Transport Research Laboratory
Creating the future of transport



Road Note
RN44

RN44: Best Practice guide for the selection of pothole repair options

M J McHale, J C Nicholls and I Carswell

Prepared for: Scottish Roads Research Board (Robert Young)

Project Ref:

Quality approved:

M McHale
(Project Manager)

Ian Carswell
(Technical Referee)

Disclaimer

Contents amendment record

This report has been amended and issued as follows:

Version	Date	Description	Editor	Technical Referee
1.0	26/11/15	Review and edit	IC	IC
2.0	19/02/16	Final review and edit	MM	IC

Contents

Executive summary

The occurrence of a pothole is regarded to be a major problem in many parts of the world. It can be defined as a deterioration of the pavement surface in which the material breaks down in a relatively short time and is lost causing a steep depression. Potholes are generally regarded by both road authorities and the public as one of the least desired pavement distresses as they can potentially damage vehicles and put road users safety at risk.

The approach to the repair of these defects is varied because they occur on different types of road and their causes can be very different. As a result, many different techniques and products are offered for the repair of potholes, all of which have advantages and disadvantages. The relative effectiveness of the different techniques and products can vary from country to country, and site to site. Some UK road authorities prefer to use one or two options in all situations for consistency, whilst others try to select the appropriate option for each type of situation. To determine the type of situation an assessment is required to be undertaken of the critical risk resulting from the defect and its location as well as the practical issues of size and rate of deterioration.

The objective of this guide is to provide a consistent approach to selecting a pothole repair material and technique from the treatments currently available. Whilst it is impossible to identify the unique "best" option for each situation, it is intended that the guidance will lead to the most appropriate option being selected. Different treatment options have been reviewed in consultation with a range of practitioners from Scottish road authorities involved in repairing potholes. The resulting discussions and information gathering has led to the development of the selection process outlined in the guide. A simple procedure utilising flowcharts has been developed to assist users to identify an appropriate pothole material/technique to treat potholes located in different situations. All available treatment options (other than resin-based and concrete mixtures, which are not explicitly covered) are recommended for at least one situation.

The main sections of the document provide general advice on the treatment options available and guidance on using the flowcharts contained within the document. It should be noted that in the absence of a standardised approach to defect categorisation and intervention levels, repair default values or criteria used in the guide are provided as examples and may vary from local situations or policies. The selection of options involves six flowcharts, with the first being for the choice between pothole or substantial road repair which is the starting point for all selections. The first flowchart directs the user to one of five different flowcharts for the pothole repair depending on the type and location of the road, or for temporary pothole repairs. The concept is to decide on the type of permanent pothole repair required, assess whether it can be completed in adequate time and, if not, then to identify an appropriate temporary repair option.

The guide was produced specifically for use in Scotland on local authority roads to select the appropriate treatment for repairing potholes, including those developed along joints. However, it is equally applicable for use on the Scottish trunk road network and on other county or trunk roads in countries with similar climates and road pavement types to Scotland. It is anticipated that the guidance will require updating as new techniques and materials become available.

Abstract

Potholes are a major problem in many parts of the world. This guide sets out the principal options for repairing potholes before describing a procedure for selecting an appropriate option for different situations using a series of flowcharts. There are default values for the various questions asked in the flowcharts, but other values can be used to reflect the local situation or policy. Whilst better selection will not affect the generation of new potholes, it should mitigate the effect of those potholes and reduce the potential for them to reappear after maintenance treatment.

1 Introduction

1.1 Objective

A pothole has been defined as a deterioration of the pavement surface in which the material breaks down in a relatively short time causing a steep depression. The approach to the repair of these defects is varied, if only because they occur in many different categories of road and their causes can be very different. As a result, there are many different techniques and products that are offered for their repair, all of which have advantages and disadvantages and whose relative effectiveness can vary from site to site. Some road authorities prefer a single option in all situations, for consistency, whilst others try to select the appropriate option for each type of situation. To determine the type of situation an assessment requires to be undertaken of the critical risk resulting from the defect and its location as well as the practical issues of size and rate of deterioration.

The objective of this guide is to provide a consistent approach in the choice of pothole treatment from the repair materials and techniques available. Whilst it is impossible to identify the unique "best" option for each situation, it is intended that the guidance will lead to the most appropriate option being selected in nearly every case. However, it is hoped to get feedback* on the guidance so that the selection process can be improved in future editions.

1.2 Approach

The guide starts with describing the consultation process that was designed to identify the techniques and materials considered to be best practice. The resulting discussions and information gathering subsequently led to the development of ideas for the guide selection procedure. The main sections of the guide provide general advice on the options available, guidance on using the flow charts and the flowcharts themselves.

---

* Please send any constructive feedback to rn44feedback@trl.co.uk.

The questions used in the flowcharts are deliberately more qualitative than quantitative in order to allow for local situations, in particular any existing contractual arrangements.

The chapter on the questions in the selection of options explains the concept behind the question and gives a default value or criterion. However, it is appreciated that some or all of those values or criteria can be changed by the user of this guide to suit the local situation or policy, provided any such changes to the selection process are duly documented.

The selection of options involves six flowcharts. The first choice is the starting point for all selections and asks whether the defect is a pothole or substantial road repair. The first flowchart directs the user to one of five different flowcharts for the pothole repair depending on the type and location of the road: strategic urban; strategic rural; non-strategic urban; non-strategic rural; and/or to a sixth flowchart for temporary pothole repairs. The concept is to decide on the type of permanent pothole repair required, assess whether it can be completed in adequate time and, if not, then to identify an appropriate temporary repair option.

1.3 Applicability and implementation

This guide was produced specifically for use on local authority roads in Scotland to select the appropriate treatment for repairing potholes, including those developed along joints. However, it is equally applicable for use on the Scottish trunk road network and on other county or trunk roads in countries with similar climates and road pavement types to Scotland. This applicability would include use by road authorities in the rest of the United Kingdom and in Ireland.

The guide is offered for use by anyone responsible for road maintenance, whether a road authority or maintenance contractor. It is intended that the adoption and implementation of this guide will lead to the various pothole repair techniques being targeted at situations where they are the most appropriate (or at least a better) solution rather than the blanket use of a single option. It is not expected to exclude any of the options because all (other than resin-based and concrete mixtures, which are not explicitly covered) are recommended for at least one situation.

2 Consultation

Three quarters of Scotland's local road authorities took part in the study either through responding to an e-Questionnaire, attending meetings or participating in a facilitated workshop. A review of the consultation process and the information collected is described below.

2.1 Literature review

Prior to the start of the consultation process, a literature review (some of the principal publications found are listed in the bibliography to this guide) was undertaken to understand the research that had already been carried out in Scotland and elsewhere. This literature review also identified the products available to repair potholes, with particular emphasis on those products readily available in Scotland.

2.1.1 Context

The literature review highlighted that potholes attract a significant amount of media attention. As a result, pothole defects in road carriageway surfacing have become what the public consider to be the definitive measure of road condition. The approach taken to address these defects is therefore an important part of the road maintenance public message that roads authorities have to communicate.

Potholes are generally regarded by both road authorities and the public as one of the least desired pavement distresses as they can potentially damage vehicles and put road users safety at risk. Depending on the severity, pothole maintenance response times are usually quite short. Often due to a lack of funding and knowledge as to the best approaches to preventing potholing, local highway authorities are forced to make emergency repairs to restore safety, rideability and serviceability. Emergency pothole repairs do not last long if the methods and materials used are unsuitable for the existing lay down conditions.

There are different types of potholes and their severity depends on the environmental conditions, traffic loading, road pavement structure and the materials used. The primary factors which cause potholes are water infiltration, surface cracking, and traffic. It should be noted that potholes can result from other causes such as diesel spillage and mechanical damage. However, the majority are caused by water being allowed access to a poorly maintained road (e.g. visible cracks on the surface, poor edge drainage) in combination with traffic.

An increasing number of heavy vehicles are using the rural road network. These roads were not designed to carry high vehicle loads and are often seen to deteriorate quickly. This phenomenon has been noted around the world, and as roads with insufficient construction deteriorate, the traffic uses alternative routes with similar consequences.

Repaired potholes do not always perform well and sometimes deteriorate rapidly after installation. On the other hand, pothole repairs may perform better than the surrounding material, with greater deflections seen in the adjacent material. However, before long, the adjacent material can begin to experience similar problems and further pothole repairs are required. The longevity and serviceability of patch materials is therefore important and this leads to the question of what materials and techniques are used in current pothole repairs. Treatment costs will play an important role in pothole repair schemes, especially if a deteriorated pavement section is scheduled for reconstruction.

Depending on the environmental conditions, including traffic loading and the road pavement structure, an untreated pothole will deteriorate quickly becoming larger and deeper. Expensive reconstruction of the pavement can result.

There is a perception by some that pothole repairs can be undertaken by unskilled labour. It is essential that inspectors are trained to identify and assess potholes and operatives are suitably trained to make best use of new materials and technologies and ensure they are correctly installed.

2.2 e-Questionnaire

A short e-Questionnaire was designed to collect information on pothole repair systems and techniques used in Scotland (Appendix A). With the assistance of the Society of Chief Officers of Transportation in Scotland (SCOTS) Roads Group, the questionnaire was emailed to individuals associated with managing road repairs across the 32 Local Authorities in Scotland. Returned questionnaires highlighted that a broad and diverse range of materials and techniques were being used. The authorities' expectations of the service life of the products and techniques were also requested and this revealed some disparities. Over half of all the authorities who corresponded agreed to take further part in the study and contacts with key professionals were established.

The principal repair options identified were chippings and emulsion; hot mix asphalt; thermal patching/joint repair; spray patching; cold applied asphalt (subdivided into regular, premium and water setting); and resin-based mixtures and concrete and hydraulically bound mixtures. The typical technique used to repair a pothole with each of these options is described in Chapter 3. Tables are provided to highlight a range of factors such as benefits; limitations; supply; material shelf life; resources required; sustainability; and examples of proprietary (or generic) types. It should be noted that the methodology for application may vary between different products in the category, and the list of examples given is not exhaustive.

