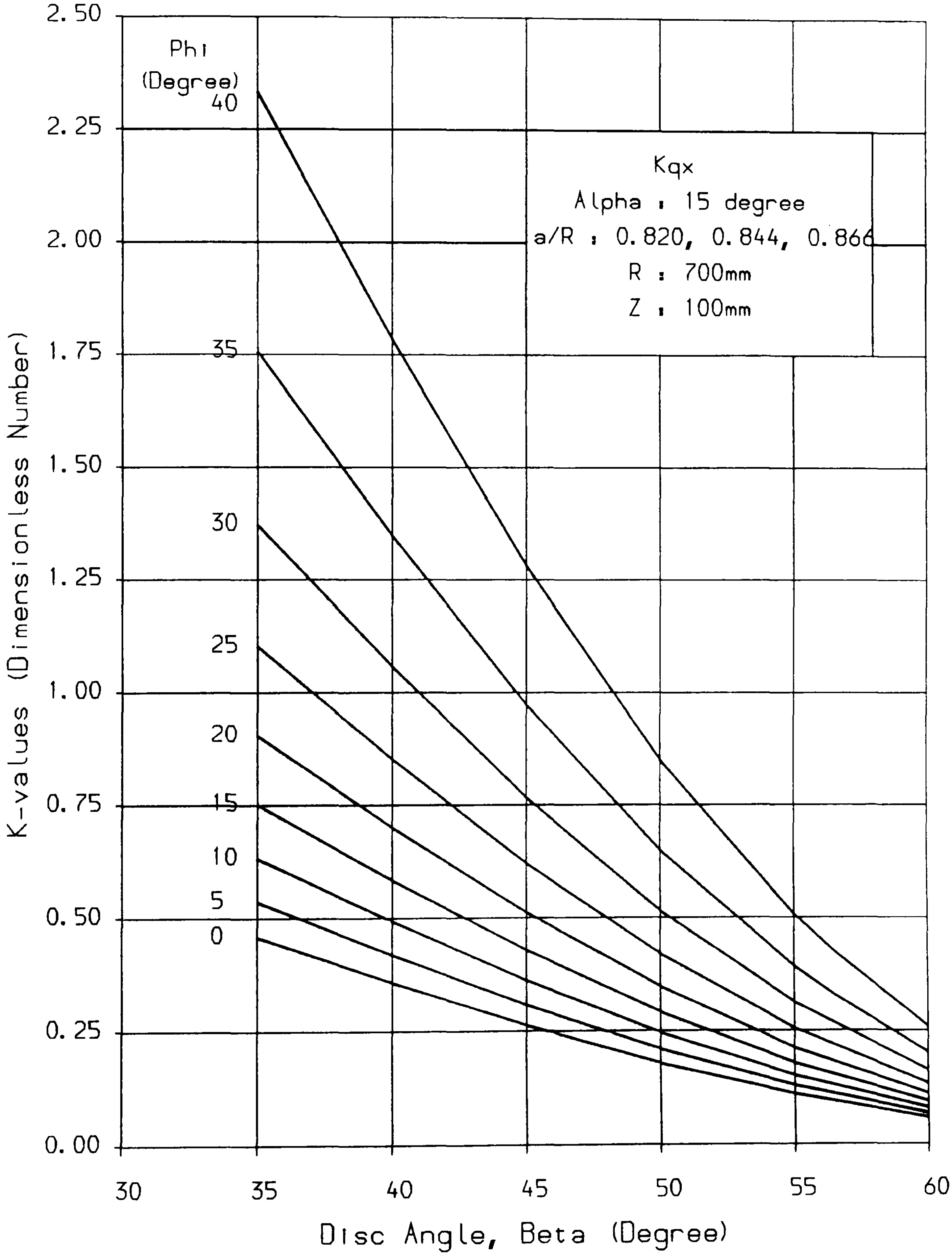

Chart 63. K-factor for Longitudinal Surcharge Force.

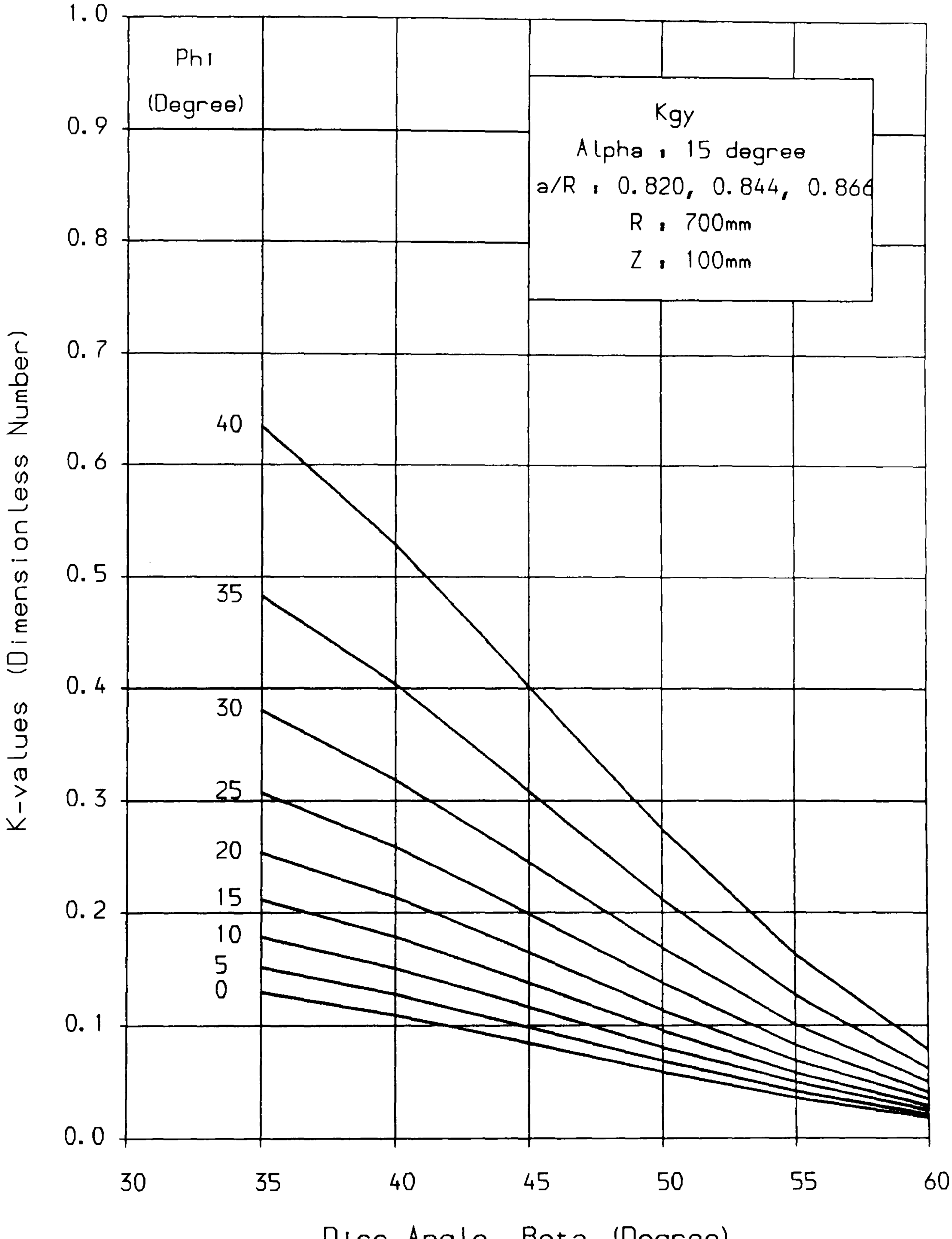

Chart 64. K-factor for Lateral Gravitation Force.

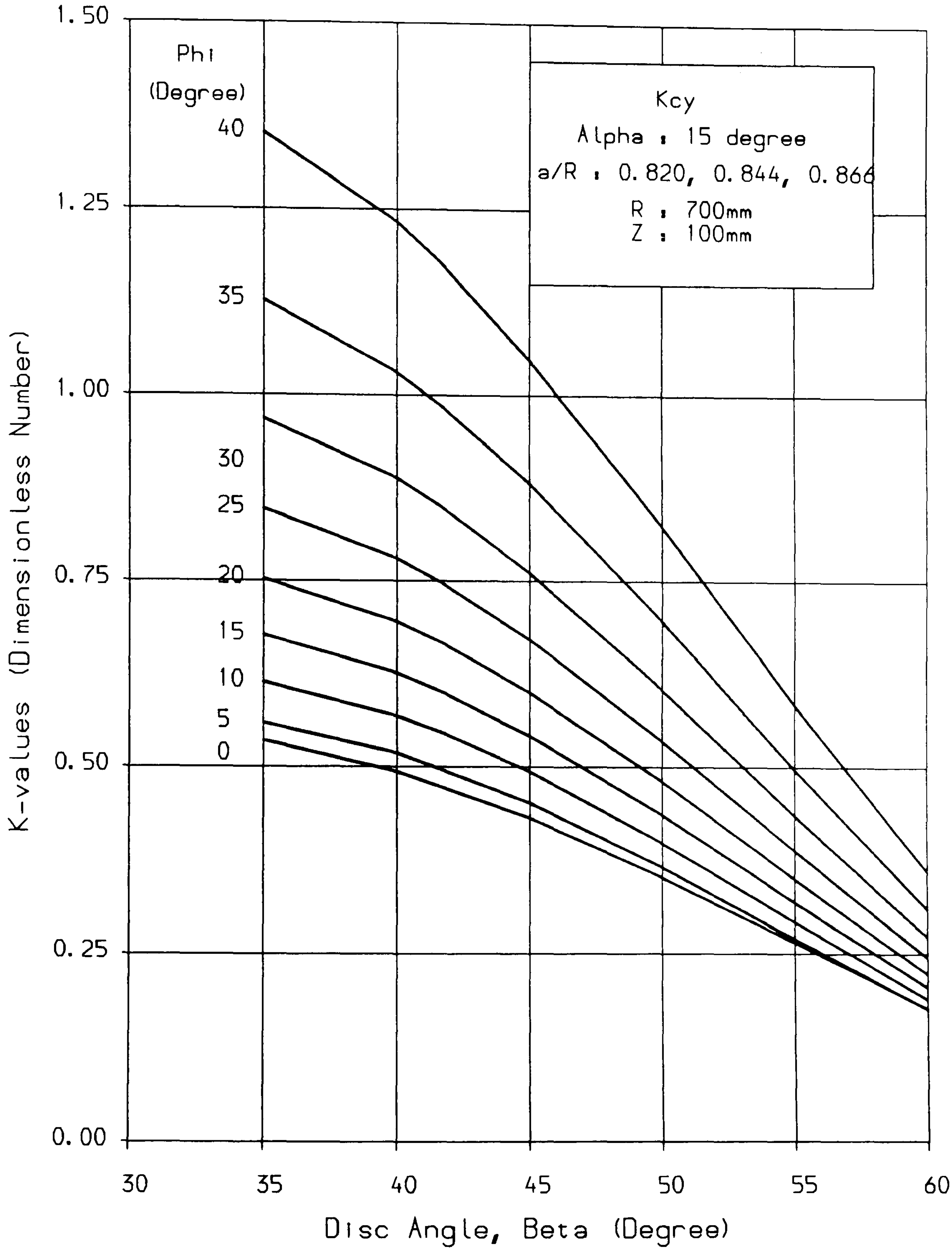

Chart 65. K-factor for Lateral Cohesive-Adhesive Force.

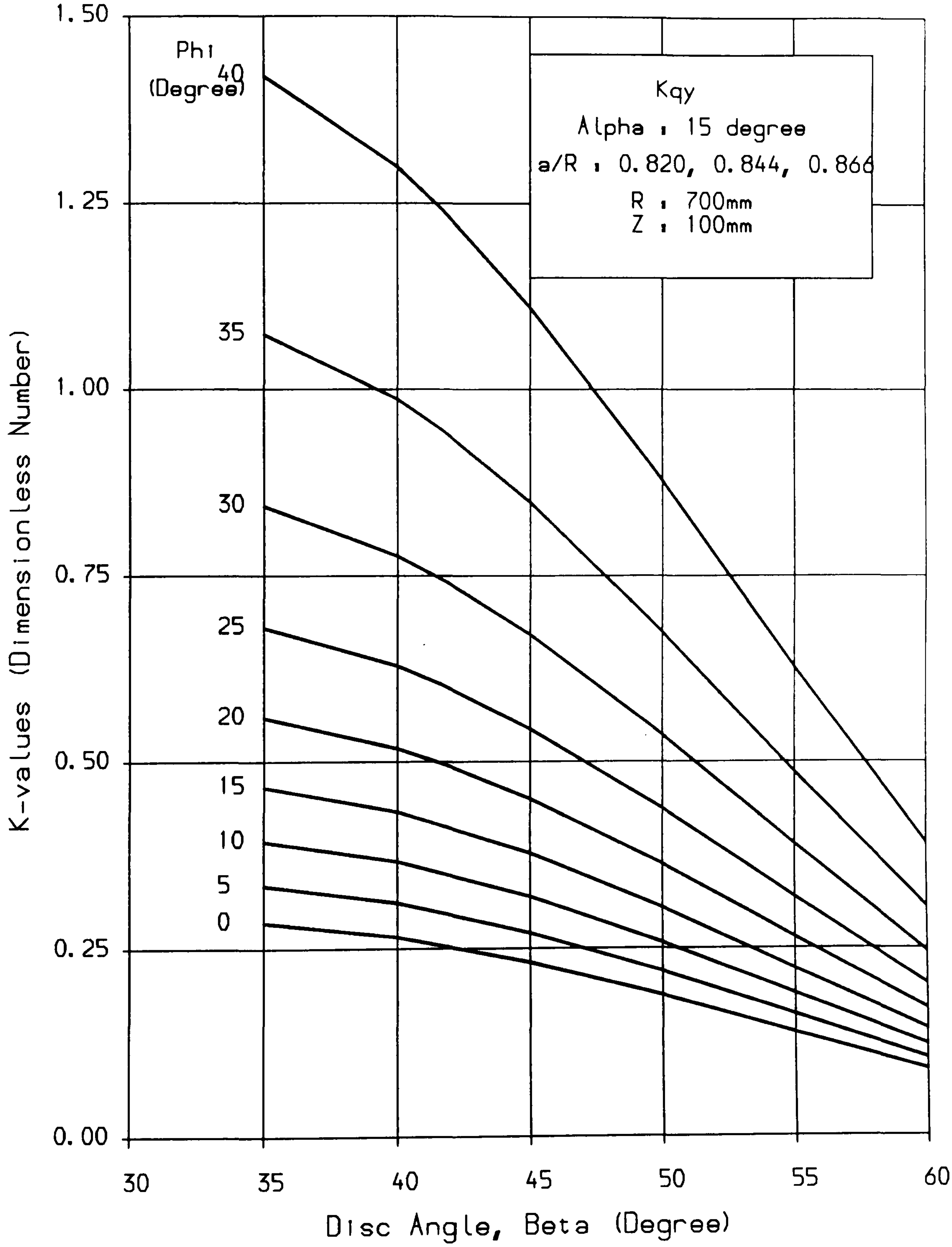

Chart 66. K-factor for Lateral Surcharge Force.

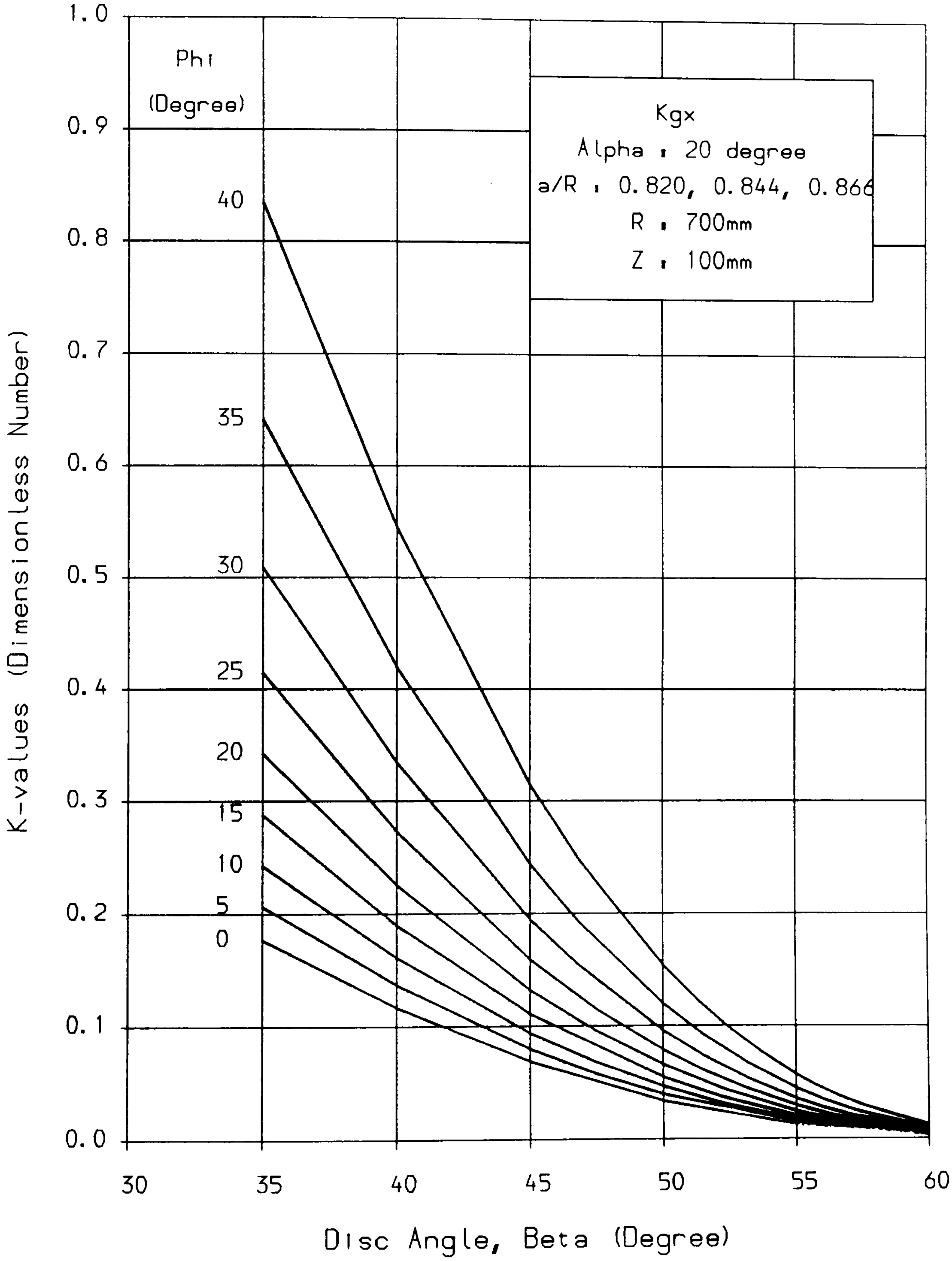

Chart 67. K-factor for Longitudinal Gravitation Force.

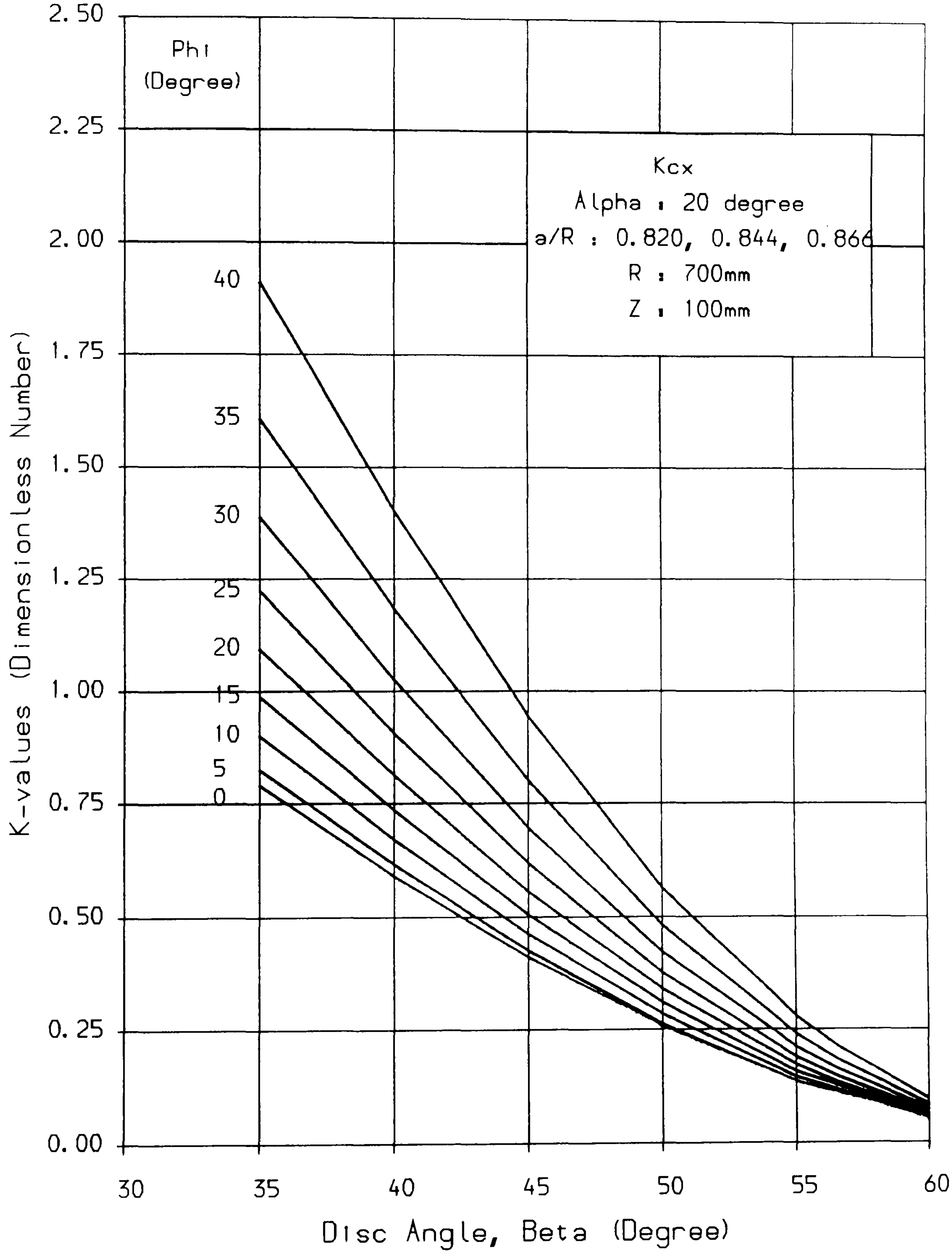

Chart 68. K-factor for Longitudinal Cohesive-Adhesive Force.

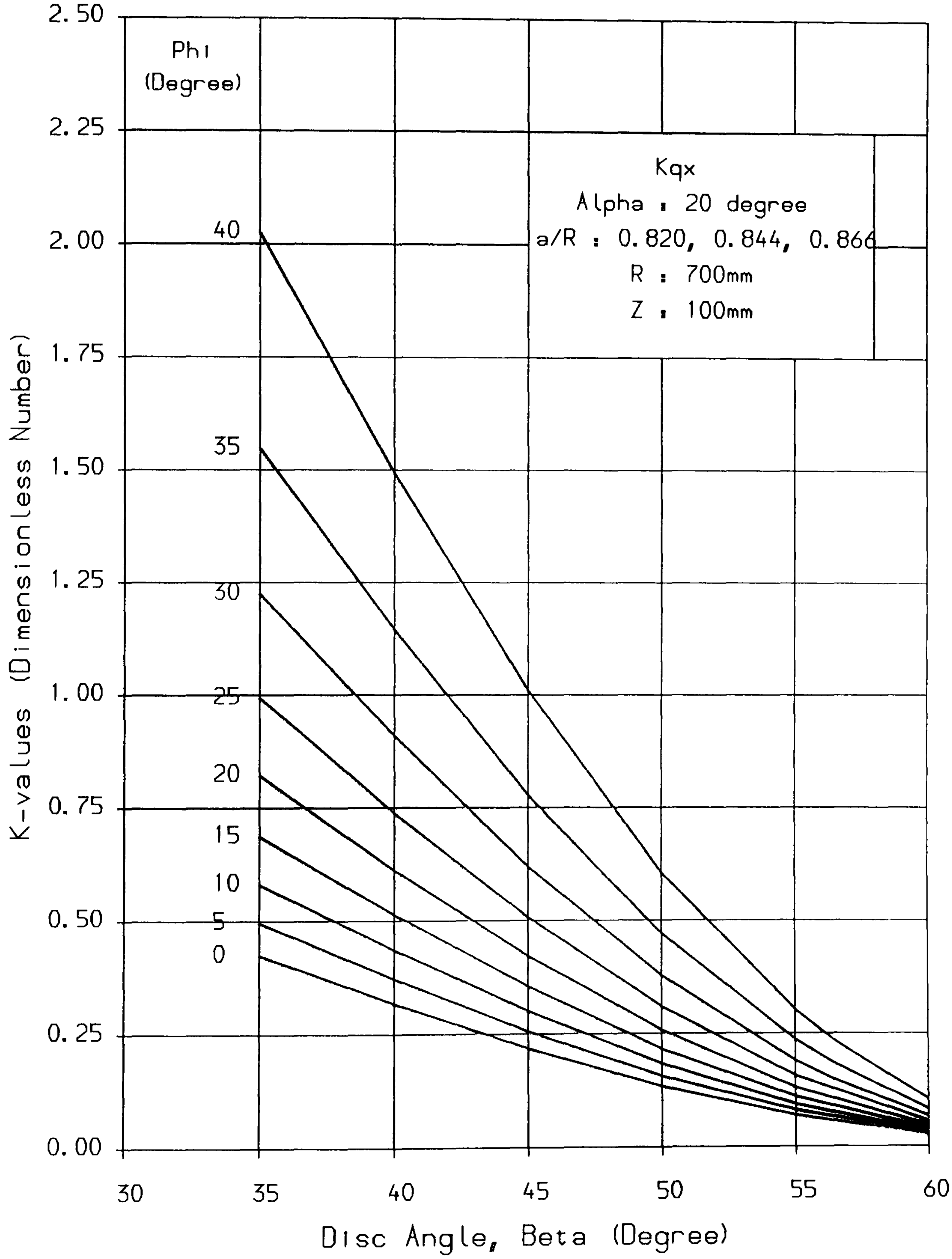

Chart **69.** K-factor for Longitudinal Surcharge Force.

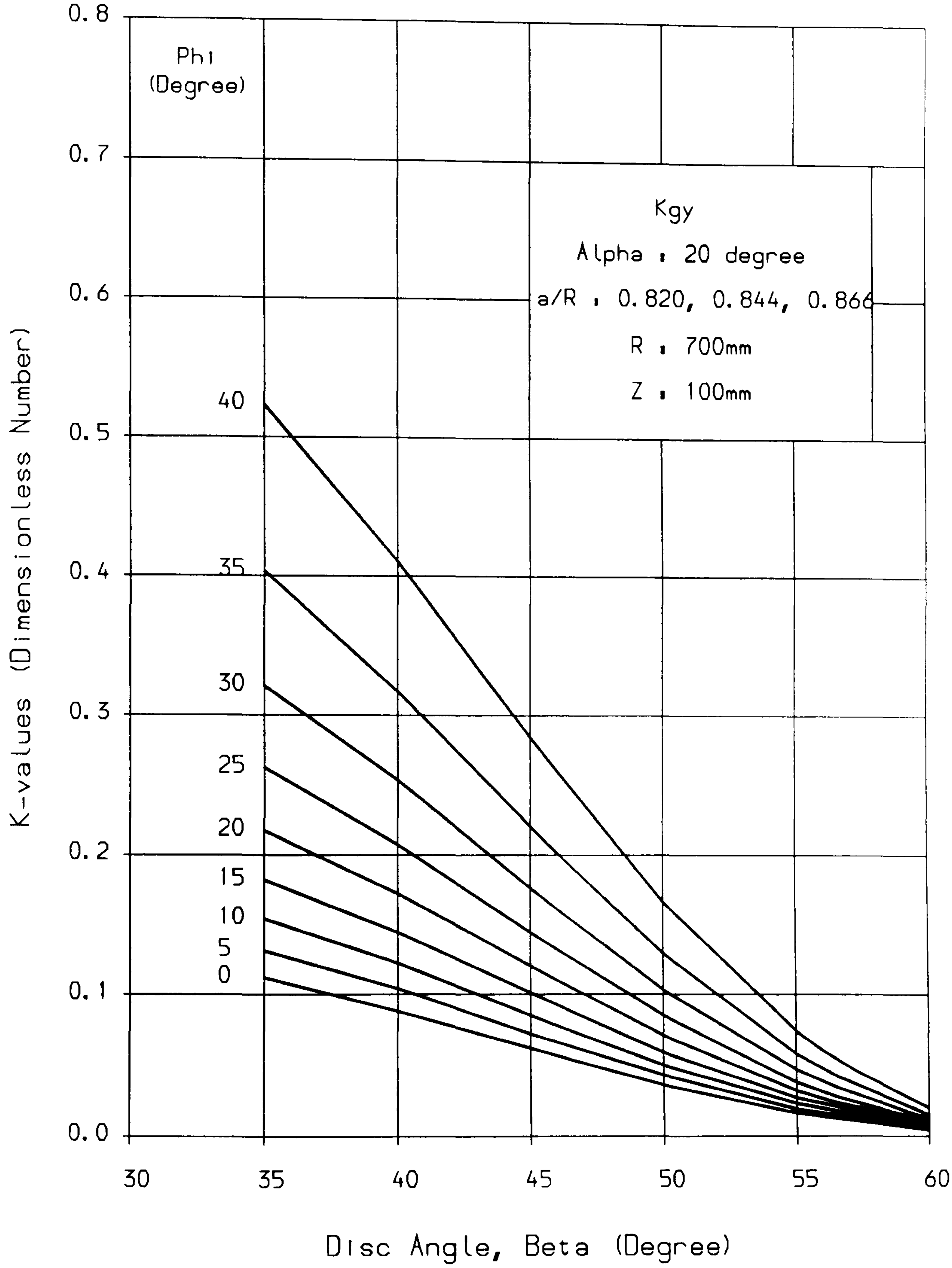

Chart 70. K-factor for Lateral Gravitation Force.

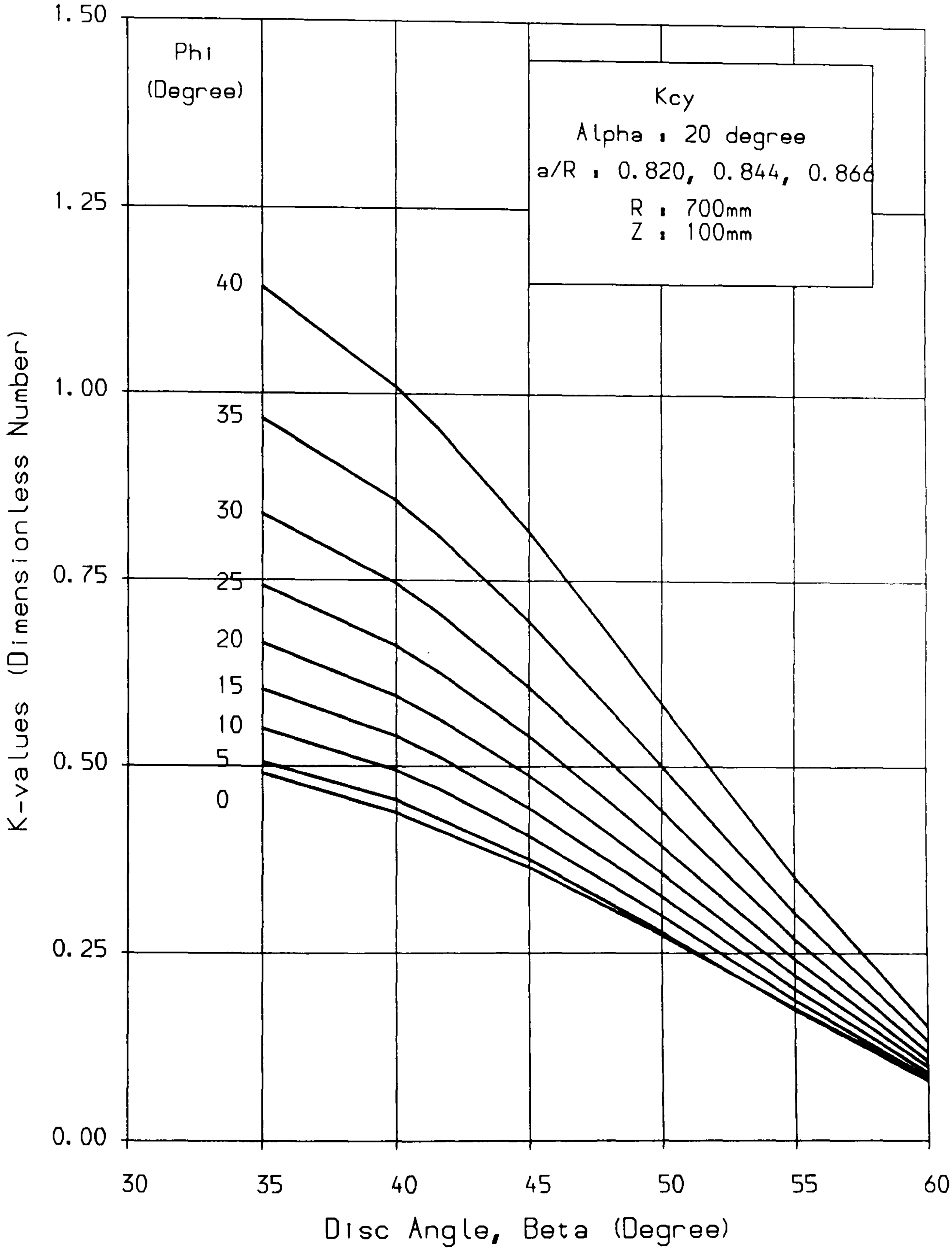

Chart 71. K-factor for Lateral Cohesive-Adhesive Force.

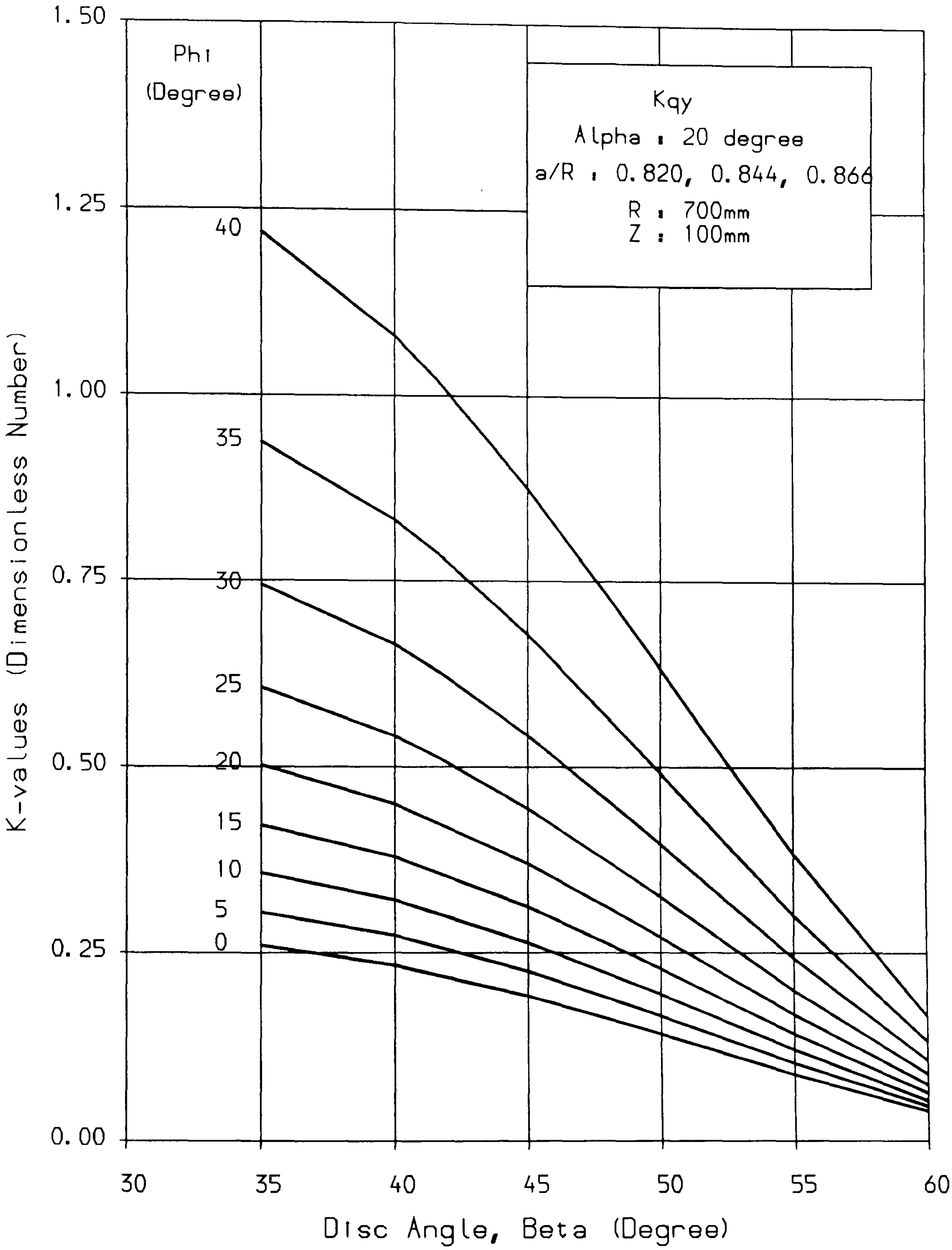

Chart 72. K-factor for Lateral Surcharge Force.

