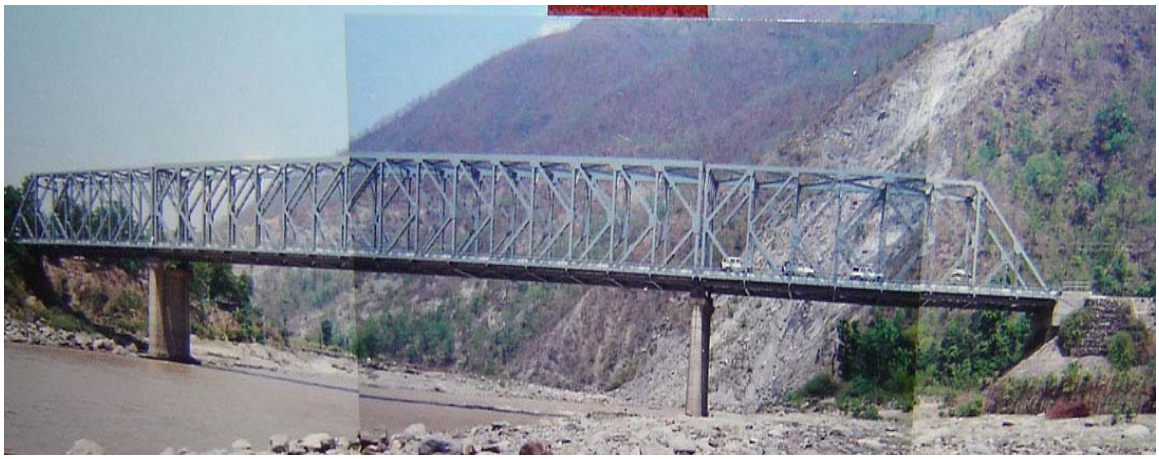
His Majesty's Government of Nepal

Ministry of Physical Planning and Works

Department of Roads

Planning and Design Branch

Bridge Unit



GUIDELINES FOR INSPECTION AND MAINTENANCE OF BRIDGES

Volume 1

1. Procedures for Inspections and Maintenance
2. Bridge Inspection Manual
3. Guidelines for Routine Maintenance

INTRODUCTION

There are over 1200 bridges constructed by Department of Roads, 1056 bridge (Bridge inventory 2005) out of these lie in the Strategic Road Network. Design of bridges are done through Bridge Unit and construction of Bridges are done by the Division Offices or the relevant Project Offices of the Department of Roads.

The Planning and Design Branch Bridge Unit is responsible for the drafting of policy and standards for inspection and Maintenance of the Department of Roads' Highway Structures. It also maintains the central Bridge Data Base for the Strategic Road Network. The Regional and Divisional Offices manage the annual inspection and maintenance of the Department's structures in their Regions and Divisions.

The maintenance activities carried out in the Division Offices are not found consistent and some (many) maintenance activities are missed out. The guidelines are meant to establish a proper standard method for the Inspections and Maintenance of the Bridges throughout all Division Offices. These Guidelines were prepared in the Bridge Unit during the Road Maintenance Project in 1996,97. The guideline is divided in to two volumes as following:

Volume I
1. Procedures for the Inspection and Maintenance of Bridges
2. Bridge Inspection Manual
3. Guidelines for Routine Maintenance of Bridges

Volume II
4. Guidelines for Minor Repairs to Bridges.

The general guideline for the inspections and maintenance with the interim norms is given in volume I.1 "Procedures for the Inspection and Maintenance of Bridges". Volume I.2 details the procedures for all types of inspections. The general routine maintenance items with the normally required frequency of the maintenance is presented in I.3 "Guidelines for Routine Maintenance of Bridges". Volume 2 " The Guidelines for Minor Repairs to Bridges" will also be published accordingly. The reader is requested to study the full contents of the manual irrespective of the type of inspection that he may be undertaking. This will assist in providing greater understanding of bridge behaviour and problems associated with bridges.

