ALTERNATE ROPEWAY TRANSIT SYSTEM FOR MANPADA ROAD

Prathmesh Nagare[1] and Dr.A.S.Wayal[2]

[1]M.Tech. Scholar, Department of Civil and Environmental Engineering, VJTI, Mumbai.
[2]Associate Professor, Department of Civil and Environmental Engineering, VJTI, Mumbai.

ABSTRACT

Cities grow in dynamic complex patterns, creating many problems. The study area of Dombivli - Manpada road has grown haphazardly in past decade due to population explosion. Manpada road attracts heavy traffic but due to narrow roads and inefficient transit options, it leads to severe traffic congestion, side friction, delays, stress, accidents and other problems. Alternate ropeway transit system provides a better public transit option and plays important role in reducing use of fossil fuels thus helping fight climate change. Total travel during peak hours is expected to double from 48000 to 88000 by 2031 which needs to be supported by various public transits. Cost benefit analysis is used here for evaluating desirability of project by weighting benefits against costs. Ropeway is expected to provide sustainable development, efficient and effective public transit option and contribute to protection and enhancement of environment.

KEYWORDS

Ropeway system, Sustainable transit, Benefit Cost Analysis, Manpada road.

1. INTRODUCTION

Transport is only sector which degrades as it grows. As per the definition given by World Commission on Economic Development, sustainable development is defined as "*development which meets present needs without compromising the ability of future generations to meet their own needs*".[1]Sustainable development is that which keeps natural resources safe for use of future generations. The 2005 World Summit on Social Development identified sustainable development goals, such as economic development, social development and environmental protection.[2] Allow the basic access and development needs of individuals, companies and society to be met in a manner consistent with human and ecosystem health and promote equity within and between successive generations.[2]Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and greenhouse gases emissions. [2](Ken Gwilliam, 2002)

2. LITERATURE REVIEW

The authors (Bergerhoff and Perschon, 2012) explain us that improvisation in technics and use of modern concepts have developed ropeways into an attractive, significant and low cost proposition for use of urban public transport.[5] Ropeways system offers plenty of secondary benefits, which make them the first option in urban transport scenario. Gondola system efficiency is reasonably higher than of other electric or combustion driven transport systems, provided that the minimum number of passengers is reached.[5]Flying over obstacles is key factor which creates opportunities for several ropeways applications. Most important benefit of Gondola or ropeways is its reduced so-called secondary costs.[5]

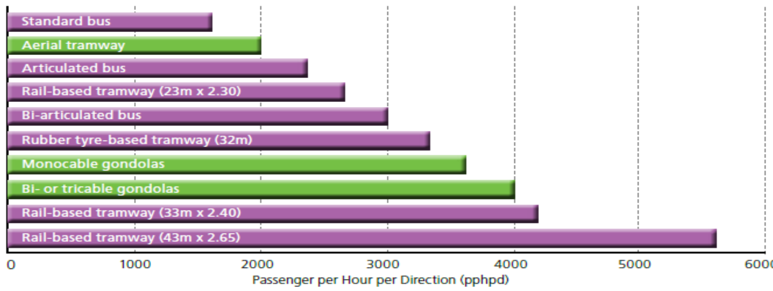


Fig.1Comparing capacities in pphpd.[5](Source - Bergerhoff and Perschon, 2012)

The authors (Ken Gwilliam, 2002 and Slobodan Mitric, 2005)in the urban development strategy paper "Cities in Transition" (World Bank 2002) studied that the liveability of developing cities depends on their being economically competitive, financially sustainable, well governed, and well managed.Its objectives are to develop a better understanding of urban transport problems in developing and transitional economies.[3][2] It articulates an urban transport strategy framework for national and city governments, and identifies the role of the World Bank in supporting governments.Various case studies are used to give better understanding of present scenario.

In this paper, authors (Akshaya Kumar Sen, Geetam Tiwari, Vrajaindra Upadhyay, 2009) estimates the marginal external costs coefficients in peak and off hours for Indian urban roads for the year 2005.[4]Cost coefficients for pollution, accidents, congestion are derived to estimate the marginal external cost of urban road traffic, which is necessary for analysing optimal urban transport prices while the other marginal external cost categories are assumed to be constant.[5]

The low amount and quality of traffic study and very scarce reliable data for Indian roads on estimation of marginal external costs of urban transport is to be noted.[4] Due to restricted parameters, multiple assumptions and diversity factors of Indian cities, it is recommended that marginal external costs estimated in this paper may be miscalculated. [4] The prerequisites data survey as mentioned in paper should be carried out for good quality results of comparisons between private and public transport modes.[4]

Total marginal external costs of urban transport (Rs./VKM).

