

**Workshop on Road Planning, Axle Loading and Pavement Design Strategy**

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**Overview of Vehicle Overloading Issues in Cambodia**

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**ABSTRACT**

The paper discusses the various factors affecting the loading of commercial vehicles and road performance in Cambodia. Overloading of road vehicles is a common problem in many developing countries due to a range of factors. Unfortunately, these can combine to accelerate road and bridge deterioration and destroy infrastructure assets at an alarming and unsustainable rate in Cambodia due to the particular problems experienced in the transport sector in this country.

The result is that road investments are wasted prematurely and total transport costs to the country are above optimum.

There needs to be a common appreciation of these factors and the degree to which they influence the current situation. Based on this appreciation and identification of the options for alleviating the problem, stakeholders need to agree on a workable strategy for bringing the axle loading situation in Cambodia closer to the optimum conditions.

The paper presents some of the options for achieving this improved situation.

***The operational environment and economics of transportation in developing countries encourage widespread vehicle overloading.***

## 1. BACKGROUND

Overloaded commercial vehicles are a serious problem in Cambodia and many developing countries. This is partly due to a number of factors prevalent in developing countries. There are also specific circumstances that accentuate the impact of some of these factors in Cambodia. The result is that commercial vehicles cause high levels of damage to road pavements and road investments deteriorate at rapid and un-economic rates. This leads to many routes being in poor condition, causing high vehicle operating and transport costs. Some routes may become impassable in severe weather or due to bridge damage. The costs of road and bridge rehabilitation are high and un-sustainable in network development terms. Appropriate initiatives are required to be taken by the Cambodian stakeholders to alleviate the current unsatisfactory situation.

## 2. THE ISSUES AFFECTING VEHICLE OVERLOADING & PAVEMENT PERFORMANCE

### 2.1 The Characteristics of the road transport sector

In the Cambodia road transport sector, as in most developing countries, the responsibilities for the provision, maintenance and care of the road infrastructure are assigned to the government. In contrast, the provision of the road transport services (haulage, people moving) is made by the private sector. The ability of the two sectors to recognise and respond to the challenges of their responsibilities influences the current unsatisfactory situation.

### 2.2 Legal Framework

#### ***Current Axle Loading Regulations***

Legal Load limits were set in November 1999 for National Primary and National Secondary Roads. There do not appear to be legal limits for other categories of road. The limits are based on Gross Vehicle Weight with some limitations on individual axle loads. The limits are based on a maximum load of 10 tonnes on a single axle and 19 tonnes on a tandem group on National Primary routes.

<b>Vehicle Category</b>	<b>National Primary Permitted Gross Vehicle Weight</b>	<b>National Secondary Permitted Gross Vehicle Weight</b>
2 axle rigid truck	16 t	16 t
3 axle rigid truck	25 t	20 t
4 axle truck and trailer	35 t	30 t
5 axle truck and semi-trailer	40 t	35 t

**Table 2.1 Current Cambodia Legal Axle Load Limits**

Tables of penalty fines are provided for axle and Gross Vehicle Weight overloading.

From initial inspection it appears that the regulations are influenced by the manufacturer's ratings of individual axle loading. However, it must be appreciated that in-service performance of vehicles and tyres is well in excess of the manufacturer's ratings. Vehicles and tyres can normally endure loadings well in excess of the manufacturer's ratings without undue vehicle damage or excessive truck operating costs.

### **Cambodia Government Initiatives**

Cambodia is cooperating with the People Republic of **China**, the **Lao** People's Democratic Republic, The Union of **Myanmar**, The Kingdom of **Thailand** and the Socialist Republic of **Vietnam** to achieve a common regional regulation of vehicles, their sizes and loading. The latest draft of the regional agreement (November 2003) available to the author contains proposed regulations for loading limits for road vehicles shown in Table 2.2. The proposed regulations will **REDUCE** the permissible axle loadings on vehicles in Cambodia.

Of particular interest for axle loading and pavement damage considerations is that the proposed regulations will not apply to "road building contracting equipment". As these are one of the perpetrating vehicle groups which cause serious damage to haul routes while constructing/rehabilitating other roads, these proposed regulations will probably have little effect on the serious axle loading situation and road pavement damage in Cambodia.

