

June 14, 2005

To: John Szerlag, City Manager

From: Brian Murphy, Asst. City Manager/Services
Steve Vandette, City Engineer
John Abraham, Traffic Engineer

Subject: Research Paper on STOP Signs - FYI

Enclosed, please find some informational materials related to STOP signs. The attached paper is a result of searching over 70 technical papers about multi-way stop signs. The study concentrated on their use as traffic calming devices and their relative effectiveness in controlling speeds in residential neighborhoods.

The summary of the paper is that researchers found that multi-way stop signs do not control speed. Following are some excerpts from the paper:

- Stop compliance is poor at unwarranted multi-way stop signs. This is based on the drivers feeling that the signs have no traffic control purpose. There is little reason to yield the right-of-way because there are usually no vehicles on the minor street. Nineteen references found this to be their finding
- Before-After studies show multi-way stop signs do not reduce speeds on residential streets. Nineteen references found this to be their finding
- Unwarranted multi-way stops increased speed some distance from intersections. The studies hypothesizing that motorists are making up the time they lost at the "unnecessary" stop sign. Fifteen references found this to be their finding
- Multi-way stop signs have high operating costs based on vehicle operating costs, vehicular travel times, fuel consumption and increased vehicle emissions. Fifteen references found this to be their finding.
- Safety of pedestrians is decreased at unwarranted multi-way stops, especially small children. It seems that pedestrians expect vehicles to stop at the stop signs but many vehicles have gotten in the habit of running the "unnecessary" stop sign. Thirteen references found this to be their finding
- Citizens feel "safer" in communities "positively controlled" by stop signs. Positively controlled is meant to infer that the streets are controlled by unwarranted stop signs. Homeowners on the residential collector feel safer on a 'calmed' street. Seven references found this to be their finding.
- Unwarranted multi-way stops may present potential liability problems for undocumented exceptions to accepted warrants. Local jurisdictions feel they may be incurring higher liability exposure by 'violating' the MUTCD. Many times the unwarranted stop signs are installed without a warrant study or some documentation. Cited by six references.
- Stop signs increase noise in the vicinity of an intersection. The noise is created by the vehicle braking at the intersection and the cars accelerating up to speed. The noise is created by the engine exhaust, brake, tire and aerodynamic noises. Cited by five references.

Multi-way Stops - The Research Shows the MUTCD is Correct!

W. Martin Bretherton Jr., P.E.(M)

Abstract

This paper reviewed over 70 technical papers covering all-way stops (or multi-way stops) and their success and failure as traffic control devices in residential areas. This study is the most comprehensive found on multi-way stop signs

The study looked at how multi-way stop signs have been used as traffic calming measures to control speed. There have been 23 hypotheses studied using multi-way stop as speed control. The research found an additional 9 hypotheses studied showing the effect multi way stops have on other traffic engineering problems.

The research found that, overwhelmingly, multi-way stop signs do NOT control speed except under very limited conditions. The research shows that the concerns about unwarranted stop signs are well founded.

Introduction

Many elected officials, citizens and some traffic engineering professionals feel that multi-way stop signs should be used as traffic calming devices. Many times unwarranted stop signs are installed to control traffic. The Manual on Uniform Traffic Control Devices (MUTCD)(16) describes warrants for installing multi-way stop signs. However, it does not describe many of the problems caused by the installation of unwarranted stop signs. These problems include concerns like liability issues, traffic noise, automobile pollution, traffic enforcement and driver behavior.

This paper is a result of searching over 70 technical papers about multi-way stop signs. The study concentrated on their use as traffic calming devices and their relative effectiveness in controlling speeds in residential neighborhoods. The references found 23 hypotheses on their relative effectiveness as traffic calming devices. One study analyzed the economic cost of installing a multi-way stop at an intersection. The reference search also found 9 hypotheses about traffic operations on residential streets.

The literature search found 85 papers on the subject of multi-way stops. There are probably many more references available on this very popular subject. The seventy-one references are

shown in Appendix A. There was a problem finding the 14 papers found in literature searches. The 14 papers are listed in Appendix B for information only. Most of the papers were from old sources and are probably out of print.

