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HOW TO DESIGN A PAVEMENT WITH AN OVERLOAD ENVIRONMENT

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1. INTRODUCTION

Within economic development of principal cities relies on the exchange of goods amongst cities, districts and regions and ultimately with the nearby countries, thereby requiring the Government to develop its transport policy to reflect these needs.

During the last five years the traffic is looking growth rapidly with different kind of vehicles and trucks. It has observed along and national and rural roads increase the traffic of non-standard truck and over loading on standards factory vehicles and some local design vehicles. These variations in made and transport vehicles are becoming hot subject of discussion between the road user and road design and engineer construction. Part of the rehabilitation roads become serious degraded as in surface as in structure before projecting life. Otherwise the Costs for routine maintenance might also be affected by changes in traffic loadings.

As pavement condition of most principal road network is not yet rehabilitated and worsens by the overloading vehicle, it is request to the Government to invest a lot of national budget for maintain it. However the pavement of existing roads could not reply and because of road design specifically for the traffic before 1970, that come nowadays to the Ministry of Public Works is intensively working on revise roads standard to be satisfaction within the national and regional.

2. DESIGN BACKGROUND

In the situation of intense and growing traffic along the principal road network, no any rehabilitated roads and reconstructed during the last ten years could be regarded as compliant to the demand of transport user. There will always be requirements for future augmentation or modification. In some situation the medium term requirements urge to modify the best short-term design for particular road and provide better option for future action.

The value of traffic to be carried by a road can be considered as the design loading that the engineer should carefully study and satisfy for projecting. Traffic volume is an important design parameter and therefore a complete methodology for considering traffic volume in the design of roads is provided in the Road Design – CAM PW 03-101-99. However the factors to calculate traffic volumes in term of passenger car units for calculating the design capacity a proposal road are differ from country to country and vary with standard which road engineer use for projecting and forecasting. The proportion of heavy vehicle in the traffic stream influence not only the structural design of road pavement, but also some aspects of geometric design, because of disparity of speeds and grades and also because of their greater width.

3. DESIGN NOTES

3.1 Design Vehicle and Charateriscs.

The physical characteristics of vehicles and the proportions of various size vehicles using the roads affect the geometric design of roads. As integration in the regional road standard design in Asean, the Ministry of Public Works and Transport has accept the design vehicle to be used for geometric design follows that use by AASHTO as in chapter 2 of AASHTO – Design Vehicles (A Policy of Geometric Design of Highway and Street (SI)). Some dimension is presenting in table 1 herewith.

Table 1: Design Vehicle Dimensions

Design Vehicle		Dimensions (m)						Turning Radius (m)
Type	Symbol	Wheel Base	Overhang		Overall Length	Overall Width	Height	
			Front	Rear				
Passenger Car	P	3.4	0.9	1.5	5.8	2.1	1.3	7.3
Single Unit Truck	SU	6.1	1.2	1.8	9.1	2.6	4.1	12.8
Truck Combination	WB-15	7.9	0.9	0.6	16.7	2.6	4.1	13.7

3.2 Traffic Design

A lot of discussion inside the definition and classification of road network in Cambodia. Following the CAM PW 103-101-99, road has classified by Rural and Urban Group. Detail of class by group please find in it. Another vision of study of design class following the administration concept it proposes here in four classes of roads. Design class from **Hierarchy** to **Access** have associated bands of traffic flow in table 2. The range of flows extends from less than 20 to 15,000 motorised vehicles per day, and covers the design condition for all single carriageways.

Table 2: Road Design Class

ROAD FUNCTION	Design Class	TRAFFIC FLOW	
		ADT	Light Vehicle[1]
HIERARCHY (Highway)	**1**	more 3,000	more 6,000
ARTERIAL (National)	**2A**	1,500 - 3,000	3,000 - 6,000
	2B	300 – 1,500	600 - 3,000
COLLECTOR (Provincial)	**3A**	150 – 300	300 – 600
	3B	50 – 150	100 – 300
ACCESS (District)	**4**	< 50	< 100

Any transport mode to be considered in the traffic flow shall be converted into light vehicle basic exclude bicycle and traditional mode of transport as oxcart etc. The converted coefficient to light vehicle has been specified in Table 3

Table 3 : Coefficient PCU

MODE OF TRANSPORT	Converted Coefficient	
	Study*	CAM PW 03-103
Light Vehicle	1.00	1.00
Motorcycle	0.50	0.75
Motorcycle with trail	0.75	0.75/1.00
Transport Truck with weight, kN		
20	1.50	2.00
60	2.00	2.00
80	2.50	2.00
140	3.00	3.00
more 140	3.50	3.30
Transport Truck with Trail, kN		
120	3.50	3.00
200	4.00	3.00
300	5.00	3.00
More 300	6.00	3.00

