Case Study of Multi-Institutional Collaboration for Final-Year Project with Mongol Koosen College of Technology

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In the field of civil engineering and infrastructure, a commonly encountered problem is aging infrastructure. According to a report by the Japan International Cooperation Agency, most road bridges in Mongolia were constructed post 1960, with assistance from China or the former Soviet Union. Notably, 49% of the 70 existing bridges in Ulaanbaatar are older than 30 years. As Ulaanbaatar has been rapidly growing, with a population of 1.67 million as of 2023, the city is suffering from severe traffic congestion. The bridges are aging, with many in need of rehabilitation, reinforcement, or replacement work. However, the simultaneous repair of numerous bridges can be prohibitively expensive. Proactive maintenance is a more cost-effective approach than reactive maintenance, allowing for the identification and repair of minor damages before they escalate, thereby reducing the overall repair costs. In FY2024, we conducted research on bridge maintenance as the final-year project for the students of Mongol Koosen College of Technology (hereafter Mongol Koosen). The National Institute of Technology (KOSEN) Tomakomai College has supported the education and research at the Mongol Koosen College of Technology since its inception in 2014, building friendly relationships on the way. Five students and one teacher from Mongol Koosen, two mentors from NIT Tomakomai, and an engineer from a civil engineering consulting firm worked on this project. After following initial online lectures regarding basic knowledge of bridges and bridge maintenance, including bridge inspection, the students researched and summarised the bridge maintenance methods used in other countries. Subsequently, we visually inspected two bridges in Ulaanbaatar city, Mongolia, researched the factors contributing to the damages, and classified them based on Mongolian standards. Finally, the students analysed the main factors contributing to bridge damage in Mongolia using data from bridge inspections. Through this final-year project, students learnt bridge inspection methods, the causes of serious bridge damage, and the importance of bridge inspection and maintenance.

Keywords: *Final-year project, bridge inspection, bridge maintenance, Mongol Koosen College of Technology*

Introduction

Since its establishment in 2014, Mongol Koosen College of Technology has received ongoing support from National Institute of Technology (KOSEN), Tomakomai College (hereafter referred to as Tomakomai Kosen) in the areas of education and research. This support has included the sharing of experience, including technical expertise and methodologies for teaching, experiments, and practical training. Consequently, a strong and collaborative relationship has been cultivated between the two institutions.

Notably, Mongolia is increasingly facing the issue of aging infrastructure, particularly bridges. Bridge deterioration in developing countries is primarily driven by two factors. The first involves early stage defects resulting from poor-quality materials and inadequate construction techniques. The second involves aging-related defects stemming from insufficient maintenance and management practices. According to Matsuo (2019), in developing countries, there is a significant shortage of well-trained bridge engineers possessing the expertise to conduct inspections and determine appropriate repair methods.

To address this challenge, bridge engineering, particularly bridge maintenance, must be incorporated into the curricula of higher education institutions. In this study, we aim to enhance bridge engineering education in Mongolia by focusing on bridge maintenance and management in the final-year project at the Mongol Koosen College of Technology (hereafter referred to as Mongol Koosen).

This paper presents a case study of a multi-institutional collaboration in a final-year project. In FY2024, a joint research project on bridge maintenance was conducted by the students of Mongol Koosen as their final-year project. The project involved five students and one faculty member from Mongol Koosen, two mentors from Tomakomai Kosen, and an engineer from a civil engineering consulting firm.

In this project, we conducted a bridge inspection with Mongol Koosen students in Ulaanbaatar, identified various defects, and analysed their causes. This project provided students with foundational knowledge on bridge maintenance and heightened their awareness of the importance of sustaining public infrastructures.

Final-Year Project 2024 (Mongol Koosen)

According to a report by the Japan International Cooperation Agency (JICA), road bridges in Mongolia are deteriorating, facing issues akin to those experienced in Japan. Therefore, to address the problem of aging bridges, a growing need is to shift the maintenance from breakdown to preventive. More than 45% of the bridges managed by the Ulaanbaatar Government were constructed between 1960 and 1991. Thus, concepts and skills related to preventive maintenance are becoming increasingly important. With this in mind, we selected '*bridge maintenance*' as the final year project theme for Mongol Koosen. The structure of this project is illustrated in Figure 1. Mentorship was provided by a teacher from Tomakomai Kosen and an engineer from Tanaka Consultant Co. Ltd. In addition, one local teacher and a Japanese civil engineering teacher, temporarily working at Mongol Koosen, provided one-on-one support to the five participating students at Mongol Koosen. The Japanese teacher was also Professor Emeritus at Tomakomai Kosen. The project aimed to inspect bridges, identify the causes of damage, evaluate and categorise damage conditions, and summarise the results.

Pre-learning Bridge Maintenance

Figure 2 illustrates the bridge maintenance cycle. In preventive maintenance, bridge inspection plays a crucial role in identifying the damage at an early stage. We visited Mongol Koosen on December 5 and 6, 2023, as Japanese mentors (from Tomakomai Kosen and Tanaka Consultant Co., Ltd.) to teach bridge inspection methods, including how to design repairs and plans for the bridge maintenance cycle. Prior to the visit, the students selected several bridges located near the Mongol Koosen campus for this study.