Multi-Way Stop Signs as Speed Control Devices

A summary of the articles found the following information about the effectiveness of multi-way stop signs and other solutions to controlling speeds in residential neighborhoods.

1. Multi-way stops do not control speeds. Twenty-two papers were cited for these findings. (Reference 1, 2, 7, 8, 10, 12, 13, 14, 15, 16, 17, 19, 20, 39, 45, 46, 51, 55, 62, 63, 64, 66 and 70).
2. Stop compliance is poor at unwarranted multi-way stop signs. Unwarranted stop signs means they do not meet the warrants of the MUTCD. This is based on the drivers feeling that the signs have no traffic control purpose. There is little reason to yield the right-of-way because there are usually no vehicles on the minor street. Nineteen references found this to be their finding. (Reference 7, 8, 10, 12, 13, 14, 15, 17, 19, 20, 39, 45, 46, 51, 55, 61, 62, 63 and 64).
3. Before-After studies show multi-way stop signs do not reduce speeds on residential streets. Nineteen references found this to be their finding. (Reference 19 (1 study), 55 (5 studies), 60 (8 studies) and 64(5 studies)).
4. Unwarranted multi-way stops increased speed some distance from intersections. The studies hypothesizing that motorists are making up the time they lost at the "unnecessary" stop sign. Fifteen references found this to be their finding.(Reference 1, 2, 7, 8, 10, 13, 14, 17, 19, 20,39, 45,46, 51, 55, 70 and 71).
5. Multi-way stop signs have high operating costs based on vehicle operating costs, vehicular travel times, fuel consumption and increased vehicle emissions. Fifteen references found this to be their finding. (Reference 3, 4, 7, 8, 10, 14, 15, 17, 45, 55 ,61, 62, 63, 67 and 68).
6. Safety of pedestrians is decreased at unwarranted multi-way stops, especially small children. It seems that pedestrians expect vehicles to stop at the stop signs but many vehicles have gotten in the habit of running the "unnecessary" stop sign. Thirteen references found this to be their finding. (References 7, 8, 10, 13, 14, 15, 17, 19, 20, 45, 51, 55 and 63).
7. Citizens feel "safer" in communities "positively controlled" by stop signs. Positively controlled is meant to infer that the streets are controlled by unwarranted stop signs. Homeowners on the residential collector feel safer on a 'calmed' street. Seven references found this to be their finding. (Reference 6, 14, 18, 20, 51, 58 and 66).

Hypothesis twelve (below) lists five references that dispute the results of these studies.

8. Speeding problems on residential streets are associated with "through" traffic. Frequently homeowners feel the problem is created by 'outsiders'. Many times the problem is the person complaining or their neighbor. Five references found this to be their finding. (References 2, 15, 45, 51 and 55).
9. Unwarranted multi-way stops may present potential liability problems for undocumented exceptions to accepted warrants. Local jurisdictions feel they may be incurring higher liability exposure by 'violating' the MUTCD. Many times the unwarranted stop signs are installed without a warrant study or some documentation. Cited by six references. (Reference 7, 9, 19, 46, 62 and 65).
10. Stop signs increase noise in the vicinity of an intersection. The noise is created by the vehicle braking noise at the intersection and the cars accelerating up to speed. The noise is created by the engine exhaust, brake, tire and aerodynamic noises. Cited by five references. (Reference 14, 17, 20, 45, 55).
11. Cost of installing multi-way stops are low but enforcement costs are prohibitive. many communities do not have the resources to effectively enforce compliance with the stop signs. Five references found this to be their finding. (Reference 1, 10, 45, 51, 55).
12. Stop signs do not significantly change safety of intersection. Stop signs are installed with the hope they will make the intersection and neighborhood safer. Cited by five references. (Reference 55, 60, 61, 62, 63).

Hypothesis seven (above) lists seven references that dispute the results of these studies.

