An-Najah National University

Faculty of Graduate Studies

Aspects of A Traffic Safety Program in Palestinian Cities

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إهداء

إلى نبع الحب والحنان .... والدتي

إلى شريكة حياتي ، ورفيقة دربي ....زوجتي

إلى فلذة كبدي ، ووحيدي ....عبد الله

إلى كل من علمني حرفا........................... أساتذتي

إلى اللذين أمدوني بالعزيمة والإصرار .... اخوتي و أصدقائي و زملائي

إلى هؤلاء جميعا ....

والى كل مخلص غيور على تراب وطنه و أمته ....

اهدي هذا العمل العلمي المتواضع ....

عرفانا بفضلهم ....

وإجلالا لقدرهم ....

شكر وتقدير

الحمد لله حمد الشاكرين .... الحمد لله أولاً وآخراً ،وعلى كلِ حال وفي كلِ وقتٍ وحين .....

و الصلاة والسلام على المبعوث رحمةً للعالمين ،بلسان عربي مبين..... وعلى آله وصحبه الطيبـــين الطاهرين...

هذا من فضل ربي ليبلوني أأشكر أم اكفر ، ومن شكر فإنما يشكر لنفسه.

أرى لزاما علي بعد أنِ وفقني الله وأعانني على إتمام هذا البحث العلمي المتواضع ، أن أتقدم بوافر من الشكر إلى أستاذي الفاضل الدكتور خالد الساحلي عرفانا مني بفضله و تفضله قبول الإشراف علـى هذا البحث، الذي أتمنى من الله العلي القدير أن يكون في ميزان حسناته، وثمرة ناضجة صالحة من ثمار علمه الفياض.

كما اغتنمها فرصة طيبة كي أتقدم بوافر الشكر ، وطيب التقدير إلى أعضاء لجنة المناقشة الأســـاتذة الأفاضل الدكتور أسامة اباظة، والدكتور سمير أبو عيشة، والدكتور خالد زيـــدان علـــى قبولهمـــا المشاركة في مناقشة هذا البحث... وعلى جهودهما الطيبة في قراءتــــه وإبــــداء الآراء الســـديدة ، والملاحظات القيمة حوله...واخيرا ، لا يفوتني أن أتقدم بالشكر و الثناء الصادق إلى كل من قـــدم النصح والإرشاد وأخص بالذكر الزميلة المهندسة فوز خضر الكوبري و إدارة شرطة مرور نــــابلس ومحكمة الصلح ، والى كل من ساهم في إخراج هذا البحث إلى حيز الوجود.

فجزى الله الجميع عني خير الجزاء......آمين.

ملخص

لقد بذلت مؤخرا جهود محدودة من اجل تحسين الأمان على الطرق. ومن الجدير بالذكر أن برنامج الأمان على الطرق (Highway Safety Program) يعتبر أمرا ضروريا لتحقيق هذا الهدف. ومن هذا المنطلق فقد تناولت هذه الدراسة السمات والخصائص من اجل إيجاد وتطوير برنامج الأمان على الطرق للمدن الفلسطينية. ويعتبر التخطيط من أهم العناصر الرئيسية في هذا البرنامج؛ ذلك أن الخطوة الأساسية في عنصر التخطيط هي عملية جمع المعلومات المتعلقة بالحوادث لتشكيل قاعدة للمعلومات (Database) عن هذه الحوادث. وان تحليل العديد من الحوادث ووضعها في قاعدة المعلومات تؤدي إلى تحديد المناطق الخطرة (Hazardous Locations) ومن ثم يتم وضع إجراءات وقائية (Countermeasures) لمثل هذه المناطق، وهذه الإجراءات من شأنها الحد أو التخفيف من خطر حوادث السير. لذلك فان تطبيق مثل هذا البرنامج سيؤدي إلى تحسين السلامة المرورية.

وتعتبر تقارير الشرطة الخاصة بحوادث السير هي من أهم المصادر في جمع المعلومات والتي بدورها تشكل قاعدة المعلومات عن هذه الحوادث (Accident Database)، وفي هذه الدراسة تم تصميم نموذج تقرير شرطة جديد لحوادث السير (Police Accident Report Form) شامل لجميع المعلومات الخاصة بحوادث السير؛ وتم أيضا تطوير برنامج محوسب خاص بتقارير الشرطة المتعلقة بحوادث السير وتمت تسمية هذا البرنامج (Accidents)، وهو سهل الاستخدام، ويمكّن مستخدمه من استخراج وتحليل ما يختاره من معلومات بسهوله ويسر.

في هذه الدراسة تمت مناقشة الخطوط العريضة لبرنامج الأمان على الطـــرق. وكذلـــك تم تحليـــل إحصائيات حوادث الطرق خلال العامين 1997-1998 في مدينة نابلس، ونتيجـــة لتحليـــل هـــذه الإحصائيات تم تحديد القيم المحددة (Threshold Values) للمناطق المرورية الخطرة.

وقد تبين من خلال البحث وبحسب القيم المحددة (Threshold Values) للمناطق الخطرة أن مـــفرق "الحسبة" هو من اكثر الأماكن خطورة في مدينة نابلس ، وأكثرها عرضة لحوادث السير، حيـــث تم عمل دراسة كاملة ومفصلة لهذا المفرق نتج عنها عدة إجراءات وقائية تمثلت في إعادة تصميم برمجـــة الإشارات الضوئية ، وإجراءات تتعلق بمراقبة شرطة المرور (Enforcement)، هذا بالإضافة إلى إعـــادة تخطيط جميع خطوط الطريق على أرضية المفرق (Pavement Marking).

و أخيرا فقد أشارت نتيجة البحث إلى الأهمية الملحة لتطبيق وتطوير برنامج الأمان على الطرق، ولهذا السبب يوصى بضرورة تبني وتطوير هذا البرنامج في جميع مدن فلسطين.

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ABSTRACT

In recent days, limited efforts were applied to improve highway safety in Palestinian cities. Establishing highway safety programs is essential to achieve this purpose. The main component in such programs is planning. The main process in the planning component is the collection of accident data to form the accident database. Then, the analysis of such database will identify the hazardous locations. Effective countermeasures should then be applied at these hazardous locations. These countermeasures should eliminate or minimize the hazards of these accidents. Therefore, the application of such highway safety program will result in safety improvements.

The police accident report form is the most important source to create the accident database. A new comprehensive police accident report was designed in this study. A new computer program "Accident" based on Microsoft Access Software was also developed in this study. This program is designed for a computerized data recording and filing. It is user friendly. It also provides options for data retrieval and analysis.

In this study, the outline of the proposed safety program for Palestinian cities was discussed. Accident data in this study were based upon accident records of years 1997 and 1998 for the Nablus City. Threshold values for identifying hazardous locations were established based on these data.

According to the established threshold values, Al-Hesba Intersection was one of the most hazardous locations in Nablus City. A detailed study was conducted for this intersection. Proper countermeasures were specified at this intersection such as retime signal, police enforcement, and repainting all pavement markings.

The results of this research showed that Palestinian cities are in dire need for the implementation of such a program. Therefore, developing the highway traffic safety program in Palestine is recommended.

CHAPTER 1

INTRODUCTION

1.1 Background

"Road accidents" are a global problem that may be caused by human factors, vehicle factors, roadway design and traffic, and environmental conditions. Most traffic accidents are the result of careless or hazardous behavior of drivers or pedestrians. The probability of accident occurrence and the severity of accidents can often be reduced by developing and implementing a highway safety program and the application of proper traffic and roadway design standards.

1.1.1 Definition of Accidents

It was reported by United Kingdom Accident Investigation Manual, 1986, that an accident is a rare, random, multifactor event, preceded by a situation in which one or more persons failed to cope with their environment. In the aggregate; however, traffic accidents are numerous and often follow certain patterns that can be identified.

Accidents reflect a shortcoming or failure in one or more components of the driver-vehicle-roadway system. It is; therefore, important for engineers having responsibility for the design and operation of streets and highways to monitor traffic accident experience and to use this information in the planning, implementation, and evaluation of corrective action (Homburger, Hall, and Loutzenheiser, 1996).

1.1.2 Accident statistics in Palestine

A report published in 1999 by the Palestinian Central Bureau Statistics (PCBS) indicated that the number of roadway accidents in the Palestinian Territories was 7,640 in 1997, of which 1,695 accidents caused tangible losses.

In 1998, a total of 5,945 fatal or injury accidents were reported. Section 2.1 includes more information on accident statistics.

These accidents represent economic and human losses in Palestine. So, it is worthy to focus more attention on the causes of these accidents, and how to minimize or eliminate them.

1.1.3 Cause of Accidents

Road accidents are attributed to three major factors. These factors are *human error, roadway conditions, and vehicle conditions.*

A. Human Error

Human factors contributing to roadway accidents include:

- High speed
- Improper overtaking
- Improper turning

- Improper stopping
- Reckless driving (carelessness)
- Driving under influence of alcohol
- Improper crossing of streets by pedestrian
- Lack of roadway maintenance
- Lack of maintenance of traffic control devices
- drivers Inexperience
- Drivers fatigue
- Spirit of adventure of adult drivers

B. Roadway Conditions

Roadway conditions contributing to roadway accidents include the following:

- Inadequate capacity
- Inadequate an improper traffic control devices
- Fixed objects, inadequate clear zone, and improper roadway alignment and or other geometric features
- Inadequate storm drain system for most streets
- Poor road maintenance

C. Vehicle conditions

Vehicle conditions contributing to traffic accidents include:

- Mechanical failures
- Excessive load on a vehicle especially for heavy vehicles
- Poor maintenance of vehicles

In addition to these factors, there are several contributing factors, which include

- Weather conditions.
- Time of day.
- Insufficient education for both drivers and pedestrians.

1.2 Goals, Objectives, and Activities

The main goal of this project is to develop a general outline for traffic safety program in Palestine. The proposed program consists of projects, countermeasures, and activities to achieve a common highway safety goal. A program may be applied to numerous locations and may include several types of countermeasures, which serve the same purpose. This research proposes a program of traffic safety to improve traffic safety conditions in Palestine. This research creates the basic outline for the proposed traffic safety program. Furthermore, this research also focused on the planning components of the proposed program. Some obstacles are expected to affect the application of this program. Some of these obstacles are mentioned in section 1.3.

The main goal can be achieved through the following activities:

- Develop a computerized systematic approach for data collection
- Effective analysis of data
- Effective remedial action for hazardous locations
- Evaluation of mutually exclusive remedial actions (countermeasures) at hazardous locations

1.3 Developing A Traffic Safety Program in Palestine

1.3.1 Background

The Palestinian National Authority (PNA) resumed its control over some parts of Palestine in 1993. Traffic accident data were collected by the Israeli government up to 1995. There is no systematic approach that deals with improving the safety program in Palestine. This is due to several reasons including:

1. Political reasons
2. Improper allocation of budget
3. Ineffective usage of specialized and qualified people
4. Lack of institutional infrastructure to deal with traffic problems

1.3.2 Existing Accident Recording System

Based on several visits to the Police Center in Nablus City, the existing reporting system that deals with accidents can be summarized as follows:

A. Court Report

This report includes somewhat comprehensive information including the time and location of the accident, weather and road conditions. Other information includes driver, damages, and injuries or fatalities. However, key information for traffic engineering purposes is lacking in this report. Figure A-1 in Appendix A illustrates the court report

The accident case is then sent to court and this report is used in the following cases:

- In case of vehicles-pedestrian accidents, and the injured did not give up their rights.
- In case of deaths.
- In case of collision between two vehicles and there was no compromise between the involved parties, and this accident contains injuries or deaths.

B. Closed Report

This report has the same information as the court report presented in Figure A-1 shown in Appendix A. When the two parties involved in an accident reach a compromise, this report is kept in the police office and is not sent to court.

C. Property Damage Only Report

This report is filled in cases of property damages where no compromise between the involved parties is reached. The report is presented in Figure A-2 in Appendix A and is filled by a police expert. This report is sent to court without the need to provide an accident diagram.

D. Public Damage Report

This report is filled in the following cases (as examples):

a. The vehicle door closed on the hand of an occupant.

b. Fixed object accidents.

1.4 Study Area

Palestine is a typical developing country located in a central location in the Middle East. Its significance is represented by its geographic location.

This research proposes a traffic safety program for Palestine in general and for Nablus City in particular. Furthermore, Al-Hesba Intersection in Nablus City was identified as one of the most dangerous intersections in the city. This intersection was used as a case study for purposes of this research.

1.5 Report Outline

This report contains ten chapters, in which Chapter 1 is the introduction to this report, while Chapter 2 is the literature review. Chapter 3 is the methodology of this research. Chapter 4 discusses the importance of accident database to determine the patterns of accidents and their causes. Chapter 5 illustrates the criteria used to determine hazardous locations. Chapter 6 deals with the effective countermeasures at specified hazardous locations and relevant engineering studies. The techniques used for ranking the proposed countermeasures are discussed in Chapter 7. Chapter 8 discusses the evaluation of applied countermeasures after their implementation, and focuses on before-after studies. The proposed action plan for the traffic safety program in Palestine is illustrated in Chapter 9. Chapter 10 focuses on a case study at Al-Hesba Intersection. Finally, Chapter 11 provides conclusions and recommendations of this study.

CHAPTER 2

LITERATURE REVIEW

The Royal Society for the Prevention of Accidents, 1998, reported an article titled "A first time for every thing." The article reported that on August 17th, 1896, a 44 year old Bridget Driscoll was knocked down and killed by a car on a terrace in the grounds of the Crystal Palace in London. The first fatal road accident recorded in Britain, involving the driver and passengers of a motor car, occurred on the 23 February 1899. While attempting to turn a corner at a speed of over 25 miles per hour (mph) the car's wheels collapsed. The occupants were thrown out and the driver and front seat passenger were killed. Newspapers of the day hoped that this terrible accident would convince drivers to take greater care and keep their speed down.

The cost of road accidents in Britain in 1997 was estimated at £28,000 per minute; this included hospital costs, property damage, police and insurance costs, lost productivity, and a national sum for pain, grief and suffering.

2.1 International Statistics

2.1.1 In the United States of America (USA)

Homburger, Hall, Loutzenheiser, and Reilly, 1996, reported the following traffic accident statistics in the USA.

1. *Fatalities.* Following a low of 24,000 fatalities per year during the Second World War, highway fatalities in the United States rose almost continuously to a peak of 54,600 in 1972. The dramatic drop of 9,000 fatalities in 1974 was primarily attributable to the energy crises, which resulted in the imposition of the 90-kilometer per hour (km/h) national speed limit. Other factors, including a reduction in travel, improved vehicle safety features and the results of a continuing effort to remove physical hazards from the roadside, and also contributed to this reduction.

Over the past two decades, annual fatalities have fluctuated between 39,200 and 51,100; there where 40,700 in 1994. The travel-based fatality rate decreased steadily over the past 65 years; in 1994, it was 1.1 fatality per 1,000,000 vehicle-kilometer (veh-km). In 1994, the National Highway Traffic Safety Administration (NHTSA) reported a fatality rate of 23.2 fatalities per 100,000 licensed drivers and 21.1 fatalities per 100,000 registered vehicles.

In 1994, multivehicle collisions accounted for 17,600 fatalities, single vehicle crashes resulted in 16,000 fatalities, and impacts with pedestrian caused 5,500 fatalities. The remaining 1,500 fatalities occurred in collision with railroad train, bicycles, and animals.

2. *Injuries.* An estimated 3.21 million persons were injured in motor vehicle crashes in 1994. Nearly 14 percent of these injuries were incapacitating while the remainder was less serious.

3. *Total Accidents.* Because the definition of a portable accident and the level of accident reporting vary among jurisdictions, the total number of traffic accidents in the U.S.A is unknown. NHTSA estimated that 11.39 million drivers were involved in 6.49 million police reported crashes in 1994.

2.1.2 In Britain

The Royal Society for the Prevention of Accidents reported that in 1901 there were 101,000 motor vehicles in Britain, and in 1997 there were approximately 27 millions. Over the same period, fatal road accidents increased from 1,070 to around 3,600 (Internet Web Site www.rospa.co.uk/rsfacts.htm, 1998). The number of fatal road accidents did not increase as much as the number of motor vehicles for a variety of reasons. In 1909, motor vehicles were not very common, but as they grew more common, people became used to them and the dangers they pose. Road safety education, training, and publicity were introduced to help people cope with those dangers. The design and construction of motor vehicles have been improved immensely so that brakes, for instance, are far more effective.

Over the years, laws have been introduced to combat specific problems. For example, because so many front seat occupants received terrible injuries in car crashes, it became compulsory to wear a seat belt in the front seat of the car.

2.1.3 Palestinian *Statistics*

1. Accidents between 1968 and 1996

The availability of accident statistics was obtained from the Israeli Statistics Center for the period between 1968 and 1996. From 1996 to present, the Palestinian National Authority (PNA) maintains accident statistics in the Palestine territories.

The number of accidents increased from 704 accidents in 1968 to 1,448 accidents in 1987. The fatal accidents also increased from 76 in 1968 to 169 fatal accidents in 1987. Injury accidents increased from 184 in 1968 to 710 in 1987. The summary of these statistics is shown in Table 2-1 (Palestinian Central Bureau of Statistics (PCBS), 1998).

Table 2-1: Statistics for the Years 1968 and 1987

YEAR	1968	1987
TOTAL ACCIDENT	704	1,448
FATAL ACCIDENT	76	169

Source: Palestinian Central Bureau of Statistics (PCBS), 1998

The number of collision accidents was 232 in 1971, while the number of pedestrian related accidents was 581. The number of collision accidents was

726, while the number of pedestrian related accidents was 692 in 1992, as shown in Table 2-2.

Table 2-2: Collision and Pedestrian Related Accidents (1971 and 1992)

YEAR	1971	1992
COLLISION ACCIDENTS	232	581
PEDESTRIAN RELATED ACCIDENTS	726	692

Source: (PCBS), 1998

The number of injuries was 1,149 in 1968. This number increased to 8,327 in 1996. This increment may be attributed to the increase in both numbers of vehicles and habitants (PCBS, 1998).

The pedestrian related accidents were decreased from 1971 to 1992, which is unlogical result. This may be attributed to the political reasons through Al-Intifada in Palestinian cities

2. Road Traffic Accidents in Palestine, 1998

The number of road traffic accidents in the Palestinian territories amounted to 7,640, of which 5,607 in the West Bank and 2,033 in Gaza Strip. In the same year, 1,695 accident brought about tangible losses. The number of road traffic accidents that caused fatality and injury in the Palestinian territories amounted to 5,945 accidents in 1998, of which 4,143 in the West Bank and 1,802 in Gaza Strip. The number of casualties resulted from those accidents reached

8,806 (6,492 in the West Bank and 2,314 in Gaza Strip). The classification of accidents by severity is shown in the following table:

Severity	Number of accidents
Slightly injured	5,513
Seriously injured	639
Fatalities	198

The slightly injured of 5,513 (4,671 in the West Bank and 1,121 in Gaza Strip), 639 seriously injured (375 in the West Bank and 264 in Gaza Strip), and 198 fatalities (112 in the West Bank and 86 in Gaza Strip). However, the number of fatalities was 180 in 1997 (PCBS, 1999). The increased fatality accidents can be contributed to the increment of traffic volume.

2.2 Accident Studies

The high accident rate on United State's highways resulted in a considerable loss of human and economic resources. It was estimated that the United States loses over $10 billion every year as a result of motor vehicle accidents (Garber and Hoel, 1996). Traffic and highway engineers are; therefore, continually engaged in the design and operation of traffic control devices on the nation's highway, with the aim of reducing the high accident rate. This effort also involves the redesigning and reconstruction of specific highways, which have high potential for accidents. To evaluate the success or failure of these efforts in reducing accident, data on the frequency and severity of accidents are needed. The need of adequate accident data and the necessity to reduce the high accident rate have led to emphasis on highway safety programs.

During the late 1960s and early 1970s, the Federal Highway Administration (FHWA) took several legislative actions that led to a significant growth in research on highway safety. For example, in the mid-sixties, the FHWA introduced the Spot Improvement Program, which attempted to identify highway locations with high accident potentials. The program also provided funds for the improvement of these locations. Also in the mid-sixties, the Highway Safety Act was passed by congress. This act set the requirements for states to develop and maintain a safety program through the Highway Safety Standards.

The maintenance of such a program was assisted by the publication of the yellow book by the American Association of State Highway and Transportation Officials (AASHTO), which was subsequently revised. These publications described safety design practices and polices. Funds were made available by the USA federal government to support the efforts of state and local government in the application of new procedures in highway safety programs. The objectives of these procedures included the development of better methodologies for the collection, analysis, and evaluation of accident data. This led to the publication of Highway Safety Improvement Program (HSIP), which was superseded by Highway safety Improvement Program Manual in the late seventies. This manual advocates that each state should develop and implement on a continuing basis, a HSIP, which has the overall objective of reducing the number and severity of accidents and decreasing the potential for accidents on all highway. The HSIP consists of the planning component, the implementation component, and the evaluation component. Each of these components consists of one or more processes as shown in Figure 2-1. The tasks involved in each of these processes are discussed below.

2.3 Planning Component of the Highway Safety Improvement Program

The planning component of the program consists of four processes as shown in Figure 2-1. These are:

1. Collecting and maintaining data
2. Identifying hazardous locations and elements
3. Conducting engineering studies
4. Establishing project priorities

The information obtained under the planning component serves as input to the other components, and results obtained from the evaluation component may also serve as input to the planning component.

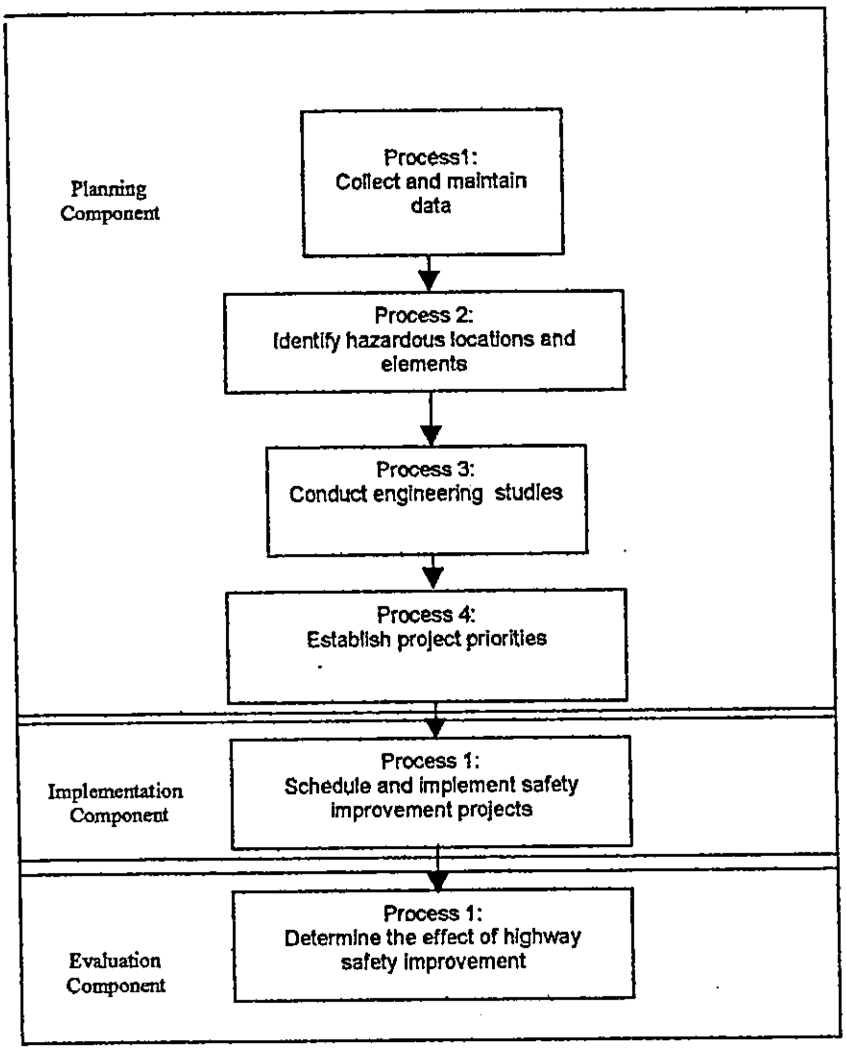


Figure 2-1: Highway Safety Improvement Program at the Process Level

Source: Redrawn from Highway Safety Engineering Studies Procedural Guide, U. S. Department of Transportation. Washington, D.C., June 1981.
(Obtained from Garber and Hoel, 1996)

2.3.1. Collecting and Maintaining Data

Accident data are usually obtained from state and local transportation and police agencies. The police on an "accident report form" usually records all information on a reported accident. The type of accident form used differs from state to state, country to country, and, sometimes, city to city. But a typical completed accident form will include information on the location of the accident, the time of occurrence, roadway and environmental conditions at time of accident, type and number of vehicles involved, a sketch showing the original paths of the maneuver of the vehicles involved, and the severity of the accident (fatal, injury, or property damage only). Figure B-2 in Appendix B shows the Virginia accident report form (Garber and Hoel, 1996), which was completed by the police officer investigating the accident.

Information on minor accidents that do not involve police investigation may be obtained from routine reports that are given at the police stations by the drivers involved as is required in some states. In the USA, drivers involved in accidents are also sometimes required to complete accident report forms, even though the police investigate the accident (Garber and Hoel, 1996).

Figure 2-2 illustrates a typical accident form to be filled by the motorist. The questions are simple and straightforward and are asked in terms that most motorists can easily interpret and answer. Police accident forms are more detailed and call for more interpretation as to the likely contributing causes of the accident. Central to any accident form is a diagram schematically illustrating the accident. While these are often poorly done, they are principal source of information for the traffic engineer in the study of individual accident locations.

In many countries, police accident forms are generally sent and stored in three different locations (McShane, Roess, Prassas, 1998):

1. A copy of each form goes to the local motor vehicle bureau for entry into the computer accident data system.

2. A copy of the form is sent to the central filling location for the municipality or district in which the accident occurred.

3. A copy of the form is retained by the officer in his or her precinct as a reference for possible court testimony.

The police office has to provide clear and accurate data on the police accident report form. The information must be provided in such a way that the person coding the information can locate it on a map or a road network.

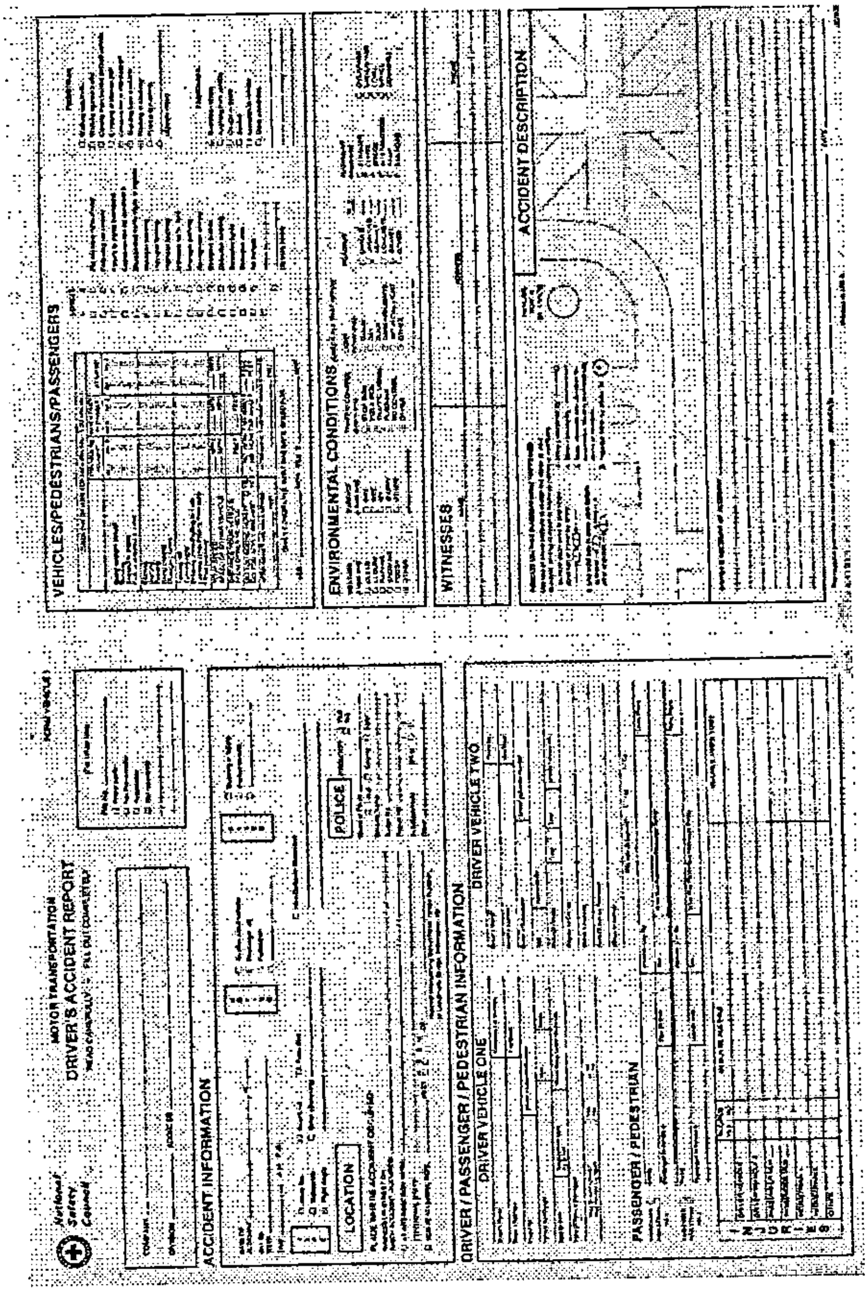

National Safety Council
MOTOR TRANSPORTATION
DRIVER'S ACCIDENT REPORT
ACCIDENT INFORMATION
LOCATION
POLICE
DRIVER/PASSENGER/PEDESTRIAN INFORMATION
DRIVER VEHICLE ONE
DRIVER VEHICLE TWO
PASSENGER/PEDESTRIAN
VEHICLES/PEDESTRIANS/PASSENGERS
ENVIRONMENTAL CONDITIONS
WITNESSES
ACCIDENT DESCRIPTION

Figure 2-2: Typical Police Accident Report Form

Source: Traffic Engineering, McShane, Roess, Prassas, 1998

A number of authorities are now beginning to include their accident data using a Geographic Information System (GIS) or digital mapping system (McGuigan, McBride, and Ryall, 1994; O'Day, 1993). This enables accident data to be incorporated within a relational data base, allowing accident sites to be overlaid on plans showing other geographic information, such as highway features, traffic flows, intersection layouts, land uses, etc.

Similar efforts were done through a masters thesis at An-Najah National University, Nablus City, Palestine (Kobari, 2000). In this thesis, a (GIS)-oriented database using TransCAD software was developed as a tool not only to identify the accident's location, but also to improve quantitative accident data analyses.

Central accident files are generally kept current for a period of one year. Records should be kept for a 12-month rotating period (McShane, Roess, Prassas, 1998). As each month begins, the records for the same month in the previous year are removed. This system requires more man power to maintain but assures that at least 11 months of accident records are readily available at all times.

A common approach to retaining records for a longer period of time is to prepare summary sheets of each year's accident records. These may be kept indefinitely, while the individual accident forms are discarded after three to five years. Table 2-3 illustrates such a summary sheet, on which all

Table 2-3: Illustrative Accident Summary Sheet

TRAFFIC ACCIDENT RECORD

LOCATION

City / Village County / State

Number	Date	Time	Private car	Private car	Private car	Private car	Commercial	Omnibus	Bicycle	Pedestrian	Other	Accident type	Weather	Road condition	Road surface	Injured	Fatal

Source: Nassau Country Traffic Safety Board, Mineola, New York (obtained from McShane, Roess, Prassas, 1998).

of the year's accidents at one location can be reduced to a single coded sheet. The form retains the basic type of accident, the number and types of vehicles involved, their cardinal direction, weather and roadway conditions, and the number of injuries and/or fatalities.

On this summery sheet, codes are usually used to describe accident types (for example, RA for right angle accidents).

The manual technique is suitable for areas where the total number of accidents is less than 500 a year, although it may be used when the total number of accident is between 500 and 1,000 annually. This technique; however, becomes time consuming and inefficient when accidents total more than 1,000 a year (Garber and Hoel, 1996). At such time, a computerized system should be used.

2.3.2. Identifying Hazardous Locations

Since accidents are rare and random, traffic safety analysis should be based on several years of data. Separate analysis are normally conducted for spot locations and extended sections of road, for urban and rural roadways, or for other conditions that could lead to different accident experience. The following techniques may be used:

1. Spot Maps

A spot map method has been one of the earliest methods for identifying hazardous locations. This method is a simple and effective way to determine hazardous locations. A spot map can be marking the location of each relevant accident on a map. The accumulation of marks at specific location indicates that this location is hazardous (Homburger, Hall, Loutzenheiser, and Reilly, 1996).

Spot maps (also called pin maps) are often used by police and other public agencies to provide a quick visual picture of accident concentration. A street map of the city area is needed and the location of each accident is identified through "spot" marks or pins. Some of these pins are colored to indicate the fatality of accident. It is usually updated on a regular (daily, weekly, or bimonthly) basis for the entire year or analysis period. The cluster of "dots" shows the concentration of accident locations throughout the city. Simple manual plotting of accidents may be desirable for small cities with few high-accident locations. Accidents can usually be placed fairly accurately. However, this method may become quite involved and time consuming for larger cities with thousands of accidents each year.

Spot maps are generally kept for one calendar year. At the end of the year, the map is photographed, and a new map is started. Special spot maps can also be kept for specific accident classes, such as pedestrian accidents, single vehicle accidents, drinking driver accidents, etc.

As reported by Kobari, 2000, the GIS-based system easily allows spot maps of large areas or with large number of accidents to be updated and displayed on a monitor or plotted on a map. Analysts can use different colors and sizes of graphical symbols to represent different types or severity of accidents or to represent "multipliers" of accidents. Spot maps are very useful for specialized situations such as pedestrian accidents or parked-car accidents.

2. Number of Accidents

The simplest method for rating the safety of a group of similar locations (e.g., urban unsignalized intersections) is to determine which have the highest accident frequency. Some jurisdictions use this technique to prepare a list of the "Twenty Highest Accident Intersections." The failure to include some measure of exposure is the major shortcoming of this technique.

The locations, which have the highest number of accidents, are called the hazardous locations. The number of accidents in a given period will be exceeding some set level. This takes no account of exposure. The simplest method for rating the safety of group of similar locations is to determine which have the highest accident frequency (Homburger, Hall, Loutzenheizer, and Reilly, 1996).

