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Analytical study on Roof Structure of a Metro Station with respect to Earthquake and Wind Effect

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Abstract: Fast moving word adopted Metro train as an important means of transportation and global development. Metro in major cities in India are now become a major public transportation media as they are fast and feasible. So, metro stations also be designed and build as modern and aesthetic structures. Roof structure plays an important role in protection and beautifying the structure. This study employed the roof structure of a metro station, as an important key element to perform seismic and wind analysis using ETAB software.

***Index Terms* - Metro, Roof structure, Seismic, Wind, ETAB**

I. INTRODUCTION

Civil construction now a day is unimaginable without the structural steel. High strength steel with ≥ 460 Mpa has been used in space structures, Multi storey buildings, different span roof structure e.g., Stations, storage buildings, airplane hangars, Ware houses etc for providing greater social and economic benefits. [1][2] The prediction study says the word steel industry heavily depend on steel recourse until the year 2050. Structural steel is an alloy of iron and carbon. It has wide variety of construction applications based on its characteristics. The annual consumption over the last twenty years has increased to the rate of 5%. The material processing and finishing technologies also has seen many significant developments like metal coating and depositions. [3] Steel building, on the other hand it is rarely used and is traditionally thought to be uneconomical for landed properties. Timber or structural brickwork is preferred in many parts of the world, but in Singapore, reinforced concrete construction is typically preferred for landed properties.

1.1 Trussed Roofs

If the span is large a framework of long span beam (Slender members) with open webs are used to support roofs. These frames are termed as trusses. The framework mostly consists of system of triangle where the axis of members meets at single joint or common point. Roof trusses generally consist of single web whereas Bridge truss have more. Roof trusses permits wide variety of roof shape designs.

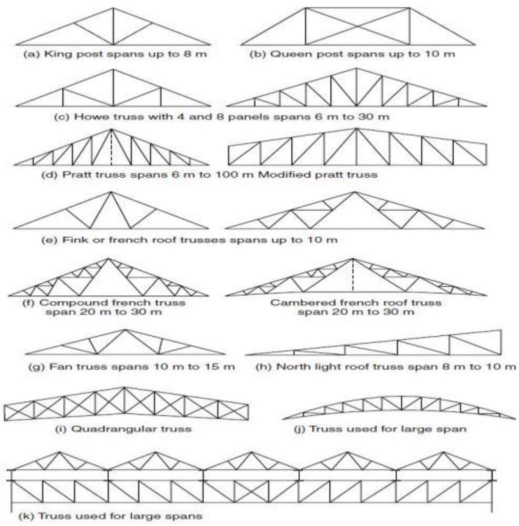

Fig.1 Types of Trussed roofs

1.2 Bangalore Metro Rail Corporation Limited (BMRCL)

Metro rails are rail-based, rapid transit services that run on a different right-of-way from all other modes of transportation in a city. The right-of-way is either underground or elevated above street level in most cases. These systems normally run at a speed of 20–35 km/h and are notable for their high capacity (50,000–75,000 passengers per hour. Metro system mainly consists of Electrified Rapid Transit Train system. Kolkata Metro is the first kind of this in India in 1984. The union cabinet approved a metro facility for the Bengaluru city on 25 April 2006. BMRCL is a joint venture between the governments of India and Karnataka, called "Namma Metro." It is India's second-longest operation and the world's 83rd-longest metro. Bangalore Metro has two main colour-coded lines as Green (phase I) and Purple (Phase II) as shown in the Figure 1.2. The first stretch (Reach-1) between Baiyyappanahalli and M.G. Road was inaugurated on 20 October 2011.

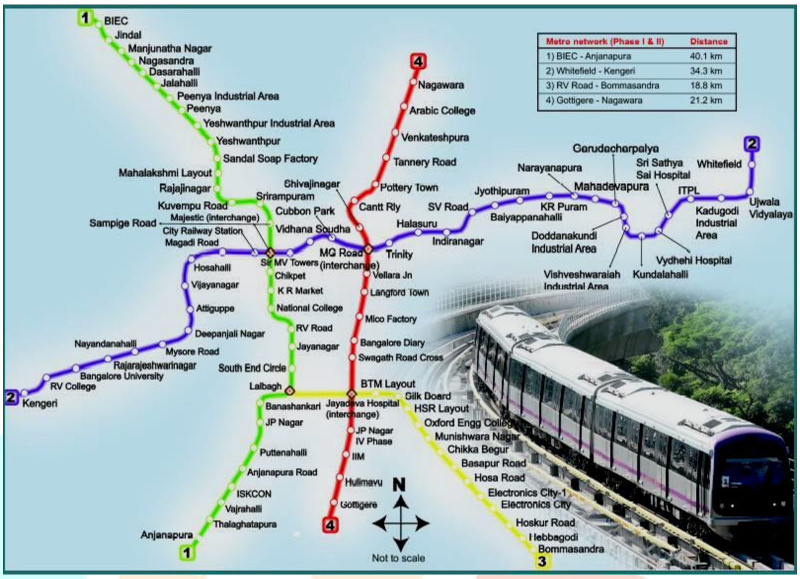

Fig.2 Bangalore Metro Route Map

II. Literature Revivew

1) Dr. Ramakrishna Hegde et.al (2018)

The study focuses on the analysis of steel truss with STAAD Pro package and compared with rigid frames considering economic role as a factor. Authors wanted to show that rigid frames are economic compared to steel structures to build. They studied a rigid frame and steel structures of span 16 m and height of 2m using STAAD pro, but they found steel structures by considering weight and cost are economical compared to rigid frames. High axial loads and increased foundation cost are the main causes for rigid frames.

