

MRPro

MUSCULOSKELETAL RISK PROFILING

EVIDENCE AND OPPORTUNITY FOR CHANGE



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Steve Perkins Associates Limited

 **HEALTHIER HIGHWAYS**
STAY WISE | REDUCE RISK | PROTECT HEALTH

Musculoskeletal risk profiling in highways – Evidence and opportunity for change

Executive Summary

Work-related musculoskeletal (MSk) disorders are a significant and persistent challenge within the UK highways sector, contributing to long-term ill health, lost working time and workforce sustainability issues. Highways work encompasses a wide range of construction, maintenance and operational activities, many of which involve high physical demands, constrained access, time pressure and exposure to adverse environments. The Musculoskeletal Risk Profiling (MRPro) research project was established to improve understanding of these hazards, by developing an evidence-based profile of MSk risk. This will enable prioritisation of interventions, influence supply chain practices and encourage investment in innovation.

Through focus groups, surveys and task analysis, using the HSE’s MAC, RAPP and ART tools, we identified a wide range of MSk risks, which we characterised into three broad types.

Historic hazards are built into existing assets, where previous designs failed to consider the impact on workers of restricted space and limited access. Other tasks are **embedded** in the nature of highways work and the way it has always been done: for example, laying cones, opening gulley and chamber covers, applying road markings, filling potholes. These need new, innovative solutions to reduce risk. Finally, there are tasks which are often **avoidable** such as carrying materials, unloading machinery and manual digging. Effective control measures frequently exist but are not be used consistently due to cost, time pressure, or culture.

We also identified many examples of good practice, including widespread use of mechanisation, careful planning, and instances where risk has been successfully designed out. However, despite these improvements, MSk risk remains deeply embedded in highways work. Many research participants had experience of work-related pain, often under-reported or accepted as an inevitable part of the job.

Action is needed at all levels of the supply chain, by contractors, designers and the client to ensure that MSk risks are managed through a hierarchy of control approach. This could include strategic interventions to:

- **Design risk out.** Client level processes should facilitate ‘health by design,’ and embed Early Contractor involvement as standard. A review of DMRB processes would be helpful to ensure that appropriate innovation is supported. Designers need a better understanding of health risk management and how they can have a positive impact
- **Raise all supply chain companies to the standards of the best.** Client-led minimum standards would encourage more consistent use of good practice by contractors including mechanisation wherever practically possible, and avoiding short cuts and unnecessary risks
- **Find new solutions for tasks which are widespread, intrinsic to highways work and potentially harmful.** This is likely to require collaboration between all parties, engagement from manufacturers and innovative sources of funding

This research demonstrates that meaningful reduction in MSk risk is achievable. Unlocking this potential requires sustained, top-down commitment, supported by funding models, standards and contracting approaches that enable innovation and best practice.

By harnessing the capability, experience and commitment already present across the sector, there is opportunity to reduce harm, improve productivity and create a healthier, more inclusive workplace; and support a workforce fit for the future.

Steve Perkins Associates Limited	steve@steveperkinsassociates.com	Steve Perkins Associates limited is a company registered in England and Wales. Registered Company number 11156626. Registered office 14 Graves Way, Anstey, Leicestershire LE7 7LX United Kingdom
	+44 (0)7875 3930015	
	www.steveperkinsassociates.com	

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Author/s		
Author 1	<i>Wendy Jones</i>	Dr Wendy Jones
29/04/26		Chartered Ergonomist & Occupational Health Specialist Steve Perkins Associates
Author 2	<i>Stephen J. Perkins</i>	Steve Perkins
29/04/26		Managing Director and Chartered Director Steve Perkins Associates
Author 3	<i>Adrian Hirst</i>	Dr Adrian Hirst
29/04/26		Chartered Occupational Hygienist and Chartered Safety & Health Practitioner Steve Perkins Associates
Author 4	<i>Carolyn Drake</i>	Dr Carolyn Drake
29/04/26		Chartered Safety & Health Practitioner Steve Perkins Associates
Approval for release		
Approved	<i>Stephen J. Perkins</i>	Steve Perkins
29/04/26		Managing Director and Chartered Director Steve Perkins Associates

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1. Introduction

Musculoskeletal (MSk) disorders caused by work are a major challenge in the UK leading to over 7 million lost working days each year¹, with the highest rates occurring in construction work. The highways sector accounts for a significant proportion of UK construction activity and is therefore likely to be a key contributor to this. On top of this, highways work includes activities such as maintenance, vegetation control and traffic management which can be high risk for MSk injury, particularly as they are often done within the constraints of a live traffic environment.

The third Road Improvement Strategy (RIS3), running between 2026–2030, has a strong focus on making the most of existing infrastructure through a greater emphasis on the renewal and maintenance of existing assets and this may further increase MSk risk. Initial Health by Design investigation work with National Highways in the Southeast Region has shown that existing assets were often not designed with future maintenance as a high priority and may introduce additional challenges due to poor access.

Musculoskeletal disorders can be acute, so that pain occurs soon after an incident occurs. However, they can also be much more insidious, developing many years after exposure to hazardous work. This can make it more difficult to demonstrate definite cause and effect in individual cases, or to get a true picture of the level of harm. Regardless, there is robust evidence about the factors which increase risk, as well as widespread documentation of the impacts of MSk disorders on individuals, employers and wider society.

Other sectors have started to examine their exposure to MSk risk. For example, recent research by the RSSB² in the UK rail industry found high rates of work-related pain amongst its workforce, often underreported to managers, and commonly assumed to be ‘part of the job.’ National Highways, however, does not have a clear understanding of the MSk risk arising from its undertakings. This research has been designed to address this deficiency by developing an MSk risk profile, highlighting tasks which are high risk and frequent across the network and the wider factors which influence risk exposure. The findings will enable evidence-based prioritisation of interventions, influence supply chain practices and encourage investment in innovation. Within this report we also identify examples of good practice and consider how to overcome barriers to sharing these more widely and embed them as business-as-usual.

This research on Musculoskeletal Risk Profiling (MRPro) was conceived in collaboration with National Highways in the wider context of **Healthier Highways**. This is an ongoing programme of culture transformation in the highways sector that aims to ensure worker health protection is addressed with the same level of focus and resource as is applied to accident prevention. Steve Perkins Associates (SPA) began working in partnership with Connect Plus on the M25 to develop Healthier Highways in 2019. Since, then it has developed into an annual programme of health culture transformation, and the approach has also spread beyond the M25 into other areas of the Strategic Road Network (SRN).

2. Background

Specific work factors associated with increased risk of musculoskeletal injury include awkward working postures, repetitive body movement and manual material handling³. These are all common in highways activities. The likelihood of injury increases with age as effects accumulate over time and can ultimately prevent people from doing their jobs.

2.1. Musculoskeletal risks in construction

Around 50% of the global construction workforce report having had back pain at some point in the previous 12 months⁴, with 37% reporting knee pain, 32% shoulder pain and 30% wrist pain. In the UK, current symptoms are reported by 40,000 construction workers, 52% of all work-related ill-health in the sector⁵. Construction workers are twice as likely to be disabled and have to leave work over a ten-year period compared to other workers, and 50% more likely than others in blue collar (manual) jobs⁶. In the UK the number of over-fiftys in construction is falling faster than numbers in the workforce as a whole. When

a sample of employers and workers were asked why people leave construction jobs early, almost 50% said this was either due to poor health or simply because the job is too physically demanding for older people⁷.

Musculoskeletal risk has been identified particularly in highways construction. Rates of musculoskeletal disorders in UK road construction operatives are up to six times higher than for those working in other elementary occupations⁸, and road construction workers in the United States commonly report injuries to the back, shoulder and knee⁹. There appears to be relatively little literature from the UK about the specific causes of MSk risk in highways work. However, a substantial programme of research observed typical highways tasks during nine different stages of road construction in the United States¹⁰ including rebar installation, concrete pouring and tunnel grouting. This identified a high incidence of poor postures in all observed job roles. For example, 35 – 55% of time for all roles was spent with the trunk in flexion (bending forward), which is a known risk factor for lower back pain, and twisting and side bending were also common. Postures such as kneeling and squatting, which carry a high risk of knee pain; and work with arms above head height were also frequently observed.

Steel fixers in particular were exposed to ergonomic hazards when performing tasks associated with the installation of concrete reinforcement¹¹. In addition to handling heavy loads and working in forward bending, they are also at high risk of injuries to hands, wrists and shoulders¹², typically associated with tying rebar.

Other construction tasks which carry manual handling risk include the laying of kerbs and paving slabs. These are identified by the Health & Safety Executive (HSE) as high-risk tasks, with targeted guidance on how to work safely. However, there is relatively little published literature around these activities other than research which highlights the difficulties of changing work practices. For example, Bust et al¹³ identified a wide range of risk reduction options including making kerbs smaller or lighter, using plastic kerbs, using in-situ slip forming, or using manual clamps or vacuum lifting devices for kerb handling; but found that they were not widely used.

2.2. Musculoskeletal risk in other highways activities

Aside from construction, manual handling risk in highways work can be associated with maintenance tasks such as vegetation management and lifting chamber covers. Traffic management is also an area with significant risk potential; as is archaeology which is often undertaken on major sites prior to new construction¹⁴, although there is very little published research in this area.

Evidence from the forestry and agricultural industry shows high musculoskeletal risk from tasks such as tree felling, chainsaw use and planting¹⁵ but there is limited research about how this translates into risk for highways vegetation maintenance. We know that tasks such as strimming and brush cutting can be problematic due to rotation and flexion of the trunk, and repetition of hand and arm movements¹⁶ and risks can vary substantially between tools of different designs¹⁷. Strimming tasks on slopes can carry an increased risk of ankle, thigh and foot pain, as well as causing more fatigue and requiring longer recovery time than working on the level¹⁸. Lawnmower use can also contribute to musculoskeletal injuries but again, the degree of risk varies with tool design such as the position and angle of handles¹⁹.

Lifting chamber covers comes with a high risk of injury due to high compression forces of the lower back²⁰. This is a problem in many sectors, and there have been numerous attempts to find good solutions. Examples include tools which use leverage to improve posture and reduce muscle load²¹, or which change the nature of the task ‘from a lift to a vertical push’ to make better use of body weight²².

Carrying and placing traffic signs during traffic management activities was identified previously by the Highways Agency as a source of ergonomic risk. An investigation in 2011²³ found that signs had been

made bigger as a response to new regulations in 2002, and that this increased risk (assessed through observation and posture scoring). Recommendations were made to reduce sign size. A later study²⁴ led to further risk reduction by demonstrating that signs did not need to be placed on the central reservation. This had clear improvements for ergonomic risk, although the main purpose of the study was to avoid the safety risk of crossing lanes of traffic. Similarly, the limited introduction of cone laying machines has substantially reduced manual handling risk as well as addressing the safety risks of cone laying in live traffic.

2.3. Barriers to change

Many of the MSk hazards in highways work are widely recognised but attempts to reduce risk reliably have been unsuccessful. For example, one study²⁵ described a widespread information campaign over a four-year period to encourage construction workers to use safer working methods. This included the use of lifting aids when handling paving slabs but found very low uptake of these safer techniques. Other research¹³ to explore why workers continued to lift paving slabs weighing 70kg found that there was low awareness and understanding of risk; and that such techniques were, 'custom and practice' and were quicker and easier than alternatives. This is unsurprising given that lifting tools and other assistive devices are often found to slow work down and reduce productivity²⁶.

It has also been suggested that designers and manufacturers need to take a more proactive approach to addressing risk¹³. However, even where attempts have been made to develop new solutions, they may be less suitable than original designs. For example, a trial of plastic kerb stones in the UK found that they reduced installation risk to operators but were not very robust on bends and in high impact areas²⁷.

Similarly, there has been slow uptake of tools to reduce MSk risk from tying rebar. These were recommended by NIOSH in the US in 2005²⁸ (having reportedly been in use in Sweden for twenty-five years before that¹¹) but were still being described as '*newly implemented*' in the UK in 2020²⁹ and were '*not yet in widespread use in the Australian construction industry*' in 2019³⁰. This may reflect the difficulty of finding one solution which works in every situation. A detailed study into the use of rebar tying solutions found that their effectiveness varied with task and there was no one suitable solution. Powered tying tools, for example, reduce the load on hand and wrist but increase forward bending. Long handled staplers reduce forward flexion for low level tasks but are unsuitable for elevated rebar tasks³⁰.

The most effective solutions described in the literature are those which take a 'participatory ergonomics' approach, where workers are involved in trialling new solutions or in designing their own. For example, a task has been described where the laying of Bitac road tape involved workers walking backwards and working in a flexed position³¹. The team of workers involved co-designed a tool to address this, which reduced ergonomic risk by around 50% whilst also improving profitability as the worker time needed to complete the task was reduced by about 80%.

2.4. Summary

In conclusion, there are many musculoskeletal risks in highways work. These include hazards which are known to be problematic in general construction work and others which are specific to highways activities. There is relatively little published research in many of these areas.

Mitigation of risk is likely to require multiple approaches.

- Employer engagement to invest in solutions and to support a positive culture. If employers do not take musculoskeletal risk seriously, it is unlikely that the workforce will³²
- Worker engagement, to find workable solutions together, and ensure buy-in to embed these
- Manufacturer engagement, to design new solutions in collaboration with the workforce
- Designer engagement to ensure that lower risk solutions are specified wherever possible.

3. Method

Our research methods can be summarised in eight key stages (illustrated in Figure 1 sequentially for simplicity):

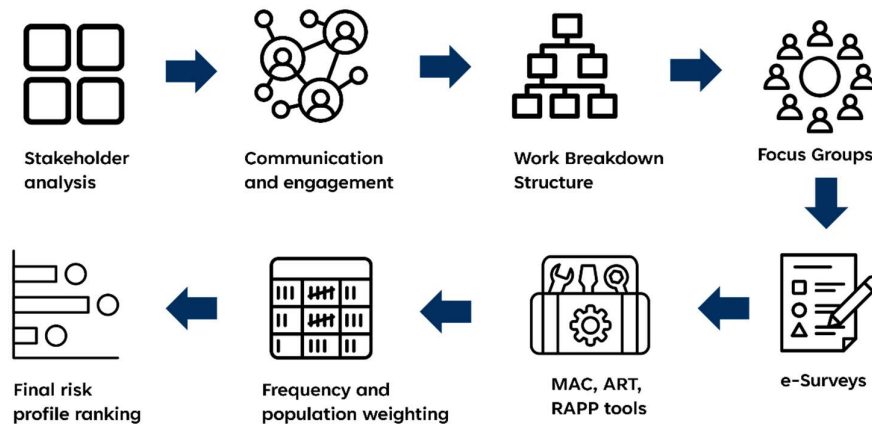


Figure 1 Summary of research stages

- i. **Stakeholder analysis** – We used the advice of various experienced industry professionals to perform stakeholder mapping to inform our communications and engagement strategy.
- ii. **Communication and engagement** – Our research was launched by the Supply Chain Safety Leadership Group (SCSLG) and subsequently managed through regular communication with the Highways Safety Hub (HSH) and Principal Designer Working Group (PDWG). We also recruited 80 MRPro champions from across the highways supply chain. These individuals acted as the conduit for MRPro communications with their company and helped recruit participants for our focus groups.
- iii. **Work Breakdown Structure (WBS)** – We needed to understand how highways build, renewals, maintenance, testing and operations are structured into work tasks. This was to ensure that when we gathered relevant data, no area or discipline within the scope of on-road delivery for any works was missed. We gathered information from the WBS of the Scheme Delivery Framework and also sought introductions to the main contractors involved in M&R and major projects.
- iv. **Focus Groups** – These cross-discipline and cross-contract groups, structured around the WBS, were our primary method of data gathering to generate a list of perceived high MSk risk tasks. We conducted 23 one-hour, online discussions, each typically involving 6-8 managers, specialists and H&S professionals (135 participants in total). We generated a list of almost 100 perceived high-risk tasks.
- v. **Surveys** - We used surveys to get information from a wider spread of people about the list of high-risk tasks. There were ten different versions of the survey, targeted at different work areas (each covering a number of focus group disciplines). Based on 285 responses we narrowed the list of high-risk tasks down to the 45 seen as most problematic.
- vi. **MAC³³, ART³⁴ and RAPP³⁵ tools** – We used these established HSE tools to carry out task analysis of the high-risk tasks, using video and photographs provided by focus group participants and other contacts.
- vii. **Frequency and population weighting** – We estimated how many times tasks are performed each day (or how long for) using focus group data. We also estimated how many workers perform these tasks each day across the strategic road network, based on a short questionnaire issued to National Highways' supply chain partners through the Commercial Managers.
- viii. **Final risk profile ranking** – We produced a final risk ranking of tasks by combining the risk scoring assessments and the frequency and population data.

Further details of research methods are given in Appendix 3.

4. Findings

We identified many activities associated with highways work that involve substantial musculoskeletal risk. We also found many examples of good practice in the management of this risk. This included widespread use of mechanisation as well as control measures which are lower down the hierarchy of control. Focus group participants were highly committed to managing musculoskeletal risk and experienced in doing so. However, they also described situations where risks were high, and mechanical aids could not be used or were very difficult to use. Additionally, they reported that not all companies work to the same standards when managing musculoskeletal risk; and that individuals sometimes make choices that increase risk, such as not using available lifting equipment, or not using good lifting technique.

The results are presented as follows:

- A summary table of 45 key tasks.
- A summary of other tasks which were not examined in detail but may still carry high risk.
- An overview of the common factors which influence MSk risk in highways work.
- A brief overview of the extent and nature of MSk harm in highways workers.
- An overview of the solutions commonly used to manage musculoskeletal risk in highways work.

More comprehensive results including detailed task analysis and summaries of tasks organised by work area can be found in Appendix 1. These are important for readers who want to understand the risks in a particular work area.

4.1. Key hazardous tasks summary table

Table shows a summary of the key tasks which we assessed. The most important aspects are:

- ‘Final Score’ which combines how hazardous a task is with how many times it is done each day.
- ‘Population exposure’ which is an indicator of how many people are doing this task each day across the strategic road network.
- ‘Worker opinion’, which uses information from the survey to show the percentage of people who considered a task to be medium or high risk.

The table is sorted by ‘Final Score’ and ‘Population exposure’, so that the tasks at the top are those which have the highest risk and are done by the most people. These are the tasks where high-level intervention (e.g. industry level) will have the greatest impact. Where hazardous tasks are carried out at a lower frequency or by a smaller number of people, **the risk still needs to be managed:** but it is more likely that this will be done at a local level or by those working within a specialist area.

A brief summary of how to interpret the ‘key hazardous tasks’ table is given in Table 4-1. There are further details in Appendix 3 of how we reached our conclusions.

The scores are not absolute, rather they are a ‘best guess’ intended to support prioritisation and encourage intervention. There is an element of pragmatism and researcher judgement in the sorting of the table.

- The list of tasks may not be complete: we have only included tasks identified by focus group attendees.
- Most task analysis is based on a single video or set of photos. We could not take into account the wide variation between individuals in how they carry out a task.
- Most assessments are based on video footage of workers who knew they were being assessed, so are likely to demonstrate ‘best practice’ in lifting technique.

