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Detection and Analysis of Vibration Noise in a Residence

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Abstract: ***In order to solve the problem of strong local vibration and noise during the operation of a residential water pump, on-site vibration and noise detection was carried out on the building. The vibration response of the building was evaluated according to the relevant norms such as human comfort, the causes of vibration and noise were analysed, and various vibration reduction schemes such as strengthening pump maintenance and rubber vibration .The causes of vibration and noise were analyzed, and various vibration reduction schemes such as strengthening pump maintenance and rubber vibration isolator were proposed according to the vibration characteristics and actual requirements. It provides technical reference for the vibration reduction design of the same type building pump.***

Keywords: Field vibration test, Equipment vibration, Z vibration level, Noise, Damping measure**.**

1. Preface

In civil building design, the pump room is the power centre of the water supply and drainage system, is an integral part of the building, its importance is self-evident, however, it is also accompanied by vibration and noise is very obvious negative impact can not be avoided [1-2]. With the improvement of living standards in towns and cities, people's requirements for the living environment are also increasing, and they are more sensitive to noise [3-4]. Especially by all kinds of service facilities (air conditioning, cooling and heating units, water supply system, power supply system, etc.) through the solid structure of the transmission of the solid sound, 16Hz-200Hz low-frequency sound, pure tone components and so on caused by the noise impacts of the people's widespread concern [5]. There are two main types of indoor pollution generated by low-frequency noise: one is generated by indoor and outdoor fixed equipment such as water supply equipment, heating equipment, lifts, etc. mainly 125Hz, 250Hz, 500Hz and other noise components. The other is applicable to the technical control countermeasures of social life noise type is mainly service facility type noise, the sound source are generated by fixed equipment, such as water pumps, boiler room, air conditioning outdoor units, lift room, etc., and the highest sound pressure level frequency are in the centre frequency of 250Hz below [6]. Therefore, the study of vibration damping and vibration isolation of water pumps is extremely important. This paper will be combined with an actual project vibration and noise measurement and analysis for detailed elaboration.

2. Engineering Background

A building is an eight-storey frame shear structure residential, located in Changchun City, Jilin Province. The building has a heating pump room on the ground floor, and the pump is a vertical pump with spring dampers and inertia block vibration damping measures. During the heating period, the operation of the pump causes large vibration and noise interference to the units directly above and adjacent to the building. In order to solve this problem, an on-site investigation of the building was carried out, relevant information was collected and collated, and on-site vibration and noise tests were carried out on the building, according to which the abnormal causes of vibration and noise were analysed, and relevant measures for vibration and noise reduction were proposed.

3. Detection Programme

The test content mainly includes: 1. Z vibration level and 1/3-octave lead hammer vibration acceleration level of each floor; 2. Indoor noise of each floor and indoor structural noise of residential buildings.

Layout of measurement points: The number and orientation of measurement points are arranged according to the relevant provisions in the Standard for Indoor Vibration Limits and Measurement Methods for Residential Buildings (GB/T50355-2018) [7]. The building has eight floors, the first two floors for the public area, three to eight floors for the standard three-bedroom and one-bathroom households, the first two floors each independent area to select three measurement points, three floors each bedroom a measurement point, three measurement points in the living room, select four households; four floors to select the same measurement points as the three floors, but only need to select the middle two households; five to eight floors to select the middle two households, a measurement point in the living room of each bedroom to reduce the living room to a measurement point. The vibration and noise measurement point layout of each floor is shown in Table 1, and the site layout is shown in Figure 1 and Figure 2.

Table 1: Measurement point layout and test type

Measurement point floor	vibration point	noise measurement point
underground pumping station	18	/
	4	1
	5	/
coat	5	3
	1	/
	3	3
	3	3
first floor	4	6
	6	3
triple	24	24
four-ply	12	12
Fifth to eighth floor	32	32

Figure 1: Schematic diagram of vibration sensor arrangement

Figure 2: Schematic diagram of noise sensor arrangement

Test conditions: The building under test was divided into two conditions based on daytime and nighttime.

