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Road and Rail Infrastructure V

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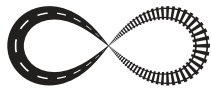
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RAIL INFRASTRUCTURE DEVELOPMENT AND CLIMATE CHANGE-CHALLENGES FOR RAIL OPERATORS

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Abstract

Significant interaction can be revealed between infrastructure operation of the railway line and climate change effects. Climate protection risk analysis can show us how we assess the climate change sensitivity of rail development projects: modernization of railway lines or railway electrifications. The rail transport facilities are usually less sensitive to the long-term changes in the average values of the climatic parameters – they are mainly affected by the extreme weather events. The planned rail infrastructure and the higher quality of transport services need adaptation strategies to be developed according to assessed risk levels. Strategies should focus on the main problems, like: a) Intensive damage of the earthwork and the substructure due to the rainfall, b) Medical meteorological effects on passengers (heat, UV rays) deterioration of the travel comfort, c) Decrease of the load bearing capacity due to the increase of water content, d) Increased dilatation moves (turnouts). This paper will describe why the application of such adaptation strategies can be advantageous for the European rail operator companies and how these documents provide opportunities for precursory planning and timing of maintenance activities.

Keywords: Rail operation, climate change, adaptation strategies

1 Introduction

If a rail infrastructure project belongs to the Annex II (ii) of the European Commission Implementing Regulation (EU) 215/2014 climate effects should be analysed. We used the European Commission guidelines [1] and national guidelines [2] as the methodology for evaluation of environmental and climate effects:

- Module 1: Identify the climate sensitivities of the project
- Module 2: Evaluate exposure to climate hazards
- Module 3: Assess vulnerability
- Module 4: Assess risks
- Module 5: Identify adaptation options

Regarding the climate risk exposure and life span, a project can be potentially affected by the climate. This means that climate change can cause physical damages and the quality of the services may degrade unless weather resistance is maintained. Suggestions for assessing project vulnerability and making the facility climate-proof are described in the following chapters.

2 Sensitivity analysis

The possible sensitivity of the general railway infrastructure to climate change is illustrated in Table 1. The larger potential effects are marked with red, the medium ones with orange and the smaller effects are green. The rail transport facilities are less susceptible to changes in the mean values of the climatic parameters over longer term but are mostly affected by extreme weather events.

Table 1 The potential climate impact on the railway transport facility

	Expected change of climate features	Expected impact		
		Physical infrastructure	Transport service	The impact of railway infrastructure on the environment
1	Increasing number of heat days and hot days (daily maximum $\geq 30/35$ °C)	Open fault of tracks. Increased dilatation movements.	Disturbance in the traffic due to the damage of the infrastructure. The damage of the infrastructure increases the risk of accidents. Negative medical and meteorological effects on passengers.	–
2	Increasing frequency and intensity of heat-waves (daily minimum ≥ 20 °C)	Open fault of tracks. Increased dilatation movements.	Disturbance in the traffic due to the damage of the infrastructure. The damage of the infrastructure increases the risk of accidents. Negative medical and meteorological effects on passengers.	–
3	Reduction of cold extremities / decreasing number of frosty days	Decreasing number of rail fractures, overhead line ruptures	–	–
4	Increasing length of droughty periods	–	Due to the limitations of free visibility increasing probability of sandstorms affecting visibility and higher risk of accidents	–
5	Decreased cloud formation and rising time of UV radiation	–	Unfavourable medical and meteorological effects on passengers, loss of comfort	–
6	Increasing intensity of precipitation	Damage of the soil structure and the earthwork substructure (wash-out or cracking of the basis, sagging, decreasing stability of the railway embankment). Increased risk of damage caused by movement.	Sudden floods may hinder the traffic and the accessibility of the platforms when the underpasses and the low-lying traffic facilities get flooded. Deteriorating comfort and accessibility of the platforms. The increased water content weakens the bearing capacity of the soil therefore traffic limitation may be required.	The railway infrastructure prevent the flow of the water from the surrounding areas
7	Increasing number and intensity of stormy weather events and rainstorms	Overloading of the drainage system. Damage of the additional infrastructure (e.g. lighting, barriers, etc.)	Increased risk of accidents.	–
8	Inland waters	–	–	The railway line facilities prevent the flow of the water from the surrounding areas
9	Floods	The increased water content weakens the bearing capacity of the soil. Wash-out of the soil and the rail system.	Sudden floods may hinder the traffic when certain traffic facilities get flooded. Traffic limitation may be required due to the weakened bearing capacity of the soil.	The railway line facilities prevent the flow of the water from the surrounding areas
10	Transformation and weakening of forest flora and fauna, spread of invasive species, disease and pests	–	–	Mass spread of some invasive plant species on the railway embankments

