Technical Infrastructure Increasing Resistance in the Natural Environment

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http://doi.org/10.29227/IM-2020-01-43

Submission date: 12-01-2020 | Review date: 17-04-2020

Abstract

The natural environment has its specific patterns that a human must take into account during realisation of any technical infrastructure of the world countries. Underestimating the dangers that can arise from natural phenomena has often serious consequences. For some constructions of technical infrastructure, especially their line constructions, there will be a high number of operational accidents with extremely negative impact on the supplied regions with energy or drinking water. Other types of technical infrastructure for example in nuclear power have a potential to create a natural emergency threaten the environment not only in the country of their dislocation but also in the long term to change living conditions in entire regions.

The following article deals with this issue in a suffcient basic range suggests chat ways and means to recognize the threat of danger and then based on risk analysis to eliminate the consequences to an acceptable level.

Keywords: *technical infrastructure, system resistance, risk, risk analysis, consequences elimination*

Introduction

When constructing any technical work, the designer must take into account local natural conditions. Accordning to different regions and climatic zones, the building in question may have different functional characteristic and safety parameters and conditions. These differences are manifested not only on the object above the ground but especially on the line constructions.

The object or line structure must meet the specified parameters of resistance to the effect of normal natural influence and at the same time according to the specific conditions of its dislocation in the area, other conditions that have the potential to arise only periodically at different intervals. In Europe these include in particular floods, landslides, soil load-bearing instability, like undermining, and water conditions. Also in some regions seismic influences of varying intensity and probability of their occurrence are present as well.

When assessing them it is necessary to start with historical records as well as geophysical, climatic and hydrological knowledge of the environment. Failure or underestimation of this information very often reduces the resistance of buildings and their assemblies, increases operating costs and also shortens the buildings life.

1. Potential of nature emergencies and their negative consequences

In order to build an object or line structure in any country, such as Europe, the building´s investor must recpect local legislative (building law, water law,..) for the location of the building as well as the common EU legislation. Their adherence increases the resistance of buildings to the effect of axtraordinary events and in particular protects the original natural environment.

However some objects and line structures of technical and transport infrastructure (water works, bridge structures, security elements) must be also built in areas with an increased risk risk of emergencies of a natural character:

- floodplains of recipients,
- territory with seismic aktivity,
- significantly sloping areas in mountain locations.

In practice, the above-mentioned natural hazards are often simultaneously amplified by concurrent anthropogenic safety influences in industrial areas or territories through which certain types of pipelines (oil pipelines, transport of chemicals, wastewater tratment by the industry) pass. The highest probability of occurence of an extraordinary event and extent of extensive consequential damages are buildings which must be for technical reasones (gravity water inflow) located in the flood areas of the recipients such as wastewater treatment plants, see Fig. 1. and other water works, eventually transport infrastrucutre construction.

As a rule in the case of transport infrastructure constructions there is no pernament or long-term reduction in utility values or subsequent secondary damage. They are designed and built for high resistance to the effect of natural influences caused by floods. A similar statement applies to a large part of the water works (dams, rainwater and wastewter outlets).

Specific water works with relatively complex technologies such as sewage treatment plants, wastewater pumping stations, monitoring systems, have a low degree of natural flood resistance. Since they are of irreplaceable importance in the area and it the natural environment protection, it is always necessary to count on the risk of buildings flooding and thein technologies and to prepare for an extraordinary event, for example in the manner specified in chapter 3 in this article.

The potential for other emergencies caused by natural phenomena is different depending on the type of facility and its location in the area. To a fundamental extent, natural events on the technical infrastructure cause the following conditions:

- breaks and cracks in pipe systems during landslides,

Fig. 1. Destruction of gas tank due to floods in Ostrava in 1997 [1]
Rys. 1. Zniszczenie zbiornika gazu z powodu powodzi w Ostrawie w 1997 r. [1]

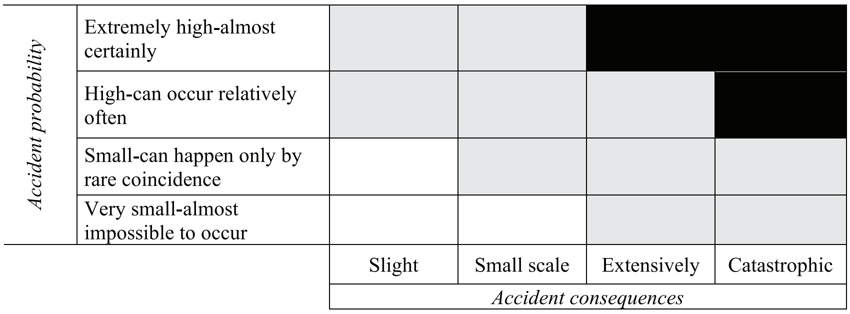

Fig. 2. Model of MU risk rate matrix and its consequences in technical infrastructure [3]
Rys. 2. Model macierzy stopy ryzyka MU i jego konsekwencje dla infrastruktury technicznej [3]

- foundation structural joints disruption of building structures,
- spot and area corrosion of metalic materials deposited in the ground,
- in extreme cases the destruction of object strucutres.

