

THE INCREASING IMPACT THAT CLIMATE CHANGE IS HAVING ON THE UK'S HIGHWAY MAINTENANCE SERVICE

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Abstract

Currently highways and their maintenance in the UK are designed based on historic climate. However, as the climate changes, they are being subjected to very different climatic conditions over their design life. The cost of not adapting could be vast in terms of disruption to traffic, public safety and infrastructure repairs. Climate change is already beginning to have an influence on UK highways – for example, drier summers causing more incidences of subsidence and periods of increased extreme rainfall creating a greater frequency of flooding. These kinds of weather events will become more frequent in the future.

The key implications of climate change for highway maintenance have been identified as:-

- Increased risk of flooding from rivers, streams and inadequate drainage.
- Deterioration and damage to highway structures from subsidence, severe and high temperatures.
- Increased risk of landslips.
- Damage to structures from high winds
- Increased road safety problems due to adverse driving conditions and deterioration of infrastructure.
- Prolonged growing season affecting highway verges, trees landscapes and biodiversity.
- Rising sea levels increasing the risk of erosion effecting coastal roads and footways.

The Department of Transport on the advice of the UK Roads Board funded a research project to investigate and provide national guidance on the impacts of climate. This guidance was published in June 2008.

The guidance considers the impacts of high and low temperatures on flexible and rigid pavements and their functions.

In terms of the consequences of an increase in extreme flooding events the Government commissioned a report to consider the whole issue of flood management in the UK. Consequently the Pitt report was published on 2008 making a number of recommendations including the need for Local Authorities to review the adequacy of the drainage infrastructure.

Increased landslips particularly in Scotland has led to a new approach of monitoring and managing high risk sites on the Scottish network roads.

Key Words: Climate change, adaptation, flooding

Introduction

Climate change is happening now and due to the inertia that exists in our climate, past greenhouse gas (including CO₂) emissions mean that changes are now inevitable over the next 40 years. After that period, any further climatic changes will be determined by a number of key factors, including: increases or reductions in local and global emissions, technological advances to reduce or mitigate

emissions and their effects, and any social change. Therefore, in the UK local authorities need to adapt their policies and standards for these inevitable changes to our climate for at least the next 40 years, and assist in reversing these changes thereafter by reducing CO₂ emissions now.

Historically, policy making decisions have been based on past climatic conditions but

now it is necessary to base them on predictions for the future so as to minimise the impact of changing weather patterns and events.

There is specific evidence that climate change is already having an influence on the UK's highways, specifically as a result of:

- Drier summers causing greater subsidence and pavement deterioration;
- Wetter winters and more severe heavy rain causing flooding and drainage related pavement failures; and
- Increased 'storminess' leading to increased damage to highway structures and increased safety concerns.

Climate change will not affect all areas of the UK uniformly. Drought and high temperatures are more of a threat in South-east England and flooding, storms and heavy rain are the biggest threat in Scotland. The impacts of climate change on pavements are influenced by factors including; soil type, geography, topography, geology, pavement condition and levels of trafficking.

Climate has a large influence on pavement construction and maintenance. Currently, past climate is used to plan construction and maintenance activities. However, changes in climate mean that practices currently used may not be appropriate for the future climate and therefore for the full life of the pavement. New highways are generally designed and constructed for a nominal design life of up to 40 years, with the expectation that periodic replacement of the surface course will occur every 10 to 15 years. Ensuring that highway construction and maintenance carried out now is suitable for the future climate is essential in preventing premature deterioration over time.

The affect of climate change on road pavements

The climate has always been one of the primary factors that affect the performance of both carriageway and footway pavements. However, the extent to which climate affects the pavement also depends on many other factors, such as the characteristics of the

pavement (materials, structure and condition), drainage, underlying geology, topography and traffic. Each of these may in itself present a hazard to the pavement. In general, the consequences of these hazards are deterioration of the surface, underlying layers and structure of the pavement, and occasionally, in the event of extreme weather, catastrophic failure. The hazards are also inter-linked, for example rutting due to heavy traffic increases at high temperatures.

