MAURITIUS RESEARCH COUNCIL

INNOVATION FOR TECHNOLOGY

OIL SPILLAGE- THE DAMAGE CAUSED TO OUR TAR RD

Final Report

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MAURITIUS RESEARCH COUNCIL

SMALL SCALE RESEARCH GRANT SCHEME

Oil spillage-The damage caused to our tar roads

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OIL SPILLAGE: The damage caused to our tar road.

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Key Words: Heavy vehicles, oil spillage, damaged tar roads

Abstract:
Oil spillage caused by heavy vehicles and its economic impact has been poorly studied in Mauritius. Oil is a precious commodity for remote and isolated small islands developing states, especially when it is imported from far and in small quantity. Wastage of this commodity is having direct economic impact, and this is even worse when costly infrastructure gets damaged on the way.

The study specifically evaluated the economic damage caused by oil spillage. The results show that considerable damages have been caused by oil spillage to road infrastructure in many areas and are a serious threat to environment and society. Findings also suggest that some preliminary precautionary measures can reduce oil spillage to a great extent and there is an urgent need to revise the actual retail practices, at the same time involved all stake holders in using some basic guidelines.

1. INTRODUCTION

Today's is a fast–changing world. The growth of industry, population and transportation has led to planet-wide concerns of energy with special concerns to fossil fuel, which is a limited resource.

This commodity is extremely precious when it is bought in foreign currency, imported from far and in small amount. The price of fuel in Mauritius has increased by many folds in the last decades and is likely to increase as world-wide demand is increasing.

Wastage of such an expensive commodity is not only having a direct financial implication for the country, but the oil spillage is causing further damage to public infrastructure. Road damage caused by oil spillage is a hazard to road users and oil spillage is also a direct threat to our land and marine environment. This can lead to pollution, contamination of fresh water, loss in biodiversity and even coral bleaching.

Oil spillage prevention is inexpensive; it simply requires some preliminary precautions, modification of equipment to bring some corrective measures. Decreasing oil spillage can save a lot not only in direct foreign exchange, and

also prevent damage to road infrastructures and at the same time it would also protect our land and marine environment from further degradation for the future generation.

2. MATERIALS AND METHODS

2.1 Study Area

The study area included all the main roads or roads commonly used by heavy vehicles such as trucks and buses, it covers all the coastal roads and main roads in the all the towns and main villages of the whole island of the Republic of Mauritius. The trunk road from Grand Bay to Plaine Magnien / Airport is not included.

The main roads chosen are based on the Map from EOI Philips atlas for Mauritius .The estimated road length is measured using the appropriate scale given on the map for road network on the whole island. The actual distance covered is the distance covered by the vehicles used for investigation, based on the vehicle meter.

The whole island is divided into **17** localities and for an estimated total road length of **525** kilometers.

The study area also covered all the major stake holders in the transport activities including the National Transport Corporation and other local private companies like the Triolet Bus Service, Rose Hill Transport, Mauritian Bus Transport, United Bus Service and other private bus owners

2.2. Data collection

The first set of data was collected to quantify the actual road damage due to oil spillage at the studied area. Results obtained are an estimated percentage on damage caused due to oil spillage.

The road width varies from **7.6 to 8.5** meters, and an average road width of **8** meters was taken for the purpose of this work. Width of road damages was estimated from **1** to **5** meters. Damages below **1** meter were not recorded. Road with damages exceeding **5** meters were extremely rare. Oil spill damages were usually oval in shape, the minimum and maximum diameters were noted and an average road width was estimated.

The estimated length of road damage was usually taken by the existing road markings between the numbers of road light reflectors. The distance between two reflectors is **12** meters on a straight road and **6** meters on road curves according to the local standard. Broken **Hazard white line** leading to a full white line on a road curve is **4** meters and the distance between **two-hazard lines** is **1**

meter. The broken white lines present in the middle or side of the road measures **1** meter and are **1** meter apart. Measurement of road damages was based on the distance between the reflectors which is **12** meters on straight road and **6** meters on road curves, in some cases broken white lines and hazard lines were used to estimate length of road damages. Most of the main roads are marked and are equipped with reflectors. Actual road measurement was taken in some isolated or remote places.

A vehicle was used to take the measurement using the vehicle dashboard meter as the actual distance covered. One person recorded the length of damages by counting the damages between the number of reflectors and the hazard lines and the second person estimated the width of damages. All the 17 localities were covered in 10 days.

The second set of data concerned the social and economic aspects of the problem and data were collected, using surveys and semi- structured interviews with individual from different stake holders. The semi- structured interviews were based on a combination of short and open ended questions. The purpose of the Survey/Interview was to find out on the perception, attitudes and behavior of all stake holders regarding the problem. At the same time it would give an aperçu of how much they are concerned about this issue and how far they are ready to help to tackle this problem.

The third sets of data were collected on simple elementary tests and observations, on the effect of diesel on tar, location of fuel tanks in heavy vehicles, filling techniques and tank capacity.

All laboratory tests were carried out at **Central Water Authority Laboratory,** under the supervision of Mr. A. K Gopaul, Senior laboratory technician.

