Exploring the impact of highway construction standards on the development of the highway industry in the Northwest Territories

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Abstract. This paper aims to investigate the role of highway engineering construction standards in promoting the development of the highway industry and accelerating the realization of China's strategic goal of becoming a 'transportation power.' It summarises the current situation of developing domestic highway industry standards and their implementation. Using Northwest China as an example, the effectiveness of technical highway engineering standards is explored through the statistics of highway mileage, highway quality, and other relevant aspects. This text discusses the effectiveness of implementing highway engineering technical standards in the northwest region, the problems encountered during construction, and the current state of industry development. It provides a reference for constructing the Xinjiang regional transportation standard system.

Keywords: highway engineering, highway construction, industry development, implementation effectiveness, standard system

1 Introduction

The state of the road infrastructure in modern conditions affects the economy of the region [1]. Northwest China is gaining increasing attention from the state as a bridge and channel in the Belt and Road initiative1. Since the 18th CPC National Congress, transportation in the region has experienced a period of high-quality development, and transportation projects are currently at their peak of construction. The transportation industry has undergone significant changes, with the highway sector experiencing further development, resulting in increased mileage and improved capacity for transportation services.

Standards are crucial for economic activities and social development[3]. The national technical standard system has reached a relatively advanced stage in developed

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countries. At every level of social and economic life, the development of transportation must be guided by national technical standards to adapt to the market economy[4]. To ensure technical standards are unified, and highway projects are guided effectively, the Ministry of Transportation and Communications has issued 75 industry standards for highway construction as of April 2020. These include Technical Standards for Highway Engineering (JTG BOl-2014) and Specification for Geological Survey of Highway Engineering (JTG C20-2011), which provide specifications and guidance for highway construction.

Similarly, local governments have issued local standards to achieve regional uniformity and meet local needs. Highway technical standards have matured from basic theoretical research to systematic policy research over the past 20 years[5]. This paper explores the role of construction standards in promoting the construction of highways in Northwest China and the problems encountered during implementation. The focus is on the highway engineering standards system and its effectiveness in achieving this goal.

2 Status of road development and standards in the Northwest Territories

2.1 Current status of road development in the Northwest Territories

The rapid development of highways can be attributed to a series of national policy guidance for highway construction [6]. Since the 18th CPC National Congress, the development of highways in the northwest region of China has undergone historic changes and made significant achievements under the strong leadership of the CPC Central Committee and the State Council. This progress has provided powerful support for economic and social development, national unity and progress, and long-term peace and stability of the border. By the end of 2022, the total length of roads in Northwest China had reached 691,900 kilometers. Highways now connect cities with a population of over 200,000 and prefecture-level administrative centers. Focusing on ethnic, border, old revolutionary, and contiguous areas with unique difficulties, we have promoted the high-quality development of the 'Four Good Rural Roads.' We have completed the construction of a total of 2.36 million kilometers of new and reconstructed rural roads across the country. This has enabled townships and villages with the necessary conditions to be connected to hardened roads, passenger buses, and postal services. The problem of difficult road access in impoverished areas has been solved historically. The people of the northwestern region have made significant progress towards a moderately prosperous society through the innovative 'Transportation +' mode of assistance. The construction of the transportation hub in the core area of the Silk Road Economic Belt in Xinjiang has been expedited,taking on a key role in regional and international connectivity[7]. Chinese standard highways have been extended to neighboring countries.

2.2 Current status of relevant standards in the highway industry

China's highway industry has a multi-level standard system structure that ranges from national standards to industry, local, and group standards. This system runs through all stages of highway construction, management, maintenance, and operation. The technical, management, and service standards required for highway engineering, from planning and construction to maintenance and management, are included. Safety, environmental protection, and economic evaluation standards are also incorporated. The aim is to meet the highway industry's development needs within a specific timeframe.

3 Highway engineering construction standards

3.1 Highway engineering construction standard system

Highway construction standards are based on science, technology, and practical engineering experience and consist of modules for project management, surveying, design, testing, inspection, construction, supervision, and costing.

3.2 Industry standards

The highway construction industry standards account for the highest proportion, totaling 494 and 73.6%. Since 2014, the average annual number of released highway construction industry standards has exceeded 30 and remained stable. As shown in Table 1, the number of secondary standards under the industry standard of highway construction category varies greatly. Of the total number, 323 items, accounting for 65.1%, were construction industry standards, while only three items, accounting for less than 1%, were supervision standards.

