## What is speed study?

Speed has always been a significant factor in accidents and in determining safety on our roads. In laymen's term, speed study is the measurement of how fast or slow the vehicles are in a traffic stream. There are two types of speed study; spot speed study and travel time study. In spot speed study, the speed of a vehicle is measured instantly at a specific point, whereas, travel time study is used to calculate the efficiency or delays of a route. In this report, spot speed study would be conducted to determine if the traffic stream has a higher or reduced speed after an event. Radar meters, stopwatch and pneumatic tubes can be used to perform the study. Spot speed analysis has various applications in the transportation field such as, helping to establish speed limits on roads, monitoring performance of existing traffic controlling methods and to set road design parameters. It can provide critical information about the condition of a road and whether further modifications would be needed. Since, it is an important measurement, the survey needs to be done accurately and in the proper way. Data for speed studies are normally collected during off peak periods in weekdays for general speed trends.

## Methodology

In our survey, a before-after spot speed study was performed to analyze if the speed has significantly increased after the repair works of a major arterial. The speeds of two vehicle classes were recorded with a radar meter pointed at the vehicles during an off-peak period in a weekday. Assuming 95% confidence interval, a sample size of 165 vehicles in each class were taken. The two vehicle categories were passenger car and bus. Two sets of data were taken for each vehicle category before and after the repair works of the road. For proper measurements, accurate line of sight was ensured while taking the readings with the meter. To ensure random sampling, speed readings from every fourth vehicle. After the data was taken, a frequency and cumulative distribution graph was generated and to chi-square goodness-of-fit test was performed to show the statistical significance of the data.

## Analysis and Results

In the case **of passenger cars**, the before-after data produced the following results:

| Passenger Car | | |
|---|---|---|
| | **Before** | **After** |
| **Mean speed, $\bar{X}$** | 46.82 mph | 51.09 mph |
| **Standard Deviation, s** | 9.71 | 8.65 |
| **Pace (mph)** | 42.5-52.5 | 49.8-59.8 |
| **Mode (mph)** | 49 | 54.9 |
| **15th percentile** | 37.5 mph | 42 mph |
| **50th percentile** | 47.5 mph | 53 mph |
| **80th percentile** | 52 mph | 59 mph |

