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Demand analysis of the large truck parking at expressway rest areas in Japan

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Abstract

Since September 2021, NEXCO Central Japan has been working to collect information using ETC free-flow antennas at almost of expressway rest areas. The obtained data includes a lot of significant information, such as the date and time of inflow/outflow of vehicles equipped with ETC on-board units, so it is useful to consider the solution of the congestion problem of large truck parking lots at expressway rest areas. In this study, by using the free-flow data described above and the results of a questionnaire survey of truck drivers, we analyzed the demand of expressway rest areas precisely and estimated the effects of TDM measures.

Keywords:

Truck parking, Free-flow data, Transportation demand management (TDM)

1. Introduction

The purpose of this study is to analyze the demand for large truck parking at the expressway rest areas in Japan. Then, we try to test the hypothesis that the congestion problem of large truck parking lots can be solved by charging a parking fee at expressway rest areas and the provision of off-expressway rest facilities.

Truck drivers are required to take breaks/rests before, during, and after their journeys, as stipulated by the Japanese Labor Standards. For this reason, it is very important for truck drivers to be able to park reliably at the rest areas on expressways. Currently, however, large truck parking lots at the expressway rest areas are very crowded especially at night. Since line-haul trucking generally takes place at night, this congestion problem has a significant negative impact on the business model of line-haul trucking.

The expressway companies that manage the expressway rest areas have been working to expand rest areas and increase the number of parking lots, but their efforts are now facing physical limits. Recently they have installed dual-use parking lots (parking lots that can be used by two small vehicles or one large vehicle, and are expected to make more efficient use of the parking supply), and have enhanced the provision of information (providing information on the availability of parking lots by vehicle type), but this has not led to a satisfactory solution to the above problem.

We consider that analyzing the parking demand of trucks during congested hours and proposing TDM based on the characteristics of truck drivers is required to solve this problem. Fortunately, NEXCO Central Japan began recording free-flow data on the inflow and outflow of many rest areas on the Tomei and Shin-Tomei Expressways in September 2021. This study will utilize these free-flow data and the results of a previously conducted driver questionnaire survey to analyze the demand for large truck parking lots and to clarify the knowledge needed to solve the congestion problem.

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2. Target of Analysis and Research Hypothesis

2.1 Target of Analysis

In Japan, road categories are classified into four. The most highly classified road category is expressways, and most of them are toll roads. Their actual length is 8,922 km, which is 0.7% of the total in terms of length, but 15.7% of the total in terms of traffic volume. Today, three expressway companies (NEXCO East Japan, NEXCO Central Japan, and NEXCO West Japan) are responsible for the construction, renewal, management, and toll collection of expressways.

The Tomei Expressway and Shin-Tomei Expressway, which are the target of the analysis, are part of Japan's largest trunk road network connecting the two major cities of Tokyo and Osaka, with the daily traffic volume of approximately 84,000 vehicles (44,000 vehicles on the Tomei and 40,000 vehicles on the Shin-Tomei). The expressways have two types of rest areas. One is the "Service Area: SA", which is located at intervals of about 50 km and has parking lots, toilets, stores, restaurants, and fuel stations. Another is the "Parking Area: PA", which is located at intervals of about 15 km and has parking lots, toilets, and stores. In this study, we will analyze seven rest areas that are within 100 km of Tokyo on the Tomei and Shin-Tomei Expressways and for which free-flow data set is available (Figure 2.1).

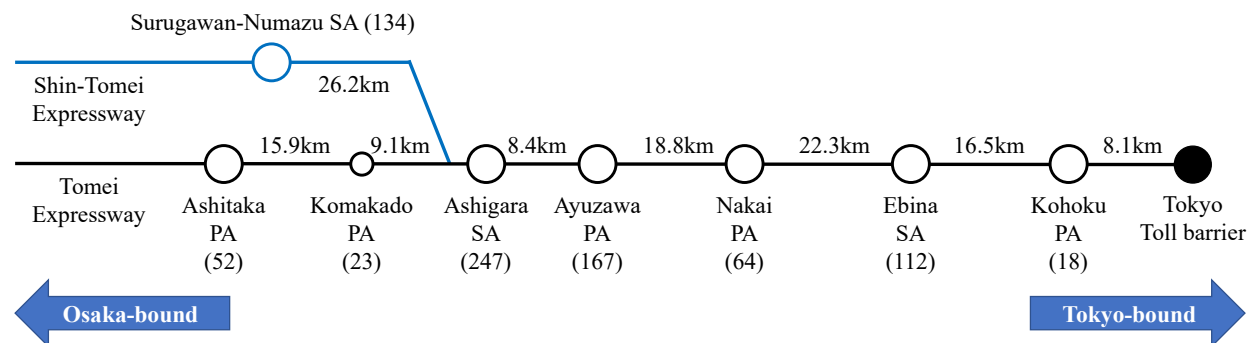


Figure 2.1 Target of analysis

Note: The number in parentheses is the number of large vehicle parking lots.

