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Experimental Study of Combined Vibration Effect Due To Existing Railway and Upcoming Metro Train in Ahmedabad City

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Abstract: *The vibrations induced by metro trains have raised more and more attention along with the development of the mass transition system in many cities of World. With the continuous expansion of Ahmedabad city, metro has become a primary choice to ease the heavy traffic, as its convenience, capacity and safety. However, the vibration induced by metro trains may be affect structures and people nearby. In this project work we are analyzing the vibration impact due to Ahmedabad metro along with existing railway vibration and its effects on existing engineering structures. Vibrations in engineering structures located along the metro route are measured using 16-channel vibration analyzer due to existing railway. Vibrations of metro are predicted using SAP200 modeling. The level of vibrations will be analyzed by addition of existing railway vibration and vibration which can be induced during operations of metro in Ahmedabad..*

1. Introduction

Being a mass transition system for Ahmedabad city, some parts of the metro lines have to be built in dense populated residential areas where a lot of masonry buildings, or even fragile historic buildings are located. In dense populated residential areas, the vibration going to induce due to metro trains may receive many complainants as it causes shaking of windows, or pictures hanging on walls and rumbling noise more than 16 hours a day. In extreme cases, the vibration even damages the structures of the surrounding metro structures. During peak hours, as there are 35 trains will pass by the same line in an hour, the vibration will be much more serious. Thus, the vibration going to induce by the metro trains will bring great influence to the surrounding environment. How much vibration may going to induce to control the vibration within the allowed range has become a primary concern along the metro track structures.

1.1 About Metro Link Express for Gandhinagar and Ahmedabad (MEGA)

The proposed metro alignment provides north-south connectivity in Ahmedabad city from Visat to APMC running along the Ashram road on most of the sections. The other corridor Thaltej to Vastral provides east to west connectivity and passes through important nodes of Kalupur, Ashram road, Thaltej and Industrial areas on the east of Ahmedabad. The proposed metro alignment provides north-south connectivity in Ahmedabad city from Visat to APMC running along the Ashram road on most of the sections. The other corridor Thaltej to Vastral provides east to west connectivity and passes through important nodes of Kalupur, Ashram road, Thaltej and Industrial areas on the east of Ahmedabad.

2. Methodology & Instrumentation

As vibration is detrimental to structure, it was decided to measure level of vibration in terms of different motion parameters e.g. acceleration, velocity etc. Due to railway train movement and metro train movement, propagation of vibrations in three directions becomes important. Thus propagation of vibration was measured in

1. Longitudinal direction
2. Transverse direction
3. Vertical direction

16 channel vibration analyser as shown in fig.1 & very sensitive uni-axial & tri-axial accelerometers were used to measure vibrations in all the three directions as discussed above. Accelerometer when connected with analyser can take data in terms of voltage and convey to sixteen channel vibration analyser. Sixteen channel vibration analyser instruments can analyse the data and convert it in terms of acceleration and natural frequency with help of NV Gate software. NV Gate, the OROS vibration software platform, can perform the analysis and measurements of recorded data.

Fig.1- Sixteen Channel Vibration Analyzer Instrument

2.1 Measurement of railway train vibration

For measurement of vibration induced due to existing railway train, sensors were placed nearby structures along the track using plate as shown in fig. 2 during the passage of train at different locations as shown in fig 3

Fig.2- Placing Of Sensors

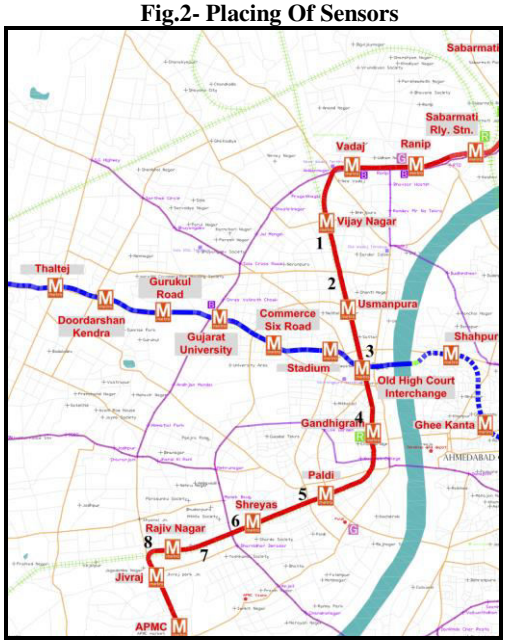

Fig.3- Observation Locations along Railway Corridor

2.2 Prediction of structural vibration due to Metro rail

The structural vibrations produced due to operation of metro train are predicted by simulating the proposed structural systems loaded with a movement of metro train. Structural vibrations are determined at the top of the substructure and at the ground level due to movement of metro train.