<b>AXLE CONFIGURATION</b>	<b>Proposed Regional maximum Loading GVW<sup>1</sup></b>	<b>Current Cambodia Main Road Regulations GVW<sup>1</sup></b>
3 axle rigid truck	21 tonnes	25 tonnes
4 axle rigid truck	25 tonnes	-
4 axle articulated	32 tonnes	-
5 axle articulated	36 tonnes	40 tonnes
6 axle articulated	38 tonnes	-

**Table 2.2 Proposed South East Asia Regional Axle Loading Regulations and current Cambodia Main Road Regulations.**

In the proposed initiatives, there seems to be little consideration of the actual and feasible axle load control situation in Cambodia, and the consequences for road pavement design and performance. The evidence available from Cambodia (and elsewhere) is that axle loading enforcement is lax and that the current and proposed levels of legal loading are inappropriate, uneconomic and unenforceable.

A Cambodian Road Law is currently being drafted. However, the author's review of the latest version of the document available to him showed that there is insufficient recognition of the axle loading situation and consequences for road pavement damage. There is no effective provision for the rational monitoring, control, penalisation and deterrence of axle overloading.

An Inter-ministerial Declaration by MPWT and MRD dated 23 June 2003 includes an article restricting the gross vehicle weight of vehicles on rural roads to 6 tonnes. The Declaration also prohibits the use of vehicles with trailers, containers or trucks with extended or modified bodies on provincial roads. Also included is the possibility for road authorities to install "safety" pillars with a width clearance of 2.3 metres on rural roads to prevent access by large

<sup>1</sup> GVW = Gross Vehicle Weight

commercial trucks. For provincial roads, authorities may install a frame 2.5 metres width and 3.5 metres wide to restrict access. The Declaration also permits the road authority to lower the loading limit for specific roads if necessary during the rainy season, during floods or where road pavements or bridges are weak. The Declaration raises issues regarding whether some of the articles are appropriate in their present form, the need to cooperate with other authorities and the feasibility of effective implementation.

### 2.3 Road Pavement Performance

Road pavement performance depends on a number of factors, including:-

- Weather, flooding and road physical environment
- Appropriate design
- Construction quality according to design assumptions
- Appropriate maintenance in a timely manner
- Vehicle loading in accordance with the pavement design

#### *Weather, Flooding and Road Physical Environment*

Cambodia suffers from a number of local factors that affect the performance of road pavements. These include:-

- High rainfall in the wet season
- Weak subgrade conditions in large areas of the country
- Flooding of some routes and variable water tables
- Lack of good construction materials in many locations.

#### *Appropriate Design*

Bituminous (flexible) pavement design is normally based on assessment of the expected vehicle axle loading during the 'life' of the road pavement, based on a "fatigue" mode of deterioration. Axle loading by heavy vehicles is of particular concern for all paved routes. Developing countries usually suffer from widespread vehicle overloading. Efforts to control axle loading in developing countries are generally unsuccessful<sup>2</sup>. It is therefore necessary to be aware of the situation and influence of overloading on road pavement performance, in the design and management of road pavements.

The current MPW&T Roadworks Standards explain the traditional pavement design relationship between axle loading and road pavement damage for paved roads<sup>3</sup>.

Pavement damage has been empirically related to axle loading measured in Equivalent Standard (80kN single axle – dual tyre wheel) Axles, or ESA, according to the following table of axle types and groups, and formula (from Cambodia Road Design Standards 1999):-

*Table 2.5.1 Axle Loads Which Cause Equal Damage*

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

<sup>2</sup> The Control of Axle Loading in Tanzania, R C Petts, IRF Conference, Cairo, 1986

<sup>3</sup> There are no relationships established for axle load related damage to gravel or earth roads, although it is clear that overloaded vehicles do a disproportionate amount of damage to these surfaces. The US Forest Department have derived gravel road thickness designs based on axle loading.

$$\text{No. of standard axles for same damage} = \left( \frac{\text{Load on axle group}}{\text{Appropriate load from Table 2.5.1}} \right)^{\text{EXP}}$$

The exponent in the formula will depend on a number of factors relating to the pavement, its condition and 'environment' and the spectrum of vehicle traffic. However, for relatively light bituminous pavements in developing countries an exponent of 4 is usually taken to be appropriate.

