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Cognition and System Characteristics of Resilience Connotation of High-speed Railway Construction System in Goaf Area

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Abstract

Due to the influence of the internal and external environment of the goaf and the system, and considering the particularity of the construction itself, the safety accidents in the high-speed railway construction will have serious consequences and seriously endanger the safety and reliability of the construction. Resilience can be used to describe the ability of the system to resist disturbance and quickly recover to normal state. Therefore, an accurate description of the resilience of the construction system and an overview of the characteristics of the construction system are important means to improve the risk resistance of the high-speed railway construction system in the mined-out area. Based on the literature research of resilience concept, the connotation of resilience concept of high-speed railway construction system in goaf area is discussed. Based on the engineering system theory, starting from the structure of the system, the characteristics of the construction of high-speed railway above the goaf are pointed out, which provides a certain reference for the reesilience evaluation and improvement of the high-speed railway construction system in the subsequent goaf site.

Keywords

Resilience; High-speed Railway Construction; Risk; System Characteristics.

1. Introduction

In recent years, with the support of national policy, by the end of 2020, China's railway mileage reached 146.3 million kilometers, the number and scale of high-speed railway is expanding; according to the relevant prediction, by 2030, there will be 15,000 abandoned goaf in China[1] , so in the process of high-speed railway construction, it is inevitable to cross the goaf. However, in the process of crossing the goaf, the construction is affected by geological conditions, construction environment and other factors, so that there are many risks in the construction process and frequent safety accidents. For high-speed railway, once safety accidents occur, the consequences will be very serious, so the construction risk should be effectively managed. However, the existing research on the risk of high-speed railway construction is insufficient. It only emphasizes the pre-control, cannot emphasize the ability of high-speed railway construction in goaf areas to cope with risks, and cannot meet the safety management requirements of high-speed railway construction projects. The integration of the concept of resilience will be able to emphasize the ability of the system to cope with risks in the whole process before, during and after the risk accident. At the same time, it can also emphasize the recovery ability of the system after being impacted by the outside world, which can provide new ideas and methods for the risk management of high-speed railway construction projects.

At present, there are many descriptions of the concept of resilience at home and abroad, but there is little research on the resilience of construction system,the previous research often focusing on the resilience of subway, tunnel and other safety systems,and the research on the resilience of high-speed

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railway construction system is less, and the construction of high-speed railway, the role of goaf can not be ignored. Therefore, starting from the definition of resilience, the connotation of its of high-speed railway construction system in goaf site is analyzed, the characteristics of the construction system are studied to make the research credible.

2. Concept of Resilience of High Speed Railway Construction System in Goaf Site

2.1 Concept of Resilience

The word resilience comes from the Latin word 'resilio', which means rebound, originated in engineering; in 1973, Holling[2] introduced resilience into the ecological system and defined resilience as the absorption and buffering capacity of the system to shocks or disturbances ; in 2015, the Resilience Alliance and the United Nations Disaster Reduction Strategy Organization defined the concept of resilience, emphasizing the recovery, anti-interference and learning ability of the system; in 2017, Huang et al[3]. proposed the definition of system security resilience, that is, resilience is the ability of the system to resist, buffer, absorb and recover from adverse events.

In recent years, the concept of resilience has been widely concerned by academic circles. The existing research on the concept of resilience has the concepts of engineering resilience[4][5], system safety resilience[3][6] and management resilience[7].

2.2 Resilience Connotation of High-speed Railway Construction System in Mined-out Area

The existing research on the definition of resilience is generally consistent, which refers to the ability of the system to effectively resist, absorb, adapt and recover in the face of interference. In this paper, referring to the research results of the existing system resilience and combining with the construction characteristics, the resilience of the high-speed railway construction system in the mined-out area is described as the process in which the construction system can resist the risks from the external environment and the internal system and finally recover.

3. High-speed Railway Construction System in Mined-out Area

The system is composed of two or more organic connection, interaction elements, with a specific function, structure and environment of the whole. Each element that constitutes this whole can be a single thing, or a group of sub-systems and subsystems composed of things. The system is also a part of a larger system or environment that it belongs to, and interacts with it to form a system as a whole.

The construction of high-speed railway in mined-out area is greatly influenced by internal and external factors. Through the introduction of the concept of engineering system, the influence of mined-out area on high-speed railway construction can be clarified, and the construction system of high-speed railway in mined-out area can be more deeply understood, so that the research is more targeted. In this paper, the narrow definition of engineering is used. Taking the high-speed railway construction project in goaf site as the research object, a conceptual scheme is transformed into an engineering entity through construction. The whole process is called high-speed railway construction in mined-out areas. Similar to general engineering, it contains the following nine factors:

(1) Users: the main objects of the high-speed railway construction project in the mined-out area are passengers.

(2) Objective: Through the performance and function of the high-speed railway construction project in the mined-out area, the work is carried out under the mined-out area, and finally some positive consequences are brought.

(3) Resources: the basic material conditions to achieve user expectations.

