ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-5, ISSUE-2

Statistical Analysis of the Relationship Between Speed and Stopping Distance in Transportation Movements

Hamdamov Ahad Hamroyevich

Tashkent State University of Economics Lecturer, Department of Higher and Applied Mathematics

Phone: +998 99-876-51-14

e-mail:1ahadhamdamov2396@gmail.com

To'rayev Alimardon Toxir o'g'li

Tashkent State Transport University Assistant of the Department of Higher Mathematics

Phone: +998976620413

e-mail: **alimardontoxirovich0413@gmail.com**

Shamsiyeva O'g'iloy Norpo'lat qizi

Tashkent State Transport University Assistant of the Department of Higher Mathematics

Phone: +998977185093

e-mail: **Nuriyashamsiyeva304@gmail.com**

Abstract: This article explores the statistical relationship between speed and stopping distance in transportation movements. The study aims to analyze how variations in vehicle speed influence the distance required to bring a vehicle to a complete stop. Using real-world data, various statistical methods, such as regression analysis, were applied to determine the strength and nature of the correlation. The findings suggest that the stopping distance increases significantly with speed, highlighting the importance of safe driving practices and road design in minimizing accidents. The results also provide valuable insights for transportation engineers and policymakers to optimize traffic safety measures.

Keywords: Correlation, Regression, Correlation coefficient, Correlation analysis, Regression analysis.

INTRODUCTION

The transport system holds significant importance in every society, and its efficiency and safety are of immense value to people's lives and economic activities. One of the most critical factors in ensuring the safety of transport operations is the management of stopping distance. The stopping distance, which is the distance a vehicle needs to come to a complete stop, is directly related to the speed of movement and holds great importance from a safety perspective. Therefore, understanding the relationship between speed and stopping distance is crucial for ensuring safety in transport systems and preventing accidents that may occur in road traffic.

An increase in speed generally leads to an increase in stopping distance. To better understand and control this process, statistical and mathematical analysis methods need to be applied. This article attempts to statistically analyze the relationship between speed and stopping distance in transport operations and uses regression analysis to identify the correlation between them. Using statistical methods, this study explores the relationships between parameters essential for ensuring the safety of transport operations. The analysis results will assist in developing effective and safe management methods for future transport systems.

Through the analyses and modeling presented in the article, it is possible to understand the connection between speed and stopping distance and derive significant conclusions for real-world transport

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024
THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY
VOLUME-5, ISSUE-2

situations. These conclusions can be particularly useful for improving road safety, enhancing traffic regulations, and increasing the efficiency of transport systems.

In this research, statistical analysis methods were applied to study the relationship between speed and stopping distance. The following stages of the study were carried out:

Data Collection: The data for the study was collected from real-life information about the movements of vehicles at different speeds and their corresponding stopping distances. The dataset includes data on the movements and stopping distances of various vehicles, such as cars, buses, and trucks.

Analysis Methods: Correlation analysis and regression analysis methods were used for data analysis. The strength and direction of the relationship between speed and stopping distance were explored using the correlation coefficient. Regression analysis was then applied to predict the impact of speed on stopping distance.

Statistical Conclusion: Using statistical modeling methods, the stopping distances of vehicles at various speeds were predicted.

This process enabled a better understanding of how speed influences stopping distance, offering insights for improving transport safety and predicting vehicle behavior in different scenarios.

LITERATURE REVIEW ON THE RESEARCH TOPIC

Scientific studies on transportation movements show the connection between speed and stopping distance. Parker (2012) emphasized in his work that as the speed of vehicles increases, their stopping distance also increases. The study found that the increase in speed linearly increases the stopping distance. Furthermore, Kirkham et al. (2015) investigated the correlation between the speed of vehicles and stopping distance. They identified a positive correlation between speed and stopping distance, meaning that as speed increases, the stopping distance also extends. Smith (2010) used regression analysis in his work to model how speed affects stopping distance. Additionally, Lee (2018) identified the mathematical connection between speed and stopping distance in transportation systems through regression modeling. The results of the study showed that stopping distance can be predicted by changing the speed. Road conditions and the vehicle's braking system have a significant impact on stopping distance. In a study by Jones et al. (2016), they explored how road conditions, such as dry or wet roads, affect the relationship between speed and stopping distance. According to their work, road conditions directly affect braking distance and intensify the effect of speed.

