7600.10.
203

No. RW/NHIII/COORD/86/84 *Dated the 12th July, 1985*

CIRCULAR

A reference is invited to Ministry's letter of even number dated the 18th March, 1985 addressed to all State Chief Engineers with copy endorsed to all Technical Officers, on the subject of Economic Analysis of major highway projects, followed by Ministry's letter of even number dated the 21st March, 1985, on the subject addressed to all Technical Officers dealing with roads in the Headquarter's Office of the Roads Wing.

2. A case study on Economic Analysis of Alternative Proposals for Pavement Widening of Shillong-Jowai Section of National Highway 44 in Meghalaya has been conducted using I.R.C. Publication 30 "Manual on Economic Evaluation of Highway Projects in India" and the newly developed Traffic Simulation Model. A copy of the Economic Analysis carried out is enclosed for illustrating the methodology and approach to be adopted for conducting similar evaluation studies.

Encl : As above.

To all Technical Officers dealing with Roads in the H.O.

CASE STUDY ON ECONOMIC ANALYSIS — ALTERNATIVE PROPOSALS FOR PAVEMENT WIDENING OF SHILLONG —JOWAI SECTION OF N.H. 44 IN MEGHALAYA

1. INTRODUCTION

Economic evaluation of Highway Projects has assumed special significance due to scarcity of resources and competing demands from various sections in a developing economy needing allocation of the scarce resources in the most beneficial and selective manner. Highway economic analysis, also called Highway Project appraisal, is a technique whereby the costs of and benefits from a scheme are quantified over a selected time horizon and measured by a common yardstick. The technique is also named as cost-benefit anaysis.

2. SALIENT POINTS OF THE STUDY PROJECT

2.1 3.2 km stretch of Shillong-Jowai Section of NH. 44 in Meghalaya has been selected for economic evaluation of various alternative strategies of pavement widening. The work of widening of the reach Mile 31 and 32 of this section stands included in the annual plan 1984-85. At present, the reach has a signle lane pavement with inadequate formation width. The work of widening and strengthening of the carriageway to 5.5 metres (intermediate lane) up to 15th mile from Shillong has been sanctioned and is in progress.

2.2 Due to recent discovery of coal bearing area near Jowai, the traffic has significantly increased. The average daily traffic-count recorded on the 26th December, 1983 to 1st January, 1984 was :

Fast Moving vehicles :

i)	Cars, Jeeps, Vans etc.	450 nos.
ii)	Buses	114 nos.
iii)	Trucks	1022 nos.
iv)	Motor-cycles, Scooters	8 nos.

SLOW MOVING VEHICLES

i)	Cycles	1 no.

2.3 The terrain of N.H. 44 from Shillong to Jowai is predominantly hilly/rolling with sharp curves and steep gradients. The State P.W.D. has been requesting the Ministry to consider widening the carriageway to double lane in view of increasing traffic volume. Considering the overall financial implication of the pavement widening project covering a significant length of road vis-a-vis the prevailing resource constraints it was deemed prudent to conduct economic evaluation of the various alternative strategies for pavement widening, also using the recently developed traffic simulation model, so that a techno-economically viable alternative could be selected.

Various options considered were :

i) Widening to two-lane pavement

ii) Widening to intermediate lane pavement

iii) Retain the existing single lane ("Do nothing" or "Null" alternative)

2.4 PEAK HOUR TRAFFIC CONSIDERED FOR ANALYSIS

	Type of Vehicle	Traffic in 1983 in No. of vehicles per hour.	Projected Traffic 1986	1991	1996
i)	Cars, Jeeps & Vans	45	56	80	115
ii)	Buses & Trucks	114	141	203	292
iii)	Motor cycles	1	1	2	2
	Total	160	198	285	409

2.5 ASSUMPTIONS MADE FOR ANALYSIS

i) Peak hour traffic considered 10% of ADT.

ii) Growth rate as 7.5% per year.

iii) Period of construction as 2 years

iv) Equal directional distribution

2.6 CUMULATIVE RISE AND FALL PER KILOMETRE

As computed from the longitudinal profile of the road.

Ist km = 31.53 m
2nd km = 29.85 m
3rd km = 20.17 m
4th km (part) = 13.0 m

In view of the prevailing gradients,the terrain has been taken as rolling.

3. TOTAL TRANSPORTATION COST

It consists of :

i) Cost of construction of the facility initially

ii) Periodic cost of maintaining the facility over its design life.

iii) Road user cost

3.1 Initial cost of construction of the facility (widening and strengthening of 3.2 km stretch)

i) FOR TWO-LANE PAVEMENT

Pavement widening = Rs 43.34 lakhs
Formation widening = Rs 26.31 lakhs

Rs 69.65 lakhs

ASSUME TWO YEARS CONSTRUCTION PERIOD

Economic cost of road construction and maintenance = 0.8 (Financial cost)
Economic cost of construction in 1985 = ½ × 69.65 × 0.8
= Rs 27.86 lakhs
Economic cost of construction in 1986 = Rs 27.86 lakhs

ii) FOR INTERMEDIATE-LANE PAVEMENT

Pavement widening = Rs 27.61 lakhs
Formation widening = Rs 26.31 lakhs

Rs 53.92 lakhs

Economic cost of construction in 1985 = ½ ×53.92 × 0.8
= Rs 21.57 lakhs
Economic cost of construction in 1986 = Rs 21.57 lakhs