(4) Actors: the ability, quality, credibility, code of conduct and moral requirements of the main contractor, sub-contractor, supplier, top management and supervision units, logistics support units and these organizations and their individuals.

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(5) Methodology and technology: the technology and management tools used by the actors to achieve the engineering tasks undertaken.

(6) Process: namely, the location and state of the start and end of the high-speed railway construction project in the mined-out area and the steps included.

(7) Time: the duration of the entire project and the timing relationship of different activities when constructing high-speed railway above the goaf.

(8) Activities: in each stage and step of the whole project, the rules and practices that actors should be based on.

(9) Environment: the natural environment, social environment and external environment above the goaf in the process of high-speed railway construction.

The basic elements of the above nine projects constitute the basic content of the high-speed railway construction project in the mined-out area, which includes the basic properties and characteristics of the project, and describes the relationship between people, things and things, and people and things contained in the project. The eight basic elements outside the environmental factors are within an engineering boundary. Under the condition of environmental factors, they are closely related and interact with each other to form an engineering system. Therefore, according to the basic characteristics of the nine basic elements, the high-speed railway construction system in the mined-out area is divided into seven subsystems:

(1) Construction object system: the high-speed railway entity above the goaf to be built includes various components of the high-speed railway project, such as subgrade engineering, demolition engineering, engineering design, goaf management, etc.

(2) Construction process system: that is, all steps to be experienced in the construction of high-speed railway in mined-out areas: construction preparation, mined-out area management, subgrade engineering construction, loud and T beam erection, track slab laying and track engineering construction, comprehensive commissioning and trial operation.

(3) Construction organization system: an organic collection of all organizations, individuals and their skills, knowledge structure, organizational norms, moral standards and codes of conduct involved in the completion of high-speed railway construction.

(4) Construction technology system: namely, high-speed railway construction technology activities in mined-out area and all the principles, methods and means used.

(5) Construction support system: that is, all the entities supporting technology and management activities, such as mechanical materials, construction materials, daily production and life of personnel, etc.

(6) Construction management system: an organic collection of management activities such as principles, methods and means used in the construction of high-speed railways in mined-out areas.

(7) Construction environment system: that is, the system composed of natural environment, social environment and construction environment in goaf during construction, which affects the construction process of high-speed railway engineering.

4. Difference between High-speed Railway Construction System in Goaf Site and High-speed Railway Construction System in Common Site

The high-speed railway construction in mined-out area is different from the general high-speed railway construction. In addition to the common subgrade settlement, slope collapse, midline position deviation in subgrade construction, subgrade cracks, insufficient compaction and other construction problems, the effect of load generated during construction on mined-out area foundation and high-speed railway subgrade and its influence on construction should be considered. Therefore, in order to find the uniqueness of the research object, the construction system of high-speed railway in goaf area is analyzed from the following two aspects :

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4.1 On the Basic Elements of Engineering

The basic engineering factors of high-speed railway construction in mined-out area and non- mined-out area are compared to clarify the characteristics of high-speed railway construction system in mined-out area in this study (Table 1).

Table 1. Comparison of Basic Elements of Engineering

Basic elements	Construction Engineering of High Speed Railway	High Speed Railway Construction Project in Goaf Site	Differe-ntiation
User	Passenger	Passenger	N/A
Target	It can work normally in normal environment, eventually get high-speed railway entity.	It can work normally in the dangerous environment of goaf, and finally get the high-speed railway entity.	Yes
Resource	Basic material conditions for achieving the objectives	On the basis of realizing the basic material conditions of the target, the materials, equipment, tools, facilities and information needed for the treatment of goaf are added.	Yes
Actor	System contractors, logistics support units, ability, quality, and moral standards	In addition to the basic ability and quality of contractors, management and supervision units, the ability to deal with the goaf environment	Yes
Methods and techniques	Means of achieving engineering tasks, including technical and managerial aspects	In addition to technical and management tools, responses to mined-out areas and technologies should also be included	Yes
Process	The construction preparation, subgrade engineering construction, loud and T beam erection, track slab laying and track engineering construction, comprehensive commissioning and trial operation process of high-speed railway construction are required.	Construction preparation, goaf treatment, subgrade engineering construction, loud and T beam erection, track slab laying and track engineering construction, comprehensive commissioning and trial operation process of high-speed railway construction in goaf site.	Yes
Time	The duration of the whole project during high-speed railway construction and the timing relationship of different activities.	The duration of the whole project and the time sequence relationship of different activities during the construction of high-speed railway above the goaf.	Yes
Activity	Regulations and practices that should be followed by actors throughout each stage and step of the project.	Regulations and practices that should be followed by actors throughout each stage and step of the project.	N/A
Environment	The system composed of natural environment, social environment and construction environment in construction affects the construction process of high-speed railway engineering.	The system composed of natural environment, social environment and construction environment in goaf during construction affects the construction process of high-speed railway engineering.	Yes

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4.2 From a Risk Perspective

The mined-out area refers to the underground cavity left after the mining of underground ore bodies. After the local lower ore bodies are mined, a cavity is formed, and the surrounding stress balance is destroyed, resulting in the redistribution of stress and the formation rupture and collapse[8]. It is the root of the risk. The status of the mined-out area plays a crucial decisive role in the possibility and severity of the risk of the mined-out area[9] . For example, the geological conditions of mines, such as whether the rock mass structure is complete, whether the geological structure is complex, and whether the surrounding rock structure is complete, have a great influence on the stability of the mined-out area formed after mining and the possible risk types. From the risk generated in the construction process of high-speed railway in the mined-out area and the system disturbance caused by the risk, the stability of the construction system is an important source of risk.

