Durability of potholes filled with waste materials

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Abstract: Repairing and maintenance of potholes continues to be a serious problem for road construction organizations as they need to be reconstructed time to time. For rural and suburb areas the maintenance of potholes is rarely done because of high cost of materials and availability of equipment. Here is when the idea of using waste materials in potholes patching is bolded. With rapid increase of population and construction industry the disposal of waste material seems to be a major challenge for country like Afghanistan where large amount of plastic is being disposed to environment which due to non-biodegradable properties of plastic it would stay in environment almost forever and will cause pollution. Hence, the utilization of waste plastic is a big need for countries. Simultaneously, with spreading cities and upgrading roads lack of origin materials may occur on the other hand waste demolished materials from destructed buildings are being disposed on country sides and often in cities which create land pollution and traffic congestion. However, they can be used in road construction as a replacement of natural aggregate and fillers. Which will reduce in cost of the projects and help in reduction of these materials form environment. In this research poly ethylene plastics (PE) were used as admixture of bitumen in 4%, 6%, 8% and 10% which came out that 8% is best for the mix. Accordingly waste demolished aggregate was used as a fully replacement of original aggregate. Basic aggregate tests were done on demolished aggregate and it was found that it can be used in bitumen mixes for use in district roads and village roads.

Keywords: Potholes; waste plastic; demolished aggregate

1. Introduction

Holes having varies size and shape in pavement are called potholes. There are numerous reasons in forming potholes but the main one can be extraction and contraction of water that is below the pavement of road. In this paper it Sometimes repairing of potholes in asphalt pavements is not taken serious in road agencies [1]–[3]. But, the repairing process of potholes needs a vast portion of money and effort. On the other hand, potholes are potentially dangerous to drivers also causes vehicle damage which seems to be a challenge for both users and road agencies. That is why a proper knowledge in selection potholes patching materials and methods can help a lot in reducing the driver frustration and maintenance budget.
Based on durability and patching method different mixes are being used in potholes. If higher durability patching is desired, suitable material and complex patching methods should be used. Hence, some admixtures are widely used in asphalt mixes to improve its performance and durability. However, when it comes to fund and budget inexpensive materials and practices are being used to reduce the cost of the project [4]–[8]. Such as: waste materials as binders of fillers in asphalt mixes. Plastics can be a suitable solution for pavement corrugation and potholes as it is widely available and cheap. Plastic is classified into two main groups: thermoplastics and thermoses. Thermosets are initially used in road construction due to their high strength and durability. Various researches have been done globally to recycle and reuse plastic. The literature review shows that plastic is a non-biodegradable material which is a major cause of environment pollution and global warming. Plastic road are a new idea and yet there is no road is fully made with plastic. However, plastic in small amounts (1%-10%) is used in many roads as an admixture in bitumen that can increase strength better resistance and performance in long time. Nevertheless, it is used with aggregate as coating which this coated aggregate can have higher durability and smoothness. In countries having hot and humid climate plastic pavements can have greatest option. Along with enhancing properties of mix and improving the road quality using waste plastic in road construction will help in pollution problem which is considered the main intention for its usage. Moving further, with improving in [9]–[12] construction industry a high amount of natural resources is consumed, specially road construction which requires a substantial quantity of materials. since road industry consumes a potential amount of aggregate which makes it a good option for reusing waste for raw materials. Among all other waste materials waste aggregates from demolished buildings can be used in both maintenance and building process of road networks as it is available in both urban and suburb areas. Although recycled demolished aggregate is having lesser quality than the original aggregate but if treated and cleaned properly proved to work fine in local roads [13]–[15]. Several studies have been done on usage of RCA in road construction and have found that it is an economical way. In this paper PET as an admixture with bitumen and demolished recycled aggregate were used to find an alternative patching mix for potholes instead on standard or traditional mixes used presently. Properties of recycled aggregate and PET were tested with basic tests on aggregate and bitumen. In addition, a comparison between natural bitumen and modified bitumen was performed to ensure the improvement in properties of bitumen. Finally, an optimum PET percentage was found which the mix is having maximum stability [16]–[18].

