Analysis of Vibration Reduction in RC Building

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Abstract – This study outlines the study of passive vibration isolation using open trench. The modelling and analysis are carried out using STAAD Pro Software. In STAAD Pro, soil is modelled as eight nodded solid element, beams and columns are modelled as two nodded beam elements. The time history analysis is carried out by applying harmonic load. Before performing time history analysis, the static analysis is done to finalise the sizes of columns and beam. After performing the time history analysis, the frequency domain graph is obtained. For each floor, a node having highest velocity is noted and its frequencies are converted into one-third octave band and from that rms velocity is found. The model with open trench are compared with the generic vibration criterion curve. From curve, suitability of structure housing sensitive equipment is found.

Key Words – Vibration Isolation, Open Trench, Time History Analysis, STAAD Pro Software

I. INTRODUCTION

The repetitive motion that can be measured and seen in a structure is what is sometimes referred to as vibration. Ground vibration brought on by a number of elements, including machine foundations, traffic, dynamic compaction or blasting, due to construction equipment, etc., may be distressing to nearby structures and inconvenient for humans. The majority of vibrations created by diverse sources travel through the soil medium as Rayleigh waves. Even buildings adjacent that contain sensitive technology are disturbed by these vibrations, which also have an effect on building occupant comfort. The four main components for studying ground-borne vibrations are "the source," which creates the vibration and is depicted by the USER'S CHAMBER instrument, "propagation path," which travels through the soil medium, "receiver," which one is the nearby building and represents the building housing sensitive equipment, and "interceptor," which is depicted by the wave barrier, the open trench.

II. METHODOLGY

The structure is now modelled and analysed using STAAD Pro. Static analysis in STAAD Pro is used to finalize the dimensions of beams and columns. Using STAAD Pro, the time history analysis is carried out, and a plot of frequency v/s velocity is produced from the frequency domain. A node with the highest velocity on each floor is identified, its frequencies are converted into a 1/3 octave band, and the rms velocity was determined.

Table 1. Structural Components

Structural components	Dimensions
Plan dimension	61m×72m
Beams (building with USER’S CHAMBER instrument)	300mm×500mm
Beams (building housed with sensitive equipment)	300mm×500mm
Columns (building with USER’S CHAMBER instrument)	300mm×450mm
Columns (building housed with sensitive equipment)	450mm×450mm
Width of footing(B)	4m
Grade of concrete	M 35
Grade of steel	Fe 415

1. Model of Open trench

The following formula is used to determine the trench's size.
The width of trench is fixed as 1.5m.
The shear modulus of the soil and the Rayleigh wave velocity are used to determine the trench's depth.
Shear wave velocity of soil = 235.65
Shear modulus = 943625.12
Rayleigh wave velocity (V_r) = $0.9V_s$
$V_r = 0.9\times235.65 = 212.08$
Rayleigh wave length (Lr)= Vr/f …… where f is dominant frequency.
Lr=212.08/55 = 3.856
Depth of trench /length of Rayleigh wave =1.33
Depth of trench =1.33×3.856 =5.4m
Therefore, width of trench is taken as 1.5m and depth is taken as 5.4m.

