高等学校双语教学教材

杨孝宽　贺玉龙　著

Introduction to Traffic Engineering

交通工程总论

人民交通出版社
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内 容 提 要

本书为高等学校双语教学教材。全书共分8章，第1章简要介绍了交通工程学的发展史以及定义、研究范围和目标；第2章包含交通工程中常用的基本概念包括：机动性和可达性，道路分类，连续流和间断流以及驾驶员和车辆的特性；第3章讨论了流量、速度、密度以及三者之间的关系；第4章详细介绍了地点速度、出行时间和延误的特性；第5章讲述了统计学在交通工程中的应用；第6章讨论了道路通行能力，主要介绍了高速公路基本路段和双车道通行能力的计算；第7章描述了交叉口设计的基本过程；第8章介绍交通控制设备。

本书可作为高等院校交通工程、交通运输、土木工程等专业本科生双语教学用教材，也可供从事交通工程研究的专业技术人员参考。

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PREFACE

Transportation industry has seen mushroomed development in China since economic reform and opening to the outside world in late of 1970s. After 30-year development, transportation has become the backbone of China's economy. Urbanization has proceeded so fast that expansion of cities and birth of new city and town have pushed and stimulated transportation facilities to develop into full swing, resulting in urgent need of transportation professionals.

Bilingual program was initiated at the mid of 1990s by the Ministry of Education of China, aiming at fostering accredited colleges and universities to provide some basic courses in English, with Chinese explanation. Traffic engineering was introduced into mainland China in 1979 and Beijing University of Technology was the first to offer traffic engineering course for undergraduates nationwide. Since then many colleges and universities have prepared to open this course and put traffic engineering into official discipline of the school. This textbook comes out after more than 6 year preparation and deliberation. The textbook is particularly designed for Chinese students because the course is taught in bilingual format.

This book is based on author's 6-year bilingual teaching practice as well as nearly 30-year studying and working experience in China and the USA. Lessons have been learned from errors and mistakes in the process of building the structure of this book. Therefore, this book is unique in that it is designed to tailor student's needs and requirement of credit hours designated for this course. The text is composed of 8 chapters covering fundamentals and applications in traffic engineering filed. The objectives of this text are to lay solid foundation for students to study other related courses and get hand-on knowledge of traffic engineering, as well as lead students to professional arena. This text is appropriate for undergraduate students to study in one semester.

In order to have Chinese students better understand the contents of the text, some technical terms are translated into Chinese and they are enclosed within parentheses after the terms. While written at an introductory level, this book can also serve as a reference for practicing traffic engineers as well as for students in

graduate course. It is anticipated the book will benefit academic development of traffic engineering in China.

The authors are indebted to the help from teaching assistants who provide much energy and time for the accomplishment of this book. They are: Ai Qingyi, Cao Jing, Zhang Xue, Jing Bingfeng, Lei Lei and Li Lingjie. Thanks should also go to Zhao Yifu and Lan Jinhua who are working at Dean's office of the Beijing University of Technology for their strong supports in the opening and development of this bilingual course that paves the way for the shape of the textbook.

It should be pointed out that this book, as a bilingual teaching material, is still at fledgling stage and leaves rooms for improvement. Comments and suggestions from readers are warmly welcome.

The Authors
Beijing University of Technology
Summer 2010

前　言

20 世纪 70 年代末发生在中国的经济改革和对外开放，促使交通行业得到迅猛发展，已经成为中国经济的支柱之一。同时，城市化进程的发展也加速并刺激交通设施的全面提升，从而导致交通专业人员的大量需求。

双语教学是教育部在 20 世纪 90 年代启动的教学计划，旨在有条件的学校和专业开设使用英语和中文两种语言进行授课的课程。交通工程作为一门学科，是在 20 世纪 70 年代末介绍到中国大陆，北京工业大学在全国率先开设交通工程专业，从此，交通工程专业如雨后春笋在全国许多高校设置。本教材经过 6 年的精心准备和反复修改才得以出版，主要是为在我国高校开设交通工程双语教学的本科生教学使用。