2. Literature review

Researcher from around Europe has investigated about potholes. Through a questioner they have asked stockholders in different parts of Europe how materials, techniques, and durability estimation were selected? Mostly improper materials or techniques were applied. Hence, an evaluation of existing practices and tests were done and based on the results, durability or life cycle cost analysis was lunched and a guideline was made on how to select a technique or material with a durability according to existing pavement estimated lifetime. reviewed of different waste materials for road construction. The optimum dose of plastic is approximately 6%-8% by weight of bitumen and 0.4%-0.5% by overall weight of bituminous mix. Moreover, various usages suggested for municipal waste instead of throwing them away to environment. an overview on usage of recycled aggregate on bituminous mixes is done and found that recycled aggregate can be a suitable materials for hot mix asphalt in flexible pavements. Though the RCA has a poor quality and will result in various engineering properties of a hot mix asphalt in comparison with mixes having natural aggregate. In this paper several treatments are suggested that help in mitigation of this problem. concluded that addition of high density polyethylene (HDPE) and polypropylene (PP) in standard bitumen is known to improve viscoelastic properties of bitumen. However, results in changing its rheological behaviour. These two types of plastic were tested and observed that they are having different amount of effect on bitumen properties for example softening point is increased but penetration value is decreased. Meanwhile, Overall absolute and dynamic viscosities of binder in enhanced. it was found that, plastic mixed bitumen have good results in comparison with standard bitumen. Moreover, these properties will start to decrease when plastic is used more than 8%, so they have suggested and optimum 5%-10% of plastic in bitumen mix. Plastic mixed bitumen will help in decreasing sound
pollution also help in removing plastic waste from environment. Usage of waste materials as a replacement for conventional materials. It was found that recycled aggregate is soft compared with plain aggregate and it can be used in sub base but not in surface course. The admixture of plastic with bitumen will enhance its properties. The optimum percentage of replacement of original material with waste material is 4% plastic and 20% aggregate. Investigated the usage of plastic waste with bitumen which found if waste plastic is added to aggregate to coat it, it will enhance the aggregate impact value which its toughness is increased, crushing value decreased which means aggregate got stronger, increase in specific gravity, reduction in stripping value which shows that coated aggregates are more suitable to use for bituminous pavements than simple aggregate. Plastic is a good admixture because it can be used in large amount, it can be recycled and mixed in bitumen with a small amount of money which helps in overall cost of bitumen with reducing bitumen weight in 10% which is almost % of whole mix. Usage of waste plastic in road construction industry even in a scale of 10% will reduce almost all waste plastics being thrown to environment nowadays. Besides all these plastic in any form mixed with bitumen will improve its basic properties and makes it more stable.

3. Materials used

3.1 Recycled building demolished aggregate

Aggregate was collected from south campus of Chandigarh University from a demolished building. Firstly, cleaned and then hammered to desired size of smaller than 53mm. Aggregates passing from 4.75mm sieve are called fine aggregates and those retained are called course aggregate. For study purpose aggregate used in this paper is according 6th revision of MORTH specification, see figure 1.

![Figure 1. Waste demolished aggregate and Crushing aggregate into desired size](image)

3.2 Treatment and preparation of demolished waste materials

Frist material was collected in big concrete blocks shape. then, hammered in an average size of below 53 mm usable for sieve analysis and cleaned from other unwanted particles like steel bars, bricks, nails etc. After that, it was washed and finally left in oven for almost 24 hours.

3.3 Recycled waste plastic

Plastic bottles were collected for this purpose. Soft cold drink and water bottles are made of polyethylene terephthalate (PET) which are the most common used plastic type. In most of countries they are recycled and reused to make textiles and PET bottles again. For this study plastic bottles were collected from campus canteen and cafeteria, see table 1.
3.4 Treatment and preparation of waste plastic

Plastic cold drink and water bottles were collected. After washing and drying they were shredded and melt in a pot by heater then mixed with bitumen.

