STUDY OF OVERTAKING ON SLIPPERY TWO-LANE ROAD

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1. Abstract

In winter, slippery roads emerge in cold regions like Hokkaido. The braking distance on these roads exceeds that on dry roads. Accordingly, the Road Structure Act provides that the braking distance on slippery roads be calculated in consideration of the decline in the friction coefficient between tire and road surface.

It also becomes more difficult for vehicles to accelerate and decelerate on slippery roads. Accordingly, calculation of PSD on slippery roads should consider the decline in friction coefficient. However, the Road Structure Act does not provide for such consideration. Furthermore, aborting of overtaking caused by the perception error of driver should be analyzed comprehensively on roads of two opposing lanes.

In this study, a model of overtaking model and a model of aborting overtaking that consider the slippery road are developed. The following conclusions were obtained. The length of overtaken vehicle, the speed of overtaking vehicle and the friction coefficient between tire and road surface have a large effect on the PSD, but the ascent slope does has no such effect. The speed of overtaking vehicle and the friction coefficient between tire and road surface have a large effect on the aborting safety ratio, which indicates the difficulty of aborting, but the ascent slope and the length of vehicle have no such effect.

2. Introduction

In winter, slippery roads emerge in cold regions like Hokkaido. The braking distance on these roads is greater than on dry roads. Accordingly, the Road Structure Act provides that, on slippery road, this distance be calculated in consideration of the decline in friction coefficient between tire and road surface.

On slippery roads it becomes more difficult for vehicles to accelerate and decelerate. Accordingly, calculation of PSD on such roads should consider the decline in friction coefficient. However, the Road Structure Act does not provide for such consideration. Furthermore, aborting of overtaking caused by the perception error of driver should be analyzed comprehensively on a road of two opposing lanes.

This study developed an overtaking model for slippery roads. The vehicle acceleration is calculated using both the friction coefficient between tire and road surface and the driving performance curve. The vehicle length, the reaction time of driver and the ascent slope are incorporated into the model. Under the supposition that there is perception error of driver regarding the speed of oncoming vehicle and the PSD, a model of aborting overtaking also is developed, which defines the safe distance to abort. The ratio of the safe distance to abort to the PSD is defined as the aborting safety ratio. The model analyzes aborting.

3. Overtaking model (2)

・Maximum acceleration of vehicle

When the driving force of vehicle T exceeds the driving resistance R, i.e. when $T-R>0$, the vehicle accelerates. In this case, the maximal acceleration a_{MAX} [m/s^2] is calculated by Eq. 1.

$$a_{MAX} = g \cos\theta \,(T - R)/(W + \Delta W) \quad [\mathrm{m/s^2}] \qquad 1$$

where W, ΔW, g and θ indicate the weight of vehicle, the weight of vehicle's wheel assembly (tire, wheel, axle), the acceleration due to gravity and the ascent slope (i%), respectively. The maximum acceleration a_{SUP} [m/s^2] is calculated by Eq. 2, because slipping arises in the case of $T-R>\mu_t W_R$.

$$a_{SUP} = g \cos\theta \;\mu_t W_R/(W+ \Delta W) \quad [\mathrm{m/s^2}] \qquad 2$$

where μ_t and W_R indicate the friction coefficient between tire and road surface and the partial weight of drive wheel. When the ascent slope is gentle, it can be supposed that $g \cos\theta \fallingdotseq g$, a_{MAX} and a_{SUP} are approximated by Eq. 3 and Eq. 4, respectively.

$$a_{MAX} = g\,(T - R)/(W + \Delta W) \quad [\mathrm{m/s^2}] \qquad 3$$

$$a_{SUP} = g\,\mu_t W_R/(W+ \Delta W) \quad [\mathrm{m/s^2}] \qquad 4$$

It is supposed that $\Delta W/W$=0.08, after the fashion of Japanese Industrial Standards (JIS). Accordingly, the maximal acceleration considering the friction coefficient between tire and road surface a_{max} [m/s^2] is calculated by Eq. 5.

$$a_{max}=min(a_{MAX}, a_{SUP}) \quad [\mathrm{m/s^2}] \qquad 5$$

The driving force of vehicle T is calculated by Eq. 6 (1).

$$T = \frac{270}{V_m} H \eta \{1.1 - 1.1(\frac{V}{V_m} - 0.7)^2\} \quad \text{[kg]} \qquad 6$$

where H [PS], V [km/h] and V_m [km/h] indicate the maximum power output of vehicle, the speed of vehicle and the speed of vehicle at maximum engine rev. These numbers are obtained from the driving performance curve of vehicle.

