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Considerations on the value of modulus of subgrade reaction

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Summary

In structural design practice of rigid road pavements, the subgrade stiffness is generally represented by the modulus of subgrade reaction, now universally known as subgrade support or by the symbol K (K Value). As the in situ determination of the K value is laborious, a synthesis of correlations between K value and other deformability characteristics of the subgrade such a CBR and the dynamic elastic modulus E for which standardized values are available, is presented in this paper. Based on this synthesis, design values for the modulus of subgrade reaction have been adopted and proposed for the use in the frame of the actual structural method of design of rigid road pavements, elaborated by INCERSTRANS in collaboration with the Faculty of Civil Enginering of Iasi.

KEYWORDS: rigid pavements, structural design, modulus of subgrade reaction, deformability characteristics

1. INTRODUCTION

The modulus of subgrade reaction, universally known by the symbol K, is the number of pounds per square inch of subgrade reaction per inch of slab deflection, pounds per cubic inch or kN/m^3 .Usually this parameter, characterizing the subgrade stiffness is measured in situ), by applying a static load , on a 30-in diameter bearing block (plate).

According /6/, "no time rate of load application is included in the definition for modulus subgrade reaction, but the fact is that fast moving traffic loads are less severe in their slab-bending effect than static loads" and therefore it is assumed that static loads are significant loads for this purpose. As this process is quite laborious and costly, for preliminary design stages (pre-feasibility -SPF or feasibility-SF stages)and for construction objectives of minor importance such as local roads, parking or storage surfaces, K Values , obtained on the base of the following types of correlations are recommended to be used:

$$E_{\text{elasticitate dinamic}} - CBR \qquad [\,MPa\ ;\ \%\,] \qquad (1)$$

$$K - CBR \qquad [\,MN / m^3\ ;\ \%\,] \qquad (2)$$

2. STUDIES OF VARIOUS CORRELATIONS

2.1. Studies undertaken for correlations of type (1)

For correlations of type (1) the following relations have been considered:

LCPC Paris : $E = 5(CBR)$ (3)

TRRL London: Table1

Table1. Correlations of type (1) recommended by TRL specifications

CBR [%]	1,5	2	5	15
E [MPa]	23	27	50	100

C. Regis : $E = 8{,}5\ (CBR)^{0{,}825}$ (4)

G. Jeuffroy : $E = 6{,}5\ (CB\ R)^{0{,}65}$ (5)

Shell : $E = 10{,}0(CBR)$ (6)

TEM / 1 / Table 2 :

Table 2. Correlations of type (1) recommended by TEM specifications:

CBR [%]	1,5	2	3	4	5	6	7	8
E [MPa]	14,5	20,0	26,5	32,0	37,5	42,0	46,0	50,0

For the correlations given in Table 1 and Table 2, the involved equations (Table 3) have been determined ; x = CBR ; y = E [MPa]:

Table3. The involved equations for the correlations given in Table1 & Table 2

Correlation	Equation	Coefficient of correlation	Standard deviation	Statistical residue
TRRL (table 1)	$y = \dfrac{a*b + c*x^d}{b + x^d}$	1,000	0,0	0,0
TEM	$Y = a+b*x+\ldots+f*x^5$	0,999	0,047	< 0,03

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The pairs: CBR –E values for those six correlations of type (1) are presented in Table 4:

Table 4. The pairs: CBR –E values, for those six correlations of type (1)

CBR [%]	E [MPa] for the correlations: :					
	(3)	(tab.1)	(4)	(5)	(6)	(tab.2)
1,5	7,5	23,0	12,0	8,5	15,0	14,5
2	10,0	27,0	15,0	10,0	20,0	20,0
3	15,0	35,0	21,0	13,5	30,0	26,5
4	20,0	42,5	26,5	16,0	40,0	32,0
5	25,0	50,0	32,0	18,5	50,0	37,5
6	30,0	56,5	37,5	21,0	60,0	42,0
7	35,0	63,0	42,5	23,0	70,0	46,0
8	40,0	69,0	47,5	25,0	80,0	50,0

In technical specifications for the structural design of rigid pavements/5/ the Shell correlation has been retained , as this correlation ensures a resonable correlation of the design values of the dynamic elastic modulus of subgrade for flexible/semirigid road pavement structures.

2.2. Studies undertaken for correlations of type (2)

For correlations of type (2): C.T.12 AIPCR /2/, TEM /1/ and PCA /3/, the results from Table 5 have been obtained:

Table 5. Correlations of type (2)

CBR [%]		10	9	8	7	6	5	4	3
K [MN/m$^{3]}$	CT 12	60	55	52	48	42	37	33	27
	TEM	55	51	48	46	41	37	33	27
	PCA	54	52	49	45	42	38	33	27
K_{mediu}[MN/m^3]		56	53	50	46	42	37	33	27

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For K_{mediu} , the correlation (7): x= CBR; y=K, from below has been derived :

$$y = 8,74 + 6,75*x - 0,202*x^2 \qquad (7)$$

this correlation having the following statistical parameters: R (the coefficient of correlation) =0,999; the standard error =0,323; statistical residue < 0,50.

The E [MPa] / CBR [%] / K [MN/m^3] values, adopted according /5/ , for the P_1 …P_5 types of subgrade soils, for the climatic types I…III and for the hydrological conditions 1…2b, are presented in Table 6:

Table 6 The adopted values of E / CBR / K, for the various types of subgrade soils

<table>
<tr><th rowspan="2">Climatic Type</th><th rowspan="2">Hidrological conditions</th><th colspan="5">The adopted values of E / CBR / K for the various types of subgrade soils</th></tr>
<tr><th>P₁</th><th>P₂</th><th>P₃</th><th>P₄</th><th>P₅</th></tr>
<tr><td rowspan="3">I</td><td>1</td><td rowspan="9">100/10/56</td><td rowspan="5">90/9/53</td><td>70/7/46</td><td rowspan="2">80/8/50</td><td>80/8/50</td></tr>
<tr><td>2a</td><td rowspan="5">65/6,5/44</td><td>75/7,5/48</td></tr>
<tr><td>2b</td><td>70/7/46</td><td>70/7/46</td></tr>
<tr><td rowspan="3">II</td><td>1</td><td rowspan="2">80/8/50</td><td>80/8/50</td></tr>
<tr><td>2a</td><td rowspan="2">70/7/46</td></tr>
<tr><td>2b</td><td>80/8/50</td><td>70/7/46</td></tr>
<tr><td rowspan="3">III</td><td>1</td><td>90/9/53</td><td rowspan="3">60/6/42</td><td>55/5,5/39</td><td>80/8/50</td></tr>
<tr><td>2a</td><td rowspan="2">80/8/50</td><td rowspan="2">50/5/37</td><td rowspan="2">65/6,5/44</td></tr>
<tr><td>2b</td></tr>
</table>

The design value of the reaction modulus K_0 , at the superior level of subgrade is obtained function of the value of the subgrade reaction modulus K and the equivalent thickness (type AASHO Road Test), by using the diagram SBA /STBA Paris /4/.

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3. CONCLUSIONS

In the frame of the Romanian method of structural design of rigid roads pavement structures/5/, the reaction subgrade modulus K [MN / m^3] represents the stiffness characteristic of the subgrade.

The correlations between the value of the reaction subgrade modulus K and the E the dynamic elastic modulus –MPa) and CBR [%], for which laboratory or standard design values are available, permit the evaluation of the design values K, at least for the preliminary design stages, thus eliminating the in situ laborious and tedious studies.

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