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Cost Effective Analysis of Lane Widening (Single Lane To Double Lane)

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Abstract- **The purpose of the study was to determine the cost effective analysis of lane widening. Information concerning traffic volume was obtained for over 5km of roads to design traffic and traffic load in terms of standard axle load for next 10 years. The need for widening of road from single lane to two lanes is justified as per the capacity of road. Experimental tests on sub grade was done for different soil samples of sub grade .Design of purposed flexible pavement was done considering the CBR value of sub grade and traffic load obtained as per IRC: 37-2001.Detailed estimate was done as per OPWD manual. And the value of cost-benefit ratio was calculated. Since this value comes more than one, the road is economically viable for the proposed lane widening.**

Keyword- lane widening, single lane, double lane, traffic load and cost-benefit ratio method.

I. INTRODUCTION

The present road (SH-34) carry medium to heavy traffic. It is assessed that it carries about 40% of the total road traffic, although it was only about 4% in length. Due to expansion of the road network in rural areas, traffic on these roads continued to rise; still it is in single lane carriageway. For conversion of two laning it requires the entire length to minimum two lane standards and some segments with additional hard shoulders. Strengthen of weak pavement is necessary in order to improve the riding.

The literature review provides guidelines to assist in the improvements of single lane to double lane carriage way in cost effective manner. . A better understanding between present status of the traffic and its demand is necessary. Yinhai Wang Ngan&Atli Bjorn E. levy in TNW, Feb-2008 [1] studied the safety improvement programme of roads in cost effective manner.Jenniferoxley,BruceCorbin(ISBN,April,2004) [2]studied that introduction of speed reduction measures installation of barrier system, introduction of grade separated intersection are used to reduce crash and injury risk up to 10-12%. Zenger, C.V. and Mayes, J.G, in KBH, July1979 [3]) has further studied that the effects of geometrics and operation on accidents to determine the cost effectiveness of widening lanes and shoulders on rural roads, two lane roads. Mehul I Patel, Prof. N.G.Raval, Volume: I, Issue: X, July – 2012[4] studied the laboratory investigations on a number of soil samples procured from different roadwork sites and give the relationship between CBR value of sub grade soil and moisture content. Dr. (Mrs.) Bandanna Tare and Er. Raj Mohammad Khan[5] studied that the need for widening of road from single lane to two lanes is justified as per the capacity of road and NPT value is positive, the project becomes viable.

Details of Project study area: The present road (Parlakhemundi-Mohana road, SH-34) came under Gajapati District of Odisha. The district is lying between18^0.46' North and 19^0.39'North latitude and 83^0.48' east and 84^0.08'East longitude. The area is abutting the state boundary i.e. Andhra Pradesh towards South. This road is of 102.9 km length having plain terrain with some section of rolling terrain,which connects district headquarter of Gajapati district(Parlakhemundi) and passing through thickly populated tribal blocks of the district.

Problems due to existing lane width: The entire length of road proposed in this project is black topped surface, mostly single lane carriage way of 3.30mt having crust thickness of 300mm.The details of road section under study were collected through Test Pit. Existing Crust Composition on present road had found as follows in the following Table .

TABLE I (Showing existing crust composition)

Thickness	**Composition**
150 mm	Sub grade soil
150 mm	WBM
25 mm	SDBC

Objectives:

- The main objective of this paper is to investigate the traffic volume survey, to design the computation of future traffic.
- Provisions for the improvement of existing pavement based on pavement design (as per IRC: 37-2001).
- Cost benefit ratio after widening from single lane to double lane.