该教材的出版，可以说是作者 6 年的双语教学实践以及近 30 年国内外学习和工作经历的结晶，通过精心总结前人的经验和成果后编撰成书，因此，该书的独道之处在于它是根据交通工程专业本科生教学的要求量体裁衣定制的。该书共分为八章，涵盖了交通工程的基础理论和应用。本书的教学目标是为本科生奠定牢固的专业基础，掌握交通工程基本技能并逐渐引导学生步入交通领域。本书适合本科生一个学期的教学量。

为使中国学生更好地理解和掌握书中的内容，作者在一些交通行业词汇后面加注中文翻译。尽管本书所介绍的内容是学科最为基础的部分，然而，它仍可作为交通工程师和研究生的参考用书。

作者借此机会向为该书出版作出贡献的历届助教表示感谢，他们是：艾庆毅、曹静、张雪、金冰峰、雷蕾和李玲洁。还要特别感激北京工业大学教务处赵一夫和兰劲华老师，他们对双语教学强有力的支持和帮助促成了本书的出版。

应当指出，作为双语教学教材，本书仍处于探索阶段，恳请各位读者斧正。

作　者

2010 年夏于北京工业大学

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Chapter 1 Introduction

In this chapter the definition, scope and objectives of traffic engineering will be introduced, together with systems composing of traffic engineering field. In addition background of traffic engineering as a professional will also be elaborated. Technical terms related to traffic engineering that may confuse undergraduate students are illustrated to differentiate the meanings of the terms implied in this discipline. Challenges and issues traffic engineers face will be discussed at the final section of this chapter.

1.1 Definition, Scope and Goal

In wake of growth of urbanization and development of automobile industry, traffic problems have become a major concern facing the urban planners and decisions makers. As transportation facilities have been in place and used by road users so routinely that transportation system has become an important component in people's daily life. *Traffic Engineering*（交通工程）, one of the elements in *transportation system*（运输系统）, has gradually matured to become an independent discipline being taught at colleges and universities worldwide. The definition of traffic engineering is the phase of *transportation engineering*（运输工程）that 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*（运输方式）. It should be noted here that if anyone flips over any textbook of traffic engineering he/she will find there are more than one definition for traffic engineering. In order not to make students being confused and easy to understand we choose this definition as the best alternative in this book. This choice is based on authors' teaching and working experiences in China as well as in the USA.

Transportation engineering is defined as a discipline applying technology and scientific principles to the planning, functional design, operation, and management of facilities for all modes of transportation. In general there are five modes of transportation including: roadways, railways, waterways, air and pipe. Traffic engineering focuses on the roadway system, referring to land or surface transportation facilities. Likewise, *traffic modes*（交通方式）refer to the conveyance means that are operated on highway system such as: automobile, truck, bus, motorbike, bicycle. Walking in some references is also considered a way of movement from one location to the other location. However, since majority of the walking behavior have nothing to do with the development of traffic facilities and it does not involve in the renovation and production of manufacturers like auto industry walking is not included in traffic modes in this text.

Traditionally, scope or coverage of traffic engineering deals with *surface*

(*land, highway, roadway*) *transportation* (陆路运输或陆路交通) and relationships and connection with other modes of transportation. Therefore, the main task of traffic engineering is intended to study how to move people and goods by highway or roadways and how to connect with other mode of transportation in an efficient way to fulfill transporting people and goods. As mentioned above, the principal modes that traffic engineers have to deal with include: automobile, bus, truck, motorbike, and bicycle. However, *terminals* (枢纽), *transfer center* (换乘中心) and *port* (*hub* 港口) are also the facilities that traffic professionals have to work with. This kind of work should be accomplished through cooperation and coordination due to its comprehensiveness and interest-sharing feature. Though responsibility of traffic engineers has broadened with development and expansion of transportation systems they should keep in mind that their main duty is to plan, design, maintain, and manage highway systems.

The ultimate goal of traffic engineering is to explore how to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods. It should be pointed out that movement of a physical body does not necessarily formulate a trip unless this movement has a determined purpose. Any movement without specific purpose can not constitute so-called traffic. Traffic denotes the movement with specific objective.

