International Journal for Housing Science and Its Applications
Publish August 4, 2025. Volume 46, Issue 3 Pages 9092-9102

https://doi.org/10.70517/ijhsa463181

Computational study on non-contact acoustic wave monitoring data processing method based on BIM technology and its calculation in the reinforcement design of human defense project

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Abstract BIM is a discipline that combines construction engineering and information science, which can well solve the relevant problems arising in urban human defense projects and also improve the efficiency of visualization. Firstly, the acoustic wave sensor is used to obtain the acoustic wave monitoring data of the building construction site, and for the data with noise, the Kalman filtering method can be used for denoising, so as to obtain the real building construction site data. According to the real data of the construction site after noise reduction, the BIM model of the construction site is established, and a non-contact acoustic wave monitoring data processing method based on BIM technology is designed. Starting from the definition scope of the civil defense project, the computational research program of BIM technology in the reinforcement design of the civil defense project is formulated, with the help of which the reinforcement design of the civil defense project is explored and analyzed. In the time interval of 120ms and 765ms, the reinforced civil defense project shows excellent impact resistance performance, and the displacement slope of the project reinforced nuclear level 6 civil defense wall is significantly larger than that of the nuclear level 5 civil defense wall. In summary, the method of this paper has an important guiding value to improve the safety and stability of the human defense project, and accelerate the pace of high-quality development of the building.

Index Terms BIM, Kalman filter, human defense project, reinforcement design

I. Introduction

While China is concentrating on economic construction, it is also strengthening national defense construction and promoting the coordinated development of national defense construction and economic construction, while the construction of human defense is an important part of national defense construction and has an irreplaceable role [1]-[3]. Human defense project is a specialized project set up to protect people's life and property safety, resist war, disaster and other serious harm to social security events, which is of great significance for defending people's life and property safety and maintaining the country's war potential, and it is an important strategic facility in China [4]-[7]. Due to the influence of funding, policy and other factors, many projects are shelved before construction is completed, the age of the project is long, the project is started again when the national policy and norms have new changes, the design needs to readjust the program [8]-[10]. For the completed human defense projects, they need to be renovated and reinforced to have the intended human defense functional requirements, which can save resources and also alleviate the status quo of serious shortage of per capita sheltering area in the city [11]-[13].

Non-contact acoustic monitoring data processing method consists of ultrasonic probe and signal reception processing and other parts, in the reinforcement design of the human defense project, relying on laser scanning, optical measurement or radar and other technologies, through the measurement of reflected light or electromagnetic waves in the project to be tested to obtain information, especially based on the non-contact acoustic monitoring data processing method of the BIM technology, these tools to collect data in a different way, in the human defense engineering reinforcement design can play an important role in the calculation [14], [15].

With the support of building information modeling (BIM) technology, a non-contact acoustic wave monitoring data processing method is designed, the main principle of which is to use Kalman filtering to reduce the noise of acoustic wave monitoring data based on BIM technology and sensors. After that, combined with the current reinforcement design points of the civil defense project, the reinforcement design and calculation of the civil defense project is carried out from three parts: the foundation part, the civil defense wall, and the beam and plate construction. A project engineering is selected as an example of this research, using the model in this paper and simulation analysis software, together with the case study on the reinforcement design of the civil defense project, in order to promote the level of high-quality development in the field of architectural design.

II. Acoustic Monitoring Data Processing Based on BIM Technology

II. A. Concepts and characteristics of BIM technology

II. A. 1) Basic Concepts of BIM Technology

In order to meet the development of the times and the needs of the society, the information technology represented by BIM technology has emerged and has been put into the field of architectural engineering.CAD technology in the field of construction is called the first information technology revolution, which makes the designers to free their hands and throw away the drawing boards, however, in the process of construction, due to the fragmentation of the information between the various departments of the various phases can not be shared in a timely manner, in the face of this problem, the emergence of BIM technology, and bring the second technology revolution. BIM technology came into being to face this problem, and at the same time brought the second technological revolution. BIM technology is a kind of multi-dimensional model information integration technology developed on the basis of CAD technology, which is based on 3D model and can be expanded to nD in 4D and 5D. BIM technology was formally put forward by Autodesk, and then began to be popularized in the field of construction, and widely accepted and recognized by related professionals.

II. A. 2) Characteristics of BIM technology

(1) Visualization

Visualization is the most important feature of BIM technology, which gives BIM technology a significant advantage over traditional technical methods [16]. BIM technology visualization can directly present the proposed building, the parties involved do not need to spend their brains to imagine, giving us the most realistic visual experience.