The effect of overloading can be conveyed by the following examples for a single dual-tyre-wheel axle based on this exponent.

Axle Load (tonnes)	Number of equivalent standard axles (ESA)
8.0	0.9
12.0	4.6
16.0	15
20.0	35

**Table 2.3 Effect of axle load on assessed pavement damage**

It is important to appreciate the situation with respect to loading and road pavements in Cambodia. Nearly all of the research on axle loading and pavement damage has been conducted in developed countries. Factors such as climate, flooding, range of loading, road user discipline and control, construction techniques, construction quality control and maintenance regimes etc. can have a significant effect on pavement performance.

Therefore there is considerable uncertainty regarding the prediction of the effects of any particular level of loading in Cambodia. Furthermore, there is the basic problem of predicting traffic growth<sup>4</sup>, the mix and loading of vehicles, and even vehicle technology well into the future, to assess what the particular level of loading will be through the design period of a road pavement.

In consequence of the foregoing there is a fundamental problem in the accurate prediction of the axle loadings and their effects over the 'design life' of the road pavement in Cambodia.

### ***Construction Quality According to Design Assumptions***

There are uncertainties regarding the quality of road construction in Cambodia due to a number of factors, including:-

- Experience, remuneration and motivation of supervisory staff
- Availability of good quality materials
- Competence and availability of testing and quality control procedures
- Competitive and operational pressures on contractors and consultancy staff
- Low development of professional standards.

These factors affect the performance of road pavements.

<sup>4</sup> Normal, diverted and generated traffic and growth.

### ***Appropriate Maintenance in a timely manner***

The experience regarding maintenance of road pavements in Cambodia is poor. Timely maintenance is rarely carried out and this shortens pavement life and increases long term costs. This is due to:-

- Insufficient maintenance funding
- Poor allocation and implementation of available resources
- Lack of appropriate management arrangements and systems
- Often the need to rehabilitate, rather than lower cost maintenance.

### ***Vehicle loading in accordance with the pavement design***

Vehicle design and manufacture is developed completely within the private sector and is driven by the global commercial pressures of vehicle users for increased loads and lower unit costs. The capacity and durability of commercial trucks has increased over the years to meet these demands. Trucks are often modified locally to increase capacity and can operate without undue additional owners' costs at well above vehicle rated design and typical legal road loadings. Trucks used for haulage of primary construction materials, lumber and long distance haulage are particularly susceptible to be grossly overloaded compared to legal load limits. The rapid infrastructure development in the region (particularly China and Vietnam) adds to the pressures for overloading.



Image 1 – Truck bodies extended in China to increase load capacity



Image 2 – Truck bodies extended in Cambodia to carry at least 20m<sup>3</sup> of construction materials on 3 axles.



Image 3 – Lax vehicle registration and control can allow very large body capacity and pavement & bridge damaging vehicle configurations.



Image 4 – Grossly overloaded truck with main axle springs near physical limits.

Evidence produced by other authors demonstrates that axle overloading in Cambodia is widespread and serious. The premature failure of road pavements and bridges, and shortage of information on axle loading suggests that road design in Cambodia is generally not carried out with due recognition of the current axle loading and road maintenance situation.

## **2.4 Control of overloading**

Studies in other developing countries have found overloading of vehicles to be extremely difficult to control. This is due to a range of factors including:-

- Poor drafted legislation
- Current legal limits are uneconomic and un-enforceable
- Lack of clarity of responsibility for vehicle and axle control
- If police responsible, they often have little interest in enforcement
- Poorly paid enforcement teams
- Bribery of enforcement teams
- Poorly equipped enforcement teams (equipment, vehicles etc.)
- Insufficient deterrence in the fine structure and enforcement
- Strong economic pressures for operators to overload.

It appears that a number of these issues apply to Cambodia.

## **2.5 Total Transport Costs**

Total road transport costs to the Cambodian economy consist of two components:-

- The costs of provision and maintenance of the road infrastructure, and
- The costs of transporting goods and people on the roads

The former cost burden is carried by the government or community. The latter costs are carried by the transporters and users, and are passed onto the public through their operating costs and charges.