It is supposed that the driving resistance R consists of the air resistance, the rolling resistance and the resistance due to gravity. Eq. 7 expresses the driving resistance R.

$$R = W \sin\theta + W \cos\theta\ \mu_r + \lambda S V^2 \quad \text{[kg]} \qquad 7$$

Where μ_r, S and λ indicate the rolling resistance coefficient, forward surface area of vehicle and the air resistance coefficient, respectively. When the ascent slope is gentle it can be supposed that $\sin\theta \fallingdotseq i/100$ and $\cos\theta = 1.0$. R is approximated by Eq. 8.

$$R = (W/100)\, i + W\mu_r + \lambda S V^2 \qquad 8$$

・**Development of overtaking model**

The following five assumptions are made for the purpose of calculating PSD.

(1) At the start of overtaking, the overtaking vehicle is driving on a road of two opposing lanes at the same speed as the overtaken vehicle.
(2) The overtaking vehicle accelerates to the overtaking speed when it starts overtaking.
(3) The lengths of the overtaking vehicle and the overtaken vehicle should be introduced.
(4) The reaction time of driver should be introduced.
(5) The safety distance between vehicles should be introduced.

PSD comprises the following four distances and is expressed (in meters) by Eq. 9 (Fig. 1).

$$PSD = d_1 + d_2 + d_3 + d_4 \qquad 9$$

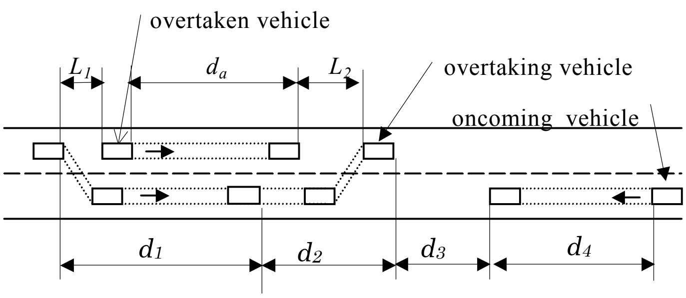

Figure 1. *PSD*

These distances are calculated based on the space headway of vehicles, because of the introduction of vehicle lengths.

d_1: The driving distance between the point where the overtaking driver judges that overtaking is possible and enters the opposing lane to accelerate, and the point where the speed of the overtaking vehicle reaches the overtaking speed.

The d_1 is calculated by Eq. 10.

$$d_1 = (1/3.6) V_0 (t_1 + \varepsilon_1) + (1/2) a t_1^2 \qquad 10$$

where V_0 [km/h], a [m/s^2], ε_1 [sec] and t_1 [sec] indicate the speed of overtaken vehicle, the average acceleration of overtaking vehicle, the reaction time of overtaking driver and the acceleration duration, respectively.

d_2: The driving distance between the point where the overtaking vehicle reaches overtaking speed and the point where the overtaking vehicle reenters the cruising lane at a safe distance from the overtaken vehicle. The d_2 is calculated by Eq. 10.

$$d_2=(1/3.6)Vt_2 \qquad 11$$

where V [km/h] and t_2 [sec] indicate the overtaking speed and the duration of overtaking speed, respectively.

d_3: The safe distance between the overtaking vehicle and the oncoming vehicle when the overtaking is completed. These distances are determined after the fashion of the Road Structure Act (Table 1) (1).

Table 1. Safe distance

speed of overtaking vehicle (km/h)	80	60	40
speed of overtaken vehicle (km/h)	65	45	30
safe distance (m)	60	40	25

d_4: The distance driven by the oncoming vehicle until the overtaking vehicle completes the overtaking. The d_4 is calculated by Eq. 12.

$$d_4=(1/3.6)V(t_1+t_2+\varepsilon_1) \qquad 12$$

In Fig. 1, L_1 and L_2 indicate the safe distance for stopping in our model. It is supposed that Eq. 13 expresses L_1 and L_2.

