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DISASTER MANAGEMENT AND RECOVERY TECHNIQUES FOR ROAD ADMINISTRATORS

A PIARC TECHNICAL REPORT

TECHNICAL COMMITTEE E.3 *DISASTER MANAGEMENT*

WORLD ROAD ASSOCIATION
MONDIALE DE LA ROUTE

STATEMENTS

The World Road Association (PIARC) is a nonprofit organization 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 2016– 2019and 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 organizations or agencies.

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EXECUTIVE SUMMARY

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A PIARC TECHNICAL REPORT

Road networks are one of the most important infrastructure elements that support all kinds of socio-economic activities. In the case of disasters, the role of a road network is more crucial. The purpose of road disaster management is to increase resilience of road networks, effectively and efficiently. Resilience of road networks include not only resilience of the network itself (e.g., planning and construction of alternative road network or alternative transportation) but resilience of road facilities and road-related organizations (e.g., establishing a Business Continuity Plan (BCP)).

This report includes various case studies and the best practices for improving disaster management techniques. They are readily applicable to both developing and developed countries. Administrative mechanisms vary widely from country to country, and we did not focus on disaster management techniques that are applicable to specific countries. Note also that risk awareness plays a key role in managing disasters. Hence, careful investigation of risk awareness of the public and road organizations will be necessary when applying the disaster management techniques studied in this report in practice.

We studied disaster management and recovery techniques for road administrators from the four aspects, i.e., monitoring and detection of vulnerability, education and training, coordination and cooperation, and emergency operations and recovery approaches. These four aspects are vital areas to improve the current disaster management techniques and adapt them to the change of environment and society.

Bruneau and Reinhorn [1] mentioned that resilience consisted of the four properties: robustness, redundancy, resourcefulness and rapidity. Among the above-mentioned four aspects, "monitoring and detection of vulnerability" and "education and training" are important factors to enhance resourcefulness. "Coordination and cooperation" and "emergency operations and recovery approaches" contribute to enhancing rapidity. The major contents of this reports are as follows.

1. Monitoring and detection of vulnerability

Natural disaster management starts from the detection of phenomena which may cause damage to roads or road transportation. There are suitable ways and methods of detection for each kind of disaster. Monitoring is often applied in the case of where the disaster occurs and is identified or limited to narrow areas. Occurrence of disasters depends on environmental conditions. When occurrence of a disaster does not depend on the location or environmental condition of the place, it effectively leads to an increase of robustness of the road network by analyzing vulnerability of the road network under effects of disaster. In this chapter, we present three case studies: monitoring for rock fall along a national highway in Austria, vulnerability analysis for earthquake and flashfire in the USA and landslides in the Czech Republic.

2. Education and training

In road disaster management, the resilience of the road network is increased by systematic preparation of resources (e.g., material, machinery and human resources) from ordinary time before a disaster occurrence. Education and training are also necessary to increase resilience. Education and training for a severe disaster become complex because of cooperation among a wide variety of road organizations in such a situation. In this chapter, we present two case studies: establishment and utilization of a training center for application of temporary bridges in the Czech Republic and a training and education program for technical staff at the California Department of Transportation.

3. Coordination and cooperation

Road organizations as well as road networks may be damaged in major disasters. As a result, this leads to the fact that road organizations are unsystematic and they cannot grasp damage or demand help from other organizations. Increasing robustness and resourcefulness of road organization improves resilience of the road network. In this chapter, we present two case studies. The first is TEC-FORCE in Japan. TEC-FORCE is the national government's supporting system for local governments that suffered damage by a severe disaster. The second case study is the Incident Command System in the USA. This case study shows the standard system and procedures followed in emergency conditions, not just during natural disasters.

4. Emergency operations and recovery approaches

In this chapter, we present four case studies on emergency operation and short-term recovery. First, we report an example of emergency management in the nationwide level in the USA, and then show several case studies. These examples indicate the importance of preparedness of resources e.g., material and human resources and preparedness for effective utilization of these resources.

Finally, we hope that the information and best practices described in this report will be shared among the international road community and applied to road disaster management practice in countries having to deal with natural disasters.

CONTENTS

1. INTRODUCTION

1.1. SCOPE AND OBJECTIVES

Quarentelly [2] defined a disaster as "a crisis situation that far exceeds the capabilities." Disaster management can therefore be explained as a series of activities to improve the capability of society. Disaster management usually aims to reduce, or avoid, the potential losses from hazards, assure prompt and appropriate response to a disaster, and achieve rapid and effective recovery. Disaster management can be achieved by assembling many element management techniques.

The Terms of Reference of the 2016-2019 Strategic Plan for TC E.3 are presented in Table 1.1.

TC E.3.1 Disaster Management	
Strategies	***Outputs***
To maintain and disseminate information related to road administration response strategies for natural disasters. Study and document practices to ensure a quick and safe recovery from major disasters.	Update of the Disaster Management Manual elaborated by TC 1.5 (Risk Management) in current cycle. Report on case studies and recommendations.

Table 1.1: Terms of Reference for TC E.3.

Technical Committee (TC) E.3 "Disaster Management" of PIARC focuses on two major current disaster management activities that aim to lessen the impact of disasters. One is "disaster information management for road administrators" and the other one is "disaster management and recovery techniques for road administrators." In order to conduct research on these two topics, TC E.3 was split into two working groups (WGs):

WG1 - Disaster Information Management for Road Administrators (Issue TC E.3.1)

- To maintain and disseminate information related to road administration response strategies for natural disasters.

WG2 - Disaster Management and Recovery Techniques for Road Administrators (Issue TC E.3.1)

- Study and document practices to ensure a quick and safe recovery from major disasters.

Current disaster management techniques are summarized in Figure 1.1. Each management phase, "Mitigation," "Preparedness," "Response," and "Recovery" includes soft and hard management techniques. WG1 covers the area of soft management techniques such as "Disaster management with public" and "Information sharing and management." WG2 covers the area of conventional but well-advanced techniques for disaster management. These are regarded as hard management techniques.

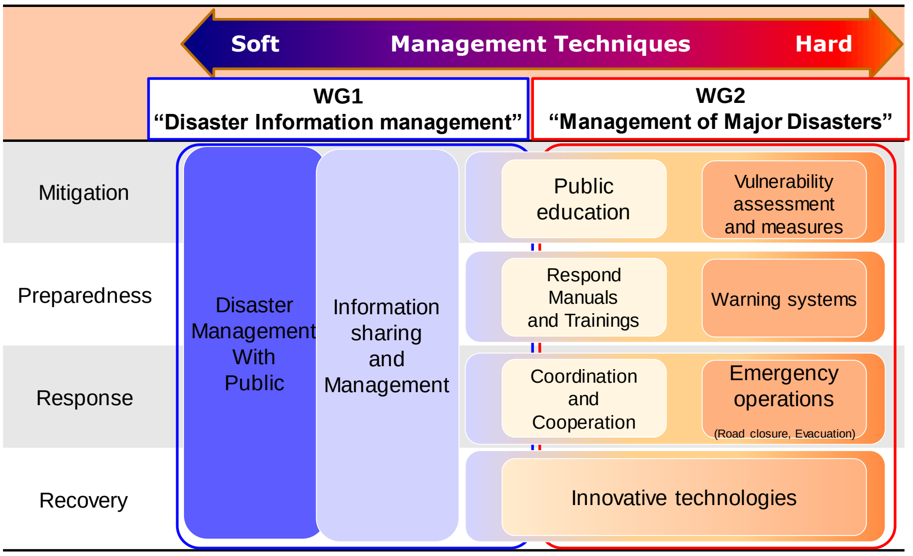


Figure 1.1: Overview of techniques in disaster management and the study area in this cycle.

1.2. DAMAGE AND VULNERABILITY ASSESSMENT AGAINST MAJOR NATURAL HAZARDS

Road transport, as a subsystem of the transport system, performs the largest transport performance in both passenger and freight transport. It has an irreplaceable role in supporting business in the region and in attracting foreign investors and tourism. The basic prerequisite for an efficient and effective transport system is the existence of a transport network. Disturbance of the road transport system may be due to causes inside or outside the system. In practice, such a crisis situation can only arise from the cause outside the system (natural disaster, environmental or industrial accident, terrorist attack...).

At the same time, it is necessary to realize the basic characteristics of the land transport:

- links with other modes of transport and areas of activity - inter-modular structure
- open infrastructure - free access
- fast growing networks
- Large volume of passengers

Threats to be assessed will be divided into threats as a result of natural events, human or technical failure and the threat of terrorism and criminal behavior. These can occur in many ways, accidentally or deliberately. Accidental threats include those caused by natural causes and physical activity, such as damage caused by floods, fires, building activities, while intentional acts include physical attacks, electromagnetic attacks, cyber-attacks, and human aspects. Their range can be local, regional and national. At the same time, it is always necessary to consider the hazardous potential of other equipment and infrastructures, whose disturbance of functionality can cause a domino effect. For example, as a result of the transfer of fire from nearby facilities, there may be debris in a nearby facility due to a failure of supply facilities. Also due to events in close temporal contexts such as the occurrence of a second delayed explosion or more present disturbances at different locations, which may, under certain circumstances, give rise to an exponential effect, while rescue and recovery measures may be interrupted, or resources bind to a false spot, i.e., to adopt scattered or deviant measures.

All of the above options may have a negative impact on the safety and security of land transport in the following areas:

- Land supply chain logistics including cargo security
- public transport
- cybersecurity transport information systems

In this context, it is necessary to mention the fact that security risks have changed diametrically in recent years, and the greatest emphasis is now on the threat of terrorism in all international organizations, in particular CBRN protection and cyber security. Transport depends mainly on computerized control systems. Over the last few years, a number of serious cyber-attacks have been reported. The introduction of electronic freight transport systems could, for example, be a successful computer attack with a major impact on supply chain and economy. A major threat is computer crime for land transport that uses these systems. Thus, it is important to ensure that traffic is resistant to cyber-attacks. Consideration should be given to measures aimed at safety and security in the transport sector. This could include the requirement for transport operators to have computer backup systems that will allow the rapid restoration of key activities, particularly with regard to traffic safety and cyber-attacks.

In evaluating, it is necessary to emphasize the complexity and heterogeneity of the risk factors considered: human (lack of awareness, insufficient staff qualifications, human failures, criminal behavior) organization (concentration of indispensable resources, infrastructure outsourcing) nature and the environment (natural disasters, infections and epidemics) technology (complexity of the system, IT dependence, integration of IT systems into networks, standardization of techniques and components, interconnection of infrastructure and the Internet).

In the context of the above, the main tasks are defined:

- Analyze and reduce identified threats and risks
- Ensure the supervision and protection of persons, property, services, events and vital sectors
- Extend and strengthen cynber security
- Resilience of sites, individuals, industries and networks
- Effective crisis management and crisis communication

The impacts of a crisis situations may cause restrictions on the ability to drive or close traffic on some roads, damage to bridges and roads, slowing down or stopping maintenance at the expense of restoring, slowing down or stopping investment construction, and slowing or stopping other activities that may impact the national economy. Critical transport infrastructure should only include systems in which failure or destruction would seriously affect the security of the state, the economy, the health and safety of the population, the functioning of the state administration and the dependence of other sectors.

In order to assess the impacts of the crisis situation, it is necessary to consider the specific territorial conditions and, above all, the specific transport needs of the territory, including:

- Acute exits (ambulances, firefighters, police, emergency services for gas, water, electricity, etc.)
- supply of territory (food, drinking water, medicines, various products, etc.)

- Ensuring transport accessibility for the accessibility of schools, offices, courts, health facilities and employment,
- technological transport of raw materials, semi-finished products and finished products,
- business and business trips,
- Leisure (entertainment, culture, sports, recreation, etc.)
- extraordinary transportation (evacuation of persons, animals and property, removal of consequences of natural or technological disasters).

1.3. Possible impacts of crisis situations in the context of large-scale disasters

1.3.1. Impact on Life and Human Health

The possibility of death of persons, damage to health of persons by injury or illness can be assumed when it is necessary to carry out the emergency exit by ambulance, or other emergency response type vehicle. Transport for the distribution of medical material or to provide transport for the evacuation of the persons from the vulnerable area etc. and at the same time, road transport infrastructure to implement these transports either by road or alternative mode of transport, Independently of traffic infrastructure disruption, the lives and health of people are particularly at risk of traffic accidents, or accidents or events at technological facilities near the transport route..

1.3.2. Destruction or Damage to Property

The destruction or damage to the property of the carrier or transporter (means of transport, goods transported, including packaging or relevant transport infrastructure - e.g., terminals, logistics centers, railway stations, handling equipment) can occur either in a traffic accident or as a result of extraordinary events such as a fire or a spill of a hazardous substance. The impossibility of providing extraordinary road transport for evacuation, to eliminate the consequences of natural or technological disasters due to stopping road transport, poses a risk of further damage to movable and immovable property, in the event that such transport cannot be secured by any other mode of transport.

1.3.3. Damage to the Environment

In the event of a traffic accident or stopping extraordinary road transport for evacuation and the removal of natural or technological disasters, the possibility of damage to the environment (e.g., leakage of fuel or dangerous goods or waste being transported during a traffic accident or during transport itself) may be possible and countermeasures should be addressed.

1.3.4. International Impacts

In the context of international impacts, consideration should be given to limiting or possibly stopping international road transport across the affected area, depending on the degree of damage to the transport route. As a result, movement of persons or goods are restricted.

1.3.5. Economic Impacts

Stopping road transport and the failure to ensure the transport needs of other modes of transport for a longer period of time may mean a collapse of the economy. Some examples of this are the interruption or stopping of production chains caused by the absence of transport logistics and the inability to distribute food, water and pharmaceuticals.

1.3.6. Social Impacts

Social impacts for the population will cause road traffic to stop for longer periods, and at the same time the inability to ensure the transport needs of other modes of transport while providing transport services for the accessibility of schools, offices, courts, healthcare facilities and employment.

1.3.7. Desired Target State and Focus of Activity

The aim of crisis planning in the field of road transport is to prepare the road transport system so that:

- Civilian and military transport needs are satisfied with the highest quality and in the shortest possible time,
- Damage caused by the crisis situation is minimized in both human lives and in material values,
- We must be effectively prepared and ensured to use the necessary human and material resources.

2. MONITORING AND DETECTION OF VULNERABILITY

Natural disaster management starts from detection of phenomena which may cause damage to roads or road transportation infrastructure. There are suitable ways and methods of detection for each kind of disaster. Monitoring is often applied in the case of where the disaster occurs and is identified or limited to a narrow area. Occurrence of disaster depends on environmental conditions. When occurrence of disaster does not depend on the location or environmental condition of the place, it effectively leads to an increase of robustness of road network by analyzing vulnerability of road network under effects of disaster. In this chapter, we present three case studies: monitoring for rock fall along a national highway in Austria, vulnerability analysis for earthquake and flashfire in the USA and landslides in the Czech Republic.

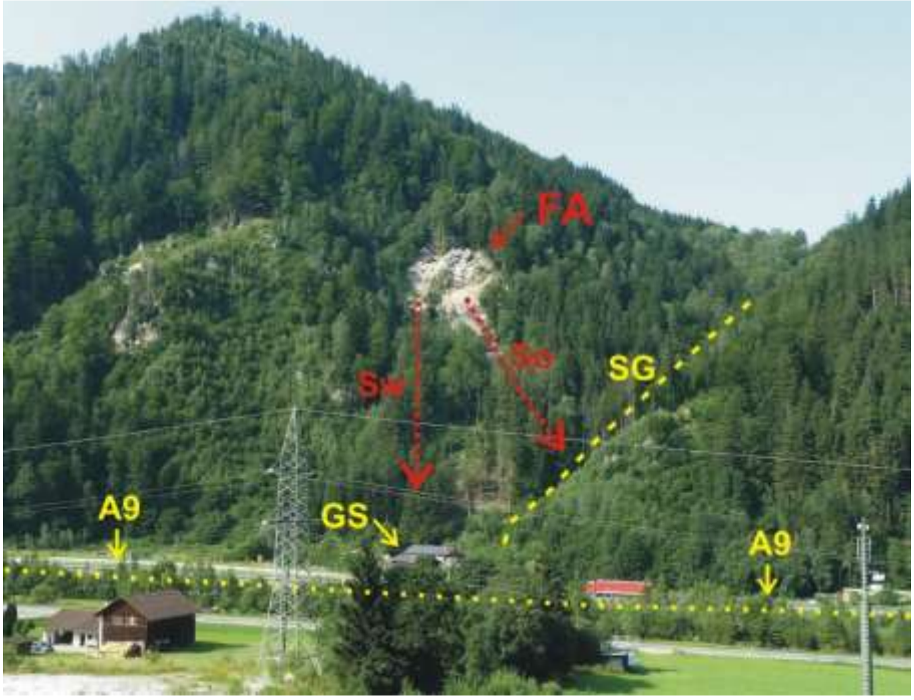
2.1. ROCK FALL HAZARD ON THE A9 PYHRN MOTORWAY NEAR WALD/SCHOBERPASS - GEOTECHNICAL FAILURE ANALYSIS AND SAFETY MANAGEMENT

2.1.1. Introduction

In July 2012, a rock fall took place on the A9 Pyhrn motorway, near the small Austrian town of Wald/Schoberpass. Rock mass that remained in the rockslide area represented a latent risk for both the valley area lying below the rock fall as well as the A9 Pyhrn motorway. After the immediate implementation of primary safety measures, a safety management plan was prepared which was followed until construction-related safety measures were carried out. The continuous geotechnical assessment of the failure probability, carried out by means of a geodetic monitoring system, was an essential part of safety management. A differentiated consideration of various geotechnical failure scenarios allowed for the systematic closure of potentially dangerous locations in terms of both area and duration.

