Chapter 1

INTRODUCTION

1.1 MOUNTAIN RISK ENGINEERING (MRE)

Mountain Risk Engineering may be defined as "the science and art of engineering mountain infrastructure giving due consideration to natural and human processes, and the tolerable risks to and from infrastructures". Infrastructural engineering practices in hill and mountain areas are deficient in their approaches to solving problems specific to slope environments. This deficiency is a consequence of the folowing facts:

- traditional engineering education is not adequately oriented to the hills and mountains,
- traditional geological education is not oriented to problem-solving skills specific to civil engineering needs for linear infrastructures such as roads, railways, and canals,
- a comprehensive treatise or integrated material (for training and reference on hill infrastructural activities at the various stages of a project cycle) does not exist at present, and
- environmental aspects, not traditionally considered, require that solutions to hill road problems use a multi-disciplinary approach.

Mountain Risk Engineering is an integrated approach to solving the infrastructural engineering problems of hilly and mountainous areas. It's aim is to evolve cost-effective and site-specific designs, as well as environmentally conscious construction and maintenance practices. This can be achieved by basing engineering analysis and design on techniques to transform the constraints of hazards into tolerable risks.

1.2 PURPOSE OF THE MRE HANDBOOK

Mountain Risk Engineering must be practised to minimize the large economic and environmental costs (that will be experienced by infrastructural agencies and beneficiary groups) wherever the gaps in the traditional engineering practices for slope environments are likely to cause substantial loss. The first and foremost necessity of the process involved in updating current engineering practices to fit the MRE approach is a comprehensive handbook on MRE for application and training. This handbook contributes to the MRE adoption process by providing engineering approaches based on geological, environmental, and economic considerations specific to the mountain environments of developing countries.

The contents of this handbook will serve to establish a common ground for engineers and geologists involved in infrastructural projects in mountainous areas. Professionals in each of these disciplines have developed expertise in one or several of the areas covered by the handbook, depending upon the strength of their previous education and experience. However, familiarity with each of the topics included in the handbook will allow each discipline to appreciate the need of the other discipline and gear them towards making more effective contributions to sustainable mountain infrastructure through either the direct application of their skills or through soliciting the services of experts from respective disciplines to promote the development of environmentally sound and safe infrastructures in the mountainous areas of the Hindu Kush-Himalayan (HKH) countries.

1.3 STRUCTURE OF THE MRE HANDBOOK

The MRE Handbook consists of two parts, i.e., 1) Subject Background and 2) Application Guide, and these have the following characteristics.

- The contents are mainly derived from a compilation of existing literature. These have been selected, interpreted, synthesized, and laid out by using experiences of hill road problems in the middle mountains of Nepal. The contents provide ready reference material on relevant problems to practitioners and teachers.

- Although problem definitions and subsequent recommendations are based on Nepalese hill roads, the handbook is believed to be applicable, to a large extent, to all linear infrastructural works in all hilly regions of the HKH and other mountainous areas.

- The suggested techniques in the handbook are based on state-of-the-art reviews and their relevance to developing countries.

1.4 CONTENTS OF THE MRE HANDBOOK

There are twenty chapters under Subject Background-Part I. Chapters 2 to 8 are on geology. Knowledge of geological processes (Chapter 2) helps civil engineers to understand the variability in the forces and material properties over time so that the stability analysis is fully cognisant of these facts and so that the hazards and risks involved over the life of the infrastructure are well considered. The knowledge of the origin of rocks and soils (Chapter 2 and Chapter 3) helps in understanding the strength and behaviour of such rocks and soils over a longer time period. Chapters 4 and 5 give an introduction to Structural Geology and the Tectonic Setting of the *Himalaya* respectively.

Understanding of geological measurements and stereographic projections (Chapters 6 and 7) for rocks are essential to civil engineers because the joints and their orientations in the rocks determine the stability, conditions, and type of likely failure of these rocks. Slope stability analysis of rocks is not possible unless the direction and inclination of joints vis-a-vis the direction and inclination of the slope, along with the joint roughness, type of material filling the joints, and presence of water in the joints are measured in the field and plotted in the figure.