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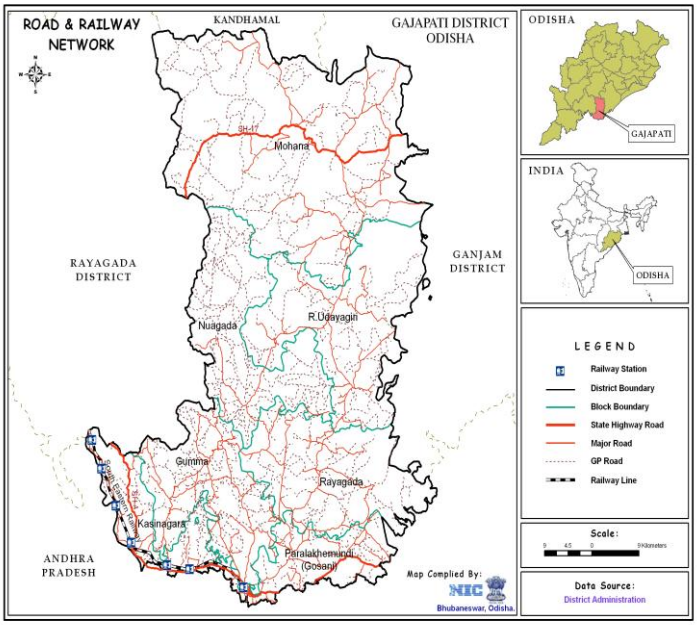
Fig.1(Road network of Gajapati district)

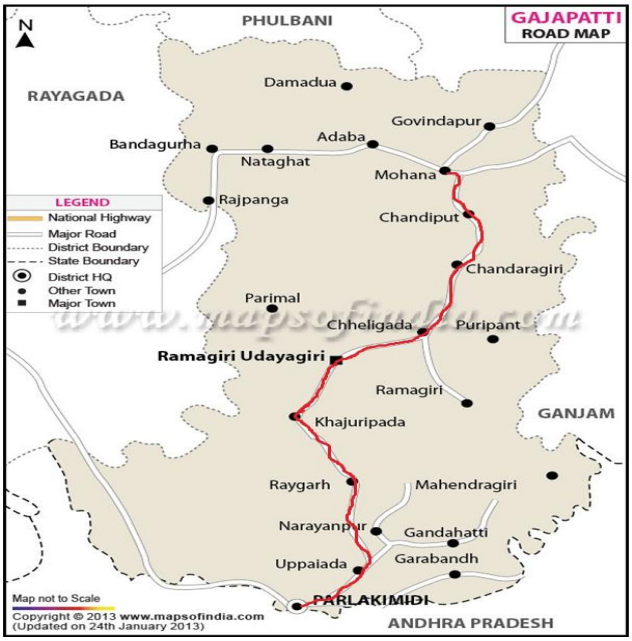


Scope:

Since, this has been badly distressed in several stretches due to plying of heavy commercial vehicle, improvement of this is essential to cater the modern traffic demand to facilitate the people of this region.

Above studies, motivated the authors to investigate the traffic survey, design of traffic, design of pavement and cost-benefit ratio analysis to know economic viable of the project

Fig.2 (Road selected 0 to 5 km chainage)



II. METHODOLOGY ADOPTED

Based on the selected route, to achieve the objectives a methodology is adopted which includes the following steps and results of each step have been calculated they are.

A. Design Analysis

B. Cost Analysis

A. Design Analysis

It includes computation of design traffic, experimental studies on sub grade and design of pavement.

B. Cost analysis

It includes detailed road development, estimate of purposed lane and cost- benefit ratio method.

1) Computation of design traffic:

In this method, computation of traffic study for the road may be carried out as per IRC: 9, the work is done for a week and the survey results are shown in the to determine the Passenger Car Unit (P.C.U.) per day, using the equivalency factor given by the IRC and commercial vehicle per day (CVPD) are tabulated in Since the existing road is a single lane, design traffic should be based on total number of commercial vehicle per day (CVPD) in both directions is to be determined.

