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Effect of Road Traffic Vibration on Historic Structures

KEYWORDS: Vehicular Traffic, Peak particle velocity, Ground borne vibration.

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ABSTRACT *Vibration are one of many environmental factors that acts on a buildings and potentially reduce their lifetime. Vibration are most frequently blamed for deterioration of historic buildings. This paper discussed the measurement of vibration amplitude generated due to road traffic at historical structures and correlate them with the various damage criteria for building elements. There are number of common vibration sources like road and rail traffic, blasting, earthquake, sonic boom, construction vibrations and machinery vibration. Vibrations arising from road and rail traffic and its effect on historic buildings have become a subject of concern in modern world especially amongst the residential areas. There may be concern about possibility of adverse long-term effects of vibrations on historic buildings, especially those in a weak condition. Here discussed the max. peak particle velocity generated due to road traffic at two historic structures in Ahmedabad.*

Introduction:
Vibrations surround us, for nature provides its own vibration sources such as earthquakes, wind and ocean waves. With the advent of the technological era, vibration sources have multiplied and have become a concern to residents of modern buildings and to those whose task and desire it is to preserve historic ones. A number of common vibration sources (including road and rail traffic, sonic boom, construction vibrations, blasting and earthquakes) and how they affect historic buildings will be discussed in this paper.

The literature concerning vibration effects on historic buildings is not abundant, especially that relating to permissible and safe vibration levels, and conclusive studies of damage from vibrations are rare. This is not surprising when one considers the complex nature of the problem and the interrelation among the many environmental factors that cause deterioration of historic buildings.

Vibrations are most frequently blamed for deterioration of historic buildings while other detrimental effects are apparently ignored. This may be ascribed to the fact that the human being is very sensitive to vibrations and becomes alarmed at levels generally well below the danger level for most buildings.

Traffic vibration:
Vibrations arising from road and rail traffic and its effect on historic buildings have become a subject of concern in recent years. The effects of traffic vibrations on buildings, as for most other vibration problems, can be conveniently divided into three components: source, transmission path and receiver. This simplifies the consideration of cause and effect and subsequent discussion of remedial action.

i) Vibration Source
Rolling wheels on an elastic or imperfect contact material generate waves that then propagate downward and outward. The principal variables that effect vibration amplitudes are vehicle speed and weight, type of vehicle suspension ,roughness of the rolling surface, and the stiffness of the wearing surface and sub-base.

ii) Transmission Path
Waves generated at the source propagate outward through the ground. They are attenuated in the soil over distance and by material damping effect. Sometimes, however, they can be channelled in a certain direction,owing to layering of the soil, in such a way that there will be little attenuation or even some amplification. Soft and saturated soils transmit vibrations more readily than sandy, dry ones. While rock readily transmits vibrations, the small amplitudes generated and the high frequencies of the propagated waves usually pose little danger to a building's integrity.

iii) Vibration Receiver
For present purposes, the vibration receiver is the historic building under consideration and the occupants within it. After vibrations enter the building through the foundations, they may amplify by factors of from 2 to 5 in propagating to higher storeys. This will depend on the nature of the vibration (the frequency content) and the vibration susceptibility of the building component (beam, wall, floor, windows, etc.) as governed by the natural frequency and damping. Vibrations can induce secondary effects such as rattling of dishes or other furnishings, acoustic radiation from components and direct annoyance of the occupants.

Remedial Action
Unacceptably high vibrations can be reduced at the source, in the transmission path, or at the receiving end. The suitability of any one or a combination of these actions will depend on the circumstances that present themselves. The vibration source can be treated as follows: traffic can be re-routed and thus eliminated altogether; heavy vehicles can be restricted; speed of vehicles can be reduced; surface irregularities (potholes, manhole covers, washboards, cobblestones, &.) can be eliminated or minimized by road improvements or re-surfacing; stiffness of the road surface and its sub-base can be increased and isolation pads over limited sections of a road can be installed.

Remedial measures applied to the transmission path include trenching between vibration source and building, followed by backfilling with a slurry; and piles or holes can be placed in specific geometric patterns between the source and the receiver-'. These measures are generally difficult to carry out and are, perhaps, the least effective.

Vibrations arriving at and propagating through a building can sometimes be reduced by use of damping strips or tuned dampers; the resonance frequency and, therefore, the vibration behaviour can be changed by stiffening or bracing a component; or a building or component can be placed on

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flexible supports4. It is recognized, however, that although the latter is possible in principle and would be theoretically effective, placing an existing building on flexible supports is generally not practical.

Long-Term Effects of Vibrations

Although traffic vibrations may not cause deterioration in the short term, there is some concern about long-term effects on historic buildings. Two possibilities stand out as potential problem areas: building material fatigue and building foundation settlement.