*Table 1 Results of Passenger Cars*

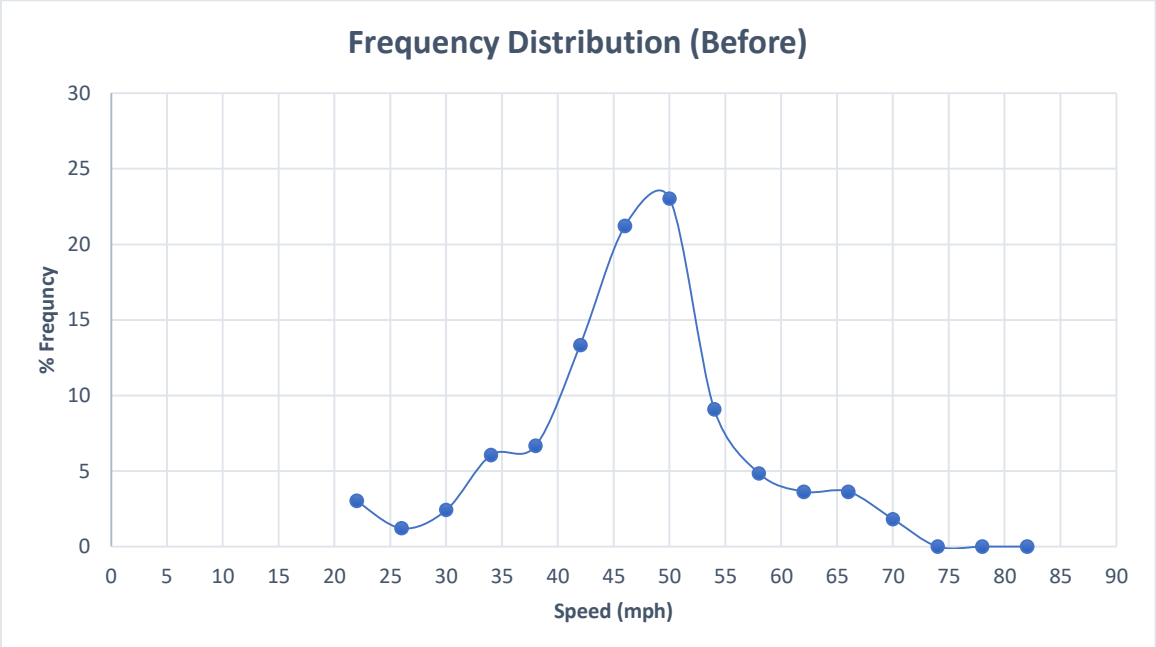


*Figure 1 Frequency Distribution of PC (before))*

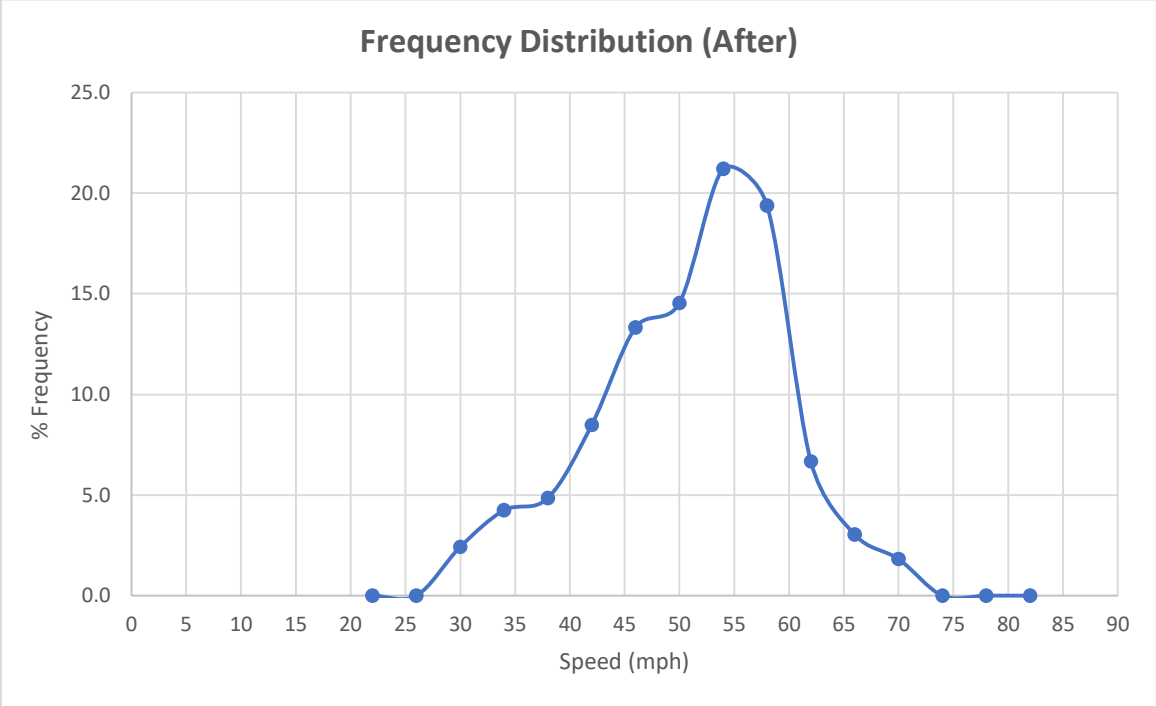


*Figure 2 Frequency Distribution of PC (after)*

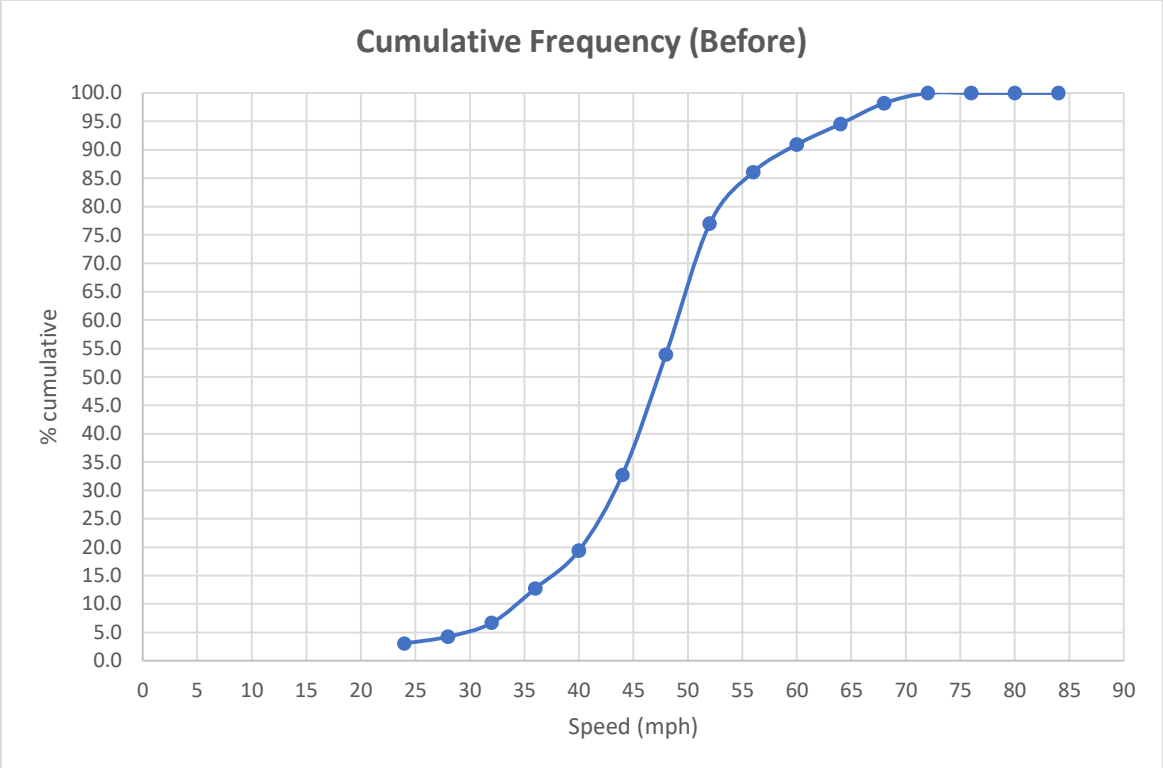


*Figure 3 Cumulative Distribution of PC (before)*

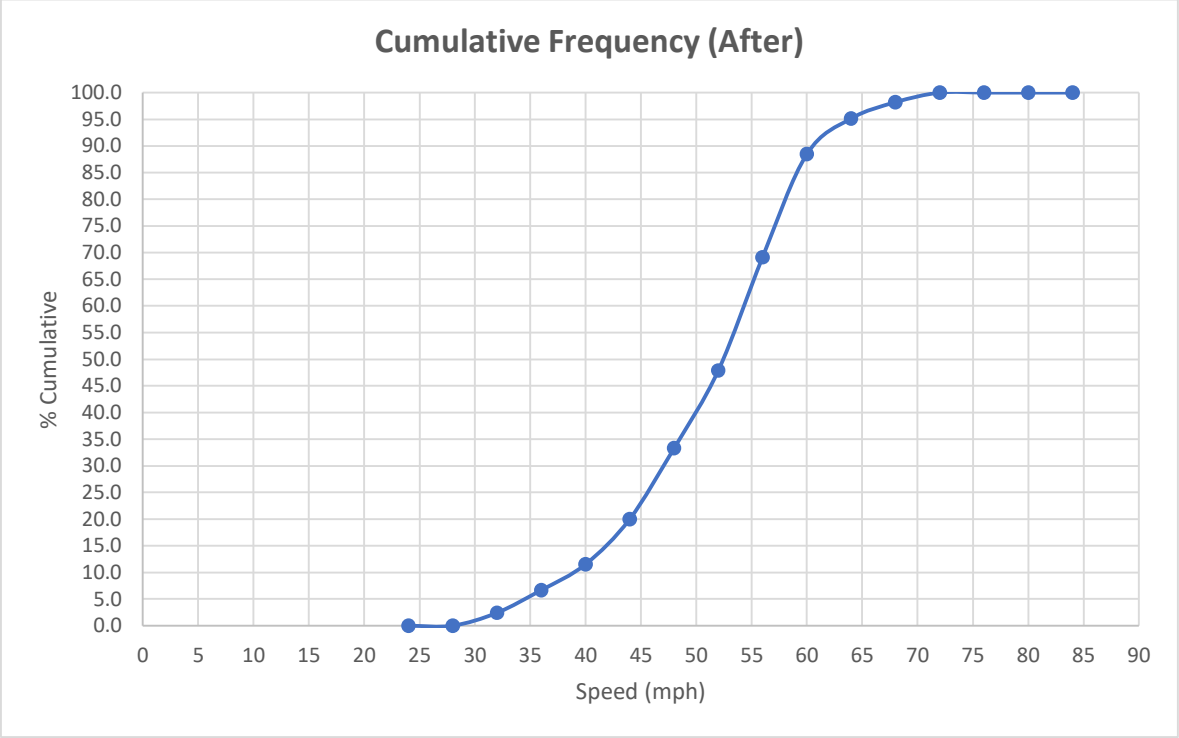


*Figure 4 Cumulative Distribution of PC (after)*

To verify the statistical significance of the data, a chi-square goodness-of-fit test was performed in the following table:

| Chi-Square Test (Before) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Speed Group | | Observed frequency, n | Lower Limit (Std. Normal) | Upper Limit (Std. | Prob, z<=zd (lower | Prob, z<=zd (upper | Prob. Of Occurrence in Group | Theoretical Frequency, f | Combined Groups, n | Combined Groups, f | χ2 Group |
| Lower limit | Upper limit | | | | | | | | | | |
| 20 | 24 | 5 | -2.8 | -2.3 | 0.0029 | 0.0094 | 0.0065 | 1.0749 | | | |
| 24 | 28 | 2 | -2.3 | -1.9 | 0.0094 | 0.0263 | 0.0169 | 2.7915 | 7 | 3.8664 | 2.53964 |
| 28 | 32 | 4 | -1.9 | -1.5 | 0.0263 | 0.0635 | 0.0372 | 6.1326 | 4 | 6.1326 | 0.74161 |