The performance of asphalt pavements is affected by climate, in particular temperature and moisture. The climate impacts on the materials within the pavement, from the asphalt surface course, through the main structural layers down to the subgrade. These functions are interdependent, because structural failure of the base will affect the surface layers, and damage to the surface layers can lead to deterioration of the lower layers.

It is recommended the following measures to be taken to avoid future damage of road surfacing:

- Undertake a risk assessment to identify the most vulnerable areas of the network and develop priority actions to be carried out. Implement a targeted programme of improvement
- Ensure asset management plans take account of adaptations required for climate change in resurfacing programmes
- Review new material and treatment choices and specify appropriate replacements
- Use polymer modified binders that are less prone to binder stripping and other materials with a greater 'stiffness'

Example of hot temperatures damaging asphalt pavements

The exceptional heat in the summer of 2006 caused significant damage to the rural highways of Leicestershire. As a lot of these roads have evolved from cart tracks, they often consist of only a thin bituminous surfacing on top of the granular layers that have then been maintained over the years with multiple surfacing dressings. The lack of

full depth asphalt construction, as is found on the county's trunk and principal roads, makes the rural highways more vulnerable to climate change. In July 2006 around 80km of these roads were damaged by the high temperatures. The softened road surface led to rapid formation of clusters of potholes and wheel-track rutting. Loss of texture depth resulted in a decreased skid resistance. The loss of skid resistance is particularly dangerous to motorcyclists and cyclists. Leicestershire County Council used salt spreaders to apply dust to the road surface, temporarily filled the potholes and patched repairs. An approximate average cost of undertaking more permanent repairs to these roads, by a thin resurfacing to 'seal' the surface and prepare it for future dressing, would cost in the order of £2 million. This expenditure would decrease the budget available to maintain the County's busier roads and meet performance targets. The Highways and Transportation Department has applied for additional funding to help adapt these roads to the higher temperatures expected from climate change.

Recommended measures taken to avoid damage to bridges and other structures

- Carry out a risk assessment to identify which structures are most at risk from climate change. Identify the nature and frequency of changes that are needed to the inspection and maintenance regimes of bridges and other structures
- Increase the number and frequency of maintenance works carried out to increase the BCI values for bridges assessed as liable to risks from climate change. Ensure that all strengthening and repair work that is outstanding for failed or below standard bridges is carried out
- Carry out flood studies with the help of other agencies and organisations
- Ensure that all data (new and historical) is transferred into a single system to make assessments of maintenance and repair priorities, and needs, more effective

Affect of increased rainfall

There is recognition that increased rainfall is the most significant risk to highway, as

evidenced by recent events in the UK. Sections of highway will be prone to flooding for which it may be too costly or impossible to implement flood protection measures (usually the responsibility of the Environment Agency). These areas at risk need to be identified and included in the asset management system so that assets on these sections can be managed and maintained to reflect the conditions.

It is recommended that UK local authorities invest in asset management and location reviews, carry out drainage surveys and improve the knowledge of drainage assets, hydraulic capacity and ownership, and carry out flood studies with the help of other agencies and organisations. Risk assessments should be undertaken to determine vulnerable areas and establish a prioritised scheme for maintenance.

The Pitt Report

In June 2008, a report by the Cabinet Office was released which looked at the flooding that occurred in the UK during the summer of 2007. This report, 'The Pitt Review: Learning lessons from the 2007 floods', summarises the flooding that took place and looks at methods of planning for and forecasting flooding, responses to flooding, the recovery process, and methods of reducing the risk of flooding and its impacts. The review uses evidence from public experience and opinion throughout the document and direct quotes from those affected are featured throughout.

