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ALTERNATIVE MATERIAL USED IN PAVEMENT CONSTRUCTION

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DECLARATION

We declare that the project seminar report titled "ALTERNATIVE MATERIAL USED IN PAVEMENT CONSTRUCTION" is bonafide work carried out by us, under the guidance of Dr.V.Srihari Further we declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

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CERTIFICATE

This is to certify that the project seminar on "ALTERNATIVE MATERIAL USED IN PAVEMENT CONSTRUCTION" is bonafide work of (Anuj Patel, Rohit Waghmare, Ehtesham Ali sayyed) in part of the academic requirements for the third term of Post Graduate Programme in Advanced Construction Management (PGP ACM). This work is carried out by them, under my guidance and supervision.

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Executive Summary

Many roads agencies have been experiencing problem of premature failure of pavements like potholes, roughness, cracks and etc. which leads to poor performance of roads and its life. On the other hand, plastics, rubbers, fly ash, broken glass etc are increasing day by day. Waste like plastic bottles, polymers, cups, waste tyres, fly ash and broken glass can be re-used by powdering or blending it with crusher's and can be coated over aggregate and bitumen by any heating process. In this study we will be using polymer and crumbed rubber as a binder with respect to aggregate and bitumen. In bituminous roads, we use materials like aggregate (of various sizes), grit and bitumen. The various tests will be conducted during this study on aggregates such as crushing value, impact value, abrasion value, and specific gravity and also on bitumen penetration value, ductility, softening point.

Keywords— Waste Plastic, Crumbed rubber, Fly ash, Broken glass, Aggregate, Bitumen.

CHAPTER-1

INTRODUCTION

1.1 GENERAL

Now-a-days disposal of different wastes produced from different industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement.

1.2 INTRODUCTION:

Plastics & rubber are user-friendly but not eco-friendly as they are non-biodegradable generally, it is disposed by way of land filling or incineration of materials which are hazardous. Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics.

Road surface with neat bitumen can cause bleeding in hot climate, may develop cracks in cold climate, possess fewer load bearing capacity and can cause serious damages because of higher axle load in present conditions due to rapid infrastructure development. Useful life of bituminous overlays has reportedly declined 7-8 from average life of 5-6 years in the past to about 3-4 years at present as compared to average pavement life (5-6 years) in abroad. India has to raise transportation system to a higher level both in terms of length and quality. This study presents the use of waste in hot bituminous mixes to enhance pavement performance, protect environment and provide low cost roads.

Fly ash is a fine residue of coal combustion in the Thermal Power Plants. With the increasing demand of power and coal being the major source of energy, more no. of Thermal Power Plants have been setup. The thermal grade Indian coal contains 35 to 45% of ash resulting in generation of huge quantity of fly ash. Management and disposal of fly ash is an environmental issue. Storage of ash in ponds and mounds also require large amount of land. The State of Odisha is in the course of rapid industrialization, as a result power requirement has considerably increased. Coal being the main raw material for thermal power generation, ash is the essential by product. Huge quantity of bottom ash & fly ash are generated from boilers of coal fired Thermal Power Plants (TPP). Fly ash being light in weight is collected in Electro Static Precipitator (ESP) & Bag Filters connected to the coal fired boilers of the TPPs. The ash collected from this air Pollution control equipment are either transported in the form of slurry to the Ash Pond or deposited in dry form, in ash Mounds otherwise. Internationally fly ash is considered as a byproduct which can be used for many appliances.

In order to address the problems associated with fly ash management, various opportunities of utilization has been explored. Besides use of fly ash in manufacture of construction material, land development, mine void filling, the use of fly ash for road construction has also increased phenomenally in India with an annual utilization of about 8.82 million tonnes in road construction, which constitutes about 16 per cent of total utilization. Hence use of fly ash for road and embankment construction is thus justifiably called high-volume ash utilization. The typical approach for redemption of soft subgrade has consisted of removal of poor soil and its replacement with large quantity of crushed rock. The high cost of removal of poor top soil and transportation of aggregates, along with increasing interest in re-usable of industrial by product has prompted investigation to find out solution that compliments the need of highway construction. Use of fly ash for stabilization of soft sub-grade as a replacement to soil is one of these solutions.

Increasing pressures to recycle more wastes and minimize the amount of materials placed in landfills are forcing reconsideration of potential uses of waste glass in highway construction and maintenance operations. The federal government and many state legislatures are mandating studies to find such uses. Because the volume of aggregate needed for highway construction is so large, the use **of** waste glass in this manner offers a potential for utilizing most if not all glass unsuitable for other purposes.

1.3 AIM:

Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with following benefits:

(a) Post construction pavement performance studies are to be done for these usage of alternate materials used for construction of low volume roads.
(b) After the details study of the characteristic and property analyzing will be done.
(c) After analyzing comment will be done whether how good it is and the advantages or disadvantages.

CHAPTER-2

LITERATURE REVIEW

2.1 PLASTIC:

Plastic is everywhere in today's lifestyle. It is used for packaging, protecting, serving, and even disposing of all kinds of consumer goods. With the industrial revolution, mass production of goods started and plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, communication or InfoTech has been virtually revolutionized by the applications of plastics. Use of this non-biodegradable (according to recent studies, plastics can stay unchanged for as long as 4500 years on earth) product is growing rapidly and the problem is what to do with plastic-waste. Studies have linked the improper disposal of plastic to problems as distant as breast cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in human sperm count and quality. If a ban is put on the use of plastics on emotional grounds, the real cost would be much higher, the inconvenience much more, the chances of damage or contamination much greater. The risks to the family health and safety would increase and, above all the environmental burden would be manifold. Hence the question is not 'plastics vs no plastics' but it is more concerned with the judicious use and re-use of plastic-waste.

Plastics & rubber are user-friendly but not eco-friendly as they are non-biodegradable generally, it is disposed by way of land filling or incineration of materials which are hazardous. Plastic is versatile material and a friend to common man becomes a problem to the environment after its use. The better binding property of plastics in its molten state has helped in finding out a method of safe disposal of waste plastics.

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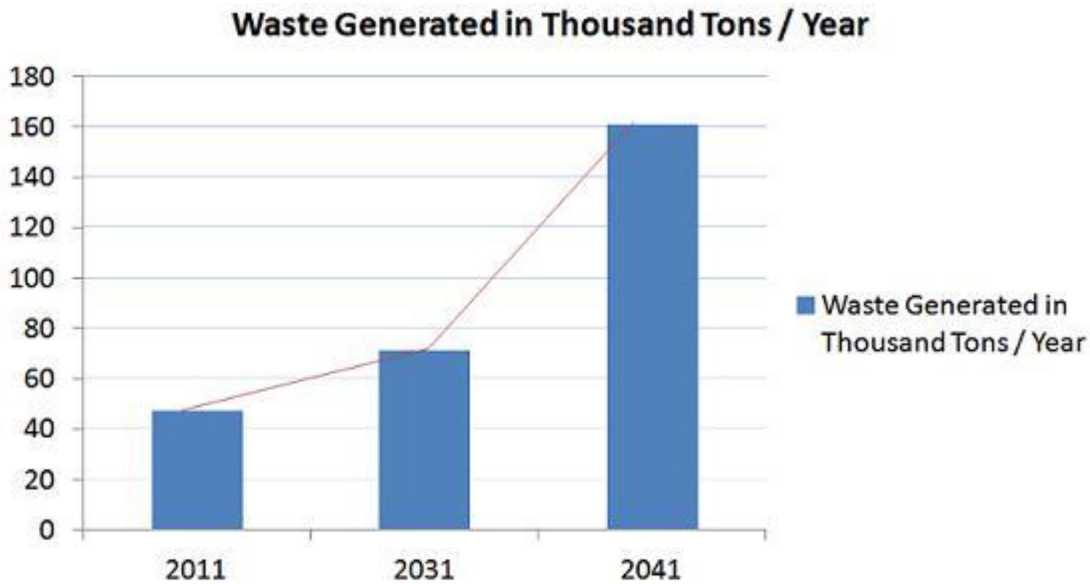

