

**STUDY ON WORK ZONE MANAGEMENT IN
HIGHWAY REHABILITATION PROJECTS IN URBAN
AREAS**

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Degree of Master of Engineering

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Sri Lanka

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Thesis submitted in partial fulfillment of the requirements for the degree
Master of Engineering in Highway and Traffic Engineering

Department of Civil Engineering

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Sri Lanka

August 2017

DECLARATION

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ABSTRACT

The safe and efficient flow of traffic through work zones is a major concern to transportation officials (government authorities, contractors), the public, businesses, and road users. Key areas for performance measures of work zones include delays, user costs, exposure, safety, and public perception.

This paper presents an investigation on current work-zone practices in highway rehabilitation projects around Colombo and sub-urbs. Three (03) ongoing road rehabilitation projects have been identified for the study. Separate questionnaire surveys were carried out for road users and for residents/ businesses to identify the major difficulties, inconveniences and probable reasons. The major issues identified are; dust and noise pollution, lack of advanced signage, increment in travel time, accesses and utility disturbances, and drainage issues. The root causes identified are; lack of focus on guidelines, non availability of experienced and qualified officers, lack of space, higher traffic volume throughout the day, and public interferences. With the reference with the guidelines of other countries, a comprehensive check list has been suggested at the conclusion.

Key words: Work-zone Management, Traffic Management, Road User Safety

TABLE OF CONTENTS

ABSTRACT	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES	vii
LIST OF TABLES	x
1. INTRODUCTION	1
1.1 Background	1
1.2 Introduction	2
1.2.1 Noise Pollution.....	3
1.2.2 Air pollution	3
1.3 Objective	4
1.4 Research Methodology.....	4
2. LITERATURE REVIEW.....	5
2.1 Assessing Public Inconvenience in Highway Work Zones.....	5
2.2 Strategy to Minimize User Inconvenience during Road Rehabilitation	5
2.3 Available Guideline	6
2.3.1 <i>Manual on Traffic Control Devices; Part II, Road Work Areas- Second Edition by Ministry of Transport and Road Development Authority, Sri Lanka</i>	6
3. METHODOLOGY	9
3.1 Galle Road (A002) (Ratmalana – Moratuwa section)	9
3.1.1 <i>General Observations</i>	10
3.2 Colombo - Horana Road (B084) (Boralesgamuwa – Piliyandala section)	13
3.2.1 <i>General Observations</i>	15
3.3 Ethulkotte – Kohuwala Road (B120) (Ethulkotte – Pitakotte section)	17
3.3.1 <i>General Observations</i>	18
4. ANALYSIS OF WORK-ZONE PRACTICES	20
4.1 Dust Generation and Air Pollution.....	20
4.2 Noise Pollution.....	24

4.3 Disturbances to the Service Connections.....	26
4.4 Disturbances to the accesses	28
4.5 Travel Time Increment/ Reduction of Fuel Efficiency	28
4.6 Lack of Space for the Pedestrians	29
4.7 Traffic Management.....	32
5. QUESTIONNAIRE SURVEYS	41
5.1 Questionnaire for Road Users	41
5.1.1 B120 Road.....	41
5.1.2 B084 Road.....	46
5.1.3 A002 Road.....	52
5.2 Questionnaire for Residents/ Business Places	56
5.2.1 B120 Road.....	57
5.2.2 B084 Road.....	60
5.2.2 A002 Road.....	64
5.3 Comparison of Responses for Each Road based on Road User Responses.....	67
5.3.1 Dust Generation as an Inconvenience	67
5.3.2 Possible Damages to Vehicles as an Inconvenience.....	68
5.3.3 Inadequate Safety Arrangements as an Inconvenience.....	68
5.3.4 Incapable Traffic Controllers as an Inconvenience.....	69
5.3.5 Road Side Friction as an Inconvenience.....	69
5.3.6 Increment of Travel Time as an Inconvenience	70
5.3.7 Lack of Advanced Signage as an Inconvenience.....	71
5.3.8 Overall Comparison and Possible Reasons.....	71
5.3.9 Ranking of Road User Inconveniences	74
5.4 Comparison of Responses for Each Road based on Responses from Residents and Business Places	75
5.4.1 Access Damages as an Inconvenience	75
5.4.2 Drainage Issues as an Inconvenience	75
5.4.3 Dust Generation as an Inconvenience	76
5.4.4 Utility Interruptions as an Inconvenience.....	76
5.4.5 Water Pollution as an Inconvenience	77
5.4.6 Noise as an Inconvenience	77
5.4.7 Overall Comparison and Possible Reasons.....	78
5.4.8 Ranking of Road User Inconveniences	80

6. ANALYSIS OF INCONVENIENCES	81
6.1 Prioritized list of Inconveniences.....	81
6.2 Air Pollution.....	81
6.2.1 <i>Dust Generation</i>	81
6.2.2 <i>Harmful Emissions</i>	82
6.2.3 <i>Proposed Air Pollution Mitigation Measures</i>	82
6.3 Noise Pollution.....	83
6.3.1 <i>Proposed Noise Pollution Mitigation Measures</i>	84
6.4 Increment of travel time	85
6.4.1 <i>Proposals to minimize traffic delays</i>	85
6.5 Disturbances to the accesses	86
6.5.1 <i>Proposals to minimize inconveniences due to access damages</i>	86
6.6 Interruptions to the utility lines	87
6.6.1 <i>Strategies to Minimize Interruptions to the Utility Lines</i>	87
7. CONCLUSION AND RECOMENATIONS	89
7.1 Summary of Findings.....	89
7.1.1 <i>Summary of Findings at B120 Road Workzone</i>	89
7.1.2 <i>Summary of Findings at B084 Road Workzone</i>	89
7.1.3 <i>Summary of Findings at A002 Road Workzone</i>	90
7.2 Limitations of the Study.....	90
7.2.1 <i>Selection of Workzones</i>	90
7.2.2 <i>Data Collection and Sample Sizes</i>	91
7.3 Recommendations for Future Work.....	91
7.3.1 <i>Economic Loss during Road Rehabilitation Works</i>	91
7.3.2 <i>Road Users' Safety and Workers' Safety</i>	92
7.4 Recommendations	92
7.4.1 <i>Introduction and Implementation of a Check List</i>	92
7.4.2 <i>Proper Co-ordination and Communication</i>	96
7.4.3 <i>Strict Adherence to the Guidelines</i>	96
REFERENCE LIST	97
ANNEX 1-1: QUESTIONNAIRE USED FOR ROAD USERS	98
ANNEX 1-2: QUESTIONNAIRE USED FOR RESIDENTS	99

ANNEX 02 - GUIDELINES FOR TEMPORARY TRAFFIC MANAGEMENT DURING ROAD CONSTRUCTION	100
APPENDIX 1 - RANKING CALCULATION FOR ROAD USER INCONVINENCES	110
APPENDIX 02 - RANKING CALCULATION FOR RESIDENTS/ BUSINESSES INCONVINENCES	113

LIST OF FIGURES

Figure 3-1: Location map of Maliban Junction – Nalluruwa Project Road.....	10
Figure 3-2: Disturbances to the Pedestrian Foot-walks	11
Figure 3-3: Lane provided from opposite direction	11
Figure 3-4: No space for pedestrians	12
Figure 3-5: Properly arranged temporary sign boards	12
Figure 3-6: Traffic diversion during night time	13
Figure 3-7: Location Map of Pamankada – Kesbewa Road Project	14
Figure 3-8: Dust Generation on ABC Fill.....	15
Figure 3-9: Demarcation of work-zone.....	15
Figure 3-10: Water stagnation at ABC Fill.....	16
Figure 3-11: Poor Barricading at the middle of the carriageway.....	16
Figure 3-12: No safe passage demarcated for pedestrians	17
Figure 3-13: Location Map of B120 Road.....	18
Figure 3-14: Existing drain walls raising to provide foot-walks.....	19
Figure 3-15: Single pile traffic allowed in construction zones	19
Figure 4-1: Dust Generation on completed ABC fill.....	23
Figure 4-2: Water lines to be relocated at B084 Road project.....	27
Figure 4-3: Electricity posts/line to be relocated in B084 Road project	27
Figure 4-4: No space for the pedestrians at B120 Road Project	30
Figure 4-5: Temporary pedestrian Bridge at B084 Road Project	31
Figure 4-6: Temporary Pedestrian Crossings at B084 Road Project	32
Figure 4-7: Endangered pedestrian movement at B084 road.....	32
Figure 4-8: Traffic Management during the reconstruction of a culvert; phase 1	33
Figure 4-9: Traffic Management during the reconstruction of a culvert; phase 2	34
Figure 4-10: Traffic Management during culvert construction at A002 road.....	35
Figure 4-11: Traffic Management during culvert construction at B084 road.....	35
Figure 4-12: Proposed traffic management during road widening works of B084 project; phase 1	36
Figure 4-13: Proposed traffic management during road widening works of B084 project; phase 2	37
Figure 4-14: Proposed traffic management during asphalt paving of outer lane of B120 project.....	38

Figure 4-15: Proposed traffic management during asphalt paving of inner lane of B120 project.....	39
Figure 4-16: Traffic Management during asphalt paving at B120 road.....	40
Figure 5-1: Responses in Travel Time Increment of B120 Road	42
Figure 5-2: Impact of Dust Generation of B120 Road.....	42
Figure 5-3: Impact of Possible Damages to Vehicles in B120 Road.....	43
Figure 5-4: Impact of Inadequate Safety Arrangements of B120 Road.....	43
Figure 5-5: Impact of Incapable Traffic Controllers of B120 Road	44
Figure 5-6: Impact of Road Side Friction of B120 Road.....	44
Figure 5-7 Impact of Increment of Travel Time of B120 Road.....	44
Figure 5-8: Impact of Lack of Advanced Signage of B120 Road.....	45
Figure 5-9: Responses in Travel Time Increment of B084 Road	47
Figure 5-10 Impact of Dust Generation of B084 Road.....	48
Figure 5-11: Impact of Possible Damages of Vehicles of B084 Road	48
Figure 5-12: Impact of Inadequate Safety Arrangements of B084 Road.....	48
Figure 5-13: Impact of Incapable Traffic Controllers of B084 Road	49
Figure 5-14: Impact Road Side Friction of B084 Road	49
Figure 5-15 Impact of Increment of Travel Time of B084 Road.....	49
Figure 5-16: Impact of Lack of Advanced Signage of B084 Road.....	50
Figure 5-17: Responses in Travel Time Increment of A002 Road	52
Figure 5-18: Impact of Lack of Advanced Signage of B084 Road.....	53
Figure 5-19: Impact of Lack of Advanced Signage of B084 Road.....	53
Figure 5-20: Impact of Lack of Advanced Signage of B084 Road.....	54
Figure 5-21: Impact of Lack of Advanced Signage of B084 Road.....	54
Figure 5-22: Impact of Lack of Advanced Signage of B084 Road.....	54
Figure 5-23: Impact of Lack of Advanced Signage of B084 Road.....	55
Figure 5-24: Impact of Lack of Advanced Signage of B084 Road.....	55
Figure 5-25: Responses in Impact of Inconveniences of B120 Road	57
Figure 5-26: Inconveniences due to Access Damages of A002 Road	58
Figure 5-27: Inconveniences due to Access Damages of A002 Road	58
Figure 5-28: Inconveniences due to Dust Generation of A002 Road	58
Figure 5-29: Inconveniences due to Utility Interruptions of A002 Road	59
Figure 5-30: Inconveniences due to Water Pollution of A002 Road.....	59

Figure 5-31: Inconveniences due to Noise of A002 Road	59
Figure 5-32: Responses in Impact of Inconveniences of B084 Road	61
Figure 5-33: Inconveniences due to Access Damages of B084 Road	61
Figure 5-34: Inconveniences due to Drainage Issues of B084 Road	62
Figure 5-35: Inconveniences due to Dust Generation of B084 Road	62
Figure 5-36: Inconveniences due to Utility Interruptions of B084 Road.....	62
Figure 5-37: Inconveniences due to Water Pollution of B084 Road	63
Figure 5-38: Inconveniences due to Noise of B084 Road	63
Figure 5-39: Responses in Impact of Inconveniences of A002Road.....	64
Figure 5-40: Inconveniences due to Access Damages of A002 Road	65
Figure 5-41: Inconveniences due to Drainage Issues of A002 Road.....	65
Figure 5-42: Inconveniences due to Dust Generation of A002 Road	65
Figure 5-43: Inconveniences due to Utility Interruptions of A002 Road	66
Figure 5-44: Inconveniences due to Water Pollution of A002 Road.....	66
Figure 5-45: Inconveniences due to Noise of A002 Road.....	66
Figure 5-46: Comparison of Dust Generation as an Inconvenience	67
Figure 5-47: Comparison of Possible Damages to Vehicles as an Inconvenience ...	68
Figure 5-48: Comparison of Inadequate Safety Arrangements as an Inconvenience	68
Figure 5-49: Comparison of Incapable Traffic Controllers as an Inconvenience.....	69
Figure 5-50: Comparison of Road Side Friction as an Inconvenience	70
Figure 5-51: Comparison of Increment of Travel Time as an Inconvenience	70
Figure 5-52: Comparison of Lack of Advanced Signage as an Inconvenience	71
Figure 5-53: Comparison of Highest Impact on Each Road.....	75
Figure 5-54: Comparison of Inconvenience of Each Factor	76
Figure 5-55: Comparison of Access Damages as an Inconvenience	76
Figure 5-56: Comparison of Drainage Issues as an Inconvenience	77
Figure 5-57: Comparison of Dust Generation as an Inconvenience	77
Figure 5-58: Comparison of Utility Interruptions as an Inconvenience	78
Figure 5-59: Comparison Water Pollution as an Inconvenience	78
Figure 5-60: Comparison of Noise as an Inconvenience.....	78
Figure 5-61: Comparison of Highest Impact on Each Road.....	79
Figure 5-62: Comparison of Inconvenience of Each Factor.....	80
Figure 6-1: Entrance/outlet Tyre Wash.....	83

LIST OF TABLES

Table 4-1: Air Quality Permissible Limits	22
Table 4-2: Noise Generation in Construction Activities.....	24
Table 4-3: Categorizing Noise Levels.....	25
Table 4-4: Permissible Noise Levels	25
Table 5-1: Recommendations to Minimize Inconvinineces in B0120 Road as per the responses received.....	46
Table 5-2: Recommendations to Minimize Inconvinineces in B084 Road as per the responses received.....	51
Table 5-3: Recommendations to Minimize Inconvinineces in A002 Road as per the responses received.....	56
Table 7-1: Number of responce received for each types of questionnaire surveys....	91
Table 7-2: Proposed Checklist to be followed in construction activities.....	93

1. INTRODUCTION

1.1 Background

With the end of long lasting civil war in the country, the authorities have decided to allocate adequate funds to the infra-structure development projects. With the intension of attracting foreign investors to the country, the government invests for mega scale development projects including ports, airports, road network, sewerage etc.

Since an improved road network has become increasingly important today with the emergence of new communication avenues, a good and reliable transport network remains vital. There is a very strong positive correlation between a country's economic development and the quality of its road network.

The Government has made significant efforts to improve the road situation as seen in the increased amounts allocated to the sector over the past few years.

Simultaneously, the Road Development Authority and the Municipal Councils of Colombo and suburbs had decided to improve the existing conditions of the internal road network. Therefore, the major roads were identified to be improved, and allocated to contractors after the formal tender procedure.

From the road users' point of view, the improvement of the road network would be beneficial in the following ways;

- Reduction of travel time

With the improvements carried out to the road geometry, pavements layers, traffic lights and other road furniture, the capacity of the roads would be increased. Hence the certain section of the road could accommodate more traffic. Therefore the time required for a certain journey would be reduced with the improvement of Level of Service.

- Reduction of fuel cost

With the reduction of the time spent on the traffic congestions, the fuel efficiency would be improved. Ultimately the fuel cost incurred would be reduced with the improvements to the road network.

-
- Improvement of Safety and Reduction of probability of accidents

With the every road rehabilitation/ improvement project, the road furniture would be installed. By introducing traffic lights, roundabouts, foot-walks, guard rails, guard fences, pedestrian fences, crash barriers etc. the probabilities of incurring traffic accidents would be reduced.

- Aesthetically pleasing appearance

In most of the urban road rehabilitation/ improvement projects, an effort would be made towards constructing aesthetically pleasing environment. By means of introducing flower pots, small plants at the centre median would be an example for the improvement of environment.

- Reduction of inhaling hazardous gases

When the travel time spent on the roads get reduced, the amount of hazardous gases during the traffic congestion would be reduced, which could be dangerous for the lungs, especially for the pedestrians, cyclists and motor cyclists.

1.2 Introduction

Even though the road users would be greatly benefited after the completion of the rehabilitation works, the most of them would have to face several difficulties during the construction period. In general, the following had been identified as the major difficulties the road users and adjacent property owners have to bear;

- Traffic Congestion and time wastage (increment of travel time)
- Increment of vehicle operating cost (possibility of damaging the vehicles)
- Safety issues (higher possibility facing traffic accidents)
- Water, Air and Noise pollution
- Vibration; subsequently damaging the adjacent private properties
- Disturbance to the accesses
- Disturbance to the existing drainage
- Temporary interruption to the utility lines

The main target of this study would be study current work zone management practices in Sri Lanka, and to propose strategies to minimize the public inconveniences.

1.2.1 Noise Pollution

Noise generation is one of the major issues the road users and the resident would have to face during the road rehabilitation/ improvement projects. The major construction activities which results irritating noise would be listed as below;

- Aggregate crushing activities
- Pre-cast pile driving
- Sheet pile driving
- Bored pile socketing and hacking
- Excavation works
- Rock blasting activities
- Asphalt and concrete batching plant operations
- Electrical generators and air compressor operations
- Heavy machinery and equipment operations

1.2.2 Air pollution

One of the most irritating negative effect the road users would have to face during the road construction works would be the air pollution. Air pollution is the introduction of harmful substances including particulates and biological molecules into atmosphere. It may cause diseases, allergies or death in humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment.

The most common road construction activities which would result air pollution would be categorized as;

- Roadway excavation
- Sub base and base construction
- Aggregate crusher plant activities
- Asphalt and concrete batching plants

-
- Borrow pits and stock pile activities
 - All machine and plant operations

1.3 Objective

The main objective of the study would be;

- Study the current work zone management practices in Sri Lanka
- Identification of the inconveniences to be borne by the road users during the highway rehabilitation projects
- Analysis of the inconvenience identified
- Develop proposals to minimize the inconveniences

In addition to the major objectives, the study would be beneficial to the relevant authorities for the development of ‘guide lines’ to the contractors during highway rehabilitation projects.

1.4 Research Methodology

Three (03) nos. highways Rehabilitation/ Improvement projects would be identified for the study. The proposed project would be;

- Galle Road (A002) (Ratmalana – Moratuwa section)
- Pamankada – Kesbewa Road (B084) (Boralesgamuwa – Piliyandala section)
- Ethulkotte – Kohuwala Road (B120) (Ethulkotte – Pitakotte section)

Separate questionnaire surveys would be carried out for the road users and the adjacent property owners regarding the inconveniences they face. The answers received would be analysed, and the most crucial inconveniences would be identified. The inconveniences would be listed according to the importance.

The Water, Air and Noise pollution would be monitored at some selected locations and those would be compared with the relevant standards.

Simultaneously, the project sites would be investigated and the shortcomings of the contractors would be identified.

2. LITERATURE REVIEW

2.1 Assessing Public Inconvenience in Highway Work Zones

‘Assessing Public Inconvenience in Highway Work Zones’ by Andrew. S. Griffith and McGregor Lynde; Final Report, SPR Project, Oregon Department of Transportation and Federal Highway Administration Washington, D.C

The purpose of the study was to investigate highway users’ views and their priorities relating to highway work zones. As the research methodology, they have selected the following focus groups and assessed.

- general motorists
- school bus drivers
- business owners
- fire and emergency service personals
- truck drivers

The major findings of the study could be summarized as follows;

- Lack of advance signage
- Lack of speed limitations
- Lack of identifiable work zone marking for temporary lanes and lane changes
- Night time visibility problems

Their major suggestions suggested to minimize the public inconveniences are;

- Increasing the alertness
- Increasing the visibility and location of flagmen
- Consider the glare from the construction lighting etc.

2.2 Strategy to Minimize User Inconvenience during Road Rehabilitation

The purpose of the study was to identify strategies to minimize inconveniences caused during road rehabilitation works

The methodology adopted was carrying out questionnaire survey and investigation on 7 nos. on-going and 1 no. recently completed project covering urban and rural areas.

Major Inconveniences identified were;

- Noise pollution,
- Travel time increment
- Disturbances to the accesses
- Disturbances to the drainage patterns
- Interruptions to utility services
- Suggested proposals
- Proper planning prior to commence
- Promotion of pre-cast items
- Introduction of systemized public review system

The suggestions the author suggested were;

- Noise pollution
 - Use of noise barriers
 - Use latest technologies and mechanisms
- Air Pollution
 - Use dust traps
 - Use of entrance/ exit tyre wash
 - Maintain existing pavement in good condition
 - Construct dust traps around the perimeter of the crusher plant
- Access disturbances
 - Pre-planning
 - Half by half construction

2.3 Available Guideline

2.3.1 Manual on Traffic Control Devices; Part II, Road Work Areas- Second Edition by Ministry of Transport and Road Development Authority, Sri Lanka

This is the guideline widely used and adopted in Sri Lanka. Starting from about 1992, the Road Development Authority (RDA) had been focusing attention on the need for a manual of Traffic Signs and Markings, and some draft proposals had been made.

Consequently the first Manual on Traffic Control Devices was published in 1997, which was in conformity with the stipulations given in the Vienna Convention.

In 1999, however, the National Road Safety Secretariat (NRSS) was requested by the then Ministry of Transport & Highways to carry out a revision to the above Manual, in particular reference to the proposed Expressways.

The original Manual had been prepared in two parts: Part 1, depicting Traffic Signs, Road Markings and Traffic Signals and Part II, depicting Traffic Control Devices for Road works. In the revision of the Manual, the same distinction was maintained in order that the importance of traffic control during road works is emphasized. Difference, however, is that, they are published as two separate books in the revised Manual.

During the process of revision, whilst maintaining the original sequence of presentation, amendments and additions were made to the text and also to the diagrams as needed. As regards the Expressways, a series of new additions were made to the Traffic Signs that are especially applicable to them. Also, variations were made to key dimensions of the signs as applicable to expressways. In the revised version, conformity with the provisions of the revised Vienna Convention of 1995 was ensured.

Enquiries regarding the revised Manual on Traffic Control Devices may be made direct to the Planning Division, Road Development Authority.

As per this manual, the traffic control devices that could be used for ensuring road safety are:

- Traffic Signs
- Traffic Cones
- Barricade Boards
- Road Humps along with road markings
- Rumble Strips
- Lamps/ Lighting Devices
- Temporary Traffic Light Signals

-
- Flagmen

Certain measures are especially important to be observed at road works. Some of these factors are:

- All road works, even minor maintenance measures, should be planned well in advance, as far as possible
- Signing of road work areas should be uniform and consistent all over the road network
- All traffic control devices should be kept in good condition
- The function of the traffic control devices should be checked regularly, especially in darkness
- The behaviour of workmen should always be good in order to gain respect and confidence of the drivers
- As soon as a road work is finished the traffic control devices should be removed
- Someone should always be responsible for the traffic control devices at the work site
- A good rule of thumb is to always use as few traffic control devices as possible but as many as necessary.

The planning should be based on factors that have an impact on the quality of the work and the safety at the work site.

Such factors could be, for instance:

- the traffic volumes; and their variations by the hours and by the day
- the road standards
- the speed limits
- possibilities for the provision of detours
- Other planned works in the same area (such as the supply of electricity, water, telecom, etc.)

The guidance provided in the manual to be implemented during the construction activities being carried out in road projects are shown in Annex. 01.

3. METHODOLOGY

The following highway rehabilitation projects have been identified for the study of the work zone management.

- Galle Road (A002) (Ratmalana – Moratuwa section)
- Colombo - Horana Road (B084) (Boralesgamuwa – Piliyandala section)
- Ethulkotte – Kohuwala Road (B120) (Ethulkotte – Pitakotte section)

These road stretches have been selected based on the number of lanes available for the traffic. Galle Road (A002) section from Ratmalana to Moratuwa has 3 lanes in each direction whereas Colombo – Horana Road (B084) section from Boralesgamuwa to Piliyandala section consists of 2 lanes at either side of the centre median. There are only 2 lanes (2 lane single carriageway) in Ethulkotte – Pitakotte section of Ethulkotte – Kohuwala Road (B120). Therefore by observing and analysing these selected road sections, it would be possible to cover entire road network of the urban context.

While the work zone management practices being studied, separate questionnaire surveys were carried out to study the responses from the road users and the adjacent property owners.

3.1 Galle Road (A002) (Ratmalana – Moratuwa section)

Colombo - Galle - Hambantota – Wellawaya Road (A002 Road) is one of the most important roads of the country connecting the capital to the Southern Province and the Districts. The length of the road is 115.85km.

Within Colombo, the A2 serves as a north-south backbone to the city. It is split into two one-way streets from Colombo Fort to Wellawatte, in order to ease traffic flow.

The rehabilitation of the road had been carried out as section by section. A separate project was implemented for the section of Kollupitiya to Wellawatta. Another separate project was introduced to rehabilitate the sections of Maliban Junction to Cross Junction and Cross Junction to Nalluruwa. The section of Maliban Junction to Cross Junction is a 3 lane dual carriageway and the Cross Junction to Nalluruwa sections is a 4 lane single carriageway.

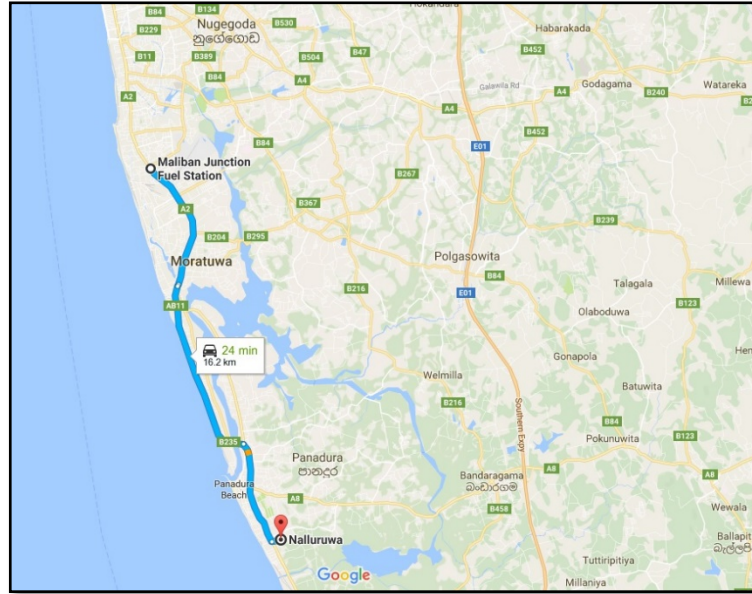


Figure 3-1: Location map of Maliban Junction – Nalluruwa Project Road

3.1.1 General Observations

During the initial study on the project management, it was revealed that there were separate officers in-charge on Safety as well as Traffic Management. The Project Manager has granted full responsibility to the aforementioned officers, and all the required resources had been provided to them in sake of Public Safety and Traffic Management.

General observations during the study could be listed as below;

- Increase of probability of traffic accidents
- Poor planning of works
- Disturbances to services connections
- Poor temporary signage and traffic management
- Increased dust and noise
- Disturbances to the drainage



Figure 3-2: Disturbances to the Pedestrian Foot-walks



Figure 3-3: Lane provided from opposite direction



Figure 3-4: No space for pedestrians



Figure 3-5: Properly arranged temporary sign boards



Figure 3-6: Traffic diversion during night time

3.2 Colombo - Horana Road (B084) (Boralesgamuwa – Piliyandala section)

Being one of major links to capital of Sri Lanka, improvement and upgrading of Pamankada Kesbewa Road has been prioritized by Government of Sri Lanka. Due to recurrent increase in traffic density, at present, the project road is serving in its full capacity by which extended travel time, accident risks, fuel wastage and high vehicle maintenance cost, logistic expenses, have become major impacts to the country's economy. Having considered above factors existing 2 lane narrow roads will be improved to four lane standard in order to cater future traffic demand and mobility requirements. Further, future extension of project road intends the most important link to Southern Expressway at Kahathuduwa Interchange

A trace of 9.9 km existing 2 lane road will be improved to 4 lanes road with more accessibility options at traffic controlled major intersections. Proposed Hard Shoulder and Soft Shoulder on either side add additional widths in overtaking, parking, in an emergency, pedestrians and cyclists. Proposed Center Island will separate directional split providing safer traveling. Proposed extensions and reconstructions of road structures, bridges and the drainage system facilitate immediate drain out of specially rain and waste water discharges avoiding blockages and floods.

Moreover, proposed 4 lane by-pass road, a new trace of 2.86 km in length mostly fallen in a marshy terrain, will bypass the project road at Piliyandala town as the best solution to the root cause of the traffic congestion in project road. This consists of construction of a new road with major intersections and road structures.

Through this national road improvement project having total length of 13.76km which connect Colombo to Southern Express Way, the expectations of Sri Lankan transportation industry will turn up to a new era linking Colombo, capital of Sri Lanka, to other parts of the country.

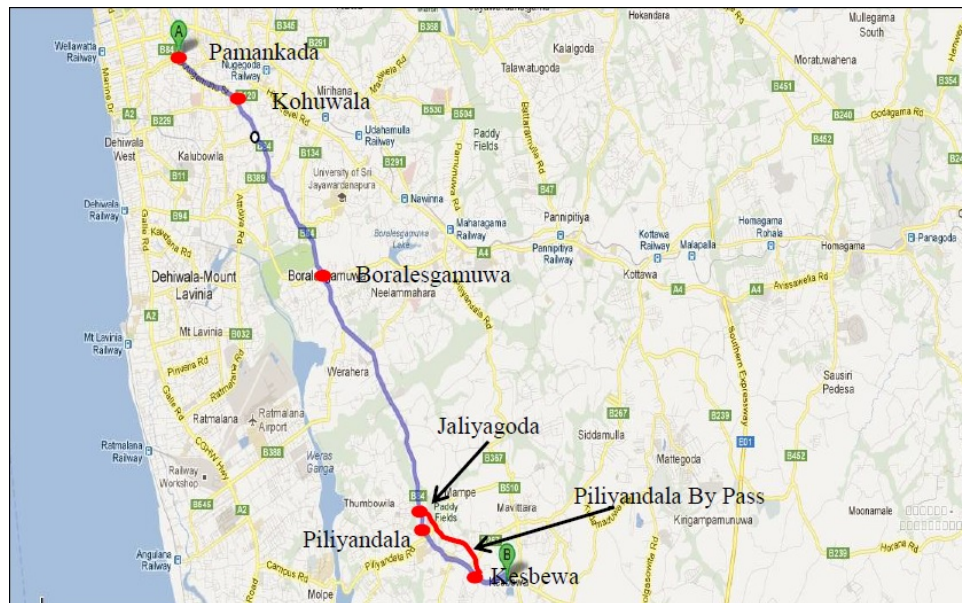


Figure 3-7: Location Map of Pamankada – Kesbewa Road Project

3.2.1 General Observations



Figure 3-8: Dust Generation on ABC Fill



Figure 3-9: Demarcation of work-zone



Figure 3-10: Water stagnation at ABC Fill



Figure 3-11: Poor Barricading at the middle of the carriageway



Figure 3-12: No safe passage demarcated for pedestrians

3.3 Ethulkotte – Kohuwala Road (B120) (Ethulkotte – Pitakotte section)

Ethulkotte – Mirihana – Kohuwala Road is a 'B' grade road running across Ethulkotte, Pitakotte, Mirihana, Nugegoda and ends at Kohuwala junction. The total length of the road is 5.95km. It is a 2 lane single carriageway from Ethulkotte up to Nugegoda. From Nugegoda up to Kohuwala, this road is a 4 lane single carriageway. In certain stretches, a centre median has been introduced. The rehabilitation/ improvement involved asphalt concrete relaying, construction of foot-walks for the pedestrians, improved drainage, and improvements to intersections; Ethulkotte, Pitakotte, Mirihana, Pagoda Junction, Nugegoda Super Market Junction and Nugegoda Fly-Over Junction. From

But the queue generation was considerable at most of the times because of the nature of the traffic on this road.



