# ACCIDENT INVESTIGATION IN NORTH CORRIDOR WEST JAVA INDONESIA

*Muhammad Idris*

***SUMMARY***

*Traffic accidents on the Highway National running along Java's north corridor account for a particularly high share of accidents in Indonesia. Reports by the mass media indicate that human error was the main cause of many of these accident. This paper describes the magnitude and seriousness of the road accidents at selected sites on this highway in West Java and makes some suggestions for countermeasures at the blackspots for accident reduction.*

*A systematic accident investigation approach was used to identify the black links using accident and fatality rates. The worst location or blackspots were ranked by Equivalent Accident Numbers (EAN). The accidents at each selected site were then analyzed by means of the Sticks Diagrams to identify the common accident types. Normal tests and Chi-Square tests were used to identify predominant accident types. The results of these analyses led to further on site investigation to find out possible local problems and identify and develop appropriate countermeasures.*

***RINGKASAN***

*Kecelakaan lalu-lintas pada Jalan Raya Nasional sepanjang jalur pantai utara (pantura) Jawa merupakan salah satu penyumbang terbesar angka kecelakaan di Indonesia. Berdasarkan pemberitaan media massa, mengindikasikan bahwa faktor kesalahan manusia merupakan penyebab utama kecelakaan. Tulisan ini akan mencoba menjelaskan persoalan utama serta tingkat keseriusan kecelakaan lalu-lintas pada lokasi terpilih pada jalur pantura Jawa Barat, khususnya di Wilayah Kepolisian Cirebon. Lebih lanjut, tulisan ini juga akan memberikan beberapa saran penanganan lokasi rawan kecelakaan guna mengurangi angka kecelakaan.*

*Metoda penyelidikan kecelakaan yang sistematik telah digunakan untuk mengidentifikasi ruas terburuk menggunakan tingkat kecelakaan serta tingkat keseriusan kecelakaan. Penentuan lokasi terburuk atau lokasi rawan kecelakaan dilakukan dengan menerapkan teknik statistik "NORM" serta teknik EAN (Equivalent Accident Number). Kecelakaan lalu-lintas pada lokasi terpilih kemudian dianalisa menggunakan Diagram Batang guna mengidentifikasi type kecelakaan secara umum. Uji statistik yaitu Uji Normal serta Uji Chi-Kuadrat juga telah dimanfaatkan untuk menetapkan tipe kecelakaan dominannya pada lokasi terpilih tersebut. Hasil analisis ini kemudian dimanfaatkan pada penyelidikan lapangan guna mencari problem lokal yang mungkin dan untuk mengidentifikasi serta mengembangkan teknik penanganan yang tepat.*

## I. INTRODUCTION

The National Highway along the northern corridor of Java (Pantura) provides the main road transport link between the capital of Indonesia, Jakarta, and the commercial cities of Central and East Java. This highway is a primary arterial and the section selected for study runs from Pamanukan to Losari in West Java. It is divided into 5 links, viz.: link N009 (Pamanukan-Lohbener), N010 (Lohbener-Jatibarang); N025 (Jatibarang-Palimanan), N024 (Palimanan-Cirebon), and N013 (Cirebon-Losari).

Until recently Indonesian experienced rapid economic growth. This was matched by significant increases in traffic volume in the last decade which also resulted in increases in traffic accidents. Based on information from the Indonesian Traffic Police, The Northern Corridor of Java was the most dangerous highway in Indonesia and the section adjacent to the town of Cirebon in West Java had a particularly poor accident record. The mass media have also exposed the lack of safety for many sections of this highway.

Accident investigation carried out by the Police has mostly identified the human factor as the main cause of accidents. Whereas road and vehicle factors are almost never identified. However it seems likely that road factors could play a part and that engineering countermeasures could be effective in reducing accidents. The Institute of Road Engineering (IRE) has developed a systematic and scientific approach to investigating road accidents and developing remedial measures and this approach was used to study accidents on the 5 links listed above.

## II. METHODOLOGY

The research methodology which was used in this study was adapted from "Twelve Steps of Accident Investigation" which was developed by IRE and The Transport Research Laboratory (TRL) in the Technical Assistance and Research Training Project (TARP2). There were three main stages i.e. (1) identification of blackspots, (2) analysis of the accident patterns at selected blackspots, (3) identification of the "best" countermeasures.

The first step in stage (1) was the identification of the most dangerous link by examining accident rates (in accident/$10^8$ Veh. per km) and fatality rates (in fatal accident/$10^8$Veh. per km). The link with the highest rates was selected for further study. Statistical methods such as Norm and Standard Deviation techniques were used to identify the worst sites which had accident frequencies at least one standard deviation greater than the norm. These were selected as blackspot sites for detailed investigation. Equivalent Accident Numbers (EAN) were then used to rank each location in order to prioritize the sites for investigation.

In stage 2, accident patterns of the blackspot were analyzed by using the following approaches: (1) Stick Diagrams through the Triple-L System (MAAP : Microcomputer Accident Analysis Package) (Hills and Elliot, 1987); (2) Chi Square and Z test to determine whether dominant accident types were significantly different from the accident patterns for the whole link (RoSPA, 1992); and (3) Collision diagrams (NAASRA, 1988).

This analysis was followed by detailed investigation and additional surveys e.g. (1) traffic volumes, (2) spot-speeds, (3) vehicles manouvers, (4) driver behavior and knowledge. There after the main contributory factors were identified for each site, and suitable countermeasures chosen by single site approach (RoSPA, 1992).

## III. BLACKSPOT IDENTIFICATION

Figure-1 shows the accident rates and fatality rates for each road link. The accident rates at each link were: N009 (14.68), N025 (11.24), N024 (10.02), N010 (7.15), N013 (5.03). The fatality rates were: N009 (12.43), N025 (8.80), N024 (7.25), N010 (7.15), and N013 (3.64). From these figures it is clear that link N009 was the worst link and this was selected for further investigation.

Figure-2 shows the accident distribution by kilometer for the link N009. The Norm line represents the mean number of accidents for the link and the standard deviation line represents the number of accidents equal to the mean plus one standard deviation. The accident frequencies which exceed the standard deviation line are defined as backstops. The figures shows that there were six backstops and their ranking by accident frequency is shown in Table-1.

**Figure 1**
ACCIDENT RATES ON THE PANTURA, 1995 - 1996

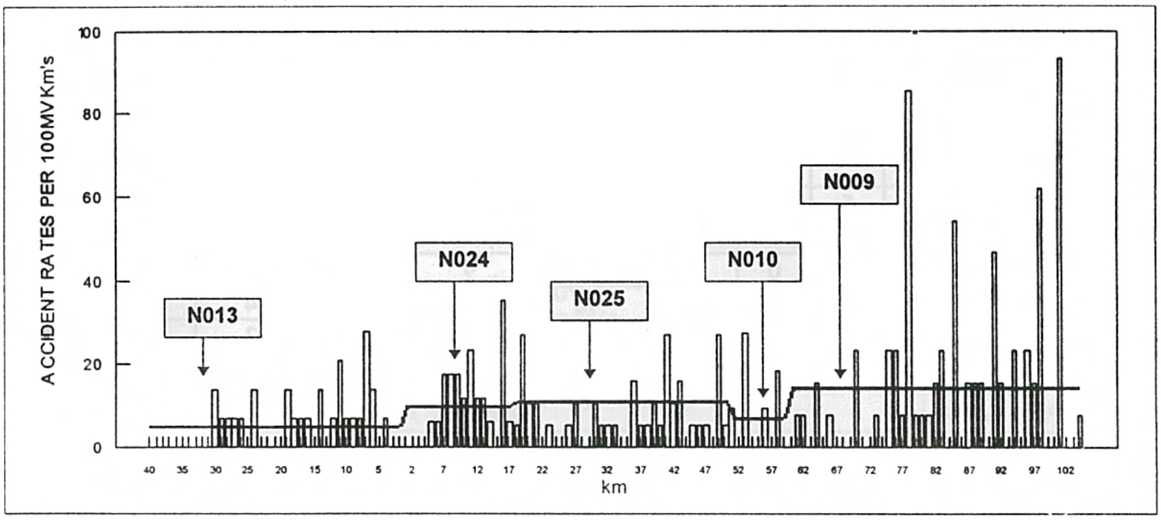


Figure 2.
ACCIDENT BLACKSPOTS ON PANTURA LINK N00, 1995 - 1997

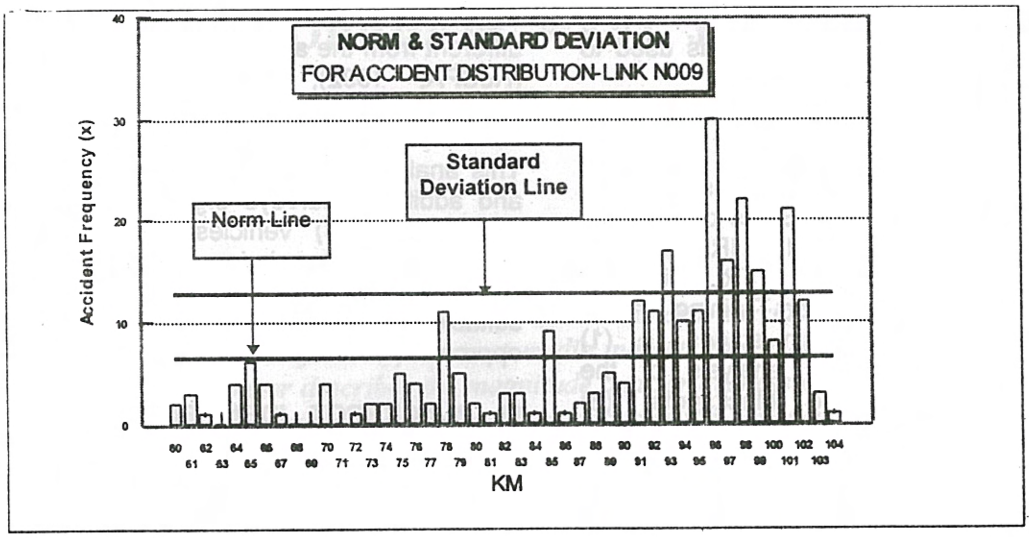



Table 1
RANK OF SELECTED SITES

| No. | Location/sites km | Accident Frequency | Rank |
|---|---|---|---|
| 1 | 96 | 30 | 1 |
| 2 | 98 | 22 | 2 |
| 3 | 101 | 21 | 3 |
| 4 | 93 | 17 | 4 |
| 5 | 97 | 16 | 5 |
| 6 | 99 | 15 | 6 |