Various shock absorbing devices and rail track interaction play significant role in reducing the level of vibrations at the source i.e. at rail level. Model have been prepared in SAP2000 with the design operating speed of the metro train of 100 kmph neglecting the effect of rail track interaction and various shock absorbing devices to be used to reduce the effect of vibrations. This is probably the worst condition and let's first determines the level of vibrations and sees whether it is within acceptable limits or not.

Equation shown below is used for calculation of vibration on any receptor, induced due to any mechanical source of vibration located at distance D meters.

$PPV_{(Receptor)} = PPV_{(source)} (1/D)^{1.5}$

D= distance from source in m.

The computer model is shown in the fig.4-

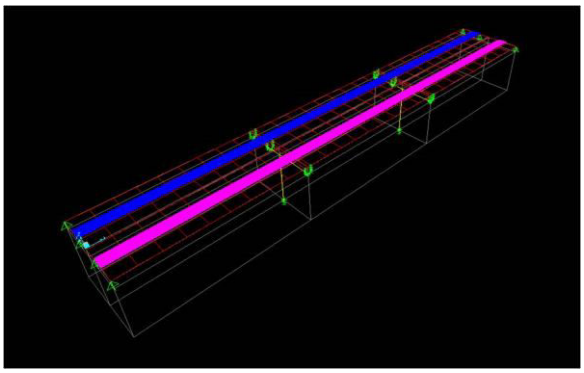

Fig.4- Computer Model Of 3 Span Of Main Line Of Metro Rail

Two lane of 1.676 m width each at 5.55 m c/c is considered and metro train loading, as mentioned above, is applied on these lanes. Following load cases are considered in the analysis:

Case -1: Train travelling in one lane, and
Case -2: Trains travelling in opposite directions in different lanes

3. ANALYSIS AND RESULTS

The peak particle velocity obtained at the ground level in load case -1 is 2.941 mm/sec and in load

case-2 is 4.411 mm/sec. Thus peak particle velocity of 4.411 mm/sec is available at the ground level.

Table 1 shown below depicts the PPV values obtained at different locations along metro route due to existing railway vibrations and predicted values of metro train vibrations for different locations and its propagation at sites considered for study.

Table 1: Peak Particle Velocity for vibration test conducted at different locations in Ahmedabad

Estimated Peak Particle Velocity due to metro train at GL near pier (mm/sec)= **4.411**					
Sr. No	**Description of Location**	**Distance From Track Alignment (m)**	**Peak Particle Velocity due to Railway (mm/sec)**	**# Estimated Peak Particle Velocity due to Metro Train (mm/sec)**	**Estimated Peak Particle Velocity due to Railway and Metro Train (mm/sec)**
1	Vijaynagar	17	1.222	0.0629	1.285
2	Usmanpura	15	1.123	0.0759	1.199
3	Old Highcourt	20	1.155	0.0493	1.204
4	Gandhigram Rly	15	1.114	0.0759	1.19
5	Paldi	15	1.02	0.0759	1.096
6	Shreyas	23	1.013	0.04	1.053
7	Rajivnagar	28	1.024	0.0298	1.053
8	Jivraj	24	0.982	0.0375	1.02

$PPV_{(Receptor)} = PPV_{(source)} (1/D)^{1.5}$
Where D= distance of site from source in m

4. CONCLUSIONS

Based on the preliminary visit and the vibration measurement test conducted on the structures along the metro corridors and existing railway corridor, following conclusions are made due to combined effect of railway and metro train:

1. The ranges of PPV obtained due to combined vibrations effect at all observed location sites are within tolerance limits prescribed by various international standards to avoid structural damages.
2. As per Australian standards for human perception of vibrations, level of vibration is in noticeable range by humans.
3. Vibrations in structures located along the railway corridor are predominant than the estimated vibrations due to metro train.
4. Vibrations due to train are increases with increase of train speed.

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