3.5 Bitumen

Bitumen is a petroleum refining process by-product. Which is used as a binder in flexible pavement mixes. For this study purpose 80/100 grade bitumen was used.

4. Methodology

Sample collection: which includes collection waste plastic in form of plastic bottles and demolished aggregate. Second step is determination of properties of materials, from plastic types PET was selected and also basic tests on aggregate were performed to determine its properties. Determination of properties of materials. Polyethylene Terephthalate (PET) Waste (recycled from water and cold drink bottles) and waste demolished aggregate (collected from a demolished building) were selected for this purpose. And, basic aggregate tests were performed to determine the properties of these materials. Tests to be conducted are: Basic tests on recycled demolished aggregate, Tests on bitumen, marshal stability test and Preparing the design mix of recycled aggregate and plastic mixed bitumen.

5. Laboratory testing

5.1 Basic tests on recycled demolished aggregate

5.1.1 Sieve analysis (IS: 2386–Part4)

Gradation of aggregate is the distribution of its particle size through sieve analysis. For the test purpose around 30kg of sample was taken. Since it was no possible to sieve it all in once it was performed into two stages. Gradation was done with sieve analysis in shaking machine with 53mm on top and 75micron in bottom above base plate. Gradation was done with sieve shaker machine. Then, according to MORTH
5.1.2 Crushing value test (IS: 2386-Part4)

This test is done to determine the crushing resistance of aggregate under wheel load or any other crushing load. Aggregates used in pavement should have sufficient strength to resist against traffic load it means the more value is high the more it is having stability. For this test aggregates passing from 12.55mm sieve and retaining at 10mm sieve are used. Then the aggregate is filled in crushing value mold in three layers and tamped 25 times by the small hammer. After that the mold is set carefully under compression testing machine and a load of 40ton at a rate of 4ton per minute is applied. Finally, the crushed sample is collected and sieved through 2.36mm sieve. The amount of aggregate passing from 2.36mm with respect to the total weight of sample is calculated to determine the crushing value test.

5.1.3 Impact value test (IS:2386-1963-part4)

Toughness of aggregate is determined through this test. Toughness of aggregate shows how it resist under impact load of traffic in a pavement. If aggregate does not have enough toughness it will crush under traffic impact load causing failure in pavement, cracks and potholes. That is why, aggregate should be tested for toughness before using it in pavement to ensure its impact resistance. Aggregates passing from 12.5mm and retaining at 10mm sieve is taken. Then the mold is filled with aggregate in three layers and tamped 255 times. A hammer having 13.5kg-14kg weight is subjected to the mold from a height of 38cm. Finally, after 25 blows of hammer aggregate from mold is taken and sieve from 2.36mm. The percentage of aggregate passed from sieve is related to total weight of sample is calculated that is known as impact value of aggregate.

5.1.4 Los Angeles Abrasion Test (IS: 2386–Part4)

The relative quality of aggregate is specified through this method. This test testes is done to determine the abrasion and though resistance of aggregate like: degradation, disintegration and degradation. When the traffic is moving over a pavement the small particles of soil and sang between tires and road surface result in abrasion of aggregate. Thus, the aggregate should be tested for toughness before using it in pavement to ensure its impact resistance. Aggregates passing from 12.5mm and retaining at 10mm sieve is taken. Then the mold is filled with aggregate in three layers and tamped 255 times. A hammer having 13.5kg-14kg weight is subjected to the mold from a height of 38cm. Finally, after 25 blows of hammer aggregate from mold is taken and sieve from 2.36mm. The per centum of aggregate passed from sieve is related to total weight of sample is calculated that is known as impact value of aggregate.

