International Journal of Modern Developments in Engineering and Science
Volume 5, Issue 4, April 2026
www.ijmdes.com | E-ISSN: 2583-3138 | RESAIM Publishing | www.resaim.com

Planning of Metro Rail Alignment Along Gurudwara to Madhurawada Corridor, Visakhapatnam

Bandhikana Ramya[1], Rajana Haritha[2*], Meesala Sumathi[2], Laveti Jyotsna Priya[2], Pitta Pavana Jyothi[2]
[1]*Assistant Professor, Department of Civil Engineering, Dr. Lankapalli Bullayya College of Engineering, Visakhapatnam, India*
[2]*UG Student, Department of Civil Engineering, Dr. Lankapalli Bullayya College of Engineering, Visakhapatnam, India*

***Abstract*: This project presents the architecture planning and design of an integrated elevated metro corridor with a flyover between Gurudwara Junction and Madhurawada in Visakhapatnam. The proposed corridor spans approximately 12.3Km along the primary urban arterial route and aims to alleviate traffic congestion, enhance transportation efficiency, and support sustainable urban mobility. Lane widths typically range from 3.0m to 3.5m, with median widths between 1m and 2m. Several signalized intersections, limited shoulders and footpaths in congested areas, and roadside contribute to frequent traffic delays, particularly during peak hours. The corridor experiences high traffic volumes with mixed vehicular composition, including buses, cars, two-wheelers, and auto-rickshaws, resulting in significant congestion at major junctions. To address these challenges, the proposed design incorporates an elevated metro system supported by piers positioned along the median, minimizing land acquisition and surface disruption. Grade separators such as flyovers at major intersections and underpasses at critical junctions are integrated to ensure uninterrupted vehicular movement and reduce traffic conflicts. The integrated metro-flyover system is expected to significantly improve traffic flow, reduce travel time, and provide a reliable public transport alternative.**

***Keywords*: Metro rail alignment, Architecture layout, AutoCAD, Geometrical data.**

1. Introduction

A metro system is an electric passenger railway transport system used in urban and metropolitan cities to carry large numbers of people with high frequency and capacity. It is designed with grade separation, meaning it operates independently from road traffic, which reduces congestion and allows higher speeds. Metro systems can be underground, elevated, or at ground level, but elevated metro systems are more economical and easier to construct compared to underground systems. An elevated metro mainly consists of two major components: piers and box girders. piers are vertical supporting structures constructed in different shapes, such as cylindrical, elliptical, square, and rectangular. They support the bridge spans and station structures. The box girder is the main horizontal load-carrying member used extensively in metro bridges, especially in curved alignments due to its high torsional rigidity and bending stiffness. Box girders may be classified into single cell, multi cell type, depending on structural requirements.

Fig. 1.

2. Literature Review

S. Ponnaluri et al., (2011) in their study of the Impact of metro rail systems on urban Transportation analyzes how metro systems reduce road congestion and improve urban mobility. Metro systems help decrease the number of vehicles on roads. This leads to smoother traffic flow and less travel delay. Provides fast, reliable, and efficient public transport. Helps people reach destinations public destinations quickly. Reduces air pollution by lowering vehicle emissions.

V. K. Raina et al., (2014) in their study of Planning and Design of Urban Metro Systems explain planning methods, route alignment, station design &passenger demand analysis for metro rail systems.

Nafis Anwari, Md. Shamsul Hoque, and Md. Rakibul islam et al., (2016) in their study of the Effectiveness of flyovers constructed over railway line explains that traffic congestion at railway level crossings causes long vehicle delays and interruptions in traffic flow. It also states that constructing flyovers over railway lines helps vehicles move without stopping for trains, which reduces congestion and improves traffic efficiency.

*Corresponding author: haritharajana0@gmail.com

Shivam Pandey et al., (2019), Planning, Designing and Proposing a Flyover Road Using AutoCAD, explains how to design and plan a flyover road using AutoCAD. Due to increasing population and vehicles, traffic congestion at road intersections has become a major problem. To solve this, flyover are proposed to improve traffic flow by diverting vehicles above intersections.

Tamrakar Gaurav Fattelal et al., (2025). Development and design of a flyover using AutoCAD focuses on the planning and design of a flyover using AutoCAD to solve traffic congestion problems at busy road intersections.

