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Use of Plastics Waste in Construction of Tar Road

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Introduction

Bitumen is an 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. The steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is the need of the hour.

Elastomers like natural rubber, crumb rubber, SBR, etc., as well as Plastomeric substances like Polyethylene, Ethylene Vinyl Acetate and Ethylene Butyl Acrylates are mixed with Bitumen to modify the properties. Modified Bitumen possesses better quality.

Today the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. They either get mixed with Municipal Solid Waste and/or thrown over land area. If not recycled, their present disposal is either by **land filling** or by **incineration**. Both the processes have certain impact on the environment. Under this circumstance, an alternate use for the waste plastics is also the need of the hour.

Thiner polythene carry bags are most abundantly disposed of wastes, which do not attract the attending rag pickers for collection for onward recycling, for lesser value.

Again, these polythene/polypropylene bags are easily compatible with Bitumen at specified conditions.

The waste polymer bitumen blend can be prepared and a study of the properties can throw more light on their use for road laying.

Modified Bitumens

Addition of natural or synthetic polymers to bitumens is known to impart enhanced service properties. By adding small amounts of polymers to bitumen, the life span of the road pavement may be considerably increased. The purpose of bitumen modification using polymers is to achieve desired engineering properties such as increased shear modulus and reduced plastic flow at high temperatures and/or increased resistance to thermal fracture at low temperatures.

Homopolymers, like high and low density polyethylene and polypropylene, as well as random and block copolymers, like ethylene-vinyl acetate, ethylene/propylene, styrene-butadiene copolymer have been used as bitumen modifiers.

However, the major obstacle to usage of polymer-modified bitumen in paving practice has been their tendency towards gross phase separation under quiescent conditions at elevated temperatures. A precise study on processing conditions of binders and polymeric additives selection are, thus required.

Moreover, incompatibility, unstabilization of emulsions, higher cost of polymer and cumbersome procedure of the preparation of the mix add to the complexity of the process.

Reuse of Waste Plastics

Plastics – as Binder and Modifier

Waste plastics (polythene carry bags, etc.) on heating softens at around 130°C. A study using thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover the softened plastics have a binding property. Hence, the molten plastics materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction.

Study on Waste Plastics for Road Construction:

Determination of solubility of polymer in Bitumen.

The waste polymers such as polyethylene (as sheets) polypropylene (sheets; film) and polystyrene (thermocole) are soluble to the extent of 1 to 2% of the bitumen.

It was observed that we need to characterise the two types 1 waste plastics-bitumen blend containing <2% and 2, the mix containing >2%.

Samples were used to carry out the following tests namely,

1. Softening Point 2. Penetration Value 3. Flash & Fire Point and 4. Ductility Test.

Determination of softening point:

It is 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.

Penetration Value:

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

Ductility:

Data shows that the ductility increases by the addition of polymer to Bitumen.

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.

Flash and fire point

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

Characterisation of Waste Plastics-Bitumen-Aggregate mix for flexible Pavement:

The utility of the Waste Plastics-Bitumen – Aggregate mix for flexible pavement construction is characterised by studying 1. Stripping value, and 2. Marshall stability value of the mix.

Method – I

Soluble region (<2% plastics) waste

Stripping value

Waste plastics are dissolved in bitumen (2% PE) and the blend is coated over aggregate. It is tested by immersing in water. Even after 72 hrs., there is no stripping showing increased resistance to water. This shows that the blend has better resistance towards water. This may be due to better binding property of the polymer-bitumen blend.

Marshall Test:

The Marshall stability values were determined for the waste polymer bitumen blend having the percentage of maximum 2%.

The study shows that waste plastic-bitumen blend has higher strength compared to pure bitumen, whose value is approx. 1100 kg.