5.1.5 Specific gravity and water absorption test (IS:2386-1963-part3)

Water absorption test determines the quantity of water absorbed by aggregate and the quality and strength of aggregate is calculated by specific gravity. 2kg of recycled aggregate was taken and cleaned from unwanted fine particles. Then, aggregate sample was filled in a bucked having a wire where it should immerse fully in water and leave it for 24 hours in waterer absorption apparatus where the temperature is around 22˚C-32˚C. Aggregate is taken out from bucked after 24 hours and left in room temperature for 1 hour then dried with a cotton. Next, weight of aggregate is noted(W1). Dried aggregate was put in oven at a temperature between 100-110˚C for 24 hours then weight of aggregate is taken after
removing from oven (W2). Finally, water absorption is calculated through formula \[ \frac{(W1-W2)}{W2} \times 100\% \].

5.2 Tests on bitumen mixed with PET

5.2.1 Penetration test (IS: 1203-1978)

This test determines softness or harness of bitumen by measuring the depth of nail in to bitumen in 5 seconds which penetrates vertically. This test should be performed in specified 25°C temperature. This test also specifies grade of bitumen for example a grade of 30/40 means that it’s penetration value is between 40-50 at standard test condition. For each trial 3 reading is taken from centre and edges.

5.2.2 Ductility Test (IS: 1208-1978)

Ductility of bitumen shows how it is able resist in deformation and elongation without braking. It is measured in Cm; which standard sample will elongate without braking or tearing apart. Bitumen is heated and filled in metal plate. Molds and samples are cooled in room temperature then in water at 27°C. Then, excess bitumen is cut from the plate by a knife to level it. Finally, plate is left in the ductility test machine for 90 minutes. Sides of the plate are unhooked and machine is turned on. Observe the bitumen carefully and note the point in Cm where bitumen brakes and that is ductility value of bitumen. According BIS minimum ductility value is 73mm.

5.2.3 Softening Point Test (IS: 1205-1978)

Softening point is a property of bitumen which shows the tendency of bitumen to flow in increasing temperatures. Also, it is used for classification of bitumen. Bitumen is melted and filled in ring ball apparatus which is immersed in distilled water at a temperature of 30°C-80°C. samples is observed and the temperature in which balls envelope in bitumen as two disks got soften and balls fall a distance of 1 in (25mm).

5.3 Marshal Stability Test and Flow Test (ASTM D6927 – 06)

This method is commonly used to design bituminous concrete mix. Stability of bituminous mix defines maximum load that can be carried by compacted sample at a standard temperature of 60°C. Between 0 to maximum load carried by sample in marshal stability test time, the flow is measured in amount of deformation in units of 0.25mm. This test helps in determining the optimum amount of binder content for the mix with aggregate in % [9].

5.3.1 Test specimen preparation

1.2 kg of sieved aggregate is taken and heated in oven to the required mixing temperature. Bitumen is added to aggregate at different percentages at and mixed properly. The mix is returned to oven and heated to required compacted temperature. The mix is placed in mold fitted with a collar and base plate then a filter paper is placed on top and bottom of the sample. Mold is placed in marshal compaction pedestal and compacted with 75 blows. Then sample is inverted and compacted again with the same process. The base of sample is removed and sample is extracted by extractor. sample is cooled in room temperature for few hours. Weight of dry sample and submerged is taken to measure the density of sample.

5.3.2 Test procedure

Sample is heated in water bath for 30-40 minutes at temperature of 60°C. Sample is placed and cantered
carefully in marshal stability loading machine. Flow meter is placed above sample and reset to dial to zero Load is applied through machine at a rate of 50 millimetres per minute. The maximum loading obtained and flow recorded from digital indicator screen is noted in mm.

