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Modelling a services lifetime cost analysis

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SUMMARY

A model has been developed to enable an economic analysis of alternative road and stormwater drainage construction combinations for any given township, taking both capital and maintenance costs into account. The model can be used to determine which construction combination will give the lowest lifetime costs, under different maintenance conditions.

INTRODUCTION

The provision of vehicular access to and within a township, and the stormwater drainage of a township, are important factors in the overall economics of the project.

There is a need for a tool whereby to assess the standard of road and stormwater drainage infrastructure that is to be provided, and its cost-effectiveness when all costs, excluding vehicle operating costs but including road and stormwater maintenance, are taken into account.

It is recognised that minimum expenditure on roadworks during the initial construction stage may not be cost-effective since major maintenance or even reconstruction may be necessary within a very short time after completion. On the other hand, initial construction to too high a standard will have an adverse effect on the affordability of the individual erven.

"Cost" need not be only road construction and maintenance cost, but can also be expressed as inconvenience to the user. Thus, at the extreme, building a rudimentary road and then maintaining it perfunctorily infers a low lifetime cost of that road, but a very poor service.

A model has been established to assist in the identification of cost-effective combinations. The main objectives in developing this model were :

- to show the importance of including maintenance costs in the overall cost comparison of construction options;
- to provide a tool which can be utilised to answer the question "how much money should be invested in the initial construction of the roads and stormwater drainage in order to provide the most cost-effective network within a development and which will be acceptable to the residents both now and in the future?"; and
- to provide a method for comparing the present value of the initial construction cost and the maintenance cost over the economic life of the development (and particularly to show the effect of varying the maintenance standard from that initially chosen as appropriate for a particular construction standard), and hence to optimise the use of available short and long term funds.

STANDARDS OF CONSTRUCTION AND MAINTENANCE

Selected technically feasible standards of construction for roads and stormwater drainage, which are appropriate to the proposed development, should be identified during the preliminary design stage, and each costed. The range of these may include bladed tracks, blended and shaped gravel roads, surfaced roads, surface stormwater drainage systems and underground stormwater reticulation, amongst others.

An appropriate standard of maintenance, based on the type of maintenance operations required, and an associated cost, should then be assigned for each system.

The authors' firm has a substantial data bank of construction and maintenance costs, built up from many jobs undertaken or proposed throughout South Africa, and particularly from studies using the NISPAM pavement management package. It is on this data bank that the general inferences, made later in this paper, are founded.

LEVELS OF SERVICE

A level of service can be attributed to a particular road and stormwater drainage combination by assessing the probable performance of the road over a given period. Road and stormwater drainage combinations are allocated a level of service in terms of Table 1, which indicates the criteria used. These are based on accessibility and ride quality.

TABLE 1 : PROPOSED LEVELS OF SERVICE

LEVEL OF SERVICE	RIDE QUALITY	
	DRY	WET
A	Good	Good
B	Good	Fair
C	Fair	Poor
D	Poor	Very rough
E	Very rough	Impassable
F	Access on foot only	

As defined here, level of service is unrelated to the usual traffic engineering definition, which represents a measure of the operational characteristics, ability to merge and speed adjustments required to find a gap in the traffic flow. Level of service should rather be seen as a combination of the possibility of utilising the road in all weather conditions and its acceptability to the user in the access it provides, together with the maintenance required to provide that given access and ride quality.

Selection of a level of service is therefore based on a subjective assessment of the performance of the road in terms of inter alia the following -

- preparedness of the community to accept occasional inconvenience (e.g impassable road after heavy rain, at least until the repair gang finishes work)
- rutting, potholing and surface deterioration
- effectiveness of drainage
- dust generation
- safety.

For the purposes of the model, it is initially assumed that each road and stormwater drainage combination will be well maintained in order to keep the initial level of service. The effects of relaxing maintenance standards are studied later in this paper.

THE MODEL - AN EXAMPLE

An actual township development may illustrate use of the model. The vertical axis on the Figures 1 and 2, although to scale, has been rendered dimensionless, in order to emphasise that the method has been verified by data collected from many case studies.