(2) Coordination

The coordination of BIM transforms all the problems encountered in the pre-construction stage (soft and hard collision between pipeline and pipeline, collision between building and structure, etc.) from after-the-fact treatment to before-the-fact prevention, which reduces a large number of engineering changes, and at the same time, greatly improves the synergy efficiency among all the parties involved, and effectively realizes the cost control.

(3) Optimization

The application of BIM technology adjusts the optimization model, visually presents the difference between before and after optimization, highlights the advantages of BIM technology, reduces the frequency of engineering changes, rework phenomenon, improves the quality of the project, and achieves the purpose of effective cost control.

(4) Simulation

The simulation of BIM technology can be carried out throughout the whole life cycle of the building, and there are corresponding simulations at all stages. Simulation characteristics can make the abstract design visualization, virtual implementation of various building processes, making managers to make judgments in advance, timely development of solutions, in order to the actual work can be carried out smoothly.

II. B. BIM technology related software

II. B. 1) Commonly used software for BIM technology

The rapid development of BIM technology at home and abroad is mainly attributed to the software it contains.BIM software can create a 3D design platform as a prerequisite for the realization of BIM technology, reflecting the importance of BIM software [17]. Software is the heart of BIM technology, when the software runs smoothly, the value of BIM technology can be better realized.BIM is not only the building information model, or coordinated and synchronized processing of the management approach, its application in the construction industry in various professions, and the early investment decision-making stage, design stage, construction stage to the final operation and maintenance stage of the whole life cycle of the construction project. So rely on a BIM software can not solve the needs of BIM, it also needs a number of different functions of the software to run together.BIM technology software is numerous, and these software has a good compatibility between the software, so the modeling and cost analysis for the traditional software to be much faster. In this paper, BIM software is divided into eight categories: conceptual design and feasibility study software, BIM core modeling software, BIM analysis software, fabrication drawings and prefabrication processing software, construction management software, quantitative and budgetary software, scheduling software, and file sharing and collaboration software.

II. B. 2) Overview of BIM software

(1) Revit is developed and researched by Autodesk, Inc. in the United States and designed a series of software such as Revit Architecture and Structure. The software is currently more commonly used modeling software, in the

construction phase can be accessed at any time the relevant schedules, model modification can be automatically coordinated with any changes. At the same time to assist Navisworks software to implement collision detection, to avoid the occurrence of changes.

(2) Navisworks and Revit software are designed by the same company (Autodesk), i.e., Revit files can be imported into Navisworks to achieve seamless integration. The software is integrated visualization, simulation and analysis of 3D models. Navisworks software has the function of checking the collision conflict, resulting in a collision report, the collision area is clearly presented, which greatly improves the accuracy, reduces the engineering changes, and improves the quality and efficiency of project management.

(3) BIM5D is a software developed by Quanta, based on the 3D model, the software can import Project progress files and Gccp5.0 cost files to form 5D models. The software has model visualization view. Division of flow section. 5D simulation of construction works and generation of corresponding capital curve diagrams. It is possible to search for materials according to any one of the ways such as floor, component, etc., and it is possible to export all kinds of reports.

II. C.Non-contact acoustic monitoring data processing methods

II. C. 1) Overall framework

The flow of the remote monitoring data visualization method for building construction site integrating BIM technology and sensor monitoring system is shown in Fig. 1. The specific steps are as follows:

(1) Establish the data acquisition model of the building construction site, and conduct data acquisition and fusion of the building construction site through sensors.

(2) Denoising the noisy data by Kalman filtering method to obtain the real construction site data.

(3) Establish the BIM model of the construction site based on the real data of the construction site after noise reduction.

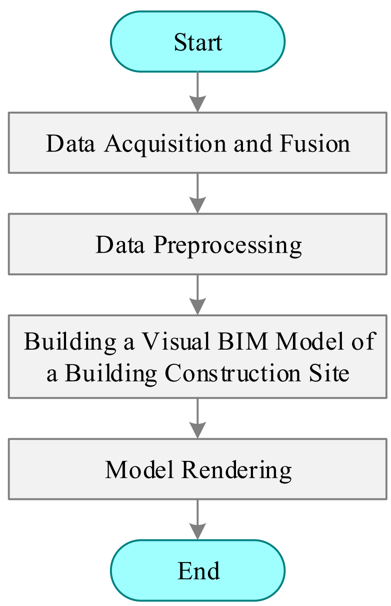


Figure 1: Visualization of remote monitoring data at construction sites

II. C. 2) Acoustic Sensor Based Data Acquisition and Fusion

If the dataset of the building construction site is $H_i(x)$, the data of the building construction site is collected by the established construction site data collection model, and the dataset for obtaining the sampled data of the building construction site can be expressed as:

$$u = h \times f + \eta \tag{1}$$

where: h denotes the set of association rules for construction site data. f denotes the real construction site data collected according to the construction site data collection model. η denotes the interference factor. $\times$ denotes convolution. The information of the construction construction site is fused in different scopes to establish the statistical model of the construction construction site, and the acquired statistical feature quantity of the construction construction site can be expressed as:

$$s(t) = u + \eta \tag{2}$$

Modeling of building construction site features based on the amount of statistical features of the building construction site to obtain the set of feature distributions of the data distribution of the building construction site, if the N -dimensional vector of the building construction site features is denoted by $x(t)$, then we have:

$$x(t) = As(t) + n(t) \tag{3}$$

where: A is the feature dimension. $n(t)$ is the noise vector. The judging statistic for data fusion for obtaining features of a building construction site can be expressed as:

$$\mu(n) = \begin{cases} \beta_1 \left[1 - \exp\left(-\alpha_1 |x(t)(n)|^2\right)\right] & E\left[|e(n)|^2\right] > K \\ \beta_2 \left[1 - \exp\left(-\alpha_2 |x(t)(n)|^2\right)\right] & Other \end{cases} \tag{4}$$

where: the statistical eigenvalues of the data characterizing the building construction site are denoted as K. $\alpha_1 > 0$ and $\alpha_2 > 0$. The highest similarity feature quantity is denoted as $\lambda_{\max}$ and the dataset $0 < \beta_1 < \frac{1}{\lambda_{\max}}$, $0 < \beta_2 < \frac{1}{\lambda_{\max}}$. Obtaining the database of building construction site by principal component analysis with error $MSE = E\left[|e(n)|^2\right] > K$, the value of α_2 and the value of β_2 take the smallest, and completing the fusion of the data of the construction site to the data of the construction site, and using the result of this data fusion as a basis for the construction construction site remote monitoring data visualization to provide support.

II. C. 3) Kalman filter based data preprocessing

(1) The state prediction formula is as follows:

$$X(k|k-1) = qX(k-1|k-1) + pU(k) \tag{5}$$

(2) The covariance prediction is calculated as follows:

Where: q is the linear equation state transfer matrix. p is the noise matrix. $X(k-1|k-1)$ is the optimal estimate of the data collected by the sensor from the building construction site at $k-1$. $U(k)$ is the control amount of the data collected by the sensor from the building construction site at k, and the predicted value of the data collected by the sensor from the building construction site at k, $X(k-1|k-1)$, can be obtained by $X(k|k-1)$ and $U(k)$.

(2) The covariance prediction is calculated as follows:

$$D(k|k-1) = qD(k-1|k-1)q' + L \tag{6}$$

where: q' is the transpose matrix of q. L is the covariance of the presence of noise in the data collected from the building construction site by the sensor, so the covariance of $D(k|k-1)$ can be obtained by the covariance $D(k-1|k-1)$ of $X(k-1|k-1)$.

(3) The Kamaner gain value is calculated as follows:

$$Fg(k) = \frac{D(k|k-1)H'}{\left[HD(k|k-1)H' + R\right]} \tag{7}$$

where: H is the monitoring matrix. H' is the transpose matrix of H. R is the noise covariance of the data collected from the building construction site by the sensor, and the value of Cannerman gain $Fg(k)$ can be obtained by $D(k|k-1)$ and R.

(4) The state update is calculated as follows:

$$X(k|k) = X(k|k-1) + Fg(k)\left[Z(k) - HX(k|k-1)\right] \tag{8}$$

where: $Z(k)$ is the monitoring value of the sensor at k. By correcting $X\left(k \mid k-1\right)$ at k by $Z(k)$, the optimal predicted value of $X\left(k \mid k\right)$ for the sensor-collected building construction site data at k can be obtained.

(5) The covariance update is calculated as follows:

$$D\left(k \mid k\right)=\left[I-Kg\left(k\right)H\right]D\left(k \mid k-1\right) \tag{9}$$

where: I is the unit matrix. By combining the above Kalman filtering steps, the noise removal of sensor acquisition data can be realized and the data quality can be improved.

II. C. 4) Monitoring data visualization

The application layer organizes the construction site data collected and fused by the sensors, applies Revit 2016 software to build a static virtual construction site model, and constructs the mapping relationship between the actual construction site and the virtual construction site model through the dynamics data contained in the actual construction site, so as to simulate the important data of the construction site. Based on the monitoring data, the monitoring personnel can find out the potential safety hazards in the construction site and deal with them in a timely manner, realizing the visualization of the remote monitoring data in the construction site and enhancing the safety of the construction site.

