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Estimating the Vehicle Operating Cost through Railway Over Bridge

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Abstract - *Understanding the vehicle working expense is or vehicle operating cost is fundamental to sound arranging and administration of street ventures. While the framework costs borne by streets offices are generous, the expenses borne by streets clients are much more noteworthy. To qualify these connections, World Bank started a cooperative worldwide examination which prompted the vehicle working costs connections created in this investigation, and presents these in a little simple to utilize PC program which can be utilized freely of the bigger model.*

The HDM-VOC program predicts the different parts of vehicle working costs in light of street and vehicle qualities and unit costs in a free stream movement condition. The vehicle working expenses was additionally evaluated by Indian Road Congress parameters. IRC gives a few conditions to assess the VOC for various kinds of vehicles like autos, LCV, transport and so forth in IRC SP 30:2009. This paper is planned to evaluate the vehicle working expense of ROB at LC-70, Sitapura, Jaipur. For this reason world bank investigation of VOC and IRC SP 30:2009 are utilized. By the utilization of these examinations computed the VOC with geometric outline components of ROB at various velocities. These rates are 100 and 120 kmph.

Key Words: **Vehicle operating cost (VOC), geometric elements of road, LC-70 (Lacation), HDM-VOC (Software used)**

Introduction

The Jaipur Development Authority (JDA) has approved the design of railway over bridge (ROB) to be built on Jaipur-Sawai Madhopur railway track in Sitapura area. This would be the first Y-shaped ROB in the city. The estimated cost of the ROB is Rs 116 crore.

The length of the over bridge will be 925 meters. It will start ahead of Mahatma Gandhi crossing.

It will be a six-lane ROB and its one wing will move in the north direction towards the slip lane connecting Sitapura.

Project Location

This ROB will ease traffic on Road connection Sitapura Industrial area to Jaipur - Tonk Road (NH-12). LC No. 70 is located between Sanganer and Shivdaspura Stations on Jaipur-Sawai Madhopur BG Railway Line.

Sight Distance for Various Speeds

Speed (km/h)	Sight distance (meter)		
	Stopping	intermediate	Overtaking
20	20	40	-
25	25	50	-
30	30	60	-
35	40	80	-
40	45	90	165
50	60	120	235
60	80	160	300
65	90	180	340
80	120	240	470
100	180	360	640
120	240	480	720

(Source: irc.gov.sp.023:1993)

Design table of Summit Curve (Tonk Road Side) for SSD

Design Speed (m/s)	n1	n 2	N	S	Calculated Length of Curve (L)	Adopted Length of Curve (L)	a	(R)	Highest point on the curve(X) from BVCS point	RL of the highest point (Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	0.033	0	0.033	180	226.6	230	13939.0	6969.6	230	3.795	648.25	878.25	362.05	369.64	365.85
120	0.033	0	0.033	240	346.6	350	21212	10606.0	350	5.775	648.25	998.25	362.05	373.60	367.83

Design table of Summit Curve (Tonk Road Side) for OSD

Design Speed (m/s)	n1	n2	N	S	Calculated length of curve (L)	Adopted length of curve (L)	a	R	Highest point on the curve(X) from BVCS point	RL of the highest point (Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	0.033	0	0.033	640	989.09	1000	60606.1	30303.0	1000	16.5	648.25	1648.25	362.05	395.05	378.55
120	0.033	0	0.033	720	1149.09	1150	69696.9	34848.5	1150	18.975	648.25	1798.25	362.05	400.00	381.03

Design table of Summit Curve (Mahatma Gandhi Hospital Side) for SSD

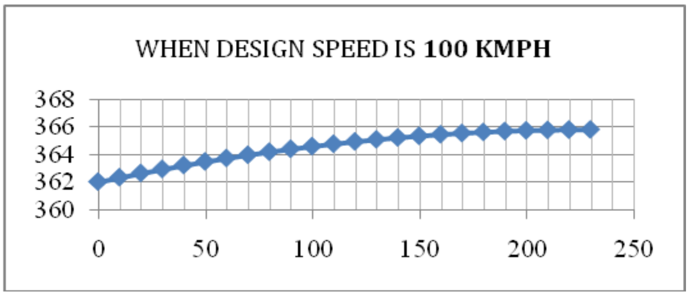
Design Speed (m/s)	n1	n2	N	S	Calculated length of curve (L)	Adopted length of curve (L)	a	R	Highest point on the curve(X) from BVCS point	RL of the highest point (Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	0.033	0	0.033	640	989.09	1000	60606.1	30303.0	1000	16.5	648.25	1648.25	362.05	395.05	378.55
120	0.033	0	0.033	720	1149.09	1150	69696.9	34848.5	1150	18.975	648.25	1798.25	362.05	400.00	381.03

Design table of Summit Curve (Mahatma Gandhi Hospital Side) for OSD

Design Speed (m/s)	n1	n2	N	S	Calculated length of curve (L)	Adopted length of curve (L)	a	R	Highest point on the curve(X) from BVCS point	RL of the highest point(Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	0	-0.025	0.025	640	1104	1105	88400	44200	0	0	934.77	2039.77	364.2	364.2	364.2
120	0	-0.025	0.025	720	1264	1265	101200	50600	0	0	934.77	2199.77	364.2	364.2	364.2