3. RESULTS

3.1. Actual road coved and estimated damage due to oil spillage

List of localities, road length covered and estimated area of road damages

LOCALITIES	MAIN ROAD Area. (.000 M^2)	Actual Road Covered. Car Meters (Kilometers)	Places Covered	Area of damage in M^2	Percentage Of Damages.
Terre Rouge/Grand River North West	120.8	9.6 5.5 (15.1)	1.Terre Rouge To GRNW Via Old Road 2.GRNW To Les Pailles via Mauvilac.	576 288 (864)	0.715

Grand Bay area	290.4	10.5 5.5 20.3 (36.3)	1.Grand Gaube to Grand Baie Via Pereybere. 2.Grand Baie to Mon Choicy Via Pointe aux Cannonier. 3.Vel Round About To Terre Rouge Via F du Sac, Morcellement, Arsenal.	1288 420 1008 (2716)	0.935
Triolet	96.	12	Mon Choisy to Pamplemousses Via Triolet	1456	1.516

Pamplemouses	276.	12.3 8.5 13.7 (34.5)	1.To Abercrombie Via Calebasses. 2.Pamplemousses To D' Epiney 3.Mapou to Grand Gaube Via Fond du Sac Petit Raffay	732 880 744 (2356)	0.853
Goodlands /Riviere du Rempart	396.	9.6 16.6 14.2 6.7 16.6 9.1 (72.8)	1.Grand Gaube To Grand Baie ViaPetit Raffray 1.GoodLands to Riv. Du Rempart Via Poudre D'Or 2.Riv. Du Rempart To Lallmatie Via Amaury Riv Du Rempart To Flacq 3. Grand Gaube to Piton Via Cottage 4. Piton to Port Louis Via Pamplemousses . (Pipe Laying Pamplemousses to calebasses)	1300 1836 1164 1080 120 216 (5716)	1.443

Flacq area	179.2	16.6 5.8 (22.4)	1.Pamplemousses To Lallmatie Via Brise Verdire 2.Lallmatie To Flacq Via FUEL SE	1786 648 (2434)	1.358

Bon Acceuil / Bel Air	448.	10.6 8.7 9.5 13.5 13.7 (56.0)	1.Brise Verdiere Via Pont Blanc 2.Flacq To Bel Air 3.Bel Air To Grand Sable Via GRSE 4.Grand Sable To Vieux Grand Port. 5.Vieux Grand Port To Plaine Magnien Via Mahebourg.	504 758 1268 2438 1898 (6866)	1.532
Moka	392.8	11.2 !7.3 13.3 7.3 (49.1)	2.MGI To Quartier Militaire Via Moka St.Pierre 3.Quartier Militaire To St.Jullien D'Hottement 3.St Julien D'Hottement To Post de Flacq 4. Post de Flaq to Roche Noire	1008 1080 1260 1180 (4528)	1.152
Beau Bassin / Rose Hill	89.6	8.5 2.7 (11.2)	1.G.R.N.W To Rose Hill Via Old Road. 2.Beau Bassin To Rose Hill Via Mont Roches.	504 576 (1080)	1.116
Black River	244.8	11.7 18.9 (30.6)	1.Petite Rivirere To Flic an Flac Jr Via Bambous 2.Flic en Flac To Quatre Bones	1248 1216 (2464)	1.006
Quatre Bornes	29.6	3.7	1.Quatre Bornes la lauise To St Jean R A.	432	1.459
Vacoas / Phoenix	228.8	28.6	1. Vacoas to Chemin Grenier Via La Marie	2020	0.882

Curepipe	136.	10.7 6.3 (17.0)	1.Eau Coulee RA To Forestside RAVia Old Road. 2.Phoneix To La Marie Via Gymkana	1372 632 (2004)	1.473
Grand Port	214.4	26.8 (26.8)	2.Plaine Magnien To Grand Sable Via Mahebourg.	2648 (2648)	1.235

Riviere des Anguilles	255.2	13.7 9.7 8.5 (31.9)	Chemier grenier To Riviere Des Anguilles Riviere Des Anguilles to L'escalier L'Escalier to Plaine Magnien	2288 1248 788 (4324)	1.69
Surinam	528.8	18.5 8.1 18.6 20.9 (66.1)	1.Chemin Grenier To Bel Ombre. 2.Bel Ombre To Baie du cap 3.Baie du Cape To Case Noyale 4. Case Noyale To Flic En fLac Jr.	1588 1020 1292 972 (4872)	0.921
Rose Belle	91.2.	4.2 7.2 (11.4)	1.Nouvelle France To Rose Belle Via Old Road 2.Rose Belle To Air Port Jr Via Old Road	648 504 (1152)	1.263
TOTAL	4017.2	525.5		52756	20.55

Estimated road damage due to oil spillage

The average road width was taken to be **8** meters for all localities.
All the figures have been worked out up to **three** decimal points.
An estimated percentage of error was calculated on taking actual measurement at **10** estimated spots and this varies from **8 to 15 %**

