

Through, Over, or Under Guardrail Penetration by Guardrail Height

WA-RD 742.1

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December 2009



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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. WA-RD 742.1		2. GOVERNMENT ACCESSION NO.		3. RECIPIENTS CATALOG NO.	
4. TITLE AND SUBTITLE Through, Over, or Under Guardrail Penetration by Guardrail Height				5. REPORT DATE December, 2009	
				6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S) Washington State Department of Transportation Design Policy, Standards & Research Team Brad Manchas, Research Analyst Dave Olson, Manager				8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Washington State Department of Transportation Design Policy, Standards & Research MS 47330 Olympia, WA 98504				10. WORK UNIT NO.	
				11. CONTRACT OR GRANT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS				13. TYPE OF REPORT AND PERIOD COVERED	
				14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.					
16. ABSTRACT This report evaluates whether a clear correlation between guardrail height and penetration of the guardrail exists in the collision and roadside features inventory datasets available for Washington State. In particular, do guardrail heights of 27 inches or lower experience more through, over, or under penetrations (TOU) than 28 inch or greater guardrail installations					
17. KEY WORDS guardrail height, penetration, through, over, under, collision				18. DISTRIBUTION STATEMENT	
19. SECURITY CLASSIF. (of this report) None		20. SECURITY CLASSIF. (of this page) None		21. NO. OF PAGES 11	22. PRICE

Objective:

To evaluate whether a clear correlation between guardrail height and penetration of the guardrail exists in the collision and roadside features inventory datasets available for Washington State. In particular, do guardrail heights of 27 inches or lower experience more through, over, or under penetrations (TOU) than 28 inch or greater guardrail installations.

Data Sources, Quality, and Limitations:**Collision Data:**

A total of 10.25 years of collision data was used in this evaluation, 1999 through the first quarter of 2009. The collision data was obtained from the Washington State Department of Transportation (WSDOT) Transportation Data Office (TDO) Collision section.

Guardrail collisions are defined by the TDO into three collision types. These are dependent on how the vehicle struck the guardrail and the outcome: the face, the leading edge, or through, over or under (TOU). The last category of TOU is of particular interest as this collision type indicates a penetration of the safety feature.

The TOU collision type cannot be defined regarding which of the three manners of penetration occurred in a collision without an examination of each collision report. This examination of each collision report to define the specific penetration type did not occur in this study.

For this 10.25-year period, all three-guardrail collision types were associated to the guardrail data set where a valid guardrail height was available. This association identified 1,806 collisions for evaluation. Of the 1,806 collisions, 1,518 struck the guardrail face, 198 struck the leading end and 90 were of the TOU collision type.

Of the 1,806 collisions used in this evaluation almost one third were found to be on limited access divided highways, with the balance on two lane undivided highways. The speed limits within the evaluated areas ranged from a low of 50 mph to a high of 70 mph. There was no evaluation based on speed limits and TOU penetrations.

Guardrail Data:

Guardrail height data used in this evaluation was obtained from the TDO's Roadway Features Inventory Program (RFIP). The RFIP data consists of different roadway feature data; its collection is primarily for use in a Geographic Information System (GIS) format. Guardrail and its RFIP defined attributes (height, location and type) are one of the feature datasets collected, and this is the data used in the evaluation. This evaluation was limited to "W-beam" guardrail only.

This guardrail dataset is not complete for the entire state system as the RFIP collection is an ongoing program. The data collection is conducted by each region independently; as a result, the completeness of the guardrail dataset varies across regions.

Another limiting aspect to the analysis was identified within this RFIP dataset. The data collected is in two differing formats; inches and decimal feet. A number of records could not be defined as to which format was used, and they were deleted from the analysis dataset. This deletion also included a number of records where the values were clearly incorrect. If a value could not be clearly defined, it was removed from the dataset. This further limited the available records for analysis.

The guardrail heights reported in the analysis are in inches. The dataset itself reported these values in either decimal feet or in fractional values of inches. Those records in decimal feet were converted to inches and the value was rounded to the nearest full inch value. This same process was used in those records collected in inches, as they too were collected in fractional values of an inch.

The majority of the locations evaluated, where both valid guardrail heights and a collision occurred are located in the North Central and Northwest regions of the state. Roughly, 70% of the locations are in these regions, with the balance throughout the rest of the state.

This evaluation does not imply that the above regions experience more guardrail collisions than the rest of the state, rather that the RFIP data collection for the specific data elements of this study (valid data on guardrail height and location) is more complete in these regions.

Dataset Consolidation Methodology:

The RFIP guardrail datasets were collected and stored to be used in ArcGIS. The data used in the analysis were in three different datasets, of which only one of the datasets had Linear Referencing Systems (LRS) location data values: State Route number and milepost. The other two datasets location data were recorded in “X,Y” coordinate values: Latitude and Longitude.