6. **Results and discussion**

6.1 *Basic tests on recycled demolished aggregate*

Table 1. Aggregate gradation

| Sieve Size (mm) | Specific requirement (Passing) | Percentage Passing | Total Weight in gm. 3600 |
|-----------------|--------------------------------|--------------------|--------------------------|
|                 | Min.                          | Max.               |                          |
| 26.000          | 100                           | 100                | 100.00                   |
| 19.000          | 90                            | 100                | 95.00                    |
| 9.500           | 56                            | 80                 | 70.00                    |
| 4.750           | 35                            | 65                 | 52.00                    |
| 2.360           | 23                            | 49                 | 37.00                    |
| 0.300           | 5                             | 19                 | 12.00                    |
| 0.075           | 2                             | 8                  | 5.00                     |
| Pan             |                                |                    |                          |

![Figure 3. Gradation chart](image)

Table 2. Aggregate impact value

| No | weight of aggregates in gm (W1) | particles passing from 2.36mm sieve in gm (W2) | Aggregate impact Value | Average Value |
|----|---------------------------------|-----------------------------------------------|------------------------|---------------|
| 1  | 269                             | 49                                            | 18.22                  |               |
| 2  | 289                             | 77                                            | 26.64                  | 21.37         |
| 3  | 270                             | 52                                            | 19.26                  |               |
Table 3. Aggregate crushing value

| No | Total Weight of sample in gm (W1) | Weight of sample retaining at 1.7mm sieve in gm (W2) | Impact Value in percentage = ((W1 - W2)/W1)*100% | Average Value |
|----|---------------------------------|--------------------------------------------------|--------------------------------------------------|---------------|
| 1  | 2760                            | 570                                              | 20.65                                            |               |
| 2  | 2705                            | 532                                              | 19.67                                            | 20.77         |
| 3  | 2500                            | 550                                              | 22.00                                            |               |

Table 4. LOS Angeles Abrasion Test

| No | Total Weight of sample in gm (W1) | Weight of sample retaining at 1.7mm sieve in gm (W2) | Abrasion Value in percentage = ((W1 - W2)/W1)*100% | Abrasion Value |
|----|---------------------------------|--------------------------------------------------|--------------------------------------------------|---------------|
| 1  | 5000                            | 3682                                              | 26.36                                            | 27.18         |
| 2  | 5000                            | 3546                                              | 29.08                                            |               |
| 3  | 5000                            | 3695                                              | 26.1                                             |               |

Table 5. Specific Gravity and Water Absorption Test

| Weight of dry aggregate in gm (W1) | Weight of aggregate suspended in water (W2)g | Weight of basket suspended in water (W3)g | Weight of saturated aggregate in water (W2-W3)g=(W5)g | Weight of oven dried aggregate (W4)g | Specific Gravity Test = (W4/(W1-W5)) | Water Absorption Test = ((W1-W4)/W4) × 100% | Average Value for Specific Gravity | Average Value for Water Absorption |
|------------------------------------|---------------------------------------------|----------------------------------------|-------------------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|----------------------------------|----------------------------------|
| 2000                               | 1330                                        | 7                                      | 1321                                            | 1999                                | 2.94                                  | 0.05                                 | 2.95                             | 0.37                             |
| 2000                               | 1328                                        | 7                                      | 1319                                            | 1983                                | 2.91                                  | 0.86                                 |                                  | 2.95                             |
| 2000                               | 1340                                        | 7                                      | 1332                                            | 1996                                | 2.99                                  | 0.20                                 |                                  |                                  |

Table 6. Different aggregate tests results

| Name of test                          | Test results | Acceptance limits          |
|---------------------------------------|--------------|----------------------------|
| Impact value test                     | 21.37 %      | 24 % max (MORTH)           |
| Los angles abrasion test              | 27.18 %      | 30 % max (MORTH)           |
| Water absorption test                 | 0.37 %       | 2 % max (MORTH)            |
| Specific gravity test                 | 2.95 %       | 2.5-3% max (MORTH)         |
| Crushing strength test                | 20.77 %      | 30 % max (BIS & IRC)       |

