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ENSURING THE NETWORK REMAINS OPERATIONAL DURING UNPRECEDENTED CONDITIONS

A PIARC BRIEFING NOTE - PROCEEDINGS FROM PIARC PANEL DISCUSSION AT HIGHWAYS UK IN OCTOBER 2024

TECHNICAL COMMITTEE 1.5 *DISASTER MANAGEMENT*

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2024– 2027 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

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AUTHORS/ ACKNOWLEDGEMENTS

This report has been prepared by Technical Committee 1.5 Disaster Management for the World Road Association (PIARC) following the presentations and panel discussions presented at Highways UK in October 2024.

The authors of this report are members of Technical Committee 1.5 Disaster Management and the panelists for the Highways UK presentation "Ensuring the network remains operational during unprecedented conditions" on 16th October 2024. All have made significant contributions to share the knowledge of how their countries and organisations deal with disaster management during extreme weather events. They are listed below in alphabetical order.

The panel were welcomed by:

- **Mr Dave BUTTERY UK 1st Delegate to PIARC, Chair of UK Roads Leadership Group and Department for Transport Director for Roads Strategy**

And

- **Mr John A. LAMB, UK representative for the Disaster Management Committee and Chair of the UK Adaptation, Biodiversity & Climate Board** (Ldr, WG3, TC1.5, PIARC)

Name	Country	Affiliation
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COWAN, Maureen	Canada	Regional Director, Transport Canada
DEEMING, Hugh	UK	Founder, HD Research
ENGELBRECHT, Chris	USA	Director Safety and Emergency Management Division Missouri Department of Transportation
GRIFFIN, Heather	UK	Principal Resilience Consultant, AtkinsRealis
LAMB, John	UK	Chair of the Adaptation, Biodiversity and Climate Change Board, UK Roads Leadership Group
MUNSLOW, Jonathan	UK	Chair – Climate Adaptation Subbord, UK Roads Leadership Group
OBATA, Yoshinori	Japan	Executive Director, Hanshin Expressway Research Institute for Advanced Technology
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Quality control of this document was carried out by Caroline EVANS, Australia, PIARC Strategic Theme Coordinator – Road Administration, and PIARC General Secretariat.

EXECUTIVE SUMMARY

2024R02EN

ENSURING THE NETWORK REMAINS OPERATIONAL DURING UNPRECEDENTED CONDITIONS - PROCEEDINGS FROM PIARC PANEL DISCUSSION AT HIGHWAYS UK IN OCTOBER 2024

A PIARC BRIEFING NOTE

PIARC TC Committee 1.5 Disaster Management is one of 21 PIARC committees for the 2024-2027 cycle. It's purpose is to advance research, share expertise, and promote international cooperation in disaster management. The committee is structered with 4 working groups, covering the topics of:

- WG1 Coping with Extreme Weather
- WG2 Social Resilience, Task Force Gender Inclusion and Diversity Issues in Disaster Management
- WG3 Infrastructure Resilience and the Supply Chain, and WG4 the update of the Disaster Management Manual.
- WG4: Update of Disaster Management Manual

Technical Committee 1.5 held the second committee meeting in the United Kingdom (UK) during the week commencing 14th October 2024. The Highways UK event was held on the 16th and 17th October, bringing together the people responsible for planning, developing, managing, maintaining and future proofing the UK's roads networks.

Members of TC 1.5 as experts in Disaster Management from across the globe, were asked to present and participate in a panel discussion at Highways UK "PIARC Disaster Management Committee Panel: Ensuring the network remains operational during unprecedented conditions." Highways UK is a major event for the highways and transportation industry in the UK that provides a conference, exhibition, and networking opportunities. This briefing note provides details on the thought provoking, highly relevant and applicable presentations and discussions taking place at this event. It was of high importance given the unprecedented extreme weather events that are occurring more and more frequently around the world. It also focused on the critical nature of our road networks in providing not only growth and well being to our economies but also the essential connections required for societies to thrive, as well as a vital necessity during our responses to these extreme events.

CONTENTS

1. INTRODUCTION

Highways UK requested PIARC TC 1.5 experts in Disaster Management to present and participate in a panel discussion titled ***Ensuring the network remains operational during unprecedented conditions***. The aim was to share best practice and lessons learned from around the world in disaster management activities responding to extreme weather events affecting road networks. Figure 1.1 shows the speakers and presenters for the session.

This report is structured to provide summaries of each presentation, a summary of the panel discussion, a wrap up and recommendations.

 **Jonathan Munslow** Chair – Climate Adaptation Sub board UK Roads Leadership Group	 **Kwanele Simelane** Project Manager South African National Roads Agency
 **Hugh Deeming** Founder HD Research	 **John Lamb** Chair of the Adaptation, Biodiversity and Climate Change Board UK Roads Leadership Group
 **Maureen Cowan** Regional Director Transport Canada	 **Yoshinori Obata** Executive Director Hanshin Expressway Research Institute of Advanced Technology
 **Yukio ADACHI** Senior Fellow Hanshin Expressway Co., Ltd.	 **Micheal Pearson** Director of Transportation, Vancouver Island British Columbia Ministry of Transportation and Infrastructure
 **Chris Engelbrecht** Director – Safety & Emergency Management Division Missouri Department of Transportation	 **Carol Valentine** Head of Business Services Kent County, UK

Figure 1.1 Speakers and Presenters for Highways UK PIARC Disaster Management Panel Discussion

2. PRESENTATION SUMMARIES

John Lamb Chair of the Adaptation, Biodiversity and Climate Change Board of the UK Roads Leadership Group hosted and introduced the panel of presenters at the Highways UK event. John represents the UK on the PIARC Technical Committee 1.5 Disaster Management on behalf of the UK's Department for Transport. He welcomed the UK 1st Delegate to PIARC Mr Dave Buttery.

