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Vibration Detection and Analysis on a Large-scale Coal Screening Factory Building

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Abstract. It puts forward a method of dynamic detection, through studying on the problem of resonance between structure and machine about a large-scale coal screening factory building. The detection result shows that partial flats of this multilayer factory building have reflected a resonance phenomenon between machine and structure. This paper also expounds that the thoughts about the dynamic detection method of resonance problem between machine and structure, that how to judge the resonance sources quickly and accurately with dynamic detection and that theoretically analysis the causes of resonance, providing reliable scientific basis for the vibration detecting on large-scale factory building which possesses dynamic machines.

Introduction

Power equipment upstairs has become a form of design, With the further development of coal screening toward the fine, more power equipment needs to be installed on different floors, so as to meet the needs of the production process, which makes the plant structure becomes more complex. In the same floor of different types, different types of power equipment, Bending force differences of plant structure to produce the great, together with the floor openings, vertical conveying Pipeline cross floor Unicom and cross axis crane beam and auxiliary equipment installation, mechanical and structural occurred resonance causes more complex, but more difficult to detect. Therefore, it is still an important research topic to study the safety of the structure of large power plant.

Abroad on the construction of the resonance of the study carried out earlier, in 1988 the Swedish Building Research Committee released the floor vibration design guidelines for the calculation of the floor from the frequency of the formula to do a preliminary summary; In 1990, according to a series of research work in the seventy's, the design requirements of the wood floor were established; In 1997, Murray studied the vibration of building structure, and put forward the criterion of floor vibration acceleration limit. A lot of researches on the problem of building resonance have been carried out in China. By simplifying the structure model and dynamic characteristic of the industrial factory building in 2003, Guoyan Wang, the calculation method of the floor vibration caused by the operation of the mechanical equipment is discussed; Study on Lunhai Zhi, separate power equipment factory in the industrial base or support and building the main structure, can obtain ideal damping effect; Study on Rui Du show that when the vibrating screen is installed in the adjacent axis, the maximum response of floor power, there are significant differences in the amplitude of vertical direction and horizontal direction; The vibration acceleration and frequency of the vibration screen in the industrial plant are obtained by Gang Xue. The vibration acceleration and frequency are obtained, which provide a scientific basis for the vibration of the floor.

In order to ensure the safety of building structure in Linhuan coal fine sieve, the plant source judgment, self-vibration frequency detection and forced vibration detection based on. Analysis structure resonance causes, for workshop damping reinforcement scheme provide theoretical support.

General Situation of Coal Preparation Plant Project

In Linhuan coal fine sieve workshop for the reinforced concrete frame structure (C35), a total of four layer structure, the top part contains jump layer. The building height is 31.1 m, the longitudinal length of the plant is 161.5 m, and the transverse length is 44 m. Frame column size is 700 mm * 700 mm, the main beam size is 350 mm * 900 mm, the second beam size is 300 mm * 400 mm, the thickness of the cast-in-place concrete floor is 180 mm.

Plant within the large power equipment (crushing unit, screening unit) are located in the fourth layer (as shown in Fig. 1), second, three layers of electromagnetic separation equipment installed. During the operation of the units in the building, workshop floor, doors and windows will produce larger amplitude of vibration, and accompanied by the external skin shedding, hopper, seismic joint surrounding concrete cracking phenomenon. In addition, in the actual production process, due to mechanical and structural resonance of the reasons, the production staff often appears symptoms of physical discomfort. In order to solve a series of hazards caused by resonance, the steel coil spring vibration damping system has been replaced with a rubber damping pad, but the floor vibration phenomenon has not been significantly improved. Through the research on the structure and mechanical resonance of large scale coal screening plant, a fast and efficient method for the dynamic detection of resonance is presented.