Total Road covered **525.5** Kilometers.
Out of **4,017,200 M2** of road covered **52,756 M2** show damages.
The percentage of damages varies from **0.7 to 1.6 %.**
The estimated average road damage was **1.20 %.**

3.2. Survey among heavy vehicles drivers

1.Out of 130 drivers surveyed the results are as follows:

Years of Experience

Less than 5 years	10 to 15 years	More than 15 years	Total
41	56	33	130

2. Type of company:

Private Individual	Private Company	Govt. Company	Total.
74	23	33	130

3. When do you do your refilling of diesel?

Morning	Afternoon	Any time during the day
30	91	19

4. Do you have any specific reason(s) for doing so?

Yes	No	Not always
34	86	10

Those who say 'Yes' to the above question, the reasons given are grouped under the following:

Reasons	Numbers
A. To prevent the accumulation of air.	12
B. Prevent the formation of 'Dew' at night.	6
C. Save time in the morning.	12
D. It is the usual practice	4

The reasons A & C were very popular. Responses given for reason B were all experienced drivers.

5. Re-fuelling is done per:

Gallons	Liters	Fixed sum of money	Filled completely
Nil	Nil	20	110

6. In case you fuelled your vehicles completely. Do you have any specific reason(s) for that?

Reasons	Numbers
A. To prevent the accumulation of air.	70
B. Prevent the formation of 'Dew' at night.	30
C. Keep a stock	10
D. Save time in the morning.	20

7. Do you always check if the tank cap is properly closed after a refilling?

Yes	No	Not always
130	Nil	Nil

8. Have you noticed that our roads are damaged on road curves and bus stop?

(Photos were shown to the interviewees)

Yes	No
130	Nil

9. What do you think have caused this road damage?

Bad quality of tar	33
Speed	Nil
Oil spillage	74
None of the above	23

10. Have you ever noticed that oil is spilled on our road?

Yes	No
130	Nil

11. In case of oil spillage, what according to you may have caused this oil spillage?

Tank not properly closed	82
Overflow	Nil
Over filled	32
Speed	26

12. According to you, who is to be blamed in case of oil spillage?

The owner	12
The retailer	Nil
The tank designer	Nil
All of them	Nil
The Driver	118

Out of 75 Private Individual heavy vehicles drivers interviewed all of them blamed and agreed that the driver or the owner are responsible for oil spillage.

13. What do you think can be done to tackle this problem?

Reduce speed on road curves.	95
Do refilling two or three times during the day.	Nil
Do not fill the tank completely during the day.	35
Put a fixed amount of petrol that will not fill the tank completely.	Nil
Design new type of tank that will avoid oil spillage.	Nil
The filling gun length should be increased to prevent over filling.	Nil

Questionnaire B

3.3 Interviews

3.3.1 Heavy Vehicles owners.

Out of 30 heavy vehicles owners interviewed the result is as follows:

1. Number of years working in transport sector.

Less than 5 years	10 to 15 years	More than 15 years
10	20	Nil

2. Type of company

Private Individual	Private Company	Govt. Company
27	2	1

3. Do you decide on the refilling time and amount of diesel to be put in your vehicles?

Yes	No	Done automatically
28	Nil	2

4. Refilling is done per:

Gallons	Liters	Fixed sum of money	Filled completely
Nil	Nil	Nil	30

5. In case you asked to refill completely. Do you have any specific reason for that?

Reasons	Numbers
To prevent the accumulation of air.	18
Prevent the formation of 'Dew' at night.	6
Save time in the morning	4
The usual practice	2

6. Do you always order for checking, if the tank is in proper order?

Yes	No	Done regularly
30	Nil	Nil

7. Have you notice that our roads are damaged on road curves and bus stop? (Photos were shown to interviewees)

Yes	No
30	Nil

8. What do you think have caused this road damage?

Bad quality of Tar	3
Speed	12
Oil spillage	25
None of the above	Nil
Load	15

9. In case of oil spillage, what according to you may have caused this oil spillage?

Tank not properly closed: Leyland caps not properly closed

Overflow	25
Over filled	2
Speed	3

10. Have you ever notice that oil is spilled on our road?

Yes	20
No	10

11. Who is to be blamed in case of oil spillage?

The owner	Nil
The retailer	Nil
The tank designer	5
All of them	Nil
The driver	25

12. What do you think we can do to tackle this problem?

Reduce speed on road curves.	23
Do refilling two or three time during the day.	Nil
Do not fill the tank completely during the day.	Nil
Put a fixed amount of petrol that will not fill the tank completely.	Nil
Design new type of tank that will avoid spillage.	Nil
The filling gun length should be increased to prevent over filling.	Nil

Questionnaire C

3.3.2 Petrol Dealers: Retailers (Fueling Stations).

Out of 20 Retailers interviewed the result is as follows:

1. Years of experience

Less than 5 years	10 to 15 years	More than 15 years
3	5	12

2. Type of company.

Private Individual	Private Company	Supplier's Company
11	7	2

3. When you usually do refilling of diesel to buses and trucks:

Morning	Afternoon	Any time during the day
Sometimes –3	6	14

4. Do they have any specific reason(s) for doing so?

Yes	20
No	Nil

Reasons	Numbers
To prevent the accumulation of air.	14
Prevent the formation of 'Dew' at night.	6
Save time in the morning	15
The usual practice	7

5. Refilling is usually done per:

Gallons	Liters	Fixed sum of money	Filled completely
Nil	Nil	Sometimes-7	20

6. In case they filled completely. Do you have any specific reason for that?

Reasons	Numbers
To prevent the accumulation of air.	18
Prevent the formation of 'Dew' at night.	6
Save time in the morning	14
The usual practice	8

7. Refilling is done per:

Gallons	Liters	Fixed sum of money	Filled completely
Nil	Nil	Nil	20

7 (a). Do you usually advise them to fill completely?

