REVIEW PAPER ON PROLIFERATION OF GROUND VIBRATIONS INDUCED BY MOVING TRAIN

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Abstract:- *The vibrations in railway transport are still an ongoing important issue. As there is increase in speed, size, as well as weight of rail vehicles, the effects of vibrations generated when a train moves also grows. The results of the review whose aim is to identify the vibration effect on the environment of the railway infrastructure. In order to analyze, the research on a test track equipped with typical devices of the railway infrastructure, such as crossing signaling devices, point machines was conducted. This review aims at analyzing the forms and distributions of vibrations in the actual environment in which they occurs. . Buildings located close to transportation experience structure-borne sound and vibration due to passing train which can be disruptive to the operations of sensitive equipment's in manufacturing, and medical facilities, also can be annoying to human occupants in residential, office, and commercial buildings. The paper focuses on testing of a full-scale building study of ground-borne vibrations and a prediction of avoiding the effects.*

Keywords: *Vibrations, Moving Train, FTA (Fire Traffic Area), FFT (Fast Fourier Transformation),*

1. INTRODUCTION

One of the most important issues in railway transport is safety. Train movements on the railway infrastructure are observed through a signaling system and a well-defined set of rules. The European Railway Traffic Management System (ERTMS) aims at replacing the many different national train control and command systems in Europe and make a standardized system [1]. The innovative approaches in railway safety system is described by the US patent i.e. Railway using acoustic monitoring [3]. It is based on method of monitoring of a railway system which includes a track and train, with application of acoustic functionalities using track circuits. A very important and ongoing issue is the consequences that are being faced due to ground borne vibrations. This review presents the results of experiment on the passage of a Thalys HST at a speed of 314 km/h.

Shopping malls, apartments, hotels, office buildings and other public facilities are close to the track as well as there are buildings which are connected to metro station directly. The characteristic of the high-density multi-purpose land used is that it not only reduces environmental pollution and energy consumption, but also improves the quality of people leaving around that area. But the trains that are frequently passing many times creates an effect on the nearby locality.(3) It radiates the noise and transmits the vibrations to area around which causes many bad effects on the structures as well as the people living in it. Thus it is essential to study the influence of the vibrations and find an efficient method to reduce the effect.(5) The train usually runs on one side of the building while the subways are running underground i.e. beneath the building which is nearby and hence the vibration from the source is transfer to the foundation of the building.

2. MAIN SOURCE OF VIBRATION

The main buildings of a metro area are composed of a maintenance building, a parking where the staff works and the local buildings where people live. The rail can be divided into three types in accordance with the characteristics of rails. The throat area, where trains run into individual parking berths, it has a lot of small-radius curved rails, rail joints and turns i.e. the minimum radius of curve is about 150 m. The storage tracks in the parking garage and in the maintenance building have relatively slower speed of trains. The testing line is where the train has the highest speed in the metro area which is used to test performance of trains and ensure safe operations before the trains are put into practice. The vibration and noise appear in all directions as the train passes.(5) The vibration characteristics are associated with many factors, such as speed, rail types, sleepers, ballast, subgrade, building foundation and structure. The vibration of the train power system and rail structure, the dynamic interaction of wheel/rail and wheel/rail irregularity are the main vibration sources for rail structure. The trains running on the testing line at a higher speed and small radius curved rails in the throat area are main vibration sources while the vibrations of the storage tracks are relatively smaller due to the slow speed.(2) In general, noise increases with speed and trains length. In the testing line, noise is mainly affected by trains' accelerations and high speeds while in storage area there are no turnouts and rail curves as well as the speed of the train is also low. The noise occurred on rail joints are negligible.(5)