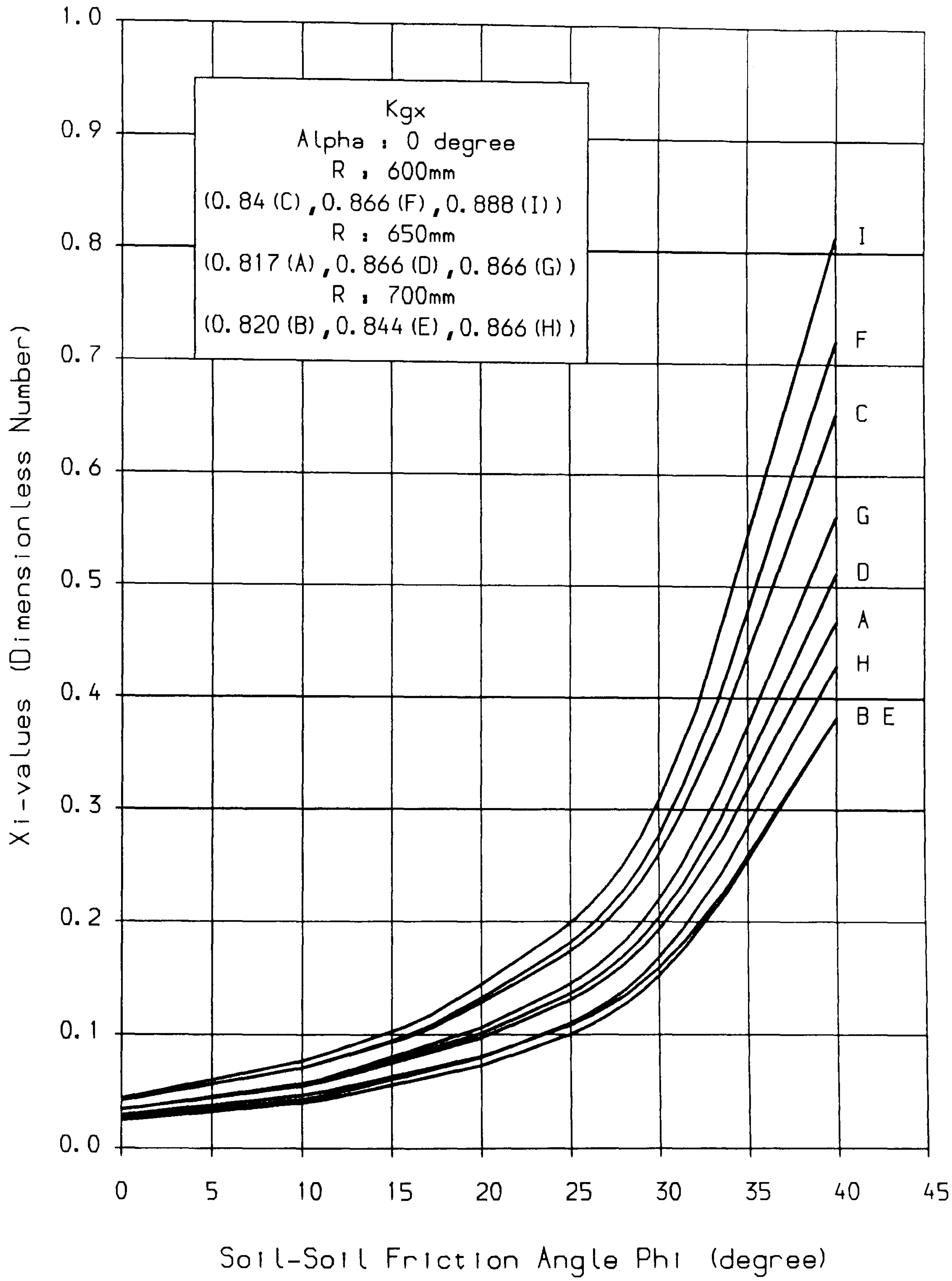

Chart 73. Xi-Values for Correction Equation.

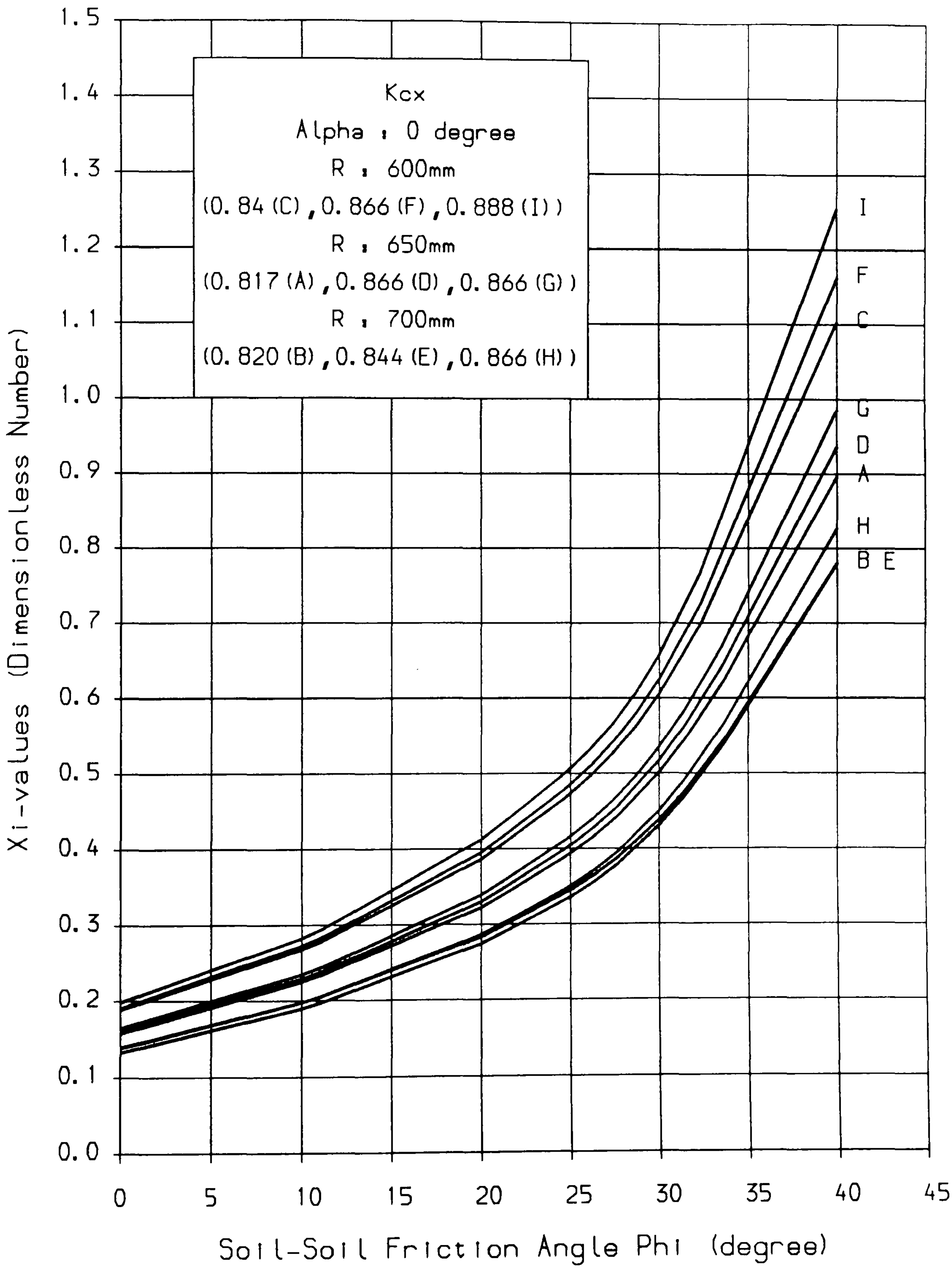

Chart 74. Xi-Values for Correction Equation.

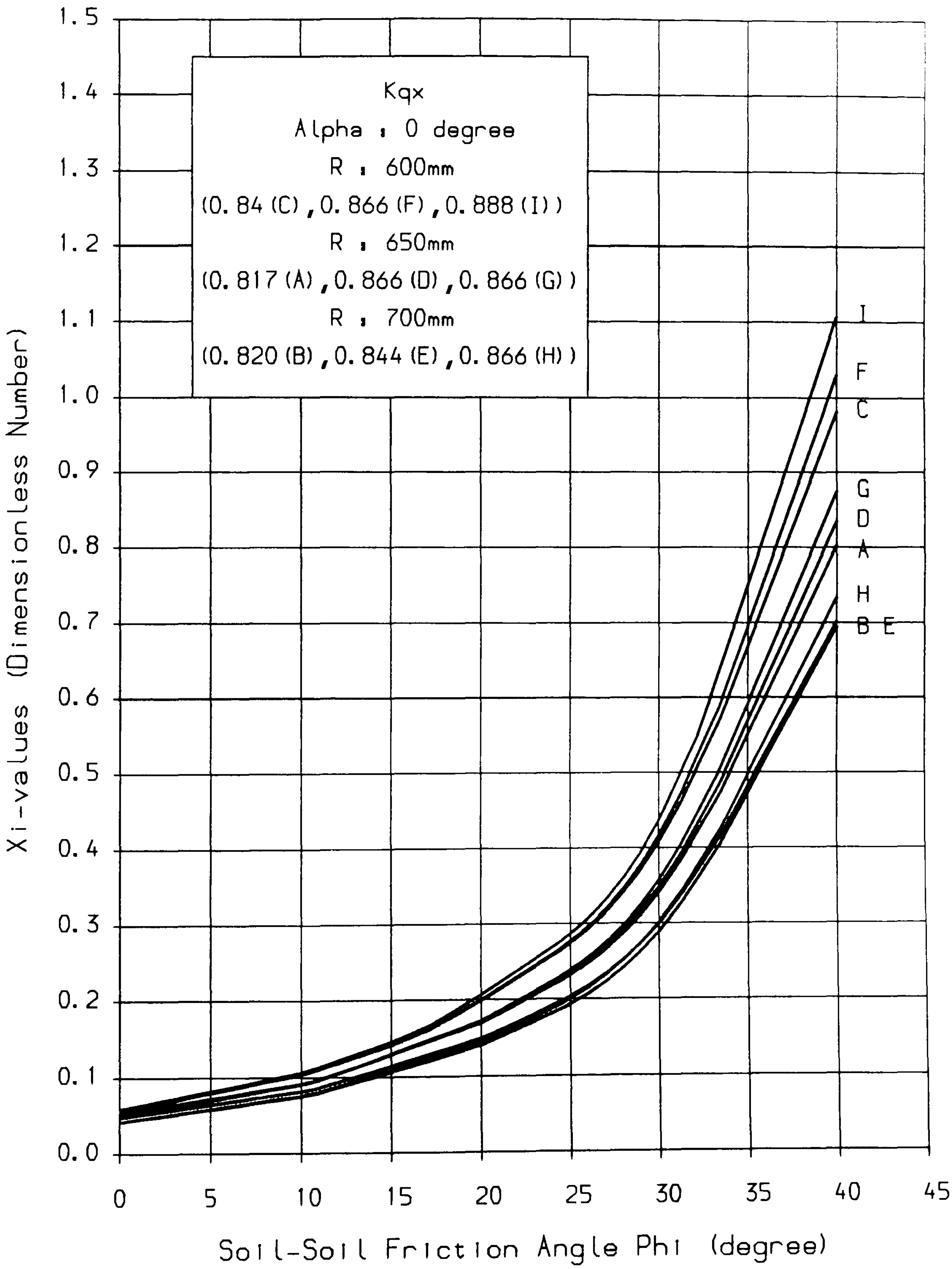

Chart 75. Xi-Values for Correction Equation.

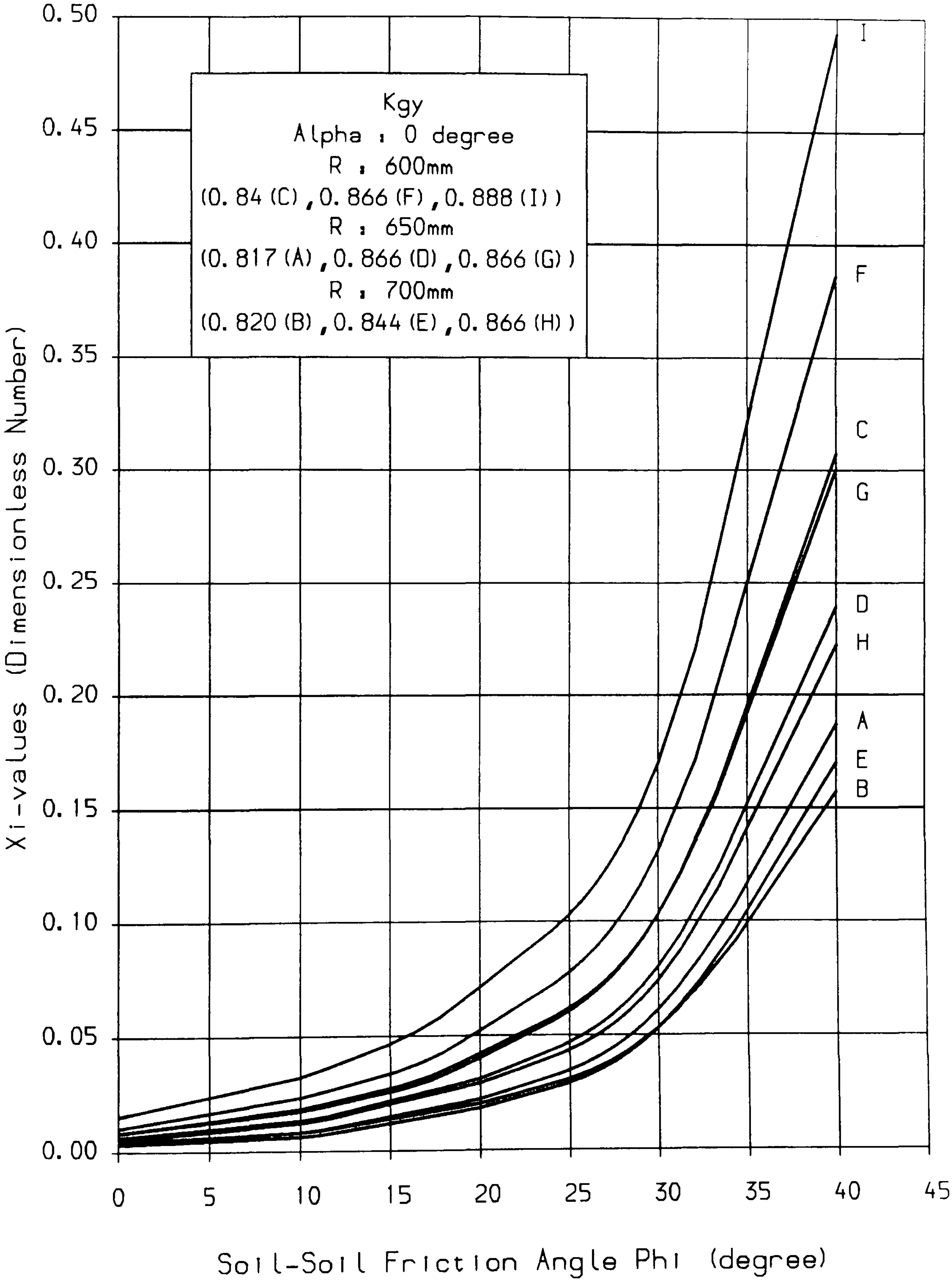

Chart 76. Xi-Values for Correction Equation.

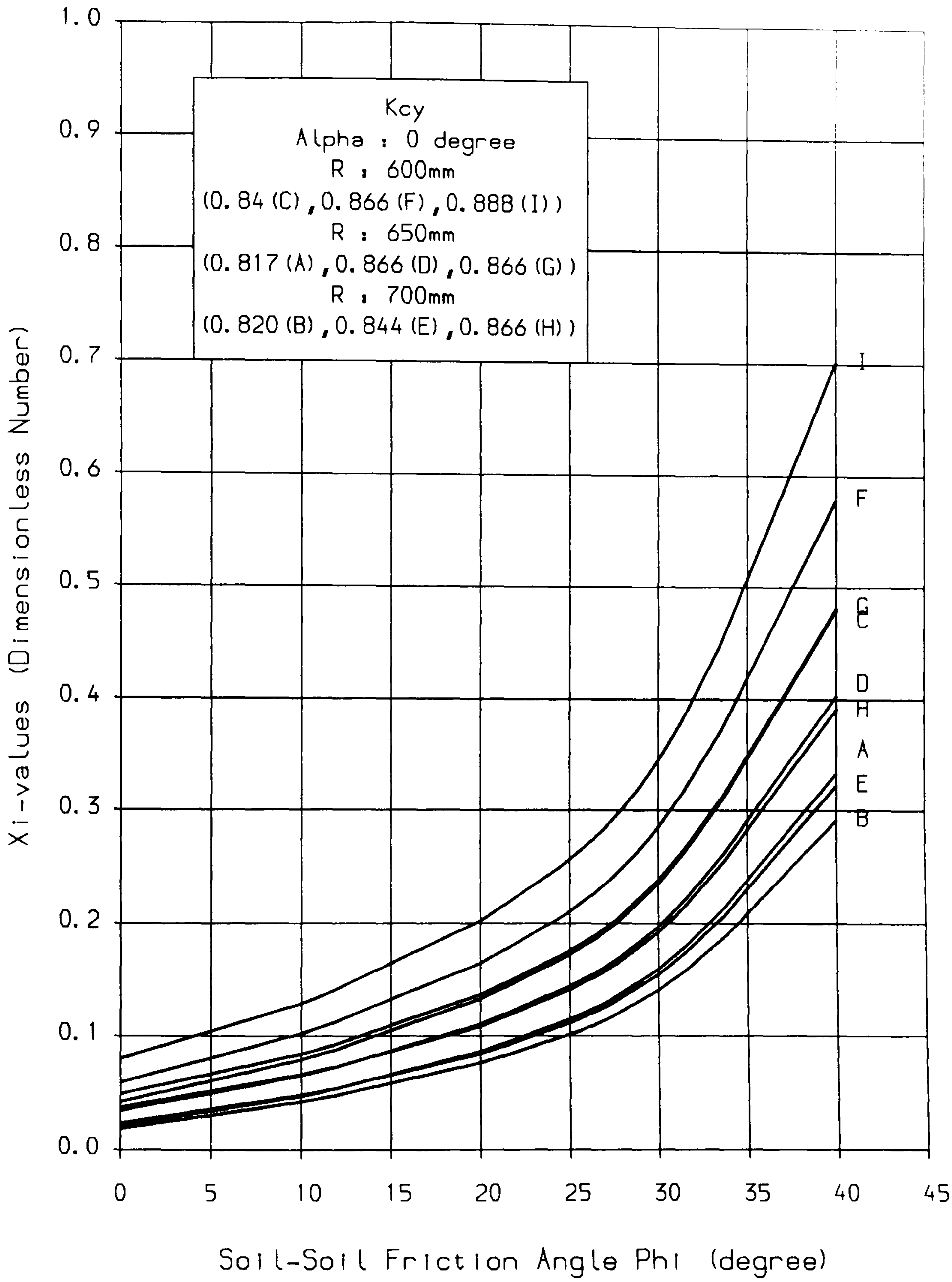

Chart 77. Xi-Values for Correction Equation.

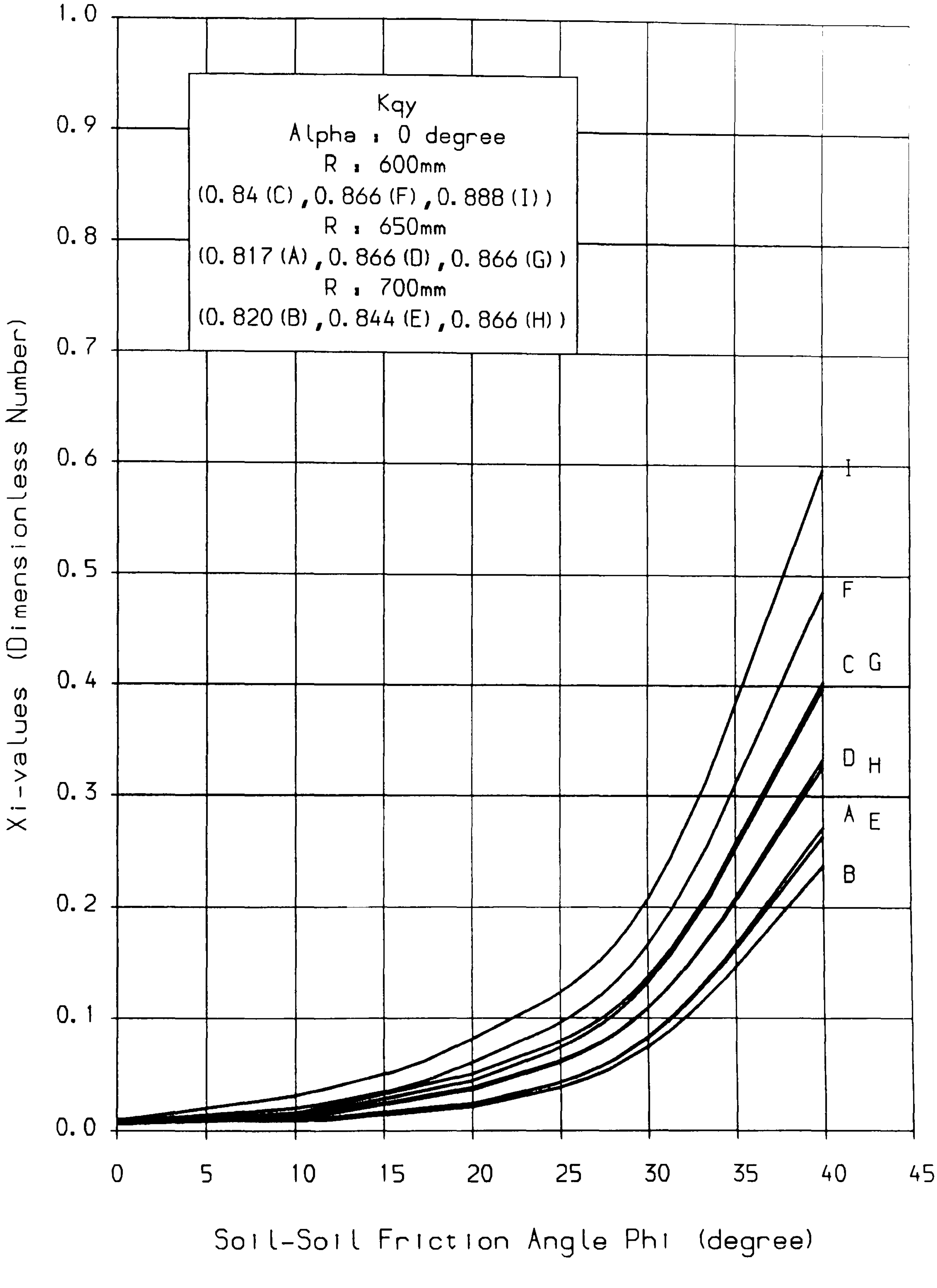

Chart 78. Xi-Values for Correction Equation.

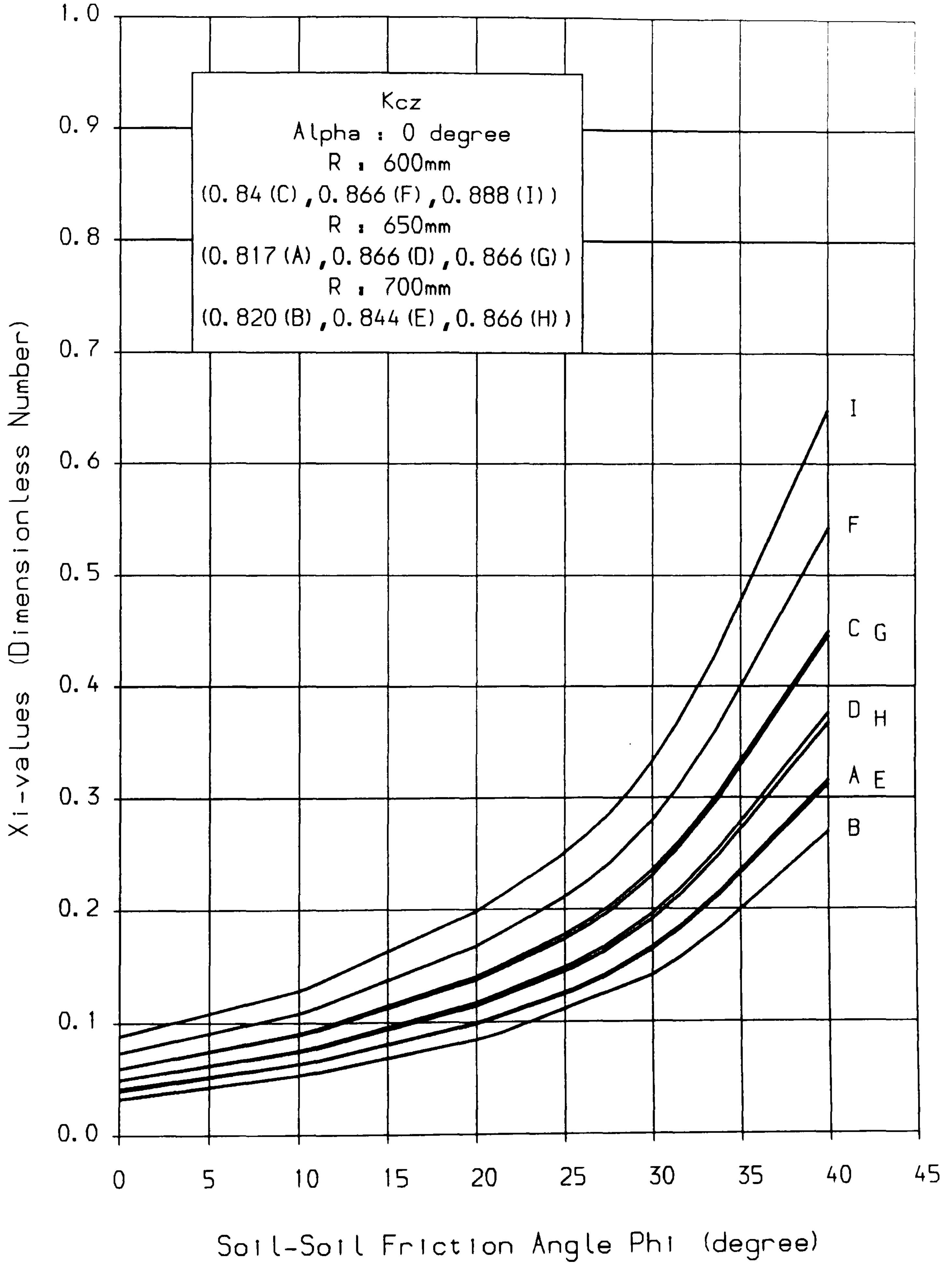

Chart 79. Xi-Values for Correction Equation.

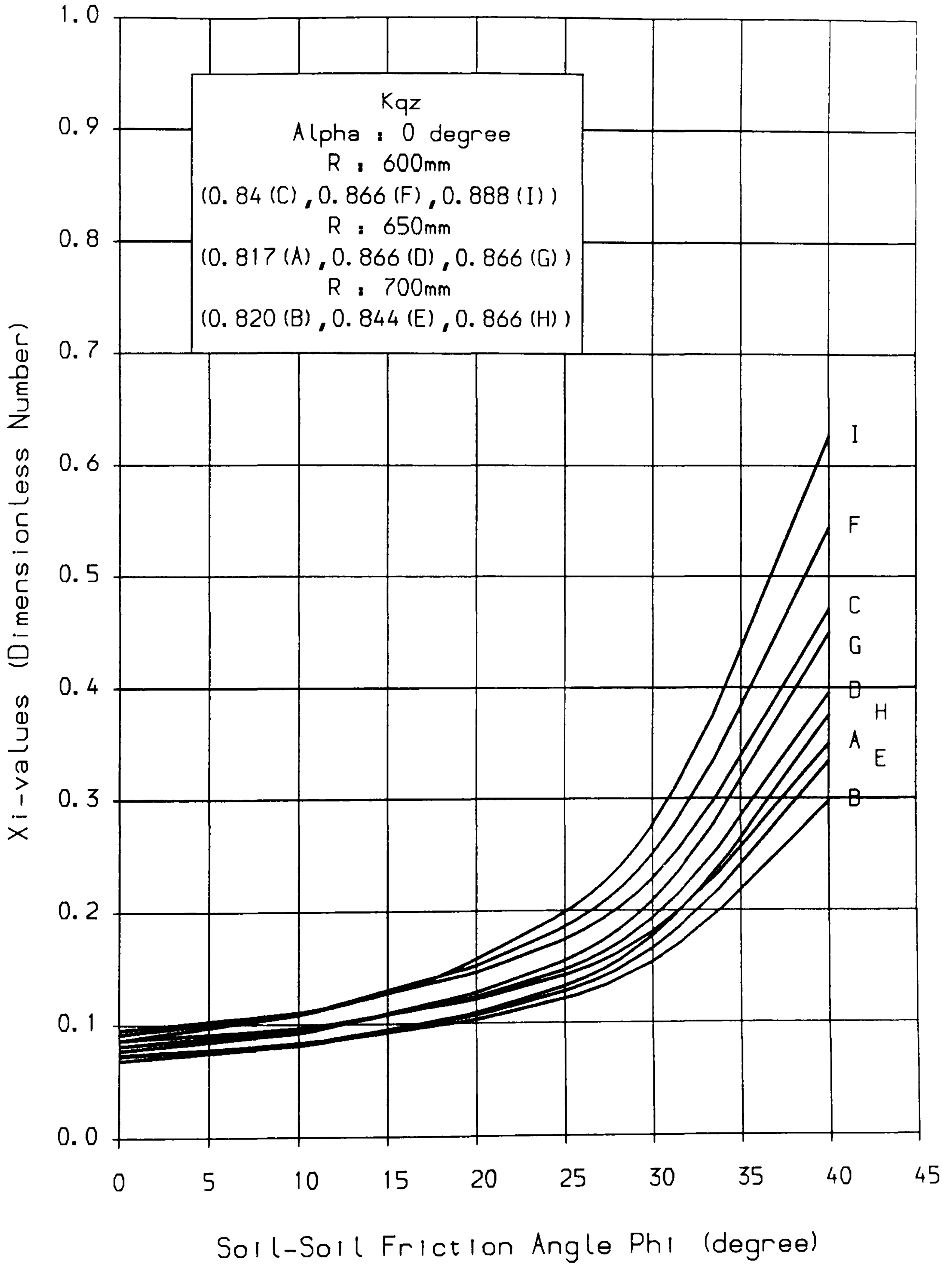

Chart 80. Xi-Values for Correction Equation.

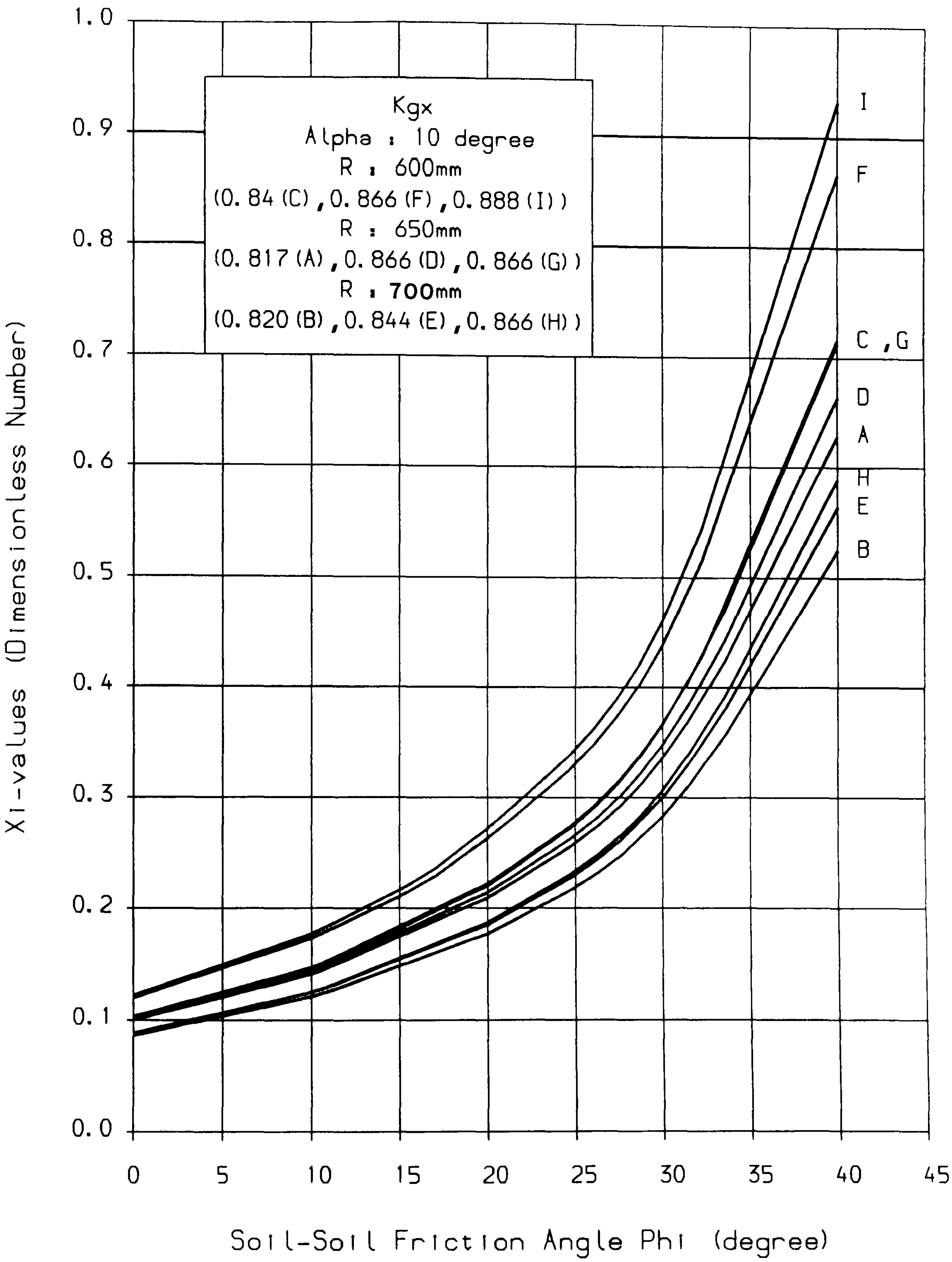

Chart 81. Xi-Values for Correction Equation.

