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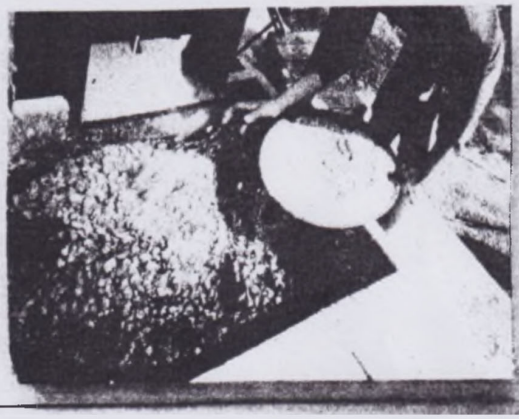
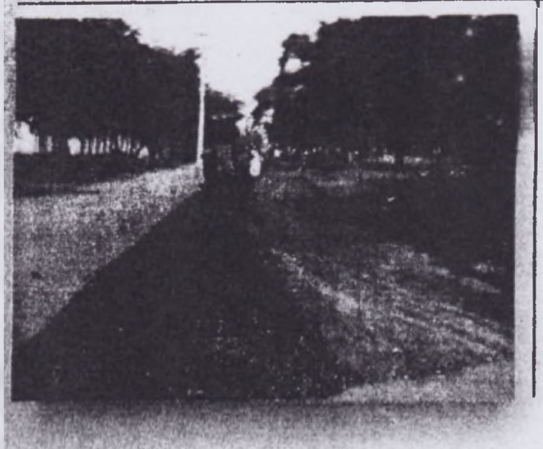
(71)

Indicative Operational Guidelines on Construction of Polymer - Bitumen Roads

(Reuse of Plastics Waste in Road Construction)





CENTRAL POLLUTION CONTROL BOARD
MINISTRY OF ENVIRONMENT & FORESTS
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E-mail; cpcb@alpha.nic.in; Website: www.cpcb.nic.in

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1.0 INTRODUCTION

Plastics have become an integral part of the modern society. Of late, the tremendous growth in the use of plastics disposable, such as packaging materials, house-hold consumer goods, automobiles, building containers, agriculture, electrical and electronics goods, health care products etc. The throwaway culture, lack of awareness and indifference among common people has lead to huge quantity of such waste on roads and pavements, gardens and parks, low-lying area, sewage drains, water bodies, along railway tracks and everywhere. Plastics are non-biodegradable and often have very long working lifetime, and end-of-life plastics can be recycled into a second life application. Plastics are ubiquitous made-up of "mers" of ethylene, styrene and acryl-amide and each of these may be polymerised to make different products mainly made-up of hydrocarbons.

In India, the consumption of plastics have increased many fold from 4000 t/a (1990) to 4 million tonnes per annum (2001) and it is expected to rise 7.5 million tonnes per annum during the year 2007. The per capita plastic consumption is 3.8 kg/annum. With the increase of plastics consumption, plastic wastes have also attracted attention for the last few years due to widespread littering on landscape, which not only affects environment but also human beings and cattle. Plastic wastes especially plastic carry bags are major threat to the environment. At present, there is no other method except recycling, to dispose of the plastics waste. The recycling of plastics has its own limitations and emits fugitive emissions. The percentage of plastics waste in Municipal Sold Waste (MSW) in metro cities is shown in Table-1.

To address the plastics waste disposal issue, an attempt has been made to describe the possibilities of reusing the plastics waste, especially post-consumer plastics waste, in road construction. This document explains the method of collection, cleaning process, shredding, sieving and then mixing with bitumen for road laying. To authenticate the work, a study was entrusted to Thiagarajar college of Engineering, Madurai to collate and compile the information related to "Reuse of Plastics Waste in Road Construction".

Table - 1

		Charactersitics (% by Wt)							
S. No	**Name of Metro city**	**Paper**	**Textile**	**Leather**	**Plastic**	**Metal**	**Glass**	**Ash,fine earth & others**	**Compost able matter**
1	Ahmedabad	6:0	1.0	-	3.0	-	-	50.0	40.0
2	Bangalore	8.0	5.0	-	6.0	3.0	6.0	27.0	45.0
3	Bhopal	10.0	5.0	2.0	2.0	-	1.0	35.0	45.0
4	Bombay	10.0	3.6	0.2	2.0	-	0.2	44.0	40.0
5	Calcutta	10.0	3.0	1.0	8.0	-	3.0	35.0	40.0
6	Coimbatore	5.0	9.0	-	1.0	-	-	50.0	35.0
7	Delhi	6.6	4.0	0.6	1.5	2.5	1.2	51.5	31.78
8	Hyderabad	7.0	1.7	-	1.3	-	-	50.0	40.00
9	Indore	5.0	2.0	-	1.0	-	-	49.0	43.00

S. No	Name of Metro city	Characersitics (% by Wt) Paper	Textile	Leather	Plastic	Metal	Glass	Ash,fine earth & others	Compost able matter
10	Jaipur	6.0	2.0	-	1.0	-	2.0	47.0	42.00
11	Kanpur	5.0	1.0	5.0	1.5	-	-	52.5	40.00
12	Kochi	4.9	-	-	1.1	-	-	36.0	58.00
13	Lucknow	4.0	2.0	-	4.0	1.0	-	49.0	40.00
14	Ludhiana	3.0	5.0	-	3.0	-	-	30.0	40.00
15	Madras	10.0	5.0	5.0	3.0	-	-	33.0	44.00
16	Madurai	5.0	1.0	-	3.0	-	-	46.0	45.00
17	Nagpur	4.5	7.0	1.9	1.25	0.35	1.2	53.4	30.40
18	Patna	4.0	5.0	2.0	6.0	1.0	2.0	35.0	45.00
19	Pune	5.0	-	-	5.0	-	10.0	15.0	55.00
20	Surat	4.0	5.0	-	3.0	-	3.0	45.0	40.00
21	Vadodara	4.0	-	-	7.0	-	-	49.0	40.00
22	Varanasi	3.0	4	-	10.0	-	-	35.0	48.00
23	Viskhapatnam	3.0	2.0	-	5	-	5	50	35.00
Average		**5.7**	**3.5**	**0.8**	**3.9**	**1.9**	**2.1**	**40.3**	**41.80**

Source: CPCB Report on status of solid waste generation, collection, treatment and disposal in Metro cities: 1999 -2000.

2.0 THE MAJOR USES OF IMPORTANT POLYMERS ARE AS FOLLOWS:

- **Low density polyethylene (LDPE)** : bags, sacks, bin lining, and squeezable detergent bottles etc
- **High density polyethylene (HDPE)** : bottles of pharmaceuticals, disinfectants, milk, fruit juices, bottlecaps etc
- **Polypropylene (PP)** : bottle cap and closures, film wrapping biscuits, microwave trays for ready- made meals etc.
- **Polystyrene(PS)** : yoghurt pots, clear egg packs, bottle caps, lids etc
- **Foamed Polystyrene** : food trays, egg boxes, disposable cups, protective packaging etc
- **Polyvinyl Chloride(PVC)** : mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, binders, folders and pens; medical disposables; etc
- **Polyethylene Terepthalate (PET)** : bottle fizzy drinks.

