EVALUATION OF 38 YEARS OF ROLLOVER CRASH TESTING DRAG FACTORS FOR CRASH RECONSTRUCTIONS

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INTRODUCTION

Recent publications of naturally occurring steer induced rollover crash test results have focused attention on their utility relative to a historical database of dolly rollover test results used in crash reconstruction. A comparison was conducted of numerous historical studies by reexamination of the original works, analysis of their data, and centralized compilation and analysis of their results. Instances were identified where presented original results may require reevaluation because of the analysis technique employed (extrapolation versus integration) and accounting for instrumentation offset errors (Stevens, 2011) that develop by placing the Global Positioning System (GPS) antenna away from the vehicle Center of Gravity. An analysis was preformed demonstrating a corrected result. In total 81 dolly rollover crash tests, 24 naturally occurring rollover crash tests, and 102 reconstructed rollovers were identified. Of the 24 naturally occurring tests 18 were steer induced rollover tests. Distributions of the various rollover drag factors are presented.

RESULTS

The range of drag factors for all examined dolly rollovers was 0.38 g to 0.50 g with the upper and lower 15 percent statistically trimmed. The average drag factor for dolly rollovers was 0.44 g (Standard Deviation = 0.064) with a reported minimum of 0.31 g and a reported maximum of 0.61 g. The range of drag factors for the set of naturally occurring rollovers was 0.39 g to 0.50 g with the upper and lower 15 percent statistically trimmed. The average drag factor for naturally occurring rollovers was 0.44 g (Standard Deviation = 0.063) with a reported minimum of 0.33 g and a reported maximum of 0.57 g.

Reevaluation of roll phase analysis published in two papers reporting results of rollover tests on an actual highway (Asay, 2009 and 2010) found lowered average roll phase drag factors as shown in table 1. The average roll phase drag factor published in the papers was 0.53 g (min = 0.39, max = 0.74) and the average reevaluated drag factor was 0.45 g (min = 0.36, max = 0.52). Reevaluation was performed from data published in the papers. A final analysis should be conducted using the actual test data.

Published results of reconstruction derived roll phase drag factors (Hight, 1972) between 0.40 g and 0.65 g was confirmed as the range representing the middle 60% of pre-1972 reconstructed rollover crashes on flat ground, figure 3. The reconstructed drag factors were in a range of 0.04 g to 1.20 g for all 102 plotted results, including downhill rollovers and rollovers with vertical drops. For rollovers on flat ground the reconstructed range was 0.21 g to 0.83 g.

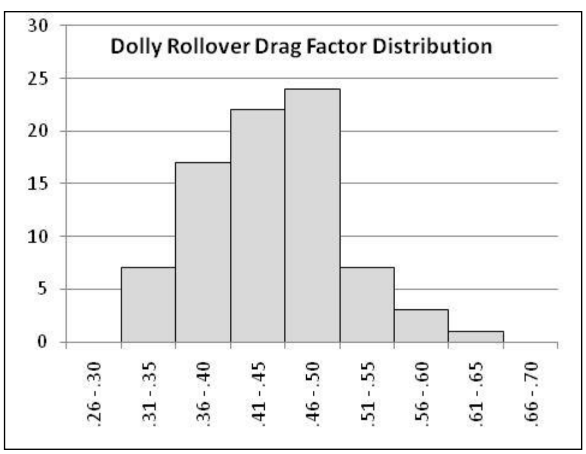

Figure 1. Dolly Rollover Drag Factor Distribution.

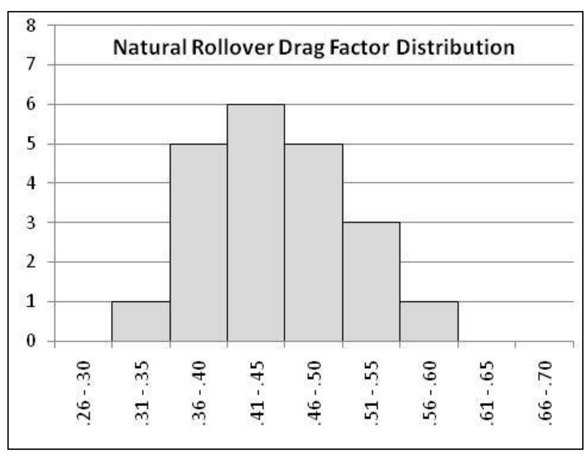

Figure 2. Naturally Rollover Drag Factor Distribution.