In Japan, there are the labor standards, such as the continuous driving hours and rest periods for truck drivers, to prevent traffic accidents caused by long hours of driving. For example, truck drivers must take a short break (at least 30 minutes) every four hours of continuous driving. In addition, truck drivers must, in principle, take a longer rest (at least 8 hours) before and after the journey, up to 13 hours. Therefore, securing parking lots at the expressway rest areas used for long-distance truck transportation is very important for the compliance and safety of truck drivers.

2.2 Research Hypothesis

Regarding this shortage of large truck parking at expressway rest areas, Misui et al. (2021) have analyzed the TDM through a review of previous studies, interviews with expressway companies, and statistical data analysis (Table 2.1). TDM includes temporal equalization and spatial equalization. Temporal equalization is to reduce congestion by directing the parking demand during the congested time to the time before and after the congested time. Although the burden on users and expressway companies is small, it is not easy to achieve because logistics is a derived demand and delivery times are specified by shippers. Spatial

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equalization refers to directing parking demand to more available locations during the same period, and includes equalization within the same rest area, equalization among nearby rest areas, and equalization with off-expressway rest facilities. Specific measures that can be taken for them include providing information on full capacity in advance, charging for the use of rest areas, providing dual-use parking lots, and adjusting tolls on temporary exits to use off-expressway rest facilities.

However, it is necessary to clarify what kind of trucks park at the rest areas during the congestion period and what kind of characteristics these truck drivers have to consider whether the TDM measures are effective or not. Therefore, this study attempts to verify the hypothesis that "the congestion problem of large truck parking lots can be solved by charging for expressway rest areas and providing off-expressway rest facilities" through demand analysis based on the TDM measures, shown in Table 2.1.

Table 2.1 Classification of TDM measures for large vehicle parking lots

Category	TDM measures		Expected behavioral changes		Expected measure effect
	Current Policy	New policy in this study	Short-time users	Long-time users	
Temporal equalization	Advance information on parking lots	-	No	No	No
	-	Charging	Small	Small	Small
Spatial equalization within the same rest area	Dual-use parking lots	-	Medium	Medium	Medium
	-	Charging	Small	Medium	Medium
Spatial equalization between nearby rest areas	Realtime information on parking lots	-	No	Small	Small
	-	Charging	Small	Medium	Medium
Spatial equalization between the expressway rest area and the off-expressway rest facilities	-	Providing the off-expressway rest facilities	Small	Large	Large

Source: revision of Table 6, Misui et al. (2021)

3. Analysis of parking demand using free-flow data

3.1 Overview of free-flow data

NEXCO Central Japan, which manages the Tomei and Shin-Tomei Expressways, used to conduct periodic utilization surveys to determine the level of congestion at the expressway rest areas. However, this survey was conducted only on two days (one weekday and one weekend day) at intervals of several years, and did not provide a real-time grasp of congestion. In response to this problem, NEXCO Central Japan has been working to collect information using ETC free-flow antennas, and since September 2021, the number of rest areas for which data can be obtained has been increased, and data set is now available at seven out of eight rest areas within 100 km of the Tokyo Toll Barrier. The data set includes the date and time of inflow/outflow of vehicles equipped with ETC on-board units at rest areas, the type of vehicle, the inflow/outflow IC of the expressway, and the date and time of the inflow/outflow. By analyzing the data obtained, it is possible to clarify the time spent at rest areas and the number of vehicles parking by time of day.

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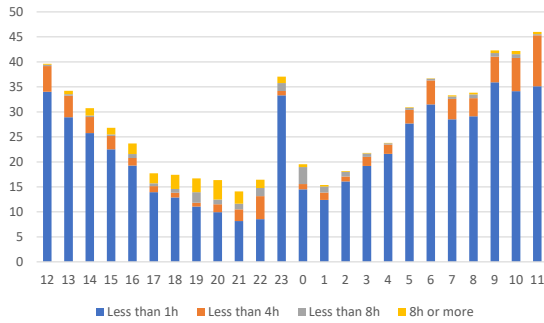


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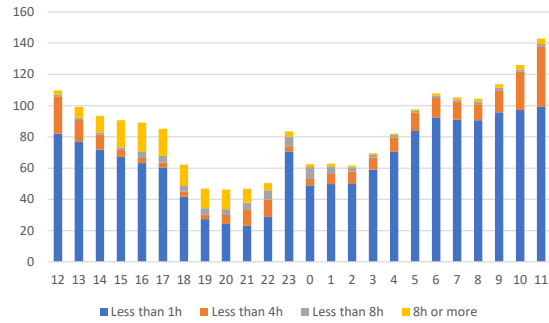


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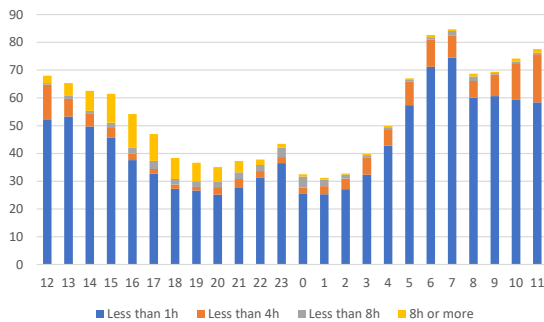