Table 1. Number of level 3 standards for each road construction category

form	project management	investigations	devise	experimental
quantities	8	22	65	27
percentage	1.6%	4.4%	13.3%	5.4%
form	sensing	construction	supervise	construction cost
quantities	35	323	3	11
percentage	7.0%	65.1%	0.6%	2.2%

3.3 Local standards

The Northwest region has a vast geographical area with a transportation infrastructure that includes many points and long lines, sharing similar geographic features and transportation characteristics. According to [8], some standards have a certain degree of universality. In 2014, Shaanxi Province issued the Safety Design Guidelines for Highway Tunnels (DB61/T 546-2012), the earliest safety standard for highway tunnel construction in Northwest China. In the same year, they also issued the Technical

Regulations for the Design and Construction of Concrete Bridges Reinforced by Steel Plate-Concrete Combination. Gansu Province issued the Rural Roads Engineering Technical Standards (DB62/T 2934-2018) for rural roads in 2019. The establishment of local standards has significantly aided the construction of highways in Northwest China.

By 2023, the five northwestern provinces (Shaanxi, Gansu, Ningxia, Qinghai, and Xinjiang) will have a total of 177 highway construction standards, covering all aspects of project management, surveying, design, testing, inspection, construction, supervision, and cost, as shown in Figure 1. While the standards are relatively comprehensive, they only account for 18.97% of the national total, leaving significant gaps in some modules.

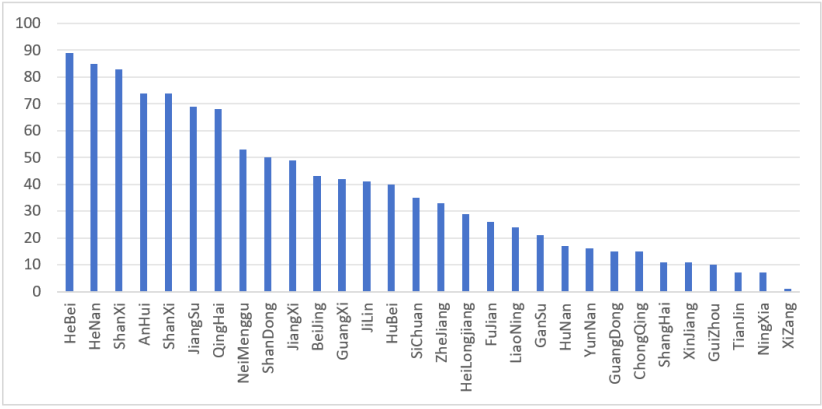

Fig. 1. Number of local standards in road construction category by provinces

4 Effectiveness of the implementation of highway engineering construction standards in the Northwest Territories

4.1 Quality of roads

The quality of construction in highway projects is a crucial indicator for assessing the development of the highway industry. The level of quality has a significant impact on aesthetics, safety, economy, and sustainability. Strengthening testing, inspection, and quality control can ensure the safety and durability of highway projects while reducing construction costs and improving construction safety [9]. Xinjiang has released an action plan to improve transportation construction quality by 2025. As a result of this plan, there has been a significant improvement in the quality of transportation construction projects. The coverage rate of standardized high-speed and primary highways has reached 100%. The rate of CNC steel processing equipment and intelligent prestressing tensioning and compression equipment has also reached 100%. Upon first-time acceptance, the national and provincial trunk lines have achieved a 100% pass rate.

The standardization of the inspection process ensures project quality. Currently, there are 35 relevant highway construction inspection and acceptance standards as of 2023. In 2019 and 2021, Shaanxi Province and Gansu Province respectively released the Technical Specification for Prestressing Inspection of Bridge Structures (DB61/T 1288-2019) and Technical Specification for Dynamic Modulus Inspection of Highway Subgrade Compaction Quality (DB62/T 4343-2021) to improve the quality and durability of the project. These efforts are aimed at achieving a more substantial transportation and quality country.

4.2 Road mileage

As shown in Table 2, by the end of 2022, the Northwest Territories had 691,900 roads, a 25.57% increase from 2012 when 551 kilometers were completed. The data is almost double the amount of roads compared to 2002.