III. Calculation of BIM technology in the reinforcement design of human defense project

Through the above description, it can be seen that the inspection data processing method based on BIM technology can provide data support for the reinforcement design of human defense engineering. Combined with the characteristics of the reinforcement design of the human defense project, the inspection data processing method based on BIM technology will be used to calculate the parameters of the construction and wall in the reinforcement design of the human defense project, and the specific calculation is applied to the renovation design of the foundation part, the renovation and reinforcement of the human defense wall, and the renovation and reinforcement of the beam members. Details are as follows:

III. A. Characteristics of reinforcement design for civil defense works

III. A. 1) Civil defense works

People's air defense project (full name of people's air defense project) is an engineering building used to protect personnel, materials and equipment from killing and destroying by air-attack weapons in wartime, and it is an important material guarantee for the implementation of people's air defense in wartime. Human defense works include underground protective buildings built separately for the protection of personnel and material shelter, people's air defense command, medical rescue, etc., as well as basements that can be used for air defense during wartime in combination with ground buildings.

III. A. 2) Essentials of reinforcement design for civil defense works

(1) All-specialty: the design of civil defense engineering is a comprehensive project involving many specialties, and its design process needs the synergy of various professional fields, which is generally accomplished by the common design of building, structure, water supply and drainage, heating and ventilation, and electrical specialties, so the timely cooperation of multiple specialties becomes an essential link in the design of civil defense engineering.

(2) integration of peace and war: the design of human defense engineering needs to fully consider the needs of peace and wartime, and in the design to meet the needs of peace and war conversion. In the space layout, as well as wartime need to be installed in place of fixed walls, doors and windows, equipment, etc., should be considered as much as possible with the combination of the usual use, can be shared as much as possible to share, to avoid duplication of design, and adhere to the principle of the economics of peace and war conversion to ensure the realization of the two functions of the conversion and take into account.

(3) Complexity of pipe synthesis design: the pipeline in the human defense project is concentrated and complex arrangement, so it must be a comprehensive design of the pipeline. The purpose of pipeline synthesis is to reasonably compress the pipeline layout space, reduce the changes in the later stage, to avoid the unreasonable concentration of equipment pipelines lead to a reduction in the net height of the project or due to changes in the problem caused by the nest, rework. There are three important links in the comprehensive design of pipelines in the human defense project: first, collision check to ensure that the pipeline systems do not interfere with each other. The second is to strictly control the vertical clearance distance between pipelines to adapt to the height limitations of underground space. Third, detailed review of pipeline reserved holes to ensure accurate construction in the concrete structure. The civil defense project is an underground project, the height limit is strict, and the civil defense

wall are concrete structure, the construction of pipelines and cable bridges through the civil defense wall must be pre-buried casing, so detailed planning and in-depth design adjustments to the pipeline before construction is extremely critical to ensure that the construction is in place at one time.

(4) the special nature of the mouth design: the mouth of the civil defense project is an important part of the civil defense project, is the underground and the ground to keep in touch with the necessary connections, it is not only related to the protection of the wartime confinement function, the usual wartime ventilation, but also related to the works of the personnel in and out of the evacuation. Such as personnel, equipment in and out of the project ventilation, water supply and drainage and internal and external links to set up a variety of pipelines, etc., must set up a certain number of entrances and exits, vents, water supply and drainage and internal and external links to a variety of pipeline orifices. These orifices are collectively referred to as the mouth of the human defense, it is not only an important way to contact the project, but also easy to expose and suffer from enemy attacks on the main target of destruction, but also the weakest part of the project protection.

III. B. Computational application performance

III. B. 1) Retrofit design of the foundation section

The foundation and negative two floors of this project have been constructed, and the foundation scheme is grouted piles + bearing platform + waterproof slab. Due to the adjustment of the location and scope of the atrium in the upper building scheme, and the change of the load in the local area, it is calculated that there are about 50 places with insufficient pile resistance. Two options are provided, namely, increasing the resistance to pile pullout and increasing the counterweight:

(1) Increasing the resistance to pile pullout requires breaking the foundation footing. As the groundwater level is 0.5m from the outdoor ground, the destruction of the base plate will cause great difficulties to the later construction due to the large water pressure, and the construction quality is not guaranteed.