With the increase in the number of heat days and the frequency of heat-waves, the risk of the open fault of tracks is more common, and the dilatation movements also will increase in the case of built structures. Open fault of tracks might cause disturbance in traffic. Nevertheless, the medical and meteorological effects of heat are unfavourable to rail and road users, the

risk of accidents may increase. The increase in lengths of droughty periods is associated with decreased cloud formation and rising time of UV radiation. During the rainless, dry periods sandstorms occur more easily which are deteriorating the visibility and increase the risk of accidents. The increase in UV radiation has negative medical and meteorological effects on passengers. The increasing intensity of precipitation may damage the structure of the soil and the earthwork substructure, causing the wash-out or cracking of the basis, sagging, decreasing stability of railway embankment. Stormy weather events, sudden floods may cause overflowing in the drainage system, damage the supplementary infrastructure, hinder the traffic and the accessibility of the platforms when the underpasses and the low-lying traffic facilities get flooded.

In the case of flooding and inland waters the railway line facilities prevent the flow of the water from the surrounding areas, while prolonged flooding weakens the bearing capacity of the soil, therefore traffic limitation may be required. The neglected railway embankments provide an opportunity for the mass spread of some invasive plant species.

3 Adaptation Strategy

The compliance with the technical specifications for design and construction ensures the stability of the infrastructure and its resistance to weather conditions. The expected increase in rainfall intensity makes inevitable a review of the design process for drainage structures (increasing design limit values, installing spill-ways and temporary water storages).

The more frequent extreme weather events cause traffic disruptions – so they might need operational and maintenance interventions. A list of the adaptation options for the operating phase is shown in the following Table 2:

Table 2 Adaptation measures at the operational phase

Infrastructure	Proposed adaptation strategy
1 Open fault of tracks	<ul style="list-style-type: none"> · keeping the embedment in standard condition – especially in the arcs sensitive to open fault (closing the metal embedment arching upward) · monitoring the track temperature in the exposed curves
2 Increased dilatation moves (turnouts)	<ul style="list-style-type: none"> · speed limitation on the hot days at the crucial spots
3 Intensive damage of the earthwork and the substructure due to the rainfall	<ul style="list-style-type: none"> · cleaning regularly the water drainage systems, ensuring drainage · early recognition of water bags · regular status control of the soil mechanics
4 Overload of the drainage system	<ul style="list-style-type: none"> · cleaning regularly the water drainage systems, ensuring drainage
5 Damage of the additional infrastructure	–
Transport service	–
6 Hindrance of transport	<ul style="list-style-type: none"> · developing scenarios for the unexpected events, traffic management plans for the passenger transportation
7 Risk of accidents due to the damaged infrastructure	<ul style="list-style-type: none"> · Central Traffic Control / Remote control for overhead lines power supply signalling system · visual control of the line inspection
8 Medical meteorological risk of accidents	<ul style="list-style-type: none"> · preparation for the hot days · compliance with the work safety regulation
9 Decrease of the load bearing capacity due to the increase of the water content	<ul style="list-style-type: none"> · traffic limitation – weight limitation · early recognition of water bags · regular status control of the soil mechanics

Table 2 Adaptation measures at the operational phase (*continued*)

Effects of the railway infrastructure on the environment		
10	Hindered absorption of the water from the nearby areas	–
11	Medical meteorological effects on passengers (heat, UV rays) deterioration of the travel comfort	<ul style="list-style-type: none"> · shading the stations and the platforms, · ensuring access to drinking water · waiting rooms, protected platforms, wind screening walls
12	Invasive species of plants spread on the embankments	<ul style="list-style-type: none"> · control of the mass spread of invasive species (weed control) · plantation and care of indigenous species

4 Case Study – Railway Line Development between Budapest and Esztergom

In 2017 our planning group prepared grant application for the major project “Railway Line Development Between Budapest and Esztergom – Phase II: Electrification and additional construction works” to be financed from Cohesion Fund and from European Regional Development Fund. This project was one of the priority railway project of the Hungarian Integrated Transport Operational Programme (ITOP) in the programming period between 2014 and 2020. As a part of the grant application Climate Risk Assessment and Vulnerability Screening was done as well. The study followed the methodology described above.

While the previous chapters generally referred to rail infrastructure, this section presents a case study. We have found the following project specific and particular characteristics:

4.1 Project sensitivity analysis

The railway line is less sensitive for the increase in the number of heat days and the frequency of heat-waves. Newly built tracks are not at risk of open fault because of technological reasons. Increased dilatation movements may occur at turnouts.

