

时代教育·国外高校优秀教材精选

交通工程(基础)

TRAFFIC ENGINEERING

英文版·原书第3版



P. 罗斯·罗格
(美) S. 普拉萨丝·艾琳娜 著
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交通工程学是典型的新兴交叉学科, 交通工程作为国家的“生命血液循环系统”涵盖了广泛的工程应用领域。本书是美国英文原版教材, 由 Pearson Education 公司 2004 年出版第 3 版。原版教材共 27 章, 除第 1 章交通工程概述外分为 4 个部分: 交通系统组成及其特性、交通研究及要点、高速公路和乡村公路系统的应用、城市道路系统应用。考虑到中国的实际情况, 我们将第 1 章及前两部分作为基础分册, 而后两部分作为应用分册, 两分册分别出版, 而且征得原作者和出版公司的同意, 在部分章后补充了相应的中国交通现状及发展。这两个分册均可作为高等学校交通类专业的教材, 也可供从事交通运输工程领域的研究人员及工程技术人员学习参考。

本书为基础分册, 内容包括交通工程概述、道路使用者和车辆特性、道路及其几何特性、交通控制装置概述、交通流特性、智能运输系统、统计在交通工程中的应用、交通量研究及特性、速度和运行时间及延误研究、交通事故研究和统计、停车特性及设施等。

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关于中文补充内容的说明

中国是世界上历史最悠久的国家之一。远古时期,中国就用木棒作为运输工具进行觅食、狩猎等生产活动。在畜牧时代,人们通过对某些野兽,如牛、羊、驴、马、骆驼和大象等,进行驯化使其成为家畜,供人役使,成为人类的运输动力,同时人类发明了撬作为运输工具。中国是最早使用车辆的国家之一。早在 4600 多年前的黄帝时代就已发明了舟车,夏朝就设有掌管车辆制造的机构,即“车正”,商代中国的车工已能制造出相当精美的两轮车。在古代用马、牛、骆驼或人来牵引车轮进行运输。在周秦汉代的殉葬品中,不断发现车和马。三国时马钧发明指南车,科学家张衡发明了计里鼓车,明代制成了帆车,清朝发明了铁甲车。中国也是最早重视道路规划与设计的国家。古诗经中记述“国道如砥,其直如矢”来说明道路几何设计很好,平整、笔直。春秋战国时期,齐桓公、晋文公在黄河和长江流域建有四通八达的车道,在秦岭地区修筑了“金牛道”。秦始皇统一六国后,修建了全国性“驰道”和“驿道”,将春秋战国时期各诸侯所修筑的道路连接成网,实现了“10 里设亭 30 里设驿”。汉代的丝绸之路成为中国对外交流的重要通道。唐代初步建成以长安为中心的四通八达的驿道网,此外唐代还采取上下分行,靠左行走的交通规则。礼记中也有“道路男子由右,妇人由左,车从中央”的记载。

中国交通的发展与世界交通发展的历程基本相同,但由于近代发展的曲折,使得世界交通发展的高速公路阶段与智能运输阶段几乎同时,在近 20 年得到发展。这样,中国交通工程的发展大致经历了步行、马车、汽车、高速公路及智能运输共同发展的四个阶段。

从欧洲工业革命到大约 20 世纪 70 年代中期,尽管中国没有与世界先进水平同步发展,但近年来中国经济的稳步发展使得交通运输得到举世瞩目的迅猛发展。随之而来的就是交通拥堵、交通事故较多、农村运输落后、网络系统尚未完善和服务水平较低等问题,解决交通问题已成为各级政府和广大工程技术人员研究的重点领域。特别是今天中国正处于高速公路及智能运输共同发展的时期,急需交通工程领域的专业人才。

交通工程学是研究道路交通中各种交通现象的基本规律及其应用的一门正在发展的新兴学科,其社会性、系统性、实践性与综合性均很强。尤其是进入 21 世纪以来,科学技术交叉融合与经济全球化日趋明显,科技对于经济增长的作用日益显著,教育在国家经济与社会发展中的地位日益重要。中国经济已融入到世界经济的发展进程之中,国家间在相互竞争的同时又在寻求合作共赢。面对国际、国内社会与经济发展所出现的新特点,中国的高等教育迎来了新的发展机遇,同时也面临着教育国际化的挑战。面对这样的形势与要求,国家着力提高高等教育的水平与质量。近年来,依据教育部第四次全面修订的高等学校本科专业目录及培养“宽口径”复合型人才的要求,对人才的培养规格、培养模式、课程体系和内容都应作出适时调整和改革。教材建设是教学改革的重要环节之一,全面做好教材建设工作,是提高教学质量的重要保证。