Table 2
RANKING OF SITES BY EAN

| No. | Sites km. | Total ACC. | Severity | | | | EAN | | | | Total EAN | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ft | Ho | SI | DO | 12Ft | 3Ho | 3SI | 1DO | | |
| 1 | 96 | 30 | 12 | 5 | 7 | 6 | 144 | 15 | 21 | 6 | 186 | 2 |
| 2 | 98 | 22 | 11 | 9 | 0 | 2 | 132 | 27 | 0 | 2 | 161 | 3 |
| 3 | 101 | 21 | 16 | 3 | 0 | 2 | 192 | 9 | 0 | 2 | 203 | 1 |
| 4 | 93 | 17 | 4 | 5 | 4 | 4 | 48 | 15 | 12 | 4 | 79 | 6 |
| 5 | 97 | 16 | 6 | 6 | 1 | 3 | 72 | 18 | 3 | 3 | 96 | 5 |
| 6 | 99 | 15 | 9 | 3 | 2 | 1 | 108 | 9 | 6 | 1 | 124 | 4 |

Table-2 shows how the accidents at each site were weighted according to their severity (Fatal=12; Hospital=3; Slight Injures=3; Damage Only=1) and gives the EAN for each site. This tables shows that using EAN changed the ranking of sites. This ranking was used to determine the priority for in-depth investigation

## IV. ACCIDENT PATTERN ANALYSIS

The main accident characteristics at each sites were determined by using the Stick Diagrams facility of the Triple-L System Software. The dominant accident types were then tested against the norms for the link using Chi-Square test and Z test to determine whether they were significantly different from the typical accident pattern on the link. The dominant factors and the test results are shown in the Table-3. Sites with a typical patterns are more likely to have unusual road characteristics which will respond to road improvements. On the basis of ranking and test results, three sites were selected for detailed investigation as follows :

(1) km 101.0 to 102.0 (21 accidents), (2) km 96.0 to 97.0 (30 accidents), and (3) km 97.0 to 98.0 (16 accidents).

The pattern of accident at the three sites selected are summaries below:

*Km 101.0 to 102.0:* Twenty-one recorded accidents were scattered over the km length at this site. Approximately 50% were head-on accidents, 25% were pedestrian accidents, 10% were rear-end accidents, 10% were head to side accidents, and 5% were side-swipe accidents. The head-on accidents were caused by high speed and lack of anticipation and the pedestrian accident were also caused by high speed. 60% of the accidents occurred in dawn or twilight and 27% at night. Typical vehicles involved were M/C's (28%), heavy trucks (25%), Buses (25%), Cars (18%), and bike's (4%). For all head-on accidents, typical vehicle maneuvers were straight-on and overtaking. The head-on and dawn/dusk accidents were significantly more frequent than normal for the link.

**Table 3**
CHI-SQUARE TEST AND Z TEST FOR TYPYCAL ACCIDENT AT SIX BLACKSPOT

| No. | Sites (location) Sta/km: | Total Acc. | TYPICAL ACCIDENT (Weighting) | |
|---|---|---|---|---|
| | | | Typical Acc (%) | Significance |
| 1 | 101 | 21 | Head-on (50%)<br>M/C Problem (28%)<br>Lighting condition (down/ twilight (60%) | 5%<br>20%<br>0.1% & 0.5%* |
| 2 | 96 | 30 | Rear-end (33%)<br>Head-on (23%)<br>Truck (41%)<br>Accident on night time (33%) | 0.1% & 20%*<br>20%<br>5% & 10%*<br>10% |
| 3 | 98 | 22 | None (not significant) | - |
| 4 | 99 | 15 | None (not significant) | - |
| 5 | 97 | 16 | Rear-end (50%)<br>Overtaking (25%) | 1% & 1%*<br>10% |
| 6 | 93 | 17 | Ped. accident (36%)<br>Car (34%) | 10%<br>5% & 0.1% |

*) Chi-Square
significance = probability of the distribution at the site being the same as that for the link

*__Km. 96.0 to 97.0 :__* Many of the 30 accidents at this site were clustered between km. 96.3 to 96.65. For all the accidents, 33% were rear-end, 26% were pedestrian, 23% were head-on, and 12% involved multiple collisions. The main causes of accidents were high speed (53%), overtaking (16%), failing to give priority and lack of anticipation (22%). The main vehicle types involved were heavy trucks (41%), Cars (21%), Buses (19%), M/C's (15%). The most common vehicle manouvers were straight-on and overtaking. At this site rear-end accidents and the high involvement of trucks were different from the normal link pattern.

*__Km 97.0 to 98.0:__* At this site the 16 accidents were evenly dispersed along its length. Of these 16; 50% were rear-end accidents, 25% head-on accidents, 12.5% head to side accidents, 6.25% side-swipes accidents, and 6.25% loss of control accidents. The main causes of the accidents were high speed (38%), lack of anticipation (25%), overtaking (25%). The main vehicles involved at this site were Buses (28%), Heavy trucks (24%), Cars (21%), M/C's (18%), and vehicles maneuvers were mostly straight-on (55%) and overtaking (21%). This site's most unusual feature was the very high proportion of rear end collisions.

