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Construction Project Management special reference to Building Vibration Analysis

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ABSTRACT

Construction often occurs near or adjacent to other existing structures. The Construction activities of demolition of structures, blasting of hard items, piling for making foundation, and compaction of soils for making floor are frequently generate vibrations. Certainly tunnel drilling and trench excavation produce significant levels of noise and vibration. The movements of traffic like heavy vehicles, railways and train can also significantly impact vibrations too. These unfavorably affect structure safety, human comfort, and equipment functionality. Vibration creates direct impact on the existing structure by surface waves. Vibration indirect impact induce the differential settlement of the bearing soils. This causes for differential settlement and distress of the foundation and load-bearing walls. For controlling and maintaining the vibration within the compliance requirements, vibration analysis is commonly to be carried out by monitoring systems and the study on the impact of vibration on the surrounding during the construction period. This research paper focus on vibration

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parameters, testing process and find out the root causes of the problem and improve the

design on achieving the project management effectiveness and efficiency.

1.INTRODUCTION

In India more than 50% investment in Infrastructure which includes road infrastructure,

bridges, flyovers, ports of sea and air, railways, building of commercial and residential and

etc. In these, residential buildings are cover major share because no one can live with out

shelter. Majority of these residential building are done by hard earned money of the middle

class and upper middle class people who spent their major life time for repayment of loan.

For them simple and economic vibration testing method is required to protect the structure

when they face vibration problem . In this research paper such vibration testing technique is

explained to understand the importance, and how it is correlated with construction project

management activities.

Key words "Vibration, amplitude, organizational design, construction project management

"

2. SIGNIFICANCE

The construction activity making noise and vibration to the surrounding. Vibration

monitoring is vital on construction sites, mining sites, and in industries. It plays a

critical role in preventing structural damage, enhancing worker safety, reducing

community complaints, and more. Noise and vibration monitoring is increasingly

required to reduce the followings:

a) risk of structural damage,

b) minimize complaints from the people of surrounding,

c) comply with regulatory requirements.

d) for preventing damage to the infrastructure

e) for protecting the precision equipments

f) maintaining positive community relations,

g) to avoid excessive levels that could lead to exceedance and even lead to

dropping of project and shutdowns.

3. PURPOSE OF THE STUDY

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- a) To Protect the building asset
- b) Elimination of unwanted expenditures
- c) Reduce the cost of maintenance and educate the owner of asset

4. OBJECTIVES OF THE STUDY

- a) Formulate the system to be followed
- b) Review the finding in periodical manner
- c) Standardize the system

5. LITERATURE REVIEW

(1) Full-scale dynamic response of an RC building under weak seismic motions using earthquake recordings, ambient vibrations and modeling by Clotaire Michel, Philippe Guéguen, Saber El Arem, Jacky Mazars, Panagiotis Kotronis Earthquake Engineering & Structural Dynamics 39 (4), 419-441, In countries with a moderate seismic hazard, the classical methods developed for strong motion prone countries to estimate the seismic behaviour and subsequent vulnerability of existing buildings are often inadequate and not financially realistic. The main goals of this paper are to show how the modal analysis can contribute to the understanding of the seismic building response and the good relevancy of a modal model based on ambient vibrations for estimating the structural deformation under weak earthquakes. We describe the application of an enhanced modal analysis technique (frequency domain decomposition) to process ambient vibration recordings taken at the Grenoble City Hall building (France). The frequencies of ambient vibrations are compared with those of weak earthquakes recorded by the French permanent accelerometric network (RAP) that was installed to monitor the building. The frequency variations of the building under weak earthquakes are shown to be less (~2%) and therefore ambient vibration frequencies are relevant over the elastic domain of the building. The modal parameters extracted from ambient vibrations are then used to determine the 1D lumped-mass model in order to reproduce the inter-storey drift under weak earthquakes and to fix a 3D numerical model that could be used for strong earthquakes. The correlation coefficients between data and synthetic motion are close to 80 and 90% in horizontal directions, for the 1D and 3D modelling, respectively. Copyright © 2009 John Wiley & Sons, Ltd. Fundamental periods of vibration of RC buildings in Portugal from in-situ experimental and numerical techniques

ISSN: 0937-583x Volume 89, Issue 12 (Dec -2024)

