SETTING UP CATALOGUE OF PAVEMENT STRUCTURES OF HIGHWAY IN VIETNAM

Nguyen Xuan DAO
Professor, Doctor
Research Institute for Transportation Science and Technology (RITST)
1252 Lang Road, Ha Noi, Vietnam
Fax: +84-4-834-3403
E-mail: VKHCNGTVT@FPT.VN, RITST@hn.vnn.vn

Ngo Minh THANH
Researcher
Research Institute for Transportation Science and Technology (RITST)
1252 Lang Road, Ha Noi, Vietnam
Fax: +84-4-834-3403
E-mail: VKHCNGTVT@FPT.VN, RITST@hn.vnn.vn

Tran Viet HA
Engineer
Research Institute for Transportation Science and Technology (RITST)
1252 Lang Road, Ha Noi, Vietnam
Fax: +84-4-834-3403
E-mail: VKHCNGTVT@FPT.VN, RITST@hn.vnn.vn

Abstract: Catalogue of the pavement structure of the Highway shows typical structures set-up for highway pavement structures using high-ranking surface layers. In Vietnam, the high ranking surface layers are hard ones. It takes only a small rate in the road network. Thus, in this article, it is mainly to introduce the selection methods of the structures of high-ranking pavement using bitumen that used only for the 3rd grade road upwards.

In this report, research results on setting up catalogue of high-ranking pavement structure in Vietnam are briefly reported.

Key Words: Road Roughness, Surface Texture, Measurement Techniques, Profile, Highway

1. CLASSIFICATIONS OF TRAFFIC VOLUME

1.1 Equivalent Standard Axle Load

Equivalent Standard Axle Load used for setting up catalogue is two-wheel single axle load of 10 ton as follows:

- Axle load: 10 tons
- Pressure on pavement: 6.0 daN/cm^2
- Diameter of wheel track: 33 cm

However, this catalogue is not used for the road where the number of heavy vehicle with axle load exceeding 20% of above Equivalent Standard Axle Load occupies more than 5% of traffic volume (forest roads, mineral roads, industrial zone roads) or vehicles with axles load far different from Equivalent Standard Axle Load. For this specific case, the pavement structure must be calculated and design with suitable axle load in accordance with design standard 22 TCN-211-93 of flexible pavement structure.

1.2 Equivalent Traffic Volume (Tn)

The lifetime of the road is 15 years when setting up this catalogue. The traffic volume is converted to Equivalent Standard Axle Load passing a cross section in a day at the end of operation period and called Equivalent Traffic Volume Tn.

The assumption that the growth trend of traffic is exponential will be used for determining average volume of Equivalent Standard Axle Load/day at considered year (Tn) and Equivalent Axle Load after n years ($\sum$ Tn).

1.3 Determining the Required Elastic Modulus (Eyc)

Required elastic modulus reflexes strength capacity of the pavement structure and is determined by actual operating experiences depending on traffic volume. The bigger traffic volume requires the bigger elastic modulus. Base on statistic on acceptable pavement condition at the end of operation period of different pavement structures under various loading, the relationship between the required elastic modulus and traffic volume can be established as follows:

$$Eyc = A + B.\ln(m)$$

Where:
A- Coefficient depending on pavement type and group of Equivalent Standard Axle Load. For high-ranking pavement using asphalt concrete layer, Equivalent Standard Axle Load 10 tones, then A=700 daN/cm^2;
B- Coefficient, main characteristic for repeated affect of load. For high ranking pavement, Equivalent Standard Axle Load 10 tones, then B=200 daN/cm^2
m- Traffic volume converted to Equivalent Standard Axle operating in the last service year of the given pavement type, Equivalent Standard Axle Load 10 tones/day.

1.4 Classification of Traffic Volume Category

a. Comment on Traffic Flow in Vietnam

According to [5], in big cities as Hanoi, Ho Chi Minh city, Danang, traffic vehicle types show the low living standard. Motorcycles occupies largest proportion (60-80%); cycles (10-35%); car (2-4%); truck and bus 1% respectively. This comes to the conclusion that urban roads in Vietnam have not required much on the thickness of the structure.

According to [9], statistic results on axle loads on roads especially on highway No.1A show that the number of the light vehicle with axle load <5 tons is dominant (70-80%); over-loaded vehicle (axle load >10 tons) exceeding allowable level 5% in many areas in spite of being controlled in recent years (as figure 1); however, in general it is possible to use axle load 10 tons as Equivalent Standard Axle Load [9] for the whole network.

