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Skidded Distance V. Initial Velocity of Vehicle in Chain Accidents on Highways

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ABSTRACT

The objective of this study is to determine the influence of skidded distance on the initial velocity of the first vehicle in a chain accident on highways involving three vehicles. Regression analysis on the results of these variables was conducted. Excellent correlation coefficient was found for the relationship at α = 0.05 significance level. The influence of Skidded Distance on the Initial Velocity is shown by a quadratic equation (Initial velocity = -5E-05 Skidded distance ^{2} -0.05 Skidded Distance + 113.21) with R = 1.

KEYWORDS: *Accident Reconstruction, Chain Accident, Initial Velocity, Regression Analysis, Skidded Distance.*

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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 [6,7,8]. All the accidents caused elastic deformations only[9,10]. There are no significant plastic deformations [11,12].

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. C2 picked up the energy from C1 and hit C3. The weight ratios of C1/C2 and C2/C3 are noted. Again one half of the energy of C2 was transmitted to C3.

The following equations were used.

1. The total product of mass and velocity of Car2 is equal to that of Car 3 as shown in the following equation.
   $M_2 u_2 = m_3 u_3$ (2)
   Where, m_2= mass of vehicle C2 and u_2 is the velocity of C2. M_3= mass of C3 and u_3 = velocity of C3.
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 Determinig the Initial Velocity while Table II gives the Engineering Calculations for Mixed Variables for Case 6 thorugh 10 for Determinig the Initial Velocity. Engineering Calculations for Case 1 through Case 5; Case 6 through Case 10; and Case 11 through Case 15 for Determinig the influence of Skidded Distance on the Initial Velocity are given in Tables III, IV, and V 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 [13,14,15]. Fig. 1 shows the influence of Skidded Distance on the Initial Velocity. This relationship is described by a quadratic equation (Initial velocity = -5E-05 Skidded distance ^{2} -0.05 Skidded Distance + 113.21) with R = 1.

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

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Car3					
Velocity after the second accident, ft/sec	110.78	93.60	117.11	105.28	98.01
Weight Ratio, C3/C2	1.28	1.25	1.23	1.21	1.19
Velocity before the second accident, ft/sec	75	55	72	60	58
Weight, pounds	2300	2500	2700	2900	3100
Car2					
Weight, Pounds	1800	2000	2200	2400	2600
Weight Ratio, C2/C1	0.64	0.61	0.59	0.62	0.65
Velocity after the first accident, ft/sec	91.43	96.50	110.71	109.43	95.40
Velocity before the first accident, ft/sec	38	36	45	42	48
Car1					
Weight, pounds	2800	3300	3700	3900	4000
Final Velocity (after skidding, and before first accident) ft/sec	68.70	73.33	78.15	82.99	61.62
Skidded Distance, ft	8	11	13	15	19
Pavement Friction	0.35	0.35	0.35	0.35	0.35
Deceleration, ft/sec^2	11.27	11.27	11.27	11.27	11.27
Initial Velocity, ft/sec	70	75	80	85	65

Table II. Engineering Calculations for Mixed Variables for Case 6 through Case 10 for Determinig the Initial Velocity.

	Case 6	**Case 7**	**Case 8**	**Case 9**	**Case 10**
Car3					
Velocity after the second accident, ft/sec	111.11	105.49	113.48	109.55	105.02
Weight Ratio, C3/C2	1.18	1.17	1.16	1.15	1.08
Velocity before the second accident, ft/sec	70	62	66	68	52
Weight, pounds	3300	3500	3700	3900	4100
Car2					
Weight, Pounds	2800	3000	3200	3400	3800
Weight Ratio, C2/C1	0.68	0.70	0.67	0.68	0.73

Velocity after the first accident, ft/sec	96.91	101.48	109.81	95.32	114.41
Velocity before the first accident, ft/sec	50	53	55	39	58
Car1					
Weight, pounds	4100	4300	4800	5000	5200
Final Velocity (after skidding, and before first accident) ft/sec	64.07	67.64	73.08	76.60	82.45
Skidded Distance, ft	23	27	33	38	42
Pavement Friction	0.35	0.35	0.35	0.35	0.35
Deceleration, ft/sec^2	11.27	11.27	11.27	11.27	11.27
Initial Velocity, ft/sec	68	72	78	82	88

Table III. Engineering Calculations for Case 1 through Case 5 for Determininig the Relationship between Skided Distance and Initial Velocity.