Yes	20
No	Nil

8. Do you have any specific reason to do so?

Reasons	Numbers
To prevent the accumulation of air.	18
Prevent the formation of 'Dew' at night.	6
Save time in the morning	4
The usual practice	2

9. Do you always check if the tank cap is properly closed after a refilling?

Yes	20
No	Nil

10. Have you notice that our roads are damaged on road curves and bus stop? (Photo shown to interviewees)

Yes	20
No	Nil

11. What do you think have caused this road damage?

Bad quality of Tar	Nil
Speed	Nil
Oil spillage	20
None of the above	Nil

12. Have you ever notice that oil is spilled on our road?

Yes	20
No	Nil

13. In case of oil spillage, what according to you may have caused this oil spillage?

Tank not properly closed	5
Overflow	Nil
Over filled	12
Speed	3

14. Who is to be blamed in case of oil spillage?

The drivers	20
The retailers	Nil
The tank designers	Nil

15. What do you think we can do to tackle this problem?

Reduce speed on road curves.	16
Do refilling two or three time during the day.	Nil
Do not filled the tank completely during the day.	14
Put a fixed amount of petrol that will not fill the tank completely.	Nil
Design new type of tank that will avoid spillage.	12
The filling gun length should be increased to prevent over filling.	Nil

3.4. Results from experiment and observation

3.4.1 Solubility of tar in petroleum products.

An attempt was made to verify the solubility of tar in petroleum products, and the results are given below:

	Minutes					
Tar / aggregate mixture in g/minutes	0	15	30	60	75	90
Diesel.	1.96	1.82	1.68	1.62	nil	nil
Motor Oil.	1.66	1.61	1.56	1.46	1.32	1.28
Kerosene	3.18	3.03	1.42	Nil		
Petrol	2.36	Nil				

N.B: The initial readings of tar/aggregate pieces indicated at time 0, were obtained after placing the tar / aggregate mixture in their respective liquids, removed, dried and weighed.

Tar was highly soluble in petrol 2,36g or more of tar / aggregate mixture dissolved in less than 15 minutes.

The experiment also showed that tar was also soluble in diesel and kerosene. Motor oil affected tar moderately.

In all cases, the increased in solubility of tar brought softness of the tar / aggregate mixture. The tar quickly loses the strength to hold the stone/gravel aggregate together and so the solid stone/gravel gets detached and dropped at the bottom of the beaker.

3.4.2 Tank type, location and oil spillage

The simple experiment that was carried out to study the amount of water spilled from the two types of tanks (rectangular and cylindrical). Results are given below:

Time tilted/Seconds	Amount of water spilled/ml	
	Rectangular	Cylindrical
60	75	20
72	135	29
75	143	64
84	152	49
56	125	26
Total 347	630	188

630 ml of water was spilled out of the rectangular tank compared to the 188 ml from the cylindrical tank subjected to the same time of tilting. The rectangular tank showed 3 times more spillage than the cylindrical one.

Other factors such as viscosity of the liquids used were not taken into consideration. The experiment actually verify the movement of liquid in the two type of tanks and the amount of liquid that poured out during when subject to the same tilting.

An exercise was carried out to make a complete study on heavy vehicles' tanks to know their shape and location.

Results obtained, are summarized in the table below.
Mark of vehicles / Type of tank / Location

Mark of vehicles	Rectangular	Cylindrical	Right	Left	Center
Hino Buses	✔		✔		
Daihatsu	✔		✔		
Toyota	✔		✔		
Tata		✔			✔
Mitsubishi	✔		✔		
Isuzu	✔				✔
Nissan	✔			✔	
Ashok Leyland		✔			✔
DAF Leyland	✔			✔	
Bedford	✔			✔	

3.4.3 Fuelling techniques

The techniques of fuelling are the same on all fueling stations. Re-filling of tanks is done by a fueling gun which is **41 to 45 cm** in length and the penetrating nose of the fuelling gun is **9 to 12 cm.**

All the new fuelling guns are equipped with an automatic cutting device (ACD) that switched off the pump in case of overflow.
Usually, the tank is completely filled until the filling gun automatically cut off.
However, many petrol dealers complained that the scum produced in diesel fuelling cut the filling well before the tank was filled and thus reduced the daily sale.
In such cases, the fueling boy forced in the supply by manually controlling the filling gun or by pulling the gun out at the same time slowly pouring the liquid in.
This was the usual practice in almost all the fuelling stations.