The students had not studied bridge engineering; therefore, prior to the field bridge inspection, we provided online and face-to-face lectures on the fundamental concepts of bridge structures and maintenance practices.

Bridge Inspection Activities

Bridge inspections were conducted on the Gurvaljin Bridge and Bridge 32, as shown in Figures 3 and 7, respectively. Both bridges were made of prestressed concrete. The Gurvaljin Bridge and Bridge 32 span approximately 108 m and 49 m, respectively. According to publicly available sources, the Gurvaljin Bridge was constructed in 1989 and repaired in 2010. During the inspections, students were instructed on practical techniques such as crack marking and hammering tests,

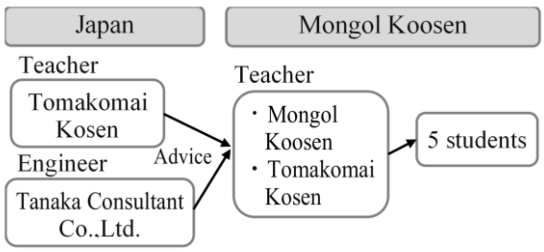

Figure 1 Project structure

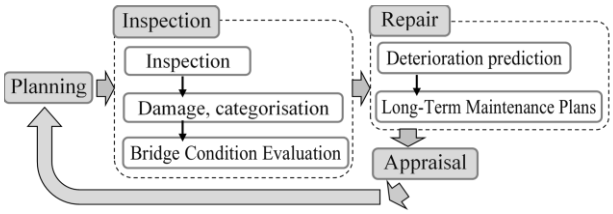

Figure 2 Bridge maintenance cycle

Figure 3 Gurvaljin Bridge (L = 108 m)

Figure 4 Bridge inspection

(a)Free lime (b) Pothole

Figure 5 Slab from Gurvaljin Bridge

as illustrated in Figure 4. Following bridge inspection, the students independently revisited both bridges approximately five times to inspect them in more detail.

On the Gurvaljin Bridge, free lime deposits and a pothole were observed on the sidewalk, as shown in Figure 5. The presence of free lime was attributed to

Figure 6 Uncovered pier

water leakage, whereas the potholes were likely caused by poor construction quality, possibly because of insufficient concrete filling. Furthermore, as shown in Figure 6, the piers were exposed above the ground level, suggesting that sediment runoff from the foundation may have occurred because of rainwater erosion.

Bridge 32 exhibited more extensive free lime deposits along the entire girder, as shown in Figure 8. Figure 9 shows the damage caused by the freeze-thaw cycles. The exposed steel reinforcement in Figure 9(a) arises when the water within the concrete freezes and expands, leading to surface cracking. Figure 9(b) depicts the deterioration of the concrete abutment caused by repeated freeze-thaw cycles; the concrete has disintegrated and resembles soil. Figure 10 shows the damage around the bearing area. The first observation involved spalling at the edge of the girder with a section of concrete measuring over 40 mm in length and 4 mm in depth. The second is a misalignment of the base plate, which has shifted from its intended position relative to the edge plate of the girder. Additionally, concrete delamination along the edge of the girder was confirmed through hammering tests, indicating that the steel reinforcement was rusting and expanding.

Classification and Characteristics of Bridge Damages

Table 1 presents the classification of concrete damage based on the Mongolian Bridge Code (refer to S. Hasnavch, *Use of Reinforced Concrete Bridges*, 2019). The code categorises damage into five levels ranging

Figure 7 Bridge 32 (L = 49 m)

Figure 8 Free lime

(a) Exposed steel bars (b) Concreate deterioration

Figure 9 Freeze-thaw damage

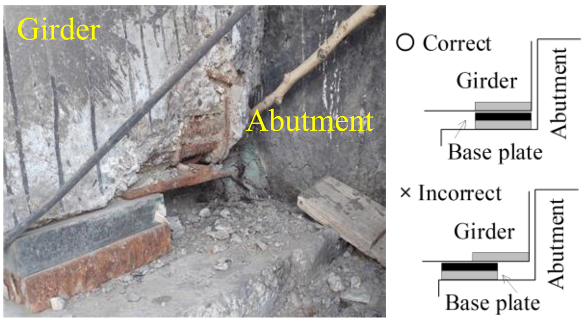

Figure 10 Deteriorations around the bearing

Table 1 Classification of concrete damage

Degree of damage	Description of the degree of damage
0: No damage at all	The size and growth of cracks are within the allowed standard. For example: The size of the crack opening and growth of damage in reinforced concrete structures is within 0.2 mm. No special measures are required to correct this.
1: Low-impact damage	Damages exceed the limits permitted by the standards. These damages need to be repaired because although they do not affect the basic transport and operational characteristics of the bridge, they may gradually affect it.
2: Influential damage	Damages adversely affect the basic transport and operational characteristics of the bridge structure. This does not pose a direct threat to the operation of the structure. Repairs to such damage are conducted in a planned sequence.
3: Dangerous but repairable damage	Damage in this category significantly reduces the basic transport and operational performance of the bridge structure but is not catastrophic.
4: Irreparable damage	This category includes damage that threatens structural collapse, compromises the load-bearing capacity of the components, or makes the bridge unusable without strict restrictions, such as closing lanes to traffic, restricting truck traffic, or preventing any operation.

from 0 (no damage) to 4 (irreparable damage). Students were provided with reference materials on general bridge inspection practices, and they independently researched documents relevant to the Mongolian standard that appeared to align with the principles of preventive maintenance. Based on this classification, the students evaluated both Gurvaljin Bridge and Bridge 32 as falling under Category 2, indicating 'influential damage'. In addition, the students analysed the characteristic damage patterns observed in Mongolian bridges.