2) Vaseem Inamdar and Arun Kumar (2014)

This research studied steel bracings on 15 storey steel frame. Pushover analysis is made based on stiffness and ductility. Performance comparison made between ISMB and ISNB steel sections. Displacement analysis also performed using ETAB software. Results shown that the performance of bracing elements is greatly influenced by the adopted sections for bracing system.

3) Richard JSchmidt et.al (2012)

In this study authors says that the rafter pairs are generally employed in timber buildings as partially because they placed in many ways to attract mode design objectives. They have examined seven common rafters with different support conditions. The detailed structural analysis and evaluation on impact on roof made and discussed. Conclusions drawn on bending moments, collar tied rafters, ridge support, collar struts and purling supported rafter systems.

4) Massimiliano Ferraioli and Angelo Lavino (2018)

This study investigated Seismic displacement on retrofit of RC buildings by using hysteric dissipative braces. A 3 D model of damped braced structure is adopted and properties are defined using seismic characteristics. This study mainly addresses the issues with seismic design of damped braces, effect of forces, modes contribution, effect of irregularities and effect of torsion. The design proposed was first validated with nonlinear static and dynamic analysis and then it is applied to the real structure.

III. Methododlogy

Standard Codes used,

- Dead Loads: Code: IS875-1987 (Part-1)
- Material properties are considered according to IS875-1987 (Part-1)
- Live Loads: Code: IS875-1987 (Part-2)
- The model is a commercial and live load values are taken from IS875-1987(Part-2)
- The seismic load calculations will be carried out in accordance with IS: 1893:2002.
- Wind loads: IS 875: Part 3
- Design wind speed: Vz= Vb*k1*k2*k3

Table -1 Different structural loads assigned on model

Dead load	3.75 kN/m^2
Ceiling suspended loads	2.0 kN/ m^2
Live load	5.0 kN/ m^2
Masonry Wall loads	22.0 kN/m3 including plastering
Purlins (Steel Roof)	
Height	6.68 m
spacing	1.2 m
length	8 m
G.I sheet loading	0.131 kN/ m^2
Roof Live load	1.5 kN/ m^2
Total load	1.631*6.7*1.2=13.113 kN
Load on 6.7m purlin	(13.113)/(2*6.7)= 0.99 kN/m =1 kN/m