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

Method – II:

Modified process (Higher percentage region)

Addition of waste plastics 10% – *(for Illustration only)*

Wt. of Aggregate:	1200 gms
Wt. of Bitumen:	60 gms
Wt. of Waste Plastics:	0.6 gms

Alternate method was innovated to find an effective way of using higher percentage of waste plastics-bitumen mix. In this method, initially the aggregates were heated to around 170°C. Then the plastic wastes, in the form of small pieces (passing 4.75 mm sieve – normally with a thickness of 60 micron and below) were added to the heated aggregate. This has enabled to give an uniform coating of plastics waste over the aggregates. To this hot plastics coated aggregates, the hot bitumen was added. An uniformly coated mix was obtained. This was used for carrying tests: (1) Stripping Test, and (2) Marshall Test.

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. Even after 96 hrs., there was no stripping. This again shows that the waste plastic-bitumen coated mix has good resistance towards water. This may be due to (1) Increased binding of the waste-plastics-bitumen blend, and (2) Coating of polymer (a non-wetting material) over the aggregate.

2) *Marshall Test:*
It is observed that the addition of waste plastics (PE) increases the Marshall Stability Value.

It is observed that the Marshall Stability Value obtained is generally much higher than for the pure bitumen mix. It is also observed that the addition of waste plastics reduces the need of bitumen. It is observed that the addition of lower percentage of bitumen with waste plastics blend shows much higher Marshall Stability Value. It is also helping to reduce the quantity of bitumen to the extent of 10% to 15%.

Effect of Variation of Polymer content with the variation of bitumen

It is observed that the addition of waste plastic increases the Marshall Stability Value to a fairly high value. It is also observed that the addition of 10% waste plastics gives higher value at the optimum percentage of Bitumen (4.6%). Higher percentage of waste plastics, though give higher Marshall Stability Value, they need increased percentage of Bitumen. In general, it may also be concluded that this method 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.

Results and discussion

It is observed that the polymer-blended bitumen has better properties regarding Softening Point, Penetration Point, Ductility, Stripping Value and Marshall Stability Value. Hence the blend can be used for laying flexible pavement.

Method I:
The blending was tried by directly mixing the shredded polymer with hot bitumen at 160°C. Here the mixing of higher percentage of polymer was rather difficult due to large difference in the viscosity of the molten polymer and that of Bitumen. A powerful mechanical stirring was needed to ensure effective mixing to get a better blend. This also needed the addition of stabilizers and proper cooling, yet the blend was not stable and the maximum percentage that can be added was around 2%. Only test roads were laid using this method.

Method II:
A novel technique is developed to use higher percentage of waste plastics in road construction and using this technique an alternate method is being used.

In this method, the waste polymer was added on the hot aggregate (170°C). The polymer was coated over the aggregate. Here the spreading was easy. The hot aggregate was coated with polymer uniformly. Then the Bitumen was added. The mixing of bitumen with polymer was taking place at the surface of the aggregate. The temperature was around 155-163°C. Both the polymer and bitumen were in the liquid state. With the increase of surface area of contact, the mixing of polymer film with bitumen film would be better as both are similar in chemical nature and are in liquid state. And thus a better blend is formed. This blend is having better binding property, which is observed from its properties like Marshall Stability Value, etc.

The formation of fairly uniform coating is also observed from the experimental results. This technique was used for the construction of road using Mini Hot Mix plant.

On the basis of above reasoning various aspects regarding the Polymer-Bitumen road are also being discussed below:

Stripping Test
Most of the aggregates used in road construction have greater affinity for water due to inherent wetting nature of the aggregate than for bitumen. This results in the penetration of water between aggregate and bitumen layer. Thus bitumen film is often stripped off the aggregates in the presence of water. This stripping results in pot-hole formation.

When polymer is coated over aggregate, the coating reduces its affinity for water due to non-wetting nature of the polymer and this resists stripping. Moreover the polymer-bitumen blend is having higher binding property too. This also resists stripping and hence pot-hole formation is very much reduced.

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 this 5% acetic acid solution (EPT) and it is observed that there is 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.

Pot-hole Formation
Stagnation of water over bituminous surface results in stripping of bitumen. This subsequently results in pot-hole formation. In the case of polymer bitumen blend, the penetration of water is not much. Hence

the pot-holes are not formed easily. This is observed in the various test stretches laid by the author at different places.

