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VIBRATION ISOLATION PROBLEM IN MULTISTOREY BUILDINGS

(A CASE STUDY)

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SUMMARY

The vibration isolation for a Multistorey hospital building of eight storeys housing a set of air compressors for central air conditioning system in the ground floor of the complex is to be studied and proper recommendations shall be made to avoid complications involving sophisticated and sensitive equipments used for surgical operations. Added to this are the traffic induced vibrations caused by the vehicles around the building. Actual vibration readings are taken when all the compressors are running and all are off and then remedial measures are suggested.

GENERAL

Vibration problems in a multistorey buildings are caused by many factors. Wind induced vibration, traffic, induced vibrations, vibrations induced by housing heavy machinery like air compressors inside the building are a few examples. Of these the first two viz. wind induced and traffic induced vibrations can be mitigated to a certain extent since they will be sporadic but the last mentioned vibration is due to the heavy machinery housed inside this building poses a very big problem. Since at the present case it was not possible to keep the air compressors outside the building, a solution has to be arrived at to make the building useful when all the compressors are being run.

THE LOCATION OF THE AIR COMPRESSORS AND ITS EFFECTS

The plan and elevation of the building are shown in Fig. 1. The building is surrounded by a road with heavy traffic on one side and on the other side by a railway line. But the measurements taken at peak

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hours do not show any noticeable vibration level which will hamper the working inside. Hence the effect of traffic induced vibration can be ignored. This building is located near the seashore and the wind induced vibrations also during the months of heavy wind are not very marked.

For the central air conditioning of the building, five numbers of 90 TR capacity of A/C. plants are installed and they are located at the ground floor of the building. The building is a framed structure of eight storey height and founded on piles. All the plants are resting on special concrete foundation and these machine foundations are separated from the floors by means of rubber pads. Twelve sets of rubber pads of four numbers in each set are used for isolation purposes.

Out of the five A/C plants one unit is kept as stand by. The chilled water pipe lines are extending from ground floor to fourth floor and also there are fourteen Air Handling Units installed at both the extreme corners of each floor, where air conditioning facilities are provided.

THE ACTUAL VIBRATION MEASUREMENTS AND THEIR ANALYSIS

The company which has installed the air compressors has provided rubber pads between the foundation and the floor. In addition to taking measurements at various points near the compressor in the ground floor, in the operation theatres in the first and second floor, in the eighth floor, the rubber pads used for vibration isolation were also tested for their static deflection. The entire operation of taking the readings were repeated after switching off all the compressors also.

The vibration amplitude readings are tabulated in Table 1. These readings are analysed with following view points.

(i) Whether the existing levels in full load operations are detrimental to the safety of the building.

(ii) Whether the existing levels cause any discomfort to the personnel.

THE REPORT

Regarding (i), stated above in the light of the data quoted in reference (1), the displacement levels will not cause any structural damage. As far as the comfort and interference with human activity is concerned the levels observed may cause slight discomfort. In order to improve the existing situation a little more isolation is recommended. The present isolation degree (f/fn) works out to be around 4.5. A degree of isolation of the order of at least 6 to 8 is preferable which means increasing the static deflection of the isolator by having softer pads.

All the five compressors were tested by running any four compressors at a time as per the design norms adopting permutation and combination of the available five units and the amplitudes of the vibration were recorded while running the compressors. All the readings recorded are as detailed in the Annexure-I.

When the compressors 1,2,3 and 5 are working, the amplitudes measured in all the operation theatres of I and II floors except theatre No. 9 and 10, are less than 1 Micron i.e. in 16 theatres the amplitude of the vibration is almost NIL.

When the compressors 1,2 and 3 are alone used (switching off 4 and 5) the amplitudes measured in the operation theatres (of I and II floors) 9 and 10, varies from 1 to a peak value of 3.75 microns only. Obviously in the other 16 theatres it is less than one micron only.

As per the heat load calculations the total tonnage required for the use of operation theatres is around 210 TR only. When the plant 1,2 and 3 (3 Nos. of 90 TR each) are on and running with full capacity the chilled air throw would be around 270 TR which is more than what is required as per the design norms and the amplitudes of vibration level is also less than one micron in most of the theatres.