2.1.2. Event

On July 23rd, 2012 - two days after intensive rainfall in Upper Styria, which e.g. caused a tremendous mud flow event in St. Lorenzen near Trieben, which destroyed numerous buildings - a rock fall event was registered at the Pyhrn motorway in the area Wald / Schoberpass between the tunnel Wald and the tunnel Pretallerkogel. Residents observing the event informed the ASFINAG by telephone that larger rock mass fell off from a rock face north of the motorway. An immediate field inspection of the locality showed that rock mass of several hundred cubic meters had released from a rock slope approx. 160 meters above the valley and motorway level (Figure 2.1). The majority of the detached rock masses were deposited in the slope area below the detachment area in the form of tongue-shaped block heap. However, individual blocks of up to several meters in diameter reached the bottom of a lateral valley. The area of the valley floor, including the buildings of a Sawmill - at the foot of the slope, as well as a motorway - tens of meters from the slope - were not reached by the stone impacts of this event.



FA: rock fall area, Sw, So: western and eastern rock fall path, SG: lateral valley, GS: privately owned sawmill building, A9: Pyhrn Motorway

Figure 2.1: Rock fall near Wald, overview map.

2.1.3. Immediate Measures and Monitoring

In the course of the first geological field inspection, it was found that the rock fall had released as part of a larger, apparently episodically moving rock mass. In the detachment area of the rock face, further falling hazard of rock masses were identified, whereby an acute failure potential was assumed in particular for one large rock boulder. This single large block had a cubature of approx. 40 m³ and had already slipped out a few meters from the fresh head scarp (Figure 2.2). Considering the block size, the block geometry, the possible initial fall height and the general slope geometry, an acute hazard to the motorway was identified. Hence, the motorway was closed to traffic.

1: large rock boulder blasted on 2012/07/24, 2: rock failure occurred on 2012/07/26, Blue circles: position of geodetic targets

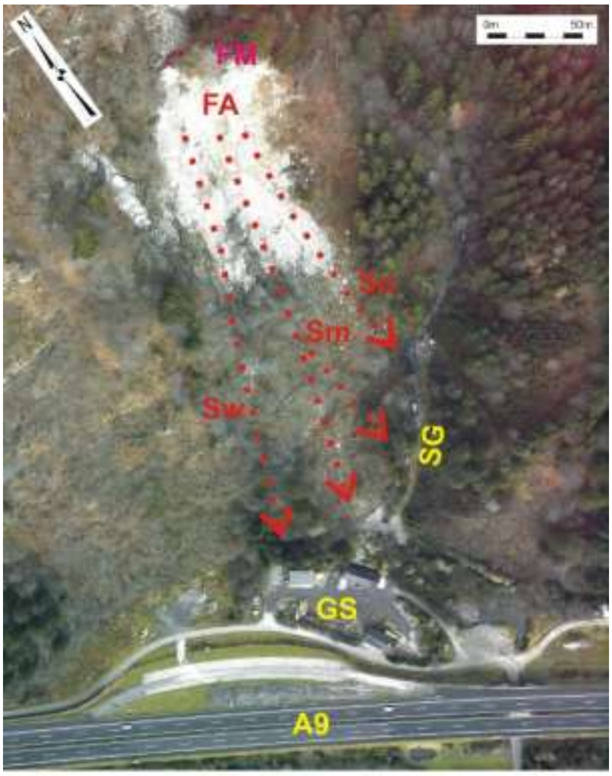
Figure 2.2: Detailed map of rock-fall detachment area (screen width: approx. 55m).

On the next day of the rock fall event, the large single boulder was blasted by a specialist company. The block was fragmented by a large number of blast holes, so that in the course of the blast none of the small-sized rock fragments reached the bottom of the valley. After a manual clearing of loose rock parts in the detachment area, the acute danger of the highway was banned. With the implementation of further monitoring measures and considering the favorable weather forecast, the motorway could be opened to the traffic again on the same day.

To monitor the situation in the detachment area and possible further movements, a geodetic permanent monitoring was installed. The observation system consisting of an automatic theodolite (measuring robot) in the valley floor and 17 geodetic measuring prisms in the rock detachment area was set up for intervals of 15 min for high-resolution measurement series and went into operation two days after the rock fall event.

2.1.4. Hazard Analysis

The rock fall occurred from an approx. 30 m high rock face of quartz-rich sericitic schist of the permotriassic "Rannachformation." The affected rock cliff was located at the front of a larger mass movement (Figure 2.3). Some 5 to 15 m behind the fresh rock scarp, new opened cracks could be identified in the field, indicating displacement of several decimeters. The gaps followed a small morphological nape, which proved that the rock mass was subject to significant movements before the recent event. The volume of the entire mass movement was in the order of several thousand cubic meters. The rock mass was internally divided by open gaps into partial clods and blocks. The rock fall event of July 23rd, 2012 affected only the most exposed area of the mass movement.



FM: moved rock mass, FA: rock fall area, Sw, Sm, So: western, middle and eastern rock fall path, SG: lateral valley, GS: privately owned sawmill building, A9: Pyhrn Motorway, bright spots in the lateral valley indicate fresh rock boulders

Figure 2.3: Aerial photography in November 2012 (source: Energie Burgenland Geoservice GmbH).

The results of the geodetic monitoring of the rock face showed displacements of approx. 7 to 18 cm over a period of approx. 3.5 months (Figure 2.4). One measuring point in the western (left) part of the detachment area showed a total displacement of more than 50 cm. The displacement vectors had inclinations between 28° and 47° and indicated movements of the rock mass directed along the slope line. There is a clear correlation between precipitation events and increased movement rates of the rock mass (marked by vertical dashed lines).

The monitoring data showed continuous movements with individual sudden increases in the displacement rates. The accelerations where identified to be triggered by stronger precipitation events. Continuous movement rates of 0.5 to 1 cm per week turned out as "normal behavior" of the rock mass, whereas heavy rainfall events caused episodic increases in movement rates of up to 3 cm per day. A short phase (few hours) of acceleration and a longer phase of reduction of movement rates (over several days) could be distinguished. The results of the geodetic monitoring showed that the rock fall of 23.07.2012 occurred during a period of significantly increased movement rates. Therefore, a causal connection between the rock fall and the precipitation events of 20/21 July 2012 can be considered as proved.

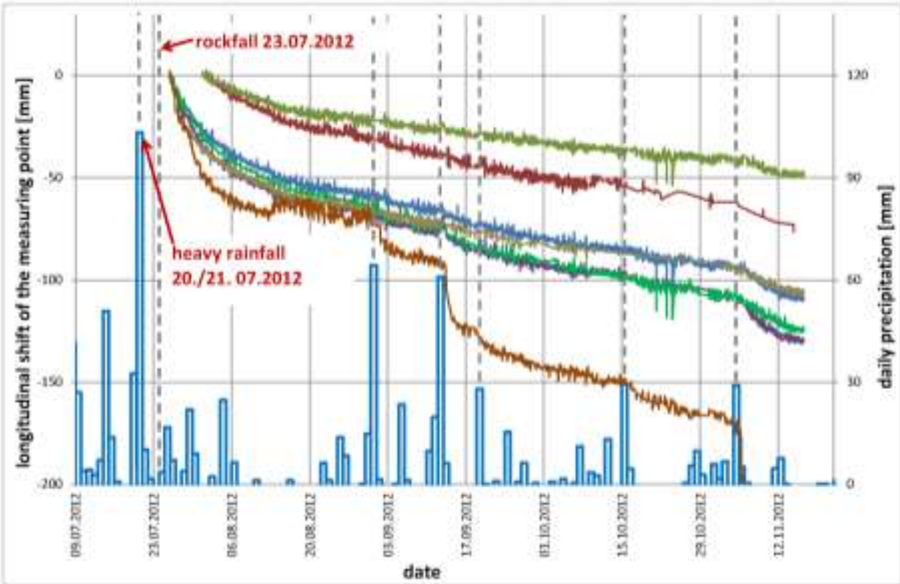


Figure 2.4: Results of geodetic displacement measurements (longitudinal displacement of geodetic reading points in the western rock fall area) and precipitation data (daily amounts) from the measuring station at Gaishorn.

The recent detachment area as well as the entire mass movement can be subdivided into a western (left) and an eastern (right) part. As a consequence of the cambered shape of the slope below, different rock fall tracks could be assigned to these two areas (see Figures 2.1 and 2.3). While rock falls from the eastern part were expected to fall into the lateral valley, the supposed track of the western section led directly towards the valley floor, where the buildings of a private sawmill and the motorway were located.

Potential further rock fall events were to be expected particularly after stronger precipitation events. Based on the morphological and geological conditions of the mass movement, a failure of single blocks or partial areas of the rock mass - similar to the event of 23.07.2012 - had to be expected. However, a sudden large-scale failure of the complete rock mass was considered to be unlikely.

2.1.5. Safety Management

As further rock failure from the mass movement was possible, the motorway was still exposed to rock fall hazard. Therefore, a safety management plan was developed immediately after the event of July 23rd, 2012, in order to act as a directive until protective structures where installed. The aim of the safety management plan was to ensure the safety of motorway operation with the highest possible availability. In addition to the motorway, the entire potentially endangered site in the valley floor (building of an occasionally operated private sawmill, municipal road, lateral valley) was included in the safety management plan.

An important part of the safety management plan was the ongoing continuous assessment of the stability of the rock mass in order to be able to take appropriate measures in case of potential failure. For the geotechnical assessment of the stability of the rock face and the probability of failure, warning criteria were defined (Figure 2.5). In addition to a constant monitoring of the precipitation forecast as well as regular site inspections, geodetic permanent monitoring was of major importance. The geodetic monitoring system was coupled to an automatic warning system, which was designed to send warning messages to the relevant project participants in case of exceedance of warning values. Warning values were defined with regard to displacement rates as well as to total displacement amounts of the individual measuring points. A movement increase to 10 mm / 24 h proved to be useful as a warning value for the displacement rates. For the total displacement, warning values were specified individually for the measuring points and periodically updated.

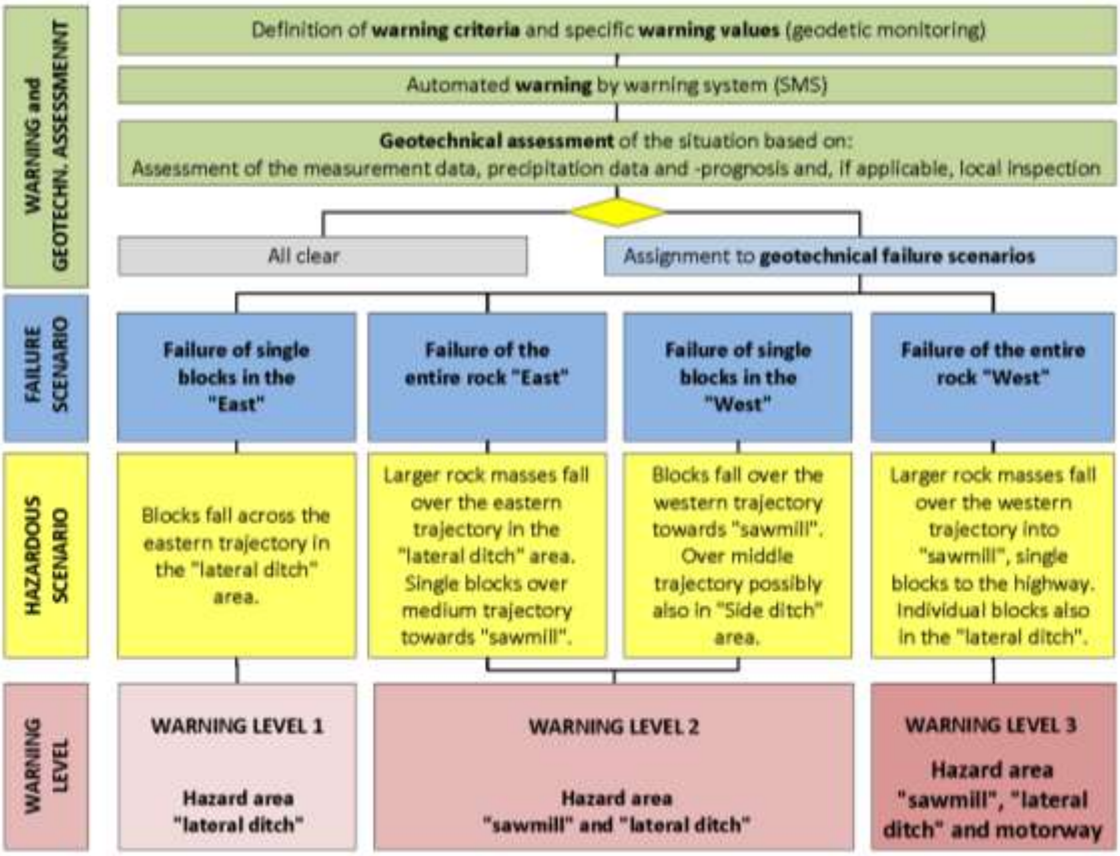


Figure 2.5: Main features of the safety management plan including geotechnical failure scenarios as well as danger scenarios and related alarm levels.

In the case of a warning value exceeded and a correspondingly warning message by SMS, the safety management plan required for an immediate checking and interpretation of the geodetic monitoring data. Actual displacement diagrams of the latest measurement data were generated automatically and were provided to the project participants via a server at any time. Based on the information available, the geotechnical situation was assessed and, in case of a potential failure, the assignment to a geotechnical failure scenario was done. Four failure scenarios and related hazard scenarios were predefined (Figure 2.5), which should be refined and stated more precisely as needed. The four scenarios distinguished were taken into account the expected rock fall path as well as the cubature of the rock zone which was prone to failure.

For the areas immediately adjacent to the slope (Sawmill and a lateral valley), a detachment of individual smaller rock blocks already posed a threat. On the other hand, an impact on the highway several tens of meters from the slope was only expected in case of a failure of larger rock masses in the western part of the rock face.

According to the different failure and hazard scenarios three warning levels were defined. For warning levels 1 and 2, the authorities (municipality) were supposed to close the areas directly at the toe of the slope to public access. Warning level 3 also required a closure of the motorway by ASFINAG. However, warning level 3 was not accomplished in the period of application of the safety management plan.

2.1.6. Application of Safety Management Plan - Example

On July 26th, 2012, three days after the main rock fall event, the monitoring system installed recorded a significant increase in the movement rate of two measuring points. The measuring targets were located on a jointed rock wedge of approx. 50 m³ in the upper section of the rock face (Figure 2.2). The affected rock wedge was formed by middle steep slickenside discontinuities, dipping from the rock face, and thus undercutting the rock mass. In contrast to the results of the monitoring the day before, the rock wedge showed significantly higher movement rates compared to the measuring points in the surrounding areas. In the evening of July 26th, another significant increase in the rate of movement was observed (Figure 2.6). From geotechnical point of view, a short-term "failure of blocks in the area of East" was considered as very likely. In case of failure rock blocks where supposed to fall along the eastern path towards the "lateral valley." Thus, a hazard to the motorway was not expected.

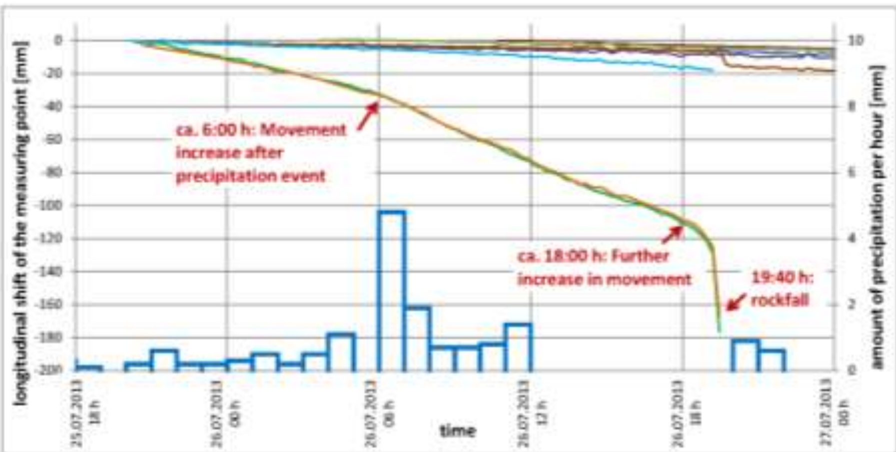


Figure 2.6: Geodetic monitoring results of the subsequent event that took place on 2012/07/26 and precipitation data (hourly values) taken from the measuring point at Gaishorn.

According to the safety management plan a closure of the side valley was required, which was still valid from the time of the main rock fall event. In addition, a telephone warning was given to the residents and landowners.

At 19:40 h, the rock wedge failed. The rock mass divided into blocks of several m³, which followed - as predicted - the eastern rock fall path. A block of approx. 5 m³ fell to the "lateral valley." Hence, the rock fall impact occurred within the area closed according to the safety management plan. The motorway in operation was not affected.

