The maintenance for present infrastructures in southern part of Japan

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Abstract. In general, governments used to increase the number of public works for their economic recovery. In United State, huge number of bridges, roads and tunnels were constructed in 1920’s. The lifetime of infrastructures is regarded as fifty years in general. In addition, the budget for maintenance of infrastructure had been decreased from the latter half of 1960s to 1970s. Therefore, most of these infrastructures were decayed in 1980’s and this period is called as ‘America in Ruins’. In Japan, enough number of power generators were required to launch heavy industries after World War II. To export these products, ports and highways were constructed. Furthermore, the bullet train ‘Shinkansen’ and urban expressways in Tokyo were constructed for Olympic game held in 1964. In 2010’s, most of these infrastructures seem to reach their life time. However, government doesn’t have enough budget for renovations. Therefore, new standards and technologies for repair and inspections are being required. Nowadays, huge number of infrastructures are under construction in Malaysia. Similar issues of United States or Japan may be occurred in this fifty years. In this paper, recent policy of government and new technologies including methods and equipment for maintenance of infrastructures in southern part of Japan are shown.

1. Introduction
In Japan, factors to threaten security, the relief of the nation including the outbreak of natural disaster and an accident, increase as never before. According to the attitude survey of the nation of December, 2005, people more than 70% of population feel that present Japan is dangerous and must wrestle for an issue for security to establish reliable society immediately [1]. On the other hand, the number of public works is decreasing by progress of low birth-rate and aging, and most of infrastructures built more for the rapid economic growth period is greeting the time of the update. In addition, the construction of main ports, airports and the beltways of major cities are pushed forward strategically in long term in China or Korea in late years. In contrast, Japan made their effort into the development that kept the balance between areas as seen in a conventional national overall development plan. As a result, the global position of the main ports of our country decreased and reached the result to fall behind China or Korea in late years. In contrast, Japan made their effort into the development that kept the balance between areas as seen in a conventional national overall development plan. As a result, the global position of the main ports of our country decreased and reached the result to fall behind China or Korea from the viewpoint of future international aviation service demand in the major airport. If international competitiveness of our country decreases, finance to social capital maintenance becomes difficult and might not be able to perform the investment for the making of safe reliable society enough. The governmental policy for this issue is that the important point investment in three major urban areas where main industry (Tokyo, Osaka and Nagoya), ports, airports are located is necessary to evade an
international competitiveness drop of Japan. In these areas, it is necessary to make business continuity plan beforehand not to mention airports, ports, the expansion of the beltway so that these infrastructures are not felt into functional decline by natural disaster or terrorism. In addition, the organization which gives urban area aspect each other three major a backup function to avoid falling into functional decline by any chance thinks with need. Under such situation, the maintenance for infrastructures should be realized to find security, the relief of the nation while the social capital investment that took a certain balance development between areas into consideration as before being absolutely difficult, and applying the limited resources and staff based on the agreement of the nation efficiently. Furthermore, developing countries also may be going to face same situation in future. In this study, the technologies for life time extension in local areas in Japan are shown.

2. Historical background of public works in U. S. and Japan

Figure 1 shows the comparison the number of bridges constructed in Japan to that in U. S. Construction works have been influenced by the economic condition of society. For example, Roosevelt, President of United States, produced job opportunities for huge number of unemployed person during his public works to recover from recession due to World War I. Under this public works, called as ‘New Deal’, more than 8.5 million workers who built 650, 000 miles of highways and roads, 125, 000 public buildings as well as bridges, reservoirs, irrigation systems, parks, playgrounds and so on. It is shown that number of constructed bridges increased from 1927 to 1941 in red bars of Figure 1. From the latter half of 1960s to 1970s, the works for maintenance and updating for roads were not enough because the budget related with highways was reduced in this period. However, the lifetime of infrastructures, especially bridges, are estimated at 50 years. Therefore, the deterioration of the infrastructure got serious issue in 1980s. 1980s in U. S. was called as the period of ‘Ruined U. S.’, and collapse by the deterioration, the damage, suspension of traffic occurred successively. To solve this issue, the tax for gasoline that had been kept the standard in 1959 doubled from in spite of sustained inflation.

Similar issues are also expected in Japan. After World War II, huge number of power stations, highways and ports were required to launch heavy industries and export. In addition, the Olympic games were held in Tokyo in 1964. It is shown that huge number of bridges was constructed from 1962 in blue bars of Figure 1. Most of these infrastructures reach their life time in 2010s.

According to Ng, about 1000 bridges were built in 1981 and 1982 and about 100 bridges are built every year to 1999 except 1992 and 1993 in Malaysia [2]. These bridges also reach their lifetime in 2030s. Furthermore, it may be seen that the economic growth cannot be expected in future because the that between 4.0 and 6.0% can be seen nowadays [3].
3. Incidents related with collapsed infrastructures in Japan
In early 21 century, not only enough economic growth is not being expected but also younger generation is getting small in Japan same as other full growth countries [4]. Then, enough budgets for reconstruction are not obtained with tax incomes. To avoid issues occurred in U. S., Ministry of Land, Infrastructure, Transport and Tourism in Japan established the manual for inspection for bridges and tunnels, and diagnosed following this manual. Thorough this procedure, fractures of diagonal members in truss bridges were observed in 2007. However, the crown of Sasago tunnel in Chuo expressway was collapsed and nine passengers died in 2012 though the inspection was done. Therefore, unified standard of soundness for existing infrastructures and technologies for life time extension of infrastructures were required immediately.