3. Methodology

A. Architecture of a Metro-Line Flyover

Study of existing road conditions
↓
Collecting of geometrical data
↓
Traffic volume studies
↓
Create ground alignment (roads)
↓
Create flyover alignment (elevated)
↓
Develop profiles & super elevation
↓
Crete corridors
↓
Architecture layout of station
↓
Finalizing drawings
↓
Documentation

1. *Study of existing road conditions*: Pavement condition: studying the current road surface. Analysing adjacent buildings and zones (residential vs. commercial).
2. *Collecting Geometrical Data*: Lane width of existing road, types of lanes and availability of signals.
3. *Traffic Volume Studies*: PCU (passenger Car Units): Converting different vehicle types into a standard unit to measure capacity.
4. *Create Ground Alignment (Roads)*: Horizontal alignment- Designing the curves and straight paths of the road at ground level. Planning how the flyover will impact existing junctions.
5. *Create Flyover Alignment (Elevated)*: Pier placement: positioning the Pillars to avoid existing lanes and underground obstacles. Determining the distance between piers based on structural requirements and ground-level clearance of the span.
6. *Create corridors*: Modelling, Integrating the horizontal and vertical alignment into a single 3D model cross section.
7. *Architectural Layout of Station*: Platforms organising the levels for ticket counters vs. train boarding, multi-model integration. planning the bus stop, Rickshaw stands, or parking at the base. Accessibility Positioning of lifts, escalators, and stairs for passenger flow.
8. *Finalising Drawings*: General Arrangement Drawings- The "master plan" showing all dimensions and views.
9. *Documentation*: Detailed project Reports.

4. Geometrical Data

Fig. 2. Gurudwara junction

Table 1

Parameter	Value
Road type	Urban arterial
No. of lanes	4 lanes
Lane Width	3.25-3.5m
Carriageway	14m
Shoulder	Kerb (0.51-0m)
Median	1-2m
Footpath	1.5-3m (in patches)

Fig. 3. Maddilapalem junction

Table 2

Parameter	Value
Road type	Major arterial
No. of lanes	4-6 lanes
Lane width	3.5m
Carriage way	14-21m
Shoulder	1-1.5m
Median	2-3m
Row	30-40m

Fig. 4. Hanumanthuwaka junction

Table 3

Parameter	Value
Road type	National Highway
No. of lanes	6-Lanes
Lane width	3.5m
Carriage way	21m
Shoulder	1.5-2.5m
Median	3-5m
Row	45-60m

Fig. 5. Yendada junction

Table 4

Parameter	Value
Road type	Sub-arterial
No. of Lanes	2-4 Lanes
Lane width	3.0-3.5m
Carriage way	7-14m
Shoulder	0.5-1.5m
Median	0-1.5m
ROW	18-24m

Fig. 6. Madhurawada junction

Table 5

Parameter	Value
Road type	Arterial
Lane width	4-6 lanes
Carriage way	3.5m
Carriage way	14-21m
Shoulder	1-2.5m
Median	2-4m
ROW	30-45m

5. Traffic Volume Study

A. Field Data Collection Details

Date: 03-01-2026 to 05-01-2026

Time: 7:00 AM-9:00 AM to 3:00 PM - 5:00 PM

Table 6
Gurudwara junction

Time	Bikes	Autos	Cars	Bus	HV	Cycles
8:30-8:45	434	200	242	15	0	1
8:45-9:00	406	215	219	21	1	2
9:00-9:15	414	197	197	27	1	0
9:15-9:30	401	224	224	12	2	0
9:45-10:00	418	230	206	18	0	1
10:15-10:30	432	190	200	09	1	0
3:00-3.15	397	180	190	6	1	0
3.15-3.30	375	189	236	8	3	4
3.30-3.45	400	175	265	18	1	0
3.45-4.00	394	160	211	27	0	0
4.00-4.15	450	144	191	36	0	0
4.15-4.30	600	125	186	24	0	0
4.30-4.45	575	169	246	12	1	0
4.45-5.00	551	152	151	24	2	2
PCU	0.5	1	1	3	3	0.5
Total	7087	2973	3401	302	14	12
Percentage	51.39%	21.56%	24.66%	2.19%	0.1%	0.08%

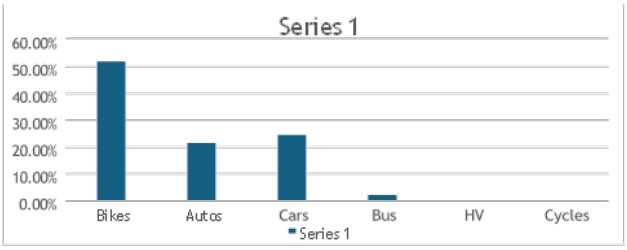

Fig. 7.