Note :

1. For Special Transport mode, the converted coefficient shall relatively accept in depend of it own weight.
2. In the mountain area, the converted coefficient shall increase in 1.20 times (for this study only)

Nevertheless for the projection traffic for the road network under responsibility of the Ministry Public Works and Transport are not considering some local mode of transport as oxcart, house cart for case study, but the non standard vehicles are consider as group of medium lorries. More efficiency to this consideration the classification should be looking with weight factor as important. The study case of oxcart and horse cart where the user preferable utilize as local mode of transport should consider as serious once for the degradation of road because of non-standard tyres of them. The converted coefficient of ox and horse cart present in table 4.

Table 4: Coefficient PCU of non standard mode of transport

MODE of Transport	Converted Coefficient
Oxcart	0.50
Horse cart	0.75
Non-standard (Kau Yunn)	1.00
Non standard(local agriculture vehicle)	2.00

3.3 Traffic loading

Axle number, load distribution, loading rate and tyre pressures can be significant in determining pavement performance. Not only must the current traffic be taken into account, but the change in volume and composition during the design period must also be estimate. If no axle load data is available it is more convenient to undertake the axle load of heavy vehicle as factor important for the pavement design. Detail guidance on carrying out axle load surveys and analysing the results is given in TRRL road note 40 (1978)

On certain roads it may be necessary to consider whether the axle load distribution of the traffic travelling in one direction is the same as that of the traffic travelling in the opposition direction. Significant differences between the two streams can occur on roads serving docks quarries, cement works etc., where the vehicles travelling one way are heavily loaded but are empty on the return journey. In such case the results from the more heavily trafficked lane should be used when converting commercial vehicle flows, to the equivalent number of standard axles for pavement design. Similar, special allowance must be made for unusual axle load on road which mainly serves one specific economic activity, since this can result in particular vehicle type being predominant in the traffic spectrum. However, the damage due to different axle groups is dependent on the axle spacing, the number of types per axle, the load on the group and the suspension.

In general, it is appropriate to consider axle groups loading of the standard vehicle as follows:

- single axle with single wheels;
- single wheels single axle with dual wheels;
- tandem axles both with dual wheels;

- tri-axles all with dual wheels.

Table 5: Equal damage axle loading (CAM PW 03-102-99)

Axles	**Single**	**Single**	**Tandem**	**Tri axle**
Configuration	**Single**	**Dual**	**Dual**	**Dual**
Load(kN)	53	80	135	181

The standard axle is defined as a single axle with dual wheels that carries a load of 8.20 tonnes. Loads on the axle configuration (shown in table 5) could cause the same amount of damage as the standard axle. For the axle group loads than those in table 5, the ultimate axle loads that damage to the pavement can express as the number of standard axles which produce the same damage. Following the world experience on pavement road design the number of equivalent standard axle for the same damage could calculate as follows:

No. of standard axle for same damage = [(load on axle group)/(appropriate load from table 5)]^{exp}

Where the exponent **(exp)** may depend on the type of pavement. Practically a value of 4 is adopted for the exponent in which case the number of standard axles for the same damage is using as the number of equivalent standard axles (ESA)

Relating the damage load in table 5, the magnitude of maximum loading is commonly controlled by legal load limits. Traffic surveys load meter studies are often used to establish the relative magnitude and occurrence of the various loading to which a pavement is subjected. Prediction or estimation of the total traffic that will use a pavement during its design life is a very difficult but obviously important task. Most design procedure provides for an increase in traffic volume on the basis of experience some estimate growth rate.

In general view for comparison with the different standards for the world leading pavement design, the standard load design can find in table 6.

Table 6: Design standard load for Road Pavement

	Standard axle load (tonne)	Reference source
USA	8.2	Design of Pavement Structure(AASHTO) 18 kpi-single axle
Australia	8.2	AusRoad, Pavement design 1992. Revised edition 2002, it uses tyre pressure equal to 750 kPa.
Japan	10	Asphalt pavement design, 1989.

3.4 Method design

The general design procedure for road pavement is the CBR Method, which is the formulation of CBR value of sub-grade and cumulative traffic volume during design period. By the mean time, the Ministry of Public Works and Transport had approved the above selected method to design pavement.

