Effect of Road Geometry on Free Flow Speed

An Empirical Analysis using ETC 2.0 Data

道路幾何構造が自由走行速度に与える影響:ETC2.0 に基づく実証分析



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# Introduction

Knowledge about the free-flow speed is important to evaluate safety and performance of roads. Previous studies concluded that impact of road alignment on free-flow speed on expressways is negligible. However, the combined effect of both horizontal and vertical alignments are not considered and utilization of spot speed data cause data limitation errors appearing in results. Hence, this study aims to understand the impact of the combined effect of road alignment on free-flow speed in Japanese expressways using ETC 2.0 data.



Study Area : 0km to 268.9 km of Tomei Expressway



Schematic Diagram of ETC 2.0 System

ETC 2.0 is considered as the world's first I2V collaboration system. The vehicle on-board device can record the speed, time & position of the vehicle and uploaded to the ITS system through ITS spots.

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|--------------------|---|--|--|--|
| 40309315833_001503 | D00000 2.014020+13 138.5007 15.1835 0 97 97.723 1010 3  |  |  |  |
| 40209235822 001302 | 000000 2.014025+13 130.8996 25.1854 0 104 98.133 1010 3   |  |  |  |
| 40209233822 001302 | 000000 2.034022+13 138.8993 35.1783 0 104 98.341 1010 3   |  |  |  |
| 40399235822_001302 | 000004 2.01402E+13 138.899 35.1767 0 102 98.546 1010 3  |  |  |  |
| 40209235822 001300 | 100000 2.014025+13 138.8578 15.173 0 96 38.967 1010 3   |  |  |  |
| 40209235822_001302 | 500000 2.014025+13 138.8968 35.1714 0 97 99.168 1010 3  |  |  |  |
| 40309235822_003300 | 000000 2.034020+13 138.8555 33.5899 0 95 99.376 1010 3  |  |  |  |
| 40309235822_001302 | 500000 2.054020+13 138.8556 15.5852 0 80 75.653 1010 3<br>000000 2.054020+13 138.8556 15.5852 0 93 93 64 1010 3 |  |  |  |
| Re                 | y variables   |  |  |  |
| •                  | Longitude   |  |  |  |
| •                  | Latitude  |  |  |  |
| •                  | GPS Time  |  |  |  |
| •                  | Spot Speed  |  |  |  |
| •                  | Vehicle ID  |  |  |  |
|                    | Kilometer Point   |  |  |  |
| -                  | KIIOITIELEI FOITIL  |  |  |  |

- Route Code
- Direction

### **Data Preparation**



### Analysis

110 horizontal curve sections located in Tomei Expressway downbound direction was selected. Only the sections located in basic segments were considered because presence of ramp, tunnel, interchange etc. can affect free-flow speed of drivers.



These graphs evident that the free-flow speed is varying with the vertical alignment as well.

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curvature & gradient

The selected dataset were further divided based on the shape of the vertical alignment and then, multiple linear regression was applied to find the significant factors for each category.



| Type of<br>orizontal Curve<br>Sections | Significant Variables         | Coefficient | p -<br>Value | R²   |
|--|-------------------------------|-------------|--------------|------|
| All                                    | Speed Limit                   | 0.0646      | 0.0337       | 0.95 |
|  | Gradient Value at Start       | -0.6977     | 0.0000       | 0.35 |
| Category 1                             | Length of Previous<br>Tangent | -7.4552     | 0.0158       |      |
|  | Length of Next Tangent        | 17.4754     | 0.0415       | 0.72 |
|  | Vertical Grade                | -2.8401     | 0.0199       |      |
| Category 2                             | Speed Limit                   | 0.1132      | 0.0056       |      |
|  | Gradient Value at Start       | -0.5842     | 0.0000       | 0.70 |
|  | K-Value                       | -7.5899     | 0.0002       |      |
| Category 3                             | -                             |             |              | 0.38 |

K-value of Horizontal Alignment

## **Conclusion & Future Works**

The study found that no significant impact can be observed from horizontal alignment on free-flow speed in curve radius range 550m - 10,000m. However, the vertical alignment does have a significant impact on free-flow speed.

In future works, the individual speed profiles will be analyzed to identify the effect of road alignment on the own behavior of different drivers

#### Acknowledgement

The authors express the gratitude for Central Nippon Expressway Company for providing data