

# Minimum Spanning Tree of Stations on Proposed Pune City to Nashik City Railway Route Network in Maharashtra State

**Shankar D Ugale<sup>1</sup>, Dr. Madhukar M Palve<sup>2</sup>**

Research Scholar, Mathematics Department, JITU University, India<sup>1</sup>

Prof. Ramkrishna More Arts, Commerce and Science College Pune, India<sup>2</sup>

**Abstract:** This research paper is deal with the construction of minimum spanning tree of stations to station network in Proposed Pune city to Nashik city railway line in Maharashtra state. Nodes in network are railway stations on Pune city to Nashik city railway route and edges and arcs are proposed railway lines that link the stations.

The distance between stations is computed using Longitude and Latitude and official government websites. We applied Prim's algorithm to determine minimum spanning tree with Pune Station as a starting point. The result gives alternate railway rout between Pune and Nashik cities with minimum distance.

**Keywords:** Spanning tree, Minimum spanning tree, Network, Prim's algorithm etc.

## I. INTRODUCTION

An optimal solution of a network is great interest of researcher. Optimal network is useful in designing of networks of telephone lines, railway lines, roads, electric lines, gas pipelines, Travelling salesman problem, cluster analysis, real time face tracking and verification. A minimal spanning tree is one of the most fundamental and intensively studied problems in network optimization with many theoretical and practical applications.

There are many algorithms for the determination of minimum spanning tree namely Kruskal's Algorithm, Prim's Algorithm, and Boruvka Algorithm. The Prim's algorithm was designed by Robert clay Prime in 1957. Prim's algorithm starts with picking up any arbitrary vertex from the graph and put it into empty spanning tree.

In this paper we construct minimum spanning tree covering cities of Maharashtra state namely Pune Station , Hadapsar station , Manjiri Station ,Kolwadi Station ,Wagholi Station ,Alandi Station , Chakan station, Rajgurunagar Station , Bhorwadi Station , Manchar Station , Narayangaon Station ,Alephata Station, Bota Station, Jambut Station ,Sakur Station , Ambhore Station, Sangamner Station, Devthan Station, Chas station ,Dodi station, Sinner Station, Mohadari Station, Shinde Station ,Nashik Road Station etc.

## II. LITERATURE REVIEW

Minimum Spanning Trees have many application of graph theory in today's world specially in building a road networks, Railway lines etc. The shortest spanning tree can be seen in Nursing Doe's book [3-10], pages 60-90. A study on Minimum Spanning Tree Of City to City Road Network in Nigeria by Effanga , E.O.and Edeke, Uwe.E. (2016) ISOR Journal of Mathematics (Jul.-Aug.2016) Page No. 41 to 45 is very helpful for this research paper.

Discrete Mathematics Page No. (5-3) to (5-45) Tech-Neo Publication by Dr.Shafi K.Pathan , Rameshwar M Indoriya , Lomesh K.Ahire(2020) can be useful for minimum spanning tree.

## III. SCOPE

The Minimum Spanning tree is very useful in optimization technique. The proposed Pune - Nashik Railway Line distance is approximate 235 kilometers but with the help of Prim's algorithm we can reduce the distance up to 195 kilometers.

#### IV. RESEARCH METHODOLOGY

Weighted Graph  $T$  is called minimum spanning tree, if its weight is minimum than other spanning trees of graph  $G$ .  $V$  be the all nodes and  $E$  be the all arcs joining to nodes. Then network is defined by pair  $(V, E)$ . In network arc joining two distinct node is denoted by  $(i, j)$ .

A sequence of arcs joining to different nodes forms a path in a network. Two nodes in the network are connected if there is path between those two nodes. In this research paper initially Pune Station to Nashik road Station Railway line network is constructed. Then Prim's algorithm is applied to obtain minimum spanning tree. After getting minimum spanning tree of Railway line between Pune Station and Nashik road Station then some stations are added on the same route.

**Figure 1** shows Network between Pune Station and Nashik road Station, while **Figure 2** shows Minimum spanning tree of the network. **Figure 3** shows Comparison between Proposed network by Government of India and network from minimum spanning tree.