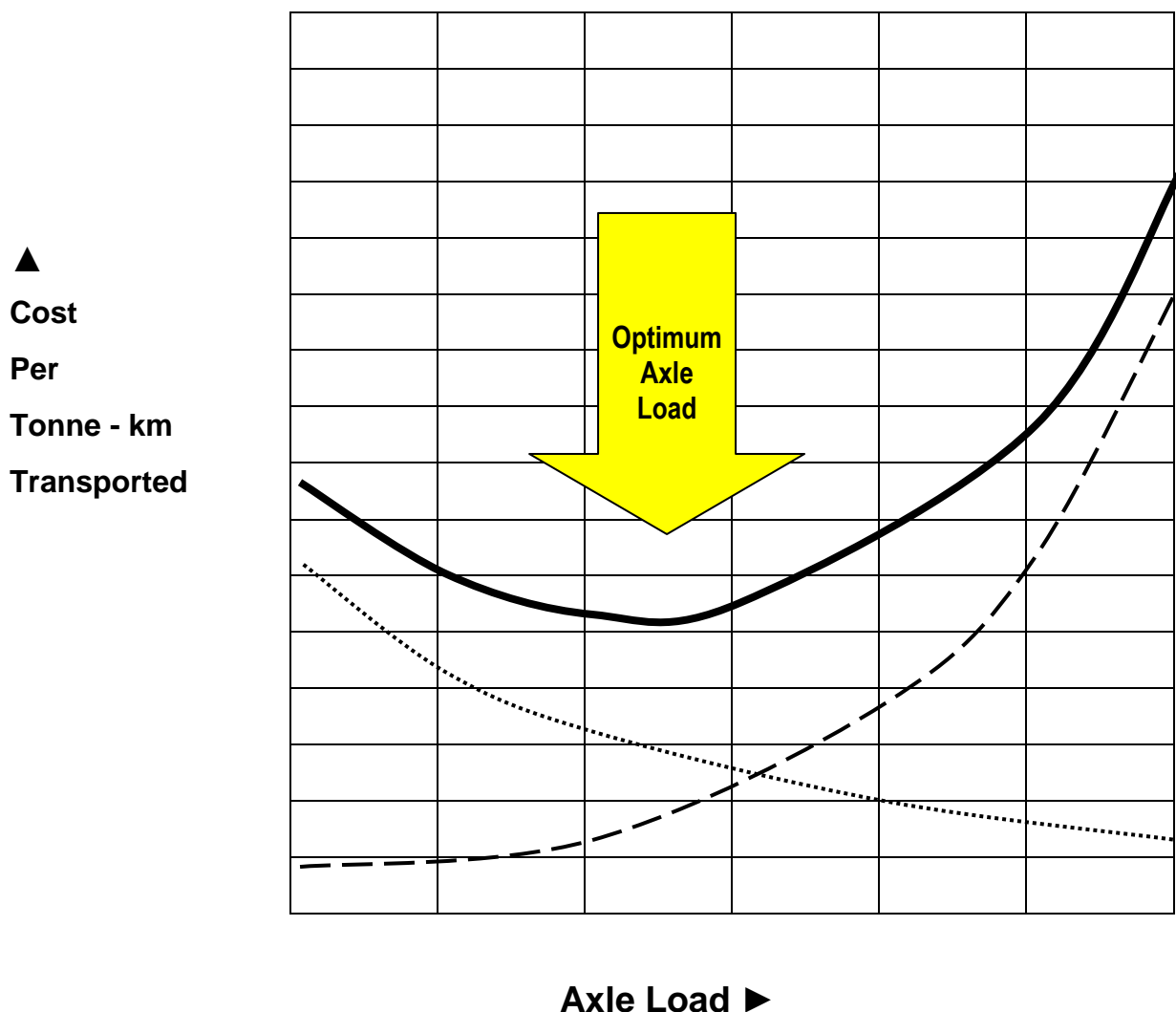
In general for the situations of the relatively light road pavements found in Cambodia, the following applies:-

- The stronger the road pavement, then the greater its load carrying capacity, however construction costs increase.
- The greater the vehicle loading (within limits that are anyway usually above the legal restrictions), then the lower the unit costs of transport to the operator and hence customer/public.

