BRI International Green Development Coalition
2021 Policy Study Series

Green Development Guidance for BRI Projects Phase II Task 2:

Guide for Key BRI Sectors Highways and Railways

In April 2019, Chinese and international partners officially launched the BRI International Green Development Coalition (BRIGC) at the Second Belt and Road Forums for International Cooperation. BRIGC aims to establish a policy dialogue and communication platform, an environmental knowledge and information platform, and a green technology exchange and transfer platform, so as to advance global consensus, understanding, cooperation, and action of a green Belt and Road Initiative (BRI).

BRIGC officially launched the *Joint Research on Green Development Guidance for BRI Projects* (GDG) in 2019. The joint research aims to explore the guidelines on the assessment and classification of BRI projects from the perspective of mitigating and managing the climate and eco-environmental impacts. In December 2020, the Phase I report *Green Development Guidance for BRI Projects Baseline Study* was officially released. The phase I Baseline Study proposed "1 project classification mechanism" and "9 recommendations" (the "1+9") to accelerate the green development of BRI and reduce the negative impact of BRI projects.

The interconnection of transportation infrastructure, represented by railways, highways, ports and airports, is a key element of the BRI cooperation. As a priority cooperation area, China has made solid progress in facilities connectivity with BRI participating countries. Based on the Green Development Guidance for BRI Projects Baseline Study, this report establishes a life-cycle ecological and environmental evaluation indicator system and corresponding green solutions for railway and highway projects in the BRI participating countries. The report provides guidance for the planning and design of railway and highway infrastructure, and technical reference for construction units to carry out green railway and highway projects, so as to promote better harmonization between transportation infrastructure and the natural environment. The report puts forward targeted policy recommendations, such as conducting ecological and environmental assessments before project construction, identifying major environmental risks, applying the best feasible technologies and best practices for green development of railway and highway projects, strengthening the eco-environmental management capacity building of enterprises and projects, and continuously improving the green development of overseas railway and highway projects with Chinese investments.

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Executive Summary

The connectivity of transportation infrastructure, represented by railways, roads, ports and airports, is a priority area of Belt and Road cooperation. Promoting the development of green transportation infrastructure under the BRI is crucial to the building of Green Silk Road. Based on the Green Development Guidance for BRI Projects Baseline Study, the Report, focusing on the railway and highway projects of BRI participating countries, aims to provide a life-cycle ecological and environmental management system and green development solution for BRI railway and highway infrastructure projects, provide guidance to the planning and design of railway and highway infrastructure projects, and offer a technical reference for the green construction of railway and highway projects, in order to promote the integrated development and harmonization of transportation and environmental protection.

As a priority area for jointly building the Belt and Road, infrastructure connectivity between China and BRI participating countries has made positive progress. However, some transportation projects are faced with ecological and environmental risks in site and route selection, land occupation, and noise control with potential affects to the migration of wildlife, especially in ecological and environmentally sensitive areas.

Developing a feasible environmental impact assessment indicator system is the basis for conducting environmental impact assessment. Considering the need for basic data acquisition and quantitative assessment, the Report proposed the environmental impact assessment indicator system for railway and highway projects respectively, covering site and route selection, ecological and environmental impact, noise and vibration impact, water environment impact, atmospheric environment impact, solid waste treatment, information disclosure and public engagement, and environmental risk prevention.

To meet the requirement of life-cycle, whole-process, integrated green transportation infrastructure development, the Report implements green development concepts throughout the process of planning, design, construction, operation and maintenance and analyzes green technologies and requirements for the three stages of project design, construction and operation and maintenance with related cases for reference.

To promote the green development of BRI railway and highway projects, the Report proposes policy recommendations on ecological and environmental impact assessment prior to project construction, the identification of ecological and environmental risks, adoption of best practices and technologies for the green development of railway and highway projects, and capacity building of enterprises and project teams in ecological and environmental management, in order to achieve the high-quality green development of overseas railway and highway projects.

Chapter 1. Introduction

1.1 Research Background

Since being proposed 8 years ago, the Belt and Road Initiative (BRI) has become the world's largest and most extensive platform for international cooperation. According to China's Trade and Investment Cooperation Under the Belt and Road Initiative in the First Half of 2021, China is the largest contributor of global FDI in 2020, with the FDI from developed countries shrinking by 58%, which fully shows that China is playing an increasingly important role in promoting the green recovery of the global economy.

Chinese President Xi Jinping has repeatedly stressed the importance of strengthening ecological and environmental cooperation to promote the building of Green Silk Road. In November, 2020, the fifth plenary session of the 19th CPC Central Committee adopted the CPC Central Committee's Proposals for formulating the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035. The document pointed out that China will "uphold openness, integrity and environmental-friendliness" and "promote the high-quality development of the Belt and Road". Meanwhile, China also announced the vision to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060", proposed new measures to fulfill NDCs, and decided to incorporate carbon peaking and carbon neutrality into it overall plan for ecological civilization construction. On 21 September, 2021, Chinese President Xi Jinping announced in his statement delivered at the general debate of the 76th session of the United Nations General Assembly that "China will set up support for other developing countries in developing green and low-carbon energy, and will not build new coal-fired power projects abroad". The series of decisions made by China gained positive response from the international community. The development of Green Silk Road has huge potential and promising prospect with countries around the world putting climate governance and green recovery on the agenda.

Enhancing ecological and environmental risk prevention and management is necessary in the process of building Green Silk Road, which guarantees high-quality project implementation under the framework of BRI. Since 2013, the Chinese government has issued a series of policy documents to strengthen ecological and environmental risk prevention and management along the Belt and Road. With constant improvement in the green investment and financing system, the ecological and environmental risk management for overseas investment projects has also been significantly improved.

Transportation infrastructure connectivity, represented by railways, roads, ports and airports, is a priority area for BRI cooperation. Meanwhile, it is almost inevitable for infrastructure connectivity projects to have ecological and environmental impacts due to land occupation and technical complexity. Statistics show that the six economic corridors and six connectivity networks expand through multiple biodiversity hotspot areas. Therefore, promoting the green development of transportation infrastructure is of great significance to building Green Silk Road.

In April 2017, then Ministry of Environmental Protection, Ministry of Foreign Affairs, the National

Development and Reform Commission (NDRC), and Ministry of Commerce jointly issued Guidelines on Promoting Green Belt and Road. One of the major tasks proposed by the document is to "promote green infrastructure construction to safeguard ecological and environmental quality; develop environmental standards and regulations for infrastructure construction; improve ecological and environmental services for major infrastructure construction projects along the Belt and Road; and promote the application of standards and best practices in energy conservation and environmental protection in the development of green transportation, green buildings and clean energy". In April 2019, President Xi Jinping stressed in his keynote speech at the Opening Ceremony of the Second Belt and Road Forum for International Cooperation that "the Belt and Road aims to promote green development. We may launch green infrastructure projects, make green investment and provide green financing to protect the Earth which we all call home". These documents and statements all require the green development of transportation infrastructure.

In December, 2019, BRI International Green Development Coalition (BRIGC) launched the Study on Green Development Guidance on BRI Projects and published the Baseline Study Report in December, 2020. The study aims to develop clear and actionable classification system and green development guidelines for BRI projects, guide BRI projects to pursue green, low-carbon and sustainable development, provide green solutions to BRI participating countries and projects, and inform decision-making of financial institutions, businesses and governments of BRI participating countries.

Based on the baseline study, the 2021 study focuses on road and railway infrastructure projects and develops sectoral green development guidelines that provide assessment indicator system and solutions to overseas investment projects in identifying and preventing ecological and environmental risks, and improving the quality of ecological and environmental management.

1.2 Research Objectives

The study will provide life-cycle ecological and environmental management system and green solutions to road and railway infrastructure construction projects under the framework of BRI, covering the whole process of feasibility study, design, construction, operation and maintenance. The study will provide guidance to the planning and design of road and railway projects, offer technical reference for the construction of green road and railway projects, and promote the integrated development of transportation and environment, so as to contribute to the global biodiversity conservation and the building of a community of shared destiny for mankind.

1.3 Definition of Green Transportation Infrastructure

Green transportation infrastructure (roads, railways) refers to infrastructure projects that meet the requirements of green development. Through coordinating the relation between project quality, resource utilization, environmental impact, biodiversity conservation and operation efficiency, green transportation infrastructure projects could achieve optimal outcomes in terms of durability, resilience, landscape coordination, environmental-friendliness, energy conservation, safe operation, and follow-up services with

advanced philosophy, technological improvement and scientific management.

The study focuses on road and railway projects under the framework of BRI. On the scale of time, the study covers the whole life cycle of road and railway projects and implements the concept of green development into every stage of project planning, design, construction, operation and maintenance. On the scale of space, the study focuses on the direct and indirect environmental impacts of projects, and requires the implementation of the concept of green development in the construction of both the project proper and affiliated facilities.

Chapter 2. Development of Railway and Highway Projects along BRI

2.1 Progress Overview of BRI Highway & Railway Projects

The “going out” philosophy of China's high-speed rail construction and highway construction is becoming more and more important in promoting the in-depth development of economic globalization and green transformation. As a priority for joint construction of Belt and Road Initiative (BRI), relevant infrastructure has seen full efforts and positive progress made by China in connecting with countries along the route.

On the one hand, the number of China-Europe Railway Express trains is increasing, and its role as a strategic channel has become more and more prominent. Data shows that China-Europe Railway Express trains have made over 40,000 trips in total, opening 73 routes, reaching over 160 cities of 23 European countries, and transported more than 50,000 types of goods, which effectively guarantees the stability and smoothness of the international industrial chain and supply chain as well as promotes common development between regions, bringing more vitality for the joint construction of BRI projects. Since 2021, China-Europe Railway Express trains have continued to maintain strong growth. As of the end of August, a total of 10,030 trips has been made, 964,000 TEUs transported, an increase of 32% and 40% year-on-year respectively and approximately 97.9% of containers on the round-trip train are fully loaded, two months ahead of last year in terms of over 10,000 trips made annually.

The positive development of China-Europe Railway Express is just a case in which transportation has contributed to the construction of the “Belt and Road Initiative”. In recent years, China has strengthened its connectivity partnership with the countries along the “Belt and Road”, and constructed an all-round, multi-level and comprehensive transportation connectivity network, promoting the diversified, independent, balanced and sustainable development of countries along the route.

On the other hand, a large number of cooperation projects in the transportation field have taken root. Over the past eight years, the level of international connectivity under the “Belt and Road Initiative” has continued to improve. At present, the structure of "six corridors, six routes, various countries and ports" has basically taken shape, a large number of cooperation projects have emerged, and infrastructure connectivity has been continuously deepened.

Railway is an area of infrastructure construction under the "Belt and Road Initiative" that has attracted much attention. Relying on China's advantages in railway technology and construction, cooperation with countries and regions along the route has continued to expand. Key railway projects include Boten-Vientiane Railway, Bangkok-Nong Khai High-Speed railway, Budapest-Belgrade Railway, Moscow-Kazan High-speed Railway, Muse-Mandalay Railway, Jakarta-Bandung High-Speed Railway, Mekka-Madina High-speed Railway, East Coast Rail Link, Gemas-to-Johor Baru Electrified Double-Tracking Railway, Abuja–Kaduna Railway, Addis Ababa–Djibouti Railway, Mombasa–Nairobi Standard Gauge Railway, Nigerian Coastal Railway, Khunjerab Railway, China-Kyrgyzstan-Uzbekistan Railway and so on. According to incomplete statistics, China has invested and participated in the construction of 86 "BRI" Railway projects in total, of which railway projects

in Asia ranked 1st in number, accounting for 45.3%, followed by Africa, 37.2% of all.

Expressway connectivity with neighboring countries is also accelerating. The Kunming–Bangkok Expressway, Kunming-Hanoi-Haiphong Expressway, and two major expressways of China-Pakistan Economic Corridor were opened to traffic, the Blagoveshchensk-Heihe Bridge was completed, the Western Europe-Western China (WE-WC) Highway was progressing steadily. With the joint construction of the "Belt and Road Initiative" as a cooperation platform, China has signed 22 bilateral and multilateral intergovernmental Agreements on international road transportation with 19 countries. International roads from China to Russia via Mongolia, from China to Uzbekistan via Kyrgyzstan, from China to Uzbekistan via Tajikistan, from China to Russia (Dalian-Novosibirsk), and from China to Vietnam have realized the trial operation of direct international road transportation, and the coverage of international road network has been further expanded. According to the incomplete statistics, China has invested and participated in the construction of 93 "BRI" Expressway projects in total, of which the highway projects in Asia ranked 1st in number, accounting for 47.3%, followed by Africa, 28% of all.

It is worth noting that although China's transportation infrastructure construction has made important progress in "going out", producing more and more extensive influence, but in terms of ecological environment protection, a comprehensive theoretical and management system has not yet been formed.

2.2 Analysis of the Main Ecological & Environmental Impacts

Among the railways and expressways constructed and operated in the countries along the route, due to the overlapping of long-distance linear traffic projects with local eco-environmentally sensitive areas and other reason, much attention has been paid to eco-environmental risks in terms of location and route selection, impact on animal migration, project land occupation, noise impact and so on.

The first is to select a site and route cutting through the protected area. For example, the Mombasa-Nairobi Railway in Kenya constructed and operated by China Road & Bridge Corporation passes through natural reserves such as Nairobi National Park and Tsavo National Park. For this reason, the project’s route selection and design focused on rational use of existing traffic corridors to reduce the second division of the ecological system of the protected area for less land occupation.

The second is that the route effects on the animal migration pathways. For example, according to the living habits of large animals such as elephants and giraffes, the engineers of Mombasa-Nairobi Railway have set up bridge-type animal pathways at many places across the Railway, and appropriately extended the approach span of cross-river bridge at large rivers to increase the height of bridge to facilitate the passage of animals. The viaduct of the grand bridge in Nairobi National Park Bridge spans the entire park area, convenient for all kinds of animals to pass. Since the Northern Expressway in Sri Lanka passes through tropical regions, in order to avoid areas of rare species, animal pathways were set up along the animal migration route. The environmental impact assessment of the Boten-Vientiane Railway investigated the distribution and migration pathways of Asian elephants, analyzed the impact of project construction on the activities of Asian elephants and their migration corridors, and proposed such protective measures as putting forward route plans to

avoid the main activity areas of Asian elephants, ensuring exposed areas on surface not involving the existing migration pathways of Asian elephants, extending the tunnel, adjusting the position of inclined shaft of the tunnel, replacing the road with a bridge, setting up isolation fences, sound and light barriers, and strengthening management and others.

The third is that the project occupied land and affected the local ecosystem. For example, the Mombasa-Nairobi Railway caused damage to the mangrove vegetation in the Mombasa Mangrove Wetland Park. For this reason, the project team adopted methods of drawing a red line before construction to minimize logging, and pre-burying water pipe culverts during construction to ensure the healthy growth of mangroves, protecting mangroves after construction and others. The construction of Jakarta-Bandung High-Speed Railway has reduced the green area and reduced the water storage capacity of the underlying surface. At the same time, irregular dumping of some construction residues has affected urban drainage. The Boten-Vientiane Railway occupied parts of the forest vegetation while passing through tropical rainforest nature reserves and environmentally sensitive areas, which has a certain impact on the local ecosystem and biodiversity.

The fourth is that noise problems during the operation of railways and expressways are widespread. For example, the East-West Expressway in Algeria, when designing speeds, traffic flow, and asphalt pavements, witnessed the noise in some residential sensitive areas exceed the standard, so that noise barriers and other measures need to be taken to reduce noise. The Mombasa-Nairobi Railway used sound barrier beams on the grand bridge that spanned Nairobi National Park, and installed sound barriers in the Park to reduce the noise of trains passing by.

In addition, ecological environment management procedures and requirements of some countries are more complicated. For example, in the environmental assessment of the MAR2 Expressway project in Colombia, archaeologists, parasite transplant experts, and zoologists must be invited to conduct site surveys before construction and there were many approval procedures with strict requirements, which will take a long period. As the impact of global climate change becomes more and more significant, some railway and expressway projects constructed and operated in coastal lowlands and alpine regions should also take into consideration the impact of rise of future temperature and sea level on railway and expressway projects, as well as improve planning and adoption measure.

