

ACCESS MANAGEMENT: MEDIAN TREATMENTS AND THEIR EFFECTS ON REDUCING CRASHES ON IOWA'S URBAN ARTERIALS

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ABSTRACT

Safety on our nations roadways is becoming of great concern with an increasing amount of vehicles on the roads resulting in higher vehicle miles traveled per year. Mitigating efforts to minimize crashes have been heavily studied in recent years. With almost 3.4 million people injured in 1997, the increased concern of safety measures has spurred the investigation of access management techniques. Specifically, the use of medians in the State of Iowa as a mitigating effort to reduce the occurrence and severity of crashes on arterial roadways will be investigated. This paper attempts to justify the use of medians on arterials as a function of overall reduction in economic loss due to injury and property damage costs. This justification will investigate crashes on several segments of arterials across the State of Iowa. Selected segments will be compared in terms of overall crash costs as a function of median usage and this paper will attempt to justify improvements based on cost comparisons.

INTRODUCTION

“Access Management is the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity, and speed. It attempts to balance the need to provide good mobility for through traffic with the requirements for reasonable access to adjacent land uses.” *Federal Highway Administration* (1)

According to the National Highway Traffic Safety Administration, in 1997, 42,013 persons were killed in automobile crashes and 3,399,000 were injured (2). This fact alone has urged me to investigate mitigating efforts to reduce traffic crashes in the State of Iowa. The purpose of this report is to give a justification for the increased use of access management techniques in Iowa and the United States.

The State of Iowa currently has a comprehensive Access Management Awareness Program, a program sponsored by the Iowa Department of Transportation, underway and this paper will expand upon this report by focusing on levels of access management. Specifically this report will evaluate the effectiveness of medians on lowering the number of crashes on roadways resulting in injury and property damage and whether the economic

savings pays for the cost of improvements on existing or new infrastructure. This paper will expand upon recent literature, and the findings that access management techniques have greatly reduced the number of crashes on U.S. roadways and particularly across the State of Iowa. This report will address the following questions:

- What are anticipated and actual goals of access management programs?
- How significant do medians contribute to lowering crash rates on urban arterials in Iowa?
- Does access management provide a justification for improvements on our existing infrastructure?

Benefits of Access Management

There are a number of social and economic benefits that are received from implementing access management strategies. The most important benefit from access management is that motorists experience fewer crashes. Access management can reduce crashes as much as 50% while increasing travel speeds by as much as 40% (3). A reduction of congestion is experienced resulting in the efficient flow of vehicles through the road networks and improved travel time on roads with good access controls. The Colorado DOT reported that access-related crashes cost the State approximately \$900 million in 1994 (1).

Fewer delays and crashes reduce transportation costs for individuals, businesses, and taxpayers. Fewer delays allow businesses to ship and receive more products, thereby increasing their output. Property damage and personal injury are obvious results of crashes. A reduction in crashes helps to control the increasing insurance costs relative to property, health, and life, and reduces the loss of work time, benefiting both employees and employers.

Costs of Crashes

“While it is unpleasant to think of human life and injury in monetary terms, this is precisely what must be done if safety improvements are to be taken into account...when highway investment decisions are made” (3). Motor vehicle crashes cost society millions of dollars as well in lost wages, insurance costs, etc. According to 1994 statistics, the economic cost of crashes in the State of Iowa totaled \$1.4 billion dollars (4). According to the Iowa Department of Transportation (IDOT), cost estimates related to motor vehicle crashes exist for fatal injuries and personal injuries. This data is represented below in Table 1.