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(2) Fundamental periods of vibration of RC buildings in Portugal from in-situ experimental and numerical techniques by CS Oliveira, M Navarro in Bulletin of Earthquake Engineering 8, 609-642. Since the early nineteen seventies we have been measuring the in-situ dynamic characteristics of the different structures built in Portugal, essentially based on ambient vibration and using expedite techniques. A data-base containing not only the fundamental dynamic characteristics of those structures but also their most important geometric and constructive properties has been created with the aim of setting correlations between construction typologies and fundamental periods or frequencies, and damping characteristics, and calibrate numerical modelling of those structures. This paper presents the main results for circa 197 reinforced concrete (RC) buildings, obtaining the fundamental period as a linear function of height or number of storeys for different typologies and situations, and showing that numerical models, made for a number of illustrative cases, can reproduce with great accuracy the in-situ measurements. The main parameters having remarkable influence on the overall correlation laws are identified and a measure of uncertainty deduced. Comparisons with published formulae for other regions of the world show that we can group these laws by regions with similar expression within each group but with large variations from group to group. Discussion on how to deal with the elongation of the periods of vibration due to moderate and large amplitude motion, causing changes in the seismic behaviour and on appearance of damage, will also be briefly introduced, keeping in mind current code practices.

6. RESEARCH GAP

In Construction industry various studies has been conducted, whereas such studies has not covered the small residential building. The surveys have been conducted in high rise building and machinery applications. It is required to make he a valiant attempt for small building vibration study and this is for the first time, study has been encountered to identify the levels of vibration in small building.

7. INVESTIGATION METHODOLOGY;

Descriptive research design could be used. It is a type of research design that aims to obtain information to systematically describe a phenomenon, situation, or population. More specifically, it helps answer the what, when, where, and how questions regarding the research problem, rather than the why.

Primary data and Secondary data are taken. It Meaning refers to the first hand data gathered by the researcher himself. Secondary data means data collected by someone else earlier. Source Surveys, observations, experiments, questionnaire, personal interview, etc. Government publications, websites, books, journal articles, internal records etc.

Technical area of organizational design covers Sampling plan and Procedures, Testing Procedures, Instrument used, Calibration of the instruments and Flow chart with flow chart

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symbol with attractive Colors and etc,. .

This research paper is prepared with primary data of soil tests conducted and the various

information collected from secondary sources.

It require activities of; a) Planning for Tests to be conducted at site locations; b) Preparing

equipment and man power; c) Conducting test at the site; d) Collecting data; d) Analyzing

the data; e) Reporting the profile; f) Corrective action; g) Inspection for the corrective action

; h) Standardize the design.

For the explaining purpose the real time vibration study in taken as follows;

7.1 Introduction

During the study on 21st March' 2024, Building / Floor vibration measurements were

recorded at five specified locations in a Two Storey Building using Low frequency range

measuring geophones in the building at Nandanam Chennai. At each point, Vibration

Amplitude measurements were recorded in three perpendicular axes (i.e Vertical,

Longitudinal / Axial & Transverse / Hor).

This test was basically carried out to measure and record the vibration level at building as

higher Vibration levels were reported by the residents in Second Floor in the above

mentioned address. Since First floor is not occupied all the time, effect of vibration on

First Floor was not known.

Vibration measurements were carried out using three channels Ground Vibration

Measuring Instrument with Geophone and Single channel FFT Analyzer 03 Nos. with 03

Nos. accelerometer (one accelerometer in each direction). The detailed vibration data

recorded during the visit is enclosed.

Guidelines for understanding and reading the recordings are provided under Methodology

section.

7.2 Methodology- Ground Vibration Measurement:

7.2.1 Vibration

Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium

point. The oscillations may be periodic such as the motion of a pendulum or random such

as the movement of a tyre on a gravel road. Vibration is occasionally "desirable". For

example the motion of a tuning fork, the reading a wood wind instrument or harmonica, or

the cone of a loud speaker is desirable vibration, necessary for the correct functioning of

the various devices.

More often, vibration is undesirable, wasting energy and creating unwanted sound – noise.

For example, the vibration motions of engines, electric motors, or any mechanical earth

moving equipment in operation are typically un wanted.

In the present context, floor vibration measurements were recorded using Low frequency

range measuring geophones. At specified point, Vibration Amplitude measurements were

recorded simultaneously in three perpendicular axes (i.e. Transverse (Horizontal), Vertical,

Longitudinal(Axial) using tri-axial Geophone.

7.2.2 Vibration Amplitude:

Vibration amplitude can be measured and expressed as:

1. Displacement

2. Velocity

7.2.2.1 Vibration Displacement

The vibration displacement is simply the total distance traveled by the vibrating part from

one extreme limit of travel to the other extreme limit of travel. This distance is also called

the "peak- to-peak displacement".

Peak-to-peak vibration displacement is expressed in micrometers (sometimes called

microns), whereonemicrometer equals one-

thousandthofamillimeter(1micrometer=0.001millimeter).

