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Development of Highway Transport Infrastructure along the Belt and Road

Lei Yang[1], Ma Junhai[2], Zhang Yuchun[3], Huang Chengfeng[1] , Zhou Jianting[1] , Wu Hongbo[4]

1. Chongqing Jiaotong University, Chongqing 400074, China
2. China Communications Construction Co., Ltd., Beijing 100088, China
3. Southwest Jiaotong University, Chengdu 610031, China
4. CCCC Highway Bridges National Engineering Research Centre Co., Ltd., Beijing 100088, China

Abstract: The economic, societal, and natural environments of countries included in the Belt and Road Initiative are diversified and complex, thus introducing numerous constraints to the highway traffic infrastructure connectivity along the route. Moreover, this connectivity currently requires strategic research and guidance. Based on numerous investigations and special studies, the highway development of major economic corridors comprehensively evaluated in this study are presented in this paper. The paper also summarizes the constraints that confront highway construction along the route. An overall construction and promotion idea from the aspects of strategic thinking and technical solutions is also proposed. The requisites and foundations determine the highway direction, which determines the natural and environmental barriers; these barriers determine the key projects, and the projects determine the technical solutions. On this basis, the developmental paths and key engineering proposals for the highway traffic infrastructure of the main economic corridors along the Belt and Road can be formulated. For specific implementations, a construction sequence should be proposed after evaluating the complexity and capital requirement of key control projects, and feasible financing and operating plans should be conceived based on the social and economic environments of projects.
Keywords: Belt and Road; highway; engineering technology; infrastructure

1 Introduction

In an effort to intensify economic globalization, China has proposed a new model of international cooperation—the Belt and Road Initiative (BRI) [1]. A priority of the BRI is the enhancement of the connectivity of Eurasia's infrastructure through the construction of several economic corridors on land according to the economic agglomeration and radiation functions of integrated transportation passageways The countries located in the BRI regions generally have inconvenient transportation and relatively undeveloped infrastructure. To accelerate economic advancement, it is necessary to vigorously develop transportation infrastructure and enhance the connectivity in these areas. In this regard, highway transportation is flexible and convenient and affords unique technical and economic advantages. The construction of highway transportation infrastructure is therefore crucial in the realization of interconnection in the Eurasian region. The elimination of bottleneck roads and the upgrade of

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Corresponding author: Huang Chengfeng, professor at Chongqing Jiaotong University. Major research field is transportation development strategy. E-mail: zhenwushanxia@163.com
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infrastructure along the BRI areas would aid in reinforcing the weak links in the infrastructure that currently restrict the augmentation of cooperation among countries in the BRI regions. These countries have complex and diverse characteristics in terms of politics, economy, culture, religion, and geographical conditions [2]. In view of these, strategic research and guidance are urgent requisites to overcome the many constraints and problems encountered in building road interconnections.

2 Highway interconnections in major corridors

2.1 Highway interconnections in China–Pakistan Economic Corridor

(1) Accessibility. The early Karakoram Highway was completed in 1978, and the Karakoram Highway expansion project was completed in September 2015. At present, the highways between Kashi and Gwadar Port can barely support freight tasks; accordingly, the rebuilding and expansion of certain roads are ongoing.

(2) Reliability. In view of the complex geological conditions and severe natural disasters that occur in summer, damage to Karakoram Highway during the aforementioned season is highly probable [3]. The probability of sustaining damage after the expansion, however, is lower, and highway reliability is expected to gradually increase.

(3) Capacity. The design speed of the entire line is 40–60 km/h, but in some sections, speeds can reach up to 100 km/h. The expansion is expected to effectively shorten logistics time and reduce transportation costs.

2.2 Highway interconnections in Bangladesh–China–India–Myanmar Economic Corridor

(1) Accessibility. The Stilwell Road, built during World War II, is a historical example of Bangladesh–China–India–Myanmar cooperation; it has long been in a state of disrepair. A secondary highway linking Tengchong to Myitkyina was opened to traffic in April 2007, indicating that further road connections between China and India are feasible despite poor geographical conditions. The Bangladesh–China–India–Myanmar highway corridor has three directions: north, south, and middle lines.

