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Feasibility Study on the Introduction of Personal Rapid Transit System in Visakhapatnam

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Abstract: ***Higher traffic growth rates have resulted in the environment getting severely polluted. Indian metropolitan cities are already facing certain challenges with severe traffic congestion and pollution. Developed countries have devised different solutions to protect the environment and natural resources like fossil fuels. Some of them paid off and some did not. Personal Rapid Transit (PRT) is being proposed as one of solutions for this problem which has already met with a higher degree of success. Economical, efficient, zero pollution levels and safety are the few aspects which make PRT more acceptable than other conventional modes of intermediate transportation system. This paper discusses about the application of PRT in Indian cities in general and in particular its feasibility for Visakhapatnam city - one of the fastest growing cities in India. It already faces serious traffic problems. On the contrary, it is one of the most polluted cities in India (Numbeo, 2017). Visakhapatnam recorded an average vehicular growth rate of more than 10% per annum during 2009-2017. Consequently, more than half a million people of the city preferred to travel on public transport, and another one million people travelled using private modes of transport. Hence, it is feasible to implement the personal rapid transit system in Visakhapatnam.***
Key words: Rapid transit; Eco-friendly; Transportation data; Girder design; Pod cars.

I. INTRODUCTION

The most important transport problems are often related to urban areas and take place when transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban existing needs in Visakhapatnam. Where the city already had the traffic problems with congested roads and inadequate planning added extra pressure on existed traffic conditions. In 2016, the government announced that the country would skip the BS-5 norms altogether and adopt BS-6 norms by 2020. While the norms help to bring down the pollution levels, they invariably result in increase in vehicle cost due to improved technology. The study of personal rapid system may be best suited for the present traffic scenario, as it is eco-friendly, economical, intelligent with 24/7 availability. Introduction of personal rapid transit system in Visakhapatnam will act as a feeder to the existing transportation modes.

Personal rapid transit system is a new on-demand-system which is developed specially for urban cities. This is a small light (850kg empty weight) weight vehicle. The car is designed for 4 to 6 passengers travelling from an origin to a destination without intermediate stops. It is sufficient enough to carry the passengers along with space for extra luggage like wheelchair, shopping carts etc. These are run by electric driven motors installed in each car. These pod cars are equipped with air conditioning which can change according to the climatic conditions. The wheels are small in size and run on a particular path and are made of solid rubber. The pod cars are run on specially designed elevated guideway. The design, construction and maintenance of these guideways are cost effective when compared to the conventional mode of transportation systems like monorail, metro-rail etc.

Increased traffic on urban roads requires an innovative and sustainable mode of transportation, as an alternative that can meet the increase in population trends. This system can be an effective public mass transit system that can function not only as a major means of transportation in dense areas as well as it can be employed as a feeder network for the proposed metro service for the city of Lucknow (India). Shumank et al., (2014) suggested reduction of air pollution from road networks in Lucknow, so as to improve the functional level of personal rapid transit acceptable to the road users.

Based on studies conducted at Masdar city (U.A.E) and Heathrow airport (London), the implementation challenges of personal rapid transit were observed. In Masdar city for a length of 1.1 miles of guide way was provided for 5 stations with 13 pod cars and in Heathrow airport for 2.4 miles of guideway, 3 stations with 21 vehicles were provided. Design and construction of guide way was found to be difficult when compared to planning, operation and maintenance of PRT (Lowson et al., 2013).

Different travel modes viz., monorail, Metrorail were considered as possible alternatives for reducing the traffic congestion. But no significant reduction in congestion was observed. Implementation of PRT was suggested as a ‘way-out-of’ the problem. PRT implementation on a smaller scale may help the planners to connect remote sites from regional transit. Guideway can be designed in a way such that it aligns with the surrounding architecture (Joerg et al., 2011).

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Physical parameters and costs have been compared for APM (automated people movers) like monorail, Metrorail, with the infrastructural requirements for implementation of PRT. Amongst many parameters a comparison was made in terms of number of carriages required and quantity of material utilised in construction. It is of the opinion that PRT may be implemented at one-third the cost of an APM (James et al., 2011).

Sharma et al., (2014) studied the performance of PRT with other modes of transportation. The study revealed that PRT is an efficient mode of travel to manage the urban traffic and to help solve the associated problems. PRT can be used as a feeder for long distance transportation modes. It is pollution-free and it can act as a good transportation mode for movement of people locally.

PRT attracts more researchers from different domains (Mehdi et al., 2014). It is suggested that optimizing the energy used by a PRT system is an important and challenging problem that has a direct impact on the cost of new transportation mode.