4. DISCUSSION AND DATA ANALYSIS

4.1 Estimated road damage

With an estimated percentage of error of **8 to 15 %** and on a total **525.5 Kilometers** road covered, the estimated average road damage is **1.20 %.** Or out of **4,017,200 M2** of road investigated **52,756 M2** showed damages.

It would be difficult to evaluate the estimated cost of damage caused by oil spillage or amount of oil spilled. However the damage can be quantified in terms of repairs or resurfacing taking into consideration the actual tarring cost in cubic meters.

4.2 Survey and interviews

4.2.1 Years of Experience

The purpose of this question was to find out the number of years of experience in the transport business and at the same time find out if there is a correlation between experience and responsibility as far as Oil spillage was concerned.

4.2.2 Type of company:

Before preparing the questionnaire, from the preliminary interviewed carried out among heavy vehicles users, there was a general belief in the public that government owned companies, ministries and departments tend to neglect their vehicles and are therefore more responsible for oil spillage.

This question was to address this particular issue. At the same time, it would try to establish responsibility as far as oil spillage is concerned in various heavy transport sectors, namely private individuals, private companies and government owned companies and departments.

It is clear that private heavy vehicles owners and private company drivers are more responsible as far as maintenance and repairs are concerned. And most of the time the driver is also the owner of the vehicles.

They all gives oral statement that new heavy vehicles have appropriate technology and were fitted with devices to avoided oil spillage.

4.2.3 Time refueling any specific reason:

These questions were meant to know the refueling time of the day and at the same instance to know if they have any specific reason(s) to do so.
Responses obtained from all parties clearly show a high preference for afternoon fueling of tanks. But when they were asked if they had any specific reasons to do so, all drivers/owners confirmed that this is the usual practice. Only late working vehicles refueled the next day.
Only some isolated cases of refueling are done during the day among private bus owners.

4.2.4 Re-fuelling.

It is clear that re-fuelling is done completely from the responses obtained from drivers, owners and retailers and this is the usual practice. Only some private owners agreed to refuel against a fixed sum of money.

Reason(s) for refueling completely

Question 3 refers to the time of re-fueling, whereas this question was meant to seek out reasons why re-fueling were done completely.
Accumulation of air and dew were the most plausible answers, among heavy vehicles drivers and owners.
However, 'Save time in the morning' was also a popular honest answer among bus owners.

4.2.5 Check of tank cap after fuelling.
The checking of tank cap after refueling was assertive in all cases and seemed to be a routine practice.

4.2.6 Notice of roads damages (Show Photographs)

All the drivers, owners and retailers agreed, having noticed this type of road damages on road curves and other public places

4.2.7 Experiment on solubility of tar on petroleum products

In the tar / aggregate mixture, the soluble tar loses the holding capacity and the aggregate components get separated. The tar roads affected by oil spillage, the mixture of tar/aggregate are also subjected to other secondary effects such as rainwater, friction due to sliding tyres and heavy weight.

A combined effect of above factors makes the road chafed at road curves and roundabouts.

At bus stops, the frequent use of the place and prolong stoppage, increased the spilled quantity of liquid and thus show greater damages. Fuel tank leakage is the only obvious answer to oil spillage at these places when the vehicles are at rest most of the time.

Unfortunately, experiments in the decrease in hardness or loss in tar holding capacity could not be tested.

4.2.8 Filling techniques.

The general practice of selling petrol products in fixed cash amount instead of selling per quantity also encouraged the over-fueling.

The survey revealed the high preference of fueling in the afternoon. Petrol pump owners have confirmed this fact.

Distance between fuelling opening and actual tank opening varies in length depending on the position of the tank. Tanks located in the center of a vehicle showed greater distances.

The fuelling gun is directly introduced in the tank fueling outlet, this action is repeated daily, with time the daily penetration of the fueling gun in the mouth of the tank fueling outlet damages the margin of the fueling mouth. This makes it no more liquid tight and thus allows fuel to lick out from heavy vehicles, during tilted actions. This is more apparent in vehicles above 5 years.

It was observed that most of the damages occurred at road curves. The oil spilled also damages the white line road marks.
The spread pattern of the road paint shows clearly that the oil was spilled from the right hand side of the vehicles
The white line margin next to the driver position was not affected; the paint shows a spread away from the driver position, on the other side of the road. Road reflectors were missing in many affected places; this was common where damages exceed **5** cm in depth.

4.2.9 Stake holder's perception on road damages.

The responses obtained for question number 10 which capture the observations of all the interviewees having noticed leaked oil on road curves and bus stops seem to confirm that oil spillages are greatly responsible for this type of road damages.

Opinions seem to be divided for question 11 with 82 drivers attributing the cause for oil spillage due to 'tank not properly closed' even though all of them responded positively for question 7.

4.2.10 Overfilling

Overfilling would cause Overflow - Both options revealed the same answer, therefore both options were taken as one.

Most of the drivers blamed themselves for any oil spillage and the drivers working for government companies blamed the owners.