Vehicle type	Congestion	Air pollution	Accidents	Noise	Total	Total (USD/VKM)
Petrol car						
Peak small	4.91	0.28	0.067	0.05	5.307	0.118
Peak big	4.91	0.31	0.067	0.05	5.337	0.119
Off-peak small	0.32	0.27	0.067	0.13	0.787	0.017
Off-peak big	0.32	0.30	0.067	0.13	0.817	0.018
Diesel car						
Peak small	4.913	1.674	0.067	0.05	6.704	0.149
Peak big	4.913	2.736	0.067	0.05	7.766	0.173
Off-peak small	0.316	1.030	0.067	0.13	1.543	0.034
Off-peak big	0.316	1.665	0.067	0.13	2.178	0.048
Bus						
Peak	9.826	14.140	1.771	0.49	26.227	0.583
Off-peak	0.632	9.106	1.771	1.28	12.788	0.284

Notes:

1. Conversion rate: 1 US Dollar=Rs. 45.00 (Indian Rupees).
2. Occupancy rate in buses: Peak: 66 and Off-peak: 30. This implies total per kilometer (pkm) MEC for buses would be: Rs. 0.40 (or US $ 0.001) in peak and Rs. 0.43 (or US $ 0.001) in Off-peak period.
3. For cars, the difference between pkm and vkm would be marginal, as in 2005 the average occupancy rate in cars was 1.3.

Fig.2 Marginal cost co efficients[4] (Source -Akshaya Kumar Sen, Geetam Tiwari, Vrajaindra Upadhyay, 2009)

The authors (Eco Northwest, Parsons BrinckeroffQuade& Douglas Inc.2002) discuss and concludes that postulates or laws make sense in the theory but in general become complex when tested them to practical situations and in details. The realities of the type, extent, and reliability of the complex data for making these measurements compound the problem.[6] The result is that rigorous evaluations of transit projects are not done well, not done efficiently, or not understood by the ultimate audience of policymakers and the public. This guidebook takes a step toward addressing these problems. The guidebook gives us the methodology to carry out cost benefit analysis while focusing from point of view of a local municipal corporation to actually do the measurement and make the analysis for actual tasks.[6]

3. PROBLEM STATEMENT & METHODOLOGY

3.1 Problem Statement

- To ensure sustainable development of Manpada road transport systems.
- To provide sustainable alternative transport system which solvespresent traffic crisis and has cost benefit ratio greater than one.

3.2 Aim of paper

- To identify issues with high density narrow urban city roads. i.e. Manpada road (Dombivli)
- To calculate costs, benefits and impacts of alternate transport system on Manpada road
- To analysis multiple factors of alternate ropeway and present transport system using cost benefit analysis for Manpada road.

3.3 Procedure

a. Study and literature review of present ropeway transit systems.
b. Comparative study of alternate transport systems for Manpada road through preliminary traffic surveys.
c. Traffic data surveys of Manpada road through primary and secondary data collection with respect to cost, energy, environment, safety, speed, congestion, fares, etc.
d. Assessment of above all above features of sustainability for ropeway urban public transport system.
e. Cost-benefit analysis of the ropeway transit for Manpada road.
f. Results and conclusions to suggest changes and impact on existing transport infrastructure.

4. STUDY AREA: DOMBIVLI STATION TO MANPADA SHIL PHATA JUNCTION (MANPADA ROAD).

Dombivli east railway station to Shil phata junction road or Manpda road is a highly dense traffic, narrow and congested road. The roadis evolved as the feeder road for Dombivli local station passengers for Mumbai due to major job opportunities in Mumbai city. This road is one of oldest business market place and major road, also an important link to newly developed job destination of Navi Mumbai. There is no new space available for expansion, also traffic flow cannot be disturbed for long time. Thus horizontal growth is not an option. Only vertical growth with LRT, Ropeway, Metro like transits with low right of way (RoW) are feasible options in this situation. Selection of the most appropriate mass transit mode can be difficult to all those who are interested in a new medium to high-capacity transit system for their city and want to manage the investment and maintenance costs of their new public mass transit system.[7] Buses are the backbone of the public transport system for many cities, and will remain so, for the foreseeable future. [7]A positive reallocation of road space from cars to buses will assist operations and will capitalize on the efficiency of buses in using that road space, but even this option is not available in this case.

[7] The ropeways are ideal in special situations just like the Manpada road. The annual average daily traffic on the Project Road is more than 15,000 PCU's.

Annual growth rate of autos and taxis in Dombivli is 8.8% and 19.4%. Taxis are growing at much higher rate than autos. Daily trips by auto and taxis is on average 16 and 10 respectively with trip length of 3.4 km and 5.1 km and capacity of 3 & 4 persons each. Autos charge Rs.18 and taxis charge Rs.30 for trip of Dombivli-Manpada petrol pump. Buses charge Rs.10. The frequency of KDMT buses is 1 per 15 min in peak hours and 1 per 30 min during rest of day. The average occupancy of bus is 33. While estimated people travelling during morning and evening peak hours is 0.88million from this road.

Fig.3 Actual Google map of study area (https://maps.google.com/)

Fig.4 Traffic congestion near Dombivli station area (Source – On Site photos)

The interruptions that cause traffic congestion are:

- Road Intersections and punctures present in the link in form of intersecting roads.
- Encroachments in form of hawkers, pavement dwellers, temporary structures etc.
- Road Side Friction.
- Proximity of houses, shops etc. to the pavement edge leads to 'spillover' of activities on to the pavement road.
- Pedestrian traffic associated with all of those above.