Anderson et al., (1988) discussed a description of the PRT system and the process of and basis for its development; including discussions of technical areas of dependability, safety, evacuation and rescue, power requirements, and performance, discussions of the state of development, development plans, process of certification, and problems in implementation of the PRT concept.

Anderson et al., (1994) discussed about the safety of personal rapid transit systems which involve design, back-up power supplies, vehicle and passenger protection.

A comparison between the conventional mode and modern transportation mode in urban areas was attempted (Juster and Schonfeld, 2013). Three factors, viz., social factors, technical factors and economical factors were considered to study the mode shift behaviour. It is concluded that PRT as a choice would be comparable to other transportation systems, and its efficiency would be determined based on the results and outputs of social, technical and economic models.

Udit et al., (2016) used the stated preference technique to record the willingness of the respondents to shift to PRT. During the survey in the study area of Dwarka (New Delhi) Stated Preference Technique helped respondents to make informed decisions about their mode choices. The areas to be surveyed sectors were selected such that they have high population density, residential, commercial and institutional land use which would ensure sufficient production and attraction of travel trips. It is concluded that, further studies should be conducted to assess other issues related to PRT and to better understand the practical applications and feasibility of PRT as a feeder as well as a stand-alone public transport system for urban areas.

Chaudhary and Sharma (2016) conducted a survey in Varanasi city on the number of people who travelled on each mode, number of trips and mode split patterns and presented the financial analysis for the construction of PRT and concluded that for Varanasi city, PRT is perfectly suitable.

II. METHODOLOGY

A. Data pertaining to public transport

This data includes the number of bus depots in Visakhapatnam, number of buses in each depot, number of trips made by each bus every day, and the occupancy ratio of each depot. There are five major bus depots in Visakhapatnam. More than 5,00,000 people travelled in the city region commuting by buses operated by Andhra Pradesh Road Transport Corporation (APSRTC). Among those 5,00,000 people more than 2,00,000 people travelled in 61 routes. During peak hours these buses are overcrowded.

TABLE I. Congested routes of five bus stations

Name Of The Bus Station	Routes	Occupancy ratio (%)	No. of passengers
Waltair	10	59	39420
Maddilapalem	16	65	39406
Simhachalam	6	65	35835
Gajuwaka	18	59	42080
Vizag steel city	9	68	43479
Total			200220

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B. Data regarding vehicular growth percentage in Visakhapatnam

When it comes to private mode of transport, people prefer to use their own vehicle rather than public transport mode. It is estimated that more than 1millon people travelled using private modes of transport including bikes and cars and on IPTs such as motorcabs and auto rickshaws.

C. Number of Registered Vehicles in Visakhapatnam in Last 10 Years

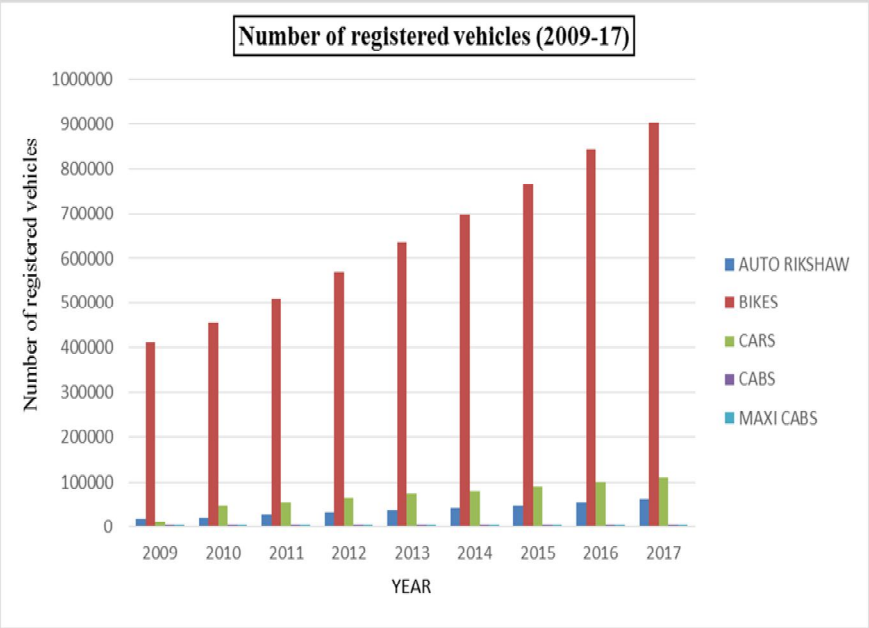

Fig. 1 Registered vehicles in Visakhapatnam

By analysing the above data the following are the vehicular growth rate in various modes.