2.1.7. Experience

The safety management plan proved to be a viable instrument for ensuring safety in a potential hazard. A detailed analysis of geotechnical failure scenarios allowed for an identification and differentiation of hazard scenarios. Based on that, safety measures were initiated and implemented in a clearly defined and short-term manner.

The rock fall event presented above proves that even in rock masses of hard rocks with supposedly brittle material properties, a failure does not occur abruptly, but is projected through a phase of increasing movement. This phase of acceleration can be used for the prognosis of a possible failure as well as for the assessment of the current hazardous situation. Precondition for a successful application is a geodetic monitoring system of high resolution - in terms of measuring frequency as well as accuracy.

In the present case, a geodetic measuring system with installed measuring prisms was used. Using measuring robots and GSM data transmission, measurements were carried out at intervals of 10 to 15 minutes and automatically provided to the project participants. Over the given measuring distance of approx. 400 m between theodolite and measuring points, a sufficient measuring and repetition accuracy could be achieved. Individual incorrect measurement as well as mismeasurements due to misty weather condition occasionally led to erroneous warning messages, but did not significantly impair the system function.

Careful attention should be payed to the design of the layout of the geodetic measuring targets to be installed in the area of potential rock failure. In addition to a high number of measuring points, a careful selection of each position of the measuring targets based on a geotechnical failure model is essential.

For the interpretation of the data, a permanent, prompt, expert assessment of the geotechnical situation or any changes is essential. This requires a high availability and consistent standby of the supervising specialists involved.

Furthermore, clearly defined procedures and responsibilities ("who is responsible for what") are indispensable of a successful implementation of the safety management plan.

2.1.8. Status Quo and Outlook

In the autumn of 2012, structural stone impact protection measures were set. Following the specifications of the ONR 24810 (National Guideline for Technical Stone Impact Protection - New Release 15.01.2013), which was already in draft form at this time, rock fall models were carried out and protective measures were planned. According to a variant study of different types of rock guards and protection dams, a dam construction was carried out, which protects the highway against future rock fall events from the rock slope.

Further investigation from the past years show that within the approx. 1 km long highway section between the tunnel Wald and the tunnel Pretallerkogel several mass movements occurred. The recent as well as the older geological studies provide evidence that large parts of the slopes are affected by a deep-seated landslide. Therein, more compact rock mass crop out as rock steps and cliffs. Latent or episodic movements can lead to progressive loosening of the rock structure and thus cause potential for rock failure.

For a more detailed assessment of the geological conditions and for the assessment of possible additional potential hazards, detailed investigations were carried out in the slope area mentioned above. The investigations included a high-resolution laser scanning of the ground surface, detailed geological field work as well as periodic measurements on an extended geodetic measuring point network. Based on the results of the investigation, any areas with a potential for failure and hazards were identified at an early stage. Furthermore, based on danger and risk analyses (carried out in 2015) additional protective structures are planned. Thus, the safety of the motorway operation can be ensured in the future.

2.2. ShakeCast - Earthquake Response and Modeling

Caltrans has many tools at hand for identifying potential damage to our state highway bridge inventory following a major earthquake. United States Geological Survey's (USGS) ShakeMap and ShakeCast are used to inform critical decision-making in the initial minutes to hours following a major earthquake, a time when information about the extent of damage and impacts to highway infrastructure is sparse.

ShakeCast is a web-based application that automatically retrieves shaking intensity data from Shake Map, analyzes it against individual bridge and building performance parameters, and generates emails with lists of potential impacts on the most damage susceptible facilities in the most severely shaken areas within minutes of an event. ShakeCast email alerts, interactive website and analysis results provide timely information to Caltrans responders that raise situational awareness and reduce Caltrans' response time in the aftermath of a major earthquake.

Earthquake shaking forces exerted on bridges are provided from USGS ShakeMap. ShakeCast then processes this data against a pre-determined fragility model and automatically alerts specified operators, inspectors and others via cell phone and/or email. The alert message will contain a list of bridges more likely to be impacted within regions of strong shaking. Individual bridges identified by ShakeCast for any particular event should not be considered definitive. ShakeCast does not define nor mandate a specific emergency response protocol for Caltrans. Rather, ShakeCast informs Caltrans responders with the best available information during a time window immediately following an earthquake when information about the extent of damage and impacts to highway infrastructure is not well known. The ShakeCast analysis performed does not account for other possible impacts to bridges due to ground failure (for example, landslides, liquefaction, fault crossings or co-seismic slip).

The bridge fragility used in ShakeCast is derived from existing engineering research and follows the methodology described in the United States Federal Emergency Management Agency's (FEMA) 2012 Multi-Hazard Loss Estimation Methodology called Hazus. Bridge fragility is determined by a range of asset-specific details including year of construction, length of spans, column heights, material types, and number of spans. The output is a 'potential impact class' state based on a statistical assessment of the probability of the state for each bridge.

Strong caution is advised in the interpretation of ShakeCast analysis results, as the two primary data sources from which the analyses are based upon – ShakeMap and HAZUS bridge fragilities – carry significant limitations, as follows:

1. HAZUS bridge fragilities were developed using research and modeling of east coast bridges and may not adequately reflect the performance characteristics of the California bridge inventory.
2. HAZUS bridge fragilities were intended to model typical highway bridges and may not adequately represent the performance of unusual, long span, and/or complex bridges (e.g. California Toll Bridges).
3. ShakeMap and the ShakeCast analysis performed do not account for liquefaction, landslides, or surface fault rupture. A separate analysis should be done to identify impacts of these types of shaking induced ground failure.

Even though the modeling of typical highway bridges may not adequately represent the damage potential for bridges that are more complex, longer, or otherwise outside normal design parameters (for example, bridges which have been seismically retrofitted), it is important to have information available during the first minutes after the ground begins shaking.

The following graph shows an example of how damage probability is determined for a bridge. At each bridge, ShakeCast analyzes the measured/interpolated ground motion against a pre-determined fragility model. Probabilities of damage relative to varying levels of shaking (or "fragility") can be determined in advance for each bridge.

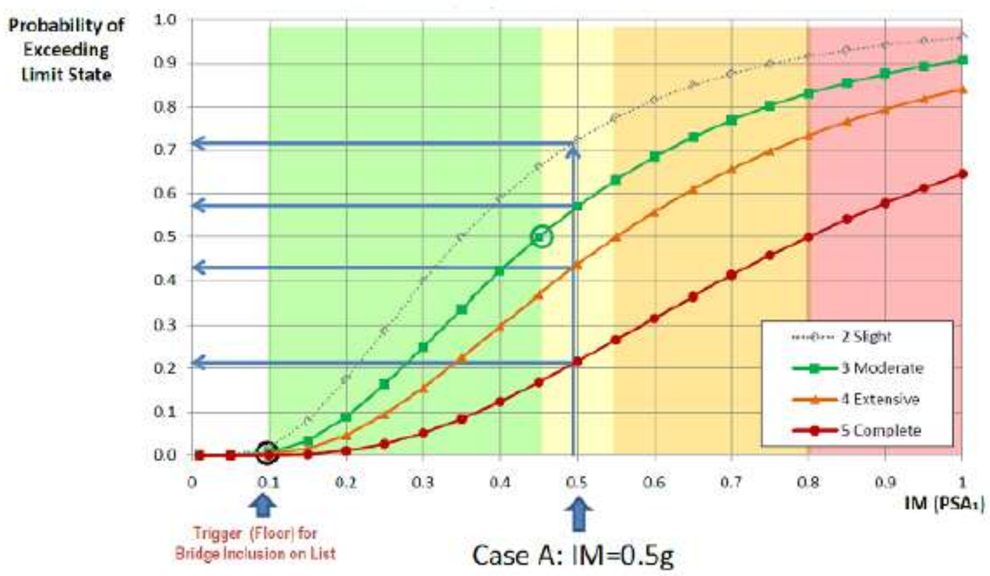


Figure 2.7: Probability of exceeding limit state.

USGS developed the first version of ShakeCast in 2004, with an updated version in 2008. It is open-source software, meaning that agencies such as Caltrans can work with the core USGS version to modify and customize the application to meet their specific needs, which would not be possible with a proprietary version.

The current ShakeCast V3 came into use in 2015, the product of a three-year research project between USGS and Caltrans. Its predecessor, V2, played a critical role in helping Caltrans respond to impacts from the Aug. 24, 2014 Napa Quake. Within 48 hours of the Napa Quake, Caltrans inspected all seven Bay Area toll bridges and no damage was found on any of those structures. Caltrans bridge inspectors, working in four two-person teams, also inspected 29 state highway bridges in Napa, Solano and Contra Costa counties, thanks to ShakeCast's ability to deliver localized, accurate information based on the its modeling and predictive capacity.

Numerous public agencies use ShakeCast, including the International Atomic Energy Agency, whose seismic branch monitors the world's nuclear power plants. ShakeCast is also used by the United States government equivalent, the Nuclear Regulatory Commission, and numerous major private sector businesses.

Caltrans is taking the lead to provide technical assistance to other United States Department of Transportation (DOTs) agencies throughout the United States, in a ShakeCast pool fund study in Collaboration with USGS. This pool fund study will help those interested DOTs achieve the same level of competence as Caltrans in using ShakeCast and ShakeMap at their Agencies.

The Asian Pacific Economic Cooperation (APEC), which the United States is part of, has presented ShakeCast to its members as a tool to improve resilience in the global supply chain, based on the success that Caltrans has had with ShakeCast. The US-APEC Technical Assistance to Advance Regional Integration (US-ATAARI) Project, of which Caltrans Employees have donated their time in assisting this group, is promoting ways to help supply chains in the Asia Pacific region withstand and recover from disasters. One approach is hazard mapping and risk modeling, which can help governments and businesses identify vulnerabilities in the supply chain, then design mitigation strategies in response.

ShakeCast has the potential of being a tool used globally, enhancing infrastructure resiliency for communities, governments and businesses, with Caltrans helping to pave the way.

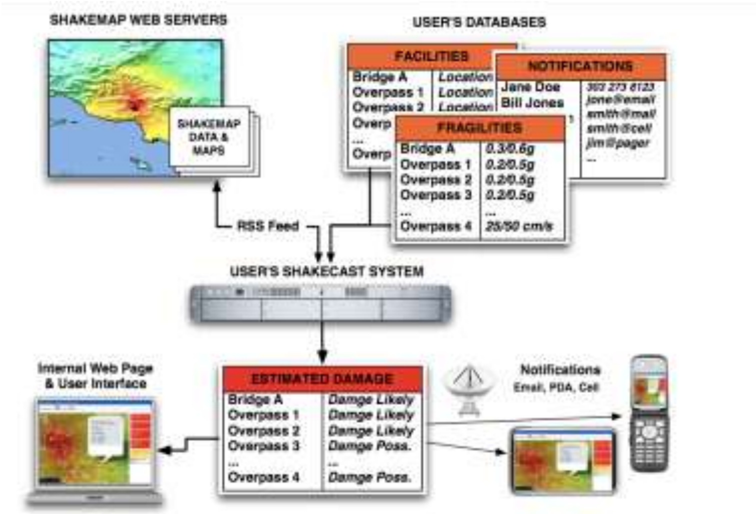


Figure 2.8: Information flow.

Figure 2.8 shows the path of the information flow once the SHAKECAST data is processed through the User's SHAKECAST system.

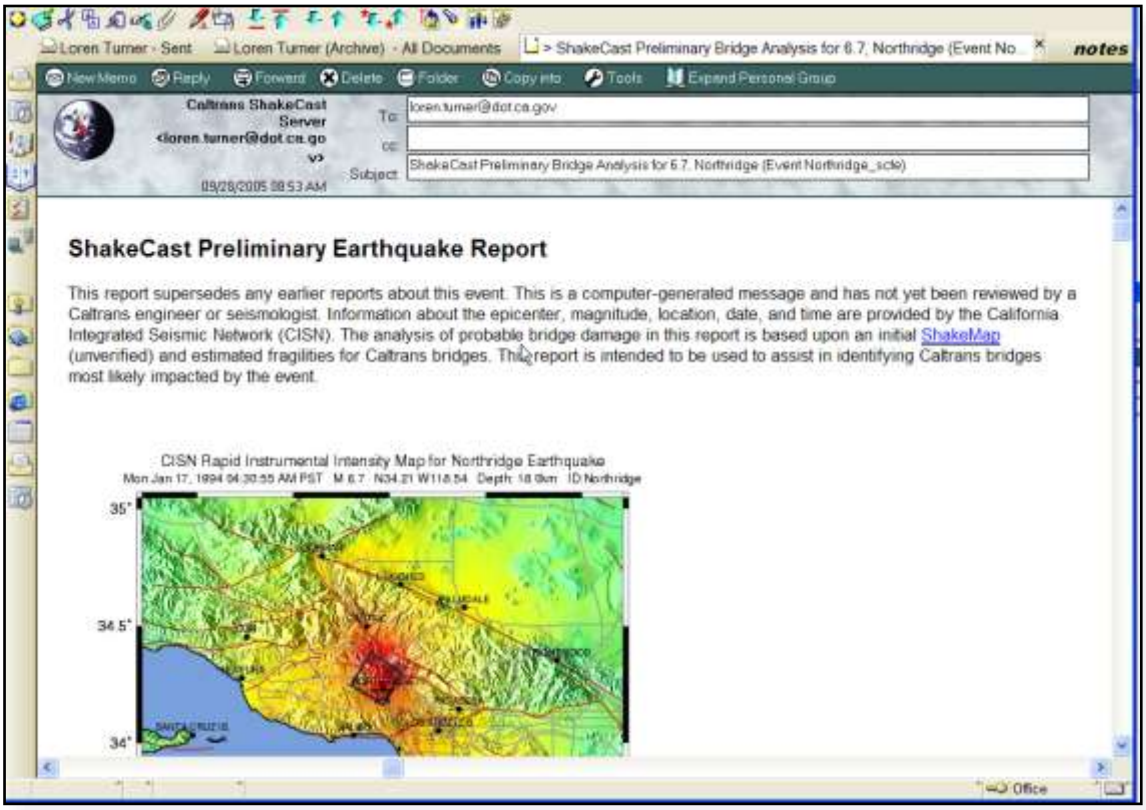
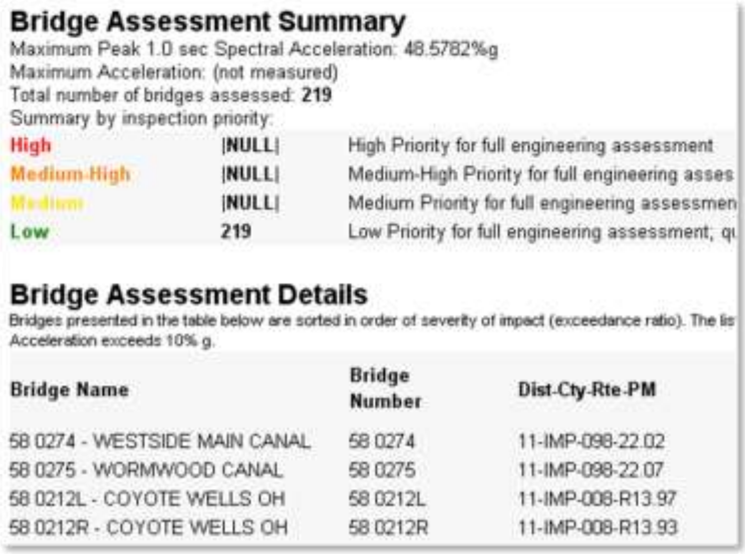


Figure 2.9: Emailed ShakeMap report.

One of the Products of the SHAKECAST system is a ShakeMap, which is shown in Figure 2.9. It shows the area of intense shaking, which may vary based on geology. For example, the most shaking may occur further away from the earthquake epicenter.



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 48.5782%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: **219**
Summary by inspection priority:

High	**[NULL]**	High Priority for full engineering assessment
Medium-High	**[NULL]**	Medium-High Priority for full engineering asses
Medium	**[NULL]**	Medium Priority for full engineering assessmen
Low	**219**	Low Priority for full engineering assessment; qu

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The lis
Acceleration exceeds 10% g.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM
58 0274 - WESTSIDE MAIN CANAL	58 0274	11-IMP-098-22.02
58 0275 - WORMWOOD CANAL	58 0275	11-IMP-098-22.07
58 0212L - COYOTE WELLS OH	58 0212L	11-IMP-008-R13.97
58 0212R - COYOTE WELLS OH	58 0212R	11-IMP-008-R13.93

Figure 2.10: Bridge summary report.