The conclusions (e.g as to with what standards of construction the lifetime optimum lies) are however applicable only to this example. For any other township development, its own data must be collected and family of curves plotted.

The six road and stormwater drainage combinations which were considered feasible for this particular township development are shown in Table 2. They were assigned levels of service and were then cost-analysed.

TABLE 2 : COMBINATIONS OF CONSTRUCTION CONSIDERED IN THE COST ANALYSIS

STANDARDS OF CONSTRUCTION		LEVEL OF SERVICE
ROAD	STORMWATER	
Track	None	E-
Bladed track with compaction	Off-road channel (unlined)	E+
Blended in situ material wearing course with improved subgrade	On-road channel (unlined)	D
Imported wearing course material, shaped	Off-road channel, lined	C
Premix surface with full layer work	Kerb, channel and limited pipes	B
Premix surface with full layer work	Kerb, channel and pipe system	A

Economic evaluation

The base date for the economic analysis was taken as the end of construction, and all construction costs were assumed to be incurred at this time. It was also assumed that the facilities had no residual value at the end of the 20-year analysis period. A discount rate of 4% per annum was used, but this may vary for each project, depending on the developer's or local authority's assessment of the real cost of money.

The total present value of costs for the six combinations considered, calculated over the analysis period of 20 years, is presented graphically as Figure 1.

The cost curves of Figure 1 indicate that the model has the potential to identify a cost-effective combination of road and stormwater drainage construction for townships. At the chosen discount rate, the initial construction costs decrease while the maintenance costs increase with decreasing level of service.

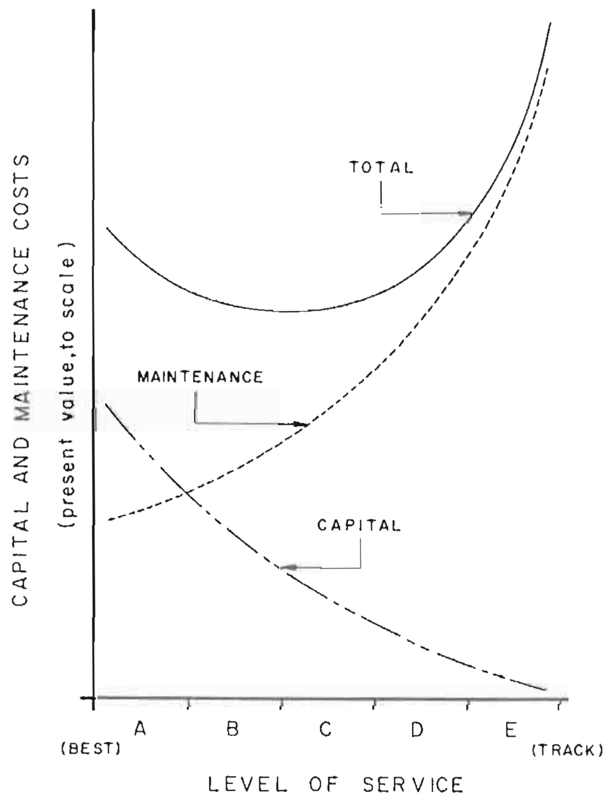

FIGURE 1 : PRESENT VALUE COSTS, WITH MAINTENANCE FOR CONSTANT LEVEL OF SERVICE

Lifetime maintenance costs many times the initial construction cost may be incurred where facilities falling within level of service E are provided. On the other hand, initial construction costs of facilities within level of service A+ are greater than the present value of lifetime maintenance costs.

It is evident in the case of this particular township that the most economic lifetime combination will be that giving a level of service between levels B and C.

At this service level, the present value of maintenance costs is significantly higher than the present value of the initial construction costs. This is obviously to a developer's advantage, but places a large responsibility on the local authority if the desired level of service is to be maintained throughout the service life of the facility.

