ECONOMIC AND FINANCIAL ANALYSIS FOR REINFORCED SOIL WALL IN SUBMERGED CONDITION

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ABSTRACT

This paper presents an economic and financial viability of Reinforced Soil (RS) wall in submerged condition. Indian Roads Congress (IRC): Special Publication (SP): 102-2014 is the basic guideline for RS wall and this guideline is silent for construction of RS wall in submerged condition. Different guidelines discourage to use RS wall in the submerged condition. Federal Highway Administration (FHWA) recommended to construct RE Wall in this condition to provide stone aggregate in reinforced zone with depth up to High Flood Level(HFL)+0.3 m along with warping using geo-textile. A case study is adopted for analysis using conventional concrete wall and reinforced earth retaining wall. Economic analysis and financial viability has been carried out considering the case study using Highway Design and Maintenance (HDM) 4 Model accepted internationally. It is found that maximum Net Present Value (NPV) and Economic Internal Rate of Return (EIRR) and minimum Total Transportation Cost (TTC) are found for the case of provision conventional concrete wall. Therefore, it is concluded that conventional concrete wall is best option and this shall be considered and recommended for the case of bridge/irrigation canal to avoid failure of RS Wall. Financial analysis has also been carried out and it is found that the same option is also viable financially from the same case study.

Keywords: *NPV, IRR, FIIR, HDM 4, TTC, HDM-4, TPC, R E Wall*

1. INTRODUCTION

Reinforced Earth (RE) Wall is used on the both sides of Vehicular Over Pass, Rail Over Pass, Flyover and bridge approaches including valley side in case of a hill road in place of stone / RCC wall. RE Wall construction is easier, cheaper and requires lesser time i.e., faster construction. RE Wall is also constructed in different projects in Bangladesh. RE Walls are designed using AASHTO, BS Code, IRC Code and other standard codes.

IRC Code generally discourages to construct RE Wall near water body (IRC: SP: 84-2018, IRC: SP: 87-2020) and these codes clearly mentioned that RE Wall construction should be avoided near water body. Sometimes river, canal pipe and box culverts cross or run parallel to RE Wall. As a result submergence condition may occur during the design life of 100 years of RE Wall. In the case RE Wall shall be constructed above high flood level of river, full supply level of irrigation canal to avoid submergence. RE walls along streams and canals require calculation for the extra burden /force by hydrostatic pressure. A minimum differential hydrostatic pressure equal to 1.0 m of water is recommended in AASHTO for design.

In the case of rapid draw down rapid drawdown situation water temporarily trapped behind the wall panels can create an unbalanced head condition and reduce the factor of safety in relatively fine-grained (sandy to silty) backfills and there is a chance of eroding and / or removing fine soil in this condition. To avoid this problem it is suggested to adopt fully permeable draining aggregate material backfill for such Reinforced Earth structures. This fill material has high shear strength parameters that give higher design factors of safety for slipping and reinforcement pullout.

Alternately, No. 57 stone material as mentioned in Table 1 as specified in AASHTO M 43 may be provided as reinforced filling material for the entire reinforced zone of the wall up to the maximum depth of submergence of the wall. A geocomposite as filter media may be provided at the interface of the No. 57 coarse aggregate and reinforced backfill above it, at the interface of the retained backfill behind it, and at the interface of the coarse gravel and subgrade beneath it. The geotextile should meet the filtration and serviceability criteria as mentioned Section 700 of MORT&H 2013. Adjoining sections of geotextile filter/separator shall be overlapped by a minimum of.3 m. An example detail is shown in Figure1.