2.1. ATMOSPHERIC RIVER WEATHER EVENT, BRITISH COLUMBIA, CANADA

Mike Pearson, P. Eng. Director of Transportation, Vancouver Island District, British Columbia Ministry of Transportation and Infrastructure.

Maureen Cowan, Regional Director, Transportation Security and Emergency Preparedness, Transport Canada.

British Columbia is the third largest Province in Canada, behind Quebec and Ontario. It is roughly 4 times the size of the UK. The geography is very diverse in British Columbia with mountains covering 75% of the Province, along with 26,000km of coastline. In terms of transportation infrastructure, there are 46,000km of highways, 3 Class 1 Railways, 2 Major Ports (Vancouver being Canada's largest) and 25 Coastal Ferries.

2021 was a particularly challenging year for British Columbia with multiple events occurring (including being in midst of the COVID pandemic). These tested emergency response plans and capabilities on multiple fronts including flooding, fire, heat dome, and the total destruction of the remote Village of Lytton (population 210 people). The main event was the Atmospheric River event in November 2021, which had devastating impacts on the southwest corner of the Province and negatively affected supply chains across Canada.

This presentation covered how these events have shaped Transport Canada's current thinking. This led to the development of the National Supply Chain Strategy as Canada continues to improve and fine-tune the countries approach to climate adaptation and the resilience of the transportation system, infrastructure and supply chain.

On the Southwest Coast of British Columbia, a lot of rain is expected in the months of October, November and December 2025. In fact, the rainiest place in all of Canada is Henderson Lake on Vancouver Island with an annual average of 6.9 metres of rain. Three days before the event, when the first Atmospheric River was forecast, it was not unexpected for the time of year. See Figure 2.1. It was a significant event that did trigger flood warnings and travel advisories, but again, not unexpected for this time of year.

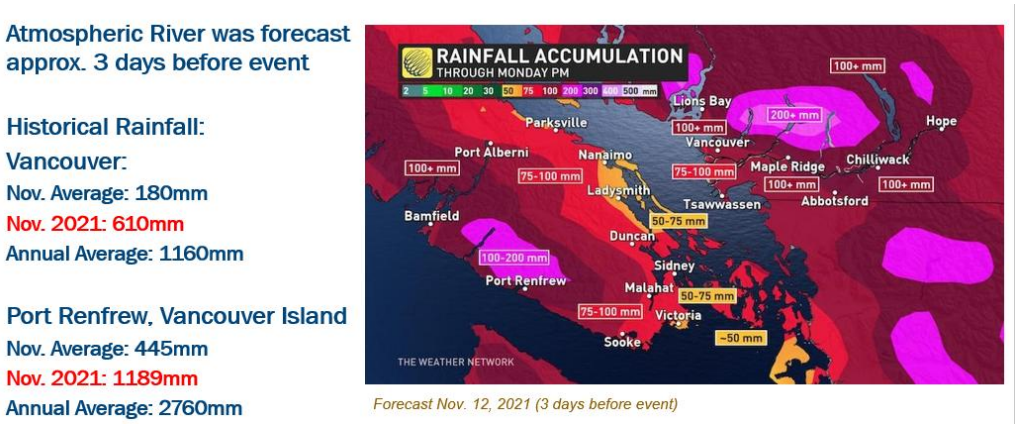

Figure 2.1 Rainfall Accumulation through Monday PM

The Province is the lead agency for the operational response and recovery during natural disasters. Mike Pearson's role is central in the response and includes coordinating operational staff the field, collecting and sharing information on infrastructure damage, and prioritizing and allocating resources (engineering, equipment, construction). A critical part of the successful response to this event was the coordinated response and close collaboration with the Federal Government, the Provincial Government, Local Governments, Indigenous Communities and Members of the Transportation Industry.

To collect field information quickly (i.e. carry out a rapid impact assessment) the Province is currently using a mobile app called "Survey123". This application is used in normal day to day business for identifying maintenance issues and auditing contractors, hence operational staff are very familiar with using it. This proved extremely helpful for the operational emergency response. Field staff were able to quickly conduct rapid assessments of highway corridors and major structures with photo evidence and field notes. This information was used by the Emergency Operation Center(s) to coordinate and prioritize the use of Engineering resources, equipment, and mobilizing construction contractors.

In Canada, almost all jurisdictions use the Incident Command System structure. This proved to be extremely effective in organizing internal resources and information sharing. Because of the common Emergency Operating Center structure, the coordination and information flow between authorities was standardized. This allowed all agencies to disseminate information quickly and to adapt to rapidly changing conditions, utilizing new information to reallocate resources and reprioritize actions as needed. It also allowed those agencies and industry dealing with issues outside of the immediate response (like the supply chain and agricultural impacts) to have informed discussions and carry out effective decision making.

In a transportation emergency like the 2021 Atmospheric River, Transport Canada's Emergency Preparedness team plays a critical role. They are the eyes and ears of the Minister of Transport; gathering and sharing information, as well as actively engaging and collaborating with partners (other federal departments, provincial authorities, local governments, indigenous communities, and the transportation industry).

