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Research Paper

SELECTION OF ROAD TRACK TO DETERMINE OPTIMIZED VALUE OF WHEEL DIMENSION AND SPEED RATIO BETWEEN CRANK AND WHEEL FOR CYCLE RICKSHAW

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The main objective of this work is to recommend the wheel diameter and speed ratio between crank and wheel under certain test conditions for the purpose of reducing strain of pedaling on rickshaw puller ergonomically. Psyologial issue shall be addressed for determining the optimum diameter and speed ratio. For the same, the specific road track of 8.840 Km is identified which simulate the all road condition during the field trial. The rising and falling gradient of the track which is selected is determined with the help of auto level, leveling staff, odometer and measuring tape. The method of height of collimation system is used to determined different points of elevation. This gives the idea about the variation in slope of the road. For project design, the traffic flow data is also colleted. This also helps to study future traffic trends and assisting in predicting traffic flows in the future for a given period.

Keywords: Cycle rickshaw, Road track, Pulse rate, Wheel diameter, Speed ratio

INTRODUCTION

The road is one of mode of transportation, catering a wide range of vehicles, pedestrians including cycle-rickshaw. The road transportation is the only type which could give maximum service to one and all. It has maximum flexibility for travel with reference to route, direction, time and speed of travel etc. through any type of road to provide point-to-point travel.

For short distance trips, a cycle rickshaw is a popular mode of transport in Indian cities. The basic intention of undertaking of experimental is to find the way in which maximum power can be extracted without much of exertion for cycle-rickshaw puller (John Seabury *et al.*, 1977; Davis and Hull, 1981; Mats Ericson, 1988; and Mahalle and Awari, 2011).

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SELECTION OF TRACK

The amount of energy that can be supplied by a puller depends up on speed, torque on the crank, and duration for which pedaling is required to be done. For shorter duration of pedaling, higher energy levels of puller are feasible. Lokomy (1986) has shown that as exercise time increases power output drops from 150 watts to 80 watts approximately. When time period increases even further this power is reduced to a much lower level.

Cycle rickshaw pedaling is required to be done continuously for longer duration; hence data related to short duration tests is not relevant. Data related to long duration tests only is considered.

The survey has shown that maximum 8 Km distance is traveled by a rickshaw puller at a stretch which takes around 40-60 minutes approx. Thus the proposed road track is selected and measured with odometer which is 8.840 Km. This comprise of total six rounds, out of which three are forward and three are opposite, which simulate all road condition.

The experimental set up mainly consists of road track, cycle-rickshaw (model-03 in no's) and measuring instrument such as—UT-100 Pulse Oximeter.

The layout of road track is shown in Figure 1.

Survey of the Track

The schematic rise and fall gradient of proposed experimental road track is carried out as such. The track of nearly 8.840 Km is considered for different rising and falling gradients. So that it should stimulate all possible road condition. The survey of the track which is selected is carried out with the help of following instruments as shown in Figure 2.

Auto Level

It has combine feature of the Wye and dumpy level. The main feature is the introduction of a prismatic compensator consisting of three mirrors arranged suitably. Autolevel determine the relative difference between two or more points by measuring (with a staff) from the ground level to the line of collimation as shown in Figure 4.