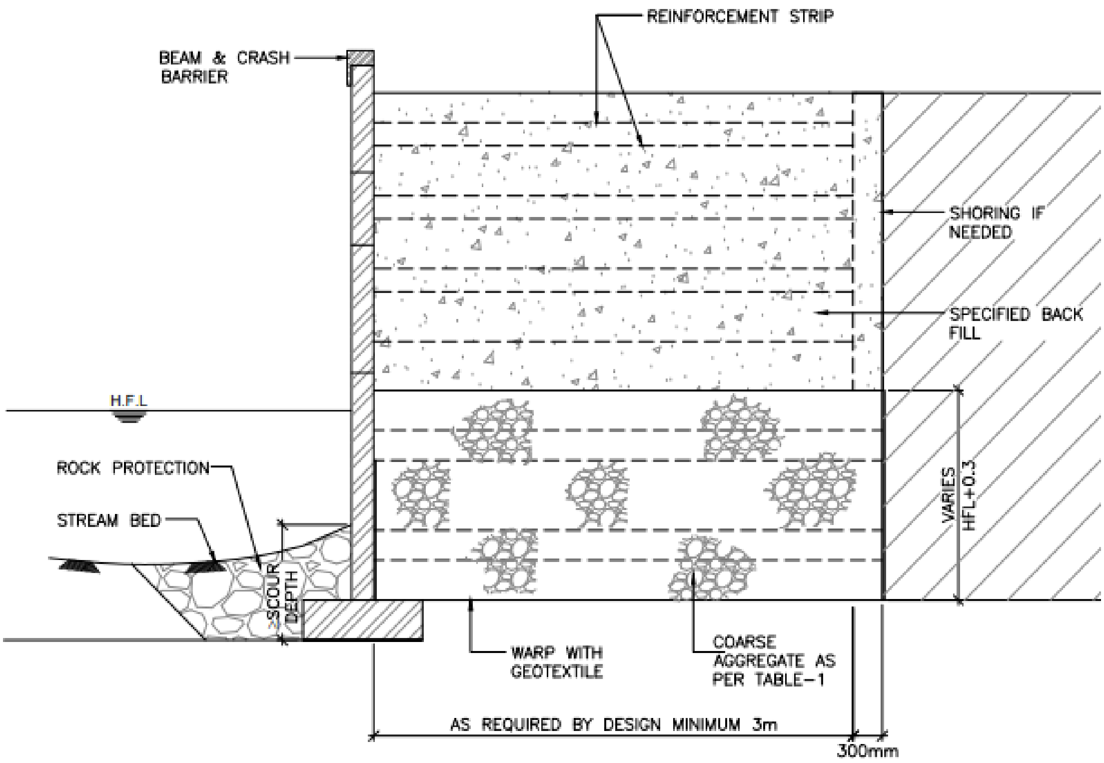

Figure.1 Typical RE Wall in Submerged Condition

Table 1 Grading of Free Draining Material

Sieve Size(mm)	Passing (%)
37.5	100
26.5	95-100
13.2	25-80
4.75	0-10
75micron	0-5

Construction of RE Wall in submerged condition involves huge cost. Conventional Reinforced Cement Concrete retaining wall is an alternative option. Economic analysis and financial viability are required to adopt best option for Government funding project and Public Private Partnership (PPP) project.

Highway Design and Maintenance (HDM 4) Standard model is generally used for economic analysis and lifecycle analysis for a highway project. The model has different sub-models. This model is generally used project level, program level and network level analysis.

The straightforward data files required for running HDM 4 using Road system, Vehicle taskforce, road construction works and configuration of HDM.Financial analysis is carried out to determine financial viability of any infrastructure project including road and highway projects. Generally an excel sheet is developed based on standard practice /standard software and this sheet is used to determine financial viability of a project.

It is not generally recommended to construct Reinforced Soil (RS) wall in submerged condition to avoid failure of RS wall. IRC: SP:84-2019 recommended that RS shall not be provided near water body. It will reduce EIRR. Commercial viability analysis with cost of RS wall needs to be carried out for a road project. Literature review on economic analysis and financial analysis have been reviewed and presented in the next section.

2. PAST STUDIES ON ECONOMIC ANALYSIS AND FINANCIAL ANALYSIS

2.1 On Economic Analysis

Kery and John 2003 established to bring about Local Government Authority (LGA) roads in an economically optimization using most current distress models for the main highways of the State Road Authority System (SRAS).

Life-Cycle Cost Analysis (LCCA) of infrastructure project, including pavements, to take a longer-term approach that is used, primarily to confirm sustainability and evaluate the effects of today´s conclusions correctly (Haas et al. 1999).

LCCA is a method for assessing entire economic worth of a practical project section by examining original costs and reduced upcoming costs, such as those for repairs, rebuilding, restoration and resurfacing. One of the most significant components in the LCCA process is either a system level or an assignment level and optimizes Total Transportation Cost (TTC) (Vadakpat et al. 2000).