13. Unwarranted multi-way stops have been successfully removed with public support and result in improved compliance at justified stop signs. Cited by three references. (Reference 8, 10, 12).
14. Unwarranted multi-way stops reduce accidents in cities with intersection sight distance problems and at intersections with parked cars that restrict sight distance. The stop signs are unwarranted based on volume and may not quite meet the accident threshold. Cited by three references. (Reference 6, 18, 68).
15. Citizens feel stop signs should be installed at locations based on traffic engineering studies. Some homeowners realize the importance of installing 'needed' stop signs. Cited by two references. (References 56, 57).
16. Multi-way stops can reduce cut-through traffic volume if many intersections along the road are controlled by stop signs. If enough stop signs are installed on a residential or

collector street motorists may go another way because of the inconvenience of having to start and stop at so many intersections. This includes the many drivers that will not stop but slowly 'cruise' through the stop signs. This driving behavior has been nicknamed the 'California cruise'. Cited by two references. (Reference 14, 61).

17. Placement of unwarranted stop signs in violation of Georgia State Law 32-6-50 (a) (b) (c). This study was conducted using Georgia law. Georgia law requires local governments to install all traffic controls devices in accordance with the MUTCD. This is probably similar to traffic signing laws in other states. Cited by two references. (Reference 19, 62).
18. Special police enforcement of multi-way stop signs has limited effectiveness. This has been called the 'hallo' effect. Drivers will obey the 'unreasonable' laws as long as a policemen is visible. Cited by two references. (Reference 39, 46).
19. District judge orders removal of stop signs not installed in compliance with city ordinance. Judges have ordered the removal of 'unnecessary' stop signs. The problem begins when the traffic engineer and/or elected officials are asked to consider their intersection a 'special case'. This creates a precedent and results in a proliferation of 'special case' all-way stop signs. Cited by two references. (Reference 59, 62).
20. Some jurisdictions have created warrants for multi-way stops that are easier to meet than MUTCD. The jurisdiction feel that the MUTCD warrants are too difficult to meet in residential areas. The reduced warrants are usually created to please elected officials. Cited by two references. (Reference 61 and 70).
21. Citizens perceive stop signs are effective as speed control devices because traffic "slows" at stop sign. If everybody obeyed the traffic laws, stop signs would reduce speeds on residential streets. Cited by one reference. (Reference 55).
22. Removal of multi-way stop signs does not change speeds but they are slightly lower without the stop signs. This study findings support the drivers behavior referenced in item #4, speed increases when unwarranted stop signs are installed. Speed decreases when the stop signs were removed! Cited by one reference. (Reference 64).
23. Multi-way stops degrade air quality and increase CO, HC, and Nox. All the starting and stopping at the intersection is bad for air quality. Cited by one reference. (Reference 68).

Speed Control Issues

24. There area many ways to "calm" traffic. Cited by twenty-two references. (Reference 1, 14, 20, 32, 33, 34, 35, 36, 37, 38, 40,41,42, 44, 45, 46, 47, 48, 50, 51, 53 and 66).

They include:

- (a) Traffic Chokers
- (b) Traffic Diverters
- (c) Speed Humps
- (d) Roundabouts
- (e) Neighborhood Speed Watch
- (f) Sidewalks and Other Pedestrian Solutions
- (g) Neighborhood Street Design
- (h) On-Street Parking
- (i) One Way Streets
- (j) Street Narrowing

25. Other possible solutions to residential speed. Most speeding is by residents - Neighborhood Speed Watch Programs may work. This program works by using the principle of 'peer' pressure. Cited by seven references. (Reference 2, 30, 31, 36, 42, 48 and 53).
26. Reduced speed limits are not effective at slowing traffic. Motorists do not drive by the number on the signs, they travel a safe speed based on the geometrics of the roadway. Cited by five references. (Reference 1, 20, 39, 46 and 69).
27. Local streets should be designed to discourage excessive speeds. The most effective way to slow down traffic on residential streets is to design them for slow speeds. Cited by two references. (Reference 43, 52).
28. Speeding on residential streets is a seasonal problem. This is a myth. The problem of speeding is not seasonal, it's just that homeowners only see the problem in 'pleasant' weather. That's the time they spend in there front yard or walking the neighborhood. Cited by one reference. (Reference 2).
29. Speed variance and accident frequency are directly related. The safest speed for a road is the speed that most of the drivers feel safest driving. This speed creates the lowest variance and the safest road. Cited by one reference. (Reference 47).
30. The accident involvement rate is lowest at the 85th percentile speed. The 85th percentile speed is the speed that most drivers feel comfortable driving. The lowest variance is usually from the 85th percentile speed and the 10 mph less. Cited by one reference. (Reference 47).
31. Psycho-perceptive transverse pavement markings are not effective at reducing the 85th percentile speed but do reduce the highest speed percentile by 5 MPH. Cited by one reference. (Reference 47).
32. The safest residential streets would be short (0.20 miles) non-continuous streets that are 26 to 30 feet from curb to curb width. The short streets make it difficult of drivers to get up to speed. Cited by one reference. (Reference 52).