Test process: in accordance with the measurement point arrangement, calibration sensor arrangement, and at the same time turn on the high-power pump, the vibration and noise measurement for 60s, each measurement point in turn repeat the steps to complete all the measurements.

4. Vibration and Noise Measurement Results

4.1 Vibration Measurement Results

According to the relevant provisions of the Standard for Indoor Vibration Limits of Residential Buildings and Their Measurement Methods (GB/T 50355-2018), acceleration measurements were carried out at measurement points on each floor of the building, and the typical time-domain diagrams of some of the test points and the results of the testing and analysis are shown in Figure 3, and the transmission of Z vibration level with the floor of the representative test point was selected Figure 4.

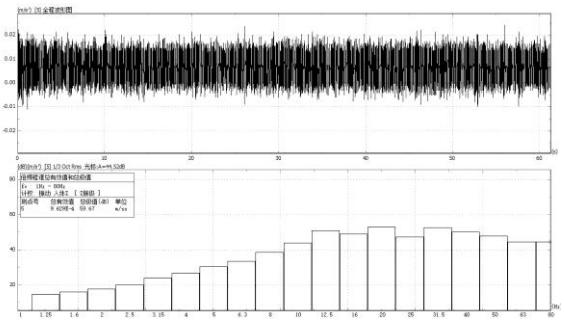

Figure 3: Typical vibration level analysis of some detection points

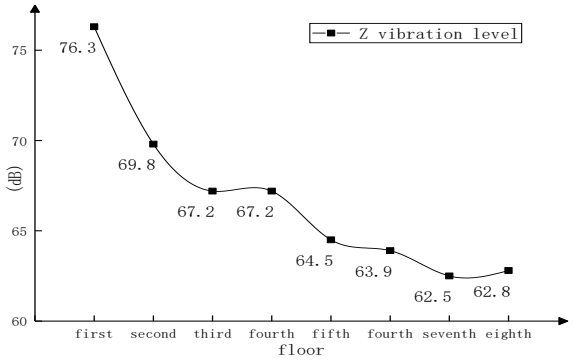

Figure 4: Transmission of indoor Z vibration level along the floor (dB)

4.2 Vibration Noise Results

According to the relevant provisions in the Standard for Indoor Vibration Limits and Their Measurement Methods for Residential Buildings (GB/T 50355-2018) and General Specification for the Built Environment (GB 55016-2021), noise measurements are carried out separately on each floor of the building, and typical time-domain diagrams and test results of some test points are shown in Figure 5.After data collation, representative test points are selected, and the noise transmission situation with the floor is shown in Figure 6. The transmission situation is shown in Figure 6.

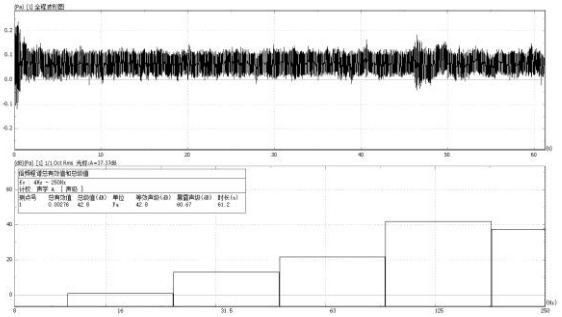

Figure 5: Typical sound level analysis of some test points

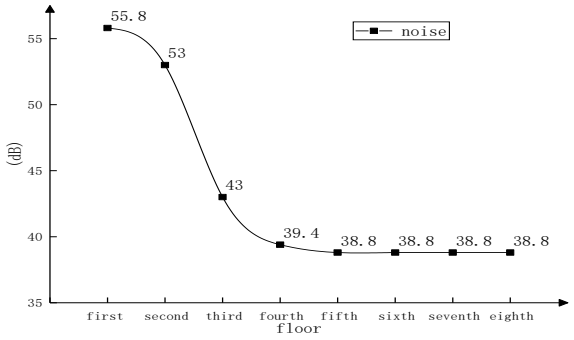

Figure 6: Indoor noise variation curve with floor

By analysing the vibration and noise results of each floor, it can be seen that with the increase of floors, the vibration and noise are decreasing. None of the vibration levels exceeded the permissible limit (78dB), but more than 60 per cent of the room noise exceeded the limit according to the specification. Although the structural noise did not exceed the limit, the structural noise in the low-frequency zone was far below the limit, and the limit of the adjacent structural noise in the high-frequency zone is shown in Figure 7 (Note: the value in parentheses is the corresponding value of the 1/1-octave centre frequency). The superposition of air noise and vibration-induced structure noise leads to noise exceeding the