4.1 Road Transport Office (RTO), Dombivli (East)

According to RTO officer Rokade Sir and Ahire Sir, intersection points along road are most difficult points. People are stressed out due to slow traffic and thus break lanes, creating chaos. Most of footpaths are captured by hawkers and most of the roads are filled with parking and pedestrians thus find their way through road and little space remaining is used by vehicles. The Manpada road is actually 2 lane (12m each), 24m wide internal city road according to DP, but due to parking problem only 9m road is available for use, adding to problem is pedestrians walking on road. The recent national traffic accident data shows that 17 deaths are caused every hour on Indian roads.

The fine collected from illegal parked vehicles and rule breakers is,

2014 – 19053 cases (Rs.20, 65,800)
2013 – 16403 cases (Rs.18, 56,500)
2012 – 25660 cases (Rs.28, 12,900)
2011 – 28120 cases (Rs.30, 30,800)
2010 – 31978 cases (Rs.36, 45,500)

The number of major accidents recorded over the years are,

2014 – 100, 2013 – 167, 2012 – 112, 2011 – 120, 2010 – 183.

4.2 Traffic survey report

The population growth for KDMC region during 1961-2001 based on census data and forecast for period 2001-2031 by KDMC is presented below. Based on past trends of growth rates, population forecast for year 2021 and 2031 is 21.14 lakhs and 28.41 lakhs. This shows population and transit challenges are going to get worse sooner or later. Present roads are insufficient to carry load.

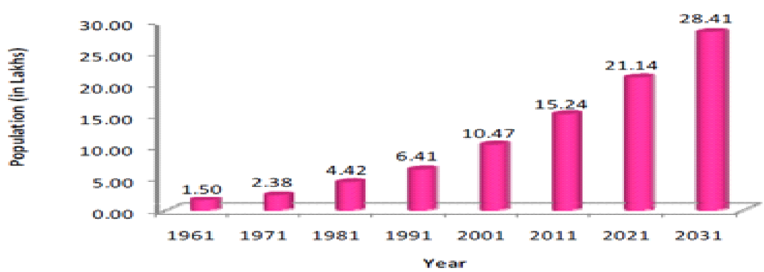


Fig.5 Population forecast[14] (Source - KDMC Traffic Survey report. Integrated traffic and mobility plan for KDMC 2009)

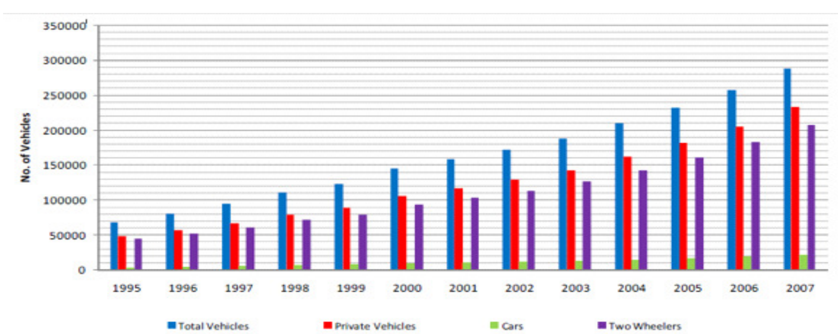


Fig.6 Number of vehicles[14](Source - KDMC Traffic Survey report. Integrated traffic and mobility plan for KDMC 2009)

KDMT operated a fleet of 125 buses in 2005-06, now the number has risen to 160. KDMC is largely dependent on Mumbai for most of its economic activity, it is developed as the residential hub of city. The internal city roads were not developed for such explosive growth, hence the traffic volumes and traffic congestion on road is constantly rising.

4.2.1. Peak Hour vehicle survey.

Table No. 1. Peak hour vehicle survey

Id : 24.2.16	Road Name : Manpada Station Road			
Time Interval	2 Whlr - Up	3 Whlr Auto - Up	Car-Jeep-taxi - Up	Govt-Bus - Up
Evening peak				
15:05 - 16:05	844	1246	120	5
16:05 - 17:05	916	1282	102	6
17:05 - 18:05	860	1170	98	6
18:05 - 19:05	912	1380	108	6
19:05 - 20:05	1064	1416	114	6
20:05 - 21:05	971	1092	78	5
MorningPeak				
07:05 - 08:05	722	812	88	5
08:05 - 09:05	741	890	112	6
09:05 - 10:05	828	996	88	6
10:05 - 11:05	936	1180	102	6
11:05 - 12:05	830	1020	114	5
12:05 - 13:05	706	962	82	4

