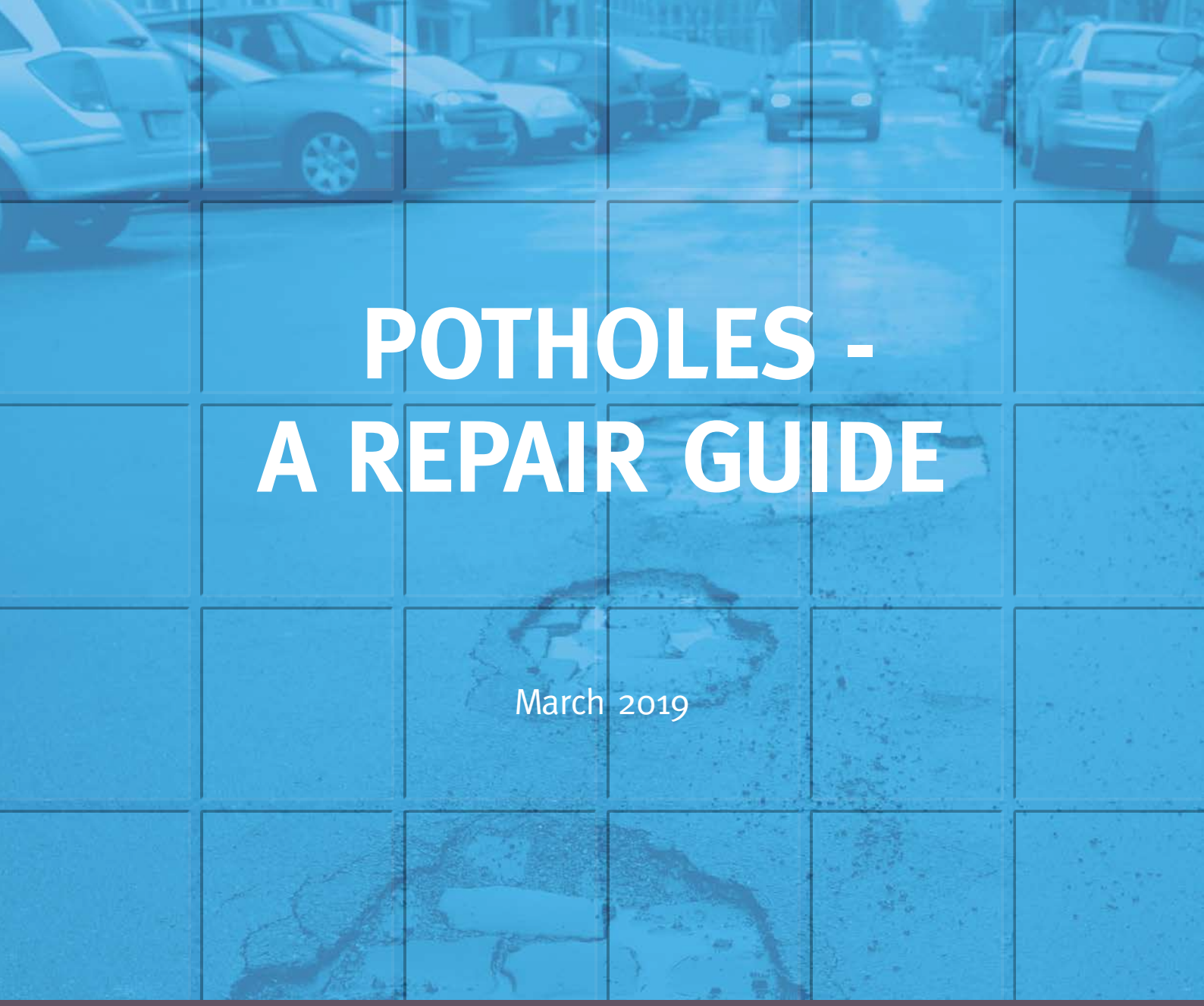

POTHOLES - A REPAIR GUIDE

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INTRODUCTION

Across Britain, the 2017 / 18 winter caused more potholes to appear than have been seen for many years – affecting the surface of motorways, all-purpose trunk roads and local roads. This impacted directly on the ability of the general public to use any part of the road network in the way that they perhaps had in the past or had come to expect. The consequence of this has been public dissatisfaction, increased claims for vehicle damage and justifiable concern about the overall state of the nation's roads.