Figure 1: Layout of Road Path

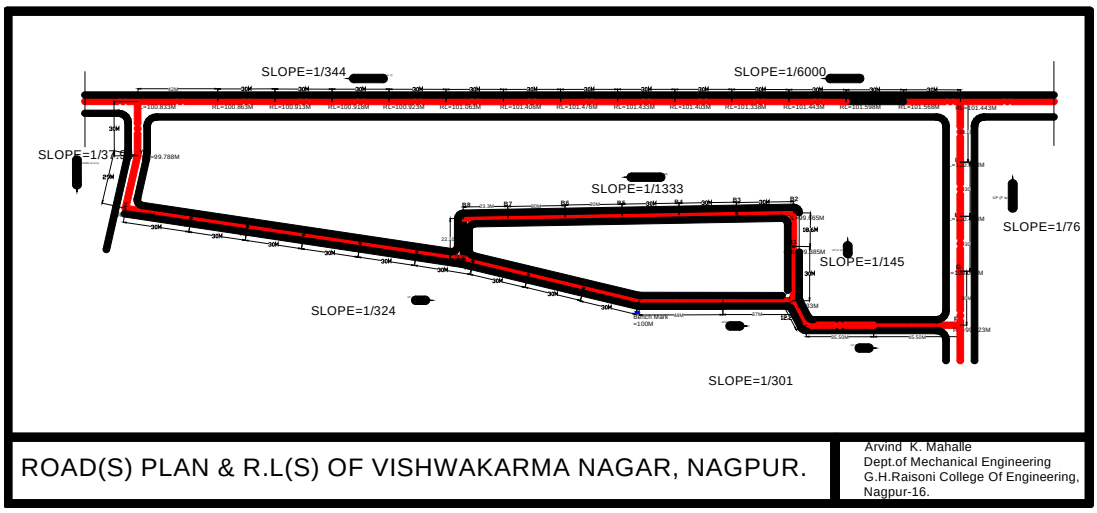


Figure 2: Survey of Track

Figure 3: Measuring Tape

Figure 4: Auto Level

Once the staff is above or below the visible line, too far away for an accurate sighting, the instrument is to move to a new location. In this way, survey is proceeding in a series of step, each steps being link by a repeat reading to the 'change point'. In this way a series of complete survey link to each other by a common point.

Leveling Staff

It is made of pine or deodar wood, 4 meters in height as shown in Figure 5. It comprises of two meters wooden pieces with the joint assembly. Each member is divided in to 200 divisions, the thickness of the graduations being 5 mm.

While taking readings, the staff should be truly vertical. To take the reading correctly, the staff is moved a little towards the level and then away from the level, the minimum reading observed shall be the correct reading.

Odometer

The odometer is ideal for measuring distances, flat surfaces of streets, roads, path or highways as shown in Figure 6. Odometers

Figure 5: Staff

Figure 6: Odometer

are accurate models with a mechanical counter in the measuring wheel. Measuring wheels perimeter has been highly precise rectified with to get a great accuracy. The odometer wheel automatically measures up to 9999, 9 meters (Diameter of Wheel = 318.5 m = 1 m of circumference).

Measuring Tape (Cloth-30 mt)

The measuring tape (cloth – 30 mt.) is used for marking the various points on the selected road track as shown in Figure 3.

After considering the track ,temporary bench mark is assumed, RL = 100 M, in the vicinity of Vishwakarma Nagar (south part of Nagpur, M.S). By using Autolevel, different points of elevation is determined by using method of height of collimation system.

Method of Height of Collimation System

The height of collimation system consists of finding the elevation of the plane of collimation, for the every set up of the instrument and then obtaining the reduced levels of points with reference to the respective plane of collimation. To begin with the elevation of the plane of collimation, the first set up of the level is determined by adding the back sight to the reduced level of the benchmark.

Reduced Level

The system of working out the reduced levels of points from the staff reading taken in the road track is termed as reducing levels. The Reduced Level (RL) of a point is the elevation of the point with reference to some datum.

The reduced level of the intermediate points and first change point are then obtained by subtracting the staff reading taken on these points from the elevation of the plane of collimation. When the instrument is shifted to the second potion, a new plane of collimation is set up. The levels of the two planes of collimation are calculated by means of the back sight and foresight taken on the change point. The elevation of this plane is obtained by adding the new back sight taken of the change point from the second potion of the level to the reduced level of the first change point.

The RL of the successive points and the second change point are found by

subtracting their staff readings from the elevation of this plane of collimation. The process is repeated until all the RL are worked out. On completing the reduction of levels, the accuracy of the arithmetical work is checked by the following:

Arithmetical Check: In order to check that the readings are correctly entered and the calculations are correctly made, an arithmetical check is applied. The difference between the sum of the back sights and the sum of the fore sights should be equal to the difference between the last and first reduced levels.

$$\Sigma BS - \Sigma FS = \text{Last } RL - \text{First } RL$$

The different *RL* of the track at different interval is shown in Table 1 and Table 2 respectively.