#### V. DISCUSSION

**Tree:** A connected circuit less graph is defined as tree. Tree is also nonlinear structure.

**Spanning Tree:** Let  $G$  be a connected graph. A subgraph  $T$  of  $G$  is called spanning tree of  $G$  if  $T$  is a tree and  $T$  passes through each vertex of  $G$ .

**Minimum Spanning Tree (MST):** Weighted Graph  $T$  is called minimum spanning tree, if its weight is minimum than other spanning tree of graph  $G$ . The number of edges in MST are  $n-1$  where  $n$ = number of nodes. The minimal Spanning tree has application in creation of Railway line network that links several cities where line between two cities may pass through one or more other cities.

##### Minimum Spanning Tree Algorithm (Prim's Algorithm):

Let  $G(V, E)$  be connected graph.

**Step-I:** Select any arbitrary vertex  $V_0$  in the graph  $G$ . Set,  $MST = \{V_0, \Phi\}$ .

Initially MST have only one vertex, there is no edge selected.

**Step-II:** Find the edge  $e_i = \{V_0, V_0\}$  in set of edges  $(E)$  such that one end of edge is  $V_0 \in MST$

And other end is in non-selected region of graph and its weight is minimum.

So,  $MST = \{\{V_0, V_1\}, \{e_i\}\}$

**Step-III:** Choose next edge  $e_x = \{V_x, V_j\}$  in such a way that it's one end  $V_x \in MST$  and

Other end belongs to unselected area of graph. The weight of the edge  $e_x$  should be minimum or small as possible. Now include vertex  $V_j$  and  $e_x$  to MST.

**Step: IV:** Repeat the step –III, until MST contains all the vertices of graph  $G$ . The set MST

Will give the minimum spanning tree of graph  $G$ .

#### VI. METHOD OF DATA COLLECTION

The Data is used for this study is generated using Longitude / Latitude Converter software which makes use of Longitude and Latitude of cities in Maharashtra state which lies on Pune city to Nashik city Railway line.

The distance between two cities is approximate distance having error up to one kilometer. Number of Stations and Proposed Railway Line maps and other information are taken from Government websites **MAHARASHTRA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD**, a joint venture of government of Maharashtra and ministry of railway [www.maharail.com](http://www.maharail.com).

A **Table 1** shows Longitude and Latitude of cities in Maharashtra which lies between Pune and Nashik cities, while **Table 2** shows Station to station distances.

Table 1: Longitude and Latitude of cities on Pune Nashik Railway Line

S/N	Name of Station	Longitude	Latitude	S/N	Name of Station	Longitude	Latitude
1	Pune	73.874238	18.5293	21	Akole	74.007291	19.538946
2	Shivajinagar	73.851643	18.532229	22	Alephata	74.103823	19.173668
3	Khadaki	73.841085	18.562988	23	Bota	74.153884	19.262839
4	Dapodi	73.83276	18.580847	24	Jambut	74.215489	19.31566
5	Kasarwadi	73.821001	18.60757	25	Sakur	74.266451	19.348056
6	Moshi	73.84896	18.679382	26	Ambhore	74.267673	19.465846
7	Bhosari	73.847427	18.632031	27	Sangamner	74.162495	19.556292
8	Hadapsar	73.927796	18.527001	28	Devthan	74.057913	19.628486
9	Manjiri	73.987797	18.524371	29	Chapadgaon	74.042199	19.705695
10	Kolwadi	74.033714	18.533979	30	Chas	74.069908	19.705753
11	Wagholi	74.000255	18.594356	31	Dodi	74.06611	19.764245
12	Alandi	73.943283	18.682972	32	Sinner	73.989754	19.812923
13	Chakan	73.922147	18.767349	33	Mohadari	73.904004	19.898382
14	Rajgurunagar	73.903586	18.858587	34	Shinde	73.870817	19.924946
15	Bhorwadi	73.939416	18.94677	35	Nashikroad	73.842067	19.948198
16	Manchar	73.955285	19.00159				
17	Narayangaon	73.984918	19.105203				
18	Otur	73.983253	19.259033				
19	Nachanthav	73.975507	19.390892				
20	Kotul	73.967744	19.435173				