新的历史阶段急需国际化的高素质人才,高等教育应当在全球化条件下改变教学模式,在专业教学中进行双语教学是一种先进的方式。对于专业目录调整后的交通工程专业来讲,更应该根据高等教育新的要求和近年来道路交通的发展,适应国内人才需求和人才国际化发展的需要。机械工业出版社由此提出了组织编写高等学校交通工程专业双语教材的设想。这一设想得到了开设该专业的有关高等学校的广泛响应与支持。2005 年 12 月,机械

工业出版社委托北京理工大学负责对《交通工程》原版教材进行分析评价并确定出版方式。

经过充分的调查研究和分析,我们认为英文原版《交通工程(Traffic Engineering)》已于2004年出版第3版,在美国以及英国、澳大利亚、新加坡、南非、加拿大、墨西哥、日本等国广泛用作教材。本教材学科内容符合中国高等学校交通工程专业教学大纲的基本要求,除第1章无问题以及第22章无参考文献外,其他章后均列出了详细的参考文献和问题。本教材主要作为交通工程专业和交通运输专业等交通类专业本科双语教材,也可作为研究生教材使用,还可供成人教育、交通管理人员以及相关技术人员参考。

本教材出版的目的在于使学生系统、全面地掌握交通工程的基本知识、理论、概念和方法,在专业英语能力上有所提高,为学生以后深入学习、研究交通工程学和从事交通工程实际工作和国际交流奠定基础。

英文原版由美国 Polytechnic University 运输工程系 Roger P. Roess 教授、Elena S. Prassas 助理教授和美国 Polytechnic University 运输与系统工程系 William R. McShane 教授编著,由 Pearson Education 公司2004年出版。英文原版全书共27章,除第1章交通工程概述外分4个部分。

第1部分是交通系统组成及其特性,包括道路使用者和车辆特性、道路及其几何特性、交通控制装置概述、交通流特性、智能运输系统5章;第2部分是交通研究及要点,包括统计在交通工程中的应用、交通量研究及特性、速度和运行时间及延误研究、交通事故研究和统计、停车特性及设施研究5章;第3部分是高速公路及乡村公路系统的应用,包括高速公路和多车道公路的通行能力与服务水平分析、高速公路及多车道公路的交织及分流合流、双向双车道乡村公路、高速公路及乡村公路的信号标志4章;第4部分是城市道路系统应用,包括交叉口控制概述、交叉口信号控制基本原理、信号配时与设计基础、交叉口设计元素及方案、实际信号控制和检测、信号控制交叉口分析、信号控制交叉口分析的应用、无信号控制交叉口分析、干线及网络的信号协调、干线性能分析、干线规划与设计、城市道路网络交通规划与运营12章。

限于篇幅并考虑交通工程学课程教学的内容,确定把英文原版教材分为《交通工程(基础)》和《交通工程(应用)》两册出版。

《交通工程(基础)》从交通工程的理论方面按人车路环境的主线确定了教材内容,对交通工程的人车路环境交通基本要素及交通流基本参数的相关概念和整体系统进行了全面概述,在综合交通工程研究内容的基础上,分交通系统组成及其特性和交通研究及要点两个部分,主要适用于本科生的交通工程学教学,同时也可作为研究生和广大工程技术人员的参考书。

《交通工程(应用)》主要从交通工程的应用方面按通行能力和服务水平的主线叙述,对交通工程的交通规划设计及管理控制的相关概念和整体系统进行了全面概述,分高速公路及乡村公路系统的应用和城市道路系统应用两个部分,主要适用于研究生和广大工程技术人员参考,同时也可用于本科生交通控制与管理及规划的专业教学。

考虑到教材主要用于中国,经与中美出版机构等协商,确定在部分章结尾处增加中文补充内容。中文补充内容力求反映中国交通发展的历史和中国交通科技发展的先进水平,突出中国交通的特色,材料主要来源于综合性手册、图书及标准法规,大多数只是进行了纲要性介绍,起到引领作用,教材使用者可依中文补充内容及中文参考文献进一步查阅详细内容。

第1章所加中文补充内容为A1中国道路交通特点与标准法规体系,其他有关章所加中文补充内容分别为A2道路交通参与者与车辆的特性分析,A3中国道路特性分析,A4中国交通管理与控制,A5道路通行能力和道路交通规划,A6智能运输系统体系框架和标准化及公共交通系统,A8中国道路交通量特性和交通调查,A9中国行车速度和行车时间分布特性,A10中国道路交通事故分析,A11中国停车规划与设计,A14中国农村公路的设计标准和管理,A15中国道路交通标志,A26中国区域经济发展及区域交通网络建设。