Table 1: Details of Leveling Using Height of Collimation at Site (Outer Path)

Point No.	Chainage	Length	Back Sight	Intrmediate Sight	Fore Sight	Height of Collimation	Reduce Level	Remark
BM @ Pole			1.435			101.435	100.000	BM
A	0.0	0		1.325		101.435	100.110	
B	44.0	44.0		1.245		101.435	100.190	
C	37.0	81.0	1.105		0.780	101.760	100.655	CP1
D	12.2	93.2		1.355		101.760	100.405	
E	35.5	128.7		0.805		101.760	100.955	
F	45.5	174.2	1.685		0.610	102.835	101.150	CP2
G	30.0	204.2		1.415		102.835	101.420	
H	30.0	234.2		1.075		102.835	101.760	
I	30.0	264.2	1.800		0.695	103.940	102.140	CP3
J	33.2	297.4		1.170		103.940	102.770	
K	30.0	327.4		1.045		103.940	102.895	
L	30.0	357.4	0.970		1.015	103.895	102.925	CP4
M	30.0	387.4		1.125		103.895	102.770	
N	30.0	417.4		1.180		103.895	102.715	
O	30.0	447.4	1.145		1.165	103.875	102.730	CP5
P	30.0	477.4		1.115		103.875	102.760	
Q	30.0	507.4	1.140		1.070	103.945	102.805	CP6
R	30.0	537.4		1.210		103.945	102.735	
S	30.0	567.4	0.940		1.555	103.330	102.390	CP7
T	30.0	597.4		1.080		103.330	102.250	
U	30.0	627.4	1.195		1.085	103.440	102.245	CP8
V	30.0	657.4		1.200		103.440	102.240	
W	30.0	687.4		1.250		103.440	102.190	

Table 1 (Cont.)

Point No.	Chainage	Length	Back Sight	Intrmediate Sight	Fore Sight	Height of Collimation	Reduce Level	Remark
X	42.0	729.4	0.410		1.280	102.570	102.160	CP9
Y	30.0	759.4		1.455		102.570	101.115	
Z	29.0	788.4	1.255		1.965	101.860	100.605	CP10
A1	30.0	818.4		1.480		101.860	100.380	
A2	30.0	848.4		1.430		101.860	100.430	
A3	30.0	878.4	1.440		1.355	101.945	100.505	CP11
A4	30.0	908.4		1.360		101.945	100.585	
A5	30.0	938.4		1.080		101.945	100.865	
A6	30.0	968.4	1.585		0.705	102.825	101.240	CP12
A7	30.0	998.4		1.510		102.825	101.315	
A8	30.0	1028.4		1.130		102.825	101.695	
A9	30.0	1058.4		0.810		102.825	102.015	
A10	30.0	1088.4			0.965	102.825	101.860	
	Arithmetic Check		16.105	27.850	14.245		1.860	
			BS-FS	1.860			OK	

Table 2: Details of Leveling Using Height of Collimation at Site (Inner Path)

Point No.	Chainage	Length	Back Sight	Intrmediate Sight	Fore Sight	Height of Collimation	Reduce Level	Remark
A			1.435			101.435	100.000	BM
B1	0.0	0.0		1.325		101.435	100.110	
B2	44.0	44.0		1.245		101.435	100.190	
B3	37.0	81.0	1.105		0.780	101.760	100.655	CP1
B3-1	0.0	81.0	1.700			103.460	101.760	
B4	30.0	111.0		1.645		103.460	101.815	
B5	18.6	129.6		1.365		103.460	102.095	
B6	30.0	159.6		1.550		103.460	101.910	
B7	30.0	189.6	1.315		1.475	103.300	101.985	CP2
B8	30.0	219.6		1.440		103.300	101.860	
B9	30.0	249.6		1.570		103.300	101.730	
B10	30.0	279.6		1.800		103.300	101.500	
B11	23.3	302.9	1.330		2.075	102.555	101.225	CP3
B12	22.1	325.0			1.525	102.555	101.030	
	Arithmetic Check		6.885	11.940	5.855		1.030	
				1.030			OK	

Survey Details

- Each round consists of one outer path and one inner path.
- Length of each round path = 1473.35 mt.
- Total number of rounds to be consider for reading - 6(3-forward rounds, 3-opposite rounds) to ensure total length of track as 8.840 Km, which is a requirement of the long path.