- Our judgments have been influenced by the opinions/experiences of workers we spoke to for this research; they may not be representative of the workforce as a whole.
- For some tasks, it was not always clear which was the best assessment tool to use, particularly for tasks which have high demand on the shoulder and upper body (e.g. using a hoe, pulling cables)
- For some tasks, no tool was considered suitable to do a structured assessment e.g. digging, raking, using a mattock; and tasks where the hazard relates mostly to constrained posture rather than to load bearing
- Scores should not be compared between different types of tasks, e.g. between RAPP and ART or between MAC Lift, Carry and Team operations. This is because the assessment criteria are different in each case include varying numbers of factors and differing scoring systems, so the outputs are not directly comparable.
- We excluded tasks where the main MSk risk related to hand arm vibration as these are generally managed separately in the workplace and are subject to specific legislative requirements.

The table also shows where the HSE might categorise a task as carrying a possible or probable risk of significant injury, based on guidance provided to HSE inspectors³⁶. This is typically where there is a high load combined with other risk factors such as twisting, lifting loads above the head or lifting with the arms a long way from the body. Again, this assessment is a 'best guess' as the risk in practice will vary depending on particular circumstances and individual working techniques. Tasks which have not been flagged in this way may still carry substantial risk, particularly those which involve lighter loads but have high frequency or poor postures.

The 'Possible Solutions' shown in the table are largely from discussions in the focus groups and from survey responses. This is not a comprehensive list of the possible ways to address each task. In all cases, the aim should be to implement solutions which are as far up the hierarchy of control as possible. More detailed examples of challenges and possible solutions are contained in the summaries for each work area in Appendix 1.

Explanatory notes for key hazardous tasks summary

Table 4-1 Legend/ explanatory notes for Table 4-2 (further details are in Appendix 3)

Element	Legend and notes
Work area	Arc: Archaeology Cmn: Common tasks EnW: Enabling works GI: Ground investigation LV: Landscaping and vegetation Pvt: Pavement Rec: Recovery Scf: Scaffolding Str: Structures Tec: Technology and signage TM: Traffic Management
Worker opinion	% of survey respondents who said that the task was medium or high risk 60% or more 40-59% Less than 40% Scores with a * are from a very small number of participants so may not be representative
Assessment tool	MAC ³³ , ART ³⁴ and RAPP ³⁵ were used for task analysis There are different variants depending on the exact nature of the task being assessed
Task Score	Outcome of task analysis A higher score indicates higher risk, but scores are not comparable between different task types (For ART assessments, the score shown is the Task Score not the total score, as duration has been considered separately.)
Task frequency/duration	These scores are based on data shared by focus group participants. Other companies may work in different ways D: very frequent (more than 100 times per day, or done for longer than 8 hours) C: frequent (20-100 times per day or done for 4-8 hours) B: Moderate (5-20 times per day, or done for 2-4 hours) A: Low (up to five times per day or for less than 2 hours)
Final score	This comes from a combination of task score and task frequency. Where there is no task score, a qualitative assessment has been made Very high risk High risk Medium risk
Population exposure	This is an estimate of how many people do this task each day. It is an approximation, based on responses from 40 members of the supply chain. Very high (e.g. many teams per area, every day) High (e.g. one or two teams per area, every day) Not known Moderate (e.g. one team per area, once a week) Low (e.g. one team per area, once a month or less)
HSE flag	This uses criteria given to HSE inspectors for Initial Enforcement Expectations following MAC/ART/RAPP assessment ³⁶ Probable significant harm Possible significant harm
Particular hazards	Based on assessment results and researcher observation
Possible solutions	Based on survey/focus group feedback and researcher assessment

Key hazardous tasks summary

Table 4-2 Summary of scores for high-risk tasks

Order	Work area	Task	Worker opinion	Assessment tool	Task Score	Freq/ Duration	Final score	Population Exposure	HSE flag	Particular hazards	Possible solutions
1	Scf	Erecting scaffolding (lifting and carrying tubes and boards)		MAC lift	21	D				High loads; High frequency task	New industry solutions? Improved tools and equipment; Good planning; Culture
2	TM	Pick up and lay cones	71/56	MAC lift	18	D				Very repetitive task, involves twisting and forward bending	Mechanical means e.g. ACLM; New industry solutions needed?
3	Pvt	Crash barriers: install	52	MAC team	26	C				High load; Poor posture, deep forward bend to secure fixings	Design of barriers: consider MSK risk in specification
4	Pvt	Clear channels with shovel to remove soil, debris etc	60	ART	24	C			If > 4 hours	Twisted posture; Unpredictability of obstacles	Mechanical means
5	Arc	Use a trowel	79	ART	24	C			If used >4 hours	High load on wrist; kneeling	Ensure best/lightest tools; Ensure good technique; Task rotation
6	Cmn	Open and/or reinstall chamber covers and gulleys	79	MAC lift	19	C			If heavy or stuck	High load; Very high/unpredictable load if seized	Design - consider MSK risk in specification; Mechanical means; New industry solutions?
7	Cmn	Open hinged chambers and gulleys	76	MAC lift	18	C			If heavy or stuck	High load; Very high/unpredictable load if seized	Design - consider MSK risk in specification; Mechanical means; New industry solutions?
8	Cmn	Carry materials in tubs or buckets	64	MAC carry	19	C				High load, repetitive task	Mechanical means; Task design - delivery close to point of use
9	TM	Erect roadside signs	27	MAC lift	21	C				High load, multiple elements, obstacles	Technical solutions e.g. electronic signs; Mechanical means
10	Cmn	Lift/move bags of cement or similar	68	MAC lift	19	C				High load, repetitive task	Mechanical means
11	Cmn	Lift equipment on/off vehicles	78	MAC team	19	C				High loads; twisted posture	Mechanical means

Worker opinion	Task frequency/duration	Final Score	Population exposure	HSE flag
60% or more	D: very frequent (> 100 times or > 8 hours/day)	Very high risk	Very high (e.g. many teams per area, every day)	Probable significant harm
40-59%	C: frequent (20-100 times or 4-8 hours/day)	High risk	High (e.g. one or two teams per area, every day)	Possible significant harm
Less than 40%	B: Moderate (5-20 times or 2-4 hours/day)	Medium risk	Not known	
*indicates small sample size	A: Low (<5 times or <2 hours/day)		Moderate (e.g. one team per area, once a week)	
			Low (e.g. one team per area, once a month or less)	

Order	Work area	Task	Worker opinion	Assessment tool	Task Score	Freq/ Duration	Final score	Population Exposure	HSE flag	Particular hazards	Possible solutions
12	Cmn	Carry bags of cement or similar	68	MAC carry	14	C				High load, repetitive task	Mechanical means; Task design – delivery close to point of use
13	Cmn	Work/carry loads on slopes or uneven ground	81	Not assessed – too variable. Adds to other risks							Design for better access
14	Cmn	Manual digging, shovelling	71	Not assessed, not suited to scoring						High load, repetitive task, twisting	Mechanical means
15	Cmn	Use a Stihl saw	57	Not assessed, not suited to scoring.						Very deep forward bend; high precision task; constrained foot posture	Use cradle
16	Pvt	Rake/shovel road surface		Not assessed, not suited to scoring						Poor posture, high/unpredictable force	Mechanical means
17	Str	Break out concrete	66	MAC lift	17	C				High load, poor postures	Mechanical means; Design to reduce future risk
18	Pvt	Lay kerbs (2 people)	88	MAC team	17	C				High load	Design – new materials; Mechanical means; 2-person task
19	Str	Work in restricted spaces	80	Not assessed – issue is around posture rather than load						Poor posture	Local management; Design to reduce future risk
20	LV	Using a chainsaw (including in a harness)	85	MAC lift	18	C				Unpredictability, extreme postures	Dynamic Risk Assessment, ensure good practice; Ensure best/lightest tools
21	Arc	Dig or use a mattock	89	Not suited to scoring – can assess load of lifting mattock but not of it striking soil						Repetitive tasks, can be high impact	Ensure best/lightest tools; Ensure good technique; Task rotation
22	Tec	Pull/install cables	74	RAPP (not wheeled)	14	C					
23	LV	Dragging branches	85	RAPP (not wheeled)	21	B				High load (variable)	Mechanical solutions
24	Pvt	Fill/repair potholes including prep	51	MAC lift	20	C				Heavy loads, deep forward bend	Technological solutions; New industry solutions needed?
25	Pvt	Paint letters and signs on highway	43	MAC carry	15	C				Deep forward bend, high static load	Technological solutions; New industry solutions needed?

Worker opinion	Task frequency/duration	Final Score	Population exposure	HSE flag
60% or more	D: very frequent (> 100 times or > 8 hours/day)	Very high risk	Very high (e.g. many teams per area, every day)	Probable significant harm
40-59%	C: frequent (20–100 times or 4-8 hours/day)	High risk	High (e.g. one or two teams per area, every day)	Possible significant harm
Less than 40%	B: Moderate (5-20 times or 2-4 hours/day)	Medium risk	Not known	
*indicates small sample size	A: Low (<5 times or <2 hours/day)		Moderate (e.g. one team per area, once a week)	
			Low (e.g. one team per area, once a month or less)	

Order	Work area	Task	Worker opinion	Assessment tool	Task Score	Freq/ Duration	Final score	Population Exposure	HSE flag	Particular hazards	Possible solutions
26	EnW	Work in manholes	83*	Not assessed – issue is around posture rather than load						Challenging postures	Design with maintenance in mind
27	Cmn	Carry loads up ladders	84	Not assessed – too variable. Adds to other risks							Mechanical means
28	Arc	Use a hoe		ART	21	C				Repetitive task	Ensure best/lightest tools; Ensure good technique; Task rotation
29	Arc	Push geophysics cart	21	RAPP (wheeled)	15	C				Unpredictable terrain	Mechanical solutions; Ensure cart is designed to minimise MSK risk
30	Scf	Coupling scaffolding using a spanner		ART	18	C				High load on wrist	?impact wrench?
31	Str	Work whilst abseiling	74	Not assessed – MSK risk but not necessarily a handling task						Challenging postures, instability	Local management; Design to reduce future risk
32	Cmn	Wheelbarrow	50	RAPP (wheeled)	16	B			If on poor ground	Can be high load, unpredictable if on poor terrain	Mechanical means; Powered barrow
33	Str	Rebar: fix/tie	59	ART	26	B				High load on wrists and hands; Repetitive task	Better tool design
34	Gl	Carrying casings	25*	MAC team	24	B				May be long distances, poor terrain	Design/Planning to minimise distances travelled
35	Gl	Carrying samples	75*	MAC team	20	B				May be long distances, poor terrain	Design/Planning to minimise distances travelled
36	Pvt	Lay flags (2 people)	66	MAC team	14	C				High load	Design – new materials Mechanical means; 2-person task
37	Str	Lift very heavy items e.g. steel beams	85	Not assessed, very variable						Very high load; Poor postures	Local management; Design to reduce future risk
38	Str	Carry materials up scaffold/tower	83	Not assessed, very variable						May include carrying high load	Mechanical means; Design to reduce future risk

Worker opinion	Task frequency/duration	Final Score	Population exposure	HSE flag
60% or more	D: very frequent (> 100 times or > 8 hours/day)	Very high risk	Very high (e.g. many teams per area, every day)	Probable significant harm
40-59%	C: frequent (20-100 times or 4-8 hours/day)	High risk	High (e.g. one or two teams per area, every day)	Possible significant harm
Less than 40%	B: Moderate (5-20 times or 2-4 hours/day)	Medium risk	Not known	
*indicates small sample size	A: Low (<5 times or <2 hours/day)		Moderate (e.g. one team per area, once a week)	
			Low (e.g. one team per area, once a month or less)	

Order	Work area	Task	Worker opinion	Assessment tool	Task Score	Freq/ Duration	Final score	Population Exposure	HSE flag	Particular hazards	Possible solutions
39	EnW	Installing gabion walls	67*	ART	21	C				Constrained posture; High load on hands and wrists	Alternate process/design
40	Str	Hydro demolition	77	Not assessed, risk is likely to be similar to breaking out concrete by drilling, or higher						High load, unpredictable	Mechanical/robotic solutions
41	Arc	Carry soil samples on site	95	MAC Carry	13	B				May be long distances, poor terrain. Potential high load	Use mechanical means where possible
42	LV	Loading branches into chipper	85	MAC lift	14	B				High load (variable)	Mechanical solutions
43	Rec	Pushing a car	100*	RAPP (wheeled)	14	A					Dynamic Risk Assessment, ensure good technique
44	Pvt	Road markings with a mobile pram	36	RAPP (wheeled)	10	B				High static load, asymmetric posture	
45	Gl	Hand auguring	75*	ART	16	A				High load, especially in heavy soils	Consider alternative methods; Dynamic Risk Assessment, ensure good practice

Worker opinion	Task frequency/duration	Final Score	Population exposure	HSE flag
60% or more	D: very frequent (> 100 times or > 8 hours/day)	Very high risk	Very high (e.g. many teams per area, every day)	Probable significant harm
40-59%	C: frequent (20-100 times or 4-8 hours/day)	High risk	High (e.g. one or two teams per area, every day)	Possible significant harm
Less than 40%	B: Moderate (5-20 times or 2-4 hours/day)	Medium risk	Not known	
*indicates small sample size	A: Low (<5 times or <2 hours/day)		Moderate (e.g. one team per area, once a week)	
			Low (e.g. one team per area, once a month or less)	

4.2. Other hazardous tasks

Some hazardous tasks identified in focus groups were not assessed in detail either because we did not have enough information about them or because there was too much variation in the nature of the task. Table 4-3 summarises these tasks, which might benefit from further investigation.

Table 4-3 Other hazardous tasks

<p>Other tasks:</p> <ul style="list-style-type: none"> • using tremie forks • replacing LED lanterns • recovery work under HGVs • fitting large vehicle tyres • rebar installation • installing manholes 	<p>These tasks were identified in focus groups and/or survey as being high risk. There was insufficient information available to assess them as part of this research, but they would merit further investigation.</p>
Drilling for ground investigations	<p>There are many elements to this task, and different approaches (rotary, cable percussive). It was identified as high risk both before and during the research but there was insufficient information/too much variation to do further assessment as part of the research. It merits further investigation.</p>
Fencing	<p>This was mentioned in several focus groups. As there is such a wide variety of styles and circumstances, detailed assessment was not practical. Musculoskeletal risk and ease of use should be considered when choosing which style of barrier to use in any particular situation.</p>
Building walls, laying bricks and blocks	<p>This is a common construction task, not specific to highways, and has a known high risk of musculoskeletal harm. It is important to follow best practice to minimise risk.</p>
Painting and surface preparation	<p>This task does not typically involve heavy loads. However, it is highly repetitive and can be high risk for hand/arm injuries. Further investigation to identify best practice and how to minimise risk is recommended.</p>
Block paving	<p>This is more common on local roads than on the strategic network. It has potential hazards including prolonged kneeling and bending, also high load on the hands and fingers. Further investigation should be considered.</p>
Work in poor postures – manholes, bridges and concrete work, chambers, up trees when abseiling	<p>These are included in Table 4-2 but have not been scored. They are very variable tasks and can be high risk even where there are no loads involved. Load bearing adds additional risk.</p>
Processing soil samples in laboratory (archaeology, ground investigation)	<p>This was discussed in focus groups but didn't score very highly in the survey. It can involve prolonged bending and risk of low back pain so would merit further investigation.</p>

4.3. Common overall factors contributing to risk

4.3.1. Nature of highways work

Some aspects of work in highways increase musculoskeletal risk in ways that are difficult to avoid. These include inclement **weather**; the need to wear **PPE** which can make work more demanding (e.g. goggles which interfere with vision, gloves which make gripping harder or influence posture, needing to wear heat resistant gloves);

and a common risk of **prolonged immobility** while waiting for work to start (e.g. for TM crews and traffic officers) followed by sudden intense work. Worksites can be **small or have limited access**, making it harder to use mechanical lifting equipment and sometimes meaning that tools or equipment must be carried over long distances. Work may be conducted, or loads carried, on steep embankments which greatly increases risk; and there can also be high stress, particularly when working close to live traffic.

4.3.2. Balance between workforce and public

Worker risk can be increased by the need to minimise disruption to the public. Work on the highways commonly takes place at **nighttime**, and there are often **significant time pressures**. Limiting road/lane closures as far as possible can make it **harder to use lifting equipment** and can also mean that work has to be carried out over several days, increasing the need to set up and clear away work.

4.3.3. Cost

The benefits of reducing MSK injuries are long term and can be difficult to quantify, but implementing control measures can increase upfront costs substantially. For example, hiring machinery such as Vac-Ex will add cost. It appears from focus groups that some parts of National Highways are more likely to authorise their use than others. Other examples reported included cone laying machines which are up to three times the cost of a standard TM truck; lower risk chamber covers (e.g. hinged, spring loaded) being much more expensive than traditional ones; and better quality gloves, which make gripping easier because they fit well, costing several times as much as cheap ones. One participant suggested that the control measure they most needed was, *“pricing jobs correctly so we have the money to use mechanical aids”*.

4.3.4. Company factors

The availability of high quality vehicles and tools is an important contributor to worker risk. For example, both focus group and survey participants commented on the benefit of having modern, well-designed plant compared to older machinery and vehicles. There were many examples of good practice generally, such as the routine use of excavators with various attachments to avoid the need to lift by hand or to eliminate exposures from road breaking; or trials of innovative solutions such as exoskeletons. However, there were also examples, particularly in the survey, of companies where such solutions would not be widely available. When asked what the best ways would be to reduce musculoskeletal risk in their work, some participants gave examples such as powered winches to remove heavy equipment, or providing a vehicle with a tail lift, or even providing suitably comfortable boots: items which would be standard practice in other organisations. Overall, 61% of respondents thought that risk could be reduced by buying better tools.

“I can't get a Tele handler in and I can't get a hi-ab, but the client won't close the road, so all you can do is keep making this [piece of bridge] smaller and smaller and smaller, so it's a manageable piece that two guys can lift”
(Focus group participant)

“They will say you've got a 72 hour possession - get it done”
(Focus group participant)

“I'd use a Vac-Ex on every contract, but [the client] don't want to pay for it”.
(Focus group participant)

“We're actively being pushed to use them [Vac Ex] now rather than people digging holes”
(Focus group participant)

“Better vans were given out, with the seats higher up. This is making access and egress a whole lot easier.”
(Survey participant)

“I believe that a lot of issues come from not having the best tools available for the work at hand and not using the tools at hand to the best of their ability”.
(Survey participant)

Training is another company factor which can influence risk. Several organisations involved in the research provide **task specific manual handling** training which is a more effective control measure than generic training. The downside of worker training is that it can be seen as having passed responsibility to the worker. There were examples in focus groups where it was explained that someone had been injured *‘even though’* they had done manual handling training; and examples of incident reporting where injuries occurred because people had failed to comply with what they knew to be good lifting practice. Employers also influence risk through their **expectations and culture**, and the extent to which they accept or challenge poor behaviour.

4.3.5. Worker factors

Worker **knowledge** will influence how they consider musculoskeletal risk and whether they make good decisions. For example, there were examples of 25kg being seen as a cutoff point by research participants, with anything lighter than that being acceptable: but load weight is only one risk factor and loads lighter than 25kg can still be hazardous. There was a tendency amongst some to underestimate the risks from repetitive low load tasks and those with poor posture whilst being more aware of the risks from less frequent handling of higher loads.

