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# LAHORE-ISLAMABAD MOTORWAY (M-2) EXPERIENCE-LESSONS AND IMPROVEMENTS FOR FUTURE PROJECTS

BY

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# LAHORE-ISLAMABAD MOTORWAY (M-2) EXPERIENCE- *Lessons and Improvements for future projects*

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*Abstract:* **The concept of access control facility was first time introduced in Pakistan by opening of Lahore-Islamabad Motorway Project. The need for efficient road transportation in Pakistan can not be denied as more than 85% of the modal split is being shared by the highway system. Being the first mega highway project in Pakistan, this Motorway project has been criticized, however very few benefits have been highlighted. It is envisaged that with proper management skills and sound engineering practices this project can play a vital role in the national economy. Also, this project can prove to be a milestone in learning some basic lessons thereby improving the future projects. The operation and management of motorway plays a vital role in success of a project. The aim should be to maximize the revenue and minimize the operational and maintenance expenses to have more returns on this toll facility. Various possible suggestions are given in this paper to make this project economically and financially viable and also various aspects are highlighted in design to improve the future projects.**

## 1. INTRODUCTION

Pakistan relies predominantly on its road network for the transportation of both freight and passengers. Thus, an effective road network is absolutely vital to the national economy. Government of Pakistan has planned a phased program for construction of motorways in the country keeping in view the geographic placement of Pakistan. As it is ideally situated to serve as a transit corridor for the Central Asian States. This expressway system would serve as a trade route to Middle East, Asia and Asia-Pacific regions. Pakistan certainly required having a necessary expressway system in place prior to opening of this international trade route.

In anticipation to this effect, GOP has already taken initiative. Lahore-Islamabad Motorway, 337 kms long, six lanes divided, limited access motorway has been constructed. This section of the Trans-Pakistan motorway is the first tolled motorway stretch of Pakistan. It is planned to be followed by a series of sections prioritized in a manner to suit the national economy. The design for approximately 600 kms has been completed and yet another 425 kms stretch is under designed currently.

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In addition to the above, another 700 kms of coastal road is under construction. This East-West coastal link namely Makran Coastal Road in the south along the Arabian Sea. The detailed design and feasibility of the project has been completed.

The current status of motorway/expressway network of Pakistan as planned is given in Table 1.

**Table 1: Pakistan Motorways**

| Designated No. | Section Location | Length (km) | Status |
|---|---|---|---|
| M-1 | Peshawar-Islamabad | 154 | Under Construction |
| M-2 | Islamabad-Lahore | 335 | Completed |
| M-3 | Pindi Bhattian-Faisalabad | 52 | Under-Construction |
| M-4 | Faisalabad-Multan | 200 | Pre-Construction Stage |
| M-5 | Multan-D.G. Khan | 85 | Pre-Construction Stage |
| M-6 | D.G Khan-Ratodero | 330 | Pre-Construction Stage |
| M-7 | Ratodero-Kakkar-Hub-Kchi | 450 | Pre-Construction Stage |
| M-8 | Gawadar-Ratodero | 892 | Pre-Construction Stage |
| M-9 | Hyderabad-Karachi | 135 | Pre-Construction Stage |
| M-10 | Karachi-Northern By Pass | 64 | Pre-Construction Stage |

The changing attitudes and preferences of the donor agencies coupled with the resource constraints of the Government has lead NHA to involve private sector in financing of some of its projects. The first project executed on the basis of co-financing by an international private sector company M/s. DAEWOO of South Korea (40% of the Project cost) and Government of Pakistan (60% of the project cost) is Lahore-Islamabad Motorway Project.

## 2. LAHORE-ISLAMABAD MOTORWAY

Lahore-Islamabad Motorway Project is primarily meant for linking the Provincial Capital (Lahore) with the Federal Capital (Islamabad) and providing access to other major population /commercial centers of the area to Lahore and Islamabad. It is a 6 lane divided controlled access highway passing through the districts of Lahore, Sheikhupura, Gujranwala, Sargodha, Jhelum, Chakwal, Attock and Rawalpindi. An agreement, for the design and subsequent construction of a four lane limited access tolled Motorway between Lahore and Islamabad, at the contract value of Rs 23.467 billion was initially signed on 30th December 1991 with *M/s* Daewoo Corporation a Korean Company. National Highway Authority appointed Snowy Mountains Engineering Corporation (SMEC) of Australia as the Consultants for reviewing the design and supervising the construction work of Project.