3. Accident Rates

If reliable traffic volume data are available, accident rates provide a superior tool for identifying hazardous locations. On a section of a road with length L (km) and average daily traffic (ADT) of v vehicles which experienced A accidents in a 3-year period, the accident rate R (per million.veh.km) is given by:

$$R = A \times 1{,}000{,}000 / (3 \times 365 \times L \times v)$$

At an intersection or similar spot location with a total entering volume of V_e vehicles per day, the accident rate, R_e, per million entering vehicles (MEV) is given by:

$$R_e = A \times 1{,}000{,}000 / (3 \times 365 \times V_e)$$

The average accident rate R_{av} on a section of road is given by:

$$R_{av} = \text{SUM}(A_i) \times 1{,}000{,}000 / (3 \times 365 \times \text{SUM}(L_i \times v_i))$$

When calculating $R_{av.}$ (the average accident rate at a location), if the rate of accident exceeds this average then this location is called a hazardous location. In this method, the traffic volumes of the roads or intersections should be given. This method may yield misleading results on sections with small amounts of travel. Some locations with high number of accidents may reflect high volumes and have relatively low accident rates. A small number of accidents at a remote location with low volumes may produce a high accident rate.

4. Number-Rate

To help guard against the shortcoming of the methods described above, some agencies have established cutoff values for both the number of accidents (per km/year or per intersection/year) and the rate of accidents. This method is normally applied by first selecting a large sample of high accident locations based on a "number of accidents" criteria. Then, accident rates are computed and the locations are priority ranked by accident rate (Highway Safety Improvement Program User's Manual, 1981; Homburger, Hall, and Loutzenheiser, 1996; Ogden, 1997).

5. Rate Quality Control

This methodology has been adopted from the quality control techniques used in industrial engineering. It defines as hazardous those sections or spots with observed accident rates higher than would be expected due to normal variation. Using the average accident rate for similar locations, a critical rate C_i is calculated for each location from:

$$C_i = R_{av} + k \times (R_{av} / m)^{1/2} + 1 / (2m)$$

Where k establishes the level of statistical significance (k = 1.645 for α = 0.05) and m travel on a particular section (expressed in million veh.km); if travel = 47,000,000 veh.km, then m = 47.

If the actual accident rate R_i for a section of road exceeds its calculated critical rate C_i, it is potentially a hazardous location and deserves a further study (Homburger, Hall, Loutzenheiser, and Reilly, 1996; Highway Safety Improvement Program User's Manual, 1981).

6. Rating by Accident Severity

Past accidents are weighed according to their severity to produce an index being used as the selection criteria. This method involves listing each accident occurring at a site under one of three severity classes: fatal (F), personal injury (PI), and property damage (PD). Several weighing scales have been used, but a typical one is given as (Garber and Hoel, 1996):

Fatality =12

Personal injury = 3

Property damage only = 1

The disadvantage in using this scale is the large difference between the severity scales for fatal and property damage accidents. This effect can be reduced by using lower weight for fatal accidents, especially at locations where fatal accidents are very rare in comparison with other accidents.

7. Potential Accident Reduction

This is the difference between the observed and expected accident experience calculated from the site and traffic flow characteristics. The selection criteria are to select sites which will maximize the accident reduction if their accident history can be reduced to the expected value (Ogden, 1996).

8. Expected Value Method

It is a mathematical method used to identify locations with abnormal accident characteristics (Garber and Hoel, 1996). The analysis is carried out by determining the average number of a specific type of accident occurring at several locations with similar geometric and traffic characteristics. This average, adjusted for a given level of confidence, indicates the expected value for the specific type of accident. Locations with accident values higher than the expected value is considered as over-representing that specific type of accident. The expected value can be obtained from the equation:

$$E_v = X_{av} \pm ZS$$

E_v = Expected Value

X_{av} = Average number of accidents per location

S = Estimated standard deviation of accident frequency

Z = The number of standard deviations corresponding to the required confidence level.

2.3.3. Conducting Engineering Studies

After a particular location has been identified as hazardous, a detailed engineering study is performed to identify the safety problem. Once the safety problem is identified, suitable safety-related countermeasures can be developed.

The *first* task is to analyze accident data; the *second* task is to perform the physical condition of the site; finally, the third task is to conduct the cause of accident analysis to determine the specific safety deficiencies at the study site (Garber and Hoel, 1996).

The output of this process is a listing of safety improvement projects for each site which should be priority ranked before implementation (Highway Safety Improvement Program User's Manual, 1981)

Details of conducting engineering studies are also discussed in Chapter 6.

2.3.4. Establishing Project Priorities

The purpose of this task is to determine the economic feasibility of each set of countermeasures and to determine the best alternatives among feasible mutually exclusive countermeasures. The benefit cost ratio will be applicable to specify the best countermeasure. Benefits can be evaluated by the number of reduced accidents. Cost can be determined from the costs of constructing and operating the proposed countermeasure. The NHTSA recommends the costs of each accident severity (Garber and Hoel, 1996).

In these steps, projects are ranked and selected. Economic analysis is also conducted. Details of ranking, selecting, and economic appraisals of projects and appropriate measures for Palestinian cities are discussed in Chapter 7.

2.4 Implementation and Evaluation

The implementation of the proposal selected is the next step. The evaluation component involves the determination of the effectiveness of the highway safety improvement. It is required to collect data before and after the implementation to determine the existence of the benefit. The importance of this task appears when using these data at other similar projects (Garber and Hoel, 1996).

The evaluation techniques include controlled experimentation, control sites, time trend comparison, and before-and-after analysis (Ogden, 1997; Box and Oppenlander, 1976; Andreassen, 1989; Hutchinson and Mayne, 1977).

Details of these techniques and their applicability to safety study in Palestinian cities are discussed in Chapter 8.

2.5 Road Safety and Programs

Management of road safety becomes a major challenge, and different countries have responded to this challenge in different ways. As an example, there are three approaches to this challenge in the United Kingdom, Australia, and the United States (Ogden, 1997).

2.5.1 United Kingdom

The Government in 1987 set a target of reducing road casualties by one third by year 2000 compared with the average for 1981-85 (Department of Transport in U.K, 1987).

This suggested that such a plan had seven components:

- Planning
- Information
- Engineering
- Education and Training
- Enforcement
- Encouragement
- Coordination of Resources

These plans were on place, and local authorities in Britain were well attuned to the philosophy and implementation of road safety programs (Brownfield, 1993). Importantly, they had the legislative requirement to:

- Carry out a program of measures designed to promote road safety

- Carry out studies into accidents
- In light of those studies, take measures to prevent accidents
- In constructing new roads, take measures to reduce possibility of accidents when the roads come into use
- Carry out road safety audit on new road proposals

2.5.2 Australia

In Australia, a national strategy with the aim of reducing road crashes and their human and economic costs in real terms during the 1990s and into the next century has been prepared (Federal Office of Road Safety, 1992). The strategy developed specific goals (e.g. to reduce road fatalities to 10 per 100,000 population by 2001 with corresponding in injury) and specific priorities. To achieve this target, there were eight strategic objectives:

- Major stakeholder ownership and participation in road safety
- Road safety as a major public health issue
- Road safety as a major economic strategy
- Road safety as a priority in the management of transport and land use
- Safer vehicle, safer roads, and safer road users
- Integrated framework for road safety planning and action
- Strategic research and development program
- Rationalization of federal and territory programs

2.5.3 United States

In the United States, the most recent initiative related to road safety management at the national level has been the requirement within the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) that states must develop management systems for seven areas related to highways, including the preparation of a safety management system (SMS), by October 1994 and be fully operational by October 1996. The program includes:

- Coordinating safety programs
- Investigating hazardous safety problems
- Early consideration of safety
- Identify safety needs of special user groups
- Maintaining and upgrading

CHAPTER 3

METHODOLOGY

3.1 Introduction

The main objective of this research is to improve traffic safety in Palestinian cities. This objective can be achieved through the development and improvement of highway safety program. In this research, general outlines of such program will be determined.

In Palestinian cities it is very essential to adopt a highway safety program. A clear and effective program was defined by Federal Highway Administration (FHWA). The Highway Safety Improvement Program (HSIP) consists of components for the planning, implementation, and evaluation of safety programs and projects. This research focuses on the planning component to be adopted in Palestinian cities. The proposed (HSIP) must suit the conditions of Palestinian cities.

3.2 Methodology for Highway safety Planning Components

The main components of the planning process of the highway safety program and methodologies for developing such a program for Palestinian cities consists of four major processes, these are:

1. Collecting and Maintaining Data
2. Identifying Hazardous Locations

3. Conducting Engineering Studies
4. Establishing Project Priorities.

In this research these four processes with the evaluation process will be discussed.

The methodology of this research is based on the following items:

1. Review existing international planning and evaluation processes.
2. Select the steps and techniques, which suite the Palestinian cities.
3. Determine the values and thresholds related to these processes through the analysis of available data.

3.2.1 Collecting and Maintaining Data

Every state should collect and maintain the data of accidents to form the database. The main source of these data is the police accident reports. Several forms will be reviewed in this research. A new police accident report will be presented in this research to be adopted for Nablus City in particular as well as other Palestinian cities.

International efforts of collecting and maintaining data will be reviewed. The applicability of specific items in these efforts for Palestinian cities will be examined.

Necessary modification will also be applied to make this process suitable for Palestinian capabilities. The manual versus computerized data recording system will also be examined, and suitable measures will be identified.

3.2.2 Identifying Hazardous Locations

The locations of abnormal accident occurrence at sites called hazardous locations (HL). Several techniques for identifying HL will be reviewed in this research. The most appropriate measures for Palestinian cities will be determined. The threshold values for links and intersections based on roadway classes will be calculated on international methods appropriate for Palestine.

3.2.3 Conducting Engineering Studies

After determination of hazardous locations, these sites should be studied and analyzed to determine the potential countermeasures. Methodology for analyzing accidents will be identified. The most appropriate steps for Palestine will be determined. New forms to be used for Palestinian cities will also be developed.

3.2.4 Establishing Project Priorities

The purpose of this process is to determine the economic feasibility of each set of countermeasures and to determine the best alternative among feasible mutually exclusive countermeasures. This involves the use of many of the techniques discussed in this research. The preferable techniques for Palestinian cities will be suggested.

3.2.5 Evaluation

Techniques must be established to evaluate the effectiveness of treatments for the hazardous locations. Available techniques will be reviewed and the most appropriates ones will be identified. Specific steps and numerical values for Palestinian cities will also be developed and determined.

The action plans of the highway safety program for Palestinian cities will be summarized

The processes of the planning and evaluation component are clarified in Chapters 4, 5, 6, 7 and 8.

The application of the developed highway safety program will be conducted at one of the most hazardous locations in Nablus City. The purpose of this case study is to illustrate the implementation of appropriate steps proposed in this program.

CHAPTER 4

COLLECTING AND MAINTAINING DATA

4.1 Introduction

In order to further improve the safety of the highway system, traffic engineers must have information and data on the location, frequency, severity, and types of accidents that are occurring. There can be no hope of determining why such accidents occur, and of developing corrective measures, unless details describing their occurrence are recorded.

The study of traffic accidents is fundamentally different from that employed to observe other traffic stream parameters. Because accidents occur relatively infrequently, and at unpredictable times and locations, they cannot be objectively observed as they occur. Thus all accident data come from secondary sources; motorist and police accident reports. A system for gathering, storing, and retrieving such information in a useful form must be carefully designed and monitored to provide the traffic engineer with the data needed to properly evaluate and correct traffic deficiencies.

Such information base must allow the following critical analysis to take place.

1. Identification of locations at which unusually high numbers of accidents occur.

2. Detailed functional evaluation of high accident locations to determine contributing causes of accidents at the location.
3. Development of general statistical measures of various accident-related factors to give insight into general trends, common causal factors, driver profiles, and similar information.
4. Developments of procedures that allow the identification of hazards before large number of accidents occur.

Accident data-collection and record system accomplish the first three of these important requirements.

4.2 Accident Filing System

The ultimate basis for all accident data and information is the individual accident report. Every state or country requires that any motorists involved in an accident in which property damage in excess of a stated limit occurs must report that accident to the country, state, or city motor vehicle bureau. In addition, more serious accidents, particularly those involving injury or death, will be investigated by a police officer, who will also file an accident report.

The police accident report is very useful, as often the officer has been trained in filling these out and is an impartial observer of the accident. Motorists' forms are clearly not unbiased, and various participants in the accident may turn in markedly different versions of the facts.

4.2.1 Manual Filing System

All motorist accident report forms are sent to the central motor vehicle bureau and are entered into the state's central computer accident data system. In many countries, police accident forms are generally sent and stored in three different locations: the motor vehicle bureau, a central filling location for the municipality or district in which the accident occurred, and a copy is retained by the officer in his or her precinct.

The central municipal or district accident file is frequently the traffic engineer's most useful source of information for the detailed examination of high accident locations. The state and/or municipal computer files are most useful for the generation and analysis of general statistical information.

Central files may be administered in a variety of ways. Often a single filling system is centrally maintained for a city, government, or region. In larger areas, separate files may be maintained for various subdivisions of the jurisdiction. A traffic department may maintain such systems, a separate agency established for the purpose, or by a police department. In the latter case, a separate traffic division is often established within the police agency.

The following systematic approaches are the basic items in collecting and maintaining data:

A. Location Files

The engineer should be able to retrieve reports of all accidents occurring at a specific location over a specified time interval. This allows patterns in the types, times, and circumstances of accidents occurring at the location to be examined.

The police office has to provide clear and accurate data on the police accident report form. The information must be provided in such a way that the person coding the information can locate it on a map or a road network. Thus the information ideally is of the form "m meters north-east of the intersection of X street and Y street", or "outside Number n, Z Street", or at location a.b meters on Highway A (where a and b are specific distance markers on the highway). Information like "3 Km east of town B", or incomplete information like "between town C and town D" is not helpful. Some sites are difficult to code precisely, for example, sites within a roundabout. Various reference methods in use for location of accidents were described by Zegeer, 1982.

The coder's task, having received the accident report form with the location information on it, is to translate that information onto a referencing system. There are two basic options (Ogden, 1996):

1. A coded road network, where each node (intersection) is numbered; accidents at nodes are coded according to the relevant node number, while these between nodes (mid-block or link accidents, or accidents at minor, un-numbered intersection) are coded with reference to the adjacent node(s).

2. A grid reference system, based upon a national geographic grid.

Although a street numbering system is outside this thesis, it is recommended that each node or link must be numbered. The location at mid-block can be determined by the number of each street or by the name of each street, the number of link, the number of node, and the distance with the direction from the numbered node. An example; suppose an accident occurred at Faisal Street at a distance of about 20m to the east of node number 5. This can be summarized as (Faisal, 5, 20 east). It can be abbreviated as (Street name, Node number, Distance with direction from the nearest node) or (St, N, L).

B. Retention of Records

As discussed in the literature review, central accident files are generally kept for a 12 months rotating period.

After removal of records from the active file, they should be retained in a "dead-file" system organized exactly in the same way as the active file for a period of three to five years. To preserve space, such records may be microfilmed. After three to five years, most accident records will be discarded, or removed to a warehouse location.

C. Accident Summary Sheets

The accident summary sheet was discussed in the literature review. In this summary sheet the basic type of accident, the number and types of vehicles involved, their cardinal direction, weather and roadway conditions, and the number of injuries and/or fatalities.

The use of summary sheets is recommended for Palestine. A proposed summary sheet for Palestine is shown in Table 4-1. This table is easy to use, has comprehensive data, and abbreviates all information in a small space. This data is used for analysis objectives. The suggested abbreviations are presented in Table 4-2.

The analysis of this data leads to determining the overrepresenting type of accident. Besides, the causes can also be determined. Therefore, the most suitable countermeasure is applied to minimize the hazards at this location.

4.2.2 Computer Recording System

In the computerized recording system of accidents, each item of information on the accident report form is coded and stored in a computer file. This technique is suitable for areas where total number of accidents per year is higher than 500. With this technique, facilities are provided for storing a large amount of data in a small space.

The computerized technique also facilitates flexibility in the choice of methods used for data analysis and permits the study of a large number of accident locations in a short time. There are; however, some disadvantages associated with this technique. These include the high cost of equipment and the requirement of trained computer personnel for the operation of the system.

Table 4-1: Proposed Summary Sheet for Palestine

PALESTINIAN NATIONAL AUTHORITY

TRAFFIC ACCIDENT RECORD / SUMMARY SHEET TABLE

CITY / VILLAGE *YEAR*

Case number	Location (Intersection)	Location (Link)	Time	Date	Day	Number of lanes	Accident lane	Traffic control	ADT	Type of accident	Cause of accident	Fatal	Injury	Property damage only	Number of vehicles involved	Vehicle type1	Vehicle Type2	Vehicle Type3	Weather condition	Surface condition	Road condition (W/D)	Light condition (D/N)

Table 4-2: Codes and Abbreviations to be Used in a Summary Sheet

Traffic Control	Stop sign (SS) Yielding sign (YS) Traffic signal (TS) Policeman (P) No control (NC)
Type of Accident	Vehicle-Vehicle collision (V-V) Vehicle-Pedestrian collision (V-P) Moving vehicle with fixed object (V-F) Skidding of vehicle (SKD) Overturned vehicle (OVT)
Cause of Accident	Roadway related accident (RD) Driver related accident (DR) Vehicle related accident (VEH)
Weather Condition	Clear (CL) Cloudy (CD) Raining (RN) Snowing (SN)
Surface Condition	Asphalt (AS) Concrete (CT) Gravel (GR) Dirt (DT)
Road Condition	Wet (W) Dry (D)
Light Condition	Day (D) Night (N)

When the data is stored by the computer technique, retrieval requires only the input of appropriate commands into the computer for any specific data required, and this is immediately given as output.

Most computer systems are programmed to regularly provide statistical reports of the numbers of accidents or rates by location, environmental characteristics, and analysis of types of accidents.

Computer system can provide many types of useful outputs. Most agencies will accommodate requests for special reports. These take more efforts and costs, as the system must be specially programmed to provide a particular form of output.

Kobari, 2000, reported that the total intersection accidents in Nablus City were 322 accidents for the 1997 and 1998 years. In other words, the average number of accidents was about 161 accidents a year. Besides, there were 493 link accidents in years 1997 and 1998. The average number of link accidents was 246 accidents a year. Therefore, the total intersection and link accidents were 407 accidents a year. But, it must be noticed that there is a high number of accidents that were not registered in the total accidents by police center due to several reasons.

The average number of accidents in Nablus City for the last two years was slightly less than 500 (which is 407 accidents as mentioned). However, the use of a computerized record system should be planned for the city in the near future. It is well known that there are many accidents that go unreported. Also, computerized accident system is superior for retrieval and analysis of data.

At the present time, the manual recording system is used in Nablus City. The traffic police department should upgrade their accident recording system to be computerized. However, until then the department should continue their manual system with the recommended improvements in this research.

4.3 Police Accident Report

Police reports are very efficient. They are used as judge tools between the parties of accident vehicles involved. Another objective used by specialists is to minimize the hazard of accidents. These objectives can be achieved through investigation of the data existing in the police report.

The advantages of the police accident report can be summarized as follows:

- Very useful document used in courthouse
- Very useful information for analyst.

Investigation of these information leads to determine the hazardous locations and effective countermeasures suggested by the analyst.

4.3.1 Proposed Police Accident Report for Palestine

In this thesis, a proposed police accident report to be used for Palestine in general, and Nablus City in particular, was developed as shown in Appendix C. The proposed form is easy for traffic police expert to deal with, and has a comprehensive data to be used by the traffic police administration, courts, and insurance agencies. It can also be used for analysis purposes. A computerized recording system of this accident report was also developed in this thesis to be used by the traffic police administration in Palestine.

The suggested Police Accident Report can be easily filled out manually. Besides, it was made ready for an easy computer coding system.

The proposed police accident report contains the following information:

1. Case number for each accident
2. Day, time, and date of accident
3. Location of accident
4. Driver information
5. Owners of vehicles information
6. Vehicles information
7. Accident type
8. Accident causes
9. Environmental conditions:
   - Weather conditions
   - Surface conditions
   - Traffic control

- Light conditions
- Roadway conditions
- Alignment
- Surface type

10. Injuries and fatalities information
11. Description of accident
12. Accident diagram

The police accident reports create a good database for the analyst. After a period of time each location will have a full description of all accidents occurred at this location. From the database of each location, the analyst can create the collision diagram. The collision diagram gives a full description for all accidents occurred at that location. This description will help the analyst to take a suitable action to minimize the hazards of accidents.

4.4 Summary

Police accident reports are important sources for creating the accident database. These reports can be filled manually. To increase efficiency and save time, using a computerized system of maintaining accident information is encouraged. It also provides a powerful analysis tool.

In Palestine, it is recommended to adopt the following system for the retention of accident records:

- "Active Files": these are the files that are kept current for a period of one year. As the records of each month are recorded in the files, the records for the same month in the previous year will be removed.

- "Dead Files": these are the files that are removed from the active files. It is suggested to maintain these files for a period of five years. After five years these files will be discarded. Some files that are not finished yet at the courthouse should be kept active.

In Palestine, accident files are suggested to be stored at different locations:

1. A copy of each form goes to the local motor vehicle bureau.
2. A copy of each form goes to the highway safety agency for analytical purposes.
3. A copy of each form is retained at the local traffic police office.
4. A copy of each form goes to the courthouse at the city where the accident occurred.

A suggested report form for Palestine was presented by Dornier SystemConsult, 2000. This form is shown in Appendix B, Figure B-1. Another report form by Garber and Hoel, 1996, is also presented in Appendix B, Figure B-2. These forms have a comprehensive and valuable data, but the suggested form is easier and more suitable to be used in Palestinian cities.

A proposed police accident report form for Palestine is designed for easy coding of information into a computerized system. It can also be used for the manual filling system. A summary sheet of accidents is also suggested in this research.

The use of summary sheets is highly recommended for Palestine. A proposed summary sheet for Palestine is shown in Table 4-1. The suggested abbreviations are also presented in Table 4-2.

CHAPTER 5

IDENTIFYING HAZARDOUS LOCATIONS

5.1 Introduction

The locations with an unusually or notably high number (or rate) of accidents are called *hazardous locations*. In Chapter 4, collecting and maintaining data was discussed. Hazardous locations should be based upon this information. Since accidents are rare and random, traffic safety analyses should be based upon several years of data.

The identification of hazardous locations process is predicated on being able to identify a specific site or group of sites where some form of remedial road or traffic engineering treatments may be applied to reduce the number of accidents occurring at such sites, or reduce their severity. Few treatments will reduce both accident frequency and accident severity. Most reduce only one or the other. However, either outcome is a benefit since both will reduce the cost of accidents at the site.

5.2 Objective of Hazardous Road Location (HRL) Program

The overall goal of a (HRL) program is to (Sanderson and Cameron, 1986):

1. Identify locations at which there is both high risk of accident losses and an economically justifiable opportunity for reducing this risk.
2. Identify countermeasure options and priorities, which maximize the

2. Identify countermeasure options and priorities, which maximize the economic benefits from the (HRL) program.

5.3 Identification of Hazardous Locations

The following techniques are used to determine the hazardous locations:

- **Spot Maps**
- **Number of Accidents**
- **Accident Rate**
- **Number-Rate of Accidents**
- **Rate Quality Control (RQC)**
- **Rating by Accident Severity**
- **Potential Accident Reduction (PAR)**
- **Expected Value**

Details of these methods are discussed in literature review.

5.4 Determination of HRL in Palestine

It should be mentioned that most injury and fatal accident records are available in Palestinian cities in general and Nablus City in particular with respect to the property damages accident records. Most property damage accidents are not reported, thus are not accounted for. Therefore, the determination of HRL in Palestine at the present time will be based on injury and fatal accidents only.

It is recommended as an initial stage for Palestine, to use spot maps and to use colored pins to indicate the sites of high number of accidents. A computerized program such as a GIS-based program will also help in using spot maps and makes it more efficient.

It is also recommended, in a later stage when the safety program is more developed, to use "Number-Rate" of accidents method to determine high accident locations. The rate method can be used only where the volumes are known at locations of accidents. Otherwise, hazardous locations can be determined based on frequency (number of accidents) threshold being the basic indicator in this case. To determine the threshold of both the rate and frequency, statistical methods should be applied. The expected value statistical method described before is recommended to be used to estimate these thresholds because it is based on accident statistics of all intersections or links in the network. In addition, it considers a specific statistical confidence level. Therefore, it is expected to produce reliable results.

The analyst has a choice to determine the confidence level to determine the expected value. The majority of publications which deal with this statistical methods use the confidence level of 95 percent. Therefore, a 95 percent confidence level is also recommended for use in Palestine. The formula to be used in this method is

$$E_V = X_{av} \pm ZS$$

Where terms are as defined before and Z = 1.96.

5.4.1 Expected Values for Links and Intersections – General

With reference to the data in Nablus City provided by Kobari, 2000, the analysis showed that the expected value for all intersection accident frequency was 3.3 accidents per year for the year 1997-1998 data.

The expected value for the intersection accident rate was 0.4 accidents per million entering vehicles. Furthermore, the expected value for accident frequency at links was 3.3 accidents per year. Table 5-1 summarizes these results.

Table 5-1: Expected Values at All Intersections and Links in Nablus City[1]

	At Intersection	At Links
Frequency of Accidents (accidents / year)	3.263[2]	3.301[3]
Rate of Accidents (Accidents per MEV / year)	0.402[2]	N/A[4]

Notes:
(1) Results are based on 1997-1998 accident data.
(2) Based on 126 intersections.
(3) Based on 493 links.
(4) Volume data at links were not available.

The thresholds to be used can be summarized as the following:

At intersection E_V = **3.3** accidents (for accident frequency)

At intersection $E_v = 0.4$ accidents per million entering vehicles (for accident rate)

At links $E_v = 3.3$ accidents (for accident frequency)

These expected values are consistence with the values obtained from Kobari, 2000. The analysis was done upon the same data.

Detailed calculations that lead to the above results are shown in Appendix D. These threshold values give some flexible judgement for the analyst. Besides, each city in Palestine has its own situation and may yield different results.

5.4.2 Expected Values Based on Road Classification

Based on the data obtained from Kobari, 2000, the following table (Table 5-2) summarizes these data. The expected values were calculated according to the highway classification in Nablus City.

Table 5-2: Expected Values of Accident Frequency at Intersections According to Roadway Classification – Nablus City (1)

Intersection Type	Number of Accidents per two years	Number of Intersections	Average Number of Accidents per Intersection (X_{av})	Estimated Standard Deviation of Accident Frequency (S)	Expected Values at Intersection (E_V) (2) for two years
Main/Main	90	29	3.10	3.14	9
Main/Collector	38	17	2.24	2.46	7
Collector/Collector	21	24	0.875	1.7	4

Note (1): Accident records for the period of two years.

(2); Expected value (2-years) were calculated based on equation Ev = Xav + ZS.

(3): Accidents rates at secondary road intersections were not available.

Therefore, the expected value thresholds for the accident frequency based on the above classification for the period of one year will be the following:

E_V (Main/Main intersections) = 4.5 accidents / year

E_V (Main/Collector intersections) = 3.5 accidents / year

E_V (Collector/Collector intersections) = 2 accidents / year

The expected value threshold for the accident rates was calculated for the Main/Main intersections only. This was because traffic volumes were available only at these intersections. The average accident rates at Main/Main intersections was 0.19 accidents/MEV, and the standard deviation of accident rates was 0.21. Therefore, the expected value for the period of two years was 0.61 accidents / MEV, and the expected value for the period of one year was 0.31 accidents / MEV. So, the expected value was taken to be 0.3 accidents / MEV. Detailed calculations were presented in Appendix E.

The thresholds of expected values for both frequency and rate at main links were calculated to be as follows:

E_V at main links based on accident frequency = 4 Accidents / year.

E_V at main links based on accident rate = 0.8 Accidents / MEV. Km / year.

Detailed calculation were presented in Appendix F.

Calculation of expected values at collector and secondary links based on accident frequency or rate was not possible because data was either not available or could not be easily assigned or calculated at specific links.

Applying the above thresholds indicated that Al-Hesba and Al-Adel Intersections were the most hazardous intersections in Nablus City.

Several interviews were made with drivers and police traffic experts about their perception of the hazardous locations in Nablus City. Drivers and police experts agreed that Al-Hesba Intersection is the most hazardous location in Nablus City. For this reason, Chapter 9 discusses a safety study at Nablus City to be applied at Al-Hesba Intersection.

Furthermore, the accidents data at Al-Hesba Intersection were collected from police reports and the courthouse. There were 15 accidents occurred at this intersection from 1/4/1999 to 1/9/2000. Details of safety study are presented in Chapter 9.

According to the threshold values at links, Al-Quds Street was the most hazardous location based on accident frequency criterion. It had 49 accidents per two years according to Kobari, 2000. Furthermore, Askar-Balata Street was also the most hazardous location based on accident rate criterion. It had 2 accidents/MEV per two years according to Kobari, 2000 also.

5.5 Summary

Hazardous locations are those locations that have higher number or rate than some expected or critical values. The main aim of determining these hazardous locations is to apply a proper treatment at these locations. This treatment will lead to minimizing the cost of accident through the reduction of accident numbers or severity.

The spot map method is recommended to be used in Palestine at the initial stage. Colored pins may be used at these maps. Besides, it is recommended in Palestine (when the traffic volume is available) to use the accident rate method to determine the hazardous locations. Where there are no available traffic volumes, the accident frequency method is recommended. The expected value is the statistical method to be used to specify thresholds for both rate and frequency of accidents.

In this research, only major intersections in Nablus City were included in the analysis. These are intersections of main/main, main/collectors, and collectors/collectors. Sites with zero accidents should be included in the analysis to determine the expected value and be updated after certain number of years.

In Nablus City, the following threshold of expected values are suggested to be adopted. Each city in Palestine has its own accident situation and may yield different threshold results. However, in the absence of any other information, these values may be used by other cities in Palestine.

Accident Frequency Thresholds

Overall intersections	E_V = 3.3 accidents / year
(Main/Main intersections)	E_V = 4.5 accidents / year
(Main/Collector intersections)	E_V = 3.5 accidents / year
(Collector/Collector intersections)	E_V = 2.0 accidents / year
At all links (Mid-block)	E_V = 3.3 accidents / year
At main links	E_V = 4 accidents / year

Accident Rate Thresholds

Overall intersections	E_V = 0.4 accidents / MEV / year
(Main/Main intersections)	E_V = 0.3 accidents / MEV / year
Main links	E_V = 0.8 Accidents / MEV. Km / year.

These threshold values should be periodically updated every 3 to 5 years. This period is consistent with the period for which several agencies keep accident records.

The determination of hazardous locations, through the accident analyses, is the basis for the treatment of these hazardous locations. This extent of treating hazardous locations depends upon the available budget. This budget should be spend first on the most hazardous locations. Then, it should be spend on the less hazardous locations, and so on. This process is continued until the available budget is totally spend.

CHAPTER 6

CONDUCTING ENGINEERING SAFETY STUDIES

6.1 Introduction

In Chapter 5 the hazardous locations were determined. In this chapter a detailed engineering study for hazardous locations is discussed. Conducting engineering studies is the third step in the planning process shown in Figure 2-1.

There are two main tasks in conducting engineering safety studies:

1. Studying the accident data to determine the type of accidents at hazardous locations, then the cause of accident can be identified. Table 6-1 indicates the possible causes for each type of accident.
2. Conducting a field review of the study site. This includes inspection of physical condition of the site and an observation of traffic operation. Table 6-2 indicates the data required to identify the safety deficiencies at the study site.

The suitable countermeasures are applied at the accident site, when the type and cause of accident are determined, according to the effectiveness of each one. Table 6-3 shows the general countermeasures for different safety deficiencies. To specify the type and possible cause of accident,

Table 6-1: Probable Accident Causes for Different Types of Accidents

ACCIDENT PATTERN	*PROBABLE CAUSES*
Left–turn head-on collision	Large volume of left turn Restricted sight distance Too short amber phase Absence of special left-turning phase Excessive speed on approaches
Right-angle collisions at signalized intersections	Restricted sight distance Excessive speed on approaches Poor visibility of signal Inadequate signal timing Inadequate roadway lighting Inadequate advance intersection warning sign Large total intersection volume
Right-angle collisions at unsignalized intersections	Restricted sight distance Large total intersection volume Excessive speed on approaches Inadequate roadway lighting Inadequate advance intersection warning signals Inadequate traffic control devices
Rear-end collisions at unsignalized intersections	Driver not aware of intersection Excessive speed on approach Slippery surface Lack of adequate gaps Large number of turning vehicles Crossing pedestrians Inadequate roadway lighting
Rear-end collisions at signalized intersections	Slippery surface Large number of turning vehicles Poor visibility of signals Inadequate signal timing Unwarranted signals Inadequate roadway lighting
Pedestrian-vehicle collisions	Restricted sight distance Inadequate protection for pedestrians School crossing area Inadequate signals Inadequate phasing signal

Source: Adopted from Highway Safety Engineering Studies Procedural Guide, U.S. Department of Transportation, Washington, D.C., June, 1981.

(Obtained from Garber and Hoel, 1996.)

Table 6-2: Data Needs for Different Possible Causes

Possible Causes	*Data Needs*	*Procedures to Be Performed*
	Rear-end collisions at unsignalized intersections	
Drivers not aware of intersection	▪ Roadway inventory ▪ Sight distance characteristics ▪ Speed characteristics	▪ Roadway Inventory Study ▪ Sight Distance Study ▪ Spot Speed Study
Slippery surface	▪ Pavement skid resistance characteristics ▪ Conflicts resulting from slippery surface	▪ Skid Resistance Study ▪ Weather-Related Study ▪ Traffic Conflict Study
Large number of turning vehicles	▪ Volume data ▪ Roadway inventory ▪ Conflict data	▪ Volume Study ▪ Roadway Inventory Study ▪ Traffic Conflict Study
Inadequate roadway lighting	▪ Roadway inventory ▪ Volume data ▪ Data on existing lighting	▪ Roadway Inventory Study ▪ Volume Study ▪ Highway Lighting Study
Excessive speed on approaches	▪ Speed characteristics	▪ Spot Speed Study
Lack of adequate gaps	▪ Roadway inventory ▪ Volume data ▪ Gap data	▪ Roadway Inventory Study ▪ Volume Study ▪ Gap Study
Crossing pedestrians	▪ Pedestrian volumes ▪ Pedestrian/vehicle conflicts ▪ Signal inventory	▪ Volume Study ▪ Pedestrian Study ▪ Roadway Inventory Study
	Rear-end collisions at signalized intersections	
Slippery surface	▪ Pavement skid resistance characteristics ▪ Conflicts resulting from slippery surface	▪ Skid Resistance Study ▪ Weather-Related Study ▪ Traffic Conflict Study

Continued

Table 6-2: Continued

Possible Causes	*Data Needs*	*Procedures to Be Performed*
	Rear-end collisions at signalized intersections	
Large number of turning vehicles	• Volume data • Roadway inventory • Conflict data • Travel time and delay data	• Volume Study • Roadway Inventory Study • Traffic Conflict Study • Delay Study
Poor visibility of signals	• Roadway inventory • Signal review • Traffic conflicts	• Roadway Inventory Study • Traffic Control Device Study • Traffic Conflict Study
	Left-turn head-on collisions	
Large volume of left-turns	• Volume data • Vehicle conflicts • Roadway inventory • Signal timing and phasing • Travel time and delay data	• Volume Study • Traffic Conflict Study • Roadway Inventory Study • Capacity Study • Travel Time and Delay Study
Restricted sight distance	• Roadway inventory • Sight distance characteristics • Speed characteristics	• Roadway Inventory Study • Sight Distance Study • Spot Speed Study
Too short amber phase	• Speed characteristics • Volume data • Roadway inventory • Signal timing and phasing	• Spot Speed Study • Volume Study • Roadway Inventory Study • Capacity Study
Absence of special left-turning phase	• Volume data • Roadway inventory • Signal timing and phasing • Delay data	• Volume Study • Roadway Inventory Study • Capacity Study • Travel Time and Delay Study
Excessive speed on approaches	• Speed characteristics	• Spot Speed Study

Source: Adapted from *Highway Safety Engineering Studies Procedural Guide*, U.S. Department of Transportation, Washington, D.C., June 1981.