Considering rising and falling gradient, Outer path is mark with points: A to Z and A1 to A9 and inner path: B1 to B12 with help of Odometer. At these points, pulse is recorded during the experimentation (Cho *et al.*, 1999). The variation of chainage of outer ring (A-A9) and inner ring (B1-B12) is shown in Figure 7 and Figure 8 respectively.

TRAFFIC DATA COLLECTION

Traffic volume is the number of vehicles crossing a section of road per unit time at any selected time in a specified direction. Traffic

Figure 7: Variation of Levels of Outer Road Path

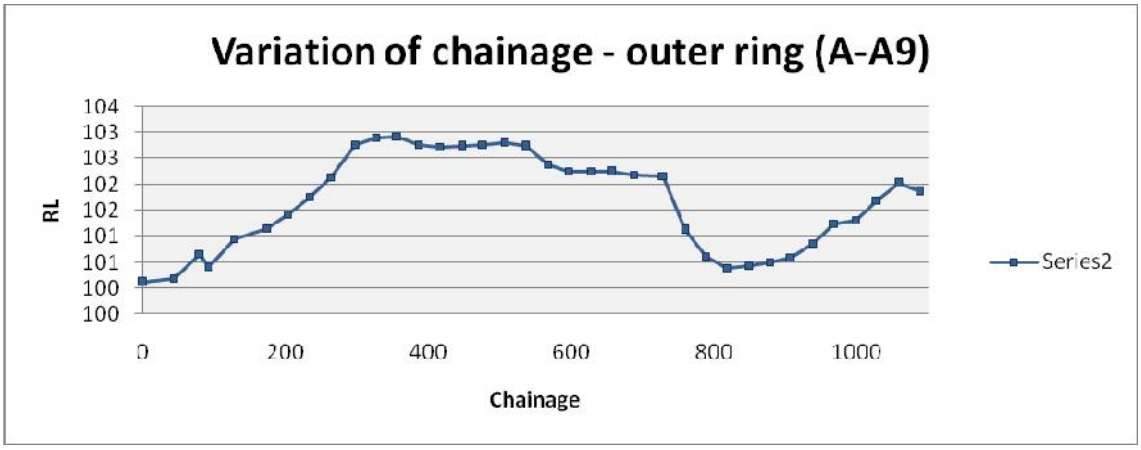
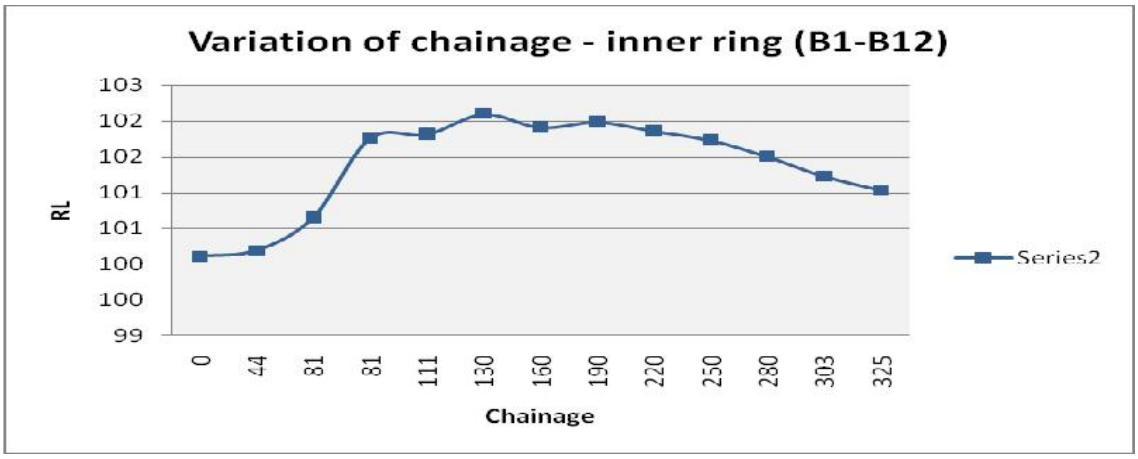