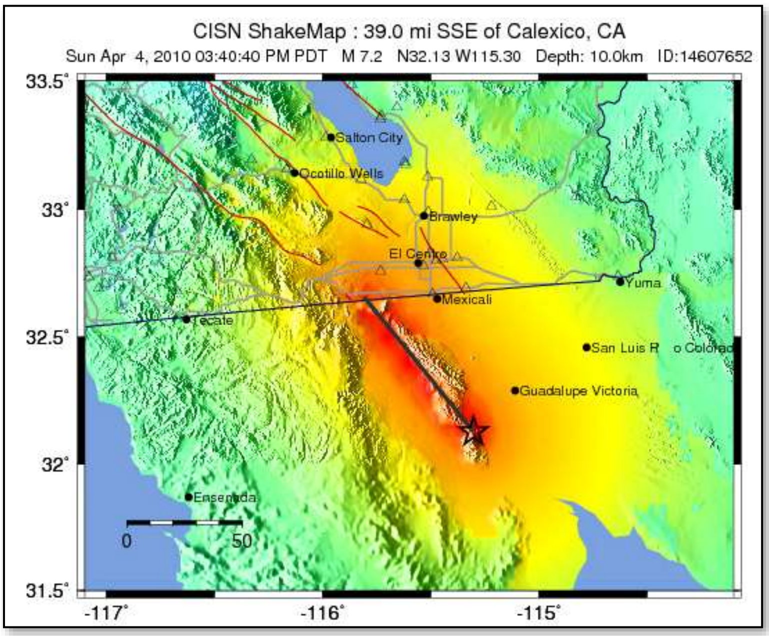


Figure 2.11: ShakeMap.

The ShakeMap (Figure 2.11) is supplemented with a bridge summary report (Figure 2.10). This report helps the engineers conducting inspections to prioritize which bridges to look at. The impacted bridges may be further away from the epicenter and bridges closer to the epicenter may not be impacted at all. Inspectors will eventually inspect all the bridges in a given mile diameter of the epicenter, to be inclusive of all bridges. SHAKECAST has modernized post-earthquake inspections of bridges, as well as buildings, roadway segments and all other types of infrastructure that can be modeled through SHAKECAST. SHAKECAST can also be used for exercises for emergency management and other planning purposes.

Figure 2.12: Earthquake impact to bridge.

Figure 2.13: Inspection photograph.

Inspection photographs of a bridge that was identified for assessment through the SHAKECAST system.

2.3. FIRECAST - FIRE DANGER FORECASTING

Every year, California deals with a fire season that can be catastrophic. Damage to the Transportation system can be unpredictable due to the changing path of a fire. Knowing more about the potential for a fire and its expected path can help Caltrans better protect field staff and the traveling public, stage equipment and resources to prevent or minimize damage to roadways and structures on the state highway system and manage needed operational changes (such as road closures). Advance notice of fire danger can also be used to predict areas where air quality may be dangerous. Caltrans is in the process of developing such an early warning system for wild fires that has been labeled "FIRECAST."

Figure 2.14: Hillside on fire.

The impacts to the transportation infrastructure, due to fires, may not be apparent until it is too late. The transportation network can quickly become incapacitated due to the impacts of fire and smoke.

Figure 2.15: Burnt guardrail.

Impacts from fire may include safety elements of the network being destroyed, such as metal beam guard rail - as seen in Figure 2.15. It is important to design the safety elements, in fire prone areas, to be resilient to the impacts of fires. Caltrans has a steel post policy, to mitigate for fire prone areas. Wood products are not used for safety elements and steel post are used instead.

Currently, Caltrans provides an early-morning notice to its staff of fire danger ratings (low, moderate, high, very high or extreme) collected from the U.S. Forest Service Wildland Fire Assessment System (WFAS). Caltrans has done a Preliminary Investigation project, which is named FIRECAST, to learn how other public agencies provide advance notice of potential fire emergencies and advise and assist staff in the field conducting daily activities during periods of heightened fire danger. Caltrans is especially interested in practices, tools, systems and models used to provide early warning and ongoing notice of fire emergencies that may impact transportation systems and operations.

To support this effort, this Preliminary Investigation gathered information on tools and resources employed by the following types of agencies to provide early warning and ongoing notice of fire emergencies:

- State departments of transportation (DOTs).
- Other California agencies, including the Governor's Office of Emergency Services and CAL FIRE.
- Other government agencies with responsibilities related to fire notification and management, such as the U.S. Forest Service, state fire agencies and forest services, and offices of emergency management.
- Other countries that have relevant experience with wildfires.

Through a literature search, we identified a variety of tools and other resources used to manage wildland fire incidents and keep fire responders and others working in the field advised of potential fire danger and active fires. The types of tools were - Incident Management Tools, Fire Mapping, and Assessment and Warning Tools.

While resources such as maps and incident reporting systems are readily available for identifying the potential for wildfire and tracking active fires once they occur, we did not find it to be a common practice among state agencies to publish procedures about the provision of early warning and ongoing notice of fire emergencies. Most information found was best practices for staff in responding to wildland fires. However, there was not information that specifically identifies staff with early fire warning or ongoing notification of fire movement.

Caltrans believes that early warning systems can be of great benefit for pre-staging of equipment and personnel to minimize damage and increase the safety of our employees and the travelling public during a fire event. Caltrans has been proactive in early warning systems that have proven their worth. Other systems Caltrans has been involved with are ShakeCast and FloodCast.

2.4. FLOODCAST - FLOOD DANGER FORECASTING

Flooding, and the effects and impacts of flooding along transportation networks, has caused billions of dollars of damage and countless deaths throughout the world. Technology currently exists, but must leveraged, to accurately locate those areas along a transportation network that are susceptible to flooding. Many Departments of Transportations (DOTs), in the United States, have a bridge flood monitoring program for structures that are susceptible to bridge scour. These systems monitor bridges for pending failure due to scour. Additionally, most DOTs have inundation mapping and use inundation modeling in the design of their transportation infrastructure.

Although there are weather and climate tools and systems available for predicting changes in the weather and climate conditions, they have not yet been integrated to provide sufficient planning and prediction modeling information required by DOTs to carry out flood planning, risk management, mitigation, operations, and emergency response activities.

There's currently research being conducted by the Transportation Research Board, of the National Academies, to interpret and harmonize the available technologies into a suite of tools and methods for use by decision makers at DOTs. Such research is intended to support DOTs in their efforts to develop and deploy emergency management early warning systems that can be applied to flood prediction and warning for enhanced flood event decision making and situational awareness for transportation resilience by harnessing available processes, tools, and hydrometeorology network capabilities.

The objectives of this research are to develop a strategic framework and a prototype tool for enhanced flood event decision making. The framework and tool should help DOTs plan, manage risks, mitigate hazards, and respond to flood and flash flood events. The framework and tool will address not only immediate flood impacts, but also cascading, escalating impacts.

Given the large amount and diversity of applicable data and tools, the framework design will be flexible and scalable to accommodate the available data sets and allow users to easily share both data and products with other users, thereby fostering collaboration across government organizations and the private sector.

The intent of this tool is to help make the transportation network, which is prone to flooding, safer - thus saving lives.

Figure 2.16: Cars caught in flash floods.

Drivers can easily drive into harm's way in flooding events. The purpose of the FloodCast warning system is to increase network safety by providing real time data to the network operators, so they can make informed decisions in regards to network safety.

Figure 2.17: Texas Wash Bridge washed out.

Figure 2.17 shows the Texas Wash Bridge on Interstate 10 in California's desert. A flash flood destroyed the bridge. Interstate 10 is a major east west corridor.

Figure 2.18: Evaluating Texas Wash Bridge.

Caltrans first responders are evaluating the area, as shown in Figure 2.18. Fortunately, there was no loss of life in this event. It is the hope that FloodCast will warn Caltrans Officials of potential impacts to the network due to Flooding and appropriate safety measures will be taken to help the traveling public.

2.5. EPIDEMIOLOGICAL APPROACH TO DETERMINING THE RISK OF ROAD DAMAGE DUE TO LANDSLIDES

Disruption of segments of roads can have a significant impact on the vulnerability of the entire network. Natural disasters are frequent causes of disruptions of this kind. Our approach focused on determining the risk of road disruptions due to landslides. We utilized methodology widely used in the field of epidemiology. We had available data on the location of the landslides, the road network and a list of the disrupted road segments. With the use of a 2×2 table, we determined the relationship between landslide data and road segment disruptions and derived the risk coefficient based on the number of landslides in the vicinity of the road and its length.

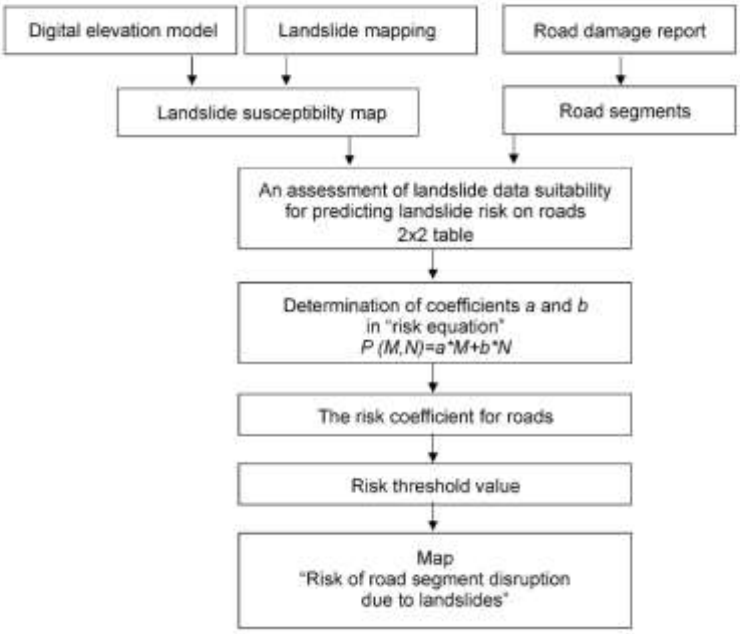


Figure 2.19: Flowchart describing the process leading to the disruption risk map.

	Damage		
	Yes	No	Sum
Landslide			
Yes	51	227	278
No	11	698	709
Sum	62	925	987

Table 2.1: Data for 2×2 table where two stages of road damage and landslide occurrence near roads are compared.

The result is a disruption risk map with risk coefficients ranging from 0 to 47.94. In order to distinguish the riskiest segments, we calculated a threshold of 12.40 with the use of a risk breakdown in a group of segments without damage. Nineteen percentage (402 km) of the road network in the Zlín region (eastern part of the Czech Republic), where the methodology was applied, is located beyond this threshold. The benefits of this approach stem from its speed and potential to define the riskiest areas on which a detailed geomorphologic analysis can be focused.

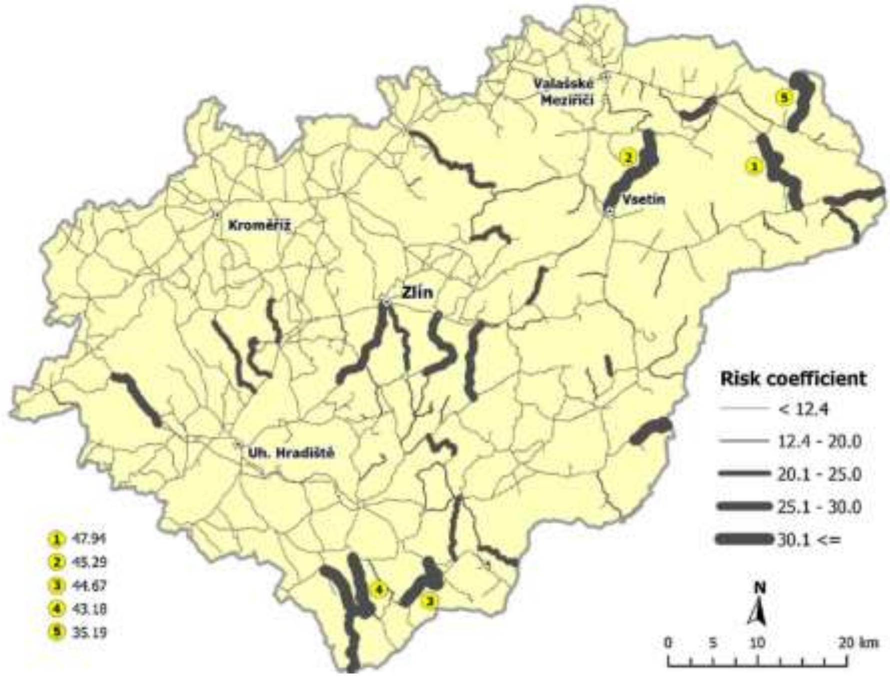


Figure 2.20: Disruption risk map. Road segments with risk coefficient above 12.4 are depicted by solid line symbols.

2.6. Evaluating road network damage caused by natural disasters in the Czech Republic between 1997 and 2010

Road networks play a vital role in maintaining a functioning modern society. Many events perceptibly affect the transport supply along these networks, especially natural disasters such as floods, landslides, and earthquakes. Contrary to more common disruptions of traffic from accidents, or maintenance closures, natural disasters are capable of destroying large numbers of roads and usually cover vast areas. When evaluating network damage, no single measure alone is able to describe the full extent of network destruction.

In this study, we investigated six highly damaging natural disasters, which occurred in the Czech Republic between 1997 and 2010. They were all induced by extreme rainfall or by rapid snowmelt and resulted in floods and landslides. Their impacts were evaluated with respect to the damage to road networks and decreased serviceability. For mutual comparison of the impacts and their analysis we used several criteria, described in the paper, related to economic impacts, physical harm to individuals and infrastructures, and the effects on connectivity and serviceability.

We also introduced a new measure based on the network efficiency index which considers the importance of nodes based on their population. Moreover, we provide a detailed analysis of one such event in July 1997 that significantly affected the road network of the Zlín region.

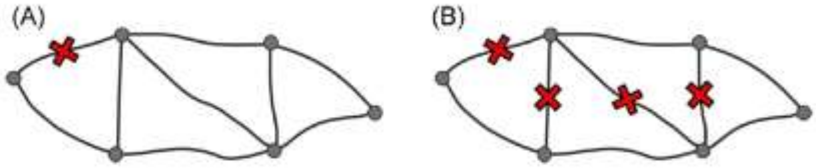


Figure 2.21: Figure caption?

Region	Year	Month	V_t	V_{tp}	Damaged links		L^a	Components	Cut off population	
					Abs.	%			Abs.	%
ZLK	1997	7	0.30	0.33	121	13.1	78.4	47	67,442	11.3
MSK	1997	7	0.10	0.05	98	6.4	88.9	32	17,418	1.3
OLK	1997	7	0.10	0.08	52	2.7	95.2	14	44,245	6.1
ZLK	2010	5	0.09	0.09	28	3.0	95.3	11	16,932	2.8
LBK	2010	8	0.09	0.06	39	3.2	94.8	12	11,112	2.6
JHC	2002	8	0.08	0.18	91	3.2	95.2	18	1996	0.3
ULK	2010	8	0.07	0.06	68	3.0	94.5	19	8042	0.9
JMK	2006	4	0.04	0.02	24	1.1	97.9	4	2844	0.2
LBK	2009	7	0.04	0.04	21	1.7	97.6	4	1126	0.3
MSK	2010	5	0.03	0.01	39	2.6	94.2	7	2862	0.2
ULK	2002	8	0.03	0.03	34	1.5	97.3	11	3491	0.4
ZLK	2006	4	0.02	0.03	14	1.5	97.7	5	2470	0.4
JHC	2006	4	0.02	0.01	38	1.3	97.5	7	284	0.0
OLK	2009	6	0.02	0.01	20	1.0	97.6	8	5665	0.8
PAK	2006	4	0.02	0.02	37	1.9	96.7	4	452	0.1
KVK	2002	8	0.02	0.01	10	1.1	97.5	4	935	0.3
JMK	2009	7	0.02	0.01	34	1.5	97.8	5	843	0.1
PAK	1997	7	0.02	0.02	20	1.0	98.0	5	876	0.2
ZLK	2009	6	0.01	0.02	5	0.5	99.7	2	280	0.1
OLK	2006	4	0.01	0.02	13	0.7	98.7	4	2479	0.3
JHC	2009	7	0.01	0.00	15	0.5	99.3	3	38	0.0
STC	2002	8	0.01	0.01	30	0.5	99.2	4	610	0.1
ULK	2009	7	0.01	0.01	14	0.6	98.6	3	340	0.0
OLK	2010	5	0.01	0.00	9	0.5	99.0	1	0	0.0
MSK	2009	7	0.00	0.00	10	0.7	98.6	2	228	0.0
JMK	2010	5	0.00	0.00	13	0.6	98.8	1	0	0.0

[a] Ratio of broken and unaffected networks after Chang and Nojima (2001).

Table 2.2: Impacts of natural disasters on regional road networks.

Table 2.2 shows six characteristics which were used for comparison of damage for regional road networks which took place in the respective years and months.

3. EDUCATION AND TRAINING

In road disaster management, quick repair of a road network is increased by systematic preparation of resources (e.g., material, machinery and human resources) from ordinary time before a disaster occurrence. Education and training are also necessary to increase rapidity. Education and training for a severe disaster become complex because of cooperation among a wide variety of road organizations in such a situation. In this chapter, we present two case studies: establishment and utilization of training center for application of temporary bridges in the Czech Republic and training and education program for technical staff in the California Department of Transportation.

3.1. TRAINING CENTER OF THE MINISTRY OF TRANSPORT, CZECH REPUBLIC

3.1.1. Introduction

After several floods, which occurred in the Czech Republic during the few last decades, we made the same important improvements in crisis management, which lead to new approaches and solution. The analysis of the need for rapid bridge reconstruction in large-scale crisis situations has shown that without systematic organizational, material and personnel training, it is not possible to ensure this recovery. Current construction technologies allow construction of bridges, arches whose lengths hundred meters or more span high above the valley. The renovation of these structures is extremely demanding. Without the prior practical preparation and without the massive use of special detachable structures, it is practically impossible to use in real time.