Then the projected traffic (A), is to be calculated as per the present traffic data's by using the following formula,

$$A=P\,(1+r)^{x+n}$$

Where,A= number of commercial vehicles per day for design

P = number of commercial vehicles per day at last count

r = Annual growth rate of commercial traffic

n = Number of years between the last count and the year of completion of construction

x = design life in years

Further, the design traffic is considered in terms of the cumulative number of standard axles (in the lane carrying maximum traffic) to be carried during the design life of the road. This can be computed using the following equation,

$$N = 365/r * \{(1+r)^{n-1}\} *A*D*F*10^{-6} \quad (1)$$

Where N=Cumulative no. of standard axles to be created for the design

A=Initial traffic in the year of completion of construction in terms of projected traffic

F=Vehicle damage factor=3.50 (for 150-1500CVPD)

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D=Lane distributor factor=0.75

n=Design life in year

r=Annual growth rate of commercial vehicle=7.50%

2) Experimental studies on sub grade: The main function of sub grade is to provide adequate support to pavement and for this the sub grade should possess sufficient stability under adverse climate and loading conditions. . Following tests should be done from 0km to 5km chain age and they are:

3) Grain size analysis (IS: 2720-part 4): The sieve analysis was carried out simply, in taking weighed quantity (500gm) of the disturbed sample for chain age of 0/0km to 1/0 km , soaking it in water overnight and washing out the finer fraction through 75 micron IS sieve. The fraction retained was dried and then passed through a series of sieves. The test results are shown in the A graph was drawn taking particle size along x-axis and percentage finer along y-axis which was shown in the Graph.

(IS: 2720-part 5): The numerical difference between liquid limit and plastic limit was calculated as plasticity index (P.I.). The test was carried out in a Casagrande liquid limit device. The moisture content of which a soil water mix when rolled into a thread on a glass plate starts crumbling at 3mm diameter gives the plastic limit (P.L.). The casagrande device, in which a cup containing a groove specimen was made to fall on a rubber plate. The number of blows to close the groove to a length of about 12.5 mm was determined for different moisture content .The test results for liquid limit and plastic limit are shown in.The moisture content corresponding to 25 blows was determined as the liquid limit when a graph was drawn between umber of blows and moisture content along the x-axis and y-axis respectively. This graph was also known as flow curve was shown in the Graph.

4) Proctor compaction (IS: 2720-part 7): This test was conducted to determine the achievable density in field and the optimum moisture content required for compaction. It was conducted in a proctor mould. The soil sample (about 2 kg of air dried soil and passing through 4.75 mm sieve, add to this soil certain percentage of water based on dry weight uniformly and mix it carefully) was compacted in three layers giving 25 blows on each side by a standard rammer at five different moisture contents. The test results for dry weight and water content are shown in. A graph was drawn between moisture content and dry density along x-axis and y-axis respectively to determine the optimum moisture content (OMC), which was shown in the Graph. The other two sample of chain age from 1/0km to3/0km was done to know the OMC in the same manner.

5) The California Bearing Ratio (CBR): IS 2720-part 16

It was extensively used for design of flexible pavements in India. The test was carried out on a sample (about 4.5 kg of oven dried and add required quantity of water to the soil, mix it thoroughly) compacted in the prepared mould in five layers and each layers receives 55 blows of the specified rammer and soaked for four days. The CBR of the specimen was computed from the load needed for 2.5 mm/5.0 mm penetration of a standard plunger determined from the graph between penetration and load. The test result are shown in and the load- penetration graph was shown in the Graph .The other two sample of chain age from 1/0km to 3/0 km was done to compute the CBR value in the same manner.

6) Design of pavement (as per IRC: 37-2001): The pavement designs was calculated, using the given traffic load and soil strength as per the pavement design curve and catalogue of IRC: 37-2001 .