According to [6], [9] the highest traffic volume in Vietnam in some sections especially on Highway No. 1A is 4,300 vehicle 10T/day/direction equivalent to flow grade T of France. It can be considered to be reference value when determining upper limit of traffic volume during setting up the catalogue.

According to the experiences of developing countries, annual growth rate of traffic volume can vary from 4-15%. When the information in this matter is not available, the rate can be taken from 7-10% for the whole traffic volume. According to the statistic done continuously from 1988 to 1997 on motorized vehicle in big cities and on the whole country [8], it is shown that the annual growth rate is about 10% that will be taken as traffic volume for setting up catalogue.

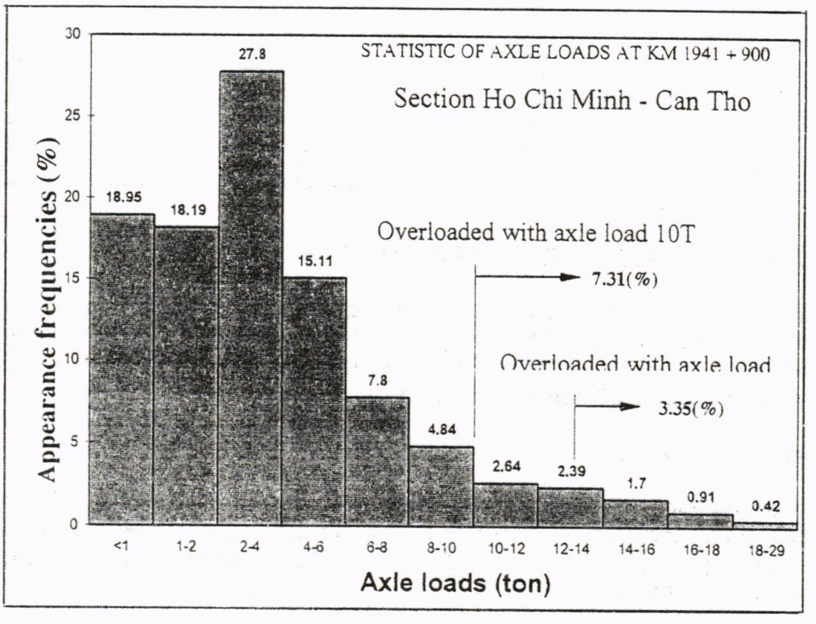

Figure 1. Statistic of Axle Loads

b. Classification of traffic volume categories

Basing on above studied traffic flow in Vietnam, on evaluation scale of traffic volume for high-ranking roads used in existing pavement design procedures (Standard 22 TCN 211-93), referring classification of traffic volume categories of other countries [2], [3], [4] etc. the traffic volume for high-ranking roads in Vietnam can be divided into 9 classes as shown in table 1.

In case of the service life of road is different from 15 years and the growth rate of traffic volume (i) is different from 10% then the formula (5) can be used for calibrating the relation between average traffic volume/day (Tn) in the n^{th} year with accumulate traffic volume in n years ($\sum$Tn) before determining traffic volume category (Ti)

$$Tn = \frac{\sum Tn.i.(1+i)^{n-1}}{365.\left[(1+i)^n - 1\right]} \qquad (5)$$

Table 1: Classification of traffic volume for high-ranking highway

Traffic volume category	15 years accumulate equivalent standard axle 10T (ΣTi) (10^6) when growth rate i=10%	Equivalent traffic volume/day after 15 service years T_{15}	Required elastic module according to traffic volume category Eyc (daN/cm^2)
T1	0.1 - 0.2	20 - 50	1470
T2	0.2 - 0.3	51-100	1600
T3	0.3 - 0.6	101-200	1780
T4	0.6 - 1.2	201-400	1900
T5	1.2 - 2.4	401-800	2040
T6	2.4 - 4.3	801-1400	2150
T7	4.3 - 6.7	1401-2200	2240
T8	6.7 - 12.2	2201- 4000	2360
T9	12.2 - 24.6	4001- 8100	2500

2. CLASSIFICATION OF ROADBED SOIL CATEGORIES

Roadbed soil classification serving the calculation of pavement structure when setting up catalogue is classified by load bearing capacity of bed soil. Load bearing capacity (shear stress τ, elastic modulus Eo) of bed soil depends mainly on type of bed soil, compactness of bed soil K and estimated moisture content (a) of road bed.