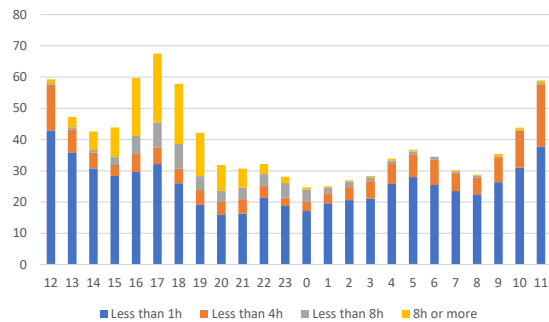
(a) Kohoku PA



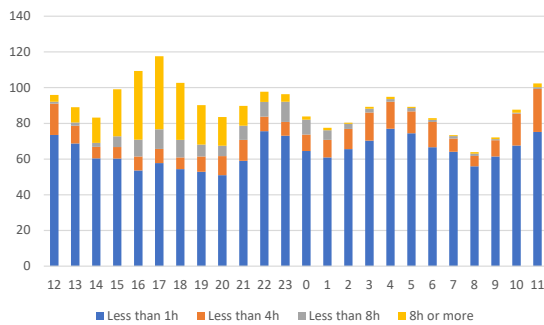
(b) Ebina SA



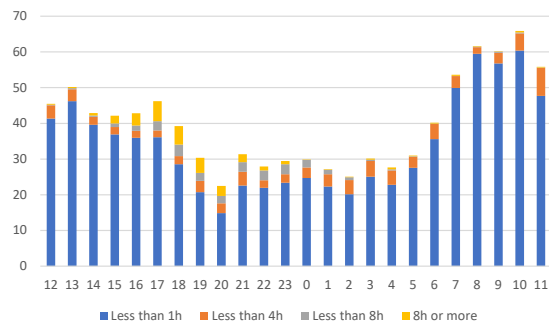
(c) Nakai PA



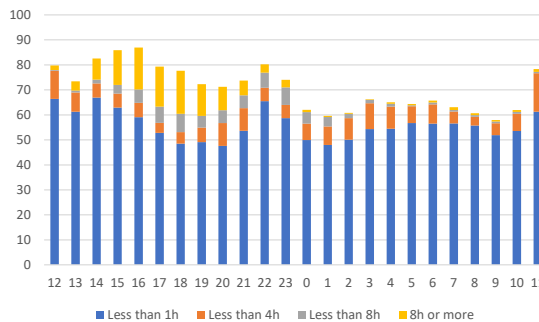
(d) Ayuzawa PA



(e) Ashigara SA



(f) Ashitaka PA



(g) Surugawan-Numazu SA

Figure 3.1 Number of inflow vehicles by time of day

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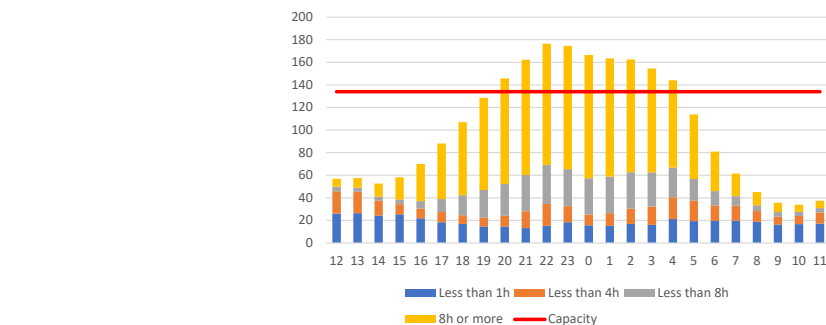
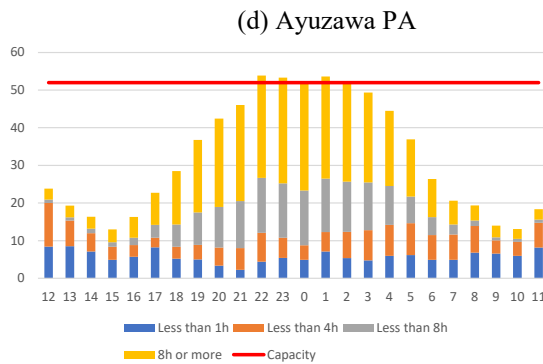
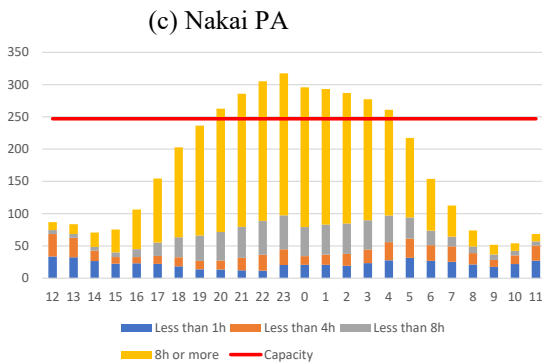
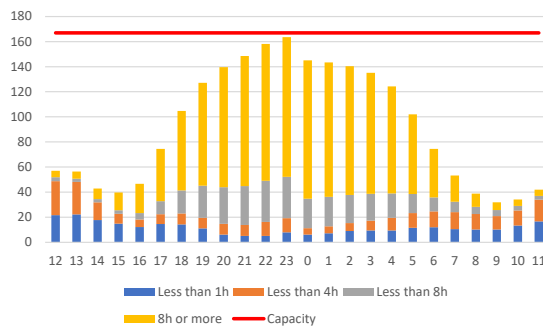
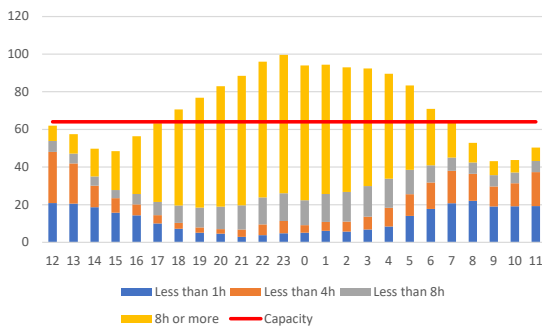
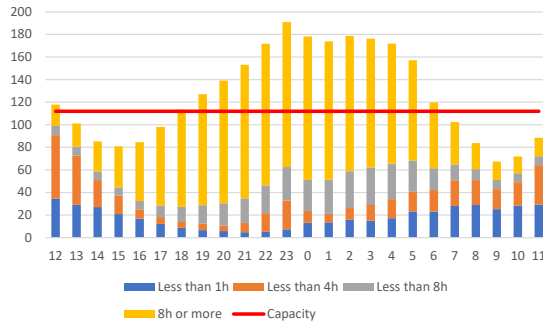
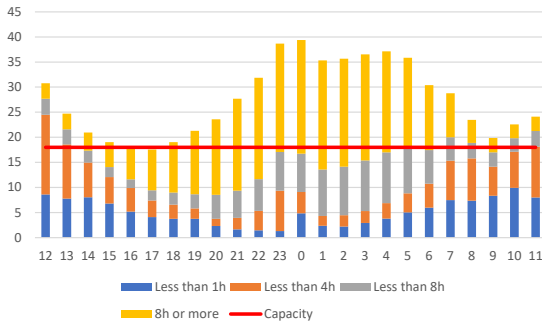


Figure 3.2 Number of parking vehicles by time of day

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3.2 Analysis Results

In this study, we used the free-flow data set for September 2021 and analyzed it from two perspectives. The first perspective is the number of inflow vehicles (large vehicles) by time of day and duration of stay. The results of the analysis based on this perspective are shown in Figure 3.1.

There are three points to be understood from these figures. Firstly, the bottom of the inflow of vehicles (the lowest time period) is between 9:00 p.m. and 1:00 a.m., which is earlier the closer you are to Tokyo and later the farther away from Tokyo. Also, the farther away from Tokyo, the more flat the shape of the inflow graph becomes. Secondly, the inflow of vehicles staying