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Mitigating Risk and Future Management of UK Railway Track and Earthworks in an Emerging Extensive Climate Change Situation

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Abstract

This paper is the next in a series by the principal author and follows on from a significant change and refocusing of the strategy in the UK relating to the safety of railway passengers associated with events allegedly initiated by climate change events. These climatic events have become more prevalent in the last five years particularly those associated with severe storms usually crossing the Atlantic Ocean and affecting the British Isles. The methods adopted in the study involve analysing data from current investigations into earthwork stability, the consideration of reports and linking these back to current theory and practice of hot weather and storm management in the UK. The other area to be covered in this paper relates to global warming where increasing temperatures have an impact upon the ability of the steel rail systems to withstand the expansion and forces associated with the expansion properties of steel as a material when subject to ambient temperatures and exposure to direct sunlight. The authors have carried out research to establish areas of modelling and good practice and critically compare these and there are a series of recommendations which relate to management of temperature risk, ballast management and remote monitoring techniques.

Keywords: Climate change, Temperatures, Track maintenance, Buckles, ballast, Embankments.

1 Introduction

There has been significant change and refocusing of the strategy in the UK relating to the safety of railway passengers associated with events allegedly initiated by climate change events. The key incident that instigated this change was the fatal Carmont train accident in Scotland in August 2020 [1] where three people lost their lives when a train derailed following a collision with debris that had been washed onto the line.

These climatic events have become more prevalent in the last five years particularly those associated with severe storms usually crossing the Atlantic Ocean and affecting the British Isles. There is need to look at the stability of earthworks and associated drainage systems which were designed and constructed well over a hundred and fifty years ago when science, engineering and technology was limited especially the understanding of soil mechanics. This is now described as "legacy infrastructure" and was certainly not designed for the climatic conditions that would occur many years later. The other area to be covered in this paper relates to global warming where increasing temperatures have an impact upon the ability of the steel rail systems to withstand the expansion and forces associated with the expansion properties of steel as a material when subject to ambient temperatures and exposure to direct sunlight. The current system for dealing with unknown situations in hot weather is to impose what is known as "blanket speed restrictions" which can cover large sections of routes.

There have been a number of specific developments to mitigate risk which will be investigated for management of the assets involving a wide range of monitoring processes. In complex rail engineering systems, a risk-based approach towards safety is now accepted as being preferable to prescriptive line closures or very restrictive speed restrictions. It is obvious that safety on railways is paramount, however, this approach has to be linked to the overall context of transportation. Closing or restricting railways may overload other forms of transport and lead to further deaths or injuries on road systems. The authors have carried out research to establish areas of modelling and good practice and will critically compare these and make recommendations.

2 Methods

There are two aspects being considered for this paper. Railway earthwork stability in relation to recent problems and the aspects of temperature on rail and track management. The authors have analysed a series of reports and studies into the link between climate change and earthwork stability and degradation. The UK Rail Accident Investigation Branch has been investigating failures since 2009. A recent study into predicted climate change on the earthworks of the West Coast Mainline of the UK Rail Network" [2] and another study on future preparedness is considered [3]. To complete the analysis there are also technical articles in the engineering press which are being considered [4].

The other fundamental effect of a warming approach is weather instability which some researchers are suggesting is a combination of temperature rise and greenhouse gas distribution. If there is a range of density of gases combined with "holes" in the ozone layer, pressure distribution can be more varied and intense which can manifest in large and erratic air flow movements. These can have the main effect of causing more tropical type storms which move across the planet.[5][6]

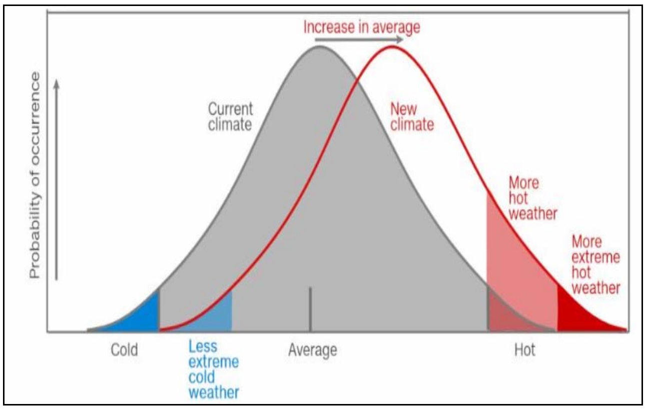

Figure 1 New Climate (CNN news)