3.1.2. Training Center for Temporary Bridge Construction

The Department of Security of MoT considers the practical training and use of temporary bridge constructions as an important part of the crisis preparedness of the transport sector in the framework of the road and railway infrastructure. That is why in the territory of the Czech Republic in the town Kojetín, a Training center of the Ministry of Transport (TC MoT) was built. The aim of this training is to prepare the resources of the forces according to their specific employment in the system of economic measures for crisis situations in order to be able to deal with crisis situations especially in railway and road transport to ensure timely and quality reaction in the implementation of preventive and type crisis measures, crisis management and planning, thus contributing not only to the timely and effective fulfillment of the tasks in restoring the operability of the disturbed railway and road transport infrastructure, but also to the adoption of economically efficient solutions and procedures for the use of temporary structures, especially in case of disruption or destruction of permanent bridge structures.

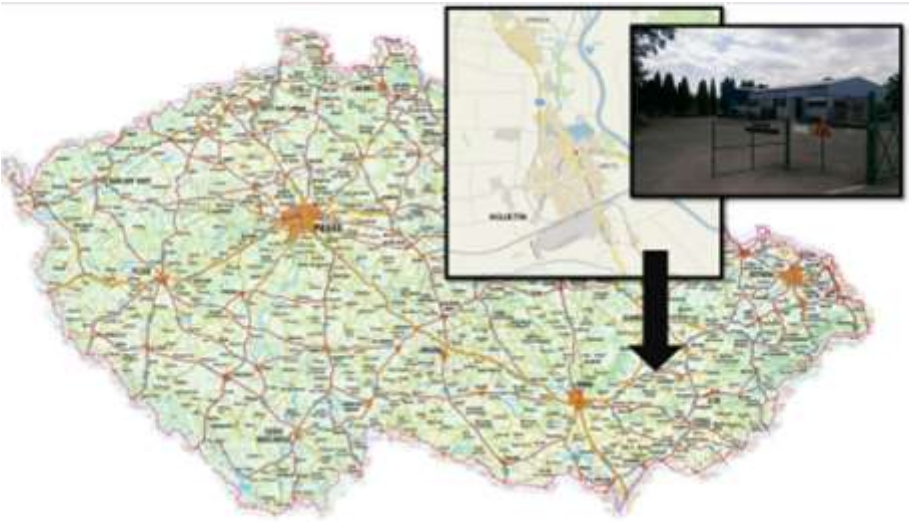


Figure 3.1: Localization of the Training center of the Ministry of Transport in Kojetín.

TC MoT is made up of a main building that provides sufficient capacity for lodging, training and dispensing. Another part is the two steel halls in which the training material is stored, including its maintenance and care. For the imposition of heavy components are used outdoor asphalt surface on which training takes place. The overall technical condition TC MoT, does not require any extraordinary repairs and the need to perform only routine maintenance. All efforts to prepare resources for solving this issue are based on the basic a summary of measures to restore transport infrastructure includes:

- Planning
- Construction and technical measures
- Provision of resources and their preparation
- Preparation of activation of forces and resources
- Own recovery, which is divided into: - site survey, designing, construction work

Figure 3.2: Training Center of the Ministry of Transport.

3.1.3. Training and Education System

Therefore, MoT organizes a comprehensive package of training and education activities in the form of short-term professional courses and work meetings regularly every year at its TC MoT in Kojetín.

This long-term continuous training and education is regularly organized to improve the preparedness for dealing with crisis situations in transport; especially in the realization of the reconstruction of the transport infrastructure, especially damaged or destroyed bridge structures. Self-preparation is intended not only for specialists from the transport sector but also for other affected and cooperating subjects and persons outside it. The system is currently necessary to develop two basic levels:

- Preparation of employees in the form of short-term courses.
- Preparation of students by the inclusion of specialized topics of crisis management in the structure of subjects of higher and secondary schools.

Training and educational activities are done both for and outside the transport sector. It is focused mainly on the issues of traffic and transport engineering. The Participants are from intended for secondary technical schools and universities, the organizations responsible for the maintenance and construction of transport infrastructure, crisis management bodies of municipalities, regional authorities, ministries and other central administrative authorities, departments of transport and road management, as well as the specialists of the Army of the Czech Republic, organizations ensuring protection of the state material reserves, designers and suppliers of temporary bridges. Under the agreement, is set very close international cooperation. In this field the training has well trained employees of the Ministry of Transport of the Slovak Republic.

3.1.4. Course Participants

Training and education enable workers to decide on the use of structures in crisis situations and, in individual cases, to plan forces and means to build, including the execution of rough time calculations. The Courses provides information on the maintenance system, storage, material handling, shipping policy, and ordering material for the construction of an intermediate bridge as well. Course participants are from:

- private construction companies
- organizations that provide planning
- employees of crisis centers of municipalities, regions and companies with a focus on road transport
- employees of the Defense Ministry of Transport and engineer expertise
- organizations and businesses that protect temporary bridge structures and ensure their pick for the restoration of bridges
- students civilian and military universities and colleges aimed at building bridges (as practice for theoretical training provided by the second subsystem)

Participants of the course are sent by the employer or the school on the basis of course applications, which are submitted in writing to the course organizer. Participants of the MoT are provided free accommodation and food. With regards to the provision of the economic measures for crisis situations system to the benefit of the State, no fee should be charged to the participants.

3.1.5. Types of Courses

The content of basic professional subjects forms the theoretical basis for practical training while respecting the principles of the safe work and filling professional training courses which provide the necessary knowledge relevant topic for organizing the construction of the pillars and temporary bridges, including gaining practical manual skills, using different kinds of assembly technology and the assembly of assembly compartments. Part of the course is to inform the participants of the course with the laws, decrees, regulations, and related textbooks.

The maximum effectiveness of the courses can be achieved by focusing not only on the theoretical but also practical handling of the construction of intermediate bridges using material that is stored in the state material reserves for this purpose (the share of practical, methodical training, group or individual exercises and demonstrations should not be less than 70 % of course duration).

According to the content, the courses are divided into four basic groups:

1. Crisis management course for acquiring basic knowledge and practical skills in the construction of a temporary bridge using provisional constructions that will enable management to decide on the use of the structures in crisis situations and, in simple cases, to design or plan forces and means of construction including the execution of rough time calculations.
2. The course of construction companies for practical mastering of basic technological procedures in the construction of a temporary bridge in crisis situations, including organization of work in individual working groups using different technical means.
3. The course for employees of warehouses and storage organizations of the state reserves to gain a comprehensive overview of the system of the maintenance, storage and handling, the principles for its transport on vehicles and the implementation of the order to use its own temporary bridge construction.
4. Working meetings with the Crisis Management Bodies at Regional and Local Levels are focused on acquiring and deepening knowledge, skills and habits useful in emergency situations, exchanging experience and coordinating with each level of management involved in the task of ensuring economic crisis management, focuses in particular on the areas of basic principles in securing material resources, crisis management and planning and critical infrastructure protection or soft targets protection in the transport, i.e., practical principles for selecting the most appropriate type of temporary bridge with the knowledge on the following factors, such as for which kind of transport and the traffic intensity is the temporary bridge built, spatial options for selecting of the type of temporary bridge, width arrangement, required area for mounting, assessment of the curvature of the connecting temporary bridge roads and, above all, whether it is located in an urban or rural area due to the impact of the noise from the operation, the winter maintenance and if it will operate with pedestrians in mind, in order to select the appropriate type with sidewalks. As a result of these joint negotiations and cooperation is a set of recommendations and questions for further solutions affecting the provision and use of temporary bridge to ensure transport services in the affected area.

Figure 3.3: TMS Bridge training in TC MoT Kojetín.

3.1.6. Organization of Courses, Educational and Training Activities

For each course, the MoT appoints a course leader and a lecturer who is present throughout the training. The MoT may delegate the powers of the course leader and leader to non-ministry staff. The course manager may be a qualified natural person who has a university degree in the relevant field, or in another transport field. The training of the lead lecturer, lecturers, Instructors and service technicians is the responsibility of the training organization or is determined by the number of employees of the TC MoT.

To conduct the training process, personnel is entrusted by the organization for each course written preparation under the MoT issued learning programs, curriculum courses, forms of organizing training guidelines, technical and material support etc. Written preparation must be processed so that it does not exceed the daily teaching (including repetitions and individual training) for more than 10 lessons (1 lesson may last no longer than 50 minutes).

Each course ends with an exam. The tests are carried out in the form of variant tests in the range of 10 - 20 questions. Questions must be formulated to verify the effectiveness of the instruction and training with respect to the objectives set for the individual courses. Every participant who attends a training course or working meetings of at least 90% of the set number of hours and completes a test will receive a certificate from the MoT of the Czech Republic. Certificate is an essential precondition for consent to any request for commercial loans of materials, temporary bridge structures and other commodities destined for resort transportation stored in the warehouses of state material reserves, applied by the contractor bridges or other structures and out of crisis.

At the end of each course, the lead lecture for the MoT prepares an evaluation of the course, including a proposal for supplementing or repairing consumed or damaged material.

Figure 3.4: Working Meeting with the Crisis Management Bodies at Regional and Local level of the Pardubice Region in TC MoT Kojetín.

3.1.7. Conclusion

The contribution of the TC MoT is considerable, and its activities are an integral part of the preparation and implementation of economic measures for crisis situations in the transport sector, which proved besides the normal situations and construction activities in the reconstruction and maintenance of transport infrastructure, especially in dealing with the consequences of the great floods in 2002, 2009, 2010 and 2013.

The graduates of the courses for the construction of road and railway temporary bridge construction not only contributed to the construction of a temporary bridge and pillar, but overall, the approach, management methodology and methods of action taken in dealing with crisis situations associated with the destruction or damage to transport infrastructure as a result of crisis situations, thus improving the fulfillment of the basic functions of the state in securing the transport serviceability of the affected area.

The prepared staff are able to analyze the situation and its impacts on the transport services of the affected area, to assess the suitability, feasibility and economic impact of the proposed solutions, to assess the suitability of the use of certain material which is stored in state material reserves and, if necessary request its release, or even manage the work.

The involvement of a wider range of businesses and corporations, including government and educational institutions in the training and education process in the issue of the use of temporary bridges in the reconstruction of the affected areas, increasing the readiness of both the transportation segment, as well as other concerned ministries to build and practical use of temporary bridges, which significantly contributes to increasing the resilience not only of transport but also of other infrastructures in crisis situations. This also achieves an increase in efficiency and recoverability of funds spent on the protection of such structures in the state material reserves.

Last but not least, it is necessary to mention the significant contribution of the training center's activities in the development and deepening of cooperation not only at national but also at international level.

3.2. EMERGENCY MANAGEMENT TRAINING AT CALTRANS

3.2.1. Introduction

Depending upon their potential role, the 19,000+ employees of Caltrans all require some level of training to effectively respond to any type of incident or event. To meet this challenge, our team is creating a fresh approach to meeting our employee's training needs. Organized around five levels of capabilities, our emerging Emergency Management Academy uses contemporary course delivery, such as webinars and video conferencing, alongside tradition classroom instruction. Whether the material is delivered by our staff or an outside program, our approach remains consistent with federal and state standards.

3.2.2. Emergency Management Academy

The State Emergency Services Act explains that all state employees could be called on to help during times of need. Our Academy acknowledges that some Caltrans staff are needed in their offices to help maintain normal government operations when others are called away by the incident. The Academy presents the core elements of the National Incident Management System (NIMS), Incident Command System (ICS) Standardized Emergency Management System (SEMS), and more, with increasing levels of detail depending on the needs of the student.

Beginning with general awareness training, the Level 5 course is proposed as a short online training course delivered to all employees via their desktop computers. Those without computers will be given classroom instruction. Level 4 training is a classroom course geared towards senior and executive managers. The focus is an overview of what Caltrans does or may be called to do during emergencies. It previews what typically occurs in the field as well as the office functions that support these activities. It also explains basic roles and responsibilities within the management structure needed to meet our expected obligations to the public while fully supporting our teams in the field.

Level 3 begins the more detailed training and is geared towards field supervisors. We help them understand the structure and flow of information used by ICS and how to incorporate those methodologies in the field. Training is met through a combination of online coursework offered by FEMA's Independent Study Program, hosted through their Emergency Management Institute (EMI).

Level 2 training is designed for those who work in the emergency operations center within their District or Caltrans Headquarters. These staff are expected to work within ICS procedures to support field activities and maintain the flow of verbal and written communication needed to effectively manage an incident.

Level 1 training is the highest level and requires instructor level capabilities as well as the ability to interact with state and federal partners regardless the type of location of incident.

Some of the elements of the Academy are already being delivered through our Maintenance Equipment Training Academy (META). All new field employees are given awareness level training before they engage in more detailed training and study. Likewise, in-house webinars open to all employees are offered quarterly to explain the fundamentals of emergency management.

3.2.3. Self-Study

FEMA's online Independent Study Program offers over 200 courses in a broad array of subjects depending on the needs of the student. Caltrans directs its employees to these courses depending on their response role. Beyond the core courses of IS 100, 200, 700 and 800, a sample of commonly completed courses relevant to transportation, planning and response include:

- IS 100 PWb – Intro to the Incident Command System for Public Works
- IS 200 – ICS for Single Resources and Initial Action Incident
- IS 700 – National Incident Management System (NIMS), an Introduction
- IS 800 – National Response Framework, an Introduction
- IS 230 – Fundamentals of Emergency Management
- IS 235 – Emergency Planning
- IS 293 – Mission Assignment Overview
- IS 547 – Introduction to Continuity of Operations
- IS 552 – The Public Works Role in Emergency Management
- IS 632 – Introduction to Debris Operations
- IS 775 – EOC Management and Operations
- IS 801 – Emergency Support Functions (ESF) #1 Transportation
- IS 821 – Critical Infrastructure and Key Resources Support Annex.

One of the essential values of the Independent Study courses is that the material can be incorporated into any agencies training curriculum. FEMA has consolidated years of lessons-learned into each of the classes helping to maintain high level of standard instruction. When added to the variables of different agencies, the outcome is a standard that allows outside agencies to follow a common framework while still recognizing geographic and functional differences.

3.2.4. Incorporating FEMA's EMI at Caltrans

At Caltrans we use a variety of resources from the Emergency Management Institute. The Independent Study Program noted above is the most popular because the online format is easily accessible to all employees across the state. More important, the course material can be downloaded in PDF format allowing for future reference as well as incorporation in to various instructional formats. Additionally, the material becomes a launching point for research into agency-specific methods that address unique situations in our state. Beyond this, EMI has a resident facility in Maryland with dormitories, classrooms, and a research library. The interaction with other emergency management practitioners from around the country is invaluable to continually improving operational methodologies within Caltrans.

Closer to home, the California Specialized Training Institute (CSTI) is the integrated training program for the Governor's Office of Emergency Services (Cal OES). With all CSTI and Cal OES courses in one program, the availability the breadth of material is open to more Caltrans employees across the State. Additionally, CSTI offers a robust instructor training program focused on FEMA standards. Such training ensures that all those receiving instruction from a CSTI approved instructor are receiving a consistent and standardized course that allows many different agencies to work well together regardless of environment. Caltrans supports and encourages those in its instructor cadre who want to pursue this level of professional training to do so. Caltrans has trainers who have completed the program with others signing up for the first time or completing refresher training.

The goal is to maintain a proactive core of trainers who continually seek to improve their capabilities for those who will support emergency activations both in the field and in the office.

4. COORDINATION AND COOPERATION

Road organizations as well as road networks may be damaged in major disasters. As a result, this leads to the fact that road organizations are unsystematic, and they cannot grasp damage or demand help from other organizations. Increasing robustness and resourcefulness of road organization improves resilience of road network. In this chapter, we present two case studies. The first is TEC-FORCE in Japan. TEC-FORCE is the national government's supporting system for local governments that suffered damage by a severe disaster. The second case study is the Incident Command System in the USA. This study is the standard system and procedures followed in emergency conditions, not just natural disasters.

4.1. TECH-FORCE ACTIVITIES AFTER THE 2016 KUMAMOTO EARTHQUAKE, JAPAN

TEC-FORCE (Technical Emergency Control Force) is a system to support local governments by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) when a major disaster occurs. TEC-FORCE activities include prevention of secondary disasters, investigation of disaster damage for quick restoration, recovery works using special machinery and high-level technical advice. The Disaster Countermeasures Basic Law of Japan provides that municipal governments are primarily responsible for disaster response. It is difficult for municipal governments to accumulate knowledge and experience for major disasters because of their low frequency of occurrence. In case of a major disaster, the whole area of municipality can be damaged and/or resources for disaster response are insufficient. The significance of TEC-FORCE is to support damaged local governments by MLIT which has the expertise in disaster management and is well equipped for it.

TEC-FORCE has been sent many times since 2008 when it was established. TEC-FORCE is not a system only for road disasters but for all kinds of disasters. We introduce TEC-FORCE activities on road facilities in the 2016 Kumamoto earthquake in this section.