Another federal role is to provide advice and guidance. In the case of Maureen Cowan's department, they provide information regarding federally regulated transportation (air, marine, rail) and can assist by exercising federal regulatory authorities and leveraging expertise. For

example, Transport Canada can restrict airspace to help facilitate an efficient and safe response from the air and issue emergency directions and orders to help facilitate evacuations. The Federal role also ensures responsiveness to formal requests for assistance that may come from the Provinces and/or territories. These requests can take many forms, such as requests for financial resources, requests for personnel with Incident Command Systems Training to provide surge capacity and sustainability for the response, specialized aviation and marine assets, and military resources).

In addition, Safety and Security are paramount during any emergency response and the Government of Canada also has the role of ensuring that the response activities taking place are conducted in accordance with federal safety and security legislative requirements.

Lessons Learned

The consequences of the November 2021 Atmospheric River were not localised; with Vancouver as Canada's Pacific Gateway, the impact in British Columbia negatively affected the already stressed national trade flows and supply chains. The extent of the damage from the atmospheric river event completely cut off British Columbia's Lower Mainland and Fraser Valley by land (road and rail) from the rest of Canada for 3 days.

Whilst secondary highway routes were opened within days of the initial event, these highways were not designed for high volumes of traffic and as such, were restricted to commercial vehicles and essential service vehicles only. Subsequent rainfalls impacted these routes as well, resulting in an incredibly fragile connection to Canada.

Highway 5 (the main freeway and trade corridor) was opened 35 days after the event. Three Canadian Class 1 railways were also disrupted for 20 days by mudslides and washouts that severely damaged or destroyed transportation infrastructure. This had the compounding effect of cutting off transportation to/from the Port of Vancouver (the largest port in Canada and fourth largest in North America) resulting in a decrease of 80% of shipping container traffic by early December 2021.

The Atmospheric River of 2021 hindered the movement of goods estimated to be more than $170 million per day due to lost train capacity, increased congestion at the Port of Vancouver and lost output (i.e., production cuts and lost imports/exports).

Total estimated cost from the Atmospheric River:

- ~ $4B to date
- ~ $675M in insured damages
- 5 deaths
- ~600,000 livestock lost

Total climate induced event 2021 losses (estimated, these are difficult to quantify and could likely increase)

- ~$7B
- 1.4M livestock
- 626 deaths

As a result of this event, a Canadian National Transportation Supply Chain Strategy was developed to identify locations most susceptible to climate-related natural disasters, prioritize investment in key trade corridors, develop working groups and increase engagement with industry and to collect and share supply chain information more openly. This work is being led by the National Supply Chain Office, put in place by Canada's Minister of Transport in December 2023.

The extensive damage to the BC Provincial Highway network has influenced how we are adapting our design guidance to "build back better." In addition to the adaptation of our design guidance for infrastructure we are also exploring new ways to systematically look at our highway network vulnerability and resilience, and to prioritize our investment in key trade corridors to reduce the future risk to the supply chain.

2.2. UK'S 1ST NATIONAL RESILIENCE TO EXTREME WEATHER (HAZARDS) SURVEY

Dr Hugh Deeming, Research Consultant, HD Research Ltd. for UK Roads Leadership Group (UKRLG)

In November 2023 the UK Roads Leadership Group (UKRLG) carried out a first of its kind Winter Hazards survey. Moving beyond the traditional Winter Service data collection (e.g. size of salt stocks), the Hazards survey was designed to explore Local Highway Authorities' experiences with a range of hazards that are being enhanced by climate change (i.e., hazards whose effects are increasing in frequency, intensity, and/or magnitude, as a result of the warming climate).

The need for this survey had been identified in a review of the sector's Lessons from Extreme Weather Emergencies. That review identified that whilst the sector had become extremely proficient at managing snow and ice risk as business-as-usual, its ability to effectively manage the increasing frequency and intensity of other weather hazards (e.g. floods, heatwave) was being constrained by an inconsistent understanding of the nation's 200+ highway authorities' hazard exposure and network vulnerabilities.

From an adaptation perspective, the Hazards survey was designed to create a baseline understanding of the entire national highway network's exposure to winter, flood, heat, and geo-hazard risks.

Lessons Learned

Unsurprisingly, the survey found that hazard exposure and the experience of hazards varied across authorities. For example:

- whilst~ 25% of respondents (n =64) had experienced main river or coastal flooding during 2023, that figure doubled to 52% in respect to surface water flood incidents (i.e., a local authority responsibility)
- In terms of geo-hazards (e.g. landslides), whilst just over 23% of the national sample had experienced these in 2023, the analysis 'Pennine 17' authorities (i.e., authorities covering England's elevated central belt), this figure rose to 55%.

However, the survey also identified key differences in the processes authorities had in place to manage extreme weather events. For example, whilst a majority reported they proactively managed their drainage infrastructure, others were either used reactive or hotspot-only regimes.

Against this only 50% of those on reactive regimes reported they had processes in place to respond in a consistent way Red, Amber, or Yellow, weather warnings.

The UKRLG Hazards survey has revealed key differences in the way climate-change enhanced hazards are being experienced by highway authorities. Previous business-as-usual approaches that focused on developing competencies and capabilities in respect to managing winter hazards (snow and ice) are no longer sufficient to ensure the resilience of our lifeline highway network.