Table 2.1 Brief Introduction of Railway and Highway Projects Case Study along BRI

Type	Project Status		Country	Project Name	Project Progress	Environmental Risk and Respondent Measures
Railway	Newly Built	Completed	Kenya	Mombasa-Nairobi Railway	Opened in 2017	The surface morphology along the Mombasa-Nairobi Railway is relatively complicated, and the area through which the Railway passes is located in the eastern part of the Great Rift Valley. The impact of the construction of the Mombasa-Nairobi Railway on the natural environment is mainly reflected in: permanent occupation of land, affecting surface vegetation along the Railway, changing the original function of the land, affecting existing ecosystems, causing soil erosion and pollution damage to water sources, the construction of bridges along the Railway as well as the culverts changing the original hydrological environment; the dust generated during the transportation of construction vehicles not only causing air pollution but also affecting the growth of surrounding vegetation. The Mombasa-Nairobi Railway has formulated corresponding measures such as route selection, ecological protection, water protection, air protection, solid waste treatment, sound and vibration environmental protection, as well as supporting regulatory requirements. By delineating key environmental protected areas, corresponding animal pathways and protection fences were designed for different animals to avoid the second division of wild animals and plants.
			Kenya	Nariobi-Malaba Railway Phase I	Opened in 2019	For the route through Nairobi National Park, engineered designed roadbed and bridge schemes and conducted comparisons, as well as analyzed the environmental impact from the atmospheric environment, water environment, noise and vibration, solid waste treatment and other aspects to propose environmental protection measures.

Type	Project Status		Country	Project Name	Project Progress	Environmental Risk and Respondent Measures
			Indonesia	Jakarta-Bandung High-Speed Railway	Started in 2016	The noise standards during the construction and operation periods are in compliance with the relevant requirements of *Decree of the State Minister for Environment of the Republic of Indonesia concerning Noise Level Standards (KEP48/MENLH/11/1996)*, and The vibration standards during the construction and operation periods shall be implemented in accordance with *Decree of the State Minister for Environment of the Republic of Indonesia concerning Vibration Level Standards (KEP-49/MENLH/11/1996).*
			Laos	Boten-Vientiane Railway	To be completed in 2021	Boten-Vientiane Railway is a railway that fully adopted China's railway technical standards. During construction, the environmental protection measures are strictly implemented in accordance with Laos's domestic laws and regulations, and the design takes into serious consideration China's railway environmental protection standards, and effective environmental protection measures are adopted to minimize the impact.
			Malaysia	Gemas-to-Johor Baru Electrified Double-Tracking Railway	Started in 2018	Developed an environmental accident plan during the construction period, including the project's environmental accident organization, the distribution of key staff's responsibilities and the reporting procedures to be adopted in the event of an environmental accident.
Highway	Newly Built	Completed	Algeria	East-West Highway	Completed in 2012	The East-West Highway in Algeria has adopted noise protection measures.

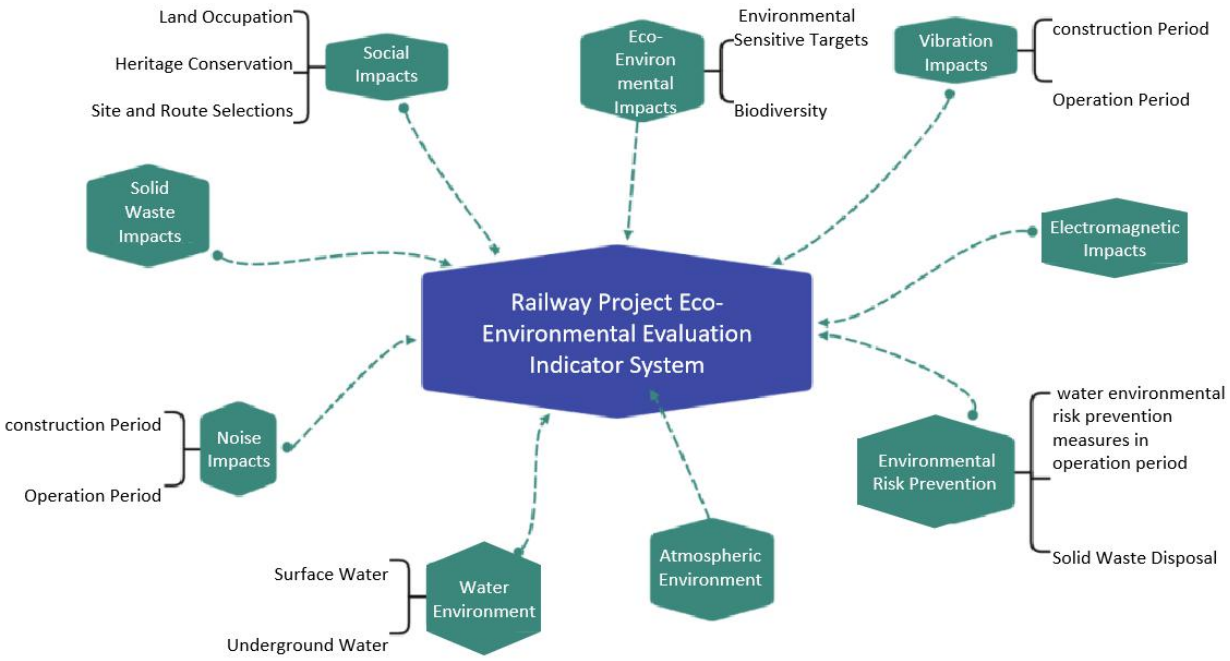
Type	Project Status		Country	Project Name	Project Progress	Environmental Risk and Respondent Measures
			Thailand	Kunming–Bangkok Expressway	Completed in 2013	The rainforest vegetation coverage and water areas around the tropical rainforest section around the Kunming-Bangkok Highway have decreased, and the area of construction land and bare land has increased. However, overall land use types have not changed much, indicating that the construction and operation of this section of Expressway does not have a serious impact on the surrounding areas, and the natural ecological environment has been well maintained. The changes of land use in the surrounding areas of the investigated section are mainly manifested in the mutual conversion among construction land, bare land and vegetation coverage. The impact of this section on land use is within 5 km, of which the impact within 3 km is relatively serious, and the further the areas are away from the Expressway, the smaller will be the degree of influence.
		Under Construction	Pakistan	Karakoram Highway	Completed in 1979, upgraded after 2006, Reconstruction and Extending Project Phase I completed in 2013. Reconstruction and Extending Project Phase II started in 2016.	Public participation: In the summer of 2009, visits and investigations were conducted on various ecological and environmental problems that might arise from the reconstruction and expansion of the China-Pakistan Highway. Residents along the China-Pakistan Highway attached great importance to environmental protection of natural ecology as well as social and cultural protection, and put forward relevant suggestions. The China-Pakistan Karakoram Highway passes through Pakistan's Khunjerab National Park, and the vegetation protection technology in the engineering design was proposed in the key sections of the China-Pakistan Highway vegetation protection. Through the implementation of these technologies, at least about 4,600 square meters of vegetation have been protected from destruction. In April, July, September of 2009 and from June to July of 2010, the animals distributed along the China-Pakistan Highway were observed, and carried out were comprehensive

Type	Project Status		Country	Project Name	Project Progress	Environmental Risk and Respondent Measures
						and systematic classification, sorting and statistics collecting.

Chapter 3. BRI Railway and Highway Project Evaluation Index System

3.1 Basis for the Construction of Evaluation Index System

The establishment of a representative environmental impact evaluation index system serves as the basis of environmental impact evaluation, and the indicators which are most quantifiable and comparable and can present major outstanding impacts shall be selected. In a bid to improve the comparability among the same influencing factors of various transportation infrastructure projects, and to consider the needs of basic data acquisition and quantitative evaluation, the index system to be selected for railway and highway construction projects is as follows.



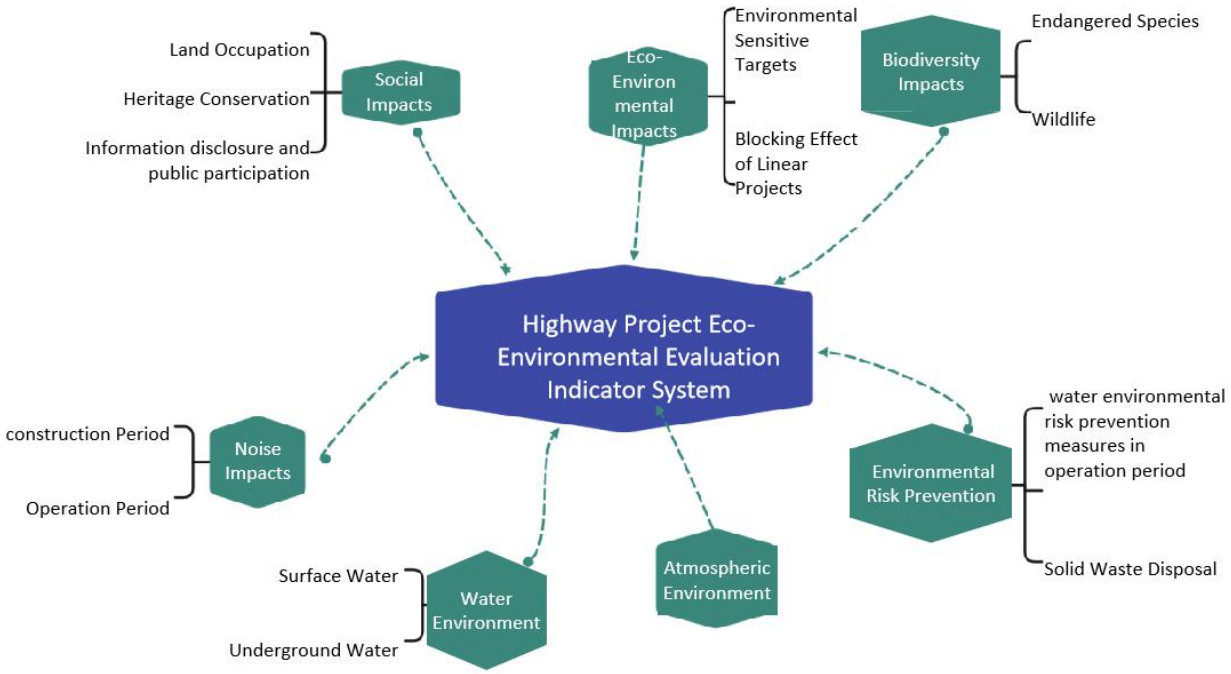


Figure 3.1 Schematic Diagram of Ecological Environment Evaluation Index System for Railway and Highway Projects

3.2 Eco-environmental evaluation index system of railway projects

3.2.1 Site and route selections

When it comes to new railways, we shall pay attention to the comparison and selection of the environmental impact of the route location. The indicators to be selected and compared should be targeted and operable. We shall refrain from locating these projects in environmentally sensitive areas (national and local statutory protected nature reserves, scenic spots, water source reserves, germplasm resources reserves, cultural relics, etc.), areas with concentrated noise-sensitive buildings, etc. If it is really necessary for the projects to pass through the environmentally sensitive areas, permission documents of the relevant local management departments need to be provided.

3.2.2 Ecological environmental impact

1. Focus on the severity of the impact of project construction and construction methods on environmentally sensitive areas and their protected objects as well as the scope of such an impact, and the coordination with important scenic spots and scenery.

2. Keep a watchful eye on whether the construction of the project occupies and indirectly affects habitats

and foraging areas of wild protected animals (including the source of drinking water), and the long-term and irreversible impact of construction and operation on the living habits and the passage of wild animals; keep a watchful eye on the impact of land occupation during the construction of cofferdam and pier of river-crossing bridges on the migration and reproduction of rare fish species; keep a watchful eye on the impact on the area, distribution, quality and quantity of protected plants, and put forward feasible protective measures or compensation measures according to the severity and scope of the impact.

3. Keep a watchful eye on the rationality of the selected site environment of soil-taken fields and spoil ground, optimize the soil-taken fields and spoil ground, as well as private use (of engineering materials), and seek comprehensive utilization of soil sources from various local construction sites or others, in order to optimize the feasibility for setting up soil-taken fields and spoil ground. Keep a watchful eye on the environmental rationality of construction makeshift roads, construction sites and other major temporary engineering settings, so as to optimize the settings.

4. According to the protection requirements concerning the target of sensitive environmental protection, make arguments and analysis from the perspective of optimizing routes, optimizing construction organization schemes as well as ecological protection and restoration or compensation measures, and we must clearly put forward the protection measures of each sensitive target.

5. From the perspective of the compliance with the requirements of ecological functional zoning and ecological fragile areas as well as the protection of biodiversity, demonstrate the overall impact of the construction process on the function and structure of key protected wild animals and plants and ecosystems in ecologically sensitive areas, put forward ecological compensation measures, carry out ecological monitoring during the construction and operation periods, and promote environmental supervision during the construction period.

3.2.3 Noise impact

1. Keep a watchful eye on the scope and severity of the impact of construction sites and construction makeshift roads on the environment, and put forward the setting principles of noise prevention measures from the perspective of management and engineering.

2. Clarify the specific household/population number and distribution dispersion degree of each sensitive point within 30m from the center line of the railway outer rail and in different functional areas; keep a watchful eye the noise prediction results (including contribution value and predicted value), the super-standard amount, the super-standard range and the increment compared with the current situation in the boundary and different functional areas of sensitive points; when the sensitive points are multi-storey buildings, they shall be predicted at different heights.

For the reconstruction and expansion projects, we need to clarify the changes of noise before and after the project and the reasons for the changes.

3. According to the noise prediction results and the specific conditions of sensitive points, based on the host country policies, technical feasibility and economic benefit analysis, clarify the principles of route optimization, sound barriers and sound proof windows, function replacement, demolition and damping rails. Clarify the information of standard attainment after taking measures to prevent and control noise pollution.

Measures of setting up noise barriers should be given priority to road sections of the over-standard sensitive points in the areas where the effect of sound barriers is effective in noise reduction; keep a watchful eye on the type, height, length, noise reduction effect and standard attainment analysis of the noise barriers. Measures such as route layout featured by passengers inside and cargos outside, control of driving speed, adjustment of operation period, prohibition of honking and other measures can be taken into account in sections passing through built-up areas of a city. Keep a particularly watchful eye on the noise prediction results, super-standard amount and measures taken at the sensitive points in the intersections between the projects and the existing railways and existing highways.

4. Necessary planning and control requirements shall be put forward for the road sections in the planning areas of cities and towns. At the same time, we shall keep a watchful eye on tracking and monitoring of noise during the operation period, and the measures should be adjusted in a timely manner according to the monitoring results.

5. Keep a watchful eye on the equivalent sound level prediction results and protection distance of pure railway noises under different train speeds, traffic flow sections, different route forms and different line heights in the near and long term of projects.

6. Make sure that the conditions for installing sound barriers shall be reserved for the routes of the projects passing through the sensitive land in urban planning areas, and strictly control the functions of the buildings on both sides of the railway, especially the first row of buildings.

3.2.4 Vibration impact

1. Keep a watchful eye on the scope and severity of environmental impact of construction sites and construction makeshift roads; focus on the sensitive points affected by tunnel blasting construction, and put forward vibration prevention measures from the perspective of management and engineering.

2. Clarify the severity and scope of railway vibration on the vibration sensitive points, the condition of exceeding the standard, and analyze the effectiveness and feasibility of the measures.

3. Clarify the vibration prevention measures according to the vibration prediction results and economic benefit analysis. At the same time, the requirements of tracking and monitoring of vibration during the operation period and timely additional measures shall be put forward.

3.2.5 Water environmental impact

1. Surface water environmental impact

(1) Put forward protection schemes of the projects crossing the water source protected areas, and keep a watchful eye on the feasibility of avoiding the protected areas and transferring the water intakes. For projects with freight business, keep a particularly watchful eye on environmental risk emergency plans and environmental risk prevention measures.

(2) Clarify that production wastewater and domestic sewage shall not be discharged into water source protected areas and sensitive water bodies during the construction period. Keep a watchful eye on the

impact of mud and suspended matters on water quality during bridge pile foundation construction, especially on bridges involving drinking water source intake, and clearly put forward protection measures, such as not setting up piers in water or carrying out bridge pile foundation construction during the low water period.

The water quality of the intakes shall be monitored during the construction period.