TABLE 1 Injury Classification Estimated Associated Costs

Fatal Injury	\$800,000
Major Injury	\$120,000
Minor Injury	\$8,000
Possible Injury	\$2,000

Although there exists discrepancies between agencies to these exact dollar values, for the purposes of evaluation, IDOT values will be used. According to the U.S. 20 Corridor Study, crash rates by hundred million vehicle miles of travel on different levels of highway type exist (3). According to this study, for example, if an existing 2-lane highway is to be rebuilt as a 4-lane expressway, the average fatality rate on the highway might be expected to decline from 2.34 to 1.20 crashes per million vehicle miles traveled. I suggest that if this same analysis were applied to urban arterials using raised medians to those that do not, we may expect to find similar conclusions. I would also suggest that if we were to lower crash rates, the difference in the indexed “costs” of personal injuries and fatalities, combined with property damage, would in turn pay for the differences in construction costs for implementing raised medians on arterial corridors versus not using median control techniques. For example, the construction costs for a 1-mile section of arterial without a raised median is approximately \$1 million. The same arterial could be built with a raised median for approximately \$1.1 million. The costs of right-of-way can only be handled on a case-by-case basis; therefore will not be taken into account in this report.

There are many types of costs associated with crashes. The two costs used in this report include: property damage and an indexed injury costs per crash. Not only do crashes cost the persons involved in the crash, but can be translated into costs covered by taxpayers and employers. Costs covered by employers resulting from motor vehicle crashes fall into three categories.

- Health fringe benefit costs are the costs of fringe benefits paid because of illness and injury. This covers a wide range of costs including, but not limited too, Worker’s Compensation, sick leave, medial insurance, etc.
- Non-fringe costs are incurred to employers when crashes happen when employed including: legal expenses, damage to property, health insurance, and loss of worker productivity.
- Wage premiums; the wages paid to employees who work in high-risk environments and are considered payment in advance for possible injuries.

These costs amounted to \$18.3 billion dollars in health fringe benefits costs, \$24.8 billion in non-fringe costs, and \$11.6 billion in wage-risk premiums for a total of \$54.7 billion in employer costs nationwide in 1995 dollars (6). This report will compare only the costs of property damage and the indexed costs of injuries for analysis purposes.

ACCESS MANAGEMENT TECHNIQUES

Access management requires careful planning considerations of land use and of the current transportation system to be an effective technique for reducing crashes. The following techniques exemplify current trends in access management techniques (1).

- Regulate driveway spacing, corner clearance, and sight distance.
- Increase minimum lot frontage and setback requirements along thoroughfares and regulate lot width-to-depth.
- Restrict the number of driveways per existing parcel or lot and consolidate access wherever feasible.
- Treat properties under the same ownership and those consolidated for development as one property for the purposes of access control.
- The use of Continuous Two-way Left-turn lanes (TWLTL).
- Utilization of medians.
- Driveway Spacing and Regulation.

The regulation of a minimum spacing between driveways is a regulatory method to reduce the number of driveways, driveway density, on major arterial streets. This technique, diagramed in Figure 1, can be implemented at existing locations or during driveway permit stages. Driveway location and design greatly affects the ability to safely enter and exit a parcel of property. If not properly spaced, drivers may be unable to see or anticipate traffic

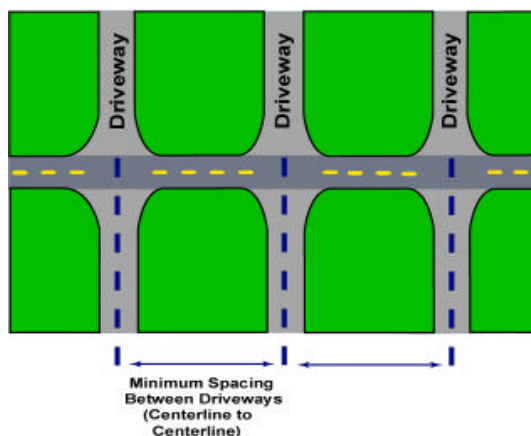


FIGURE 1 Driveway Spacing Regulations

on the road, and traveling motorists on the road may not have adequate time to slow or yield to entering vehicles. Reasonable spacing between driveways is important to the safety and capacity of roadways, as well as the appearance of a corridor. Aesthetically, corridors can become more pleasing to the eye by limiting the number of access points thereby increasing the amount of open/green space that can be used by businesses. By promoting consolidation of driveways for adjacent parcel owners, numerous property owners are connected with common

entrances. This allows vehicles to circulate between businesses without entering the major arterials (4). “This technique indirectly reduces the frequency of conflicts by separating adjacent, basic conflict areas and limiting the number of basic conflict points per length of highway” (7). A conflict point occurs where the path of two traffic movements intersect. This technique is expected to reduce the severity of rear-end collisions as it allows more deceleration distance for motorists.