Fig 1 Plastic generation over no .of years (Dr. R. Vasudevan)

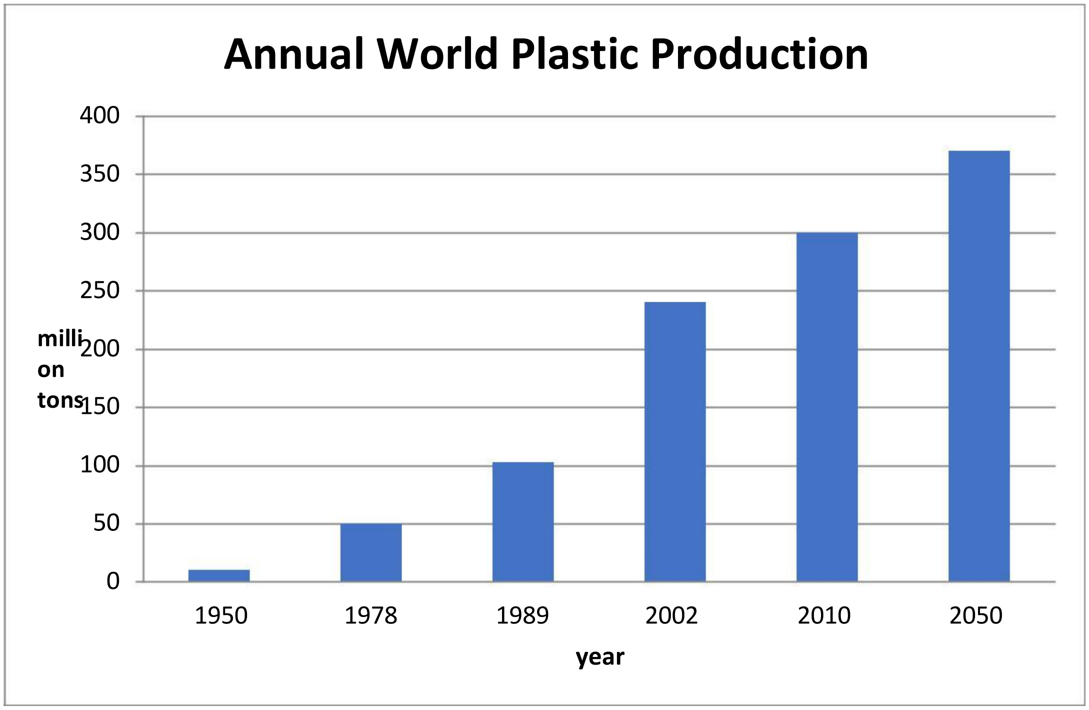

Fig .2 Plastic generation over no. of years (Prof.C.E.G. Justo)

Waste Plastic	Origin
Low Density Polyethylene (LDPE)	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles.
High Density Polyethylene (HDPE)	Carry bags, bottle caps, house hold articles etc.
Polyethylene Terephthalate (PET)	Drinking water bottles etc.,
Polypropylene (PP)	Bottle caps and closures, wrappers of detergent, biscuit, vapors packets, microwave trays for readymade meal etc.,
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. 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, folders and pens, medical disposables; etc.

Table 1 Waste Plastic and its Source (verma s.s)

Prof.C.E.G. Justo States that addition of 8.0 % by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4 % bitumen by weight of the mix or about 9.6 kg bitumen per cubic meter (m 3) of BC mix. Modified Bitumen improves the stability or strength, life and other desirable properties of bituminous concrete mix.

Dr. R. Vasudevan states that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased Softening point and decreased Penetration value with a suitable ductility. When it used for road construction it can withstand higher temperature and load. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution and so on.

According to V.S**. Punith,** (2001), Some encouraging results were reported in this study that there is possibility to improve the performance of bituminous mixes of road pavements. Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. Thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Softened plastics have a binding property. Hence, it can be used as a binder for road construction.

Sundaram & Rojasay (2008) studied the Effective blending technique for the use of plastic waste into bitumen for road laying and Polymer-bitumen mixtures of different compositions were prepared and used for carrying out various tests.

Verma S.S. (2008). Concluded that Plastics will increase the melting point of the bitumen. This technology not only strengthened the road construction but also increased the road life.

Dr. R.Vasudevan and S. Rajasekaran, (2007) stated that the polymer bitumen blend is a better binder compared to plain bitumen.Blend has increased Softening point and decreased Penetration value with a suitable ductility.

Mohd. Imtiyaz (2002) concluded that the mix prepared with modifiers shows:-Higher resistance to permanent deformation at higher temperature.

Sabina et al (2001) studied the comparative performance of properties of bituminous mixes containing plastic/polymer (PP) (8% and 15% by wt of bitumen) with conventional bituminous concrete mix (prepared with 60/70 penetration grade bitumen). Improvement in properties like Marshall Stability, retained stability, indirect tensile strength and rutting was observed in Plastic modified bituminous concrete mixes. The laboratory studies conducted by CRRI in utilization of waste plastic bags in bituminous concrete mixes have proved that these enhance the properties of mix in addition to solving disposal problems. The results indicated that there was an improvement in strength properties when compared to a conventional mix. Therefore, the life of pavement surfacing using the waste plastic is expected to increase substantially in comparison to the use of conventional bituminous mix.