The MORTH 6th revision is used for evaluation of aggregate test. Gradation of aggregate was done by sieve analysis method, from combined gradation graph it can be seen that demolished aggregate is under MORTH specification and can be used in flexible pavements. Moving further, result obtained from aggregate impact value test is 21.37% and maximum value recommended by MORTH is 24% which means that the aggregate used is strong enough. The value found from aggregate crushing test is 20.77% and the maximum value recommended by IRC and BIS is 30% hence the aggregate used is resistance.
enough to crushing while vehicle load is action on pavement. Value obtained from Los Angeles test is 27.18% which is lower than maximum value recommended by MORTH (30%). So, recycled aggregate is resistant to abrasion while under vehicles wheel load. According MORTH specification maximum value allowed for water absorption and specific gravity are respectively 2% and 2.5-3%. Result obtained from specific gravity and water absorption are under MORTH recommendation. Therefore this aggregate can be used for construction purposes in fixable pavements.

6.2 Tests on bitumen mixed with PET

Table 7. Penetration Value Test

| PET percentage(%) | Dial reading | Average penetration value |
|-------------------|--------------|--------------------------|
|                   | Number of trials |                     |
|                   | 1   | 2   | 3   |     |     |
| 0                 | 86  | 84  | 85  | 85  |     |
| 6                 | 81  | 80  | 82  | 81  |     |
| 8                 | 79  | 78  | 77  | 78  |     |
| 10                | 76  | 75  | 74  | 75  |     |
| 12                | 72  | 71  | 69  | 70.66667 |     |
| 14                | 68  | 70  | 70  | 69.33333 |     |

Figure 4. Penetration graph

Table 8. Ductility Test

| PET percentage(%) | Ductility reading (cm) | Average Ductility value |
|-------------------|------------------------|-------------------------|
|                   | Number of trials        |                         |
|                   | 1   | 2   | 3   |     |     |
| 0                 | 77.8 | 78  | 79  | 78.26667 |     |
| 6                 | 88.3 | 89.5| 87.2| 88.33333 |     |
| 8                 | 93.2 | 91.8| 92.4| 92.46667 |     |
| 10                | 96.8 | 95.7| 95.3| 95.93333 |     |
| 12                | 100 | 99.4| 99.7| 99.7 |     |
| 14                | 102.3 | 101.6| 101.2| 101.7 |     |
From the penetration test it can be observed that with the increase of PET penetration value decreases which means that bitumen gets harder and more stable. In addition, the resistance of the mix against rutting is improved. Looking at softening point test it can be clearly seen that with increase in percentage of PET penetration value of bitumen rises which means that with addition of PET the tendency of bitumen in higher temperature to flow increases. The results from ductility test clears that the more PET is
added to bitumen the more bitumen is deformable and elongate without braking, see table 1 to 9 and figure 3 to 6.

6.3 *Marshal stability test*

Table 10 Flow, Stability and Air voids of mix without PE

| Bitumen % | Gt  | Gm  | Vv  | Vb  | VMA | Stability (Kg) | flow (mm) |
|-----------|-----|-----|-----|-----|-----|----------------|-----------|
| 5.00      | 2.55| 2.46| 3.75| 11.37| 15.12| 1655.00        | 3.48      |
| 5.50      | 2.54| 2.43| 4.04| 12.32| 16.36| 1515.00        | 3.49      |
| 6.00      | 2.52| 2.44| 3.23| 13.40| 16.62| 1485.00        | 3.52      |
| 6.50      | 2.50| 2.45| 2.13| 14.51| 16.64| 1255.00        | 3.51      |

![Figure 7. Stability graph](attachment:image)

![Figure 8. Air voids graph](attachment:image)
From the marshall stability calculation on bituminous mix without PET it can be seen that the air voids graph is ascending when bitumen used amount is 5% up to 5.5% where mix is having maximum air voids and then when the amount of bitumen is increased it descends back. Maximum flow is achieved when 6% of bitumen is added and starts decreasing when percentage of bitumen is increased. Stability and amount of bitumen is having indirect relation it means that starting from 5% the more bitumen is added to the mix the more stability is declined, see table 10 & 11 and figure 7 to 9.