## V. SPOT SPEED and DRIVER BEHAVIOR

Figure-3 shows the typical spot speed distributions of three different vehicle types viz.: (1) Cars, (2) Buses and (3) Trucks. Average spot speed of each vehicle types are 90Kph (Bus), 84Kph (Car), and 64Kph (Truck).

The proportion of vehicles exceeding the design speed (80Kph) were 35% (Bus), 15% (Car), 5% (Truck), whereas the percentages of vehicles breaking the speed limit of 70Kph were 70% of Buses, 35% of Cars, 10% of Trucks.

Speeding is clearly a problem along this link with buses being the worst offenders. Lack of anticipation and dangerous overtaking indicate that speeding may not be only contributory factor and surveys were carried out of drivers overtaking behaviour and their knowledge and reasons for their behaviour.

The results of the vehicle maneuvers surveys averaged across the three selected sites were as follows :

(1) 31% of drivers overtook safety according to the correct procedures,

(2) 17% of drivers overtook on the left side i.e. contrary to correct procedures,

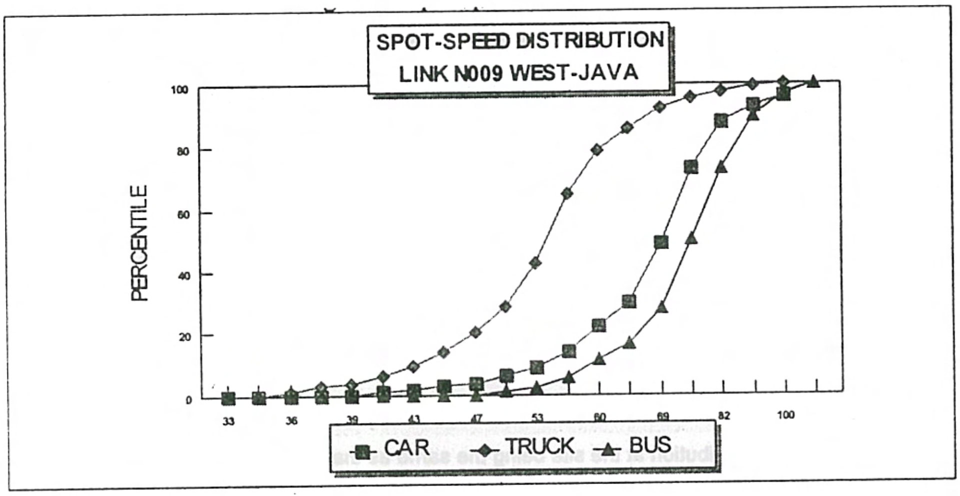
(3) 50% of drivers overtook on the right side too close to oncoming vehicles,

(4) 5% of drivers overtook vehicles which were already overtaking another vehicle (high risk).

This survey was followed up with driver interviews particularly for Bus and Truck drivers. The results from a sample of 300 drivers were as follows (Idris & Faried, 1998) :

(1) 60% of Truck drivers and 40% of Bus drivers tend to use the middle of road continuously,

**Figure 3**
**SPOT SPEED DISTRIBUTION**



(e) strength
(f) soil rock name
(g) other characteristics such as slake durability

**4. 4. 2. Mass description my include:**

(a) size, angularity, percentage and distribution of harder fragments
(b) Spacing and nature of discontinuities
(c) Geological structure

**4. 2. Joint Survey Records**

The engineering properties of rock mass stability particularly in rock exposures are usually controlled by discontinuities sucuh as joints. At the site locations where there are surface exposures of the rock mass, a joint surveyy can be carried out.

This survey is important because the results obtained can be used to assess the risk of joint controlled instability. For accurate results, a join survey should be carried out by a suitable experienced geotechnical engineer or engineering geologist.

**4. 3. Measurement Techniques for Discontinuities**

The measurement techniques used at exposed rock face are “the scanline” and “the Window” sampling techniques.

**4. 3. 1. Scanline Sampling**

As a rough guide the sample zone should contain bertween 150 and 350 discontinuities data, of which about 50% should have at least one end visible. An approximately planar rock face is selected that is large relative to the size and spacing of the discontinuities exposed.
The scanline them selves are simply measuring tapes, between 2 and 30 meters long, pinned with masonry nails and wire to the rock face along its strike and line of maximum dip. Further scanline should be set up on a sechond rock face, approximately at the right angles to the first, to minimise the orientation sampling bias.

**4. 3. 2. Window Sampling**

The measurement technique is essentially the same as for scanline sampling except that all discontinuities that have portion of their trace lenght within a difined area of the rock face intersect the scanline

This method can be defined by setting up a rectangle of measuring tapes pinned to the rock face. The window should be as large as possible in order to minimise sampling bias effect, with each side of a length such that it intersects between 30 and 100 discontinuities.

**V. DATA PROCESSING AND PRESENTATION**

**5. 1. Systematic Collection and Presentati**on

One of the important aspects of rock slope analysis is the systematic collection and presentation of geological data. It can than be properly evaluated and incoporated into stability analysis (Hoek and Bray, 1981). In recording dip and dip direction, the data can be written as dip/dip direction, example 45/060, (the dip of plane must lie between 0 and 90 and the angle of dip direction lies between 0 and 360 ). The presentation of data also can be provided in a convenient manner by using spherical projections.