3.2 COST OF MAINTENANCE

a) Ordinary repairs per year

i) For two-lane pavement = 0.8 × 14,700 × 3.2
= Rs 37,600/-

ii) For 1½ lane pavement = 0.8 × 13,500 × 3.2
= Rs 34,600/-

iii) For single lane pavement = 0.8 × 12,500 × 3.2
= Rs 32,000/-

(b) PERIODIC RENEWAL/3 YEAR

i) For two lane pavement = 0.8 × 78300 × 3.2
= Rs 2,00,400/-

ii) For 1½ lane pavement = 0.8 × 61,500 × 3.2
= Rs 1,57,400/-

iii) For single lane pavement = 0.8 × 40,950 × 3.2
= Rs 1,04,800/-

4. DETERMINATION OF HIGHWAY COSTS

4.1 The first two components of the total transportation i.e. the cost of construction of the facility initially and the periodic cost of maintenance of the facility over its design life are known collectively as 'Highway Costs'.

4.2 The cost of construction of the facility includes :

i) Survey, investigation and design costs

ii) Lane acquisition costs

iii) Construction costs

iv) Physical contingences (unforeseen items and unforeseen increase in cost not attributable to escalation and unforeseen increase in quantities)

v) Supervision, quality control and administration charges.

4.3 The cost of maintenance of the facility includes :

i) Ordinary repairs, such as patch repairs, pot-hole filling, dressing earthwork etc.

ii) Periodic repairs, such as renewals and resurfacing

iii) Operational expenses, such as traffic signals, traffic aid posts, lighting, policing etc.

iv) Supervision and administration charges.

4.4 When dealing with the highway costs, it is necessary to phase the same year by year. Similarly in the case of maintenance costs, the year-by-year costs have to be identified.

4.5 DIFFERENCE BETWEEN ECONOMIC COSTS AND FINANCIAL COSTS

In economic analysis, one is concerned with economic costs and not financial costs. Economic costs are based on the "opportunity cost" of each of the constituents of the cost, such as labour, material and machinery. In order to device the economic costs, these constituents have to be isolated, quantified and adjusted on the basis of certain principles.

4.6 SHADOW PRICING

Adjustments needed in the prices of goods and wages to make them reflect truly their market value are known as shadow pricing.

(i) Shadow wage rate is half the actual wages paid.

(ii) There is no need to shadow-price for semi-skilled and skilled labour since there is generally a scarcity of these categories and the market wages more or less reflect this situation.

(iii) Shadow-price foreign exchange at 20% above the official rate.

(iv) For commodities produced both locally and imported (e.g. fuel oil), border price should be considered (c.i.f. price).

(v) Taxes like import duty, excise duty and sales tax and licence fees levied by the Govt. on a number of items are not considered in the economic cost. (These are in fact transfer payments within the economy).

(vi) Subsidies granted to certain commodities (e.g. levy cement) should be disregarded.

The above principles of shadow pricing apply equally to the cost stream (highway construction and maintenance cost) and the benefit stream (road user benefits).

4.7 TREATMENT OF INFLATION

Escalation and inflation, both on the cost stream and the benefit stream, are disregarded.

4.8 INTEREST ON CAPITAL COST OF CONSTRUCTION :

Since Highway projects in India are at present financed solely from Govt. funds, there is no need to include yearly interest on the initial cost of construction in economic analysis.

5. ROAD USER COST

It is composed of the following main components.

(i) Vehicle operating cost

(ii) Time cost

(iii). Accident cost

5.1 VEHICLE OPERATING COST

5.1.1 Cost of operation of vehicles is a function of :

i) Pavement width

ii) Rise and fall of road

iii) Road roughness

Formulae used :

$$\text{Log}_e \text{ VOCB} = 0.5972 + \frac{1.2253}{W} + 0.0112\,RF + 0.000037\,RG$$

$$\text{Log}_e \text{ VOCT} = 0.5869 + \frac{1.1999}{W} + 0.00982\,RF + 0.000025\,RG$$

$$\text{Log}_e \text{ VOCC} = 0.7351 + \frac{1.2201}{W} + 0.0148\,RF + 0.000076\,RG$$

VOCB Cost of operation of buses/trucks/cars per km (in Rs/km) exclusive of taxes.
VOCT
VOCC

W = Pavement width in metres

RF = Cumulative rise and fall measured from the vertical profile of the road in terms of the metres of rise and fall per kilometre.

RG = Roughness in mm/km

Cost of operation of two wheelers = $\frac{1}{5}$ VOCC

5.1.2 Cost of operation of various categories of vehicles (car, bus, truck and two wheeler) have been worked out in Rs/vehicle for alternative pavement widths and horizon years 1986, 1991 and 1996 and are shown in table 1. For facility of illustrating the technique of economic analysis the period of analysis has been reckoned as 10 years.