More than 50% of the plastics are used for packaging. These packaging materials are mainly carry bags, sachets, cement bags, cups, thermocole, laminated sheets etc. In

spite of various information regarding problems of waste plastics it is observed that there is a steady increase in the use of plastics.

A survey of the various materials available in the market shows that most of them are made up of PE, PP, and PS as shown in Table-2.

Table - 2

Plastic material	Hotels	Railway	Airport	Community Hall	Tourist center	Nature of Plastics
Cup	Yes	Yes	No	Yes	Yes	Poly ethylene
Carry bag	Yes	Yes	Yes	Yes	Yes	Poly ethylene
Water bottle	Yes	Yes	Yes	Yes	Yes	PET
Cool drinks bottle	Yes	Yes	Yes	Yes	Yes	PET
Chocolate covers	Yes	Yes	Yes	Yes	Yes	Polyester+Poly ethylene+metalised polyester
Parcel cover	Yes	Yes	Yes	Yes	Yes	Poly ethylene
Supari cover	Yes	Yes	No	Yes	Yes	Polyester+Poly ethylene
Milk Pouche	Yes	Yes	No	Yes	Yes	LDPE
Biscuit covers	Yes	Yes	Yes	Yes	Yes	Polyester+Poly ethylene
Decoration papers	No	No	No	Yes	No	BOPP

Source: Project Studies carried out at TCE, Madurai

In addition to the major polymers namely Polyethylene, Polypropylene and Polystyrene PET and PVC, there are other polymers ABS, Nylon, polycarbonate etc. which are also in use. However, their contribution to the solid waste is less.

3.0 PLASTICS WASTE IN INDIA

Plastics goods after completion of their useful life find their way into waste. The phenomenal growth of plastics and their consumption in terms of products of short and intermediate life spans have resulted in significant generation of waste. The rapid rate of urbanization throughout the world has led to the creation of increasing amounts of waste and in turn poses great difficulties for disposal. The problem is more acute in developing countries like India, where economic growth as well as urbanization is quite rapid. Often post consumer waste is associated with packaging, which in turn finds an association with plastics. Plastics have become a major threat because of non-biodegradability and high visibility in the waste stream. Their presence in the waste stream poses a serious problem, as there is no efficient management of plastic waste.

Plastic waste has attracted widespread attention in India, particularly in the last five years, because of widespread littering of plastics on the landscape of India. The environmental issues of plastic waste arise predominantly due to the throwaway culture that plastics propagate, and also the lack of an efficient waste management system.

Problems have been identified due to unorganised systems in collection, transportation and disposal.

It is observed in 1997 that the waste plastics generated in India is more from post consumer waste, as shown in Table-3.

3.1 Trend of post consumer waste

Table - 3

Description	1995 -1996	2001-2002	2006-2007
Total polymers	1889	4374	8054
Process waste (2%)	38	87	161
Post consumer waste*	870(46%)	1966(45%)	3624(45%)

*** Post consumer waste includes reprocessable mixed plastics waste**
Source: National Plastic Waste Management Task Force (1997)(fig. in thousands tones)

The predominant sources of post consumer plastic wastes are:

- Municipal sources that include residential households, markets, small commercial establishments, hotels and hospitals,
- Packing films from Industries.
- Automotive wastes, agricultural wastes, industrial waste and construction debris.

4.0 WASTE PLASTICS: A PROBLEM TO ENVIRONMENT –IS IT SO?

Plastics, a versatile material and a friend to common man became a problem to the environment after its uses. The useful plastic materials are bags, cups, thermocole, and tubes in addition to the other molded materials. These plastic materials are cheap, easily available with less value added to the disposed waste materials. Hence, they are used once or twice and then littered outside. This results in the accumulation of plastic with the municipal solid waste. Though the percentage of plastics in municipal solid waste is less than 5%, it affects the process of disposal. Instead of converting the municipal solid waste into valuable product, it is being predominantly landfilled. The major problems of plastic are non-biodegradability, thermal degradability and toxic nature of important polymers.

4.1. Non-biodegradability

Plastics are organic high molecular weight compounds, are not soluble in water and wetting property in water is nil. Hence, they do not undergo bio degradation. Some of them may be slightly soluble in some organic solvents and still the solubility is very poor.Because of the non-biodegradability, the plastic remain as it is without chemical change for many years, whether it is present in water or mixed with earth. Due to this, when it is present either in the drainage system or in water channel it can clog the path and creates problems like less flow, stagnation of wastewater causing hygiene problems.

When mixed with solid waste it reduces the rate of bio-degradability of the organic solid waste. When mixed with earth, the water flow is affected. The land fertility is also reduced. Their presence in MSW also gives eyesore.

4.2. Thermal behaviour

Plastics on heating undergoes changes in three stage first stage, become soft but no gas is produced; second stage, they undergo decomposition releases gases like methane and ethane etc. which affect the environment. On burning temperature between 700-1200 °C, they produce gases mainly CO_2, and CO. These gases are air pollutants. In case of PVC, Cl_2 and HCL gases are evolved. These gases also add to the air pollution and they may also help in the formation of toxic compounds like dioxins and furans.

4.3 Toxicants and their Effects

(During Manufacture, Recycling and Incineration)

Table - 4

Plastics	Toxicants	Health Effects	Alternative Material
PVC	Lead, cadmium, phthalates and chloroparaffins, organochlorines like dioxin, vinyl chloride	Cancer, foetal death and spontaneous abortions, altered intelligence and low intelligence	Polyolefins, LLDPE, UDPE, Ethyl Vinyl Acetate, PET
Polystyrene	Benzene, styrene, 1,3 - butadiene	Styrene oxide is carcinogenic and is a reproductive toxin.	_____
PET	UV stabilizers, pigments, flame retardants	Irritation to eyes and respiratory tract and also may cause cancer	_____

Source: Life in Plastics by Edwards and Kellet (P 160-164)

- Of the various harmful substances produced during thermal degradation of plastics the knowledge regarding the formation of dioxin is very important. **Dioxin** may cause abnormalities in the male and female reproductive systems, learning disabilities, different types of cancers, leukaemia and other diseases;

4.4. PVC and Dioxin

PVC softens around 212 °C. When it exposed to light, it decomposes to Cl_2 and HCl. These are toxic gases. When burnt they produces more toxic gases.

It is reported that above 500 °C, cyclisation of PVC could take place resulting in the formation of cyclic chlorinated compounds. These compounds are referred as dioxins.