The Kyushu Regional Development Bureau of MLIT covers the whole district of Kyushu Island, including Kumamoto. They sent technical experts to the Kumamoto area that was heavily damaged by the earthquake from the outside of Kumamoto immediately after it occurred. The Shikoku, Chugoku and Kinki Regional Development Bureaus around Kyushu also sent technical staffs to Kumamoto area. The National Institute for Land and Infrastructure Management(NILIM) and the Public Works Research Institute(PWRI) sent research staffs for detailed investigation of damaged structures and advice for recovery works.

Special remote-control machinery for recovery efforts at dangerous locations and helicopters to grasp wide-area disaster information were sent to the earthquake-impacted area. Their activities are summarized in the following:

1. Damage investigation

Road facilities in Kumamoto area were severely damaged. In the mountainous area, the road network was damaged by rock falls and slope failures. Helicopters were often operated from Fukuoka Airport to Kumamoto Airport and further to the earthquake-impacted area to grasp wide-area information of damage. TEC-FORCE Headquarters in Fukuoka implemented efficient operations g based on information from TEC-FORCE staffs in Kumamoto. TEC-FORCE staffs in Kumamoto inspected various road facilities and investigated the causes of road facility damage.

2. High-level technical advice

Teams of NILIM and PWRI researchers carried out detailed and advanced investigation at the site of sever and unique damage. They investigated the cause of damage, and they advised temporary countermeasures to prevent spread of damage and plans for future recovery works.

3. Proxy execution of recovery works by MLIT

MLIT carried out recovery works of local roads that had been severely damaged by the earthquake on behalf of local governments for quick restoration.

The road network is important infrastructure which supports all kinds of social activities during normal times. When a severe disaster occurs, the road network undertakes a role in supporting emergency activities such as rescue, prevention of secondary disaster and recovery works. It is important that the road network has high durability and redundancy. At the same time there's a limit. It is also necessary to take measures after road facilities are damaged by a disaster.

Figure 4.1: Technical advice to prefectural staff by TEC-FORCE at rock fall site.

Figure 4.2: Technical advice to prefectural staff by TEC-FORCE at damaged tunnel site.

Figure 4.3: Discussion on the damaged facilities.

4.2. Incident Command System

4.2.1. Introduction

The Incident Command System (ICS) is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. ICS is normally structured to facilitate activities in five major functional areas: Command, Operations, Planning, Logistics, and Finance and Administration. It is a fundamental form of management, with the purpose of enabling incident managers to identify the key concerns associated with the incident - often under urgent conditions - without sacrificing attention to any component of the command system.

ICS was developed in the 1970s following a series of catastrophic fires in California's urban interface. Property damage ran into the millions, and many people died or were injured. The personnel assigned to determine the causes of these outcomes studied the case histories and discovered that response problems could rarely be attributed to lack of resources or failure of tactics. Surprisingly, studies found that response problems were far more likely to result from inadequate management than from any other single reason.

The Incident Command System:

- Is a standardized management tool for meeting the demands of small or large emergency or nonemergency situations.
- Represents "best practices" and has become the standard for emergency management across the country.
- May be used for planned events, natural disasters, and acts of terrorism.
- Is a key feature of the National Incident Management System (NIMS).

The ICS is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to enable effective and efficient domestic incident management. A basic premise of ICS is that it is widely applicable. It is used to organize both near-term and long-term field-level operations for a broad spectrum of emergencies, from small to complex incidents, both natural and manmade. ICS is used by all levels of government - Federal, State, local, and tribal - as well as by many private-sector and nongovernmental organizations. ICS is also applicable across disciplines. It is normally structured to facilitate activities in five major functional areas: command, operations, planning, logistics, and finance and administration.

4.2.2. Essential Features

The 14 essential ICS features are listed below:

Standardization:

- Common Terminology: Using common terminology helps to define organizational functions, incident facilities, resource descriptions, and position titles.

Command:

- Establishment and Transfer of Command: The command function must be clearly established from the beginning of an incident. When command is transferred, the process must include a briefing that captures all essential information for continuing safe and effective operations.
- Chain of Command and Unity of Command: Chain of command refers to the orderly line of authority within the ranks of the incident management organization. Unity of command means that every individual has a designated supervisor to whom he or she reports at the scene of the incident. These principles clarify reporting relationships and eliminate the confusion caused by multiple, conflicting directives. Incident managers at all levels must be able to control the actions of all personnel under their supervision.
- Unified Command: In incidents involving multiple jurisdictions, a single jurisdiction with multiagency involvement, or multiple jurisdictions with multiagency involvement, Unified Command allows agencies with different legal, geographic, and functional authorities and responsibilities to work together effectively without affecting individual agency authority, responsibility, or accountability.

Planning/Organizational Structure:

- Management by Objectives: Includes establishing overarching objectives; developing strategies based on incident objectives; developing and issuing assignments, plans, procedures, and protocols; establishing specific, measurable objectives for various incident management functional activities and directing efforts to attain them, in support of defined strategies; and documenting results to measure performance and facilitate corrective action.
- Modular Organization: The Incident Command organizational structure develops in a modular fashion that is based on the size and complexity of the incident, as well as the specifics of the hazard environment created by the incident.
- Incident Action Planning: Incident Action Plans (IAPs) provide a coherent means of communicating the overall incident objectives in the context of both operational and support activities.
- Manageable Span of Control: Span of control is key to effective and efficient incident management. Within ICS, the span of control of any individual with incident

management supervisory responsibility should range from three to seven subordinates.

Facilities and Resources:

- Incident Locations and Facilities: Various types of operational support facilities are established in the vicinity of an incident to accomplish a variety of purposes. Typical designated facilities include Incident Command Posts, Bases, Camps, Staging Areas, Mass Casualty Triage Areas, and others as required.
- Comprehensive Resource Management: Maintaining an accurate and up-to-date picture of resource utilization is a critical component of incident management. Resources are defined as personnel, teams, equipment, supplies, and facilities available or potentially available for assignment or allocation in support of incident management and emergency response activities.

Communications/Information Management:

- Integrated Communications: Incident communications are facilitated through the development and use of a common communications plan and interoperable communications processes and architectures.
- Information and Intelligence Management: The incident management organization must establish a process for gathering, analyzing, sharing, and managing incident-related information and intelligence.

Professionalism:

- Accountability: Effective accountability at all jurisdictional levels and within individual functional areas during incident operations is essential. To that end, the following principles must be adhered to:
- Check-In: All responders, regardless of agency affiliation, must report in to receive an assignment in accordance with the procedures established by the Incident Commander.
- Incident Action Plan: Response operations must be directed and coordinated as outlined in the IAP.
- Unity of Command: Each individual involved in incident operations will be assigned to only one supervisor.
- Personal Responsibility: All responders are expected to use good judgment and be accountable for their actions.
- Span of Control: Supervisors must be able to adequately supervise and control their subordinates, as well as communicate with and manage all resources under their supervision.
- Resource Tracking: Supervisors must record and report resource status changes as they occur.
- Dispatch/Deployment: Personnel and equipment should respond only when requested or when dispatched by an appropriate authority.

4.2.3. Modular Organization

Standardization of the ICS organizational chart and associated terms does not limit the flexibility of the system. (See the chart on the next page.) A key principle of ICS is its flexibility. The ICS organization may be expanded easily from a very small size for routine operations to a larger organization capable of handling catastrophic events. Flexibility does not mean that the ICS feature of common terminology is superseded. Note that flexibility is allowed within the standard ICS organizational structure and position titles.

4.2.4. Position Titles

At each level within the ICS organization, individuals with primary responsibility positions have distinct titles. Titles provide a common standard for all users. For example, if one agency uses the title Branch Chief, another Branch Manager, etc., this lack of consistency can cause confusion at the incident.

The use of distinct titles for ICS positions allows for filling ICS positions with the most qualified individuals rather than by seniority. Standardized position titles are useful when requesting qualified personnel. For example, in deploying personnel, it is important to know if the positions needed are Unit Leaders, clerks, etc.

Listed below are the standard ICS titles:

Organizational Level	Title	Support Position
Incident Command	Incident Commander	Deputy
Command Staff	Officer	Assistant
General Staff (Section)	Chief	Deputy
Branch	Director	Deputy
Division/Group	Supervisor	N/A
Unit	Leader	Manager
Strike Team/Task Force	Leader	Single Resource Boss

Table 4.1: Standard ICS titles list.

4.2.5. ICS Structure

The ICS structure is shown in Figure 4.4.

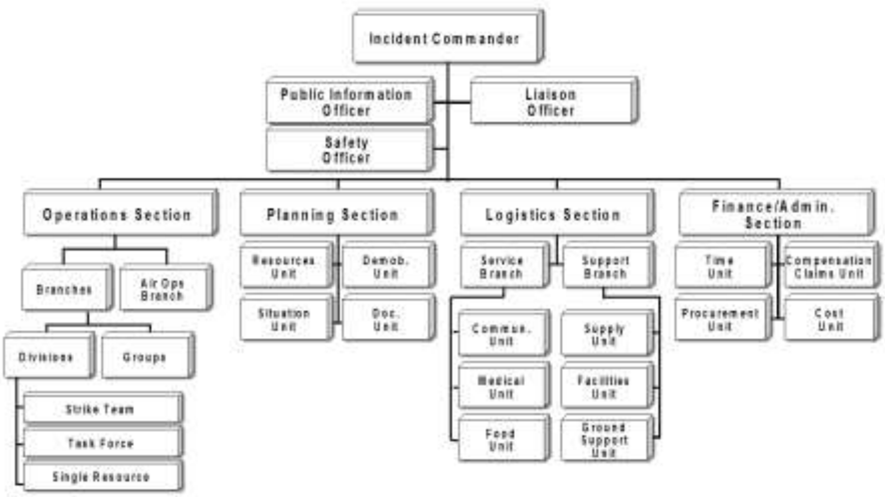


Figure 4.4: ICS structure.

5. EMERGENCY OPERATIONS AND RECOVERY APPROACHES

In this chapter, we present four case studies on emergency operation and short-term recovery. First, we report an example of emergency management in the nationwide level in the USA, and then show several case studies. These examples indicate the importance of preparedness of resources e.g., material and human resources and preparedness for effective utilization of these resources.

5.1. EMERGENCY MANAGEMENT AND RESILIENCE IN TRANSPORTATION

This section will discuss emergency management and resilience as applied to a countries transportation system. The paper will review those precepts and concepts that are at the forefront of the discussion today.

A disruption in a country's transportation system could start out as a local event that has cascading effects not only throughout the local transportation system, but the local economy as well and may grow to impact a region, a country, and eventually world economies through the effect of a country's dependency and interdependency on each other.

5.1.1. Emergency Management and Resiliency

Emergency Management

Emergency Management is the formation of plans through which communities reduce exposure to hazards and manage disasters. Emergency Management does not prevent or eliminate threats or hazards. It focuses on creating plans, best management practices, and standardized operating procedures to decrease the impact of disasters.

Emergency management has its foundation in the protection of life, property and the environment and consists of four overlapping phases:

Preparation – Preparation involves the activities undertaken in advance of an emergency, including developing operation capabilities, training, preparing plans, and improving public information and communications systems.

Response – Response is defined as the actions taken to save lives and protect property during an emergency event.

Recovery – At the onset of an emergency, emergency management officials begin recovery efforts. Recovery is both a short-term activity intended to restore vital life - support systems, and a long-term activity designed to return infrastructure systems to pre- disaster conditions. Recovery also includes cost recovery efforts.

Mitigation and Prevention – Mitigation planning includes a review of ways to eliminate or reduce the impact of future emergencies. Specific hazard mitigation plans are prepared following a federally declared disaster. They reflect the current risk analysis and mitigation priorities specific to the declared disaster. An alternate and more common term for mitigation is prevention. In the field of emergency services, however, the term prevention is used to refer to stopping an event from happening. Emergency managers point out that while it is possible to prevent terrorist attacks, it is not possible to prevent earthquakes. It is, however, possible to reduce or mitigate their impact.

An Emergency Operations Plans (EOP) objective is to mitigate, prepare for, respond to, and recover from emergencies impacting California's State Highway Infrastructure, as well as any other emergencies where Caltrans is mission tasked to respond. The Caltrans EOP is consistent with various federal emergency planning concepts, such as the FEMA National Response Framework (NRF), Federal and State Catastrophic Concept of Operations (CONOPS), and COOP/COG Plans. The Caltrans EOP is centered on the California Standardized Emergency Management System (SEMS) and the Incident Command System (ICS) and is part of a larger framework that supports emergency management within the state. This larger framework is directed by the State of California Emergency Plan, hereinafter referred to as the SEP. The Caltrans EOP has the following purposes:

- Provides a central and unified resource for the planning for, and execution of, operations during an emergency, and the recovery following an emergency.
- Describes the manner in which Caltrans responds to and manages natural or human-caused emergencies, events, and incidents, including technological or nuclear related incidents and large non-emergency based events.
- The organization, functions and sections to which Headquarters and District personnel, their Divisions and Districts, may tentatively be assigned in their activated Headquarters Department Operations Center and District Emergency Operations Center during an emergency.
- Methods of preparation for, response to, and management of emergencies resulting from natural or human-caused disasters, technological incidents, nuclear related incidents or large events, including evacuations.
- Handling and reporting serious injuries or fatalities that occur during an employment activity of Caltrans employees or employees under contract with Caltrans.
- Caltrans' operations in the State Operations Center (SOC), the Regional Emergency Operations Centers (REOCs), and the various local Operational Areas, and its role in the State of California Emergency Plan.
- Funding and emergency administrative and financial guidelines, such as the procedures for requesting Director's Orders or resource allotment.
- Integrates and Coordinates the Emergency Management Concepts of Preparedness, Response, Recovery, and Mitigation with other Caltrans plans, manuals, and directives.
- Identifies its place in relation to the SEMS, and further describes the relationship of Caltrans' Emergency Operations to the 5 Primary Functions of the Incident Command System (ICS).
- Specifies the various alternate communication tools that may be used during or while managing an emergency that impacts the normal methods of communications.

Another aspect of Emergency Management that is sometimes over looked but should be addressed, is human behavior. Human behavior in carrying out the emergency management mission should be addressed. How people actually react and why certain behaviors occur during emergencies should be mitigated for in plans. We should accept what does happen and, not what we want to believe happens. What we plan, and what people actually do is increasingly different. We should design systems to support what people actually do.

Resiliency

Resiliency incorporates hazard mitigation and land use planning strategies; critical infrastructure, environmental and cultural resource protection; and sustainability practices to reconstruct and harden the built environment, as well as revitalize economic, social and natural environments. A resilient system ensures the economic and social

An "All Hazards & Security Guidance Plan" for Transportation Departments is vital to identify the methods used to reduce risks to the transportation system infrastructure posed by possible acts of natural, technological, and human-caused hazards. This plan should highlight the processes used to strengthen preparedness and promote timely response and recovery procedures that significantly reduce deaths, injuries, and other disaster losses.

The overall intent of a guidance plan is to begin to identify and manage risks and potential vulnerabilities associated with a Transportation Department's assets and infrastructure in order to minimize operational disruptions, ensure economic and social well-being to communities and ensure business and government continuity after catastrophic disasters.

Highway transportation is essential to the economy of every country. The closure of a highway may result not only in inconvenience but may also cause serious economic loss to the traveling public. It is the duty of a Transportation Agency to minimize impacts to the motoring public, costly interruptions due to traffic and economic loss. The goal is to provide a safe and efficient transportation system with maximum performance and accessibility along with preserving and enhancing resources and assets throughout a country's economy.

The California Department of Transportation's (Caltrans) approach to vulnerability outlined below was developed to help guide future planning and programming processes. It outlines actions to be taken to achieve long-term highway system resiliency.

The approach includes the following key elements:

Exposure:

Define the elements and locations of the highway system (roads, bridges, culverts, etc.) that may be exposed to changing conditions caused by climate change, including sea level rise, storm surge, wildfire, landslides, etc. Key indicators for this measure include the value and timing of expected changes (at what year could you expect these conditions to occur).

Consequence:

Identify the implications of extreme weather or climate change on Caltrans assets. Key variables include estimates of cost of damage, and the duration of closure to repair or replace the asset. The consequence of failure from climate change would include such concerns as (among others):

Figure 5.1: Flow path for vulnerability assessment.

- Sea levels and storm surge inundating roadways and bridges forcing their closure, which could affect goods movement and the traveling public.
- Wildfire primary and secondary effects (debris loads/landslides) on roadways, bridges and culverts.
- Precipitation changes, and other effects such as changing land use, that combined could increase the level of runoff and flooding.

Prioritization:

Develop a method to support investment decisions among multiple options that each reflect future climate risk, including such considerations as:

- Timing – How soon can the impacts be expected?
- Impacts – What are the likely costs to repair/replace? What is the likely duration of outage? What are the likely impacts on travel/goods movement?
- Safety – Who will be directly or indirectly impacted? How can impacts to vulnerable populations be avoided?

By using this approach, Caltrans can capitalize on its internal capabilities to identify projects that increase highway system resiliency.

Resiliency in the Recovery Phase of a transportation network results in the restoration of transportation infrastructure, assets, and systems to their conditions prior to the incident. Recovery can and should involve rebuilding the network beyond its previous condition to a greater standard that is more resilient against future disasters. Resiliency in the recovery phase includes such efforts as improving materials and construction methods to increase the strength of infrastructure, establishing redundancies in the transportation network using Intelligent Transportation Systems (ITS), and improving the common links between transportation modes and communities. Resiliency in the recovery phase should result in a network that has a vibrant ability to absorb damage from a future disaster and thereby bounce back rapidly following the incident.

