Chapter 4

Sustainable Traffic

4.1 South-North Expressway of Montenegro

To realize the design objective of pursuing green development and environmental protection, the South-North Expressway of Montenegro Project adopted the green design strategy and technical solutions of closed drainage systems, reduced the content of water pollutants on the road surface, and reached the EU standard for wastewater discharge (EN858). The closed drainage system, featuring high technical integration and process innovation, can be effectively harmonized with expressway construction. The “green and environmentally-friendly” design concept can fully filter out water pollutants on the road surface, reduce the damage caused by surface water to water resources and the environment along the road, and produce favorable environmental and social benefits.

4.1.1 Background

The South-North Expressway is the largest infrastructure project since the founding of Montenegro, and also the first of its kind in the country. Following its completion, the expressway will become part of the international road traffic network, lead to many countries in Central Europe, and drive the economic and social development of Montenegro and the entire Central and Eastern Europe. Therefore, the project has attracted wide attention from the entire Europe.

4.1.2 Project Overview

The South-North Expressway of Montenegro stretches from its southern city Bar Harbor to Boljare in the north, with a full length of around 180 km. According to the plan prepared by the government of Montenegro, construction is divided into five phases, giving priority to the 41 km section from Smokovac to Matesevo. Started in May 2015, construction was undertaken by the China Road and Bridge Corporation (CRBC) of China Communications Construction Company Limited (CCCC), with the contracted amount reaching EUR 809 million (Fig. 4.1).

This section is also the most difficult one in terms of technology and engineering. It mainly includes 20 main bridges, 16 tunnels, four interchanges, one service zone,

Fig. 4.1 Location of the project (green part)

Fig. 4.2 Construction site of the Podgorica bridge (2018)

one maintenance area and four toll stations. The total length of tunnels and bridges are 18.3 km and 6.25 km respectively, accounting for 60% of the entire section. In October 2019, the two sections from Smokovac to Matesevo were formally joined, marking the final stage of the construction of its main structure (Fig. 4.2).

4.1.3 Green Design Strategies and Technical Solutions

(1) Green Design Strategies

The South-North Expressway of Montenegro Project stretches over the Tara River, which is called “Tear of Europe”, and River Moraca, a main river in Montenegro. To preserve water resources and the environment, the project team envisioned environmentally-friendly drainage for the closed drainage system.

The design concept and core idea are as follows. Under the impact of various vehicles, water on the road surface is normally polluted by hazardous substances such as tire bits, oil stains and pitch particles, so it cannot be directly discharged to the natural environment. Instead, the water can only be discharged after it is collected, precipitated and purified via a special drainage system. Admittedly, not all surface catchment is polluted. According to this idea, continuous rainfall will wash away dirty substances from the road surface. Only the first 20% of surface catchment is the most contaminating, and the rest of the 80% that follows can be directly discharged into the surface drainage or natural environment. Therefore, the core of the closed drainage system is to collect and dispose of the first 20% of surface catchment, precipitate and filter

Fig. 4.3 Plan of the closed drainage system

Fig. 4.4 Profile of the closed drainage system

it, and discharge it into the natural environment after it meets certain ecological and environmental indexes.

(2) Technical Solutions

The design of closed drainage is mainly targeted at rainwater on the carriageway and other road surface water, and mainly comprises side ditches, water-collecting well, inspection wells, drainpipes, settling ponds and oil–water separators (Figs. 4.3 and 4.4).

The working mechanism of closed drainage design is as follows. In a drainage system unit, road surface water flows into the side ditch from longitudinal and cross slopes, flows into the reasonably placed water trap, then into the inspection well, and eventually follows installed tubes to the processing terminal. Through setting up pipes with different elevations at the diversion inspection well, the system directs the first 20% sewage into the settling pond for purification in the oil–water separator and then release it. The remaining 80% of rainwater is directly discharged through the branches. Every component of the system has been scientifically analyzed and proved with distinct characteristics.

The closed drainage system can be closely combined with the design and construction of expressways. As the entire system is embedded in the roadbed, the system is both practical and decorative. While greening and protecting the environment, it does not affect the geometric shape and appearance of the expressway. Hence, it is a brand-new design concept and technique (Figs. 4.5, 4.6, 4.7 and 4.8).

Fig. 4.5 Water trapper and inspection wells along the roadbed

Fig. 4.6 Connection between the inspection well and drainage pipes

4.1.4 Environmental Benefits and Related Experience

The closed drainage system of the South-North Expressway of Montenegro Project complies with local hydrologic and meteorological conditions, as well as EU requirements for sewage discharge. With the system in place, under 10-min heavy rainfall (10-year recurrence interval), water on the surface of the expressway can be fully filtered and meet the requirements of the EU standard (EN858), i.e. pollutants content less than 5 ml/L, meaning that it can be directly discharged.

