DESIGN & OPERATIONAL CRITERION FOR TOLL ROADS IN SRI LANKA

Amal S. Kumarage, PhD, MCIT, AMIE(SL)
Dept. of Civil Engineering,
University of Moratuwa,
Sri Lanka.

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Abstract

There is presently much discussion on the introduction of toll roads in Sri Lanka. This follows practices in other countries, an increase of which has been observed under BOO/BOT schemes in recent years. This paper discusses some aspects of the design and operational features that should be incorporated in tolls roads in Sri Lanka.
1. INTRODUCTION

State funding of highway construction at the present times, has a very high opportunity cost and is therefore often delayed, thus withholding essential infrastructure facilities required for socio-economic development. Cost of Projects are also high due to lax financial discipline. Incentives for improvements to enhance user benefits are low as no direct benefit is received by the state agency for doing such.

A contemporary variation of highway construction is to give the operational part to the private sector. In such a case, that operators revenue should be based on a measure of increasing road user benefits, such as reductions in delays, roughness, accidents etc. The operator would then be motivated to make investments in maintenance, intersection control, provision of off-street parking, safety measures etc. In order to harness private sector capital and also its financial discipline in order to reduce costs of construction and operation, private sector could be invited to invest in highway projects. Revenues could be earned through lease of advertising space, lease of development rights on state owned property and in the case of new projects, by the collection of tolls. Toll revenues in Sri Lanka commensurate with its wage levels would require a large proportion of revenues to be earned through sale of advertising rights and road side development rights. Considering the limitations for these, wholly private sector funded projects may be restricted to relatively smaller projects such as, construction and operation of intersection control devices (roundabouts, traffic signals), pedestrian crossings, car parks, bus shelters etc.

In the case of larger projects, public-private joint ventures would be more appropriate. However, in such instances, the controlling share should be with the private sector such that, construction and operational advantages may be realised. Profits and risks may however be shared equitably. The advantage to the state would then be reduced capital investment, lower project cost and no maintenance on its part.

Private sector investment should however, be adequately regulated. For projects fully funded by the private sector, a state agency such as the RDA could be the regulating agency. However, for joint venture projects, where the public sector is represented by the RDA, a separate regulating body such as the National Highway Council in Pakistan (NHA, 1996) may be more appropriate. The design and operational criterion for toll roads would then be an extremely important aspect that would need to be subject to these regulations. Some of the criterion for toll roads are discussed below.
2. **TOLLS**

An essential attribute of highways should be that tolls shall be levied only in respect of new infrastructure and not in respect of facilities rehabilitated / replaced from which tolls have not been levied previously. Upgrading of an existing non-toll facility to a toll facility should be considered only under exceptional circumstances, where it can be established beyond reasonable doubt, that there would be no loss of access to the legitimate beneficiaries of the existing facility.

The charging of a toll would add to the existing cost of travel to the user, which would be mostly made up of vehicle operating cost (or fare) and value of travel time. Thus higher the toll rate, lower would be the percentage of users on the toll facility. Table 1 shows a typical relationship between toll rate, residual traffic percentage and toll revenues for a 130 km intercity highway proposal in Sri Lanka.

<table>
<thead>
<tr>
<th></th>
<th>No Toll</th>
<th>Fixed Charge Rs. 10/=</th>
<th>Variable Charge (x) Rs./km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Percent Residual</td>
<td>100.0%</td>
<td>98.6%</td>
<td>88.8%</td>
</tr>
<tr>
<td>Traffic Flow</td>
<td></td>
<td></td>
<td>222.8</td>
</tr>
<tr>
<td>Revenue in Year</td>
<td>0.0</td>
<td>44.9</td>
<td></td>
</tr>
<tr>
<td>2001 Rs (mn)</td>
<td></td>
<td></td>
<td></td>
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</table>

**Table 1**

*Typical relationship between toll rate residual Traffic and toll revenue (Case Study)*

From a private sector point of view, optimum toll rate (y) would be that which maximises his revenue. However, as shown in Table 1 at this toll rate which is Rs. 2/= per km. only around 50% of the potential users can be make use of the facility even though there maybe excess capacity available on the highway.