Figure 3-14: Existing drain walls raising to provide foot-walks



Figure 3-15: Single pile traffic allowed in construction zones

4. ANALYSIS OF WORK-ZONE PRACTICES

At a glance, all the considered road rehabilitation/ improvement projects has caused significant discomfort to the road users and adjacent residents/ business places. The main reason for these inconveniences seems to be the lack of attention paid on the road user confront.

4.1 Dust Generation and Air Pollution

One of the most irritating negative effect that the road users have to face during the road construction works would be the pollution. Air pollution is the introduction of harmful substances including particulates and biological molecules into atmosphere. It may cause diseases, allergies or death in humans; it may also cause harm to other living organisms such as animals and food crops, and may damage the natural or built environment.

The most common road construction activities which results in air pollution can be categorized as;

- Roadway excavation
- Sub base and base construction
- Aggregate crusher plant activities
- Asphalt and concrete batching plants
- Borrow pits and stock pile activities
- All machine and plant operations

The roadside residents and property owners face air pollution throughout the construction phase of the road. The amount of dust generated during the activities would be enormous, and the roadside resident would have to inhale the pollutants which may be hazardous for their health.

The pollutants blown through the wind reduces the visibility for the motorists which may increase the probability of accident occurrences. Even though the contractors spray water on their work-zones, the dust generation seems to be enormous. This dust generation becomes higher during the dry season.

It could be noted that most of the Contractors do not pre-plan their activities to minimize air pollution. For example, they excavate at ad-hoc locations, sub-base/ base materials at random stretches, but do not proceed to the next step. At some stretches where aggregate base course had been compacted, they do not proceed to applying prime coat on top of the base layer for commencement of asphalt paving.

Most of the possible dust generation could be avoided by spraying water frequently on the dried surfaces. But, unfortunately most of the contractors do not spray water due to lack of resources and to maximum their profit.

Moreover, the smoke and other emissions resulting from the construction machinery and equipment is considerably higher as most of those machineries are old machines with minimal maintenance done.

During the road construction activities, especially when single pile traffic is allowed for a certain road stretch, the vehicular movement becomes slow, and the vehicle would have to travel at lower speeds which increase the fuel consumption. Increased fuel consumption leads to increase in emissions.

The Central Environmental Authority has gazetted the regulations for the air quality; National Environmental (ambient air quality) Regulations 1994 representing the user and limits of specified materials for any process, trade or industry which will be hazardous for the environment. The limitations specified in the aforementioned publications are tabulated in Table 4-1.

Table 4-1: Air Quality Permissible Limits

Pollutant	Averaging Time *	Maximum		Method of Measurement
		Permissible Level		
		Mg/ m ³	Ppm	
Carbon Monoxide	8hr	10	9	Non-dispersive infrared Spectroscopy
Nitrogen Dioxide	1 hr.	30	26	Colouring using Saltzman method or equivalent (gas phase chemiluminescence)
	Anytime	58	50	
	24 hr.	0.1	0.05	
	8 hr.	0.15	0.08	
Sulphur Dioxide	1hr.	0.25	0.13	Pararosaniline method of equivalent (pulsed fluorescent method)
	24 hr.	0.08	0.03	
Ozone	8hr.	0.12	0.05	Chemiluminescence method or equivalent (ultra violet photometric method)
	1 hr.	0.2	0.08	
	1 hr.	0.2	0.1	
Lead	Annual	0.0005	-	Hi-volume sampling, wet ashing/atomic absorption or spectroscopy.
Suspended Particulate Matter (SPM)	24 hr.	0.002		Hi-volume sampling & Gravimetric
	Annual	0.1	-	
	24 hr.	0.3	-	
	8 hr.	0.35	-	
	3 hr.	0.45	-	
	1 hr.	0.5	-	

*(Minimum number of observations required to determine the average over the specified period:

- 03 hour average – 03 consecutive hourly averages.
- 08 hour average – 06 hourly averages.
- 24 hour average – 18 hourly average
- Yearly average – 09 monthly averages with at least 02 monthly average each quarter.

By wet chemistry methods or by automated analyzers.

Source: National Environmental (ambient air quality) Regulations 1994

In some of the road rehabilitation projects, it is required by Client to monitor the air quality at certain places at certain intervals. But in general, the Central Environmental Authority does not intervene for the air quality issues unless certain complaints are made.

In most of the considered road projects for this study, the residents/ business places have lodged complaints to Contractor, to the RDA and to the Police complaining about the excessive dust they have been experiencing due to the construction activities.

The figure 4-1 shows how dust is generated due to the dry surface of the compacted aggregate base course.



Figure 4-1: Dust Generation on completed ABC fill

4.2 Noise Pollution

Noise generation is one of the major issues the road users and the resident would have to face during the road rehabilitation/ improvement projects. The major construction activities which results in irritating noise are listed as below;

- Aggregate crushing activities
- Pre-cast pile driving
- Sheet pile driving
- Bored pile socketing and hacking
- Excavation works
- Rock blasting activities
- Asphalt and concrete batching plant operations
- Electrical generators and air compressor operations
- Heavy machinery and equipment operations

The Table 4-2 illustrates the general noise levels generated during the construction activities.

Table 4-2: Noise Generation in Construction Activities

Equipment	Noise Level at 7m in dB
Air Compressor	109
Crow Bar	115
Truck, Scraper, or Grader	94
Excavator	112
Loader	112
Roller Vibrator	108
Poker Vibrator	113

The noise generated during the construction activities would be irritating especially in sensitive areas such as schools, religious locations, elderly and children's homes, hospitals, courts, etc.

In order to limit the noise pollution, National Environmental (Noise Control) Regulations No. 1 of 1996 had been published and enforced by the gazette on 23rd

May 1996 limiting the maximum permissible noise levels. The permissible noise levels are stipulated in four (04) categories;

- Low noise
- Medium noise
- High noise
- Silent Zone

The permissible noise levels are stated in Schedule I of National Environmental Noise Control Regulations 1996 (924/12).

Table 4-3: Categorizing Noise Levels

Area	LAeq'T	
	Day Time	Night Time
Low Noise	55	45
Medium Noise	63*	50
High Noise	70	60
Silent Zone	50	45

Maximum permissible Noise levels at Boundaries of the properties in LAeq ,T, for industrial activities are stated in Schedule IV of the same publication.

Table 4-4: Permissible Noise Levels

Area	LAeq'T	
	Day Time	Night Time
Rural Residential Area	55	45
Urban Residential Area	60	50
Noise Sensitive Area	50	45
Mixed Residential	63	55
Commercial Areas	65	55
Industrial Area	70	60

During the study, it was revealed that most of the construction activities causing higher noise have been limited to the day time as per the regulations from the local authorities. In some of the projects, the residents have made complaints to the Contractor, to RDA and even Police regarding the noise they experience due to the construction activities.

It should be noted that most of the road Contractors do not pay their attention on sensitive places such as schools, religious places, children's homes and elderly homes during their constructing activities. Especially the school children face enormous difficulties due to the noise generated.

4.3 Disturbances to the Service Connections

During most of the road rehabilitation projects, the existing utility lines would have to be relocated, mostly due to the widening of the carriageway, and due to the improvements to the horizontal alignment of the road. The electricity posts and lines, telecom posts and lines, water pipe lines of NWSDB and other utility lines are being relocated.

During the relocation of these utility lines, the nearby residences and business places would have to face inconveniences, and in addition, the business places would have to bear financial losses as well.

Most of the time, the electricity line relocations are carried out by CEB or LECO, and they generally publish a schedule prior to the commencement. Most commonly, they disconnect the electricity supply at about 8.30AM and they supply connection again by 5.30PM. During the daytime, the residences and business places would have to bear the interruption.

However, the water connections and telecom connections are not relocated in a schedule. In most of the locations, the residence and business places would have to bear prolonged interruptions, sometimes even for a couple of days.



Figure 4-2: Water lines to be relocated at B084 Road project

In addition to the utility relocation process, electricity, water, telecom lines for individual residences and business places get damaged during the construction activities. The main reason identified for this is lack of as-built drawings from the respective authority, and the lack of attention towards underground utility lines during the excavation processes. For these kinds of damages, the contractors do not hold responsibility to inform the respective authorities for rectifications.



Figure 4-3: Electricity posts/line to be relocated in B084 Road project

4.4 Disturbances to the accesses

Another major inconvenience experienced by the adjacent residents/ business places is the disturbances of their property access from the road during the rehabilitation/ improvement project.

Commercial accesses, house accesses and bi road connections get disturbed during the construction activities especially due to construction of the side drains/ change of vertical profile of the road etc. In addition, material storage, deep excavation etc. has also affected access.

Without proper planning, contractors commence drain excavations without informing the houses/ business places, bi road connections etc. They do not pay attention to complete the construction works with the minimal disturbances to the residents and other users. Most of the house/ business place accesses are provided with temporary access with cat-walk plates/ steel plates during the construction phase. But it could be seen that most of these temporary accesses do not facilitate vehicle movement. As such, most of the residents would have to park their own vehicles outside of their land for a prolonged period until their accesses are reinstated.

4.5 Travel Time Increment/ Reduction of Fuel Efficiency

During the road rehabilitation/ improvement projects, the motorists would have to face congestions due to the construction activities carried out in confined areas. Where there are alternatives routes are available, the traffic is diverted into these routes. Special public notices are published over the printed and electronic media about these alternative routes advising motorists to avoid the debilitating road as much as possible.

However, motorists would have to face congestions during construction activities especially when one lane is closed and allowing only single pile traffic. When one lane is closed for a certain stretch, the queue generation would be at a higher rate. Once traffic is allowed from one direction, the traffic would have to crouch through the work zone with a minimal speed, and at a lower gear as well.

Moreover, when a road is being rehabilitated, the pavement conditions get deteriorated over the project duration. The construction machinery, equipment and temporary

material storage would be at the either sides of the road. This would affect as a side friction for the motorists, and they would have to reduce their speed accordingly.

Especially in B120 road project, the traffic congestion experienced almost throughout the project duration because of the lack of space during construction activities. In the section from Ethulkotte to Mirihana, the carriageway width available was about 7.0m and there were only 2 traffic lanes available. As such, one lane had to be closed for the certain length for almost all the construction activities such as excavations, utility relocations, side drain constructions, asphalt milling, asphalt paving, concreting converts and drains etc.

On average, the travel time in between Ethulkotte to Mirihana had been increased by almost 50% during the day time during construction activities.

4.6 Lack of Space for the Pedestrians

In most of the road rehabilitation projects, the contractors pay less attention towards the pedestrians. Even though they arrange traffic management system during the construction activities, most of them neglect the pedestrians.

In particular, the provision for the pedestrians was minimal at Ethulkotte – Mirihana – Kohuwala Road (B120) Road project because of the lack of the space available. As per the existing conditions, there were no foot-walks available at most of the stretches. The carriageway has been paved with asphalt concrete up to the side drain wall. As such, there were practical difficulties for the provision for safe passage for the pedestrians.



Figure 4-4: No space for the pedestrians at B120 Road Project

In Colombo – Galle – Hambantota Road (A002) Road, there were existing foot-walks at the either sides of the carriageway at most of the stretches. Therefore the provision of safe passage for the pedestrians was not a difficult task compared to the B120 Road project.

At the culvert/ bridge constructions, the provision of pedestrian passage is very critical task. Because of the space limitations, most of the contractors tend to neglect the pedestrian movement endangering them for probable accidents.

However, it should be noted that the pedestrians were well treated in B084 Road project in most of the locations. They have provided temporary pedestrian bridges at certain locations as well.



Figure 4-5: Temporary pedestrian Bridge at B084 Road Project

In most of the road rehabilitation projects, the pedestrian crossings get neglected. Especially after the Binder Course is laid, the existing pedestrian crossings get disappeared, and in general, the Contractors do not provide temporary pedestrian crossings until the Wearing Course is laid. Because of the disappearance of the pedestrian crossings, the pedestrians would be exposed to oncoming traffic.

However, it should be highlighted that the Contractor has provided temporary pedestrian crossings at B120 Road project which is not so common. They have painted temporary pedestrian crossings with yellow paints on the Binder Course.



Figure 4-6: Temporary Pedestrian Crossings at B084 Road Project

However, there were numerous locations where pedestrians were endangered by not providing safe passage for them during the construction activities. The figure 4-7 shows one such location in B084 project.



Figure 4-7: Endangered pedestrian movement at B084 road

4.7 Traffic Management

For almost every RDA road project, it is mandatory to submit a ‘Traffic Management Action Plan’ prior to commencing construction activities. But in practice, the contractors do submit this document for the Consultants only due to the fact that they

are contractually bound to submit the same. The Contractors normally do not follow the approved documents during the construction phase.

In the approved 'Traffic Management Action Plan' the contractors have to submit their proposal on the traffic management, including the diagrams indicating the signage, and other relevant details in common scenario.

The figure 4-8 and figure 4-9 show how the Contractor has planned to manage traffic at B084 road project during the reconstruction of culverts.

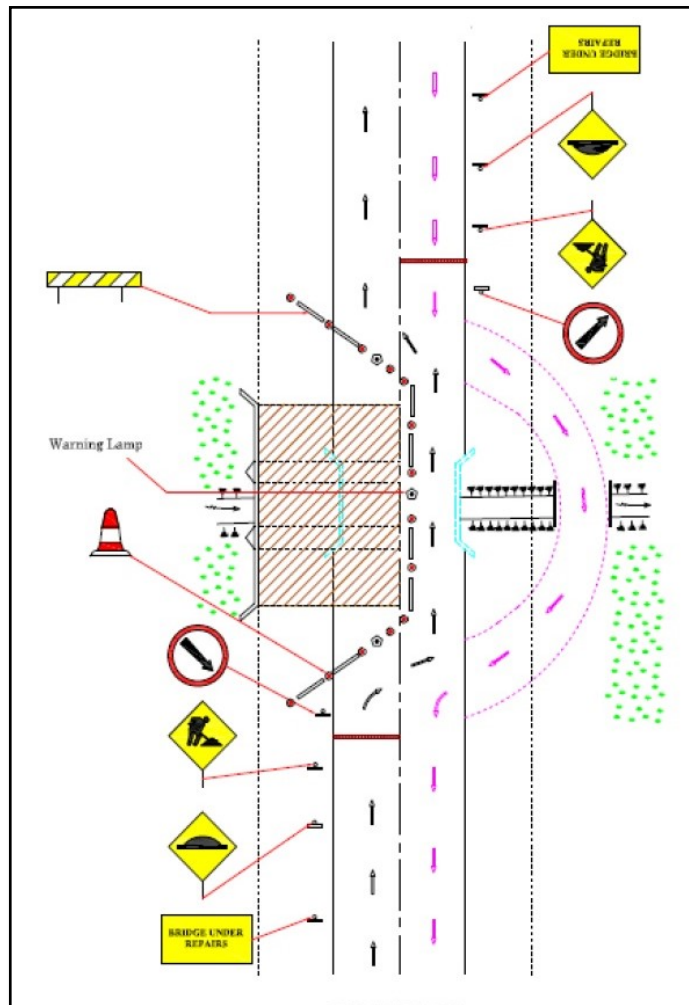


Figure 4-8: Traffic Management during the reconstruction of a culvert; phase 1

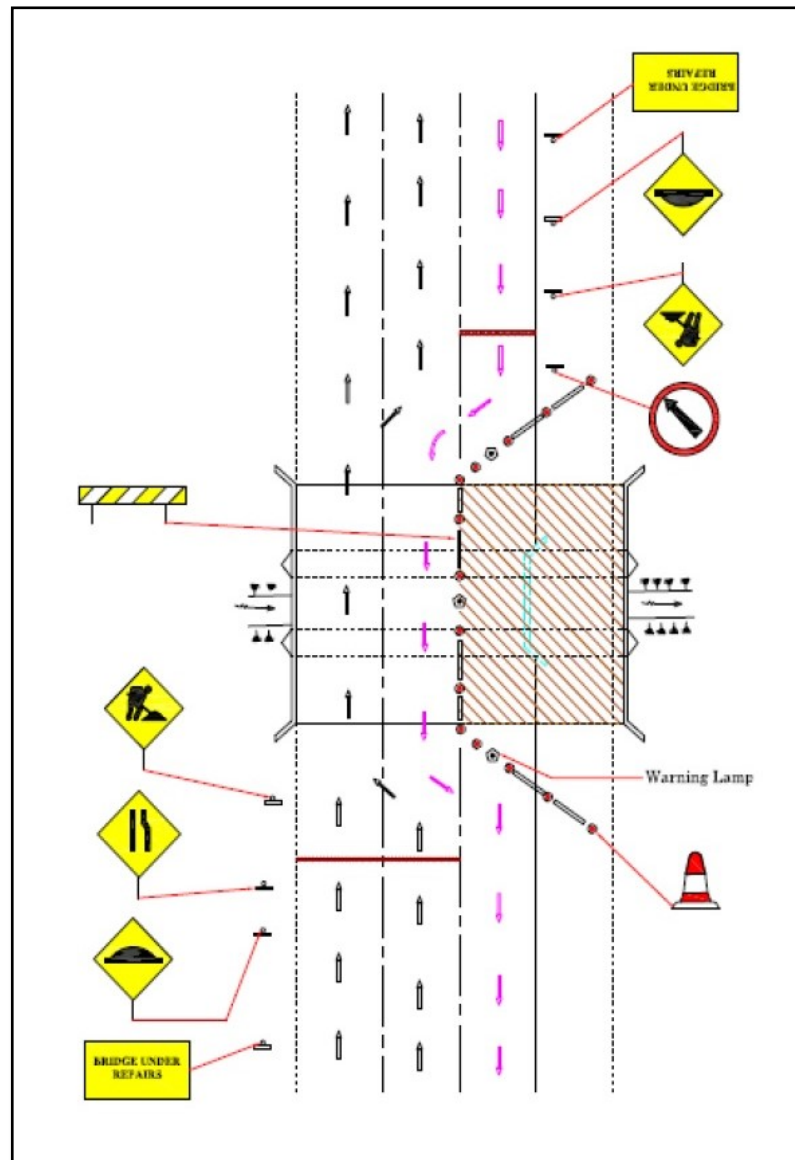


Figure 4-9: Traffic Management during the reconstruction of a culvert; phase 2

The figure 4-10 shows how traffic management is executed at A002 Road project where one lane is closed for the construction activities.



Figure 4-10: Traffic Management during culvert construction at A002 road



Figure 4-11: Traffic Management during culvert construction at B084 road

The figures 4-12 and 4-13 show the proposed traffic management during the road widening works of B084 road project.

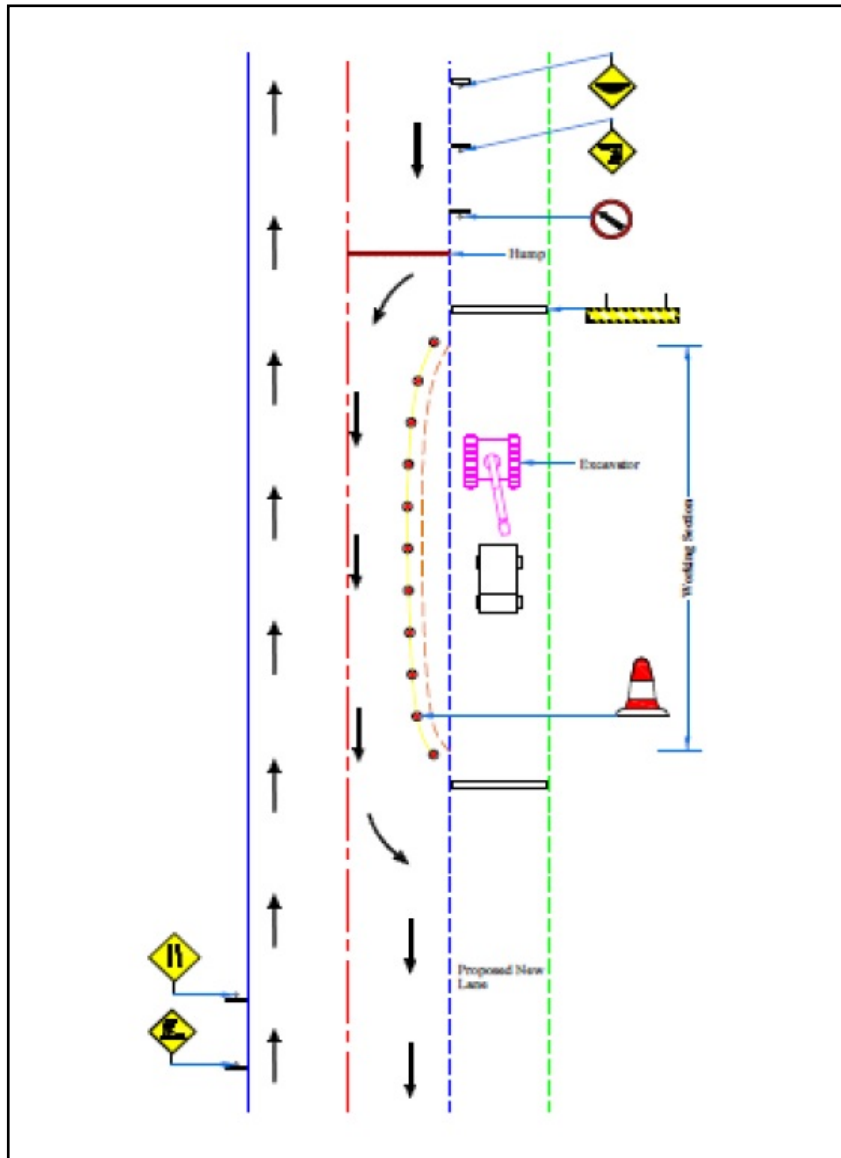


Figure 4-12: Proposed traffic management during road widening works of B084 project; phase 1

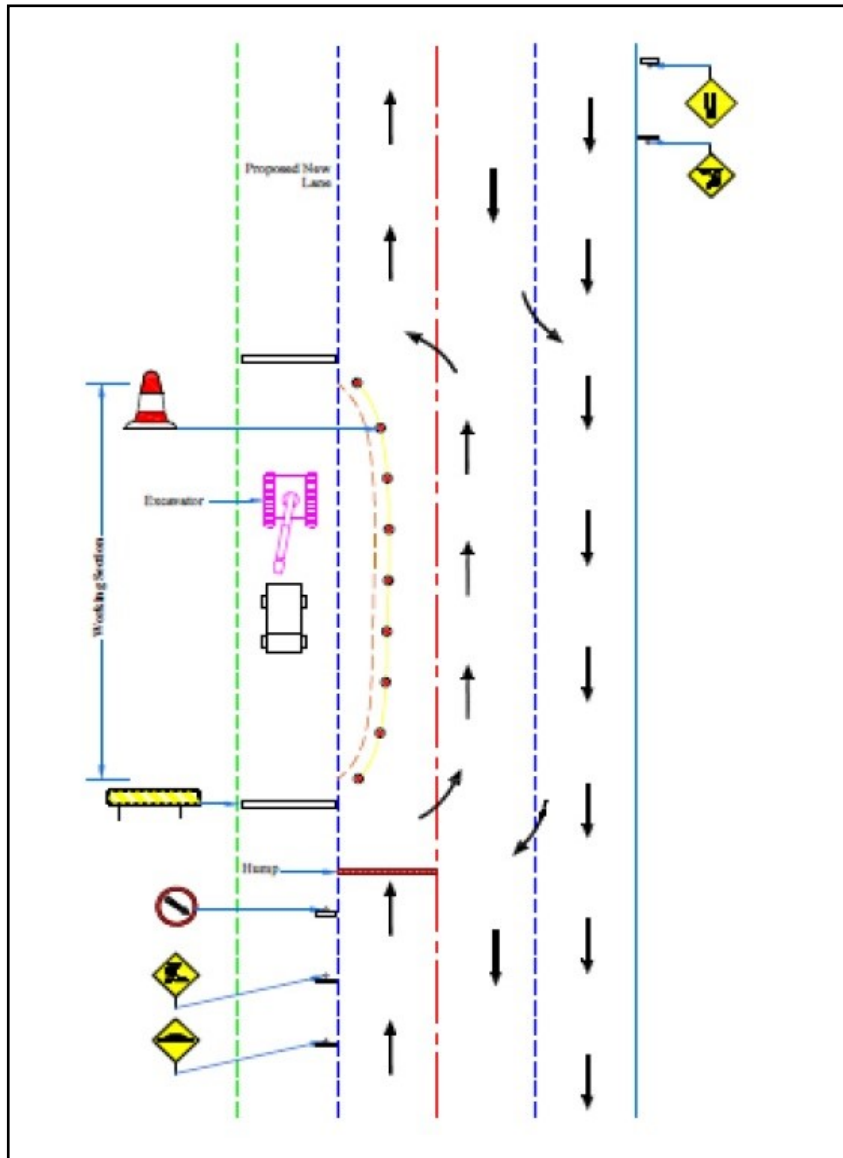


Figure 4-13: Proposed traffic management during road widening works of B084 project; phase 2

The figure 4-14 and 4-15 show the proposed traffic management plan to be executed during the asphalt paving activities of B120 project.

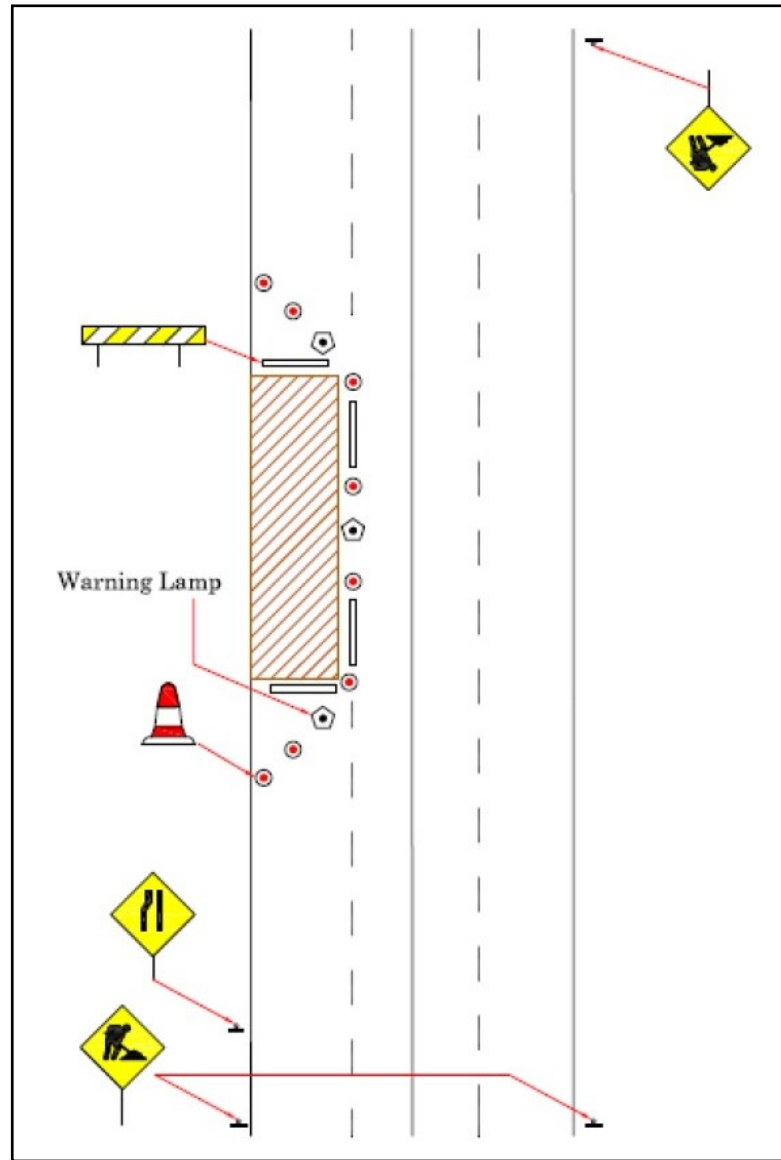


Figure 4-14: Proposed traffic management during asphalt paving of outer lane of B120 project.

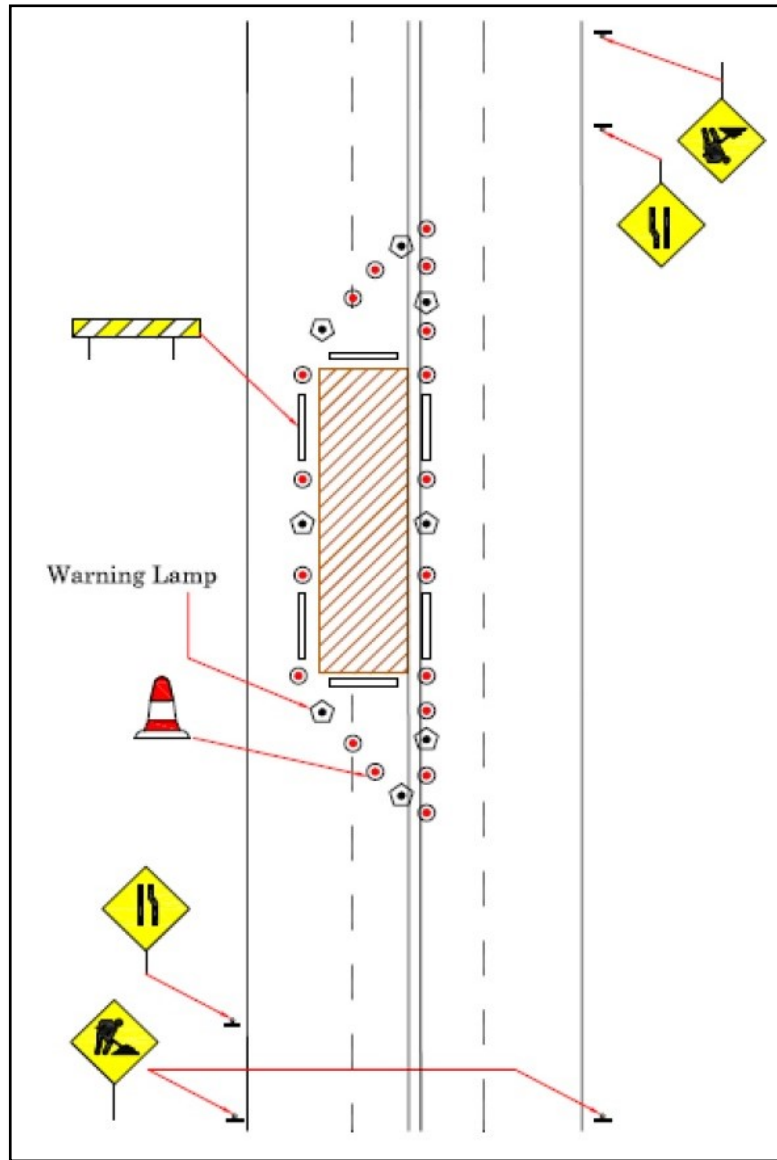


Figure 4-15: Proposed traffic management during asphalt paving of inner lane of B120 project.