| 32 | 36 | 10 | -1.5 | -1.1 | 0.0635 | 0.1326 | 0.0691 | 11.3974 | 10 | 11.397 | 0.17133 |
| 36 | 40 | 11 | -1.1 | -0.7 | 0.1326 | 0.2412 | 0.1086 | 17.9197 | 11 | 17.920 | 2.67203 |
| 40 | 44 | 22 | -0.7 | -0.3 | 0.2412 | 0.3856 | 0.1445 | 23.8357 | 22 | 23.836 | 0.14137 |
| 44 | 48 | 35 | -0.3 | 0.1 | 0.3856 | 0.5482 | 0.1626 | 26.8227 | 35 | 26.823 | 2.49299 |
| 48 | 52 | 38 | 0.1 | 0.5 | 0.5482 | 0.7029 | 0.1548 | 25.5362 | 38 | 25.536 | 6.08340 |
| 52 | 56 | 15 | 0.5 | 0.9 | 0.7029 | 0.8276 | 0.1247 | 20.5678 | 15 | 20.568 | 1.50725 |
| 56 | 60 | 8 | 0.9 | 1.4 | 0.8276 | 0.9125 | 0.0849 | 14.0151 | 8 | 14.015 | 2.58160 |
| 60 | 64 | 6 | 1.4 | 1.8 | 0.9125 | 0.9615 | 0.0490 | 8.0793 | 6 | 8.079 | 0.53511 |
| 64 | 68 | 6 | 1.8 | 2.2 | 0.9615 | 0.9854 | 0.0239 | 3.9401 | 9 | 6.342 | 1.11385 |
| 68 | 72 | 3 | 2.2 | 2.6 | 0.9854 | 0.9952 | 0.0099 | 1.6255 | | | |
| 72 | 76 | 0 | 2.6 | 3.0 | 0.9952 | 0.9987 | 0.0034 | 0.5673 | | | |
| 76 | 80 | 0 | 3.0 | 3.4 | 0.9987 | 0.9997 | 0.0010 | 0.1675 | | | |
| 80 | 84 | 0 | 3.4 | 3.8 | 0.9997 | 0.9999 | 0.0003 | 0.0418 | | | |
| | | | | | | | | **165** | **165** | **165** | **20.5802** |
| | | | | | | | | | | **p-value (%)** | **0.835** |