$$S_m = l + \frac{v}{3.6} + \frac{v^2}{2g\mu_t * 3.6^2}$$

$$L_1=L_2=S_m \quad \text{on dry surface}$$

$$L_1=L_2=\min(S_m, 70) \quad \text{on slippery surface} \qquad 13$$

where S_m [m], l [m] and v [km/h] indicate the safe space headway, the distance where the following vehicle can stop safely if the leading vehicle stops suddenly (provided by the Road Structure Act), and the speed of following vehicle, respectively (1). When L_1 and L_2 are considered in the model, t_2 and d_2 are calculated by Eq. 14 and Eq. 15, respectively.

$$t_2=3.6(d_a+L_1+L_2-d_1)/(V-V_0) \qquad 14$$

$$d_2=(1/3.6)Vt_2 \qquad 15$$

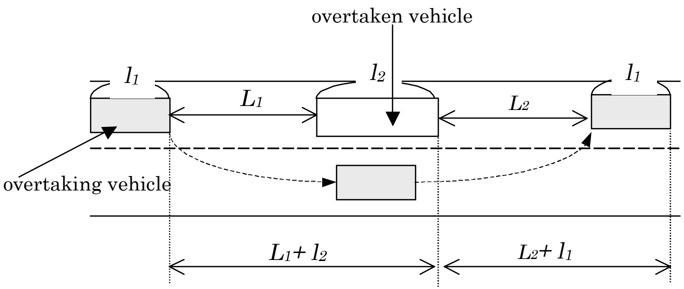

Figure 2. Real space headway considering the length of vehicles

where d_a indicates the distance that the overtaken vehicle drives during $t_1+t_2+\varepsilon_1$ and is expressed by Eq. 16.

$$d_a=(1/3.6)V_0\,(t_1+t_2+\varepsilon_1) \quad 16$$

Let l_1 [m] and l_2 [m] be the lengths of the overtaking vehicle and the overtaken vehicle, respectively. In this case, real space headway L_1* and L_2* are calculated by Eq. 17 and Eq. 18, respectively (Fig.2).

$$L_1{}^*=L_1+l_2 \quad 17$$

$$L_2{}^*=L_2+l_1 \quad 18$$

4. Model for aborting of overtaking (2)

・The maximal deceleration of vehicle

It is supposed that the maximal deceleration of vehicle d_{max} [m/s^2] is determined by the weight of vehicle, the friction coefficient between tire and road surface and the ascent slope. The d_{max} is calculated by Eq. 19 in this model.

$$d_{max}=\ (g\mu_t W\cos\theta+W\sin\theta)/(W+\Delta W)$$
$$\fallingdotseq (g\mu_t W\ +Wi/100)/(W+\Delta W) \quad [\text{m/s}^2] \quad 19$$

・Model of avoidance of overtaking

The following five assumptions are made.

(1) There is the perception error by overtaking driver: The *PSD* perceived by the overtaking driver is shorter than the real *PSD*, and the speed of the oncoming vehicle perceived by the overtaking driver is less than the real speed.
(2) The lengths of overtaking vehicle and overtaken vehicle should be introduced.
(3) The reaction time of driver should be introduced.
(4) The safety distance between vehicles should be introduced
(5) The minimum speed of the overtaking vehicle should be introduced.

Consider the case of the overtaking driver beginning to abort t_a [sec] after starting overtaking. It is supposed that the reaction time of the overtaking driver is ε_2 [sec] and the space headway between the overtaking vehicle and the overtaken vehicle after ($t_a+\varepsilon_2$) [sec] is x_a [m]. The x_a has positive value when the overtaken vehicle is in front of the overtaking vehicle. The x_a and the speed of the overtaking vehicle at the time V_a should be considered in two cases: that where the overtaking vehicle is accelerating (Fig. 3), and that where it is not accelerating (Fig. 4). Eq. 20 and Eq. 21 express x_a and V_a in each case, where V_{min} in Fig. 3 and Fig. 4 indicates the minimal speed of the overtaking vehicle and is supposed as 20 [km/h].