The use of a continuous two-way-left-turning-lane (TWLTL) in Figure 2, utilizes a middle lane designated as a left-turning lane only. These lanes allow turning traffic to be removed from thru traffic lanes, thereby decreasing the risk of rear-end crashes. Traffic turning left into a drive is removed from the overall traffic flow of the system and these vehicles must yield to all other traffic before exiting the roadway onto a parcel of property.

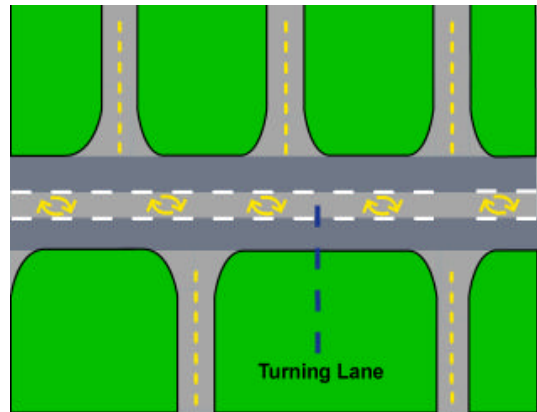


FIGURE 2 Continuous Two-Way-Left-Turning-Lane

MEDIAN TREATMENTS

AASHTO’s Green Book defines a raised median as “...the portion of the highway separating the traveled way for traffic in opposing directions,” and that, “A median is highly desirable on arterials carrying four or more lanes” (8). The utilization of medians, raised or grass, physically separates two or more lanes of traffic and limits turning and cross-traffic. Medians greatly reduce the occurrences of crashes by restricting motorists from making excessive left-turns, by providing freedom from interference of opposing traffic, by limiting the number of motorists crossing over lanes of oncoming traffic, and by reducing headlight glare (1). Raised medians may also greatly affect the aesthetics of a corridor by allowing limited landscaping to be done.

The use of medians and the median type to be used depends on many factors of the roadway and land development. First, the type of highway that is being planned, (i.e., two-lane or four-lane,) and the existing or predicted traffic volumes that would warrant the use and type of median technique, dictate whether a median will be used or not. Second, several land use considerations have to be made when determining the use of medians including: development of property adjacent to the road, (i.e., commercial or industrial), the average annual daily traffic (AADT) these land uses will produce, and the availability of right-of-way. Thirdly, the speeds and existing types of access control may warrant the treatment of medians (9).

There are four basic types of medians recommended for use by the Iowa DOT. These are depressed, raised, painted, and closed.

1. Depressed medians are used with divided highways, which have a common ditch, usually considered grassy medians
2. Raised medians are typically used in urban areas where curbs are used on the outside of the pavement. Raised medians are typically constructed of concrete or may be a concrete-framed raised earth median, which is occasionally landscaped.
3. Painted medians are yellow paint-striped and thus provide no physical barrier other than distance between opposing traffic lanes. Their efficiency relies solely on a driver's ability to readily perceive the painted indication (7).
4. Closed medians are normally used on freeways or expressways in locations with very high traffic volumes or where the amount of separation between opposing directions of travel is minimal or being reduced (such as when inside lanes are being added in the existing median).

Potential Problems Mitigated by Medians

Potential safety problems exist at every intersection or driveway along highway corridors. What effect does median implementation have on the likelihood of crashes? These potential crash points, known as conflicts, can be minimized using the aforementioned median designs. The following diagrams illustrate these conflict points on major arterial roadways. A normal intersection without medians results in 32 conflict points relevant to intersection traffic flow. With the use of a raised (or in some instances a painted median), these conflict points decrease to 18. These techniques prevent some turning movements, while removing turning traffic from thru lanes. These types of medians can be used with or without traffic signaling thereby increasing the prevalent locations of their implementation.