本书既可作为交通工程等交通类专业学生的入门教材,又可作为土木工程专业公路与城市道路工程等专业方向

学生的选修课教材。中文补充内容是在充分吸取国内外近年来交通工程学的研究成果和有关教学实践经验的基础上,根据理论结合实际、系统性与先进性并重、循序渐进并力求符合教学规律的原则进行编写的。本书在内容取舍上,力求从中国的交通工程实际出发,兼顾交通类专业的培养要求,系统地阐述了人、车、路的交通特征,交通调查分析,道路通行能力,交通规划以及交通管理与控制。对交通流理论、交通安全、停车场规划等也作了概括性的论述。

本教材由机械工业出版社组织,由北京理工大学负责中文补充内容的编写。补充内容以章为单元,力求反映中国交通发展的历史和中国交通科技发展的先进水平,突出中国交通的特色,力求符合高等教育的基本规律。参加中文补充内容编写的人员都是交通运输工程学科的骨干力量,他们在长期的教学与科研实践中积累了丰富的经验。

中文补充内容引用了国内科技项目研究成果和有关标准,参阅了近年来出版的相关教材,还吸收了部分使用本书的教师和同学的宝贵意见。因此,中文补充内容除凝结了各参编教师的教学及科研经验外,也包含了许多读者的见解和学习经验。

原版书共 27 章,我们对其中 13 章加了中文补充内容,《交通工程(基础)》包括 10 章,《交通工程(应用)》包括 3 章。原版书 Index 部分,在《交通工程(基础)》的页码后标注(1);在《交通工程(应用)》的页码后标注(2)。

中文补充内容的统稿工作由北京理工大学高利教授负责。第 1、3、5、10、26 章的中文补充内容由高利编写,第 6、14、15 章的中文补充内容由赵亚男编写,第 4、8、11 章的中文补充内容由吴绍斌编写,第 2、9 章的中文补充内容由陈雪梅编写。

由于中文补充内容的编写人员水平所限,难免出现错误和不当之处,恳请读者给予批评指正。

中文补充内容的编者
北京理工大学 高利 等

Preface

Traffic engineering covers a broad range of engineering applications with a common focus: the nation's system of highways and streets. Often defined as the nation's "lifeblood circulation system," this important part of the national infrastructure supports the vast majority of inter-and intra-city movement of both people and goods. Thus, the system plays a role in every important aspect of our society—including the economy, the environment, assurance of public safety and security, basic mobility for all societal functions, and basic access to the most remote regions of the country.

Traffic engineering involves a variety of engineering and management skills—including planning, management, design, construction, operation, control, maintenance, and system optimization. Because the focus of the traffic engineer's work is a most visible part of the public infrastructure, it is a field that also involves politics at virtually every level of government. Thus, the traffic engineer is called on to exercise a broad range of skills and must be sensitive to a wide range of issues to be effective.

This is the third edition of this textbook. It incorporates new standards and analysis techniques from the *Manual on Uniform Traffic Control Devices* (Millennium Edition), the *Highway Capacity Manual* (Fourth Edition, 2000), the *Policy on Geometric Design of Highways and Streets* (Fourth Edition, 2001), and other current standards. Like the first two editions, the text can be used for a survey course at the undergraduate or graduate level, as well as for a series of more detailed courses. At Polytechnic, the text is used in a two-course undergraduate sequence and a series of four graduate courses.

The text is organized in four major functional parts:

- Part I : Components of the Traffic System and their Characteristics
- Part II : Traffic Studies and Programs
- Part III : Applications to Freeway and Rural Highway Systems
- Part IV : Applications to Urban and Suburban Street Systems

Chapters have been added on Intelligent Transportation Systems; Parking, Signing, and Marking; Analysis of Unsignalized Intersections; and Arterial Planning and Management. Additional material on functional and geometric design and on marking and signing of facilities has also been added.

As in the first two editions, the text contains many sample problems and a wide variety of homework and project assignments that can be used in conjunction with course material. A solutions manual is available. The authors hope that faculty, practicing professionals, and students find this text useful and informative, and they invite comments and/or criticisms that will help them continue to improve the material.

The authors wish to thank the following reviewers for their comments and helpful suggestions: Carroll J. Messer, Texas A&M University; Emily Parentella, California State University, Long Beach; Mark Virkler, University of Missouri—Columbia; and William Sproule, Michigan Technological University.

