MOTT MACDONALD

Multiple Framework Agreement for Transport Research

Evaluation of Road Studs

15 December 2021

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
01	20/05/20	JG	AJF	ACF	Final Issue
02	15/01/21	JG	AJF	ACF	Incorporated SRRB Comments
03	15/12/21	JG	AJF	ACF	Incorporated accessibility guidance

Document reference: 403938 | 1 |

Information class: Standard

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1. Introduction

Road studs are guiding devices that produce light, either by reflecting incident light or through Light Emitting Diodes (LED), to warn, guide or inform road users. They are located on the road surface to supplement road markings, and can be mounted to, anchored or embedded within, the road pavement. Trunk road Operating Companies and Transport Scotland have highlighted their concern that the stick down road studs do not remain in place for an adequate amount of time in comparison with other methods. Whilst stick down studs appear to be the cheaper option, short term concerns have been raised over the lifetime in which they perform. Anecdotal evidence from the Operating Companies has shown that these studs are remaining in place only a matter of months against the performance of milled in studs. Winter maintenance operations, such as snow ploughing, appear to shorten the life of these studs with reports of ploughs physically removing them from the network. It appears that no monitored comparison information exists to determine which studs offer the best long-term cost benefits or what factors influence product choice.

The Scottish Road Research Board commissioned Mott MacDonald Limited to undertake a research study into this perceived issue with a view to determining if this is a stud type or construction issue.

This report covers the initial desk study, reviewing the life of stick down road studs against traditional milled in studs to understand how they compare in life expectancy and performance. This was done by first reviewing the existing literature on road studs, determining whether there are any studies that have previously investigated the difference in performance between stud variations. External factors, such as traffic or weather conditions, that can influence the performance of road studs, was also investigated within this review.

Questionnaires were issued to each of the Operating Companies currently working on Transport Scotland's trunk road network with a view to understanding the common trends and issues experienced by those managing and maintaining the road network.

Section 2 collects the information gathered during review of existing literature covering the use of road studs and previous findings with their performance.

Section 3 details the methodology of this report and what data was collected for analysis.

Section 4 covers the results of the data analysis and discussion of them.

Section 5 presents the conclusions of the analysis, as well as subsequent recommendations regarding the use of road studs on the network.

2. Literature Review

Before any data analysis was undertaken, a literature review was conducted to enhance the understanding of how road stud performance is perceived for surface mounted and milled in studs. Additionally, certain activities or conditions have been investigated within these studies that would not have been possible to replicate for this report, therefore it was important to review these findings when making recommendations at the end of this study.

The method of gathering literature for review was via the Internet, using search engines and Google Scholar to gather existing research and publications on the topic of road studs.

Additionally, key terms were used to narrow the search results and find research that was similar and relevant to the studies that required investigating.

The following details a list of some of these key terms that were searched for:

- “road studs”, “road markers”, “raised pavement markers”, “surface mounted”, “milled in”, “cat’s eyes”, “road stud products”;
- “installation”, “operation”, “maintenance”, “snowploughing”;
- “retro-reflectivity”, “durability”, “lifecycle”, “performance”, “cost”

2.1 Current stud products

Prior to investigating the existing research, a review of current road stud products was carried out. This was to gain an understanding of the products currently on the market, as well as the specifications and key benefits as detailed by the stud manufacturers and suppliers. The manufacturers considered for this review were 3M, Stimsonite, Halifax, Allux and Clearview.

3M and Clearview provide case studies for their products online, highlighting some of the key benefits on road schemes where each product was installed. These case studies show anecdotal evidence, and quantitative data in some cases, that their product is an effective solution for improving visibility and ultimately road safety within the UK. Consequently, these products become more credible, due to the testimonies of past customers, in comparison to competing stud models.

One of the key specifications that is mentioned across all these products is their compliance with the British Standard EN1463: Road marking materials – retroreflecting road studs (Parts 1 and 2). This declaration indicates that the products meet a minimum requirement that permit their use on UK roads. Further details on Part 1 and 2 of these standards are provided within Sections 2.5 and 2.6.

2.2 Lower durability

The subject of road studs, and how they perform under various road conditions, has frequently featured in previous studies. There have been similar experiences where road studs are failing at a faster rate than expected, therefore forcing the need to investigate what factors are shortening their lifespan.

Zhang et al. (2009) conducted a study on behalf of the Texas Department of Transportation (TxDOT) following complaints from several of its district departments, concerning mass failure of road studs on their respective networks. Of the mass failures reported, a significant portion of the studs were disappearing within weeks of installation, carrying further cost implications for the affected departments. Zhang et al. (2009) highlighted that there were previous studies from the late 1980s and 1990s discussing the ineffectiveness of studs on high traffic roads, which emphasised that the issue being experienced by the TxDOT district departments was not unique.

It was reported that the most common stud failures experienced were poor retention on pavements, breaking of stud bodies or lenses, and reduced retroreflectivity. Multiple possible factors were typically responsible for these failures, which included high traffic volume, high loading (such as trucks/HGVs), sand abrasion, and environmental factors like temperature, humidity, and ultraviolet radiation (Zhang et al., 2009). Zhang et al. (2009) highlighted further studies that have suggested that poor manufacturing and inadequate installation practices are also key contributors to poor stud durability.

As part of their analysis, Zhang et al. (2009) completed a field study where they evaluated stud performance periodically on various test sites for a total of 24 months. The evaluation consisted of both retroreflectivity monitoring and visual observations, with focus on the condition of the stud case, lens surface and lens interior. The chosen sites had differing test conditions, so comparison could be made between various external factors and the resulting impacts that they have on retroreflectivity and durability.

As expected, retroreflectivity and stud condition deteriorated over the 24 months, with significant decline experienced during the first 6 to 12 months. However, there were no incidences of mass failure with regards to stud loss on any of the test decks, with only one tested model exhibiting lost studs over the test period. This may have been a result of careful installation practices from the contractors, since these studs would be getting monitored and tested (Zhang et al., 2009). On observation of the test decks in comparison to regular installations, there was evidence of better installation quality on the test decks, highlighting its importance on improving stud durability.

A drawback of this investigation is that all stud models tested were surface mounted products, with no milled in studs evaluated. Although the findings regarding external factors and their impact on performance remain valid, further research should be conducted to understand if the magnitude of these factors is consistent across the two stud variations.

Another study, conducted by Du Preez (2013), investigated the performance of various road stud models that had been installed on the South African National Roads Agency Limited (SANRAL) network. This was to establish a pattern for the conditions under which a specific stud performs sufficiently, as well as identify the most likely mode of failure and whether it was linked to a specific road condition or category. It was identified that the main reason for stud failure was the structural failure of the stud body or lens, with sandblasting affecting reflectivity over time also proving to be a significant contributor to stud failure (Du Preez, 2013).

However, as this investigation focuses primarily on the South African road network, the results presented cannot be correlated to the Scottish road network due to the inherent differences in road construction techniques and materials. South African and Australian roads consist predominately of granular layers with surface seals (Du Preez, 2013), in comparison to the thick asphalt roads that are exhibited in Europe and the US. As a result, the interaction between the studs and the road surface differ, ultimately impacting how the studs would perform.

Additionally, the climates experienced in each of these locations could also have an influence on the results above. South Africa and Texas both possess regions of arid climate, as well as some areas that are more humid. In comparison, Scotland possesses a much more temperate climate with more incidences of wetter weather throughout the year,

Zhang et al. (2009) attempted to mitigate the influence of climate within their research by gathering data across multiple Texan districts with varying climates, however overall, the regions investigated would still have seen much warmer weather when compared to Scotland.

As a result, the difference in climates and how they may impact the durability of road studs, was not investigated within these studies, and hence has been overlooked as a possible contributing factor.

2.3 Snowploughing

The durability of road studs has already been questioned in past research. There are reports of this issue being exacerbated by extensive periods of snowploughing following adverse weather conditions, with ploughs physically removing the studs from the road. There have been road stud products

introduced in recent years to combat this, claiming that they are able to withstand frequent snowploughing and remain securely on the pavement. However, these claims are disputed as they appear to contradict anecdotal evidence.

In a study of the Kentucky road network, Agent and Green (2009) evaluated the effectiveness and durability of ‘snowploughable’ road studs. They highlighted that other transportation departments across the US had previously raised concerns regarding studs becoming loose from the pavement, with the Missouri Department of Transportation conducting a survey on this topic in 2005.

The responses from this survey varied, with some indicating that there were no issues with loose road studs while other responses claimed there were problems, particularly after extensive periods of snowploughing. Other factors that were highlighted as potential contributors to the poor durability were pavement condition, poor installation, design of the road stud casting, and wet-cut procedures that weakened the stud bonding to the road surface (Agent and Green, 2009).

Following on from this, Agent and Green (2009) conducted a separate survey for the Kentucky road network, with the intention of estimating the number of road studs that were missing for various road types. Data was collected for two lane and four lane roads, as well as asphalt and Portland cement concrete (PCC) pavements. The percentage of studs missing along with the durability of the asphalt pavements was also noted, which was rated based on the pavement age and its condition.