Common types of damage include deterioration caused by water infiltration, such as free lime deposits, corrosion of steel reinforcement, and freeze-thaw cycles. These types of damage are typically associated with surface cracks, often resulting from poor material quality or substandard construction practices. Other frequently observed issues include defects caused by construction deficiencies such as potholes (Figure 5(b)) and misalignment of the base plate. This analysis provided the students with a clear understanding of the importance of ensuring construction quality in maintaining long-term durability and serviceability of bridges.

Questionnaire for Participating Students

After completion of the final year of the project, a questionnaire was administered to gather feedback on the project theme. Questions were prepared in advance, and a local teacher facilitated discussions with the students based on these questions. The questionnaire results are presented in Table 2. The response to Question 2 in Table 2 indicates that the students recognised the role of poor construction quality in causing bridge damage. Question 3 reflected the growing awareness of the importance of bridge maintenance. Students appeared to understand the critical role of regular inspections in identifying damages at an early stage. Question 4 explored how the students' perceptions of bridges changed as a result of the research. All the students reported a shift in their thinking about bridges. Their responses suggest that they are now more interested in bridges and understand the importance of addressing damage in the early stages to reduce repair costs and promote sustainability. Their awareness of bridge maintenance also increased.

Such awareness is essential for future infrastructure development in Mongolia and highlights the importance of fostering engineers who understand and value preventive maintenance.

Table 2 Questionnaire for participating students

Q1. What first got you interested in this theme of the final-year project?
・ *We are studying civil or structural engineering, and we found it interesting to explore other areas of construction.*
Q2. What impressed you while inspecting the bridge?
・*In our country, bridges are often damaged due to mistakes made during construction—for example, when they are not built according to quality requirements and standards, or when construction is careless. After several years of use, these mistakes can eventually lead to bridge collapse.*
Q3. What do you think should be done to maintain Mongolia's bridges in the future?
・ *It is necessary to make regular inspection a routine practice and then take appropriate maintenance and repair measures. This will help prevent major risks and losses in the future. I think it is important for experts to be more careful in conducting inspections regularly.*
Q4. How has your thinking about bridges changed as a result of this research?
・*Before conducting bridge research, I would just walk across a bridge without thinking. Through this research, I learnt what causes bridges to fail, why they deteriorate, how much damage can occur, and when repairs are no longer possible.* ・*I used to think monitoring a bridge was simple, but now I understand that it involves identifying the causes and severity of damage more deeply.* ・*In the past, I crossed bridges without giving it much thought. Now, I am more conscious of their condition. I realised that if a bridge collapses, it can have a huge impact on human lives and the economy. I have even started to subconsciously look for signs of damage.* ・*I learnt the names of bridge components and causes of collapse. I also learnt that if damage is not repaired while it is still minor, it can worsen and become more expensive to fix.*

Conclusions and Future Prospects

This paper presents a case study on a multi-institutional collaboration in a final-year student project. The project served as a source of motivation and inspiration for the participating students. Student engagement with real-world infrastructures in the field is crucial because such experiences enhance the understanding of practical engineering challenges. The project significantly increased students' awareness of construction quality and the importance of maintenance. Furthermore, it provided insights into the common types of bridge damage, enabling students to estimate the progress of deterioration and to develop strategies for preventing similar failures. As many countries are currently facing the challenge of aging infrastructure, engineers who recognise the importance of long-term infrastructure sustainability are required. Educating students in acquiring the knowledge and experience required to address these challenges is a vital responsibility of academic institutions.

However, we were unable to obtain official specifications for road bridges in Mongolia. One possible reason for this is Mongolia's historical background as a former satellite state of the Soviet Union, which likely influenced the adoption of Soviet-based bridge standards. Consequently, students were required to refer to specifications from other countries in the absence of localised guidelines. In addition, there are significant climatic differences between Mongolia and Japan. For example, Japan has a humid climate that makes steel corrosion a critical concern for infrastructure maintenance. In contrast, Mongolia has low precipitation and an extremely dry climate. Therefore, the extent to which Mongolian conditions cause corrosion problems remains unclear, as data on this issue are limited. Overall, because of differences in national standards, languages, and context, there were aspects of the project where we, as mentors, faced challenges in providing adequate support. Regarding future prospects, long-term exposure data on structures in Mongolia should be collected to better understand infrastructure deterioration under Mongolian conditions. In addition, we would like to involve a Mongolian consulting firm to discuss the specifications.

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