As the collision data were located in LRS values, to accurately locate these collisions to the specific guardrail and its associated height there was a need to convert the X,Y coordinates to LRS values. A common key in the three RFIP guardrail datasets was used to integrate these three files into a single dataset. This resulted in a LRS begin and end point of State Route and milepost value for each specific guardrail run. Each run was further defined by its specific height; at each height change of one inch or more, a new segment was defined.

In accurately associating a specific collision to a specific guardrail segment and height the dataset required further analysis. In some cases guardrail can be found on both sides of the roadway. A collision occurs at specific point to the right or left of the roadway. Where the guardrail is on both sides of the roadway a method was required to define which run of the guardrail was struck.

The RFIP dataset contains a field of “direction to inventory”; this field was tied to the collision’s impact location to identify which guardrail segment that was impacted. For

example, a guardrail segment located on the median shoulder was associated with a median or left shoulder impact location of the collision.

There remained an issue with the RFIP dataset where there appeared to be duplicates for the same guardrail segment. This apparent duplication was found to be: having multiple runs at the collision location, guardrail segments that changed heights at the specific collision point, or a data collection issue where there truly was a duplicate record.

To resolve and identify the correct values it was necessary to plot these guardrail segments in a GIS layer using ArcGIS and then plot the collision points. By using the GIS map created and other tools like SR-View (WSDOT's photo/road log); it was possible to identify the specific guardrail struck.

This resulted in a final dataset where 1,806 collisions are identified with specific locations and the type of impact with the guardrail, along with height of the guardrail at each impact location.

Findings:

These findings are presented in a “naive” study analysis; the limited data and the data quality in certain circumstances prevent a more exhaustive look at the data. However, in the following charts the collision experience, TOU penetrations, and injury severity by height are examined.

The reader should exercise caution in interpreting the height data. Representative heights are measured along a run of guardrail based on field observation of height variations. The height of the rail at the precise location of a collision is a linear interpretation of field measured heights. The height ranges presented in this report are intended to evaluate linear trends in barrier performance relevant to barrier height.

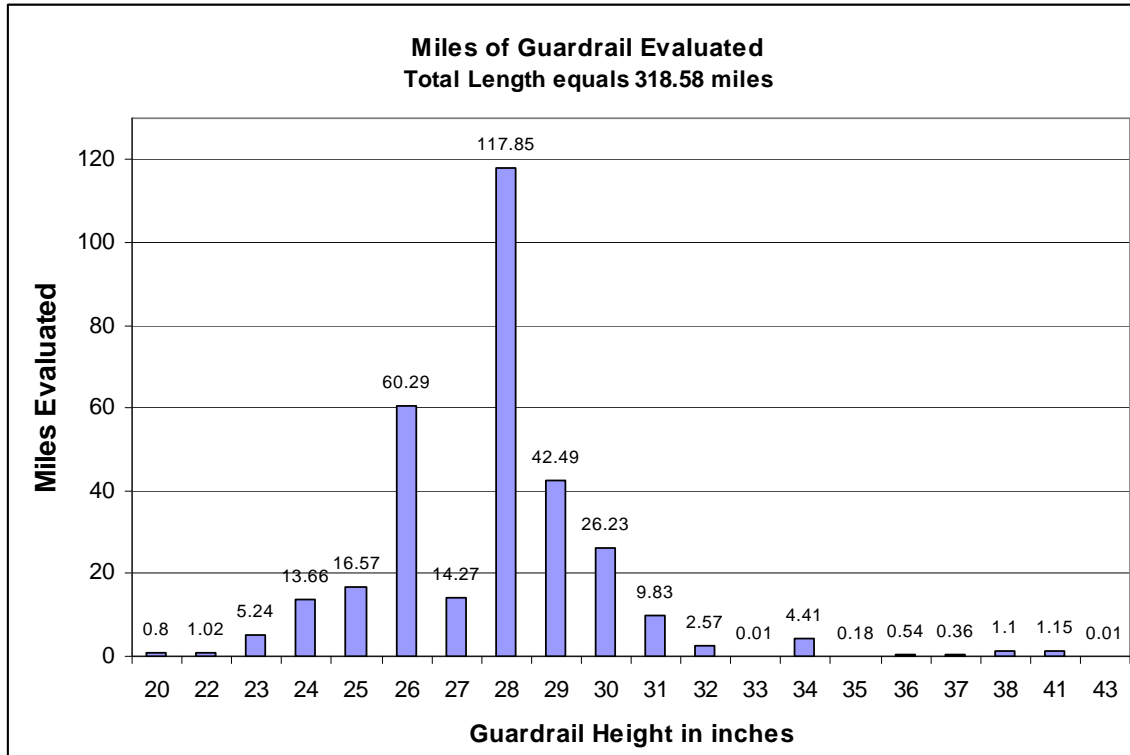


Figure 1

Figure 1 shows the range of heights of guardrail and the associated length of miles within the analysis. It is clear that the majority of the data available will be of guardrail with heights below the 31-inch threshold.

Whether this is an accurate proportional reflection of the statewide system heights is unclear, as the data collection is not yet complete. The total number of miles is simply a sum of those segments of guardrail where a collision occurred and that had a valid height value associated.