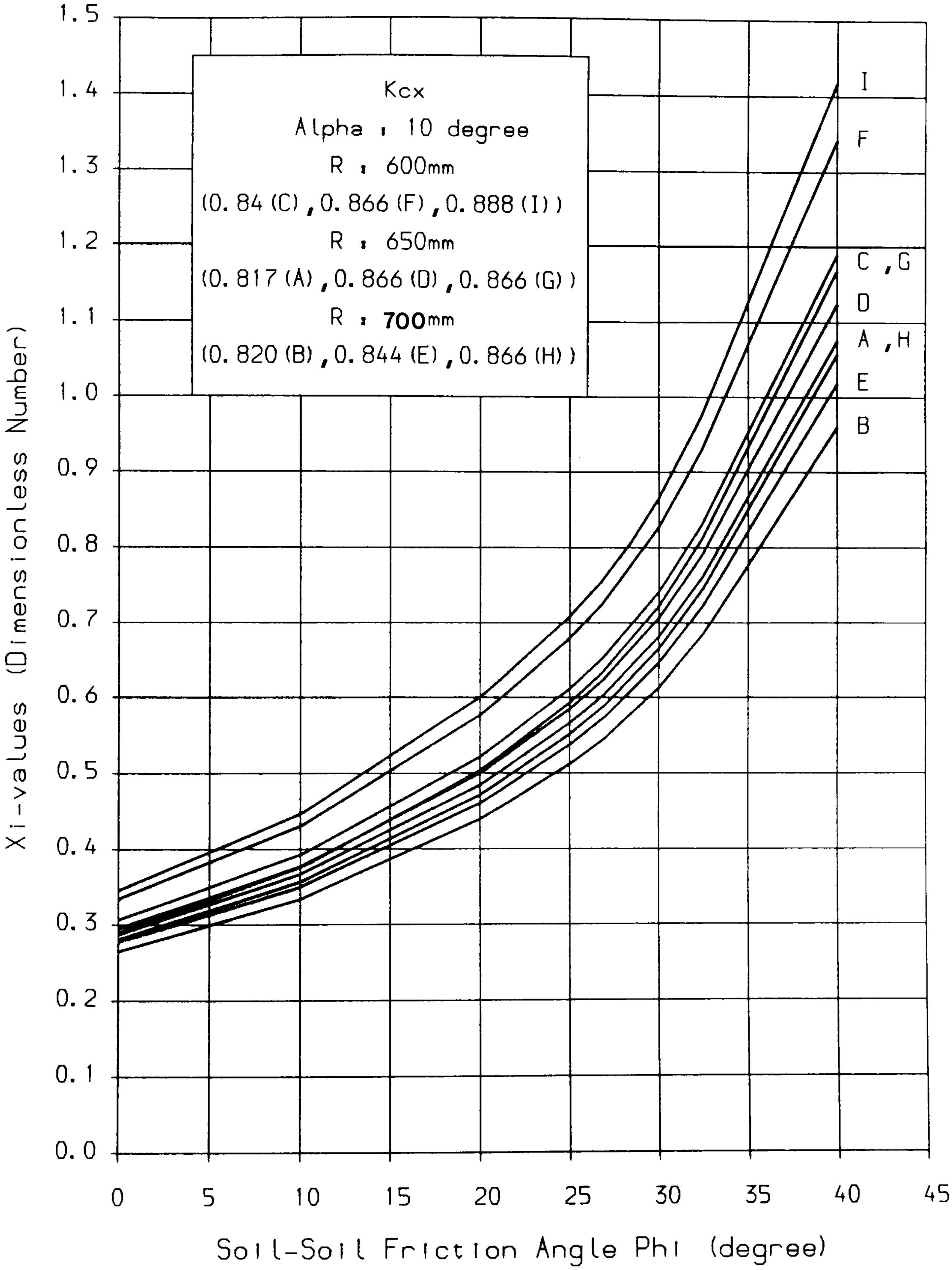

Chart 82. Xi-Values for Correction Equation.

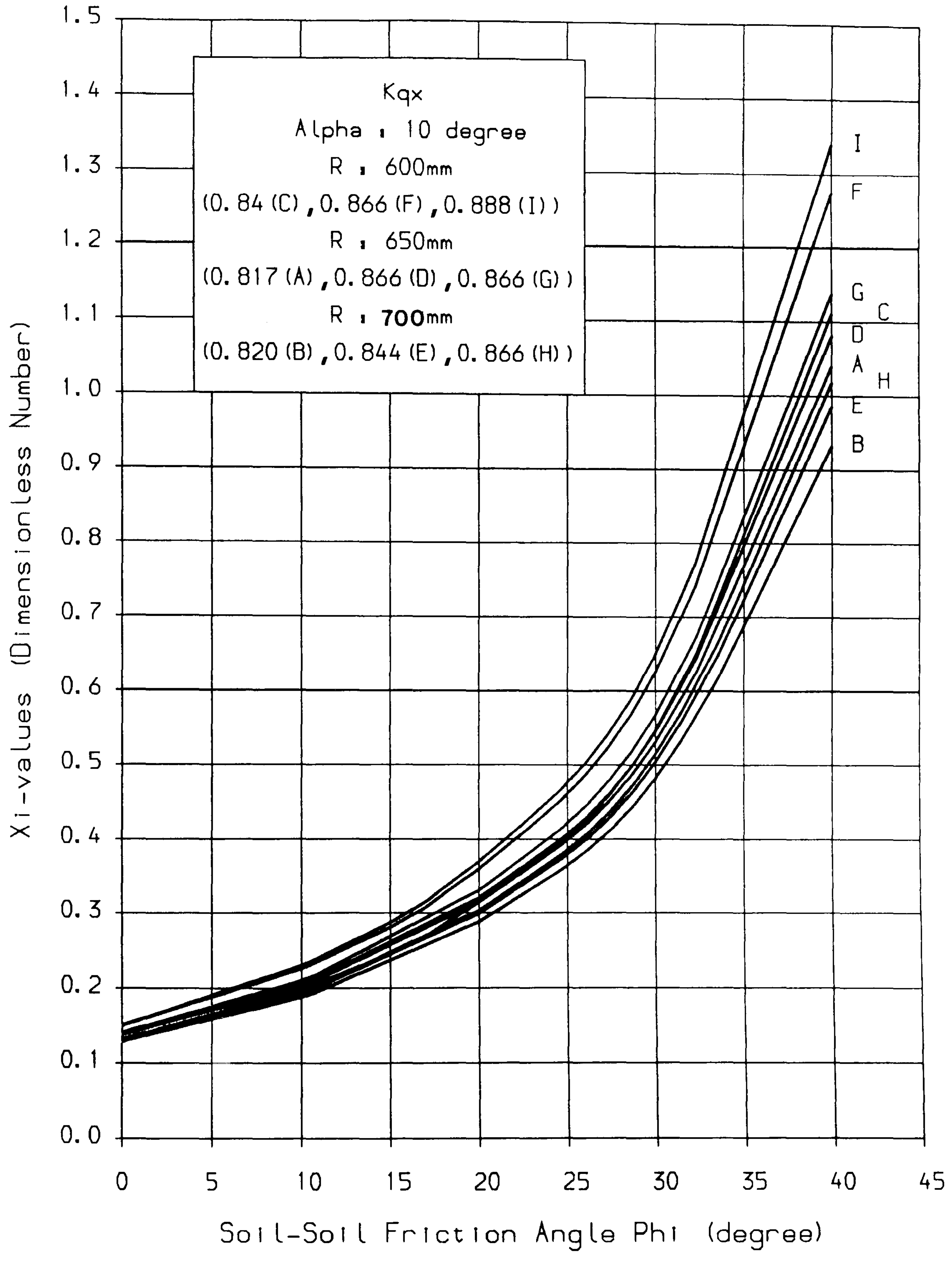

Chart 83. Xi-Values for Correction Equation.

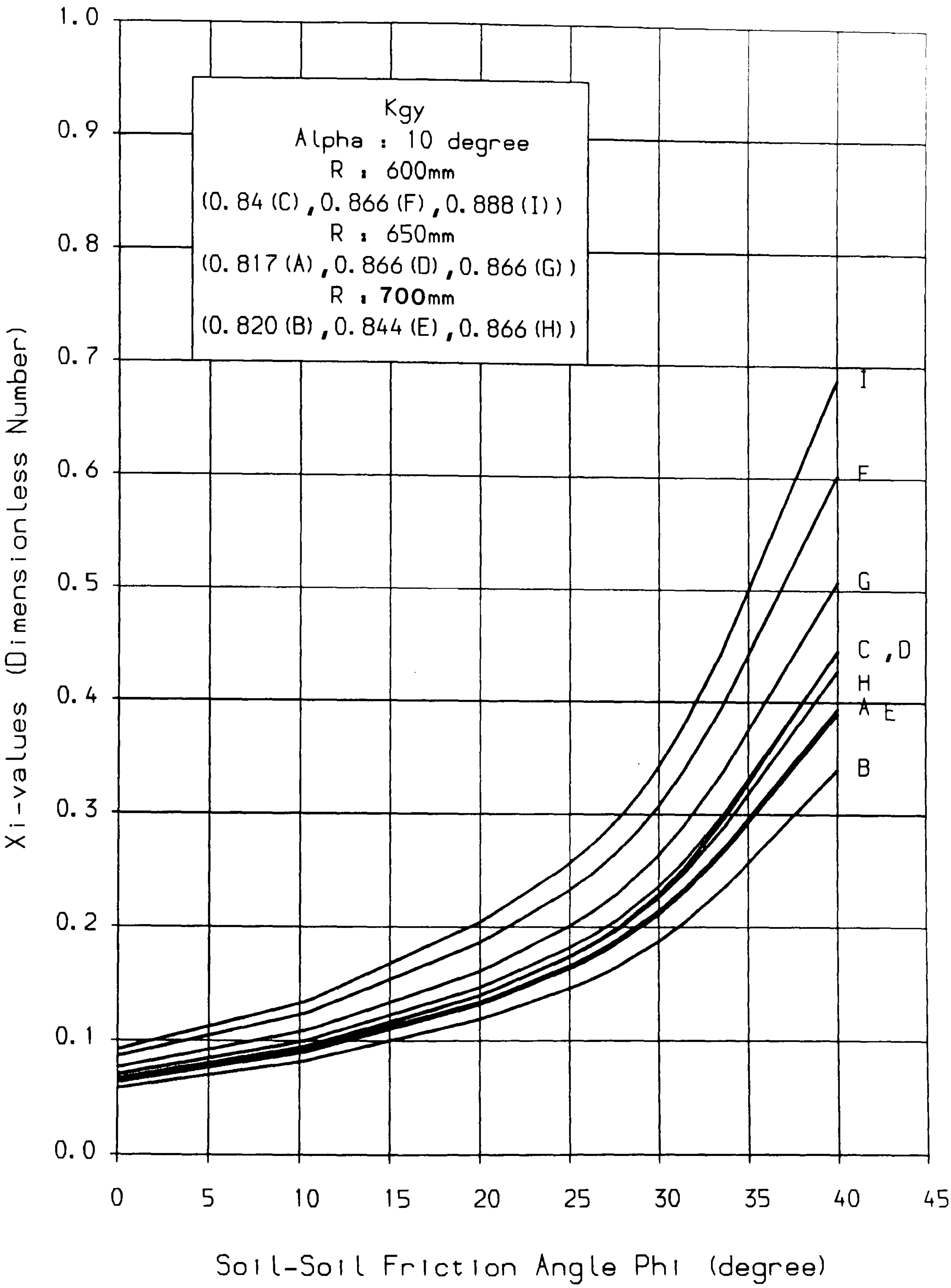

Chart 84. Xi-Values for Correction Equation.

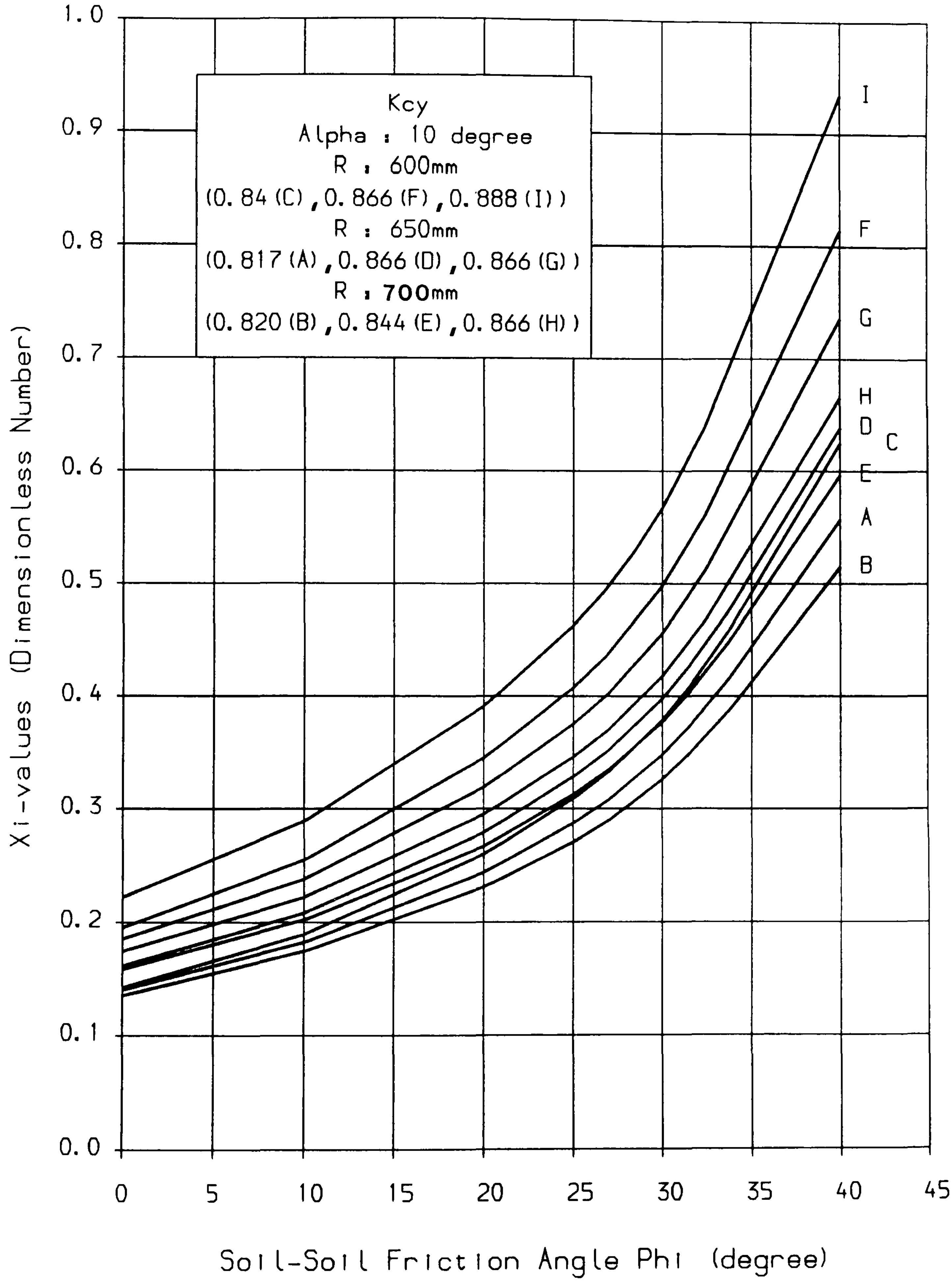

Chart 85. Xi-Values for Correction Equation.

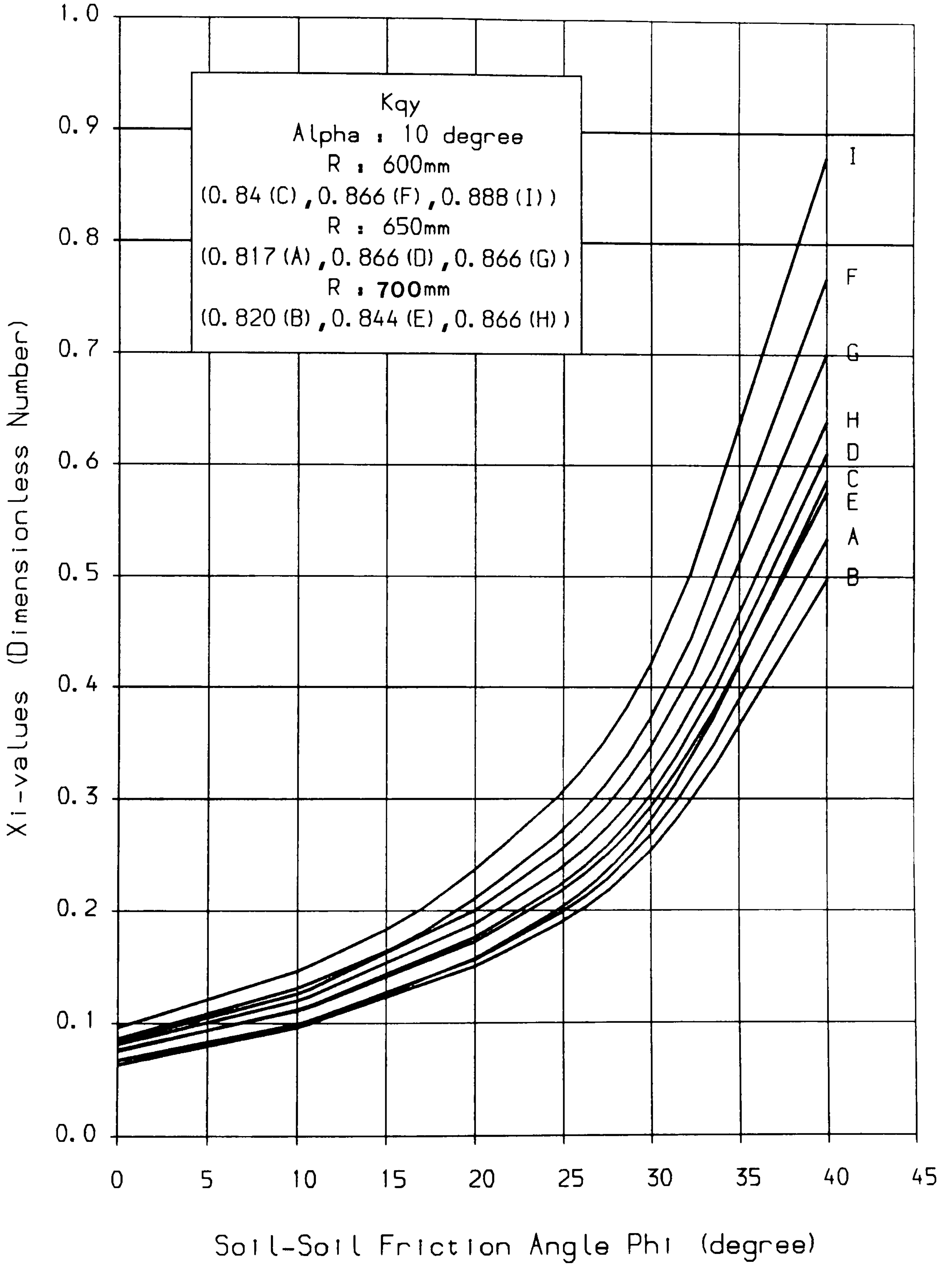

Chart 86. Xi-Values for Correction Equation.

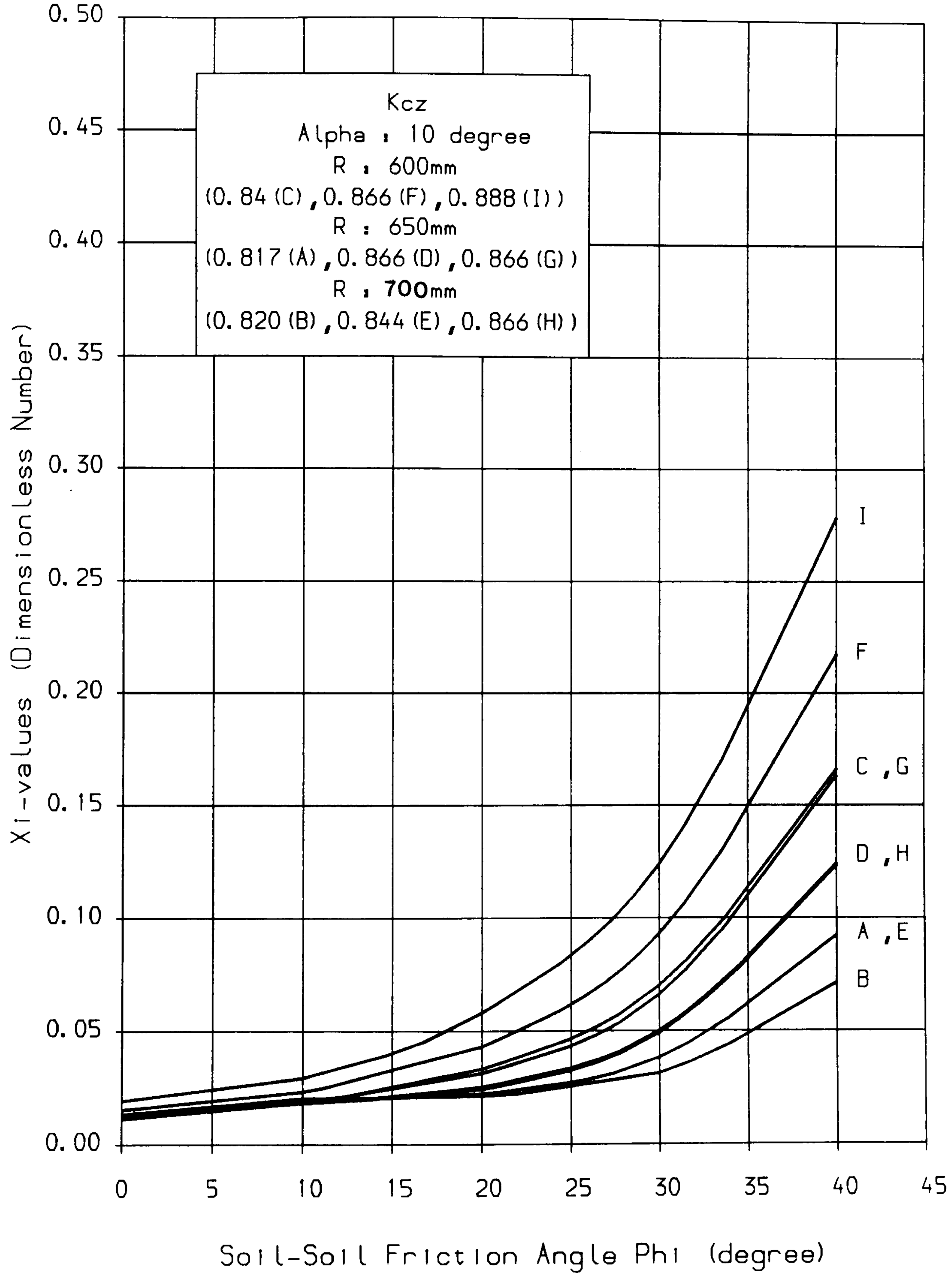

Chart 87. Xi-Values for Correction Equation.

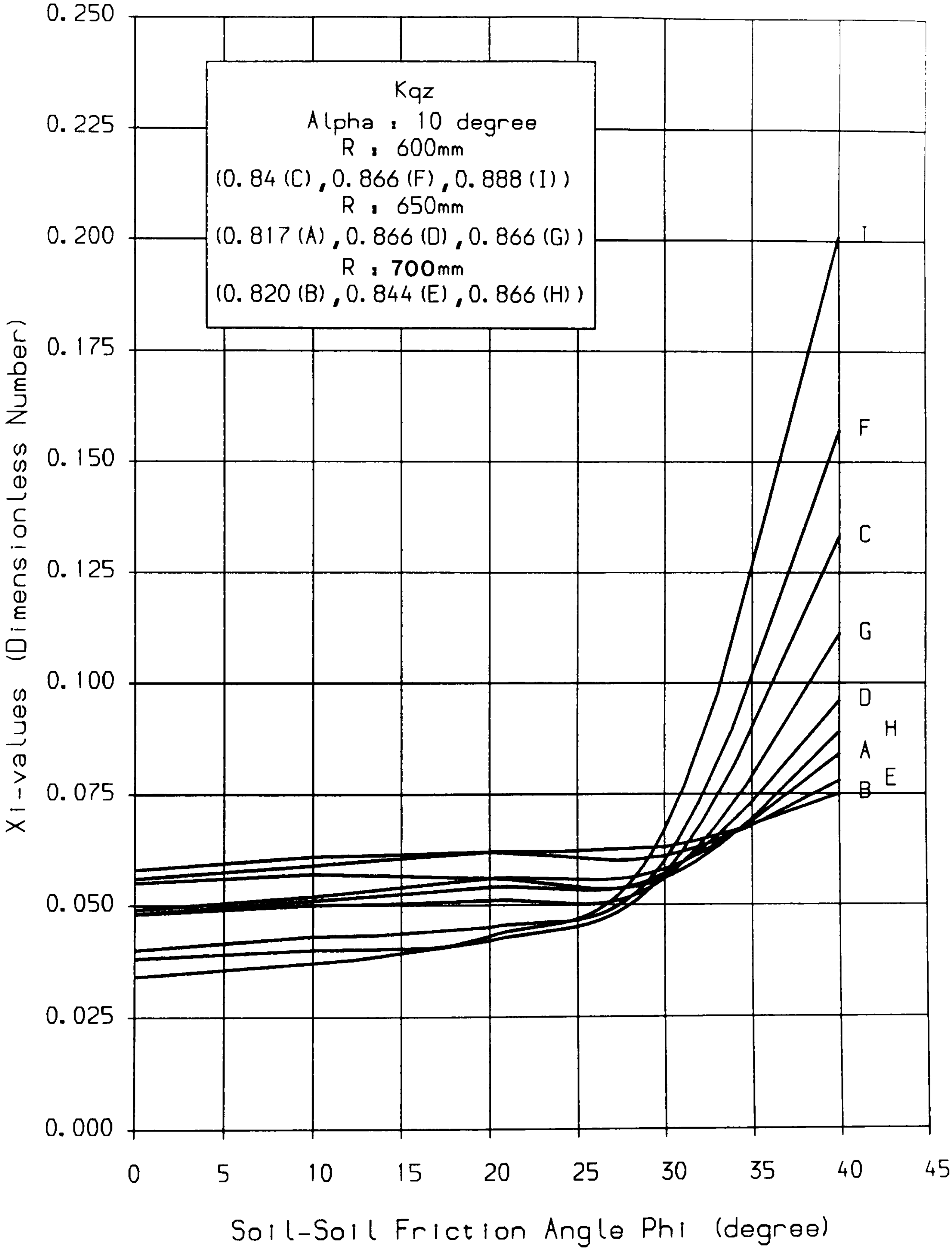

Chart 88. Xi-Values for Correction Equation.

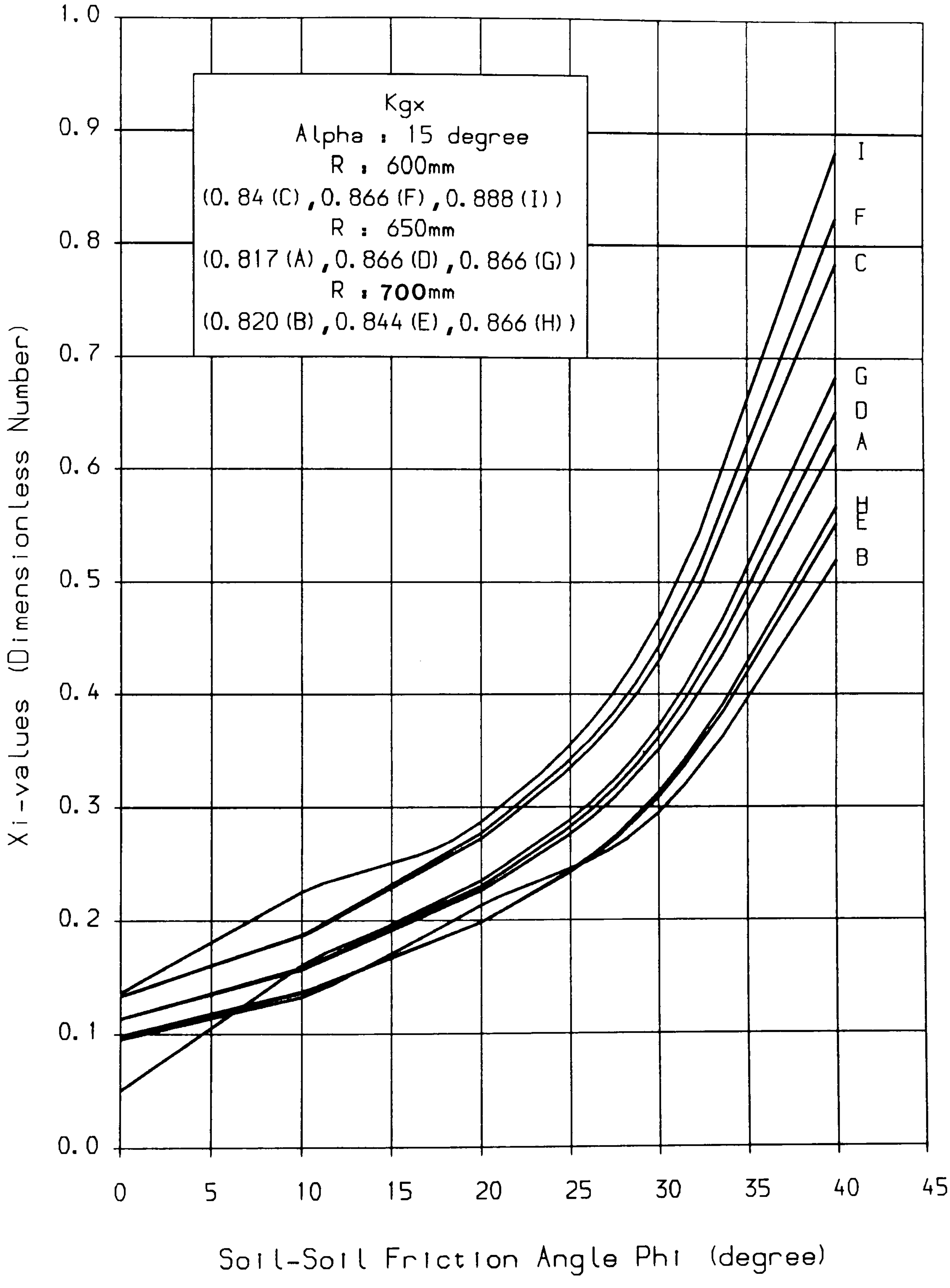

Chart 89. Xi-Values for Correction Equation.

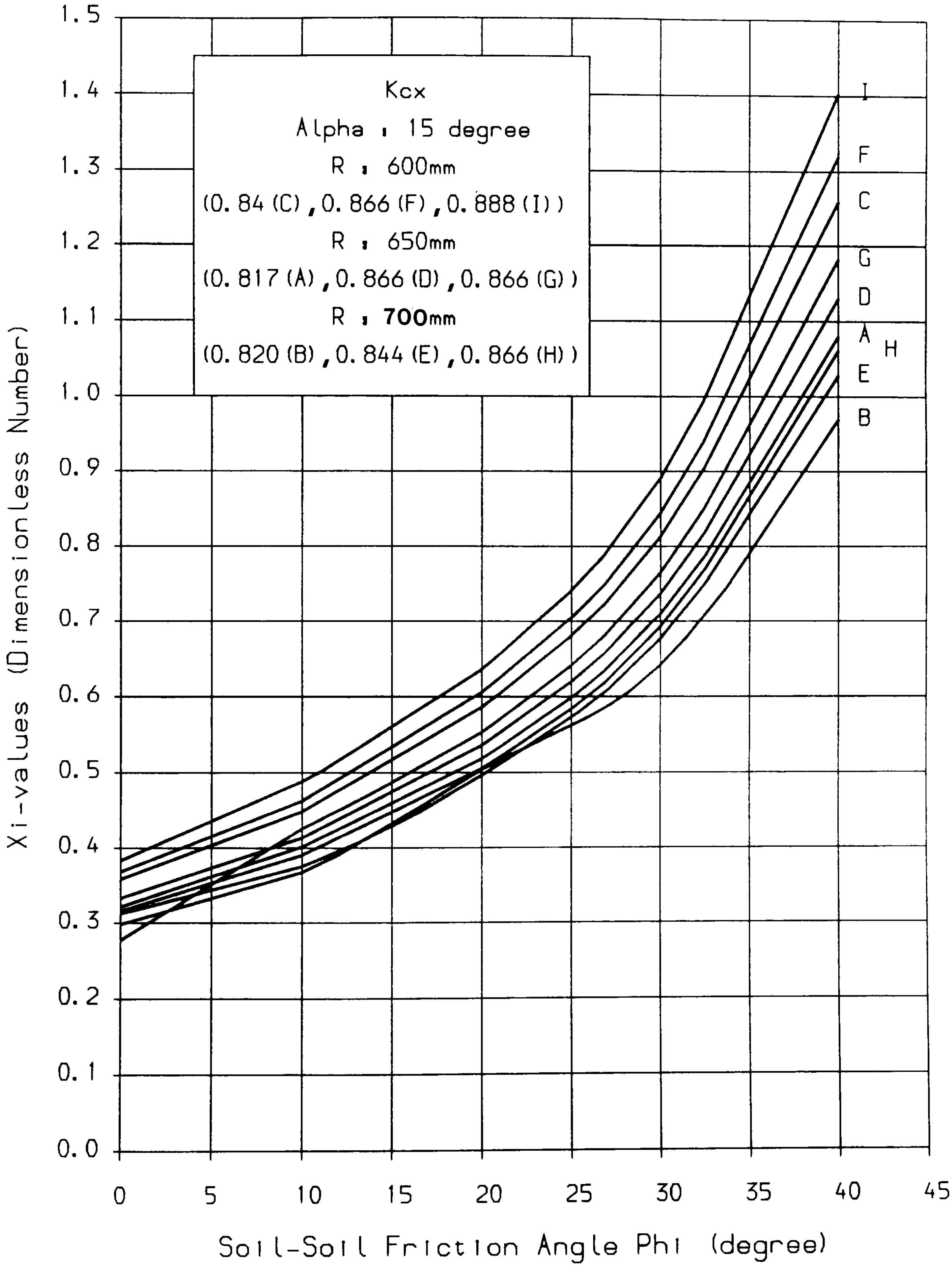

Chart 90. Xi-Values for Correction Equation.

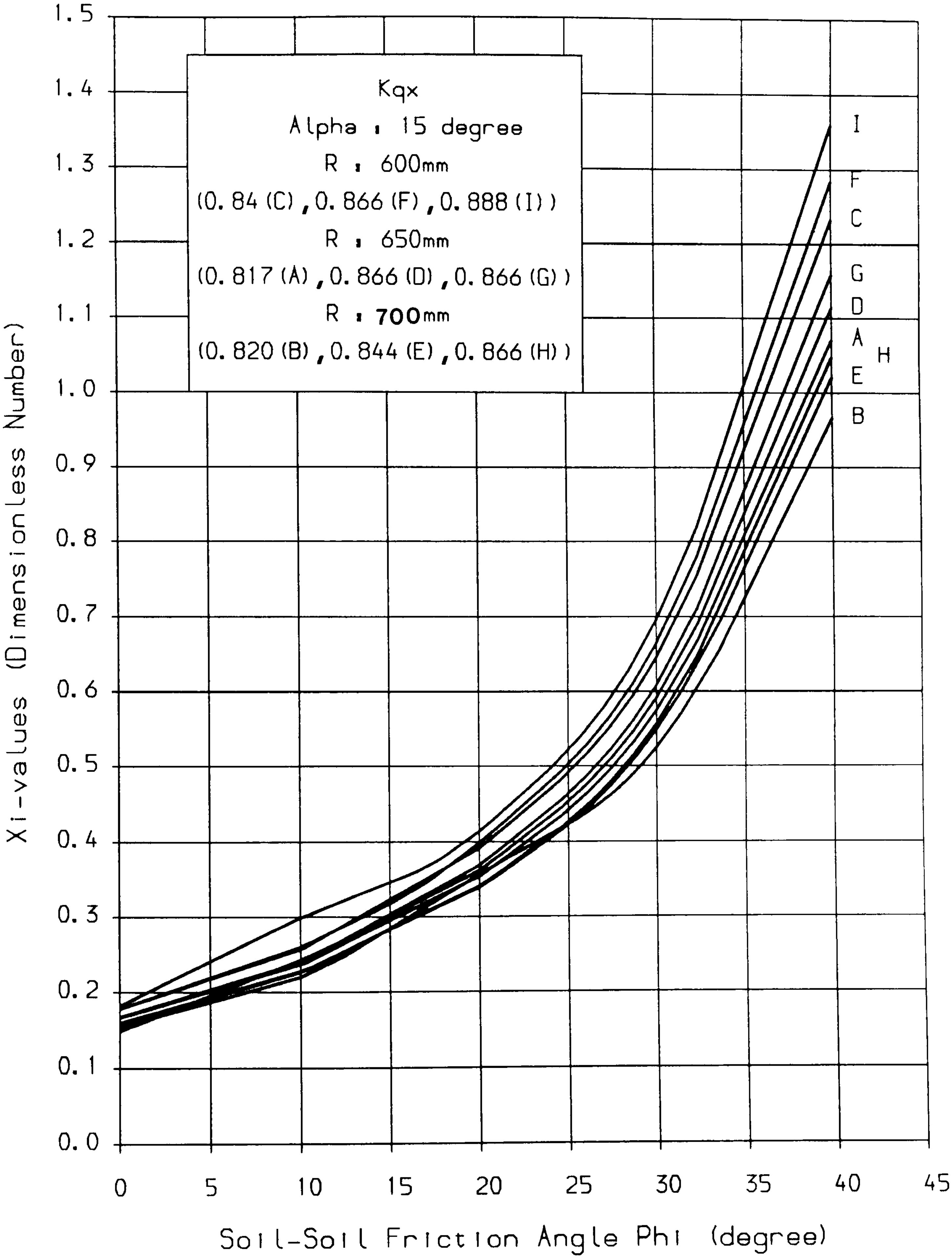

Chart 91. Xi-Values for Correction Equation.