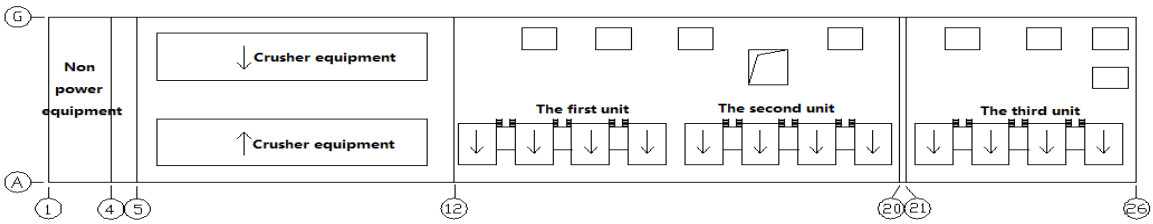

Fig. 1 Equipment layout of the fourth floor.

Dynamic Detection Scheme

In order to detect the forced vibration frequency and different structure under dynamic loads quickly and effectively, using DZQ48/24/12 high resolution seismic instrument for detecting instrument. Point acceleration spectrum acquisition by pulsation measurement instrument, and can be carried out by digital filter settings according to the needs (high and low band pass filter) acceleration spectrum into frequency spectrum.

Vibration Source Judgment. The factory in the second and third floors are for electromagnetic separation equipment and speed with less mixing equipment, the structure of torsion force is small, it is not possible to is caused by structure vibration source. Observation found that across the floor of the vertical conveying pipes, floor vibration is obvious, preliminary judgment, causing structural vibration source is provided with a crushing unit, screening units of the fourth layer. In addition, the installation of the crane beam and the steel structure working platform, which is in the span of the workshop, strengthens the vibration wave propagation.

The fourth floor a total of eight crushers, each of the four as a unit, two units of equipment in a direction opposite to the rotation (represented by the arrow in Fig. 1); sieving machine, a total of 12, each of the four as a unit, three sets of equipment rotation direction exactly the same (represented by the arrow in Fig. 1). In order to quickly and accurately determine the reason for the vibration of the plant, the dynamic testing is carried out in accordance with the direction of the 1 axis to the 26 axis. The detection point is the geometric center point of the frame corner node, the vertical and horizontal beam across the middle and the floor slab, and the acceleration time history curve is obtained, which is converted to the frequency domain spectrum.

Dynamic test results show that: in the case of all the unit operation, the structure of the fundamental frequency is 14.8 Hz, much higher than the natural frequency of the plant 3.9 Hz (shown in Fig. 2); Five axis to axis 12 points frequency spectrum, random disturbance frequency was higher (as shown in Fig. 3), but closer to the screening unit, random disturbance frequency is

less, the surrounding appeared without interfering with the frequency of the ideal frequency spectrum (as shown in Fig. 4); In measuring point orientation sieve extension will continue to close to the process, sampling signal maximum amplitude magnitude from e+003 mV to e+005 mV (Fig. 3 and Fig. 4). From this judgment, the screening machine has a great influence on the structural vibration, which is the basis for the follow-up of the natural frequencies and the arrangement of the forced vibration detection schemes under different conditions.

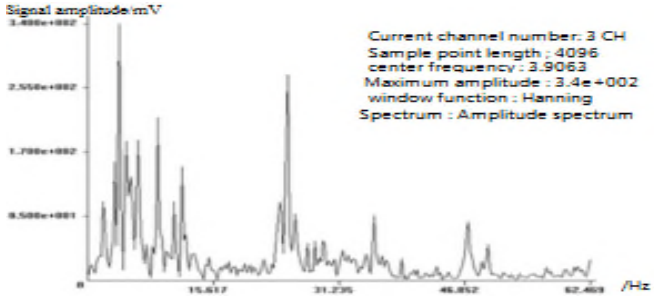

Fig. 2 Frequency detection results of the structure.

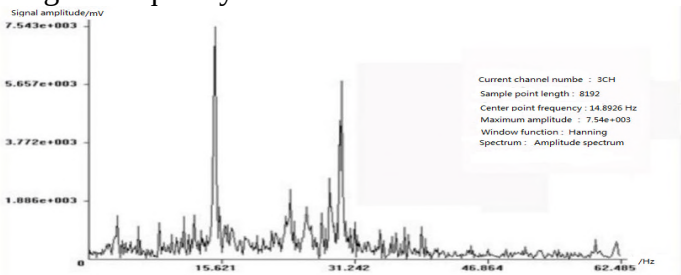

Fig. 3 Frequency-domain picture of the points among axes 5 to 12.