Every winter, highway authorities endeavour to keep their main road networks safe for all road users through the provision of a winter maintenance service, applying salt (in various forms) to combat snow and ice, and giving vehicles traction on the road surface. For some local highway authorities, the winter of 17/18 meant their winter maintenance service spanned a whole six-month period, with an intense period of treatment during the 'Beast from the East'.

In many cases, the same resource would be deployed to grit the roads and to attend to the present and emerging potholes. This left local authorities, in particular, with the dilemma of how best to use a relatively limited but skilled resource to keep the network as safe as possible – prioritise the gritting of the roads over filling in the potholes, or vice versa? With additional resource hard to come by and the human and financial consequences of not gritting roads of significant concern, the number of potholes continued to grow to the bewilderment of the general public. Many other authorities that did not face this resource challenge were simply unable to cope in any case, due to the extreme rate of deterioration in road condition.

This briefing note will reflect upon the many aspects that caused the 2017 / 18 winter to be so challenging – in different ways – for Britain. It will also set out advice for what can be done in future winters, particularly if such a challenging set of circumstances re-occur. The predicament that faces everyone, however, is that no simple solution exists, but steps can be taken to prevent the situation being any worse than it really needs to be.

What are potholes and why do they appear?

There is no nationally agreed definition of a pothole, although most road users consider surface defects of any shape or size to be a pothole. Equally, there is no clamour to actually define what a pothole is – be that on a road, footpath or cycle route. Each highway authority is responsible for the maintenance and improvement of its own particular road network – each differing in overall condition and prone to deterioration by various factors, such as age, environment, weather or level of traffic.

Road surfaces will deteriorate because of two main factors, though – traffic and weather. The greater number (and weight) of vehicles using a road, the faster the road surface wears out – particularly those of a 'flexible' nature (i.e. containing bitumen as the binder that holds the road stones together in a fairly stable structure). Over time, this flexibility diminishes and the surface essentially snaps – by cracking and crazing.

This deterioration is exacerbated by both hot and cold weather extremes. The high temperatures this summer have had an impact on that bitumen, either evident through rutting or roads seemingly melting. But sub-surface geological conditions can also make certain roads susceptible to drought and shrinkage, often exacerbated by roadside trees and vegetation extracting moisture from below the bound road surfaces. This results in movement of the road surface and, in particular, transverse and longitudinal cracking.

The most damaging impact comes from sub-zero temperatures. If water can penetrate even the smallest of cracks in a road surface or where a single stone has become detached from the bitumen, a pothole will appear – it's just a matter of time. When the temperature falls below zero, the water turns into ice. As ice requires more space than water, it acquires that space by attacking the surrounding road surface, loosening and forcing out the surrounding material. That creates more space for water to get into and the damage caused the next time temperatures fall below zero is even greater. This is known as the freeze / thaw cycle.

Even though summer 2018 saw sustained periods with no rain, there was enough rainfall in the autumn and winter of 2017 / 18 to create a high groundwater level across much of the country – with more on and off-road flooding locations becoming apparent. This exposed many rural roads that have evolved over time from being simple stone tracks to important local routes, with relatively thin bitumen-based ('bound') road surfaces, to a 'double jeopardy' – a freeze / thaw cycle attacking the top surface of the road, and the bottom surface as well. With repeated sub-zero temperatures in relatively remote locations, deep and wide potholes formed at an alarming rate. Although this document will not speculate on environmental change, extreme weather events are seemingly occurring on an increasing scale – with road surfaces often a casualty.







Can we prevent potholes from forming?

The answer to this question is ‘yes’ and ‘no’. In circumstances where groundwater levels are high and the bound road surface is relatively thin, fragmentation can potentially begin below the road surface, even if the upper surface is crack-free. Equally, a road surface cannot remain crack-free indefinitely, although it will last longer if it is lightly trafficked and does not experience much temperature variation.