$$\text{when} \quad \varepsilon_1 < t_a + \varepsilon_2 \leqq \varepsilon_1 + t_1, \; x_a = L_1 + l_2 - 0.5a(t_a - \varepsilon_1 + \varepsilon_2)^2$$

$$V_a = V_0 + 3.6a(t_a - \varepsilon_1 + \varepsilon_2) \qquad 20$$

$$\text{when} \quad t_a + \varepsilon_2 > \varepsilon_1 + t_1, \; x_a = L_1 + l_2 - [0.5at_1^2 + \{(V - V_0)/3.6\}(t_a - \varepsilon_1 + \varepsilon_2 - t_1)]$$

$$V_a = V \qquad 21$$

The time t_c [sec] indicates the time interval between when the overtaking driver starts overtaking and when the space headway between the oncoming vehicle and the overtaking vehicle equals 0. Eq. 22 expresses t_c on the supposition that perception error regarding *PSD* and the speed of oncoming vehicle are Δd [m] and Δv [km/h], respectively (Fig. 5).

$$t_c = (PSD - \Delta d - L_1 - l_2)/\{(V_0 + V + \Delta v)/3.6\} \qquad 20$$

It is supposed that aborting should be finished by the time the space headway between the oncoming vehicle and the overtaken vehicle equals 0. That is, the time interval of $t_c - (t_a + \varepsilon_2)$ is allowed for the overtaking driver to finish aborting. The time interval of *adt* [sec] that is required for the overtaking vehicle to decelerate to the minimal speed is calculated by Eq. 23.

$$adt = (V_a - V_{min})/(3.6a_d) \qquad 23$$

where a_d indicates the deceleration of the overtaking vehicle. The d_f and d_s indicate the driving

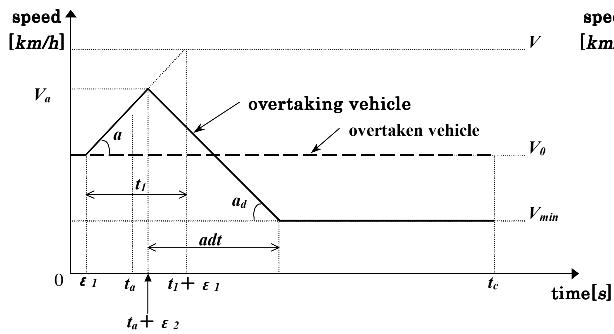

Figure 3. Time-speed relationship of aborting when the overtaking vehicle accelerates

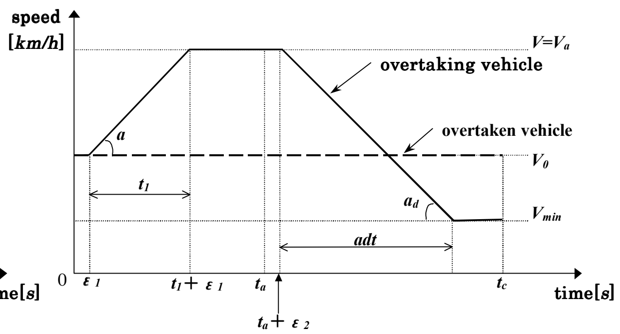

Figure 4. Time-speed relationship of aborting when the overtaking vehicle drives at the overtaking speed

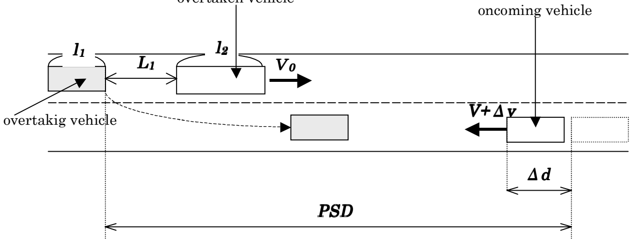

Figure 5. Relationship between the oncoming and the overtaking vehicle

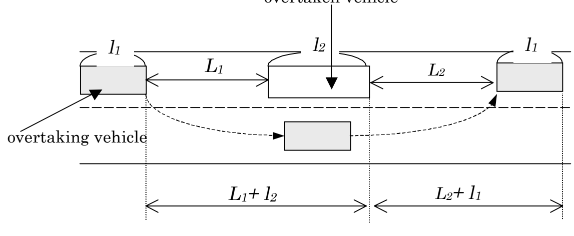

Figure 6. The relative distance when aborting finishes

distance of the overtaking vehicle and that of the overtaken vehicle during time interval $t_c-(t_a+\varepsilon_2)$, respectively. These distances should be considered in two cases: that where the overtaking vehicle needs to decelerate to the minimum speed, and that where the overtaking vehicle need not decelerate to the minimum speed. These are calculated by Eq. 24 and Eq. 25, respectively.

