IMPROVEMENT OF ROADWORK SCHEDULING USING THE CALENDAR SYSTEM TO RESTRICT PEAK TRAFFIC DAY WORK

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Abstract: Since unexpected delays caused by roadwork are a typical cause of motorists’ dissatisfaction, practical roadwork management is the present focus. To minimize roadwork’s adverse effect on highway traffic, construction is to be scheduled for off-peak traffic periods. This report outlines the development and use of a roadwork scheduling tool called the “Calendar System” prepared by the Akita National Highway Office. The Calendar is used to restrict construction on “no-work days” corresponding to annual peak traffic periods and marked preliminarily according to previous years’ traffic profiles collected by permanent traffic counters. Although the system is a static management method that cannot reflect influence of construction on highway traffic, it is easy to prepare and to use, brings highway administrators no additional work costs, and effectively reduces drivers’ time loss due to roadwork in cases where annual traffic fluctuation is large enough and has a stable traffic pattern.

Key Words: roadwork, off-peak scheduling, Calendar

1. INTRODUCTION

Maintaining and rehabilitating aged highway infrastructure has become an issue of increasing importance as the facilities, which have been constantly expanding since the High Economic Growth Period of the 1960’s and 1970’s, deteriorate due to increasing traffic, aging materials, and/or obsolete designs. The ratio of maintenance expenditures to total road investments, therefore, tends to increase in many developed countries.

In spite of their importance, maintenance and rehabilitation projects on existing roads, which often cause traffic congestion and unexpected travel delay, often frustrate road users. Roadwork management under increased traffic and motorist dissatisfaction becomes one of the main challenges facing highway administrators in many countries. The Japanese Highway Administrator, the Ministry of Land, Infrastructure and Transport, as well as other countries’ highway agencies, treats reduction and better management of roadwork as a major issue of Performance Management in Terms of Customers’ Satisfaction.
To address the adverse impact of work zones, the following principal measures have been taken in many countries:

- shortening project duration through innovative techniques, work zone management and/or traffic management
- providing road users with travel and work zone information to influence their behavior and to reduce their exposure to work zones
- scheduling roadwork for off-peak traffic periods to minimize traffic congestion and the number of affected road users

The first strategy focuses on innovative techniques; the use of prefabricated materials, quick-curing concrete and innovative paving machines, for example. An example of innovative management might be accelerating the pace of contractors through nonstop work schedules, full road closures and contracting options such as “cost-plus-time” bidding. Also, the “Collective Work Zone” option is adopted in large cities in Japan. Under this option, all agencies and companies responsible for various facilities such as electricity, water, and gas cooperate to develop a large scale and long term work plan so that the construction projects of different facilities in the same area are scheduled to be undergone at the same time to reduce recurrent roadwork and total construction time in the long run.

The second strategy suggests that preliminary information about work zones and alternate routes can divert road users from a route under construction, easing congestion and reducing dissatisfaction. Even if the information about the work zone and the congestion does not divert drivers from affected routes, the recognition of the congestion and its cause might lessen their frustration.

A night-work option is a typical example of the third strategy in many countries. Japanese highway offices have conventionally adopted following off-peak period scheduling options:

- To do night-work on heavy traffic highways where remaining one traffic lane has more than 600 vehicles/hour in case of a two-lane highway and/or remaining each traffic lane has more than 1,000 vehicles/hour in case of a three or more traffic lane highway
- To perform roadwork during off-peak traffic hours and/or off-peak traffic days according to their experiences

While Japanese highway offices have usually specified only special holydays, vacation seasons and/or festival days as peak traffic days based on their experiences, this report outlines a strategy specifying peak traffic days throughout a year based on annual traffic data collected by permanent traffic counters (PTC) in previous years so as to perform better and objective roadwork management.

