THE USE OF GLASS FIBRE ADDITION TO REINFORCE A ROAD PATCH

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ABSTRACT  
This paper summarizes a research project that investigated a pot-hole repair material that had glass fibres incorporated to improve the durability of the repair. As there is no standard method to evaluate pot-hole repair materials a new methodology called the Pothole Displacement Test was developed to substantiate this claim. The method involves making a base asphalt slab, creating a circular fracture to simulate a pot-hole or underlying weakness and determining the resistance to loading of the applied pot-hole repair material. Using this methodology, the investigation suggests that the use of chopped glass fibres may significantly increase the life of a pot-hole or reinstatement repair.

KEY WORDS: Potholes, chopped glass fibres, Pothole Displacement Test.
1. INTRODUCTION
Pothole and reinstatement failures affect utilities, maintenance schedules and road users. They are found in most road networks around the world. In the UK they cost motorists approximately £320 million per year [1]. They may be defined as defined as a pit or hole produced by wear or weathering especially in a road surface [2].

There are a number of basic ways to do road patching. The simplest is to lay material manually into the hole. The second is by a technique called velocity patching. The velocity patching process is used to repair potholes and repair cracks on the road surface before they become potholes, helping to extend the life of the road.

This paper summarizes a research project that investigated a pot-hole repair material that had glass fibres incorporated to improve the durability of the repair. As there is no standard method to evaluate pot-hole repair materials a new methodology called the Pothole Displacement Test was developed.

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![Figure 1 Pot-hole partially filled with water [3]](image-url)
2. LITERATURE REVIEW

There are many different types of pot-hole and re-instatement failure. Figure 1 shows a typical pot-hole in an asphalt surfacing material. The pot-hole has developed to be quite large and is partially filled with water. In such a condition they will cause damage to the vehicle.

Lay [4] describes the formation of a pothole saying that the contact pressure from the tyre of a moving vehicle forces water downwards through the road surface through small cracks. The water pressure builds up requiring instant relief so it travels under the surface until it reaches a spot of low resistance and blows out and upwards.

The pressure that blows out is the same as the pressure applied by the tyre from the moving vehicle. This small hole starts to fill with water and with the effects of traffic begins to form into a pothole.

Mallick and El-Korchi [5] identified similar reasons for pothole formation. They stated that water is a very important factor that must be considered when designing a pavement. Water can seriously harm a pavement therefore it is a necessity to provide proper drainage for both surface and sub-surface water. Water also affects the road users as standing water can cause hydroplaning, skidding and crashes.

Depressions allow water to build up on the road surface, which affects the road users and can be forced down through the layers to create potholes.

It is impossible to completely prevent water from flowing inside a pavement, when water gets underneath the road surface it can physically remove materials, which will lead to the formation of potholes.

Mallick and El-Korchi [5] state that utility trenches as one of the main causes of potholes. The other main causes include insufficient thickness of the pavement, poor drainage, paving defects and unsealed cracks.

Summers [6] discussed the effect of reinstatements by utility companies. He stated that a large number of potholes in urban areas are created by the poor reinstatement of trenches by utility companies.

The cause of failure of many trench reinstatements was the layers below the surface layer not being compacted adequately and the material being used for the reinstatement not being of good quality. Figure 2 shows a typical failed trench reinstatement.

Li and Metcalf [8] conducted tests on asphalt concrete slabs to better understand the development of cracking in asphalt concrete. They stated that an asphalt concrete surface will have flaws even before it bears any load. For example, high air voids initiate micro cracking which with loading develop into large dominant cracks that eventually become potholes.

Another reason for pothole failures is damage due severe frosts. Figure 4 shows how water enters the surface layer and freezes to eventually form of a pothole [7].
Figure 2 Example of a failed utility trench reinstatement [6]

Figure 4 Pothole formation due to frost damage [7]
3. THE VELOCITY PROCESS AND THE CHOPPED GLASS FIBRE MATERIAL ASSESSED IN THIS INVESTIGATION

Figure 3 shows the typical velocity type patching process [9,10]. This has a number of distinct stages. A high volume blower first removes water and debris from the pothole. A coat of binder is then applied to the surface to seal it and form a good bond between old and new material.