(2) Increase the counterweight can be through concrete counterweight or steel counterweight. After calculation, there are total 16 places to increase concrete counterweight (268.7m^3), the total weight is about 6882kN, if it is changed to steel pressure weight, it can reduce 2/3 accounted for, but the cost increases 18 million yuan. Comprehensive comparison, the final use of increased concrete counterweight, concrete counterweight back pressure height to the bottom of the beam or plate bottom.

III. B. 2) Rehabilitation and reinforcement design of walls and columns for human defense

The renovation of the air defense wall is mainly divided into demolition of the wall, the new wall and due to changes in elevation caused by the first demolition after the increase of these cases, the design process according to the wall, column calculations to take a different design of the renovation. For the new wall, the upper reinforcement of the wall when anchored into the beam with the use of reinforcement planting, other cases correspond to the wall on both sides of the 400 mm range plate concrete chiseling, in accordance with the “design of air defense basement loads and basement structural structure” practice of binding reinforcement, cleaning chiseling and then poured with C40. The reinforcement of the frame column of the negative two floors of the air defense mainly adopts the method of enlarged section. The concrete strength grade of the enlarged part is increased by one level compared with the original column, and C45 micro-expansion concrete is used to pour and ensure the quality of pouring. The enlarged section is divided into unilateral enlargement and full-section enlargement. Due to the consideration of the impact of the increased section on the parking space, part of the frame columns were also structurally strengthened by increasing the steel plate hoops, and the angles and splice plates were made of Q355B.

III. B. 3) Design of retrofit reinforcement of beam and slab elements

According to the existing building requirements and arrangement of the original part of the beam to remove and add to meet the existing use of functional and wartime protection requirements. The reinforcement of frame beams mainly adopts the method of enlarged section. The concrete strength grade of the enlarged part was C40, and the pouring quality was ensured. Part of the frame beam support also uses the way of structural reinforcement of adhesive steel, steel plate Q355B. adhesive steel encounter columns need to be turned up 600mm. according to the results of the calculation of the original components for the review, the strength does not meet the current design requirements of the plate for reinforcement, the reinforcement of the slab is mainly used in the carbon fiber reinforcement method, the use of carbon fiber composite material (high-strength level I) reinforcement, after the calculation of the method in this paper, the reinforced beams and boards are to meet the The beams and slabs after reinforcement meet the requirements for use.

IV. Examples of human defense project reinforcement design investigation and analysis

IV. A. Validation analysis of data processing methods for human defense project monitoring

IV. A. 1) Summary of works

This project includes a section of rail transit in a city in North China, including two stations in A and B and two intervals of two-lane tunnel, the line is east-west. The design starting and ending mileage of the two station intervals of A and B is K2+517.828~K3+310.300, the right line is 746.236m long, and the left line is 746.142 long, including one shaft, one cross passage and concealed excavation intervals. The interval is constructed by shallow buried bank excavation method, a construction shaft is set up, located in the open space on the north side of the road at the mileage of K2+915 on the right line, and the construction cross passage is set up in conjunction with the contact passage during the period of use. The interval line spacing is 4.2~12.5m, the minimum radius of the line plane is 1481m, and the maximum radius is 1853m. The maximum longitudinal slope of the longitudinal section of the line is 8.4‰, the minimum longitudinal slope is 2.13‰, and the buried depth of the top plate of the structure is about 8.5-10.5m. The depth of burial of the structural floor is about 14.5 to 15.8m.

IV. A. 2) Analysis of data processing results

In the actual human defense project measurement, the sensor is used to determine the measurement angle of the compartment point measurement method, the data points are discrete distribution, in order to carry out the overall analysis of the overall section of the human defense project and posture observation, the need to obtain the space of the continuous data graphics, so it is necessary to measure the data for the language out. The pre-processing method used is the noise reduction method, which uses the finite function values of the test data measured in the calculation area to generate a specific function graph according to the different requirements of accuracy. The specific function values are given as an approximation of the test data at the required points in the calculation area. Noise reduction processing methods are used according to the general requirements of engineering accuracy, which include the closest proximity method, linear method, and 111. Through the analysis of the results of big data processing and computer simulation, the results of the three noise reduction methods, including the nearest neighbor method, linear method and Kalman filter, are compared, as shown in Figs. 2-4, in which the Kalman filter has the best noise reduction effect. Therefore, Kalman filter is used for data processing to get the monitoring results of all measurement points on the tunnel section, which is convenient for data processing and analysis.

