

Suitability Evaluation of Tunnel Engineering to Protect Ecological Environment

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Abstract: Transport development bring a negative impact on human survival ecological environment, such as destruction of vegetation, air pollution, soil erosion and other environmental issues. The actuality proves that the use of tunnel development of underground space can improve traffic quality, while also protecting the environment. Therefore, tunnel engineering and utilization of underground space are to protect the ecological environment to be effective ways for realizing economic sustainable development of economy. In this paper, based on the practical application at home and abroad, for the big cities, mountain areas, river waters, the suitability evaluation and beneficial discussion about the transportation by using tunnel to protect the ecological environment are of great practical significance to protect and improve the ecological environment.

1. Introduction

Ecological environment protection issues have received more and more attention in the world, the economic development make the world face a common problem, that human life environment has been damaged to a different degree. Such as building highways lead to destruction of forests and grasslands and other vegetation, frequent occurrence of slip of highway slope and debris flows, noise generated by vehicles affect the living and automobile exhaust pollute air. By means of tunnel engineering developed underground space, which not only offer the possibilities for transport development and traffic quality improvement, but also save land resources, improve ecological environment. Therefore, tunneling and underground space development is an important measure for economic sustainable development. Based on the practical application at home and abroad, for the big cities, mountain areas, river waters, the suitability of the transportation using tunnel to protect the ecological environment is discussed in the paper.

2. Suitability of the underground expressway to protect urban ecological environment

With the economic development, a large urban population is growing rapidly, city size is expanding, the number of cars is increasing at the rapid of 15% per year, and the cities traffic congestion problems are becoming more severely^[1]. To solve urban traffic congestion problems, some cities take advantage of air resources, which built a large elevated road. However, there are a lot of drawbacks in the construction of elevated road, such as noise generated by vehicles running in the elevated road affect the nearby residents' daily life; emissions produced by the vehicle on the elevated road and the road aggravate air pollution in the city, and ecological environment is becoming worse; the emergence of elevated road, just like "waistband" in the city, affect the city's visual appearance. The influence of noise, vibration and pollution leads to depreciation of the real estate along the elevated road, ecological environment deterioration, and decrease in the city's comprehensive competitiveness.

The foreign practice indicates^[2], the construction of urban underground expressway, which make full use of underground space, is to solve urban traffic congestion, while a very effective way of protecting the environment. In Boston, U.S., 1994, removed the original six-lane elevated road, in the original position' built 8 to 10 lane underground expressway and four-lane tunnel which was through the Boston Harbor and led to the airport. At the same time built boulevard, green spaces and urban development land on the removal elevated road. In 2002, the Moscow Third Ring Road

run through Lie Fuer regions, which is well-known for its beautiful scenery and many cultural relics, without destroying its cultural landscape, government decided to build in the 36 meters deep underground expressway through the area. As the underground expressway will not only cut off noise from the vehicle^[3], but also can set up the facilities to filter and break down smoke dust hazardous substances in automobile exhaust, filtered and processed by the facilities emission is almost pollution-free air, carbon monoxide in the air reduced by 12%^[4], the city's air quality has been significantly improved, and the city's ecological environment has been well improved.

At present, because of a serious shortage of land and space resources, coupled with the shackles of cultural landscape can not be a significant expansion of the ground road facilities, many large cities make a full use of the underground space and construct some underground expressways, which is the only way for sustainable urban development^[5]. The style of these expressways are underground closed, keeping pedestrians and bicycles from ground interference, from rain, snow and other inclement weather conditions' influence, so the vehicles possess some characteristics including high speed, safety and comfort, and great traffic capacity. The data show that day and night traffic capacity of the three-lane with width of 14 m can reach 80,000 or more. The advantage is obvious in the underground construction, reducing the land use, no need for relocation and land acquisition, and saving construction investment. The reason why Japan decided to build an underground highway is savings in investment in large extent. According to their project cost estimates, the underground expressways lower than the elevated road way 20 to 30%. In addition, expressway protect underground construction style and history of the city's cultural landscape, and to create favorable conditions for making green for urban garden, realizing separation of people and vehicles, building pleasant and beautiful open floor space, and building a good ecological environment. Fully using underground space to develop tunnel, which no doubt should be an effective way to improve the living environment, protect urban style.