2.2 RUBBER:

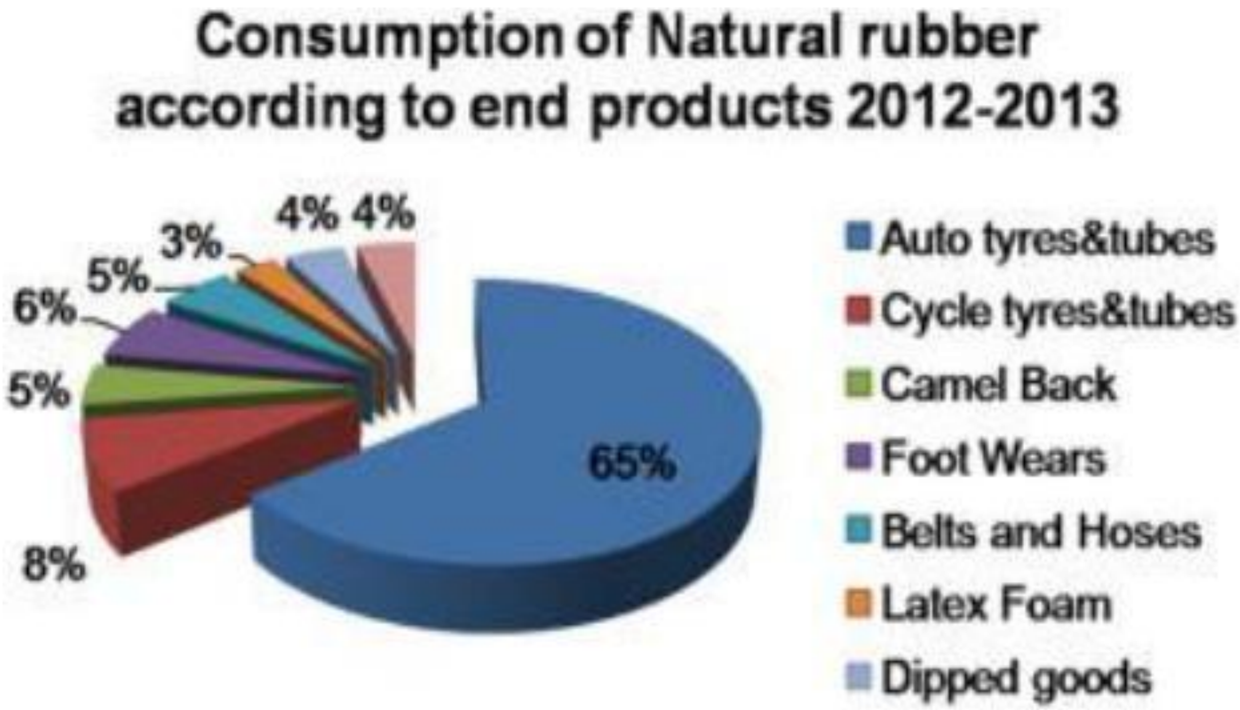

Fig .3 rubber consumption over no. of years (International Journal of Environmental Science and Development)

2.2.1 NEED FOR RUBBERIZED BITUMEN

- Increasingly aggressive traffic conditions.
- Severe climatic conditions with daily and seasonal variation of temperature.
- Need to maintain roads at higher serviceability level.
- Increased fatigue resistance of bituminous mixes under repeated loading and higher degree of flexibility.
- Improved cohesion which assists resistance to weathering and adhesion to reduce risks of binder being stripped by water.
- Achieve higher stiffness modulus to minimize thickness of resurfacing in urban areas and to avoid milling.
- Resistance to cracking, raveling, deformation and creep failure.

2.2.2 ADVANTAGES OF RUBBERIZED BITUMEN OVER PLAIN BITUMEN

- Rubberized bitumen has higher softening point, giving more stability to the pavement during hot months.
- Much improved Elastic Recovery over 60, giving resistance to fatigue.
- Improved resistance to stripping due to water repellent properties.
- Lower susceptibility to daily and seasonal temperature variation.
- Better age resistance properties.
- Much improved Elastic Modulus increases load carrying capacity.
- Delays oxidization of mixes thus enhanced pavement life.

2.2.3 WASTE TYRE CRUMB FOR ROADS

- As per MORTH directives for NHAI that an approx. 30 km road is to be constructed every day.
- Keeping in view the above, an approx. 750 MT of bitumen is to be used for wearing course every day.
- If Waste tyre crumb is to be used with bitumen for wearing course, an approx. 250 nos' of tyre waste can be consumed in roads every day or 100,000 nos of waste tyre annually.

2.2.4 LIMITATIONS:

- increased costs for the preparation of modified binder.
- increased viscosity is a complication for laying the asphalt mixture.
- low bulk density and low modulus of elasticity, both characteristics results in more difficult compaction of resulting asphalt mixture.

- The technology of hot asphalt mixtures production requires the exact temperature of mixing and storage time.
- During the mixing and storing the asphalt mixture becomes very sticky, and its preparation, storage and compacting become more difficult.
- generally, focus on additional cost if highway designers will not allow a reduced pavement layer thickness due to the proven properties of rubberized bitumen.
- the lack of rubberized bitumen binder and mix standards, the lack of trained personnel, and uncertainty and doubt about how long AR will last.

Many researches were carried out by many scholars and professors of civil engineering in this field, to find the ways and crumb rubber mix in conventional bitumen to improve in engineering properties of bitumen.

Patel Chirag B (2013),By using the waste plastic and Crumb Rubber as a modifier the properties of bitumen will be change and this change in physical properties like softening point, penetration value, elastic recovery and Marshall stability was checked by different test. In this study we used modifier in proportion (1%,2%,3% and 4%) by the weight of bitumen.

R.Vasudevan et.al. (2007), Has studied that the crumb rubber modified bitumen and they construct different stretches and perform field study with the help of National Transport Planning and Research Centre, Trivandrum. From this field study they concluded that the entire road having a good skid resistance value and from bump instigator study a good surface evenness.

Shankar (2009), The crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design conventional bitumen (60/70) also. This has resulted in much improved characteristics and for characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

Siddharth Rokade (2012), The Crumb Rubber was added to 60/70 grade bitumen in varying percentage of 8%, 10% and 12%. The mix was prepared with 5 % bitumen and the varying percentages of Crumb Rubber. The bitumen when mixed with Crumb Rubber is termed as Crumb Rubber Modified Bitumen (CRMB). The results observed that the Marshal Stability Value are increased from 8% to 10% Crumb Rubber and then it is decreased 12% of Crumb Rubber of the weight of bitumen is the optimum dose for getting enhanced strength characteristics of mix.

Mohd Hizam HARUN & Roziawati RAZAL(2003), Public Works Department of Malaysia As bitumen additive, various forms of rubber which include scrap rubber from motor vehicle tyres (crumb rubber) have been used . The objectives of the trial were to compare the performance of bituminous overlay incorporating crumb rubber modified bitumen in mitigating reflective cracking with a similar overlay using conventional penetration grade 80-100 bitumen. A full-scale road trial was successfully constructed on Route 2. Section Nos. 340 - 345, in Kuantan, in June 2003.

Nuha S. Mashaan(2012),In their study presented the application of crumb rubber modifier in the asphalt modification of flexible pavement. From the results of previous study, it aspires to consider crumb rubber modifier in hot mix asphalt to improve resistance to rutting and produce pavement with better durability by minimizing the distresses caused in hot mix asphalt pavement. Hence, road user would be ensured of safer and smoother roads.

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2.3 FLY ASH:

The table given below shows the generation and utilization of fly-ash for the year 2010 and 2011 in India which aware us the contemporary consumption rate

Table 2. Generation and utilization of fly-ash in India 2010 and 2011 (Source: Central Electricity Authority annual Report 2010-11, 2011-12)

	2010-11	2011-12
No. of coal/Lignite based thermal power station (India)	88	90
Installed Capacity	80548 Mega Watt	83797 Mega Watt
Total Ash generated	131.09 Million Tons	66.49 Million Tons
Total Ash utilized	73.13Million Tons	36.26 Million Tons
Percentage Utilization	55.79%	54.33%

Table 2 Generation of Fly Ash (CEA annual report)

In the financial year 2016-17 it is expected to increase the production of fly-ash around 300-400 MT/year. The large amount of fly-ash produced if not utilized in right quantity will be hazardous to environment

Table 3 - Fly-ash utilization during the year (2010)
(Source CEA annual report 2010-2011)

S.No.	Mode of Fly-ash Utilization	Utilization (Million Tons per annum)	Percentage Utilization
1.	Cement	35.47	48.50
2.	Reclamation of low lying area	9.31	12.73
3.	Roads and Embankments	8.52	11.65
4.	Mine Filling	6.04	8.26
5.	Bricks & Tiles	4.61	6.30
6.	Agriculture	1.27	1.74
7.	Others	7.91	10.82
	Total	73.13	100