2.3. Rapid Impact Assessment - Deploying State of the Art in Resilience and Response

Jon Munslow, Chair Climate Adaptation Sub-board, UK Roads Leadership Group (UKRLG)

Jon presented on implementing Rapid Impact Assessment in a Local Highways Authority within the UK. The scale, breadth, and depth of impacts from extreme weather events are often not understood by local authorities and the multi-agency response, which is in turn impaired by transport impacts / the highway response. Roads and highways are increasingly being understood as 'community lifelines' and their stabilisation and restoration seen as critical elements of response and recovery during a disaster. However, road networks and processes have not been adapted to the extreme events we are experiencing more and more often as a result of climate change. In the UK there is a lack of concerted coordination and inclusion of Local Highway Authorities in planning by Local Resilience Forums.

An effective Rapid Impact Assessment informs the dynamic risk management of the ongoing situations on the ground, as an event unfolds across the highway network. It is a structured process that can be followed across multiple site locations to build a network level picture. It supports the defensible prioritisation of response and one version of the truth. A shared situational awareness.

Setting up a Rapid Impact Assessment such as Stormchain utilises a Desktop and Mobile App, awareness and training are essential on use of the app for the Local Highways Team but also across the wider Local Authority. The system should be used to provide assurance and engage with highways teams, strategic decision-making and communications teams and emergency planning teams. Involvement from wider teams such as local resilience partners and responders is crucial, as is the supply chain. Pre-event, use of the system should be tested and exercised to build muscle memory.

Key components:

- Incident Management, can be used to create shared situational awareness in control centres, etc., with information shareable with external partners,
- The Impact Matrix approach supports informed decision making
- Mobile RIA App – can be used on site,
- Forces good habits
- Supports the development of RIA competencies

Wider benefits of using a purpose-designed Rapid Impact Assessment system include its compatibility with business-as-usual operations (e.g. Out-of-hours; collision damage reporting), which can build and maintain muscle memory between major incidents. As a standardised data

collection procedure, it also supports recovery of third-party damage costs supports budgets and resourcing and takes stress and pressure off teams.

2.4. DIGITAL TWIN IN DISASTER MANAGEMENT

Yoshinori Obata, Director, Hanshin Expressway research institute for advanced technology.

Osaka is the second biggest city in Japan. Structures are getting older, where Kobe town has experienced severe collapsing due to earthquakes. Hanshin Expressway Infrastructure - Cyber Management System (Hi-CMS) has been developed to predict and evaluate the performance of structures during seismic events by using data analysis and simulations based on earthquakes. See Figure 2.2.

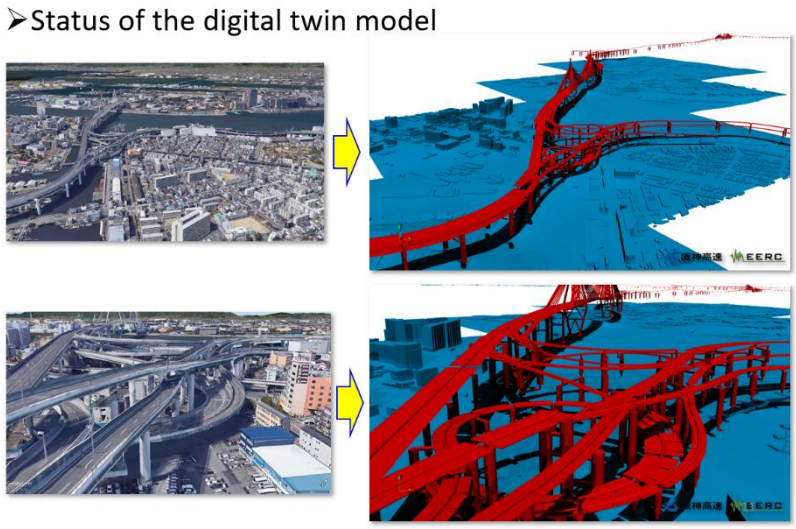

Figure 2.2 Status of the Digital Twin Model

The Expressway is required to work as a local lifeline under major disasters. To prevent and mitigate a disaster, there is a need to predict expressway damage before. It is possible to find which areas and routes would be severely damaged by simulating the seismic response of a wide-area of road network. Using this simulation, the aim is to improve disaster prevention and mitigation measures, such as seismic countermeasures and emergency transportation planning in advance.

With the development of IT technology, usage of digital twin for maintenance and management of infrastructure is progressing. The digital twin creates a virtual model of the structures that make up wider infrastructure, and use real-time data from sensors and data collection devices to reproduce the state and operation of the real-world structure in real time. If an unexpected earthquake occurs, digital twin can calculate dynamic analysis for seismic design at anytime, meaning a recovery plan can be developed quickly.

As disasters around the world become more severe, the use of digital twin technology will not only allow us to constantly monitor the condition of structures, but also make it easier to respond to disasters before and after they occur through simulation.

During and immediately following a disaster it is necessary to re-open highways as quickly as possible for multiple reasons, not least to assist in the disaster response, to allow emergency vehicles to use the highway, saving lives and protecting people. Utilising digital twin results for Business Continuity Plans in advance can assist by determining safe and accessible routes for people to use. See figure 2.3. .