This guideline is published as it was prepared in the project, it is proposed to implement throughout the Division Offices, feedback will be collected and revisions will be updated. The approval was made on 060/1/10 from the secretary of the Ministry of Physical Planning and Works. Comments and criticisms are invited for any omission or additions or suggestions to improve the content.

Part 1
Procedures for Inspection and Maintenance of Bridges

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Part 1
Procedures for the Inspections and Maintenance of Bridges

1. SCOPE

This document describes the inspection and maintenance requirements and sets out the way in which this work is implemented and recorded. It applies to all bridges forming part of the Divisional Bridge Stock, defined below in the next paragraph. For purposes of this document a bridge is defined by the Nepal Road Standards (2027), (First Revision 2045) as a structure more than 6 metres in length. Less than 6m in length, structures are classified as culverts and are not included in the bridge inventory. The Division still has a maintenance responsibility for minor structures however procedures for these are described elsewhere in the DOR Road Maintenance Manual (2055).

2. THE DIVISIONAL BRIDGE STOCK

The Divisional Bridge Stock for which the Department of Roads has a maintenance responsibility is made up only of those structures on the Strategic Road Network (National Transport Policy 2058). All other bridges are either District or Municipality property and shall be maintained by these agencies. The management responsibility of the bridges which are not in the Strategic Road Network shall be handed over to concerned Authorities.

3. DIVISIONAL BRIDGE DATA BASE

The Divisions are required to keep and update records for all Strategic Highway Bridges for which they have a maintenance responsibility. The combined records form the Bridge Data Base which is made up of:

Bridge Inventory Record Card:	All the basic information about the bridge
Drawings:	Construction and as built drawings
Reports:	Inspection and design reports etc.
• Maintenance records	Maintenance manuals, records, estimates etc. Details of contract of maintenance and repair work
• Calculations:	Design and any rehabilitation works.

A copy of the Bridge Inventory Record Card was produced by the Bridge Unit for all the bridges on the Strategic Road Network. A copy was distributed to each Region and Division for all Strategic Road Network Bridges in that Region and Division in 1997. Drawings, design reports and calculations could be incomplete, especially for the older bridges. The Division should rectify any deficiencies in the Documentation, if possible. The Bridge unit shall assist in updating these records in Divisions and Regions periodically. Updating of the bridge inventory and condition survey is under progress through the RMDP component for the year 2004-05.

The Division will have to update the Bridge Data Base for the new bridges either constructed by Division itself or by a project. The Divisions shall be responsible to provide appropriate copies of those records to the Regional Office and Bridge Unit. However, the list of items to be included in the bridge data base is not definite and the Divisions shall include other items which are relevant to maintenance of the structure.

The Data Base in the Bridge Unit shall be updated periodically to assist in management of the bridge stock.

4. BRIDGE INSPECTIONS

The prime objective of the inspection is to safeguard the bridge for the general movement of the public. The methodology and inspection procedures are described in detail in the Bridge Inspection Manual. The inspection result will be the basis to program the routine maintenance and to priorities additional maintenance as well as rehabilitation works. There are four categories of inspection:

- Superficial
- Routine
- Principal
- Special

The routine inspection is the bridge inspection that the Division will carry out each year. This is a general examination of the structure to detect evidence of distress that might require repair or maintenance attention. The other inspection that is primarily used in the Division is the Superficial, or informal inspection.

The principal inspection consist of a more detailed inspection of the structure generally from within the touching distance, and often involving a certain amount of non-destructive testing. This will normally be undertaken by qualified bridge engineers either from the consultant or the Bridge Unit.

The special Inspection is carried out to investigate a specific problem, after a major accident or event, such as earthquake or flooding, or passage of unusually heavy loads.

5. MAINTENANCE RESPONSIBILITY

New Structures

Bridges are constructed generally under a separate project or directly by the Divisions. For the bridges constructed under a project, the Divisional Engineer should carry out a joint acceptance inspection of a new structure about one month before the issue of a completion certificate or opening of the structure to traffic. This inspection will identify outstanding works under the contract and identify any specific maintenance needs. The project shall be responsible for rectifying all the defects defined under the contract

during the defect liability period.
The Divisional Engineer should carry out another joint inspection with the Engineer and the Project Manager about one month before the end of the Maintenance Period. This is to confirm that all work outstanding under the contract has been carried out.