for a long time (more than 8 hours) is significant around 16:00 to 18:00. Thirdly, the number of inflow vehicles peaks at 23:00 at the rest areas closer to Tokyo (Kohoku PA, Ebina SA, Nakai PA), which is thought to be an inflow of vehicles for the purpose of applying the midnight discount system (a system that provides a 30% discount on expressway tolls for those who use the expressway between midnight and 4:00 a.m.).

The second perspective is the number of parking vehicles by time of day (large vehicles). Figure 3.2 shows the results of the analysis based on this perspective (showing the number of vehicles parking at each hour).

There are three things that can be understood from this figure. Firstly, we can see that the peak number of parking vehicles (the most frequent time period) is between 22:00 and midnight, and that it is earlier the further away from Tokyo, and later the closer to Tokyo. Secondly, we can see that during the peak hours, about 60% to 70% of the vehicles parked for more than 8 hours parking. Thirdly, a comparison with the capacity of large vehicle parking lots, shown by the red line, shows that congestion is more significant at rest areas closer to Tokyo (Kohoku PA, Ebina SA, Nakai PA).

4. TDM analysis based on the questionnaire survey of truck drivers

4.1 Summary of the questionnaire survey of truck drivers

In this study, we conducted a questionnaire survey of truck drivers. Table 4.1 shows the overview of the questionnaire survey.