Table 6-3: General Countermeasures for Different Safety Deficiencies

Left-turn head-on collisions	
Large volume of left-turns	• Create one-way street • Widen road • Provide left-turn signal phases • Prohibit left-turns • Reroute left-turn traffic • Channelize intersection • Install stop signs (see MUTCD)* • Revise signal sequence • Provide turning guidelines (if there is a dual left-turn lane) • Provide traffic signal if warranted by MUTCD* • Retime signals
Restricted sight distance	• Remove obstacles • Provide adequate channelization • Provide special phase for left-turning traffic • Provide left-turn slots • Install warning signs • Reduce speed limit on approaches
Too short amber phase	• Increase amber phase • Provide all red phase
Absence of special left-turning phase	• Provide special phase for left-turning traffic
Excessive speed on approaches	• Reduce speed limit on approaches
Rear-end collisions at unsignalized intersections	
Driver not aware of intersection	• Install/improve warning signs
Slippery surface	• Overlay pavement • Provide adequate drainage • Groove pavement • Reduce speed limit on approaches • Provide "slippery when wet" signs
Large numbers of turning vehicles	• Create left- or right-turn lanes • Prohibit turns • Increase curb radii
Inadequate roadway lighting	• Improve roadway lighting
Excessive speed on approach	• Reduce speed limit on approaches
Lack of adequate gaps	• Provide traffic signal if warranted (see MUTCD)* • Provide stop signs
Crossing pedestrians	• Install/improve signing or marking of pedestrian crosswalks

Continued

Table 6-3: Continued

	Rear-end collisions at signalized intersections
Slippery surface	• Overlay pavement • Provide adequate drainage • Groove pavement • Reduce speed limit on approaches • Provide "slippery when wet" signs
Large number of turning vehicles	• Create left- or right-turn lanes • Prohibit turns • Increase curb radii • Provide special phase for left-turning traffic
Poor visibility of signals	• Install/improve advance warning devices • Install overhead signals • Install 12-in. signal lenses (see MUTCD)* • Install visors • Install back plates • Relocate signals • Add additional signal heads • Remove obstacles • Reduce speed limit on approaches
Inadequate signal timing	• Adjust amber phase • Provide progression through a set of signalized intersections • Add all-red clearance
Unwarranted signals	• Remove signals (see MUTCD)*
Inadequate roadway lighting	• Improve roadway lighting

**Manual on Uniform Traffic Control Devices*, published by FHWA.

Source: Adapted from *Highway Safety Engineering Studies Procedural Guide*, U.S. Department of Transportation, Washington, D.C., June 1981.

(Obtained from Garber and Hoel, 1996)

analysis of accident data, and site analysis should be determined. Site analysis includes the following:

1. Condition diagram
2. Police accident report
3. Accident histogram
4. Collision diagram

The above four elements are discussed in this chapter.

6.2 Accident Reduction Capabilities of Countermeasures

Implementing a proposed proper countermeasure is expected to reduce the number of accidents. Accident reduction capabilities are used to estimate the reduction in the number of accidents during a given period. There are values in different countries or states for accident reduction capabilities known as *accident reduction* factors (AR). Table 6-4 indicates the accident reduction for low cost treatment (ITE, 1992). It is suggested to use these values in Palestinian cities because there are no available such values.

Table 6-4: Accident Reduction for Low-Cost Treatments

Treatment	Accident Reduction (%)
Anti-skid	50
Improved signing at junctions	46
Modifications to existing trafic signals	30
New traffic signals	46
New pelicans (crosswalks)	40
New zebras (crosswalks)	44
Super-elevation	75
Lining and signing not at bends	32
Lining and signing at bends	55
Minor junction changes (not roundabouts)	52
Pedestrian refuges	19
Pedestrian barriers	43
New street lighting	24
Resurfacing	34
Alterations to roundabouts	20
Area studies	50

Source: ITE, 1992

In using the AR factors to determine the reduction in accidents due to the implementation of a specific countermeasure, the following equation is used:

# of Accidents Prevented = N x AR x (ADT after period / ADT before period)

where:

N = expected number of accidents if countermeasure is not implemented and if the traffic volume remains the same.

AR = accident reduction factor.

ADT = average daily traffic.

6.3 Process of Diagnosis

The Highway Safety Guidelines published by the United Kingdom (UK) Institution of Highway and Transportation (1990) suggested that there are six steps in the diagnosis phase (Ogden, 1997).

- Study detailed accident reports.
- Data sorting to determine groups of accident types and the locations where they occur.
- Data amplification by detailed on site investigation.
- Detailed analysis of all data.
- Identification of dominant factors and/or road features.
- Determine the nature of the accident problem.

Therefore, most accident investigations involve two aspects which are related to diagnosis of road safety problems . The first involves an in-office analysis to identify predominant vehicle maneuvers and the accident types which are occurring (e.g., a disproportionate incidence of night time accidents implies a need for delineation, lighting, etc). The second aspect is an on-site analysis involving observation of road features and driver behavior (Ogden, 1997).

6.4 Analysis of Accident Data

The reasons for analyzing traffic accident data are the following:

1. To identify any accident pattern that may exist.
2. To determine the probable causes of accidents with respect to drivers, highways, and vehicles.
3. To develop countermeasures that will reduce the rate and severity of accidents.

These objectives could be achieved through studying briefly all information from the accident histogram, collision diagram, condition diagram, and police accident report.

To facilitate the comparison of results obtained from the analysis of accidents at a particular location with those of other locations, use is made of one or more accident rates. These accident rates are determined on the basis of exposure data, such as traffic volume and length of road section being considered. Commonly used rates are per million of entering vehicles and rate per 100 million vehicle miles.

6.5 Accident Patterns

Two commonly used techniques to determine accident patterns are:

1. Expected value analysis

2. Cluster analysis

A suitable summary of accident data can also be used to determine accident patterns.

6.5.1 Expected Value Analysis

Details about the expected value analysis were presented in Chapter 2.

6.5.2 Cluster Analysis

Cluster analysis involves the identification of a particular accident characteristic from the accident data obtained at a site. It identifies any abnormal occurrence of a specific accident type in comparison with other types of accidents at the site. For example, if there are two rear-end collision, one right-angle accident, and six left-turn accidents at an intersection during a given year, the left-turn accidents could be defined as a cluster or grouping, with abnormal occurrence at the site.

6.6 Determination of Accident Causes

Having identified the hazardous locations and the accident pattern, the next stage in the data analysis is to determine possible causes of accidents. The types of accidents identified are matched with a list of possible causes from which several probable causes are identified. Table 6-1 shows a list of possible causes for different types of accidents.

The environmental conditions existing at the time of accidents and field review may also help in the identification of other possible causes of accidents.

6.7 Detailed Analysis

The ITE,1992, reported that, when locations have been identified for further analysis, the normal procedures of analysis include the following:

1. Obtaining all accident data and reports for a time period of at least two years.
2. Preparing a summary report of the accident data, including dates and times of accidents, weather conditions, road conditions, type of accident (e.g., sideswipe, angle, rear-end), type of vehicles involved, driver actions, and other information from report forms.
3. Preparing a collision diagram to identify patterns of accident occurrence that can assist the analyst in looking for engineering solutions.
4. Preparing a condition diagram or inventory sketch of the location, including physical features such as traffic control devices, pavement conditions, utility poles and building lines, and others as appropriate.
5. Obtaining other data such as traffic speeds and volumes, vehicle classifications, and signal timing.
6. Visiting locations to observe and become familiar with specific site characteristics, traffic patterns, and other information not readily available from reports or inventories. A Field Inventory form can be filled by an engineer. This form contains considerable information about the road or intersection geometry. Furthermore, it has the information about the surface type and defects, traffic control, speed limit, land uses, etc.

A proposed Field Inventory form for Palestine is shown in Appendix G.

The above processes will assist the engineer in identifying and analyzing environmental, site, or traffic characteristics that may be contributing to traffic accidents. When such causes are identified, the engineer or analyst can evaluate corrective measures that are known to be effective.

The final stage in the process is to evaluate the actual effectiveness of specific measures after they have been put into place. Evaluation techniques are well-documented in Chapter 7, but a fundamental requirement is that any necessary data be identified and collected for both the period prior to and following implementation. The evaluation results, whether positive, neutral, or negative should be documented to improve the knowledge base of the responsible agency and the profession as a whole.

The site analysis includes four items. These are:

- Condition diagram.
- Police accident report.
- Accident histogram.
- Collision diagram.

6.7.1 Condition Diagram

A condition diagram describes the following:

1. All physical and environmental conditions at the accident site under study
2. Geometric features of the site, the location and description of all traffic controls (sign, signals, markings, lighting, etc.), and all relevant features of

the roadside environments, such as the location of objects, driveways, land uses, and so on.

The diagram must encompass a large enough area around the location to include all potentially involved features. This may range from several hundred feet on intersection approaches to ¼ - ½ mile on rural highway sections (McShane, Roess, and Brassas, 1998). Figure 6-1 illustrates a condition diagram for an intersection in a suburban community.

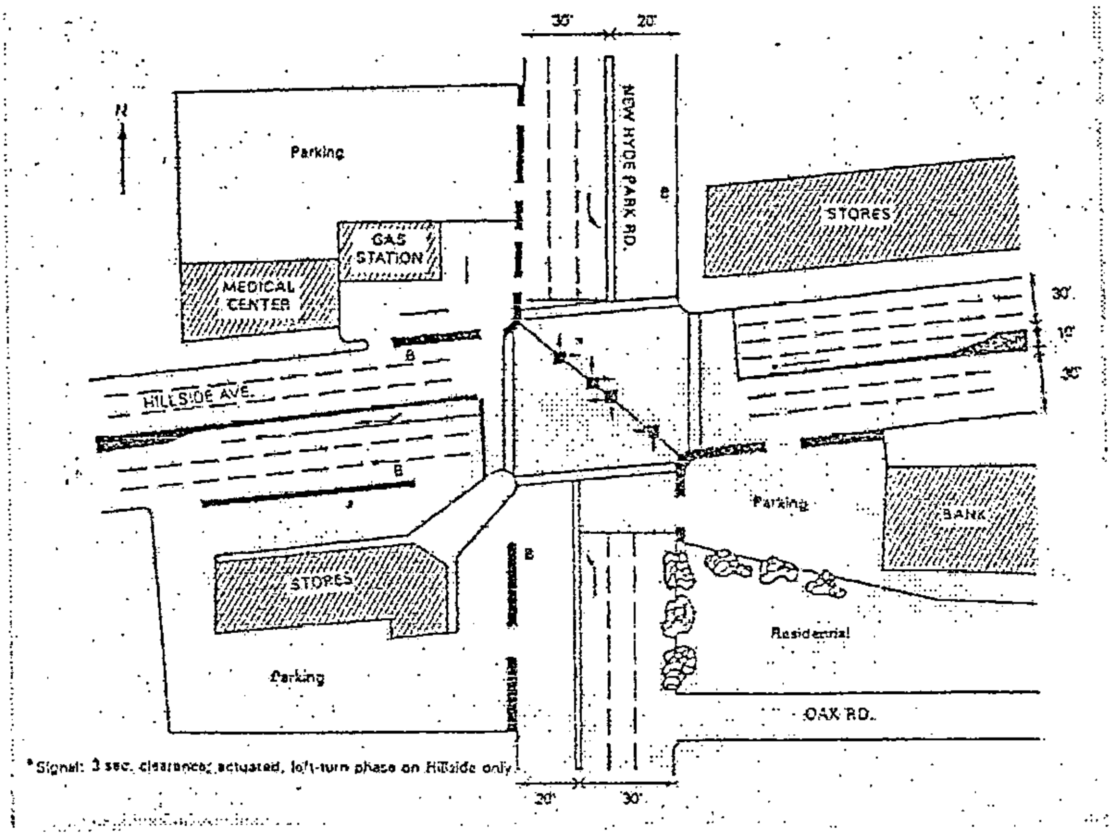


Figure 6-1: Typical Condition Diagram

Source: Adapted from Traffic Engineering by McShane, Roess, and Brassas, 1998.

A field inventory form will assist in documenting information about the site. As mentioned before, a proposed "Field Inventory Form" to be used in Palestine was developed in this research, and is presented in Appendix G.

6.7.2 Police Accident Report

This report plays an important role to identify and analyze the accident. This report is efficient to provide information for potentially effective countermeasures at an accident site. The police officer attending the scene of accident is required to fill out a form that contains information about the vehicle, driver, pedestrian, and road. These information are found in a police accident report (refer to police accident reports shown in Appendix B). A new police accident report was designed in this research and is presented in Appendix C.

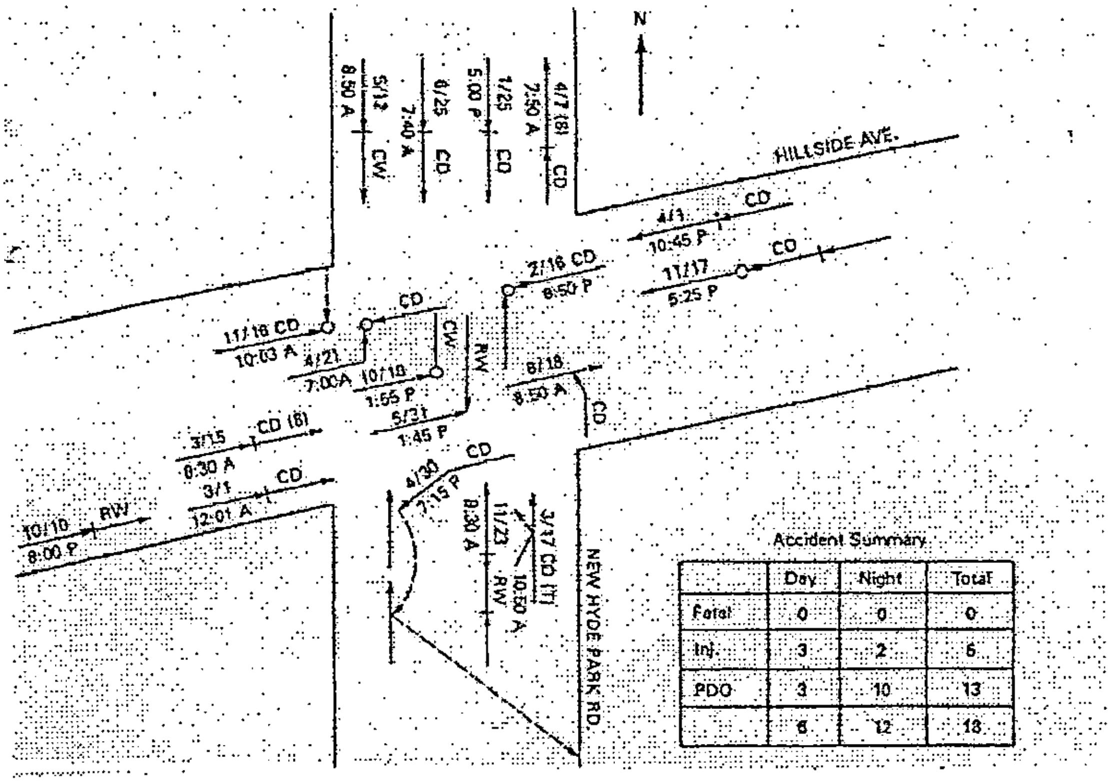
6.7.3 Accident Histograms

Accident histograms are particularly useful in the analysis and evaluation of the safety performance of a stretch of highway. It provides a plot of accident frequency versus accident location, thus allowing the analyst to identify areas of 'accident concentration' (Abdelwahab, 1997). These areas are usually major intersections, access roads, or a section with poor road geometry (e.g., sharp curve, restricted sight distance, etc.).

6.7.4 Collision Diagram

These diagrams present pictorial information on individual accidents at a location. Different symbols are used to represent different types of maneuvers, types of accidents, and severity of accidents. The date and time (day or night) at which the accident occurs are also indicated. Figure 6-2 shows a typical collision diagram. One advantage of collision diagrams is that they give information on the location of the accidents, which statistical summaries do not give. Collision diagrams may be prepared manually either by retrieving data field manually or by a computer when data are stored in a computer file.

A collision diagram is a schematic representation of all accidents occurring at a given location over a specific period, generally from one to three years. Each collision is represented by a set of arrows, one for each vehicle involved, which schematically represents the type of accident and directions of all vehicles. Arrows are labeled with codes for vehicle types, date and time of accident, and weather conditions. Arrows are placed on a schematic, not-to-scale drawing of the intersection, with no interior details shown. One set of arrows represents one accident. It should be noted that arrows are not necessarily placed at the exact location of accident on the drawing. Several accidents may have taken place at the same spot. Arrows are placed to illustrate the occurrence of accidents, as close to the actual spot as possible while still clearly indicating each accident as a separate set of symbols. Figure 6-3 lists the standard symbols and codes used in the preparation of collision diagrams.



	Day	Night	Total
Fatal	0	0	0
Inj.	3	2	5
PDO	3	10	13
	6	12	18

Figure: 6-2 Typical Collision Diagram

Source: Traffic Engineering by McShane, Roess, and Brassas, 1998.

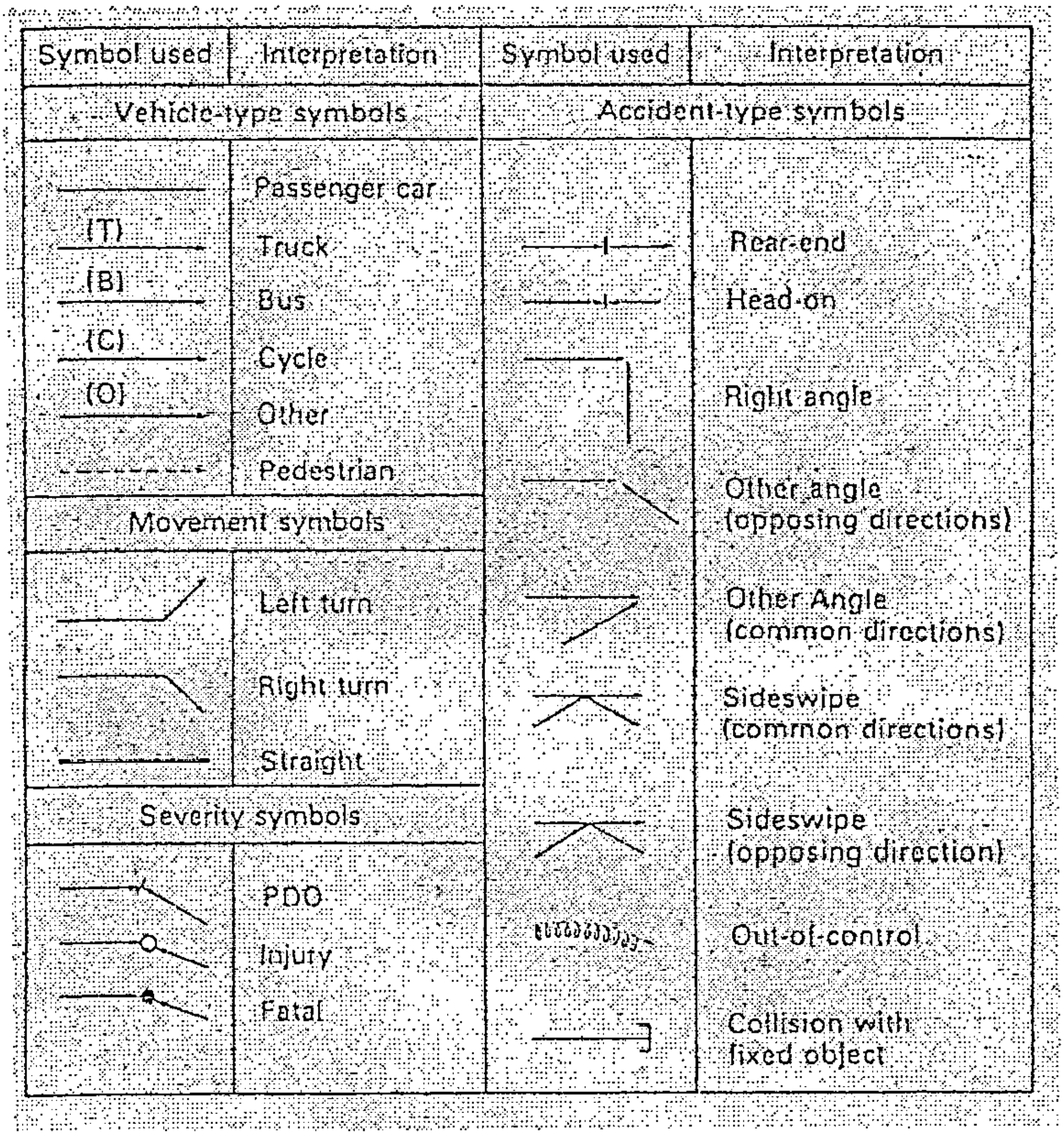


Figure: 6-3: Standard Symbols for Collision Diagram

Source: Traffic Engineering by McShane, Roess, and Brassas, 1998.

In summary the collision diagram has the following information:

1. Type of accident
2. Severity of accidents
3. Light condition
4. Directions of all vehicles
5. Date and time of accident
6. Weather conditions
7. Road surface condition
8. Indications to identify the pattern of accident

6.8 Problem Analysis

As reported by Ogden,1997, the basic information is obtained from accident reports, site visit, and other gathered information. The following questions are key to the accident problem analysis process (Andreassend, 1983):

- Are accidents associated with a physical condition of the road, and can this situation be eliminated or corrected?
- Is visibility adequate, and can this be corrected, or if not is there adequate warning?
- Are the existing signs, signals, and pavement marking doing the job for which they were intended? Are replacement needed?
- Is traffic properly channeled to minimize the occurrence of conflicts?
- Would accidents be prevented by prohibition of a specific movement (e.g., a right or left turn), or by giving it priority (e.g., exclusive turn phase at a traffic signal)?

- Can some of the traffic be diverted to other streets where the accident potential is not as great?
- Are night time accidents out of proportion to daytime accidents indicating the need for special night time protection (lighting, delineation, etc.)?
- Do conditions show the need for additional traffic law enforcement?

Answering these questions will provide detailed information that will be the basis for analyzing the accident problems at the study site.

6.9 Economic Analysis

Economic analysis summarizes an economic feasibility of the elected countermeasures. This implies identification of costs and benefits. Costs are the capital and continuing costs for constructing and operating the proposed countermeasure (investment, operating, and annual maintenance costs). The benefits are obtained by the expected number of prevented accidents by an assigned cost for each type of accident severity. Table 6-5 shows costs proposed by the National Highway Traffic Safety Administration (NHTSA). These costs will be different from country to country or from state to state depending upon the costs for each type of accident severity for that state or country. The detailed economic analysis is presented in Chapter 6.

Table 6-5: Some Typical Accident Unit Costs

Accident Severity	PDO	Minor Injury	Moderate Injury	Serious Injury	Severe Injury	Critical Injury	Fatal
Costs ($)	1,481	6,145	26,807	84,189	158,531	589,055	702,281

Source: The Economic Cost of Motor Vehicle Crashes, 1990, and National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington, D.C., September 1992.

6.10 Interpretation of Results

McShane, Roess, and Brassas, 1998, gave an interpretation of the result for a collision diagram (Figure 6-2). Accidents are generally grouped by type. The predominant accidents illustrated in Figure 6-2 are rear-end and right-angle accidents. For each type of accident, three questions must be asked and answered. These are:

1. What driver actions lead to the occurrence of such an accident?
2. What conditions existing at the location could contribute toward drivers taking such actions?
3. What changes can be made to reduce the chance of such actions occurring in the future?

As an example of interpretation of results, consider the rear-end collision of the Figure 6-2 . Rear-end collision normally occurs when the lead vehicle stops suddenly or unexpectedly, and/or when the following driver follows too closely for the prevailing speed and environmental conditions. While tailgating by a following driver is not correctable by design or control, a number of factors may contribute to vehicles stopping suddenly at the intersections depicted in Figure 6-2.

At signalized intersections, frequent quick stops are often related to a mistimed yellow or clearance interval. If the interval is too short, vehicles attempting to continue through the intersection will have to stop suddenly to avoid being hit by crossing vehicles. Therefore, the timing of the clearance interval must be checked in cases such as these.

The condition diagram of Figure 6-1 shows an unusual number of driveways allowing access to and egress from the street right at or near the intersection area. Unexpected movements in and out of these driveways could cause mainline vehicles to stop suddenly. Another noticeable condition is that STOP lines are located well back from the sidewalk line, particularly in the northbound direction. Thus, vehicles are stopping at positions not normally expected, and following drivers may be surprised and unable to respond on time to avoid a collision.

Potential corrective actions flow from this. Several driveways in the immediate intersection area should be closed, and STOP lines moved to more normal locations. The clearance intervals must be checked and retimed. Signal sight lines with respect to trees and so on should be checked. Further, since most of the accidents are occurring at night, lighting and visibility under these conditions should be studied.

Clearly, this analysis is illustrative. Each situation and location will have its own unique characteristics, requiring the application of the traffic engineer's skills in an insightful and innovative ways. The tools of site analysis, and the collision and condition diagrams, are not the end result of an analysis. But merely the most effective means of depicting complex information. As noted previously, accident site analysis is quite complicated, using all the traffic engineer's knowledge of design, operations, controls, and safety.

6.11 Summary

It was stated that the planning component of the Highway Safety Improvement Program consists of four processes. Conducting engineering studies is the third process, after collecting data and determining hazardous locations. The main aim of this process is to identify effective countermeasures to eliminate or minimize the hazards of accidents.

In summary, it is suggested for Palestine that the following four steps are applied to achieve the main aim of determining effective countermeasures for each accident. These steps are also summarized schematically in Figure 6-4.

1. Determination of the type of accidents through deep study of the accident histogram, collision and condition diagrams, and police accident report.
2. Determination of the cause of accidents according to Table 6-1or traffic engineer's judgement. This can be achieved also by road investigation, in addition to a deep study of the collision and condition diagrams and police report.
3. Determination of the data required to identify the safety deficiencies according to Table 6-2.

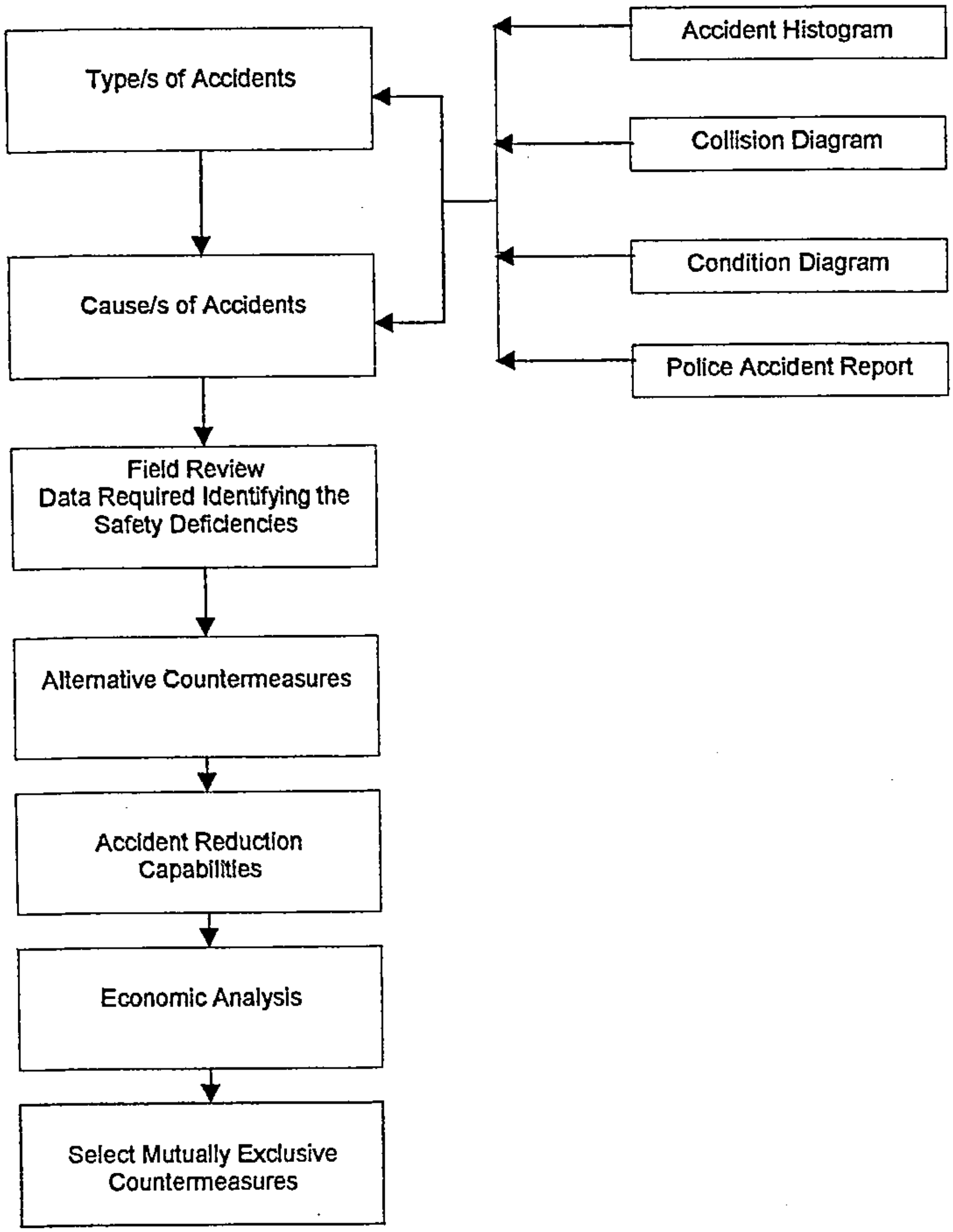


Figure 6-4: Major Recommended Steps in Conducting Engineering Studies Process for Palestine.

4. Determination of the best effective countermeasures. To optimize the best remedial actions economic analysis should be done.

CHAPTRE 7

ESTABLISHING PROJECT PRIORITIES

7.1 Introduction

The fourth process of the planning component is the establishment of project priorities. After conducting engineering studies and determination of specific countermeasures, then these measures should be studied well to maximize their benefits.

The process of establishing project priorities aims at maximizing the total safety benefits within the constrains of available funds. This process involves the ranking of hazardous locations, which were previously determined.

7.2 Ranking and Project Selection

After identifying hazardous locations and determination of remedial actions "countermeasures", the implementation will follow these steps. If there is no sufficient budget to implement all the countermeasures and projects, ranking of the projects will be efficient and essential in this case.

The Institute of Highway and Transportation in its road safety guidelines outlined seven steps to be followed in systematically selecting projects for inclusion in a hazardous road locations program (Ogden, 1996):

1. Determine the range of measures likely to influence the dominant accident types and road features
2. Test the measures to insure that:
   - a decrease in accidents is likely to occur
   - no future increases are likely in other accident types
   - no unacceptable effects are likely on traffic or environment
3. Conduct economic assessment of costs and benefits
4. Select measures likely to give the greatest benefits
5. Consult the public to ensure acceptance by the community affected
6. If necessary, amend proposal
7. Select sites for priority treatment and develop action plans

In ranking sites and developing a prioritized work program, the use of formal economic appraisal procedures is an invaluable aid.

In recent years, it has become both possible and more common to perform a formal appraisal of traffic engineering road safety projects. There are two reasons for this. Firstly, governments are requiring road and safety agencies to show that investment in such projects is worthwhile. Secondly, the data to permit a more rigorous form of appraisal are becoming available.

Ogden, 1996, suggested two types for ranking the road safety improvement projects:

1. A formal economic appraisal in which costs and benefits are calculated and compared.

2. A "goals achievement" approach (such as cost-effectiveness approach), whereby projects are ranked, but no attempt is made to assess their economic benefits against their costs.

7.2.1 Economic Appraisal of Road Safety Projects

Economic appraisal is essentially concerned with the economic efficiency. It also indicates not only whether the project is worthwhile, but also indicates which is the best project or set of projects to undertake. It consists of six stages:

- Identification of relevant benefits and costs
- Valuation of benefits and costs
- Reduction of all future benefits and costs to their equivalent present day values
- Comparison of benefits and costs according to an explicit decision criterion
- Sensitivity testing where values are uncertain or risks are high
- Presentation of results

In the following discussion, the meaning of each stage is discussed.

A. Benefits and Costs

Benefits. The benefits of a road safety-engineering program comprise savings in road accident costs, which are estimated to result from the construction or introduction of a road safety measure. These may be due to a reduction in costs resulting either from a reduction in the number of accidents or a reduction in the severity of accidents, or sometimes from both.

Costs. Although there are several ways in which costs can be calculated, the best definition is that the costs of a project are its initial capital cost, which usually involves only the costs that are incurred up-front as the project is designed and built.

B. Valuation of costs and benefits

In many countries, the estimation of accident costs was created. In Palestinian cities Jadalla, 2000, was discussed the costs of such accidents, as we will see later.

The valuation of costs is usually straightforward; this is the engineering estimate of the cost of the job.

The valuation of benefits is more difficult, since it involves placing an economic value on accidents and thus on accident savings. As well as the actual valuation of the cost of accidents; the way in which these valuations are expressed is important. Until recently, most jurisdictions used very broad average values. For example, the average cost of a rural accident and an urban accident, or the average cost by accident severity. The UK approach to economic evaluation is typical; it is based upon the use of an average cost of accidents by location (rural, urban, motorway) and by severity (fatal, serious, slight) (Ogden, 1996).

Recently; however, a potentially much more powerful approach has emerged. This is based on the calculation of the average cost of particular accident types. This enables a more detailed analysis of the benefits of the treatments to be undertaken, particularly in instances where there may be little effect upon accident frequency. But, a significant effect upon accident severity. The need for such artifacts as severity indices to arbitrarily weigh the incidence of different accident severity to develop a ranking is no longer necessary.

Andreassen, 1992, has pioneered this approach. Andreassen's average standardizes costs for nineteen accident type groups, based on 1987-88 data for the state of Victoria, Australia, are shown in Table 7-1. However, average costs per accident will be somewhat different for various countries since the cost structure will vary.

Also Table 7-2 shows costs proposed by the National Safety Council (NSC) and the National Highway Traffic Safety Administration (NHTSA).

Jadallah, 2000, studied accident costs by type in Palestine based on records of the insurance companies. Accidents for cost purposes was classified as slight, medium, sever, very sever, fatality type 1, and fatality type 2. Based on NSC (1979), minor injury accidents was included as part of the property damage accidents, as shown in Table 7-2. Table 7-3 shows the proposed accident costs by type.