Divisions must have the opportunity to visit the bridge during construction to increase the understanding of the construction methods and structural behavior.

In the case of the bridges constructed by the Divisions, the joint inspection shall be carried out by the Division Engineer and a representative from the bridge unit. Other conditions will remain same as above.

New structures shall have a Principal Inspection by the Bridge Unit as soon as practicable after completion. The second Principal Inspection shall be conducted after four or five years of the initial Principal Inspection to ensure that latent defects are recorded and appropriate action is taken within the limitation period.

Existing Structures

Routine maintenance and Recurrent Maintenance (minor repair works) shall be the responsibility of the Division and will have to be carried out under the Planned Maintenance Program defined by the Strengthened Maintenance Division (SMD) process. In case of periodic maintenance of some items such as repainting of railing of the bridges shall also be carried out in similar manner.

Periodic maintenance such as repainting of steel structure shall be carried out under Planned Maintenance Program prepared from the condition survey. The work may be carried out under a project or by the Divisions. Similarly Rehabilitation (major repair works), improvement and replacement will also be carried out under a project or by the Divisions. Separate budget are prepared for these type of works based on the condition survey.

6. MAINTENANCE MANUALS AND REPAIR MANUALS

Guidelines for the Routine Maintenance of Highway Bridges

The Guidelines for the Routine Maintenance of Bridges addresses the requirements for routine maintenance identifying the vital regular maintenance works. The manual will:-

- provide the guidelines for the routine maintenance of highway bridges.
- form the basis on which the Maintaining Division can prepare estimates and implement for the work.

Specific Maintenance Manuals

Some bridges have specific maintenance manuals that apply solely to a particular bridge or group of bridges. An example is the Karnali Bridge. Every new Project should produce a manual, including as-built drawings, giving a complete record of the bridge. Section 8 gives recommendations for the contents of Maintenance Manuals.

Guidelines for Minor Repair (Recurrent Maintenance) of Bridges

The minor repair works are those activities which directly affect function of bridge, but are within repairable capability of division. Neglecting them can lead to more serious problem and activities could become major activity.

The Manual for the Minor Repair of Bridges is compiled to give information on bridge repair methods and techniques to enable these operations to be undertaken. Minor repair works are kept separate from routine maintenance activities. This is to aid monitoring of bridge problems and comparative cost. By analyzing cost estimates of repetitive repairs, it will be highlighted whether an alternative repair technique, or a replacement component may be appropriate

Major Repairs and Rehabilitation.

These will have job-specific specifications based on the Specification for Roads and Bridges, or amendments thereof.

7. MAINTENANCE PROCEDURES IN THE DIVISIONS

"Study the past if you would define the future" Confucius (551- 479 BC)	'I have six loyal serving men, they tell me all I know. Their names are what and when and where, and how and why and who.' Kipling

The work that falls within the remit of the Division is:-

- all routine maintenance, plus
- all minor repair works within the technical capability of the Division which is classified as Recurrent Maintenance.
- Prepare the cost estimate for major backlog maintenance / major repair with the help of Bridge Unit.

Activity Summary

1. Inspect Bridges	6. Programme the Work
2. Analyse the reports	7. Implementation
3. Define activities	8. Supervision
4. Prepare Cost Estimate	9. Review
5. Prioritise work	

1. Inspect Bridges

Using the Inspection Manual as a guide, complete the Routine inspection report forms for each of the bridges in the Division. The condition, extent and urgency are noted in the form. Also identify the recurrent maintenance items (minor repair works) and record it. The timing of the inspections will be to suit the YPO.

2. Analyse the Reports

Using the Summary sheet make a list of the work activities for each bridge. The activities which is beyond capacity of Division should be referred to the Bridge Unit through Regional office.