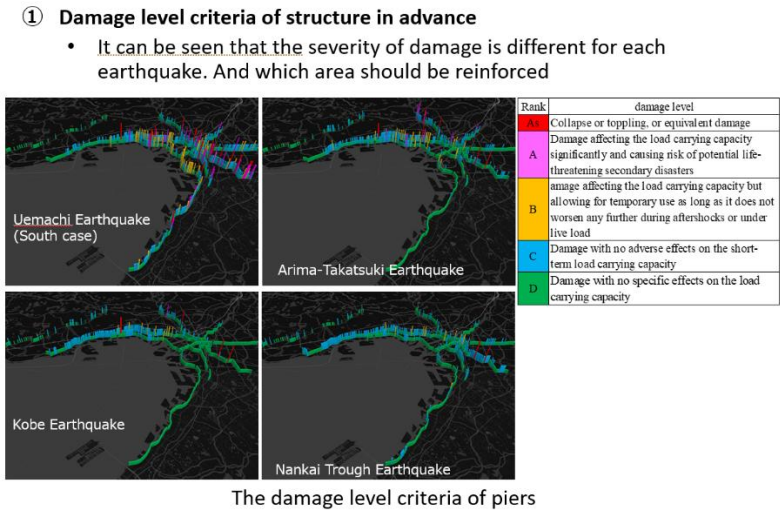

Figure 2.3 Damage level criteria of structure in advance

The digital twin technology in Hanshin Expressway does not allow real-time monitoring of conditions, and the simulation model is for earthquakes only. However, it is hoped that future technological innovation will make digital twin technology a tool that can be used easily and conveniently in real time. Continual investment in such technologies can bring positive benefits to future planning and response.

3. DISCUSSION

The presentations in section 2 were followed by a panel discussion with members of Technical Committee 1.5 Disaster Management, hosted by Chris Engelbrecht.

Chris Engelbrecht, Director Safety and Emergency Management Division, Missouri Department of Transportation, USA, PIARC Technical Committee 1.5 Disaster Management English Speaking Secretary.

Yukio Adachi, PIARC Chair of Technical Committee 1.5 Disaster Management, Senior fellow of Hanshin Expressway Company Ltd, Japan.

Kwanele Simelane, Project Manager, South African National Roads Agency, South Africa.

Carol Valentine, Chair of UK Winter research group.

3.1. LESSONS LEARNED FROM EXTREME WEATHER EVENTS

The discussion, led by Chris Engelbrecht, featured the lessons learned from the presentations.

Maureen Cowan responded that Transport Canada now have a National Supply Chain Office Strategy to prepare for and mitigate against the similar effects on the supply chain as were observed during the atmospheric river in 2021. Mike Pearson advised that at a provincial level, Canada is preparing the road network from an engineering perspective and adapting design standards, whilst looking across the entirety of the network at those critical routes.

Hugh Deeming and Jon Munslow discussed the importance of collaboration in early planning, as when an event occurs you're in the midst of dealing with the impacts, so there is a necessity to think critically about dependencies beforehand. In other words, looking at other critical services or lifeline services that are dependent on the road networks. The UK's National Underground Asset Register was discussed, and how utilising the register will help organisations better understand their risks and interdependencies.

Within the context of UK Highways, there is a need to improve communications prior to, during and after an event. Cross service, cross sector, cross industry communications need to evolve and be enhanced for extreme weather events, not just for winter resilience which the UK is well versed in responding to. Within the public sector and local authorities within the UK the information and expertise for planning for and responding to extreme weather events on road networks sits with a small number of operational staff for each authority.

Kwanele Simelane described the planning and response to the extreme weather events of recent years in South Africa. Kwanele explained about the droughts about 6-7 years ago, followed by floods 4 years later and the occurrence of snow / winter weather in 2023. This caused road networks in 8 out of 9 provinces to shut down due to snow during the spring season. Transport operators issued warnings to the public not to travel due to the infrequent and unfamiliar nature of the weather hazards. However, members of the public chose to travel to experience the snow first hand further causing issues with keeping the network open and operational.

In Japan Yukio Adachi advised of the shortage of engineers but increasing number of earthquakes meaning Japan cannot "build back better" necessarily. Liaison with technology companies is key in

this respect with the acknowledgment that sometimes technology can build back better than local government.

3.2. CUSTOMER EXPECTATIONS

A question from the audience was asked in relation to managing customer expectations during an extreme weather event, and the wider customer piece within communities.

Carol Valentine from Kent County Council talked about the necessity of clear communications before the event occurs, in relation to winter gritting in the UK where the extreme temperatures and snow and ice are expected and predicted in advance. In Kent information was rolled out to the public in October 2024 via social media entitled 'Gritter Twitter'. Here, the council engaged with the public and equipped local communities with the information and means to help themselves. For flooding, which is the main extreme weather event experienced in the UK due to climate change, work is done engaging with customers, the public, via the Local Resilience Forum, the multi-agency resilience forum operating at a local level.

Yukio Adachi described the policy for closing roads in Japan in response to rain, snow, typhoons, etc., and how it is well understood by the public. See Figure 3.1. Disaster Warning Levels are communicated out to the public well in advance at pre-planned times when an event is forecast / expected (for example at 48 hours prior to the event, 24 hours prior, 2 hours etc). Drivers / customers get used to the communications and are increasingly engaging in good behaviours following these sequenced weather warnings. These levels start with an alert and reminders to re-consider travel, check alerts etc, moving to orders for road closures and no travel.

