Monitoring Algorithm of Stress Point of Concrete Penstock in Large Construction Engineering

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Abstract. With the rapid development of the national construction industry, cracks and other problems often appear in the concrete structure during the initial and subsequent construction. When these problems develop further, the structural safety of the entire building may be compromised. Therefore, it is necessary to analyze the causes of cracks and other problems in concrete buildings, and be able to monitor and analyze these problems in time, and then propose reasonable solutions. This is already a problem that the entire construction technicians urgently need to solve. This paper studies the algorithm for monitoring stress points of concrete penstocks in large construction projects. Firstly, it uses literature research to explain the form of stress nodes in large-scale construction projects and the deficiencies in the research on the stress nodes of concrete penstocks in large-scale construction projects. In the experiment, the existing 3 algorithms are used to detect the force points, and compare their detection degree and false alarm rate. The experimental results show that the detection effect of the KNN algorithm is obviously inferior to the other two algorithms with the same neighbor parameters. Its detection rate is only 91%, and the false alarm rate reaches 30%. The other two algorithms are equivalent. The detection effect of the KNN algorithm is obviously inferior to the other two algorithms, the detection rate is poor, the outlier force points that are obviously deviating from the whole around the dense force points are not recognized, and the data of many normal force points located at the edge of the sparse area Instead, it was recognized as abnormal. Among the three algorithms, the detection rate of the NLOF algorithm is better, reaching 99%, which is significantly higher than the other two algorithms.

Keywords: Construction Engineering, Stress Point Monitoring, Concrete Pressure, Monitoring Algorithm

1. Introduction

In recent years, with the rapid growth of the national economy, especially after the economic crisis, in order to maintain growth and promote growth, the state has invested heavily in infrastructure, and the state has invested 3 trillion yuan in infrastructure investment [1-2]. High-performance concrete is widely used in these infrastructures, such as bridges, highways, house construction, water saving and
other aspects closely related to human life [3-4]. At present, they have brought huge difficulties to the industry, and it is very important to monitor the pressure points of pressure pipes in these concrete buildings [5-6].

In the research on the monitoring algorithm of stress points of concrete pressure pipes in large construction projects, many scholars have studied them and achieved good results. For example, Qian W et al. conducted reciprocating loading tests on 8 steel concrete beam-column joints, and proposed reasonable [7-8]. The mathematical model can accurately predict the ultimate bearing capacity of nodes [9]. Wang E et al. proposed a parameter grouping algorithm based on the Kolomogorov complexity model based on information distance measurement. This method combines information theory with grouping algorithms to locate extreme data in the data during the grouping process [10]. Waljee et al. proposed a specific concept "information distance", which can detect extreme values in data by measuring information distance [11]. Lim D proposed a LOF algorithm for detection algorithms based on external foundations. The main difference between this algorithm and other algorithms is that there is no need to consider the overall data distribution, just complete the local data distribution around the data object. Due to the complexity of the data distribution pattern in the actual data set, the extreme value detection usually limits the actual effect of the global outer area detection method, and this local density-based algorithm can usually achieve good application effects [12].

This paper studies the algorithm for monitoring stress points of concrete penstocks in large construction projects. Firstly, it uses literature research to explain the form of stress nodes in large-scale construction projects and the deficiencies in the research on the stress nodes of concrete penstocks in large-scale construction projects. In the experiment, the existing 3 algorithms are used to detect the force points, and compare their detection degree and false alarm rate.

2. Research on monitoring algorithm of stress points of concrete pressure pipes in large construction projects

2.1. Forms of force-bearing nodes of concrete pressure pipes in large construction projects

2.1.1. Semi-rigid connection node. The so-called semi-rigid node is a form of connection between rigidity and modularity. Under the action of external force, the connection node between the steel pipe and the beam can not only transmit the bending moment, but also transmit the shear force. It has many special forms, and one connection form is the expansion end plate type. This form of knotting is more likely to cause local grinding of the steel pipe. It is connected by bolts, which requires higher welding, more structure, and difficult to ensure rigidity requirements. Another connection method is to connect the steel beam flange to the concrete column with concrete through the connector, and the beam steel mast is connected to the steel tube column by high-strength bolts. The use of this joint has many advantages, for example, it not only improves the ductility and seismic performance of the joint area, but also greatly reduces the number of on-site welding, and it is also convenient for on-site installation and construction.

2.1.2. Internal clapboard node. The internal diaphragm node is used to adjust the diaphragm to the steel pipe column filled with concrete. The steel beam mast and the concrete pipe column wall are connected by high-strength bolts. The steel beam can be welded directly to the steel pipe or indirectly welded to the steel pipe wall, but it must be connected to the protruding part welded to the steel pipe. This type of knot is most suitable when the side length of the tube row is large.