TABLE 2. Growth rates of different modes of transport (for Visakhapatnam)

S.no.	Mode	Growth rate
1.	Auto-rickshaw	8.57
2.	Maxi cabs	6.14
3.	Cabs	10.05
4.	Cars	8.7
5.	Bikes	12.50

The following pie-chart gives the distribution of public and private modes of transport in Visakhapatnam.

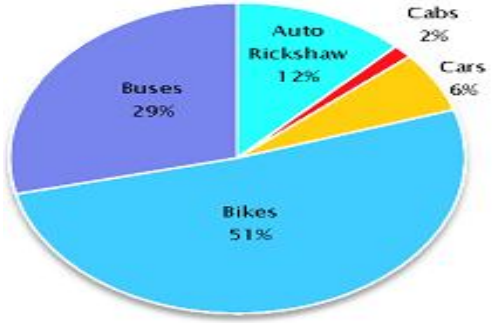

Fig. 2 Distribution of public and private mode of transport in Visakhapatnam

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III. DESIGN OF GUIDEWAY FOR POD CARS FOR THE PRT

By analysing all the data from public and private mode of transport, it is feasible to implement the personal rapid transit for Visakhapatnam in few selected routes.

For the implementation of this project, it required elevated guideway.

The PRT systems offer benefits in transport effectiveness. Their small-scale design also results in terms of cost, and infrastructure cost. The pod cars run on specially designed elevated guideway. The piers of these guideways are not built very heavily because the guide ways have to carry only light weights. A smooth surface is provided to run the wheels of a pod car. The width of the pod car decided the width of pavement. A power cable has to be inserted in the pavement which will provide energy to the pod cars. The guide way is the only largest cost element in the total infra-structure of this project.

The various stages of designing a guideway.

A. Design of Girder

With the guideway typically constructed on an elevated level, there is a requirement for either track to come down or the stations to be constructed elevated as well. Because of the space constrains the spatial planning in existing cities pose, bringing the track to grade level is typically not an option. The length of the guide way to reach the ground level becomes restrictive of achieving this. Hence stations are constructed elevated as well. The guide way has to be constructed at least 6m height above ground level.

