DESIGN OF CONCRETE BLOCK PAVEMENTS
Tables or analytical methods
A comparison's study

G.H. TSOHOS, Prof.-Dr
Highway Engineering Laboratory, University oh Thessaloniki
N.E. ILIOU, Dr-Eng.
Highway Engineering Laboratory, University oh Thessaloniki

Summary

The design of concrete block pavements can be based either on catalogues of standardised structures, or analytical methods.

This paper deals with existing catalogues of countries, namely France, Germany, Spain and also with some of the more frequently used analytical methods.

It compares separately the two types of design procedures and also it tries to find out the influence of each design factors of the analytical methods on the thickness of the base or sub-base.

1. Introduction

Because of the increasing use of concrete paving blocks, it seems necessary to compare the existing design methods, which are divided into two main groups [1].

- catalogues of standard structures
- analytical methods, which cover a very waste area, beginning of pure empirical , continuing with modified design methods for flexible pavements and ending on computer based mechanistic methods.

The second group seems to be more accurate. The mechanistic method to be also more complex and normally entail computer - based analysis. So it has been decided to be examined empirical methods, which are more suitable to be applied in every day design problems. The following design procedures, in different countries will be examined:

Catalogues : Spain, France and Germany
Empirical methods : USA, England, Japan, Netherlands, Australia

2. Design Methods

2.1. Catalogues of standardised structures

The table 2.1 summarises the factors on which each method has been based. [2], [3], [4].

Table 2.1 : Factors taken into account by various design catalogues.

Catalogue	Factor	
	Traffic (Trucks/Day)	Soil bearing capacity (CBR)
France	T_6 0-10 T_5 10-25 T_4 25-50	$10 \geq P_2 > \varnothing$ $20 \geq P_3 > 10$ $50 \geq P_4 > 20$
Spain	C_4 0-4 C_3 10-25 C_2 15-24 C_1 25-49 C_0 50-150	So 3-5 S1 5-10 S2 > 10
Germany (RstO 86)	VI < 10 V 10-60	1-10

From table 2.1 it is clear that the comparison between the catalogues is very difficult because of the different traffic and bearing capacity categories , which were used to develop the given categories.