The toll rate at which economic benefits are maximised is where the optimum volume of traffic is using the highway. Let us say that the toll rate at which this volume of traffic will use.

This is shown in Figure 1 where it is most likely that for Sri Lankans applications y > x. Therefore, it is clearly necessary to correctly identify x and y so that optimum economic benefits that can be realised from the project are not eroded in pursuit of a much smaller financial optimum which would be the desired objective of the investor.
Therefore, the state could consider an operating subsidy after restricting tolls at x. The level of the subsidy would then be y-x. In general, subsidies offered to state operators are 'now-a-days' considered irrational and subsidies offered to private operators generally frowned upon. However, a rational hypothesis can be established for an operating subsidy when y > x as shown in Figure 1.

If we were to assume that the economic optimum toll rate (x) is Rs. 1.00 per km, whereas the financially optimum rate (y) is Rs. 2.00 per km, then according to Table 1, residual traffic increases to 68 percent such that, total earnings of the operator increases by 35 percent being matched by an equal operating subsidy from the state.

This is truly a win-win scenario where even the necessity for guaranteeing minimum traffic levels will not be required. Conversely, an upper limit maybe placed such that the subsidy will be removed in stages when traffic levels exceed projected levels.
3. **TOLLS REVISIONS**

Guidelines are also necessary for tolls revisions, and the frequency of making such revisions. A typical highway project will incur 80% cost for construction and 20% cost for maintenance. Since maintenance costs are subject to inflation, a tolls revision based on an inflation index is desirable. However, on the other hand, a foreign investor who has incurred the construction costs would be more concerned regarding the change in exchange rate. Thus a revision based on exchange rate is also desirable.

Therefore, an annual revision of the maximum toll rates may be permitted. The toll adjusted for escalation that will be allowed in any year may be calculated as the maximum of;

(a) \[ t_0 \left(1 + \frac{r}{100}\right) \], where \( t_0 \) is the existing maximum toll and \( r \) is the annual rate or growth (%) in the Colombo Consumer Price Index (All Goods), over the most recent time period of 12 months for which statistics are published by the Central Bank of Sri Lanka.

(b) \[ t_0 \left(1 + \frac{e}{100}\right) \] where \( e \) is the rate of change in the rupee value of the US dollar over the most recent 12 month time period as published by the Central Bank of Sri Lanka.
4. TOLL STRUCTURE

A typical toll structure used abroad, based on Passenger Car Unit (PCU) equivalence will look similar to the values given in Table 2.

<table>
<thead>
<tr>
<th>Vehicle Category</th>
<th>Equivalent Rate in Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Cars/Van/Jeeps/Pick Ups</td>
<td>1.0</td>
</tr>
<tr>
<td>B. Minibus / Bus</td>
<td>1.5</td>
</tr>
<tr>
<td>C. Truck (2 or 3-axle rigid), Tractor without trailer</td>
<td>2.0</td>
</tr>
<tr>
<td>D. Tractor with trailer</td>
<td>3.0</td>
</tr>
<tr>
<td>E. Truck - trailer, Multi-axle Truck</td>
<td>4.0</td>
</tr>
<tr>
<td>F. Three-Wheelers</td>
<td>0.5</td>
</tr>
<tr>
<td>G. Motorcycles</td>
<td>0.25</td>
</tr>
<tr>
<td>H. Non-Motorized Vehicles</td>
<td>No Toll</td>
</tr>
</tbody>
</table>

**Table 2: Toll Rate Based on PCU Equivalent Values**

This type of toll structure determines the equivalent toll rate for different classes of vehicles is often based on international Passenger Car Unit (PCU) Values i.e. based on the road space utilization. However an alternative analysis is shown in Table 3 when performed using PCU values for Sri Lanka (Kumarage, 1996) and Cost of Vehicle Operation (HFA, 1996). The financial (out of pocket) cost per passenger is calculated with and without a 2/= per PCU km toll rate.