A mixing system coats aggregate with emulsion. This is then blown into the pothole. The velocity of the applied mix can be altered depending on circumstances. The top of the patch is finally finished off with dry aggregate to allow traffic to use the road immediately.

The asphalt material assessed in this investigation had the addition of 30 to 40mm chopped glass fibres. It was claimed that the resulting 3d network of fibres within the material improved its durability [10].

4. TEST METHODOLOGY

As there is no standardized method to evaluate a pot-hole or reinstatement repair material, a new test methodology was developed i.e. the Pothole Displacement Test.

4.1 Preparation of test specimen slabs

The test specimen slabs used for the investigation were manufactured from a bulk sample of 10mm asphalt concrete wearing course made with Silurian greywacke and 100pen grade unmodified bitumen. The test specimens were 305
x 305 x 50mm in size and compacted using a Cooper Roller Compactor. Their compacted density ranged from 2.08 to 2.19.

4.2 Creation of a circular fracture in the test specimen

One of the key aims of the investigation was to develop a laboratory method that resulted in the test slab failing in a manner similar to a pot-hole i.e. a roughly round circular hole.

Initial attempts to achieve this using different types of simulated laboratory trafficking were unsuccessful. Eventually a simple method of placing the test slab on a 50mm diameter steel sphere was found to cause the test slab to form a doomed deformation and circular fracture pattern.

The steel sphere was then removed and the slab allowed to reform to its original flat shape. Although flat the slab still kept its circular fracture pattern. Figure 4 shows the deformed test specimen starting to relax after the steel sphere was removed.

![Figure 4 Deformed test specimen starting to relax after the steel sphere has been removed](image)

4.3 Types of test specimen

Four types of test specimen were made for testing:

- Type 1 - the original slab.
- Type 2 - the original slab with a circular fracture system.
- Type 3 - the original slab with the chopped glass fibres layer.
- Type 4 - the original slab with the circular fracture system and the chopped glass fibres layer.

4.4 Application of chopped glass fibre layer

Slabs were taken on-site and the chopped fibre layer applied in two thicknesses i.e. 25 and 35mm [10].
4.5 Test specimen assessment using the Pothole Displacement test

Each test specimen slab was supported at its four edges and placed upside down in an environmental chamber at 30°C. A displacement dial gauge was placed directly below the centre of the test specimen. The test apparatus is shown in Figure 5.

Two weights i.e. a 10kg sitting on top of a smaller diameter 1kg was set on top of the test specimen. The weights are shown in Figure 6. This arrangement caused the smaller weight to punch down through the test specimen in a circular manner as shown in Figure 7. The displacement this caused was recorded at five-minute intervals using a simple web camera looking at the digital dial gauge. Displacement was recorded until the smaller weight fell through the slab. This methodology is called the Pothole Displacement Test and allows test specimens to be easily compared by plotting displacement against time. The time taken for a 10mm displacement was subsequently selected as being most appropriate for comparison purposes.
4.6 Testing

Half of the test specimens had the steel sphere placed underneath them to create a circular cracked weakness. They were then placed onto a level surface and allowed to return to their original shape.

Two of the untreated test specimens and 2 of the treated test specimens with circular cracked finish were assessed for displacement using the Pothole Displacement Test.

The four remaining test specimens were coated with the pothole repair material containing the chopped fibres. The coating was 25mm and 35mm thick made with fibres chopped 30 to 40mm in length added to the aggregate and emulsion. This was applied by air pressure to the surface of the slabs and compacted by hand using a hand weight.
5. ANALYSIS OF DATA
The time taken for a 10mm displacement is plotted in Figure 8 as a percentage of the time taken for the 10mm AC slab. Polynomial trends were plotted to each data set and found to have similar displacement / time curves. These are plotted in Figures 9 to 12. In each figure a coding has been used to describe each test specimen i.e. S7.SP.RP means Test Specimen 7 with Simulated Pothole (circular fracture) and Road Patch (chopped fibre layer).