As such, all the operation theatres and connected wards, intensive care unit etc., in and around the area, can safely be used with the airconditioning facility, by using the A.C. Plants 1,2 and 3 without any problem.

When the additional load for VIP rooms and other important rooms etc. is added, the additional tonnage of air conditioning required as per

the heat load is around 140 TR. To augment this additional load, one more compressor is to be necessarily switched on. When the compressor No. 5 is added with the compressor 1,2 and 3 the amplitudes of vibration, recorded is only 1 micron, in all the operation theatres and other places, except the operation theatres 9 and 10, where the vibration level is around 3.75 to 5 microns.

Normally, the amplitude of vibration level in such high rise building without any machinery would be around 1 to 2 microns due to wind action, movements of live loads and other environs like vehicular traffic etc. In the present case, even with the machinery in the ground floor the recorded amplitudes of vibration level is only about 1 micron when 3 compressors are working and rises to a peak value of 3.75 micron when the 4th compressor is added to the system ie. compressor No. 5.

This amplitudes of vibration level is acceptable and unavoidable for such high rise buildings. As such, the entire building can be used safely with plants 1,2 and 3.

The plant No. IV when it is switched on, the amplitude of vibration increases and hence the machine requires some adjustment. As per the original design, one of the unit has to be kept as standby. Hence, the plant No. IV can be isolated and kept as standby. If the plant No. IV is proposed to be used, keeping one of the other units as standby, the increase in amplitudes of the vibration level can be brought down within the permissible level by balancing the same to run in synchronization with other units. The same can be done for plant No. 5 also to the extent needed.

RECOMMENDATIONS

From the results, recorded, the vibration level is far below, for such huge structural building. Hence, the operation theatres except 9 & 10 and other areas for which air-conditioning facilities is provided with 5 Nos. 90 TR (1 No. as standby) can be safely used by running either with the combination of plant 1, 2 and 3 for part load or 1,2,3 and 5 for the total load at a time keeping the plant No. IV as standby.

TABLE 1 VIBRATION DISPLACEMENT MEASUREMENTS

Location	All machines max.Amplitude (microns)	on Predominent frequency (Hz)	All machines max.Amplitude (microns)	off predominent frequency (Hz)	With pumps only working(8 Nos) (microns)
M/c 3					
1 V	2.5		0.5		2.5
2 V	37.5	2.5			
1 H	2.5		1.25		1.9
2 H	37.5				
3 H	1				
3 V	1				
4 H	2.5				
4 V	4.38				
M/c 4					
5 H	62.5	2.5			
5 V	50.3	2.5			
6 H	5	2.5			
6 V	5	2.5			
2nd Floor Operation Theatre					
9 V	7.5	Beat Frequency of 0.6 or 36 rpm			
Horizontal	2				
Above					

Location	All machines max.Amplitude (microns)	on Predominent frequency (Hz)	All machines max.Amplitude (macrons)	off predominent (Hz)	With pumps only working (8 Nos) microns)
Unit 4					
Theatre					
10 at 2 points on either side of the bed	10				
Horizontal	5				
Vertical	5				
8th Floor					
Vertical	15	1.6	5		
Horizontal	5		5		
2nd Floor					
OT 9 H			2		
OT 9 V			1		
OT 10 H			1		
OT 10 V			1		

Annexure—1 Vibration Level Recordings Taken

S.No.	Details	Position of the seismic pickup	Amplitudes in Microns	Remarks
I	Unit III	1. On the bed	15	Units 1,2,
		2. On the floor near the bed	2.5	3 and 5 on
		3. Near the column	<1	
II	Near the condenser pump	4. On the floor	4.7	
III	Unit III	1. On the bed	20	
		2. On the floor near the bed	4.7	1,2,3 and
		3. Near the column	2	4
		4. On the floor	1 to 1.5	
IV	Near Unit IV	1. On the bed (Chiller)	125	
		2. On the floor near the bed	6.25	
		3. Near the column (Guage Board)	3	
		4. Near the compressor	50	1,3,4 and 5
V	I floor Theatre No. 10	On the floor near the bead	7.8 to 12.5	
	Theatre No. 9.	—do—	7.8	