The Akita National Highway Office (hereinafter referred to as “the Office”), which is confronted with strict constraints such as heavy snowfall limiting the number of days on which work is possible and some highway sections with fluctuating traffic and no alternate routes, has been developing and revising a scheduling tool called the “Calendar System” since FY2004. Under the system, roadwork is to be scheduled to avoid peak traffic days preliminarily designated every fiscal year according to past traffic profiles. Recently, the system has been highly appreciated in Japan as a successful example of performance management for road administration based on objective indicators. This report outlines how the Office has developed and revised the system and how effective it is.
2. SCOPE OF STUDY

2.1 Study Area and Implementing Agency
The Office, located in Akita Prefecture, is a branch office of the Ministry of Land, Infrastructure and Transport. Figure 1 shows the location of the Prefecture and highways under the Office’s jurisdiction.

Akita Prefecture, which has a population of 1,213,655 (October 1, 1995), is located in the northeastern part of Honshu Island on the Japan Sea side, and shares the same latitude as Beijing, Madrid and New York. Geographical features include an area of about 11,612 square kilometers (the 6th largest prefecture in Japan), the “Ou Sanmyaku” mountain range in the eastern portion averaging 1000 meters in height, the “Dewa Sanchi” mountains in the central portion averaging 400 meters in height, three large rivers running through the mountains, inland basins along the rivers, and plains along the seacoast. As for climatic features, Akita experiences long winters accompanied by heavy snowfall. Mountain areas and some basins are particularly well known for overwhelming snowfall.

The Office administrates 191km of three arterial national highways running through the central portion of Akita: Route 7, extending from Niigata City to Aomori City and running along the coastline; Route 13, extending from Fukushima City to Akita City and connecting the major inland basins in Tohoku; and Route 46, which runs from Morioka City to Akita City and crosses the mountains in between. These indispensable highways with heavy traffic connect prefecture capitals and other large cities to support economic and everyday activities.

Highways under the Office’s jurisdiction are divided into five sections, each of which has a PTC recording traffic 365 days a year. Table 1 describes the features of each section. The Office has conventionally conducted maintenance and rehabilitation work at night on Sections 4 and 5 because of the constant heavy traffic during the day. Contrarily, daytime work has been performed on Sections 1, 2 and 3.
Table 1 Features of the road sections administrated by the Akita Highway Office

<table>
<thead>
<tr>
<th>Section</th>
<th>Length (km)</th>
<th>Lanes</th>
<th>Average Traffic*</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 Kakunodate</td>
<td>26.2</td>
<td>2</td>
<td>7,221 (1,484)</td>
<td>mountains and small plains with a small town area</td>
</tr>
<tr>
<td>Section 2 Sengan</td>
<td>29.4</td>
<td>2</td>
<td>3,811 (1,101)</td>
<td>Mountains</td>
</tr>
<tr>
<td>Section 3 Kisakata</td>
<td>10.1</td>
<td>2</td>
<td>6,471 (2,042)</td>
<td>narrow coastal plains with a small town area</td>
</tr>
<tr>
<td>Section 4 Honjo</td>
<td>50.5</td>
<td>2</td>
<td>24,337 (6,525)</td>
<td>coastal plains with a medium town area</td>
</tr>
<tr>
<td>Section 5 Akita</td>
<td>75.2</td>
<td>2 &amp; 4</td>
<td>29,107 (8,446)</td>
<td>coastal plains with a large town area</td>
</tr>
</tbody>
</table>

* Upper figure indicates daytime traffic during a 12-hour period. Lower figure in ( ) indicates nighttime traffic during a 12-hour period.

2.2 Scope of Studied Roadwork

The scope of the studied roadwork must be clarified because there are many differences with regard to ownership, objective, scale, duration and so on. This report is concerned with typical maintenance and rehabilitation projects which are accompanied by traffic lane closures, interfere with traffic on existing roads, and are defined in the shaded area in Figure 2. Of course, the target roadwork of the Calendar System is the same.