*Table 2 Chi-square test of PC (before)*

| Chi-Square Test (After) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Speed Group | | Observed frequency, n | Lower Limit (Std. Normal) | Upper Limit (Std. Normal), | Prob, z<=zd (lower limit) | Prob, z<=zd (upper limit) | Prob. Of Occurrence in Group | Theoretical Frequency, f | Combined Groups, n | Combined Groups, f | χ2 Group |
| Lower limit | Upper limit | | | | | | | | | | |
| 20 | 24 | 0 | -3.6 | -3.1 | 0.0002 | 0.0009 | 0.0007 | 0.1163 | | | |
| 24 | 28 | 0 | -3.1 | -2.7 | 0.0009 | 0.0038 | 0.0029 | 0.4830 | | | |
| 28 | 32 | 4 | -2.7 | -2.2 | 0.0038 | 0.0136 | 0.0099 | 1.6254 | | | |
| 32 | 36 | 7 | -2.2 | -1.7 | 0.0136 | 0.0405 | 0.0269 | 4.4320 | 11 | 6.657 | 2.8339 |
| 36 | 40 | 8 | -1.7 | -1.3 | 0.0405 | 0.0999 | 0.0594 | 9.7932 | 8 | 9.793 | 0.3284 |
| 40 | 44 | 14 | -1.3 | -0.8 | 0.0999 | 0.2061 | 0.1063 | 17.5374 | 14 | 17.537 | 0.7135 |
| 44 | 48 | 22 | -0.8 | -0.4 | 0.2061 | 0.3604 | 0.1543 | 25.4526 | 22 | 25.453 | 0.4684 |
| 48 | 52 | 24 | -0.4 | 0.1 | 0.3604 | 0.5419 | 0.1815 | 29.9395 | 24 | 29.940 | 1.1783 |
| 52 | 56 | 35 | 0.1 | 0.6 | 0.5419 | 0.7148 | 0.1730 | 28.5434 | 35 | 28.543 | 1.4605 |
| 56 | 60 | 32 | 0.6 | 1.0 | 0.7148 | 0.8485 | 0.1337 | 22.0554 | 32 | 22.055 | 4.4839 |
| 60 | 64 | 11 | 1.0 | 1.5 | 0.8485 | 0.9322 | 0.0837 | 13.8122 | 11 | 13.812 | 0.5726 |
| 64 | 68 | 5 | 1.5 | 2.0 | 0.9322 | 0.9747 | 0.0425 | 7.0102 | 8 | 11.171 | 0.9001 |
| 68 | 72 | 3 | 2.0 | 2.4 | 0.9747 | 0.9922 | 0.0175 | 2.8834 | | | |
| 72 | 76 | 0 | 2.4 | 2.9 | 0.9922 | 0.9980 | 0.0058 | 0.9610 | | | |
| 76 | 80 | 0 | 2.9 | 3.3 | 0.9980 | 0.9996 | 0.0016 | 0.2595 | | | |
| 80 | 84 | 0 | 3.3 | 3.8 | 0.9996 | 0.9999 | 0.0003 | 0.0568 | | | |
| | | | | | | | | **165** | **165** | **165** | **12.9395** |
| | | | | | | | | | | **p-value (%)** | **4.401** |

*Table 3 Chi-square test of PC (after)*

In case of **buses**, the following results were obtained from the before-after spot speed study:

| Bus | | |
|---|---|---|
| | **Before** | **After** |
| **Mean speed, $\bar{x}$** | 37.22 mph | 40.67 mph |
| **Standard Deviation, s** | 7.02 | 7.25 |
| **Pace (mph)** | 34-44 | 35.5-45.5 |
| **Mode (mph)** | 38 | 41.5 |
| **15th percentile** | 29.8 mph | 34 mph |
| **50th percentile** | 37.5 mph | 41 mph |
| **80th percentile** | 44 mph | 48.2 |