Table 7-1: Costs by Accident Type

Accident type[1]		Urban	Rural
One-vehicle accident types		$	$
001-003	pedestrian crossing road	79,300	148,800
605	permanent obstruction	56,000	89,800
609	hit animal	18,100	22,700
701-702	off road, on straight	30,700	54,400
703-704	off road, on straight, hit object	55,200	88,900
705	out of control on straight	31,200	53,900
801-802	off road, on curve	44,400	84,100
803-804	off road, on curve, hit object	69,500	107,200
805	out of control on curve	32,900	56,600
Two-vehicle accident types			
101-109	intersection, adjacent approaches	38,500	90,300
201	head on	86,800	186,400
202-206	opposing vehicles turning	46,800	85,000
301-303	rear end	26,400	58,200
305-307	lane change	22,100	81,600
308-309	parallel lanes, turning	25,300	68,400
207,304	U-turn	38,700	81,500
407	vehicle leaving driveway	31,900	69,700
503,506	overtaking, same direction	21,600	55,300
601	hit parked vehicle	21,700	42,200

Source: Andreassen, 1992

(Obtained from Ogden, 1996)

Table 7-2: National Safety Council and National Highway Traffic Safety Administration Accident Cost

Source	Accident Severity	Cost Per Involvement
NSC (1979)	Fatal	$160,000
	Nonfatal disabling injury	6,200
	Property damage (including minor injuries)	870
NHTSA (1975)	Fatality	87,175
	Critical injury	192,240
	Sever injury – life threatening	89,955
	Sever injury – not life threatening	8,085
	Moderate injury	4,350
	Minor injury	2,190
	Average injury	3,185
	Property damage only	520

Source: Adapted from Highway Safety Engineering Studies Procedural Guide, U.S. Department of Transportation, Washington, D.C., June 1981.
(Obtained from Garber and Hoel, 1996)

Table 7-3: Proposed Costs of Accident by Injury Type

Severity	Cost ($)
Slight or property damage only[1]	775
Medium	4,616
Sever	18,251
Very sever	62,068
Fatality	37,996

Source: Jadallah, 2000.
Note **(1)**: Property damage (including minor injuries), as classified by NSC, 1979 (obtained from Garber and Hoel, 1996)

C. Discounting

Future cash flows need to be reduced to equivalent present-day values, because the value of a dollar in the future is less than the value of a dollar today. This is referred to as discounting. There are two situations relevant to the present analysis. There are:

The present worth, P, of a single sum of $S, n years in the future, at a discount rate of i percent per annum is:

$$P = S / (1 + i)^n$$

Similarly, the present worth, P, of a stream of annual sums of $R, at the end of each year for n years in the future, at a discount rate of i percent per year is:

$$P = R \times \{ (1+i)^n - 1) / i (1+i)^n \}$$

Currently, values of discount rate range between 4 and 7 percent are commonly used. In Palestine, the value of interest rate ranges from 5 to 6.5 percent according to the Commercial Bank of Palestine. The appraisal period of time, over which future benefit streams are discounted, needs to be carefully assessed. Typically, for traffic engineering works, an appraisal period of around five years is used (Ogden, 1996). However, a longer period is appropriate if traffic is expected to be reasonably stable. Longer time periods would usually be used for major construction projects, perhaps 10-20 yeas. In Palestine there is no definite value for life period of construction. Life period depends on the nature of the construction and experience.

D. Decision Criteria

Having calculated the present value of the future stream of benefits and costs, these are used to calculate an index, which is used to assess the worth of the treatment, and perhaps to rank it against other candidate projects. In general, five such criteria are in use for the economic appraisal of projects:

- Net present value (NPV)
- Benefit-cost ratio (B/C)
- Internal rate of return (IRR)
- Payback period
- First year rate of return

The most common criteria are NPV and B/C. Therefore, these two methods are discussed here.

Net Present Value:

The net present value (NPV) of a project is simply the present value, PV, of its net benefit stream. It is obtained by discounting the stream of net benefits produced by the project over its lifetime, back to its value in the chosen base period, usually then present. The net present value formula is (Perkins, 1994):

$$NPV = \sum (B_t - C_t) / (1 + r)^t$$

Where

B_t = project benefits in period t

C_t = project costs in period t

r = the appropriate financial or economic discount rate

n = number of years for which the project will operate

The decision rule for mutually exclusive projects is to accept the project with the highest NPV. It produces information, which is readily understood, and is easiest to calculate.

Benefit - To - Cost Ratio Method (B / C)

The B/C is the monetary accident savings divided by the improvement cost. Using this method, costs and benefits may be expressed as either an equivalent annual or present worth value of the project. Any project with B/C greater than one is considered economically successful and the project with the highest ratio is considered most considerable. The B/C technique is probably the most commonly used of the economic analysis techniques (Highway Safety Improvement Program User's Manual, 1981).

E. Sensitivity Test

An appraisal should always be subjected to a sensitivity test to assess how a change in the assumptions will affect the range results. In particular, a range of expected accident reductions should be assessed, since one can never be certain as to what the actual outcome will be. Using a low and a high estimate of possible and realistic outcomes is always good practice. If the outcome is favorable, even if a pessimistic forecast is used, one can be confident that the project is worthwhile. Conversely, if the outcome is unfavorable, even with optimistic assumptions, one can be confident that the project is unlikely to be worthwhile. The middle ground - favorable under optimistic and favorable under pessimistic assumptions - requires the traffic engineer to do more work to try and get a better forecast.

F. Presentation of Results

The final phase of the appraisal process involves the presentation of the results of the analysis to the decision-making body. Tabular or graphical presentations, highlighting the economic benefits, the accident savings, and the expected performance against accident reduction targets are all useful devices.

7.2.2 Goals Achievement Approach to Project Appraisal

This is an alternative to the economic appraisal approach described before. It aims to show the extent to which alternative proposals achieve a range of pre-set goals. The goals may be both quantifiable (e.g., economic) and non-quantifiable (e.g., social and environmental). The essence of evaluation is to present the decision-maker with information about the consequences of alternative courses of action.

Criteria or measures of effectiveness are represented in Figure 7-1, where the one axis lists the measures, which are to be used to assess the various goals, and the other lists the alternatives. The entries in the cells are the values of each measure for each alternative, in natural units (i.e., no attempt is made to reduce the measures to common terms, such as dollars).

There are two specific techniques for goal achievement approach, which are:

- Goals achievement matrix
- Cost effectiveness

A. Goals Achievement Matrix

This approach takes a matrix of the form shown in Figure 7-1, with the purpose of determining the extent to which each alternative will meet objectives that are been set in advance. The objectives are measured in terms of the listed criteria (Hill, 1968). In general, these objectives are the benefits to be derived, and it is the likely success or failure in doing so on which the alternatives are assessed.

A modification of this approach is to use a simple assessment scale to determine whether the alternative contributes towards goal achievement (+), whether it detracts from it (-), or has no effect (0). Weights may be introduced for each criterion, and an overall index is calculated. For example, Cambridgeshire County Council in the UK uses a weighting scale to reach an overall assessment of the score of a proposed project based on (Ogden, 1996):

- Accident (number and severity)
- Congestion
- Cyclist and pedestrian convenience and safety
- Environmental effects of traffic on residence, schools, and shopping centers
- Environmental effects of the project (trees, open space, signing, etc)

Criteria	Unit	Alternative			
		A	B	C	D
Safety Factors					
Total accidents	number				
Casualty accidents	number				
Accident costs	$				
Economic Factors					
Capital cost	$				
Maintenance cost	$				
Vehicle operating cost	$				
Accident costs	$				
Accessibility Factors					
Car travel	person-hour				
Public transport travel	person-hour				
Truck travel	truck-hour				
Cyclist travel	cycle trips				
Energy Factors					
Fuel consumed	litres				
Environmental Factors					
Emissions (by type)	ppm				
Noise (houses above x dBa)	number				

Figure 7-1: Typical Evaluation Matrix

Source: Ogden, 1996

The advantage of these techniques is that they assist the decision-maker to make decisions where there are disparate objectives, which cannot readily be converted to a single measure of effectiveness, such as dollars.

B. Cost Effectiveness

The cost effectiveness approach to decision making fits into this general category of goal assessment. This is because it is essentially concerned with determining the extent to which each set of alternatives contributes to the attainment of prescribed objectives. It is most applicable where:

- There is a fixed budget, and the aim is to achieve maximum results from that expenditure.
- There are specified objectives, and the aim is to determine the cheapest way of achieving it.

Where it differs from economic evaluation techniques is that it says nothing about how worthwhile the objective is. There is no measure of worth or value about the objectives or the results of the analysis. Therefore, the cost effectiveness approach has relevance to road safety project appraisal only to the extent that it assists in screening and ranking alternatives. These alternatives are essentially similar in nature and can be assessed with respect to a single objective, such as reducing the number of accidents. For example, if an agency has a simply expressed goal of reducing the number of accidents in total (or perhaps reducing the number of casualty accidents, or fatal accidents), then the economic benefits or other impacts of remedial schemes are essentially irrelevant to that goal.

A cost effectiveness approach, which simply lists the expected accident reduction from each of various alternative schemes, would be appropriate to that goal. It would indicate to the decision-maker the set of treatments, which are expected to have the maximum potential to reduce accident frequency.

This procedure is based upon the computation of a cost for the achievement of a given unit of effects (a given reduction in accidents). The steps to be followed are:

1. Determination of initial cost
2. Determination of operation cost, maintenance cost, and repair cost (OMR)
3. Selection of units of effectiveness to be used in the analysis (number of total accidents prevented, number of accidents by type prevented, number of fatalities or fatal accidents prevented, number of personal injuries or personal injury accidents prevented, or PDO accidents prevented)
4. Determination of the annual benefit (cost of total number of accidents prevented)
5. Determination of interest rate and life period
6. Determination of total annual cost (TAC)
7. Calculation of the annual benefit in terms of annual number of prevented accidents
8. Calculation of (TAC / annual prevented accidents).

7.3 Summary

The main aim of establishing project priorities is to determine the economic feasibility of each set of countermeasures, and to determine the best alternative among feasible mutually exclusive countermeasures.

The first step is ranking the projects; the remedial actions for hazardous locations. This can be achieved by *economic techniques*. The second step is to identify the *cost effectiveness* for each countermeasure to maximize the benefits. This also can be done by using *Goals Achievement Matrix and Cost Effectiveness Approach.*

Finally, establishing project priorities gives a full justification for decision-makers. It provides information including data about the hazard and the best remedial actions being submitted in a simple and logical form.

For Palestine, the two methods are recommended. Cost effectiveness approach is recommended because it has a definite and specific objective. The most important objective is the reduction of accident severity. A cost effectiveness approach can be applied when there is a fixed budget and a specific objective, as mentioned before. Furthermore, the economic appraisal is recommended to justify the application of countermeasures at hazardous locations. The economic appraisal gives an idea for decision-makers to make their decisions.

Therefore, the two techniques should be applied while analyzing the alternatives.

CHAPTER 8

IMPLEMENTATION, MONITORING, AND EVALUATION

8.1 Introduction

After determination of hazardous locations and the most economic feasibility is determined for the countermeasures, then the next step is to undertake and implement these countermeasures. After a period of time, these countermeasures must be evaluated. The best evaluation must be based upon the monitoring. Noting that monitoring is also based upon database existing before the implementation, besides collecting data after implementation. Monitoring is a task that did not exist on the scheduling program illustrated in Figure 2-1. However, it must exist because it is the most suitable way for evaluation.

In this chapter, the purpose of monitoring is discussed, and four evaluation techniques are illustrated. The result of evaluation should show the significant reduction of the accident rates or frequencies due to the implementation of specific countermeasures.

This chapter focuses on the before-and-after technique evaluation for its widely use. In addition, the advantages and disadvantages are discussed; also its application, common sources of mistakes made in comparing before-and-after data, analysis of data, and a convenient significance test for accident reduction.

8.2 Monitoring

Monitoring may be simply defined as the systematic collection of data about the performance of road safety treatments after their implementation (Ogden, 1996). It is the way by which the effectiveness can be measured.

The Institute of Highways and Transportation (1990) defined the purposes of monitoring as the following:

- Assess the effects of accident occurrence in relation to safety objectives
- Assess the effects on the distribution of traffic and speeds of motor vehicles
- Call attention to any unintended effects on traffic movements or accident occurrence
- Assess the effects of the scheme on the local environment
- Learn of public response to the scheme in terms of its acceptability in general and peoples' concerns

Ward and Allsop, 1982, suggested that road safety schemes potentially effect the following parameters and thus some or all of them may need to be monitored. These parameters are:

- The number and type of accidents
- The severity of accidents
- The distribution of accidents over the road network

- Traffic flows and travel times
- Turning movements and delays at intersections
- Access times and distances within residential areas
- Routes taken by motorist, cyclists, and pedestrians
- Operations of buses

8.3 Challenges of Evaluation Techniques

Monitoring gives an idea about what really is happening, but evaluation attempts to compare between what really has happened and what is expected to happen. There are some factors (challenges) affecting this process. These are:

- There may be changes in the road environment, such as traffic flow, enforcement, laws, etc. These changes affect the data obtained to study the specific applied countermeasures.
- The accident occurs in random and rare events, besides there are fluctuations, which happen during the years. Nothing can be done in the analysis, but statistical analysis justified it by what is so called regression to the mean.
- Seasonal factors must be taken into account. Some factors, which may affect road safety, vary in a systematic way throughout the day, and others throughout the year (rain, hours of daylight, perhaps traffic flow, etc.). The selection of factors such as control sites and before-and-after periods must take these variations into account. It would be incorrect to compare the summer (before) accident record if one was trying to assess the effect of skid resistant pavements, for example.

- There may be a long-term trend in accident occurrence, and thus changes over time in the number or rate of accidents at a site may merely reflect global trends. For this reason, it is usually necessary to use some form of control group and compare accidents at the test site with those at the control site.

8.4 Evaluation Techniques

There are mainly four ways or techniques by which evaluation of the countermeasures can be done after its implementation. These four techniques are:

- Controlled experimentation
- Comparisons using control sites
- Time trend comparison
- Before-and-after studies

8.4.1 Controlled Experimentation

All other factors are held constant except the factor whose effect is being investigated. This approach is rarely, if ever, applicable in road safety engineering because in the real world it is not possible to hold every thing constant.

8.4.2 Comparisons Using Control Sites

In this method, the before-and-after studies of the effect of a determined treatment is made between the treated site and the control site. Before applying a specific countermeasure at a hazardous site, the number, rate, or severity of accidents could be defined. After implementation, data must be taken to a similar hazard site, which is called a control site. This must be done to account for the changes applied on the treated site, which affect the trend changes in accident frequency, rate, or severity. In other words, the results for the before-and-after period at the treated site are compared with the results for the control site. The process; therefore, involves:

- Determining in advance the relevant objectives (e.g., accident types intended to be affected) and the corresponding evaluation criteria (e.g., accident frequency or accident rate).
- Identifying a control site or (preferably) a set of control sites where no remedial works have been or are intended to be introduced.
- Monitoring both the treated site(s) and the control site(s) to obtain numerical values of these criteria before the treatment and again after the treatment.
- Comparing the 'before' and 'after' results at both the treated and control sites.
- Considering whether there are other plausible explanations for the changes, and correcting for them, if possible.

The control sites should satisfy the following criteria (Ogden, 1996):

- Be similar to the treated sites in general characteristics (e.g., network configuration, geometric standard, land use, socio-economic characteristics, enforcement practices, etc).

- Be geographically close.
- Have the same or similar traffic flows.
- Not be affected by the treatment at the test site.
- Not be treated in any way themselves for the period of the before-and-after study.
- Have accident records and other data (if applicable) which are consistent in both collection criteria and coding covering the period of the study.

The before and after periods for both the test sites and the control sites must, of course, be the same. It is not, however, essential that the before period be the same duration as the after period. Figure 8-1 illustrates the number of 'before' accidents against the number of 'after' accidents at a site, for both the test sites and control sites (County Surveyors' Society, 1991).

The extent to which there is a change in accidents in the after period is indicated by the departure from the 45-degree line. If; therefore, there is a noticeable tendency for points representing the treated sites to be well below the 45-degree line compared with the control sites, this suggests that the treatment is having a positive effect.

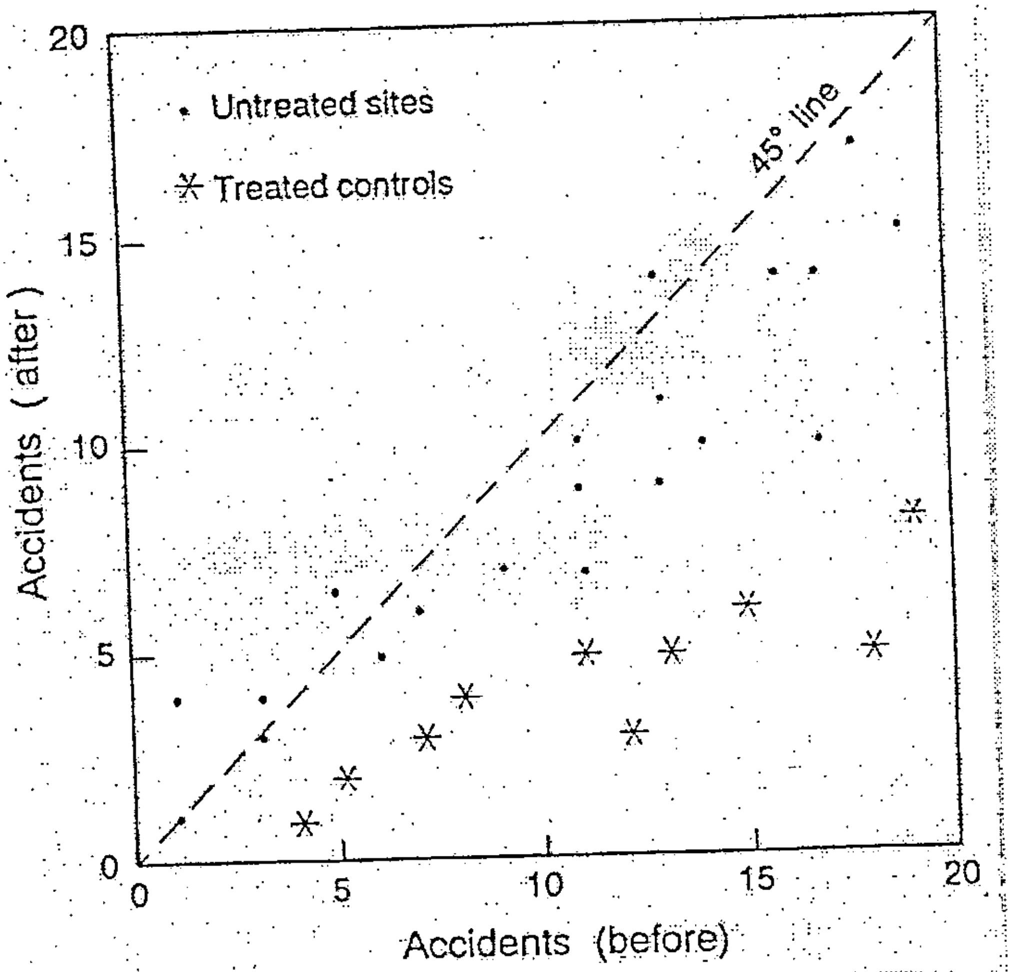


Figure 8-1: Comparison of Accident Data Before and After Treatment

Source: Ogden, 1996.

8.4.3 Time Trend Comparisons

This technique represents a model of trend accidents over time without using control sites. It involves (Ogden, 1996):

- Determining in advance the relevant objectives (accident types intended to be affected) and the corresponding evaluation criteria (e.g., accident frequency or accident rate).
- Obtaining data on each of the criteria for an extended period of time, both before and after implementation of the treatment.

- Developing a model-based on the 'before' period.
- Comparing projections based upon the model for the 'after' period with the measured criteria for that period.
- Considering whether there are other plausible explanation for the changes, and corresponding for them if possible.

This method is useful in some aspects of road safety where a substantial countermeasure has been introduced at a given point in time (e.g., seat built legislation, drink driving laws, etc) (Andreassen, 1989; Hutchinson and Mayne, 1977). Its application to road safety engineering is more limited, since it is difficult, if not impossible, to control for all the variables in a real world analysis. As a result, it is very difficult to isolate the effect of a specific treatment from many other factors, which could plausibly have had an influence.

8.4.4 Before-and-After Technique

It is the simplest method to evaluate the effectiveness of traffic improvements. It compares the accident record at the site before and after the implementation of the changes. Usually the evaluation criteria used in this method are frequency or rate of accidents. This method involves:

- Determining in advance the relevant objectives (e.g., accident types intended to be affected) and the corresponding evaluation criteria (e.g., accident frequency or accident rate).
- Monitoring the site or area to obtain numerical values of these criteria before the treatment and again after the treatment.

- Comparing the 'before' and 'after' results.
- Considering whether there are other plausible explanations for the changes, and correcting them if possible.

The following items clarify the disadvantages when using this method, and show the suitable procedure while using this technique.

1. The data, which was prepared before the study period should be taken and be considered a trusted data.

2. The main purpose of this technique is to measure the effect of treatment, and if this treatment has a significant effect on site or not. So, it is necessary to determine the accidents by type, by time, and by weather conditions. It will be useful to create a collision diagram for site before and after the treatment. Accidents can be separated by a severity classification in making comparisons as reported by the Manual of Traffic Engineering Studies (Box and Oppenlander, 1976). Reporting of property-damage only accidents is often erratic and not as regular as reporting of injury and fatal accidents. Improper analyses may result if totals of all types of accidents are compared regardless of severity, particularly where accident frequency is low.

3. The periods of time for before and after treatment should not be less than one year to make sure it has the same seasonal fluctuations during the year. The recommended of minimum period is one year; three years is

generally regarded as a reasonable period for trends to be established and a large enough data set to be obtained (Ogden, 1996). Nicholson, 1987, recommended five years from the viewpoint of statistical confidence. These periods should exclude the period while work was in progress, and in fact, it may be sensible to omit data from the period immediately following implementation, while the system is 'settling down' (Box and Oppenlander, 1976).

4. As reported by the Manual of Traffic Engineering Studies (Box and Oppenlander, 1976), a common error encountered in comparisons is failure to take account of other changes that influence traffic. For instance, if traffic signal timing is improved at an intersection. However, at the same time curb returns are cut back and the pavement improved, any subsequent changes in traffic behavior or accident rates should not be attributed to the signal improvement alone but also to the other improvements. Any changes that affect traffic at the location under study should be taken into account. If the improvement involves an area-wide basis, such as the institution of a safety campaign or motor vehicle inspection program, the accident patterns are used on an area-wide basis to show the effect of the change.

5. Before-and-after technique must take into account the trend in the reduction (or increment) of accident which reflect the nationwide trend. In some countries the reduction of accident may be dominant despite there are no treatment applied. During trend reduction, the treatment was not actually responsible for this reduction.

6. When using before-and-after technique, the number of accidents before and after implementation must be divided by the 'before' and 'after' exposure. If traffic volume is considerably less after the change than before, then total accident frequency would naturally decline due to decreased traffic volume. Attributing the entire reduction in accidents to the traffic engineering measure instituted is incorrect. A portion of the reduction is due to decreased traffic exposure.

7. When before-and-after technique is applied, it is very important to check the improvement to be significant, and this improvement resulting from actual treatment, and not as a result of chance variation. Figure 8-2 indicates whether the change of data before and after treatment is significant or not.

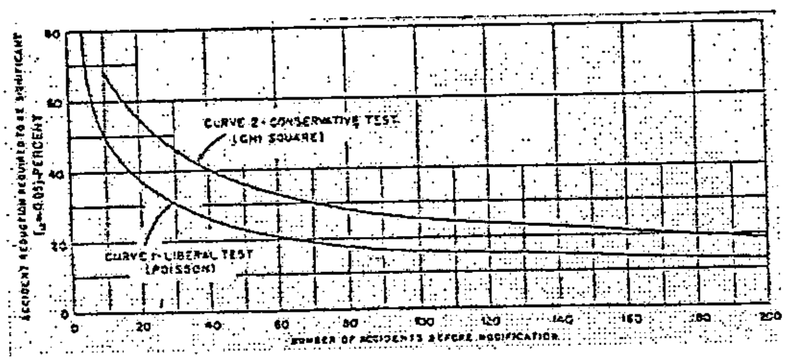


Figure 8-2: Curves of Significance Test for Accident Reduction

Source: Manual of Traffic Engineering Studies by Box and Oppenlander, 1976.

8.5 Data Analysis

When the statistical evaluation has been completed of the before and after data, it must be known whether the treatment is effective or not. An appropriate test of significance can be determined using the following equation:

$$t = (X_{av1} - X_{av2}) / (S_1^2 / N_1 + S_2^2 / N_2)^{1/2}$$

Where t = statistic of the t distribution

X_{av1} = mean of first sample

X_{av2} = mean of second sample

S_1 = standard deviation of first sample

S_2 = standard deviation of second sample

N_1 = number of measurements in first sample

N_2 = number of measurements in second sample

The computed value of (t) is then compared with the critical (t value) or (t_c) as obtained from Table 8-1 to determine the significance between the two sample means.

The value of t_c is selected in accordance with the specified level of confidence coefficient (1-α). The value of 0.05 is often chosen for α.

If the computed value of (t) is greater than (t_c), then the difference between the means is considered as significant and not just due to chance variation alone. The difference between the two means is defined as non-significant and due just to chance alone when the calculated (t) value is less than the critical t value (t_c).

Table 8-1: Table of Critical t (t_c) Values

Degrees of Freedom	Level of α		
	0.10	0.05	0.01
1	6.314	12.706	63.657
2	2.920	4.303	9.925
3	2.353	3.182	5.841
4	2.132	2.776	4.604
5	2.015	2.571	4.032
6	1.943	2.447	3.707
7	1.895	2.365	3.499
8	1.860	2.306	3.355
9	1.833	2.262	3.250
10	1.812	2.228	3.169
11	1.796	2.201	3.106
12	1.782	2.179	3.055
13	1.771	2.160	3.012
14	1.761	2.145	2.977
15	1.753	2.131	2.947
16	1.746	2.120	2.921
17	1.740	2.110	2.898
18	1.734	2.101	2.878
19	1.729	2.093	2.861
20	1.725	2.086	2.845
21	1.721	2.080	2.831
22	1.717	2.074	2.819
23	1.714	2.069	2.807
24	1.711	2.064	2.797
25	1.708	2.060	2.787
26	1.706	2.056	2.779
27	1.703	2.052	2.771
28	1.701	2.048	2.763
29	1.699	2.045	2.756
30	1.697	2.042	2.750
40	1.684	2.021	2.704
60	1.671	2.000	2.660
120	1.658	1.980	2.617
∞	1.645	1.960	2.576

Source: Manual of Traffic Engineering Studies by Box and Oppenlander, 1976.

A convenient significance test for accident reduction is performed by use of the curves in Figure 8-2. The procedure first involves computing the average number of accidents per year before the improvement. The accident reduction is then determined by subtracting the average annual number of accidents before from the average annual number after the improvement. This difference is divided by the average annual number for the before conditions and multiplied by 100 to obtain the actual percentage of accident reduction.

This value is compared to the critical percentage figure that is obtained from Figure 8-2 for the appropriate curve. The accident reduction is judged as significant only when the actual percentage exceeds the critical value.

The following example was obtained from the Manual of Traffic Engineering Studies (Box and Oppenlander, 1976). A traffic signal was installed at an intersection where the average annual accident total was computed to be 25 accidents per year from data collected over a three-year period. Only 18 accidents occurred in the first year after the installation was completed. The actual percentage of accident reduction is equal to {(18 – 25) / 25 } x 100, which is equal to 28 percent, and is less than the critical value of 34 percent which is read from Figure 8-2 for curve 1. Therefore, the installation of a traffic signal did produce an actual reduction in traffic accidents, but this reduction was not significant at the 95 percent level.

8.6 Summary

The simplest and applicable method of the treatment evaluation is "before-and-after" technique. So, it is recommended to be used in Palestine. This method proceeds as follows:

- Determine the advance relevant objectives (e.g., the reduction of all accidents).
- Obtain and compare the data before and after treatment.
- Consider other plausible explanations for the changes.
- 2-3 years is recommended to be the period for analysis.
- The number of accidents before and after implementation must be divided by the relevant traffic volume.
- Figure 8-2 is applied to ensure that the improvement resulting from actual treatment is significant.

CHAPTER 9

ACTION PLAN

9.1 Introduction

The main objective of this research is to introduce a traffic safety program for Palestine. First of all, there is no traffic safety program in Palestine. To establish such program in Palestine, it is recommended to create an effective and applicable highway traffic safety program. The suggested main framework for this program was illustrated in Figure 2-1.

There are many factors that affect this program. Among these factors are the following (Wilbur Smith associates Universal Group, 2000):

1. Enact the appropriate laws and legislation covering roadway operation, driving licensing, and vehicle licensing.
2. Establish the traffic courts, fines, and penalties.
3. Initiate communications and cooperation between the agencies involved in roadway safety.
4. Establish the databank and computer works necessary for client / server operation in conjunction with data collection, storage processing, and statistical evaluation.
5. Initiate data collection programs regarding highway operational characteristics and accident data.

6. Initiate policy and guidelines for roadway planning, design, construction, operation, and maintenance.
7. Establish a highway improvement program focusing on operational features like signs and pavement markings.
8. Procure equipment and new technology to upgrade first aid administrated by ambulances and hospitals.
9. Initiate training programs in the safety agencies.
10. Initiate roadway safety programs for school children.
11. Initiate mass media roadway safety awareness programs.

The proposed system should be tested for effectiveness and workability under local conditions. Duration of several years is needed to develop a highway safety system. This duration is necessary to establish a database about the highway accidents and locations.

In this chapter the framework of highway safety program is discussed. Besides, it focuses on the main steps that should actually be applied for the Palestinian cities. The recommended action plan discussed in this chapter is based on steps and analysis presented in chapters 4 through 8.

9.2 Establishing a Traffic Safety Unit

To establish a considerable highway safety program for Palestinian cities, a traffic safety unit, under the umbrella of Ministry of Transportation (MOT), should be established. The main tasks for this unit can be summarized as follows:

a) An effective coordination with the Traffic Police Department, the municipality, Palestinian Central Bureau of Statistics, Ministry of Local Government, and other related safety agencies.

b) Employees of the Traffic Safety Unit with high qualifications are to be involved in traffic safety program through this unit.

c) Procure equipment that is needed in developing highway traffic safety program.

d) Learn from international safety expertise to assist in the safety program.

e) Filing, analyzing, and applying an effective treatment for all highway accidents, which occurred in a certain area (e.g., city). Furthermore, this unit should establish a database for these accidents.

9.3 Collecting and Maintaining Data

It is the first main item in the highway safety program, which includes the following items:

9.3.1 Accident Reporting and Filing System

A new police accident report is proposed in this study, as shown in Appendix C. The existing police reports should be completely replaced with the proposed one. The accident report is designed to be easily incorporated into a computerized system once it is developed. Accident data can be filed either manually or using computers. A computer program for filing accidents is also proposed in this research. This proposed program is user friendly. It also allows for easy retrieval and analysis of accident data. Detailed information about this program is illustrated in Appendix H.

9.3.2 Accident location

It is suggested that each intersection be located by a "node." While at midblock it can be located as follows: (Street name, Node, Distance away from node with its direction) or (ST, Node, Dist.).

9.3.3 Retention of Records

In Palestine, it is recommended to adopt the following system for the retention of accident records:

- "Active Files": these are the files that are kept current for a period of one year (12 months). As the records of each month are recorded in the files, the records for the same month of the previous year will be removed. After this period, accident records will be discarded or removed to a warehouse location.
- "Dead Files": these are the files that are removed from the active files. It is suggested to maintain these files for a period of five years. After five years these files will be discarded, except for cases that are not finished yet at the courthouse.

In Palestine, accident files are suggested to be stored at different locations:

1. A copy of each form goes to the local motor vehicle bureau.
2. A copy of each form goes to the highway safety agency for analytical purposes.
3. A copy of each form is retained at the local traffic police office.
4. A copy of each form goes to the courthouse at the city where the accident occurred, if the case is not resolved and needs to go to court.

9.3.4 Accident Summary Sheet

It is very useful and practical to summarize accidents periodically for each key location or region of the city in a summary sheet. This summary sheet should be comprehensive and easy to read.

A proposed summary sheet for Palestine is recommended. This summary sheet was shown in Table 4-1.

9.4 Identifying Hazardous Locations (HL)

Among several methods to identify HL, spot maps are recommended to be used in Palestine, especially at the early stages of implementing the highway safety program. Besides, spot maps can create a graphical database for accident records for a year.

It is also suggested that an accident rate method be used once the accident safety program is more developed and data is more available and accessible. If traffic volume data is not available, the accident frequency method can be used to determine HL. The expected value statistical method is recommended to be used to determine threshold values for HL.

Caution must be used while identifying HL by rate or frequency (number) of accident method. This is because the accident frequency does not relate the number of accident to the exposure (traffic volume). In addition, the low volumes can cause misleading results when using the accident rate method.

9.5 Conducting Engineering Safety Studies

When the hazardous locations are determined. The following procedures are to be followed at each location by qualified traffic engineers:

1. Determine accident types. Then, identify probable causes using Table 6-1.
2. Obtain the data needed and the suitable treatment to be applied from Table 6-2, as well as the traffic engineer's professional judgement.
3. Conduct a field inventory of the accident location. A proposed field review form was illustrated in Appendix G.
4. Establish a condition diagram, which was illustrated in Figure 6-1.
5. Establish a collision diagram, which was illustrated in Figure 6-2. This diagram is a graphical presentation of accidents.
6. Determine alternatives to be applied at the HL. A list of alternative treatments was presented in Table 6-3.
7. Determine effective and suitable countermeasures to be applied at HL based on both benefit/cost ratio and cost effectiveness methods.
8. The major recommended steps in conducting engineering studies process for Palestine are illustrated in Figure 6-4.

9.6 Establish Project Priorities

Two methods are suggested to be used in Palestine. These methods are used to specify the most effective countermeasures to be applied at HL. These methods are:

1. Economic appraisal (Benefit/Cost Ratio) or (B/C)
2. Goals achievement approach (Cost Effectiveness Method).

9.6.1 Economic Appraisal -- Benefit / Cost (B/C) Analysis

The steps to be followed in this method are:

1. Determine the initial cost (I) of implementing the safety improvement being studied.
2. Determine the net annual operating, maintenance, and repair costs (OMR) of implementing countermeasures.
3. Determine the annual accident reduction as shown in Appendix I.
4. Determine accident costs.
5. Determine the annual benefit or Equivalent Uniform Annual Benefit (EUAB).
   EUAB = number of accidents reduced x average cost of an accident
6. Determine the interest rate (r), which is suggested to be equal to 4% for the current conditions. This value varies according to the available price at local banks.
7. Determine the service life of treatment (n) as shown in Appendix I (Table I-1).
8. Determine the Capital Recovery Factor (CRF), which is equal to $\{r(1+r)^n\} / \{(1+r)^n - 1\}$.
9. Determine the Equivalent Uniform Annual Cost (EUAC), which is equal to
   EUAC = OMR + CRF x (I)
10. Calculate B/C = EUAB/EUAC.