Figure 2 shows the number of collisions by the guardrail height. Not surprisingly, it is very similar to Figure 1, illustrating that the greatest number of miles exposed to traffic within this study has the greatest number of collisions.

In Figure 3 the three guardrail collision types; face, leading end or TOU are segregated by guardrail height. This reflects all 1,806 collisions. Again, the guardrail heights where we have the greatest mileage exposed to traffic shows the greatest number of penetrations. This chart does show a seemingly consistent balance between the three categories at each height of the guardrail.

In Figure 4, the total number of collisions per height of the guardrail is shown along with the number of those collisions that penetrated the guardrail at the same height. In the 1,806 collisions, there were 90 instances where the vehicle penetrated the guardrail.

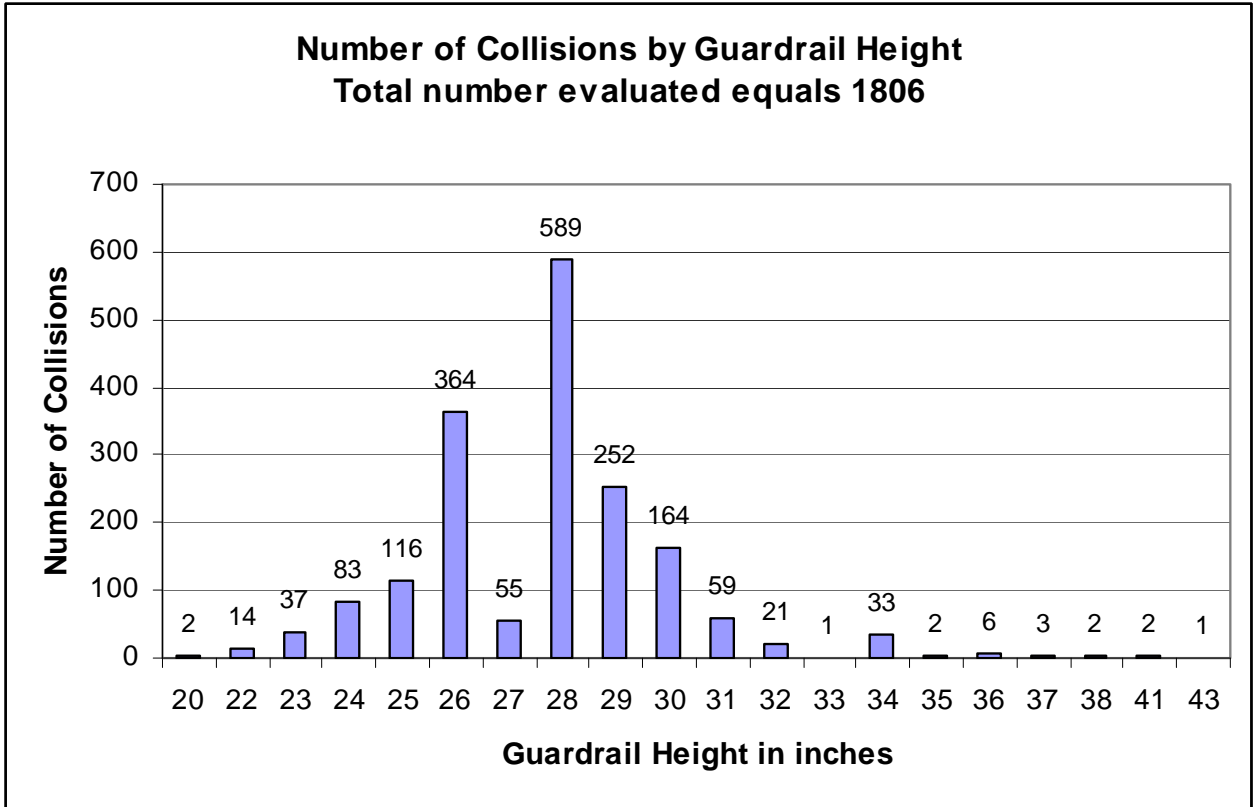


Figure 2

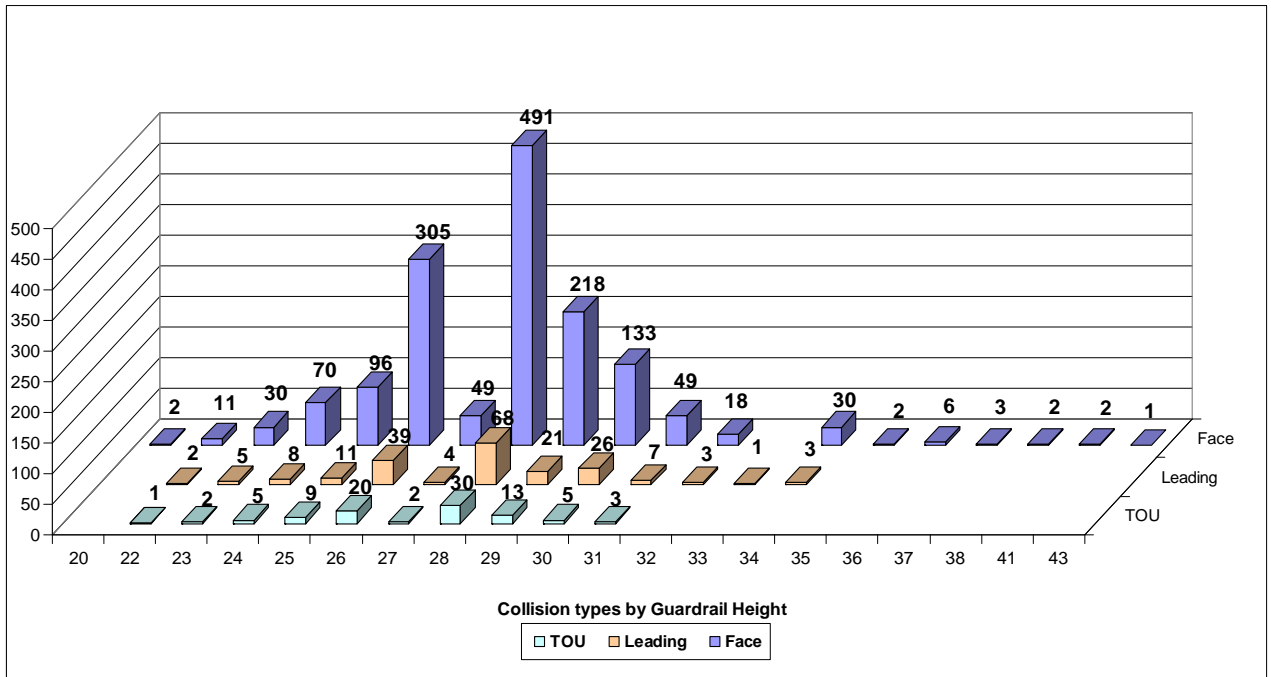


Figure 3

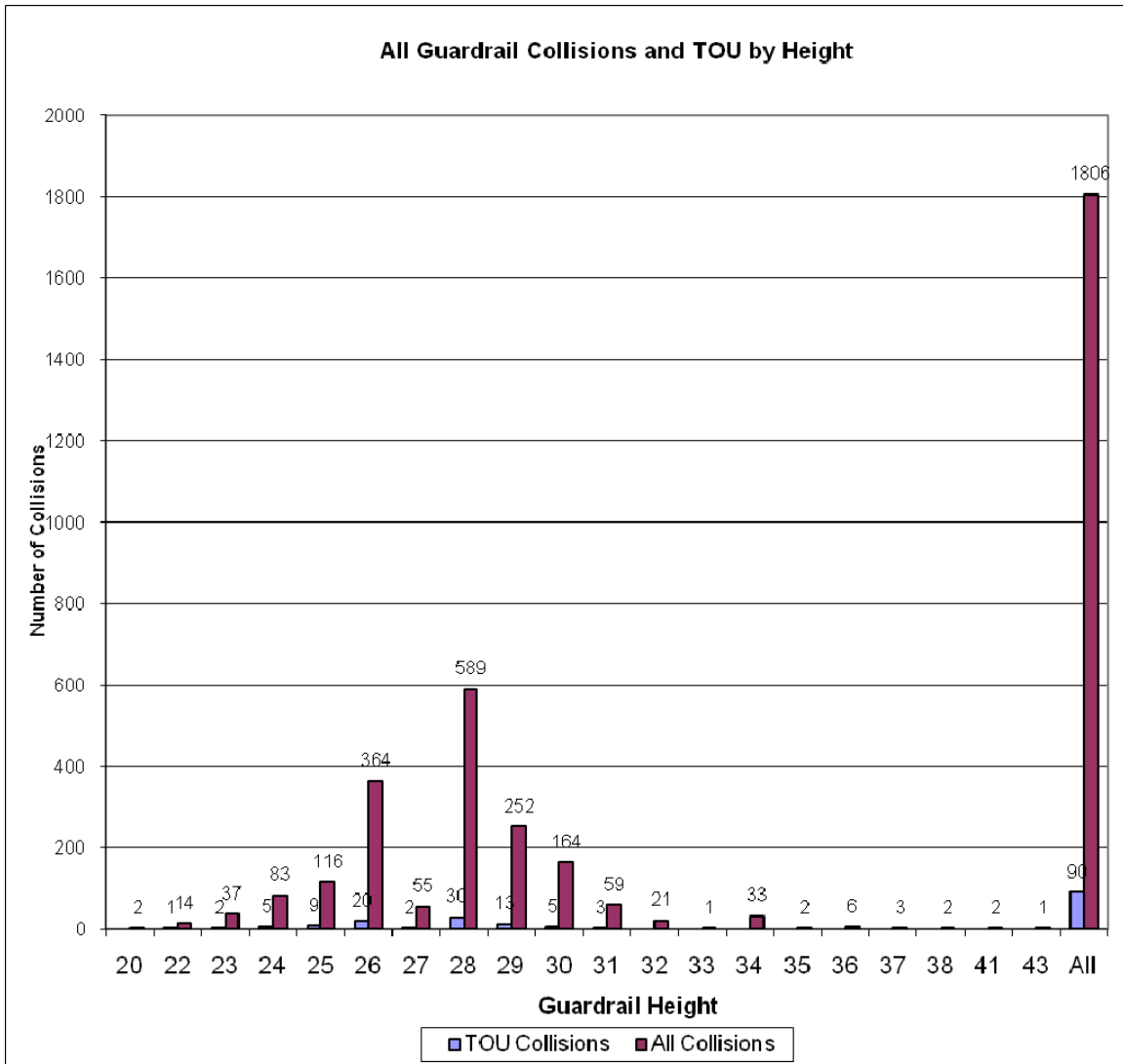


Figure 4

The previous charts in Figures 1 – 4, show that collision data for guardrail heights above 34 inches are very limited, with 16 collisions associated with a valid height of greater than 34 inches.

Of these 16 collisions; ten were Property Damage Only (PDO), four were Possible injuries, one Evident Injury, and one Serious injury. There were no instances of a TOU collision within these 16 collisions.

The lengths of guardrail run where these 16 collisions occurred totals 3.34 miles out of the total 318.58 miles of the dataset (or slightly more than 1% of the total mileage).

With this lack of TOU collisions and the limited data for collisions above 34 inches, these will not be shown in most of the following charts, however the total number of collisions and injury severity data will reflect these 16 collisions.

Figure 5 shows the percentage of collisions that were TOU penetrations at each guardrail height. Within the study, the average of all collisions that penetrated guardrail at all heights was 5.0%. In this view, it appears there is no real trend indicated in these data at guardrail heights greater than 26 inches.

It might be helpful to look at the data in a tighter range of heights. If we look at the data between 26 to 31 inches in height, we find that 85% of the total mileage evaluated is within this range (301.19 miles). 85% of the total collisions (1,538 collisions) and 83% of all TOU penetrations (75 TOU collisions) are also within this range of heights.

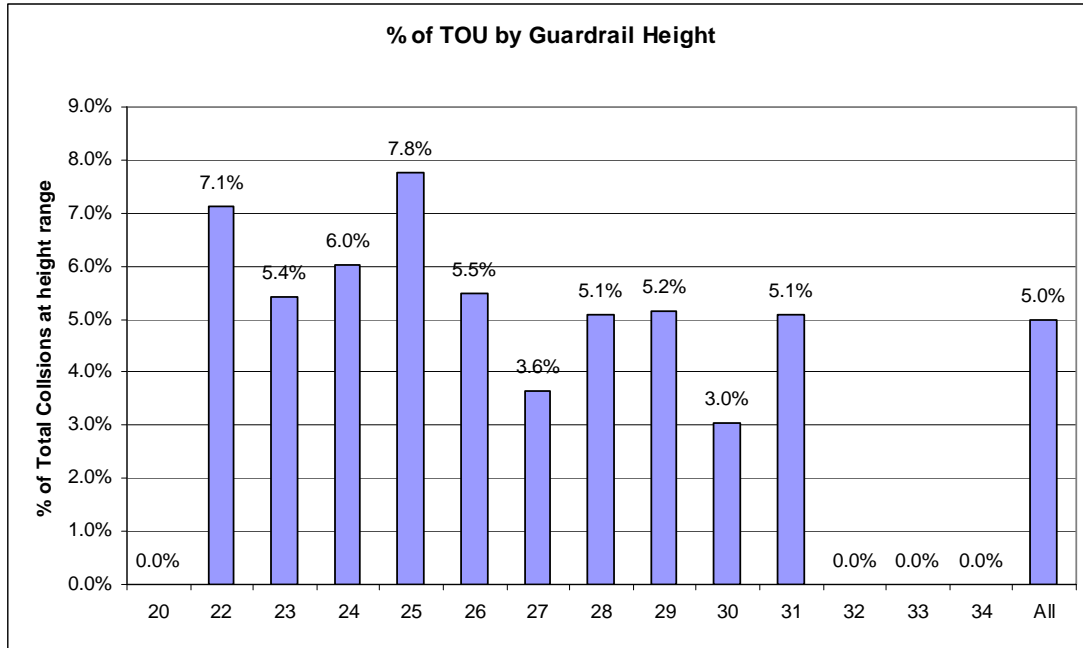


Figure 5

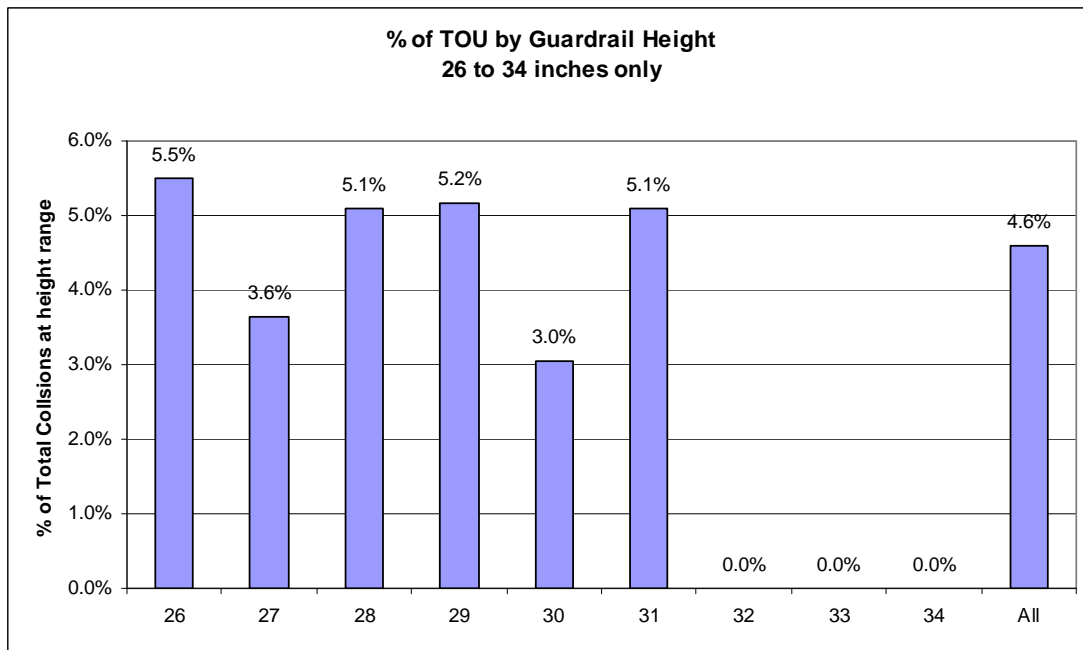


Figure 6

Figure 6 shows this range of 26 to 31 inch heights, and the percentage of those collisions that are TOU penetrations. These percentages are rather consistent across this 6 inch height range and do not indicate any clear benefit of guardrail at heights above the 27 inch point reducing TOU penetrations. The difference in the “All” value between Figures 5 and 6 is related to a tighter range of heights, Figure 6 using the total of the 26 to 31 inch range.

In looking to injury severity associated to guardrail height data caution should be used in interpreting the data as previously discussed.

Figure 7 shows the number of no injury or property damage only (PDO) collisions along with the total number of collisions at the associated height of the guardrail. In this view, it appears that the experience of PDO is roughly similar across the height ranges.

Figure 8 shows this similar experience more clearly by charting the percentage of collisions that are PDO at the specific guardrail height. In the range of 26 to 31 inches, as an average 60% of all collisions are PDO. In the instance of the 33 inch range, the 100% reflects a single collision which was a PDO collision.

Figure 9 shows the number of serious and fatal collisions by height. The total number of fatal collisions within this set of 1,806 collisions was 20 of which four were TOU; the total of serious injury collisions was 64 of which eight were TOU. This chart was carried to the 37 inch height to reflect the single serious collision that occurred at this height. In looking at this data, it appears that fatal and serious collisions are dropping off above the 28-inch height; this may be more of a function of the limited data and mileage evaluated than an accurate conclusion however.

Looking to Figure 10 where this same fatal and serious data is shown as a percentage of the collisions, it is clear there is no performance increase at higher than the 28-inch point. In fact, it is clear that there is no clear relationship between guardrail height and the percentage of serious and fatal collisions.

The lack of a consistent trend in regards to injury severity is maybe due to the limited data available or it maybe a function of other unevaluated conditions such as vehicle type, roadway geometrics, speed limits or driver actions. These separate conditions were not analyzed in this study.

Conclusions

There are no clear trends or indicators that guardrail height between 27 and 31 inches reduces or increases the number of TOU collisions. With the data available, it appears that the percentages of TOU are consistent between heights of 26 to 31, a six-inch span. With injury severity, the percentage of PDO collisions seems to be rather consistent across the height ranges evaluated, however the percentage of serious and fatal collisions does not exhibit a similar trend across the height ranges.