**5. 2. Stereographic Projection**

Spherical projection is a graphical method whereby data on three-dimensional orientation of planar and linear features can be presented and analysed in two dimensions on sheet of paper, (Priest, 1985). This method is used in rock mechanics for analysing planar discontinuities, such as fracture, fasult, fissures and bedding planes that occur at various orientations within rock mass.

## VII. COUNTERMEASURES

The investigation indicates that the dominant causes of accidents were high speed and dangerous overtaking. Remedial measures related to these factors and some local problems as shown in the Collision Diagrams (Appendices 1, 2, 3) were proposed as follows :

1) Remedial measures for speed reduction were:
   (1) warning and mandatory speed limits signs,
   (2) rumble strip or rumble areas on approach to junctions and pedestrian crossings,
   (3) gateways to alert drivers that they are entering low speed areas,
2) Remedial measures for overtaking problems were:
   (1) continuous double line centre markings or concrete medians,
   (2) overtaking zones using road marking and traffic signs.
3) Remedial measures for pedestrians were:
   (1) at grade marked crossing with median refuge and street lighting,
   (2) speed reduction devices on approach to crossings,
   (3) warning signs,
   (4) speed limit signs.
4) Remedial measures for junctions were :
   (1) provide speed limit signs and/or road markings,
   (2) provide speed reducers i.e. rumble strips or rumble areas,
   (3) improve design of junction including protected turning lanes, weaving lanes and road widening to allow for unrestricted straight ahead lanes,
5) Improvements to the visibility, roughness, and shoulder conditions are also likely to help reduce the overtaking accident problems.

## VIII. CONCLUSIONS

- Over all, this paper has shown that the application of a systematic accident investigation methodology (which was developed by IRE and TRL) using 3-L data was successful for identifying the worst locations on rural road, the contributory factors, and for developing suitable treatments which have potential to reduce dominant accident types.

- The study found that high speed, dangerous overtaking and close following were the major factors contributing to the high incidence of head-on and rear-end collisions. The strong influence of driver behavior in accidents was supported by behavioral studies and interview surveys. Although most accidents on the highway along the Northern Corridor of Cirebon (West Java) were due to the human factor it seems likely that road design and road condition also had some effect on driver behavior and changes in design could lead to reduced speeds and fewer dangerous overtaking manouvers.

- Remedial measures and treatment design were proposed to reduce the dominant accident types. These were selected by considering the main factors and local conditions using a systematic and scientific approach for reducing accidents at single sites.

## IX. REFFERENCES


[1] Baguley CJ, (1984):"The British Traffic Conflict Technique", paper on International Calibration Study Conflict Techniques, Spriger-Verlag Berlin Heidelberg New York Tokyo

[2] Bang K, DR (1996):"Physical Engineering Improvement and Low Cost": paper on Indonesian Road Safety Workshop 25-29 November 1996, Jakarta

[3] County Surveyors Society, Department Transport (1994):" Traffic Calming" in practice, County surveyors and Landor Publishing Ltd., London.

[4] Davies OL and Goldsmith PL (1986):"Statistical Methods in Research and Production", Fourth Edition, Longman, London and New York

[5] Department of Transport (1986): "Accident Investigation Manual". Royal Society for the prevention of accident, Birmingham (U.K).

[6] Departement of Transport (xxxx): "Killing speed and saving lives", The Government's strategy for tackling the problem of excess on our roads, DOT, U.K.

[7] Downing. AJ (1997):"Engineering Approach To Accident Prevention & Reduction", RRDP Report, June 1997, Transport Research Laboratory-U.K. & Institute of Road Engineering, Bandung

[8] Hill BL and Elliot GJ. (1990): "Micro Computer Accident Analysis Package, user guide", Transport and Road Research Laboratory, Crowthorn.

[9] Idris Muhammad (1997):"Pengembangan Teknologi Penanggulangan Lokasi Rawan Kecelakaan" (Development of Accident Blackspot Countermeasures: Urban Road), Laporan Akhir Studi T.A. 1996/1997, Puslitbang Jalan, Balitbang P.U., Bandung

[10] Idris Muhammad (1998): "Penanggulangan Lokasi Rawan Kecelakaan" (Development of Accident Blackspot Countermeasures: Rural Road), Laporan Akhir Studi T.A. 1997/1998, Puslitbang Jalan, Balitbang P.U., Bandung

[11] Institute of Road Engineering (IRE) (1993):"Accident Blackspot Investigation and The Development of Low Cost Countermeasures". Report of Consulting services project for technical assistance and research training, March, Bandung.

[12] Iskandar H (1994):"Analisis Data Kecelakaan Lalu-lintas di Jalan Tol Jakarta-Cikampek",Paper: disajikan dalam Konfrensi Tahunan Teknik Jalan ke-5, Bandung.

[13] Kirk Stephani (1997):"Source book of road accident countermeasures and engineering design features-A comparative study of their relative effectiveness at reducing and preventing accidents", Project Report PR/osc/125/97, Unpublished Project Report, TRL-U. K., Crowthorne

[14] NAASRA (1988):"Road Crashes; guide to Traffic Engineering Practice", NAASRA, NSW-Australia.