Figure 2 UK Slope failure (courtesy T. Morgani)

The second aspect of the paper is the effect of global warming and extreme weather which is connected and although we have not had a repeat of the very hot summer in 2018 in the UK, there have been some notable unusual high temperatures in February and November which may "catch out" the maintainers who carry out hot and cold weather precautions on a planned seasonal basis. It is commonly believed across the UK in particular, that rail temperature is typically 1.5 times the value of air temperature as measured in degrees celsius, although it does depend upon a number of aspects such as the amount of direct sunlight particularly relating to the geographical positioning where north-south cuttings were more vulnerable than east-west. It is also dependent upon the prevailing wind and its direction. The UK current standards for emergency speed restrictions (ESR) are where air temperature > 36ºC impose a 45/90 mph ESR; > 41ºC impose a 30/60 mph; > 26ºC in UK impose a 30/60 mph ESR where there is inadequate ballast or low ballast shoulders. The figures shown as 30/60 are 30 mph for freight vehicles and 60 mph for bogied passenger.

3 Results

The UK government agency, RAIB, has since 2009 investigated 11 earthwork failures that resulted in debris being deposited on the railway and published reports on a range of landslips. Many were associated with drainage issues. the potential for events to occur at locations where examinations had not identified a high risk of failure, and the likelihood of precipitation triggering the event. The key recommendations indicated the importance of providing an effective drainage system. The main discovery from the Carmont accident [1] is the poor design, construction and maintenance of drainage systems in general and more importantly the lack of sufficient handover and quality assurance of completed work. Evidence indicates that there are many hundreds of such schemes not properly processed through UK CDM Regulations with a "health and safety file". This should be provided to the client in order to carry out maintenance, understand construction and make informed judgements about future enhancements including drainage provision.

Work was done by Sweeney in 2016 [7] and Morgani [2] in 2022, particularly, included the testing of earthwork material and the addition of water content to model seasonal variations and climate change associated additional precipitation. The results are shown below and indicate California Bearing Ratio reductions, ie reduced bearing capacity.

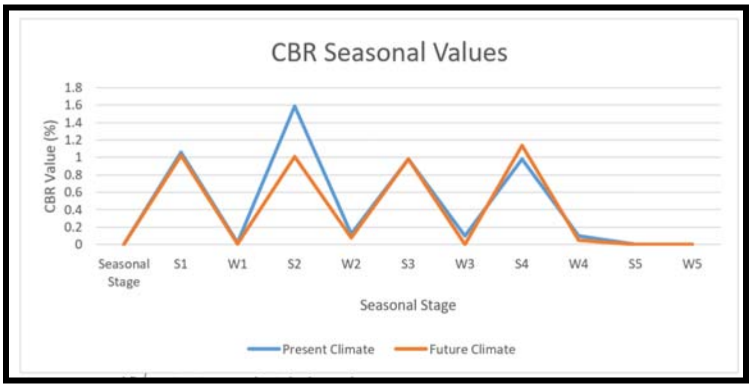

Figure 3 Seasonal Fluctuations in CBR value in both samples (Morgani, T)

The UK now has some interesting records regarding temperatures and in many places this will mean that special measures have to be taken for managing the weather impact upon general safety and for planning of maintenance. The influence of general higher temperatures in North Africa at + 2 ºC have led to increasing UK temperatures with a record in South England in July 2019 of a high of 38.7°C. In Scotland in January 2010 there was a low of -23.3ºC but in February 2019 there was a high of 20.6ºC caused by a Saharan wind. In July 2018, many areas of the UK saw temperatures exceed 30°C for over 15 days in a row which although it did not trigger the "blanket" arrangements, where ballast is short or the Critical Rail Temperature (CRT) is below 15 ºC a 30/60mph ESR is needed and this can have a major impact upon train performance. Data has been analysed [8] where ESR's may be needed mainly due to insufficient prestress.