The results of the survey showed that as pavement condition deteriorated, the percentage of missing stud castings increased. Across the “new”, “good” and “fair” pavement condition ratings, the percentages of castings missing remained relatively low, registering 0.4%, 0.9% and 5.0% respectively. Only when the pavement condition was considered “poor” does the percentage significantly increase, with a reported 30.8% of castings missing for 292 miles of asphalt road. However, the condition ratings provided are subjective, with no explanation of the criteria for these ratings or supplementary images of the pavements. As a result, it is difficult to confirm whether the ratings provided are valid.

Agent and Green (2009) also held discussions with snowplough operators to understand their experiences and opinions regarding ‘snowploughable’ studs. Most operators had experienced road studs being removed whilst snowploughing, although the frequency that they reported varied significantly. They suggested that the studs were loosening due to receiving multiple hits from the snowplough blades, with removals happening more frequently on pavements that were older or in a poorer condition, reinforcing the survey

results that they received. Furthermore, the operators were of the consensus that the condition of the pavement was the main factor affecting the durability of the road studs, with poor stud installation another potential cause (Agent and Green, 2009).

2.4 Cost implications

There are not many studies available that provide direct cost comparisons between the surface mounted and milled in stud variations. However, cost has been a driver for previous studies, with the cost implications associated with poor stud durability highlighted. On top of the price of the stud, installation and maintenance costs also need to be considered. These will vary depending on method of installation, as well as on the performance of the stud. As studs become dislodged or faulty on the network, additional maintenance costs will build as a result so understanding the best value for money is essential.

Du Preez (2013) wanted to identify which road studs could meet the minimum requirements at the lowest cost, by understanding the various road conditions and how they influence stud performance. The research involved surveying various route managers across the Western region of the South African road network, to gather details on which studs were used and how they were performing. Additionally, the route managers would provide details on the traffic and road conditions in each area to assist with final stud recommendations. At the end of this study, Du Preez (2013) was able to recommend three different stud models for use across the South African road network (Ferro Lynx, STA+52 and Rhino). These stud models are unavailable within the UK, so simply taking these recommendations would not be possible. However, the testing exercise itself should not be disregarded, as it provided a useful method of analysing individual stud products under various field conditions, which ultimately led to deciding a cost-effective solution for the different road networks.

Gartner, Stamatiadis and Srinivas (2016) conducted research to investigate alternatives and best practices in retroreflective ‘snowploughable’ road studs. In 2008, the Massachusetts Department of Transportation (MassDOT) started to use recessed road studs on their network over ‘snowploughable’ studs, following concerns over their performance. However, similar issues arose with the use of recessed studs. In particular, the need to replace missing studs was leading to significant maintenance costs for the department.

A survey was conducted among other departments of transportation across the US and Canada to understand their road stud solutions and their opinions of them, as well as the associated costs. Across the responses, the most common road stud solution was temporary raised studs, followed by ‘snowploughable’ studs (raised and recessed), raised non-‘snowploughable’, then LED studs

being utilised the least. The temporary studs offered the lowest associated costs; however, they also offer lower durability in comparison to the other stud products (Gartner, Stamatiadis and Srinivas, 2016). Additionally, despite recessed studs costing more to install and maintain, there is no conclusive evidence that they perform better than raised 'snowploughable' studs. This suggests that the most expensive solution may not always be the best, so it is worth investigating further how each stud solution performs under varying conditions.

2.5 BS EN 1463-1: Initial performance requirements

As well as considering academic literature concerning the performance of road studs, the standards outlining the requirements for road stud performance in the UK has also been reviewed.

Based on BS EN 1463-1:2009 Part 1 – Initial performance requirements, road studs should not present any sharp edges to traffic for safety reasons and should only use tools or machinery recommended by the manufacturer. All road studs must be permanently and clearly marked with the number and year of European Standard, name or trademark of the manufacturer and type of road stud. Different types of road studs have different dimensions to follow, photometric requirements, colorimetric requirements, daytime visibility and resilience of depressible road studs.

In order to check the resilience of depressible road studs, a depression testing machine and stable bed plate are needed. Testing is carried out at 23 ± 2 ºC. Road studs should be mounted securely on the bed plate and the depressible part of the road stud is subjected to 72000 depressions at a rate of (60±3) depressions per minute. Permanent deformation to such an extent that reflecting part is permanently or partially obscured is observed and assessed.

2.6 BS EN 1463-2: Road test performance specifications

As detailed within the Traffic Signs Regulations and General Directions (TSRGD) 2016, all reflective road studs used on UK roads must achieve a class S1 in the primary assessment of BS EN 1463-2: Road test performance specifications. To achieve a class S1, the test requires that a minimum of 42 of 50 test studs are remaining on the road surface at the end of the test period – the test period is 1 year for permanent studs, and 4 months for temporary studs. This minimum testing requirement ensures that all road stud products, whether surface mounted or milled in, are durable enough to withstand the test conditions. However, if traffic conditions worsen, or other external factors become involved, then the durability of these stud products can suffer as a result.

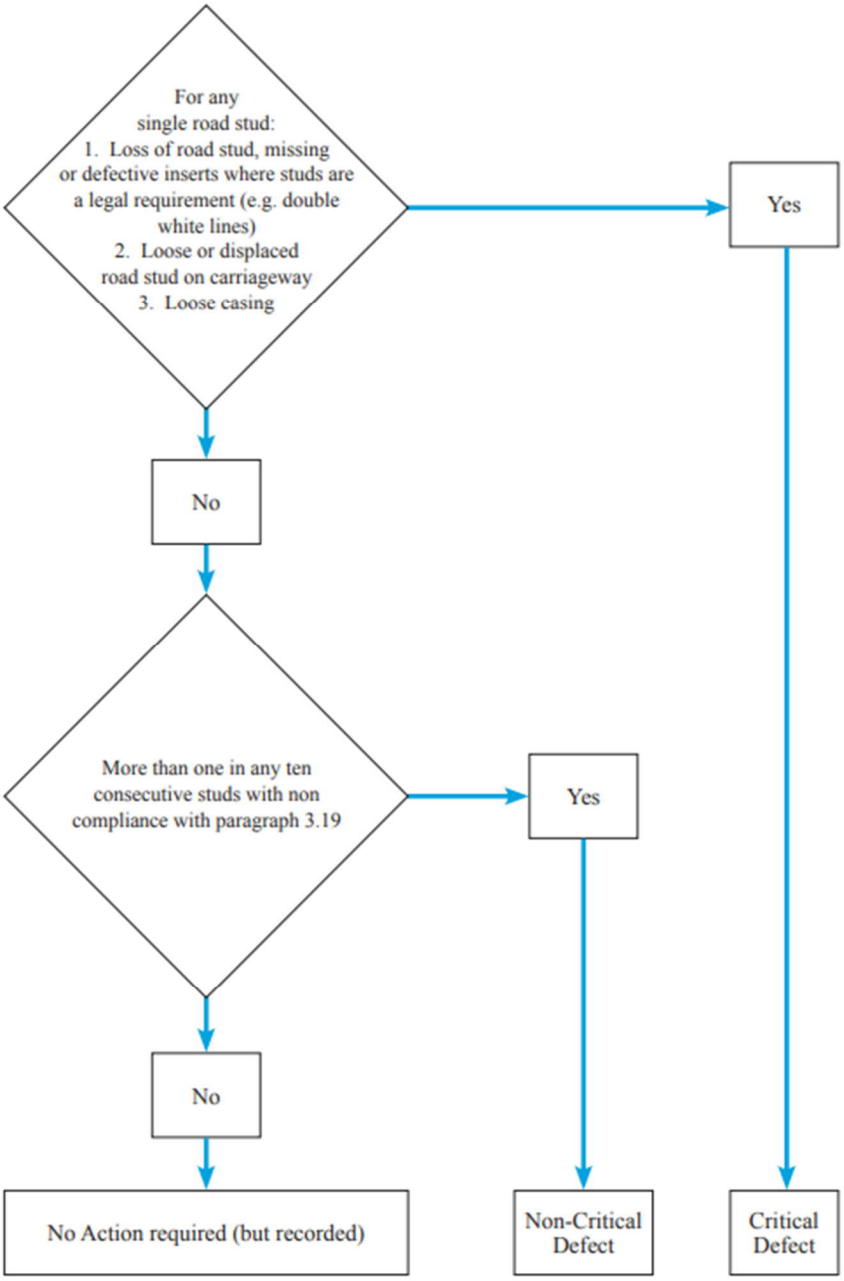
For the assessment, test studs are installed on a dual carriageway with two lanes in each direction, with the national maximum speed limit in place. The annual average daily traffic (AADT) for the test area should be at least 5,000 vehicles for the total carriageway, with traffic consisting of 10% to 25% heavy vehicles. Tests are carried out on asphalt road surfaces of an age of 1 year or more and are in a good condition

Test results will be heavily dependent on weather, traffic and road surface conditions, hence why these details are to be included in the report for the test site. Additionally, it is recommended to produce a weather report at the end of a road trial. This can be either based on data from the nearest meteorological station or from the test site itself. The report can include a monthly account of mean minimum and maximum day temperatures, the cumulated precipitations of water (mm) and the number of sand scattering and ploughing actions.