Table 2: City to City Railway Network Showing Distances in Kilometer

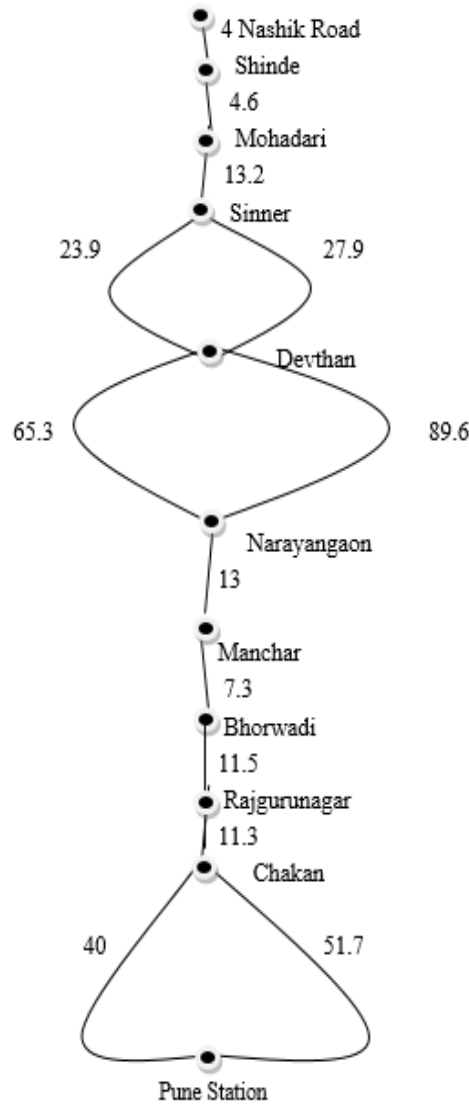
City	Pune	Shivajinagar	Khadaki	Dapodi	Kasarwadi	Moshi	Bhosari	Hadapsar	Manjiri	Kolwadi	Wagholi	Alandi	Chakan
Pune		3.4						6.7					
Shivajinagar	3.4		4.6					9.05					
Khadaki		4.6		3.2									
Dapodi			3.2		4.2								
Kasarwadi				4.2		9.5	5.9						
Moshi					9.5		6.3						13.4
Bhosari					5.9	6.3		15.4					
Hadapsar							15.4		7.3				
Manjiri								7.3		6			
Kolwadi									6		8.5		
Wagholi										8.5		12.5	
Alandi											8.5		10.7
Chakan						13.4						10.7	
Rajgurunagar													11.3
Bhorwadi													
Manchar													
Narayangaon													
Otur													
Kotul													
Akole													
Alephata													
Bota													
Jambut													

Ambhore													
Sangamner													
Devthan													
Chapadgaon													
Chas													
Dodi													
Sinner													
Mohadari													
Shinde													
Nashikroad													

City	Rajgurunagar	Bhorwadi	Manchar	Narayangaon	Otur	Nachanthav	Kotul	Akole	Alephata	Bota	Jambut	Sakur	Ambhore
Pune													
Shivajinagar													
Khadaki													
Dapodi													
Kasarwadi													
Moshi													
Bhosari													
Hadapsar													
Manjiri													
Kolwadi													
Wagholi													
Alandi													
Chakan	<b>11.3</b>												
Rajgurunagar		<b>11.5</b>											
Bhorwadi	<b>11.5</b>		<b>7.3</b>										
Manchar		<b>7.3</b>		<b>13</b>									
Narayangaon			<b>13</b>		<b>18.1</b>				<b>14.6</b>				
Otur				<b>18.1</b>		<b>15.7</b>							
Nachanthav					<b>15.7</b>		<b>6</b>						
Kotul						<b>6</b>		<b>13.3</b>					
Akole							<b>13.3</b>		<b>43</b>				
Alephata				<b>14.6</b>				<b>43</b>		<b>12.2</b>			
Bota									<b>12.2</b>		<b>9.7</b>		
Jambut										<b>9.7</b>		<b>7.5</b>	
Sakur											<b>7.5</b>		<b>14.1</b>
Ambhore												<b>14.1</b>	
Sangamner													<b>15.9</b>
Devthan													
Chapadgaon													
Chas													
Mohadari													
Shinde													
Nashikroad													

