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Forensic Examination of Critical Special Geotechnical Measures

M Duffy-Turner (Coffey Geotechnics Ltd), M G Winter (Winter Associates Limited), I M Nettleton (Coffey Geotechnics Ltd) and G Butler (Coffey Geotechnics Ltd)

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Executive summary

The effective design, specification and construction of Special Geotechnical Measures (SGMs) is critical to the efficient operation of the National Highways Strategic Road Network (SRN). Given the required performance of the SRN in terms of resilience, reliability, redundancy and recovery it is essential that SGMs are themselves reliable in terms of performance and life; resilient to external conditions such as earthworks deterioration and extraordinary conditions (e.g. climate change).

The locations of all such SGMs are stored in National Highways' Geotechnical and Drainage Management System (GDMS) and the SGMs are inspected periodically, the more recent introduction of a taxonomy for the SGMs, which includes around 100 different types, allows for the effective interrogation of the system to identify emerging issues related to some SGM-types. This is especially important as the early installations of some SGMs are approaching the end of their, typically 60-year, design life and the design, specification and application of many of these techniques is based on limited studies.

In this context, the primary objective of this study is timely in that it seeks to validate, or otherwise, the predicted long-term performance of selected SGMs.

Data derived from GDMS was used to identify those SGMs that are most prevalent on the SRN, those that are most often co-located with defects, and those that are most often associated with verified defects. This information was then used to help with the development of a questionnaire survey to sample the experience of the National Highways Geotechnical Community. The results of the survey, along with more detailed consultations with National Highways and other UK asset owners, identified the following SGMs for potential further study:

- Counterfort Drains (CFDR) – Gravel-filled drains extending to full earthwork depth/height.
- Block Walls (BLCW) – Precast concrete modular block gravity walls.
- Gabion Walls (GABN) – Gabion gravity retaining walls.
- Regrade (REGD) – Earthworks repair comprising conventional fill, typically regraded to an angle shallower than the original construction.
- Reinforced Soil solutions including components of:
    - Metallic Reinforcement (MTLK) – Metallic reinforcement such as straps or mesh, usually used in conjunction with a facing system for strengthened earthworks.
    - Geogrids (GEGD) – Slopes of any angle reinforced using geosynthetic grids which interlock with the fill material.
    - Polymeric straps are included in this category.
- Soil Nails (SNAL) – Slopes of any angle reinforced using soil nails, except where any facing mesh actively contributes to stability.

Extensive background and commentary on the issues encountered for each of the SGMs identified above is given as a summary of the available advice and guidance on the design, specification and construction of each SGM-type.

A methodology has been developed to enable the prioritisation of site investigations to examine and exhume these SGMs with a view to identifying further actions.

Block Walls, Gabion Walls, Counterfort Drains, Reinforced Soil and Soil Nails have been examined where possible and, where appropriate, information from failures and other cases in which expert opinion has been sought has been gathered. This along with the background and commentary presented herein has been used to develop an Information Note for each of the five SGM types.

The sites inspected and the recommendations contained in the five Information Notes are reported herein. The main finding from this project is that, with the exception of Counterfort Drains, there is no compelling evidence that when properly designed, specified, constructed and maintained these SGMs cannot meet the required design life. For Counterfort Drains the in-service life is likely to be limited to between 15 and 25 years before major refurbishment in the form of cleaning or replacement of the drainage media is required. In all cases there is a need to improve practices and the guidance available, as set out in the recommendations, including for example a review of the Manual of Contract Documents for Highway works, Volume 1 Specification for Highway Works as it relates to Reinforced Soil.

Throughout this project, contractor self-certification has been raised and evidenced as one of the outstanding issues that leads to poor construction, subsequent poor performance and early-life failure of not only SGMs but other forms of construction. Indeed, this has been highlighted on other National Highways projects on which the authors have worked and in work for other infrastructure owners and operators both in the UK and overseas.

It is considered that a move to cease Contractor self-certification and revert to a more conventional client-led Construction Quality Assurance scheme in order to ensure quality of execution of Works is strongly indicated.

Also strongly indicated is, earlier and more extensive operational and maintenance geotechnical input to Major Works in order to ensure specification compliance, acceptability for use and handover to the operator.

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1 Introduction

The National Highways Strategic Road Network (SRN) relies upon a wide range of Special Geotechnical Measures (SGMs) to strengthen or enhance the natural geological materials, or engineering materials derived from them, to form earthworks. There are currently around 100 SGM-types (see Appendix A), and the design, specification and application of many of these techniques is based on limited studies. Many of these techniques have been in service for periods approaching their predicted design lives (60 or 120 years). This project was initiated in order to take account of this timing to validate the previously predicted long-term performance of these SGMs.

Special Geotechnical Measures (SGMs) are defined as "… *measures over and above general earthworks construction required to; mitigate geotechnical risk associated with ground related hazards or remediate geotechnical defects that may have resulted from the presence of geo-hazards. Similar techniques implemented to facilitate widening or other improvements are, for the purposes of this task, also classified as Special Geotechnical Measures*" (Atkins/Jacobs, 2020).

Planned SRN Major Projects and Operational Renewals presented a significant and innovative opportunity to undertake forensic examination, including the potential exhumation of elements, to determine the validity of existing design, specification and application guidance. As many of the SGMs were nearing the end of their design lives it was also a unique opportunity to determine their in-service performance against that predicted and relied upon in terms of design life. A number of cases, both on and off the SRN, had come to light where the selection, design, specification or application of some SGMs had issues that affected their performance and design-life.

Given the required performance of the SRN in terms of resilience, reliability, redundancy and recovery it is essential that SGMs are themselves reliable in terms of performance and life; resilient to external conditions such as earthworks deterioration and extraordinary conditions (e.g. climate change).

This report details the work undertaken, and the findings from, all three phases of a project to forensically examine critical Special Geotechnical Measures (SGMs) installed on the National Highways Strategic Road Network.

The overall aim of the project was to better understand the long-term performance of SGMs to enable investment decisions for future improvements and renewals. Workshops have indicated that National Highways and their supply chain have concerns about several SGMs (e.g. Soil Nails, Reinforced Soil, Geotextiles, etc.). This work therefore provides recommendations on which SGMs require further investigation to enable appropriate guidance on the assessment of the condition, future use, design, specification and construction for selected SGMs.

At the outset it was anticipated that outcomes could follow a range of possibilities. These might include that some SGMs need further guidance to be developed for design, specification and/or construction in order to continue as viable SGM options on the National Highways SRN. Other SGMs could be reviewed and found to have limited to no potential for future use on the National Highways SRN for reasons that might include, but not necessarily be limited to, technical, environmental and safety factors. Additionally, the performance of existing applications may be found to be inadequate relative to the assumptions made at the design stage and their longer-term suitability potentially compromised; in such cases, advice would need to be provided on the potential need for decommissioning of SGMs. Other instances could lead to no further action being required.

The work will enable National Highways to appropriately employ (or otherwise) the selected SGMs on the SRN and to assess the future requirements for upgrading or replacing SGMs nearing their end of life.

The project has been delivered in three phases. Phase 1 identified and prioritised SGMs for future forensic and other examination and assessment in subsequent phases of work. Investigation in the form of site examinations were conducted in Phases 2 and 3. The work was structured to produce Information Notes on each SGM type containing advice and guidance on their future use or otherwise. These incorporate information on design, specification, construction, inspection and maintenance, as applicable. The Information Notes particularly address the need, or otherwise, for action in terms of changes to, for example, the Design Manual for Roads and Bridges (DMRB) and/or Manual of Contract Documents for Highways Works (MCHW).

Block Walls, Gabion Walls, Counterfort Drains, Reinforced Soil and Soil Nails were examined where possible and information from failures and other cases in which expert opinion has been sought has been gathered. This along with the background and commentary presented herein has been used to develop an Information Note for each of these five SGM types.

The sites inspected and the recommendations contained in the five Information Notes are reported herein.

Section 2 of this report details the results from the interrogation of the GDMS, describes the process used for a questionnaire survey of the wider National Highways geotechnical community as well as the associated results therefrom, and the wider consultations that collectively lead to the identification of SGMs for further study.

Section 3 gives extensive background and commentary on the issues encountered for each of the SGMs identified above and a summary of the available advice and guidance on the design, specification and construction of each SGM-type. This section was developed as part of Phase 1 of the work and built upon for the Information Notes for each of the critical SGMs.

Section 4 details the methodology developed to enable the prioritisation of site investigations to examine and exhume these SGMs.

Section 5 reports on the examinations and other work undertaken to produce the Information Notes on Block Walls (Winter et al., 2022a), Gabion Walls (Duffy-Turner et al., 2022a), Counterfort Drains (Nettleton et al., 2022), Reinforced Soil (Winter et al., 2022b) and Soil Nails (Duffy-Turner et al., 2022b) to guide their future design, specification, construction, maintenance and inspection. This section includes the recommendations made for each of the SGM types and overarching recommendations that apply to all of the SGMs and potentially more widely.

Section 6 summaries the main findings from the project and draws pertinent conclusions.

2 SGM Identification and Selection

To identify potentially problematic SGMs a staged, or tiered, approach has been taken. First, the SGM and defect data extracted from GDMS by Atkins/Jacobs (2020) has been interrogated to provide a coarse and varied view of the most problematic SGMs on the network (see Section 2.1). It was anticipated that this process would highlight around 10 to 20 SGMs.

It is, however, clear that the National Highways geotechnical research and development community, and the wider Geotechnical Supply Chain have a wealth of knowledge that may be variably present in the data logged in GDMS. To extract this information a detailed questionnaire survey was undertaken (see Sections 2.2). It was expected that this process would assist with the validation of the SGMs identified from the GDMS data while potentially adding some that were not highlighted and/or eliminating some that were highlighted. Opportunities for the forensic investigation of SGMs are discussed in Section 2.3 and other UK asset owners were also consulted (see Section 2.4).

This more formal aspect of this stage of the work was followed by discussions between the project team (Coffey, Winter Associates and National Highways), to reduce the number of selected SGMs to no more than six. This smaller group would provide a manageable pool from which specific opportunities for forensic investigation could be selected in later phases of the work (see Section 2.5).

2.1 Known SGMs and Defects

Atkins/Jacobs (2020) interrogated the National Highways SGM inventory contained within GDMS to produce data relevant to SGMs and their condition on the network. This exercise was, in part, intended to produce a tool suitable for use in a wide range of tasks within the National Highways Geotechnical Resilience Programme.

Of interest to this project was the inclusion of both the numbers of SGMs present and defect data within the inventory and its interrogation. The Atkins/Jacobs data included both the numbers of each SGM present on the network and the number of each SGM co-located with defects (Figure 2.1). More importantly, the numbers (Figure 2.2) and percentages (Figure 2.3) of each SGM-type that had been verified to have a defect were presented.

Access to the data used by Atkins/Jacobs to produce Figures 2.1 to 2.3 allows a very simple preliminary analysis to show that the most common (100 or more instances) SGMs are as follows:

- Filter Drain (FILT): 2,570
- Non-Specific Retaining Wall (NSRW): 1,737
- Gabion Wall (GABN): 798
- Block Wall (BLCW): 669
- Mass Concrete Wall (CNCW): 661
- Regrade (REGD): 641
- Toe Drain (TODR): 581
- Sheet Pile Wall (SHPL): 439
- Geogrid (GEGD): 418
- Slope Drain (SLDR): 387
- Geotextile (GETX): 325
- Counterfort Drain (CFDR): 322
- Soil Nails (SNAL): 303
- Masonry Wall (BKRW): 215

- Herringbone Drainage (HBDR): 198
- Rock Netting / Mesh (SMEH): 192
- Crest Drain (CSDR): 125
- Stone Wall (STNW): 114
- Lime Stabilisation (LMST): 107
- PVC Pile Wall (PVCS): 104

Similarly, the SGMs that are most frequently co-located with defects (50 or more instances) are as follows:

- Filter Drain (FILT): 647
- Non-Specific Retaining Wall (NSRW): 182
- Toe Drain (TODR): 115
- Gabion Wall (GABN): 104
- Block Wall (BLCW): 95
- Slope Drain (SLDR): 83
- Counterfort Drain (CFDR): 81
- Mass Concrete Wall (CNCW): 80
- Geogrid (GEGD): 77
- Regrade (REGD): 61
- Herringbone Drainage (HBDR): 54
- Sheet Pile Wall (SHPL): 54
- Geotextile (GETX): 52
- Soil Nails (SNAL): 50

The SGMs most frequently associated with verified defects (five or more) are as follows:

- Filter Drain (FILT): 56
- Block Wall (BLCW): 38
- Slope Drain (SLDR): 32
- Non-Specific Retaining Wall (NSRW): 26
- Toe Drain (TODR): 26
- Geogrid (GEGD): 23
- Mass Concrete Wall (CNCW): 22
- Gabion Wall (GABN): 20
- Stone Wall (STNW): 15
- Counterfort Drain (CFDR): 9
- Geotextile (GETX): 8
- Buttress (BTTR): 8
- Masonry Wall (BKRW): 7
- Regrade (REGD): 6
- Crest Drain (CSDR): 6
- Rock Netting / Mesh (SMEH): 6
- Non-Specific Anchor (NANC): 5
- Crib Wall (CRIB): 5

On a percentage basis, the SGMs associated most frequently (5% or more) with verified defects are as follows:

- Buttress (BTTR): 44%
- Scaling (SCAL): 33%
- Rock Mattress (ROCM): 14%
- Stone Wall (STNW): 13%
- Grout Injection (GROT): 13%
- Toe Berm (TOBR): 11%
- Rock Fill (ROCF): 11%
- Shotcrete (SHOT): 10%

- Rock Trap / Catch Ditch (DITC): 10%
- Soil Nail Mesh (SNMS): 10%
- Crib Wall (CRIB): 8%
- Non-Specific Anchor (NANC): 8%
- Slope Drain (SLDR): 8%
- Concrete Sandbag Wall (CNSB): 8%
- Dentition (DNTT): 7%
- Block Wall (BLCW): 6%
- Geogrid (GEGD): 6%
- Crest Drain (CSDR): 5%
- Erosion Mat (ERSN): 5%
- Rock Armour (ROCA): 5%

The picture painted by these lists is rather mixed. It is clear that Filter Drains and various types of retaining wall (including Non-Specific Retaining Walls) are, unsurprisingly, the most common form of SGM found on the National Highways network; Geogrids, Geotextiles and Soil Nails are also frequently encountered. A similar picture is observed from the data for those SGMs most frequently co-located with defects with the addition of Slope Drainage and Counterfort Drains.

When verified defects and the percentages are considered Filter Drains, various types of retaining walls (again including Non-Specific Retaining Walls) and Geosynthetics remain important but SGMs associated with rock slopes (e.g. Rock Trap / Catch Fence and Dentition) also emerge as an important issue.

A slightly more rigorous examination of the above lists is presented in Table 2.1. This simply highlights in which of the above lists each of the relevant SGM appears. Several SGMs appear in the three numerical lists but not in the percentage lists, these include Filter Drains, Non-Specific Retaining Walls and Gabion Walls for example. This may be simply because of the large number of such SGMs present on the network and the number of defects may still be significant. Other SGMs appear in at least some of the numerical lists and the percentage list – these include Block Walls, Geogrids, Slope Drains, Stone Walls, Buttresses, Non-Specific Anchor, Crib Wall and, when Soil Nail Mesh is also included, Soil Nails.

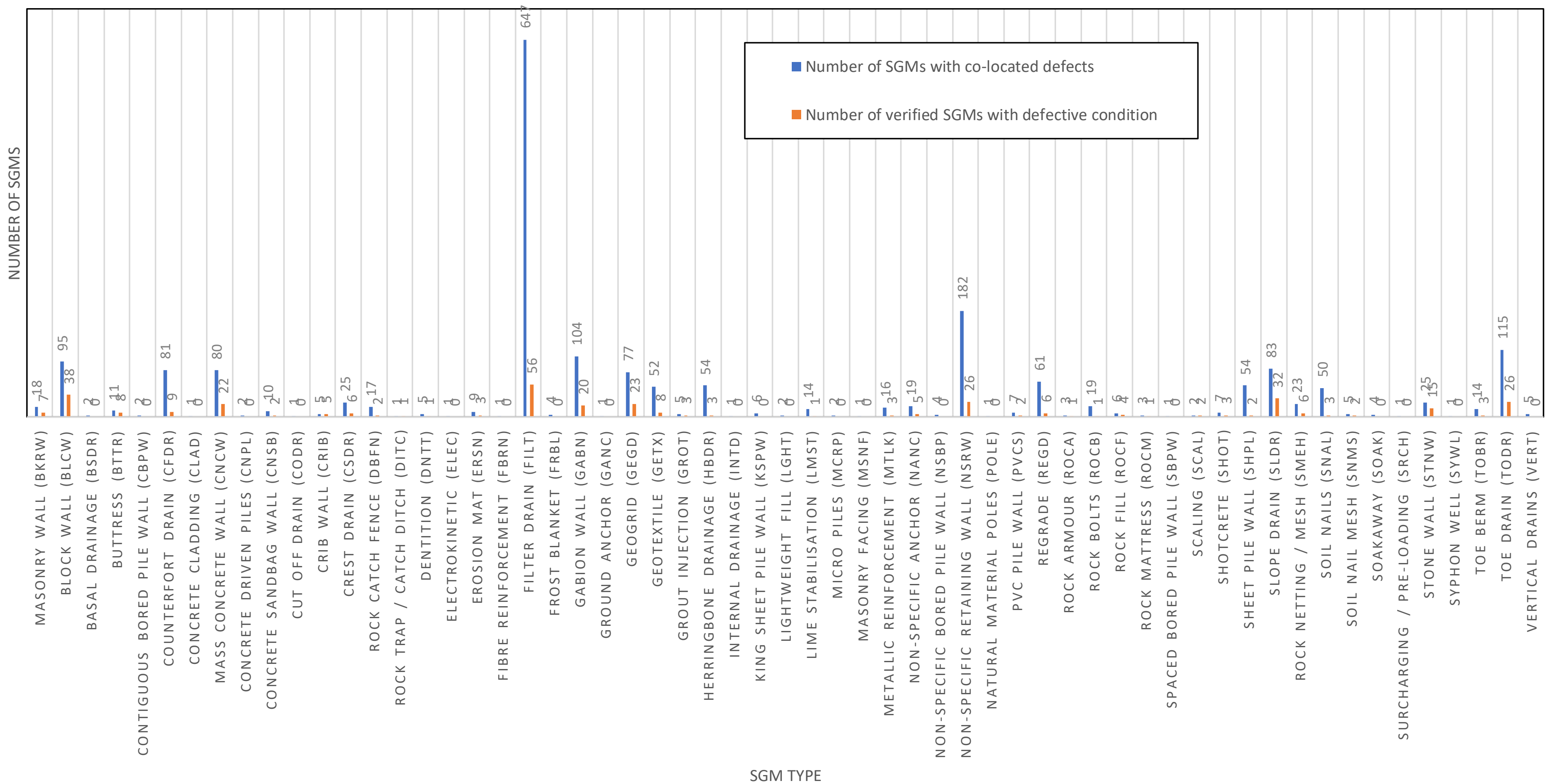


Figure 2.1: Numbers of verified SGMs with co-located defects and SGMs that have been verified as defective (after Atkins/Jacobs, 2020)

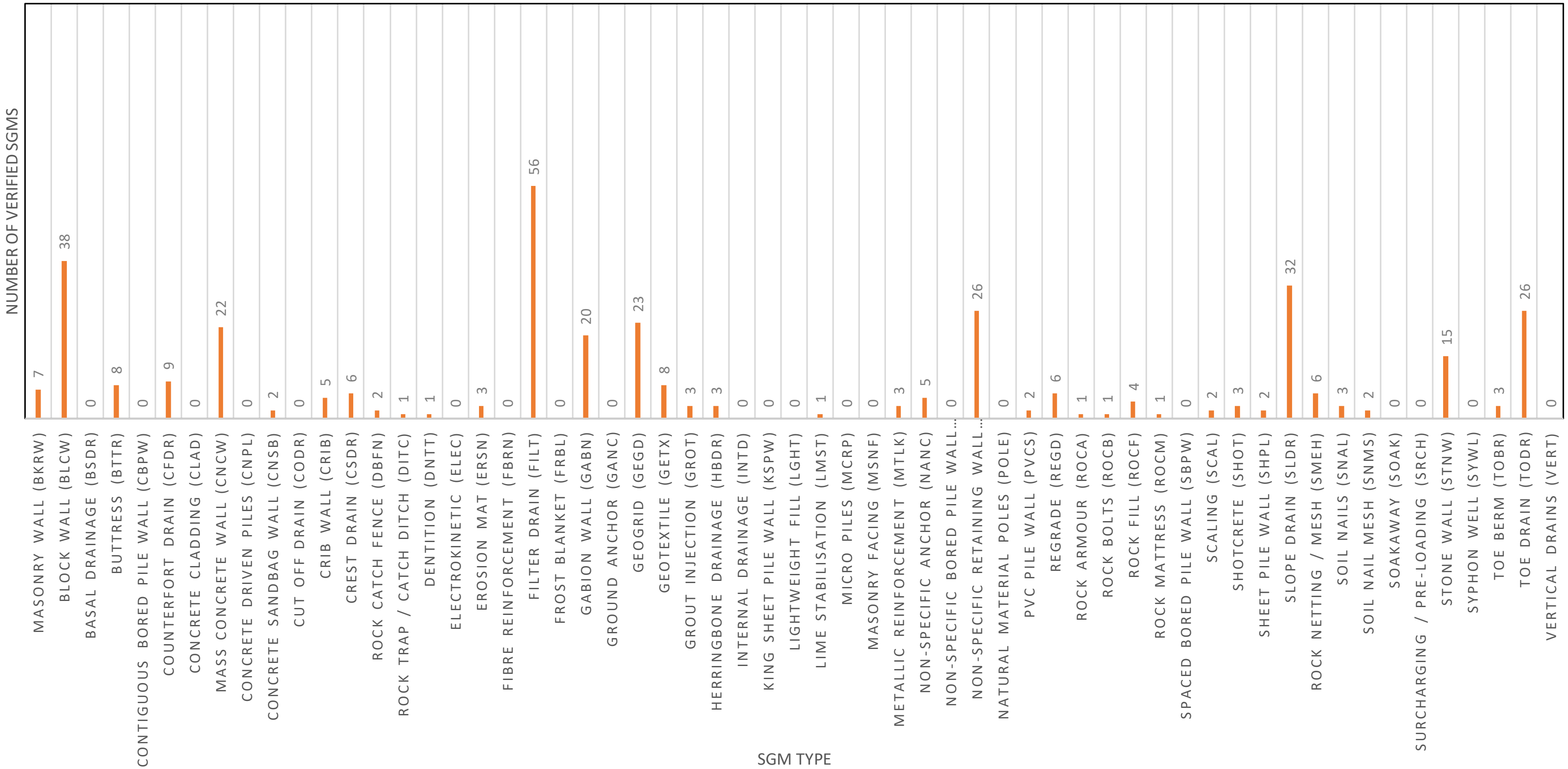


Figure 2.2: Numbers of each SGM that have been verified as defective (drawn from Figure 2.1 but with a larger scale to allow more detail to be resolved) (after Atkins/Jacobs, 2020)

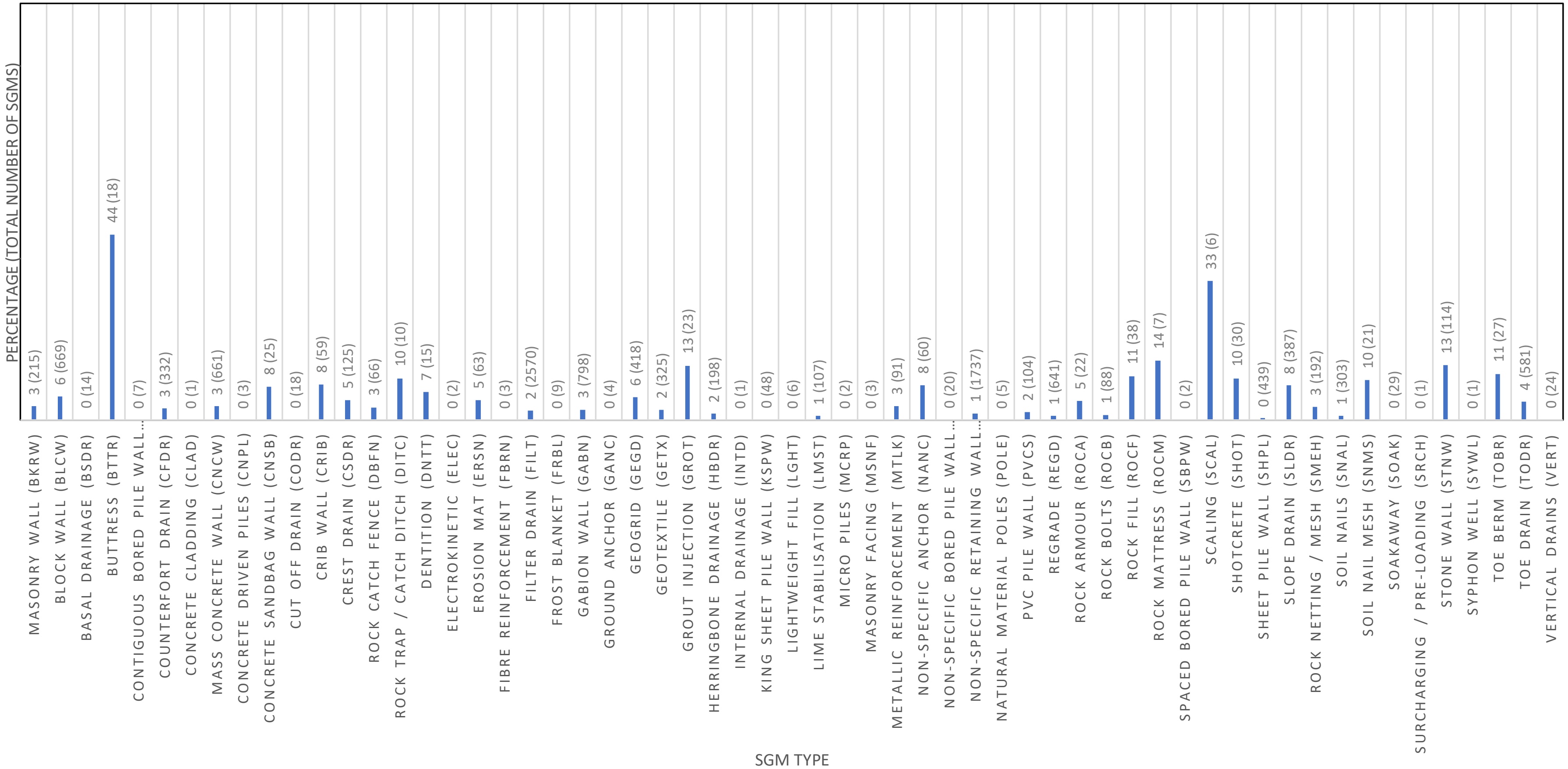


Figure 2.3. Percentages of each SGM that have been verified as defective compared to the total number of each SGM (after Atkins/Jacobs, 2020)

Table 2.1: SGMs classified by which of the categories they appear in in the foregoing lists, number of SGMs, number of SGMs co-located with defects, number of SGMs co-located with verified defects and percentage of SGMs co-located with verified defects

SGM	Number	Co-located	Verified defects	Percentage
Filter Drain (FILT)	x	x	x	
Non-Specific Retaining Wall (NSRW)	x	x	x	
Gabion Wall (GABN)	x	x	x	
Block Wall (BLCW)	x	x	x	x
Mass Concrete Wall (CNCW)	x	x	x	
Regrade (REGD)	x	x	x	
Toe Drain (TODR)	x	x	x	
Sheet Pile Wall (SHPL)	x	x		
Geogrid (GEGD)	x	x	x	x
Slope Drain (SLDR)	x	x	x	x
Geotextile (GETX)	x	x	x	
Counterfort Drain (CFDR)	x	x	x	
Soil Nails (SNAL)	x	x		x*
Masonry Wall (BKRW)	x		x	
Herringbone Drainage (HBDR)	x	x		
Rock Netting / Mesh (SMEH)	x		x	
Crest Drain (CSDR)	x		x	x
Stone Wall (STNW)	x		x	x
Lime Stabilisation (LMST)	x			
PVC Pile Wall (PVCS)	x			
Buttress (BTTR)			x	x
Non-Specific Anchor (NANC)			x	x
Crib Wall (CRIB)			x	x
Scaling (SCAL)				x
Rock Mattress (ROCM)				x
Grout Injection (GROT)				x
Toe Berm (TOBR)				x
Rock Fill (ROCF)				x
Shotcrete (SHOT)				x
Rock Trap / Catch Ditch (DITC)				x
Soil Nail Mesh (SNMS)				x*
Concrete Sandbag Wall (CNSB)				x
Dentition (DNTT)				x
Erosion Mat (ERSN)				x
Rock Armour (ROCA)				x

* Appears as Soil Nail Mesh (SNMS) in the percentage list.

Atkins/Jacobs Consultations

Consultations were undertaken within Atkins/Jacobs and with other asset owners. Figure 2.4 shows an extract from the Task 1-456 Interim Summary Report (Atkins/Jacobs, 2020) detailing the main SGM causes of concern for other asset owners.

Asset owner	SGMs of concern	Cause of issues
Welsh Government	Soil nails, gabions, geotextiles, drainage	Poor design and unsuitable ground conditions. Environmental impacts (i.e. heavy storms)
Network Rail	Soil nails, lime stabilisation, and electrokinetic stabilisation	Most issues are around installation
Transport for London	Counterfort drains, drainage, sheet piles, and other pile based retaining walls	Maintenance of drainage assets and build up of water behind retaining walls
Various AJJV	Soil nails, gabions, and drainage	Mainly related to waterlogging and poor construction

Figure 2.4: Extract showing the summary of asset owner consultations (from Atkins/Jacobs, 2020 Table 5)

What was evident to Atkins/Jacobs (2020) from the consultation was that there are relatively few SGMs which are a problem on the infrastructure network, and they can often be attributed to issues during construction or localised problems. Defects are also more commonly picked up after the occurrence of a significant event; therefore, there is limited knowledge of precursory features which could be potentially monitored.

2.2 Questionnaire Survey

A questionnaire was devised to derive information on problematic SGMs including locations and examples of such SGMs, as well as those that could potentially be subject to forensic investigation in later phases of this project.

The questionnaire was structured so as to allow respondents to describe up to five different SGMs and to give up to five examples of each SGM. It was sent to 72 individuals including National Highways' geotechnical team, members of the Geotechnical Resilience Programme, Smart Motorway Programme Delegates Geotechnical Advisers and the wider Geotechnical Supply Chain. The questionnaires were sent by email and three were undeliverable and one was deemed to be outside their remit by the recipient. A total of nine (9) returns, most of which were joint returns covering approximately 17 respondents, were received describing 16 SGM-types with a total of 52 examples.

National Highways' network is currently structured into a number of Areas for maintenance and improvement. These Areas were updated in January 2020 (Highways England, 2020) and encompass the following:

- South West – Cornwall, Devon, Somerset, Avon, Wiltshire and Gloucestershire (former Areas 1 and 2).
- Area 3 – Hants, Berks, Surrey, Oxon, Dorset, Wilts and part of Bucks.
- Area 4 – Kent, Surrey, East Sussex & West Sussex.

- Area 5 – M25 (including associated link roads, Dartford Tunnel and stubs & tails from M25 to GLA boundary), Berks, Bucks, Herts, Essex, Kent and Surrey.
- Area 6 – Essex, part of Cambridgeshire, Suffolk, Peterborough and Norfolk.
- Area 7 – Leicestershire, Northamptonshire, Derbyshire, Nottinghamshire, Lincolnshire, part of Warwickshire, Rutland and part of Oxfordshire.
- Area 8 – Part of Cambridgeshire, Bedfordshire, Hertfordshire and part of Suffolk.
- Area 9 – West Midlands, Herefordshire, Worcestershire, Shropshire, Staffordshire, Warwickshire and part of Gloucestershire.
- North West – Cheshire, Greater Manchester, Merseyside and Lancashire & Cumbria (former Areas 10 and 13).
- Area 12 – Yorkshire and Humberside Ports Motorways.
- Area 14 – Northumberland, Tyne & Wear, Durham and North Yorks.

Questionnaires were returned from respondents in Areas 3, 4, 5, 6, 7, 9, 12, 14, SW and NW (note that there is currently no Area 11). The respondents comprised a number of roles on the network including Geotechnical Advisers (GAs) and Geotechnical Maintenance Liaison Mangers (GMLEs) for the Operations Areas, and Designers Geotechnical Advisers (DGAs) and the Geotechnical Lead for the Smart Motorways Programme for Major Projects.

The survey was split into two sections (Table 2.2).

Table 2.2: Survey sections

Part 1	• Where a selection could be made of up to five SGM Types that are of concern on the SRN
Part 2	• Where location and project specific details can be added into the questionnaire

The form of the questionnaire is reproduced in Appendix B and the summary results are presented in Appendix C.

Table 2.3 presents the overall number of entries for each SGM Type.

Two responses were received by email, in addition to the questionnaires, with the respondents stating that they had reservations about the construction and longevity of gabions and that gabions have caused problems previously both for National Highways and other asset owners. These have been included in brackets in the Table 2.3.

Table 2.3: Summary of the number of entries in the questionnaire for each SGM Type

SGM Category	SGM Sub-Category	SGM Type & Quad Code	No. of Entries
Drainage	Drainage	Counterfort Drain (CFDR)	11
		Filter Drain (FILT)	4
Earthworks	Ground Improvement	Grout Injection (GROT)	3
	Material Modification (Soil Mixing)	Lime Stabilisation (LMST))	3
	Material Replacement	Rock Fill (ROCF)	1
		Tyre Bales (TYRB)	1
	Reprofiling	Regrade (REGD)	8
	Rock Cut Management	Rock Netting / Mesh (SMEH)	2
		Shotcrete (SHOT)	1
	Strengthened Earthwork	Electrokinetic (ELEC)	1
		Ground Anchor (GANC)	2
		Soil Nails (SNAL)	6
Structures	Piles	Sheet Pile Wall (SHPL)	2
	Retaining Walls	Block Wall (BLCW)	1
		Gabion Wall (GABN)	3 (2)
		Stone Wall (STNW)	3

2.2.1 Discussion on Part 1 Responses

Part 1 of the survey related to general concerns regarding Types of SGMs. Examples included the following:

- Why does this SGM give cause for concern?
- Where do your concerns and issues lie with this SGM?
- Where are the main gaps in knowledge of the performance and behaviour of this SGM?

A total of 23 Part 1 responses were given from the nine returns. Of these 23, 16 individual SGM Types (see Table 2.3) were identified as causing a concern to the SRN.

Counterfort Drains (CFDR), Ground Anchors (GANC), Regrade (REGD), Rock Netting/Mesh (SMEH) and Soil Nails (SNAL) were the only types to be selected by more than one respondent. Counterfort Drains were selected in three of the questionnaires (one from Area 3, one from Area 4 and one from a questionnaire which covered Areas 3, 7, 9 and SW). Regrades were selected in two of the questionnaires (one from Area 3 and one from SW). Ground Anchors were selected in two of the questionnaires (one from Area 4 and one from NW). Rock

Netting/Mesh was selected in two of the questionnaires (one from Area 4 and one from a questionnaire covering Areas 12 and 14). Soil Nails were selected in two of the questionnaires (one from Area 4 and one from a questionnaire covering Areas 4 and 5).

Causes of Concern

There were a number of options given in the questionnaire for why the SGM gives cause for concern. The results for this are presented in Figure 2.5.

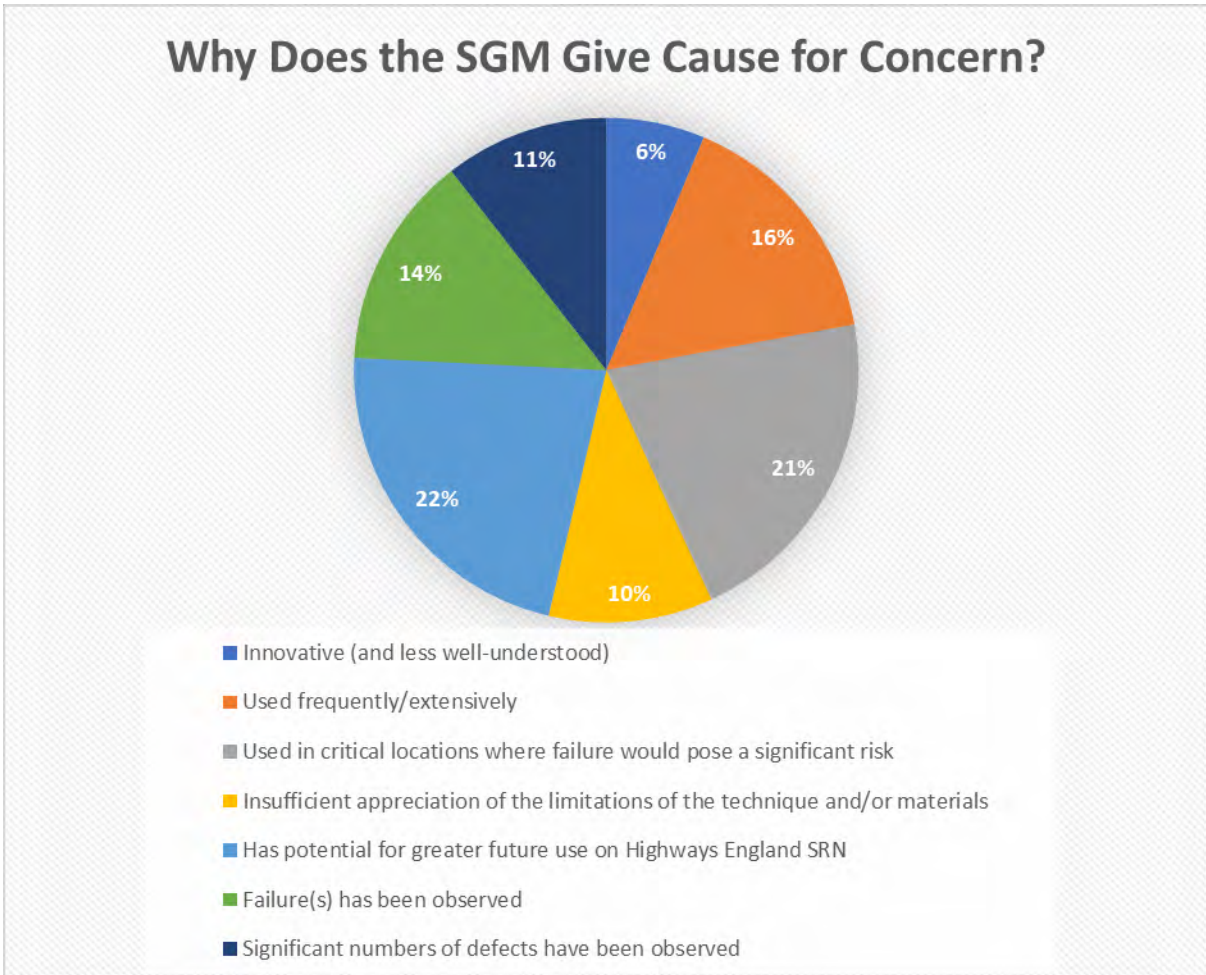


Figure 2.5: Percentages of causes of concern regarding SGMs

A significant number (six) of the respondents stated that they were concerned as the SGM was innovative and less well understood; these concerns were related to Tyre Bales, Electrokinetic, Ground Anchors, Soil Nails and Sheet Pile Walls. This is an interesting observation as Ground Anchors, Soil Nails and Sheet Pile Walls have been used in remediation of slopes for several decades, in the case of Soil Nails for almost 30 years and are SGMs that would not necessarily be thought of as innovative. The reasons for such SGMs being considered innovative and less well understood are not clear, but they may relate to:

- Lack of exposure to such SGMs through either training or experience.

- Lack of knowledge of 'what has been installed', 'why the work was undertaken' and how it is performing, due to a lack of design/construction records and key elements being 'hidden elements' which are not readily accessible for inspection and testing.

In the case of ground anchors, for example, this might relate to the ground conditions extant in their geographical area.

Fifteen of the responses said that a concern was that the SGMs were used frequently or extensively across the network. Extensive use of an SGM implies that if there are problems then these are likely to be extensive and high in number and associated with a proportionately high risk and cost. Counterfort Drains, Regrades, Rock Netting/Mesh and Soil Nails were selected at least twice by different respondents.

Twenty of the responses said that a concern was that the SGMs were used in critical locations where failure would pose a significant risk. Only Tyre Bales and Block Walls did not feature in this category and Counterfort Drains, Regrades, Rock Netting/Mesh, Ground Anchors and Soil Nails were selected by at least two different respondents.

Ten of the responses said that a concern was that there is insufficient appreciation of the limitations of the technique and/or materials relating to the SGM. This was selected for Counterfort Drains (selected by two respondents), Rock Fill, Regrades, Shotcrete, electrokinetic, Ground Anchors, Soil Nails, Sheet Pile Walls and Stone Walls.

Twenty-one of the responses thought the SGM has potential for greater future use on the National Highways SRN. All of the 16 SGM types were selected with the exception of sheet pile walls.

Thirteen of the responses were for SGM types where failures have been observed. These include Counterfort Drains, Filter Drains, Rock Fill, Regrades, Rock Netting/mesh, Soil Nails, Sheet Pile Walls, Gabion Walls and Stone Walls. SGM types Counterfort Drains, Regrades and Soil Nails were selected by at least two respondents.

Ten of the responses were for SGM types where significant numbers of defects have been observed. The same SGM types were identified as where failures have been observed with the exceptions of Rock Fill and Rock Netting/Mesh which were not identified as having significant number of defects, and ground anchors which were identified as having a significant number of defects, but no failures observed. It is interesting that Ground Anchors were selected as having significant numbers of defects, but no failures observed. It may be possible that this was an error in the completion of the sheet or that the respondent only considers failure to be a total failure of the slope or SGM.

The respondents were also given the opportunity to explain why they thought the SGM was a cause for concern. These comments are presented in Table 2.4.

Concerns Related to Phase of Work

Within the response for Part 1 there is a section that relates to concerns with specific phases of the SGM lifecycle. This considers whether the concern, or issues, lie within the Design, Specification, Construction, Maintenance or Resilience of the SGM and where the main gaps in knowledge occur. It was acceptable within the questionnaire to select more than one option. An extraction of the results for this part of the questionnaire is presented in Table 2.5.