## 2.1 SCOPE OF WORK

The Project envisages the construction of a 334 Km. of Motorway facility with two link roads of *8.5* Km. connecting Islamabad at G.T Road junction of Kashmir Highway and *7.5* Km. connecting Lahore at Kala Shah Kaku on G.T. Road. It is further being connected with the Multan Road (N5) through the Lahore Bypass, the length of which is 17 kms. Each of the six lanes will be 3.5 meters wide coupled with 3 meters outer shoulder and 1.7-meter inner shoulder forming a total paved width of 33 meters with a median barrier of 0.6 meter. There are 11 interchanges to facilitate the entry and exit points to the major cities /towns and proposed industrial zones along the motorway. In addition 35 flyovers and 190 subways/ underpasses have been provided for crossing of local population. Dykes and chutes have been provided for effective drainage protection and safety of embankment slope. Similarly guardrails are being installed
as a safety measure at the edge of outer shoulders.

## 2.2 EXISTING HIGHWAY ALTERNATE

Essentially, for all north/south movements between Islamabad and Lahore N-5 GT Road is the only viable route. The GT Road (N-5) is almost dualised with various levels of pavement surface conditions. Along GT Road there are numerous road junctions where vehicles can enter and leave the road. Many of these junctions are inadequately signed and do not meet the current practice by international design standards. *The current mix of traffic ranges from animal drawn carts, bicycles, cars, Jeeps and trucks. There are obvious conflicts between fast and slow moving vehicles. Due to overloading of majority of trucks the truck move at a creep speed thereby reduces the capacity and cause delay in the traffic stream. In summary, in spite of the construction of dual carriageway along this route, existing route between Lahore –Islamabad causes high driver stress levels and low average speeds.*

## 2.3 HIGHWAY DESIGN AND ROAD GEOMETRY

The highway design i.e., geometric design is base on a design speed of 120 kph along the full length of this motorway except in the hilly terrain, where the speed of vehicles was compromised probably based on the economic factors. In the salt range the geometric design of road could have been further improved, especially the super-elevation would have been adjusted to meet the higher travel speeds. It is important to understand the basic concept of providing a circular curve, as a vehicle traverses a circular curve; it is subjected to a *centrifugal force*, which pulls it towards the outer side of the curve. To maintain the vehicle on the circular path, a sufficient *centripetal force* is required to balance the inertial forces associated with the given path. In road design, this is provided by *side friction* developed between the tire and pavement and by the slope of the road surface from the out side of the curve down to the inside called the *super elevation.*

The super elevation to be adopted is chosen primarily on the basis of safety, but other factors to be considered are comfort and appearance. Normally, the super elevation applied to a road should take into account;

- Design speed of the curve ($85^{th}$ % speed)
- Tendency of very slow moving vehicles to track towards the center
- Stability of high laden commercial vehicles

The maximum super elevation ranges from 12% in mountainous terrain to 6-7% in flat terrain. Recommended maximum values are 6% for rural highways and 3% for freeways.

- The radii of various curves in salt range does not match with the design speed of 50-60 kph, thereby meaning that the design speed can not be maintained on some of these curves because of the sharp radii and low value of super elevations on these curves. This is probably because of the reason that increase in the radii could change the alignment, which could increase in the cost of the project.

- The actual speed observed at two of the most critical curves show that all types of vehicles except buses are over speeding at these curves. This means that these vehicles are not moving at safe speed while traversing/negotiating these curves. The over speeding at these curves is probably due to higher down hill gradient i.e., > 7%.

- Figure 1 & 2 can explain the problem of super elevation on sharp curves. Figure 1 shows the amount of (e%) required for various radii at a safe speed of 40 kph. It can be clearly depicted from this graph that in order to have safe travel speed of 40 kph, the radius of the curve must range between 30 to 40 meters for a super elevation range of 0 to 12%. Similarly, Figure 2 explains that for a safe travel speed pf 25 kph, the radius of the curve must range between about 11 to 17 meters for the same range of super elevation.

- Some very sharp curves are followed by S-type curves immediately with out any transition in between them. This situation is the most dangerous as far as driver behavior is concerned, consequently warrant to the safety of the highway.