	Case 1	**Case 2**	**Case 3**	**Case 4**	**Case 5**
Car3					
Velocity after the second accident, ft/sec	112.71	112.45	112.20	112.09	111.88
Weight Ratio, C3/C2	1.00	1.00	1.00	1.00	1.00
Velocity before the second accident, ft/sec	60	60	60	60	60
Weight, pounds	2100	2100	2100	2100	2100
Car2					
Weight, Pounds	2100	2100	2100	2100	2100
Weight Ratio, C2/C1	0.68	0.68	0.68	0.68	0.68
Velocity after the first accident, ft/sec	105.42	104.91	104.39	104.18	103.77
Velocity before the first accident, ft/sec	40	40	40	40	40
Car1					
Weight, pounds	3100	3100	3100	3100	3100
Final Velocity (after skidding, and before first accident) ft/sec	88.63	87.94	87.24	86.96	86.39
Skidded Distance, ft	10	15	20	22	26
Pavement Friction	0.38	0.38	0.38	0.38	0.38
Deceleration, ft/sec^2	12.24	12.24	12.24	12.24	12.24
Initial Velocity, ft/sec	90	90	90	90	90

Table IV. Engineering Calculations for Case 6 through Case 10 for Determininig the Relationship between Skidded Distance and Initial Velocity.

	Case 6	**Case 7**	**Case 8**	**Case 9**	**Case 10**
Car3					
Velocity after the second accident, ft/sec	111.78	11.67	111.41	111.14	110.87
Weight Ratio, C3/C2	1.00	1.00	1.00	1.00	1.00
Velocity before the second accident, ft/sec	60	60	60	60	60
Weight, pounds	2100	2100	2100	2100	2100
Car2					
Weight, Pounds	2100	2100	2100	2100	2100
Weight Ratio, C2/C1	0.68	0.68	0.68	0.68	0.68
Velocity after the first accident, ft/sec	103.56	103.35	102.82	102.29	101.75
Velocity before the first accident, ft/sec	40	40	40	40	40
Car1					
Weight, pounds	3100	3100	3100	3100	3100
Final Velocity (after skidding, and before first accident) ft/sec	86.11	85.82	85.11	84.39	83.66
Skidded Distance, ft	28	30	35	40	45
Pavement Friction	0.38	0.38	0.38	0.38	0.38
Deceleration, ft/sec^2	12.24	12.24	12.24	12.24	12.24
Initial Velocity, ft/sec	90	90	90	90	90

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

	Case 11	**Case 12**	**Case 13**	**Case 14**	**Case 15**
Car3					
Velocity after the second accident, ft/sec	110.60	110.33	110.05	109.77	109.49
Weight Ratio, C3/C2	1.00	1.00	1.00	1.00	1.00
Velocity before the second accident, ft/sec	60	60	60	60	60
Weight, pounds	2100	2100	2100	2100	2100
Car2					
Weight, Pounds	2100	2100	2100	2100	2100
Weight Ratio, C2/C1	0.68	0.68	0.68	0.68	0.68
Velocity after the first accident, ft/sec	101.21	100.66	100.11	99.55	98.99
Velocity before the first accident, ft/sec	40	40	40	40	40
Car1					
Weight, pounds	3100	3100	3100	3100	3100
Final Velocity (after skidding, and before first accident) ft/sec	82.92	82.18	81.44	80.68	79.92
Skidded Distance, ft	50	55	60	65	70
Pavement Friction	0.38	0.38	0.38	0.38	0.38
Deceleration, ft/sec^2	12.24	12.24	12.24	12.24	12.24
Initial Velocity, ft/sec	90	90	90	90	90