By this method design, it is generally procedure to determine the physical property and bearing capacity of sub-base material that can be found as CBR value and estimated cumulative traffic load of large vehicles during design life. Assisting to the Project Engineer the Ministry had adopted for use in the Cambodian Road Standard Design – Part 2 for the Pavement, some orientation design of flexible pavement functioning with CBR of sub-grade and traffic group as design catalogue.

ILLUSTRATED PART OF CAM PW 03-102-99

2.1 DESIGN OF NEW FLEXIBLE PAVEMENTS

New flexible pavements shall be designed in accordance with the following charts.

Chart 1	Granular Roadbase / Surface Dressing
Chart 2	Composite roadbase (Unbound & Cement) / Surface Dressing
Chart 3	Granular Roadbase / Semi-Structural Surface
Chart 4	Composite Road base / Semi-Structural Surface
Chart 5	Granular Roadbase / Structural Surface
Chart 6	Composite Roadbase / Structural Surface
Chart 7	Bituminous Roadbase / Semi-Structural Surface
Chart 8	Cement Roadbase / Surface Dressing

Traffic Classes(10 million ESA)

T1 = < 0.3
T2 = 0.3 – 0.7
T3 = 0.7 – 1.5
T4 = 1.5 - 3.0
T5 = 3.0 - 6.0
T6 = 6.0 – 10
T7 = 10 – 17
T8 = 17 – 30

Sub-grade strength classes(CBR%)

S1 = 2
S2 = 3, 4
S3 = 5 – 7
S4 = 8 – 14
S5 = 15 – 29
S6 = 30+

CHART 1 GRANULAR ROADBASE / SURFACE DRESSING

	T1	T2	T3	T4	T5	T6	T7	T8
S1	SD 150 175 300	SD 150 225* 300	SD 200 200 300	SD 200 250* 300	SD 200 300* 300	SD 225 325* 300		
S2	SD 150 150 200	SD 150 200 200	SD 200 175 200	SD 200 225* 200	SD 200 275* 200	SD 225 300* 200		
S3	SD 150 200	SD 150 250	SD 200 225	SD 200 275*	SD 200 325*	SD 225 350*		
S4	SD 150 125	SD 150 175	SD 200 150	SD 200 200	SD 200 250	SD 225 275		
S5	SD 150 100	SD 150 100	SD 175 100	SD 200 125	SD 225 150	SD 250 175		
S6	SD 150	SD 150	SD 175	SD 200	SD 225	SD 250		

Note:

1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater.

The substitution ratio of sub-base to selected fill is 25mm : 32mm

2 * A cement or lime-stabilised sub-base may also be used.

CHART 2 COMPOSITE ROADBASE (UNBOUND & CEMENT) / SURFACE DRESSING

	T1	T2	T3	T4	T5	T6	T7	T8
S1	SD 150 150 300	SD 150 175 300	SD 150 200 300	SD 150 225 300	SD 150 275 300	SD 150 125 150 300	SD 150 125 175 300	
S2	SD 125 150 200	SD 150 150 200	SD 150 175 200	SD 150 200 200	SD 150 250 200	SD 150 125 125 200	SD 150 125 175 200	
S3	SD 125 150 100	SD 125 150 125	SD 150 150 125	SD 150 175 150	SD 150 225 150	SD 150 125 125 150	SD 150 125 150 150	
S4	SD 125 150	SD 125 175	SD 150 175	SD 150 200	SD 150 250	SD 150 125 125	SD 150 125 175	
S5	SD 125 125	SD 125 125	SD 150 125	SD 150 150	SD 150 175	SD 150 200	SD 150 250	
S6	SD 150	SD 150	SD 175	SD 200	SD 225	SD 125 150	SD 125 175	

Note:

Sub – base to fill substitution not permitted

CHART 3 GRANULAR ROADBASE / SEMI – STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1			50 175 200 300	50 175 250* 300	50 175 300* 300	50 175 325* 300		
S2			50 175 175 200	50 175 225* 200	50 175 275* 200	50 175 300* 200		
S3			50 175 225	50 175 275*	50 175 325*	50 200 350*		
S4			50 175 150	50 175 200	50 175 250	50 175 275*		
S5			50 150 100	50 175 125	50 175 150	50 200 175		
S6			50 150	50 175	50 200	50 225		

Note:

1 * Up to 100mm of sub–base may be substituted with selected fill provided the sub–base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub–base to selected fill is 25mm : 32mm

2 * A cement or lime–stabilised sub–base may also be used.