In Britain, those circumstances will very rarely apply, particularly with the road network experiencing growing levels of traffic. The forecast that traffic levels will increase by at least 50% on all types of road between 2010 and 2040 suggests that roads will deteriorate at an ever-quicker rate. In rural locations, farm vehicles and the heavy goods vehicles conveying livestock and produce are getting heavier and larger, straddling the edge of the road surface and the adjacent soft verge. Consequently, this depresses the soft verge (leaving deep, long ruts) and forces the road edges outwards, opening up longitudinal cracks for water to exploit.

Of paramount importance in preventing potholes from forming is to avoid water penetration into the road surface in the first instance. A relatively new road surface can seemingly remain flexible longer by using spray-applied ‘rejuvenators’ that help to keep the bitumen active and defer the point at which it starts to stiffen and crack. The more common approach to keep water at bay is surface dressing or, where this isn’t a suitable treatment (e.g. in a cul-de-sac where power-steering can rip away the aggregate), microsurfacing. Of course, keeping highway drainage systems working as effectively as possible is a key area of maintenance activity, helping to minimise surface water ponding or even flooding, as well as preventing unnecessary road surface degradation, particularly edge deterioration.

If these early preventative approaches are not deployed, a flexible road surface will begin to break down. Where a bitumen-based overlay has been applied to a concrete road surface (a typical scenario deployed in ‘wealthier’ times to reduce road surface noise), the visual appearance can become poor – particularly if the overlay becomes detached in large areas (i.e. delaminate). As the overlay is likely to be quite thin (between 10mm and 40mm), it is highly unlikely that the resultant defects in such locations will actually present a safety hazard. However, the defect may be challenging for cyclists or motorcyclists, particularly if the deterioration is slender and along the direction of travel – creating rutting that might trap a wheel. In such circumstances, the longer-term solution might be to remove some of the surrounding overlay as a more permanent response, rather than infill where the surfacing material has become detached.

Prevention and a better cure

The HMEP Potholes Review (published in April 2012) stated that local authorities should adopt the principle that prevention is a better cure in order to improve the resilience of the highway network and minimise the occurrence of potholes. However, this is best achieved through long-term funding arrangements and good asset management processes – requiring carriageway life-cycle planning investment strategies and preventative maintenance treatments.

The current situation for many local authorities is that the condition of the road network is beyond the point where preventative maintenance techniques alone will suffice with the level of funding available. Potholes are essentially the result of failing roads arising from the cumulative impact of years of under investment in highway maintenance.

By the end of October 2018, each highway authority must have considered and adopted the Well-Managed Highway Infrastructure Code of Practice and developed a risk-based approach for highway maintenance, particularly in such circumstances. There must be a system in place locally to treat defects of varying size and depth. That system will vary from one local authority to another, depending on the overall network condition, the interpretation of asset management, level of available resources (financial, equipment and personnel) and how risk is viewed. Response times and treatments are based on local needs, material availability, consideration of highway users and an assessment of risk.

Possible factors to consider

The following may all influence the type of repair that is undertaken:

- **Existing road structure, particularly thin evolved roads**
- **Traffic type and volume**
- **Weather / climate / season**
- **Road geography / alignment**
- **Quantity / clustering of defects**
- **Defect location relative to road width (i.e. vehicular wheel path)**
- **Traffic management for that physical environment**
- **Risk level**
- **Safety criteria / urgency**

The permanency of any repair will not only depend upon the above factors, but also the care and attention given to the quality of the work done. A combination of these factors may very well dictate that only a temporary repair may be possible in order to safeguard both the operational workforce deployed to effect a repair, and the road users passing the works location.

The aspiration of any local highway authority should be to maximise the proportion of right first-time repairs. However, it must also be recognised that, last winter, the sheer number of rapidly appearing road defects meant that a high proportion of permanent repairs was simply not achievable. Equally, remaining at one location to pick up all defects (some of lesser urgency) may have left other more urgent repairs elsewhere untreated for longer – thereby inadvertently placing the public at a greater overall risk.

In extreme circumstances, local highway authorities may need to deviate from normal, preferred working practice in order to fulfil the statutory responsibility, under Section 41 of the Highways Act 1980, of keeping the highway as safe as possible.