2.3 Meetings

Contact details provided by the e-Questionnaire were used to set up meetings to promote the background and aim of the study, and to collect additional information. Meetings were held with individuals involved with the management of pothole repairs and those involved with the supervision of the repairs. Experience of using materials and techniques and the rationale for their specific use were discussed.

Follow-up visits were arranged to view some of the materials and techniques being used in the field. This provided the opportunity to discuss the material and techniques in more detail with both managers and operators. Techniques and materials viewed in operation included hot mix asphalt, thermal patching, spray patching, and cold applied materials, including water setting.

2.4 Workshop

All 32 Scottish local road authorities were invited to a facilitated workshop held in Aberdeen on 20 February 2015. Delegate's views on a range of topics were collected through the use of facilitated workgroups. Road authority representatives were asked 15 key questions and a summary of their responses is shown in Appendix B. Interactive discussions were held to debate and refine the content and scope of this guide.

3 Repair options

3.1 Chippings and emulsion

This process is the simplest option, with loose material being removed and a mixture of aggregate chippings and bitumen emulsion being used to fill the pothole. Some compaction is needed.

Benefits	Limitations	Supply
Readily available and quick to mobilise.	Not particularly durable. Generally classified as temp or semi-permanent. Application is weather sensitive.	No standard packaging.
Material shelf life	**Resources required**	**Sustainability**
Dependant on emulsion.	Chippings, emulsion, shovel, hand tamper and one operative plus TM.	May require regular treatments. Recyclable.

3.2 Hot mix asphalt

There are several generic types of hot mix asphalt, as defined in the BS EN 13108 series of product standards. Ideally, the material should match the existing material type, or at least the properties, of the surrounding surfacing. A flowchart for the choice of which type of asphalt should be chosen was developed by Atkins on behalf of CSS (now ADEPT). The flowchart (Paterson *et al.*, 2010) is reproduced in Figure 1, for completeness. Materials described as "matrix dominated" are those with an extensive binder/filler/fine aggregate matrix (such as hot rolled asphalt) and "aggregate dominated" materials are those with extensive stone-to-stone contact (such as macadam [asphalt concrete] and stone mastic asphalt).

If there is deterioration surrounding the actual physical defect, e.g. cracking or crazing, then this damaged area around the pothole needs to be removed. The process is typically carried out as follows: cut out the area with a saw and/or kango or by planing, e.g. mini road planer or JCB mounted with a planer arm; sweep out debris and apply an emulsion bond coat into the area; fill with hot mix asphalt from vehicle mounted hotbox; if HRA is being used, add chippings as required; hand tamp the leading edge in order to minimise creep from the roller; roll and, dependant on the condition of the surrounding surface course, overband the edges of the patched area with an approved bitumen sealant.

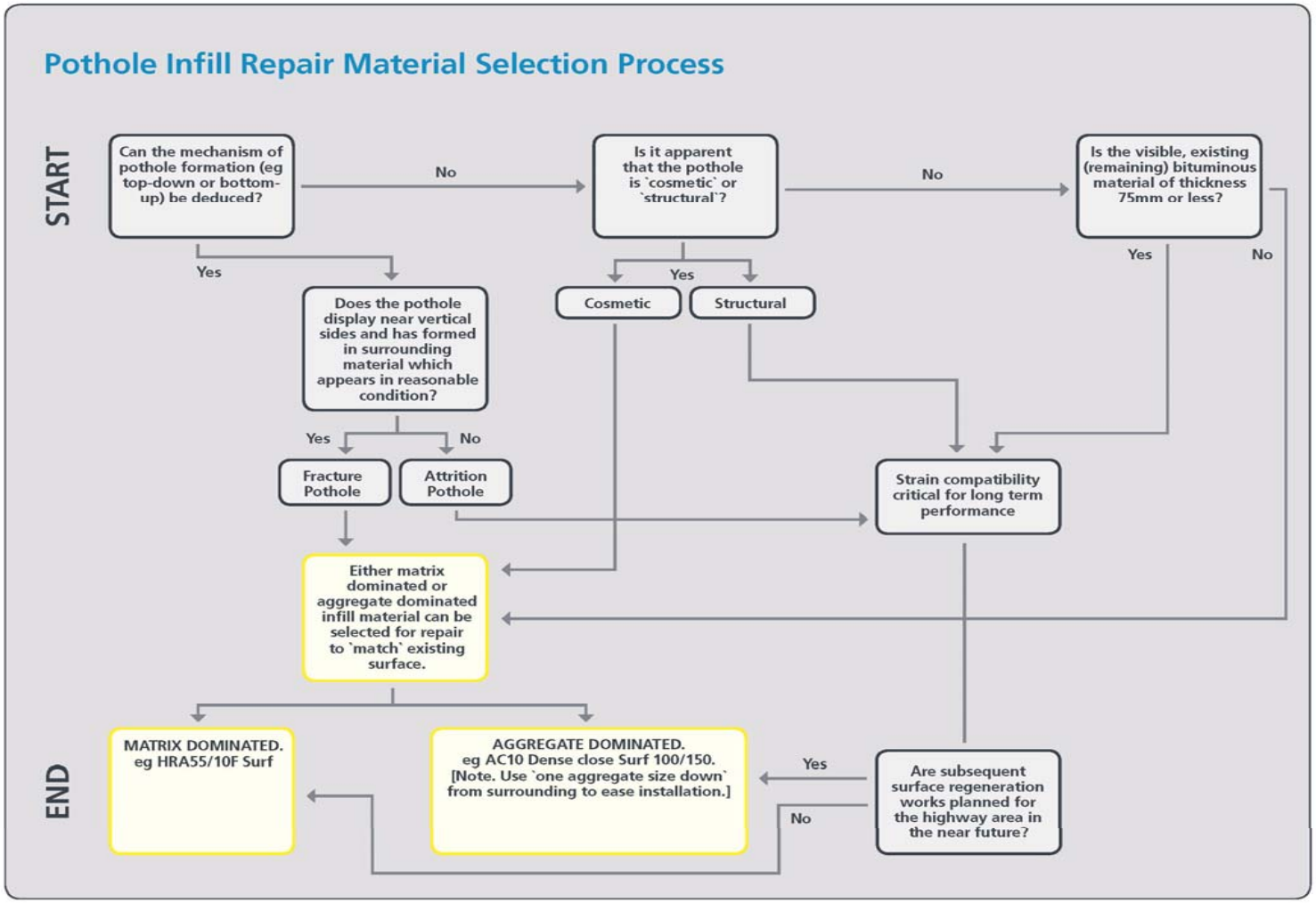


Figure 1: Pothole infill material selection process (Paterson *et al.*, 2010)

Benefits	Limitations	Supply
Matches existing surfacing (if same generic type). Generally classified as a permanent repair; good durability.	Time and space required to carry out repair, which requires the material to be fresh.	From mixing plant.

Material shelf life	Resources required	Sustainability
Within same day before mixture cools.	Cutters or JCB with planer attachment, hot box, sweeper with driver, roller, brush, shovel, hot mix asphalt, emulsion, chippings (if HRA) and operatives plus TM (typically 3 to 4 man squad).	Planed material may require to be taken to a certified disposal site. Recyclable.

Generic types	Hot rolled asphalt, Macadam (asphalt concrete) and Stone mastic asphalt

3.3 Thermal patching

This process is suited to repairing discrete areas of defects, particularly where a few potholes can be heated at once. Productivity can also be increased where required repairs are located within a short distance. The heater unit is positioned over the defective area and heated to a temperature recommended by the manufacturer (the temperature is material/construction dependant). This should take about 8 minutes but can take longer. Remove heater unit and mix up heated road surface with a shovel/rake. Add bitumen rejuvenator to hot material on road. Add new hot material (bagged 6mm material) as required. Hand-tamp the edges and roll with a hand-propelled roller.

Benefits	Limitations	Supply
Existing material is reused and matches material present. Generally classified as a permanent repair. Seamless repair.	Specialised equipment needed and durability dependent on rejuvenator and its even distribution. Not suitable for dry bound roads, i.e. requires a minimum asphalt thickness of 25mm.	Bagged additional mixture.

Material shelf life	Resources required	Sustainability
No issues.	Van incorporating heater unit and boiler, hand roller, shovel, rake, bitumen rejuvenator, bagged 6mm material and two operative plus TM.	Essentially, in-situ recycling. Minimal additional replacement material required.

Proprietary examples	Nuphalt (Nu-Phalt) and Minuteman (Kasi Infrared Europe)

3.4 Spray patching

The damaged area is cleaned, prepared, sealed and filled in one operation. A high volume, low pressure blower removes all loose debris from the pothole. The pot hole is coated with a bitumen emulsion to seal it from moisture. Aggregate is then mixed with the bitumen emulsion and blown into the pothole at high velocity. After the pot hole has been filled, a light layer of dry aggregate is applied to the patch (see below), preventing the patch from adhering to tyres prior to the emulsion fully curing.

Benefits	Limitations	Supply
Quick to apply with only limited delay to reopening. Can be used to seal joints.	Rural application - spray of chippings may not be suitable in built-up areas. Generally classified as a semi-permanent repair. Weather sensitive.	Spray patching system contains hopper for aggregate and emulsion tank.

Material shelf life	Resources required	Sustainability
No limit beyond life for emulsion.	Component materials, patching equipment and one operative plus TM.	May require repeat treatments.

Proprietary examples	Jetpatch (Jetpatcher UK), Velocity patch (Velocity) and Roadmaster (Archway Products)

3.5 Cold applied asphalt

The performance of cold applied asphalt can be improved if the area is properly prepared, i.e. cutting to remove deteriorated material (squaring off), cleaning the pothole of debris and the application of a bond coat.