The standard specifies that test studs should be installed based on technical specifications given by the manufacturer, highlighting the importance of correct installation practices in their performance. Periods of application should be when the weather conditions are suitable. For instance, when the road surface temperature is at least 3 °C above dew point of the air and road surface temperatures to be between 10 °C and 50 °C. It is practical to keep the periods as short as possible. It is also recommended to test temporary studs between April and June.

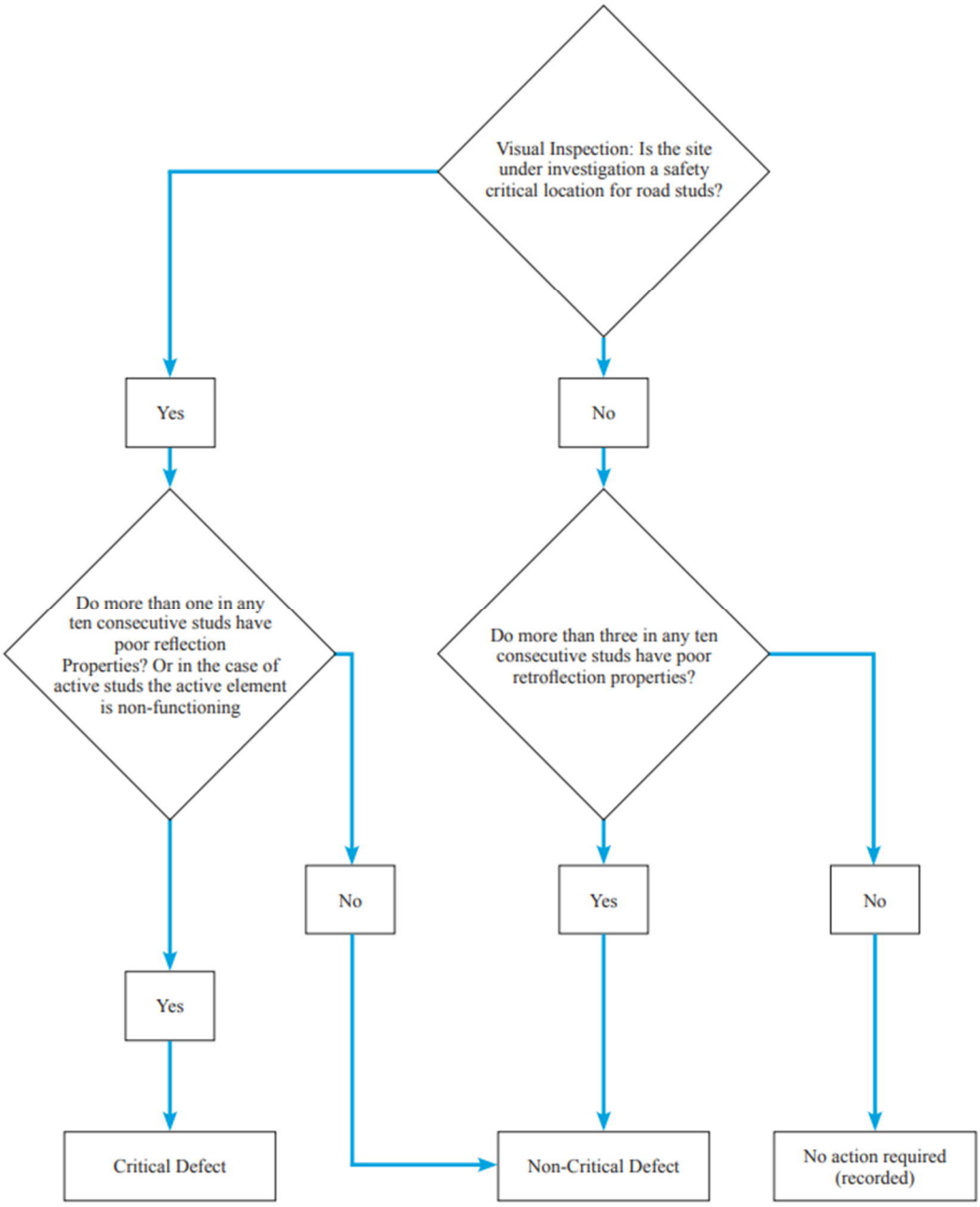
A road trial is split into 6 stages: daylight examination, night-time examination, primary assessment, selection of test studs for photometric testing, removal of selected test studs and photometric test. The process diagrams for daylight and night-time examinations are shown in Figure 2.1 and Figure 2.2. Daylight examination tests whether the enveloping profiles of all test studs present sharp edges to traffic as a result of damage, wear or separation of parts of the stud. If the total number of studs remaining is less than 45, assessment will be considered void. Non-conforming studs are to be removed as soon as possible before the next stage. Night-time examination tests are carried out after sunset, with headlights of a car on dipped beam and driver aligned with the line of studs. Test studs with no retroreflection are considered non-conforming. Retroreflectivity is determined at 50m ± 3m for permanent studs and 20m ± 2m for temporary studs. Primary assessment counts the remaining conforming test studs from previous stages. 10 test studs are then selected using their position number. The selected test studs are then removed for photometric test. During the removal, it is important to ensure there is no damage to the reflective lens to be tested.

Figure 2.1: Daytime assessment of retro-reflecting road studs



Source: TD26/17 Volume 8 Section 2 Part 2

Figure 2.2: Night-time assessment of retro-reflecting road studs



Source: TD26/17 Volume 8 Section 2 Part 2

2.7 Solar and Intelligent Road Studs

Based on case studies that were reviewed as part of this research, one stud product that should be considered for wider use is solar road studs, see Figure 2.3. Highways England (HE) has installed more than 4,500 solar road studs along A38. Usual road studs would require car headlights to reflect light, but solar road studs have embedded panels that absorbs power in the day and generate their own light at night through a battery powered LED. As a result, they can be visible from as far as 900m in favourable conditions. Solar studs are extremely robust even through snowploughing activities, so recurring maintenance would not be needed. The initial cost of a solar stud unit will be higher than the milled in stud, but the lifetime cost might be lower.

Figure 2.3: Clearview Intelligence – Solar road studs

Intelligent road studs, see Figure 2.4, are gaining more popularity throughout the years because they can synchronise with traffic lights, directing drivers to the right lane without confusion. These studs are usually used in roundabouts on busy roads. Using road studs that can be controlled improves driver's safety on roads as it will be easier for drivers to navigate the junctions. Intelligent road studs have only been used in one busy roundabout in Edinburgh to date, therefore there is the opportunity to expand this to other busy roundabouts across Scotland to analyse their performance. These studs have a modular design hence they are upgradable. They are easy to install, have low cost of maintenance and low power consumption. Also, they are embedded into roads, so they can resist snow ploughing, making them 'snowploughable'.

Figure 2.4: Clearview Intelligence – Intelligent road studs

3. Methodology

As part of the analysis for this study, Mott MacDonald compiled a questionnaire that was distributed to the Operating Companies on Transport Scotland's trunk road network, covering various areas with regards to the use of road studs and their performance.

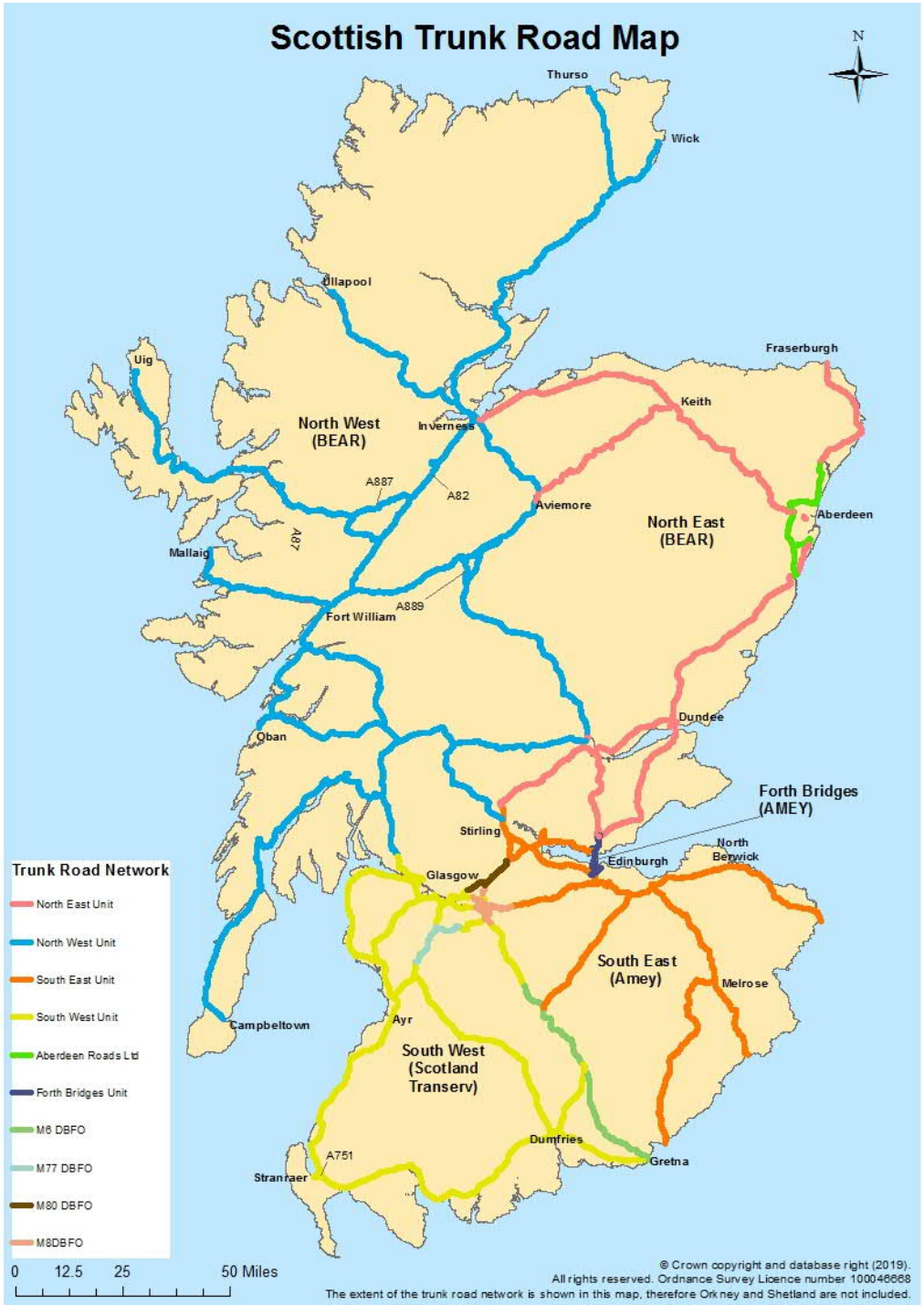
The topics covered by the questionnaire were as follows:

- Road studs – model, supplier, type (stick down/milled in/both)
- Installation of the studs
- Maintenance
- Performance
- Monitoring/testing
- Road network – road surface, width, traffic volume, % of heavy vehicle traffic
- General – any other comments regarding road studs

The questionnaire was distributed to a total of 28 contacts, across the four units of Transport Scotland's trunk road network – North East (BEAR); North West (BEAR); South East (Amey); and South West (Transerv) – as shown in Map 3.1. The responses received were then analysed to understand the common trends and issues that are experienced across each of the Operating Companies, followed by recommendations based from the findings.

The full responses to the questionnaires are included within the Appendices of this report.

Map 3.1: Scottish trunk road map



Source: Transport Scotland

4. Results and Discussion

4.1 Overview

Mott MacDonald received a total of 5 responses from the 28 questionnaires that were sent out, one response each from the North East, North West and South West units; and 2 responses from the South East unit. The reported road studs used by each of the Operating Companies can be seen in Figure 4.1. To avoid duplicating results, if a reported road stud model appeared across both responses from the South East unit, it was only considered as one operating company in the figures below.

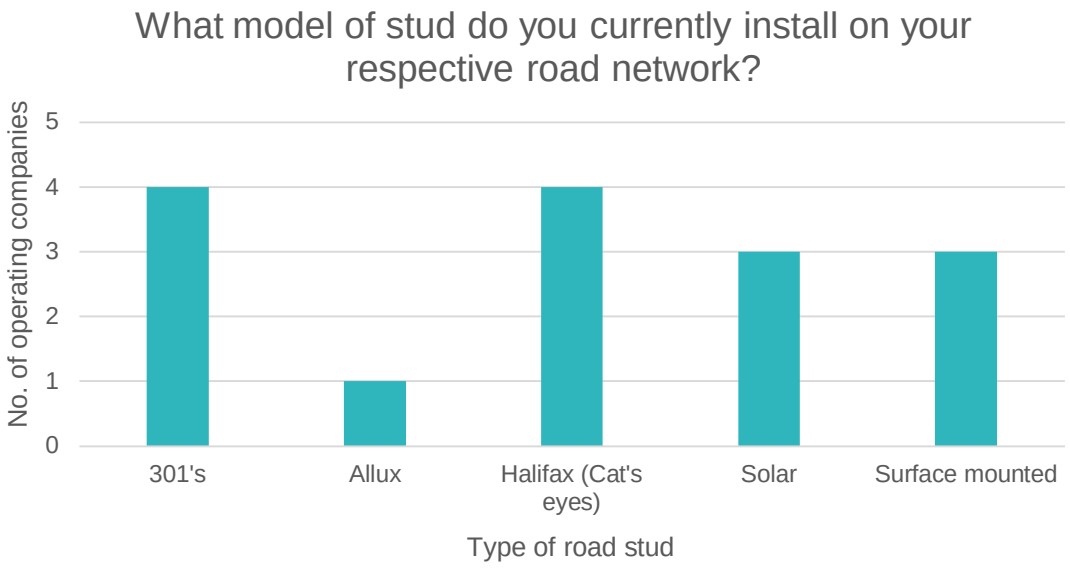


Figure 4.1: Road studs used by Operating Companies on trunk road network

Based on the results received, the Halifax (Cat's eyes) and the 301's variations are the most used studs across the Operating Companies that responded, with all 4 units using them currently in their respective areas. Of the two models, the Halifax type is the most preferred model of the studs that the Operating Companies use, see Figure 4.2, due to its high maintainability whilst not at the detriment of performance. They are labelled as robust and their rubber inserts can be easily replaced to improve the retroreflectivity levels if required. Additionally, as the inserts are depressible, repeated tyre action can facilitate self-cleaning of the stud lenses.

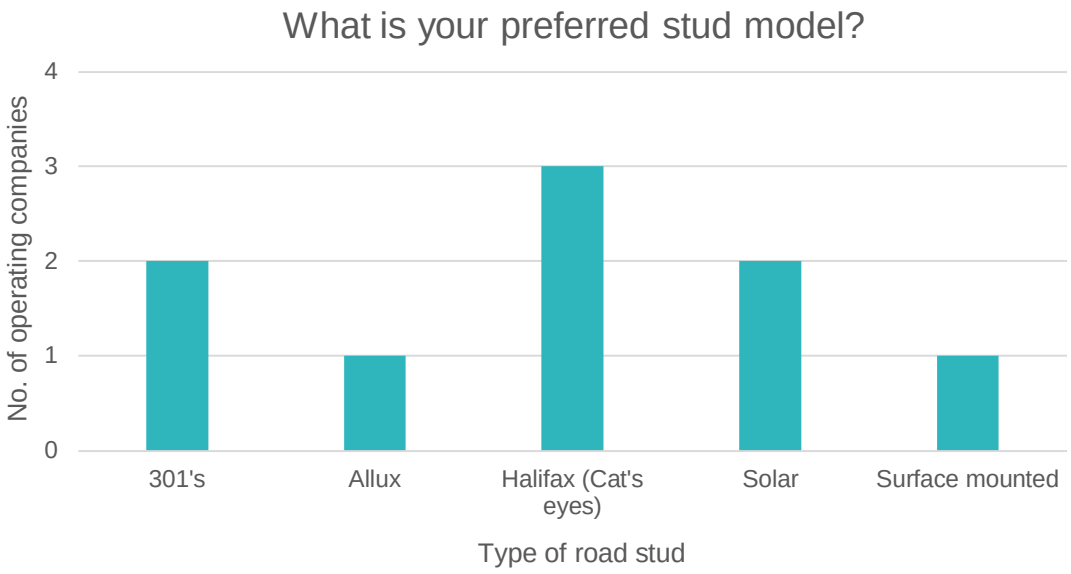


Figure 4.2: Preferred stud models of Operating Companies

It is recognised by respondents that the inserts for the Halifax model do not last as long in theory as the 301's, which also benefit from high maintainability due to its removable lenses. The 301's are considered as a good all-round milled in, or 'inset', stud with possessing high performance and durable casings which are able to withstand the large loadings typically experienced on high volume roads.

Clearview's solar powered studs were considered as the highest performing product by one respondent as it is ideal for remote areas, or dangerous roads where greater warning is needed for road users. They are also robust enough to withstand passing traffic with no adverse effects to the solar technology inside, assuring reliable year-round operation.

Allux studs are fairly durable and provide high retroreflectivity in wet night conditions when illuminated by vehicle headlights. This product has been trialled by one of the Operating Companies - although the concept was considered better than the 301's, they believe that performance is not as high as it should be. However, another respondent has found the Allux stud to be successful in the past and are currently awaiting the arrival of the more superior Allux 2 model, although there are concerns over the price.

Stick down studs are used across most of the Operating Companies, as they are quick to install and can be laid on warm material following road resurfacing. When compared to milled in stud models, they possess significantly poorer durability and are known to fail quickly on the road network, particularly in areas of high traffic volume or following extensive snowploughing. Table 4.1 shows a

summary of the road studs currently used on the trunk road network, with some of the benefits that they provide.

Model		Benefits
3M 301's		• Reflectors protected by cast iron guide rails • Snowploughable • Highly impact resistant
Halifax Cat's eyes		• Depressible and self-cleaning • Snowploughable • Castings can be fully cleaned and reconditioned
Allux		• Impact and abrasion resistant • Minimum re-engineering of road surface • Compatible with bitumen stud grout or two component acrylic adhesive system
Clearview Solars		• Better distance visibility in comparison to retroreflective studs • Snowploughable housing available for product • Long lasting, carefree operation
Stick down studs		• Cheap • Lightweight • Glass faced to resist scratching and maintain retroreflectivity

Table 4.1: Stud products used on Scottish trunk road network

4.2 Installation

Installation of stick down studs takes a shorter time when compared to milled in studs. Typically, it takes around 30 seconds to 1 minute for a single stick down stud to be installed while milled in studs take approximately 5 minutes each. For a larger installation exercise, i.e. a new road scheme, consideration should be given to the type of road, spacing of studs and the road layout itself as these factors will impact the overall installation time. With regards to how often new road studs were being installed on each network, the responses varied but on average it appeared that it was occurring a week after each surfacing scheme. On top of the longer installation time, there is a larger installation cost for milled in studs in comparison to stick down studs. This is due to the need for specialist equipment to install these studs, as well as actioning the appropriate traffic management measures for the duration of the process.

4.3 Performance

Operating Companies reported that the life duration of milled in studs ranged from 2 to 10 years, while stick down studs can last as short as a few weeks up to several years, depending on the location. Studs on roads with lower traffic volumes usually last longer than those with a higher volume of traffic, due to reduced loadings on the stud bodies and lenses. The reported number of studs replaced annually by each Operating Company ranged between 6,000 to 20,000 units, including resurfacing studs.

The North West and South East units reported approximately 20,000 studs were replaced annually in each of their respective networks by their Operating Companies, whereas the South West unit reported between 6,000 and 10,000 studs for their region; there were no values provided for the North East unit. With reference to the Scottish trunk road map shown above in Map 3.1, the North West region occupies a much larger road network in comparison to the South East, yet they both have reported similar values for annual stud replacement.

This could be attributed to the higher volumes of traffic experienced in the South East region. Based on monthly average daily traffic flows recorded at a series of Automated Traffic Classifer (ATC) sites, A720 Dreghorn in the South East was the busiest site from the sample in 2018 (Transport Scotland, 2020a), in comparison to the A835 Aultguish in the North West region which exhibited the lowest average trunk road traffic flows over the year. Additionally, A7 Langholm in the South East unit had the highest percentage of heavy good vehicle traffic in 2017, providing additional stress to the road network in that region. However, the values provided by the Operating Companies are only approximations, in the absence of more detailed data. Without further information from the Operating Companies themselves on which trunk roads are the most affected, it cannot be confirmed whether the reasons mentioned are contributing to certain units exhibiting higher annual numbers of stud replacement.

Higher cost and time implications are associated with replacement of milled in studs in comparison to stick down studs because of the equipment and traffic management measures that are required.

The Operating Companies were asked what the most common reason for failure in road studs was, the results of this can be seen in Figure 4.3.

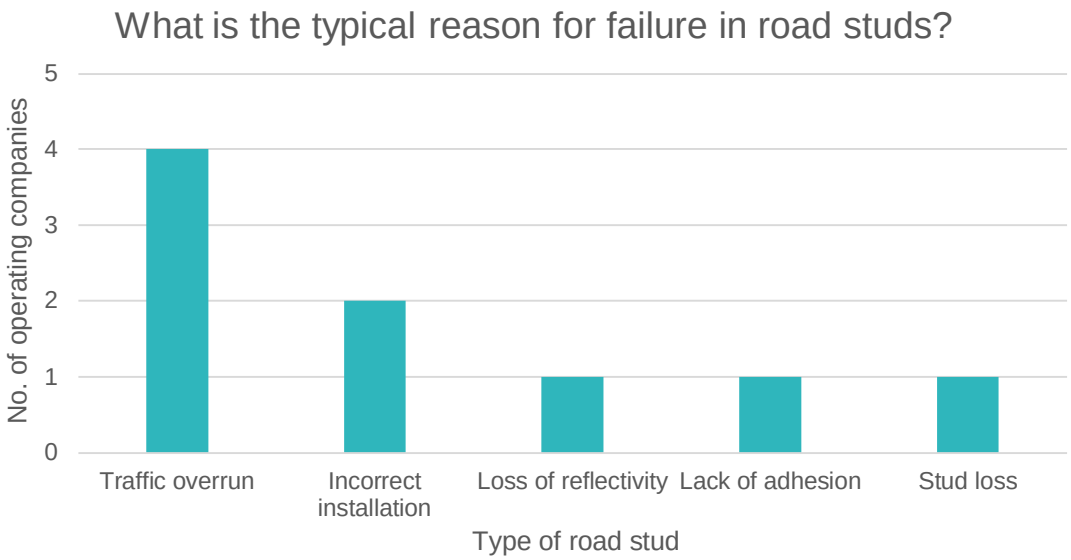


Figure 4.3: Reasons for road stud failure

Across the participants, traffic overrun was considered the most common reason for failure in road studs. This suggests that the placement of studs could be tailored more appropriately to certain areas to ensure that performance and value for money are maximised. Some of the factors reported to influence performance were material of the road surface, condition of road surface, speed of vehicles, lane widths and volume of heavy vehicles. These factors are consistent with those highlighted during the literature review. As a result, these factors must all be taken into consideration when deciding on a suitable stud product.

Additionally, all respondents had experienced stud failure as a result of snowploughing, with this occurrence happening more frequently with stick down studs. With regards to milled in products, they perform much better in comparison when exposed to extensive snowploughing. Depending on how persistent the weather is over time, the rate of failure can increase drastically. Data from the MET office states that Scotland has an average of 38.1 days of snow or sleet falling per year, based on records from 1981 to 2010. The number of days may increase or decrease depending on area, with more mountainous areas experiencing more frequent and heavier snowfall on average. The Cairngorms is the snowiest place in the UK with 76.2 days of snow or sleet per year. However, the amount of snow that lies is much lower than this, with an average of 26.2 days across Scotland. Additionally, there was no available data on how frequently snowploughing was required within Scotland annually.

4.4 Monitoring

Responses show that the Operating Companies undertake regular inspections to monitor performance and retroreflectivity of the studs. However, no in-house testing is carried out prior to their use on the network. Although all studs are compliant with British Standards EN1463 Parts 1 and 2, additional testing could be completed to evaluate the structural integrity of the studs, especially since traffic overrun was reported as the most common reason for stud failure.

4.5 Additional comments from Operating Companies

Operating Companies also suggested that contracts should be more specific to not allow cheaper alternatives, otherwise cost will be the biggest factor when choosing the type of studs. Research should also be conducted to trail cheaper, sustainable and durable options. Cohesion of binder should also be improved so studs stick longer and require less maintenance.

5. Conclusions and Recommendations

There are five key conclusions/recommendations that can be drawn from this study.

- Carry out a detailed whole-life cost comparison between stick down and milled in studs, looking at unit price, installation cost/time, maintenance and life span.
- Understand the contractual arrangements driving stud replacement on the Scottish trunk road network.
- Undertake a data gathering exercise to understand the reasons for and/or patterns of stud failures on the Scottish trunk road network.
- Implementation of trial sites to monitor stud performance across various locations.
- Establish a set of national guidelines for the use of road studs on certain parts of the Scottish trunk road network.

From the questionnaire responses, milled in studs appear to exhibit a higher level of performance and durability in comparison to stick down studs. Regular maintenance is required to ensure that studs do not become loose and present a danger to road users. However, despite the milled in studs themselves being more expensive, it cannot be determined from these survey results alone which stud offers the best cost benefit over its lifecycle. The responses were limited to the four Trunk Road Operating Companies and they provided primarily qualitative or opinion-based survey responses with no supporting data. Without further information, it is difficult to validate the responses that have been received, and therefore truly understand how each of the chosen road stud products differ. Additionally, there is a lack of existing literature discussing road studs on the UK road network or providing a whole-life cost comparison between different stud products. It remains unclear which of the studs discussed in the analysis provides the best solution. As a result, a further cost benefit analysis is recommended to evaluate and compare the different stud products that are available. Different aspects to consider in the analysis should include the method of delineation (reflective or LED stud), installation and maintenance time, public inconvenience during road closure, labour costs and average lifespan of studs.

It is important to understand what is driving the use of certain products on the Scottish trunk road network. If the Operating Companies are not required to replace studs ‘like for like’ then it may be the case that the cheapest unit price is the main factor in determining stud selection. Trunk road maintenance contracts should be reviewed to ensure that the most suitable stud for each given situation is selected, regardless of cost.

The next stage for this review would be to gather data on road stud use across the trunk road network to ascertain whether there are common reasons for failures locations. Data sets gathered could include; location, replacement frequency, traffic volumes, weather conditions, existing stud type and replacement stud type. A further data gathering exercise could be conducted, possibly extending out to local authority bodies to gather their experiences of road studs and how they perform in each area. Additionally, to complement the survey, various test sites could be created to monitor stud products and their performance over a chosen test period. The test conditions can be varied to understand more conclusive what factors affect performance and how each product compares.

The result of the recommendations above would culminate in the production of a set of guidelines for the use of road studs on the Scottish trunk road network. These guidelines would advise on the type of stud to be used in different scenarios and could be tailored to be route or area specific, depending on the outcome of the trial sites.

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Appendices

Appendix A – NE Unit Operating Company Questionnaire Response

MOTT MACDONALD

Road Studs Questionnaire

1 Brief

Through this survey, we will be able to identify, collect and analyse data and results to gain a holistic understanding about problems faced with regards to road studs. Your responses will only be used for survey purposes. This should take about 15 – 20 minutes of your time to complete.

2 Road Studs

2.1 What model of road stud do you currently install on your respective road network? List all the models used.

Road Craft 301, Halifax with rubber pad, Clearview Solar Powered Stud, 3M Surface Mounted

2.2 Who supplies the road studs to you?

Halifax - Reflecting Road Studs, 301s - Road Craft, 3M – stick on type, Clearview – Solar studs

2.3 Have you changed road stud suppliers recently?

No

2.4 If so, what road studs have you used in the past? And why did you change?

2.5 What is your preferred model you have used? And why?

Road Craft 301 are a good all round inset stud, the performance is good and the fixed lens lasts for a long time so no need to go back to re-rubber as with traditional Halifax type (Durability, less interventions and high performance), Clearview is the highest performing road stud and is ideal for areas of higher danger where greater warning is needed (Improved performance and durability)

2.6 Is your preferred model the one you currently use? If not, why?

Mostly

2.7 Have you ever tried drill in studs on any roads?

We mill studs using a dedicated Cats eye vehicle with milling head and vacuum to clean debris

2.8 If so, how was its performance against stick down studs? Provide reasons.

Surface mounted studs can come off due to traffic volumes and Snow ploughing, inset type studs are much longer lasting

2.9 Which roads did you install drill in studs?

A96, A95, A90, M90 M8 ,A82 A87 A83 A85,A84, A720

2.10 What is the cost comparison between stick down and drill in studs?

Around 3 or 4 times the price

2.11 What is the typical life duration for the stud models used?

Halifax renew rubber pad every 2 years unless exposed to heavy traffic volumes, Roadcraft 301 studs between 5 and 10 years, Clearview Solar studs between 5 and 10 years. Stud life duration depends traffic volumes and the road alignment

3 Installation

3.1 What is the typical installation time of the road studs used?

Depends on traffic management. Around 5 mins a stud

3.2 What is the duration for first installation of studs of a 1km road?

Total closure 3 to 4 hrs at 9 centres but the stud spacings necessary for the road layout will determine how many studs are needed for the 1km length

3.3 What is your method of installation? E.g. Machinery

Cats eye vehicle with milling head and vacuum

3.4 What actions from the local council are required for the installation? E.g. full/partial road closure

Full closure due to centre line working is the ideal solution but we can install studs with Stop/Stop working provided by a TM contractor

3.5 How often do you install new road studs on the network?

Often, every week we are installing cat's eyes on the network

3.6 How many road studs do you install in one outing?

Around 200 to 250 depending on Traffic management and the stud spacings also impacts output

4 Maintenance

4.1 How often do you carry out maintenance/replacement works for road studs?

We often replace the rubber pads in Halifax type road studs but this is done often enough and in most parts of Scotland you will find Halifax type studs where the lenses no longer functions, 301 and Solar type studs do not need to be maintained. When the housing on all types of studs becomes worn it needs to be lifted out of the road and the surface repaired before a replacement stud can be reinserted

4.2 How many road studs do you replace in one outing?

Depends on Traffic management and the stud types

4.3 Do you have a record of how many road studs are being replaced? Can you provide evidence?

Possibly but would take time to gather information

4.4 Approximate figure of number of road studs replaced annually.

No records kept

4.5 During maintenance work, what measures are required? i.e. full/partial road closure, temporary traffic lights, working at night

The preferred option is a road closure due to road worker safety and can be done night or day, but Stop/Stop works can be used during day time only

4.6 Are there differences between the measures taken for stick on or drill in road studs?

Stick on type studs can be done more quickly and do not need a specialist piece of drilling equipment, they can be laid from a traditional road marking vehicle, drill in studs require a purpose built vehicle

5 Performance

5.1 What are the key characteristics you look for in road studs? i.e. retro reflectivity, durability, reliability

All the characteristics are very important

5.2 What is the typical reason of failure in road studs?

This varies from the correct use of the different types of studs, traffic volumes and installation in poor weather

5.3 Are there any other notable performance issues with the road studs during adverse weather conditions (heavy rain, heavy snow, high winds)?

All studs need to be installed into dry surface and some porous types of surface present a problem with the holes filling with water

5.4 Does the brightness of studs diminish as time passes?

YES all studs will wear as traffic scratches the lens

5.5 Have you experienced failure of road studs due to snowploughing?

Yes surface mounted studs are often effected by snowploughing

5.6 If so, how often do they fail due to snowploughing?

Whenever you snow plough a route with stick on type studs

5.7 How durable are your road studs against snowploughing?

Most are fine with exception of Surface mounted

5.8 Any other maintenance/operational activities that affect the life span of road studs?

Traffic volumes

6 Monitoring/Testing

6.1 Do you monitor the performance and condition of the road studs during its lifecycle?

No

6.2 If so, how frequently do you monitor the performance and condition of the road studs?

6.3 Do you monitor/inspect the road studs following adverse weather conditions (i.e. heavy rain, heavy snow, high winds)? And how?

No

6.4 Do you test any road studs prior to use on the road network?

All the studs used EN1463 part 1 and 2.

6.5 If so, what tests do you use?

As above

7 Road Network

7.1 With regards to road stud maintenance, what type of road is maintained most frequently?

Halifax need pads replaced every two years, if not more. Road Craft 301/290 and Clearview Solar stud should last 5 to 10 years' maintenance free.

7.2 What roads are you responsible for maintaining? Any evidence?

Re pad Halifax

7.3 When maintaining road studs, are there any common issues/details about the road surface itself? E.g. material of road surface, damaged road surface, high speed, narrow lane width, high volume of heavy vehicles

Halifax studs are not changed often enough causing cleaning problems with casting being blocked with dirt.

7.4 Average Daily Traffic (ADT) values for affected roads?

7.5 Percentage of HGV on affected roads?

7.6 For each type of road, what safety measures do you need to take in order to maintain the road with regards to road studs?

Correct traffic management should be in place, risk assessment and method statement.

8 General

8.1 Any other comments about stud's situation on Transport Scotland roads?

Appendix B – NW Unit Operating Company Questionnaire Response

MOTT MACDONALD

Road Studs Questionnaire

1 Brief

Through this survey, we will be able to identify, collect and analyse data and results to gain a holistic understanding about problems faced with regards to road studs. Your responses will only be used for survey purposes. This should take about 15 – 20 minutes of your time to complete.

2 Road Studs

2.1 What model of road stud do you currently install on your respective road network? List all the models used.

Halifax, 301 & Surface mounted

2.2 Who supplies the road studs to you?

N/A

2.3 Have you changed road stud suppliers recently?

N/A

2.4 If so, what road studs have you used in the past? And why did you change?

2.5 What is your preferred model you have used? And why?

Halifax for maintainability

2.6 Is your preferred model the one you currently use? If not, why?

Gradually *** inc in use. A previous Transport Scotland instruction to only use stick-ons (as they are cheaper) has been relaxed.

2.7 Have you ever tried drill in studs on any roads?

Halifax & 301 are milled in

2.8 If so, how was its performance against stick down studs? Provide reasons.

Stud loss is vastly reduced as stick-ons suffer losses through ploughing & heavy trafficking

2.9 Which roads did you install drill in studs?

All North West truck roads

2.10 What is the cost comparison between stick down and drill in studs?

2.11 What is the typical life duration for the stud models used?

Halifax (insert) 5 years, 301 up to 10 years, stick-ones depend on location

3 Installation

3.1 What is the typical installation time of the road studs used?

Approx 5 mins

3.2 What is the duration for first installation of studs of a 1km road?

Depends on spacing

3.3 What is your method of installation? E.g. Machinery

301, Halifax – Machine ; Stick-ons – Hand

3.4 What actions from the local council are required for the installation? E.g. full/partial road closure

None – we are the trunk road operator. We use stop/stop, contraflow or closure for centre line working

3.5 How often do you install new road studs on the network?

All the time

3.6 How many road studs do you install in one outing?

Depends on traffic management & spacing

4 Maintenance

4.1 How often do you carry out maintenance/replacement works for road studs?

Rolling programme

4.2 How many road studs do you replace in one outing?

Depends on traffic management & spacing

4.3 Do you have a record of how many road studs are being replaced? Can you provide evidence?

See 4.4.

4.4 Approximate figure of number of road studs replaced annually.

Approx 20,000 (includes those replaced as part of resurfacing)

4.5 During maintenance work, what measures are required? i.e. full/partial road closure, temporary traffic lights, working at night

Depends on road layout & network restrictions

4.6 Are there differences between the measures taken for stick on or drill in road studs?

Not in terms of traffic management

5 Performance

5.1 What are the key characteristics you look for in road studs? i.e. retro reflectivity, durability, reliability

All of the above are required

5.2 What is the typical reason of failure in road studs?

Stud loss

5.3 Are there any other notable performance issues with the road studs during adverse weather conditions (heavy rain, heavy snow, high winds)?