Figure 1: Test line area

3. TESTING LINE SETUP

Three setups were selected (1) setup A, on the ground near train tracks; (2) setup B, on the platform away from buildings; and (3) setup C, in the building, as shown in Fig. 2. . All setups were measured in one-hour intervals from 1 to 4 pm, beginning with setup A and ending with setup C. The vertical and horizontal accelerometers were set perpendicular to the track on the ground and platform with different distances from the testing line and at the centers of the selected floors in the 14-story building. The vertical and horizontal accelerometers were set perpendicular to the track on the ground and platform with different distances from the testing line and at the centers of the selected floors in the 14-story building. The vertical accelerometers, which were 28 m away from the testing line with same elevation. An open channel was made 2m away from track o store the cables and it was throughout the testing line. (2)

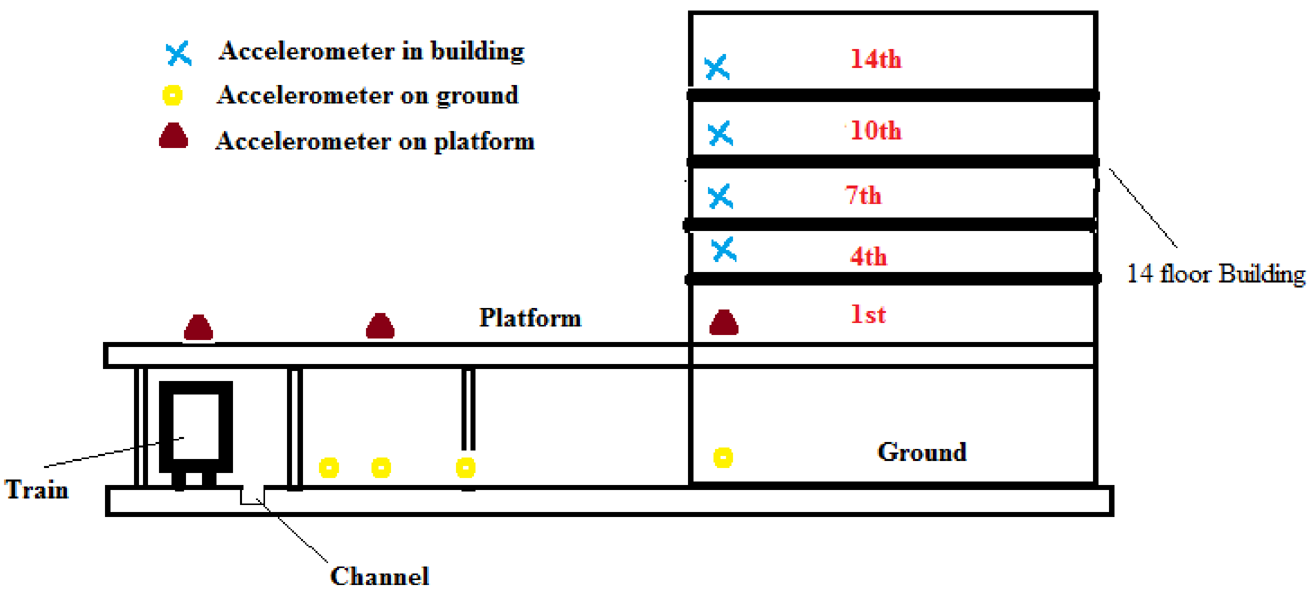


Figure 2: 14 floor building setup for measuring vibrations

3.1 Vibration response on ground level

It was observed that the vibration levels noted on vertical and horizontal accelerometers changed with respect to the distance. . The reference velocity was taken as 1×10^{-6} in./s according FTA. The vibrations were 5-10db greater of the train as compared to the other accelerometers away from the track. Vertical vibrations were greater than horizontal accelerometer within 14 m from the track. However, from 14 m to 28 m, vibration levels in both directions were all most same. . The first measurement on the ground was at 7 m away from the track centerline. There was an average reduction of about 0.6 dB/m within 7 to 28 m further away from the track. (2)