Table 1: Cost of operation of vehicles for the study stretch for alternative pavement widths in years 1986, 1991 and 1996 in Rs/vehicle.

Pavement width and year		Cost of operation in Rs/vehicle			
		VOCC	VOCB	VOCT	VOCTW
Two	1986	3.62	10.87	9.85	0.72
Lane	1991	3.76	11.07	9.97	0.75
	1996	3.90	11.28	10.09	0.78
Intermediate	1986	3.79	11.40	10.32	0.76
lane	1991	3.94	11.61	10.45	0.79
	1996	4.09	11.83	10.58	0.82
Single	1986	4.58	13.23	11.80	0.92
Lane	1991	4.58	13.23	11.80	0.92
	1996	4.58	13.23	11.80	0.92

Note : Cost of operation for intermediate years may be interpolated.

5.1.3 Following assumptions have been made with regard to the roughness values in the absence of actual roughness measurements. With the acquisition of roughometers it should be possible to quantify the actual values.

	Roughness values in mm/km.		
Pavement width	1986	1991	1996
Two-lane	4000	4500	5000
Intermediate-lane	4000	4500	5000
Single-lane	5000	5000	5000

5.2 TRAVEL TIME SAVINGS

5.2.1 Savings in travel time are enjoyed by bus passengers, car passengers and two-wheeler riders. These are also relevant in respect of the commodity in transit. The following values at 1984 price level have been used in the present analysis based on results from the Road User Cost Study.

(i) Car and two wheeler passengers — Work trip — Rs 13.13/hour

Non work trip — Rs 3.28/hour

(ii) Bus passengers — Work trip — Rs 7.19/hour

Non Work trip — Rs 1.80 hour

(iii) Commodity in transit — Rs 3.00/hour

Take work trips as 75 per cent of total and non work trips as 25 per cent of total.

5.2.2 The occupancy of cars, two wheelers and buses should be found from actual surveys. In absence thereof, the following values have been assumed.

Average occupancy of a car	4.0
Average occupancy of a two-wheeler	1.5
Average occupancy of a bus	43.0

5.2.3 Based on the above assumptions, value of travel time per vehicle is worked out as below.

Value of travel time per car = $(0.75 \times 13.13 + 0.25 \times 3.28) \times 4$
= Rs 42.67/hour

Value of travel time per bus = $(0.75 \times 7.19 + 0.25 \times 1.80) \times 43$
= Rs 25.23/hour

Value of travel time per two-wheeler = $(0.75 \times 13.13 + 0.25 \times 3.28) \times 1.5$
= Rs 16.00/hour

5.2.4 For computation of travel time cost, vehicle speed is another parameter needing quantification. This has been arrived at by the use of the recently developed Traffic Simulation Model. For single lane pavement journey speeds could not be simulated. These have, therefore, been worked out on the basis of speed-volume relationships recommended in 'Manual on Economic Evaluation of Highway Projects in India' (IRC — Special Publication 30) as given below :

Considering the terrain as rolling, journey speeds on single-lane pavement are :

V_C	(Speed of cars)	= 42.43 — 0.084 HV
V_B	(Speed of buses)	= 40.07 — 0.069 HV
V_T	(Speed of trucks)	= 37.05 — 0.052 HV
V_{TW}	(Speed of two-wheelers)	= 37.69 — 0.052 HV
	Where HV	= Hourly traffic volume (No. of vehicles in peak hour)
		= 0.1 ADT
ADT		= Average daily traffic in number of vehicles.

The average simulated/calculated journey speeds in km/hour for various vehicles types are indicatd in table 2.

Cost of travel time for various vehicle types in Rs/vehicle are shown in table 3.

5.3 ACCIDENT COST SAVINGS

These have not been taken into account in the present case since scant data with regard to the accident rate and costing is available which may be inadequate to provide a basis for inclusion in economic analysis at the present. It may be possible to do so after a satisfactory level of data bank has been achieved.

5.4 BENEFITS FROM HIGHWAY IMPROVEMENTS

The benefits from highway improvements can be classified as :—

(i) ROAD USER BENEFITS

(a) Vehicle operating cost savings.

(b) Value of travel time savings

(c) Value of savings in accident costs

(ii) SOCIAL BENEFITS

(a) Improvements in environmental standards i.e. air and noise pollution, aesthetics etc.

(b) Improvements in agriculture, industry, trade and mining.

(c) Improvements in health and education.

(d) Improvements in administration, law and order and defence.

It is at present possible to quantify only the direct road user benefits. Full quantification of benefits can be possible only after evaluation of other aspects is possible on the basis of further research. In the present case study, therefore, only the direct road user benefits have been considered.

6. TECHNIQUE OF ECONOMIC EVALUATION

6.1 The basic objective of the economic analysis is to determine the most ideal solution from among a number of alternatives. In the case study the two alternative options i.e. intermediate laning or two-laning of the existing single lane pavement have been evaluated and compared with the "do-nothing" alternative.

6.2 METHODS OF ECONOMIC EVALUATION :

Three common methods of economic evaluation are :—

(i) Net present Value Method

(ii) Internal Rate of Return Method

(iii) Benefit/Cost Ratio Method

All these methods are based on the Discounted Cash Flow Technique of discounting all future costs and benefits to a common year. In this case the base year chosen is 1985.