Strictly control the daily discharge amount of production wastewater and domestic sewage during the operation period, strictly control the concentration and destination of sewage pollutants according to the function of receiving water body, and keep a watchful eye on the technical feasibility of sewage treatment. If the wastewater and domestic sewage are discharged into the urban sewage pipe network, we shall make sure the current situation and planning of urban drainage and sewage treatment facilities, and the connection between the projects and the local urban sewage treatment plant setting.

2. Groundwater environmental impact

(1) Keep a watchful eye on the distribution of important environmentally sensitive points such as surface water bodies, springs, wells and water-based scenic spots in mountain tunnel sections, demonstrate the relationship between them and the projects, and clarify the relevant engineering content and construction technology. Before the development and construction of the projects, there must be the relevant work basis of the regional geological and hydrogeological conditions along the projects, the quality of groundwater, and the development and utilization of groundwater.

Keep a watchful eye on the strata, lithology, geological structure, hydrogeological conditions relating to each tunnel of the projects, the residents above the tunnel, near the entrance and exit and the affected areas on both sides of the middle line of the tunnel, the specific distribution of surface water (including landscape water), paddy fields, irrigated land, residents' water intake methods and water intake points; focus on the tunnels that may involve water diversion faults, water-rich carbonate rocks and shallow-buried tunnels.

(2) We must demonstrate the impact of the projects on groundwater source protected areas, springs, important surface water bodies (such as reservoirs), wetlands, water-based scenic spots, residential living and production water, etc.; focus on demonstrating the impact of the construction of structural fracture developed tunnel, karst tunnel and shallow-buried tunnel on groundwater environment, as well as the impact of the construction of bridges and station pile foundation on groundwater quality, and put forward the corresponding protection measures.

(3) Verify the treatment measures of tunnel drainage and environmental protection investment, clarify the function of receiving water bodies, analyze the accessibility of drainage indicators, and allocate environmental protection-related investment.

(4) Clarify the monitoring plan of the water level or water quantity and water quality of the environmentally sensitive targets near the sensitive tunnels, the amount of water gushing from the tunnel construction and its scope of impact, and set aside special compensation funds for the impact of tunnel gushing water on residents' daily living and production water, formulate a water supply plan.

3.2.6 Electromagnetic impact

1. Keep a watchful eye on the evaluation scope and standards of the electrified railways, mobile communication base stations and traction substations, and clarify the transmission mode and voltage of the catenary wires.

2. Control requirements for sensitive buildings are put forward when the impact of traction substations and base stations exceed the standard.

3.2.7 Atmospheric environmental impact

Keep a watchful eye on the scope of boiler heating, the content of total sulfur and ash in fuel, the process and efficiency of dedusting and desulfurization, and the feasibility that air pollutants must meet the discharge standard.

3.2.8 Solid waste disposal

1. The domestic waste generated in the construction camp shall be collected by special personnel and sent to the relevant sanitation departments for centralized disposal. Hazardous wastes such as waste oil residue (mud) and wiping oilcloth produced in the course of locomotive maintenance, waste transformer oil produced by transformer substations, batteries and other hazardous wastes must be disposed of in accordance with the relevant regulations of the host countries.

2. In an area where the radioactive content passing through rock strata of the tunnel is abnormal, investigation of the radionuclide content of the rock core shall be carried out in the stage of engineering exploration, and the disposal requirements of radioactive solid waste should be put forward according to the relevant radioactive pollution regulations of the host countries.

3.2.9 Information disclosure and public participation

Keep a watchful eye on dissenting opinions resulting from public participation and their implementation, and return visits should be paid to members of the public who hold dissenting opinions. For projects that are sensitive to the environment and have a large number of dissenting opinions, hold symposiums and hearings when necessary, ensure that the public explanation are listened, and satisfy the reasonable environmental protection demands put forward by the public in a timely manner, and, in particular, focus on the villages and towns divided by the projects as well as schools and residents close to the project route positions.

3.3 Eco-environmental evaluation index system of railway projects

3.3.1 Ecological environmental impact

1. Keep a watchful eye on the impact of project construction and construction methods on ecologically sensitive areas. Clarify the mileage, length, mode, zoning of adjacent or traversing areas, type and area of

land occupation, biological loss and temporary engineering arrangement in ecologically sensitive areas involved in the projects. Focus on the scope and severity of the impact of the project construction process and construction methods on the ecologically sensitive areas and their protected objects. For wetlands, also keep a watchful eye on the impact of engineering construction methods on the connectivity of wetland water systems. For scenic spots, also keep a watchful eye on the coordination between the projects and important landscapes and scenic spots. For water-based projects, keep a watchful eye on the impact of waste residues and tunnel drainage resulting from long tunnels on vegetation and water body in ecologically sensitive areas.

2. Keep a watchful eye on the barrier effect of linear engineering, and when there are other linear projects, we shall pay attention to its superposition effect. It includes the cutting and fragmentation of habitats, the blocking of hydrological conditions of rivers, the supply of water sources in wetlands, the migration of wild animals and the transfer of livestock (in pastoral areas).

3. Keep a watchful eye on the environmental impact of site selection of temporary projects. The soil-taken fields and spoil ground shall specify the areas where projects are prohibited or unsuitable to be launched, and made clear that basic farmland shall not be occupied for temporary projects.

Keep a watchful eye on the environmental rationality of temporary engineering settings such as construction makeshift roads and construction sites in order to optimize the settings. Clarify the width of the construction & operation zones in different ecological areas, optimize the construction technology in the ecologically sensitive and ecologically fragile areas, and reduce the width of the construction & operation zones.

4. Ensure the ecological environment protection measures. Keep a watchful eye on the consistency between the protection measures of each sensitive target and the protection requirements, focus on the route, construction methods, optimization of construction organization schemes, as well as the analysis and demonstration of the feasibility of ecological protection and restoration or compensation measures. Ecological protection and restoration or compensation measures should be in line with the biodiversity protection, ecological functional zoning and requirements of ecological fragile areas.

3.3.2 Biodiversity

1. Keep a watchful eye on the impact on endangered and protected species. Clarify whether the construction of the projects occupies and indirectly affects the habitats of endangered or key wild animals (such as breeding places, overwintering ground, foraging sites, drinking water source areas, etc.); keep a watchful eye on the direct, indirect and cumulative effects of construction and operation on the habitats, population and behaviors of wild animals, and keep a watchful eye on the impact of construction cofferdams and piers of river-crossing bridges on the migration and reproduction of protected fish. Keep a watchful eye on the impact on the area, distribution, quality and quantity of protected plants.

2. Keep a watchful eye on the measures related to wildlife protection. Focus on the analysis and demonstration of the feasibility and rationality of proposed protective measures from the perspective of avoiding or mitigating the adverse impacts of habitat occupation, destruction and cutting, as well as blocking, behavioral interference (such as noise, lighting) and traffic fatalities. Keep a watchful eye on the effectiveness of route selection and optimization of engineering structures (bridges, tunnels, culverts) in mitigating the

effects of habitat segmentation, migration obstructing, wetland water supply blockage and so on. Keep a watchful eye on the scientificalness and rationality of wildlife passage design (including location, type, net height, layout of small habitats inside and outside the channel, design of auxiliary facilities such as fences, and management requirements during the operation period, etc.). Focus on whether the design of the wildlife passage takes into full account the characteristics of topography and surrounding environment, the size, ecological habits and migration routes of the target species.

Keep a watchful eye on the protection measures taken for ancient and famous trees and protected plants and the feasibility of ex-situ protection and habitat compensation.

3.3.3 Acoustic environmental impact

1. Keep a watchful eye on the impact of noise during the construction period and the prevention and control measures. Based on the construction & operation mode of different projects and equipment of the projects, provide the noise distance up to the standard in the daytime and nighttime. Focus on the impact on noise sensitive points, put forward targeted noise prevention and control measures during the construction period, such as reasonable arrangement of construction & operation time sequence, high noise equipment away from sensitive points, and setting up mobile sound barriers. Keep a watchful eye on the noise impact of tunnel construction (such as blasting) on the sensitive points at the top of the tunnels and near the tunnel entrances.

2. Clarify the measures and effects of noise control. According to the degree of noise exceeding the standard, the specific conditions of sensitive points and public opinions, and based on economic and technical analysis, put forward targeted noise control measures, including local optimization of routes, low-noise pavement, relocation, replacement of building functions, sound barriers, sound insulation windows and speed limits, etc.; for those who exceed the standard seriously, a variety of control measures can be taken. Clarify the effect and standard attainment of the projects after the implementation of noise reduction measures, specify the cost of noise control and include it in the project investment estimates.

Noise barrier measures should be given priority to the sensitive road sections which exceed the standard and are located in the effective noise reduction areas of the sound barriers, and keep a watchful eye on the type, material, height, length, noise reduction effect and the standard attainment after measures are taken. For the sensitive points where the scale is small, the distribution is scattered, or the noise barriers are difficult to meet the requirements of noise reduction, measures of sound insulation windows can be taken, and keep a watchful eye on the type of sound insulation windows, the design of sound insulation and the standard attainment after measures are taken.

Keep a particularly watchful eye on the noise prediction results, super-standard amount and measures taken for the sensitive points in separated subgrades and in the intersections between the projects, the existing highways and the existing railways; keep a particularly watchful eye on the noise control measures and effects that have been implemented on existing highways, the remaining noise problems and the specific rectification measures for reconstruction and expansion projects.

3. Conditions for installing sound barriers shall be reserved for routes of the project passing through the sensitive land sections in the urban planning areas and strictly control the functions of the buildings on both

sides of the highway, especially the first row of buildings.

4. Clarify the planning and control requirements on both sides of highways. Based on the noise prediction results, calculate the noise protection distances in the daytime and nighttime of different target years, different road sections and different functional areas are, and put forward the planning control distance requirements of the whole routes, especially on both sides of the road sections in the urban planning areas.

5. Clarify the noise monitoring requirements during the operation period. According to the situation of noise exceeding the standard in sensitive points, put forward a noise tracking and monitoring plan during the operation period; focus on monitoring residential areas, schools, hospitals and homes for the elderly that may exceed the standard, and adjust measures according to the monitoring results in a timely manner.

3.3.4 Water environment impact

1. Surface water environmental impact

(1) Clarify the target of surface water protection. Keep a watchful eye on the location relationship between highways and rivers, canals, lakes and reservoirs along the routes, including water bodies the routes cross, accompany and receive effluent. Keep a watchful eye on the environmental and hydrological conditions of important waters (such as river width, water depth, flow direction, rate of flow, water level, etc.), and clarify the function of the water bodies. Keep a watchful eye on the position and length of the river-crossing bridges, the number of piers in the water, the operation mode of water-based construction and the main engineering quantity, and keep a watchful eye on the route form, length and relative distance of the accompanying highways.

(2) Keep a watchful eye on the environmental sensitivity of surface water. Clarify whether the projects involve sensitive functional water bodies, surface source protected areas for drinking water (including surface water sources for drinking water that are not divided into protected areas), and whether the water bodies have the function of providing drinking water. Clarify the scope and division of water source protection zones, the setting of the water intakes, the amount of water supply, the use of the water supply, the relationship between the projects and the water source protected areas, and the engineering contents in the protected areas.

(3) Clarify the environmental quality of surface water. Keep a watchful eye on the monitoring of surface water quality status quo, including the representativeness of point locations specified, monitored items and setting of monitoring period, and the rationality of the monitoring results and the analysis of the reasons for exceeding the standard. Focus on the monitoring data of water environment quality status quo related to water source protected areas and sensitive water bodies.

(4) Keep a watchful eye on the impact on water environment and protection measures during the construction period. Keep a watchful eye on the output, treatment, reuse and discharge of production wastewater and domestic sewage during the construction period, and the production wastewater and domestic sewage shall not be discharged into water source protected areas and sensitive water bodies, and avoid important wetlands to the greatest extent. Keep a watchful eye on the impact of mud and suspended matters on water quality during the construction of bridge pile foundation, protective measures must be put forward, such as not setting piers in water, adopting advanced construction methods and operation during

the low water period, etc. Temporary construction sites such as construction camps, prefabrication yard, mixing stations and material stacking yard must be set up far away from sensitive water bodies, etc.

(5) Keep a watchful eye on the protection measures of water source protected areas. If a route crosses or is close to the water source protection area, keep a watchful eye on the impact of engineering construction on the water quality of the intakes, and put forward specific protection schemes. The water quality of the intakes shall be monitored on a regular basis during the construction period.

(6) Clarify the impact on water environment and protection measures during the operation period. Clarify the production amount and treatment mode of production wastewater and domestic sewage, discharge concentration of main pollutants, discharge direction and water bodies receiving the sewage in each service area and toll station during the operation period. Analyze the economic and technical feasibility of the sewage treatment process; keep a watchful eye on the applicability of the treatment process and the durability and effectiveness of the treatment facilities for those with small sewage production and low environmental temperature. If there is an access to the urban sewage pipe network, the planning, construction and operation of the sewage treatment plant and its supporting pipe network shall be clarified, and analyze the reliability of sewage access and reliance treatment.

2. Groundwater environmental impact

(1) Keep a watchful eye on the environmental hydrogeological conditions along the routes of the projects, including groundwater types, burial conditions, aquifer lithology, water-rich degree, recharge and discharge conditions, etc., and clarify the environmental quality of groundwater along routes of the projects, and clarify the domestic water intake of the surrounding residents.

(2) Keep a watchful eye on the target of groundwater protection along the routes. Focus on the groundwater source protected areas and water sources involved along the routes, and clarify the scope and zoning of groundwater source protected areas, distribution of water source wells, daily exploitation volume and water supply, etc. Clarify the hydrogeological conditions such as the thickness of aeration zone, anti-seepage performance, aquifer structure, water level depth, groundwater flow direction, hydraulic relationship between surface water and groundwater and so on in water sources. Clarify the location relationship and construction mode between the projects and groundwater source protected areas and intake wells (springs); focus on the setting of routes, service areas and temporary construction sites.

(3) Keep a watchful eye on the distribution of sensitive targets around the tunnels. At the top of the tunnel, near the entrance and exit and on both sides of the middle line of the tunnel, try to avoid sensitive targets, such as residents, springs, wells, surface water bodies (including landscape water bodies), paddy fields, and residents' water intake methods and points in the affected areas.

(4) Keep a watchful eye on the environmental impact on main groundwater. Keep a watchful eye on the impact of the projects on groundwater source protected areas and water sources, water intake wells, springs, important surface water bodies (such as reservoirs), wetlands, water-based scenic spots, residential living and production water, etc.; focus on the impact of tunnel construction, bridge and yard pile foundation construction, as well as the deep excavation road construction on groundwater environment, and put forward the corresponding protection measures.

(5) Keep a watchful eye on the treatment mode, discharge direction and possible environmental impact of groundwater drainage in tunnel construction, verify the treatment measures of tunnel drainage and environmental protection investment, clarify the function of receiving water bodies, and analyze the accessibility of drainage index.

(6) Keep a watchful eye on the groundwater environment monitoring plan of the sensitive targets in the vicinity of the tunnels, set aside special compensation funds for the impact of tunnel water gushing on residents' daily living and production water, and formulate a water supply plan.

3.3.5 Impact on the atmospheric environment

1. During construction, the mixing station, prefabrication yard and material storage yard should be set away from dense residential area. Pay attention to the fugitive dust problem brought by the construction and the corresponding environmental protection measures needed.

2. Consider a concentrated source of atmospheric pollution coming from service facilities along the project route. Select the environment-wise optimum heating system based on the local condition, and give preference to energy-efficient heating methods such as electricity and new energies.

3. Pay attention to the distribution of residents and automobile exhaust at the entrance, exit and vent of long and big tunnel; Check coal dust problem for coal-transporting highway projects.

3.3.6 Disposal of solid wastes

1. Consider the amount and proposed disposal of domestic garbage produced in construction camps and management and service facilities along the project route. For reconstruction and extension projects, reclaimed asphalt pavement and recycling of coal gangue waste should be encouraged.

2. Evaluate the management and disposal of toxic, hazardous and radioactive solid wastes along the construction and related routes of the highway.

3. If the tunnel passes through areas with abnormal radioactive content in the rock stratum, investigation into the radioactive nuclide level in the rock core should be carried out in the exploration stage of the project, and requests for radioactive solid waste disposal should be made.

3.3.7 Preservation of cultural relics

1. Clarify the distribution of cultural relics protection sites along the project. Be clear about the name and protection level of the sites, the object and scope of protection, and the division of construction control zone. Define the positional relation between the project and the protection site and clarify the construction form of the project.

