

# Engineering Geomorphology Theory and Practice

by P. G. Fookes, E. M. Lee and J. S. Griffiths

Geomorphology is a scientific discipline studying genesis, evolution and contemporary dynamics of the Earth's surface forms. Relief is omnipresent; it surrounds us and determines our existence possibility. Therefore, we are not surprised by the fact that people have speculated about the forces and mechanisms creating relief forms since antiquity.

It was engineers who were confronted with relief form dynamics every day while constructing ports, canals and roads. In practice, those people were dealing with geomorphology in large scales, studying details. That was, of course, of great practical significance. So, since ancient times engineers have influenced development of geomorphology, because many geomorphologic processes have an impact on human activity, and inversely, human activity influences geomorphologic processes. Today, this research field is dealt with by applied geomorphology defined by Brunnsden et al. (1978) as an application of geomorphological techniques and analysis to the solution of regional planning problems, environmental management, as well as engineering or similar problems. Consequently, engineering geomorphology is a part of applied geomorphology.

The book *Engineering Geomorphology - Theory and Practice* explains how to study the Earth's surface and processes forming it, as well as how geomorphology can help engineers while designing and constructing buildings, which can resist natural forces, and so improve the quality and safety of life.

This book enables a very clear and concise introduction into the problems of engineering geomorphology. Relief changes and their consequences in so-called engineering time (10-100 years) make its main framework. Therefore, the need for recognising specific conditions, which are the consequence of previous and recent characteristics of every particular area, is being constantly emphasised.

The book consists of five parts. The first one briefly presents basic concepts in geomorphology. Causes and mechanisms of relief form changes have been

presented very concisely, but clearly, as well as their consequences from the aspect of geomorphologic systems. Systems on the Earth's surface are conceptual models used for explanation of sediment and energy transfer. They enable mutual connection of particular relief forms in a given area. Many systems on the Earth's surface are exceptionally complex and a change in one part of such a system will cause a change in another one. That complexity is the most prominent in dynamic systems, to which the greatest attention in this book has been paid.

Numerous important factors influence the surface systems on the Earth. Distribution of forces on the Earth's surface (stress distribution), geological setting and materials have the primary impact on the change of relief forms. Hardness of materials represents an exceptionally important quality for engineering geomorphology. It is the result of the previously mentioned factors and climate that is, in its turn, responsible for the quantity and sort of mobile sediments, all of which has a direct influence on the way and rapidity of relief change in time.

Geomorphologic processes are essentially influenced by climatic changes, however, from the aspect of engineering geomorphology, climatic variations appearing in shorter time periods are much more important, such as the short ice age in the Middle Ages. The sea level change is another important factor having impact on geomorphologic processes, because the change of the coast line position conditions the change of the potential energy available in landscape.

Change of relief forms is a natural phenomenon, but it can represent a hazard or risk for engineering projects. Hazards are events, in this case geomorphologic processes, which can have a strong impact on people and property in a certain area and certain time, while risk is the probability of hazard and its bad effects. Therefore, the appraisal of exogenous process risk is of crucial importance for construction projects.

On the other hand, the opposite situation is also important, i.e. the appraisal

of the construction project impact on the environment, because building activity can also have a major influence on surface processes. Potential influences should be evaluated according to specific conditions in a certain area. Although some influences can give the impression of local ones, they can have an indirect impact on the entire surface system.

Understanding and knowledge of geomorphologic environments and landscape history is important for engineering geomorphology because it can help identify suitable locations for construction resources.

Second, third and fourth parts of this book represent in detail the functioning of different systems - slope, fluvial and coastal ones, as well as how they influence the surface conditions, cause hazards and assure the resources for construction projects.

A significant part of all constructions takes place on slopes. Consequently, slope inclination categories can be defined according to the building exploitability of relief, from very suitable for building (0-2°) to those completely unsuitable (>32°). The question of slope mobility is connected with that regarding destructive morphologic processes and state of equilibrium. The role of water, wind and soil on slopes has been considered in detail. Special attention has been paid to engineering-geomorphologic mapping of the landslide sites, and generally to the appraisal of the slope process risk. Problems of building in karst areas are discussed as well.