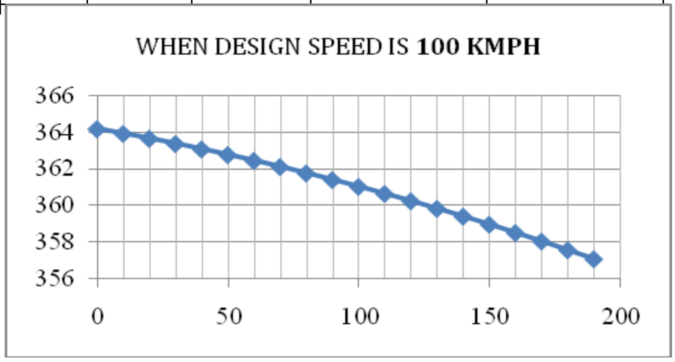
Summit curve I (Tonk Road Side) at 100 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	362.055	0	362.055
2	10	362.385	0.007173915	362.3778261
3	20	362.715	0.02869566	362.6863043
4	30	363.045	0.064565236	362.9804348
5	40	363.375	0.114782641	363.2602174
6	50	363.705	0.179347877	363.5256521



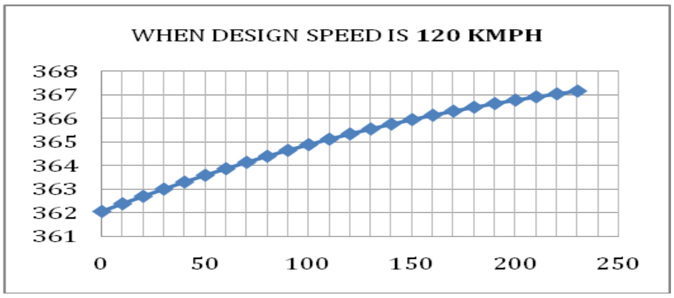
Summit curve II (Hospital Side) at 100 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	364.2	0	364.2
2	10	363.95	0.006578947	363.9434211
3	20	363.7	0.026315789	363.6736842
4	30	363.45	0.059210526	363.3907895
5	40	363.2	0.105263158	363.0947368
6	50	362.95	0.164473684	362.7855263



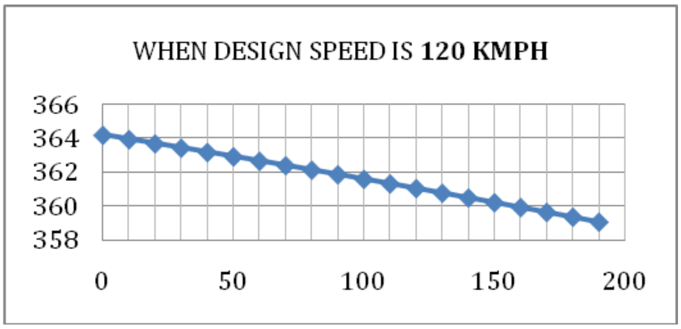
Summit curve I (Tonk Road Side) at 120 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	362.055	0	362.055
2	10	362.385	0.004714286	362.3802857
3	20	362.715	0.018857144	362.6961429
4	30	363.045	0.042428574	363.0025714
5	40	363.375	0.075428576	363.2995714
6	50	363.705	0.11785715	363.5871429



Summit curve II (Hospital Side) at 120 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	364.2	0	364.2
2	10	363.95	0.001131222	363.9488688
3	20	363.7	0.004524887	363.6954751
4	30	363.45	0.010180995	363.439819
5	40	363.2	0.018099548	363.1819005
6	50	362.95	0.028280543	362.9217195



Design Table for Valley Curve (Tonk Road Side)

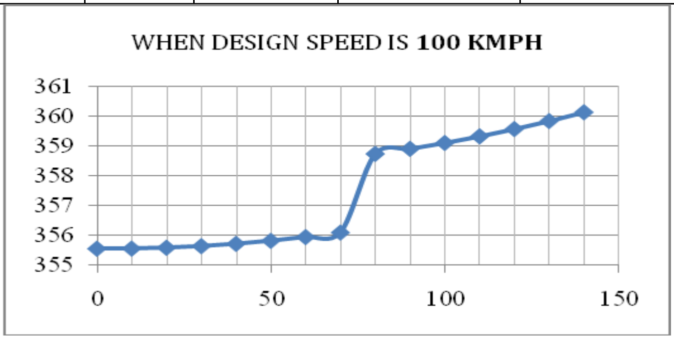
Design Speed (m/s)	n1	n2	N	S	Calculated length of curve (L)	Adopted length of curve (L)	a	R	Highest point on the curve (X) from BVCS point	RL of the highest point(Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	-0.00079	0.033	0.034	180	131.19	140	8213.5	4106.77	-3.4020	0.001409	425.64	565.64	355.57	355.68	355.68
120	-0.00079	0.033	0.034	240	189.59	200	11733.64	5866.82	-4.8600	0.002013	425.64	625.64	355.57	355..74	355.74

Design Table for Valley Curve (Mahatma Gandhi Hospital Side)