(2) Reliability. The expressway between Kunming and Tengchong in China has been completed. The construction of the expressway between Tengchong and Houqiao commenced in March 2017 and is expected to be completed by 2020. The roads of Myanmar, India, and Bangladesh located in this corridor are mainly tertiary roads. From a macro-perspective, the roads in the Bangladesh–China–India–Myanmar Economic Corridor frequently cross mountains, valleys, and rivers. These roads have low technical quality levels and poor linear shapes, which are considerably affected by disasters and natural environment.

(3) Capacity. China has long been Myanmar’s largest trading partner. The transportation of goods at the China–Myanmar border is implemented via highways. The demand for border trade in the Bangladesh–China–India–Myanmar Economic Corridor is relatively large but limited by the customs clearance capacity of land ports and highway capacity. Road transport capacity and efficiency should be improved.

2.3 Highway interconnections in China–Mongolia–Russia Economic Corridor

(1) Accessibility. The China–Mongolia–Russia Economic Corridor has three major international exchange and cooperation Chinese land ports, such as the Manzhouli, Erenhot, and Ceke ports. The main directions and key nodes of the highway corridor are as follows: Dalian–Manzhouli–Ulaanbaatar–Moscow, Beijing–Erenhot–Ulaanbaatar–Moscow, and Xi’an–Ceke–Ulaanbaatar–Moscow.

(2) Reliability. The road transport infrastructure in Mongolia and Far East Russia is in a state of deterioration. In Mongolia, the overall road paving rate is low, and numerous roads are in disrepair.

(3) Capacity. The two main highways of the China–Mongolia–Russia Economic Corridor are located in the eastern part of China and Mongolia, making it impossible to reach Mongolia in all directions. The cross-border transport of coal products in the west of Mongolia is inconvenient because of the imperfect road network. Exports from Mongolia, Southwest Russia, and Northwest China have to bypass Erenhot, resulting in higher transportation costs. Moreover, the transportation infrastructure in Far East Russia does not effectively support the integrated land, sea, and air logistics system. This does not only hinder the economic development of the region, but also affects the transit transport capacity of Russia to connect Europe and Asia.

2.4 Highway interconnections in China–Indochina Peninsula Economic Corridor

(1) Accessibility. The 1660-km long Kunming–Mohan–Boten–Vientiane highway was completed in 2002. All highway sections in China have been asphalt-paved, whereas the sections in Laos are mainly tertiary roads. The

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Kunming–Bangkok road has a total length of 1880 km. In December 2013, the Houeisay Bridge was officially opened, marking the completion of the international highway corridor connecting China, Laos, and Thailand. In 2001, the joint efforts of China and Vietnam have led to the opening of the Red River Bridge at their border, indicating the preliminary completion of the Kunming–Hekou (China)–Lao Cai (Vietnam)–Hanoi highway corridor. In October 2013, the Suolongsi–Mengzi Expressway (79 km) in Yunnan officially opened, signifying the completion of the Kunming–Hekou Expressway. The Nanning–Friendship Pass Expressway, the first expressway connecting the Association of Southeast Asian Nations, was completed in December 2005. Along this direction, the highway from Lang Son to Hanoi in Vietnam is ongoing construction (with a planned total length of 155.7 km), and a highway connecting China and Vietnam is expected to be completed in the near future.

(2) Reliability. The China–Indochina Peninsula Economic Corridor has a high inter-connectivity level as well as highways with high standards and good technical quality. It also has a good historical basis for trade and transportation based on traditional land ports.

(3) Capacity. The Kunming–Vientiane highway is 1660-km long, and travel time is approximately 24 h. The travel time of some international shuttle services from Kunming to Luang Prabang, Laos lasts approximately 20 h by road. The travel time without considering the time for customs clearance processing, which has a relatively high efficiency, is approximately a 30-h drive through Kunming–Vientiane–Bangkok Highway. It also requires approximately 7 h to drive through the 400-km long Nanning–Friendship Pass–Lang Son–Hanoi Highway Corridor without considering the time for clearance processing, which is also highly efficient.