City	Sangamner	Devthan	Chapadgaon	Chas	Dodi	Sinner	Mohadari	Shinde	Nashikroad				
Pune													
Shivajinagar													
Khadaki													
Dapodi													
Kasarwadi													
Moshi													
Bhosari													
Hadapsar													
Manjiri													
Kolwadi													
Wagholi													
Alandi													
Chakan													
Rajgurunagar													
Bhorwadi													
Manchar													
Kotul													
Akole		12.2											
Alephata													
Bota													
Jambut													
Sakur													
Ambhore	15.9												
Sangamner		14.6											
Devthan	14.6		9.8	9.7									
Chapadgaon		9.8		4		14.1							
Chas		9.7	4		7.5								
Dodi				7.5		10.7							
Sinner			14.1		10.7		13.2						
Mohadari						13.2		4.6					
Shinde							4.6		5				
Nashikroad								5					

**Pune city to Nashik City  
Railway Network**



**Figure1**

## VII. RESULT

The result of applying Prim's algorithm to the network in figure 1 is as shown in figure 2. Proposed Distance between Pune city railway station to Nashikroad railway station given by MAHARASHTRA RAIL INFRASTRUCTURE DEVELOPMENT CORPORATION LTD, a joint venture of government of Maharashtra and ministry of railway is approximately 235.15 Kilometers. Proposed 24 Stations between Pune city to Nashik city is given by MAHARAIL are Pune Station , Hadapsar station , Manjiri Station ,Kolwadi Station ,Wagholi Station ,Alandi Station , Chakan station, Rajgurunagar Station , Bhorwadi Station , Manchar Station , Narayangaon Station ,Alephata Station, Bota Station, Jambut Station ,Sakur Station , Ambhore Station, Sangamner Station, Devthan Station, Chas station ,Dodi station, Sinner Station, Mohadari Station, Shinde Station ,Nashik Road Station.

Applying Prim's algorithm for network in figure 1, Minimum spanning tree is obtained in figure 2 and total distance of 195.10 kilometers is obtained. 22 Stations between Pune city to Nashik city are given by MST are Pune Station , Shivajinagar station , Khadaki Station ,Dapodi Station ,Kasarwadi Station ,Bhosari Station , Moshi Station , Chakan station, Rajgurunagar Station , Bhorwadi Station , Manchar Station , Narayangaon Station ,Otur Station, Nachanthav Station, Kotul Station, Akole Station ,Devthan Station, Chapadgaon station, Sinner Station, Mohadari Station, Shinde Station ,Nashik Road Station.

Figure 3 shows two different Railway lines between Pune city to Nashik city. Blue Color Railway Lines is proposed by Government of Maharashtra and Ministry of Railway and Red color lines is minimum spanning tree Railway line.

## Minimum Spanning Tree Network between Pune City and Nashik City.

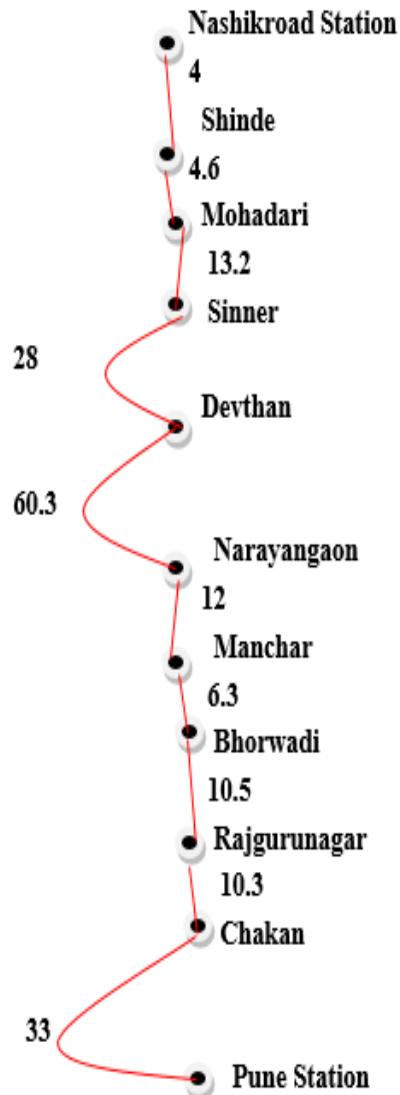


Fig.2

Minimum Spanning Tree Route (Red Color) and Government Proposed Route (Blue Color)