Airphoto Interpretation (Chapter 8) enables the identification of various features, in a larger area, influencing road stability. Many of these features are difficult to observe in the field without the help of air photos.

Chapter 9, Soil Mechanics, although generally familiar to civil engineers, is included in the handbook to serve as a refresher to civil engineers and as an introduction to geologists. Chapter10, Rock Mechanics, is intended to provide concepts of rock slope analysis to civil engineers and geologists.

Chapter 11, Geophysics, is included because measurements of surface conditions alone do not provide sufficient insight into the type of rock, soil, and the presence of water below the surface. Major slope stability analysis requires geophysical investigations on the surface supported by some drilling to ascertain the properties of the material deep below the ground.

Chapters 12 and 13 provide insight into various types of landslides, mechanisms of landslides, and methods of stablity analysis for slopes and landslides.

Chapter 14 provides concepts of hazards and risks for the predication of landslides from the existing conditions of the materials and the processes, and assessment of likely damage to infrastructure by the occurience of landslides. Hazard and risk assessment is a tool for decision-making under uncertainty. It is a planning tool at the prefeasiblity stage assessment, a management tool at the feasibility stage, and a design optimization tool at the detailed design stage of a project cycle.

Chapters 15, 17, 18, and 19 are intended to provide specific skills in evolving a cost- effective and durable design of various components of mountain roads, in particular, and other mountain infrastructures, in general.

Chapter 16 provides an introduction to roadside ecological concerns along with methods of biotechnical stabilization designs. The section on biotechnical stabilization is aimed at providing a clear concept of the role of plantation and vegetation in slope stabilizations.

Chapter 20 outlines basic concepts and methods of economic analysis to engineers and geologists engaged in infrastructural projects.

Part II - Application Guide-consists of six chapters (Chapters 21 to 26).

Chapter 22 deals with various aspects of the selection process at the prefeasibility stage and Chapter 23 deals with the site-selection process at the feasibility stage. Since the rigor of investigation and analysis depends upon the scale of work; the minor, medium, and major roads are treated separately. Chapter 24 deals wth problem identification, practical guidelines, and illustrative examples for the various activities in the detailed survey and design of a mountain road.

Chapters 25 and 26 provide a brief outline of problems and approaches during the construction and maintenance of a road project.

1.5 EVOLUTION OF THE MRE HANDBOOK

The handbook is an outcome of several stages of feedback and improvement.

1. A draft manual was prepared by ICIMOD under a two year (1988-89) Mountain Risk Engineering Programme sponsored by the Commission of the European Communities. This draft version was tested through a nine-week pilot training programme, involving 20 mid-career engineers and geologists from the HKH countries, which took place from February 6 to April 10, 1989, at ICIMOD.

2. Within the two year MRE programme framework the 1988 draft manual was improved after receiving feedback from the 1989 pilot training course and the final version was a two volume, four part manual in folder form which was circulated for restricted use.

3. As a final stage of the two year MRE Programme, a 3 day international consultative meeting was held at ICIMOD in February 1990 to solicit review of the manual by international academicians, decision-makers from infrastructural agencies in the HKH countries, and international and local consultants practising in Nepal.

4. Practical use of the MRE approach by the Department of Roads, HMG, Nepal in 1990.

5. A six month MRE Phase II Project, under the sponsorship of the Swiss Development Cooperation (SDC) and the German Technical Cooperation Office (GTZ), in Nepal, has enabled further improvement and revision of the 1989 manual and resulted in the present version entitled " The Mountain Risk Engineering Handbook"

1.6 USING THE MRE HANDBOOK

1.6.1 *Users of the MRE Handbook*

The primary target groups for the MRE Handbook are practising engineers and geologists in mid-career. The secondary target groups are undergraduate and graduate level students in academic institutions. The tertiary target groups are donor agencies, decision-makers, and consulting firms. Last, but not least, prospective researchers may find the handbook useful for identifying new areas of research on mountain road issues.