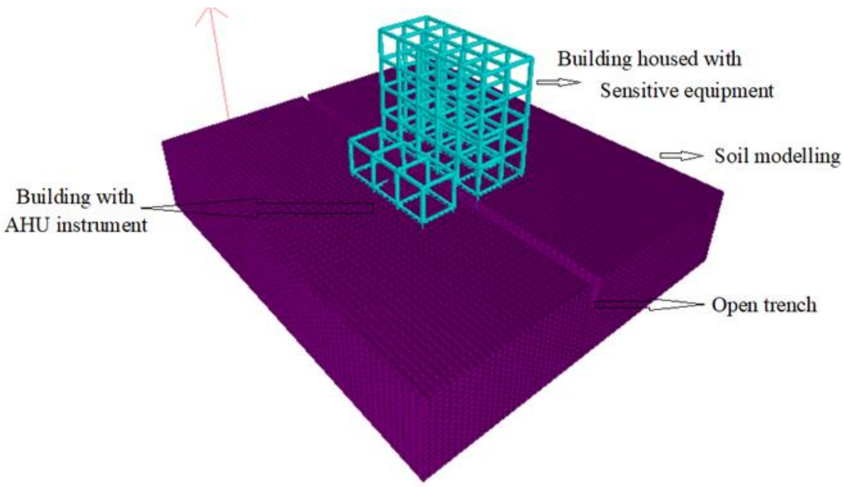

Fig.1 Rendered view of model with open trench

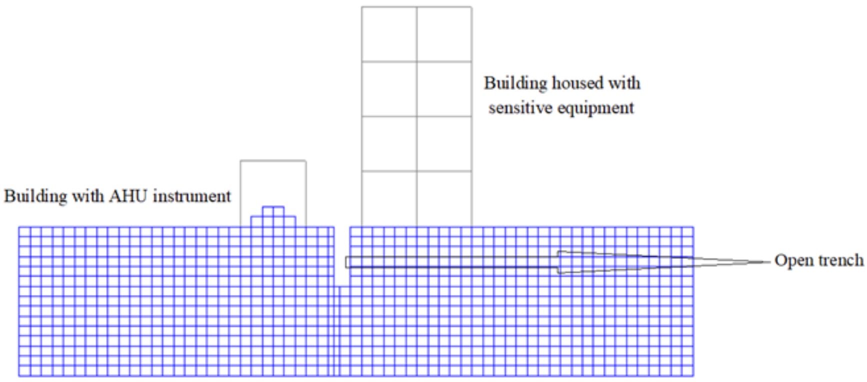

Fig.2 Model with open trench

III. RESULTS AND DISCUSSIONS

STAAD Pro is used to analyse the dynamic loads of three structures. Mode shapes, modal participation factors, and frequency domain plots are the results. To determine rms velocity, obtained frequencies are divided into a number of 1/3rd octave bands.

Table 2. Frequency for one third octave bands

Lower frequency	Central frequency	Higher frequency
3.37	3.8	4.30
4.21	4.781325	5.40
5.31	6.020644	6.75
6.75	7.581195	8.52
8.52	9.546241	10.71
10.71	12.02063	13.50
13.50	15.1367	17.04
16.96	19.05972	21.43
21.35	24	27
26.91	30.2208	33.92
33.83	38.05403	42.78
42.70	47.91764	53.83
53.75	60.33789	67.76
67.67	75.97747	85.31
85.23	95.67083	107.42

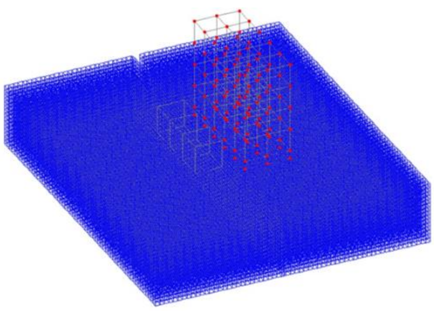

Fig.3 Model with open trench

The model with a open trench is depicted in the above illustration. The chosen nodes in the model above are taken into account when representing the output results. For the purpose of showing the results, all nodes on each floor of the building that include sensitive equipment are taken into consideration. The data was recorded in a text file, the frequency domain graph was taken into account, and each node's 1/3 octave band values are computed. The highest value of each node reflects the node's rms value, and the node with the greatest rms value in a floor is taken into consideration when comparing the results. RMS values are determined from each one third octave band value.

The rms value was computed and the results are recorded in a text file. The node with the highest value is node 2092 out of all the nodes. Therefore, the node 2092 is taken into consideration to reflect the ground floor results for the model with open trench.