when $t_c-(t_a+\varepsilon_2)>adt$ $d_f=\{(V_a-3.6a_d\cdot adt)/3.6\}(t_c-t_a-\varepsilon_2)+0.5a_d\cdot adt^2$

$$d_s=(V_0/3.6)(t_c-t_a-\varepsilon_2) \quad 24$$

when $t_c-(t_a+\varepsilon_2)\leqq adt$ $d_f=\{(V_a-3.6a_d(t_c-t_a-\varepsilon_2))/3.6\}(t_c-t_a-\varepsilon_2)+0.5a_d\ (t_c-t_a-\varepsilon_2)^2$

$$d_s=(V_0/3.6)(t_c-t_a-\varepsilon_2) \quad 25$$

In both cases, the condition for safely finishing the aborting considering the vehicle lengths is expressed by Eq. 26 (Fig. 6).

$$x_a+(d_s-d_f)-(L_3+l_2)\geqq 0 \quad 26$$

where L_3 indicates the safe distance expressed by Eq. 27.

$$L_3=min(L_1, 70) \quad 27$$

The t_a^{max} indicates the maximal time that satisfies Eq. 24. We define the safe distance to abort as D_a [m] and the aborting safety ratio as D_R [%]. D_a indicates the driving distance of the overtaking vehicle during time interval $t_a^{max}+\varepsilon_2$. Eq. 28 and Eq. 29 yield D_R and D_a, respectively.

$$D_R=D_a/PSD \quad 28$$

when $t_a^{max}+\varepsilon_2\leqq t_1+\varepsilon_1$, $D_a=(V_0/3.6)(t_a^{max}+\varepsilon_2)+0.5a(t_a^{max}-\varepsilon_1+\varepsilon_2)^2$

when $t_a^{max}+\varepsilon_2> t_1+\varepsilon_1$, $D_a=(V_0/3.6)(t_1+\varepsilon_1)+0.5a(t_1-\varepsilon_1)^2$

$$+(V/3.6)(t_a^{max}+\varepsilon_2-t_1-\varepsilon_1) \quad 29$$

D_R indicates that the smaller D_R becomes, the more difficult it becomes to abort.

5. Computer simulation

・Settings

Computer simulations were conducted under the three conditions of road surface: dry, snowy and icy. Their friction coefficients are shown in Table 2 (2). Table 3 shows the values used to calculate the driving resistance of overtaking vehicle.

Table 2. Friction coefficient between tire and road surface

condition of surface	dry	snowy	icy
friction coefficient	0.7	0.3	0.2

Table 3. Values used to calculate driving resistance

weight of vehicle (t)	coefficient of rolling resistance	coefficient of air resistance	forward surface area of vehicle (m^2)
1.235	0.013	0.0017	1.97

Table 4 and Table 5 show the maximums of acceleration and deceleration of the overtaking vehicle calculated by Eq. 5 and Eq. 19, respectively, using the values in Table 2 and Table 3. The maximum decelerations of the overtaking vehicle on dry surface are supposed to be 60% of the value calculated by Eq. 19, to provide a safety margin. These accelerations and decelerations were used in computer simulation.

Table 4. Maximum acceleration of overtaking vehicle [m/s^2]

ascent slope	condition of surface	change in speed of overtaking vehicle $V_0 \rightarrow V_a$ (km/h)		
		30→40	45→60	65→80
0%	dry	1.730	1.889	1.135
	snowy	1.342	1.342	1.135
	icy	0.895	0.895	0.895
3%	dry	1.462	1.622	0.867
	snowy	1.342	1.342	0.867
	icy	0.895	0.895	0.867
6%	dry	1.195	1.354	0.600
	snowy	1.195	1.328	0.600
	icy	0.895	0.895	0.600

Table 5. Maximum deceleration of overtaking vehicle [m/s^2]

ascent slope	dry	snowy	icy
0%	3.74	1.60	1.07
3%	3.76	1.62	1.09
6%	3.77	1.64	1.10

Table 6 shows the supposed vehicle lengths and perception errors.