2.1.3. Diaphragm through node. The baffle is installed in the steel pipe and passes through the steel pipe to form the baffle. The steel pipe and the plate are connected by welding. The steel beam mast and the outer wall of the steel column are frictionally connected with high-strength bolts through the connecting plate, and the steel beam is welded to the inner baffle buried inside and outside the steel pipe. This type of node has the advantages of relatively clear power transmission path, reliable load
transfer function and better seismic performance. However, as the partition passes through the column, the steel column is split at the top and bottom, making the column discontinuous, which will weaken the rigidity and load-bearing capacity of the column. In addition, the on-site welding workload is relatively large, and the quality is not easy to guarantee. However, the advantage of this type of node is that the entire node module can be prefabricated in the factory, and the on-site manufacturing process is relatively simple. In addition, the size of the column section can be changed to meet the needs of skyscrapers.

2.1.4. Strengthen the ring node. At present, the relatively mature research is to enhance the ring node, which is also one of the most widely used rigid connection nodes. According to different positions, it can be divided into two types: outer reinforcement ring and inner reinforcement ring. According to its working principle, no matter which form of reinforcement ring is used, the upper and lower reinforcement rings form the tension and pressure transmitted from the end of the bracket. The advantages of steel joints are not only simple power transmission paths, greater joint stiffness, higher bearing capacity, and better mechanical properties, but most importantly, it can achieve "strong columns and weak beams, strong joints and weak beams" Design "components". However, the disadvantage of this type of connection is that the steel consumption is relatively high, the construction process is relatively complicated, and the requirements for installation and operation personnel and equipment at the construction site are relatively high.

2.1.5. Anchor rigid connection nodes. Weld the T-shaped anchor plate to the steel tube of the concrete-filled steel tube column. Its position is directly on the upper and lower flanges of the steel beam, and directly opposite to it. When pouring concrete, there is no need to remove the anchor plate, nor do it need to be poured in advance. It is only necessary to cover the anchor plate with concrete to withstand the maximum tensile force of the beam flange and beam tip, and the vertical welding can transmit the shear force from the beam. The advantage of anchor joints is that the structure is relatively simple and the consumption of steel is less. The disadvantage is that the overall rigidity of the joint structure is relatively small, and it is not convenient to weld the anchor plate, and it is only used when the pipe diameter is large and the volume is small.

2.1.6. Horizontal plate node. This type of knot formed by placing the crossbar on the steel pipe can not only increase the bearing capacity of the knot area, but also increase the overall stiffness of the knot. However, the disadvantage of this type of node is that it consumes a lot of steel. In addition, it is inconvenient and difficult to construct in steel pipes. When pouring concrete, it will affect its speed and quality. The inner wall of the steel pipe may also be locally damaged, thereby reducing the overall load-bearing capacity of the beam-column joint.

2.2. Insufficiency of the research on the stress joints of concrete pressure pipes in large construction projects

(1) In a common structure, its mechanical efficiency, ease of construction and economy cannot be achieved at the same time. In actual engineering applications, certain types of joints perform better in terms of mechanical performance, which also increases the overall stiffness of the joint. However, this type of joint uses a lot of materials and is relatively complicated to build. Other types of joints are relatively simple in structure, relatively easy to build and consume less material, but their mechanical properties are not ideal.

(2) Affect the appearance and use of buildings. The structural form of the seam often conflicts with the appearance and function of the building, making the floor beams and floor slabs unable to be flexibly arranged.

(3) The beam-column connection is not flexible in application. At present, there are some conventional types of nodes in the engineering field. If the floor layout is relatively specific, such as a
non-rectangular beam system, the height and height of each beam are different, and the application of beams and columns is therefore limited.

(4) The experimental research on concrete beam-column joints is relatively scattered and lacks a systematic layout, especially for the seismic performance of beam-column joints. In addition, the work done is mainly for actual projects, and the continuity and systematicness of the experiment is very poor. Moreover, there is a lack of integrated evaluation methods and standards, which can also be reflected in node testing.

(5) There is no complete set of calculation and analysis theories. At present, there is no complete theory of experimental research and theoretical research involving concrete column joints of concrete columns, so it is difficult to make a more complete and accurate assessment of the mechanical properties of column joints. So far, there is no relatively complete and mature calculation theory for beam-column joints of reinforced concrete pipe structures.

2.3. Monitoring algorithm for stress points of concrete pressure pipes in large construction projects

2.3.1. Local outlier detection algorithm based on density. The LOF algorithm first calculates the locally available density of each data point, and then calculates the extreme value coefficient of each data point through the locally accessible density, and extracts the largest outer edge (n) outside. In the calculation method, the distance between the data point and the adjacent data object and the local density of the data point neighborhood are the two important factors that ultimately reach the limit factor. The formula of the LOF algorithm:

\[ I_{rd_k}(p) = \frac{1}{\sum_{o \in N_k(p)} \text{reah} - \text{dist}_k(p,o) / |N_k(p)|} \]  \hspace{1cm} (1)