5.1.2. Interdependencies

All of the other sectors, such as communications and water distribution, depend on the transportation sector to accomplish their missions. In addition, the various modes of transportation must pay attention to each other, for example, highways lead to airports, ports of entry, rail stations – and vice versa. What impacts on a subcomponent of the transportation sector may impact the others. It is important that emergency operations plan address the concerns inherent with these interdependencies.

5.1.3. Modes of Transportation

Transportation, and the many modes within thereof, must be first defined, before we can understand:

1. Why does that mode exist?
2. Who they serve?
3. Who owns a particular mode?
4. The ties between Social Infrastructure and commerce in regards to transportation.

Modes:

- Aviation
- Highway Infrastructure (surface transportation)
- Maritime Transportation System
- Mass Transit and Passenger Rail
- Pipeline System
- Freight Rail

5.1.4. Customers of the System

We will break down the customers of the system to that of supply chain and social infrastructure.

Supply Chain:

Assessing disaster risk for the supply chain (economic resilience) is important and a great way to start assessing resilience of the system through all modes of transportation.

"A supply chain view of the transportation system must collectively consider all aspects of the commodity being shipped…recognizing that freight crosses jurisdictions, modes, industries, and is constantly changing to meet higher service standards and lower cost expectations"

Seven principles of supply chain resilience (as developed by the Asian Pacific Economic Cooperation)

- Information Sharing
- Disaster Risk Management and Hazard Mapping
- Planning and Business Continuity Management
- Policy and Regulations
- Regional Cooperation
- Critical Infrastructure and Intermodalism
- Human Resources Capacity Management

Social Infrastructure:

Social Infrastructure is a subset of the infrastructure sector and typically includes assets that accommodate social services. We should assess those hazards to the transportation system that impact the support of a community.

In addressing the Supply chain issues are addressed, social infrastructure needs may be addressed.

5.1.5. Identify Hazards to the Transportation System

The following are some standard hazard types that many countries may face.

- Biological Threat
- Chemical Threat
- Drought
- Earthquake
- Fire
- Flood
- Heat
- Hurricane

- Landslide
- Radiation and Nuclear
- Tornado
- Tsunami
- Volcano
- Wildfires
- Winter Storm

5.1.6. Phases of Emergency Management

- Planning
- Response
- Recovery
- Mitigation

Apply the Seven Principles of Supply Chain Resilience to the 4 Phases of Emergency Management, as well as all of the hazard types applicable to the Transportation Infrastructure within a country.

5.1.7. Tools

- Hazard mapping
- FireCast – fire danger forecasting
- FloodCast – Flood danger forecasting
- ShakeCast – post earthquake inspection
- GIS
- Early Earthquake Warning
- Operational Earthquake Forecasting

5.1.8. Plans

The following are some of the plans that a transportation agency should have.

- Emergency Operations Plan
- Continuity of Operations/Continuity of Government Plan
- Continuity of Business Plan
- Winter Operations Plan
- Infrastructure Protection Plan
- Influenza Plan

5.1.9. Mapping

Using mapping is a critical tool in a responding to a hazard and adding resilience to the transportation system. Some of the mapping would include, but not limited to the following.

- Lifeline Routes
- Emergency Supply Chains
- Detour Maps
- Communications maps
- Routes of Importance
- Hazard Mapping

5.1.10. Hazard Mapping

The development and use of hazard maps for transportation networks enhances resilience of the system. A hazard map identifies a hazard, usually a natural hazard, in a particular area on the network. This information can be used in the planning and design of a transportation system.

The information can also be used in developing trade routes/corridors that incorporate identified hazards, helping with the continuity of operations as well as economic resilience tied to network performance/safety.

5.1.11. Training/Academia/Studies/Technology/ITS/Communications

- Emergency Operations Center/Incident Command Post Training
- Hazard Specific Exercises
- Transportation Corridor Studies
- Economic Impact Studies
- Emergency Communications
- Roadside Weather Information System (Weather Station)
- Changeable Message Signs
- Highway Advisory Radio

Why is this topic of Hazard Mapping and Resilience, Emergency Management and Infrastructure protection as applied to transportation systems, so important?

Simply -

"Transportation systems are fundamental to a civilization. Whether we are talking about the Roman Empire or today's modern Society. A resilient transportation system is "KEY" to a Nation's greatness"

5.2. Application of Michi-no-eki, Roadside Station to Emergency Operations

A "Michi-no-eki" that is a roadside station, is a kind of road facility developed by a road authority collaborating with local governments. A Michi-no-eki has three major functions: a rest space for road users, providing information for road users and local residents, and promoting regional development, which is the core of collaboration among local governments. A Michi-no-eki must have at least a rest facility, an information service facility, and a regional development promotion facility. The rest facility includes parking lots and restrooms that can be used free of charge for 24 hours a day. The information service facility offers traffic information, local sightseeing information, and emergency medical information. The regional development promotion facility is, for example, cultural facilities and recreation facilities. The rest facilities are developed by road authorities. The regional development promotion facility are developed by local governments. The information service facilities are developed by road authorities or local governments. In 1991, the first Michi-no-eki was developed on a trial basis, and a total of 1,117 Michi-no-ekis are registered as of April 2017.

There are various forms of Michi-no-ekis depending on the local situation. A Michi-no-eki fulfills a function of local community hub during normal times. Such application of Michi-no-eki from normal time is very meaningful in that its existence is known by many road users and local residents at the time of a disaster.

In the Niigataken Chuuetsu-oki Earthquake of 2004, Michi-no-ekis were used as regional disaster relief bases in the aspects of supporting evacuees, hubs of rehabilitation and reconstruction, and providing information service. Examples of the use are the following.

1. Conference rooms and parking lots of Michi-no-ekis were used as shelters for evacuees.
2. Michi-no-ekis near the disaster-impacted area supplied disaster information to road users.
3. Spa facilities of Michi-no-ekis were opened for free.
4. Temporary houses were constructed at parking lots of Michi-no-ekis.

In 2007, the Ministry of Land, Infrastructure, Transport and Tourism launched to put efforts into providing Michi-no-ekis with disaster relief functions such as private power generation and stock of emergency water and food.

In the Great East Japan Earthquake of 2011, Michi-no-ekis on a hill were used for evacuation from tsunamis. In the water or power outage areas, some Michi-no-ekis were operated for 24 hours a day by using private power generation. Michi-no-ekis served as hubs of mutual support among local residents, local farmers brought their products to Michi-no-ekis and local residents bought them in particular.

A Michi-no-eki plays a role as a hub of rescue activities by the Self-Defense-Forces in the disaster-impacted area. The Japanese Government formulated an action plan for the earthquakes that may occur directly beneath the Tokyo metropolitan area. In the plan, Michi-no-ekis are situated as assembly bases and hubs of activities for the Self-Defense-Forces. Various facilities are being developed at these Michi-no-ekis.

Michi-no-ekis organize regional councils for each area and form an organization across the country. In the Kumamoto Earthquake of 2016, Michi-no-ekis outside the impacted area collected and sent their own stocked food and water to the Michi-no-ekis in the impacted area. A Michi-no-eki is expected to play a key role in "self-help", "public help" and "mutual help" in case of a disaster such as an earthquake or tsunami. Self-help means that residents and road users help themselves, public help is a form of support in which the Government including the Self-Defense-Forces helps residents, and mutual help is that residents help each other.

Figure 5.2: Image of Michi-no-eki.

(Michi-no-eki Nasukogen Yuainomori: photo provided by Michi-club)

Figure 5.3: The bustle of market in michi-no-eki in normal time.

(Michi-no-eki PATIO Niigata: photo provided by Mitsuke-city)

Figure 5.4: Storage in michi-no-eki for disaster.

(Michi-no-eki Tenku-sansan:

Photo provided by Disaster Control Center, Kumakogen town, Ehime Pref.)

Figure 5.5: Activity of SDF (Self Defense Force) using michi-no-eki parking.

(Michi-no-eki Asobounosato Kugino:

Photo provided by the Contact Secretariat of Kyushu-Okinawa Michi-no-eki)

5.3. Practical use of temporary bridges to ensure the rapid recovery for transport service ability of affected areas

5.3.1. Introduction

The basic prerequisites for the successful management of any crisis situation in order to satisfy basic needs of people in the impacted territory, allowing the survival of crisis situations without serious damage to health and to support the activities of the armed forces and the armed security forces and fire brigade and emergency services, the security of the basic transport functions, in particular the mobility of the transport infrastructure, seems to be evident.

In terms of modal split, between modes of transport, in most crisis situations exploits the segment of road and rail transport and whether they are carrying out the evacuation of the population or their property, rescue and relief work, or recovery of the affected area.

5.3.2. Strategy Temporary Replacement Bridge

One of the most problematic areas for ensuring traffic on the transport route is to ensure the functionality of critical artificial structures and one of the most important are bridges, which in most cases can be considered a narrow throat on the roads. This narrow neck should be kept sufficiently permeable, and if not otherwise, measures such as the construction of a temporary replacement bridge. In recent years, there has been an increased interest in temporary bridge structure. This is mainly due to the management of detour routes when repairing, reconstructing or exposing both bridges and roads.

Management of Detour Routes

Designing and approving a detour route is often made more difficult by the property manager of the road in question, after which the detour route is designed and demanded by mayors of municipalities and towns on detour routes that mostly require the repair of existing roads and bridges, which is very costly and disproportionately increases the cost of the repair, reconstruction or construction. For these reasons, construction project documentation has begun to project to a greater extent, on the basis of the investor's requirements, temporary bridge as separate structure objects, which minimize the undesirable negative effects arising from the operation of detour routes. Temporary bridges are, if possible, fitted in close proximity to a repaired or built object, the detour route is minimal and public transport practically passes along the same route.

Managing any Crisis Situation

The need to maintain or re-establish transport functionality as quickly as possible is a basic, generally recognized reason for successfully managing any crisis situation. Ensuring access to the affected areas, saving lives, removing the wounded, securing supply and promptly removing the damage. The experience of the rehabilitation of the transport infrastructure, particularly as a result of the catastrophic floods of 1997 and 2002, but also of the flash floods in the years to come, has confirmed that bridge structures are the most vulnerable and at the same time the most difficult to recover on the affected roads.

5.3.3. System of Management and Basic Technological Procedures

System of management and basic technological procedures for bridge renewal based on subsequent types and degrees of damage to bridge structures in crisis situations that may arise due to the effect of the impact of different kinds of threats of natural and other threats:

Light damage to bridge structure without impact on load capacity (Figure 5.6)

- Damage to the load bearing structure of the bridge with bearing capacity (Figure 5.7)
- Destruction of the bridge object (Figure 5.8)
- Damage or destruction of the access road (Figure 5.9)

Figure 5.6: Light damage to bridge structure after floods 1997 in the Czech Republic.

Figure 5.7: Damage to the supporting structure of the bridge due to floods 2002 in the Czech Republic.

Figure 5.8: Destruction of the bridge structure during the flood of 2002 in the Czech Republic.

Figure 5.9: Destruction of both access roads to the bridge due to floods 2009 in the Czech Republic.

Security System Management

The recovery and response to these threats are realized and within the set security system management and fulfillment of the obligations of individual entities and their activities in the context of the below mentioned basic framework Management of the Provisional Bridges under Crisis Situations:

Leader: Ministry of Transport

Partners: Administration of State Material Reserves

- Ministry of Defense
- University of Defense Brno
- Road and Motorway Directorate
- Technical Schools
- Private Businesses

Users: Bridge Owners (Stricken Regions, Municipalities, Infrastructure Managers), where each of the above entity has its active role in the following process of crisis management.

Basic Technological Procedures

All activities of these entities then lead to the fulfillment of the objectives and the fulfillment of the individual tasks within the Implementation of the building temporary bridges for different stages of realization.

1. Construction preparation

Ensuring building permits, depositing of debris, Landscaping, Disconnection of utility networks, ensuring site space, Securing auxiliary building materials - road panels, aggregates, construction timber)

2. Construction realization

Moving of building materials and technology; Focus and positioning of the roadway, positioning of the bridge and pillars; Positioning of the crane; Construction of the roadway; Construction of the individual parts of the bridge; Ejection of the bridge; Stacking of the bridge and construction of ramps on the bridge; Facilities (e.g. barriers, pedestrian walkways, traffic signs); Handover of the bridge to the traffic controller.

3. Operation and maintenance

Performing regular inspections and prescribed Technical conditions maintenance.

5.3.4. Current Procedures for Requesting and Solving the Requirements for the Construction

Basic Principle for the Provision of Material Resources

The basic principle for the provision of material resources is not to require the material resources available in their own administrative district, that is to say, that only the requirements for material resources that the Crisis Team cannot ensure within its territorial or material scope, such as:

- Scheduled provision of material resources as a result of unfavorable development of the crisis cannot be achieved (e.g., these funds have been destroyed or access restricted, etc.)
- Foresight resources are to be secured by a higher level crisis management entity according to the plan of unsecured necessary deliveries
- the crisis solutions require resources that have not been planned and cannot be retrofitted in their own administrative district

The main sources of the system for the rapid recovery of damaged or destroyed bridges in crisis situations include the operating materials of organizations entrusted with the exercise of state ownership rights. For road bridges it is the Road and Motorway Directorate.

Creating Emergency Reserves

The Ministry of Transport (MoT) establishes a requirement for materials of temporary bridges in emergency supplies of the State Material Reserves Administration pursuant to Act No. 241/2000 Coll., On Economic Measures for Crisis Conditions and on Amendments to Certain Related Acts, and is responsible for justifying their need and specifying individual specifications and quantities. Uninsured requirements applied by regional authorities in the field of maintenance and rehabilitation of transport routes are included in the request.

The purpose for creating emergency reserves in the context of emergency management only supplement the resources located in the ownership of business entities, which are used to their normal commercial activity, and where those who do the kind or amount is not sufficient to solve the crisis.

5.3.5. Processes and Principles for Selecting the Most Appropriate Type of Bridge Provision

The problem of designing and constructing alternative bridges can be divided into two basic and quite different processes. In the first case, it is necessary to construct a replacement bridge in the normal situation, for example as a construction bridge or as a replacement bypass during the planned reconstruction of the permanent bridge. In this case, the Building Act is strictly followed, and the preparation of the project documentation and the structure itself are in line with current industry practices. In the second case, if the relevant crisis situation declared, the process is shortened for the construction of the temporary bridges, which has the entire construction process significantly shorten and simplify.

When planning the designer should consider the following factors in his proposal:

- Intensity of traffic for selecting one-way or two-way temporary bridge
- Find out for which traffic is deployed. Whether bus only + personal, or unlimited for site traffic.
- Spatial options for casting the selected type temporary bridge, width arrangement, required area for temporary bridge mounting by sliding or using a temporary pillar located in place obstacles, assessment of the bending ramps of the ramp communications
- Whether the temporary bridge is located in an intravilan or extravilan with respect to the noise impact on the surroundings from car traffic.
- How long will the temporary bridge be deployed for winter road maintenance
- Whether the temporary bridge will operate pedestrian traffic for selecting the appropriate type with sidewalks.
- Cooperate with the investor and discuss with the mayor, if the temporary bridge is deployed in an urban area, inform local residents about potential impact of the noise.

5.3.6. Temporary Bridges Type

The designer has based the proposal on the following types of provisional bridges, which can be used in the civilian sector to convert public automobile traffic and pedestrians.

The one-way temporary bridges include temporary bridges type: BB Bailey Bridge, TMS heavy bridge set, MS bridge set, Mountable road bridge set MMS 2005, Mabey Universal, Plate bridge provision, VITKOVICE a solid beam, ZM 16 railway bridge and ZM 60 railway bridge.

The two-way temporary bridges include bridge type: VITKOVICE a solid beam and MMT 100 MAMUT.

Footbridge

For the area of pedestrian conversion, we divide temporary bridges with a footbridge or without footbridge. This footbridge can be single-sided or double-sided. Sidewalks can be fitted without special measures only on temporary bridges MMS 2005, Mabey Universal and VITKOVICE type. On temporaries BB, TMS and MMT 100 can be equipped with sidewalks only on condition that on the basis of project documentation adjustments are made on the pavement works and railings. Temporary bridges of type MS, ZM 16 and ZM 60 do not have the possibility to mount sidewalks.

5.3.7. Experiences and Improvement of Technical Parameters

Based on long-term experience of floods and other crisis situations using the overview of the use of temporary bridges from emergency stockpiles to remove the consequences of the floods in 1997 to 2013 and bearing in mind that, in improving conditions for quality transport services of regions and the whole territory, transport within the framework of improving the quality of public transport services by speeding up the construction of the necessary transport infrastructure and effective protection and maintenance of the existing transport infrastructure, the MoT presented a proposal for a significant reduction of the emergency reserves.

Results of the Study Carried out on the Current Supplies of Emergency Stocks

The MoT continuously reassesses the need and, above all, the scope of the crisis planning created in connection with the development of the security situation, in the context of real security threats to the transport system.

The following conclusions are drawn from the results of the study carried out on the current supplies of emergency stocks stored at the State Material Reserves Administration (SMRA).