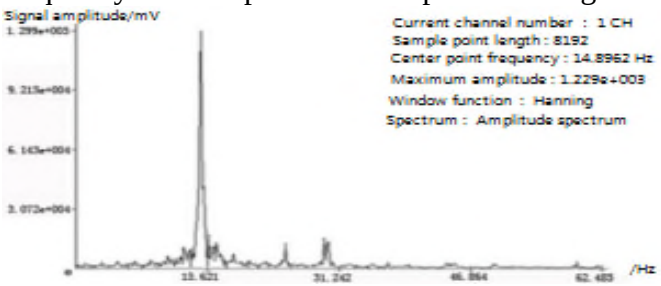

Fig. 4 Proper frequency-domain picture.

Natural Frequency Detection. After the whole unit is shut down, the self-vibration characteristics of the plant are detected. Detection points and contents include: frame structure beam column node Y, Z, X three direction of the detection of the characteristics of the vibration; the detection of Z to self-vibration characteristic of the beam and the plate around the Screening machine is arranged as shown in Fig. 5.

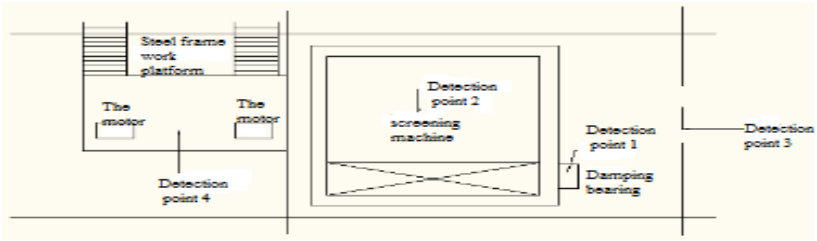

Fig. 5 Schematic diagram of the points.

The No. 1 gauging point located in the reinforced concrete foundation damping. The secondary beam, which is located in No. 2 at the bottom of the device; the longitudinal frame beam; 3 point is located in the transverse frame beam; No. 4 in steel structure work platform, specifically for the

middle position of the two motor. The detected acceleration curve into a frequency spectrum after filtering processing, can get the fundamental frequency of the structure is 3.9 Hz.

The Forced Vibration Detection. According to the distribution of the unit, it is divided into three groups to measure the acceleration pulse. The first group only run screening unit 1, second sets of operation screening machine 1, 2 units, third sets of operation of all screening units. Point layout includes equipment around the point (Fig. 5), the layer frame corner node, part of the beam column node, the detection structure in the above case, the beam, plate vertical (direction Z) and beam column angular node of the acceleration time history curve. Test results show that: under the three conditions, a Z direction vibration frequency were 14.9Hz, 14.7Hz, 14.8 Hz, namely the forced vibration frequency of structure are basically the same, indicating that the structure of forced vibration and equipment operation number and location independent.

Cause Analysis of Resonance

The Establishment of Finite Element Model. Combined with the field test results, the Midas finite element software is used to analyze the dynamic characteristics of the structure in order to find out the reason of vibration. Due to the installation in the workshop production more ancillary devices, modeling requires the following simplified [8]: on the structural dynamic response of large equipment is simplified for solid block body weight, ignoring the suspension under floor light steel crane beam, conveying pipeline of the stiffness of the structure. The calculation model consists of frame beam, sub beam and floor (Fig. 6), which is used to calculate the natural vibration characteristics of the structure. The Lanczos method is used to extract the first 6 order vibration modes of the structure (Table 1).

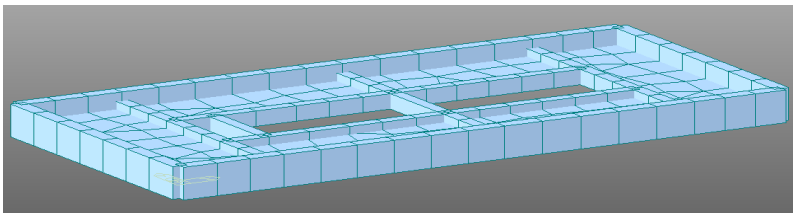

Fig. 6 Calculation model of the structure.