3.5.1 Regular

All loose material is swept out from the pothole, ensuring that no water is present in the pothole. No bitumen spray required although can be used. Compaction needed on each layer.

Benefits	**Limitations**	**Supply**
Reduced time to complete repair and no waiting time before trafficking.	Susceptible to wet conditions and limited durability. Generally classed as a temporary repair.	25kg bags, 1 tonne bulk bags or bulk delivery
Material shelf life	**Resources required**	**Sustainability**
No specific limit in bagged form.	Material, van, brush, vibrating plate, and 2 operatives plus TM.	May require repeat treatments.
Proprietary examples*	Colpatch (Colas)	

3.5.2 Premium

The pothole area is swept out. The need to spray with bitumen bond agent from a can is dependent on the system used. The material is usually compacted using a vibrating plate or a hand tamper. The material initially keeps the shape from the tub or bag but soon breaks up with a shovel. Material can also be used to reinstate around barrier and traffic sign poles.

Benefits	**Limitations**	**Supply**
Reduced time to complete repair, no waiting time before trafficking and provides moderate durability.	Susceptible to wet conditions and provides only moderate durability. Generally classed as semi-permanent repair	25kg plastic tubs, bulk bags or bulk material.
Material shelf life	**Resources required**	**Sustainability**
6 months to one year in bulk or two years in bags.	Material, van, brush, vibrating plate and two operative plus TM.	No sustainability issues.
Proprietary examples*	Ultracrete (Instarmac) and QPR (Lagan Bitumen)	

* The classification of examples between regular and premium has been made based on whether the products are claimed to be temporary or permanent repairs. Experience with these products may lead to their classification being re-defined by clients.

3.5.3 *Water setting*

All loose material is required to be swept out from the pothole before filling. No bitumen bond spray is required. Material is shovelled into the pothole and roughly hand-tamped. Trafficking by vehicle tyres completes the compaction process. The material is designed to be laid in very heavy rain and even underwater.

Benefits	Limitations	Supply
Can be used in wet weather conditions. Reduced time to complete repair and provides moderate to good durability.	High material cost. Generally classed as semi-permanent repair.	25kg tub.

Material shelf life	Resources required	Sustainability
Up to 12 months.	Material, van, brush, hand tamper and two operative plus TM.	Compatibility with surrounding material, e.g. asphalt, may cause breakdown adjacent to repair.

Proprietary examples	Viafix (Viatec UK)

3.6 Resin-based mixtures

Brush or blow out any loose debris and standing water from the pothole. Open the resin tin and loosen any sediment that may have occurred with a stick or drill and whisk. Open the hardener bottle and pour into the resin, mixing thoroughly for 2-3 minutes. When thoroughly mixed, pour into a bucket containing the aggregate and mix thoroughly. Pour the required amount of the mix into the pothole and spread out with a trowel, the mixing stick or similar item. Tamp down the aggregate mix firmly paying particular attention to the edge of the pothole to ensure a good bond, fill up and level off as required. The repair should be ready for traffic within 20-60 minutes.

Benefits	Limitations	Supply
Generally classified as a permanent repair; good durability.	Curing time required before trafficking. High material cost.	Large bucket with aggregate, tin of resin, bottle of hardener, mixing stick and pair of disposable gloves

Material shelf life	Resources required	Sustainability
Not given.	Van, 3-part kit, trowel, tamper and one operative plus TM.	Compatibility with surrounding material, e.g. asphalt, may cause breakdown adjacent to repair.

Proprietary examples	Resin-Pot-Fix (Global Resins) and Degafill (Degafloor)

Resin-based mixtures are not directly considered as an option in the flowcharts of this guide, but they could be used as an alternative permanent repair material where different thermal and flexural properties do not create further problems.

3.7 Concrete and hydraulically bound mixtures

Brush or blow out any loose debris and standing water from the pothole. Fill with concrete, compact and level off. Wait for the concrete to cure sufficiently to allow trafficking.

Benefits	**Limitations**	**Supply**
Generally classified as a permanent repair; good durability.	Curing time required before trafficking.	Various.

Material shelf life	**Resources required**	**Sustainability**
Not relevant.	Material, van, trowel, tamper and one operative plus TM.	Compatibility with surrounding material, e.g. asphalt, may cause breakdown adjacent to repair.

Concrete and hydraulically bound mixtures are also not directly considered as an option in the flowcharts of this guide, but they could be used as an alternative permanent repair material where different thermal and flexural properties should not create further problems.

3.8 Relative costs

The different techniques described above cost different amounts to carry out effectively. However, the cost of repairing potholes is not just the cost of the repair technique but is dependent on a number of factors, including the following:

a) The repair technique chosen
b) The accessibility of the site
c) The traffic management required (which can vary with the repair technique and the type of road)
d) The number of pothole repairs to be undertaken in the locality at that time
e) The distance from the works depot (particularly for techniques requiring hot mixed material)
f) The time (day/night, weekday/weekend, winter/summer, etc.)

For the techniques listed in the previous sections, a rough ranking of their relative material costs **only** are:

- Chippings and emulsion
- Spray patching
- Regular cold applied asphalt
- Premium cold applied asphalt
- Concrete and hydraulically bound mixtures
- Hot mix asphalt
- Thermal patching
- Resin-based mixtures
- Water setting cold applied asphalt

It should be noted that some of the differences are small and may depend on the particular environment, road structure and product selected. In addition the overall cost of installation and durability needs to be considered as the cheapest material may not provide the best solution. The aim of this guide is to assist the user to select the most appropriate system for a specific situation.

4 Questions in selection of flowchart options

Flowcharts provided in Section 5 are intended to manage the process of selecting the most appropriate repair option. This chapter provides relevant information that should be considered when a decision is required as part of the process. The concept behind a question is described and where relevant a default value or criterion is given. However, as stated earlier in the guide, it is appreciated that some authorities may wish to change these default values or criteria to suit their local situation or policy.

4.1 Frequency of defect

Question asked by the flowchart in Section 5.1 as "**Frequency?**"

Potholes have been defined (Nicholls, 2012) as:

> *"A local deterioration of the pavement surface in which the material breaks down in a relatively short time and is lost causing a steep depression"*

With the following notes:

[1] Generally, potholes require rapid remedial action to maintain the safety of road users.

[2] Potholes will also need to be reinstated to maintain the functional requirements and comfort of road users, but the time-constraints on rectification to meet these requirements will not be as immediate.

[3] Potholes will typically have a depth of at least 30mm and an area equivalent to a diameter between 100mm and 1m with the values for a specific situation depending on several factors including the traffic speed and intensity, the type of vehicle (particularly the presence of bicycles and pedestrians) and the climate.

[4] Potholes can grow once they have emerged, but generally stop growing after a certain time. However, other potholes can appear close to an existing one.

[5] Potholes can occur due to several mechanisms (such as fracture, attrition and seasonal effects).

On the other hand, the term is generally used by the general public to mean any small defect in a road surface whether or not it is a local deterioration or one of many defects in a general area of deteriorated road surfacing. If it is the latter, there is little point in repairing each "pothole" separately other than on a temporary basis for safety reasons; resurfacing or, at least, major patching is required.

In order to assess whether a defect is a localised pothole or a defect in an area of failed surfacing, the frequency of defects in the surrounding area needs to be compared against a critical frequency. It is proposed to use a reference area of 40m². The number of lanes/construction rips* considered together will be dependent on whether or not there was any difference in the construction or use of them (e.g. different lanes on a dual carriageway carrying different traffic or different rips where one has deteriorated more extensively due to being delivered cold). For a 3.65m standard lane width, this measure represents a length of 11m.

* Paving machines lay asphalt mats in strips known as rips. The width of the rip will be dictated by the size of the machine and width of the road being surfaced, but typically be the lane width.

If the frequency of defects is less than a critical frequency, it will be treated as a localised pothole. If the frequency of defects is greater than a critical frequency it is treated as a symptom of a failing surfacing. It is proposed to set the default critical value as three defects per 40m², but it is appreciated that this number and/or the area to be considered can be changed to suit local conditions and/or maintenance policies.

4.2 Length over which defects occur

Question asked by the flowchart in Section 5.1 as "**Over length?**"

The surfacing may be failing in a relatively small area. A typical example of this could be a single cold load found at the end of a construction rip which has low density owing to inadequate compaction. The extent of the replacement should be consistent with the extent of the failure. The default criterion is that, if not more than two adjacent 40m² areas (using the default value for frequency) are defective, the failure can be considered as over a "Limited" length requiring patching over an area that incorporates all the defects while, for more than two adjacent 40m² areas, the failure can be considered as over an "Extensive" length requiring resurfacing. It is appreciated that the number of adjacent areas can be changed to suit local definitions of patching and/or maintenance policies.

4.3 Size of defect

Question asked by the flowchart in Section 5.1 as "**Size?**"

From a European questionnaire on the definition of potholes (Nicholls, 2012), "the (minimum) depth varied between less than 20mm to over 50mm with a mode at 40mm that was used by nearly 40% of those giving a value … the diameters varied from less than 75mm to 1m with a mode of 100mm to 145mm". Therefore, it is proposed to set the default minimum dimensions as a depth of 40mm and a diameter of 100mm, below which the defect is not considered a pothole but a minor defect requiring monitoring. It is appreciated that these dimensions are suggestions only and can be changed to suit existing maintenance contracts, local conditions and/or maintenance policies.

4.4 Location of defect on road

Question asked by the flowchart in Section 5.1 as "**Location on road?**"

Some smaller defects can be in a critical location and, as such, require maintenance rather than monitoring for safety. The critical locations will depend on the type of road user or significant traffic type, e.g. cyclist, motorcyclist, pedestrian. The default frequency or proportion to make a type of traffic significant is at least either 100/day or 20%. It is appreciated that these situations and dimensions can be changed to suit local conditions and/or maintenance policies.