Different people and groups of people **perceive musculoskeletal risk differently**. For example, the average score for carrying bags of cement (the percentage of survey participants who rated the task as medium or high risk) was 68%; but only 38% of TM workers scored it as high or medium risk. Carrying buckets of material was scored at 64% overall; but only at 33% by landscaping and vegetation management workers; pushing a wheelbarrow was a medium/high risk task for 50% overall, but for 89% of archaeologists. And digging was a medium/high risk task for 71% overall, but only for 43% of vegetation workers. These variations may reflect higher skill in particular tasks, or a higher level of fitness, or that the task is actually different. However, it may also indicate a higher risk tolerance in some work areas, or a tendency to underestimate familiar risks, particularly those which carry a risk of gradual harm rather than immediate injury.

Some workers choose to take musculoskeletal risk, even when there are safer options available, often out of **habit** or to make a job **quicker or ‘easier’**: choosing not to use a lifting aid which might take time to set up, not using the tail lift to unload materials, choosing to take breaks in their plant rather than walking to welfare, jumping out of vehicles instead of climbing down.

Age might also influence musculoskeletal risk. Commonly, younger people are expected to do the most physically demanding tasks; they might lack skill or have poor technique. They will learn behaviours from others, who may have worked in high-risk ways. They may also be under peer pressure from colleagues and feel *‘invincible.’*

“I know larger organisations have better initial training, but there are a lot of smaller companies where they want that young person on the tools straight away and they simply don't have the time or the internal capability.”
(Focus group participant)

“We're allowed to carry a 25K bag of concrete.”
(Focus group participant)

“A lot of the guys will look at it and go, yeah, I can handle that. It's no problem. Two of us, grab this and I'll grab that end.”
(Focus group participant)

“It's 15 minutes to set all this up [gully lifting aid] or two minutes to grab the J bar out. They're always reverting back to the J bar.”
(Focus group participant)

“They're creatures of taking the path of least resistance, and sometimes it's easier for them just to pull it off or push it off the side of the vehicle and let it drop onto the ground.”
(Focus group participant)

However, there were also suggestions in focus groups that younger workers are less willing to work too hard and take risks than previous generations of workers; and they also have the benefit of better training and a change of culture. Older workers typically have better skills and techniques, but many are already carrying injuries from many years of work.

Worker fitness is another factor which may influence injury risk. An issue mentioned in one of the focus groups was that workers (particularly older ones) may work mostly in plant-based roles and become largely sedentary. They are then less fit and more injury prone if they have to get involved temporarily in high demand tasks.

4.3.6. Design factors

Musculoskeletal risk is influenced by structures being **designed without construction, repair and maintenance in mind**. This results, for example, in workers having to adopt poor postures or fit into small spaces to undertake tasks. There are many instances of this on the highways network. Although a lot are historic there are also many examples of risk still being designed in.

A key challenge is that the **Design Manual for Roads and Bridges (DMRB) supports the status quo**. There is a reliance on traditional solutions; and significant costs and delays involved if a designer wants to depart from approved products and designs.

The **fragmented and often long design process** adds extra challenges. Preliminary costings based on generic solutions make it difficult to subsequently use innovative but more expensive solutions. Often, contractors don't get involved in the process until it is too late to challenge the design; or they simply comply with design requirements, even though they are aware of better options.

Planning for **maintenance** is a particular challenge, examples were given in focus groups of maintenance workers having to walk long distances carrying 50kg batteries to maintain CCTV equipment; and having to crouch to make their way across motorway gantries.

Other concerns raised included **designers lacking knowledge** about how things are built and maintained; insufficient knowledge about **sites and estate**, so that locations e.g. for ground investigation are chosen without ensuring there is access for equipment; and **overengineering**, so that additional digging, formwork and concreting are required prior to installation of assets.

Early contractor involvement (ECI) was reported to work well in some areas, less so in others. There were also examples shared of good practice, where designers have specified innovative solutions. These included the use of 'stick on kerbs' which are much lighter to install, and the use of concrete slabs rather than using flags to construct a low-level retaining structure. Such solutions often bring additional benefits as well as reducing health risk. The concrete slabs, for example, enabled work to be completed more quickly, reducing the need for prolonged traffic management. Lightweight

“Some of the manual kerb lifters, you're still lifting, so it will clamp the kerb and make it easier. So your posture is better. But you're still physically lifting, so guys don't really see the benefit in it.”

(Focus group participant)

“We've had cages designed for...a bridge base... They were designed in such a way where the only way that you could fix the top...was to lie on your back effectively within the cage and be fixing above you.”

(Focus group participant)

“There were 30 projects..., 3 departures... those departures cost £165,000 ... without actually paying for anything else to be different, just in paperwork”.

(Focus group participant)

“How can you not provide off-network access on a dual carriageway going through almost a rural area? It would alleviate so many problems with getting to assets and manual handling assets for technology people”.

(Focus group participant)

“Some of the sign bases that we do. Crikey, you could build a skyscraper on it”.

(Focus group participant)

polymer kerbs were used by Connect Plus³⁷ on a scheme at Bricket Wood to reduce carbon but had the additional benefit of reducing musculoskeletal risk substantially.

“They could get in contact with us a lot earlier...so we can help them design it, with products in the market.”
(Focus group participant)

4.4. How much musculoskeletal injury occurs?

In the survey, a question was asked about whether people had aches and pains which they believed to be related to work on highways project. Of the 199 who answered this question, 55% (110 individuals) said ‘yes’, with the location of pain being shown in Table 4-4Table .

Table 4-4 Location of work-related pain, survey data

Pain location	Number of participants (n=199)
Back pain	73
Knee pain	44
Shoulder pain	42
Wrist or arm pain	31
Neck pain	21
I do not have aches or pains that are related to work	89

Of those who did have work-related pain, only half had told their employer. Reasons for not doing so included that it was an inevitable part of the job or that it was an inevitable part of aging. Some also indicated that it was historic, and that the industry had improved in recent years. There was also a lot of discussion in focus groups about the injuries that participants and their colleagues had developed over the years as a result of their work.

4.5. What solutions are commonly used?

There is widespread use of mechanisation and other means of high-risk reduction at source. This was discussed in focus groups and specific examples were given in the survey. These included, for example.

- “Kerb lifters attached to an excavator for laying kerbs.”
- “Streetmasters and Monti breakers instead of breaking out by hand for weeks at a time.”
- “Hydraulic lifting beams / gantries for positioning bridge joints instead of manual handling.”
- “Having material delivered close to point of use.”
- “Mechanical lifting, for example lorry mounted crane.”
- “Milwaukee pipe cutting tool to chop through cable instead of manually doing it with hacksaw.”
- “Mini excavators for smaller digging operations, Vac-Ex’s for excavations near services.”
- “I designed and built a cone repair machine, minimising injury risk to ankles and wrists”.

There were also examples of innovative solutions such as use of remote-controlled compactors and mowers, and trials of exoskeletons. Other companies have used posture sensors to train workers to use better lifting technique.

However, solutions further down the hierarchy of control were also frequently mentioned including job rotation (e.g. “15 minutes on, 15 minutes off”), two-person lifting, and ensuring good lifting technique. These are good practice and may be important aspects of risk management, but they should only be the last line of defence once other measures have been implemented.

4.6. Potential barriers to sharing and implementing good practice

During the conduct of our research many people talked about their experience of sharing good practice in the industry. There was a widespread view that sharing has increased in recent years and is continuing to improve. Sharing of good practice and ‘lessons learned’ works particularly well through the supply chain within major projects. Some companies use social media such as LinkedIn for sharing successes as well. However, we also encountered various views on why good practice in musculoskeletal risk reduction is not always widely shared or implemented. These can be broadly grouped under the following headings.

4.6.1. Cost

Cost pressures on contractors mean there can be a reluctance to spend money on innovation and improvement if existing approaches will still get the job done. As one Focus Group participant said about Traffic Management innovation, “*we’ll wait until we’re forced to do it*”.

4.6.2. Competitive advantage

Safety is an imperative for National Highways and contractors are scored on Health & Safety performance, innovation etc. in bid processes. This can be a barrier to sharing, because it’s seen as part of their competitive advantage.

4.6.3. Mandating Lot Contractors

Some Major Projects Principal Contractors expressed a view that they prefer to use their own supply chains, because they work regularly with those suppliers and have spent time setting their KPIs and influencing their cultures. They feel this ensures that good Health & Safety practice is more likely. However, they sometimes have to use Lot Contractors who have been appointed by National Highways. They say it’s harder to influence such contractors and hold them to account to their standards, because a Lot Contractor can say “*I’m doing it my way because National Highways has already approved me*”.

4.6.4. Lack of appropriate contractor forums

We observed that in some focus groups (each based on a particular discipline) participants from different organisations already knew each other and were used to sharing good practice. This was mostly because of membership of a common highways trade association (e.g. TMCA, RSMA etc) and/or involvement in a National Highways Procurement forum (e.g. Steelwork, Pavements etc), both of which facilitated sharing of best practice.

In other cases, participants appreciated the opportunity for informal sharing which the focus group provided as it was not something they usually had. This might be either because they had no trade association or forum, or they did, but did not consider it to be an independent organisation which was a suitable forum for sharing.

4.6.5. Contracting models

If we consider the development of improvements and innovation in addition to sharing existing solutions, contracting models may give rise to barriers. In the Scheme Delivery Framework (SDF)

and Maintenance & Repair (M&R) models their fixed-term tightly defined scope disincentivises the introduction of mid-term improvement for which contractors can claim funding. With contract durations ranging from five to eight years, coupled with a short 18-month tender window, there is limited opportunity to develop, trial and scale meaningful improvements within the contract cycle. Missing the start of a contract period effectively renders an innovation unviable until the next contracting model begins, greatly slowing progress and reducing the incentive to innovate.

5. Conclusions

When conducting this research, we found many examples of good practice: widespread mechanisation, examples of risk being designed out, careful planning and risk management and good working practices. Despite this, highways work continues to carry a high risk of musculoskeletal risk, and a significant proportion of the workforce have associated work-related ill-health. This has practical and financial consequences for the sector and for individuals. It also influences who is able to work in highways. Reducing musculoskeletal risk wouldn't just reduce harm, it would also enable recruitment from a more diverse workforce as those with lower strength or fitness or with prior health conditions would still be able to do tasks effectively and safely.

We have categorised the musculoskeletal risks of highways work into three broad types to illustrate the different challenges and the approaches which may be helpful to overcome them, although inevitably there will be overlaps between them.

5.1. Historic and harmful

Some highly hazardous tasks are very much 'baked in' to the fabric of the highways network: manoeuvring heavy beams and bearings when there is limited space to get access for mechanical solutions; breaking out concrete for hours on end in constrained positions; having to cross gantries or crawl into spaces on hands and knees. Generally, these risks cannot be eliminated, they can only be managed through careful risk assessment and best practice at the point of work. In the longer term, organisational solutions are needed, taking every opportunity to design out risk when structures are built, repaired, replaced or refurbished so that future generations inherit a safer workplace.

5.2. Embedded and enduring

Many hazardous tasks are intrinsic to the nature of highways work and persist because the work is done the way it has been done for decades. Manufacturers, companies and individuals have sought solutions, sometimes with good success, but for the most part the risks are tolerated and recognised as an inevitable part of the job. Many different factors can contribute to tasks being hazardous, for example:

- lifting chambers and gully covers: this is high risk because of the heavy loads involved, made worse by their unpredictability and tendency to seize which means loads can be many times higher than expected.
- cone laying: this involves lower weights but is a high frequency task and involves twisting and bending, which magnifies the risk.
- tasks such as tying rebar and using trowels: these involve low loads but are very high frequency, placing demands on the vulnerable joints of the wrists and hands.
- tasks such as applying road markings: these involve minimal lifting but prolonged work in poor postures, such as deep forward bending (where the 'load' is the two thirds of the body weight being supported by the overextended lower back) and static positions.
- complex tasks such as fitting crash barriers or filling potholes: these involve multiple risk elements including high loads, high frequencies and poor postures.

Given how widespread they are, these hazards need high level solutions: new materials, tools or machines, new ways of working which eliminate or significantly reduce the risk. Some hazardous tasks we investigated are not specific to highways (e.g. scaffolding, archaeology, tying rebar, many landscaping and vegetation management tasks) so there is scope to collaborate more widely to develop solutions. In some cases, solutions have been developed but not widely adopted. Partly this is down to cost, culture and lack of awareness but may also indicate that some solutions still need further development to be 'good enough' for universal use.

5.3. Avoidable but accepted

Finally, there are tasks where solutions exist but are not used consistently. Examples include carrying bags of cement, lifting heavy machinery off the back of vehicles, shovelling to clear channels, manual digging, and laying flags or kerbs by hand. Mechanical solutions are not usable in every situation due to the nature of the work. However, we also found evidence that workers may take short cuts or use less safe means for expediency, because high level controls are not provided to them by their employer and sometimes, because they don't recognise that the risk is there. It is not possible to quantify how often 'less good' practice occurs, only to be confident that it does occur at least some of the time.

5.4. Evidence and opportunity for change

Musculoskeletal risk in highways work is deeply embedded, widely accepted and sometimes underestimated. However, this research also found many examples of good practice and widespread commitment to manage risk well. The people we spoke to understand that musculoskeletal risks are important, and many of them carry pain from their own past exposures. They understand the hazards and they care about their teams and colleagues. They also have significant expertise at solving problems.

This capability and commitment must be harnessed at all levels and enabled by a top-down commitment to support new solutions and ensure that funding models encourage innovation and best practice. This will create opportunities to design highways workplaces which are fit for a future workforce: and ensure that the workforce are fit to work in highways.

“Don't think it won't creep up on you because it does...it might not be today or tomorrow you feel the pain, but in three years, five years, ten years, you'll feel the pain. And believe me, that soon comes...”

(Focus group participant)

6. Recommendations

To tackle musculoskeletal risk in highways work, strategic interventions are needed to:

- Design risk out: intervention at the top of the hierarchy of control
- Raise all supply chain companies to the standards of the best
- Find new solutions for tasks which are widespread, intrinsic to highways work and potentially harmful.

Action is needed at all levels of the supply chain. It is recommended that:

6.1. All parties

- a) Consider the health of construction and maintenance workers at the earliest stages of every project or proposal.
- b) Use a hierarchy of control approach to managing risk.
- c) Find ways to improve sharing of good practice within and between disciplines where this does not currently happen.
- d) Identify and investigate hazardous tasks which have not been covered in this research.

6.2. Industry

- e) Establish an industry wide (or cross-industry) forum to develop new solutions for the highest risk tasks such as cone laying, raising gulleys, opening chamber covers, filling potholes, road marking by hand, tying rebar. This is likely to require collaboration with manufacturers as well as engagement with the workforce. Innovative sources of funding might be needed to enable this.

6.3. National Highways, and other clients

- f) Embed processes to support 'health by design.'
- g) Embed Early Contractor Involvement as standard.
- h) Review DMRB procedures so that they encourage innovation where appropriate; make it more straightforward (cheaper and quicker) to get suitable departures approved.
- i) Set expectations for supply chain good practice in managing MSk risk.
- j) Ensure contracts are costed to support good ways of working.
- k) Review design processes, DMRB standards, and contracting models to encourage development and adoption of new solutions.

6.4. Designers/design companies

- l) Support designers to understand health risks and how their work can make a difference.
- m) Address barriers to innovation in design.
- n) When upgrading/replacing structures work with the client to reduce future health risk.

6.5. Contractors

- o) Use mechanisation wherever possible.
- p) Make 'good practice' the norm: buy best available tools, deter unnecessary risks or short cuts.
- q) Use the MAC tools to improve understanding of task risk, how it varies between individuals and situations, and how to reduce it.
- r) Provide suitable training and education: targeted and task specific.
- s) Encourage reporting of work-related musculoskeletal harm.

Appendices

Appendix 1 - Task analysis and summary by work area

Appendix 2 - Case studies of good practice

Appendix 3 – Research method details

Appendix 4 – References

Appendix 1 - Task analysis and summary by work area

This appendix includes a summary for each 'Work Area'. It provides a list of the tasks identified during the research and the workforce perception of risk from these; the key challenges faced; and some examples of good practice. It presents detailed task risk analysis for the most problematic tasks, using the MAC³³, ART³⁴ and RAPP³⁵ tools.

The task risk analysis scores are not definitive, rather they are a 'best guess' intended to encourage good practice, intervention and innovation.

- Most assessments are based on a single video or set of photos. They cannot take into account the wide variation between individuals in how they carry out a task.
- We have generally taken a 'worst case' approach – assuming bad weather, poor ground conditions, load weights at the higher end of normal practice.
- Most assessments are based on video of workers who knew they were being assessed, so are likely to demonstrate 'best practice' in lifting technique.
- The list of tasks may not be complete: we have only included tasks identified by focus group attendees.
- Our judgments have been influenced by the opinions/experiences of workers we spoke to for this research; they may not be representative of the workforce as a whole.
- Assessments were made using ART, MAC and RAPP. These are reported by the HSE as suitable to assess around 80% of tasks which are high risk for musculoskeletal harm. For some tasks, it was not obvious which was the best assessment tool to use, particularly for tasks which have high demand on the shoulder and upper body (e.g. using a hoe, pulling cables). For other tasks, no tool was considered suitable to do a structured assessment e.g. digging, using a mattock; and tasks where the hazards is related largely to constrained posture rather than to load bearing
- We were not able to gather worker perceptions of force, this is particularly relevant where ART was used for assessing risk

Scores should not be compared between different types of tasks, e.g. between RAPP and ART or between MAC Lift, Carry and Team operations. This is because the assessment criteria are different in each case include varying numbers of factors and differing scoring systems, so the outputs are not directly comparable.

Task risk analysis also includes an indication of where the HSE might categorise a task as carrying a possible or probable risk of significant injury, based on guidance provided to HSE inspectors³⁶. This is typically where there is a high load combined with other risk factors such as twisting, lifting loads above the head or lifting with the arms a long way from the body. Again, this assessment is a 'best guess' as the risk in practice will vary depending on particular circumstances and individual working techniques. Tasks which have not been flagged in this way may still carry substantial risk.

A1.1. Common tasks

These tasks were identified in multiple focus groups, they may be part of many job roles.

Workforce assessment of risk

Table A1 Workforce assessment of risk for common tasks

Common tasks	Workforce assessment	Number of responses
Carry loads up ladders	84	179
Work/carry loads on embankments or slopes	81	215
Work/carry loads on uneven ground	80	226
Lift breakers or whacker plates on/off vehicles	78	188
Lift chamber covers or lids	76	199
Roll/fit large vehicle tyres	75	139
Manual digging, shovelling	71	207
Carry bags of cement or similar	68	200
Carry materials in tubs or buckets	64	216
Use a Stihl saw	57	163
Push a wheelbarrow	50	209
Rake or spread materials	39	191
Sit for a long time (e.g. in an office)	33	223
Stand for a long time	31	232
Drive/operate heavy plant	29	200
Put up temporary barriers	22	202
Vehicle maintenance	21	201
Drive a car, van or lorry	20	245
Get in and out of a vehicle/cab	16	250
Use a smart phone/tablet on site	15	231

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Raising ironworks

Lifting chamber covers is a common requirement for many worker groups, for example to gain access for installation of cabling and connections.