The implementation of direction median openings, diagramed in Figure 3, is a technique that decreases the major conflict points to four. This technique does not allow thru traffic traveling north and south. This type of design offers one of the safest types of access management that can be applied to intersections, but is not widely used across the

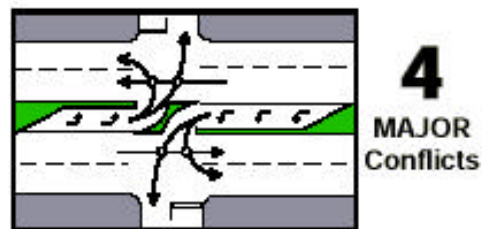


FIGURE 3 Directional Median Opening

State of Iowa.

The next intersection-controlling median is the left-in only, diagramed in Figure 4. This technique only allows for left-turns off major roadways and eliminates any other type of movement. Again, these are only sparsely used in the State, but minimize the major conflict points to two.

The final type of median treatment that can be used on roadways is that of a full-center median. This treatment decreases the major conflict points to zero. A restrictive median is the safest type of access management technique, but does not allow left-turns to be made either onto a parcel of property or roadway. These techniques are commonly used in Iowa on arterials with high volumes of traffic. This is represented below in Figure 5.

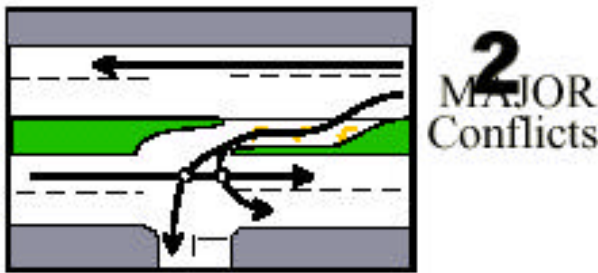


FIGURE 5 Left-In Only Median

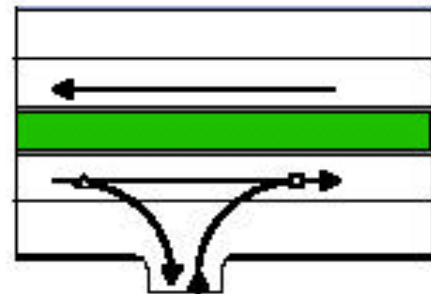


FIGURE 4 Full-Center Median

A REVIEW OF MEDIANS AND THEIR EFFECTS

In one of the earliest studies conducted in 1968, indicated the safety advantages of nontraversable medians over traversable medians in urban areas by comparing the crash experience on two multi-lane streets in Springfield, Illinois. Crash rates on the painted (traversable) median were 2.63 times that of the curbed (nontraversable) median. Analysis also showed that the street having the curbed median had lower crash rates at all locations (i.e., intersections and mid-blocks other than driveways and private driveways) (10).

“It has been demonstrated that median access control results in a substantial reduction in the number of crashes together with a reduction in the associated social and economic costs of injuries, fatalities, and property damage” (3). A review of literature reveals a consensus that the undivided cross section is associated with more crashes than the TLWLT and raised-curb median (10).

According to Bonneson, et al. 1998, the raised-curb median treatment is associated with fewer crashes than the undivided cross section and TWLTL (10). This is based on a safety model represented by regression analysis

that predicts the expected annual crash frequency for a street segment based on its length, average daily traffic demand, median treatment, adjacent land use and total access point density.

According to statistics from a retrofit project in Atlanta, Georgia, an existing TWLTL was replaced by a raised median on a 4.34-mile section of highway during 1989-1990. The results of a before and after study show a 37 percent reduction in total crashes and a 48 percent drop in injury rate (3).

Analysis of Jimmy Carter Blvd., also in Atlanta, Georgia shows that installation of the Jersey median resulted in a substantial reduction in the number of crashes and the crash rates. The total number of crashes decreased by 32 percent and the crash rates decreased by 27 percent on the north section and by 47 percent on the south section when the TWLTL was replaced with the Jersey Barrier (3).