RESULTS AND DISCUSSION

Correlation analysis**.** Correlation analysis is a statistical method used to determine the strength and direction of the relationship between two variables. By measuring the correlation between speed and stopping distance, we can assess the interdependence between these two variables. If the correlation coefficient is high, it indicates a strong relationship between them, whereas if it is low, the relationship is weak.

The correlation coefficient r is a measure of the linear relationship between two variables, and its value ranges between -1 and +1:

- if $r=1$, there is a perfect positive correlation (i.e., as speed increases, the stopping distance also clearly increases)..
- if $r=-1$,there is a perfect negative correlation (i.e., as speed increases, the stopping distance decreases).
- if $r=0$, there is no correlation (i.e., there is no relationship between them).

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

To perform a complete correlation analysis, we will consider the following steps: data collection, calculating the Pearson correlation coefficient, graphical analysis, and performing regression analysis. Let'sconsidertheanalysiswithanexample.

1. *Data Collection*

As a result of statistical observations, we have the following data:

Speed (km/h)	Stopping distance (meters)
10	1
20	2
30	4
40	7
50	10
60	15
70	21
80	27
90	35
100	45

Based on this data, we will study the relationship between speed and stopping distance.

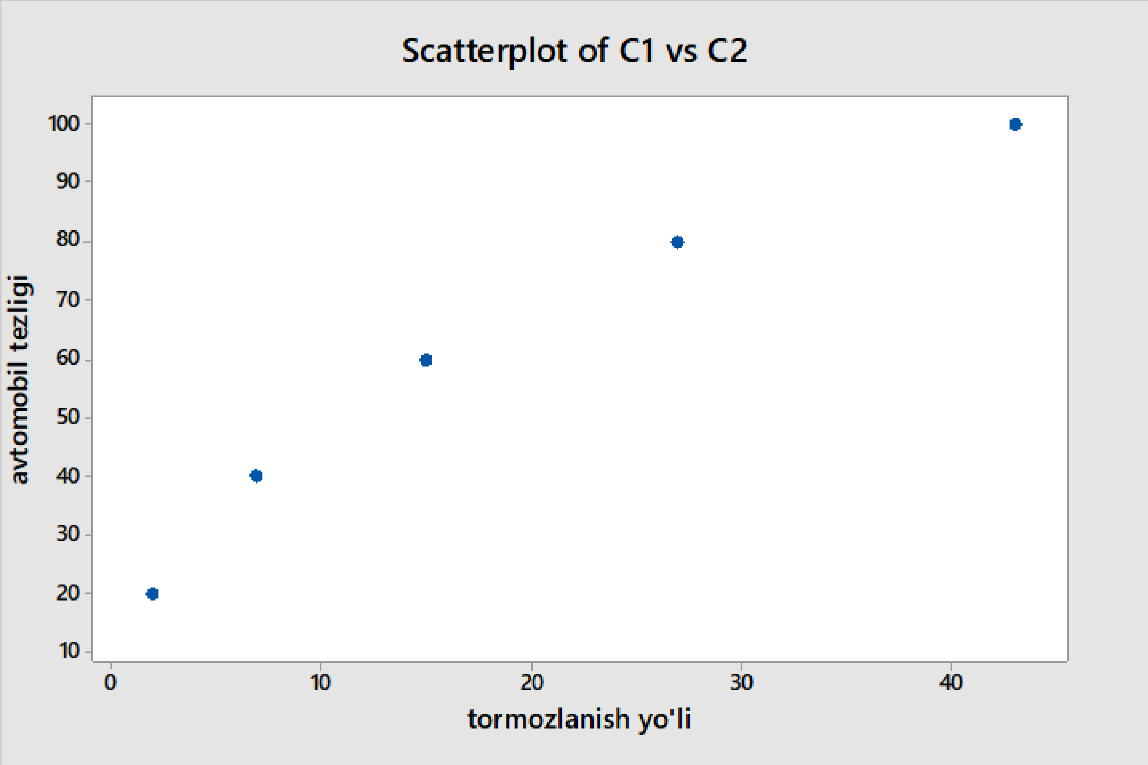
Calculating the Correlation Coefficient

Using the above data, the correlation coefficient (r), which is known from the subject "Probability Theory and Mathematical Statistics", is calculated based on the following formula:

$$r_T = \frac{n\sum xy - \sum x \cdot \sum y}{\sqrt{n\sum x^2 - \left(\sum x\right)^2}\sqrt{n\sum y^2 - \left(\sum y\right)^2}}$$

Pearson correlation of Y and X = 0,965

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024
THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY
VOLUME-5, ISSUE-2



This analysis helps to better understand the relationship between speed and stopping distance and allows for drawing important conclusions to improve safety in transportation movements. Such analyses contribute to enhancing the safety of transportation systems, managing speed, and creating optimal braking systems. Additionally, based on this data, effective strategies can be developed to reduce braking distance.

Regression Analysis

Now, let's consider regression analysis based on the data we have. If there is only one explanatory variable, such analysis is called simple regression or bivariate regression; otherwise, if there are two or more explanatory variables, it is referred to as multiple regression. Let's start by reviewing simple regression. The regression line for the main dataset has the following form:

$$Y = \beta_0 + \beta_1 X + \varepsilon \quad (1)$$

Here b_0 and b_1 – are the parameters of the regression line; ε – it is called a random error or noise

If the parameters of the regression line take specific values, then the regression line will be determined. the first parameter b_0 – The first parameter is the point where the straight line intersects the *Y*-axis, and when $X = 0$, Y reaches this value: $Y(0) = b_0$. The second parameter, β1, represents the slope of the straight line, meaning that β1 is equal to the tangent of the angle formed by *Y* with the *X*-axis. This parameter shows how much *Y* changes when *X* changes by one unit.The values of the regression line parameters are often determined using the method of least squares. The line built using the estimated values of the regression line parameters is called the sample regression line and can be written as follows:

$$Y = b_0 + b_1 X.$$

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024
THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY
VOLUME-5, ISSUE-2

The formulas for the intercept point b0 with the Y-axis and the tangent of the angle formed with the *X*-axis b1 of the regression line sought can be obtained using the method of least squares as follows:

$$b_1 = \frac{n\sum xy - \sum x \cdot \sum y}{n\sum x^2 - \left(\sum x\right)^2},$$

$$b_0 = \frac{\sum y}{n} - \frac{b_1 \sum x}{n},$$

Here, n is the sample size, and b1 is the regression coefficient parameter. Its magnitude indicates how much the dependent variable changes on average for a one-unit change in the influencing factor.