Safety is the priority that traffic engineers look after in their career. One of the responsibilities for traffic planners and engineers is to ensure the safety and security of traffic facilities. In addition to safety high efficiency in terms of rapidness is also the objective traffic professionals try to pursuit. As is known that time has values. Thus, it is very important to move people and goods as quickly as possible. It should be mentioned that there is always a *tradeoff* (均衡) between safety and efficiency in the planning, design and management of highway facilities. Transportation industry plays a key role in economic development of any nations. As a result, the objective of traffic engineering is to promote economic growth and improve living standard of people. With improvement of quality of people's lives road users expect to receive more comfortable, convenient, and environmentally friendly services of transportation. To achieve these objectives is not an easy thing. Some conflicts among the objectives may occur and the mission of traffic professionals is to make great efforts to compromise the conflicts and to optimize the resources to have transportation systems best meet requirements of road users.

1.2 Traffic System

To better understand function and characteristics of traffic facilities it is

necessary to know the elements that shape the traffic system (or highway system). It is widely acknowledged that traffic system is composed of highway (or roadway), vehicle, road users, and general environment.

■ Highway Planning, Design, and Management

Highway is a general term describing any facilities providing services of vehicles running on it. Highway system can be as large as a national freeway network or as small as a town's street network. There are three things related to the highway system: planning, design and management.

Highway planning is defined as a process of comprehensive plan of highway system, involving land use plan, network plan of roadway with different categories, layout of traffic facilities, corridor plan, transit and parking planning. This process often needs more historical data and vision of decision makers who are responsible for the consequences of the planning. Highway planning is also considered a part of transportation planning.

Highway design involves geometric characteristics of the roadway that mainly affect traffic flow and operation. *Geometric designs* (几何设计) are the main tasks that traffic engineers have to accomplish to guarantee the safe and smooth movement of vehicles running on the roadways. As traffic engineers they do not necessarily understand the structural design of highway facilities but should have some basic knowledge of structural features. Geometric design deals mainly with horizontal, vertical and cross section alignment of highway facilities. The vehicle-based design has been gradually replaced by human-centered design over decades.

Highway management refers to the proper control and management of traffic facilities once upon they are in place. Lessons learned from the past indicate that highway facilities can't function efficiently without executing appropriate control and management strategies. *Access management* (出入口管理) is a tool to deal with the control, design, and management of roadways in terms of layout of median, opening of driveway, as well as spacing of intersection signals.

Issues related to planning and construction of terminals, transfer center and port are discussed within the sphere of highway network.

■ Vehicles Characteristics

In traffic engineering, vehicles are an important element in the design and management of roadways. In light of the fact that design of vehicles is not what traffic engineering students need to master some basic features of vehicles should be studied in the undergraduate course. What traffic engineers are concerned in terms of vehicles include physical size, turning characteristics, dynamic feature and *climbing capability* (爬坡能力) of vehicles. With regard to dynamic features of

a vehicle they indicate braking characteristics, acceleration rate and deceleration rate. In light of the fact that vehicles are so diverse it is necessary to define a *standard vehicle*（标准车）or design vehicle as specification for the design of roadway facilities. Generally, passenger car is designated as design vehicle only in parking area, either on street parking or off street parking.

Besides, electrical bike and bicycle should also be taken into consideration in the roadway design, particularly in the urban area. Bike lane should be incorporated in the profile of the urban roadways to separate bike traffic from vehicular traffic. Bicycle traffic draws more and more attention from traffic professional with development of zero emission movement of transportation.

■ Road Users

Road users, in broad sense, include drivers, biker and pedestrians. With regard to drivers, traffic engineers try to do everything possible to explore the *driving behavior*（驾驶行为）through various ways. *Visual acuity*（视力）and *reaction process*（反应过程）are considered two utmost important factors related to driver's characteristics. As is known, personality and psychology of the driver also greatly influence driving task but it is very difficult to search for.

As road users bikers and pedestrians are also involved in the studies of traffic engineering for the sake of safety. This is particularly true for the populated cities. Walking speed and gap-acceptance behavior of pedestrians are the most important elements in traffic engineering studies. Observance of traffic law and regulations is also a key factor, which can be improved through education.