S.No.	Details	Position of the seismic pickup	Amplitudes in Microns	Remarks
VI	II Floor Theatre 10	—do—	2.5 to 3.75	
	Theatre 9	—do—	4 to 5	
VII	Operation Theatre 6	Near the table	0.6	
	Operation Theatre 8		0.8 to 1.25	
	Operation Theatre 7		<1	1, 3, 4, and 5 on
VII	8th Floor		11.25 to 6.875	
IX	8th Floor		4	
X	II Floor Operation Theatre 10	Near the bed	5	4 off 1, 3, 5, running.
	Operation Theatre 9		2.2	
	Operation Theatre 8		1 to 1.8	
XI	I Floor Operation Theatre 10		6.875	Running 1, 2, 3 and 5

Location	All machines max.Amplitude (microns)	on Predo-minent frequency (Hz)	All machines max.Amplitude (macrons)	off predo-minent (Hz)	With pumps only working (8 Nos) microns)
	—do—			1.875	Switch off all 1 to 4 compressor
	—do—				Switch off AHU also
	—do—				1,2,3 running.

References

1. Merritt. F.S., "Building Construction Head Book", McGraw Hill, New York, 1965
2. Bernack. L.L., "Noise & Vibration Control, McGraw Hill, New York.

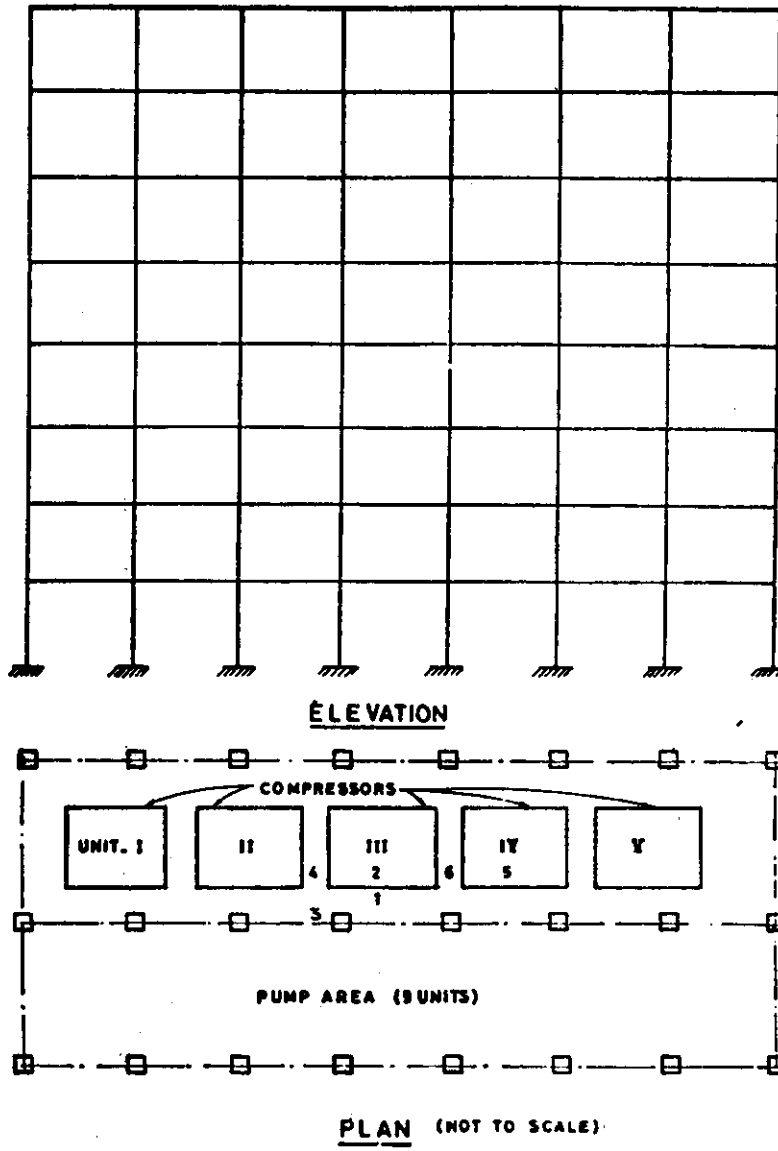

Fig. 1. Layout showing the Compressor Plant and the points where vibration measurements have been made