Date: 06-01-2026 to 08-01-2026
Time: 7:00 AM-9:00 AM to 3:00 PM – 5:00 PM

Table 7
Maddilapalem junction

Time	Bikes	Autos	Cars	Bus	Hv	Cycles
7:00-7:15	148	112	56	5	1	0
7:15-7:30	162	119	59	0	0	0
7:30-7:45	176	127	63	4	1	0
7:45-8:00	189	136	68	0	1	0
8:00-8:15	203	144	72	3	0	0
8:15-8:30	114	151	76	3	0	0
8:30-8:45	198	142	71	4	1	0
8:45-9:00	187	134	67	5	0	0
3:00-3:15	179	126	64	4	0	0
3:15-3:30	168	119	61	0	0	0
3:30-3:45	161	111	58	6	0	0
3:45-4:00	250	106	56	5	0	0
4:00-4:15	290	101	54	2	0	0
4:15-4:30	241	96	52	5	0	00
4:30-4:45	283	91	51	6	0	0
4:45-5:00	164	87	49	1	2	0
Total	2868	1910	977	53	6	0
PCU	0.5	1	1	3	3	0.5
Total	1434	1902	977	159	18	0
Percentage	33.93%	22.36%	28.75%	3.54%	0.4%	0%

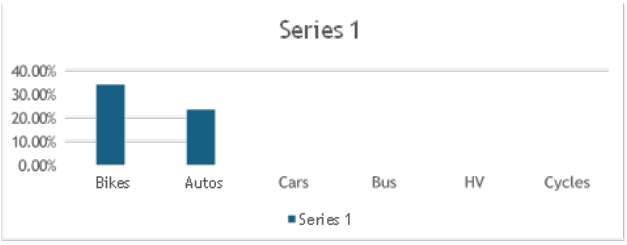

Fig. 8.

Date: 06-01-2026 to 08-01-2026
Time: 7:00 AM – 9:00 AM, 3:00 PM- 5:00 PM

Table 8
Hanumanthuwaka junction

Time	Bikes	Autos	Cars	Bus	HV	Cycles
7:00-7:15	340	182	232	14	7	0
7:15-7:30	410	216	211	21	6	2
7:30-7:45	416	194	195	12	11	0
7:45-8:00	380	223	222	26	17	0
8:00-8:15	430	189	240	13	12	0
8:15-8:30	400	230	203	19	11	1
8:30-8:45	420	243	220	22	9	0
8:45-9:00	433	190	199	15	7	0
3:00-3:15	392	182	226	9	4	0
3:15-3:30	387	189	219	5	6	3
3:30-3:45	350	173	245	10	9	0
3:45-4:00	402	164	196	16	10	1
4:00-4:15	414	212	221	23	3	2
4:15-4:30	424	230	198	34	0	0
4:30-4:45	435	200	221	21	1	1
4:45-5:00	440	260	224	25	2	0
Total	6473	3277	3476	285	115	10
PCU	0.5	1	1	3	3	0.5
Total	3236	3277	3476	855	345	5
Percentage	47.46%	24.03%	25.47%	2.09%	0.84%	0.07%