6.2.1 NET PRESENT VALUE (NPV) METHOD

In this method, the stream of costs/benefits associated with the project over a specified period of time is calculated and discounted at a selected discount rate to yield the present value. Benefits are taken as positive and costs as negative and the summation yields the NPV. Any Project with a positive NPV is reckoned as acceptable. While comparing more than one project, a project with the higher NPV is accepted.

6.2.2 BENEFIT/COST (B/C) RATIO METHOD

All costs and benefits are discounted to their present worth and the ratio of the benefits to costs is calculated. If the B/C ratio is more than one, the project is deemed worth implementation.

6.2.3 INTERNAL RATE OF RETURN (IRR) METHOD

The internal rate of return is the discount rate which makes the discounted future benefits equal to the initial outlay i.e. it is the discount rate which makes the stream of cash flows to zero.

The solution for the appropriate discount rate can be found by trial and error. In the present analysis a graphical technique has been used and found to be quite workable. Three alternative discount rates are chosen and the discounted stream of cash flows is calculated. A graphical plot of discount rates versus net cash flow enables accurate determination of IRR, which is the discount rate which yields zero cash flow.

No doubt with a computer programme, the work is rendered very simple.

6.3 METHOD CHOSEN FOR THE CASE STUDY

IRR method has been selected for the case study in view of the following advantages :—

(i) The computed rate of return can be easily compared with the market rate of interest.

(ii) It avoids the need for selecting a discount rate initially.

(iii) It is well-suited for use in CAD model.

(iv) It is popular with international lending agencies like the World Bank.

In order to tide over the tedious computations, graphical method, as explained above, has been used rendering the computation work simpler. Manual analysis had to be resorted to since the software (programme) for evaluation in respect of intermediate/two lane strategies is not presently available. Computer programme has so far been developed for pavement widths more than two lane pavements.

7. COMPUTATIONS FOR ECONOMIC EVALUATION :

7.1 Based on costs of operation and travel time for various vehicles indicated in Table 2 and 3 and cost of construction and maintenance worked out in para 3 above, the transportation cost comprising of costs of construction, maintenance, vehicle operation and travel time has been calculted yearwise for the analysis period 1985-1986, and for single lane, inter-

mediate lane and two-lane pavements and shown in tables 4 and 5. The traffic has been projected for different years based on 7.5% anticipated growth rate and is shown in table 4.

7.2 Tables 6, 7, 8 and 9 show the IRR calculation for the following options :

(i) Table-6 for intermediate lane pavement vis-a-vis single lane, without considering cost of travel time.

(ii) Table-7 for two lane pavement vis-a-vis single lane, without considering cost of travel time.

(iii) Table-8 for intermediate lane pavement vis-a-vis single lane, considering cost of travel time.

(iv) Table-9 for two-lane pavement vis-a-vis single lane, considering cost of travel time. Graphical plots for determination of IRR for the above options are shown in Annexures I & II.

7.3 For discounting the future benefits and cost to the present worth (base year 1985), necessary table showing present worth (PW) factors against number of years is annexed (Annexure III)

8. CONCLUSIONS

The computations as shown in the above noted tables yield the following IRR values.

	Widening strategy	IRR VALUE	
		Without time cost	With time cost
1.	Intermediate-lane pavement	21.2%	48.6%
2.	Two-lane pavement	21.75%	50.4%

As may be observed form the above results, the alternative proposal for widening the existing single lane to two lane pavement yields slightly higher economic return as compared to intermediate lane strategy (50.4% IRR against 48.6%). In addition it affords better travel speeds as may be seen from table 2. Additionally it affords better level of service for the traffic with diminished accident risks due to lesser congestion. Moreover the differential economic return should be higher for two lane option in case the normal 20 year analysis period is considered.

Keeping all these considerations in view, it was decided to go in for two-laning of the study stretch.

TABLE 2 : AVER AGE SIMULATED/CALCULATED JOURNEY SPEEDS FOR VEHICLE TYPES IN KM/HOUR

PAVEMENT WIDTH & YEAR		AVERAGE JOURNEY SPEED IN KM/HOUR			
		CAR	BUS	TRUCK	TWO WHEELER
TWO LANE	1986	43.15	36.15	36.15	43.15
	1991	42.40	35.80	35.80	42.40
	1996	40.05	34.55	34.55	40.05
INTERMEDIATE LANE	1986	34.75	30.30	30.30	34.75
	1991	32.05	28.95	28.95	32.05
	1996	28.70	26.25	26.25	28.70
SINGLE LANE	1986	25.80	26.40	26.80	27.40
	1991	18.50	20.40	22.23	22.87
	1996	8.07	11.85	15.78	16.42