3 Restrictions on highway infrastructure development in BRI areas

First, the construction of the Belt and Road highway transportation infrastructure is considerably affected by the political, economic, and social stability of partner countries. The BRI countries significantly differ in politics, economy, culture, and religion; geopolitics is complicated, and some countries are unstable. The policies of different parties toward China also vary. Highway construction is time- and capital-consuming and susceptible to political and market risks. Some non-traditional dangers, such as terrorism and transnational crime along the Belt and Road highways, also exist [4]. These dangers have introduced security risks to the construction and operation of highway infrastructure, resulting in the indirect increase in cost and problems.

Second, the countries and regions involved in the BRI have uneven economic progress, thus making road project financing problematic. This implies that an innovative finance model is critical to the construction of transportation infrastructure. The BRI involves many countries and regions, and the level of economic development and market openness of different countries significantly differ. The imperfect business environment (e.g., laws, regulations, credit systems, and energy supplies) of many countries constrains the innovation of finance schemes, ultimately resulting in insufficient road construction funds.

Third, road construction technology standards differ, and there is a dearth of planning coordination among different countries. The standards of highway planning, design, technology, construction, procurement, installation, and management among the BRI countries and regions also vary. Projects that require cooperation to build cross-border road transportation infrastructure lack common planning and development blueprints. International road transport also involves problems that include insufficient coordination, varied process standards, numerous customs clearance procedures, high operating costs, and low mutual recognition of law enforcement.

Fourth, the BRI highway transportation construction is confronted with complex natural conditions and severe climate challenges. The construction of highways along the route has encountered not only severe weather (e.g., high temperature and extreme cold), but also problematic construction conditions in special geological and ecologically fragile areas (e.g., complex mountainous areas with difficult terrain, expansive soils, and deserts). Inadequate construction technology and safety are also major construction problems.

4 Development strategies of highway infrastructure in BRI regions

4.1 Development visions

The development visions of the BRI are as follows: to build a Eurasian interconnected highway transportation system and work closely with other transport modes to serve the BRI regions; to promote policy coordination, facility connectivity, unimpeded trade, financial integration, and people-to-people bonds based on a convenient highway transportation network; to build a community with a shared future.

4.2 Development principles

First, make full use of the convenient and flexible road transportation systems; rationally allocate and intensively use highway transportation resources; consider using other transportation modes; coordinate transportation, economies, populations, industries, and ecological environments; promote facilities and trade links between countries and regions along the route.

Second, assess the accessibility, reliability, and transportation efficiency of existing roadways; exploit existing road transportation networks; prioritize the reconstruction and expansion of existing roadways.

Third, focus on key cities and nodes, such as seaports, land ports, and airports; prioritize the construction of missing road sections in key corridors; build a backbone highway network to achieve efficient interconnection between BRI countries and regions.

Fourth, consider highway construction as an opportunity to promote technical exchanges and standard docking to achieve complementary advantages and common development.

4.3 Development strategies

According to the BRI as well as the technical and economic attributes of road transportation in the area, focus should be set on the planning and construction of highway infrastructure development in four economic corridors: the China–Mongolia–Russia, China–Pakistan, Bangladesh–China–India–Myanmar, and China–Indochina Peninsula Economic Corridors. The overall construction and promotion strategies include the following: the demand and foundation determine the directions and the directions determine the natural and environmental barriers. Key barriers determine key projects and key projects determine the key technical solutions. The strategy includes five specific aspects: (1) deploy the construction direction, and form synergy with other modes of transportation according to the overall planning of the economic corridors; (2) identify corridor hubs and node cities, and match traffic demand according to the indicators of social and economic activities; (3) use key land ports as the starting point, actively promote technical standards to be unified or coordinated, and publicize China’s highway standards; (4) comprehensively apply technology and management methods, and improve the operational capability and reliability of existing highway routes; (5) preferentially realize the connectivity of key node cities and form a backbone road network supporting the economic corridors.