Raise and reinstall gulley covers is a high demand task for those working in pavement and vegetation management. The number of drainage covers opened in one day for cleansing could be 30, 60, even 100 or more per team. Damaged ones will need to be replaced.

Covers can vary in weight between 20kg and 80kg or higher. Some are hinged, while others need to be lifted out completely; some are designed in several pieces. Covers can often be seized and will be struck with a hammer or levered with a J bar to try and release them.

“It’s the gulley cleansing operations and lifting seized lids, they are the bane of my life really. We’ve tried various different tools over the years and bits of equipment...and we’ve yet to come across anything that makes our operatives lives easier.”
(Focus Group participant)

Solutions and challenges

- Mechanical/hydraulic lifting aids can be used, but they are not always suitable or accessible. There was widespread agreement that there is no perfect solution, and particularly that mechanical aids don't always work when lids are seized
- Lifting aids are difficult to use when space is limited
- They can be time consuming to set up, so are not always considered worthwhile for single lifts.
- Newer designs of chamber cover may carry lower risk e.g. newer, lighter materials, but they are also more expensive.

“Numerous occasions we've broken hydraulic lifting or chains just to lift up the chamber because they've either seized or the weight of them.”
(Focus group participant)

Lifting equipment out of vehicles

Many focus group participants mentioned the risks of lifting heavy machinery from the back of vehicles e.g. hydraulic breakers, whacker plates, and temporary traffic lights. These can weigh 30 – 50 kg or more. They will usually be a two-man lift.

Solutions and challenges

- Mechanical lifting solutions are used where possible but may not be available due to space constraints or time limits, particularly for a small job.

Lifting and carrying bags of cement or similar

Many workers carry multiple bags of cement or other materials between locations, including:

Transferring bags of cement from a lorry or pallet to the point of use.

Loading thermoplastic into a boiler for road markings. Bags typically weigh 20–25kg each and may be handled between floor level and chest height. Examples were given in focus groups of 40 bags of thermoplastic being loaded, and of cement bags being carried 50–100m along scaffolding.

Carrying bags of road repair material to the point of use.

Lifting bags of grout into a mixer for use when mini piling.

“We've had to take 80 bags up four flights of scaffold and along a scaffold and into position where you've got to then mix it and pour it again in a really cramped position.”
(Focus group participant)

Solutions and challenges

- Delivering materials as close as possible to the point of use using mechanical means is the target, but not always possible.
- Conveyors can be used to reduce risk when transferring material into boilers, although this might increase cost as well as increasing weight on the back of the vehicle.
- Ideal handling techniques for a bag of cement will be close into the body, but it is possible that some workers carry over their shoulder which will add additional risk from twisting, lifting higher and holding the load asymmetrically.

Carrying buckets of material

Pothole repairs might require up to 30 buckets of repair material which are then poured into a hole (they might need to be shaken out if they are cold). Typical weight will be 20 – 25kg, and sometimes, “they’ll have one in each hand, depending on how big the potholes are.”

Buckets of mixed cement might be carried 100m or more.

Hand digging

Hand digging might be needed in a range of roles including geological investigation, installation of signs or lighting columns and erection of fences.

Solutions and challenges

- Where possible, excavators or Vac-Ex will be used. Some work areas are too small for this, or there is a risk of buried services. There are also additional costs for equipment hire, which may limit use.

Wheelbarrows

Wheelbarrows can be used to reduce the risk of manual carrying of materials or equipment. However, they can be challenging to use, particularly on uneven surfaces or slopes. Where possible, tractors or other mechanised means are used to transport large quantities of materials.

Working/carrying on slopes, uneven ground, carrying loads up ladders

Many lifting and carrying tasks are done on embankments which can be very steep, uneven, overgrown etc. On occasions, workers may need to carry items up ladders.

Using a Stihl saw

Stihl saws are used for many jobs and can involve work in an extreme forward bending position.

Solutions and challenges

- Using a cradle reduces bending and also reduces HAVS exposure.
- This can involve additional work to lift the cradle from the vehicle; and additional time to set up. Also, cradles are reportedly not widely available for battery operated models.

“Someone is going to carry that [bucket] up an embankment, over a bridge, down the other embankment.”

(Focus group participant)

“We supply our guys with cradles but if I’m honest...they don’t see them as something that’s beneficial until their back goes.”

(Focus group participant)

Task risk analysis of common tasks

Table A2 Risk analysis of common tasks using MAC

MAC Assessment – Common tasks	Team operation	Lift	Carry	Carry	Carry
Risk factors	Lift equipment from lorry	Lift cement bags	Carry cement bags	Carry 1 bucket	Carry 2 buckets
Load weight/frequency	4	4	4	4	6
Hand distance from the lower back	6	6	0	3	3
Vertical lift zones	1	1			
Torso twisting and sideways bending OR Asymmetrical torso or load	2	2	0	1	0
Postural constraints	0	1	0	0	0
Grip on the load	2	2	2	1	1
Floor surface	1	1	1	3	3
Carry distance	0		2	2	2
Obstacles on route	1		3	2	2
Communication, co-ordination and control					
Environmental factors	2	2	2	2	2
Total score †	19*	19*	14	18*	19*

† scores are not directly comparable between different types of task.

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber/red load and other risk factors.

Assumptions:

Equipment

- 50kg load, two-person lift.
- Reasonable handholds, picked up from below knee height.
- Carried 2-4 m.

Cement bags

- 25kg, lifted or carried 2 per minute.
- Picked up from below knee height (but not floor level); up to chest height.
- Carried close to body; carry over 10m (if load is carried over shoulder, this is likely to increase risk but has not been assessed in detail).
- Lifting posture may involve bending and twisting on occasions e.g. to access the back of a pallet.

Buckets

- 25kg, every 2-5 minutes.
- Carry 4-10m; one obstacle or slope.

Table A3 Risk analysis of further common tasks using MAC

MAC Assessment – Common tasks	Lift	Lift	Lift	Lift
Risk factors	Open hinged ironwork	Open heavy or stuck hinged ironwork	Lift ironwork with key	Lift heavy or stuck ironwork
Load weight/frequency	4	6	4	6
Hand distance from the lower back	3	3	6	6
Vertical lift zones	1	1	0	0
Torso twisting and sideways bending OR Asymmetrical torso or load	2	2	1	1
Postural constraints	1	1	1	1
Grip on the load	1	1	1	1
Floor surface	2	2	2	2
Carry distance				
Obstacles on route				
Communication, co-ordination and control				
Environmental factors	2	2	2	2
Total score †	16*	18‡	17*	19‡

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber load and other risk factors

‡ indicates that the task may be classed as ‘probable risk of significant injury’ by the HSE due to the combination of red load and other risk factors

Assumptions:

- 25kg lift every five minutes.
- Heavy ironwork 40kg every 5-30 minutes.

If a cover was completely seized and a substantial effort was made to release it, this could result in a higher load (greater than 50kg equivalent) and very high risk of injury.

Table A4 Risk analysis of common tasks using ART

RAPP Assessment – Common tasks	Wheel- barrow
Risk factors	Score
A-1 Load weight	2
A-2 Posture	3
A-3 Hand grip	0
A-4 Work pattern	0
A-5 Travel distance	3
A-6 Condition of equipment	0
A-7 Floor surface	4
A-8 Obstacles on route	2
A-9 Other factors	2
Total score	16*

*indicates that the task may be classed as possible risk of significant injury by the HSE due to the combination of amber load and other risk factors.

Assumptions:

- Wheelbarrow load up to 100kg, pushed over 30m.
- Slight slope.
- On uneven, muddy terrain.
- Interspersed with other activities.

A1.2. Pavement

This is a broad topic area covering the construction, refurbishment and maintenance of pavement. Specific focus groups were focussed on pavement, road surface maintenance, road restraint systems and road markings. Tasks identified as potentially high risk included:

- **Laying kerbs:** including laying new areas and repairing existing areas. A typical kerb stone is 900mm long and weighs 20 – 50 kg. Up to 75-100 may be laid in a shift.
- **Gulley emptying** (this is covered in Appendix 1.1, under Common Tasks).
- **Laying flags:** typically 40kg each.
- **Clear channels with shovel to remove soil, debris etc** include clearing debris which builds over time, or after grit blasting, concrete rubble etc. Debris may be 5-6 inches deep, 100m per person per shift. After grit blasting, may clear 20 x 20kg bags of rubble (4 people).
- **Crash barriers: install,** usually 5m long, around 60kg. Lifting aids can be used but take longer and don't allow 'finesse' e.g. to align bolt holes.
- **Repetitive shovelling and raking** when laying road surface: this can be done for around half of each working day, and involves poor postures, often working against resistance as paving materials harden as they go off.
- **Crash barriers: remove damaged,** weight might be up to 100kg (barrier plus bolts). Might be bent out of shape, under load, therefore difficult to use mechanised lifting; might be cut into pieces, but generally they are cut as little as possible. Working at low height, around 610mm.
- **Road markings** (at junctions, smaller roads); **mark letters and signs on highway.** Including loading material into jug then pouring into mould, then tracing the shape or line on the ground. Workers may also use weighted ropes to mark out a line before painting.
- **Fill/repair potholes:** taking 20kg tubs off van, carrying, tipping into hole. There may be additional tasks to prepare the hole e.g. cutting out. Cheaper or lower carbon materials can be harder to handle if they don't flow as easily.
- **Road marking with a mobile pram:** use involves asymmetric load, high static load, uneven gait. Weighs 130kg when full.
- Pour and float cement.
- Hot laying of antiskid: 15 – 20kg bucket, poured into hand mould, spread quickly. Postures adopted are similar to applying road markings.
- Install fencing.
- **Crash barriers: fix bolts** – could be prolonged poor posture, high load on hands in poor positions. Power tools used to secure bolts may weigh 8kg or more. Some systems are better than others.
- **Crash barriers: maintain, tension checking** – probably high risk, due to prolonged poor posture (bending).
- Joint painting in road repairs.
- Lay or replace studs (0.5kg – 2.5kg) – low load, high repetition, bending and kneeling. – e.g. 250 studs in four hours, up to 2000 per night. Can be automated sometimes.
- Road gritting and associated tasks – dragging hoses, cleaning vehicles, cleaning up salt overspill.

“It would be bending and stooping... It's all bend, stoop.” (Focus group participant talking about road marking)

“I can no longer physically pick up a jug and rotate it through its full range of motion when there's weight in it, because my wrists are knackered... I have sciatica. ... my right shoulder, that's completely knackered.”
(Focus group participant)

Other tasks mentioned in the survey included dipping (measuring depths); operation of hot compressed air system; block paving; drilling into CBGM (cement bound granular material) for setting out pins; jumping on and off trucks.

Workforce assessment of risk

Table A5 Workforce assessment of risk for pavement tasks

Pavement	Workforce assessment	Number of responses
Lay kerbs	88	72
Raise and reinstall iron works and gulleys	79	72
Build walls with bricks or blocks	73	70
Lay flags	66	65
Clear channels with shovel to remove soil, debris etc	60	80
Crash barriers: remove damaged	57	69
Crash barriers: install	52	69
Fill/repair potholes including prep	51	80
Pour and float cement	49	73
Paint lane markings by hand	49	78
Hot laying of antiskid	47	78
Install fencing	46	69
Paint letters and signs on highway	43	79
Road marking with a mobile pram	36	74
Crash barriers: fix bolts	33	70
Crash barriers: maintain, tension checking	32	66
Joint painting in road repairs	30	77
Lay or replace studs	26	76
Road gritting and associated tasks	18	66

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Evidence of harm

Out of 69 who completed the survey, 34 (49%) have aches and pain from work, most commonly back pain. In the focus groups it was discussed that many older workers have long standing back pain and have difficulty with repetitive bending and other demands.

Specific challenges

Sites are often small and inaccessible (narrow verges, work on embankments etc) which makes it harder to get lifting machinery in e.g. when replacing barriers, lifting kerbs off a lorry.

Machinery set-up can take a lot longer than doing a job by hand e.g. 3-4 times as long when installing barriers; 15 – 20 minutes to set up a gulley cart.



Figure A1 Installing crash barriers is a physically demanding task, requiring loads to be lifted from close to the floor. Other aspects of the task such as cutting old barriers out or securing fixings also require prolonged forward bending (pictures courtesy of Carnell Group)

Control measures and good practice

- Use of mechanical aids or excavators for road breaking, kerb lifting, pavement cutting, compacting.
- Kerb lifters: mechanised ones e.g. attached to an excavator are used especially for new build work. Manual kerb lifters are more common for repairs or where there is limited access.
- Installation of barriers which need less maintenance.
- Use of lighter manhole covers.
- Use of lighter kerbs.
- Long handled tools/moulds for road painting.
- Ensuring vehicles/delivery points are as close to point of work as possible.

Scope for improvement

Designers: hardware and materials are generally chosen for commercial reasons and/or to comply with the DMRB. Worker risks at installation or maintenance are rarely considered.

There may be options for new kerbs, new materials, new tools etc; provided these comply with the DMRB. Many participants reported having tried without success to develop/procure effective solutions.

Buying better tools (59%), developing better tools (62%) or using new products/materials (58%) were seen as effective, achievable solutions by survey participants.

Task risk analysis for pavement

Table A6 Risk analysis of pavement tasks using MAC

MAC Assessment - Pavement	Team operation	Team operation	Carry	Team operation	Lift
Risk factors	Laying kerbs with kerb lifter	Laying flags with suction grip	Painting white line/signs	Installing crash barriers	Filling potholes
Load weight/frequency	4	4	0	4	4
Hand distance from the lower back	6	3	6	6	6
Vertical lift zones	0	0		1	3
Torso twisting and sideways bending OR Asymmetrical torso or load	1	1	1	2	2
Postural constraints	1	1	3	1	1
Grip on the load	0	0	1	4	1
Floor surface	1	1	0	2	1
Carry distance	0	0	2	1	
Obstacles on route	2	2	0	2	
Communication, co-ordination and control	0	0		1	
Environmental factors	2	2	2	2	2
Total score†	17*	14*	15	26*	20*

† scores are not directly comparable between different types of task.

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber load and other risk factors.

Assumptions:

Kerb stones, flags

- 40kg weight, one every 5 minutes; interspersed with other tasks.
- Kerbs, flags are close to point of use (2-4m).
- Two-person task (If one person does the task alone the risk will be greatly increased due to higher weight and worse posture, this has not been assessed in detail).
- Using a kerb lifter/suction flag lifter. (If lifted without an aid, the risk will be greatly increased due to worse posture, this has not been assessed in detail).

Barriers

- 60kg, carry distance 4-10m.
- 2-3 person task.
- Communication affected by traffic noise.

Road painting:

- Assessment shown is for one single element, estimated at 4-10m ‘carry’ distance.
- Additional risk factor of hot materials being handled.

Filing potholes:

- Bag/bucket of filler 25kg.
- Poured in at or below floor level.

Table A7 Risk analysis of pavement tasks using RAPP

RAPP Assessment - Pavement	Using mobile pram
Risk factors	
A-1 Load weight	0
A-2 Posture	3
A-3 Hand grip	2
A-4 Work pattern	1
A-5 Travel distance	1
A-6 Condition of equipment	0
A-7 Floor surface	1
A-8 Obstacles on route	0
A-9 Other factors	2
Total score	10

Assumptions:

- Pram weight 130kg, distance 10 – 30m.
- One hand is controlling paint flow as well as pushing pram.
- Could be on slope; plus need to keep feet to the side of painted line.
- Other factors – weather; need to manage paint release at the same time as pushing; wearing gloves.

Table A8 Risk analysis of pavement tasks using ART

ART Assessment - Pavement	Clearing channels with either arm
Risk factors	
A1 Arm movements	6
A2 Repetition	3
B Force	4
C1 Head/neck posture	2
C2 Back posture	2
C3 Arm posture	2
C4 Wrist posture	1
C5 Hand/finger grip	0
D1 Breaks	2
D2 Work pace	0
D3 Other factors	2
Task score	24*

*indicates that the task may be classed as ‘risk of significant injury’ by the HSE if it is undertaken for longer than 4 hours per day.

Assumptions:

- Work pace 11-20 shovel strokes per minute.
- Break or change of activity every 1-2 hours.
- Extra factors: Weather, inconsistency/jolt from hitting stones etc.

A1.3. Structures

This is a broad topic area covering the construction, refurbishment and maintenance of structures. Specific focus groups considered concrete; waterproofing, bearings, joints, steel corrosion protection; structures maintenance; steelwork. Tasks identified as potentially high risk included:

- **Lifting very heavy items e.g. steel beams, bearing replacement:** these will mostly be done using mechanical means, but manual manoeuvring might be needed, particularly at the end of the task or where there is very limited space. Examples from focus groups include two workers manoeuvring an 80kg beam, or several workers managing a 1 tonne bearing.
- **Breaking out concrete:** this often requires prolonged, static postures, in restricted spaces, potentially for several hours a day.
- **Carrying materials up scaffold/tower:** An example was given of needing to transport eighty x 25kg of materials up three levels of scaffolding and then 60m horizontally.
- **Work in restricted spaces:** this is associated with replacing bearings, drilling out concrete, working on scaffolds in confined areas. It may involve work in static postures, with arms outstretched or extended; or crouching.
- **Hydro demolition:** this is used as an alternative way of breaking out concrete.
- **Rebar - carry and install:** size, shape and grip are variable, very poor surface to walk on.
- **Rebar - fix/tie:** involves high frequency twisting movements of hand/wrist, task may be repeated hundreds of times.
- **Surface and painting preparation** – this can be very repetitive, even though the loads involved are not heavy.
- **Work whilst abseiling.**
- **Bolt steel sections in situ on gantry or bridge.**
- **Pour and float cement.**
- **Position loads lowered by a crane.**
- **Other tasks mentioned by survey participants included:** installing setting out pins, carrying survey equipment, spray concrete, erecting falsework or formwork.

“There's always a certain amount of pushing and pulling and coercing into position.” (Focus group participant)

“Confined space entry: It's a very physically demanding job, potentially crawling and climbing through structures.” (Survey participant)

Workforce assessment of risk

Table A9 Workforce assessment of risks for structures tasks

Structures	Workforce assessment	Number of responses
Lift very heavy items e.g. steel beams	85	59
Carry materials up scaffold/tower	83	59
Work in restricted spaces	80	60
Build walls with bricks or blocks	77	57
Hydro demolition	77	57
Rebar: carry and install	75	59
Work whilst abseiling	74	53
Drill out concrete	66	59
Replace bridge bearings	60	55
Rebar: fix/tie	59	58
Bolt steel sections in situ on gantry or bridge	46	57
Use a manual hoist/gin wheel	42	57
Pour and float cement	38	58
Install fencing	36	58
Position loads lowered by a crane	28	57
Apply paints, coatings including prep	21	56

'Workforce assessment' shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

'Number of responses' is the number of people who answered this question in the survey.

Evidence of harm

Out of 48 survey respondents, 26 (54%) reported pains or injuries related to work, back pain was the most common; then knee and wrist/arm.

Specific challenges

Work is conducted on structures which were built many years ago, and which often have poor access to refurbish or maintain.