Dioxin Formation

The fear about the formation of Dioxin, the toxic compound, during the heating of polymers is always in the mind of people.

In the process of the preparation of polymer-bitumen aggregate mix, the temperature used is only ≈ 170°C and no chlorine or copper is present in the system. Moreover, the polymer materials used are polyethylene, polypropylene and are polystyrene only and we do not use polyvinyl chloride. Hence, there is no possibility of presence of chlorine in the system. Hence Dioxin does not form during the use of waste polymer for road construction. So it is a safe disposal of waste polymers.

Effect of Bleeding

The increase in the softening point shows that there will be less bleeding during summer. Bleeding accounts, on one side, increased friction for the moving vehicles and on the other side, if it rains, the bleedings accounts for the slippery condition. Both these adverse conditions are much reduced by polymer-bitumen blend.

Special Aspects

- The whole process is very simple.
- It needs no new machinery.
- The technology is also very simple.
- The waste plastics available in the surrounding area can be used then and there.
- Moreover crumb rubber required 180°C whereas 60/70 grade bitumen needs 160°C only. This accounts for fuel conservation.

Roads – already laid: Using waste polymer bitumen aggregate mix, roads have been laid at different places at Tamil Nadu using different surface area and different composition.The conditions of roads are under observation and they are performing well till today.

A scheme for laying Waste Plastics – Tar road in rural area for 1000 km was launched on 16th July 2003 at Namakkal by the Honourable Chief Minister of Tamil Nadu Dr. J. Jayalalitha.

Significance and Utilization Potential

- The polymer bitumen blend is a better binder compared to plain bitumen.
- The blend has increased Softening Point and decreased Penetration Value with a suitable ductility.
- When used for road construction it can withstand higher temperature. Hence it is suitable for tropical regions.
- It has decreased Penetration Value. Hence its load carrying capacity is increased.
- The blend with aggregate has no Stripping Value. So it can resist the effect of water.
- The Marshall Stability Value is high.
- The bitumen required can be reduced depending upon the % of polymer added. It is a good saving too.

If 1 ton of Crumb is used, the cost is Rs. 13,000.

If 1 ton 60/70 grade bitumen is used, the cost is Rs.10,000.

4% of bitumen is saved. Hence the cost is Rs. 9,600.

100 kg of waste plastics costs Rs. 500.

Total cost Rs. 10,100.

The quality is definitely better than CRMB with the saving of Rs. 2,500/Ton

Moreover CRMB requires 180°C whereas 60-70 grade bitumen requires 160°C. This helps fuel conservation.

- The waste polymer, otherwise causing disposal problem by way of **land filling** and **incineration** has a better place to stay.
- The operation temperature is below 160-170°C.
- No toxic gas is produced. Dioxin is not formed during this process.
- Disposal of waste plastic will no longer be a problem.
- The binding properties of polymer also improve the strength of mastic flooring.
- The use of waste plastics on the road has helped to provide better place for burying the plastic waste without causing disposal problem. At the same time, a better road is also constructed. It also helps to avoid the general disposal technique of waste plastics namely land-filling and the incineration, which have certain burden on ecology.
- By spraying the waste polymer pieces (passing 4.5 mm) the mixing is done. The process is simple and easy.

News from India

National Green Corps (Eco-clubs)

We all know that we are part of the environment we live in. And the solution to many environmental problems lie in our attitude towards environment. Be it awareness to keep our surroundings clean or the realisation to conserve natural resources by re-using and recycling wherever possible, they all are attitudinal. On the surface it looks simple. But changing the attitudes of 100 crore people is not going to happen overnight. The best way to attempt to bring about a change in the attitudes in the society is through children. They have no vested interests. They are impressionable. They are our future. They are the single most important influence in any family.

With this realisation the **Ministry of Environment & Forests (MoEF),** Government of India, has decided to launch the National Green Corps Programme (NGC) in all Districts of our vast country.