There is therefore a conflict of interest in loading between the costs of provision of the road and transport of goods on it. As axle loading increases then unit operators' costs reduce, however road pavement damage costs increase.

For each road pavement there will be a level of loading at which the total costs of road provision and operators' transport costs will be a minimum as shown in Figure 2.1. This is the Optimum Axle Load for that pavement. It is in the government's and communities' interest to encourage transporters to operate around this level of loading.

If transporters are restricted to operating below this optimum level, through inappropriate legislation/control, then the unit costs of transport will rise and the prices of all goods and services will also increase significantly.



**Figure 2.1 – Concept of Optimum Axle Load**

**Key**

—————	Total Transport Costs	$TTC = TC + PDC$
.....	Transporter's Costs	TC
-----	Pavement Damage Costs	PDC

If transporters are allowed to operate well above the optimum axle load, then their units cost will be low, however the costs to the communities and government in terms of increased road construction, maintenance and rehabilitation costs (and severance costs due to impassable roads and bridges) will be extremely high and unsustainable.

The author believes that the current loading situation in Cambodia is closer to the latter situation. Efforts are therefore required to bring transporters' loading closer to the optimum

loading situation. Further investigations are required to be carried out on the Cambodia road network to determine optimum axle loadings for the various categories of road.

### **3 POSSIBLE OPTIONS FOR ACTION**

It is feasible to reduce the incidence of overloading, and the high costs to the country. However it will probably require an agreed sector wide strategy involving all key stakeholders, and a number of complementary initiatives from the following list of options:-

- Independently monitor the actual loading situation on the Cambodia road network on a regular basis (to establish the current situation and effects of future initiatives).
- Determine the optimum axle load regime for each category of road from analysis of the existing road network and transport operation costs. Regulations and enforcement should aim to encourage operators to load close to the optimum.
- Establish different legal axle and gross vehicle load limits for Main, Tertiary and Urban roads reflecting the pavement capacity, bridge capacity, traffic requirements and road ownership.
- Encourage delegation of responsibilities (and powers) of traffic control/restriction to private road operators on some main roads and to the communities for tertiary roads. Legal ownership and traffic control issues would need to be addressed.
- Establish forum and sector partnership with commercial operators' and contractors' representatives to agree workable axle load control arrangements.
- Establish legal, workable, independent, axle control team arrangements with motivation to achieve effective operations, adequate equipment and funding.
- Develop effective and equitable arrangements and penalties for gross violators, including removing excess loads, possibly preventing the truck from operation for a punitive period of time and fines that reflect the pavement damage caused.
- All bridges should have load limits posted at the bridge sites. All routes should have a consistent load capacity for efficient through transportation.
- Effective and appropriate vehicle weight, size and axle configuration regulations and inspection arrangements. Appropriate penalties for violators.
- Physical barriers for secondary and tertiary roads to prevent access by large vehicles, and controlled by the road owners/community. Legal arrangements to allow load reduction or route restrictions in wet weather/flooding.
- Pavements must be designed in recognition of realistic assessment of expected vehicle loading AND maintenance capacity and funding.
- Earthworks and pavements must be constructed in accordance with designs using appropriate quality control procedures.
- Road maintenance must be arranged and properly resourced at appropriate levels to achieve minimum transport costs.
- Media campaign to advise the public and operators of the new initiatives and the high public costs caused by violators.
- Further local research is required on pavement construction options to determine which paving types are more suitable for heavy loading conditions in Cambodia, and the layer thicknesses required.
- Where private developers, contractors, quarry operators and hauliers plan to use routes not designed for heavy vehicles, appropriate bridge and pavement strengthening should be arranged in advance AND AT THEIR COST.
- Construction projects should include the necessary strengthening of pavements and structures on materials haulage routes.
- Arrangements and realistic charges for abnormal/special loads should be established.
- Public reporting of axle control operations performance and violations.

These initiatives will have financial, economic, social and cultural dimensions which should be thoroughly investigated and discussed with stakeholders. Further information and knowledge is required to be gathered to enable informed decisions to be made regarding the foregoing options.

There is need for stakeholder agreement on a pragmatic approach to improve the situation nationally and encourage the transport sector to operate at economic and sustainable levels of vehicle and axle loading.