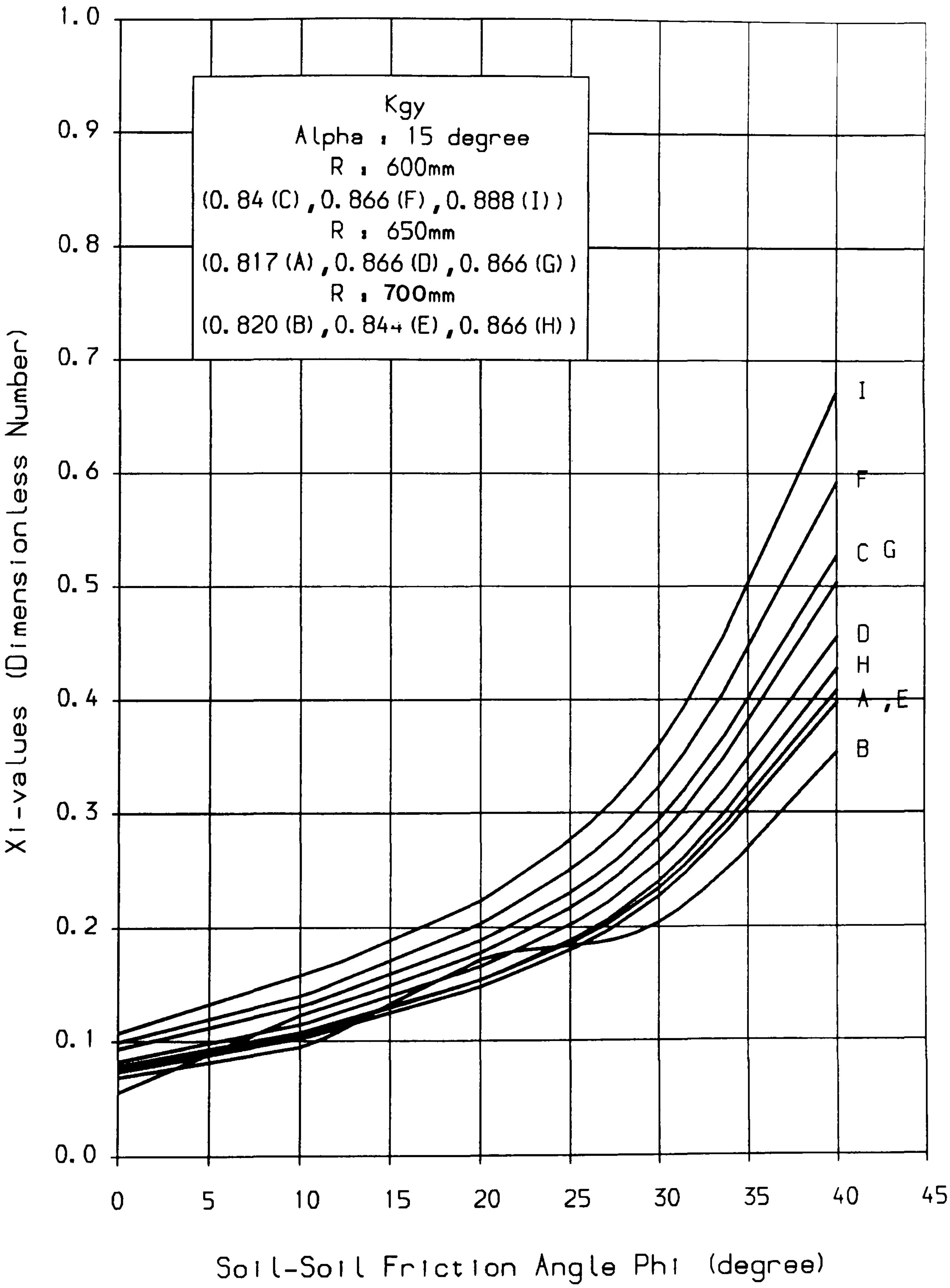

Chart 92. Xi-Values for Correction Equation.

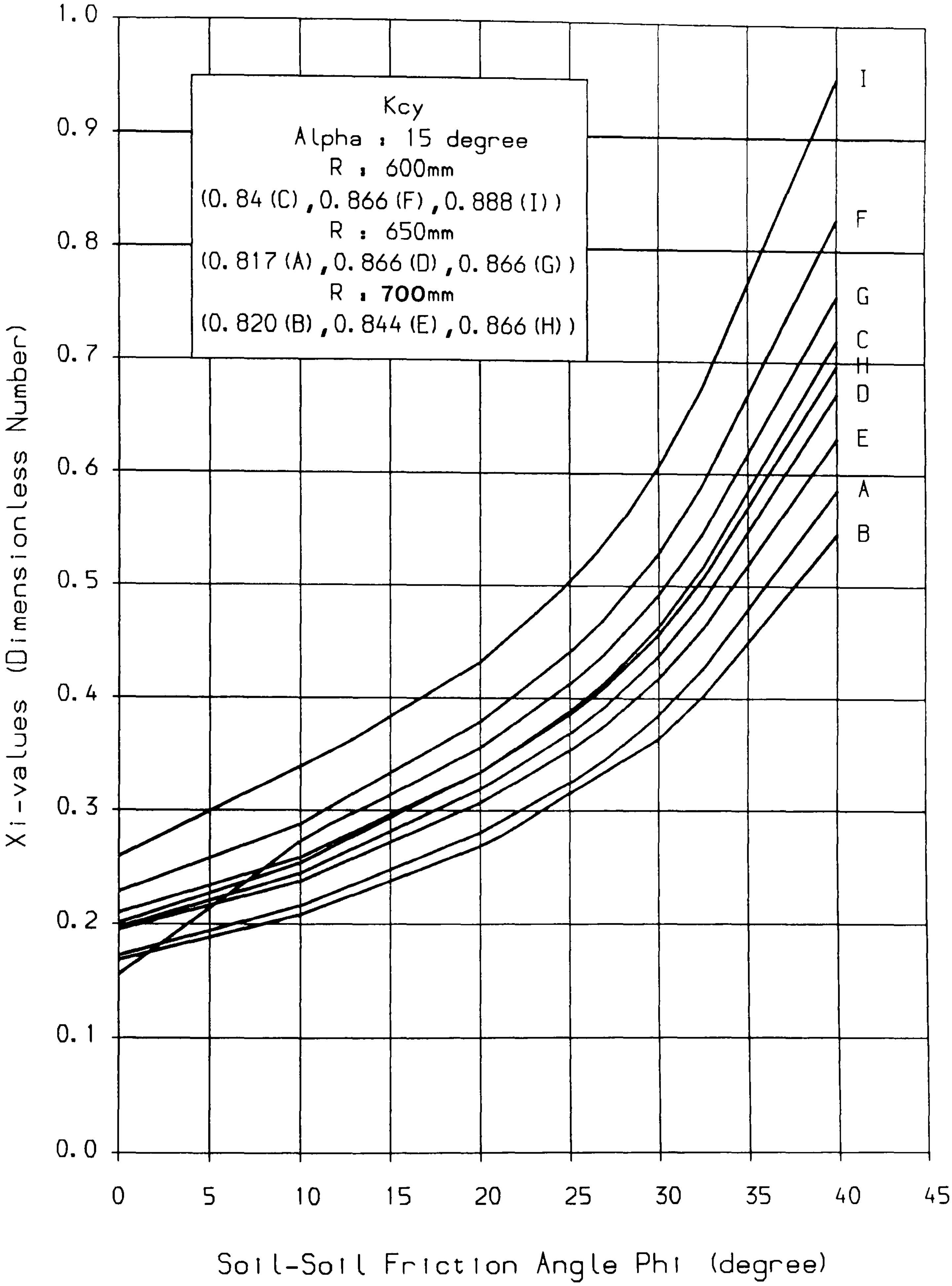

Chart 93. Xi-Values for Correction Equation.

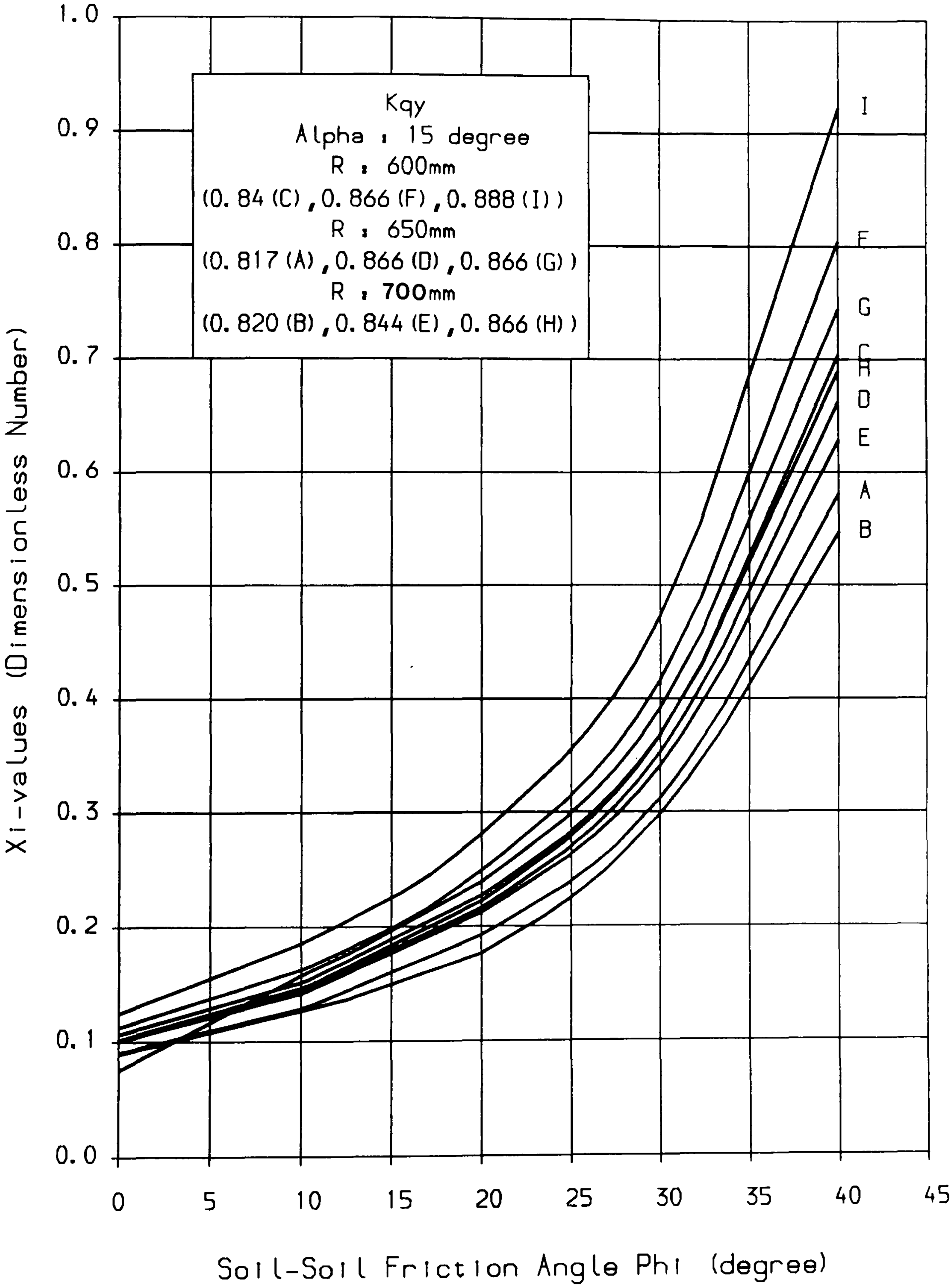

Chart 94. Xi-Values for Correction Equation.

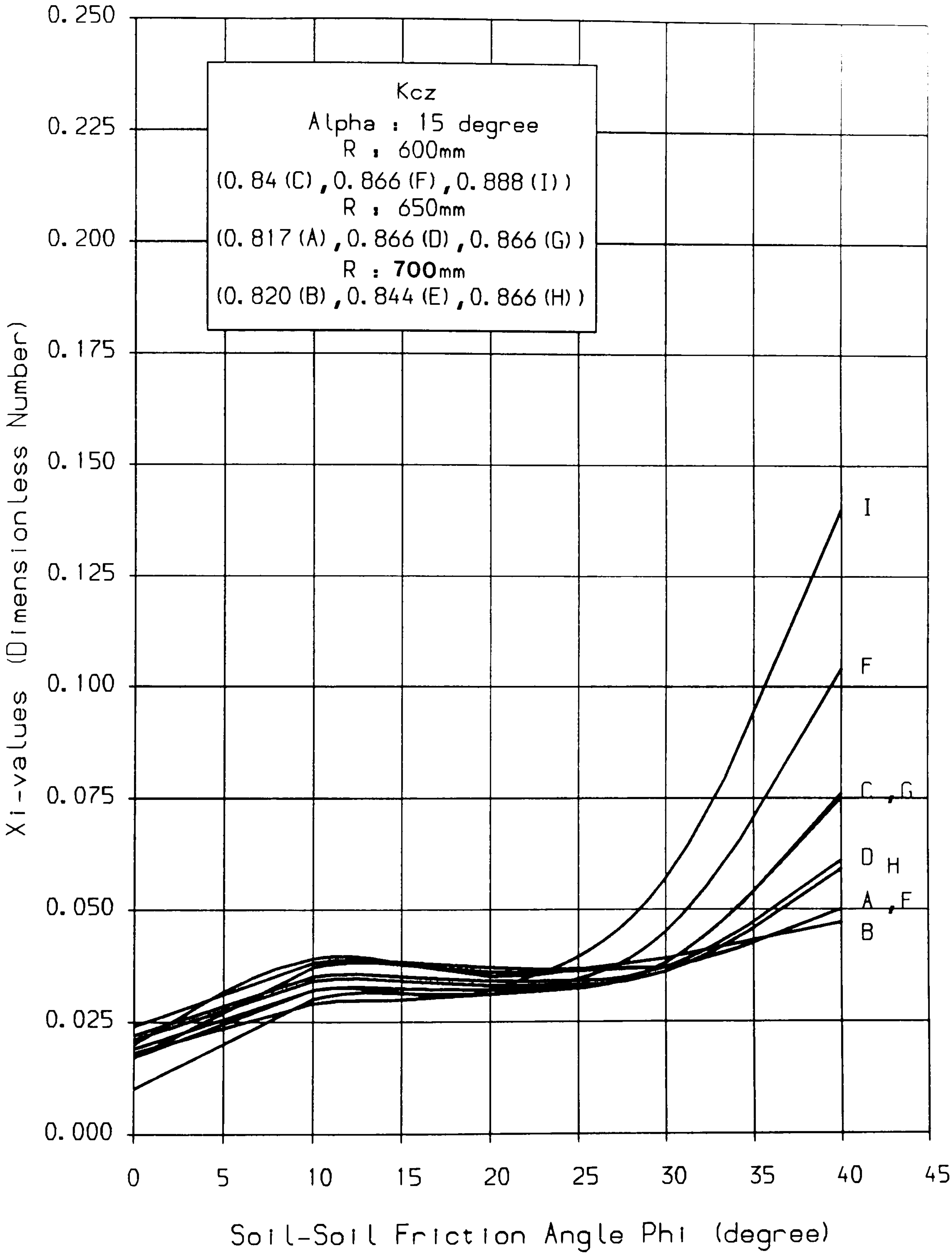

Chart 95. Xi-Values for Correction Equation.

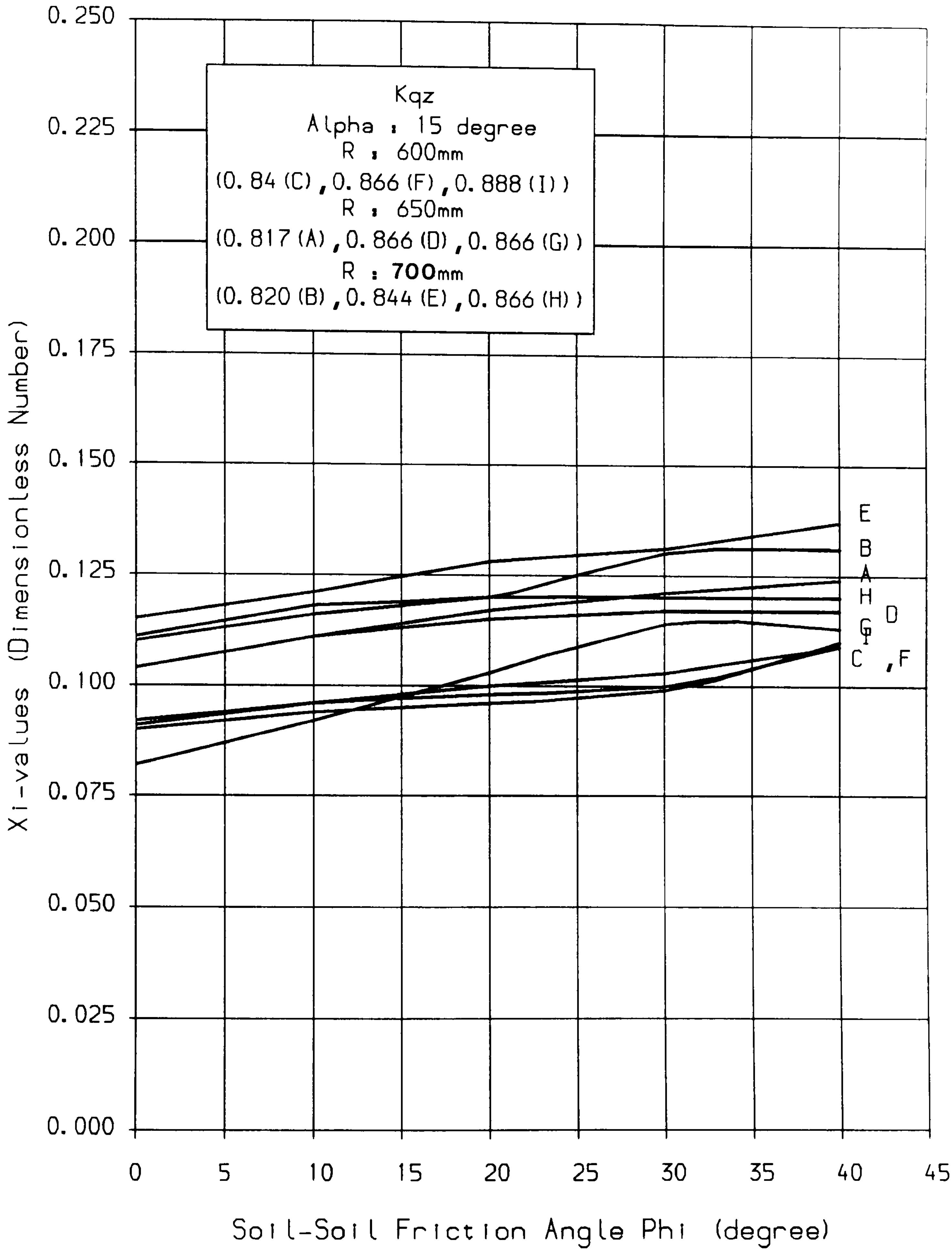

Chart 96. Xi-Values for Correction Equation.

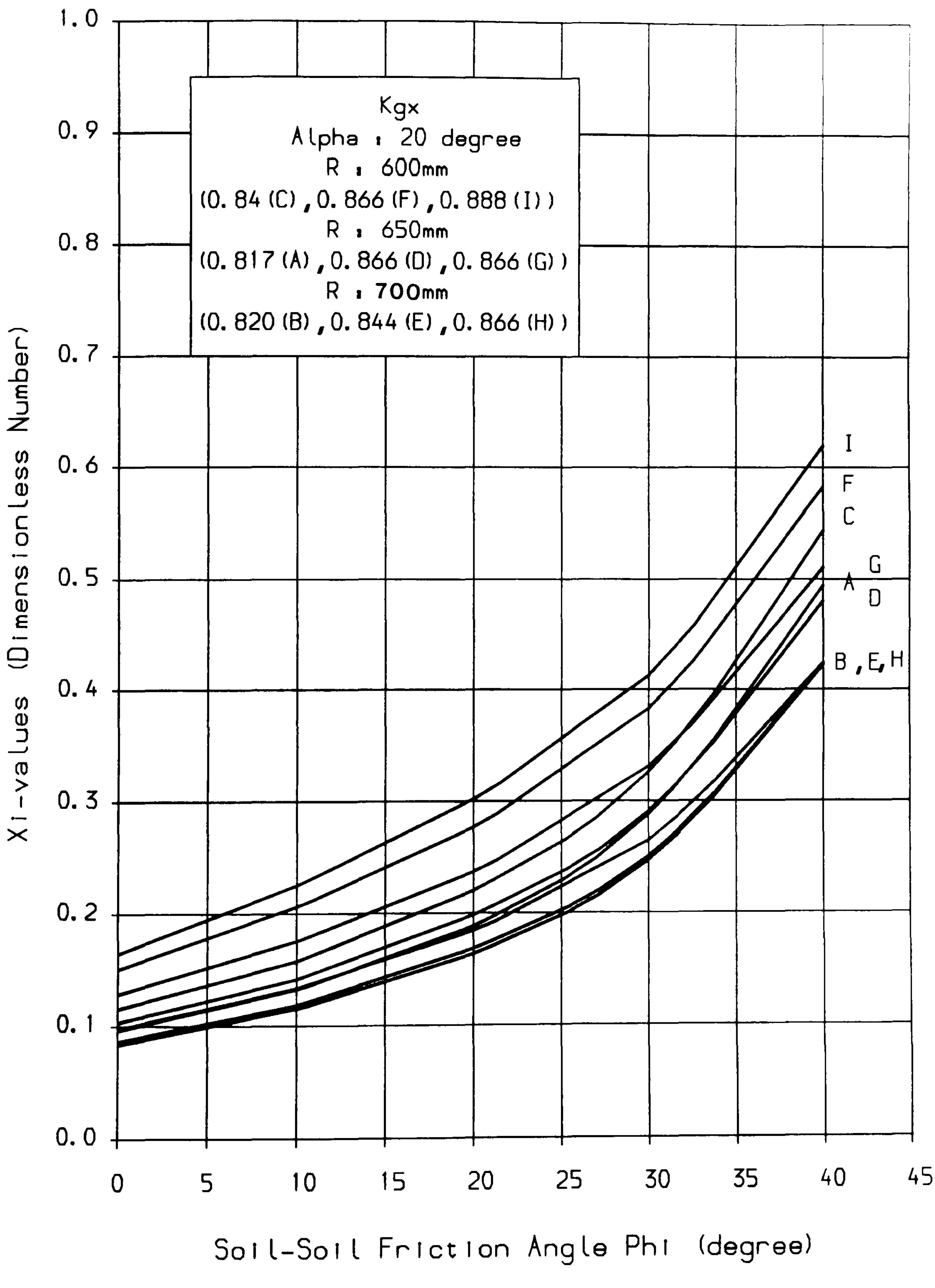

Chart 97. Xi-Values for Correction Equation.

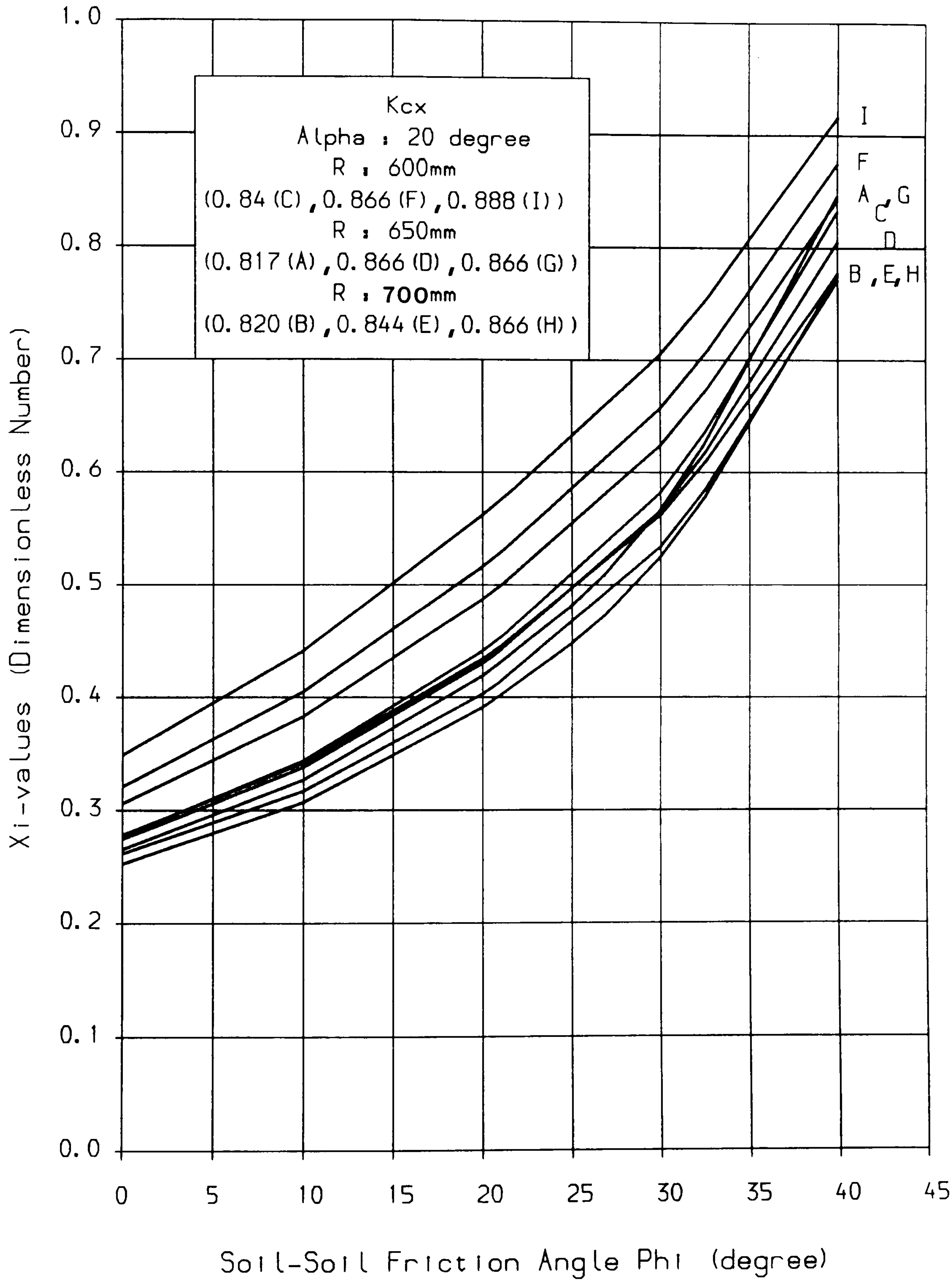

Chart 98. Xi-Values for Correction Equation.

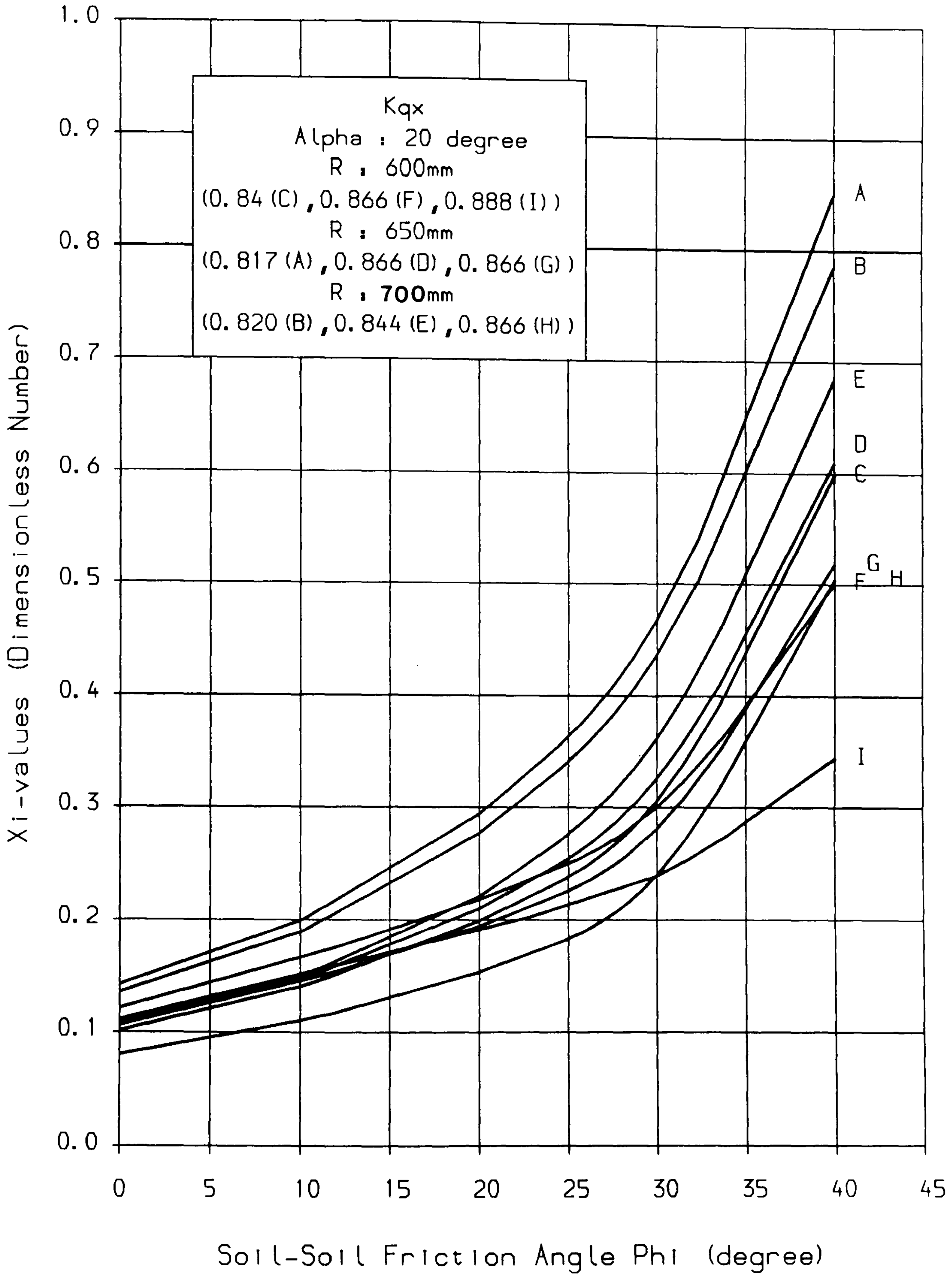

Chart 99. Xi-Values for Correction Equation.

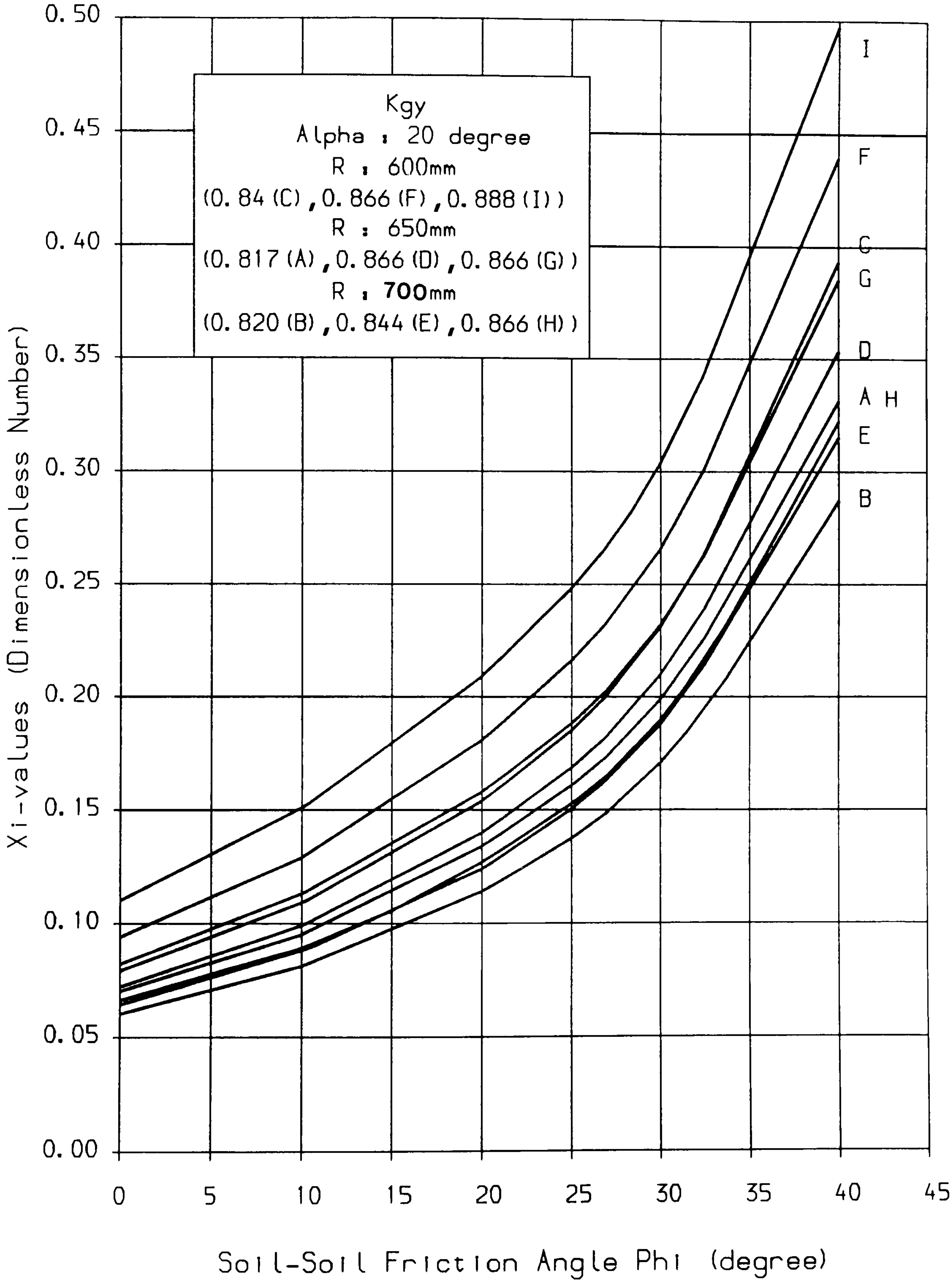

Chart 100. Xi-Values for Correction Equation.

