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Influence of Pavement Friction on the Initial Velocity of Vehicle in Highways Accidents

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ABSTRACT

The objective of this study is to determine the influence of pavement friction on the initial velocityof the vehicle on highways. Regression analysis on the results of these variables was conducted. Excellent correlation coefficient was found for therelationship at α = 0.05 significance level. The influence of Pavement Friction on the Initial Velocity is shown by a quadratic equation (Initial velocity = -0.37 Pavement Friction ^{2} + 8.04 Pavement Friction + 80) with R = 1.

KEYWORDS: *Accident Reconstruction, Chain Accident, Initial Velocity, Pavement Friction, Regression Analysis.*

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I. INTRODUCTION

Accident reconstructing engineering is the planning, surveying, measuring, investigating, analyzing, and report making process on the intricate engineering details of how accidents occurred. The analysis and conclusions are based on the extensive application of fundamental principles of physics and engineering including Newton's Laws of Motion [1] and First Law of Thermodynamics [2]. The first law of thermodynamics when applied to accidents states that the total energy before and after the accident will be the same. The input variables include roadway, vehicle, driver and environmental conditions. Accident reconstruction engineering studies can be utilized by the industry, city and state governments for modifying the structural facilities such as roads. The modifications may include obtaining improved friction factors, increased number of lanes and lane widths and better site distances. Vehicle manufacturers use the results of the studies for developing better designs of vehicles. Some of the recent vehicles may use event data recorder containing information on the speed of the vehicle before and at the time of the accident. Some manufacturers, such as GM and Ford, allow downloading the information from these boxes after an accident [3]. The results of the accident reconstruction studies are also used for producing better navigations aids to assist the drivers.In this study the guidelines of Accreditation Commission for Traffic Accident Reconstruction (ACTAR)[4] are used. There are many research studies on the application of accident reconstruction engineering principles. One of the most important one is that of Hurt's [5]. Hurt found that motorcyclists needed to develop their capabilities on controlling skids and proper use of helmets significantly reduced head injuries. Hurt further found that out of all the turning movements, the left turners were the most involved ones in the accidents while turning in front of the oncoming motorcycles.

II. SCOPE OF THE STUDY

The study is limited to the accidents caused by negligent drivers of cars hitting the parked cars.All the accidents caused elastic deformations only[6,7]. There are no significant plastic deformations [8].

III. METHODOLOGY

C1 was travelling at certain speed, feet per second and skidded s feet before hitting C2. One half of the energy was transmitted from C1 to C2. C2 was travelling at certain speed, feet per second before the accident. The weight ratios of C1/C2 are noted.

The following equations were used.

1. The total product of mass and velocity of Car1 is equal to that of Car 2 as shown in the following equation.
   $m_2u_2 = m_1 u_2$ (2)
   Where, $_2$= mass of vehicle C2 and u_2 is the velocity of C2. m_1= mass of C1 and u_1 = velocity of C1.
2. Deceleration was calculated by using Equation1.
   Final velocity was calculated by the following equation.
   $$u = \sqrt{v^2 - 2 * a * s} \quad (3)$$

Where, u= initial velocity of the vehicle, ft/sec
v=final velocity, ft/sec
a= deceleration of the vehicle, ft/sec^2
s= skidded distance, feet

IV. RESULTS AND DISCUSSION

The following assumptions were made in this study

1. The energy lost in sound produced by the accident is negligible.
2. The energy lost in causing the slight angular movement of the vehicle is negligible.

Professional engineering principles allow the application of the above two assumptions in the appropriate engineering calculations.

Table I shows the Engineering Calculations for Mixed Variables for Case 1 through Case 5 for Determininig the Initial Velocity while Table II gives the Engineering Calculations for Mixed Variables for Case 6 thorugh 7 for Determininig the Initial Velocity.

Engineering Calculations for Case 1 through Case 5; Case 6 through Case 10; Case 11 through Case 15, and Case 16 through Case 20 for Determininig the influence of Pavement Friction on the Initial Velocity are given in Tables III, IV, V, and VI respectively.

The following regression relationship was found with statistically significant correlation coefficient for predicting the performance of the engineering variables. The relationship was significant at $\alpha = 0.05$ significance level [9,10,11].