2. Check whether the temporary construction site is set within the scope of cultural relics protection and the construction control zone, and pay attention to the impact of ground subsidence on cultural relics caused by construction and drainage of precipitation in the tunnel, as well as possible vibration impact on cultural relics when vehicles pass through bridges in the operation period.

3.3.8 Prevention of environmental risks

1. Define measures to prevent water environmental risks in operation period, especially the risks caused by bridges or roadbeds spanning or accompanying preserved functional water bodies, major wetlands or protected source drinking water areas. Strengthened safety guardrails should be set up, bridge or road runoff collection systems and supporting accident pools should be built, the volume and seepage control measures of accident pools should be taken into consideration, and warning signs and slow-down signs should be put up in both sides of such sensitive sections.

2. Attach importance to emergency response plans for dangerous goods transportation. Requests should be made to formulate management system and emergency response plans concerning dangerous goods transportation. Draw up emergency training plan and conduct emergency drills for risk accidents on a regular basis. The emergency response plan should be incorporated into the local governments' emergency response plans, so as to set up emergency-response institution and linkage mechanism. Be clear about the local governments' emergency response system and resources.

3.4 Table of Assessment Indicators of Railway/highway Projects

Based on the above-mentioned indicators, the indicator system for assessing the ecological environment of "Belt and Road" railway and highway projects is constructed as below.

3.4.1 Indicator system for assessing the eco-environmental impact of railway projects

Table 3.1 Railway Project Eco-Environmental Assessment Indicators

Level I Indicator	Level II Indicator	Related requirements
Social assessment	Selection of location and route	Document of the host country's legal permission should be gained.
		Scheme comparison and selection of project route and location should be conducted. Environmentally sensitive areas (including natural reserves, scenic spots, water conservation areas and planting resource protected areas defined by national and local laws) and noise-sensitive buildings-concentrated areas should be avoided.
	Information disclosure and public participation	Pay attention to public disagreement and response to such disagreement, and pay a visit to people who hold disagreement. For projects that are environmentally sensitive and attract large opposition, colloquia or hearings should be held when necessary, and explanations to the public should be made. Resolve proper environmental claims made by the public in a timely manner, and pay special attention to villages and towns divided by the project, and schools and residents near the project route.
	Land nature or land occupation	Consider the relocation of original residents or occupation of cultivated land.
Impact on ecological environment	Protection targets of sensitive environment	Consider the degree and scope of impact of the construction process and methods on environmentally sensitive areas and the protected objects, and their coordination with major scenic spots and scenery.
		Clearly put forward protection measures for sensitive targets.
	Biodiversity	Assess whether the construction occupies or indirectly affects wildlife's habitat and foraging habitat (including drinking water sources). Consider the long-term, irreversible impact the construction and operation may have on the living habits and passage of wildlife. Assess the impact of cross-bridge cofferdam and pier on the migration and breeding of rare fish species. Consider the influence on the coverage, distribution, quality and quantity of protected

		plants.
		Put forward ecological compensation measures, carry out ecological monitoring during construction and operation, and promote environmental supervision during construction.
Noise impact	Impact in the construction period	Bring forward principles for establishing measures of noise prevention and control in construction sites and access roads from management and engineering perspectives.
	Impact in the operation period	Based on noise predictions and detailed information of the sensitive sites, combined with analysis of the host country policies, technical feasibility and economic effectiveness, define principles for adopting measures of route optimization, sound barrier, sound-proof window, function replacement, residents relocation and damping rails. Clarify the goal attainment after taking measures to prevent and control noise pollution.
Vibration impact	Impact in the construction period	Pay special attention to sensitive sites affected by blast working in the tunnel, and put forward targeted vibration prevention and control measures from management and engineering perspectives.
	Impact in operation period	Based on vibration prediction and economic effectiveness analysis, set out measures for vibration prevention and control, as well as for vibration tracing monitoring in operation period. Requirements of the measures should be supplemented in a timely manner.
Impact on water environment	Impact on surface water environment	Assess whether the project crosses over water source conservation areas, whether a protection plan is proposed, and whether it is feasible to bypass the protection zone and transfer the water intake.
		Production wastewater and domestic sewage produced in construction period should not be discharged into water source conservation areas and sensitive water bodies. Pay attention to the impact on water quality of mud and suspended solids produced during bridge pile foundation construction, especially for bridges related to intake of drinking water sources, and clearly put forward protection measures.
	Impact on groundwater	Check the distribution of major surface water bodies, springs, wells, water-related scenic spots and other environmentally sensitive sites in mountain tunnel sections, and demonstrate the feasibility of the corresponding

	environment	protective measures.
		It is important to demonstrate the impact on the groundwater environment caused by construction in structurally-fractured tunnel, karst tunnel and shallow tunnel along the project, as well as the impact on groundwater quality brought by construction of bridges and station pile foundation. Corresponding protection measures should be proposed.
		Verify the treatment of tunnel drainage, define the function of receiving waters, analyze the reachability of drainage targets, and allocate investment on environmental protection.
		Define a plan to monitor the water level or water yield, and water quality of the environmentally sensitive targets around sensitive tunnels. Be clear about the water inflow and its affecting range of the construction in the tunnel. Should the inflow affect the residents' domestic and production water, reserve special fund to compensate and make up a water supply plan?
Electromagnetic impact		Check the scope and standards for evaluating electrified railways, mobile communication base stations and traction substations, and make clear the transmission mode and voltage of catenary contact wires.
Impact on the atmospheric environmental		Consider the heating range, the content of total sulphur and ash in the fuel, the technique and efficiency to remove dust and sulphur, and the feasibility to reach standards for air pollutant emissions.
Disposal of solid wastes		Domestic garbage generated in the construction camps should be collected by designated personnel and transferred to relevant sanitation department for centralized treatment. Hazardous wastes including waste oils, sludge and wiping cloth coming from locomotive maintenance and repair, along with waste transformer oil and accumulator coming from substation need to be disposed of in accordance with the regulations of the host country.
		If the tunnel passes through areas with abnormal radioactive content in the rock stratum, investigation into the radioactive nuclide level in the rock core should be carried out in the exploration stage, and requests for radioactive solid waste disposal should be made in accordance with the radioactive pollution regulations of the host country

3.4.2 Indicator system for assessing the eco-environmental impact of highway projects

Table 3.2 Highway Project Eco-Environmental Assessment Indicators

Level I Indicator	**Level II Indicator**	**Related requirements**
Social assessment	Land nature or land occupation	Consider the relocation of original residents or occupation of cultivated land.
	Protection of cultural relics	Check whether the temporary construction site is set within the scope of cultural relics protection and construction control zone, and pay attention to the impact of ground subsidence on cultural relics caused by construction and drainage of precipitation in the tunnel, and possible vibration impact on cultural relics when vehicles pass through bridges in the operation period.
	Information disclosure and public participation	Pay attention to public disagreement and response to such disagreement, and pay a visit to people who hold disagreement. For projects that are environmentally sensitive and attract large opposition, colloquia or hearings should be held when necessary, and explanations to the public should be made. Resolve proper environmental claims made by the public in a timely manner, and pay special attention to villages and towns divided by the project, and schools and residents near the project route.
Impact on ecological environment i	Impact on ecologically sensitive areas in construction period	Importance should be placed on the degree and scope of impact of the construction process and methods on environmentally sensitive areas and the protected objects. For wetlands, attention should also be paid to the impact of construction methods on the connectivity of wetland water systems. For water-related project, assess the impact of waste slag in long and big tunnel and tunnel drainage on vegetation and water bodies in ecologically sensitive areas. Assess the rationality of the environment for setting temporary works such as construction access roads and sites.
		Clearly put forward protection measures for sensitive targets.

	Barrier effect of linear engineering.	Attention should be paid to superposition effect. This includes dividing and fragmenting habitats, cutting the hydrological condition of rivers and water supply of wetlands, and blocking wildlife migration and field transfer of livestock.
	Ecological and environmental protection measures in operation period	Check if the measures of protecting sensitive targets conform with the protection requirements. Pay special attention to optimizing the route, construction methods and organization plans, and analyzing and demonstrating the feasibility of ecological protection and restoration, or the compensation measures.
Biodiversity	Impact on endangered and protected species	Be clear about whether the construction occupies or indirectly affects the habitats (including breeding place, wintering habitat, foraging place and drinking place) of endangered or key protected wildlife. Consider the direct, indirect and accumulative impact of the construction and operation of the project on the habitat, population and behaviors of wildlife. Assess also the impact of cross-bridge cofferdam and pier on the migration and breeding of rare fish species. Consider the influence on the coverage, distribution, quality and quantity of protected plant.
	Wildlife protection measures	Consider mainly from aspects of avoiding or alleviating such adverse impacts as occupying, damaging, cutting and blocking habitats, behavioral interference including noise and lights, and traffic fatalities. Evaluate the analysis and demonstration of the feasibility and rationality of proposed protection measures. Assess whether optimizing plans such as route selection and engineering structures (bridges, tunnels and culverts) is effective in alleviating impacts of dividing habitats, blocking migration and cutting wetland supplies. Assess whether the design of wildlife passage is scientific and reasonable, factors to be considered including the site, pattern, clear height, setting of small habitats inside and outside the passage, design of auxiliary facilities such as fences, and management requirements in operation period. Pay close attention to whether the terrain and other surrounding features, the figure of the target species, their ecological habits and migration routes are fully considered in designing the passages.
		Assess the protection measures for ancient and famous trees and protected plants, and the feasibility of ex-situ

		conservations and habitat compensations.
Impact on acoustic environment	Impact in the construction period	Close attention should be paid to the impact on noise-sensitive sites, and targeted noise control measures should be proposed. Consider also the noise impact of tunnel construction (such as blast working) on sensitive sites near the top and portals of the tunnel
	Impact in the operation period	Based on noise -exceeding level, details of the sensitive sites and public opinion, combined with economic and technological analysis, put forward targeted noise control measures such as local optimization of route, low noise pavement, resident relocation, housing function replacement, sound barrier, sound-proof window and speed limit. Confirm the effect and goal attainment of noise control measures. Work out the noise control costs and incorporate them into budget estimation of investment.
		Define noise monitoring requirements in operation period. Residential areas, schools, hospitals, nursing homes and other places that may have standard-exceeding noise should be intensively monitored, and measures should be timely adjusted according to monitoring results.
Impact on water environment	Impact on surface water environment	Be clear about whether the project involves preserved functional water bodies or drinking surface water source protected areas (including unclassified drinking surface water sources), and if the water body has drinking function.
		Pay attention to the quantity, treatment, reuse and discharge destination of production wastewater and domestic sewage in the construction period, which should not be discharged into water source protected areas and sensitive water bodies, and not into major wetlands if possible. Consider the impact of mud and suspended solids produced during bridge pile foundation construction on water quality, and put forward protection measures.
		Assess the protection measure for water source conservation areas. Should the construction span over or be close to water source conservation area, focus on the impact on the quality of intake water and bring up specific protection plans. In construction period, the water quality of water intake should be monitored regularly.
		Clarify the impact on water environment and corresponding protection measures. Define the quantity and treatment of production wastewater and domestic sewage generated by service areas and toll gates in operation period, as well as

		the emission concentration, destination and receiving water bodies of major pollutants.
	Impact on groundwater environment	Consider the groundwater protection targets along the route. Focus on the groundwater source protected areas and water sources. Be clear about their hydrogeological conditions including thickness of aeration zone, anti-seepage performance, aquifer structure, depth to water table, direction of groundwater flow, and hydraulic connection between surface water and groundwater. Clarify the positional relation among the project site, groundwater source protected areas and water intake wells /springs, as well as the construction method. Check in particular the setting of route, service areas and temporary construction sites.
		Consider the distribution of sensitive targets around the tunnel. Such areas of tunnels as the top, the surrounding of entrance and exit and both sides of the center line should be set in ways that try to avoid sensitive targets as residents, springs, wells, surface water bodies (including scenic water bodies) and paddy field, as well as in a way not to affect the water-getting methods and sites of the residents.
		Assess the impact on groundwater source protected areas and water sources, water intake wells, springs, major surface water bodies (such as reservoirs), wetlands, water-related scenic spots, residents' domestic and production water, etc. Pay attention to the impact on groundwater environment caused by construction of tunnel, pile foundation of bridges and stations, and deep-cut road sections. Propose corresponding protection measures.
Impact on atmospheric environment		Pay attention to concentrated source of atmospheric pollution of service facilities along the project route. Select the environment-wise optimum heating system based on the local condition, and give preference to energy-efficient heating methods such as electricity and new energies.
Disposal of solid wastes		Consider the amount and proposed disposal of domestic garbage produced in construction camps and management and service facilities along the project route. For reconstruction and extension projects, reclaimed asphalt pavement and recycling of coal gangue waste should be encouraged.
		Evaluate the management and disposal of toxic, hazardous and radioactive solid wastes along the construction and related routes of the highway.

		If the tunnel passes through areas with abnormal radioactive content in the rock stratum, investigation into the radioactive nuclide level in the rock core should be carried out in the exploration stage of the project, and requests for radioactive solid waste disposal should be made.
Prevention of environmental risks	Measures to prevent water environmental risks in operation period	Evaluate the risks caused by bridges or roadbeds spanning or accompanying preserved functional water bodies, major wetlands or protected source drinking water areas.
	Emergency response plan for dangerous goods transportation	Requests should be made to formulate management system and emergency response plans concerning dangerous goods transportation

Chapter 4. Green Solution and Cases for Transportation Infrastructure

The green transportation infrastructure construction is in line with the requirements for green development, and focuses on the full life cycle, the whole process and the omni-directional greening. In the practical engineering projects, it addresses the implementation of the green development concept in the whole process of planning, design, construction, operation and maintenance. This study will comb the green technology and requirements in the design, construction and operation & maintenance stages, providing the corresponding reference cases.

4.1 Green Engineering Design

4.1.1 Scientific design of construction scheme

(1) General requirements

The overall design of highways and railways shall adhere to the general objective of "orienting to people and holding safety the first; pursuing natural harmony and ecological environment protection; adjusting measures to local conditions and saving resources; taking reasonable technology and improving services". High attention shall be paid to the implementation of the green concept, and the most appropriate project type, the greenest technical scheme and the most natural construction materials shall be considered from the beginning of design. It is also necessary to fully understand the factors affecting the construction scheme, scientifically demonstrate the technical standards, and reasonably determine the construction scheme and scale according to the local conditions.

(2) Highway case

The reconstruction and expansion project of the Xiaomengyang-Mohan Section of the Kunming-Mohan Expressway (hereinafter referred to as "Xiaomengyang-Mohan Expressway") is located in Mengla County, Jinghong City, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province. It lies in the China-Indochina Peninsula Economic Corridor, and in the "Xishuangbanna Region in Southern Yunnan", which has the most abundant biodiversity in China. In addition, the Xiaomengyang-Mohan Expressway involves many ecologically sensitive regions, such as nature reserves, scenic spots and aquatic germplasm resource reserves. Therefore, the task of green development is challenging. During construction of the Xiaomengyang-Mohan Expressway, the characteristics of the reconstruction and expansion project and the features of the ecological environment along the line are firmly understood, and then a reasonable construction scheme is determined through specialized analysis and calculation and in-depth scheme discussion, and the measures of "three new sections, seven braided sections, nine sections of separated subgrade, and ten widened sections" were adopted[1]. "Three new sections" refers to the construction of three new highway sections in full breadth in the project. "Seven braided sections" refers to the construction of seven highway sections in the "braided" manner, i.e., the long and steep downslope of the existing highway is changed to an upslope, and a new downslope is constructed, effectively resolving the danger of steep slope. "Nine sections of separated

subgrade" refers to the construction of nine sections of separated subgrade in half breadth after the flexible consideration of the influencing factors along the highway. "Ten widened sections" refers to the widening of ten highway sections. The existing road and corridor resources are utilized to the maximum through the flexible and reasonable use of the horizontal and vertical linearity indicators of the line. While realizing ecological environment protection, the continuity, balance and unity of indicators of the new and existing sections are ensured.