When heated beyond 350 °C PVC decomposes releasing, Cl_2, HCl etc. In the presence of metals like Iron or Copper, the following reaction may take place resulting in the production of Dioxin. The possibility of forming Dioxin is more in an incineration where PVC is burnt. The ash that settles at the bottom helps in the formation of Dioxin.

$$PVC \xrightarrow[200 - 700\ ^{\circ}C]{} Cl_2, HCl, \text{etc,}$$

$$C + O_2 + Cl_2 \xrightarrow[350\ ^{\circ}C]{\text{Copper}} \text{Dioxin – more during downward cooling}$$

5.0 ENVIRONMENTAL IMPLICATION DUE TO MISMANAGEMENT OF WASTE PLASTICS

The garbage handling culture in India is very poor. In addition to this, the plastic material like carry bags, cups, thermocole are not having resale value. Hence they are littered around. This culture is in practice with most of the organisation, educational institutions, hotels, community halls, Railway stations, Airports and other public places. Most of the food materials and provisions are packed only in plastics. After use, the waste plastics are littered either on the streets or the street corner. There is no specific organization to collect the waste plastics, and gets accumulated with the MSW. It is therefore important that necessary measures to be taken at different levels.

The general people are to be motivated to develop the garbage culture. The public places like hotels, community halls, etc are to be compelled to follow the right garbage.

culture and the necessary arrangements are needed to collect, segregate and hand over the waste plastic to the proper person/authority for disposal. Presently, the plastics wastes are mostly disposed by land filling or by burning which are not environment friendly.

6.0 MANAGEMENT OF WASTE PLASTICS

Reduce, Reuse and Recycle is the right options of managing the waste materials.

6.1 **Reduce**:

The most direct way to eliminate the problems that stem from producing, using, and disposing of plastic packaging is to reduce the use of packaging. Retailers and consumers can select products that use little or no packaging, and when packaging is necessary, select packaging materials that can be recycled.

6.2 Recycle

Plastics waste made up of PE, PP and PS can be recycled. They are either pure or dye mixed polymers. Hence they can be recycled. In the process of recycling, the material may loose its plastics property. So the recycling is almost restricted to 5-6 times. Beyond this it becomes a waste material. Before it becomes a waste material it may be put in to use.

The laminated plastics contain two or more different polymers, PE & PET, PE & Aluminium. It is not easy to recycle these laminated materials. Hence, it is disposed along with the MSW.

The thermosetting plastics like Bakelite; Nylon, Melamine etc. cannot be reused or recycled, hence, it is thrown into garbage. Compounded plastics have restriction in recycling. The recycled plastics will be of inferior quality. The recycling process can reduce consumption of virgin polymers and also reduces solid waste load. The recycling depends on various factors such availability of plastics waste quality. There is need for more research to find methods and techniques for recycling processes, however, improved recycling processing available in which both quality of product is improved as well as process is environmental friendly.

7.0 DISPOSAL TECHNIQUES

7.1 Landfilling

It is a process used for disposing of plastics waste materials, which are non-degradable in nature. Generally house debris, industrial wastes like slag, flyash etc. are disposed using this purpose. Municipal solid waste, once considered as a source of organic manure, now is used for landfilling, because it contains higher percentage of inorganic materials. Moreover, the waste plastics are also mixed with the MSW. The presence of plastics in MSW, affects the quality of the landfilling materials. The strength of the land is reduced due to its in pervious nature which reduce the biodegradability of organic matter.

Indirectly, the waste plastics are disposed along with MSW. It is only helping to postpone the actual problem of plastics waste disposal. Moreover, the availability of landfill site is already decreasing. They are being transported to long distances. This increases the cost of disposal. If the waste plastics are segregated at source (domestic, community places, etc.) and collected separately, this will prevent the mixing of plastics waste in Municipal solid waste and will help in the disposal of plastics waste in many ways;

- The segregated plastics can be recycled or reused safely;
- The plastics free MSW can be converted into value added manure and can be reused. This helps to solve the problem of non-availability of space for land filling;
- MSW free from waste plastics, if used for landfilling, can act as better filler.

7.2 Incineration

The scientific burning of the waste material. It is known as incineration. Different types of incinerators are being used. Normally, the waste material is heated between 700 to 1200º C and burnt completely. The gases are driven out and the residue ash is used for landfilling. For the incineration process maintenance of temperature is very important. The incineration process produces toxic gases, if the temperature is not properly maintained. Generally, the gases evolved are CO, CO_2 and toxic gases like SO_2 etc. In India, this technique is not encouraged or practiced.

The thermal decomposition of plastics waste releases toxic gases like CO & CO_2 similar to other organic solid waste. If PVC is present, as electrical wire, toys, etc. in the solid waste, it releases Cl_2, and HCl. As mentioned earlier, the Cl_2 can help the formation of Dioxin. Moreover, most of the MSW are not burnt scientifically but burnt in open air, without maintaining temperature between 700 – 1200 °C. There are more possibilities of having lower temperature between 300 to 400 °C. This causes the formation of dioxin. Even the MSW containing plastics waste burnt in an incineration, the ash that settles may also help Dioxin formation in the presence of Cl_2.

7.3 Reuse

The term reusability is more linked to the reuse of the objects, water bottles, water-cans etc. but this may reduce the consumption of virgin polymers per year. Using some of the important properties of the waste plastics, like its binding property when softened or its solubility in organic solvent etc. various reuses needs to be innovated. This can help in solving the plastics waste disposal problem.

The use of waste plastics for the construction flexible pavement, making pavement blocks; light roofing etc. have been developed at Dept. of Chemistry, Thiagarajar College of Engineering, Madurai. This technology has been already implemented in Tamilnadu, Pondicherry, Mumbai and Cochin.

The aggregate is heated to around 200°C. To this add shredded processed waste plastics. Mix it effectively and mould it to a suitable size. The product has good compression strength and flexural strength as shown in Table-5.

Table - 5

Types of Polymer	Compressive Strength	Flexural strength
PE	>150 tons	500 kg
PP	>150 tons	250 kg
PS	>150 tons	250 kg

Source : Project studies at TCE

These values are higher in the products like concrete tiles and mosaic tiles. It shows that the molten plastics materials can be used as a binder, and it can be mixed with binders like bitumen to enhance the binding properties. Virgin polymer-bitumen blends were prepared and their properties were studied. It is observed that polymer bitumen

blend has improved qualities as road construction materials.(Oscar González Uranga, Departamento de Ciencia y Tecnología de Polímeros.Facultad de Química, Universidad del País Vasco.P. O. Box 1072, E-20080, San Sebastián, Spain).

Experiments were carried out to determine the softening temperature of various important plastics materials available in the market, which are, after use littered and mixed with solid waste. The results are shown in Table-6.