2.1 Soil Classification

Based on common soil types in roadbed construction in Vietnam, on research results of roadbed design standard and sub-base in the thermal – hydrological condition in Vietnam [10], when setting up catalogue, the soil is classified according to the grain composition and plastic index shown in table.

Table 2. Soil bed classification according to the grain composition and plastic index.

Soil type		Plastic index Ip (%)	Grain composition		Using for road bed
			Grain ϕ (mm)	Proportion (%)	
Gravel, sandy gravel, macadam (2.0 – 40.0) mm			> 2.00	> 50	Very suitable
Sand (0.05-2.0) mm	Gravel		> 2.00	25-50	Very suitable *But requiring a cover layer for road talus*
	Large-size grain		> 0.50	> 50	
	Middle-size grain		> 0.25	> 50	- as above -
	Small-size grain		> 0.10	> 75	
	Fine grain (dust)		> 0.05	> 75	Not very suitable
Clay sand	Light, a large-size grain	1 - 7	0.05-2.00	> 75	Very suitable
	Light		- as above -	> 50	Suitable
	Dust		- as above -	20-50	Not very suitable
	Heavy dust		- as above -	< 20	Not suitable

Table 2. Soil bed classification according to the grain composition and plastic index. (Cont.)

Loamy clay	Light	7-12	- as above -	> 40	Suitable
	Light dust	7-12	- as above -	< 40	Not very suitable
	Heavy	12-17	- as above -	> 40	Suitable
	Heavy dust	12-17	- as above -	< 40	Not very suitable
- Clay	Light	17-27	- as above -	> 40	Suitable
	Dust	17-27	- as above -	*Nil*	Not very suitable
	Fat	> 27	- as above -	*Regulation*	Not suitable

When there are 10-15% (volume) of particle with size >2mm in soil, the above mentioned clay sand, sandy clay, clay must be added the word "Sandy gravel".

Besides the above mentioned classification and evaluation, following pavements of soil are considered to be important properties during evaluation of soil quality for road construction:

- Dry density of soil: if < 1.6 → bad
  From 1.8 - 1.9: meet requirement
  > 2.05: very good

- Organic component in the soil: if organic component excesses more than 2% or 3% then soil belong to bad type. It needs to be removed and can not be used for roadbed filing.
- If the soil contains >5% salt in total dry soil volume then is can not be used for filling upper layer of roadbed but for lower layer at the depth of 1 – 1.5m from the roadbed.

2.2 Compactness

If the roadbed is compacted well it will have high strength. With high compactness, the moisture content of the roadbed varies less. Thus, with the time, the strength of the roadbed will be more stabilized. Therefore, when the roadbed well compacted, the load bearing capacity of the pavement structure also will be increased in general. It leads to the fact that the thickness of the costly upper pavement layer can be reduced.

Considering capacity of the existing compaction equipment, result on roadbed design standards and bottom layer in the thermal – hydrological condition in Vietnam, when setting up catalogue, it is assumed to take the compactness of soil K ≥ 0.98 (proctor compaction standard) for every soil types of roadbed.

2.3 Estimated Moisture Content

Vietnam is located in tropical climate area with dry and rainy seasons. However, research results in thermo-hydrolic conditions of roadbed in Vietnam show that when building new highway, if the density index of embankment K ≥ 0.98 then the soil under pavement is not in high moisture. Even in areas suffering from a lot of floods like Red river delta and Mekong delta, the moisture contents are less than 0.7.

Estimating moisture content of bed soil in road design bases on reasons causing moisture and on terrain though which the road runs to determine the approximate moisture content a_i by following formula:

$a_i = W/W_{ch}$
Where W – where moisture content of soil (%); W_{ch} – liquid limit of soil (%)

Based on type of moisture causing and topography of the line area, the estimated moisture content a_i of bed soil can be determined. According to design standard of the flexible pavement structure of Vietnam, the type of moisture causing in roadbed can be classified into 3 types according to condition of moisture causing as follows:

<u>Type 1</u>: The road bed can limit the affect of the source of moisture causing if the roadbed is not always flooded; underground water level is lower 1.5m than bottom layer of roadbed, which is filled up by sandy clay or 0.8m when filled up with clay sand and good drainage on the surface. If it is flooded from time to time, not longer than 3 months, then the road shoulder must be filled up with sandy clay with compactness $K \geq 0.95$ and the shoulder must be $\geq$ 1.5-2.0m wide. The surface layer of the pavement structure must be waterproof. The bottom layer must be constructed tight material as compacted soil with K = 0.95- 0.98 or by soil or treated sand.