There is a high level of variability in work situations, so project-specific solutions will often be needed

Access to use mechanical means of lifting may also be limited, either because there is inadequate space, or because it would necessitate road closures.

Control measures and good practice

- Mechanical aids for lifting – hydraulic lifting beam, cranes, A frames, excavators etc.
- Powered rebar tying tools.
- Automatic rigs for drilling multiple holes.
- Battery powered mastic guns.

“If you're drilling into the wall at the back of the bearing shelf, there might not be room for you to actually be on the bearing shelf, so you're stood on a scaffold, so you're kind of reaching.”

(Focus group participant)

Sometimes you have to lay down because it's the only way of getting into a gap that's 500mm.”

(Focus group participant)

- Exoskeletons have been trialled with some success e.g. for drilling overhead. These can greatly reduce the load. However, they do not eliminate poor posture and as a solution they are lower on the hierarchy of control than using engineering solutions such as drilling rigs.
- Pallet lifting tables for mixing materials.



Figure A2 A drilling rig can be used to eliminate the MSK demands of drilling holes overhead (Photograph courtesy of Concrete Repairs Ltd (CRL))

Scope for improvement

It is important that new projects are designed with refurbishment and maintenance in mind, to ensure that for future generations have better, safer access.

For some tasks, improved tools could reduce risk, survey participants suggested that buying better tools (63%), developing better tools (56%), or using new materials/products (55%) were good, achievable solutions. For example, rebar tying is a task which is high risk for hand/arm injury; but it was suggested that current automated solutions are “*difficult and ineffective compared to manual, especially given the precision required*”.

Hydro demolition can be a quicker way of breaking out concrete than traditional methods, and hence may reduce overall MSK risks, depending on the loads involved, which are difficult to measure. However, it can introduce new hazards (noise, dust, containment issues); and also takes more material out than traditional drilling, so more concrete must be put back in. Robotic hydro demolition may be a way forward for some situations.

Task risk analysis for structures

Table A10 Risk analysis of structures tasks using MAC

MAC Assessment - Structures	Lift	Lift
Risk factors	Drilling upwards into concrete	Drilling forwards into concrete
Load weight/frequency	4	4
Hand distance from the lower back	3	0
Vertical lift zones	3	0
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	1	2
Postural constraints	3	3
Grip on the load	1	1
Floor surface	1	1
Carry distance		
Obstacles on route		
Communication, co-ordination and control		
Environmental factors	1	1
Total score	17*	12*

*indicates that the task may be classed as 'possible risk of significant injury' by the HSE due to the combination of amber load and other risk factors'

Assumptions:

- Load is estimated as 'amber': it includes holding a 10kg drill and applying a moderate force. There is a fixed posture (static load) which can be more demanding than high frequency lifting.
- Although the drill has a handle, the postures adopted mean this isn't always used in the intended way.
- Work may be carried out in restricted space e.g. with insufficient headroom.
- It is likely that hydro demolition has at least similar MSk demands to breaking out with a drill, potentially higher. The postures are similar, the loads may be the same or higher; the force is backwards, i.e. the operator is resisting the force rather than applying it, therefore has less control.

Table A11 Risk analysis of structures tasks using ART

ART Assessment - Structures	Tying rebar
Risk factors	
A1 Arm movements	6
A2 Repetition	0
B Force	4
C1 Head/neck posture	2
C2 Back posture	2
C3 Arm posture	4
C4 Wrist posture	2
C5 Hand/finger grip	2
D1 Breaks	2
D2 Work pace	0
D3 Other factors	2
Task score	26*

*indicates that the task may be classed as 'possible risk of significant injury' by the HSE if it is undertaken for longer than 4 hours per day.

Assumptions:

- Break or change of activity every 1-2 hours.
- Risk assessment includes potential to work at (or below) floor level or above shoulder height. This has higher risks than work at chest height.
- Work is self-paced.

A1.4. Enabling works

This summary is based on three focus groups: Piling & Embedded Retaining Walls; Drainage and Earthworks. Focus group attendance (n=12 in total) and survey completion (n=7) were low, so review of hazards may be incomplete for this area.

Tasks identified as potentially high risk included:

- Manholes: access/ work in. Poor postures are a particular challenge, managing loads which are typically lowered by winch.
- **Install gabion walls, fill baskets.**
- Manholes: install. Risks include work in poor postures; and stabilising large objects whilst being positioned using machinery.
- Use tremie forks or beams.
- Install crib walls.
- Clear culverts.
- Hammer wedges for piling casings.
- Install trench boxes.
- Mini piling.
- Move, connect polymer pipes.
- Access/egress of plant cabs.
- Prolonged seating in plant cabs.
- Tasks associated with plant maintenance including tyre changes.

Workforce assessment of risk

Table A12 Workforce assessment of risk for tasks in enabling works

Enabling work	Workforce assessment	Number of responses
Lay flags	83	6
Manholes: access/work in	83	6
Build walls with bricks or blocks	71	7
Install gabion walls, fill baskets	67	6
Manholes: install	67	6
Use tremie forks or beams	67	6
Install crib walls	50	6
Clear culverts	43	7
Hammer wedges for piling casings	43	7
Install trench boxes	29	7
Mini piling	29	7
Move/connect polymer pipes	29	7

'Workforce assessment' shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

'Number of responses' is the number of people who answered this question in the survey.

Evidence of harm

There is insufficient data available to report on this. It is likely that musculoskeletal risks are lower than for other work groups, particularly for work carried out on new sites where there is more control over the work environment than for maintenance or refurbishment activities.

Control measures and good practice

- There is widespread use of machinery, plant and other mechanical solutions for materials handling, particularly during enabling works.
- Examples were given of risk reduction when installing manholes. These included using pre-fabricated sections, which eliminate or reduce the need for benching; and work planning so that where benching is required this is completed early, when access is easy, rather than at a later stage after all manholes have been installed.
- The quality of vehicles and plant make a substantial difference to operator comfort and risk. Modern vehicles were discussed as being a significant improvement on older models.

Scope for improvement

Operator risk from prolonged sitting and from access and egress will be influenced by the design of plant (e.g. layout, whole body vibration risk) and by worker behaviours (e.g. climbing out of cab versus jumping down; leaving cab for breaks).

Designer-led solutions are important e.g. for risks around manhole installation.

Task risk analysis for enabling works

Table A13 Risk analysis of enabling works tasks using ART

ART Assessment – Enabling works	Install gabion wall
Risk factors	
A1 Arm movements	3
A2 Repetition	3
B Force	4
C1 Head/neck posture	2
C2 Back posture	2
C3 Arm posture	2
C4 Wrist posture	1
C5 Hand/finger grip	2
D1 Breaks	0
D2 Work pace	0
D3 Other factors	2
Task score	21

Assumptions:

- Frequent short breaks or changes of activity e.g. between stacking stones and doing other tasks.
- Dominant arm does most stone-stacking tasks.
- There is additional risk to the legs and knees from squatting down inside the basket.
- The assessment only covers filling the gabion wall basket. Additional risks (e.g. climbing in and out of basket, tying baskets together) have not been assessed.

A1.5. Technology and signage

This covers the installation maintenance and refurbishment of Road lighting and CCTV; Permanent traffic signs; Technology.

Tasks identified as potentially high risk included:

- **Pull/install cables** - using a winch, with manual effort to start; or by hand e.g. for smaller cables, with several people working together. Cables could be 300m or longer.
- LED upgrades to lanterns - new lanterns up to 20kg, up to 20 fitted per shift (after removing old one).
- Work in restricted spaces (e.g. chambers, cabinets).
- Accessing motorway gantries.
- Installing/replacing posts for traffic signs.
- Installing/attaching traffic signs.
- Installing 4" ducting, could be over verges, uneven ground, couple be several km long.
- Peg & mark cable locations.
- Maintain lamp columns.
- Maintain /clean traffic signs.

“I've seen it a lot, where I've been on site and you can't get the winch in and you've got teams of guys. Sometimes it might only be three guys, one at the drum end and two at the pulling end and they're pulling over 300 metres of cable and you're in sort of a squat position.”
(Focus group participant)

For many of these tasks the risks arise as much from uncomfortable postures and poor terrain as from load bearing. This can make them less obvious than other risks, and also more difficult to assess.

Workforce assessment of risk

Table A14 Workforce assessment of risk for technology and signage tasks

Technology and signage	Workforce assessment	Number of responses
Pull/install cables	74	27
Work in restricted spaces	56	27
Install/replace posts for traffic signs	50	22
Install/attach traffic signs	45	22
LED upgrades to lanterns	43	23
Install 4" ducting	37	19
Repair traffic signals	29	21
Bolt steel sections in situ on a gantry or bridge	27	15
Peg & mark cable locations	23	22
Work in cabinets	21	28
Maintain lamp columns	17	18
Maintain /clean traffic signs	9	22

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Evidence of harm

Work related pain was reported by 9 out of 22 survey respondents (41%), most commonly back and knee pain.

Specific challenges

There are particular challenges when updating, reusing or repairing older installations. For example, cables get snagged on older cables inside ducting, or dirt leads to clogging. When replacing lamps, it can be difficult to release stuck bolts to remove older units.

Work can be challenging where a worksite is remote e.g. walking (and carrying loads) along overgrown paths, walking up multiple flights of stairs.

Traditional motorway gantries often involve ladder access and crossing gantries in uncomfortable positions (e.g. bent over to avoid overhead struts). These ergonomic risks are reduced by non-accessible gantries which are increasingly being used. However, these introduce other health and safety hazards.

Working from MEWPs introduce challenges such as over-stretching to avoid having to reposition the MEWP; and compensating for MEWP movements e.g. if the cradle catches the wind.

Control measures and good practice

- Cranes are often used e.g. for replacing posts and signs, these are usually a safer option than MEWPS.
- Where signposts have been installed using sleeves this makes replacement easier, as it eliminates the need to re-dig foundations.
- Internet and wireless solutions are reducing the need for cabling and enable fault find without needing to access cabinets.

Scope for improvement

Designers could consider ease of installation alongside other factors when specifying – e.g. different models of LED lamp influence the MSk risk of the work installing it.

Design led solutions are also important when making decisions about the location of technology infrastructure e.g. ensuring that there is good access for installation and maintenance access.

Task risk analysis for technology and signage

Table A15 Risk analysis of technology and signage tasks using RAPP

RAPP Assessment – Pulling small cables	Pulling small cables
Risk factors	
A-1 Load weight	2
A-2 Posture	6
A-3 Hand grip	0
A-4 Work pattern	0
A-5 Travel distance	3
A-6 Condition of equipment	
A-7 Floor surface	1
A-8 Obstacles on route	0
A-9 Other factors	2
Total score	14*

*indicates that the task may trigger additional questions by the HSE due to the combination of amber/red load and other risk factors.

Assumptions:

- Load is estimated as medium (equivalent to 25 – 50kg) based on visible assessment of effort involved.
- Distance is over 10m.

This task and associated risk is likely to be highly variable.

Pulling large cables with the aid of a winch is also likely to be a high risk task but we were unable to obtain video footage to assess this.

Table A16 Risk analysis of technology and signage tasks using ART

ART Assessment – Pulling small cables	Pulling small cables through ducting with right arm
Risk factors	
A1 Arm movements	3
A2 Repetition	3
B Force	9
C1 Head/neck posture	2
C2 Back posture	2
C3 Arm posture	4
C4 Wrist posture	1
C5 Hand/finger grip	0
D1 Breaks	0
D2 Work pace	0
D3 Other factors	2
Task score	26*

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE if it is undertaken for longer than 4 hours per day.

Assumptions:

- Force is considered high, due to the visible effort required to pull the cable.
- Work is self paced.

This task and associated risk is likely to be highly variable. There is additional risk to legs and knees if the individual is kneeling to undertake the task.

Only small cables have been assessed; we have not been able to get video footage to assess pulling large cables using a winch.

A1.6. Traffic Management

Tasks identified as high risk in traffic management (TM) included:

- **Laying and picking up traffic cones** Typically, 250 – 300 cones (8-10kg each) will be laid during a two-hour period (around 4km) and then picked up at the end of the closure.
- **Installing temporary traffic signs, frames and sandbags.** Signs can be up to 1500mm high, and A frames up to 2600mm (weighing 22kg approx.). Two sandbags (10 – 20kg each) are required to stabilise each frame. The number of signs installed will vary but could be 20 – 40 per closure, more (e.g. 70 – 80) for long term road works. Each item is handled up to four times – loading the lorry at the yard, installing the sign, removing the sign, unloading the lorry at the yard.
- Installing temporary traffic lights.
- Putting up temporary barriers.
- Filling sandbags.

Workforce assessment of risk

Table A17 Workforce assessment of risk for traffic management tasks

Traffic management	Workforce assessment	Number of responses
Pick up traffic cones from a moving vehicle	71	41
Lay traffic cones from a moving vehicle	56	41
Install temporary traffic lights	35	40
Install temporary traffic signs, frames and sandbags	27	41
Pick up traffic cones from ground level	18	40
Lay traffic cones from ground level	15	40

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Evidence of harm

Seventeen out of 31 survey respondents (55%) reported injury or pains related to work, especially back and shoulder pain.

Cone laying was identified as ‘*the biggest cause of complaint*’ for TM crews in one of the focus groups. The twisting, leaning and repetitive nature of the task are particularly problematic.

There are major time constraints when setting up road closures, and additional pressure from working in live traffic.

For cone laying, there is additional MSk demand from working whilst standing on a moving vehicle. Vehicle speed is controlled by the team but there might be differences between individuals in their preferences on how fast to go.

Loading cones onto the vehicles with a forklift can reduce MSk risk at the yard but can also make it harder to reach the top of the pile of cones on the vehicle, as they will be on a pallet which makes them higher.

“I’m 48 this month and Dave’s a little bit younger than me and both of our backs are shot. And I guarantee it’s down to [work in TM].”
(Focus group participant)

“As an industry the whole night revolves around us installing the TTM. There is always pressure and complaints ‘the TTM took too long to install.’”
(Survey participant)

Specific challenges

When installing large signs there is extra risk from the wind, which can add sudden strain and twist the body.

Sandbags can become much heavier if they are wet. There may be variability in sandbag weight.

Control measures and good practice

- The M25 has four automated cone laying machines, which avoid the need for manual cone laying (see case study).
- The use of SfR (Signalling for Roadworks) on some motorways, where lane closure notices are on the overhead gantry, has greatly reduced the need for signage in these scenarios.
- The amount of signage has been reduced in recent years by changes to protocols so that signs are not needed on the offside of the highway.
- Forklifts, lorry mounted cranes, and tail lifts are often used to load and unload vehicles at the yard.
- One company has trialled wearable devices which alert workers to poor posture. These may be most useful as part of a training programme to improve work techniques.

Scope for improvement

There is a need for increased use of cone laying machines or other mechanised solutions. However, they require capital outlay; and there is some industry resistance to their use.

Ensuring that mechanical methods are used more consistently when loading TM vehicles at the yard would reduce risk from handling traffic signs and frames.

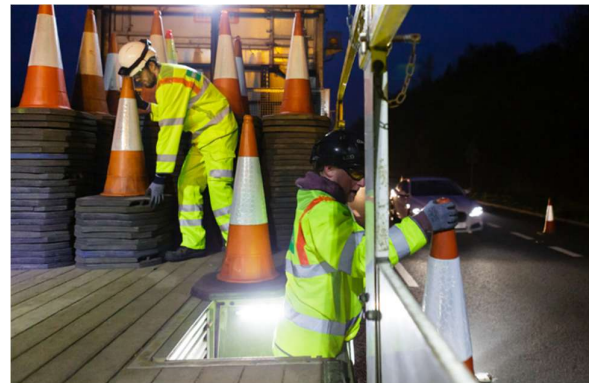


Figure A3 Team of two operatives laying traffic cones for TTM at night. (Photograph courtesy of HW Martin)

Task risk analysis for Traffic Management

Table A18 Risk analysis of TM tasks using MAC

MAC Assessment – Traffic Management	Lift	Lift	Lift
Risk factors	Unloading and erecting signs at roadside	Laying/picking up cones	Passing/stacking cones
Load weight/frequency	4	0	0
Hand distance from the lower back	6	6	3
Vertical lift zones	3	3	3
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	2	2	2
Postural constraints	1	3	1
Grip on the load	1	1	1
Floor surface	2	1	1
Environmental factors	2	2	2
Total score	21*	18	13

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber load and other risk factors.

Assumptions:

- Each cone weighs 8-10kg, 300 cones are put down in 2 hours, 300 cones are picked up in 2 hours, and there are no lights on cones.
- A frame weighs 22kg, sign weighs 10kg, and 2 sand bags are used weighing 10 kg each.
- 30 signs and frames may be installed.

For cone laying, MAC scores are similar regardless of whether cones are being laid or collected, although survey respondents experienced picking up cones as the higher risk aspect. There is variability between operators – some twist more than others, some do more forward leaning, some overextend the arm more.

Adding lamps increases risk. For the person stacking and unstacking, there is an extra task to pick up a lamp. For the person cone laying, the cone is harder to handle, and there is a temptation to put the thumb in the top of the cone.

For sign installation, there is additional risk exposure if signs have to be carried far from the vehicle at the roadside.

A1.7. Archaeology

Tasks identified as potentially high risk included:

- Digging or using a mattock: Using a mattock/shovel to break and remove soil, transferring it into a wheelbarrow. This is particularly demanding in clay soil. The physical demand will increase if the wheelbarrow is not positioned nearby.
- **Using a trowel** to scrape the surface of the dig. This is more demanding in clay soil and stony ground. It also involves kneeling or squatting for prolonged periods.
- **Collect and transport soil samples on site:** buckets of soil need to be carried for transport off site.
- Process soil samples in a laboratory: buckets of sample soil will be tipped into a water tank, separated out, then may be examined on a bench or under a microscope.
- **Using a hoe:** this is a faster alternative to trowel use for cleaning the surface of a dig.
- On site sieving.
- **Geophysical surveying** – this involves pushing or carrying a scanner across an area of land.

Any of these tasks can be undertaken for a whole shift, or workers may alternate between them.

Workforce assessment of risk

Table A 19 Workforce assessment of risk for archaeology tasks

Archaeology	Workforce assessment	Number of responses
Collect and transport soil samples on site	95	19
Dig or use a mattock	89	19
Use a trowel	79	19
Process soil samples in a laboratory	47	15
On site sieving	26	19
Put up temporary barriers around a dig site	24	17
Geophysical surveying	21	14

‘Workforce assessment’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘Number of responses’ is the number of people who answered this question in the survey.

Evidence of harm

Fifteen out of 18 (83%) who responded to the survey reported injury or pain related to work, especially back pain and shoulder pain. Knee, wrist/arm and neck pain were also reported.

Three acute injuries were reported to National Highways over a three-year period related to archaeological tasks, two of these were associated with using a mattock. Focus group attendees identified cases of tendonitis associated with using a trowel.

“We have a lot of really heavy duty equipment, massive carts and ATVs and all the stuff that goes with all of that and we also have a lot of handheld basic equipment which tends to take a long term toll on people's bodies. I think it is very labour intensive.”

(Focus group participant)

Specific challenges

Workers need to avoid damaging the archaeology – this reduces scope to use mechanical equipment.