5 Highway infrastructure development paths in major corridors

5.1 China–Pakistan Economic Corridor

Considering that the highway infrastructure in the China–Pakistan Economic Corridor is exposed to harsh conditions, it is suitable to position Urumqi and Kash as regional highway hub nodes with special emphasis on planning the Recht–Islamabad highway (KKH Phase II), Karachi–Lahore Expressway, and Islamabad–Draismail Khan–Surabu Highway. In this specific implementation plan, it is necessary to connect the missing sections in the China–Pakistan Economic Corridor. The technical quality level of the Karakoram Highway should also be upgraded, and the feasibility of building the China–Pakistan Expressway should be considered. In the planning, it is necessary to consider the future construction of a highway network serving South and West Asia. In the short term, focus should be on the construction of Pakistan’s north–south highway with the Lahore–Karachi highway segment as the core and convenient connection to Gwadar Port. This segment can encourage China and Pakistan to jointly launch multimodal transport as well as improve transportation efficiency and strengthen supply guarantee functions.

Suggestions for the major aspects of the project include rebuilding the Karakoram Highway in accordance with the standards of first-class highways to improve the reliability and efficiency of transportation in the China–Pakistan Economic Corridor.

5.2 Bangladesh–China–India–Myanmar Economic Corridor

In this corridor, the objectives include improving the low-quality level of existing highways, implementing technical transformation on certain sections, and expanding the financing channels to focus on the backbone highway network among important node cities along the route. It is also necessary to plan and develop three key highway corridors: the Kunming–Ruili–Mandalay–Yangon International Expressway, Myanmar Myitkyina–India Redondo International Highway Improvement Project (secondary road reconstruction project), and Mandalay–Kyauk Phyu–Dhaka high-grade highway construction project. It is important to improve the technical quality level of highways,

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prioritize the construction of the southern route of the Bangladesh–China–India–Myanmar International highway corridor, and improve the level of interconnection. It is also necessary to strengthen political mutual trust, enhance the business environment, and promote road interconnections through energy corridor projects.

The suggestions for the major items of the project include constructing the Kunming–Ruili–Mandalay–Yangon International Expressway, upgrading the existing low-grade highway corridor, and building fast, convenient, and highly reliable international highway passages.

5.3 China–Mongolia–Russia Economic Corridor

For this corridor, it is important to improve the highway facilities in Mongolia and the far east part of Russia, focusing on three major highway corridors: Dalian–Manzhouli–UlanBator–Moscow, Beijing–Erenhot–Ulaanbaatar–Moscow, and Xi'an–Ceke–Ulaanbaatar–Moscow. The following steps should be taken to maximize the economic corridor: exploit the three main land ports of Manzhouli, Erlianhot, and Ceke; upgrade the technical quality level of existing routes of Erlianhot and Manzhouli Ports; build heavy highways linking the Ceke land Port; improve the customs clearance efficiency of highway ports; and strengthen the competitiveness and attractiveness of road transport in the China–Mongolian–Russian Economic Corridor.

The suggestions for the major project include constructing the Ceke (China)–Daranzadgard (Mongolia) high-grade highway project. The capital of Mongolia's South Gobi Province, Daranzadgard, is an important transportation hub in central and southern Mongolia; thus, connecting Ceke port and Daranzadgard can promote the economic, trade, and energy cooperation with Mongolia in the central and western regions of Inner Mongolia (China).

5.4 China–Indochina Peninsula Economic Corridor

The current status of highway infrastructure interconnection and transportation efficiency in the China–Indochina Peninsula Economic Corridor is good. It is therefore important to exploit existing highways, optimize the highway network, and strengthen logistic functions. The following steps must be taken to maximize the economic corridor: designating Kunming and Nanning as regional highway hubs, optimizing the direction of the China–Inland Peninsula international highway, focusing on the construction of the Kunming–Hekou–Lao cai–Muang Xay international highway corridor, reducing the distance between key ports, and building a highway network for Southeast Asia. This will improve the transportation competitiveness of international highways in this region, and the passage through the highway will be smooth and convenient.

The suggestions for the major project include constructing the Kunming–Hekou–Lao Cai–Muang Xay international expressway project. This route can optimize the road network of China, Vietnam, and northern and central Laos as well as provide road transport support for the further development of sub-regional cooperation.