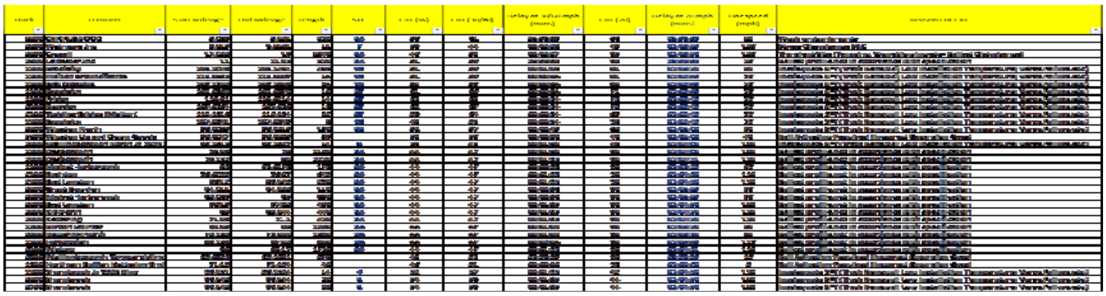

Figure 4 Data on Critical Rail Temperatures and Emergency Speed Restrictions (Chamberlain, S)

Figure 5 Continuously welded track showing ballast shortage where ESR will be applied above 26 ºC (B,Counter)

4 Conclusions and Contributions

The first area of study was embankment stability and drainage effectiveness. A risk register should be created with comprehensive criteria for assessment. Firstly, this needs to be related to historical evidence which can be extracted from previous incidents and track quality data. Secondly, it will be necessary to establish slope angle, related curvature, material and moisture content including efficacy of current drainage systems. Remote monitoring systems, motion sensors and CCTV should be installed that can be linked to train control systems. To enhance real time risk, a comprehensive meteorological prediction system will enhance knowledge to mitigate risk. It is essential also to establish neighbour's legal liabilities including land use regulations and educate them regarding risks to railway infrastructure. Also, the processes adopted could be transferred to the highway, river and canal sectors.

The second area of study is related to the effects of hot weather and how these can be mitigated and reduce performance problems whilst maintaining safety. The current standards for application of ESR's for hot weather should be reviewed and risk assessed for blanket speeds as it will not be long before the UK will have air temperatures above 36 ºC regularly and even 41 ºC.

Regarding the 26 ºC threshold limit for shortage of ballast this should be clearly identified and risk assessed, to avoid major performance issues. The other area of major concern is switch and crossing expansion which can also instigate railway points failures.

A track buckle or misalignment is not created solely by hot weather, other factors will exist such as ballast disturbance or deficiency, seized or incorrectly set rail joints, rail creep, poor top and line, or incomplete maintenance work. There is little evidence that low stress-free temperature (SFT) was the major cause. The current SFT of 27 ºC should increase by around + 6 ºC. There is much evidence that stress is rolled out over time so it may be better to have a higher SFT.

Research [8] has shown that 50% of the resistance to buckling at the sleeper comes from bottom friction and the rest is sleeper end and ballast shoulder resistance. The best immediate approach is to avoid ballast shortage and quickly correct geometrical deficiencies by more focused track quality related maintenance regime.

References

[1] RAIB Report, (2022) *Derailment of a passenger train at Carmont, Aberdeenshire 12 August 2020;* report published 10/03/2022.

[2] Morgani, T. (2022) *A Study into the Effects of Predicted Climate Change on the Earthworks of the West Coast Mainline of the UK Rail Network;* BEng(Hons) Dissertation University of Derby.

[3] Tomlinson-Wrenn, S. (2022) *Railway Infrastructure: Is the United Kingdom prepared for the future?;* MSc Dissertation University of Derby.

[4] Kennedy, C. (2022) *Getting to grips with the weather;* New Civil Engineer March 2022 Magazine of the Institution of Civil Engineers.

[5] Balasubramanian A. (2018) *Extreme Climatic (Weather) Events;* Centre for Advanced Studies in Earth Science University of Mysore.

[6] Network Rail (2017) *Cilmate Change adaptation Report,* Network Rail website www.networkrail.co.uk

[7] Sweeney, J. (2016) *Comparison of seasonal deterioration and subgrade erosion* PWI Journal Volume 134 Part 1

[8] Chamberlain, S (2022) *Hot weather operational impacts on the UK Rail Infrastructure* MSc Dissertation University of Derby.

[9] Franklin, A. (2017) *Track buckling resistance and the maintainer - How did we get where we are today? Some theory and lessons learned*, Network Rail Conferences.