Sites are often remote from roads, across wet or uneven ground. The land may be rutted or sloped and may be covered in vegetation.

The workforce are often new graduates who initially have little experience or work hardening in field archaeology.

Workers sometimes have to use insulated tools in case of cable strike – these are higher risk “because they’re heavy and they bounce which is really difficult to control.”

“The nature of archaeology means we cannot avoid such tasks, and that muscle ache/pain is inevitable.”
(Survey participant)

“Using a hoe has caused me the most injuries. I have a long term back injury from prolonged use.”
(Survey participant)



“We have a team of about 25 or 30 geophysicists and we only have three ATV (all terrain vehicles).”
(Focus group participant)

Figure A4 Using a mattock can involve working for long periods in a forward leaning position, and clay soils can require considerable force. Buckets of soil might need to be carried a long way across uneven ground

Control measures and good practice

- Mechanisation: including use of vehicles to transport soil, carry out geophysics survey etc (this is expensive; and not suitable for all locations).
- Better tools – e.g. lighter, well maintained.
- Good technique – training (see case study).
- Task rotation, rest breaks.
- Choices of tools e.g. some prefer long handled shovels.
- Height adjustable tables for processing soil samples and finds (see case study).

“We had one recently where somebody was swinging an old mattock, which was blunt, in clay. So obviously you were then getting... severe impact injuries from using old blunt equipment. You know, naturally we got it all replaced and we saw a significant improvement.”
(Focus group participant)

Scope for improvement

Scope for increased use of mechanisation.

Scope to buy better tools (95% of survey respondents said this would help and was achievable) or develop new ones (68% advocated this).

In the past, there has been relatively little sharing of good practice in archaeology, although this is starting to change.

Task risk analysis for archaeology

Table A 20 Risk analysis of archaeology tasks using MAC

MAC Assessment - Archaeology	Carry	Carry
Risk factors	Carrying one bucket of soil	Carrying two buckets of soil
Load weight/frequency	0	4
Hand distance from the lower back	0	0
Vertical lift zones		
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	1	0
Postural constraints	0	0
Grip on the load	0	0
Floor surface	3	3
Carry distance	2	2
Obstacles on route	2	2
Communication, co-ordination and control		
Environmental factors	2	2
Total score	10	13

Assumptions:

- 15kg of soil per bucket, carried >10m

Table A21 Risk analysis of archaeology tasks using RAPP

RAPP Assessment – Archaeology	Pushing Geo-physical cart
Risk factors	
A-1 Load weight	0
A-2 Posture	3
A-3 Hand grip	0
A-4 Work pattern	1
A-5 Travel distance	3
A-6 Condition of equipment	0
A-7 Floor surface	4
A-8 Obstacles on route	2
A-9 Other factors	2
Total score	15

Assumptions:

- Geophysical cart weighs 30 – 40kg
- Distance more than 30m

Table A22 Risk analysis of archaeology tasks using ART

ART Assessment - Archaeology tools	Using a trowel - dominant arm	Using a hoe – forward arm
Risk factors		
A1 Arm movements	6	3
A2 Repetition	6	6
B Force	4	2
C1 Head/neck posture	1	2
C2 Back posture	2	2
C3 Arm posture	2	2
C4 Wrist posture	1	2
C5 Hand/finger grip	0	0
D1 Breaks	0	0
D2 Work pace	0	0
D3 Other factors	2	2
Total score	24*	21

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE if it is undertaken for longer than 4 hours per day.

Assumptions:

- Breaks – 10 second or more breaks/change of activity every few minutes.
- Work is self-paced.
- Heavy soil e.g. clay. Lighter soils may have lower risk.
- Other factors: wearing gloves, cold weather, could be working in poor light.

Additional risks: high load on the shoulder when using a hoe; high load on the knees when using a trowel.

A1.8. Vegetation management

Tasks identified as potentially high risk included:

- **Trees: cut and prune** This includes multiple elements: including removal of the cut wood, and feeding branches into a chipper. Trees may also be felled completely. Tree work may be carried out from a climbing harness.
- **Gulley emptying** (this is covered in Appendix A1.1 Common tasks).
- **Strimming:** Strimmers can weigh 10 – 15kg (usually supported by a harness) and often involve repetitive twisting over many hours.
- **Tree planting:** plant typically 20 -30 per hour; or may be up to 2000 small plants in a day, carry bag of 10 – 20kg.
- **Grass cutting:** ride on mowers (risks from whole body vibration).
- **Turfing:** risks are increased by mechanised production which produce bigger pieces of turf, weighing up to 20kg each (some focus group participants reported wildflower turf up to 50kg). Weight can be very variable depending on water content.

Other tasks mentioned later in the research include using a mattock; using an auger; using a hedge cutter or brush cutter; and stacking timber (when left on site for ecology purposes).

Workforce assessment of risk

Table A23 Workforce assessment of risk for vegetation management tasks

Landscaping and vegetation	Workforce assessment	Number of responses
Trees: cut and prune	86	14
Gulley emptying	63	8
Installing fencing	50	14
Strimming	40	15
Turfing	33	9
Trees: plant	21	14
Grass cutting	7	15

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Evidence of harm

Work related aches and pains were reported by 5 out of 13 respondents (38%).

Specific challenges

Tree work is a highly variable task in unpredictable environments, involving unknown weights e.g. when taking trees or branches down. Work may often be carried out in restricted spaces, at height, on slopes or embankments or while suspended in a harness.

There may be constraints on machinery use e.g. if access is limited; if clearing scrub to look for cabling; if there is a risk of breaking nearby windows (which limits use of flails).

Most vegetation work is seasonal e.g. tree work almost stops for nesting season (except for hazardous trees) and grass cutting season is limited.



Figure A5 Tree work includes a range of activities to remove the cut wood, in variable environments (photos courtesy of Servtron Green Services)

Control measures and good practice

- Use of mechanised alternatives e.g. roboflail for clearing scrub; mechanised tree removal for large scale work.
- Use of MEWPS to reduce tree climbing.
- Battery operated machinery can be lighter than petrol fuelled (and can also reduce HAVS exposure).
- Robot-controlled machinery.

“Clearing bramble, we now have a tracked machine controlled by remote control so this takes away the problem of holding a hedge cutter all day.”

(Survey participant)

Scope for improvement

Access is reported to be a challenge, particularly across farmland, which means equipment and materials must be carried further.

Improved video of the network soft estate has been suggested as a way of reducing the need for inspections and also enabling better preparation in advance of work.

The use of a workbench when splicing has been suggested to reduce prolonged bending.

Task risk analysis for vegetation management

Table A24 Risk analysis of vegetation management tasks using MAC

MAC Assessment – Vegetation management	Lift	Lift
Risk factors	Feeding 30kg branches into shredder	Holding/ operating chainsaw
Load weight/frequency	0	0
Hand distance from the lower back	6	6
Vertical lift zones	1	3
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	2	2
Postural constraints	1	3
Grip on the load	1	0
Floor surface	1	2
Carry distance		
Obstacles on route		
Communication, co-ordination and control		
Environmental factors	2	2
Total score	14	18

Table A25 Risk analysis of vegetation management tasks using RAPP

RAPP (no wheels) Assessment	Dragging branches
Risk factors	
A-1 Load weight	2
A-2 Posture	6
A-3 Hand grip	1
A-4 Work pattern	1
A-5 Travel distance	3
A-6 Condition of equipment	
A-7 Floor surface	4
A-8 Obstacles on route	2
A-9 Other factors	2
Total score	21*

*indicates that the task may trigger additional questions by the HSE due to the combination of amber load and other risk factors.

Assumptions:

- Feeding branches into a chipper is done by dragging, not lifting, so only half of weight will be lifted.
- Chain saw weight has been estimated at 9kg.
- Chainsaw use might be at ground level or in a tree (e.g. in a harness).
- Branches will be allowed to drop; there will be additional risk if they are held or thrown.
- Tree branches maximum weight estimated at 30kg, dragging distance more than 10m.
- Ground may be muddy, steep slope.
- Other factors: poor weather; branches may be difficult to grasp (e.g. uneven, sharp).

A1.9. Ground investigation

Tasks identified as potentially high risk included:

- **Carry samples/cores:** samples are usually 1-1.5m long. Typically 10 - 12m of core per day, up to 20m per day.
- **Hand auguring:** this was reported as an uncommon but high-risk task.
- **Hand digging** (this is covered in Appendix A1.1. Common Tasks).
- **Unload and carry casings/tools: casings weigh 40 – 80 kg.**
- Cable percussive drilling: multiple elements to this, very variable.
- Rotary drilling:- multiple elements to this, very variable.
- Carry samples in laboratory.
- Window sampling.
- Process samples in laboratory.

Workforce assessment of risk

Table A26 Workforce assessment of risk for Ground Investigation tasks

Ground investigation (GI)	Workforce assessment	Number of responses
Carry samples/cores	75	4
Hand auguring	75	4
Dig inspection pits	50	4
Cable percussive drilling	50	4
Rotary drilling	33	3
Carry samples in laboratory	33	3
Unload and carry casings/tools	25	4
Window sampling	0	3
Process samples in laboratory	0	3

'Workforce assessment' shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

'Number of responses' is the number of people who answered this question in the survey.

Prioritising risk in this work areas was difficult as only 4 survey responses were received. In focus groups there were differences of opinion on which were the best/ worst ways of drilling; none of them are low risk. There are multiple elements to the tasks, and risk varies substantially depending on distances, underfoot conditions and extent of mechanisation. Further work would be required to properly prioritise risk management in this area.

Evidence of harm

There is insufficient data available to report on this.

Specific challenges

Access issues are a major challenge, requiring workers to carry equipment over rough ground; particularly as equipment is not designed to be easily carried.

Work on slopes, work in cold weather, working in the dark with poor lighting all increase risk.

Hand digging e.g. of inspection pits is common, as a Vac-Ex can be too expensive for a small job; also, it can be difficult to get access to some sites.

Control measures and good practice

- Mechanisation where possible.

Scope for improvement

It was suggested in focus groups that better positioning of boreholes by designers would sometimes reduce risk e.g. by improving access; especially where sites for investigation are selected without visiting.

Task risk analysis for ground investigation

Table A27 Risk analysis of GI tasks using MAC

MAC Assessment – ground investigation	Team operation	Team operation
Risk factors	Carrying samples	Carrying casings
Load weight/frequency	0	4
Hand distance from the lower back	3	3
Vertical lift zones	3	3
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	1	1
Postural constraints	1	1
Grip on the load	2	2
Floor surface	3	3
Carry distance	3	3
Obstacles on route	2	2
Communication, co-ordination and control	0	0
Environmental factors	2	2
Total score	20	24*

*indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber load and other risk factors’.

Assumptions:

- Core sample weight 30kg (estimated core weight 10 – 20kg per meter, sample box carries 2 x 1m).
- Casings estimated 60kg each.
- It is assumed this is a two-person lift.

- May lift from floor level.
- Other factors: ground conditions may be poor, weather may be bad.
- Carry distance may be greater than 10m.

Table A28 Risk analysis of GI tasks using ART

ART Assessment – ground investigation	Using an auger Either arm
Risk factors	
A1 Arm movements	3
A2 Repetition	0
B Force	9
C1 Head/neck posture	0
C2 Back posture	2
C3 Arm posture	0
C4 Wrist posture	1
C5 Hand/finger grip	0
D1 Breaks	0
D2 Work pace	0
D3 Other factors	1
Total score	16

A1.10. Scaffolding

This summary is based on a focus group discussion. No survey responses were received about scaffolding.

Tasks identified as high risk included:

- Loading scaffolding materials onto lorries at the yard.
- Unloading on site.
- Manually carrying materials up scaffold.
- Fastening scaffolding couplers with a spanner or impact wrench.
- Dismantling scaffolding (and returning materials to the yard).

Scaffolding tubes are heavy (up to around 28kg) and unwieldy (up to 6.3m long). The specific weight can vary as newer tubes may be lighter weight. Scaffolding boards can be up to 3.9m long, weighing 18kg. A 3m board weighs around 14kg, although boards may be lighter as they get older and dryer, or heavier if they are wet.

Evidence of harm

This is a known high-risk activity, discussed in industry and academic literature. The key risks relate to the high volume of materials handled which have been estimated as about 15 tonnes per day per worker as each item is often handled several times. There are additional risks from fastening scaffolding clamps.

“I love scaffolding and the reason I stopped is tendonitis in both wrists, and that's from turning [the] spanner.”
(Focus Group participant)

Specific challenges

Scaffolding tubes and boards are heavy, unwieldy, and highly variable.

Focus group participants said that impact wrenches are commonly replacing spanners as the main tool for securing fixings as they are more comfortable. The switch to impact wrenches is reported to often be ad hoc, with workers providing their own tools, which may introduce additional risks. They also increase noise levels and therefore risk of hearing damage.

There are additional challenges which are specific to highways scaffolding, such as getting materials to the point of use to construct hanging or bridging scaffolds. Other scaffolding may be constructed within traffic closures, limiting the use of cranes and hi-abs, or requiring materials to be unloaded further away and hand carried.

Control measures and good practice

- National Highways mandate contractors to be members of associated bodies (such as NASC) and therefore working to a specified standard.
- Early discussions and good planning are important e.g. to get vehicles closer to the scaffolding site and minimise carrying.
- Most scaffolding companies will use forklifts to load and unload their vehicle at the yard.
- Hoist systems are also available to lift scaffolding materials up and down the scaffold.
- New products are lighter e.g. tubing may be 3.2mm thickness down from 4mm; some products are 2.7mm.
- System scaffolding may result in lower risk due to shorter, lighter tubes and fixings: see case study.
- Using shorter scaffolding tubes may reduce risk. For example, Trad scaffolding cut their 6m tubes down to 5m, which are lighter and more manageable.

Scope for improvement

Historically, scaffolding has a ‘macho’ culture, which can make it difficult to implement risk management measures.

Lifting/hoist systems may not be widely used. They were reported in the focus group as having limitations e.g. they don’t carry many tubes and can thus slow the job down; or they may work better with shorter tubes than longer ones.

“I know some companies where they don't let someone leave the yard unless they can ‘flip a long’ and that still goes on.”*

(Focus Group participant)

* This refers to a practice of throwing a 6.3m pole, weighing over 25kg, from the shoulder into an upright position.

Task risk analysis for scaffolding

Table A29 Risk analysis of scaffolding tasks using MAC

MAC Assessment - scaffolding	Lift	Carry
Risk factors	Lifting tube between one point and another	Carrying tube
Load weight/frequency	4	4
Hand distance from the lower back	6	0
Vertical lift zones	3	
Torso twisting and sideways bending OR Asymmetrical torso or load (carrying)	1	1
Postural constraints	1	3
Grip on the load	2	2
Floor surface	2	3
Carry distance		1
Obstacles on route		2
Communication, co-ordination and control		
Environmental factors	2	2
Total score	21*	19

* indicates that the task may be classed as ‘possible risk of significant injury’ by the HSE due to the combination of amber load and other risk factors.

Assumptions:

- 20kg tube, lifted 1-2 times per minute.
- Carrying route is 4-10m, some obstacle.

Table A30 Risk analysis of scaffolding tasks using ART

ART Assessment	Fixing couplings with spanner - Dominant arm
Risk factors	
A1 Arm movements	3
A2 Repetition	6
B Force	2
C1 Head/neck posture	1
C2 Back posture	2
C3 Arm posture	2
C4 Wrist posture	1
C5 Hand/finger grip	0
D1 Breaks	0
D2 Work pace	0
D3 Other factors	1
Total score	18

Assumptions:

- Task is interspersed with other work (e.g. lifting tubes).
- Work is self-paced.

A1.11. Recovery

Participants in this focus group worked as traffic officers, incident support or vehicle recovery professionals.

Tasks identified as potentially high risk included:

- **Pushing cars:** traffic officers each do this 1-2 times per month.
- Lifting cones and signs from vehicle: 20 cones in stacks of 5. Signs are metal but foldable. Up to 10 incidents per day for each traffic officer.
- Moving debris from the carriageway: e.g. bumpers, wheels, loads from lorries.
- Working under HGVs: e.g. to disconnect brakes/prop shafts; up to 3 times per day for vehicle recovery.

Workforce assessment of risk

Table A31 Workforce assessment of risk for recovery tasks

Recovery	Workforce assessment	Number of responses
Pushing cars	100	3
Working under HGVs	67	3
Lifting cones and signs from vehicle	33	3
Moving debris from the carriageway	0	3

‘**Workforce assessment**’ shows the percentage of survey respondents who said each task was either high or medium risk. The task is shaded **red** where this was 60% or more of respondents, **amber** where it was 40 – 59%, and **green** where it was fewer than 40%.

‘**Number of responses**’ is the number of people who answered this question in the survey.

Evidence of harm

There is insufficient data available to report on this (only 5 survey responses were received).

Specific challenges

Much of this work is being done in or close to live traffic. It may also be done where there is limited space, e.g. with narrow lanes, so that hi- abs can’t be used for vehicle recovery.

For traffic officers, there can be prolonged periods of inactivity, followed by a need to move very quickly, “from zero to hero”, which increases the risk of musculoskeletal injury.

Vehicles are changing. For example, different techniques are needed to handle electric vehicles, as their wheels lock on shut down.

“our job is getting different... possibly harder... the manufacturers certainly aren't making it any easier for us as the recovery.”
(Focus Group participant)

Control measures and good practice

- Use of Hi-abs for vehicle recovery where possible.
- Improved vehicles for traffic officers with higher sitting position, which makes it easier to get in and out.

- National Highways used the HSE MAC tool to assess traffic officer risk. This confirmed that the need for sudden activity was the key risk rather than particular aspects of the task itself. They have sought to address this with measures to encourage workforce fitness and stretching.

Scope for improvement

Vehicle recovery operators are often micro companies with only 1 or 2 vehicles and associated staff. They have no formal network which makes it harder to share good practice.

Task risk analysis for pushing a car

Table A32 Risk analysis of recovery tasks using RAPP

RAPP (wheeled) Assessment	Pushing car
Risk factors	
A-1 Load weight	2
A-2 Posture	6
A-3 Hand grip	0
A-4 Work pattern	0
A-5 Travel distance	3
A-6 Condition of equipment	0
A-7 Floor surface	1
A-8 Obstacles on route	0
A-9 Other factors	2
Total score	14

Assumptions used in task analysis:

- Estimated car weight of 2000kg.
- Pushing distance could be 10m or more.
- Two people are pushing together and sharing the load equally. If one person pushes a car alone, the load score goes up to 8, very high risk.

Appendix 2 - Case studies of good practice

We have included six case studies of good practice to illustrate what improvement in musculoskeletal risk reduction looks like in real highways work places. The principles and techniques behind these improvements are applicable to many other work areas.

- A. Cone laying – mechanisation and elimination of MSk risk
- B. Dry stone walling – improved job planning
- C. Robotic hydro demolition - mechanisation and elimination of MSk risk
- D. System approaches to scaffolding risk – substitution to reduce MSk risk
- E. Reducing risk in Archaeology – Task specific training, risk assessment and work equipment
- F. Pre-cast concrete for low level retaining structures – design-led solution, elimination of MSk risk

Case study A - Cone laying

Challenge

Laying traffic cones is an integral part of Traffic Management (TM). Cones are laid to close one or more lanes before highways work is undertaken, then collected in once it is finished. Several hundred crews could be laying cones across the strategic road network each night. It is a high-risk task due to the twisting and forward bending postures typically adopted by workers.