9.6.2 Goals Achievement Method (Cost Achievement Approach)

This procedure is based upon the computation of a cost for achieving a given unit of effects (a given reduction in accidents). The steps to be followed are:

1. Determine the initial cost of construction of the proposed treatment (I).

2. Determine the operation, maintenance, and repair of construction costs (OMR).
3. Select units of effectiveness to be used in the analysis (number of total accidents prevented, number of fatalities or fatal accidents prevented, number of personal injuries or personal injury accidents prevented, or PDO accidents prevented).
4. Determine the interest rate (r), which is suggested to be equal to 4% for the current conditions.
5. Determine the service life of treatment (n) as shown in Appendix I.
6. Determine the Capital Recovery Factor (CRF), which is equal to $\{r(1+r)^n\} / \{(1+r)^n - 1\}$.
7. Determine the Equivalent Uniform Annual Cost (EUAC), which is equal to

   EUAC = OMR + CRF x (I)
8. Determine the annual accident reduction factor as shown in Appendix I.
9. Calculate the annual benefit in terms of annual number accidents prevented.

   The prevented accidents = number of accidents x accident reduction factor
10. Calculate EUAC per annual prevented accidents.

9.7 Implementation, Monitoring, and Evaluation

The "before-and-after" technique is recommended to be used in Palestine for monitoring and evaluating of the effectiveness of countermeasures. The following procedures are to be used in this technique:

- Determine in advance the relevant objectives (e.g., the reduction of all accidents).
- Obtain and compare the data before and after the treatment.

- Take into account the trend in the reduction (or increment) of accident which reflects the nationwide accident trend.
- Consider other plausible explanations for the changes.
- Consider a two to three-year period for the before and after analysis. These periods should exclude the period while work is in progress, and in fact, it may be sensible to omit data from the period immediately following implementation, while the system is 'settling down'.
- Divide the number of accidents before and after implementation by the relevant traffic volume.
- Make sure that the improvements are a result of the actual treatment using Figure 8-2.

The applicable steps of this recommended action plan are applied in a safety study at one of the key hazardous locations in Nablus City. This safety study is discussed in details in Chapter 10.

CHAPTER 10

SAFETY STUDY IN NABLUS CITY – AL-HESBA INTERSECTION

10.1 Introduction

This chapter discusses the improvement of traffic safety for one of the hazardous intersections in Nablus City. This safety study was based upon the processes being discussed in previous chapters. This hazardous location is Al-Hesba Intersection. In this chapter the following items are discussed:

- The identification of Al-Hesba Intersection as a hazardous location.
- The methodology adopted to analyze the problem at the study intersection.
- Collecting accident data.
- Analysis of accident types and causes.
- Condition and collision diagrams.
- Proposed countermeasures and appraisals.
- Evaluation of each countermeasure.
- Conclusions and recommendations.

10.2 Description

Reference to the condition diagram shown in Figure 10-1, Al-Hesba Intersection connects between two main refugee camps: Askar Refugee Camp and Balata Refugee Camp. Besides, it connects between the center of Nablus City and the Vegetable Market, which is called "Al-Hesbah." Al-Hesba

Intersection is located on the eastern side of Nablus City. Farmers and produce retailers transport their goods from Al-Hesba to Nablus City center. This forms a vital movement at this intersection. Besides, this intersection connects between the residential zone, which is called "Al-Masaken" and the center of Nablus City. These activities resulted in a heavy movement of vehicles.

Although, traffic signals were recently installed at Al-Hesba Intersection (traffic signals were installed in 1999), it is still one of the most hazardous locations in Nablus City. Several interviews were made with drivers and police traffic experts about their perceptions of hazardous locations in Nablus City. Drivers and police experts agreed that Al-Hesba Intersection is the most hazardous location in Nablus City. Accident frequency and rates are discussed later in this chapter. This is why this intersection was selected to be the subject of the case study.

10.3 Study Methodology

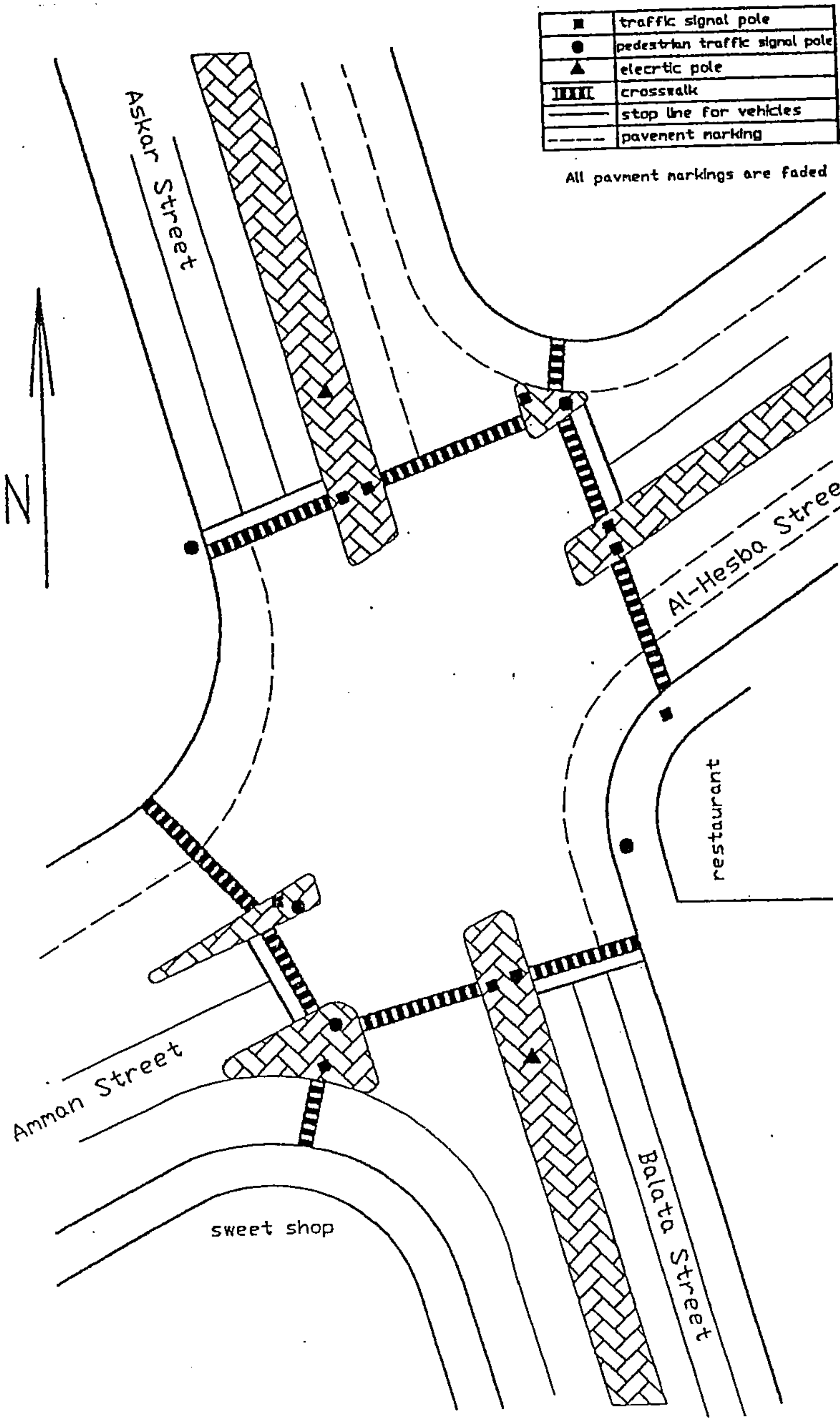
The main goal of this case study is to improve traffic safety conditions at this intersection by specifying the most effective countermeasures. The countermeasures must minimize (or eliminate if possible) the existing accidents. The tasks of this study include field review, existing traffic conditions, collecting accident data, establish collision diagram, proposed treatments (countermeasures), evaluation of each countermeasure, and recommendations.

10.3.1 Field Review

Field visits were made at this intersection during the midday peak hours of a typical weekday on August, 2000. The following observations were made at Al-Hesba Intersection during the peak hours:

1. It is a 4-leg intersection. The condition diagram shown in Figure 10-1 describes the existing geometry, lane distribution, sidewalks, traffic signalization, and surrounding buildings.
2. Heavy traffic volumes existed on all approaches during the peak period of the day.
3. Long traffic queues were formed especially from the direction of Amman Street (Eastbound approach).
4. Pedestrian volume was low.
5. Pavement markings were faded (crosswalks, stop lines, and the lane lines).
6. Signal lenses were well visible for all approaches.
7. Asphalt surface condition on all approaches was good.
8. Some drivers traveled at high speeds especially on Amman and Askar Streets. Several of these drivers crossed the intersection during the amber phase and even into the red phase.
9. The east-west approaches are not aligned properly; they are skewed.

The Field Inventory form, which is proposed in Appendix G, was filled as shown in the same Appendix.


traffic signal pole
pedestrian traffic signal pole
elecrtic pole
crosswalk
stop line for vehicles
pavenent marking
All pavment markings are faded
N
Askar Street
Al-Hesba Street
restaurant
Amman Street
sweet shop
Balata Street

10.3.2 Existing Traffic Conditions

A recent traffic volume count was conducted in July, 2001 as shown in Appendix J. According to this count, the peak volumes on all approaches at Al-Hesba Intersection were the following:

From Al-Hesba direction = 449 vehicles / hour

From Balata Camp direction = 343 vehicles / hour

From Askar Camp direction = 399 vehicles / hour

From Amman Street direction = 567 vehicles / hour

Based on information provided by Nablus Municipality, the signal timing at Al-Hesba intersection was:

Amman Street (green time = 24 seconds)

Balata Street (green time = 18 seconds)

Al-Hesba Street (green time = 24 seconds)

Askar Street (green time = 13 seconds)

Yellow time on all approaches = 4 seconds (1 second before green and 3 seconds after green).

Therefore, the cycle length was 95 seconds. The intersection signal operates as a four-phase signal.

The signal timing was also verified in the field. Signal phasing are shown in Appendix J.

The evaluation of the existing signal design at this intersection using the Highway Capacity Software (HCS-3) program showed the intersection overall level of service of D. Therefore, the intersection is congested. Detailed HCS-3 analysis is presented in Appendix K.

10.3.3 Accident Data Collection

The accident data at Al-Hesba Intersection were gathered from the Police Traffic Department and Nablus Courthouse. Accidents were registered at a special book at the police station 'Registration Book.' Every accident has its own case number. Case numbers at the courthouse were different for the same accidents.

The police accident report consisted of some useful information, a sketch (accident diagram) and description of the accident. However, the accident diagram prepared by the traffic police existed only at the courthouse.

All information gathered from the police station and the courthouse for these accidents are summarized in Table 10-1. These accidents occurred from the period dated 1/4/1999 to 1/9/2000 after the traffic signal was installed. A collision diagram is presented in Figure 10-2. This diagram summarizes all accidents occurred at Al-Hesba Intersection for the study period.

The information was gathered over a period of 17 months. This study period was from the date of installing traffic signals till the date of analysis for this

Table 10-1: Summary of Accidents at Al-Hesba Intersection

Palestinian National Authority
Accident Summary

Country : Palestine
Location: Al-Hesba Intersection
City : Nablus
From : 1/4/1999
To: 1/9/2000

No.	Case Number	Date	Day of Week	Time of Accident	Fatality	Injury	Property Damage	Day / Night	Wet / Dry	Weather Condition	Cause of Accident	Type of Accident
1	100/99	7/4/99	Wed.	13 : 15		1	Yes	D	W	Raining	Ex.S	RE
2	111/99	24/4/99	Sat.	13 : 00		1	Yes	D	D	Clear	IOB	BR
3	129/99	9/5/99	Sun.	05 : 15	1	5	Yes	D	D	Clear	TSV	RA
4	164/99	6/6/99	Sun.	09 : 30		2	Yes	D	D	Clear	TSV	RA
5	294/99	13/9/99	Tues.	05 : 10		2	Yes	D	D	Clear	TSV	RA
6	344/99	23/10/99	Sat.	10 : 00		1	Yes	D	D	Clear	Ex.S	RE
7	3/2000	3/1/2000	Mon.	14 : 25		2	Yes	D	W	Raining	Ex.S	RE
8	34/2000	27/1/2000	Thurs.	16 : 00		2	Yes	D	W	Raining	TSV	RA
9	37/2000	27/1/2000	Thurs.	13 : 00		1	Yes	D	W	Raining	TSV	RA
10	55/2000	13/2/2000	Sun.	19 : 00		1	Yes	N	W	Raining	IP	SS
11	140/2000	6/5/2000	Sat.	17 : 30		2	Yes	D	D	Clear	TSV	RA
12	145/2000	11/5/2000	Thurs.	15 : 00		1	Yes	D	D	Clear	TSV	RA
13	195/2000	15/6/2000	Thurs.	11 : 30		4	Yes	D	D	Clear	TSV	RA
14	255/2000	12/9/2000	Sat.	10 : 15		5	Yes	D	D	Clear	TSV	RA
15	269/2000	13/9/2000	Sun.	16 : 30		1	Yes	D	D	Clear	TSV	RA
Total					1	31						

Total	Fatality	Injury	PDO	RE	RA	SS	BR	Day	Night	Dry	Wet	Ex.S	TSV	IOB	IP	Raining	Clear
No.	1	14	0	3	10	1	1	14	1	10	5	3	10	1	1	5	10
%	6.7	93	0	20	67	6.7	6.7	93	7	67	33	20	67	7	7	33	67

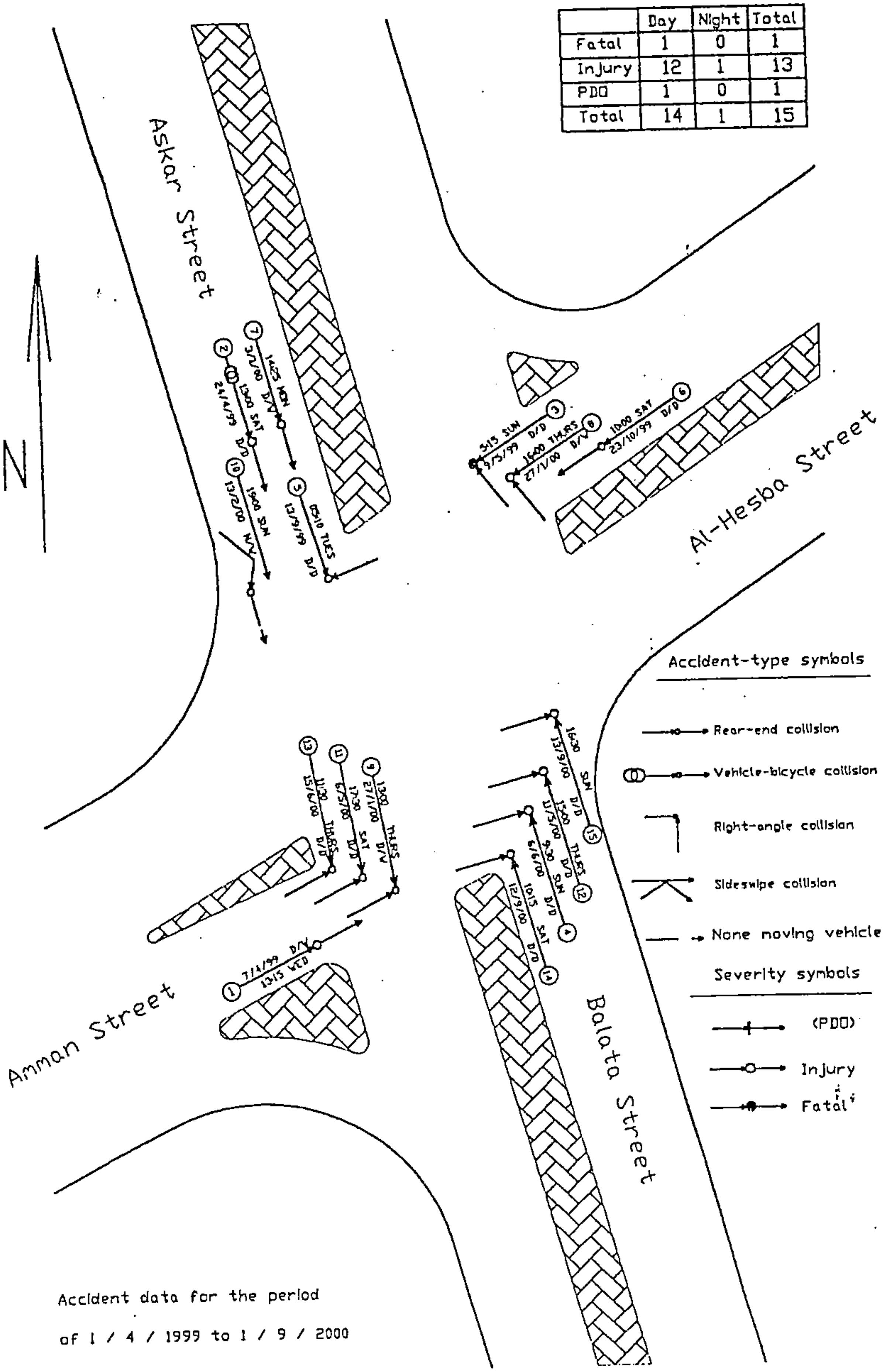
Total daily vehicles entering = 22,000 vehicles per day

Average No. of Accidents per year = 11 accident
Accident Rate: 1.37 / MEV

RE	Rear-End Collision	Ex.S	Excessive Speed	D / D	Day / Dry
SS	Sideswipe Collision	IOB	Illegal occupant Bicycle	D / W	Day / Wet
BR	Bicycle Related Accident	TSV	Traffic Signal Violation	N / D	Night / Dry
RA	Right-Angle Accident	IP	Improper Passing	N / W	Night / Wet

Accident summary

	Day	Night	Total
Fatal	1	0	1
Injury	12	1	13
PDO	1	0	1
Total	14	1	15



intersection in this study. The number of accidents considered in this study was 15 accidents per 17 months. It is equal to an average of 11 accidents per year. The sum of all vehicles entering this intersection was 1,758 vehicles at the peak hour.

Using a "K" factor of 0.08 for Nablus City (Jadalla, 2000), the average daily traffic (ADT) was equal to 1,758 / 0.08, which is equal to approximately 22,000 vehicles per day. "K" factor is the ratio of peak hour volume to the average daily volume.

Accident rate = (number of accident per year x 1,000,000) / (ADT x 365)

= (11) (1,000,000) / (22,000) (365)

= 1.37 accidents per million entering vehicles

This accident rate exceeds the threshold of the expected value for the average accident rate, which was determined to be 0.3 accidents per million entering vehicles for intersections of main streets.

The threshold of the expected value for the accident frequency was determined to be 4.5 accidents per year. At Al-Hesba Intersection, the number of accidents was 11 accidents per year, which exceeds the threshold.

For these reasons, Al-Hesba Intersection was determined to be a hazardous location.

10.3.4 Accident Analysis

The analysis of Table 10-1 indicated that the right angle collision was the highest percentage (67%) of accident types during the study period at Al-Hesba intersection. It also indicated that injury accidents were the highest percentage (93%). Besides, day accidents were the highest percentage (93%), dry accidents were also the highest percentage (67%), and accidents in clear weather condition were the highest percentage (67%). In addition, the highest percentage for the cause of accident was the traffic signal violation (67%). Therefore, it was concluded that the predominant type and cause of accidents were angle accident and traffic signal violation, respectively.

Based on Table 6-1, the listing of probable causes for right angle collisions at signalized intersections are the following:

1. Restricted sight distance
2. Excessive speed on approaches
3. Poor visibility of signals
4. Inadequate signal timing (too short amber phase)
5. Inadequate roadway lighting
6. Inadequate advance intersection warning sign
7. Large total intersection volume

In addition, the field review confirmed the following probable causes of accidents:

1. Excessive speed on approaches as shown in spot speed study in Appendix M
2. Improper of signal timing as a possible cause for vehicles to drive on yellow and even into the red phase. Driver's behavior is also another possible cause of this problem.
3. Large total intersection volume

The other probable causes listed in Table 6-1 were eliminated since the sight distances were adequate on all approaches, clear visibility of signals, and accidents occurred at daylight, as depicted from accident records.

10.3.5 Potential Safety Improvement Alternatives

Countermeasures for each probable cause of accident were shown in Table 6-3. Potential countermeasures for the study intersection are summarized in Table 10-2.

Table 10-2: General Countermeasures for Safety Deficiencies at Al-Hesba Intersection

No	PROBABLE CAUSE	POTENTIAL COUNTERMEASURES
1	Excessive speed on approaches	Reduce speed limits on approaches Adjust amber phase Install rumble strips
2	Too short amber phase (improper signal timing)	Signal Retime Provide all-red phase Adjust amber phase Provide progression through a set of signalized intersections Install signal actuation
3	Large total intersection volume	Add lane Retime signal

Based on the field review and Table 10-2, the suggested countermeasures at the study intersection are:

1 - Redesign signal timing with special attention to all-red phase and amber phase.

2 - Enforcement.

3 - Repaint all pavement markings properly.

The candidate measures depend on the available budget. However, all these measures are relatively low cost and financially feasible.

10.3.6 Establishing Project Priorities

These measures are discussed in the following subsections. In this study, only the modification of signal timing and enforcement will be analyzed as accident reducing measures for immediate consideration. After implementation of these measures, further analysis should be done. If the analysis indicate the need for more measures, other actions such as implementation of rumble strips, flashing beacons, and warning signs may be considered. Rumble strips are discussed in Appendix N with the detailed calculations of its cost.

10.3.6.1 Retime Signal / Introduce All Red Phase

The all red phase is provided mainly for safety reasons. It allows for the clearance of vehicles from the middle of intersection before the start of the following green time (a new phase).

The following equation identifies the length of yellow plus all red clearance interval (McShane, Roes, and Prassas, 1998):

$$Y = t + \{S_0 / (2a + 64.4g)\} + \{(W + L) / S_0\}$$

Where Y = sum of yellow change plus all red clearance intervals, sec.

t = reaction time (taken to be 1 second)

S_0 = initial approach speed of vehicle, feet per second (fps)

g = percent grade

a = deceleration rate of vehicles, ft / sec^2 (10 ft / sec^2)

W = distance from the departure stop line to the far side of the farthest conflicting traffic lane, ft

L = length of standard vehicle, usually taken to be 20 ft (6m)

At Al-Hesba Intersection, the distance for the stop line at Amman Street to the potential conflicting traffic lane was computed at site to be equal to 20m (65.6 feet). Based on a spot speed study conducted at this intersection, the approach speed was calculated to be 44 Km / hr (40.1 fps) (which is the 85th percentile speed as shown in Appendix M).

Applying the above equation

$Y = 1 + \{40.1 / (2 \times 10)\} + \{[(20 + 65.6)] / 40.1\}$

$= 5.14$ seconds.

Use: Yellow interval = 4 seconds

All red interval (needed) = 5.14 – 4

= 1.14 seconds

The calculated all red intervals for the other three approaches ranged between 1.16 seconds and 1.18 seconds.

Therefore, one second of all red was introduced for each phase and the existing phasing was maintained. As a result of this, green intervals were adjusted to maintain a cycle length of 95 seconds. The improved signal timing is shown in Appendix J.

The capacity analysis of the new signal timing for the study intersection was conducted using HCS-3 software. The signal timing was slightly adjusted to maintain balanced levels of service (LOS) on all approaches. The comparison of LOS for existing and new signal timings is presented in Table 10-3. Detailed HCS-3 worksheets are presented in Appendix K.

Table 10-3: Performance Measures for Existing and Proposed Signal Timings

	Cycle Length (Sec.)	Intersection Delay (veh/sec.)	Intersection LOS
Existing Condition	95	37.7	D
New Timing	95	40.3	D

10.3.6.2 Police Enforcement

Excessive speeds were observed in the field and accident records indicated that there were several accidents caused by excessive speed. Therefore, speed limits should be enforced. High fines should be imposed on drivers who violate the speed limit on all approaches at Al-Hesba Intersection. This action requires the availability of policemen at the intersection to control speed violators. Police enforcement is also needed to control the problem of traffic signal violations. A general work schedule for policeman is introduced in a later section in this chapter.

10.3.6.3 Pavement Marking

It was noticed in the field review that stop lines and crosswalk markings on all approaches were completely faded. This situation created confusion for drivers, especially since approaches are skewed. Therefore, this measure (new pavement marking) is very essential to be applied. The impact of this on reducing accidents is minimal. Therefore, its numerical impact on the overall accident reduction was ignored.

10.3.7 Evaluation of Countermeasures

There are two methods to evaluate countermeasures, as mentioned in section 7.2, these are:

1. Economic appraisal
2. Goals achievement approach

10.3.7.1 Economic Analysis

Costs are the capital and continuing costs for constructing and operating the proposed countermeasures. Benefits are the expected number of prevented accidents. The Benefit/Cost ratio method and cost effectiveness, which were recommended for use in Palestine, are the criteria that were applied at Al-Hesba Intersection safety study.

A. Expected Reduction in Accident Due to Safety Improvement

At Al-Hesba Intersection, all suggested measures are to be applied. The overall accident reduction factor is obtained from the individual accident reduction factor according to the following equation (Garber and Hoel, 1996).

$$AR_m = AR_1 + (1 - AR_1) AR_2 + (1 - AR_1)(1 - AR_2) AR_3 + \ldots \ldots\ldots\ldots\ldots + (1 - AR_{m-1}) AR_m .$$

Where

AR_m = overall accident reduction factor for multiple mutually exclusive improvements at a single site.

AR_i = accident reduction factor for a specific countermeasure.

m = number of countermeasures at the site.

It is necessary to list all the individual countermeasures in order of importance. The countermeasure with the highest reduction factor will be listed first, and its reduction factor will be designated AR_1. The countermeasure with the second highest reduction factor will be listed second and its reduction factor be designated as AR_2, and so on.

Table 10-4 presents all the suggested countermeasures, which are to be applied at Al-Hesba Intersection. Besides, it presents the average accident reductions, life period of the applied measures, and the sources of these information.

The resultant accident reduction, when applying the above equation, was AR_m = 0.44 percent.

Table 10-4: Average Accident Reduction and Life Period

Countermeasure	Average Accident Reduction*	Life (year)	Source
Modification to existing traffic signal	AR_1 = 30%	10	ITE, 1992
Enforcement	AR_2 = 20%+	NA	Ogden, 1996

* Reduction will be applied to accidents that may be potentially affected.

NA: Not applicable

+ The same reduction for installing of red light camera.

B. Accidents Cost

Based on Jadallah, 2000, the cost of accident per injury type was summarized in Table 7-3.

C. Benefits of Accident Reduction

From the above calculation, Ar_m = 44%.

Number of related fatality accidents (for the study period of 17 months) = 1

Number of related slight injury accidents (for the study period of 17 months) =12

Total number of accidents (for the study period of 17 months) = 15

The remaining two accidents were discarded because these accidents were unusual. The first accident described that a bicycle hit the rear of a vehicle. This case was rare (case number is 111/99) and was not related to the deficiencies discussed before. The other discarded accident was a broken vehicle stopped at the corner of intersection, which was struck by the improper passing vehicle from the right side.

According to the computed resultant accident reduction, the benefit that could be gained by the accident reduction is as follows:

Fatality accident reduction = 44% x 1 = 0.5 accident (one accident per two years)

Slight injury accident reduction = 44% x 12 = 5 accidents per year

D. Benefits in U.S. Dollars

According to Table 7-3, the costs of prevented accidents are:

Fatality accidents = 0.5 x 37,996 = $18,998

Slight injury accidents = 5 x 775 = $3,875

Total = $22,873

This benefit was for accidents obtained over a period of 17 months. Therefore, the annual benefit would be 22,873 (12 / 17) = $16,145.

E. Costs of Measures

- *Enforcement*

The average monthly salary of a traffic policeman is approximately $300. The estimated needed work schedule for policemen at this intersection is 4 policeman-hour for three days a week, which is equal to 52 hours per month. So, the salary of this part time, which is equal to 0.3 of month, is equal to $90.

- *Pavement Marking*

At Al-Hesba Intersection, the areas of all markings were computed to be 175 square meter. Several local contractors priced this item to be $2.5 / square meter. So, the total cost for this measure is equal to $437.5.

- *Retime Signal*

The cost of signal re-timing is minimal; therefore, it was ignored.

The initial cost, annual operating cost, annual maintenance cost, and total annual costs of all measures are presented in Table 10-5.

Table 10-5: Initial, Annual, and Maintenance Costs of Enforcement and Pavement Marking

Measure	Initial Cost ($)				Life period (Years)	CRF	Annual Maintenance cost ($)	TAC ($)
	Unit	Cost / Unit ($)	Quantity	Cost ($)				
Enforcement (Salary of Policemen)	No.	12 months x 90	1					1080
Pavement Marking	M^2	2.5	175	437.5	3	0.36	100	258
Total								1338

Notes:

The Capital Recovery Factor (CRF) is the factor, which converts a fixed payment or present value at the beginning of a project's life into an equivalent fixed periodic payment.

$$CRF = \{ r(1+r)^n \} / \{(1+r) - 1\}$$

The total annual cost (TAC) is simply the initial cost times the capital recovery factor plus the annual operation, maintenance, and repair (OMR) costs.

Detailed calculations are presented in Appendix L.

F. Benefit/Cost (B/C) analysis

Equivalent uniform annual benefit = $16,145

Equivalent uniform annual cost = $1338

B/C = $16,145 / $1338 = 12

10.3.7.2 Goals Achievement Approach

As mentioned in item 7.2, there are two specific techniques for goal achievement approach, which are:

1. Goals achievement matrix.
2. Cost Effectiveness.

As recommended before, B/C ratio and cost effectiveness methods will be used at Al-Hesba Intersection.

Based on the previously mentioned steps of the cost effectiveness method, the TAC =$1338. The total average number of annual accidents prevented is equal to (44%) (12/17) (13) = 4 accidents. Therefore, the cost effectiveness is equal to $1338/4 = $335 per accident.

10.4 Conclusion

There were several factors that might have contributed to the high number of accidents at Al-Hesba Intersection. These factors are:

- The existing traffic signal phasing design, especially the short amber phase.
- Violation of the traffic signal as a result of the lack of enforcement.
- All pavement markings, such as stop lines for vehicles, crosswalks for pedestrian, and lane lines were completely faded.
- Careless drivers.

Several countermeasures were suggested for implementation. The benefit/cost analysis showed that applying the potential countermeasures shown in Table 10-2 were beneficial in reducing accidents relative to their costs. The results of treatments were:

1. Benefit/cost ratio = 12
2. Cost effectiveness = $335 per accident

Based on these results the priorities for implementation of countermeasures is retiming of signal, enforcement, and pavement marking.

It is also recommended to impose monetary fines on drivers who violate traffic laws. Paying citation fee makes drivers take good care and give their full attention while driving.

CHAPTER 11

CONCLUSIONS AND RECOMMENDATIONS

11.1 Introduction

The aim of this study is to develop a general highway safety program for Palestine with Nablus City as the case study. This program consists of three components. These components are planning, implementation, and evaluation. This study focused on the planning component. The planning component consists of four processes. These are:

1. Collect and maintain data
2. Identify hazardous locations
3. Conduct engineering studies
4. Establish project priorities

The study also focused on monitoring and evaluation of treatments. Applying such a program will improve highway safety in Palestine.

11.2 Conclusions

The study of the components and processes of the highway safety program resulted in the following conclusions:

1. Existing safety program

a) There is no existence of a traffic safety program in Palestine.

b) The main function of the existing traffic accident procedures is just to judge between the involved parties of an accident.

c) No analysis techniques of accidents exist.

d) Property damages only (PDO) accidents were not reported.

e) No systematic approach of collecting and retrieval of data.

f) Collecting and filing data are done manually.

g) Recently, the police department started to use the computer just to keep the facts of accidents in the computer memory.

2. Collecting and maintaining data process

a) A new police accident report form should be established. This form has to be comprehensive and serves all involved parties such as police, insurance companies, and traffic engineers. This form can be used manually or computerized. A new police accident report is designed and recommended for use in this study.

b) A summary sheet should be used to record all the accidents at each location or for all locations for analytical purposes, and to maintain accident data. A summary sheet is designed and provided in this research. The location of intersection could be located by node number, while the location of intersection could be located by Street name, node number, and distance with its direction.

c) The accident locations should be determined by the link-node method.

3. **Identifying hazardous location process**

a) Spot map methods should be used at the initial stage to determine the hazardous locations.

b) In case of available traffic volume data, the accident rate method is recommended for use to determine the hazardous location. In the absence of traffic volume data, the accident frequency method is recommended for use to determine the hazardous location. The recommended values of these thresholds are the following:

Accident Frequency Thresholds

Overall intersections	E_v = 3.3 accidents / year
(Main/Main intersections)	E_v = 4.5 accidents / year
(Main/Collector intersections)	E_v = 3.5 accidents / year
(Collector/Collector intersections)	E_v = 2.0 accidents / year
At all links (Mid-block)	E_v = 3.3 accidents / year
At main links	E_v = 4 accidents / year

Accident Rate Thresholds

Overall intersections	E_v = 0.4 accidents / MEV / year
(Main/Main intersections)	E_v = 0.3 accidents / MEV / year
Main links	E_v = 0.8 Accidents / MEV. Km / year.

4. **Conducting engineering safety studies**

The following actions should be used through the highway safety program to facilitate the engineering analysis.

a) Obtain data from the police accident report form.

b) Conduct field review.

c) Establish a condition diagram.

d) Construction a collision diagram.

5. **Establish project priorities**

The methods that are recommended for use to determine the effectiveness of treatments are:

a) Economic method – Benefit/Cost (B/C) ratio method.

b) Goals achievement method (cost effectiveness method).

6. **Implementation, monitoring, and evaluation**

There are several techniques to evaluate the implementation of treatments. In Palestine, "Before-and-After" technique should be applied to measure the effectiveness of implemented treatments at hazardous locations.

7. **Safety study**

Several recommended countermeasures at the study site of Al-Hesba Intersection will plan an effective role to provide safety improvements, such as rumble strips, enforcement, flashing beacons and warning signs, and modifying of the traffic signal. The B/C ratio for the proposed alternatives was 12 and the cost effectiveness method yielded a $ 335 per accident.

8. **In general**

In Palestine, there are several challenges facing the development of a safety program. Among these challenges are:

a) Proper budget allocation

b) Political conditions

c) Effective use of local experience

d) Lack of central agencies to improve safety in general

11.3 Recommendations

This study showed the importance of developing and applying the suggested highway safety program. As a result of this study the following recommendations were depicted:

1. The elements of the safety program presented in this thesis are general outline, which form the first step to establishing a more detailed and comprehensive safety program in Palestine. It is recommended that other serious efforts should be started to build this program based on the steps and procedures established in this research.
2. It is recommended that the suggested element of the highway safety program forms and computer software in this study as well the process be implemented. This program can be implemented gradually to fit the budget and required expertise.
3. It is recommended to apply the suggested countermeasures at Al-Hesba Intersection.
3. Establishment of a centralized agency for each city among Palestinian cities to adopt the suggested highway safety programs is also necessary to maintain and operate this program.