4.5 Type and location of road

Question asked by the flowchart in Section 5.1 as "**Type and location of road?**"

For this guide, the type of road is classified as either "Strategic" or "Non-strategic". Guidance on carriageway hierarchy can be found in 'Well-maintained Highways' published by the UK Roads Liaison Group (www.ukroadsliaisongroup.org). For simplicity, the definition of strategic can be taken as classified roads (A or B) while the definition of non-strategic can be taken as all C-class and unclassified roads. However, it is appreciated that these classifications can be changed to suit local conditions and/or maintenance policies provided such changes to the selection process are duly recorded. Alternative classifications could be based on road categories, as defined in *Specification for the Reinstatement of Openings in Highways* (HAUC, 2012), or on commercial vehicles per lane per day, as in Road Note 39 (Roberts and Nicholls, 2008).

For this guide, the location of the road is classified as either "urban" or "rural". Urban can be defined as an area of built environment (usually 40mph or less) and amenity sufficient to attract people, stationery cars and other items alongside and near the carriageway that would be affected by any works undertaken. Rural is where there are few people, stationery cars and other items alongside and near the carriageway that would be affected by any works undertaken. The precise number of people and cars (excluding the passing vehicles) that constitute a change from urban to rural is left as a subjective decision.

4.6 Response timing achievable

Question asked by the flowcharts in Sections 5.1, 5.2, 5.3, 5.4 and 5.5 as "**Response timing?**"

This question relates to whether staff and other resources are available and there is a suitable weather window for undertaking the selected repair technique within the required time frame. This time frame includes the time needed to get to the defect (important if the site is distant from the relevant depot) and the time for setting up appropriate traffic management, which can be extensive for some techniques. The minimum required response times and the definition of defects by category should have already been set by the road authority (e.g. Well-maintained Highways COP). Table shows the range in times used by Scottish road authorities. The response timing is "Not achievable" if the *SCOTS Proposal* timing cannot be met, for whatever reason, and "Achievable" if it can be met.

Table 1: Range of possible response times for the category of defect

Response required *	Category 1	Category 2	Category 3	Category 4
Minimum	1.5 hrs	24 hrs	5 days	28 days
Maximum	24 hrs	20 days	30 days	Monitor
SCOTS Proposal	*4 hrs*	*7 days*	*30 days*	*Monitor*

* The range of minimum and maximum response times was based on an internal survey of Scottish local authorities carried out by the Society of Chief Officers of Transportation in Scotland (SCOTS) in 2014. The study aims to standardise response times across Scotland the latest proposals are shown.

The extent of traffic management (TM) required can affect the practicality of undertaking certain pothole repair techniques. Major TM tends to be required on more major roads, particularly in built-up areas and this guide assumes TM will be required for strategic roads. It is recognised that the response times required in Table 1 will affect the ability to select a permanent repair option first time.

4.7 Life expectancy of surfacing

Question asked by the flowcharts in Sections 5.2, 5.3 and 5.4 as "**Life of surfacing?**"

Even if the road surface has not, as yet failed (Sections 4.1 and 5.1), the material can have a limited expected life. The reasons can include new traffic calming schemes or developments as well as the surfacing nearing the end of its serviceable life. In such situations, any repairs only have to last as long as that expected life, although there is no reason to restrict the expected life of the repair if there are no cost implications. The expected life of the surfacing is taken as "Limited" when it is less than that of the relevant repair technique and "Extensive" when it is greater. It should be noted that, in answering this question, some iteration may be needed because the expected service life of the repair will not be known until the question has been answered. The default expected service lives are given in Table , although it is appreciated that these lives can be changed to reflect the local available products and any experience with them. The quoted service lives are based on local authority responses to an e-Questionnaire (see Section 2.2).

Table 2: Expected service lives of pothole repair techniques

Material		Expected service life	
		Strategic	Non-strategic
Chippings and emulsion		6 months	1 year
Spray patching		3 years	>3 years
Cold applied asphalt	Regular*	1 year	2 years
	Premium*	3 years	>3 years
	Water setting**	1 year	3 years
Hot mix asphalt		>3 years	>3 years
Thermal patching / joint repair		2 years	3 years
Concrete and hydraulically bound mixtures**		>3 years	>3 years
Resin-based mixtures**		>3 years	>3 years

* These estimates assume the area is properly prepared.

** Materials may not be compatible with surrounding material and may cause breakdown of area adjacent to repair.

4.8 Traffic intensity

Question asked by the flowcharts in Sections 5.2 and 5.3 as "**Traffic intensity?**"

In order to extend the time before future maintenance is required on heavily trafficked roads, a more permanent pothole repair is often required. However, this can be at the cost of a longer period of congestion while the current repairs are undertaken. As a guide to selecting the type of repair, default categories of criticality are given in Table although it is appreciated that these categories can be changed to suit local conditions and/or maintenance policies.

Table 3: Categories of criticality for road sites

Site Category *	Traffic (cv/lane/day)				
	0 – 500	501 – 1000	1001 - 3000	3001 - 5000	Over 5000
A1 & A2	Moderate	Moderate	Critical	Critical	Critical
B1 & B2	Not critical	Moderate	Moderate	Critical	Critical
C	Not critical	Not critical	Moderate	Moderate	Critical
G1/G2	Not critical	Not critical	Moderate	Moderate	Critical
Q	Not critical	Moderate	Critical	Critical	Critical
R	Moderate	Moderate	Critical	Critical	Critical
S1/S2	Not critical	Moderate	Moderate	Critical	Critical

* As defined in HD 36/06 (Highways Agency *et al.*, 2006)

4.9 Extent of work

Question asked by the flowchart in Section 5.4 as "**Extent of work?**"

Some repair techniques require items of equipment which will not be efficient if there is significant mobilisation between each repair. The extent of work is regarded "Limited" if there are fewer potholes to repair in an area than necessary for efficiency or "Extensive" if there is at least that number. The default critical frequency is ten potholes within a square mile, but it is appreciated that this value can be changed to suit the availability of the equipment locally and/or maintenance policies.

4.10 Existing structure

Question asked by the flowchart in Section 5.5 as "**Existing structure?**"

Many local roads, particularly in rural areas, have evolved, often from ancient trackways, rather than being designed. As such, the depth of bound surfacing can be very thin and some repair techniques, or their preparation work, will destroy the surfacing rather than repair it. The pavement structure will be considered "Adequate" (for such techniques) if there is at least a critical thickness of bound surfacing and "Limited" if not. The default critical thickness is 50mm, but it is appreciated that this value can be changed to suit local circumstances and/or experience.

4.11 Weather conditions

Question asked by the flowchart in Section 5.6 as "**Weather?**"

Adverse weather, in particular precipitation and extreme cold, can make some of the repair techniques ineffectual. The default weather is that it is considered "Wet and/or icy" when there is rain sufficient to pond on the ground and/or there is ice or frost present on the ground and/or the temperature is at or below 3°C, otherwise it is considered "Clement". It is appreciated that these conditions can be changed to suit local circumstances and/or experience.

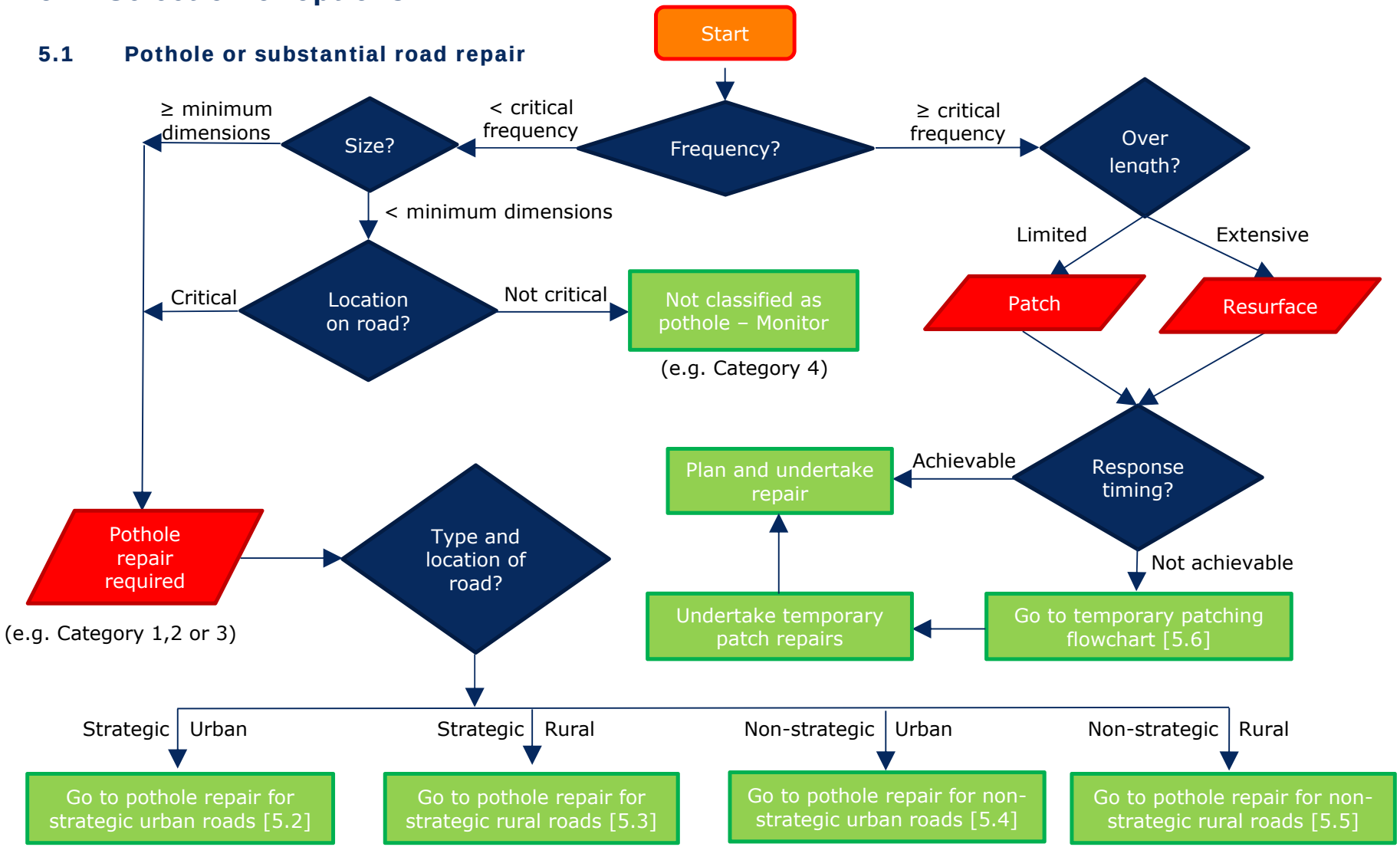
4.12 Urgency for permanent repair

Question asked by the flowchart in Section 5.6 as "**Urgency for repair?**"

