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Transmission of Ground Vibration on Road Side Structures

Daha S Aliyu[1], Yusuf Abdulfatah Abdu[2] and Danjuma A Yusuf[3]

[1] Department of Civil Engineering, Kano University of Science and Technology, Wudil, Nigeria
[2]Department of Mechanical & Automobile Engineering, Sharda University, Greater Noida, India
[3]Department of Architecture, Kano University of Science and Technology, Wudil, Nigeria
abdulfatahabduyusuf@gmail.com

ABSTRACT

This paper discussed the general, problem of ground vibrations generated by road construction, operation methods generated due to road traffic and rail on the soil surface caused by different operations. Vibrations are one of many environmental factors that act on a building and potentially reduce their lifetime. Traffic induced vibrations, which are transferred through the ground, may interfere with the proper operation of vibration sensitive equipments. Vibrations are most frequently blamed for deterioration of historical buildings, there number of common vibration sources like road and rail traffic, earthquake.

Key words: Ground vibration, road traffic, soil surface, earthquake

INTRODUCTION

Vibration is one of the main factors for fatigue in structure. Vibrations produced by different sources propagate from one medium to another [6]. Long term exposure to vibrations can cause damages in buildings leading to minor effect such as cracks. These minor damages in critical cases could result in collapse, especially in historic buildings [7]. The resulting vibrations are, therefore, known as forced vibrations. Impulsive shocks give rise to transient vibrations. On the other hand they excite the natural frequencies of the soil-structure combination and result into the vibrations which are known as free vibrations [9]. It is unusual for vibration from sources such as buses and trucks to be perceptible, even in locations close to major roads. Some common sources of ground-borne vibration are trains, buses on rough roads, and construction activities such as blasting, pile-driving and operating heavy earth-moving equipment [4]. The effects of ground-borne vibration include feel able movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls and rumbling sounds etc [3].

Ground-Borne Vibration by Traffic and Rail

Most vibration problems, traffic vibrations can be characterized by a source-path Fig.1. Vehicle contact with irregularities in the road surface such as potholes, cracks and uneven manhole covers which induces the dynamic loads on the pavement waves, which propagate in the soil, eventually reaching the foundations of adjacent buildings and causing them to vibrate [12], [10]. Traffic vibrations are mainly caused by heavy vehicles such as buses and trucks. Passenger cars and light trucks rarely induce vibrations that are perceptible in buildings. Ground-borne vibration caused by the dynamic impact forces generated in the rail interphase due to irregularities of both wheels and tracks that can propagate in the soil and excite the foundation walls of nearby buildings, beneath ground [6]. Heavy freight trains emit ground vibration with predominant frequency components in the range 4–30 Hz. If the amplitude is sufficient, this may be felt by line side residents, giving rise to disturbance and concern over possible damage to their property [1]. A semi-empirical model for predicting low frequency vibration that may annoy building occupants in areas with soft ground conditions has been developed and used for the planning of a new high speed railway line in Norway [2].

Impact of Ground-Borne Vibration

Vibration generated by road vehicles and by trains can have significant environmental impact on nearby buildings. The general complexity of the problem is inhabitants perceive vibration either directly as motion in floors and walls or indirectly as reradiated noise [11]. A third and very significant source of disturbance is due to movement of household objects, especially mirrors, or by the rattling of window panes and glassware. In all these cases the problem of ground-borne vibration is important at frequencies typically up to 200 to 250 Hz [7], [13]. Vibration at higher frequencies is generally attenuated rapidly with distance along the transmission path through the ground. Vibration can travel long distances from its source. For a ground with soft clay or silt, ground borne vibration may produce annoyance to people in buildings more than 200 m away from tracks [4]. More and more people are calling for measures to protect the environment, and environmental degradation caused by railways is also a matter of concern. It is now well recognized that train speeds cannot be raised further without first considering how the extra speed might negatively impact the environment [8].

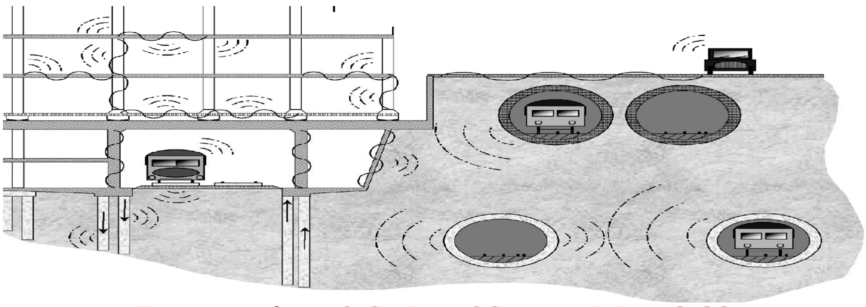

Fig. 1 Sources of ground vibration and the Transmission paths [1]

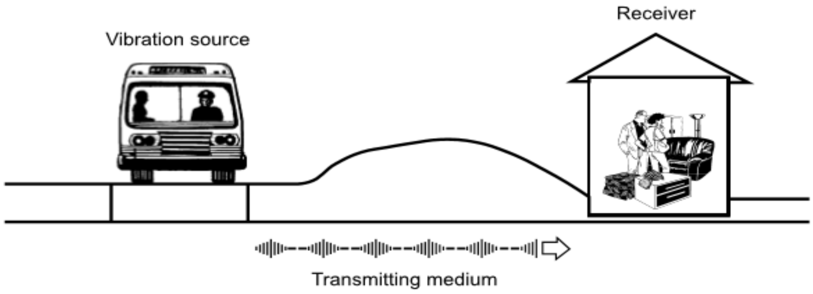

Fig. 2 The traffic vibration can be characterized by a source path-receiver scenario [12]

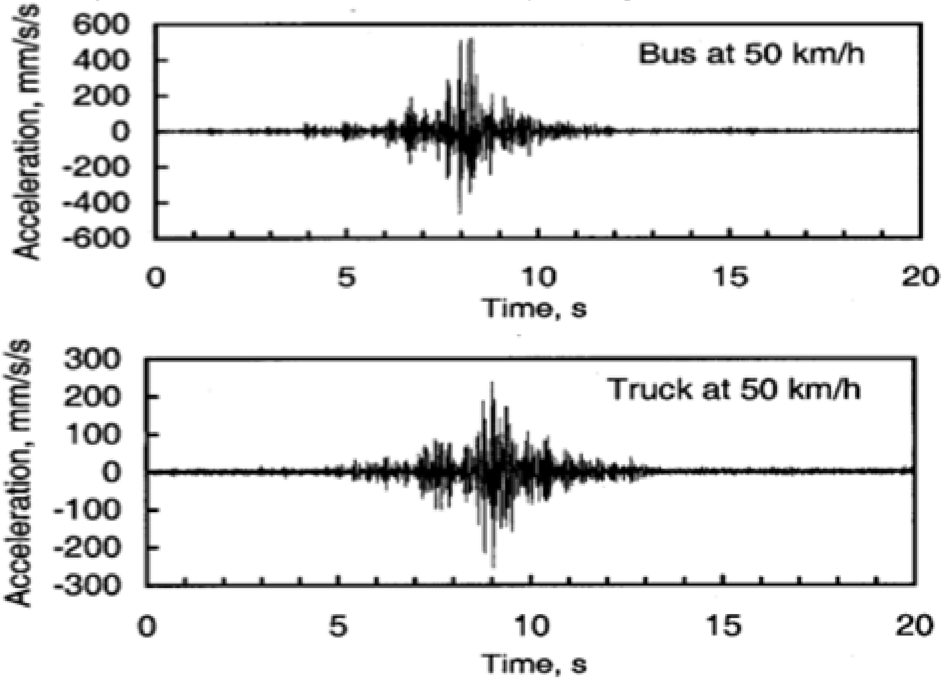

Fig. 3 Comparison between vibration levels induced by a transit bus and truck (Vibration levels are significantly different because of difference in suspension system) [12]

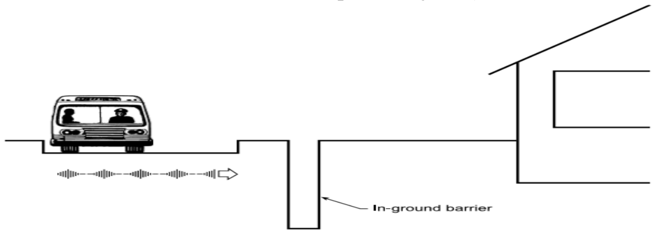

Fig. 4 Illustration of in-ground vibration barrier [11]