CHART 4 COMPOSITE ROAD BASE / SEMI – STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1			50 150 175 300	50 150 200 300	50 150 250 300	50 150 125 125 300	50 150 125 150 300	50 150 150 150 300
S2			50 150 175 200	50 150 200 200	50 150 225 200	50 150 125 125 200	50 150 125 150 200	50 150 150 150 200
S3			50 150 150 125	50 150 150 150	50 150 200 150	50 150 250 150	50 150 125 125 150	50 150 150 125 150
S4			50 150 150	50 150 175	50 150 225	50 150 250	50 150 125 150	50 150 150 150
S5			50 125 125	50 150 125	50 150 150	50 150 175	50 150 225	50 150 125 125
S6			50 150	50 175	50 200	50 100 150	50 150 150	50 150 150

Note:

Sub – base to fill substitution not permitted

CHART 5 GRANULAR ROADBASE / STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1						100 200 225* 350	125 225 225 350	150 250 250 350
S2						100 200 225* 200	125 225 225 200	150 250 250 200
S3						100 200 250	125 225 250	150 250 275
S4						100 200 175	125 225 175	150 250 175
S5						100 200 100	125 225 100	150 250 100
S6						100 200	125 225	150 250

Note:

1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm

2 * A cement or lime-stabilised sub-base may also be used.

CHART 6 COMPOSITE ROADBASE / STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1						100 150 200 350	125 150 250 350	150 150 125 125 350
S2						100 150 200 200	125 150 250 200	150 150 125 125 200
S3						100 150 175 125	125 150 200 125	150 150 225 125
S4						100 150 175	125 150 200	150 150 225
S5						100 150 150	125 150 150	150 150 150
S6						100 100 150	125 100 150	150 100 150

Note:

Sub-base to fill substitution not permitted

CHART 7 BITUMINOUS ROADBASE / SEMI-STRUCTURAL SURFACE

	T1	T2	T3	T4	T5	T6	T7	T8
S1				SD 150 200 350	50 125 225* 350	50 150 225* 350	50 175 225* 350	50 200 250* 350
S2				SD 150 200 200	50 125 225* 200	50 150 225* 200	50 175 225* 200	50 200 250* 200
S3				SD 150 250	50 125 250	50 150 275*	50 175 275*	50 200 275*
S4				SD 150 175	50 125 200	50 150 200	50 175 200	50 200 200
S5				SD 150 125	50 125 125	50 150 125	50 175 125	50 200 125
S6				SD 150	50 125	50 150	50 175	50 200

Note:

1 * Up to 100mm of sub-base may be substituted with selected fill provided the sub-base is not reduced to less than the roadbase thickness or 200mm whichever is the greater. The substitution ratio of sub-base to selected fill is 25mm : 32mm

2 * A cement or lime-stabilised sub-base may also be used.

CHART 8 CEMENT ROADBASE / SURFACE DRESSING

	T1	T2	T3	T4	T5	T6	T7	T8
S1	SD 150 150 350	SD 150 175 350	SD 175 175 350	SD 200 200 350	SD 200 225 350	SD 200 250 350		
S2	SD 150 150 225	SD 150 175 225	SD 175 175 225	SD 200 175 225	SD 200 225 225	SD 200 275 225		
S3	SD 150 150 125	SD 150 150 125	SD 175 150 125	SD 200 175 125	SD 200 200 125	SD 200 225 125		
S4	SD 150 150	SD 150 150	SD 175 150	SD 200 100 100	SD 200 150 100	SD 200 200 100		
S5	SD 150 100	SD 150 100	SD 175 100	SD 175 150	SD 200 175	SD 200 200		
S6	SD 150	SD 150	SD 175	SD 200	SD 225	SD 250		

Note:

A granular sub – base may also be used.

4. CONCLUSIONS

As in this study the overload vehicles from standard and non standard vehicle intend to decrease the design life of road pavement and come to degrade quicker road surfacing. The environment design for and against to the heavily vehicle request to add fund on normal road investment in deed the road are not subjecting to use as economic and socio development of the projecting region. Redesign the existing road pavement is not the best choice for the whole national roads. Structures along the roads are also affected by the overloaded vehicles. Nevertheless the pavement design method can assist the designer to solve the aspect of loads but overloading case is not to be preferable for the country.

Prevention of overload vehicles along the roads is mean to extend life of road and serviceability in transport sector. Nowadays MPWT is setting some control system to monitoring and implementing the corrective actions against them. Various mitigation measures have been implemented in the main national roads with different regulations, sub-decree and furthermore with road law.

6. REFERENCES

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3. AusRoads. Pavement Design. 1992.
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