8.0 DIFFERENT TYPES OF PACKAGING PLASTICS AND THEIR THERMAL BEHAVIOUR

The thermal behavior different kind of plastics are presented in Table 6 below:

Table - 6

Sl. No	Name of the company	Classification	Chemical Composition	Film thickness (Micron)	Softening Point, °C
1	Britannia marie gold Reynolds	Laminated	Polyester + Polyethylene	40	120
2	Reynolds	Laminated	Pearlized BOPP + BOPP	90	105-110
3	Surf Powder	Laminated	Polyester + Polyethylene	40	175
4	Aavin	Three Layer	LDPE	60	120-130
5	Ajantha Supari	Laminated	Polyester + Polyethylene + Metalized Polyester	70	125-130
6	Good Day Biscuit	Laminated	Polyester + Polyethylene + Metalized Polyester	40	160-170
7	Lays Chips	Laminated	Polyester + Polyethylene	50	85-90
8	Nizam Supari	Laminated	Polyester + Polyethylene	50	65
9	Agar Sticks Packed Paper	Laminated Laminated	Polyester + Polyethylene + Metalized Polyester	70	160-170
10	Carry bags	Film	PE,PP	10	130
11	Cups	Disposal cups	PE or PS	60	130 -140
12	Thermocole	Foam	PS	-	120
13	Industrial packaing material	Film	PE , PS	40-60	140

Source: Plastics Processing and Environmental Aspects, Shriram Institute for Industrial Research, Delhi

For, A Mamuari
MPCB
With thanks — Samuda

It is observed that most of the filmy materials are made up of PE, PP, PS and they have the softening range between 130 to 150 °C. it also observed that there is no evolution of gaseous products during the heating of these materials (Table - 7). Hence, these materials can be used for road construction. The materials that can be used are.

1. Film having thickness <60 micron.
2. Disposable cups
3. Thermocole – EPS
4. Laminated film made up of PE & PET
5. Laminated film made up of PE & Aluminum
6. Bi-axially Polypropylene (BOPP)

The waste plastics are available in plenty. Use of these materials in flexible road construction can help in many ways like easy disposal of waste, better road construction, and prevention of pollution and bitumen resource conservation. Films, Laminated films, foam and disposable cups can be used for road construction. A film having thickness less than 60micron can be used for road construction. Normally, laminated films, containing layers of PE and PET and aluminum-coated films are not easily recycled. These laminated films can be used for road construction. In addition, the BOPP film can be used for road construction. Films made up of PVC are not used for road construction, because of evolution of toxic gases like chlorine and HCl during heating.

9.0 STUDY ON THE USE OF WASTE PLASTICS FOR ROAD CONSTRUCTION

9.1 Determination of solubility of polymer in Bitumen

The waste polymers such as polyethylene (sheets) polypropylene (sheets and film) and polystyrene (thermocole) are soluble in hot bitumen to the extent of 1 to 2% only. It was observed that we need to characterize the two types; (1) waste plastics-bitumen blend containing <2%; and (2) the mix containing >2%.

Blend samples were used to carry out the following tests namely,

1. Softening point; 2. Penetration Value; 3. Flash & Fire point; and 4. Ductility test

9.2 Determination of softening point

The blends of different composition with different polymers have been prepared and their softening points were determined.

Table – 7

% of polymer in Bitumen	Softening Point (Degree Celsius)			
	PE	PP	PS	CRUMB+PE
0	50.2	50.2	50.2	55
0.5*	52	57	53	57
1.0*	60	61.5	60	63
2.0*	58.2	58.5	57	60
5.0**	62.0	61.0	59	62

Softening point of bitumen used was 50.2
Source: Experiments conducted at TCE, Madurai (IS 1205:1978)

It was observed that the softening point increases by the addition of polymer to the bitumen. The influence over the softening point is depended on the chemical nature of the polymer added. There is a variation in the rate of increase of softening point based on the type of polymers, like PE, PP, PS and PET.

Note: **The percentage of polymer added is always with respect to the weight of bitumen used.**

9.3. Penetration Test

Table – 8

% of polymer in Bitumen	Penetration Value (100 gm, 5 seconds, at 25 deg. C) ($1/10^{th}$ of mm)			
	PE	PP	PS	CRMB 55
0	70.0	70.0	70.0	55
0.5*	68	70.3	71.3	54
1.0*	67	68.57	68.5	53
2.0*	55.7	62.75	62.7	50
5.0**	52	-	-	41
10.0**	<40	-	-	<40

Source: Experiments conducted at TCE, Madurai (IS 1203: 1978)

The increase in the percentage of polymer decreases the penetration value. This shows that the addition of polymer increases the hardness of the bitumen.

9.4 Ductility

The following data shows that the ductility is increasing by the addition of polymer to Bitumen.

Table - 9

Percentage of Polymers	Ductility		
	PE	PP	PS
0	20.0	20.0	20.0
0.5*	28.1	31.5	28.6
1.0*	29.3	79.9	26.9
2.0*	35.4	72.9	20.7

Source: Experiments conducted at TCE, Madurai (IS 1208 : 1978)

The increase in the ductility value may be explained as follows. The long polymer molecules when mixed hot, physically interlock the material and this may help to reduce cracking at the surface.

9.5 Flash and fire point

The study of flashes and fire points of the polymer–bitumen blend helps to understand the inflammability nature of the blend.

Flash and Fire point
Table - 10

Percentage of Polymer	Polyethylene		Polypropylene		Polystyrene	
	Flash Point	Fire Point	Flash Point	Fire Point	Flash Point	Fire Point
0.25	280	340	320	345	240	300
0.5	290	350	330	340	270	310
0.75	295	330	333	350	280	315
1.00	340	350	342	355	295	320

Source: Experiments conducted at TCE, Madurai (IS 1209 : 1978)

The above study shows that the polymer-blended bitumen has improved properties with respect to its use as binder for road construction. The use of polymer-bitumen blend for road construction can be further strengthened by studying the properties like Stripping value and Marshall value of the mix prepared using waste plastics- bitumen blend and aggregate.

9.6 Characterization of Waste Plastics-Bitumen-Aggregate mix for flexible Pavement

Method – I
(Soluble region (<2% plastics) waste)

a. Stripping value

Waste plastics are dissolved in bitumen (2% PE) and the blend is coated over aggregate. It is tested by immersing in water (ISI code) after 72 hrs., there was no stripping showing its increased resistance to water. This shows that the blend has better resistance to water, this is because of better binding property of the polymer – bitumen blend (Ref: Bituminous mixture edited by Robert En hunder Thomas Telford, London)

b. Marshall Test:

The Marshall Stability Values (MSV) were determined for the waste polymer bitumen blend having the percentage of maximum 2% (in the soluble region). (Table –11)

Table - 11

Percentage of Waste Polymer	Marshall Stability Value in kg
0	1100
1	1600
1.5	1680
2	1780

Source: Experiments conducted at TCE, Madurai (ASTM - D 1559)

This shows that waste plastic-bitumen blend imparts higher strength compared to pure bitumen, whose value is approx. 1100 kg. Though the polymer-bitumen blend is showing better properties, the mixing of waste plastics with bitumen is a difficult process. Normally, the solubility of plastics in bitumen is <2%, to dissolve even this small quantity, it requires strong and continuous stirring.