Table 2. Statistics on road mileage in the five northwestern provinces

	Gansu	Qinghai	Xinjiang	Ningxia	Shaanxi	Northwestern Province	nationwide	percentage
2004	4.08	2.81	8.68	1.25	5.27	22.09	187.07	11.81%
2005	4.13	2.97	8.95	1.31	5.45	22.81	334.52	6.82%
2006	9.56	4.77	14.37	1.99	11.33	42.02	345.7	12.16%
2007	10.06	5.26	14.52	2.06	12.13	44.03	358.37	12.29%
2008	10.56	5.66	14.67	2.1	13.1	46.09	373.02	12.36%
2009	11.4	6.01	15.07	2.18	14.41	49.07	386.08	12.71%
2010	11.89	6.22	15.28	2.25	14.75	50.39	400.82	12.57%
2011	12.37	6.43	15.52	2.45	15.2	51.97	410.64	12.66%
2012	13.12	6.6	16.59	2.65	16.14	55.1	423.75	13.00%
2013	13.36	7.01	17.02	2.86	16.52	56.77	435.62	13.03%
2014	13.81	7.27	17.55	3.13	16.71	58.47	446.39	13.10%
2015	14.01	7.56	17.83	3.32	17.01	59.73	457.73	13.05%
2016	14.3	7.86	18.21	3.39	17.25	61.01	469.63	12.99%
2017	14.23	8.09	18.53	3.46	17.44	61.75	477.35	12.94%
2018	14.32	8.21	18.90	3.54	17.71	62.68	484.65	12.93%
2019	15.14	8.38	19.42	3.66	18.01	64.61	501.25	12.89%

2020	15.6	8.51	20.92	3.69	18.07	66.79	519.81	12.85%
2021	15.66	8.62	21.73	3.76	18.34	68.11	528.07	12.90%
2022	15.72	8.77	22.31	3.83	18.56	69.19	535.48	12.92%
total	233.32	127.01	316.07	52.88	283.4	1012.68	8075.95	

4.2.1Modeling.

In order to explore whether the increase in the number of road construction standards promotes the growth of road mileage, we use SPSS27.0 to conduct regression analysis. We selected the data from 2012 to 2022 for analysis, and defined the cumulative number of industry standards and the cumulative number of local standards as X_i and N_t , respectively, and the total mileage of the five northwestern provinces as Y_i and M_t , respectively, with X_i and N_t as the independent variables, Y_i and M_t as the dependent variables, it stands for year. To do regression analysis on the total mileage of the five northwestern provinces, the following model was chosen as follows:

Model 1

(Industry standard number - highway miles):$Y_i = kX_i + b$ (1)

where k and b are constants

(Number of local standards - highway miles):$M_t = aN_t + c$ (2)

where a and c are constants

Model 2

(Number of industry standards - miles of highway):

$Y_i = k\log X_i + b$ (3)

where k and b are constants

(Number of local standards - highway miles):$M_t = a\log N_t + c$ (4)

where a and c are constants

4.2.2Determination of the validity of the regression model.

From Table 3, we can get model I, R value were 0.993a , 0.950a ; coefficient of determination R-squared were 0.986, 0.927, are greater than 0.30, indicating that the regression equation of the goodness of fit is relatively good, the F change in the amount of the significance of the calibration value are <0.01<0.05, so the regression model setup is effective.

The R-value of model two is 0.931a , 0.967a respectively; the R-square of the coefficient of determination is 0.867, 0.903 respectively, which are all greater than 0.30, indicating that the regression equation has a goodness of fit, and the significance check values of the amount of change in F are all <0.01<0.05, so the regression model is set up effectively.

Table 3. Tests of the regression model

Comprehensive calibration of regression models				
		R	R-square	The amount of change in the significance F
Model 1	(1)	0.993[a]	0.986	<0.01
	(2)	0.950[a]	0.927	<0.01
Model 2	(3)	0.931[a]	0.867	<0.01
	(4)	0.967[a]	0.903	<0.01

4.2.3Regression model analysis.

As can be seen from Table 4, the P-values of the independent variables of both models are <0.01<0.05, indicating that both the cumulative number of industry standards and the cumulative number of local standards have a statistically significant effect on the total mileage of the five northwestern provinces[10] .