Since mostly road curves and roundabouts showed damages, it was a popular belief from responses obtained from the survey and interviews carried out that the main cause of these road damages are due to oil spillage.
It was also obvious from the previous study that the tank shape and location may be responsible for oil spillage in heavy vehicles. Most of the vehicles used rectangular tank, only a few vehicles like TATA and ASHOK LEYLAND were equipped with cylindrical tanks. On road curves, moving vehicles take a sloping

position, the fuel tank get tilted to provoke oil spillage. Rectangular tanks although being more popular, were seen to favor more spillage. This information was confirmed from the mechanic working for the National Transport Company.

4.2.11. What do you think can be done to tackle this problem?

It is clear from their statement that they are ready to help to tackle this problem. Reduce speed on road curves seem to be the solution for the problem. However, many of them agreed that incomplete tank filling could also be a solution.

4.3. Other Damages.

Damages caused by rainwater, tap water leakage, and overhead irrigation are not included in this study.

Shade or tar road found under side road trees show considerable damage and this was apparent at Old Flacq road, Le Morne hills and in some coastal roads.

It was obvious from observation made at several places, that rainwater washes the dissolved tar. Water is definitely having an effect on our tar road, this was apparent during this study especially in Overhead Irrigation Zone.

Road curves that can be drove with an average speed of **30** kilometers and above were more affected compared to curves that required a speed below **20** kilometers.

Some roads for example the roads from Quartier Militaire to St Julien were old and showed lots of damaged patches. Damages caused by oil spillage were difficult to estimate.

The Trunk Road from Grand Bay to Airport Junction does no show much damage on the straight roads. However, damages were found on roundabouts.
Considerable damages were found at both Phoenix roundabout and the coastal roads curves from Pointe aux Piments to Grand Gaube.

Damages were also found at many Bus Stops, the degree of damages clearly shows that tar roads were more affected at places where longer stopping time were required compared to Bus Stops at remote places.

5. CONCLUSION AND RECOMMENDATIONS

The general objective was to identify the cause of road damages and to propose remedial solutions. Other specific objectives were to estimate the actual extent of the problem and identify specific causes and propose corrective measures.

5.1. Solubility of tar.

Trucks owners usually recommend application of diesel at contact surfaces before tar is loaded on the vehicles, to prevent premixed asphalt from sticking with contact surfaces and also allowed easy unloading and cleaning of trucks.

This was confirmed in the experiment carried out on solubility of tar, showing that tar is highly soluble in fueling liquids. Therefore, oil spillage is definitely affecting our tar roads, damages more frequently observed at road curves and places that require long stopping time also revealed that oil spillage is due to tillage and leakage.

5.2. Spillage due to tank type.

The experiment carried out to verify spillage due to different types of tanks revealed that rectangular tanks were more likely to cause spillage compared to cylindrical tanks.

5.3. Road Curves and Road Markings.

It was observed that most of the damage occurred at road curves. The oil spilled also affected the road markings.

The dissolved paint pattern of the road clearly showed that the oil was spilled from the right hand side of the vehicles. The white-line margin next to the driver's position was not affected; the paint showed a spread away from the driver's position that is; on the other side of the road. This observation was confirmed by the fact that most of the heavy vehicles' tanks were located on the right hand side.

5.4. Road reflectors.

Road light reflectors were missing in many affected places; this was very common where damages exceed 5 cm in depth.

5.5. Road Curves, Roundabouts and Bus Stops.

Road curves that required a speed below **20** kilometers were less affected.

Most of the roundabouts showed considerable damage, the Phoenix roundabouts is a good example. Some coastal roads curves were also badly affected.

Bus Stops that required longer stopping-time were more damaged as compared to bus stops at remote places.

5.6. Effect of water and sunlight on tar road.

Damages caused by rainwater, water linkage, and overhead irrigation are not included in this study. However, this was apparent especially in overhead irrigation zone. Shade or tar road found under side road trees show considerable damage also this was observed at Old Flacq road, Le Morne hills and in some coastal roads.

5.7. Dew condensation

Heavy vehicle users filled their tank completely in the afternoon to prevent the presence of air in fuel tank that can cause accumulation of dew, due to condensation of water vapour due to decrease in night temperature . This was the most popular belief among both drivers and owners.

Night condensation seemed to be a problem in the past, however, these days all new vehicles are equipped with a water-separating device before the diesel is supplied to the nozzle.

5.8. Tank filling

In all cases, the tanks were filled below neck level and this was done automatically because the fuel-filling gun was fitted with automatic cut-off device. An increase in the actual **diesel-filling gun of about 100mm** may decrease oil spillage considerably by preventing overfilling.

The increase in length would bring down the storing capacity but this did seem to be a problem for **Mauritius** as the maximum distance covered by our buses did not exceed **250 Kilometres a day**.

Mostly the tank was completely filled until the filling gun automatically cut off. The **extra or forcing supply of fuel seemed to be more likely to be spilled**. This was the usual practice in almost all the filling stations.

Tank caps showed no leakage only for about 6-12 months. The yearly servicing of tanks recommended by the manufacturers **was not observed** by heavy vehicle owners.