6 Finance and operation of highway infrastructure development in BRI regions

6.1 Financing and construction models

The characteristics of BRI road construction financing include the following: (1) large capital demand; (2) unstable income and long payback period; (3) cooperation involving multiple countries and multiple currencies; (4) persistent and urgent financing needs. Participating in the cross-border road transportation infrastructure construction provides an unprecedented opportunity for Chinese enterprises to "go global"; however, it also introduces several exigencies to Chinese enterprises along with evident risks that cannot be ignored.

Countries that have long-term stability, good economic and social development prospects, and close relationships with China can adopt the build–operate–transfer (BOT), public–private partnership (PPP), or finance–design–construct–operate (FDCO) schemes for the construction of highway infrastructure. For countries with low levels of development that urgently require funds to improve transportation infrastructure and in which long-term political risks are considerable and policy stability is not guaranteed, road construction can be implemented through the finance–design–construct model. Countries with outdated infrastructure and imperfect technical systems but sufficient funds can use the engineering procurement–construct–operate and design–construct scheme as well as other modes of highway project construction. For a few countries with good development levels and perfect technical standard systems, the construction enterprise can adopt the engineering procurement construction (EPC) or design–build (DB) modes to implement the project.

6.2 Operating models

According to the project's functional positioning and financing mode, the operation of highway transportation infrastructure can be classified into four types: government-monopolized operation, government competition, PPP, and private completion (Table 1). The operation and management mode of highways are significantly affected by the sources of transportation infrastructure construction. The operation of highway infrastructure should therefore be adapted to the financing mode. For road transportation infrastructure projects that adopt the FDCO, the operations management can adopt the franchising model, in which project construction is wholly privately invested. In this model, a private company performs operations management, and the operating income belongs to private investors. For projects that adopt EPC+O, DBO, EPC or DB, the operations management can employ the entrusted operation model, in which the government provides the construction funds but does not directly manage operations. The company entrusted with operations has control over the project income and bears the daily operating expenses of the project. For a few countries with sufficient funds and complete technological systems, the government-financed projects can be implemented by the state according to the direct management model.

Table 1. Finance and operation models of highway infrastructure.

Classifications	Fund Source	Operator and manager	Advantages	Disadvantages	Applicable conditions
Government-built and monopolized operation	Funding and subsidies from central and local governments	Direct operations management of local government subsidiaries	Guarantees the welfare of transportation	Absence of competition may lead to inefficiency; heavy pressure on government finance	Small passenger flow and strong financial capacity
Government-built and dominated competition	Government grants and corporate bonds	Competitive operation of several state-owned companies	Focus is fixed on the welfare of transportation; competition is conducive to improving service levels	Excessive government intervention may lead to low efficiency	Guaranteed passenger flow and profit through assured financial subsidy
Public–private partnership	Government grants, commercial loans, private investment, and transportation bonds	Private company operation and management but government intervention dominates	Frees government from financing pressure; improves operational efficiency	Creates conflict between social public interest and private profit	Large passenger flow and developed capital market
Privately constructed and operated	Full private investment	Private company operation and management	Government sustains no risks or financial pressure; strict control on construction and operating costs	Profit is targeted and tolls increase	Large passenger flow and weak government financing

7 Key problems in highway infrastructure construction in BRI regions

7.1 Technology problems and solutions

Historical data and case analysis indicate that there are four types of naturally occurring problems encountered in highway construction along the BRI that should be overcome.

(1) Frozen soil problems in cold high-altitude areas. Frozen soil, which can cause road subsidence, longitudinal cracking, tumbling, and asphalt pavement cracking, have been observed in Tibet, Xinjiang, Pakistan, and Nepal.

(2) Frequent earthquakes. The China–Pakistan Economic Corridor passes through the Pamir Plateau seismic belt, and the Bangladesh–China–India–Myanmar Economic Corridor is in the Mediterranean–Himalayan seismic belt; hence, both corridors are located in high-risk earthquake zones. The damage that earthquakes may cause to highway infrastructure includes the collapse and cracking of the supporting structure, subgrade subsidence and burial, and slope collapse and cracking.

(3) Geological disasters (e.g., landslides and mudslides). In northern Pakistan, debris flow frequently occurs. In the Bangladesh–China–India–Myanmar Economic Corridor, the risk of mudslides in mountains and valleys is high.