Taken together the above events can seriously undermine the general infrastructure of whole regions for a number of days or even weeks. However the self-preparation prevention for addressing the different kinds of natural influences on technical infrastructure must result from risk analysis using appropriate methods and optimizing ways of recognising the treats in question.

2. Means and methods of emergencies recognition

Current knowledge and possibilities of technology can be detected in time by a number of potentials hazards [2] In their practical application, technical tools for project management and management need to be put in the place. One way to proceed with risk analysis is to use an appropriate analysis method. The following is the technical infrastructure for which the region is largerly dependent on operability and reliability.

Already in the first engineering risk analysis phase to develop risk checklist in accordance with the overall concept included in the mind map, see Table 1 and 2 which indicate weaknesses and strengths of the system.

Subsequently from the primary information from the checklist the risk analysis need to be continued using for example the FMEA method through a sequential step involving a risk matrix. The matrix can také various forms. One of the altrenative form and structure options for the matrix is shown in the following Figure 2.

From the matrix output the individual relationships must always be sufficiently clear from the point of view of the extraordinary risk events, its probability and consequences for the opearting systems of assessed operating set. Of course, the other ways of engineering risk analysis can also be used in practice. However each used method must have the outputs sufficiently understandable to the user, for example the state administration, the municipal authorities and also the infrastructure managers [4].

3. Possibilities of technical residence increasing in the area

The resilence of each technical infrastructure is always based on the knowledge of the environment in which is located and preventive prepardness to deal with emergencies. This knowledge will result from the risk analysis performed before any construction on the technical infrastructure. From a pragmatic point of view i tis advisable to increase the resilence of the subjekt infrastructure in two steps.

Increasing the infrastructure buildings resilence

Underground or overground buildings have almost always a major impact on the reliability of energy supplies or drinking water for the region in question. Their purpose is to increase or decrease the hydraulic and technical parametre sof the systém or to accumulate the trasported medium. These objects can be relatively well protected from the effects of anthropogenic influences. Substantially more complicated, before the occurence of natural phenomena, depending on the different types dislocation of object structures.

To increase the infrastructure buildings operational resistance can be done for example:

- always know in detail the stability of the soil environment under the building and its weaknesses when changing climatic conditions,
- knowledge of the risk object flooding and potential levels of flooding at different levels of risk,

Tab. 1. Selection of vulnerability checklist – gas supply to the region
Tab. 1. Wybór listy kontrolnej podatności na zagrożenia – dostawa gazu do regionu

	MUTUAL DEPENDENCES			
1.1	**Underground gas storage facility**	Yes	No	Note
1.1.1	Does the natural gas storage facility have the sufficient capacity to overcome MU,extrenal supply lockouts for a region of more than 65 days?	yes		The tray capacity is realized for max 97 days of average consumption.
1.1.2	Can the gas supply from this reservoir be a serve for the neighboring region in the event of a crisis on the primary multinational distribution system?		no	There is insufficient capacitive interconnection through the piping of both regions, including additional technical system equipment.

Tab. 2. Selection of vulnerability checklist – drinking water sources for consumer
Tab. 2. Wybór listy kontrolnej podatności na zagrożenia – źródła wody pitnej dla konsumenta

	MUTUAL DEPENDENCES			
2.1	**Raw surface water source for drinking water treatment**	Yes	No	Note
2.1.1	Does the drinking water source for the water supply system have sufficient passive and active elements when entering the contaminant into the water tank?	yes		Operational and safety measures allow water to be taken from the water treatment plant for several different horizons of accumulated raw water.
2.1.2	Does the drinking water treatment plant have sufficient technological equipment to treat water of quality significantly exceeding the raw water parametres in A3 category?		no	UV technology is equipped with a technology for water treatment of category A2.

- proposes based od previous points, to suggest building foundation in a way that avoids the reduction of its static stability in crisis situations,
- at the alternative hazard mentioned to allow the emergency threat,easy and rapid evacuation of threatened technology elements,
- to incorporate operational and handling rules into strategic object buildings and in general also into crisis management plats of relevant region.