| PET % | Bitumen % | stability (Kg) | Flow (mm) |
|-------|-----------|----------------|-----------|
| 4.00  | 5         | 1578           | 4.11      |
|       | 5.5       | 1602           | 4.12      |
|       | 6         | 1613           | 4.14      |
|       | 6.5       | 1592           | 4.18      |
| 6.00  | 5         | 1635           | 4.25      |
|       | 5.5       | 1653           | 4.22      |
|       | 6         | 1665           | 4.20      |
|       | 6.5       | 1630           | 4.22      |
| 8.00  | 5         | 1935           | 4.23      |
|       | 5.5       | 1953           | 4.23      |
|       | 6         | 1950           | 4.24      |
|       | 6.5       | 1915           | 4.21      |
| 10.00 | 5         | 1697           | 4.31      |
|       | 5.5       | 1725           | 4.30      |
|       | 6         | 1743           | 4.36      |
|       | 6.5       | 1697           | 4.35      |
From the marshal stability results it can be noted that the stability of mixture is ascending with increasing PET up to 8%, maximum stability is achieved at 8%. moving further from 8% the stability will start descending, see table 10 and figure 10 & 11.

7. **Conclusion**

Aim of this paper was utilizing of waste material e.g. PET and demolished aggregate in a large scale for construction proposes like highway maintenance and pothole patching in an eco-friendly and economic way. Basic tests on recycled aggregate was performed. Moreover, PET was shredded and mixed with bitumen in 5, 5.5, 6, and 6.5 percentages. Basic test on bitumen modified with waste plastic were performed. Finally, mixture of demolished aggregate PET and bitumen were tested for flow and stability by Marshal stability test, which results are concluded as below:

1. Based on the results obtained from basic tests on recycled demolished aggregate it can be concluded that though the properties of waste aggregate are lower than the natural aggregate but it fulfils MORTH desired requirements. Thus, Usage of recycled demolished aggregate in highway construction specially potholes patching can save a vast amount of money, natural resources and will help in reducing construction waste from environment.
2. Waste plastic and demolished aggregate utilization process is very useful and effective in removing waste material from environment and improving the mix properties as they are completely recycled without any harmful impact to the environment. This paper encourages further researchers to investigate on waste materials and large amount of utilization of PET.
3. It is observed that usage of waste plastic in bitumen increases it properties and modified bitumen is having better performance than conventional bitumen.
4. Maximum stability of mix is achieved in 5.5% bitumen containing 8% PET in it as an admixture.
5. Pothole patching with PET and recycled demolished aggregate would help road agencies to perform the patching process more stable, easy to perform, more economically and eco-friendly.

8. Future scope and Practical application of research

With increasing in population countries tend to expand urbanization with building new cities and upgrading existing ones. Where road network is a basic requirement. Hence, Road construction industry is one of fastest growing industries in the world recently. The more roads we plan to construct or rebuild the more conventional material is needed where at some point humankind would face problems or even run out of natural resources. On the other hand, these would require a huge amount of money and fund. So hereby this research and other papers published on utilization and reusing waste material encourages further researches and deep studies on waste materials utilization. Also, will help in reducing the waste material from environment and decrease in amount of natural resources usage. For the time waste plastic is only used as an admixture of bitumen or coated on aggregate and very less attempts have been done to build roads entirely from waste plastic. Moreover, there are several types of plastics and polymers which have not been investigated for usage in faxable pavements. But, if researches focus more on waste plastic definitely usage of plastic waste would be in a larger scale with better results in the future where not only plastic and construction waste are not trash and pollution but usable material in construction. It was concluded in the paper that PET improves the bitumen properties and it will make the road more durable and sustainable so it will reduce the maintenance cost and prevent from potholes. Simultaneously, if potholes are patched with modified mix will be more durable than the conventional mix.

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