Fig. 4.7 Installation of oil–water separators

Fig. 4.8 Close combination between the closed drainage system and the expressway

There are many rivers and national forest parks along the South-North Expressway of Montenegro, and the road also stretches across some private lands. With extremely strict environmental requirements, the design of a closed drainage system fully filters wastewater on the road surface and satisfies EU standards on discharge without affecting road performance. In addition, through adjusting the property of its internal parts, the system is able to meet environmental protection requirements and discharge

standards in different areas and environments. Along the expressway, especially in districts with high protection standards of water resources and high environmental sensitivity, e.g. natural reserves, ecological preservation areas and drinking water source areas, the system is able to avoid or significantly reduce the road sewage-induced damage to nearby water resources and the natural environment, thus effectively improving the ecological environment.

The closed drainage system in the South-North Expressway of Montenegro is a brand-new design and part of the construction work, leading to higher costs. However, from the perspective of protection of environment and ecological civilization during project construction, such huge one-off investment brings about enormous value. The application of such a green design concept avoids potential environmental damage or pollution from the origin, and thus saves spending in repairing such damage, which is immeasurable.

4.2 Peljesac Cross-Sea Bridge of Croatia

The Peljesac Cross-sea Bridge of Croatia project has employed a mix of measures—optimization of design and the construction plan, reasonable allocation of resources, noise reduction by the application of a Bubble Screen, long-distance marine transportation of drilling slag and in-depth cooperation with local specialized firms—to protect the marine environment and promote green construction, which contributes to energy efficiency, material saving and the protection of the marine environment.

4.2.1 Background

Dubrovnik in southern Croatia is a famous tourist spot. However, a ride from the capital Zagreb to the city has to pass the roughly 20 km “Neum Corridor” in Bosnia and Herzegovina. During peak seasons, the Corridor is often overwhelmed by vehicles awaiting clearance. Building a cross-sea bridge over the Bay of Mali Ston in the Adriatic Sea will connect southern and northern Croatia, and residents commuting between the south and the north will no longer have to enter or depart the border. A few minutes’ drive will replace the original two to three-hour travel (Fig. 4.9).

In April 2019, Chinese Premier Li Keqiang investigated the Peljesac Bridge Project with the company of Croatian Prime Minister Andrej Plenković. Premier Li said that the Peljesac Bridge is a bridge of friendship, which not only connects both sides of the bay, but also carries the friendship between the two peoples, contributing to peace, stability, prosperity and development of the region. It is also a bridge of people’s livelihood, as it facilitates the flow of people and goods, offers convenience to local residents’ life, strongly promotes economic and social development, and improves people’s livelihood in Croatia.

Fig. 4.9 Blueprint of the bridge

Prime Minister Plenković stated that the Peljesac Bridge is a major infrastructure project carried out by Croatia and China and symbolizes the friendship and cooperation between the two countries. The bridge, long expected by the Croatian people, finally took shape with help from Chinese friends. Its completion will greatly help people with their travel, effectively promote local development, offer new market opportunities for Chinese enterprises, and play a demonstrative role in the pragmatic cooperation between Europe and China.

4.2.2 Project Overview

The Peljesac Bridge and its access roads is the costliest construction project to date in Croatia, with an estimated total construction cost of roughly EUR420 million. According to the plan, the project includes both the cross-sea bridge and its access roads. In particular, the bridge is 2.4 km long and 22.5 m wide, with a navigation clearance of 55 m; the access roads are 1.5 km long and 12 m wide. In June 2017, the EU officially approved the project and decided to undertake 85% of its construction cost (EUR 357 million).¹ In January 2018, a consortium led by China Road and Bridge Corporation (CRBC) won the bid for Phase I of the Peljesac Bridge and its access roads. The contract value is roughly EUR 280 million, and the construction period is 36 months. On July 31, 2018, the project was commenced (Fig. 4.10).

The Bay of Mali Ston in the Adriatic Sea, where the Peljesac Bridge is situated, belongs to the EU marine natural reserve, and is a key water for the EU to protect endangered species and their habitat. Besides, well-developed local fish breeding and

¹ <http://hr.mofcom.gov.cn/article/jmxw/201801/20180102698900.shtml>

Fig. 4.10 Construction site of the bridge

tourism industries are highly environmentally demanding. Therefore, reducing the impact of construction on the surroundings and carrying out environmental protection in strict compliance with local laws and regulations has become the key of the project.