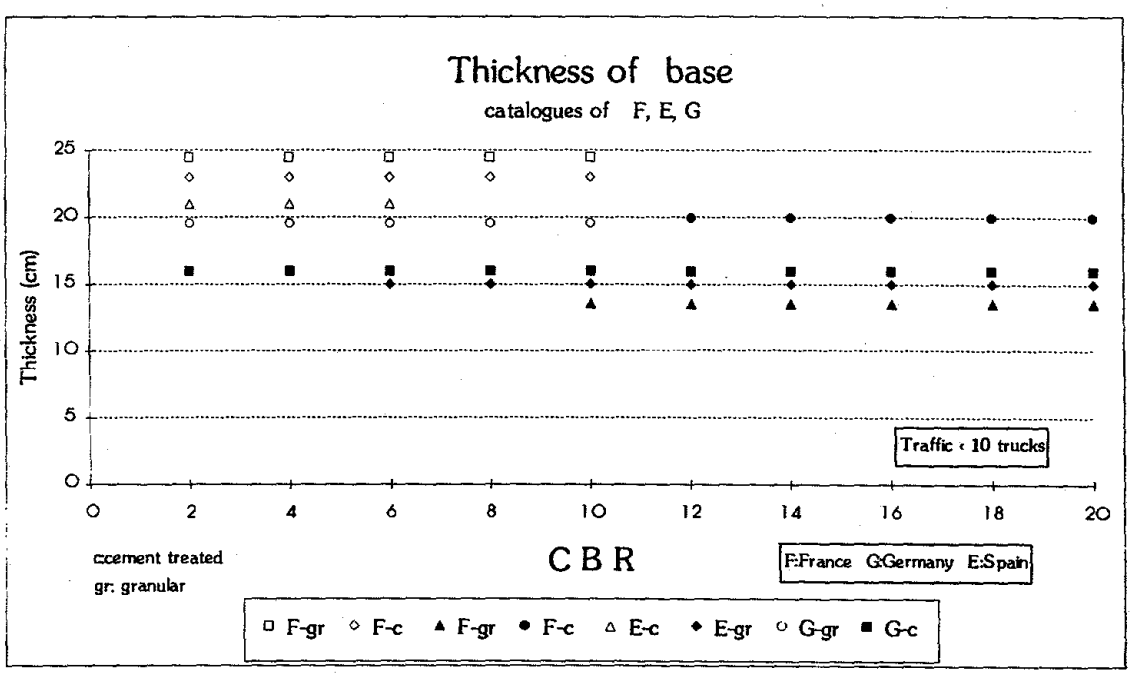


Fig 2.1 Thickness of base (Catalogues review)

Fig 2.1 summarises the base thickness (either granular or cement treated) for a traffic of 10 trucks per day and a soil of bearing capacity from 1-20 CBR. This case was common to all referred methods

From Fig. 2.1. it can be remarked

- For the same bearing capacity, the differences are important.
- As the bearing capacity increases the differences of thickness are decreasing.

2.3 Analytical design methods.

The variety of design methods is enorm. As it has been said in the introduction the empirical methods, which are combination of experimental research and a numerical procedure will be examined.

2.2.1. Methods developed in USA [5].

This method has been based on the basic initial design equation published by AASHTO in 1986. The authors have prepared graphical solutions of the equation, covering granular base, asphalt or cement treated base and for a traffic range of equivalent axles from $1x10^5$ to $3x10^7$

2.2.2. Methods developed in United Kingdom [7].

A Research team has prepared charts for the design of industrial and airport pavements[7]. Because of its special pavement application this method will not be considered.

The design method follows a general approach which is to use an accepted method for the design of bituminous surfaced roads. The design method is included in BS7533.

2.2.3. Method developed in Japan [8].

The method is based on the following formulas.

$$H=28.0\ N^{0.1}/CBR^{0.5} \qquad T_A=3.84N^{0.16}/CBR^{0.3}$$

$$T_A'=a_1T_1+\ldots\ a_nT_n\geq T_A \qquad H'=T_1+T_2\ldots\ldots+T_n\geq 0.8H$$

Where

H	:	Thickness of pavement (cm)
T_A	:	Design thickness for the total pavement thickness using hot mix (asphalt) for surface and binder course.
N	:	Total number of wheel application (throughout the design period) converted to 5t wheel load applications (wheel/direction)
$a_1 \ldots a_n$	:	Conversion coefficients
$T_1 \ldots T_n$	:	Thickness of each layer (cm)

2.2.4. The Netherlands's method[9]

The method's design criterion is rutting depth. The method based on experimental and theoretical considerations has developed charts for the design of the base thickness.

2.2.5. Australian method [10].

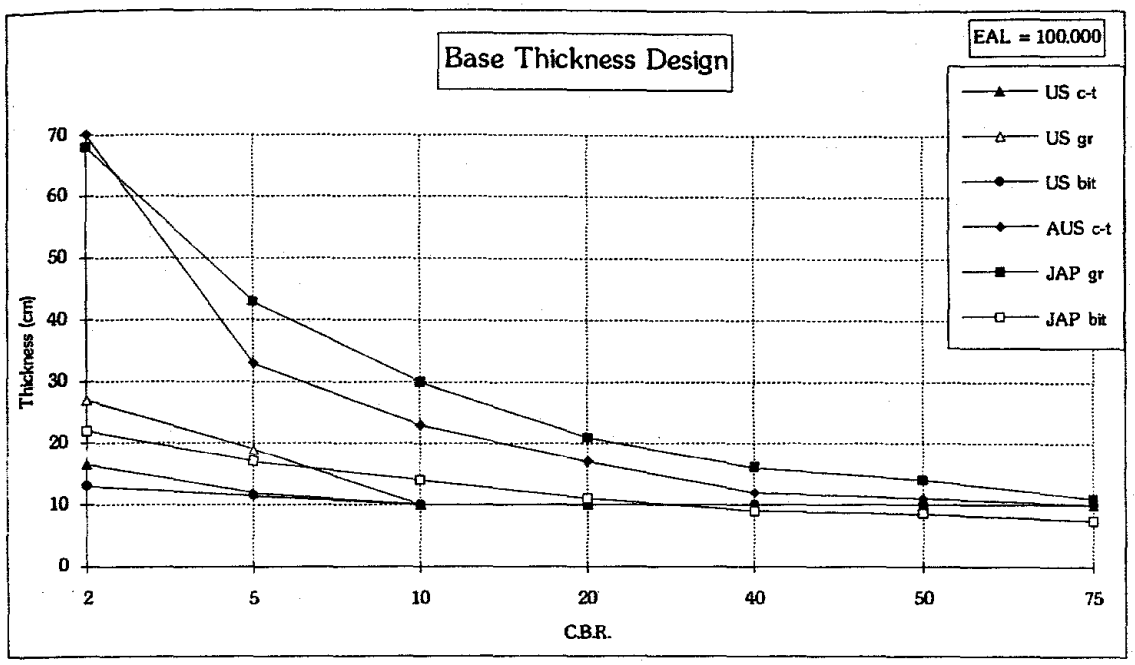
The design factors are the soil bearing capacity and the traffic (as 8,2 axles) . The whole procedure can be done using a design chart.