Figure 4-16: Traffic Management during asphalt paving at B120 road

5. QUESTIONNAIRE SURVEYS

In order to study the work-zone management in view of the road users/ residence and business place owners, a separate questionnaire survey had been conducted for A002 road, B084 road and B0120 road projects. The questionnaire for the road users and the questionnaire for the residence/ business place owners is shown in Annexure 1.

5.1 Questionnaire for Road Users

A comprehensive questionnaire had been distributed among road users both motorists and non-motorists within the ongoing project road sections. In the questionnaires were prepared to check the types of inconveniences caused to the road users, as well as the reasons for those inconveniences as per the road users' perspective.

5.1.1 B120 Road

Total number of 264 persons have been interviewed through the questionnaire survey, and their Responses were recorded. Pedestrians, private vehicle drivers/ passengers, passengers/ drivers of public transport buses were the target group for the study.

Increment in Travel Time

All the responders have experienced in increasing the travel time. But the percentage of travel time increment differs according to the type of road user. Most increment had been recorded from the passengers of the public transport busses. The Figure 5-1 illustrates the distribution of the travel time increment.

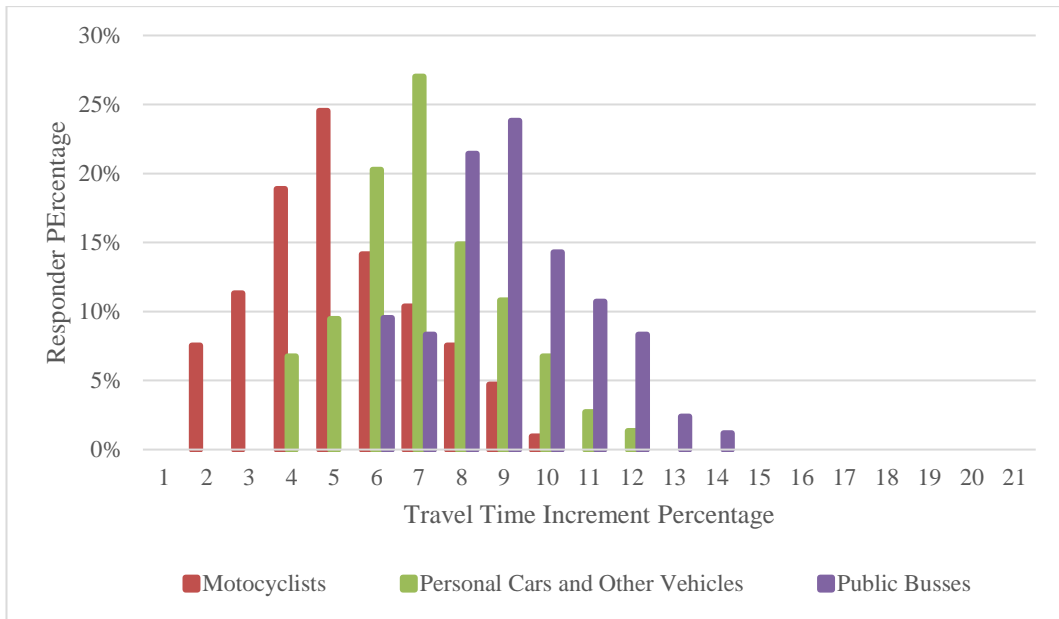


Figure 5-1: Responses in Travel Time Increment of B120 Road

Types of Inconveniences and the Impacts

Dust generation and the increment of the travel time were identified as the highest impact on the inconveniences experienced by the road users. Most of the responders were reasonably happy with the traffic management and advance signage. The figures 5-2 through 5-8 show the variance of the impact levels.

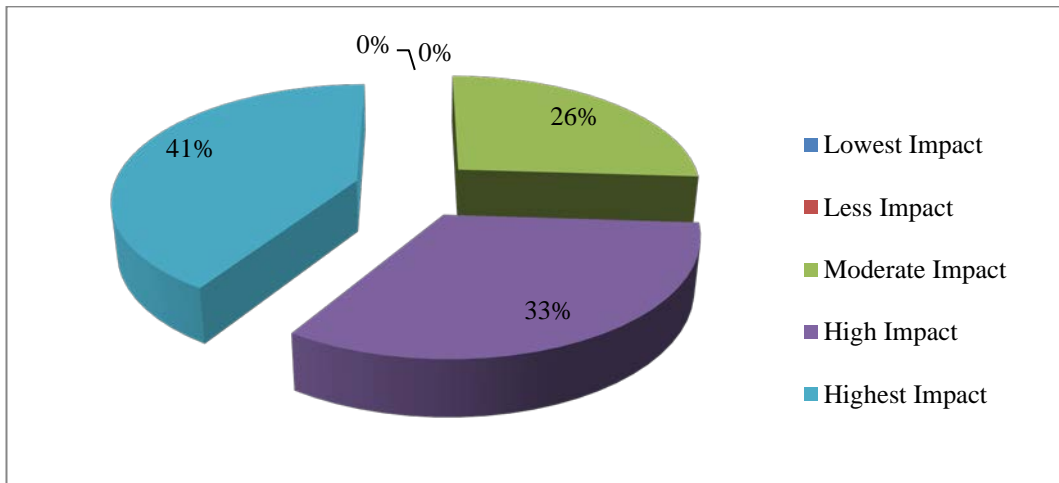


Figure 5-2: Impact of Dust Generation of B120 Road

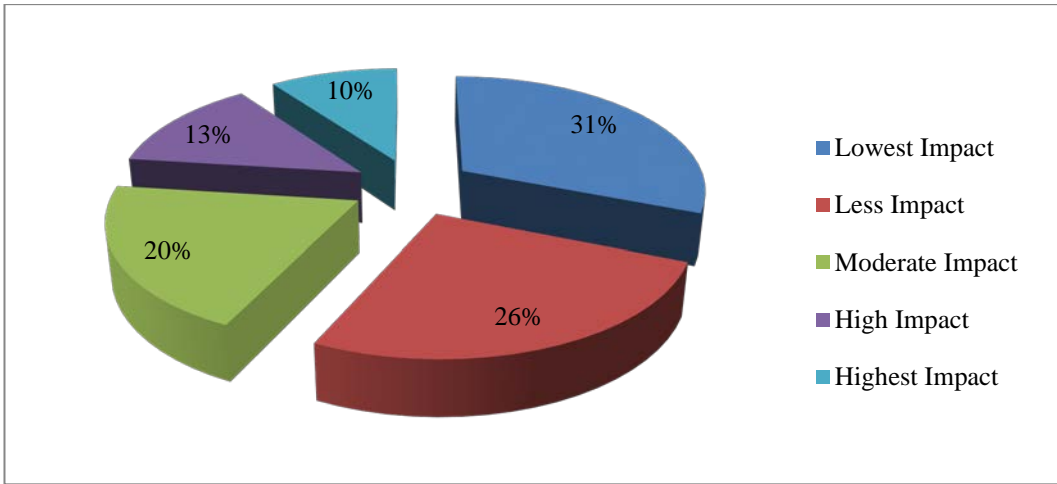


Figure 5-3: Impact of Possible Damages to Vehicles in B120 Road

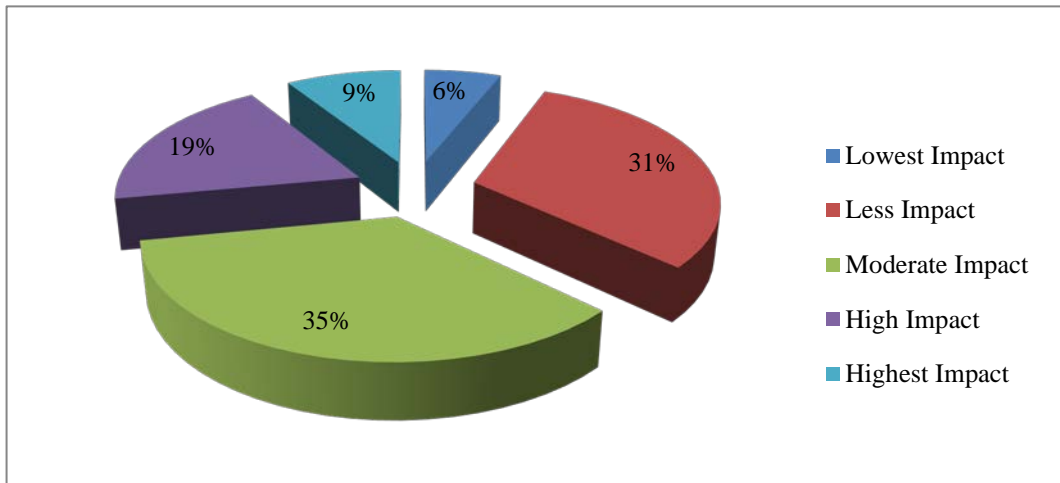


Figure 5-4: Impact of Inadequate Safety Arrangements of B120 Road

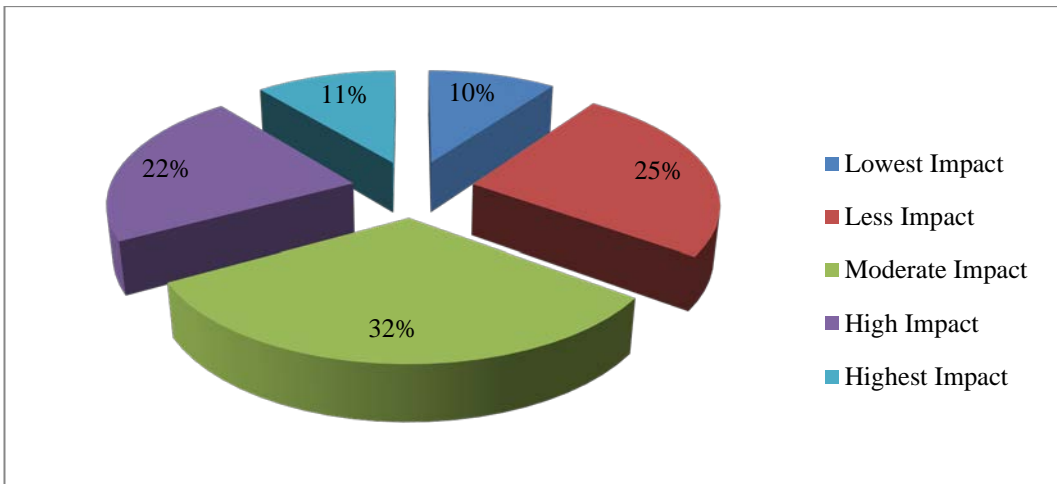


Figure 5-5: Impact of Incapable Traffic Controllers of B120 Road

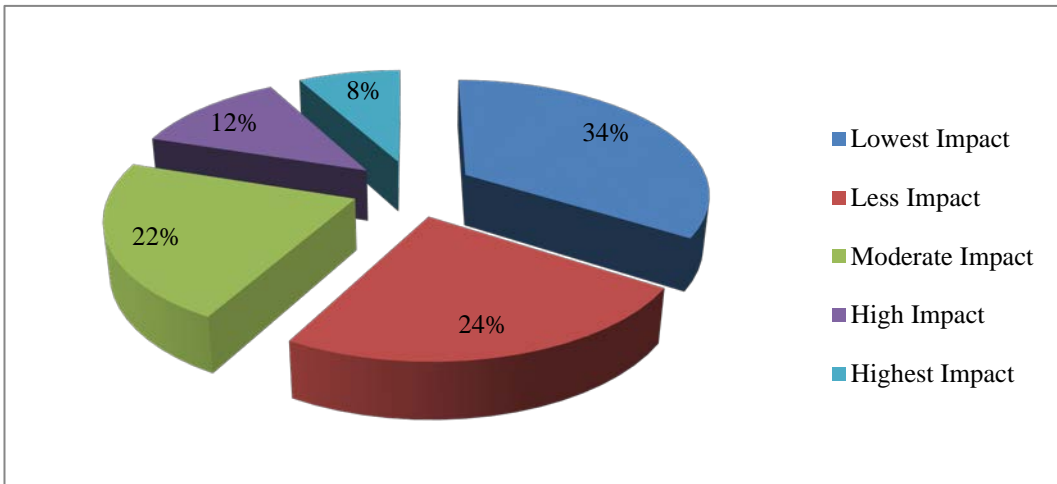


Figure 5-6: Impact of Road Side Friction of B120 Road

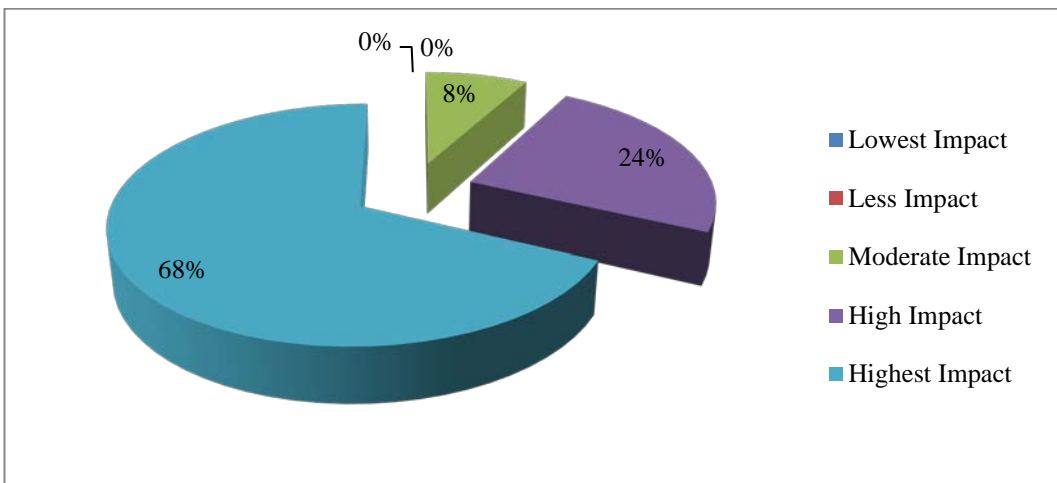


Figure 5-7 Impact of Increment of Travel Time of B120 Road

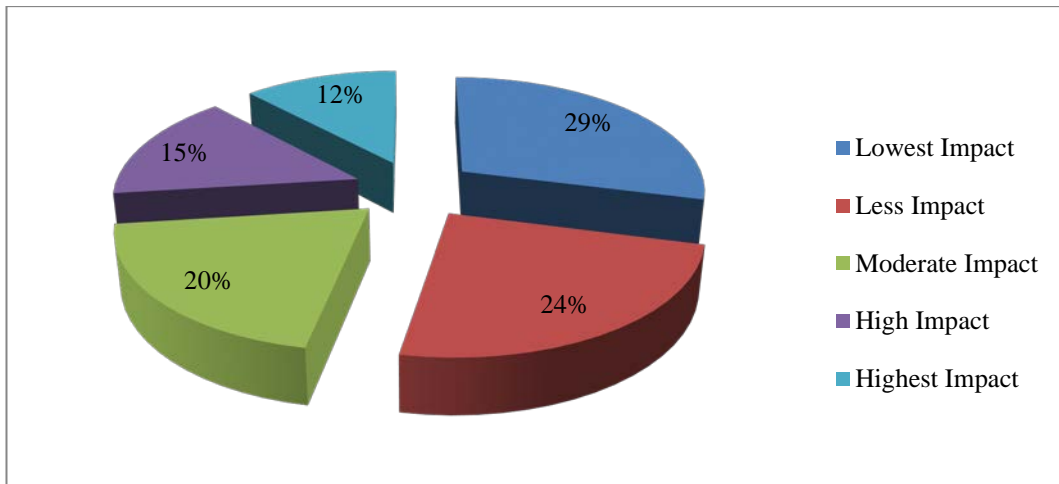


Figure 5-8: Impact of Lack of Advanced Signage of B120 Road

Recommendations

Based on the recommendations from the responders, it could be identified that most of them have recommended that the dust mitigations by means of frequent spry of water should be carried out. In addition, they have recommended to provide safe passage for the pedestrians, as well as provision of priority for the public transport vehicles.

The below table shows the Reponses received from the responders of B120 Road.

Table 5-1: Recommendations to Minimize Inconveniences in B0120 Road as per the responses received

Recommendation	Least Recommended	Less Recommended	Moderately Recommended	Recommended	Highly Recommended
Response	1	2	3	4	5
Allocate experienced traffic controllers	9%	28%	33%	11%	19%
Place sign boards well advance	7%	5%	33%	26%	29%
Maintain pavement in motorable condition	3%	14%	34%	22%	25%
Place speed humps to control the speed	45%	30%	18%	7%	0%
Properly demarcate construction boundaries	14%	9%	22%	26%	29%
Spray water frequently to prevent dust generation	0%	0%	6%	26%	68%
Improve lighting during night time	5%	22%	35%	29%	9%
Provide safe passage for pedestrians	4%	8%	13%	22%	53%
Provide priority for public transport vehicles	3%	5%	19%	33%	41%
Use blinkers at night	9%	15%	27%	24%	25%

Complains on inconveniences

Out of the total responders, none of them have made any official complain to any of the responsible officers/ organizations regarding the inconveniences. However, 30% of responders stated that the inconveniences they had to be borne would be ‘unacceptable’ while 68% stated that it is ‘moderately acceptable’. Only 02% responded with ‘acceptable’.

5.1.2 B084 Road

Total numbers of 256 persons have been interviewed through the questionnaire survey, and their Responses were recorded. Pedestrians, private vehicle drivers/ passengers, passengers/ drivers of public transport buses were the target group for the study.

Increment in Travel Time

All the responders have experienced in increasing the travel time. But the percentage of travel time increment differs according to the type of road user. Most increment had been recorded from the passengers of the public transport busses. The Figure 5-9 illustrates the distribution of the travel time increment.

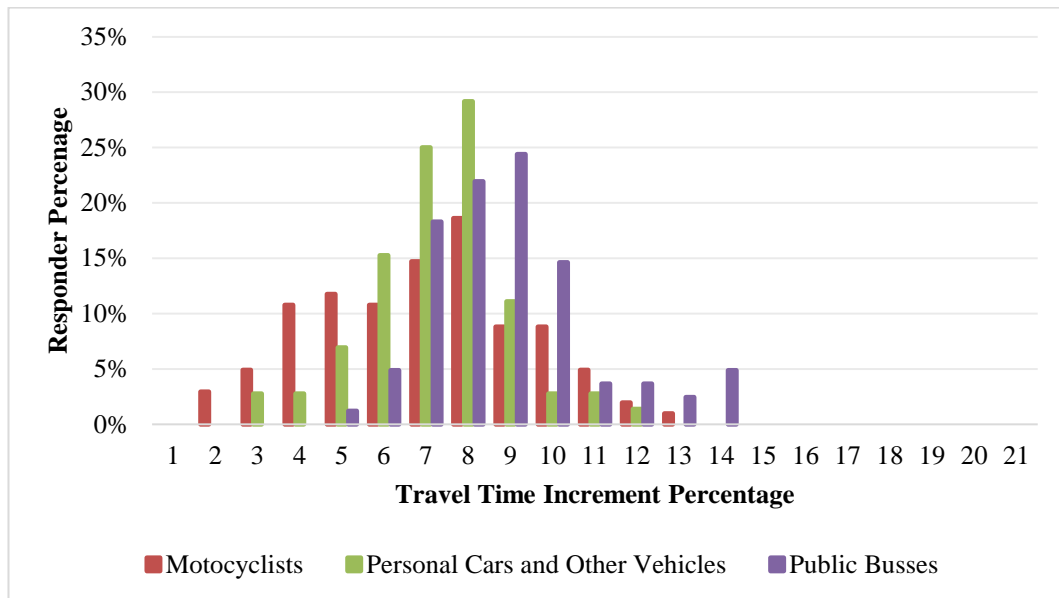


Figure 5-9: Responses in Travel Time Increment of B084 Road

Types of Inconveniences and the Impacts

Dust generation and the increment of the travel time were identified as the highest impact on the inconveniences experienced by the road users. The figures 5-10 through 5-16 show the variance of the impact levels.

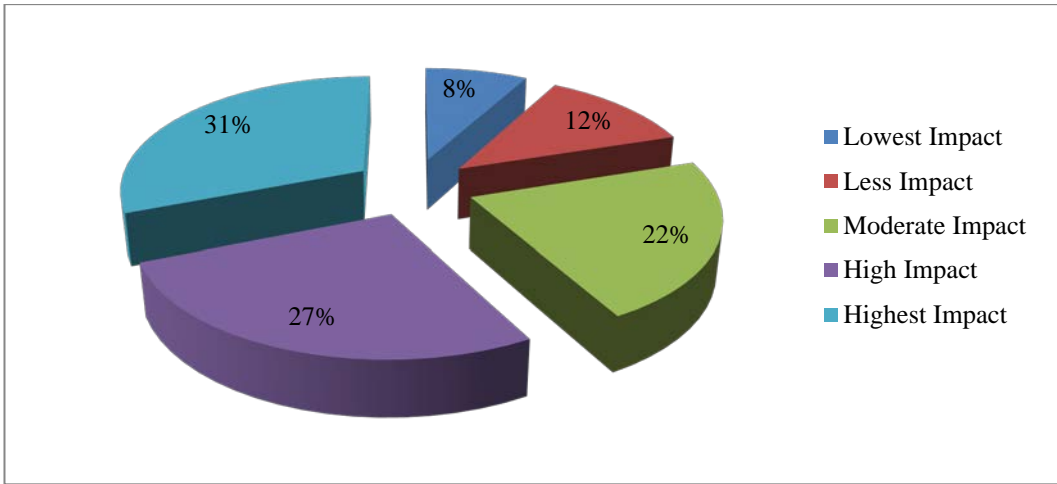


Figure 5-10 Impact of Dust Generation of B084 Road

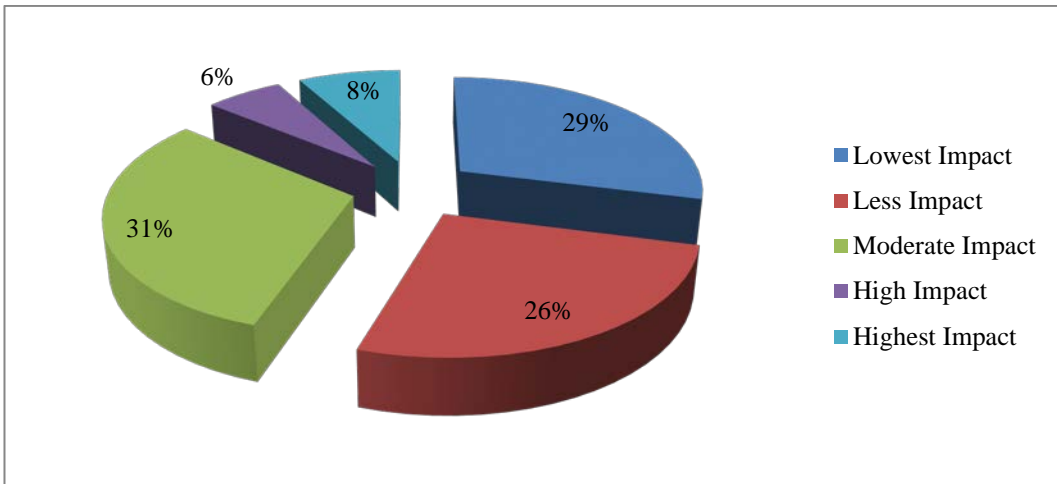


Figure 5-11: Impact of Possible Damages of Vehicles of B084 Road

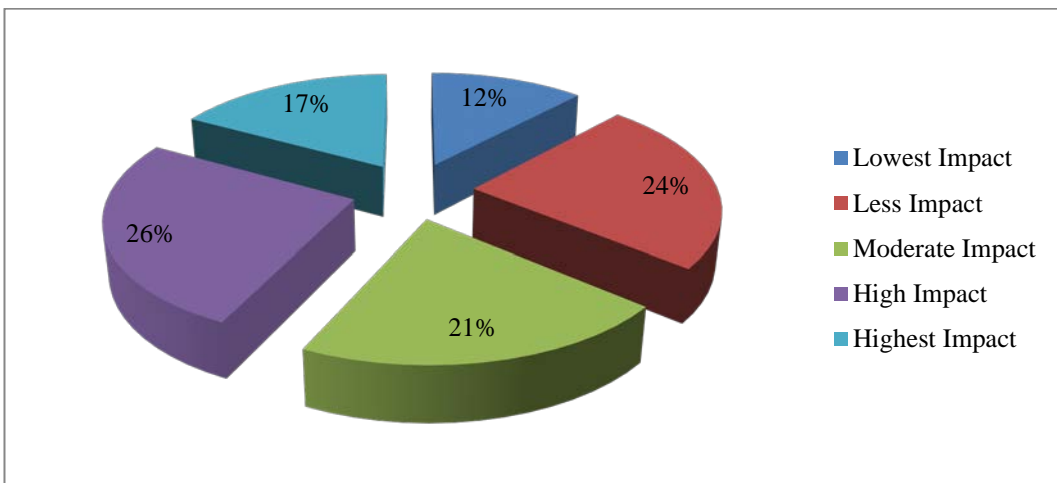


Figure 5-12: Impact of Inadequate Safety Arrangements of B084 Road

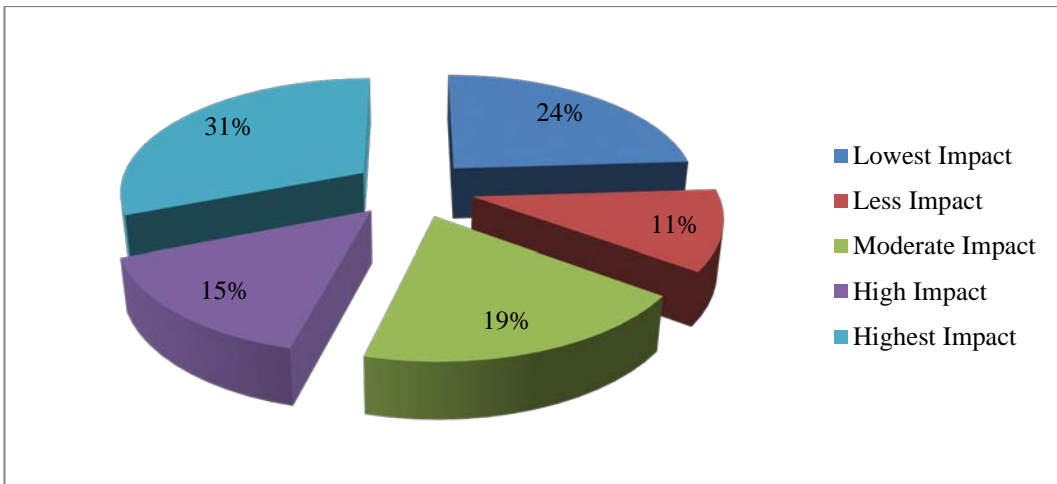


Figure 5-13: Impact of Incapable Traffic Controllers of B084 Road

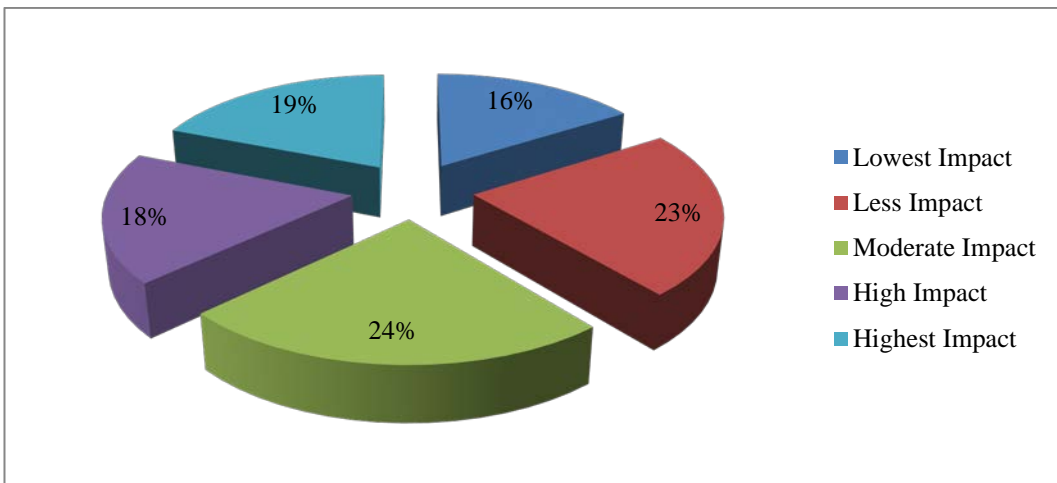


Figure 5-14: Impact Road Side Friction of B084 Road

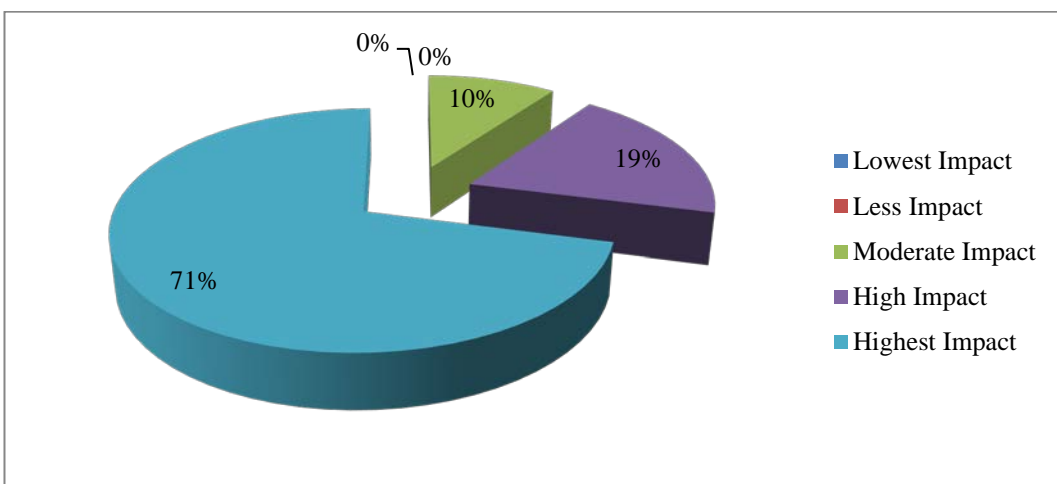


Figure 5-15 Impact of Increment of Travel Time of B084 Road

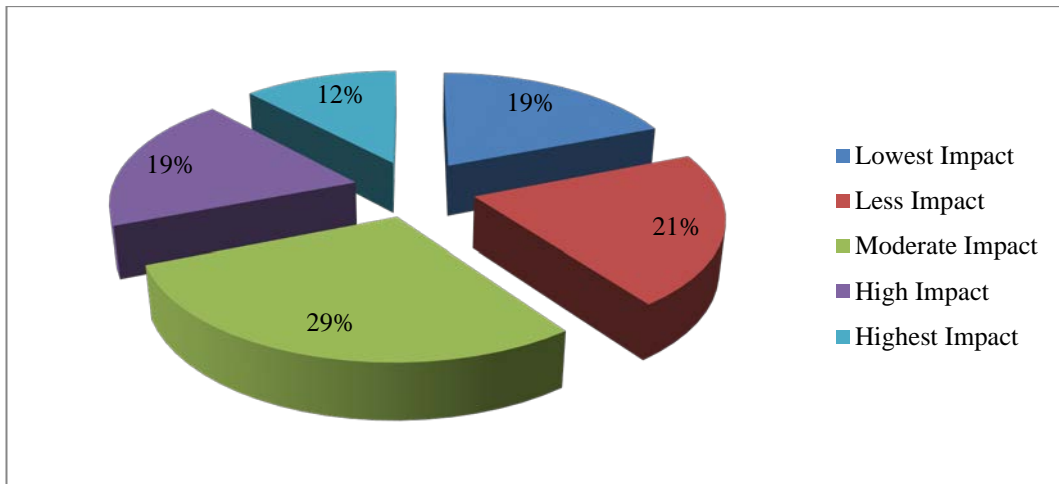


Figure 5-16: Impact of Lack of Advanced Signage of B084 Road

Recommendations

Based on the recommendations from the responders, it could be identified that most of them have recommended that the dust mitigations by means of frequent spray of water should be carried out. In addition, they have recommended to provide safe passage for the pedestrians, as well as provision of priority for the public transport vehicles.

