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What is 'Infrastructure Physics'?

Bijan Adl-Zarrabi*

Chalmers University of Technology, Gothenburg, 412 96, Sweden

Abstract

Since 2014, the research group 'Infrastructure Physics' sits at the department of Civil and Environmental Engineering, Chalmers University of Technology. A number of researchers wonder 'What is infrastructure physics?' The aim of the paper is to explain and clarify the research field 'infrastructure physics' and its system boundary with other close research fields, such as building physics. Furthermore, some ongoing research projects will be presented briefly. Infrastructure consists of the basic physical systems of a society e.g. transportation, communication, sewage, water and electric systems. Physical infrastructure elements are always exposed to outdoor climate e.g. solar radiation, rain, driving rain, wind, and moisture and temperature variations. The harsh environment around the infrastructure causes different types of destructions that can reduce the function ability in the short time perspective and also reduce the service life time of an infrastructure. Furthermore, extreme weather conditions may cause undesired service interruptions of a system e.g. traffic stop due to flooding. Generally, infrastructure involves a heavy investment for the society which needs also maintenance under long period of time. In other to make the investment more efficient, it is possible to use our infrastructure for other proposes in addition to the initial proposes. For instance, energy harvesting in the vicinity of transport infrastructure. 'Infrastructure physics' deals with physics behind the phenomena related to physical behaviour of the materials, components and systems involved in infrastructure, in their specific environmental condition (underground, subsea, surface) in order to increase their accessibility and efficiency.

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* Corresponding author. Tel.: +46317721988
E-mail address: zarrabi@chalmers.se

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1. Introduction

Infrastructure owners, generally public organizations, in many developed countries, report infrastructure aging, infrastructure failing and that funding has been insufficient to repair and replace them. In urban areas the problem is particularly more severe due to the growing populations that stress society's support systems, among them physical infrastructures. Furthermore, the concept of 'smart city systems' is more and more discussed among international researchers and policy makers. Even if there is still confusion about what a smart city is, smart infrastructure is an essential part of the forthcoming smart cities e.g. new mobility modes require new type of infrastructure. Finally, climate change/global warming should be treated urgently thus the existing and forthcoming infrastructure should be climate neutral. It should also be noted that in many parts of the world, fundamental infrastructure is yet to be in place.

The complex and multidisciplinary picture described above indicates that engineers and researchers dealing with infrastructure under the 21st century, face difficult challenges. They should adopt their solution for fundamental infrastructure to urbanization, digitalization, modernization and threat of climate change. Furthermore, the solutions should be sustainable and proper attention should be given to environmental issues and energy-use. Finally, the solutions should be economically feasible.

Handling a multidisciplinary challenge needs firstly competence in each discipline and secondly competence over the borderline of each discipline e.g. the borderline between structural and nonstructural performance of an infrastructure. The aim of this paper is to define the research field 'Infrastructure physics' and describe how 'Infrastructure physics' complements and supports the field of infrastructure engineering.

2. Definitions/ classifications/limitations

Configuration of the research area 'Infrastructure Physics' needs description of the vision, aim, road map, classification of different types of infrastructure and declaration of some definitions and limitations.

- *Vision:* the vision of the 'infrastructure physics' is 'Forever accessible infrastructure'.

- *Aim*: promoting and being actively involved in research, development and innovations related to physical characteristics of the infrastructure in all stage of its lifetime i.e. design, production, operation and maintenance.

- *Definition of physical infrastructure*: The physical infrastructure can be defined as 'the physical components of interrelated systems providing services essential to enable, sustain, or enhance societal living conditions. The physical infrastructure typically conclude technical structures such as transport infrastructure (road and rail networks, bridges, tunnels), water supply network, heating and cooling supply network, sewers network and, electrical and telecommunication grids.

- *Classification of physical infrastructure*: The physical infrastructure can be divided into two main categories namely surface infrastructure and underground infrastructure. The surface infrastructure includes transport infrastructure, masts for electrical and communication infrastructure, harbours, bus and train terminals and airports. The underground infrastructure includes piping network for water-, heat- and natural gas supply, electrical and communication cables, tunnels that include also subway train network.

- *Roadmap*: In order to plan a roadmap for a number of infrastructure network with different functionalities, it is necessary to find out the common denominator and the major differences.

  Denominator: some major common denominators for all types of physical infrastructure are: heavy initial investment, operation and maintenance costs, length of the infrastructure and their exposure to outdoor climate. The common demands for the physical infrastructure are: accessibility, long-term service time, cost efficiency and sustainability.