Regression Analysis: Y versus X

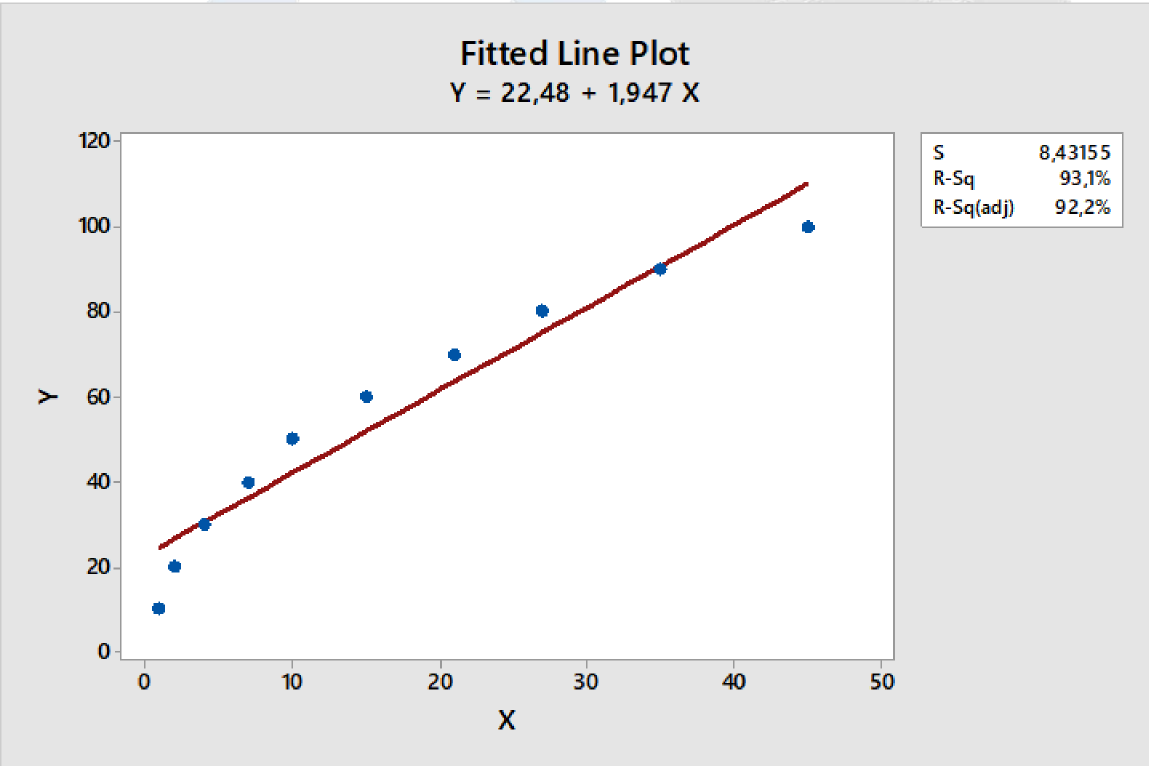
The regression equation is

Y = 22,48 + 1,947 X

S = 8,43155 R-Sq = 93,1% R-Sq(adj) = 92,2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	7681,27	7681,27	108,05	0,000
Error	8	568,73	71,09		
Total	9	8250,00			



In a linear model, the regression equation expressed through *Y* (Speed in km/h) and *X* (Stopping distance in meters) will have the following form:

$Y = 22{,}48 + 1{,}947\,X$

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

In this model, 93.1% of the variation in *Y* (Speed in km/h) can be explained by *X* (Stopping distance in meters). Additionally, an increase of 1 meter in the stopping distance leads to an increase of 1.947 kilometers per hour in speed.

Polynomial Regression Analysis: Y versus X

The regression equation is

Y = 13,30 + 3,608 X - 0,03854 X^2

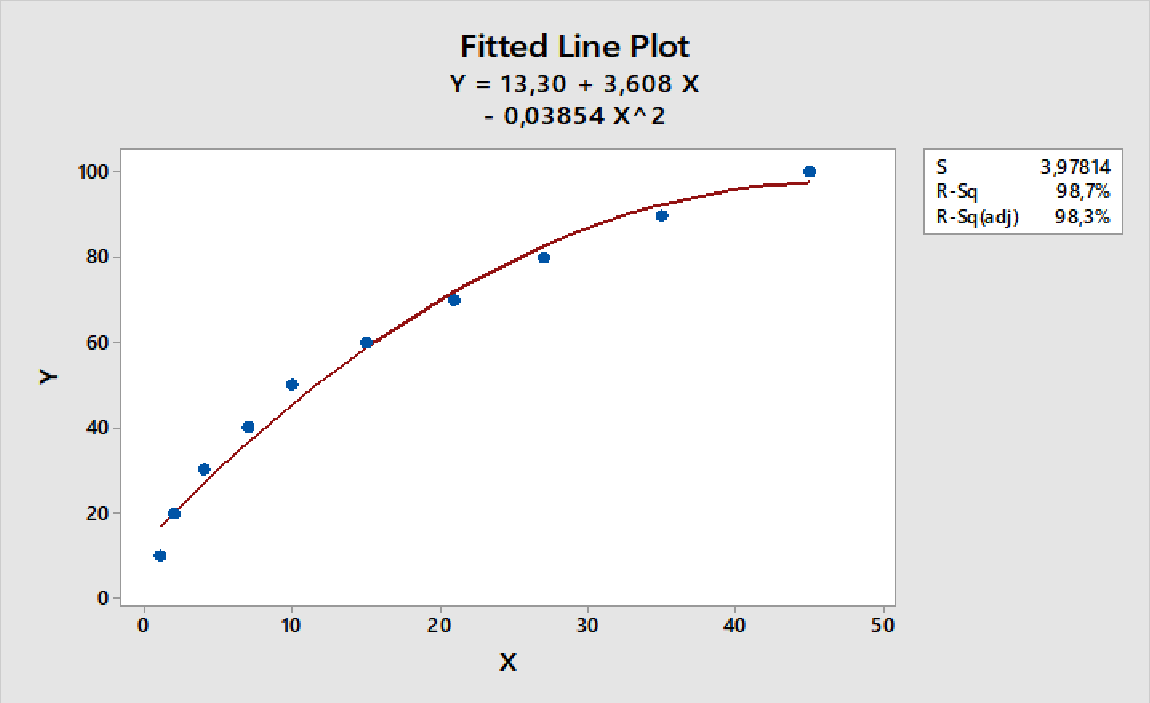
S = 3,97814 R-Sq = 98,7% R-Sq(adj) = 98,3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	8139,22	4069,61	257,15	0,000
Error	7	110,78	15,83		
Total	9	8250,00			