limit [8-10]. Water pump vibration process of the pump and inertia block as a whole, piping support and other multiple vibration caused by the upper structure vibration, vibration through the solid structure spread to the surrounding, the surrounding objects also produced vibration, vibration so that the air in contact with the vibration, the noise in the air into the human ear the vibration triggered by structural noise. Structural noise propagation speed, distance, so the top floor, may be superimposed on the external environmental noise caused by the upper floor noise exceeds the standard. Vertical pumps using spring damping is also one of the reasons for noise exceedance, spring oscillation, resulting in increased vertical vibration, high-frequency part of the vibration isolation effect is poor, the upper high-frequency part of the structural noise is close to the limit.

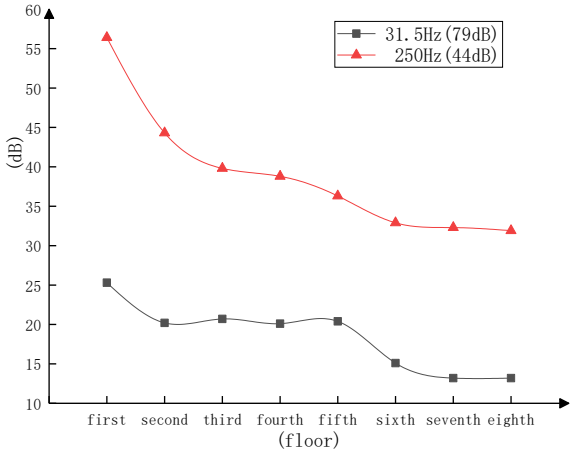

Figure 7: Structural noise variation curve with floor

5. Conclusions and Recommendations

Comprehensive analysis of the above, the current heat exchange station pump operation is the main source of vibration. Water pump operation will produce noise, noise attenuation is faster, if the heat exchange room and the pump room do sound insulation measures, the noise of water pump operation does not cause the noise of the top floor. Based on the vibration and noise aspects of the vibration response of the building, and according to the structural form and on-site testing and analysis results, the following conclusions are obtained through the analysis and research of the vibration response of the building:

1) According to the results of each measurement point, the Z vibration level of each floor of the residential building does not exceed the permissible limit of vibration level, the 1/3-octave lead vibration acceleration level of each functional room of the residential building does not exceed the permissible limit, and the indoor noise of each functional room of each floor of the residential building exists in excess of the permissible limit of indoor noise of daily life of 40dB [11].

2) The operation of the pump causes some disturbance to the structure, and the vibration will not cause discomfort to the residents, but the noise will have a very unfavourable impact on people's normal life.

3) strengthen the pump maintenance, water pump in the operation process will be damaged because of impeller cavitation, lack of oil or adulteration of impurities, etc. lead to vibration and noise intensification, which requires good maintenance and management: start the pump to drain the air in the worm case; timely discovery of water pump impeller cavitation perforation and replacement; pump idling or suction height exceeds the maximum cavitation margin of the water pump should be stopped in a timely manner; timed maintenance, the oil has impurities to be promptly Replacement [12-13].

4) The rubber vibration isolator is used under the water pump, and multi-layer rubber vibration isolation pads are set at the bottom of the inertia block or the separate water pump inertia block is cancelled, and the overall floating floor is set to form a double-layer vibration isolation system. [14-15], the vibration isolation principle is the rubber vibration isolation pads and spring dampers in the vibration into the vibration isolation system after the play of their respective isolation, play the effect of isolation vibration [16-17]. Setting up elastic support that is, in the pipe through the wall floor with elastic pads or rubber casing isolation to reduce the pump system vibration along the pipe wall propagation [18-20].

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