In the construction of high-speed railway above the goaf, the load generated in the construction and the load generated by mechanical equipment and personnel are transmitted to the underground, and the subsidence of the goaf occurs, and even the foundation of the stable goaf is activated and deformed, which further leads to the deformation of the subgrade, affects the stability of the construction, and has a huge impact on the construction safety and even the operation safety of the high-speed railway. In view of this influence on the stability of mined-out area and the stability of high-speed railway subgrade, the risks of the system are studied from the perspective of their interaction:

Firstly, the effect of mined-out area foundation on high-speed railway subgrade: because the surface of mined-out area has ' two movement ' and ' three deformation '[10], with the surface movement and deformation of mined-out area, it also affects the stability of high-speed railway subgrade in mined-out area. When the high-speed railway subgrade is located above and above the edge of the goaf, it has different effects on the high-speed railway subgrade, but it will directly damage the subgrade and generate risks.

Secondly, the effect of high-speed railway subgrade on mined-out area foundation: there are caving zone and fracture zone under mined-out area foundation, and the bearing capacity and anti-interference ability of the two zones are relatively poor. Under the action of construction load, the internal structure of the subgrade transmits load downward, and further brings it to the mined-out area foundation, so that the accumulated settlement deformation of the mined-out area foundation occurs.

4.3 Characteristics of High-speed Railway Construction System in Mined-out Area

The mined-out area is located underground. There are many hidden projects, and the construction materials are complex. In addition, due to improper operation or insufficient detection in the construction, the foundation of the mined-out area and the subgrade of the high-speed railway sink or tilt, and the deformation of the track structure are adversely affected, which endangers the safety of railway operation and construction. The influence of the subgrade settlement on the project is persistent. In the construction, the monitoring and measurement of the site by the construction personnel, the design of the subgrade structure and the specific construction organization should be focused on. In general, it has the characteristics of complex construction materials, hidden construction process, large construction interference and high risk occurrence frequency.

5. Conclusion

The introduction of resilience concept into high-speed railway construction system can provide new ideas for risk management of railway construction projects. Through the definition of resilience, the resilience connotation of high-speed railway construction system in mined-out area is analyzed, and the characteristics of construction system are studied to ensure the uniqueness and scientificity of the study, which provides ideas and methods for the application of toughness concept in high-speed railway construction system.

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References

[1] L.Yuan, Y.D. Jiang, K. Wang, et al. Scientific thinking on precise development and utilization of closed / abandoned mine resources in China (Journal of Coal), Vol.43(2018) No. 01, p. 14-20.

[2] C. S. Holling. Resilience and Stability of Ecological Systems (Annual Review of Ecology and Systematics), Vol. 4 (1973).

[3] L. Huang,C. Wu, Mian. Y, et al. Application of toughness theory in safety science (China Journal of Safety Science), Vol. 27 (2017) No. 03, p. 1-6.

[4] E. Specking, B. Cottam, G. Parnell,et al. Assessing Engineering Resilience for Systems with Multiple Performance Measures (Risk analysis : an official publication of the Society for Risk Analysis). Vol. 39 (2017) N0. 09.

[5] J. Demetrios, K. Roy. A Novel “Resilience Viewpoint” to aid in Engineering Resilience in Systems of Systems (SoS),Vol.28(2018) No.01.

[6] Y. Wang, H. Jin, S.S. Fu, et al. The thinking transformation of system security : a comparative study of risk and resilience (Journal of Safety Science),Vol. 28 (2018) No. 01, p. 62-68.

[7] F. Liang, L.L. Cao. Linking Employee Resilience with Organizational Resilience: The Roles of Coping Mechanism and Managerial Resilience (Psychology research and behavior management), Vol. 14 (2021).

[8] J. C. Wang. ' Activation ' law and stability evaluation of goaf under railway load (Qingdao University of Technology) , 2016.

[9] Z. W. Shang.Research on risk analysis and control scheme of goaf in traditional mining areas in Hebei Province (Hebei University of Economics and Trade), 2021.

[10] L. W. Ren, H. Ning, Y.F. Zou, et al. Research status and prospect of high-speed railway subgrade deformation control in mined-out area (Journal of Coal), Vol. 46 (2021) No.08,p. 2534 – 2547.