Figure 3.1 Disaster Warning Levels, Japan

Hugh Deeming described the severe floods in Hull in the UK where thousands of properties were flooded. There was a lack of consistent impact data. Learning from the event Hugh described how the communications piece had to be built into the explanation, or the why, behind the mitigation measures at the time of implementation.

Within the UK, Jon Munslow described the Meteorological Office's (Met Office) improved weather warnings. Significant work has been carried out by the Met Office National Situation Centre in

communicating and engaging with the public and now potential individual or community actions to mitigate risks are provided in conjunction with weather warnings. This engagement and the information provided on weather warnings are clear and provided regularly (i.e., up to 5-days ahead). Although the complexity of weather forecasting can mean that there are still times when warnings can be escalated as an event evolves and with little notice, which means on-going research is still required.

Mike Pearson described the good coordination of agencies in emergency management at the Ministry of Transport in Canada. Here, an Incident Command System is used whereby communications go from a local level up to federal.

Jean-Francois Lepine, Director of Civil Safety at the Ministry of Transport in Quebec, and also a member of PIARC TC1.5 Disaster Management posed a question in respect to the importance of having staff with the skills to use the technology discussed. Carol Valentine advised for the UK there is great benefit in cross collaboration. Most of the technical support comes from consultancies, whereas operational staff within authorities are working on the “day job” and in response to events.

Kwanele Simelane reiterated the issues following the snow in 2023, with the key decisions to be made around closing the road and how to get the correct messages across to the community. In cases the community are very interested in actively participating / viewing the novel event rather than taking a precautionary approach. Essentially communications to communities are always harder as they want to see what is happening first hand.

3.3. TECHNOLOGIES IN DISASTER PREPAREDNESS AND RESPONSE

Chris Engelbrecht posed the question on use of digital twin for other hazards. Yoshinori Obata advised that at present in Osaka digital twin is utilised primarily for earthquakes, however there is the hope with investment that use can be expanded in future years. With a local government making a disaster map to inform hazards it should be easy to understand the possible areal extent of digital twin simulations.

Jon Munslow discussed the use of task-specific rapid impact assessment systems and the way they can inform calls for support and collaboration. Investing in collaboration might not necessarily be financial, but by way of mutual aid from other local authorities for example.

Chris Engelbrecht explained how each of the 50 states in the USA often communicate and respond differently from a technological perspective. Often coordination at borders is not as seamless as it could be, especially with federal partners. With regards to technology and customer service, as in South Africa the experience tends to be that the public needs to see what is going on before they will fully believe it, if they can be shown via webcam imagery for example it helps a lot.

Kwanele Simelane discussed the use of technology in general in Lower to Middle–Income Countries (LMICs) and how there is a need to invest, a need to utilise technology, such as digital twin, and to look at other hazards. The intention is always to build back better.

Tim Rowland-Deverell from the Department for Transport in the UK posed the question of how to make technology, in the context of the developed world accessible to other parts of the world. Yukio Adachi gave an overview of PIARC and how the association and Technical Committees aims are to share knowledge. This is a core function of PIARC. Technical Committee 1.5 supports LMICs

by sharing knowledge, lessons learned and best practices in Disaster Management and also updates and maintains the Disaster Management Manual, available for all. The manual covers a range of technologies that can be utilised and identifies the crucial issues for consideration in a disaster management strategy.

Kwanele advised that extreme weather was not a priority for South Africa previously, however now as members of PIARC, sharing knowledge, engaging and refining implementation of mitigation measures, they have joined the community, and this will hopefully encourage other LMICs.

4. WRAP UP

4.1. RECOMMENDATIONS FROM THE ATMOSPHERIC RIVER EVENT IN BRITISH COLUMBIA 2021:

Immediate strategies which Provincial and Federal governments are working on together with industries, include the following:

- Diversion to alternative Ports (Prince Rupert)
- Prioritizing essential loads, ensuring full loads
- Diversion of highway trucks through the US via Washington State (reducing/removing border crossing requirements)
- Essential travel orders for the general public to prioritize the movement of commercial goods/services (and emergency response)
- Limit non-essential vehicles to 30 litres of fuel (gas and diesel)
- Highway Travel Restrictions (Non-essential) Orders (through legislation)
- Enforcement of Travel Restrictions via Highway Checkpoints

As a part of the development of the Canadian National Transportation Supply Chain Strategy, being led by the Transport Canada National Supply Chain Office, below are some of the strategies being undertaken to protect the supply chain from the effects of extreme weather:

- Digitization and supporting the use of innovative technologies to optimize the existing footprint and introduce efficiencies that reduce carbon emissions. Supporting the transportation industry in the creation and use of new technologies, fuels and tools requires agile regulatory processes that are responsive to technological advances in a timely way.
- Work with partners (Federal, Provincial, Local, Indigenous Groups and Communities) to identify locations that are most vulnerable to climate-related or other natural disasters ("chokepoints" that can be a single point of failure in the event of a disruption from extreme weather events), develop alternative routes and options to address these vulnerabilities.
- Facilitate strategic policy, regulatory and investment decisions by governments and industry.
- Prioritize and support significant investments in transportation infrastructure to keep rural, remote, and vulnerable communities (including BC's Fraser Canyon, Fraser Valley, and Lower Mainland) connected. This is vital for future growth, and resilience in the face of unpredictability and risk caused by extreme weather events.
- Work towards the National Trade Corridors Fund (NTCF), Transport Canada's primary supply chain infrastructure-related contribution program, becoming a permanent program with ongoing and sufficient funding, along with expanding the list of eligible investments and segmenting its funding for specific industries.
- Establish government–industry transportation supply chain crisis working groups in each province and territory and at the federal level to prepare for and be ready to mitigate unplanned transportation supply chain disruptions, particularly those related to natural disasters stemming from climate change.