3.2 Vibration response on platform level

There are basically two different paths of vibration transmission from vibration source to the building, which contribute to the total vibration response of platform and building. The one path is from columns near the track to the platform and then building and other path is from the ground to the columns and then to building.(4) The vibrations induced by the trains were about 5–10 dB greater than typical ambient vibrations form both directions. The vertical vibration levels were 5–10 dB greater than levels in horizontal direction within 14 m. However, the peak levels were close in both directions at 28 m from the testing line. For horizontal vibration, the velocity levels were almost below 20 Hz while amplified zones were observed above 20 Hz at 28 m. It is also possible that due to some error at that distance, the vibration at horizontal levels is higher i.e. 20Hz to 63Hz. For the vertical vibrations it showed peak at 16Hz whenever any train passed by the testing line.(5) The peak velocity levels decreased with a rate of around 0.2 dB/m on the platform, which was not as high reduction across it to the building as compared with transmission across the ground that decreases more rapidly toward the building. This may be due to the platform was not a heavily damped structure. In addition, the two different paths of vibration transmission may also cause this difference due to the open channel was only on one side of the track and it may have a small impact on vibration transmission at the other side. It resulted an amplification of vibration on the platform by 6 dB or greater compared to the ground vibration levels at 28 m from testing line. (2)

3.3 Vibration response on 14 floor building

Overall, the surrounding vibration levels are well below that of train-induced vibrations, especially for peak levels in frequency. The vibration levels in vertical direction were 5 dB or greater than in the horizontal direction. For the horizontal direction, the velocity levels was comparably below 31.5 Hz and increased rapidly above 63 Hz while the peak levels at every floor were below 50db. For the vertical direction, the average peak levels occurred was 50 Hz with values between 53 to 64 db. The peak levels increased slightly from 1st floor to 4th floor, and then decreased from 4th floor to 10th floor and finally amplified on the top floor. The difference in the velocity levels of the pass-by trains were 3-7db. (2)

4. DISCUSSION OF MEASURED LEVELS

The review is useful for designing effective vibration reduction methods in metro depots, and for developing analytical models of building vibrations. Whereas at the testing line area and throat area, the vertical vibrations always decreased with distance from the track while the horizontal vibrations did not show different paths of vibration transmission from vibration source to the building. . For the testing line area, the platform vibrations were around 10 dB and lower than the vibrations at throat area, even though the speed of trains at the testing line area was faster. The interaction between the wheel and rail joint may also be responsible for the difference.(5) The area near the throat needs to be improved efficiently as more vibration were induced as compared to the single track running train. From observation we can say that vertical vibrations were more as compared the horizontal vibrations. According to the FTA the induced vibrations generally reduces in level as it propagates through a building and rise 1 to 2 dB per floor. The vertical vibrations slightly increased on the lower floors, then decreased on the middle floors, and increased again on the top floor because there was no structure above the top floor to absorb the vibrational energy. For the 14 floor building at testing area, the average rise rate of vibration was about 1 dB per floor from 1st floor to 10th floor. During experimentation the FTA guidelines were taken into consideration.

4.1. Vibrations for human comfort

The factors that affect the human comfort are amplitude and frequency of vibrations. According to ISO2631-1 (International Organization for Standardization, 1997), the main frequencies of vibration impact on humans is within 1–80 Hz. The FTA gave an vibration impact criteria that the train induced vibration should be 75 db for institutional land uses in day time, while 72 db for the residential area and buildings where people sleep. Thus, the average velocity levels at midfrequencies within 10 m from the tracks at throat area are close to the FTA limit value of 72 dB for residences. If the buildings are built on the platforms nearly about 40m away from the track then the chances of increase in vibrations can be observed as resonance can also occur. Hence this review says to carefully study the construction of buildings near tracks within 40m of radius. Thus the vibration levels in the 14floor building at testing line area were less than the limit value by 10 to 20 dB and at around 50 Hz. (12)