Presentation of a detailed field research in fluvial geomorphology has been analysed in the third part of the book. It can be best seen from the table with basic geomorphologic problems, then defines for each of them necessary entry and outgoing data which enable solving of those problems. At the end, there is an engineering solution of the mentioned problems. Then follows a reverse scheme with engineering projects and their impact on geomorphologic processes in local and regional scales. Therefore, this part of the book analyses drainage basins, fluvial

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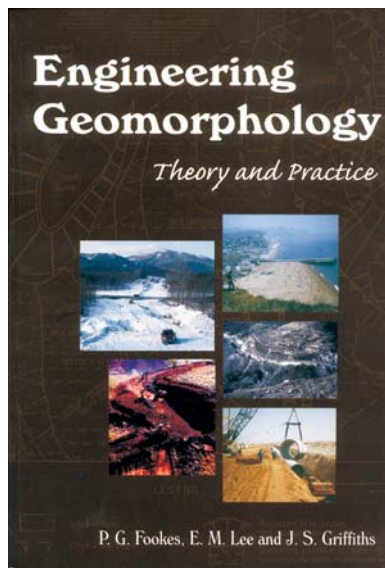
Geomorfologija je znanstvena disciplina koja proučava genezu, evoluciju i suvremenu dinamiku oblika Zemljine površine. Reljef je sveprisutan, on nas okružuje, određuje mogućnost egzistencije. Stoga ne čudi činjenica da su ljudi od davnina spekulirali o silama i mehanizmima koji su oblikovali reljefne oblike.

Upravo su inženjeri bili ti koji su se svakodnevno suočavali s dinamikom reljefnih oblika pri izgradnji luka, kanala i cesta. Ti su se ljudi u praksi susretali s geomorfologijom u krupnim mjerilima, proučavajući detalje. To je, naravno, imalo veliko praktično značenje. Tako su inženjeri odavno utjecali na razvoj znanja iz područja geomorfologije jer mnogi geomorfološki procesi utječu na ljudsku aktivnost i obrnuto, ljudska aktivnost utječe na geomorfološke procese. Tim bremenitim područjem istraživanja bavi se danas primijenjena geomorfologija koju Brunsdén i dr. (1978) definiraju kao primjenu geomorfoloških metoda i analiza u rješavanju problema prostornog planiranja, gospodarenja okolišem te rješavanju inženjerskih i drugih sličnih problema. Dakle, inženjerska je geomorfologija dio primijenjene geomorfologije.

Knjiga Inženjerska geomorfologija - Teorija i praksa objašnjava kako proučavati Zemljinu površinu i procese koji je oblikuju te kako geomorfologija može pomoći inženjerima pri osmišljavanju i podizanju građevina koje odolijevaju prirodnim silama i tako poboljšavaju kvalitetu i sigurnost života.

Ova knjiga omogućuje vrlo jasan i jezgrovit uvod u probleme inženjerske geomorfologije. Promjene reljefa i posljedice tih promjena u tzv. inženjerskom vremenu (10-100 god.) glavna su joj okosnica. Stoga se neprestano naglašava potreba prepoznavanja specifičnih uvjeta koji su posljedica nekadašnjih i recentnih obilježja svakog pojedinog područja.

Knjiga se sastoji od pet dijelova. Prvi dio prikazuje ukoliko osnovne koncepte u geomorfologiji. Vrlo koncizno, a jasno izlažu se uzroci i mehanizmi promjena reljefnih oblika te njihove posljedice s aspekta geomorfoloških sustava. Sustavi na površini Zemlje su konceptualni modeli koji se koriste za objašnjavanje prijenosa



sedimentata i energije, a omogućuju međusobno povezivanje pojedinih reljefnih oblika na nekom području. Mnogi sustavi na Zemljinoj površini su iznimno složeni te će promjena u jednom dijelu sustava izazvati promjenu u drugom. Ta kompleksnost je najizraženija u dinamičkim sustavima, kojima je u ovoj knjizi posvećena najveća pažnja.