Table 2.4: Respondent comments regarding other reasons why the SGMs give cause for concern (Part 1 of the questionnaire) (continued …)

SGM Type	Concerns/Issues from the Respondent
Counterfort Drain (CFDR)	*"Counterfort drains are present along the network, however the majority of instances their location is only inferred from as built drawings. Historically little to no maintenance has been undertaken on counterfort drains unless as part of larger schemes."* *"Unless designed with carrier pipe & filter wrap, the efficiency declines after 10-15 years, requiring difficult maintenance."*
Filter Drain (FILT)	*"No routine inspection of the filter drains are undertaken, only reactive to either flooding events or geotechnical failures. As such poor condition filter drains which are causing or contributing to geotechnical defects are not identified until after failure occurs. Better inspection/maintenance could reduce the risk to the geotechnical asset"*
Grout Injection (GROT)	*"Main concern is about achieving full void penetration and proving the effectiveness of the grout injection. In some examples, the issue is also caused by drainage, but unless that is also repaired the solution is only partially effective."*
Lime Stabilisation (LMST)	*No response relating to concerns.*
Rock Fill (ROCF)	*"Please note this refers to granular replacement more generally (e.g. use of 1A/6N/6F5 etc.), not specific to rock fill i.e. granular shoulder replacement / full height granular repairs. Not sure whether other instances have been identified."*
Tyre Bales (TYRB)	*"main concern is about practicality and difficulties of production and construction."*
Regrade (REGD)	*"Historic regrades are present but with limited as built information. Failures have occurred in locations of over-steepening."* *"Solution perceived as low cost & simple but it often not robust enough and repeat failures occur."*
Rock Netting / Mesh (SMEH)	*"Misunderstanding of compatibility of meshes from different manufacturers."*
Shotcrete (SHOT)	*"Risk identified post construction inspections."*
Electrokinetic (ELEC)	*"Lack of certainty over long term performance and relationship to drainage condition often overlooked. Potentially not a solution in isolation."*
Ground Anchor (GANC)	*"Major infrastructure element with no maintenance record."*

Table 2.4 (… continued): Respondent comments regarding other reasons why the SGMs give cause for concern (Part 1 of the questionnaire)

SGM Type	Concerns / Issues from the Respondent
Soil Nails (SNAL)	*"Hybrid Reinforced Soil and Soil Nailed slope with topsoil gabion face." – Not necessarily a comment on concern.*
Sheet Pile Wall (SHPL)	*"Several sheet piled walls and solutions have limited as built information, including dates of construction."*
Block Wall (BLCW)	*No response relating to concerns.*
Gabion Wall (GABN)	*"Gabion fill often settles, leading to distortion. Poor quality filling. Wash out of fines in water environments. Difficult to repair defects."*
Stone Wall (STNW)	*"Often have little design basis. Often of considerable age. Construction details often unknown."*

Table 2.5: Extraction of the questionnaire results indicating the responses regarding the concern with specific phases of the SGMs

	Concerns and issues with this SGM.					Main gaps in knowledge of SGM performance and behaviour				
SGM Type	**Design**	**Specification**	**Construction**	**Maintenance**	**Resilience**	**Design**	**Specification**	**Construction**	**Maintenance**	**Resilience**
Counterfort Drain (CFDR)	3	3	2	3	3	0	1	2	2	2
Filter Drain (FILT)	0	0	1	1	1	0	0	1	1	1
Grout Injection (GROT)	1	1	1	1	1	0	0	1	0	0
Lime Stabilisation (LMST)	0	0	1	0	0	0	0	0	0	0
Rock Fill (ROCF)	1	0	1	0	1	1	0	1	0	1
Tyre Bales (TYRB)	1	0	1	0	1	0	1	1	1	1
Regrade (REGD)	3	1	1	0	2	1	0	2	0	2
Rock Netting/Mesh (SMEH)	1	1	0	2	2	0	1	0	2	1
Shotcrete (SHOT)	1	1	1	1	1	1	1	1	0	1
Electrokinetic (ELEC)	1	1	1	1	1	1	1	1	1	1
Ground Anchor (GANC)	0	0	0	2	2	1	0	1	2	2
Soil Nails (SNAL)	1	1	1	2	3	1	1	1	2	3
Sheet Pile Wall (SHPL)	1	1	1	1	1	1	1	1	1	1
Block Wall (BLCW)	0	0	0	1	1	0	0	0	1	1
Gabion Wall (GABN)	0	1	1	1	1	0	1	1	1	1
Stone Wall (STNW)	1	0	0	1	0	0	0	0	1	1
TOTAL	15	11	13	17	21	7	8	14	15	19

Severity of Concerns

There were three options given for the severity of concerns, as set out in Table 2.6.

Of the Part 1 responses, six (29%) SGMs were rated as a Minor concern, 12 (57%) as an Intermediate concern and three (14%) as a Major concern. The SGM types recorded as a Major concern were Filter Drains, Rock Netting/Mesh and Ground Anchors.

Table 2.6: Options for severity of concern given in the questionnaire

Minor	• Visual or otherwise observable but no indication of risk to people or the operation of the SRN.
Intermediate	• Such that intervention and/or non- routine maintenance is required.
Major	• A defect that poses a threat to the safety of users, workers or other parties such that immediate action is required.

Of the 23 responses to 'Concerns and Issues' with this SGM in Part 1, the only SGMs not thought to have a problem with resilience are lime stabilisation and stone walls. Whilst there is an overwhelming concern with the resilience of the SGMs, the other phases of work are also thought to be a concern with at least 50% of SGMs being selected in each category with the exception of specification.

Of the 23 responses to 'Main gaps in knowledge of the performance and behaviour of this SGM' the only SGMs not thought to have a problem with resilience are lime stabilisation and grout injection.

Electrokinetic, Soil Nails and Sheet Pile Walls are all thought to have problems relating to the design, specification, construction, maintenance and resilience of the SGM. The responses for Counterfort Drains, Shotcrete, Gabion Walls, Tyre Bales, Regrades and Rock Netting/Mesh also indicate that there are major concerns with the majority of phases of the SGM lifecycle.

2.2.2 Discussion of Part 2 Responses

Part 2 of the questionnaire allowed the respondent to select up to five example cases of each SGM type where they have had problems on the SRN. In this section they were able to give the location of the SGM, the DMRB HD 41/15 classifications (since replaced by CS 641 but referred to as HD 41/15 here as that document was extant at the time of the survey), report references, access details, planned works and a description of the defects, issues, concerns and problems associated with the SGM.

A summary of the results is presented in Appendix C.

Locations

As stated previously in Section 2.2 there were 52 examples of SGMs given in the questionnaire responses, spread between 16 SGM types. The Eastings and Northings given for each SGM example have been used to determine which Area for maintenance it falls within. The Areas have been based upon the July 2019 Network Management map (Highways England, 2020). Table 2.7 highlights which SGM types are of concern in which Areas.

The SGMs that appear to exhibit the most widespread problems include Counterfort Drains, Grout Injection, Regrades, Rock Netting/Mesh, Ground Anchors, Soil Nails and Gabion Walls which are all of concern in at least two maintaining Areas.

Table 2.7: Locations of the SGM types across the SRN and maintenance Areas

SGM Type	Area	Region	No. of Examples
Counterfort Drain (CFDR)	3	South East	3
	4	South East	4
	7	East Midlands	3
	9	West Midlands	1
Filter Drain (FILT)	3	South East	4
Grout Injection (GROT)	3	South East	1
	SW	South West	1
	6	East	1
Lime Stabilisation (LMST)	4	South East	3
Rock Fill (ROCF)	SW	South West	1
Tyre Bales (TYRB)	7	East Midlands	1
Regrade (REGD)	3	South East	6
	SW	South West	2
Rock Netting / Mesh (SMEH)	4	South East	1
	14	North East	1
Shotcrete (SHOT)	14	North East	1
Electrokinetic (ELEC)	9	West Midlands	1
Ground Anchor (GANC)	4	South East	1
	NW	North West	1
Soil Nails (SNAL)	4	South East	5
	14	North East	1
Sheet Pile Wall (SHPL)	3	South East	2
Block Wall (BLCW)	4	South East	1
Gabion Wall (GABN)	3	South East	1
	9	West Midlands	2
Stone Wall (STNW)	SW	South West	3

HD 41/15 (CS 641) Classifications

HD 41/15 (DMRB HD 41/15 has now been replaced by CS 641 but it was used for this project as it was extant at the start of the study), provides best practice guidance for the inspection and maintenance management of the highway Geotechnical Asset and part of this is the assessment and grading of features. An option was given in Part 2 of the questionnaire to select a Feature Class and a Feature Location Index which together provide an Initial Feature Grade Assessment for the SGM example.

Of the 52 SGM examples, 46 were given an Initial Feature Grade, 45 were given a Subsequent Feature Grade and the higher of the two was selected as the final HD 41/15 (CS 641) Feature Grade (these are shown in Figure 2.6).

The HD 41/15 (CS 641) Feature Grades are used to determine the recommended geotechnical intervention with Feature Grade 5 having the highest priority and Feature Grade 1 the lowest. Table 2.8 shows the recommended geotechnical interventions given in HD 41/15 (CS 641) for each Feature Grade.

A Feature Grade of 5 was recorded for SGM examples within Counterfort Drains (one), Grout Injection (one), Regrades (two), Rock Fill (one) and Rock Netting/Mesh (one). All of the Feature Grade 5s had a Feature Class of 1A 'Major Defects' and 33% of them had a Location Index A which are assets that ensure the safety of users, workers or other parties, or safeguard the environment (DMRB HD 41/15, CS 641).

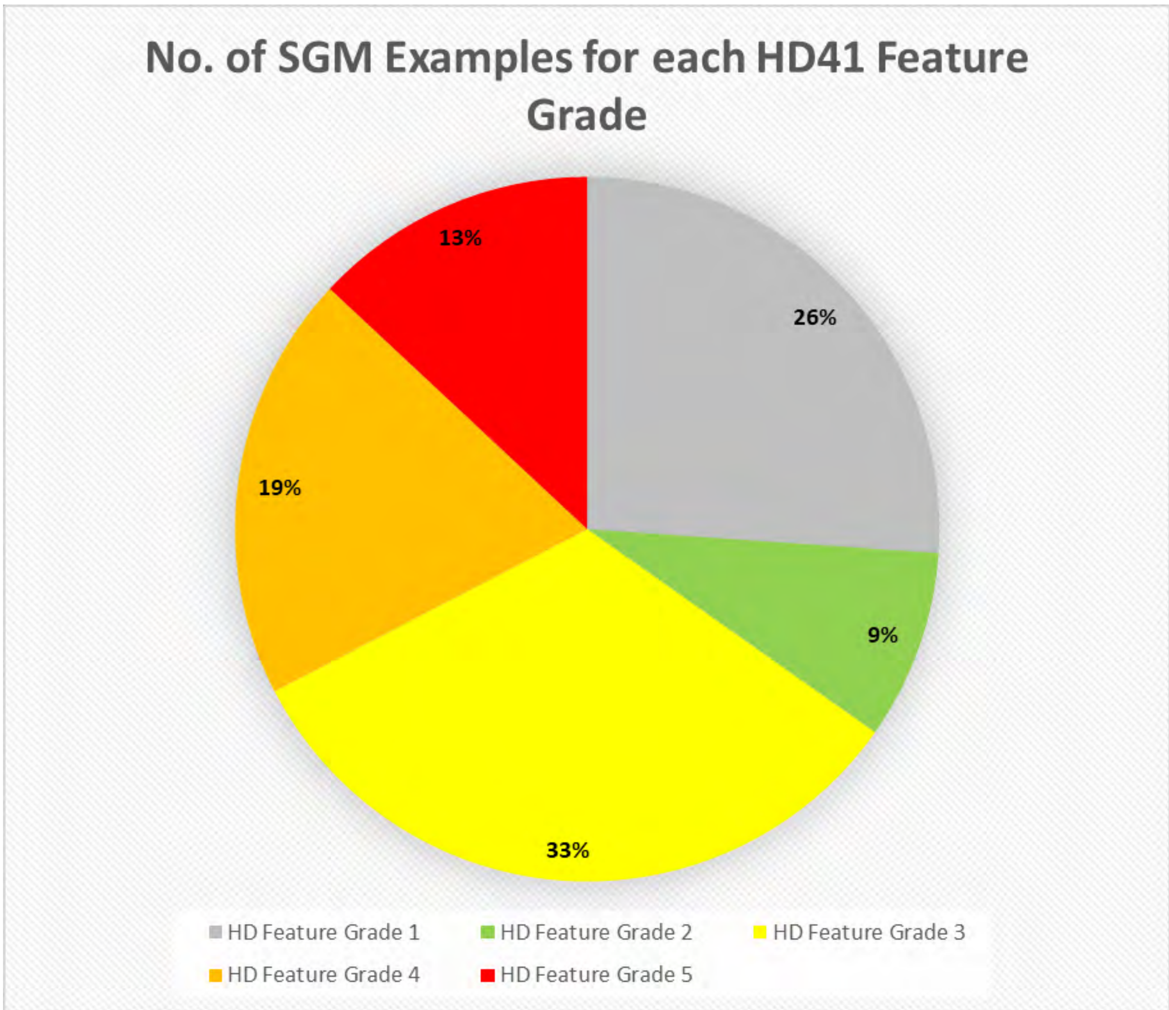


Figure 2.6: Percentages of SGM examples within each Feature Grade

Table 2.8: Recommended geotechnical interventions from DMRB HD 41/15 (CS 641) for each Feature Grade

Feature Grade	Recommended intervention
5	•Timely intervention to ensure safety should be undertaken. •Remedial intervention should be programmed typically within one year. •Assess inspection and monitoring requirements. Contingency planning required in preparation for any accelerated deterioration.
4	•Remedial or preventative intervention should be programmed typically within 5 years. Assess inspection and monitoring requirements. Contingency planning required in preparation for any accelerated deterioration.
3	•Remedial intervention not generally required within 5 years however remedial or preventative intervention may be programmed as part of other schemes.
2	•Remedial intervention is not required, but preventative intervention may be required. Works do not need to be programmed and may be done as part of other schemes.
1	•Remedial or preventative intervention is not required.

Planned Work

An option was given in Part 2 of the questionnaire to state if works were planned at the site and if they were, was the plan to excavate or remove the SGM. Locations where excavation or removal of the SGM is planned may be used as an opportunity for forensic investigation.

Of the 52 SGM examples, 25 of the sites have planned work and of these 14 are planning to excavate or remove the SGM. These include Counterfort Drains, Gabion Walls, Regrades, Rock Fill, Rock Netting/Mesh and Sheet Pile Walls.

2.2.3 SGMs Causing Concerns

Following review of the questionnaire data the Project Team discussed the overall results to determine the SGMs that are causing concern on the network and these are reported in Appendix D and Appendix E. A short summary of each one is given below.

Block Walls were selected by one respondent who had concerns with their maintenance and resilience.

Counterfort Drains were selected by several respondents indicating that problems are widespread. The concerns expressed relate to design, specification, construction, maintenance and resilience so may be viewed as all-encompassing.

Electrokinetic has been identified in the questionnaire as there being an insufficient appreciation of the limitations of the technique and/or materials. This SGM was one of the measures examined as part of Task 1-147 Innovative Geotechnical Repair Techniques (Nettleton et al., 2018).

Filter Drains have only been indicated to be a problem by Area 3 and there are concerns with the fact there are no routine inspections or maintenance and that they have insufficient flow capacity.

Gabion Walls have been selected by several respondents indicating that problems are widespread. The responses indicate that some of the Gabion Walls are in critical locations where failure may pose a significant risk to the network and that defects and failures have occurred.

Ground Anchors were selected by two respondents, and they are thought to be of 'Major' concern as the defect identified poses a threat to the safety of users, workers or other parties such that immediate action is required and that they are used in critical locations where failure would pose a significant risk. There are concerns with their maintenance and resilience.

Grout Injection was indicated to be a problem in three responses and the main concerns raised are over the perceived lack of knowledge on how to install it effectively; and once installed, how to test that it has successfully filled the voids.

Lime Stabilisation has been selected as an SGM being used on the network but there were no issues identified with it.

Regrades were selected by several respondents indicating that problems are widespread. The responses indicate that the regrades are used frequently on the network and some of these are in critical locations where failure may pose a significant risk to the network and that there are concerns with the design, specification, construction and resilience of the SGM.

Rock Fill was indicated to be a problem in one location and there were concerns with the design, construction and resilience of the SGM; however, this same slope was also reported as a Regrade and possibly falls into that SGM type.

Rock Netting/Mesh is indicated by responses to be of 'Major' concern as the identified defect poses a threat to the safety of users, workers or other parties such that immediate action is required. There are concerns with the design, specification, maintenance and resilience of the netting/mesh.

Sheet Pile Walls are only indicated to be a problem in Area 3 and there are concerns with the design, specification, construction, maintenance and resilience of the SGM.

Shotcrete was only selected by one respondent and there were concerns with the design, specification, construction, maintenance and resilience of the SGM.

Soil Nails have been selected by several respondents indicating that problems are widespread. The responses indicate that some of these Soil Nails are in critical locations where failure may pose a significant risk to the network and that numerous defects and failures have occurred.

Stone Walls were only indicated to be a problem in questionnaires returned from the South West and the concerns are with their design, maintenance and resilience. A big worry with the walls is that they are often of unknown age and are used in situations where they are not fit for purpose.

Tyre Bales were indicated to be a problem in one location; however, the concerns with the installation are actually part of the design indicating that the designer was not familiar with Tyre Bales and how they should be used in this case.

2.3 Opportunities for Forensic Investigation

As part of the project scope, one of the main tasks was to identify opportunities to undertake forensic examination of the SGMs including exhumation of elements to determine the validity of the existing design, specification and application guidance. The original plan was to use the results of the questionnaire together with locations where SRN Major Projects and Operational Renewals were planned in the next few years to determine the locations for examination. The Road Investment Strategy 2 (RIS2) commenced in 2020 (and runs to 2025) and identifies locations for major works over that period. This had the scope to afford additional opportunities to examine and/or exhume SGMs, although it was anticipated that relatively few RIS2 schemes would reach construction stage during the currency of this project.

As discussed in Section 2.2, the questionnaire gave the option to state if works were planned at the site; and if so, to detail the timing of the plan to excavate or remove the SGM. Of the 52 SGM examples, 25 of the sites have planned work and of these 14 are planning to excavate or remove the SGM. A correlated list of identified categorised SGMs and locations with the potential for forensic examination is presented in Appendix D (this list, from the questionnaire survey, includes Counterfort Drains, Gabion Walls, Regrades, Rock Fill, Rock Netting/Mesh and Sheet Pile Walls).

2.4 Additional Asset Owner Consultations

The project team undertook consultations with other asset owners including Transport Scotland and Network Rail. A summary of the consultations is provided in Appendix F.

One of the main concerns of the asset owners is drainage, specifically regarding maintenance of drainage particularly linked to legacy drainage systems where installation/construction details, and sometimes location details, are unknown.

Other causes of concern are the lack of evidence for long term performance/durability of SGMs particularly with regards to Soil Nails and Reinforced Soil.

2.5 Selection of SGMs for Further Study

A long list of potential SGMs for further evaluation was determined from the analysis of SGM statistics and the SGM questionnaire. These were listed along with some commentary on the inclusion or otherwise of each SGM into a shortlist for discussion with National Highways. This list, as prepared by the project team from the survey and precursor work as well as the view from within the team, is as follows:

- Block Wall (BLCW) – included in shortlist as although not evidenced to be a major problem from the questionnaires, this was picked up during the Atkins/Jacobs work in Task 1-456 (Atkins/Jacobs, 2020).
- Counterfort Drain (CFDR) – included in short-list.
- Electrokinetic (ELEC) – do not include as covered in the IGRT project (Nettleton et al., 2018).
- Filter drain (FILT) – included in short-list.
- Gabion Wall (GABN) – included in short-list.
- Ground Anchor (GANC) – do not include as not evidenced to be a major/widespread problem.
- Grout Injection (GROT) – do not include as not evidenced to be a major/widespread problem.
- Lime Stabilisation (LMST)) – do not include as not evidenced to be a major/widespread problem.
- Regrade (REGD) – included in short-list.
- Rock Netting/Mesh (SMEH) – do not include as not evidenced to be a major/widespread problem.
- Rock Fill (ROCF) – do not include as the issues raised do not really confirm problems. The one problem identified could be included under Regrade.
- Sheet Pile Wall (SHPL) – do not include as not evidenced to be a major/widespread problem.
- Shotcrete (SHOT) – do not include as not evidenced to be a major/widespread problem.
- Soil Nails (SNAL) – included in short-list.
- Stone Wall (STNW) – do not include as not evidenced to be a major/widespread problem. In addition, such features are unlikely to be used in future works as SGMs, most likely being used for landscape-related features for visual/aesthetic reasons.
- Tyre Bales (TYRB) – do not include, the issues raised seem to make it clear that the available guidance on design, specification and construction was either not followed or is presented out of context and is about issues wider than tyre bales.

The shortlist was discussed with National Highways and it was considered somewhat surprising, given previous discussions with the National Highways Geotechnical Community, that Reinforced Soil (usually Metallic Reinforcement) was not included. Likewise, Geotextiles/Geogrids but there is some confusion as to the SGM status of these as Geotextiles and Geogrids are components of SGMs, not SGMs as such.

A large number of conversations have been conducted around the issue of SGMs and their defects within the National Highways geotechnical community, not least at the Geotechnical Supply Chain Engagement Event in October 2018. In many of these conversations it was clear that Soil Nails and Gabion Walls were a frequent issue for those charged with operating and maintaining the network. It is therefore unsurprising that these SGMs have been shortlisted.

Regrades were highlighted in the questionnaire results as being of interest, making up 15% of the 52 SGM examples given; however, these had not been flagged as a major problem within Task 1-456 and they are not perceived to be a major issue internally within National Highways. The project team has come across a number of slope failures related to the construction of Regrades both on the SRN and for other asset owners. Therefore, it was concluded that Regrades should still be included as one of the SGMs for potential further study, albeit that it is acknowledged that it is unlikely that Regrades will be subject to forensic investigation as part of potential future work.

The discussions with National Highways resulted in the following SGMs (along with their definition provided by Atkins/Jacobs, 2020), that are considered to be of paramount importance, being selected for further study:

- Counterfort Drains (CFDR) – Gravel-filled drains extending to full earthwork depth/height.
- Block Walls (BLCW) – Precast concrete modular block gravity walls.
- Gabion Walls (GABN) – Gabion gravity retaining walls.
- Regrade (REGD) – Earthworks repair comprising conventional fill, typically regraded to an angle shallower than the original construction.
- Reinforced Soil solutions including components of:
    - Metallic Reinforcement (MTLK) – Metallic reinforcement such as straps or mesh, usually used in conjunction with a facing system for strengthened earthworks.
    - Geogrids (GEGD) – Slopes of any angle reinforced using geosynthetic grids which interlock with the fill material.
    - Polymeric straps are included in this category.
- Soil Nails (SNAL) – Slopes of any angle reinforced using soil nails, except where any facing mesh actively contributes to stability.

The schema provided by Atkins/Jacobs (2020) stated that the search term for Block walls (BLCW) included ‘walls’ so other types including slab-on-edge. breeze block and stone walls have also been returned within the Block Wall results.

3 Evaluation of the Adequacy of Available Guidance

3.1 Available Guidance for the Selected SGMs

The six SGMs selected for potential further study in Section 2 are Counterfort Drains (CFDR), Block Walls (BLCW), Gabion Walls (GABN), Regrades (REGD), Geogrids (GEGD) and Metallic Reinforcement (MTLK) as components of Reinforced Soil solutions (including polymeric straps), and Soil Nails (SNAL).

Existing standards and guidance documents for the selected SGMs include sources such as British Standards, CIRIA guides, National Highways documents, TRL reports and those available to other industry sectors with infrastructure assets, for example, Network Rail. Some of the documentation reviewed gives overarching design philosophies and approaches, rather than detailed design guidance for a specific SGM type.

When undertaking design and specification of the selected SGMs, reference would be made initially to those documents specifically applicable to highways works, the Design Manual for Roads and Bridges (DMRB) and the Specification for Highway Works contained within the Manual of Contract Documents for Highway Works (MCHW Volumes 1 and 2). Following this, the expected hierarchy of reference documentation would be British Standards, CIRIA documents, and published TRL reports.

Table 3.1: Matrix of information available for each SGM type

Document Source:	National Highways (MCHW/ DMRB)			British Standards			CIRIA			TRL			Network Rail		
Guidance on:	D	S	C	D	S	C	D	S	C	D	S	C	D	S	C
Block Walls															
Counterfort Drains															
Gabion Walls															
Regrades															
Reinforced Soil															
Soil Nails															

Key:	
D - Design	
S - Specification	
C - Construction	

These sources vary in the information supplied and the matrix shown in Table 3.1 illustrates the range of information available for the selected SGMs across the different information sources. These are split further into specific documents, along with the level of information provided, for each SGM in the following sections. The guidance documents presented in the tables have been limited to national and asset owner standards and research facilities. Other information is available in technical and research papers, and books and these are referenced where relevant. The following sections were developed as part of Phase 1 of the work and built upon for the Information Notes for each of the critical SGMs (Duffy-Turner et al., 2022a, 2022b; Netttleton et al., 2022; Winter et al., 2022a, 2022b).

3.2 Counterfort Drains

3.2.1 Background

Counterfort Drains (CFDR), defined as *gravel-filled drains extending to full earthwork depth/height*, have been used since the first half of the nineteenth century (Hutchinson, 1977) to stabilise embankments and cuttings with high groundwater pressures (Macdonald et al., 2012; Bromhead, 1984; Hutchinson, 1977).

Counterforts are also commonly used in conjunction with Crest Drains, Slope Drains (Herringbone Drains) and Toe Drains to provide both surface and groundwater drainage for slopes (Burland et al., 2012). Where counterforts are backfilled with rock fill they can be used to provide strengthening or 'buttressing' to earthworks and are also known as Rock Ribs (Hutchinson, 1977).

It should be noted that separate SGM types have been defined for Herringbone Drains (HBDR), Slope Drains (SLDR) and Rock Ribs (RIBS) within the drainage SGM category (for definitions, see Appendix A).

Counterfort Drains usually run down the 'fall line' of slopes, i.e. the line of greatest slope which is usually perpendicular to the crest of the slope (e.g. Figure 3.1). They are typically 0.6m to 1.2m wide trenches (Figure 3.2) which are normally lined and covered with a geotextile filter/separator, to prevent erosion in the slope and silting up of the drain. Older examples may have a granular filter material rather than geotextile. They are usually filled with stone or granular backfill and may have a slotted 'collector' pipe laid in the base.

Counterforts are typically between 2m and several metres deep and are often designed to penetrate below known slip planes to drain them. Counterfort Drains can provide an additional buttressing effect when installed at relatively close spacings of between 5m and 10m (Macdonald et al., 2012), indeed Hutchinson (1977) specifically defined Counterfort Drains as: "*…drains which penetrate into solid ground beneath a slip surface, and therefore also provide some mechanical buttressing to the slope…*".

Counterfort Drains are commonly used to address problems as they arise during the construction of infrastructure embankments and cuttings and as emergency remedial works on existing embankments and cuttings (reparative design) (Figures 3.3 and 3.4).

3.2.2 Issues Experienced

Based on the questionnaire issued to the National Highways geotechnical teams and supply chain the following issues were identified:

1. Lack of as built records with locations or basis of design.
2. On-site Counterfort Drains not locatable.
3. No ‘collector’ pipes.
4. Erosion of/adjacent to Counterfort Drains.
5. Clogging (silting up) of filter encountered on site (Figure 3.5). This correlates well with the authors’ experiences of the use of standard geotextile filter/separator products being specified and used, based on published or in-house standard design details, often with little consideration of the soils.
6. Build-up of vegetation within the Counterfort Drains leading to a lack of functionality (Figure 3.6).

Figure 3.1: Construction of a Counterfort Drain on a steep slope (26°) above a live railway line on the Cumbrian Coast Railway. The counterfort is being constructed using a Menzi Muck slope climbing excavator with a winch line (image the authors)

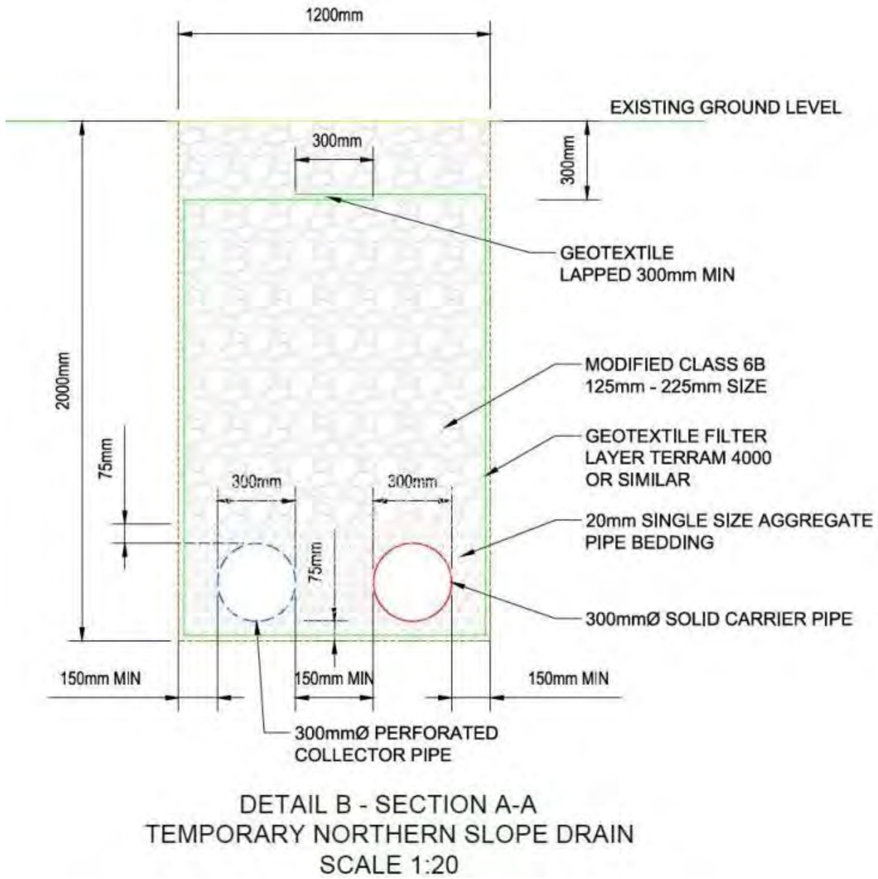


Figure 3.2: Example of a site specific Counterfort Drain detail to deal with water from a crest cut-off drain via a carrier pipe and also to expedite water picked up by the counterfort getting out of the counterfort via the collector pipe (drawing the authors)

Figure 3.3: Regraded slope on the Cumbrian Coast Railway with Counterfort Drains. The upper slope is clayey till and the lower slope is glacial sand believed to be an esker. The counterforts also have slope (herring bone) drains to pick up localised water. The slope drain on the second counterfort from the left is just evident on the completed slope in Figure 3.4 (image the authors)

Figure 3.4: Regraded slope on the Cumbrian Coast Railway with Counterfort Drains. The upper slope above the rock fill blanket is clayey till and the area covered by the rock fill blanket is glacial sand (believed to be an esker). The counterforts also have slope (herring bone) drains to pick up localised water, they are generally concealed by the rock blanket. The top of one such slope drain can be seen on the fourth counterfort from the left side, as shown in Figure 3.3. This highlights the need for detailed as built records to aid with future inspections, analysis and maintenance (image J Murphy and Sons Ltd.)

Figure 3.5: Drain with a smeared geotextile and contaminated granular drainage aggregate (image the authors)

Figure 3.6: Build-up of vegetation within the Counterfort Drain leading to a reduction in functionality along the A14: M1 J19 to A14 J1 (from Kier, 2019)

Based on the experience on various infrastructure earthworks across the UK the authors would also add the following issues:

1. Lack of positive tie in with slope crest drainage or water courses. These should have a 'carrier pipe' for them with a positive outfall at the discharge point to avoid infiltration and saturation of the cutting/embankment, particularly near the toe.
2. Counterforts should have a 'collector' pipe to pick up water and ensure it is conveyed out of the slope as readily as possible to prevent the possibility of increased pore pressures (Macdonald et al., 2012).
3. Lack of definition of the problem and inappropriate solutions can lead to ineffective drainage solutions: e.g. surface water can flow across, rather than be captured by, drains which are designed for groundwater seepage as a result of the presence of top seals or geotextile filter wraps.
4. Lack of clear understanding of definitions of Counterfort Drains versus Slope Drains (Herringbone Drains) and records of such. This is particularly important where the Counterfort Drains have also been designed to act as Rock Ribs (Hutchinson, 1977). To act as these reinforcing Rock Ribs the Counterfort Drains must extend/penetrate the slip surface for a sufficient distance to enable their shear resistance to be mobilised.
5. Poor construction of Counterfort Drains, Filter Drains and Slope Drains including 'smearing' of geotextile filters and 'contamination' of drainage aggregates and Rock Fill with finer grained material during installation (see also Figure 3.5).
6. Adoption of standard spacings (typically 5m to 10m) rather than targeting of Counterfort Drains, and associated Slope Drains, to pick up discrete water issues: e.g. springs, natural soil pipes, water bearing lenses, and so on. At some sites the drains

appear to have been constructed after the topsoil and this may have made it difficult to identify the locations at which the water erupted at the surface.

3.2.3 Guidance

There is little in the way of detailed design/specification advice or procedure in the recently published (within 5 to 10 years) guidance on the design of Counterfort Drains in the usual sources such as CIRIA Guides, TRL Reports, British Standards, DMRB/MCHW or Network Rail Standards.

The guidance that is provided mainly points the designer to papers by Hutchinson (1977) and Bromhead (1984). Significantly, for Counterfort Drains there is no British Standard information and very little in the way of other standards or guidance. Table 3.2 gives a summary of the relevant documentation available, with an indication of the level of information provided in these documents.

Similarly, for construction, there is little in the way of detailed advice in the recently published (within 5 to 10 years) guidance on the construction of Counterfort Drains in the usual sources such as CIRIA Guides, TRL Reports, British Standards or the DMRB/MCHW. There are construction detail drawings in the Network Rail Standards and there is some good guidance in Hutchinson (1977) and Macdonald et al. (2012).

Table 3.2: Matrix of relevant documentation available for Counterfort Drains (CFDR)

Level of information provided:		Relevant to:		
Background, Marginal, Comprehensive		Design	Specification	Construction
Publisher	**Document number and title**	**CFDR**	**CFDR**	**CFDR**
CIRIA	CIRIA (Perry et al., 2003a) C591 Infrastructure cuttings - condition appraisal and remedial treatment			
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment			
NH	MCHW Vol 1 Series 600 Earthworks / Vol 2 NG 600			
Literature	Hutchinson (1977): Assessment of the effectiveness of corrective measures in relation to geological conditions and types of slope movement			
NR	NR/CIV/SD/327 Standard Detail: Drainage systems - slope drainage details RD1, RD2, RD3			
NR	NRL2CIV005 (Network Rail, 2016) Drainage systems manual			
TRL	TRL PPR341 (Carder et al., 2008) Drainage of Earthwork Slopes			

3.3 Block Walls

3.3.1 Background

Block Walls (BLCW), defined as *precast concrete modular block gravity walls* may be reinforced or unreinforced, the former usually using a system of tie-back using either polymeric or metallic mesh (Figure 3.7). For the purposes of the current exercise only gravity Block Walls (i.e. those without tie-back) have been taken into account.

Typically, such walls are used on the SRN as low-height walls around features such as telecommunications housings.

Reported defects on the National Highways SRN include cracking of individual blocks. These may be caused by either incorrect construction such that concentrated loads are generated rather than the blocks being placed square on top of each other or by subsequent movement of the retained material.

3.3.2 Issues Encountered

The only issue encountered from the survey was concern surrounding the maintenance and resilience of Block Walls although no specific details were given. Other evidence points to issues with cracking of individual blocks.

Other issues encountered during the inspections described in Section 5 included the loss of mortar and individual blocks; lack of drainage provision from the rear face; bulging, leaning and sinking of walls; gross instability; efflorescence; and uncertainty surrounding the ownership of and thus the responsibility for the condition and associated maintenance of some older walls.

Figure 3.7: Modular Block Wall at M23 J9 (©AVIS)

3.3.3 Guidance

In this context, Block Walls are modular precast walls also known as 'dry-stack masonry' walls. In either case, these are designed as gravity retaining walls and as such are not always specifically discussed in many of the guidance documents. Table 3.3 summarises the range of information provided for design, specification and construction of Block Walls. The most comprehensive source of design guidance for gravity retaining walls is the British Standard BS 8002, the Code of Practice for earth retaining structures. Other documentation specifically mentions 'dry-stack masonry' walls, and refers to the design methodologies for gravity walls, for instance CIRIA C516 (Chapman et al., 2000) and Burland et al. (2012).

When it comes to specification and construction, the guidance is not particularly comprehensive for Block Walls. In many cases, the use of a particular manufacturer's product would likely mean the manufacturer would be approached directly for guidance in this instance.

Table 3.3: Matrix of relevant documentation available for Block Walls (BLCW)

Level of information provided: Background / Marginal / Comprehensive		Relevant to:		
		Design	Specification	Construction
Publisher	**Document number and title**	**BLCW**	**BLCW**	**BLCW**
BSI	BS 8002 (BSI, 2015) Code of practice for earth retaining structures	Marginal	Marginal	Marginal
BSI	BS EN 1997-1 +A1:2013 (BSI, 2013a) Eurocode 7: Geotechnical design - Part 1: General rules	Marginal	Background	Background
CIRIA	CIRIA (O'Reilly & Perry, 2009) RP723 Dry stone retaining walls and their modifications – condition appraisal and remedial treatment	Marginal	Marginal	Marginal
CIRIA	CIRIA (Chapman et al., 2000) C516 Modular gravity retaining walls, design guidance	Marginal	Marginal	Marginal
CIRIA	CIRIA (Perry et al., 2003a) C591 Infrastructure cuttings - condition appraisal and remedial treatment	Background	Background	Background
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment	Background	Background	Background
ICE	ICE (Burland et al., 2012) Manual of geotechnical engineering	Marginal	Background	Background

3.4 Gabion Walls

3.4.1 Background

Gabion Walls (GABN) are defined as *gabion gravity retaining walls* and walls formed from gabion baskets form inherently flexible structures. This can be beneficial in terms of the accommodation of movements without reaching either ultimate state or serviceability failure. This is, however, demonstrably poorly understood and there are a number of examples in which Gabion Walls have been adjudged to have failed despite accommodating movements without distress. Most prominent amongst those known to the authors is an approximately 80m long, 2m high Gabion Wall that had accommodated rotational movements of up to around 15 to 20 mm which was removed and replaced with rock fill in April 1994 (see also Section 3.5). While there is no doubt that the failure of the slope behind the wall was such that a small-scale structural feature such as the Gabion Wall would not provide effective remediation in the long-term, it was also clear that, in the short-term, the replacement of the Gabion Wall with rock fill accelerated the failure.

This simple example serves to illustrate that Gabion Walls if constructed correctly, and when their inherent behaviour is correctly understood by those responsible for maintenance, can provide an inherently flexible and resilient structure that is capable of withstanding quite significant stresses and deforming with those stresses without reaching the ultimate limit state; the serviceability limit state is, of course, one that is slightly more subjective. Figures 3.8 and 3.9 show examples of well-constructed gabions.

Figure 3.8: Gabion Wall used as a debris trap at B9176 Struie (from Winter et al., 2009)

Like all SGMs Gabion Walls, and the associated baskets, must be designed and constructed in a manner sympathetic and appropriate to their form and behaviour. The stone used to fill them must be of a size and shape such that it does not wash out, or otherwise, exit the basket. It must be clean, hard and durable such that weathering does not lead to a loss of material and subsequent issues with the structural integrity of the baskets. This is especially true of the stone used at the front-face of the baskets. Figure 3.10 illustrates a well-constructed basket although the type of stone used has the potential to deteriorate over time, especially in the water-rich environment in which it is placed.

The use of gabion baskets also affords excellent opportunities to incorporate attractive waste building stone, particularly as the facing fill to the baskets (Figures 3.11 and 3.12).

Filling by tipping into the gabion baskets is rarely an effective construction technique and the baskets can be damaged by such an approach. This may take the form of changes to the shape and structural integrity of the baskets themselves and can potentially lead to the completed baskets failing to perform their structural function in the short-term and/or the longer-term. It may also take the form of damage to the galvanising or plastic coating of the wire that forms the basket compromising the protection afforded to the steel underneath and leading to corrosion. Damage to the coating of the wire can also be caused by mechanical tools used to fix the facing and damage may lead to later breakages of the wires, loss of fill material and structural integrity, and the need for potentially costly repairs or reconstruction. This can be particularly problematic when the baskets are placed in potentially corrosive environments such as adjacent to a live carriageway.

Figure 3.9: Gabion Wall at A835 Loch Dromer showing the embankment being successfully retained by the Gabion Wall, as well as providing bank scour protection, in comparison to the adjacent part of the embankment which is failing (from Winter & Anderson, 2002)

Figure 3.10: Well-constructed gabion basket filled with a stone that has the potential to deteriorate in the environment in which it is placed (image the authors)

The design, specification and construction of gabions baskets historically has been led by manufacture-produced guidance and there is relatively little independently-produced guidance.

Figure 3.11: Gabion Wall faced with waste building stone, M876 Junction 1 to Junction 2 (from Winter & Anderson, 2002)

Figure 3.12: Gabion Wall faced with waste building stone, M876 Junction 1 to Junction 2 (image the authors)

3.4.2 Issues Experienced

The primary issues surrounding the use of gabion baskets include:

1. Failure to assess the foundation conditions adequately leading to differential settlement and outward rotation of Gabion Walls.
2. Poor quality fill (undersized material, oversized material, incorrect shape and/or contamination of fill with fines) and poorly placed fill (lack of bracing during construction, tipped fill even to front faces).
3. Failure to follow manufacturers' guidance and step Gabion Wall rows back and/or lean the wall back. This can lead to walls failing to meet even the basic rules of thumb for retaining wall design: i.e. ensuring that the resultant load acts through the middle third of the base of the wall. There are cases in which the failure to ensure that such requirements have been met has led to the differential settlement of walls.
4. Poor construction with inadequate tying of gabion baskets.
5. Poor construction with overlapping and interlinked basket panels failing to from discrete containers. This is often associated with the cutting of the wires/panels and potential loss of service life.
6. Inappropriate and/or poorly-placed fill.
7. Damage to galvanisation and/or plastic coating during construction/installation leading to a shortened design life.
8. The inappropriate use of single-corrosion protected baskets (i.e. galvanisation only) in locations that are potentially highly corrosive, including locations where saline spray may be present during the winter months, leading to premature failure.
9. Many of the above issues feed into the primary concern regarding the use of gabion baskets which is the ability, or lack thereof, of the wire mesh, and to a lesser extent the stone fill, to achieve a suitable design life. This is particularly the case if gabion baskets are used in a structural context where the required life is 120 years.

It is worth noting that in the past gabion baskets have typically been single-corrosion protected using galvanisation of the mesh. In recent years the requirement for double-corrosion protection has been introduced to cater for construction locations where this may be needed due to the potential for higher rates of corrosion (e.g. BS EN 10223-3: BSI, 2013b; BS EN 10223-8: BSI, 2013c; MCHW 1 Clause 626). Such locations may include structures adjacent to the road where salt spray may increase corrosivity during the winter months. It is against this background that all of the images presented in this section illustrate gabion baskets with single-corrosion protection.

3.4.3 Guidance

Gabion Walls are designed as gravity retaining walls and as such are not always specifically discussed in many of the guidance documents. Table 3.4 summarises the range of information provided for design, specification and construction of Gabion Walls. The most comprehensive source of design guidance for gravity retaining walls is the British Standard BS 8002 (BSI, 2015) the *Code of Practice for earth retaining structures*. Other documentation specifically mentions

Gabion Walls, and refers to the design methodologies for gravity walls, for instance CIRIA C516 (Chapman et al., 2000) and Burland et al. (2012).

When it comes to specifications the guidance is clearer, with several sources of information including mesh products and geotextiles. Some construction guidance is available; however, this is not particularly comprehensive for Gabion Walls.