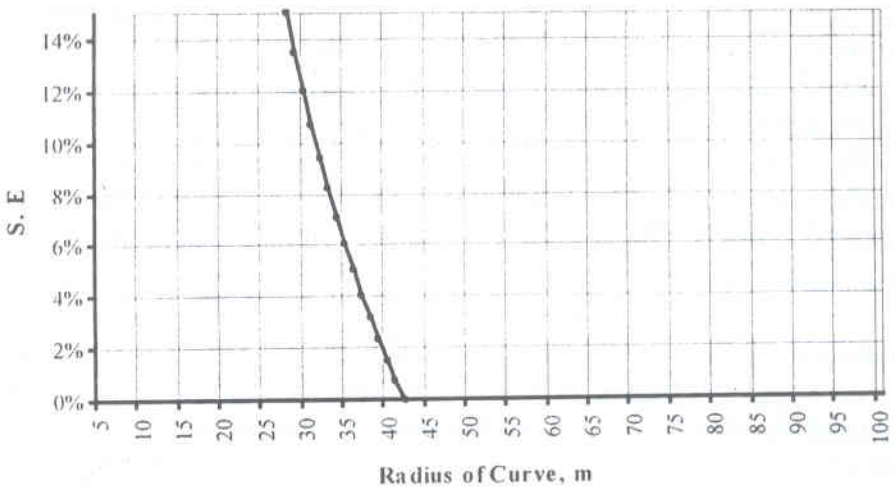


*Figure 1: Super elevation requirements for travel speed of 40 kph (f=0.3 assumed for asphalt)*

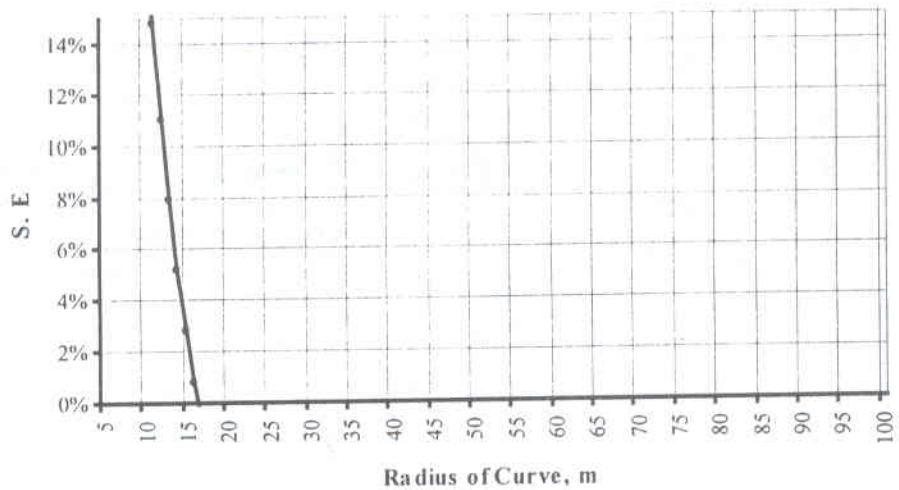


*Figure 2: Super elevation requirements for travel speed of 25 kph (f=0.3 assumed for asphalt)*

## 2.4 TOLL CHARGES AND REVENUES

Being the first ever toll road in Pakistan, forecasts of future operating revenue and cost streams for Lahore-Islamabad motorway at the initial stages could be at best an approximation. As it was not possible on the basis of historic traffic and economic data to determine more than a past trend in traffic using GT Road. The models for toll sensitivity derived/assumed at the time when there was no actual traffic on the motorway can be validated now and should be rationalized based on the actual traffic demand and price elasticity.

The revenue and price elasticities have very strong relationship, if the price elasticity of demand ($E_D > 1$), then the demand is elastic, *which means that percentage change in quantity demanded greater than percentage change in the price and the impact on revenue with price decrease is increase in revenue.* For example the case of decrease in the car duties will suddenly increase the demand of new cars, so the revenue may increase. The other case when ($E_D < 1$), the demand will be inelastic and *means that percentage change in quantity demanded is less than the percentage change in price. The revenue will increase with increase in price and decrease when the prices decrease for this case.*

A hypothetical case is given here to illustrate the concept of toll revenues and change in the toll charges. Figure 3 shows a hypothetical demand curve for a typical tolled highway, this curve shows the demand variations with increase/decrease of toll charges. A typical rural expressway with adjacent alternate route will show similar pattern of traffic demand. It is assumed that traffic will increase with decreasing toll charges and vice versa. This curve can also be developed for various categories of vehicles for Lahore-Islamabad motorway by doing the trial test with toll charges variations.

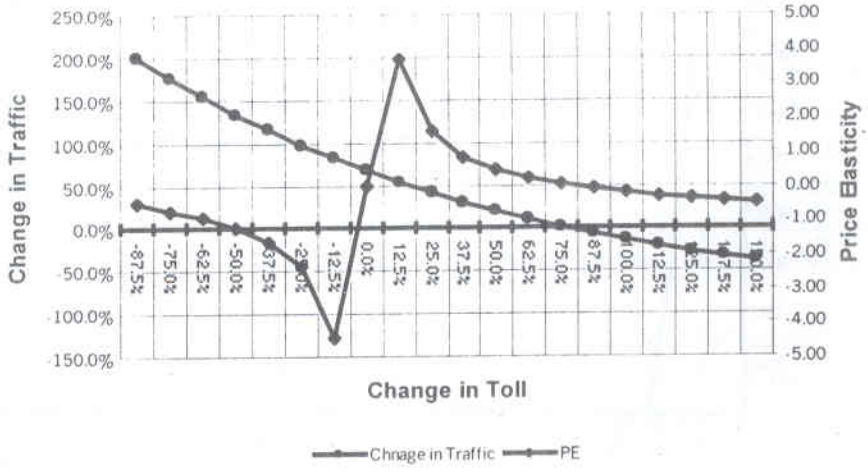


Figure 3: Traffic demand vs. change in toll charges on motorway

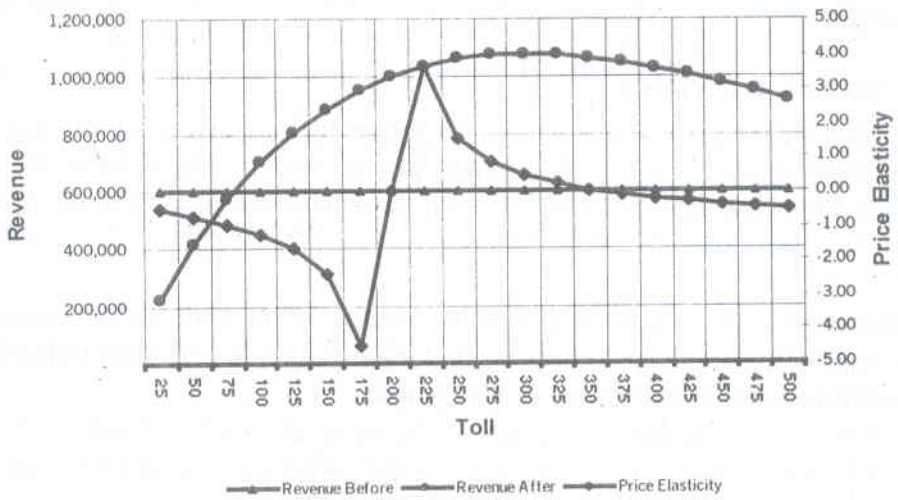


Figure 4: Change in toll charges vs. revenue generation on a toll facility

Similarly, the traffic demand will also effect the revenue generation; the effect of traffic demand is shown in Figure 4. Following important facts can be envisaged from the above example:

- The toll revenue may be increased by decreasing the toll rates, if the price elasticity of demand is elastic i.e., ($E_D > 1$).
- The demand of vehicle categories such as private cars may definitely increase with decreasing toll charges.
- The revenues may be maximized by rationalizing the toll charges for some vehicle categories.
- Similar demand curves for various vehicle categories can be developed on the motorway to maximize the toll revenue.

At present following toll charges are imposed on various categories of the vehicle as given in Table 2:

**Table 2: Current toll charges in Lahore-Islamabad motorway**

| S. No | Vehicle Type | Toll Rate / km (Rs.) |
|---|---|---|
| 1 | Car | 0.6 |
| 2 | Vans/Wagons | 0.9 |
| 3 | Buses | 1.34 |
| 4 | Rigid Trucks | 1.63 |
| 2 | Articulated Trucks | 2.1 |

It is worthwhile trying for some trial period that toll rate for cars is reduced by 50% . This might cause an increase in the toll revenues.

## 3. LESSONS LEARNT

The primary objective before us now should be that as this motorway facility has been operation for the last 3 years, what should we do to make this existing facility more viable and efficiently. There are few important lessons, which should be considered now to make better facilities in future under the given financial constraints.