Table 6. Other settings

reaction time	vehicle length [m]		perception error	
: ε_1, ε_2[s]	compact car	full-size car	Δd	Δv
0.2	4.0	10.0	0.1*PSD*	0.1*V*

・**Results**

Table 7 and Table 8 show the *PSD* when the ascent slope is 0% for the case of overtaken compact vehicle and overtaken full-size vehicle, respectively. Table 9 and Table 10 show the respective *PSD* and D_R under the supposition that the overtaken vehicle is compact car and full-size car. The upper box and lower box for each surface condition in Table 10 indicate the

Table 7. PSD (both vehicles are compact cars)

	ascent slope: 0%								
	dry (μ =0.7)			snowy (μ =0.3)			icy (μ =0.2)		
V (km/h)	80	60	40	80	60	40	80	60	40
V0 (km/h)	65	45	30	65	45	30	65	45	30
a (m/s2)	1.135	1.889	1.73	1.135	1.342	1.342	0.895	0.895	0.895
t1+ ε 1 (sec)	3.9	2.4	1.8	3.9	3.3	2.3	4.9	4.9	3.3
t2 (sec)	20.2	12.3	11.7	33.7	19.1	16.4	33.2	24.7	20.1
t1+t2 + ε 1(sec)	24.0	14.7	13.5	37.6	22.4	18.6	38.1	29.6	23.4
L1* (m)	46	28	17	74	43	24	74	56	30
d1 (m)	78	35	17	78	48	22	97	70	32
d2 (m)	448	205	130	749	319	182	738	412	223
L2* (m)	46	28	17	74	43	24	74	56	30
d3 (m)	60	40	25	60	40	25	60	40	25
d4 (m)	534	245	150	835	374	207	846	493	260
PSD=d1+d2+d3+d4 (m)	1119	524	323	1721	780	435	1740	1015	540

Table 8. PSD (overtaken vehicle is full-size car)

	ascent slope: 0%								
	dry (μ =0.7)			snowy (μ =0.3)			icy (μ =0.2)		
V (km/h)	80	60	40	80	60	40	80	60	40
V0 (km/h)	65	45	30	65	45	30	65	45	30
a (m/s2)	1.135	1.889	1.73	1.135	1.342	1.342	0.895	0.895	0.895
t1+ ε 1 (sec)	3.9	2.4	1.8	3.9	3.3	2.3	4.9	4.9	3.3
t2 (sec)	21.6	13.7	13.9	35.1	20.6	18.5	34.6	26.2	22.2
t1+t2 + ε 1(sec)	25.5	16.1	15.7	39.0	23.9	20.8	39.5	31.0	25.5
L1* (m)	52	34	23	80	49	30	80	62	36
d1 (m)	78	35	17	78	48	22	97	70	32
d2 (m)	480	229	154	781	343	206	770	436	247
L2* (m)	46	26	17	74	43	24	74	56	30
d3 (m)	60	40	25	60	40	25	60	40	25
d4 (m)	566	269	174	867	398	231	878	517	284
PSD=d1+d2+d3+d4 (m)	1183	572	371	1785	828	483	1804	1063	588

Table 9. PSD and D_R (both vehicles are compact cars)

ascent slope	surface	changes of speed of the overtaking vehicle (km/h)		
		30-40	45-60	65-80
0%	dry	323	524	1119
	dry	21.0%	24.3%	29.4%
	snowy	435	780	1721
	snowy	19.1%	21.5%	27.0%
	icy	540	1016	1741
	icy	18.3%	20.4%	23.8%
3%	dry	326	530	1142
	dry	21.2%	24.4%	29.7%
	snowy	435	780	1744
	snowy	19.1%	21.6%	27.2%
	icy	540	1016	1744
	icy	18.4%	20.6%	24.0%
6%	dry	330	537	1185
	dry	21.4%	24.6%	30.0%
	snowy	438	781	1787
	snowy	19.3%	21.7%	27.6%
	icy	540	1016	1787
	icy	18.4%	20.7%	24.5%

Table 10. *PSD* and D_R (overtaken vehicle is full-size car)

ascent slope	surface	changes of speed of the overtaking vehicle (km/h)		
		30-40	45-60	65-80
0%	dry	371	572	1183
	dry	21.0%	24.4%	29.6%
	snowy	483	828	1785
	snowy	19.3%	21.8%	27.2%
	icy	588	1064	1805
	icy	18.5%	20.7%	24.1%
3%	dry	374	578	1206
	dry	21.2%	24.6%	29.8%
	snowy	483	828	1808
	snowy	19.3%	21.8%	27.4%
	icy	588	1064	1808
	icy	18.6%	20.9%	24.3%
6%	dry	378	585	1249
	dry	21.3%	24.7%	30.1%
	snowy	486	829	1851
	snowy	19.4%	21.9%	27.7%
	icy	588	1064	1851
	icy	18.6%	20.9%	24.7%