In the case of actual road laying, large quantity of waste plastics should be mixed with hot and highly viscous bitumen. On adding the plastics it was observed that being very light in weight it floated over the hot bitumen. Hence the mixing could be possible only by having high power mechanical stirrer in the 'heat master'. In order to avoid this problem and to make road construction easier an alternative method has been worked out. Accordingly, the aggregate is heated and over the heated aggregate the plastics is added. This get softened and then coated over aggregate in a very short time. Now the bitumen is added and the mix (plastics-aggregate-bitumen) was tested for Stripping and Marshall value

Method – II: Modified process (Higher percentage region)

1) Stripping Test

The aggregate was coated with waste plastics with a known percentage and then the bitumen is coated at hot condition. The waste plastic-bitumen-aggregate mix was immersed in water and there was no stripping after 96 hrs. This shows that the waste plastic-bitumen coated mix has good resistance towards water penetration. This may be due to; (1) Increased binding of the waste plastics – bitumen blend over aggregate; and (2) Coating of polymer (a non- wetting material) over the aggregate, which gives hydrophobic property or non-witting surface to water (IS 6241: 1971)

2) Marshall Test

a) Effect of addition of waste plastics

Table - 12

% of Binder Content	Percentage of Waste Polymer	Marshall Stability Value in kg
4.6	0	1150
4.6	5	2010
4.6	10	2540

It is observed that the addition of waste plastics (PE) increases the Marshall Stability value.

b) Effect of variation of Bitumen content.

Keeping the percentage of polymer added as 10%, the bitumen content of the mix was varied and the Marshall Stability Values were determined

(Percentage of Polyethylene 10%) (By weight of Bitumen)

Table - 13

% of Bitumen	Marshall Value in Kg
4.2	1960
4.5	2520
4.6	2540
5.0	2520
5.4	2500

It is observed that the Marshall Value obtained is much higher than that of pure bitumen mix. It is also observed that the addition of waste plastics reduces the need of bitumen. For an effective binding as per the IV revision (High ways road & Bridge construction), 5% of bitumen is added. From the experimental results of TCE, it is observed that the addition of lower percentage of bitumen with waste plastics blend shows much higher Marshall value (Table – 13). It helps to reduce the quantity of bitumen to the extent of 10% to 15% and thus helping to save bitumen.

In general, it is suggested that **Method - II** is the best suited process for the use of higher percentage of plastics waste and for higher performance of the flexible pavement. Hence it may be inferred on the basis of Marshall Stability Value that the 10% blend of waste plastics is an optimum percentage for road construction, considering the cost factor and the consumption of bitumen.

10.0 STUDY ON THE NATURE OF THE POLYMER COATING ON AGGREGATE

A known quantity of aggregate (1000g) was taken and heated to around 700 °C to remove all volatile impurities. It was cooled to room temperature. The cooled aggregate was again heated to 170 °C. To the hot aggregate, 70g of waste plastics polyethylene material (passing 4.75mm and retaining 2.36mm) was added uniformly and cooled to room temperature. The aggregate – polymer blend was divided into five fractions. Each fraction was separately heated to > 700 °C to burn all the polymers coated over the aggregate. It was then again cooled to room temperature and the weights of aggregates were noted, and results are shown in table-14.

Table - 14

Weight of aggregate fraction		Difference in Weight	Percentage
Before burning	After burning		
100	99.40	0.60	6.03
200	198.65	1.35	7.30
100	99.60	0.40	4.05
300	297.80	2.20	7.40
307	304.55	2.45	8.04
1007	1000.00	7.00	7%

Average = 6.56%

Source: Experiments conducted at TCE, Madurai

This shows that the molten plastic is coated over the aggregate uniformly. It is also confirmed by another test procedure. By dissolving the coated plastics in a suitable solvent and then determining the loss of weight of aggregate it is evaluated.

11.0 OPERATIONAL GUIDELINES / MANUAL FOR ROAD CONSTRUCTION

(Raw material collection/ segregation/sorting)

11.1 Plastics waste collection, segregation & storage

Post–consumer plastics waste namely carry bags, cups, tumbiers, spoons, plates, thermocole etc are thrown alongwith MSW. Therefore, the waste plastics have to be picked-up manually from the municipal waste storage or transfer sites involving NGOs. Municipal corporations/councils may also help in process of collection. Besides, it can also be picked-up from the larger users such as Railways, Hotels, Airports, Schools, Factories, Community Halls, Banquet Halls etc. After colleting the post-consumer plastics, it is segregated for different types of plastics such as Polyethylene, Polypropylene, Polystyrene etc. However, PVC is not used in this process.

The segregated plastics waste has to be stored in a dry place. If the waste is wet, it need to be dried and stored. The collected waste can be shredded and stored easily. This occupies less space, hence large quantity of shredded waste could be stored in small yards/godowns which can be supplied for road laying when required.

Photo 1- Collections of Plastic Wastes From Municipal Garbage

Photo 2 - Sorting of Waste Plastics after Collection before Selling to Recyclers

11.2 Cleaning Process

If needed these polythene bags should be dry cleaned and thereby freed from dust and dirt. The machine design is shown below:

Photo 3 : Showing cleaning process of plastics waste

A rotating cylinder made rods is designed. At the centre, a central rod with four perpendicular shafts is fixed. The system is connected with a motor and the centre rod rotates, when power supplied. There are two openings one at the top and the other at the bottom. The waste plastics are added through the top opening and the motor is switched on. The waste material is submitted to rotation and this removes the dirt and the dust. The cleaned bags are then collected and shredded.

1.3 Shredding Machine

It is known as scrap grinder. This is available in different capacity ranges. The general configuration is that it has 4 to 5 blades, which rotate using electrical motor. This cuts the plastics film to the definite size. The design and the number of blades can be decided on the basis of the requirement namely the size, the output and the nature of the film.

Photo 4: Showing a Typical Grinding/Shredding Machine

This can cut nearly 10 to 15kg of plastic film per hour. There are many industries in Mumbai, Ahemadabad, where these types of machines are being manufactured for a given specification and shredders can be designed according to the need.

12.0 WASTE PLASTIC – AGGREGATE – BITUMEN MIX ROAD CONSTRUCTION

12.1 Polymer Modified Tar Road

On the basis of above experimental evidences the process of road laying using waste plastics is designed and the technique is being implemented successfully for the construction of flexible roads at various places in India. A brief description is given below followed by a detailed description.

Brief description

Disposed plastics waste (films, cups and thermocole) are sorted and cleaned

↓

Waste plastics to the required size (passing 6.75mm and retaining 2.36mm) are shredded

↓

Heat the aggregate to around (160 - 170^0 C)

↓

Quantitative Addition of shredded Polymer waste with proper mixing technique to get a Uniform coating at the surface (30-40 sec only)

↓

Quantitative addition of hot bitumen whose temperature is maintained between 155-163°C

↓

Mix the waste plastic –Aggregate Bitumen to get a uniform mix (composite)

↓

Bitumen –Polymer waste –aggregate mix (composite) is taken out around 130-140°C and used for road Laying

↓

Road laying is done between 110-130°C to get better result using 8 ton roller

Process-I:

2.2 Using Mini Hot Mix Plant:

This process is being used for laying Rural roads and State highways.
The process of manufacturing the mix (composite) is described below:

Step-I

Waste plastics, namely bags, cups and thermocole, made out of PE, PP & PS are collected and segregated. The dry segregated plastics are shredded into small pieces with size passing through 4.75mm sieves and retained in 2.36mm sieves as described earlier.