1. Design traffic in terms of cumulative number of standard axles (obtained from design traffic given as per 2. CBR value of sub grade (obtained from CBR test on sub grade given as per)

Then, the pavement composition layer was calculated as per IRC: 37-2001 basing on widening and overlay portions of the pavement. The composition of different pavement layer is shown in (for) and for portions of pavement)

B. Cost Analysis (It includes the following)

1) Detailed road development study: Detailed survey work was carried out to know the road development study which is done by means of two types of sections such as longitudinal and cross sections**.** A longitudinal section (L/S) is run along a predetermined line such as the centre line of a road. By plotting longitudinal sections; the nature of the ground surface along the proposed alignment maybe studied. It determines the relationship between the existing ground surface and the levels of the new work to fix up the proposed work in an economical, field feasibility and safe way. Practically, in the design of works various longitudinal sections are run along the proposed lines and the comparative costs of works along these lines are worked out. The best suited among the above is taken up for execution. In lane widening (lane conversion) the final level was fixed basing on crust thickness and existing gradient. The field party is composed of (1) A leveler who directs the ranging of the line, observers and records the staff readings and distances (2) A staff man who holds the staff on suitable points on the ground and (3) Two chainmen who measure the distances. The leveling operation should always start from a bench mark and end on a bench mark (either permanent or temporary). It shows the details such as datum line, existing ground surface and position of drainage crossings. And the detail plotting of c/s was shown in are taken during the progress of longitudinal section to obtain a clear knowledge of the undulations of the ground perpendicular to the centre line of the work (on either side of centre line) and sufficient length to cover the limits of the work. The length of cross sections on either side of the centre line varies with the nature of the proposed work at the site. Cross sections should be drawn every 100m. Checking was done to find

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out accuracy of survey work as follow Difference of level between sums of B.S. and F.S. = Difference of Level between first and last R.L.

2) Cost analysis by Cost- Benefit Ratio method: Cost analysis has been done for the entire project on the basis of overlay and widening design as per the rate from OPWD, 2008(analysis of rate), lead statement (as per quarry map), the detailed estimate was prepared per km length. Cost–benefit ratio method was typically used by governments to evaluate the desirability of a given intervention. It is an analysis of the cost effectiveness of different alternatives in order to see whether the benefits outweigh the costs.

The costs and benefits of the impacts of an intervention are evaluated in terms of the public's willingness to pay for them (benefits) or willingness to pay to avoid them (costs).

Cost-benefit analysis:

- If the PW of benefit - PW of costs >= 0.
  The alternative is considered acceptable.
- If Benefit-cost ratio B/C =PW of benefit/PW of cost >= 1
  The PW is viable.

(All benefits and costs should be expressed in discounted present values)

III RESULTS AND DISCUSSIONS

A. Design Analysis: Following results are coming,

1) For computation of traffic: Traffic Volume survey was carried out at 5 Km near Parlakhemundi –Mohana road,volume of various categories of vehicles plying on the road. Format for Traffic Volume survey is also prepared. The Traffic volume Survey was calculated in terms of Average Daily Traffic (ADT), and then change it into PCU.

Fig .3. (showing traffic survey)

TABLE III Calculation of Average Daily Traffic (ADT)

Type of vehicle	ADT	Equivalency factor as per IRC	PCU
Car/jeep/van	72	1	72
Two wheeler	580	0.5	290
LCV	7	1	7
Truck	162	3	486
Tractor	119	5	595
Cycle	455	0.1	45.5
Auto Rickshaw	4	0.2	0.8
Animal drawn	88	8	704
Bus	39	3	117
Others	33	1.5	49.5
		Total PCU =2366.8 or 2367	

TABLE IV **(Calculation of CVPD)**

SL No	Vehicle Type	CVPD
A	Light Loaded Truck	55
B	Light Bus	33
C	Light Loaded Tractor	63
D	Heavy Bus	6
E	Heavy Loaded Truck	26
F	Heavy Loaded Tanker	4
	TOTAL	187

Grand Total P.C.U per day = 2367.

Grand Total Commercial Vehicle per day, P = 187.00

X =Design life in year =10, r =Growth rate =7.5%

Projected traffic, $A= P (1+r)^{x+n}$ = 591 CVPD

Calculation of Cumulative Million Standard Axles (CMSA): CMSA have been calculated by considering the parameter,Growth rate, r =7.5 %, Vehicle Damage Factor (F) for plain terrain =3.5, Lane Distribution factor (D) = 0.75 , Projected traffic A = 591 CVPD and use "(1)".