7.2.2.2 Vibration Velocity:

Vibration velocity is rate of change of speed in other words it is the speed at which

displacement takes place. Since it is constantly changing throughout the cycle, the highest

or "peak" velocity is selected for measurement.

Vibration velocity is expressed mm/sec peak.

7.3 METHODOLOGY- GROUND VIBRATION USING VIBRO CARD

INSTRUMENT

ISSN: 0937-583x Volume 89, Issue 12 (Dec -2024)

https://musikinbayern.com DOI https://doi.org/10.15463/gfbm-mib-2024-354

Instrument Details

Four Channel FFT Analyser with Tri-axial

Geophone. Model: Vibracord DX, Make:

M/s. VibraquipoS.L.U–Spain Instrument Frequency

range 1 - 315 Hz.

Geophone:

Geophones are used to measure vibration levels at low frequencies starting from 1.0 Hz.

Although measurement of particle velocity by geophones directly yield ground /floor stress

as a product of ground /floor unit density and wave propagation velocity and ground / floor

astheratiobetween particle velocity and wave propagation velocity, geophone properties

may not be suitable for the measurements in near field of high energy vibration sources.

Geophone is connected to Four Channel FFT Analyser through a cable and placed on the

floor in such a manner that the spirit level in the geophone is in level to the ground. The

geophone collects the vibration velocity vs time and converts to vibration acceleration and

Vibration Displacement (Maximum to & from otion taking place in microns Pk-Pk).

Geophone use disaTri- axial transducer and measures Vertical, Longitudinal &Transverse

directions simultaneously.

Measurement Directions while using Vibro card Model DX

(GEOPHONE) Chan nel1: Vertical (Perpendicular to Ground Level &

equipment shaft axis) ChannelII:Longitudinal(Axial-

ParalleltoGroundlevelinEast–WestDirection)

ChannelIII:Transverse(Horizontal–ParalleltoGroundlevelinNorth–SouthDirection)

7,4 METHODOLOGY- GROUND VIBRATION USINGX-VIBER INSTRUMENT

Instrument Details:

Single Channel FFT Analyser with Accelero meter

transducer. Model: X-Viber, Make: VMI International

AB – SWEDEN Instrument Frequency range is 2 -

800 Hz.

Accelerometer:

ISSN: 0937-583x Volume 89, Issue 12 (Dec -2024)

https://musikinbayern.com DOI https://doi.org/10.15463/gfbm-mib-2024-354 Accelerometer is connected to the FFT analyzer which is a computer based digital instrument. These instruments are produced in standalone as well as laptop computer

models. A block of data digitized in an analog to digital converter are processed in a Fast Fourier Transform algorithm to obtain a spectrum.

The FFT analyzer acquires a block of data at a high sampling rate.

Measurement directions:

Ver-Vertical-Perpendicular to Floor

Axl-Axial-Parallel to Floor in East-West Direction

Hor-Horizontal-Parallel to Floor in North-South Direction

7.4 INTERNATIONAL STANDARDS & RELEVANT CLAUSES

Ground / Building / Structural Vibration studies are carried out based on DIN 4150 Part 2 &DIN 4150 Part 3, a German Standard. DIN stands for **Deutsches**Institut für Normung DIN4150Part3specifies"VibrationsinBuildingsEffectsonStructures-(PPVvalue)" Kindly find below the DIN specified limits for buildings:

DIN4150Part2:

	Bf(t)Limits as per DIN-4150 For Listed Buildings under Preservation Order						
		Day		Night			
Li	Location of Building	Lower	Upper	Lowe	Upper		
ne		limit	limit	r	limit		
				limit			
1	Building sin purely industrial areas.	0.40	6	0.30	0.60		
2	Building sin predominantly commercial	0.30	6	0.20	0.40		
	areas.						
3	Buildings in areas which are neither predominantly commercial nor predominantly residential.	0.20	5	0.15	0.30		
4	Building sin areas which are predominantly or purely residential.	0.15	3	0.10	0.20		
5	Building sin specially protectedareas	0.10	3	0.10	0.15		

ISSN: 0937-583x Volume 89, Issue 12 (Dec -2024)

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		(Suchas hospitals) or in health resorts.				

Day:DuringNormalActivity(NormalActivityreferstowalking,running,jumpingetc., andall common human activities) **Night:** During No Activity (No Activity refers to sleeping, or absence human etc.)

DIN4150 Part3:

Line	Type of structure	Guideline values for velocity, ν_i , in mr Vibration at the foundation at a frequency of 1 Hz to 10 Hz			m/s Vibration at horizontal plane of highest floor at all frequencies
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8

^{*)} At frequencies above 100 Hz, the values given in this column may be used as minimum values.