5.4 Does the brightness of studs diminish as time passes?

Yes

5.5 Have you experienced failure of road studs due to snowploughing?

Yes

5.6 If so, how often do they fail due to snowploughing?

Stick-ons will fail often

5.7 How durable are your road studs against snowploughing?

Halifax & 301s are fine but stick-ons will fail

5.8 Any other maintenance/operational activities that affect the life span of road studs?

Exposure to traffic i.e. overrun

6 Monitoring/Testing

6.1 Do you monitor the performance and condition of the road studs during its lifecycle?

Yes, through safety & detailed inspections which look at all parts of the asset

6.2 If so, how frequently do you monitor the performance and condition of the road studs?

Safety – weekly ; detailed – annually

6.3 Do you monitor/inspect the road studs following adverse weather conditions (i.e. heavy rain, heavy snow, high winds)? And how?

Not specifically

6.4 Do you test any road studs prior to use on the road network?

Must comply with EN1463

6.5 If so, what tests do you use?

7 Road Network

7.1 With regards to road stud maintenance, what type of road is maintained most frequently?

Depends on type of stud, road layout, traffic, climate & altitude

7.2 What roads are you responsible for maintaining? Any evidence?

NW trunk toads

7.3 When maintaining road studs, are there any common issues/details about the road surface itself? E.g. material of road surface, damaged road surface, high speed, narrow lane width, high volume of heavy vehicles

7.4 Average Daily Traffic (ADT) values for affected roads?

7.5 Percentage of HGV on affected roads?

7.6 For each type of road, what safety measures do you need to take in order to maintain the road with regards to road studs?

As for 3.4

8 General

8.1 Any other comments about stud's situation on Transport Scotland roads?

A drive by Transport Scotland to select the cheapest product (stick-ons) has left a legacy of stud loss

Appendix C – SW Unit Operating Company Questionnaire Response

MOTT MACDONALD

Road Studs Questionnaire

1 Brief

Through this survey, we will be able to identify, collect and analyse data and results to gain a holistic understanding about problems faced with regards to road studs. Your responses will only be used for survey purposes. This should take about 15 – 20 minutes of your time to complete.

2 Road Studs

2.1 What model of road stud do you currently install on your respective road network? List all the models used.

I'm not aware of all product names but generally we use 301 permanent stud on new schemes and in some areas we are trialling solar studs. We have a lot of cats eye type studs on the network also.

2.2 Who supplies the road studs to you?

Various, but generally materials are procured through contractors, Markon and Doody's.

2.3 Have you changed road stud suppliers recently?

Main change has been from cats eye type to 301 studs.

2.4 If so, what road studs have you used in the past? And why did you change?

See above. Change was for longevity, 301 studs are perceived to last longer without maintenance, however the issue with these is that changing the insert is not as easy as with the cat eye type.

2.5 What is your preferred model you have used? And why?

Cats eye - Maintenance is easier whilst not at the detriment of performance, albeit the inserts don't last as long (in theory) as 301's.

2.6 Is your preferred model the one you currently use? If not, why?

Depends, we work on a scheme by scheme basis and dependant on the supplier but generally we use the 301 type currently.

2.7 Have you ever tried drill in studs on any roads?

The vast majority of studs applied on our Network are milled in. I assume this is what is meant by "drill in".

2.8 If so, how was its performance against stick down studs? Provide reasons.

Milled in studs last longer than stick on studs but installation and maintenance takes longer and often requires more robust traffic management.

2.9 Which roads did you install drill in studs?

A75, A76, A77, A701, A751.

2.10 What is the cost comparison between stick down and drill in studs?

Negligible in terms of unit cost but installation and maintenance costs are higher with milled in cast studs.

2.11 What is the typical life duration for the stud models used?

Varies based on the route and location within the road. However a centre line stud would be expected to last 2-5 years. Stick on studs around 1 year.

3 Installation

3.1 What is the typical installation time of the road studs used?

A Milled in stud can be applied within 5 minutes. Stick on studs in less than a minute.

3.2 What is the duration for first installation of studs of a 1km road?

Unknown and based on centres but assuming warning line (studs at 9m centres), with traffic management I would expect this to last a full shift at least.

3.3 What is your method of installation? E.g. Machinery

Machine milled, resin applied to core then stud and casting placed in core.

3.4 What actions from the local council are required for the installation? E.g. full/partial road closure

Local authorities are only consulted if the Trunk Road closure will impact on their network in terms of the diverted traffic.

3.5 How often do you install new road studs on the network?

After each surfacing scheme, approx 4-6 times per month.

3.6 How many road studs do you install in one outing?

Varies massively but as an average I would assume 100 – 200.

4 Maintenance

4.1 How often do you carry out maintenance/replacement works for road studs?

Annually throughout the network.

4.2 How many road studs do you replace in one outing?

Not sure but depends on the stud. Stick on (surface applied) studs can be replaced quickly. Cats eyes casting can have the rubber reflector replaced quickly. 301 casings are very difficult to replace the reflector only.

4.3 Do you have a record of how many road studs are being replaced? Can you provide evidence?

Not for the whole year.

4.4 Approximate figure of number of road studs replaced annually.

Between 6000 and 10000.

4.5 During maintenance work, what measures are required? i.e. full/partial road closure, temporary traffic lights, working at night

Depends on stud type but normally stop / go traffic management will suffice. If the road is narrow and milled in studs are to be applied then a road closure may be necessary.

4.6 Are there differences between the measures taken for stick on or drill in road studs?

Generally yes as the plant required to install is greater for milled in studs.

5 Performance

5.1 What are the key characteristics you look for in road studs? i.e. retro reflectivity, durability, reliability

All of the above, in that order.

5.2 What is the typical reason of failure in road studs?

Traffic overrun, incorrect installation.

5.3 Are there any other notable performance issues with the road studs during adverse weather conditions (heavy rain, heavy snow, high winds)?

Rain / snow etc will reduce visibility but not to an extent that should not be foreseeable.

5.4 Does the brightness of studs diminish as time passes?

Yes.

5.5 Have you experienced failure of road studs due to snowploughing?

Yes, mainly with stick on, surface mounted studs.

5.6 If so, how often do they fail due to snowploughing?

Frequently.

5.7 How durable are your road studs against snowploughing?

Milled in studs are durable and 301 type studs in particular are durable.

5.8 Any other maintenance/operational activities that affect the life span of road studs?

Not that I'm aware of.

6 Monitoring/Testing

6.1 Do you monitor the performance and condition of the road studs during its lifecycle?

We carry out quarterly inspections in daytime and night time to view performance and we measure retro reflectivity annually.

6.2 If so, how frequently do you monitor the performance and condition of the road studs?

As above.

6.3 Do you monitor/inspect the road studs following adverse weather conditions (i.e. heavy rain, heavy snow, high winds)? And how?

No, other than weekly safety inspections that identify all defects.

6.4 Do you test any road studs prior to use on the road network?

Not personally.

6.5 If so, what tests do you use?

N/A

7 Road Network

7.1 With regards to road stud maintenance, what type of road is maintained most frequently?

Cats Eye type given that removing and replacing the rubber insert is easiest.

7.2 What roads are you responsible for maintaining? Any evidence?

A75, A76 (South), A701, A77 (South) and A751. I am Area Manager for Trunk Roads within Dumfries & Galloway.

7.3 When maintaining road studs, are there any common issues/details about the road surface itself? E.g. material of road surface, damaged road surface, high speed, narrow lane width, high volume of heavy vehicles

All of these issues come into play and collectively mean maintenance is required. Certain road pavement types deteriorate in a way that mean studs will become loose. Some earlier (14mm) SMA's for example where centre line joint failures were common.

7.4 Average Daily Traffic (ADT) values for affected roads?

Don’t have info to hand.

7.5 Percentage of HGV on affected roads?

Higher than 20% for A75, in and around 20% for all others

7.6 For each type of road, what safety measures do you need to take in order to maintain the road with regards to road studs?

8 General

8.1 Any other comments about stud’s situation on Transport Scotland roads?

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Appendix D.1 – SE Unit Operating Company Questionnaire Response

MOTT MACDONALD

Road Studs Questionnaire

1 Brief

Through this survey, we will be able to identify, collect and analyse data and results to gain a holistic understanding about problems faced with regards to road studs. Your responses will only be used for survey purposes. This should take about 15 – 20 minutes of your time to complete.

2 Road Studs

2.1 What model of road stud do you currently install on your respective road network? List all the models used.

Allux, Solar, stick on's, Halifax

2.2 Who supplies the road studs to you?

WJ

2.3 Have you changed road stud suppliers recently?

No

2.4 If so, what road studs have you used in the past? And why did you change?

N/A

2.5 What is your preferred model you have used? And why?

Solar's work well in very remote areas and have lasted well on the network but we normally use Halifax as our milled stud. These are robust and rubbers can be changed to help reflectivity when required. We also use a lot of stick on's as they are quick to install and can be laid on warm material.

2.6 Is your preferred model the one you currently use? If not, why?

Allux studs have been successful but we have been waiting for the allux 2 to be brought out as they are a more superior model, these studs are more expensive which is off putting to ourselves and possibly the client.

2.7 Have you ever tried drill in studs on any roads?

Yes

2.8 If so, how was its performance against stick down studs? Provide reasons. Milled studs have a better overall performance as they are more secure even in stressful situations using ploughs on gritters. Milled seem to be a rarer situation to have one pluck out. When this occurs, the hole that is left can be a hazard. Milled studs can also not be installed if the pavement is to warm. More expensive but they last a long time.