Economics of Multi-Way Stop Signs

Studies have found that installing unwarranted stop signs increases operating costs for the traveling public. The operating costs involve vehicle operating costs, costs for increased delay and travel time, cost to enforce signs, and costs for fines and increases in insurance premiums.

The total costs are as follows (Reference 55):

Operating Costs (1990) (\$0.04291/Stop)	\$ 111,737/year
Delay & Travel Costs (1990) (\$0.03401/Stop)	\$ 88,556 /year
Enforcement Costs (1990)	\$ 837/year
Cost of Fines (19 per year)	\$ 1,045/year
Cost of 2 stop signs (1990)	\$ 280
Costs of increased insurance (1990)	<u>\$ 7,606/year</u>
Total (1990)	\$210,061/year/intersection

The cost to install two stops signs is \$280. The cost to the traveling public is \$210,061 (1990) per year in operating costs. This cost is based on about 8,000 vehicles entering the intersection per day.

Another study (62) found that the average annual road user cost increased by \$2,402.92 (1988 cost) per intersection when converting from two to four way stop signs for low volume intersections.

Summary of Stop Signs as Speed Control Devices

Researchers found that multi-way stop signs do not control speed. In analyzing the 23 hypotheses for multi-way stop signs, five were favorable and 18 were unfavorable toward installing unwarranted all-way stop signs. The Chicago study (6) was the only research paper that showed factual support for "unwarranted" multi-way stop signs. They were found to be effective at reducing accidents at intersections that have sight distance problems and on-street parking.

It is interesting to note that residential speeding problems and multi-way stop sign requests date back to 1930 (63). The profession still has not "solved" this perception problem.

Summary of Economic Analysis

Benefits to control speeds by installing multi-way stop signs are perceived rather than actual and the costs for the driving public are far greater than any benefits derived from the installation of the multi-way stop signs.

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Appendix A

References used in Research of Multi-Way Stop Signs

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Appendix B

Additional References for Multi-Way Stop Signs

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**STOP SIGN
VIOLATIONS PUT
CHILD PEDESTRIANS AT RISK**

**A National Survey of Motorist Behavior
at Stop Signs in School Zones and
Residential Areas**

October 2003



INTRODUCTION

Walking is a no-cost transportation option that allows parents and children to spend time together, get exercise and improve air quality by not creating vehicle pollutants. Unfortunately, recent evidence indicates that kids are walking less. In 1969, nearly half of elementary school students walked or biked to school.¹ By 1995, only 10 percent of children traveled by foot to school.² This decline can be attributed to many causes, including traffic danger and other hazards that make walking unsafe for children.³

Decreased walking has contributed to a significant decline in child pedestrian deaths and injuries. However, pedestrian injury remains a leading cause of unintentional injury-related death among children.⁴ In 2000, 706 children ages 14 and under died⁵, an estimated 47,300 were treated in hospital emergency rooms for pedestrian-related injuries in 2001.⁶ Nearly 76 percent of these deaths and 73 percent of injuries were motor vehicle-related. The total annual cost of traffic-related pedestrian death and injury among children ages 14 and under is more than \$7.2 billion.⁷

Speeding and other driver behaviors are a contributing factor to pedestrian-related injuries. In 1999, a National SAFE KIDS Campaign survey found that two-thirds of drivers exceeded the posted speed limit in school zones during the 30-minute periods before and after school.⁸

Each year, stop sign violations are associated with approximately 200 fatal crashes and 17,000 non-fatal injury crashes.⁹ Children are at risk of injury when stop sign and pedestrian right-of-way laws are violated, yet studies investigating the rate of compliance with stop signs at intersections where children could be present have been lacking. Now SAFE KIDS and FedEx Express have closely examined driver behaviors at intersections in school zones and residential neighborhoods. This observational study determined the frequency of driver compliance with stop signs at unsignalized, marked and unmarked pedestrian crosswalks near schools and in residential areas.