Table 3 Fly Ash utilization (CEA annual report 2010)

Table 4 - Fly-ash utilization during the year (2011)
(Sources: CEA annual report 2011-2012)

S.No.	Mode of Fly-ash Utilization	Utilization in (Million Tons per annum)	Percentage Utilization
1.	Cement	17.45	48.13
2.	Reclamation of low lying area	3.16	8.72
3.	Roads and Embankments	4.72	13.02
4.	Mine Filling	2.45	6.76
5.	Bricks & Tiles	2.36	6.51
6.	Agriculture	0.37	1.02
7.	Others	5.74	15.83
	Total	36.26	100

Table 4 Fly Ash utilization (CEA annual report 2011)

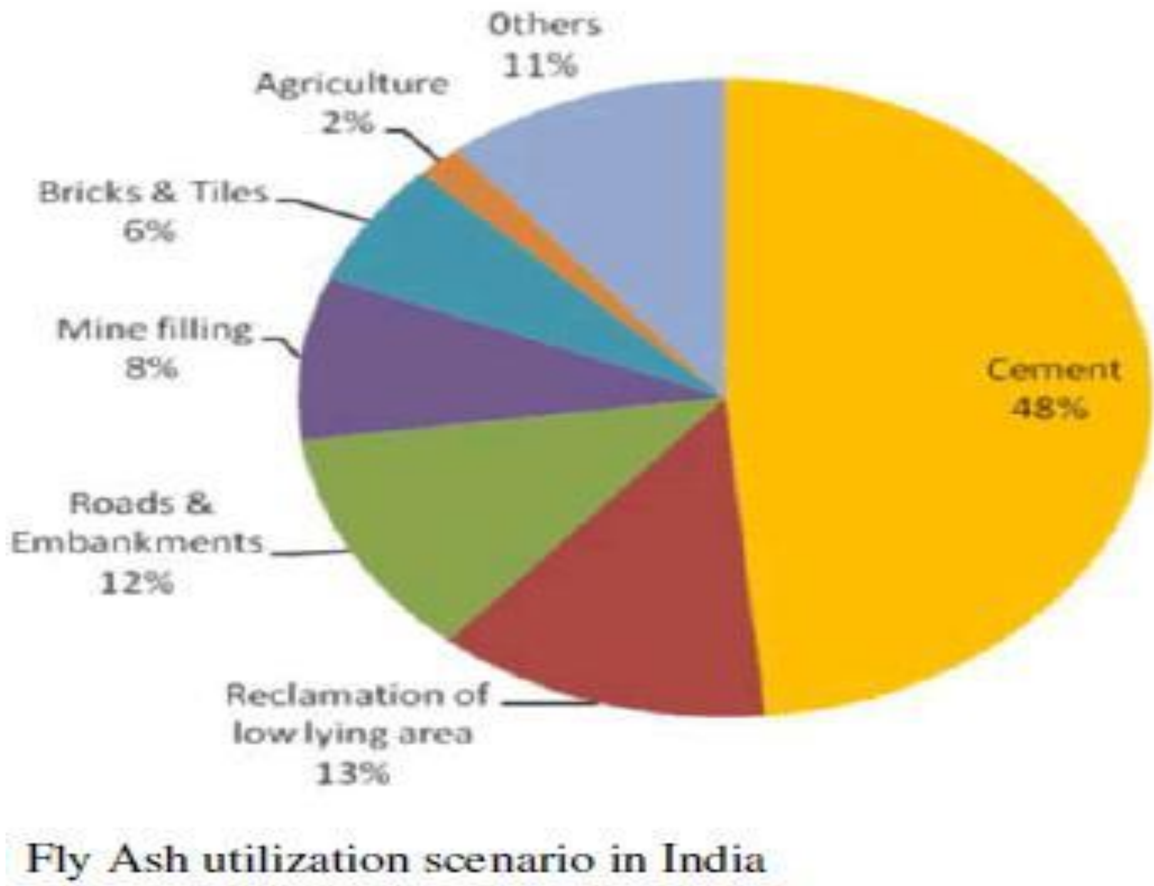


Fig. no 4 Fly Ash utilization in india (CEA annual report 2010)

India managed to use only 120million tonnes of the 220million tonnes of fly ash produced in 2012-13, with the remainder left lying inside thermal plants or dumped in open places.

The trend signals the Centre's failure to convert massive quantities of fly ash produced from burning coal into a resource that could be used for construction and industrial purposes.

The cement industry was the largest user of fly ash, consuming 57 million tonnes, while 11 million tonnes went into the making of cement substitutes.

About 14million tonnes was used for filling up mines and 12million tonnes for filling up low-lying areas. Around 11million tonnes was used for road embankments and another 8 million tonnes for bund raising.

FLY ASHUTILISATION IN ROAD CONSTRUCTION

AUGUST, 2015

PREPARED BY FLY ASH RESOURCE CENTRE (FARC)
STATE POLLUTION CONTROL BOARD, ODISHA
A/118 Nilakantha Nagar, Bhubaneswar- 751012

2.3.1 Favorable Characteristics of Fly Ash for use in Roads and Embankments The following characteristics of fly ash make it a preferred material for road construction.

- Lightweight as compared to commonly used fill material (local soils), therefore, causes lesser settlements. It is especially attractive for embankment construction over weak sub-soils where excessive weight could cause failure. Fly ash also causes lesser pressure on retaining walls due to lower weight.
- Higher value of California Bearing Ratio as compared to soil provides for a more efficient design of road pavement.
- Pozzolanic hardening property imparts additional strength to the road pavements/embankments and decreases the post construction horizontal pressure on retaining walls.
- Amenable to stabilisation with lime and cement.
- Can be compacted over a wide range of moisture content, and therefore, results in lesser variations in density with changes in moisture content.
- Easy to handle and compact because the material is light and there are no large lumps to be broken down.
- Can be compacted using either vibratory or static rollers.
- Offers greater stability of slopes due to higher angle of friction. Value of angle of internal friction increases even more upon compaction.
- High permeability ensures free and efficient drainage. After rainfall, water gets drained out freely ensuring better workability than soil, especially during monsoons. Work on fly ash fills/ embankments can be restarted within a few hours after rainfall, while in case of soil it requires much longer period.
- Faster rate of consolidation; a major part of decrease in volume occurs during primary consolidation phase, which is generally rapid, thus making it an ideal material for road fills.
- Considerable low compressibility results in ease of compaction and shows negligible subsequent settlement within the fill.
- Conserves good earth, which is precious topsoil, thereby protecting the environment.

- High sulphur contents can cause formation of expansive minerals which severely reduces the long term strength and durability. But low sulphur content Indian fly ash (less than 0.6 %) can add long term strength and durability to sub grade.
- Fly Ash effectively dries wet soil and provides an initial rapid strength gain which is very useful during construction in wet, unstable ground conditions.
- Fly Ash decreases swelling potential of expansive soils.