2.3.2. Outlier detection algorithm based on inverse nearest neighbor density. The algorithm is divided into two stages. In the first stage, according to the distance between all data points in the data set (using Euclidean distance), we can get the k nearest neighbor matrix of each data point, and then further calculate according to this k nearest neighbor relationship matrix. The number of reverse k nearest neighbors of each data point, select those points with a small number of reverse k nearest neighbors as the outlier candidate sample set, in the specific calculation process, if the number of outliers that need to be output is n, then Select 2xn points with the least number of reverse k nearest neighbors as the candidate set of outliers; in the second stage, computationally

The outlier factors of the data points in the candidate set generated in the first stage are arranged in descending order, and the top(n) outlier point with the largest outlier factor value is output. Formula as:

\[ I_{dr_k}(NN_k(p)) = \frac{\sum_{o \in NN_k} I_{dr_k}(o)}{|NN_k(p)|} \]  \hspace{1cm} (2)

3. Experiments on monitoring algorithm for stress points of concrete pressure pipes in large construction projects

3.1. The purpose of the experiment

Existing force point monitoring algorithms are tested through experiments. In the experiment, the force point data of large-scale construction engineering concrete pressure pipes are artificially synthesized, and three algorithms are used to detect the force points separately, and the experiment is carried out on the matlab platform. The neighbor parameters k are all set to 20. Through the analysis of the results, the detection of that algorithm is more accurate.
3.2. Experimental data
In the experiment, a total of 2 artificially synthesized two-dimensional data sets were used to verify the effect of the algorithm. 2 Two-dimensional artificially synthesized data sets are Dataset1 and Dataset2 respectively. Details of each data set: Dataset1 two-dimensional data set, containing 1070 data, of which 50 abnormal stress points. Dataset2 two-dimensional data set, contains 1000 data, of which 85 abnormal stress points.

3.3. Data preprocessing
The experimental data is processed, the invalid data is eliminated, and the remaining data is used for the experiment, and an Excel statistical table is created based on the data and structure. Manually input data, use SPSS17.0 software to perform statistical analysis on all data.

4. Data analysis
(1) The Dataset1 data set contains two large clusters of the same size, one with dense data distribution, and the other with relatively sparse data distribution. The experimental results of the three algorithms on the Dataset1 data set are shown in Table 1, and the nearest neighbor parameter k is set to 20.

| Algorithm | Detection rate | False alarm rate |
|-----------|----------------|------------------|
| KNN       | 91%            | 30%              |
| LOF       | 99%            | 20%              |
| NLOF      | 99%            | 20%              |

![Figure 1](image)

Figure 1. The detection rate and false alarm rate of the Dataset1 data set

It can be seen from Figure 1 that under the same neighbor parameters, the detection effect of the KNN algorithm is obviously inferior to the other two algorithms. Its detection rate is only 91%, and the false alarm rate reaches 30%. The other two algorithms are equivalent.

(2) The Dataset2 data set contains four large clusters, three of which are densely distributed, and one is relatively sparse. The experimental results of the three algorithms on the Dataset2 data set are shown in Table 2. The nearest neighbor parameter k is set to 20.
Table 2. The detection rate and false alarm rate of the Dataset2 data set

| Algorithm | Detection rate | False alarm rate |
|-----------|----------------|------------------|
| KNN       | 30%            | 9%               |
| LOF       | 50%            | 20%              |
| NLOF      | 99%            | 10%              |

Figure 2. The detection rate and false alarm rate of the Dataset2 data set

It can be seen from Figure 2 that the detection effect of the KNN algorithm is obviously inferior to the other two algorithms, and the detection rate is poor. Outlying force points that are obviously deviating from the whole around the dense force points are not recognized, but are located at the edge of the sparse area. Many of the normal stress point data are recognized as abnormal instead. Among the three algorithms, the detection rate of the NLOF algorithm is better, reaching 99%, which is significantly higher than the other two algorithms.

5. Conclusion

The concrete-filled steel tube system is a key development unit in the current building system. However, as a very important but relatively weak link in steel tube and concrete structures, the current research level is still lagging behind. Although the concrete-filled steel tube structure has been widely used in my country as heavy parts for houses, bridges, subways and factories, and a lot of research work has been carried out in China, so far, the steel tube structure has been studied, but the beam and the concrete-filled steel tube column strength still immature and perfect. This paper is based on experiments on the detection algorithm of large-scale building concrete stress points. The experimental results: First, in the case of the same neighbor parameters, the detection effect of the KNN algorithm is obviously inferior to the other two algorithms. Its detection rate is only 91%, and false alarms. The rate reached 30%, which is comparable to the other two algorithms. Second, the detection effect of the KNN algorithm is obviously inferior to the other two algorithms. The detection rate is poor. Outlying force points that are obviously deviating from the whole around the dense force points are not recognized, and many normal stress points located at the edge of the sparse area are not recognized. Instead, the force point data was identified as abnormal. Among the three algorithms, the detection rate of the NLOF algorithm is better, reaching 99%, which is significantly higher than the other two algorithms.
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