4. To enrich the accident data bank, it is recommended to establish a centralized unit in Palestine to gather accident's information (locations, types, causes, data, time, etc.) for all cities in Palestine.

5. It is recommended to conduct researches, which study each process of the components for the suggested highway safety program (Figure 2-1) in details.

6. To improve safety in Palestine, the following measures are recommended:

   a) Removal of drivers with bad accident and violation records from the roadways by suspending their licenses.

   b) Enforce traffic laws strictly by punishing all violators.

7. Establish a "Palestinian Traffic Safety Law", which will facilitate police enforcement.

8. The Palestinian Authority must procure equipment and technology for traffic police enforcement and accident reporting.

9. Traffic police should have adequate computer facilities for administration and reporting. Traffic police must be trained on the use of new equipment and procedures regarding traffic operations, accident reporting, and safety.

10. Prepare a detailed design standards manual to be applicable in Palestine. This manual will be complimented with highway safety program to eliminate the hazards of accidents.

11. It is recommended to hold seminars and lectures to enrich the knowledge of traffic police experts. This will be helpful in the analyzing highway accidents.

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APPENDIX A

EXISTING

COURT REPORT

AND

PROPERTY DAMAGE ONLY REPORTS

IN NABLUS CITY

بسم الله الرحمن الرحيم

السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
قيادة المحافظات الشمالية
ادارة المرور والتجديد
خبراء المرور

قسم المرور

التاريخ / / ١٩٩

رقم الملف

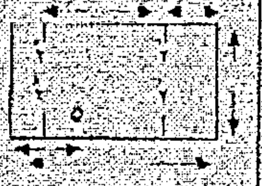
تقرير خبير مرور لحوادث الطرق

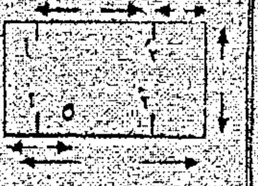
من / الى .... التاريخ .... الاسم ....

مكان الحادث	الوقت / التاريخ	ساعة الحادث
تاريخ التبليغ	الساعة	اسم المبلغ وعنوانه
ساعة وصول الخبير للمكان	تاريخ الفحص	مكان الفحص

٢ - تفاصيل السيارة والسائق / ين :

رقم السيارة	رقم السيارة	رقم السيارة
النوع	النوع	النوع
الانتاج	الانتاج	الانتاج
سنة الانتاج	سنة الانتاج	سنة الانتاج
الوزن الاجمالي المصرح	الوزن الاجمالي المصرح	الوزن الاجمالي المصرح
وزن الحمولة	وزن الحمولة	وزن الحمولة





رقم هوية السائق	رقم هوية السائق	رقم هوية السائق
الاسم الشخصي	الاسم الشخصي	الاسم الشخصي
اسم العائلة	اسم العائلة	اسم العائلة
العنوان	العنوان	العنوان
رقم رخصة السائق	رقم رخصة السائق	رقم رخصة السائق
نوع ودرجة الاصدار	نوع ودرجة الاصدار	نوع ودرجة الاصدار

٣ - حالة الطقس والرؤيا وقت الحادث / الفحص :

أ - وضع الطريق :

طريق رئيسية / فرعية / ...

مدى الرؤية :

السائق رقم ١ :

السائق رقم ٢ :

Figure A-1: Court Report (Continued)

٥ - تفاصيل الأضرار تم الكشف عليها وقت الفحص نتيجة الحادث :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٦ - أضرار بعد الحادث :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٧ - أضرار بالممتلكات بما فيها الحيوانات المشتركة بالحادث :

٨ - فحص السيارات فحصت (كتابة إذا كانت صالحة ، إذا وجدت أعطال - تفاصيل الأعطال وسببها :

سيارة رقم ١

سيارة رقم ٢

سيارة رقم ٣

٩ - الموجودات وأهميتها (نقط دم ، تبعثر رمل ، قطع زجاج ، أشياء من المصابين ، أشياء أخرى :

١٠ - آثار بريك ، آثار عجلات - النتائج وتحديد السرعة :

Figure A-1: Court Report (Continued)

١١ - صور / مخطوطات :

١٢ - خطة الإرشادات الضوئية :

١٣ - إشارات وعلامات طرق (المسافة من مكان الحادث وملاحظات لحظة الإشارات الضوئية) :

١٤ - النتائج :

Figure A-1: Court Report (Continued)

إضافات لاستعمال الخبير :

تم تسجيل هذا التقرير بيدي بتاريخ .... حسب الموجودات التي ضبطت بتاريخ ....

أنا الموقع أدناه ، خبير سير أقدم تقريري الفني بشأن حادث طرق الذي حصل بالتاريخ والمكان المبين في هذا التقرير وأقدم تقريري هذا بدل إفادة بالمحكمة وأنا أعرف جيداً أحكام القانون الجزائي بعدان الإفادة تحت القسم بالمحكمة .

تفاصيل الشهادة : حائز على شهادة خبير حوادث من تاريخ ....

خبرة العمل : العمل الفعلي كخبير حوادث من تاريخ ....

رأي الخبير

فحصت موجودات الخاصة بالحادث المذكور وسجلتها بهذا التقرير / ورسمت مخطط ، وصورت صور وتقارير عمل أخرى مرفقة والموقعة بيدي وهو جزء لا يتجزأ من هذا التقرير .

توقيع الخبير ....

تصديق ضابط الحوادث

أنـا ....

الرقم الشخصي .... الرتبة .... الاسم ....

أصادق على توقيع الخبير .... توقيع الضابط ....

Figure A-1: Court Report

السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
إدارة المرور والنجدة / نابلس
قسم حوادث السير

الرقم:
التاريخ: / / ١٩

تقرير عمل لحادث سير أضرار فقط

الـــى: ....

بواسطة: ....

إسم الحيز	الرتبه	تاريخ الحادث	الساعة	[illegible]

تفاصيل السوائق المشتركين بالحادث:

رقم السيارة ونوعها	١	٢	٣
إسم السائق			
عنوانه			
رقم الهوية			
رقم الرخصة			
شركة التأمين			
رقم البوليصة			
إنتهاء التأمين			
إنتهاء رخصة المركبة			
التوقيع للسائقين			

بيانات الحادث " كيفية وقوع الحادث وسببه " ....

....

....

رقم مخالفة المسبب للحادث ونوعها " " محكمة " " غرامه ....

توقيع مقدم التقرير	ساعة الإنتهاء	[illegible]

ملاحظات ضابط الحوادث: ....

....

توقيع ضابط الحوادث

Figure A-2: Property Damage Only Report

APPENDIX B

POLICE ACCIDENT REPORT FORMS

BY DORNIER SYSTEMCONSULT, 2000

AND

BY GARBER AND HOEL, 1996

PALESTINIAN CENTRAL ROADS ADMINISRATION
POLICE ACCIDENT REPORT

DO NOT WRITE IN THIS SPACE

TIME
DATE OF ACCIDENT 200 Day of week Hour A.M. P.M.

LOCATION
PLACE WHERE ACCIDENT OCCURRED City/Village Street
If accident was outside city limits indicate distance from nearest town Kilometers North S E W of City or Town
ROAD ON WHICH ACCIDENT OCCURRED: Give name of street or highway number
AT ITS INTERSECTION WITH Name of street or highway number
IF NOT AT INTERSECTION Meter North S E W of Show nearest intersection, street or highway, house number, Kilometer post, etc

POLICE ACTIVITY:
Time notified of accident Date Hour A.M. P.M.
What was the source of accident information? (Officer at scene, I driver contacted station, both drivers contacted station...)
Name Charge
Name Charge
Other action taken

VEHICLE NO.1
VEHICLE Year Make Type (jordan, truck, taxi, bus ...etc) License Plate Year Number
Parts of vehicle damaged Vehicle removed to: By
Owner Name Address
Driver Name Address
Driver's license Number Date of birth
OCCUPANTS
Passenger 1 Name Address
Passenger 2 Name Address
Passenger 3 Name Address
Passenger 4 Name Address

AGE	SEX	INJURY

VEHICLE NO.2 or PEDESTRIAN
VEHICLE Year Make Type (jordan, truck, taxi, bus ...etc) License Plate Year Number
Parts of vehicle damaged Vehicle removed to By
Owner Name Address
Driver Name Address
Driver's license Number Date of birth
OCCUPANTS
Passenger 1 Name Address
Passenger 2 Name Address
Passenger 3 Name Address
Passenger 4 Name Address

AGE	SEX	INJURY

WITNESSES
Name Address
Name Address

AGE	SEX

FIRST AID GIVEN BY: Injured Taken to

DAMAGE TO PROPERTY OTHER THAN VEHICLES

Name and address of owner of object struck

Name object and state nature of damage

CODE FOR INJURY

K– Dead before report made.
A– Visible signs of injury, as bleeding, wound or distressed members; or had to be carried from scene
B– Other visible injury, bruises, abrasions, swelling, limping .... etc.
C– No visible injury but complaint of pain or momentary unconsciousness.
O– No indication of injury.

ENVIRONMENTAL CONDITIONS

WEATHER (Check one): Clear, Cloudy, Raining, Snowing, Foggy, Other

ROAD SURFACE (Check one): Dry, Wet, Icy, Snowy, Other

TRAFFIC CONTROL (Check one): Stop sign, Yield sign, Traffic Signal, Flagmen, No traffic controls, Other

LIGHT (Check one): Dawn, Daylight, Dusk, Darkness, Other

ROADWAY: Divided, Undivided, Asphalt, Concrete, Gravel, Other

No. of lanes

ALIGNMENT (Check one): Straight, Curve, Bridge, Intersection, Ramp, Railroad, Overpass, Underpass, Level, Uphill, Downhill

WHAT DRIVERS WERE GOING TO DO BEFORE ACCIDENT

Driver No. 1 was headed ☐ ☐ ☐ ☐ (North S E W) (Street or highway)

Driver No. 2 was headed ☐ ☐ ☐ ☐ (Street or highway)

Driver 1 2 (Check one for each driver)

Go straight ahead; Overtake; Make right turn; Make left turn; Make U turn; Slow or stop; Start in traffic lane; Start from parked position; Back; Remain stopped in traffic lane; Remain parked

WHAT PEDESTRIAN WAS DOING

Pedestrian was going ☐ ☐ ☐ ☐ (Check one) North S E W

Along; Across .... From .... To ....

Crossing at intersection; Crossing out of intersection; Getting on or off vehicle; Walking in roadway with traffic; Walking on roadway against traffic; Standing in roadway; Working on vehicle; Working in roadway; Playing in roadway; Other in roadway; Not in roadway

CONTRIBUTING CIRCUMSTANCES

Driver 1 2 (Check one for each driver)

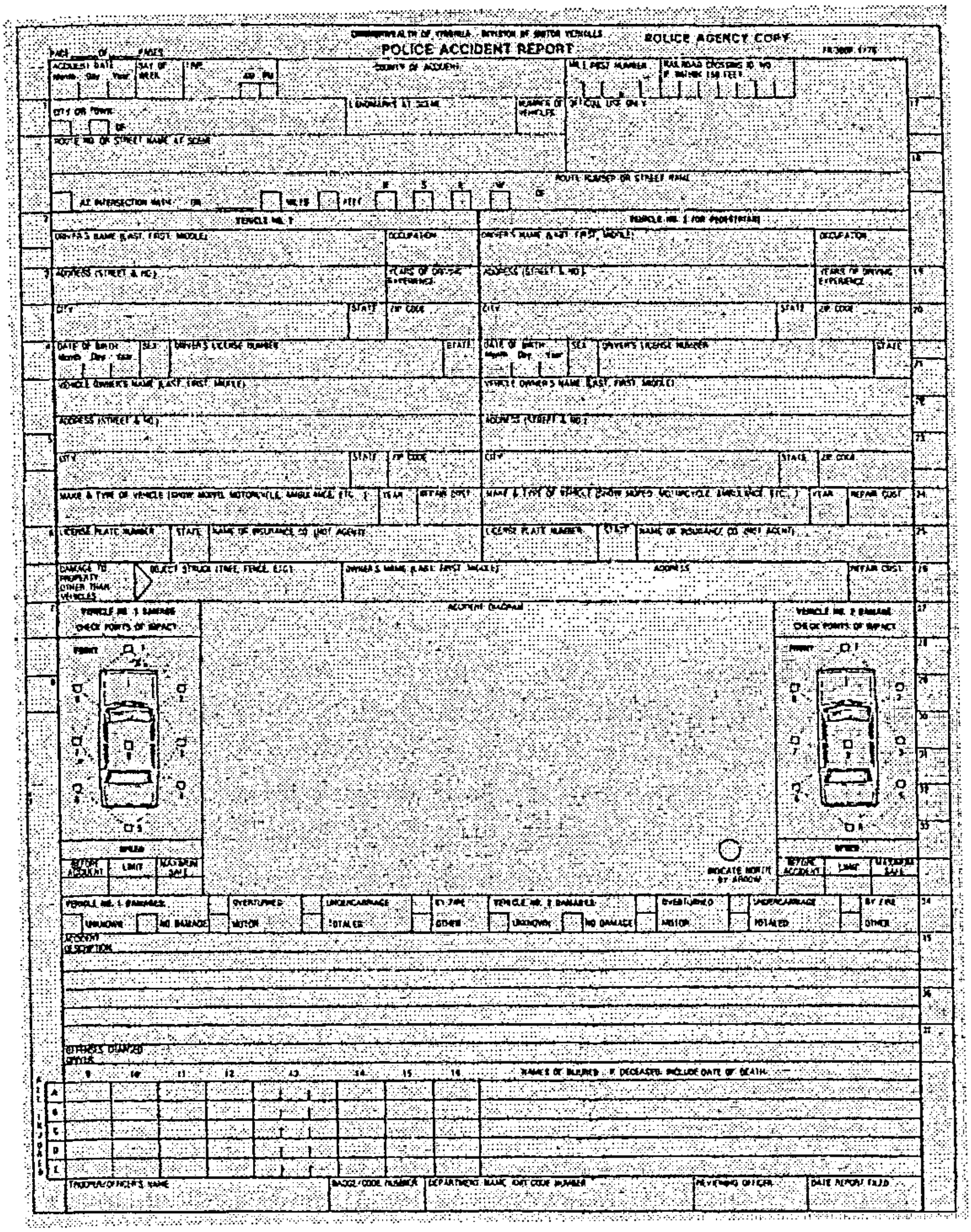
Speed too fast; Failed to yield right of way; Drove left of center; Improper overcoming; Passed stop sign; Disregarded traffic signal; Followed too closely; Made improper turn; Other improper driving; Inadequate brakes; Improper lights; Had been drinking

FIRST/SUBSEQUENT HARMFUL EVENT

- Collision With MV (Rear-end)
- Collision With MV (Head-on)
- Collision With MV (Angle)
- Collision With MV (Left Turn)
- Collision With MV (Right Turn)
- Collision With MV (Sideswipe)
- Collision With MV (Backed Into)
- Collision With Parked Car
- Collision With MV on Other Roadway
- Collision With Pedestrian
- Collision With Bicycle
- MV Hit Sign/Sign Post
- MV Hit Light Pole/Utility Pole
- MV Hit Guardrail
- MV Hit Fence
- MV Hit Concrete Barrier Wall
- MV Hit Bridge/Wall
- Collision With Traffic Gate
- MV Hit Tree/ Shrubbery
- Collision With Fixed Object Above Road
- MV Ran Into Ditch/Channel
- Ran Off Road Into Water
- Overturned
- Occupant Fell From Vehicle
- All Other (Explain)

Page 2

Figure B-1: Dornier SystemConsult Police Accident Report Form
Source: Kobari, 2000


POLICE ACCIDENT REPORT

POLICE AGENCY COPY

ACCIDENT DIAGRAM

Figure B-2: Virginia Accident Report Form
Source: Garber and Hoel, 1996

APPENDIX C

PROPOSED POLICE ACCIDENT REPORT

(IN ENGLISH AND ARABIC)

Page 1

Palestinian National Authority
Traffic Administration
Police Accident Report

Case Number	

Date of File Report	

	Day of Week	Day	Month	Year	Time
Date of Accident					
Date of reporting					
Number of vehicles involved					

Location Of Accident	
City	
Village	
At Intersection	
At Mid Block	

		Vehicle No.1	Vehicle No.2	Vehicle No.3
Drivers Information	Name			
	Address			
	Date of Birth			
	Sex			
	Identification No.			
	No. of Drivers License			
	Degree of License			
Owners of Vehicles	Name			
	Address			
	Date of Birth			
Vehicles Information	Vehicle Make			
	Type and Color			
	Vehicle Use			
	License Plate Number			
	Vehicle Production Year			
	Date of Issuing vehicle License			
	Expiry Date of Vehicle License			
	Insurance Company			
	Policy No. of Insurance Certificate			
	Expiry Date. of Insurance Certificate			
	Vehicle Damages			
	Signature of Police Expert	Signature Driver No.1	Signature Driver No. 2	Signature Driver No.3

Palestinian National Authority
Traffic Administration
Police Accident Report

Case Number		Date of File Report	

Accident Types (please circle)			
Right angle collision at signalized intersection	1	Sideswiped opposite direction	11
Right angle collision at unsignalized intersection	2	Sideswiped same direction	12
Left-turn head on collisions	3	Moving vehicle collided with parked moving vehicle	13
Right-turn head on collisions	4	Moving vehicle with fixed object	14
Rear-end collisions at signalized intersection	5	Moving vehicle with stopped vehicle	15
Rear-end collisions at unsignalized intersection	6	Moving vehicle backing against traffic	16
Pedestrian –vehicle collision (at roadway)	7	Moving vehicle and bicycle in collisions	17
Pedestrian –vehicle collision (at sidewalk)	8	Skidding of vehicle	18
Head-on collisions	9	Unknown	98
Over-turn vehicle	10	Other	99

Accident Causes (please circle)	Veh 1	Veh 2	Veh 3	Accident Causes (please circle)	Veh 1	Veh 2	Veh 3
Excessive speed	1	1	1	Improper right turn	18	18	18
Improper passing	2	2	2	Missing r.o.w for Pedestrian	19	19	19
Driving not at right side	3	3	3	Missing r.o.w for other vehicles	20	20	20
Driving under influence of alcohol	4	4	4	Driving anti road direction	21	21	21
Pedestrian under influence of alcohol	5	5	5	Poor visibility of signals	22	22	22
Changing lane unsafely	6	6	6	Restricted sight distance	23	23	23
Traffic signal violation	7	7	7	Inadequate signal timing	24	24	24
Stop sign violation	8	8	8	Following too closely	25	25	25
Other traffic control violation	9	9	9	Improper Load	26	26	26
Falling asleep	10	10	10	Improper vehicle brakes	27	27	27
Dazzling	11	11	11	Improper carriage way	28	28	28
Improper illumination	12	12	12	Opening of vehicle's door from left side	29	29	29
Illegal occupants bicycle	13	13	13	Sudden stopping	30	30	30
Leaving curb	14	14	14	Slippery surface	31	31	31
Pedestrian crossing not safely	15	15	15				
Careless Driving	16	16	16	Unknown	98	98	98
Improper left turn	17	17	17	Other	99	99	99

Palestinian National Authority
Traffic Administration
Police Accident Report

Case Number			*Date of File Report*	

Environmental Conditions

Weather		*Surface*		*Traffic Control*		*Light*		*Roadway*		*Alignment*		*Surface Type*
Clear	1	Dry	1	Stop Sign	1	Dawn	1	Divided	1	Straight	1	Asphalt
Cloudy	2	Wet	2	Yielding	2	Daylight	2	Undivided	2	Curve	2	Concrete
Raining	3	Icy	3	Traffic Signal	3	Dusk			3	Intersection	3	Gravel
Snowing	4	Snowy	4	Policeman	4	Darkness					4	Dirt
Foggy	5		5	No Control	5	Artificial Light						
Other	6	Other	6	Other	6	Other	6	Other	6	Other	6	Other

Injuries and Fatalities Information

No.	*Name of Injury or Death*	*Veh. No. Which Has the Injury or Death*	*Date of Birth*	*Description of Injuries*	*Identification Number*	*Date of Death*	*Injured Taken*	
							To	*By*
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
11.								
12.								
13.								
14.								
15.								

Number of Injuries	
Number of Fatalities	

Palestinian National Authority
Traffic Administration
Police Accident Report

Case Number		Date of File Report	

Description of Accident

....

Accident Diagram

Signature of Police Expert	

North direction should be indicated

الصفحة الأولى

السلطة الوطنية الفلسطينية
مديرية الشرطة ــ قسم المرور
تقرير حوادث طرق

رقم القضية	

تاريخ كتابة التقرير	

	اليوم في الأسبوع	يوم	شهر	سنة	الساعة
تاريخ الحادث					
تاريخ الإخبار					

موقع الحادث	
مدينة	
قرية	
مفرق	
شارع	

عدد المركبات المشتركة بالحادث	

		المركبة الأولى	المركبة الثانية	المركبة الثالثة
معلومات عن السائق	اسم السائق			
	العنوان			
	تاريخ الميلاد			
	الجنس			
	رقم الهوية			
	رقم الرخصة			
	درجة الرخصة			
مالك المركبة	الاسم			
	العنوان			
	تاريخ الميلاد			
معلومات عن المركبة	موديل المركبة			
	نوع ولون المركبة			
	تابعية المركبة			
	رقم نمرة المركبة			
	تاريخ صنع المركبة			
	تاريخ إصدار رخصة المركبة			
	تاريخ انتهاء رخصة المركبة			
	اسم شركة التأمين			
	رقم شهادة التأمين			
	تاريخ انتهاء التأمين			
	الأضرار الناتجة عن الحادث			

توقيع خبير المرور	توقيع سائق المركبة (١)	توقيع سائق المركبة (٢)	توقيع سائق المركبة (٣)

الصفحة الثانية

السلطة الوطنية الفلسطينية
مديرية الشرطة ـ قسم المرور
تقرير حوادث طرق

رقم القضية		تاريخ كتابة التقرير	

نوع الحادث (ضع دائرة)

تصادم بزاوية على مفترق طرق به إشارات ضوئية	١	صدم جانب بجانب باتجاه معاكس	١١
تصادم بزاوية على مفترق طرق بدون إشارات ضوئية	٢	صدم جانب بجانب بنفس الاتجاه	١٢
تصادم ناتج التفاف ناحية اليسار على المفترق	٣	صدم سيارة متحركة مع متحركة أخرى تريد الوقوف	١٣
تصادم ناتج التفاف ناحية اليمين على المفترق	٤	صدم جسم ثابت في الطريق	١٤
تصادم مقدمة بمؤخرة على مفترق به إشارة ضوئية	٥	صدم مركبة متحركة مع أخرى واقفة	١٥
تصادم مقدمة بمؤخرة على مفترق بدون إشارة ضوئية	٦	مركبة متجه للخلف بعكس السير	١٦
صدم عابر طريق على مسرب للمركبات	٧	تصادم مركبة مع دراجة هوائية	١٧
صدم عابر طريق على مسرب المشاة	٨	انزلاق	١٨
صدم مقدمة بمقدمة	٩	غير معروف	٩٨
انقلاب مركبة	١٠	غيرها	٩٩

سبب الحادث (ضع دائرة)	مركبة ١	مركبة ٢	مركبة ٣	سبب الحادث (ضع دائرة)	مركبة ١	مركبة ٢	مركبة ٣
سرعة زائدة	١	١	١	انعطاف لليمين بطريقة غير قانونية	١٨	١٨	١٨
تجاوز خاطئ	٢	٢	٢	عدم إعطاء حق الأولوية للمشاة	١٩	١٩	١٩
عدم السير على اليمين	٣	٣	٣	عدم إعطاء حق الأولوية للمركبات الأخرى	٢٠	٢٠	٢٠
السائق تحت تأثير الكحول	٤	٤	٤	السياقة بعكس السير	٢١	٢١	٢١
الماشي تحت تأثير الكحول	٥	٥	٥	عدم وضوح الإشارة الضوئية	٢٢	٢٢	٢٢
تغيير مسرب السير بشكل غير مناسب	٦	٦	٦	مسافة الرؤية محدودة	٢٣	٢٣	٢٣
عدم الالتزام بالإشارة الضوئية	٧	٧	٧	زمن الإشارة الضوئية غير مناسب	٢٤	٢٤	٢٤
عدم الوقوف على إشارة الوقوف	٨	٨	٨	عدم المحافظة على المسافة بين المركبات	٢٥	٢٥	٢٥
عدم الالتزام بإشارات التوجيه المروري الأخرى	٩	٩	٩	حمولة زائدة	٢٦	٢٦	٢٦
نوم السائق أثناء السياقة	١٠	١٠	١٠	عدم صلاحية فرامل المركبة	٢٧	٢٧	٢٧
الإبهار نتيجة الضوء العالي للمركبة القادمة	١١	١١	١١	عدم صلاحية الطريق	٢٨	٢٨	٢٨
إضاءة غير مناسبة	١٢	١٢	١٢	فتح باب المركبة عن جهة الشمال	٢٩	٢٩	٢٩
سير دراجة هوائية بشكل غير قانوني	١٣	١٣	١٣	وقوف مفاجئ	٣٠	٣٠	٣٠
خروج المركبة عن المسرب عند المنعطف	١٤	١٤	١٤	نعومة سطح الطريق	٣١	٣١	٣١
الماشي يقطع الطريق بشكل خاطئ	١٥	١٥	١٥				
سياقة بدون مبالاة	١٦	١٦	١٦	غير معروف	٩٨	٩٨	٩٨
انعطاف لليسار بشكل غير قانوني	١٧	١٧	١٧	غير ذلك	٩٩	٩٩	٩٩

الصفحة الثالثة

السلطة الوطنية الفلسطينية
مديرية الشرطة – قسم المرور
تقرير حوادث طرق

رقم القضية	

تاريخ كتابة التقرير	

الظروف البيئية

نوع سطح الطريق		انحناءات الطريق		طريق المركبة		الإضاءة		الإشارات المرورية		حالة سطح الطريق		الطقس	
زفته	١	مستقيم	١	مقسم	١	فجر	١	إشارة قف	١	جاف	١	صافي	١
خرسانة	٢	منحني	٢	غير مقسم	٢	ضوء النهار	٢	إشارة تمهل	٢	رطب	٢	غائم	٢
كركار	٣	تقاطع	٣			الغسق	٣	إشارة ضوئية	٣	عليه جليد	٣	ماطر	٣
ترابي	٤					معتم	٤	رجل شرطة	٤	عليه ثلج	٤	ثلج	٤
						إضاءة صناعية	٥	بدون إشارات	٥		٥	ضبابي	٥
غير ذلك	٦	غير ذلك	٦	غير ذلك	٦	غير ذلك	٦	غير ذلك	٦	غير ذلك	٦	غير ذلك	٦

معلومات عن حالات الوفيات والإصابات

الرقم	اسم المصاب أو المتوفى	رقم المركبة التي ركب بها المصاب أو المتوفى	تاريخ الميلاد	وصف الحالة	رقم الهوية	تاريخ الوفاة	الجهة التي نقل إليها المصاب	الوسيلة التي نقل بها المصاب
١								
٢								
٣								
٤								
٥								
٦								
٧								
٨								
٩								
١٠								
١١								
١٢								
١٣								
١٤								
١٥								

عدد الإصابات	
عدد الوفيات	

الصفحة الرابعة

السلطة الوطنية الفلسطينية
مديرية الشرطة ـ قسم المرور
تقرير حوادث طرق

رقم القضية	

تاريخ كتابة التقرير	

وصف الحادث

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رسم الحادث (كروكي)

	توقيع خبير السير
الاسم	
التوقيع	

اتجاه الشمال يجب أن يشار إليه

APPENDIX D

CALCULATIONS OF EXPECTED VALUES AT INTERSECTIONS AND LINKS (IN GENERAL)

Table D-1: Calculation of Expected Value of Accident Frequency at Intersections in Nablus City

Number of Accident Per Two Years	Annual Accidents at Intersection (u)	Number of Intersections (F)	Relative Frequency	F x u	F x u^2
11	5.5	1	0.008	5.5	30.25
8	4	5	0.040	20	80
7	3.5	2	0.016	7	24.5
6	3	3	0.024	9	27
5	2.5	8	0.065	20	50
4	2	12	0.097	24	48
3	1.5	12	0.097	18	27
2	1	29	0.234	29	29
1	0.5	52	0.419	26	13
Total		124	1	158.5	328.75

X_{av} =	1.278
S.D =	1.013
E_V =	3.263174224

S.D = SQRT { (Σ F X u^2 - (Σ F X u)^2 / Σ F) / F-1 }

= SQRT { (328.75 – 158.5^2 / 124) / 123 }

= SQRT 1.02

= 1.013

Z = 1.96 for 0.95 confidence level.

$E_V = X_{av} \pm ZS$

= 1.278 ± 1.96 (1.013)

= 3.263 , - 0.707

= 3.263 (approximately 3.3 accidents)

Table D-2: Calculations of Expected Value of Accident Rate at Intersections in Nablus City

Intersection ID	Intersection Name	Accident Rate(X)	X - Xav	(X - Xav)²
444	Al-Adel	0.927	0.601	0.362
695	Al-Hesba	0.791	0.465	0.217
586	Al-Hodhod Company at Alquds Street	0.679	0.353	0.125
426	Palestine / Sufian	0.679	0.353	0.125
266	Al-Kefair / Al-Mraj	0.581	0.255	0.065
335	Al-Montazah Circle	0.563	0.237	0.056
324	Western Cemetery	0.505	0.179	0.032
608	Abd-Al-Naser / Al-Quds	0.480	0.154	0.024
184	Rafidia Hospital	0.408	0.082	0.007
339	Al-Fatemyia	0.368	0.042	0.002
161	Omar Ibn Al-Khattab / Rafidia	0.321	-0.005	0.000
367	Haifa / Prince Mohammad	0.298	-0.028	0.001
528	Al-Ashghal	0.256	-0.070	0.005
415	Al-Anbeya`	0.244	-0.082	0.007
118	Al-Haj Ma`zooz Mosque	0.205	-0.121	0.015
92	Haifa-Jafa	0.205	-0.121	0.015
637	Abd-Al-Naser / Health Directorate	0.163	-0.163	0.026
338	Ahmad Al-Shaka` / Prince Mohammad	0.157	-0.169	0.028
451	Al-Dowar / Old Balata Taxi Station	0.132	-0.194	0.037
484	Al-Haj Nemer Mosque	0.131	-0.195	0.038
2070	Faisal / Al-Rahebat	0.129	-0.197	0.039
640	Othman Mosque	0.118	-0.208	0.043
622	Enterance of Balata Camp	0.116	-0.210	0.044
24	Al-Motonabi / Hifa	0.111	-0.215	0.046
23	Faisal / Al-Hijaz	0.101	-0.225	0.050
4846	Heteen Faisal	0.062	-0.264	0.069
425	Ghemata / Al-Dowar	0.059	-0.267	0.071
	SUM =	8.789		1.549

X av =	0.326	For two years	E_V =	0.804
S.D =	0.244	For one years	E_V =	0.402

Note: These are the only intersections in Nablus City, which have traffic volume data.
ID: Identification number as mentioned by Kobari, 2000.

E_V = 0.4 MEV

Table D-3: Calculation of Expected Value of Accident Frequency at Links

Number of Accidents per Two Years (u)	Number of links (F)	Fu	Fu^2
1	98	98	98
2	40	80	160
3	22	66	198
4	15	60	240
5	7	35	175
6	5	30	180
8	2	16	128
9	2	18	162
10	1	10	100
12	1	12	144
14	2	28	392
Total	195	453	1977

X_{av}	2.323
S.D	2.183

For two years	E_V =	6.602
For one year	E_V =	3.301
E_V to be used =		3.3

APPENDIX E

CALCULATION OF EXPECTED VALUE FOR THE ACCIDENT RATE AT THE INTERSECTIONS OF MAIN STREETS IN THE CITY OF NABLUS

Calculation of Expected Value for the Accident Rate at the Intersections of Main Streets in Nablus City

NO.	Accident Rates (X)	$X - X_{av}$	$(X - X_{av})^2$
1	0.00	-0.19	0.04
2	0.00	-0.19	0.04
3	0.00	-0.19	0.04
4	0.00	-0.19	0.04
5	0.79	0.60	0.36
6	0.48	0.29	0.08
7	0.12	-0.07	0.01
8	0.16	-0.03	0.00
9	0.26	0.07	0.00
10	0.21	0.02	0.00
11	0.10	-0.09	0.01
12	0.00	-0.19	0.04
13	0.13	-0.06	0.00
14	0.06	-0.13	0.02
15	0.06	-0.13	0.02
16	0.13	-0.06	0.00
17	0.10	-0.09	0.01
18	0.00	-0.19	0.04
19	0.11	-0.08	0.01
20	0.68	0.49	0.24
21	0.37	0.18	0.03
22	0.30	0.11	0.01
23	0.56	0.37	0.14
24	0.16	-0.03	0.00
25	0.32	0.13	0.02
26	0.00	-0.19	0.04
27	0.21	0.02	0.00
28	0.00	-0.19	0.04
SUM	5.30		1.25
X_{av}	0.19		
S.D	0.21		

E_v for 2 years	0.61 acc/MEV
E_v for 1 years	0.31 acc/MEV

E_v taken to be	0.30 acc/MEV

Note: Accident rate were obtained from Kobari, 2000.