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>PCU</th>
<th>Occupancy</th>
<th>Cost Per Passenger km W/O Toll (Rs.)</th>
<th>Toll Cost per Passenger km (Rs.)</th>
<th>Increase Toll Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor Cycle</td>
<td>0.6</td>
<td>1.0</td>
<td>1.50</td>
<td>1.20</td>
<td>67%</td>
</tr>
<tr>
<td>Three Wheeler</td>
<td>0.8</td>
<td>1.5</td>
<td>2.40</td>
<td>1.07</td>
<td>45%</td>
</tr>
<tr>
<td>Car</td>
<td>1.0</td>
<td>2.0</td>
<td>5.85</td>
<td>1.00</td>
<td>17%</td>
</tr>
<tr>
<td>Bus</td>
<td>2.5</td>
<td>30</td>
<td>0.30</td>
<td>0.17</td>
<td>57%</td>
</tr>
</tbody>
</table>

**Table 3**

Proportional cost increases for passengers of different vehicle types (with & without 2/= toll per pcu km)

It can be clearly seen that the lowest proportional increase is to car passengers, if a traditional PCU -
based toll structure is followed. In fact, the percentage increase to bus passenger is thrice as much as that of car passengers and two wheeler users even greater!

It can be shown by a reverse calculation that in order for different vehicle passengers to bear a proportional increase, then the toll structure should be simplified to read.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Cars / Buses</td>
<td>-</td>
</tr>
<tr>
<td>Motor Cycles / 3 Wheelers</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1 Unit</td>
</tr>
<tr>
<td></td>
<td>0.25 Units</td>
</tr>
</tbody>
</table>

The rate for goods vehicles will need to be determined on a different basis of perhaps encouraging multi-axle and container carriers to use toll ways more suited for their movement, in preference to the existing highways. Hence, given that the PCU rate will determine the toll structure between a passenger car and a two-axle truck which will be 2 Units for the latter, then the differential between say a multi-axle truck and a two axle truck should be approximately as follows:

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<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Two-axle/Three axle rigid trucks</td>
<td>-</td>
</tr>
<tr>
<td>Multi-axle/Container trucks</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2 Units</td>
</tr>
<tr>
<td></td>
<td>3 Units.</td>
</tr>
</tbody>
</table>


5. DESIGN FEATURES

Sri Lanka's present highways are used by a wide mix of road users and traffic types. There are presently only few restrictions on usage, which is limited to vehicles with extra large dimensions or weights. Apart from the variety of non-motorised usages, motorised use also takes the form of two, three, four and six wheelers in significant proportions in addition to the rapidly increasing multi-axle vehicles.

Traditionally, highway design has mostly catered for the requirements of the passenger car. The absence of climbing lanes for trucks, bus bays (till recently) or bus lanes for buses, lane configuration to accommodate two and three wheelers and lack of facilities for pedestrians, bear testimony to the fact that the requirements of the private car are generally those considered first - with other users considered almost as an after thought.

Accommodating different vehicle types on new highways has to be seen in the wider social context of the affordability of transport. Figure 2 shows the modes of transport available for regular use to average households in the Western Province. This is computed from Estimates of Operational Vehicle Fleet in Sri Lanka - 1996 Update (UOM, 1997) and Transport Surveys for CUTS Study (UOM, 1995).

Vehicle restrictions are generally placed on toll facilities, mostly because existing 'international' design standards do not provide for a wide mix of vehicles and also because the collection of tolls from non-motorised transport is considered not worthy of the effort. Therefore, many operators will
find it convenient to exclude such facilities to the majority of persons who cannot afford a private car.

Therefore, it is imperative that guidelines should be provided to ensure that the facility be designed for the use of all user categories. Restrictions on type, speed and weight maybe placed only when adequate safety cannot be provided or when economic feasibility to include a specific category does not exist. Some of these design features are discussed as follows:

5.1 Non-Motorised Access

Toll highways, following their character of requiring a separate right of way, have generally tended to sever non-motorised access in their vicinities. Sri Lanka being a densely populated country and which as shown earlier depends much on non-motorised transport should consider preserving and perhaps even enhancing access to non-motorised transport in the vicinity of toll roads. This can be done by the following:

(a) By providing under or over passes and ensuring that there is no severance to the existing crossings of gravel roads, paths and 'cart-tracks'.

(b) By improving the connectivity of the rural road network in the vicinity of the toll road such that rural transport and modes of such will be unrestrained.

(c) By providing a parallel service road, such that the benefits of the new corridor can be passed onto the large base of the rural population for their accessibility also. In order to provide adequate safety, it maybe necessary to design such as a separate service road or path.