Table 3. Classification of bed soil category according to mechanical properties and conditions

Bed soil category		Strength: E (Kg/cm^2)	Strength: CBR$^{(*)}$ (%)	Small size grain soil: Clay (I_d>17) a	c	φ	Sandy clay (I_d = 7-17) a	c	φ	Clay sand (I_d = 1-7) a	c	φ	Fine size sand(I_d < 17) a	c	φ
Đo		< 320	< 5.0	Soft bed soil need to be treated specially											
Đ1	Đ1-1	320	5	0.70	0.38	15									
		340	6	0.67	0.41	16									
		350	6	0.65	0.43	16									
		380	7	0.60	0.48	18									
		419	8												
	Đ1-2	420	8				0.70	0.28	17						
		440	8				0.67	0.31	18						
		450	9				0.65	0.33	18						
		480	10							0.70	0.10	19			
		499													
Đ2		500	10				0.60	0.38	20				0.6-0.7	0.05	36
		505	11							0.67	0.12	20			
		520	11							0.65	0.14	20			
		550	12							0.60	0.18	22			

Bed soil category	Strength: E (Kg/cm^2)	Strength: CBR$^{(*)}$ (%)	Gravel soil (< 25% particle size > 5mm): Sandy clay (I_d =7-17) a	c	φ	Clay sand (I_d =1-7) a	c	φ
Đ2	550	12	0.70	0.28	17	0.70	0.10	19
	575	13	0.67	0.31	18	0.67	0.12	20
	590	14	0.65	0.33	18	0.65	0.14	20
	599							
Đ3	600 630 > 630	15	0.60	0.38	20	0.60	0.18	22

It is suggested to use the converting formula between E-CBR as follows:

+ Loose soil $E = 140.CBR^{0.57}$
+ Adhesive soil $E = 120.CBR^{0.61}$

Based on survey and research results in the country, at the compactness K = 0.98, the estimated moisture content (a_i) may be 0.60 for every soil type in all area within the moisture causing type 1.

Type 2: The roadbed is affected by the moisture causing source between Type 1 and 3 at average level and at compactness K = 0.98. The estimated moisture (a_i) can be taken as follows:

a_i = 0.67 for soil type in flat area
a_i = 0.65 for all soil type in hilly area within the moisture causing type 2.

Type 3: The following roadbeds in thermal – hydrological condition can not limit the affect of the source of the moisture causing such as: low filled – up roadbed; road shoulder built by clay and; high level of underground water; stagnant water on the surface layer for long time; roadbed structure in an uptight one.

Based on survey and research results in the country, at the compactness K = 0.98, the estimated moisture content (a_i) may be:
a_i = 0.70 for soil type in flat area
a_i = 0.65 for all soil type in hilly area within the moisture causing type 3.

2.4 Classification of Soil (Đi)

Corresponding to the classification of in item 2.1, suggestions on compactness, estimated moisture content of roadbed in item 2.2 and 2.3, soil can be classified based on derived parameters from mechanical characteristic of common types of soil in Vietnam as in table 3.

Thus, according to soil type and moisture content, roadbed soil can be classified as following:

Table 4. Classification of Soil according to soil type.

Moisture content	0.70	0.67	0.65	0.60
Clay		Đ 1- 1		
Sandy clay	Đ 1- 2			
Clay sand				
Fine sand		Đ2		
Soil mixed with gravel			Đ3	

Or, according to bearing capacity, , roadbed soil can be classified as following:

Table 5. Classification of Soil according to bearing capacity.

Soil class	Đo	Đ1		Đ2	Đ3
		Đ1-1	Đ1-2		
Elastic Module E (daN/cm^2)		320	420	500	600
Index CBR (%)		5	8	10	15

In fact, soil Do is soil requiring replacement or special treatment. Soils with high bearing capacity (Eo = 800, 1000 etc. daN/cm^2) are often laterit or stone existing as material mines. They are seldom to be roadbed or if so, it is special case requiring separate design that is not considered in this catalogue.