5. Measuring Instrumentations

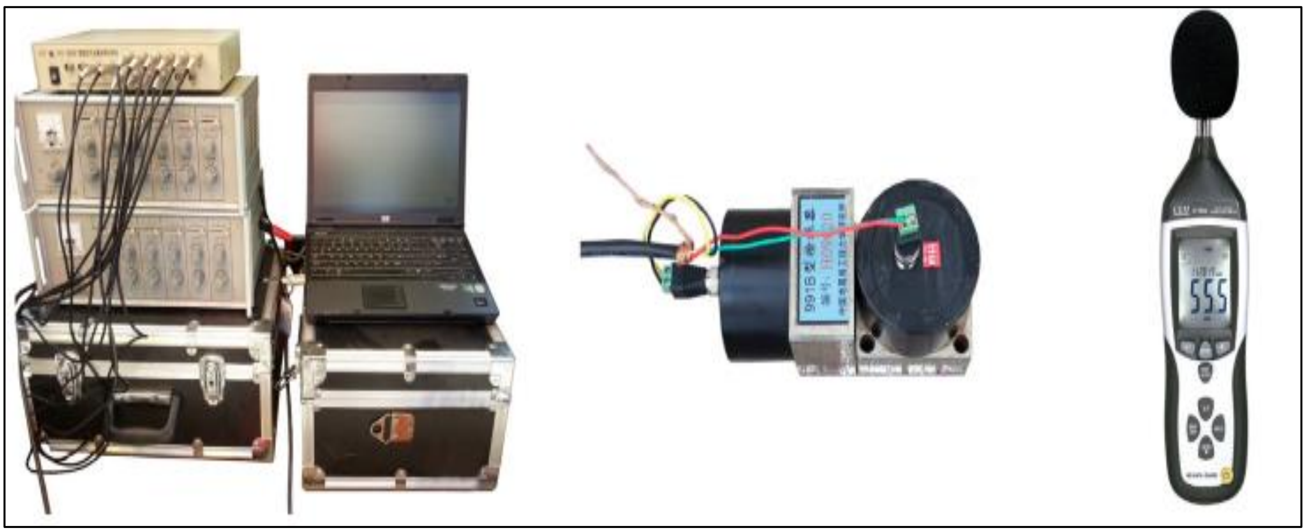
The instrumentations used in the measurement were INV306DF Data Acquisition & Signal Processing System (Fig.3a), 991B ultra-low frequency accelerometers (with sensitivity 0.3 V/m/s2 and using glue to mount (Fig.3b), 941 amplifier (Fig.3a) and DT-8852 Sound Level Meter. All instrumentations were calibrated before the measurement. For the vibration measurements, the sampling rate was 410 Hz. A total of 61 groups of ground vertical and horizontal acceleration signals were obtained, among which 51 were used for the ground vibrations and 10 were for the building vibrations.(12) According to Federal Transportation Railroad Administration (FTA) criteria, the human body responds to average vibration amplitude.(11)

As the net average of a vibration signal is zero, the root mean square (rms) amplitude is used to describe the "smooth" vibration amplitude. The metro train vibration velocity (v) was converted from acceleration (a) using eq(1) and then by using fast Fourier transform. It was computed for continuous 1 min while train was passing by. Vibration velocity level in decibels was done using Eq.

(2) and the peak level in one-third octave band was recorded. [5]

$V = a \div (i2\pi f)$ (1)

$L_v = 20\log(v/v_{ref})$ (2)



(a) (b) (c)

Figure 3: Measuring instruments

6. CONCLUSION

As the vibrations passes on both the sides equally, due to columns there is an increase in 6db as compared to the ground induced vibration level at testing line.

The increased vibration level inside the building was greater than outside area which was about 16db. The buildings within 40m radius near throat area should be well examine and modified to reduce the effects.

The spectrum of vibration exited by travelling trains has a frequency bands of 10-250 Hz in which the upper value is 80 Hz. The vibration levels measured are less as compared to FTA limit criteria of 72 db but have a lot of potential to be annoying to human comfort.

7. FUTURE SCOPE

1. Better understanding of the reasons for different corresponding frequencies of peak values for over-track buildings.
2. Use impedance modeling for predicting train-induced building vibrations.
3. Verification of a numerical model with measured data for predicting train-induced building vibration in a metro depot.
4. Development of design guidelines for the prediction and mitigation of building vibrations.
5. Use piezoelectric energy harvesting.
6. Modification of tracks.
7. Installing vibration absorbers.

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