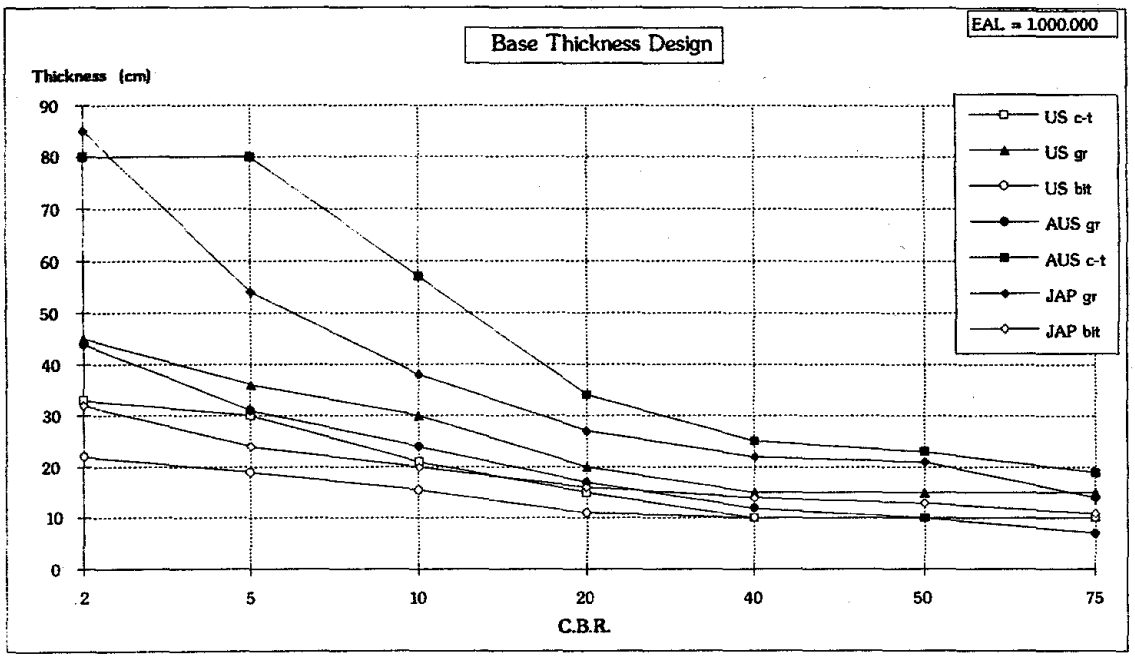
2.3. The comparison of the design methods.

To facilitate the comparison, it has been prepared the following table 2.2 and figure 2.2.

TABLE 2.2 Design method and application's domain.