Table 3.4: Matrix of relevant documentation available for Gabion Walls (GABN)

Level of information provided: Background (red) · Marginal (amber) · Comprehensive (green)

Publisher	Document number and title	Design GABN	Specification GABN	Construction GABN
BSI	BS 6031 (BSI, 2009) Code of practice for earthworks	Background	Background	Background
BSI	BS 8002 (BSI, 2015) Code of practice for earth retaining structures	Comprehensive	Comprehensive	Marginal
BSI	BS EN 10223-3 (BSI, 2013b) Hexagonal steel wire mesh products for civil engineering purposes	Marginal	Comprehensive	Marginal
BSI	BS EN 10223-8 (BSI, 2013c) Welded mesh gabion products	Marginal	Comprehensive	Marginal
BSI	BS EN 1997-1:2004+A1:2013 (BSI, 2013a) Eurocode 7: Geotechnical design - Part 1: General rules	Marginal	Background	Background
CIRIA	CIRIA (Chapman et al., 2000) C516 Modular gravity retaining walls, design guidance	Marginal	Marginal	Marginal
CIRIA	CIRIA (Perry et al., 2003a) C591 Infrastructure cuttings - condition appraisal and remedial treatment	Background	Background	Background
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment	Background	Background	Background
NH	DMRB Vol 4 Section 1 Part 2 CD 622 Managing geotechnical risk	Background	Background	Background
NH	MCHW Vol 1 Series 600 Earthworks / Vol 2 NG 600	Background	Marginal	Marginal
ICE	ICE (Burland et al., 2012) Manual of geotechnical engineering	Marginal	Background	Background
NR	NRL3CIV071 (Network Rail, 2011) Geotechnical Design	Background	Background	Background

3.5 Regrades

3.5.1 Background

Regrades (REGD) are defined as *earthworks repair comprising conventional fill, typically regraded to an angle shallower than the original construction*. The regrading of slopes to improve stability is common in earthworks construction and maintenance. There are essentially three approaches that can be taken: (1) flattening of the slope, (2) adding material (mass) to the toe of the slope, (3) removing material (mass) from the crest of the slope. In addition, regrading is often carried out in order to permit widening of the carriageway. In such cases it is rarely possible to achieve any of the three approaches and other more direct stabilisation measures may be necessary, incorporating one or more SGM(s).

Discussions on the problems with Regrades indicate that whilst the design may be adequate, it is not necessarily being controlled on site due to limited supervision. This is often driven by budget requirements only allowing for part time supervision or by a lack of understanding of some of the complexities of on-site changes to the design.

Regrades need to be managed on-site to ensure that the basis of design is still appropriate following commencement of excavation. Any differences to the anticipated ground conditions should be picked up by the designer and checked to ensure stability and overall design will still be effective. For example, the base of a fill area will usually be designed to shed water out of the slope but is this then translated into the construction and how is this known?

Reprofiling of an embankment slope to accommodate a footpath at the base of the slope at the A419 Rat Trap led to a profile that bore significant resemblance to a toe bulge. This may, in turn, have led to significant stabilisation works even though ground investigation failed to identify a slip plane (Nettleton et al., 2018).

Regrades often incorporate the provision of additional drainage, and as above, the issues regarding ensuring that design is implemented in construction are important as are many of the issues regarding Filter Drains and Counterfort Drains. It is particularly important that the drainage aspect of a Regrade is not viewed as an 'add-on' requiring little to no design or, perhaps even more importantly, construction supervision (Figure 3.13).

At the same site the removal of a Gabion Wall at the toe of a slope and its replacement with a rock fill bund (Figure 3.14) led to severe deformation and, indeed, the outward movement of the bund towards the carriageway; the total movement was estimated at close to one metre and deformation of the face of the bund to form a broadly sinusoidal profile compared to the as-constructed flat profile was also observed (Figure 3.14).

3.5.2 Issues Experienced

The primary issues concerned with Regrades include:

1. Lack of formal design and insufficient specifications.
2. Lack of adherence to formal design when carried out.
3. Poor compaction of the fill material.

4. Design carried out 'on the fly' in response to on-site problems.
5. All of the above issues can lead to problems with the construction creating problems with other features, including but not limited to drainage, even if it does solve the immediate problem.

Figure 3.13: A particularly poor example of drainage constructed as part of a Regrade (image the authors)

Figure 3.14: Removal of a Gabion Wall (not pictured) at the toe of a slope and replacement with a Rock Fill bund led to the subsequent movement of the toe bund outwards as well as significant deformation of the surface profile of the bund. Construction of the bund was in 1994 and the images show the bund in June 1999 (Left) when deformation and movement was first noted and after significant deformation and movement (Right) had taken place as of May 2016; the red lines show the approximate shape of the slope and indicate that significant outward movement and toe bulging have occurred (images the authors)

3.5.3 Guidance

There is very little reference to Regrades in the context of design, specification or construction guidance. The designer would then revert to guidance on construction of new earthworks, rather than modification of existing earthworks. Notwithstanding the above, Regrades are discussed in Hutchinson (1977), and the now withdrawn DMRB HA 43/91 in the context of corrective measures for earthworks slopes and their application in widening highways, respectively. Table 3.5 summarises the information available.

Table 3.5: Matrix of relevant documentation available for Regrades (REGD)

Level of information provided:		Relevant to:		
Background / Marginal / Comprehensive		Design	Specification	Construction
Publisher	**Document number and title**	**REGD**	**REGD**	**REGD**
BSI	BS 6031 (BSI, 2009) Code of practice for earthworks			
BSI	BS EN 1997-1:2004+A1:2013a (BSI, 1997) Eurocode 7: Geotechnical design - Part 1: General rules			
BSI	BS EN 13251 (BSI, 2016) Geotextiles and geotextile-related products, Characteristics required for use in earthworks, foundations and retaining structures			
CIRIA	CIRIA (Perry et al., 2003a) C591 Infrastructure cuttings - condition appraisal and remedial treatment			
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment			
NH	DMRB Vol 4 Section 1 Part 2 CD 622 Managing geotechnical risk			
NH	MCHW Vol 1 Series 600 Earthworks / Vol 2 NG 600			
Literature	Hutchinson (1977) Assessment of the effectiveness of corrective measures in relation to geological conditions and types of slope movement			

3.6 Reinforced Soil

3.6.1 Principles

There is a long history of the successful use of both polymeric and metallic reinforced soil, and in the UK such constructions have been used since the early-1970s.

The process was first described by Vidal (1969) and relied upon stiff, usually metallic, reinforcing elements placed in layers to reinforce the fill placed behind a wall comprised of discrete facing panels. In that respect it is different to other reinforced soil systems that rely on more flexible polymeric (geogrid or geotextile) materials to provide the reinforcing effect. This distinction between the two types of system is not made in the Manual of Contract Documents for Highway Works (MCHW). Figure 3.15 illustrates the first reinforced soil wall (using Vidal's 1969 process) constructed in the UK in 1972/3.

Figure 3.15: The first reinforced soil wall constructed in the UK at Lindsay Road, Edinburgh (from Winter et al., 2002)

In principle, metallic and polymeric reinforcement are near-identical in their application. However, there are fundamental differences in the stiffness of the elements used to achieve the reinforcement function. Metallic reinforcement is the stiffest type of reinforcing element and the potential stability, and cost, mean that typical applications include steeper walls faced with precast panels; the facing panels assist with stabilising the front face of the fill/reinforcing and crucially provide resistance to allow tension to be mobilised and interlock created between the fill and reinforcing during construction.

Geogrid is considerably less-stiff than metallic reinforcement and can be applied as a wrapped face or in conjunction with facing-panels as above; in both instances, the forces applied during the compaction of the fill layers is relied upon to mobilise tension and create interlock between the fill and the geogrid, and to thus activate the reinforcing process.

It is important to note that the design of solutions using polymeric reinforcing straps is somewhat different to the classic Vidal (1969) approach to metallic reinforcement due to the significantly lower stiffness of the polymer creating an inherently less stiff structure. In addition, such polymeric straps have been used to attach anchor blocks to the face in anchored earth walls (e.g. Brady et al., 1994a).

Reinforced soil may also be implemented using even less stiff geosynthetics including, for example, some woven and non-woven geosynthetics in a wrap-around configuration; however, these are not considered in this Information Note.

Galvanised steel elements are most commonly used in modern reinforced soil walls and care is required to avoid damage to the galvanisation during installation and compaction of the layer of fill immediately above.

One of the unknowns is how the galvanised steel reinforcing will have corroded, if at all, during the life of such structures. In this context, Blight & Dane (1989) reported on the deterioration of a metallically reinforced soil wall due to the corrosion of galvanised steel reinforcements. While such instances are seemingly rare the work of Blight & Dane (1989) was reported some 30 years ago and the potential service life of such structures is now up to around three times that which it would have been at the time; accordingly, making assumptions about the durability of such structures may well be inappropriate. A study by Beckham et al. (2005) examined galvanised steel reinforcing elements in walls approximately 40 years into their service life. While corrosion was encountered, they also found that where large sized uniformly graded fill material had been used corrosion was minimised. This is likely to be a finding that is more widely applicable to backfilled steel structures.

There is a clear distinction to be made between reinforced soil walls and reinforced soil slopes (Figure 3.16):

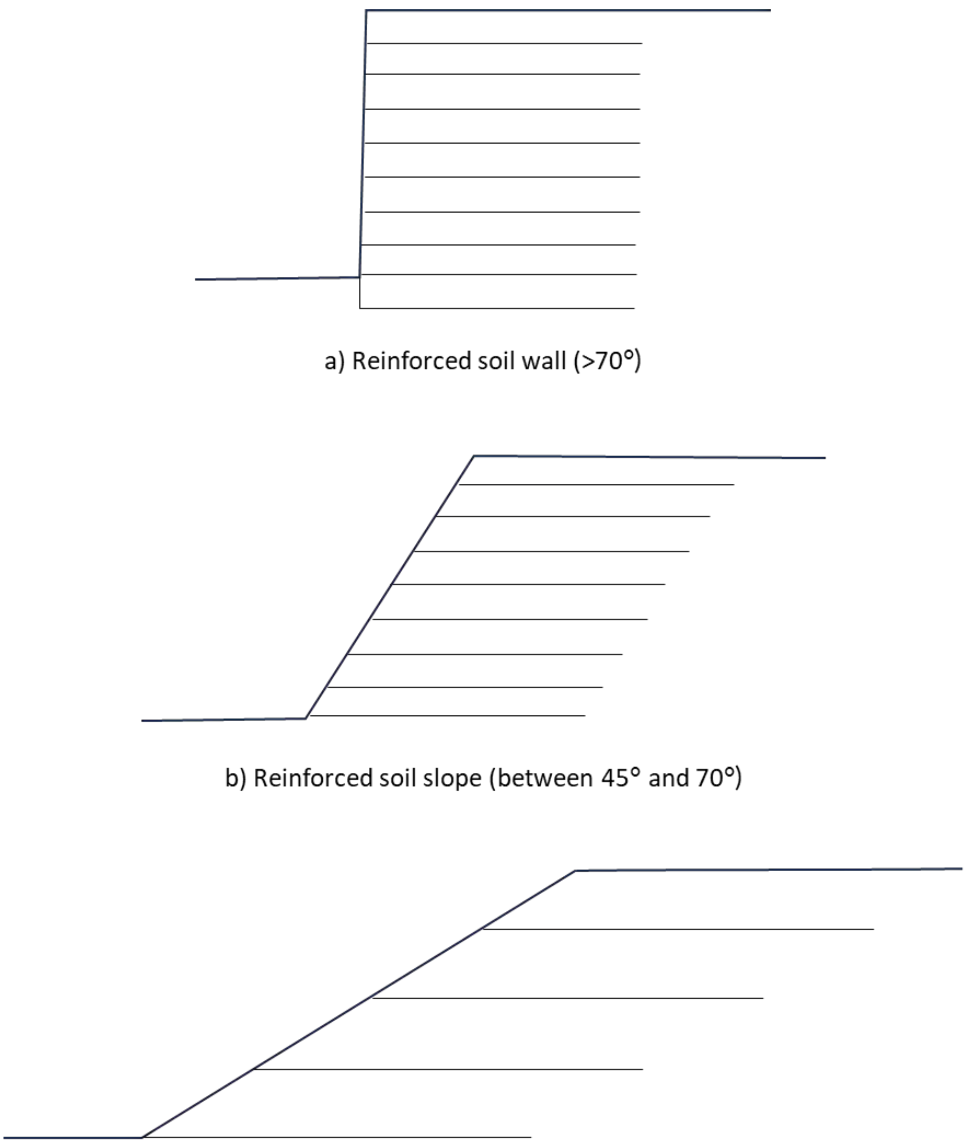
- Reinforced soil walls have a face inclination from the horizontal greater than 70°, are considered structures and have a 120-year design life. In the UK, reinforced soil walls are designed to Section 6 of BS 8006-1 using either the coherent gravity method or the tie back wedge method.
- Reinforced soil slopes have face inclinations up to or equal to 70°, are considered earthworks and have a design life of 60 years. Reinforced soil slopes can be subdivided into steep slopes, face inclination between 45° to 70°, and shallow slopes, up to 45°. Reinforced soil slopes are designed to Section 7 of BS 8006-1, with internal stability typically checked using circular and non-circular limit equilibrium methods. The partial factors used in the design of reinforced soil walls and abutments and reinforced soil slopes are different.

The majority of the observations in this report relate to reinforced soil walls.

3.6.2 Issues

The primary issues surrounding reinforced soil are as follows:

1. Potential presence of walls constructed in the 1970s using ferritic stainless steel reinforcing elements that are subject to pitting corrosion (Winter et al., 2002).
2. Installation damage of galvanised steel reinforcing elements which could potentially lead to loss of design life; notwithstanding this properly adhering hot-dip galvanisation should exhibit self-healing behaviour.
3. Poor verticality due to poor design and construction guidance and/or construction practices leaving the completed wall at too great an angle to the horizontal (Winter, 1999).



a) Reinforced soil wall (>70°)

b) Reinforced soil slope (between 45° and 70°)

c) Shallow reinforced soil slope (slopes up to 45°)

Figure 3.16: Types of reinforced soil discussed in this report

4. Excessive installation damage of geogrids (cuts, tears and abrasion) (Brady et al., 1994b).
5. Durability of geogrids, particularly where parts might be exposed to UV-light, and cuts, tears and abrasions associated with operation and maintenance activities (Brady et al., 1994c; McGown et al., 1995; Winter & Cross, 1995). Other potential related issues include the effects of fires on vegetated faces, which may become more frequent in the light of climate change.
6. Issues surrounding buildability when polymer straps are used with rigid wall facing panels particularly in achieving verticality (see also item (3) above).
7. Poorly/incorrectly specified fill materials, which is important for metallic reinforcing elements but especially so for polymeric reinforcing elements.

8. Linked to (7) above, ensuring adequate drainage both around and within the fill is essential and, as is common with drainage, often not achieved as well as might be hoped.

3.6.3 Guidance

Table 3.6 summarises guidance for reinforced soil elements.

British Standard BS 8006 (2010a) provides comprehensive guidance for the design and specification of reinforced soils, as does CIRIA SP123 (Jewell, 1996). Specification and construction advice is also available in British Standard BS EN 14475 (2006), together with some considerations for design. The MCHW provides useful information on specification and construction in Series 600 and 2500, in particular for metallic reinforcement.

Table 3.6: Matrix of relevant documentation available for Reinforced Soil (GEGD & MTLK)

Level of information provided: Background, Marginal, Comprehensive

Publisher	Document number and title	GEGD Design	GEGD Specification	GEGD Construction	MTLK Design	MTLK Specification	MTLK Construction
BSI	BS 6031 (BSI, 2009) Code of practice for earthworks						
BSI	BS 8006-1:2010+A1:2016 (BSI, 2010a) Code of Practice for strengthened/reinforced soils and other fills						
BSI	BS EN 14475 (BSI, 2006) Execution of special geotechnical works – Reinforced fill						
BSI	BS EN 13251 (BSI, 2016) Geotextiles and geotextile-related products, Characteristics required for use in earthworks, foundations and retaining structures						
NH	MCHW Vol 1 Series 600 Earthworks (622) / Series 2500 Special Structures (2502)						
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment						
CIRIA	CIRIA (Jewell, 1996) SP123 Soil reinforcement with geotextiles						

3.7 Soil Nails

3.7.1 Background

Soil nails (SNAL) are defined as *slopes of any angle reinforced using soil nails, except where any facing mesh actively contributes to stability*. The first uses of Soil Nails were claimed to be in Brazil in 1970 (Ortigao et al., 1995) to stabilise a tunnel portal in São Paulo, and in France in 1972 to increase the slope of a 965m long railway cutting at Versilles-Chantier (Rabejac & Toudic, 1974).

The technique was an evolution of the New Austrian Tunnelling Method from tunnels to slopes, and from rock to soil. Several additional soil nailing projects were carried out in France in the 1970s and the first application in the USA was reported to have been in 1976 to support three sides of a foundation excavation in Oregon (Ferworn, 1991). Applications (including some proposed applications) in the UK from the late-1980s/early-1990s road network included (Winter & Smith, 1996), the following:

- A2 Cobham (1989).
- B5400 Dolywern, Clywd (1989).
- A6 Ampthill Road, Bedford (pre-1991).
- Beaufort Road Bristol (pre-1991).
- A595 Hensingham Bypass (Snebra Ghill Bridge) (1991).
- A42 Leicestershire (March 1993).
- Cliff Drive, Poole (1993/4).
- A7 Colterscleuch Improvement (1994) (Figure 3.17).
- A96 Kintore Bypass (1994/5).
- A74 Tinny Bank Trial (1994/5) (Figures 3.18 and 3.19).
- A5 Nant Ffrancon, Gwynedd (1995).
- A31 Ashely Heath Junction (1995).
- M1 Junction 21 to 21A Widening (1995).
- M25 Junction 10 to 11 Widening (1995).
- A27 Patching (1995).
- A3 Woodbridge Hill, Guildford (1995).

Clearly the early-1990s were the time during which the use of Soil Nails came to be accepted as a viable alternative to more traditional techniques in the UK. At that time there were two competing approaches to the installation of Soil Nails, driven nails and the more commonly encountered drill and grout approach. Driven nails were typically installed using a pneumatic launcher, but this technique appears to have fallen out of use, in the UK at least, although it does appear to persist in at least parts of the USA.

In parallel with the emergence of these two techniques a robust debate was conducted in the UK technical literature regarding the mechanism of soil nail reinforcement. Myles & Bridle (1991) argued for the importance of nail bending stiffness. This was crucial to the viability of slender driven nails with a relatively small circumference and consequentially small contact area and frictional pull-out resistance if small spacings, and large numbers of, nails were to be avoided.

Figure 3.17: Construction of the A7 Colterscleuch Soil Nail slope in 1994 (image the authors)

Drill and grout nails have a relatively large circumference and a consequentially higher contact area and pull-out resistance. Experimental work showed that the axial tensile stress in a nail is activated prior to any significant shear stress (Jewell, 1990; Pedley et al., 1990a, 1990b).

Figure 3.18: Construction of the A74 (M74 Junction 14 to 15) Tinny Bank soil nail trial in 1994/5 (lack of guarding on the drill rig due to date) (image the authors)

Figure 3.19: Construction of the A74 (M74 Junction 14 to 15) Tinny Bank soil nails trial in 1994/5; the beginning of a grout bulb can be seen in the partially excavated soil nail (cavitation of the grout annulus is also evident) (image the authors)

This evidence supports the theoretical approach proposed by Jewell & Pedley (1990a, 1990b, 1991) who concluded that bending stiffness was of marginal significance in soil nailing. While there was no clear resolution to this debate in the technical literature it is perhaps telling that subsequent design guidance took the axial tensile stress approach to soil nail design.

Subsequent work by Jewell and Pedley (1992) demonstrated that only a small proportion of the maximum shear strength of a nail can be mobilised. The whole soil mass will be close to failure before the limiting shear strength of the nail is reached (BRC, 1994). This is because the small strains deforming the soil mass are efficiently transmitted across the bond between nail and soil thereby creating tensile stresses in the nail.

As early as the A74 Tinny Bank trial in 1994/5 significant bulb formation was noted of the in-situ grout annulus on excavation of the trial nails. This led to questions regarding the mechanism that provided the nail resistance and suggestions that for installations in granular materials anchoring might be more relevant than axial tensile resistance. The major unknown in this is, of course, that the location, and indeed the presence, of a grout bulb(s) is unknown until the nail is excavated (Figure 3.19). The creation of a bulb at the distal end of the nail, rather analogous to an under-reamed pile, was suggested at the time but did not preclude the presence of less distal bulbs being created as part of the construction process and remaining unknown making the design assumptions non-conservative.

Spacing and facings – the spacing of nails is clearly important in terms of ensuring that sufficient axial tensile resistance is provided in order to ensure that global stability conditions are met. However, an upper limit on spacing may also be implied by the erosional stability of the soil between the nails and this includes the effects of the facing system, often a mesh, that is applied to the face. There is of course a contention between the need for the slope to deform in order to mobilise tension in the nails and the requirement to maintain stability of the face. It may be that further research is required to establish a maximum spacing of nails in order to ensure stability of the face.

Cohesion – reports have been made of a complete loss of cohesion between the soil nail system and the surrounding soil (loss of axial tensile resistance upon which the design is based) and the nail being capable of being withdrawn from the hole using human force only.

Low height slopes – many examples have been identified of Soil Nails used to stabilise low (≤2m) height slopes in situations in which, the restricted land take has clearly driven the solution (Figure 3.20).

Figure 3.20: Example of a low-height Soil Nail reinforced slope (image the authors)

There is an issue of the potential trip hazard, and the related spike-injury hazard, caused by soil nail heads being left proud of the surface. In reality this should not be an issue if, (1) the nail heads are correctly trimmed once installed and as (2) soil nailed slopes are unlikely to be at an angle that allows for foot-based inspection other than from the top and/or bottom of the slope. In addition, it is best practice to ensure that nail heads are covered by protective caps although this appears to be applied rather inconsistently.

3.7.2 Issues Experienced

Experience from a number of historical and recent legal cases for roads and development sites, along with more general experience, has highlighted a number of issues with the selection, design, specification and installation of soil nail schemes, including:

1. Application of soil nailing in soft cohesive materials (e.g. varved silts and clays) and loose granular materials with high groundwater levels/pore pressures. It is also understood that there was an issue with carbon fibre nails in highly plastic clay on the Tyne & Wear Metro in Sunderland in the late 1990s. It should be noted that the application of Soil Nails in plastic clays is neither typical not recommended.
2. Slopes for soil nailing being cut to full depth in one go rather than being benched sequentially and over-steepening slopes during construction.
3. Breaks in construction during nailing whilst the slope is over-steepened.

4. The formation of grout bulbs in granular soils, particularly loose materials, potentially invalidating the frictional nature of the design by introducing an anchor block. The position of the anchor block(s) is additionally unknown.
5. Installation of Soil Nails which are not centralised within the borehole (Figure 3.21), often little grout is seen on failed/excavated nails.

Figure 3.21: Soil nail lying on the base of the borehole due to failure to use centralisers. This reduces the grout cover for corrosion protection and potentially reduces the bond strength (image the authors)

6. Design of steep slopes with soft/meshing faces rather than hard facings. This can lead to unacceptable deformations and in some cases failure where soft facings are not appropriate for the site conditions (e.g. Figure 3.22).
7. Failure to tighten face-plate nuts and/or to apply protective caps.
8. Inappropriate/incorrect design groundwater levels in cut slopes: e.g. assumption that the water table will drop to the base of the newly cut slope which often proves to be incorrect in both the short and long term.
9. Failure to adequately drain slopes to enable soil nailing to be an appropriate solution.

The contention between the need for centralizers and the potential for such devices to damage self-drilling nails and to impede grout placement was raised in the Geotechnical Feedback Report (GFR) for the A21 Tonbridge to Pembury works (WSP, 2019). Ultimately centralizers were installed but the design life of the nails was estimated to be reduced to 42 years.

Figure 3.22: Mesh soil nail slope facing where the slope movement forces have caused punching failure of the soil nail mesh facing. The face plate is approximately 600mm back from the facing (image the authors)

Extensive information on observed issues with soil nails was received late in the project programme from a recipient of the questionnaire survey. These centred around the following issues:

a) Poor quality control, particularly in the context of lowest price tenders and self-certification, with poor and inappropriate site supervision by drillers incentivised to install nails rapidly and a lack of the required construction records.

b) Issues surrounding the testing of Soil Nails, whether of in-service nails or sacrificial nails, were raised. These essentially highlight that when the notional pull-out resistance of the full nail length exceeds the tensile strength the nail could not be fully-tested without failure of the tendon (typically at a nail length of around 5m or more). In addition, it was noted that the notional design pull-out capacity is less than the true capacity which is limited by the tensile strength of the tendon.

c) Facings are likely to be subject to salt spray from winter service activities and, in order to achieve the required durability, steel facing materials that are plastic-coated are required. Guidance is called for that is directly associated with Soil Nails.

d) It is claimed that design loads for soil nail facings are not currently calculated correctly. Unsurprisingly soil nail design focusses on the stability of the whole slope, focussing on deep-seated failures. The argument is put forward that the design method assumes that shallow failures are handled by the facing and that facing stability is catered for by the supporting soils between the nails – clearly, if correct, this cannot be an effective means of design.

e) The nail grout interface is all-important in achieving stability. As pointed out earlier the design of Soil Nails relies upon tensional pull-out and if this is reduced and/or the effective diameter of the Soil Nails is reduced than the capacity of the Soil Nails can be significantly reduced.

f) The chrome present in UK cement was reduced to less than 2 ppm in response to concerns about the effects on the health of construction workers. Chrome provides passivation of the reaction between galvanised materials and the highly alkaline cement. With the chrome content reduced, this passivation effect is greatly reduced and the formation of a white precipitate of Calcium Zincate forms at a pH of 12 during the hydration reactions with Hydrogen gas forming as a by-product. This has led to Soil Nails being easily extracted from construction installations. It is important to note that this reaction will also be between the nail and the grout inside the plastic sleeve for double-corrosion protected nails. It is understood that video evidence of this phenomena is available, as well as further testing evidence, and it would be essential to inspect this evidence in order to better understand and articulate this potential problem. Notwithstanding this it is understood that North American practice addresses this issue by pre-treating the galvanised Soil Nails with chrome to ensure the passivation of this reaction. This is broadly consistent with reports of Soil Nails being able to be pulled out by hand.

g) The approach to corrosion losses was also challenged, noting that the approach to not including grout cover in the corrosion design, which given observed cracking in the grout seemed reasonable. Corrosion losses over the life of the structure are generally about 2mm to 3mm which coincides with the height of the ridges on the nail surface that provide most of the bond at the nail-grout interface. While this seems like a reasonable argument, the implication that only the ridges corrode may well be flawed as corrosion is likely to occur over the entire nail profile; the remaining question will be what that process does to the bond between the nail and the grout.

These issues are reported here with interpretation necessary for clarity only; it is recognised that these issues will require further checking, investigation, analysis and interpretation as part of any future forensic investigation of Soil Nails. However, the issue surrounding chrome is far from certain and may represent just one of several views from a major legal case; in addition, it may not represent the prevailing view from that case.

What does appear to be clear is that the original design philosophy and construction approach applied to Soil Nails entailing the use of double-corrosion protection appears to have been lost. While it is appreciated that considerations related to economy are important the additional resilience afforded by such protection is considered to be important. In addition, the use of self-drilled nails has come to the fore, which is clearly related to the corrosion protection issue, and raises many issues related to the durability of nails that may be damaged during installation, including by the spacers that are vital to ensure that the nail is centred in the hole but which can, in turn, compromise the ability of the grout to fill the annulus between the nail and the holes, particularly when the hole is drilled uncased.

There are also issues where self-drill nails have been installed and instability of the borehole wall has led to grout not fully filling the annulus between the soil nail and the borehole wall. Such instability can be due to drilling of self-drill nails without a stabilising weak grout flush, a practice which has become more common in recent years.

End-of-life issues also come to the fore with techniques such as Soil Nails; at that point the existing nails could either be removed (at significant cost and with some difficulty) or left in place and additional in-situ reinforcement, including additional Soil Nails or other forms of reinforcement, placed to preserve and/or reinstate the stability of the slope.

3.7.3 Guidance

Soil Nails are part of a system which includes both the tendon or Soil Nails and the slope facing, both of which interact to form a slope retention system. The SGM category (SNAL) for Soil Nails does not differentiate between the different types of flexible or rigid facing, for example, mesh or sprayed concrete, which clearly the retention system could not function without. These facing elements also fall into their own separate SGM categories, SMEH (mesh) and SHOT, (shotcrete or sprayed concrete). Guidance for the facing elements is indicated, but this has not been researched extensively as part of this project, rather soil nail systems as a whole.

Table 3.7 summarises the level of information from the available documentation.

Detailed information on the design and specification of Soil Nails is available in the British Standards BS 8006-2 (BSI, 2010b), and also CIRIA C637 (Phear et al., 2005). British Standards are also available for specification of elements of the facing components, for example sprayed concrete, BS EN 14487-1 (BSI, 2005) *Sprayed concrete - Part 1: definitions, specifications and conformity*.

Details of construction considerations are given in BS EN 14490 (BSI, 2010b).

3.7.4 General Considerations

The issues surrounding Soil Nails are many and encompass design, specification and construction.

While generalisations are fraught with difficulty the available information does seem to indicate that the design issues are generally well-understood but that, perhaps, there is room for improvement and updating of some of the design standards. This may suggest that designers are too dependent upon the standards and specifications.

Comments from the questionnaire survey appear to demonstrate that the problem is clearly understood, with drainage/water issues leading to some sort of failure, but that the solutions appear almost exclusively to address the failure with little to no attempt to address the cause. Construction practices also contribute to the issues surrounding Soil Nails, whether that be a failure to sequence the construction, to properly install the nails or to complete the installation by tightening the face plate nuts.

Table 3.7: Matrix of relevant documentation available for Soil Nails (SNAL)

Level of information provided: Background | Marginal | Comprehensive

Publisher	Document number and title	Design SNAL	Specification SNAL	Construction SNAL
BSI	BS 6031 (BSI, 2009) Code of practice for earthworks			
BSI	BS 8006-2:2011+A1:2017 (BSI, 2011) Code of practice for strengthened/reinforced soils Part 2: Soil nail design.			
BSI	BS EN 14487 (BSI, 2005) Sprayed concrete - Part 1: definitions, specifications and conformity			
BSI	BS EN 14490 (BNSI, 2010b) Execution of special geotechnical works - soil nailing			
BSI	BS EN 1997-1:2004+A1 (BSI, 2013a) Eurocode 7: Geotechnical design - Part 1: General rules			
CIRIA	CIRIA (Perry et al., 2003b) C592 Infrastructure embankments - condition appraisal and remedial treatment			
CIRIA	CIRIA (Phear et al., 2005) C637 Soil Nailing best practice guidance			
CIRIA	CIRIA (Donovan et al., 2020) C794 Grouted anchors and soil nails: inspection, condition assessment and remediation.			
NH	DMRB Vol 4 Section 1 Part 2 CD 622 Managing geotechnical risk			
ICE	ICE (Burland et al., 2012) Manual of geotechnical engineering			
NR	NRL3CIV071 (Network Rail, 2011) Geotechnical Design			
TRL	TRL 380 (Murray, 1993) Development of specifications for soil nailing			
TRL	TRL 537 (Johnson et al., 2002) Soil nailing for slopes			
USFHA	US Federal Highway Agency Manual for design and construction monitoring of soil nail walls			

4 Prioritisation of SGMs for Further Investigation

A system is needed in order to prioritise sites with SGMs for potential forensic investigation. This needs to take account of the specific SGMs and the ease and safety of site access. A scoring scheme for this purpose is given in Table 4.1. This applies scores which are intended to be cumulative (additive) for the SGM priority and site access.

The scoring system is slightly complicated as exhumation associated with site works will be required for Soil Nails and Reinforced Soil/Earth, and most examples of Counterfort Drains. In contrast, for Gabion/Block Walls and, potentially, Regrades, this is less of a necessity as detailed in-situ inspection would be adequate in most cases. This is reflected in the likelihood of works column; here the scores are based on the stage of a given project and the consequent likelihood of the works taking place within the timeframe of the current project for SGMs for which exhumation would be required, with an alternative score for those SGMs for which exhumation is not necessary.

Table 4.1: Prioritisation of site-based forensic activities

Priority of SGM	Likelihood of Works[1]	Access to Site
Soil Nails (5)	Design stage (1)	Offline (e.g. public footpath or open fields) (5)
Counterfort Drains (4)	Funding secured (2)	Supervised construction site[2] (4)
Reinforced Soil (4)	Contract placed (4)	Operator supervision[3] (4)
Gabions/Block Walls (3)	Works scheduled (5)	Hard shoulder/refuge access (1)
Regrades (1)	**OR** Excavation not required (5)	Carriageway (0)

[1] Where works are needed (unlikely to need works/excavation for gabion walls for example). If needed the timing must be within the project period.
[2] Access to a formally constituted construction site (whether traffic remains live or not).
[3] Access to a site with live traffic (without major construction works) under the supervision of these responsible for the operation of the site.

This scoring system is additive and assesses the prioritisation as follows:

$$\textit{Prioritisation} = \textit{Priority of SGM} + \textit{Likelihood of Works} + \textit{Access to Site}$$

As shown in Table 4.1 each condition has been given a score of between 0 and 5, with 0 being the least favourable and 5 being the most favourable. Using the scoring system, sites can be scored between a total of 2 and 15, which would indicate that a score of 2 is a low priority and 15 a high priority for further investigation. To demonstrate this process two hypothetical examples are proposed:

- Soil Nails (5), with contract placed (4) and supervised site (4), giving a total score of 13.
- Gabion Walls (3), excavation not required (5) and Offline – secure access (5) also giving a score of 13.

This scoring scheme was also applied to the 12 sites identified as having potential for exhumation and six additional Gabion Walls or Regrades that would not require exhumation.

The results are presented in Appendix G. As detailed and up to date information regarding the likelihood of works was not available during Phase 1 this was uniformly applied as ‘Works scheduled’ with a score of 5 (five). The range of scores achieved was 7 to 15 (15 being the maximum possible score and indicating the most favourable circumstances for potential further investigation). This illustrates how the scoring scheme was used to provide a coarse sift of suitable projects for inspection carried out in Phases 2 and anticipated in Phase 3 of this project. The process did illustrate the importance of checking the information provided, for example, access at one site had clear and safe offline access even though the questionnaire response indicated that access would be from the hard shoulder. It is pertinent to note that neither ‘Supervised construction site’ or ‘Operator supervised’ access was tested.

It is important to note that the scoring process is not intended to be definitive, but simply to provide a systematic initial evaluation that can then be interpreted and judged in order to select sites/SGMs that will be subject to further work.

5 SGM Examination

5.1 Introduction

Phases 2 and 3 of the project, which began in July 2020 and ran through to May 2022, targeted the examination and, where possible, the exhumation of the selected SGMs to assess whether reliance on particular SGMs is justified and to attempt to validate (or otherwise) design assumptions.

Phase 2 concentrated on Gabion Walls and Block Walls and included preparatory work on Counterfort Drains to allow a focus on Counterfort Drains, Soil Nails and Reinforced Soil in Phase 3. Regrades were given a lower priority following discussions with the National Highways SES Geotechnics Team and such sites were not pursued as part of this project.

Following detailed assessments of a range of SGM examples, Information Notes have been produced for Block Walls (Winter et al., 2022a), Gabion Walls (Duffy-Turner et al., 2022a), Counterfort Drains (Nettleton et al., 2022), Soil Nails (Duffy-Turner et al., 2022b) and Reinforced Soil (Winter et al., 2022b).

5.2 Review of Site Availability

This aspect of the work included liaison with National Highways and its supply chain to determine the availability of sites for on-site examination and/or exhumation. Five avenues to the identification of suitable sites were pursued:

- Review of Planned Major Projects.
- Review of RIS 2 Schemes.
- Review of Questionnaire from Phase 1.
- Review of the SGM GIS database.
- Emergency Works.

Review of Planned Major Projects

This activity included a review of the 'SGAR tracker 13 12 19' spreadsheet (Highways England, 2019) provided by National Highways, which listed major projects at different stages in the Project Control Framework (PCF) between 'Strategy, Shaping and Prioritisation' (Stage 0) and 'Closeout' (Stage 7). To identify sites for investigation those projects with an active stage of either 'Construction Preparation' (Stage 5) or 'Construction, Comm'g & Handover' (Stage 6) were reviewed in further detail.

Following review of the tracker, each site location was assessed to identify if any SGMs of interest were present and the GDMS was interrogated to find further information about the project. Where SGMs of interest were identified the Overseeing Organisation's Geotechnical Advisor (OOGA) for the project was contacted for additional information regarding timeframes and relevant contact details to arrange site visits. The Geotechnical Lead for each project was then contacted to identify exact timescales, site contact information and existing design information.

Review of RIS 2 Schemes

This included a review of the Road Investment Strategy Website http://maps.dft.gov.uk/road-investment-strategy-2/ (Figure 5.1) (Department for Transport, n.d.) to identify sites at which construction was expected to commence prior to 2025.

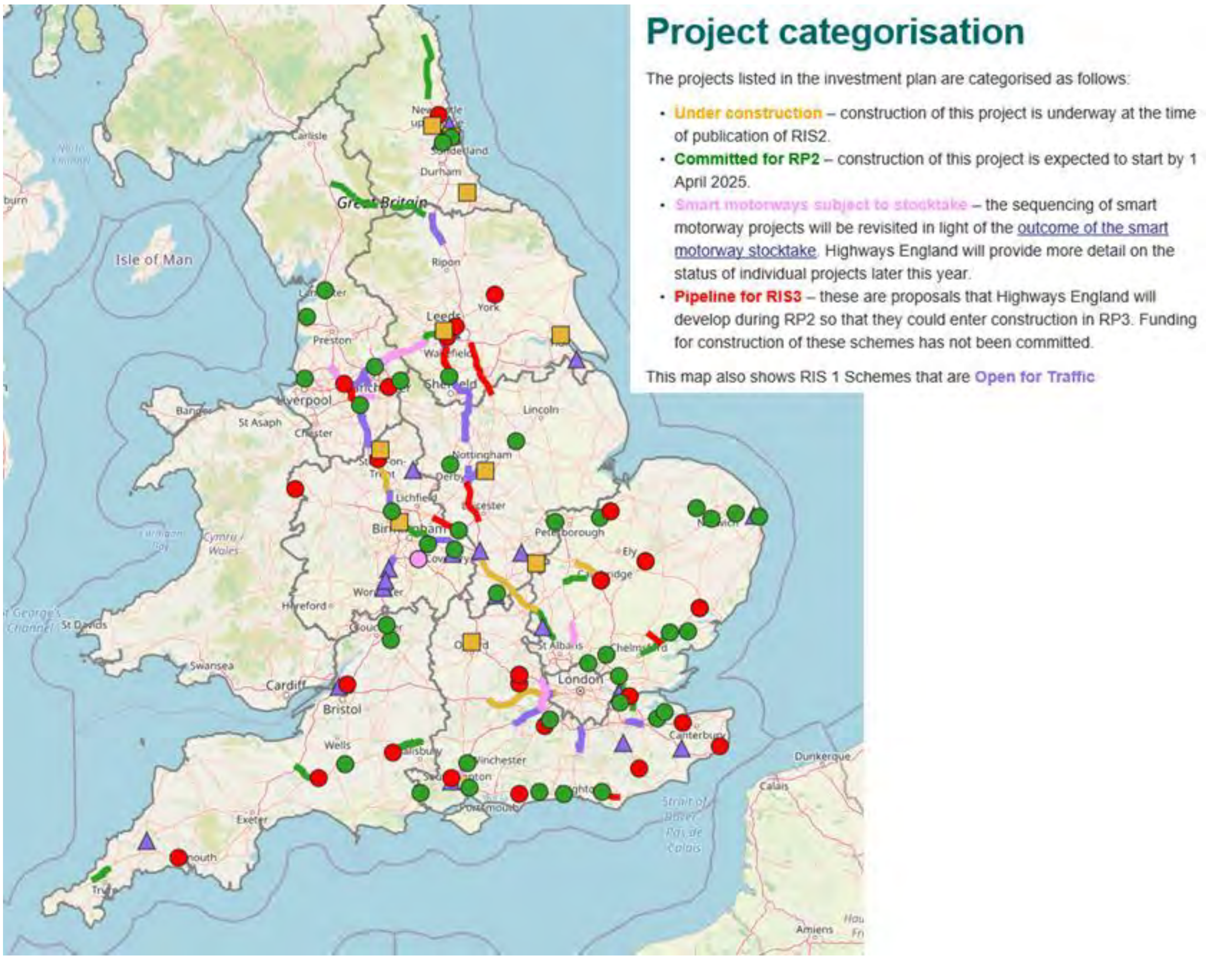


Figure 5.1. Project locations as part of the Road Investment Strategy 2: 2020-2025 (Department for Transport, accessed April 2020).

Following review of the Road Investment Strategy website each site location was assessed to identify if any SGMs of interest were present and the GDMS was interrogated to find further information about the project. Where SGMs of interest were identified, the OOGA for the project was contacted for additional information regarding timeframes and relevant contact details to arrange site visits. The Geotechnical Lead for each project was then contacted to identify exact timescales, site contact information and existing design information.

Review of Questionnaire from Phase 1

The responses received from the questionnaire survey were reviewed to identify SGMs of interest (Gabion Walls, Block Walls, Counterfort Drains and Soil Nails) that had been reported as either available to access offline or had construction planned. The questionnaire responder was then contacted to obtain further information about the site, whether it could be accessed and what, if any, were the timescales for construction. This identified nine potential sites of which two could be accessed offline.

Emergency Works

Emergency works have the potential to allow access to sites that might not otherwise be available for examination or exhumation. The nature of these is such that a flexible and responsive approach is necessary to respond to emerging opportunities that would not otherwise have been identified as, for example, a Major Project.

Review of the SGM GIS database

Originally it was envisioned that the majority of the site inspections would be via major projects or sites identified by the questionnaire. However, it became apparent that the number of SGMs available for investigation that tied in with the timescales of Phases 2 and 3 of the project was limited. Therefore, a review of the existing SGM database (Atkins/Jacobs, 2020) was undertaken in concert with QGIS, Google Maps and AVIS to identify locations for site visits. This exercise was undertaken primarily to identify Gabion Wall and Block Wall SGMs that can be assessed without being excavated. A decision was also made to include Counterfort Drains and Soil Nails in this process of examination as some important information can be obtained prior to excavation (i.e. width, spacing, use of herringbones, length, drainage connections and stone size for Counterfort Drains and spacing, nail type, nail diameter, face plate and facing details for Soil Nails). The intention was that in Phase 3 a more detailed inspection, hopefully involving exhumation, of a limited number of counterforts and soil nails would be undertaken; however, this proved very difficult to coincide with planned works; therefore, the observations and conclusions made on Counterfort Drains, Soil Nails and Reinforced Soil are based on in-situ assessment and research.

5.3 Site Examinations

38 sites were selected for on-site examination (Tables 5.1 to 5.4). Prior to the site visits information pertaining to each of the SGMs was obtained from GDMS and the National Highways Geotechnical Managers. This was reviewed for design information for each site. For some of the SGMs design information was very limited, especially in instances where the construction was quite old (i.e. prior to the 1970s where infrastructure may be coming to the end of its design life).

The site visits were undertaken over three weeks and were planned to minimise travel while maximising the number of SGMs able to be assessed. This approach was adopted both to maximise efficiency but also to minimise the exposure of those undertaking the site visits during the COVID-19 pandemic. Other strategic actions taken in this regard, in addition to detailed operating procedures, were to target the timing of site visits to periods of lower transmission, to minimise the number of different hotels used and to target overnight stays in areas of lower transmission rates. Tables 5.1 to 5.4 present the details of the sites.