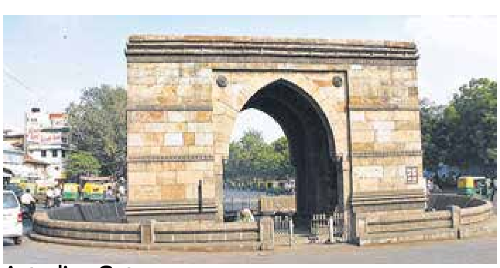
Fatigue, as the name implies, is a "tiring" of the material when high loads are applied repeatedly. Strength decreases and failure can occur at load levels well below those that cause failure under only a few load cycles. For steel and concrete fatigue behaviour is reasonably well-quantified, and strength reductions from 30% to 50% over millions of load cycles have been observed. For brick, mortar or stone, fatigue effects are not well known. A further complicating factor is the possible interaction of stresses from loads and vibrations and from other deteriorating factors such as chemical pollutants.

MEASUREMENT SYSTEM

PPV is generally accepted as the most appropriate descriptor for evaluating the potential for building damage. For human response, however, an average vibration amplitude is more appropriate because it takes time for the human body to respond to the excitation (the human body responds to an average vibration amplitude, not a peak amplitude. For vibrations induced in buildings by road traffic: (i) frequency range is normally from 4 Hz to 80 Hz; sometimes up to 125 Hz. and (ii) amplitudes are generally in the range 0.005 m/s^2 to 2 m/s^2 for acceleration and 0.05 mm/s to 25 mm/s for velocity. It is normally recommended that the noise level introduced by the complete measurement system be at least 10 dB below the minimum anticipated vibration levels and the dynamic range of the system be greater than 40 dB.

Vibrations generated due to vehicular movements are measured with help of oros-3 series analyzers. It contains transducers for measuring the data and computing system and NVGate software for real time or post analysis of data. In this paper, field measurements of the ground vibrations generated by road traffic and how its affects historical structures is discussed. The measurement is performed on two historical sites Sidi saiyad ni jali & Astodiya gate in Ahmedabad. Accelerometers are used to record ground accelerations in three directions the parallel to traffic, perpendicular to traffic and vertical directions at appropriate distances from the road.

Sidi Saiyad ni Jali

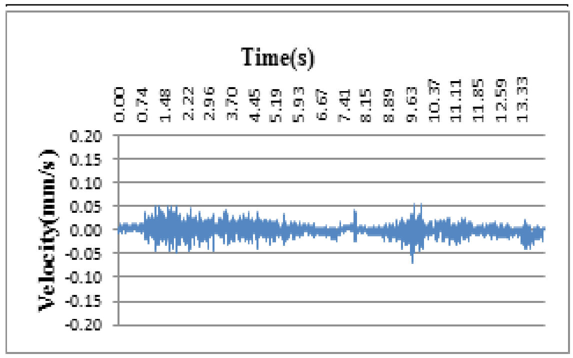


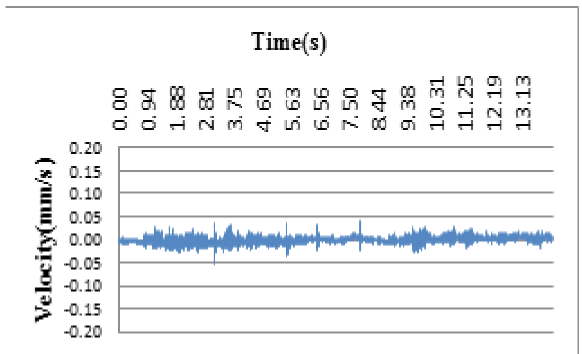
Astodiya Gate

Existing vibration criteria for historical structures for continuous vibration:

Name of standard	Continuous source PPV(mm/s)
Swiss Association of Standardization	3
AASHTO vibration criteria	2.5
German institute of standards	3-8
Dowding vibration criteria	12.5
Whiffen vibration criteria	5
Konan vibration criteria	3-6
Rudder vibration criteria	2.5

Results:





Results Table:

Name of historic structure	Max. PPV (mm/s)	
	Horizontal	Vertical
Sidi saiyad ni jali	0.05	0.05
Astodiya gate	0.1	0.12

Conclusion:

From study of different vibration criteria generally, 3mm/s(0.12in/sec) max. ppv value is taken as a safe limit criteria for historical and fragile buildings for continuous traffic vibration. Max. ppv value 0.05 mm/s at sidi saiyad jali, 0.12mm/s at Astodiya gate.From results we can say that these historical structures safe from structural & architectural damage due to traffic vibration. But, due to traffic vibration, cosmetic damage to these historical structures is possible.

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