The below table shows the Responses received from the responders of B084 Road.

Table 5-2: Recommendations to Minimize Inconveniences in B084 Road as per the responses received

Recommendation	Least Recommended	Less Recommended	Moderately Recommended	Recommended	Highly Recommended
Response	1	2	3	4	5
Allocate experienced traffic controllers	16%	16%	15%	19%	34%
Place sign boards well advance	21%	20%	19%	29%	11%
Maintain pavement in motorable condition	2%	8%	26%	27%	37%
Place speed humps to control the speed	24%	22%	19%	20%	15%
Properly demarcate construction boundaries	24%	21%	19%	17%	19%
Spray water frequently to prevent dust generation	3%	9%	24%	31%	33%
Improve lighting during night time	19%	18%	19%	24%	20%
Provide safe passage for pedestrians	6%	18%	20%	27%	29%
Provide priority for public transport vehicles	3%	12%	18%	31%	36%
Use blinkers at night	21%	24%	21%	19%	14%

Complains on inconveniences

Out of the total responders, only 3 nos. of them have made any official complain to any of the responsible officers/ organizations regarding the inconveniences. However, the authorities have not solved the complaints yet. It should be noted that 51% of responders stated that the inconveniences they had to be borne would be 'unacceptable' while 40% stated that it is 'moderately acceptable'. Only 09% responded with 'acceptable'.

5.1.3 A002 Road

Same questionnaire survey had been conducted at the project road along A002 from Ratmalana to Moratuwa. Randomly selected pedestrians, private vehicle drivers and public bus passengers responded to the survey. A total of 314 number of personas have been interviewed and responses were recorded on questionnaires survey sheets.

Increment in Travel Time

It could be identified that both public transport bus passengers and private vehicle drivers have experienced highest increment of travel time.

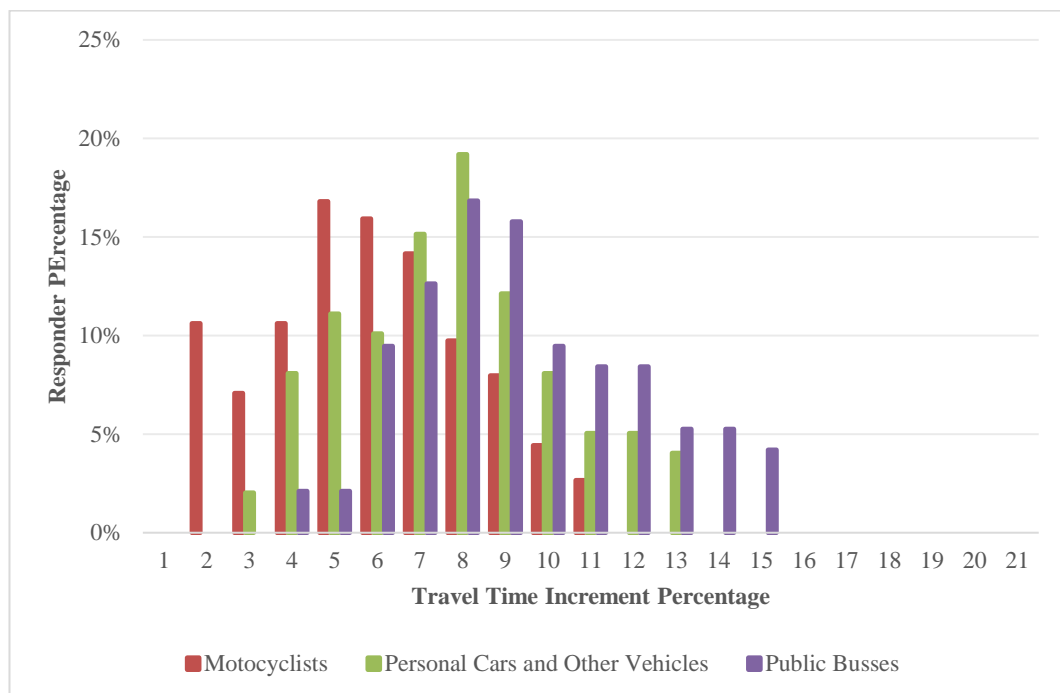


Figure 5-17: Responses in Travel Time Increment of A002 Road

Types of Inconveniences and the Impacts

The increment of the travel time seems to be the most critical inconvenience experienced by the road users. In addition, they have responded stating that the lack of advanced signage would also be an important aspect to be addressed.

The figures 5-18 through 5-24 illustrate the impact levels of each inconvenience according to the views of the road users.

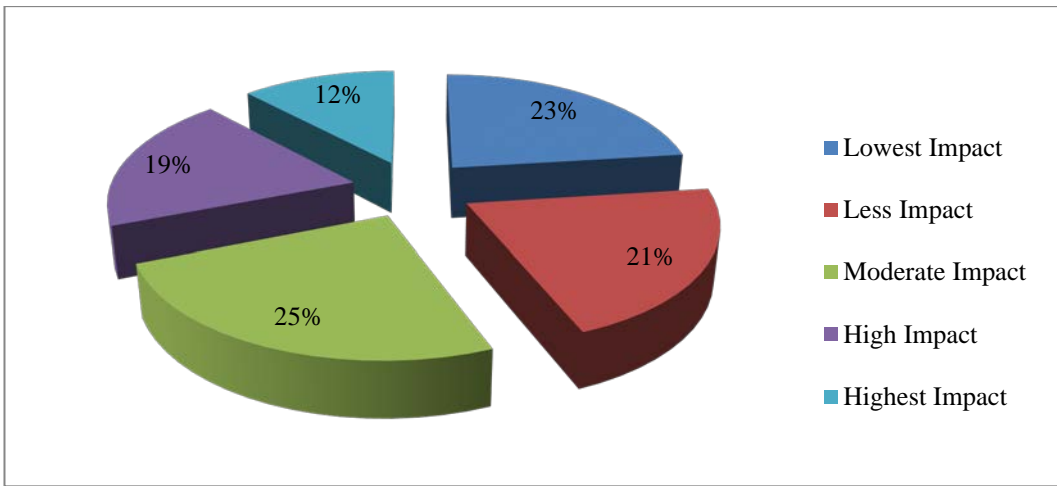


Figure 5-18: Impact of Lack of Advanced Signage of B084 Road

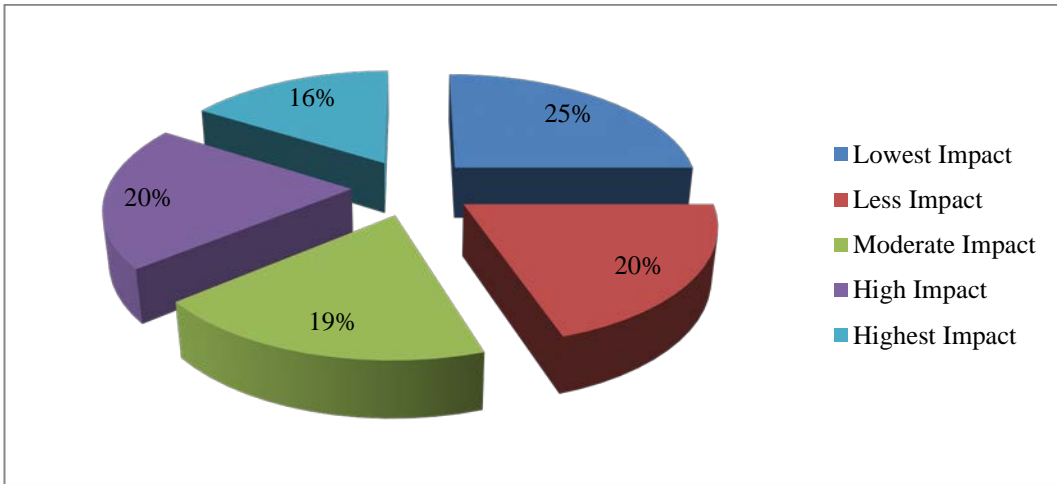


Figure 5-19: Impact of Lack of Advanced Signage of B084 Road

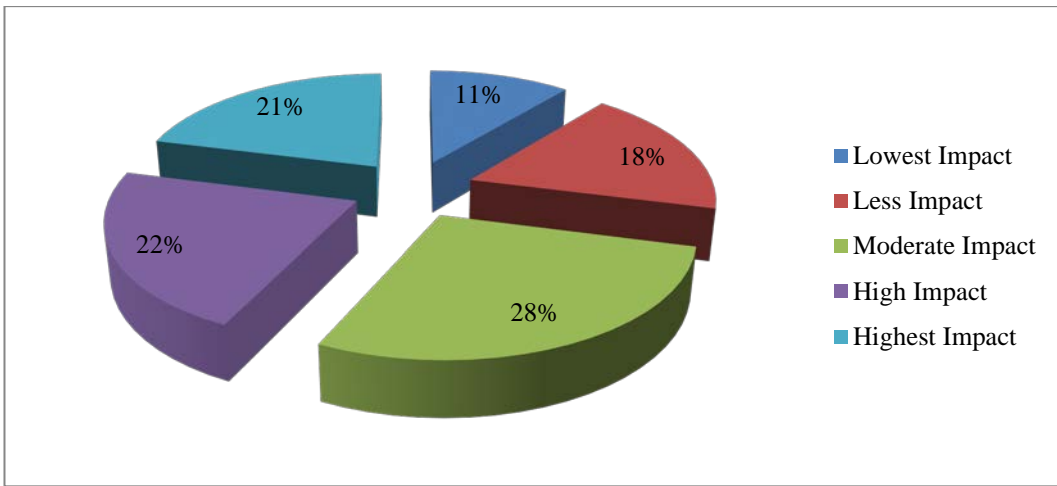


Figure 5-20: Impact of Lack of Advanced Signage of B084 Road

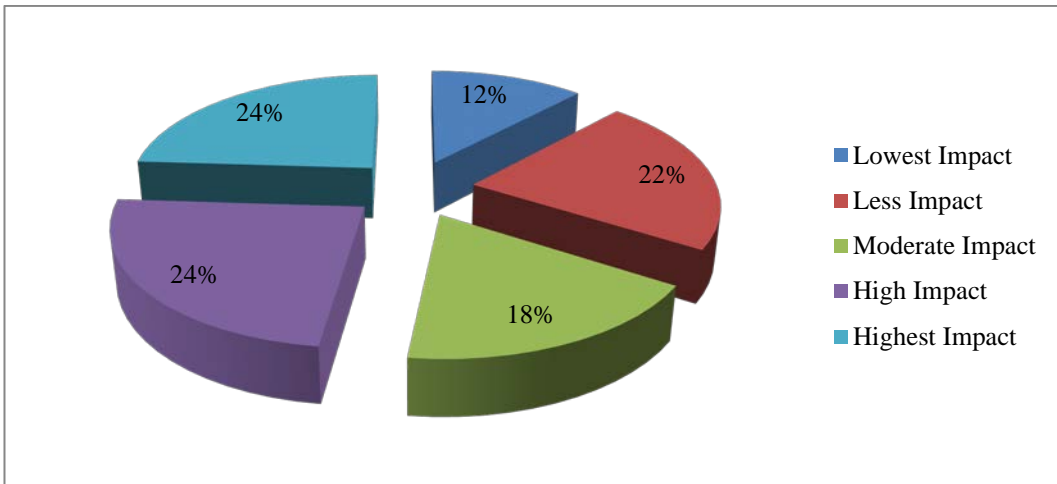


Figure 5-21: Impact of Lack of Advanced Signage of B084 Road

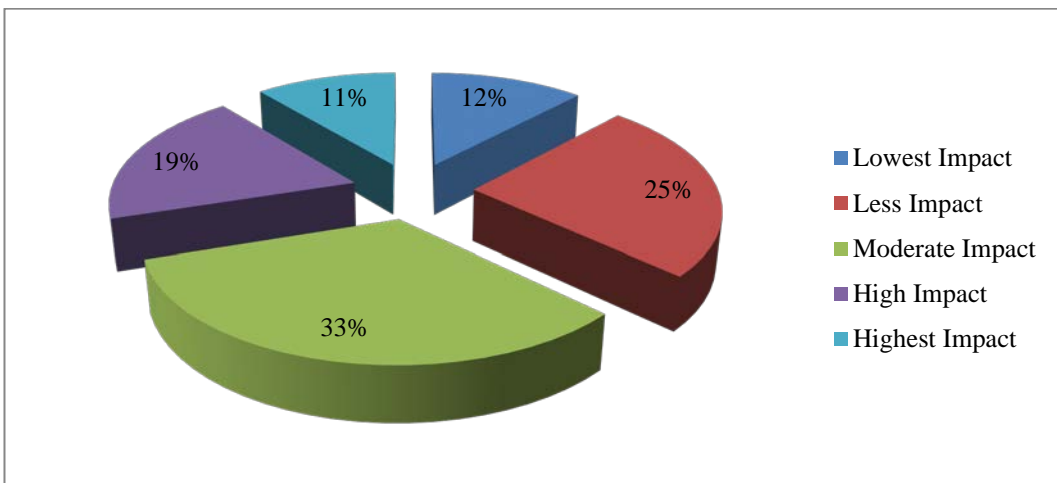


Figure 5-22: Impact of Lack of Advanced Signage of B084 Road

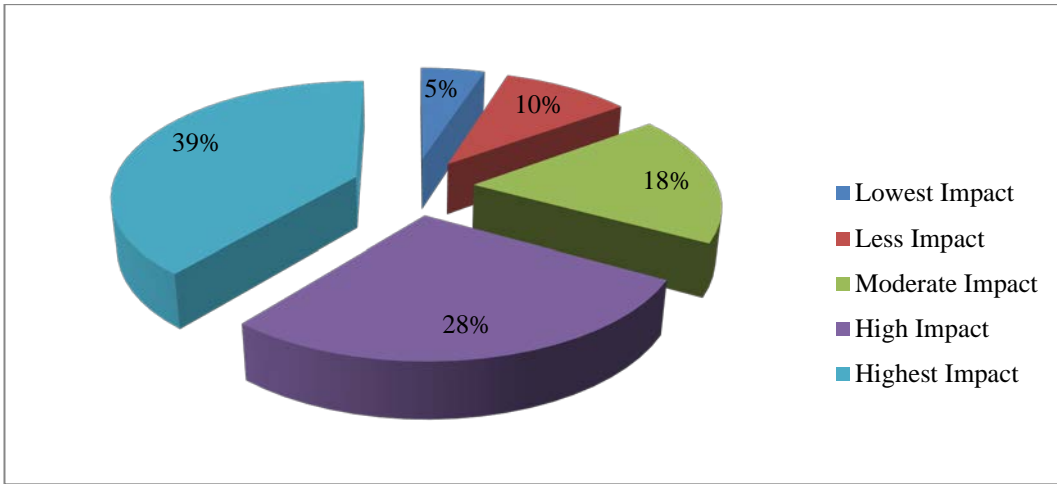


Figure 5-23: Impact of Lack of Advanced Signage of B084 Road

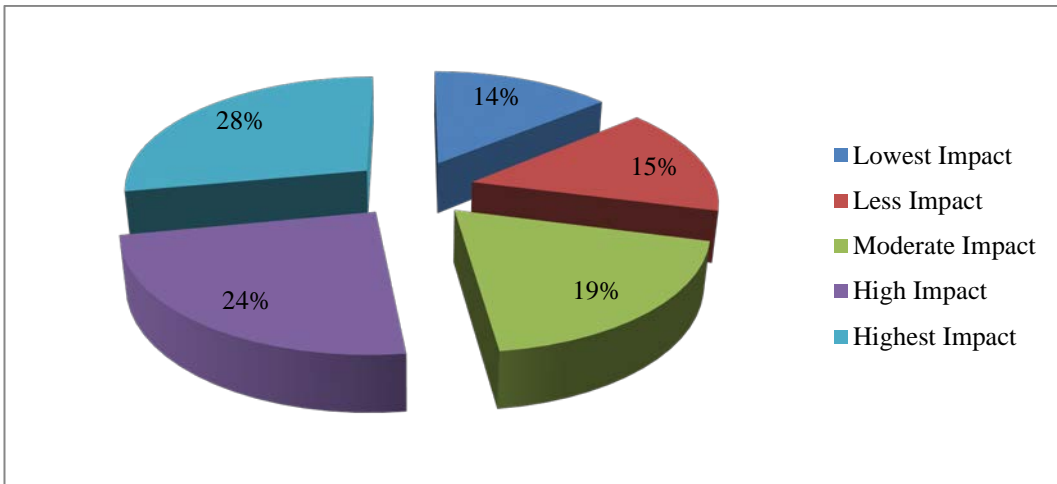


Figure 5-24: Impact of Lack of Advanced Signage of B084 Road

Recommendations

Most of the responders have stated that the lighting arrangements should be improved during the construction works at the night times due to low visibility. Moreover, the pavement condition and the lack of experienced traffic controllers have been highlighted from the questionnaire survey.

The table below shows the responses received.

Table 5-3: Recommendations to Minimize Inconveniences in A002 Road as per the responses received

Recommendation	Least Recommended	Less Recommended	Moderately Recommended	Recommended	Highly Recommended
Response	1	2	3	4	5
Allocate experienced traffic controllers	8%	18%	26%	23%	25%
Place sign boards well advance	11%	29%	15%	26%	19%
Maintain pavement in motorable condition	18%	19%	19%	23%	21%
Place speed humps to control the speed	45%	38%	15%	2%	0%
Properly demarcate construction boundaries	15%	19%	29%	22%	15%
Spray water frequently to prevent dust generation	11%	20%	18%	29%	22%
Improve lighting during night time	6%	9%	22%	29%	34%
Provide safe passage for pedestrians	19%	28%	28%	12%	13%
Provide priority for public transport vehicles	4%	9%	21%	27%	39%
Use blinkers at night	9%	12%	26%	24%	29%

5.2 Questionnaire for Residents/ Business Places

A separate questionnaire survey had been conducted among the nearby residents and business place workers regarding the inconveniences they experienced during the road construction works.

5.2.1 B120 Road

Out of the total respondents of 176 nos., 57 were business places, and the remainder was nearby residents. All of them had vehicle accesses for their premises.

Out of 176 nos. residents interviewed, 97 nos. residents had vehicle parking facilities for 1~2 spaces. 58 nos. had parking space for 3~5 vehicles and the remainder had space for more than 5 nos. vehicles. Similarly, out of 57 business places, 18 nos. had space for only 1~2 vehicles, 19 nos. had space for 3~5 vehicles and others had space for more than 5 nos. vehicles.

Types of Inconveniences Experienced

Damages to their accesses, interruptions to the utility lines, and dust generations could be identified as the major problems the residents and business places had to be experienced due to the road construction activities. The Figure 5-25 shows the variation of the responses received during the questionnaire survey.

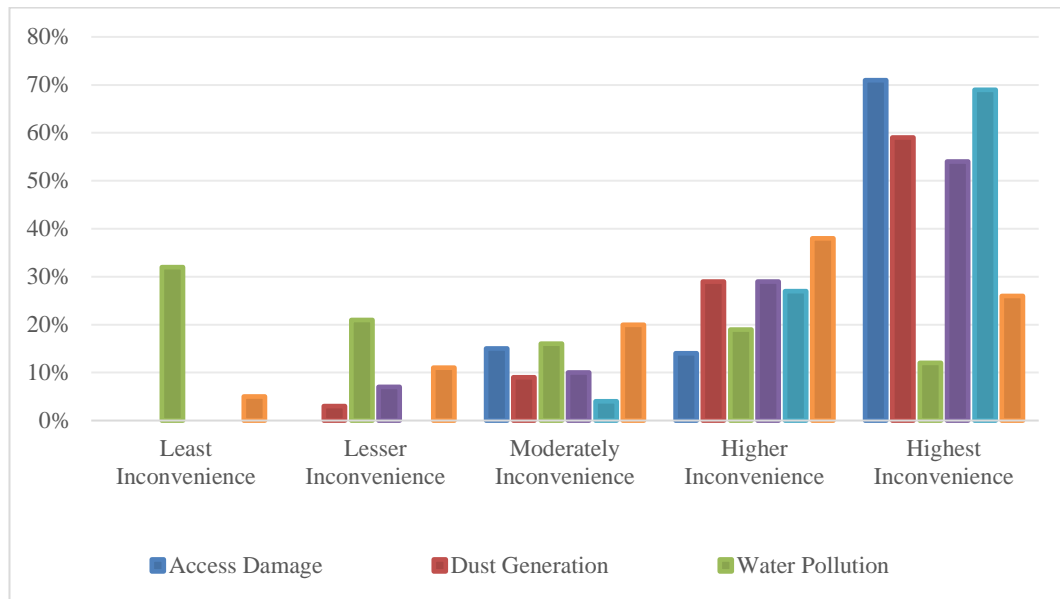


Figure 5-25: Responses in Impact of Inconveniences of B120 Road

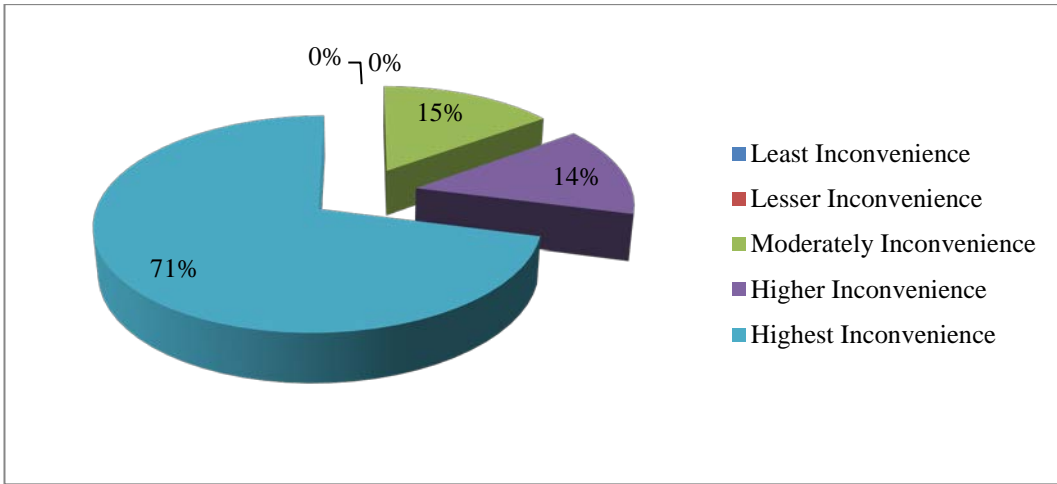


Figure 5-26: Inconveniences due to Access Damages of A002 Road

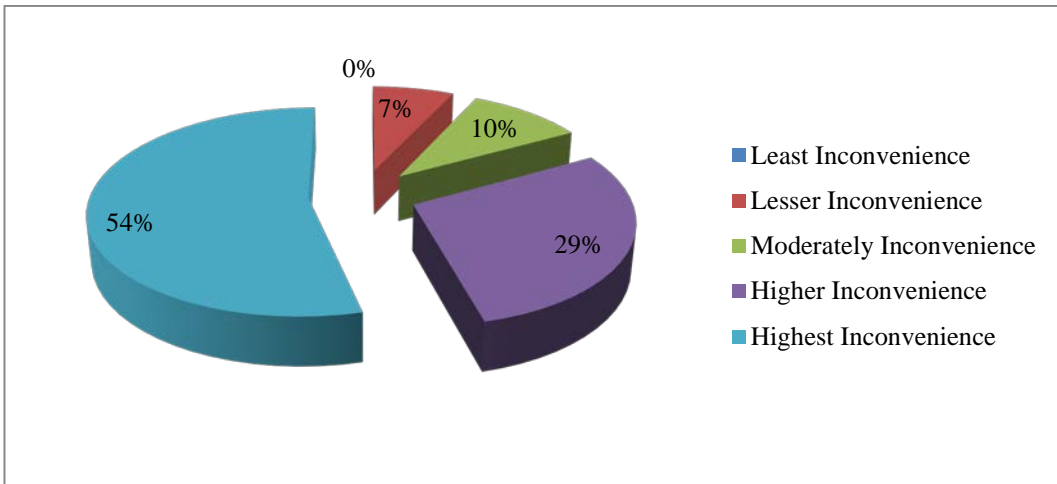


Figure 5-27: Inconveniences due to Access Damages of A002 Road

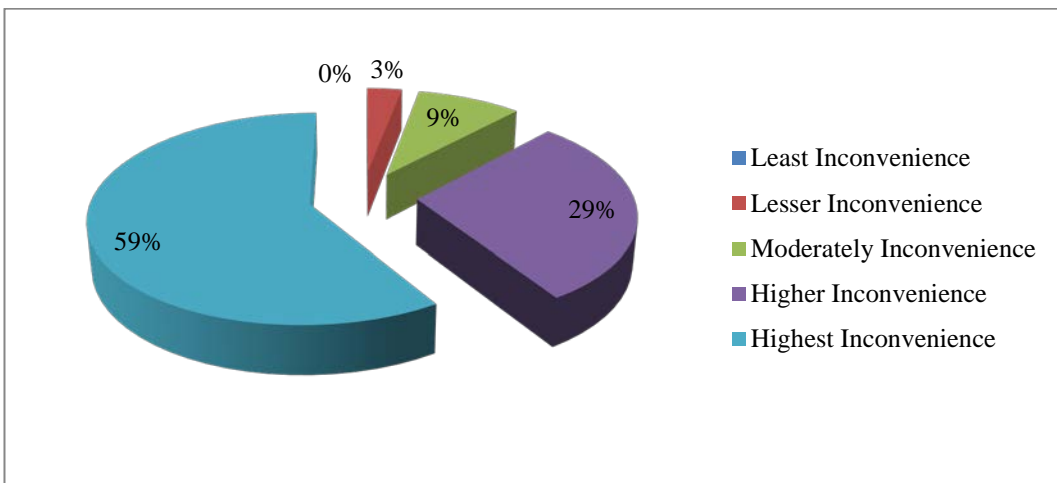


Figure 5-28: Inconveniences due to Dust Generation of A002 Road

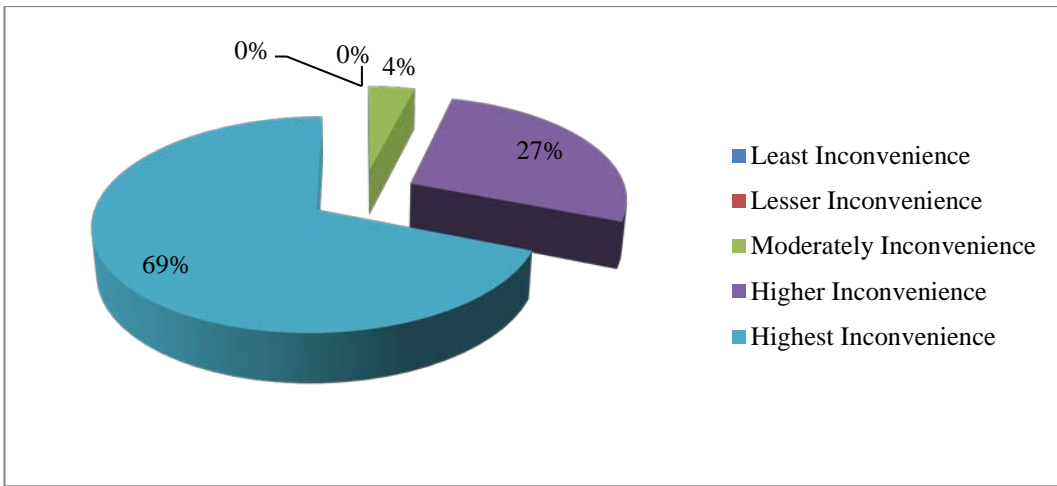


Figure 5-29: Inconveniences due to Utility Interruptions of A002 Road

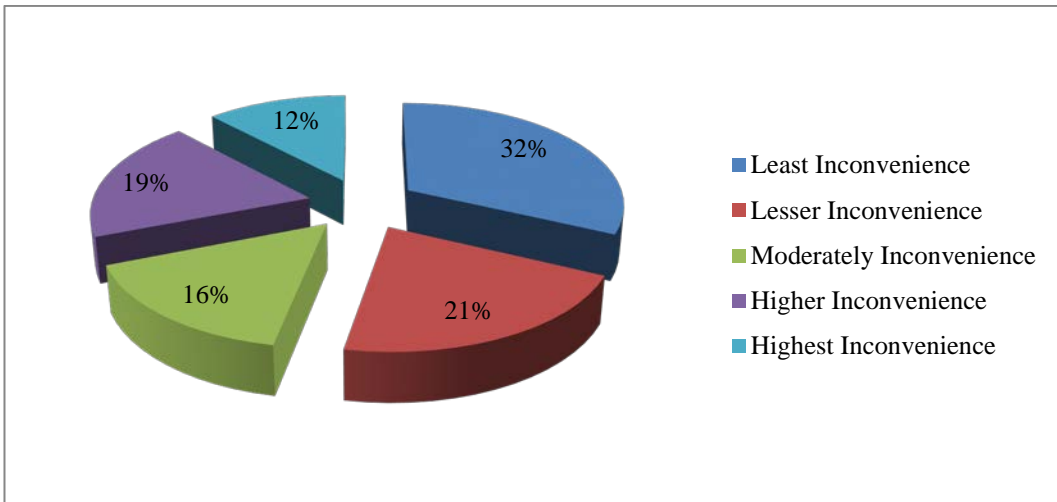


Figure 5-30: Inconveniences due to Water Pollution of A002 Road

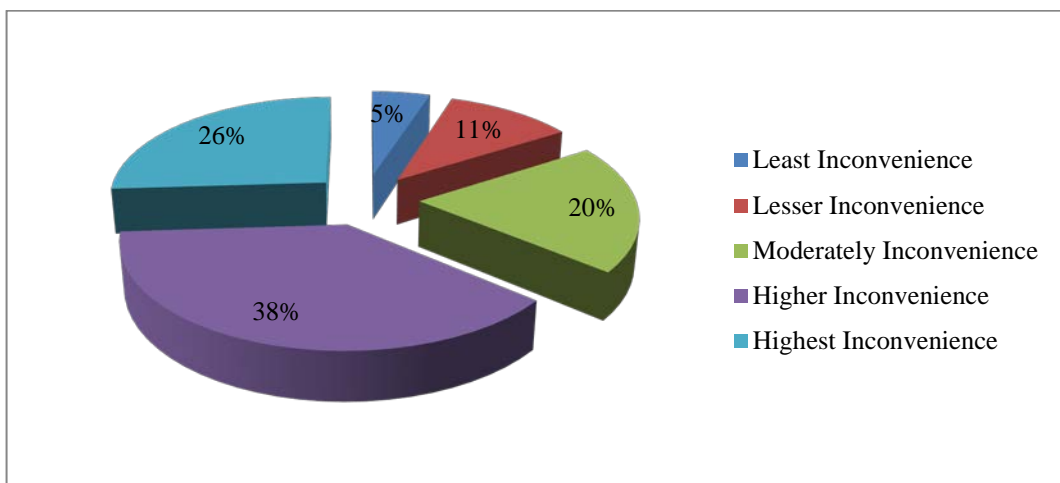


Figure 5-31: Inconveniences due to Noise of A002 Road

Complains on inconvenience

Out of total responses received, only 14 nos. have made official complains regarding the inconveniences they faced. Out of them, 3 nos. complains have been made verbally to the contractor, 4 nos. complains have been made to the Engineer/Employer as a letter, and the remainder have been made in written to the contractor. However, out of the all complaints, only 67% of them were highly satisfied on the solutions provided.