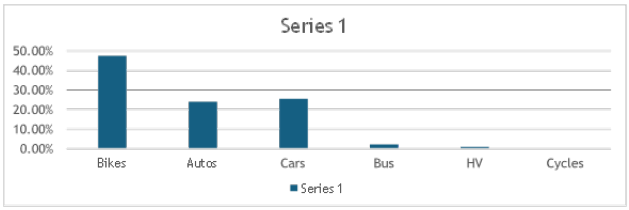

Fig. 9

Date: 06-01-2026
Time: 7:00 AM-9:00 AM to 3:00 PM – 5:00 PM

Table 9
Yandada

Time	Bikes	Autos	Cars	Bus	Hv	Cycles
7:00-7:15	126	22	14	0	0	0
7:15-7:30	144	28	15	1	0	0
7:30-7:45	148	31	18	0	0	0
7:45-8:00	143	33	21	0	0	0
8:00-8:15	178	30	19	0	0	0
8:15-8:30	183	32	60	1	0	0
8:30-8:45	188	36	18	1	0	0
8:45-9:00	203	35	25	0	0	0
3:00-3:15	215	38	19	1	0	0
3:15-3:30	198	34	18	0	0	0
3:30-3:45	203	32	25	1	0	0
3:45-4:00	222	38	28	1	0	0
4:00-4:15	212	36	19	0	0	0
4:15-4:30	278	45	23	0	0	0
4:30-4:45	282	43	26	0	0	0
4:45-5:00	241	39	29	1	0	0
Total	3169	552	333	7	0	0
PCU	0.5	1	1	3	3	0.5
Total	3169	552	333	7	0	0
Percentage	52.34%	28.47%	21.42%	2.34%	0%	0%

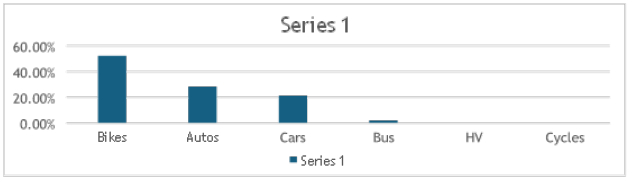

Fig. 10.

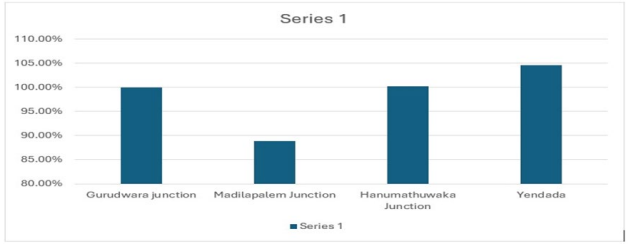

Fig. 11. Overall comparison

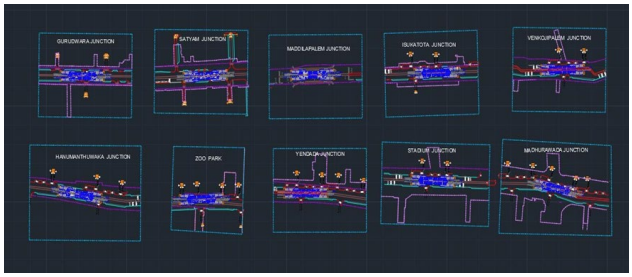

Fig. 12. Metro stations

Table 10
Overall comparison (All junctions)

Junctions	Traffic Volume	Peak hour Congestion	Main traffic Characteristics	Overall Traffic Conditions
Gurudwara junction	Traffic Volume	High	Commercial Traffic, City buses, autos, Two Wheelers	Busy Urban Junction
Maddilapalem Junctions	High	Very high	Major signalized Junction, Mixed Traffic	Heavy Conjunction
Hanumathuwaka junction	Very high	Severe	National Highway traffic	Critical Congestion Point
Yendada junction	Moderate to high	Moderate	Residential Growth Traffic	Increasing traffic load

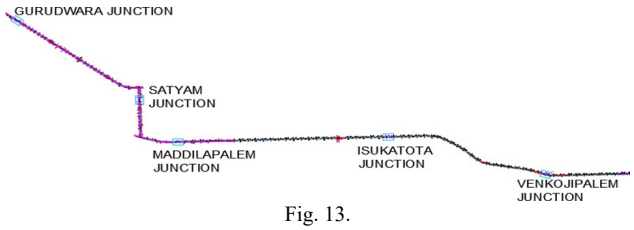

Fig. 13.