3. Suitability of the mountain tunnel to protect the natural environment

"Every mountain open, over the mountains", the traditional methods of crossing the mountains is to repair winding mountain, the main design factors considered is technology and economy. To ensure design speed and safety, the design tend to adopt high-tech targets, while overly pursuit the flat of routes, the continuity and fluency of the longitudinal linear, or to use subgrade with tall filling and deep excavation, while emphasize the linear beauty and the balance of digging and filling quantities, so produce a lot of high and steep slope^[6]. Further, because of the construction also need some temporary pavement, barrow pits, waste banks, slurry construction and other structures, as a result, the water along the winding mountain road is destroyed, soil and water loss, ground vegetation and forest are destructed, the connection and active channels of animals and plants are cut off, which causing serious damage to the ecological balance, so that the destructive vegetation are unable to replaced and restored. With the development and progress of engineering technology, appearance of full-face rock tunnel boring machine, the use of tunnel project and shallow buried tunnel engineering to cross the mountains become the new trend at home and abroad. The tunnel will not only shorten the route, keep transport fast, comfortable, greatly improve operational efficiency and to preserve vegetation and forests, thus to protect the ecological environment.

Highway construction focuses on respecting environment, combined with design conception of protection of the environment to a greatest extent in Sichuan, Guizhou Province. It changes traditional idea that open up mountains when see mountains, constructing bridge when see bridge. Highway, in Sichuan, Guizhou Province, has complicated topography. In order to protect the ecological environment, the number of bridges and tunnels is bound to increase. The accumulation mileage of the bridge and tunnel account for 49.5% of total project mileage at Xuyong-Guizhou section. Therefore, the number of bridge and tunnel is much more than conventional construction methods. The proportion of bridge and tunnel increase, so that the difficulty of construction increases, schedule delay, and investment increase. According to the idea that protect ecological environment and do not damage environment in large extent, the engineering would rather increase

the project cost but also to protect the ecological environment. In order to minimize cutting of trees, the engineering take the strategy of "early hole later out of its hole," to build, that is to say extend the length of the tunnel. It also invested 3 million to set up guardrail, animals and plants observation stations, and wildlife passage, in order to maximize the protection of animals and plants, and to maintain the ecological environment here as much as possible.

Laoshan tunnel which is located in the origin of Ninhuai expressway at Nanjing section, connecting with the North Link-line of 3rd nanjing changjiang river bridge, is three lanes in each of the two separated holes on both sides, the net width of tunnel is 14 meters, the net height is 5 meters, a total length is 3595 meters, and project estimate is 350 million yuan. According to the environmental ideas of "Don't damage is the best protection", insisting on the purpose of maximum protection, minimum influence, and strongest recovery, to pay equal attention to highway construction and environment protection, meanwhile, insisting on people and nature in harmony, to establish the construction concept of respecting nature and protecting environment. The mountain which is hundreds kilometers has tall ancient trees all green, only reached nearly 600 kinds of wild plants, including the secondary endangered animal protection, *Luehdorfia chinensis* Leech.^[7], which is unique and rare in china. Obviously, if we imply the traditional method of "exploding the mountain for the road", we have to destroy the natural landscape of the mountain and the living environment of wild animal. We should take the method of building tunnel to cross Laoshan, although the construction cost will increase, the ecological environment received protection at maximum level.

Qinling Zhongnanshan extra-Long highway tunnel is a world-class super long highway mountain tunnel. Its design is both twin-tube and four-lane with upper and lower branches. The speed is 80km per hour, total length of a single tunnel is 18.02km, twin-tube's length is 36.04km, tunnel's net width is 10.92m, and its height is 7.6m, lane width is 7.5m. Because of high elevation of Qinling hinterland, the road crossing the Qinling Mountains is above the snow line, so that vehicle safety can not be guaranteed. If the program does not use long tunnel pass through Qinling, the road will winding circuitous detour and climb. Thus it will bring the huge damage to Qinling which known as ecological botanical garden in Asia. In order to protect ecological environment, long tunnel scheme can make the line length short, reduce the ice and snow influence to the car^[8], secure the driving safety, improve the driving condition, enhance the standard of service, decrease the traffic accident and reduce the transportation cost. What's more, tunneling will protect ecological environment and make the harmonious coexistence of human and nature.