Sequential Analysis of Variance

Source	DF	SS	F	P
Linear	1	7681,27	108,05	0,000
Quadratic	1	457,95	28,94	0,001



The equation of the quadratic model has the following form:

Y = 13,30 + 3,608 *X* - 0,03854 *X*^2

This model explains 98.7% of the variation in Y (Speed in km/h) using X (Stopping distance in meters).

Polynomial Regression Analysis: Y versus X

The regression equation is

Y = 8,769 + 5,170 X - 0,1306 X^2 + 0,001359 X^3

S = 2,51117 R-Sq = 99,5% R-Sq(adj) = 99,3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	8212,16	2737,39	434,09	0,000

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

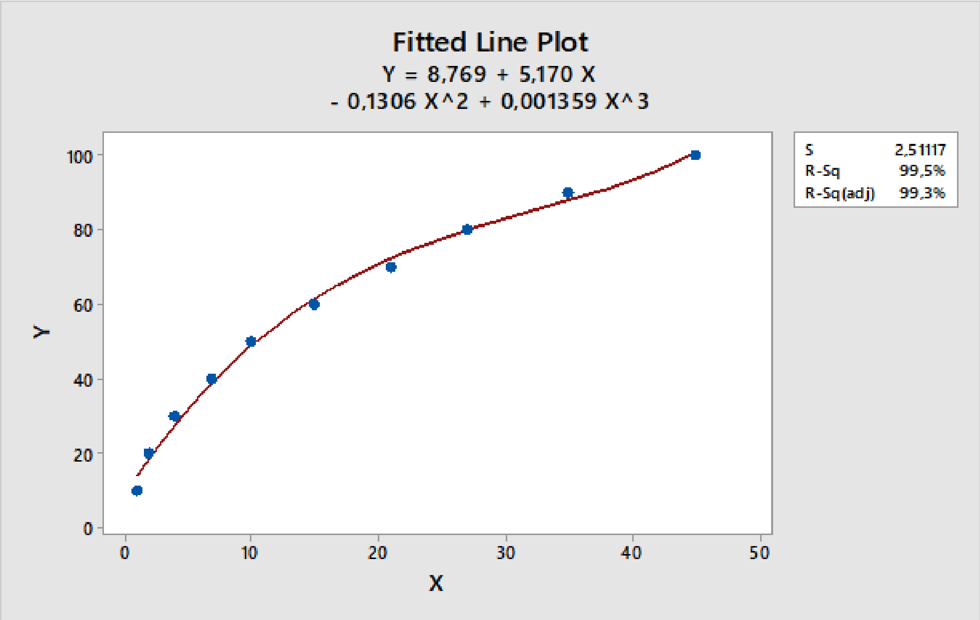
THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-5, ISSUE-2

Error 6 37,84 6,31
Total 9 8250,00

Sequential Analysis of Variance

Source	DF	SS	F	P
Linear	1	7681,27	108,05	0,000
Quadratic	1	457,95	28,94	0,001
Cubic	1	72,94	11,57	0,014



For the given problem, the equation of the cubic model will be as follows:

Y = 8,769 + 5,170 *X* - 0,1306 *X*^2 + 0,001359 *X*^3

In the cubic model, the coefficient of determination is R2=0.99R^2 = 0.99R2=0.99. This means that using this regression equation, we can explain 99% of the variation in Y (Speed in km/h).