Figure 8 10mm displacement data expressed as a percentage of the 10mm AC test specimens

Figure 9 Displacement v. time plots for test specimens 1 to 4 with no chopped fibre coating
5.1 Test specimens with no chopped fibre coating
The plots for test specimens 1 to 4 are shown in Figure 9. These specimens had no chopped fibre layer applied to their surface. The plots clearly show the act of placing 2 of the slabs on the steel sphere causing them to deform and form a circular fracture and then allowing them to become flat again, clearly had a detrimental effect on the test specimen.

Test specimens took 73 and 78 minutes to deform 10mm compared to the longer period of 139 and 146 minutes of test specimens 1 and 2. In the time it took for test specimens 3 and 4 to displace 10mm, test specimens 1 and 2 had only displaced 3.74mm and 4.18mm respectively.

5.2 Test specimens with a chopped fibre coating
The plots for test specimens 5 to 8 are shown in Figure 10. These specimens had the chopped fibre layer applied to their surface. Test specimens 5 and 8 had thickness of 25mm applied with test specimens 6 and 7 having a patch thickness of 35mm applied.

Figure 7 shows that the test specimens with the 35mm layer took longer to reach 10mm displacement. Test specimen 6 lasted 1.6 times longer than test specimen 5 because of the thicker chopped fibre layer.

Test specimen 7 lasted 1.9 times longer than test specimen 8 because of the thicker chopped fibre layer.

5.3 Test specimens without a circular fracture
The test specimens without a circular fracture were found to last longer than the test specimens with a circular fracture. Figure 11 shows that test specimens 5
and 6 took longer to reach 10mm displacement compared to test specimens 1 and 2. The average time of test specimens 1 and 2 is 142.5 minutes.

Test specimen 5 with the 25mm chopped fibre layer reached 10mm displacement at 750 minutes i.e. 5.3 times longer compared to the average time of test specimens 1 and 2 with no layer.

Test specimen 6 with the 35mm thick chopped fibre layer reached 10mm displacement after 1208 minutes i.e. 8.5 times longer compared to the average time of test specimens 1 and 2 with no layer.

5.4 Test specimens with a circular fracture

Figure 12 shows the results of the four test specimens with a circular fracture with and without the chopped fibre layer. It can be clearly seen that the chopped fibre layer extends the life of test specimens 7 and 8 even though they have the circular fracture.

The effect of the chopped fibre layer was quite marked. Within the first 15 minutes of testing test specimens 3 and 4 had displaced 7.02mm and 6.30mm respectively but test specimens 7 and 8 had only displaced 2.01mm and 1.00mm respectively.

The average time for 10mm displacement for test specimens 3 and 4 is 75.5 minutes. Test specimen 7 with its 35mm chopped fibre layer reached 10mm displacement at 920 minutes i.e. 12.2 times longer compared to the average time of test specimens 3 and 4.

Test specimen 8 with its 25mm chopped fibre layer reached 10mm displacement at 465 minutes i.e. 6.2 times longer compared to the average time of test specimens 3 and 4.
6. CONCLUSIONS

There is no standard test available for testing pothole or road patching materials. This paper has summarized the development of a new testing methodology called the Pothole Displacement Test (PDT) that allows comparison of such materials.

The methodology first creates a test sample with a circular fracture. It was clearly demonstrated that this circular fracture weakens the ability of the test specimen to support a load.

The weakened test slab with its circular fracture may then have a patching material applied to its surface. Using the example of a patching material containing chopped fibres it was clearly shown that the chopped fibre layer increased the ability of the test specimen to support a load.

It is concluded that the proposed test methodology offers a simple and cheap way to investigate pot-hole and road patching materials.

REFERENCES

[1] Potholes, Hit a pothole, found a pothole, or just fed up with potholes? Available at: http://www.potholes.co.uk/, 2010.


