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بررسی پتانسیل روانگرایی خاک با استفاده از شبکه های عصبی احتمالی و بازگشتی

توسط

علیرضا بامداد

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چکیده

بررسی پتانسیل روانگرایی خاک با استفاده از شبکه های عصبی احتمالی و بازگشتی

توسط :

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بررسی مفصلی بر کاربرد روشهای محاسبات عصبی در پیش‌بینی پتانسیل روانگرایی خاکها انجام شده است. تأکید کلی در این تحقیق براستفاده از شبکهٔ عصبی بهینه برای مدلسازی رابطهٔ پارامترهای لرزه‌ای، و خصوصیات خاک با پتانسیل روانگرایی بوده است. مشکل اکثر مطالعات مشابه گذشته در زمینهٔ پتانسیل روانگرایی عدم قابلیت تعمیم آنها بوده است. معمولاً حجم کم پایگاه داده‌ها، توزیع جغرافیایی محدود و حذف اثر بعضی پارامترهای مهم مانند Rf (فاصله تا گسل زلزله) در اینگونه کارها به چشم می‌خورد. در این تحقیق یک بانک اطلاعاتی جامع با بیشترین تعداد موارد گزارش شده تهیه شده است. برای انجام مطالعه و مدلسازی پدیدهٔ روانگرایی، از یک شبکهٔ عصبی احتمالی (PNN) مجهز به یک روش تازه جهت تعیین پارامترهای شبکه ، یک شبکه عصبی بازگشتی (RNN) و یک شبکه فازی - عصبی (ANFIS) در کنار شبکه عصبی معمولی (BPNN) استفاده شده است. ترکیب‌های مختلفی از پارامترهای ورودی و سایر خصوصیات شبکه‌ها روی هر یک از انواع شبکه‌های عصبی یاد شده بررسی شدند. برای تعیین شبکه بهینه، مقایسه‌ای بین کارآیی و پیچیدگی شبکه‌ها به علاوهٔ مطالعهٔ پارامتری انجام شد. مقایسهٔ نتایج با روشهای معمول در بررسی پتانسیل روانگرایی حاکی از افزایش دقت تخمین این پتانسیل در روش حاضر است. همچنین روشی برای تعیین ضریب اطمینان در برابر روانگرایی پیشنهاد شده است.

ABSTRACT

LIQUEFACTION POTENTIAL ASSESSMENT USING PROBABILISTIC AND RECURRENT NEURAL NETWORKS

By

Alireza Bamdad

A thorough investigation on the application of neural computing methods in prediction of liquefaction potential of soils has been performed. The emphasis was on using optimized neural network architecture to model the complex relationship between the seismic parameters, soil parameters, and the liquefaction potential. A problem that most previous similar approaches had severely suffered from was the lack of generalization. Small number of data records, limited geographical distribution, or ignoring the role of some important parameters as R_f (distance to causative fault), had been noticeable in such works. Therefore, a comprehensive database was prepared with as much field records as possible. A Probabilistic Neural Network (PNN) with a new algorithm for adapting the smoothing variable, a Recurrent Neural Network (RNN) and a neuro-fuzzy network were employed for this investigation. Different combinations of input parameters and other network features were tried for each network. Comparison of the performance and complexity of various networks, as well as parametric studies were performed in order to arrive at an optimum network. Results were then compared with empirical methods. The comparison indicates improvements in accuracy of the liquefaction potential assessment. Furthermore, a method for the evaluation of the safety factor against liquefaction has been proposed.

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Chapter 1

Introduction

Earthquakes are one of the most destructive natural hazards, if not to human life itself, most certainly to the works of man and to his social and economic structures. Indeed, natural hazards are closely related to our technological development, and although they cannot be prevented, their magnitude and after-effects can be minimized.

Damaging and destructive shocks are expected on average every few weeks at some points on the earth. They exact a terrible toll when they occur near populous centers. Undoubtedly, with the spread of urban civilization and investment in large engineering projects in seismic regions, the toll to be taken by future earthquakes, and particularly the extent of the damage, are likely to increase [1].

1.1. Background

The Nigatta Earthquake of 1964 taught that damage could result from liquefaction of the ground caused by an earthquake. During past earthquakes people had observed the phenomenon of mud or sand mixed with water blowing out of the ground. Until recently, few people questioned why sand boiling occurs or how it is related to earthquake damage, and it can be concluded that there were few attempts at scientific approaches to understanding of this phenomenon.

1.2. Characteristics

As a definition, we read in the dictionary of Soil Mechanics and Foundation Engineering: " *the state existing when saturated sandy soils loses shearing strength and effective stresses are reduced as a result of increased pore water pressure is called* ***liquefaction*** ". Causes for the rise of pore water pressure include fluctuations of ground water level and wave action in addition to the repeated actions of shear stresses on saturated sandy soil during earthquakes.

The ground where the liquefaction phenomenon occurs is generally composed of loose sandy soil saturated with water. If such ground is subjected to stresses caused by repeated earthquake motion, the pore water pressure rises in the soil, and the effective stresses in soil are lost, then the strength of the ground is eventually lost. Even if the effective stress is not completely lost, the soil becomes softer as pore pressure rises, and consequently large strains can be induced in the ground.

As the consequences of the decrease of strength of soil due to built up excess pore water pressure, various phenomena, including some strange and unusual phenomena, which cannot be seen under static conditions, may take place. Phenomena, which may occur because of soil liquefaction, are classified into eight categories:

- Sand boils and springs of water: Excess pore water pressure generated in the ground will cause water to flow upwards and water mixed with soil particles will spout out to the ground surface.
- Ground settlement: As a result of some of the ground water being released to the surface, liquefied layers will be consolidated and the ground surface will subside. The ground does not settle uniformly, and structures on the ground can be affected by uneven settlement.
- Permanent displacement of the ground in horizontal directions (lateral spread): Effective stresses are lost as the ground is liquefied. As the ground behaves like a liquid, the ground surface will displace horizontally towards the foot of a slope, even if the slope is very moderate. If such a phenomenon occurs, serious damage can be done to piles or piping buried in the ground.
- Ground oscillation: Where unliqeufied layers exist beside and below liquefied layers, the liquefied layers shake and move similar to a liquid in a container. Then the dynamic

response characteristics of the soil are changed, which may result in ground oscillation of large displacement amplitude with a long period.

- Flow slide of slopes: If soil in slopes is liquefied, flow failure may occur and the collapsed soil is carried out to a remote area.
- Loss of bearing capacity: If effective stresses are reduced, the bearing capacity of the ground may be lost.
- Failure of retaining walls: If the ground behind retaining wall structures is liquefied, horizontal earth pressures increase and the structures can be damaged.
- Buoyant rise of buried structures: Underground structures having an apparent specific gravity less than the saturated density of the adjacent ground tend to be lifted by the buoyancy of the liquefied ground in adjacent areas [2].

Therefore, it is important to determine the damage mechanism and its mode and to select effective methods in dealing with the liquefaction.

There is no need to fear the liquefaction phenomenon if it is properly understood and proper countermeasures are taken. Methods of determining the liquefaction potential of foundation soils are discussed in the following chapters.