The result for calculation of CMSA for different type of commercial vehicles is found to be 20 MSA.

2) Experimental studies on sub grade: Following test results on sub grade soil are obtained**.**

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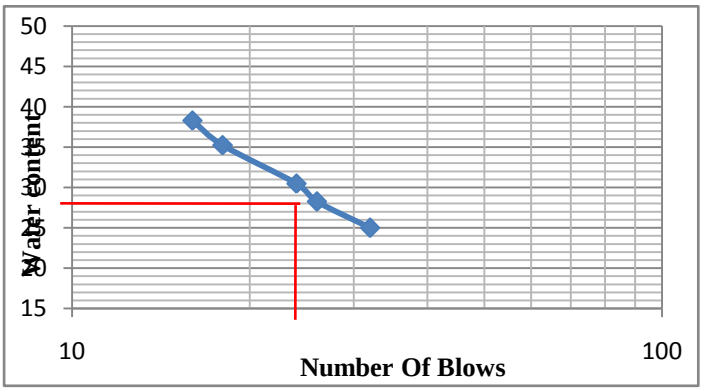
TABLE V (**Index properties of soil sub grade)**

Sl no.	L.L. in %	P.L. in %	P.I. in %	Sieve analysis in % passing			**Sand** content in%	Type Of Soil	Type of soil
				2.36 mm	0.425 mm	0.075 mm			
1	29	16	13	1.52	38.66	3.49	43.67	Clay	Clay
2	28	18.6	9.4	1.72	40.84	2.8	45.36	Clay	Clay
3	31.5	17.4	14.1	1.80	36.72	0.034	38.55	Clay	Clay

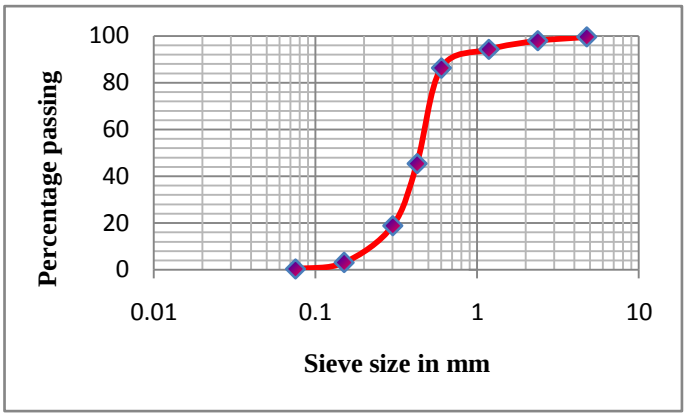
TABLE VI **(Engg. Properties of soil sub grade)**

Sl. no.	OMC in%	MDD in KN/m^3	Soaked CBR after 4 days	Moisture content after 4 days soaked in %
1	15.98	1.84	4.56	21.60
2	11.00	1.85	2.40	21.70
3	14.31	1.82	3.74	22.82

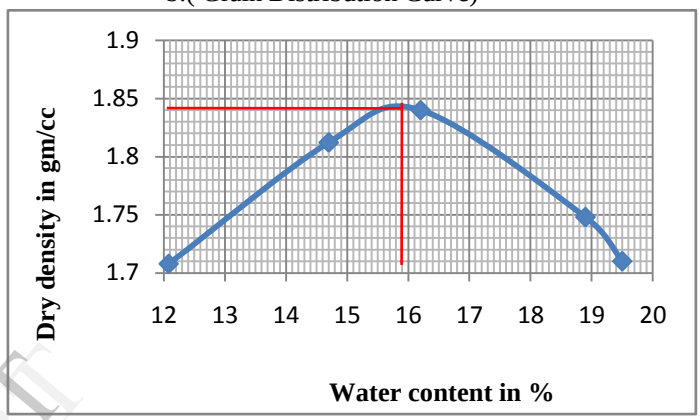
Fig.4 (Showing different graph of Sub-grade soil)