Technical aspects:

Emergency stock materials are at the limit of their life, Emergency stock materials are inappropriate for the solution of the restoration of the bridge in the intravilan (Urban Area) from the point of view of noise, stockpile materials have a limited possibility of installing a sidewalk outside of their own bridge, The MS and TMS bridge used is also inappropriate in terms of maximum axle load, Standby stock materials are made of steel that does not achieve the properties of currently used steels.

Safety aspects:

It is necessary to solve the replacement of selected elements of the current structures of the emergency stock in order to increase their safety and to preserve their life, Due to the high wear and tear of the individual spare parts, the reliability and functionality for further use of bridge assemblies cannot be guaranteed, The MS bridge is transported only as an oversized transport.

Economic Aspects:

Stocks of materials are unnecessarily large for some components and a reduction in the volume of stored material is required, the effectiveness of their further maintenance has to be considered.

Improvement of the Technical and Security Aspects of the Materials of the Temporary Bridges

Simple adjustments can be made which are used to reduce noise or increase safety at the Road and Motorway Directorate of the Czech Republic (RMD) or other private entities. RMD has been dealing with this issue on a long-term and conceptual basis, and therefore it is possible to apply the tried and tested modifications to SMRA materials without research, which have also undergone operational burdens.

RMD ensures the continuous modernization of TMS heavy bridge set construction elements, in particular to increase the safety of pedestrians and cyclists moving on temporary bridges, and to ensure the provisions of the Czech standards on the protection of human health and to reduce the effects of noise from passing vehicles.

5.3.8. Development

With rising security measurements demanded on the pedestrian traffic on temporary bridges, the re-evaluation of old military temporary bridges in stock of Czech Republic needed.

Currently, two F types of systems of temporary bridges are used in Czech Republic. Both types are a modular steel truss construction used as a single-lane road. First, Modular bridge 'MS', is used for the span up to 21 m with modulus 3.0 m. Second, Modular bridge 'TMS', is used for the span up to 42 m with modulus 3.0 m.

However, the old military temporary bridges are no longer suitable for the increasing traffic load and do not allow separate (safe) transportation of pedestrians over an obstacle without the exposure of the pedestrian to the roadway traffic lane without construction changes. The shared space for pedestrian and traffic in the roadway width is also inconvenient because of the excessive loading of one side of the bridge due to placing pedestrian traffic on one side of the bridge and therefore not enabling the traffic load to be placed to the center of the bridge causing overloading one side of the bridge. Construction companies have to secure pedestrian traffic with one way use footbridges that do not fulfil the European standard for two-lane pedestrian traffic and barrier free access and are not economical.

Figure 5.10: Temporary footbridge with span 18.0 m next to the temporary bridge 'MS' (Kozlovice, 2014).

The solution was to design a barrier free pedestrian footbridge enabling safe transportation of pedestrians over an obstacle in a separate space. The main advantage of a separate footbridge is the possibility of its independent placing, either next to the temporary bridge, or more distant to it, in order to prevent the accumulation of both motor and pedestrian traffic at critical points. The purpose of this project was to develop a temporary footbridge fulfilling utility criteria, such as systematism, section modulus, safety of traffic, barrier free access, simple assemblage and storability, and was based on new Eurocode and current national regulations. The examination of the material for endurance, and the influence of construction details used on the footbridge, were performed and on its results the technical specifications were determined.

The effective solution based on the most frequent span of standing bridges was demanded, therefore research of single-pole bridges of maximal span of 100m in network of I., II. and III. Class roads were done. The results show the most crossed obstacles are river obstacles and road obstacles. The statistic shows the percent ratio of single-pole bridges with maximal span 18.0m is 92.3% and the percent ratio of both single and multiple-pole bridges with maximal span 18.0m is 81.1%, with span 18.01- 36.0m is 15.9%, more than 36.01m is 3.0% (shown in Figure 5.11).

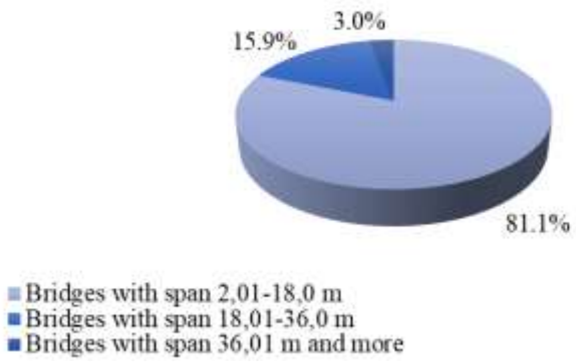


Figure 5.11: Percent ratio of both single and multiple-pole bridges in the Czech Republic.

Based on this research, the company Vladimír Fišer came with two economical version of footbridge with maximal span 18m and 36m were set up.

Another parameter necessary for designing temporary footbridge are good storability in decomposed state, with no need of an oversized transport and fast and easy assemblage. It is necessary to set a modulus defining, in this paragraph already mentioned, parameters and especially the variable span of the footbridge.

The variant of modular footbridge with variable span from 3.0m up to 18.0m was designed as steel panel truss construction with modulus 3.0m (Figure 5.12).

Figure 5.12: Modular footbridge with variable span 3.0-18.0 m.

The variant of modular footbridge with variable span from 3.0m up to 36.0m was also designed as steel panel truss construction with modulus 3.0m with headroom 2.50m (Figure 5.13).

Figure 5.13: Modular footbridge with variable span 3.0-36.0 m.

These two variants of temporary modular footbridges fulfil the European standard for two-lane pedestrian traffic and barrier free access. They can be used as both single and multiple-pole bridges with additional central pillar made of PIZMO (modular construction pillar system often used in Czech Republic). Due to their construction design they are fast to be mountable and easily to be placed at their end position (by crane or on sliding track). Their dismantling possibilities allow to be stored and transported without heavy transport. Technical Specification brochure allows immediate use without any additional time occupying testing process. Therefore, the two variants of modular temporary bridge are fast and economical solution ensuring the rapid recovery for transport service ability of affected areas or they can be used as a temporary bridge whenever needed.

5.3.9. Conclusions and Experience of Using Temporary Bridges in Practice

Over the past 20 years (1997-2018), on the basis of practical experience in dealing with crisis situations in the provision of transport services and the functionality of the transport infrastructure, the correctness of the chosen strategy of using temporary bridges. Since 1997 it has been in crisis situations used for the reconstruction of flood affected areas and built from materials stored in emergency reserves, a total of 121 provisional bridges with a total length of 3,072 meters.

Effective, efficient and fast renewal of transport services and transport functions after disasters simultaneously ensures increasing the resilience of the transport sector. The material resources that are available throughout the territory and especially in the state material reserves offer at the same time the possibility of atypical use and increase of resilience for other sectors This was during the period also verified by the practical use of these materials in various extraordinary and routine situations and in the routine work of construction companies. Diversity of use is also commensurate with the quality of education, training, and the level of invention of all sources of power involved in the system of use of these temporary constructions.

At the same time, this system is one of many very good examples of effective and efficiency cooperation civil and military sectors, public, private and academic representatives, national, regional and local levels of crisis management bodies, which also offers an opportunity for the area developing international co-operation, such as response in the form of humanitarian aid, or in the area education and training.

During the whole period, the knowledge and experience gained was verified, and the necessary implementation of the new measures were then carried for further development and improvement. Especially optimizing inventories to meet real needs in line with crisis plans and the current state of transport infrastructure, practical verification to ensuring the requirements for the transport of temporary bridges not only by road but by air as well, improving the education system and the associated enhanced education and training at all levels and, finally, getting awareness modernization of inventories with the aim of improvement of technical and safety parameters of military structures for civilian operations.

On the basis of practical experience in dealing with crisis situations in the provision of transport services and the functionality of the transport infrastructure, was confirmed the correctness of the chosen strategy of using temporary bridges.

The knowledge and experience gained was practically verified and was found the need of the necessary implementation of the new measures for further development and improvement of system.

Effective, efficient and fast renewal of transport services and transport functions after disasters simultaneously ensures increasing the resilience of the transport sector. The material resources offer at the same time the possibility of atypical use and increase of resilience for other sectors.

This was verified by the practical use of these materials in various extraordinary and routine situations and in the routine work of construction companies. Diversity of use is also commensurate with the quality of education, training, and the level of invention of all sources of power involved in the system of use of these temporary constructions.

Optimizing inventories must to meet real needs in line with crisis plans and the current state of transport infrastructure, to the requirements for the transport of temporary bridges not only by road but by air as well. The modernization of inventories and with the aim of improvement of technical and safety parameters of military structures for civilian operations is necessary as well as improving of the education system and the associated enhanced education and training at all levels.

At the same time, this system is one of many very good examples of effective and efficiency cooperation civil and military sectors, public, private and academic representatives, national, regional and local levels of crisis management bodies, which also offers an opportunity for the area developing international co-operation, such as response in the form of humanitarian aid, or in the area education and training.

5.4. CALTRANS WINTER OPERATIONS

Caltrans Maintenance takes care of over 50,000 lane miles. Of these 50,000 miles, 9,060 lane miles are designated as winter routes (Snow and Ice Routes). Caltrans spends roughly 25 million dollars each winter for snow and ice removal to keep these routes open and in a safe condition for the traveling public. Caltrans employs 5,500 permanent full-time maintenance employees. 1,950 of these designated Equipment Operator classifications. In addition, Caltrans hires 600 seasonal employees to assist with winter operations on these snow and ice routes. Depending on the severity of the winter, Caltrans spends an average of 30 million dollars for non-snow and ice related storm activities.

Caltrans Maintenance has an equipment fleet of 12,000 vehicles statewide. Caltrans snow and ice control fleet consists of roughly 2,500 of those 12,000 vehicles. Common vehicles used in snow and ice operations are plow/sander truck combinations, motor graders, front-end loaders, and currently a fleet of 77 snow blowers which is one of the largest in the nation. Caltrans owns 32 large Vactor trucks that are not only used to maintain our stormwater drainage system but are vital to our recovery efforts during heavy rain and flooding events.

Caltrans uses a number of different outlets to inform the public of current road conditions. These road conditions can change rapidly during winter storm events. Our partners who work in the Caltrans Public Information offices are in constant contact with media outlets including Facebook and Twitter sites. Caltrans utilizes over 700 Permanent Changeable Message Signs and 143 Highway Advisory Radio Stations that are monitored and changed as needed 24 hours a day 7 days a week to help keep the public aware of the ever-changing conditions. In addition, Caltrans maintains an online mapping system, called Quickmap. Quickmap has real-time road conditions that are updated continuously. Quickmap was recently upgraded to use GPS data in a new application that allows the public to view our plow truck fleet in their most recent locations.

California's varied climate and terrain brings us many challenges related to winter operations. One can literally be surfing off the coast near San Francisco and 3 hours later be snow skiing at one of the Lake Tahoe resorts above 8,000 feet in elevation. Crews in one area of the state can be dealing with 55-degree temperatures, heavy rains, flooding and high winds, while a crew 90 minutes away are dealing with 20-degree temperatures with heavy snow and freezing conditions. The varying operations connected with these dissimilar conditions use a widely diversified set of vehicles and materials.

California has four major avalanche zones located in three distinctly different areas. Caltrans uses a number of diverse tools for avalanche mitigation. The primary system used in the Sierra Nevada Mountains routes is called Gazex. The Gazex system is set up to utilize "cannon" locations that are permanently positioned in known avalanche zones. These cannons are fueled by a pre-set mixture of propane and oxygen and are detonated remotely to control the avalanche danger. By creating a "man-made" avalanche, this method aids in protecting the traveling public from nature-caused avalanches during heavy snow events. Backup systems to the Gazex include portable cannons which shoot an explosive projectile powered by compressed air.

Caltrans has some unique equipment types that have been developed from some of our own maintenance forces, and the Division of Equipment personnel in conjunction with equipment manufacturers. One of these specialized pieces of equipment is called a split-mount loader blower. It consists of a front-end loader, with an additional engine mounted on the back of the loader which powers a liftable blower unit mounted in place of the bucket on the front of the loader. These split mount blower units are vital to our avalanche cleanup operations.

Caltrans Winter Operations, in conjunction with the Division of Equipment, continue to look at new and innovative equipment that can help do our jobs safer and more efficiently. One new equipment technology we are presently piloting is called the Mechanical Ice Breaker. Like the split-mount, the Ice Breaker unit is attached to the front of a loader. Once attached to the front of the loader, this machine is used to break up the ice pack without the need for de-icing agents. While not proven to work in every condition, we are optimistic that these Ice Breaker units will help lessen our dependency on de-icing agents and shorten the time it takes to lift chain control.

Another innovative technology Caltrans has been piloting is a new sander unit that spreads sand and liquid brine simultaneously. These units not only use less material than our current sanders, they can sand multiple lanes at once. This has proven to be a very successful pilot throughout the state. To go along with the 2 pilot units, the Division of Equipment has purchased 19 additional units that we anticipate being put into service this coming winter.

As was mentioned earlier, brine is becoming one of the integral parts of our snow and ice program. Simply put, brine is a mixture of salt and water that is combined to form a 23% solution. The results are conclusive; using brine mixed at the correct rate is more effective than straight salt. By using brine, we are reducing the amount of salt by over 50% in order to treat the same area with better results. Brine can be effective both as a pre-treatment to prohibit ice and pack development as well as a post-application after ice and pack has formed. There are several types of commercial systems available that allow us to mix brine at our maintenance facilities. Presently, Caltrans has installed a total of 14 systems statewide. The newer systems currently available on the market have proven to be very effective in our brine application program. Some of these systems are used in conjunction with the facility wash racks at our maintenance yards making use of recycled wash water. Caltrans has plans to add several newer systems statewide over the next couple of years.

Caltrans is currently designing a Maintenance Decision Support System (MDSS) to assist maintenance operations with weather forecasting, weather forecast modeling, employee staffing, and material management. This system will allow for improved utilization of equipment, employee staffing levels, and more efficient material usage by better understanding what we actually need to keep the highway system in a safe condition.

MDSS can consist of numerous operating systems tied together in one source. Remote Weather Information Systems, actual weather forecasts, and data from GPS/AVL equipped vehicles, can be brought together to give our field people reliable real-time information to make the right decisions with our maintenance forces. Historical data can be used to formulate maintenance responses to forecasted weather events.

Caltrans has pledged to provide a safe transportation system for workers and users. Caltrans will promote health through active transportation and reduced pollution in communities. These are just some of the many tools Caltrans uses daily to help keep our commitment to these standards.

6. CONCLUSIONS

From the research activities conducted by WG2 of TC E.3, the following conclusions may be deduced:

- It is necessary to make decisions based on scientific knowledge and experience in detecting and the evaluation of natural disaster risk. Scientific knowledge and experience are improved through continuous and systematic monitoring and analyzing at the site. To establish the decision making system in which responsibilities of all stakeholders are clearly and critically defined is important to make effective decisions on road transport safety using integrated knowledge of various fields. When countermeasures are executed, utilization of ITS is effective because many road organizations are concerned about disaster management and use ITS as part of their decsion making.
- It is effective to include not only knowledge on the application of disaster management systems, but knowledge on disasters from the view point of science (e.g., monitoring). Education and training programs at road organizations should include cooperation with other organizations in disaster situations. It is effective to include not only road organization staff, but the residence or civil organization as participants of the program.
- As the result that not only the road network is impacted, but also road organization itself (staff) is impacted, the road organization may not be able to work effectively in restoring its' infrastructure, and may ask for assistance from other organizations.
- To increase robustness and resourcefulness, the overall resilience so to speak, of a road organization, it would help to improve resilience of the road network. It is the effective pre-establihment of plans of cooperation to a damaged area from other non-damaged areas and starting the cooperation automatically, triggered by information of the disaster occurrence without the demand of help from damaged area. Help and cooperation from to many organizations, may add confusion. In such a situation, it becomes a barrier of cooperation and coordination. Small differences among road organization e.g. difference of organization system and structure, name of division, department and position of staff. Standardization of concept and procedures for emergency and clear definition of responsibilities of various stakeholders, increases resilience of the road network through the organization's resourcefulness.
- We can find some efficient and effective directions of preparation of resources for emergency operation and short-term recovery. Preparation of various sources is effective for emergency operation and short-term recovery. Preparation for utilization of those prepared stronghold (material resources) near the damaged area increases effectiveness and efficiency of emergency operations and short-term recovery. These stored resources should exist in adequate distance from damaged area. These strongholds should be placed decentrally because severe disasters can occur anywhere. It increases the function of the stronghold, for emergency and regular use.
- Utilization of prepared resources should be match the unique situation, of each country e.g., social economics, meteorology, geology, and etc. For example,

specialized preparation of temporary bridge for floods exerts good results, utilizing programs of education, training and strategic planning.

- There is a kind of disaster e.g., snow disaster during the winter, which probability increases periodically and we are able to know certainty over time, as the storm gets closer. It is effective to hire temporary staff in preparation for the event. It is efficient to construct facilities and equipment which can be used for various purposes, during the high/low of the season e.g., changeable message sign boards.

It is recommended that future research focuses on the following areas.

- Good practice of emergency response planning.
- Evaluation and adaptation of road infrastructure to emergency situations.
- Management of emergency information through big data and social networks.
- Financial aspects of emergency management and recovery.
- Communitty health – the oppurtunitty to build back better after a disaster, with a holistic approach to communitty health. Including the mental health, and general health, needs of fisrt responders.
- The impacts of such things as pandemics to Disaster management.

7. REFERENCES

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