■ General Environment

General environment refers to the land use and landscaping along the highway, lighting along the roadway, and weather because these factors have great impact on the performance of traffic operation. Different land use will produce different type of trips, resulting in different traffic intensity. Likewise, varied landscaping provides drivers with different degree in comfort and ease during driving. In general, lighting is used on the urban roadways. The quality of lighting influences the safety of driving during night. Raining or snowing will *deteriorate*（降低）the driving quality and often trigger in *crashes*（事故）. It is true that traffic engineers have no capacity to change general environment of highway. However, being aware of the consequences that these elements will bring about to the roadway operations will assist traffic planners and engineers in figuring out the preventing ways.

1.3 Background of Development of Traffic Engineering

In next session brief introduction to history of development of traffic engineering abroad and in China will be traced. More detailed information on this topic will be found in other references. It is strongly recommended that students conduct extensive *literature review*（文献阅读）for getting in-depth knowledge about how traffic engineering has been shaped and developed over decades.

■ Brief History of Development of Traffic Engineering Abroad

It should be noted that two things have been considered the pushing powers for the birth and development of traffic engineering. One is invention of automobile. In 1885 Douglip Damller produced first experimental a four-wheel vehicle. At the same year Carl Bentz in Germany produced a real three-wheel vehicle. In 1888 the Mercedi Bentz was for the first time on sale in market, signaling the development of contemporary vehicle.

The year 1904 marked the beginning of a new era in American transportation history with the advent of automobile in considerable numbers. Moreover, the American love affair with the automobile has grown greatly since the 1920s when Henry Ford made the car accessible to the general public.

The other factor that pushes development of traffic engineering is *urbanization*（城市化）. After Second World War more and more people have swarmed into the city to seek opportunity of making fortune. As a result cities expanded and distance between location of employment and living place was longer and longer. Residents living in the city had to construct roadways to connect their travel destinations. With the advancement of new technology of vehicles many types of public transit were seen on the streets to serve the public.

With economic reform and opening to the outside world since late 1980s China has seen mushroomed growth of urbanization. Statistics shows that there were only 11 metropolitans nationwide（metropolitan denotes the city with population over one million）. However, this figure was 30 in 2004 and 118 in 2008, respectively. Comparisons of urbanization of China with other countries indicate how quickly China's process of city's expansion is about. Percentage of urbanization is considered as a measure to assess expansion level of urbanization. Great Britain took 120 years to experience percentage change of urbanization from 20% to 40%. However, China just took 22 years to reach this target. Table 1.1 shows years taken in completing this process in different countries.

Table 1.1 Years Experienced by Different Countries from 20% to 40% of Urbanization

Country	England	France	German	America	Russia & Japan	China
Years Taken	120	100	80	40	30	22

Besides, development of computer science and communication has improved traffic system. A good example is the introduction of *Intelligent Transportation System*（ITS，智能交通系统）, which brings transportation discipline into a new epoch. In general Intelligent transportation system（ITS）refers to efforts to add information and communications technology to transportation infrastructure and vehicles in an effort to manage factors that typically are *at odds*（对立）with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, travel times, and fuel consumption.

Sustainable transportation development（可持续交通发展）is a more recent concept liking environmental, economic, and social use values with the construction of traffic infrastructures. The ultimate goal is to identity the level of development that can be sustained without critical environmental damage, while meeting economic and social needs of present and future generations. Preservation of natural resources and exploration of new energy become vital steps toward sustainability. As a result environmental factors have been gradually involved in the development of transportation.

■ Development of Traffic Engineering in China

Traffic engineering was introduced into China rather late, compared to other countries. In 1980 traffic engineering course was first offered for undergraduate students at Beijing University of Technology in mainland China. In the following years many colleges and universities opened this course either affiliated to Civil Engineering Department or under Transportation College. Nowadays, there are more than 90 colleges and universities in China to offer traffic engineering program with Master and Ph.D. degrees.

The then Beijing Urban Planning Bureau started its comprehensive transportation planning work in 1982, conducing O–D survey for trucks, data collection for major and minor roadways, and delay investigation at signalized intersections. Since then transportation planning was considered an important element in the Urban Master Plan of Beijing. Traffic impact studies（TIS）have been required by transportation agencies to evaluate the potential transportation impacts of the proposed development on the surrounding neighborhood since 1990s in Beijing, symbolizing that traffic issues invite considerable concerns from all levels of government.