TABLE 3 : COST OF TRAVEL TIME FOR VARIOUS VEHICLE TYPES IN RS./VEHICLE

Year	Travel cost/car			Travel cost/bus			Travel cost/truck			Travel cost/two wheeler		
	Two Lane	1½ Lane	Single Lane	Two Lane	1½ Lane	Single Lane	Two Lane	1½ Lane	Single Lane	Two Lane	1½ Lane	Single Lane
1986	3.17	3.94	5.31	22.31	26.62	30.55	0.27	0.32	0.36	1.19	1.48	1.87
1987	3.19	4.01	5.72	22.35	26.86	32.31	0.27	0.32	0.37	1.19	1.50	1.95
1988	3.20	4.07	6.13	22.40	27.11	34.06	0.27	0.32	0.39	1.20	1.53	2.02
1989	3.21	4.14	6.54	22.44	27.36	35.82	0.27	0.33	0.40	1.20	1.55	2.10
1990	3.22	4.21	6.95	22.48	27.61	37.58	0.27	0.33	0.42	1.21	1.58	2.17
1991	3.23	4.27	7.36	22.53	27.86	39.34	0.27	0.33	0.43	1.21	1.60	2.24
1992	3.27	4.37	9.23	22.69	28.43	45.02	0.27	0.34	0.47	1.23	1.64	2.42
1993	3.31	4.47	11.10	22.85	29.00	50.71	0.27	0.35	0.50	1.24	1.68	2.59
1994	3.34	4.57	12.97	23.01	29.58	56.40	0.27	0.35	0.54	1.25	1.71	2.76
1995	3.38	4.67	14.84	23.18	30.15	62.08	0.28	0.36	0.57	1.27	1.75	2.94
1996	3.42	4.77	16.70	23.34	30.72	67.77	0.28	0.37	0.61	1.28	1.79	3.11

TABLE 4 : TRANSPORTATION COST FOR TWO LANE PAVEMENT

ALL AMOUNTS IN THOUSAND RUPEES

Year	Cost of const.	Cost of Maintenance	Traffic Volume (ADT)				Cost of vehicle operation	Cost of Travel Time				
			C	B	T	TW		C	B	T	TW	Total
1985	2,786	—	520	132	1,181	9	—	—	—	—	—	—
1986	2,786	—	559	142	1,270	10	—	—	—	—	—	—
1987	—	38	601	152	1,365	11	6326	699	1,240	133	5	2,077
1988	—	38	646	164	1467	11	6,823	754	1,341	143	5	2,243
1989	—	238	694	176	1,577	12	7,357	813	1,441	154	5	2,413
1990	—	38	747	189	1,696	13	7,938	878	1,551	166	6	2,601
1991	—	38	803	203	1,823	14	8,559	947	1,669	179	6	2,801
1992	—	238	862	219	1959	15	9231	1028	1,814	194	7	3,043
1993	—	38	927	235	2,106	16	9,955	1119	1,960	210	7	3,296
1994	—	38	997	253	2,264	18	10,739	1217	2,125	227	8	3,577
1995	—	238	1,072	272	2,434	19	11,583	1323	2,301	246	9	3,879
1996	—	38	1,152	292	2,617	20	12,492	1438	2,488	266	9	4,201

TABLE 5 : TRANSPORTATION COST FOR INTERMEDIATE LANE AND SINGLE LANE PAVEMENT

ALL AMOUNTS IN THOUSAND RUPEES

Year	Cost of Construction		Cost of Maintenance		Cost of vehicle operation		Cost of Travel time	
	Intermediate Lane	Single Lane	Intermediate Lane	Single Lane	Intermediate Lane	Single Lane	Intermediate Lane	Single Lane
1985	2,157	—	—	32	—	—	—	—
1986	2,157	—	—	137	—	—	—	—
1987	—	—	35	32	6,630	7,627	2,535	3,241
1988	—	—	35	32	7,151	8,196	2,763	3,700
1989	—	—	192	137	7,711	8,808	3,002	4,199
1990	—	—	35	32	8,319	9,472	3,263	4,756
1991	—	—	35	32	8,971	10,181	3,546	5,371
1992	—	—	192	137	9,674	10,943	3,902	6,851
1993	—	—	35	32	10,433	11,763	4,278	8,507
1994	—	—	35	32	11,255	12,648	4,698	10,390
1995	—	—	192	137	12,140	13,598	5,153	12,498
1996	—	—	35	32	13,092	14,617	5,644	14,852