Fig. 1 shows the influence of Pavement Friction on the Initial Velocity. This relationship is described by a quadratic equation (Initial velocity = -0.37 Pavement Friction ^{2} + 8.04 Pavement Friction + 80) with R = 1.

Table I. Engineering Calculations for Mixed Variables for Case 1 through Case 5 for Determininig the Initial Velocity.

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Car2					
Weight, pounds	2500	2300	2200	2800	3100
Initial Velocity, ft/sec	30	35	25	30	30
Final Velocity, ft/sec	40	45	35	45	50
Car1					
Final velocity after the accident, ft/sec	40	45	35	45	50
Weight, Pounds	2500	2300	2200	2800	3100
Weight Ratio, C2/C1	1	1	1	1	1
Final Velocity before the accident, ft/sec	50	55	45	60	70
Skidded Distance, ft	25	10	24	22	18
Pavement Friction	0.28	0.20	0.10	0.12	0.18
Acceleration, ft/sec^2	9.02	6.44	3.22	3.86	5.80
Initial Velocity, ft/sec	54.32	56.16	46.69	61.40	71.47

Table II. Engineering Calculations for Mixed Variables for Case 6 through Case 7 for Determininig the Initial Velocity.

	Case 6	**Case 7**
Car2		
Weight, pounds	1500	1600
Initial Velocity, ft/sec	40	40
Final Velocity, ft/sec	60	55
Car1		
Final velocity after the accident, ft/sec	60	55
Weight, Pounds	1500	1600
Weight Ratio, C2/C1	1	1
Final Velocity before the	80	70

accident, ft/sec		
Skidded Distance, ft	28	16
Pavement Friction	0.26	0.22
Acceleration, ft/sec^2	8.37	7.08
Initial Velocity, ft/sec	82.88	71.60

Table III. Engineering Calculationsfor Case 1 through Case 5 for Determininig the Relationship between Pavement Fraction and Initial Velocity.

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Car2					
Weight, pounds	2000	2000	2000	2000	2000
Initial Velocity, ft/sec	40	40	40	40	40
Final Velocity, ft/sec	60	60	60	60	60
Car1					
Final velocity after the accident, ft/sec	60	60	60	60	60
Weight, Pounds	2000	2000	2000	2000	2000
Weight Ratio, C2/C1	1	1	1	1	1
Final Velocity before the accident, ft/sec	80	80	80	80	80
Skidded Distance, ft	20	20	20	20	20
Pavement Friction	0.10	0.12	0.14	0.16	0.18
Acceleration, ft/sec^2	3.22	3.86	4.51	5.15	5.80
Initial Velocity, ft/sec	80.80	80.96	81.12	81.28	81.44

Table IV. Engineering Calculationsfor Case 6 through Case 10 for Determininig the Relationship between Pavement Fraction and Initial Velocity.

	Case 6	**Case 7**	**Case 8**	**Case 9**	**Case 10**
Car2					
Weight, pounds	2000	2000	2000	2000	2000
Initial Velocity, ft/sec	40	40	40	40	40
Final Velocity, ft/sec	60	60	60	60	60
Car1					
Final velocity after the accident, ft/sec	60	60	60	60	60
Weight, Pounds	2000	2000	2000	2000	2000
Weight Ratio, C2/C1	1	1	1	1	1
Final Velocity before the accident, ft/sec	80	80	80	80	80
Skidded Distance, ft	20	20	20	20	20
Pavement Friction	0.20	0.22	0.24	0.26	0.28
Acceleration, ft/sec^2	6.44	7.08	7.73	8.37	9.02
Initial Velocity, ft/sec	81.59	81.75	81.91	82.07	82.22

Table V. Engineering Calculations for Case 11 through Case 15 for Determininig the Relationship between Pavement Fraction and Initial Velocity.

	Case 11	**Case 12**	**Case 13**	**Case 14**	**Case 15**
Car2					
Weight, pounds	2000	2000	2000	2000	2000
Initial Velocity, ft/sec	40	40	40	40	40
Final Velocity, ft/sec	60	60	60	60	60
Car1					
Final velocity after the accident, ft/sec	60	60	60	60	60
Weight, Pounds	2000	2000	2000	2000	2000
Weight Ratio, C2/C1	1	1	1	1	1
Final Velocity before the accident, ft/sec	80	80	80	80	80
Skidded Distance, ft	20	20	20	20	20
Pavement Friction	0.30	0.32	0.34	0.36	0.38
Acceleration, ft/sec^2	9.66	10.30	10.95	11.59	12.24
Initial Velocity, ft/sec	82.38	82.54	82.69	82.85	83.00

Table VI. Engineering Calculations for Case 16 through Case 20 for Determininig the Relationship between Pavement Fraction and Initial Velocity.

