
Structural and Physical Aspects of Construction Engineering**Ground Settlement in Urban Structures Exposed to geo-environmental and Anthropic Hazards: a Case Study for Galati**

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Abstract

A case study including a detailed ground settlement analysis is made for a particular loess structure located in the city of Galati, Romania, in order to assess the interdependence of geo-environmental and anthropic settlement triggering factors in the urban system context. In the first part of the study, loess behavior and its effects on built environment are analyzed and discussed based on worldwide historic expertise and current issues. An integrative analysis of loess deposits in natural state, with reference to induced-hydraulic and stress conditions, which was performed by laboratory and in-situ investigations, is then reported. An assessment of basic geotechnical parameters, as well as small-scale modeling of loess settlements at wetting under self-weight were conducted in order to select the most representative experimental area, from the point of view of specific soil structure behavior. Field monitoring surveys were performed to obtain information for quantitative evaluation of settlement time-dependent evolution, by the simulation of excessive moisture. The processing and analysis of experimental data gathered for natural and improved ground conditions revealed that the settlement amplitude of loess deposits with high sensitivity to wetting under self-load can be significantly reduced by the selection of adequate consolidation solutions, based on realistic and undisturbed environmental conditions. The study of soil structure behavior under simultaneous settlement-triggering factors can be integrated in multi-hazard analysis as a support for efficient strategies and mitigation measures, with applicability in the urbanization process, building and foundation design and environmental protection.

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1. Introduction

Loess deposits are considered at global scale as one of the major geo-hazards to build environment due to damage in engineering structures and infrastructures caused by large ground settlements [1, 2]. The peculiar characteristics of loess are closely related to high porosity and permeability, low density and moisture, high apparent strength and stiffness in natural state condition. Collapsibility of loess has been attributed to its moisture sensitivity and to the volume changes induced by deformations in a metastable microstructure, linked to soil chemistry and mineralogy [3]. Collapse of loess structures can occur when internal stresses between soil particles or those due to external loads exceed structural strength upon saturation [4]. Additional loading and wetting can cause considerable modification of intrinsic properties [5, 6] due to stress redistribution and external factors as dynamic loads [7, 8]. Loess soils are also subjected to geomorphologic dynamic processes manifested by underground soil erosion, suffusion or slope failures, associated to typical landforms such as loess caves, sinkholes, depressions or gullies [9, 10]. The problem of loess genesis represents one of the most controversial issues in geosciences literature and is addressing the origin of particles, the depositional environment and the post-depositional changes [11]. Therefore, several studies have emphasized the importance of loess geological formations in the reconstruction of paleo-climatic and paleo-environmental changes during Quaternary [12] based on stratigraphy and magnetic susceptibility data [13, 14, 15]. Geological formations of loess cover 10% of global land surface and are typically widespread on geographical areas as plateaus (Chinese Loess Plateau) or along river basins (Mississippi, Rhine, Yellow River, Danube). Loess soils are covering 20% of land surface in Eastern and Central Europe areas associated with thick layers along rivers. In Romania, loess soils are distributed on about 17% of the territory and occur to a maximum elevation of 400 m, especially in Romanian and Danube Plain, South and Central Dobrogea and Moldavian Subcarpathians. The thickness of loess deposits can reach 30-35 m in the eastern part of Romanian Plain (in areas of the Romanian counties Braila, Galati, Ialomita, Fetesti) up to a maximum of 60 m on the right bank of Danube.

In built areas, settlements induced to buildings by loess collapse can affect their long-term performance during the service life. Substantial economic losses related to the damage of structural components and infrastructure facilities were reported worldwide [16, 17]. In this regard, special regulations and technical requirements for designing and construction of settlement-resistant foundations on loess were developed and improved based on accumulated experience and a large number of observations. According to geological and environmental changes, several guidelines concerning the methods for minimizing loess collapsibility in pre-design stage, ground treatment technologies and settlement monitoring are strictly recommended in order to ensure and maintain building safety and stability. Various laboratory and in-situ tests on geotechnical parameters assessment for different loess soils in Romania and implementation of soil improvement methods have been performed [18, 19, 20]. Following previous research, the present study is focused on fusing and correlating experimental tests in order to quantify and assess the basic indicators of ground settlement with special reference to loess behavior linked to geo-environmental and anthropic factors.

2. Overview of geo-environmental and anthropic issues for Galati urban area

The selection of Galati, a city with 250,000 inhabitants in Romania, as an experimental area for the study is directly connected to high exposure and vulnerability of buildings and people to geo-environmental and anthropogenic hazards, generated by geological, geomorphologic, hydro-geological and seismic conditions overlap and impact on people and building stock. Moreover, the effects of urbanization and industrial expansion have led to serious environmental, social and economic changes and to augmentation of urban geo-hazard patterns.

From geological point of view, sedimentary geological structure of studied area consists in Upper Pliocene, Pleistocene and Holocene deposits. Quaternary soil category occurred in Galati sedimentary sequence consists of thick aeolian loess layers, formed during Pleistocene glaciations, characterized by a high sensitivity to water and large settlements under self-weight.

Exposure of Galati city to urban flooding risk during heavy rainfall periods leads, due to specific geomorphologic features, to the rise of groundwater level, attributed to city location on the first level of Danube River terraces. Deficiencies in urban sewerage systems, underground accidents or thick heterogeneous fills lead to ground water infiltration, causing severe damages to foundations and building stability, induced by ground settlements. Likewise,

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