Table 5.1: Details for site inspections of Block Walls

SGM Type	SGM ID	Area	Road	Location	Eastings	Northings	Date
Block Wall	9676	7	A52	Nottingham	453520	338574	October 2020
Block Wall	7825	7	A52	Nottingham	457786	334693	October 2020
Block Wall	9407	12	A628	Crowden	407373	399305	October 2020
Block Wall	8923	12	A628	Tintwistle	402639	397407	October 2020
Block Wall	8885	12	A628	Tintwistle	402413	397305	October 2020
Block Wall	1268	SW	A303	Ilchester	351027	121606	January 2021
Block Wall	1306	SW	A30	Monkton	319613	104545	January 2021
Block Wall	9077	SW	A36	Dundas Aqueduct	378323	162595	January 2021
Block Wall	10857	SW	A38	Liskeard	223568	64425	January 2021
Block Wall	11542	SW	A36	Bath	376593	165805	January 2021

Table 5.2: Details for site inspections of Gabion Walls

SGM Type	SGM ID	Area	Road	Location	Eastings	Northings	Date
Gabion Wall	4025	7	A46	Leicester	456870	310200	October 2020
Gabion Wall	9117	9	A45	Coventry	434231	275581	October 2020
Gabion Wall	8552	8	A1	Astwick	522568	238290	October 2020
Gabion Wall	6082	8	A1307	Huntingdon	524256	271326	October 2020
Gabion Wall	10197	3	A27/M3 junction	Havant	469525	105476	October 2020
Gabion Wall	10198	3	A27/M3 junction	Havant	469392	105371	October 2020
Gabion Wall	5281	10	M60	Stockport	388654	390252	October 2020
Gabion Wall	7066	10	M60	Northenden	382432	390873	October 2020
Gabion Wall	7038	10	M60	Sale	380474	392493	October 2020
Gabion Wall	7630	7	A38	Derby	436275	340007	October 2020
Gabion Wall	7761	7	A61	Derby	436386	339922	October 2020
Gabion Wall	4435	7	M1	Sandiacre Interchange	447166	335767	October 2020
Gabion Wall	10862	SW	A38	Liskeard	223331	64669	January 2021

Site proformas were completed to capture information about each SGM and are presented in Appendices H, I, J and K for Block Walls, Gabion Walls, Counterfort Drains and Soil Nails respectively. Also included in Appendix K are case studies of Soil Nail failures that do not, as yet, appear in the published literature. The lack of Reinforced Soil sites that could be inspected led to a slightly different approach for that SGM. In this instance reliance has been placed on the published literature, the experience of the authors and colleagues, and additional relevant observations by third parties. In the latter case the sites cannot be definitively identified as future contractual claims by the parties are a possibility. The information from these site investigations has been used to develop Information Notes that will guide the design, construction, inspection and maintenance of these SGMs. As part of Phase 2 of the project, Information Notes have been produced for Block Walls (Winter et al., 2022a) and Gabion Walls (Duffy-Turner et al., 2022a) and as part of Phase 3 of the project, Information Notes have been produced for Counterfort Drains (Nettleton et al., 2022), Soil Nails (Duffy-Turner et al., 2022b) and Reinforced Soil (Winter et al., 2022b). The resulting recommendations are set out in Section 5.4.

Table 5.3: Details for site inspections of Counterfort Drains

SGM Type	SGM ID	Area	Road	Location	Eastings	Northings	Date
Counterfort Drains	NA	7	A14	Elkington	462408	277609	October 2020
Counterfort Drains	1924	SW	A30	Pathfinder Village	284326	93113	January 2021
Counterfort Drains	2053	SW	A30	Pathfinder Village	285307	92785	January 2021
Counterfort Drains	2065	SW	A30	Nr Exeter	287064	92536	January 2021
Counterfort Drains	1280	SW	A303	Horton	332272	114244	January 2021
Counterfort Drains	3329	SW	A303	Horton	332272	114244	January 2021
Counterfort Drains	NA	SW	A38	Liskeard	222625	65042	January 2021
Counterfort Drains	NA	NW	M6 J34	Lancaster	349701	465325	March 2021
Counterfort Drains	9685 (classed as slope drain)	9	M42	MP 54/2 to 54/3	425053	302348	February 2022

Table 5.4: Details for site inspections of Soil Nails

SGM Type	SGM ID	Area	Road	Location	Eastings	Northings	Date
Soil Nails	2456	10	M56	J7 Westbound	375655	384655	July 2021
Soil Nails	NA	14	A1	Cataractonium Cutting	422513	499012	August 2021
Soil Nails	6312	12	A628	Salters Brook	411812	399609	January 2022
Soil Nails	9062	12	A628	Woodhead	408193	399658	January 2022
Soil Nails	1023	7	A42	Ashby de la Zouch	437985	317873	January 2022
Soil Nails	9173	9	M6	Junction 10	399118	298379	January 2022

5.4 Recommendations for Critical SGMs

5.4.1 Block Walls

In the GDMS the different types of walls appear to not always be differentiated and Block Walls (BLCW) appears to be the default selection for all walls including Masonry Walls (BKRW) and Stone Walls (STNW). This may be an instance where SGM categories have become too highly resolved and it is recommended that consideration be given to combining these categories.

The interface between SGMs and structures is clearly an important issue, and it is not entirely clear which types of Block Wall (material, structure or function) are being recorded in IAMIS. It is recommended that the Structures Manager review the SGM layer in GDMS.

There is no compelling evidence that when properly designed, specified, constructed and maintained, including an appropriate inspection regime, Block Walls cannot meet the required design life (120 years) of such SGMs.

Advice in standards and other related documents for Block Walls is clearly limited. Through the course of this work a number of key issues have been identified and these are set out as recommendations for action in the following paragraphs.

Recommendation 1: The design of Block Walls should take due cognisance of manufacturer's information, where relevant, as well as fundamental design principles.

Recommendation 2: The provision of adequate and appropriate drainage for Block Walls should be addressed through the design, specification and construction phases.

Recommendation 3: The use of argillaceous rock to form Block Walls is not recommended, due to the possibility of rapid deterioration, in particular in locations of high exposure.

Recommendation 4: Contractor acceptance, or self-certification, of Block Walls is not recommended. It is recommended that inspection of SGMs should be certified by a UK Registered Geotechnical Adviser.

Recommendation 5: Any inspections for the acceptance of constructed Block Walls should be undertaken prior to the site becoming fully operational and it is recommended that provision for early inspection should be built into the contract.

Recommendation 6: Construction quality assurance records for SGMs should be captured in the Geotechnical Feedback Report (GFR).

Recommendation 7: Inspection of SGMs should be certified by a UK Registered Geotechnical Adviser or equivalent.

Recommendation 8: It is further recommended that National Highways consider the development of a formal risk-based approach for inspection and maintenance of Block Walls. This would assign values to attributes of Block Walls during assessment to allow prioritisation of actions including maintenance and replacement. Attributes to be considered include, but are not limited to, wall type, condition, provision and effectiveness of drainage, and proximity to road users.

5.4.2 Gabion Walls

Based on the walls inspected, which ranged from eight to 46 years old, there is no compelling evidence that when properly designed, specified, constructed and maintained, including an appropriate inspection regime, Gabion Walls cannot meet the required design life (120 years) of such SGMs.

Advice in standards and other related documents for Gabion Walls is well defined in some areas (such as specification) and limited in others (such as construction). Through the course of this work a number of key issues have been identified and these are set out as recommendations for action in the following paragraphs.

Design and Specification

Recommendation 1: That as part of the design it should be ensured that the most appropriate Gabion Wall type (woven or welded mesh) is selected for its application.

Recommendation 2: That the use of a filter/separator behind the wall should be considered in all cases.

Recommendation 3: That the requirements given in MCHW Volume 1 Clause 626 be updated to (say) 'stone fill used in gabion walls should be sufficiently durable so as not to suffer deterioration sufficient to impair the performance of the system during the design life of the installation'. This brings the recommendation broadly in line with BS 8002:2015 and would prevent the use of inappropriate stone fill.

Technical Approval

Recommendation 4: That modifying gabion baskets on site shall be reserved for only those instances in which recognised manufacturers cannot produce a prefabricated suitable solution. Any modifications should be done in accordance with manufacturer's instructions and will require agreement as part of the technical approvals process.

Recommendation 5: As part of the technical approval process it should be ensured that a Gabion Wall solution is the most appropriate for the environment. This includes careful consideration before designing Gabion Walls within tidal and marine environments, adjacent to public footpaths where vandalism is a possibility and low-height gabions placed in location where vehicle over-run is likely.

Recommendation 6: Gabion fill which does not meet the requirements of the MCHW should not be used on site unless there is a specific aesthetic requirement. Any deviations should be discussed in advance and agreed as part of the approvals process.

Construction

Recommendation 7: Issues identified during the site inspections highlighted that double corrosion protection was not always used and that the wire may be thinner than required; therefore, it is apparent that further enforcement of the specification is required by the Works Examiner.

Recommendation 8: Contractor self-certification of SGMs should not be accepted. Observations on the SRN and of the wider UK infrastructure portfolio have found the self-certification process to be suboptimal. A construction compliance certificate is required in accordance with the DMRB.

Recommendation 9: Any inspections for the acceptance of constructed Gabion Walls should be undertaken prior to the site becoming fully operational and it is recommended that provision for early inspection should be built into the contract.

Recommendation 10: Construction quality assurance records for SGMs should be captured in the Geotechnical Feedback Report (GFR).

Recommendation 11: That the inspection of SGMs should be certified by a UK Registered Geotechnical Adviser or equivalent.

5.4.3 Counterfort Drains

Counterfort Drain SGMs cannot meet the required design life for slopes of 60 years without significant intervention, as the filter/separator and drainage aggregate element are likely to need refurbishment or replacement. There is a body of evidence that suggests that this will be required at between 15 and 25 years assuming that the Counterfort Drains are maintained. There is substantial evidence that in the UK, counterfort drain design, specification and construction is frequently not at a level that would promote longevity of this nature.

Guidance

Recommendation 1: There is confusion within the industry regarding the different types of slope drains, their function, form, design, construction and potential performance. There is a corresponding lack of specific and consolidated guidance. It is considered that the provision of such guidance is a matter of some significant need, and it is strongly recommended that this be taken forward through the auspices of the Geotechnical Asset Owners Forum.

Design

Recommendation 2: It has been identified that there is a lack of official design guidance for Counterfort Drains. It is important that an appropriate opportunity is sought to produce a guidance document for the design of Counterfort Drains and that the outcomes are incorporated in appropriate standard(s).

Recommendation 3: It is recommended that the design of Counterfort Drains must clearly identify, assess and account for the following features and functions:

- Slope failure mechanism(s) and depth(s) of slip planes to be treated by the drains and/or buttresses.
- Whether the drains treat groundwater only or a combination of surface and ground water. If the latter is the case, then they must be specifically designed to cope with that combination. The specific issues that must be addressed are inter alia clogging of the drain surface and the higher flows implicit where surface water is additionally collected.
- In addition, consideration must be given to ensuring that the drain can be effectively maintained so that water does not back up and enter the slope, thereby decreasing stability and compromising the drain filter cake.
- Potential for the drain to receive significant surface/groundwater flows which may mobilise and transport the drainage aggregate causing a debris flow type failure onto the asset below.
- Careful consideration of the velocity of surface water flow and the slope gradient are critical, and interlinked factors, in ensuring that washout of the drainage aggregate does not occur. Such considerations should form an integral part of the design by determining appropriate limits on surface water flow velocity.

Recommendation 4: Given the potential for a variety of drainage systems to interact it is vital that the often-competing requirements of the various systems are clearly understood and accounted for in the design.

Recommendation 5: Carrier and collector drain functions should remain separate and where necessary a particular Counterfort Drain construction may incorporate the usual collector pipe and a carrier pipe to transport water from (say) the Crest Drain and/or Interceptor Drains to a suitable outfall at the toe.

Recommendation 6: The geotechnical designer should coordinate their design with the relevant landscape/environmental designer to ensure compatibility on planting schemes.

Construction

Recommendation 7: Regardless of flow rates a perforated collector pipe should be installed in a Counterfort Drain which outfalls into a catchpit at the toe. The catchpit at the the toe should also assist with locating the Counterfort Drains for inspection and maintenance purposes.

Recommendation 8: Mineral filters or, more commonly, geosynthetic filters/separators are required at the trench boundaries.

Recommendation 9: Significant changes in vertical and/or horizontal alignment, in particular towards the base of steep slopes, should be made wholly within a catch pit designed to resist the forces and flow transition resultant from the flows.

Recommendation 10: Following construction of the Counterfort Drains they should be physically marked on site to allow easy identification in the field. They should have the top and bottom coordinates located in the GFR and be provided in BIM format or similar.

Maintenance

Recommendation 11: The service life of filter drains, including Counterfort Drains, is likely to be in the range 15 to 25 years. Specific provision should be made for the appropriate inspection of such drains in order that they can be refurbished or replaced before their lack of functionality increases instability to an unacceptable level.

Recommendation 12: It is recommended that maintenance procedures are specifically targeted at ensuring that trees and shrubs do not grow adjacent to Slope Drains of any type. The distance between the drain boundary and such growth should be specified in the GFR.

Recommendation 13: In addition, it is recommended that vegetation maintenance precludes the deposition of vegetation debris on drain surfaces or on the surface of a slope where it can migrate onto the surface of drains.

Recommendation 14: Where Counterfort Drains and/or Slope Drains are designed to intercept surface water flows then scarification will be required to prevent clogging of the surface of the aggregate. Clearly the frequency will depend upon the site location and the environs; however, a frequency of every four years could be a reasonable starting point as this can be tied in with the maintenance required every two years.

5.4.4 Soil Nails

Soil nails systems have many components including the facing, the head plates, the method of construction and corrosion as well as the nail itself. All these interrelate in the design, specification and construction.

While generalisations are fraught with difficulty the available information does seem to indicate that the overall design issues are generally well-understood but that, perhaps, there is room for improvement and updating of some of the design standards. This may suggest that designers are too dependent upon the standards and specifications.

Comments from the questionnaire survey (Duffy-Turner et al., 2022), appear to demonstrate that the resultant problems are clearly understood, with drainage/water issues leading to some sort of failure, but that the solutions appear almost exclusively to address the failure with little to no attempt to address the cause. Construction practices play a key role to the issues surrounding soil nails, whether that be a failure to sequence the construction, to properly install the nails or to complete the installation by tightening the face plate nuts.

What does appear to be clear is that the original design philosophy and construction approach applied to soil nails entailing the use of double-corrosion protection appears to have been lost. While it is appreciated that considerations related to economy are important the additional resilience afforded by such protection is considered to be important. In addition, the use of self-drilled nails has come to the fore. This raises many issues related to the durability of nails that may be damaged during installation, including by the centralisers that are vital to ensure that the nail is centred in the hole but which can, in turn compromise the ability of the grout to fill the annulus between the nail and the holes. This is particularly relevant when the hole is drilled uncased.

There is no compelling evidence that when properly designed, specified, constructed and maintained, including an appropriate inspection regime, Soil Nail SGMs cannot meet the required design life for either slopes (60 years) or for structures (120 years) of such SGMs. However, there is substantial evidence that in the UK, soil nail design, specification and construction is frequently not at a level that would promote longevity of this nature. Through the course of this work a number of key issues have been identified and these are set out as recommendations for action in the following paragraphs.

Recommendation 1: Structural applications with a hard facing and an effective retained height of more than 1.5m and slope applications in network critical locations should be double corrosion protected. Single corrosion protection should be used only for slopes, with flexible facings, in areas of lower network criticality.

Recommendation 2: It is recommended that the design process for soil nail facing be reviewed and revised in line with the issues identified in the Information Note. It is important that an appropriate opportunity is sought to review and revise the soil nail design process as it pertains to the issue with facings and that the outcomes are incorporated in appropriate standard(s).

Recommendation 3: During the review of soil nail facings (as per Recommendation 2), the use of flexible facings, specifically for clay slopes, should be considered further. When properly constructed these flexible facings have the ability to work well; however, poor construction can lead to large vertical and horizontal deformations which have been seen on numerous soil nail schemes.

Recommendation 4: The use of centralisers should be maintained in accordance with Phear et al. (2005) and BSI 8002:2011 to ensure a continuous grout annulus around the tendon. It is recommended that all metal should be avoided in a centraliser to reduce the risk of damage to the tendon.

Recommendation 5: It is recommended that in the case of batch construction drilling should be limited to one row at a time and only grout flush should be allowed as it will assist in stabilising the bore and assist with the formation of a continuous annulus. This is especially important in weaker or more granular soils. If grout flush is not considered to be suitable for site, then consideration should be given as to whether to case the hole to prevent collapse. A detailed assessment of the ground conditions by the designer would be required to make this decision.

Recommendation 6: The effect of de-icers on soil nail systems is an issue that has been less than fully investigated and further work may be needed. In the first instance this might take the form of estimates or modelling of the quantity of de-icers affecting SGMs both above and below road level, the associated acceleration of the corrosion rate and the consequential loss of stability. The results from such work could then inform the basis of decisions on whether more detailed and complex physical investigations and tests would be required to refine the understanding of such effects.

Recommendation 7: Facings are likely to be subject to de-icing agents and, in order to achieve the required durability for the design life of the soil nail system, steel facing materials are likely to require corrosion treatment such as plastic coating. The majority of the sites inspected as part of this project had a plastic coating on the facing mesh; however, head plates and nail ends were typically exposed. Further investigation and guidance are called for that is directly associated with soil nails.

Recommendation 8: It is recommended that the MCHW 1 should include a requirement that all reinforcing geosynthetic materials used as slope facing for soil nail slopes be fully protected against UV exposure. Further, such protection should not rely on the establishment, growth or persistence of vegetation that can be unreliable on steep slopes, particularly in the context of climate change.

Recommendation 9: Investigate further the potential for debonding at the nail grout interface due to the production of hydrogen gas from a reaction between the zinc galvanisation and the hydroxides in the cement grout. If this is a concern, as initial research may suggest, the use of any chromate passivation would need to be balanced against the risks of chromium to human health.

Recommendation 10: There is a need to ensure that the design and construction of soil nail systems on the SRN takes full account of the following issues:

- Programme for the works should take weather conditions into account as cutting into soil slopes in winter is not recommended.
- If the ground conditions are not as anticipated the soil nail system (soil nails, facings and drainage) needs to be reassessed to ensure that it is still acceptable.

- Ensure that the water conditions (ground and surface water) are completely understood prior to installation of the nails and ensure that drainage provision is a consideration from the outset.
- If using bored and grouted soil nails, a tremie pipe should be inserted to the full depth of the borehole to ensure proper grout placement. The grouting should continue at low pressure until the grout emerges from the top of the hole.
- Grout take must be recorded for assessment against the anticipated grout take as this will give an indication if a hole has not been completely filled due to a blockage or collapse of the hole.
- Ensure the facing is tensioned sufficiently in accordance with the manufacturer's specifications and installation guidance. If this is not possible then an alternative facing solution (i.e. hard facing) should be used.
- Ensure the galvanisation or epoxy coating on the tendons is checked on site for damage prior to installation of the soil nails and that damaged tendons are rejected.
- Maintenance of vegetation on soil nail slopes is required to prevent damage to the facing and nails by the growth of large shrubs and trees.

5.4.5 Reinforced Soil

There is no compelling evidence that when properly designed, specified, constructed and maintained, including an appropriate inspection regime, reinforced soil SGMs cannot meet the required design life for either slopes (60 years) or for structures (120 years) of such SGMs.

Notwithstanding this it is considered that some adjustments to the current MCHW requirements are indicated, and these are set-out below as a series of recommendations that apply either to all types of reinforcement or to either metallic or polymeric reinforcement. It is also considered that a significant refresh of the current MCHW as it pertains to reinforced soil would reap benefits and this along with some wider recommendations are also set out below.

All Types of Reinforcement

Recommendation 1: Some recently used fill materials may not have met the requirements for coefficient of uniformity and it is suggested that this feature of the specification for fills should form the focus of additional quality checks in the future. This may be an issue that needs to be addressed more widely than simply in respect of reinforced soil walls.

Recommendation 2: Careful supervision by experienced engineers is required during the construction of reinforced soil walls. It is recommended that National Highways consider the most appropriate means of achieving that end in order to improve the outcomes from reinforced soil construction.

Metallic Reinforcement

Recommendation 3: The effect of de-icers on metallic reinforced walls and slopes is an issue that has been less than fully investigated and further work may be needed. In the first instance this might take the form of estimates or modelling of the quantity of de-icers entering SGMs both above and below road level, the associated acceleration of the corrosion rate and the consequential loss of stability. The results from such work could then inform the basis of decisions on whether more detailed and complex physical investigations and tests would be required to refine the understanding of such effects.

Recommendation 4: While the MCHW permits the use of certain stainless steels BSI (2006) effectively excludes their use; it is not recommended to use these materials in practice in the construction of reinforced soil walls. This highlights the need for a detailed rewrite of the MCHW with regards to permitted materials for reinforced soil walls.

Recommendation 5: Notwithstanding **Recommendation 4** above, three walls constructed in the UK in the 1970s used ferritic stainless steel and two of those may remain on the network. It is recommended that the potential presence of these walls be highlighted in some manner, to the wider geotechnical supply chain in order that when and if they are encountered appropriate action can be taken in a timely fashion.

Recommendation 6: Information on the in-service deterioration of galvanised reinforcing elements is limited. It is recommended that a planned approach to gathering such information is implemented. This would involve the placement of sacrificial reinforcing ‘coupons’ that can be recovered without deconstruction of the wall at pre-defined time intervals after construction.

Polymeric Reinforcement

Recommendation 7: In the UK only reinforced slopes between 45° and <70° will not require a facing panel but will require a wraparound, or wrap back, detail and some form of protection may be necessary. This may be in the form of vegetation, but the establishment thereof can be problematic on slopes in the steeper end of the range and some other form of sacrificial covering may be needed. In such instances reduction factors should be used as typically contained in the British Board of Agrément (BBA) certificate, or equivalent, for such systems.

Recommendation 8*:** Further to ***Recommendation 7, it is recommended that the MCHW 1 should include a requirement that all reinforcing geosynthetic materials exposed at the surface of slopes (between 45° and 70°) be fully covered whether by soil or vegetation in order to limit the risk of adverse impact on such materials due to fire, caused by arson, and other forms of vandalism such as the cutting of the geosynthetic materials. The hazards of vehicle fires or wildfire, especially in the context of climate change, remains.

Reinforced Soil and the MCHW

Recommendation 9: It seems clear that some realignment of the existing MCHW 1 will be required in order to implement the recommendations given above. In addition, the current MCHW 1 has evolved over a number of decades in respect of reinforced soil. There currently is a lack of clarity with respect to where and how polymeric reinforcement is allowed to be used and under what circumstances and at what angles to the horizontal slopes and/or walls may be formed. The specification focusses largely upon walls at angles of 70° and above to the horizontal. It is considered that a rewrite of this part of the MCHW 1 (principally Clauses 622 and 2502) to encompass specific requirements on the use of both metallic and non-metallic reinforcements is indicated and would provide significant benefits by helping to ensure that reinforced soil is used appropriately and constructively. The following observations are made for such a rewrite:

- The current specification for metallic reinforcement is generally reasonably comprehensive but could be usefully simplified and clarified.
- A similar approach is needed for polymeric reinforcement, and this should clearly distinguish between strengthened earthworks (slopes of <70°) and walls (structures ≥70°).
- Be clear on what systems and reinforcement types are permitted for strengthened earthworks and structures.
- It is also suggested that, where appropriate, the specification should clearly indicate systems and reinforcement types; these might include, for example, ferritic stainless steel and the use of polymeric straps for walls/structures or otherwise in combination with rigid facing panels.
- Updates should recognise developments in reinforcing technologies and afford the relevant professional bodies an opportunity to make an independent contribution to the update process.

It is recognised that the timescale and nature of the current MCHW update will not accommodate such changes, which will require careful deliberation and consultation, and it is recommended that this be considered for the following MCHW update cycle.

5.5 Overarching Issues

Throughout this project, contractor self-certification has been raised and evidenced as one of the most significant issues that leads to poor construction. The issues may not be apparent at the time of construction and therefore may not be addressed by the designer or client, leading to subsequent poor performance and early-life failure of not only SGMs but other forms of construction. Indeed, this issue has been highlighted on other National Highways projects on which the authors have worked and in work for other infrastructure owners and operators both in the UK and overseas.

A high-profile example of this is found in the Earthworks Task Force Report (Mair, 2021) on the Carmont Rail Disaster, which notes in the context of water management, drainage assets and the associated risks that “There is very limited supervision of drainage work by [Network Rail], with a reliance on contractor self-certification”.

It is considered that a move to cease Contractor self-certification and revert to a more conventional client-led Construction Quality Assurance scheme in order to ensure quality of execution of Works is strongly indicated. The use of contractor self-certification is not considered to be in the best interests of any party including the client, designer and, indeed the contractor.

Also strongly indicated is, earlier and more extensive operational and maintenance geotechnical input to Major Works in order to ensure specification compliance, acceptability for use and handover to the operator.

The effective implementation of these two recommendations increases the likelihood that Works are built correctly first time and greatly reduces the risks associated with future defects and deterioration. This becomes even more critical in the light of predicted climate change which is expected to exacerbate geotechnical asset deterioration.

6 Summary and Conclusions

The effective design, specification and construction of SGMs is critical to the efficient operation of the National Highways Strategic Road Network (SRN).

Many such SGMs are approaching the end of their, typically 60 year, design life and the design, specification and application of many of these techniques is based on limited studies.

This study seeks to exploit the timely opportunities afforded by construction works on the SRN to validate, or otherwise, the predicted long-term performance of selected SGMs.

Data derived from the National Highways GDMS was used to identify those SGMs that are most prevalent on the SRN, those that are most often co-located with defects, and those that are most often associated with verified defects. This information was then used to help with the development of a questionnaire survey to sample the experience of the National Highways Geotechnical Community. The results of the survey, along with more detailed consultations with National Highways and other UK asset owners, identified the following SGMs for potential further study:

- Counterfort Drains (CFDR) – Gravel-filled drains extending to full earthwork depth/height.
- Block Walls (BLCW) – Precast concrete modular block gravity walls.
- Gabion Walls (GABN) – Gabion gravity retaining walls.
- Regrade (REGD) – Earthworks repair comprising conventional fill, typically regraded to an angle shallower than the original construction.
- Reinforced Soil solutions including components of:
    - Metallic Reinforcement (MTLK) – Metallic reinforcement such as straps or mesh, usually used in conjunction with a facing system for strengthened earthworks.
    - Geogrids (GEGD) – Slopes of any angle reinforced using geosynthetic grids which interlock with the fill material.
    - Polymeric straps are included in this category.
- Soil Nails (SNAL) – Slopes of any angle reinforced using soil nails, except where any facing mesh actively contributes to stability.

Extensive background and commentary on the issues encountered for each of the SGMs identified above is given as is a summary of the available advice and guidance on the design, specification and construction of each SGM-type.

The methodology described in Section 4 enabled the prioritisation of site investigations to examine and potentially exhume examples of the selected SGMs. Section 5 reports on the examination of the critical SGMs reported on in the Information Notes for Block Walls (Winter et al., 2022a), Gabion Walls (Duffy-Turner et al., 2022a), Counterfort Drains (Nettleton et al., 2022), Soil Nails (Duffy-Turner et al., 2022b) and Reinforced Soil (Winter et al., 2022b).

In the context of the Net Zero Strategy it is important that carbon emissions are considered in the future use of SGMs (BSI, 2018; Anon., 2018).

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Appendix A Special Geotechnical Measures (SGMs)

Table A.1: Full list of SGMs and Definitions as provided by Atkins/Jacobs in February 2020

Category	Sub-category	SGM Type & Quad Code	Definition
Drainage	Drainage	Basal Drainage (BSDR)	Granular basal layer beneath an embankment with the primary purpose of providing drainage
		Counterfort Drain (CFDR)	Gravel-filled drains extending to full earthwork depth/height
		Crest Drain (CSDR)	Open or filter drains installed parallel to earthwork crest to intercept water flowing towards the earthwork
		Cut off Drain (CODR)	Cut off drains, other than crest drains
		Filter Drain (FILT)	Filter drains typically installed parallel and adjacent to the road
		Fin Drain (FIND)	Fin drains typically installed parallel and adjacent to the road
		Frost Blanket (FRBL)	A granular layer incorporated into the pavement foundation construction with the specific purpose of mitigating frost heave
		Herringbone Drainage (HBDR)	Drainage installed into the face of a slope in a herringbone pattern
		Horizontal Drains (HRZD)	Sub-horizontal drains, typically installed by drilling
		Internal Drainage (INTD)	Drainage measures present within earthworks designed to avoid the generation of hydraulic pressures on structures
		Rock Ribs (RIBS)	Slope drains backfilled with rock fill material
		Sealed Drainage (SEAL)	A sub-surface drainage system that has been sealed to prevent hydraulic continuity with underlying materials, e.g. where a road passes over a landfill site
		Slope Drain (SLDR)	Drainage, other than counterforts and herringbone, installed on the face of a slope
		Soakaway (SOAK)	A sub-surface feature formally designed to drain water into the underlying strata. Does not include infiltration ponds or ditches
		Syphon Well (SYWL)	Vertical wells designed to actively extract groundwater using a syphon arrangement
		Toe Drain (TODR)	Open or filter drain installed at the toe of a slope to collect or intercept surface and/or groundwater
Earthworks	Ground Improvement	Band Drains (BNDR)	Vertical geosynthetic drains typically installed beneath new embankments to accelerate consolidation during construction
		Concrete Columns (CONL)	Columns of concrete, typically installed by vibro-replacement techniques beneath an embankment
		Dynamic Compaction (DYMC)	Ground improvement applied to soft or loose soils by impacting the surface with a dropped or rotating mass
		Grout Injection (GROT)	Injection of grout into the ground to fill voids, mitigate movement or improve physical properties
		Lime Slurry Injection (LMSL)	Injection of slaked lime into clay soils to improve the properties of the modified ground
		Sand Wicks / Drains (SDWK)	Vertical sand-filled drains typically installed beneath new embankments to accelerate consolidation during construction
		Stone Columns (STCL)	Columns of concrete, typically installed by vibro-replacement techniques beneath an embankment
		Surcharging / Pre-loading (SRCH)	Surcharging or pre-loading of the ground to manage ground movements

Table A.1: (… Continued) Full list of SGMs and Definitions as provided by Atkins/Jacobs in February 2020

Category	Sub-category	SGM Type & Quad Code	Definition
Earthworks (Continued)	Ground Improvement (Continued)	Vertical Drains (VERT)	Vertical drains of an unspecified type installed beneath an earthwork
	Material Modification (Soil)	Cement Stabilisation (CEMM)	Addition of cement to improve the properties of earthworks fill materials
		Fibre Reinforcement (FBRN)	Addition of loose fibres to fill material to improve physical properties
		Lime Piles (LMPL)	Piles formed of quicklime or slaked lime which improve the properties of the surrounding soil
		Lime Stabilisation (LMST)	Addition of lime to improve the properties of earthworks fill materials
	Material Replacement	Lightweight Fill (LGHT)	Lightweight fill including PFA, expanded clay aggregate and polystyrene blocks
		Rock Fill (ROCF)	Rock fill placed as part of an embankment foundation in areas of soft ground
		Tyre Bales (TYRB)	Compressed bales of used tyres utilised to reinforce slopes
	Non- Specific Earthworks Intervention	Non-Specific Anchor (NANC)	Not to be used for anchors observed during inspections. This category has been applied to features identified by data-mining where an SGM Type cannot be determined. Features in this category should be superseded and updated where possible following principal inspections
	Reprofiling	Regrade (REGD)	Earthworks repair comprising conventional fill, typically regraded to an angle shallower than the original construction
		Toe Berm (TOBR)	Earthworks repair comprising the addition of a berm at the toe of a slope to improve stability
	Rock Cut Management	Buttress (BTTR)	Concrete buttresses added to a rock slope to improve stability
		Concrete Facing (CONF)	Concrete facing, other than shotcrete, used to protect a rock face
		Dentition (DNTT)	Localised use of mortar, concrete or masonry to control the weathering and degradation of a rock slope
		Rock Bolts (ROCB)	An anchor bolt for stabilising rock excavations. It transfers load from the unstable exterior to the confined interior of the rock mass
		Rock Catch Fence (DBFN)	Fencing positioned at the toe of a slope designed to catch debris falling from the slope above
		Rock Netting / Mesh (SMEH)	Netting or mesh draped over a rock face to limit or prevent blocks from detaching from the face
		Rock Trap / Catch Ditch (DITC)	A ditch, bund or combination of both at the toe of a rock slope designed to reduce the risk of falling debris reaching the carriageway
		Rockfall Shelter (ROCS)	A shelter constructed over the road to prevent falling debris accumulating on the carriageway
		Scaling (SCAL)	Removal of weathered and loose material from a rock face to reduce the potential for spalling
		Shotcrete (SHOT)	Protective facing installed by spraying concrete onto the slope
	Slope Facing	Cobbled Facing (COBB)	Cobbles or setts used as a protective facing
		Concrete Cladding (CLAD)	Precast or cast in-situ concrete cladding, other than shotcrete, used as a protective facing
		Concrete Rubble Facing (CNRF)	Recycled concrete used as a protecting facing

Table A.1: (… Continued) Full list of SGMs and Definitions as provided by Atkins/Jacobs in February 2020

Category	Sub-category	SGM Type & Quad Code	Definition
Earthworks (Continued)	Slope Facing (Continued)	Erosion Mat (ERSN)	Permanent matting or membranes designed to retain topsoil and/or resist erosion of the slope face
		Gabion Facing (GABF)	Rock-filled baskets forming a 'thin' protective blanket on a slope face
		Masonry Facing (MSNF)	Protective slope facing constructed using masonry
		Rock Armour (ROCA)	Rock boulders, or concrete equivalents, placed to mitigate erosion of slopes from high-energy fluvial environments
		Rock Mattress (ROCM)	Rock fill contained in a wire mattress used to protect from scour/erosion
		Stone Pitching (PITC)	Irregular stone blocks and mortar forming a protective facing
	Special Foundation Measures	Basal Layer (BASE)	An additional layer of fill used as foundation treatment beneath an earthwork
		Concrete Slab (Non-mining) (RAFT)	Concrete raft used to span poor ground (Other than min entries) or control ground movements
		Geomembrane (GMEM)	One or more layers of geomembrane used in pavement foundation or embankment foundation construction
		Ground Beam (GBEM)	Concrete beam, sometimes in conjunction with underlying piles, for various applications including improving embankment shoulder stability
		Raft (Mining) (MRAF)	Concrete slab or raft used to mitigate risk of ground movements associated with a mine entry or other mining-related feature
		Shear Key (SRKY)	Partial replacement of embankment foundation materials with concrete or granular material to improve the mass properties of the foundation materials
		Shear Trench (SRTR)	Partial replacement of embankment foundation materials with concrete or granular material in trenches to improve the mass properties of the foundation materials
		Starter Layer (STLR)	A specific layer at the base of an embankment identified as being required as a starter layer
	Strengthened Earthwork	Electrokinetic (ELEC)	A system combining the processes of electroosmosis and chemical grouting used to improve the volume stability of soil
		Ground Anchor (GANC)	A structural member which transmits an applied tensile force (usually at the surface) to capable ground (at depth)
		Lime Nails (LMNL)	Similar to soil nails, but with compacted lime placed around the central steel bar
		Metallic Reinforcement (MTLK)	Metallic reinforcement such as straps or mesh, usually used in conjunction with a facing system for strengthened earthworks
		Natural Material Poles (POLE)	Inclined poles, typically of Willow, installed to stabilise a slope through improving shear strength and reduction in PWP as vegetation establishes
		Geotextile (GETX)	Slopes of any angle reinforced using layers of geosynthetic fabric
		Geogrid (GEGD)	Slopes of any angle reinforced using geosynthetic grids which interlock with the fill material

Table A.1: (… Continued) Full list of SGMs and Definitions as provided by Atkins/Jacobs in February 2020

Category	Sub-category	SGM Type & Quad Code	Definition
Earthworks (Continued)	Strengthened Earthwork (COntinued)	Shear Dowel (SRDW)	bonded steel dowels installed in rock slopes to mitigate against kinematic failure
		Soil Nail Mesh (SNMS)	A soil nailed slope of any angle where the facing mesh is designed to contribute to the stability of the solution
		Soil Nails (SNAL)	Slopes of any angle reinforced using soil nails, except where any facing mesh actively contributes to stability
Structures	Embedded Walls	Anchored Sheet Pile Wall (ASHP)	Sheet piled walls with associated ground anchors contributing to the stability of the wall
		Anchored Bored Pile Wall (ABPW)	Bored pile walls with associated ground anchors contributing to the stability of the wall
		Concrete Driven Piles (CNPL)	Precast driven concrete piles
		Contiguous Bored Pile Wall (CBPW)	Retaining wall comprising a row of concrete soldier piles installed so that each pile is in contact, or near contact, with piles on either side of it
		Dowel Piles (DOWP)	Systems of individual piles installed to mitigate slope instability by increasing resistance to sliding
		Inclined Piles (INCP)	Inclined piles as used to support retaining walls, or as a slope stability measure
		King Post Wall (KPWL)	Retaining wall comprising pairs of posts (e.g. 'I'-beams) with interlocking panels (e.g. precast concrete) between
		King Sheet Pile Wall (KSPW)	Sheet piled wall comprising alternating larger/longer and smaller/shorter piles to improve overall efficiency of the design
		Non-Specific Bored Pile Wall (NSBP)	Not to be used for walls observed during inspections. This category has been applied to features identified by data-mining where an SGM Type cannot be determined. Features in this category should be superseded and updated where possible following principal inspections
		Non-Specific Pile Wall (NSPW)	Not to be used for walls observed during inspections. This category has been applied to features identified by data-mining where an SGM Type cannot be determined. Features in this category should be superseded and updated where possible following principal inspections
		Micro Piles (MCRP)	Small diameter (Typically <300mm) drilled and grouted non-displacement piles
		PVC Pile Wall (PVCS)	Walls constructed using plastic sheet piles
		Secant Bored Pile Wall (SCPW)	A retaining wall constructed for ground retention prior to excavation. The wall is formed by constructing alternating primary (female) and secondary (male) piles where the secondary piles partially cut into either side of the primary piles in order to form a continuous impervious structure
		Sheet Pile Wall (SHPL)	Sheet piled walls, not including King Sheet Pile (KSP) or plastic sheet piles
		Spaced Bored Pile Wall (SBPW)	Embedded concrete piled wall with gaps between each pile which rely on soil arching to provide retention
	Gravity Walls	Block Wall (BLCW)	Precast concrete modular block gravity walls
		Concrete Sandbag Wall (CNSB)	Walls formed using concrete-filled bagwork
		Crib Wall (CRIB)	Concrete, timber or plastic crib walls

Table A.1: (… Continued) Full list of SGMs and Definitions as provided by Atkins/Jacobs in February 2020

Category	Sub-category	SGM Type & Quad Code	Definition
Structures (Continued)	Gravity Walls	Gabion Wall (GABN)	Gabion gravity retaining walls
		Masonry Wall (BKRW)	Masonry retaining walls (Not including dry stone walls)
		Non-Specific Retaining Wall (NSRW)	Not to be used for walls observed during inspections. This category has been applied to features identified by data-mining where an SGM Type cannot be determined. Features in this category should be superseded and updated where possible following principal inspections.
		Mass Concrete Wall (CNCW)	Pre-cast and cast in-situ gravity concrete walls, including 'L'- and 'T'-shaped walls
		Stone Wall (STNW)	Stone-built retaining walls including dry stone walls
		Tied Wall (TDWL)	A retaining wall which, to perform as intended, is tied to other elements (e.g. another wall or anchor piles)
		Timber Boards (TIMB)	Informal very low height features providing superficial retention of material on slopes

Appendix B SGM Survey Questionnaire

Forensic Examination of Critical Special Geotechnical Measures
Part of the Highways England Geotechnical Resilience Programme

Special Geotechnical Measures (SGMs) include all geotechnical measures over and above general earthworks whether implemented as part of new construction, widening, other improvements, or in response to failure or geohazards (a full list is shown on the Lists Tab).

Some SGMs have been highlighted as being problematic on the Highways England Strategic Road Network and this current project has been instigated to identify / prioritise SGMs that may warrant forensic examination in order to determine their performance in relation to their specified long-term design performance, particularly as many instances of SGMs are approaching the end of their notional design life (typically 60 years).
This brief survey is intended to capture existing knowledge from the Highways England Geotechnical Resilience Programme, the Smart Motorways Programme Pier2Pier group, the Highways England GAs and DGAs on RIP, CIP and SMP projects; and GMLEs as well as the wider Highways England Geotechnical Supply Chain.

We are seeking to capture:
1.The categories of SGMs that have given rise to significant concern or issues.
2.The cause of those concerns or issues.
3.Details of particular instances, including their location, of SGMs that might benefit from further evaluation.

Highways England is grateful for your input to this important project.

Instructions for Questionnaire

Before starting save this file with the following name:

	SGM survey COMPANY NAME INITIALS.xlsx
e.g.:	SGM survey COFFEY MTB.xlsx
	As used on cells B5 and B6 on Part 1 tab:
Current:	*SGM survey .xlsx*

PART 1

Please complete Part 1 of this survey for up to five (5) SGMs that you consider to be particularly important in the context above.

PART 2

Please complete Part 2 of this survey (tabs labelled SGM) for up to five (5) different instances of each SGM (the ones you selected in Part 1 of this survey).

Please give as much information as possible but please do not allow the absence of one or more piece(s) of information to prevent you from completing the questionnaire.

Notes to assist in filling out questionnaire

- The list of SGMs is located in the Lists Tab for ease of review.
- The Reference Tab presents the tables extracted from HD 41/15 'Maintenance of Highway Geotechnical Assets'.
- Cells in white are locked and are unable to be edited to prevent overwriting the cell.
- The cells in yellow are drop down selections.
- The cells in blue are for writing free text.

Introductory page allows the the input of basic data on up to five different SGMs.

Forensic Examination of Critical Special Geotechnical Measures
Part of the Highways England Geotechnical Resilience Programme

Notes to Assist Data Input	Enter Free Text
	Select from drop down menu

Highway Area:	0
Initials:	0
Full Name:	0
Email Address:	0

PART 2

SGM ID and Instance No.	___SGM1	INSTANCE 1	INSTANCE 2	INSTANCE 3	INSTANCE 4	INSTANCE 5
SGM TYPE and Instance ID	Basal Drainage (BSDR)	___SGM1_1	___SGM1_2	___SGM1_3	___SGM1_4	___SGM1_5
Location of SGM	Road Number (e.g. M6)					
	Junction or other location (e.g. J8 or MP125/3)					
	Eastings and Northings both to six figures e.g. 123456,654321 https://gridreferencefinder.com/					
Defects Observed at this location (see HD41/15, Table 6-1 for definitions)						
Feature Location Index (see HD41/15, Table 6-2 for definitions)						
Calculation of Initial Feature Grade Assessment (see HD41/15, Table 6-3)						
If a Subsequent Feature Grade Assessment has been carried out, please specify (see HD41/15, Table 6-4)						
HAGDMS Report Reference(s) (please list all that are relevant)						
Site Access	Offline					
	Hard Shoulder					
	Carriageway					
	Works					
	Other (please specify)					
Are works planned at the site? Select Yes / No from the drop down menu						
If 'Yes' is excavation / removal of the SGM planned? Select Yes / No from the drop down menu						
If 'Yes' please give an estimated date when the works might take place (mm/yyyy)						
Give brief description of defects, issues, concerns and problems associated with the SGM. Please include summary information about how concerns were first raised, the investigations that subsequently took place and decisions that were made regarding remediation, available published references, etc.						

