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Vulnerability of the city infrastructure as a part of the resilient city concept

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Abstract

The sustainability development and operation of the city is basically dependent on its serviceable infrastructure. The understanding of different infrastructures resilience and vulnerabilities is important for the city security. In this work we focus on the notion of transportation infrastructure vulnerability. Some infrastructure types or some specific infrastructure elements can be more or less vulnerable than the others. Following mentioned facts the paper focuses on assessment of the city infrastructure vulnerability to the effects of disasters as a part of the resilient city concept. The proposed assessment is intended to be applied to the critical infrastructure.

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Keywords: vulnerability; resilience; resilient city concept; transportation infrastructure

1. Introduction

It is believed that changing climate conditions causes increased frequency of disasters occurrence with the major impacts on the health of people, property, environment and all individual parts of the society [1,2]. As a reaction on this negative trend several frameworks has been adopted by international crisis management organizations [1,3,4] and one of them is the "resilient city concept". The concept stems from an idea that the cities have much more intense relations with local citizens as it is on national level. They have greater impact on local conditions and can expediently enforce adoption of necessary changes and regulations in all areas of city social life.

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The resilient city concept is based on anticipation, mitigation and reduction of physical, economic and social impacts of disasters within a city (mainly for natural disasters with association on climate change but it is applicable also for manmade or intentional ones – we will consider natural disasters only). This is done by creating an appropriate conditions for dealing with such situations through application of various measures e.g. ensuring organized services for whole community (from common to rescue); adhering sensible building codes and spatial planning (without informal settlements built on flood plains or steep slopes); incorporating monitoring and early warning systems to protect individuals (residents), infrastructure, community assets, environment, and cultural heritage; preparing and implementing of recovery strategies, etc. [5].

Cities are dense and complex systems. They are characterized by intense, regular interactions that are structured into identifiable activity areas, or in key resource management or mobility sub-systems. In resilient city concept are divided into several components [6]: health, environmental, social/cultural, infrastructure, education, disasters, economic. In this paper we deals with "infrastructure" part and closely with its sub-part transportation infrastructure.

The character of cities as complex place-based systems is very different to that of lower-density rural areas where activities are more spatially separated and interactions are less intense. In the urban environment in particular, the resilience of a place-based system is only as great as its weakest part [5]. Therefore the understanding of the transportation network weak points (vulnerability) and its resilience to disasters is important in general and in particular critical for the city security and safety.

We argue that in many instances transport infrastructure (network) spans other components of society and its reliability and performance have significant influence on services which are provided by the other city components (healthcare – health, business continuity and industry – economic, delivering disaster relief or facilitating mass evacuations – disasters, etc.). Therefore, a vulnerability analysis of transportation network in a resilient city concept should always be viewed in a broader context – with relation to geo-spatial, industrial, social context, etc.

2. Background and Rationale

There is no consensus on the definition of vulnerability. Basically it depends on subject area (context) in which the notion vulnerability is used. In the context of transportation network one can define the vulnerability as overall susceptibility to a specific hazardous event. It is also the magnitude of the damage given the occurrence of that event [7]. There is common agreement that the vulnerability in the context of transportation network represents a measure of loss of the transportation network's capabilities to perform its functions [8,9,10]. This agreement result in determining of transportation network most vulnerable points which can cause that performance loss. Such determination requires an assessment of the specific physical parameters of the transportation network elements as well as their close surroundings (e.g. bridge piers surrounding or roads subsoil).

Some authors [11,12] argue that a system might be vulnerable to certain events but be resilient to others. Therefore is important take to account the specific risk and threat profiles to the area under analysis. Particular city areas with corresponding transport infrastructure elements can be on the one hand considerably expose to the danger of landslide because they are locate close to the steep slope but on other hand there is no danger of flood. There is also association with above mentioned requirements for assessment of specific physical parameters. In order to protect transportation elements, e.g. due to location within a flood area, can be performed e.g. hard (technical, construction) measures (pylons, barriers, etc.) which allow use these elements without limitations also in time of flood and this way decrease the sensibility of a particular element.

As the fundamental idea of resilience is derived from Ch. Darwin's research results who declares: „Not the strongest or the most intelligent will survive but a one who is the most adaptive", the assessment of transportation network infrastructure vulnerability means that we should take into account also adaptive ability of the system under analysis. It can be seen as the ability of a system to change in a way that makes it better equipped to deal with external influences (disasters) [13]. Adaptive ability is also the combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities [14].

Based on above mentioned facts and partial conclusions a system or society that is highly exposed to a threat, susceptible to its effects and less able to adapt is more vulnerable. Following these relationships a vulnerability of transportation network in the context of the resilient city can be assess by considering three types of factors: