A Study on Future Scope of Indian Expressways with a Novel Approach on Indian Transportation

R. Sathyanathan[1,*], Kishore Kowtham I[2]

[1]Assistant Professor (S.G), Department of Civil Engineering,
SRM University, Kattankulathur, Chennai

[2]M.Tech., Student, Institute of Remote Sensing,
Anna University, Chennai

[*]*Corresponding author's email: sathyanathan.r [AT] ktr.srmuniv.ac.in*

ABSTRACT---- ***The evolution of modern technological advancements and the rapid infrastructure development has led to the ultimate increase in the vehicular passenger and freight movement both in the urban as well as in the inter–cities of the state. With the advent of emerging population and environmental pollution in the transportation movement, an alternate approach in the reduction of environmental pollution and economical consideration is much needed. This has made with the current need of the hour "Sustainable Transportation Systems". This paper gives the complete solution for the sustainable transportation systems by adopting a complete case study with a detailed projected traffic forecast based on the current traffic density to meet out with the future need of the population by providing an elevated express way between inter–cities of Chennai and Trichy of Tamil Nadu state. Moreover the solution is suggested by adopting conventional techniques with the application of modern technology in the development of high speed rails in a most economical way. Further this paper provides with the techno–feasibility analysis with planning, analysing and design of the components and arriving out with the complete economic solution to meet out with the future of Indian express way in a most sustainable manner.***

Keywords—Sustainable, Transportation systems, Traffic forecast, elevated express way, Techno–feasibility analysis.

1. INTRODUCTION

Population density in all major cities around the world is growing rapidly due to economical, technological, political and sociological reasons. This has induced traffic and transportation problems in the city life [1]. Since transportation plays a vital role to improve the economy by providing access for trading and services in various sectors [2], any hindrance to transportation system has an influence on the population dynamics, urbanization, urban form, economic growth, and environmental quality [3]. In cities with effective public transport system traffic and transport problems can be prevented. Moreover acquiring urban lands are costlier, and as there exists close correlation between the land development and transport, a coordinated planning of use of land in any urban area is the need of the hour. This paper focusses on sustainable transportation system by providing an elevated express way between inter-cities of Chennai and Trichy of Tamil Nadu state, India.

Chennai is the largest industrial commercial center in South India; it is often referred as the ''Detroit of India'' and the ''Gateway to South India.'' [4]. With a population of 4.68 million, Chennai is now the fourth largest city in India [5]. The explosive increase in the population of Chennai and its suburbs can be attributed to the tremendous growth in its industrial, educational, and health sectors. Due to this rapid growth, cities such as Chennai are expected to become megacities by 2025 [6]. Trichy is located 322 Kilometers south west of Chennai and it has a large number of energy equipment manufacturing unit. Trichy sits at the confluence of two major National Highways – NH 45 and NH 67 [7]. NH 45 is one of the most congested highways in south India and carries almost 10,000 lorries on the Tirchy-Chennai stretch every night [8]. As both Chennai and Trichy are fast growing cities in India a viable transportation system is essential to ease the traffic congestion between these cities. This can be achieved by providing an elevated express corridor to regulate intra state traffic.

An elevated express corridor is a structure providing a permanent way over the existing National Highways – 45 from Chennai to Trichy. This elevated express corridor facilitates a mass rapid between inter–cities within the state of Tamil Nadu. In India recently in 2014 various elevated express corridor has been proposed and the active projects are launched between,

a. Mumbai – Ahmedabad
b. Delhi – Chandigarh – Amritsar [9]

In line with the above proposal, this project is undertaken for connecting two inter–cities Chennai and Trichy for a length of 300 km approximately. This project deals with the various parameters of the transport system viz. travelling time were the time between the two inter – cities is reduced to 2.5 hours against the present travelling time i.e. 7.5 hours which was 10 hours in the early two decades. The improvements have been maintained in two separate ways which prevents collision and accidents due to over taking.

Moreover the proposed way is an elevated corridor which prevents hindrances so that safety and security are optimised. The expected mass of this transit system after the implementation is forecasted to be 16524 per day in one direction only, this expected traffic movement is derived from the present traffic concern (April 2014) obtained from NHAI, Chennai. The cost involved for land acquisition and structures along the alignment is eliminated, since the entire alignment is taken through the centre median width (i.e. 4m) available at free of cost between the existing 4 lanes of NH –45 from Chennai to Trichy, without any structural compensation.