Pothole solutions (treatments)

Once a pothole has formed and has been identified as meeting a local highway authority's intervention criteria, there are various treatments that can be deployed:

What to use (i.e. treatment)	**Where to use** (i.e. location – rural / urban and local / national)	**When to use** (Temp / Perm) (Season)	**Risks**	**Benefits**
Patching with hot asphalt, mastic or bitumen-based material	Suitable for most locations and surfaces	Permanent, all-year round	No specific risks	Recognised and the preferred solution Accepted by users
Thermal road repairs	Most effective on hot rolled asphalt surfaces	Permanent, all-year round	May not treat an underlying failure mechanism	Restores from early stage cracking and fretting
In-situ / thermal recycling	Suitable for most locations and surfaces	Permanent, all-year round	Needs high volume of work to be a cost-effective solution	Avoids unnecessary material wastage
Spray injection patching	Most effective on rural evolved roads with low traffic flows	Mixed reports of service life and durability, particularly during autumn / winter	May not treat an underlying failure mechanism and creates surplus chippings	May be deployed on a find and fix basis
Cold applied instant material	Anywhere, however life expectancy reduces with increased traffic	Mainly temporary, however some products are fairly permanent (but may adversely affect perimeter material)	Different products are required for different locations and / or weather Lack of attention and cost of return visit and reputation	Speed of repair Some products are more durable Makes the road safe again – for a period of time

Note that all above solutions will not resolve the defective area surrounding the fixed pothole. However, in identifying the scale of the repair to be undertaken, effort should be taken to minimise the number and location of joints in the finished surface. This is not in order to avoid a 'patchwork quilt' effect, but because each material joint is a point of future failure from water ingress. However, this may be difficult to influence as new road surface joints appear due to public utility repairs and renewals.

As public utility trenches extend through all layers of bound material, they create significant maintenance challenges. Trenches (including micro-trenches) unfortunately undermine the overall strength and integrity of the road as a whole, even if the final surface reinstatement is larger than the lower levels of excavated material. The outcome for roads that have a multitude of joints is a potentially greater number of potholes for which the best solution may be large scale patching, resurfacing or even partial reconstruction.

Timing

Pothole treatment is best followed by surface dressing or similar preventative maintenance treatment. This will then create a waterproofing seal to overlay the material joints around the repaired defect.

SUMMARY

Potholes can occur at any time but they will proliferate during and following winter due to the damage caused by the freeze / thaw cycle. Water is the main enemy together with traffic volume and type, particularly for those roads which, due to funding constraints, do not receive timely intervention to extend their effective life. Highway authorities have a mixed approach to treatments depending on volume and the need for reactive or planned works.

The Pothole Review stated that local highway authorities should adopt permanent repairs as the first choice. Temporary repairs should only be used where safety cannot be managed using alternative approaches and in emergency circumstances.

Wherever and whenever possible, preventative measures should be deployed to avoid potholes appearing.

Case Study 1: Hot Material Patching

In August 2018, Surrey County Council started increasing the amount of patching work it was undertaking as part of its 'capital pothole preventative programme'. Two of its 2-man gangs use vehicle-mounted mini-planers, along with mechanised sweepers, to remove defective road surface material in preparation for a 5-man gang that then hand-lays and compacts hot material. This approach means that between 110m² and 200m² of asphalt can be laid per day.

Using mini-planers enables the quick removal of defective road surface material of varying surface areas. The application of bituminous binder to both the exposed base material and vertical edges creates a good bond between old and new road surface material, as shown in these before and after photographs.

Current thinking suggests that diamond-shaped patches may offer greater resilience to future joint failure.

For 2018/19, these Surrey County Council in-house gangs are on course to repair over 4,000 defects that would have otherwise been the subject of revenue budget-funded reactive maintenance.

Case Study 2: Thermal Road Repair

In September 2018, Brunel University reported that laboratory testing had shown that the extent of bond between hot-laid material and the existing lower temperature road surface could vary greatly, despite bitumen being applied at the interface. At that time, Suffolk County Council was considering whether thermal road repairs would be a more effective, longer-lasting alternative to more traditional hot and cold material patching techniques across all classes of road.