METHODOLOGY

Data were collected by 72 SAFE KIDS coalitions, representing 39 states and the District of Columbia. Two hundred eighty-eight intersections were surveyed, using instruments and protocols developed by the National SAFE KIDS Campaign. A total of 25,660 vehicles were observed. All surveyed intersections were marked with stop signs and had no additional traffic control measures, such as crossing guards or flashing lights. All intersections were located in a school zone (52 percent) or a residential neighborhood with child pedestrian traffic (48 percent).

Each intersection was observed for 30 minutes by two observers who collected information about vehicle body type, stopping behavior, presence of pedestrians and whether pedestrians were crossing when the vehicle arrived at the intersection. Stopping behaviors were categorized as follows:

Stop before crosswalk – the wheels of the vehicle came to a complete stop before the crosswalk or stop sign (if crosswalk is unmarked)

Stop in or past crosswalk – the wheels of the vehicle came to a complete stop in or past the crosswalk (or past the stop sign if crosswalk is unmarked)

Rolling stop – the vehicle slowed at the crosswalk (marked or unmarked), but the vehicle wheels never came to a complete stop

No stop – the vehicle did not stop or slow significantly at the intersection

All coalitions submitted their surveys to the National SAFE KIDS Campaign for analysis. TELEform 7.0 software was used for data entry. Frequencies were generated using SPSS 8.0.

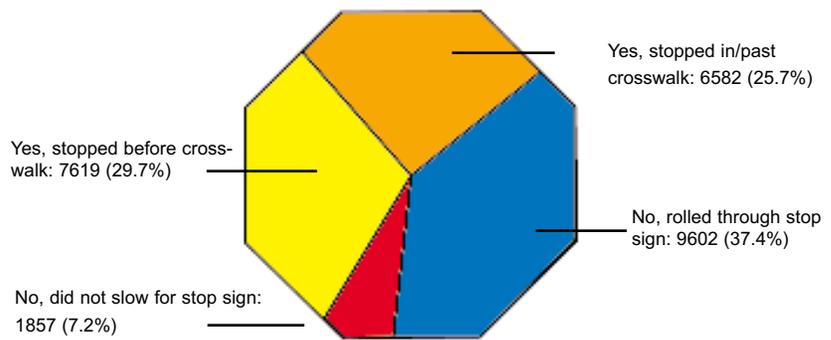


RESULTS

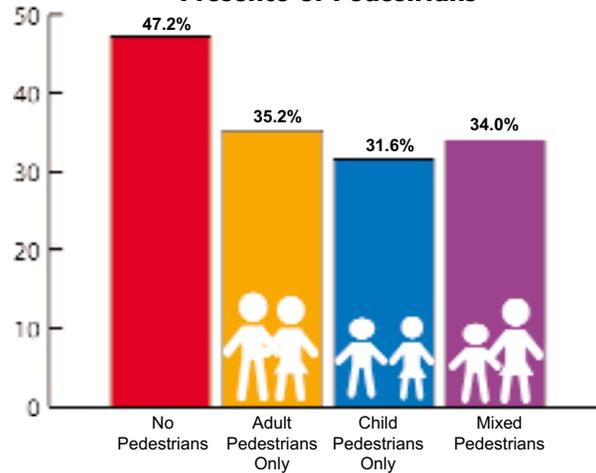
- Motorists did not obey stop signs, putting pedestrians and passengers in other vehicles at risk. Nearly half (45 percent) of vehicles surveyed violated the stop signs by not coming to a complete stop at intersections.
 - More than a third (37 percent) of motorists rolled through the stop signs.
 - Nearly a tenth (7 percent) of motorists did not even slow down for the stop signs.
- When a motorist completed a stop, the vehicle frequently stopped in or past the crosswalk, thus increasing the risk to pedestrians walking across the street. At intersections with marked crosswalks, one quarter (25 percent) of vehicles stopped in or past the crosswalks, impeding the pedestrian pathway.
- Motorists were more likely to stop when pedestrians were present.
 - Nearly a third (32 percent) of motorists violated the stop signs when child pedestrians were present.
 - Nearly half (47 percent) of motorists violated the stop signs when no pedestrians were present.
- Drivers were more likely to stop for pedestrians who were crossing than for those waiting to cross.
 - Nearly a quarter (24 percent) of drivers did not come to a complete stop at intersections where pedestrians were crossing.
 - More than a third (36 percent) of motorists violated the stop signs when pedestrians were waiting to cross.