3. Define the Work Activities

The work items for routine and recurrent (minor repair) are listed in Appendix A and B. The Divisional Engineer will decide the best way to do the maintenance work. However Division could group the works according to different Headings and let out into manageable contract packages.

4. Prepare a Cost Estimate

An interim norms for routine maintenance has been approved and being implemented. The departmental norms should be used for the recurrent maintenance (minor repair works). Many items may not be covered by the present departmental norms. The expenditure of such items shall be monitored and a basis is developed to prepare norms for such items in the department.

5. Prioritise Work

The cost estimate is compared to the available budget. Priortise the work as per the available budget and extent and function of the damage. Request additional funds if necessary.. Where additional funding is not forthcoming the Divisional Engineer will decide what work is to go ahead on the bridges and what defers until later.

6. Programme the Work

The Divisional Engineer will determine work programme for the Division. There will be a number of factors taken into account in arriving at the work programme.

These will include availability of staff for supervision (and support logistics), cash flow funding, the effect of the monsoon and the urgency of the work.

7. Implementation

The Divisional Engineer will know the best method to implement the work in the Division. The procedures and documents as per the Public Works Directives should be followed. Provide the Extracts from the Guidelines for Inspection and Maintenance of Bridges and DOR Specification. There is a sample of a routine maintenance schedule given in the Guidelines for Routine Maintenance . The manuals, or extracts from them, may be translated into Nepali if the Divisional Engineers wishes.

8. Supervision

The work is supervised by the Division to ensure that the necessary standards are achieved and to calculate progress payments to the Contractor. Once the work is complete the Divisional Engineer will record this fact in the bridge records.

9. Review

There should be a review at the end of the maintenance operations. The review will reconcile expenditure, confirm that the specification and the norms are appropriate and that the maintenance interval is adequate. The purpose of the review will be to improve the systems, techniques, specifications and updating the norms for the work.

8. RECOMMENDED CONTENTS OF MAINTENANCE MANUALS FOR NEW BRIDGES

For each structure or group of structures of similar design, the Engineer shall prepare an individual Manual of information from the design and construction phases that could have possible implications for future maintenance. The Manual shall contain the following sections:

Introduction and Location.

An outline description of the works, with map, showing the location of the various highway structures. The bridge specification and design loading should be stated.

Materials

Details of materials incorporated into the works. The lists should give the name and address of the supplier, sub-contractors and where appropriate the source. The designers should consider other items that could be of value. The details should include, but not limited to:

- Cement - aggregates, additives and admixtures, mix proportions
- Steel reinforcing - bar, mesh, pre-stressing wire, strand or bar
- Steel - plate, rolled sections, prefabricated members etc.
- Imported fill - sources

Components

This list should give the name of the manufacturer, supplier or sub-contractor, the part number and manufacturer's drawing number. Items should include:

- Expansion joints
- Bearings
- Pre-cast units
- Moving bridge equipment
- Parapets
- Waterproofing systems
- Drainage systems
- Lighting, or any electrical system

The maker's recommendations for inspection and maintenance should be included where appropriate.

Certification and Test Records

These should be grouped in appendices or folders and should include mill certificates, cement analyses, cube test results, specialist test and calibration certificates.

Paint

The contract specification, supplier's paint data sheets, maintenance painting recommendations.

As-built Drawings
Cross referenced and bound separately.

Problems Encountered During Construction
A short report supplemented with instrument readings, sketches, photographs where appropriate, of problems encountered and solutions adopted which could have implications on future maintenance.

Access and Security
Details, including drawings of access to the site, walkways, ladders, manholes etc. Security measures to prevent un-authorised access.

9. RECOMMENDED ACTIVITIES TO BE COVERED ON ROUTINE MAINTENANCE

All work is to be carried out in accordance with the Routine Maintenance Manual for bridge unless instructed otherwise, in writing, by the Engineer.

The items of routine maintenance work described in this guideline should be regarded as those which relate to bridge servicing rather than bridge repair.