Table 11. PSD and D_R (difference between full-size car and compact car)

ascent slope	surface	changes of speed of the overtaking vehicle (km/h)		
		30-40	45-60	65-80
0%	dry	48	48	64
	dry	0.0%	0.1%	0.2%
	snowy	48	48	64
	snowy	0.2%	0.3%	0.2%
	icy	48	48	64
	icy	0.2%	0.3%	0.3%
3%	dry	48	48	64
	dry	0.0%	0.2%	0.1%
	snowy	48	48	64
	snowy	0.2%	0.2%	0.2%
	icy	48	48	64
	icy	0.2%	0.3%	0.3%
6%	dry	48	48	64
	dry	-0.1%	0.1%	0.1%
	snowy	48	48	64
	snowy	0.1%	0.2%	0.1%
	icy	48	48	64
	icy	0.2%	0.2%	0.2%

difference of *PSD* and D_R, respectively. Table 11 shows the differences between values in Table 9 and Table 10 (Table 10－Table 9).

According to Table 11, the effect of vehicle length on *PSD* is large. When the speed changes of the overtaking vehicle are 30→45 [km/h], 45→60 [km/h] and 65→80 [km/h], then the differences in *PSD* are 48 [m], 48 [m] and 64 [m], and these values are not affected by the surface condition nor by the ascent slope . This indicates the difficulty of overtaking full-sized cars. In contrast, the effect of vehicle length on D_R is small. That is, D_R is little affected by the speed of the overtaking vehicle, the condition of surface and the ascent slope. We know this from Eq. 17, Eq. 18 and Eq. 26. In calculating the *PSD*, the different vehicle lengths affect the space headway (Eq. 17 and Eq. 18); however, this effect is canceled out by the space headway when aborting is finished (Eq. 26). As mentioned above, the vehicle length affects *PSD*, but this effect is a constant determined by the speed of the overtaking vehicle. The vehicle length has little effect on D_R. For this reason we consider compact cars in the following analysis.

The effect of the speed of overtaking vehicle on *PSD* is large, according to Table 9. This owes mostly to the safe distance between vehicles. The effect of the speed of overtaking vehicle on D_R is large, too: The greater is the overtaking speed, the larger is D_R. This does not mean that the faster is the overtaking speed, the easier it is to abort. Instead, the faster is the overtaking speed, the greater is *PSD*. However, because deceleration is greater than acceleration, the driving distance required for the overtaking vehicle to finish aborting becomes short compared with *PSD*.

The surface condition affects both *PSD* and D_R according to Table 9. This indicates that both overtaking and aborting become more difficult on slippery surface, mainly as a result of the decline in acceleration and deceleration of the overtaking vehicle.

The ascent slope affects both *PSD* and D_R. However, the differences are not large, according to Table 9. These results are explained by considering that acceleration and deceleration of the overtaking vehicle change according to the ascent slope; however the differences in the acceleration duration and the deceleration duration of overtaking vehicle are not large enough to generate significant differences of *PSD* and D_R.

6. Conclusions

This study developed a model of overtaking considering slippery road. Acceleration was calculated using both the friction coefficient between tire and road surface and the driving performance curve. The vehicle length, the reaction time of driver and the ascent slope were incorporated into the model. Under the supposition that there is perception error of driver regarding the speed of oncoming vehicle and *PSD*, a model of overtaking aborting also was developed, which defined the safe distance to abort. The ratio of the safe distance to abort to the *PSD* was defined as the aborting safety ratio.

The following conclusions were obtained.

1) The length of overtaken vehicle, the overtaking vehicle's speed and the friction coefficient between tire and road surface have a large effect on the *PSD*, whereas the ascent slope has no such effect.
2) The overtaking vehicle's speed and the friction coefficient between tire and road surface have a large effect on the safe ratio to abort, whereas the ascent slope and the length of vehicle have no such effect.

References

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