Since December 2018, the Council has deployed three thermal road repair machines across its network. The 8-minute heating cycle of the 1m² gas-powered burner meant that potentially, work could be completed within the Council's much-favoured 15-minute mobile temporary obstruction traffic management arrangement. In that time, the top 40mm or so of existing road surface could be heated to 200° Celsius, raked, topped up with bitumen binder and pre-heated material from the vehicle's on-board hotbox and then compacted. With no excavation, there is no waste material - but a highly effective thermal bond repair is quietly achieved, leaving no surface joints prone to future failure. Suffolk County Council is now looking to accommodate this technology by adapting some of its own fleet.

Case Study 3: In-Situ Thermal Recycling

To avoid the disposal of excavated road material, minimise the use of new raw material and remove waiting time at asphalt plants, some local authorities have pursued in-situ thermal recycling. This process entails breaking out a defective or potholed area of existing road surface to a regular shape and placing the extracted material in a mobile asphalt plant. It is then heated to a sufficient temperature to mobilise the bitumen content. Additional bagged material is mixed with the extracted material to provide sufficient hot material to provide a patch repair.

Bitumen is applied to all faces of the exposed road surface during the warming process. When sufficiently workable, the mixed material is laid and compacted to provide a permanent repair.

Suffolk County Council trialled this repair technique during the spring of 2018 when the emergence of potholes was at its peak. The flexibility to create hot repair material virtually 'on the move' enabled the Council to deliver both immediate 'make safe' and permanent repairs. By tackling all scales of defects in one site visit, as many as 50 potholes could be treated on a daily basis.

Case Study 4: Cold Applied Instant Material

Every day, local highway authorities have to 'make safe' road surface defects at locations where traffic levels are high and / or fast-moving. A temporary repair, with cold applied instant material, will invariably be the short-term fix until suitable traffic management can be deployed to enable a permanent repair. Kent County Council, however, often uses cold lay material as a permanent repair.

In some instances, when a defect is found, there is no need to carry out a repair by excavating the carriageway and saw cutting the edges. Highway inspectors and stewards, who follow a risk matrix before carrying out any work, carry material and signing in their vans so that they are able to repair a defect themselves, using an appropriate cold lay material. Milton Keynes Council has also concluded that it is not always possible to use hot material for repairs. Typically, this applies to repairs required during out of normal hours, in emergency situations, on roads requiring complex traffic management, where extremely low temperatures exist or where there is standing water. The Council has found that the one consistent item in the process is the use of overbanding to protect the newly formed joints.

The images on the left show the complete patch repair applied to a defect. Over a 2½ year period, this patch repair has not required any follow-up maintenance – as shown in the bottom image.

With the particular brand of cold lay material that it uses, Milton Keynes Council can complete permanent planned and emergency repairs on estate roads on potholes and areas up to 2m².

The Council uses cold lay material for emergency repairs on all roads, especially out of normal hours, and on defects with standing water.

Some cold lay materials can be placed directly into water-filled potholes and be compacted into place by passing traffic alone. However, in some places, the area surrounding the repair has visibly begun to fail, whereas the overbanded repair area itself is still in a positive condition. Some cold lay repair materials do become rigid, impacting over time on the untouched existing road surface surrounding the repair.

Case Study 5: Spray Injection Patching

Both East Riding of Yorkshire Council and Peterborough City Council deploy single-manned road repair vehicles. These are capable of performing spray injection patching to a high standard, on a variety of road defects, quickly and efficiently. Some machines use a flame to dry the area to be patched, but here, heated bitumen emulsion and surface dressing type aggregates are combined to provide a void-filling material, which is then covered in clean chippings and compacted to allow immediate trafficking of repairs. Capabilities extend to filling potholes, road edge repairs and patching as well as the regulating and localised surface-dressing sealing of previously repaired locations.

The machines are equipped with forward and rear facing cameras as well as automatic shut-off sensors to protect the workforce.

East Riding Council has found this method to be longer lasting than traditional pothole repair techniques, and particularly suited to more rural routes, providing sealed repairs to potholes and the covering of surface cracking. Repairs are performed in a matter of minutes with no exposure to vibrating plant and no waste or arisings. Meanwhile, Peterborough City Council reports that repairs can be completed in as little as three minutes with a success rate of 98%.

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