CHAPTER 1

# INTRODUCTION, TERMINOLOGY AND GENERAL SCOPE

There are two main tasks for contemporary bridge engineering, namely to construct new bridge structures according to the development of transportation needs and to maintain the existing bridge stock according to current and predicted traffic and safety requirements. This book is entirely devoted to the latter.

Denotation of the term *maintenance* is usually limited to the current works performed systematically by maintenance services to ensure normal and safe utilization of bridge structures. These works consist mainly of inspection, maintenance, repair and replacement, if necessary, of expansion joints, bridge deck, drainage system, railings, balustrades and barriers, pavement, bridge bearings, etc., as well as anti-corrosive protection of some elements, mostly by painting. However, the maintenance of existing bridges according to the determined technical and economical requirements demands, in many cases, some other essential actions being performed prior to the current maintenance itself. Therefore, the term *maintenance* may also be considered, more widely, as a multi-component process leading to the fulfillment of all conditions related to the safe utilization of existing bridges in the anticipated period of their future service.

In the recent two decades, rapid deterioration of bridge structures has become a serious technical and economical problem in many countries, including highly developed ones. It concerns also the concrete bridges, which for many years have been considered as durable and requiring minimum maintenance cost, while only the steel structures demand anti-corrosive protection being applied every few years.

The reasons leading to deterioration of the existing bridge stock are more or less the same in every country. The most important ones, concerning mostly bridges which have been in service 20–30 years or more, may be listed as follows:

(a) increase in traffic flows and weight of vehicles, especially their axle loads, compared to the period when the bridges have been designed and constructed,
(b) harmful influence of environmental pollution, especially atmospheric ones, on the performance of structural materials,
(c) common use of de-icing agents in countries of moderate climate,
(d) low quality structural materials as well as bridge equipment elements, such as expansion joints, waterproofing membranes, etc.,
(e) limited maintenance program or insufficient standard of maintenance,
(f) structural and material solutions particularly sensitive to damage produced by both traffic loads and environmental factors.

All the above reasons are discussed in detail hereinafter. It should be, however, emphasized that deterioration of bridges, directly resulting from overloading or material fatigue, is relatively seldom observed till now, because of safety margins in load-carrying capacity and early remedial actions undertaken. The other above mentioned factors play predominant roles in affecting deterioration of bridges and leading to their structural deficiency.

A *structurally deficient* bridge is one whose components may have deteriorated or been damaged, resulting in restrictions on its use.[1.1]

Apart from the technical condition problems, a great number of bridges built many years ago are functionally obsolete.

*Functional obsolescence* refers to a bridge's load-carrying or geometrical charcteristics; e.g., a bridge, which was designed 40 years ago for lower load levels or traffic volumes or with inadequate under- or over-clearance and which now requires restrictions on its use, is functionally obsolete in spite of its good technical condition.[1.1]

In general, however, the bridges are both structurally deficient and functionally obsolete. Therefore, depending on individual case, the following remedial actions can be undertaken:

- *repair*,
- *replacement*,
- *rehabilitation*,
- *strengthening*,
- *modernization*.

*Repair* means to mend, to put into good shape or working order again, to recondition, to renovate, to restore and to correct. Repair concerns rather the local damages of structural members or bridge equipment elements than the overall structure.

*Replacement* means to substitute, to change and to exchange. Some elements of bridge structures, mostly equipment elements, are usually replaced, e.g., expansion joints, bearings, barriers, etc. Sometimes, the structural members are also replaced, if necessary, e.g., deck elements, individual stringers, secondary or bracing elements, etc. Replacing a whole bridge is considered the last resort in the process of upgrading the existing infrastructure; it is a drastic measure and possibly the costliest.

*Rehabilitation* means to restore, to make suitable, to put back in good condition, to re-establish on a firm, sound basis, to bring back to full use, to reinstate, to renew and to revive. Rehabilitation concerns mostly the whole bridge structure, including its primary structural members.

*Strengthening* means to increase load-carrying capacity by adding more material, additional components (e.g., external prestressing), and so on.