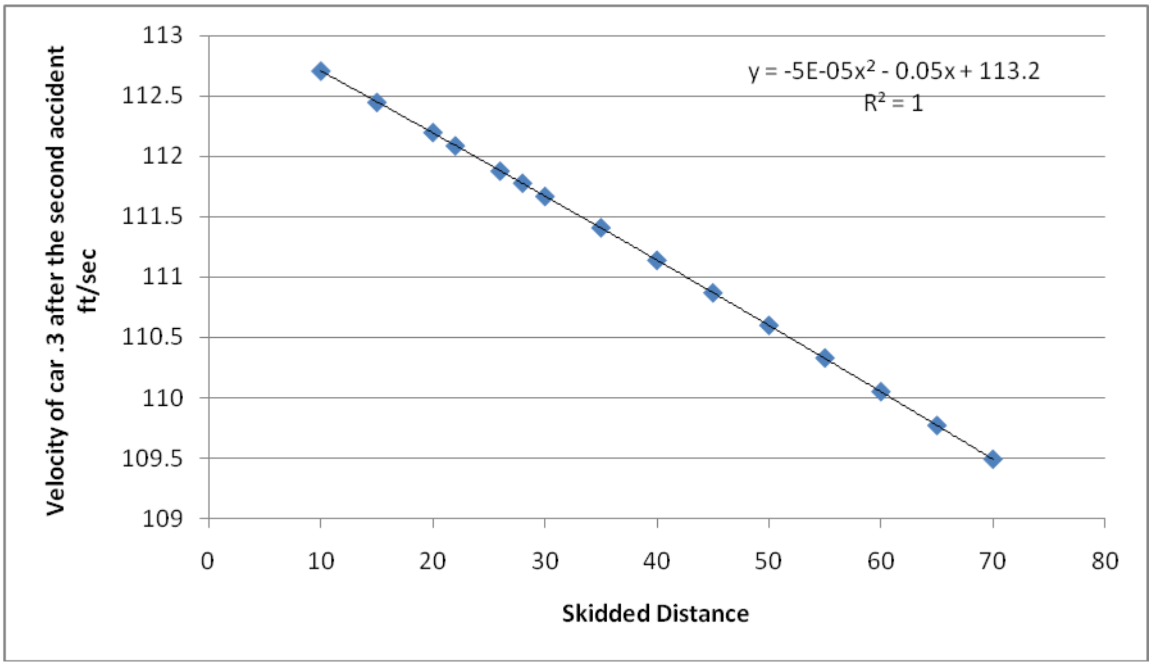

Figure 1 Influence of Skidded Distance on the Initial Velocity

V. CONCLUSIONS

The following regression relationship was found with statistically significant correlation coefficient for predicting the performance of the engineering variables. The influence of Skidded Distance on the Initial Velocity is shown by a quadratic equation (Initial velocity = -5E-05 Skidded distance ^{2}-0.05Skidded Distance + 113.21) with R = 1.

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REFERENCES

[1] Newton's Three Laws of Motion. http://csep10.phys.utk.edu/astr161/lect/history/newton3laws.html
[2] First Law of Thermodynamics. http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/firlaw.html
[3] Engber, D. The Ferrari That Split in Half. 2006. http://www.slate.com/articles/news_and_politics/explainer/2006/04/the_ferrari_that_split_in_half.html
[4] Accreditation Commission for Traffic Accident Reconstruction (ACTAR). http://www.actar.org/
[5] Hurt, H. Jr. AMA Motorcycle Hall of Fame. http://www.motorcyclemuseum.org/halloffame/detail.aspx?RacerID=398
[6] Brooks R. M.; Cetin M. Determination of the Influence of Vehicles Weight Ratio on the Initial Velocity Using the Accident Reconstruction Engineering Principles. International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 3, ISSN: 2250-2459, S. No: 159, March 2013, pp. 927-931.
[7] Brooks R. M.; Cetin M. Determination of the Influence of Pavement Friction on the Initial Velocity Using the Accident Reconstruction Engineering Principles. International Journal of Engineering Inventions, Volume 2, Issue 6, e-ISSN: 2278-7461, p-ISBN: 2319-6491, S. No: 9, April 2013, pp. 63-68.
[8] Brooks R. M.; Cetin M. Determination of the Influence of Skidded Distance on the Initial Velocity Using the Accident Reconstruction Engineering Principles. International Journal of Research and Reviews in Applied Sciences, Volume 15, Issue 3, EISSN: 2076-7366, ISSN: 2076-734X, S. No: 3, June 2013, pp. 225-229.
[9] Brooks R. M.; Cetin M. Pavement Friction V. Initial Velocity of Vehicle in Chain Accidents on Highways. International Journal of Engineering Inventions, Volume 3, Issue 2,S. No:5,e-ISSN: 2278-7461, September 2013, pp. 27-31.
[10] Brooks R. M.; Cetin M. Influence of Skidded Distance on the Initial Velocity of Vehicle in Chain Accidents at Intersections. International Journal of Modern Engineering Research, Volume 3, Issue 5, S. No:55, ISSN: 2249-6645, September-October 2013, pp. 2939-2943.
[11] Brooks R. M.; Cetin M. Influence of Pavement Friction on the Initial Velocity of Vehicle in Chain Accidents at Intersections. International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 7, S. No: 2, ISSN 2250-2459, July 2013, page 10-15.
[12] Brooks R. M.; Cetin M. Influence of Vehicles Weight Ratio on the Initial Velocity of Vehicle in Chain Accidents at Intersections. International Journal of Research and Reviews in Applied Sciences, Volume 17, Issue 2, S. No: 9, ISSN 2076-734X, EISSN: 2076-7366, November 2013, pp. 212-217.
[13] Navidi, W.Statistics for Engineers and Science. 3rd edition. 2010. McGraw-Hill. Publishing Company.
[14] Scheafter, R. L.; Mulekar, M. S.; McClave, J. Probability and Statistics for Engineers. 5th edition. 2011. Brooks/Cole Cengage Leaning Publishing Co.
[15] Carlin, B.P.; Louis, T.A. Bayesian Methods for Data Analysis. 3rdedition. 2009. CRC Press.