Routine maintenance does not cover the renewal of structural elements or components that have become unserviceable because of general wear and tear or have deteriorated for other reasons.

During the routine maintenance operation, Maintaining Division's staff should carry out a superficial inspection and anything noticed of a serious nature should be reported immediately. A sample superficial inspection report form and notes on the form are given in the Routine Maintenance Manual.

A Routine Maintenance Schedule is completed for each bridge by the Division. A sample of this form and notes on the form are given in the Guidelines for Routine Maintenance of Bridges.

The Routine Maintenance task are given in detail in Part 3: Routine Maintenance Bridges.

10. RECOMMENDED ACTIVITIES TO BE COVERED IN RECURRENT MAINTENANCE (MINOR REPAIRS)

The following are the items to be covered in Recurrent maintenance. The items are to be updated as required.

Items of minor repair work should be regarded as those which can be actioned by the Divisions without the need for technical support from the Bridge Unit.

Minor repairs may cover the renewal of structural elements or components which have become unserviceable because of general wear and tear or have deteriorated for other reasons if this work can be accomplished by the Division without technical support.

During the minor repairs, Maintaining Division's staff should carry out a superficial inspection and anything noticed of a serious nature should be reported immediately. A sample superficial inspection report form and notes on the form are given in the Routine Maintenance Manual.

A Routine Maintenance Schedule is also completed for each bridge by the Division. A sample of this form and notes on the form are given in the Routine Maintenance Manual.

The Recurrent Maintanance tasks and sample estimate forms are given in the succeeding pages.

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
River Channel, Stream-Bed and Banks Rectify minor erosion and scour problems using simple techniques. Reconstruct minor damage to protection works. Re-pointing of loose mortar, re-facing of spalled screed. Labour Plant Material *Note that major damage will call for investigation into the reason for the failure and possible redesign of new works of a different type and is therefore out of the scope of a minor repair.*				
Carried forward to summary				
Sub Structures Replace or repair broken drainage channels and extend pipes where needed to direct water leakage away from the bridge structure. Labour Plant Material Rake out and replace damaged or missing gap sealant to movement joints. Labour Plant Material Screed bearing shelves on abutments and piers to prevent water from ponding on them. Do not block movement of bearings. Labour Plant Material Emergency struts as a temporary measure. Labour Plant Material Re-pointing of loose mortar, re-facing of spalled screed. Labour Plant Material				
Carried forward to summary				

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
Superstructures				
Steel , Concrete and Timber Beams, Trusses and Decks, Concrete Slabs				
Replace or repair broken drainage channels and extend pipes where needed to direct water leakage away from the bridge structure.				
Labour				
Plant				
Material				
Fix pot-holes in surfacing on bridge deck and on approaches.				
Labour				
Plant				
Material				
Replace missing bolts and tighten loose bolts to given specification.				
Labour				
Plant				
Material				
Rake out and replace damaged or missing gap sealant to movement joints.				
Labour				
Plant				
Material				
Cut back and remove all dangerous protrusions, make safe with temporary repair as required.				
Labour				
Plant				
Material				
Minor concrete repairs to spalled concrete. This only applies to very small areas or to temporary repairs pending a permanent repair.				
Labour				
Plant				
Material				
Emergency struts as a temporary measure.				
Labour				
Plant				
Material				

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
Metal Parapets, Concrete Parapets, Timber Railings and Safety Fences Replace missing bolts and tighten loose bolts to given specification. Labour Plant Material Replace corroded or loose or damaged sections of steel parapet with equivalent standard sections. Labour Plant Material Cut back and remove all dangerous protrusions, make safe with temporary repair as required. Labour Plant Material Minor concrete repairs to parapets to restore parapet strength or temporary concrete patch pending permanent repair. Labour Plant Material Replace loose or rotten timber parapets or sections of parapet. Labour Plant Material				
Carried forward to summary				