	Case 16	**Case 17**	**Case 18**	**Case 19**	**Case 20**
Car2					
Weight, pounds	2000	2000	2000	2000	2000
Initial Velocity, ft/sec	40	40	40	40	40
Final Velocity, ft/sec	60	60	60	60	60
Car1					
Final velocity after the accident, ft/sec	60	60	60	60	60
Weight, Pounds	2000	2000	2000	2000	2000
Weight Ratio, C2/C1	1	1	1	1	1
Final Velocity before the accident, ft/sec	80	80	80	80	80
Skidded Distance, ft	20	20	20	20	20
Pavement Friction	0.40	0.42	0.44	0.46	0.50
Acceleration, ft/sec^2	12.88	13.52	14.17	14.81	16.10
Initial Velocity, ft/sec	83.16	83.31	83.47	83.62	83.93

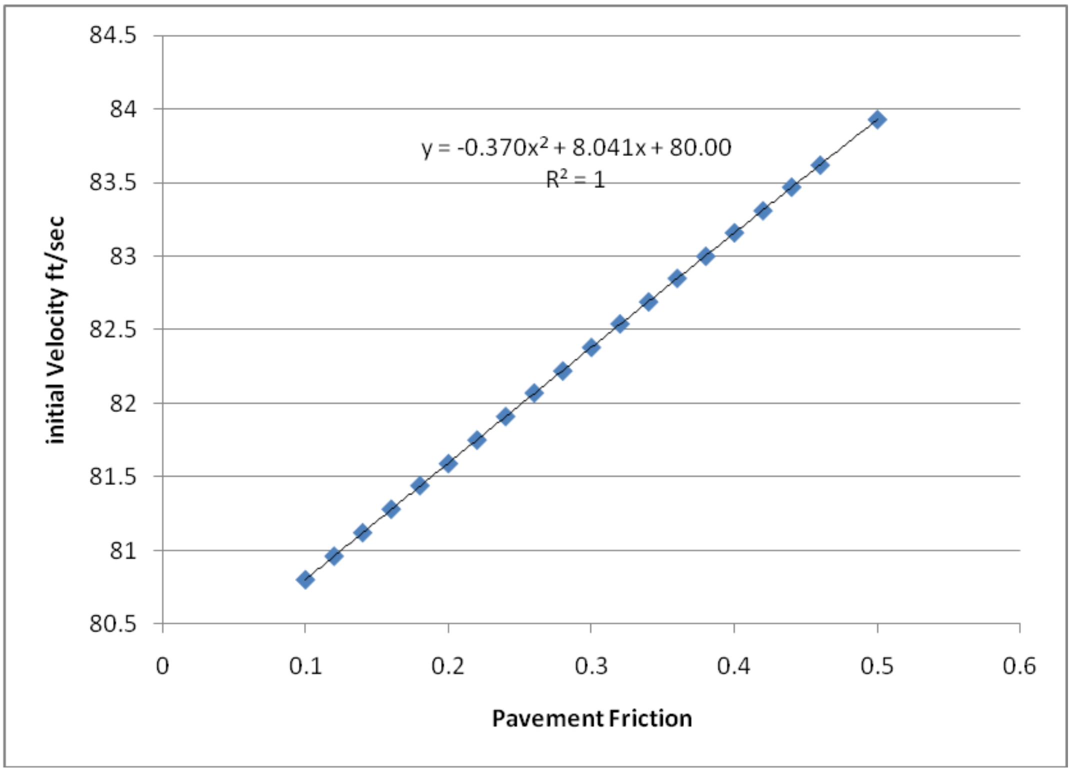

Figure 1 Influence of Pavement Friction on the Initial Velocity

V. CONCLUSIONS

The following regression relationshipwas found with statistically significant correlation coefficient for predicting the performance of the engineering variables.The influence of Pavement Friction on the Initial Velocity is shown by a quadratic equation (Initial velocity = -0.37 Pavement Friction ^{2} + 8.04 Pavement Friction + 80) with R = 1.

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