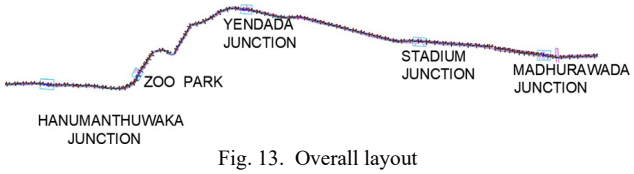

Fig. 13. Overall layout

6. Conclusion

The proposed metro line with an integrated flyover from Gurudwara to Madhurwada presents an efficient and sustainable solution to address increasing urban traffic demand. The overall stretch of 12.8 km was systematically designed by considering 10 stations out of the 5 main stations – Gurudwara, Maddilapalem, Hanumanthuwaka, Yendada & Madhurawada and 5 intermediate stations – Satyam Junction, Isukatota, Venkojipalem, Zoo Park & Stadium. Based on detailed traffic studies at major junctions, it is evident that congestion levels are high during peak hours, justifying the need for a grade-separated transport system. The analysis of traffic flow, vehicle density, and delay times helped in identifying critical junctions where metro and flyover integration can significantly reduce bottlenecks and improve overall mobility. The use of AutoCAD in planning and design ensured accuracy in alignment, sizes, and structural layout. It enabled precise mapping of the route, including distances between junctions, road widths, and spatial constraints. The calculated junction-to-junction distances provided a clear understanding of spacing for stations, piers, and transitions, leading to an optimized and feasible design. Overall, the project demonstrates that combining metro rail with a flyover system can effectively enhance transportation efficiency, reduce travel time, and support future urban growth. This integrated approach not only improves traffic conditions but also contributes to a safer, faster, and more organized transport network along the Gurudwara to Madhurwada corridor.

References

[1] T. G. Fattelal, R. R. L. Birali, and A. Pratap, "Development and design of a flyover using AutoCAD Civil 3D software," 2025.
[2] D. Lin, Z. Zhou, M. Weng, W. Broere, and J. Cui, "Tunnelling and underground space technology incorporating trenchless technology research," *Tunnelling and Underground Space Technology*, 2024.
[3] S. Yusufzada and Z. Xia, "Traffic congestion in Kabul city and suggestions for sustainable development," *American Journal of Social Sciences and Humanities*, vol. 5, no. 1, pp. 194–206, 2020.
[4] S. A. R. Sadaat, "Traffic congestion problem and possible solution in Kabul city," *International Journal of Transport and Vehicle Engineering*, vol. 12, no. 12, 2018.
[5] Bridge Engineering Technical Standards Branch, Alberta Transportation, *Standard Specifications for Bridge Construction*. Edmonton, AB, Canada, 2017.
[6] Autodesk, "Civil engineering design using AutoCAD Civil 3D," 2017. [Online]. Available: http://www.autodesk.com/products/AutoCAD-civil-3D/features/all
[7] A. Augustine and S. Eldhose, "3D model for highway alignment," *International Journal of Scientific Engineering and Research*, vol. 4, no. 3, 2016.
[8] A. N. Chandra *et al.*, "An overview towards flyover construction for lessening traffic congestion," *International Journal of Innovative Technology and Research*, vol. 4, no. 3, pp. 2934–2937, 2016.
[9] A. W. Azad, *Solid Waste Management in Kabul, Afghanistan*, M.A. thesis, TERI University, New Delhi, India, 2015.
[10] V. Golakoti, "Study of geometric features of road and accident rate," B.Tech thesis, National Institute of Technology Rourkela, India, 2015.
[11] Journal of the Indian Roads Congress, vol. 75, no. 2, 2014.
[12] Indian Roads Congress, IRC: SP: 84-2014: Manual of Specifications and Standards for Four-Laning of Highways, 2014.
[13] Wilbur Smith Associates, "Capacity development of the National Capital Region Planning Board," India, Jul. 2010.
[14] S. K. Goyal, S. Goel, and S. M. Tamhane, "Assessment of environmental benefits of flyover construction over signalized junctions: Case study," *Environmental Monitoring and Assessment*, vol. 148, no. 1–4, pp. 397–408, 2009.
[15] N. J. Garber and L. A. Hoel, *Traffic and Highway Engineering*. Cengage Learning, 2009.
[16] DIN-Fachbericht 102, *Betonbrücken*, Deutsches Institut für Normung, 2003.
[17] R. Dennis, Rural Accessibility: Footpaths and Tracks—A Field Manual for Their Construction and Improvement. International Labour Organization, Geneva, 2002.
[18] American Association of State Highway and Transportation Officials, *Standard Specifications for Highway Bridges*, 16th ed. Washington, DC, USA, 1996.
[19] Indian Roads Congress, IRC: 86-1983: Geometric Design Standards for Urban Roads in Plains. New Delhi, India, 1991.
[20] Indian Roads Congress, IRC: SP: 23-1993: Vertical Curves for Highways, 1993; and IRC: 38-1988: Guidelines for Design of Horizontal Curves.
[21] Indian Roads Congress, IRC: 92-1985: Guidelines for the Design of Interchanges in Urban Areas. New Delhi, India, 1985.