5.2.2 B084 Road

Out of the total respondents of 103 nos., 46 were business places, and the remainder was nearby residents. All of them had vehicle accesses for their premises.

Out of 57 nos. residents interviewed, 36 nos. residents had vehicle parking facilities for 1~2 spaces. 13 nos. had parking space for 3~5 vehicles and the remainder had space for more than 5 nos. vehicles. Similarly, out of 46 business places, 16 nos. had space for only 1~2 vehicles, 22 nos. had space for 3~5 vehicles and others had space for more than 5 nos. vehicles.

Types of Inconveniences Experienced

Damages to their accesses, interruptions to the utility lines, and dust generations could be identified as the major problems the residents and business places had to be experienced due to the road construction activities. The Figure 5-32 shows the variation of the responses received during the questionnaire survey.

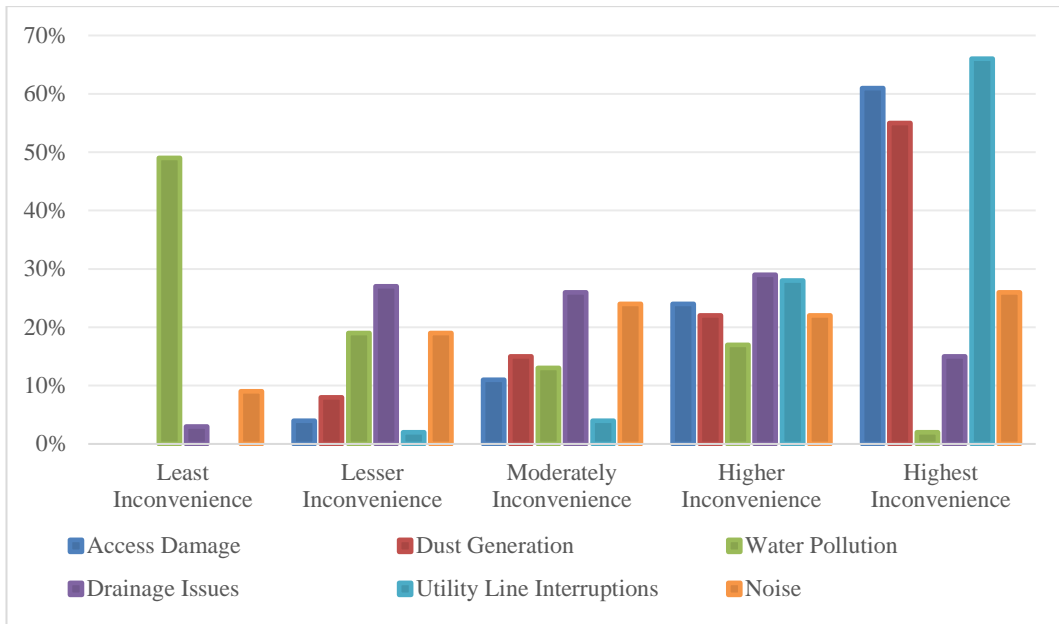


Figure 5-32: Responses in Impact of Inconveniences of B084 Road

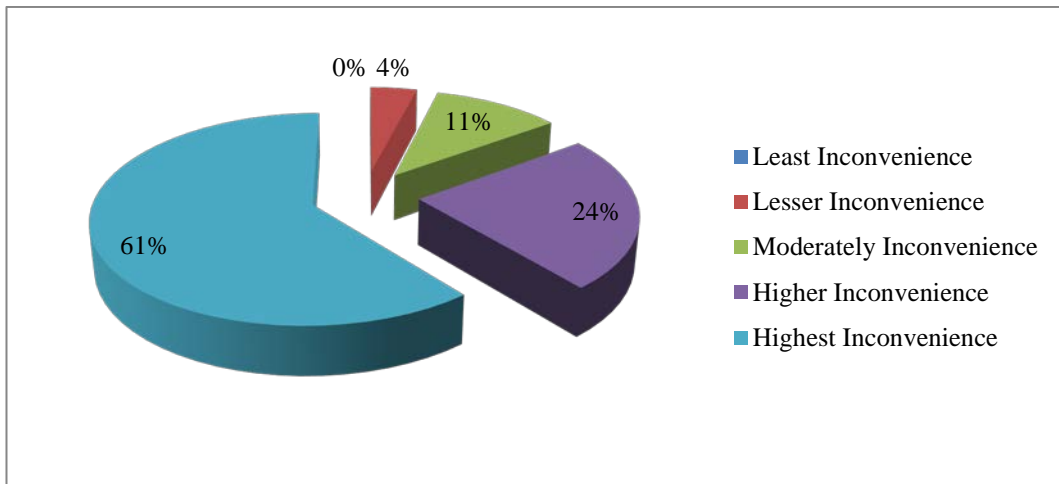


Figure 5-33: Inconveniences due to Access Damages of B084 Road

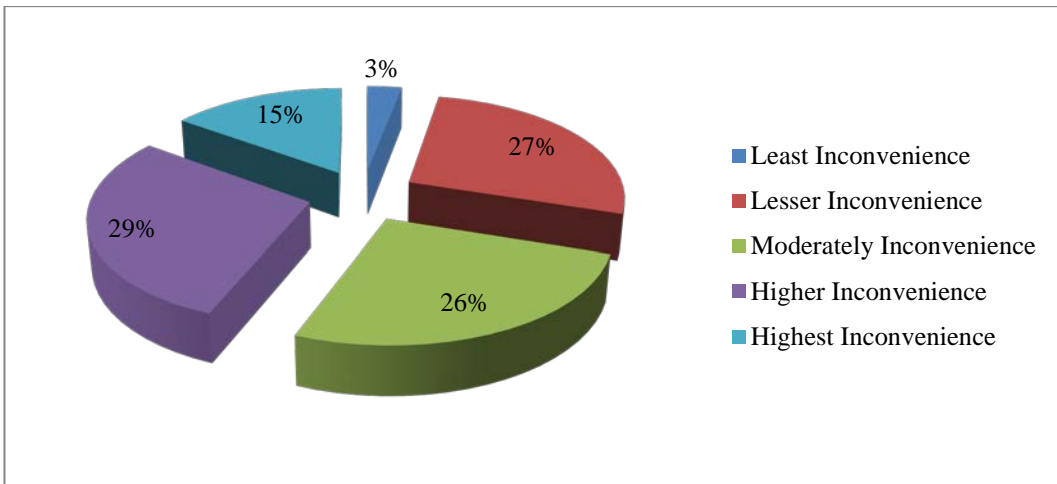


Figure 5-34: Inconveniences due to Drainage Issues of B084 Road

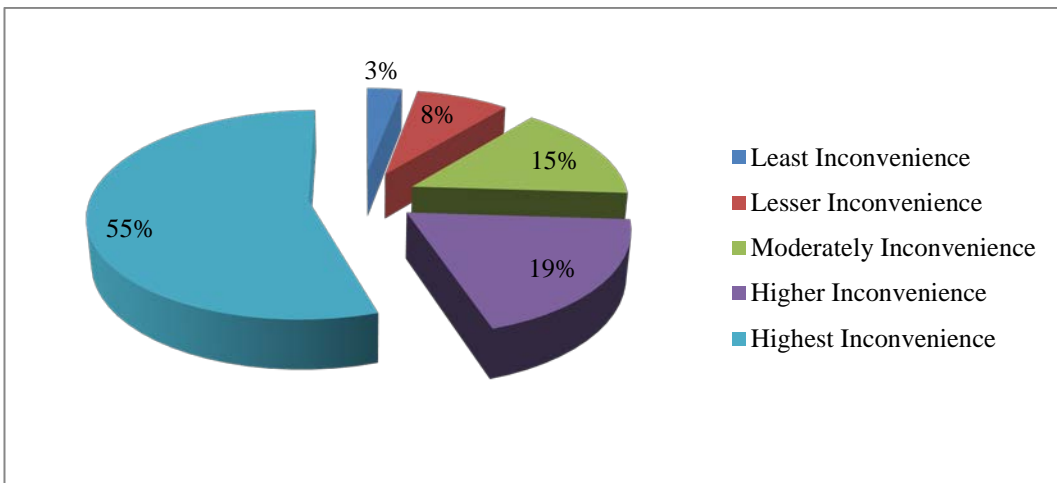


Figure 5-35: Inconveniences due to Dust Generation of B084 Road

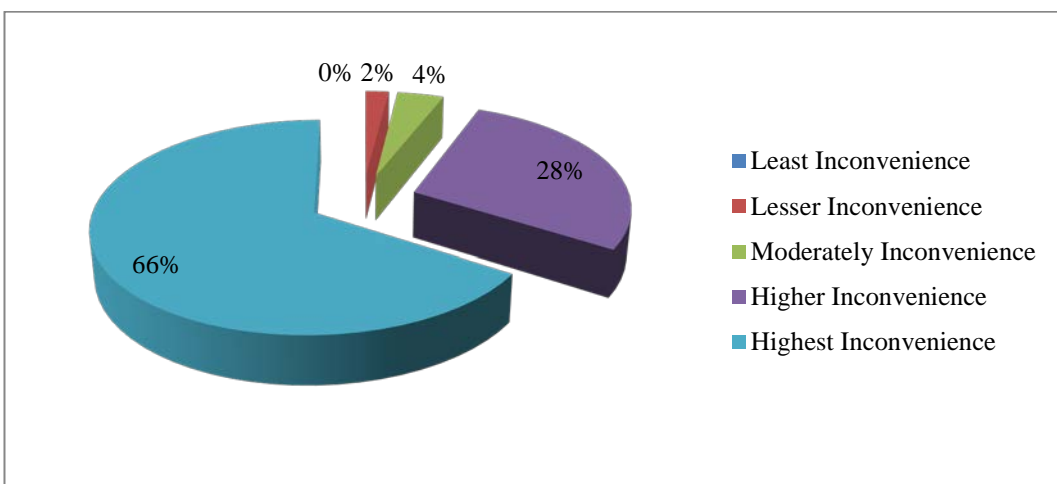


Figure 5-36: Inconveniences due to Utility Interruptions of B084 Road

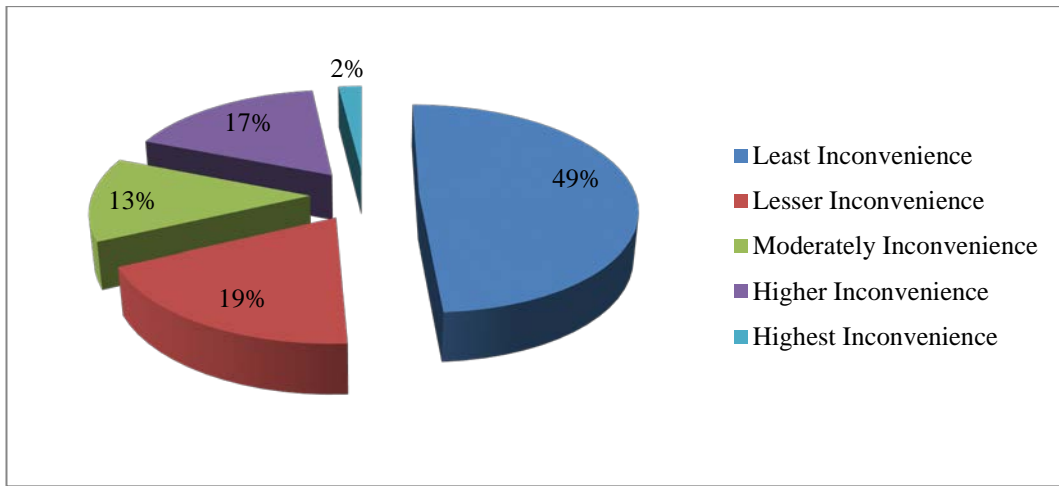


Figure 5-37: Inconveniences due to Water Pollution of B084 Road

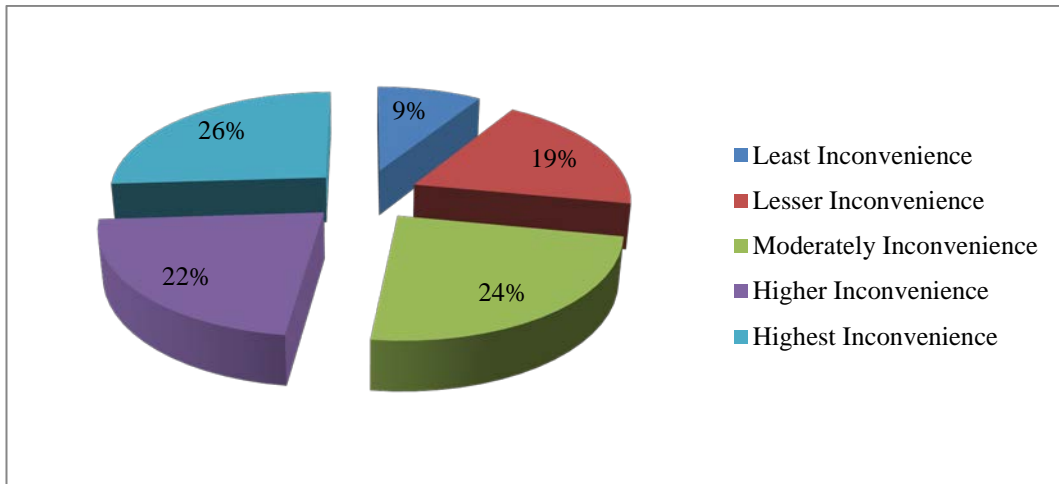


Figure 5-38: Inconveniences due to Noise of B084 Road

Complains on inconvenience

Out of total responses received, only 26 nos. have made official complains regarding the inconveniences they faced. Out of them, 7 nos. complains have been made verbally to the contractor, 9 nos. complains have been made to the Engineer/Employer verbally, and the remainder have been made in written to the contractor. However, out of the all complaints, 57% of them were unsatisfied on the solutions they were provided.

5.2.2 A002 Road

169 nos. persons have been interviewed during this questionnaire survey. Out of them, 67 were nearby residents, and the remainder was business places. All of them had vehicle accesses for their premises.

Out of 67 nos. residents interviewed, 40 nos. residents had vehicle parking facilities for 1~2 spaces. 11 nos. had parking space for 3~5 vehicles and the remainder had space for more than 5 nos. vehicles. Similarly, out of 102 business places, 32 nos. had space for only 1~2 vehicles, 57 nos. had space for 3~5 vehicles and others had space for more than 5 nos. vehicles.

Types of Inconveniences Experienced

Damages to their accesses, interruptions to the utility lines, and dust generations could be identified as the major problems the residents and business places had to be experienced due to the road construction activities. The Figure 5-39 shows the variation of the responses received during the questionnaire survey.

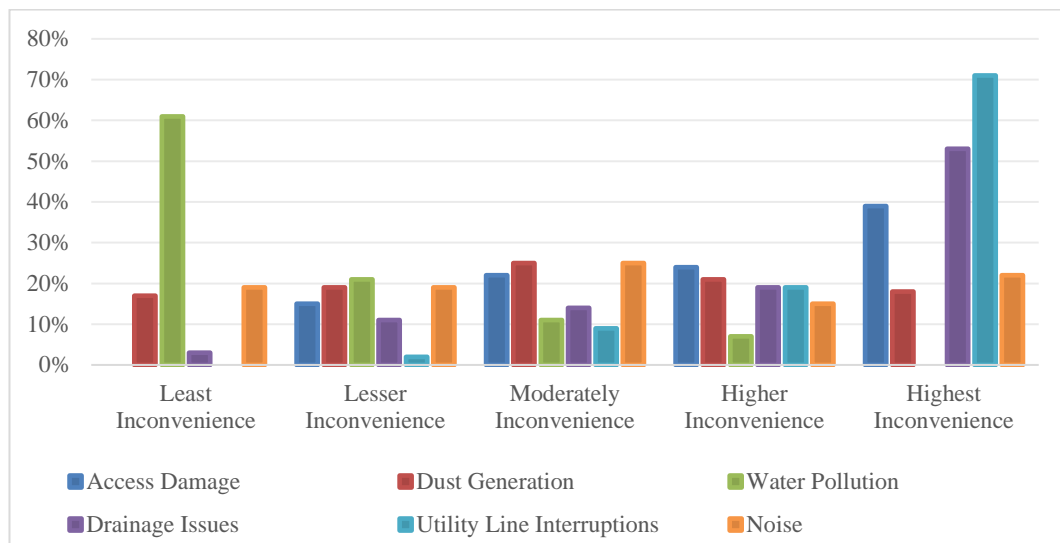


Figure 5-39: Responses in Impact of Inconveniences of A002Road

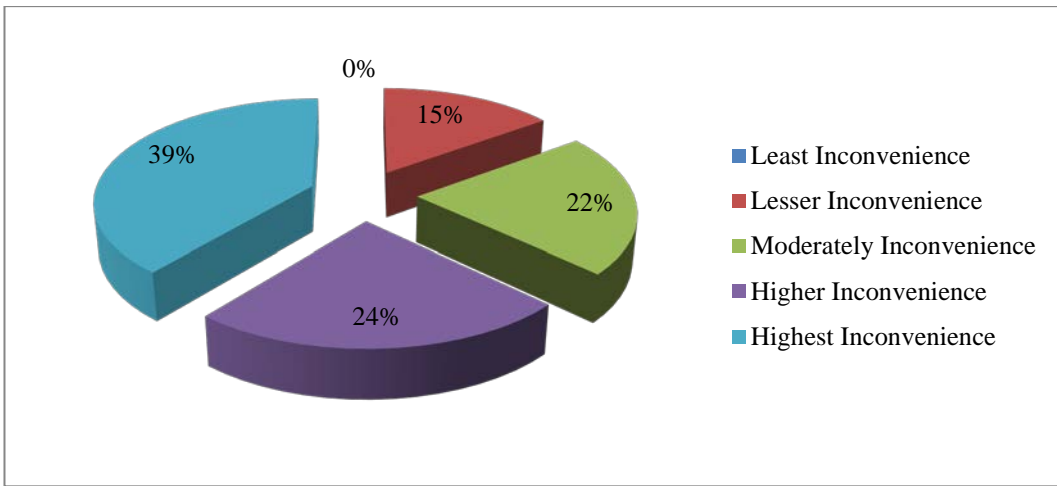


Figure 5-40: Inconveniences due to Access Damages of A002 Road

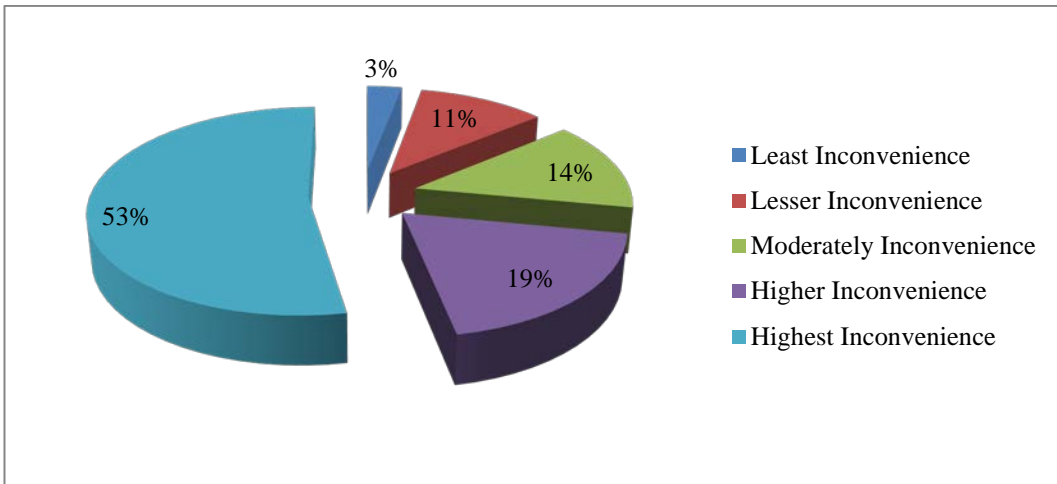


Figure 5-41: Inconveniences due to Drainage Issues of A002 Road

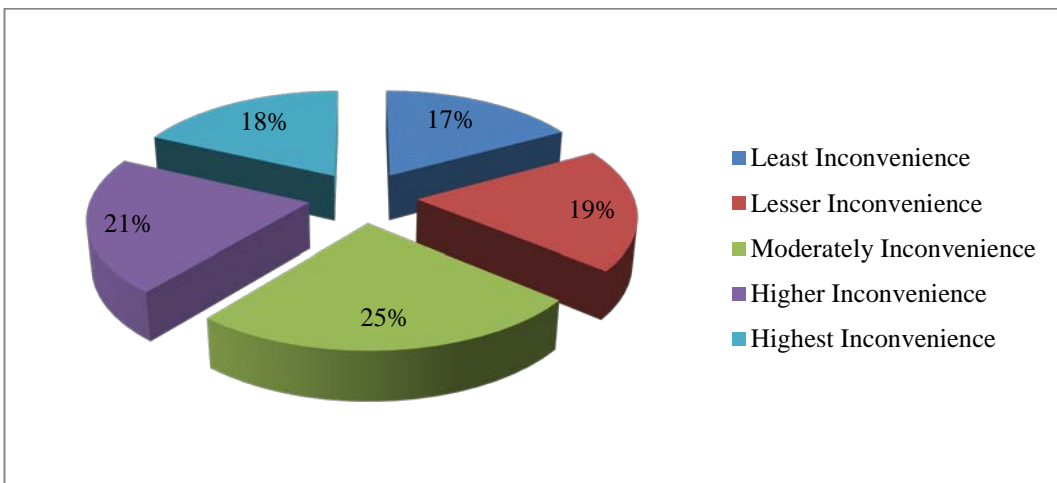


Figure 5-42: Inconveniences due to Dust Generation of A002 Road

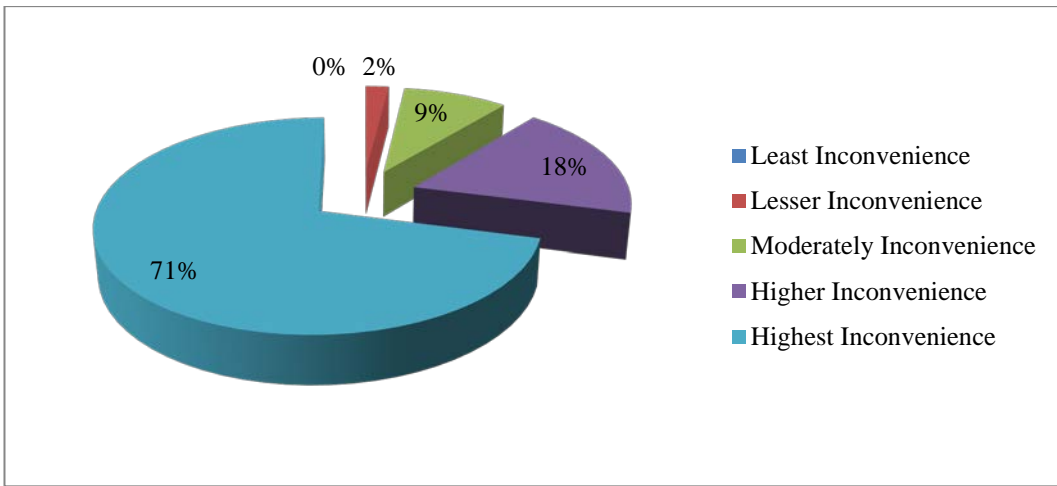


Figure 5-43: Inconveniences due to Utility Interruptions of A002 Road

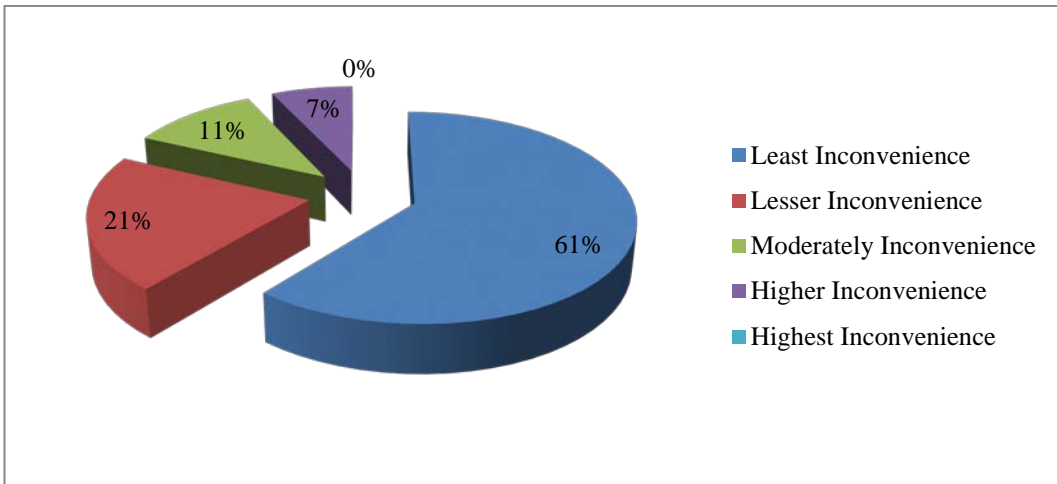


Figure 5-44: Inconveniences due to Water Pollution of A002 Road

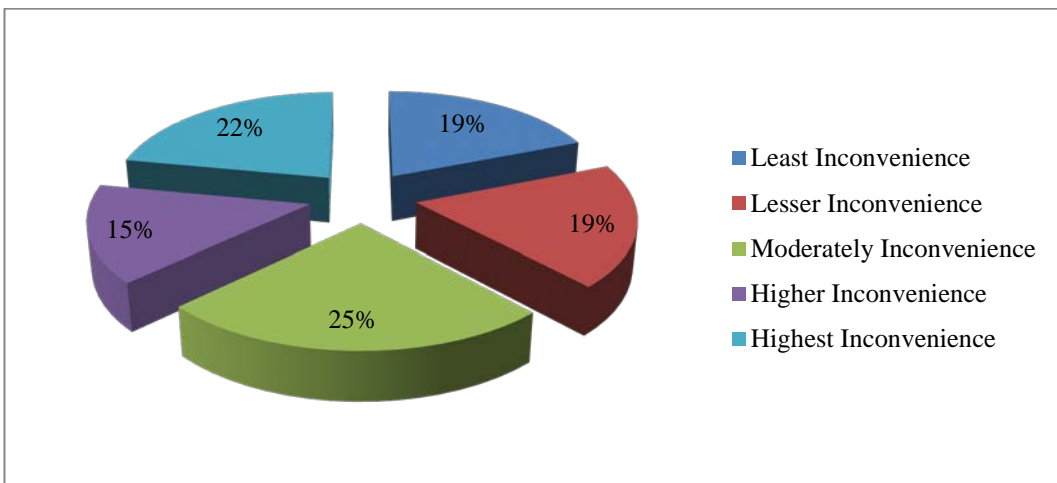


Figure 5-45: Inconveniences due to Noise of A002 Road

Complains on inconvenience

Out of total responses received, 11 nos. have made official complains regarding the inconveniences they faced. Out of them, 6 nos. complains have been made verbally to the contractor, and the remainder have been made in written to the contractor. However, out of the all complaints, 82% of them were unsatisfied on the solutions they were provided.

5.3 Comparison of Responses for Each Road based on Road User Responses

5.3.1 Dust Generation as an Inconvenience

The figure 5.46 shows that most of the responders on B20 road had believed that dust generation would have a significant impact while most of responders of A002 believed that dust generation does not have a higher impact.