LCCA has been implemented by transportation agencies in the detailed design phase of transport projects in order to expedient more cost-effective strategies, to funding choice in pavement type selection and also to evaluate the comparative costs of different restoration options within each type of pavement (Rangaraju et. al. 2008).

LCCA models deal engineers a means to assess the expected long-term monetary performance of potential design and building alternatives (Fagen and Phares 2000).

One main shortcoming in the use of LCCA for analyzing long term infrastructure projects is the uncertainty in the value of the LCCA parameters (Hesham 2005).

Accessibility is a main element of rural improvement in developing nations. This was evaluated for 2 objective purposes: t*o optimize NPV and to reduce Total Transportation Costs (TTC)***.** The design period was twenty years; economic analysis was also carried out at a discount rate of twelve percent (Veeraragavan and Reddy 2003).

2.2 On Financial Analysis

Dias and Iaonnou 1995 concluded that NPV and return on equity of a Build Operate & Transfer (BOT) project are thoughtful to the particular Debt/ Equity (D/E) proportion and that decay rapidly as the organizer takes money more than optimum amount in an effort to the extent of project's debt capacity level. The D/E proportion rules are particular to the nation.
In India, the permissible D/E proportion for road projects had been limited up to 70:30 as an encouragement to support denationalization (Malini 1997, Dias and Ioannau, 1996).
The use of optimum principal arrangement merits important care during the project estimation phase. Scientific Model to define best D/E ratio was established lastly. Tiong(1995) witnessed from his relative study of six BOT assignments from different countries that ratio of D/E varied from 100:0 to 80:20. The procedure of a static E/D ratio of 15/85 or 20/80 (H. Ali S et al, 2004) may not be appropriate for all Buid Operate & Transfer projects.

Bagui and Ghosh (2009a, 2009b) dealt with the effect of glare screen barrier uses. They observed that Vehicle Operating Cost (VOC) varied with the application of glare screen barrier and it decreases the toll tariff vehicle mode wise..

From the literature review as mentioned above, it is found that past study using RS wall in submerged condition is very limited. Therefore, there is a need of study using HDM 4 for economically viability and financial viability for using RS wall in submerged condition.

2.3 Scope

The scope of the present research work is selection of economic and financial viability of RS Wall in submerged condition. Economic analysis has been carried out taking a case study with different construction options and justified based on Total Transportation Cost (TTC), NPV, EIRR and other economic parameters like Road Agency Cost (RAC) and Road User Cost (RUC).
Financial analysis is the consideration of proposal of RS wall in submerged condition and determine viability whether this proposal is financially viable. This can be acceptable by assessing Financial Internal Rate of Return (FIRR) and NPV.

2.4 Case Study

The construction of selected section of National Highway (NH 2) is considered a case study. The project road is a two lane road with 30 km long and it will be improved by four lanes divided carriageway. Economic and financial analysis has been carried out for a case with total traffic 6000 per day at the time opening with vehicle compositions :Passenger Car:2700,Bus:900,Light Commercial Vehicle:600,Two Axle Vehicle:600,Three axle vehicle:300 and Multi-axle Vehicle:900 .Traffic growth factor has been taken from traffic report and it varies from 6 % 8.5 %Maintenance cost is mentioned in Table 2..Project cost has been determined and presented in Table 3.

2.5 Economic Analysis

HDM 4 is a useful tool for economic analysis. It uses for economic viability of the projects in project level for implementation of a particular project or network level for finalization of government network.

2.6 Framework Analysis

The proposed assessment framework is established on a cost-benefit analysis. The underlying philosophies for this exploration are as follows:

- A discount rate of 12 % is applied to forthcoming economic costs and reimbursements to get at the NPV and EIRR of the scheme;
- To examine the expenditure at fixed prices, an budget is made for comparative value rise; and
- The customary method used for the evaluation for transportation schemes has been implemented. Analysis is proficient by evaluating the suitable development proposal that hints to least TCC, which covers of following basic components shown below:

a) Road Agency Costs (RAC): building and Maintenance cost;
b) Road User Costs (RUC): Vehicle Operating, Other (like travel time costs) and Accident Cost;
c) Total Transportation Cost (TTC) =RAC+RUC