4.2.2 Peak hour travel speed survey

Table No. 2. Peak hour travel speed survey

Dombivali Manpada road	3	KM/HR	3.6 KM	KM/HR	3.6 KM	KM/HR
81 Cr						
	CAR	Speed	BUS	Speed2	Walkin	Speed
06:00	14 min	15	20 min	11	45 min	5
07:00	16 min	13	20 min	11	45 min	5
08:00	18 min	12	22 min	10	45 min	5
09:00	18 min	12	24 min	9	45 min	5
10:00	22 min	10	26 min	8	45 min	5
12:00	20 min	11	24 min	9	45 min	5
13:00	18 min	12	22 min	10	45 min	5
14:00	16 min	13	22 min	10	45 min	5
15:00	16 min	13	22 min	10	45 min	5
16:00	16 min	13	24 min	9	45 min	5
17:00	18 min	12	24 min	9	45 min	5
18:00	20 min	11	24 min	9	45 min	5
21:00	22 min	10	26 min	9	45 min	5
22:00	18 min	12	22 min	10	45 min	5
23:00	14 min	15	20 min	11	45 min	5

4.2.3 Trip rate

The volume of passengers on Manpada road is about 80,000 during morning & evening peak hours and 1.5 lakh during weekdays. The mode with easy access, lower fare, lower congestion, reliable service, attractive transit is generally preferred. About 72% of total travel demand is from employed people and students. On an average, a commuter in KDMC spends about Rs.695 per month on transport. When average expenditure is plotted against total personal income, it can be inferred that expenditure rises with rising income. Most people leave home between 7:00 am. – 10:00 am. On other hand return to home journeys spread over longer six hour period of 1:00 pm to 10:00 pm. This is closely related to work habits of workers in service sector, distribution of school trips.

4.2.4 Travel volume characteristics

As in 2009, nearly 1, 21, 098 vehicles enter and 1, 28, 785 vehicle leave KDMC every day. While at Manpada road, 19, 257 vehicles enter and 17, 710 vehicles exit daily.

Table No.3 Vehicle Count (Source - KDMC Traffic Survey report)

Vehicle Type	Manpada road during daily peak hours
2 wheeler	10879
3 wheeler/taxis	13745
Cars	2293
Buses	188

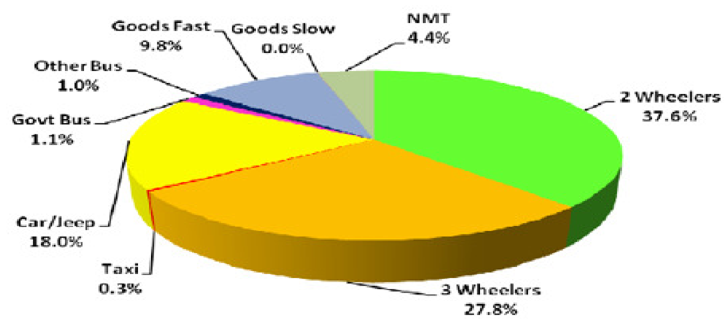


Fig.7 Vehicle count.[14](Source - KDMC Traffic Survey report
Integrated traffic and mobility plan for KDMC 2009)

Table No. 4. Land Use in 1995-2016

Landuse	**1995**		**2016**	
	Area(ha)	**%**	**Area(ha)**	**%**
Residential	1216	56.36	2138	46.89
Commercial	50	2.30	242	3.92
Industrial	210	9.75	485	9.11
Public purpose	47	2.16	393	7.82
Public utility	40	1.81	121	2.60
Recreational	16	0.75	24	0.83
Roads	232	10.74	925	16.27
Railways	340	15.88	1440	23.30
Bus depots	9	0.4	36	1.61
Total	2160	100	4165	100

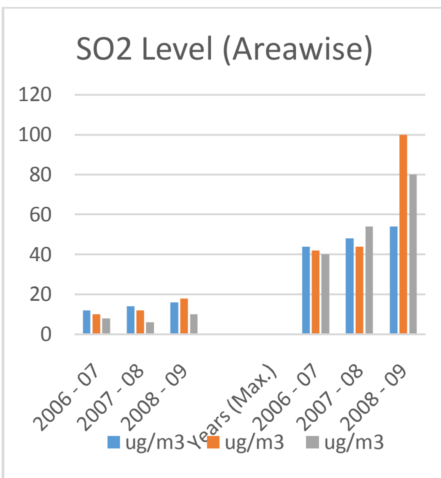
(Source – *Revised draft development plan,KDMC, 1995-2016*)

Table No.5 Average vehicle characteristics for Manpada road

Average	Auto	Taxi	Bus	Two wheeler
Trip	16	10	24	NA
Trip length	53km	58km	210km	42km
Fare	20	36	10	NA
Speed	18km/hr	16km/hr	12km/hr	22km/hr
Occupancy	3	4	36	2

4.2.5 Pollution

At Manpada road near Shivaji chowk. (Maharashtra pollution control board)



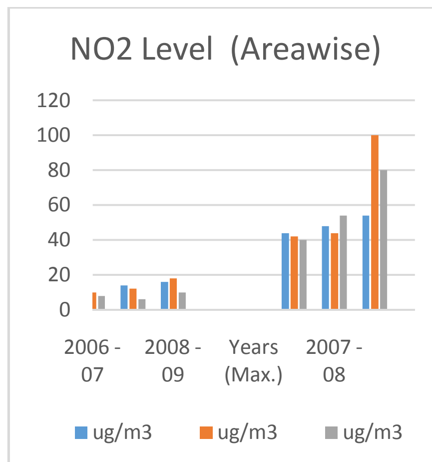


Fig.8 Air pollution details. (Source – *Maharashtra Pollution Control Board*)

Table No.6 Air pollution details.