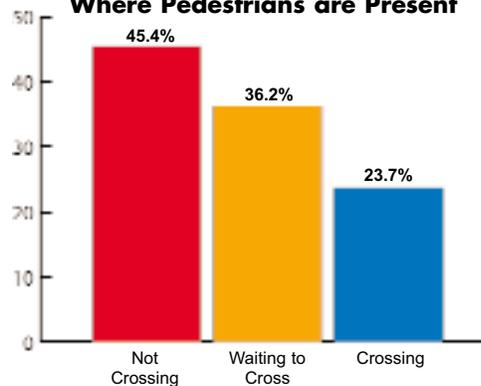
Observation of Stop Sign Violations



Stop Sign Violators in the Presence of Pedestrians



Stop Sign Violations at Intersections Where Pedestrians are Present



DISCUSSION

This observational survey of stop sign compliance in school zones and residential areas indicates that child pedestrians are at risk every day because of motorist behaviors. Child pedestrian safety must be a higher priority for our nation’s drivers.

Teaching children pedestrian safety is not enough, especially since we know that children under age 10 are exposed to traffic threats that exceed their cognitive, developmental, behavioral, physical and sensory abilities. This is exacerbated by the fact that parents often overestimate their children’s pedestrian skills.¹⁰

Child pedestrians cannot ensure their own safety, and parents cannot be sure their children are walking in a safe environment unless motorists – many of whom are also parents – respect traffic laws. Drivers need to be educated about the risks of traffic violations that they may consider to be minor, such as rolling through a stop sign. Enhanced awareness and enforcement of the laws being violated can save lives and create environments that are safe for child pedestrians.



CALL TO ACTION

Since 1999, SAFE KIDS and FedEx Express have teamed up to bring national and local attention to pedestrian safety issues. The two organizations launched the SAFE KIDS Walk This Way program, which has been instrumental in educating local communities about safe pedestrian behaviors and making school zones safer for child pedestrians. Now they are calling upon the 600 SAFE KIDS coalitions and chapters, concerned FedEx Express employees, other safety advocates, and transportation and law enforcement officials to heighten awareness in local communities about stop sign compliance and other safe driving behaviors.

Education

- Create and distribute public awareness tools like public service announcements and brochures to raise awareness of stop sign laws and penalties for violations
- Conduct media campaigns to help drivers learn about safe behaviors
- Encourage parents to walk or bike with their children to school, if possible, to decrease traffic congestion and increase safety
- Provide ongoing drivers' education through state motor vehicle departments
- Promote programs that encourage more walking and less driving, such as the Partnership for a Walkable America's International Walk to School Day
- Develop "walking school buses" or other programs that provide adult supervision along routes child pedestrians take to school

Enforcement and Enactment

- Conduct targeted stop sign enforcement campaigns regularly
- Establish new pedestrian right-of-way and jaywalking laws, and enforce existing ones
- Advocate for stricter penalties and increased fines for violators of stop sign and other traffic laws
- Support federal funding to support Safe Routes to School through the Pedestrian and Cyclist Equity Act of 2003

Engineering

- Dedicate more funds to slowing down cars and increasing the visibility of traffic signs and signals
- Evaluate effectiveness of existing traffic-calming markings, signals and signs
- Assess driving conditions in residential areas and near school zones and determine effective traffic-calming measures

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