5.9. Fuel Tanks

The tank caps were properly closed after fuelling but the **damage caused to tank-mouth due to routine fuelling,** made it dented to become no more liquid-tight and allowed spillage through leakage.

The tank location did not seem to be a major factor as far as oil spillage was concerned. All the tanks were fitted on the **right-hand side of the heavy vehicles**. This was confirmed by the pattern showed by the road markings.

Segregation of fuel in two inter-linked tanks on both sides of the vehicles could have helped in the distribution of weight as far as support fittings and balancing were concerned.

Tank capacity varied from 200 to 250 Litres. The full filled tank was about 100 Kg and the fitting devices used to hold the tank often showed damages. Mechanics of heavy vehicles at the NTC recommended a regular check up and servicing as this could be responsible for oil spillage.

All the tanks were fitted with **air ventilation valves** to equalise pressure in the tank, the excessive fuel used this passage to leak out. This was reported by the mechanic working on heavy vehicles.

6. Recommendations.

1. Use concrete pavement on curves, roundabouts and bus stops.

2. Use tar macadam resistant to Diesel and Oil.

3. Do tank servicing as recommended by manufacturers.

4. Stop over filling of tanks.

5. Reduce tank damage while fuelling.

6. Inform vehicle users that water condensation in tanks is no longer a problem.

7. Reduce speed on road curves

6.1. Other Studies and Works

It is also recommended that studies on the effect of sunlight, water, diesel and motor oil on tar be carried out to improve the quality of tar.

Further studies must be carried on tank shape, size, storage capacity and type, location on vehicles to decrease spillage of oil.

Work should be carried out on road curves to avoid or minimized oil spillage.

7. DISSEMINATION OF RESULTS.

Results	Stake Holders	Findings	Solutions	Improvements
Speed on road curves	Heavy Vehicles Drivers	Curves that required speed less than 20 km are less affected	Reduce speed especially when tanks are full.	Road users Traffic authorities
Filling of tank	Filling stations workers.	Extra fuel supply, after the automatic cutting is spilled.	Stop fuelling as soon as the ACD is activated.	Fuel company Filling station workers
Filling of tank	Filling workers/Filling stations.	Fuelling gun damage the tank opening	Precaution must be taken while fuelling.	Filling station workers
Tank Servicing	Vehicles Owners	Crack on support and other parts promote leakage	Service tank Yearly or as recommended by manufacturer.	Heavy vehicles owners & company Fitness centre Police/Legislation
Water condensation in tank	Vehicles owners and drivers	It is still believed that tank must be completely filled to prevent water condensation.	Should be informed that nowadays all vehicles are equipped with a water separating device.	Heavy vehicles owners/ drivers
Concrete road curves / Tarmac	Municipalities, Local authorities and Ministry of Infrastructure.	Road curves, roundabouts and Bus stops are damaged due to oil spillage.	Use concrete tarmac.	Municipalities, Local authorities and Ministry of Infrastructure.
Quality Tar	Tar Importers / Users	Spilled Diesel damages the currently used tar.	Use diesel resistant tar.	Fuel Trading Company

8. References:

National Transport Corporation, Bonne Terre, Vacoas.http//ntc.intnet.mu
United Bus service, Cassis, Port Louis.
Rose Hill Transport, Hugnin Road, Rose Hill, www.rht.mu
Mauritian Bus Transport, Long Mountain.
Shell Head Office, 5 St Georges Street, Port Louis. http://www.shell.com/mu-en
Marine and tar Products Co. Ltd. Bitumen emulsions & Cut backs
ABC MOTORS Co. Ltd, Military Road, Port Louis, representative of Nissan SP210 Bus Chassis.

Annex

I. Solubility of tar in diesel, Motor Oil, Petrol and Kerosene:

A simple test was carried out to check the solubility of tar in the above liquids.

Procedure:

Pieces of previously laid road tar / aggregate mixture of approximately $1cm^3$ were used in the experiment. These tar / aggregate mixture pieces were weighed and suspended using a light cotton thread in the above liquids. The amount of tar that dissolved in the liquid was determined by re-weighing the tar / aggregate mixture pieces after having properly dried between filter papers. The lost in weight was recorded after every 15 minutes for a period 90 minutes.

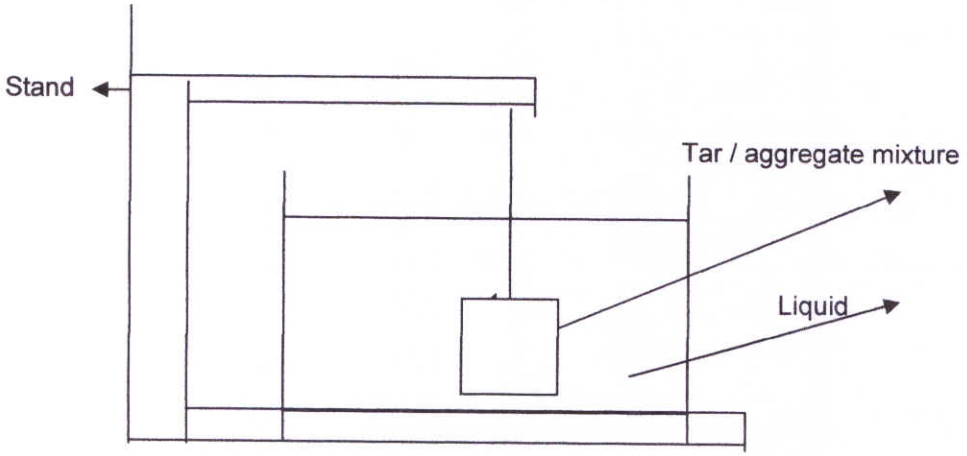

Figure 1: Experiment to test the solubility of tar in Petroleum products.