Median width has proven to decrease the number, and severity, of crashes in Illinois and Utah. According to the FHWA, total crash rate appears to decline steadily with increasing median width from 0 to 110 ft. The rate of multi-vehicle crashes declines the most with increasing median width. Some grassy medians are used as recovery areas by out-of-control vehicles, and by vehicles avoiding crashes. This exemplifies how crash rates decrease as median widths increase; vehicles exiting a roadway into a median area allow out-of-control vehicles to avoid crashes (11).

According to case studies conducted by the Center for Transportation Research and Education, Iowa State University, of the six case studies, three used retrofit median treatments. These three cases located in Ankeny, Clive, and Mason City, showed an approximate average of 36 percent decrease in average annual total traffic crashes (1).

METHODOLOGY

The methods for testing whether median usage has an effect on crash occurrences and costs incurred by crashes will be discussed in the following section. It was determined that this study would be a “blind” test of several locations across Iowa. A blind test is one that is based solely on selection criterion rather than on first hand knowledge of a study area. There are limitations to this type of study, which will be discussed further in the limitations section. The blind selection of case study location and arterial segments are discussed further below, but were made using predetermined criterion.

Case study selection was made using a variety of criteria. Using Geographic Information Systems software (GIS), cities were selected using the following criteria. First, cities that had a population of over 30,000 persons

were selected as primary location candidates. This criterion was used to limit the overall number of urban areas that would be used for analysis. Thus, the cities with the largest population in the State of Iowa were selected as urban case study areas, which makes extrapolating the analysis to larger metropolises, implementing access management, possible. Second, of these 11 cities, four cities were selected based on population, roadway criteria, and time and resource constraints.

The four cities included:

- Ames
- Des Moines
- Cedar Rapids
- Iowa City

Corridor Selection

The selection of corridors in the State of Iowa was based on several criteria. First, the corridors had to be within the city limits of one of the above four cities. Next, traffic corridors were selected based on their AADT's. An AADT of equal to, or greater than 10,000 vehicles per day, was used as a baseline of daily traffic volume. These corridors were also selected based on their federal functional classification established by the Federal Highway Administration. The federal classifications that are used in the U.S. include the following:

- Interstate
- Freeway
- Expressway
- Arterial
- Arterial Connector
- Trunk
- Municipal Arterial
- Municipal Collector
- Municipal Service
- Trunk Collector
- Area service

The only Federal Classified Roads that were selected for analysis were those classified as arterials. This classification was selected on the basis that arterials are assumed to have the highest AADT's and crash rates in urban areas.

After initial selection of appropriate cities was completed using GIS, the actual roadway segments were selected. GIS software (ArcView 3.1/3.2) was used as the basic analytical software for this analysis. A Beta version of GIS-ALAS (Accident Location and Analysis System) was used to investigate crash incidents, rates, and locations based on 1997 data for the State of Iowa. Selection of roadway segments that met the following criteria were selected as case study segments:

- Segments were selected if their AADT was 10,000 or greater.
- Roadways were selected if they were federally classified as Arterials.
- Roadways utilizing medians were selected if they also met the above criteria.

The first criterion for selection was the level of access management (high v. low) employed on the existing traffic segments. The level of access management in this case refers simply to, *whether a segment utilizes a median versus one that does not*. This resulted in a number of case study candidates, which were then queried to determine eligible case study segments. Using ArcView, the final selection was based on segments with comparable levels of AADT's and median usage, which resulted in numerous segments per city; ones that used medians and ones that did not. Approximately equal segment lengths in each city were determined based on the available segment lengths resulting from the above selection process. From this, eight case study segments were identified that would be used in the final analysis, these are indicated in Table 2. These selected road segments vary in length, as it was very difficult to find segments using medians and those that did not, which matched the predetermined selection criterion. To alleviate this problem, averages were used in the analysis of crashes and costs associated with these crashes.