*Table 4 Results of Bus*

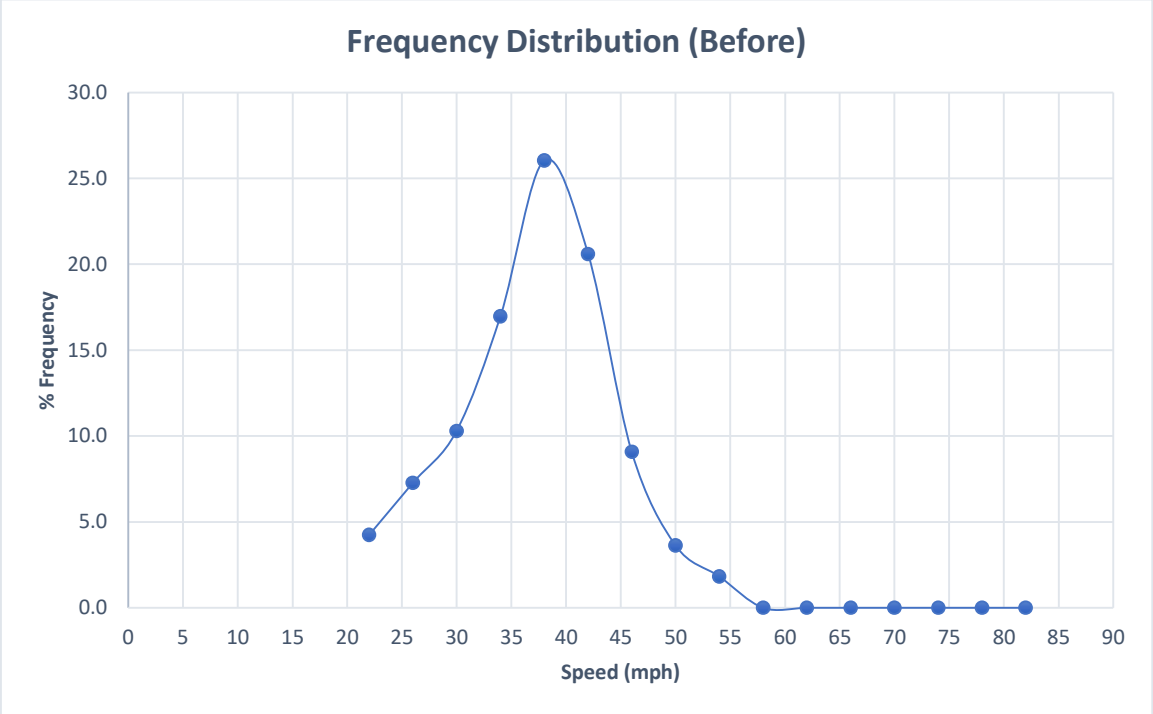


*Figure 5 Frequency Distribution of Bus (before)*

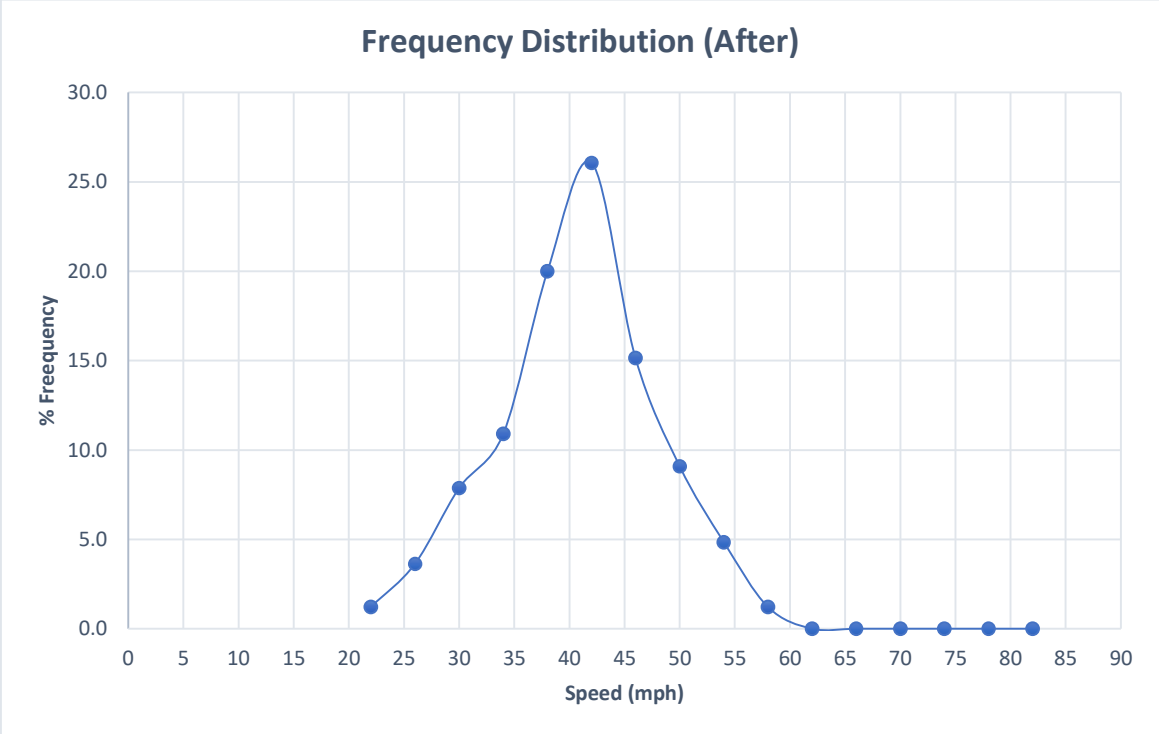


*Figure 6 Frequency Distribution of Bus (after)*

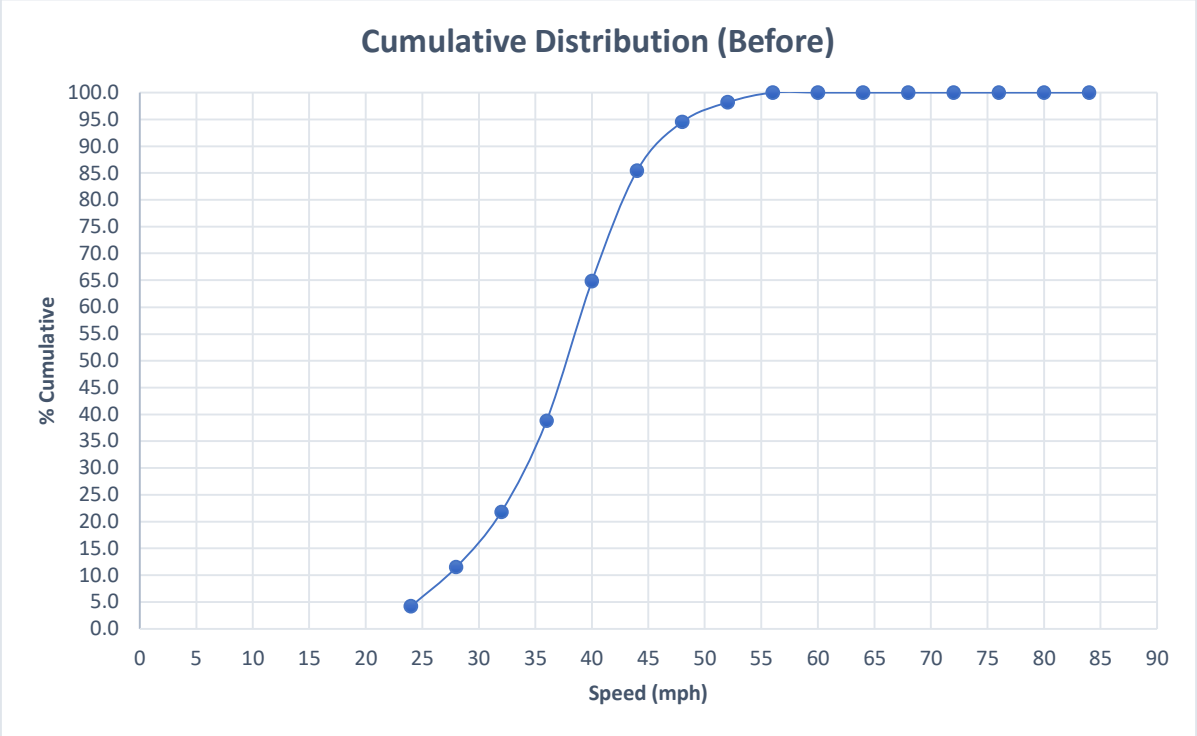


*Figure 7 Cumulative Distribution of Bus (before)*

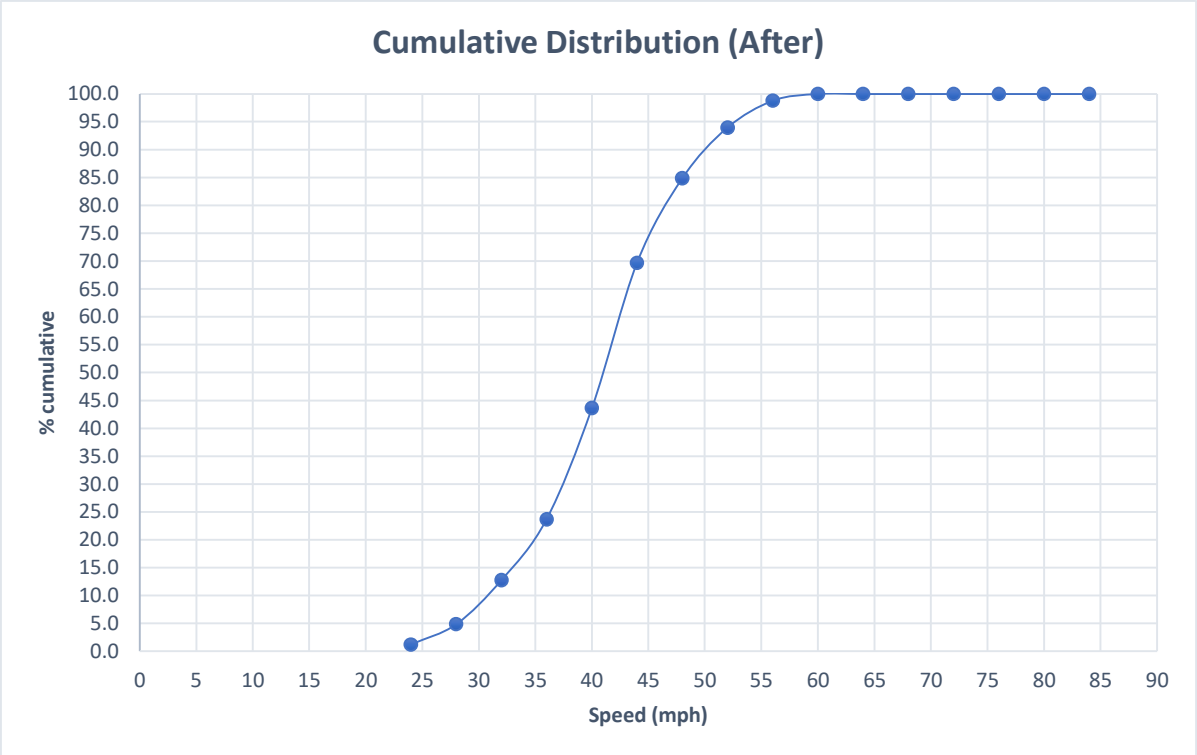


*Figure 8 Cumulative Distribution of Bus (after)*

The chi-square test performed for before-after spot speed study of bus gave the following results:

| Chi-Square Test (Before) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Speed Group | | Observed | Lower | Upper | Prob, z<=zd | Prob, z<=zd | Prob. Of | Theoretical | Combined | Combined | χ2 |