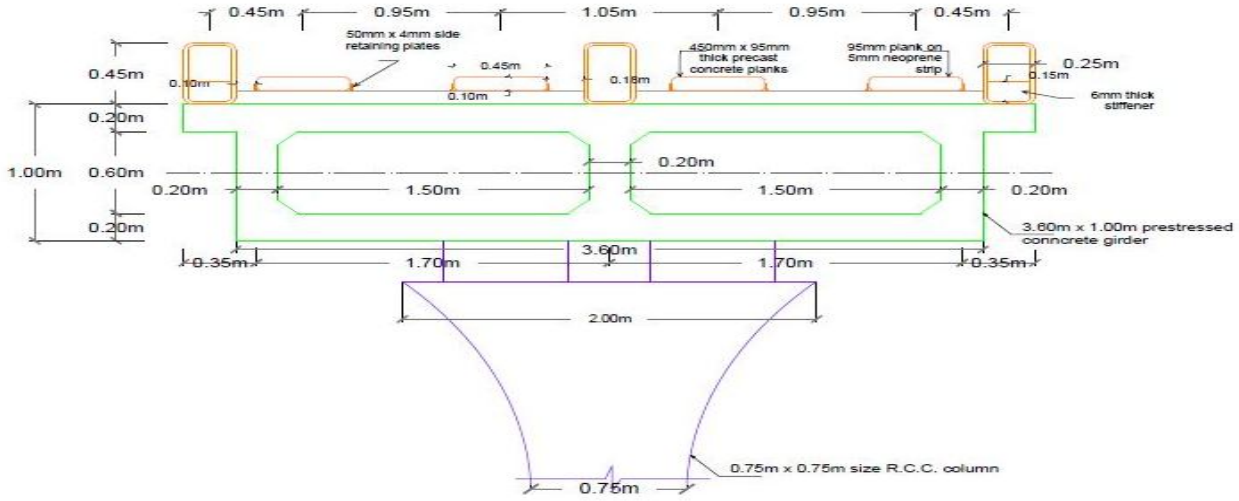

Fig. 3 Cross-sectional details of concrete girder

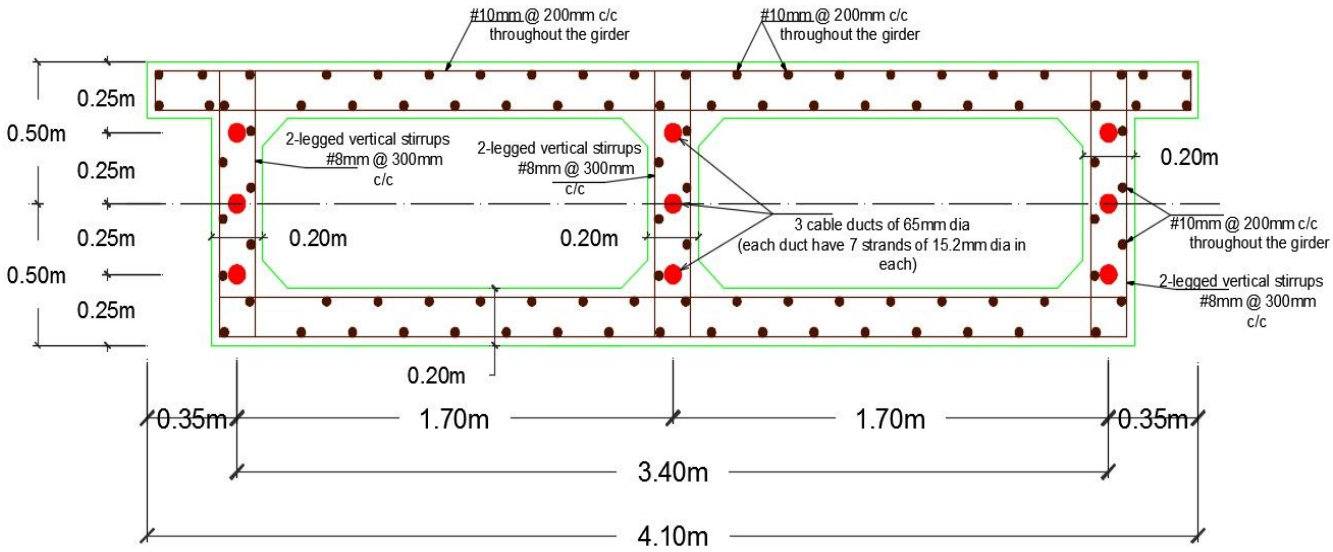

Fig. 4 Cross-sectional details of concrete girder at mid-support

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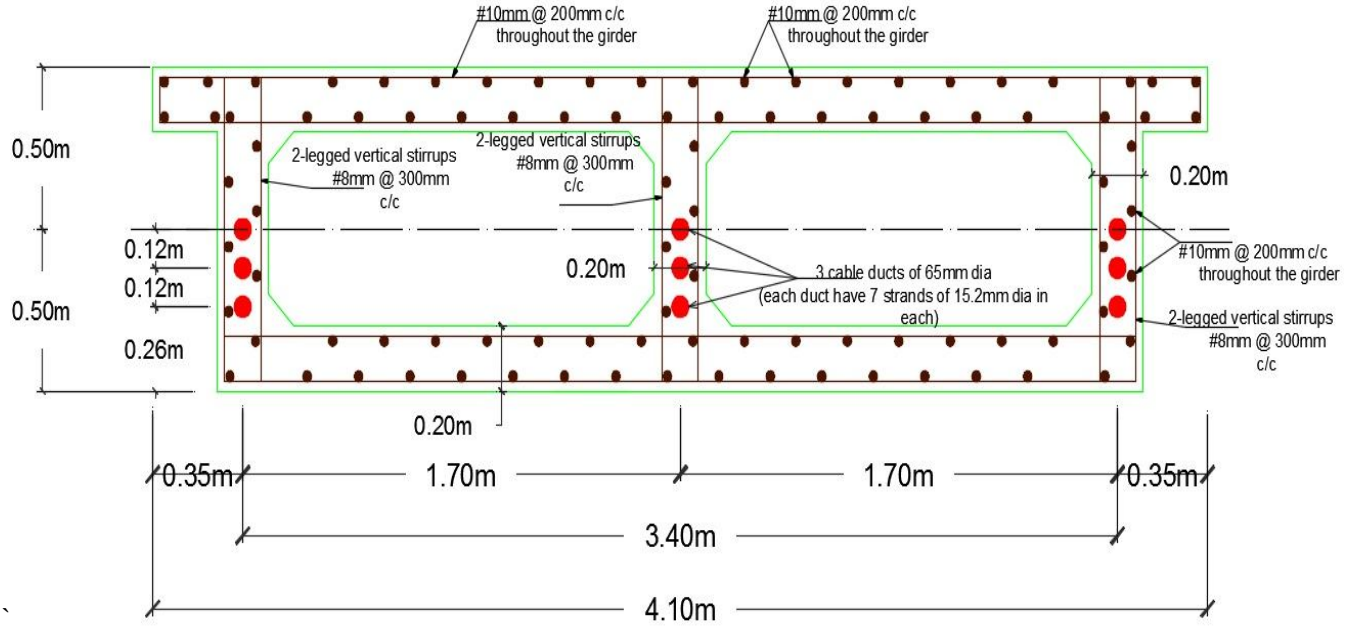