SGM-specific page allows the entry of data on up to five examples (or instances) of each SGM-type selected in the introductory page.

Forensic Examination of Critical Special Geotechnical Measures
Part of the Highways England Geotechnical Resilience Programme

Notes to Assist Data Input	Enter Free Text
	Select from drop down menu

Highway Area:	0
Initials:	0
Full Name:	0
Email Address:	0

PART 2

SGM ID and Instance No.	__SGM1	INSTANCE 1	INSTANCE 2	INSTANCE 3	INSTANCE 4	INSTANCE 5
SGM TYPE and Instance ID	Basal Drainage (BSDR)	__SGM1_1	__SGM1_2	__SGM1_3	__SGM1_4	__SGM1_5
Location of SGM	Road Number (e.g. M6)					
	Junction or other location (e.g. J8 or MP125/3)					
	Eastings and Northings both to six figures e.g. 123456,654321 https://gridreferencefinder.com/					
Defects Observed at this location (see HD41/15, Table 6-1 for definitions)						
Feature Location Index (see HD41/15, Table 6-2 for definitions)						
Calculation of Initial Feature Grade Assessment (see HD41/15, Table 6-3)						
If a Subsequent Feature Grade Assessment has been carried out. please specify (see HD41/15, Table 6-4)						
HAGDMS Report Reference(s) (please list all that are relevant)						
Site Access	Offline					
	Hard Shoulder					
	Carriageway					
	Works					
	Other (please specify)					
Are works planned at the site? Select Yes / No from the drop down menu						
If 'Yes' is excavation / removal of the SGM planned? Select Yes / No from the drop down menu						
If 'Yes' please give an estimated date when the works might take place (mm/yyyy)						
Give brief description of defects, issues, concerns and problems associated with the SGM. Please include summary information about how concerns were first raised, the investigations that subsequently took place and decisions that were made regarding remediation, available published references, etc.						

Appendix C SGM Survey Results

Survey results – Part 1

SGM Type & Quad Code		Why does this SGM give cause for concern?								Minor	Intermediate	Major	Concerns and issues with this SGM.					Main gaps in knowledge of the performance and behaviour of this SGM.				
	No. SGM in Category	Innovative (and less well-understood)	Used frequently/extensively	Used in critical locations where failure would pose a significant risk	Insufficient appreciation of the limitations of the technique and/or materials	Has potential for greater future use on Highways England SRN	Failure(s) has been observed	Significant numbers of defects have been observed	Other (please specify)	Severity of the concerns that you have regarding this SGM			Design	Specification	Construction	Maintenance	Resilience	Design	Specification	Construction	Maintenance	Resilience
Basal Drainage (BSDR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Counterfort Drain (CFDR)	10	0	2	3	1	3	2	2	3	1	2	0	3	3	2	3	3	0	1	2	2	2
Crest Drain (CSDR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cut off Drain (CODR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filter Drain (FILT)	4	0	1	1	0	1	1	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Fin Drain (FIND)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frost Blanket (FRBL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Herringbone Drainage (HBDR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Horizontal Drains (HRZD)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Internal Drainage (INTD)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Ribs (RIBS)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sealed Drainage (SEAL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slope Drain (SLDR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soakaway (SOAK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syphon Well (SYWL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Toe Drain (TODR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Band Drains (BNDR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Columns (CONL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dynamic Compaction (DYMC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grout Injection (GROT)	3	0	0	1	0	1	0	0	1	0	1	0	1	1	1	1	1	0	0	1	0	0
Lime Slurry Injection (LMSL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sand Wicks / Drains (SDWK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Columns (STCL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surcharging / Pre-loading (SRCH)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Drains (VERT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cement Stabilisation (CEMM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fibre Reinforcement (FBRN)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime Piles (LMPL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lime Stabilisation (LMST)	3	0	0	1	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0
Lightweight Fill (LGHT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Fill (ROCF)	1	0	1	1	1	1	1	0	1	0	0	0	1	0	1	0	1	1	0	1	0	1
Tyre Bales (TYRB)	1	1	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	0	1	1	1	1
Non-Specific Anchor (NANC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Regrade (REGD)	9	0	3	2	2	2	3	2	3	0	3	0	3	1	1	0	2	1	0	2	0	2
Toe Berm (TOBR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Buttress (BTTR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Facing (CONF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dentition (DNTT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bolts (ROCB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Catch Fence (DBFN)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Netting / Mesh (SMEH)	3	0	2	2	0	2	1	0	2	0	1	1	1	1	0	2	2	0	1	0	2	1
Rock Trap / Catch Ditch (DITC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockfall Shelter (ROCS)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scaling (SCAL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shotcrete (SHOT)	1	0	1	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	0	1
Cobbled Facing (COBB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Cladding (CLAD)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Rubble Facing (CNRF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Erosion Mat (ERSN)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gabion Facing (GABF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Masonry Facing (MSNF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Armour (ROCA)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Mattress (ROCM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Pitching (PITC)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Basal Layer (BASE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Slab (Non-mining) (RAFT)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geomembrane (GMEM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ground Beam (GBEM)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raft (Mining) (MRAF)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shear Key (SRKY)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shear Trench (SRTR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Starter Layer (STLR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrokinetic (ELEC)	1	1	0	1	1	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1
Ground Anchor (GANC)	2	1	0	2	1	1	0	1	2	0	1	1	0	0	0	2	2	1	0	1	2	2
Lime Nails (LMNL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Metallic Reinforcement (MTLK)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Material Poles (POLE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geotextile (GETX)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geogrid (GEGD)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shear Dowel (SRDW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Nail Mesh (SNMS)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Nails (SNAL)	5	2	2	2	1	3	2	1	2	1	1	0	1	1	1	2	3	1	1	1	2	3
Anchored Sheet Pile Wall (ASHP)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Concrete Driven Piles (CNPL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contiguous Bored Pile Wall (CBPW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dowel Piles (DOWP)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inclined Piles (INCP)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
King Post Wall (KPWL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
King Sheet Pile Wall (KSPW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Specific Bored Pile Wall (NSBP)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Specific Pile Wall (NSPW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micro Piles (MCRP)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PVC Pile Wall (PVCS)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Secant Bored Pile Wall (SCPW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sheet Pile Wall (SHPL)	2	1	0	1	1	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1
Spaced Bored Pile Wall (SBPW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Block Wall (BLCW)	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1
Concrete Sandbag Wall (CNSB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crib Wall (CRIB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gabion Wall (GABN)	3	0	1	1	0	1	1	1	1	0	1	0	0	1	1	1	1	0	1	1	1	1
Masonry Wall (BKRW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-Specific Retaining Wall (NSRW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mass Concrete Wall (CNCW)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Wall (STNW)	3	0	1	1	1	1	1	1	1	0	1	0	1	0	0	1	0	0	0	0	1	1
Tied Wall (TDWL)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Timber Boards (TIMB)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Survey Results – Part 2

SGM ID and Instance No.	SGM Type	Road	Jct/Loc	Eastings and Northings	HD 41/15 Tables				HAGDMS Ref	Site Access					Planned Work			Description
					Defects	Loc Index	IFGA	SFGA		Offline	H/S	C'way	Works	Other	Wk Planned	Exc SGM?	Date	
Areas 4&5_Atkins_SKM_SGM2_1	Block Wall (BLCW)	M23	J8-J10	Multiple locations along scheme	0	0		0	29702	No	No	Yes	0	Emergency Refuge in Cutting Areas	No	0	01/00	Recent 2019 Construction for SMP Scheme
4_A-one+_MT_SGM5_1	Counterfort Drain (CFDR)	A27	Polthooks Cutting, east bound, MP64/8 to 65/6	482907, 105922 to 483725, 105732	Class 1D	Location Index C	3	2	Unknown	Yes	No	Yes	No	0	Yes	Yes	04/25	Counterfort drains have been installed over the entire length of the cutting. Most of these have defects with a combination of water erosion and animal burrowing. We have no records of design, construction or maintenance of these. There is evidence that part of the cutting failed (an as built drawing but no other records). It is believed that the slope stability is at risk
4_A-one+_MT_SGM5_2	Counterfort Drain (CFDR)	A2	Boughton Hill, both directions, MP87/7 to 88/6	606989, 158711 to 607870, 158695	0	0		0	Unknown	Yes	No	Yes	No	0	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data (other than location), no records or evidence these have ever been mantained. Believed to be a risk to slope stability
4_A-one+_MT_SGM5_3	Counterfort Drain (CFDR)	M23	Junction 8-9, both directions, MP37/4 to 39/3	530969, 147022 to 531023, 145180	Class 2	Location Index C	2	1	Unknown	Yes	Yes	No	Yes	Might be able to access the sites using the TM for Smart Motorways?	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data, no records or evidence these have ever been mantained. Believed to be a risk to slope stability
4_A-one+_MT_SGM5_4	Counterfort Drain (CFDR)	M23	Junction 10-10a, both directions, MP47/5 to 48/5	530421, 137122 to 530385, 136158	0	0		0	Unknown	Yes	Yes	No	No	0	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data, no records or evidence these have ever been mantained. Only record is drains seen during inspections Believed to be a risk to slope stability
3_Highways England_HJK_SGM2_1	Counterfort Drain (CFDR)	M4	113/1 WB	428725 178060	Class 1D	Location Index C	3	3	0	Yes	Yes	No	No	0	No	0	01/00	Counterfort drains were installed during construction of the slope in 1971, and have never been maintained. Current defects on the slope include erosion channels and issues caused by water. The poor condition of the counterforts may be a contributing factor
3_Highways England_HJK_SGM2_2	Counterfort Drain (CFDR)	M27	21/7 WB	446356 115300	Class 1D	Location Index C	3	2	27500	No	Yes	No	No	0	No	0	01/00	Ponding water and minor soil slips on the slope are possibly caused by counterfort drains no longer functioning. Counterforts are not visible from the surface, presence is assumed from as built drawings and toe drain details show connections up-slope.
3_Highways England_HJK_SGM2_3	Counterfort Drain (CFDR)	A34	62/9 SB	449612 190219	Class 2	Location Index C	2	1	0	Yes	No	No	No	0	No	0	01/00	Counterfort drains appear to have no gravel within them, or have collapsed, causing eosion gullies to form within the slope. There are original counterforts from the construction in 1977.
7, 9, SW, 3_Kier_DLT_SGM1_1	Counterfort Drain (CFDR)	A14	J0-1	459238 277750	Class 1A	Location Index C	4	4	0	No	No	Yes	No	Access is very difficult to this section due lack of diversionary route, since a full closure is likely to be needed	Yes	No	04/20	Concern is that the counterfort drains installed at construction are not performing well after 30 years. There is no carrier pipe and the filter medium may be getting blinded with fines. There is evidence of seasonal wetting of the lower part of the cutting slope and tension cracks and slips developing in the upper slope. no maintenance has been carried out and there are concerns about cutting into the slope during maintenance work to renew the drainage. Also a high friction fill needs to be used in these settings, not standard type B filter stone. Defects have been identified during repeat PIs.
7, 9, SW, 3_Kier_DLT_SGM1_2	Counterfort Drain (CFDR)	A14	J0-1	464079 277993	Class 3	Location Index C	1	2	0	Yes	No	Yes	No	Access is very difficult to this section due lack of diversionary route, since a full closure is likely to be needed. Possible on foot access from over bridge	Yes	No	04/20	as left Note that all cutting sections on the A14 from J0 to J4 have similar concerns
7, 9, SW, 3_Kier_DLT_SGM1_3	Counterfort Drain (CFDR)	A38	MP461/4 NB south of A610 interchange	438614 350489	Class 1A	Location Index B	5	4	0	No	No	No	No	Can park in adjacent layby and walk in	No	No	01/00	A significant wedge slip occurred in coal measures soon after construction in 1970s. This was repaired in early 1980s and a 2nd repair introduced counterfort drains. Ongoing creep is still apparently occurring, suggeesting either the counterforts are not well specified, need maintaining, or the root cause is not drainage related but relates to the soil strength

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7, 9, SW, 3_Kier_DLT_SG M3_1	Electrokinetic (ELEC)	M5	J7 SB offslip	387876 252375	Class 1D	Location Index C	3	4	0	Yes	Yes	No	No	0	Yes	No	04/29	The electrokinetic has only been carried out on part of the slope and has not addressed problems with the verge and drainage. The reason was believed to be due to budget restrictions. It also leaves a trip hazard in the slope face. The residual defects were identified in the repeat PI. The long term effectiveness of the E-K treatment has not yet been proved
3_Highways England_HJK_SG M1_1	Filter Drain (FILT)	M3	MP49/1 NB	488865 159996	Class 3	Location Index A	1	1	27447, 27269, 28279, 25489, 26965, 29793	Yes	No	No	No	Defects beneath Lane 1, TM would be required to access	No	0	01/00	A filter drain was constructed within a section of cutting with running sands (Camberley Sand Formation) in high groundwater locations. Due to poor construction methods multiple voids occurred in the hard shoulder and verge due to material loss within the filter drain. The drain was disjointed and cracked within 5 years of installation. The drainage was replaced during a Smart Motorway upgrade in 2017, however voids have again been observed in June 2019.
3_Highways England_HJK_SG M1_2	Filter Drain (FILT)	M3	J10-11 SB	448566 127122	Class 1D	Location Index C	3	3	3228	Yes	Yes	No	No	0	Yes	No	07/20	Filter drain located on berm between two high cuttings. Ravelling of the cuttings is occuring, requiring maintenance every 3 years. Due to the location of the filter drain it cannot be accessed to ascertain its condition. When the filter drain was constructed it appears no consideration to future maintenance was given.
3_Highways England_HJK_SG M1_3	Filter Drain (FILT)	A3	20/5 (Hampshire)	473816 124476	Class 1A	Location Index C	4	3	29744, 30249	Yes	No	No	No	0	Yes	No	07/21	Cutting failure in part due to insufficient capacity of filter drain at the toe of the slope. Whole route in cuttings adjacent to the site have lower capacity filter drains than required. Capcity of drains was not known to be low until after geotechnical failure.
3_Highways England_HJK_SG M1_4	Filter Drain (FILT)	A3	24/6 (Hampshire)	476850 126918	Class 2	Location Index C	2	3	N/A	Yes	No	No	No	0	0	0	01/00	A filter drain at the toe of a cutting at the Liss northbound off-slip is damaged and causing seepage of water into the toe of the cutting. Currently this is a Class 2B at risk location. A drainage scheme is currently in development at the site. The saturation of the toe of the cutting, and risk to the earthwork, was only identified due to flooding in Lane 1. An issue with the filter drains in Area 3 is that no routine inspections are undertaken of the asset, therefore they are only identified as sub-standard when either geotechnical defects are identified, or as shown here a flood event occurs.
7, 9, SW, 3_Kier_DLT_SG M4_1	Gabion Wall (GABN)	A49	South of Onibury Bridge / level crossing	345378 278968	Class 1D	Location Index C	3	2	0	No	No	Yes	No	footway and field gate	No	0	01/00	Defect originally identified through PI process. Further reviewed as part of discussions for replacement of onibury bridge. Gabions were originally installed to support edge of approach earthwork to bridge. Gabions have started to tilt, indicative of poor founding and / or inadequate design. Baskets are poorly filled and bulging, indicative of lack of attention to construction quality.
7, 9, SW, 3_Kier_DLT_SG M4_2	Gabion Wall (GABN)	A27/M3	M3-A27 WB on slip adj to Langstone Harbour	469428 105410	Class 1D	Location Index C	3	2	0	Yes	No	No	No	coastal footpath from nearby car park to east	Yes	Yes	04/22	Defect is a gabion mattress used to form sea defence and erosion control. Over the years the mesh has become damaged and much of the gabion stone fill has been lost due to tidal action. Defect identified through the PI Process. GI undertaken in 2018. Works proposal is to replace the defective sections, though firm proposal yet to be determined. Cause of defect likely to be inadequate attention to sizing of stone fill and or lack of maintenance
7, 9, SW, 3_Kier_DLT_SG M4_3	Gabion Wall (GABN)	M5	J3-4 MP 18/4A	398194 279201	Class 1D	Location Index B	3	3	0	No	Yes	No	No	drive by or hard shoulder stop	No	0	01/00	Accident damage to gabion mesh caused by HGV impact. A temporary patch has been applied, awaiting permanent repair. This defect reveals the sensitivity of gabion mesh to accidental damage, though the patched solution has truned out to be surprisingly resilient. Incidentally, note how the brick retaining wall 50m south of this location leans forward, indicative of inadequate design.

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4_A-one+_MT_SGM1_1	Ground Anchor (GANC)	A259	Ferry Hill, Winchelsea	590286, 117762 to 590364, 117676	Class 3	Location Index C	1	1	19278, 16673, 26387, 26388	No	No	Yes	No	Restricted site space. Anchors can be seen from slope, but might need TM to access fully	Yes	0	01/00	Ground anchors form part of a structure have have numerous defects at the surface. Structures /geotechnical are proposing study, but currently there are no details of what work would be involved and no funding to provide timescales
10_Jacobs_CJD_SGM1_1	Ground Anchor (GANC)	M62	Eastbound between J21 and J22.	397235,414574	0	0		0	0	0	0	0	0	0	0	0	01/00	Ther is a major SGM in place but it has no maintenance records and no monitoring policy. Ther may not be an actual current defect.
SW, 6&7_KIER_DLT_SGM2_1	Grout Injection (GROT)	M5	J20 SB on slip	341800 914972	Class 1A	Location Index C	4	4	0	Yes	Yes	No	No	access from side road to the east of roundabout	Yes	No	04/22	The earthwork has been heavily dug into by badgers. A proposal is in hand to exclude them and stabilize the earthworks. One of the options is to grout up the voids. There are two ways to grout up - a) through the tunnel entrances or b) via a grid of injection holes. There are two materials - a) cement:pfa grout or b) urethane grout Either material may suit but there are concerns about achieving full void filling and proving that has been achieved. There seems to be little knowledge about the effectiveness of either injection technique in this setting (unlike filling mineworkings)
SW, 6&7_KIER_DLT_SGM2_2	Grout Injection (GROT)	M54	J3 to 2 EB	389318 689237	0	Location Index A		0	0	No	Yes	No	No	access only from hard shoulder, requiring 15 min stop or TM closure	No	No	01/00	M54 is concrete slab carriageway. Water in the foundation has led to loss of support and rocking of slabs. Urethane grout has been proposed to stabilise the slabs. However, there is a lack of confidence in a) being able to stabilise all the voids and b) in not accidentally grouting up the drainage. There is suspicion in some parts that urethane grout will not flow to fill voids, but in other parts that grout will invade the drains. There seems to be a lack of evidence / track record, although the method has also been suggested regarding stabilising run-on slabs at structures. In consequence, so far the method has not been used in this situation and instead rocking slabs are replaced with asphalt. NB, in this situation the drainage should also be refurbished to enable more effective drainage of the foundation and reduce risk of the build up of water in the future.
SW, 6&7_KIER_DLT_SGM2_3	Grout Injection (GROT)	M11	J14 (Girton interchange)	5415424 261195	Class 1A	Location Index B	5	4	0	No	No	No	No	No hard shoulder, access v difficult unless TM in place	No	No	01/00	Voids were found at the corner of the bridge abutments and wingwalls. These were stabilised by urethane grout injection, though difficulty was encountered in obtaining a backpressure at the void outlet beneath wing walls. Grout was selected to limit the flow after injection. One concern is whether the grout fully filled the void. However, filling the void is only part of the solution. The cause was due to leaking drains at the end of the bridge deck, leading to water soakaway and erosion of the backfill. These were not fixed, so the problem likely to recur. Concern is that the grouting work is not the full solution and that the root cause should also be addressed.
4_A-one+_MT_SGM3_1	Lime Stabilisation (LMST)	A21	Panthurst Farm, north bound, MP33/2	E553323 N151736	Class 3	Location Index C	1	1	PSSR: 21163; GI: 22661; GIR: 22113; GDR: 22378; GFR:	Yes	No	Yes	No	0	No	0	01/00	Major soil slip repaired by lime stabilisation in 2009. No current defects recorded. No formal monitoring, so actual performance is unknown.
4_A-one+_MT_SGM3_2	Lime Stabilisation (LMST)	A27	Hailsham Road (local road south of A27)	E557848 N105448	Class 3	Location Index C	1	1	PSSR: 21969; GI: 24407; GIR: 23829; GDR: 23979; GFR:	Yes	No	Yes	No	0	No	0	01/00	Soil slips repaired by lime stabilisation in 2010. No current defects recorded. No formal monitoring, so actual performance is unknown.
4_A-one+_MT_SGM3_3	Lime Stabilisation (LMST)	A27	Poling Layby, west bound	Start: E505790 N105676 End: E505614 N105686	Class 3	Location Index C	1	1	PSSR: 20267; GI: 19897; GR: 27851; GFR: 24865	Yes	No	No	No	0	No	0	01/00	Embankment repair using lime stabilisation in 2008. No current defect recorded. No formal monitoring, so actual performance is unknown.

SGM ID and Instance No.	SGM Type	Road	Jct/Loc	Eastings and Northings	HD 41/15 Tables				HAGDMS Ref	Site Access					Planned Work			Description
					Defects	Loc Index	IFGA	SFGA		Offline	H/S	C'way	Works	Other	Wk Planned	Exc SGM?	Date	
SW_HE_MJS_SGM1_1	Regrade (REGD)	M4	EB MP138.9 to 139.3.	405194.707,183712.497	Class 1D	Location Index B	3	0	23961, 23961, 25121, 26214, 27346	0	Yes	0	0	0	Yes	Yes	12/21	Tension crack and slumping has appeared in granular repair. Still under review.
3_Highways England_HJK_SGM4_1	Regrade (REGD)	A308M	J1 to J2 SB	488791 178852	Class 3	Location Index A	1	1	20145, 20329, 21944, 27038, 27210, 27211, 27220, 27301, 27546	No	Yes	No	No	0	No	0	01/00	Various phases of repairs have been undertaken at the site. Regrades of the slope to provide additional crest space have caused several issues, including loss of topsoil due to slope angle, and shallow rotational failures. A toe berm was constructed to provide long term stability. It appears the issues with the regrades have occurred due to poor design and lack of appreciation of geotechnical hazards at the site.
3_Highways England_HJK_SGM4_2	Regrade (REGD)	A34	72/8 SB	448952 198695	Class 1A	Location Index B	5	4	29745, 30243	Yes	No	No	No	0	Yes	No	07/21	To accommodate a wider drainage channel at the edge of pavement the crest of the embankment was steepened. This has resulted in insufficient verge width and oversteepened crest causing rotation of the VRS and drainage channel. This is possible a design or construction issue
3_Highways England_HJK_SGM4_3	Regrade (REGD)	A34	87/8 SB	449211 210579	Class 1D	Location Index C	3	2	26021	No	No	No	Yes	TM required for access	No	0	01/00	The slope appears to have been reprofiled, with new planting. However there is no historic information available including reports or ground investigation information. The mechanism of the failure, and as such the risk to the adjacent embankment, is unknown.
3_Highways England_HJK_SGM4_4	Regrade (REGD)	M4	79/2 SB	461247 173773	Class 1D	Location Index A	4	4	0	Yes	Yes	No	No	0	Yes	Yes	07/20	Seven repairs have been undertaken on the embankment, which include regrades to accommodate a v-channel in the crest. The regrades have caused over-steepening of the slope. Survey works are due to be undertaken in winter 2019 to establish the extent of the failure, and whether it is confined to the regraded sections of the slope. There is limited as built information on the regraded sections of the slope. This is an example of poor design choice in regrading the slope to a higher angle than suitable.
3_Highways England_HJK_SGM4_5	Regrade (REGD)	M27	9/9 EB	436323 116263	Class 1A	Location Index C	4	3	0	Yes	Yes	No	No	0	Yes	Yes	07/22	To accommodate an access track at the toe of an embankment material was removed and the toe was regraded. This has left the embankment toe being over-steep and movement of the slope has been exhibited. This is an example of an unplanned or undesigned regrade being undertaken causing instability to the geotechnical asset
7, 9, SW, 3_Kier_DLT_SGM2_1	Regrade (REGD)	M4	J17-16	404637 183450	Class 1A	Location Index B	5	4	0	Yes	Yes	Yes	No	0	Yes	Yes	04/22	Partial granualr repair previously carried out, but proved to be insufficient to address the issues and has re-slipped. Repeat failure identified through repeat principal inspections It is becoming increasingly difficult with high traffic flows to obtain a HS/L1 closure in which to carry out further remedial works and it is likely that part of the hard shoulder will need to be removed to carry out the works
7, 9, SW, 3_Kier_DLT_SGM2_2	Regrade (REGD)	M4	Dark lane	461182 137378	Class 1D	Location Index A	4	4	0	No	Yes	Yes	No	0	Yes	Yes	04/23	Series of local granular repairs previously carried out on narrow & steep earthwork, but the embankment found to have slipped again. Defect identified through repeat principal inspection process. It is becoming increasingly difficult with high traffic flows to obtain a HS/L1 closure in which to carry out further remedial works and it is likely that part of the hard shoulder will need to be removed to carry out the works
7, 9, SW, 3_Kier_DLT_SGM2_3	Counterfort Drain (CFDR)	M5	J8	390753 290557	Class 1D	Location Index B	3	4	0	No	Yes	Yes	No	0	Yes	Yes	04/24	Counterforts were installed about 15 years ago, but for cost / time reasons, the reconstruction of the verge & drainage were not carried out. Consequently there is ongoing deflection of the verge, kerb & drainage that now need fixing. Reported through the routine inspection and repeat PI process
SW_Highways England_RDB_SGM1_1	Rock Fill (ROCF)	M4	MP 138/9 to 139/3	404726, 183468	Class 1A	Location Index A	5	4	23961 GIR, 26214 GDR, 27346 GFR (all relating to original design and construction)	No	Yes	Yes	No	0	Yes	Yes	-	In 2017, defects were identified within a previously remediated earthwork (See current ob: 281779). The first recorded defect was in 2002 and comprised a slip and toe buldge. A subsequent PI in 2007 identified that the defect was remediated using a granular replacement (as per GDMS reports above). 412m of the earthwork was remediated, comprising 356m of shoulder replacement and 56m of full slope replacment utilising Class 6F5 imported granular material. The significant defects appear to result from a failure of the recent remedial work, which presumably was constructed and built to modern standards. The cause is not certain but consideration should be given to the fact that a granular shoulder may allow more water to penetrate deeper into the fill and hence soften the fill behind the repair/generate a preferential failure zone, particularly where granular fill is used in cohesive embankments. The scheme is currently going through Value Management.

SGM ID and Instance No.	SGM Type	Road	Jct/Loc	Eastings and Northings	HD 41/15 Tables				HAGDMS Ref	Site Access					Planned Work			Description
					Defects	Loc Index	IFGA	SFGA		Offline	H/S	C'way	Works	Other	Wk Planned	Exc SGM?	Date	
4_A-one+_MT_SGM 4_1	Soil Nails (SNAL)	A23	Pyecombe Soil Slip , north bound, MP4/5	Start: E528170 N112881 End: E528160 N112884	Class 1A	Location Index A	5	4	SoI: 30485; PSSR: 30529	Yes	No	No	No	Park off network and use footway	Yes	Yes	-	Full slope height soil slip within an are of reinforcment. Soil nails have been pulled out from face.
4_A-one+_MT_SGM 4_2	Rock Netting / Mesh (SMEH)	A23	Pyecombe Chalk Cutting, southbound,	E528017 N113042	Class 3	Location Index A	1	1	PSSR: 21174; GR: 21867; GDR: 28362; GFR:	No	No	Yes	No	0	No	0	01/00	Soil nail and rock netting repair to prevent rock fall(s) reaching the slip road. No current defect recorded. No formal monitoring, so actual performance is unknown.
12 & 14_A-one+/ Jacobs_CJ_SGM 3_1	Rock Netting / Mesh (SMEH)	A1M	MP29/5	432295, 534275	Class 3	Location Index B	1	1	0	Yes	Yes	Yes	No	0	No	0	01/00	Passive Greenax Mesh and rockbolts. Section replaced with incompatible mesh which now compromises the overall system.
3_Highways England_HJK_SG M3_1	Sheet Pile Wall (SHPL)	M4	57/5 EB	497399 170577	Class 3	Location Index C	1	1	25152	No	Yes	No	Yes	Currently within M4 J3-12 Smart Upgrade	Yes	No	01/00	Circa 1994 sheet piles were used to reinforce the toe of the slope. No design calculations are available, condition of the sheet piles and exact locations are unknown due to lack of background information. The sheet piles are completely buried now, so cannot be observed for condition.
3_Highways England_HJK_SG M3_2	Sheet Pile Wall (SHPL)	M4	60/8 EB	475830 169593	Class 1D	Location Index B	3	3	0	No	Yes	No	Yes	Currently within M4 J3-12 Smart Upgrade	Yes	Yes	-	Sheet piles installed within the slope as a stabilising measure. Extent and condition are unknown, however anticipated to be 1.2km length of slope. Terracing and minor defects have started to form in the locations where the piles are present, suggesting they are failing.
12 & 14_A-one+/ Jacobs_CJ_SGM 1_1	Shotcrete (SHOT)	A1M	68-69	423674, 560950	Class 2	Location Index C	2	1	0	No	No	Yes	No	0	No	0	01/00	Large shotcrete wall, which is looking incredibly green and suggests significant moisture content buildup behind the wall. Risk that during cold weather any freezing could fundamentally undermine the integrity of the SGM.
4_A-one+_MT_SGM 2_1	Soil Nails (SNAL)	A21	Tonbridge Bypass, both directions (6No sites). MP36/3 to 39/6	555244, 149574 to 556255, 146485	Class 3	Location Index C	1	1	21164, 22688, 25603, 22695, 27670, 25529, 17237, 25304, 21167, 22685, 22560, 16680, 27395, 25602	Yes	No	Yes	No	0	No	0	01/00	No problems or concerns. There are 6 different sites that have had soil nails installed at different times and in different ways to resolve the same problem (aging, oversteep clay embankments). A review of the performance might benefit future use/designs
4_A-one+_MT_SGM 2_2	Soil Nails (SNAL)	A21	Lower Haysden, south bound, MP40/4	556361, 145726 to 556390, 145676	Class 3	Location Index C	1	1	22686, 21173, 22687, 27498, 25600	Yes	No	Yes	No	0	No	0	01/00	Site was soil nailed at the same time and using the same method as the Tonbridge Bypass sites. The nails here were spaced further apart and a failure ocurred between them. Believed to be caused by a combination of the nail spacing and the quality of the works finish where the facing was not tight to the slope face. Later repaired with localised reinforced soil
4_A-one+_MT_SGM 2_3	Soil Nails (SNAL)	M23	Gatwick Spur, both directions (3No. Sites) MP43/8 to 44/1	529405, 141666 to 529629, 141725	Class 3	Location Index C	1	1	17251, 27995, 28372, 26330, 21182, 26872, 27177	Yes	Yes	No	Yes	Might be able to access the sites using the TM for Smart Motorways?	No	0	01/00	There are 3 different sites that have had soil nails installed at different times to resolve the same problem (aging, oversteep clay embankments). A review of the performance might benefit future use/designs. One site was damaged during VRS installation, so resilience to future works might be assessed
12 & 14_A-one+/ Jacobs_CJ_SGM 2_1	Soil Nails (SNAL)	A1M	MP125/3	4.22563E+11	Class 1D	Location Index C	3	1	0	No	Yes	Yes	No	0	Yes	No	01/00	Bulging along toe with evidence of localised failure with debris behind mesh along lower 1m of slope.
Areas 4&5_Atkins_SK M_SGM1_1	Soil Nails (SNAL)	M23	J9	5.30436E+11	0	0		0	29702	Yes	0	0	0	Access available to Toe from Peeks Brook Lane	0	0	01/00	Recent 2019 Construction for SMP Scheme
7, 9, SW, 3_Kier_DLT_SG M5_1	Stone Wall (STNW)	A36	Holcombe Close, Bathampton	377643 165968	Class 1A	Location Index C	4	4	0	Yes	No	No	No	Best accessed from Holcombe Close	No	0	01/00	Mixed stone and gabion retaining wall of unknown age. Identified through PI process. Condition of masonry and of gabions is poor. Wall appears to be stable but ongoing concerns about robustness of wall and adequacy of design to resist overturning, sliding or bearing failure. Boreholes drilled with piezometers and inclinometer.

SGM ID and Instance No.	SGM Type	Road	Jct/Loc	Eastings and Northings	HD 41/15 Tables				HAGDMS Ref	Site Access					Planned Work			Description
					Defects	Loc Index	IFGA	SFGA		Offline	H/S	C'way	Works	Other	Wk Planned	Exc SGM?	Date	
7, 9, SW, 3_Kier_DLT_SGM5_2	Stone Wall (STNW)	A36	MP 2/4 between Bathampton & Claverton (SB)	378181 165131	Class 1D	Location Index C	3	3	0	No	No	0	No	TM needed to allow a safe place to stop	No	0	01/00	Stone wall of considerable age at base of shallow embankment. Wall has long ago collapsed and provides no support to the earthwork on the east side of the road Defect identified as a result of cracking of the edge of the pavement due to potential loss of support to the edge of the carriageway
7, 9, SW, 3_Kier_DLT_SGM5_3	Stone Wall (STNW)	A36	MP 5/0 NB at Claverton	378506 162954	Class 2	Location Index A	3	3	0	No	No	No	No	TM needed to allow a safe place to stop	Yes	No	04/21	Stone wall of considerable age. No obvious design basis of the wall and clearly should not work as an earth retaining wall Wall is in variable condition with several blocks missing and extensive loss of mortar. A scheme is being developed to repair the wall. The section in question is around 4m high and changes in the masonry indicate an historic piecemeal approach to construction and to maintenance. This wall has clearly evolved as the road has been widened and straightened over the years.
SW, 6&7_KIER_DLT_SGM1_1	Tyre Bales (TYRB)	A45	EB on slip from B573 at MP180/7	486705 264073	Class 1D	Location Index C	3	2	0	Yes	No	No	No	park on B573 and walk in	No	No	01/00	Tyre bales were used experimentally to repair cutting slip. Difficulties were encountered: * obtaining a regular shape bale and thus a close "fit" * quality / irregularity of tyre bales and the bindings * detailing & cosntructing the bale array on a curve and on a falling gradient * achieving compaction of the surrounding fills, due to resilience of the bales. Large scale stability is probably good, but local stability and construction tolerances harder to achieve.

Appendix D Correlated List of SGMs and Locations

SGM ID and Instance No.	SGM Type	Area	Region	Road	Jct/Loc	Eastings and Northings	Planned Work			Description
							Work Planned	Excavate SGM?	Date	
4_A-one+_MT_SGM5_1	Counterfort Drain (CFDR)	4	South East	A27	Polthooks Cutting, east bound, MP64/8 to 65/6	482907, 105922 to 483725, 105732	Yes	Yes	04/25	Counterfort drains have been installed over the entire length of the cutting. Most of these have defects with a combination of water erosion and animal burrowing. We have no records of design, construction or maintenance of these. There is evidence that part of the cutting failed (an as built drawing but no other records). It is believed that the slope stability is at risk.
4_A-one+_MT_SGM5_2	Counterfort Drain (CFDR)	4	South East	A2	Boughton Hill, both directions, MP87/7 to 88/6	606989, 158711 to 607870, 158695	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data (other than location), no records or evidence these have ever been maintained. Believed to be a risk to slope stability.
4_A-one+_MT_SGM5_3	Counterfort Drain (CFDR)	4	South East	M23	Junction 8-9, both directions, MP37/4 to 39/3	530969, 147022 to 531023, 145180	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data, no records or evidence these have ever been maintained. Believed to be a risk to slope stability.
4_A-one+_MT_SGM5_4	Counterfort Drain (CFDR)	4	South East	M23	Junction 10-10a, both directions, MP47/5 to 48/5	530421, 137122 to 530385, 136158	Yes	Yes	04/25	Counterfort drains that were installed as part of the road construction. We have no design or as built data, no records or evidence these have ever been maintained. Only record is drains seen during inspections Believed to be a risk to slope stability.
7, 9, SW, 3_Kier_DLT_SGM1_1	Counterfort Drain (CFDR)	7	East Midlands	A14	J0-1	459238 277750	Yes	No	04/20	Concern is that the counterfort drains installed at construction are not performing well after 30 years. There is no carrier pipe and the filter medium may be getting blinded with fines. There is evidence of seasonal wetting of the lower part of the cutting slope and tension cracks and slips developing in the upper slope. no maintenance has been carried out and there are concerns about cutting into the slope during maintenance work to renew the drainage. Also a high friction fill needs to be used in these settings, not standard type B filter stone. Defects have been identified during repeat PIs.
7, 9, SW, 3_Kier_DLT_SGM1_2	Counterfort Drain (CFDR)	7	East Midlands	A14	J0-1	464079 277993	Yes	No	04/20	as left Note that all cutting sections on the A14 from J0 to J4 have similar concerns
7, 9, SW, 3_Kier_DLT_SGM3_1	Electrokinetic (ELEC)	9	West Midlands	M5	J7 SB offslip	387876 252375	Yes	No	04/29	The electrokinetic has only been carried out on part of the slope and has not addressed problems with the verge and drainage. The reason was believed to be due to budget restrictions. It also leaves a trip hazard in the slope face. The residual defects were identified in the repeat PI. The long term effectiveness of the E-K treatment has not yet been proved
3_Highways England_HJK_SGM1_2	Filter Drain (FILT)	3	South East	M3	J10-11 SB	448566 127122	Yes	No	07/20	Filter drain located on berm between two high cuttings. Ravelling of the cuttings is occurring, requiring maintenance every 3 years. Due to the location of the filter drain it cannot be accessed to ascertain its condition. When the filter drain was constructed it appears no consideration to future maintenance was given.

SGM ID and Instance No.	SGM Type	Area	Region	Road	Jct/Loc	Eastings and Northings	Planned Work			Description
							Work Planned	Excavate SGM?	Date	
3_Highways England_HJK_SGM1_3	Filter Drain (FILT)	3	South East	A3	20/5 (Hampshire)	473816 124476	Yes	No	07/21	Cutting failure in part due to insufficient capacity of filter drain at the toe of the slope. Whole route in cuttings adjacent to the site have lower capacity filter drains than required. Capacity of drains was not known to be low until after geotechnical failure.
7, 9, SW, 3_Kier_DLT_SGM4_2	Gabion Wall (GABN)	3	South East	A27/M3	M3-A27 WB on slip adj to Langstone Harbour	469428 105410	Yes	Yes	04/22	Defect is a gabion mattress used to form sea defence and erosion control. Over the years the mesh has become damaged and much of the gabion stone fill has been lost due to tidal action. Defect identified through the PI Process. GI undertaken in 2018. Works proposal is to replace the defective sections, though firm proposal yet to be determined. Cause of defect likely to be inadequate attention to sizing of stone fill and or lack of maintenance
4_A-one+_MT_SGM1_1	Ground Anchor (GANC)	4	South East	A259	Ferry Hill, Winchelsea	590286, 117762 to 590364, 117676	Yes	0	-	Ground anchors form part of a structure have numerous defects at the surface. Structures /geotechnical are proposing study, but currently there are no details of what work would be involved and no funding to provide timescales
SW, 6&7_KIER_DLT_SGM2_1	Grout Injection (GROT)	SW	South West	M5	J20 SB on slip	341800 914972	Yes	No	04/22	The earthwork has been heavily dug into by badgers. A proposal is in hand to exclude them and stabilize the earthworks. One of the options is to grout up the voids. There are two ways to grout up - a) through the tunnel entrances or b) via a grid of injection holes. There are two materials - a) cement:pfa grout or b) urethane grout Either material may suit but there are concerns about achieving full void filling and proving that has been achieved. There seems to be little knowledge about the effectiveness of either injection technique in this setting (unlike filling mineworkings)
SW_HE_MJS_SGM1_1	Regrade (REGD)	SW	South West	M4	EB MP138.9 to 139.3.	405194.707,183712.497	Yes	Yes	12/21	Tension crack and slumping has appeared in granular repair. Still under review.
3_Highways England_HJK_SGM4_2	Regrade (REGD)	3	South East	A34	72/8 SB	448952 198695	Yes	No	07/21	To accommodate a wider drainage channel at the edge of pavement the crest of the embankment was steepened. This has resulted in insufficient verge width and oversteepened crest causing rotation of the VRS and drainage channel. This is possible a design or construction issue
3_Highways England_HJK_SGM4_4	Regrade (REGD)	3	South East	M4	79/2 SB	461247 173773	Yes	Yes	07/20	Seven repairs have been undertaken on the embankment, which include regrades to accommodate a v-channel in the crest. The regrades have caused over-steepening of the slope. Survey works are due to be undertaken in winter 2019 to establish the extent of the failure, and whether it is confined to the regraded sections of the slope. There is limited as built information on the regraded sections of the slope. This is an example of poor design choice in regrading the slope to a higher angle than suitable.
3_Highways England_HJK_SGM4_5	Regrade (REGD)	3	South East	M27	9/9 EB	436323 116263	Yes	Yes	07/22	To accommodate an access track at the toe of an embankment material was removed and the toe was regraded. This has left the embankment toe being over-steep and movement of the slope has been exhibited. This is an example of an unplanned or undesigned regrade being undertaken causing instability to the geotechnical asset
7, 9, SW, 3_Kier_DLT_SGM2_1	Regrade (REGD)	SW	South West	M4	J17-16	404637 183450	Yes	Yes	04/22	Partial granular repair previously carried out, but proved to be insufficient to address the issues and has re-slipped. Repeat failure identified through repeat principal inspections It is becoming increasingly difficult with high traffic flows to obtain a HS/L1 closure in which to carry out further remedial works and it is likely that part of the hard shoulder will need to be removed to carry out the works

SGM ID and Instance No.	SGM Type	Area	Region	Road	Jct/Loc	Eastings and Northings	Planned Work			Description
							Work Planned	Excavate SGM?	Date	
7, 9, SW, 3_Kier_DLT_SGM2_2	Regrade (REGD)	3	South East	M4	Dark lane	461182 137378	Yes	Yes	04/23	Series of local granular repairs previously carried out on narrow & steep earthwork, but the embankment found to have slipped again. Defect identified through repeat principal inspection process. It is becoming increasingly difficult with high traffic flows to obtain a HS/L1 closure in which to carry out further remedial works and it is likely that part of the hard shoulder will need to be removed to carry out the works
7, 9, SW, 3_Kier_DLT_SGM2_3	Regrade (REGD)	9	West Midlands	M5	J8	390753 290557	Yes	Yes	04/24	Counterforts were installed about 15 years ago, but for cost / time reasons, the reconstruction of the verge & drainage were not carried out. Consequently there is ongoing deflection of the verge, kerb & drainage that now need fixing. Reported through the routine inspection and repeat PI process
SW_Highways England_RDB_SGM1_1	Rock Fill (ROCF)	SW	South West	M4	MP 138/9 to 139/3	404726, 183468	Yes	Yes	-	In 2017, defects were identified within a previously remediated earthwork (See current ob: 281779). The first recorded defect was in 2002 and comprised a slip and toe bulge. A subsequent PI in 2007 identified that the defect was remediated using a granular replacement (as per GDMS reports above). 412m of the earthwork was remediated, comprising 356m of shoulder replacement and 56m of full slope replacement utilising Class 6F5 imported granular material. The significant defects appear to result from a failure of the recent remedial work, which presumably was constructed and built to modern standards. The cause is not certain but consideration should be given to the fact that a granular shoulder may allow more water to penetrate deeper into the fill and hence soften the fill behind the repair/generate a preferential failure zone, particularly where granular fill is used in cohesive embankments. The scheme is currently going through Value Management.
4_A-one+_MT_SGM4_1	Rock Netting / Mesh (SMEH)	4	South East	A23	Pyecombe Soil Slip , north bound, MP4/5	Start: E528170 N112881 End: E528160 N112884	Yes	Yes	-	Full slope height soil slip within an area of reinforcement. Soil nails have been pulled out from face.
3_Highways England_HJK_SGM3_1	Sheet Pile Wall (SHPL)	3	South East	M4	57/5 EB	497399 170577	Yes	No	-	Circa 1994 sheet piles were used to reinforce the toe of the slope. No design calculations are available, condition of the sheet piles and exact locations are unknown due to lack of background information. The sheet piles are completely buried now, so cannot be observed for condition.
3_Highways England_HJK_SGM3_2	Sheet Pile Wall (SHPL)	3	South East	M4	60/8 EB	475830 169593	Yes	Yes	-	Sheet piles installed within the slope as a stabilising measure. Extent and condition are unknown, however anticipated to be 1.2km length of slope. Terracing and minor defects have started to form in the locations where the piles are present, suggesting they are failing.
12 & 14_A-one+/ Jacobs_CJ_SGM2_1	Soil Nails (SNAL)	14	North East	A1M	MP125/3	4.22563E+11	Yes	No	-	Bulging along toe with evidence of localised failure with debris behind mesh along lower 1m of slope.
7, 9, SW, 3_Kier_DLT_SGM5_3	Stone Wall (STNW)	SW	South West	A36	MP 5/0 NB at Claverton	378506 162954	Yes	No	04/21	Stone wall of considerable age. No obvious design basis of the wall and clearly should not work as an earth retaining wall Wall is in variable condition with several blocks missing and extensive loss of mortar. A scheme is being developed to repair the wall. The section in question is around 4m high and changes in the masonry indicate an historic piecemeal approach to construction and to maintenance. This wall has clearly evolved as the road has been widened and straightened over the years.