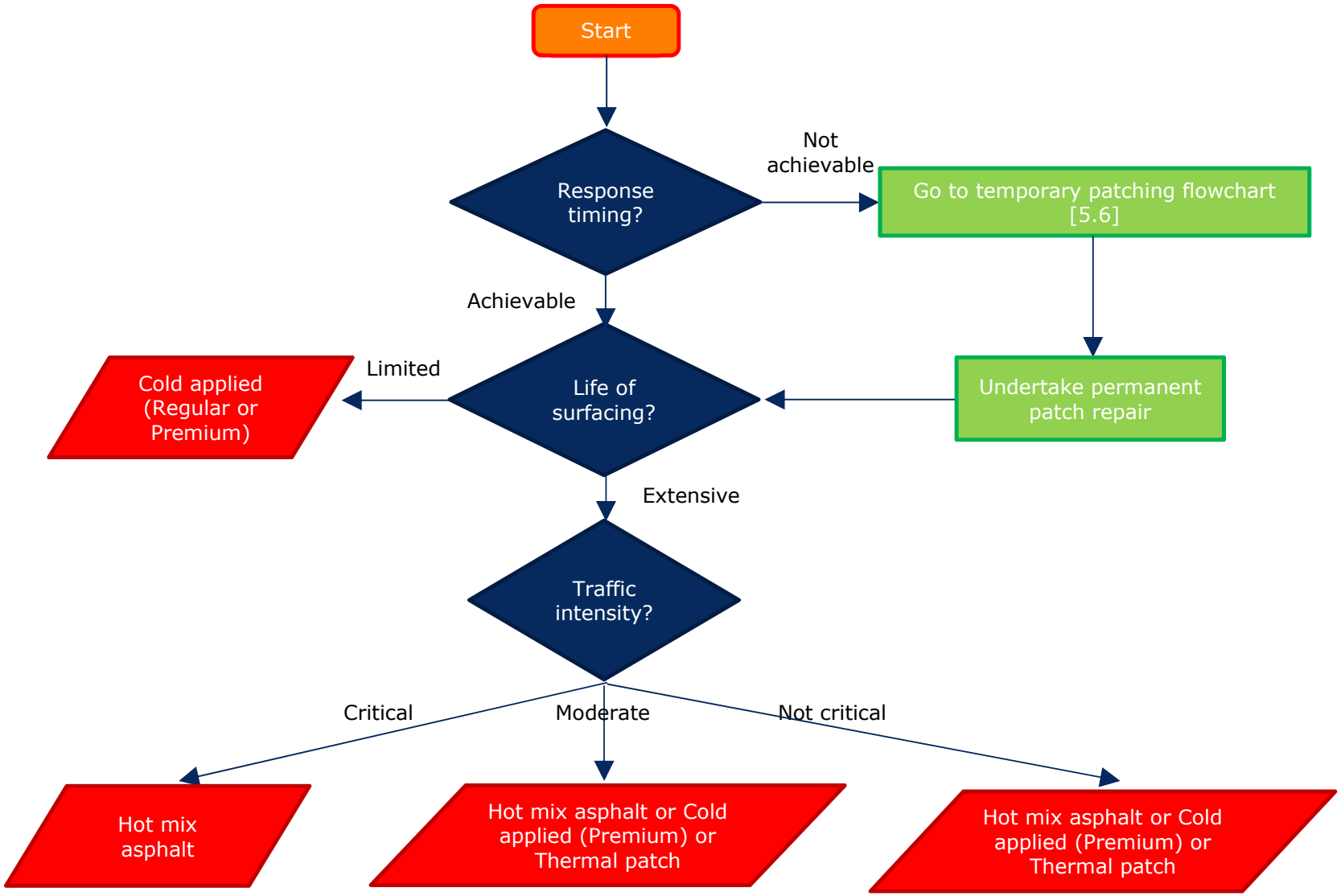
Once a temporary repair has been undertaken, the urgency for the permanent repairs to be undertaken depends on the expected service life of the temporary repair. The default criterion is that, if the temporary repair is not expected to survive and remain safe for less than one year, the urgency can be considered "As soon as practicable" while if it will be considered "Medium term" if it exceeds one year. It is appreciated that these periods can be changed to suit local circumstances and/or experience.