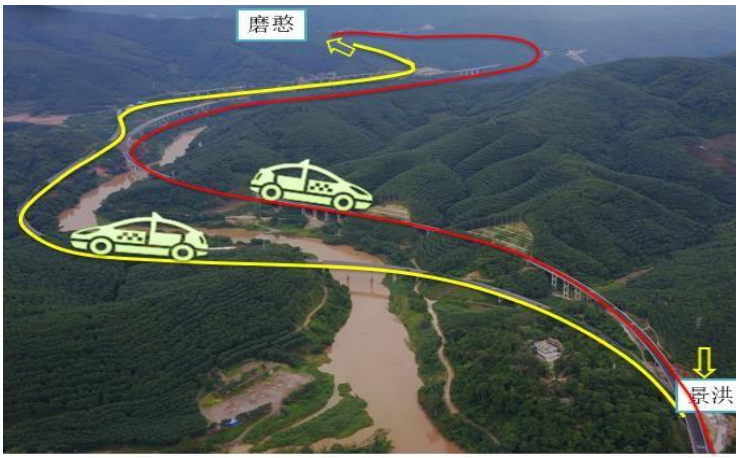


Fig. 4.1 Interweaving between upslope and downslope on new and original subgrade separated in large spacing
(Red line: downslope on new subgrade; yellow line: upslope on original subgrade)

(3) Railway case

Located in Jiangsu Province and Anhui Province, the Nanjing-Huai'an Railway runs north-south with a total length of 150.9km. It is a high-speed passenger railway accommodating intercity and long-distance passenger flows.

According to the needs of social and economic development, functional positioning and technical conditions, for the overall design of the project, full consideration is made on the engineering investment, environmental factors, travel time, adaptability of corridor capacity, smoothness of line connection, coordination of different modes of transportation and other factors influencing the construction scheme, and the technical standards are scientifically demonstrated. The minimum curve radius of the project is determined to be 7,000m for the general sections and 5,500m for the difficult sections, and the maximum gradient is determined to be 20‰ for the general sections and 30‰ for the difficult sections.

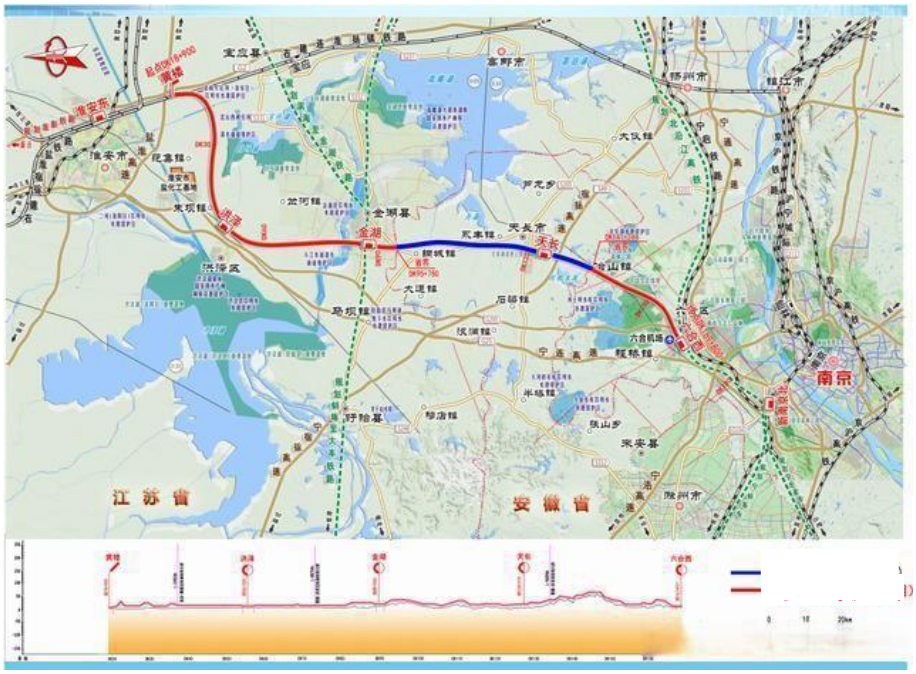


Fig. 4.2 Schematic diagram of recommended scheme

4.1.2 Intensive use of corridor resources

(1) General requirements

The design of highways and railways shall follow the principle of “overall planning, rational layout, intensive use and high efficiency”, the linear transportation infrastructure for different modes such as railway and highway and at different levels such as high speed and ordinary speed shall be promoted, the routes, bridges and other transportation corridor resources shall be intensively used in space, including encouraging the sharing of routes among new highways and railways and among expressways and ordinary highways, the existing corridors shall be fully utilized in the reconstruction and expansion projects and the provincial renovation projects, and the original facilities shall be utilized in a safe way.

(2) Bridge sharing

The Wenzhou Oujiang Beikou Bridge is located at the Oujiang Estuary in Wenzhou, starting from Huanghua, Liushi Town, Yueqing City, and ending in the middle of Lingkun Island, with a total length of 7.913km.

The co-route design is adopted for the Oujiang Beikou Bridge, with a double-deck system. The upper deck accommodates the parallel lines of the G15W3 Shenyang-Haikou Expressway (Ningbo-Dongguan), and the lower deck accommodates the G228 National Highway (Liaoning Dandong-Guangxi Dongxing). For this expressway and national highway, the vertical co-route design is realized at 0.8km from the north bank of Oujiang River. After passing a main bridge of 2.09km, separation is realized at 1.5km from the south bank of the main bridge. The co-route length is about 4.39km, accounting for 55.6% of the total length of the project. Due to the co-route design, in which the transport corridor resources are utilized as a whole, this project can save an area of about 115 mu along the line, greatly saving the land for urban traffic. In addition, for the expressway and the Nantang-Jinxiang Highway, the upper and lower decks are co-built, so the approach

bridge and the main bridge can share the same bridge foundation and substructure, significantly reducing the use of concrete, rebar, formwork, labor and other resources.

Fig. 4.3 Schematic diagram of double-deck system of main bridge and approach bridge of Wenzhou Oujiang Beikou Bridge

(3) Highway and railway route sharing

The Wuwei-Yuexi Section of the G42S Shanghai-Wuhan Expressway (hereinafter referred to as "Wuwei-Yuexi Expressway") is located in Anhui Province, with a total length of 179.526km. The route of the Wuwei-Yuexi Expressway crosses or co-routes with three important railways: Hefei-Anqing High-speed Railway, Lujiang-Tongling Railway and Hefei-Jiujiang Railway. At K68+216.4, in the form of subgrade, the expressway passes underneath the Hefei-Anqing High-speed Railway utilizing the separated interchange of the railway S219. The railway crossed in the co-route section with the Hefei-Anqing High-speed Railway is the Lujiang-Tongling Railway, where the construction conditions for the expansion of 8 lanes of this project are reserved. The railway crossed in the Tongcheng-Yuexi Section and the Anqing Branch Line Section is the Hefei-Jiujiang Railway, where the crossing with the main line is at K123+391.7 and the crossing with the Anqing Branch Line is at LK14+533. Through the co-route arrangement of highways and railways, the construction area is effectively saved and the space utilization rate is improved.

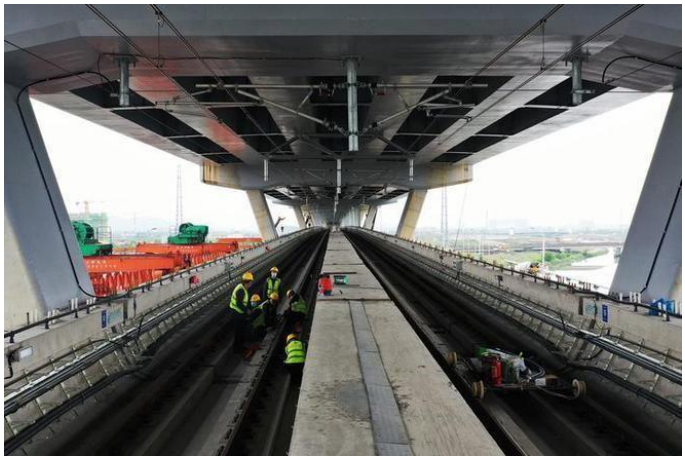


Fig. 4.4 Co-building of expressway with railway

(4) Co-building of expressway with provincial highway

The Wanning-Yangpu Expressway in Hainan Province crosses Hainan Island, with a total length of about 165km, passing through several nature reserves, and a cluster of tropical characteristic agricultural areas. It is an expressway with the most difficult terrain conditions, the most complex geological conditions, the most sensitive ecological environment, the worst natural environment, and the richest cultural resources among the projects under construction in Hainan Province. According to the principle of “overall planning, rational layout, intensive use and high efficiency”, the Wanning-Yangpu Expressway shares the same corridor with the provincial highway S307 (Wanling Town-Danzhou Section), and several interchanges (Xinjin, Yangjiang, etc.) connecting the provincial highway S307 are set along the line, promoting the regional economic development.

Fig. 4.5 Co-building of expressway with provincial highway

(5) Co-building of highway with levee

The Tianjin-Shijiazhuang Expressway is located in the south of Tianjin. The project is connected with the east-west transportation corridor of the Nangang Industrial Zone, with extremely scarce corridor resources. For the Tianjin-Shijiazhuang Expressway, the design of co-building highway with levee is adopted, where the left levee of Duliujian River and part of the river floodplain are fully used for filling, not only keeping the function of the original river and levee unaffected, but also avoiding the additional land acquisition by cleverly utilizing the land area. The mode of co-building highway with levee realizes the multi-win effect of saving corridor resources, land and earth volume and improving levee safety.

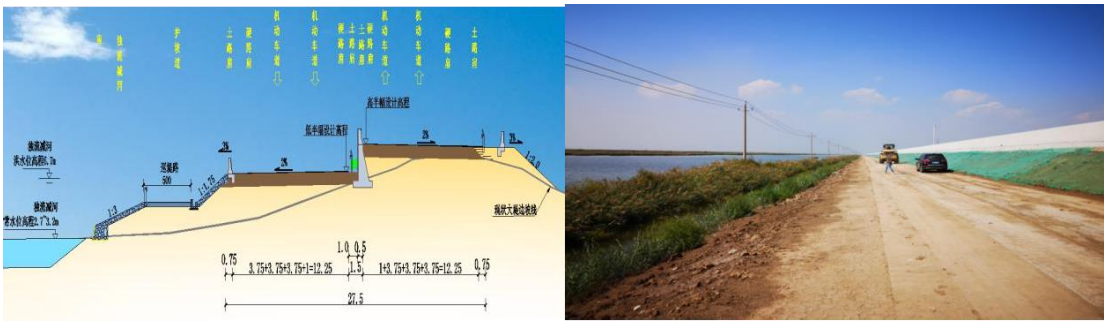


Fig. 4.6 Separated subgrade layout scheme for co-building highway with levee

4.1.3 Flexible use of technical indicators

(1) General requirements

Through the reasonable selection of standards and flexible use of technical indicators, the maximum maintenance can be provided for the coordination between the highway and railway projects and the natural and human environment. When the project is located in a region with complex construction conditions such as high altitude, extremely low temperature, frequent geological disasters and limited land use, it is recommended to select technical standards by sections and adopt the minimum or limit values of technical indicators stipulated in specifications[2].

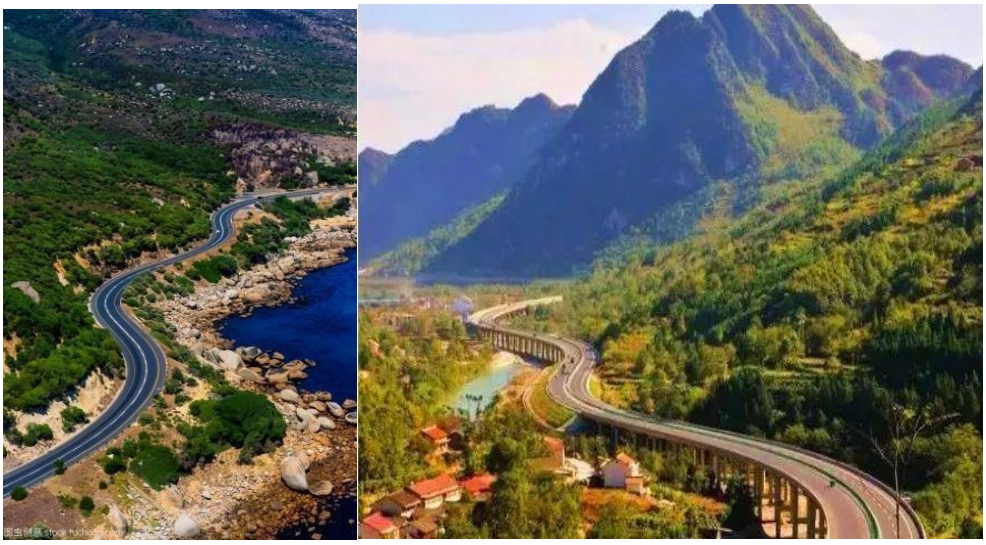


Fig. 4.7 Highways winding at the toe of mountain slopes

(2) Highway case

The post-disaster reconstruction project of the Chuan-Jiu Road starts from the northwest side of Jiuzhaigou County, passes through the north of Jiuzhaigou scenic spot, and ends at the west of Chuanzhusi Town, Songpan County. The main line of the project has a total length of 122.8km, of which 69km of the original road is utilized, 30.2km of the original road is widened, 23.6km is built for the 5 sections for disaster bypass and 3 sections for integrated tourism, and 3 sections of tourism branch lines totaling 14.7km are utilized.

In terms of the application of design standards in the post-disaster reconstruction project of the Chuan-Jiu Road, the principle of “reducing some technical indicators appropriately on the premise of ensuring the safety for special and difficult sections” is put forward. For example, the width of subgrade in some sections is increased from 8.5m to 10m in consideration of the impact of snow on driving safety in winter; for accident-prone sections, attention is paid to improving the horizontal and longitudinal plane alignment, such as vertical section leveling and horizontal curve rerouting in local sections.

Fig. 4.8 Post-disaster reconstruction project of the Chuan-Jiu Road

(3) Railway case

The Chengdu-Lanzhou Railway connects Chengdu, Sichuan Province and Lanzhou, Gansu Province. It consists of two parts: Lanzhou-Hezuo Railway and Xining-Chengdu Railway.

When selecting the speed target value, Chengdu Lanzhou Railway fully considers the matching of fixed equipment and mobile equipment of EMUs. In the Mianzhu-Maoxian Section, Maoxian-Diexi Section, Huangshengguan-Jiuzhaigou Section and a series of 18‰ 40km-60km long sections of sufficient grade, the entrance speed is 200km/h and the simulated exit speed is 180km/h. The train speeds are higher in sections of free grade.

Fig. 4.9 Chengdu-Lanzhou Railway

4.1.4 Scientific comparison of engineering schemes

(1) General requirements

With the differences in development between regions and between different geographical conditions fully considered, on the premise of ensuring the safety and functionality, the construction scheme is accurately selected through the careful comparison of engineering schemes and technical economy. In the preliminary design stage, the comparison of various engineering schemes shall be strengthened, especially for high fill, deep cut subgrade and special subgrade.

Fig. 4.10 Effect of using tunnel in the land transportation route

Fig. 4.11 Expressway occupying the minimum arable land

(2) Highway case

The National Highway G209 (Wudangshan-Shennongjia Highway) starts from Liuliping Town, Danjiangkou City, and ends at Muyu Town, Shennongjia Forestry District, with a total length of 225.1km.

In the V-shaped valley downstream the Tanjiawan Reservoir, the project was originally designed as a 4-hole 20m medium bridge with the highest pier of 20m. As a large amount of earth is excavated in the subgrade at both ends of the bridge, the scheme is optimized into a subgrade filling scheme after the technical and economic demonstration, utilizing nearly 400,000 cubic meters of abandoned earth, with nearly 20 mu of gully transformation and land reclamation.

Fig. 4.12 National Highway G209 (Wudangshan-Shennongjia Highway)

(3) Railway case

The main track of the Xining-Chengdu Railway is 836.5km in length, with a bridge-tunnel ratio as high as 80%. It passes through basins, plateaus, river valleys, mountainous areas and ten large fault zones, and is confronted with prominent geological problems such as large deformation of soft rock, high pressure gas and weak diagenetic water stability under high geostress conditions. 65% of the new project is above the altitude of 3,000m, and the line passes four national, one provincial and two county-level nature reserves. The geological conditions are extremely complicated, and the ecological protection responsibilities are heavy.

From the route selection stage, the adverse geology is bypassed to the greatest extent or the corresponding measures are taken. In addition, a shorter cross ridge tunnel scheme is adopted to reduce the risk from the source. On the one hand, the problems such as poor geological development or swamp crossing are solved by means of erecting bridges and increasing the depth of foundation columns. On the other hand, bridges are used instead of subgrade and vegetation is regularly maintained to strengthen the bypassing and protection of nature reserves.

Fig. 4.13 Xining-Chengdu Railway

4.1.5 Safety design in special sections

(1) Main types of road special sections

Special road sections include continuous long steep slopes, small radius curves, curved slope combinations, tunnels, insufficient clearance between the entrance/exit of the main line and the tunnel, special climate zones, etc.

(2) General requirements for safety design

The traffic safety facilities in special sections shall be designed in accordance with the line conditions, terrain conditions, traffic conditions, environmental conditions, management conditions, and economic conditions, and adhere to the principles of putting people and safety first, giving priority to active guidance, providing appropriate passive protection, designing systematically, and highlighting the key points. In addition, the economy, environmental friendliness, aesthetics and durability of materials shall be coordinated[3].

For sections with large terrain elevation differences, the route scheme selection and route layout of highways and railways shall try to avoid the occurrence of long steep longitudinal slopes, and turnround or spiral route development can be used to overcome the elevation differences.

For snowy and frozen areas, highways and railways shall be routed on sunny slopes where possible and shall not be routed at the toe of steep mountain slopes; in areas with wind-blown snow (sand), the routes should be laid in areas where snow (sand) circulates, such as the areas with open terrain and smooth airflow and the toe of windward slopes.

For special areas with desert, frozen soil, loess, etc., in the design of subgrade, the impact of climate, water, geology and other factors on the long-term performance of the subgrade shall be comprehensively considered, with the focus on possible subgrade defects. Through comprehensive technical and economic comparison, effective measures shall be taken according to local conditions to ensure the stability of subgrade.

Fig. 4.14 Highway in the section with spiral route development

(3) Highway case

The Ya'an-Kangding Expressway in Sichuan, with a total length of 135km, has the characteristics of long longitudinal slopes and high altitude. Due to the complex geological and terrain conditions, harsh climate, and fragile ecological environment, it is recognized as one of the most difficult expressways under construction in China, with an altitude difference of 1,750m and a bridge-tunnel ratio as high as 82%.

Through the reasonable longitudinal slope design, safety evaluation, and improvement of safety facilities, the operation safety in special sections is ensured; with disaster prevention as the core, the geological investigation, prediction and survey are strengthened, and the disaster resilience of the project is improved through the improvement of adverse geology treatment and structural design measures. In order to reduce the potential safety hazards, anti-snow sheds are also designed in the open line sections connected with tunnels, so the drivers are provided with more safety protection.

(4) Railway case

The Qinghai-Tibet Railway has a total length of 1,956km. It connects Xining, Qinghai Province and Lhasa, Tibet Autonomous Region. It is also the highest and longest plateau railway in the world. Some areas along the railway line have serious soil desertification. During the sandstorm season, the sand dunes move with the wind, which may submerge the subgrade of the Qinghai-Tibet Railway at any time.

During the design of the Qinghai-Tibet Railway, large-scale sand-fixing grids and wind break walls are planned in the main sections with wind-blown sand to block its invasion. At the same time, the measure of "using bridges instead of roads" is adopted in the places with a draught, such as Hongliang River and Cona Lake, and wind-blown sand channels are reserved so that the sand can pass freely, effectively blocking the erosion by wind-blown sand. Up to now, more than 100km of subgrade has been constructed in wind-blown sand sections along the Qinghai-Tibet Railway.

Fig. 4.15 Sand-fixing grids along the Qinghai-Tibet Railway

4.1.6 Environmental protection and landscape improvement

(1) The protection of the environment and biodiversity along the line shall be strengthened.

Overall requirements: For the route design, full consideration shall be made on the natural environment in

the areas along the line, and the environmental pollution and the adverse impact on the original ecosystem caused by the road project shall be eliminated or mitigated. Importance shall be attached to the design of pollution risk prevention in sensitive areas of the water environment, and the emergency response to risks and accidents of the water environment shall be improved. It is also required to promote the ecological and environmental protection design, take the biodiversity protection as the goal, highlight the protection of natural landforms, native vegetation, surface soil resources and wildlife, and attach importance to wetland ecological protection.

Highway case: The Xiaomengyang-Mohan Expressway in Yunnan has a total length of 167km, which is a major highway corridor connecting China and the Southeast Asian countries. The entire project is located in the tropical rainforest area of Xishuangbanna, with dense plants and diverse organisms, so there is great pressure on engineering construction and environmental protection. The concept of environmental protection is followed in route selection and engineering scheme comparison, excavation is reduced, the bridge-tunnel ratio is increased, and the ecology is protected to the greatest extent. In order to ensure that the local biological resources are not damaged, local plants are selected for greening on both sides of the line, which integrate into nature in a short time, diluting the artificial traces. In sections with reserves, a bridge & tunnel scheme is adopted to reserve a passage for wild Asian elephants, which are guided by plants that they like to eat, and the native vegetation is moved back where possible in the road area to maintain a natural biological balance.

Fig. 4.16 Picture of Xiaomengyang-Mohan Expressway

Railway case: The new Mombasa-Nairobi Standard Gauge Railway (Mombasa-Nairobi Railway) is located in Kenya. There are many national parks, wetlands and wildlife reserves along the line. In order to ensure the effective protection of the ecology along the Mombasa-Nairobi Railway, the Employer cooperates with the Kenya Wildlife Service (KWS) to study the migration paths and living habits of animals in Tsavo National Park, and set up animal passages in places where animals often migrate. The new railway is above the ground and leaves space for animals to pass through. According to statistics, the Mombasa-Nairobi Railway has 14 animal passages. For the 170km section located in the wildlife park, 88 bridges with a total length of 30km and 969 animal crossing culverts have been designed.

Fig. 4.17 The Mombasa-Nairobi Railway uses bridge instead of road to reserve animal passages

The Yuxi-Mohan Railway, as the Chinese part of the Central Route of the Pan-Asia Railway, starts at Yuxi, Yunnan, passes through Pu'er and Jinghong, and ends at Mohan Port. The forest coverage rate along the railway is relatively high, the ecological resources are rich, the environmental carrying capacity is weak, and the ecology is relatively fragile. The No. 15 stake is located at the Yexianggu Station. Therefore, at the beginning of the design, environmental protection and water and soil conservation have been incorporated into the construction, and a detailed implementation plan has been drawn up. During the construction period, personnel access to non-construction areas is strictly controlled and unauthorized digging and collection of wild plants in non-construction areas are eliminated, to mitigate the impact on protected plants. The route effectively bypasses the main activity areas of Asian elephants, and measures such as extending tunnels, using bridges instead of roads, and setting up elephant protection fences are taken, to minimize the impact of railway construction on the ecological environment along the line.

Fig. 4.18 Elephant protection fences along and picture of Yuxi-Mohan Railway

(2) The integration of the traffic landscape and the environment along the line shall be promoted.

General requirements: The highway and railway facilities shall be integrated with the surrounding scenery and landforms, integrating regional elements, appropriately highlighting the local characteristics, and avoiding traces of deliberate artificial landscaping and carving[4]. The natural landscape environment (such as mountains, lakes and tall trees) or existing buildings along the line can be used to integrate the highway, railway and environment after the analysis of the spatial relationship between the road and the environment

along the line.

Fig. 4.19 The highway landscape sections show the Muya and snowy region cultures respectively

Highway case: For the Tongnan-Rongchang Expressway in Chongqing, the landscape-themed sections are reasonably divided according to the space experience along the line, and featured landscape is appropriately provided on important road nodes such as tunnel entrances, interchange areas and service areas, highlighting the local cultural characteristics of Tongnan, Dazu and Rongchang.

Fig. 4.20 Landscape-themed sections of the Tongnan-Rongchang Expressway in Chongqing

Railway case: The Shangqiu-Hefei-Hangzhou High-speed Railway, with a total length of 794.55 km, is a high-speed railway connecting Shangqiu City in Henan Province, Hefei City in Anhui Province and Hangzhou City in Zhejiang Province. In the planning stage, the Employer has planned in advance for personnel deployment, land acquisition and demolition, optimization of construction organization, and optimization of selection of plant species, and made detailed deployment and arrangement for subgrade slopes, framework, slope protection and subsequent greening schemes. The high subgrade slope section has built-in hollow bricks and gravity retaining walls for the framework slope protection. During the construction, according to the overall requirements of “adjusting measures to local conditions, being economical and practical, and taking into account the landscape”, as well as the local climate and soil conditions, special personnel are sent to investigate and compare dozens of landscape plants, which are analyzed one by one for their economic costs, growth habits, and difficulty in maintenance and management. In the end, the best varieties are selected, which are cost-effective, cold-resistant, adaptive to barren soil, evergreen, beautifully colored, highly ornamental and easy to manage. The color block planting technology is adopted in the slope greening, so that the planting color blocks are distributed in strips according to the height of the arched framework, achieving a clear, three-dimensional and aesthetic greening effect.

Fig. 4.21 Picture of subgrade greening of the Shangqiu-Hefei-Hangzhou High-speed Railway

4.1.7 Application of digitization and information technology

(1) General requirements

LIDAR survey, geological remote sensing and other technical means can be used to obtain the three-dimensional digital ground model of the route area and the three-dimensional spatial distribution information of the geological body, so as to improve the rationality of corridor site selection and scheme comparison, and improve the design accuracy and efficiency[5]. Intelligent design can be carried out based on 3D digital information and BIM (Building Information Modeling) technology.

(2) Highway case

Case 1: The Duyun-Anshun Expressway in Guizhou starts from the Wuyang Hub in Duyun City in the east and ends at the Yangjiashan Hub in Zhenning County in the west, with a total length of 215.40km. In the project, the LIDAR survey technology is used to quickly obtain the 3D ground surface data such as DLG (Digital Line Graphic), DEM (Digital Elevation Model), and DOM (Document Object Model) that meet the design of bridge construction drawings, and automatically generate the cross-sectional ground line data required by the pier and abutment design, providing strong technical support for the scheme design, comparison and selection and the pier and abutment excavation protection.

Case 2: The total length of the main line of the Yanqing-Chongli Expressway is 114.752km, including 33.2km in Beijing and 81.552km in Hebei. For the Hebei Section of the Yanqing-Chongli Expressway, the 3D geographic information system (3DGIS) and the building information modeling (BIM) are based on establishing a 3D detailed model containing all the components of the project. In the bridge design, through construction drawing modeling and simulated assembly, collision problems are found, thereby reducing construction costs, improving production efficiency, and providing guarantee for work safety.

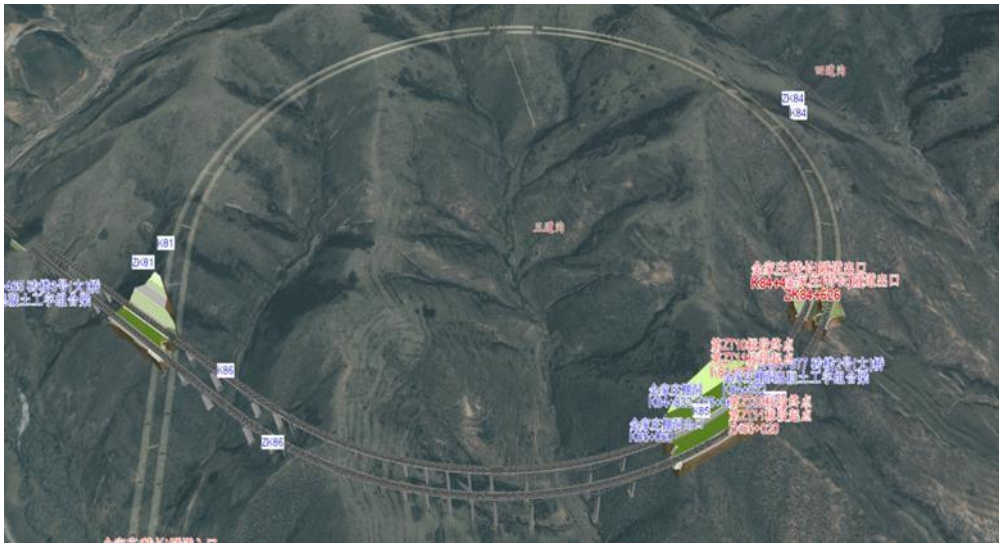


Fig. 4.22 3DGIS model of the bridge in Hebei Section of the Yanqing-Chongli Expressway

(3) Railway case

The BIM technology is applied for projects such as the Beijing-Shenyang High-speed Railway BIM pilot project, Yangquanbei-Dazhai Railway, and Indonesia's Jakarta-Bandung High-speed Railway firstly opened section to check the systematicness, compliance and conflicts of the engineering design, optimize the design schemes, and improve the design quality. Some disciplines have realized the quantity calculation based on BIM information.

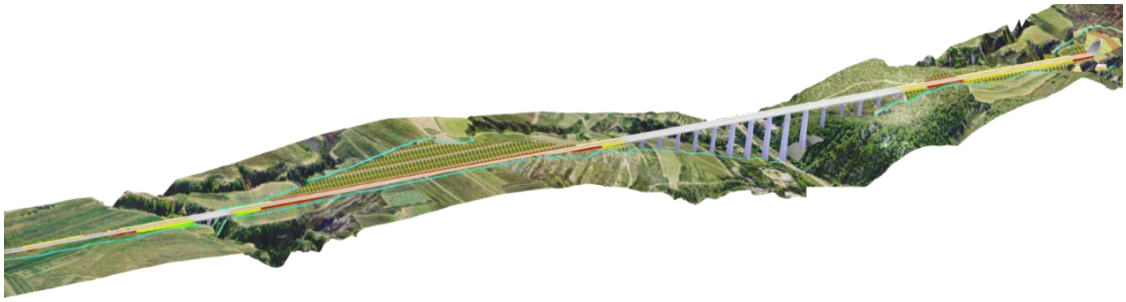


Fig. 4.23 BIM model of the Beijing-Shenyang High-speed Railway

4.2 Green engineering construction

4.2.1 Scientific construction organization

(1) General requirements

Through the construction organization design, the requirements of "zero abandonment and less borrowing" are implemented to achieve the minimum land occupation and the maximum saving. The construction is

reasonably organized to promote the coordinated allocation of resources such as earth, rock, topsoil and tunnel slag. The construction time sequence is reasonably arranged, e.g., “excavation before filling” and “bridge construction before tunnel construction”, to minimize the construction of access roads. A detailed traffic maintenance plan is developed based on the site conditions and the deployment of construction machinery is strengthened, ensuring the traffic maintenance work during the construction period.

(2) Highway case

Case 1: The Zhejiang Chun’an Section of the Liyang-Ningde National Expressway has a total length of 61.5km. The starting point is the Pingshan Industrial Park in Chun’an County, i.e., the ending point of the Hangzhou-Qiandao Lake Expressway, and the ending point is directly connected to the Hangzhou-Huizhou Expressway. The construction organization of “constructing tunnel before main works” is adopted for this project. The tunnel is excavated first, and the acceptable gravel is used for filling of the near end subgrade, and then paved to the far end, to achieve the balance between filling and excavation.

Case 2: The Pelješac Bridge and its connecting line are located in Croatia, with a total length of 2,440m. After completion, it will span the Bay of Mali Ston of Adriatic Sea and connect the Croatian territory across the sea. The pile foundation construction scheme of this project is optimized, where the whole steel pile is driven, and the steel pipe pile is formed in the factory at one time, with the welding quality fully meeting the “EXC4 B+” requirements, avoiding the disadvantages of construction after welding on the offshore construction site. Therefore, the construction risk is greatly reduced. The construction period of the optimized construction scheme is shortened by 3 months compared with the original scheme, and the number of drilling rigs, construction vessels, construction personnel, etc. is reduced accordingly.

Fig. 4.24 Pelješac Bridge and its connecting line

(3) Railway case

The Nanjing-Anqing High-speed Railway runs from Nanjing South Station to Anqing Station, with a total length of 257km, 10 stations, and a designed maximum speed of 250 km/h. For the Nanjing-Anqing High-speed Railway, the analytic hierarchy process, network planning optimization, and optimization and adjustment in implementation are used to optimize the railway construction organization design, and during the implementation of the scheme, the actual monitoring results are used to optimize the scheme.