Appendix E Summary of Issues from the Questionnaire Survey

SGM Type	No. of Entries	Discussion
Counterfort Drain (CFDR)	11	The counterfort drain SGM has been selected by several respondents indicating that problems with this SGM are widespread. The responses indicate that some of these counterforts are in critical locations where failure may pose a significant risk to the network. Also, there are concerns with the design, specification, construction, maintenance and resilience of the SGM including a lack of records of all of these elements. The descriptions of the individual examples indicate issues including collapsing of counterforts, erosion of channels, ponding water due to non-functioning counterforts and the development of tension cracks and slips. Four of the counterfort SGM locations are planned to be exhumed in future work. The project team has come across problems similar to these on other schemes.
Filter Drain (FILT)	4	The filter drain SGM has only been indicated to be a problem by Area 3. The responses indicate that the filter drains are of "Major" concern as the defect poses a threat to the safety of users, workers or other parties such that immediate action is required. There are concerns with the construction, maintenance and resilience of the filter drains and the descriptions include no routine inspections or maintenance, poor construction methods (possibly installing them into ground conditions that are unsuitable) and insufficient capacity. No filter drains are planned to be exhumed in future projects. The project team have come across issues with filter drains on previous schemes; however, are surprised that so many examples were given by the respondents.
Grout Injection (GROT)	3	The grout injection SGM was indicated to be a problem in three locations; however, from an interrogation of the data it is apparent grout injection itself isn't necessarily a problem but more so the perceived lack of knowledge on how to install it effectively and once installed, how to test that it has successfully filled the voids. Grout injection was only used in one of the examples. No grout injection SGMs are planning to be exhumed in future projects. The project team have not come across problems with grout injection if used correctly.
Lime Stabilisation (LMST)	3	The lime stabilisation SGM responses are not considered to be a problem. Lime stabilisation has been used in the three locations (all part of Area 4); however, defects have not been observed and the actual performance is unknown. No lime stabilisation sites are planning to be exhumed in future projects. The project team have not come across problems with lime stabilisation if used correctly.
Rock Fill (ROCF)	1	The rock fill SGM was only indicated to be a problem in one location and there were concerns with the design, construction and resilience of the SGM. This rock fill SGM could also fall into the regrade SGM. The description for this rock fill SGM was for failure of a previously remediated slope and the respondent thought that softening of the core fill may have been occurring during to penetration of water through the rock fill. The rock fill SGM is planned to be exhumed in future work. The project team have come across previous failures of rock fill slopes; however, the problem isn't thought to be extensive.

SGM Type	No. of Entries	Discussion
Tyre Bales (TYRB)	1	The tyre bale SGM was only indicated to be a problem in one location and there were concerns with the design, construction and resilience of the SGM. The comments given by the responder indicated problems such as obtaining a regular shape bale and not able to get a close fit. These elements are part of the design (i.e. it shouldn't be a regular shape) indicating that the designer was not familiar with tyre bales and how they should be used. No tyre bale SGMs are planning to be exhumed in future projects. The project team have mainly come across successful uses of tyre bales as a geotechnical measure.
Regrade (REGD)	8	The regrade SGM has been selected by several respondents indicating that problems with this SGM are widespread. The responses indicate that the regrades are used frequently on the network and some of these are in critical locations where failure may pose a significant risk to the network. Also, there are concerns with the design, specification, construction and resilience of the SGM. The descriptions of the individual examples indicate issues including lack of appreciation of the geotechnical hazards, lack of historical records and over-steepening of the slopes to allow installation of drainage at the crest and access tracks at the toe. An issue highlighted in two of the cases suggested that it is becoming increasingly difficult with high traffic flows to obtain a HS/L1 closure in which to carry out further remedial works and it is likely that part of the hard shoulder will need to be removed to carry out the works Five of the regrade SGM locations are planned to be exhumed in future work. The project team have come across numerous failures instigated during/following regrading of slopes, both slackening and steepening of the slopes.
Rock Netting / Mesh (SMEH)	2	The rock netting/mesh SGM has been selected to be a problem in two locations. The responses indicate that the rock netting/mesh are of "Major" concern as the defect poses a threat to the safety of users, workers or other parties such that immediate action is required. There are concerns with the design, specification, maintenance and resilience of the netting/mesh. One of the responses indicated that no defects had been recorded whilst the other was due to incompatible mesh being used which compromises the system. No rock netting/mesh SGM locations are planned to be exhumed in future work. The project team have come across numerous sites where rock netting/mesh has not been installed correctly, including incorrect horizontal joins of netting/mesh; installation of wire rope grips the wrong way round; and incorrect stitching of netting/mesh panels.
Shotcrete (SHOT)	1	The shotcrete SGM response indicated that they are used frequently on the network and some of these are in critical locations where failure may pose a significant risk to the network. There are concerns with the design, specification, construction, maintenance and resilience of the SGM. The response indicated that they are worried about a build-up of moisture behind the shotcrete wall which is indicated by a covering of the wall by green vegetation. The project team believe that greening of the shotcrete face tends to be a positive; however, without knowing the site it cannot be discounted that moisture is building up behind it. No shotcrete SGM locations are planned to be exhumed in future work.

SGM Type	No. of Entries	Discussion
Electrokinetic (ELEC)	1	The electrokinetic SGM was one of the measures selected for the *Task 1-147 Innovative Geotechnical Repair Techniques* and this has been identified in the questionnaire as there being an insufficient appreciation of the limitations of the technique and/or materials. There are concerns with the design, specification, construction, maintenance and resilience of the SGM. The description of the electrokinetic example stated that he long term effectiveness has not been proven yet and that the use of the SGM leaves a trip hazard on the slope face. Based on works completed for Task 1-147 the project team believe that electrokinetic treatment can be a successful dewatering and ground improvement technique for shallow slope failures in fine grained soils; however, there is a need for more robust and effective system components and monitoring systems. No electrokinetic SGM locations are planned to be exhumed in future work.
Ground Anchor (GANC)	2	The ground anchor SGM has been selected to be a problem in two locations. The responses indicate that the ground anchors are of "Major" concern as the defect poses a threat to the safety of users, workers or other parties such that immediate action is required and that they are used in critical locations where failure would pose a significant risk. There are concerns with the maintenance and resilience of the SGM with descriptions including no maintenance records or monitoring policy and no details of what work would be involved to remediate the defects. No current plans are in place for the exhumation of ground anchors. The project team have come across a number of projects where ground anchors have become a problem, including as a result of overstressing during testing; however, there are a number of well-known sites where good policies for managing ground anchors are in place.
Soil Nails (SNAL)	6	The soil nail SGM has been selected by several respondents indicating that problems with this SGM are widespread. The responses indicate that some of these soil nails are in critical locations where failure may pose a significant risk to the network and that numerous defects and failures have occurred. There are concerns with the design, specification, construction, maintenance and resilience of the SGM. The descriptions indicated issues with spacing of the nails allowing failures in between, bulging at the toe with debris and areas where soil nails have been pulled from the slope face. The project team have come across a number of projects where soil nails have become a problem with a number of these being involved in legal cases. One of the soil nail SGM locations are planned to be exhumed in future work.
Sheet Pile Wall (SHPL)	2	The sheet pile wall SGM has only been indicated to be a problem by Area 3 and is said to be used in critical locations where failure may pose a significant risk to the network. There are concerns with the design, specification, construction, maintenance and resilience of the SGM and the descriptions indicate that there are no background or design information available and no details of the sheet pile wall (e.g. condition and location). One of the sheet pile wall SGM locations are planned to be exhumed in future work.

SGM Type	No. of Entries	Discussion
Block Wall (BLCW)	1	The block wall SGM has only been selected by one respondent and has concerns with the maintenance and resilience of the SGM. No description is given for the SGM and no exhumation of the SGM is planned for future works.
Gabion Wall (GABN)	3	The gabion wall SGMs are stated to be a problem in three locations (within Areas 3 and 9) from the questionnaire (also mentioned combined with stone wall in the SW area); however, correspondence with the GMLE for Area 13 also highlights problems with gabions for other asset owners. This indicates that problems with this SGM are widespread. The responses indicate that some of the gabion walls are in critical locations where failure may pose a significant risk to the network and that defects and failures have occurred. There are concerns with the specification, construction, maintenance and resilience of the SGM. The project team have come across a number of projects where gabion walls have become a problem, and these are typically poor design (i.e. founded on peat), wrong size filling materials and constructions issues with packing. One of the gabion wall SGM locations is planned to be exhumed in future work.
Stone Wall (STNW)	3	The stone wall SGM has only been indicated to be a problem by the SW Area and is said to be used in critical locations where failure may pose a significant risk to the network and that defects and failures have occurred. There are concerns with the design, maintenance and resilience of the SGM. The descriptions indicate that the walls are often of unknown age and that they are of variable condition. One of the common problems the project team have come across in relation to stone walls are of them being used in situations where they are not fit for purpose. No stone wall SGM locations are planned to be exhumed in future work.

Appendix F Summary of Asset Owner Consultations

SGM Type	Asset Owner Comments	
	Transport Scotland	Network Rail
Counterfort Drain	Achieving specified cyclical maintenance is an issue and its effectiveness is periodically reconsidered. Drainage more generally is acknowledged as a maintenance issue with problems often linked to legacy drainage systems not engineered to modern standards.	There is no particular way to inspect counterforts as the filter material and pipe are not visible.
Filter Drain	As above.	As above
Grout Injection	No particular comments	No particular comments
Lime Stabilisation	No particular comments	No particular comments
Rock Fill	No particular comments	Use of rock fill as shear keys and in embankments – has worked in some instances but often methodology is not followed and design life unknown.
Tyre Bales	No particular comments	No particular comments
Regrade	Not aware of any particular issues in the context of the Scottish trunk road network. Rock fill regrades on A83 from between 15 and 25 years ago are showing some signs of distress.	Problems with regrades have included insufficient design for the site conditions leading to large failure from faulting.
Rock Netting / Mesh	Other SGMs that would be of particular interest to Transport Scotland would be rock mesh systems – early applications sufficient to mitigate risk but not necessarily engineered to current standards.	Problems on the network with rock netting and strengthening elements.
Shotcrete	No particular comments	No particular comments
Electrokinetic	No particular comments	No particular comments
Ground Anchor	No particular comments	No particular comments
Soil Nails	These have been installed increasingly widely since the 1990s with initially limited evidence of long-term behaviour/durability available. Some relatively low height slopes reinforced with soil nails (e.g. A9 Kingussie WS2+1). *MGW note A77 Haggstone nails used in highly brecciated rock.	No particular comments
Sheet Pile Wall	Widely used for temporary works but generally not for permanent works.	No particular comments
Block Wall	Some proprietary systems used in recent years for low-height retention – no known issues	No particular comments

SGM Type	Asset Owner Comments	
	Transport Scotland	Network Rail
Gabion Wall	Not generally approved for use as structures and with reservation for permanent geotechnical purposes. Generally used more in emergency works and for temporary works, while acknowledging that when done well can be both technically and visually effective as at the M876.	Can deform and are often not loaded/filled correctly.
Stone Wall	No particular comments	No particular comments
Reinforced Earth/Soil	Neither reinforced earth nor reinforced soil is used by Transport Scotland for bridge abutments only for wing walls and retaining walls. Note that reinforced earth has, in the past, been used for bridge abutments on the M8 'Claylands' and A96 Brechin Bypass. Reinforced soil walls (geosynthetic reinforcement) are becoming more widely used – like soil nails with initially limited evidence of long-term behaviour/durability available	No particular comments
Geogrid Reinforcement	To mitigate against movement above mining crown holes/other near- or at-surface holes is used from time to time. The most widely known example is the A720 Sherriff Hall Roundabout which was capped in the late-1980s.	No particular comments

Appendix G Application of Scoring Scheme

SGM ID and Instance	SGM Type	Location		Offline	H/Shoulder	C'way	Priority of SGM	Likelihood of Works	Access to Site	Final Scores
Areas 4&5_Atkins_SKM_SGM2_1	Block Wall (BLCW)	M23	J8-J10	No	No	Yes	3	5	0	8
4_A-one+_MT_SGM5_1	Counterfort Drain (CFDR)	A27	Polthooks Cutting, east bound, MP64/8 to 65/6	Yes	No	Yes	4	5	5	14
4_A-one+_MT_SGM5_2	Counterfort Drain (CFDR)	A2	Boughton Hill, both directions, MP87/7 to 88/6	Yes	No	Yes	4	5	5	14
4_A-one+_MT_SGM5_3	Counterfort Drain (CFDR)	M23	Junction 8-9, both directions, MP37/4 to 39/3	Yes	Yes	No	4	5	5	14
4_A-one+_MT_SGM5_4	Counterfort Drain (CFDR)	M23	Junction 10-10a, both directions, MP47/5 to 48/5	Yes	Yes	No	4	5	5	14
7, 9, SW, 3_Kier_DLT_SGM2_3	Counterfort Drain (CFDR)	M5	J8	No	Yes	Yes	4	5	1	10
7, 9, SW, 3_Kier_DLT_SGM4_1	Gabion Wall (GABN)	A49	South of Onibury Bridge / level crossing	No	No	Yes	3	5	0	8
7, 9, SW, 3_Kier_DLT_SGM4_2	Gabion Wall (GABN)	A27/M3	M3-A27 WB on slip adj to Langstone Harbour	Yes	No	No	3	5	5	13
7, 9, SW, 3_Kier_DLT_SGM4_3	Gabion Wall (GABN)	M5	J3-4 MP 18/4A	No	Yes	No	3	5	1	9
SW_HE_MJS_SGM1_1	Regrade (REGD)	M4	EB MP138.9 to 139.3.	0	Yes	0	1	5	1	7
3_Highways England_HJK_SGM4_1	Regrade (REGD)	A308M	J1 to J2 SB	No	Yes	No	1	5	1	7
3_Highways England_HJK_SGM4_2	Regrade (REGD)	A34	72/8 SB	Yes	No	No	1	5	5	11
3_Highways England_HJK_SGM4_3	Regrade (REGD)	A34	87/8 SB	No	No	No	1	5	5	11
3_Highways England_HJK_SGM4_4	Regrade (REGD)	M4	79/2 SB	Yes	Yes	No	1	5	5	11
3_Highways England_HJK_SGM4_5	Regrade (REGD)	M27	9/9 EB	Yes	Yes	No	1	5	5	11
7, 9, SW, 3_Kier_DLT_SGM2_1	Regrade (REGD)	M4	J17-16	Yes	Yes	Yes	1	5	5	11
7, 9, SW, 3_Kier_DLT_SGM2_2	Regrade (REGD)	M4	Dark lane	No	Yes	Yes	1	5	1	7
4_A-one+_MT_SGM4_1	Soil Nails (SNAL)	A23	Pyecombe Soil Slip , north bound, MP4/5	Yes	No	No	5	5	5	15

Appendix H Block Wall Site Proformas

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 9676
Location:	E 453520, N 338574
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry wall along the A52

The setting and location of the wall, in particular relative to the carriageway:
The masonry wall is between 1m and 1.7m high and is located along the westbound carriageway of the A52. It marks the boundary between the road and Nottingham University campus to the south. The wall is accessed via a public footpath which runs alongside it.
The wall doglegs along the access path into the University campus.

The wall alignment is quite complex with curved sections and change of stratum.
The majority of the wall is stone and mortar; however, there are 3 brick and mortar sections also present. It is not understood if the brick sections are previous repairs, blocking up of former accesses or if to facilitate alignment.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 9676
Location:	E 453520, N 338574
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry wall along the A52

Information pertaining to drainage / watercourses / salt spray:
No drainage was observed in the stone sections of the wall; however, weepholes were observed in the longer bricked section spaced approx. every 6m.

Condition and type of foundation:
Unknown

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 9676
Location:	E 453520, N 338574
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry wall along the A52

The condition of the retained slope where visible:
The retained slope was not observed.

The condition of the elements (blocks), including but not limited to block deterioration:
The stone blocks comprised sandstone and in some locations these were observed to be slightly weathered. Cracks were observed through the blocks and more commonly through the mortar. In numerous the mortar was missing.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 9676
Location:	E 453520, N 338574
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry wall along the A52

Evidence of global cracking:
Global cracking was observed (although typically localised), bulging and outward leaning of the wall was observed towards the western end.

The stability and linkages between adjacent blocks:
The wall is mortared and pieces of mortar and stone blocks/ bricks were observed to be missing in places. Cracks have been re-mortared in places.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 9676
Location:	E 453520, N 338574
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry wall along the A52

At the far west of the wall where the stone wall becomes brick, there is a section approx. 1.4m wide which has no mortar at all.

The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability:
Bulging of the wall was observed towards the western end. It was also leaning out towards the footpath in areas.

Additional Comments:
Questions to be answered – were these originally free-standing walls? Likely they were never originally built to retain material behind them.
Who owns the walls? The brick sections appear to block former driveway accesses.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 7825
Location:	E 457786, N 334693
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A52 embankment

The setting and location of the wall, in particular relative to the carriageway:
The masonry wall is 0.9m high and is retaining the A52 westbound embankment. The wall is accessed via Landmere Lane.

Information pertaining to drainage / watercourses / salt spray:
No weepholes or drainage were observed in relation to the wall.

Condition and type of foundation:
Unknown

The condition of the retained slope where visible:
The retained slope was approximately 4.2m high. There were no obvious issues with the retained slope; however, an inspection of the carriageway was not undertaken.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 7825
Location:	E 457786, N 334693
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A52 embankment

The condition of the elements (blocks), including but not limited to block deterioration:
Cracks were developing through the wall along with loss of mortar and deterioration of the blocks. Typically the blocks themselves were intact. The cracking was observed to be worse on the east section of the wall.

Evidence of global cracking:
Significant cracking but largely restricted to the top two courses and deeper only locally.

The stability and linkages between adjacent blocks:
The wall is mortared and pieces of mortar were observed to be missing in places. Cracks have been re-mortared.
It was observed that the top course of the wall appeared to have deteriorated the most (in between the coping and top row), with mortar missing almost continuously.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 7 / 7825
Location:	E 457786, N 334693
SGM Type:	Block Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A52 embankment

The bottom row shows the second most deterioration across the wall and it is likely this is to do with lack of drainage.

The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability:
Bulging of the wall was observed along the alignment and there was a rotation with the wall overturning by approximately 4°.

Additional Comments:
None

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 9407
Location:	E 407373, N 399305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628

The setting and location of the wall, in particular relative to the carriageway:
The dry stone wall is along the A628 eastbound carriageway and retains residential properties and local road above. An old horse trough embayment has been incorporated into the wall.
The site is accessed via a public footpath on the opposite side of the road.

Information pertaining to drainage / watercourses / salt spray:
No drainage was observed.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 9407
Location:	E 407373, N 399305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628

Condition and type of foundation:
Unknown

The condition of the retained slope where visible:
No issues were observed with the retained slope.

The condition of the elements (blocks), including but not limited to block deterioration:
The wall typically appeared to be in good condition; however, the eastern part of the wall had collapsed. Possibly from a vehicle strike (note that the strike would appear to have come from an access track to residential property(ies) set back form the A628.

Evidence of global cracking:
No evidence of global cracking

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 9407
Location:	E 407373, N 399305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628

The stability and linkages between adjacent blocks:
The wall is dry stone.

The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability:
The wall was observed to be collapsed at the eastern end (see photo above). Other parts of the wall were observed to have collapsed but these were set well back from the road in a wooded area.

Additional Comments:
It is not entirely clear whether the wall in question is owned by National Highways, for all or even part of its length. It is set back from the road and while at the East end it is perhaps within 2m of the road at the West end it is 50m or more from the road.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 8923
Location:	E 402639, N 397407
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628

The setting and location of the wall, in particular relative to the carriageway:
The dry stone wall is approximately 2.5m high and is the retaining wall for the A628 on the westbound carriageway. Approximately 0.5m (of the 2.5m) height is free-standing above the footpath adjacent to the A628.
The site is accessed via a pedestrian crossing to agricultural land along the A628.

Information pertaining to drainage / watercourses / salt spray:
No drainage was observed. Water was observed to be dripping off the stone; however, it was raining at the time of the inspection.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 8923
Location:	E 402639, N 397407
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628
Condition and type of foundation: Unknown	
The condition of the retained slope where visible: No obvious issues observed with the retained slope.	
The condition of the elements (blocks), including but not limited to block deterioration: Wall appears in good condition. The top two rows of the wall comprise a different stone type to the rest of the wall below. It is unknown whether this has been replaced more recently due to deterioration or damage or if it was originally designed that way.	
Evidence of global cracking: No evidence of global cracking.	
The stability and linkages between adjacent blocks: The wall is dry stone with the mortar in between the coping and the top row of the dry stone wall.	
The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability: Wall appears in good condition with no obvious instability.	
Additional Comments: As a side note the potential vulnerability of free-standing dry stone and mortared walls can be observed from the (assumed) vehicle damage to a similar wall (possibly and extension of SGM 8923 to the East) observed in the image below.	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area 12 / 8923
Location:	E 402639, N 397407
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Raining
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Dry stone wall adjacent to the A628

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628

The setting and location of the wall, in particular relative to the carriageway:
The masonry wall varies between 1.45m (east) and 1.65m (west) high and is the retaining wall for a cemetery adjacent to Chapel Brow. The wall is leaning out towards the road at approximately 5°. It comprises sandstone blocks and mortar.
The site is accessed via public footpaths along the A628.

Information pertaining to drainage / watercourses / salt spray:
Weepholes were located along the Chapel Brow side of the retaining wall (on the western edge of the cemetery). No weepholes were present on the downslope edge (A628 side) of the retaining wall.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628
Condition and type of foundation: Unknown	
The condition of the retained slope where visible: No obvious issues observed with the slope (very shallow); however, a close inspection was not undertaken of the cemetery.	
The condition of the elements (blocks), including but not limited to block deterioration: There are a number of cracks in the wall with numerous areas having undergone repair and re-mortaring. The worst affected area is along Chapel Brow with gaps up to 40mm opening up. The wall is opening up especially below the coping. No cracking of the blocks themselves was observed.	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628

Evidence of global cracking:
Significant cracking but largely restricted to the top two or three courses and deeper only locally.

The stability and linkages between adjacent blocks:
The linkage between the blocks for this retaining wall is mortar. This is missing in places and has been replaced in localised areas.
Observation indicated that the mortar in the worst condition was that in and immediately below the coping.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628
The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability: No cracking to individual blocks was observed.	
Additional Comments: The block courses dip alongside the A628 compared to the current vertical road alignment, while also dipping (up to an estimated 10°) to the horizontal. It is not entirely clear why this should be the case but it may reflect changes to the vertical road alignment and/or that of the cemetery above. This may be the reason that weep holes are not visible alongside the A628/footpath, having potentially been buried during later construction works. This retaining wall is unusual for the area which typical comprise dry stone walls. The sandstone used for the wall is also unusual. It is possible that as it is the wall for a church yard/cemetery it may have been considered a premium form of construction merit worthy of additional cost.	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID	Area 12 / 8885
Location	E 402413, N 397305
SGM Type:	Block Wall
Date:	5th October 2020
Weather:	Light rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Masonry block wall adjacent to the A628

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1268
Location:	E 351027, N 121606
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A303

The setting and location of the wall, in particular relative to the carriageway:
The masonry wall is approximately 2.5m high and is located along the A303 western embankment to the south west of Ilchester. The site was accessed via a public footpath to the east.

The wall extends to the west (left of the photo above) some distance but the majority of the wall has been buried previously during remedial works. It is assumed that the section of wall shown on the photo above has not been buried due to the presence of the watercourse below.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1268
Location:	E 351027, N 121606
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A303
Information pertaining to drainage / watercourses / salt spray: There is a watercourse present at the base of the wall and this flows into the Bearley Brook to the east which goes under the A303 through a large concrete culvert. There are weepholes present through the wall which appear to be 100mm diameter clay pipes. It is unknown whether these are clear as no water was coming out of them at the time of the inspection.	
Condition and type of foundation: Unknown	
The condition of the retained slope where visible: The retained slope was approximately 3.5m high. There were no obvious issues with the road surface; however, the verge between the vehicle restraint system and the wall was observed to be depressed where the wall was sagging.	
The condition of the elements (blocks), including but not limited to block deterioration: The wall was comprised of sandstone blocks with mortar in between. The majority of the blocks were in good conditions with slight deterioration present and limited cracking.	
Evidence of global cracking: No evidence of global cracking was observed; however, the wall as a whole was seen to be bowing and sagging (see photo below). The top of the wall was not level and looked to be sinking in the central section.	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1268
Location:	E 351027, N 121606
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A303

The stability and linkages between adjacent blocks:
The mortar was in poor condition with numerous areas suffering cracks through the mortar and loss of mortar (see photo below). The western part of the wall showed significant signs of deterioration of the mortar with a compete loss of mortar observed in the lower and upper-mid sections.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1268
Location:	E 351027, N 121606
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A303

The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability:
Although the blocks themselevs weren't showing significant signs of deterioartion, the loss of mortar and possibly the sinking of the wall is leading to signifcant distress.

Additional Comments:
There was a triangle feature (made of the same sandstone) built into the western section of the wall. It is unclear what this is for.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1306
Location:	E 319613, N 104545
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A30

The setting and location of the wall, in particular relative to the carriageway:
The masonry wall is approximately 0.9m high and is located within a layby on the western carriageway of the A30 to the north east of Monkton. A footpath runs along the edge of the layby which was used to access the block wall.

The wall looks to be comprised of local sandstone blocks of varying sizes and is mortared.

Information pertaining to drainage / watercourses / salt spray:
80mm internal diameter clay pipe weepholes were present through the wall every 6m. These were occasionally partially blocked with soil but appeared to b working with stone gravel washed out onto the footpath (see photo below).

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1306
Location:	E 319613, N 104545
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A30

Condition and type of foundation:
Unknown

The condition of the retained slope where visible: The retained slope was approximately 1.5m high. There were no obvious issues with the retained slope; however, the slopes were covered in vegetation and an inspection at the crest was not undertaken.

The condition of the elements (blocks), including but not limited to block deterioration:
There were lots of sub-vertical cracking observed mainly at the stone / mortar interface but also through some of the larger stone blocks (see photo below).

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1306
Location:	E 319613, N 104545
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A30

The top course of the wall was quite broken up compared to the lower courses and at the western end the coping stones were missing.

Evidence of global cracking:
No evidence of global cracking was observed.

The stability and linkages between adjacent blocks:
The mortar was overall in good condition; however, there were areas where it had cracked and fell out.

The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability:
No major damage or instability of the block wall was observed.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 1306
Location:	E 319613, N 104545
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A30

Additional Comments:

What appears to be a precast concrete pipe (500mm diameter) was observed in the central section of the wall with the wall constructed around it (see photo below). The purpose of this is not fully clear but it may have been an old foundation for a sign post. There is a crack approximately 500mm long down the middle of the pipe.

The wall is north facing and there was lots of moss and lichen growing on it.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 9077
Location:	E 378323, N 162595
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A36

The setting and location of the wall, in particular relative to the carriageway:

The drystone wall is approximately 1.5m high and is located along the A36 western cutting to the west of Dundas Aqueduct. The site was accessed via a public footpath and viewed from across the road.

The wall extends to the north where access is not possible; however, a drive through this area indicates that similar problems are occurring along other sections of this wall.

Information pertaining to drainage / watercourses / salt spray:

No watercourse was observed in the vicinity of the wall; however, gushing water could be heard behind it and there are drains in the road surface which may be connected.

Condition and type of foundation:

Unknown

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 9077
Location:	E 378323, N 162595
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A36
The condition of the retained slope where visible: It is understood that the slopes retained by the wall are areas of historic landsliding and that the A36 has been built upon landslide deposits. These were not assessed during the inspection.	
The condition of the elements (blocks), including but not limited to block deterioration: The wall was comprised of sandstone blocks, drystone so no mortar was present. The majority of the blocks were in good conditions with slight deterioration present and limited cracking.	
Evidence of global cracking: The wall showed significant deterioration with complete sections collapsed and other sections missing blocks (see photo below). The wall was distorted and appeared to be leaning towards the road in places. 	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 9077
Location:	E 378323, N 162595
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A36
The stability and linkages between adjacent blocks: The wall is dry stone and there doesn't appear to be any coping present.	
The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability: The collapse of complete sections and loss of blocks has led to a loss of support for the remainder of the wall. A large tree is growing at the side of the wall at the far southern end and it appears that the roots are causing further damage to the wall.	
Additional Comments: None	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 10857
Location:	E 223568, N 64425
SGM Type:	Block Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A38

The setting and location of the wall, in particular relative to the carriageway:
The mortared block wall varies between 0.35m and 1.14m high and is retaining a small cutting to the west of Liskeard. The wall is accessed via a footpath adjacent to the A38.

Information pertaining to drainage / watercourses / salt spray:
50mm diameter polypipe weepholes were present through the wall and appeared to be active with fines washing through them (see photo below).

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 10857
Location:	E 223568, N 64425
SGM Type:	Block Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A38

There was significant efflorescence present on the block wall (on both the blocks and mortar). It is possible that this has been caused by salt spray; however, it is set back quite far from the live lanes and a vehicle restraint barrier is located in between the wall and the road. This could possibly be salts leaching out of the mortar and concrete blocks or maybe marine sands have been used (see photo below).

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 10857
Location:	E 223568, N 64425
SGM Type:	Block Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A38

Condition and type of foundation:
Unknown

The condition of the retained slope where visible:
The retained slope was approximately 2m high. There were no obvious issues with the retained slope; however, the slopes were covered in vegetation and an inspection at the crest was not undertaken.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 10857
Location:	E 223568, N 64425
SGM Type:	Block Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A38
The condition of the elements (blocks), including but not limited to block deterioration: The mortar and blocks were observed to be in good condition with no cracking evident. The top row of the blocks appeared to be damper than the lower courses – this may be attributed to surface water behind the wall and may lead to deterioration in the future. A vertical crack was observed every 5.9m. Due to the frequency and distribution of the crack these looked purposeful and may have been expansion joints.	
Evidence of global cracking: No evidence of global cracking was observed.	
The stability and linkages between adjacent blocks: The western edge of the wall was exposed, and it appeared that the wall was a mass concrete wall with a block wall facing. It is not clear what type of linkage exists between the mass concrete and the block facing; however, no instability was observed.	
The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability: No damage or instability of the block wall was observed.	
Additional Comments: None	

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 11542
Location:	E 376593, N 165805
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A36

The setting and location of the wall, in particular relative to the carriageway:
The masonry block wall is approximately 1.5m high and located along the western carriageway of the A36 in Bath. The wall was viewed from across the road during the inspection.

Information pertaining to drainage / watercourses / salt spray:
Weepholes were present in the lower two courses of the wall at spacings of between 1m and 1.5m.
There were two weepholes present in the upper section of the wall – the purpose of these are unknown but it may be to drain any surface water from the garden behind the wall.
There was no evidence of salt spray observed.

Task 1-1109: SGMs Phase 2	
Block Wall Proforma	
Area / SGM ID:	Area SW / 11542
Location:	E 376593, N 165805
SGM Type:	Block Wall
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Retaining wall along the A36
Condition and type of foundation: Unknown	
The condition of the retained slope where visible: The retained slope was not visible during the inspection.	
The condition of the elements (blocks), including but not limited to block deterioration: The wall was comprised of Bath sandstone blocks of varying sizes. Coping was present across the length of the wall. No deterioration of the sandstone blocks was observed.	
Evidence of global cracking: No global cracking was observed, and the wall appeared to be in good condition.	
The stability and linkages between adjacent blocks: The wall is mortared. No loss of mortar or cracking within the mortar was observed.	
The stability of the individual elements (blocks) e.g. damage to blocks sufficient to compromise stability: Rare scuff damage to the wall (likely from vehicle collision) was observed; however, nothing to compromise the stability of the wall.	
Additional Comments: Some lichen blooms were observed on the wall (it is a north facing road).	

Appendix I Gabion Wall Site Proformas

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 9 / 9117
Location	E 434231, N 275581
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

The setting and location of the wall, in particular relative to the carriageway:

The gabion wall is located along the A45 off-slip embankment at the junction with the Stivichall Interchange. The wall varies in height between 0.85m in the west and, 1.5m high in the central section and 1.1m high in the east.

The earthwork can be accessed via a public footpath at the toe of the embankment (see photo below).

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 9 / 9117
Location	E 434231, N 275581
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining. No water was observed to be coming from the slope.

Condition and type of foundation:
Foundations not observed; however, the gabion baskets appeared to be founded into the ground between 0.1m and 0.5m dependant on the location.

The condition of the retained slope where visible:
The retained height varies across the gabion wall; in the west the slope is approximately the same height as the gabion wall whilst in the east the slope increases to have a retained height of approximately 2.5m to 3m.
There were no obvious tensions cracks or scarps visible on the retained slope; however, the slope is heavily vegetated and could not be observed in detail.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 9 / 9117
Location	E 434231, N 275581
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

The gabions comprise green plastic-coated weld mesh with apertures 75mm by 75mm. Fill material appears to be a metamorphic rock (possibly gneiss) and is typically angular and sized between 100mm and 200mm. Smaller blocks were observed down to 40mm.

There was no corrosion observed on the mesh.

In a few locations along the gabion wall, damage to the apertures was observed including bent, peeling and broken wire. This appears to have been cut purposefully, maybe vandalism (see photo below).

There were scuffs observed on the plastic mesh covering across the majority of the gabion wall which is likely to have been caused during transportation or construction. These areas may create ‘weak’ spots when it comes to future corrosion. The majority of the damage was observed at the ‘cut ends’ of the baskets where it is likely they have been cut on site and on the wrapped wire linking the basket edges.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 9 / 9117
Location	E 434231, N 275581
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 9 / 9117
Location	E 434231, N 275581
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

The stability and linkages between adjacent baskets:
The baskets where typically fastened (individually) with metal links and wrapped wire along the top and at the sides. Adjacent baskets where tied together with plastic-coated green wire wrapped round the join between the two (see photo above).

Additional reinforcement has been added to the baskets (occasionally – not as standard within each one) to maintain basket shape during filling by tying green wire around one cross hair of the aperture and feeding it back into the fill material.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
The baskets are distorted in localised areas (typically ok).
In a few locations along the gabion wall, damage to the apertures was observed including bent, peeling and broken wire. This appears to have been cut purposefully, maybe vandalism (see photo below).

Additional Comments:
None

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located in a layby on the eastbound carriageway of the A46. The gabion wall is approximately 1.7m high at the eastern extents and 0.7m high at the western extents.

Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining. Note that the aggregate covered area in front of the wall may be the top of a French drain (or similar).

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46

Condition and type of foundation:
The gabion baskets were embedded approximately 0.3m into the ground

The condition of the retained slope where visible:
The retained slope is approximately 2.5m high altogether with between 0.8m and 1.8m of slope exposed behind the gabion wall. There were no issues observed with the retained slope above the gabions.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):
The gabions comprise grey galvanized weld mesh with an aperture of 75mm by 75mm. Large parts of the galvanization were observed to be poorly covered and/or with a rather ‘orange peel’ finish and variable finish around the circumference of the wire. Peeling of the galvanisation was evident even in areas where no damage had occurred to the baskets. This may be attributed to installation damage but it is consistently poor across the wall. Where no damage or peeling had occurred but the ‘orange peel’ effect was evident it was easy to peel off the galvanisation and it was evident that it was contributing little to the corrosion protection of the underlying wire.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46

The gabions have been filled with a clean, hard and durable rock type (looks like granite) which has not undergone any significant weathering. There were some blocks that were undersized and able to fall through the apertures.

The gabion wall is in disrepair with rips present through the mesh leading to the fill spilling out onto the ground in front. This is evident in the lower part of the wall and is consistent with a vehicle impact(s) along the gabion wall with the corner between the highest and mid height gabions being affected the most.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46

The stability and linkages between adjacent baskets:
The adjacent gabion baskets (horizontal) were typically tied together with stainless steel spirals. These appear to work very effectively where used. The spirals did not appear to have been used to tie the lower baskets top face together which could have provided additional support from vehicle strikes.
The lower baskets top and front face were joined by wrapped wire of which the lacing was quite loose. The two rows of gabions were also linked vertically with laced wire.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46

Additional reinforcement has been added to the baskets by tying wire around three apertures and feeding it back into the fill material.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
The gabions were distorted along its full length on the lower row. The upper row of baskets looked well put together.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4025
Location	E 456870, N 310200
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 1.7m high along the A46
Additional Comments: The vehicle damage highlights the difficulty of making effective repairs to gabion walls even when these are well-constructed.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 8552
Location	E 522568, N 238290
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2.5m high acting along the embankment of the A1(M)

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located along the embankment to the A1 adjacent to the northbound carriageway. The gabions have been designed as wingwalls for a large (3m wide) concrete box culvert.
The site is accessed via the Astwick Services.

Information pertaining to drainage / watercourses / salt spray:
The gabion wall provides the wingwalls for a culvert and lines the channel on the east side (and part of the west). There is a 200mm polypipe protruding through the top row of gabions approximately 4m north of the culvert. There was no water coming out of the pipe at the time of the inspection.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 8552
Location	E 522568, N 238290
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2.5m high acting along the embankment of the A1(M)

A pipe outlet was located underneath the southern gabion wingwall underwater.

Condition and type of foundation:

The gabion baskets on the southern wingwall appeared to be founded into concrete. The foundations were not visible on the other aspects due to the water present in the channel.

Concrete fence posts were founded into the top row of the gabion baskets on the east side by cutting through the mesh and removing some of the fill prior to concreting. Foundations for fence posts have a diameter of 400mm.

The condition of the retained slope where visible:

The gabions obscure the majority of the retained slope. No stability issues were observed.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 8552
Location	E 522568, N 238290
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2.5m high acting along the embankment of the A1(M)

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):
The gabions comprise grey galvanized hexagonal double twist mesh with an aperture of 100mm. There was no corrosion observed on the mesh or wires. The corner on one of the gabions has unravelled and it appears that this was done purposefully to remove a piece of fill (reason unknown).

The gabions have been well filled by different rock types (all hard, clean and durable) with sizes typically between 80mm and 200mm.

The stability and linkages between adjacent baskets:
The finish of the gabion walls is a bit untidy with some lacing of wires loose and poorly fastened. This does not seem to be affecting the integrity of the wall; however, it would not be acceptable if this was visible to the public.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 8552
Location	E 522568, N 238290
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2.5m high acting along the embankment of the A1(M)
Slight bulging of the baskets was observed; however, these bulges may well have been formed at construction stage although there was some evidence of ties being used during construction to limit such bulging.	
Additional Comments: As the fence posts are located within the gabion baskets it is possible that the gabions could be affected if there were any vehicle strikes. There is a VRS between the fence posts and the carriageway to prevent this.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located along the embankment to the A1307 (previously the A14) on the westbound carriageway.
The site is reached via the access track to the Huntingdon Boathaven & Caravan Park to the south of the carriageway.

Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining.

Condition and type of foundation:
The gabion baskets were embedded approximately 0.5m into the ground.

The condition of the retained slope where visible:
The retained slope is approximately 8m high and there are areas of slope instability observed. Towards the western end of the crest of the slope above the gabion wall is Highways access to the A1307 where there are access steps, an electricity box and a large concrete base assumed to be for road signs, most likely VMS.

In this area the ground is moving away from the concrete base leaving the foundations undermined (approximately 1/3 of soil has disappeared from below it, potentially leaving the foundation in a metastable condition). The access steps are undergoing rotation with the handrail becoming detached (rail leaning up to 9°). The trees show signs of stem bending. The platform for the electricity box is settling differentially leading to disjointed concrete flags. This area is supported by a porcupine block wall which is also showing signs of hogging and sagging with joints also opening up in line with the leaning handrail.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

The gabions comprise grey galvanized hexagonal double twist mesh with an aperture of 100mm. There was no corrosion observed on the mesh.

The gabions are filled with large concrete blocks and smaller asphalt blocks up to around 900mm wide (typically 200mm to 500mm); the maximum allowable size is the lesser of 200mm or 2/3 the minimum gabion compartment dimension. Almost all of the fill is oversized.

As a result, there are large gaps present within the fill and in most locations the top edge has not been fully secured to the front face due to the bulging fill.

While no major deterioration of the concrete fill was observed it is considered that this is a distinct possibility in the future.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 8 / 6082
Location	E 524256, N 271326
SGM Type:	Gabion Wall
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A1307 (prior A14) embankment.
The stability and linkages between adjacent baskets: The adjacent gabion baskets (horizontal) were typically laced together with wire. No lacing was observed between rows of gabions. Initial observations suggest that the tops of the gabions have become unlaced; however, closer inspection indicates that the tops are only secured by wire at pinch points as the size of the blocks means it is unable to accommodate a fully closed and laced gabion.	
The stability of the individual elements (gabions) e.g. damage and distortion of baskets: The gabion wall is distorted along its full length. The distortions are visible on the wall globally and also on the individual apertures.	
Additional Comments: Both the gabion wall and the porcupine block wall are not recorded as SGMs on GDMS.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located along the coastal path embankment which is part of the construction on the south side of the westbound leg of the A27/A3(M) junction. The gabion revetments make up a series of coastal protection measures along this stretch of coastline.
The site is accessed via the coastal public footpath. It is assumed, supported by observation, that at high tide no access would be possible to the beach area.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8^{th} October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

Information pertaining to drainage / watercourses / salt spray:
The gabion revetment is located in between the coastal footpath below the A3(M) and Langstone Harbour estuary (the section is known as Chalkdown Lake). This is an estuary environment with the water reaching partway up the gabions during high tide. A culvert was observed in this stretch of coastal protection (this effectively marks the boundary between SGMs 10197 and 10198).

Condition and type of foundation:
Foundations unknown; however, at one location concrete was observed below the gabion revetment.
At the edges of the revetments the ground surrounding it is being washed away leaving them undermined.

The condition of the retained slope where visible:
The gabion revetment obscured the majority of the embankment. There were no obvious concerns relating to the footpath at this location; however, the gabions themselves were in distress.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

The gabions comprise grey galvanized welded mesh with an aperture of 75mm.

The gabions had three different stages of corrosion occurring – In the bottom section which is subject to the majority of the tidal action the corrosion is effectively complete and the mesh has been broken down and can be snapped easily. In the middle section the mesh has been partially corroded with a colour change observed but the mesh baskets are still holding their shape. In the upper section of the revetment the galvanization is still present, at least partially, and there is a noticeable colour change from the parts of the baskets below.

Where the lower baskets have completely corroded through the fill is spilling out onto the tidal flats below where the material has been (and will be) washed away by the tide.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

Typical fill size is between 100mm and 400mm and blocks of concrete have been used along with a range of other rock types. There are small block sizes present and there appear to be fines that are washing in and out of the baskets.

In one particular area it was observed that the edge of the corroded mesh was gradually cutting into a chalk block which is assumed to have come from the filled basket.

In some locations the mesh components have corroded completely and detached from the revetment. It is assumed that some of these will have been washed out to sea and others were found lying around the beach area. These are hazardous to people, dogs and marine life as the edges of the mesh are very sharp and rusty.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

The stability and linkages between adjacent baskets:

As the fill has been washed away from the lower baskets this is leaving the upper baskets unsupported. Large gaps at the top of the baskets were evident as the fill has shuffled down slope. This will reduce the support to the coastal footpath above.

The baskets appear to be attached to each other with wire wrapped round the joins. This is quite loose in places (top section) and non-existent on some of the lower section.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
The baskets are extremely distorted across the whole length. The bottom layer has in some parts completely disappeared, the top section is being undercut and starting to pull apart.

Additional Comments:
On part of the stretch of gabion revetment, armourstone has been placed on top of the mesh. This does not appear to have been built up properly as an armourstone wall, rather blocks placed individually, potentially to hold the mesh down. These could prove dangerous as they could fall down and potentially take the gabion baskets down with them.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 3 / 10197 & 10198
Location	E 469525, N 105476
SGM Type:	Gabion Wall
Date:	8th October 2020
Weather:	Raining and blustery
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion revetment at the toe of a coastal footpath.

At the end of this stretch of gabion revetments, the mesh is almost completely corroded and washed away. At this location a black geogrid has been placed on top of the mesh with armourstone built up on top.

The use of gabions, however the corrosion protection is affected, seems questionable in a marine environment.

<table>
<tr><th colspan="2">Task 1-1109: SGMs Phase 2</th></tr>
<tr><th colspan="2">Gabion Wall Proforma</th></tr>
<tr><td>Area / SGM ID:</td><td>Area 10 / 5281</td></tr>
<tr><td>Location</td><td>E 388654, N 390252</td></tr>
<tr><td>SGM Type:</td><td>Gabion Wall</td></tr>
<tr><td>Date:</td><td>5th October 2020</td></tr>
<tr><td>Weather:</td><td>Drizzling</td></tr>
<tr><td>Attending site:</td><td>Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)</td></tr>
<tr><td>Equipment Used:</td><td>Tape measure, distomat, compass clinometer, camera and notebook</td></tr>
<tr><td>Description:</td><td>1m high gabion wall at the toe of an embankment</td></tr>
<tr><td colspan="2">The setting and location of the wall, in particular relative to the carriageway:
The embankment is located below the M60 junction 1 off-slip (westbound).
The earthwork can be accessed via a public footpath at the toe of the embankment.
The gabion wall is typically overgrown with vegetation.
</td></tr>
<tr><td colspan="2">Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining. Possibly could be a toe drain present but heavily vegetated.
No water was observed to be coming from the slope.</td></tr>
</table>

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 5281
Location	E 388654, N 390252
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Drizzling
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment
Condition and type of foundation: Foundations not observed.	
The condition of the retained slope where visible: There are no obvious tensions cracks or scarps visible on the retained slope; however, the slope is not uniform as you would expect a formed earthwork to be. The upper section is typically steeper than the lower section and the general slope appears to be distorted.	
The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration): The gabions comprise green plastic-coated weld mesh. These appear to have been put together on site rather than as a ready-made basket. There are some areas where the plastic is peeling off revealing the metal wire inside. Fill material appears to be a limestone and typically sized between 100mm and 150mm. Smaller blocks were observed down to 20mm and weathering of the fill material was also observed.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 5281
Location	E 388654, N 390252
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Drizzling
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

The stability and linkages between adjacent baskets:
The baskets where typically fastened (individually) with metal links along the top and at the sides. Adjacent baskets where tied together with plastic-coated green wire wrapped round the join between the two.
Additional reinforcement has been added to the baskets to maintain basket shape during filling by tying green wire around three apertures and feeding it back into the fill material.
In some locations it was observed that the top of the basket had been tied to the top of the adjacent basket rather than its own side. The reason for this is unknown; however, this has led to voids being left within the fill (80mm to 100mm gaps at the top in some areas with the depth being unknown but clearly in excess of 300 to 400mm).

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 5281
Location	E 388654, N 390252
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Drizzling
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 5281
Location	E 388654, N 390252
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Drizzling
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	1m high gabion wall at the toe of an embankment
	
The stability of the individual elements (gabions) e.g. damage and distortion of baskets: The baskets are distorted in localised areas. No breakages of the baskets were observed.	
Additional Comments: Black small aperture geogrid was observed above the gabion wall in localised areas (see previous photo). This appeared to be either a multi-layered geogrid or it was rolled up. It is unknown if this is related to the stability of the slope above from the original construction or if it could have been installed to assist with vegetation regrowth.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7066
Location	E 382432, N 390873
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 4.5m high at 60° comprising rock fill with a mesh facing.

The setting and location of the wall, in particular relative to the carriageway:
On the bridge embankment of the Eastbound carriageway of the M60 as it goes over the Princess Parkway at Junction 5.
The earthwork can be accessed via the maintenance area off Princess Parkway. This is also the access to a United Utilities site and approximately 50% of the wall was not accessible as it was behind a locked fence ion the United Utilities maintenance area.
Fly tipping is present in the area.
The SGM varies between 3.7m and 4.5m high (the highest section is in the fenced off part) and is at approximately 60°.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7066
Location	E 382432, N 390873
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 4.5m high at 60° comprising rock fill with a mesh facing.
Information pertaining to drainage / watercourses / salt spray: No drainage or watercourses were observed during the inspection. Assumed to be free draining. No water was observed to be coming from the slope. Salt spray will be limited by the position of the slope below the road.	
Condition and type of foundation: Foundations not observed.	
The condition of the retained slope where visible: Retained slope not visible behind the SGM. Vegetation (including trees) is present between the top of the mesh and the crest of the slope. No overhanging areas of mesh were observed.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7066
Location	E 382432, N 390873
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 4.5m high at 60° comprising rock fill with a mesh facing.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

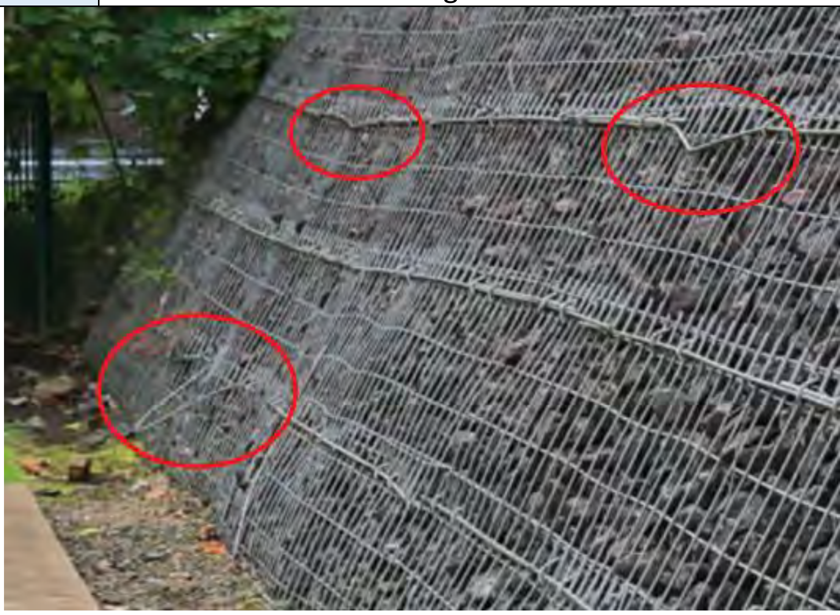
The structure comprises 9mm welded mesh with an aperture of 100mm across and 200mm high. The mesh is reinforced with 12mm horizontal bars and 12mm pins.

Mesh, horizontal bars and pins appear are galvanized and appear to be in good condition with no signs of corrosion. There is occasional staining observed on the mesh. Some of the horizontal bars were observed to have distorted or had come loose (highlighted in red on the photo below). These were located in the UU area and therefore were not accessible for closer inspection.

Fill material appears to be a blocky sandstone varying in size between 100mm and 160mm. Slightly smaller blocks were observed rarely which were able to fit through the mesh aperture.
Slight weathering observed on the fill material but typically in generally good condition.

No settlement of the fill was observed.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7066
Location	E 382432, N 390873
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 4.5m high at 60° comprising rock fill with a mesh facing.



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<tr><td>Location</td><td>E 382432, N 390873</td></tr>
<tr><td>SGM Type:</td><td>Gabion Wall</td></tr>
<tr><td>Date:</td><td>5th October 2020</td></tr>
<tr><td>Weather:</td><td>Dry</td></tr>
<tr><td>Attending site:</td><td>Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)</td></tr>
<tr><td>Equipment Used:</td><td>Tape measure, distomat, compass clinometer, camera and notebook</td></tr>
<tr><td>Description:</td><td>Strengthened slope approximately 4.5m high at 60° comprising rock fill with a mesh facing.</td></tr>
<tr><td colspan="2">The stability and linkages between adjacent baskets:
Not applicable as no baskets; however, linkages between mesh manels appear to be typically satisfactory with the exception of the bent horizontal bars in the United Utilities section of the SGM.
There was evidence observed of the slope failing behind the bars which indicates that it may be damage caused by external factors (albeit that close inspection was not possible). This highlights a vulnerability of the system to these accessible components.</td></tr>
<tr><td colspan="2">The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
No obvious distortion of the mesh – the slope appears to be uniform.</td></tr>
<tr><td colspan="2">Additional Comments:
None</td></tr>
</table>

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7038
Location	E 380474, N 392493
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 5m high at 60° comprising rock fill with a mesh facing.

The setting and location of the wall, in particular relative to the carriageway:
On the embankment slope of the M60 Junction 6 off-slip Eastbound. The mesh covers the majority of the embankment with a small (approx. 0.5m high) part of the slope at the crest vegetated.

The earthwork can be accessed via the access road to Sale Water Park.

Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining.
No water was observed to be coming from the slope.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7038
Location	E 380474, N 392493
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 5m high at 60° comprising rock fill with a mesh facing.

Salt spray will be limited by the position of the slope below the road and the fence at the crest.

Condition and type of foundation:
Foundations not observed.

The condition of the retained slope where visible:
Retained slope not visible behind the SGM.
The top 1m of the mesh was observed to be overhanging (leaning outwards) in localised areas which appears to be typically associated with the growth of tree roots behind it.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7038
Location	E 380474, N 392493
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 5m high at 60° comprising rock fill with a mesh facing.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

The structure comprises 9mm welded mesh with an aperture of 100mm across and 200mm high. The mesh is reinforced with 12mm horizontal bars and 12mm pins. Pins are irregularly spaced – measurements of spacings taken over a localised section include 450mm, 250, 550, 900, 400, 800, 400, 300, 500 and 1000mm.

Mesh, horizontal bars and pins are galvanized and appear to be in good condition with no signs of corrosion. Occasional staining/deformation of the mesh was observed.

The fill behind the mesh comprises a shaley material which is badly weathered quite across the length of the SGM. The fill varies in size from 10mm up to 400mm. The mesh comprises 7 to 8 rows (each row 0.7m high) and the degree of weathering of the fill was different in each row. The most weathered area appeared to be the 4th row consistently along the length of the SGM (approximately 2 to 3m above road surface). The best quality fill appeared to be just below this in the 3rd row. This may indicate that the fill was in a weathered state prior to placement.

At the top of the mesh there were gaps observed up to 100mm in places. It is assumed this is due to the weathering of the fill below causing settlement within the structure.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7038
Location	E 380474, N 392493
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 5m high at 60° comprising rock fill with a mesh facing.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 10 / 7038
Location	E 380474, N 392493
SGM Type:	Gabion Wall
Date:	5th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Strengthened slope approximately 5m high at 60° comprising rock fill with a mesh facing.
The stability and linkages between adjacent baskets: Not applicable as no baskets; however, linkages between mesh manels appear to be satisfactory.	
The stability of the individual elements (gabions) e.g. damage and distortion of baskets: The top 1m was observed to be overhanging in places as the mesh was being distorted by tree roots and vegetation growth at the crest. A horizontal sinuosity was observed along the length of the SGM.	
Additional Comments: The SGM is assumed to be free draining due to the coarse fill; however, as more of the fill weathers it may create some impermeable sections which may prevent free draining of any water from the slope. In addition, further internal settlement would be expected as weathering occurs.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7630 (structure ID A38/450.1)
Location	E 436275, N 340007
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 6m high along the A38.

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located on the A38 eastbound embankment at the approach to the Little Eaton roundabout. The gabion wall is approximately 2.75m high at the eastern extents and 6m high at the west.

Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining.
No water was observed to be coming from the slope; however, the ground at the toe was wet in places.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7630 (structure ID A38/450.1)
Location	E 436275, N 340007
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 6m high along the A38.

Condition and type of foundation:

The gabion baskets were embedded into the ground, potentially up to 0.85m in places (from measurement of the above ground baskets but some uncertainty is introduced by the possibility of smaller basket being used as the foundation layer).

The condition of the retained slope where visible:

The gabion wall is the full height of the carriageway. Cracks in the road surface where observed in Lane 1 (nearside) of the A38. This was measured to be approximately 7.5m from the top of the gabions at the western extent. The cracks are best developed closer to the traffic lights where the gabion wall is lower height and closer to the road. It is considered likely that the cracks are traffic related but cannot be discounted.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):

The gabions comprise green plastic-coated weld mesh with an aperture of 75mm by 75mm. No peeling of the plastic has been observed.

They appear to have been made specifically to fit the curved profile of the ground and the road with the gabion height typically being 1m and the width varying across the construction between 0.3m and 1.05m.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7630 (structure ID A38/450.1)
Location	E 436275, N 340007
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 6m high along the A38.

The gabions have been filled very neatly by hand (at least the front face) and the fill comprises a clean, hard limestone which has not undergone any significant weathering.

Due to the bespoke nature of the gabions it would be difficult to replace an individual basket. It would require whole sections to be removed and replaced.

The stability and linkages between adjacent baskets:
The gabions are not baskets as such, and instead have been constructed in situ with overlaps and joints along the horizontal and vertical planes with significant overlaps in places.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7630 (structure ID A38/450.1)
Location	E 436275, N 340007
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 6m high along the A38.

The adjacent gabion baskets (or insitu mesh) were tied together with plastic-coated green wire wrapped round the join between the two. This is also how the individual baskets themselves are tied together.
The rows of the gabions (vertically) are attached with spenax clips every 4th aperture.

Additional tie-back reinforcement was visible and is presumed to have been used to limit basket distortion during filling and construction.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
No distortion of or damage to the baskets or mesh was observed.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7630 (structure ID A38/450.1)
Location	E 436275, N 340007
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 6m high along the A38.

Additional Comments:

The gabions go back into the slope at least 1.5m (covered with vegetation from 1.5m but likely to be 2m deep) at the eastern end of the wall, this shallows towards the traffic lights at the western extents.

Where the gabion wall is greater than 3m high, the lowest two rows (one is partially buried) have a twin mesh front face installed on the basket. This may have been added to increase resistance to front face distortion. However, this appears to be integral with the front faces of the baskets and variably/inconsistently overlapped compounding the difficulty of effecting economic repair in the event of damage to one or more baskets.

The gabion wall is located on the NW arc of the roundabout (A38/B6179). A similar wall was inspected on the SW arc (A38/61) and similar observations were made and similar conclusions drawn.

<table>
<tr><th colspan="2">Task 1-1109: SGMs Phase 2</th></tr>
<tr><th colspan="2">Gabion Wall Proforma</th></tr>
<tr><td>Area / SGM ID:</td><td>Area 7 / 7761</td></tr>
<tr><td>Location</td><td>E 436386, N 339922</td></tr>
<tr><td>SGM Type:</td><td>Gabion Wall</td></tr>
<tr><td>Date:</td><td>6th October 2020</td></tr>
<tr><td>Weather:</td><td>Dry</td></tr>
<tr><td>Attending site:</td><td>Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)</td></tr>
<tr><td>Equipment Used:</td><td>Tape measure, distomat, compass clinometer, camera and notebook</td></tr>
<tr><td>Description:</td><td>Gabion wall up to 2m high along the A61.</td></tr>
<tr><td colspan="2">The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located on the A61 northbound embankment at the approach to the Little Eaton roundabout. The gabion wall is approximately 2m high.
</td></tr>
<tr><td colspan="2">Information pertaining to drainage / watercourses / salt spray:
No drainage or watercourses were observed during the inspection. Assumed to be free draining.
No water was observed to be coming from the slope.</td></tr>
<tr><td colspan="2">Condition and type of foundation:
The gabion baskets were embedded into the ground, possibly up to 0.5m.</td></tr>
<tr><td colspan="2">The condition of the retained slope where visible:
The gabion wall is the full height of the carriageway. No issues observed.</td></tr>
</table>

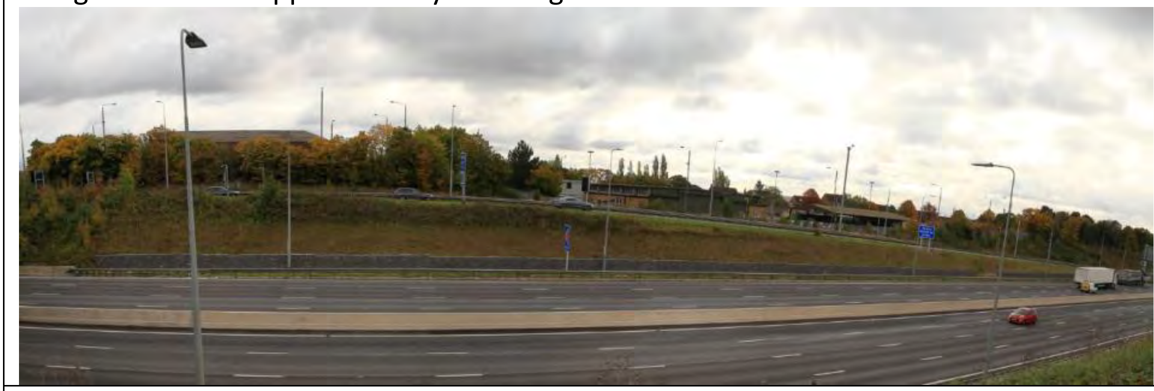
Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 7761
Location	E 436386, N 339922
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 2m high along the A61.
The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration): The gabions comprise green plastic-coated weld mesh with an aperture of 75mm by 75mm. No peeling of the plastic has been observed. They appear to have been made more regular compared to SGM 7630 across the junction. The gabion basket height is typically 1m on the top row and 0.5m on the middle and bottom rows (bottom row assumed to be partially buried). The gabions have been filled very neatly by hand (at least the front face) and the fill comprises a clean, hard limestone which has not undergone any significant weathering; however, orange staining was in the fill within three of the baskets.	
The stability and linkages between adjacent baskets: Adjacent gabion baskets are tied together with plastic-coated green wire wrapped round the join between the two. This is also how the individual baskets themselves are tied together. The rows of the gabions (vertically) are attached with metal links every 3rd aperture. Additional reinforcement has been added to the baskets by tying green wire around two apertures and feeding it back into the fill material.	
The stability of the individual elements (gabions) e.g. damage and distortion of baskets: No distortion of the baskets was observed.	
Additional Comments: The gabions go back into the slope at least 1m.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4435
Location	E 447166, N 335767
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Binoculars, camera and notebook
Description:	Gabion wall up to 1.5m high along the M1

The setting and location of the wall, in particular relative to the carriageway:

The gabion wall is located on the M1 J25 southbound on-slip embankment (carriageway side) at the Sandiacre Interchange. The site was viewed from a maintenance layby on the Sandiacre Interchange Roundabout.

The gabion wall is approximately 1.5m high.



Information pertaining to drainage / watercourses / salt spray:

No drainage or watercourses were observed during the inspection. Assumed to be free draining.

It is likely that the wall will be subject to lots of vehicle spray as it is adjacent to Lane 1 of the M1 motorway.

Condition and type of foundation:

The gabion baskets appear to be embedded into the ground by approx. 0.5m (assuming the bottom row is a 1m high gabion basket).

The condition of the retained slope where visible:

The slope above the gabion wall appears to be satisfactory and is not showing any adverse slope stability issues.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4435
Location	E 447166, N 335767
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Binoculars, camera and notebook
Description:	Gabion wall up to 1.5m high along the M1

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):
The gabions comprise galvanized double twist hexagonal mesh. No close observations made due to access. The gabions appear to have been filled neatly by hand (fill type unknown).

The stability and linkages between adjacent baskets:
Linkages unknown. Stability appears satisfactory.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
No distortion of the baskets was observed.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area 7 / 4435
Location	E 447166, N 335767
SGM Type:	Gabion Wall
Date:	6th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Binoculars, camera and notebook
Description:	Gabion wall up to 1.5m high along the M1
Additional Comments: While only distance observation was possible it is understood that the wall forms part of an extensive series of gabion walls installed as part of the M1 J23a to J25 Smart Motorway Project. It is further understood that significant construction problems were experienced (at local chainages 183480 to 184450) in the building of the gabion wall including bulging in the central section of gabion baskets with wall leaning near vertical, sagging in central section, deformed basket with loose fill and no evidence of internal bracing or corner strengthening ties to prevent bulging.	

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area SW / 10862
Location	E 223331, N 64669
SGM Type:	Gabion Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 3.5m high along the cutting of the A38

The setting and location of the wall, in particular relative to the carriageway:
The gabion wall is located in front of a rock cutting along the eastbound carriageway of the A38 to the west of Liskeard. It is approximately 3.5m high (above ground) and likely to be founded 0.5m into the ground. There are 4 rows of gabions with each row steeped back approximately 0.15m.

Information pertaining to drainage / watercourses / salt spray:
There was no drainage associated with the gabion wall and it is assumed to be free draining.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area SW / 10862
Location	E 223331, N 64669
SGM Type:	Gabion Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 3.5m high along the cutting of the A38

Condition and type of foundation:
The foundation for the wall is unknown but based on the site inspection it is considered likely that the gabions are founded approximately 0.5m into the ground.

The condition of the retained slope where visible:
The gabions obscure the majority of the retained slope. No stability issues were observed.

The condition of the elements (gabions), including but not limited to gabion basket wire damage and/or repairs, gabion basket wire corrosion protection (galvanising and/or plastic), gabion fill (including suitability and deterioration):
The gabions comprised plastic hexagonal double twist mesh with an aperture of 100mm by 120mm. There was no corrosion observed on the mesh or wires.
There appeared to be two types of gabion used, one with a light grey plastic finish and one with a darker grey plastic finish. It may be a different supplier or a different batch. It was also observed that the gabions predominantly on the upper row where rotated 90° to the ones on the lower three rows which meant the apertures where wider across than upwards (see photo below). These differences just appear to be cosmetic and do not affect the structure of the wall.

The gabion baskets were filled with a local flat building stone (mudstone / siltstone) that fit into the rock slope behind. The use of argillaceous fill may have future implications or durability; however, a more durable stone was used in the partially buried gabion where the salt spray is more likely to affect it.

The fill used was between 200mm to 700mm (oversized compare to the MCHW specification); however, this appeared to have been packed by hand (at least the front face) very neatly and no gaps where observed.

Task 1-1109: SGMs Phase 2	
Gabion Wall Proforma	
Area / SGM ID:	Area SW / 10862
Location	E 223331, N 64669
SGM Type:	Gabion Wall
Date:	27th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Gabion wall up to 3.5m high along the cutting of the A38

The stability and linkages between adjacent baskets:
The finish of the gabion walls is very neat with the baskets joined with either spenax clips or wrapped wire.

The stability of the individual elements (gabions) e.g. damage and distortion of baskets:
No damage or distortion to the gabion baskets were observed. There were tie backs present within the fill to help stabilise the face.

Additional Comments:
None

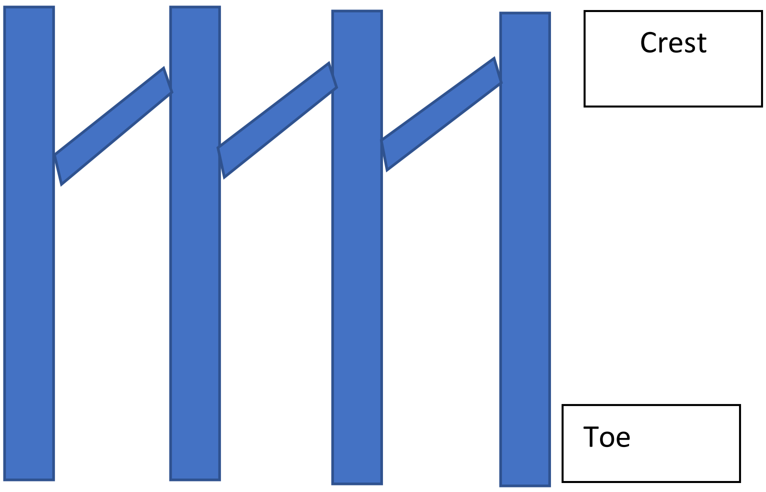
Appendix J Counterfort Drain Site Proformas

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 7 / NA (not recorded as an SGM)
Location / NGR:	E 462408, N 277609
SGM Type:	Counterfort Drains
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey Geotechnics) and Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort drains located along A14 cutting.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along a cutting on the A14. At the toe of the cutting is a layby which was used to access the SGMs.
The slope is approximately 30m long (crest to toe) and at 25°.

Information pertaining to drainage / watercourses / outfalls:
The counterforts are 1m wide and spaced every 10m (centre to centre). There are herringbone drains also present in the upper part of the slope which were 0.6m to 0.7m wide and splayed 45 ° from the horizontal approximately 3m from the crest.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 7 / NA (not recorded as an SGM)
Location / NGR:	E 462408, N 277609
SGM Type:	Counterfort Drains
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey Geotechnics) and Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort drains located along A14 cutting.



The stone used in the drains (visible at surface) was an angular granite and varied in size between 20mm to 60mm (avg 40mm).
A manhole was observed at the crest of one of the counterforts (not observed on any of the others). Adjacent to this same counterfort (just upslope of where the western herringbone joined), a white 100mm diameter PVC pipe was observed protruding through the ground surface. At the toe of this counterfort a manhole approx. 350mm x 800mm was adjacent to the emergency telephone. No other drainage at the toe was observed and it is considered likely that these manholes and pipe are connected to localised drainage from the field at the crest.
A hole was opening up adjacent to the manhole at the crest (on the downslope side). It is likely this is from burrowing animals or potentially from water erosion.
The field at the crest of the cutting is relatively flat and it appears that the majority of the field has a catchment away from the cutting to the north west.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 7 / NA (not recorded as an SGM)
Location / NGR:	E 462408, N 277609
SGM Type:	Counterfort Drains
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey Geotechnics) and Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort drains located along A14 cutting.

The overall stability of the slope in the area of the drains and the surrounding area(s):
No signs of instability were observed on the cutting.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 7 / NA (not recorded as an SGM)
Location / NGR:	E 462408, N 277609
SGM Type:	Counterfort Drains
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey Geotechnics) and Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort drains located along A14 cutting.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):

Excavation of the counterforts were not undertaken during the inspection.

The slopes were typically vegetated with grass and low-lying vegetation with trees present towards the crest of the slope. In some locations it was observed that where the vegetation had been cut previously, the detritus had been left lying on top of the drains, effectively creating a barrier to water infiltration and possibly providing fine material to clog the drains.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 7 / NA (not recorded as an SGM)
Location / NGR:	E 462408, N 277609
SGM Type:	Counterfort Drains
Date:	7th October 2020
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey Geotechnics) and Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort drains located along A14 cutting.
No distortion to the counterforts was observed. The counterforts were observed to get narrower towards the crest where it is considered likely that they have been restricted by presence of mature trees. In 2018 geomembrane was observed to be exposed at the base of the counterforts where gravel has been displaced by people walking along the layby. This was not observed during our inspection; however, the toe area of the slope had household waste tipped along it (glass, concrete, ironing board etc).	
The surrounding ground conditions: The soil in between the counterforts was observed to be a yellow clay which was cracked where it was exposed at the surface. It was very slippery underfoot.	
Additional Comments: It is unclear where the water from the counterforts drains to.	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1924
Location / NGR:	E 284326, N 93113
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Light Rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the westbound cutting of the A30 to the west of Exeter. The site was accessed via the overbridge off Five Mill Hill Road.

The slope is approximately 40m long (crest to toe) in the east of the site (adjacent to a bridge wingwall) and shallows towards the west. The slopes are approximately between 20° and 25° (becoming steeper towards the toe) and are heavily vegetated with trees and brambles making access difficult.

Information pertaining to drainage / watercourses / outfalls:
Only one counterfort was observed on the site which was located approximately 14m west of the bridge wingwall. This counterfort was 0.7m wide with some overspill to the counterfort edges. The depth of the counterfort is unknown. There were no other counterfort drains within a reasonable distance (we walked 30m+ to the west of the counterfort). Any additional counterforts present on the site would be acting as individual drains rather than a counterfort system.

A drain was observed running across the slope approximately 2/3 of the way down the slope length. This was 1m wide by 0.5m high and had clay present in the base. The counterfort observed was located between this drain and the toe of the slope (i.e. not the full length of the slope).

The stone used in the drains (visible at surface) was angular and varied in size between 20mm and 70mm (average 40mm to 50mm). The drain was observed to be covered with vegetation, but limited fines were observed (see photo below).

A filter drain was present at the toe of the slope.

Ponding was present approximately 50m to the west of the bridge wingwall. This was orange in colour indicating ferritic material (see photo below) and a spring at the base of the slope.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1924
Location / NGR:	E 284326, N 93113
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Light Rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.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Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1924
Location / NGR:	E 284326, N 93113
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Light Rain
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The overall stability of the slope in the area of the drains and the surrounding area(s):
The trees on the slope were leaning approximately 5° from vertical indicating possible instability of the slope. It is not known whether this is prior to the counterfort installation as historic design reports indicate that shallow translational slides may have been a factor on this cutting.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):
No distortion of the counterfort drain was observed.
Excavation of the counterfort was not undertaken during the inspection.
No geosynthetic wrap was observed on the slope.
The stone used in the drains (visible at surface) was angular and varied in size between 20mm and 70mm (average 40mm to 50mm). The drain was observed to be covered with vegetation, but limited fines were observed with the stone being relatively clean.

The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s).
Excavation of the counterfort was not undertaken during the inspection.

The surrounding ground conditions:
At the crest of the slope is a track in private agricultural land which was not access during the inspection.
A bridge is located to the east of the site.
The slopes were heavily vegetated with trees and brambles making access and inspection difficult.
No topsoil was observed on the slope. At surface a grey brown clay was observed.

Additional Comments:
None.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2053
Location / NGR:	E 285307, N 92785
SGM Type:	Counterfort Drain
Date:	26th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the westbound cutting of the A30 to the west of Exeter. There is a layby immediately to the west of the site which was used to access the SGMs.
The slope is approximately 30m long (crest to toe) in the east of the site (adjacent to a bridge wingwall) and shallows to ground level towards the layby in the west. The slopes are approximately 22° and are heavily vegetated with trees.

Information pertaining to drainage / watercourses / outfalls:
The counterforts are 1.2m wide and spaced every 20m. The depth of the counterforts is unknown.
The stone used in the drains (visible at surface) was angular and varied in size between 30mm to 90mm (average 50mm to 60mm). Small amounts of flaky material were observed in the stone fill. The drains were observed to be clogged up with soil and vegetation.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2053
Location / NGR:	E 285307, N 92785
SGM Type:	Counterfort Drain
Date:	26th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

Along the top of the slope is a crest drain which follows the line of the slope west towards the road and comes to a stop approximately 2m to 3m above road level. At the downslope edge of the crest drain is a 2m high concrete headwall with a small culvert approx 100mm x 100mm. The ditch is heavily vegetated (see photo below). This crest drain was not present at the top of the slope adjacent to the bridge.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2053
Location / NGR:	E 285307, N 92785
SGM Type:	Counterfort Drain
Date:	26th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The overall stability of the slope in the area of the drains and the surrounding area(s):
One of the counterforts had significant settlement located towards the crest. This is possibly caused by a loss of fines below or by loosely placed stone (see photo below).
No other distortion to the counterforts or surrounding slopes were observed.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2053
Location / NGR:	E 285307, N 92785
SGM Type:	Counterfort Drain
Date:	26th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.
The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines): Excavation of the counterforts were not undertaken during the inspection. No geosynthetic wrap was observed on the slope. The stone used in the drains (visible at surface) was angular and varied in size between 30mm to 90mm (average 50mm to 60mm). Small amounts of flaky material were observed in the stone fill. The drains were observed to be clogged up with soil and vegetation.	
The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s). Excavation of the counterforts were not undertaken during the inspection.	
The surrounding ground conditions: At the crest of the slope is a farmers track which leads downslope towards the layby. A bridge is located to the east of the site. Between each counterfort was a strip of ground through the trees which at first look appeared to be counterforts but upon closer inspection this comprised clay at ground surface and no drainage stone was observed.	
Additional Comments: It is unclear where the water from the counterforts drain to. There was no topsoil observed on the cutting.	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The setting and location of the counterfort drains, in particular relative to the carriageway:

The counterfort drains are located along the eastbound cutting of the A30 to the west of Exeter. The site was accessed via a layby to the west of the cutting.

The slope is approximately 20m to 25m long (crest to toe). The slopes are approximately 25° and are heavily vegetated with brambles. Trees are present in the upper section of the slope near the crest.

Information pertaining to drainage / watercourses / outfalls:

Only one counterfort was observed on the site and this was actually a herringbone drain. The drain width was indistinct; however, the central stem appeared to be approximately 0.9m wide with some overspill to the counterfort edges. The depth of the counterfort is unknown.

The stone used in the drains (visible at surface) was angular and varied in size between 30mm and 60mm (average 40mm). The drain was observed to be covered with vegetation and the stone fill was clogged with fines (see photo below).

A filter drain was present at the toe of the slope and the herringbone appeared to connect into this.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The overall stability of the slope in the area of the drains and the surrounding area(s):
Settlement of the herringbone drain was observed towards the toe of the slope immediately below where the 'V' of the herringbone comes into the central stem (see photo below). This has led to a sunken section of the drain and appeared to be where water has been forced to the surface.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The whole cutting appears to suffer from translations sliding (likely to be shallow). These look similar to solifluction but with longer, more persistent horizontal runs (see photos below).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):

Settlement of the drain towards the toe was observed (see section above).

On the upper slope (on the western branch of the 'V') there was an area that had water 'piping' present (i.e. where water had been forced to the surface along with aggregate carried by the water – see photo below). This water appears to have then excavated along the side of the drain causing scour along the drain edge.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 2065
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the A30.
Excavation of the counterfort was not undertaken during the inspection. No geosynthetic wrap was observed on the slope. The stone used in the drains (visible at surface) was angular and varied in size between 30mm and 60mm (average 40mm). The drain was observed to be covered with vegetation and the stone fill was clogged with fines.	
The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s). Excavation of the counterfort / herringbone drain was not undertaken during the inspection.	
The surrounding ground conditions: At the crest of the slope is agricultural land which was not accessed during the inspection. No crest drain was observed. No topsoil was observed on the slope. At surface a grey brown clay was observed.	
Additional Comments: None.	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1280
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the westbound embankment of the A303 to the south of Horton. Access to the site was via Whitney Hill road.
The slope is approximately 8m high at 30° and is located to the west of the Whitney Hill road underpass.

Information pertaining to drainage / watercourses / outfalls:
The slope here comprises a loose fine to coarse sandy gravelly fill with the gravel at surface approximately 20mm to 30mm with finer gravel below.

Strips of vegetation up to 1.3m wide were located at spacings every 4m to 5m across the slope (see photo below). The material below the vegetation strips appeared to be the same as the surrounding slope' however, it was more compact and damper.
This slope does not appear to have conventional counterforts installed but is perhaps a large drainage blanket.

At the toe of the slope is a 1.6m wide toe drain which comprises coarse angular gravel (40mm to 50mm).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1280
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The overall stability of the slope in the area of the drains and the surrounding area(s):
Across the whole slope there were numerous instances of piping observed with finer gravel washed out of the slope (see photo below).
It is possible that these areas of 'piping' could be related to animal activity; however, the holes did not appear to be very deep and the finer material was typically restricted to immediately downslope (with burrowing the material excavated often ends up around the sies of the hole aswell as downslope).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1280
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):

The material used on the slope was fine to coarse gravel, much smaller than would typically be used in a counterfort drain.

The surface was very loose and numerous 'piping failures' or animal burrows across it (see photo below).

No geosynthetic was observed on the slopes.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1280
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s).

Excavation of the counterfort drains / drainage blanket were not undertaken during the inspection.

The surrounding ground conditions:

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 1280
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303
In the west of the site and on the adjacent slope there were areas which had distinct animal burrows present indicating that animal activity is ongoing at this location.	
Additional Comments: No topsoil was observed on the site	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 3329
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the westbound embankment of the A303 to the south of Horton. Access to the site was via Whitney Hill road.
The slope is located to the east of the Whitney Hill road underpass and is approximately 8m high adjacent to the bridge and shallows to 5m high towards the eastern part of the site. The slopes are approximately 25° (getting steeper towards the bridge).

Information pertaining to drainage / watercourses / outfalls:
At the eastern end of the site the counterfort drains are 1.2m wide and spaced every 10m.
Towards the western end the counterforts are approximately 1.3m wide and spaced every 5m.
The counterforts comprise a fine gravel and coarse sand with a layer of coarse gravel (40mm to 50mm) on top (see photos below).
At the toe of the slope is a toe drain which comprises coarse angular gravel (nominally 40mm to 50mm).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 3329
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303

The overall stability of the slope in the area of the drains and the surrounding area(s):
There were no signs of instability of the counterfort drains or surrounding slopes observed.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):
The material used in the counterfort drains was coarse sand to fine gravel, much smaller than would typically be used in a counterfort drain. From a review of the pre-existing design information it was clear these counterforts were installed to increase the phi angle of the surface material rather than allow drainage of the slopes.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / 3329
Location / NGR:	E 332272, N 114244
SGM Type:	Counterfort Drain
Date:	28th January 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A303
No geosynthetic was observed during the inspection.	
The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s). Excavation of the counterfort drains were not undertaken during the inspection.	
The surrounding ground conditions: A public footpath is present at the toe of the embankment and this was observed to be ponded in numerous locations.	
Additional Comments: No topsoil was observed on the site.	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / No SGM ID
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A38.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the eastbound embankment of the A38 to the west of Liskeard. Access was to the east of the site; however, vegetation, fencing and a watercourse prevented access to the main site area so this was viewed from a distance.
The slope is approximately 9m to 11m long and the counterforts stop 2m to 3m below the crest of the embankment.

Information pertaining to drainage / watercourses / outfalls:
The counterforts were not examined up close so no observation on the stone fill was possible.
The counterfort drains appeared to be approximately 1.2m wide and closely spaced (approximately every 3m – see photo below).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area SW / No SGM ID
Location / NGR:	E 287064, N 92536
SGM Type:	Counterfort Drain
Date:	27th January 2021
Weather:	Drizzly
Attending site:	Michelle Duffy-Turner (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located on embankment of the A38.

A rockfill toe berm/bund was present below the counterforts.
A watercourse was present at the toe of the slope which appeared to flow through the site to the east.

The overall stability of the slope in the area of the drains and the surrounding area(s):
No instability of the counterfort drains or the surrounding slopes were observed during the inspection. This was only viewed from afar and only the eastern part of the site could be seen.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):
From a distance the counterfort drains appeared to be free of vegetation. It is not possible to see if the drains were clogged up with fines, but it is considered unlikely due to the age (constructed in 2015).

The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s).
Excavation of the counterfort drains were not undertaken during the inspection.

The surrounding ground conditions:
At the toe of the slope is agricultural land which was not accessed during the inspection.
The ground to the east of the site was very wet with ponding occurring adjacent to the watercourse.

Additional Comments:
None.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort drains are located along the northbound cutting of the M6 on-slip at Junction 34 to the north east of Lancaster. The site was accessed via access steps adjacent to the overbridge off Foundry Lane.
The slope is approximately 20m to 25m long (crest to toe). The slopes are approximately 30° and are vegetated with grasses and saplings (with tree guards present).

Information pertaining to drainage / watercourses / outfalls:

Description of Counterforts / Herringbones
A series of counterforts and herringbones are present along the cutting for approximately 550m. They are typically spaced between 12m and 15m; however, some were closer together (9m spacing) and some were further apart (up to 35m spacing).

The drain widths were typically 0.6m; however, in some locations the width was 0.3m (these tended to be in the central and eastern part of the cutting). The herringbone branch drains were typically at 45° coming from the crest to tie in with the main branch approximately 2/3 of the way up from the toe. The branch patterns varied across the cutting typically dependent upon the spacing. Where the drains were closer together the counterfort had one branch (generally on the north side) and where they were spaced further apart they tended to have two branches (one either side making a chevron pattern).

The stone used in the drains (visible at surface) was angular and varied in size between 20mm and 70mm (average 40mm to 50mm). The drain surface was typically observed to be clear of vegetation and sediment.

Other Drainage
A filter drain was present at the toe of the slope.

A crest drain was located along the whole cutting to the north of Overbridge 388 3/A. The crest drain varied in level with pipes and headwalls attempting to pick up low spots to take water down the slope. The first low spot was approximately 35m to the north of the overbridge. Here

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

two inlet headwalls had been installed within the crest drain with the intention assumed to be picking up water from the ditch from the north and south. A manhole was located between the two headwalls where a pipe was observed going downslope. The ditch had been shallowed on either side of the headwalls and the invert of the pipes (225mm polypipes) was approximately 100mm above the base of the ditch. The pipes were not bedded in sufficiently, especially on the southern side, with the pipe being exposed behind the headwall.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

In some places on the run up to the inlets the sides of the ditch where shallower than the pipe invert meaning that water could overtop of the ditch before making it into the pipe. This had occurred immediately adjacent to the northern inlet where a well-defined area of run-off was observed with flattened grass indicating flow path. Below this section is an area of slope repair where a 1.5m wide rockfill repair had been installed. The rock fill was angular and between 150mm and 300mm (avg 200mm).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

Further east at another low spot along the crest drain (also where a stream from the adjacent fields flowed down to the cutting), a headwall inlet was present with a 225mm polypipe to take water downslope. Like above the ditch was shallowed on the run up to the headwall from both sides and three 300mm diameter sections of pipe had been left in the base of the ditch. Downslope of this headwall there was no sign of a manhole to connect the pipe into the toe drain. It is unclear where this water is taken to.