Fig. 5 Cross-sectional details of concrete girder at mid-span

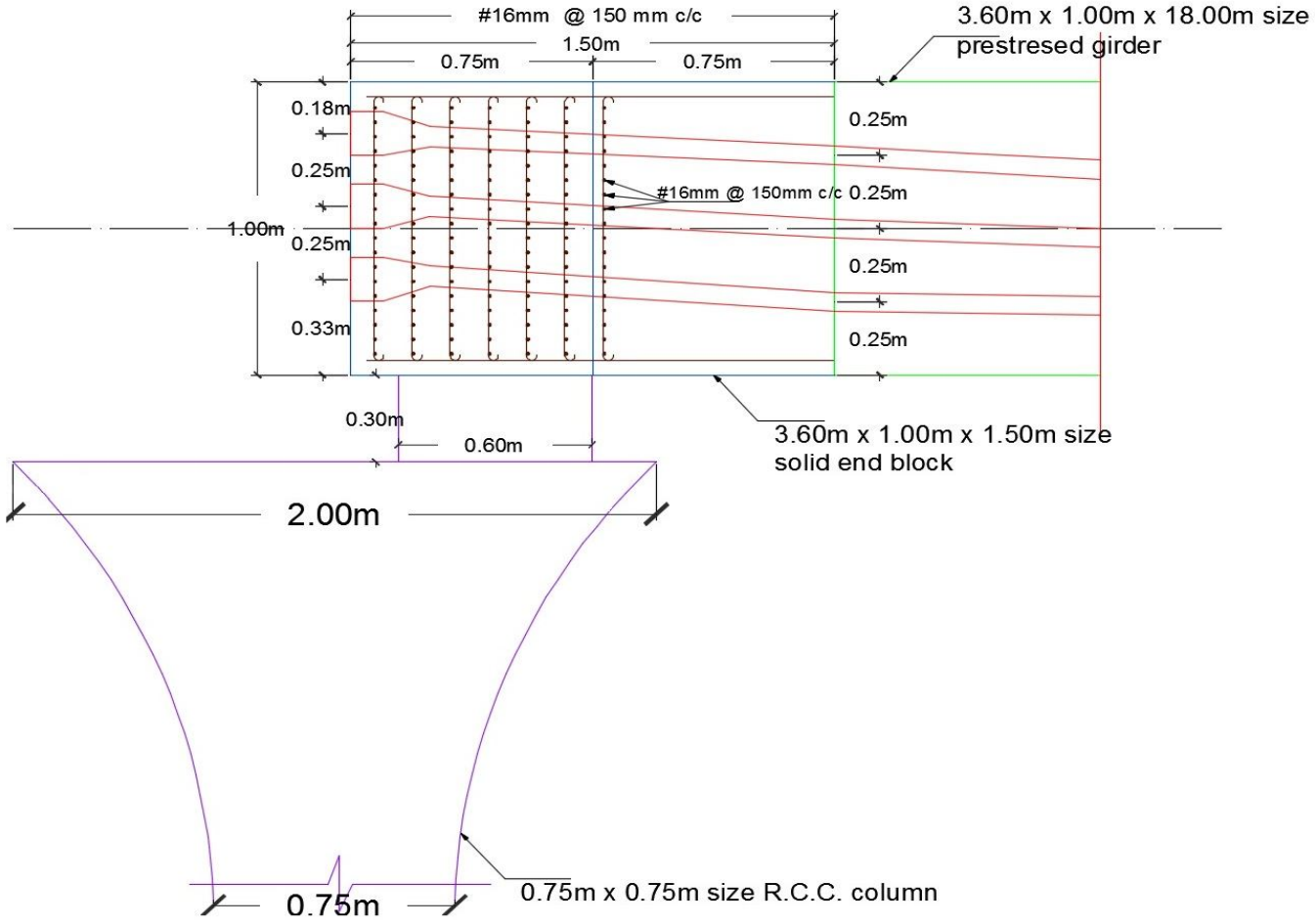

Fig. 6 Cross-sectional details of concrete girder at end solid block

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B. Design of column

The PRT and APM have recognisably common elements, especially for elevated construction, as the guide way is supported from a series of columns. The size of the column is 0.75m x 0.75m