Increasing the line construction building infrastructure

Line structures of technical infrastructure are almost always extremely threatened by natural influences. The intensity and probability of thein occurence arises from the type of territory, its geological character and climate zone in which the infrastructure is located. For example to increase the resistance of liner structures to the natural environment effects:

- physicochemical properties knowledge of the soil in which the corrosion environment inducing the steel piping system of the technical infrastructure are found,
- in a hazardous environment to increase the passive and active means of protecting the equipment in question to the highest attainable level,
- in the extremely sloping areas, implemet horizontal stress relief emelemts on the pipe system (compensators),
- in to floodplains, before its beggining and ens, place shut off valves on the pipeline, allowing for quick shutdown of the area in question, in case of an akcident caused by natural influences,
- in critical areas with unstable subsoil, redistribuce the distribution system with a back-up pipeline, allowing the transport of the specified emergency quantity medium,
- to have a kontrol and monitoring system in place to enable remote monitoring and subsequent operational management of crisis processes.

The above-mentioned basic and other measures have the potentials to substantially increase the resilence of buildings and line structures of technical infrastructure. In the upcoming new climatic conditions in Europe, periodically reccuring intense incidents can be almost assured which will affect the technical infrastructure operating systems reliability [5]. Most countries in the world have already sufficient sfientific information on the risk and with appropriate international cooperation also the means by which the hazard can be appropriately and economically eliminated to the extent feasible.

4. International cooperation and prevent coordination of emergencies in technical infrastructure

The substantial part especially the energy infrastructure of the wold is not built for its own specific state but has an international character. In many cases it converts the medium in question to several states to the point of consumption. In the years to come this form of international cooperation can be expected to deepen. Due to the lenght of pipe systems converting media or power lines, the occurence likelihood of especially natural emergencies increases with the pipe systems lenght. For example to reduce the occurence likelihood:

- carry out the following measures on the distribution systém from new discovered energy sources to transport the relevant commodity to the consumption destination
  – in the risk sections of the product route endangering its own operation or secondarily the natural environment to build specific monitoring systems enabling rapid recognition of the emergency occurence,

– carry out the transmission of information by the current most efficient transmission technology and monitoring equipment,

– the purchase of this technice by international agrément, regardless of the real international political situation and orientation of the state in which the deposits of necessary energy are located,

- to implement new elements of passive and active protection, equipment against existing natural influences on operating systems on existing production and especially distribution systems,
- to use strictly the latest climate knowledge in the new 21st century global climate conditions, based on the OSN conclusions to reduce the various types of hazards to operational infrastructure systems.

The increased number of hazards threatening the transnational technical production and distribution equipment can no longer be solved only segmentally. International cooperaton and coordination of activities will not only increase the potential and probability of a successful solution but will also save economic costs resulting from the implementation of security measures [6].

Conclusion

From the article it is clear that new threats to technical infrastructure and increasing thein resilence to the effects of natural phenomena or anthropogenic events can no longer be addressed by local means. Such solutions would not be only costly for the state concerned, but would also lack a higher level of dimension. In most cases such cooperation already exists between states. However new climatic threats and resulting consequences are clearly solvable only by means of the examples given in several cases in this article. The aim of the article is to initiate, among other things, a discussion of the issue and thus other new solutions to existing and deepening problems in infrastructure operating systems.

Acknowledgments

This work was supported by the research project VI20152019049 „RESILIENCE 2015: Dynamic Resilience Evaluation of Interrelated Critical Infrastructure Subsystems", supported by the Ministry of the Interior of the Czech Republic in the years 2015–2019.

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Infrastruktura techniczna zwiększająca oporność w środowisku naturalnym

Środowisko naturalne ma swoje specyficzne wzorce, które człowiek musi wziąć pod uwagę przy realizacji dowolnej infrastruktury technicznej krajów świata. Niedocenianie zagrożeń, które mogą wynikać ze zjawisk naturalnych, ma często poważne konsekwencje. W przypadku niektórych konstrukcji infrastruktury technicznej, zwłaszcza ich konstrukcji liniowych, występuje duża liczba wypadków operacyjnych, które mają wyjątkowo negatywny wpływ na regiony zaopatrywane w energię lub wodę pitną. Inne rodzaje infrastruktury technicznej, na przykład w energetyce jądrowej, mogą potencjalnie stworzyć naturalny stan zagrożenia, zagrażając środowisku nie tylko w kraju, ale także w perspektywie długoterminowej i może wywołać zmiany warunków życia w całych regionach. Poniższy artykuł zajmuje się tym problemem w zakresie podstawowym, proponuje sposoby rozpoznawania zagrożenia, a następnie rozwiązania oparte na analizie ryzyka w celu zredukowania konsekwencji do akceptowalnego poziomu.

Słowa kluczowe: *infrastruktura techniczna, odporność systemu, ryzyko, analiza ryzyka, eliminacja skutków*