The main objectives of this programme are to educate children about their immediate environment and impart knowledge about the eco-systems, their inter-dependence and their need for survival, through visits and demonstrations and to mobilise youngsters by instilling in them the spirit of scientific inquiry into environmental problems and involving them in the efforts of environmental preservation.

As directed by the Hon'ble Supreme Court of India and in consultation with various Institutions and Educational Departments in the country, Environmental Education has been introduced in the School Syllabus in a graded manner from Standard I to Standard XII. The objective is to create awareness of environment and its significance among the school children.

Top 10 Litter Tips

1. Smokers, put your butts in the ashtray and cigarette packs in the bin.
2. Recycle your pop cans.
3. Everyone's drinking coffee on the go - make sure your cup ends up in the bin.
4. Don't make yesterday's news tomorrow's trash.

   The real news would be if we all recycled our newspapers.
5. Gum shoe blues. Aim for the bin, not the sidewalk.
6. Fast food = Fast litter. Put the brakes on fast food litter.
7. Program your cell's speed dial to report litter hot spots.
8. Pledge to pick up one piece of litter daily.
9. *Bin there, do that*. With thousands of bins out there, just walk those few extra steps.
10. Talking trash is okay. Remind family, friends, kids and colleagues not to litter.

BIN

If we didn't use plastic in house wrap, greenhouse gas emissions would increase because we would need more energy to heat our homes. If we didn't use plastic carry out sacs and bags, our dependence upon other natural resources would increase, the volume of solid waste would increase and we would use more energy to make and ship them.

International News

Design Challenge Contest by EPIC

The EPIC "Let's Reuse It" Design Challenge contest has generated an overwhelming response from enthusiastic students across the country. The contest asked students in grades four, five and six to reuse old plastic products to create something new. The contest attracted over 100 entries in total. Among the more innovative designs were gumball machines, piggy banks, toy animals, kaleidoscopes, water fountains, cars and planes, rocket ships and even a pet dinosaur.

The Challenge invited children 14 years-old or younger to create an entirely new item from used plastic products. The contest was sponsored by the Environment and Plastics Industry Council (EPIC), a CPIA council dedicated to the responsible use and recovery of plastics resources.

This speedy "recycled" car was made by Jarod, who is a student at the Allan Johnstone School in Hardisty, AB.

The entries were put on display at Plast-Ex 2004 – a triennial industry trade show that attracted close to 10,000 visitors from around the world.

They were joined by a number of other reuse contest entries from elementary school children across Canada. In total, the reuse contests attracted more than 100 entries.

(ICPE had organised a simillar contest for school children "It's My World". Report was published in Envis, Jan.-Feb. 2004)

Adopt-a-Highway

The Adopt-a-Highway program is one of the more popular organized anti-litter activities being practised across Canada. The program tends to fall under provincial jurisdiction and asks volunteer groups or individuals to "adopt" a certain section of the highway and to become responsible for keeping that section clean. It is a program designed for those environmentally conscious citizens who wish to make a personal contribution to a cleaner environment. In addition to the cleaner environment, the volunteer(s) are recognized by a sign erected to acknowledge their efforts. Most Adopt-a-Highway programs are run by the provincial Departments of Transportation but cities and towns also get involved on a local scale.

Integrated Approach to Solid Waste Management

There are no "quick fixes" and all options for management of waste have benefits and trade-offs that must be considered. Valid solutions must be based on an integrated approach to solid waste management which appropriately incorporates the "5Rs" – Reduce, Reuse, Recycle, Recover (energy from waste) and Retain (in modern landfills). Furthermore, each "R" should undergo the same scrutiny to determine its impact on the environment, e.g., withstand a Life Cycle Assessment.

Source: www.city.toronto.on.ca/litter/tips.htm

Clean Technology

Economic development of any nation depends upon several factors such as energy production and conservation: raw materials like water, minerals, forest produce and capability and skill to manage the resources optimally. Adoption of cleaner modes of production helps in resource conservation and elimination of gaseous, liquid or solid wastes.