Physical & Geotechnical Properties of Fly Ash Vs. Soil

Sl. No.	Parameters	Fly Ash	Natural Soil
1.	Bulk Density (gm / cc)	0.9-1.5	1.3-1.8
2.	Shrinkage Limit	Higher	Could be much lower
3.	Grain Size	Major fine sand / silt & small per cent of clay size particles	Sand / silt / clay size particles depending upon type of soil
4.	Clay (per cent)	Negligible	Depends on type of soil
5.	Free Swell Index	Very low	Variable
6.	Classification (Texture)	Sandy silt to silty loam	Sandy to clayey silty loam
7.	Water Holding Capacity (WHC) (per cent)	40-60	05-50
8.	Porosity (per cent)	30-65	25-60
9.	Surface Area (m^2 / kg)	500-5000	-
10.	Lime reactivity (MPa)	1-8	Variable

Table 5 properties of Fly Ash (test results)

2.3.2 Use of Fly Ash in Road Making:

Bulk utilization of fly ash in construction has a lot of potential. National Highway Authority of India (NHAI) is currently using 100 lakh Tonne fly ash in construction in different NH projects in India and proposed to increase it two folds in the future.

The scope of utilization of fly ash in Road construction are:

• Embankments and backfills – Reinforced or unreinforced

• Stabilization of subgrade, sub-base and base course

• For replacing a part of OPC in Concrete pavements, paving blocks, kerb stones.

2.3.3 Utilisation of Fly Ash in Road Pavements:

Fly ash has been used for constructing different layers of road pavements. Utilisation of fly ash for stabilisation of sub-grades depends on the interaction between fly ash and subgrade soil. If the type of soil available in the area is found to be amenable to pozzolanic action with fly ash, strength parameters of the soil would improve when fly ash is added. This characteristics of fly ash is important in formulation of pavement specifications. Generally, clayey soils react with pozzolanic compounds present in fly ash. No such reaction is observed in case of sandy soils or gravels. Silty soils also react with fly ash but to a limited extent. This reaction can be improved by using additive such as lime. R&D studies conducted at the CSIR-Central Road Research Institute (CRRI), New Delhi on the effect of lime-fly ash stabilisation on the strength and engineering properties of different types of soils have indicated the following:

i. Addition of fly ash or lime-fly ash to soil decreases the maximum dry density of the soil and increases its optimum moisture content.
ii. The strength of soil stabilised with fly ash alone or with lime-fly ash, shows a significant improvement in California Bearing Ratio (CBR) values. The improvement in the strength characteristics depends on the proportions of the mix and the density to which mix is compacted.
iii. The unconfined compressive strength (UCS) test results of clayey soils show a decreasing trend in compressive strength with increase in addition of fly ash. This can

be attributed to changes in gradation obtained with the addition of fly ash. But the UCS values of soils treated with lime and fly ash show a significant increase in the strength.

iv. Mixing of fly ash/lime-fly ash with soil in the field should preferably be carried out by mechanical means using rotavator and adequate quality control measures should be exercised during construction.

2.3.4 Limitations for Bulk Utilisation of Fly Ash in Road Works:

The system adopted for generation, collection and disposal of fly ash coupled with administrative and techno-economic constraints have restricted the bulk utilisation of fly ash. The following points need to be considered by policy makers/ engineers/ fly ash producers:

• Thermal power plants mostly adopt wet disposal system, where in bottom ash and fly ash are mixed and disposed as slurry to ash ponds. On one hand it makes dry fly ash unavailable for replacement of cement. The coarser bottom ash is better suited as a fill material. There is urgent need to adopt dry disposal system and to make available bottom ash and fly ash separately for specific uses.

• The transportation cost component of ash sometimes limits the lead distance up to which fly ash can be economically utilised in place of borrow soil.

• The other issue of concern is the variations in properties of fly ash. The properties of fly ash vary depending upon type of coal, its pulverisation and combustion techniques, their collection and disposal systems, etc. Obviously ash from two different thermal power plants would be having entirely different properties. These factors can be taken care during characterisation and quality control operations.

• Absence of adequate fiscal incentives/subsidies to prospective users by the Government needs to be addressed. Conventional construction materials should be taxed at a higher rate to discourage their use and subsidies/incentives can be provided to contractors who utilise fly ash.

• Absence of technology transfer services has resulted in lack of awareness among engineers.

2.4 WASTE GLASS:

With the rapid economy growth and continuously increased consumption, a large amount of glass waste materials is generated. This study attends to study the performance of asphalt concrete mix, where some of fractional fine aggregate is substituted with different percentages of crashed glass materials of 5%, 10%, 15% and 20 %. The Marshall design was used to examine the influence of the Optimum Asphalt Content (O.A.C.) at different fine glass percentages and the resistance against water. Asphalt concrete mix properties can be improved by using a hydrated lime admixture and other mixtures. It is expected that the recycling and use of waste glass in asphalt mixes is feasible. Subsequently, by obtaining low price and economic mixes that will reduce the O.A.C., increase the stability and the durability of the mix, in addition to increasing the skid resistance of the road surface, this will reduce accidents and save a lot of money. By crushing and sieving, waste glass materials can be used as fine aggregates in asphalt concrete, where this is called glass asphalt. Satisfactory performance of upper asphalt pavement layers can be achieved by adding glass waste with 10% of the mix.

2.4.1 LIMITATIONS:

- The development of uniform specifications concerning sizing, levels of debris and mix limitations are needed to facilitate glass use.
- There is some uncertainty regarding the need for antistripping agents such as lime if glass is reduced to a very fine aggregate size (less than 6.35 mm (1/4 in))
- The most limiting constraint to glass use is the lack of an adequate and consistent supply of the product.
- In only a few instances, such as in the City of New York, have provisions been made to establish a continuous market supply of glass.
- The elimination of hand sorting and crushing of all glass to produce a market-ready aggregate product is probably required to achieve more widespread glass use.

Shafabakhsh and Sajed (2014) indicated that the dynamic properties of glass–asphalt concrete, the fatigue life, stiffness modulus and creep compliance are improved in comparison with those of ordinary asphalt concrete. Arabani (2011) found that the behavior of Hot Mix Asphalt (HMA) in different temperature conditions, depending on the variation of the admixture contents and the gradation of the aggregates, is improved in comparison with that of HMA mixtures.

Al-Qaisi (1981) studied the effect of filler-asphalt ratio on the properties of filler- mastic and asphalt paving mixture, using five types of filler (Portland cement, lime dust stone, hydrated lime, powder of crushed gravel and sulfur). He stated that the range of the filler-asphalt ratio required to produce the desired properties of paving mixtures is influenced by the type of filler used and that such range should be set accordingly. Also, he showed that several locally available materials could be used to replace Portland cement as filler in asphalt paving mixtures.

Salman (1983) investigated the effect of hydrated limestone and silty-sized soil filler on the properties of asphalt and showed that lime and silty-sized soil could be used as a satisfactory filler material when used in a limited range. He also concluded that, at higher filler percentage, some irregular relationship is observed between filler content and percent of air voids in the compacted mix.

CHAPTER-3

METHODOLOGY:

3.1. Method of making the mix using plastic

Basic processes required to be done before making the mix are as follows:

a) Segregation

b) Cleaning process

c) Shredding process

d) Collection process

Waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, rag pickers. Household plastic was also collected for the project work, like empty milk bags, used plastic bags etc. The collected Plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process. Less micron plastic is easily mixable in the bitumen at higher temperature (160-170°C).It is clean by de-dusting or washing if required. Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160-170°C which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°C.The mixture was stirred manually for about 20-30 minutes. In that time period temperature was kept constant about 160-170°C. Polymer-bitumen mixtures of different compositions were prepared and used for carrying out tests i.e. Penetration test, Ductility test, Flash point test & Fire point test, Stripping test, Ring and ball test and Marshall Stability value test.