TABLE 6 : I.R.R. CALCULATIONS FOR INTERMEDIATE LANE PAVEMENT WITHOUT TIME COST

ALL AMOUNTS ARE IN THOUSAND RUPEES

Year	Cost of Operation (V.O.C.)		Benefit (Saving V.O.C.)	Construction and Maintenance cost		Cost	Discounted by 20% to base year 1985		Discounted by 21% to base year 1985		Discounted by 22% to base year 1985	
	Single Lane	Intermediate Lane		Single Lane	Intermediate Lane		Benefit (B)	Cost (C)	Benefit (B)	Cost (C)	Benefit (B)	Cost (C)
1	2	3	4=2-3	5	6	7=6-5	8	9	10	11	12	13
1985	—	—	—	32	2,157	2,125	—	2,125	—	2,125	—	2,125
1986	—	—	—	137	2,157	2,020	—	1,683	—	1,669	—	1,656
1987	7,627	6,630	997	32	35	3	692	2	681	2	670	2
1988	8,196	7,151	1,045	32	35	3	605	2	590	2	575	2
1989	8,808	7,711	1,097	137	192	55	529	27	512	26	495	25
1990	9,472	8,319	1,153	32	35	3	463	1	445	1	427	1
1991	10,181	8,971	1,210	32	35	3	405	1	386	1	367	1
1992	10,943	9,674	1,269	137	192	55	354	15	334	14	315	14
1993	11,763	10,433	1,330	32	35	3	309	1	289	1	271	1
1994	12,648	11,255	1,393	32	35	3	270	1	251	1	233	1
1995	13,598	12,140	1,458	137	192	55	235	9	217	8	199	8
1996	14,617	13,092	1,525	32	35	3	205	—	187	—	171	—
						Total=	4,067	3,867	3,892	3,850	3,723	3,836
						(B-C)	+	209	+ 42		− 113	

TABLE 7 : I.R.R. CALCULATIONS FOR TWO LANE PAVEMENT WITHOUT TIME COST

ALL AMOUNTS ARE IN THOUSAND RUPEES

Year	Cost of Operation (V.O.C.)		Benefit (Saving in V.O.C.)	Construction and Maintenance cost		Cost	Discounted by 20% to base year 1985		Discounted by 21% to base year 1985		Discounted by 22% to base year 1985	
	Single Lane	Two Lane Pavement		Single Lane	Two Lane Pavement		Benefit (B)	Cost (C)	Benefit (B)	Cost (C)	Benefit (B)	Cost (C)
1	2	3	4=2-3	5	6	7=6-5	8	9	10	11	12	13
1985	—	—	—	32	2,786	2,754	—	2,754	—	2,754	—	2,754
1986	—	—	—	137	2,786	2,649	—	2,208	—	2,189	—	2,171
1987	7,627	6,326	1,301	32	38	6	903	4	889	4	874	4
1988	8,196	6,823	1,373	32	38	6	795	3	775	3	756	3
1989	8,808	7,357	1,451	137	238	101	700	49	677	47	655	46
1990	9,472	7,938	1,534	32	38	6	616	2	591	2	568	2
1991	10,181	8,559	1,622	32	38	6	543	2	517	2	492	2
1992	10,943	9,231	1,712	137	238	101	478	28	451	27	426	25
1993	11,763	9,955	1,808	32	38	6	420	1	393	1	368	1
1994	12,648	10,739	1,909	32	38	6	370	1	343	1	319	1
1995	13,598	11,583	2,015	137	238	101	325	16	300	15	276	14
1996	14,617	12,492	2,125	32	38	6	286	1	261	1	238	1
						Total =	5,436	5,069	5,197	5,046	4,972	5,024
						(B-C)	+ 367		+ 151		−52	

TABLE 8 : I.R.R. CALCULATIONS FOR INTERMEDIATE LANE PAVEMENT WITH TIME COST

ALL AMOUNTS ARE IN THOUSAND RUPEES

Year	Cost of Operation and Time cost Benefit			Construction and Maintenance cost Cost			Discounted by 30% to base year 1985		Discounted by 50% to base year 1985		Discounted by 40% to base year 1985	
	Single Lane	Intermediate Lane		Single Lane	Intermediate Lane		Benefit (B)	Cost (C)	Benefit (B)	Cost (C)	Benefit (B)	Cost (C)
1	2	3	4=2-3	5	6	7=6-5	8	9	10	11	12	13
1985	—	—	—	32	2,157	2,125	—	2,125	—	2,125	—	2,125
1986	—	—	—	137	2,157	2,020	—	1,554	—	1,347	—	1,443
1987	10,868	9,165	1,703	32	35	3	1008	2	757	1	869	2
1988	11,896	9,914	1,982	32	35	3	902	2	587	1	722	1
1989	13,007	10,713	2,294	137	192	55	803	19	453	11	597	14
1990	14,228	11,582	2,646	32	35	3	713	1	348	—	492	1
1991	15,552	12,517	3,035	32	35	3	629	1	266	—	403	—
1992	17,794	13,576	4,218	137	192	55	672	9	247	3	400	5
1993	20,270	14,711	5,559	32	35	3	681	1	217	—	377	—
1994	23,038	15,953	7,085	32	35	3	668	—	184	—	343	—
1995	26,096	17,293	8,803	137	192	55	639	4	153	1	304	2
1996	29,469	18,736	10,733	32	35	3	599	—	124	—	265	—
					Total= (B-C)	7,314	3,718 +3596	3,336	3,489 −153	4,772	3,593 +1,179	