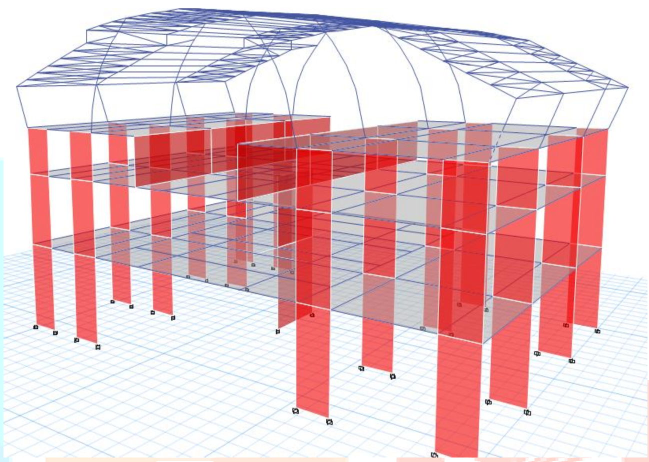

Fig.3 3D View of a metro station model

IV. Results and Discussion

4.1 Storey Displacement

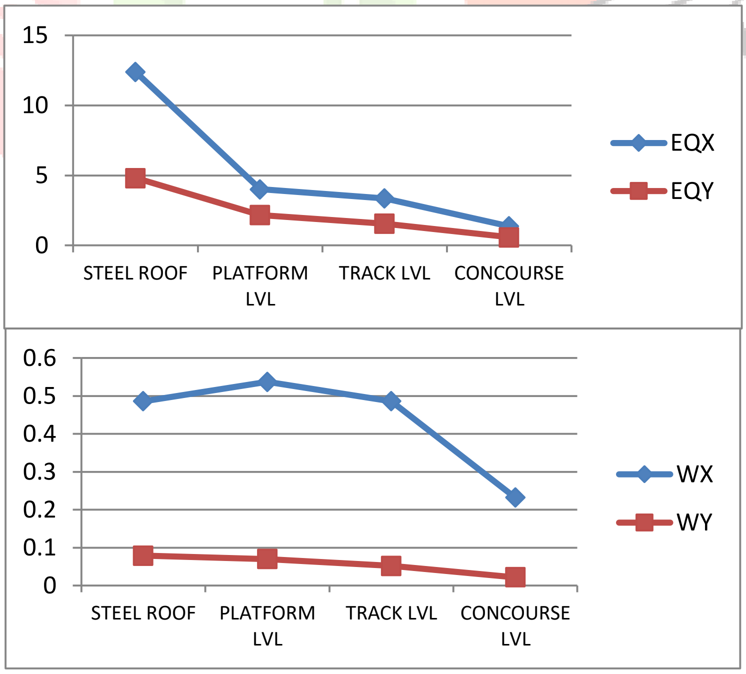

Fig.4 Storey Displacement w.r.t Earthquake and wind loads

4.2 Storey Shear

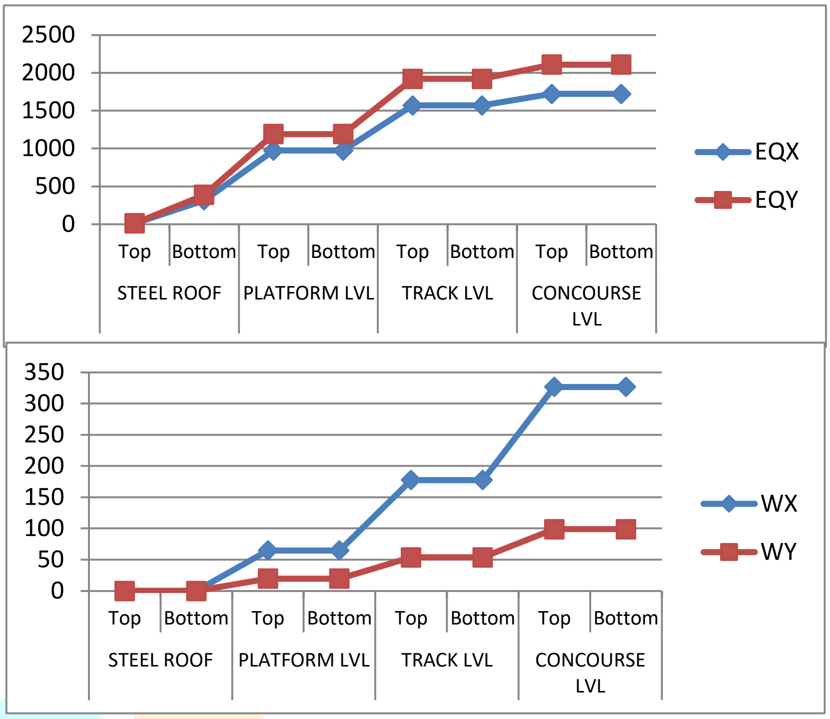

Fig.5 Storey Shear w.r.t Earthquake and wind loads

4.3 Modal Period

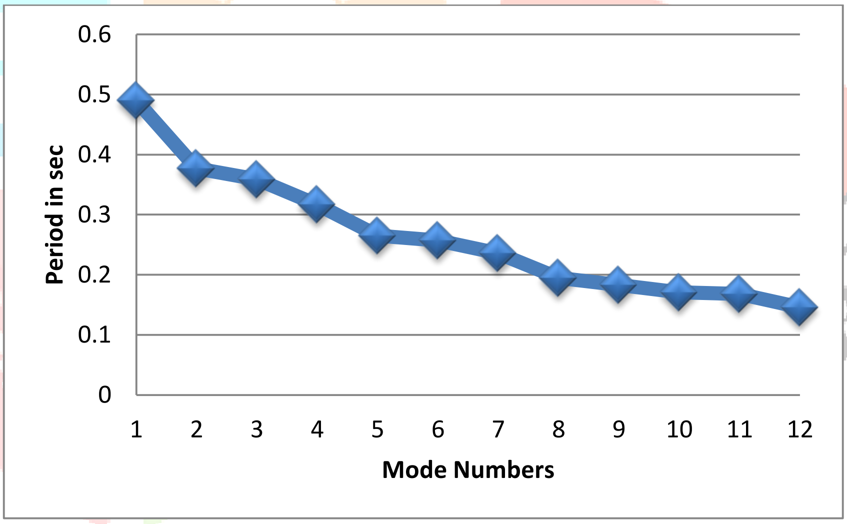

Fig.6 Natural time period for different modal shapes

V. CONCLUSIONS

Metro stations are critical structures to be studied as they include human lives. Present study investigated seismic and wind behaviour of roof steel structure and RC band rafters on a metro station model. The conclusions are enlisted below,

- Storey shear for earthquake load is higher compared to wind load.
- Earthquake load in x direction is 18.3% lesser compared to storey shear in y direction
- Storey displacement in x direction is higher than that of in y direction
- Storey displacement due to wind load in y direction is 83.74% less than that of in x direction
- Maximum Bending moment occurred is 3.354 kN-m

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