II. Experiment to calculate the amount of water spilled from rectangular and cylindrical containers when subjected to the same tilt.

Two plastic containers, both of approximately the same height, were pierced with a hole of the same diameter on the side.

Both containers were filled with the same amount of water (1500ml) and tightly fixed on large receiving trays so that the holes were on the top position (as shown in the diagram below).

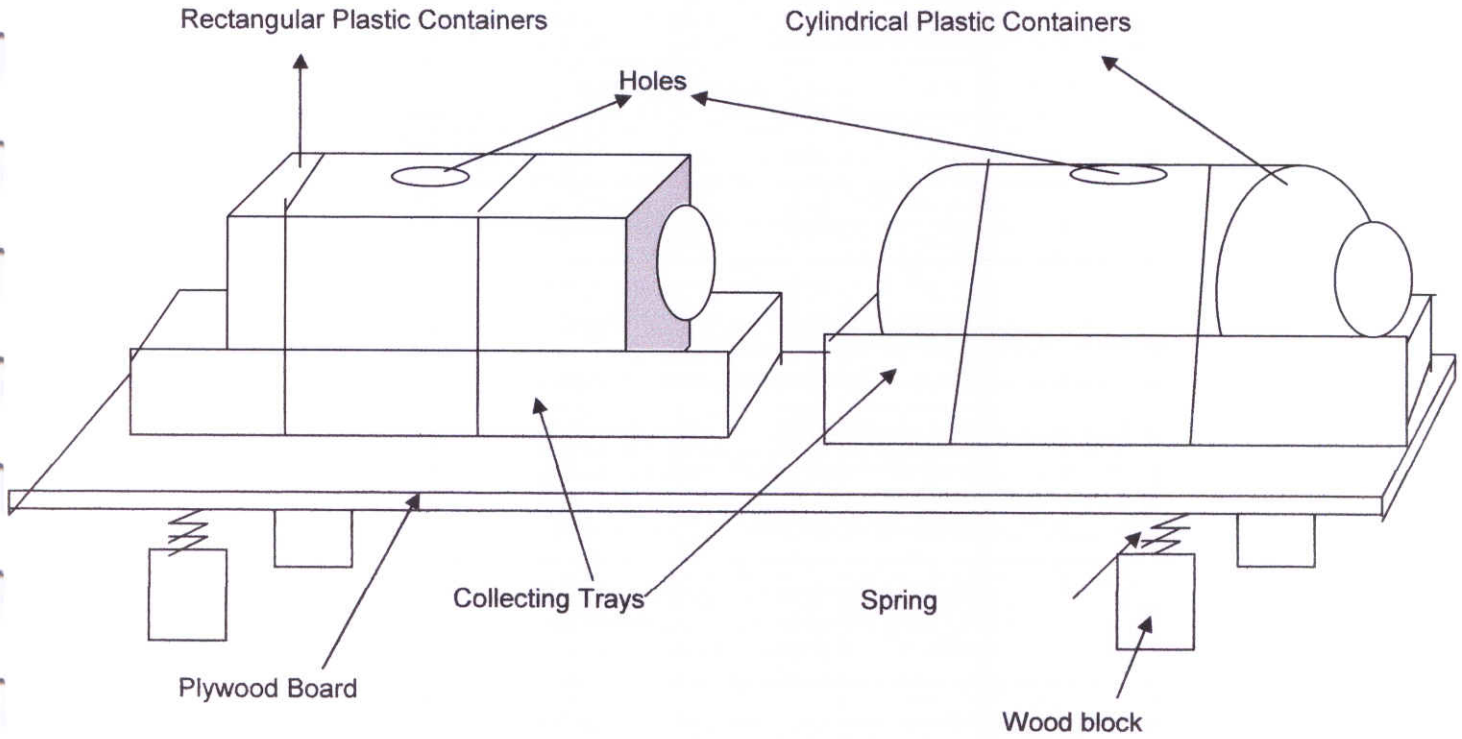

Figure 2: Experiment to of water spilled from rectangular and circular containers.

The purpose of the trays was to collect the water spilled out of the holes from the respective containers.

Both the containers were placed on a plywood platform mounted on springs and fixed to wooden blocks to allow side movement and to allow tillage.

When tilted for a fixed time, the water in both the containers was subject to the same disturbance and water spilled out through the top holes, was collected in the receiving trays. The experiment was carried out several times after measuring and returning the spilled water in their respective containers.