The tertiary group will find the handbook of value in framing the terms of reference for studies relating to hill roads in developing countries. The primary and secondary target groups may use the handbook as follows.

1.6.2 *Use of the MRE Handbook*

This handbook may be used for the following purposes:

- integrated MRE training to teachers/practising engineers and geologists for 8 to 9 weeks;

- teaching a one quarter (2.5 months) course of 12 to 15 credits or 125 hours of lectures, laboratory, and field exercises, and 47 hours of classroom or home exercises on mountain engineering to undergraduate or graduate students in civil engineering;

- practical field-based training as a project exercise for engineers already familiar with the subject background; the three stages of a road project cycle for 3 weeks to road engineers;

- one to two weeks' modular training on specific aspects of MRE to trainers/practising civil engineers and geologists;

- preparation of an institution or agency-specific application guide, code-oriented to specific infrastructures in the hill areas of developing countries; and

- preparation of terms of reference for consultants' services for various stages of mountain roads.

1.7 TRAINING CURRICULUM

Chapter	Lecture hrs.	Lab. hrs.	Field hrs.	Exercise/Home work hrs.	Total hrs
2	1.5	-	-	-	1.5
3	3.0	18.0	-	-	21.0
4	1.5	-	-	-	1.5
5	1.0	-	-	-	1.0
6	1.0	-	3.0	-	4.0
7	2.5	8.0	-	8	18.5
8	1.0	4.0	-	-	5.0
9	2.0	-	-	-	2.0
10	2.5	-	4	-	6.5
11	8.0	8.0	-	12	28.0
12	2.0	-	-	-	2.0
13	3.0	12.0	-	-	15.0
14	1.0	4.0	8	-	13.0
15	1.0	2.0	4	-	7.0
16	3.0	-	5	-	8.0
17	2.0	4.0	4	-	10.0
18	2.0	4.0	8	-	14.0
19	2.0	-	6	-	8.0
20	2.0	-	5	-	7.0
	42	64	47	20	173 = 5 weeks of 7 hours/day

The training can be organized as: 5 weeks' training with daily classroom lectures and exercises for 4 to 5 hours and daily homework for 2 to 3 hours, or 5 weeks' training at 7 hours a day.

1.7.1 *Field-based Practical Training Using Application Guide*

Project Work

i) Prefeasibility stage assessments of a 50 to 100 km long road, based upon desk work - only 3 days.

ii) Sample feasibility stage assessments of a 5 km stretch - 7 days.

iii) Design of three sections of 1km long each representing valley, climb, and ridge sections of a sample road - 10 days. Total 3 weeks.

1.7.2 *Equipment and Trainers Required for MRE Training*

The equipment needed for training in Part I is as follows:

- geologic hammer,
- geologic compass,
- rock samples,
- acid,
- stereoscopes,
- air photos,
- topographic maps, and
- personal computers.

Teachers needed for training in Part I are:

- 1 training coordinator (civil engineer) for 5 weeks
- 1 engineering-geologist for three to four weeks,
- 1 geotechnical engineer for 3 weeks,
- 1 civil engineer for two weeks,
- 1 geophysicist for one week,
- 1 natural resource specialist for one week, and
- 1 economist for one week.

Teachers needed for Part II are:

- 1 training coordinator (civil engineer for 3 weeks),
- 2 engineering-geologists for 3 weeks,
- 1 geotechnical engineer for 3 weeks, and
- 1 civil engineer for 3 weeks.

The equipment needed for Part II is as follows:

- electrical resistivity meter,
- seismograph,
- stereoscope,
- geologic compass,
- geologic hammer,
- altimeter
- a field camping equipment distomat
- air photos,
- topo maps, and
- drawing sets.