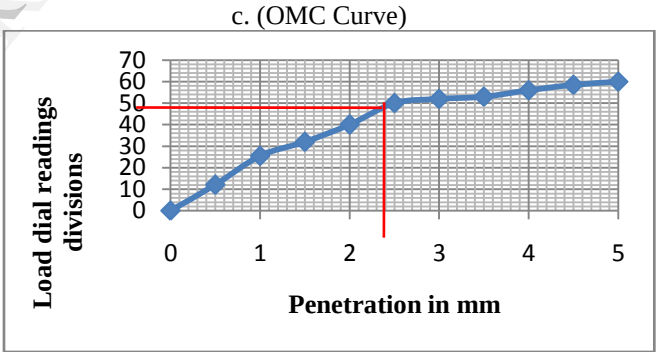
a .(Flow curve)



b.(Grain Distribution Curve)



c. (OMC Curve)



d. (Load Penetration Curve)

Since the sub grade soil is clay type having sand content of 38 to 45%, Liquid limit ranges from 28 to 32%, Plasticity index ranges from 9 to14%, Since the sub grade not have less value of 25% for liquid limit and 6% for plasticity index, the sub grade is suitable for design pavement,The values of OMC ranges from 11to 16 %,MDD from 1.82 to 1.84 g/cc, Soaked CBR values after 4 days comes out of 4%

3) Design of pavement: In this step design of pavement was calculated basing on CBR value of sub grade (4%) and CMSA (20MSA) for the road section. Following design thickness have been recommended for overlay and widening of Parlakhemundi-Mohana road.

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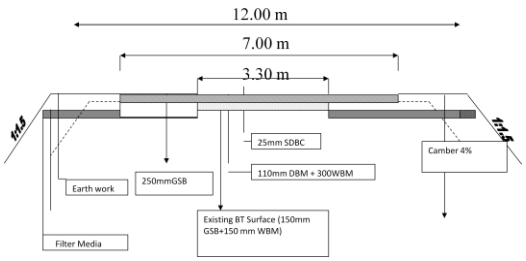
TBLEVII Thickness For overlaying portion:

Thickness(mm)	Composition
150	GSB
150	WBM
110	DBM
40	SDBC

TABLE VIII Thickness for widening portion**:** The design for widening portion has been done as per IRC: 37-2001 & the recommended crust thickness of 20 MSA and CBR 4 % are given below:

Thickness(mm)	Composition
330	GSB
250	WBM
110	DBM
40	SDBC
730	Total

Fig.5 showing (Typical Cross section of Improvement From Single lane to Double Lane)



B.Cost Analysis: Following results are coming,

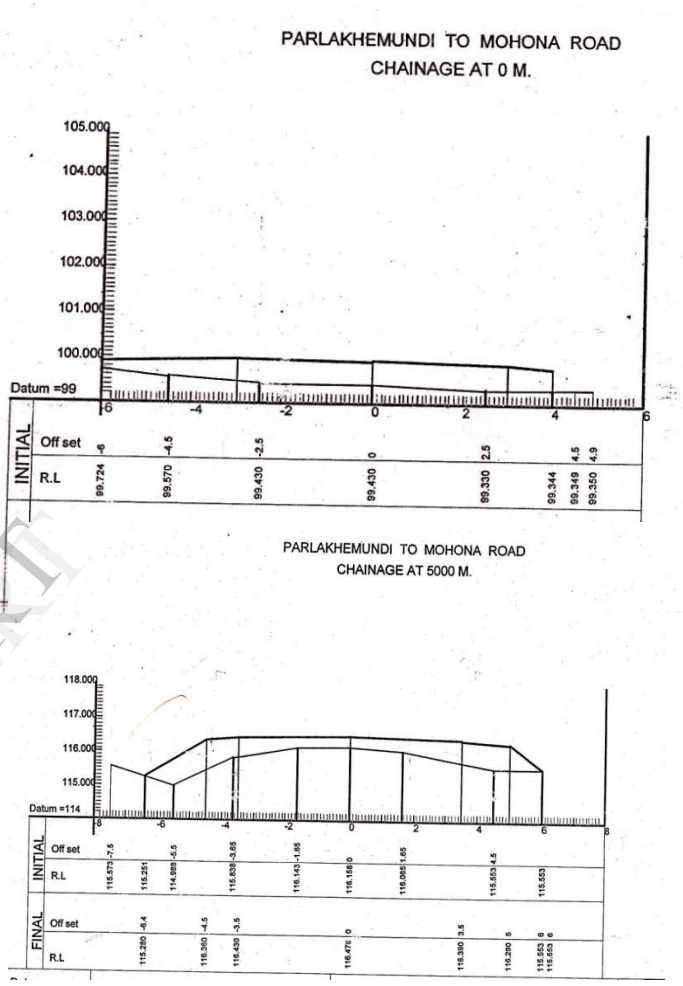
1)Detailed road development study:

A detailed survey work was carried out to know the soil profile by means of two types of sections such as L/S and C/S.Computation of earthwork was calculated and was found to be 44699.27 cum3.

TABLE IX Earth work calculation quantity

Sl. No.	Chainage in (mt)	Distance in (mt)	Area in (sqmt)	Mean area in (sqmt)	Quantity in cum
1	0	0	0	3.5465	0
2	10	10	7.093	3.5465	35.465
3	1010	1000	5.997	7.415	747.15
4	2000	1000	8.918	9.678	967.8
5	3000	1000	9.943	10.385	1038.55
6	4000	1000	8.621	8.317	831.7
7	5000	1000	6.272	11.539	1153.9
				Total	**44699.27**

Fig.6 showing C/S of Parlakhemundi to Mohana Road



2) Cost benefits ratio analysis: Cost benefit ratio has been done for the entire project on the basis of total estimate of the project (overlay and widening design) as per the schedule of rates OPWD, April 2013 and the following assumptions. The total estimated cost comes out to be Rs 4, 20, 00000(Rupees Four cores and Twenty Lakhs) only. The total estimates are prepared as per the, lead statement (quarry map of the study area).

Assumptions: Basic inputs for analysis are:

Analysis period, n = 10 years, Rate of interest, i= 10 % Construction Period: 2 years, improved Road to be opened to traffic in 2016, P=total cost of improvement=84*5=420 lakhs

Capital Recovery Factor (CRF) for various life and interest rates are calculated by the following formula,

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$$CRF = i(1+i)^n / (1+i)^{n-1} = 0.6275.$$

The Vehicle operation cost in Rs per vehicle km are fixed for the single lane road in both ways=2.5(for existing road).And for improved road it was found to be (0+1.5)/2=0.75

Additional maintain cost/year=RS.90, 000- Rs.40, 000
=Rs50, 000 *5=2.5 Lakhs

Total cost = present cost of improvement and additional maintenance cost/year=Rs. 68.35+2.5=70.850 Lakhs

Total PCU /day =2367(calculated)

Average traffic during design period= (2367+4734)/2=3550 PCU/day,Average road user cost of existing road/year=365*5*3550=59.45lakhs

Average road user cost of improved road=159.45*(0+1.5)/2=47.83lakhs

Total benefits=159.45+47.83=110.71lakhs

Cost- Benefit Ratio=110.71/70.850=1.78 (more than one)

Hence ,the project is viable.

IV CONCLUSIONS

Based on the findings of the present investigations, following conclusions are drawn.

1. The traffic volume was calculated as 2330 PCU/day in the year 2014 which exceeds the capacity of a single lane, (i.e.2000 PCU/day) as given by IRC. Hence, there is a need to widen the road up to two lanes.

2. The total pavement thickness provided for future traffic was calculated as 730 mm as per IRC:37-2001

3. The result of cost benefit ratio value is more than one (1.78). So, it can be concluded that the road is economically viable for the proposed up gradation and improvements.

4. The developed methods may be used for dealing with similar projects i.e. lane widening of different type of roads.

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