Up to 300 cones are laid for a typical 4km stretch of road closure (potentially more if there are slip lanes etc.)

- A single cone weighs 8.5kg – 10kg.
- Cones are typically 1m high, they are stacked 15 – 20 high on the vehicle.
- Each cone is handled twice when being laid, and twice when being picked up. A worker picks up each cone from a stack on the TM vehicle and turns to pass it to a colleague in a footwell (or places it close to them). The worker in the footwell takes the cone, then turns and leans forward to place it on the road. The operation is reversed when collecting the cones.
- The process takes around 1-2 hours when laying cones out, and the same to collect them in.



There are additional risk factors when laying cones by hand, which can increase the potential for musculoskeletal injury. These include:

- Exposure to cold, wet weather. This increases injury susceptibility and can also make conditions underfoot more slippery.
- Time pressure and stress: there is time pressure to complete the job as quickly as possible as there will be teams waiting to get on to their roadworks once the cones are laid; and a deadline to lift cones so that lanes can be reopened.
- Operating from a moving vehicle which increases the musculoskeletal demand to maintain stability. The vehicle speed will be adjusted to the work rate of the operatives placing cones.

Solution

Two Automated Cone Laying Machines (ACLM) have been in use on the M25 for around three years by Balfour Beatty, and two more have recently been bought. These eliminate the manual handling activity involved in cone laying.

Impact

Each cone laying machine eliminates the requirement for manual handling by two crew members, replacing up to 12 tonnes of handling each night. It also reduces worker exposure to noise and pollution. Additionally, it avoids exposing TM operatives to the safety risks of working on the back of a



moving vehicle adjacent to live traffic, as the cones are placed and retrieved by the driver using controls in the vehicle cab.

Each cone laying machine eliminates the requirement for manual handling by two crew members, replacing up to 12 tonnes of handling each night. It also reduces worker exposure to noise and pollution. Additionally, it avoids exposing TM operatives to the safety risks of working on the back of a moving vehicle adjacent to live traffic, as the cones are placed and retrieved by the driver using controls in the vehicle cab.

An additional benefit of the ACLM relates to the predictability of cone laying speed. The time taken to lay and pick up a closure is known in advance and is not influenced by operator preference, expertise or physical fitness.

Reflections and scope for further use

Use of an automated cone laying machine is a solution at the top of the hierarchy of control, as it eliminates the manual handling and other cone laying risks completely.

The main limitation is the high initial outlay, an ACLM will cost several times more than a traditional TM vehicle. This may be offset in the long term by reduced operating costs.

Cone laying technology is continuing to evolve.

- ACLMs were initially designed for motorway use where they can be used to lay long stretches of road closures. Alternative (smaller) vehicle designs have subsequently been developed which can be used for cone laying on urban or rural roads.
- Where lamps are needed, these need to be added by hand after cones have been laid. Solutions to this are currently in design

For workers who switch to sedentary activities (e.g. driving) instead of cone laying, there is a potential impact from reduced activity and fitness. Workers will need to find other ways to be active to support good health, and also to ensure that they are fit enough to safely do other aspects of their work which are physically demanding.

Greater use of ACLMs will enable a more diverse range of people to work in TM as they will not be exposed to the high physical demands of manual cone laying.



Balfour Beatty



**Connect Plus
Services**
A Balfour Beatty, AtkinsRéalis & Egis joint venture

Case study B - Dry stone walling

Challenge

Dry stone walling is a heritage construction technique, which carries particular benefits for habitat creation. However, it is a heavy and labour-intensive task. The process involves placing stones of varying sizes and shapes without the use of mortar including:

- **Standard stones**, which form the body of the wall and weigh up to 20kg each.
- **Through stones**, which span the full width of the wall and can weigh up to 40kg each.
- **Coping stones**, which form the top layer of the wall, and typically weigh up to 25kg each.

Traditionally, stones are delivered to the work site by lorry, where operatives sort through them to identify pieces of the appropriate size and shape. This sorting process is highly labour-intensive and typically involves repeated bending, twisting, and lifting of irregular, heavy materials. Individual stones can vary significantly in weight and geometry, requiring constant manual handling and repositioning before a suitable piece is selected.



This stage places a considerable physical demand on operatives, often accounting for the highest frequency of lifts in the overall process. The repetitive nature of handling combined with awkward grips and unpredictable load distribution can lead to increased fatigue, reduced productivity over time, and a higher risk of musculoskeletal injuries, particularly affecting the lower back, shoulders, and wrists.

Once selected, stones are then manually carried to the point of use and carefully positioned in place. While placement itself requires skill and precision, it is the cumulative effect of repeated handling during sorting that has the greatest impact on workforce strain and long-term health.

Solution

A 7.5 km dry stone wall is currently under construction alongside the A417 in the Cotswolds, led by Master Stone Masons UK. Several measures have been implemented to reduce manual handling risks, including:

- Stones are mechanically sorted at the quarry into through stones, standard stones and coping stones, ensuring there is no increased manual handling risk for quarry workers.
- Stones are delivered to site in bags, spaced at approximately 3 metre intervals and positioned as close to the wall line as possible.
- Operatives construct the wall using stones sourced from nearby bags, minimising carrying distances.
- Workers regularly rotate between different tasks throughout the day and alternate between working from the left and right sides of the wall to reduce repetitive strain.
- Through stones are moved using either mechanical lifting equipment or two person lifts only.
- Workers are provided with paid gym memberships and encouraged to develop task specific fitness, particularly strength in the elbows, forearms, shoulders, back and core. This also provides social benefits, as many operatives are living away from their families.

Impact

This approach significantly reduces the need for workers to manually sort stones. Traditionally, sorting is often carried out with stones at ground level, which involves frequent bending. Overall stone handling is reduced, including the handling of larger through stones, and stones are carried over much shorter distances before being used in the construction of the wall.

We conducted an onsite survey and found workers are satisfied with the working process. There have been no reported cases of fatigue, musculoskeletal injury or pain. In fact, some operatives have indicated that they feel less fatigued than expected and would be willing to work longer hours.



Reflections and scope for further use

These techniques could be applied more widely, subject to the willingness and capacity of supplying quarries to engage. For example, quarries would need sufficient space to sort stones and a commitment to mechanical sorting and bagging, to ensure that risk is not simply transferred from stone masons to quarry workers. Adequate access would also be required to place bags of stone close to the full length of the wall, which may be a limiting factor on some projects.

Working in this way is likely to increase productivity. However, it is important that there is an overall reduction in risk to workers, and that any efficiency gains are not offset, for example by operatives undertaking a similar level of manual handling while constructing greater lengths of wall within the same timeframe.

Even with these control measures in place, dry stone walling remains a highly physically demanding activity. One of the highest risk elements is lifting very heavy stones from floor level, while the highly repetitive nature of the work also presents challenges. Ongoing efforts should therefore focus on mechanising the process wherever possible. Alongside the safety benefits, there are clear productivity gains, with workers laying up to twice the length of wall that would typically be expected.



Case study C - Robotic hydro demolition

Challenge

Bow Arrow deck over the railway on the A282 near M25 J1a required immediate concrete repairs to prevent a recurring CAT 1 pavement depression and rutting. The deck was congested with rebar and had low cover which ruled out any mechanical breaking to prevent any further damage to the existing rebar.

Hydro demolition can be an effective way of removing concrete but potentially involves high musculoskeletal loads as well as other health risks.

Solution

Octavius successfully trialled a robotic hydro demolition machine with Gunite Solutions under a full closure.



Impact

The robot was remotely operated. This reduced musculoskeletal risks as well as other health risks often associated with hydro demolition such as noise, vibration and dust exposure, as well as safety risks.

Scope for further use

There may be many other situations where robotic hydro demolition can replace standard hydro demolition or use of drills when breaking out concrete.

As an added advantage, the debris was well controlled, so that future work could potentially be carried out under lane closures rather than requiring full closure. The robot productivity was also a lot higher compared to standard hydro demolition.

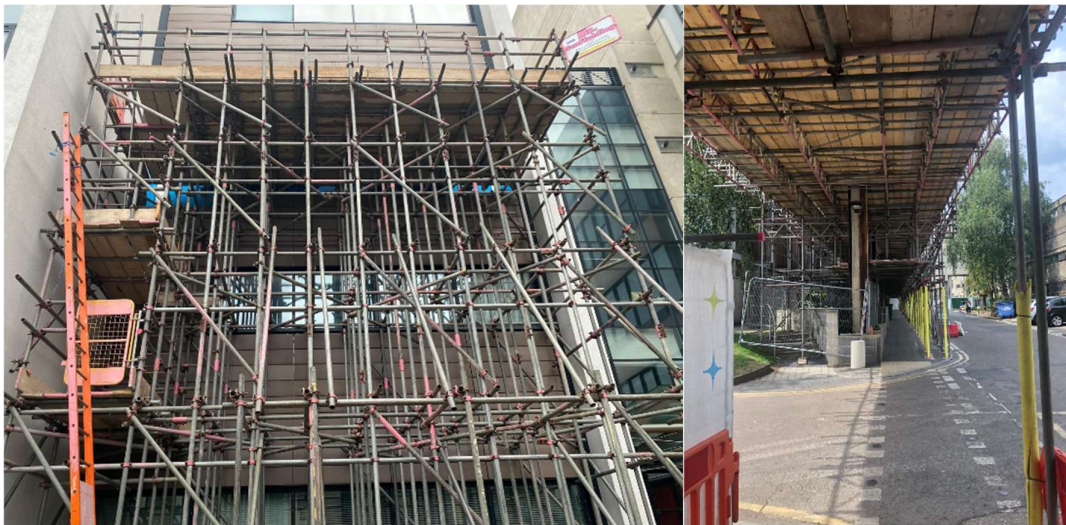


Case study D – Using System approaches to reduce scaffolding risk

Challenge

Traditional ‘tube and fitting’ scaffolding uses tubes made of galvanised steel, joined with couplers which are secured using a spanner or an impact wrench. Wooden planks are used to board out the scaffold. Scaffolding is recognised as a high-risk construction activity, with a particularly high risk of back pain, and also increased risk of long-term problems with shoulders and wrists, such as carpal tunnel syndrome.

- Tubes can be up to 6.3m long and can weigh 25 – 30kg. Boards can be up to 3.9m long, weighing 18kg. A 3m board weighs around 14kg, although boards may be lighter as they get older and dryer, or heavier if they are wet.
- Workers may choose to carry multiple components at once.
- Traditional tubes have 4mm thick walls. More modern tubes may be thinner (3.2mm or less) or made of different materials, which reduces the weight; but introduces additional variability.
- Traditionally, spanners are used to make connections, this requires high frequency twisting movements which can be associated with wrist injuries. In recent years, impact wrenches are more commonly used, which are generally recognised as carrying a lower MSk risk as well as being more efficient. They need to be used correctly to ensure scaffolding joints are secure. They will increase the noise levels on a construction site and therefore increase the risk of hearing damage.



Examples of traditional scaffolding involving a wide variety of components, including tubes of various lengths, wooden boards, and fixing clamps

Solution

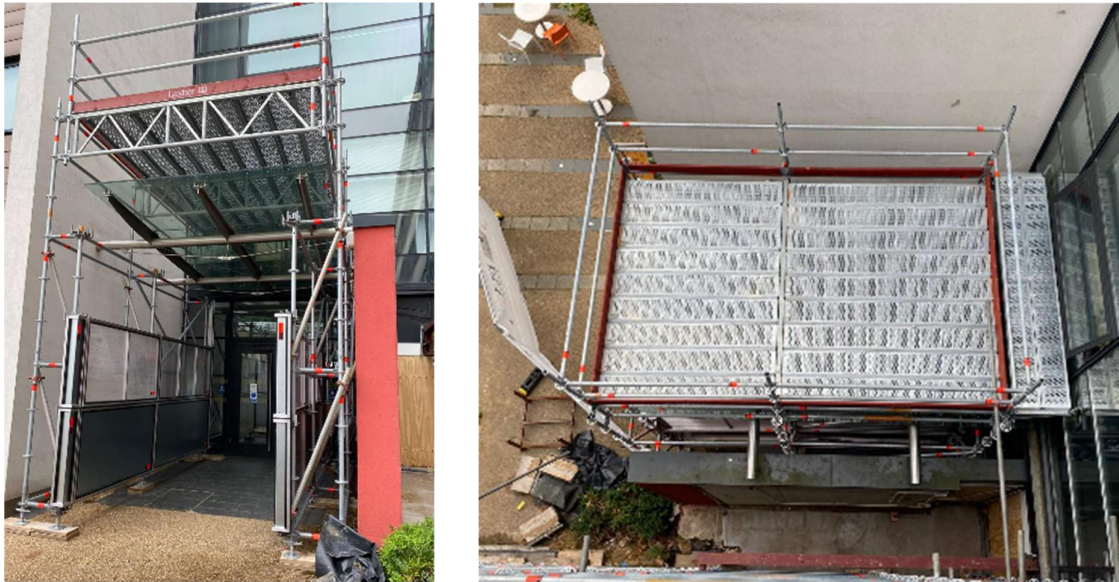
System scaffolding has been designed to be lighter and more standardised than traditional tube and fitting scaffolding. A range of systems are available.

Mr Scaffolding use system scaffolding, based on the Layher system. Components are shorter and lighter than traditional elements and have a built-in fixing system which replaces the need for couplers. Fixings are secured with a hammer, typically two strikes per wedge (impact risk is reduced by using a dead drop hammer).

Impact

The table below shows a comparison between a birdcage scaffold constructed using Traditional and System designs. Overall, the weight of the system design is around half that of the traditional i.e. workers need to do 50% or less of the lifting to construct the scaffold. They will also have reduced risk of hand and wrist injury as they will not need to use spanners or an impact wrench to connect the fittings. There is less variability; and more scope to use mechanical means for lifting.

	Traditional tube scaffolding	System scaffolding
	20m x 20m birdcage, constructed using 3.2mm gauge tube, wooden boards and drop forge fittings	20.5m x 15.5m birdcage, constructed using Layher All-round LW
Total weight	56,000kg (weight would be higher if constructed with 4mm gauge tube)	22,800kg (20,500 if lightweight system is used)
Number of separate elements	Approx. 40,000	Approx 10,000
Heaviest single item	28kg (6.3m tube, 4mm gauge)	17.4kg (4m tube including fixings)
Other advantages	<ul style="list-style-type: none"> • There is high familiarity with the traditional method amongst workers/companies (and some resistance to change away from this) • There is a standardised method, which can be constructed by any scaffolder on any project. By comparison, System construction will be brand specific 	<ul style="list-style-type: none"> • Shorter tubes are more compatible with hoists and cranes (6m tubes are often incompatible with hoist/crane use) • Tubes and boards are consistent and predictable lengths/weights • The shape of components (e.g. with fixings built in) limits the number of items which can be carried at once • No requirement to use spanner or impact wrench to make connections • Steel boards do not get heavier when wet



Examples of system scaffolding

Scope for further use

System scaffolding will be more expensive to buy, which may make it inaccessible to some companies. This cost could be offset at an industry level if there is less MSk injury to scaffolders in the long term, but this is difficult to quantify.

Costs may also be offset by reduced time/staffing needed to construct scaffolding. However, caution is needed to make sure that this does not undermine the health advantages (e.g. if workers lift the same load in a day using system but construct a larger meterage of scaffolding).

This case study focuses on the manual handling risks of scaffolding, there may be other advantages and disadvantages of system which will influence decision making, such as the speed with which complex structures can be assembled; whether system has the flexibility to accommodate all tasks and designs; the relative benefits of one brand of system over another; the preferences of the workforce; and the impact of workers having expertise only in one particular brand.

Mr.scaffolding
& System Scaffolding

Layher 

More Possibilities. The Scaffolding System.

Case study E - Reducing risk in archaeology

Challenge

Around 6000 people are employed in the UK archaeology industry. Major projects, e.g. to investigate sites prior to construction works can involve 50 - 100 field workers over weeks or months. This field work is followed by processing of soil samples, which can continue for many months afterwards. Field archaeology carries a high risk for manual handling injuries.

- Activities are physically demanding over many hours e.g., digging and using a mattock (heavy work, particularly in clay soils), trowelling (prolonged kneeling and forward bending) hoeing (twisted postures), carrying soil samples.
- Risks can be increased by the need to wear construction-related 6-point PPE which restricts movement and to use insulated tools (which are heavier) if there is a risk of cable strike
- Work is often outside, in cold or wet weather
- Many archaeologists start work straight from university, having done only a short period (e.g. 2 weeks) of practical work during their training. They may therefore not be work hardened and could have low physical fitness, at least initially.
- There are often time pressures to complete work before construction projects begin.



Task specific training and risk assessment

In 2021, Oxford Archaeology identified a spike in Accident Frequency Rate. 50% of incidents were associated with manual handling activities.

Solution

1. A company was brought in to provide manual handling training.
 - All new workers have manual handling training on day one. This includes classroom-based training about common tasks and good practice, followed by practical field-based training. The focus is on teaching them to think about what they are doing: Where are you going to put that barrow? Where will you position the spoil heap? How much does the soil in your barrow weigh? Can you reduce the need to twist? As well as specific techniques e.g. how to use a shovel with less twisting, dipping the shovel in water to prevent the soil sticking to the blade etc.
 - Workers also learn the importance of warming up, stretching etc, particularly at the start of work, after breaks, after prolonged immobility.
 - All supervisors are trained to deliver practical onsite manual handling training to their teams; to encourage warm up and stretching; and how to do risk assessment.
2. Risk assessment for activities are conducted using the HSE's MAC, ART and RAPP tools, and reviewed annually. These are used as part of face-to-face worker training, to illustrate which aspects of a tasks are particularly hazardous (e.g. twisting, bending) and show workers how to identify risk factors and minimise the risk.
3. Workers are encouraged to try different tools to see what suits them the best – some prefer shorter handles, some longer; some prefer trowels to clear a site, some prefer hoeing.

Impact

There was a marked reduction in injuries over the next two years.

The number of situations where personal risk assessment is needed due to long term health issues has also fallen.

Working in a healthier way also improves overall work progress. There is a strong synergy between good manual handling practices and good archaeological practices generally, such as alternating between different activities (digging, trowelling etc); always entering the dig at the same point and working in one direction.

Improved work equipment

A worker at Headland Archaeology reported back pain from prolonged bending to process soil samples in the laboratory.

Solution

A height adjustable table was installed.

Impact

The worker reported that this reduced pain and made working more comfortable.

The company are proceeding to install similar equipment in other laboratories.



Reflections and scope for wider use

These solutions could be helpful for others working in archaeology. They also have transferability to other disciplines:

- The principles of task specific MH training can be applied in any discipline. The HSE advises that manual handling training must be tailored to the tasks which workers carry out, rather than being generic.
- The MAC, ART and RAPP tools are helpful and easily applied techniques which enable prioritisation of risk management. They also highlight the aspects of tasks which are most problematic and can thus point towards effective solutions for risks which cannot be eliminated. The HSE offers training courses in risk assessment using these tools.
- Height adjustable working platforms could be used in other laboratory-based disciplines e.g. where soil samples are being analysed as part of Ground Investigation work. They can also be useful for many tasks being carried out at floor height, or where loads are being repeatedly lifted from ground level.
- Both cases studies also highlight the benefits of gathering data about musculoskeletal harm and encouraging early reporting of concerns, to enable solutions to be implemented.