Figure 8: Variation of Levels of Inner Road Path



volume is expressed as vehicles per day and vehicles per hour.

The traffic flow data is needed for Project Design, to study future traffic trends and assisting in predicting traffic flows in the future for a given period and to classify roads on their functional basis. The magnitude of traffic data required is to be collected, manually. It is most common method of collecting traffic flow data, which consists of assigning a person to record traffic as it passes. The traffic-counting is carried out at the specific locations throughout the road network at set interval. The duration of the count is determined prior to commencement of traffic counting.

Manual Count Classification

Manual traffic flow count is categorized by a visual assessment of the vehicle size. The manual traffic flow data collection system classifies vehicles into nine categories as follows:

- Passenger Cars
- Pick up or Van/auto rickshaw
- Trucks
- Motorcycle/scooter
- Bicycle
- Cycle-rickshaw
- Heavy Busses, Mini Busses
- Small/large bullock cart and hand cart
- Agriculture Tractors

Duration of Counting

Duration of traffic counts is dependent on the type and quality of data required. However, the parameters to be considered are the peak traffic, average traffic. It is therefore important that surveys should produce information required at the lowest possible cost and to a level of accuracy that inspires confidence in decision making for the intended goal. When carrying out short-term counting, the counting period is free of events or holidays, Days with exceptionally bad weather.

Analysis and Presentation of Traffic Data

At the simplest extreme, analysis consists of totaling different categories of vehicles in a volumetric count.

The essential part of traffic data collection process is to be analyzed on the basis of Weekly traffic census count survey and Hourly traffic census survey which is presented in a format that is easily understandable. Weekly Traffic Census Count Survey is shown in Table 3.

The traffic volume generally varies throughout the week. The traffic during the working days (Monday to Friday) may not vary substantially, but the traffic volume during the weekend is likely to differ from the working days, Daily pattern of traffic is shown in Figure 9.