Na površinske sustave na Zemlji utječu brojni važni čimbenici. Primaran utjecaj na promjenu reljefnih oblika imaju raspodjela sila na površini Zemlje (raspodjela stresa), geološka građa i sastav. Izuzetno važno svojstvo za inženjersku geomorfologiju predstavlja čvrstoća materijala koja proizlazi iz prethodnih čimbenika i klime, a o kojoj pak ovisi količina i vrsta mobilnih sedimentata, što sve skupa direktno utječe na način i brzinu promjene reljefa u vremenu.

Na geomorfološke procese bitno utječu i klimatske promjene, međutim, s aspekta inženjerske geomorfologije mnogo su važnije klimatske varijacije koje se javljaju u kraćim vremenskim razdobljima, kao što je npr. vrijeme malog ledenog doba u srednjem vijeku. Promjena morske razine još je jedan važan čimbenik koji utječe na geomorfološke procese jer promjena položaja obalne linije uvjetuje i promjenu raspoložive potencijalne energije u reljefu.

Promjena reljefnih oblika je prirodni fenomen, ali može predstavljati hazard i rizik za inženjerske projekte. Hazardi su događaji, u ovom slučaju geomorfološki procesi, koji mogu snažno utjecati na ljude i imovinu na nekom području u određenom vremenu, a rizik je vjerojatnost pojavljivanja hazarda i njegovih štetnih posljedica. Zato je procjena rizika od egzogenih procesa od ključne važnosti za građevinske projekte.

S druge strane, bitna je i obrnuta situacija, tj. procjena utjecaja građevinskih projekata na okoliš jer građevinska djelatnost može također bitno utjecati na površinske procese. Potencijalni utjecaji trebaju biti evaluirani prema specifičnim uvjetima na nekom prostoru. Iako se neki utjecaji mogu doimati samo lokalnim, oni mogu indirektno utjecati na površinski sustav u cjelini.

Razumijevanje i poznavanje geomorfološkog okoliša i razvoja reljefa u vremenu važno je za inženjersku geomorfologiju i s aspekta poznavanja lokacija mogućih resursa za gradnju.

Drugi, treći i četvrti dio ove knjige detaljno prikazuju kako funkcioniraju različiti sustavi - padinski, riječni i obalni te kako oni utječu na površinske uvjete, uzrokuju hazarde i osiguravaju resurse za građevinske projekte.

Značajan dio svih konstrukcija odvija se na padinama. Stoga se kategorije nagiba padina mogu definirati prema građevinskoj iskoristivosti reljefa, od vrlo povoljnih za izgradnju (0-2°) do onih potpuno nepovoljnih (> 32°). S tim je povezano i pitanje mobilnosti padina s obzirom na destruktivne morfološke procese i ravnotežno stanje. Detaljno se razmatra uloga vode, vjetera i tla na padinama. Posebna pažnja posvećena je inženjersko-geomorfološkom kartiranju klizišta te općenito procjeni rizika od padinskih procesa. Raspravlja se i o problemima gradnje u krškim područjima.

Prikaz detaljnog terenskog istraživanja iz područja fluvijalne geomorfologije sistematiziran je u trećem dijelu knjige. Najbolje se to vidi iz tablice koja konkretizira osnovne geomorfološke probleme te za svaki potom definira potrebne ulazne

and valley network in detail, classifies meanders, lists kinds of floods, flood zones in the world and similar. Possible damages caused by floods in different socio-economic segments are also mentioned.

The fourth part of the book deals with coasts. Coasts also represent a dynamic environment. Namely, floods and abrasion along the coast line can be a great risk for engineering projects. Problems can be the consequence of land loss (withdrawal of a cliff), various extreme conditions, such as storms and tsunamis or failure of protective mechanisms. Risk evaluation should take into account all possible scenarios and combinations of conditions which could cause various consequences. Therefore, this part of the book analyzes the impacts of wind, waves, high and low tide, transport of sediments along the coast, sedimentation and similar. Systems

like deltas and estuaries are explained in detail. The impact of protective coastal constructions on sedimentation is also considered.