5 Selection of options

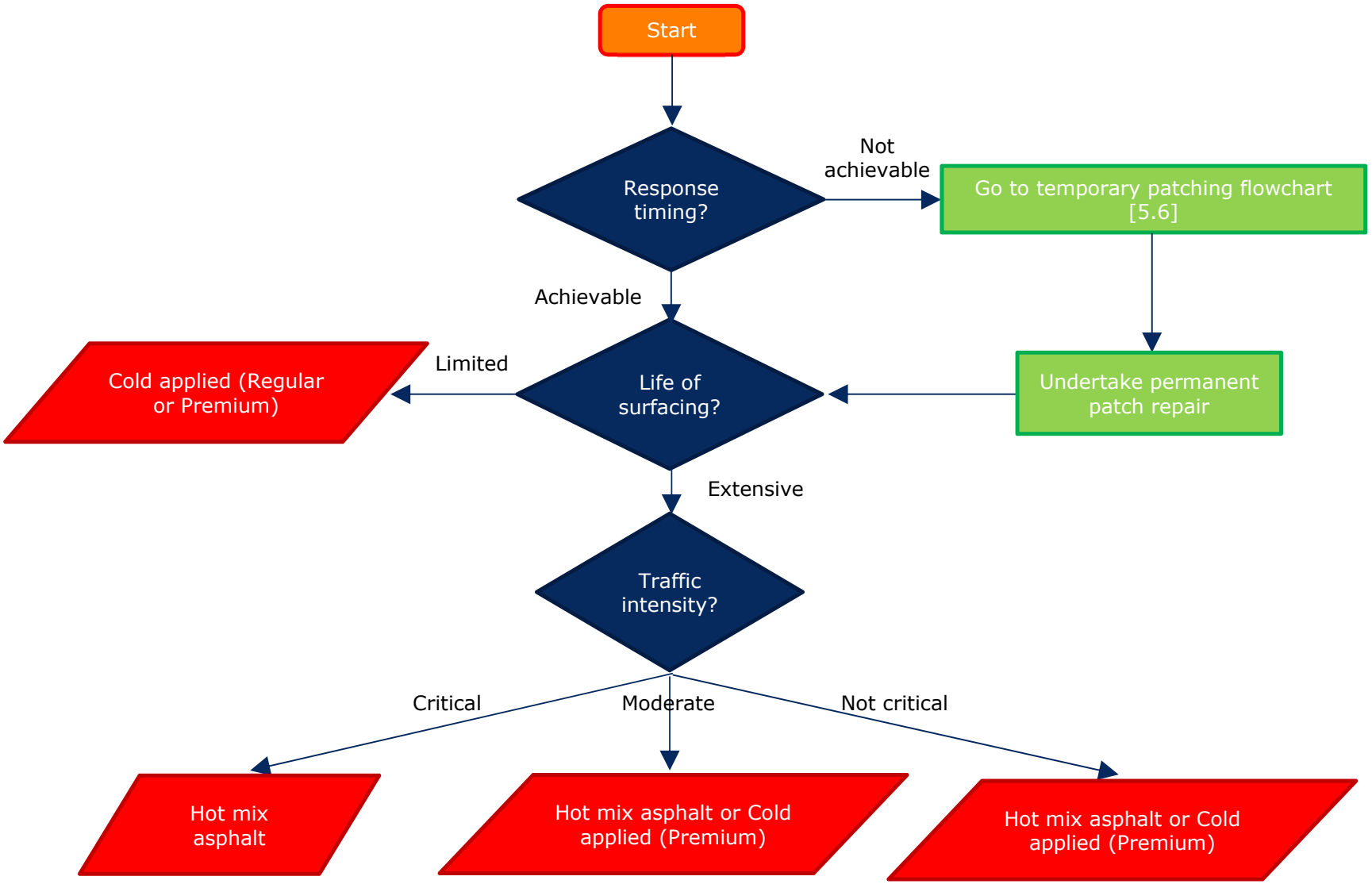
5.1 Pothole or substantial road repair



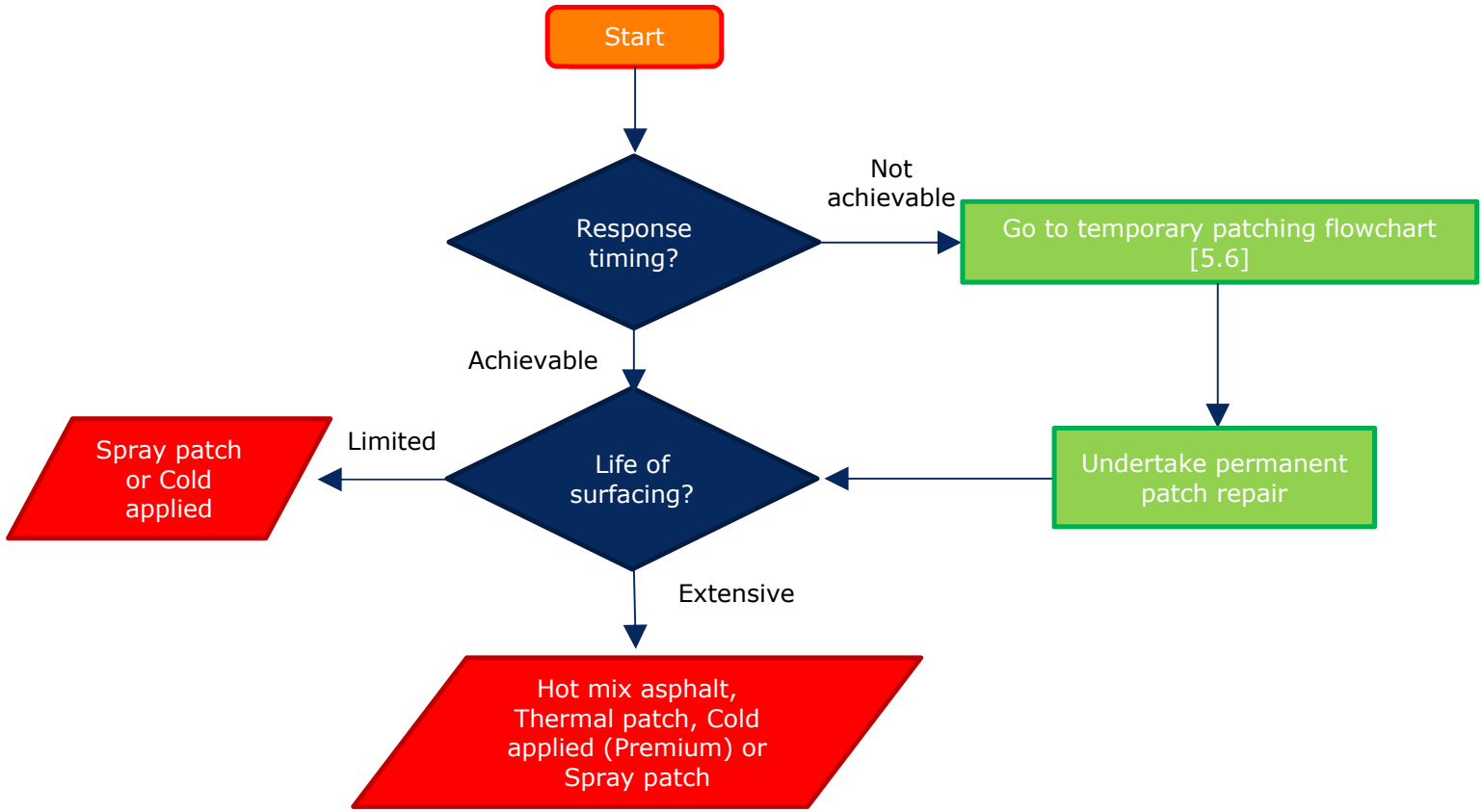
5.2 Pothole repair for strategic urban roads



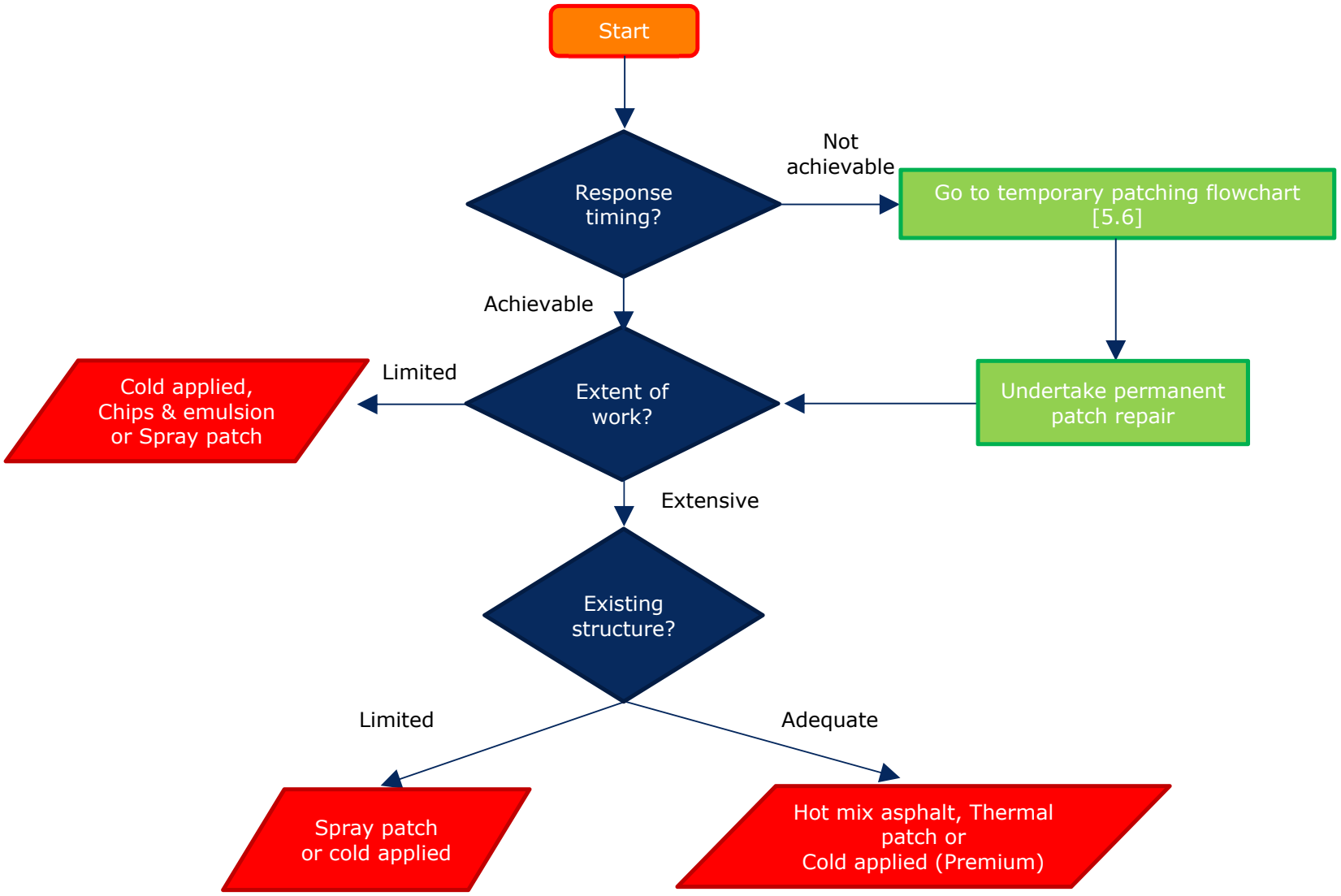
5.3 Pothole repair for strategic rural roads



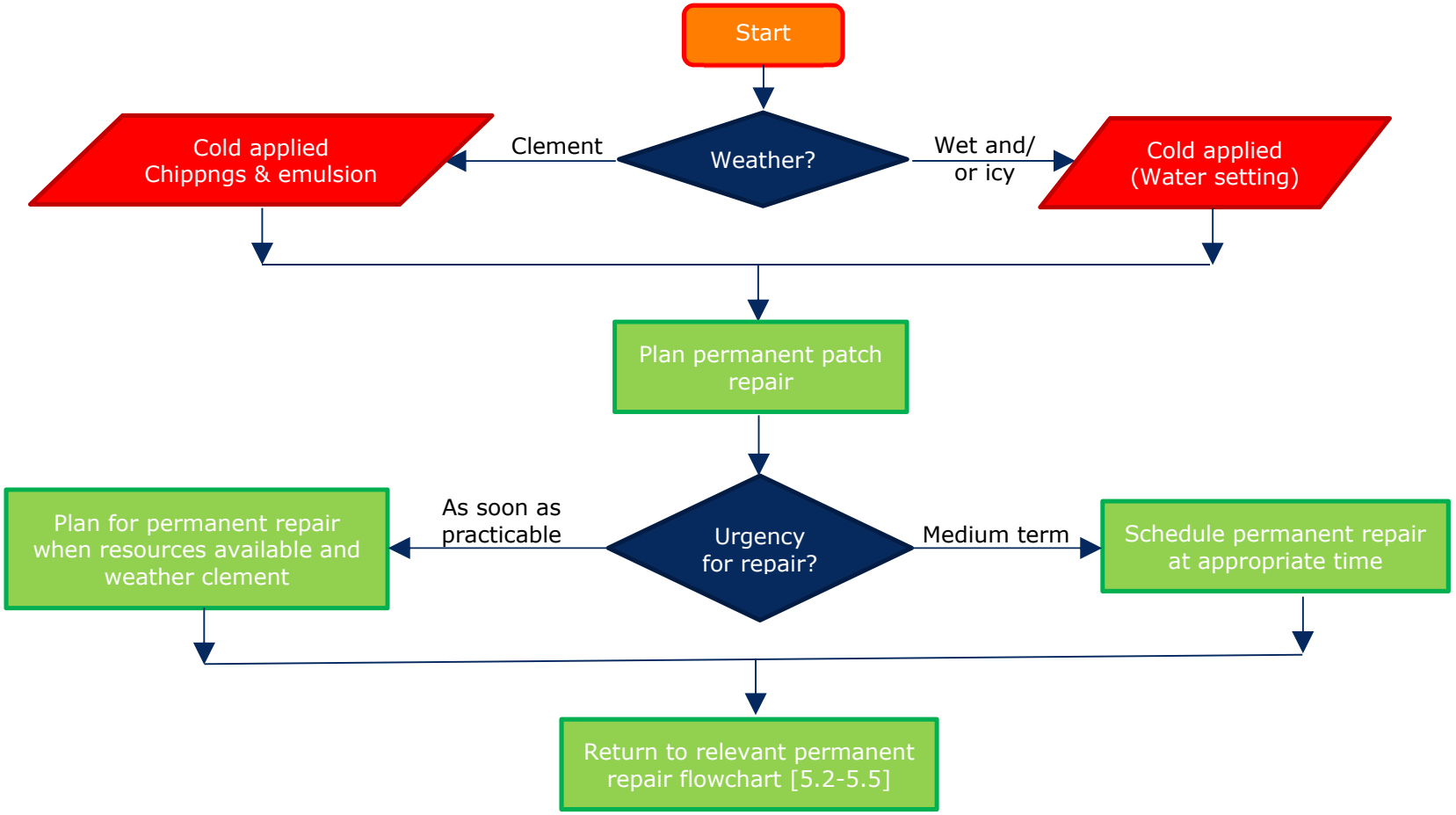
5.4 Pothole repair for non-strategic urban roads