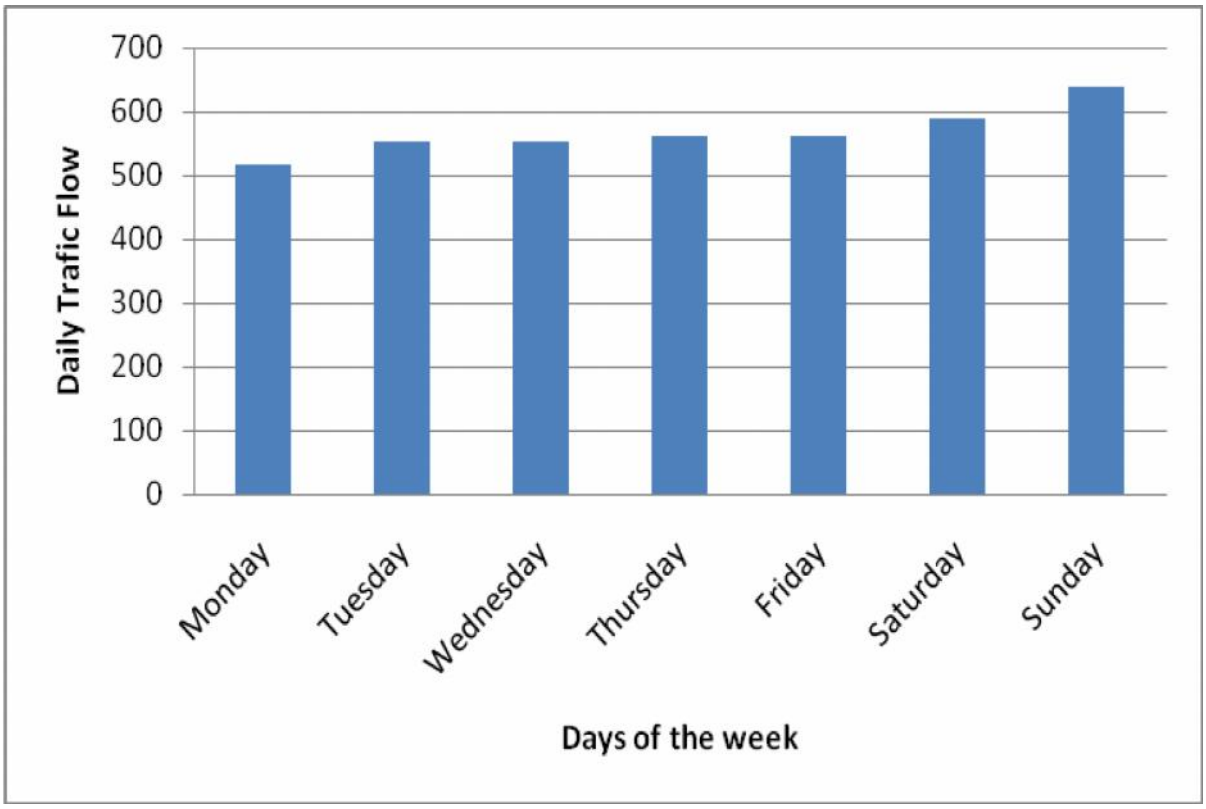
The pattern from Monday to Friday is often relatively consistent, a part from Monday morning and Friday afternoon traffic flow. The pattern during the weekend may vary considerably. The pattern also varies from Saturdays to Sundays. The pattern during the weekends is also likely to show more seasonal variation than during the working days.

On the road network during specific periods, traffic volumes changes considerably at each point in time as shown in Table 4.

Table 3: Weekly Traffic Census Count Survey Form Place-J-1, Census Point No-J-1, Direction Counted-Forward Month and Year-November-2012, No. of Days-7

Day	Cars	Pick Ups or Vans Auto Rickshaw	Trucks	Motor Cycle/ Scooter	Bicycle	Cycle Rickshaw	Heavy/ Mini Buses	Small/ Large Bullock Cart and Hand Cart	Agric Tractors	Total No. of Vehicles
	No.									
1	45	65	15	134	160	64	16	18	00	517
2	58	57	16	150	169	70	18	14	02	554
3	55	76	14	140	158	72	20	17	00	552
4	56	70	20	145	158	74	17	19	01	560
5	48	78	21	139	170	68	18	20	00	562
6	49	75	18	158	175	77	20	16	01	589
7	63	86	19	170	189	82	10	18	01	638

Figure 9: Different Average Daily Traffic Flow Levels



Typical hourly patterns of traffic flow show a number of distinguishable peaks in the morning followed by a new peak in the late evening. Hourly pattern of traffic flow is shown in Figure 10.

Table 4: Hourly Traffic Census Survey Form

Date: 03/12/20012, Place: South Part of Nagpur.