The Pitt Review presents recommendations for improved action and response in the future and also information on how these recommendations can be delivered. Attention is specifically paid to aspects of; leadership in central government, oversight at the local level, and scrutiny at the regional and local level. In response to these findings the UK Government is currently consulting on the draft Flood and Water Management Bill. The draft legislation recommends:-

- that upper tier authority take a lead role for flood risk management
- local surface water management plans are produced
- all local flood risk assets are mapped and ownership established

- all sustainable urban drainage systems (SUDS) are adopted and maintained
- upper tier authorities are given powers for emergency works to water courses and to manage local water courses

The impact of climate change on verge maintenance

Increased annual temperatures and higher levels of precipitation in the winter will lead to increased annual grass growth and growing season. A response to this would be to increase the frequency that grass cutting activities are carried out and also to increase the grass cutting season (currently typically carried out March to October). However, hotter and drier summers would mean that growth in the hottest summer months (June to August) will be reduced thus reducing the need for grass cutting activities to be carried out during these months.

With regard to tree and hedge maintenance, measures should be taken to improve the knowledge of existing tree stock. Undertake a risk assessment to determine vulnerable trees and establish a prioritised scheme for maintenance. Increase the frequency of tree and hedge inspections and maintenance. A review of the species choice for new trees to ensure the most appropriate species is selected.

Increased Wind Speed

Increased wind strength and storms may lead to increased damage to the pavement surface from debris such as structures, trees and overturned vehicles. Maintenance activities may also need to be scheduled to avoid health and safety issues for workers. Increased wind speeds will reduce the window when asphalt can be laid successfully, because wind speed has a significant influence on the rate of cooling.

Rising Sea Levels

Rising sea level and storm surges may cause permanent immersion, tidal immersion and an increased impact of salt content. The increased sea levels predicted in 2050, combined with increased wind speed, may result in greater coastal erosion, affecting coastal roads and footways, particularly in the South East of the UK

Winter Service

It is generally accepted that although weather is likely to be milder and wetter in winter, there may be more occurrences of severe weather events. Recently published UK Climate Projections say:

- The annual number of days with air frost has reduced in all regions of the UK between 1961 and 2006. There are now typically between 20 and 30 fewer days of air frost per year, compared to the 1960s, with the largest reductions in northern England and Scotland.
- There has been an increase in average winter precipitation in all regions of the UK between 1961 and 2006, however this trend is only statistically significant above background natural variation in Northern England and Scotland where increases of 30 to 65% have been experienced.

The effects of climate change have made it far more difficult for highway authorities to predict conditions from year to year. A succession of mild winters inevitably resulted in some assuming that such conditions might continue, but last winter proved that was not to be the case. Increased frequency and intensity of severe events is a known consequence of climate change and needs to be taken into account in winter service planning.

It is recommended that as a result of climate change the following actions for the winter services be undertaken:-

- Carry out risk assessment surveys to establish which routes have the highest risk of ice formation
- Re-assess and re-classify priority routes based on future climate change predictions
- Review established resources for winter service provision and consider if changes need to be made
- Provide a more flexible and responsive winter service

Landslides in Scotland

Transport Scotland instigated the Scottish Road Network Landslides Study in August 2004, when extensive and excessive rainfall caused a number of serious landslides which adversely affected the operation of the strategic network.

During that month, some areas of central and western Scotland experienced levels of rainfall more than three times the average for the time of year including intense storms. As a result a large number of landslides – more specifically *debris flows*, a particular type of landslide – was experienced in the hills of Scotland. Among those which reached the trunk road network were those on the A85 in Glen Ogle, the A83 at Glen Kinglas and Cairndow, and the A9 north of Dunkeld.

Debris flows occur with some frequency in the hills of Scotland and although these only rarely affect the main road network, when they do they can have a major effect on communities, the economy and public safety.