TABLE 2 Selected Road Segments

Location	Route	Median Usage	Length
Ames	Lincoln Way	Yes	2-Miles
Ames	Lincoln Way	No	2-Miles
Cedar Rapids	1 st Avenue	Yes	1-Mile
Cedar Rapids	1 st Avenue	No	.5-Mile
Des Moines	University Ave	Yes	3-Miles
Des Moines	University Ave	No	3-Miles
Iowa City	U.S. 6	Yes	3-Miles
Iowa City	U.S. 1	No	3-Miles

From these case studies, crash analysis techniques were used to determine:

1. Total number of crashes on each segment.
2. Injury severity of crashes on segments.
3. Calculated indexed injury cost per segment.
4. The total number of injured persons involved in each crash.
5. The total property damage sustained in each crash.

Summary crash and property data was obtained for each of the segments and is presented in Table 3. It is interesting that half of the cities had higher property damage on segments with medians and half had lower property damages. This data is contrary to what other researchers have found in the past.

TABLE 3 Summary Crash and Property Damage for Selected Segments

Location	Route	Median Usage	Total Crashes 1997	Property Damage
Ames	Lincoln Way	Yes	102	\$326,638.00
Ames	Lincoln Way	No	130	\$267,677.00
Cedar Rapids	1st Avenue	Yes	52	\$116,714.00
Cedar Rapids	1st Avenue	No	37	\$63,650.00
Des Moines	University Avenue	Yes	90	\$322,239.00
Des Moines	University Avenue	No	209	\$661,509.00
Iowa City	U.S. Hwy 1	Yes	47	\$114,888.00
Iowa City	U.S. Hwy 6	No	61	\$191,800.00

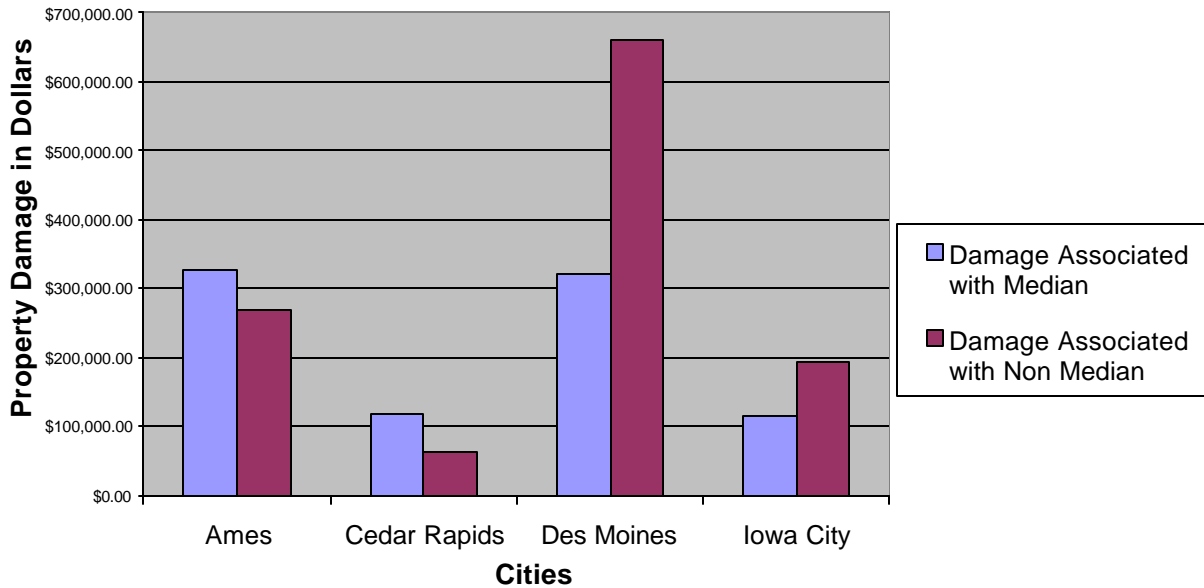
ANALYSIS

The following section constitutes the analysis of crashes on eight segments of arterials across the State of Iowa. There are two data sets that were analyzed: injury data and property damage data. Figure 6 represents the total costs of property damage in all cities. This table only illustrates the amount of property damage in comparison to segments, but does little to illustrate a difference in property damages per segments in relation to the number of crashes.