Clean technology therefore entails:

- waste prevention and reduction by reduced consumption of raw materials,
- modification and upgradation of the technological processes so that optimal utilisation of natural resources is made possible,
- adoption of preventive rather than corrective approaches to pollution control.

Waste Management and GHG Emissions

Principles:

- Greenhouse gas emissions are but one environmental parameter that is affected by waste management practices. Optimizing one parameter may have an adverse effect on another. Consideration should be given to the other impacts as well. In addition all of the various waste management options should be subjected to a cost benefit analysis so that an acceptable level of eco-efficiency is achieved. The EPIC/CSR IWM model is a tool capable of doing this and municipalities are urged to use it.
- A quantification of GHG reductions requires the Waste Manager to consider the quantity of specific materials in the waste stream and their unique disposition.

- Source reduction in which less of a particular material is used in an application normally provides more benefit in reducing GHG emissions than other options. Source reduction obtained by substituting one material for another may not provide benefit in terms of eco-efficiency. For the waste manager source reduction simply means less waste to be handled and should be taken into account in decisions affecting waste management.

- Food waste should not be landfilled since its decomposition produces a potent GHG, methane. Composting, resulting in production of CO_2, is one of the preferred alternatives since (by convention) the aerobic decomposition of non-fossil carbon to produce CO_2 is not counted as a GHG emission. In-vessel anaerobicdigestion of organic matter, such as food waste, to deliberately produce methane for use as energy should be considered as a more efficient use of the waste than composting. Existing landfills should be "mined" to capture the methane being produced by degrading wastes already there.

- The benefits of recycling result from the displacement of virgin materials minus the emissions involved in the collection, transportation and reprocessing of materials for recycling. Care must be taken that the emissions from the latter do not exceed the gains from the displacement of virgin materials. This EPIC/CSR IWM model would be an asset in assessing this.

- To maximize the benefit of GHG reduction from combustion with energy recovery, the following conditions apply:

- The material to be combusted should have a significant calorific value (>20MJ/kg.).

- The combustion efficiency should be a minimum of 30%. This may be achieved through co-generation processes to produce steam and electricity. These efficiencies are being reached in Europe.

- The use of high energy containing waste streams in co-generation systems to displace coal generally provides more benefit than other fossil fuel.

Under these conditions, the recovery of energy may provide a greater reduction in GHG emissions than does any recycling.

Source: www.cpia.ca

Sustainable Development

For sustainable development, we have to manage our resources so the needs of today's society are met without jeopardizing our ability to meet the needs of tomorrow. Here we find that plastics hold tremendous promise and optimism for the future simply because they have been designed to do more with less.

Consider the subject of Sustainable Development as a three-legged stool with the Economic Leg, the Environmental Leg and the Social Leg supporting the stool. A change or consideration in one dimension (or leg) of sustainable development will impact the other two. For example, incorrect waste management could damage the environment and add to municipal costs, reducing the funds available for social services. A dynamic balance must be maintained.

PET Bottles are Safe for Reuse

Most convenience-size beverage bottles are made from polyethylene terephthalate (PET). The FDA has determined that PET meets standards for food-contact materials established by federal regulations and therefore permits the use of PET in food and beverage packaging for both single use and repeated use. FDA has evaluated test data that simulate long-term storage and that support repeated use.

The toxicological properties of PET and any compounds that might migrate under test conditions have also been well studied. The results of these tests demonstrate that PET is safe for its intended uses.

FDA allows PET to be used in food-contact applications, including food and beverage packaging, regardless of whether the packaging is intended for single or repeated use. PET beverage bottles sold are designed for single use for economic and cultural reasons, not because of any safety concerns with PET.

In fact, refillable bottles made with the same PET resin as single-use bottles are safely reused in a number of other countries. The only difference is that refillable bottles have thicker sidewalls to enable them to withstand the mechanical forces involved with industrial collection and commercial cleaning and refilling operations.