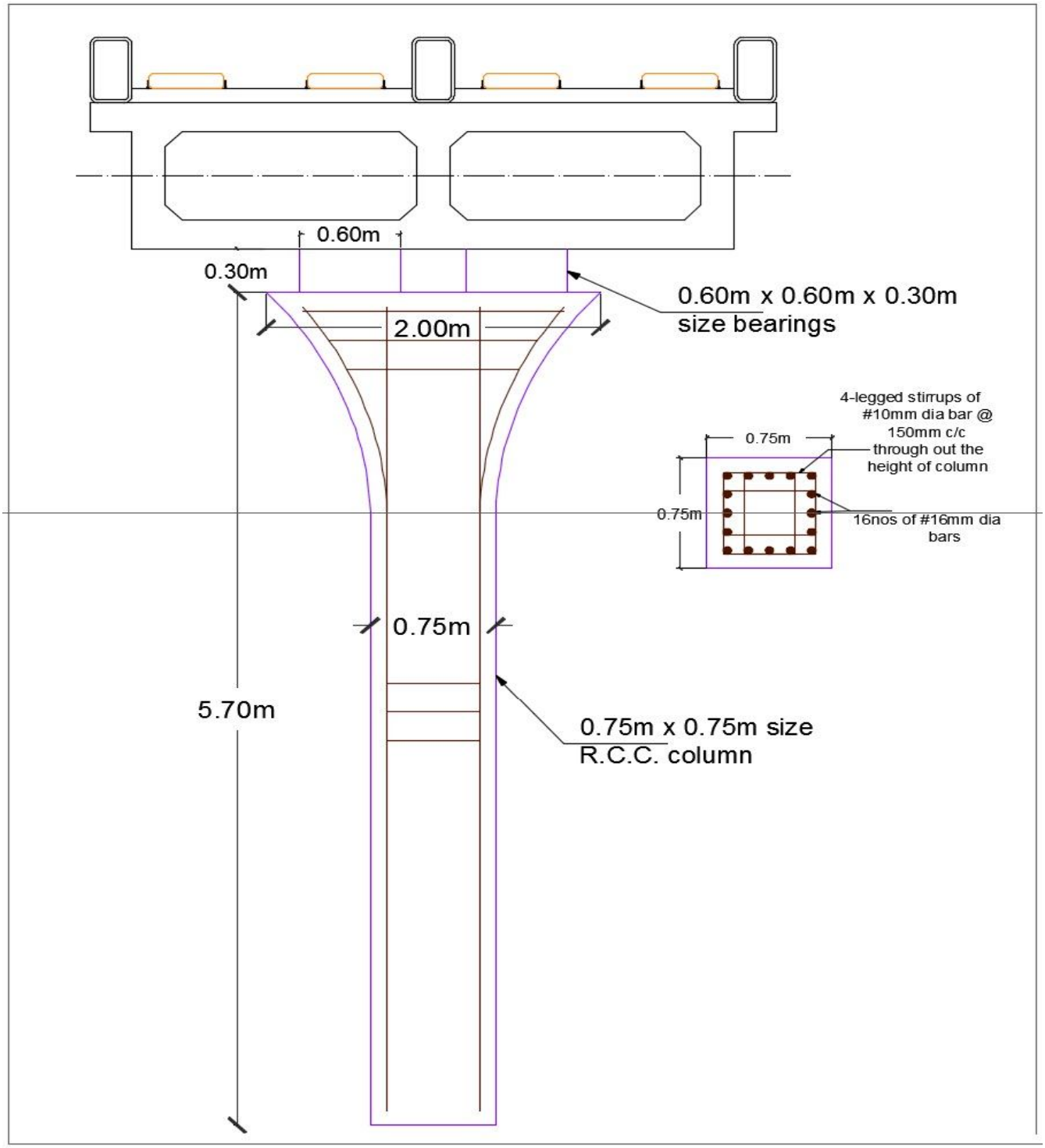

Fig. 7 Cross-sectional details of Reinforced Concrete column

C. Design of footing

The footing provided at 2.5m below the ground level. The dimensions of this footing is 4.10m wide and 0.5m depth and 12mm diameter bars provided at 100mm centre to centre. The pedestal dimensions is 0.95m*0.95m*2m.