[15] RTA, Roads and Traffic Authority of New South Wales (1989):"Road Accident in New South Wales-1989", Statistical Statement : Year Ended 31 December 1989, RTA, Sidney.

[16] RoSPA (1992):"Road Safety Engineering Manual", RosPA, Birmingham, U.K

[17] Ross A, Chris BJ, Hills B, McDonald M, Silcock D (1991):"Towards Safer Roads in Developing Countries", First Edition, TRRL and ODA, Newcastle-U.K.

[18] Taylor MAP & Young W (1988):"Traffic Analysis: New technology & New Solutions", Hargreen Publishing Company, North Meulbeurne, Victoria, Australia

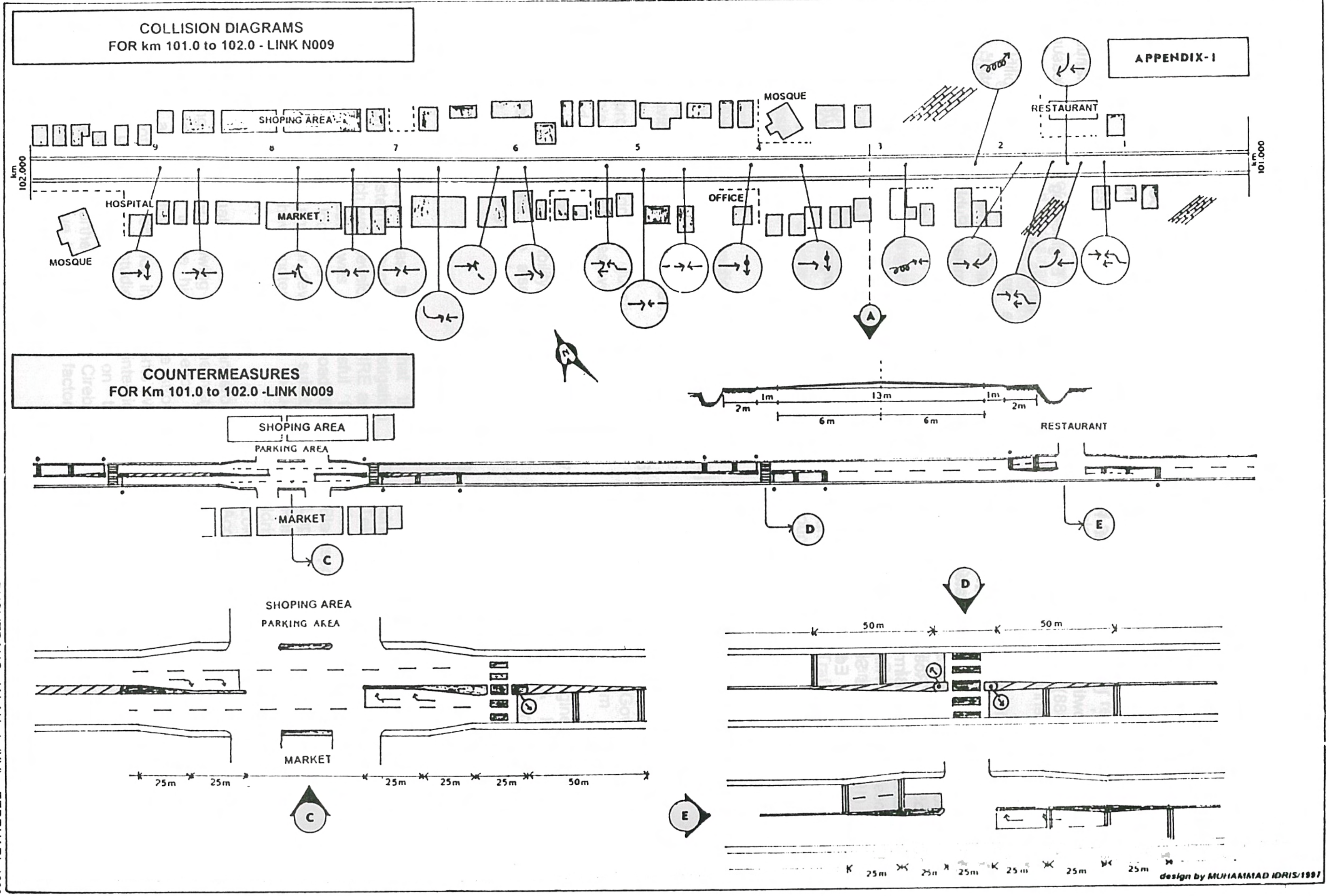
[19] Thompson N (1993):"Accident Investigation Procedures and The Development of Low Cost Engineering Improvement Schemes", TRRL and IRE, Bandung.