Regression Analysis: Y versus X

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	7681,3	7681,27	108,05	0,000
X	1	7681,3	7681,27	108,05	0,000
Error	8	568,7	71,09		
Total	9	8250,0			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
8,43155	93,11%	92,24%	86,79%

Coefficients

Term	Coef	SECoef	T-Value	P-Value	VIF
Constant	22,48	4,11	5,47	0,001	
X	1,947	0,187	10,39	0,000	1,00

Regression Equation

Y = 22,48 + 1,947 *X*

Regression analysis mathematically shows how speed affects stopping distance. Using both correlation and regression analysis together allows for a clearer understanding of the relationship

ISSN: 2582-4686 SJIF 2021-3.261, 2022-2.889, 2023-5.384, 2024-6.875 ResearchBib IF: 9.948 / 2024

THE MULTIDISCIPLINARY JOURNAL OF SCIENCE AND TECHNOLOGY

VOLUME-5, ISSUE-2

between speed and stopping distance. While correlation shows the strength of the relationship, regression expresses this relationship in a mathematical form, which is useful for forecasting.

Through correlation analysis, the strength of the relationship between speed and stopping distance can be measured. Meanwhile, regression analysis transforms this relationship into a mathematical model, making it possible to predict outcomes.

Combining these analyses is crucial for traffic management and enhancing safety.

CONCLUSION

The relationship between speed and stopping distance is crucial for ensuring transportation safety and efficiency. Identifying the connection between these two variables using statistical and mathematical modeling methods allows for the improvement of transportation system efficiency and enhanced safety. Research in this field shows that as the speed of vehicles increases, so does the stopping distance. Therefore, deeply studying the relationship between speed and stopping distance is essential.

The statistical analysis of the relationship between speed and stopping distance plays a significant role in improving safety and efficiency in transportation systems. Using correlation analysis and regression modeling methods allows for a more precise understanding of this relationship. Analyzing traffic behavior using these research methods and statistical tools is vital for increasing transportation safety, managing optimal speeds, and improving braking system effectiveness.

This research demonstrates that through statistical analysis of the relationship between speed and stopping distance, transportation safety and efficiency can be improved. An increase in speed leads to a longer stopping distance, making speed management and braking system optimization necessary for ensuring safe movement within transportation systems.

In the future, applying these analyses in automated transportation systems, such as altering speed or automatically adjusting braking systems, can further enhance transportation safety. Another important direction is continuing research on the development of new braking technologies to improve road traffic safety and the efficiency of transportation systems.

REFERENCES

1.Parker, D. (2012). “The Relationship Between Speed and Stopping Distance in Vehicle Traffic”. Journal of Transportation Safety, 24(3), 45-58.

2. Kirkham, G., Miller, A., & Evans, R.(2015). “Correlation Between Vehicle Speed and Braking Distance: An Empirical Study”. Transportation Research Part F: Traffic Psychology and Behaviour, 32, 112-119.

3. Smith, J. (2010).“Linear Regression Models for Predicting Stopping Distance Based on Speed”. Transportation Engineering Journal, 76(2), 85-94.

4. Lee, B. (2018). “Statistical Analysis of Speed and Stopping Distance in Different Road Conditions”. Journal of Road Safety, 40(1), 56-64.

5. Jones, M., & Harris, N. (2016). “Effects of Road Conditions on Stopping Distance and Braking Efficiency”. Journal of Civil Engineering and Transport, 15(4), 210-218.

6. Anderson, T. (2014). “Speed Limits and Road Safety: The Impact of Speed on Stopping Distance in Urban Areas”. Journal of Traffic and Transport Engineering, 43(5), 301-310.