Table 4. Results of regression analysis

Results of the analysis of the regression model			
	variant	B	P
Model 1	X_i	0.041	<0.01
	constant	49.300	
	N_t	0.087	<0.01
	constant	57.726	
Model 2	log Xi	35.748	<0.01
	constant	-26.506	
	log Nt	7.149	<0.01
	constant	52.048	

This leads to the predictive model:

Model 1 (number of industry standards - road miles): $Y_i = 49.300 + 0.041\, X_i$

(Number of local standards - road miles): $M_t = 57.726 + 0.087\, N_t$

Model 2 (number of industry standards - road miles): $Y_i = -26.506 + 35.748\, X_i$

(Number of local standards - road miles): $M_t = 52.048 + 7.149\, N_t$

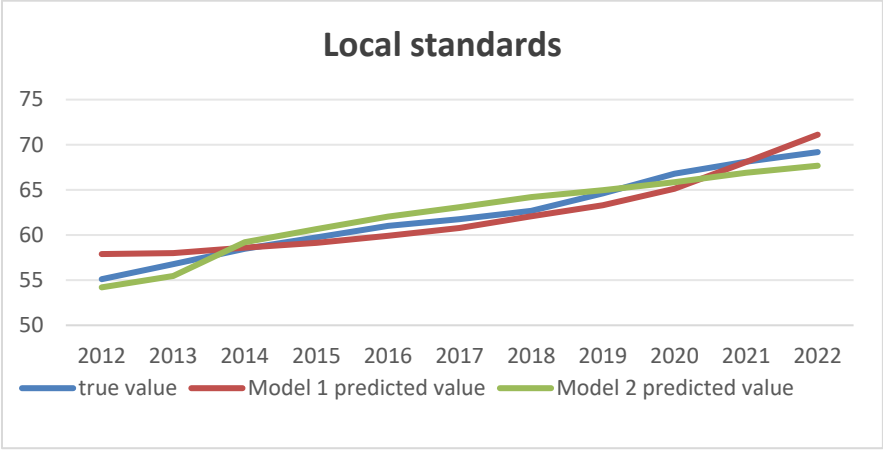

Fig. 2. Comparison of predicted results for local standards

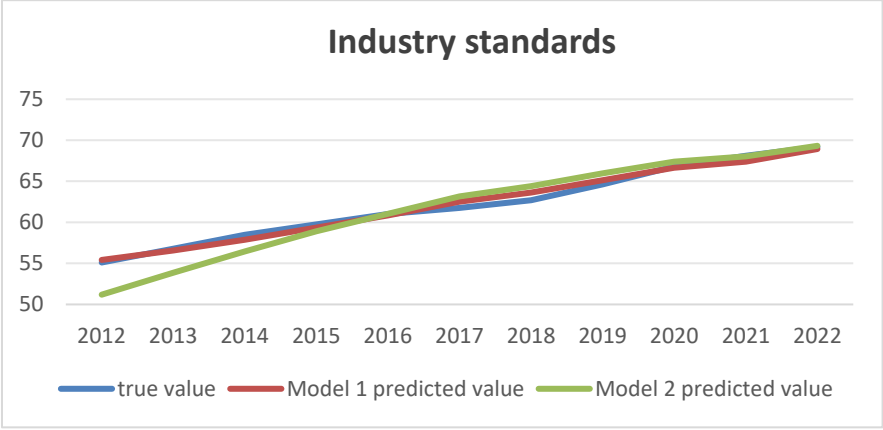

Fig. 3. Comparison of predicted results for industry standards

From Figures 2 and 3, it can be intuitively seen that the prediction results of Model I are closer to the real value, and the simulation curve fit is relatively higher, with relative errors between 0.05% and 2.05%, and the regression analysis of Model I is more reasonable.

The regression equation derived from the linear model regression is practically significant in predicting the total mileage of the five northwestern provinces in the future[11]. It can be concluded that the number of highway construction standards and the mileage of highways are positively correlated and, to a certain extent, have contributed to the development of the highway industry.

4.3 The role of road construction standards

4.3.1Promoting the widespread use of advanced technologies.

Several industry and local standards, such as 'Detection Methods for Road Transportation Vehicle Satellite Positioning System Platform' (JT/T 1120-2017) and 'Specifications for Dynamic Monitoring of Asphalt Mixture Mixing Quality on Highway Asphalt Pavements,' are widely used and technologically advanced. These standards have effectively promoted the development of highway engineering and construction and continue to facilitate their implementation in daily work.

4.3.2Improved standardization of road construction.

Highway construction standards regulate construction projects from start to finish, which includes surveying, design, testing, inspection, construction, supervision, and costing. These standards play a guiding role in the development of the highway industry.

4.3.3Achieving a high level and quality of road construction.

Standardizing project management is a macro-level standard that enhances the quality of highways and supports scientific and technological innovation in the highway industry. The construction of 'quality of the country' is promoted to achieve high-level development of the highway industry [12].

5 Improvement of the standard system of highway construction in Northwest China

In 2017, a proposal was made to improve the construction of supporting systems for highway construction in Hebei Province by using the province's construction characteristics as a guideline—the proposal aimed to address the shortfall in highway industry standards. The standard system framework was then put forward to provide a basis and reference for the planning and revision of technical standards for highway engineering in Hebei Province. The Fujian Transportation Department compiled the Fujian Transportation Standard System in 2018 based on implementing national, industry, and local standards within the province and identified issues. The system follows the standard set by the Ministry of Transportation and Communications.

Xinjiang, Qinghai, and other western regions rely heavily on the national and industry standard system. The construction of the local standard system in these areas is not yet complete. The northwest region is a vast area with complex highway engineering geological and climatic conditions. The existing national industry standards only specify the typical characteristics of provinces and cities and cannot guide the region's unique characteristics [13]. The industry and local highway engineering construction standards primarily focus on regulating the management of primary operational links of highway engineering and the technical requirements of existing materials and equipment. However, standards for intelligent and comprehensive transportation

are still lacking, which somewhat hinders the high-quality development of the highway industry in Northwest China.

6 Conclusion

This paper examines the influence of highway construction standards on the highway industry. It begins by discussing the state of the highway industry in Northwest China and the entire highway engineering standards system. The paper then analyses the line standard, highway quality, and highway operating mileage as evaluation indices to explore the number of standards and their corresponding relationships. By generalizing the standard, the paper supports constructing the transportation standard system in Northwest China and its three roles in developing the highway industry.

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Reference

1. DOI: 10.1051/e3sconf/202128108012. Olesia Lykova.The road infrastructure development impact on the economy of the region 2021-07-02
2. XIE Zilong, CHEN Chen, ZHANG Guicun. Exploration of economic development of transportation construction in the western region under "Belt and Road"[J]. China Storage and Transportation,2023(07):117-118.DOI:10.16301/j.cnki.cn12-1204/f.2023.07.080.
3. Playing a Leading Role in Standards to Promote High-Quality Development of Engineering Consulting Industry--GB/Z 40846 Basic Terminology for Engineering Consulting
4. LIU Wei. Research on local standard establishment assessment system in the context of standardization reform[J]. China Standardization,2018,(14):45-46.
5. Wu Zhenkai. Research the suitability of flat rate and support parameters of large section municipal highway tunnels [D]. Southwest Jiaotong University,2017.
6. LI Xuehui,LU Xinhu,LI Yuting. Analysis and Countermeasures on the Development of Highway Industry in Xinjiang[J]. Xinjiang Finance,2003(07):18- 21.
7. DOI: 10.1051/e3sconf/202340307009 Quan Le, Dung Nguyen Thi Tuyet, Thuan Do Van, Hùng Bui Manh .Completing the planning and implementation of plans of public investment in road infrastructure construction in Vietnam.2023-07-25
8. Zhang Guoqing. Reflections on the Development of "New Infrastructure" in Transportation in Northwest China[J]. Low Carbon World,2022,12(03):129-151.
9. DOI:10.16844/j.cnki.cn10-1007/tk.2022.03.009.Liu Gaofei, Guo Huifeng. Construction Engineering Based on SPSS construction Study on period regression prediction modeling[J]. Guangzhou Architecture,2023,51(06):59-62.

10. Zhao Yun. Analysis of the industrial structure model of Gannan Tibetan Autonomous Prefecture based on linear regression[J]. Journal of Gansu Higher Education,2023,28(05):31-35.
11. Shi Ze. Analysis of standardization of highway engineering testing and quality control[J]. Sichuan Building Materials,2024,50(02):206-208.
12. Fang Shuo. Research on the Influence and Path of Standards on China's Economic High-Quality Development [D]. Qingdao University,2023. DOI:10.27262/d.cnki.gqdau.2023.001135.
13. Li Chao. Research on Tianjin Comprehensive Transportation Standard System [D]. Hebei University of Technology,2019. doi:10.27105/d.cnki.ghbgu.2019.001445.