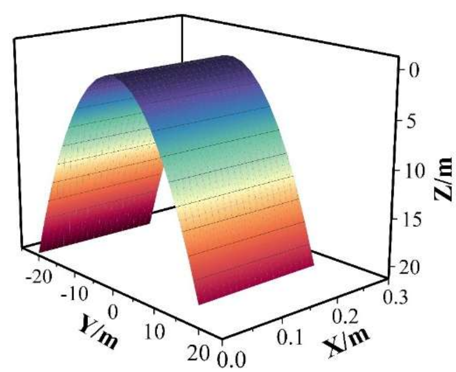


Figure 2: Nearest neighbor noise reduction result

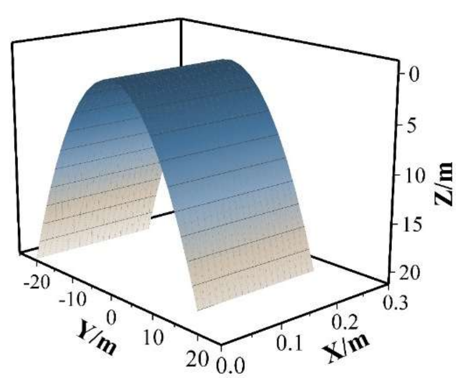


Figure 3: The result of the linear noise reduction method

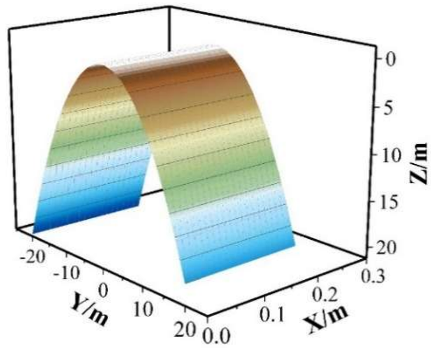


Figure 4: Kalman filtering noise reduction result

Through the data fusion analysis of on-site sensor data acquisition, actual data and model calculations, the dynamic distribution of structural stress conditions in the beam and pile units of foundations and tunnels can be simulated at various engineering stages. The results of the simulation data show that the soil pressure increases more and more due to the advancement of the foundation and tunnel depth. For example, during the erection of the steel supports at each level, the stresses in each support grow linearly from the initial value to reach the set defined value.

(1) When the excavation depth of the foundation pit reaches 7m, the simulation analysis is carried out to analyze the stress condition of St(1,6) steel support, and the simulation analysis results are shown in Fig. 5, from which it can be seen that the axial stress distribution of St(1,6) steel support ranges from 612.753 to 744.58kN, and the distribution of the force is relatively uniform, and the axial stress in the middle of the center is the largest.

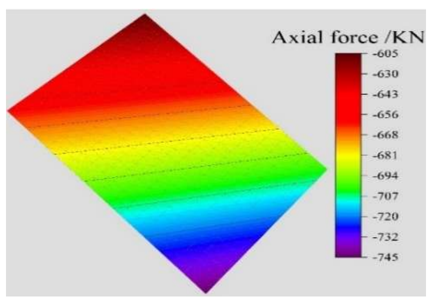
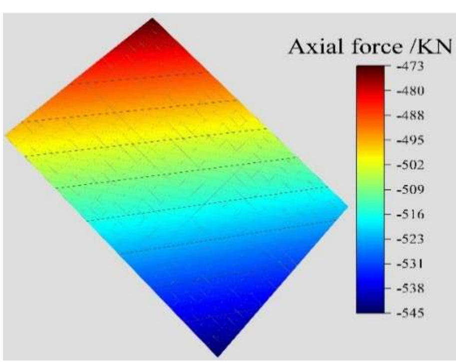
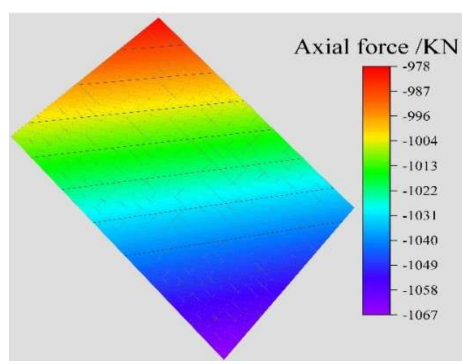


Figure 5: Axial stress distribution S (1,6) of steel supports at a depth of 7meters

(2) The axial stress distribution of St(1,6)/St(2,6) at 11m depth is shown in Fig. 6, where (a)~(b) are St(1,6) and St(2,6), respectively. When the excavation depth of the foundation pit reaches 11m, the steel support St(2,6) structure is added to the foundation pit, and it can be seen from Fig. 6 that the current steel support St(1,6) has decreased in stress compared with the previous one, while the stress on the steel support St(2,6) shows a linear increase, and the value of the stress in the part with the largest stress reaches 1059.17kN.