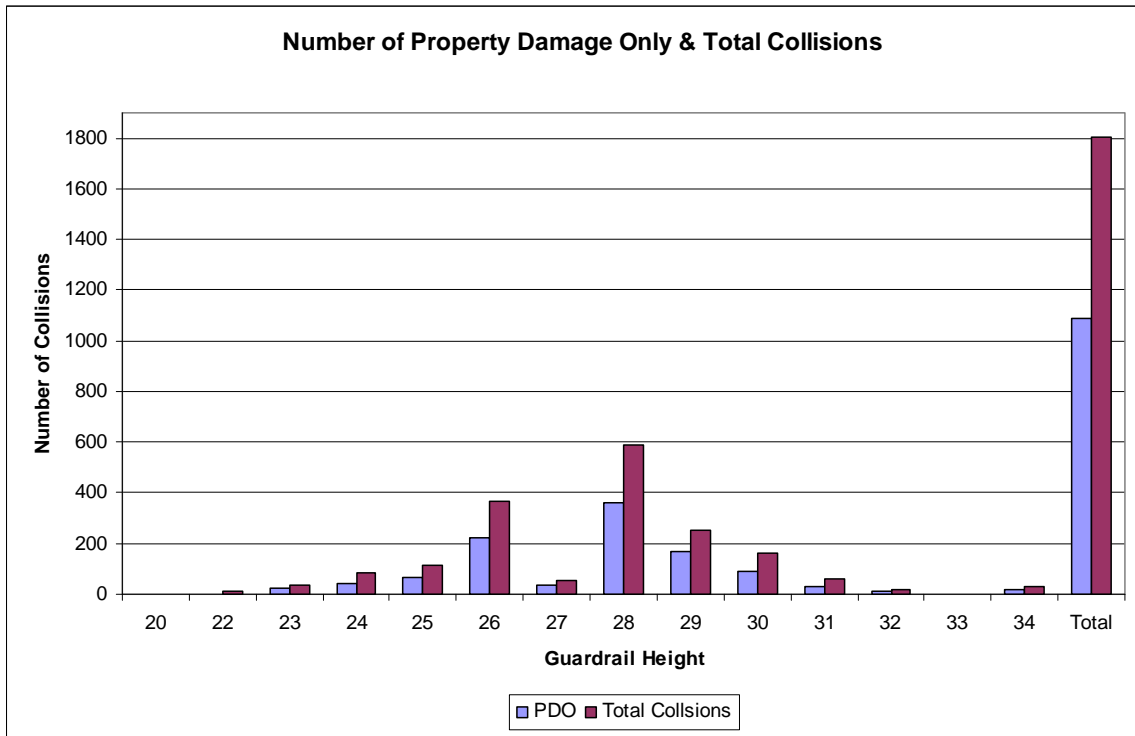


Figure 7

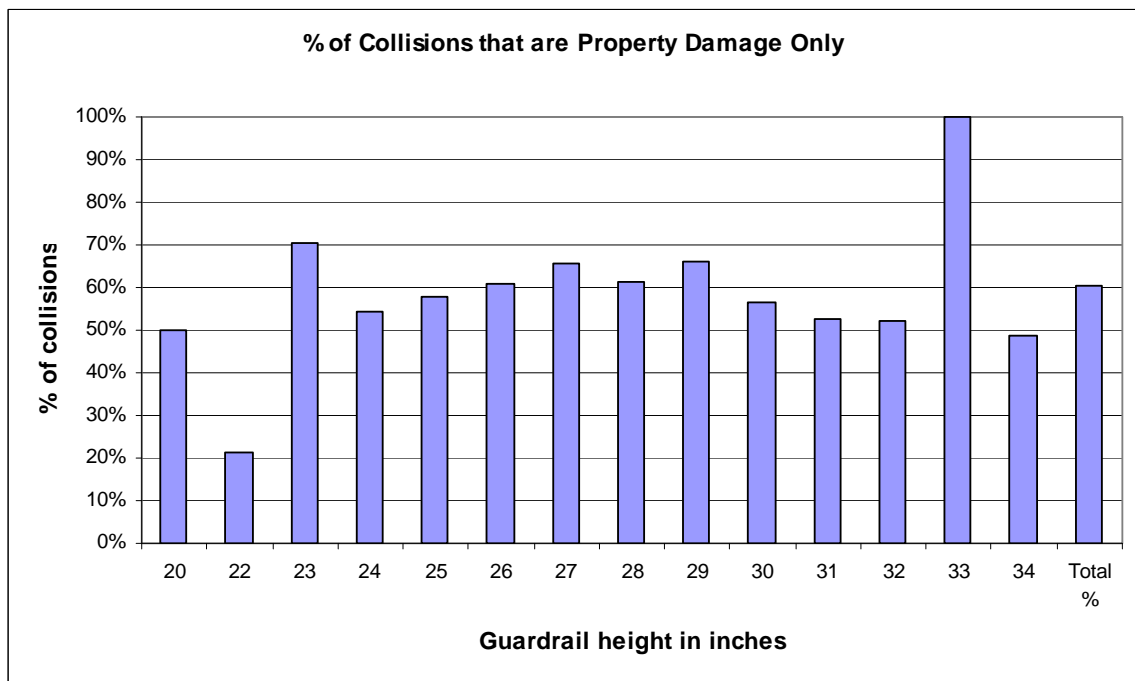


Figure 8