3.2 Waste plastics coated aggregate–bitumen mix

Aggregates → Hot aggregates

Waste plastics

Poly-coated aggregates

Hot bitumen 160°C

Polymer bitumen Aggregates mixture

3.3 Field trials

Dry process - For the flexible pavement, hot stone aggregate (170ºC) is mixed with hot bitumen (160ºC) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding property, penetration value and viscoelastic property. The aggregate, when coated with plastics improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

Advantages of Dry Process

a) Plastic is coated over stones - improving surface property of aggregates.
b) Use of waste plastic more than 15% is possible.
c) Flexible films of all types of plastics can be used.
d) No new equipment is required.
e) Bitumen bonding is strong than normal.
f) Doubles the binding property of aggregates.
g) No evolution of any toxic gases as maximum temperature is 180ºC.
h) No degradation of roads even after 5-6 yrs. after construction.

Disadvantages of Dry Process

a) The process is applicable to plastic waste material only.

Wet process – In this process, waste plastic is directly mixed with hot bitumen at 160°C.Mechanical stirrer is needed to mix the bitumen. Stabilizers and coolers are added in it to enhance its properties. Since this process requires additional components like stabilizers and coolers, additional investments and bigger plants it is not commonly used.

Advantages of Wet Process

a) This Process can be utilized for recycling of any type, size, shape of waste material (Plastics, Rubber etc.)

Disadvantages of Wet Process

a) Time consuming- more energy for blending.
b) Powerful mechanical is required.
c) Additional cooling is required as improper addition of bitumen may cause air pockets in roads.

3.4 Mix using rubber

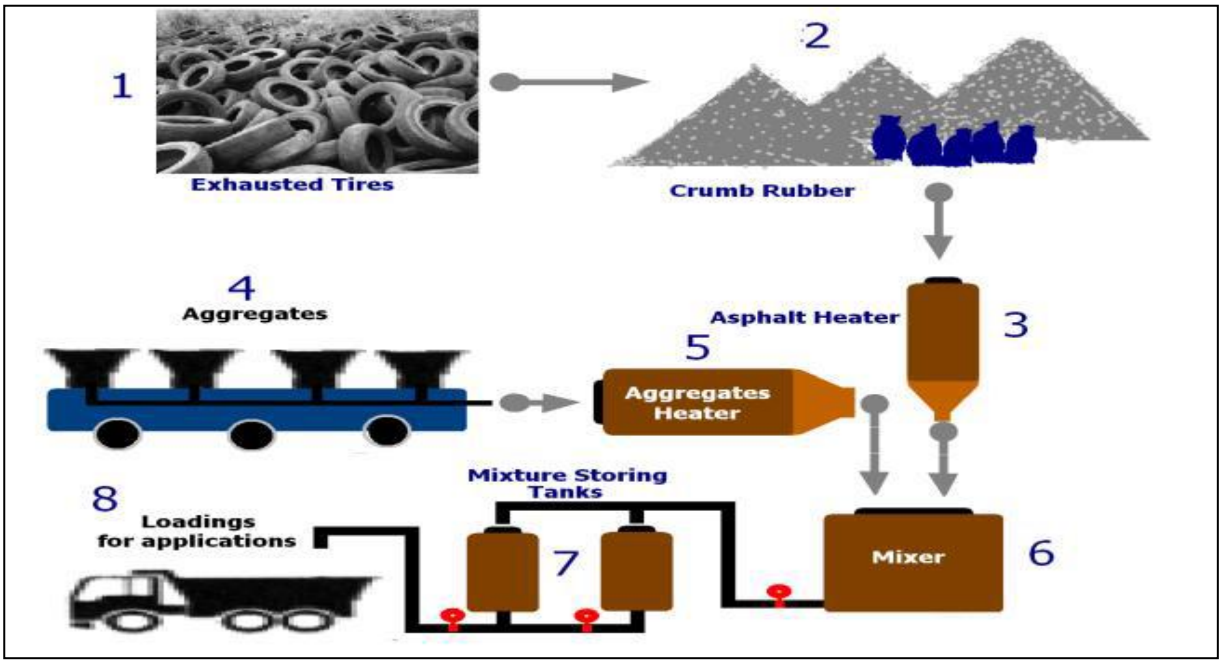
Types of rubber used

a) Crumbed rubber (CR) - It is usually defined as rubber having a particle size of 9.5mm (3/8 inch) or less. They can be classified into four groups as follows: coarse, 9.5– 6.3 mm; mid-range, 2 – 1 mm; fine, 0.4 - 0.2 mm; and superfine, 0.15 - 0.075 mm. CR is commonly obtained by using either of these processes.
b) Ambient Ground Rubber - It is obtained by shredding and grinding (milling) the tire rubber at or above ordinary room temperature.

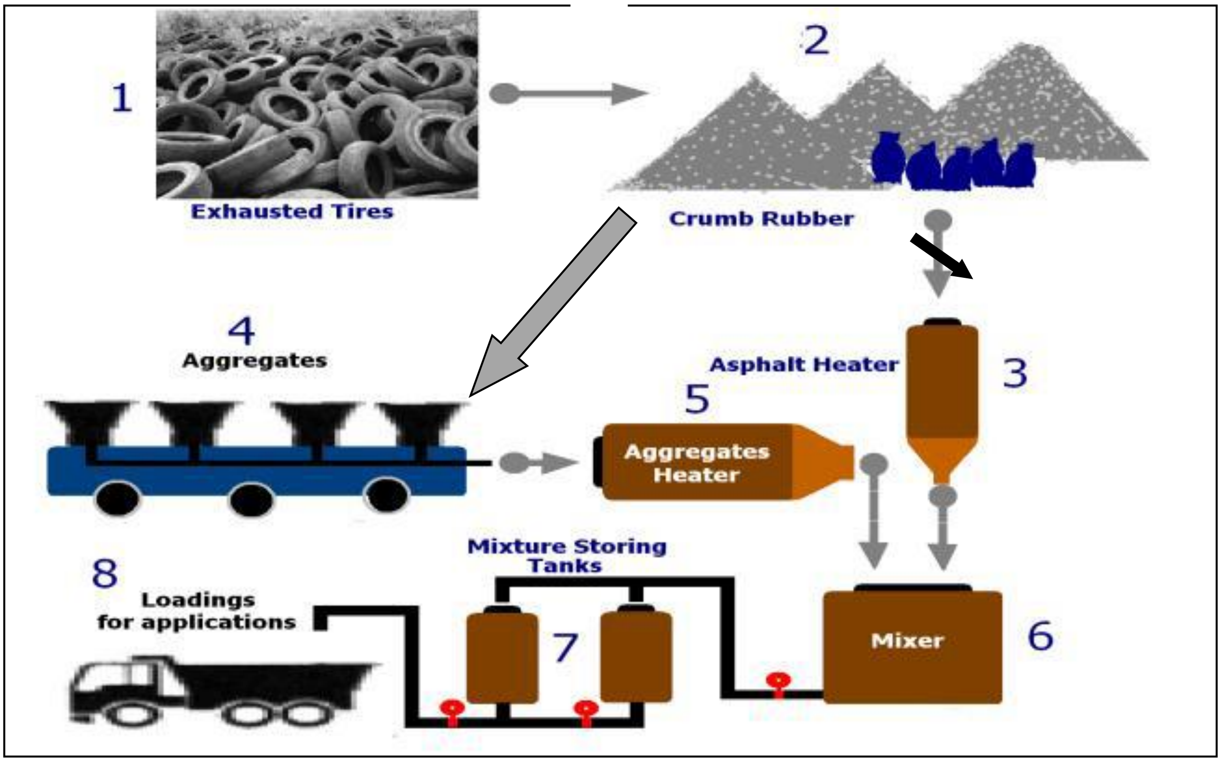
Production of asphalt mixtures with tire rubber in form of crumbed rubber (CR) is usually established by mainly one of two common ways;

a) The first one is called the wet process where rubber particles are mixed with asphalt at elevated temperature prior to mixing with the hot aggregates.
b) The second type is called dry process, where rubber particles replace a small portion of the mineral aggregate in the asphalt mix before the addition of the asphalt.