Design Speed (m/s)	n1	n2	N	S	Calculated length of curve (L)	Adopted length of curve (L)	a	R	Highest point on the curve(X) from BVCS point	RL of the highest point(Y)	BVCS	EVCS	RL of BVC point	RL of highest point on Grade Line	RL of highest point at curve
100	-0.025	-0.002	0.023	180	15.40	60	5301.5	2650.76	54.81	0.566	334.41	394.41	354.64	353.39	353.96
120	-0.025	-0.002	0.023	240	42.62	0	7068.7	3534.35	73.08	0.756	334.41	414.41	354.64	352.98	353.74

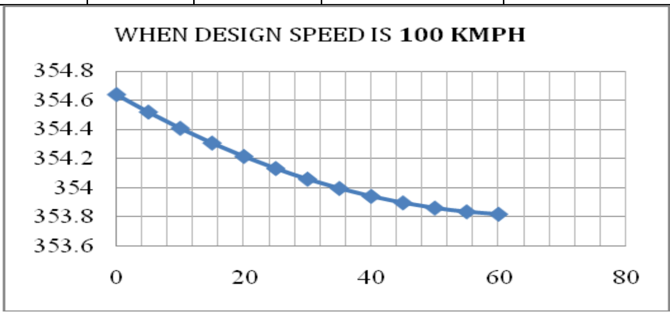
Valley curve I (Tonk Road Side) at 100 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	355.57	0	355.57
2	10	355.5621	0.012175001	355.574275
3	20	355.5542	0.048700002	355.6029
4	30	355.5463	0.109575005	355.655875
5	40	355.5384	0.194800009	355.7332
6	50	355.5305	0.304375013	355.834875



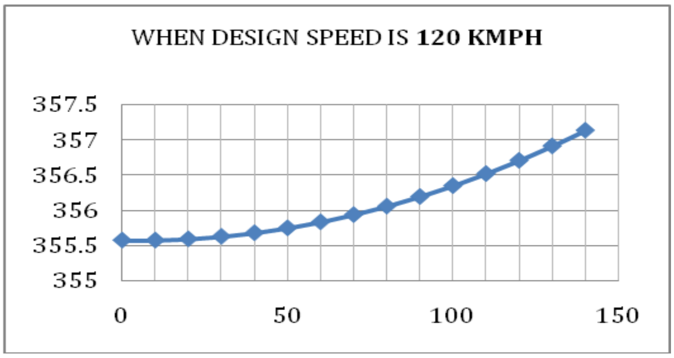
Valley curve II (Hospital Side) at 100 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	354.64	0	354.64
2	5	354.515	0.004715625	354.5197156
3	10	354.39	0.0188625	354.4088625
4	15	354.265	0.042440625	354.3074406
5	20	354.14	0.07545	354.21545
6	25	354.015	0.117890625	354.1328906



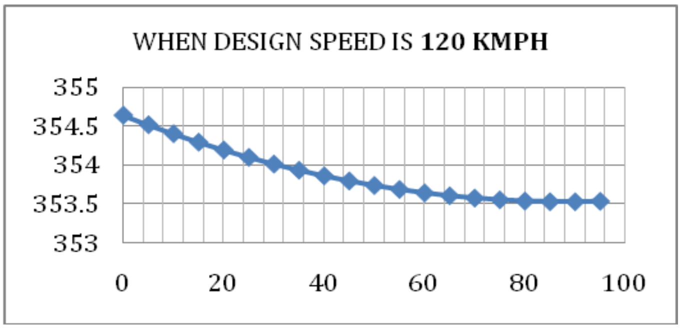
Valley curve I (Tonk Road Side) at 120 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	355.57	0	355.57
2	10	355.5621	0.008522505	355.5706225
3	20	355.5542	0.034090018	355.58829
4	30	355.5463	0.076702541	355.6230025
5	40	355.5384	0.136360072	355.6747601



Valley curve II (Hospital Side) at 120 kmph

Stations	Chainage from BVC	RL of Points on Grade Line	Ordinates B/W Curve and Grade Line	RL of Station on Curve
1	0	354.64	0	354.64
2	5	354.515	0.003536718	354.5185367
3	10	354.39	0.014146873	354.4041469
4	15	354.265	0.031830464	354.2968305
5	20	354.14	0.056587491	354.1965875
6	25	354.015	0.088417955	354.103418



Minimum Curve Radius for Different Design Speeds

Design Speed	Plain & Rolling Terrain(m)	Mountainous and Steep Terrain	
		Snow Bound Area (m)	Non-snow Bound Area (m)
20	15	15	14
25	23	23	20
30	33	33	30
35	45	45	40
40	60	60	50
50	90	90	80
65	155	Speed not applicable	
80	230		
100	360		
120	450		

(Source: irc 38:1988)

Length of Transition Curve as Per Radius of Curvature and Design Speed

Transition Lengths (m) for Plain and Rolling Terrain									
Curve Radius (m)	100 km/h	80 km/h	65 km/h	50 km/h	40 km/h	35 km/h	30 km/h	25 km/h	20 km/h
20	-	-	-	-	-	-	-	-	55
40	-	-	-	-	-	-	60	45	30
80	-	-	-	-	55	45	30	25	15
100	-	-	-	70	45	35	25	20	-
125	-	-	-	55	35	30	20	15	-
155	-	-	80	-	-	-	-	-	-
200	-	-	60	35	20	15	15	-	-
250	-	90	50	30	20	-	-	-	-
300	-	75	40	25	-	-	-	-	-
350	130	60	35	20	-	-	-	-	-
360	130	-	-	-	-	-	-	-	-
400	115	55	30	20	-	-	-	-	-