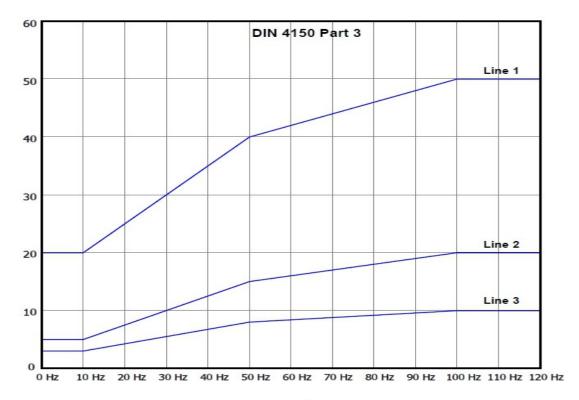
DIN4150Part3Chart:

	Measurement Location	Dir.	Vel. (mm/s ec)	Freq.in Hz	Limits(Acco rding to DIN 4150)
	Loc1: Hall	Ver	0.26	29	
01	(SecondFloor)	Long	0.05	4	Permissible
		Tran	0.04	3	
	Loc2:BedRoom1	Ver	0.17	3	Permissible
02	(SecondFloor)	Long	0.34	3	
		Tran	0.39	3	
		Ver	0.06	5	

ISSN: 0937-583x Volume 89, Issue 12 (Dec -2024)

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https://musikinbayern.com		DOI https://doi.org/10.15463/gfbm-mib-2024-354

nups.	//illusikilibayetii.com		DOIT	ups.//doi.org/10	J.13403/g10111-11110-
	Loc3:BedRoom3				Permissible
03	(SecondFloor)	Long	0.11	3	
		Tran	0.40	4	
		Ver	0.46	5	
04	Loc4:HeadRoom(Terr	Long	0.03	4	Permissible
	ace)	Tran	0.03	5	
		Ver	0.32	3	
05	Loc 5:TrainingHall	Long	0.08	1	Permissibl
	(First Floor)	Tran	0.06	2	e



BUILDING VIBRATION MEASUREMNET REPORT

ration Limits in mm / sec (RMS) as per DIN-4150 Part3- ListedBuildingsunderDwellings							
quency range	0–10Hz	10-50Hz	50-100Hz	all frequencies			
x. Vibration Velocity wed in mm/sec	5	5to15	15to20	15			
IS)							

Data sheet of Highest Amplitude Vibration Measurements Carried out on

Dir.– **Direction**

Vel.-Velocity in mm/sec RMS

During the visit on Building/ Floor vibration measurements were recorded at 05 specified locations in a using Low frequency range measuring geophones. At each point, Vibration Amplitude measurements were recorded in three perpendicular axes (i.e Vertical, Longitudinal / Axial & Transverse / Hor).

This visit was basically carried out tome asure and record the vibration level at building as higher Vibration levels were reported by the resident sin Second Floor in the above mentioned building. Since First floor is not occupied all the time, effect of vibrationon First Floor was not known.

Based on the discussion with the residents Vibration measurement locations were jointly identified along with their consultant and residents. It was decided to measure vibration amplitude at each of the following locations for 30-45 minutes continuously.

Hall in Second Floor

Bed Room1 in Second Floor

BedRoom3 in Second Floor

Head Room in Terrace

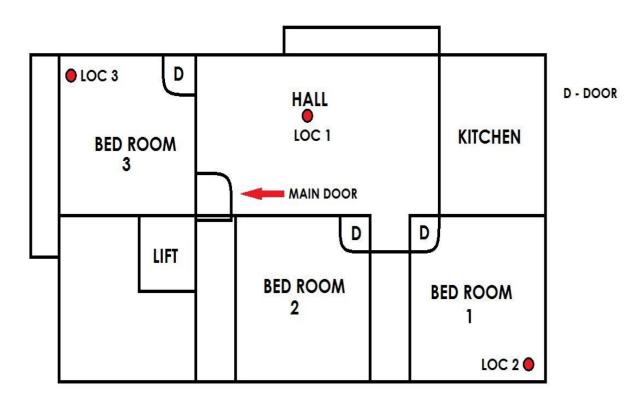
Training Hall in First Floor

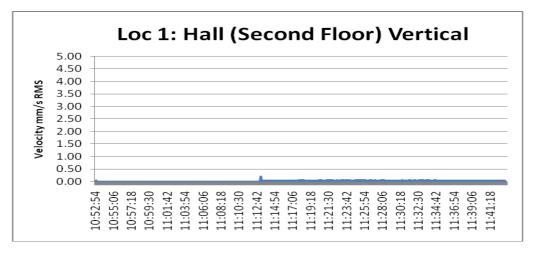
The Vibration measurement were taken in the Day time from 10.00 AMto03.00 PMwith Low Vehicle movement.