| Lower limit | Upper limit | frequency, n | Limit (Std. | Limit (Std. | (lower limit) | (upper limit) | Occurrence in Group | Frequency, f | Groups, n | Groups, f | Group |
| 20 | 24 | 7 | -2.5 | -1.9 | 0.0071 | 0.0299 | 0.0228 | 3.75821 | | | |
| 24 | 28 | 12 | -1.9 | -1.3 | 0.0299 | 0.0946 | 0.0647 | 10.6738 | 19 | 14.4320 | 1.44585 |
| 28 | 32 | 17 | -1.3 | -0.7 | 0.0946 | 0.2285 | 0.1340 | 22.1031 | 17 | 22.1031 | 1.17818 |
| 32 | 36 | 28 | -0.7 | -0.2 | 0.2285 | 0.4308 | 0.2023 | 33.3786 | 28 | 33.3786 | 0.86672 |
| 36 | 40 | 43 | -0.2 | 0.4 | 0.4308 | 0.6536 | 0.2228 | 36.7634 | 43 | 36.7634 | 1.05798 |
| 40 | 44 | 34 | 0.4 | 1.0 | 0.6536 | 0.8326 | 0.1790 | 29.5329 | 34 | 29.5329 | 0.67568 |
| 44 | 48 | 15 | 1.0 | 1.5 | 0.8326 | 0.9375 | 0.1049 | 17.3027 | 15 | 17.3027 | 0.30644 |