(Source: IRC 38:1988)

Design Table of Horizontal Curve (Tonk Road Side)

S.No.	Design Speed (km/h)	Rc (m)	e	e taken	f	PC	PT	LC (Long Chord)	Deviation Angle (ΔS)
1	120	515.52	0.124	0.07	0.149	665.25	785.25	120	13.37
2	100	358	0.124	0.07	0.149	665.25	785.25	120	19.18

Design Table of Horizontal Curve (Tonk Road Side)

Ls	Adopted Ls	θs	Shift for unit length of θ	Shift	K for unit length	K	(Δs)	(Δ)	Ts	Es	(Lc)	L
75.41	130	7.22	0.0105	1.365	0.5351	69.56	13.37	27.82	2303.03	1776.98	120.2	250.23
75.41	130	10.40	0.0151	1.963	0.4995	64.93	19.18	39.98	856.66	511.7	119.7	249.78

Design Table of Horizontal Curve (Hospital Side)

S.No.	Design Speed (km/h)	Rc (m)	e	e taken	f	PC	PT	LC (Long Chord)	Deviation Angle (ΔS)
1	120	515.52	0.124	0.07	0.149	870.43	966.43	96	10.68
2	100	358	0.124	0.07	0.149	870.43	966.43	96	15.32

Design Table of Horizontal Curve (Hospital Side)

Ls	Adopted Ls	θs	Shift for unit length of θ	Shift	K for unit length	K	(Δs)	(Δ)	Ts	Es	(Lc)	L
75.41	130	7.22	0.0105	1.365	0.5351	69.56	10.68	25.13	68.7	1.4	96.04	226.04

75.41	130	10.40	0.0151	1.963	0.4995	64.93	15.32	36.12	295.4	151.3	95.67	225.67

All the geometric analysis (tables & charts showing total horizontal & vertical profile of the ROB LC-70) is done by using the all codes from Indian Road Congress such as:

1. IRC 86:1983 is used to calculate geometric design standards for urban roads in Plains.
2. IRC SP 30:2009 is used for manual economic evaluation of highway projects in India
3. IRC 38:1988 gives guidelines for design of horizontal curves for highways and design tables
4. IRC SP 023:1993 is used to calculate the vertical curves for highways.

VOC THROUGH ROB BY WORLD BANK (HDM-VOC)

The World Bank started a community worldwide examination which prompted the VOC connections created in this investigation. These connection show in a little simple to utilize PC program, this can be utilized freely of the bigger model. The HDM-VOC program predicts the different parts of VOC in respect to vehicle & road qualities and unit cost in a free stream movement condition. Calculations are accommodated ten vehicle writes running from little auto to articulated truck, and process speed, physical amount devoured, and add up to working expenses.

APPROACH OF ANALYSIS (HDM-VOC RELATIONSHIPS)

It works into steps stated below:

1. Mean operating speed of vehicle calculated.
2. Calculate amount of resources used per 1000 vehicle-km for the components as
   - Fuel consumption
   - Lubricant consumption
   - Tire wear
   - Crew time
   - Passenger time
   - Cargo holding
   - Maintenance labor
   - Maintenance parts
   - Depreciation
   - Interest
   - Overhead

3. Apply unit costs to the resource consumptions amounts.
4. Sum the operating cost for each component & calculate the total VOC per 1000 vehicle-km.

INPUTS FOR HDM-VOC PROGRAM

1. Surface Type: The model gives two choices to street surface write: (i) Paved and (ii) Unpaved. Enter 1 to choose a cleared street, and 0 to choose an unpaved street.

2. Roughness: The street unpleasantness is characterized as the deviation of a surface from a genuine planer surface with attributes that influence vehicle progression, ride quality, dynamic burdens and seepage. Enter the normal street unpleasantness in IRI units (International roughness index, in m/km).

Quantitative Evaluation	Roughness IRI (m/km)	
	Paved Road	Unpaved Road
Smooth	2	4
Reasonably smooth	4	8
Medium rough	6	12
Rough	8	15
Very rough	10	20

(Source: World Bank Technical Paper No. 234)

3. Vertical Profile: Travel on a road can be understood in three different types between two points as A and B. These are: (i) One-way travel from A to B (ii) One-way travel from B to A (iii) Round trip travel either from A to B and back to A, or from B to A and back to B.

Take after the means underneath to process the vertical geometric totals from a definite geometric profile:

A. Start with an itemized vertical profile.

B. Divide the roadway into segments with peaks and trough as limit focuses. Decide the lengths (ls) and normal slopes (as a group and with sighns held) of the segments (gs) and shape a forbidden profile of vertical geometry.