![Figure 2 Scope of work covered by the Calendar System](image)

Nevertheless, this does not necessarily mean that the system is only applicable to projects undergone by road administrators. A highway agency could ask a utility company to schedule its work according to the system as well. The Office has asked for such cooperation even though only 20% of the work performed on areas under the Office’s jurisdiction is performed by utility companies. In Tokyo, on the other hand, 30% of the work is performed by highway agencies and 70% is performed by utility companies. Cooperation of utility companies is indispensable to ease road users’ dissatisfaction with roadwork in such areas.
3. PHASE 1 OF ROADWORK SCHEDULING

3.1 Challenges of Phase 1
The Office is confronted with strict constraints: heavy snowfall limiting days on which work is possible and fluctuating traffic caused by sightseeing travelers. The town of Kakunodate, located along Section 1, is famous for its old-fashioned mansions called Bukeyashiki which recreate the atmosphere of the Edo era. As this town attracts a lot of tourists, especially during sightseeing seasons, fluctuating traffic sometimes leads to congestion. To ease road users’ suffering within work zones during peak traffic periods, the Office developed and put into practice a prototype of the Calendar System called “Phase 1” in FY2004 for construction along Section 1.

3.2 Concept of the Prototype Calendar System
The Calendar System is a roadwork scheduling tool that a highway administrator would use to restrict roadwork during peak traffic days preliminarily marked on a calendar according to the previous years’ traffic profile.

The methodology involved in arranging the calendar for FY2004 is shown in Figure 3:
- The daily 12-hour daytime traffic volumes and their dates in FY2003 were lined up according to the size of the traffic volumes.
- The days with the 50 heaviest 12-hour daytime traffic volumes in FY2003 were noted.
- The 50 days in FY2003 were transferred to the corresponding days on the FY2004 calendar. For instance, the 20th Monday in FY2003 corresponded to the 20th Monday in FY2004.
- Assuming that the traffic pattern in FY2004 would be the same as that in FY2003, we regarded the corresponding 50 days in FY2004 as peak traffic days and declared them “no-work peak traffic days” on which construction should be restricted.
- Also declared “no-work days” were days during snowfall season (“no-work days during snowfall season”) and holidays including Saturdays, summer vacation and end and beginning of the year holidays (“no-work holidays”).
- The three kinds of no-work days were marked on a calendar, which was named “the Calendar.” Some of the no-work days might belong to 2 or 3 categories; days during snowfall season that had the heaviest traffic and fell on a holiday, for example.

### 3.3 Preparation for Phase 1

We examined traffic profiles from FY2003 to identify peak traffic days. Figure 4 shows the 12-hour daytime traffic volumes (upper column) and the frequency of roadwork (lower column) on each day in order according to volume. In Figure 4, green indicates a day during a sightseeing season and pink indicates holidays outside of sightseeing seasons. From the dates of the green columns concentrated on the left side, we can see that most of the days with the heaviest traffic were during sightseeing seasons: festival days, cherry blossom season during April and May, and weekends in autumn when tourists came to see colored leaves. Nevertheless, a lot of construction was undergone during these peak traffic days.

We identified no-work days in FY2004 according to the traffic profile shown in Figure 4. Figure 5 shows the Calendar in FY2004 arranged according to the methodology shown in Figure 3. The 50 days marked by green ovals indicate no-work peak traffic days; the 102 days marked by yellow ovals indicate no-work holidays not falling on peak traffic days; and the 58 days marked by white ovals indicate no-work days during snowfall season which do not fall on holidays.
3.4 Review of Phase 1

First, note the reduction of construction during peak traffic days. A comparison of Figures 4 and 6 shows that the frequency of roadwork during the 50 heaviest traffic days decreased from 47 to 10 after adopting the system. Gross work hours during the 50 heaviest traffic days fell by 5,721 hours in FY2004. These consequences certainly resulted from proper enforcement of the system.

