

Application Status and Trends of Bolting-Shotcreting-Mesh Supporting Technology in Underground Engineering and Its Application in Ivory Coast

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Abstract. Many gold mines deposits have been discovered recently in Ivory Coast. The current government tries all the possible ways to develop the mining sector. However, the artisanal gold mine leads the operation in all the major parts of the country. The bolting-shotcreting-mesh supporting technology, which serves as an anchorage technology, has mainly been a part of traditional civil engineering. In case we refer to the historical development of the bolting-shotcreting-mesh supporting technology in geotechnical engineering, some of its application status aspects include standard construction, design, anchoring material and construction technology. For this reason, this paper focuses on the problems of the anchorage technology and how the development trend of the anchorage technology can be useful in Ivory Coast gold's mining industry.

1 Introduction

According to its definition, Bolting-shotcreting-mesh supporting technology as an anchorage technology is a technical method with the superiority of technology and economy. So far, Bolting-shotcreting-mesh supporting technology is not only widely used in the world's major coal countries (such as China and Australia), but it can also be applied to the projects of metallurgy, water conservancy and hydropower, railway, highway, constructions and so on. This is more especially in the underground geotechnical engineering, which studies the rock masses and soil in order to develop and use the underground space resources including underground buildings, subways, highway tunnels, and so on ([1]-[4]).

For bolting-shotcreting-mesh supporting technology, anchor rods and sprayed concrete together form load-carrying structures. Fig. 1 below shows how the effect of an anchor rod and sprayed concrete would effectively limit the free flow of surrounding rock deformation, and prevent rock mass from scattering and falling.

According to historical records, the bolting-shotcreting-mesh supporting technology's historical background lie in the fact that bolts were firstly used in the supporting of rock roadways in 1911 in the US. People first used bolt cables in the West Lycia mines in 1918. In Africa, more precisely, in Algeria, a pre-stressed bolt with the bearing capacity of 10,000kN was firstly used in order to realize the stability of the dam engineering.

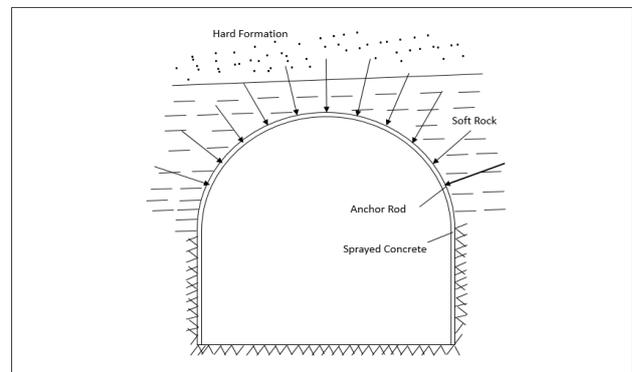


Figure 1. The bolting-shotcreting-mesh supporting schematic diagram

In 1989, Australia employed a new anchor bearing the capacity of 16500kN, which was made up of 65 sticks of steel strand. China, especially in Beijing, will also develop some big foundation pit projects, by using pre-stressed underground anchors to support pile wall structures in Beijing city such as Beijing city building, Wangfu hotel, and so on ([5], [6]).

The recent deep exploration in Ivory Coast showed that the country possesses rich mineral resources. Though the government has paid more attention to mining development than before, the management of artisanal gold mines remains a key problem in the Ivory Coast mining industry. In addition, many of the mines are unexplored and many known deposits are undeveloped which has hindered the rapid growth of economy. Therefore, we face enormous problems in its level of

development. The problems are of an environmental, technological, economic, and local society nature issue.

Nowadays, to face the underground engineering in many aspects, the bolting-shotcreting- mesh supporting technology will be used and spread deeply, in order to enhance mining development. Some countries such as Australia, Britain, USA, FIB, Japan and China, have successively promulgated the technical manual of an underground anchor. Even if in this decade, many researchers and scholars have obtained many research achievements in the supporting technology and theory, there is still a need for more deep researches working to reach the goal. Hence, the importance to find the development trend of the supporting technology according to its applied status is required. That is why this paper strongly suggests the use of Bolting-shotcreting-mesh supporting technology in the Ivory Coast mining industry, in order to reduce the risks of artisanal mining in the country ([7]-[11]).

2 Application statuses

2.1 Standard construction

The government of Ivory Coast can, in order to design and construct the geotechnical anchorage technology economically and safely, use bolt shotcrete supporting technology specification, soil anchor design and construction specifications, bolt shotcrete supporting technology specification, rock and soil anchor rod technical procedures, which will reflect the new achievement in the Ivory Coast anchorage technology field as it has been done in China several decades ago.

Ivory Coast has the biggest hydraulic which produces and provides electricity to many neighbouring countries such Burkina Faso and Mali. Hence, the department of hydraulic and electric engineering and construction department can also be the main corresponding industrial standard, including hydraulic pre-stressed anchorage design specification, construction of foundation pit supporting technology procedures, water and electricity engineering pre-stressed anchorage design specification, hydropower project construction specification support by rock bolt shotcrete and reinforced cement-soil pile anchors, to support technology procedures.

2.2 Design method

The types of projects differ from one to another, so some big differences exist among the design methods and analytical theories in the geotechnical anchorage technology. The anchorage design methods applied in underground geotechnical engineering are: analytical method, including elastic-plastic analysis and ultimate analysis, empirical method including engineering analogy method and expert experience method, and new Austrian tunneling method. For sure those methods can be useful in Ivory Coast as it has been successful in China.