*Modernization* is a form of upgrading by adding new features, e.g., new traffic flow arrangement, new signs, new lighting, new barriers. This term is commonly applied to structures designed and constructed prior to availability of these modern features. However, modernization can also be considered in a wider meaning. For instance, upgrading of the bridge requires in many cases its strengthening, new traffic flow arrangement requires the widening of the bridge deck, and so on.

Moreover, the term *retrofitting* is used in some situations. *Retrofit* is a strengthening procedure applied to an existing structure, not necessarily although in many cases related to seismic strength. It is applied usually after it is found that the original design is not sufficient in light of newly gained experience.

All the above mentioned terms define various actions concerning bridge works of different scale and importance. However, it is very difficult to consider these actions as fully separate ones. For instance, rehabilitation of a bridge often requires its adequate strengthening or replacement and repair of some of its elements, etc. Therefore, *repair, replacement, rehabilitation, strengthening and modernization* have usually many relations to each other and they may be considered to be the components of *maintenance* in its wider meaning, as mentioned above.

This book is entitled "*Bridge Rehabilitation*" but its content also covers many technical and economical problems related to other above mentioned bridgeworks performed to improve the technical condition and functional features of the structures.

Bridge rehabilitation covers many complex engineering problems as well as economical ones. Moreover, in the recent few years, many modern rehabilitation methods and non-conventional material solutions to improve the durability of bridge structures have been developed. Therefore, it is necessary to select some of the most important problems for presentation in this book. It has been done according to the author's subjective choice.

This book is focused mostly on rehabilitation of concrete bridges. This is due to the fact that on the one hand they represent a great majority of the bridge population in many countries and on the other hand, their rehabilitation is in general much more complex than in the case of steel bridges. Moreover, maintenance works, e.g., anti-corrosive coatings, are usually performed more systematically on steel bridges. Therefore, their technical condition is generally better than the concrete ones.

Rehabilitation problems concerning wooden and stone bridges are neglected in this book because of their specific and unique character related in many cases to the historical merit of the structures.

This book is also focused mostly on highway bridges. This is due to several reasons. Highway bridges are much more numerous and therefore, their rehabilitation needs are more evident than those related to the railway bridges. Railway bridges, mostly built of steel, are generally in a better position, as the intensity of rail traffic and the increase of loads are less pronounced than in the case of highway bridges. On the other hand, however, the problems concerning rehabilitation of railway bridges are

specific due to the fact that they were often built at the end of the XIXth century and at the beginning of the XXth century and exceeded their design life. These bridges, constructed in many cases by puddled steel, constitute at present a difficult technical problem concerning their actual load-carrying capacity, fatigue and the possibility of their strengthening.[1.2] Rehabilitation of railway bridges, including their modernization for rail traffic with high speed, requires a separate book. The problems related to railway bridges are only touched on in this book.

Some problems concerning bridge rehabilitation in several countries are formulated according to more or less official guidelines, regulations and other engineering requirements, e.g., Ref. 1.3. In spite of their practical importance, they are not the main basis of this book. This book is mostly aimed at postgraduate students. According to the author's opinion, it requires a more general presentation of the problems, including also outlines of theoretical approaches in certain cases. Thereby, information presented in this book can be useful for the readers independent of more or less official regulations applied in given countries. However, for practical illustration, some practical structural and material solutions used for bridge rehabilitation are described in examples given in the majority of the chapters.

## References

1.1. I. M. Friedland, "The practice of bridge management in the United States", *Proc. Int. Bridge Conf. Warsaw '94*, Vol. 1, 20–22 June 1994 (Road and Bridge Research Institute, 1994), pp. 215–223.

1.2. K. Flaga, "Materials and techniques in repair and renewal of bridge structures", *Post Conf. Proc. Int. Bridge Conf. Warsaw '94*, 20–22 June 1994 (Road and Bridge Research Institute, 1994), pp. 31–37.

1.3. L. G. Silano (ed.), *Bridge Inspection and Rehabilitation — A Practical Guide* (John Wiley & Sons, Inc., 1993), 288 pp.