| 48 | 52 | 6 | 1.5 | 2.1 | 0.9375 | 0.9823 | 0.0448 | 7.3922 | 9 | 10.315 | 0.16767 |
| 52 | 56 | 3 | 2.1 | 2.7 | 0.9823 | 0.9962 | 0.0140 | 2.3024 | | | |
| 56 | 60 | 0 | 2.7 | 3.2 | 0.9962 | 0.9994 | 0.0032 | 0.5227 | | | |
| 60 | 64 | 0 | 3.2 | 3.8 | 0.9994 | 0.9999 | 0.0005 | 0.0864 | | | |
| 64 | 68 | 0 | 3.8 | 4.4 | 0.9999 | 1.0000 | 0.0001 | 0.0104 | | | |
| 68 | 72 | 0 | 4.4 | 5.0 | 1.0000 | 1.0000 | 0.0000 | 0.0009 | | | |
| 72 | 76 | 0 | 5.0 | 5.5 | 1.0000 | 1.0000 | 0.0000 | 0.0001 | | | |
| 76 | 80 | 0 | 5.5 | 6.1 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | | | |
| 80 | 84 | 0 | 6.1 | 6.7 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | | | |
| | | 165 | | | | | | **164** | **165** | **164** | **5.6985** |
| | | | | | | | | | | **p-value (%)** | **22.28** |