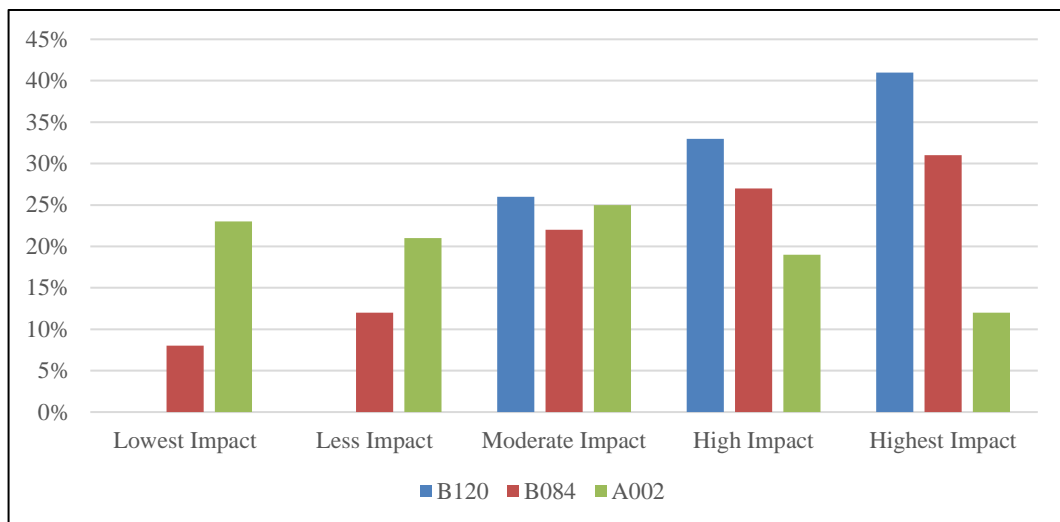


Figure 5-46: Comparison of Dust Generation as an Inconvenience

5.3.2 Possible Damages to Vehicles as an Inconvenience

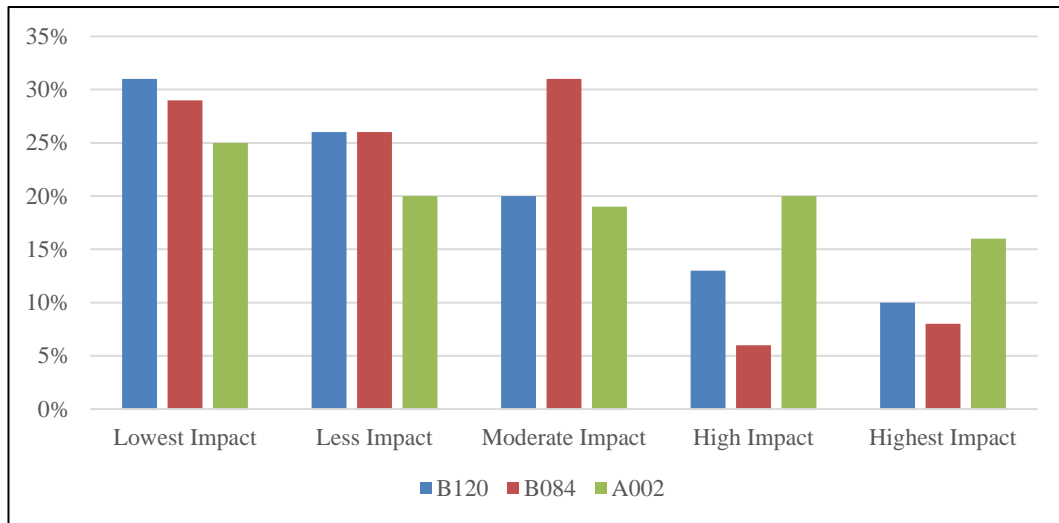


Figure 5-47: Comparison of Possible Damages to Vehicles as an Inconvenience

The figure 5-47 shows that in general, possible damages to the vehicles is not believed to be a significant factor on all these selected road stretches. However, it could be visible that most of B120 road users have believed that their vehicles would not be damaged during the road construction activities. Moreover, it indicates that most of A002 road users had an idea that possible damages to their vehicles as a significant factor.

5.3.3 Inadequate Safety Arrangements as an Inconvenience

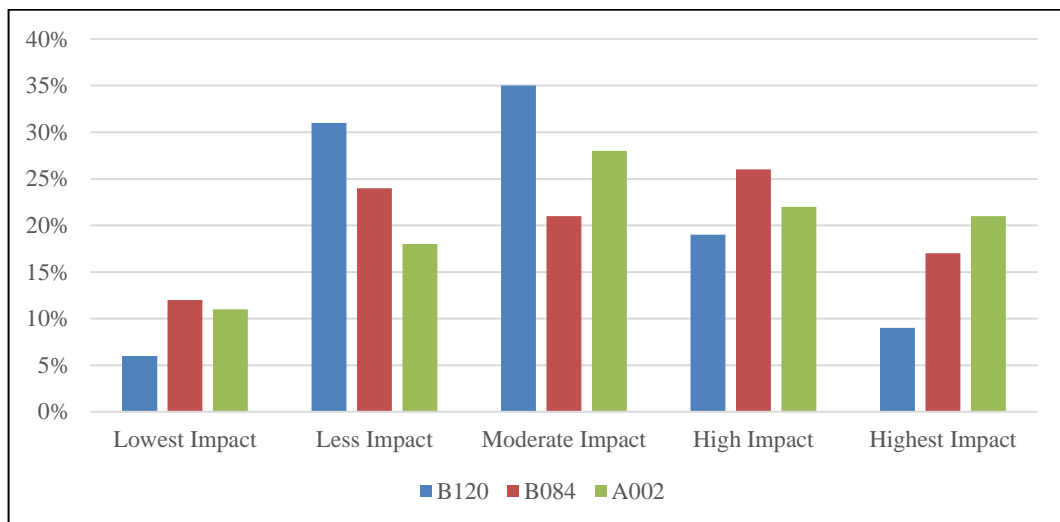


Figure 5-48: Comparison of Inadequate Safety Arrangements as an Inconvenience

The figure 5-48 shows that most of the road users of all the selected road stretches believed that the impact on inadequate safety arrangements is very less. But among them, road users of A002 have believed the impact is relatively high.

5.3.4 Incapable Traffic Controllers as an Inconvenience

The figure 5-49 shows that road users of B004 have experienced relatively higher impact due to incapable traffic controllers. B120 road users have moderately experienced inconveniences due to incapable traffic controllers during the works zone management.

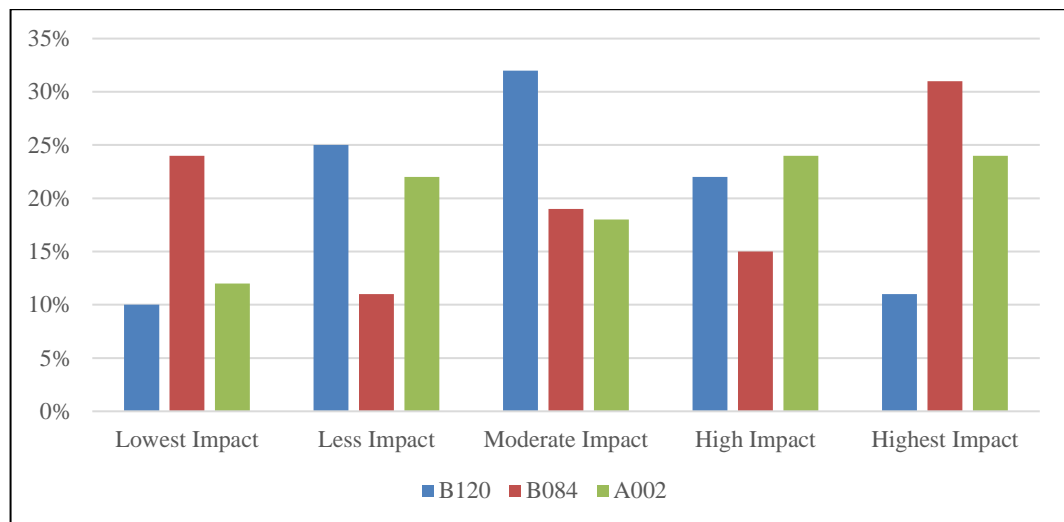


Figure 5-49: Comparison of Incapable Traffic Controllers as an Inconvenience

5.3.5 Road Side Friction as an Inconvenience

The figure 5-50 shows that most of the road users of all three selected work zones have believed that the road side friction would not have a significant impact as an inconvenience. Especially the road users of B120 road have believed that the impact on same is very insignificant.

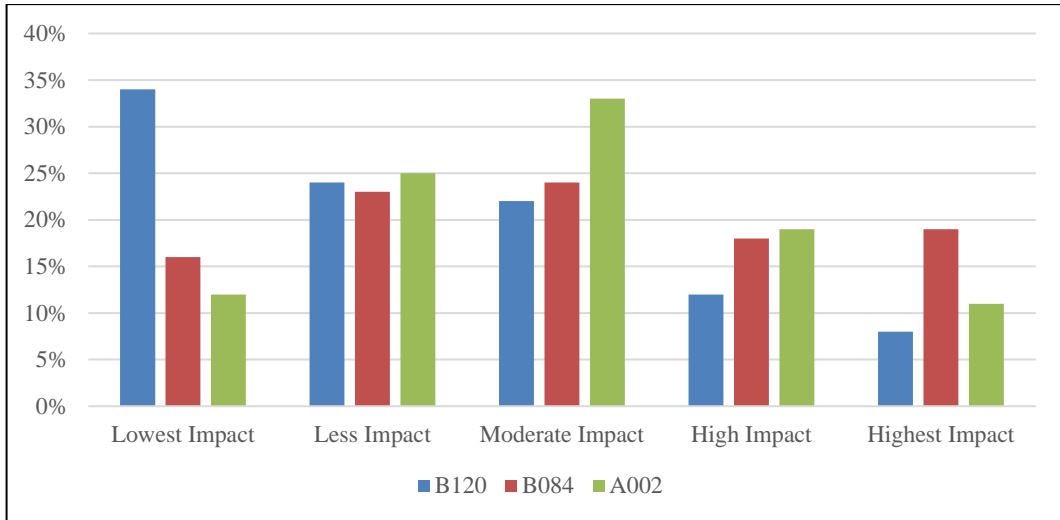


Figure 5-50: Comparison of Road Side Friction as an Inconvenience

5.3.6 Increment of Travel Time as an Inconvenience

As per figure 5-51, almost all the responders of all three selected work zones have believed that the increment of travel time during the construction activities has the highest impact as a user inconvenience. Therefore it is quite clear that increment of travel time is the major cause of inconvenience.

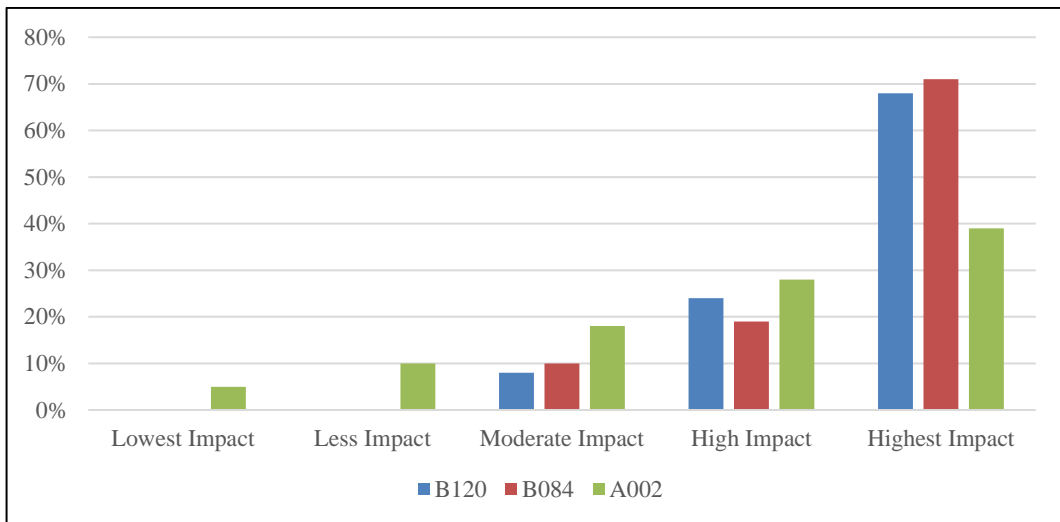


Figure 5-51: Comparison of Increment of Travel Time as an Inconvenience

5.3.7 Lack of Advanced Signage as an Inconvenience

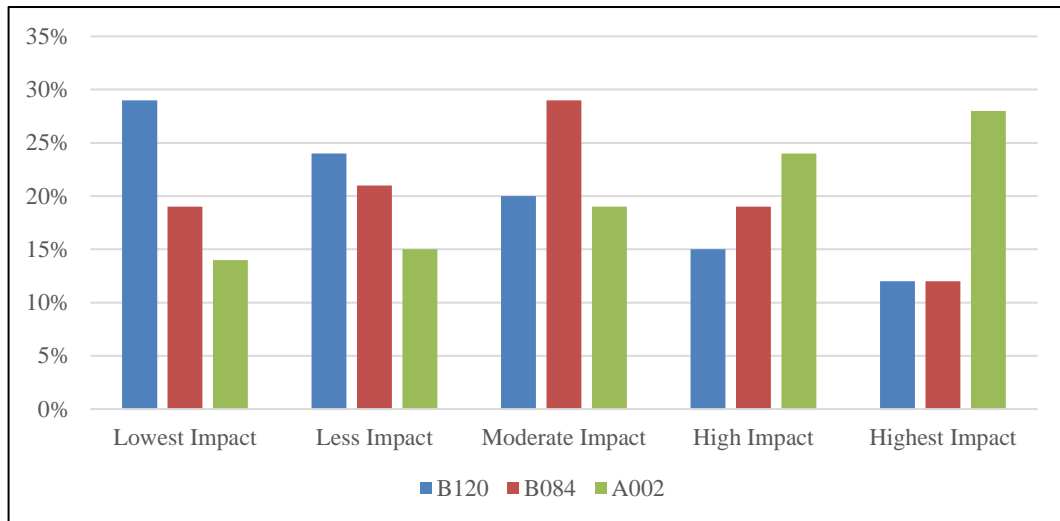


Figure 5-52: Comparison of Lack of Advanced Signage as an Inconvenience

The figure 5-52 shows that the responders of A002 road had believed that lack of advanced signage has a higher impact while most of the B120 road users have believed otherwise.

5.3.8 Overall Comparison and Possible Reasons

The highest impact (most significant factor of inconvenience) of all the selected road sections could be identified as 'Increment of Travel Time' by the close observation of the above charts. Out of the responders of the questionnaire surveys,

- 68% of B120 Road users
- 71% of B084 Road users
- 39% of A002 Road users

Believed that the increment of travel time as the most significant inconvenience. The major reasons for the increment of travel times in B120 road section could be listed as inadequate space for traffic lanes during the road construction activities since this road stretch is a 2 lane single carriageway. In contrast, since A002 road stretch has 3 lanes for either directions, only 39% of responders believed increment of travel time as most significant factor.

The figure 5-53 shows the comparison of highest impact of each road section.

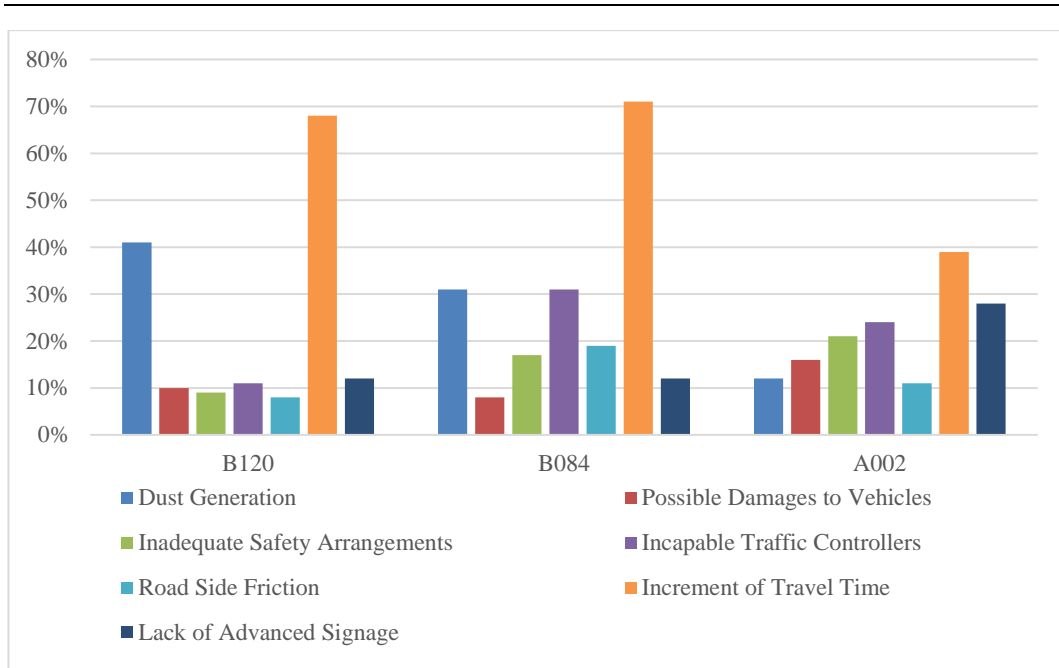


Figure 5-53: Comparison of Highest Impact on Each Road

When the questionnaire survey records are compared for each of the road stretch selected, the following factors could be identified as minimal effects on road users;

- Possible damages to vehicles
- Inadequate safety arrangements
- Road side friction

Since all the selected road sections were maintained in motorable conditions, most road users were in the opinion that possibilities of their vehicles being damages is minimal.

Even though several shortcomings were observed in safety arrangements, the road users have not identified those deficiencies due to their lack of knowledge on safety guidelines. The road users might have thought that the provided safety arrangements were within the guidelines/ standards.

Road side friction also has not identified by the road users since most of them were not aware of this scenario. The material storage, road side works etc. definitively should have affected the traffic flow. But the drivers could not identify this affect. Therefore they have not believed road side friction as a major inconvenience.

Similarly, the following factors could be identified as moderately significant for the selected road stretches.

- Dust generation
- Incapable traffic controllers
- Lack of advanced signage

Dust generation was significant in B120 road section and B084 road section since the contractors had to keep the base layer exposed to traffic for several days because they could not achieve the required compaction. The major reason for this scenario is the vibration of tandem rollers could not be used for compaction because of the adjoining buildings. The building walls/ boundary walls could have been cracked/ collapsed if the vibration is used. Once the exposed ABC layer become dried, dust generation was enormous.

Allocation of incapable/ inexperienced traffic controllers had affected the traffic especially in B084 and A002. At the times of single pile traffic is allowed within a certain stretch, the traffic controllers could have communicated with each other to determine stop/ go. They should have used the stop/ go sign with additional blinker lights, etc. But lack of experience/ knowledge on traffic management affected the traffic flow in those projects.

Lack of advanced signage had been considered as a major inconvenience only on A002 road. This may be due to shortcomings of sign board placing specially during lane closures of this 6 lane road sections. Once the drivers encounter a sudden lane closures without any advanced sign boards, they would have stranded all of a sudden. However, since B120 and B084 road stretches are 2 lane and 4 lane respectively, the effect on drivers on sudden lane closure would be minimal.

The impacts comparison of each incontinence of each factor is shown in Figure 5-54.

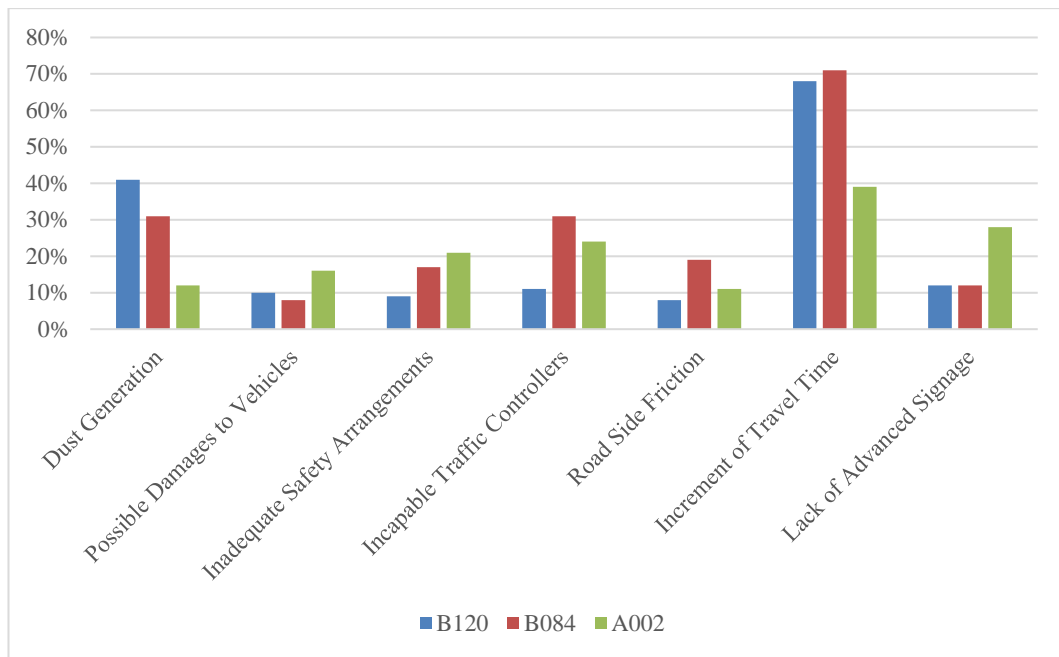


Figure 5-54: Comparison of Inconvenience of Each Factor

5.3.9 Ranking of Road User Inconveniences

Based on the responses received from the road users, their points of views were analyzed by assigning weights for the levels of the impacts they have experienced.

By the calculation of weighted averages across the selected road stretches, the inconveniences had been ranked by assigning them 'inconvenience points'.

The order of inconveniences according to the ranking is;

1. Increment of Travel Time (Points 19.40)
2. Dust Generation (Points 15.71)
3. Incapable Traffic Controllers (Points 14.07)
4. Inadequate Safety Arrangements (Point 13.89)
5. Lack of Advanced Signage (Points 13.17)
6. Road Side Friction (Points 12.21)
7. Possible Damages to Vehicles (Points 11.55)

The calculation of the ranking is provided as Annex 03.

5.4 Comparison of Responses for Each Road based on Responses from Residents and Business Places

5.4.1 Access Damages as an Inconvenience

The comparison of the responses from the residents and business place owners who considered the disturbances to their access as a major inconvenience is shown in Figure 5-55. It could be noticed that most of the responders have believed that they had to face difficulties due to access disturbances, especially in B120 road.

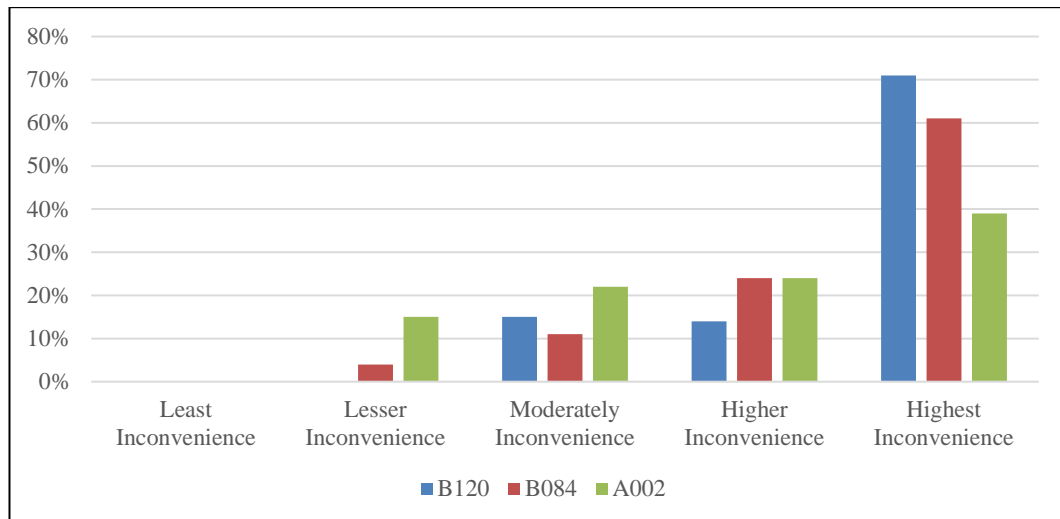


Figure 5-55: Comparison of Access Damages as an Inconvenience

5.4.2 Drainage Issues as an Inconvenience

Drainage issues is considered as a major difficulty faced in A002 road and B120 road. As per the following Figure 5-56, residents of B084 road had to face comparatively less inconveniences.

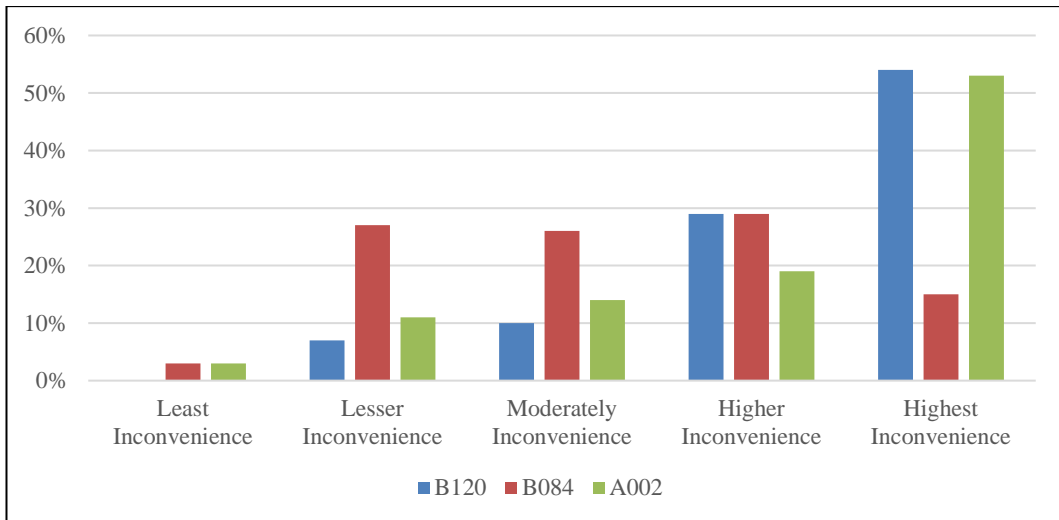


Figure 5-56: Comparison of Drainage Issues as an Inconvenience

5.4.3 Dust Generation as an Inconvenience

Generation of excessive dust during construction activities seemed to be a very noticeable inconvenience in B120 road and B084 road projects as per the Figure 5-57. However, most of the A002 road residents had mixed inconveniences.

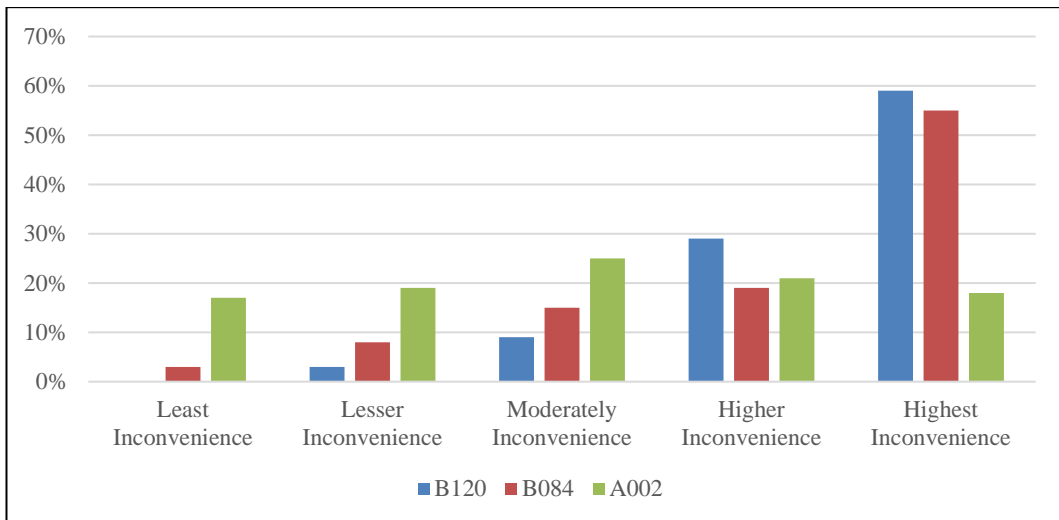


Figure 5-57: Comparison of Dust Generation as an Inconvenience

5.4.4 Utility Interruptions as an Inconvenience

It could be clearly identified that most of the responders of all considered projects have believed that the continuous interruptions of the utilities (i.e.: electricity, water, telephone, internet etc.) has the highest impact on their day to day life as per Figure 5-58.

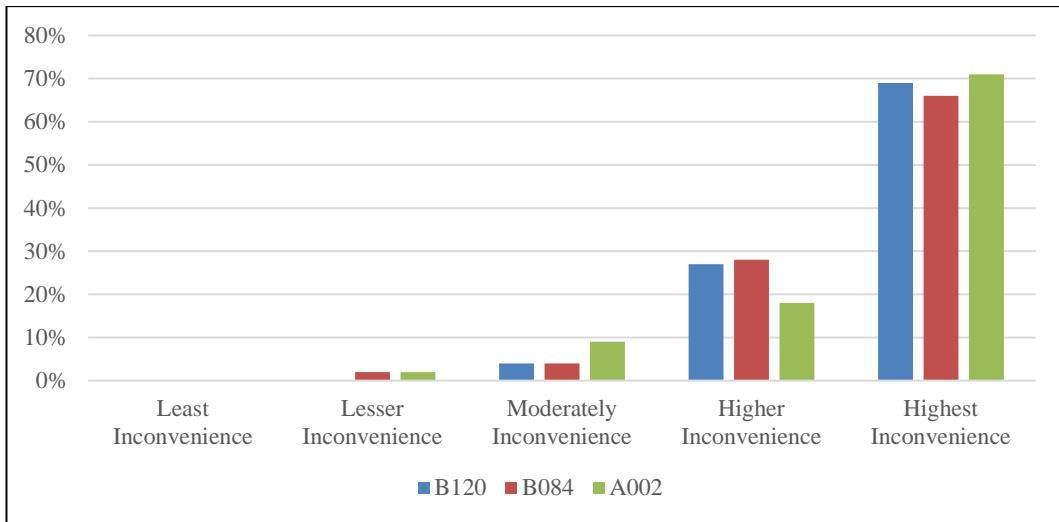


Figure 5-58: Comparison of Utility Interruptions as an Inconvenience

5.4.5 Water Pollution as an Inconvenience

As per Figure 5-59, majority of the responders of all considered work zones have considered project had believed that water source pollution had less impact on them.

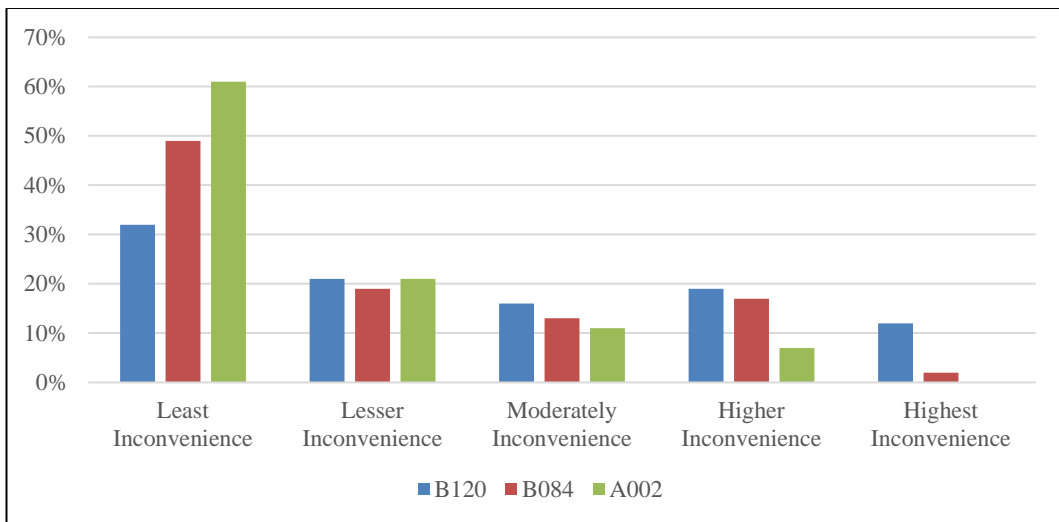


Figure 5-59: Comparison Water Pollution as an Inconvenience

5.4.6 Noise as an Inconvenience

The excessive noise generation could be noticed in almost all the work zones during the construction activities. However, as per Figure 5-60, the responders had experienced mixed levels of inconveniences on noise generation.