Vehicle	Reference	Test No.	Published trip speed (mph)	Reevaluated trip speed (mph)	Roll distance (ft)	Published Drag factor	Reevaluated Drag factor
96 Buick Skylark	SAE2009-01-1544	test 2	45.6	41.6	122.4	0.57	0.47
84 AMC Eagle	SAE2009-01-1544	test 3	36.4	34.6	82.2	0.54	0.49
87 Ford Taurus	SAE2009-01-1544	test 5	27.1	27.1	62.5	0.39	0.39
91 Ford Escort	SAE2009-01-1544	test 6	51.6	51.6	173.6	0.51	0.51
96 Oldsmobile Bravada	SAE2010-01-0521	test 1	63.4	57.2	266.6	0.50	0.41
91 Isuzu Rodeo	SAE2010-01-0521	test 2	50.7	44.4	185.3	0.46	0.36
94 Nissan Pathfinder	SAE2010-01-0521	test 4	41.3	36.7	114.1	0.50	0.39
02 Ford Explorer	SAE2010-01-0521	test 6	35.2	32.4	78.6	0.53	0.45
98 Ford Expedition	SAE2010-01-0521	test 7	34.0	28.7	52.5	0.74	0.52
91 Montero	SAE2010-01-0521	test 8	66.1	61.0	242.6	0.60	0.51

Table 1. Summary of the original and reevaluated results from test on an actual highway.

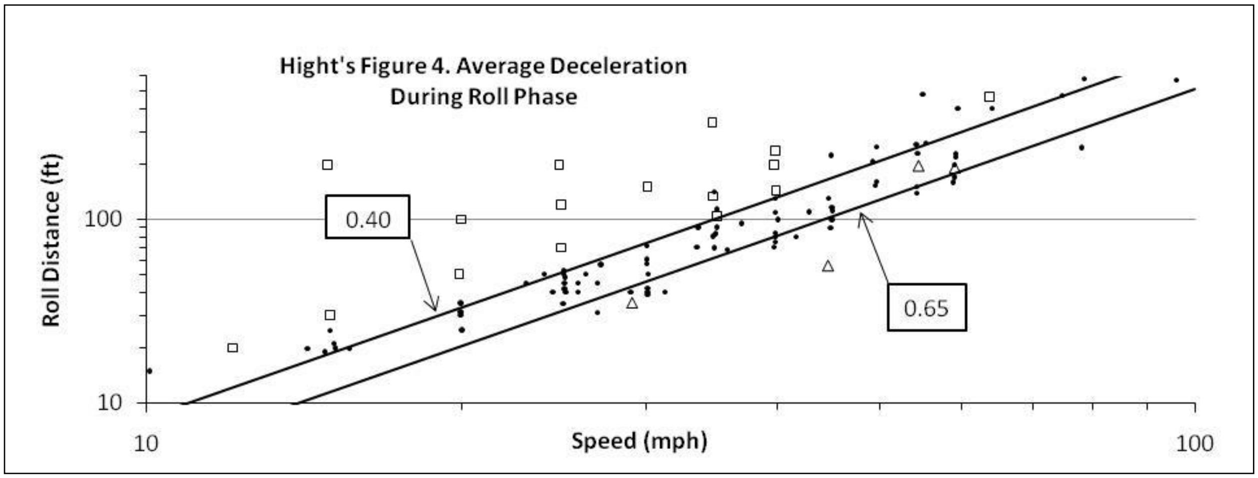

Figure 3. The original Hight Figure was recreated above by digitizing the original graph. Boxes represents downhill roll and triangles represented vertical drop before landing on flat ground. Level ground incidents were depicted with a point.

CONCLUSION

- Dolly rollover tests suggest that the appropriate drag factor range for use in rollover reconstruction, excluding special circumstance, is 0.38 to 0.50. The finding is from the calculated results of 81 dolly rollover crash tests statistically trimmed to exclude the upper and lower 15 percent.
- Reevaluation of roll phase analysis of rollover tests on an actual highway found lowered average roll phase drag factors. The average roll phase drag factor as published in the papers was 0.53 g (min = 0.39, max = 0.74) and the average reevaluated drag factor was 0.45 g (min = 0.36, max = 0.52). Natural rollover tests suggest the appropriate drag factor range, excluding special circumstances, is 0.39 to 0.50. The finding is from the calculated results of 21 naturally occurring rollover crash tests statistically trimmed to exclude the upper and lower 15 percent.

REFERENCES

- Hight, Philip V., Siegel, Arnold W., and Nahum, Alan M., Injury Mechanisms in Rollover Collisions, SAE Paper 720966.
- Asay, Alan F. and Woolley, Ronald L., Rollover Testing on an Actual Highway, SAE 2009-01-1544.
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