*Figure 9 Chi-square test of Bus (before)*

| Chi-Square Test (After) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Speed Group | | Observed | Lower | Upper | Prob, | Prob, | Prob. Of | Theoretical | Combined | Combined | χ2 |
| Lower limit | Upper limit | frequency, n | Limit (Std. | Limit (Std. | z<=zd (lower | z<=zd (upper | Occurrence in Group | Frequency, f | Groups, n | Groups, f | Group |
| 20 | 24 | 2 | -2.9 | -2.3 | 0.0022 | 0.0108 | 0.0086 | 1.41413 | | | |
| 24 | 28 | 6 | -2.3 | -1.7 | 0.0108 | 0.0403 | 0.0295 | 4.8746 | 8 | 6.2887 | 0.46566 |
| 28 | 32 | 13 | -1.7 | -1.2 | 0.0403 | 0.1159 | 0.0756 | 12.4822 | 13 | 12.4822 | 0.02148 |
| 32 | 36 | 18 | -1.2 | -0.6 | 0.1159 | 0.2599 | 0.1439 | 23.7484 | 18 | 23.7484 | 1.39140 |
| 36 | 40 | 33 | -0.6 | -0.1 | 0.2599 | 0.4634 | 0.2035 | 33.5760 | 33 | 33.5760 | 0.00988 |
| 40 | 44 | 43 | -0.1 | 0.5 | 0.4634 | 0.6772 | 0.2138 | 35.2788 | 43 | 35.2788 | 1.68990 |
| 44 | 48 | 25 | 0.5 | 1.0 | 0.6772 | 0.8441 | 0.1670 | 27.5480 | 25 | 27.5480 | 0.23568 |
| 48 | 52 | 15 | 1.0 | 1.6 | 0.8441 | 0.9410 | 0.0969 | 15.9859 | 15 | 15.986 | 0.06080 |
| 52 | 56 | 8 | 1.6 | 2.1 | 0.9410 | 0.9828 | 0.0418 | 6.8928 | 10 | 9.732 | 0.00736 |
| 56 | 60 | 2 | 2.1 | 2.7 | 0.9828 | 0.9962 | 0.0134 | 2.2080 | | | |
| 60 | 64 | 0 | 2.7 | 3.2 | 0.9962 | 0.9994 | 0.0032 | 0.5253 | | | |
| 64 | 68 | 0 | 3.2 | 3.8 | 0.9994 | 0.9999 | 0.0006 | 0.0928 | | | |
| 68 | 72 | 0 | 3.8 | 4.3 | 0.9999 | 1.0000 | 0.0001 | 0.0122 | | | |
| 72 | 76 | 0 | 4.3 | 4.9 | 1.0000 | 1.0000 | 0.0000 | 0.0012 | | | |
| 76 | 80 | 0 | 4.9 | 5.4 | 1.0000 | 1.0000 | 0.0000 | 0.0001 | | | |
| 80 | 84 | 0 | 5.4 | 6.0 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | | | |
| | | 163 | | | | | | **165** | **165** | **165** | **3.8822** |
| | | | | | | | | | | **p-value (%)** | **56.65** |

*Figure 10 Chi-square test of Bus (after)*

## Discussion

For Passenger Cars:

After comparing the results from the before-after studies, it can be seen that the mean speed, mode, pace, $15^{th}$, $50^{th}$ and $85^{th}$ percentile increased after the road repair works were done. The chi-square test value for the before and after study were 20.5802 and 12.9395, respectively. The probability of these scores were 0.84% and 4.4% which is less than 5% meaning that the test results had a significant statistical difference. So, at 95% confidence level, it can be said that there was a significant change in the speed of passenger cars before and after the road was repaired.

For Buses:

The results from the before-after speed study show that the mean speed, mode, pace, 15th, 50th and 85th percentile increased after the road repair works were done. The chi-square test value for the before and after study were 5.6985 and 3.8822, respectively. The probability of these scores were 22.28% and 56.65% which is well over 5% meaning that the test results did not have a significant statistical difference. So, at 95% confidence level, it can be said that although the mean speed has increased, there was not a significant change in the speed of buses before and after the road was repaired.

## Budgeting

| Budget Preparation | | | | | | | |
|---|---|---|---|---|---|---|---|
| Spot Speed Study | | | | | | | |
| # | Item | Unit | Shift | Location | Direction | Unit Cost | Total (BDT) |
| 1 | Supervisor | 1 | 1 | 1 | 1 | 2500 | 2500 |
| 2 | Surveyor | 2 | 1 | 1 | 1 | 1500 | 3000 |
| 3 | Transportation | 1 | 1 | 1 | 1 | 300 | 300 |
| 4 | Printing forms | 1 | 1 | 1 | 1 | 2000 | 2000 |
| 5 | Refreshment | 3 | 1 | 1 | 1 | 300 | 900 |
| 6 | Radar Meter | 2 | 1 | 1 | 1 | 35000 | 70000 |
| 7 | Training + Pilot | 1 | 1 | 1 | 1 | 5500 | 5500 |
| 8 | Data entry | 1 | 1 | 1 | 1 | 350 | 350 |
| 9 | Miscellaneous | 1 | 1 | 1 | 1 | 3500 | 3500 |
| 10 | Consulting firm's overhead | 1 | 1 | 1 | 1 | 1 | 88050 |
| 11 | City VAT + Tax (15% + 10%) | | | | | | 22012.5 |
| | **Total** | | | | | | 110062.5 |
| | After 5% discount | | | | | | **104559** |

**Appendix**

A sample of the form used to record the speed data is given below:

| Speed Group | | Passenger Cars | Total |
|---|---|---|---|
| Lower limit (mph) | Upper limit (mph) | | |
| 20 | 24 | 𝍸 | 5 |
| 24 | 28 | \|\| | 2 |
| 28 | 32 | \|\|\|\| | 4 |
| 32 | 36 | 𝍸 𝍸 | 10 |
| 36 | 40 | 𝍸 𝍸 \| | 11 |
| 40 | 44 | 𝍸 𝍸 𝍸 𝍸 \|\| | 22 |
| 44 | 48 | 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 | 35 |
| 48 | 52 | 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 \|\|\| | 38 |
| 52 | 56 | 𝍸 𝍸 𝍸 | 15 |
| 56 | 60 | 𝍸 \|\|\| | 8 |
| 60 | 64 | 𝍸 \| | 6 |
| 64 | 68 | 𝍸 \| | 6 |
| 68 | 72 | \|\|\| | 3 |
| 72 | 76 | | 0 |
| 76 | 80 | | 0 |
| 80 | 84 | | 0 |
| | | | 165 |