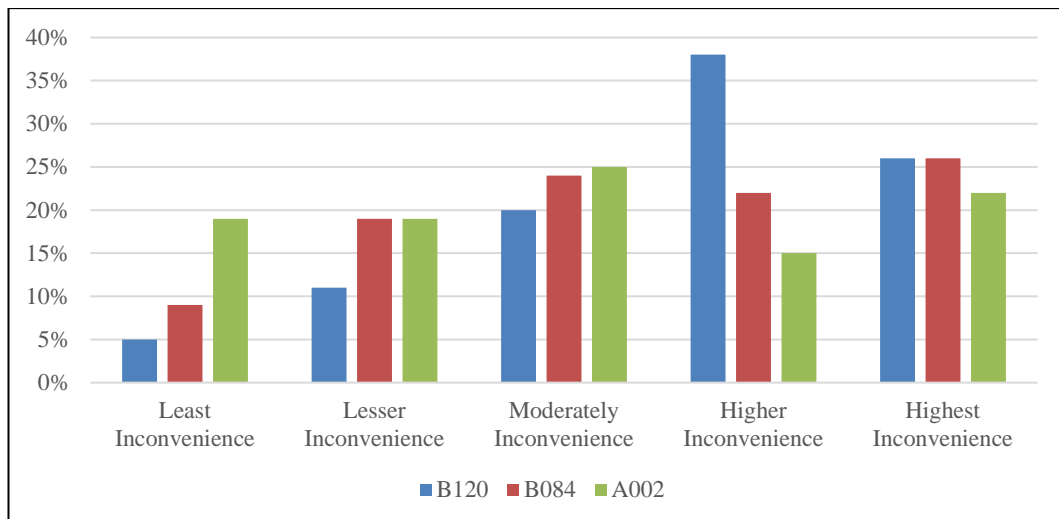


Figure 5-60: Comparison of Noise as an Inconvenience

5.4.7 Overall Comparison and Possible Reasons

According to the questionnaire surveys, it could be identified that the most significant inconvenience caused to the residents/ business places is ‘Interruption of Utility Services’.

- 69% of B120 Road users
- 66% of B084 Road users
- 71% of A002 Road users

have believed that utility interruptions are affecting their day-to-day life.

The main reasons for their opinions could be identified as;

- Interruptions/ damages to water supply pipe lines
- Interruptions/ damages to electrical supply lines
- Interruptions/ damages to telecommunication lines

In all these selected projects, the residents/ business places were not informed on the planned interruptions in advance. Therefore they could not plan their work accordingly. Moreover, the lack of skilled workers, spare parts, tools, equipment and alertness resulted in delays on rectifications of damages of utility lines. The non-availability of reliable as-built drawings has resulted several damages of underground utility lines.

The Figure 5-61 shows the comparison of impacts of each road section.

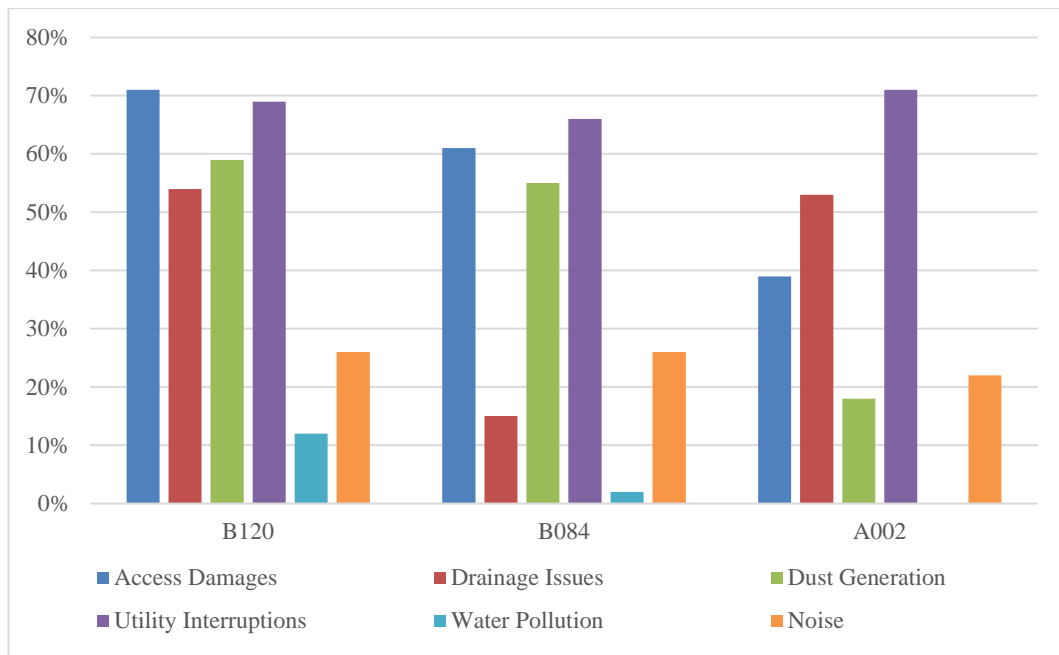


Figure 5-61: Comparison of Highest Impact on Each Road

Drainage issues found to be significant factor in B120 road and A002 road whereas it is minimal in B084 road. That may be due to the blockage of the existing side drains during construction activities in B120 and A002 roads. Regular maintenance and clearing blocked drains in A084 road have minimized the affect on residents.

Damages/ disturbances to the property accesses has affected the residents significantly. The highest inconvenience identified in B120 road is ‘access damages’. Similarly, 61% of B084 road and 39% of A002 road have identified access damages as a major inconvenience. During side drain constructions and foot-walk construction works, the existing accesses are being disturbs more often.

Water source pollution is identified as the least affected factor among all these projects. That may be due to the availability of pipe borne water in all these road stretches. Most of the residents and businesses are not taking water from wells. Therefore they might have not identified any pollution of water sources.

Nuisance due to noise generation during road works moderately affected the residents and businesses. Since most of noise generation activities were not allowed during the night times, the residents might not have experienced major incontinence. However, businesses have experienced nuisance due to excessive noise.

Comparison of degree of inconvenience of each factor is shown in Figure 5-62.

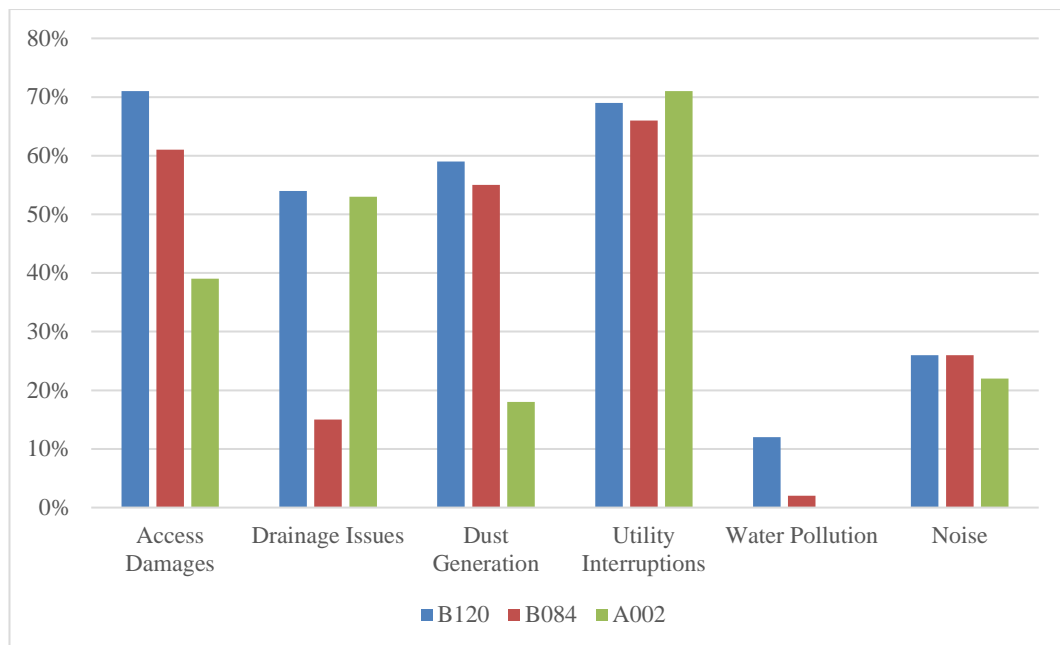


Figure 5-62: Comparison of Inconvenience of Each Factor

5.4.8 Ranking of Road User Inconveniences

Based on the responses received from the residents and businesses, their points of views were analyzed by assigning weights for the levels of the impacts they have experienced. By the calculation of weighted averages across the selected road stretches, the inconveniences had been ranked by assigning them ‘inconvenience points’. The calculation of the ranking is provided as Annex 04.

The order of inconveniences according to the ranking is;

1. Utility Interruptions (Points 20.94)
2. Access Damages (Points 19.37)
3. Drainage Damages (Points 17.73)
4. Dust Generation (Point 17.40)
5. Nuisance due to Noise (Points 15.19)
6. Water Pollution (Points 9.37)

6. ANALYSIS OF INCONVENIENCES

6.1 Prioritized list of Inconveniences

During the study, it was revealed that the road users and the nearby residents face enormous difficulties during the road rehabilitation projects. Even during the rehabilitation, the road users should have been provided the facilities with minimal disturbances. As described in the above chapters, the critical issues identified could be listed as below;

- I. Air pollution
- II. Noise pollution
- III. Travel time increment
- IV. Disturbances to the accesses
- V. Interruptions to the utility lines

The most of the above inconveniences could have been minimized with proper planning prior to the commencement of the activities.

6.2 Air Pollution

6.2.1 Dust Generation

During the study of the considered rehabilitation/ improvement projects, it was revealed that the most critical issue was air pollution, and mainly due to the excessive dust generation. Dust generation is enormous in following activities;

- Aggregate crusher, quarry operations
- Roadway excavation
- Subbase/ base construction
- Concrete and asphalt batching plant operations
- Stockpile operations
- Rock drilling and blasting

In addition, air pollution becomes increased due to poor maintenance of the existing carriageway. The pavements cracks propagated and the potholes are generated. If the potholes are not treated, the pothole spreads across the pavement, and dust generations would become increased. In addition to the project roads, the contractors often neglect

the pavement conditions of the by roads which have been used to transport material. It could be identified that the most of these local roads become deteriorated rapidly due to the excessive loads transported from the project vehicles, especially roads to the crusher, concrete and asphalt batching plants, and the workshop.

Another major activity in which excessive dust generation experienced is the stockpile operation. Most of the soil stockpiles were not properly covered, nor wetted. Therefore the dust particles were blown through the wind, and the most of the nearby properties were covered by a layer of dust which would be harmful for the health.

6.2.2 Harmful Emissions

Hazardous emissions such as CO₂, CO, NO₂, are emitted to the atmosphere during machinery and plant operations. In addition, these emissions become excessive during the slow moving traffic especially when single pile traffic is allowed during construction activities. All those harmful emissions would be hazardous for the health, which could cause lung diseases and cancers as well. And some of the emission gases would be harmful for the environment as well.

6.2.3 Proposed Air Pollution Mitigation Measures

Air pollution could be minimized by taking few steps by the contractors. Some of the recommendations could be listed as below;

- Cover the stockpiles properly
- Frequently spray water not allowing the earthen surfaces become dried
- Cover dump trucks during transportation
- Spray water to the soil stockpiles before being transported to site
- Proper maintenance of the existing roads and by-roads in motorable condition
- Promote latest asphalt plants and concrete batching plants in which dust generation is minimized
- Construct dust traps around the perimeter of the crusher plant
- Construction of entrance/outlet tyre wash

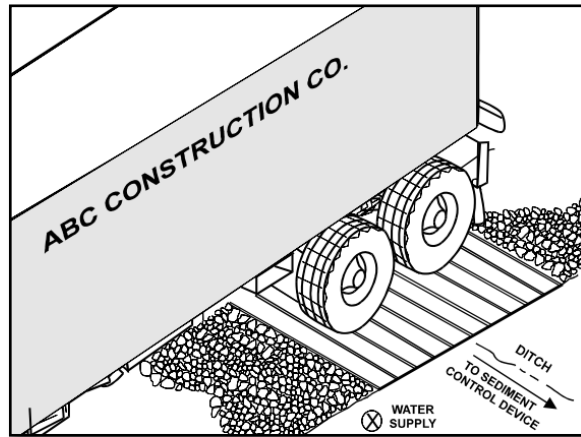


Figure 6-1: Entrance/outlet Tyre Wash

- Maintain machines and equipment properly to minimize emission of harmful gases
- Maintain relatively higher speeds of the traffic even within the work-zones with proper safety arrangements
- Minimize unnecessary movement of heavy machinery

6.3 Noise Pollution

Noise generation is one of the major issues the road users and the resident would have to face during the road rehabilitation/ improvement projects. The major construction activities which results irritating noise would be listed as below;

- Movement an operation of heavy machinery and equipment
- Subbase and base construction
- Aggregate crushing activities
- Pre-cast pile driving
- Sheet pile driving
- Bored pile socketing and hacking
- Excavation works
- Rock blasting activities
- Asphalt and concrete batching plant operations
- Electrical generators and air compressor operations

Excessive noise adjacent to the residential area would be annoying for the residents. Most importantly, the noise would be annoying nearby schools, pre-schools, elderly homes and religious places where calmness would be expected.

6.3.1 Proposed Noise Pollution Mitigation Measures

It is suggested to prepare a 'Noise Pollution Mitigation Pan' before the commencement of the construction works, in the planning stage. In preparation of this report, the locations and types of machineries and equipment to be used should be identified. The probable noise levels should have to be estimated from the past data and from other sources. If the probable noise levels exceed the regulations at the sensitive locations such as schools, temples, courts etc. then alternative methodologies should have been identified. It may require some alternative techniques or machinery to be used for those identified locations. In addition, all the construction team including machine operators should have been thoroughly advised to minimize unnecessary noise generation as much as possible.

Most of the construction machinery and plants used in our country seems to be relatively old machinery which has been used before being imported to Sri Lanka. Most of the contractors hesitate to invest on latest machinery because of the lack of initial capital. However, most of the conventional machineries have been developed to increase the efficiency while the heat and noise generation are reduced. Therefore, it is suggested to use quieter machineries and equipment during construction activities. Electric or hydraulic powered equipment generate less noise compared with the conventional diesel powered equipment.

It is advisable to locate the quarry, aggregate crusher, concrete batching plant, asphalt plant and workshop at a farther place where inhabitants are less. Those locations should be covered with noise control curtains.

At the road construction works, it is suggested to use temporary noise barriers to minimize the noise passed into the locality. For the locations where electric generators, jack hammers, drills, poker vibrators, air compressors etc. these kinds of temporary barriers would be ideal. These barriers could be made of fiber glass, plywood, plastics etc.

6.4 Increment of travel time

It is almost unavoidable to prevent the increment of the travel time during the road rehabilitation/ improvement project is being carrying out. However, the time wasted due to these construction activities could be minimized by proper planning prior to the commencement of works.

These delays would be caused due to;

- Traffic management plans executed
- Poor condition of the existing pavement (lack of maintenance)
- Roadside friction due to temporary storage and construction activities
- Traffic accidents
- Lack of advance signs and notices

6.4.1 Proposals to minimize traffic delays

Alternative routes should have been identified at the initial stages of the project, and the road users and the general public should have been informed about the proposed road rehabilitation/ improvement works to be executed. By means of electronic media and printed media, the alternative routes should have been published, and the road users should have been advised to avoid the project road as much as possible.

The traffic patterns should have been studied together with an origin-destination survey. Then the related construction works should be planned to minimize the disturbances to the traffic during the peak times.

In 2 lane single carriageway roads, one lane should have been closed to the traffic during base/ subbase construction and asphalt paving activities. Therefore there is no alternative other than allowing single pile traffic on the available lane. At these kinds of situations, the queue generation would have to be considered. The queue should not be generated up to nearby intersections, otherwise the other roads also get affected due to this queue. It is also suggested to minimize the construction works at during the peak hours.

6.5 Disturbances to the accesses

Both business places and residences have badly affected by the disturbances to their accesses for a prolonged period. These kinds of disturbances to the accesses could be occurred mostly due to the grade (elevation) difference due to the improvement of the vertical profile of the road. At most of the times, the road finish levels would be raised. In addition, during the side drain construction, sub-base and base construction, asphalt paving could be identified as the major construction activities which could cause disturbances to the existing property accesses. In some of the locations, even a pedestrian access had not been provided during the construction.

6.5.1 Proposals to minimize inconveniences due to access damages

At most of the locations, the disturbances to the private proper access could not be avoided at all. However, the inconvenience could be minimized by proper planning prior to commencing works.

The most ideal solution for the disturbances of the accesses is the use of pre-cast drain sections especially for the accesses. The drain type, width and wall height should have been determined early, and suitable drain sections should have constructed at a separate location (at pre-cast yard or any other convenient location). The length of each part should be determined (generally 2m, 3, and 4m suggested). If the required drain sections is already cast and ready, then it can be placed on required location on a compacted ABC layer. Thereafter the access could be completed rapidly by providing the suitable cover-slabs on top of the drain walls. By adopting and practicing this method, the time duration of the accesses being damaged could me drastically reduced.

The existing access should be disturbed only if all the required resources are ready, and only if there is an assurance that the access could be reinstated with the minimal disturbances to the users. If the existing access is already damaged for the construction works, the contractor should focus on reinstating it at the earliest possible.

If the access is damaged for construction of side drains, it is suggested to provide temporary access by means of steal plats or cat-walk plates.

Another important suggestion is to construct the private property access in two halves, at two stages. This strategy would be ideal for the commercial places where the width of the existing access is 6m or more. During the construction of one half of the access, the remaining half could be used in this method.

It is also suggested to discuss with the property owners about their convenient time for the access constructions. Weekends and public holiday would be ideal for the access construction of business places.

6.6 Interruptions to the utility lines

Most of the residences and business places have suffered due to the interruptions of their utility lines such as water supply, electricity and telecommunication lines. These disturbances could be occurred during two different stages.

- Utility line relocation process
- During construction activities by mistakes

At most of the road rehabilitation projects, the existing utility lines adjacent to the road edge would have to be relocated prior to the construction activities. Generally, this relocation would be carried out by directly by the respective utility organization.

In addition, the existing utility lines could have been damaged accidentally during road construction activities especially during the roadway excavations and side drain excavation processes.

6.6.1 Strategies to Minimize Interruptions to the Utility Lines

The disturbances to the utility lines during the utility relocation process could not be avoided at all. However, the respective authorities should inform the users about their relocation plan and schedule prior to the commencement. They should publish their schedule such that all the probable users are informed about the interruptions. Then the users could have planned their activities accordingly.

The damages to the existing utility lines are occurred during the excavations the main reason for these kinds of damages is the lack of as-built drawings of the layout plans even with the respective authority. Under these circumstances, trial pits should have dug in pre-determined intervals to check the types and depths of each underground

utility line. In addition, the adjacent residents could be consulted to get an initial idea of the types and locations of each underground utility line.

The metal detectors could be used to identify underground electricity cables, and GI pipes. In these cases, the exact location of the each line could have been identified.

The construction team should be well equipped with the spares and equipment to repair any damages to the water pipe lines.

However, most of these damages to the underground utility lines could have been minimized by allocating experienced excavator operators, and the excavations should be carried out with care.

7. CONCLUSION AND RECOMENATIONS

Major findings of each workzone are summarized and compared in this chapter followed by the limitations of the study together with recommendations for future studies.

7.1 Summary of Findings

7.1.1 Summary of Findings at B120 Road Workzone

The increment of travel time due to workzone activities could be identified as the factor affected the road users mostly. Dust generation and air pollution could be identified as the next factor which has resulted inconveniences to the road users of B120 road.

When the residents and business places are concerned, damages to property accesses and interruptions to the utility services could be identified as the major factors.

The major reasons for the travel time increments were due to frequent traffic congestions resulted during the construction activities because lack of additional space for the vehicle movement along this project road since the entire stretch was a 4 lane single carriageway.

Lack of proper planning and poor coordination of works have resulted delays of completing property accesses causing inconveniences to the residents and business places.

7.1.2 Summary of Findings at B084 Road Workzone

When the road users are concerned, the increment of travel time is the main factor affected the road users. The lack of additional space at the either side of the road has contributed the roadside friction and subsequent traffic congestions. Since this road stretch was a 2 lane single carriageway, only single pile traffic had to be allowed in certain workzones.

In the meantime, interruptions to the utility services and disturbances to the property access have resulted in convinces to the residents the most. The reinstate of the property accesses have taken several days because of the lack of coordination of the construction team.

7.1.3 Summary of Findings at A002 Road Workzone

Increment of travel time due to traffic congestions, lack of (improper) advanced signage and allocation of incapable traffic controllers could have been identified as the major issues resulted inconveniences to the road users of A002 road section.

Even though the contractor has tried his best to minimize the disturbances to the road users, significantly higher traffic volumes specially during the peak hours has caused traffic congestions.

When the adjacent residents and businesses are concerned, the interruptions to the utility services, and blockage of drainage systems could be identified as the most significant factors affected.

Underground utility lines were damaged during roadway excavation very frequently. Even though the contractor has allocated several teams for the necessary repair works at the damaged locations with the coordination of the relevant authorities, the residents and businesses had to bear inconvenience until they are being reinstated. The unavailability of (or erroneous) as-built drawings of the underground utility cables has contributed for several damages.

7.2 Limitations of the Study

7.2.1 Selection of Workzones

The workzones had been selected considering the number of carriageways and the number of lanes available in each workzone.

As mentioned in Chapter 02, Galle Road (A002) section from Ratmalana to Moratuwa has 3 lanes in each direction whereas Colombo – Horana Road (B084) section from Boralessgamuwa to Piliyandala section consists of 2 lanes at either side of the center median. There are only 2 lanes (2 lane single carriageway) in Ethulkotte – Pitakotte section of Ethulkotte – Kohuwala Road (B120).

When the A002 road is concerned, the rehabilitation project was for the entire section of Maliban Junction (Ratmalana) to Nalluruwa. However, the study had been limited to the stretch of Maliban Junction (Ratmalana) to Moratuwa. This road section had

been selected due to the similarity of the road alignment, geometry, traffic conditions and land use patterns.

Similarly, when B084 road is concerned, the ongoing rehabilitation/ improvement project was from Pamankada to Kesbewa. However, the study had been limited to the section from Boralesgamuwa to Piliyandala because of the road geometry and land use patterns.

The study had been limited to Ethulkotte to Pitakotte in B120 road although the entire section from Ethulkotte to Kohuwala had been rehabilitated / improved by the road project.

7.2.2 Data Collection and Sample Sizes

The number of responses received for each types of questionnaire surveys are shown in Table 7-1. Obtaining responses for questionnaire surveys from the road users was difficult because most of the road users were reluctant to spend their time on the surveys.

Table 7-1: number of responses received for each types of questionnaire surveys

Road Stretch (Workzone)	Road Users	Residents/ Businesses
A002	314	169
B084	256	149
B120	264	233

7.3 Recommendations for Future Work

7.3.1 Economic Loss during Road Rehabilitation Works

The generation of traffic congestions and lengthy vehicle queues would be practically unavoidable during rehabilitation of existing roads. Thereby the fuel wastage and loss of time would be affecting the country's economy as well.

The probabilities of occurring traffic accidents generally increased at the road workzones. Those accidents would affect the country's economy by several ways.

Moreover, the disturbances to the property accesses and interruptions for the utility services would affect the business by means of loss of opportunities.

Therefore it is suggested to study the economic loss during the road rehabilitation projects.

7.3.2 Road Users' Safety and Workers' Safety

There are possibilities of occurring traffic accidents during rehabilitation works of existing roads. Similarly, the workers also would be exposed for accidents in workzones. Therefore it could be suggested to study the safety of the road users as well as the workers.

7.4 Recommendations

7.4.1 Introduction and Implementation of a Check List

Based on the findings of the research, the following check list is proposed to be implemented during construction activities in order to minimize the inconveniences of the road users and other stakeholders.

The asphalt, concrete and crusher plant activities, access disturbances, road user safety, travel time increment, dust generation, utility line interruptions, possibilities of traffic accidents and each construction activity are addressed in this check list.

Table 7-2: Proposed Checklist to be followed in construction activities

Activity	Impact		Migratory Measures	Check
	User Type	Impact		
Aggregate Crusher, Concrete and Asphalt plant activities	Pedestrians	H	Use dust screens	
			Cover the stockpiles	
	Residents	H	Spray water frequently	
			Cover dump trucks during transportation	
	Motorists	M	Construct dust traps and entrance/outlet tire wash	
Disturbances to accesses	Pedestrians	L	Make residents aware of the possible disturbances to their access, and discuss migratory measures	
			Remove existing access only 1st half, and the remainder after providing access to the 1st half	
	Residents	H	Check for possibilities of using pre-cast drain sections for the accesses	
			Pre-plan subsequent activities to provide the accesses with minimal inconveniences to users	
	Motorists	H		

Activity	Impact		Migratory Measures	Check
	User Type	Impact		
Possible injuries to pedestrians	Pedestrians	H	Barricade all construction zones	
	Residents	M	Illuminate work zones during night times	
	Motorists	-	Provide safe passage for pedestrian movements	
Dust generation during ABC laying	Pedestrians	H	Compact at Optimum Moisture Content	
	Residents	H		
	Motorists	M		
Dust generation in roadway excavation and disposing	Pedestrians	H	Remove excavated soil to disposal yard immediately	
	Residents	H		
	Motorists	M		
Noise and harmful emissions during machine operations	Pedestrians	H	Maintain machines and service them regularly	
			Minimize unnecessary machine operations	
	Residents	H	Use temporary noise/dust barriers at residential areas	
			Avoid double handling of material	
	Motorists	M	Measure noise levels generated during each and every activity	

Activity	Impact		Migratory Measures	Check
	User Type	Impact		
Increment of travel time	Pedestrians	L	Introduce alternative routes	
			Make the public aware of the possible delays due to construction activities	
	Residents	-	Allocate experienced traffic controllers	
			Provide proper signs and barricading	
	Motorists	H	Make road sides clear to minimize road side friction	
Interruptions to utility lines	Pedestrians	-	Make residents aware of the possible interruptions to the utility lines, and discuss migratory measures	
			Coordinate with relevant utility authority to provide re-connections at the earliest	
	Residents	H	Pre-plan subsequent activities to connect with minimal inconveniences to users	
			Keep machines, tools, materials, spares ready for immediate repairs for possible damages	
	Motorists	-		

Activity	Impact		Migratory Measures	Check
	User Type	Impact		
Possibilities of damages vehicles	Pedestrians	-	Maintain existing road in motorable conditions	
	Residents	-	Avoid material stockpiles at road sides	
			Allocate experienced traffic controllers together with all signs and barricades	
	Motorists	H	Keep work zones illuminated during night times	

7.4.2 Proper Co-ordination and Communication

A well-defined co-ordination and communication should be introduced for the workzones from which entire project implementation team and other stakeholders such as utility authorities for smooth construction process with minimal disturbances to the general public.


7.4.3 Strict Adherence to the Guidelines

It is suggested to make strict adherence of the guidelines mandatory for all road construction/ rehabilitation projects with frequent following-up by the clients. The clients should be empowered to charge any penalty from the contractors if they do not follow the guidelines.