2.5 Classification of Roadbed Soil (N_j)

- * If directly using soil with class Đi for roadbed soil then roadbed soil can be classified respectively as follows:

Table 6. Classification of Soil

Roadbed soil class	No	N1		N2	N3
		N1-1	N1-2		
Elastic Module E (daN/cm^2)		320	420	500	600
Index CBR (%)		5	8	10	15

* If strengthening low grade soil (N1-1 & N1-2) by using a soil bearing layer with higher grader or by materials without cohesion the roadbed can be upgraded as in table 4.

3. PARAMETERS OF PAVEMENT MATERIALS

Parameters of material are selected based on the results of applying Design Standard TCN 211-93 by taking upper limit (large value) in considering that the construction machine capacity will be improved much more than at the time of setting up the catalogue. Experiences, test results in laboratory as well as actual road construction designs like Bac Thang Long – Noi Bai, Highway No. 183, 5, 14, 22, Lang – Hoa Lac etc. were also taken into construction.

4. PAVEMENT COMPUTATION PROGRAM ACCORDING TO 22TCN 211-93

4.1 Computation Program

The program was established by following ways: Designing independent module so that the module can be used for computation right after completed; Then step by step completing the program system.

The program system consists of two main parts: database and computation program using above database for evaluating structures.

* Database:

Data on every structure (mechanical characteristics and geometric characteristics of material layers in the structure) can be set up by two ways: input parameters sequentially following the instruction of the program. Those parameters will be saved in a text file; or using any word software to create a Formatted Test File like data file in the first way.

* Computation program

Design procedure for flexible road pavement 22 TCN 211-93 regulates that design Computation for flexible road pavement is to compute and test 3 strength specifications: compute elastic settlement level through deformation resistance capacity (Elastic modulus) of the whole structure in order that the elastic modulus must be higher than required elastic modulus. Compute tensile-flexural stress at the bottom layer of material pattern in order to avoid crackle. Compute shearing stress in bed soil and soft material layers to check if is accessed the allowable limit. Each above specification will be tested by a respective module in the program. All such modules have same program structure and working sequence:
+ Sub-program for realizing data from file.
+ Sub-program for computing and converting a multi-layer structures into two-layer structure.

Table 7. Using bearing lagers.

Road bed Category	Using bearing layer	Thickness	Road Bed grade
N1-1	- Soil grade D3 (Mixing clay sand, sandy clay and < 25% of gravel compacted K ≥ 0.98)	60 cm	N2
	- Soil aggregate type D (with > 0-10% ϕ > 5 mm, 25-50% ϕ < 5 mm)	30cm	N2
	- - as above -	50 cm	N3
	- Soil aggregate type C (with >15-35% ϕ > 5 mm, 15-35% ϕ < 5 mm)	20 cm	N2
	- - as above -	30 cm	N3
	- Soil aggregate type B (with >35-55% ϕ > 5 mm, 15-30% ϕ < 5 mm)	20 cm	N2
	- - as above -	25 cm	N3
	- Soil aggregate type A (with >40-75% ϕ > 5 mm, 15-30% ϕ < 5 mm)	15cm	N2
	- - as above -	25cm	N3
	- Gravel with > 60% grain size >2.0mm, and <10% grain size <0.5mm	15cm	N3
	- Clay, sandy clay strengthening with 8-12% lime or sandy clay, clay, sand, black strengthening with 6-8% cement.	15cm	N2
	- - as above -	20cm	N3
N1-2	- Soil grade §3 (clay sand, sandy clay mixing with < 25% gravel, compacted K ≥ 0.98).	40cm	N2
	- Soil aggregate type D (with >0-10% ϕ > 5 mm, 25-50% ϕ < 5 mm)	15cm	N2
	- Soil aggregate type D (with >0-10% ϕ > 5 mm, 25-50% ϕ < 5 mm)	30cm	N3
	- Soil aggregate type C (with >15-35% ϕ > 5 mm, 18-35% ϕ < 5 mm)	15cm	N2
	- Soil aggregate type C (with >15-35% ϕ > 5 mm, 18-35% ϕ < 5 mm)	20cm	N3
	- Soil aggregate type B (with >35-55% ϕ > 5 mm, 15-30% ϕ < 5 mm)	18cm	N3
	- Soil aggregate type A (with >40-75% ϕ > 5 mm, 10-25% ϕ < 5 mm)	15cm	N3
	- Gravel with > 60% grain size >2.0mm, and <10% grain size <0.5mm	15cm	N3
	- Clay, sandy clay strengthening with 8-12% lime or sandy clay, clay, sand, black strengthening with 6-8% cement.	15cm	N3
N2	- Soil aggregate type D (with >0-10% ϕ > 5 mm, 25-50% ϕ < 5 mm)	20cm	N3
	- Soil aggregate type C (with >15-35% ϕ > 5 mm, 18-35% ϕ < 5 mm)	15cm	N3