Secondly, let us discuss the constraint of predictability with respect to future traffic patterns. Figure 6 shows that the Office was not able to avert all roadwork during the 50 peak traffic days in FY2004 (after adopting the System). This is not because some urgent work was done on no-work days, but because some construction was done on some of the 50 days with the heaviest traffic in FY2004 that were not marked as no-work days at the beginning of the fiscal year. We were not able to predict precisely the 50 peak traffic days in FY2004 based on the traffic profile of FY2003. Figure 7 indicates a fair correlation between daily traffic in FY2003 and that in FY2004. The 10 scatter plots within the shadowed area, however, indicate 10 days not marked on the Calendar which had less traffic than the 50th heaviest traffic day in FY2003 and, contrarily, had more traffic than the 50th heaviest traffic day in FY2004.
Thirdly, the issues of workability and choosing a reasonable number of no-work days must be mentioned. The Office found that roadwork restriction under the system did not bring about any serious adverse effects such as prolonged duration of projects, suspension of projects, and/or cost over-run. Nevertheless many no-work days in autumn provided the contractors with little time to spare because most projects had to be completed before mid-December due to the impending heavy snowfall. Actually some contractors of roadwork raised complaint of strict scheduling constraint. This shows that it is practical to restrict roadwork during peak traffic days using the system as long as the number of no-work peak traffic days is determined properly. Specifically, the number should be determined and revised reasonably based on traffic patterns and experience.

4. PHASE 2 OF ROADWORK SCHEDULING

4.1 Challenges of Phase 2
Based on the achievement and review of Phase 1, challenges of the next stage were identified as follows:
- Determining a reasonable number of no-work days. If the number is too small, effects of off-peak scheduling, namely the reduction of traffic affected by roadwork is too small. If the number is too large, the strict restriction will affect contractors’ performance adversely and work will possibly be restricted on days when traffic is not particularly heavy. Thus, neither a number too small nor one too large is effective. Furthermore, a
reasonable number may depend on traffic features. How should we determine a reasonable number of no-work days?

- Increasing the accuracy of predicting a year’s peak traffic days according to the previous years’ traffic profiles. Actually, we might have to decrease the number of no-work days if the prediction lacks accuracy.
- Examining traffic patterns in order to study said conditions and to establish a methodology applicable to the different attributes of highways.

### 4.2 Concept of a Revised Calendar System

We took the following conditions into consideration when designing the methodology for arranging the Calendar:

- **Variability of Traffic:** We cannot enjoy the merits of off-peak scheduling if the difference of traffic volumes between peak traffic days and off-peak traffic days is too small. In light of this, predicted peak traffic days should be determined according to the variability of traffic so that said difference will be significantly large.

- **Predictability of Traffic:** We cannot enjoy the merits of off-peak scheduling if predicted peak traffic days frequently turn out to exhibit almost average traffic. Keeping this in mind, predicted peak traffic days should be determined according to the predictability of traffic so that they will be more likely to have significantly heavier traffic.

- **Availability of Alternate Routes:** Drivers are seriously affected by work zones if they do not have alternate routes. In such cases, a highway agency has to secure enough no-work days.

**Figure 8 Revised methodology for arranging the Calendar**

Based on the above mentioned conditions, the Office established the revised methodology for arranging the Calendar for FY2006 shown in Figure 8. While it is similar to the prototype, the following two steps were incorporated additionally:
Setting the number of no-work peak traffic days according to the “Variability of Traffic,” the “Predictability of Traffic,” and the “Availability of Alternate Routes.” The higher the variability and predictability of the traffic, and the lower the availability of alternate routes a highway section has, the larger the number of no-work days that is to be allocated. The “Variability of Traffic” is measured in terms of the coefficient of variation of the previous year’s traffic. The “Predictability of Traffic” is measured in terms of the regression correlation coefficient ($R^2$) of two years’ worth of traffic data. The “Availability of Alternate Routes” is measured in terms of the number of alternate routes.

Modifying the Calendar slightly according to sequences of holidays to enhance predictability. Some gaps between special holidays and Saturdays and Sundays change each year. These gaps often affect traffic, which tends to increase during consecutive holidays. In this step, no-work peak traffic days which fall near consecutive holidays on the Calendar are to be arranged according to past traffic profiles.