Table 1. Vibration characteristics of the structure.

Modality	Frequency/ Hz	Vibration type
Mode 1	14.1	Flat bending coupling
Mode 2	16.4	Flat bending coupling
Mode 3	24.3	Flat bending coupling
Mode 4	25.2	Flat bending torsion coupling
Mode 5	27.2	Flat bending torsion coupling
Mode 6	33.7	Flat bending torsion coupling

Simulation Analysis of Structure. The structure of the natural vibration frequency of 3.9 Hz, sieving machine bending force direction are vertical downward, and frequency are far greater than the fundamental frequency of the structure, Therefore, only the vertical vibration of the floor is analyzed. To compare the different situations of forced vibration result: sieving machine for structure interference frequency (14.7 Hz ~ 14.9 Hz) and structural natural vibration modal frequency of 14.1 Hz (Fig. 7) 1 close, therefore caused a sieving machine and the floor flat bending coupling vibration. Directly under the dead load and bending force of the secondary beam stiffness

and rigidity of frame beam difference larger, since the vibration amplitude is larger, which makes structural dynamic response increases. According to GB 50583 - 2010 " the buildings and structures of coal preparation plant design specifications ", coal preparation plant commonly used power equipment operating frequency divided into three types of [9]: the speed of less than 400 r/min for low-frequency classes and speed in 400 r/min ~ 2 000 r/min for intermediate frequency, speed is greater than 2 000 r/min for high frequency type. Correlation statistics show that: the vertical natural frequencies of the beam and slab in most coal preparation plant are usually in the range of 9 Hz ~ 26 Hz, which is equivalent to the power equipment of 540 r/min ~ 1560 r/min. According to the manufacturers to provide information, in Linhuan Coal Preparation Plant sieving machine for self-vibration frequency is 900 R / min, the self-vibration frequency should in 9 Hz ~ 26 Hz, the structure simulation analysis, test results obtained frequency anastomosis.

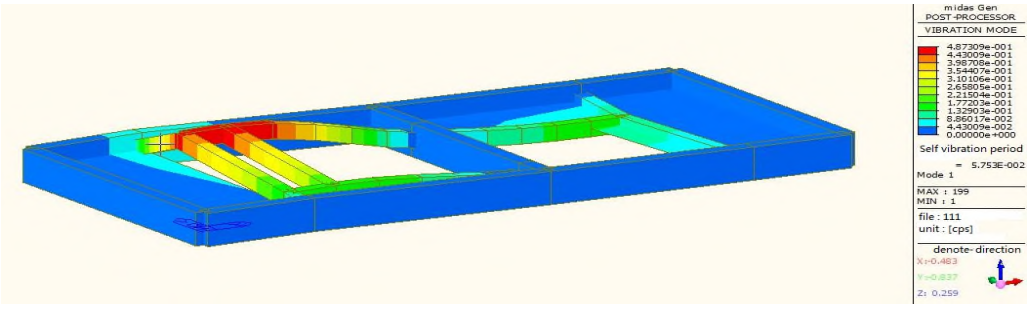

Fig. 7 The first natural vibration modal of the structure.

Conclusion

(1) Preliminary judgment of structure vibration found that source is installed with the fourth layer of the crushing plant and screening machine unit, wherein, the screening machine has great influence on the vibration of the structure. The structure fundamental frequency is 3.9 Hz, and the Z to vibration frequency is 14.9 Hz, 14.7 Hz and 14.8 Hz, respectively, which indicates that the forced vibration of the structure has nothing to do with the number of equipment running and the position of the equipment.

(2) The bending force generated by the screening machine is the cause of the resonance of the beam plate under the equipment. Equipment on the structure of the interference frequency and beam slab vertical vibration to the 1st mode frequency close to and directly under the dead load and torsion force time stiffness of beam and frame beam stiffness difference between the larger, so that dynamic response increases.

(3) On the test results, the replacement of equipment damping system measures do not reduce the intensity of vibration, to ensure the safety of building structure, effective measures should be taken to enhance the secondary beam and floor stiffness.

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