Table 4.1 Overview of the questionnaire survey

Item	Description
Survey schedule	Thursday, January 13, 2022, 21:00 - Friday, January 14, 2022, 5:00
Survey location	Ebina SA, Nakai PA, Ayuzawa PA (all on the Tomei Expressway, Tokyo-bound)
Survey targets	Truck drivers who use the rest areas
Number of responses	Ebina SA 74, Nakai PA: 62, Ayuzawa PA: 140, total 276 (of which 267 were valid responses*) *Those whose vehicle size is outside the scope of the survey (small truck) and those who did not answer vehicle size (9 responses in total) are treated as non-valid responses.
Questions for respondents	(1) Use of the rest area this time, (2) Satisfaction with the use of the rest area this time, (3) Agree or disagree with the charging for use of rest areas, (4) Willing to use the off-expressway rest facility for trucks, (5) Agree or disagree with the charging for use of rest areas if the off-expressway rest facilities for trucks are provided, (6) Desired location of the off-expressway rest facilities for trucks, (7) Selection of the expressway rest areas to be used during journey, (8) Recognition of the dual-use parking lots, (9) Others (overview of this Journey, driver's age/years of experience, vehicle attributes)

Note: Prior to the implementation of this survey, we conducted a pre-test at the Ashitaka PA from December 9 to 10, 2021. In addition, we had planned to conduct a similar survey from January 20 to 21, 2022, at Ashigara SA and Surugawan-Numazu SA, but those surveys have been postponed due to the spread of COVID-19.

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4.2 Results of a questionnaire survey for truck drivers

Figure 4.1 shows the results for and against the charging of the expressway rest areas. Here, the question was asked for all the rest areas on the Tomei and Shin-Tomei expressways, assuming that a charge of 50 yen per hour would be levied for nighttime use. Although this was an expected result since the question was asked to the drivers themselves, only 22% of the respondents agreed ([Agree] / [Somewhat agree]). The result indicates that it is difficult to gain the understanding of users by simply charging a fee. In addition, figure 4.2 shows the results of asking the respondents who agreed with the idea how much they would be willing to pay if a charging rate is increased. Respondents who disagreed ([Disagree] / [Somewhat disagree]) were asked whether they would be willing to pay a charge if the first hour is free (Figure 4.3). Figure 4.2 shows that about 60% of the respondents answered that they would accept a charge of 100 yen. Figure 4.3 also shows that even if the first hour were made free, the number of respondents agreeing would only increase by 10%.

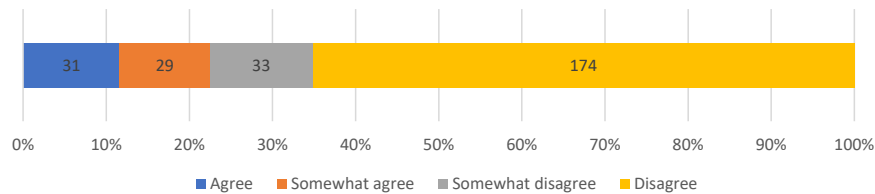


Figure 4.1 Agree or disagree with the charging for use of rest areas

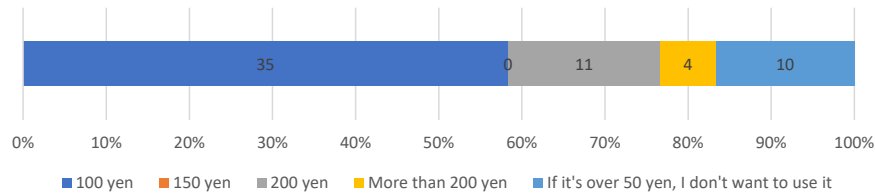


Figure 4.2 Willingness to pay if the charging rate is increased (Respondents who agreed)

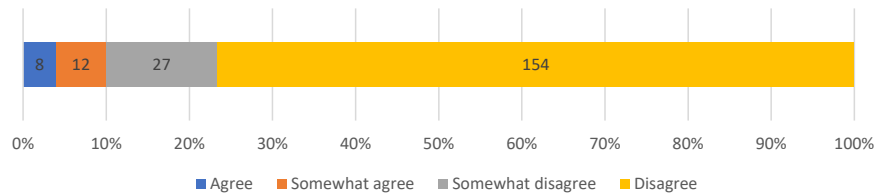


Figure 4.3 Agree or disagree with the charging if the first hour is free (Respondents who disagreed)

Figure 4.4 shows the results of the willingness to use the off-expressway rest facilities for trucks, assuming that they are provided. Here, the question is based on the assumption that a truck-only rest facility (free of charge) with only parking lots, vending machines, and toilets will be provided at a location about 10 minutes away from the expressway rest area. About 90% of the respondents answered that they would be willing to use the facility ([Want to use] / [Somewhat want to use]). This suggests that many truck drivers are looking for an environment where they can park safely even if their driving time increases. In addition, figure 4.5 shows the results of a survey that asked positive respondents about the facilities they would like to see if these off-expressway rest facilities were charged (500 yen per visit). Figure 4.5 shows that the need for shower facilities and restaurants is relatively large. There was also a

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suggestion that 500 yen per visit was too expensive. Figure 4.6 shows the results of asking the negative respondents ([Do not want to use] / [Somewhat don't want to use]) about the facilities they would like to have in order to use them. Figure 4.6 shows that many drivers are not willing to use the facilities even if they are improved. This suggests that there are drivers who find it difficult to use the off-expressway rest facilities due to time constraints.