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With these events, roads can be crushed by earthquakes, blocked by mudslides, and tumbled by groundwater seepage, severely hampering traffic flow.

(4) Floods. The Pakistan–China Economic Corridor (Lahore to Karachi) is located in the Indus Plain, which is a frequently flooded area. The Bangladesh–China–India–Myanmar Economic Corridor, located in the Ganges Delta, may be inundated when the waters in the estuary of the Ganges and Brahmaputra Rivers swell. The river network is dense and is situated in the tropical monsoon climate zone where flooding naturally occurs. The main forms of damage caused by floods to highway facilities include road erosion, subgrade erosion and collapse, bridge erosion, and road flooding.

7.2 Technical solutions

Chinese civil engineering construction enterprises have acquired considerable experience from previous projects to deal with high altitude, sand, and other special construction environments. Based on the engineering problems that have been encountered in specific regions and special environments, the Chinese engineering community has formulated a relatively complete set of technical solutions (Table 2), which can guide the construction of BRI highways.

In the context of the BRI, many international highway construction projects will be initiated, and international engineering project cooperation will become more frequent. These construction projects are complex and require extensive experience and high level of project management. In specific projects, managers can fully draw on and refer to similar previous projects and assimilate unique experiences based on actual conditions.

Table 2. Technical solutions to key problems.

Key problems	Technical solutions
Permafrost, high altitude, and geological disasters	Subgrade construction technology in permafrost regions: crushed rock struts, and heat pipe subgrade
	Plateau tunnel construction technology: ventilation and oxygen supply technology for high-altitude mountain tunnels
	Concrete construction technology in plateaus and cold areas: thermal insulation measures, and durable concrete design technology
	Concrete construction technology in plateaus and cold areas: construction of protective nets, construction of retaining walls, and anchor frame technology
Huge mountains and canyons	Subgrade construction technology in permafrost areas (ibid.)
	Plateau tunnel construction technology (ibid.)
	Concrete construction technology in plateaus and cold areas (ibid.)
	Construction technology for bridge and culvert foundation in alpine mountain areas: open-cut tunnel technology, bored cast-in-place pile technology, bridge seismic measures
	Bridge construction technology in alpine gorge areas: construction technology for super-long-span suspension bridges
Earthquakes	Shock absorption design and protective measures
Flood disasters	Canyon river section: protection of flooded retaining walls, stone-built slope protection, mortar block stone, chipped stone slope protection
	Severe erosion with severe side erosion: gravity retaining walls are used for protection, and gabion foot guards, spur dams, and shun dams are set according to the position of the retaining wall and water flow direction
	Plain area: raise the height of roadbed, strengthen the shoulders, and build flood retaining wall
Desert roadbed design and construction	Subgrade construction technology: low-water content aeolian sand roadbed filling construction technology, and double-drive vibration roller compaction process
	Route ontology protection technology: pebble protection, clay protection, turf protection, and chemical curing agent protection
	Protective measures on both sides of route: set up sand barriers, install sand prevention fences, and protect afforestation vegetation.

7.3 Application and promotion of technical standards

Competition in terms of technical standards has increasingly become the primary form of rivalry in the field of international construction engineering. The choice of standards directly affects the competitiveness of enterprises in the market [5]. Through scientific and technological innovations, result application, and operational practices, the Chinese transportation industry has made major breakthroughs in transportation equipment, traffic information, intelligence, and traffic safety and transportation infrastructure, forming a series of new technologies and processes. It has considerably enhanced the core competitiveness and sustainable development capability of China's transportation industry. These new technologies and processes are the important targets and breakthroughs for the internationalization of Chinese standards. China should therefore formulate intellectual property management measures of relevant technical standards at the soonest time possible to promote patent and technology standardization in the transportation field. Moreover, superior technologies and relevant technical standards should be analyzed and compared with international and regional standards, and the feasibility of the standardization of these technologies should be demonstrated. China should strengthen the theoretical research on standards, adopt advanced technology from foreign standards, and strengthen the competitive advantages of Chinese standards in environmental protection, safety, and people-oriented management. The goal is to enhance the reputation of and trust on Chinese companies in the international engineering construction market and improve the overall competitiveness through efforts in technology and patents.