Ultimately the economic growth rate of the surroundings is increased, since the travelling time is reduced between the inter cities; It will feed nearby rural areas along the alignment to make a rapid and mass movement between inter – cities resulting in growth of education, employment and industrial activity [10], [11]. Finally, the cost of investment for implementation of the project and its return is arrived. After finalizing the feasible alignment, the entire length is spanned according to the geometric requirements and the suitable realistic design components shall be adopted.

2. METHODOLOGY

2.1 Detailed Study

The entire study area adopted for this project lies on NH – 45. which is a 625 km stretch. This project mainly concentrates on adopting a section along the highway that is between the inter cities of Chennai and Trichy. The advent of development has led to the extension of city boundaries. In case of north along NH – 45 it starts from Perungaluthur as its origin with the end of old Trichy highway at the southern end of the section.

Considering future development and other major acquisition problems the current project proposes a starting point at Paranur nearer to the existing Chengalpattu toll, where sufficient land for originating the project is under the government so hence acquisition is not a major case. Moreover the area is well connected at present with the local buses and suburban trains at frequent interval.

2.2 Alignment Planning

The origin is at Paranur nearer to the existing Chengalpattu toll which forms 0/0. The destination is at Sirangam near Trichy, which is at the chainage 273/273 of the project. Further, this place is also well connected by frequent shuttle buses operated by both private and government. Besides this is also a major place of attraction in the state. The exact geographic coordinates are given in Table 1 and Figure 1 below,

Table 2.1: Alignment OD coordinates

Place	Latitude	Longitude
Origin	$12^{o}43'46.01"N$	$79^{o}58'59.88"E$
Destination	$10^{o}51'37.13"N$	$78^{o}42'34.04"E$

Figure 1: Alignment OD coordinates of Study area

2.3 Materials and Methodology

The entire alignment is done using Google earth with reference to real earth coordinates. Analysis and design of various elements of like beam, slab, pier, and pile will be done manually using predefined excel work sheets conforming to the Indian Railway Standard 25 tones Axle loading for both live and dead load (IRS CBC) and the plan modules are arrived with AUTOCAD software. The economic growth rate is arrived out by collecting the traffic census detail collected in the toll gate located along the NH – 45 and the existing traffic at present is analysed. With the help of the recommendations provided in MORTH – 5 standards the traffic at present is used to arrive at the future traffic which is predicted to happen in the next 15 years. Overall after arriving out with the entire design for the most economic cases, a complete estimation cum cost analysis of the complete project is done. Finally the results and outcome are compared and analysed to meet out with the objectives of this project.

2.4 Economic Growth Rate Analysis

The economic growth rate at present can be evaluated with the help of the traffic census detail. The collected traffic data at present is compared with both past and the future traffic and desirable solutions are drawn out from this analysis. This analysis not only provides vehicular movement but also the growth that is going to happen in the projected years of study with the help of the data acquired. The assessment of traffic data helps to understand the existing traffic characteristics on these major roads. The traffic survey results are expressed in terms of Annual Average Daily Traffic (AADT), traffic composition, directional distribution and peak hour flow. These data are very important to estimate the future traffic on these roads.

Table 2.2: PCU Factors

SL.NO.	VEHICLE TYPE	EQUIVALENT PCU FACTOR	
		% COMPOSITION OF VEHICLE TYPE IN	
		0 – 5%	>5%
FAST MOVING VEHICLES			
1.	Two wheelers, motor cycle or scooter	0.5	0.75
2.	Passenger car, Pick up Van	1.0	1.0
3.	Auto-rickshaw	1.2	2.0
4.	Light commercial vehicle	1.4	2.0
5.	Truck or bus	2.2	3.7
6.	Agricultural tractor trailer	4.0	5.0
SLOW MOVING VEHICLES			
7.	Cycle	0.4	0.5
8.	Cycle rickshaw	1.5	2.0
9.	Animal drawn	1.5	2.0
10.	Hand drawn	2.0	3.0

Urban roads are characterized by mixed traffic conditions, resulting in complex interactions between various kinds of vehicles. To cater to this, it is usual to express the capacity of urban roads in terms of a common unit. The unit generally

employed is the 'Passenger Car Unit' (PCU). The various PCU factors for different vehicle classes and converted equivalent PCUs with their relative interference value are given in Table 2.2.