Class	No. of locations	Range of SO2 2007	2008	Range of NO2 2008	2009	Range of RSP 2008	2009
Industrial	14	8-40	8-33	12-49	13-59	51-160	44-240
Residential	18	5-35	8-47	6-53	10-111	40-186	46-172
Commercial	8	7-19	8-56	10-41	15-136	50-107	59-294

(Source – *Maharashtra Pollution Control Board*)

5. PRIMARY PROJECT DETAILS

Project details: Ropeway for Manpada Road

- Manpada road(24m width)
- Climate - Hot & Humid. Low wind speeds.
- Total Length - 4 km
- Gondola spacing – 100m (every 30sec)
- 4Intermediate halt stations + 1 Integrated Dombivli station.
- 30 ballast at 100m to 150m spacing.
- Peak hours traffic - 9000 pphpd
- Gondola Speed –18-30 km/h
- Gondola capacity – 6000 pphpd
- 30 Gondolas with 30 seats each

Table No.7 Impact factors

Category	Improved Transit Service	Increased Transit Travel	Reduced Automobile Travel	Transit-Oriented Development
Indicators	Service Quality (speed, reliability, comfort, safety, etc.)	Transit Ridership (passenger-miles or mode share)	Mode Shifts or Automobile Travel Reductions	Portion of Development With TOD Design Features
Benefits	• Improved convenience and comfort for existing users. • Equity benefits (since existing users tend to be disadvantaged). • Option value (the value of having an option for possible future use). • Improved operating efficiency (if service speed increases). • Improved security (reduced crime risk)	• Increased user security, as more users ride transit and wait at stops and stations. • Mobility benefits to new users. • Increased fare revenue. • Increased public fitness and health (by stimulating more walking or cycling trips).	• Reduced traffic congestion. • Road and parking facility cost savings. • Consumer savings. • Reduced chauffeuring burdens. • Increased traffic safety. • Energy conservation. • Air and noise pollution reductions.	• Additional vehicle travel reductions ("leverage effects"). • Improved accessibility, particularly for non-drivers. • Reduced crime risk. • More efficient development (reduced infrastructure costs). • Farmland and habitat preservation.
Costs	• Increased capital and operating costs, and therefore subsidies. • Land and road space. • Traffic congestion and accident risk imposed by transit vehicles.	• Transit vehicle crowding.	• Reduced automobile business activity.	• Various problems associated with more compact development.

5.1 Site Selection

The length of road is 4 km. The Dombivli station will be integrated with ropeway transit. The recommended spacing between two stations is min. 750m. Therefore only 3-4 stations can be placed in between origin Dombivli station and destination Shil phata. The following site were found most suitable for intermediate stations. These are most used bus stations on Manpada road. There exist enough free space for construction.

Fig.9 Site selection for stations

The following sites were found most suitable for placing ballasts. The height of ballast depends upon span between them. Thus 100-150m of span is selected and height of ballast is 30m. Around 30 such supports are to be provided along 3.6km road. The space required is hardly 1 square meter, so mostly intersection points are selected.

Fig.10 Site selection for ballasts

Location of 5 planned stations and 30 ballasts.

1. Dombivli station - Shivaji Chowk (120m) – Gupta store (120m) – Siyaram store (130m) - Chaar rasta (130m)- Navjevan Hospital (140m) – RoyalGift (140m)
2. Gav Devi (150m) – BSNL (160m) – Icon Hospital (150m) - United Bank (120m)
3. Shiv Udyog BT (140m) – Sleepwell (160m) - Star colony BT (130m) - Sai Temple (140m) - Big Bazar (160m)
4. Decent eye care ST (120m) - Sagaon BT (140m) – Sanghvi (160m) - Sanghvi BT (160m) – VNS industry (130m)
5. Pimpaleshwar (130m) – Shyamrao Vithalrao Bank (140m) - Shani Mandir (160m) – DMart (120m) - Rotex road (130m)
6. Sagaon Kalyan Shil phata Road.(150m)

6. COST BENEFIT ANALYSIS

6.1 Cost benefit analysis criteria.

- All significant impacts should be addressed
- Relative differences between alternative policies are often more important than absolute impacts
- The distribution of impacts can be more important that their totals.
- A benefit or cost in the future has less value than the same one now.
- Base year – 2016. Target year – 2020.