2.7 Assumptions

The following assumptions are adopted for economic analysis:

- Economic cost is taken as 0.9 of financial cost;
- Average cost per km is taken for economic analysis;

- Different costs like, vehicle mode wise cost, tire cost, fuel cost, repair cost, rehabilitation costs, working, non-working cost, value of time have been calculated based on IRC: SP:30;
- Default calibration factors have been considered in the analysis;
- Discount rate is adopted 12 % as recommended by the World Bank;
- Project is analyzed for design period of 20 years;
- Condition responsive maintenance schedule is considered;
- Pavement condition, inventory data of existing road have been used for analysis; and
- With and without improvement / rehabilitation has been considered.

2.8 Input Files

The input data files required for HDM 4 and input parameters related to maintenance during operation period are already presented in Table 2. Project level analysis has been carried out in the present study. All input data have been collected to conduct economic analysis.

3. ECONOMIC ANALYSIS FOR DETERMINATION OF REINFORCED SOIL WALL IN SUBMERGED CONDITION

3.1 Background

RS wall is used in different conditions. It is economical and this may be used as an alternative of conventional reinforced cement concrete wall and it is constructed quickly comparing other mode of the protection works. Presently, it is also observed that RS wall is proposed on irrigation canal, minor / major bridges structures, where there is a chance of submergence of RS wall which may be one of the causes of failure of RS wall.

IRC: SP: 102-2014 is silent of provision of RS wall in submerged condition. Federal Highway Administration (FHWA) proposed with some improvements backfill material. Aggregate / stone is to be used up to High Flood Level (HFL) + 0.3 m and same will be warped with geo-textile already shown in Figure.1.

3.2 Speed

The existing road is a two lane of the selected section National Highway (NH) 2 and it is proposed to two upgrade four lanes divided carriageway with 5 m wide median and un-paved shoulders.Pavement condition of existing road is fair to poor condition with average speed of 20 km/hr.

3.3 Costing and Maintenance Alternative

There are proposed 20 RS walls on minor bridges, major bridges and river canal with feeder road/inspection road. Length of road 30 km with project cost is Rs 105 million/km in 2006. But, there is a chance failure of RS wall which needs additional maintenance cost.

The project cost will be increased to Rs.110 million for the case of using concrete wall. Cost will be increased to Rs.115 million per km for using aggregate reinforced material on reinforced zone with depth equal HFL+0,3 m.

Maintenance policy has been mentioned in Table 2.

Table 2: Maintenance Policy

Alternative	Description of Work	Intervention Criteria
i) Functional	40 mm Asphalt Concrete	Schedule every fifth year
ii) Structural	40 mm Asphalt Concrete + 60 mm Binder	Schedule every tenth year.

	Concrete	
iii) Predictable Repair	Patch, pot-hole repair, sealing of crack, cleaning of drain, culvert bridge etc.	Schedule annually

For this project, the following alternatives have been taken.

Case – 1 : Base Case Option – do least
This case is :regular repair - annually, serviceable overlay – every 5th year, essential overlay - every 10 th year.

C*ase – 2 : Improvement Options*
The following improvement options have been considered for economic analysis as follows:

a) Widening and strengthening of current 2 lanes road to 4 lanes road and regular repair, serviceable and fundamental strengthening as mentioned in Table 2 with project cost Rs105 million per km+RS wall on Bridge location.
b) Same as (a) + RS wall is replaced by conventional concrete wall with cost Rs.110 million per km
c) Same as (a) + RS wall with aggregate stone in reinforced with project cost Rs.115 million per km +RS wall with aggregate stone in reinforced zone.
d) Widening and strengthening of current 2 lanes road to 4 lanes road and regular repair, serviceable and fundamental strengthening in Table 1 with project cost Rs (105+15) million will be used at fifth year for repairing RS wall per km +RS wall on Bridge location+ maintenance and repair of RS wall.

HDM 4 is used for Economic analysis. Results of economic analysis for different cases as mentioned above have been presented in Table 3 for 30 km length of the road.