Method	Design Factors				Concrete Block thickness (cm)
	Traffic (8,2t axles)	Bearing capacity of soil (CBR)	Base course	Sub-base course	
USA	10^5 - $2x10^7$	2-100	c-t gr b-t	---	8
G.B.	$0,5x10^6$ to $12x10^6$	2 -	bit	gr	6-8
Japan	No limits because of absolute numerical solution				
NL	10^4 - 10^7	5 - 85	gr	gr	> 8
AUS	10^5 - 10^7	0 - 100	c-t	gr c-t	6-10





c-t: cement treated gr.: granular bit: bitumen treated

Fig 2.2 Base thickness design (correlated with C.B.R.)

2.3 Conclusions

- For low bearing capacity values (CBR < 20), the differences are important either on catalogues of standardised structures (CBR < 10) or analytical methods (CBR < 20). The standardised structures though, seems to be more accurate.

- As the bearing capacity increases (CBR >20) the differences of thickness are decreasing. The base-subbase thickness design for this range of bearing capacity values is available only in analytical methods.

- For high bearing capacity values (CBR > 20), all the analytical methods - the only available design methods - give similar results.

ARISTOTELION UNIVERSITY OF THESSALONIKI - FACULTY OF TECHNOLOGY
CIVIL ENGINEERING DEPARTMENT - TRANSPORTATION & ORGANISATION SECTION

HIGHWAY ENGINEERING LABORATORY
540 06 THESSALONIKI - GREECE
Professor G. TSOHOS.

TEL. 031-995746
FAX 031-260-914

References

1. Shakel B. **"Computer based procedures for the design and specification of concrete block pavements"** Proceedings: 4th International concrete block paving conference, Auckland, 1992, vol. 1, p. 79.

2. Grebin G. - Justesen Chr. F.P **"Concrete block pavements"** Proceedings: International Symposium on Concrete Roads, London 1982, Session 5, Paper 4, pp. -

3. - **"Manual de Pavimentos de Adoquines de Hormigon"** Institut de Technologia de la Construccio de Catalunya, Barcelona 1987, pp 17-18, 21.

4. **"Richtlinien fur die standardisierung des Oberbaues von Verkehrs - flachen RStO86"**. Forschungs gesellschaft fur strassen - und Verkehrs wesen, Ausgabe 1986, Tafel 3.

5. Rada G.R. - Smith DR - Miller J.S - Witczak M.W. **"Structural Design of Interlocking Concrete Pavements in North America"** Proceedings 4th International concrete block paving conference, Auckland 1992, vol. 1 pp. 99-116.

6. Beaty AMS **" Interlocking Concrete Block Pavements for Roads",** International Conference Concrete 2000, Dunchee, 1993 pp.1161-1176.

7. Knapton J. - Cook I.D. **"Design Methods for Clay and Concrete Block Paving"** Proceedings 4th International Concrete Block Paving Conference, Auckland 1992 vol. 1, pp. 27-50.

8. Ushida K. - Ohmori H. - Mishi J. **"Structural Design of Interlocking Concrete Block Pavement in Japan"** Proceedings 4th International Concrete Block Paving Conference, Auckland 1992, pp. 71-78.

9. Houben L. J. Metal **"The Dutch design method for concrete block road pavements"** Proceeding 3rd International Concrete Block Paving Conference, Rome 1988, pp. 156-169.

10. Shakel B. **"The design of interlocking concrete block pavements for road traffic"** 1st International Conference on Concrete Block Paving, Newcastle 1980.

SUMMARY

This paper deals with the problem of concrete block pavement design. Some years ago, concrete blocks were used for low - volume roads or cycle - tracks. During the last years they have been used also for pavements supporting heavy traffic like runways, ports etc.

Nowadays the design is carried out either using tables of standard structure (for given subgrade and traffic conditions) or analytical methods.

The paper summarises the existing design methods and tables. It realises also the influence of the corresponding to each procedure design factors (sensitivity analysis) and it compares the various design procedures.

The main remarks are:
- comparison between tables and numerical methods, but also between procedures of the same kind, is very difficult or sometimes impossible.
- the use of each method depends on the possible available data and the desired, consequently accuracy, importance of the planed structure.

Finally they are given guidelines for choosing the most adapted design procedure for each case study.