Regarding the complexity of engineering-geomorphologic questions and regionally conditioned variety, special attention is paid to methods of investigation, especially the field ones. The aim is, of course, the most precise prediction of relief development and determination of the future change characteristics. Therefore, the fifth part of the book presents usual research methods (modelling, use of geographic information system, aerial photogrammetry, satellite images for field evaluation and geomorphologic mapping) of geomorphologic processes which can influence construction activity. The book concentrates on pragmatic techniques which the authors consider the most valuable ones in all kinds of engineering research.

Generally, the book is well structured, reviewed and systematic. It was written simply and clearly, with numerous very useful synthetic tables and block-diagrams. The book was primarily designed for construction engineers, geomorphologists and to those dealing with environment protection problems. It can serve as a textbook for graduate and doctor's studies of geography (applied geomorphology), geology and civil engineering.

The book *Engineering Geomorphology - Theory and Practice* has been published in English in March 2007. It has ISBN 10: 1-904445-38-1, ISBN 13: 978-1904445-38-8, consists of 288 pages in A4 format, softback. The publisher is Whittles Publishing, Dunbeath, Caithness, Scotland, UK, KW6 6EY, tel: +44(0)1593-731 333; fax: +44(0)1593-731 400; e-mail: [info@whittlespublishing.com](mailto:info@whittlespublishing.com), [www.whittlespublishing.com](http://www.whittlespublishing.com)

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i izlazne podatke koji omogućuju rješavanje tih pitanja. Na kraju se navodi inženjersko rješenje navedenih problema. Slijedi obrnuta shema gdje se navode inženjerski projekti i njihov utjecaj na geomorfološke procese u lokalnom i regionalnom mjerilu. Stoga se u ovom dijelu knjige detaljno obrađuju drenažni bazeni, riječna i dolinska mreža, klasificiraju meandri, navode vrste poplava, poplavne zone u svijetu i sl. Navode se i moguće štete izazvane poplavama u različitim društveno-gospodarskim segmentima.

Četvrti dio knjige posvećen je obalama. Obale su također dinamičan okoliš. Naime, poplave i abrazija uzduž obalne linije mogu predstavljati veliki rizik za inženjerske projekte. Problemi mogu biti posljedica gubitka zemljišta (povlačenje klifa), različiti ekstremni uvjeti, kao što su oluje i tsunamiji ili pak zakazivanje obrambenih mehanizama. Procjena rizika treba uzeti u obzir sve moguće scenarije i kombinacije uvjeta koji mogu uzrokovati različite

posljedice. Stoga se u ovom dijelu knjige razrađuje utjecaj vjetrova, valova, plime i oseke, transporta sedimentata uzduž obale, sedimentacije i sl. Detaljno se obrazlažu sustavi poput delti i estuarija. Posebno se razmatra pitanje utjecaja zaštitnih obalnih građevinskih objekata na sedimentaciju.

S obzirom na složenost inženjersko-geomorfoloških pitanja i regionalno uvjetovanu raznovrsnost, posebna se pažnja posvećuje metodama rada, osobito onima na terenu. Cilj je, dakako, što točnija prognoza razvoja reljefa i utvrđivanje obilježja tih budućih promjena. Stoga peti dio knjige prezentira uobičajene metode istraživanja (modeliranje, uporabu geografskog informacijskog sustava, aerofotogrametrije, satelitskih snimaka te terensku evaluaciju i geomorfološko kartiranje) geomorfoloških procesa koji mogu utjecati na građevinsku djelatnost. Knjiga se fokusira na pragmatične tehnike koje autori smatraju najvrjednijima u svim vrstama inženjerskih istraživanja.

Općenito, knjiga je dobro strukturirana, pregledna i sistematična. Pisana je jednostavno i jasno, uz brojne vrlo korisne sintetske tablice i blok-dijagrame. Knjiga je ponajprije namijenjena građevinskim inženjerima, geomorfolozima te onima koji se bave problemima zaštite okoliša. Može služiti kao udžbenik na diplomskom i doktorskom studiju geografije (primijenjena geomorfologija), geologije i građevinarstva.

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