Source: www. plasticsinfo.org/beveragebottles/faq.html

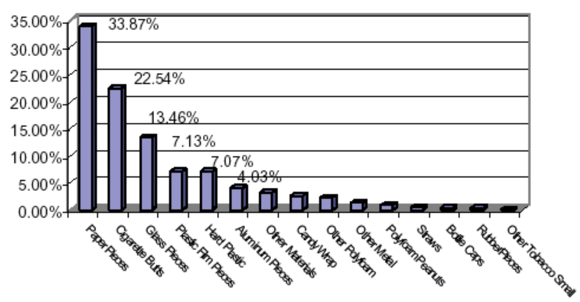
What you can make out of Plastics Waste

Original Product	*Recycled Product*
Soft drink bottles, peanut butter jars, etc.	Household cleanser bottles, carpets, paint brushes, insulation for clothing.
Milk, water and juice jugs, bleach & fabric softener containers, grocery bags, toys, and liquid detergent bottles.	Soft drink bottle base cups, detergent and bleach bottles, trash bags, trash cans, recycling bins, traffic barrier cones, plastic lumber, pails and fly swatters.
Clear food packaging, shampoo bottles, cooking oil bottles, glass cleaner bottles, some cosmetic bottles, and plumbing pipes.	Floor mats, pipes, hoses, and mud flaps.
Food wraps and bread bags, dry cleaning bags, and some dairy container lids.	Garbage can liners, grocery, litter and convention bags, flying disks, plastic lumber and lawn furniture
Bread, cheese and some snack food wraps, cereal box liners, yogurt & margarine containers, and medicine bottles.	Brooms, snow brushes, paint buckets, video cassette storage cases, fast food trays, lawn mower wheels, automobile battery parts, and ice scrapers.
Video cassette cases, compact disc jackets, fast food sandwich containers, hot drink cups, disposable cutlery, and some dairy containers.	Video cassettes cases, flower pots, trash cans, food service trays, building insulation, and desk top accessories like letter openers, clipboards and rulers, etc.
All other plastics not mentioned above such as multilayer packaging, and polycarbonate and ABS which are often used to make consumer durables.	Although the recycling of these plastics is currently limited, some products made from polycarbonate and ABS are being recycled into pens, ice scrapers, snow brushes, street signs and concrete supports.

Toronto – Litter Audit

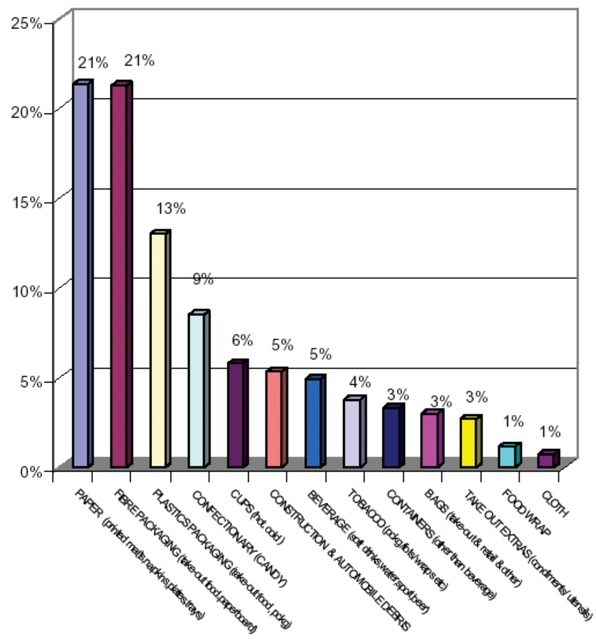
A recent litter audit done by one of Canada's largest cities found that paper products represented over 40 per cent of all large littered items. Other large items littered included: plastics packaging (13%), confectionery (9%), cups (6%), construction (5%), beverage bottles (5%), tobacco (4%), other containers (3%), bags (3%) and others.

City of Toronto – Small Litter by Category



In terms of small litter, there were a variety of products and materials littered.

Toronto Large Litter by Category



Source: www.cpia.ca

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