- Increase visibility of data and interactions across the supply chain. The lack of visibility contributes to inefficient forward planning, lagging responses to emergencies and a siloed approach to resolving issues that should be viewed as cross-cutting. The need to increase visibility is further emphasized by a sector-wide shift from just-in-time to just-in-case operations that requires built-in redundancies to navigate issues as they arise and respond accordingly.

As highlighted, the extent of the damages to the Provincial Highway network were extensive. Highway 5 (Coquihalla) which is the main freeway and critical part of the National Trade Corridor lost 7 bridges with an additional 20 damaged sites over 130km. As a result, B.C. Ministry of Transportation and Infrastructure are "building back better" and adapting design guidance to take into consideration extreme weather events. Figure 2.2 shows the original configuration at Bottletop Bridge on Highway 5 and the new configuration with future climate events considered. There is significantly more room (64%) for major hydraulic events and the abutments are now on piles, the same as the piers. This allows the river more room to play within its natural channel and also provides a co-benefit of better wildlife passage.

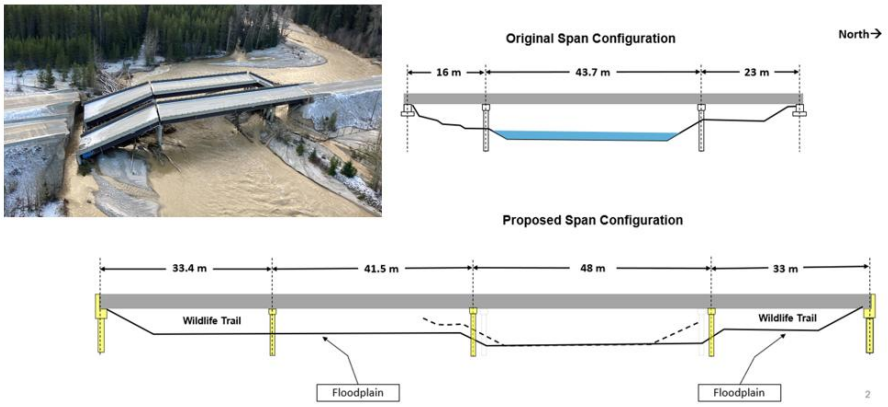

Figure 2.2 Original and New Configuration at Bottletop Bridge on Highway 5

In addition to adaptation of design guidance for infrastructure, B.C. Ministry of Transportation and Infrastructure are also looking at new ways to systematically view highway networks vulnerability and resilience to prioritize investment in key trade corridors (with support from Federal partners) to reduce the future risk to the supply chain.

4.2. Recommendations from the UK's 1st National Resilience to Extreme Weather (Hazards) Survey

There is an imperative to develop consistent metrics and technical methodologies for recording the impacts and remediation costs of extreme weather hazards in accordance with asset information management principles. These all-hazards approaches to data collection need to be consistent, if they are to underpin our understanding of adaptation challenges and priorities. This should include consistent Rapid Impact Assessment following hazard events, to inform defensible decisions regarding the immediate prioritisation of stabilisation and restoration works to identify hazard 'hot spots,' where adaptation options should be prioritised for integration into 'Build Back Better' recovery.

There is a need for highway practitioners at all levels to increase their understanding of all-hazards resilience. This should involve training and exercising which is tailored to inform and support the sector's critical role in both collaborative emergency management and in leading in the delivery of lifeline resilience.

Transport Ministries and Highway Authorities should jointly agree the frameworks necessary for councils to conduct Climate Change Risk Assessments that are not wholly future looking but encompass the full range of contemporary risks for which greater resilience is needed now.

The nature of contemporary extreme-weather events has reached a point where Ministries must commission the development of a highways' emergency response supply chain and professional-networking mutual aid contingency framework. This should operate on a pan-regional basis to negate the risk of neighbours being unable to assist each other in an emergency because both have been impacted to their capacity by the same event.

4.3. Recommendations from Rapid Impact Assessment, deploying state of the art in resilience

Impact should be understood in terms of the equation:

Impact = (Damage x Consequences) x Duration of effect on user communities

The adoption of this definition underlines the importance of the sector developing a consistent Rapid Impact Assessment methodology and technologies. Highways represent crucial lifelines for our communities, so when disrupted decisive interventions are needed to prioritise, stabilise and restore them effectively. Rapid Impact Assessment supports this process by providing consistent information for decision-makers. Consistency also means that RIA can be used to ensure support can be offered where most needed (including transboundary).

Wider benefits of using a Rapid Impact Assessment technology include help in understanding what is occurring day to day, used habitually Rapid Impact Assessment helps out of hours. It also supports recovery of third-party damage costs. Supports budgets and resourcing and takes stress and pressure off teams.

4.4. Recommendations from Digital Twin in Disaster Management

With the development of IT technology, usage of digital twin for maintenance and management of infrastructure is progressing. If an unexpected earthquake occurs digital twins can calculate dynamic analysis for seismic design at anytime, meaning a recovery plan can be developed quickly.

Utilising digital twin results for Business Continuity Plans in advance can assist by informing the pre-determination of safe and accessible routes for people to use. There is a need to continuously invest in this technology.