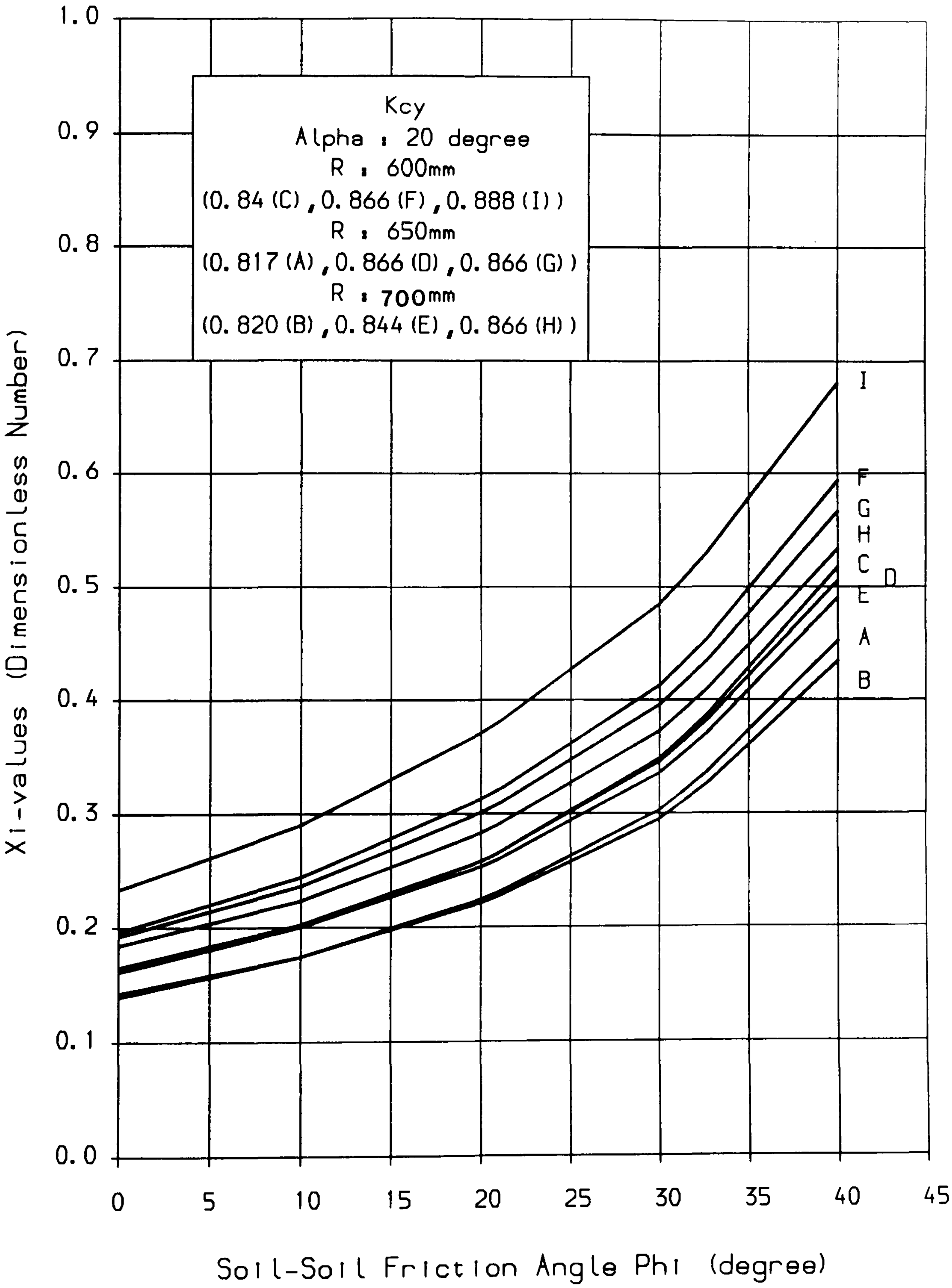

Chart 101. Xi-Values for Correction Equation.

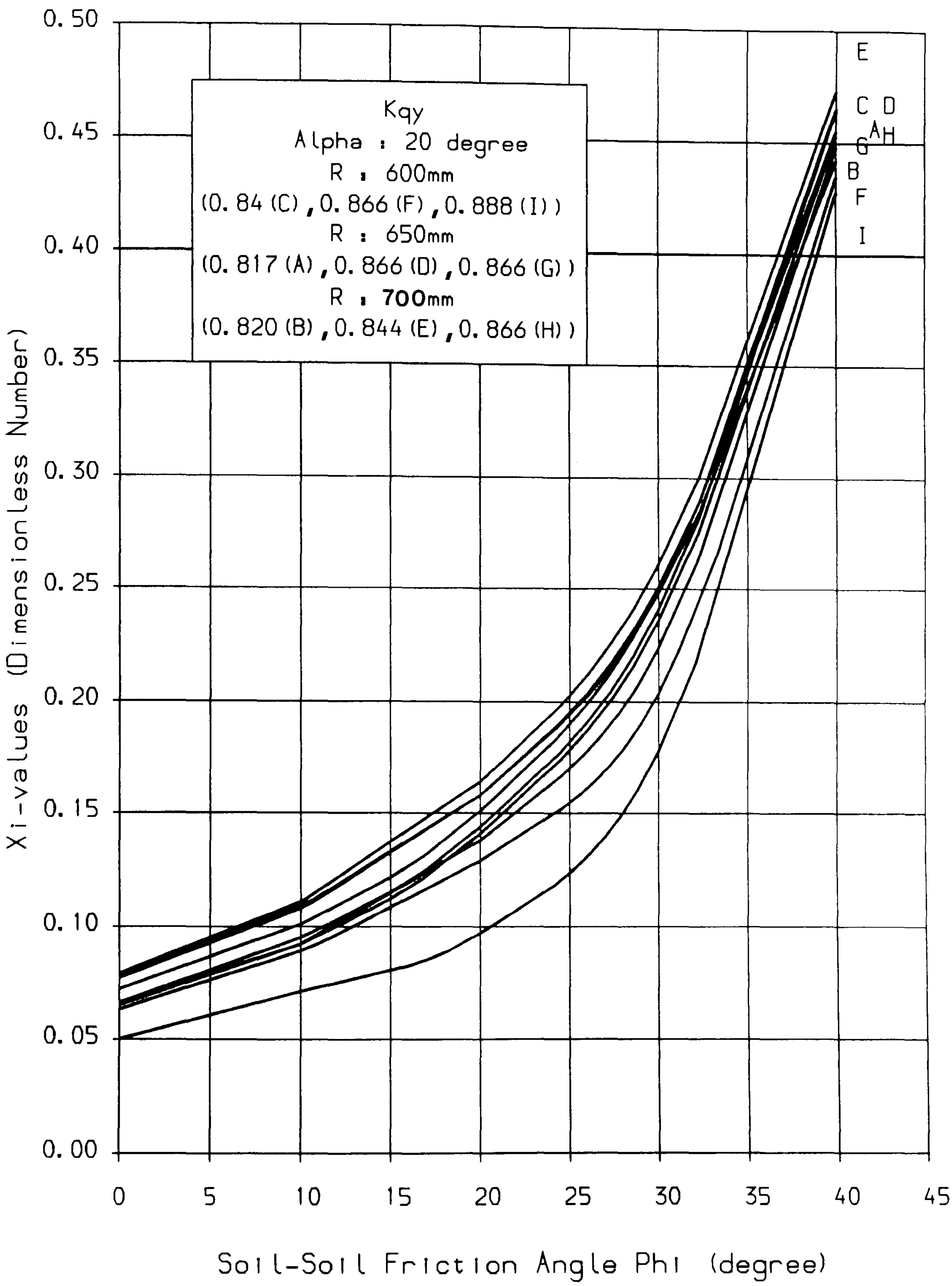

Chart 102. Xi-Values for Correction Equation.

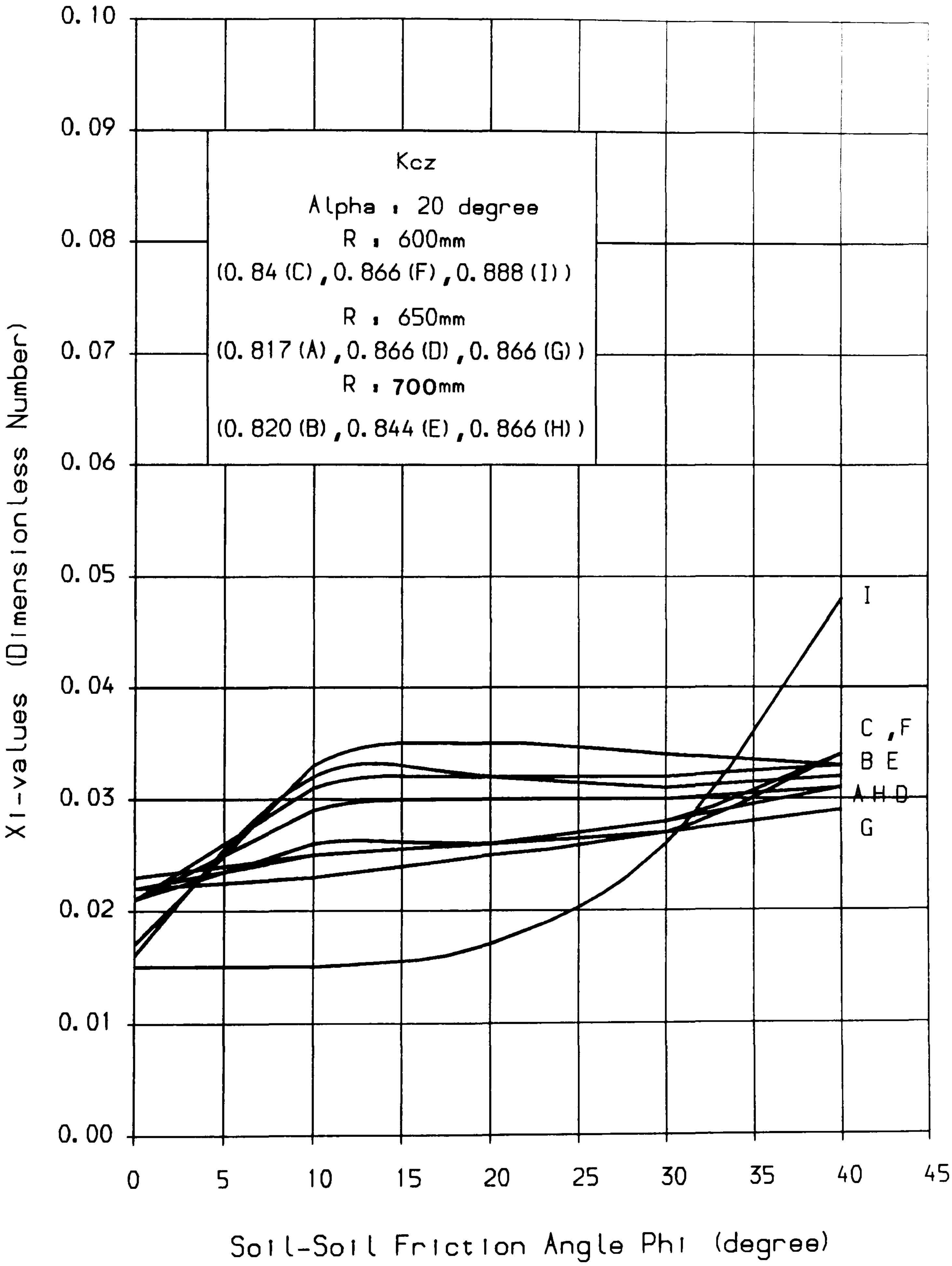

Chart 103. Xi-Values for Correction Equation.

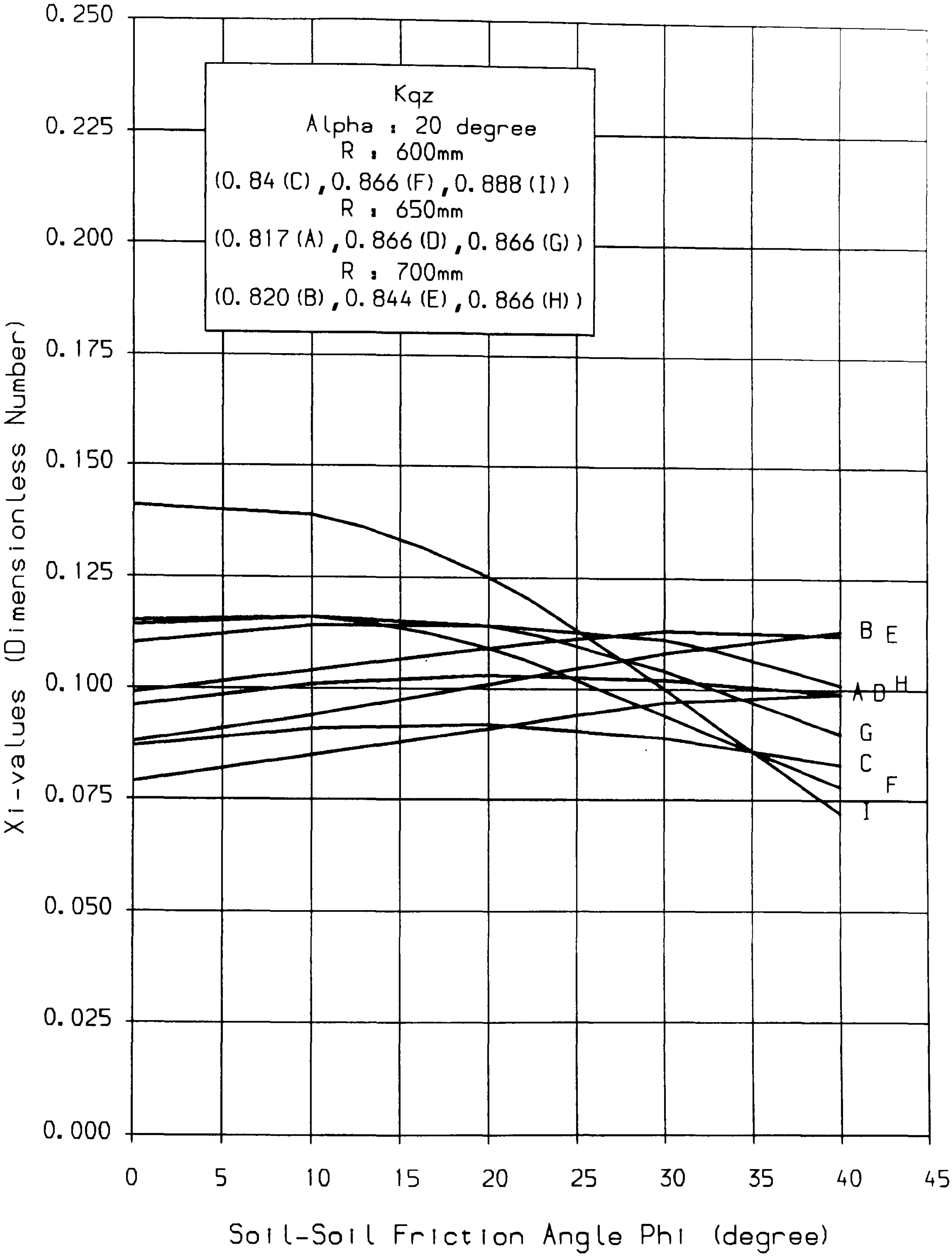

Chart 104. Xi-Values for Correction Equation.

Table : 1

K-factor for Vertical Gravitation Force (Kgz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.817	0	0	0.439	0.465	0.479	0.482	0.473	0.455
		5	0.465	0.479	0.482	0.473	0.455	0.521
		10	0.479	0.482	0.473	0.455	0.521	0.550
		15	0.482	0.473	0.455	0.521	0.550	0.566
		20	0.473	0.455	0.521	0.550	0.566	0.568
		25	0.455	0.521	0.550	0.566	0.568	0.556
		30	0.521	0.550	0.566	0.568	0.556	0.535
		35	0.550	0.566	0.568	0.556	0.535	0.622
		40	0.566	0.568	0.556	0.535	0.622	0.656
	10	0	0.347	0.343	0.324	0.293	0.253	0.207
		5	0.343	0.324	0.293	0.253	0.207	0.407
		10	0.324	0.293	0.253	0.207	0.407	0.402
		15	0.293	0.253	0.207	0.407	0.402	0.379
		20	0.253	0.207	0.407	0.402	0.379	0.343
		25	0.207	0.407	0.402	0.379	0.343	0.296
		30	0.407	0.402	0.379	0.343	0.296	0.243
		35	0.402	0.379	0.343	0.296	0.243	0.481
		40	0.379	0.343	0.296	0.243	0.481	0.473
	15	0	0.313	0.299	0.269	0.228	0.178	0.127
		5	0.299	0.269	0.228	0.178	0.127	0.366
		10	0.269	0.228	0.178	0.127	0.366	0.350
		15	0.228	0.178	0.127	0.366	0.350	0.315
		20	0.178	0.127	0.366	0.350	0.315	0.267
		25	0.127	0.366	0.350	0.315	0.267	0.209
		30	0.366	0.350	0.315	0.267	0.209	0.149
		35	0.350	0.315	0.267	0.209	0.149	0.431
		40	0.315	0.267	0.209	0.149	0.431	0.411
	20	0	0.291	0.271	0.234	0.186	0.131	0.076
		5	0.271	0.234	0.186	0.131	0.076	0.340
		10	0.234	0.186	0.131	0.076	0.340	0.317
		15	0.186	0.131	0.076	0.340	0.317	0.275
		20	0.131	0.076	0.340	0.317	0.275	0.218
		25	0.076	0.340	0.317	0.275	0.218	0.154
		30	0.340	0.317	0.275	0.218	0.154	0.090
		35	0.317	0.275	0.218	0.154	0.090	0.399
		40	0.275	0.218	0.154	0.090	0.399	0.372

* K-values calculated for the depth of 100mm

Table : 2

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.817	0	0	0.443	0.473	0.510	0.557	0.619	0.699
		5	0.473	0.510	0.557	0.619	0.699	0.454
		10	0.510	0.557	0.619	0.699	0.454	0.485
		15	0.557	0.619	0.699	0.454	0.485	0.523
		20	0.619	0.699	0.454	0.485	0.523	0.572
		25	0.699	0.454	0.485	0.523	0.572	0.635
		30	0.454	0.485	0.523	0.572	0.635	0.715
		35	0.485	0.523	0.572	0.635	0.715	0.464
		40	0.523	0.572	0.635	0.715	0.464	0.496
	10	0	0.416	0.386	0.354	0.319	0.283	0.246
		5	0.386	0.354	0.319	0.283	0.246	0.428
		10	0.354	0.319	0.283	0.246	0.428	0.397
		15	0.319	0.283	0.246	0.428	0.397	0.363
		20	0.283	0.246	0.428	0.397	0.363	0.327
		25	0.246	0.428	0.397	0.363	0.327	0.289
		30	0.428	0.397	0.363	0.327	0.289	0.251
		35	0.397	0.363	0.327	0.289	0.251	0.441
		40	0.363	0.327	0.289	0.251	0.441	0.409
	15	0	0.412	0.357	0.298	0.239	0.179	0.124
		5	0.357	0.298	0.239	0.179	0.124	0.423
		10	0.298	0.239	0.179	0.124	0.423	0.366
		15	0.239	0.179	0.124	0.423	0.366	0.306
		20	0.179	0.124	0.423	0.366	0.306	0.244
		25	0.124	0.423	0.366	0.306	0.244	0.183
		30	0.423	0.366	0.306	0.244	0.183	0.126
		35	0.366	0.306	0.244	0.183	0.126	0.436
		40	0.306	0.244	0.183	0.126	0.436	0.377
	20	0	0.432	0.353	0.273	0.194	0.121	0.060
		5	0.353	0.273	0.194	0.121	0.060	0.442
		10	0.273	0.194	0.121	0.060	0.442	0.362
		15	0.194	0.121	0.060	0.442	0.362	0.279
		20	0.121	0.060	0.442	0.362	0.279	0.198
		25	0.060	0.442	0.362	0.279	0.198	0.123
		30	0.442	0.362	0.279	0.198	0.123	0.061
		35	0.362	0.279	0.198	0.123	0.061	0.455
		40	0.279	0.198	0.123	0.061	0.455	0.372

* K-values calculated for the depth of 100mm

Table : 3

K-factor for Vertical Surcharge Force (Kqz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.817	0	0	0.132	0.134	0.150	0.162	0.168	0.190
		5	0.134	0.150	0.162	0.168	0.190	0.213
		10	0.150	0.162	0.168	0.190	0.213	0.236
		15	0.162	0.168	0.190	0.213	0.236	0.259
		20	0.168	0.190	0.213	0.236	0.259	0.281
		25	0.190	0.213	0.236	0.259	0.281	0.299
		30	0.213	0.236	0.259	0.281	0.299	0.310
		35	0.236	0.259	0.281	0.299	0.310	0.203
		40	0.259	0.281	0.299	0.310	0.203	0.232
	10	0	0.167	0.140	0.127	0.111	0.131	0.145
		5	0.140	0.127	0.111	0.131	0.145	0.252
		10	0.127	0.111	0.131	0.145	0.252	0.240
		15	0.111	0.131	0.145	0.252	0.240	0.224
		20	0.131	0.145	0.252	0.240	0.224	0.203
		25	0.145	0.252	0.240	0.224	0.203	0.179
		30	0.252	0.240	0.224	0.203	0.179	0.157
		35	0.240	0.224	0.203	0.179	0.157	0.267
		40	0.224	0.203	0.179	0.157	0.267	0.256
	15	0	0.161	0.123	0.103	0.113	0.115	0.111
		5	0.123	0.103	0.113	0.115	0.111	0.247
		10	0.103	0.113	0.115	0.111	0.247	0.221
		15	0.113	0.115	0.111	0.247	0.221	0.193
		20	0.115	0.111	0.247	0.221	0.193	0.161
		25	0.111	0.247	0.221	0.193	0.161	0.130
		30	0.247	0.221	0.193	0.161	0.130	0.104
		35	0.221	0.193	0.161	0.130	0.104	0.267
		40	0.193	0.161	0.130	0.104	0.267	0.242
	20	0	0.150	0.115	0.115	0.115	0.106	0.083
		5	0.115	0.115	0.115	0.106	0.083	0.238
		10	0.115	0.115	0.106	0.083	0.238	0.205
		15	0.115	0.106	0.083	0.238	0.205	0.168
		20	0.106	0.083	0.238	0.205	0.168	0.133
		25	0.083	0.238	0.205	0.168	0.133	0.101
		30	0.238	0.205	0.168	0.133	0.101	0.061
		35	0.205	0.168	0.133	0.101	0.061	0.263
		40	0.168	0.133	0.101	0.061	0.263	0.228

* K-values calculated for the depth of 100mm

Table : 4

K-factor for Vertical Gravitation Force (Kgz)

R=700mm	$\alpha(°)$	$\phi(°)$	$\beta(°)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.820	0	0	0.409	0.433	0.446	0.447	0.438	0.421
		5	0.433	0.446	0.447	0.438	0.421	0.485
		10	0.446	0.447	0.438	0.421	0.485	0.513
		15	0.447	0.438	0.421	0.485	0.513	0.526
		20	0.438	0.421	0.485	0.513	0.526	0.527
		25	0.421	0.485	0.513	0.526	0.527	0.516
		30	0.485	0.513	0.526	0.527	0.516	0.494
		35	0.513	0.526	0.527	0.516	0.494	0.580
		40	0.526	0.527	0.516	0.494	0.580	0.611
	10	0	0.319	0.312	0.291	0.260	0.220	0.176
		5	0.312	0.291	0.260	0.220	0.176	0.374
		10	0.291	0.260	0.220	0.176	0.374	0.366
		15	0.260	0.220	0.176	0.374	0.366	0.342
		20	0.220	0.176	0.374	0.366	0.342	0.304
		25	0.176	0.374	0.366	0.342	0.304	0.258
		30	0.374	0.366	0.342	0.304	0.258	0.206
		35	0.366	0.342	0.304	0.258	0.206	0.441
		40	0.342	0.304	0.258	0.206	0.441	0.431
	15	0	0.286	0.269	0.238	0.197	0.149	0.100
		5	0.269	0.238	0.197	0.149	0.100	0.335
		10	0.238	0.197	0.149	0.100	0.335	0.315
		15	0.197	0.149	0.100	0.335	0.315	0.279
		20	0.149	0.100	0.335	0.315	0.279	0.230
		25	0.100	0.335	0.315	0.279	0.230	0.174
		30	0.335	0.315	0.279	0.230	0.174	0.117
		35	0.315	0.279	0.230	0.174	0.117	0.393
		40	0.279	0.230	0.174	0.117	0.393	0.370
	20	0	0.263	0.240	0.202	0.154	0.101	0.051
		5	0.240	0.202	0.154	0.101	0.051	0.308
		10	0.202	0.154	0.101	0.051	0.308	0.281
		15	0.154	0.101	0.051	0.308	0.281	0.237
		20	0.101	0.051	0.308	0.281	0.237	0.181
		25	0.051	0.308	0.281	0.237	0.181	0.119
		30	0.308	0.281	0.237	0.181	0.119	0.060
		35	0.281	0.237	0.181	0.119	0.060	0.361
		40	0.237	0.181	0.119	0.060	0.361	0.329

* K-values calculated for the depth of 100mm

Table : 5

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.820	0	0	0.381	0.407	0.439	0.480	0.533	0.603
		5	0.407	0.439	0.480	0.533	0.603	0.391
		10	0.439	0.480	0.533	0.603	0.391	0.417
		15	0.480	0.533	0.603	0.391	0.417	0.450
		20	0.533	0.603	0.391	0.417	0.450	0.493
		25	0.603	0.391	0.417	0.450	0.493	0.547
		30	0.391	0.417	0.450	0.493	0.547	0.617
		35	0.417	0.450	0.493	0.547	0.617	0.399
		40	0.450	0.493	0.547	0.617	0.399	0.427
	10	0	0.349	0.320	0.288	0.255	0.220	0.185
		5	0.320	0.288	0.255	0.220	0.185	0.359
		10	0.288	0.255	0.220	0.185	0.359	0.329
		15	0.255	0.220	0.185	0.359	0.329	0.296
		20	0.220	0.185	0.359	0.329	0.296	0.261
		25	0.185	0.359	0.329	0.296	0.261	0.225
		30	0.359	0.329	0.296	0.261	0.225	0.189
		35	0.329	0.296	0.261	0.225	0.189	0.370
		40	0.296	0.261	0.225	0.189	0.370	0.339
	15	0	0.342	0.290	0.236	0.182	0.129	0.082
		5	0.290	0.236	0.182	0.129	0.082	0.351
		10	0.236	0.182	0.129	0.082	0.351	0.298
		15	0.182	0.129	0.082	0.351	0.298	0.242
		20	0.129	0.082	0.351	0.298	0.242	0.186
		25	0.082	0.351	0.298	0.242	0.186	0.132
		30	0.351	0.298	0.242	0.186	0.132	0.083
		35	0.298	0.242	0.186	0.132	0.083	0.362
		40	0.242	0.186	0.132	0.083	0.362	0.307
	20	0	0.351	0.279	0.207	0.138	0.077	0.031
		5	0.279	0.207	0.138	0.077	0.031	0.359
		10	0.207	0.138	0.077	0.031	0.359	0.286
		15	0.138	0.077	0.031	0.359	0.286	0.211
		20	0.077	0.031	0.359	0.286	0.211	0.141
		25	0.031	0.359	0.286	0.211	0.141	0.079
		30	0.359	0.286	0.211	0.141	0.079	0.031
		35	0.286	0.211	0.141	0.079	0.031	0.370
		40	0.211	0.141	0.079	0.031	0.370	0.294

* K-values calculated for the depth of 100mm

Table : 6

K-factor for Vertical Surcharge Force (Kqz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.820	0	0	0.124	0.126	0.140	0.152	0.158	0.177
		5	0.126	0.140	0.152	0.158	0.177	0.200
		10	0.140	0.152	0.158	0.177	0.200	0.221
		15	0.152	0.158	0.177	0.200	0.221	0.242
		20	0.158	0.177	0.200	0.221	0.242	0.263
		25	0.177	0.200	0.221	0.242	0.263	0.279
		30	0.200	0.221	0.242	0.263	0.279	0.290
		35	0.221	0.242	0.263	0.279	0.290	0.191
		40	0.242	0.263	0.279	0.290	0.191	0.217
	10	0	0.153	0.127	0.115	0.099	0.113	0.123
		5	0.127	0.115	0.099	0.113	0.123	0.231
		10	0.115	0.099	0.113	0.123	0.231	0.218
		15	0.099	0.113	0.123	0.231	0.218	0.201
		20	0.113	0.123	0.231	0.218	0.201	0.181
		25	0.123	0.231	0.218	0.201	0.181	0.157
		30	0.231	0.218	0.201	0.181	0.157	0.135
		35	0.218	0.201	0.181	0.157	0.135	0.244
		40	0.201	0.181	0.157	0.135	0.244	0.232
	15	0	0.146	0.110	0.091	0.097	0.095	0.087
		5	0.110	0.091	0.097	0.095	0.087	0.224
		10	0.091	0.097	0.095	0.087	0.224	0.198
		15	0.097	0.095	0.087	0.224	0.198	0.170
		20	0.095	0.087	0.224	0.198	0.170	0.138
		25	0.087	0.224	0.198	0.170	0.138	0.105
		30	0.224	0.198	0.170	0.138	0.105	0.081
		35	0.198	0.170	0.138	0.105	0.081	0.243
		40	0.170	0.138	0.105	0.081	0.243	0.217
	20	0	0.133	0.100	0.098	0.094	0.081	0.055
		5	0.100	0.098	0.094	0.081	0.055	0.213
		10	0.098	0.094	0.081	0.055	0.213	0.180
		15	0.094	0.081	0.055	0.213	0.180	0.144
		20	0.081	0.055	0.213	0.180	0.144	0.106
		25	0.055	0.213	0.180	0.144	0.106	0.071
		30	0.213	0.180	0.144	0.106	0.071	0.040
		35	0.180	0.144	0.106	0.071	0.040	0.236
		40	0.144	0.106	0.071	0.040	0.236	0.201

* K-values calculated for the depth of 100mm

Table : 7

K-factor for Vertical Gravitation Force (Kgz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.840	0	0	0.481	0.509	0.524	0.526	0.516	0.496
		5	0.509	0.524	0.526	0.516	0.496	0.573
		10	0.524	0.526	0.516	0.496	0.573	0.605
		15	0.526	0.516	0.496	0.573	0.605	0.621
		20	0.516	0.496	0.573	0.605	0.621	0.622
		25	0.496	0.573	0.605	0.621	0.622	0.609
		30	0.573	0.605	0.621	0.622	0.609	0.584
		35	0.605	0.621	0.622	0.609	0.584	0.687
		40	0.621	0.622	0.609	0.584	0.687	0.724
	10	0	0.395	0.391	0.372	0.339	0.296	0.246
		5	0.391	0.372	0.339	0.296	0.246	0.464
		10	0.372	0.339	0.296	0.246	0.464	0.460
		15	0.339	0.296	0.246	0.464	0.460	0.437
		20	0.296	0.246	0.464	0.460	0.437	0.398
		25	0.246	0.464	0.460	0.437	0.398	0.347
		30	0.464	0.460	0.437	0.398	0.347	0.289
		35	0.460	0.437	0.398	0.347	0.289	0.550
		40	0.437	0.398	0.347	0.289	0.550	0.544
	15	0	0.349	0.334	0.303	0.259	0.206	0.150
		5	0.334	0.303	0.259	0.206	0.150	0.409
		10	0.303	0.259	0.206	0.150	0.409	0.392
		15	0.259	0.206	0.150	0.409	0.392	0.355
		20	0.206	0.150	0.409	0.392	0.355	0.303
		25	0.150	0.409	0.392	0.355	0.303	0.242
		30	0.409	0.392	0.355	0.303	0.242	0.176
		35	0.392	0.355	0.303	0.242	0.176	0.482
		40	0.355	0.303	0.242	0.176	0.482	0.461
	20	0	0.325	0.303	0.264	0.212	0.153	0.093
		5	0.303	0.264	0.212	0.153	0.093	0.380
		10	0.264	0.212	0.153	0.093	0.380	0.355
		15	0.212	0.153	0.093	0.380	0.355	0.309
		20	0.153	0.093	0.380	0.355	0.309	0.248
		25	0.093	0.380	0.355	0.309	0.248	0.179
		30	0.380	0.355	0.309	0.248	0.179	0.109
		35	0.355	0.309	0.248	0.179	0.109	0.446
		40	0.309	0.248	0.179	0.109	0.446	0.416

* K-values calculated for the depth of 100mm

Table : 8

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.840	0	0	0.469	0.500	0.539	0.590	0.655	0.741
		5	0.500	0.539	0.590	0.655	0.741	0.478
		10	0.539	0.590	0.655	0.741	0.478	0.511
		15	0.590	0.655	0.741	0.478	0.511	0.552
		20	0.655	0.741	0.478	0.511	0.552	0.605
		25	0.741	0.478	0.511	0.552	0.605	0.672
		30	0.478	0.511	0.552	0.605	0.672	0.759
		35	0.511	0.552	0.605	0.672	0.759	0.485
		40	0.552	0.605	0.672	0.759	0.485	0.520
	10	0	0.477	0.447	0.414	0.379	0.343	0.306
		5	0.447	0.414	0.379	0.343	0.306	0.490
		10	0.414	0.379	0.343	0.306	0.490	0.459
		15	0.379	0.343	0.306	0.490	0.459	0.426
		20	0.343	0.306	0.490	0.459	0.426	0.389
		25	0.306	0.490	0.459	0.426	0.389	0.352
		30	0.490	0.459	0.426	0.389	0.352	0.313
		35	0.459	0.426	0.389	0.352	0.313	0.504
		40	0.426	0.389	0.352	0.313	0.504	0.473
	15	0	0.455	0.398	0.337	0.275	0.212	0.152
		5	0.398	0.337	0.275	0.212	0.152	0.467
		10	0.337	0.275	0.212	0.152	0.467	0.409
		15	0.275	0.212	0.152	0.467	0.409	0.346
		20	0.212	0.152	0.467	0.409	0.346	0.282
		25	0.152	0.467	0.409	0.346	0.282	0.217
		30	0.467	0.409	0.346	0.282	0.217	0.155
		35	0.409	0.346	0.282	0.217	0.155	0.482
		40	0.346	0.282	0.217	0.155	0.482	0.421
	20	0	0.476	0.393	0.309	0.224	0.146	0.078
		5	0.393	0.309	0.224	0.146	0.078	0.488
		10	0.309	0.224	0.146	0.078	0.488	0.403
		15	0.224	0.146	0.078	0.488	0.403	0.316
		20	0.146	0.078	0.488	0.403	0.316	0.229
		25	0.078	0.488	0.403	0.316	0.229	0.149
		30	0.488	0.403	0.316	0.229	0.149	0.079
		35	0.403	0.316	0.229	0.149	0.079	0.503
		40	0.316	0.229	0.149	0.079	0.503	0.415

* K-values calculated for the depth of 100mm

Table : 9

K-factor for Vertical Surcharge Force (Kqz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.840	0	0	0.098	0.108	0.130	0.152	0.168	0.196
		5	0.108	0.130	0.152	0.168	0.196	0.177
		10	0.130	0.152	0.168	0.196	0.177	0.206
		15	0.152	0.168	0.196	0.177	0.206	0.237
		20	0.168	0.196	0.177	0.206	0.237	0.268
		25	0.196	0.177	0.206	0.237	0.268	0.296
		30	0.177	0.206	0.237	0.268	0.296	0.318
		35	0.206	0.237	0.268	0.296	0.318	0.154
		40	0.237	0.268	0.296	0.318	0.154	0.190
	10	0	0.173	0.151	0.142	0.130	0.124	0.135
		5	0.151	0.142	0.130	0.124	0.135	0.263
		10	0.142	0.130	0.124	0.135	0.263	0.255
		15	0.130	0.124	0.135	0.263	0.255	0.244
		20	0.124	0.135	0.263	0.255	0.244	0.228
		25	0.135	0.263	0.255	0.244	0.228	0.207
		30	0.263	0.255	0.244	0.228	0.207	0.187
		35	0.255	0.244	0.228	0.207	0.187	0.272
		40	0.244	0.228	0.207	0.187	0.272	0.267
	15	0	0.173	0.138	0.119	0.107	0.105	0.103
		5	0.138	0.119	0.107	0.105	0.103	0.263
		10	0.119	0.107	0.105	0.103	0.263	0.239
		15	0.107	0.105	0.103	0.263	0.239	0.212
		20	0.105	0.103	0.263	0.239	0.212	0.181
		25	0.103	0.263	0.239	0.212	0.181	0.147
		30	0.263	0.239	0.212	0.181	0.147	0.115
		35	0.239	0.212	0.181	0.147	0.115	0.280
		40	0.212	0.181	0.147	0.115	0.280	0.258
	20	0	0.167	0.123	0.108	0.103	0.097	0.080
		5	0.123	0.108	0.103	0.097	0.080	0.260
		10	0.108	0.103	0.097	0.080	0.260	0.227
		15	0.103	0.097	0.080	0.260	0.227	0.189
		20	0.097	0.080	0.260	0.227	0.189	0.149
		25	0.080	0.260	0.227	0.189	0.149	0.111
		30	0.260	0.227	0.189	0.149	0.111	0.076
		35	0.227	0.189	0.149	0.111	0.076	0.284
		40	0.189	0.149	0.111	0.076	0.284	0.249