4.2.3 Plan of Green Construction

(1) Narrowing the Scope and Time of Construction Impact Through Well-thought-out Planning

First, the plan for pile foundation construction has been optimized. There are a total of 150 steel pipe piles in the bridge (including test piles), with a total length of 15,483 linear meters and total weight of 31,100 tons. Compared with the conventional technique of bored perfusion, complete steel pipes are driven into the ground in the project with China's "Xiongcheng No.1" pile driving barge. Meanwhile, the steel pipes are molded in one take, and their welding quality fully satisfies the requirements of "EXC4 B + ". Therefore, there is no need to start construction after welding them on site, thus greatly reducing the risks of offshore construction. After optimization, the construction period has been reduced by three months, and the number of drilling machines, working vessels and staff has also been curtailed. Second, the plan for building the submerged elevated pile cap has also been optimized. Precast concrete cofferdam, used in the original design, occupies much space and is time-consuming. Following the optimization, precast concrete cofferdam floor and steel bolster plates are spliced to form a cofferdam structure, which enables not only simultaneous construction in the water, but also the recycling of these plates, thus significantly saving space and controlling environmental impact (Fig. 4.11).

Fig. 4.11 Construction of steel pipes (Left: steel pipe transportation; Right: steel pipe welding)

(2) **Use of Bubble Screen to Reduce Noise and Protect the Marine Environment**

The relatively huge noise from the welding process of steel pipes influences marine life. The project reduced noise with bubble screens: Air comes into pipes placed on the surface of seabed, and rising bubbles at the opening of pipes form a closed Bubble Screen. Due to difference between the density of air and water, the Bubble Screen causes high damping loss and scattering to noise transmission, brings noise out of the water and discharges it into the air. In addition, when the bubbles come out, water is disturbed and sound produced, which alarms marine creatures and allows them to escape from the construction area, so as not to be harmed (Figs. 4.12 and 4.13).

Thanks to the installation and successful application of bubble screen-enabled noise reduction devices, the steel pipe welding process could comply with

Fig. 4.12 Principle diagram of bubble screens

Fig. 4.13 Bubble screen-enabled noise reduction device (white annular duct)

local environmental protection and noise protection laws. No marine creatures have died from sound waves or high-energy vibration, and no complaint from nearby residents has been received.

(3) **Strict Control of Marine Pollution.**

The project team has allocated special funds for energy conservation and environmental protection. In 2019, more than RMB 4 million was invested in environmental protection facilities, mainly including purchasing oil barrage at sea to prevent possible oil spills, and using two barges to send drilling slag 20 nautical miles away for centralized discharge. The team also transformed three-level wastewater settling tanks into level-four tanks and connected all the wastewater-producing pipelines to ensure 100% recycling of wastewater. A treatment system of domestic sewage has been set up, and qualified local sewage treatment companies hired for regular disposal, so as not to cause any environmental pollution. As a result, marine pollution accident has taken place during construction (Fig. 4.14).

According to a report released by the sea bathing water quality in Croatia, in line with the standards set forth by the *Regulation on Sea Bathing Water Quality* (OG 73/08) and *Directive 2006/7/EC concerning the management of bathing water quality*, sea water quality in the construction area of the bridge was rated as EXCELLENT in both 2018 and 2019. The seven monitoring points set up by the agency within 50 km of the construction area were also rated as EXCELLENT.

4.2.4 Sound Social Benefit

The Peljesac Bridge is a project awarded to the consortium formed by the CRBC through open tendering and fair competition, which complies with market principles

Fig. 4.14 Third-party inspection of the construction equipment and domestic sewage treatment system in the living quarter

Fig. 4.15 Main construction materials and equipment meet CE certification

and EU rules. It is not only the first EU-funded infrastructure project undertaken by Chinese enterprises within the EU, but also the largest bridge project won by Chinese enterprises in the EU by now.

The project follows EU construction standards for bridges. Notably, the making of its steel structure has met the highest EXC4 standard in Europe. To better integrate into EU's construction system, the company undertaking the project has successively cooperated with eight design consulting firms within the EU for upfront issues, such as engineering design, safety and environmental protection consulting, legal and tax registration. It has worked together with 17 construction enterprises within the EU on measurement, geological surveys, experiments and testing, safety training and engineering consulting. It has also collaborated with 65 equipment and material suppliers from countries like Croatia, Romania and Poland (Fig. 4.15).

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