As disasters around the world become more severe, the use of digital twin technology will not only allow us to constantly monitor the condition of structures, but also make it easier to respond to disasters before and after they occur through simulation.

Under current extreme weather events, there will be a need to use digital twin models for efficient advance preparations and post-disaster planning.

5. CONCLUSIONS

The discussions and presentations at Highways UK 2024 have highlighted the growing challenges of ensuring the resilience of road networks amid increasingly frequent and severe extreme weather events. The insights shared by PIARC Technical Committee 1.5 Disaster Management members and panellists during the session "Ensuring the Network Remains Operational During Unprecedented Conditions" underscored the necessity of proactive disaster management strategies, international collaboration, and innovative solutions to mitigate the impacts of climate-related disruptions.

A key takeaway from the discussions is that disaster management must evolve beyond reactive responses to encompass comprehensive risk assessment, robust contingency planning, and the integration of new technologies. The experiences shared from various countries demonstrate that investment in predictive analytics, early warning systems, and resilient infrastructure design can significantly enhance the ability of road networks to withstand extreme weather conditions.

Furthermore, effective collaboration between governments, transport agencies, and private sector partners is essential to develop adaptive strategies that ensure network reliability. The importance of knowledge exchange, as demonstrated in this forum, cannot be overstated. By learning from global best practices and leveraging innovative approaches, road authorities can better prepare for and respond to future disasters.

PIARC Technical Committee 1.5 on Disaster Management remains committed to advancing research, sharing expertise, and fostering international cooperation in disaster management. The insights gathered from Highways UK 2024 will inform our ongoing work, ensuring that best practices continue to be developed and implemented to safeguard road networks worldwide.

The below are key conclusions in this session.

5.1. RECOMMENDATIONS FOR DECISIONS MAKERS

5.1.1. Improve how to cope with extreme weather events

- Prioritise investments in transportation infrastructure to ensure connectivity for rural, remote, and disaster-prone communities ensuring resilience and future growth.
- Better prepare for inevitable impacts through Rapid Impact Assessment.
- With the development of IT technology, usage of digital twin for maintenance and management of infrastructure is progressing. Under current extreme weather events, there will be a need to use digital twin models for efficient advance preparations and post-disaster planning.

5.1.2. Improve social resilience

- Collaborate with various stakeholders (Federal, Provincial, Local, Indigenous) to identify vulnerable "chokepoints" in transportation networks, and develop alternative routes to safeguard against disruptions caused by extreme weather events and natural disasters.
- Facilitate and support strategic policy, regulatory, and investment decisions that enable sustainable growth and infrastructure development across the transportation sector.

5.1.3. Improve infrastructure resilience for supporting supply chain

- Establish government-industry working groups at all levels to prepare for and mitigate unplanned disruptions, particularly those stemming from climate change, enhancing transportation supply chain readiness.
- Improve data transparency and coordination across the supply chain to enhance planning, emergency responses, and a shift toward more resilient "just-in-case" operations, addressing inefficiencies and siloed approaches.
- Wider benefits of using a Rapid Impact Assessment app include help in understanding what is occurring day to day, used as a habit Rapid Impact Assessment helps out-of-hours. It also supports recovery of third-party damage costs. Supports budgets and resources and takes stress and pressure off teams

5.2. RECOMMENDATIONS FOR PIARC

- The impact of modern extreme weather events can have a profound effect on any country and region. This is not just a problem for each country or region, but a challenge that needs to be addressed on a global scale. PIARC members need to look beyond their borders to share best practices on mitigating the effects of extreme weather events and building resilience.
- It is essential to develop consistent metrics and methodologies for tracking the impacts and remediation costs of extreme weather, following asset management principles, to support adaptation efforts. It is preferable to maximize the information sharing function of PIARC to widely share examples of what is being worked on in the world in this area and to provide feedback to practice.
- Supporting the adoption of consistent Rapid Impact Assessment methods and technologies will increase the sector's ability to understand and quantify disaster impacts locally, nationally and internationally through a defensible process: thus, informing recovery and adaptation priorities in ways that advance international Disaster Risk Reduction (DRR) goals.

6. REFERENCES

[1] DEEMING, H. (2021) *Emergency Preparedness, Response and Recovery: identifying lessons learned by UK highways sector from extreme-weather emergencies (2015-2020)* A report prepared for the Department for Transport and the Local Government Technical Advisers Group, HD Research, Bentham, UK.

[2] Emergency Flooding Event - November 2021 | Flickr

[3] https://www.international.gc.ca/trade-commerce/economist-economiste/analysis-analyse/logistics-vulnerability-vulnerabilite-logistique.aspx?lang=eng

[4] https://www.theweathernetwork.com/en/news/weather/forecasts/strong-atmospheric-river-targets-the-west-coast-more-heavy-rain?utm_source=vancouver%20is%20awesome&utm_campaign=vancouver%20is%20awesome%3A%20outbound&utm_medium=referral

[5] https://www.theweathernetwork.com/en/news/weather/forecasts/how-british-columbias-catastrophic-rainfall-flooding-was-foretold-days-before

[6] https://www.theweathernetwork.com/en/news/weather/forecasts/heat-dome-inflates-over-western-canada-the-harbinger-of-all-time-warmth

[7] https://www.cftktv.com/evacuation-notices-due-to-flooding-have-been-rescinded-1.5460006

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