5.5 Pothole repair for non-strategic rural roads



5.6 Temporary pothole repairs



6 Summary and conclusions

A poorly maintained road or overloaded pavement will exhibit cracking allowing the ingress of water, which in combination with traffic, will lead to the occurrence of potholes. There are different types of potholes and their severity will depend on the environmental conditions, traffic loading, road pavement structure and the materials used in its construction.

Pothole repairs do not always perform well and sometimes deteriorate rapidly after installation. On the other hand, pothole repairs may perform better than the surrounding material, with greater deflections seen in the adjacent material. The selection of a pothole repair material or technique is therefore important to optimise the longevity and serviceability of the repair.

This guide is based on a review of available information and consultation with practitioners from Scottish road authorities involved in pothole repairs. A range of techniques and materials have been identified, and discussions have led to the development of ideas for a selection procedure. The guide provides general advice on generic repair options available and a simple procedure has been developed to identify an appropriate pothole material or technique for a range of situations.

Flowcharts are provided that are intended to assist the process of selecting the most appropriate repair option. The process involves decision making and the relevant information that should be considered is provided. The concept behind a question is described and where relevant a default value or criterion is given. However, it should be noted that owing to the absence of national standards, it is appreciated that some authorities may wish to change these default values or criteria to suit their local situation or policy.

It is intended that the resulting procedure will lead to the various pothole repair options being targeted at situations where they are the most appropriate solution rather than the blanket use of a single option. All the options (other than resin-based and concrete mixtures, which are not explicitly covered) are recommended for at least one situation.

The guide was produced specifically for use in Scotland on local authority roads to select the appropriate treatment for repairing potholes, including those developed along joints. However, it is equally applicable for use on the Scottish trunk road network and on other county or trunk roads in countries with similar climates and road pavement types to Scotland. It is anticipated that the guidance will require updating as new techniques and materials become available.

Acknowledgements

The work described in this report was carried out in the Infrastructure Division of the Transport Research Laboratory. The authors are grateful to:

- Douglas Hill (SCOTS) for providing LA contacts and assistance with the questionnaire;
- Dougie McKay, Dundee City Council/Tayside contracts for advice and help in the preparation of this guide;
- Aberdeen City Council for hosting the workshop and workshop attendees for providing information and ideas:
  - James Anderson, Falkirk Council
  - Charlie Armstrong, East Renfrewshire Council
  - Lawrence Baldie, Dundee City Council/Tayside contracts
  - Richard Blain, Aberdeen City Council
  - Steven Brookfield, West Lothian Council
  - Andy Brown, Perth and Kinross Council
  - Ian Cameron, Moray Council
  - Mike Cheyne, Aberdeen City Council
  - Sandy Dall, Fife Council
  - Ian Daniels, Aberdeenshire Council
  - Jake Eadie, Perth and Kinross Council
  - Martin Gannon, Inverclyde Council
  - Brian Ingram, Aberdeen City Council
  - Russell King, Angus council
  - Bill Liddle, Fife Council
  - Ross McDonald, West Lothian Council
  - Dougie McKay, Dundee City Council/Tayside contracts
  - John McMartin, East Lothian Council
  - Keith Milne, Aberdeenshire Council
  - Gary Mitchell, Glasgow City Council
  - Brian Orde, East Renfrewshire Council
  - Robbie Paterson, Moray Council
  - Callum Redpath, , East Lothian Council
  - Dorothy Reid, Falkirk Council
  - Andrew Robins, Glasgow City Council
  - Ann Williamson, Aberdeen City Council

References

Highways Agency, Transport Scotland, Transport Wales and The Department for Regional Development Northern Ireland (2006). Surfacing materials for new and maintenance construction. *Design Manual for Roads and Bridges, Volume 7 Pavement design and maintenance, Section 5 Surfacing and surfacing materials, Part 1, HD 36/06*. Norwich: The Stationery Office. Available from www.standardsforhighways.co.uk/ha/standards/dmrb/vol7/section5/hd3606.pdf (last accessed May 2015).

Highways Authorities & Utilities Committee (2010). Specification for the Reinstatement of Openings in Highways. Norwich: The Stationary Office. Available from www.gov.uk/government/publications/specification-for-the-reinstatement-of-openings-in-highways (last accessed May 2015).

Nicholls, J C (2012). Definition of the term "pothole" and selection of test and evaluation methods for materials used in their repair. *Durable pothole repairs project deliverables 1 and 2*. Brussels: FEHRL. Available from http://www.fehrl.org/?m=32&id_directory=6964 (last accessed May 2015).

Paterson, J, S Leckie, C Walsh, M Gibb, A Taggart and S Biczysko (2010). Potholes and repair techniques for local highways. *Report CSS79-05 for ADEPT*. Roads Liaison Group. Available from www.ukroadsliaisongroup.org/en/utilities/document-summary.cfm?docid=73BC2560-AB35-480C-90703C6A36E7C811 (Last accessed May 2015).

Roberts, C, and J C Nicholls (2008). Design guide for road surface dressing. *TRL Road Note 39 (6th edition)*. Crowthorne: TRL Limited. Available from www.trl.co.uk/reports-publications/road-notes/report/?reportid=6308 (last accessed May 2015).

Bibliography

Asphalt Industry Alliance (2015). Annual local authority road maintenance survey (ALARM). London: HMPR Limited. Available from http://www.asphaltindustryalliance.com/news-press.asp?info=ALARM+survey+2015 (Last accessed Nov 2015).

Council for Science and Industrial Research (2010). Potholes: A technical guide to their causes, identification, and repair. CSIR Built Environment. www.csir.co.za/pothole_guides/ (Last accessed Nov 2015).

Highways Maintenance Efficiency Programme (2012). Potholes Review – Prevention and a Better Cure. London: Department for Transport. www.dft.gov.uk/publications/pothole-review (Last accessed Nov 2015).

Ipavec, A (2013). Summary of existing standards, techniques, pothole repair materials and experience with them. *Durable pothole repairs project deliverable 3*. Brussels: FEHRL. Available from http://www.fehrl.org/?m=32&id_directory=6964 (last accessed Nov 2015).

Kubanek, K (2013). Final report. *Durable pothole repairs project deliverable 5*. Brussels: FEHRL. Available from www.fehrl.org/?m=32&id_directory=7022 (last accessed Nov 2015).

Paterson, W D O (1987). Road deterioration and maintenance effects – Models for planning and management. Baltimore, USA: John Hopkins Press. Available from http://documents.worldbank.org/curated/en/1987/12/700720/road-deterioration-maintenance-effects-models-planning-management (last accessed Nov 2015).

Rahman, M, and N Thom (2012). Performance of asphalt patch repairs. London: Institution of Civil Engineers. Available from http://www.innovationresearchfocus.org.uk/Issues/93/IRF93_ICE.html (last accessed Nov 2015).

Road Surface Treatments Association and Association of Directors of Environmental, Economy, Planning and Transport (2013). Code of practice for innovative patching systems. Wolverhampton: RSTA. Available from http://www.rsta-uk.org/downloads/RSTA-ADEPT-Code-of-Practice-for-Innovative-Patching-Systems-2013.pdf (last accessed Nov 2015).

Wilson, T, and A Romine (1999). Materials and procedures for repair of potholes in asphalt-surfaced pavements – Manual of practice. *FHWA-RD-99-168*. Washington DC, USA: Federal Highway Administration. Available from https://www.fhwa.dot.gov/pavement/pub_details.cfm?id=139 (last accessed Nov 2015).

Appendix A Pothole e-Questionnaire

Instructions for Use

Before You Begin

This spreadsheet is designed to be easy to complete.

Information gathered from your spreadsheet will be used to compile information Scotland-wide about the materials and techniques used by local authorities to repair potholes.

Entering Data

Enter generic data relating to the survey in the General Information box.

In the Repair Materials box please indicate what materials have been used to repair potholes in the last 12 months. For the main options Cold Mix Asphalt (CMA), Hot Mix Asphalt (HMA) and Cement Based Materials (CBM) select Yes or No in the blue drop down boxes.
If other materials have been used please specify by typing into the box labelled 'other'.

Pothole Repair Study

General Information

Local Authority Name

Address

Postcode

Contact person/ position

Contact no.

Email

Repair Materials

Have you used these materials in the last 12 months?

CMA HMA CBM

Other: e.g., epoxy resin.

Please provide a general overview of the material/technique used, e.g. product name, repair technique used, repair type.