* K-values calculated for the depth of 100mm

Table : 10

K-factor for Vertical Gravitation Force (Kgz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.843	0	0	0.415	0.443	0.478	0.523	0.581	0.658
		5	0.443	0.478	0.523	0.581	0.658	0.424
		10	0.478	0.523	0.581	0.658	0.424	0.453
		15	0.523	0.581	0.658	0.424	0.453	0.490
		20	0.581	0.658	0.424	0.453	0.490	0.536
		25	0.658	0.424	0.453	0.490	0.536	0.596
		30	0.424	0.453	0.490	0.536	0.596	0.674
		35	0.453	0.490	0.536	0.596	0.674	0.430
		40	0.490	0.536	0.596	0.674	0.430	0.461
	10	0	0.377	0.347	0.316	0.282	0.247	0.212
		5	0.347	0.316	0.282	0.247	0.212	0.387
		10	0.316	0.282	0.247	0.212	0.387	0.357
		15	0.282	0.247	0.212	0.387	0.357	0.325
		20	0.247	0.212	0.387	0.357	0.325	0.290
		25	0.212	0.387	0.357	0.325	0.290	0.254
		30	0.387	0.357	0.325	0.290	0.254	0.217
		35	0.357	0.325	0.290	0.254	0.217	0.399
		40	0.325	0.290	0.254	0.217	0.399	0.368
	15	0	0.369	0.316	0.261	0.204	0.149	0.098
		5	0.316	0.261	0.204	0.149	0.098	0.380
		10	0.261	0.204	0.149	0.098	0.380	0.325
		15	0.204	0.149	0.098	0.380	0.325	0.268
		20	0.149	0.098	0.380	0.325	0.268	0.209
		25	0.098	0.380	0.325	0.268	0.209	0.152
		30	0.380	0.325	0.268	0.209	0.152	0.100
		35	0.325	0.268	0.209	0.152	0.100	0.392
		40	0.268	0.209	0.152	0.100	0.392	0.335
	20	0	0.378	0.303	0.227	0.155	0.090	0.039
		5	0.303	0.227	0.155	0.090	0.039	0.388
		10	0.227	0.155	0.090	0.039	0.388	0.311
		15	0.155	0.090	0.039	0.388	0.311	0.233
		20	0.090	0.039	0.388	0.311	0.233	0.158
		25	0.039	0.388	0.311	0.233	0.158	0.092
		30	0.388	0.311	0.233	0.158	0.092	0.039
		35	0.311	0.233	0.158	0.092	0.039	0.400
		40	0.233	0.158	0.092	0.039	0.400	0.320

* K-values calculated for the depth of 100mm

Table : 11

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.843	0	0	0.093	0.102	0.124	0.144	0.160	0.186
		5	0.102	0.124	0.144	0.160	0.186	0.168
		10	0.124	0.144	0.160	0.186	0.168	0.195
		15	0.144	0.160	0.186	0.168	0.195	0.225
		20	0.160	0.186	0.168	0.195	0.225	0.254
		25	0.186	0.168	0.195	0.225	0.254	0.281
		30	0.168	0.195	0.225	0.254	0.281	0.302
		35	0.195	0.225	0.254	0.281	0.302	0.146
		40	0.225	0.254	0.281	0.302	0.146	0.180
	10	0	0.155	0.134	0.124	0.111	0.104	0.109
		5	0.134	0.124	0.111	0.104	0.109	0.234
		10	0.124	0.111	0.104	0.109	0.234	0.225
		15	0.111	0.104	0.109	0.234	0.225	0.212
		20	0.104	0.109	0.234	0.225	0.212	0.195
		25	0.109	0.234	0.225	0.212	0.195	0.174
		30	0.234	0.225	0.212	0.195	0.174	0.148
		35	0.225	0.212	0.195	0.174	0.148	0.243
		40	0.212	0.195	0.174	0.148	0.243	0.236
	15	0	0.155	0.123	0.104	0.083	0.085	0.079
		5	0.123	0.104	0.083	0.085	0.079	0.236
		10	0.104	0.083	0.085	0.079	0.236	0.212
		15	0.083	0.085	0.079	0.236	0.212	0.185
		20	0.085	0.079	0.236	0.212	0.185	0.154
		25	0.079	0.236	0.212	0.185	0.154	0.121
		30	0.236	0.212	0.185	0.154	0.121	0.089
		35	0.212	0.185	0.154	0.121	0.089	0.252
		40	0.185	0.154	0.121	0.089	0.252	0.229
	20	0	0.148	0.107	0.091	0.083	0.072	0.052
		5	0.107	0.091	0.083	0.072	0.052	0.230
		10	0.091	0.083	0.072	0.052	0.230	0.197
		15	0.083	0.072	0.052	0.230	0.197	0.160
		20	0.072	0.052	0.230	0.197	0.160	0.121
		25	0.052	0.230	0.197	0.160	0.121	0.081
		30	0.230	0.197	0.160	0.121	0.081	0.050
		35	0.197	0.160	0.121	0.081	0.050	0.251
		40	0.160	0.121	0.081	0.050	0.251	0.217

* K-values calculated for the depth of 100mm

Table : 12

K-factor for Vertical Surcharge Force (Kqz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.843	0	0	0.662	0.708	0.766	0.842	0.942	1.075
		5	0.708	0.766	0.842	0.942	1.075	0.677
		10	0.766	0.842	0.942	1.075	0.677	0.725
		15	0.842	0.942	1.075	0.677	0.725	0.786
		20	0.942	1.075	0.677	0.725	0.786	0.864
		25	1.075	0.677	0.725	0.786	0.864	0.966
		30	0.677	0.725	0.786	0.864	0.966	1.102
		35	0.725	0.786	0.864	0.966	1.102	0.688
		40	0.786	0.864	0.966	1.102	0.688	0.740
	10	0	0.725	0.708	0.690	0.669	0.647	0.622
		5	0.708	0.690	0.669	0.647	0.622	0.745
		10	0.690	0.669	0.647	0.622	0.745	0.728
		15	0.669	0.647	0.622	0.745	0.728	0.708
		20	0.647	0.622	0.745	0.728	0.708	0.686
		25	0.622	0.745	0.728	0.708	0.686	0.662
		30	0.745	0.728	0.708	0.686	0.662	0.635
		35	0.728	0.708	0.686	0.662	0.635	0.768
		40	0.708	0.686	0.662	0.635	0.768	0.750
	15	0	0.763	0.713	0.653	0.584	0.505	0.413
		5	0.713	0.653	0.584	0.505	0.413	0.784
		10	0.653	0.584	0.505	0.413	0.784	0.731
		15	0.584	0.505	0.413	0.784	0.731	0.669
		20	0.505	0.413	0.784	0.731	0.669	0.598
		25	0.413	0.784	0.731	0.669	0.598	0.515
		30	0.784	0.731	0.669	0.598	0.515	0.420
		35	0.731	0.669	0.598	0.515	0.420	0.808
		40	0.669	0.598	0.515	0.420	0.808	0.753
	20	0	0.822	0.737	0.637	0.523	0.392	0.248
		5	0.737	0.637	0.523	0.392	0.248	0.842
		10	0.637	0.523	0.392	0.248	0.842	0.754
		15	0.523	0.392	0.248	0.842	0.754	0.651
		20	0.392	0.248	0.842	0.754	0.651	0.533
		25	0.248	0.842	0.754	0.651	0.533	0.399
		30	0.842	0.754	0.651	0.533	0.399	0.252
		35	0.754	0.651	0.533	0.399	0.252	0.866
		40	0.651	0.533	0.399	0.252	0.866	0.775

* K-values calculated for the depth of 100mm

Table : 13

K-factor for Vertical Gravitation Force (Kgz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.844	0	0	0.351	0.374	0.404	0.442	0.491	0.557
		5	0.374	0.404	0.442	0.491	0.557	0.358
		10	0.404	0.442	0.491	0.557	0.358	0.383
		15	0.442	0.491	0.557	0.358	0.383	0.414
		20	0.491	0.557	0.358	0.383	0.414	0.453
		25	0.557	0.358	0.383	0.414	0.453	0.504
		30	0.358	0.383	0.414	0.453	0.504	0.571
		35	0.383	0.414	0.453	0.504	0.571	0.364
		40	0.414	0.453	0.504	0.571	0.364	0.390
	10	0	0.314	0.286	0.255	0.223	0.190	0.157
		5	0.286	0.255	0.223	0.190	0.157	0.323
		10	0.255	0.223	0.190	0.157	0.323	0.294
		15	0.223	0.190	0.157	0.323	0.294	0.263
		20	0.190	0.157	0.323	0.294	0.263	0.229
		25	0.157	0.323	0.294	0.263	0.229	0.195
		30	0.323	0.294	0.263	0.229	0.195	0.161
		35	0.294	0.263	0.229	0.195	0.161	0.333
		40	0.263	0.229	0.195	0.161	0.333	0.303
	15	0	0.303	0.254	0.203	0.152	0.104	0.061
		5	0.254	0.203	0.152	0.104	0.061	0.312
		10	0.203	0.152	0.104	0.061	0.312	0.261
		15	0.152	0.104	0.061	0.312	0.261	0.208
		20	0.104	0.061	0.312	0.261	0.208	0.156
		25	0.061	0.312	0.261	0.208	0.156	0.106
		30	0.312	0.261	0.208	0.156	0.106	0.063
		35	0.261	0.208	0.156	0.106	0.063	0.322
		40	0.208	0.156	0.106	0.063	0.322	0.269
	20	0	0.307	0.239	0.171	0.108	0.055	0.018
		5	0.239	0.171	0.108	0.055	0.018	0.315
		10	0.171	0.108	0.055	0.018	0.315	0.245
		15	0.108	0.055	0.018	0.315	0.245	0.176
		20	0.055	0.018	0.315	0.245	0.176	0.111
		25	0.018	0.315	0.245	0.176	0.111	0.056
		30	0.315	0.245	0.176	0.111	0.056	0.018
		35	0.245	0.176	0.111	0.056	0.018	0.325
		40	0.176	0.111	0.056	0.018	0.325	0.253

* K-values calculated for the depth of 100mm

Table : 14

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.844	0	0	0.091	0.099	0.119	0.136	0.150	0.173
		5	0.099	0.119	0.136	0.150	0.173	0.160
		10	0.119	0.136	0.150	0.173	0.160	0.185
		15	0.136	0.150	0.173	0.160	0.185	0.212
		20	0.150	0.173	0.160	0.185	0.212	0.238
		25	0.173	0.160	0.185	0.212	0.238	0.262
		30	0.160	0.185	0.212	0.238	0.262	0.281
		35	0.185	0.212	0.238	0.262	0.281	0.142
		40	0.212	0.238	0.262	0.281	0.142	0.173
	10	0	0.142	0.121	0.111	0.098	0.090	0.091
		5	0.121	0.111	0.098	0.090	0.091	0.215
		10	0.111	0.098	0.090	0.091	0.215	0.204
		15	0.098	0.090	0.091	0.215	0.204	0.190
		20	0.090	0.091	0.215	0.204	0.190	0.172
		25	0.091	0.215	0.204	0.190	0.172	0.151
		30	0.215	0.204	0.190	0.172	0.151	0.125
		35	0.204	0.190	0.172	0.151	0.125	0.223
		40	0.190	0.172	0.151	0.125	0.223	0.215
	15	0	0.140	0.109	0.090	0.070	0.069	0.059
		5	0.109	0.090	0.070	0.069	0.059	0.213
		10	0.090	0.070	0.069	0.059	0.213	0.189
		15	0.070	0.069	0.059	0.213	0.189	0.161
		20	0.069	0.059	0.213	0.189	0.161	0.131
		25	0.059	0.213	0.189	0.161	0.131	0.098
		30	0.213	0.189	0.161	0.131	0.098	0.068
		35	0.189	0.161	0.131	0.098	0.068	0.228
		40	0.161	0.131	0.098	0.068	0.228	0.204
	20	0	0.131	0.093	0.077	0.067	0.054	0.032
		5	0.093	0.077	0.067	0.054	0.032	0.205
		10	0.077	0.067	0.054	0.032	0.205	0.172
		15	0.067	0.054	0.032	0.205	0.172	0.136
		20	0.054	0.032	0.205	0.172	0.136	0.098
		25	0.032	0.205	0.172	0.136	0.098	0.061
		30	0.205	0.172	0.136	0.098	0.061	0.029
		35	0.172	0.136	0.098	0.061	0.029	0.225
		40	0.136	0.098	0.061	0.029	0.225	0.190

* K-values calculated for the depth of 100mm

Table : 15

K-factor for Vertical Surcharge Force (Kqz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.844	0	0	0.613	0.655	0.709	0.779	0.872	0.996
		5	0.655	0.709	0.779	0.872	0.996	0.627
		10	0.709	0.779	0.872	0.996	0.627	0.671
		15	0.779	0.872	0.996	0.627	0.671	0.728
		20	0.872	0.996	0.627	0.671	0.728	0.800
		25	0.996	0.627	0.671	0.728	0.800	0.895
		30	0.627	0.671	0.728	0.800	0.895	1.021
		35	0.671	0.728	0.800	0.895	1.021	0.638
		40	0.728	0.800	0.895	1.021	0.638	0.686
	10	0	0.663	0.643	0.619	0.593	0.563	0.529
		5	0.643	0.619	0.593	0.563	0.529	0.682
		10	0.619	0.593	0.563	0.529	0.682	0.660
		15	0.593	0.563	0.529	0.682	0.660	0.636
		20	0.563	0.529	0.682	0.660	0.636	0.608
		25	0.529	0.682	0.660	0.636	0.608	0.576
		30	0.682	0.660	0.636	0.608	0.576	0.540
		35	0.660	0.636	0.608	0.576	0.540	0.702
		40	0.636	0.608	0.576	0.540	0.702	0.680
	15	0	0.692	0.637	0.573	0.499	0.414	0.317
		5	0.637	0.573	0.499	0.414	0.317	0.710
		10	0.573	0.499	0.414	0.317	0.710	0.654
		15	0.499	0.414	0.317	0.710	0.654	0.587
		20	0.414	0.317	0.710	0.654	0.587	0.511
		25	0.317	0.710	0.654	0.587	0.511	0.423
		30	0.710	0.654	0.587	0.511	0.423	0.323
		35	0.654	0.587	0.511	0.423	0.323	0.732
		40	0.587	0.511	0.423	0.323	0.732	0.673
	20	0	0.740	0.651	0.548	0.430	0.298	0.158
		5	0.651	0.548	0.430	0.298	0.158	0.758
		10	0.548	0.430	0.298	0.158	0.758	0.666
		15	0.430	0.298	0.158	0.758	0.666	0.560
		20	0.298	0.158	0.758	0.666	0.560	0.439
		25	0.158	0.758	0.666	0.560	0.439	0.304
		30	0.758	0.666	0.560	0.439	0.304	0.160
		35	0.666	0.560	0.439	0.304	0.160	0.779
		40	0.560	0.439	0.304	0.160	0.779	0.685

* K-values calculated for the depth of 100mm

Table : 16

K-factor for Vertical Gravitation Force (Kgz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.419	0.446	0.482	0.528	0.587	0.665
		5	0.446	0.482	0.528	0.587	0.665	0.424
		10	0.482	0.528	0.587	0.665	0.424	0.454
		15	0.528	0.587	0.665	0.424	0.454	0.492
		20	0.587	0.665	0.424	0.454	0.492	0.539
		25	0.665	0.424	0.454	0.492	0.539	0.601
		30	0.424	0.454	0.492	0.539	0.601	0.681
		35	0.454	0.492	0.539	0.601	0.681	0.425
		40	0.492	0.539	0.601	0.681	0.425	0.458
	10	0	0.408	0.379	0.347	0.314	0.279	0.244
		5	0.379	0.347	0.314	0.279	0.244	0.419
		10	0.347	0.314	0.279	0.244	0.419	0.389
		15	0.314	0.279	0.244	0.419	0.389	0.357
		20	0.279	0.244	0.419	0.389	0.357	0.322
		25	0.244	0.419	0.389	0.357	0.322	0.287
		30	0.419	0.389	0.357	0.322	0.287	0.250
		35	0.389	0.357	0.322	0.287	0.250	0.430
		40	0.357	0.322	0.287	0.250	0.430	0.400
	15	0	0.408	0.353	0.295	0.236	0.178	0.123
		5	0.353	0.295	0.236	0.178	0.123	0.420
		10	0.295	0.236	0.178	0.123	0.420	0.363
		15	0.236	0.178	0.123	0.420	0.363	0.304
		20	0.178	0.123	0.420	0.363	0.304	0.243
		25	0.123	0.420	0.363	0.304	0.243	0.183
		30	0.420	0.363	0.304	0.243	0.183	0.126
		35	0.363	0.304	0.243	0.183	0.126	0.432
		40	0.304	0.243	0.183	0.126	0.432	0.374
	20	0	0.418	0.340	0.260	0.182	0.111	0.053
		5	0.340	0.260	0.182	0.111	0.053	0.430
		10	0.260	0.182	0.111	0.053	0.430	0.349
		15	0.182	0.111	0.053	0.430	0.349	0.267
		20	0.111	0.053	0.430	0.349	0.267	0.187
		25	0.053	0.430	0.349	0.267	0.187	0.114
		30	0.430	0.349	0.267	0.187	0.114	0.054
		35	0.349	0.267	0.187	0.114	0.054	0.443
		40	0.267	0.187	0.114	0.054	0.443	0.360

* K-values calculated for the depth of 100mm

Table : 17

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.042	0.059	0.088	0.117	0.143	0.162
		5	0.059	0.088	0.117	0.143	0.162	0.111
		10	0.088	0.117	0.143	0.162	0.111	0.145
		15	0.117	0.143	0.162	0.111	0.145	0.182
		20	0.143	0.162	0.111	0.145	0.182	0.221
		25	0.162	0.111	0.145	0.182	0.221	0.259
		30	0.111	0.145	0.182	0.221	0.259	0.292
		35	0.145	0.182	0.221	0.259	0.292	0.073
		40	0.182	0.221	0.259	0.292	0.073	0.114
	10	0	0.148	0.134	0.129	0.121	0.108	0.100
		5	0.134	0.129	0.121	0.108	0.100	0.230
		10	0.129	0.121	0.108	0.100	0.230	0.226
		15	0.121	0.108	0.100	0.230	0.226	0.218
		20	0.108	0.100	0.230	0.226	0.218	0.207
		25	0.100	0.230	0.226	0.218	0.207	0.190
		30	0.230	0.226	0.218	0.207	0.190	0.168
		35	0.226	0.218	0.207	0.190	0.168	0.231
		40	0.218	0.207	0.190	0.168	0.231	0.231
	15	0	0.162	0.134	0.117	0.098	0.082	0.075
		5	0.134	0.117	0.098	0.082	0.075	0.246
		10	0.117	0.098	0.082	0.075	0.246	0.226
		15	0.098	0.082	0.075	0.246	0.226	0.201
		20	0.082	0.075	0.246	0.226	0.201	0.173
		25	0.075	0.246	0.226	0.201	0.173	0.140
		30	0.246	0.226	0.201	0.173	0.140	0.105
		35	0.226	0.201	0.173	0.140	0.105	0.258
		40	0.201	0.173	0.140	0.105	0.258	0.239
	20	0	0.162	0.123	0.099	0.081	0.068	0.052
		5	0.123	0.099	0.081	0.068	0.052	0.249
		10	0.099	0.081	0.068	0.052	0.249	0.216
		15	0.081	0.068	0.052	0.249	0.216	0.180
		20	0.068	0.052	0.249	0.216	0.180	0.140
		25	0.052	0.249	0.216	0.180	0.140	0.099
		30	0.249	0.216	0.180	0.140	0.099	0.060
		35	0.216	0.180	0.140	0.099	0.060	0.268
		40	0.180	0.140	0.099	0.060	0.268	0.235

* K-values calculated for the depth of 100mm

Table : 18

K-factor for Vertical Surcharge Force (Kqz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.624	0.667	0.722	0.794	0.888	1.015
		5	0.667	0.722	0.794	0.888	1.015	0.634
		10	0.722	0.794	0.888	1.015	0.634	0.680
		15	0.794	0.888	1.015	0.634	0.680	0.738
		20	0.888	1.015	0.634	0.680	0.738	0.813
		25	1.015	0.634	0.680	0.738	0.813	0.911
		30	0.634	0.680	0.738	0.813	0.911	1.040
		35	0.680	0.738	0.813	0.911	1.040	0.637
		40	0.738	0.813	0.911	1.040	0.637	0.688
	10	0	0.717	0.703	0.689	0.673	0.656	0.639
		5	0.703	0.689	0.673	0.656	0.639	0.737
		10	0.689	0.673	0.656	0.639	0.737	0.723
		15	0.673	0.656	0.639	0.737	0.723	0.708
		20	0.656	0.639	0.737	0.723	0.708	0.691
		25	0.639	0.737	0.723	0.708	0.691	0.673
		30	0.737	0.723	0.708	0.691	0.673	0.653
		35	0.723	0.708	0.691	0.673	0.653	0.758
		40	0.708	0.691	0.673	0.653	0.758	0.744
	15	0	0.765	0.720	0.666	0.603	0.531	0.448
		5	0.720	0.666	0.603	0.531	0.448	0.787
		10	0.666	0.603	0.531	0.448	0.787	0.739
		15	0.603	0.531	0.448	0.787	0.739	0.683
		20	0.531	0.448	0.787	0.739	0.683	0.618
		25	0.448	0.787	0.739	0.683	0.618	0.543
		30	0.787	0.739	0.683	0.618	0.543	0.457
		35	0.739	0.683	0.618	0.543	0.457	0.811
		40	0.683	0.618	0.543	0.457	0.811	0.762
	20	0	0.826	0.747	0.654	0.546	0.423	0.285
		5	0.747	0.654	0.546	0.423	0.285	0.848
		10	0.654	0.546	0.423	0.285	0.848	0.766
		15	0.546	0.423	0.285	0.848	0.766	0.670
		20	0.423	0.285	0.848	0.766	0.670	0.558
		25	0.285	0.848	0.766	0.670	0.558	0.432
		30	0.848	0.766	0.670	0.558	0.432	0.290
		35	0.766	0.670	0.558	0.432	0.290	0.874
		40	0.670	0.558	0.432	0.290	0.874	0.788

* K-values calculated for the depth of 100mm

Table : 19

K-factor for Vertical Gravitation Force (Kgz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.453	0.479	0.492	0.492	0.480	0.458
		5	0.479	0.492	0.492	0.480	0.458	0.542
		10	0.492	0.492	0.480	0.458	0.542	0.571
		15	0.492	0.480	0.458	0.542	0.571	0.585
		20	0.480	0.458	0.542	0.571	0.585	0.584
		25	0.458	0.542	0.571	0.585	0.584	0.568
		30	0.542	0.571	0.585	0.584	0.568	0.540
		35	0.571	0.585	0.584	0.568	0.540	0.654
		40	0.585	0.584	0.568	0.540	0.654	0.687
	10	0	0.353	0.344	0.320	0.285	0.240	0.191
		5	0.344	0.320	0.285	0.240	0.191	0.416
		10	0.320	0.285	0.240	0.191	0.416	0.405
		15	0.285	0.240	0.191	0.416	0.405	0.377
		20	0.240	0.191	0.416	0.405	0.377	0.334
		25	0.191	0.416	0.405	0.377	0.334	0.282
		30	0.416	0.405	0.377	0.334	0.282	0.224
		35	0.405	0.377	0.334	0.282	0.224	0.494
		40	0.377	0.334	0.282	0.224	0.494	0.480
	15	0	0.317	0.296	0.261	0.214	0.160	0.107
		5	0.296	0.261	0.214	0.160	0.107	0.372
		10	0.261	0.214	0.160	0.107	0.372	0.348
		15	0.214	0.160	0.107	0.372	0.348	0.306
		20	0.160	0.107	0.372	0.348	0.306	0.250
		25	0.107	0.372	0.348	0.306	0.250	0.188
		30	0.372	0.348	0.306	0.250	0.188	0.125
		35	0.348	0.306	0.250	0.188	0.125	0.439
		40	0.306	0.250	0.188	0.125	0.439	0.410
	20	0	0.289	0.261	0.217	0.162	0.104	0.050
		5	0.261	0.217	0.162	0.104	0.050	0.339
		10	0.217	0.162	0.104	0.050	0.339	0.306
		15	0.162	0.104	0.050	0.339	0.306	0.254
		20	0.104	0.050	0.339	0.306	0.254	0.190
		25	0.050	0.339	0.306	0.254	0.190	0.122
		30	0.339	0.306	0.254	0.190	0.122	0.059
		35	0.306	0.254	0.190	0.122	0.059	0.398
		40	0.254	0.190	0.122	0.059	0.398	0.359

* K-values calculated for the depth of 100mm

Table : 20

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.362	0.386	0.417	0.456	0.507	0.576
		5	0.386	0.417	0.456	0.507	0.576	0.367
		10	0.417	0.456	0.507	0.576	0.367	0.393
		15	0.456	0.507	0.576	0.367	0.393	0.425
		20	0.507	0.576	0.367	0.393	0.425	0.467
		25	0.576	0.367	0.393	0.425	0.467	0.520
		30	0.367	0.393	0.425	0.467	0.520	0.590
		35	0.393	0.425	0.467	0.520	0.590	0.369
		40	0.425	0.467	0.520	0.590	0.369	0.397
	10	0	0.339	0.311	0.280	0.248	0.215	0.181
		5	0.311	0.280	0.248	0.215	0.181	0.348
		10	0.280	0.248	0.215	0.181	0.348	0.319
		15	0.248	0.215	0.181	0.348	0.319	0.288
		20	0.215	0.181	0.348	0.319	0.288	0.255
		25	0.181	0.348	0.319	0.288	0.255	0.220
		30	0.348	0.319	0.288	0.255	0.220	0.186
		35	0.319	0.288	0.255	0.220	0.186	0.358
		40	0.288	0.255	0.220	0.186	0.358	0.328
	15	0	0.334	0.283	0.230	0.176	0.125	0.078
		5	0.283	0.230	0.176	0.125	0.078	0.343
		10	0.230	0.176	0.125	0.078	0.343	0.291
		15	0.176	0.125	0.078	0.343	0.291	0.236
		20	0.125	0.078	0.343	0.291	0.236	0.181
		25	0.078	0.343	0.291	0.236	0.181	0.128
		30	0.343	0.291	0.236	0.181	0.128	0.080
		35	0.291	0.236	0.181	0.128	0.080	0.354
		40	0.236	0.181	0.128	0.080	0.354	0.300
	20	0	0.337	0.266	0.195	0.127	0.069	0.026
		5	0.266	0.195	0.127	0.069	0.026	0.347
		10	0.195	0.127	0.069	0.026	0.347	0.273
		15	0.127	0.069	0.026	0.347	0.273	0.200
		20	0.069	0.026	0.347	0.273	0.200	0.130
		25	0.026	0.347	0.273	0.200	0.130	0.071
		30	0.347	0.273	0.200	0.130	0.071	0.026
		35	0.273	0.200	0.130	0.071	0.026	0.357
		40	0.200	0.130	0.071	0.026	0.357	0.282

* K-values calculated for the depth of 100mm

Table : 21

K-factor for Vertical Surcharge Force (Kqz)

R=650mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.048	0.063	0.089	0.115	0.139	0.155
		5	0.063	0.089	0.115	0.139	0.155	0.113
		10	0.089	0.115	0.139	0.155	0.113	0.144
		15	0.115	0.139	0.155	0.113	0.144	0.178
		20	0.139	0.155	0.113	0.144	0.178	0.213
		25	0.155	0.113	0.144	0.178	0.213	0.247
		30	0.113	0.144	0.178	0.213	0.247	0.277
		35	0.144	0.178	0.213	0.247	0.277	0.081
		40	0.178	0.213	0.247	0.277	0.081	0.118
	10	0	0.137	0.122	0.117	0.107	0.093	0.084
		5	0.122	0.117	0.107	0.093	0.084	0.212
		10	0.117	0.107	0.093	0.084	0.212	0.206
		15	0.107	0.093	0.084	0.212	0.206	0.197
		20	0.093	0.084	0.212	0.206	0.197	0.183
		25	0.084	0.212	0.206	0.197	0.183	0.165
		30	0.212	0.206	0.197	0.183	0.165	0.142
		35	0.206	0.197	0.183	0.165	0.142	0.215
		40	0.197	0.183	0.165	0.142	0.215	0.212
	15	0	0.147	0.119	0.102	0.083	0.067	0.057
		5	0.119	0.102	0.083	0.067	0.057	0.222
		10	0.102	0.083	0.067	0.057	0.222	0.201
		15	0.083	0.067	0.057	0.222	0.201	0.176
		20	0.067	0.057	0.222	0.201	0.176	0.147
		25	0.057	0.222	0.201	0.176	0.147	0.115
		30	0.222	0.201	0.176	0.147	0.115	0.081
		35	0.201	0.176	0.147	0.115	0.081	0.234
		40	0.176	0.147	0.115	0.081	0.234	0.214
	20	0	0.144	0.107	0.084	0.065	0.051	0.033
		5	0.107	0.084	0.065	0.051	0.033	0.222
		10	0.084	0.065	0.051	0.033	0.222	0.189
		15	0.065	0.051	0.033	0.222	0.189	0.153
		20	0.051	0.033	0.222	0.189	0.153	0.114
		25	0.033	0.222	0.189	0.153	0.114	0.074
		30	0.222	0.189	0.153	0.114	0.074	0.038
		35	0.189	0.153	0.114	0.074	0.038	0.239
		40	0.153	0.114	0.074	0.038	0.239	0.206

* K-values calculated for the depth of 100mm

Table : 22

K-factor for Vertical Gravitation Force (Kgz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.422	0.446	0.457	0.457	0.445	0.424
		5	0.446	0.457	0.457	0.445	0.424	0.504
		10	0.457	0.457	0.445	0.424	0.504	0.531
		15	0.457	0.445	0.424	0.504	0.531	0.543
		20	0.445	0.424	0.504	0.531	0.543	0.542
		25	0.424	0.504	0.531	0.543	0.542	0.526
		30	0.504	0.531	0.543	0.542	0.526	0.499
		35	0.531	0.543	0.542	0.526	0.499	0.608
		40	0.543	0.542	0.526	0.499	0.608	0.638
	10	0	0.321	0.311	0.286	0.251	0.207	0.161
		5	0.311	0.286	0.251	0.207	0.161	0.379
		10	0.286	0.251	0.207	0.161	0.379	0.366
		15	0.251	0.207	0.161	0.379	0.366	0.336
		20	0.207	0.161	0.379	0.366	0.336	0.294
		25	0.161	0.379	0.366	0.336	0.294	0.243
		30	0.379	0.366	0.336	0.294	0.243	0.188
		35	0.366	0.336	0.294	0.243	0.188	0.450
		40	0.336	0.294	0.243	0.188	0.450	0.433
	15	0	0.286	0.264	0.227	0.181	0.130	0.080
		5	0.264	0.227	0.181	0.130	0.080	0.335
		10	0.227	0.181	0.130	0.080	0.335	0.309
		15	0.181	0.130	0.080	0.335	0.309	0.266
		20	0.130	0.080	0.335	0.309	0.266	0.212
		25	0.080	0.335	0.309	0.266	0.212	0.152
		30	0.335	0.309	0.266	0.212	0.152	0.094
		35	0.309	0.266	0.212	0.152	0.094	0.396
		40	0.266	0.212	0.152	0.094	0.396	0.365
	20	0	0.259	0.229	0.185	0.132	0.077	0.030
		5	0.229	0.185	0.132	0.077	0.030	0.303
		10	0.185	0.132	0.077	0.030	0.303	0.268
		15	0.132	0.077	0.030	0.303	0.268	0.216
		20	0.077	0.030	0.303	0.268	0.216	0.154
		25	0.030	0.303	0.268	0.216	0.154	0.090
		30	0.303	0.268	0.216	0.154	0.090	0.035
		35	0.268	0.216	0.154	0.090	0.035	0.357
		40	0.216	0.154	0.090	0.035	0.357	0.315

* K-values calculated for the depth of 100mm

Table : 23

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.316	0.337	0.364	0.399	0.444	0.504
		5	0.337	0.364	0.399	0.444	0.504	0.321
		10	0.364	0.399	0.444	0.504	0.321	0.344
		15	0.399	0.444	0.504	0.321	0.344	0.372
		20	0.444	0.504	0.321	0.344	0.372	0.408
		25	0.504	0.321	0.344	0.372	0.408	0.455
		30	0.321	0.344	0.372	0.408	0.455	0.516
		35	0.344	0.372	0.408	0.455	0.516	0.323
		40	0.372	0.408	0.455	0.516	0.323	0.348
	10	0	0.285	0.258	0.228	0.198	0.166	0.135
		5	0.258	0.228	0.198	0.166	0.135	0.293
		10	0.228	0.198	0.166	0.135	0.293	0.265
		15	0.198	0.166	0.135	0.293	0.265	0.235
		20	0.166	0.135	0.293	0.265	0.235	0.203
		25	0.135	0.293	0.265	0.235	0.203	0.171
		30	0.293	0.265	0.235	0.203	0.171	0.138
		35	0.265	0.235	0.203	0.171	0.138	0.301
		40	0.235	0.203	0.171	0.138	0.301	0.273
	15	0	0.276	0.228	0.180	0.132	0.087	0.048
		5	0.228	0.180	0.132	0.087	0.048	0.284
		10	0.180	0.132	0.087	0.048	0.284	0.235
		15	0.132	0.087	0.048	0.284	0.235	0.185
		20	0.087	0.048	0.284	0.235	0.185	0.135
		25	0.048	0.284	0.235	0.185	0.135	0.089
		30	0.284	0.235	0.185	0.135	0.089	0.050
		35	0.235	0.185	0.135	0.089	0.050	0.292
		40	0.185	0.135	0.089	0.050	0.292	0.242
	20	0	0.275	0.210	0.146	0.088	0.041	0.011
		5	0.210	0.146	0.088	0.041	0.011	0.283
		10	0.146	0.088	0.041	0.011	0.283	0.216
		15	0.088	0.041	0.011	0.283	0.216	0.150
		20	0.041	0.011	0.283	0.216	0.150	0.091
		25	0.011	0.283	0.216	0.150	0.091	0.042
		30	0.283	0.216	0.150	0.091	0.042	0.011
		35	0.216	0.150	0.091	0.042	0.011	0.292
		40	0.150	0.091	0.042	0.011	0.292	0.223

* K-values calculated for the depth of 100mm

Table : 24

K-factor for Vertical Surcharge Force (Kqz)

R=700mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.866	0	0	0.052	0.065	0.089	0.113	0.134	0.148
		5	0.065	0.089	0.113	0.134	0.148	0.114
		10	0.089	0.113	0.134	0.148	0.114	0.142
		15	0.113	0.134	0.148	0.114	0.142	0.173
		20	0.134	0.148	0.114	0.142	0.173	0.205
		25	0.148	0.114	0.142	0.173	0.205	0.236
		30	0.114	0.142	0.173	0.205	0.236	0.263
		35	0.142	0.173	0.205	0.236	0.263	0.085
		40	0.173	0.205	0.236	0.263	0.085	0.120
	10	0	0.128	0.112	0.105	0.095	0.081	0.071
		5	0.112	0.105	0.095	0.081	0.071	0.196
		10	0.105	0.095	0.081	0.071	0.196	0.188
		15	0.095	0.081	0.071	0.196	0.188	0.178
		20	0.081	0.071	0.196	0.188	0.178	0.163
		25	0.071	0.196	0.188	0.178	0.163	0.144
		30	0.196	0.188	0.178	0.163	0.144	0.121
		35	0.188	0.178	0.163	0.144	0.121	0.199
		40	0.178	0.163	0.144	0.121	0.199	0.195
	15	0	0.133	0.106	0.089	0.070	0.054	0.042
		5	0.106	0.089	0.070	0.054	0.042	0.202
		10	0.089	0.070	0.054	0.042	0.202	0.180
		15	0.070	0.054	0.042	0.202	0.180	0.154
		20	0.054	0.042	0.202	0.180	0.154	0.125
		25	0.042	0.202	0.180	0.154	0.125	0.093
		30	0.202	0.180	0.154	0.125	0.093	0.061
		35	0.180	0.154	0.125	0.093	0.061	0.213
		40	0.154	0.125	0.093	0.061	0.213	0.192
	20	0	0.129	0.093	0.071	0.048	0.037	0.019
		5	0.093	0.071	0.048	0.037	0.019	0.198
		10	0.071	0.048	0.037	0.019	0.198	0.166
		15	0.048	0.037	0.019	0.198	0.166	0.130
		20	0.037	0.019	0.198	0.166	0.130	0.092
		25	0.019	0.198	0.166	0.130	0.092	0.055
		30	0.198	0.166	0.130	0.092	0.055	0.022
		35	0.166	0.130	0.092	0.055	0.022	0.215
		40	0.130	0.092	0.055	0.022	0.215	0.181