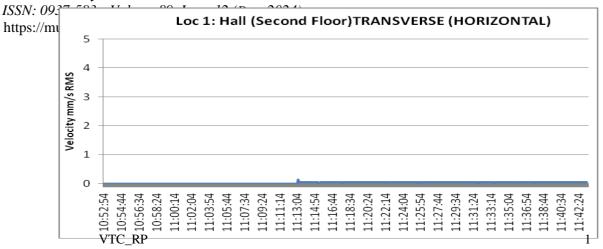
Inference: The analysis reveals that vibration amplitudes recorded on the day **are low and well with in limits** as per Din Standard **DIN 4150 Part 3**.

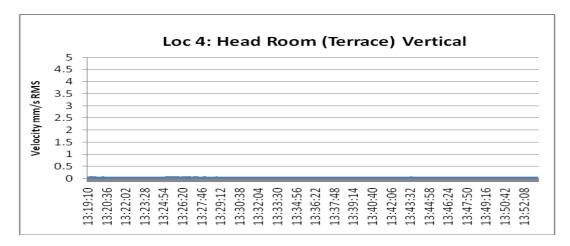
The vibration levels are found to be low and with in the limits as per standard DIN4150 Part3.

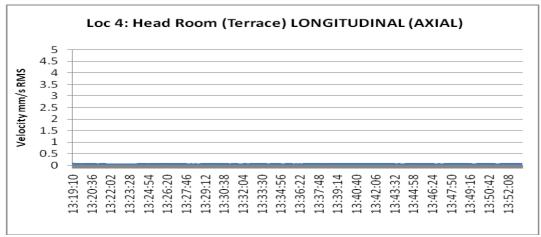
Vibration measurement Locations



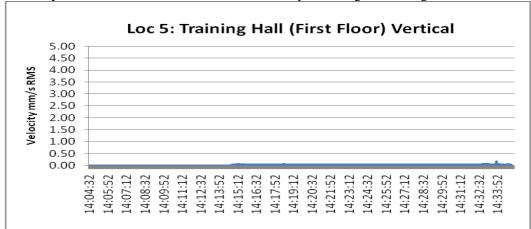








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8. OPPORTINITY FOR FUTURE DEVELOPMENT

This paper deals about the vibration measurement of small building floors for the particular time and specified locations. Likewise the test can developed more numbers and in different locations to get the very detailed information.

LIMITATIONS

Traditional vibration monitoring systems are associated with limitations such as expensive devices, complicated setups, and complex operating mechanisms. Some monitoring systems have built-in remote data transmission, processing, and access facility may produce in effective data.

CONCLUSION & RECOMMENDATION

Conclusion:

During the visit, Building/ Floor vibration measurements were recorded at 05 specified locations in a Two Storey Building at No 20/3, 14thStreet, Nandanam Extension, Nandanam, Chennai using Low frequency range measuring geophones. At each point, Vibration Amplitude measurements were recorded in three perpendicular axes (i.eVertical, Longitudinal/ Axial & Transverse / Hor). This test was basically carried out to measure and record the vibration level at building as higher Vibration levels were reported by the residents in Second Floor in the above mentioned address. Since First floor is not occupied all the time, effect of vibration on First Floor was not known.

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Based on the discussion with the residents Vibration measurement locations were

jointly identified along consultant and residents. It was decided to measure vibration

amplitude at each of the following locations for 30-45 minutes continuously at (1) Hall

in Second Floor; (2) BedRoom1inSecondFloor, (3) BedRoom3inSecondFloor, (4)

Head Room in Terrace, and (5) Training Hall in First Floor

The Vibration measurement are taken in the Day time with Low Vehicle movement.

The analysis reveals that vibration amplitudes recorded on the day are low and well

within limits as per Din Standard DIN 4150 Part 3.

Recommendation:

Vibration monitoring is closely regulated in many countries. Specific regulations

and standards vary from one country to another, but they all aim to ensure the

safety of workers and residents near construction sites and industrial facilities. It is

essential to put financial penalties and project delays when it exceeds.

Training to be given to management personnel and technical personnel on

planning, monitoring, maintaining detailed report, controlling, implementation

of corrective measures when noise and vibration levels exceed allowable

thresholds and ultimately plan for compliance.

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