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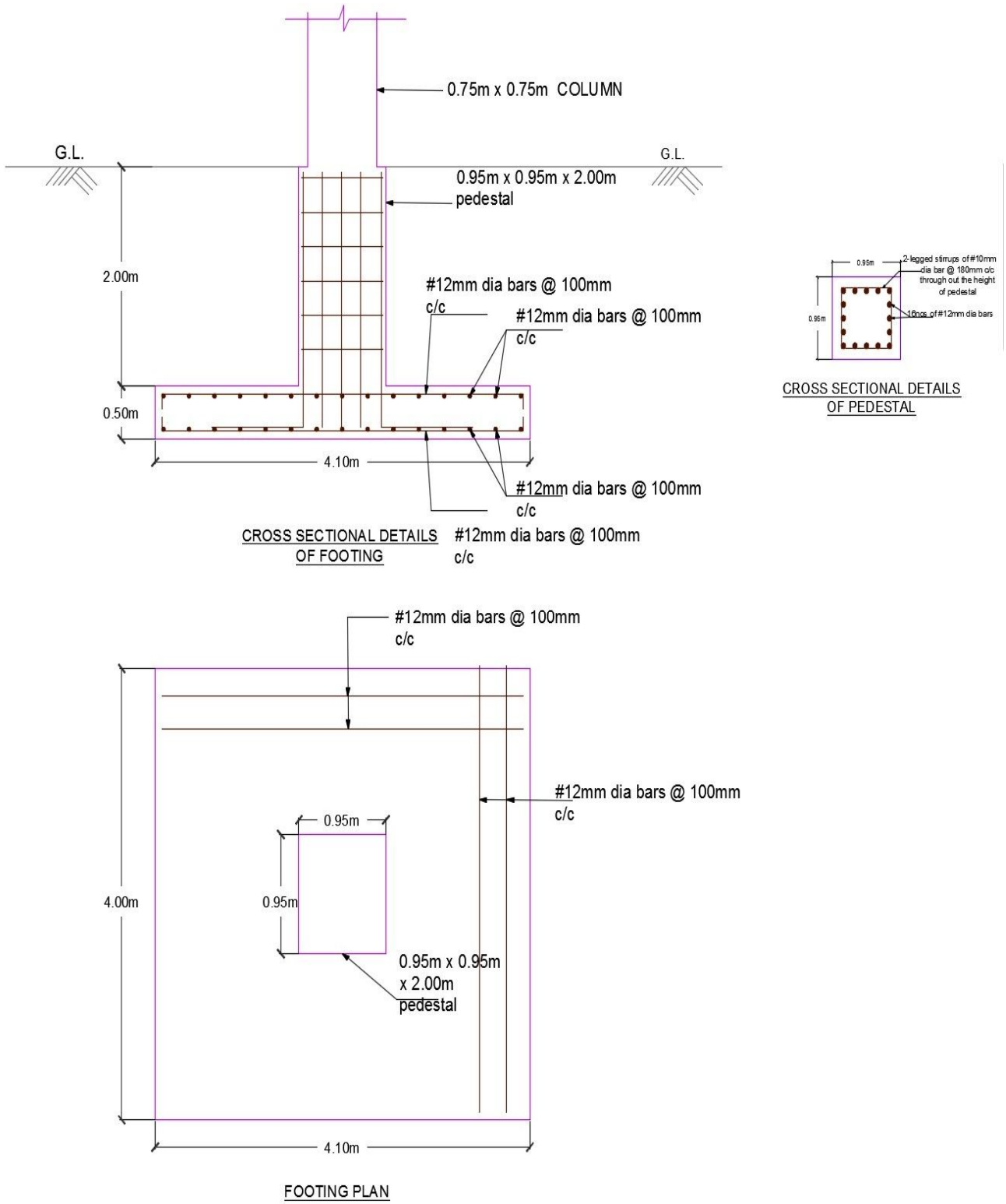

Fig. 8 Plan and cross-sectional details of footing

IV. CONCLUSIONS

A. From the above study, it is observed that due to rapid growth in population, Visakhapatnam city needs an alternative and an improved mode of transport like the PRT to meet the increasing demand for travel on public transport system. The special

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characteristics of PRT being economical, eco-friendly, 24/7 availability may prove to be an efficient transportation mode for Visakhapatnam. It can also act as a feeder for the existing mode of public transportation.

B. It is observed that more than 500,000 people are travelling daily by Government-run public transport system. Out of which 200,000 people are of the opinion that the bus routes on which they preferred to travel, such routes are severely congested leading to enormous delay in reaching their respective destinations. One of the many reasons for this delay is attributed to the bus stoppages at many bus stops enroute and also due to several signal stoppages enroute. This has led to many commuters shifting their travel mode choice to cabs, by pooling themselves. Though the cabs have to obey the traffic signals, but very frequent stoppages enroute for picking up people is very minimal. As the PRT system is designed in such a way that it is immune to the aforementioned probems, hence it would prove to a better choice for commuters.