C. Determine the 'positive gradient (ps) of each section:
If the gradient of sections is positive, i.e., $g_s \geq 0$, then:
$$p_s = g_s.$$
If the gradient of sections is negative, i.e., $g_s < 0$, then:
$$p_s = 0$$

D. Determine the negative gradient (n_s) of each section:
If the gradient of sections is positive, i.e., $g_s \geq 0$, then:
$$n_s = 0$$
If the gradient of section s is negative, i.e., gs < 0, then:
$n_s = |gs|$, where $|gs|$ is the absolute value of g_s

E. Determine the 'rise' of each section. Multiply length and positive gradient to get pl_s:
$$Pl_s = Ps\, l_s$$

F. Determine the 'fall' of each section. Multiply length and negative gradient to get nl_s:
$$nl_s = n_s\, l_s$$

G. Specify the segments with positive gradient (uphill travel). Enter the length ls of the section if the section has a positive gradient; enter zero if the section has a negative gradient:
$$P_s = l_s \qquad \text{if } gs \geq 0$$
$$P_s = 0 \qquad \text{if } gs < 0$$

H. Form the totals of columns to get L, PL, NL and P, respectively.
I. Compute the average vertical geometric characteristics.

The recommended range for positive gradient (PG) and negative gradient (NG) is from 0 to 12 percent. The range for the proportion of uphill travel (LP) is from 0 to 100 percent.

Computation of Vertical Aggregates for 100 kmph

Section	Length (m)	Gradient (Fraction)	Positive Gradient (Fraction)	Negative Gradient (Fraction)	Rise (m)	Fall (m)	Uphill Travel (m)
1	70	-0.00079	0	0.00079	0	0.0553	0
2	70	0.0333	0.0333	0	2.331	0	70
3	115	0.0333	0.0333	0	3.8295	0	115
4	115	0	0	0	0	0	0
5	95	0	0	0	0	0	0
6	95	-0.025	0	0.025	0	2.375	0
7	30	-0.025	0	0.025	0	0.75	0
8	30	-0.002365	0	0.002365	0	0.07095	0
	L= 620				**PL= 6.1605**	**NL= 3.25**	**P= 185**
AVERAGE POSITIVE GRADIENT (PG)= (PL/P)*100= 3.33%							
AVERAGE NEGATIVE GRADIENT (NG)= [NL/(L-P)]*100= 0.747%							
AVERAGE UPHILL TRAVEL= (P/L)*100= 29.84%							
RF= {(365.85-355.57)+(364.2-353.96)}/.910= 22.55 m/Km							

Computations of Vertical Aggregates for 120 kmph

Section	Length (m)	Gradient (Fraction)	Positive Gradient (Fraction)	Negative Gradient (Fraction)	Rise (m)	Fall (m)	Uphill Travel (m)
1	100	-0.00079	0	0.00079	0	0.079	0
2	100	0.0333	0.0333	0	3.33	0	100
3	175	0.0333	0.0333	0	5.8275	0	175
4	175	0	0	0	0	0	0
5	155	0	0	0	0	0	0
6	155	-0.025	0	0.025	0	3.875	0
7	40	-0.025	0	0.025	0	1	0
8	40	-0.002365	0	0.002365	0	0.0946	0
	L= 940				**PL= 9.1575**	**NL= 5.0486**	**P= 275**
AVERAGE POSITIVE GRADIENT (PG)= (PL/P)*100= 3.33%							
AVERAGE NEGATIVE GRADIENT (NG)= [NL/(L-P)]*100= 0.765%							
AVERAGE UPHILL TRAVEL= (P/L)*100= 29.25%							
RF= {(367.83-355.57)+(364.2-353.74)}/.910= 24.97 m/Km							

Average Horizontal Geometric Characteristics

Average Geometric Characteristics	Symbol	One way Trip		Round- trip
		A to B	B to A	
Average Curvature	C	K/L	K/L	K/L
Average Super elevation	SP	S/L	S/L	S/L

(Source: World Bank Technical Paper No. 234)

Computations of Horizontal Aggregates for Design Speed 100 kmph

Curvy Section	Length (m)	Radius of Curvature (m)	Curvature (deg/km)	Super Elevation	cl_s	sl_s
1	249.8	360	159.2356688	0.07	39777.07006	17.486
2	225.7	360	159.2356688	0.07	35939.49045	15.799
					75716.56051	**33.285**
ROAD LENGTH = 910m						
HORIZONTAL CURVATURE = 75716.56051/910 = **83.20**						
SUPERELEVATION = 33.285/910 = **0.036**						

Computations of Horizontal Aggregates for Design Speed 120 kmph

Curvy Section	Length (m)	Radius of Curvature (m)	Curvature (deg/km)	Super Elevation	cl_s	sl_s
1	250.2	520	110.2400784	0.07	27582.06761	17.514
2	226	520	110.2400784	0.07	24914.25772	15.82
					52496.32533	**33.334**
ROAD LENGTH = 910m						

HORIZONTAL CURVATURE = 52496.32533/910 = **57.69**
SUPERELEVATION = 33.334/910 = **0.037**

Altitude of Terrain: The model uses height of landscape (the normal rise of street over the mean ocean level, in meters) to process the air protection from the vehicle movement. The prescribed range for elevation (AL) is from 0 to 5000 meters.

Effective Number of Lanes: The model gives two choices to the powerful no. of paths: (i) one lane (ii) more than one lane. Enter 1 to choose the solitary path (lane) street, and 0 to choose an in excess of one path street.