Step: II

(a) The solid aggregate (granite, ceramic) with proper proportion of metals having different size and dust (quarry dust) is heated to around 170°C in the Mini hot mix plant and the heated materials is transferred to the adjacent puddling chamber.

(b) Simultaneously the Bitumen 60/70 or 80/100 is heated to around 160°C. The following precautions should be taken during the road laying process:
i) Heating to higher temperature (>160°C) should be avoided. If heated to higher temperature, bitumen looses slowly its binding property. This will be very well seen by the formation of potholes.
ii) Periodical temperature monitoring is very important at every stage of the process. The aggregate temperature is to be checked. The temperature of the bitumen is to be noted, and temperature of the mix during road laying is also to be monitored. The monitoring of the temperature can be very easily done by using Infra Red (IR) thermometer (Model No: AZ8868).

Step: III

The heated aggregate is transferred to puddling chamber, where it is continuously stirred. To this shredded plastic is sprayed to get an uniform coating at the surface of the aggregate. The quantity of addition of plastic depends on the nature of the surface to be prepared. The percentage addition can vary from 5 to 10% by weight to the weight of Bitumen. The added plastics gets softened and coated over the aggregate within 30 to 45 seconds, and the aggregate look like oily coated aggregate.

Step: IV

The aggregate is coated with plastics waste. To this, add the Bitumen (160°C) and mix uniformly, maintaining the temperature in the range of 155 to163 deg. C which is very important.(as per the specification IRC) After mixing, the material is withdrawn at around 140°C and the polymer-bitumen mix (composite) is used for road laying. **The mix (composite) is referred as waste plastics-aggregate-bitumen mix**. The road is laid between 110-130°C temperature.

Photo 5 - Adding of shredded plastics into Bitumen

Step: V

Photo – 6 Showing Polymer-Bitumen Mix.

The polymer tar road is laid by spreading uniformly the waste plastics aggregate bitumen mix as per the specification of IRC. It is rolled using 8 tons roller. Proper monitoring of; (1) temperature ;and (2) quantity of addition of plastics are very important. Here the waste polymer is coated over the aggregate at around 160°C and over this the Bitumen is added. The molten plastics waste not only covers the surface of the aggregate but also binds well with the aggregate and helps bitumen for better bindin with the aggregate.

The added binding property with the addition of plastics, helps to improve the quality o the road in terms of withstanding increased load & abrasion, preventing bleeding cracking and improving resistance of water penetration.

Process – II:

13.0 ROAD LAYING USING CENTRAL MIXING PLANT (CMP)

For laying long roads with less time schedule it is necessary to use Central Mixin Plant. The aggregates are transferred from the hoppers by means of conveyer belt t the rotating hot drum. There, it is heated to around 170°C and then mixed with ho bitumen. The bitumen-coated aggregate is then collected and transported (This is the

existing procedure as per the IRC specification). The same process is used for laying polymer tar road, it is described as follows.

Photo- 7 Showing Road laying process

In this process, the aggregates are added through different hoppers and they are transported by means of conveyer belt into the hot rotating drum.

The addition of waste plastics is done near the first and second hopper and it gets mixed with the moving aggregate in the cold condition itself.

3.1 Addition of plastics waste

For a given period of 30 seconds, if one tonnne of bitumen is used, the plastics quantity needed is 100kg. This 100kg of properly shredded waste plastics is to be added uniformly over a period of 30 seconds i.e.3.33 kg/minutes over the moving conveyer. This is done manually. This process can be mechanised to avoid errors. Attempts are being made to design suitable machinery. It is getting transported to the hot drum where the aggregate is heated to around 170°C and the waste plastics get melted and coated over the aggregate. The bitumen is added subsequently and the aggregate polymer bitumen mix is released and collected in the Tipper, which is having proper insulation. The material collected in Tipper is uniformly coated and has a temperature of 140°C. This is

Photo – 8. Polymer-Bitumen Road leveling process at Thanjaur (TN)

transported to the road laying spot where it is spread over using a paver machine. Before spreading, the surface has to be given tack coat using either emulsion or 60/70 bitumen as per Indian Roads Congress (IV) revision specifications, 8 tons roller is used for compacting.

The process using Central Mixing Plant helps to have better mixing and thereby ensuring better quality roads. It is due to the following steps; **(1)** the coated aggregate is transported through a conveyer belt to the dipper; **(2)** it is transported to the site; **(3)** it is filled from dipper to paver ;and **(4)** paver itself mixes the materials during the laying. As each step contribute for better mixing, the roads laid by this technology are much better. Roads laid at Salem*, Bharat Petroleum*-Tanjore, Pondicherry* and Mumbai* are all functioning well.

13.2 Laying of bitumen road – Indian Roads Congress specification

There are different types of bitumen roads they are, Dense Bituminous Macadam (DBM), Bituminous Macadam (DM), Semi Dense Bituminous Concrete (SDBC), Bituminous Concrete (BC) etc. They differ in **1)** composition of the aggregate **2)** type of bitumen used and **3)** thickness of layer. Bitumen is a useful binder for road construction and different grades of bitumen like 30/40, 60/70, and 80/100 are available on the basis of their penetration values. Waste plastics can be used for different types of bitumen roads and the technology of road laying is same as prescribed by the Indian Roads Congress Specifications IV revision.

14.0 MERITS OF THE POLYMER – BITUMEN ROAD

14.1 Stripping test and pot hole formation

Granite aggregates used in road construction have great affinity for water due to inherent wetting nature of the aggregate. Bitumen has very poor water wetting property. This results in the penetration of water between aggregate and Bitumen layer if water is stagnated over the surface. Thus bitumen film is often stripped off the aggregates because of the penetration of water, which results in pothole formation. This is accelerated during the movement of vehicle. When polymer is coated over aggregate, the coating reduces its affinity for water due to non-wetting nature of the polymer and this resists the penetration of water. More over the polymer – bitumen blend is having higher binding property. Hence the penetration of water is reduced which resists stripping and hence no pothole formation takes place on these roads.

14.2 Leaching test

Polymers are not soluble in water or acids and even in most of the organic solvents. (The Toxicity test solution is 5% acetic acid). The polymer waste is tested with 5% acetic acid solution and it is observed that there was no dissolution of polymer. Therefore, it may be concluded that polymer will not leach out of the bitumen layer, even after laying the road using waste plastics-bitumen-aggregate mix.