4.2 Assessment of the location exposure

The exposure testing was performed on the following basis:

- National Adaptive Geospatial System (NATÉR) [4],
- Flood risk management – Preliminary risk assessment annexes of the country report (BLUE maps) [6],
- Earthquake Maps – <http://www.georisk.hu/Maps/maps.html> [7].

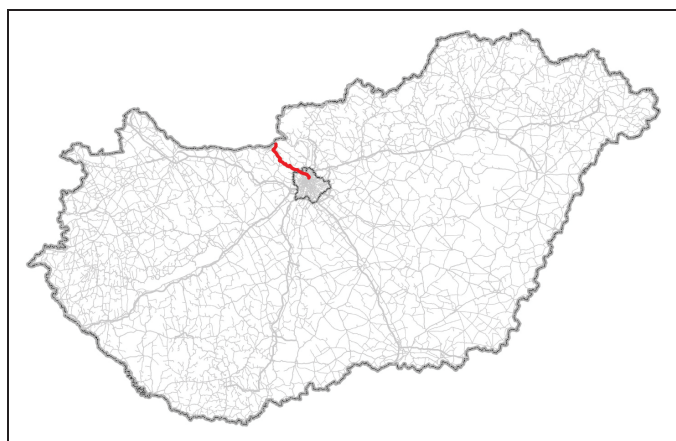


Figure 1 Location of the Budapest-Esztergom railway line

The railway line is located in the northern part of the country, Figure 1. This region is less exposed to the increase in the annual number of the hot days and heat alert days, to the increase of frequency and intensity of heat-waves, but more exposed to the increase in number and intensity of stormy weather events and thunderstorms.

4.3 Analysis of the potential effects

The potential effects depend on the project sensitivity and the degree of exposure to climate changes of project site. To evaluate the potential effect of the certain climatic parameters we have built up a sensitivity matrix. We found that potential effects of the following events are considered high:

- Stormy weather events,
- Increasing number of heat days and hot days
- Increasing frequency and intensity of heat-waves

‘Increasing intensity of precipitation’ is estimated to have medium potential effect, and in case of other events the extent of the exposure/sensitivity and so the potential damage is supposed to be low, such as:

- Inland water,
- Transformation and weakening of forest flora and fauna,
- Flood,
- Reduction of cold extremities,
- Increasing length of droughty periods,
- Rising time of UV radiation.

4.4 Risk assessment

The risk is a product of the extent of potential damage and the probability of occurrence. Impacts of climate change related phenomena on the physical infrastructure, on transport services and on the impact of transport facilities on the environment were taken into account, considering the consequences and estimating the probabilities of the adverse events:

Table 3 Risk assessment matrix

Probability	Consequence / Impact				
	Disastrous	Significant	Moderate	Slight	Insignificant
Al. certain	–	–	–	–	–
Very likely	–	–	–	–	–
Likely	–	Hindrance of the transport		Overload of the drainage system; Medical meteorological effects on passengers worse travel comfort	–
Unlikely	–	Open fault of tracks; Intensive damage of earthwork and substructure due to rainfall	Risk of accidents due to the damaged infrastructure	Increased dilatation moves; Hindering absorption of water from nearby areas	–
Rarely occurring	–	Medical meteorological risk of accidents	Decrease of load bearing capacity due to increase of water content	Invasive species of plants spread on the embankments	Damage of the additional infrastructure

The risks shown in the Table 3 above are indicated by green if the extent of the Impact/Probability is low, yellow if it is medium, orange, when it can be considered high, and red, if it is extreme high. The low risks can be often managed by the self-regulation of the system, but high and extreme risks need external intervention. For railway infrastructure managers it is crucial to identify such operational risks, and they have to face the challenges. It can result increasing operating costs and need for supplementary services and measures on the passenger side.

5 Conclusion

As a conclusion, the application of such adaptation strategies can be advantageous for the European rail operator companies, and these studies provide opportunities for precursory planning and timing of maintenance activities. The rail transport facilities are usually less sensitive to the long-term changes in the average values of the climatic parameters – they are mainly affected by the extreme weather events, like intense showers and thunderstorms. We cannot ignore the human factors, we should pay attention on passengers, train drivers and railway staff to compensate medical meteorological effects of extreme heat. The specific features of the investment in the case are the following:

- Newly built tracks are not at risk of open fault because of construction technological reasons,
- technical standards for design and specifications for construction partly involve the impact of climate change, still the design process for drainage structures need to be reviewed and adopted to the location,
- More focus on passenger infrastructure is needed.

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