[20] United Nations (1989):" Road Safety Manual on Low-Cost Engineering Countermeasures", United Nations, Addis Ababa, Africa

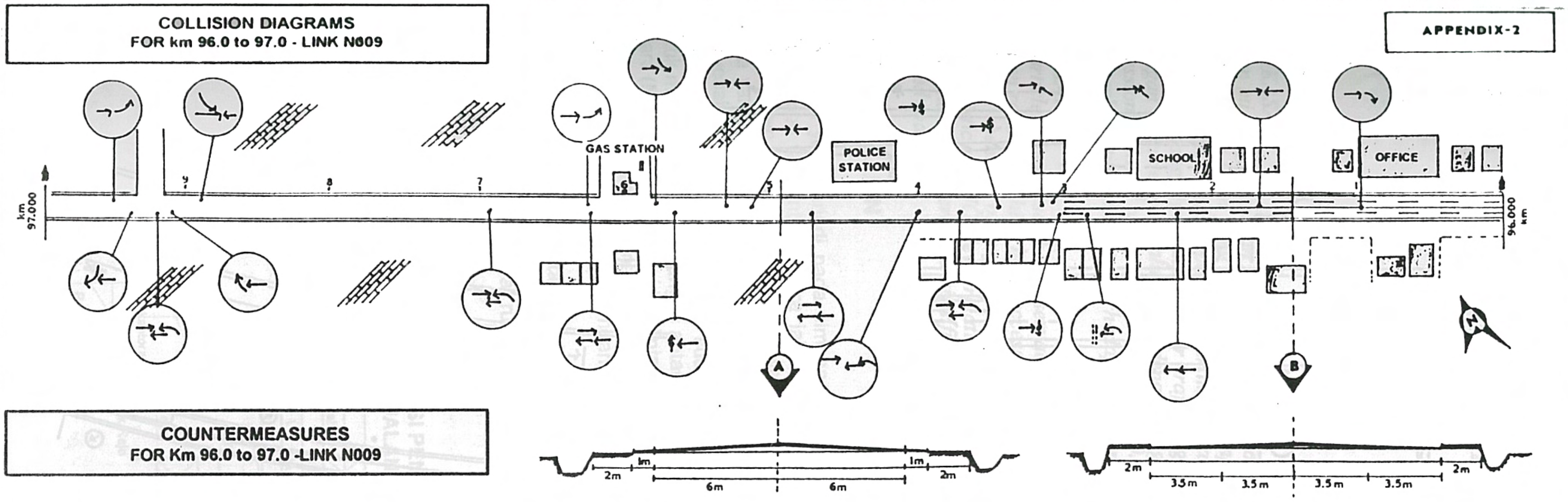
[21] Walpole and Myers (1989):'Probability and Statistics for Engineers and Scientist" 4th-edition, Mcmillan Publishing Company, New York.

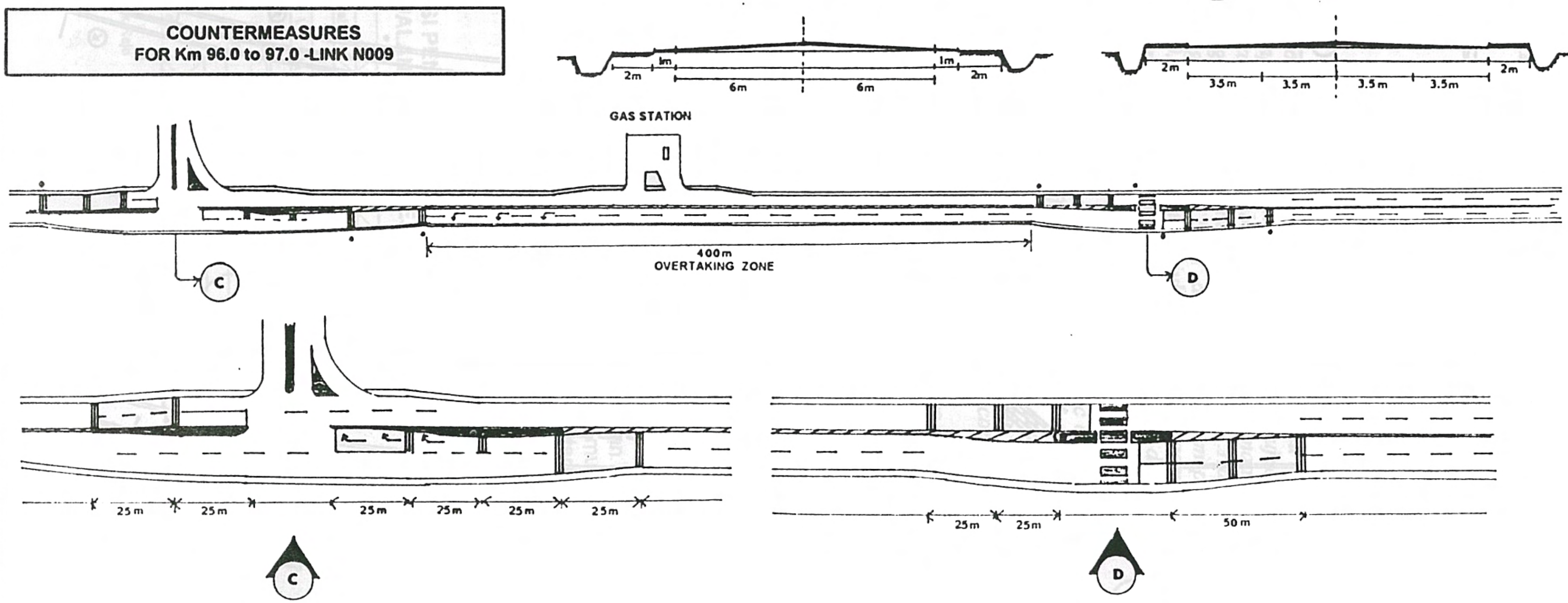
***Penulis :***

*Drs. Muhammad Idris, Staff Balai Teknik Lalu Lintas dan Lingkungan Jalan, Pusat Litbang Jalan.*