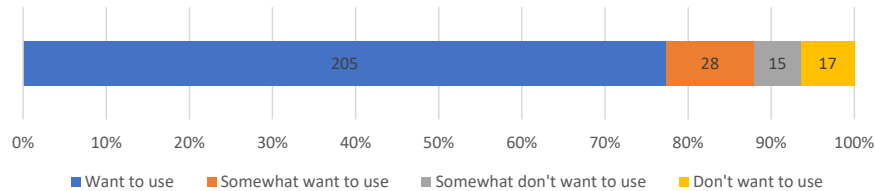


Figure 4.4 Willingness to use the off-expressway rest facilities for trucks

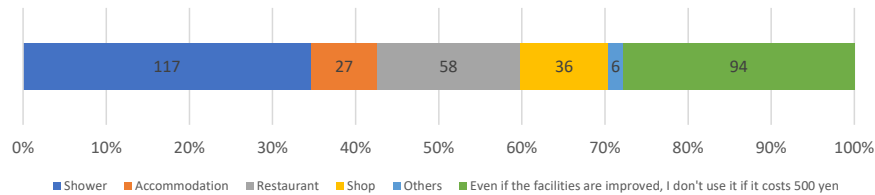


Figure 4.5 Facilities requirements if the off-expressway rest facilities are charged (positive respondents)

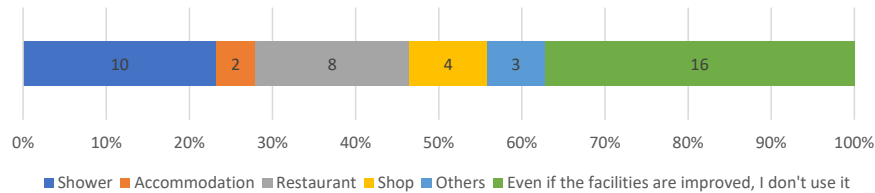


Figure 4.6 Facilities requirements to use the off-expressway rest facilities (negative respondents)

Figure 4.7 shows the results of a survey on the agreement or disagreement with the charging of rest areas, based on the assumption that the off-expressway rest facilities described above are provided. Figure 4.7 shows that 36% of the respondents agreed with the idea ([agree]/[somewhat agree]), which is a significant difference (1% level) compared to the results shown in Figure 4.1. This result implies that the provision of off-expressway rest facilities is effective in making users accept the charging of the expressway rest areas. Figure 4.8 shows the results of the question about the choice of expressway rest areas (charged) and off-expressway rest facilities (free). Figure 4.8 shows that 73% of the respondents choose the off-expressway rest facilities. 50 yen per hour may seem to be cheap, but the effect cannot be ignored.

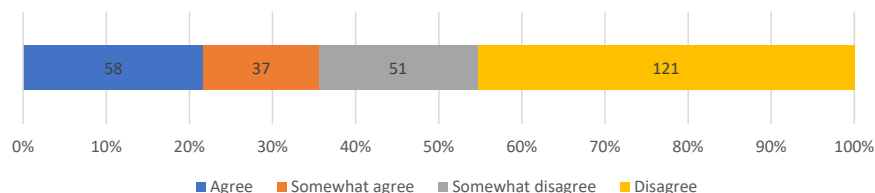


Figure 4.7 Agree or disagree with the charging for use of rest areas if off-expressway rest facility is provided

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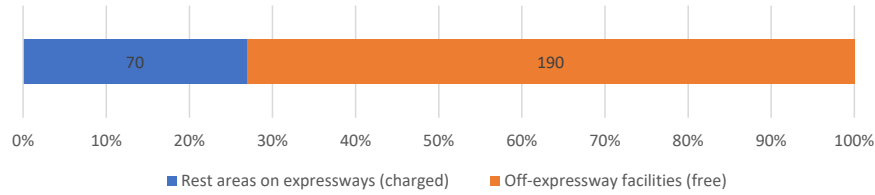


Figure 4.8 Choice of expressway rest areas (charged) and off-expressway rest facilities (free)

In addition, in the analysis, we also conducted a cross-analysis according to parking time ([Less than 1h]/[Less than 4h]/[Less than 8h]/[8h or more]) at the expressway rest areas (Figures 4.9 to 4.12), but no significant differences were found.

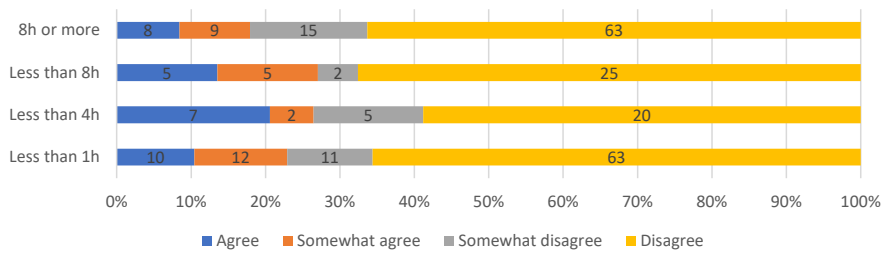


Figure 4.9 Agree or disagree with the charging for use of rest areas by parking time