The equivalent PCUs of different vehicle categories do not remain constant under all circumstances. Rather, these are a function of the physical dimensions and operational speeds of respective vehicle classes. In urban situations, the differential speed among different vehicle classes is generally low and as such the PCU factors are predominantly a function of the physical dimensions of the various vehicles. Nevertheless, the relative PCU of a particular vehicle type will be affected to a certain extent by increase in its proportions in the total traffic. Considering all these factors, the conversion factors recommended in IRC 106–1990 [12] are adopted for this project.

2.5 Growth Rate Projections

The traffic data and the vehicular movement are studied using google earth live traffic mode besides the one way traffic data is collected at Paranur toll gate located at the origin of this project. The variations in the vehicle their relative motion and density are clearly depicted in Figure 2, where the colours indicate the speed of traffic on the road. Green means there are no traffic delays. Orange means there's a medium amount of traffic. Red means there are traffic delays. The more red, the slower the speed of traffic on the road. Also the continuous dot indicate the continuous movement of vehicles.

Figure 2: *Live traffic data from google earth*

The details of the annual potential traffic that has occurred in the year 2014 are converted and adopted in the standard PCU factors as given in Table 2.3.

Table 2.3: Traffic details with PCU factors

Type of vehicle	Passenger vehicles			Total (i)		Commercial vehicles				Total (ii)		Total (i + ii)	
	BUS	CAR	3AXLE	VEHICLE	PCU	LCV	MAV	HMV	7AXLE	VEHICLE	PCU	VEHICLE	PCU
PCU Values		1	4			1.4	4	4	4				
7Days	3223	8001	2317	13541	29194	3430	40	538	14	4022	7170	17563	36364
1 Day	460	1143	331	1934	4171	490	6	77	2	575	1024	2509	5195
I Hour	19	48	14	81	174	20	0	3	0	24	43	105	216

Therefore the traffic data collected were projected for the following years viz. 2020, 2025 and 2030 at an average rate of 7.5% compounded every year. These data are projected in Table 2.4, 2.5, 2.6 and shown in Figure 3.

Table 2.4: Total projected traffic in PCU

	2009	2011	2013	2014	2020	2025	2030
7 Days	24625	28780	33636	36364	56120	80568	115666
1 Day	2597	4156	4675	5194	8017	11510	16524
1 Hour	108	173	195	216	334	480	688

Table 2.5: Projected passenger traffic in PCU

	2009	2011	2013	2014	2020	2025	2030
7 Days	14597	23355	26275	29194	45055	64682	92860
1 Day	2086	3337	3754	4171	6436	9240	13266
1 Hour	87	139	156	174	268	385	553

Table 2.6: Projected commercial vehicles in PCU

	2009	2011	2013	2014	2020	2025	2030
7 Days	24625	28780	33636	36364	56120	80568	115666
1 Day	2597	4156	4675	5194	8017	11510	16524
1 Hour	108	173	195	216	334	480	688

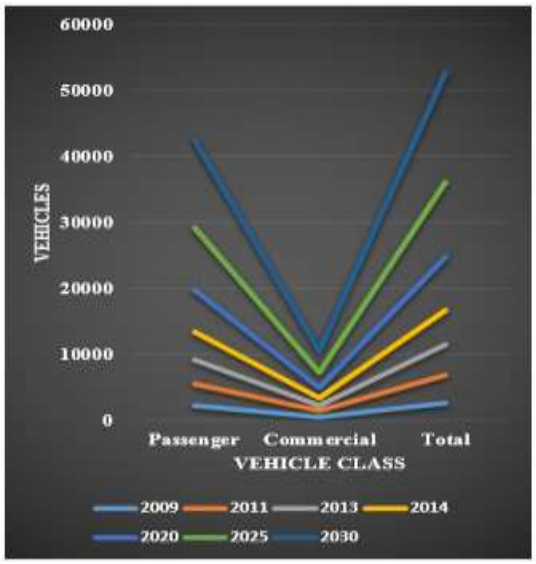

Figure 3: *Projected traffic data.*

3. FINDINGS/ RESULTS

The data that were projected and calculated shows a considerable increase in vehicular freight movement in the projected years along the existing NH – 45. Since the expansion of road becomes very difficult due to the constraints of land in our country and moreover the high cost of land acquisition happens to be the major cost in any project, an alternate solution is the need of the hour to overcome this constraint. Hence it is very clear that this project on elevated corridor would provide a suitable alternate mode of sustainable transportation in the near future.