Vehicle Type: Any type of vehicle can be selected now. We are selecting small car for our dissertation.

Desired Speed: The coveted speed requirement (VDESIR) is the coveted vehicle speed without the impact of street seriousness factor. On a straight, level and smooth street, despite the fact that the driving, braking, bend and ride seriousness speed imperatives don't exist, the vehicle still does not regularly go at the speed managed by its own particular greatest or even utilized power.

Tire Wear Information:

The tire wear taken & uses by model as following:

- Number of tires per vehicle
- Wearable volume of rubber per tire (dm^3)
- Retreading cost per new tire cost ratio (fraction)
- Maximum number of recaps
- Constant term of tread wear model (dm^3/m)

Wear coefficient of tread wear model (10-3 dm^3/kJ)

Recommended Wearable Volume of Rubber per Tyre

Vehicle	Recommended Wearable Volume of Rubber per Tyre (dm^3)
Buses	5.6 - 8.0
Light trucks	2.0 - 3.5
Medium trucks	6.5 - 9.3
Heavy trucks	6.3 - 8.8
Articulated trucks	6.0 - 8.5

(Source: World Bank Technical Paper No. 234)

The model uses fixed tear-wear coefficient for the rubber loss volume prediction, (dm3/1000 tire-km)

Unit Costs: Unit costs can either be financial or economic. Various unit costs required are such as:

- New Vehicle Price
- Fuel Cost
- Lubricants Cost
- New Tire Cost
- Crew Time Cost
- Passenger Delay Cost
- Maintenance Labor Cost
- Cargo Delay Cost
- Annual Interest Rate
- Overhead per vehicle-km

After giving all required data as input in the software we get following results:

Passenger Car Sample Data (Result Report):- For 100 kmph

1. Vehicle Speed	km/hr		100
2. Physical Quantities per 1000 vehicle-km			
Fuel consumption	liters		85.23
Lubricants consumption	liters		01.85
Tyre wear	# of equivalent new tires		00.06
Crew time	hours		10.00
Passenger time	hours		10.00
Cargo holding	hours		10.00
Maintenance labor	hours		02.27
Maintenance parts	% of new vehicle price		00.16
Depreciation	% of new vehicle price		00.43
Interest	% of new vehicle price		00.23
3. Total VOC per 1000 vehicle-km	**$**	**190.47**	**100%**
Fuel	$	98.01	51.46%
Lubricants	$	12.81	06.73%
Tyres	$	02.99	01.57%
Crew time	$	15.00	07.88%
Passenger time	$	00.00	00.00%
Cargo holding	$	00.00	00.00%
Maintenance labor	$	04.99	02.62%
Maintenance parts	$	10.98	05.76%
Depreciation	$	29.96	15.73%
Interest	$	15.73	08.26%
Overhead	$	00.00	00.00%

Passenger Car Sample Data (Result Report):- For 120 kmph

1. Vehicle Speed	km/hr	120
2. Physical Quantities per 1000 vehicle-km		
Fuel consumption	liters	96.82
Lubricants consumption	liters	01.85
Tyre wear	# of equivalent new tires	00.06
Crew time	hours	08.33

Passenger time	hours	08.33
Cargo holding	hours	08.33
Maintenance labor	hours	02.27
Maintenance parts	% of new vehicle price	00.16
Depreciation	% of new vehicle price	00.41
Interest	% of new vehicle price	00.21

3. Total VOC per 1000 vehicle-km	**$**	**198.34**	**100%**
Fuel	$	111.34	56.14%
Lubricants	$	12.81	06.46%
Tyres	$	02.99	01.51%
Crew time	$	12.50	06.30%
Passenger time	$	00.00	00.00%
Cargo holding	$	00.00	00.00%
Maintenance labor	$	04.99	02.51%
Maintenance parts	$	10.98	05.53%
Depreciation	$	28.40	14.32%
Interest	$	14.32	07.22%
Overhead	$	0.00	00.00%

DISCUSSION OF VOC

As clearly shown by tables we can easily observe that the VOC calculated at 100 kmph vehicle speed is lesser than the VOC calculated at vehicle speed 120kmph. So it is obvious that the design vehicle speed with respect to VOC should be considered as 100 kmph.

VEHICLES OPERATING COST OF ROB BY IRC

The distance related and time related VOC calculated as following:

(A)For Speed 100 kmph:

<u>**Distance related economic costs:**</u>

1. **Free Speed (V):**

Free Speed (V) = 73.14 - (0.711*RF) - 0.00171*(RG - 2000)
Where,
RG = 2000 mm/km
RF = 22.55 m/km
V = 73.14 - (0.711*22.55) - 0.00171*(2000-2000)
V = 57.11 kmph
So, take V = 58 kmph

2. **Fuel:**

Fuel consumption (FC) = 21.85+ (504.15/V)+0.004957*V^2 +0.000652*RG+1.0684*RS-0.3684*FL
Where,
V= 58 km/h
RS = 6.77 m/km
RG = 2000 mm/km
FL = 3.57 m/km
(FC) = 21.85+(504.15/58)+0.004957*58^2+0.000652*2000 + 1.0684*6.77-0.3684*3.57
(FC) = 54.44 liters/1000 km
Unit cost of petrol is 76 Rs/liter.
So, the fuel cost = 54.44*76 = **4137.44 Rs/1000 km**