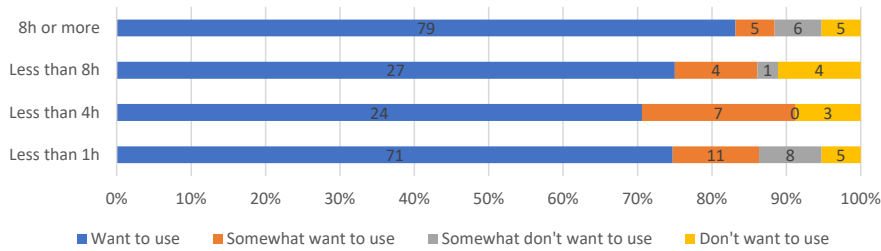


Figure 4.10 Willingness to use the off-expressway rest facilities for trucks by parking time

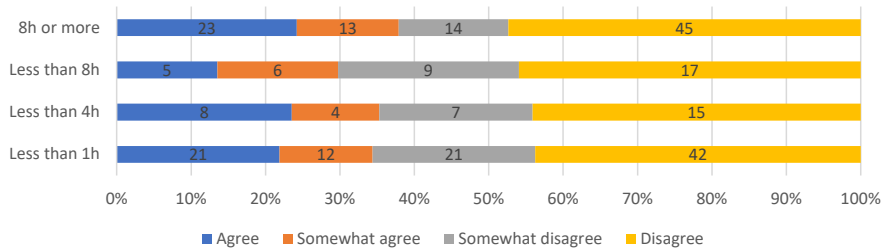


Figure 4.11 Agree or disagree with the charging for use of rest areas if off-expressway rest facility is provided by parking time

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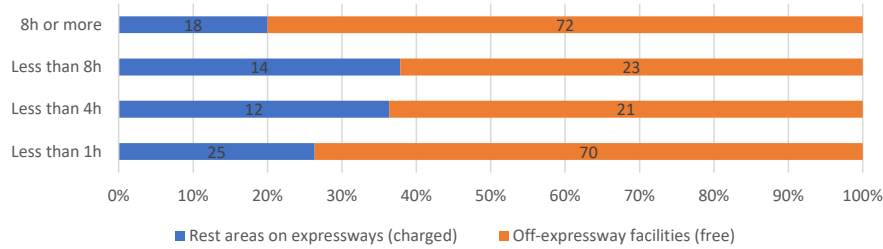


Figure 4.12 Choice of expressway rest areas and off-expressway rest facilities by parking time

4.3 Analysis of the effects of TDM

Based on the results of the choice of expressway rest areas (charged) and off-expressway rest facilities (free) shown in Figures 4.8 and 4.12, we quantitatively show the effect of TDM measures in two cases. The first case is the equalization of rest areas with neighboring rest areas through the charging of rest areas. If a fee is charged only at the rest areas closer to Tokyo (Kohoku PA, Ebina SA, and Nakai PA), which are more congested, it will encourage the use of rest areas farther away from Tokyo, and as a result, the congestion at the rest areas will be equalized (Figure 4.13). However, this would not completely solve congestion, as even overall, the number of parking vehicles exceeds capacity from 8 pm to 4 am (Figure 4.14).

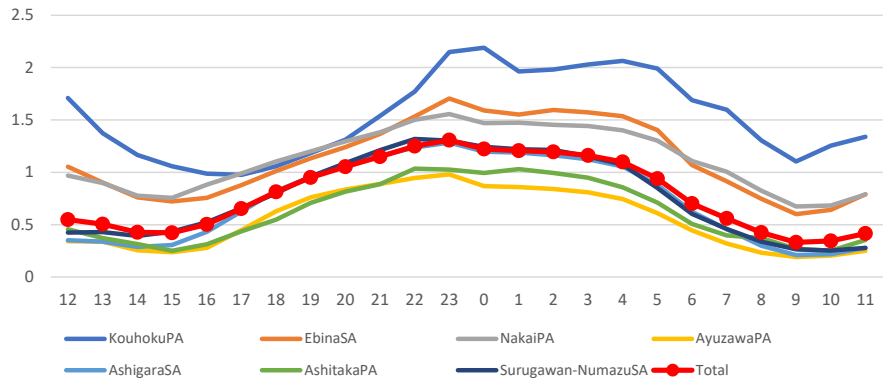


Figure 4.13 Congestion rate by rest area (number of parking vehicles/capacity)

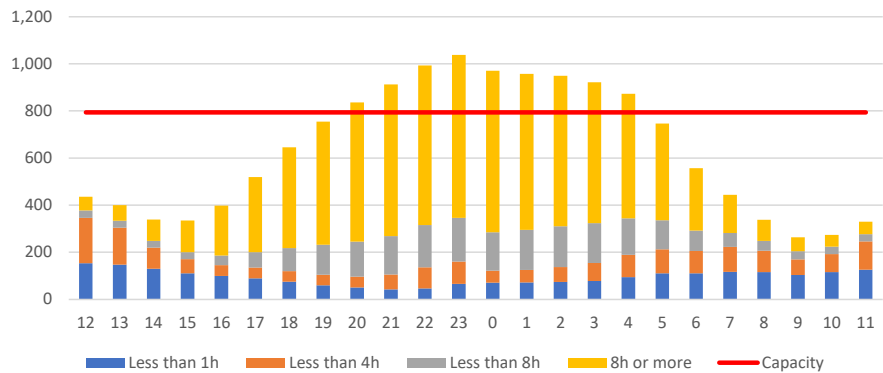


Figure 4.14 Number of parking vehicles by time of day (total of 7 rest areas)