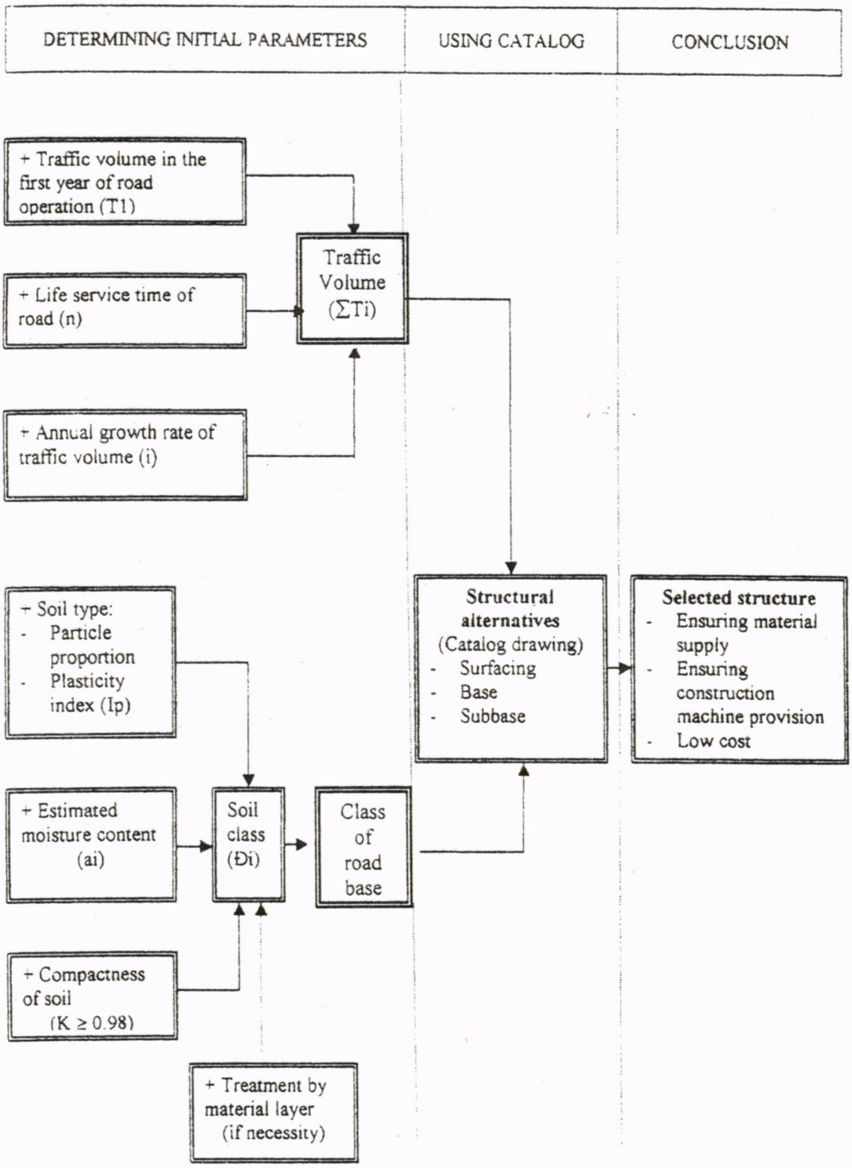

Figure 2. Sequence of pavement design using catalogue

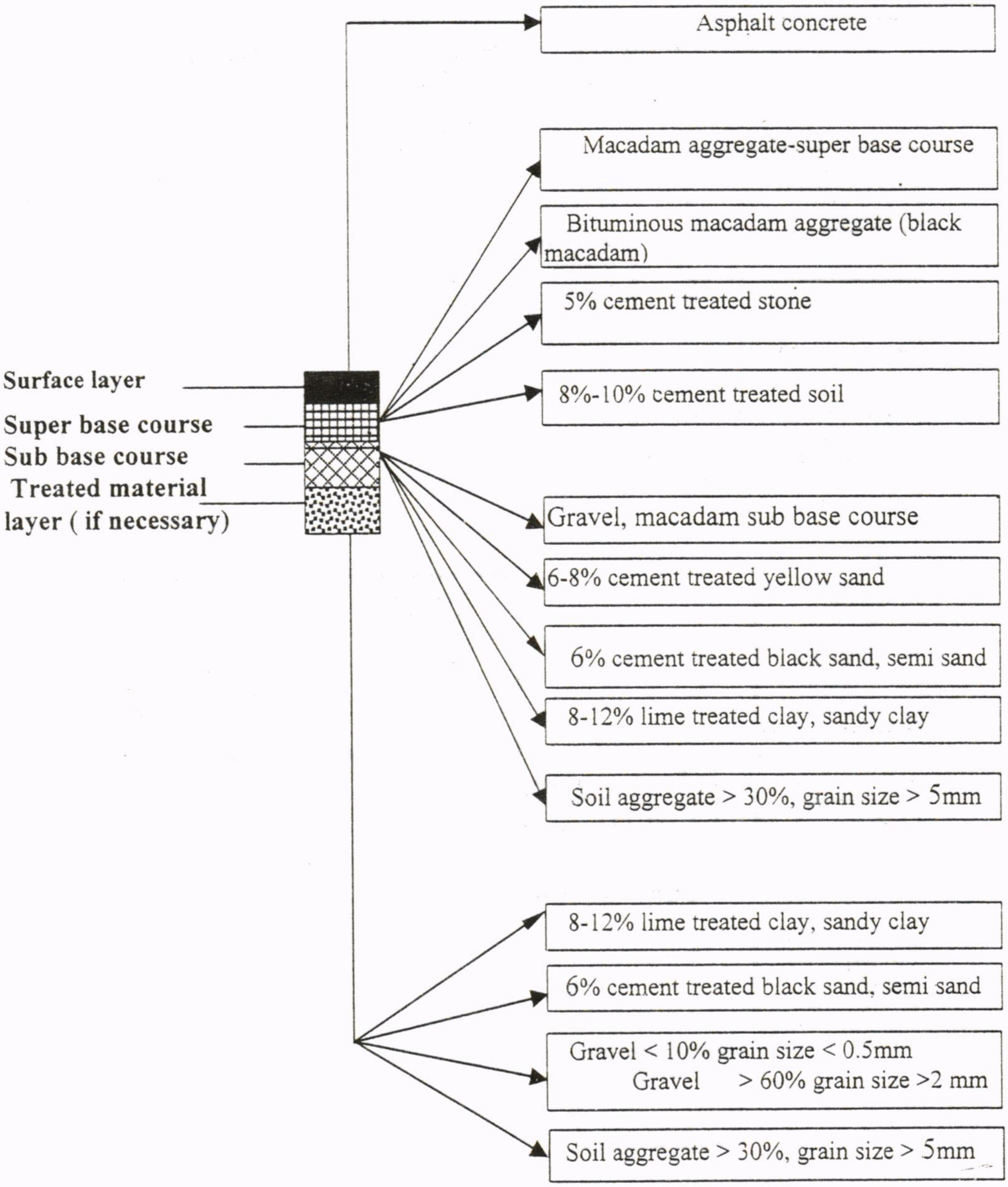

Figure 3. Typical structures of high-ranking Highway pavements in Vietnam

+ Sub-program for computing stress, displacement of two-layer structure. This program is used instead of nomogram. This sub-program is set up from data arrays of which the most important is correlation arrays – a data array that each its element is a correlation function between thickness of structural layer and values needed to be determined by stress or displacement.

+ Sub-program for testing and comparing internal forces in structural layers with allowable limit values.

* Output

After computing, the program will give the value of internal force in pavement structure and the result of comparison between them and allowable values. All computation results will be put into data file.

4.2 Obtained Results and Development Trend

* Obtained results

+ A program with all modules has been constructed that can compute parameters of pavement structure according to 3 standards of procedure 22-TCN 211-93.

+ High accurate results, the error is < 5%.

+ Simple and convenient use of the program contributes to the capacity and quality of pavement design work.

* The program has been studying to complete, such as enhancing the interface capacity to the users, reducing error and extending utilization possibility of the program in computing various pavement structure.

5. TABLES ON SAMPLED STRUCTURE OF HIGH-RANKING HIGHWAY PAVEMENT

The catalog consists of structure tables arranged depending on two parameters: traffic volume category Ti and roadbed category. After determining the values of above parameters, there will be some structures seem to suite with such parameters. The designers can consider the economic aspect, material supply ability and construction machines to choose the most suitable structure (See figure 2: Brief sequence of pavement design, figure 3 and appendix A).