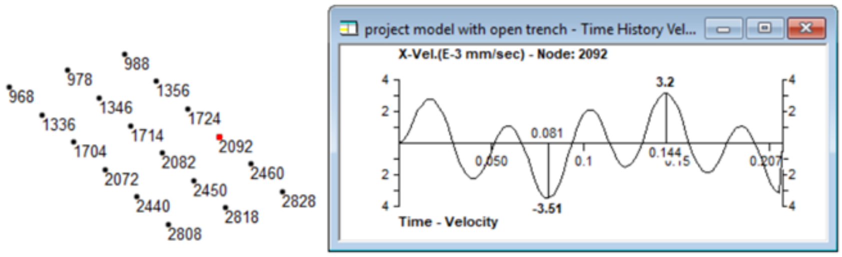

Fig.4 Time -Velocity plot for 2092 node of model with open trench

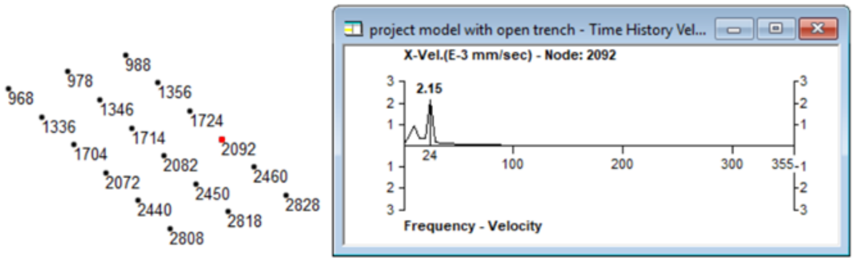

Fig.5 Frequency -Velocity plot for 2092 node of model with open trench

Table 3. Calculations of rms value for each central frequency for node 2092 of model with open trench

Central frequency(fc)		**rms value** V 1/3 octave band at fc = $[\sum_{f=0.89fc}^{f=1.12fc}(V^2nb)]^{1/2}$
fc = 4.781325 1.12fc=5.355084 0.89fc=4.781325	4.781325=0.0005124 4.800307=0.000514 5.355084=0.000565	0.0009198
fc = 6.020644 1.12fc=6.74312 0.89fc=5.3583	5.3583=0.000566 6.74312=0.000695	0.000896
fc = 7.581195 1.12fc=8.4909 0.89fc=6.7472	6.747=0.000696 8.4909=0.000859	0.001106
fc = 9.546241 1.12fc=10.6917 0.89fc=8.4961	8.4961=0.0008596 9.600615=0.000963 10.6917=0.0008298	0.001533
fc = 12.02063 1.12fc=13.4631 0.89fc=10.6983	10.6983=0.0008289 13.4631=0.000491	0.000964

fc = 15.13637 1.12fc=16.95527 0.89fc=13.4713	13.4713=0.00049 14.400922=0.000377 16.9527=0.0003897	0.0007309
fc = 19.05972 1.12fc=21.3468 0.89fc=16.9631	16.9631=0.0003898 19.201229=0.000401 21.3468=0.0012303	0.001352
fc = 24 1.12fc=26.88 0.89fc=21.33	21.33=0.001227 24.001536=0.002154 26.88=0.001556	0.002927
fc = 30.2208 1.12fc=33.8473 0.89fc=26.8965	26.8965=0.001552 28.80184= 33.602151=0.000160 33.8473=0.0001588	0.001949
fc = 38.05403 1.12fc=42.6205 0.89fc=33.8680	33.8680=0.0001587 38.402458=0.000137 42.62050.000122	0.0002426
fc = 47.91764 1.12fc=53.6677 0.89fc=42.6460	42.6466=0.0001219 43.202766=0.000120 48.003073=0.0001085 52.803380=0.000097 53.6677=0.00009537	0.000245
fc = 60.33789 1.12fc=67.5784 0.89fc=53.7	53.7=0.00009531 57.603687=0.000088 62.403995=0.000081 67.204302=0.000075 67.5784=0.0000911	0.00017034
fc = 75.97747 1.12fc=85.0947 0.89fc=67.6199	67.6199=0.0000910 72.004609=0.000104 76.804917=0.000066 81.605224=0.000062 85.0947=0.00005981	0.00017572
fc = 95.67083 1.12fc=107.1513 0.89fc=85.1470	85.1470=0.0000597 86.405531=0.000059 91.205838=0.000055 96.006146=0.000053 100.806453=0.000050 105.606760=0.000048 107.1513=0.0000473	0.00014114

Table 4. Results for model with open trench

Sl.no	**Node number**	**level**	**rms value in mm/sec**	**rms value in Micro inch/sec**	**rms value in micro meter/sec**
1	2092	Ground level	0.002927	9.729	2.928
2	3782	First floor	0.00046714	10.79	0.4672
3	3846	Second floor	0.0002742	18.4	0.2742
4	3856	Third floor	0.0002471	104.050	0.2471

IV. CONCLUSIONS

Open trench is used to evaluate the isolation of the vibration. The present study found that the vibration transferred from the USER'S CHAMBER building to the building housing sensitive equipment is least in the model with open trench. According to the results of the study, open trenches are the most effective method for isolating vibration. The rms value is found to be 2.928 micro meter per second with trench at ground level and 0.4672 micro meter per second with trench at first floor. From generic vibration criterion curve it can be concluded that with open trench in third floor V C – E equipment can be placed. In second floor V C – E equipment can be placed.

V. REFERENCES

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