Stick on's are quick to install, can be put down on warmer surfaces. They are cheaper. Stick on's don't seem to last long especially if they are installed onto stressful areas.

2.9 Which roads did you install drill in studs?

Our motorways and A class roads

2.10 What is the cost comparison between stick down and drill in studs?

Approx £8

2.11 What is the typical life duration for the stud models used?

milled is 5 years, stick on is 2.

3 Installation

3.1 What is the typical installation time of the road studs used?

Stick on seconds, milled 2 mins.

3.2 What is the duration for first installation of studs of a 1km road?

Eight hours for stick on but 16 for milled

3.3 What is your method of installation? E.g. Machinery

3.4 What actions from the local council are required for the installation? E.g. full/partial road closure

3.5 How often do you install new road studs on the network?

Weekly

3.6 How many road studs do you install in one outing?

250 milled or 450 stick on'

4 Maintenance

4.1 How often do you carry out maintenance/replacement works for road studs?

Few times a year

4.2 How many road studs do you replace in one outing?

250 milled or 400 stick on's

4.3 Do you have a record of how many road studs are being replaced? Can you provide evidence?

N/A

4.4 Approximate figure of number of road studs replaced annually.

20000

4.5 During maintenance work, what measures are required? i.e. full/partial road closure, temporary traffic lights, working at night-

All different TM set ups, days and nights, mainly closures.

4.6 Are there differences between the measures taken for stick on or drill in road studs?

Mainly time on the road

5 Performance

5.1 What are the key characteristics you look for in road studs? i.e. retro reflectivity, durability, reliability-

All the above and cost.

5.2 What is the typical reason of failure in road studs?

Vehicle over runs

5.3 Are there any other notable performance issues with the road studs during adverse weather conditions (heavy rain, heavy snow, high winds)?

Yes so we don't put them down in these conditions

5.4 Does the brightness of studs diminish as time passes?

Yes this part of the lifecycle

5.5 Have you experienced failure of road studs due to snowploughing?

Mainly with stick on's but yes.

5.6 If so, how often do they fail due to snowploughing?

Regularly

5.7 How durable are your road studs against snowploughing?

Milled are good, stick on's aren't

5.8 Any other maintenance/operational activities that affect the life span of road studs?

Studs going down under the wrong conditions.

6 Monitoring/Testing

6.1 Do you monitor the performance and condition of the road studs during its lifecycle?

We carryout regular inspections for reflectivity and performance.

6.2 If so, how frequently do you monitor the performance and condition of the road studs? Are they there? Are they reflective?

Reflectivity is monitored twice a year, maintenance is carried once a year.

6.3 Do you monitor/inspect the road studs following adverse weather conditions (i.e. heavy rain, heavy snow, high winds)? And how?

NO

6.4 Do you test any road studs prior to use on the road network?

WJ do

6.5 If so, what tests do you use?

7 Road Network

7.1 With regards to road stud maintenance, what type of road is maintained most frequently?

Motorways seem to be our more frequently maintained roads due to the majority on A class roads having milled studs.

7.2 What roads are you responsible for maintaining? Any evidence?

All trunk roads in the South East Unit.

7.3 When maintaining road studs, are there any common issues/details about the road surface itself? E.g. material of road surface, damaged road surface, high speed, narrow lane width, high volume of heavy vehicles.

TS2010 Seems to require more bitumen to allow application of stick on studs. If the area is highly stressed then the road studs are more likely to become damaged or missing.

7.4 Average Daily Traffic (ADT) values for affected roads?

Anything from 6000 to 60000

7.5 Percentage of HGV on affected roads?

7% to 35%

7.6 For each type of road, what safety measures do you need to take in order to maintain the road with regards to road studs?

Use the appropriate Traffic management to allow maintenance,

8 General

8.1 Any other comments about stud's situation on Transport Scotland roads?

We should be trailing more new products on the market to get a more sustainable durable product.

Appendix D.2 – SE Unit Operating Company Questionnaire Response

MOTT MACDONALD

Road Studs Questionnaire

1 Brief

Through this survey, we will be able to identify, collect and analyse data and results to gain a holistic understanding about problems faced with regards to road studs. Your responses will only be used for survey purposes. This should take about 15 – 20 minutes of your time to complete.

2 Road Studs

2.1 What model of road stud do you currently install on your respective road network? List all the models used.

Allux, 301's, Surface Mounted and Halifax

2.2 Who supplies the road studs to you?

WJ

2.3 Have you changed road stud suppliers recently?

Not within the last 6 years

2.4 If so, what road studs have you used in the past? And why did you change?

We have used all the road studs that are in the UK market. Each has with various results

2.5 What is your preferred model you have used? And why?

The 301 is my preferred stud at th moment as the casing is durable and they now have removable lenses which is ideal for future maintenance. I have trialled the Allux stud recently and although I like the concept better, their performance was not as high as it should be. Step in the right direction though.

Is your preferred model the one you currently use? If not, why?

The STRU contracts are price led therefore surface mounted studs will always be favourable to the business.

2.6 Have you ever tried drill in studs on any roads?

Yes

2.7 If so, how was its performance against stick down studs? Provide reasons

Although longer to install, results are more durable overall -especially on high stress areas.

2.8 Which roads did you install drill in studs?

301's and Allux

2.9 What is the cost comparison between stick down and drill in studs?

There is no cost comparison. Surface mounted are much cheaper but poor performance, therefore not value for money in my opinion.

2.10 What is the typical life duration for the stud models used?

Millled in studs – years. Surface Mounted weeks/months/years depending on where its placed

3 Installation

3.1 What is the typical installation time of the road studs used?

Surface Mounted Studs – no more than a 30secs to a minute for each.

3.2 What is the duration for first installation of studs of a 1km road?

Depends on road alignment and layout???

3.3 What is your method of installation? E.g. Machinery

As per the manufacturer's guidelines? Surface mounted is with bitumen.

3.4 What actions from the local council are required for the installation? E.g. full/partial road closure

The question is random to answer accurately.

3.5 How often do you install new road studs on the network?

For every road surfacing scheme, we do. Typically 9 schemes a month of various lengths

3.6 How many road studs do you install in one outing?

As above – depends on layout.

4 Maintenance

4.1 How often do you carry out maintenance/replacement works for road studs?

Each month

4.2 How many road studs do you replace in one outing?

Varies

4.3 Do you have a record of how many road studs are being replaced? Can you provide evidence?

Contractual evidence is with our Client

4.4 Approximate figure of number of road studs replaced annually.

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4.5 During maintenance work, what measures are required? i.e. full/partial road closure, temporary traffic lights, working at night

All of the above

4.6 Are there differences between the measures taken for stick on or drill in road studs?

Time & Cost being the main measure

5 Performance

5.1 What are the key characteristics you look for in road studs? i.e. retro reflectivity, durability, reliability

All the above

5.2 What is the typical reason of failure in road studs?

For Surface mounted lack of adhesion. Millled in – reflectivity over time

5.3 Are there any other notable performance issues with the road studs during adverse weather conditions (heavy rain, heavy snow, high winds)?

During snow fall, Snow ploughs rip off the surface mounted studs

5.4 Does the brightness of studs diminish as time passes?

Yes

5.5 Have you experienced failure of road studs due to snowploughing?

Yes – Mainly Surface mounted

5.6 If so, how often do they fail due to snowploughing?

If weather persists over a period of time then it can be quite a high rate

5.7 How durable are your road studs against snowploughing?

Surface mounted perform better if placed on the outside of edge lines. Centrelines and studs are the usual failures. Milled in studs perform much better under these circumstances.

5.8 Any other maintenance/operational activities that affect the life span of road studs?

The cohesion with the bitumen being used. Laying temps. Is the Surface course a dense or open texture.

6 Monitoring/Testing

6.1 Do you monitor the performance and condition of the road studs during its lifecycle?

Yes as per the contract.

6.2 If so, how frequently do you monitor the performance and condition of the road studs?

Weekly inspections as well as annually

6.3 Do you monitor/inspect the road studs following adverse weather conditions (i.e. heavy rain, heavy snow, high winds)? And how?

Not directly although picked up again during inspections.

6.4 Do you test any road studs prior to use on the road network?

No

6.5 If so, what tests do you use?

N/A

7 Road Network

7.1 With regards to road stud maintenance, what type of road is maintained most frequently?

A Class – with poor geometry

7.2 What roads are you responsible for maintaining? Any evidence?

A and M Class

7.3 When maintaining road studs, are there any common issues/details about the road surface itself? E.g. material of road surface, damaged road surface, high speed, narrow lane width, high volume of heavy vehicles

Yes, all the above, Will the stud be applied to a dense material or open

7.4 Average Daily Traffic (ADT) values for affected roads

From 4msa to 200msa

7.5 Percentage of HGV on affected roads?

Anything up to 30%

7.6 For each type of road, what safety measures do you need to take in order to maintain the road with regards to road studs?

If on the centreline then we would prefer to use a milled in stud under a road closure. If we use surface mounted studs and fail, then we are exposing personell to live traffic with the remedial

8 General

8.1 Any other comments about stud's situation on Transport Scotland roads?

Research is required to various application for various textures ranging from HRA to 14m SMA

Cohesion of binder – what works best

Contract needs to be more specific and not allow cheaper alternatives