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
Components ***Expansion Joints and Bridge Joint Systems*** Cut back and remove all dangerous protrusions, make safe with temporary repair as required. Labour Plant Material Rake out and replace damaged or missing gap sealant to movement joints. Labour Plant Material Repair/replace damaged or worn out drainage systems. Extend drainage pipes to direct water off structure where needed. Labour Plant Material Replace missing bolts and tighten loose bolts to given specification. Labour Plant Material Re-weld top cover plates where broken loose Labour Plant Material Replace gaskets etc. where this is required in specific maintenance manual. Labour Plant Material Repair cracks in adjacent surfacing and wearing course. Labour Plant Material ***Replacement of expansion joints is outside of the scope of minor repairs.***				
Carried forward to summary				

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
Components – *Bearings* Screed bearing shelves on abutments and piers to prevent water from ponding on them. Do not block movement of bearings. Remove bedding mortar that may obstruct movement of the bearings. Labour Plant Material				
Sliding Clean back all corrosive deposits. Introduce oil to interface of bearing surfaces and check for movement. Repaint exposed bearing surface, excluding contact surface. Clean contact surfaces where accessible and re-grease/lubricate in accordance with manufacturer's instructions, in the maintenance manual. Labour Plant Material				
Repair/replace missing/ loose bolts, minor areas of mortar bedding loss, minor concrete spalls. Labour Plant Material				
Repair/replace/renew grease boxes as required. Labour Plant Material				
Elastomeric Repair minor damage to bearing plinth. Labour Plant Material				
Roller Remove general debris and dirt. Clear and clean roller surfaces where accessible and re-grease if necessary. (Identify Manufacturers instructions in maintenance manual). Check for movement. Replace damaged, loose bolts and minor areas of mortar bedding loss, minor concrete spalls. Clean back all corrosive deposits. Repaint exposed bearing surface, excluding contact surface. Repair/replace/renew grease boxes as required. Labour Plant Material				

Task Summary	Cost for Bridge No.			
	Qty.	Unit	Rate	Amount
Special Bearings, PTFE etc. **Minor repairs to bolts and concrete bearing items. Check for movement.** Refer to manufacturers instructions and maintenance manual. Labour Plant Material Earthquake restraints Replace loose bolts and/or parts. Replace damaged and/or corroded members. (Report this work to Bridge Unit) Labour Plant Material *All other work on bearings is outside of the scope of a minor repair.*				
Carried forward to summary				
Protective Systems Touch up paint system to minor damaged and/or corroded areas after correct preparation. Labour Plant Material **Bridge Signs** Repaint all signs including chevrons using specified paints. Labour Plant Material Replace all damaged signs, including chevrons. Labour Plant Material				
Carried forward to Summary				

The Estimate shall be prepared as per the approved Departmental Specification and Norms.

Recurrent Maintenance (Minor Repair) of Bridges - Cost Estimate Summary

Cost Estimate Summary - Bridge No.		
	Amount in Words	Amount in figures
River Channel , Stream-Bed and Banks		
Sub Structures		
Superstructures		
Components -Expansion Joints and Bridge Joint Systems		
Components - Bearings		
Protective Systems, Bridge Signs		
Sub-Total		
Allow 15% contractor's overhead		
Sub-Total		
Allow .....% VAT		
Sub-Total		
Allow 5% physical contingencies		
TOTAL		

Estimator/Engineer .....

Date.....

Checked by .....

Date.....

Approved by Divisional Chief .....

Date.....

11. SAFETY

Bridge work usually takes place in very dangerous situations. Safety must always be the prime consideration in all inspection and maintenance operations. Accidents do not happen but are caused and human error is to blame for the majority of accidents. The most important factor is to generate awareness of hazards, at every level of working. Engineers, as the managers of site works, are responsible for the safety of both workers and other people, including road users.

The departmental safety documents such as Safety at Road Works: A Code of Practice for Signing at Road Works and Safety at Bridges shall be followed while conducting the maintenance and repair works.

Principles of Accident Prevention

There are three good reasons for preventing accidents at work (or at any other time).