4.3 Preparation for Phase 2
Following the revised methodology, we examined the traffic profiles and network conditions of each section and made the following observations:

Firstly, we examined the variability of the traffic. Figure 9 plots a profile of 12-hour daily traffic along each road section in terms of a percentage of each annual average. It shows that the differences between the 50th largest traffic day and an average traffic day were relatively small along Sections 4 and 5. We found, therefore, that to restrict work on the 50th largest traffic day was not sensible on Sections 4 and 5.

Secondly, we examined the correlation between the traffic in FY2004 and FY2005 to consider predictability (see Figures 10-14). Although every section had significant correlation, we had difficulty predicting precisely which days would be the 50 heaviest traffic days for each section according to its past traffic profile except for Section 2, which had strict correlation.

Thirdly, we examined the availability of alternate routes because work zones affect regional traffic as a whole in areas with few alternate routes. Sections 2 and 3 had no alternate routes crossing the prefecture boundary. Most of Section 1 had only poor alternate routes that were narrow and/or covered long distances.

![Figure 9 Variability of 12-hour traffic volumes along each section in FY2005](image-url)
The above mentioned observations resulted in the number of no-work peak traffic days shown in Table 2. As we do not have a simple formula to calculate the number, engineers of highway agencies should carefully observe data plots like Figures 9–14 and utilize their experiences regarding highway maintenance to determine the number. Note that those numbers at
nighttime on Sections 4 and 5 were identified as 0 although several days with some of the heaviest traffic were regarded as no-work holidays.

Table 2 Traffic and network features and number of no-work days in FY2006

<table>
<thead>
<tr>
<th>Section *</th>
<th>Variability of traffic**</th>
<th>Predictability of traffic***</th>
<th>Availability of alternate Routes****</th>
<th>Number of no-work peak traffic days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 (daytime)</td>
<td>Medium (0.174)</td>
<td>Medium (0.572)</td>
<td>Low</td>
<td>30</td>
</tr>
<tr>
<td>Section 2 (daytime)</td>
<td>High (0.491)</td>
<td>Very high (0.982)</td>
<td>Low – None</td>
<td>50</td>
</tr>
<tr>
<td>Section 3 (daytime)</td>
<td>Medium (0.235)</td>
<td>High (0.749)</td>
<td>Low – None</td>
<td>50</td>
</tr>
<tr>
<td>Section 4 (nighttime)</td>
<td>Low (0.115)</td>
<td>Medium (0.651)</td>
<td>High - Medium</td>
<td>0</td>
</tr>
<tr>
<td>Section 5 (nighttime)</td>
<td>Low (0.109)</td>
<td>Medium (0.634)</td>
<td>High</td>
<td>0</td>
</tr>
</tbody>
</table>

* “()” indicates whether traffic is daytime or nighttime.
** The figure indicates the coefficient of variation of the data set of daily 12-hour traffic volumes on each section in FY2005.
*** The figure indicates the regression correlation coefficient (R²) measured based on the relationship between the response variable “daily 12-hour traffic volume in FY2005” and the predictor variable “daily 12-hour traffic volume in FY2004.”

Table 3 shows the number of no-work days in the three categories and the net number of no-work days for each section. Every section has a different number of no-work days in accordance with traffic and road features.

Table 3 Number of no-work days in each Section in FY2006

<table>
<thead>
<tr>
<th>Section</th>
<th>Peak traffic days</th>
<th>Holidays</th>
<th>Snowfall season*</th>
<th>Net no-work days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1</td>
<td>30</td>
<td>35</td>
<td>82</td>
<td>144 (365)</td>
</tr>
<tr>
<td>Section 2</td>
<td>50</td>
<td>35</td>
<td>82</td>
<td>166 (365)</td>
</tr>
<tr>
<td>Section 3</td>
<td>50</td>
<td>35</td>
<td>82</td>
<td>161 (365)</td>
</tr>
<tr>
<td>Section 4</td>
<td>365</td>
<td>41</td>
<td>82</td>
<td>365</td>
</tr>
<tr>
<td>Section 5</td>
<td>365</td>
<td>39</td>
<td>82</td>
<td>365</td>
</tr>
</tbody>
</table>

* Upper figure indicates daytime number. Lower figure indicates nighttime number.
* The figure excludes no-work holidays.