4. Suitability of the mountain tunnel to protect the natural environment

When the transport need to across waterway, whether choose a bridge or underwater tunnel will be in use, which is decided primarily According to the shipping, hydrology, geology, ecological environment, the amount of demolition work and other specific construction conditions to conduct a comprehensive comparative analysis and scientific studies. Tunnel program is a better choice for large vessels to across the waterway. As we all know, the unit cost of tunnel is higher than bridge, but bridge always have an impact on shipping due to the bridge height and width restrictions. For example, Nanjing Yangtze River Bridge Limited by the height, the traffic capacity of Golden waterway reduced from 10,000 tons to 4,000 tons. Therefore, if we want to meet the shipping weight more than 10 to 20 million tons, bridge will need to have vertical clearance of more than 50 to 60 meters, also the width of the bridge and the length of bridge approach need to be scaled. And all of that will result to greatly increasing the cost and difficulty of the bridge. What is more, that is bound to make vehicles drive slowly on the uphill of bridge approach with long distances using the limit 4 percent slope according for shortening the length of bridge approach. Consequently, not only the traffic capacity of the bridge is reduced, but also environmental pollution owing to more fuel consumption and exhaust emissions is aggravated. At this point, comprehensive benefit from using underwater tunnel project is better than the bridge one. The biggest advantage of underwater tunnel is that the urban environment pollution of noise, dust and exhaust gas generated by cars can be avoided^[9]. In addition, channel clearance is not occupied during the operation period^[10], which

helps protecting waterway shipping from harsh weather conditions and make cars run comfortably and smoothly. On the contrary, Bridge is vulnerable to weather changes such as typhoons, fog, rain and snow. So bridge transport could not operate around the clock. And it is difficult to ensure the traffic capacity of bridge and to avoid traffic accidents.

To meet the needs of two banks of waterways development in modern city, if using the bridge to cross river, then the construction of bridge may involve a large number of urban house removal and occupation of land, resulting in a total investment of bridge construction is higher than the underwater tunnel. In this circumstances, the comprehensive benefit of tunnel is better than bridge in technology, economic, and environment. For example, Xiamen East Passage Submarine Tunnel Construction, bridge program need 514.8 acres of land and 3.3 billion yuan, but tunnel program need only 30 acres of land and 3.25 billion yuan. So, tunnel program is not only economical, but also can save a lot of urban land. Its economic and social benefits are superb. Besides, the water with high maintenance requirements of environment and landscape. It can well keep the original beautiful natural water scenery and protected the harmony riverside visual landscape. To some extent, building bridges may interfere with the natural beauty^[11].

Underwater tunnels can effectively resist earthquakes, typhoons, tsunamis and other natural disasters. Moreover, in war situation, as a transportation hub, bridge is the first attack object. Once the bridge is destroyed, not only its traffic will be disrupted, but also it will hinder normal sea shipping. So, taking into consideration for the force majeure, underwater tunnel is superior to bridge. It should be noted that disaster loss of underwater tunnel is greater than bridge in the event of fire, floods, explosions and other emergencies.

In conclusion, underwater tunnel is a more appropriate program than bridge from overall efficiency of society, economy, environment and resisting force majeure. Firstly, using underwater tunnel through waters can make little impact on the urban environment in the way of avoiding traffic noise, dust and exhaust gas pollution. Secondly, structural stability and durability of tunnel can greatly extend the life of the tunnel. But bridge exposed to the air always inevitably withstand a variety of adverse environmental factors. Thirdly, around the clock operations can greatly enhance the transport efficiency from the impact of adverse weather conditions.

5. Conclusion

The suitability of transportation using tunnel project through the urban, mountains and rivers protect ecological environment including:

- (1) Reduce the noise and exhaust generated by vehicles to pollute the environment.
- (2) Save urban land resources, improve the urban ecological environment, and preserve the human landscape.
- (3) Reduce the vegetation damage in mountain areas and protect the animals and plants natural ecological environment.
- (4) Keep from the influence of adverse weather, and ensure smooth traffic flow during a whole day.
- (5) Underwater tunnel does not affect water shipping and maintain the natural landscape of the original waters.
- (6) Resist strongly natural disasters and war destruction.

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