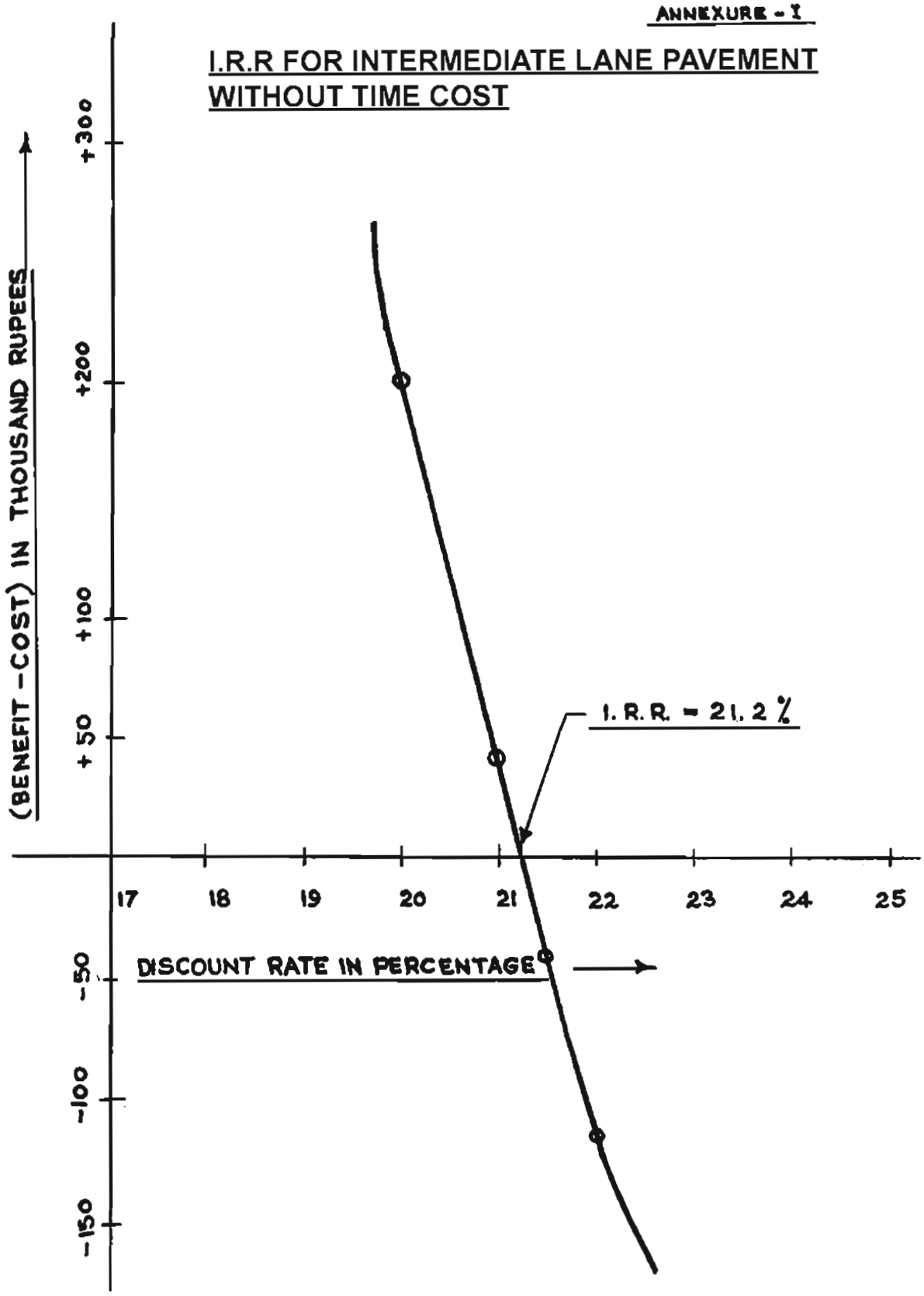
TABLE 9 : I.R.R. CALCULATIONS FOR TWO LANE PAVEMENT WITH TIME COST

ALL AMOUNTS ARE IN THOUSAND RUPEES

Year	Cost of Operation and Time Cost Benefit			Construction and Maintenance cost Cost			Discounted by 30% to 1985		Discounted by 50% to 1985		Discounted by 40% to 1985	
	Single Lane	Two Lane		Single Lane	Two Lane		Benefit (B)	Cost (C)	Benefit (B)	Cost (C)	Benefit (B)	Cost (C)
1	2	3	4=2-3	5	6	7=6-5	8	9	10	11	12	13
1985	—	—	—	32	2,786	2,754	—	2,754	—	2,754	—	2,754
1986	—	—	—	137	2,786	2,649	—	2,038	—	1,766	—	1,892
1987	10,868	8,403	2,465	32	38	6	1,459	4	1096	3	1,258	3
1988	11,896	9,066	2,830	32	38	6	1,288	3	839	2	1,031	2
1989	13,007	9,770	3,237	137	238	101	1,133	35	639	20	843	26
1990	14,228	10,539	3,689	32	38	6	994	2	486	1	686	1
1991	15,552	11,360	4,192	32	38	6	868	1	368	1	557	1
1992	17,794	12,274	5,520	137	238	101	880	16	323	6	524	10
1993	20,270	13,251	7,019	32	38	6	860	1	274	—	476	—
1994	23,038	14,316	8,722	32	38	6	822	1	227	—	422	—
1995	26,096	15,462	10,634	137	238	101	771	7	184	2	368	3
1996	29,469	16,693	12,776	32	38	6	713	—	148	—	315	—
						Total= (B-C)	9,788	4,862 +4926	4,584	4,555 +29	6,480	4,692 +1788