3. **Tire cost:**

Tire life (TL) = 68771-147.9*RF-26.72*(RG/W)
Where,
RG = 2000 mm/km
W = 7 m
(TL) = 68771-147.9*22.55-26.72*(2000/7)
(TL) = 57801.57 km
Unit Tire cost = 3250 Rs
So, the tire cost = 3250/57.80157 = **56.23 Rs/1000 km**

4. **Lubricants costs:**

Engine oil (EOL) = 1.7048+0.03319*RF+0.0005241*(RG/W)
(EOL) = 1.7048+0.03319*22.55+0.0005241*(2000/7)
(EOL) = **2.6 liters/1000 km**
Other oil (OL) = 1.631+.05167*RF+.001867*(RG/W)
(OL) = 1.631+0.05167*22.55+.001867*(2000/7)
(OL) = **3.33 liters/10000 km**
Grease (G) = 2.816+0.2007*RF
(G) = 2.816+0.2007*22.55
(G) = **7.34 kg/10000 km**
Unit cost: EOL = 130 Rs/liter
OL = 248.25 Rs/liter
G = 112.35 Rs/kg
So, the Engine oil cost = 130*2.6 = **338 Rs/1000 km**
Other oil cost = 248.25*.333 = **82.67 Rs/1000 km**
Grease = 112.35*.734 = **82.46 Rs/1000 km**
So, the Lubricants cost = 338+82.67+82.46 = **503.13 Rs/1000 km.**

5. **Spare cost**

Spare cost (SP) = {0.0018*(RG-2000)*10^{-5}}*NP
Where,
NP = cost of new vehicle = 4, 50,600 Rs
SP = {0.0018*(2000-2000)*10^{-5}}*450600
SP = 0.00 paisa/km

6. **Maintenance Labor cost**

(LC) = 0.5498*SP
Where,
SP = 0.00 paisa/km
So, LC = 0.00 paisa/km
So, distance related economic cost = 4137.44+56.23+503.13+0.00+0.00 = 4696.8 Rs/1000 km

<u>**Time related economic cost**</u>

1. **Fixed cost**

F_x = 370.14/UPD
Where,
UPD = 6.187*V = 6.187*58 = 358.846 km/day
F_x = 370.14/358.846 = 1.03 Rs/year
So, F_x = **1.03 Rs/1000 km**

2. Depreciation cost
DC = 70.85/UPD = 70.85/358.846 = 0.19744 Rs/km
So, DC = **197.44 Rs/1000 km**

3. Passenger time cost
PT = 227.82/V = 227.82/58 = **3.9279 Rs/km**
So, PT = 3.9279*1000 = **3927.9 Rs/1000 km**

So, time related economic cost = 1.03+197.44+3927.9 = 4126.37 Rs/1000 km

Total VOC = 4696.8+4126.37 = 8823.175 Rs/1000 km

(B) For Speed 120 kmph

Distance related economic costs

1. Free Speed (V):
Free Speed (V) = 73.14 - (0.711*RF) - 0.00171*(RG - 2000)
Where,
RG = 2000 mm/km
RF = 24.97 m/km
V = 73.14 - (0.711*24.97) - 0.00171*(2000-2000)
V = 55.39 kmph
So, take V = 56 kmph

2. Fuel
Fuel consumption (FC) = 21.85+ (504.15/V)+ 0.004957*V^2 +0.000652*RG+1.0684*RS-0.3684*FL
Where,
V= 56 km/h
RS = 10.06 m/km
RG = 2000 mm/km
FL = 5.55 m/km
(FC) = 21.85+ (504.15/56)+0.004957*56^2 +0.000652*2000+1.0684*10.06-0.3684*5.55
(FC) = 56.40 liters/1000 km
Unit cost of petrol is 76 Rs/liter.
So, the fuel cost = 56.40*76 = **4286.4 Rs/1000 km**

3. Tire cost:
Tire life (TL) = 68771-147.9*RF-26.72*(RG/W)
Where,
RG = 2000 mm/km
W = 7 m
(TL) = 68771-147.9*24.97-26.72*(2000/7)
(TL) = 57443.65 km
Unit Tire cost = 3250 Rs
So, the tire cost = 3250/57.44365 = **56.58 Rs/1000 km**

4. Lubricants costs:
Engine oil (EOL) = 1.7048+0.03319*RF+0.0005241*(RG/W)
(EOL) = 1.7048+0.03319*24.97+0.0005241*(2000/7)
(EOL) = **2.68 liters/1000 km**
Other oil (OL) = 1.631+.05167*RF+.001867*(RG/W)
(OL) = 1.631+0.05167*24.97+.001867*(2000/7)
(OL) = **3.45 liters/10000 km**
Grease (G) = 2.816+0.2007*RF
(G) = 2.816+0.2007*24.97
(G) = **7.83 kg/10000 km**

Unit cost: EOL = 130 Rs/liter
OL = 248.25 Rs/liter
G = 112.35 Rs/kg
So, the Engine oil cost = 130*2.68 = **348.4 Rs/1000 km**
Other oil cost = 248.25*.345 = **85.646 Rs/1000 km**
Grease = 112.35*.783 = **87.97 Rs/1000 km**
So, the Lubricants cost = 348.4+85.646+87.97 = **522.016 Rs/1000 km**