2.3 Anchorage material

In the case of Ivory Coast, we also will increase the varieties of anchors as it had been done recently in order to improve the adaptability of anchorage material in different working conditions, and increase its economy. Normally the ordinary anchors which are applicable in engineering practices include the grouting type and mechanical type pre-stressed anchor, tensile type and compressive type pre-stressed anchor, loading-distributed anchor, whole-bond type anchor, hollow grouting anchor, friction anchor bolt and many others.

It is notable that the Ivory Coast economy still weak, and not strong as countries such as Australia, USA or China. As such, applying the early strength cement anchor for the binding material of the rock bolt remains the proper method, and it is a fast and cheap method. The pulling resistance of the cement volume anchor can bear up to 145kN after 3 hours installation in Ivory Coast.

3 Development trend

3.1 Technical study

The theoretical researches of anchorage technology in geotechnical engineering are as follows:

(1) The research on the force-transferring mechanism should consider the fact that the bond stress is not uniform, and proposes a calculation method for the real bearing capacity of anchor.

(2) According to the half theory and half experience design philosophy, a calculation method of the bolt supporting system that considers the anchor group effect should be proposed.

(3) Studying the anchorage mechanism including the effect of pre-stress on the stress distribution in rock or soil mass, the effect of anchorage solid on the physical and mechanical properties of rock or soil mass, the interaction between the anchor and the rock or soil mass.

(4) Study and propose the reasonable simulation model, and the force-transferring rule in tensile type, compressive type and shear type anchorage solid.

(5) Study the simulation method of anchorage effect and mechanical effect of the anchor.

(6) Study the working mechanism of composite soil nailing wall and its design method.

(7) Study the theoretical analysis of an anchorage system and its computing method.

(8) Study the relationship between the bonding property of the bonding part of the anchor, and the bonding length, and study the factors affect the anchorage effect.

(9) Study the effect of pre-stress of an anchor on the stress redistribution of the rock and earth mass, and its mechanical properties.

(10) Study the anchor properties and design method under special conditions like earthquakes, impacts, dynamic loads, high temperatures.

3.2 Engineering application

The applied research of anchorage technology in geotechnical engineering is as follows:

(1) Research, development and application of high strength anchor.

(2) Research and development of light, high efficient, rapid and multi-functional drilling rig and its equipment; the development of the comprehensive anchoring machine; research and development of the comprehensive pre-stressed bolt cable.

To apply to large geotechnical anchorage engineering, recently, Ivory Coast will introduce all kinds of crawler-type hydraulic machines and some new type of drilling machines from some countries such as USA, German, Italia' China and Japan. Some drilling rigs made in China such as CM351 type, KQJ-100B type, QZ-100K type rock bolt drilling rig and 811L type, YTM87 type, KGM5 type soil anchor drilling machines, can be useful in the Ivory Coast because they can protect the casing well, and drill up 60 m ([11]-[14]).

(3) Develop new kinds of anchors and new technology; improve industrialized production of the anchor and its devices. Additionally, develop removable core bolts and enlarged-top bolts, self-drilling bolt, pressure-relief anchor, high strength pre-stressed long bolt cable.

To improve the adaptability of anchorage material in different working conditions and increase its economy, the varieties of anchors have been increased in recent years. The friction type rock bolt, including slot-tube anchor and water expansion anchor, has many advantages. For example, it can make the surrounding rock under three dimensional pre-stress status after installed, have good ductility. Its anchorage force could be increased substantially when the surrounding rock moves or is shaken. As such, it is especially applicable for soft rock surroundings or blasting effect underground projects. So far, this kind of friction type anchor has been applied into more than 100 underground coal mine projects. Anchors with resin bonding and anchors with early hardening cement has the characteristics of early strength, enough supporting resistance timely, which are used more and more. Compared with the normal anchor, pressure-relief anchor or retractable type anchor can bear bigger deformation. And its application can supply a more effective supporting method for the roadway with big deformation or affected the dynamic loading.

(4) Improve the long-term performance of anchor and safety assessment of anchorage projects, improve the construction quality control and project reliability detection, test the grouting density, and study real-time monitoring and network transmission test technology on the basis of network information.

(5) Study the pre-stress loss control and anticorrosion, control of mechanical stability and chemical stability of soil bolt anchor, pre-stressed bolt cable stability under the conditions of formation creep, steel relaxation, temperature change, impact force, and earthquake.

(6) Develop an expert system for the design of bolt-shotcrete supporting technology under different geological conditions.

(7) Discover how to recycle the anchor. According to the development history of the recyclable anchor structure, there have been many kinds of recyclable anchors including the slant wedge, double wedge, expanding shell bolt, invert sphenoid bolt, cement bolt, and so on.

4 Conclusions

The technology geotechnical anchorage technology still cannot satisfy the requirement of engineering practices, even if it has made much progress in the past several years. For this reason theoretical research and engineering practices should be improved and innovated in order to influence the outcome of the engineering practices requirements. And its applied range and status will be spread and developed with the improvement of the technology level. As new trends come in the Ivory Coast mining industry, the country needs to develop and apply electrical isolation bolts technology in order to test the anticorrosion property, which can become anchor standard in Ivory Coast and Africa. Ivory Coast can also develop soil anchors in order to change the force-transferring mechanism and decrease the fixed length. The artisanal gold mines over the country will greatly be reduced.

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