Table 3 Economic Parameters

Case	**Project Cost Per km(Rs. Million) Economic/ Financial**	**Economic Parameter (Rs. Million)**				**IRR (%)**
		NPV	RAC	RUC	TTC	
‘a	Not included due to	unsafe	design			
‘b	110 / 122	2314.5	2768.9	17924.1	20693.0	20.7
‘c	115 / 128	2188.8	2894.7	17924.1	20818.7	20.0
‘d	120 133	1788.7	2870.9	18349.9	21220.8	19.4
Base	-	-	99.46	22908.1	23997.6	-

Note: Case a is uncertain and RS wall may be failed at any point of time during construction and operation period and this option is discarded and cost is not included in Table 3. It is technically unsound practice and it needs extra maintenance and repair cost of RS wall which is covered in Case d. Finally, it is found from above table (Table 2) that Case b is best option, neglecting Case a. Case c is the best practice which is mentioned in FHWA may be considered but it is not cost effective. Total transportation cost is minimum for the Case b. Hence, it may be concluded that reinforced cement concrete wall is best option bridge structure. Failure of risk is least for this case. Hence, it can (Case b) be considered. NPV, RAC, RUC and TTC are plotted and presented in Figure 2. However, case C may be considered an alternative option.

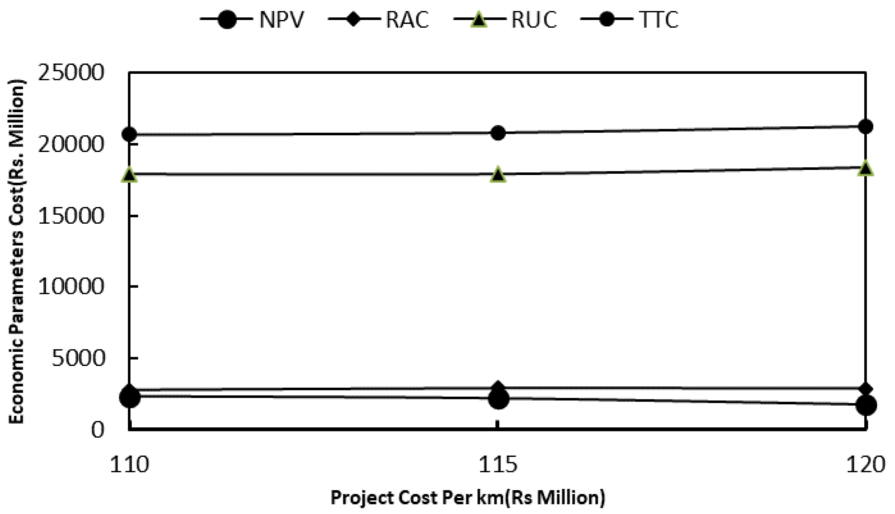

Figure :2 Different Economic Parameters

From Table 3, it has been established that maximum net present value is found for Case b and followed by Cases c and d. Hence, the case b is most economically viable option and tailed by cases c and d.

4. FINANCIAL ANALYSIS

Standard Excel sheet has been developed and Total Project Cost (TPC) and financial parameters have been determined and presented here in.

A financial model has been proposed in this present study to determine financial viability of the project.

4.1 Assumptions

The followings assumptions have been made for financial analysis:

1. Funding of a project is raised up by a mixture of debt and equity. A finance is available from single lender or from different lenders with the similar term of annual identical repayments;
2. The Government of India will bear land acquisition cost;
3. The expenditure during construction are predetermined;
4. The toll rate fixed by the Government of India ; and
5. Devaluation of the TPC is permissible during operation period.

Theoretical Framework

Ranasinghe (1996) has established a basic method to determine TPC for projects in power sector project which is used in commercial analysis. This model has been *modified in the present study incorporating Maintenance Cost During Construction (MCDC)* to use in road project and defined as follows (Bagui and Ghosh 2011):

TPC=BC+EDC+IDC +MCDC (1)

Where,

TPC = Total Project Cost;

BC = Base Cost ;

EDC = Escalation during Construction;

IDC = Interest during Construction; and

MCDC = Maintenance cost during construction.