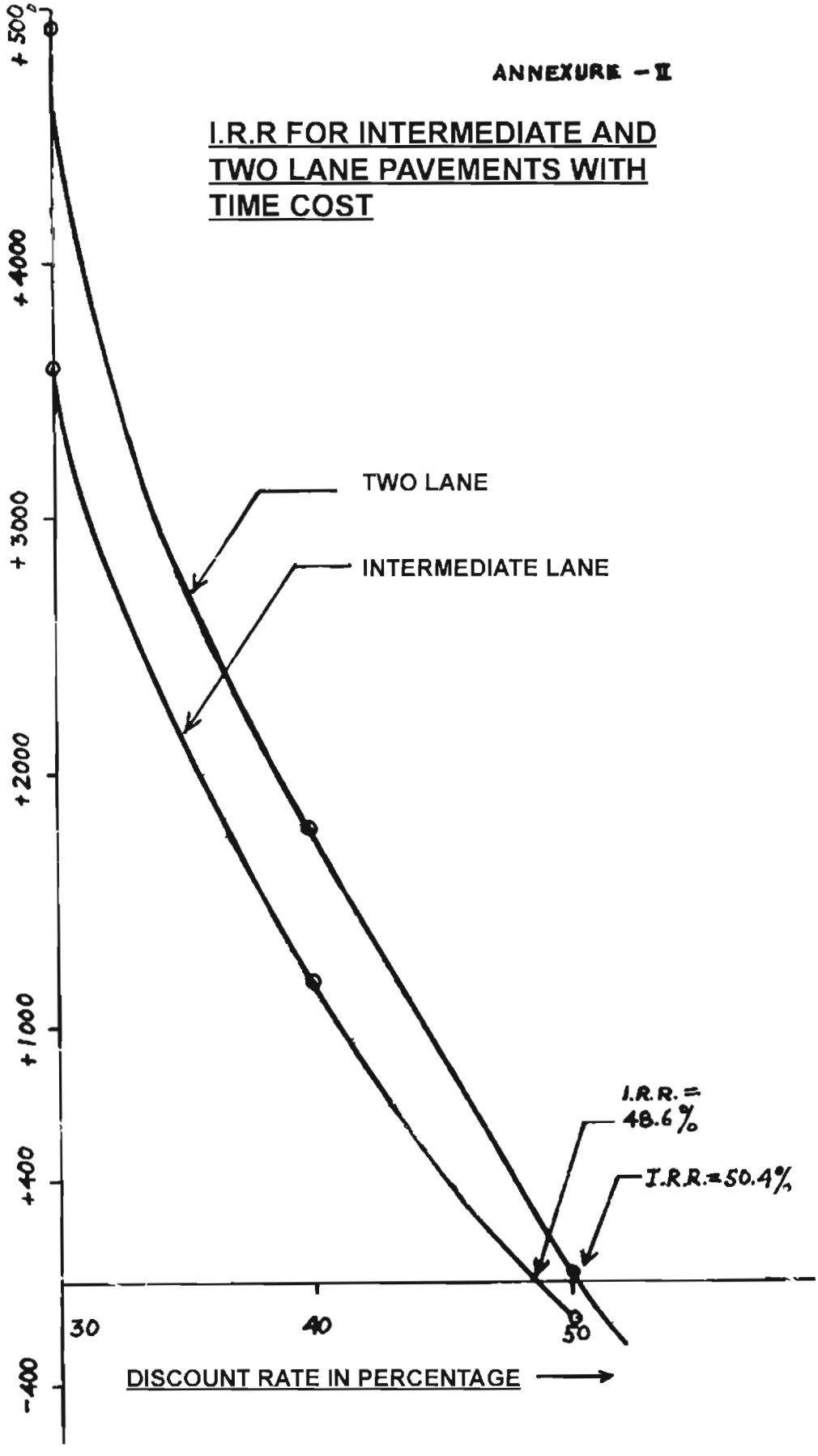
ANNEXURE - I

I.R.R FOR INTERMEDIATE LANE PAVEMENT WITHOUT TIME COST



ANNEXURE – II

I.R.R FOR INTERMEDIATE AND TWO LANE PAVEMENTS WITH TIME COST



ANNEXURE III

PRESENT WORTH FACTORS FOR FUTURE BENEFITS/COSTS

No. of Years	PW Factors		
	Discount Rate 20%	Discount Rate 21%	Discount Rate 22%
1	0.8333	0.8264	0.8197
2	0.6944	0.6830	0.6719
3	0.5787	0.5645	0.5507
4	0.4823	0.4665	0.4514
5	0.4019	0.3855	0.3700
6	0.3349	0.3186	0.3033
7	0.2791	0.2633	0.2486
8	0.2326	0.2176	0.2038
9	0.1938	0.1799	0.1670
10	0.1615	0.1486	0.1369
11	0.1346	0.1228	0.1122
12	0.1122	0.1015	0.0920
13	0.0935	0.0839	0.0754
14	0.0779	0.0693	0.0618
15	0.0649	0.0573	0.0507

ANNEXURE - IV

I.R.R. FOR TWO LANE PAVEMENT WITHOUT TIME COST