(a) St(1,6)



(b) St(2,6)

Figure 6: The axial stress distribution of St (1, 6)/St (2, 6) at a depth of 11m

It can be seen that the design axial stress extreme value of the foundation and tunnel enclosing steel support is about 1059.17kN, while the calculated stress data reaches 1500kN, which is 70.6% of the design extreme value, and has been close to the warning value, and the parameters of the initial support in the original design scheme are small. Accordingly, the optimization plan is proposed: (1) For the unexcavated part, make design changes again, optimize the existing design structure, and strengthen the rigidity of the initial support. (2) For the excavated part, it is necessary to install additional steel support in time and appropriately increase the prestressing level to improve the overall stress distribution of the steel support stress conditions, in order to achieve the purpose of anti-pit instability. Through the results of simulation data, the parameter problems in the original design scheme can be found with the sensor monitoring, and the program modification and change can be carried out for the unexcavated and excavated portion, which is applicable to a variety of situations such as unreasonable change of the design scheme parameters at the design stage, and unreasonable change of the design parameters during the construction process with unreasonable stress conditions, and the parameter design of the design scheme has been effectively monitored and managed in both the design and construction stages.

IV. B. Computational investigation of BIM technology in reinforcement design

IV. B. 1) Calculation of load-bearing capacity in reinforcement design

The human defense wall is mainly damaged by overall bending, so it mainly calculates whether the positive section bending bearing capacity of the manually engineered reinforced nuclear level 6 human defense wall meets the nuclear level 5 human defense wall. According to the relevant provisions of the Design Code for Reinforcement of Concrete Structures GB50367-2013 and the Code for the Design of People's Air Defense Basements GB 50038-2005, when reinforcing the tensile side concrete surface of the rectangular cross-section bending member, the bending capacity of its positive section should be determined according to the following formula:

$$M \le \alpha_1 \alpha_c f_{cd} bx\left(h-\frac{x}{2}\right)+f_{yd}^{'} A_{s0}^{'}\left(h-a^{'}\right)-f_{yd} A_{s0}\left(h-h_0\right) \tag{10}$$

$$\alpha_1 \alpha_c f_{cd} bx = f_{yd} A_{s0} + \psi_f f_f A_{fe} - f_{yd}^{'} A_{s0}^{'} \tag{11}$$

$$\psi_f = \frac{\left(0.8\varepsilon_{cu} h / x\right)-\varepsilon_{cu}-\varepsilon_{f0}}{\varepsilon_f} \tag{12}$$

$$x \ge 2a^{'} \tag{13}$$

where, M is the design value of bending moment after constructing the upgrade, α_c is the concrete strength utilization factor under dynamic loading. x is the height of the concrete compression zone, b is the width of the calculation cell of the slab and strip, f_{cd} is the compressive dynamic strength of the concrete, f_{yd} , $f_{yd}^{'}$ are the design values of tensile and compressive dynamic strength of tensile and compressive reinforcement of the original section, A_{s0} , $A_{s0}^{'}$ are the cross-sectional areas of the tensile and compressive reinforcement in the original section, $a^{'}$ is the distance from the point of compression of the longitudinal compression reinforcement to the nearside of the cross-section, h_0 is the effective height of the cross-section before the construction of the upgraded section, f_f is the design value of the tensile strength of the fibrous composite, A_{fe} is the effective cross-sectional area of the fiber compliant material, ψ_f is the strength utilization coefficient introduced by considering that the actual tensile strain of the fiber composite material does not reach the design value, and when $\psi_f > 1.5$, take $\psi_f = 1.5$. ε_{cu} is the design value of the tensile strain of the fiber composite material, ε_{f0} is the hysteretic strain of the fiber composite material when considering the effect of the secondary force, and if the effect of the secondary force is not taken into account, take $\varepsilon_{f0} = 0$.

Calculation of the bending capacity of the normal section of a nuclear class 5 human defense wall:

$a_s^{'} = a_s = 10mm$, $x = 2a_s^{'} = 20mm$, $h_0 = h - a_s = 300 - 10 = 290$.

$M = f_{yd} A_s \left(h_0 - a_s^{'}\right) = 400*1700*\left(290-10\right) = 190.4KN \cdot m$.