Income is made from fee paid by road users during the service period, which is permanent based on practical feasibility of the schemes. The net currencies available in current value specified by NCAi can be determined as follows (Ranasinghe1996):

NCAi=PBITi-TAXi+DEPi-Di for i=1, 2…….n (2)

Where,
NCAi=Net Cash available;
PBITi = Profit Before Interest and Tax;
TAXi = Tax;
DEPi =Depreciation; and
Di = Annual Debt Installment for i^{th} year.
TAXi= (PBITi-INTi). TAXi =Tax rate for i=1, 2…… n (3)

Where,
INTi = Interest to be paid in the i^{th} year.

4.2 Repayment

Let r be interest of debt, P be debt and D be re-payment amount. Re-payment plan is considered and untaken ./
At the of n th year Outstanding / Capital will be zero.
Hence
$P(1+r)^n-D(1+r)^{n-1}- D(1+r)^{n-2}$-------D(1+r)-D=0 (4)

$(1+r)^n= D(1+r)^{n-1}+ D(1+r)^{n-2}$------+D(1+r)+D= $\frac{D(1+r)^n-1}{1+r-1}$ (5)

Pr $(1+r)^n = \frac{D(1+r)^n-1}{r}$ (6)

$$\text{Pr} = \frac{D[(1+r)^n-1]}{(1+r)^n} \quad (7)$$

An amount of Debt at the year j = (D- Pr) $(1+r)^{j-1}$ (8)
Taking value of Pr, amount of debt decreases to:

$$Dj = D[1-\frac{(1+r)^n-1}{(1+r)^n}](1+r)^{j-1} \quad (9)$$

$$Dj = D(1+r)^{-(n-j+1)} \quad (10)$$

Equation 10 is the main formula for repayment schedule fixed by the Government of India for a project when same amount payment shall be re-paid by the BOT Operator / Concessionaire.

4.3 Depreciation

Reduction is estimated based on the following formula (Chandra 2008):

$$DEP_1 = BV_0 r$$
$$DEP_2 = BV_0 r(1-r)$$
$$DEP_i = BV_0 (1-r)^{(i-1)} r \quad (11)$$

Where,
DEP = Depreciation charge;
BV = Book value; and

r = Depreciation rate.

4.4 Operation and Maintenance Cost

These expenditures include O & M of road cost, salaries of employees, indirect costs and insurance cost and other costs. These costs are estimated and considered in analysis as recommended by Lehman (1988).

Project economic cost is mentioned in Table 3 and financial cost for different cases are calculated as: Financial cost=economic cost/0.9 and financial analysis was carried out considering all these costs along with RE wall maintenance, periodic and structural overlay cost and other consideration. Due lesser traffic, the project was not viable financially and Viability Gap Funding (VGF) was found to be 35 % and summary of financial analysis is presented in Table 3.
Rate of interest on debt and return of equity holder are taken fifteen percent and twenty percent respectively. Discount rate has been estimated using following Equation:

$$\text{Discount rate} = (\text{Equity}\times 20+\text{debt}\times 15)/100 \tag{12}$$

Finally financial analysis has been carried out Total Project Cost Vs Equity and FIRR, Discount Rate Vs Equity are plotted and presented in Figrue.3 and Figure.4 respectively
From Figure.3, it is found that TPC decreases with increasing Equity.
From Figure.4, it is observed that FIRR increases with increasing equity and reach maximum value and decreases after attaining maximum value.
FIRR for different cases are calculated and presented in Table 4. From Table 4, it is found that maximum FIRR and NPV are obtained from the case of least financial cost i.e., Option 2 (Case b) is also best option which may be considered.