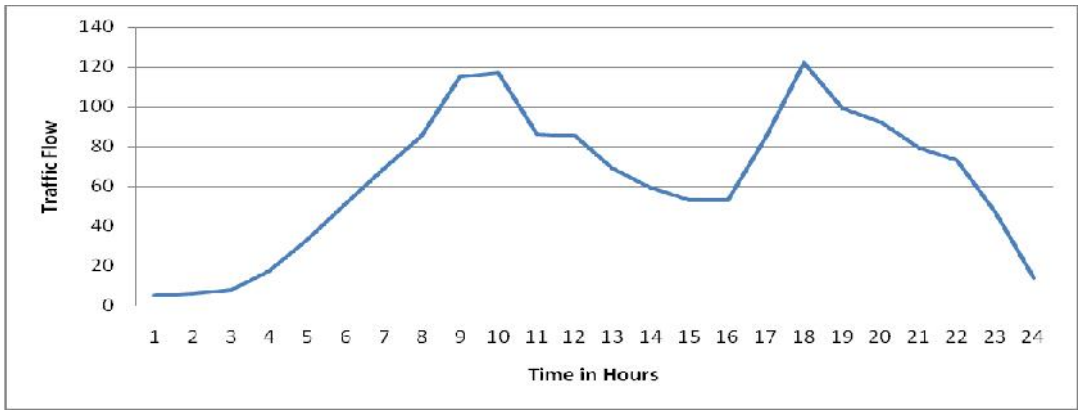
Time from: 6.00 am to 6.00 am, Census Point No. J-1,

Direction Counted: Forward Weather: Normal

Counted Heading: Beginning of day: 6.00 am Monday End of Day: 6.00 am Tuesday

S. No.	Hours ì / Types of Vehicles í	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	No. of Vehicles																								
1	Cars	0	0	2	3	4	4	2	6	13	11	14	10	8	7	7	6	9	16	15	13	13	14	10	2
2	Pick Ups Vans or Auto Rickshaw	3	3	2	4	4	6	10	13	20	18	14	15	12	10	11	8	15	19	17	17	16	15	11	6
3	Trucks	0	0	0	1	0	0	0	1	5	3	3	4	2	1	0	2	1	1	0	0	0	1	0	0
4	Motor Cycle/ Scooter	0	2	1	2	4	8	19	23	27	32	19	20	14	15	12	13	18	27	20	18	15	14	3	1
5	Bicycle	0	0	1	3	10	15	18	20	25	30	20	21	18	16	13	14	20	32	26	20	19	19	17	5
6	Cycle Rickshaw	2	1	2	4	6	12	15	14	19	17	12	12	9	7	8	7	14	19	14	17	12	7	4	0
7	Heavy/Mini Buses	0	0	0	0	0	3	2	4	5	5	4	3	3	3	2	3	6	7	6	7	4	3	2	0
8	Small/Large Bullock Cart and Hand Cart	0	0	0	0	5	3	3	2	1	1	0	0	2	0	0	0	2	0	1	0	0	0	0	0
9	Agriculture Tractors	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Total No. of Vehicle		**5**	**6**	**8**	**17**	**33**	**51**	**69**	**85**	**115**	**117**	**86**	**85**	**69**	**59**	**53**	**53**	**85**	**122**	**99**	**92**	**79**	**73**	**47**	**14**

Figure 10: Traffic Flow Variation



CONCLUSION

The cycle rickshaw is a local means of transport and also known as pedicab, cyclo, or trishaw in different part of the world. Cycle rickshaws are human-powered, i.e., are pulled by a person on foot, a type of tricycle designed to carry passengers in addition to the driver.

Energy to diver the cycle-rickshaw is provided by human being who works as an engine. The muscle power, basically those of buttocks, upper leg and lower leg transmitted to the pedal-cranks, which ultimately driver the rear wheels. The cracking mechanism is used for conversion of muscle power into the useful torque. Rickshaw puller propels the vehicle at his choice of speed and accordingly adjusts the pedal force and repetitive rhythm of muscles. To increase the power conversion of the cycle-Rickshaw puller and therefore to minimize the energy expenditure of rickshaw puller while pulling heavy load measuring approximately 250 kg, it is felt necessary to optimize wheel diameter and speed ratio of cycle-rickshaw.

In view of above, the experimentation is carried out on proper road track with detailed study of road track having slop up as well as down, slope shown on the layout which is enough to record consumption of energy of Rickshaw puller, reading of various parameters like blood pressure, pulse rate recorded while moving the rickshaw in forward as well as in opposite direction.

Since, this road track is representing every possible road condition, the concern track is considered for design of experimentation work (Cho *et al.*, 1999; and Martin and Spirduso, 2001).

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