ROGER P. ROESS
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CHAPTER

1

Introduction to Traffic Engineering

1.1 Traffic Engineering as a Profession

The Institute of Transportation Engineers defines traffic engineering as a subset of transportation engineering as follows [1]:

Transportation engineering is the application of technology and scientific principles to the planning, functional design, operation, and management of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods.

and:

Traffic engineering is that phase of transportation engineering which deals with the planning, geometric design and traffic operations of roads, streets, and highways, their networks, terminals, abutting lands, and relationships with other modes of transportation.

These definitions represent a broadening of the profession to include multimodal transportation systems and

options, and to include a variety of objectives in addition to the traditional goals of safety and efficiency.

1.1.1 Safety: The Primary Objective

The principal goal of the traffic engineer remains the provision of a safe system for highway traffic. This is no small concern. In recent years, fatalities on U.S. highways have ranged between 40,000 and 43,000 per year. While this is a reduction from the highs experienced in the 1970s, when highway fatalities reached over 55,000 per year, it continues to represent a staggering number. More Americans have been killed on U.S. highways than in all of the wars in which the nation has participated, including the Civil War.

While total highway fatalities per year have remained relatively constant over the past two decades, accident rates based on vehicle-miles traveled have consistently declined. That is because U.S. motorists continue to drive more miles each year. With a stable total number of fatalities, the increasing number of annual vehicle-miles traveled produces a declining fatality rate.

Improvements in fatality rates reflect a number of trends, many of which traffic engineers have been instrumental in implementing. Stronger efforts to remove dangerous drivers from the road have yielded significant dividends in safety. Driving under the influence (DUI) and driving while intoxicated (DWI) offenses are more strictly enforced, and licenses are suspended or revoked more easily as a result of DUI/DWI convictions, poor accident record, and/or poor violations record. Vehicle design has greatly improved (encouraged by several acts of Congress requiring certain improvements). Today's vehicles feature padded dashboards, collapsible steering columns, seat belts with shoulder harnesses, air bags (some vehicles now have as many as eight), and antilock braking systems. Highway design has improved through the development and use of advanced barrier systems for medians and roadside areas. Traffic control systems communicate better and faster, and surveillance systems can alert authorities to accidents and breakdowns in the system.

Despite this, however, over 40,000 people per year still die in traffic accidents. The objective of safe travel is always number one and is never finished for the traffic engineer.

1.1.2 Other Objectives

The definitions of transportation and traffic engineering highlight additional objectives:

- Speed
- Comfort
- Convenience
- Economy
- Environmental compatibility

Most of these are self-evident desires of the traveler. Most of us want our trips to be fast, comfortable, convenient, cheap, and in harmony with the environment. All of these objectives are also relative and must be balanced against each other and against the primary objective of safety.

While speed of travel is much to be desired, it is limited by transportation technology, human characteristics,

and the need to provide safety. Comfort and convenience are generic terms and mean different things to different people. Comfort involves the physical characteristics of vehicles and roadways, and is influenced by our perception of safety. Convenience relates more to the ease with which trips are made and the ability of transport systems to accommodate all of our travel needs at appropriate times. Economy is also relative. There is little in modern transportation systems that can be termed "cheap." Highway and other transportation systems involve massive construction, maintenance, and operating expenditures, most of which are provided through general and user taxes and fees. Nevertheless, every engineer, regardless of discipline, is called upon to provide the best possible systems for the money.

Harmony with the environment is a complex issue that has become more important over time. All transportation systems have some negative impacts on the environment. All produce air and noise pollution in some forms, and all utilize valuable land resources. In many modern cities, transportation systems utilize as much as 25% of the total land area. "Harmony" is achieved when transportation systems are designed to minimize negative environmental impacts, and where system architecture provides for aesthetically pleasing facilities that "fit in" with their surroundings.

The traffic engineer is tasked with all of these goals and objectives and with making the appropriate trade-offs to optimize both the transportation systems and the use of public funds to build, maintain, and operate them.

1.1.3 Responsibility, Ethics, and Liability in Traffic Engineering

The traffic engineer has a very special relationship with the public at large. Perhaps more than any other type of engineer, the traffic engineer deals with the daily safety of a large segment of the public. Although it can be argued that any engineer who designs a product has this responsibility, few engineers have so many people using their product so routinely and frequently and depending upon it so totally. Therefore, the traffic engineer also has a special obligation to employ the available knowledge and state of the art within existing resources to enhance public safety.