5. Spare cost
Spare cost (SP) = {0.0018*(RG-2000)*10^{-5}}*NP
Where,
NP = cost of new vehicle = 4, 50,600 Rs
SP = {0.0018*(2000-2000)*10^{-5}}*450600
SP = 0.00 paisa/km

6. Maintenance Labor cost
(LC) = 0.5498*SP
Where,
SP = 0.00 paisa/km
So, LC = 0.00 paisa/km

So, distance related economic cost = 4286.4+56.58 +522.016+0.00+0.00= 4864.996 Rs/1000 km

Time related economic cost

1. Fixed cost
F_x = 370.14/UPD
Where,
UPD = 6.187*V = 6.187*56 = 346.472 km/day
F_x = 370.14/346.472 = 1.068 Rs/year
So, F_x = **1.068 Rs/1000 km**

2. Depreciation cost
DC = 70.85/UPD = 70.85/346.472 = 0.2045 Rs/km
So, DC = **204.5 Rs/1000 km**

3. Passenger time cost
PT = 227.82/V = 227.82/56 = **4.068 Rs/km**
So, PT = 4.068*1000 = **4068 Rs/1000 km**

So, time related economic cost = 1.068+204.5+4068 = 4273.568 Rs/1000 km

Total VOC = 4864.996+4273.568 = 9138.564 Rs/1000 km

Comparison of VOC by IRC and HDM-VOC Model with Their Respective Parameters at 100 kmph

S.No.	Element	Cost by IRC (Rs/1000 km)	Cost by HDM-VOC ($/1000 km)	Cost by HDM-Voc in Rs (1$ = 65 Rs)
1	Fuel	4137.445	98.01	6370.65
2	Tire costs	56.23	02.99	194.35
3	Lubricant cost	503.13	12.81	832.65

4	Spare cost	0	-	-
5	Maintenance labor cost	0	4.99	324.35
6	Fixed cost	1.03	-	-
7	Depreciation cost	197.44	29.96	1947.4
8	Crew time	-	15.00	975
9	Maintenance parts	-	10.98	713.7
10	Interest	-	15.73	1022.45
11	Overhead	-	0.00	0.00
12	Passenger time	3927.9	0.00	0.00
13	Cargo holding	-	0.00	0.00
14	**TOTAL VOC**	**8823.175**	**190.47**	**12380.55**

Comparison of VOC by IRC and HDM-VOC Model with Their Respective Parameters at 120 kmph

S.No.	Element	Cost by IRC (Rs/1000 km)	Cost by HDM-VOC ($/1000 km)	Cost by HDM-Voc in Rs (1$ = 65 Rs)
1	Fuel	4286.4	111.34	7237.1
2	Tire costs	56.58	02.99	194.35
3	Lubricant cost	522.016	12.81	832.65
4	Spare cost	0	-	-
5	Maintenance labor cost	0	4.99	324.35
6	Fixed cost	1.068	-	-
7	Depreciation cost	204.5	28.40	1846
8	Crew time	-	12.50	812.5
9	Maintenance parts	-	10.98	713.7
10	Interest	-	14.32	930.8
11	Overhead	-	0.00	0.00
12	Passenger time	4068	0.00	0.00
13	Cargo holding	-	0.00	0.00
14	**TOTAL VOC**	**9138.564**	**198.34**	**12891.45**

CONCLUSION:

- In this thesis for assessing an arranged ROB permits a snappy and exact survey of vehicle working expense at that ROB. The HDM-VOC model is assessed in light of geometric qualities (levels, length and flat bends and vertical bends), speed and street surface write and condition. The yield of the HDM-VOC display is the VOC while the vehicle goes along a highway at configuration speed. This VOC is framed by various kinds of costs like fuel cost, oil cost, tire cost and so forth.
- Since the utilization of a few parameters in HDM-VOC was distinct in compare with IRC rules, so I calculated the VOC according to IRC rules as well. (IRC SP 30:2009)
- By using HDM-VOC demonstrate for ROB at LC-70, Sitapura Jaipur, VOC at configuration speed 100 and 120 kmph has been calculated for a small passenger car. By results we can say that VOC for speed 100 kmph was lesser than what it was for speed 120 kmph. Along these lines the geometric plan of ROB can be improved for the situation configuration speed of 100 kmph.
- The model might be valuable in discovering fuel proficient and naturally well disposed thruways with respect to the fact that the vehicular fuel utilization straight forwardly influences the cost of vehicle task as well as produces ozone harming substances and toxin emissions.
- By the utilization of the IRC rules for ROB at LC-70, Sitapura Jaipur, VOC at speed 100 and 120 kmph is calculated for a small passenger car. By the determination of VOC for these two outline speeds, I can state that VOC for 100 kmph was lesser. Along this the design can further be improved for configuration speed 100 kmph for getting more reduced cost of vehicular operations.

FUTURE SCOPE:

- VOC can be calculated for all types of vehicles by using this model.
- Fuel demand can easily be determined by using this model.
- VOC calculations always allow us to identify the requirements of highway's repair and maintenance works.
- The modification of further updating of model can also be achieved by these requirements.

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