Note the difference in the definitions of holidays in Phase 1 and Phase 2. The Office modified the rule of the system regarding holidays so that roadwork is strictly restricted for 24 hours only on special holidays such as: consecutive holidays in May, days during the summer vacation season, days at the beginning of January, and special festival days. On the other hand, construction could be done on Saturdays and Sundays in cases of strict scheduling constraints and/or lack of an alternative schedule. Constraints on the system regarding
roadwork scheduling were, in a sense, slightly eased. The net number of no-work days along Section 1 in Phase 2 (FY2006) was 144 while that of Phase 1 (FY2004) was 260. The numbers cannot be compared because the no-work days in Phase 2 do not include all Saturdays and Sundays.

4.4 Review of Phase 2

4.4.1 Comparison between Phase 1 and Phase 2
While constraints on the system regarding road work scheduling were eased in Phase 2, we appreciate that, with regard to the enforcement of Phase 1, contractors’ performance could possibly be improved and traffic affected by work zones could be decreased or remain almost the same on each Section.

The accuracy of predicting year’s peak traffic days was also enhanced as for Section 1. In FY2004 and 2005, 10 days and 13 days out of the 50 days marked on the Calendar under the previous system were not the actual 50 heaviest traffic days respectively. Contrarily, only 2 days out of the 30 days marked on the Calendar under the revised system were not the actual 30 heaviest traffic days in FY2006.

4.4.2 Efficiency of the Calendar
To evaluate the reduction of traffic affected by roadwork in FY2006, we prepared Figure 15, which shows a comparison of “Number of affected Vehicles” without the Calendar and that with the Calendar for each section. While the latter is an actual figure corresponding to total number of vehicles passing through work zones, the former is an imaginary figure calculated by assuming that roadwork had not been restricted by the Calendar and had been done at random during daytime.

![Figure 15 Comparison of affected vehicles “with” and “without” the Calendar](image)

* “Number of affected vehicles without the Calendar” for each section is calculated by multiplying the “Average daytime hourly traffic volume” by the “Sum of actual lane closure hours.”

** “Number of affected vehicles with the Calendar” for each section is calculated by totaling “Actual hourly traffic volume” multiplied by “Actual lane closure hours” shown in Equation (1).

\[
\sum_i \int_a^b q_i \, dt
\]

where, \( q_i \): traffic volume per unit time during work zone \( i \)
Figure 15 suggests the followings:

- Higher traffic fluctuation leads to a higher reduction of traffic affected by work zones if the system is applied. Even if the number of no-work days is increased, the amount of affected traffic cannot decrease in an area with low traffic fluctuation. Because Section 2 has higher traffic fluctuation than Section 1 and 3 have, the System reduces more affected vehicles along Section 2 than along Section 1 and 3.

- The difference between daytime traffic and nighttime traffic is usually much larger than that between daytime traffic on peak traffic days and daytime traffic on off-peak traffic days. Working at night reduces the amount of affected traffic dramatically while it is accompanied by possible cost escalation. Note that the effect seen on Sections 4 and 5 results from working at night rather than from using the system.

We can evaluate efficiency improvement achieved in the Calendar according to the above mentioned “Number of affected vehicles” and “Average time loss per affected vehicle” corresponding to approximately 1.3 minutes, which was measured by prove cars at Kakunodate in November 2005 and should be verified by the other observations. “Time loss due to work zone”, “Time loss in terms of currency” and “Effect of scheduling” are shown in Table 4. We can observe that the Calendar functioned most effectively along Section 2, of which annual traffic has the largest fluctuation.