The main differences between these processes include size of rubber; in the dry process rubber is much coarser than wet process rubber, amount of rubber; the dry process uses rubber 2 to 4 times as much as the wet process, function of rubber; in the dry process the rubber acts more like an aggregate but in the wet process it acts more like the binder, and finally the ease of incorporation into the mix; in the dry process no special equipment is required while in the wet process special mixing chambers, reaction and blending tanks and oversized pumps are required.



A



B

Fig 5: Production of asphalt mixtures

(A-Up) Rubberized asphalt mixture by wet process

(B-Below) Rubberized asphalt mixture by dry process [4]

Note: the arrows make the differences between the two figures.

Explanation of numbers of top figures:

1- Whole tires 2- Powder of waste tires

3- Heat of Asphalt 4- Aggregates

5- Heat of aggregates 6- Storage of mixture

7- Mixing bitumen with aggregates

8- Loading & transportation to the site

A. The Wet Process

The binder produced from wet process, or the McDonald process, is called asphalt rubber. It has been defined by American Society for Testing and Materials (ASTM) as "A blend of asphalt cement, reclaimed tire rubber, and certain additives in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles."

In wet process, asphalt is blended with a crumb rubber modifier (CRM) in a specialized blending unit at elevated temperatures (190 - 225°C) for a minimum of 45 min to promote the chemical bonding of the components. During the blending process, CR swells and softens with the asphalt. This reaction is influenced by the blending temperature, the time the temperature remains elevated, the type and amount of mechanical mixing, the size and texture of CR, and the aromatic component of the asphalt. CRM typically ranges from 18 to 22% by weight of the asphalt. Extender oils are sometimes used to reduce viscosity and promote workability of the asphalt rubber as well as to increase the compatibility between the asphalt and CR. The diagram in Figure 1 shows production of asphalt rubber mixes using the wet process. Asphalt rubber mix is used primarily in open graded and gap graded Hot Mix Asphalt (HMA). It is also used in spray applications for seal coats and pavement interlayers and as a crack sealant.[2]

B. The Dry Process

As aforementioned, in the dry process, CR is added to the aggregate in a hot mix plant operation prior to adding the asphalt. There is relatively little reaction between the asphalt and CR in the dry process. In essence, CR replaces a portion of the aggregate.

The dry process can be used in dense graded, open graded, or gap graded HMA. The most commonly used dry process was developed and patented in the late 1960's in Sweden and in 1978 in USA. The performance of pavements using this process has met with mixed reviews and, as a result, the dry process is not widely used for modifying asphalt pavements.

CHAPTER-4

TEST CONDUCTED IN THE COLLEGE PREMISES:

Aim: Practical test conducted on the aggregate, plastic-coated Aggregate, bitumen and plastic-bitumen mix.

Material:
1. Aggregates (passing through sieve 12.5 mm)
2. Waste plastic (15% in proportion with wt. of agg)
3. Bitumen
4. Vessel
5. Stirrer
6. Kerosene, woods

Apparatus:
1. Weighing machine
2. Abrasion testing machine
3. Penetration testing machine
4. Aggregate impact test
5. Crushing testing machine

4.1 Procedure:

Part 1: (Preparation of plastic\rubber coated aggregate)

a) We collected around 3kg of aggregate in a vessel.
b) Then we searched for waste plastic in the college premises and collected approx. 15% by wt. of aggregate i.e.
c) We collected waste woods and material for burning process as we had to maintain the temperature of about 160^0C.
d) We than started the procedure for coating the plastic over the aggregate by DRY PROCESS.
e) We started heating the aggregate and made sure that the temperature gets up to 160^0C.
f) As we noted that the aggregate is heated good enough, then we started adding plastic/rubber into the vessel in which aggregate was getting heated.

g) We added plastic/rubber part by part so that is gets melt and coated properly over the aggregate, and stirred it thoroughly.
h) Stirring it thoroughly is very necessary part.
i) We made it sure that the process is completed properly and rightly.
j) This process almost required about 40 mins. of the time.
k) Thus the aggregate coated with plastic/rubber is collected in another vessel.

Part 2: (Preparation of bitumen-plastic bitumen-rubber mix)

a) We took about 1 kg of bitumen of grade 60/70 in a vessel and started heating it up to a temperature of about 140-160 degree c.
b) Then we just use the WET PROCESS to prepare the plastic\rubber-bitumen mix.
c) That is, we added plastic/rubber to the bitumen solution by 15% by the weight of bitumen mix and stirred it thoroughly.
d) Thus after completely boiling the bitumen solution and bringing it back to the liquid state and thus seeing the plastic added is liquefied or dissolved completely in the bitumen solution.
e) Thus preparing the plastic/rubber-bitumen mix and further using it for testing.

4.1 Implementation work:

Here we did the implementation of the work on 3 patches of 1 m x 1 m area of each patch in the college premises. While doing this we just collected different materials such as bitumen, waste plastic/rubber, aggregate passing through 12.5mm sieve, drums, woods (for burning), kerosene, roller, and hired 2 labors as an helping hand for us.

Since we wanted to study the characteristic and behavior of plastic at different % by wt. of aggregate, as we wanted to study the changes which happens by the addition of plastic. Hence we made 3 patches of bitumen pavement by different weight of plastic added i.e. 15% , 20%, of plastic by wt. of aggregate and normal aggregate-bitumen mix.

Heating bitumen & plastic

Non-Plastic & pastic coated aggregates

Penetration test

Conducting impact test

Abrasion test

Laying patches of non-plastic & pastic coated aggregates

Fig 6 : Lab Testing

We thus made the patch and collected some polymer-aggregate-bitumen mix and made some laboratory testing on that collected sample of plastic/rubber coated agg-bitumen mix (15%), and plastic/rubber coated aggregate-bitumen mix (20%) and normal aggregate-bitumen mix.

Thus testing all the three sample in the lab and obtaining various readings on the test such as Penetration test, Abrasion test, Aggregate impact test, Crushing test and so on. Thus by comparing the readings and observing, the behavior and we can state the advantages and dis-advantages of the results which we obtained. Following pictures show how we conducted the practical.

CHAPTER-5

TEST RESULTS

5.1 Plastic:

1. **Determination of softening point**:

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

% of polymer in bitumen	Softening point
0	50.2
10	60
20	58.2

Table no . 6 : 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.