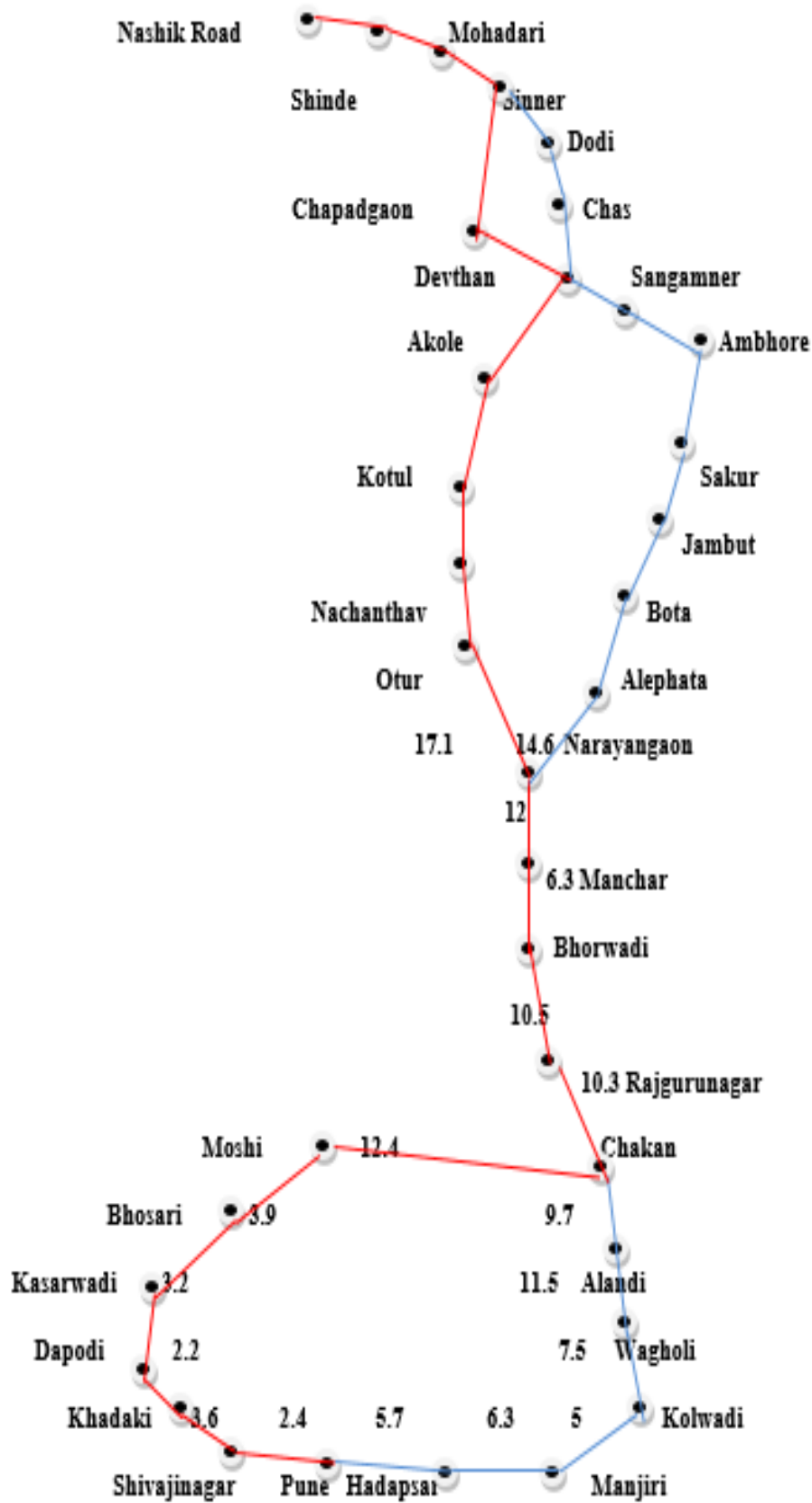


Fig.3



**VIII. CONCLUSION**

The shortest Railway network so constructed using prim's algorithm can be used for various purposes. For Example alternate Railway line, distance, cost, transportation of agricultural goods, connectivity to industrial zones such as Moshi, Talegaon, Chakan, Khed, Sinner and Nashik. Etc.

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