Fortunately, during the events of August 2004 there were no injuries, but other factors were significant. Road closures and long diversions had the effect of restricting access to already relatively remote communities and were a substantial inconvenience to road users. This included tourist traffic, which is generally at its peak in the summer months when landslides can often occur.

In light of the above, and acknowledging that climate change may further increase the prevalence of landslides, Transport Scotland recognised the need to act.

The first part of the Scottish Road Network Landslides Study considered the cause and effect of landslides and proposed the development system for assessing and ranking the hazards posed by debris flows. (A second study, the Scottish Road Network Climate Change Study, examined the distinct, but related, issue of climate change and its broader impacts on the road network) The system for assessing and ranking debris flows has since been developed and applied across the entire coverage area of Scotland's trunk road network.

The introduction of a hazard assessment process

The hazard assessment process involves the graphical information system (GIS)-based spatial determination of zones of susceptibility which are then related to the trunk road network by means of plausible flow paths to determine specific hazard locations. This approach enabled the rapid analysis of large volumes of data. This desk-based approach to hazard assessment was then supplemented by site-specific inspections to give a hazard score for each site of interest.

The subsequent hazard ranking involved the development of exposure scores predicated primarily upon the risk to life and limb, but also taking some account of the socio-economic impact of debris flow events. The exposure scores were combined with the hazard scores to give site-specific scores for hazard ranking from which a listing of high hazard ranking sites in Scotland was produced.

Processes for the management and mitigation of debris flow hazards have been developed and two approaches are described:

- Exposure reduction, which involves for example education, warning, signing and road closure
- Hazard reduction, which includes engineering measures that protect the road, reduce the opportunity for debris flow to occur, or involve realignment of the road

Specific recommendations to achieve this and to further develop and improve the management process relate to:

- A series of management actions predicted towards exposure reduction.
- Opportunities for the physical hazard reduction on new works and rehabilitation schemes.
- The vital role of the development of rainfall-monitoring systems and interpretative techniques to enable pro-active warning of debris flows to be brought into play in future years.
- The value of studying the ongoing effects of climate change on the

prevalence of debris flows, of carrying out an evaluation of the economic effects of debris flow events, and working with the Forestry Commission in order to ensure that best practices are adopted in terms of forestry harvesting and hill slope stability.

- The need for a continuing site inspection programme to validate all four priorities of sites on the network, and the role of re-assessment and re-inspection at some time in the future.
- Consideration of actions relating to rock slope surveys.
- The need for separate assessment of scree-slope sections in Glen Coe and on Skye.

Conclusion

Climate change is having a real impact on the management and maintenance of highway networks. Highway authorities should assess the vulnerability of their highway networks to climate change. In doing so authorities should make full use of their local knowledge of their network and how it has been affected by extreme weather events in the past. Whilst each authority's risk assessment and solution will be unique, authorities will benefit from recording and sharing their experience of climate effects on their networks. The 3CAP study is an excellent example of how three local authorities have undertaken these assessments and identified the most effective adaptation responses based on a risk and possibility management approach.

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Biography

Matthew is a Director of Highways, Transportation and Waste Management for Leicestershire County Council. He is also both Chair of the UK Roads Board, the CSS Engineering Committee and Midland Highway Alliance Board.

He graduated with an honours degree in Civil Engineering at Cardiff, Diploma in Management Studies at Nottingham Trent University.

He has played a major role in the development of Highway Asset Management in the UK in leading projects to produce national guidance.

He has also prepared, published and presented a number of papers both in Europe and Australia on highways, transportation and traffic management.

Matthew has won a number of awards both for his personal contribution and on behalf of the organisations that he has worked for. Most notably this year, the UK National Transport Award for Outstanding Contribution to Local Transport. In 2008, the Constructing Excellence Achievers Award and in 2005, the UK Surveyor/ICE Municipal Boards Engineer of the year.

He has also been chairman for both the Institution of Civil Engineers and Institution of Highways and Transportation local Branch Committees in both the Midlands and East Anglia.



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