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ANNEX 1-1: QUESTIONNAIRE USED FOR ROAD USERS

University of Moratura		<i>Questionnaire Survey on Impacts on Road Users during Road Construction</i>		
Road	Date and Time			
Duration <input type="text"/> Years <input type="text"/> Months	Recorder			
Project Status: <input type="text"/> Ongoing <input type="text"/> Completed	Sheet No:			
Type of user <input type="text"/> <input type="text"/> Motorist <input type="text"/> Pedestrian <input type="text"/> Passenger				
Road Users				
1.	Travel distance along project Road	<input type="text"/>	km	
2.	Time duration taken before the project	<input type="text"/>	hours	<input type="text"/> Minutes
3.	Time duration taken during the project	<input type="text"/>	hours	<input type="text"/> Minutes
4.	Did you experience any inconvenience during the construction phase?	Yes <input type="checkbox"/> No <input type="checkbox"/>		
5.	Types of Inconveniences experienced and their Impact on Travel time and Comfort <i>(Assign 5 for highest impact and 1 for lowest impact)</i>			
	Incapable (or lack of) traffic controllers	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Lack of advanced signage	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Inadequate safety	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Roadside friction due to construction	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Lack of dust control	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Possible Damages to vehicles	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Increment of Travel Time	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
6.	What are the improvements suggested? <i>(Assign 5 for highly recommended and 1 for least recommended)</i>			
	Allocate experienced (capable) traffic controllers	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Place sign boards well in advance	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Maintain pavement in motorable condition	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Place speed humps to control the speed	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Properly demarcate construction areas (using barricade)	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Spray water frequently to control dust	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Improve lighting at dangerous spots (during night)	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Demarcate passages for pedestrians	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Provide priority to public transport vehicles	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Use blinkers during night time	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
	Other	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3
7.	Have you made any official complain on the inconveniences experienced?	Yes <input type="checkbox"/> No <input type="checkbox"/>		
8.	What is your level of satisfaction on the actions they took for your complain? <i>(Assign 5 for highest satisfaction and 1 for highest dissatisfaction)</i>			
	<input type="text"/> 1	<input type="text"/> 2	<input type="text"/> 3	<input type="text"/> 4
9.	Your overall satisfaction on inconveniences experienced;			
	<input type="checkbox"/> Unacceptable	<input type="checkbox"/> Moderately acceptable	<input type="checkbox"/> Acceptable	

ANNEX 1-2: QUESTIONNAIRE USED FOR RESIDENTS

University of Moratura <i>Questionnaire Survey on Impacts on adjacent Property Owners / Users during Road Construction</i>		
Road	Date and Time	
Duration <input type="text"/> Years <input type="text"/> Months	Recorder	
Project Status: <input type="text"/> Ongoing <input type="text"/> Completed	Sheet No:	
Location Town	Chainage	Side
Type of Property <input type="text"/> Property Owner <input type="text"/> Commercial <input type="text"/> Residential		
Residents and Property Owners		
1. Ownership of the property	<input type="checkbox"/> Owned <input type="checkbox"/> Rented (or leased)	
2. Number of occupants (or employees)	<input type="checkbox"/> 1 ~ 5 <input type="checkbox"/> 6 ~ 10 <input type="checkbox"/> > 10	
3. Type of access	<input type="checkbox"/> Only pedestrians <input type="checkbox"/> Vehicle access	
4. Width of the access	<input type="checkbox"/> 1 ~ 5m <input type="checkbox"/> 6 ~ 10m <input type="checkbox"/> > 10m	
5. Number of parking spaces available	<input type="checkbox"/> 1 ~ 2 <input type="checkbox"/> 3 ~ 5 <input type="checkbox"/> > 5	
6. Types of Inconveniences experienced and their impact <i>(Assign 5 for highest inconvenience and 1 for least inconvenience)</i>		
Access damage	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
Air pollution (Dust)	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
Water pollution	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
Drainage issues	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
Utility line damages	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
Noise Pollution	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
.....	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
7. Have you made any official complain on the inconveniences experienced?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
7. If yes, how did you make the complain?		
Verbally to the contractor	<input type="text"/>	
Verbally to the Engineer/ Employer	<input type="text"/>	
Letter to the Engineer/ Employer	<input type="text"/>	
Letter to the contractor	<input type="text"/>	
By other personal contact	<input type="text"/>	
7. What is your level of satisfaction on the actions they took for your complain? <i>(Assign 5 for highest satisfaction and 1 for highest dissatisfaction)</i>	<input type="text"/> 1 <input type="text"/> 2 <input type="text"/> 3 <input type="text"/> 4 <input type="text"/> 5	
8. Did you encounter any financial loss due to road construction activities?	Yes <input type="checkbox"/> No <input type="checkbox"/>	
9. Your overall satisfaction on inconveniences experienced;	<input type="checkbox"/> Unacceptable <input type="checkbox"/> Moderately acceptable <input type="checkbox"/> Acceptable	

ANNEX 02 - GUIDELINES FOR TEMPORARY TRAFFIC MANAGEMENT DURING ROAD CONSTRUCTION

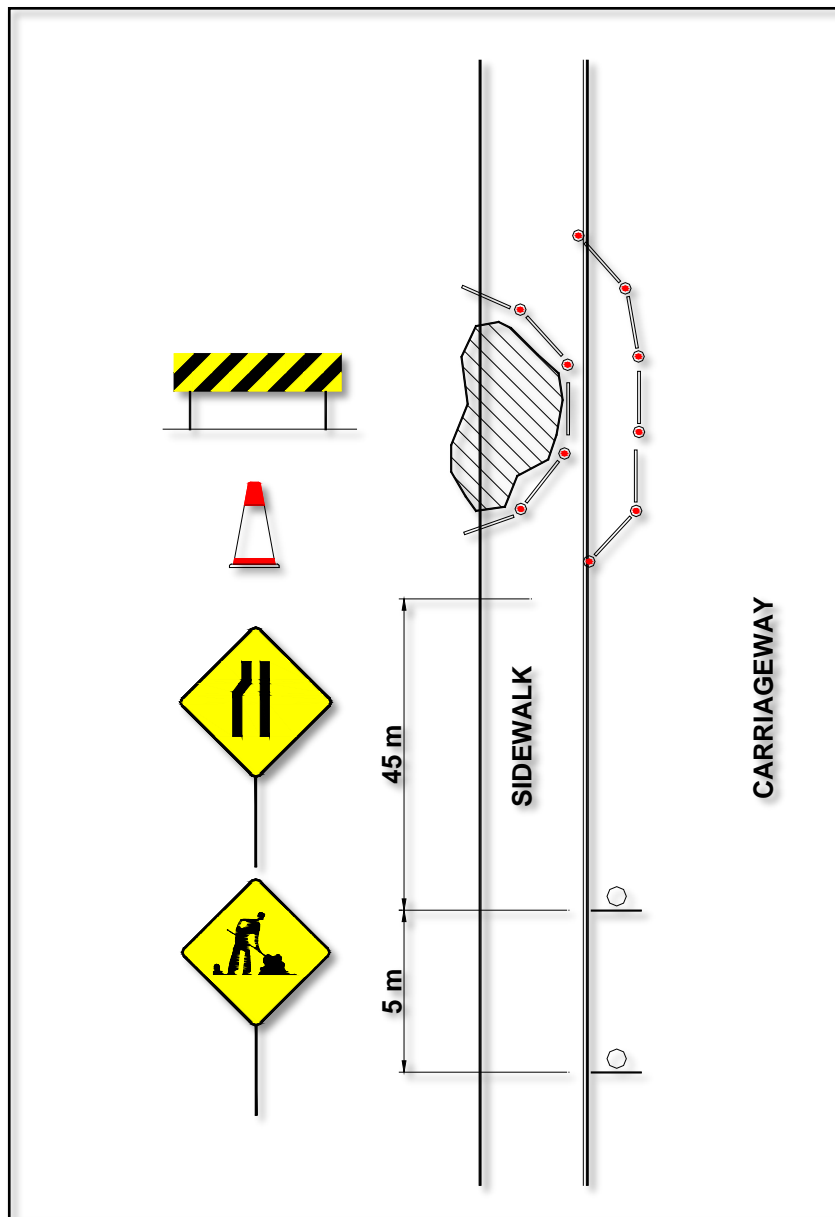


Figure A2-1: Maintenance operation of short duration on Pedestrian Sidewalk

Source: Manual on Traffic Control Devices, Part II

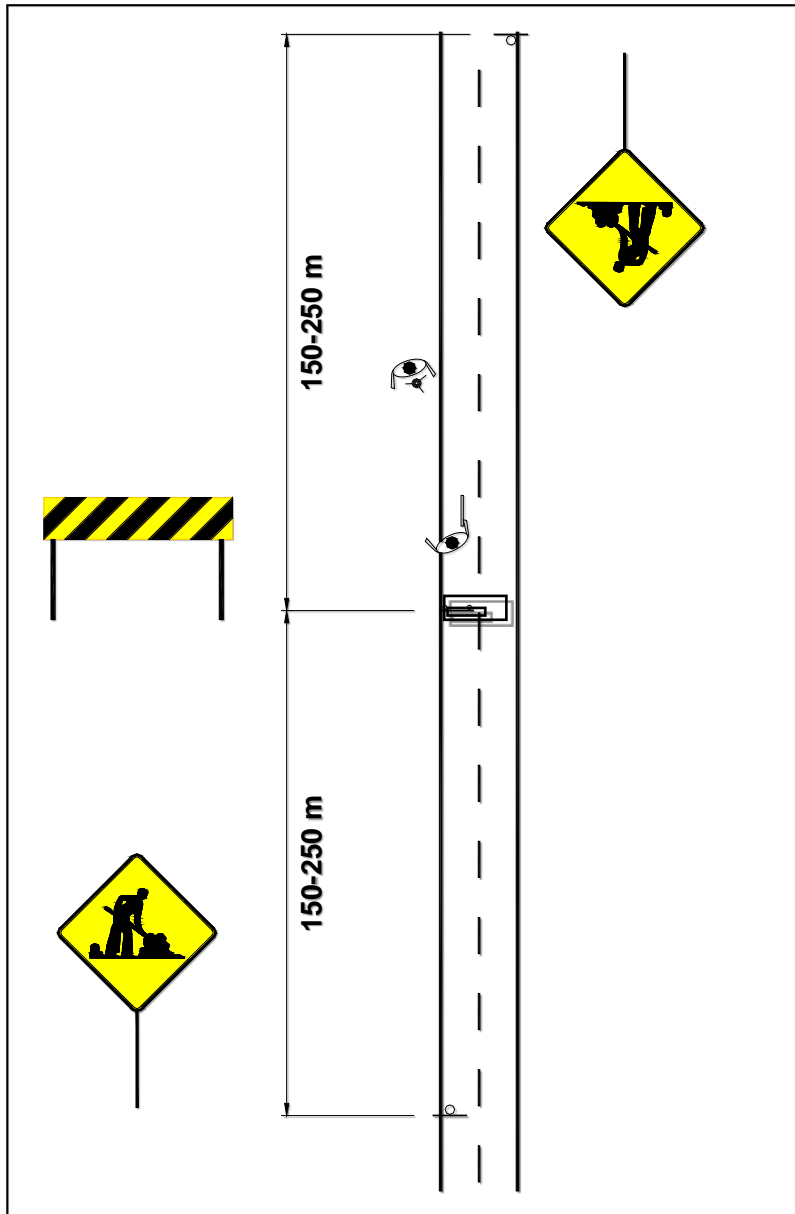


Figure A2-3: Survey on road or in close vicinity of the road

Source: Manual on Traffic Control Devices, Part II

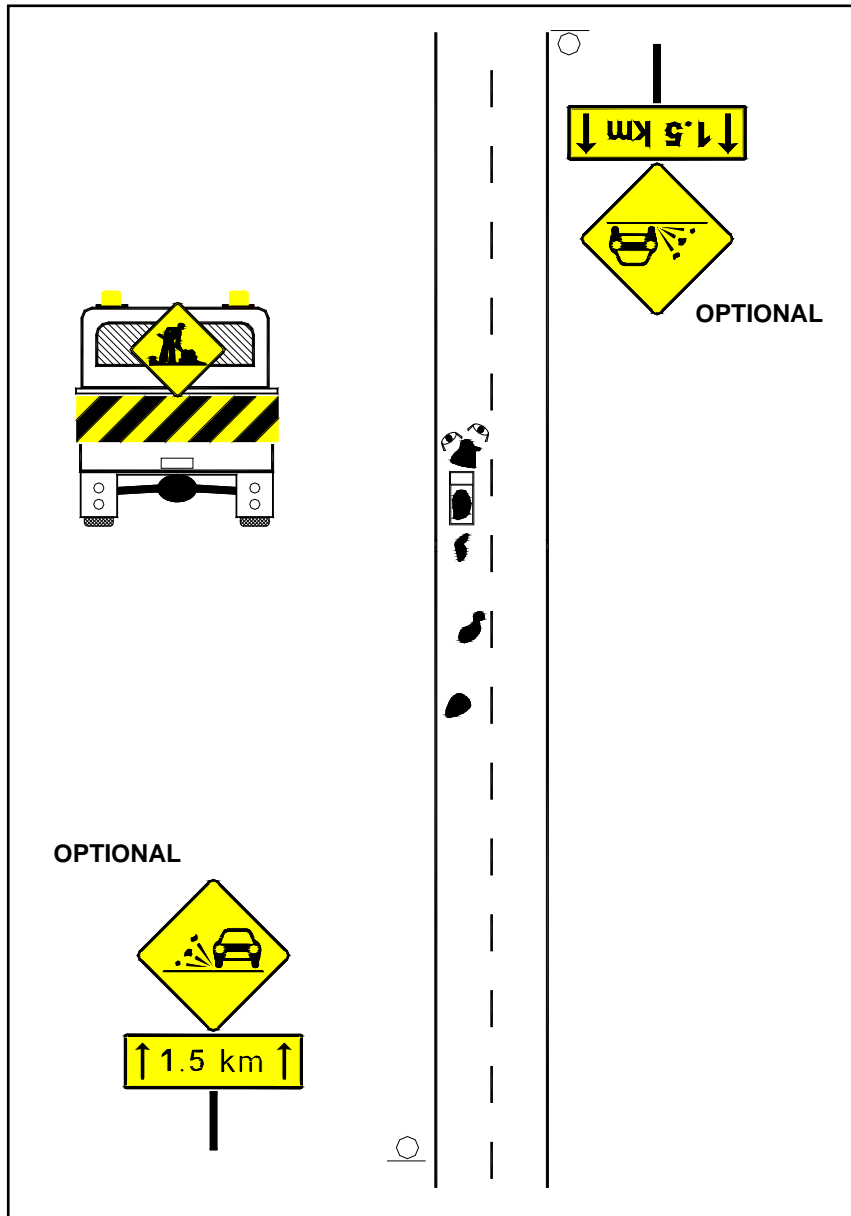


Figure A2-4: Asphalt patch work

Source: Manual on Traffic Control Devices, Part II

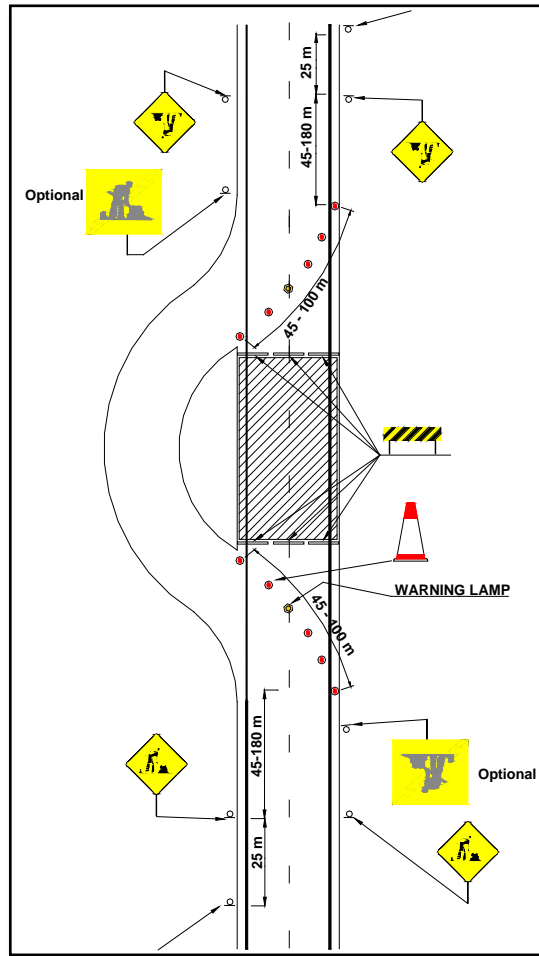


Figure A2-6: Simple Diversion

Source: Manual on Traffic Control Devices, Part II

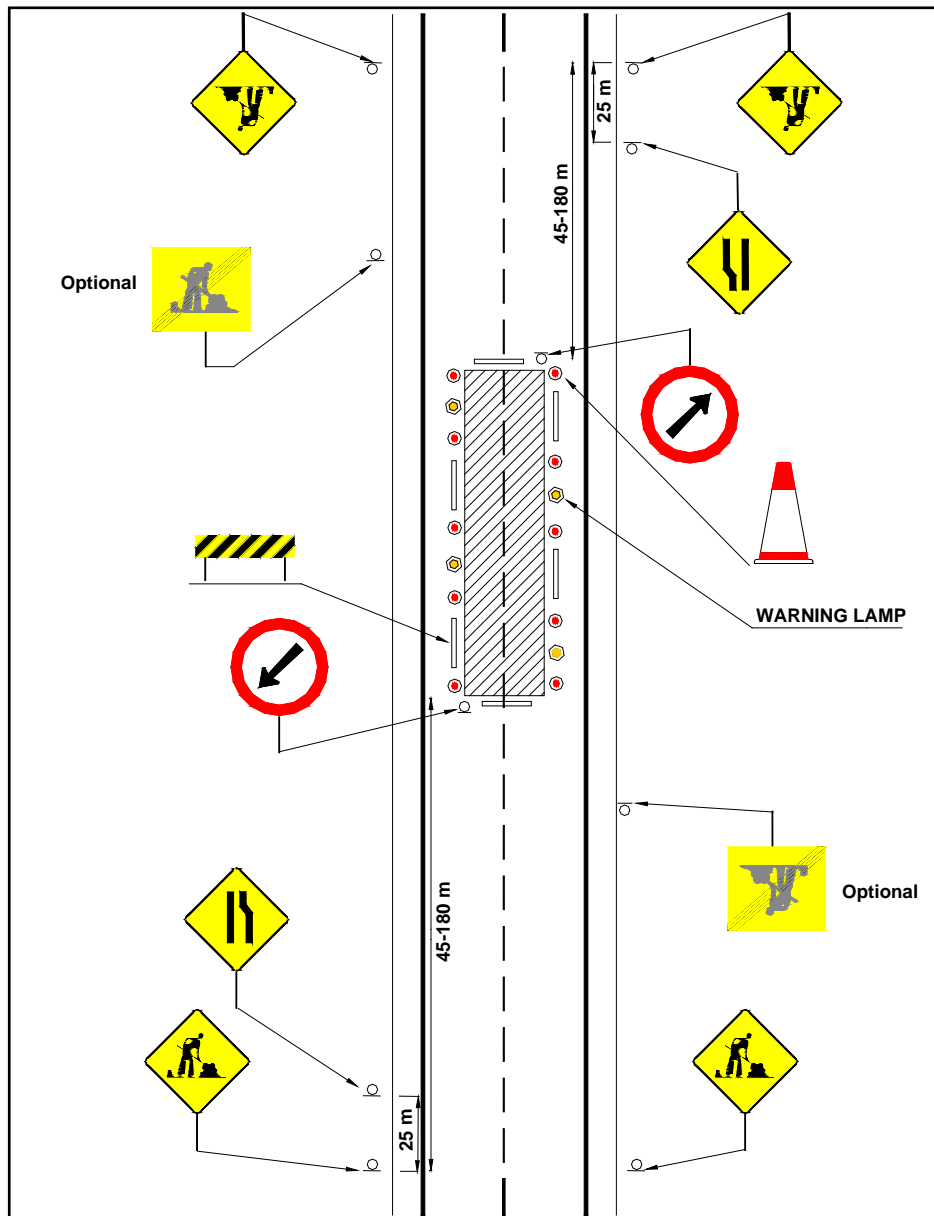


Figure A2-7: Repairs to the Centre Section of the Carriageway

Source: Manual on Traffic Control Devices, Part II

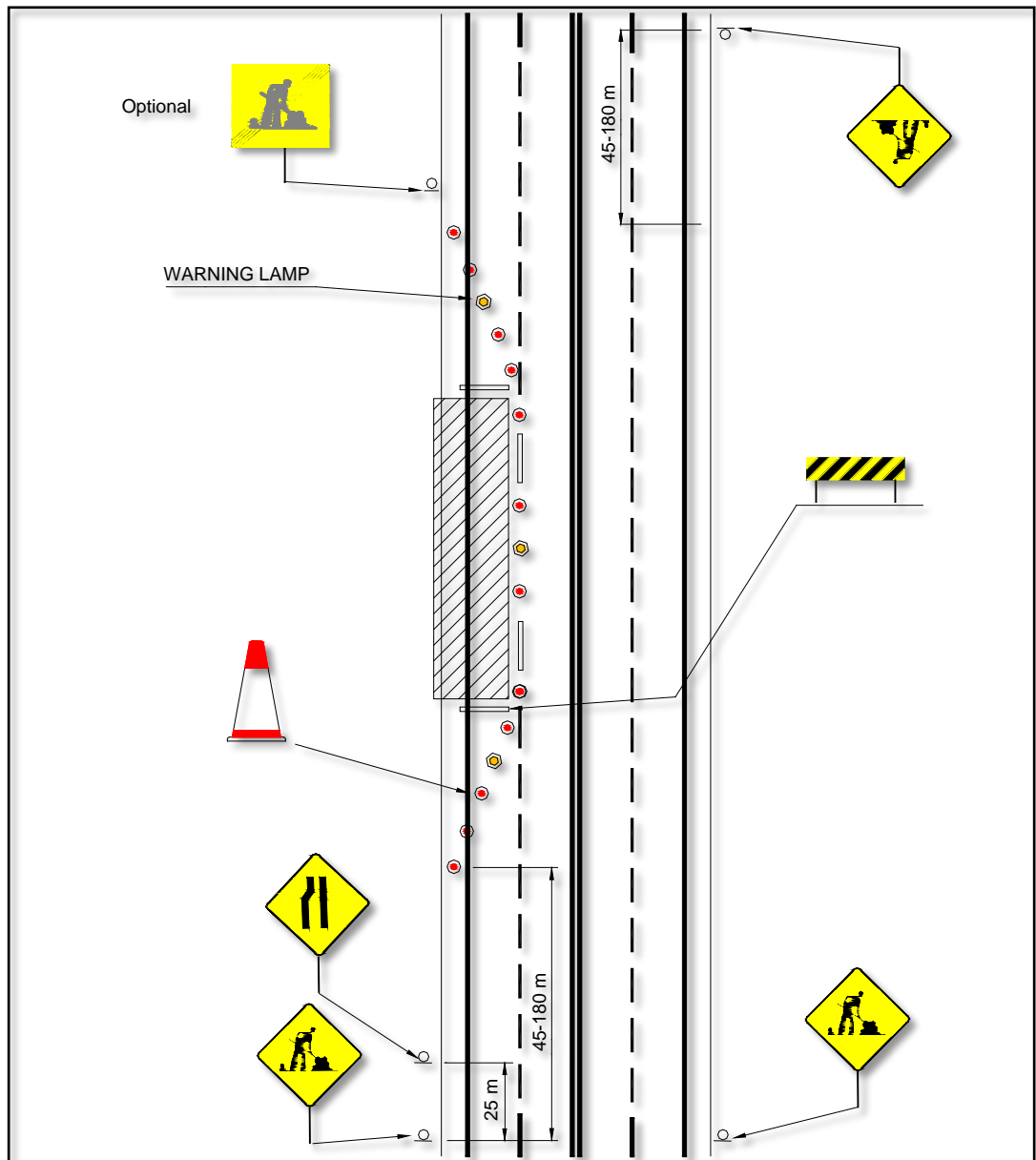


Figure A2-8: Repairs to an Outer Lane of a 4-lane Road without Centre Median

Source: Manual on Traffic Control Devices, Part II

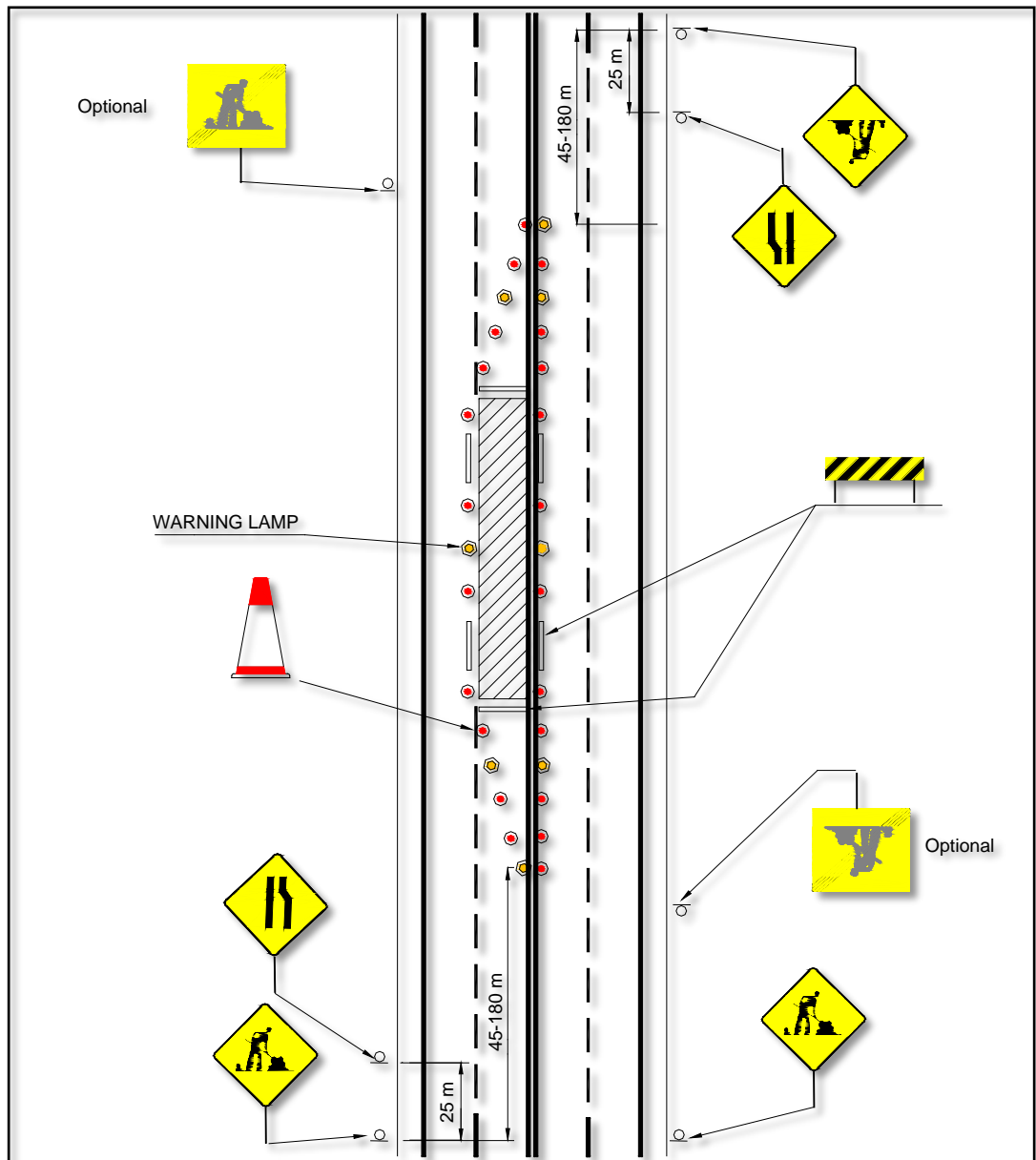


Figure A2-9: Repairs to an Inner Lane of a 4-lane Road without Centre Median

Source: Manual on Traffic Control Devices, Part II

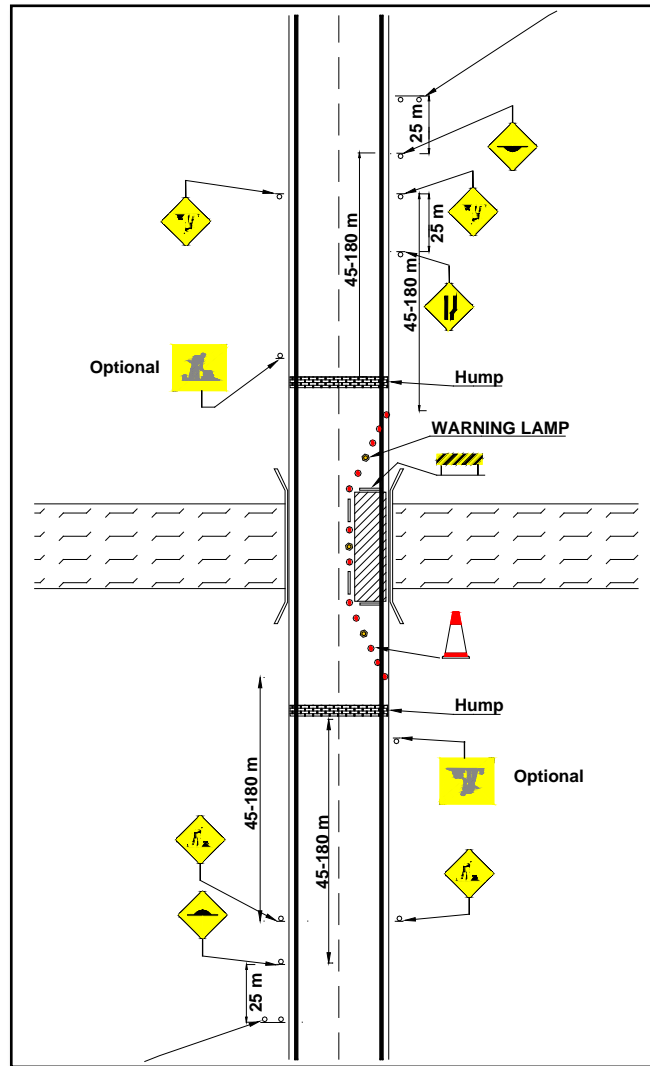


Figure A2-10: Repairs to Bridges/Culvert

Source: Manual on Traffic Control Devices, Part II

**APPENDIX 1 - RANKING CALCULATION FOR ROAD USER
INCONVINENCES**

Dust Generation									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	-	-	8	8	39	39	47	15.71
Less Impact	2	-	-	12	25	35	71	96	
Moderate Impact	3	46	137	23	68	42	127	332	
High Impact	4	58	232	28	111	32	128	472	
Highest Impact	5	72	361	32	160	20	101	622	
Total		176	730	103	372	169	466	1,569	
Possible Damages to Vehicles									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	55	55	30	30	42	42	127	11.55
Less Impact	2	46	92	27	54	34	68	213	
Moderate Impact	3	35	106	32	96	32	96	298	
High Impact	4	23	92	6	25	34	135	251	
Highest Impact	5	18	88	8	41	27	135	264	
Total		176	431	103	245	169	477	1,153	
Inadequate Safety Arrangements									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	11	11	12	12	19	19	42	13.89
Less Impact	2	55	109	25	49	30	61	219	
Moderate Impact	3	62	185	22	65	47	142	392	
High Impact	4	33	134	27	107	37	149	390	
Highest Impact	5	16	79	18	88	35	177	344	
Total		176	517	103	321	169	548	1,386	

Incapable Traffic Controllers									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	18	18	25	25	20	20	63	14.07
Less Impact	2	44	88	11	23	37	74	185	
Moderate Impact	3	56	169	20	59	30	91	319	
High Impact	4	39	155	15	62	41	162	379	
Highest Impact	5	19	97	32	160	41	203	459	
Total		176	526	103	328	169	551	1,405	
Road Side Friction									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	60	60	16	16	20	20	97	12.21
Less Impact	2	42	84	24	47	42	85	216	
Moderate Impact	3	39	116	25	74	56	167	358	
High Impact	4	21	84	19	74	32	128	287	
Highest Impact	5	14	70	20	98	19	93	261	
Total		176	415	103	310	169	493	1,219	
Increment of Travel Time									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	-	-	-	-	8	8	8	19.40
Less Impact	2	-	-	-	-	17	34	34	
Moderate Impact	3	14	42	10	31	30	91	164	
High Impact	4	42	169	20	78	47	189	437	
Highest Impact	5	120	598	73	366	66	330	1,294	
Total		176	810	103	475	169	652	1,937	

Lack of Advanced Signage									
Impact	Weight	B120		B084		A002		Total	Points
Lowest Impact	1	51	51	20	20	24	24	94	13.17
Less Impact	2	42	84	22	43	25	51	178	
Moderate Impact	3	35	106	30	90	32	96	292	
High Impact	4	26	106	20	78	41	162	346	
Highest Impact	5	21	106	12	62	47	237	404	
Total		176	452	103	293	169	570	1,314	

**APPENDIX 02 - RANKING CALCULATION FOR RESIDENTS/
BUSINESSES INCONVINENCES**

Access Damages									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	-	-	-	-	-	-	-	19.37
Lesser Inconvenience	2	-	-	10	20	47	94	115	
Moderately Inconvenience	3	40	119	28	84	69	207	411	
Higher Inconvenience	4	37	148	61	246	75	301	695	
Highest Inconvenience	5	187	937	156	781	122	612	2,330	
Total			1,204		1,132		1,215	3,551	
Drainage Issues									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	-	-	8	8	9	9	17	17.73
Lesser Inconvenience	2	18	37	69	138	35	69	244	
Moderately Inconvenience	3	26	79	67	200	44	132	411	
Higher Inconvenience	4	77	306	74	297	60	239	842	
Highest Inconvenience	5	143	713	38	192	166	832	1,737	
Total			1,135		835		1,281	3,251	
Dust Generation									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	-	-	8	8	53	53	61	17.40
Lesser Inconvenience	2	8	16	20	41	60	119	176	
Moderately Inconvenience	3	24	71	38	115	79	236	422	
Higher Inconvenience	4	77	306	49	195	66	264	765	
Highest Inconvenience	5	156	779	141	704	57	283	1,765	
Total			1,172		1,062		955	3,189	

Utility Interruptions									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	-	-	-	-	-	-	-	20.94
Lesser Inconvenience	2	-	-	5	10	6	13	23	
Moderately Inconvenience	3	11	32	10	31	28	85	147	
Higher Inconvenience	4	71	285	72	287	57	226	798	
Highest Inconvenience	5	182	911	169	845	223	1,115	2,870	
Total			1,228		1,172		1,438	3,838	
Water Pollution									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	84	84	125	125	192	192	401	9.37
Lesser Inconvenience	2	55	111	49	97	66	132	340	
Moderately Inconvenience	3	42	127	33	100	35	104	330	
Higher Inconvenience	4	50	201	44	174	22	88	463	
Highest Inconvenience	5	32	158	5	26	-	-	184	
Total			681		522		515	1,718	
Noise									
Impact	Weight	B120		B084		A002		Total	Points
Least Inconvenience	1	13	13	23	23	60	60	96	15.19
Lesser Inconvenience	2	29	58	49	97	60	119	275	
Moderately Inconvenience	3	53	158	61	184	79	236	578	
Higher Inconvenience	4	100	401	56	225	47	188	815	
Highest Inconvenience	5	69	343	67	333	69	345	1,021	
Total			974		863		948	2,785	