CMA e.g., Colpatch, Velocity Jet Patching, Emergency Rep

HMA

CBM

Other:

What are your service life expectations for each type of pothole repair? (Select from drop-down list)

Emergency Temporary Permanent

What type of areas do you cover? (select all that apply)

CITY
URBAN
SEMI-URBAN
RURAL
ISLAND

Are you interested in taking further part in this research, e.g. allowing an observer to watch repairs as they are carried out / providing further details?

Select

User Notes:

Please add any other information that you think may be relevant.

Appendix B Workshop findings

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.1: What is a pothole?		
Hazard Carriageway Defect Intervention level (Investigatory level) Perception Depth of defect Anywhere on carriageway/footway Easily identifiable Size?	Localised defect in carriageway that may cause damage or injury Pothole is a subjective term used by the public Fear of litigation	Hole that causes vehicle/ pedestrian damage – insurance claim Size – category – dynamic – risk assessment 30-40 mm preventative repair? – ignore anything out of council criteria Category 1 – 24 h? • Service a: o Cat A. 24 h o Cat B. 5 days • Service b: o Cat 1. 4 h o Cat 2. 24 h o Cat 3. 7 days • Service c: o Cat 1. 24 h o Cat 2. 5 days o Cat 3. 28 days

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.2: What are the major causes of potholes?		
Weather Drainage Sealing of joints Stress levels (junctions etc.) Utilities Structural failure in construction Previous/ temporary repairs Experience of laying/ repairing materials Build outs/ traffic calming Contamination Serviceable life of road Delayed Intervention Top laid surfacing – not reconstruction Funding – politics Iron works	Water Ingress Materials Topography Road widening Spending Patterns Inspection periods	Freeze/ thaw End of service life Flooding Increased vehicle size (wider)/ volume Construction depth Road drainage/ water ingress Lack of investment Edge damage Material/ laying problems Increased traffic speed Service installation/ joint failure Road gradient/ stresses	Water ingress – drainage issues Compaction – not to standards Design of original construction Poor workmanship – inspection against repair Vehicle modern compared to road make up Rural – timber lorries – wind turbines - farmers STAT Utilities

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.3: Why do pothole repairs fail?		
Maintenance Procedures Choice of Material Poor workmanship Temporary repairs not followed up Location of potholes – stress site, traffic levels Traffic management issues – delay in repairs Not looking at cause of failure Contamination Depth of repair Adjoining surface condition Repair Method Boundary issues – ownership	Wrong/temporary materials Lack of compaction, Incorrect compaction Area around the pothole fail Original failure factors (water ingress etc.) Not laid as per manufactures instructions Well prepared/good procedure	Poor workmanship – method of repair - wrong type of repair Lack of foresight Extent of initial repair not adequate Cost Political/public Lack of engineering in decision making
Q.4: Planning and use of materials		
Reporting – road priority Weather Hierarchy – roads priority – location Time of year Size and depth of defect Urgency Availability of squad/operators	Location, time of day/year Traffic management and required Effectiveness Severity of defect Ease of use Cost Urban/ Rural Type of defect Suitability for the class/type of road Condition of the surrounding road	Cold lay Performance Whole life costs Hot material Time of day Quick fix Timescale Category of defect Time of year Manpower/resources Budget Extent Location/ time management

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.5: Important factors in use of hot materials		
Health and safety Squad availability and size Plant – maintain temperature Road state – water etc. Distance from quarry Bonding Weather Season Programme Communication	Keeping it hot Quick compaction Material type Joint and sealers/ bond coat Versatile material	Health and safety/ training Downtime at quarry Wasting cold material Distance from quarry Increased labour/ plant costs Experienced operatives Extreme weather conditions
Q.6: Important factors in use of cold material		
Emergency repair Temporary/ permanent repairs Pothole size – deformation of large potholes High/ low stress. Locations Squad size Product Season Follow up repair?	Type of material Compaction/ preparation Range of experience across the group Preparation is key!!!! Toolbox talks. info	Same points as in question (5) Colas cold patch (summer/ winter mix) (storage benefit) (Instarmac) – wet mix – stay live – deforms under traffic Viafix Canadar Delayed set Less disruption
Q.7: Experience of cement based material or other additive		
Viafix – material cost high – works very well – whole life cost good Ultra-crete wet – not a good experience Stirling Lloyd Safecrack/ joint fill – expensive, tidy if used with shoe – works well – perfect colas joint fill	Viafix/ Viaquick • Excellent • Expensive (material) • But cost effective • Easy use • Semi-permanent	Archway jetpatching – using fibre additive (does not handle water) Viafix – storage Nimpactocoat (nimpi)

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.8: Experience in repair materials/processes		
Viafix – excellent experience – easy to use/ quick Colas Cold patch – works well, reasonably priced if bought in bulk and made fresh. Some problems with bagged product. No workability in winter for some little waste. Inconsistency of supply material HRA – performs well and lasts long time. More prep required. Enriched DBM – similar to HRA – cheaper but doesn't last well Public perception – hot repairs blend in with existing. Thermal patching – good results, seamless joints – need to get output to be cost effective.	Varied across the group Evolution through different products Hot/Cold/Hot A variety of products can be used and are used Latitude/location changes materials used Emulsion/chip sealing Coldpatch Change in cutback material	Previous points in other questions Preparatory mixes used for rural roads Asphalt materials for urban locations Sand carpet materials for footpath bit's repairs

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.9 & Q.10 & Q.11: Patching System – What type of repair techniques have you used and experience?		
Spray Injection patching – jetpatcher/ velocity/Archway. Successful product – more rural application. Range of bitumens giving different results. Surface dress pre-treatment. Care needed in rural areas and windy conditions Thermal patching – very successful especially urban locations – seamless patch. Works on footways. Good for utility repairs. Good on joint repairs. Needs good output for viability. Maintains strength Conventional Patching – traditional - well proved. T/M required. Adds carriageway strength. Emulsion and chip – cheap, easy, quick, pre surface dress preps. Plane/Patch: similar to conventional patching. T/M adds carriageway strength. Cold repairs as before (question 6) Crack repairs/joint fretting; • Colas joint fill – good – easy thermos repairs – good temp control required • S.L. safecrack – good, expensive, cold applied effective, long lasting • Viafix – easy use, cold, early intervention, different aggregate sizes	Spray injection (jet patching): • Troublesome in the urban environment • Can spray crazed area around • SD contractors will not spray over JP • Weather dependant • Rural roads only? • Training issues • Signage required can be expensive • Works better in-house (or can do) • After care can be an issue. Bleeding in the summer • Interim treatment (5-6 years) Nu-plant/Rhino patch: • Any turning areas would incur failures • Good mileage with footway repairs prior to slurry seal • Surface too open (finish). A thin layer • Location choice!! • Works better 30mm • Works well in urban areas • There has been an improvement in materials (more binder rich) • Smaller patches works better 40-60mm • Logistics (urban area's better)	Jetpatching (summer month's life costs?) Roadmaster – Archway (summer month's life costs?) Nuphalt thermal process – restricted winter Rhinophalt – site specific Joint repair systems – overband sealing – weather dependant Slurry seal – weather dependent Multihog plaining machine • Limitation on road surface e.g. asphalt • Cost constraint • Need it working all the time Viafix – performance v. cost

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.12: Collaboration with other authorities		
Central belt authorities collaborate Collaboration through SCOTS/APSE etc. Information learned from sales reps.	Scots - shared information Local collaboration on various projects Strategic level collaboration	Tayside contracts – DCC/PKC/AC ELBF – Edinburgh, Lothian, Borders and Fife Bear/Amey – little partnership works
Q.13: Do you interact with the public?		
Info on council website Local press Councillor interaction Letter drops etc. ahead works and information boards Internet reporting tool (app?) for defects Customer surveys	Letter drops Local press Notification (advance signs) On the website? Links to SCOTS website central Fear if info being used against us Open days for councillors/press Feedback questions Survey monkey – winter maintenance Back to back notification/survey	Various methods of taking contact information • Call centres • Phone • E-mail • Letters • Reply to contactor to if requested Orders via paper at the moment but "exploring" mobile working Public perception of potholes and repairs is much higher than before
Q.14: Are engineers/inspectors trained in dealing with potholes?		
Inspectors HAUC trained/supervisors courses City and guilds/SVQ qualified Supervisors courtroom trained Engineers generally receive no further training other than professional qualifications	Roads inspector training certificates available Age balance Formal training programme? In house training facilities becoming less common Other inspectors training new recruits SVQ level 3 (education)	No specific industry trains on pothole identification Might have "tool box talks", learning from experienced inspector (** they might have bad habits) NRSWA – yes. Trains from work squads – Focus on specific aspects of work Regular communication with workforce to help quality/productivity etc.

Table B.1: Workshop response to questions (Cont.)

Group 1	Group 2	Group 3
Q.15: Can treatment be costed to provide best value		
See Table A.2.	Long term project (if possible) Whole life cost – So many variables Winter maintenance setting workforce levels – Budget to keep them going the rest of the year Adept – compared SD with HRA	Some councils charge (rate)/defect Costing Contractors on maintenance to do more work rather than council No "fear" factor for council employees Council too restrictive e.g. health and safety factors etc. Council terms and conditions e.g. illness, holidays etc. Short-sightedness of service heads Get what you pay for.

Table B.2: Group 1 cost effectiveness

Treatment/System	Heavy		Light		Notes
	Urban	Rural	Urban	Rural	
Cold (v)	4	4	3	3	1 = Ineffective/poor value 5 = Excellent * Preferred for rural joint repairs # Risk of spraying vehicles/ buildings
Cold (STAND)	2	3	3	3	
HRA/DBM	4-5	4	3-4	2?	
Thermal	3	1	4-5	1	
Joint (STAND)	4-5	3-4	4-5	3	
Joint (RESIN)	4	1	4-5	1	
JetPatching*	1#	4-5	2#	4-5	
Emulsion and chips	1	4	2	4	