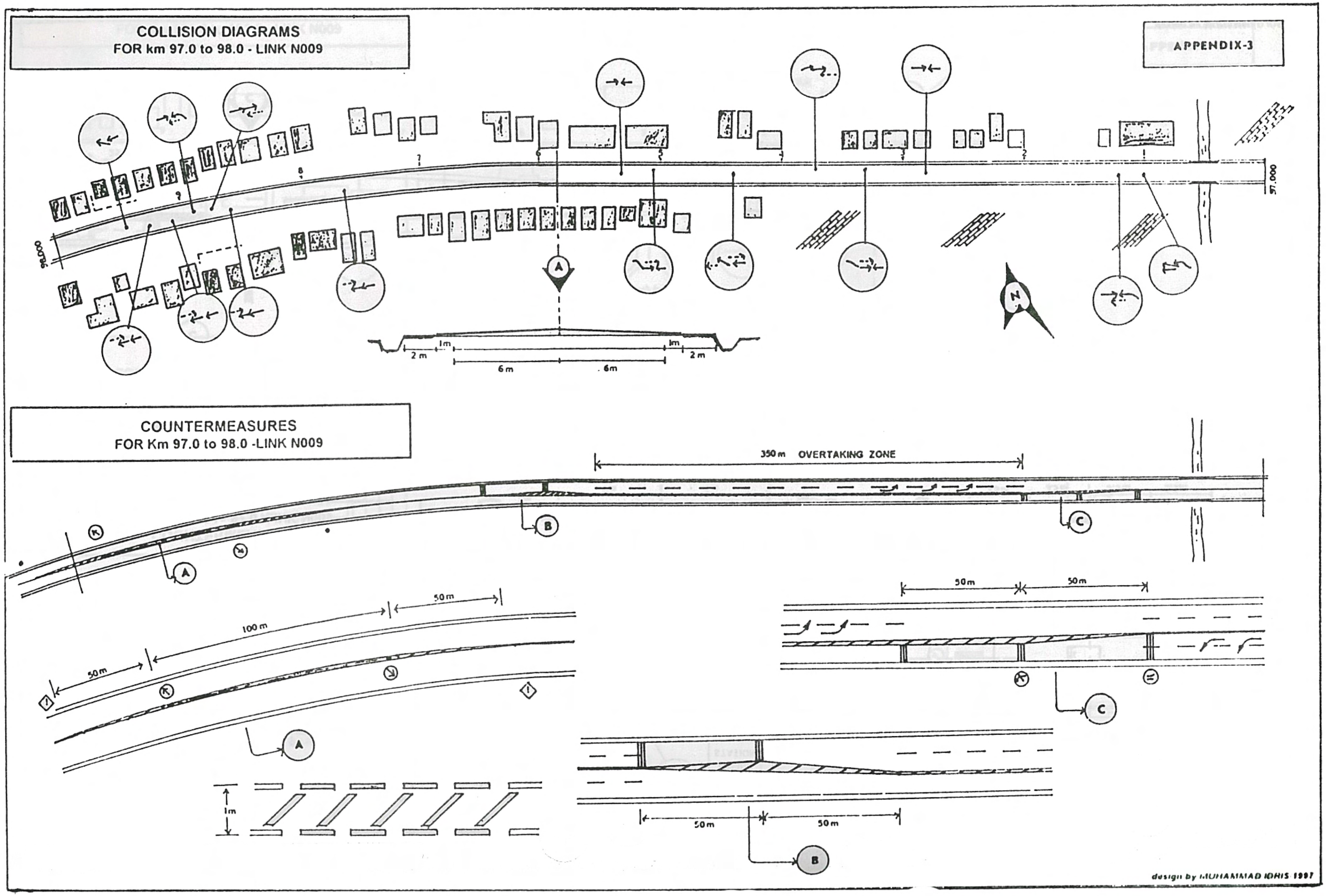

COLLISION DIAGRAMS
FOR km 101.0 to 102.0 - LINK N009
APPENDIX-I
SHOPING AREA
MOSQUE
RESTAURANT
HOSPITAL
MARKET
OFFICE
km 102.000
km 101.000
COUNTERMEASURES
FOR Km 101.0 to 102.0 -LINK N009
1m
13m
2m
6m
SHOPING AREA
PARKING AREA
MARKET
RESTAURANT
25m
50m
design by MUHAMMAD IDRIS/1997

APPENDIX-2




design by MUHAMMAD IDRIS 1997


COLLISION DIAGRAMS
FOR km 97.0 to 98.0 - LINK N009
APPENDIX-3
98.000
97.000
2 m
1m
6 m
6m
COUNTERMEASURES
FOR Km 97.0 to 98.0 -LINK N009
350 m OVERTAKING ZONE
50 m
100 m
1m
design by MUHAMMAD IDRIS 1997