2. Penetration Test:

Penetration test

% of polymer in bitumen	Penetration Value
0	70
10	67
20	55.7

Table no . 7 : Penetration test

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

Observation table:

Penetration initial (cm)	Dial reading final (cm)	Penetration value (mm)	Mean penetration value (mm)
246	515	26.9	40.43
246	620	37.4	
197	254	57	

Table no . 8 : Mean Penetration Value

Conclusion- As per penetration value of given sample is 40.33mm it is concluded that the given sample is of A45+545. [Fig 3.1]

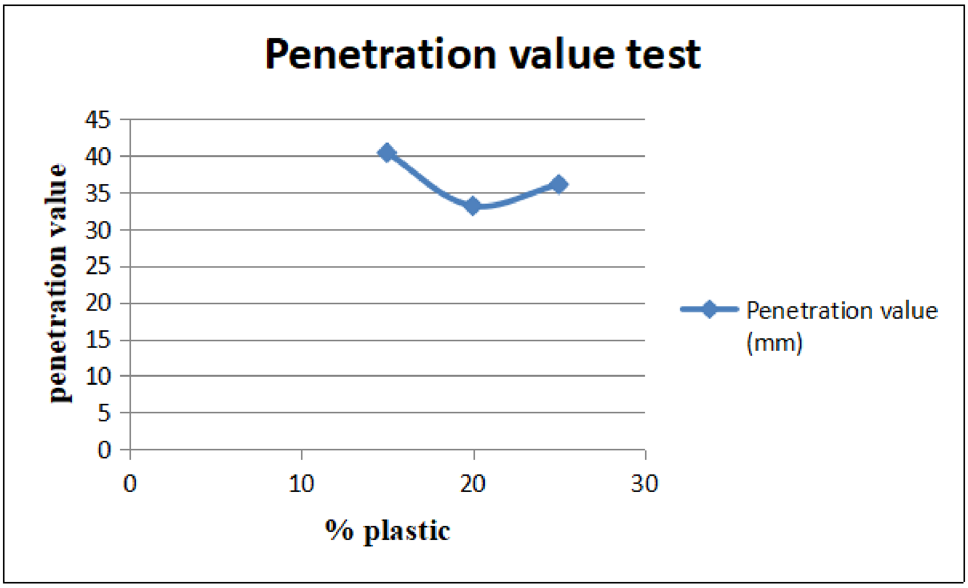


Fig 7: Penetration value test

3. Aggregate impact test

Observations:

Weight of empty mould=1.8kg

Weight of mould+aggregate=2.442kg

Weight of mould +plastic coated aggregate=2.441kg

Weight of sample W3 (aggregate) =0.641kg, (plastic coated aggregate) =0.641kg

Observation table:

	Total wt of sample W3(mm)	Total wt of sample passing IS 2.36mm sieve W1(mm)	Total wt of sample retained W2(mm)	W1(W3-W2)	(W1/W3)* 100	Average impact value %
Aggregate	0.641	0.08	0.564	0.017	23.32	23.32
Plastic coated aggregate	0.641	0.065	0.578	0.0041	10.140	10.15

Table no . 9 : Aggregate impact test value

Conclusion- The average impact value of given samples are 23.32% and 10.15% respectively. Hence as per IRC classification, aggregate is satisfactory whereas plastic coated aggregate is strong.

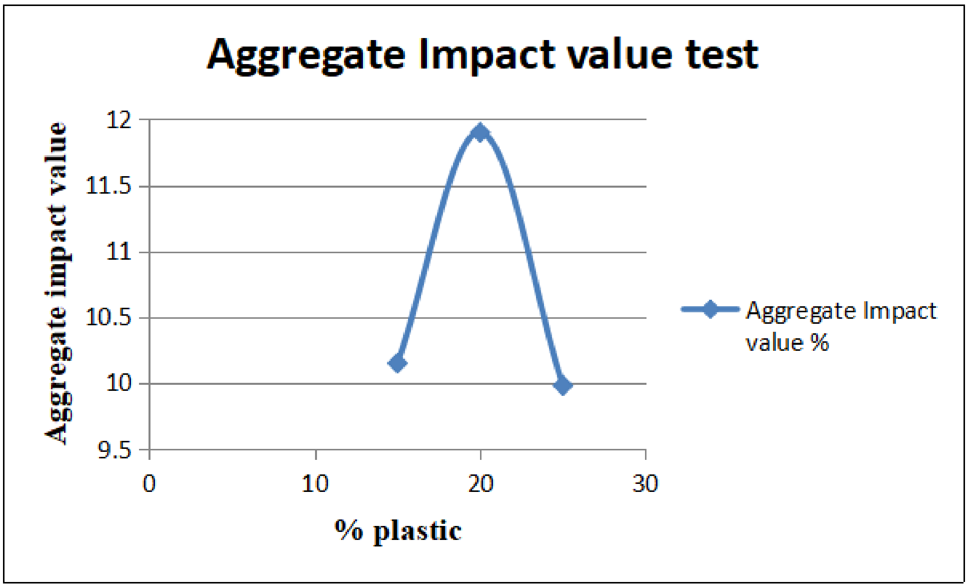


Fig 8: Aggregate impact value test

4. Ductility Test:

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

% of polymer in bitumen	Penetration Value
0	20
10	29.3
20	35.4

Table no .10: Ductility Test

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.

5.2 RUBBER:

1. Penetration test

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25o C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, the size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred.

% of CRMB	Penetration Value (mm)
0	69
10	38.67
15	14.11

Table no.11 : Penetration test

Result: Penetration Test were done for normal bitumen and modified bitumen with 0%, 10% and 15% of rubber waste content. The result was shown in Table 2. From the result of the test, the penetration value for normal bitumen was 69 mm. Penetration value decreased with the increased amount of the rubber waste added. Lower penetration value making harder grade of asphalt, giving additional strength to the road and reduces water damage.

2. Softening Point Test:

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5oC per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

% of CRMB	Mean softening Value (mm)
0	42.75
10	51.65
15	55

Table no.12 : **Softening Point Test**

Result: Softening Point Test was done for normal bitumen and modified bitumen with 0%, 10% and 15% of rubber waste content. The result was shown in Table 3. From the result of the test, the softening point for normal bitumen was 42.75˚c. Softening Point increased with the increased amount of the rubber waste added. This showed that the bitumen becomes less susceptible to temperature changes as the content of rubber waste increased.

3. Ductility Test:

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking.

% of CRMB	Mean sample Value (mm)
0	73
10	35
15	24.2

Table no 13 : Ductility Test

Result: Ductility test was done for normal bitumen and modified bitumen with 0%, 10% and 14% of rubber waste content. The result was shown in Table 4. The result shows that the rubber waste added will harden the bitumen. The bitumen becomes more viscous and harden, which would be useful to obtain stiffer bitumen asphalt.

CHAPTER-6

CONCLUSION:

1.Penetration value test result shows that Penetration value decreased with the increased amount of the plastic\rubber waste added. Lower penetration value making a harder grade of asphalt, giving additional strength to the road and reduces water damage. Lower Penetration thereby making a harder grade of asphalt, giving additional strength to the road and reduces water damage.

2.Softening point test shows that Softening Point increased with the increased amount of the plastic\rubber waste added. This showed that the bitumen becomes less susceptible to temperature changes as the content of plastic\rubber waste increased. Increase of Softening Point, thereby giving it protection against hot climatic conditions.

3.Ductility test result shows that the plastic\rubber waste added will harden the bitumen. The bitumen becomes more viscous and harden, which would be useful to obtain stiffer bitumen asphalt.

4.The biggest advantage of using plastic\rubber bitumen is that the road life increases in comparison to the normal bitumen whereas the cost increase on the road.

5.Improved adhesion aggregates and binder thereby giving better strength, stability and longer life.

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