*** K-values calculated for the depth of 100mm**

Table : 25

K-factor for Vertical Gravitation Force (Kgz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.888	0	0	0.497	0.525	0.539	0.538	0.524	0.499
		5	0.525	0.539	0.538	0.524	0.499	0.598
		10	0.539	0.538	0.524	0.499	0.598	0.630
		15	0.538	0.524	0.499	0.598	0.630	0.644
		20	0.524	0.499	0.598	0.630	0.644	0.642
		25	0.499	0.598	0.630	0.644	0.642	0.623
		30	0.598	0.630	0.644	0.642	0.623	0.591
		35	0.630	0.644	0.642	0.623	0.591	0.725
		40	0.644	0.642	0.623	0.591	0.725	0.762
	10	0	0.394	0.385	0.361	0.323	0.275	0.222
		5	0.385	0.361	0.323	0.275	0.222	0.466
		10	0.361	0.323	0.275	0.222	0.466	0.456
		15	0.323	0.275	0.222	0.466	0.456	0.426
		20	0.275	0.222	0.466	0.456	0.426	0.380
		25	0.222	0.466	0.456	0.426	0.380	0.324
		30	0.466	0.456	0.426	0.380	0.324	0.261
		35	0.456	0.426	0.380	0.324	0.261	0.556
		40	0.426	0.380	0.324	0.261	0.556	0.543
	15	0	0.354	0.333	0.296	0.245	0.188	0.129
		5	0.333	0.296	0.245	0.188	0.129	0.417
		10	0.296	0.245	0.188	0.129	0.417	0.392
		15	0.245	0.188	0.129	0.417	0.392	0.347
		20	0.188	0.129	0.417	0.392	0.347	0.288
		25	0.129	0.417	0.392	0.347	0.288	0.220
		30	0.417	0.392	0.347	0.288	0.220	0.151
		35	0.392	0.347	0.288	0.220	0.151	0.494
		40	0.347	0.288	0.220	0.151	0.494	0.464
	20	0	0.324	0.294	0.247	0.188	0.125	0.066
		5	0.294	0.247	0.188	0.125	0.066	0.380
		10	0.247	0.188	0.125	0.066	0.380	0.345
		15	0.188	0.125	0.066	0.380	0.345	0.290
		20	0.125	0.066	0.380	0.345	0.290	0.221
		25	0.066	0.380	0.345	0.290	0.221	0.146
		30	0.380	0.345	0.290	0.221	0.146	0.077
		35	0.345	0.290	0.221	0.146	0.077	0.448
		40	0.290	0.221	0.146	0.077	0.448	0.406

* K-values calculated for the depth of 100mm

Table : 26

K-factor for Vertical Cohesive-Adhesive Force (Kcz)

R=600mm	$\alpha(^\circ)$	$\phi(^\circ)$	$\beta(^\circ)$					
$\frac{a}{R}$			35	40	45	50	55	60
0.888	0	0	0.371	0.396	0.428	0.468	0.522	0.592
		5	0.396	0.428	0.468	0.522	0.592	0.373
		10	0.428	0.468	0.522	0.592	0.373	0.399
		15	0.468	0.522	0.592	0.373	0.399	0.434
		20	0.522	0.592	0.373	0.399	0.434	0.477
		25	0.592	0.373	0.399	0.434	0.477	0.533
		30	0.373	0.399	0.434	0.477	0.533	0.606
		35	0.399	0.434	0.477	0.533	0.606	0.368
		40	0.434	0.477	0.533	0.606	0.368	0.398
	10	0	0.368	0.340	0.310	0.278	0.245	0.211
		5	0.340	0.310	0.278	0.245	0.211	0.377
		10	0.310	0.278	0.245	0.211	0.377	0.349
		15	0.278	0.245	0.211	0.377	0.349	0.318
		20	0.245	0.211	0.377	0.349	0.318	0.286
		25	0.211	0.377	0.349	0.318	0.286	0.252
		30	0.377	0.349	0.318	0.286	0.252	0.217
		35	0.349	0.318	0.286	0.252	0.217	0.386
		40	0.318	0.286	0.252	0.217	0.386	0.358
	15	0	0.365	0.313	0.258	0.203	0.149	0.099
		5	0.313	0.258	0.203	0.149	0.099	0.375
		10	0.258	0.203	0.149	0.099	0.375	0.322
		15	0.203	0.149	0.099	0.375	0.322	0.265
		20	0.149	0.099	0.375	0.322	0.265	0.208
		25	0.099	0.375	0.322	0.265	0.208	0.153
		30	0.375	0.322	0.265	0.208	0.153	0.101
		35	0.322	0.265	0.208	0.153	0.101	0.386
		40	0.265	0.208	0.153	0.101	0.386	0.331
	20	0	0.371	0.297	0.221	0.150	0.086	0.036
		5	0.297	0.221	0.150	0.086	0.036	0.382
		10	0.221	0.150	0.086	0.036	0.382	0.305
		15	0.150	0.086	0.036	0.382	0.305	0.227
		20	0.086	0.036	0.382	0.305	0.227	0.153
		25	0.036	0.382	0.305	0.227	0.153	0.088
		30	0.382	0.305	0.227	0.153	0.088	0.037
		35	0.305	0.227	0.153	0.088	0.037	0.393
		40	0.227	0.153	0.088	0.037	0.393	0.314

* K-values calculated for the depth of 100mm

Table : 27

K-factor for Vertical Surcharge Force (Kqz)

R=600mm	α(°)	φ(°)	β(°)					
$\frac{a}{R}$			35	40	45	50	55	60
0.888	0	0	-0.019	0.003	0.037	0.073	0.108	0.139
		5	0.003	0.037	0.073	0.108	0.139	0.038
		10	0.037	0.073	0.108	0.139	0.038	0.076
		15	0.073	0.108	0.139	0.038	0.076	0.118
		20	0.108	0.139	0.038	0.076	0.118	0.163
		25	0.139	0.038	0.076	0.118	0.163	0.211
		30	0.038	0.076	0.118	0.163	0.211	0.255
		35	0.076	0.118	0.163	0.211	0.255	-0.015
		40	0.118	0.163	0.211	0.255	-0.015	0.030
	10	0	0.123	0.115	0.115	0.112	0.104	0.090
		5	0.115	0.115	0.112	0.104	0.090	0.198
		10	0.115	0.112	0.104	0.090	0.198	0.199
		15	0.112	0.104	0.090	0.198	0.199	0.197
		20	0.104	0.090	0.198	0.199	0.197	0.190
		25	0.090	0.198	0.199	0.197	0.190	0.178
		30	0.198	0.199	0.197	0.190	0.178	0.160
		35	0.199	0.197	0.190	0.178	0.160	0.192
		40	0.197	0.190	0.178	0.160	0.192	0.197
	15	0	0.147	0.124	0.111	0.094	0.074	0.057
		5	0.124	0.111	0.094	0.074	0.057	0.225
		10	0.111	0.094	0.074	0.057	0.225	0.208
		15	0.094	0.074	0.057	0.225	0.208	0.187
		20	0.074	0.057	0.225	0.208	0.187	0.161
		25	0.057	0.225	0.208	0.187	0.161	0.131
		30	0.225	0.208	0.187	0.161	0.131	0.098
		35	0.208	0.187	0.161	0.131	0.098	0.231
		40	0.187	0.161	0.131	0.098	0.231	0.216
	20	0	0.154	0.120	0.097	0.073	0.051	0.034
		5	0.120	0.097	0.073	0.051	0.034	0.235
		10	0.097	0.073	0.051	0.034	0.235	0.204
		15	0.073	0.051	0.034	0.235	0.204	0.169
		20	0.051	0.034	0.235	0.204	0.169	0.131
		25	0.034	0.235	0.204	0.169	0.131	0.090
		30	0.235	0.204	0.169	0.131	0.090	0.050
		35	0.204	0.169	0.131	0.090	0.050	0.249
		40	0.169	0.131	0.090	0.050	0.249	0.219

* K-values calculated for the depth of 100mm

PROGRAMME : P1

```
*     ******************************************************
*     *       Soil Forces on a Disc Implement              *
*     *       Disc Analysis Vector Soln for Soil Block     *
*     *       Soil Block Geometry :E-PLANE Stepped         *
*     *       Soil Forces on the Disc :3-Orthogonal Directions *
*     ******************************************************
*
      SUBROUTINE BISECT(XL,XU,FUNC,Y,IFLAG)
*     Procedure for locating the root Y in int XL,XU
*     Flag Values: 0=Solution Found; 1=No Solution;
*     2=Number of iterations exceeded
*
      XACC=1.0E-04
      FMID=FUNC(XU)
      F=FUNC(XL)
      IF(F*FMID.GE.0.0)THEN
      IFLAG=1
      Y=0.0
      RETURN
      ENDIF
      IF(F.LT.0.0)THEN
      Y=XL
      DX=XU-XL
      ELSE
      Y=XU
      DX=XL-XU
      ENDIF
*
      DO 10 J=1,40
       DX=DX/2.0
       XMID=Y+DX
       FMID=FUNC(XMID)
       IF(FMID.LT.0.0) Y=XMID
       IF(ABS(DX).LT.XACC.OR.FMID.EQ.0.0)THEN
       IFLAG=0
       RETURN
       ENDIF
   10 CONTINUE
      IFLAG=2
      RETURN
      END
*
*     *********************************************
      SUBROUTINE BRAC(FX,BL,BU,NB)
*     Search for 2 roots and brackets values found
*
      DIMENSION BL(2),BU(2)
      NB=0
      X=0.0
      INT=18
      DX=361.0*ARSIN(1.0)/(90.0*FLOAT(INT))
```

```
      FP=FX(X)
*
      DO 10 I=1,INT
        X=X+DX
        FC=FX(X)
        IF(FC*FP .LT. 0.0) THEN
        NB=NB+1
        BL(NB)=X - DX
        BU(NB)=X
        END IF
*
        FP=FC
        IF(NB .EQ. 2) RETURN
   10 CONTINUE
      RETURN
      END
*     ********************************************
      SUBROUTINE BRAC1(FY,BL,BU,NB)
*     Search for 2 roots and brackets values found
*
      DIMENSION BL(2),BU(2)
      NB=0
      Y=0.0
      INT=18
      DY=361.0*ARSIN(1.0)/(90.0*FLOAT(INT))
      FP=FY(Y)
*
      DO 10 I=1,INT
        Y=Y+DY
        FC=FY(Y)
        IF(FC*FP .LT. 0.0) THEN
        NB=NB+1
        BL(NB)=Y - DY
        BU(NB)=Y
        END IF
*
        FP=FC
        IF(NB .EQ. 2) RETURN
   10 CONTINUE
      RETURN
      END
*
*     ********************************************
      FUNCTION FB1(T)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
      X=R1*COS(T)
      Y=R1*SIN(T)
      FB1=(X-XC)*(X-XC)  +  (Y-YC)*(Y-YC)+
     +     (D-ZC)*(D-ZC)  - R3*R3
      RETURN
      END
*
*     ********************************************
      FUNCTION FB2(T)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
      X=R2*COS(T)
      Z=R2*SIN(T)
      FB2=(X-XC)*(X-XC)  +  (E-YC)*(E-YC)+
     +     (Z-ZC)*(Z-ZC)  - R3*R3
      RETURN
```

```
      END
*     ******************************************
      FUNCTION FB3(T)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
      Y=COS(T)
      Z=SIN(T)
      FB3=XC*XC + (Y-YC)*(Y-YC)+
     +    (Z-ZC)*(Z-ZC) - R3*R3
      RETURN
      END
*     **************************************************
      SUBROUTINE SCRUB(ATHETA,X0,Y0,Z0,NS,NE)
*     Search for co-ordinate points on the disc edge
*     Status: 0=Scrubbing, 1=Non scrubbing
*     State: 2=Point above the soil surface
*            3=Point below the soil surface
*
      REAL ATHETA(40),X0(40),Y0(40),Z0(40)
      INTEGER NS(40),NE(40)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3/SCR/ALPHA,BETA,RADN
*
      TH=ASIN((D-ZC)/R3)
      DO 200 N=1,40
       SPACE=2.50*RADN
       THETA=TH+SPACE*FLOAT(N-1)
       ATHETA(N)=THETA/RADN
*
       X=R3*COS(THETA)*SIN(BETA)+R3*SIN(THETA)*SIN(ALPHA)*COS(BETA)
       Y=R3*SIN(THETA)*SIN(ALPHA)*SIN(BETA)-R3*COS(BETA)*COS(THETA)
       Z=-R3*SIN(THETA)*COS(ALPHA)
*
       X0(N)=XC-X
       IF(X0(N).LE.1.0E-04.AND.X0(N).GT.0.0) THEN
       X0(N)=0.0
       ELSE
       ENDIF
       Y0(N)=YC-Y
       Z0(N)=ZC-Z
*
       IF(X0(N).LE.0.0) THEN
       NS(N)=0
       ELSE
       NS(N)=1
       ENDIF
*
       IF(ABS(Z0(N)-D).LE.(1.0E-02).AND.ABS(Z0(N)-D).GT.0.0) THEN
       Z0(N)=D
       ELSE
       ENDIF
       IF(Z0(N).GE.D) THEN
       NE(N)=3
       ELSE
       NE(N)=2
       ENDIF
  200 CONTINUE
      RETURN
      END
*
*     **********************************************************
      SUBROUTINE PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,
```

```
     +       AMU,BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
      COMMON /SCR/ALPHA,BETA,RADN/PSF1/ABETAX,ADELTA,APHI,RADHS
     +        /PSF2/C,AD,GAMMA,Q/PSF3/ALPHAR,RL,Z
*
*     Data Reduction
*
      BETAX=ABETAX*RADN
      PHI=APHI*RADN
      DELTAX=ADELTA*RADN
*
      IF(PHI.GE.1.0E-06) CDEL=ASIN(SIN(DELTAX)/SIN(PHI))
      IF(PHI.LT.1.0E-06) CDEL=ASIN(AD/C)
      ACDEL=CDEL/RADN
      PSI=45.0*RADN+PHI/2.0
      APSI=PSI/RADN
      EPS=45.0*RADN-PHI/2.0
      AEPS=EPS/RADN
      AMU=(CDEL + DELTAX)/2.0
      AAMU=AMU/RADN
      THP=PSI+AMU
      ATHP=THP/RADN
      THN=PSI-AMU
      ATHN=THN/RADN
      FP=TAN(PSI)
*
*     Limits and Discont. Angles
*
      ALPHRD=90.0*RADN-AMU
      BETAW=AMU-EPS+ALPHAR-90.0*RADN
      AALPRD=ALPHRD/RADN
      ABETAW=BETAW/RADN
      ZETA=ALPHAR+AMU
      OMEGA=(ZETA-ASIN(SIN(PHI)*SIN(ZETA)))/2.0
      AOMEGA=OMEGA/RADN
*
*     Constrained Adhesion Requirement
*
      IF(PHI.GE.1.0E-6) THEN
      AD=C*TAN(DELTAX)/TAN(PHI)
      ELSE
      RADHS=2.5/3.0
      AD=C*RADHS
      END IF
*
*     Rupture Block Type Identification
*
      IF(ALPHAR-ALPHRD.GT.1.0E-06) GO TO 109
      IF(OMEGA-ALPHAR.LT.1.0E-06) GO TO 203
      GO TO 204
  109 IF(BETAX-BETAW.GT.1.0E-06) GO TO 201
      GO TO 202
*
*     Basic Rupture Surface  *Type 1*
*
  201 DELTA=DELTAX
      IFLAG=2
      ADELM=ADELTA
      KT=1
  206 ETA=ALPHAR-EPS-THN
      RS=RL*SIN(THP)/COS(PHI)
```

```
      T=RL*SIN(THN)/COS(PHI)
      U=RS*EXP(ETA*TAN(PHI))
      V=U*SIN(EPS)
      F=U*COS(EPS)
*
      D1=V/2.0
      D2=2.0*V/3.0
      DW=2.0*F/3.0
      DQ=F/2.0
      D5=RS*COS(PHI)/2.0
      D4=2.0*RS*COS(PHI)/3.0
*
      F1=2.0*C*V*FP
      F2=GAMMA*V*V*FP*FP/2.0
      F1D=Q*V*FP*FP
      W1=F*V*GAMMA/2.0
      AM=-3.0*TAN(PHI)
      RHO1=EPS+ETA
      AMW1=GAMMA*U*U*U/(3.0*(AM*AM+1.0))
      AMW2=EXP(AM*ETA)*(AM*COS(RHO1)+SIN(RHO1))
     +    -AM*COS(EPS)-SIN(EPS)
      AMW=AMW1*AMW2
      IF(PHI.LT.1.0E-06) GO TO 600
      AMC=C*(U*U-RS*RS)/(2.0*TAN(PHI))
      GO TO 601
  600 AMC=C*RS*RS*ETA
  601 QF=Q*F
      F4=(F2*D2+W1*DW + AMW)/D4
      F5C=(F1*D1+AMC)/D5
      F5Q=(F1D*D1+QF*DQ)/D5
*
      W2=GAMMA*RL*T*SIN(THP)/2.0
      A2=C*T
      AF=C*RL
      IF(KT.EQ.3) THEN
      RHO2=THP-PHI-PHI*DELR
      ELSE
      RHO2=THP-PHI-PHI
      ENDIF
      RHOW=THP+ALPHAR-PHI
*
      PG=(W2*SIN(RHOW) + F4*COS(PHI))/SIN(RHO2)
      PC=(AF*COS(THP-PHI) + (F5C+A2)*COS(PHI))/SIN(RHO2)
      PQ=F5Q*COS(PHI)/SIN(RHO2)
      RDIST=2.0*F/Z
      GO TO 205
*
*      Rupture Surface with a Boundary Wedge *Type 3*
*
  202 THP=180.0*RADN-(ALPHAR-BETAX)
      KT=3
      THN=(ALPHAR-BETAX)+PHI-90.0*RADN
      RHO3=PHI+2.0*(ALPHAR-BETAX)
      ANG=SIN(PHI)*COS(RHO3)/(SIN(PHI)*SIN(RHO3)-1.0)
      DELTAM=ATAN(ANG)
      ADELM=DELTAM/RADN
      DELR=DELTAM/DELTAX
*
      DELTA=DELTAM
      IFLAG=3
```

```
      GO TO 206
*
*     Rupture Surface with a Discontinuity  *Type 2*
*
  203 RHO4=180.0*RADN-ALPHAR+OMEGA-THP
      IFLAG=0
      KT=2
      T=RL*SIN(ALPHAR-OMEGA)/SIN(RHO4)
      U=RL*SIN(THP)/SIN(RHO4)
      V=U*SIN(OMEGA)
      F=U*COS(OMEGA)
*
      W3=GAMMA*(F*V+RL*T*SIN(THP))/2.0
      A2=C*T
      AF=C*RL
      QF=Q*F
      RHO5=(THP-PHI-PHI)
      RHO6=(THP-PHI+ALPHAR)
      ADELM=ADELTA
      DELTA=DELTAX
*
      F1=2.0*C*V*FP
      F2=GAMMA*V*V*FP*FP/2.0
      F1D=Q*V*FP*FP
      PG=(W3*SIN(RHO6)-F2*COS(RHO6))/SIN(RHO5)
      PC=(A2*COS(PHI)+AF*COS(THP-PHI)-F1*COS(RHO6))/SIN(RHO5)
      PQ=(QF*SIN(RHO6)-F1D*COS(RHO6))/SIN(RHO5)
      RDIST=2.0*F/Z
*
      GO TO 205
*
*     Rupture Surface with a Rankine Wedge  *Type 4*
*
  204 F=Z/TAN(EPS)
      IFLAG=1
      KT=4
      G=Z/TAN(ALPHAR)-F
*
      U=Z/SIN(EPS)
      F1=2.0*C*Z*FP
      F1D=Q*Z*FP*FP
      F2=GAMMA*Z*Z*FP*FP/2.0
      W4=GAMMA*F*Z/2.0
      W5=GAMMA*G*Z/2.0
      A3=U*C
      Q1=F*Q
      Q2=G*Q
      AF=C*(Z/SIN(ALPHAR))
      RHOR=PHI+2.0*(EPS-ALPHAR)
      DELTAM=ATAN(SIN(PHI)*COS(RHOR)/(1.0-SIN(PHI)
     +    *SIN(RHOR)))
      ADELM=DELTAM/RADN
      DELR=DELTAM/DELTAX
      DELTA=DELTAM
      DELTAM=PHI*DELR
      RHO7=PSI-ALPHAR-DELTAM
      RHO8=ALPHAR+DELTAM
      RHO9=EPS-ALPHAR-DELTAM
*
      PG=(W4*COS(PSI)+F2*COS(EPS))*COS(RHO7)
```

```
     +    + W5*COS(RHO8)
      PC=(F1*COS(EPS)-A3*SIN(PHI))*COS(RHO7)
     +    +A3*SIN(RHO9)-AF*SIN(DELTAM)
      PQ=(Q1*COS(PSI)+F1D*COS(EPS))*COS(RHO7)
     +    + Q2*COS(RHO8)
      RDIST=(G+2.0*F)/Z
*
*     OUTPUT OF CALCULATED DATA:
*
  205 PT=PG+PC+PQ
      RETURN
      END
*
*     ******************************************************
*                          MAIN PROGRAMME
*
      DIMENSION DE1(2),DE2(2),BB1(2),BB2(2)
      DIMENSION C1(40),C2(40),C3(40),C4(40),GG1(2),GG2(2)
      REAL ATHETA(40),X0(40),Y0(40),Z0(40),AL(11),AZ(11)
      INTEGER NS(40),NE(40)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
     +        /SCR/ALPHA,BETA,RADN/PSF1/ABETAX,ADELTA,APHI,RADHS
     +        /PSF2/C,AD,GAMMA,Q/PSF3/ALPHAR,RL,Z
      EXTERNAL FB1,FB2,FB3
      RADN=ARSIN(1.0)/90.0
*
  501 FORMAT(3F10.0)
  502 FORMAT(2F10.0)
  503 FORMAT(F10.0)
  504 FORMAT(' '/' ',3X,'Alpha',4X,'Beta',6X,'a'/' ',2F8.2,F7.3)
  505 FORMAT(' '/' ',3X,'AlphaD',2X,'BetaD'/' ',2F8.1)
  506 FORMAT(' ',5X,'No Solution in Specified Range')
  507 FORMAT(' '/' ',23X,'C',23X,'D',22X,'E',13X,'FLAGS')
  508 FORMAT(' ',6X,'D',3(9X,'X',6X,'Y',6X,'Z'),
     +       5X,'D',3X,'E')
  509 FORMAT(' ',F7.3,3(3X,3F7.3),3X,2I3)
  510 FORMAT(' '/' ',23X,'A',22X,'B',13X,'FLAGS')
  511 FORMAT(' ',6X,'E',2(9X,'X',6X,'Y',6X,'Z'),
     +       5X,'B',6X,'R2',4X,'ALPHAR',4X,'Z',4X,'L')
  512 FORMAT(' ',F7.3,2(3X,3F7.3),3X,I3,2X,5F7.3)
  513 FORMAT(' '/' ',3X,'Scrubbing')
  514 FORMAT(' ',3X,'P',10X,'PX',8X,'PY',8X,'PZ',7X,'LAMDAR',
     +        4X,'GAMAR',4X,'DELTAR')
  515 FORMAT(F10.3,6(F10.3))
  516 FORMAT(' '/' ',7X,'C',5X,'PHI'/' ',F8.2,F8.1/
     +   ' ',7X,'Z',3X,'ALPHAR',4X,'BETA'/' ',F8.2,2F8.1/
     +   ' ',7X,'Q',3X,'GAMMA'/' ',2F8.2/
     +   ' ',7X,'AD',3X,'DELTA'/' ',F8.2,F8.1)
  517 FORMAT(' '/' ',5X,'PSI',5X,'EPS',6X,'MU'/' ',3F8.1/
     +   ' ',5X,'DEL',5X,'TH+',5X,'TH-'/' ',3F8.1/' ')
  518 FORMAT(' ','BASIC RUPTURE SURFACE')
  519 FORMAT(' ','BOUNDARY WEDGE  MOB. FRICT.= ',
     +   F8.1,'  BETA LIM. =',F8.1)
  520 FORMAT(' ','BASIC DISCONTINUITY'/
     +   ' ',' OMEGA=',F6.2,'  ALPHD=',F6.2)
  521 FORMAT(' ','RANKINE DISCONTINUITY')
  522 FORMAT(' ',7X,'P*G',7X,'P*C',7X,'P*Q',8X,'P'/' ',4F10.3)
  523 FORMAT(' ',4X,'PCX',5X,'PCY',5X,'PCZ',5X,'PGX',5X,'PGY',
     +          5X,'PGZ',5X,'PQX',5X,'PQY',5X,'PQZ'/' ',9F8.3)
*
```

```
*       Input Data :
*
  101 READ(5,501) AALPHA,A,D
  102 READ(5,502) C,AD
  103 READ(5,503) GAMMA
  104 READ(5,503) ABETAX
  105 READ(5,503) AQ
  106 READ(5,503) APHI
  107 READ(5,503) ADELTA
  108 READ(5,503) CONST
*
*       Data Reduction :
*
      R1=SQRT(1.0-D*D)
      R3=SQRT(1.0-A*A)
*
      DO 300 N=1,10
      SPACE=(90.0*RADN)/9.0
      BETA=SPACE*FLOAT(N-1)
      ABETA=BETA/RADN
      ALPHA=AALPHA*RADN
      PHI=APHI*RADN
      TNA=TAN(ALPHA)
      TNB=TAN(BETA)
      DALPHA=ATAN(TNA/(SQRT(1.0+TNB*TNB)))
      DBETA=ATAN(TNB/(SQRT(1.0+TNA*TNA)))
      ADA=DALPHA/RADN
      ADB=DBETA/RADN
      Q=AQ*COS(BETA)
      WRITE(6,504)AALPHA,ABETA,A
      WRITE(6,505)ADA,ADB
*
*       Co-ordinates of the Disc Centre
*       and Intersection Points :
*
      XC=A*COS(DBETA)*COS(ALPHA)
      YC=A*COS(DALPHA)*SIN(BETA)
      ZC=A*COS(DBETA)*SIN(ALPHA)
*
      CALL BRAC(FB1,DE1,DE2,NB1)
      T1=DE1(1)
      T2=DE1(2)
      T3=DE2(1)
      T4=DE2(2)
*
      CALL BISECT(T1,T3,FB1,QE,ME)
      CALL BISECT(T2,T4,FB1,QD,MD)
      XD=R1*COS(QD)
      YD=R1*SIN(QD)
      ZD=D
*
      XE=R1*COS(QE)
      YE=R1*SIN(QE)
      ZE=D
*
*     WRITE(6,507)
*     WRITE(6,508)
*     WRITE(6,509)D, XC,YC,ZC, XD,YD,ZD,
*    +               XE,YE,ZE, MD,ME
*     WRITE(6,510)
```

```
*     WRITE(6,511)
*
      R=1.0
      PCX=0.0
      PCY=0.0
      PCZ=0.0
      PGX=0.0
      PGY=0.0
      PGZ=0.0
      PQX=0.0
      PQY=0.0
      PQZ=0.0
*
      DO 200 I=1,11
      SPACE=ABS(YE-YD)/10.0
      IF(YD.GE.YE) THEN
      E=YD-SPACE*FLOAT(I-1)
      ELSE
      E=YE-SPACE*FLOAT(I-1)
      ENDIF
*
      B=ABS(YE-YD)/10.0
      S=D*D+E*E
      IF((1.0-S).LT.1.0E-06)THEN
      WRITE(6,506)
      GOTO 200
   99 ELSE
      XA=SQRT(1.0-S)
      YA=E
      ZA=D
      ENDIF
*
      R2=SQRT(1.0-E*E)
      CALL BRAC(FB2,BB1,BB2,NB2)
      T5=BB1(1)
      T7=BB2(1)
      CALL BISECT(T5,T7,FB2,QB,MB)
*
      IF(I.EQ.1.0.OR.I.EQ.11.0) THEN
      XB=XA
      YB=YA
      ZB=ZA
      ELSE
      XB=R2*COS(QB)
      YB=E
      ZB=R2*SIN(QB)
      ENDIF
*
      IF((ZB-D).LT.1.0E-03) THEN
      AL(I)=0.0
      AZ(I)=0.0
      ALPHAR=0.0
      END IF
      IF(I.LT.2.0) THEN
      GOTO 200
      ELSE
      AL(I)=SQRT((XA-XB)**2+(YA-YB)**2+(ZA-ZB)**2)
      AZ(I)=ZB-D
      ENDIF
      RL=(AL(I)+AL(I-1))/2.0
```

```
      Z=(AZ(I)+AZ(I-1))/2.0
      ALPHAR=ASIN(Z/RL)
      ALR=ALPHAR/RADN
*
*     WRITE(6,512)E,XA,YA,ZA, XB,YB,ZB,MB,R2,ALR,Z,RL,Q
*
      CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
     +     BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
*     WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
*     WRITE(6,516)C,APHI,Z,ALR,ABETAX,Q,GAMMA,AD,ADELTA
*     IF(IFLAG.EQ.2) THEN
*     WRITE(6,518)
*     GOTO 401
*     ELSEIF(IFLAG.EQ.3) THEN
*     WRITE(6,519) ADELM,ABETAW
*     GOTO 401
*     ELSEIF(IFLAG.EQ.0) THEN
*     WRITE(6,520) AOMEGA,AALPRD
*     GOTO 401
*     ELSEIF(IFLAG.EQ.1) THEN
*     WRITE(6,521)
*     ENDIF
* 401 WRITE(6,522)PG,PC,PQ,PT
*
*     Force Calculation on the Concave
*     Contact section :
*
      Y=E+B/2.0
      Y1=E+B
      Y2=E
      UC=Z/2.0
      R4=SQRT(1.0-Y**2)
      RD=SQRT(R4**2-(RL/2.0)**2)
      RDD=SQRT(RD**2+(RL/6.0)**2)
      TH1=2.0*ATAN((RL/2.0)/RD)
      TH2=ASIN(RD/RDD)
      TH3=90.0*RADN-TH2
      RCL=TH1*R4
      PCA=PC*COS(PHI)/COS(DELTA)
      PQR=PQ*COS(PHI)/COS(DELTA)
      PGR=PG*COS(PHI+TH3)/COS(DELTA)
*
*     Components of Pc:
*
      PCX1=PCA*SIN(DELTA+ALPHAR)+AD*RCL*COS(ALPHAR)
      PCZ1=PCA*COS(DELTA+ALPHAR)-AD*RCL*SIN(ALPHAR)
      PCR1=SQRT(PCX1**2+PCZ1**2)
      THC=ATAN(PCZ1/PCX1)
      Y=E+B/2.0
      UC=Z/2.0
      RC=SQRT(1.0-(UC+D)**2)
      CNU=ASIN(ABS(Y/RC))
      PCE=PCX1*COS(CNU)*B
      PCXE=PCE*COS(CNU)
      PCZE=PCZ1*B
      IF(Y.LE.0.0) THEN
      PCYE=-PCE*SIN(CNU)
      ELSE
      PCYE=PCE*SIN(CNU)
      ENDIF
```

```
*
*     Components of Pg:
*
      THG=90.0*RADN-DELTA-ALPHAR
      PGX1=PGR*COS(THG)*B
      UG=2.0*Z/3.0
      RG=SQRT(1.0-(UG+D)**2)
      GNU=ASIN(ABS(Y/RG))
      PGE=PGX1*COS(GNU)
      PGXE=PGE*COS(GNU)
      PGZE=PGR*SIN(THG)*B
*
      IF(Y.LE.0.0) THEN
      PGYE=-PGE*SIN(GNU)
      ELSE
      PGYE=PGE*SIN(GNU)
      ENDIF
*
*     Components of Pq:
*
      THQ=90.0*RADN-DELTA-ALPHAR
      PQX1=PQR*COS(THQ)*B
      QNU=CNU
      PQE=PQX1*COS(QNU)
      PQXE=PQE*COS(QNU)
      PQZE=PQR*SIN(THQ)*B
*
      IF(Y.LE.0.0) THEN
      PQYE=-PQE*SIN(QNU)
      ELSE
      PQYE=PQE*SIN(QNU)
      ENDIF
*
*     Output calculated data:
*
      PCX=PCX+PCXE
      PCY=PCY+PCYE
      PCZ=PCZ+PCZE
      PGX=PGX+PGXE
      PGY=PGY+PGYE
      PGZ=PGZ+PGZE
      PQX=PQX+PQXE
      PQY=PQY+PQYE
      PQZ=PQZ+PQZE
  200 CONTINUE
      WRITE(6,523)PCX,PCY,PCZ,PGX,PGY,PGZ,PQX,PQY,PQZ
      FPX=PCX+PGX+PQX
      FPY=PCY+PGY+PQY
      FPZ=PCZ+PGZ+PQZ
*
*     Scrubbing Identification :
*
      CALL SCRUB(ATHETA,X0,Y0,Z0,NS,NE)
      J=0
      DO 500 K=1,40
      IF(NS(K).EQ.0.AND.NE(K).EQ.3) THEN
      J=J+1
      ELSE
      GOTO 500
      ENDIF
```

```
  500 CONTINUE
 *
      Q=0.0
      BPX=0.0
      BPY=0.0
      BPZ=0.0
      BPRXE=0.0
      BPRYE=0.0
      BPRZE=0.0
      IF(J.LT.2.0) THEN
      GOTO 400
      ELSE
      ENDIF
 *
      CALL BRAC1(FB3,GG1,GG2,NB3)
      T9=GG1(1)
      T11=GG2(1)
      CALL BISECT(T9,T11,FB3,QG,MG)
 *
      XG=0.0
      YG=COS(QG)
      ZG=SIN(QG)
 *
      XF=0.0
      YF=SQRT(1.0-D**2)
      ZF=D
 *
      DO 900 M=1,5
      SPACE=ABS(YF-YG)/5.0
      B=ABS(YF-YG)/5.0
      YM=YF-SPACE*FLOAT(M)
 *
      RM=SQRT(1.0-YM**2)
      THR1=ATAN(SQRT(RM**2-D**2)/D)
      ALRD=90.0*RADN-(180.0*RADN-THR1)/2.0
      ALRR=180.0*RADN-ALRD
 *
 *    Force Calculation for the Scrubbing Contact Area (above
 *    the limiting value ALPWN) :
 *
      CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
     +     BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
      ALPWN=(135.0*RADN-PHI/2.0)+BETAX+AMU
      IF(ALPWN.LT.ALRR) THEN
      ALPHAR=180.0*RADN-(45.0*RADN+PHI/2.0)
      RLR=(RM-D)/SIN(ALRD)
      RL=RLR/(2.0*SIN(45.0*RADN-PHI/2.0))
      Z=RLR/(2.0*TAN(45.0*RADN-PHI/2.0))
 *
      CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
     +     BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
 *    WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
 *    WRITE(6,516) C,APHI,Z,ALR,ABETAX,Q,GAMMA,AD,ADELTA
 *    IF(IFLAG.EQ.2) THEN
 *    WRITE(6,518)
 *    GOTO 402
 *    ELSEIF(IFLAG.EQ.3) THEN
 *    WRITE(6,519) ADELM,ABETAW
 *    GOTO 402
 *    ELSEIF(IFLAG.EQ.0) THEN
```

```
*      WRITE(6,520) AOMEGA,AALPRD
*      GOTO 402
*      ELSEIF(IFLAG.EQ.1) THEN
*      WRITE(6,521)
*      ENDIF
* 402  WRITE(6,522)PG,PC,PQ,PT
*
       DELTA=ADELTA*RADN
       AC=C*RL
       PT=PG+PC
       W=(RLR*Z*GAMMA)/4.0
       PV=2.0*COS(45.0*RADN-PHI/2.0)*(PT+AC)-W
       PR=PV/COS(DELTA+ALRD)
       PH=PR*COS(ALRR-90.0*RADN-DELTA)
       BPCZE=-PV*B
*
       VR=(RM-D)/2.0
       BRR=SQRT(1.0-(VR+D)**2)
       BCNU=ASIN(ABS(YM/BRR))
       BPRXE=PH*COS(BCNU)*B
       BPRYE=-PH*SIN(BCNU)*B
       ELSE
       ALPHAR=ALRR
       RL=RLR
       Z=RM-D
*
*      Force Calculation for the Scrubbing Contact Area (below
*      the limiting value ALPWN) :
*
       CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,AMU,
      +     BETAX,ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
*      WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
*      WRITE(6,516) C,APHI,Z,ALR,ABETAX,Q,GAMMA,AD,ADELTA
*      IF(IFLAG.EQ.2) THEN
*      WRITE(6,518)
*      GOTO 403
*      ELSEIF(IFLAG.EQ.3) THEN
*      WRITE(6,519) ADELM,ABETAW
*      GOTO 403
*      ELSEIF(IFLAG.EQ.0) THEN
*      WRITE(6,520) AOMEGA,AALPRD
*      GOTO 403
*      ELSEIF(IFLAG.EQ.1) THEN
*      WRITE(6,521)
*      ENDIF
* 403  WRITE(6,522)PG,PC,PQ,PT
*
       RMD=SQRT(RM**2+(RL/6.0)**2)
       TH4=ACOS(RM/RMD)
       BRCL=AD*RM*THR1
       BPCA=PC*COS(PHI)/COS(DELTA)
       BPGR=PG*COS(PHI-BTH2)/COS(DELTA)
*
*      Components of Pg:
*
       BTHG=90.0*RADN-DELTA-ALPHAR
       BPGX1=BPGR*COS(BTHG)*B
       VG=2.0*Z/3.0
       BRG=SQRT(1.0-(VG+D)**2)
       BGNU=ASIN(ABS(YM/BRG))
```

```
      BPGE=BPGX1*COS(BGNU)
      BPGXE=BPGE*COS(BGNU)
      BPGZE=BPGR*SIN(BTHG)*B
      BPGYE=-BPGE*SIN(BGNU)
*
*     Components of Pc:
*
      BPCX1=BPCA*SIN(DELTA+ALPHAR)+BRCL*COS(ALPHAR)
      BPCZ1=BPCA*COS(DELTA+ALPHAR)-BRCL*SIN(ALPHAR)
      BPCR1=SQRT(BPCX1**2+BPCZ1**2)
      BTHC=ATAN(BPCZ1/BPCX1)

      VC=Z/2.0
      BRC=SQRT(1.0-(VC+D)**2)
      BCNU=ASIN(ABS(YM/BRC))
      BPCE=BPCX1*COS(BCNU)*B
      BPCXE=BPCE*COS(BCNU)
      BPCZE=BPCZ1*B
      BPCYE=-BPCE*SIN(BCNU)
      ENDIF
*
*     Output calculated data:
*
*     WRITE(6,523)BPCXE,BPCYE,BPCZE,BPGXE,BPGYE,BPGZE
      BPX=BPX+BPCXE+BPGXE+BPRXE
      BPY=BPY+BPCYE+BPGYE+BPRYE
      BPZ=BPZ+BPCZE+BPGZE+BPRZE
  900 CONTINUE
*
*     FINAL OUTPUT CALCULATED DATA :
*
  400 PX=(FPX+BPX)*CONST
      PY=(FPY+BPY)*CONST
      PZ=(FPZ+BPZ)*CONST
      P=SQRT((PX**2)+(PY**2)+(PZ**2))
      ALAMDR=ACOS(ABS(PX/P))
      BLAMDR=ALAMDR/RADN
      AGAMAR=ACOS(ABS(PY/P))
      GAMAR=AGAMAR/RADN
      ADELTR=ACOS(ABS(PZ/P))
      DELTAR=ADELTR/RADN
*
      WRITE(6,514)
      WRITE(6,515)P,PX,PY,PZ,BLAMDR,GAMAR,DELTAR
*
  300 CONTINUE
  110 STOP
      END
```