APPENDIX F

CALCULATION OF EXPECTED VALUES FOR THE ACCIDENT RATE AND ACCIDENT FREQUENCY AT MAIN ROADS

Calculation of Expected Value for the Accident Rate at Main Streets (Mid-block)

Street Name	Accident Rate (X)	$X - X_{av}$	$(X - X_{av})^2$
Nemer	0	-0.505238095	0.25526553
Shouytra	0	-0.505238095	0.25526553
Zoiot	1.16	0.654761905	0.42871315
Askar-Balata	2	1.494761905	2.23431315
Sofian	0.49	-0.015238095	0.0002322
Ashaka'	0	-0.505238095	0.25526553
Hesba	0.64	0.134761905	0.01816077
University	0.35	-0.155238095	0.02409887
Douar	0.32	-0.185238095	0.03431315
Askar	0.57	0.064761905	0.0041941
Ghemata	0.54	0.034761905	0.00120839
Rafidia	0.37	-0.135238095	0.01828934
Palestine	0	-0.505238095	0.25526553
Mohammad	0	-0.505238095	0.25526553
Alquds	1.16	0.654761905	0.42871315
Haifa	0.71	0.204761905	0.04192744
Fisal	0.97	0.464761905	0.21600363
Amman	0.72	0.214761905	0.04612268
Jamal	0.61	0.104761905	0.01097506
Jamal-Amman	0	-0.505238095	0.25526553
Kendi	0	-0.505238095	0.25526553
Summation	10.61		5.29412381

Average of accident rate (X_{av})	0.505238095	
S.D	0.514496055	
$E_v = X_{av} + 1.96 * S.D$ (For two years)	1.513650363	acc/million.veh.Km
$E_v = X_{av} + 1.96 * S.D$ (For one year)	0.756825181 Taken to be 0.8	acc/million.veh.Km

Calculation of Expected Value for the Accident Frequency at Main Links

Street Name	Number of Accident (X)	$X - X_{av}$	$(X - X_{av})^2$
Nemer	0	-6.309524	39.81009
Shouytra	0	-6.309524	39.81009
Zoiout-A	7	0.690476	0.476757
Zoiout-B	4	-2.309524	5.333901
Askar-balata	6	-0.309524	0.095805
Sofian-A	0	-6.309524	39.81009
SofianB	6	-0.309524	0.095805
Shaka'	1	-5.309524	28.19105
Hesba	11	4.690476	22.00057
Univesity-A	4	-2.309524	5.333901
Univesity-B	2	-4.309524	18.572
Douar	2	-4.309524	18.572
Askar	17	10.690476	114.2863
Ghemata	2	-4.309524	18.572
Rafidia 1	14	7.690476	59.14342
Rafidia 2	8	1.690476	2.857709
Palestine-A	0	-6.309524	39.81009
Palestine-B	0	-6.309524	39.81009
Mohammad	5	-1.309524	1.714853
Alquds	49	42.690476	1822.477
Haifa1	4	-2.309524	5.333901
Haifa 2-A	22	15.690476	246.191
Haifa 2-B	5	-1.309524	1.714853
University	1	-5.309524	28.19105
Mohammed	0	-6.309524	39.81009
Fisal 1	18	11.690476	136.6672
Fisal 2-A	4	-2.309524	5.333901
Fisal 2-B	9	2.690476	7.238661
Fisal 2-C	6	-0.309524	0.095805
Fisal 3-A	0	-6.309524	39.81009
Fisal 3-B	4	-2.309524	5.333901
Fisal 3-C	1	-5.309524	28.19105
Fisal 3-D	3	-3.309524	10.95295
Fisal 3-E	3	-3.309524	10.95295
Amman-A	2	-4.309524	18.572
Amman-B	25	18.690476	349.3339
Jamal-A	3	-3.309524	10.95295
Jamal-B	14	7.690476	59.14342
Jamal-Amman	2	-4.309524	18.572
Kendi	0	-6.309524	39.81009
Soliman	0	-6.309524	39.81009
Tunis	1	-5.309524	28.19105
Summation	265		

Average of accident frequency (X_{av})	6.30952381	
S.D	0.829208337	
$E_v = X_{av} + 1.96 * S.D$ (For two years)	7.93477215	acc / two years
$E_v = X_{av} + 1.96 * S.D$ (For two years)	3.967386075 Taken to be 4	acc / year

APPENDIX G

FIELD INVENTORY FORM

FIELD INVENTORY FORM

DATE		
GOVERNORATE	CITY	LOCATION

Road type ☐ midblock ☐ intersection

Number of legs of intersection ☐ 3 ☐ 4 ☐ Multi

Pavement markings ☐ Good condition ☐ Poor condition ☐ Doesn't exist

				Median Opening	
Roadway	East Approach	☐ Divided	☐ undivided	☐ Yes	☐ No
	West Approach	☐ Divided	☐ undivided	☐ Yes	☐ No
	South Approach	☐ Divided	☐ undivided	☐ Yes	☐ No
	North Approach	☐ Divided	☐ undivided	☐ Yes	☐ No

Number of lanes
EB .... lanes
WB .... lanes
SB .... lanes
NB .... lanes

Horizontal alignment	N-S	☐ Straight	☐ Curve
	E-W	☐ Straight	☐ Curve
Vertical alignment	N-S	☐ Gradient	☐ Level
	E-W	☐ Gradient	☐ Level

Shoulder	East Approach	☐ Yes	☐ No	Width = m
	West Approach	☐ Yes	☐ No	Width = m
	South Approach	☐ Yes	☐ No	Width = m
	North Approach	☐ Yes	☐ No	Width = m
Sidewalk	East Approach	☐ Yes	☐ No	Width = m
	West Approach	☐ Yes	☐ No	Width = m
	South Approach	☐ Yes	☐ No	Width = m
	North Approach	☐ Yes	☐ No	Width = m

Drainage facilities ☐ Good ☐ Poor ☐ Doesn't exist

Surface type ☐ Asphalt ☐ Concrete ☐ Gravel ☐ Dirt

Roughness ☐ Rough ☐ Smooth

Surface defects ☐ Rutting ☐ Potholes ☐ Corrugation ☐ Bleeding
☐ Raveling ☐ Nothing ☐ Others

Traffic control	☐ Stop sign ☐ yield sign ☐ Traffic signal ☐ Policeman ☐ No control
Parking control in the vicinity	☐ Parking ☐ No parking
Loading facilities in the vicinity	☐ Yes ☐ No
Land uses	☐ Commercial ☐ Residential ☐ Industrial ☐ School zone ☐ Mixed ☐ Other
Night light condition	☐ Good ☐ Fair ☐ Poor

Speed limit

EB = Km / h
WB = Km / h
SB = Km / h
NB = Km / h

Roadside feature

Poles	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Rocks	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Side slopes	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Trees	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Safety barriers	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Other	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach

Visibility of traffic control devices

EB	☐ Good	☐ Fair	☐ Poor
WB	☐ Good	☐ Fair	☐ Poor
SB	☐ Good	☐ Fair	☐ Poor
NB	☐ Good	☐ Fair	☐ Poor

Sight distance

EB	☐ Good	☐ Poor
WB	☐ Good	☐ Poor
SB	☐ Good	☐ Poor
NB	☐ Good	☐ Poor

FIELD INVENTORY FORM

DATE 16/8/2000
GOVERNORATE Palestine CITY Nablus LOCATION AL-Hesba Int.

Road type	☐ midblock	☒ intersection	
Number of legs of intersection	☐ 3	☒ 4	☐ Multi
Pavement markings	☐ Good condition	☒ Poor condition	☐ Doesn't exist

				Median Opening	
Roadway	East Approach	☒ Divided	☐ undivided	☐ Yes	☒ No
	West Approach	☒ Divided	☐ undivided	☐ Yes	☒ No
	South Approach	☒ Divided	☐ undivided	☐ Yes	☒ No
	North Approach	☒ Divided	☐ undivided	☐ Yes	☒ No

Number of lanes	EB ..3...	lanes
	WB ..3...	lanes
	SB .3....	lanes
	NB ..3...	lanes

Horizontal alignment	N-S	☒ Straight	☐ Curve
	E-W	☒ Straight	☐ Curve
Vertical alignment	N-S	☐ Gradient	☒ Level
	E-W	☒ Gradient	☐ Level

Shoulder	East Approach	☐ Yes	☒ No	Width = m
	West Approach	☐ Yes	☒ No	Width = m
	South Approach	☐ Yes	☒ No	Width = m
	North Approach	☐ Yes	☒ No	Width = m
Sidewalk	East Approach	☒ Yes	☐ No	Width = 2 m
	West Approach	☒ Yes	☐ No	Width = 3 m
	South Approach	☒ Yes	☐ No	Width = 3 m
	North Approach	☒ Yes	☐ No	Width = 2 m

Drainage facilities	☐ Good	☒ Poor	☐ Doesn't exist	
Surface type	☒ Asphalt	☐ Concrete	☐ Gravel	☐ Dirt
Roughness	☒ Rough	☐ Smooth		
Surface defects	☐ Rutting	☐ Potholes	☐ Corrugation	☐ Bleeding
	☒ Raveling	☐ Nothing	☐ Others	

Traffic control	☐ Stop sign ☐ yield sign ☒ Traffic signal ☐ Policeman ☐ No control
Parking control in the vicinity	☐ Parking ☒ No parking
Loading facilities in the vicinity	☐ Yes ☒ No
Land uses	☒ Commercial ☐ Residential ☐ Industrial ☐ School zone ☐ Mixed ☐ Other
Night light condition	☒ Good ☐ Fair ☐ Poor

Speed limit

EB = 50 Km / h
WB = 50 Km / h
SB = 50 Km / h
NB = 50 Km / h

Roadside feature

Poles	☒ East Approach	☒ West Approach	☒ South Approach	☒ North Approach
Rocks	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Side slopes	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Trees	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Safety barriers	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach
Other	☐ East Approach	☐ West Approach	☐ South Approach	☐ North Approach

Visibility of traffic control devices

EB	☒ Good	☐ Fair	☐ Poor
WB	☒ Good	☐ Fair	☐ Poor
SB	☒ Good	☐ Fair	☐ Poor
NB	☒ Good	☐ Fair	☐ Poor

Sight distance

EB	☒ Good	☐ Poor
WB	☒ Good	☐ Poor
SB	☒ Good	☐ Poor
NB	☒ Good	☐ Poor

APPENDIX H

POLICE ACCIDENT REPORT

PROGRAM – "ACCIDENTS"

Introduction

In Appendix C, a new police accident report form was proposed. A new program for data and analysis compatible with this accident report was developed as part of this study. This program enables the traffic police expert to record all accident information. Each item in the accident report form is coded and thus will be stored in a digital file. This program is based on Microsoft Access program; it was named "Accidents."

Advantages of "Accidents" program

a) It is a user-friendly program

b) This program stores a large amount of data in a small space

c) It allows for easy retrieval and analysis of accident data

d) "Accidents" permits the user to draw a sketch for the accident

How to Use "Accidents"

a) The first screen is a welcome sheet and gives choices to "exit" or to "continue", as presented in the attached documents.

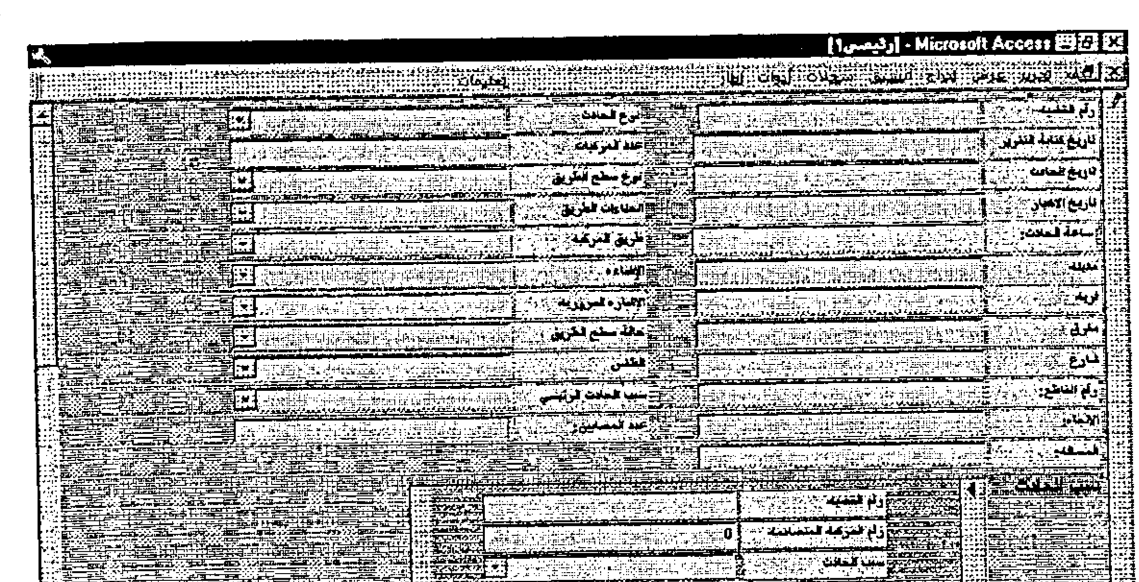
b) Once "continue" option is chosen, the second screen gives four choices, which are:

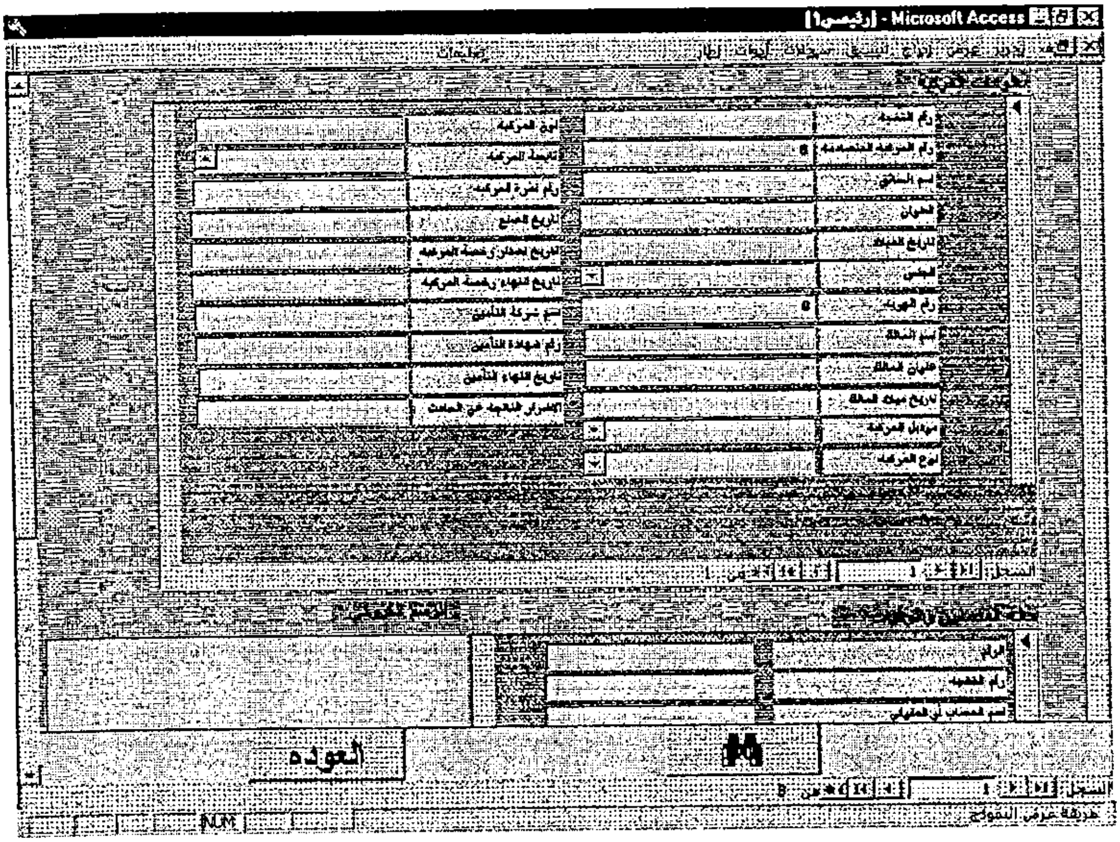
1. Accidents
2. Information
3. Reports
4. Add New Fields
5. Exit

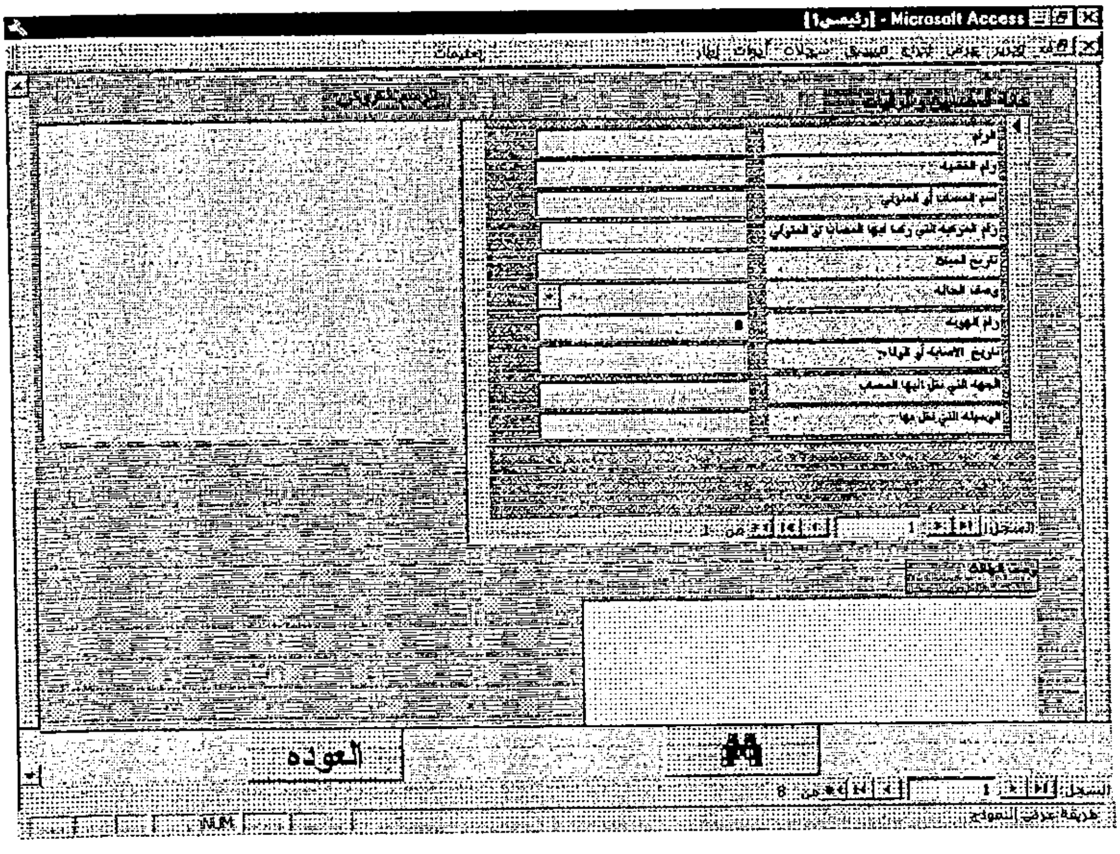
- The "Accidents" option opens the screen of data input for each accident exactly as it appears in the proposed police accident report. Input data is filled at this screen which contains all information about the vehicles, drivers, injuries, and the description of an accident.
- The "information" option opens the screen, which gives multi choices to retrieve accidents records.
- The "reports" option informs about general information, vehicle information, and injury information for an accident record.
- "Add new fields" option makes this program more flexible. This action gives a chance to add more fields and information in the future, as needed
- "Exit" option returns to the main menu.

The following figures describe the above actions of the program.

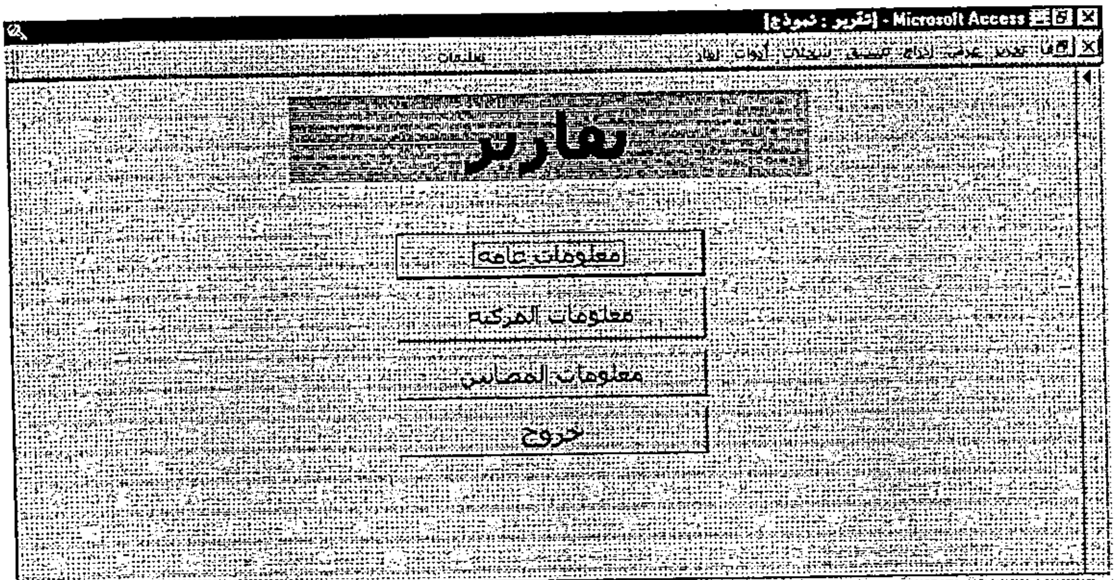

Microsoft Access - [قائمة البرامج : نموذج]
برنامج الحوادث
الحوادث
استعلامات
تقارير
اضافة الى حقول
خروج

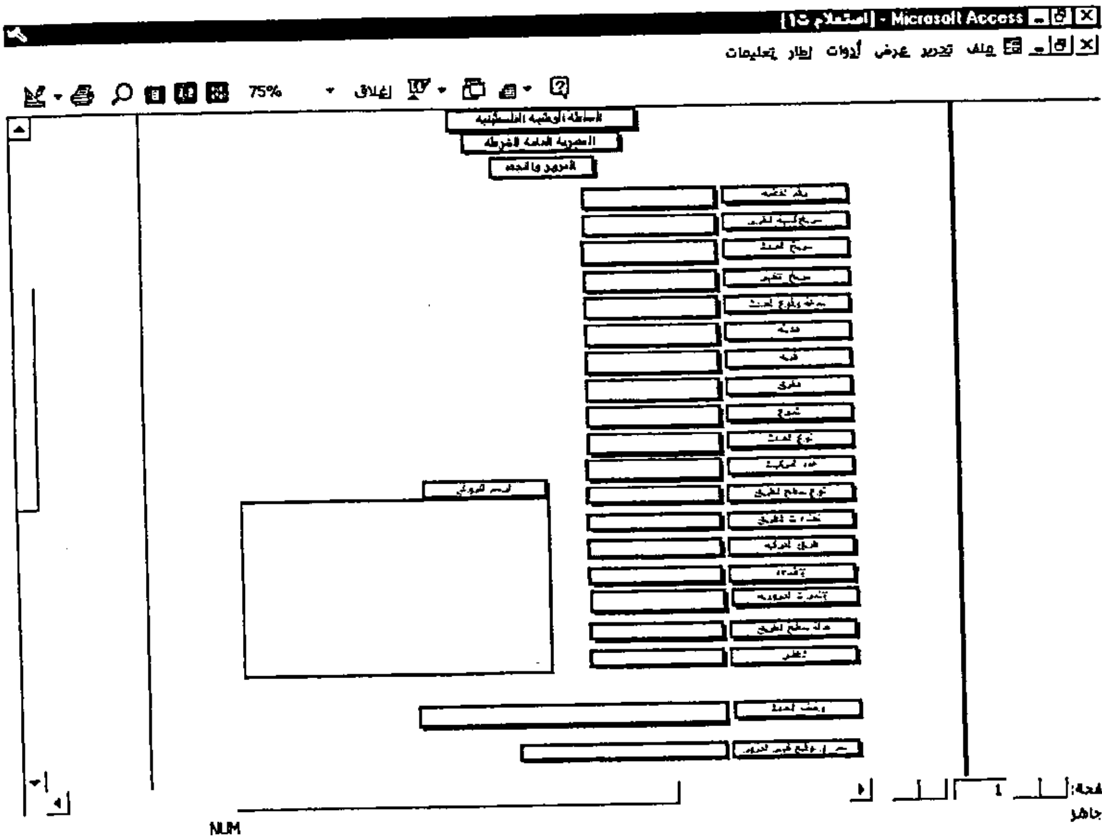

Microsoft Access - [رئيسي1]
رقم القضية
نوع الحادث
عدد المركبات
سبب الحادث الرئيسي
عدد المصابين
العودة

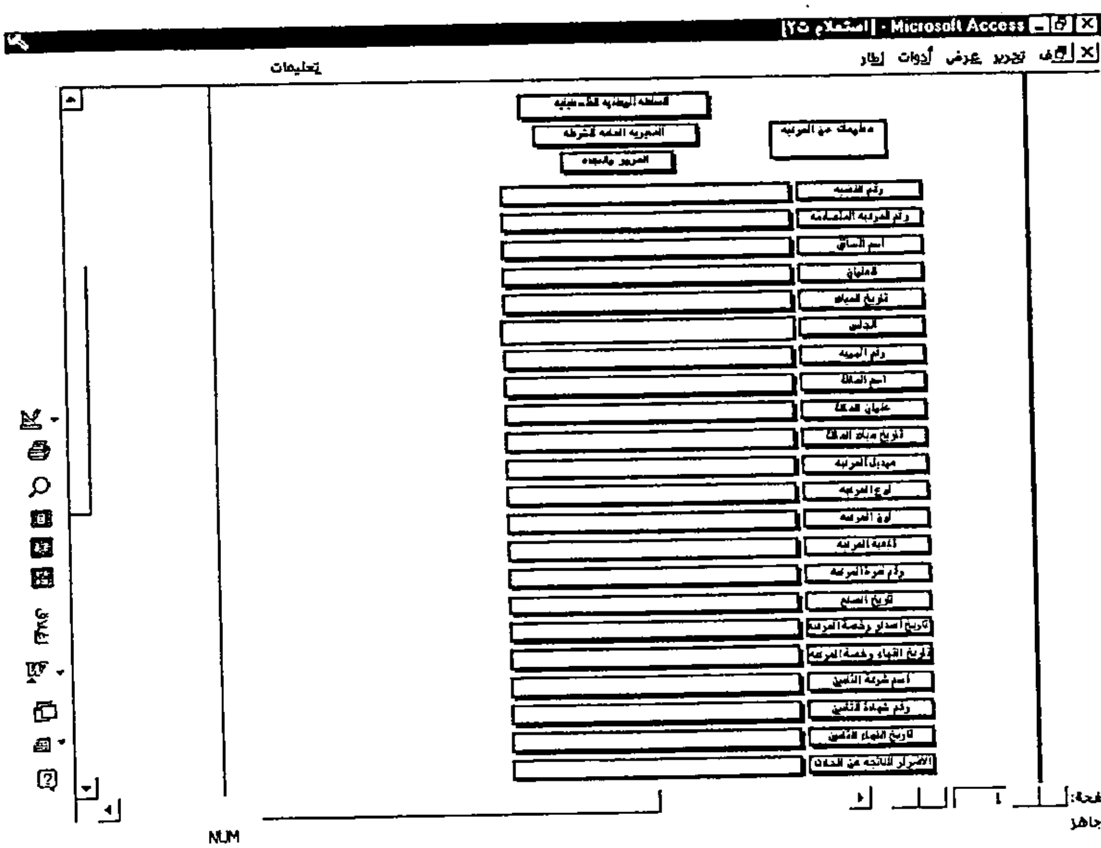

Microsoft Access - [رئيسي1]
العوده

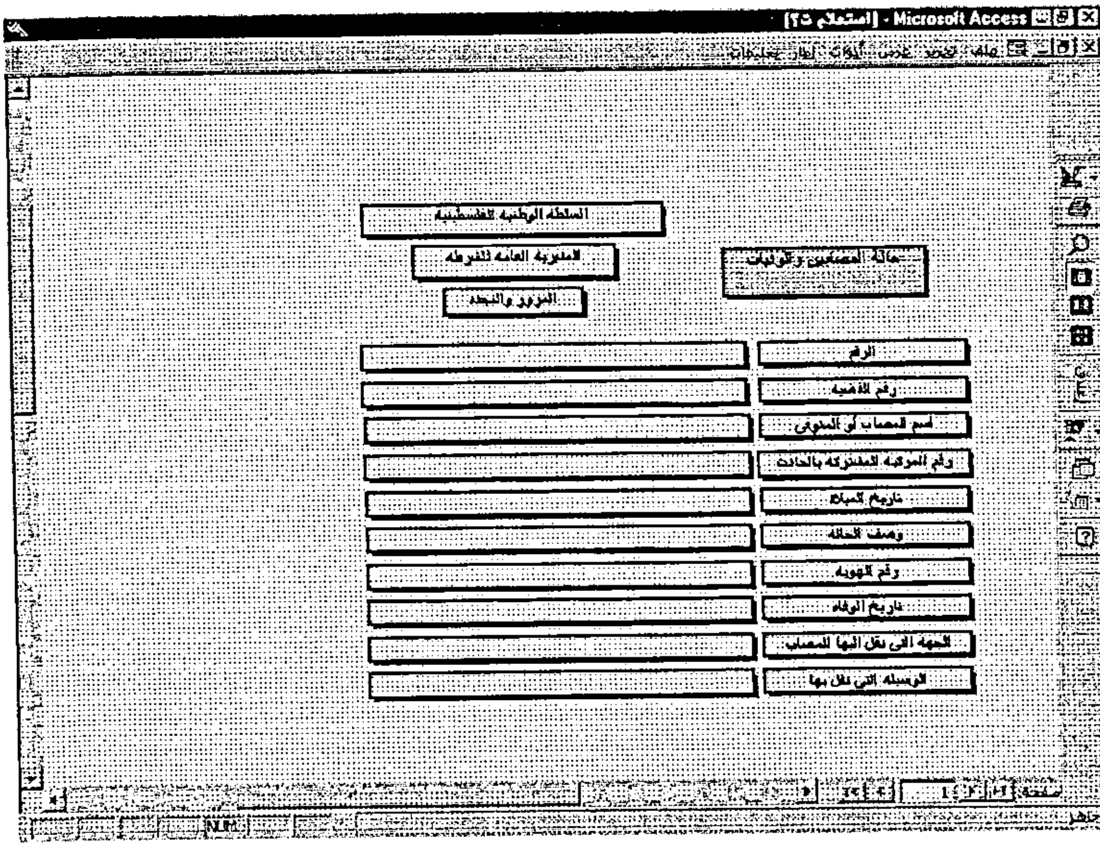

Microsoft Access - [رئيسي1]
العوده


Microsoft Access
استعلامات
استعلام حالة المصابين
خروج


[تقرير : نموذج] - Microsoft Access
تقارير
معلومات عامة
معلومات الحركة
معلومات المصابين
خروج


Microsoft Access - [استعلام ١٥]
ملف تحرير عرض أدوات إطار تعليمات
75%
إغلاق
السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
المرور والنجدة
صفحة:
جاهز
NUM


Microsoft Access - [استعلام ٢٥]
ملف تحرير عرض أدوات إطار تعليمات
السلطة الوطنية الفلسطينية
المديرية العامة للشرطة
المرور والنجدة
معلومات عن المركبة
رقم القضية
رقم المركبة المتصادمة
اسم السائق
العنوان
تاريخ الميلاد
الجنس
رقم الهوية
اسم المالك
عنوان المالك
تاريخ ميلاد المالك
موديل المركبة
نوع المركبة
لون المركبة
رقم محرك المركبة
تاريخ التسليح
تاريخ إصدار رخصة المركبة
تاريخ انتهاء رخصة المركبة
اسم شركة التأمين
رقم شهادة التأمين
تاريخ انتهاء التأمين
الأضرار الناتجة عن الحادث
صفحة:
جاهز
NUM


Microsoft Access
السلطه الوطنيه الفلسطينيه
المديريه العامه للشرطه
المرور والنجده
الرقم
اسم المصاب أو المتوفى
رقم المركبه المشتركه بالحادث
تاريخ الميلاد
وصف الحالة
رقم الهويه
تاريخ الوفاه
الجهه التي نقل اليها المصاب
الوسيله التي نقل بها
NUM


Microsoft Access
اضافة معلومه لحقل
سبب الحادث
حالة سطح الطريق
نوع الحادث
نوع سطح الطريق
الاضاءه
حالة الطقس
انحناءات الطريق
خروج
NUM

The Aim of "Accidents"

- This program creates a computerized database for accidents. From this database, the analyst can determine the hazardous locations at specific sites. This program gives specific types and causes of accidents. So, the analyst can also specify reasonable and effective countermeasures at hazardous locations.
- This program saves time and efforts. This program also serves for an easy retrieval of accident information.

Summary

As shown in Appendix L, the police accident report form has very useful information. These information form a database for traffic safety analysis. The analysis of database will result in the determination of the types and causes of accidents at hazardous locations. Therefore, effective countermeasures can take place at these hazardous locations. To make this process more easy and to save time and efforts, a computer program "Accidents" is suggested in this thesis to be applied in Palestine.

This program is user friendly, stores a large amount of accident information, and information is easy to be retrieved. The suggested program is the first trial in Palestine. Efforts could be applied to make it more flexible and more effective to be used in Palestine in the near future.

APPENDIX I

ANNUAL ACCIDENT REDUCTION

AND

SERVICE LIFE OF TREATMENT

Table I-1: Accident Reduction Factors for Highway Safety Projects

Type of Project	Average Accident Reduction	Life (years)
Flashing beacons	20% of all accidents	10
New safety lighting	15% of night accidents	15
Curve correction	50% of all accidents	20
Rumble strips	50% of drift off road accidents	10
Superelevation correction	50% of run-off-road accidents	20/10†
Truck escape ramps	75% of run-away truck accidents	20
New left-turn channelization:		
w/o left-turn phase	15% of all accidents	20/10†
With left-turn phase	35% of all accidents	20/10†
Non-signalized	35% of all accidents	20/10†
Two-way LT lane	25% of all accidents	20/10†

† - 20 years with standard geometrics with widening; 10 years with substandard geometrics.

Source: Homburger, J. Hall, R. Loutzenheiser, and W. Reilly, 1996

Table I-2: Accident Reduction Factor

Evaluation of Safety Improvements by Construction Classification, 1974–1987

Type of Improvement and Construction Classification	Indexed Cost of Evaluated Improvements (millions)	Percent Reduction in Accident Rates After Improvements			Cost-Per-Accident Reduced (thousands)		Benefit/Cost Ratio
		Fatal	Injury	Fatal + Injury	Fatal	Fatal + Injury	
INTERSECTION & TRAFFIC CONTROL	562.3	37	15	15	344.5	18.7	4.0
Channelization turning lanes	297.3	48	23	24	510.9	19.7	2.8
Sight distance improvements	7.8	44*	31	32	371.4	22.8	3.6
Traffic signs	19.6	34	3	4	59.2	15.7	20.9
Pavement markings and/or delineators	33.7	15	(1)*	(1)	751.8	—	1.6
Illumination	13.2	45	8	9	122.6	16.8	10.3
Traffic signals upgraded	63.1	40	22	22	412.1	8.6	4.0
Traffic signals, new	127.3	49	21	21	344.5	10.5	5.1
STRUCTURES	307.7	50	28	29	752.2	92.1	1.7
Bridge widened or modified	79.8	49	22	23	1,077.9	103.8	1.2
Bridge replacement	156.9	72	47	49	1,201.6	139.3	1.1
New bridge construction	26.2	77*	40	43	1,637.8	223.2	0.8
Minor structure replacement/improved	39.0	16	20	21	227.1	39.8	4.5
Upgraded bridge rail	5.6	72*	41	45	189.5	39.4	6.5
ROADWAY AND ROADSIDE	1,971.3	31	13	13	722.2	54.0	1.8
Widened travel way	511.0	9*	7	7	4,041.3	174.2	0.4
Lanes added	212.9	(2)	13	13	—	66.8	0.1
Median strip to separate roadway	56.8	73	17	19	382.4	72.8	3.2
Shoulder widening or improvement	88.3	28	11	12	497.9	37.9	2.6
Roadway realignment	379.9	61	32	34	1,193.2	111.1	1.1
Skid resistant overlay	468.4	26	18	19	837.0	30.3	1.8
Pavement grooving	12.6	34*	15	15	377.3	14.5	3.8
Upgraded guardrail	149.7	42	8	9	151.2	31.5	8.1
Upgraded median barrier	7.4	45*	28	29	192.8	10.8	7.0
New median barrier	58.9	62	0*	3*	224.7	*213.6	5.4
Impact attenuators	10.7	31*	36	36	390.0	8.0	4.0
Flatten side slopes/regrading	36.5	(25)*	7	8*	—	102.2	—
Bridge approach guardrail transition	4.8	61*	44	45	200.9	25.8	6.3
Obstacle removal	15.0	49	22	23	202.5	36.0	6.4
RAILROAD-HIGHWAY CROSSINGS	331.2	89	63	67	570.0	354.2	2.2
New flashing lights	55.0	91	74	77	551.4	103.5	2.2
New flashing lights and gates	138.1	92	84	86	591.8	115.3	2.1
New gates only	63.2	90	78	80	432.8	96.7	2.8

Note: Numbers in parentheses ( ) indicate increased accident rates.
*No significant change at the 95% confidence level.