C. For a fast developing city like Visakhapatnam, the introduction of PRT may lead to reduction in queue lengths of buses, waiting time, travelling time from origin to destination and helps to bring down the pollution levels, as PRT is designed to run on batteries and has a dedicated guide way. It also provides comfortable and safe journey to the passengers at an affordable cost.

D. The design, construction and maintenance of PRT is less, compared to other mass rapid transit modes. Hence the implementation of PRT in Visakhapatnam may change the current scenario, by making transportation easier and smarter.

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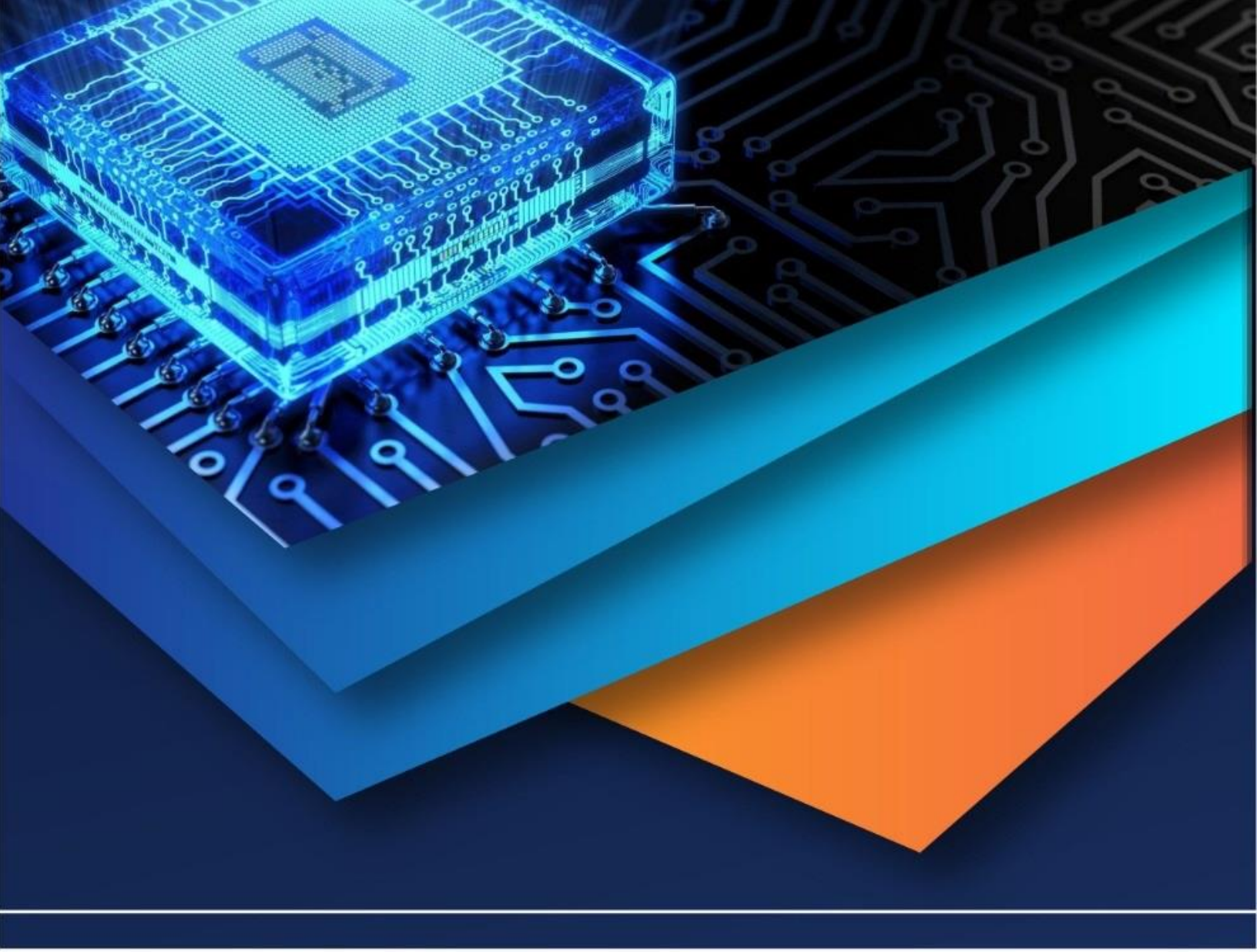

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