Fig. 4.25 Nanjing-Anqing High-speed Railway

4.2.2 Overall planning of yard construction

(1) General requirements

The station construction shall be planned in terms of space and time, so as to achieve “compact layout” in space and “orderly connection” in time, integrate and utilize land resources, and reduce the amount of land occupied by temporary works. The layout design of the construction station and site shall take into account the convenience of construction and transportation. The construction contractor shall focus on the combination of temporary works (such as temporary construction stations, access roads, temporary bridges, construction electricity, and construction water) with permanent works. It shall also consider the combination of temporary support, retaining, protection, drainage and other measures with the design scheme during the construction.

(2) Highway case

The Putian-Yanling Expressway is constructed according to the two-way six-lane standard, with a design speed of 100km/h, and the entire line runs through 3 provinces: Fujian, Jiangxi and Hunan.

The access roads for the construction of the Yongtai Wutong-Youxi Zhongxian Section (in Fuzhou City) of the Putian-Yanling Expressway are properly planned through the strengthened communication with the local government and the consideration of the local development planning. The construction of the access roads at the exit of the Jianfeng Mountain Tunnel is based on the renovation and widening of the existing village roads after considering the local development planning and the factors such as outbound transportation of woods. This reduces the quantities of construction of temporary access roads, saves expenses, and greatly reduces the acquisition of temporary land. After completion of the project, the access roads are used as local planned roads, so the access roads and other temporary works become convenient roads and prosperity roads for people along the line. The siting of the T-beam precast yard of the project follows the principle of combining permanent works with temporary works. The sites are selected on permanent land such as the toll plaza and the main line subgrade, which saves 52 mu of temporary land and effectively utilizes the resources.

Fig. 4.26 T-beam precast station

(3) Railway case

The XQNQ-7 bid section of the Xingguo-Quanzhou Railway, with the main line length being 38.5km, is located in the mountainous area of Fujian, with many gullies, difficult construction conditions, and high technical difficulties. For this, a total of 3 power supply arm lines (permanent and temporary works combined) are designed to provide power for the engineering construction, reasonable arrangement is made for the route sections across villages and towns, the construction schedule is arranged in order of priority, and communication is made with the relevant departments of the local government in advance, effectively promoting the construction progress.

Fig. 4.27 Xingguo-Quanzhou Railway

4.2.3 Improvement of the information-based management

(1) General requirements

Establish an information-based management system for highway and railway construction with intelligent networking and joint control. Build a construction site video monitoring network, master the construction site conditions of key sections and key parts throughout the period, and strengthen the safety guarantee and behavior monitoring. Strengthen the UAV system used for the aerial survey of expressway construction and surrounding environment, and advocate the real-time monitoring of test data and important points.

(2) Highway case

Hunan Province promotes the application of real-time monitoring technology for mixing plants, implements real-time acquisition, transmission and storage of concrete production data of mixing plants, and comprehensively promotes the intelligent subgrade and pavement compaction monitoring system. Henan Province has established a video monitoring platform for construction dust, installs video monitoring, PM2.5, PM10 and other monitoring equipment at yards, bridges, tunnels, and main road intersections along each project, and implements a 24-hour monitoring system, so as to effectively ensure timely rectification and control of construction dust. For the Jiuzhaigou-Mianyang Expressway in Sichuan, the intelligent management of massive data is realized by establishing a big data system platform. During the construction and operation of the Yanqing-Chongli Expressway (Hebei Section), the digital platform, video monitoring and other technologies are utilized to realize the information-based management of the whole process and improve the overall efficiency.

Fig. 4.28 Monitoring center of the Yanqing-Chongli Expressway (Hebei Section)

(3) Railway case

In the Work Area VIII for the communication, signal, power and electrification works of the Haolebaoji-Ji'an Railway, combining the Internet and cloud platform technology, an integrated platform for smart construction sites is established for the entire line, solving the previous problems such as difficult data acquisition, repetitive work of front-line personnel, and information island among departments. For the Yancheng-Nantong High-speed Railway, a digital construction management platform is established, which brings together various modules such as labor management, material management, safety management, quality management, basic data management, BIM-5D smart construction site data decision-making, and infrastructure production management, setting up a framework for smart management.

Fig. 4.29 Haolebaoji-Ji'an Railway

4.2.4 Promotion of the use of advanced technology and equipment

(1) General requirements

Actively promote the use of energy-saving, land-saving, water-saving and material-saving construction techniques to reduce waste water, solid waste, noise and exhaust emissions from construction sites. Promote the application of new technology, new materials, new processes and new equipment in terms of green and low-carbon development, energy-saving and environmental protection. Actively use natural gas and other clean energy to mix the asphalt mixture, and add dust treatment equipment at the mixing plants to reduce the emission of smoke, dust, sulfur dioxide and other pollutants.

(2) Highway case

For the Wanning-Yangpu Expressway in Hainan, the warm mixing technology of asphalt mixture is adopted in the sections passing through scenic spots, nature reserves and adjacent cities and towns, reducing greenhouse gas emissions by 1,272t. In the reconstruction and expansion project of the Jihe-Heilongjiang Provincial Boundary (Hunchun)-Dongning Section of the Dandong-Altay Highway (a national highway in Heilongjiang Province), polymer elastomers are added to the base asphalt to change the workability of asphalt binder and realize the normal temperature construction, with significant energy-saving effects. In the Chongqing Tongnan-Rongchang Expressway Project, the mixing effect of cement-stabilized macadam is improved, the cracks in the semi-rigid base course are reduced, and the goal of reducing the cement consumption of cement-stabilized macadam base course by 20% is achieved.

Fig. 4.30 The warm mixing technology of asphalt mixture in the Hainan Wanning-Yangpu Expressway Project has significant energy-saving effects

During the driving of steel pipe piles of the Pelješac Bridge and its connecting line, a lot of noise will be generated, which will have an impact on marine life. Therefore, for the project, the bubble curtain noise reduction technology is adopted, where pipes are arranged on the surface of the seabed, and air is introduced into the pipes, so that the bubbles rising from the opening of the pipes form a closed bubble curtain, which generates high damping loss and scattering effect for noise propagation, and emits the noise to the air from the water surface. In addition, the bubbles in the process of being discharged will cause disturbance and sound in the water body, alerting the marine animals, so that the marine animals at close distances are kept away from the construction areas to avoid damage. The setting and successful use of the bubble curtain noise reduction device make the driving of steel pipe piles meet the relevant requirements of the local environmental protection law and noise protection law. No marine life has been killed by sound waves or high-energy vibration, and no complaint has been made by surrounding residents.

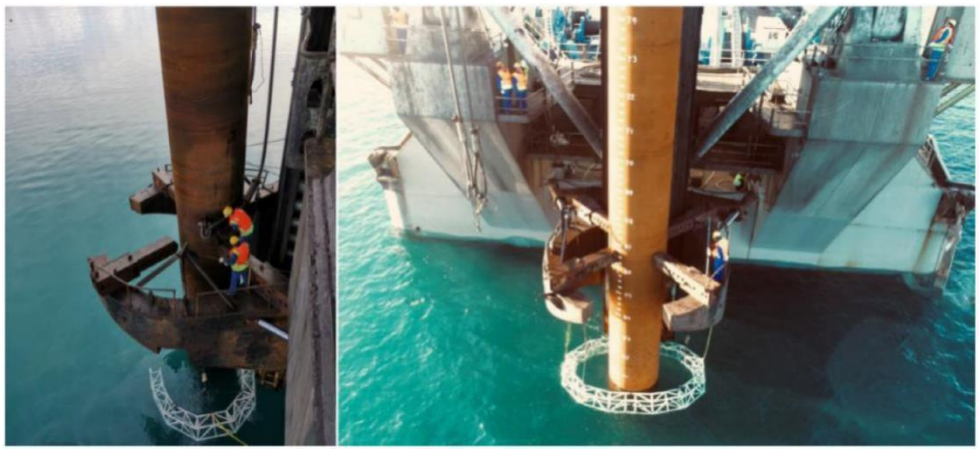


Fig. 4.31 Bubble curtain noise reduction device (white circular pipes)

(3) Railway case

The Ganlanba Super Major Bridge on the Yuxi-Mohan Railway is located in Jinghong City, Xishuangbanna Dai Autonomous Prefecture, Yunnan Province, with a total length of 3.5km and a total of 108 piers. The

Ganlanba Bridge passes through the quicksand section. During the construction, the drilling rig cannot make holes in the quicksand layer, and the unevenness of the stratum hardness causes a large deviation among drill holes. After striving to make technological breakthrough, bentonite and caustic soda are mixed into a slurry, which is injected into the unfavorable geology, preventing the hole wall from slipping and ensuring the smooth progress of the construction. In the construction of large-volume concrete for cushion caps, cooling pipes are arranged in the caps and the temperature is lowered by water circulation, which effectively controls the thermal cracking of the large-volume concrete and ensures the construction quality.

Fig. 4.32 Ganlanba Super Major Bridge

4.2.5 Strict construction management for environmental protection

(1) General requirements

Detail the relevant environmental protection requirements in the bidding documents and contract clauses, formulate the special environment-friendly construction schemes for special environment-sensitive points, strengthen the education and training of construction personnel, effectively improve the ecological construction awareness, and standardize the operation behaviors.

Animal and plant protection: Control the construction working planes of temporary land, subgrade excavation, and tunnel portal excavation to avoid damage to surrounding vegetation caused by over-excavation. Optimize the construction scheme, reduce the interference with wild animals, set up the publicity boards to promote the care for wild animals and natural vegetation on and around the construction sites, and educate the construction personnel.

Water environment protection: The construction contractor shall actively adopt economical and applicable equipment or technology, carry out proper wastewater treatment and recycling, and avoid direct discharge

of wastewater.

Atmospheric environment protection: During the construction in environment-sensitive areas such as residential areas, hospitals, schools and wildlife reserves, clean transportation, clean construction and exhaust gas control shall be strengthened to reduce the impact of construction operations on surrounding sensitive targets and the health of construction personnel.

Acoustic environment protection: In view of the key links and processes that generate noise and vibration, measures such as sensitive target protection, blasting vibration and noise reduction, and mechanical process noise reduction shall be comprehensively applied, and the extent and time period of the impact caused by construction noise and vibration shall be controlled.

(2) Highway case

Case 1: For the Zhengzhou-Xixia Expressway in Henan, the liquid interval blasting technology is used in the tunneling, which makes innovations in solving the problems of the traditional engineering blasting technology: the explosive energy is not fully utilized and the environmental pollution is caused. This reduces the use of explosives and the vibration on surrounding rock. The mixing plant is provided with a fully enclosed silo shed to control the dust, the electrostatic precipitator is installed in the cement silo, and collection buckets are used to collect the cement dust in the mixing plant. These measures effectively reduce the impact of cement dust, and the recycling of dust leads to the reduction of resource waste.

Case 2: For the section from Yangdian in Liangdang County to Lijiahe in Huixian County of the Changle-Tongren Highway on G316 Line in Gansu Province, the hydraulic tunnel blasting technology is vigorously promoted during the construction, achieving favorable economic and social benefits. Compared with the traditional smooth tunnel blasting, the hydraulic blasting technology improves the utilization rate of explosives, effectively controls the over-excavation and under-excavation of tunnel, reduces the dust concentration after blasting, speeds up the construction progress, and achieves the effect of energy-saving and environmental protection.

Case 3: The Project Department for the Pelješac Bridge and its connecting line has set up a special fund for energy-saving and environmental protection, purchased offshore oil dams to prevent possible oil spills, put into use two hopper barges, and transported the drill slag to 20 nautical miles away for collective discharge. The original 3-level wastewater sedimentation tank is transformed into a 4-level sedimentation tank and all production wastewater pipe networks are connected to ensure 100% recycling of production wastewater. A domestic sewage treatment system is installed and a local qualified wastewater treatment company is engaged for the regular treatment of wastewater to ensure that it does not cause any pollution to the environment.

Fig. 4.33 Third-party testing of construction equipment and sewage treatment equipment in living quarters in the Pelješac Bridge and Connecting Line Project

(3) Railway case

The Beijing-Shanghai Railway has a total length of 1,463km. It is a Class I double-track electrified railway (passenger and freight) connecting Beijing and Shanghai. The line runs north-south and is one of the major north-south arteries in China's railway network.

The Beijing-Shanghai High-speed Railway Project implements environmental protection monitoring and environmental monitoring throughout the line. During the construction, water quality monitoring, atmospheric monitoring and vibration monitoring are carried out for some sensitive areas along the line, and scientific and reasonable ecological environment protection measures are formulated on this basis, not only effectively reducing the impact of railway construction on the ecological environment, but also laying a solid foundation for the smooth progress of railway construction.

Fig. 4.34 Beijing-Shanghai Railway

4.3 Operation and maintenance of green projects

4.3.1 Standardization of process

(1) General requirements

For the operation and maintenance of highways and railways, the goal shall be serving the public's travel needs, a life-cycle maintenance cost concept shall be established, the guidance policies and technical standards suitable for national conditions shall be developed, the management and standardization systems for railway and highway maintenance shall be developed and improved, and the road condition testing and maintenance process shall be standardized; the management organization shall strictly implement the maintenance project management procedures and improve the approval and review systems for major projects; for technically difficult projects, experts shall be organized to conduct technical demonstrations.

(2) Requirements for highways

The highway maintenance work shall strictly follow the relevant national management measures and technical specifications for highway maintenance, tunnel maintenance, pavement maintenance, etc., adhere to scientific and standardized management, and improve the quality and efficiency of maintenance. The maintenance projects shall be organized and implemented following the procedures of preliminary work, plan preparation, project design, project construction, and project acceptance, and the work flow of each procedure shall be stipulated.

(3) Requirements for railways

Railway maintenance mainly includes the maintenance of railway subgrade, tracks, bridges, tunnels and buildings. The principle of "order, safety and orderliness" shall be followed, and the maintenance work shall be classified into overhaul, medium repair and repair[6].

4.3.2 Establishment of mechanisms

(1) General requirements

Clarify the setup and work responsibilities of railway and highway operation and maintenance management organizations, establish and improve the scientific decision-making system for highway maintenance, and strengthen the construction of the guarantee mechanism for management and maintenance funds. Focus on improving the maintenance patrol mechanism, operation management system, video monitoring system, wind, rain and snow monitoring system, etc., and establish and improve the emergency operation mechanisms, such as prediction and early warning, emergency response, and information release.

(2) Requirements for highways

Unified leadership and hierarchical responsibilities shall generally be implemented for the management of highway maintenance projects, and the maintenance project management work in the corresponding region shall be performed according to the hierarchical management responsibilities determined by each country. The general scope of use of the maintenance project funds shall include the highway technical condition

inspection and evaluation, maintenance decision consulting, maintenance design, maintenance implementation, project management and quality control, project acceptance, project post-evaluation, and supervision consulting.

(3) Requirements for railways

It is recommended to take the "trace-based" management as the starting point for railway maintenance. The ledger management mechanism may be used. Where conditions permit, an electronic ledger may be promoted to optimize the management efficiency and improve the work efficiency, forming a working mechanism of "whole-process trace retention, real-time monitoring, process management and dynamic evaluation".

4.3.3 Regular patrols

(1) General requirements

Railway and highway patrols shall generally follow the principle of "prevention first and prevention and control combined". The management entity shall establish the decision-making scheme and plan for preventive maintenance measures for different inspection and evaluation conditions, maintenance needs and objectives in accordance with the inspection indicators and frequencies specified in the national standards and regulations of each country. It is encouraged that each country should use the automated rapid inspection technology to carry out the patrols.

(2) Requirements for highways

Highways can be subject to classified patrols according to the actual conditions of each country and the requirements of international norms, focusing on the inspection and evaluation of subgrade, pavement, bridges, tunnels, and auxiliary facilities. Generally, highway patrols in rainy seasons shall be strengthened in rainy areas or areas where highways are frequently subject to flooding, and the frequency of inspections shall be increased during flood seasons or periods of frequent severe weather.

(3) Requirements for railways

Railway patrols may be carried out according to the actual requirements of each country and with reference to the international norms, focusing on the status of the overhead contact system, power supply equipment, signal equipment, track electrical equipment, transponders, train wireless dispatching communication equipment, and other facilities and equipment.