Case study F – Pre-cast concrete for low level retaining structures

Challenge

A traditional way of constructing low level retaining walls alongside the highway is to use paving slabs placed end-on against the soil. Paving slabs are heavy (30 – 40kg) and difficult to manoeuvre, carrying a high risk of acute and longer term musculoskeletal injury.

Solution






Precast concrete panels can be used instead.

Impact

The concrete panels are lifted into place mechanically, so there is no manual handling involved, eliminating the musculoskeletal risk.

As well as reducing MSk risk, this approach is also quicker and therefore reduces the time taken to complete the task, and the impact of road/lane closures on the public. The panels have a longer life and requires less frequent inspections than the more traditional paving slab solutions.



MANUAL HANDLING – LOW-LEVEL RETAINING STRUCTURES		WLD.001				
 Description of Event <i>A flat edge solution was designed as a low-level retaining structure without consideration for working area</i>						
Population at Risk Construction and Maintenance Workers, Inspectors and Travelling Members of Public (MoP)	Potential Mitigation Measures					
Hazardous Activity and Residual Risk Description <ul style="list-style-type: none"> Construction of low-level retaining structure using flag on edge with restricted site access requires manual handling with an assessed residual risk of 'an almost certain' likelihood of extreme harm incurred. A flag on edge retaining structure has a shorter design life than other solutions, increased construction period and requires a shorter interval between inspections. 	Design <ul style="list-style-type: none"> Eliminate manual handling of materials by designing a pre-cast concrete panel solution that requires mechanical handling. 	 <p>Photo precast concrete panels</p>				
Potential consequences of this event <ul style="list-style-type: none"> In 2021 HSE estimated that there were 40,000 workers suffering with musculoskeletal disorders. The musculoskeletal disorder incident rate is 1.8%. Extended period of TTM required leading to greater exposure to workers and public. 	Construction <ul style="list-style-type: none"> Design temporary works for access and installation of precast panels to reduce TTM duration and reduce onsite manhours. 					
 <p>Photo of flag on edge retaining structure</p>	Maintenance / Operations <ul style="list-style-type: none"> Periodically assess safety and serviceability at a reduced frequency when precast panels are used. 					
Safety Hub Alert Database <ul style="list-style-type: none"> Sub-category 2 MoP TTM incursions has 8 alerts including 1 fatality. 	Further Guidance and Reading <ul style="list-style-type: none"> RtB 8 – Manual Handling RtB 26 – Safety by Design DMRB GD 304 – Designing health and safety into maintenance INDG 143 Manual handling at work – a brief guide L23 Manual handling, Manual handling operations regulations 1992. Guidance on regulations. 					
 <p>Please send ideas for Whole Life Design safety shares to wellbeing@nationalhighways.co.uk</p>	LEAN	Alternative Materials				
	Alternative Plant	Reduced Labour	Improved end user benefits	Reduced Activity Duration	Reduced Defects	Reduced Reportable Accidents

Appendix 3 – Research method details

This appendix expands on the method summaries in §3 of the main report.

1. Stakeholder analysis

We used the advice of various experienced industry professionals to perform an initial stakeholder mapping exercise. This was then refined as our understanding of the industry developed during our communication and engagement activity. The results are shown in Figure A6 MRPro Stakeholder map. The map shows the balance between interest in the success of this research and influence over its success. This enabled us to prioritise our communication over the course of the project appropriately. It should be noted that a stakeholder map focussed on achieving improvement in MSk risk reduction would look different.

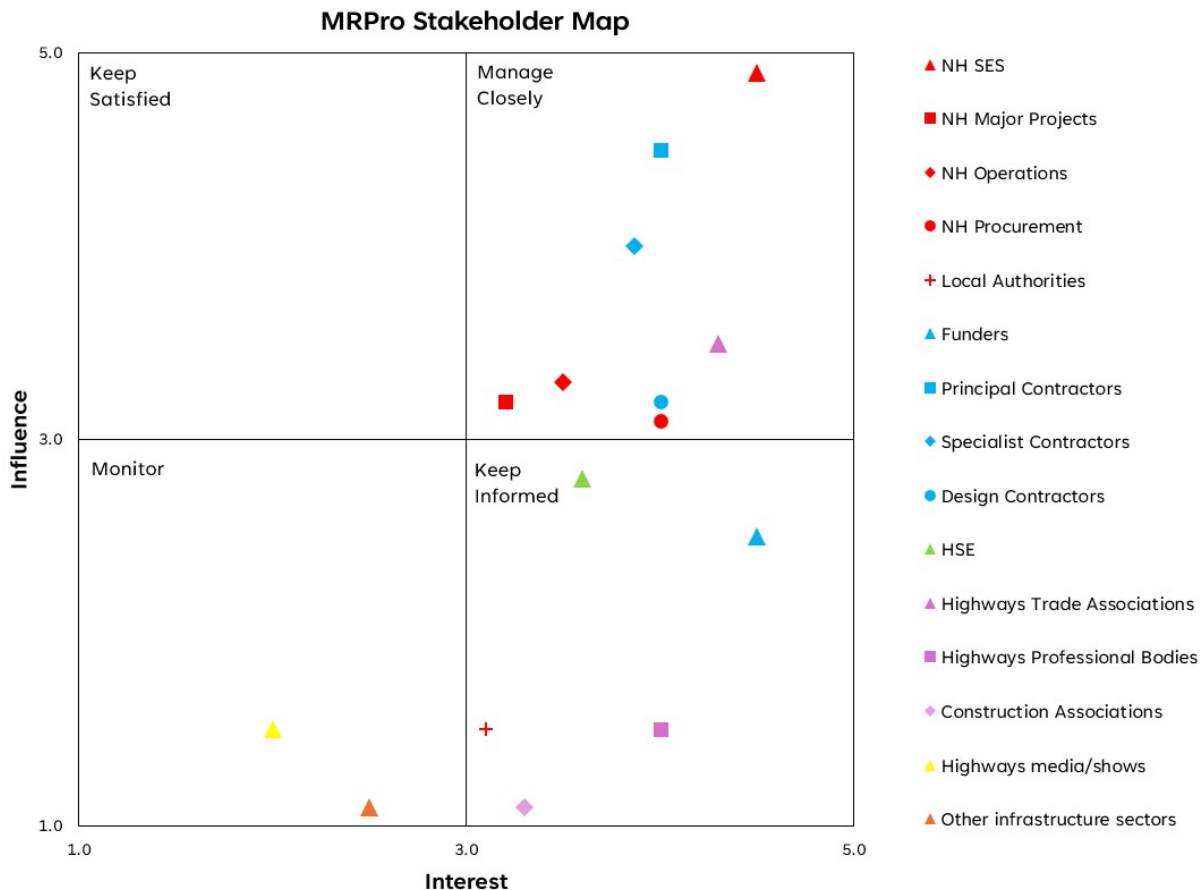


Figure A6 MRPro Stakeholder map

2. Communication and engagement

Our research was launched by the Supply Chain Safety Leadership Group (SCSLG) and subsequently managed through regular communication with the Highways Safety Hub (HSH) and Principal Designer Working Group (PDWG). We also recruited over 80 MRPro champions from across the highways supply chain. These individuals acted as the conduit for our MRPro communications with their company and provided relevant participants for our focus groups.

During the course of the research we also connected with a number of other groups and organisations both within and outside the highways sector including, National Highways Engagement Council, National Highways Major Projects Forum, National Highways Operations HSW Managers group, National Highways Commercial Managers forum, various National Highways Procurement community groups, the Institute of Highways Engineers (IHE), the Chartered Institute of Highways and Transportation (CIHT), the Traffic

Management Contractors Association (TMCA), the Road Safety Markings Association (RSMA), the Supply Chain Sustainability School (SCSS), Local Council Road Improvements Group (LCRIG), the Health and Safety Executive (HSE) Prevention Programme, HSE Science Centre Ergonomics group and Network Rail.

These connections helped us shape our research, gather data and establish channels for the communication of the results and recommendations to the industry.

3. Work Breakdown Structure

We needed to understand how highways build, renewals, maintenance, testing and operations are structured into work tasks to ensure that when we gathered relevant data, no area or discipline within the scope of on-road delivery for any works was missed.

National Highways Band and Lot structure is the top level of the Scheme Delivery Framework (SDF). Behind this high level overview lies a detailed WBS for every type of product and service covered under the SDF and PDF (Pavement Delivery Framework) contracts. This provided a clear view of the WBS for these works. In addition to this we needed to add in three further aspects to ensure our view of the WBS was comprehensive for the whole SRN.

- **M&R (Maintenance and Response)** services are delivered via Operations regions through a specified M&R contractor for each region. National Highways Supplier Relationship Managers provided the relevant contractor connections for us.
- **Major Projects** use large Tier 1 Main contractors, through the Regional Delivery Partnerships (RDP) framework, who maintain their own supply chains. Some of these contractors lie outside the SDF and PDF so it was necessary to connect directly with the large Tier 1's to understand the job families involved in their type of works. For example earthworks and piling contractors will be used much more frequently in Major Projects new build work than in renewals works performed under SDF/PDF.
- **National Highways on-road employees** covers directly employed staff such as Traffic Officers, Construction Assurance Managers and Inspectors. These are managed through Operations regionally. After discussions with the Operations HSW team it was decided that the key group to include from an MSk risk perspective was Traffic Officers.

Pulling all of this together, as shown in Figure A7, provided a comprehensive picture of the WBS for on-road activities on the SRN.

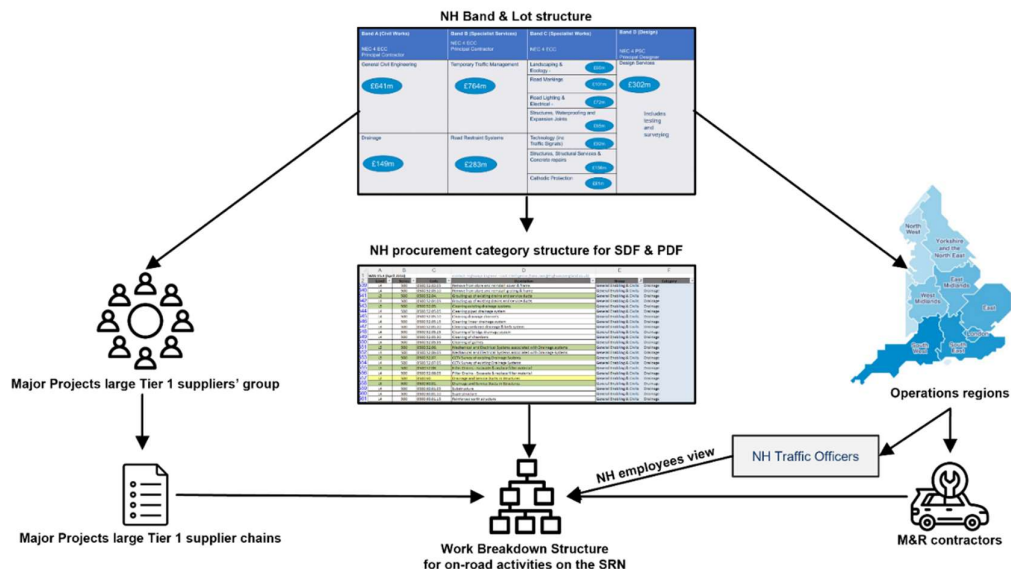


Figure A7 Constructing highways WBS

4. Focus groups to identify high-risk tasks

We organised 23 online focus groups, each lasting one hour, mapped to the work breakdown structure. Each group had up to 8 participants, most had 6 or 7. There were 135 attendees overall, who were typically managers, specialists or H&S professionals; many had experience of frontline work. Some participants attended more than one focus group.

The main question we asked was “Which tasks in this area of work worry you the most in terms of musculoskeletal risk? Which tasks are most likely to cause aches and pains or injuries to muscles and joints over the years someone is in a job?” For the tasks identified, we asked participants to share more detail about the activity: what loads were being handled, where, how far and in what circumstances (e.g. space constraints, bad weather). We asked them to share photographs to illustrate tasks and the risk factors involved.

We also talked about the workforce, particularly the impact of getting older; and what the specific challenges are for new or inexperienced workers. Finally, we discussed solutions to MSk risk, either ones already in use or ones which could be adopted or developed; and what the barriers are to new solutions being introduced, shared and adopted.

One of the focus groups was organised for designers, and we asked different questions. We asked about the role of designers in reducing manual handling or posture risk for the workforce during construction or maintenance. We discussed whether designers had the skills and knowledge to do this effectively, what risks could be most successfully addressed through design solutions and what the barriers are to reducing MSk risk through design.

From these discussions we produced a list of 100 high-risk tasks, with around 3-6 identified in each group. Many of these were specific to work type. However, some tasks were common across many work areas, such as unloading and carrying bags of cement, lifting chamber and gulley covers and hand digging.

5. Surveys to refine list of high-risk tasks

We used surveys to narrow down the list of high-risk tasks and also to get information from a wider spread of people. There were ten different versions of the survey, targeted at different work areas. Each survey included a list of specific tasks (between 4 and 19, depending on job roles covered), and 20 common tasks and asked:

- How hazardous do you think these tasks are in terms of musculoskeletal injuries?
- Have we missed any key hazardous tasks?
- What solutions are commonly used?
- What other solutions might be helpful?
- Do you or your colleagues have aches and pains which you think are related to work?

The survey was created in Survey Monkey and could be completed on a phone, tablet or PC. It was anonymous, although people could add their contact details if they wished e.g. to share details of a good solution. Participants could also opt into a prize draw, with five people winning a £50 voucher.

The survey was completed by 285 individuals, summarised in Table A33 Summary of survey responses by work area. Of these 285 people, at least 139 (49%) had frontline experience of doing the tasks discussed; 86 were managers/supervisors, and 14 were H&S professionals (80 people did not answer the question).

Table A33 Summary of survey responses by work area

Work area	Number of responses
Pavement	93
Structures	65
Enabling works	10
Technology and Signage	32
Traffic management	41
Archaeology	19
Landscaping and vegetation	16
Ground Investigation	4
Scaffolding	0
Incident response	5
Total	285

We used the survey findings to identify the tasks which were of most concern: typically, those where more than 60% of survey respondents said the task was either high risk ('very problematic, high risk of long-term injury') or medium risk ('usually managed well but still causes long term pain for some people'). A few tasks were added to this list because the research team considered them high-risk based on focus group discussions, regardless of survey feedback; and a few tasks were removed because there was limited information about them, they were too variable to evaluate, or they were not very specific to highways work. The final list included 45 tasks.

6. Task risk analysis

For these tasks, we did a detailed analysis of risk.

- We gathered video footage and photographs from focus group participants and other contacts and supplemented these with publicly available materials where necessary.
- We scored the tasks using the HSE's MAC³³, RAPP³⁵ and ART³⁴ tools. For each task, we chose the most appropriate tool:
 - MAC: lifting (and lowering), carrying and team handling operations
 - ART: repetitive moving of the upper limbs (arms and hands)
 - RAPP: for manual pushing and pulling operations involving whole-body effort
- We assumed 'worst case' for assessments. For example, we assumed that weather was always bad, that distances or loads were the highest likely. Where multiple postures were adopted within a task, we chose the worst aspect.
- Based on assessments, we highlighted tasks which the HSE might identify as carrying a risk of significant harm, using criteria provided to HSE inspectors³⁶. This is typically tasks which involve a high or moderate load, as well as other high-risk characteristics such as twisting or bending.
- A small number of tasks (e.g. digging, working in restricted spaces) were not suited to assessment with any of the tools.

The HSE tools were chosen because they are based on robust scientific evidence, are quick and easy to use (by researchers and also in operational situations) and produce user friendly outputs which highlight the main aspects of risk.

The tools do not give definitive risk scores – the MAC and RAPP tools do not have a cut-off point to show what is 'acceptable' or 'unacceptable'. However, they can be used to compare different tasks of the same type e.g. which lifting task is highest risk, or which pushing/pulling task is highest risk, so that interventions can be prioritised.

6.1. Task frequency

The ART tool guidance includes ‘duration’ as a multiplier (so that ART Task Scores are reduced if tasks are done for less than a day or increased if they are done for longer than 8 hours). The MAC and RAPP tools do not fully take this into account. This is important because a task which is done for 8 hours a day, or carried out twenty or fifty times a day will have a higher cumulative risk than one which is done for only an hour or two or carried out only once or twice.

For each task on the list we did an estimate, based on focus group findings, of task frequency/duration: how many times a task is typically done in a day or how long it is done for (all day or part of the day). Based on the duration categories shown in the ART guidance, this was used to generate a multiplier for all Task scores (MAC, RAPP or ART) (**Error! Reference source not found.**). For ART tasks, this duration is shown separately from the Task scores in the summary tables to maintain consistency with MAC and RAPP scores.

Table A34 Risk multiplier, based on task frequency/duration

Task frequency/duration	Multiplier
Very frequent: more than 100 times per day, or done for longer than 8 hours	1.50
Frequent: 20–100 times per day or done for 4-8 hours	1.00
Moderate: 5-20 times per day, or done for 2-4 hours	0.75
Occasional: done up to five times per day or for less than 2 hours	0.50

A Final Score for each task was calculated based on the task score and the multiplier. Tasks were then determined to be medium, high or very high risk (Table A35)

Table A35 Categorisation of tasks, based on final scores

Tool used	Medium risk	High risk	Very high risk
ART	8 and lower	18 - 21	24 and above
MAC carry	Below 10	14-19	
MAC lift	Below 11	15-21	27 and above
MAC team		14-18	26 and above
RAPP wheeled	Below 8	12 and above	
RAPP not wheeled		12 - 16	
Not assessed		Qualitative assessment	

The categorisation used in Table A35 was pragmatic: we sorted tasks according to the tool used for assessment and prioritised them within that subset, taking into account researchers’ judgment and the comments about risk from focus groups etc. The cut-off points are non-continuous as they are based on actual scores.

6.2. Population exposure

We wanted to get an indication of how often tasks are carried out across the National Highways network. If a task is carried out by several hundred people each day or night, this means that a lot of people will benefit if the risk is reduced.

Where high risk tasks are carried out by a smaller number of people, **the risk still needs to be managed.** But it is more likely that this will be done at a local level or by those working within a specialist area; rather than being led by National Highways.

Through contact with commercial managers, we asked a wide range of National Highways' supply chain partners to estimate how often they do certain tasks (daily, weekly, monthly etc.). The responses were then combined to get a rough approximation across the entire network. We characterised population exposure as:

- Very high (e.g. many teams per area, every day)
- High (e.g. one or two teams per area, every day)
- Moderate (e.g. one team per area, once a week)
- Low (e.g. one team per area, once a month or less)

We scored all the 'common' tasks as 'very high' by default because workers in many different jobs do them and may do them most days.

This metric is an approximation, it is intended to be comparative rather than exact, to highlight the tasks which have the very highest exposures. Also, the data we collected were largely related to M&R, SDF and PDF contracts; they may underestimate exposures related to major projects.

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