PROGRAMME : P2

```
*      **************************************************
*      *   K-Factors Calculated per unit Projected Width   *
*      *   Disc Analysis Vector Solnution for Soil Block   *
*      *   Soil Block Geometry :E-PLANE Stepped:           *
*      *   Soil Forces on the Disc :3-Orthogonal Direction *
*      **************************************************
*
       SUBROUTINE BISECT(XL,XU,FUNC,Y,IFLAG)
*           Procedure for locating the root Y in int XL,XU
*      Flag Values: 0=Solution Found; 1=No Solution;
*      2=Number of iterations exceeded
*
       XACC=1.0E-04
       FMID=FUNC(XU)
       F=FUNC(XL)
       IF(F*FMID.GE.0.0)THEN
       IFLAG=1
       Y=0.0
       RETURN
       ENDIF
       IF(F.LT.0.0)THEN
       Y=XL
       DX=XU-XL
       ELSE
       Y=XU
       DX=XL-XU
       ENDIF
*
       DO 10 J=1,40
        DX=DX/2.0
        XMID=Y+DX
        FMID=FUNC(XMID)
        IF(FMID.LT.0.0) Y=XMID
        IF(ABS(DX).LT.XACC.OR.FMID.EQ.0.0)THEN
        IFLAG=0
        RETURN
        ENDIF
    10 CONTINUE
       IFLAG=2
       RETURN
       END
*
*      ********************************************
       SUBROUTINE BRAC(FX,BL,BU,NB)
*      Search for 2 roots and brackets values found
*
       DIMENSION BL(2),BU(2)
       NB=0
       X=0.0
       INT=18
       DX=361.0*ARSIN(1.0)/(90.0*FLOAT(INT))
```

```
      FP=FX(X)
*
      DO 10 I=1,INT
        X=X+DX
        FC=FX(X)
        IF(FC*FP .LT. 0.0) THEN
        NB=NB+1
        BL(NB)=X - DX
        BU(NB)=X
        END IF
*
        FP=FC
        IF(NB .EQ. 2) RETURN
   10 CONTINUE
      RETURN
      END
*
*     *******************************************
      FUNCTION FB1(T)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
      X=R1*COS(T)
      Y=R1*SIN(T)
      FB1=(X-XC)*(X-XC) + (Y-YC)*(Y-YC)+
     +    (D-ZC)*(D-ZC) - R3*R3
      RETURN
      END
*
*     ************************************************
      FUNCTION FB2(T)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
      X=R2*COS(T)
      Z=R2*SIN(T)
      FB2=(X-XC)*(X-XC) + (E-YC)*(E-YC)+
     +    (Z-ZC)*(Z-ZC) - R3*R3
      RETURN
      END
*
*     ************************************************
      SUBROUTINE SCRUB(ATHETA,X0,Y0,Z0,NS,NE)
*     Search for co-ordinates of points of the disc edge,
*     status and state. Status: 0=Scrubbing, 1=Non scrubbing
*     State: 2=Point above the soil level
*            3=Point below the soil level
*
      REAL ATHETA(40),X0(40),Y0(40),Z0(40)
      INTEGER NS(40),NE(40)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3/SCR/ALPHA,BETA,RADN
*
      TH=ASIN((D-ZC)/R3)
      DO 200 N=1,40
       SPACE=2.50*RADN
       THETA=TH+SPACE*FLOAT(N-1)
       ATHETA(N)=THETA/RADN
*
       X=R3*COS(THETA)*SIN(BETA)+R3*SIN(THETA)*SIN(ALPHA)*COS(BETA)
       Y=R3*SIN(THETA)*SIN(ALPHA)*SIN(BETA)-R3*COS(BETA)*COS(THETA)
       Z=-R3*SIN(THETA)*COS(ALPHA)
*
       X0(N)=XC-X
       IF(X0(N).LE.1.0E-04.AND.X0(N).GT.0.0) THEN
```

```
      X0(N)=0.0
      ELSE
      ENDIF
      Y0(N)=YC-Y
      Z0(N)=ZC-Z
*
      IF(X0(N).LE.0.0) THEN
      NS(N)=0
      ELSE
      NS(N)=1
      ENDIF
*
      IF(ABS(Z0(N)-D).LE.(1.0E-02).AND.ABS(Z0(N)-D).GT.0.0) THEN
      Z0(N)=D
      ELSE
      ENDIF
      IF(Z0(N).GE.D) THEN
      NE(N)=3
      ELSE
      NE(N)=2
      ENDIF
  200 CONTINUE
      RETURN
      END
*
*     ******************************************************
      SUBROUTINE PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,
     +            ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
      COMMON /SCR/ALPHA,BETA,RADN/PSF1/ABETAX,ADELTA,APHI,RADHS
     +        /PSF2/C,AD,GAMMA,Q/PSF3/ALPHAR,RL,Z
*
*     Data Reduction
*
      BETAX=ABETAX*RADN
      PHI=APHI*RADN
      DELTAX=ADELTA*RADN
*
      IF(PHI.GE.1.0E-06) CDEL=ASIN(SIN(DELTAX)/SIN(PHI))
      IF(PHI.LT.1.0E-06) CDEL=ASIN(AD/C)
      ACDEL=CDEL/RADN
      PSI=45.0*RADN+PHI/2.0
      APSI=PSI/RADN
      EPS=45.0*RADN-PHI/2.0
      AEPS=EPS/RADN
      AMU=(CDEL + DELTAX)/2.0
      AAMU=AMU/RADN
      THP=PSI+AMU
      ATHP=THP/RADN
      THN=PSI-AMU
      ATHN=THN/RADN
      FP=TAN(PSI)
*
*     Limits and Discont. Angles
*
      ALPHRD=90.0*RADN-AMU
      BETAW=AMU-EPS+ALPHAR-90.0*RADN
      AALPRD=ALPHRD/RADN
      ABETAW=BETAW/RADN
      ZETA=ALPHAR+AMU
      OMEGA=(ZETA-ASIN(SIN(PHI)*SIN(ZETA)))/2.0
```

```
      AOMEGA=OMEGA/RADN
*
*
*     Constrained Adhesion Requirement
*
      IF(PHI.GE.1.0E-6) THEN
      AD=C*TAN(DELTAX)/TAN(PHI)
      ELSE
      RADHS=2.5/3.0
      AD=C*RADHS
      END IF
*
*     Rupture Block Type Identification
*
      IF(ALPHAR-ALPHRD.GT.1.0E-06) GO TO 109
      IF(OMEGA-ALPHAR.LT.1.0E-06) GO TO 203
      GO TO 204
  109 IF(BETAX-BETAW.GT.1.0E-06) GO TO 201
      GO TO 202
*
*     Basic Rupture Surface  *Type 1*
*
  201 DELTA=DELTAX
      IFLAG=2
      ADELM=ADELTA
      KT=1
  206 ETA=ALPHAR-EPS-THN
      RS=RL*SIN(THP)/COS(PHI)
      T=RL*SIN(THN)/COS(PHI)
      U=RS*EXP(ETA*TAN(PHI))
      V=U*SIN(EPS)
      F=U*COS(EPS)
*
      D1=V/2.0
      D2=2.0*V/3.0
      DW=2.0*F/3.0
      DQ=F/2.0
      D5=RS*COS(PHI)/2.0
      D4=2.0*RS*COS(PHI)/3.0
*
      F1=2.0*C*V*FP
      F2=GAMMA*V*V*FP*FP/2.0
      F1D=Q*V*FP*FP
      W1=F*V*GAMMA/2.0
      AM=-3.0*TAN(PHI)
      RHO1=EPS+ETA
      AMW1=GAMMA*U*U*U/(3.0*(AM*AM+1.0))
      AMW2=EXP(AM*ETA)*(AM*COS(RHO1)+SIN(RHO1))
     +   -AM*COS(EPS)-SIN(EPS)
      AMW=AMW1*AMW2
      IF(PHI.LT.1.0E-06) GO TO 600
      AMC=C*(U*U-RS*RS)/(2.0*TAN(PHI))
      GO TO 601
  600 AMC=C*RS*RS*ETA
  601 QF=Q*F
      F4=(F2*D2+W1*DW + AMW)/D4
      F5C=(F1*D1+AMC)/D5
      F5Q=(F1D*D1+QF*DQ)/D5
*
      W2=GAMMA*RL*T*SIN(THP)/2.0
```

```
      A2=C*T
      AF=C*RL
      RHO2=THP-PHI-PHI
      RHOW=THP+ALPHAR-PHI
*
      PG=(W2*SIN(RHOW)  + F4*COS(PHI))/SIN(RHO2)
      PC=(AF*COS(THP-PHI)  +  (F5C+A2)*COS(PHI))/SIN(RHO2)
      PQ=F5Q*COS(PHI)/SIN(RHO2)
      RDIST=2.0*F/Z
      GO TO 205
*
*      Rupture Surface with a Boundary Wedge *Type 3*
*
  202 THP=180.0*RADN-(ALPHAR-BETAX)
      KT=3
      THN=(ALPHAR-BETAX)+PHI-90.0*RADN
      RHO3=PHI+2.0*(ALPHAR-BETAX)
      ANG=SIN(PHI)*COS(RHO3)/(SIN(PHI)*SIN(RHO3)-1.0)
      DELTAM=ATAN(ANG)
      ADELM=DELTAM/RADN
*
      DELTA=DELTAM
      IFLAG=3
      GO TO 206
*
*     Rupture Surface with a Discontinuity  *Type 2*
*
  203 RHO4=180.0*RADN-ALPHAR+OMEGA-THP
      IFLAG=0
      KT=2
      T=RL*SIN(ALPHAR-OMEGA)/SIN(RHO4)
      U=RL*SIN(THP)/SIN(RHO4)
      V=U*SIN(OMEGA)
      F=U*COS(OMEGA)
*
      W3=GAMMA*(F*V+RL*T*SIN(THP))/2.0
      A2=C*T
      AF=C*RL
      QF=Q*F
      RHO5=(THP-PHI-PHI)
      RHO6=(THP-PHI+ALPHAR)
      ADELM=ADELTA
      DELTA=DELTAX
*
      F1=2.0*C*V*FP
      F2=GAMMA*V*V*FP*FP/2.0
      F1D=Q*V*FP*FP
      PG=(W3*SIN(RHO6)-F2*COS(RHO6))/SIN(RHO5)
      PC=(A2*COS(PHI)+AF*COS(THP-PHI)-F1*COS(RHO6))/SIN(RHO5)
      PQ=(QF*SIN(RHO6)-F1D*COS(RHO6))/SIN(RHO5)
      RDIST=2.0*F/Z
*
      GO TO 205
*
*     Rupture Surface with a Rankine Wedge  *Type 4*
*
  204 F=Z/TAN(EPS)
      IFLAG=1
      KT=4
      G=Z/TAN(ALPHAR)-F
```

```
*
      U=Z/SIN(EPS)
      F1=2.0*C*Z*FP
      F1D=Q*Z*FP*FP
      F2=GAMMA*Z*Z*FP*FP/2.0
      W4=GAMMA*F*Z/2.0
      W5=GAMMA*G*Z/2.0
      A3=U*C
      Q1=F*Q
      Q2=G*Q
      AF=C*(Z/SIN(ALPHAR))
      RHOR=PHI+2.0*(EPS-ALPHAR)
      DELTAM=ATAN(SIN(PHI)*COS(RHOR)/(1.0-SIN(PHI)
     +   *SIN(RHOR)))
      ADELM=DELTAM/RADN
      DELTA=DELTAM
*     DELTAM=PHI
      RHO7=PSI-ALPHAR-PHI
      RHO8=ALPHAR+PHI
      RHO9=EPS-ALPHAR-PHI
*
      PG=(W4*COS(PSI)+F2*COS(EPS))*COS(RHO7)
     +   + W5*COS(RHO8)
      PC=(F1*COS(EPS)-A3*SIN(PHI))*COS(RHO7)
     +   +A3*SIN(RHO9)-AF*SIN(PHI)
      PQ=(Q1*COS(PSI)+F1D*COS(EPS))*COS(RHO7)
     +   + Q2*COS(RHO8)
      RDIST=(G+2.0*F)/Z
*
*     OUTPUT OF CALCULATED DATA:
  205 PT=PG+PC+PQ
      RETURN
      END
*
*     *******************************************************
*          MAIN PROGRAMME
*
      DIMENSION DE1(2),DE2(2),BB1(2),BB2(2)
      DIMENSION C1(40),C2(40),C3(40),C4(40)
      REAL ATHETA(40),X0(40),Y0(40),Z0(40),AL(11),AZ(11)
      INTEGER NS(40),NE(40)
      COMMON /FC/XC,YC,ZC/FCC/R1,R2,D,E/FCCC/R3
     +       /SCR/ALPHA,BETA,RADN/PSF1/ABETAX,ADELTA,APHI,RADHS
     +       /PSF2/C,AD,GAMMA,Q/PSF3/ALPHAR,RL,Z
      EXTERNAL FB1,FB2
      RADN=ARSIN(1.0)/90.0
*
  501 FORMAT(3F10.0)
  502 FORMAT(2F10.0)
  503 FORMAT(F10.0)
  504 FORMAT(' '/' ',3X,'Alpha',4X,'a',5X,'d',5X,'z',
     +       5X,'Q'/' ',F8.2,4F7.3)
  505 FORMAT(' '/' ',3X,'AlphaD',2X,'BetaD'/' ',2F8.1)
  506 FORMAT(' ',5X,'No Solution in Specified Range')
  507 FORMAT(' '/' ',23X,'C',23X,'D',22X,'E',13X,'FLAGS')
  508 FORMAT(' ',6X,'D',3(9X,'X',6X,'Y',6X,'Z'),
     +      5X,'D',3X,'E')
  509 FORMAT(' ',F7.3,3(3X,3F7.3),3X,2I3)
  510 FORMAT(' '/' ',23X,'A',22X,'B',13X,'FLAGS')
  511 FORMAT(' ',6X,'E',2(9X,'X',6X,'Y',6X,'Z'),
```

```
     +       5X,'B',6X,'R2',4X,'ALPHAR',4X,'Z',4X,'L')
  512 FORMAT(' ',F7.3,2(3X,3F7.3),3X,I3,2X,5F7.3)
  513 FORMAT(' '/' ',3X,'Scrubbing')
  514 FORMAT(' ',3X,'P',10X,'PX',8X,'PY',8X,'PZ',7X,'LAMDAR',
     +        4X,'GAMAR',4X,'DELTAR')
  515 FORMAT(F10.3,6(F10.3))
  516 FORMAT(' '/' ',7X,'C',5X,'PHI'/' ',F8.2,F8.1/
     +    ' ',7X,'Z',3X,'ALPHAR',4X,'BETA'/' ',F8.2,2F8.1/
     +    ' ',7X,'Q',3X,'GAMMA'/' ',2F8.2/
     +    ' ',7X,'AD',3X,'DELTA'/' ',F8.2,F8.1)
  517 FORMAT(' '/' ',5X,'PSI',5X,'EPS',6X,'MU'/' ',3F8.1/
     +    ' ',5X,'DEL',5X,'TH+',5X,'TH-'/' ',3F8.1/' ')
  518 FORMAT(' ','BASIC RUPTURE SURFACE')
  519 FORMAT(' ','BOUNDARY WEDGE  MOB. FRICT.= ',
     +    F8.1,'  BETA LIM. =',F8.1)
  520 FORMAT(' ','BASIC DISCONTINUITY'/
     +    ' ',' OMEGA=',F6.2,'  ALPHD=',F6.2)
  521 FORMAT(' ','RANKINE DISCONTINUITY')
  522 FORMAT(' ',7X,'P*G',7X,'P*C',7X,'P*Q',8X,'P'/' ',4F10.3)
  523 FORMAT(' ',4X,'PCX',5X,'PCY',5X,'PCZ',5X,'PGX',5X,'PGY',
     +           5X,'PGZ',5X,'PQX',5X,'PQY',5X,'PQZ'/' ',9F8.3)
  524 FORMAT(' ',4X,'PHI',4X,'DELTA',4X,'C',4X,'GAMMA'/' ',4F8.2)
  525 FORMAT(' '/' ',2X,'BETA',4X,'R',4X,'Kgx',4X,'Kcx',4X,'Kqx',
     +       4X,'Kgy',4X,'Kcy',4X,'Kqy',4X,'Kgz',4X,'Kcz',4X,'Kqz')
  526 FORMAT(F7.1,10F7.3)
*
*      Input Data :
*
  101 READ(5,501) AALPHA,A,D
  102 READ(5,503) C
  103 READ(5,503) GAMMA
  104 READ(5,503) ABETAX
  105 READ(5,503) Q
  106 READ(5,503) APHI
  107 READ(5,503) ADELTA
  108 READ(5,503) CZ
  109 READ(5,503) RSP
*
*      Data Reduction :
*
      R1=SQRT(1.0-D*D)
      R3=SQRT(1.0-A*A)
*     WRITE(6,504) AALPHA,A,D,CZ,Q
*     WRITE(6,524)APHI,ADELTA,C,GAMMA
*     WRITE(6,525)
*
      DO 300 N=8,13
      SPACE=(90.0*RADN)/18.0
      BETA=SPACE*FLOAT(N-1)
      ABETA=BETA/RADN
      ALPHA=AALPHA*RADN
      PHI=APHI*RADN
      TNA=TAN(ALPHA)
      TNB=TAN(BETA)
      DALPHA=ATAN(TNA/(SQRT(1.0+TNB*TNB)))
      DBETA=ATAN(TNB/(SQRT(1.0+TNA*TNA)))
      ADA=DALPHA/RADN
      ADB=DBETA/RADN
*     WRITE(6,504)AALPHA,ABETA,A
*     WRITE(6,505)ADA,ADB
```

```
*
      R9=(D/COS(ALPHA))-A*TAN(ALPHA)
      W=2.0*(SQRT(R3**2-R9**2))*COS(BETA)*RSP
*
*     Co-ordinates of the Disc Centre
*     and Intersection Points :
*
      XC=A*COS(DBETA)*COS(ALPHA)
      YC=A*COS(DALPHA)*SIN(BETA)
      ZC=A*COS(DBETA)*SIN(ALPHA)
*
*
      CALL BRAC(FB1,DE1,DE2,NB1)
      T1=DE1(1)
      T2=DE1(2)
      T3=DE2(1)
      T4=DE2(2)
*
      CALL BISECT(T1,T3,FB1,QE,ME)
      CALL BISECT(T2,T4,FB1,QD,MD)
      XD=R1*COS(QD)
      YD=R1*SIN(QD)
      ZD=D
*
      XE=R1*COS(QE)
      YE=R1*SIN(QE)
      ZE=D
*
*     WRITE(6,507)
*     WRITE(6,508)
*     WRITE(6,509)D, XC,YC,ZC, XD,YD,ZD,
*    +               XE,YE,ZE, MD,ME
*     WRITE(6,510)
*     WRITE(6,511)
*
      R=1.0
      PCX=0.0
      PCY=0.0
      PCZ=0.0
      PGX=0.0
      PGY=0.0
      PGZ=0.0
      PQX=0.0
      PQY=0.0
      PQZ=0.0
*
      DO 200 I=1,11
      SPACE=ABS(YE-YD)/10.0
      IF(YD.GE.YE) THEN
      E=YD-SPACE*FLOAT(I-1)
      ELSE
      E=YE-SPACE*FLOAT(I-1)
      ENDIF
*
      B=ABS(YE-YD)/10.0
      S=D*D+E*E
      IF((1.0-S).LT.1.0E-06)THEN
      WRITE(6,506)
      GOTO 200
   99 ELSE
```

```
      XA=SQRT(1.0-S)
      YA=E
      ZA=D
      ENDIF
*
      R2=SQRT(1.0-E*E)
      CALL BRAC(FB2,BB1,BB2,NB2)
      T5=BB1(1)
      T7=BB2(1)
      CALL BISECT(T5,T7,FB2,QB,MB)
*
      IF(I.EQ.1.0.OR.I.EQ.11.0) THEN
      XB=XA
      YB=YA
      ZB=ZA
      ELSE
      XB=R2*COS(QB)
      YB=E
      ZB=R2*SIN(QB)
      ENDIF
*
      IF((ZB-D).LT.1.0E-03) THEN
      AL(I)=0.0
      AZ(I)=0.0
      ALPHAR=0.0
      END IF
      IF(I.LT.2.0) THEN
      GOTO 200
      ELSE
      AL(I)=SQRT((XA-XB)**2+(YA-YB)**2+(ZA-ZB)**2)
      AZ(I)=ZB-D
      ENDIF
      RL=(AL(I)+AL(I-1))/2.0
      Z=(AZ(I)+AZ(I-1))/2.0
      ALPHAR=ASIN(Z/RL)
      ALR=ALPHAR/RADN
*
*     WRITE(6,512)E,XA,YA,ZA, XB,YB,ZB,MB,R2,ALR,Z,RL,Q
*
      CALL PASFOR(PG,PC,PQ,PT,AF,IFLAG,APSI,AEPS,AAMU,DELTA,
     +     ACDEL,ATHP,ATHN,ADELM,ABETAW,AOMEGA,AALPRD)
*     WRITE(6,517) APSI,AEPS,AAMU,ACDEL,ATHP,ATHN
*     WRITE(6,516)C,APHI,Z,ALR,ABETAX,Q,GAMMA,AD,ADELTA
*     IF(IFLAG.EQ.2) THEN
*     WRITE(6,518)
*     GOTO 401
*     ELSEIF(IFLAG.EQ.3) THEN
*     WRITE(6,519) ADELM,ABETAW
*     GOTO 401
*     ELSEIF(IFLAG.EQ.0) THEN
*     WRITE(6,520) AOMEGA,AALPRD
*     GOTO 401
*     ELSEIF(IFLAG.EQ.1) THEN
*     WRITE(6,521)
*     ENDIF
* 401 WRITE(6,522)PG,PC,PQ,PT
*
*     Force Calculation on the Concave
*     Contact Section :
*
```

```
      Y=E+B/2.0
      Y1=E+B
      Y2=E
      UC=Z/2.0
      R4=SQRT(1.0-Y**2)
      RD=SQRT(R4**2-(RL/2.0)**2)
      RDD=SQRT(RD**2+(RL/6.0)**2)
      TH1=2.0*ATAN((RL/2.0)/RD)
      TH2=ASIN(RD/RDD)
      TH3=90.0*RADN-TH2
      RCL=TH1*R4
      PCA=PC*COS(PHI)/COS(DELTA)
      PQR=PQ*COS(PHI)/COS(DELTA)
      PGR=PG*COS(PHI+TH3)/COS(DELTA)
*
*     Components of Pc:
*
      PCX1=PCA*SIN(DELTA+ALPHAR)+AD*RCL*COS(ALPHAR)
      PCZ1=PCA*COS(DELTA+ALPHAR)-AD*RCL*SIN(ALPHAR)
      PCR1=SQRT(PCX1**2+PCZ1**2)
      THC=ATAN(PCZ1/PCX1)
*
      Y=E+B/2.0
      UC=Z/2.0
      RC=SQRT(1.0-(UC+D)**2)
      CNU=ASIN(ABS(Y/RC))
      PCE=PCX1*COS(CNU)*B
*
      PCXE=PCE*COS(CNU)
      PCZE=PCZ1*B
      IF(Y.LE.0.0) THEN
      PCYE=-PCE*SIN(CNU)
      ELSE
      PCYE=PCE*SIN(CNU)
      ENDIF
*
*     Components of Pg:
*
      THG=90.0*RADN-DELTA-ALPHAR
      PGX1=PGR*COS(THG)*B
      PGZE=PGR*SIN(THG)*B
      UG=2.0*Z/3.0
      RG=SQRT(1.0-(UG+D)**2)
      GNU=ASIN(ABS(Y/RG))
      PGE=PGX1*COS(GNU)
      PGXE=PGE*COS(GNU)
*
      IF(Y.LE.0.0) THEN
      PGYE=-PGE*SIN(GNU)
      ELSE
      PGYE=PGE*SIN(GNU)
      ENDIF
*
*     Components of Pq:
*
      THQ=90.0*RADN-DELTA-ALPHAR
      PQX1=PQR*COS(THQ)*B
      PQZE=PQR*SIN(THQ)*B
      QNU=CNU
      PQE=PQX1*COS(QNU)
```

```
      PQXE=PQE*COS(QNU)
*
      IF(Y.LE.0.0) THEN
      PQYE=-PQE*SIN(QNU)
      ELSE
      PQYE=PQE*SIN(QNU)
      ENDIF
*
*     Output calculated data:
      PCX=PCX+PCXE
      PCY=PCY+PCYE
      PCZ=PCZ+PCZE
      PGX=PGX+PGXE
      PGY=PGY+PGYE
      PGZ=PGZ+PGZE
      PQX=PQX+PQXE
      PQY=PQY+PQYE
      PQZ=PQZ+PQZE
  200 CONTINUE
*     WRITE(6,523)PCX,PCY,PCZ,PGX,PGY,PGZ,PQX,PQY,PQZ
      FPX=PCX+PGX+PQX
      FPY=PCY+PGY+PQY
      FPZ=PCZ+PGZ+PQZ
*
*     Scrubbing Identification :
*
      CALL SCRUB(ATHETA,X0,Y0,Z0,NS,NE)
      DO 500 K=1,40
      IF(NS(K).EQ.0.AND.NE(K).EQ.3) THEN
      WRITE(6,513)
      GOTO 110
      ELSE
      GOTO 500
      ENDIF
  500 CONTINUE
*
*     Final output calculated data:
*
  400 PX=FPX
      PY=FPY
      PZ=FPZ
      P=SQRT((PX**2)+(PY**2)+(PZ**2))
      ALAMDR=ACOS(ABS(PX/P))
      BLAMDR=ALAMDR/RADN
      AGAMAR=ACOS(ABS(PY/P))
      GAMAR=AGAMAR/RADN
      ADELTR=ACOS(ABS(PZ/P))
      DELTAR=ADELTR/RADN
*
*     K-factor Determination :
*
      AKGX=(PGX*RSP/W)/(GAMMA*(CZ**2))
      AKCX=(PCX*RSP/W)/(C*CZ)
      AKQX=(PQX*RSP/W)/(Q*CZ)
      AKGY=(PGY*RSP/W)/(GAMMA*(CZ**2))
      AKCY=(PCY*RSP/W)/(C*CZ)
      AKQY=(PQY*RSP/W)/(Q*CZ)
      AKGZ=(PGZ*RSP/W)/(GAMMA*(CZ**2))
      AKCZ=(PCZ*RSP/W)/(C*CZ)
      AKQZ=(PQZ*RSP/W)/(Q*CZ)
```

```
*
*     WRITE(6,514)
*     WRITE(6,515)P,PX,PY,PZ,BLAMDR,GAMAR,DELTAR
      WRITE(6,526)ABETA,RSP,AKGX,AKCX,AKQX,AKGY,AKCY,AKQY,AKGZ,AKCZ
*
  300 CONTINUE
  110 STOP
      END
```

PROGRAMME : P3

```
*      ********************************************
       SUBROUTINE EXPFIT(A,B,C,ESQ, N,X,Y, IFLAG,ITER)
*        This algorithm will fit a curve defined by the
*        equation y = a*exp(b*x) + c to specified sets
*        of x and y. Flag other than zero implies set
*        number of iterations have been exceeded.
*        Ref; CACM No. 275
*
       DIMENSION X(N), Y(N)
       IFLAG=0
       EPS=0.001
       LMAX=40
*
*      Computation of initial estimate :
*
       B=2.0*ALOG( ABS(((Y(N) - Y(N-1))*(X(2) - X(1)))/
     +  ((Y(2) - Y(1))*(X(N) - X(N-1)))))/
     +  (X(N) + X(N-1) - X(2) - X(1))
       A= (Y(N) - Y(N-1))/((X(N) - X(N-1))
     +   *EXP((B*(X(N) + X(N-1)))/2.0)*B)
       M=(N+1)/2
       C=Y(M) - A*EXP(B*X(M))
       ESQ=0.0
*
       DO 200 I=1,N
          ESQ=ESQ + (Y(I) - C -A*EXP(B*X(I)))**2
  200  CONTINUE
*
*       Computation of corrections :
*
       ITER=0
       SAVE=0.0
       DO 201 L=1,LMAX
*
       ITER=ITER + 1
       SEX1 =0.0
       SEX2 =0.0
       SXIEX1=0.0
       SXIEX2=0.0
       SX2EX2=0.0
       SYI=0.0
       SYIEX1=0.0
       SXYEX1=0.0
*
       DO 202 I=1,N
          EX1=EXP(B*X(I))
          EX2=EX1*EX1
          XIEX1=X(I)*EX1
          XIEX2=X(I)*EX2
          XI2EX2=X(I)*XIEX2
*
```

```
        SEX1=SEX1 + EX1
        SEX2=SEX2 + EX2
        SXIEX1=SXIEX1 + XIEX1
        SXIEX2=SXIEX2 + XIEX2
        SX2EX2=SX2EX2 + XI2EX2
        SYI=SYI + Y(I)
        SYIEX1=SYIEX1 + Y(I)*EX1
        SXYEX1=SXYEX1 + Y(I)*XIEX1
  202 CONTINUE
*
      D11=SEX2
      D12=SXIEX2*A
      D13=SEX1
      D22=SX2EX2*A*A
      D23=SXIEX1*A
      D33=N
*
      E1=-SEX2*A - SEX1*C + SYIEX1
      E2=-SXIEX2*A*A - SXIEX1*C*A + SXYEX1*A
      E3=-SEX1*A - N*C + SYI
*
      DEL11=D22*D33 - D23*D23
      DEL12=D13*D23 - D12*D33
      DEL13=D12*D23 - D13*D22
      DEL22=D11*D33 - D13*D13
      DEL23=D12*D13 - D11*D23
      DEL33=D11*D22 - D12*D12
      DEL  =D11*DEL11 + D12*DEL12 + D13*DEL13
*
      U=(E1*DEL11 + E2*DEL12 + E3*DEL13)/DEL
      V=(E1*DEL12 + E2*DEL22 + E3*DEL23)/DEL
      W=(E1*DEL13 + E2*DEL23 + E3*DEL33)/DEL
*
      A= A + U
      B= B + V
      C= C + W
      ESQ=0.0
*
      DO 203 I=1,N
      ESQ=ESQ + (Y(I) - C - A*EXP(B*X(I)))**2
  203 CONTINUE
*
        IF(L .EQ. 1) GO TO 700
        IF(ABS(SAVE - ESQ) .LT. EPS) THEN
        GO TO 701
        ELSE IF (L .LT. LMAX) THEN
        GO TO 700
        ELSE
        GO TO 702
        END IF
*
  700 SAVE= ESQ
  201 CONTINUE
  702 IFLAG =1
  701 RETURN
      END
************************************************
*          Main Programme
*
      DIMENSION XX(20), YY(20), YC(20), DIFF(20)
```

```
*
  500 FORMAT(' ', 13X,'a',13X,'b',13X,'c',9X,'Stat Error',
     +        4X,'F', 4X,'I'/3E14.4,5X,E14.4,2I5)
  501 FORMAT(' ',13X,'x',13X,'y',12X,'Yc',10X,'Diff')
  502 FORMAT(' '/' ',4E14.4)
  503 FORMAT(' '/' ','Group Index No.=',I3)
*
  100 READ(5,'(I3)') MM
  101 READ(5,'(I3)') NN
*
      IF(NN .LT. 0) THEN
      NROUTE= ABS(NN)
      GO TO (100,102), NROUTE
      END IF
*
      READ(5,'(2F10.0)') (XX(J),YY(J), J=1,NN)
*
      CALL EXPFIT(AA,BB,CC, ERR,NN, XX,YY, ISIG,ITR)
*
      DO 300 K=1,NN
         YC(K)=AA*EXP(BB*XX(K)) + CC
         DIFF(K) = YY(K) - YC(K)
  300 CONTINUE
*
      WRITE(6,503) MM
      WRITE(6,500) AA,BB,CC,ERR,ISIG,ITR
      WRITE(6,501)
*
      DO 301 K=1,NN
         WRITE(6,502) XX(K),YY(K),YC(K),DIFF(K)
  301 CONTINUE
*
      GO TO 101
  102 STOP
      END
```