4.3.4 Personnel training

It is required to strengthen the training on specialized knowledge and technical skills for operation and maintenance personnel, formulate an operational maintenance skill training system, adopt flexible and diverse methods such as communication, book learning and skill practice to improve the training effects, strengthen the safety training and education, and improve the safety awareness[7].

Chapter 5. Recommendations on Promoting Green Development of Railway and Highway Projects under the Belt and Road Initiative

In order to promote green development of BRI railway and highway projects, eco-environmental assessment can be conducted prior to the project to identify major problems on eco-environmental protection, while applying the best and most feasible technologies and cases of green development of railway and highway projects to strengthen eco-environmental management of enterprises and projects and to continuously improve the level of green development of overseas railway and highway investment and construction projects.

5.1 Adopting Evaluation Index System to Explore and Implement BRI Project Assessment

5.1.1 Assess and Identify the Eco-Environment Status of Overseas Investment Projects

Eco-environmental technology assessment agencies may conduct systematic inspections on eco-environmental management of existing overseas projects and assist enterprises to develop documentation and archiving system to comprehensively investigate the situation of eco-environmental protection. Environmental impact assessment and environmental performance assessment for key transportation infrastructure projects are required, while technical guidance and services should be subsequently provided to tackle the problems discovered during the assessments.

5.1.2 Strengthening Eco-Environment Guidance on Overseas Investment Projects

It is advised to establish an ecological environmental guidance mechanism for overseas investment projects to explore and establish basic environmental requirements for overseas railway and highway investment and construction projects, and to evaluate the level of green development based on eco-environmental evaluation index system and corresponding requirements during the planning of such projects. Projects with obvious ecological and environmental problems should be promptly recognized whereas green projects using advanced environmental protection technologies should be better supported. Projects that may pose potential ecological and environmental problems should be further guided and regulated during and after operation, and the potential problems should be dealt with in a timely manner.

5.1.3 Promoting green development of outward credit and loan

It is suggested that eco-environmental assessment be included in bank credit decision-making process. With reference to the evaluation index system and requirements proposed in this report, China's domestic financial institutions can establish eco-environmental assessment systems suitable for respective industries.

For green transportation projects, strong financial support policies shall be formulated to facilitate a number of overseas green projects for demonstration and publicity purposes; projects that are not equipped with advanced environmental protection technologies or do not meet global green standards shall be supported with caution.

5.2 Promoting the application of the best available technology

The construction, reconstruction and expansion projects of highways and railways in the "Belt and Road" Initiative shall fully observe the concept of green transportation and the related requirements. During the design and construction, in accordance with the relevant technical requirements of "green transportation", the green and low-carbon technology shall be actively applied and promoted in the design, construction and operation stages.

(1) In the overall design, it is required to implement the idea of full life cycle, balance and coordination, comprehensively consider all aspects of construction, management and maintenance, and implement the concept of green transportation construction to every aspect of infrastructure through scientific design of construction scheme, intensive use of corridor resources, flexible selection of technical indicators, scientific comparison and selection of engineering scheme, safety design for special sections, environmental protection, landscape improvement, and application of digitalization and information technology, so as to create a transportation project that is resource-saving, environment-friendly, comfortable to operate, and better in quality[8].

(2) In terms of subgrade and pavement, the principle of "making no damage is the greatest protection" shall be implemented, and the idea of "zero abandonment and less borrowing" shall be advocated. By controlling the filling and excavation, coordinating the earth allocation, recycling the solid waste and waste materials, and selecting various environment-friendly engineering facilities, the organic coordination between the subgrade and pavement works and the natural environment is realized.

(3) In terms of construction of bridges and culverts, in accordance with the requirements of industrialized construction, it is required to highlight the safety, durability and leading technology, and achieve green and durable bridge projects through comprehensive bridge scheme comparison and selection, standardized design, integrated construction and maintenance design, environmental protection design, and other measures.

(4) In terms of tunnel construction, the requirements for functional and structural safety shall be satisfied, and resources shall be saved (energy saving, land saving, water saving and material saving), environment protected and pollution reduced in the full life cycle of the tunnel, achieving harmonious coexistence with the natural environment. Reasonable tunneling scheme, advanced construction technology, effective use of tunnel slag, and optimized ventilation and lighting measures shall be adopted, and the use of clean energy shall be vigorously promoted, so as to minimize the impact on the natural environment of the mountains and protect the ecological resources[9].

(5) During project construction, the construction organization, material procurement, on-site construction, project acceptance, etc. shall be controlled, and the management and supervision of the entire construction process shall be strengthened. Overall planning shall be made for the utilization of resources such as land,

equipment, buildings, topsoil, and construction materials, and the utilization efficiency of the resources shall be effectively improved. It is also necessary to fully comply with the requirements of environmental protection and water and soil conservation during the construction, focus on promoting the protection of native vegetation and water environment in the construction period, improve the water and soil conservation measures on the construction sites and premises, strengthen the construction noise and vibration control, control the construction dust, and formulate a special construction scheme when environment-sensitive areas are involved, so as to reduce the impact of construction on the environment. The focus shall be on reducing the solid waste, using the clean energy, and adopting the low-energy-consumption construction processes and high-energy-efficiency mechanical equipment, so as to achieve low energy consumption and low emissions in the highway construction process.

5.3 Strengthening the construction of ecological environment management capacity of transportation enterprises with external projects

5.3.1 Introducing the stewardship environmental protection services

The concept and services of environmental protection stewardship shall be introduced into the project construction, providing integrated environmental protection services and solutions such as monitoring, supervision, construction and operation of environmental protection facilities, and pollution control. Through normalized “physical examination” and “inquiry”, early warning and targeted measures shall be put forward in time to avoid environmental accidents.

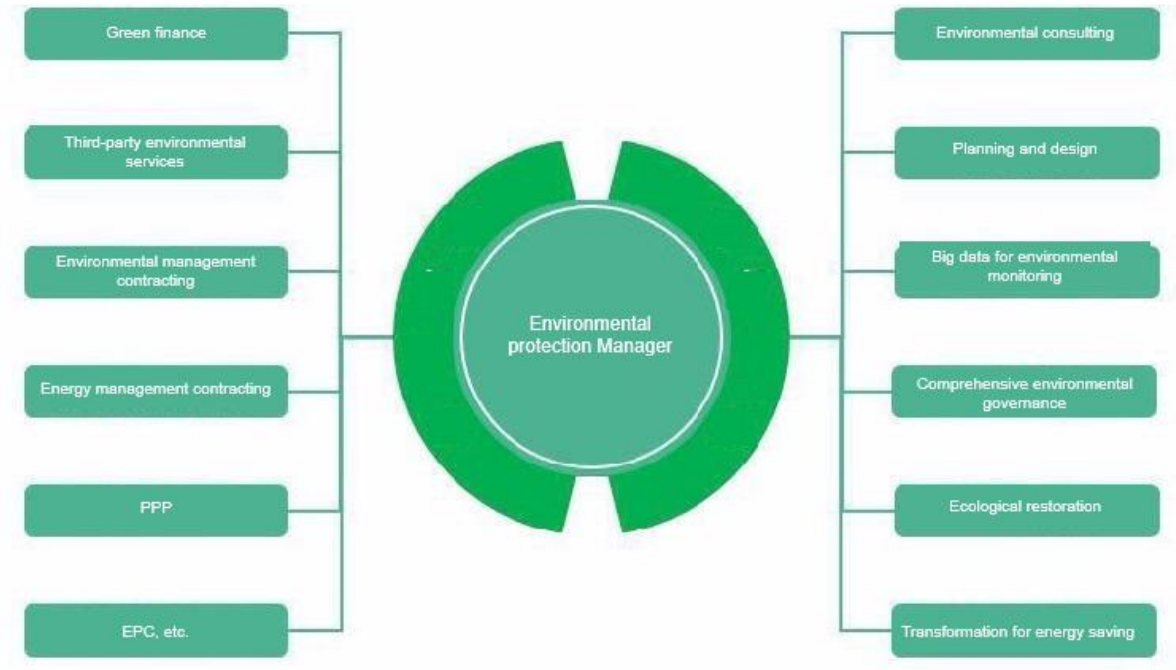


Fig. 5.1 Schematic diagram of environmental protection Manager

5.3.2 Carrying out the special design for green project

In order to ensure a green project, a reasonable green construction scheme can be formulated in the early stage of the engineering feasibility study based on the characteristics of the project. In the planning and design stage, special green design shall be carried out focusing on pollution prevention, ecological restoration, resource saving and recycling.

5.3.3 Establishing a construction quality, health, safety, environment management system (QHSE)

In the construction phase, the quality, health, safety, environment management of highway and railway infrastructure shall be integrated following the principle of systematic management, and the PDCA (Plan—DO—Check—Action) principle shall be followed to build the quality, health, safety, environment (hereinafter referred to as QHSE) management framework mode. The focus shall be on establishing a QHSE system document with the Employer as the core and a quality management mechanism with the risk control as the goal, and clarify the responsibilities of all parties involved in the project construction.

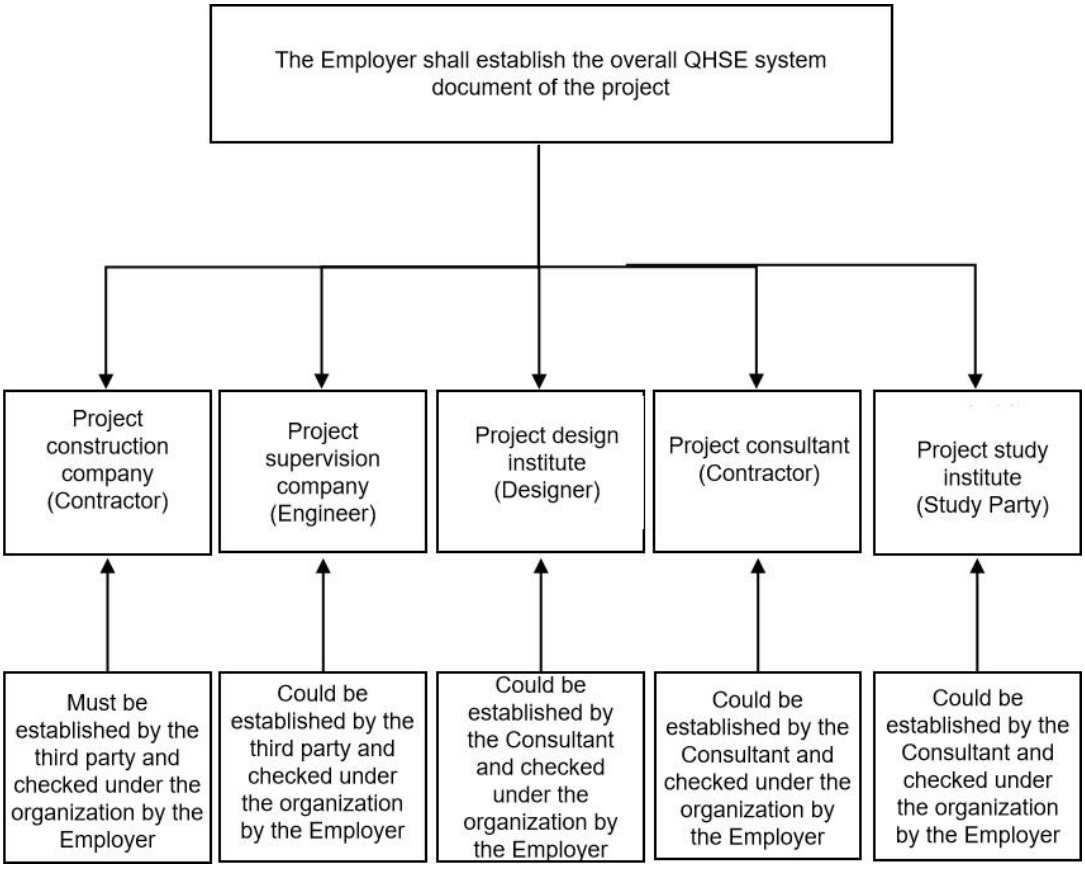


Fig. 5.2 QHSE management system for specific project construction

5.3.4 Implementing the full-chain environmental management

With environmental quality improvement as the core, environmental impact assessment shall be carried out

in the planning stage, environmental protection and water conservation management shall be strictly implemented in the construction process, and follow-up assessment shall be carried out in the operation stage. In the early planning and design, great attention shall be paid to the implementation of the concept of green development; for the construction process, the most suitable project type, the most efficient techniques, and the most natural and environment-friendly construction materials shall be selected; the end treatment and green operation shall be strengthened[10].

5.3.5 Establishing an emergency response mechanism for environmental events

An emergency response mechanism for environmental emergencies shall be established from the aspects of conducting risk assessment of environmental emergencies, improving risk prevention and control measures, investigating hidden environmental safety hazards, formulating emergency plans, and strengthening the construction of emergency response capabilities. In addition, multi-departmental and cross-regional collaboration for railway and highway emergency management shall be strengthened, and a rapid notification and joint response mechanism for early warning information shall be established. The transportation emergency drills shall be regularly organized and conducted, a railway and highway emergency management training system shall be established, and the capacity of railway and highway emergency response and support shall be improved.

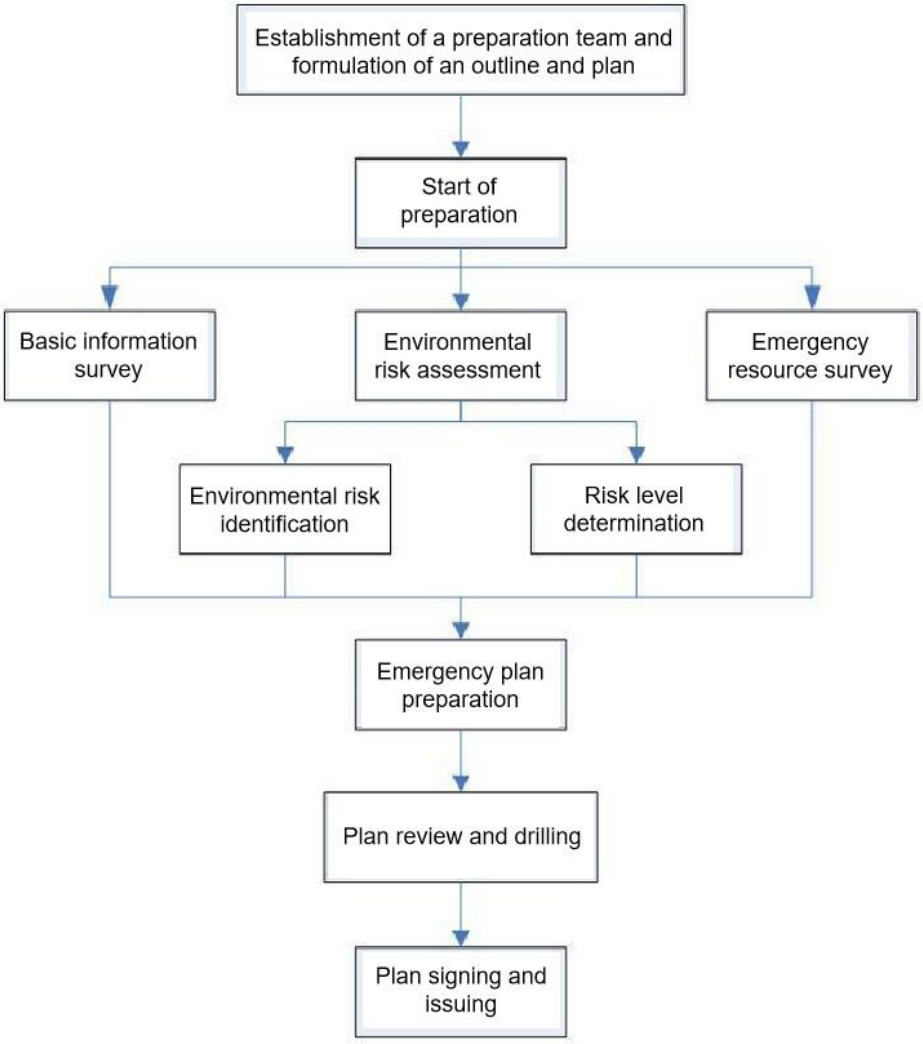


Fig. 5.3 Flow chart of environmental emergency response

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