- The concept of motorway should be considered in a true spirit, i.e., provision of controlled excess alternate corridor for fast, through, long distance and efficient traffic considering the safety, comfort and low stress levels for the users.
- The movement of long distance freight traffic more efficiently and safely.
- Economic activity must be generated along the motorway corridor to meet the anticipated traffic levels in the generate estimated finances.

The above aspects were considered while making this motorway. However, the various warrants for its justification needs to be further considered, which lead us to think on the following important requirements:

- As stated above, a motorway should be used by the long distance freight traffic, on the other hand on Lahore-Islamabad motorway; the trucks are reluctant to travel because of the following main reasons:
  - The axle load control being enforced on the motorway, where as the alternate route although having being tolled has no such restrictions.
  - The steep gradient in the salt range, as majority of truck fleet in Pakistan consists of old Bedford trucks (about 69%). The low engine power of these trucks further cause more difficulties for them to negotiate higher longitudinal grades.

- Lahore-Islamabad motorway is one link of the entire motorway system; the traffic diversions and generations one motorway will depend upon the conditions on the alternate route. The alternate GT Road route between Lahore and Islamabad is overall shorter in length and has many big cities along its alignment. Under the prevailing higher prices of fuel and longer distance on motorway, users are making a competitive choice between both routes. So, the actual traffic on motorway cannot be expected until the completion of adjoining motorway links for north/south corridor.

- The staggered and unplanned delayed time of completion of other adjoining motorways is causing a great loss in terms of delayed project costs and loss of precious toll revenues.

- Alignment of any motorway corridor should be based on sound engineering practices keeping in view the economy in construction. The salt range alignment is a good lesson for future.

- Keeping in view the local driver behaviors/culture in Pakistan and age of the vehicle fleet, it will be more appropriate to have small rest areas more frequently (@ of every 25-30 km) rather than very huge facilities at far more distances.

- The operation and management needs lot of improvement at a minimum cost. The tolling equipment can be more high-tech having pre-audit automated system to avoid leakage. Introducing the appropriate technology can further reduce the cost of tolling operations.

- Currently, on an average Rs. 1.4 to 1.5 millions per day are generated as toll revenue to M-2, which will make about Rs. 500 millions per year. The revenue generated is far less than anticipated/required, so there is a definitely need to consider measures to increase this revenue and minimize the O&M and maintenance costs.

## 4. CONCLUSIONS & RECOMMENDATIONS

Keeping in view the above considerations and needs, following recommendations may help in improving future motorway projects:

- We have following choices to solve the major problems of negotiating sharp curves in salt range on this project;
  - Either, we increase the radii of all sharp curves
  - or, increase the super elevation where possible or otherwise;
  - Somehow, the vehicles speed can be reduce for safety purposes.

- Measures must be considered to increase the toll revenue on the motorway, which can only be accomplished by increasing the traffic volumes on motorway. Some of the options which can be tried are:
  - Considering trial periods for various lower toll rates for all vehicle categories and development of traffic demand models. The price elasticity of demands can be calculated to rationalize the toll charges and comfort to road users.

  - Based on the above trial period actual results, there is a strong possibility that revenue may increase by lowering the toll rates if price elasticity is greater that unity.

  - The existing N-5 route has very congested urbanization along its alignment, so only through traffic is using the motorway at the moment. Therefore, it is very

important that some sort of industrial development (Industrial zones) be created along this new corridor so that migration of skilled and unskilled labor from rural area may create commercial/economic activities in adjacent areas.

- Over loading of trucks is a common practice in Pakistan, as truckers face weight enforcement on motorway, so majority of overloaded trucks are traveling on GT Road. It is very strongly recommended that the over loading control must be enforced on the alternate route also to divert these trucks to motorway.

- Timely completion of the other links for motorway projects so that north/south link is completed.

- One the other hand road users have felt a difference between a tension free drive with the opening of this motorway section. Now at least users have a choice to use a better facility.

- Lahore-Islamabad motorway has played a pivotal role in developing toll culture in Pakistan. People must realize that they have to pay for a better service.

- Such mega projects are only sustainable if properly evaluated based on the sound engineering and financial practices.

- We must avoid very steep longitudinal gradient on our major highways because of rutting of asphalt is likely to occur on such areas under heavy loads with increased rate of loading due to reduced speeds and high temperatures in summers. Where, such grades are unavoidable due to economic reasons, the truck lanes must be constructed with rigid pavements.

- The commercial aspects of toll road projects must be given emphasis to justify the investment.