5.2 Two & Three Wheeler Facilities

International highway design standards such as AASHTO and TRB usually follow traffic flow and composition in western countries. Third World countries such as Sri Lanka, have vastly different traffic mix on our highways more in keeping with the economic circumstances of its population. Toll roads must therefore be consistent in providing mobility to as wide a cross-section of the population. In this respect, the design features for toll highways should truly represent an indigenous character as opposed to those of foreign situations.

This is important from a perspective of social equitability such that new and improved highway facilities are not restricted for the socioeconomic activities of the relatively significant proportion of the population that would be dependent on two and three wheelers transport mobility.

In such a design, accommodating the two and three wheelers is an absolute requirement. It is however a challenging task, as the operating characteristics of these are fundamentally different to four
wheelers. Hence, highway design engineering needs to be creative in formulating a design such that provision for these vehicles are also included without substantial detriment to the mobility of the four wheelers and the safety of the two and three wheelers.

5.3 Public Transport
New toll roads should support wider transport policy. For example, the Colombo Metropolitan Regional Study (UDA, 1997) has identified that in order to manage transport efficiently within the province bus passenger shares at the Western Provincial Boundaries should be around 70% by the year 2010. The corresponding share at the Colombo City Limits is pegged at 55%. Thus it is vital that the priority given to public transport be built into the design of toll roads depending on their locality and their functionality.

The corresponding special designs may include one or more of the following measures:

(a) Incorporation of bus-only lanes and other priority measures,
(b) A toll structure which is not disadvantageous to bus passengers and
(c) Incorporation of intersections, entries and exits at critical points on the toll roads such that bus routes could be diverted to the toll way.

5.4 Safety
Since, toll roads by virtue of their requirement to attract and retain users, will require a design such that maximum speeds are generated in order to minimise travel times. Moreover, other design features required to minimise the occurrence of accidents and also to mitigate the loss or damage in the event of an accident may not rank as top priorities in the financial viability of a toll road. It is therefore the duty of the state and its regulator to incorporate minimum safety standards in the design. Some design features not seen in highway design in Sri Lanka as at yet, need to be incorporated in new highway projects, particularly in toll highways. Some of these features are listed as follows:

(a) Creation of a **recovery zone**, such that vehicles leaving the road due to going out of control could be recovered instead of impacting with heavy objects within such a zone.
(b) Creation of a **divided highway** when speeds are over 50 kmph, with wide centre medians where space is available for such.
(c) Design of impact absorbing **crash barriers** both on the centre-median and on the edge of the highway, where an adequate recovery zone cannot be provided.
(d) **Lighting** at all intersections and wherever road geometry changes, such as at bridges and over or under passes.
(e) Placement of crash barriers at merging sections such as at points of entry to ramps.
(f) **Separation** of non-motorised and pedestrian traffic as discussed earlier, with corresponding safety provision for each user category. Placement of such rights of way within or beyond the recovery zone is one such possibility.

(g) Placement of **electronic traffic surveillance** and enforcement devices, such as speed cameras, changeable message signs in order to enforce discipline and also communicate road conditions to motorists.

(h) Design of **climbing lanes** in the incline for higher grades and run-off lanes in the decline direction for the use of heavy vehicles such that safety and serviceability be improved when the percentage of heavy vehicles is high, as would be the case on Sri Lankan highways.

(i) Incorporation of **rest areas and turn out areas** at regular intervals in order to provide adequate facilities to ensure that motorists have an opportunity to maintain alertness.
6. CONCLUSIONS

The paper analyses the need for private sector funding in highway projects given restrictions in traditional sources of funding hitherto available for the highways sector. Within such a scenario, the state needs to recognise the design, safety and operational guidelines and regulations that need to be enforced.

This paper has discussed, the toll rates, toll structures, operating subsidies, design considerations and safety features that are necessary in evaluating the design of a given toll highway.

Toll rate, structure and subsidies are discussed in terms of ensuring that economic objectivity is not lost while seeking financial returns usually pursed by toll road developments. Other features suggested are also discussed in the light of ensuring user benefits and minimisation of economic cost.
7. ACKNOWLEDGEMENTS
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8. REFERENCES