6.2 Preliminary Screening: Short listing projects.

- Since the Manpada road is narrow and densely congested, there are very few mass transit opportunities available here. Among the few feasible alternatives are: LRT (Mono/Metro), BRT and Ropeway.
- Although BRT seems to be first choice, it is impossible to successfully implement BRT on this road because of lack of space. The Manpada road is just 24m narrow road with very high density traffic. The BRT has high right of way which is not available in case of Manpada road and also it uses fossil fuels hence BRT option is rejected.
- The capacity of Metro rail is about 60,000 pphpd. While traffic demand of Manpada road is merely 5000-6000 pphpd. Thus the implementation of Metro will definitely result in unused capacity and loss in opportunity cost. Metro rail doesn't suit traffic demand of Manpada road and hence is rejected.
- Thus only the mono rail and ropeway are suitable options for Manpada road. Comparative study of both shows us that ropeway has many more advantages than mono rail and is also more cost effective than mono rail. Also ropeway is more cost optimal and flexible than mono rail, hence it is adopted.

Transit Mode	Commuter Rail	Metro	Monorail	LRT	BRT
ROW Options	Exclusive ROW / Sharing with Long Distance Trains	Exclusive ROW Grade Separated	Elevated Monorail – 5 m	At-Grade Exclusive ROW (20 m minimum and addnl. 8m at stations); Elevated LRT – 10m	Exclusive ROW (28m minimum and addnl. 7m at stations) Semi-exclusive; Mixed traffic lanes
Station Spacing (Approx)	3 -15 km	1 - 2 km	1 km	1.5 km	0.5 km
Vehicles	Locomotives with the set of Passenger coaches	High platform cars operating in multiple car trains sets	High platform cars operating in multiple car trains sets, electric propulsion	Articulated, double articulated low floor can operate in multiple car sets, electric propulsion	Standard, articulated double articulated low or high platform cars diesel/hybrid propulsion, Electric Trolley Bus
Seated Capacity	90-185 per car	60-80 Per Car	25 - 45 Per Car	65-85 Per Car	40 Standard; 75 Articulated; 125 double articulated
Total Capacity	-	100 – 250 per car	50 - 100 per car	75 – 225 per car	50 – 100 Standard
Average Speed	40-70 kmph	25-55 kmph	25-40 kmph	25-50 kmph	25-50 kmph
Headways	-	3 min	2 min	2 min	1 min
Passenger Throughput PPHPD	Up to 75,000	40,000 - 60,000	Up to 20,000	20,000 (At grade) Up to 40,000 (Elevated LRT)	5,000 – 8,000 Up to 25,000 (with articulated buses and overtaking facilities)
Min.Curve Radius	50 m	150 m	Elevated -50 m	At Grade - 25 m Elevated LRT – 100m	25 m
App O & M Cost per km	40-60 lakhs	100-200 Lakhs	40-60 Lakhs	50-60 Lakhs	10 Lakhs
App Capital Cost per km (Rupees)	80 Crores	250 Crores (Elevated) 550 Crores (Underground)	80 Crores	150 Crores	20 Crores
Environmental (sound level)			75 dBA	90 dBA	
Implemented Cities (International)	Moscow. Jakarta, Johannesburg, Buenos Aires	Bangkok, Kuala Lumpur, Mexico City, Cairo	Tokyo, Kuala Lumpur, Sydney, Seattle	Hong Kong, Shanghai, Kuala Lumpur	Istanbul, Taipei, Bogota, Curitiba, Pitts Adelaide
Implemented Cities (India)	Mumbai, Chennai, Kolkata, Hyderabad	Delhi, Kolkata, Bangalore, Chennai Under implementation	Under Implementation in Mumbai	Kolkata	Ahmedabad, Delhi

Fig.11 Alternate Mass transit systems.[17]
(Source –Stephen Luke, Mac Macdonald, 2012)

6.3 Cost consideration

The cost of travel involves direct marginal monetary costs, such as transit fares, fuel costs, tire deterioration and the cost of an individual's time spent traveling.[8]

Some external costs such as indirect social costs are not measured in the total cost of travel. By reducing these externalities, social benefits can be gained.

6.4 Benefit consideration

To measure aggregate net user benefits, the analyst needs to know the amount of travel before the improvement (by mode and time of day using a travel demand model), the perceived costs for these travel patterns (per unit of travel), the amount of travel after the improvement, the perceived costs for the changed travel patterns.