A number of land drains (typically 75mm VE clay pipes) where observed in the slope with water issuing from them. The slopes surrounding these were typically wet and covered in hydrophilic vegetation. A land drain was also observed in the base of the ditch where water was flowing into and presumably into the adjacent counterfort downslope (assumed due to no water issuing from the slope downslope at this location).

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

The overall stability of the slope in the area of the drains and the surrounding area(s): There were a number of places on the cutting where instability was observed. Immediately to the north of the overbridge a tension crack and bowl feature approximately 8m wide was observed. This was located below one of the land drains and the area was extremely boggy. The filter drain at the toe of the slope in this area was covered by the slipped deposits.

As described in the section above an area of rockfill repair has been undertaken on the slope (presumably replacing an existing herringbone). It was observed that water is still flowing over the top of the ditch and into the head of this repaired area. This is further cutting into the slope and at present there is a 0.6m high scarp which appears to be regressing upslope. It is expected that this will continue unless the ditch is reinstated above. The soil type in this area was observed to be a sandy, silty clay.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines):

The stone used in the drains (visible at surface) was angular and varied in size between 20mm and 70mm (average 40mm to 50mm).

The drain surface was typically observed to be clear of vegetation and sediment and the drainage stone looked in good condition.

No geosynthetic wrap was observed on the slope or inside the counterforts.

The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s).

Excavation of part of the counterfort (down 350mm), was undertaken during the inspection using a hand held tool. The stone at the top of the counterforts was clean; however, at approximately 200mm deep the counterfort was very wet and fines were present.

No geosynthetic was observed on the slope or inside the counterforts

Full excavation of the counterfort was not undertaken.

The surrounding ground conditions:

At the crest of the slope is agricultural land which falls towards the cutting at approximately 5°.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area NW / No SGM ID – located at M6 Jct 34
Location / NGR:	E 349701, N 465325
SGM Type:	Counterfort Drain
Date:	11th March 2021
Weather:	Dry
Attending site:	Michelle Duffy-Turner and Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Counterfort Drain site located in a cutting along the M6.

Additional Comments:

Based on communication with National Highways prior to the site visit it is understood that the slope drains were installed retrospectively due to issues arising following construction. The three main issues were identified by David Brown as the following:

- *More water bearing soils were encountered during the excavation of the cutting, which probably wasn't helped by the fact that the finishing off of the cutting areas coincided with the three named storms at the end of 2015 and start of 2016, Desmond (the most damaging), Eva and Frank, which led to additional problems.*
- *The additional problem, which caused some surface slips and the installation of additional measures and herringbones was that the cutting is 1 in 2.25 but the topsoil thickness specified for landscape planting was 450mm. This is particularly thick and as it took some time for the landscaping to become established, the heavy rainfall brought in by the storms led to localised slips and the requirement for additional slope drainage to be installed.*
- *The other issue on the NB on slip, is that we have a significant amount of surface water coming in to the top of the cutting and at one location this comes down a small valley to the top of a counterfort and I don't think that the top of batter drainage ditch or the counterfort was designed to take this volume of water, so this has now been added to our drainage hot spots, as water is getting on to the carriageway at this location.*

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 9 / 9685 (slope drain)
Location / NGR:	E 425053, N 302348
SGM Type:	Slope Drain
Date:	23rd February 2022
Weather:	Drizzly
Attending site:	Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Slope Drain site located on cutting of the M42.

The setting and location of the counterfort drains, in particular relative to the carriageway:
The counterfort (slope) drains are located along the westbound cutting of the M42 approximately 1.7km north of the M42 Junction 10 and 165m south of the Hermitage Hill Overbridge.
Access to the site was via the night-time works on the M42 and the team was escorted to site by the Kier site manager.

Information pertaining to drainage / watercourses / outfalls:
Drains were present vertically down the slope and slope parallel drains were also encountered. The upper part of the slope generally appeared well-drained. In contrast, the lower part of the slope was considerably wetter, and spring-like features were observed at locations consistent with a geological boundary.
The flow of water from one of these features had caused soil to clog the surface of the drain and water, soil and debris to reach the hard shoulder. It is understood that water and debris have in the past reached lane one.
The edge of carriageway filter drain at the toe of the slope had been inundated with soil and vegetative debris, seemingly over a long period, and its current efficacy is not known. However, inspection of a grated catch pit (see photo below) demonstrated that water was running freely in the pipe within this drain. No positive connection to the vertical slope drain could be observed within the catch pit. It is likely that the vertical slope drain simply buts up to the edge of carriageway filter drain.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 9 / 9685 (slope drain)
Location / NGR:	E 425053, N 302348
SGM Type:	Slope Drain
Date:	23rd February 2022
Weather:	Drizzly
Attending site:	Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Slope Drain site located on cutting of the M42.
	
The overall stability of the slope in the area of the drains and the surrounding area(s): No instability of the slope was observed; however, the visit was undertaken at night so visibility was poor.	
The surface condition of the drains prior to excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines): Surface clogging due to a build up of leaf litter and humous and washing in of fines were all observed. This clogging was worsened where trees were found to be growing on top of drain and also where roots had actively followed and invaded the course of drains (see photos below). No geosynthetic or other form of filter was encountered.	

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 9 / 9685 (slope drain)
Location / NGR:	E 425053, N 302348
SGM Type:	Slope Drain
Date:	23rd February 2022
Weather:	Drizzly
Attending site:	Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Slope Drain site located on cutting of the M42.

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 9 / 9685 (slope drain)
Location / NGR:	E 425053, N 302348
SGM Type:	Slope Drain
Date:	23rd February 2022
Weather:	Drizzly
Attending site:	Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Slope Drain site located on cutting of the M42.

The condition of the drain during excavation, including any distortion to the drain line, and the condition of any geosynthetic wrap and stone drainage media (type, deterioration, clogging/presence of fines). If at all possible, these features should be assessed at a number of depths and positions in the drain(s). Excavation of the counterfort drains were not undertaken during the inspection.
The surrounding ground conditions: No instability of the slope was observed; however, the visit was undertaken at night so visibility was poor.
Additional Comments:

Task 1-1109: SGMs Phase 2	
Counterfort Drain Proforma	
Area / SGM ID:	Area 9 / 9685 (slope drain)
Location / NGR:	E 425053, N 302348
SGM Type:	Slope Drain
Date:	23rd February 2022
Weather:	Drizzly
Attending site:	Ian Nettleton (Coffey) & Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Slope Drain site located on cutting of the M42.
The remedial design solution at that site includes two counterfort drains connected to low angle herringbone drains. These will be difficult to construct, much more so than either a vertical or horizontal drain due to the angle of excavation and excavator relative to the slope.	

Appendix K Soil Nail Site Proformas

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 10 / 2456
Location	M56 J7 Westbound – E 375655, N 384655
SGM Type:	Soil Nails
Date:	15/07/2021
Weather:	Dry and warm
Attending site:	Ian Nettleton and Michelle Duffy-Turner (Coffey)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail embankment along M56 slip road

The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slope is located along the westbound off slip at Junction 7 of the M56. The site was accessed via the M56 J6 to J8 work site hosted by Galliford Try.

The slope was heavily vegetated with nettles and brambles during the inspection and the soil nails could not be identified.

Information pertaining to drainage / watercourses / salt spray:
The Birkin Brook flows at the toe of the embankment.

Condition and type of foundation:
Foundation not visible

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 10 / 2456
Location	M56 J7 Westbound – E 375655, N 384655
SGM Type:	Soil Nails
Date:	15/07/2021
Weather:	Dry and warm
Attending site:	Ian Nettleton and Michelle Duffy-Turner (Coffey)

The condition of the retained slope where visible:
Slope not visible below the vegetation; however, no obvious signs of instability were observed.

The condition of the nails prior to excavation (as far as they can be observed): e.g. can the nails be moved by applying force to the nail head:
Nails not visible – we walked along the whole length of this area but could not see them. The construction drawings showed a topsoil cellular arrangement over the nails, therefore, it is likely they are buried.

The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:
No excavation being undertaken.

The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 10 / 2456
Location	M56 J7 Westbound – E 375655, N 384655
SGM Type:	Soil Nails
Date:	15/07/2021
Weather:	Dry and warm
Attending site:	Ian Nettleton and Michelle Duffy-Turner (Coffey)
tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability): No excavation being undertaken	
Additional Comments: None	

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 14 / No ID
Location	A1(M) – E 422513, N 499012
SGM Type:	Soil Nails
Date:	26/08/2021
Weather:	Wet
Attending site:	Mike Winter (Winter Associates)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail cuttings along A1(M)

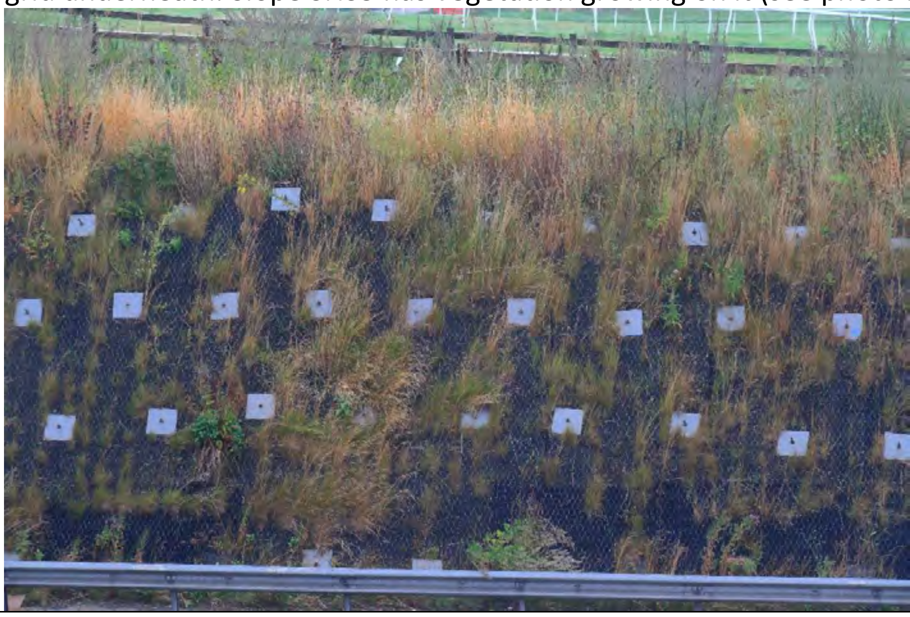
The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slopes are located along the northwbound and southbound carriageways of the A1 to the north west of Catterick. Nailing was undertaken across three slopes; adjacent to the northbound carriageway to the south (SNS1) and north of Fort overbridge (SNS2 – see photo below), and adjacent to the southbound carriageway to the south of Fort overbridge (SNS3). The site was accessed via the overbridge.

Information pertaining to drainage / watercourses / salt spray:
The cutting is adjacent to the A1(M); therefore will be subject to salt spray in winter. There are no visible watercourses (apart from a ditch at the toe); however, it is known that counterfort drains are present on the slopes behind the facing.

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 14 / No ID
Location	A1(M) – E 422513, N 499012
SGM Type:	Soil Nails
Date:	26/08/2021
Weather:	Wet
Attending site:	Mike Winter (Winter Associates)

Condition and type of foundation:
Foundation not visible

The condition of the retained slope where visible:
Slope not visible below the facing; however, no obvious signs of instability were observed.
Two of the soil nail cuttings (SNS1 and SNS2) were faced with a rigid stone filled mattress and the other cutting (SNS3) was faced with a double twist mesh with a black finer geogrid underneath. Slope SNS3 has vegetation growing on it (see photo below).



The condition of the nails prior to excavation (as far as they can be observed): e.g. can the nails be moved by applying force to the nail head:
The soil nail slopes were observed from a distance so no tactile inspection undertaken. The head plates appeared to be secure to the face and no obvious signs of nay issues with the nails.

The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:
The nail heads appeared to be in good condition with slight corrosion observed on the nail ends. The nails are a solid bar so no grout was observed.

Task-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 14 / No ID
Location	A1(M) – E 422513, N 499012
SGM Type:	Soil Nails
Date:	26/08/2021
Weather:	Wet
Attending site:	Mike Winter (Winter Associates)

The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability):
No excavation being undertaken

Additional Comments:
None

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 6312
Location	A628 - E 411812, N 399609
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail slope adjacent to layby

The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slope is located along the eastbound carriageway of the A628 to the east of Manchester. It is located immediately adjacent to a public layby.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 6312
Location	A628 - E 411812, N 399609
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

General Description of Soil Nailed Slope

It is understood that the soil nails were installed on the slope following a large slope failure. The slope is a combination of soil and rock outcrops (typically the rock is present in the upper section of the soil nailed slope). There are 5 rows of nails overlain with a white triple twist mesh (PVC coated galvanized steel rockfall netting) that goes all the way down to the toe (this mesh is covered in vegetation and soil at the toe of the slope in some localised areas). The slope is approximately 35° on the lower slopes becoming steeper where the rock outcrops are present in the upper section.

The spacing on the nails was 2m horizontally and between 1m and 1.5m vertically (for the lower rows of nails which could be measured manually in the field from ground level). The faceplates were 300mm x 300mm.

Some of the soil nails (particularly on the 2rd row) had caps present over the nail head. Where these were present the ends had been painted with a galvanizing paint and no corrosion was observed (see image below). Historical imagery viewed via Google Maps shows caps were present on the lower two rows and on the netting dowels following construction, so it is assumed that the majority of these caps have been lost since construction in 2012.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 6312
Location	A628 - E 411812, N 399609
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

Information pertaining to drainage / watercourses / salt spray:
No drainage was observed on the slopes; however, the facing type (flexible mesh) should allow for free draining of the slope.
It is likely the head of the nail and the mesh will be susceptible to salt spray, especially in the lower sections of the soil nailed slope.

The condition of the retained slope where visible:
A lot of the slope was obscured by vegetation (see image below); however, the slope appeared to be in good condition where visible with no signs of instability observed.

The condition of the nails prior to excavation (as far as they can be observed): e.g. can the nails be moved by applying force to the nail head:
The majority of the lower row had faceplates that were loose and could be moved by hand; however, the soil nails were secure and could not be moved.

Occasional soil nails were observed to be misaligned to the face plate.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 6312
Location	A628 - E 411812, N 399609
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:
Grout loss was visible in the annulus of some of the soil nails (hollow bar) and surface rust was visible at the bar end (see image below); however, no signs of pitting were observed.

The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability):
No excavation undertaken

Additional Comments:
The soil nails on the lower row appeared to protrude into the layby which could potentially cause vehicle impact damage.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 9062
Location	A628 - E 408193, N 399658
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail slope and retaining wall adjacent to A628

The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slope is located along the eastbound carriageway of the A628 to the east of Manchester. It is located immediately adjacent to a public layby which has been closed. A concrete barrier is in place preventing vehicular access to the layby.

General Description of Soil Nailed Slope
The soil nail slope comprises six rows of nails with the lower two rows going through a block wall which is retaining the slope. This wall was in poor condition prior to the works; a comment in the GDR indicated that the wall would be rebuilt; however, photos of the construction show that the wall is still in poor condition so it must have been left in place. It is understood that the original retaining wall was affected by a landslide and soil nails were selected as the most appropriate remedial measure.

The soil nails have a 1.5m horizontal spacing and a 1m vertical spacing and the rows are staggered.

The slope is faced with a double twist steel mesh coated with grey PVC (detailed in the GDR) which is also draped over the retaining wall. Above the mesh is a black Geomat installed for the

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 9062
Location	A628 - E 408193, N 399658
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

retention of fines and topsoil. This is comprised of a plastic type mesh (polypropylene monofilaments is given in the project GDR).
The lower two rows of head plates are 300mm by 300mm and have been painted in bitumen which is wearing off (see image below).

Information pertaining to drainage / watercourses / salt spray:
There were two channels observed on the slope; one to the west which appeared to be a historical track and one to the east which had a headwall located immediately to the north east of the soil nailed section. The west drain channelled water into the back of the west corner of the retaining wall whilst the east drain channelled water to the east of the retaining wall.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 9062
Location	A628 - E 408193, N 399658
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

The condition of the retained slope where visible:
The wall appeared to be bulging; however, it is known this was already in poor condition prior to soil nailing as it was being affected by slope instability behind it, so it is likely the bulging is related to previous movement.

The condition of the nails prior to excavation (as far as they can be observed): e.g. can the nails be moved by applying force to the nail head:
The nails and head plates appeared to be stable and secure and were not able to be moved by hand.

The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:
Where the soil nails had been installed through the wall, the bar was exposed which could lead to corrosion in the future (see image below).

Limited grout loss was observed from the soil nail annulus and slight surface corrosion was observed on the cut off end of the bar (proximal end).

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 12 / 9062
Location	A628 - E 408193, N 399658
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)
The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability): No excavation undertaken	
e	

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 7 / 1023
Location	A42 - E 437985, N 317873
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail slope adjacent to A42

The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slope is located along the northbound carriageway of the A42 to the north east of Ashby de la Zouche. It is located immediately adjacent to an emergency layby.

General Description of Soil Nailed Slope
The soil nail slope comprises two rows of nails with a vertical and horizontal spacing of 1m. The nails are 22mm and appear to be hollow bar self drills; however, this is considered unlikely due to the age of the nails (approximately installed in 1991 prior to the common use of self drill nails).

The face plate comprises a circular steel nut and the facing comprises 120mm wide concrete cloth straps/planks (or similar) with a thickness of 3 to 5mm (see image below) in a cross pattern arrnagement (with the soil nail located where the vertical and horizontal straps cross). In the middle of the conclete cloth straps is a black geogrid with 1 inch aperture. This geogrid carries on up the slope above the soil nailed section.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 7 / 1023
Location	A42 - E 437985, N 317873
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

Information pertaining to drainage / watercourses / salt spray:
No drainage was observed on the soil nail slope.

The condition of the retained slope where visible:
The slope was observed to be bulging with the concrete cloth straps heavily bowed, especially the vertical ones (see image below).
The geogrid in between the concrete cloth straps was brittle and broke apart with light pressure. This may be suffering from UV deterioration.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 7 / 1023
Location	A42 - E 437985, N 317873
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

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The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:
The nails showed loss of grout from the annulus and pitting corrosion on the nail ends (see image below).

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 7 / 1023
Location	A42 - E 437985, N 317873
SGM Type:	Soil Nails
Date:	11th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability):
No excavation undertaken

Additional Comments:
None

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 9 / 9173
Location	M6 - E 399118, N 298379
SGM Type:	Soil Nails
Date:	12th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)
Equipment Used:	Tape measure, distomat, compass clinometer, camera and notebook
Description:	Soil nail slope adjacent to M6 – Access via Sisk Traffic Management as part of the M6 Junction 10 Improvement Scheme

The setting and location of the soil nail slope, in particular relative to the carriageway:
The soil nail slope is located along the northbound carriageway of the M6 at junction 10 and the off slip is located above it. At the time of inspection the nearside lane was barriered off as part of the M6 Junction 10 Improvement works; however, part of the soil nailed slope is directly adjacent to the carriageway and part of it adjacent to an emergency layby and gantry.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 9 / 9173
Location	M6 - E 399118, N 298379
SGM Type:	Soil Nails
Date:	12th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

General Description of Soil Nailed Slope

The soil nail slope is approximately 2.5m high at 60° then becomes shallower up to the slip road above. There are two rows of nails with alternated nails of the same row being offset approximately 0.3m. There is a 1.2m vertical spacing and a 1m horizontal spacing between the nails.

The head plates are 200mm by 200mm and the facing is a double twist steel mesh (appears PVC coated) with a black fine coiled geosynthetic mesh behind it. The fine mesh was quite breakable and likely there to assist with the establishment of vegetation rather than reinforcement.

Information pertaining to drainage / watercourses / salt spray:

No drainage was observed at the site. The soil nail slope is likely to be exposed to salt spray as it is directly adjacent to the network.

The condition of the retained slope where visible:

The soil nail slope was observed to have bulging between the nails and typically the deformation was midslope and seemed to be more evident in the far north and far south of the soil nail slope.

Some of the faceplates appeared to be rebated into the slope suggesting that the slope is moving outwards around them. These were approximately between 50mm and 70mm behind the plane of the slope face.

The condition of the nails prior to excavation (as far as they can be observed): e.g. can the nails be moved by applying force to the nail head:

The nail heads and face plates were all secure and tight to the face.

The condition of the nail heads (corrosion, mechanical integrity) prior to excavation:

Grout loss was visible in the annulus of some of the soil nails (grout loss observed between full loss, half loss and no loss). Most of the nail heads had corrosion visible at the bar ends (see image below).

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 9 / 9173
Location	M6 - E 399118, N 298379
SGM Type:	Soil Nails
Date:	12th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

The condition of the nails during and after excavation, including but not limited to grout presence, continuity and integrity; presence of double corrosion protection (e.g. plastic tube); presence of nail spacers; position of nail in the hole; condition of nail (including corrosion and mechanical stability):

No excavation undertaken

Additional Comments:

Trees were observed to be growing out of the slope from behind the mesh (see image below). This is not currently affecting the soil nails; however, it is damaging the facing and may lead to further issues with the facing and nails as the trees continue to grow.

Task T-0077: SGMs Phase 3	
Soil Nail Proforma	
Area / SGM ID:	Area 9 / 9173
Location	M6 - E 399118, N 298379
SGM Type:	Soil Nails
Date:	12th January 2022
Weather:	Dry
Attending site:	Mike Winter (Winter Associates Ltd) and Michelle Duffy-Turner (Coffey Geotechnics Ltd)

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018
Year of Failure:	Various – 2015 to 2017

Details Obtained from the Following Sources:

- A1L2B. 2018. A1 Dishforth to Barton Improvement, Leeming to Barton Section, Geotechnical Feedback Report (GDMS Ref 30694).
- Atkins. 2017. A1 Leeming to Barton, Soil Nails: Design Approach for Global Stability-Atkins Check, Technical Note. Unpublished (GDMS Ref NA).

Summary of Scheme:

In order to facilitate widening of the mainline carriageway through Cataractonium Cutting, east and south east of Thornbrough Farm, the lower slopes were steepened, with support provided by soil nails. Nailing was undertaken across three slopes; adjacent to the northbound carriageway to the south (SNS1) and north of Fort overbridge (SNS2), and adjacent to the southbound carriageway to the south of Fort overbridge (SNS3).

Summary of Failure

Between early October 2015 and April 2016 a number of failures occurred during the construction of the northbound soil nail slopes, soil nail slopes 1 and 2. The failures were characterised by a series of conventional slip and slumping failures.

From July 2016 to February 2017 progressive deformation of the soft faced sections of soil nail slope 2 took place, culminating in intervention from the HA Geotechnical Advisor, effectively condemning the original nailing and facing installed on the soil nail slopes. This deformation presented as 'slumping' of the mid and lower half of the slope, with localised slope crest regression where material had mobilised below. Soil nail slope 1 also showed – to a lesser extent – evidence of deformation at the slope toe.

Observations Made on Site:

The failures were characterised by a series of conventional slip and slumping failures.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

Figure 1: Extract of construction phase pre-nailing/facing failure, Soil Nail Slope 1 Plate 27 (image) taken from A1L2B Geotechnical Feedback Report.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

Figure 2:. Extract of post construction phase post-nailing/facing softening and flow failures (slumping at the toe), Soil Nail Slope 2 Plate 30 (image) taken from A1L2B Geotechnical Feedback Report

Failure Mechanisms:

The cause of these failures was probably a result of a number of factors including:

- Excavation in inclement weather, including working over 2015/16 winter period.
- Slopes left unsupported (un-nailed/faced) for significant periods of time, particularly on SNS1 with slope left over Christmas 2015 break partly nailed and faced.
- Full height excavation and nailing/facing of slopes, rather than benched excavation with top-down nailing/facing.
- A general lack of tension in a number of elements in the facing system, allowing progressive deformation of the slope face to take place until tension was finally mobilised. This included:

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

- o Lack of tension in facing mesh when applied to slope. Mesh not applied taut' and locally observed to be loose, with slack available.
- o Loose head plate nuts. Numerous nuts observed to be loose and not fully engaged throughout works.
- o Lack of crest and toe facing mesh tie-in for significant periods of time.
- o Mesh not anchored at crest and toe due to delays in installing the SNS1 and SNS2 crest anchor selvedge cable and SNS3 anchor trench, and due to disruption caused by retrospective road box cutting and drainage installation works adjacent to the toe of the slope.
- o Regular damage to mesh at toe of slope, requiring splicing repairs, and a temporary but often significant prolonged loss of tension in the facing system.

- Low volume water flow/seepage through slope face which softened exposed materials. This was considerably more prevalent on SNS2 where an often persistent seepage of groundwater was observed, emanating through and over the upper slope and discharging both over the crest and from within the face. Flows were more prevalent at the locations of historic coarse stone drainage grips encountered during the original slope excavation. It is thought that these water flows emanated from a perched water body generated at a sharp permeability contrast between the relatively high permeability Made Ground Archaeology deposits and the underlying relatively low permeability Glacial Till, with incised ditches and channels present at the base of the archaeology allowing water to flow onto the fresh exposed soil on the 55° slope face.
- For the construction phase failures some seepages were observed at lower levels, appearing to use the soil nail bores as flow conduits.

Severing of original stone filled counterfort trenches allowing water to flow over newly cut exposed soil and progressively soften its surface.

Remediation:
Soil Nails – SNS1 and SNS2
Between May and July 2017 a phase of investigation into the status of the nails across the slopes took place, including:

- Additional production testing (SNS1, SNS2 and SNS3), and
- Selected extraction of working nails (SNS1 and SNS2)

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

The results of this investigation resulted in the condemnation of the original nails installed on the soil nail slopes. Between September and October 2017, in light of the results of the additional testing and extraction investigation, nail layouts were re-designed for SNS1 and SNS2. New nails were offset from the original nails.

Facing – SNS1 and SNS2

The facing deformation concerns outlined above culminated in a series of site visits by the Client's Geotechnical Advisor and Client's Agent, effectively condemning the original facing system installed on the soil nail slopes. Between February and July 2017 a period of optioneering took place, followed by re-design of the facing system for SNS1 and SNS2.

Between August 2017 and February 2018 re-nailing and re-facing works were carried out across SNS1 and SNS2. Broadly the works comprised the following sequence:

1. Removal of original facing product and head plates (Geobrugg Greenax steel wire mesh).
2. 500mm slope trim back (around original nails) to competent ground, including overdig at original wide counterfort drains (SNS2 only), where soft ground was observed on site and where temporary shotcrete repair was to be removed.
3. Placement of geocomposite drainage strips and separator fabric.
4. Placement of impermeable crest membrane (SNS2 only).
5. Excavation to existing slope toe drain, inspection and replacement of drain filter media surround (SNS2 only).
6. Placement of double layer of A393 structural mesh and temporary placement of geotextile layer for protection during subsequent re-nailing works.
7. Installation of full set of new nails across slopes (layout offset from original nails).
8. Construction of concrete toe plinth, and
9. Construction of stone-filled mattress facing.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

Figure 3: Photograph of SNS2 showing nail placement (old and replacement)

Figure 4: Photograph of SNS1 showing nail placement (old and replacement)

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018

Soft Facing – SNS3

In April 2017 concerns were raised – post-Geotechnical Report certification – by the Client's Geotechnical Advisor with respect to the durability and suitability of the original facing product (Geobrugg Greenax). Concerns centred on a difference of opinion between the designer and the HA Geotechnical Advisor with respect to the corrosion environment at the location of the soil nail slopes.

Following review by the design team, and considering the limited time which was available to implement repairs, a new facing product (Maccaferri MacMat-R) was installed. The original product was left derelict, insitu, behind the new product.

Figure 5: Photograph of SNS3 showing replacement facing product

Quality Control

Due to concerns relating to the quality of workmanship during the original nailing and facing works the CMSJV Quality Control Plan (QCP) for original nailing works was re-visited, with more stringent checks introduced at all stages of the nailing and grouting operations.

A new QCP was developed for the re-facing works, with a series of checks introduced during slope trim back, installation of the drainage layer and A393 structural mesh placement, construction of the concrete toe plinth and formation of the stone-filled mattress construction and infill. Hold points were introduced where necessary to enable inspection and sign-off by the Geotechnical DSR team.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 14 / SGM: No SGM recorded
Location	A1(M) / Cataractonium Cutting
SGM Type:	Soil Nails
Scheme Name:	A1 Dishforth to Barton Improvement
Year of Installation:	2015 to 2018
All re-nailing works were witnessed, on a full-time basis, by the Geotechnical DSR team, such that independent as-built drilling & grouting construction records could be generated. Similarly, re-facing works were witnessed by the Geotechnical DSR team to provide confidence in the quality of the workmanship.	

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 4940
Location	A21 Lower Haysden
SGM Type:	Soil Nails
Scheme Name:	A21 Lower Haysden
Year of Installation:	2011
Year of Failure:	2011

Details Obtained from the Following Sources:

- Balfour Beaty Mott Macdonald (BBMM). 2010. A21 Lower Haysden, Geotechnical Design Report (GDMS Ref 25600)
- Balfour Beaty Mott Macdonald (BBMM). 2013. A21 Lower Haysden, Geotechnical Feedback Report (GDMS Ref 27498)

Summary of Scheme:

A soil slip on a large embankment was identified during the Principal Inspection of the A21 in 2006. The defect was located adjacent to the southbound carriageway of the A21, approximately 550m to the west of Lower Haysden village. As the slip was localised to a relatively small length of the embankment, the main cause of the failure was believed to be due to the material in the clayey fill layer being affected by increased porewater pressure in the soil during prolonged rainfall and reducing the strength of the soil. The slip was limited to the top half of the slope where the clay has lower strength parameters than the soil below.

The aim of the remedial works at the site was to stabilise an over steep slope, preventing further deterioration and progressive slope failure. In order to retain as much of the existing vegetation on the lower embankment slope as possible, only the upper most 3.5m of the slope was soil nailed.

Work to repair the soil slip at Lower Haysden comprised the installation of three horizontal rows of 4.5m long soil nails, within the top 3.5m of the embankment.

Summary of Failure

Following completion of works, slumping was identified over and between the soil nails, beneath the reinforced geogrid (see Figure 1). Out of four other sites soil nailed on the A21 in the same way, the Lower Haysden site was the only one affected by this problem.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 4940
Location	A21 Lower Haysden
SGM Type:	Soil Nails
Scheme Name:	A21 Lower Haysden
Year of Installation:	2011

Figure 1: Extract of Completed works, six months on. Image taken from BBMM 2011 Report showing the slumping between the nails.

Observations Made on Site:
Following re-inspection of the site 6 months after completion of these works, slumping was identified over and between the soil nails, beneath the reinforcing geogrid.

Failure Mechanisms:
It was determined that the failure was due to the embankment fill having a lower sand content than at the other sites on the A21 and failure occurred because:

- The lower sand content allowed the soil nails to be spaced further apart due to higher soil shear strength. However, this then made shallow slumping between the nails more likely.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 4940
Location	A21 Lower Haysden
SGM Type:	Soil Nails
Scheme Name:	A21 Lower Haysden
Year of Installation:	2011
• The geogrid facing was designed to prevent the shallow slumping. However, this requires the facing to have an intimate contact with the soil. In reality this was not possible as the higher granular content of the soil made the final trimmed surface more irregular than at the other A21 sites. One of these issues alone would not have been a problem, but both together meant the slumping was able to occur.	
Remediation: The slumping was rectified by unpinning the geogrid facing and excavating the slope to a depth of 1.2m from the crest of the earthwork in 400mm deep benches (phase two). The excavation was lined with geogrid and backfilled with Class 6I well graded granular material, voids above the upper most row of nails were filled with ST2 concrete. The slope facing geogrid was then reinstated following the works.	
Any Further Information: None	

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 7 / 8169 (Metallic Reinforcement)
Location	M1 widening project at Junction 21/21A
SGM Type:	Soil Nails
Scheme Name:	M1 Widening
Year of Installation:	1995
Year of Failure:	1995

Details Obtained from the Following Sources:

- GIBB. 1996a. M1 Widening. Soil Nailing – Northbound Carriageway CH 23170 – 23250. Failure of the Facing Panels (GDMS Ref 1261)
- GIBB. 1996b. M1 Rapid Widening Scheme, Junction 21-21A, Geotechnical Feedback Report (GDMS Ref 1263)

Summary of Scheme:

The M1 widening project at Junction 21/21A was designed to increase the width of the motorway within the existing land take. This involved widening an existing cutting and securing the slopes using soil nails. Facing panels covered the excavated slopes.

Summary of Failure

Following heavy rain an 80m section of the soil nailed area north of the A47 overbridge on the Northbound carriageway became waterlogged causing the face panels to bulge. Ultimately failure of the facing panels occurred over a length of 20m to 30m. Following detailed inspection, it was concluded that the failure was not related to the soil nails but only the soil facing panels.

Observations Made on Site:

A series of drainage ditches were present above the cutting, beyond the highway boundary which all flowed into a collector ditch running parallel to the motorway above the cutting. Some of the ditches were found to be blocked; however, this was observed across the whole cutting rather than in the localised area of failure. In the vicinity of the failure there was water observed to be leaking from weep holes placed along the A27 bridge abutment and adjacent retaining wall. After the facing panels were removed from the slope to reduce pressures at the back, water seepage from the cutting face, above the top row of nails, could be seen. It was inferred that at this locality, a high perched water table had been established after a high intensity rainfall event.

Although some of the facing panels deformed 200mm to 300mm, the corresponding soil nails and soil plate were found to be intact.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 7 / 8169 (Metallic Reinforcement)
Location	M1 widening project at Junction 21/21A
SGM Type:	Soil Nails
Scheme Name:	M1 Widening
Year of Installation:	1995

Failure Mechanisms:

Topsoil, placed between two layers of mesh for the facing, became saturated and in a fluid suspension and was unable to transfer any shear which was required to make the facing work. It acted as a dense fluid and increased pressure on the mesh. The two layers of facing mesh used for the design work separately taking loads by tension only and act as diaphragms, i.e. before they are able to carry any load they need to deform. However, the mesh was not continuous but consisted of panels connected together by clips, which were not capable of providing sufficient connection when significant deformation occurred. Figure 1 below provides an extract of the soil panel failure from the GIBB report (GIBB, 1996).

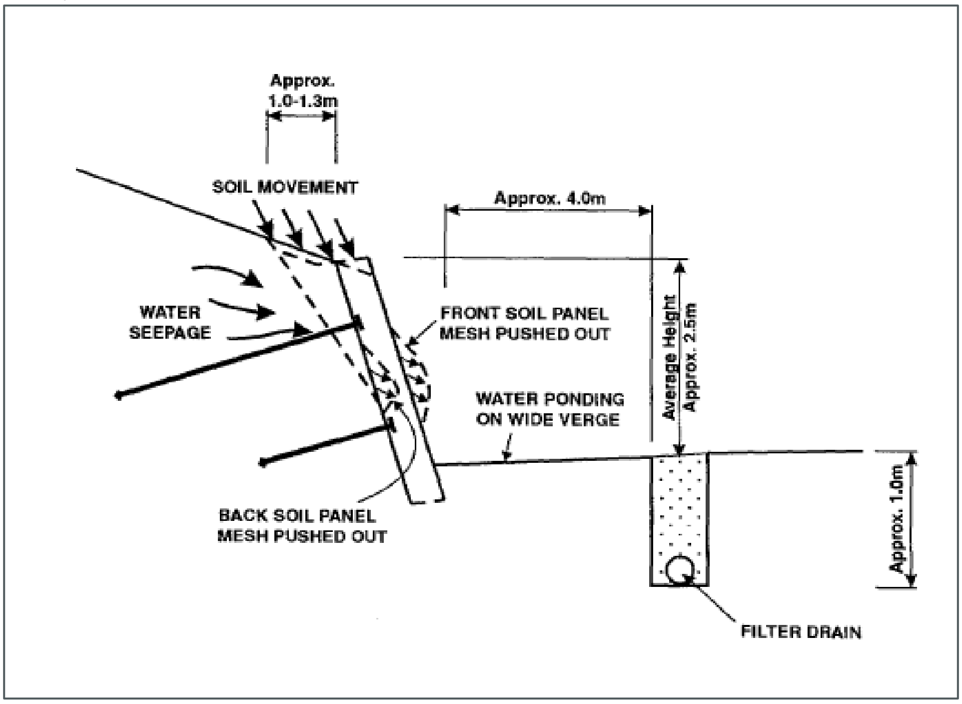

Figure 1: Extract of Soil Panel Failure Mechanism taken from GIBB 1996a Report.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 7 / 8169 (Metallic Reinforcement)
Location	M1 widening project at Junction 21/21A
SGM Type:	Soil Nails
Scheme Name:	M1 Widening
Year of Installation:	1995

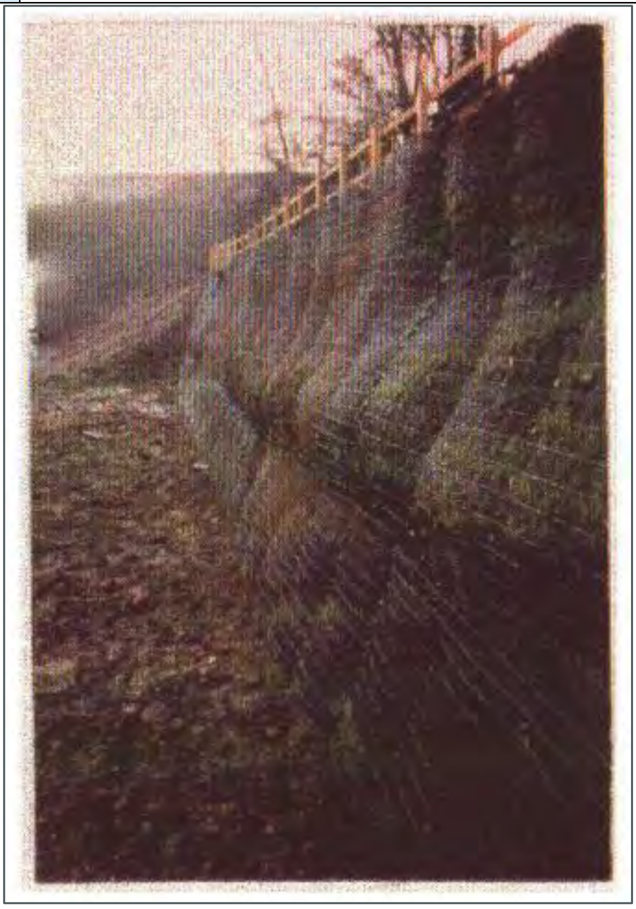

Figure 2: Extract of Soil Panel Failure Plate 1 (image) taken from GIBB 1996a Report.

Remediation:
Remedial action was undertaken including excavating the slipped material, refixing the galvanised steel plates to the slipped plane, excavating the verge and backfilling with a layer of 400mm thick type B filter material connected to the drainage system and backfilling in front of the slope with class 1C rockfill.
.

Any Further Information:
None

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 396
Location	M23 Gatwick Spur
SGM Type:	Soil Nails
Scheme Name:	M23 Gatwick Spur
Year of Installation:	2003
Year of Failure:	2011

Details Obtained from the Following Sources:

- Balfour Beaty Mott Macdonald (BBMM). 2011. M23 Gatwick Spur. Soil Nail Damage Factual Report (GDMS Ref 31716)
- Atkins. 2002. M23 Junction 9 Sites E1, E2 and 19, Strengthened Earthworks Appraisal Form (GDMS Ref 17251)

Summary of Scheme:

The soil nails were installed along the embankment to remediate previously failed embankment slopes and to prevent regressive failures. As part of the works 12 rows of regularly spaced soil nails to a depth of 4m were installed to retain the slope. The exposed surface between the nails was contained using a reinforced composite mat and steel mesh reinforcement held in place by nail bearing plates and proprietary pins at the edges.

Summary of Failure

BBMM were advised by Amey that during a site visit in June 2011, they observed some of the soil nails on the northern side of M23 Gatwick Spur embankment to have been damaged. The site was located on the M23 Gatwick Spur between junctions 9 and 9a where two areas of soil nails had been installed by Atkins in 2003.

Observations Made on Site:

On 15th September BBMM visited site and two nails were found to be damaged, one was completely missing and one nail was intact but required the nut to be retightened (Figure 1). In addition to the damage to the soil nails, the galvanised steel mesh placed on the slope had been disturbed. During the visit it was also observed that the top row of nails had been installed around 300mm from the crest rather than the 1.35m shown on the design drawings.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 396
Location	M23 Gatwick Spur
SGM Type:	Soil Nails
Scheme Name:	M23 Gatwick Spur
Year of Installation:	2003

Figure 1. Extract of Damaged Soil Nail Photograph 1 (image) taken from BBMM 2011 Report.

Failure Mechanisms:
No failure mechanism was given; however, discussions with the Area 4 Managing Agents indicated that the nails may have been damaged by a contractor installing the safety barrier at the crest of the embankment.

Remediation:
The upper three rows of soil nails were cut flush with the existing ground level. Replacement nails were installed on a like for like basis at a 0.5m off set to the existing (upper three rows only. A protective coating of galvafroid was used to cover any exposed parts of the nails. 250mm x 250mm x 8mm galvanised mild steel head plates were used to cap the soil nails. The existing mesh covering the slope remained in place.

Task-0077: SGMs Phase 3	
Soil Nail Case Study	
Area / SGM ID:	Area 4 / 396
Location	M23 Gatwick Spur
SGM Type:	Soil Nails
Scheme Name:	M23 Gatwick Spur
Year of Installation:	2003
A new mesh was placed over the existing and held in place by the head plates of the nails and proprietary pins at the edges. The mesh used to cover the slope face was a composite mat and steel mesh.	
Any Further Information: No Geotechnical Report was produced for the safety barrier installation works which was deemed a non-conformance by Highways England.	

Forensic Examination of Critical Special Geotechnical Measures

The effective design, specification and construction of Special Geotechnical Measures (SGMs) is critical to the efficient operation of the National Highways Strategic Road Network (SRN). Given the required performance of the SRN in terms of resilience, reliability, redundancy and recovery it is essential that SGMs are themselves reliable in terms of performance and life; resilient to external conditions such as earthworks deterioration and extraordinary conditions (e.g. climate change). Around 100 different types of SGMs are used on the SRN and the early installations of some SGMs are approaching the end of their design life and the design, specification and application of many of these techniques is based on limited studies. This project has produced, in addition to this report, Information Note on Gravity Block Walls, Gabion Walls, Counterfort Drains, Soil Nails and Reinforced Soil that report on investigations of these critical SGMs and makes recommendations on their future use.

Other titles from this subject area

PPR 890	Innovative geotechnical repair techniques: effectiveness of electrokinetic geosynthetics. Nettleton, I M, Seddon, R & Winter, M G. 2018
PPR 873	Innovative geotechnical repair techniques: effectiveness of fibre reinforced soil. Seddon, R, Winter, M G & Nettleton, I M. 2018
PPR 874	Innovative geotechnical repair techniques: effectiveness of willow poles. Winter, M G, Seddon, R & Nettleton, I M. 2018
PPR 891	Innovative geotechnical repair techniques: recommendations and guidance for management of future Highways England trials with innovative techniques. Winter, M G, Nettleton, I M & Seddon, R. 2018

TRL
Crowthorne House, Nine Mile Ride,
Wokingham, Berkshire, RG40 3GA,
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

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