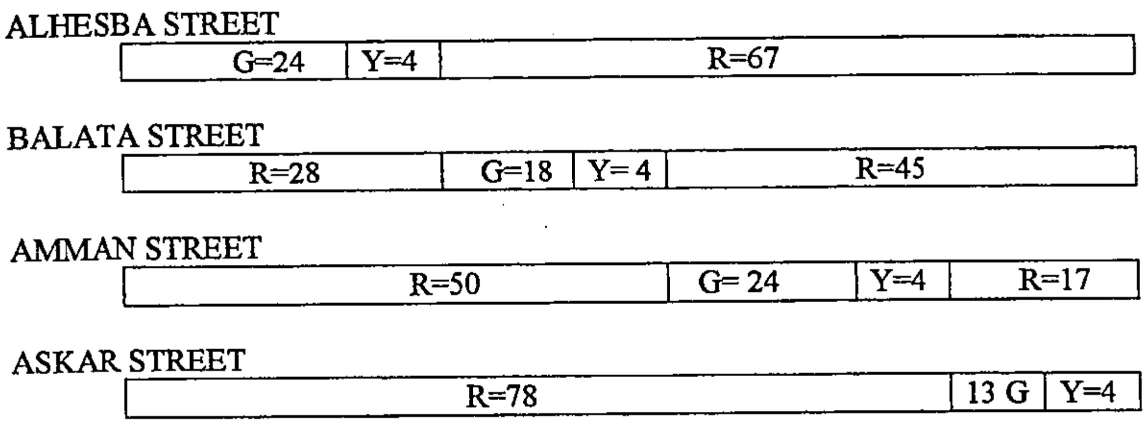
Accident Reductions for Low-Cost Treatments

Treatment	Accident Reduction (%)
Anti-skid (Calcined Bauxite)	30
Improved signing at junctions	46
Modifications to existing traffic signals	30
New traffic signals	46
New pelicans (crosswalks)	40
New zebras (crosswalks)	44
Superelevation	75
Lining and signing not at bends	32
Lining and signing at bends	55
Minor junction changes (not roundabouts)	52
Pedestrian refuges	19
Pedestrian barriers	43
New street lighting	24
Resurfacing	34
Alterations to roundabouts	20
Area studies	50

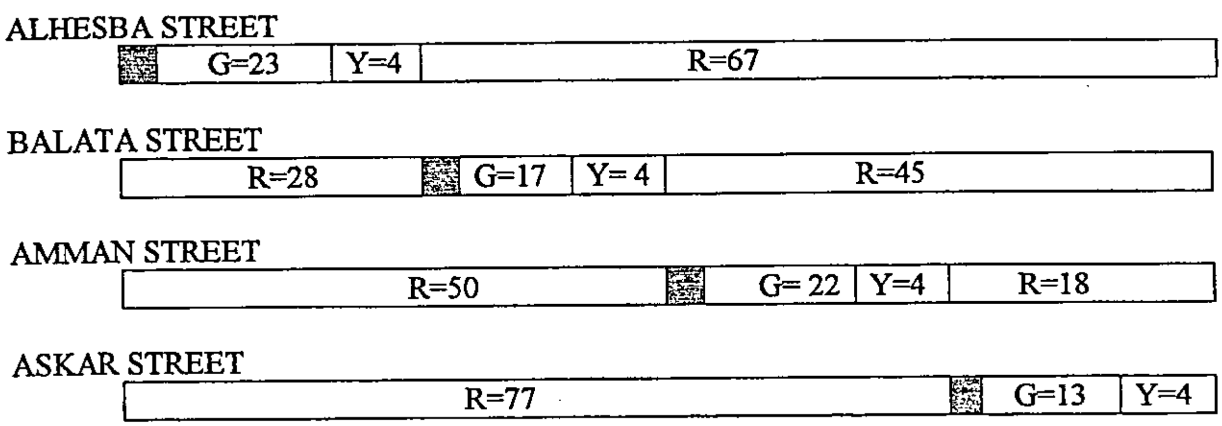
Source: Traffic Engineering Handbook, Institute of Transportation Engineers (ITE, 1992).

APPENDIX J

SIGNAL PHASING AT AL-HESBA INTERSECTION



Existing Signal Timing / Phasing



Modified Signal Timing / Phasing

Notes:

G : Green time

R : Red time

Y : Yellow time

■ : All-Red time = 1 second

APPENDIX K

HCS WORK SHEET

Capacity Analysis of Existing Conditions

HCS: Signals Release 3.1b

Inter:
Analyst: HUSSEIN ABU ZANT
Date: 11/5/2001
Intersection:
Time Period Analyzed:

City/St: NABLUS / PALESTINE
Proj #: **EXISTING CONDITIOPNS ANALYSIS**
Period:

No errors to report.

E/W St: AL-HESBA / AMMAN

N/S St: BALATA / ASKAR

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	1	1	1	1	1	1	1	1	1	1	1	1
LGConfig	L	T	R	L	T	R	L	T	R	L	T	R
Volume	272	236	59	68	303	78	74	105	164	41	105	253
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
RTOR Vol			0			0			0			0

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left	P				NB	Left	P			
	Thru	P					Thru	P			
	Right	P					Right	P			
	Peds						Peds				
WB	Left		P			SB	Left		P		
	Thru		P				Thru		P		
	Right		P				Right		P		
	Peds						Peds				
NB	Right					EB	Right				
SB	Right					WB	Right				
Green		24.0	24.0					18.0	13.0		
Yellow		4.0	4.0					4.0	4.0		
All Red		0.0	0.0					0.0	0.0		

Cycle Length: 95.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capcity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	456	1805	0.66	0.253	39.2	D		
T	480	1900	0.55	0.253	35.2	D	36.4	D
R	408	1615	0.16	0.253	28.5	C		
Westbound								
L	456	1805	0.17	0.253	28.5	C		
T	480	1900	0.70	0.253	40.6	D	36.8	D
R	408	1615	0.21	0.253	29.2	C		
Northbound								
L	342	1805	0.24	0.189	34.3	C		
T	360	1900	0.32	0.189	35.6	D	39.1	D
R	306	1615	0.59	0.189	43.4	D		
Southbound								
L	247	1805	0.19	0.137	38.0	D		
T	260	1900	0.45	0.137	43.3	D	137.9	F
R	221	1615	1.27	0.137	193.7	F		

Intersection Delay = 37.7 (sec/veh) Intersection LOS = D

Capacity Analysis of Modified Signal Timing

HCS: Signals Release 3.1b

Inter:
Analyst: HUSSEIN ABU ZANT
Date: 11/5/2001
Intersection: AL-HESBA INTERSECTION
Time Period Analyzed:

City/St: NABLUS / PALESTINE
Proj #: **SAFETY STUDY (AR=1 & REDUCE G)**
Period:

No errors to report.

E/W St: AL-HESBA / AMMAN

N/S St: BALATA / ASKAR

SIGNALIZED INTERSECTION SUMMARY

	Eastbound L	Eastbound T	Eastbound R	Westbound L	Westbound T	Westbound R	Northbound L	Northbound T	Northbound R	Southbound L	Southbound T	Southbound R
No. Lanes	1	1	1	1	1	1	1	1	1	1	1	1
LGConfig	L	T	R	L	T	R	L	T	R	L	T	R
Volume	272	236	59	68	303	78	74	105	164	41	105	253
Lane Width	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
RTOR Vol			59			78			164			253

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4			5	6	7	8
EB Left	P				NB	Left	P			
Thru	P					Thru	P			
Right	P					Right	P			
Peds						Peds				
WB Left		P			SB	Left		P		
Thru		P				Thru		P		
Right		P				Right		P		
Peds						Peds				
NB Right					EB	Right				
SB Right					WB	Right				
Green	23.0	22.0					17.0	13.0		
Yellow	4.0	4.0					4.0	4.0		
All Red	1.0	1.0					1.0	1.0		

Cycle Length: 95.0 secs

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capcity	Adj Sat Flow Rate (s)	Ratios v/c	Ratios g/C	Lane Group Delay	Lane Group LOS	Approach Delay	Approach LOS
Eastbound								
L	437	1805	0.69	0.242	41.4	D		
T	460	1900	0.57	0.242	36.7	D	39.2	D
R	391	1615	0.00	0.242	27.3	C		
Westbound								
L	418	1805	0.18	0.232	30.2	C		
T	440	1900	0.77	0.232	46.1	D	43.2	D
R	374	1615	0.00	0.232	28.0	C		
Northbound								
L	323	1805	0.25	0.179	35.4	D		
T	340	1900	0.34	0.179	36.9	D	36.3	D
R	289	1615	0.00	0.179	32.0	C		
Southbound								
L	247	1805	0.19	0.137	38.0	D		
T	260	1900	0.45	0.137	43.3	D	41.8	D
R	221	1615	0.00	0.137	35.4	D		

Intersection Delay = 40.3 (sec/veh) Intersection LOS = D

APPENDIX L

CALCULATIONS OF TOTAL ANNUAL COST FOR POLICE ENFORCEMENT AND PAVEMENT MARKING TO BE APPLIED AT AL-HESBA INTERSECTION

Based on the Commercial Bank of Palestine, the interest rate (r) was approximately 5.75 percent. To account for inflation, use the interest rate to be 4 percent. The life period (n) was used as shown in Table 9-5.

$$TAC = (CRF)\ C_o + OMR$$

To convert the values in Table 9-5 into Equivalent Annual Uniform Cost (EUAC) or (TAC) the following calculations were applied:

EUAC for Enforcement limit speed

TAC = $1080 / year.

EUAC for pavement marking

TAC = 437.5 x .36 + 100

= $258 / year.

SUM of TAC = $1338 / year.

APPENDIX M

SPOT SPEED STUDY

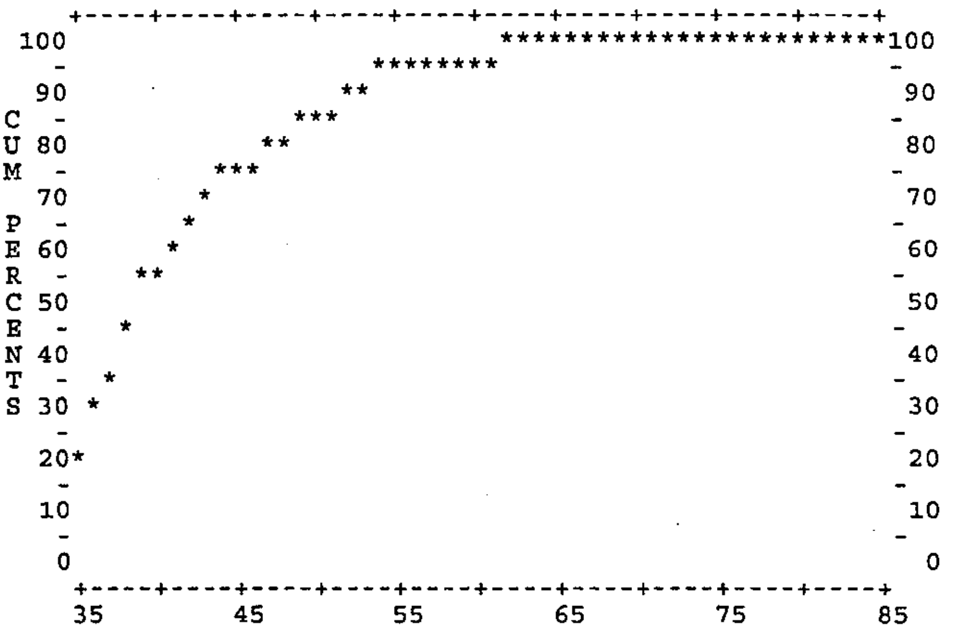
Bather Belrose Boje, Inc. SPEEDPLOT Program

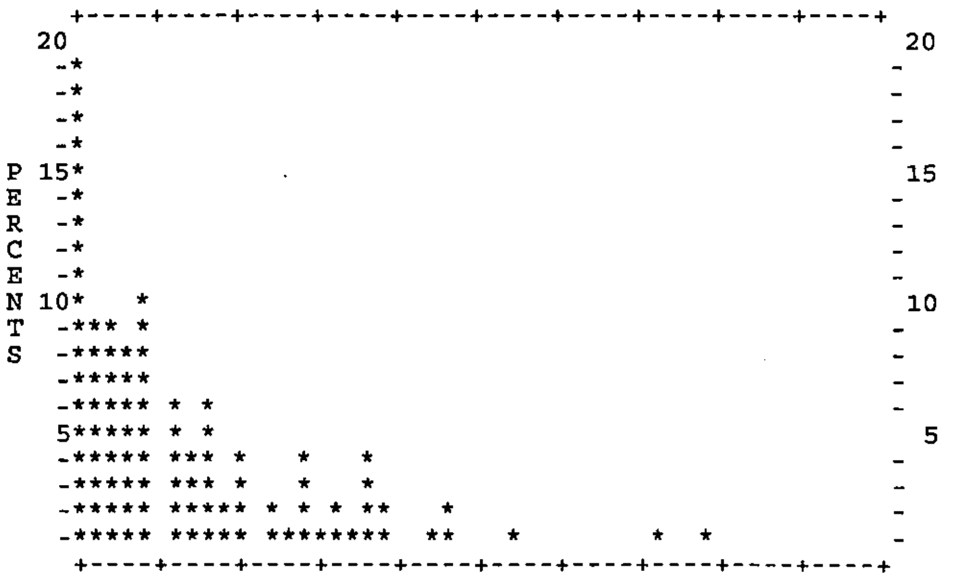
STREET................ 0 Blk. BALATA STREET
LIMITS................ 20 to 70

DIRECTION(S)..........SN
DATE..................11/5/2001
TIME..................4:22
POSTED SPEED LIMIT.... 0

50TH PERCENTILE SPEED.................39
85TH PERCENTILE SPEED.................50
10 MPH PACE SPEED..........35 through 44
PERCENT IN PACE SPEED.............. 73.0
PERCENT OVER PACE SPEED.............27.0
PERCENT UNDER PACE SPEED............ 0.0
RANGE OF SPEEDS.................35 to 74
VEHICLES OBSERVED.................. 100
AVERAGE SPEED.......................42.0

SPEED	NO.	PCT.	CUM. PCT.
35	19	19.0	19.0
36	9	9.0	28.0
37	9	9.0	37.0
38	8	8.0	45.0
39	10	10.0	55.0
40	0	0.0	55.0
41	6	6.0	61.0
42	4	4.0	65.0
43	6	6.0	71.0
44	2	2.0	73.0
45	4	4.0	77.0
46	0	0.0	77.0
47	2	2.0	79.0
48	1	1.0	80.0
49	4	4.0	84.0
50	1	1.0	85.0
51	2	2.0	87.0
52	1	1.0	88.0
53	4	4.0	92.0
54	2	2.0	94.0
55	0	0.0	94.0
56	0	0.0	94.0
57	1	1.0	95.0
58	2	2.0	97.0
59	0	0.0	97.0
60	0	0.0	97.0
61	0	0.0	97.0
62	1	1.0	98.0
63	0	0.0	98.0
64	0	0.0	98.0
65	0	0.0	98.0
66	0	0.0	98.0
67	0	0.0	98.0
68	0	0.0	98.0
69	0	0.0	98.0
70	0	0.0	98.0
71	1	1.0	99.0
72	0	0.0	99.0
73	0	0.0	99.0
74	1	1.0	100.0





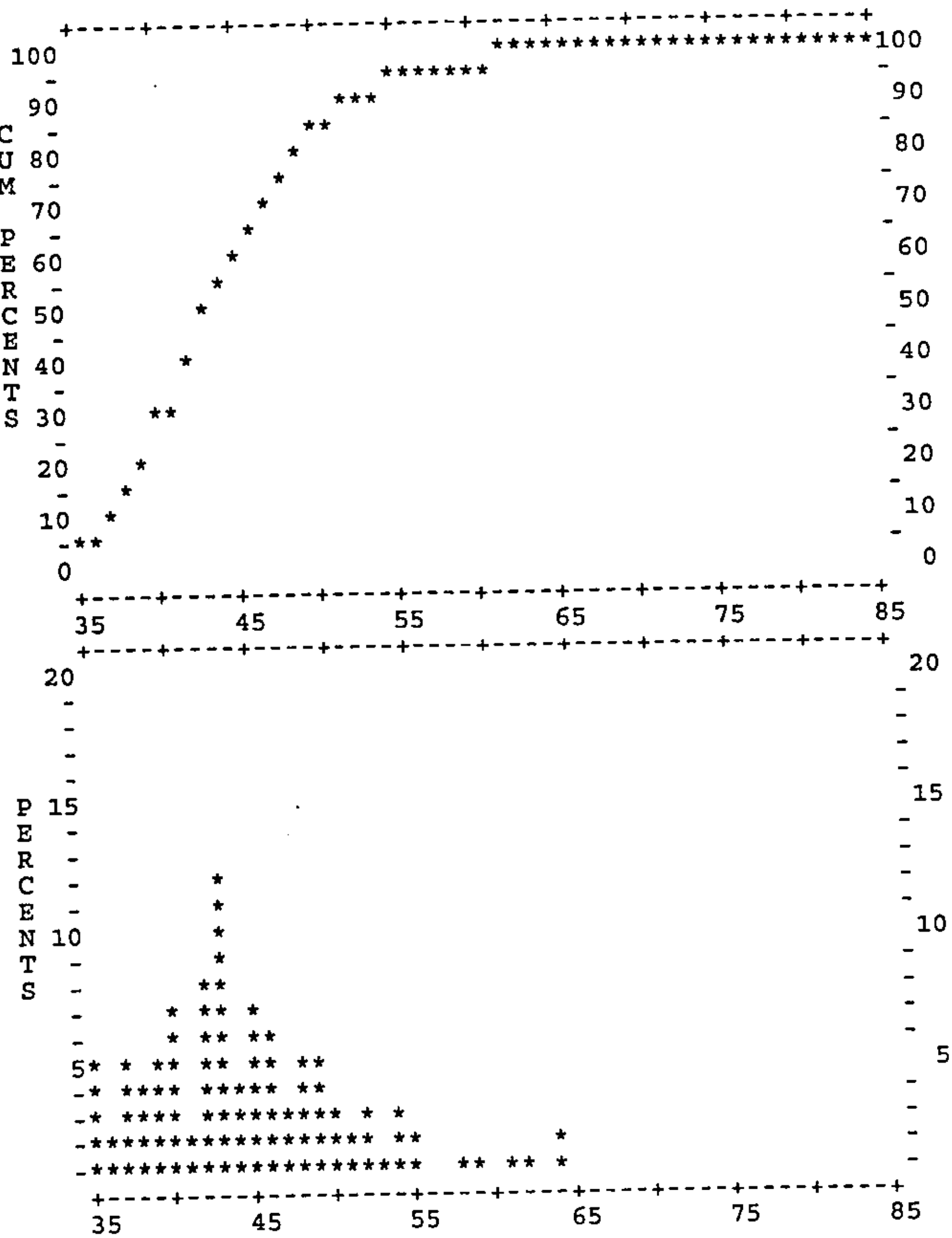
Bather Belrose Boje, Inc. SPEEDPLOT Program

STREET................ 0 Blk. ASKAR STREET
LIMITS................ 20 to 70

DIRECTION(S)..........NS
DATE..................11/5/2001
TIME..................4:48
POSTED SPEED LIMIT.... 0

50TH PERCENTILE SPEED.................43
85TH PERCENTILE SPEED.................51
10 MPH PACE SPEED..........37 through 46
PERCENT IN PACE SPEED.............. 60.0
PERCENT OVER PACE SPEED.............33.0
PERCENT UNDER PACE SPEED............ 7.0
RANGE OF SPEEDS.................35 to 64
VEHICLES OBSERVED.................. 100
AVERAGE SPEED.......................44.9

SPEED	NO.	PCT.	CUM. PCT.
35	5	5.0	5.0
36	2	2.0	7.0
37	5	5.0	12.0
38	4	4.0	16.0
39	5	5.0	21.0
40	7	7.0	28.0
41	2	2.0	30.0
42	8	8.0	38.0
43	12	12.0	50.0
44	4	4.0	54.0
45	7	7.0	61.0
46	6	6.0	67.0
47	3	3.0	70.0
48	5	5.0	75.0
49	5	5.0	80.0
50	3	3.0	83.0
51	2	2.0	85.0
52	3	3.0	88.0
53	1	1.0	89.0
54	3	3.0	92.0
55	2	2.0	94.0
56	0	0.0	94.0
57	0	0.0	94.0
58	1	1.0	95.0
59	1	1.0	96.0
60	0	0.0	96.0
61	1	1.0	97.0
62	1	1.0	98.0
63	0	0.0	98.0
64	2	2.0	100.0



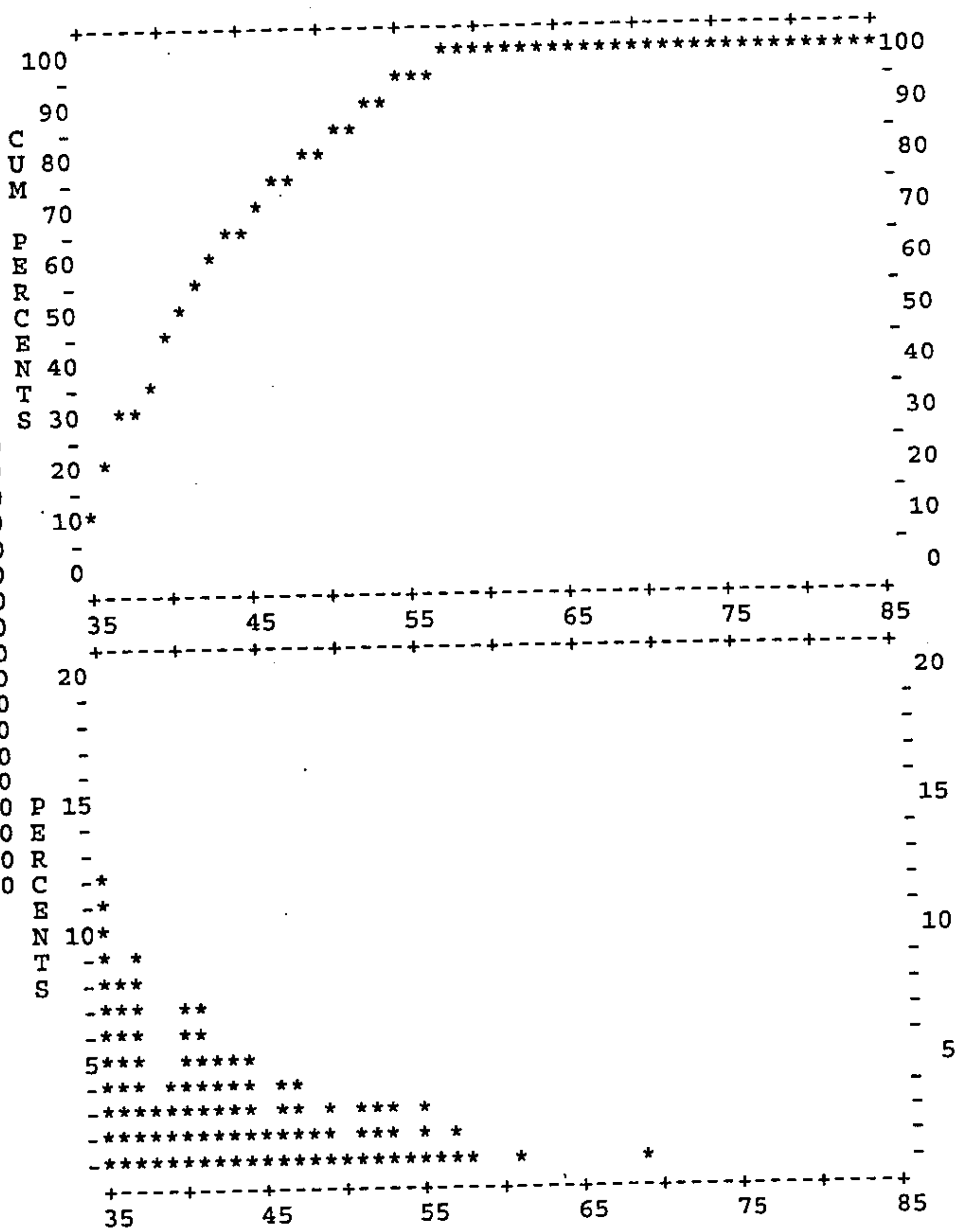
Bather Belrose Boje, Inc. SPEEDPLOT Program

STREET................ 0 Blk. AL-HESBA STREET
LIMITS................ 20 to 70

DIRECTION(S)..........EW
DATE..................11/5/2001
TIME..................4:05
POSTED SPEED LIMIT.... 0

50TH PERCENTILE SPEED.................41
85TH PERCENTILE SPEED.................52
10 MPH PACE SPEED..........35 through 44
PERCENT IN PACE SPEED.............. 65.0
PERCENT OVER PACE SPEED.............35.0
PERCENT UNDER PACE SPEED............ 0.0
RANGE OF SPEEDS................35 to 69
VEHICLES OBSERVED...................100
AVERAGE SPEED.......................43.2

SPEED	NO.	PCT.	CUM. PCT.
35	12	12.0	12.0
36	8	8.0	20.0
37	9	9.0	29.0
38	3	3.0	32.0
39	4	4.0	36.0
40	7	7.0	43.0
41	7	7.0	50.0
42	5	5.0	55.0
43	5	5.0	60.0
44	5	5.0	65.0
45	2	2.0	67.0
46	4	4.0	71.0
47	4	4.0	75.0
48	2	2.0	77.0
49	3	3.0	80.0
50	1	1.0	81.0
51	3	3.0	84.0
52	3	3.0	87.0
53	3	3.0	90.0
54	1	1.0	91.0
55	3	3.0	94.0
56	1	1.0	95.0
57	2	2.0	97.0
58	1	1.0	98.0
59	0	0.0	98.0
60	0	0.0	98.0
61	1	1.0	99.0
62	0	0.0	99.0
63	0	0.0	99.0
64	0	0.0	99.0
65	0	0.0	99.0
66	0	0.0	99.0
67	0	0.0	99.0
68	0	0.0	99.0
69	1	1.0	100.0



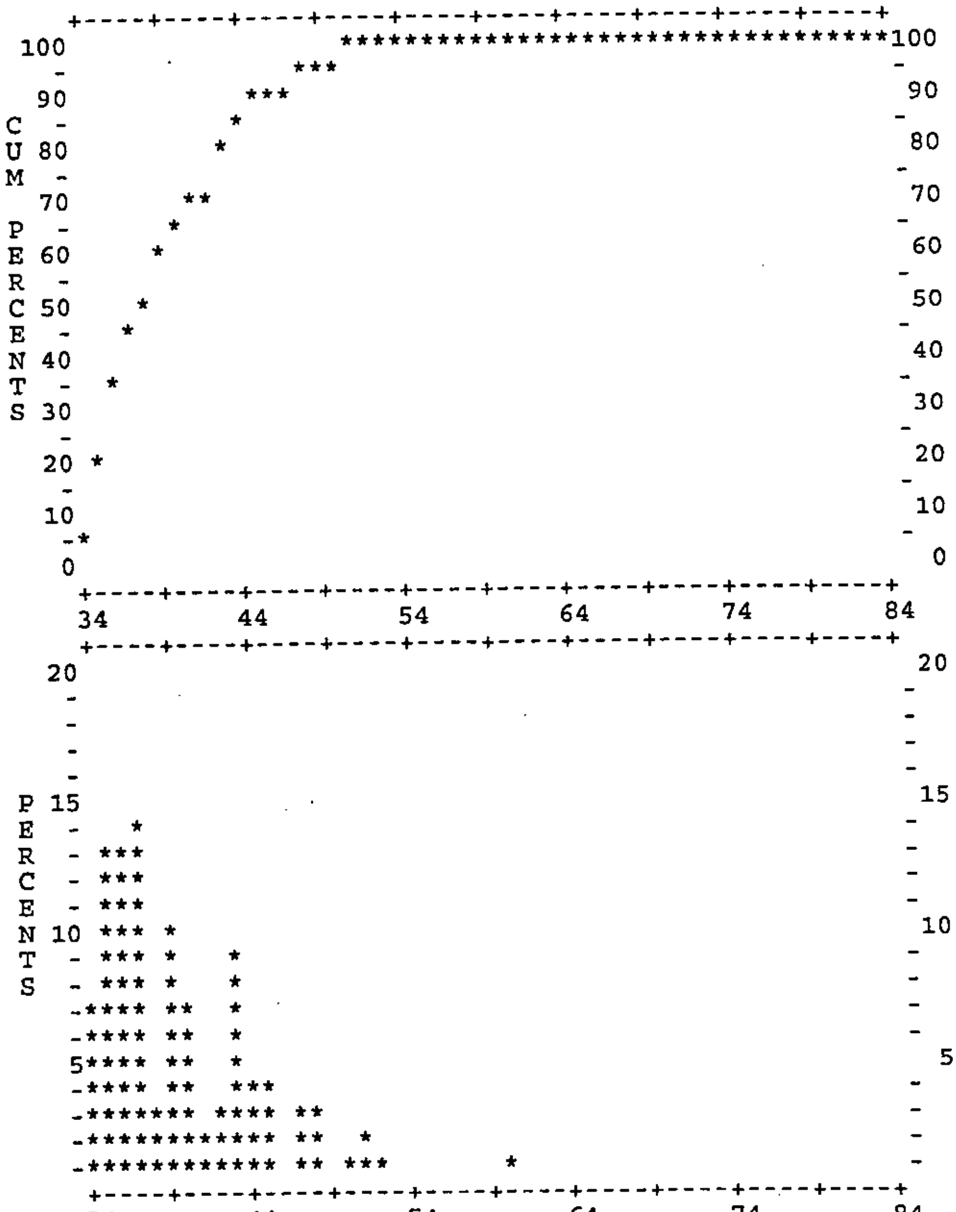
Bather Belrose Boje, Inc. SPEEDPLOT Program

STREET................. 0 Blk. AMMAN STREET
LIMITS................. 20 to 75

DIRECTION(S)..........NS
DATE..................11/5/2001
TIME..................3:01
POSTED SPEED LIMIT.... 0

50TH PERCENTILE SPEED.................38
85TH PERCENTILE SPEED.................44
10 MPH PACE SPEED..........34 through 43
PERCENT IN PACE SPEED............. 81.0
PERCENT OVER PACE SPEED.............19.0
PERCENT UNDER PACE SPEED............ 0.0
RANGE OF SPEEDS.................34 to 60
VEHICLES OBSERVED.................. 100
AVERAGE SPEED.......................39.6

SPEED	NO.	PCT.	CUM. PCT.
34	7	7.0	7.0
35	13	13.0	20.0
36	13	13.0	33.0
37	14	14.0	47.0
38	3	3.0	50.0
39	10	10.0	60.0
40	7	7.0	67.0
41	2	2.0	69.0
42	3	3.0	72.0
43	9	9.0	81.0
44	4	4.0	85.0
45	4	4.0	89.0
46	0	0.0	89.0
47	3	3.0	92.0
48	3	3.0	95.0
49	0	0.0	95.0
50	1	1.0	96.0
51	2	2.0	98.0
52	1	1.0	99.0
53	0	0.0	99.0
54	0	0.0	99.0
55	0	0.0	99.0
56	0	0.0	99.0
57	0	0.0	99.0
58	0	0.0	99.0
59	0	0.0	99.0
60	1	1.0	100.0



APPENDIX N

RUMBLE STRIPS

Rumble strips

Rumble strips are transverse strips of rough texture surface used to supplement standard or conventional traffic control devices. Rumble strips may be used to alert drivers of unusual or unexpected traffic conditions or geometry, or to bring the driver's attention to other warning devices. They provide a vibratory and audible warning that supplements visual stimuli (Manual on Uniform Traffic Control Devices "MUTCD", 1994). The effect of applying this measure is presented in the following table:

Countermeasure	Average Accident Reduction*	Life (year)	Source
Installing of rumble strips	AR = 15%	5	ITE, 1992

Uniform Standards

While not treated in details in the MUTCD, rumble strips are recognized devices in basic traffic engineering tests. However, no specific warrants or design standards are given. Examples of designs currently in use are shown in Figure bellow:

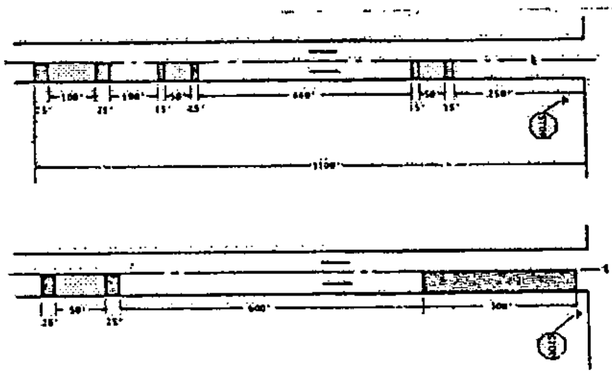


Figure 10-3: Typical Rumble Strips Design

Source: State of the Art Report: Residential Traffic Management. Federal Highway Administration, 1980.

A rumble strip may consist of raised strips or depressed grooves. The cross-section may be rectangular, domed, or trapezoidal in shape. The strips or grooves should be placed transverse to the direction of traffic. The intervals between rumble strip pads should be reduced as the distance to the hazard diminishes, to create a sensation of deceleration for motorists.

For the study intersection, rumble strips are recommended to be installed on all approaches because of the existing excessive speed on these approaches. The cost of this measure is presented in the following table:

Measure	Initial Cost ($)				Life period (Years)	CRF	Annual Maintenance cost ($)	TAC ($)
	Unit	Cost / Unit ($)	Quantity	Cost ($)				
Rumble Strips	Lump Sum	500	4	2000	5	0.225	100	550

Notes:

The Capital Recovery Factor (CRF) is the factor, which converts a fixed payment or present value at the beginning of a project's life into an equivalent fixed periodic payment.

$$CRF = \{ r (1 + r)^n \} / \{(1 + r) - 1\}$$

The total annual cost (TAC) is simply the initial cost times the capital recovery factor plus the annual operation, maintenance, and repair (OMR) costs.

EUAC for rumble strips

C_o = $2,000

CRF = 0.225

TAC = (CRF) C_o + OMR

= 0.225 x 2,000 + 100

= $550 / year.