"Cost-Benefit Analysis *is a* procedure for evaluating the desirability of a project by weighting benefits against costs. [9] Results may be expressed in different ways, including internal rate of return, net present value and benefit-cost ratio"[10](Manar A. El Gammal, 2007 and American Transport department)

Table No.8 Analysis during peak hour

Analysis during Peak hour

Data type	Symbol	Unit	Autos + Taxi		Buses		Two wheelers		Ropeway	
			Base Case	With Proj.	Base Case	With Proj.	Base Case	With Proj.	Base Case	With Proj.
Corridor Length	L	km	4	4	4	4	4	4	4	3.6
Vehicles	M	No.	1282	562	9	9	936	568	-	30
Passenger / Vehicle	D	No.	3	3	54	36	2	2	-	30
Capacity	Q	pphpd	3846	1686	486	324	1862	1136	-	3600
Speed	S	Km/hr	18	25	12	20	22	28	-	25
Travel Time	T	Min./pass.	22	16	26	16	18	9	-	11
No. of trips	P	No.	16	22	24	30	-	-	-	45
Fares	F	Rs./pass.	15	15	10	10	-	-	-	10
Value of time	Y	Rs. / hr	40	40	40	40	40	40	-	40
Cost of time	N	Rs. / hr	14.66	10.66	17.33	10.66	12.00	6.00	-	7.00
Total travel time benefit	U	Rs. / pass	-	4.00	-	7.00	-	6.00	-	7.00
Travel Volume	V	Pass*km	15384	6744	1944	1296	7448	4544	-	12960

Costs

1. Construction Costs

- Station + Electromechanical installations = 5 stations x 50crore = 50crore.
- Gondola = 60 x 25lakhs = 15 crore.
- Ballasts = 30 x 30lakhs = 9 crore.
- Ropeway = 4km x 18lakhs = 72 lakhs.
- Control building = 2.4 crore.
- Construction cost = 1.2 crore. (140 days)
- Land acquisition = 4 crore.

Total = 82.52 crore.

Interest rate = 10%(Assumed). Therefore, Total cost in 2020 = Rs. 123.65 crore.

2. Operation and maintenance cost
   Electricity = 700m watts
   Electricity + IT Staff + Repairs/Replace + Beautification/Cleaning + Overheads = 5-10% installation cost = 3 crore per year.
   Total = 12 crore.

   Interest rate = 10%Total cost in 2020 = 17.87 crore.

   Total cost = Rs. 123.65 + Rs. 17.87
   = Rs. 141.52 crore

Secondary costs

1. Right of way impacts
2. Capital cost
3. Security and insurance cost
4. Traffic related agencies.

Benefits

1. Travel time saving = pphpd x working hrs. x time value saving

   = 3600 pphpd x 18hrs x 5 Rs/hr.
   = Rs. 3,24,000 daily x 260 days/yr.
   = Rs. 8,42,40,000 yearly x 4 yrs.
   = Rs. 33,69,60,000 in 2020.

2. Travel fare income = pphpd x working hrs. x fares

   = 3600 pphpd x 18hrs x 10 Rs/hr.
   = Rs. 6,48,000 daily x 260 days/yr.
   = Rs.16,84,48,000 yearly x 4 yrs.
   = Rs. 67,37,92,000 in 2020.

3. Environmental benefits = Reduction noise pollution
   + Reduction in air pollution
   = Rs. 29,80,97,280 +
   Rs. 1,68,66,720
   = Rs. 31,49,64,000 in 2020.
   Reduction in air pollution = Marginal cost coefficient

   Rs / Vkm x Total Vkm

   = 0.28 x (7448 - 4544) + 1.674 (15384 - 6744) + 14.140 (1944-1296)
   = 813 + 14463 + 9162 = Rs 15924 hourly x 18
   = Rs 2,86,632 daily x 260 = Rs. 7,45,24,320 x 4
   = Rs. 29,80,97,280 in 2020.
   Reduction in Noise pollution = Marginal cost coefficient
   Rs / Vkm x Total Vkm
   = 0.05 x (7448 - 4544) + 0.05 (15384 - 6744) + 0.5 (1944-1296)
   = 145 + 432 + 324 = Rs. 901 hourly x 18
   = Rs. 16218 daily x 260 = Rs. 42,16,680 x 4
   = Rs. 1,68,66,720 in 2020.

4. Safety benefits = Marginal cost coefficient Rs / Vkm
   x Total Vkm

Safety = 0.67 x (7448 - 4544) + 0.67 (15384 - 6744) + 1.71 (1944-1296)

= 1945 + 5788 + 1108 = Rs. 8841 hourly x 18
= Rs. 1,59,138 daily x 260 = Rs. 4,13,75,880 x 4
= Rs. 16,55,03,520 in 2020.

Total Benefits = Rs. 33,69,60,000 + Rs. 67,37,92,000
+ Rs. 31,49,64,000 + Rs. 16,55,03,520
= Rs. 150,12,19,520

Secondary benefits

1. Reduction in traffic congestion
2. Fuel conservation
3. Land use impact

4. Option value
5. Last mile connectivity
6. Better service
7. Increase tourism coefficient

Total Cost = Rs. 141.52 crore. Total Benefits = Rs. 150.12 crore
Benefit / Cost ratio = Rs. 149 crore / Rs. 150.12= 1.06> 1.00.