4. Policy of maintenance work and design for repair
Recently, the condition rating system of bridge is being attempted in Malaysia [5]. In this section, the policy of maintenance work and design for repair in Japan is shown. In 2014, the ministerial ordinance of periodic inspection work for infrastructures was enforced as shown in Figure 2 [6]. In this ordinance, two steps are defined for maintenance of infrastructures. First step means the periodical diagnoses for each infrastructure and second one means appropriate repair and reinforcement for the infrastructures those are categorized into the corruption at the first step. During this procedure, the cause of corruption should be found at first, the removal of the cause or treatment for the damage should be done next. In Japan, it is said that this procedure is similar to the work by medical doctors. The approach for removal or treatment in this ordinance is mentioned below.
Figure 2. Ministerial ordinance of periodic inspection work for domestic infrastructure (in Japanese)[6].

4.1. Work for extraction the deterioration factor and the cause
(1) Internal factor
In this ordinance, the internal factor is defined in used materials, design and execution for infrastructures. Drawings and specifications are very useful for this work. However, it is difficult to find these documents for aged infrastructures sometimes. Even if they are able to be found, protective covering and reinforcing rods are not often located to go along the design. For these cases, the soundness for infrastructures should be estimated using the feature of deformation, destructive or non-destructive testing.

(2) External factor
In this ordinance, the external factor is defined as environment and conditions of infrastructures. Salt damage in the coast area, frost damage in cold districts, chemical damage in hot spring areas should be taken into account for infrastructures. Furthermore, fatigue should also be into account when damages mentioned above occurred repeatedly.

(3) Initial flaw
In this ordinance, the initial flaw means shrinkage cracks on the surface, thermal cracks under construction, candied bean slabs due to poor quality of compaction or mould, cold joint of concrete and shortage of protective covering.

(4) Deterioration
In this ordinance, deterioration means salt damage, neutralization, frost damage chemical damage and fatigue generated due to corrosion of reinforcing bars, condition of concrete surface or pitch or direction of cracks.
(5) Injury
In this ordinance, injury means damages due to collision or cracks generated by bending moments or shear stresses depending on the direction or position.

4.2. Estimation of deformation mechanism
At first, shape or type of structure should be grasped. Next, the deterioration mechanism should be concluded using results from destructive or non-destructive test or qualification test. Then, logical adjustments should be made to deformation mechanism with the reasoning or drawing figures.

4.3. Diagnosis for injury
The cause of injuries should be identified from result of deterioration or deformation mechanism obtained from procedures shown above. Then, the necessities of preparation, including present soundness and deterioration prediction in future, should be examined. In this procedure, section repair method, crack injection method, surface protection method, carbon fiber reinforcement and outer cable reinforcement are included.

4.4. Suggestion and choice of method for preparation
Following results from the procedure shown above, the effective method for the preparation work should be chosen. During this procedure, the effect, the cost or the experience of construction should be compared among several methods. At the same time, the limit and quality of the preparation work should be decided by explanation and agreement of managers.

5. Example of life time extension work
In Malaysia, material type of 87.88% bridges is concrete [2], and many problems in concrete members are also seen [7]. In this section, some examples of life time extension work in local area of Japan are shown. The example of maintenance work in Kagoshima prefecture, shown in Figure 3, dealt in this section. Kagoshima prefecture is one of local government in Japan and located in southern part of Kyushu Island. The capital city of this prefecture, Kagoshima City, is approximately 970 km away from Tokyo. This prefecture also includes a chain of islands stretching further to the southwest of Kyushu for a few hundred kilometres. Furthermore, this prefecture boasts a chain of active and dormant volcanoes, including the great Sakurajima. Most of the economic sector is focused in Kagoshima City and the surrounding area and this prefecture has strong agricultural roots, which are reflected in its most well-known exports. As mentioned above, the central government of Japan has not assigned enough budgets for update of infrastructures in recent years. Therefore, many constructors in this prefecture have not been able to choose but work related with agriculture. The constructors staying in this field began to relate with life time extension work. There are several life time extension methods shown below [8].

Figure 3. Position of Kagoshima Prefecture.
5.1. Filling method for crack
Filling method for crack is applied for cracks whose width is more than 1.0 mm. Polymer cement mortar or epoxy resin is used as the material for filling. Figure 4 shows the work of this method.

![Figure 4. Work for crack filling.](image)

5.2. Injection method into crack
The Injection method into crack is applied for cracks whose width is within 0.2 and 1.0 mm. Grouting material in epoxy resin system or acrylic resin system, polymer cement for injection is used for this work. Figure 5 shows the work of this method. Cracks are still found by operators’ eyesight in this work. For tunnels or pavements, the image analysis or machine tool can be used for finding cracks. Structures of existing bridge are too complicated to find cracks using these technologies.

![Figure 5. Injection method into crack.](image)

5.3. Powder Impregnation method on the surface
Powder Impregnation method on the surface is applied to avoid degradation on the surface of concrete. This method does not work immediately like the surface coating method. On the other hand, the effect lasts for a long term due to its refinement [9]. Figure 6 shows the work of this method.
6. Conclusion
After World War II, huge number of infrastructures like railways, roads, bridges, tunnels, ports, airports and so on, were constructed and most of them seem to finish their life time in 2010s in Japan. At the same time, the government does not prepare enough budgets for reconstruction of them. In this study, the works for life time extension of infrastructures in one of local places of Japan, Kagoshima, are shown. Rising countries also may face same issues in future. There are significant matters not only to establish the technologies of life time extension for infrastructures but also to choose the shape of structures so that the image analysis or machine tool can be used for finding cracks.

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