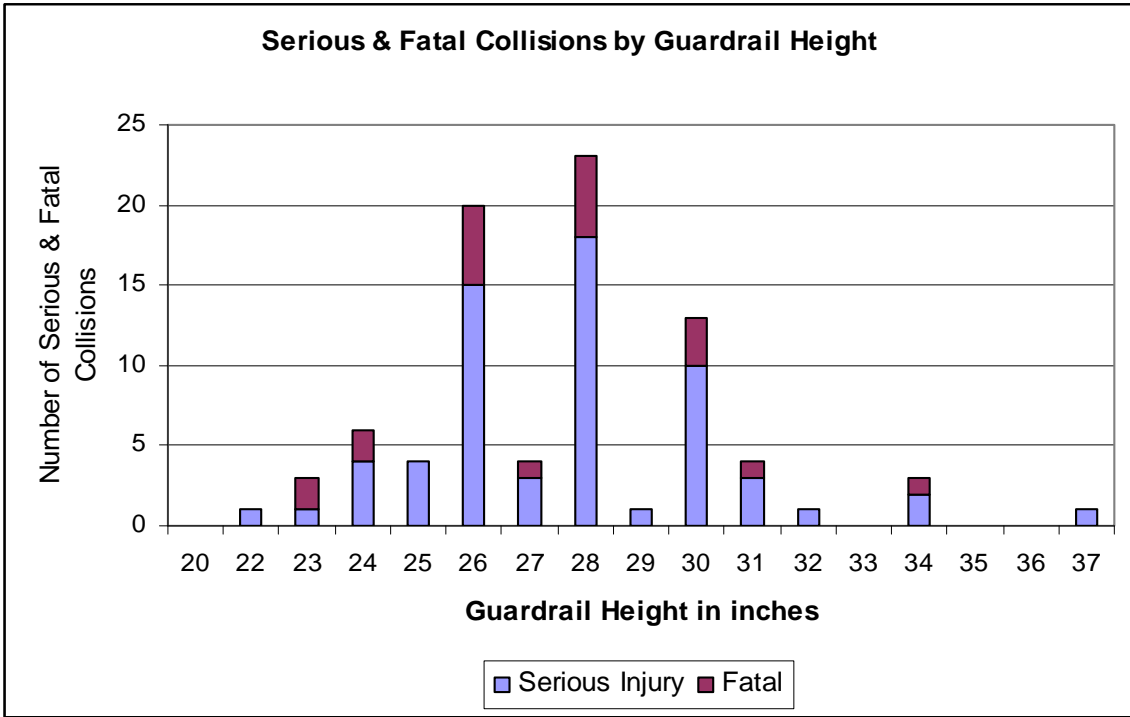


Figure 9

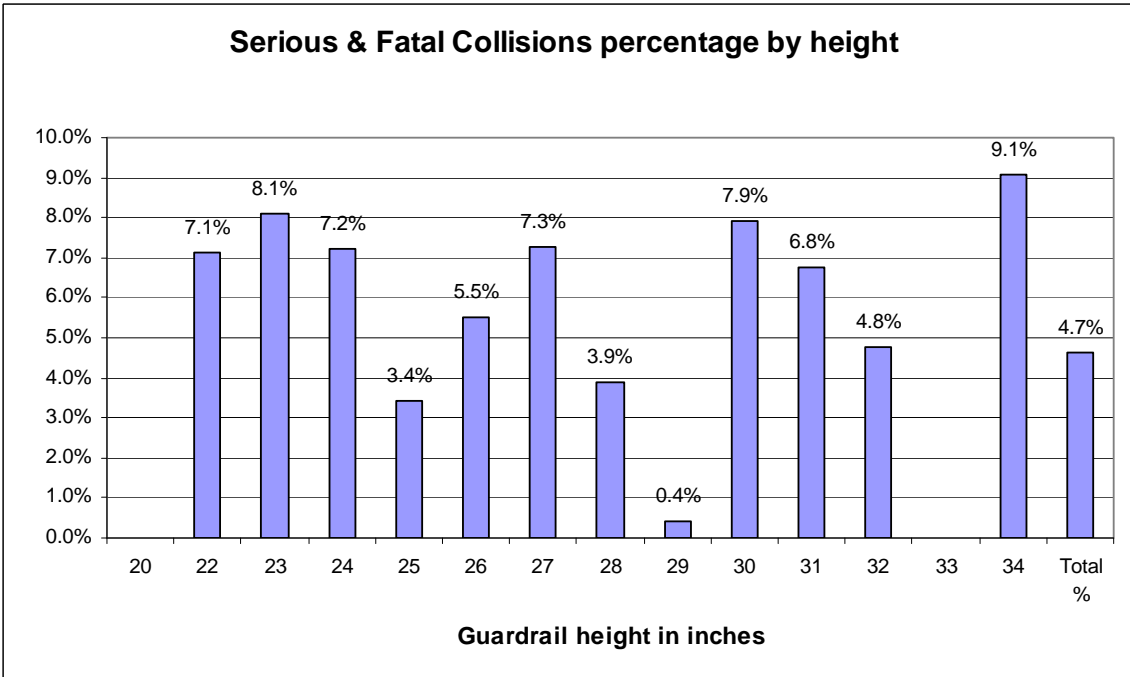


Figure 10