ALTERNATE ROPEWAY TRANSIT SYSTEM FOR MANPADA ROAD

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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.³ Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and greenhouse gases emissions.³ (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.⁴ 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
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. 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. 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.

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. 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. The prerequisites data survey as mentioned in paper should be carried out for good quality results of comparisons between private and public transport modes.

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

Fig.2 Marginal cost coefficients (Source - Akshaya Kumar Sen, Geetam Tiwari, Vrajaindra Upadhyay, 2009)
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 solves present 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 Manpada road is a highly dense traffic, narrow and congested road. The road is 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.
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 0.88 million from this road.

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

![Fig.4 Traffic congestion near Dombivli station area](https://maps.google.com/)

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,

<table>
<thead>
<tr>
<th>Year</th>
<th>Cases</th>
<th>Fine (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>19053 cases</td>
<td>Rs.20,65,800</td>
</tr>
<tr>
<td>2013</td>
<td>16403 cases</td>
<td>Rs.18,56,500</td>
</tr>
<tr>
<td>2012</td>
<td>25660 cases</td>
<td>Rs.28,12,900</td>
</tr>
<tr>
<td>2011</td>
<td>28120 cases</td>
<td>Rs.30,30,800</td>
</tr>
<tr>
<td>2010</td>
<td>31978 cases</td>
<td>Rs.36,45,500</td>
</tr>
</tbody>
</table>

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.

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

**Fig.6 Number of vehicles (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

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>2 Whlr - Up</th>
<th>3 Whlr Auto - Up</th>
<th>Car-Jeep-taxi - Up</th>
<th>Govt-Bus - Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evening peak</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15:05 - 16:05</td>
<td>844</td>
<td>1246</td>
<td>120</td>
<td>5</td>
</tr>
<tr>
<td>16:05 - 17:05</td>
<td>916</td>
<td>1282</td>
<td>102</td>
<td>6</td>
</tr>
<tr>
<td>17:05 - 18:05</td>
<td>860</td>
<td>1170</td>
<td>98</td>
<td>6</td>
</tr>
<tr>
<td>18:05 - 19:05</td>
<td>912</td>
<td>1380</td>
<td>108</td>
<td>6</td>
</tr>
<tr>
<td>19:05 - 20:05</td>
<td>1064</td>
<td>1416</td>
<td>114</td>
<td>6</td>
</tr>
<tr>
<td>20:05 - 21:05</td>
<td>971</td>
<td>1092</td>
<td>78</td>
<td>5</td>
</tr>
<tr>
<td>Morning Peak</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07:05 - 08:05</td>
<td>722</td>
<td>812</td>
<td>88</td>
<td>5</td>
</tr>
<tr>
<td>08:05 - 09:05</td>
<td>741</td>
<td>890</td>
<td>112</td>
<td>6</td>
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<tr>
<td>09:05 - 10:05</td>
<td>828</td>
<td>996</td>
<td>88</td>
<td>6</td>
</tr>
<tr>
<td>10:05 - 11:05</td>
<td>936</td>
<td>1130</td>
<td>102</td>
<td>6</td>
</tr>
<tr>
<td>11:05 - 12:05</td>
<td>830</td>
<td>1020</td>
<td>114</td>
<td>5</td>
</tr>
<tr>
<td>12:05 - 13:05</td>
<td>706</td>
<td>962</td>
<td>82</td>
<td>4</td>
</tr>
</tbody>
</table>

4.2.2 Peak hour travel speed survey

Table No. 2. Peak hour travel speed survey

<table>
<thead>
<tr>
<th>Time</th>
<th>Car 3 KM/HR</th>
<th>Car 3.6 KM/HR</th>
<th>Bus 3 km/HR</th>
<th>Bus 3.6 km/HR</th>
<th>Walking 3.6 km/HR</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:00</td>
<td>15</td>
<td>20</td>
<td>11</td>
<td>05</td>
<td></td>
<td></td>
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<td>07:00</td>
<td>13</td>
<td>20</td>
<td>11</td>
<td>05</td>
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</tr>
<tr>
<td>08:00</td>
<td>12</td>
<td>22</td>
<td>10</td>
<td>05</td>
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<td>09</td>
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</tr>
<tr>
<td>13:00</td>
<td>12</td>
<td>22</td>
<td>10</td>
<td>05</td>
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</tr>
<tr>
<td>14:00</td>
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<td>22</td>
<td>10</td>
<td>05</td>
<td></td>
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<tr>
<td>15:00</td>
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<td>10</td>
<td>05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>13</td>
<td>24</td>
<td>09</td>
<td>05</td>
<td></td>
<td></td>
</tr>
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<td>17:00</td>
<td>12</td>
<td>24</td>
<td>09</td>
<td>05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18:00</td>
<td>11</td>
<td>24</td>
<td>09</td>
<td>05</td>
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<td></td>
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<tr>
<td>19:00</td>
<td>10</td>
<td>26</td>
<td>09</td>
<td>05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20:00</td>
<td>11</td>
<td>24</td>
<td>09</td>
<td>05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:00</td>
<td>12</td>
<td>22</td>
<td>10</td>
<td>05</td>
<td></td>
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</tr>
<tr>
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<td>12</td>
<td>22</td>
<td>10</td>
<td>05</td>
<td></td>
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</tr>
<tr>
<td>23:00</td>
<td>15</td>
<td>20</td>
<td>11</td>
<td>05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 the 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 the 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)

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Manpada road during daily peak hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 wheeler</td>
<td>10879</td>
</tr>
<tr>
<td>3 wheeler/taxis</td>
<td>13745</td>
</tr>
<tr>
<td>Cars</td>
<td>2293</td>
</tr>
<tr>
<td>Buses</td>
<td>188</td>
</tr>
</tbody>
</table>

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

Table No. 4. Land Use in 1995-2016

<table>
<thead>
<tr>
<th>Landuse</th>
<th>1995</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (ha)</td>
<td>%</td>
</tr>
<tr>
<td>Residential</td>
<td>1216</td>
<td>56.36</td>
</tr>
<tr>
<td>Commercial</td>
<td>50</td>
<td>2.30</td>
</tr>
<tr>
<td>Industrial</td>
<td>210</td>
<td>9.75</td>
</tr>
<tr>
<td>Public purpose</td>
<td>47</td>
<td>2.16</td>
</tr>
<tr>
<td>Public utility</td>
<td>40</td>
<td>1.81</td>
</tr>
<tr>
<td>Recreational</td>
<td>16</td>
<td>0.75</td>
</tr>
<tr>
<td>Roads</td>
<td>232</td>
<td>10.74</td>
</tr>
<tr>
<td>Railways</td>
<td>340</td>
<td>15.88</td>
</tr>
<tr>
<td>Bus depots</td>
<td>9</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>2160</td>
<td>100</td>
</tr>
</tbody>
</table>

(Source – Revised draft development plan, KDMC, 1995-2016)
Table No.5 Average vehicle characteristics for Manpada road

<table>
<thead>
<tr>
<th>Average</th>
<th>Auto</th>
<th>Taxi</th>
<th>Bus</th>
<th>Two wheeler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip</td>
<td>16</td>
<td>10</td>
<td>24</td>
<td>NA</td>
</tr>
<tr>
<td>Trip length</td>
<td>53km</td>
<td>58km</td>
<td>210km</td>
<td>42km</td>
</tr>
<tr>
<td>Fare</td>
<td>20</td>
<td>36</td>
<td>10</td>
<td>NA</td>
</tr>
<tr>
<td>Speed</td>
<td>18km/hr</td>
<td>16km/hr</td>
<td>12km/hr</td>
<td>22km/hr</td>
</tr>
<tr>
<td>Occupancy</td>
<td>3</td>
<td>4</td>
<td>36</td>
<td>2</td>
</tr>
</tbody>
</table>

4.2.5 Pollution

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

![SO2 Level (Areawise)](image1)

![NO2 Level (Areawise)](image2)

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

Table No.6 Air pollution details.

<table>
<thead>
<tr>
<th>Class</th>
<th>No. of locations</th>
<th>Range of SO2 2007-08</th>
<th>Range of NO2 2008-09</th>
<th>Range of RSP 2008-09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>14</td>
<td>8-40</td>
<td>12-49</td>
<td>51-160</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-33</td>
<td>13-59</td>
<td>44-240</td>
</tr>
<tr>
<td>Residential</td>
<td>18</td>
<td>5-35</td>
<td>6-53</td>
<td>40-186</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-47</td>
<td>10-111</td>
<td>46-172</td>
</tr>
<tr>
<td>Commercial</td>
<td>8</td>
<td>7-19</td>
<td>10-41</td>
<td>50-107</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8-56</td>
<td>15-136</td>
<td>59-294</td>
</tr>
</tbody>
</table>

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

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.
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.

![Fig.11 Alternate Mass transit systems](image)

Fig.11 Alternate Mass transit systems


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.

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. \cite{9} Results may be expressed in different ways, including internal rate of return, net present value and benefit-cost ratio.\cite{10}(Manar A. El Gammal, 2007 and American Transport department)

Table No.8 Analysis during peak hour

<table>
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<tr>
<th>Data type</th>
<th>Symbol</th>
<th>Unit</th>
<th>Autos + Taxi</th>
<th>Buses</th>
<th>Two wheelers</th>
<th>Ropeway</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Base Case</td>
<td>With Proj</td>
<td>Base Case</td>
<td>With Proj</td>
</tr>
<tr>
<td>Corridor Length</td>
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<td>km</td>
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<td>1686</td>
<td>486</td>
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<tr>
<td>No. of trips</td>
<td>P</td>
<td>No.</td>
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<td>22</td>
<td>24</td>
<td>30</td>
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<tr>
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<td>Total travel time benefit</td>
<td>U</td>
<td>Rs. / pass</td>
<td>-</td>
<td>4.00</td>
<td>-</td>
<td>7.00</td>
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<tr>
<td>Travel Volume</td>
<td>V</td>
<td>Pass*km</td>
<td>15384</td>
<td>6744</td>
<td>1944</td>
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</table>

Costs

1. Construction Costs
   - Station + Electromechanical installations = 5 stations x 50 crore = 50 crore.
   - Gondola = 60 x 25 lakhs = 15 crore.
   - Ballasts = 30 x 30 lakhs = 9 crore.
   - Ropeway = 4 km x 18 lakhs = 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 = 700 m 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. 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 increase profits 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!

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