1. Injury accidents result in a great deal of pain and suffering for those affected.
2. Accidents at work cost a lot of money, especially when damage accidents are included. Costs are incurred through interruptions to work, quality reduction and environmental damage, as well as medical or funeral costs.
3. It is a legal and moral requirement to safeguard the health and safety of employees and others who might be affected by the Department's operations.

Accidents don't happen; they are caused! They are usually the result of human error. Studies of the primary responsibility for accidents suggest that human error on the part of management accounts for 61% of accidents, employees accounts for 18% with joint responsibility accounting for 12%, giving a figure of over 90% where human error has been responsible for causing the accident.

Once a hazard has been identified, one or more of the following actions can be taken to remedy the situation:-

1. Eliminate. Remove the hazard completely from the working area (*e.g.* removal of loose debris from above a working area).
2. Reduce/substitute. Reduce the hazard to an acceptable level by reducing its scale of substituting it for something less dangerous (*e.g.* replacing damaged tools with better ones).
3. Isolate. Enclose the hazard so there is no interface between people and the hazard (*e.g.* barriers around excavations).
4. Control. Control the number of people at risk by systems of working or by engineering methods (*e.g.* reduce the number of people in close proximity at any one time).

5. Protection. Provide personal protective equipment aimed at minimising the level of injury (*e.g.* provision of boots and hard hats to labourers).
6. Discipline. Introduce self discipline in following safe procedures, or management discipline by enforcing standards of operation (*e.g.* insist labourers use adequate scaffolding when working on high bridges).

Safety Checklist

The facilities for safety are not always established properly. Even simple Personal Protective Equipment (PPE) such as reflective jackets are not commonly used. Nevertheless, the responsible manager must endeavour to promote the highest standard of safe working practice and not simply accept ad hoc standards. This includes training and educating the work force in accident prevention and the proper use of plant and equipment. There are sound economic reasons for the development of safety policy as well as humanitarian ones. Lost time results when accidents occur and this costs money. Plant damaged in an accident may be hard to repair or replace. Efforts must be made to maintain and strive to improve safety performance. The brief checklist indicates *some* of the areas that will require attention:-

- responsibilities of management, supervisors and workers
- training, safety policy, accident prevention plan, safe working practice
- sanitation, drinking water, toilets, washing facilities, first aid room
- fire prevention, extinguishers, emergency procedure, no smoking areas materials
- tidiness, tripping hazards, falling objects, removal of debris, oil
- protective equipment, hard hats, goggles, ear protectors, boots, harness, clothing
- ventilation, welding, painting
- hand and portable tools, maintenance and use
- excavation and demolition, temporary works, scaffolding, excavation support
- working on slopes, over steep ravines, over water
- safety of the general public
- confined spaces, working under water
- electrical hazards
- safe clearance procedure, machines, roads, rail
- steelwork, handling, transporting and erection
- safety nets, lighting
- traffic and project vehicles, speed limits, signs
- cement and epoxy handling, manufactures instructions, hazardous substances
- safety signs, warning signs
- emergency services, emergency contact procedures, distance to hospitals

- health and safety, safety officers, first aiders, accident reporting, analysis
- explosives, handling and use
- project specific aspects - extent of facilities in remote locations malerial areas, etc.

The list is not meant to be comprehensive and will vary with location and the type of work. There is much more to the principles of accident prevention; these are only the very basics. The most important factor is to generate awareness of hazards, at every level of working.