6. CONCLUSION

The setting up this catalogue of the pavement structure for Vietnam will introduces to designers the available structures, which have been computed based on operation experiences of roads in many years or tested in the whole country. It also frees the designers from monotonous jobs of calculation.

The available computation modules of the catalogue will promote the standardization of material works and industrialization of items in road construction line. These also allow the simplification of the technical investment policies; limitation of the number of structure types in order to make the designers concentrate to selection of accepted pavement structures.

REFERENCES

1. Prof. Dr. Nguyen Xuan Dao (2-1974), **Forwards to Setting up Catalogue and Standardization of Pavement Structures of Highway in Vietnam, RITST** Journal, Hanoi

2. **Pavement structure Catalog 1977,** France.

3. **A guide to the structure design of bitumen sufaced roads in tropical and sub-tropical countries** — Overseas road note 31, Overseas Center, TRL, 1993.

4. **Structural design of interurban and rural road pavements, TRH**, pp4-70, Pretoria, South Africa, 1985.

5. **Final report on research of urbal transportation management in Vietnam.**

6. **Data of the national highway No1A rehabilitation and improvement project, TEDI,** 4/1996.

7. **Report on Traffic survey of Hanoi university of Transportation and Communication,** 5/ 1997.

8. **Data static of Vehicles on Road network of Vietnam,** Vietnam Road Administration.

9. **Report on Traffic survey on national highway No1A by Weight in motion system,** RITST, 1996-1998.

10. **Draft of Design code of Roadbase and Bottom Layer in the thermo-hydrological Conditions in Vietnam**, a item of the scientific-technological research subject No. 10-05, carried out by Prof. Dr. Nguyen Xuan Truc, Hanoi

11. **Design Code of Flexible Pavement No. 22 TCN-211-93,** Ministry of Transport, 1993.

12. **Guide to design pavement structure, AASHTO 1986, 1993.**

Appendix A. An example of pavement structures

Table 8.

A1 5% CEMENT TREATED STONE BASE		T1 0.1 - 0.2 ($x10^6$ tr.10t) Eyc = 1470 [daN/cm²]	T2 0.2 - 0.3 ($x10^6$ tr.10t) Eyc = 1600 [daN/cm²]	T3 0.3 - 0.6 ($x10^6$ tr.10t) Eyc = 1780 [daN/cm²]	T4 0.6 - 1.2 ($x10^6$ tr.10t) Eyc = 1900 [daN/cm²]	T5 1.2 - 2.4 ($x10^6$ tr.10t) Eyc = 2040 [daN/cm²]	T6 2.4 - 4.3 ($x10^6$ tr.10t) Eyc = 2150 [daN/cm²]	T7 4.3 - 6.7 ($x10^6$ tr.10t) Eyc = 2240 [daN/cm²]	T8 6.7 - 12.2 ($x10^6$ tr.10t) Eyc = 2360 [daN/cm²]	T9 12.2 - 24.6 ($x10^6$ tr.10t) Eyc = 2500 [daN/cm²]
N1	N 1-1 Eo = 320 (daN/cm²)									
	N 1-2 Eo = 420 (daN/cm²)									
N2	Eo = 500 (daN/cm²)				50 Bm 5 Br 7 Đx 18 Cx6 20	52 Bm 5 Br 7 Đx 20 Cx6 20	55 Bm 5 Br 7 Đx 18 Cx8 25	60 Bt 7 Br 8 Đx 20 Cx8 25	62 Bt 7 Br 8 Đx 22 Cx8 25	
N3	Eo ≥ 600 (daN/cm²)				42 Bm 5 Br 7 Đx 15 Cx6 15	47 Bm 5 Br 7 Đx 15 Cx6 20	52 Bm 5 Br 7 Đx 15 Cx6 25	55 Bm 7 Bl 8 Đx 18 Cx6 22	55 Bt 7 Br 8 Đx 20 Cx8 20	60 Bt 7 Br 8 Đx 20 Cx8 25

Layer legend

- Compacted asphalt concrete of fine grain containing mass macadam (Bm)
- Compacted asphalt concrete of medium size grain containing mass macadam (Bt)
- Aerated asphalt concrete of great size grain containing adequate macadam (Bm)
- 5% cement treated stone (Dx)
- 6% cement treated yellow sand (Cx6)
- 8% cement treated yellow sand (Cx8)

I.17