Table -1 Comparison of Vibration Levels (mm/sec^2, rms) Induced by a Bus and Truck

Location	25kM/h		50kM/h	
	Bus	Truck	Bus	Truck
Ground in front of house	20.3	19.7	64.6	33.0
External foundation Wall	11.4	10.3	30.8	15.5
Mid-point of floor in 1st Story	20.4	20.8	62.7	30.3
Mid-point of floor in 2st Story	35.3	37..4	90.5	46.6

In-Ground Vibration Barriers

Vibration is one of the primarily factors to be considered for fatigue in structure. Vibrations produced by different sources propagate from one medium to another. Long term exposure to vibrations can cause damages in buildings leading to minor effect such as Studies show that the depth of an in-ground vibration barrier has to be at least equal to one Rayleigh wavelength to achieve a significant reduction in vibration levels with a minimum factor of 0.25 is usually significant to be considered. In the case of traffic vibrations, very deep barriers would be needed in excess of 10 m, because of the low-frequency nature of these vibrations.

EFFECT OF VIBRATIONS ON PEOPLES

Building vibrations caused by road traffic are not a health and safety concern; they are more a problem of annoyance [10]. Vibrations may be unacceptable to occupants because of annoying physical sensations produced in the human body, interference with activities such as sleep and conversation, rattling of window panes and loose objects, and fear of damage to the building and its contents [5]. The goal of research is to satisfy people with the exact quality, product, quantity, and price in the shortest amount of time [14].

Research on ground-borne vibration, especially from underground railways, has recently gained prominence on account of the need to establish new underground tunnels in cities. There is also pressure to put high-speed intercity lines underground near residential areas. A particular feature of underground trains is the widespread notion that once undergrounds the problem of noise goes away. But pure vibration in the absence of noise can be unnerving and more disturbing than vibration from visible and audible surface trains.

PREDICTION METHODS

It is generally accepted that the amplitude of ground vibration at any point away from the explosion depends on:

- Distance of the point of measurement from the point of origin.
- Weight of charge detonates at a time.
- The propagation characteristics of the medium between the origin and point of measurement
- Energy compiling between the explosive and the confining medium.

SUGGESTED SOLUTIONS AND PREVENTIVE STRATEGIES

It is suggested that there may be a conditions in which the presence of underlying layers of soil or bedrock may cause reflection and refraction effects of the body waves generated by tie vibration source, and may be generated and enhance the transfer of subsurface Rayleigh waves. These effects may not be detected on the ground surface, but they may cause the large vibrations in an adjacent building and cause damage either by repetition of stress loading or by direct rupture, or cause disturbance to the occupants.

Solutions and preventive strategies that have been suggested to minimize vibration to an acceptable level include periodic maintenance of road surfaces, speed and control of traffic flow, improvement of the road structure, soil improvement, sufficient distance between roads and buildings, screening of vibration using in-ground barriers, and building isolation systems. Some of these measures have proven to be effective.

Buildings can be protected against ground vibrations using number techniques. A trench or ditch constructed between the site and adjacent buildings can minimize the transmission of vibrations through the ground provided that the ditch is enough deep. Another method of working is to use of wheeled dozers rather than tracked dozers could be considered where ground conditions permit. Vibrations from sheet piling can be reduced by the use of specialized piling equipment which employs hydraulic pressure rather than impact loading to drive the piles.

CONCLUSION

An analysis of the explosive induced vibration tests showed that damage in a building was most directly related to the peak particle velocity in the ground. Building damage may occur but it is unlikely to be caused solely by the vibrations by them self and it is expensive. In the case of existing buildings, most practical remedial measure is to maintain the road regularly. While in new developments, the distance between the road and the building should be in a far distance, improvement of soil structure, and in-ground pile barriers. Future work is also needed to determine and in what techniques the fatigue damage may be caused to buildings close to road construction sites because of the repetition of stress loading and on the effects of substrata on ground vibration propagation.

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