If the desired level of service has been previously defined by the developer or local authority, it will be necessary to analyse that portion of the graph in greater detail. Other construction combinations must be costed, in order to determine a combination of road and stormwater drainage construction standard having a minimum present value of costs within the required level of service.

EFFECT OF REDUCING MAINTENANCE

In developing the model thus far, the limitation was imposed that the road receive the maintenance necessary for the level of service to remain constant with time.

Our firm also did exercises, similar to the preceding, on the consequences of reducing the necessary regular maintenance.

Our data confirms what one would intuitively expect, inter alia that if the local authority knows it is not going to spend enough on maintenance to keep up the initial high level of service, the lowest lifetime cost combination shifts the initial optimum choice towards lower and (in lifetime terms) cheaper initial standards.

The same actual development example is chosen, to illustrate the point. Figure 2, appropriately read as an overlay on Figure 1, refers. The most economic lifetime combination shifts, with progressively reducing maintenance, to that initially giving a level of service between C and D, and then, if maintenance is to be "poor", between D and E. (Plots on the horizontal axis are against those levels of service to which the combination will in course of time likely stabilise, given the named maintenance.)

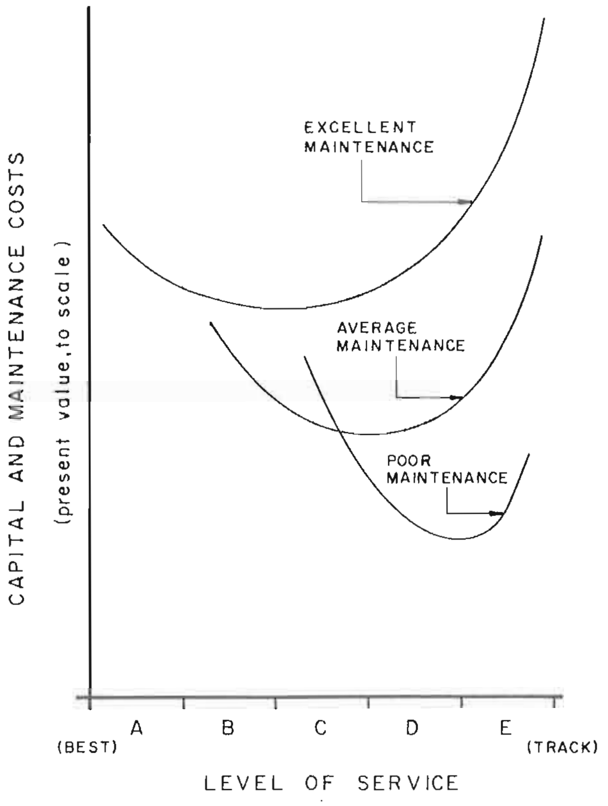

FIGURE 2 : PRESENT VALUE COSTS, WITH LESSER MAINTENANCE

FURTHER WORK ON THE MODEL

Further work that should be carried out to develop the model to its full potential, should include :

i) The effect of, having neglected maintenance and allowed the road to deteriorate, having to rebuild.

ii) Clear identification of the job creation potential of maintenance and construction work associated with lower initial construction, and the likelihood of small enterprise promotion. This potential could in some circumstances justifiably sway selection of the standard of initial construction.

CONCLUSIONS

i) This paper has demonstrated that initial provision of the highest standard of construction does not imply that the lowest lifetime costs will be applicable. The need is thus paramount to select township infrastructure standards that will result in lowest lifetime costs.

ii) A model has been developed to enable an economic analysis of alternative road and stormwater drainage construction combinations for any given township, taking both capital and maintenance costs into account. The model can be used to determine which construction combination will give the lowest lifetime costs, under different maintenance conditions.

iii) Indeed, it is possible to go even further. With careful economic evaluation, it is possible to reassess current norms for engineering standards, and still provide a particular community with the information that will enable them to participate in what would for them be striking a balance between costs and acceptable level of service. Bearing in mind that communities understandably want the highest initial standard they can get, the use of lower standards will have to be presented to them as a trade-off that enables them to get another desirable service in exchange.