<table>
<thead>
<tr>
<th>Section (Scheduling option)</th>
<th>Time loss due to work zone* (thousand hours)</th>
<th>Time loss in terms of currency** (million JY)</th>
<th>Effect of scheduling *** (million JY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1 (Calendar)</td>
<td>19.0</td>
<td>82.8</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>17.5</td>
<td>76.1</td>
<td></td>
</tr>
<tr>
<td>Section 2 (Calendar)</td>
<td>13.9</td>
<td>60.2</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>9.9</td>
<td>43.2</td>
<td></td>
</tr>
<tr>
<td>Section 3 (Calendar)</td>
<td>6.9</td>
<td>29.9</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>6.3</td>
<td>27.5</td>
<td></td>
</tr>
<tr>
<td>Section 4 (Night work)</td>
<td>44.2</td>
<td>192.2</td>
<td>141.1</td>
</tr>
<tr>
<td></td>
<td>11.8</td>
<td>51.1</td>
<td></td>
</tr>
<tr>
<td>Section 5 (Night work)</td>
<td>122.4</td>
<td>531.9</td>
<td>377.9</td>
</tr>
<tr>
<td></td>
<td>35.4</td>
<td>154.0</td>
<td></td>
</tr>
</tbody>
</table>

Upper figure indicates “without” case and lower one indicates “with” case.
* “Number of affected vehicles” multiplied by “Average time loss per vehicle affected by work zone”
** “Time loss due to work zone” multiplied by “Time benefits” corresponding to 4,347 Japanese Yen per vehicle hour
*** Difference between “Time loss in terms of currency” of “with” case and that of “without” case

Daytime roadwork scheduling by the Calendar reduced road users’ costs by 26.1 million JY along Section 1, 2 and 3 in FY2006 while it did not increase work costs of the highway offices or contractors. On the other hand, night work reduced road users’ costs by as much as 519.0 million JY along Section 4 and 5 in FY2006 while it leaded to the work cost escalation by approximately 10-15%. Although scheduling roadwork on off-peak traffic days does not bring as much saving on time loss as night work, we regard the former as easy to prepare and cost effective for highway offices with enough PTCs.
As the above mentioned evaluation is only one of possible analyses, benefits of the “Calendar System” might be higher and followings should be noted:

- Compared with worst scheduling case, saving on time loss due to roadwork would be larger.
- “Time loss per vehicle affected by work zone” should be carefully examined because it would be higher in case of peak traffic days.

5. CONCLUSIONS

The Office has developed a tool called the “Calendar System” to schedule roadwork for off-peak traffic days. It has the following outstanding features:

- The system assists in scheduling work during the day as well as at night. Nighttime work, which effectively reduces impact on traffic because the difference between daytime traffic and nighttime traffic is usually large, costs 10-15% more than daytime work because of increased workers’ wages and the installation of extra safety devices. Therefore, scheduling work for daytime hours by the system also holds value since it reduces road users’ time loss and does not force additional work costs on highway administrators or contractors.
- The system is easy to prepare for road administrators with PTCs. If an agency has access to PTCs and the annual traffic pattern is stable, the agency can specify peak traffic days and can easily prepare the Calendar.
- The system is easy to understand and use. Although the system contains only a static management method that cannot reflect roadwork’s influence on highway traffic, no-work days are determined and marked on a calendar at the beginning of a fiscal year so that even low-skilled engineers can easily understand and schedule work days without studying traffic profiles by themselves.

Off-peak scheduling strategies such as the Calendar System are practical and effective if traffic has large fluctuation and a stable annual pattern as long as the number of no-work days is determined properly based on experience and local traffic conditions. Note that too many no-work days increase contractors’ burden and bring no marginal benefit of road users. To judge the effectiveness and to set a reasonable number of no-work days, the Office introduces the following practical indicators:

- Variability of traffic measured in terms of the coefficient of variation of yearly traffic
- Predictability of traffic measured in terms of the regression correlation coefficient ($R^2$) of two years’ worth of traffic data
- Availability of alternate routes measured in terms of the number and condition of alternate routes

We wish for the system to be applied to other areas facing work zone issues and strict constraints. The diffusion of the system would lead to an accumulation of good experience and skills enabling its further revision so that work zone impact on traffic and security can be eased and the performance of highway administration can be greatly enhanced.
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