The formation of dioxins, the toxic compound, during the heating of polymers, under the following conditions:

$$\text{Carbon + Oxygen + Chlorine} \xrightarrow[\text{Copper Catalyst}]{\text{300 - 400°C}} \text{Dioxin}$$

Presence of Chlorine, Copper and appropriate temperature are needed to form the Dioxin. In the process of preparation of polymer Bitumen aggregate mix, the max. temperature is kept as ≈ 170°C and no chlorine or copper is present in the system. The polymer materials used are polyethylene, polypropylene and polystyrene, and use of polyvinyl chloride is not suggested, hence, there is no possibility of presence of chlorine in the system and dioxins are not formed during the use of waste polymer for road construction because temperature is not favourable. So it may be considered a safe method of disposal of waste polymers.

14.3 Effect of Bleeding

The softening temperature of bitumen is between 45-50^{0}C. During summer in India the atmospheric temperature is higher than in tropical regions, and hence bleeding takes place. Bleeding accounts, on one side, increased friction for moving vehicles and during rains create slippery condition. Both these adverse conditions are much reduced by using polymer aggregate bitumen blend as road construction materials. Waste polymer-bitumen blend shows higher softening temperature. This increase will reduce the bleeding of bitumen during the summers.

14.4 Effect of fly ash

Addition of waste plastics, generally improves the strength of the road. The addition of fly ash to the polymer aggregate bitumen mix improves the strength of the flexible pavement. The strength depends upon quantity of the fly ash and the polymer added. It is also observed that the fly ash does not leach from this mixture. Above all, for 1000m x 3.5m road nearly 10 to 15 tons of fly ash is used. Disposal of fly ash becomes easy by this process.

14.5 Special Aspects

- The whole process is very simple. The existing technology is slightly modified.
- It needs no new machinery and the available Mini hot-mix plant and Central mixing plant can be used.
- The waste plastics available in the surrounding area can be picked-up and used then and there.
- The process is eco-friendly
- Waste Plastic gains resale value
- Job opportunities in terms of rag pickers, segregators increase.
- Roads laid at various places (table - 15) using this technique are performing well.

15.0 DEMERITS

There is no observable demerit either in this process or in the road characteristics. For the past 2 years various roads laid using waste plastics are functioning well.

The success of the process depends upon 1) The collection of waste from the source and 2) the segregation of the waste from the MSW. Planning and proper execution for this work is needed

16.0 OTHER WORKS ON THE DISPOSAL OF WASTE PLASTICS

M/s. K. Poly Flex (p) chem. Bangalore has developed waste plastic modified bitumen and this can be used for road construction. Nearly 8% mixture of plastics is manufacture as per their publication and this is used for road construction. This work has been already implemented at Bangalore. It is observed from the literature (paper titled-Utilization of waste plastics bags in bituminous mix for improved performance of roads (unpublished) by Prof C. E. G. Justo;) that the performances of charge roads are good.

Central Road Research Institute, New Delhi on 14th Nov 2002, also made a report on this work. According to this report the polymer modified bitumen has better marshal value, less rutting etc. This work also supports the work done at Thiagarajar College of engineering and helps to confirm that the plastic-aggregate-bitumen mix road will definitely withstand heavy load and will not easily be affected by rain.

17.0 PLASTICS-TAR ROADS AND THEIR PERFORMANCES –CASE STUDIES

The polymer-tar road using this technology was laid at different places in Tamil Nadu and the list is enclosed. Specific cases have been discussed below to show some important aspects of the road, road laying, monitoring performance and waste collection.

Case Study - I

1.	Place	: **Thiagarajar College of Engineering, Madurai**
2.	Road laying authority	: Management of TCE
3.	Date of Laying	: 23rd march 2002
4.	Road length	: Length 60" x width 18"
5.	Plant	: Hand Machine
6.	Source of waste	: Waste plastics collected from the College
7.	Date of monitoring	: 7th Jan'05
8.	Process	: Using waste plastics blended bitumen

The plastic road is very good and is equal in every respect compared to the adjacent road laid using plain bitumen. No pothole cracking has developed so far.

Case study – 2

1. Place : **Lenin Street - Kovilpatti**
2. Road laying authority : Municipality – Kovilpatti
3. Date of Laying : 4th October 2002
4. Road length : 300m x 3.5 width
5. Chief guest : Collector, Tuticorin & M.L.A, Kovilpatti
6. Plant : Mini hot mix plant
7. Source of waste : Segregated from MSW
8. Date of monitoring : 11th Nov'04
9. Process : Polymer –aggregate – bitumen mix

Observations

- There is no rutting, potholes and cracking even after two years.
- The people living in that street have developed two bin culture and they separate the waste plastics at the source and the Kovilpatti municipal corporation in collecting the waste separately.

Case study - 3

1. Place : **Mannar College Road- Madurai**
2. Road laying authority : Highways, Madurai
3. Date of Laying : 5th Oct' 2002
4. Road length : 200m x 7m width
5. Plant : Mini hot mix plant
6. Source of waste : Industrial plastics waste
7. Date of monitoring : 11th Dec'04
8. Process : Polymer –aggregate – bitumen mix

Observations:

This plastic-bitumen blend road was laid over existing damaged concrete road and the road laying was found to be equally good. It was laid under the direct supervision of Highways authorities. Road is in good condition and stable. There is no pothole or crack.

Case study – 4

1. Place : **Jumbulingam Street , Chennai**
2. Road laying authority : Chennai Corporation
3. Date of Laying : 22nd Nov' 2002
4. Road length : 500m length x 7m width
5. Plant : Mini hot mix plant
6. Source of waste : Municipal waste plastics /Industrial plastics waste
7. Date of monitoring : 15th Dec'04
8. Process : Polymer –aggregate – bitumen mix

Observations:

Road is in good condition and stable. There is no pothole or crack.

Case study - 5

1. Place : **Brindavanam Street – Salem**
2. Road laying authority : Corporation, Salem
3. Date of Laying : 17th April 2003
4. Road length : 1.5 km x 7m width
5. Plant : Central mixing plant
6. Source of waste : segregated plastics waste from MSW/ plastics waste collected by the students
7. Date of monitoring : 30th Oct'04
8. Process : Polymer –aggregate – bitumen mix

Observations:

Road is in good condition and stable. There is no pothole or crack.

Case study -6

1. Place : **Bharat petroleum Plant - Tanjore**
2. Road laying authority : General manager, Bharat Petroleum Chennai
3. Date of Laying : 25th March' 2004 (CD enclosing)
4. Road length : 1.5 km x 10m width
5. Plant : Central Mixing plant
6. Source of waste : Segregated plastics from MSW
7. Date of monitoring : 3rd January'05
8. Process : Polymer –aggregate – bitumen mix

Observations :

The polymer aggregate bitumen blend road was laid at the factory site of Bharat Petroleum Ltd. at Tanjore during March' 04 over the existing WPM. A distance of 1.5km with a width of 10m was laid. Here heavier trucks having more than 40 tons load are plying both ways daily. The authorities have given a satisfactory report about the functioning of the road.