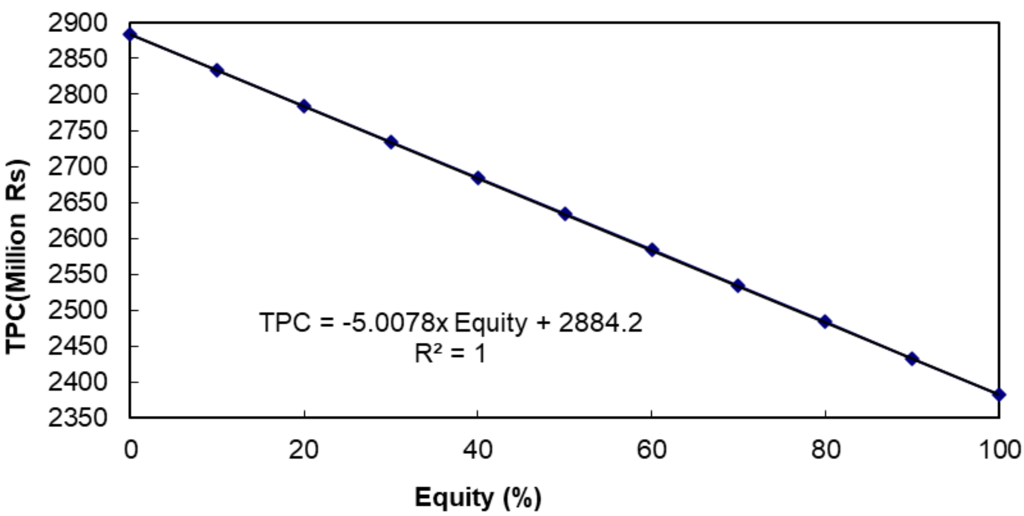

Figure:3 Variation of Equity Vs. TPC

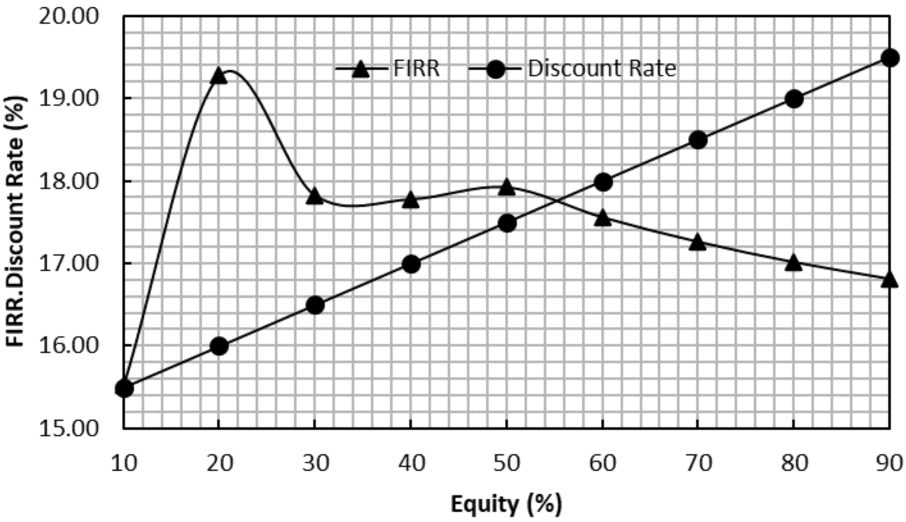

Figure:4 Determination Optimum Debt Equity Ratio

Table 4 Financial Parameters

Case	Project Cost Per km (Rs. Million)	FIRR (%)	NPV (Rs. Million Rs)
‘b	122	19.27	408
‘c	128	18.60	334
d	133	17.9	258

5. DISCUSSION AND CONCLUSIONS

Economic analysis and financial analysis have been carried out for a case study with different provision of RS Wall, conventional concrete wall, RS wall with stone in the reinforced zone and RS wall with maintenance of RS wall i.e., three cases as mentioned in this present study. HDM 4 is used for economic analysis and a spread sheet was developed based on past texts and revised for necessity of the present needs. Following inferences / conclusions may be drawn:

- Total Project Cost (TPC) is a function of equity as shown in Fig.3. It varies Rs 828 million to Rs 686 million. From Figure 3, it is also found that total project cost decreases linearly with negative slope with R^2=1.
- From economic analysis, it is found that total transportation cost is lowest for the case of provision of conventional concrete wall on water retaining structures namely bridge and canal for a road project. Therefore, it suggested to avoid RS wall in this condition.
- FIRR increases non-linearly for equity up to 20 % and it decreases for equity more than 20 %.
- Optimal investment of lender and concessionaire can be determined using present proposed model. It varies from 0.8 to 0.9(Feasible range of project). It varies from case to case.
- It is observed from Fgure 4 that at optimal debt equity ratio of 4(0.8/0.2)
- From Figure 4, it is also found that FIRR increases with increasing equity up to optimal equity of 20 % and thereafter it decreases with increasing equity.
- Project is viable for equity range of 10-55 % and project is not financial viable for equity more than 55 % as noticed from Figure 4. This is varying in nature.
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