The mean property damage per crash was calculated to find deviations in damage for segments using a high level of access management versus segments that use a low level of access management. It was found that only Iowa City experienced, on average, a lower amount of property damage on segments using a high level of access management, while Ames, Cedar Rapids, and Des Moines experienced an increased amount of property damage on segments with a high level of access management. On average, it was found that property damage on segments with

a raised median was \$3,025.70 in comparison to an average of \$2,710.84 per crash on segments not using a raised median. Although, the total amount of property damage for segments using raised medians was \$880,479.00 compared to \$1,184,636.00 on segments without a median. This is one of the only comparisons between segments that justifies the use of raised medians.

FIGURE 6 Property Damage in Select Cities



Injury costs were calculated using the Iowa DOT Indexed Costs for Crash Injuries. Using the personal injury values, total costs per injury could be calculated for each of the segments. In all but the Iowa City segments, total indexed injury costs were higher on segments using medians versus segments not using raised medians. This is very interesting to observe, as one would be led to believe that injury costs on segments using access management would be lower, as we would expect the total number of crashes to be lower. One of the explanations for this is the fact that there were more major injuries on segments using raised medians.

The last analysis of segments and crashes was comparing the injury rates to the level of access management. A calculated injury rate per crash showed that on average, the injury rate for crashes on arterials with raised medians was higher. Again, this is contrary to previous research on injuries and access management. Finally, the following table summarizes the total costs (property damage and indexed injury costs) for each of the cities. Although, only one of the cities shows a lower cost for the use of medians, a total savings for all cities is equivalent to \$943,222.00.

TABLE 4 Total Costs of Crashes on Segments

City	Total Costs for Crashes-Median Usage	Total Costs for Crashes-Non Median Usage
Ames	\$1,230,638.00	\$693,677.00
Cedar Rapids	\$270,714.00	\$141,650.00
Des Moines	\$1,476,239.00	\$3,751,509.00
Iowa City	\$1,302,888.00	\$701,800.00

CONCLUSIONS AND LIMITATIONS

In summary, these case studies reveal that medians may not have the effect on crash reduction as theorized. Through analysis of segments, it was found that in most cases, injury rates and property damages actually increased on segments using raised medians. If we compare the previously discussed construction costs for arterials, we find that there are no cost savings, associated with crashes, between median and non-median usage. What do these results tell us? First, that the usage of medians as a crash reduction technique may not be warranted on arterial streets in Iowa. This may be a false conclusion, as there are many other factors, which will be discussed, that could affect the outcome of this analysis. Although, based on the methodology of selecting segments based on a blind technique, the analysis is valid. This leads to the shortcoming and limitations of this study.

First, the selection of segments was not made considering many important variables. Case study segments were based on a limited number of criteria. Had these segments been based on further criteria, such as access points, zoning of land, etc., the segments chosen would have inevitably been quite different. Finally, if more resources had been available, a more thorough study could have been completed taking into consideration these other variables. This study does not justify the initial argument because the data clearly shows that the treatment of arterial segments with medians, versus those not utilizing a type of median, has no significant effect on crash incidents, injury cost, or on property damage. Further research is needed to prove that the reduction in crashes will pay for the difference in construction/conversion costs on Iowa’s arterials to improve our current transportation network. Referring back to the questions that would be addressed by this paper, we have failed to answer the following: “Does Access Management provide a justification for improvements on our existing infrastructure in terms of crash costs?”

Suggestions for Improvement

I suggest that this study should be repeated not using a blind selection technique. This technique allows one to do analysis to a certain extent, but has many limitations. Conclusions can be drawn from this report, but the data is not very useful or convincing to make valid and sound conclusions. This study would have to be repeated with

first hand knowledge of a selected areas before conclusions can be drawn to the effectiveness of raised medians at limiting the number of crashes and severity. The severity of the crashes may in fact increase with the use of medians as this study has shown, but is that what is really happening on our transportation networks. Further research in this area is needed to determine that.

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