Case study - 7

1. Place : **Parry & Co, Ranipet, Chennai**
2. Road laying authority : Parry & Co, Chennai
3. Date of Laying : July 2003
4. Road length : 200m x 3.5m width
5. Plant : Mini hot mix plant
6. Source of waste : Segregated plastics from MSW
7. Process : Polymer – Ceramic waste – bitumen mix

Observations:

Parry & co, Chennai has a good amount of ceramic waste. It was crushed and used for road laying. Polymer-ceramic- bitumen mix was used to lay the road at the factory site, which is situated near Ranipet.

The road is good and stable and it shows that ceramic waste can also be used for road laying instead of granite aggregate. This study also demonstrates the possibility of reusing waste material form a Ceramic unit

Case study -8

1. Place : **Asaripallam - Nagercoil**
2. Road laying authority : Municipality, Nagercoil
3. Date of Laying : 16th May' 2003
4. Road length : 600m x 3.75m width
5. Plant : Mini hot mix plant
6. Source of waste : Segregated plastics from MSW
7. Date of monitoring : 13th Nov'04
8. Process : Polymer –aggregate – bitumen mix

Observations:
Nearly 1 km rural road was laid over WBM by the village panchayat using mini hot mix plant process. The road is stable. People also feel good about this road. The people have already sent representation to the collector to lay plastic road in the other areas also

Case study -9

1. Place : **Kuzhithurai - Nagercoil**
2. Road laying authority : Municipality, Kuzhithurai
3. Date of Laying : 4th July' 2003
4. Road length : 300m x 3.75m width
5. Plant : Mini hot mix plant
6. Source of waste : Segregated plastics from MSW
7. Date of monitoring : 13th Nov'04
8. Process : Polymer –aggregate – bitumen mix

Observations:
Road is in good condition and stable. There is no pothole or crack.

Case study: 10

1. Place : **New Prabhadevi Road (Opp. Samna Press), G – S Ward, Mumbai**
2. Road laying authority : Bombay Municipal Corporation,
3. Date of Laying : 7th Dec' 2004
4. Road length : 400m x 3.75m width
5. Plant : Central Mixing plant
6. Source of waste : Segregated plastics from MSW
7. Date of monitoring : 3rd January'05
8. Process : Polymer –aggregate – bitumen mix

Observations:
Road is in good condition and stable. There is no pothole or crack. Further observation are continued.

Photo 9- Showing spreading of polymer-Bitumen at New Prabhadevi Road (Opp. Samna Press), Mumbai

18.0 ENVIRONMENTAL ASPECTS OF CONSTRUCTION OF ROADS

During road laying process, mixing of plastics material, do not create any environmental hazards, however, plastics –bitumen road is eco-friendly. By using waste plastics, the burning of waste plastics is reduced, which in turn prevents, addition of green house gases into atmosphere. Following points shall be noted :

- No gas evolution - no air pollution
- No Leaching
- No pot hole formation during water stagnation
- No bleeding during summer
- Easy disposal of waste plastics in a useful way
- Eco-friendly

19.0 COST & MATERIAL REQUIRED FOR POLYMER – BITUMEN ROAD LAYING

a. Laying of Bitumen Road – Indian Roads Congress (IRC) Specifications

There are different types of bitumen roads. They are, Dense Bituminous Macadam, Bituminous Macadam. These roads differ in 3-ways; **1**. Composition of the aggregate; **2**. Type of bitumen used; and **3**. Thickness of layer. Bitumen is useful binder for road construction. Different grades of bitumen like 30/40, 60/70, and 80/100 are available on

the basis of their penetration values and these grades can be used as IRC Specifications. Waste plastics (10% in place of bitumen) can be used for these different types of bitumen roads. The technology of road laying is very much the same as prescribed by the Indian Roads Congress (Section 500, IV revision) Specifications. A detailed cost and material description for laying of **Semi Dense Bituminous Concrete (SDBC) 25 mm road** (on existing road) is indicated below: -

Materials Required:

For 1000Mx3.75M (25mm) Road	:11.250 tons (60/70 grade) bitumen needed
Shredded Plastics Required	: 10% by weight (passing 4.74mm sieve & retaining 2.36 mm).
Bitumen replaced (saved) by 10/ % Plastics	: 1.125 tons
Actual Bitumen Required	: 10.125 tons
Aggregate (11.2mm)	:70.875 Cu.M
Aggregate (6.7mm)	: 43.125 Cu.M
Aggregate Dust	: 23 625 Cu.M

Cost Estimate (At Madurai): The total cost including material as mentioned above, labour charge etc. (At Madurai) is approx. 5.00 lakh, however, the cost may be different from place to place and have to be calculated accordingly. The cost break-up is given below:

(i)	Collection of littered plastics	:	Rs. 0.50 lakh
(ii)	Cost of shredder and other equipments	:	Rs. 0.50 lakh
(iii)	Laying of road with material, labour etc.	:	Rs. 4.00 lakh
	Total:		**Rs. 5.00 lakh**

20.0 ROADS LAID USING WASTE PLASTICS

Table - 15

Locations	Process	Blend Composition	Area	Date	Nature of Road
TCE	Polymer Blending with Bitumen	5% PE 1% PE	60'x 5'	23rd March -02	Concrete Road
Kovilpatti	Polymer Blending with aggregate. Mixing with Bitumen	10% PE	600'x12'	4th October-02	WBM road
Madurai	Polymer Blending with aggregate. Mixing with Bitumen	15% PE	180'x10'	5th October-02	Concrete Road
Salem	Polymer Blending with aggregate Mixing with Bitumen	10% PE	1000'x12'	15th October-02	Concrete Road
Komara-palayam	Polymer Blending with aggregate. Mixing with Bitumen	10% Mixture *	300'x12'	15th October-02	Concrete Road

Locations	Process	Blend Composition	Area	Date	Nature of Road
Chennai **	Polymer Blending with Metal and the Mixing with Bitumen	12% Mixture *	600'x18'	22nd November-02	Concrete Road
Trichy	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture *	600'x18'	10th January-03	Concrete Road
Salem #	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture *	5000'x 18'	17th April-03	WBM
Erode	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture *	1500'x 24'	7th May-03	Bitumen road
Theni	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture *	300'x18'	10th May-03	WBM
Nagercoil	Polymer Blending aggregate Mixing with Bitumen	10% Mixture *	1500'x18'	16th May-03	WBM
Madurai-Kombadi	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture *	1.4 km		WBM
TCE, Men's Hostel Madurai	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture	300m x 3.5 m	19th Jan'04	Concrete Road
Ooty	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture	600m x 3.5 m	3rd June'05	Bitumen road
Kochi	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture	600m x 3.5 m	13th March'05	Bitumen road
TCE- Car parking	Polymer Blending with aggregate Mixing with Bitumen	10% Mixture	5000sq.m	8th July'05	Concrete Road

- **Road waste Plastics** **** Ten more Roads laid during May 2003**

 # Central Mixing Plant

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