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The second case is the equalization between the expressway rest areas and the off-expressway rest facilities. If off-expressway rest facilities are provided and a charge is made for the use of the expressway rest areas for more than 8 hours, 80% of drivers who park more than 8 hours will use off-expressway rest facilities, as shown in Figure 4.12. In this case, the number of parking lots at the expressway rest areas would be well below capacity, solving the congestion problem, but requiring the provision of very large (over 500 lots) off-expressway rest facilities (Figure 4.15). If the conversion to the off-expressway rest facilities can be controlled to half (40% of the total who park more than 8 hours) by applying a lower charge, the expressway rest areas will not be congested and the required size of off-expressway rest facilities can be limited to about 300 cars (Figure 4.16).

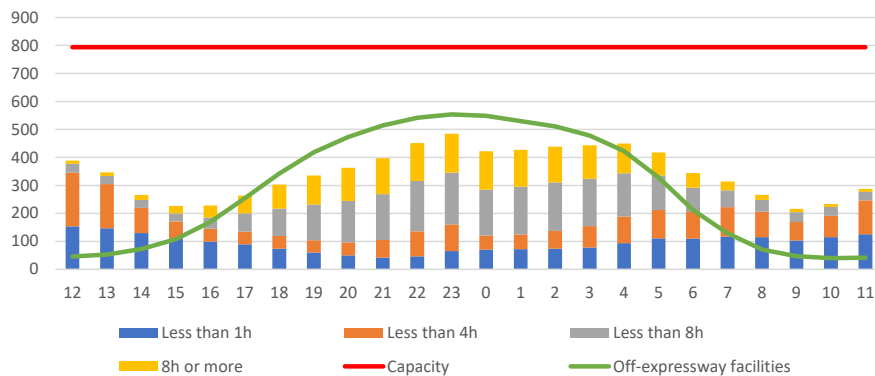


Figure 4.14 Number of parking vehicles by time of day if 80% of drivers use the off-expressway facilities

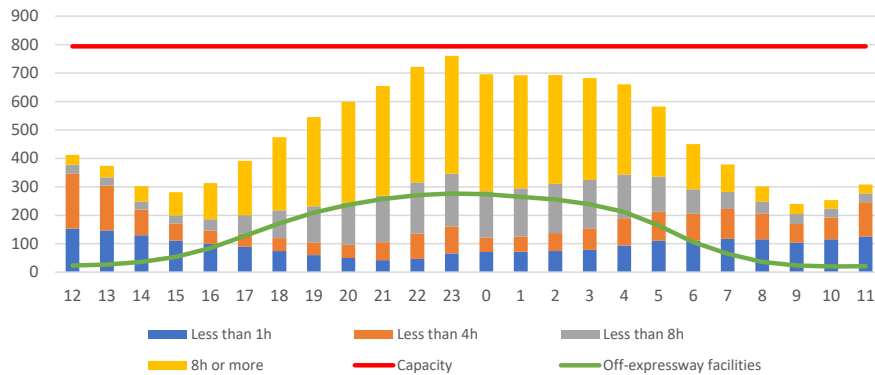


Figure 4.14 Number of parking vehicles by time of day if 40% of drivers use the off-expressway facilities

5. Conclusion

In this study, we conducted a demand analysis using free-flow data and estimated the effect of TDM measures using the results of a questionnaire survey conducted on truck drivers. The main findings of this study are the following two points. Firstly, although the tendency to use parking lots at neighboring rest areas is similar, there is a difference in congestion conditions. Therefore, if "spatial equalization among neighboring rest areas" can be achieved through charging, some improvement can be realized, although it is difficult to completely solve the congestion problem. Secondly, the level of acceptance of the charging of the expressway rest areas will increase if the off-

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expressway rest facilities are provided. By combining the charging of expressway rest areas and the provision of off-expressway rest facilities, a "spatial equalization between expressway rest areas and off-expressway rest facilities" can be achieved.

As for future issues, the following two points can be mentioned, especially regarding the questionnaire survey for truck drivers. Firstly, to consider more effective equalization of demand, it is necessary to analyze whether or not to charge for rest areas, and whether or not truck drivers are willing to use off-expressway rest facilities, based on attributes of truck drivers other than the duration of their parking. Secondly, the questionnaire survey analyzed this time does not provide sensitivity analysis on the level of charging, conditions for using off-expressway rest facilities, exclusive use (exclusive use for trucks or shared use with other types of vehicles), and who bears the burden (drivers or transportation companies). We would like to take this into account in the remaining surveys, which are currently being postponed.

Acknowledgements

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