7. CONCLUSION

- Cost benefit analysis shows that the system is highly beneficial if implemented properly. Considering various additional secondary benefits available added to the cost benefit ratio for system is 1.06>1.00 is very good and acceptable.
- Travel time will be as less as 11 min and average speed shall be 25km/hr which is much greater than 13km/hr of bus, 18 km/hr of two wheeler and 15km/hr of auto.
- To solve last mile crisis and increasesprofits and passenger volume, Park and ride option should be provided.
- The ropeway system has low space requirements. Thus no new space is needed.
- The ropeway transit has capacity of 6000 pphpd. Thepeak hour road traffic volume is 9000 pphpd. Thus reduction in traffic congestion and other traffic related problems.
- The Gondola frequency can be changed according to the travel demand.
- The Gondola or ropeway transit doesn't use fossil fuels, hence reductionin pollutionand use of electricity as non-polluting fuel which can be generated using solar energy from gondolas and stations.
- The ropeway gondolas are user friendly and provide more privacy and better comfort hence will be more preferred.
- The gondolas system will attract many tourists due to pleasant city top view it provides.
- Reports says gondolas are safer than all other modes available. Thus many valuable lives shall be saved. Only 9 major accidents have been recorded on present ropeway transit systems built after 2002.
- The Dombivli station, likewise, intermediate stations will be integrated with important buildings thus saving station costs.
- It will create new job opportunities in construction, operation and maintenance for system.
- The minimum and maximum speed of a Gondola is 18km/hr. and 45 km/hr.
- Ropeway projects are easier to implement and to operate than BRT projects and others
- The overall congestion will come down by 40-50%. Travel volume will also increase with added option value.
- Ropeway transit offer a sound technical and economic model for mass public transport at a fair and inexpensive price
- Ropeway transit well can be first high level public transport system in many developing cities, opening the minds and creating the environment for entire multi-modal systems.

ACKNOWLEDGEMENTS

This project is successfully completed with guidance and support of KDMC officials, KDMT officers and officials of Road transport department of Dombivli, VJTI staff and encouragement from my friends. Thanks to everyone!

REFERENCES

1. World Commission on Environment and Development, (1987), *Our Common Future.*
2. Ken Gwilliam, (2002), World Bank Report -*"Cities in Transition"*
3. Slobodan Mitric (2005),*"Towards discussion of support to Urban Transport development in India."*

4. Akshaya Kumar Sen, Geetam Tiwari, Vrajaindra Upadhyay, (2009),*"Estimating marginal external cost of transport."*
5. Joachim Bergerhoff andJürgen Perschon, (2012),*"Urban Ropeway As a Part Of Sustainable Urban Transport Network In Developing Countries."*
6. Eco Northwest, Parsons Brinckeroff Quade & Douglas Inc.,(2002), *"Estimating the benefits and costs of public transit projects : A guidebook for practioners"*
7. Francis Kühn, *"Bus rapid or light rail transit for intermediate cities."*
8. Jennifer Blonn, Deven Carlson, Patrick Mueller,Ian Scott, (2006),*"Transport 2020 Bus Rapid Transit: A Cost Benefit Analysis"*
9. Manar A. El Gammal, (2007), *"Evaluation of Cultural Heritage Benefits to Urban Economic Development and Sustainability."*
10. American transportation department. *"Improving Practices of CBA guidebook"*
11. Sudhakar Yedla, (IGIDR) Mumbai, India,*"Climate Change Mitigation Initiatives in Urban Transportation – Assessment of Retrofitting Strategies to Promote NMT in Indian Cities."*
12. Sudarsanam Padam, Sanjay Kumar Singh,*"Urbanization and urban transport in India: the search for a policy."*
13. Wondimu Abeje, *"Sustainable Urban Mobility Planning for Coping Challenges of Urban Transportation in the Fast Urbanizing Ethiopia."*
14. LEA consultants (Final KDMC traffic survey report),(2005),*"Integrated traffic and transportation policy for KDMC."*
15. Sergej Težak, Ph.D., Drago Sever, Ph. D., Marjan Lep, Ph.D., *"Increasing the Capacities of Cable Cars for Use in Public Transport."*
16. Dingra, Chhavi, EAMBRQ, India. *"Enabling sustainable mobility in Indian cities through good governance."*
17. Stephen Luke, Mott Macdonald, *"Public Transport Mode Selection: A Review of International Practice."*
18. Banerjee, Walker, Kanafani, University of California, Berkeley,*"Automobility in an Indian City."*

Author

Prathmesh Nagare Born in Nashik, India 1993. He Graduated from Government College of Engineering and Research, Avsari, Pune University. He is currently pursuing PG in M.Tech. Construction Management at Department of Civil and Environmental Engineering inVeermata Jijabai Technological Institute, Mumbai University.

Dr. A. S. Wayal is presently working as Associate Professor, Civil and Environmental Engineering Department, Veermata Jijabai Technological Institute, (V.J.T.I.), Mumbai. He has published number of research papers on varying topics, including water conservation, in National and International Journals and conferences. Areas of his research interest are Water resource Engineering, Surface water hydrology & Construction materials etc. He is member of editorial board of "Journal of Indian Water Works Association" and "Journal of Hydrologic Engineering", ASCE. He is also guiding M.Tech and Ph.D. students. He has worked as a consultant for various government projects and others.