Calculation of the bending capacity of a normal section of a reinforced nuclear class 6 man-wall:

It is assumed that a high-strength Class 1 orthotropic paste with 6 layers, a single layer thickness of 0.174 mm, a width of 250 mm and a spacing of 250 mm is used. x is taken as $2a_s^{'}$, $x = 2a_s^{'} = 20mm$, $b = 1000mm$,

$h_0 = h - a_s = 300 - 10 = 290$. $\psi_f = \frac{(0.8\varepsilon_{cu} h / x) - \varepsilon_{cu} - \varepsilon_{f0}}{\varepsilon_f} = 1.072 > 1.0$, taking 1.0 when $A_{fe} = 250*0.174*4*3 = 516$. $\alpha_1 \alpha_c f_{cd} bx = 1.0*1150*150 = 172500N$. $M = 247.14kN \cdot m > 190.4KN \cdot m$, the proposed BIM technology based reinforcement design for human defense project in this paper meets the user's needs.

IV. B. 2) Simulation analysis

Figure 7 shows the time course curves of horizontal displacements in the wall under the simplified blast shock load of nuclear level 5 for the engineered reinforced nuclear level 6 human defense wall and nuclear level 5 human defense wall. The blast shock wave is a monotonically varying primary impulse load, and the deformation of the human defense wall fluctuates up and down with time, resulting in forced vibration, and the displacement tends to decrease with the attenuation of the shock load due to the damping effect. The simplified shock wave action time of nuclear level 5 is 765ms, in the first 120ms, the horizontal displacement in the wall of the engineered reinforced nuclear level 6 human defense wall is slightly larger than that of the nuclear level 5 human defense wall, but the constraints of the strips reduce the amplitude of the structural displacement very well. During the period from 120ms to 765ms, the strips restrained the manhole wall to generate vibration, which gave better play to its excellent impact resistance, and the monotonically decreasing slope of the displacement of the engineered reinforced nuclear level 6 manhole wall was significantly higher than that of the nuclear level 5 manhole wall. After 765ms, the impact load disappeared, and no obvious free vibration appeared in the nuclear 5-level manhole wall, while the strips still exerted their advantages of good toughness and restrained the structural deformation, and the residual displacement of the engineered reinforced nuclear 6-level manhole wall was obviously smaller than that of the nuclear 5-level manhole wall. Overall, the impact resistance of the project-reinforced nuclear level 6 human defense wall meets the requirements of nuclear level 5 human defense wall.

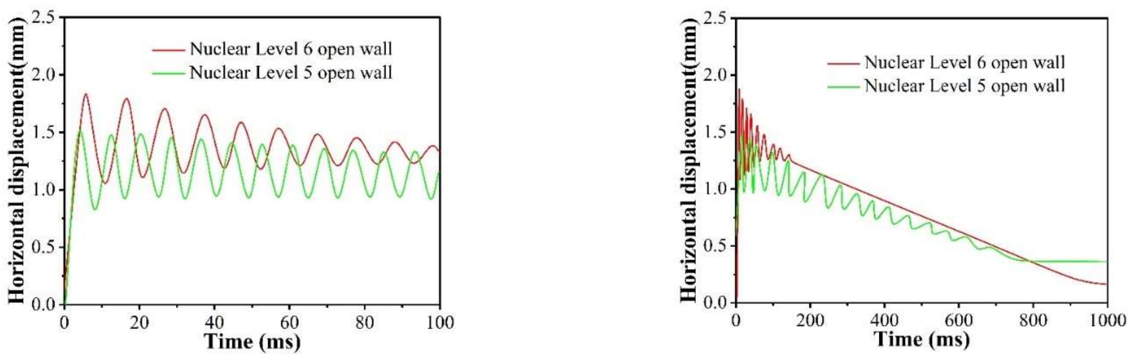


Figure 7: The time-history curve of horizontal displacement in the wall

V. Conclusion

Based on the characteristics of BIM technology, this paper designs a non-contact acoustic wave monitoring data processing method based on BIM technology, and puts this method into the reinforcement design of human defense project. Taking a person's defense project as a reference, the method of this paper is used to explore and analyze the example of human defense reinforcement design. After processing the acoustic wave monitoring data, it is found that the stress of member St(1,6) shows a monotonically decreasing trend, while the stress on St(2,6) shows a monotonically increasing trend, and its maximum value is 1059.17kN, which is 70.6% of the extreme value of the reinforcement design and close to the warning value, which is able to satisfy the requirements of the current standard of reinforcement design of the civil defense engineering and further improve the safety coefficient and the coordination of the civil defense engineering. Enhancement.

Funding

Research on the application of nondestructive testing and remote monitoring based on BIM technology in early civil air defense engineering in the identification and reinforcement design work (contract number: KG913700001630559891202217).

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