3.1. Cost Analysis

On the basis of consideration of all conflict points on the route the total number of span has been arrived out to be 8650**.** Depending on site requirements two type of box girder spanning 40m and 20m are designed. All the box are supported on a single pier cap which is then supported on a single pier to the pile cap [13], [14]. As the load has to be transferred is very high and also by considering the varying strata of the soil profile, the foundation has been designed as friction pile where the maximum safety design length adopted is 30 m.

After completion of the entire analysis and design the following are the components to be considered for the design of the most economical sections and the detailed cost of construction and implementation are given below in Table 3.1.

Table 3.1: Cost Estimation

Component	Requirement	Cost / unit in Rs.(lakhs)	Total cost in Rs.(crores)
Span	8650		
40m box	5000	60	3000
20m box	3650	33	1204.5
Pier	8652	3	259.56
Pile cap	8652	15	1297.8
Pile	34608	8	2768.64
Total cost in Rs.(crores)			8530.5

3.2. Cost comparison

The total cost of construction of this project is estimated as Rs. 8530.5 Crores, in addition to the construction cost the following are the other considerations,

- Electrification and station @ 20% – 1706.1 crores
- Approaches and track @ 20% – 1706.1 crores
- Other cost and escalation @ 10% – 853.0 crores

Hence the total implementation cost comes out to be Rs.12795 crores. The expected return out of this project @ 10 years and 10% per annum to be Rs. 1279.5 crores and hence on a daily income it requires Rs. 3.05 crores.

The calculated PCU values at time of implementation in the year 2030 is 16524 which accommodates 66096 passenger per day at a cost Rs. 461.45 per passenger. Whereas the current average cost of travel is Rs.250. as per the cost of various classes of current bus tariff between Chennai and Trichy.

4. CONCLUSION

Thus in this paper, the complete techno feasibility study has shown that implementation of this technique in rural and interstate would reduce the economy as well as the environmental pollution in an efficient manner. Also the time of travel is ultimately reduced to 2 hours which reduces the increasing population in the city so that people return to place after their work on a daily basis. This saves the availability of resources for the future. Thus this system has proven to be a sustainable mode of transportation in the near future.

5. ACKNOWLEDGMENT

The authors would like to thank the authorities and the officials of the National Highways Authority of India, Chennai–25, and Sothern railway, Construction and Management, Egmore, Chennai–4 for providing with all the required data and also supporting with necessary assistance in the complete design of the project.

6. REFERENCES

[1] Yakup Egercioglu and Kader Dogan (2016), "Effective sustainable public transportation approaches in Izmir", Procedia – Social and behavioural sciences 223 (2016), pp. 487–492.
[2] Wahidi, R. (2013). Portrait of Roads and Bridges Infrastructure Development in Indonesia. Bogor: Eternal Press.
[3] Sjafruddin, A. (2009). Development of Transport Infrastructure for Supporting Sustainable Development Based Sciences. ITB, Bandung. 11 pp. http://www.opi.lipi.go.id/data/1228964432/data/-13086710321319703573.makalah.pdf. Retrieved September 10, 2016.
[4] U.S. International Trade Commission (2007). Competitive conditions for foreign direct investment in India. http://si.conquestsystems.com.ezproxy1.lib.asu.edu/statistical, Retrieved September 12, 2016.
[5] Census of India (2011).http://www.census2011.co.in/census/city/463-chennai.html., Retrieved September 8, 2016.
[6] Joerin, J., Shaw, R., Takeuchi, Y., and Krishnamurthy, R. (2014). The adoption of a climate disaster resilience index in Chennai, India. Disasters, 38(3), 540–561.
[7] "Karaikal Port – Road Connectivity". MARG. Retrieved 7 September 2013.
[8] "Four-lane highway cuts cost, improves profit". *The Hindu. 10 April 2013*. Retrieved 3 September 2013.

[9] Indian Railways Institute of Civil Engineering (2008), "Vision of high speed rail in India". Ministry of Indian Railway–
Research and Scientific Development Organization, India.
[10] Leong Chan and Fahad Aldhaban, "Technology transfer with case studies in the high speed rail industry", PICMET Proceedings, PP.32–66, August, 2009.
[11] Raghuram G, "Developing high–speed rail network in India", HSRS Proceedings, 2013.
[12] IRC: 106(1990), "Guidelines for capacity of urban roads in plain areas'.
[13] Segio Ruiz, "Dynamics of pre–stressed concrete railway bridges", Licentiate thesis Stockholm (Sweden), PP. 132–156, 2001.
[14] UIC 772 R, "Standard principles for the use of bearings made from various materials for railway bridges", International Union of Railways, 1987.