The countries and regions along the Belt and Road adhere to various types of road construction standards (Table 3). It is therefore necessary to consider standard docking and coordination problems. The construction standards of China in transportation infrastructure have entered the world's advanced ranks. The BRI provides opportunities for these standards to be globally accepted. The feasible standards for docking include the (1) direct application of Chinese standards, (2) integration of Chinese standards with host country standards, and (3) cooperation among countries in the region to formulate new standards.

Table 3. Current status of highway construction standards along BRI.

Economic corridor	Major highway standards along the corridors			
China–Mongolia–Russia Economic Corridor	Russia	Mongolia	China	–
	Russian standards	European and American standards	Chinese standards	–
New Eurasian Continental Bridge Economic Corridor	Germany	Poland, Belarus	Russia, Kazakhstan	China
	German standards	European standards	Russian standards	Chinese standards
China–Pakistan Economic Corridor	Pakistan	China	–	–
	British standards	Chinese standards	–	–
Bangladesh–China–India–Myanmar Economic Corridor	Bangladesh	China	India	Myanmar
	British standards	Chinese standards	British standards	British standards
China–Indochina Peninsula Economic Corridor	China	Vietnam	Cambodia	Thailand and Malaysia
	Chinese standards	American standards	French standards	British standards

8 Guarantee policies for highway transportation infrastructure development in BRI areas

8.1 Design financing platforms

In financing and promoting the road transport infrastructure projects, it is necessary to fully comply with market rules. It is important to exploit multiple financing choices, such as internal financial, extra-territorial third-party, commercial, developmental, and policy-based financial resources, according to different attributes and functional positioning of projects. The BRI encompasses a wide geographical area with numerous external influencing factors; hence, it is necessary to consider third party resources, especially those with developed economies and rich financial resources, when coordinating such resources to build the BRI into a platform that transcends boundaries.

8.2 Co-cultivating talents to promote communication

In accordance with the Silk Road philosophy of "mutual learning and mutual benefit," a group of scientific and technological talents have become acquainted with each other through the "characteristic brand" of science and formulated technology. This group would cooperate with the "Chinese story" to promote "the commonwealth of the people" through scientific and technological exchanges. Relevant countries and organizations can strengthen talent

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exchange along the region through joint talent training [6]. They can enhance mutual understanding and trust through talent exchange as well as provide a foundation for broader international scientific and technological cooperation. Through engineering construction project training technology and talent management, they can explore talent cultivation mechanisms, talent inputs, and input policies. To assemble a team of high-level engineering and technical talents, the recruitment and training system of those with scientific and technological capabilities for road construction must be implemented through international cooperation.

8.3 Technical innovation cooperation and exchange

The highway transportation infrastructure construction along the Belt and Road is confronted with many engineering and technical problems that must be resolved through technological innovations and experimentations. Innovations in areas that include novel platforms, construction process control and guarantee mechanisms, and technology exchange platforms are necessary. Furthermore, it is crucial to strengthen the communication of science and technology innovation policies and support the development of the policy making capacity of BRI countries. Communication and docking for planning and preparation are also required.

9 Conclusions

Strengthening the research on the development strategy for highway transportation infrastructure construction along the Belt and Road is a strategic requirement for the efficient, effective, and orderly advancement of future BRI highway transportation infrastructure construction. The conduct of strategic analysis in this field is significant for promoting industries that are advantageous to the construction of China's transportation infrastructure. It is also important to advocate Chinese standards, technology, and equipment to the world apart from advancing the development of the BRI.

To better promote the level of interconnection and intercommunication among the BRI regions, it is crucial to steadily advance highway transportation infrastructure construction along the routes. In this process, it is necessary to combine strategic thinking and technical solutions as well as following the trend "demand and foundation determine the directions and directions determine the natural and environmental barriers." Moreover, "key barriers determine key projects and key projects determine the key technical solutions." Apart from the foregoing, based on assessment of the difficulty level and capital requirements of key control projects, it is necessary to demonstrate reasonable construction schedules and select feasible financing plans and operational strategies that adapt to the socio-economic environment of the projects.

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