Safety Guidelines for Working on Bridges

1. No-one may gain access to the site unless they are authorised by the Engineer or the Contractor. This is easier to enforce on new sites but more difficult with maintenance work on existing bridge. However, there is a greater need to address safety on existing bridges as these are often in use by the general public. Wherever possible the working area should be isolated from the public.
2. All persons engaged in bridge work of any kind must be trained or under training in the precautions to be followed, apart from the detailed training for their particular job.
3. No person may work unaccompanied unless they are in a safe area. All personnel must leave the work area to take refreshments, meals *etc*.
4. During site works, all working areas shall be clearly marked off and personnel informed of the dangers.
5. All access equipment, ropes and tackle must be regularly inspected and adequately maintained in a sound condition.
6. Where persons could fall over the edge of a bridge or embankment slope, temporary guard rails or ropes should be installed. All persons exposed to a risk of falling must be provided with a secure and well anchored safety line. Such a rope must be of sufficient strength to provide them with safe arrest in the event of a fall.
7. Care must be taken to prevent tools and loose objects falling from the bridge. Loose articles should be raised or lowered in a safe manner. They should not be carried up or down ladders, unless in the case of small items, which may be carried in a suitable shoulder bag.
8. Toe boards shall be fitted to platforms to prevent articles from being accidentally kicked over the side onto people below.
9. Extreme care must be exercised on bridge sites during adverse weather con-

ditions (wind, rain, fog and darkness create their own hazards in addition to the hazards inherent in slope work) and supervision must assess the conditions with great care before allowing access. Only where absolutely necessary may persons work in heavy rain or during the hours of darkness. In such cases, no person shall work unaccompanied.

10. Any scaffolding that is used must be composed of good quality materials. Permanent materials shall be used when specified. Bamboo should be freshly cut, of strong and flexible nature. Scaffolding must be correctly erected by competent persons and of appropriate capacity.

11. Ladders must be in good condition and adequate for the job. Ladders should extend one metre beyond the landing point and must be on a firm base, correctly pitched and lashed as soon as is possible. Unlashed ladders must be "footed".

12. If there is any potential hazard to personnel below where the slope work is taking place, adequate temporary warning notices, barriers and a "look out" person shall be employed.

13. Appropriate protective clothing shall be used, including, where necessary, shoes with slip resistant soles.

14. Special safety procedures shall be followed for work in confined spaces, with hand and mechanical tools and plant, at high levels, alongside live traffic, close to the general public and buildings, and with hazardous substances.

Part 2
Bridge Inspection Manual

CONTENTS

Part 2
Bridge Inspection Manual

1.0 THE PURPOSE OF BRIDGE INSPECTIONS

1.1 Aims

Bridge inspection forms an essential part of the process of bridge management, the objectives of which are to maintain the existing bridge stock in safe and serviceable condition and to plan and undertake maintenance and replacement work. Bridge inspections therefore need:-

(a) To provide assurance that the bridge is structurally safe and fit for its intended use.

(b) To record systematically and periodically the condition of the structure.

(c) Monitor any change of condition with time, thus providing early warning of problems.

(d) To provide information from which maintenance repairs, strengthening or replacement work can be identified and planned.

(e) To provide a basis upon which to estimate the level of funding for maintenance work on bridges.

(f) To provide feedback to designers and bridge owners on those features which are likely to give maintenance problems, in order to prevent the continuation of design faults in new bridges.

1.2 Requirements

In order to satisfy these aims the following requirements must be met:-

- The inspections must be carried out regularly and in a thorough, systematic and consistent manner.
- The results of the inspections must be reported in a systematic way.
- The results of the inspections must be communicated effectively to the Maintenance Divisions so that appropriate remedial work can be planned and undertaken.

2.0 TYPES OF INSPECTION

Bridge inspections can be divided into four types:-

- Superficial
- Routine
- Principal
- Special

2.1 Superficial inspections

Superficial Inspections are a quick check for damage or obvious faults which might lead to accidents or high maintenance costs. Staff from the Maintenance Division are encouraged to be vigilant and report anything needing urgent attention in any bridge. Examples are impact damage from vehicles, flood damage or insecure expansion joint plates.

Superficial inspections are not restricted to Divisional staff and anyone involved with highway and bridge maintenance should note anything unusual about a bridge whenever they are traveling, and report it to the Divisional Engineer or his staff. Such action can prevent the development of serious problems between routine inspections.

The inspections are made during the course of other duties whenever staff are in the vicinity of the structure. They are not normally the cause of a special visit. Inspections are made from ground and deck level without the provision of access equipment.

Should any Superficial Inspection reveal a possible defect or hazard to the road user the Division shall take such action as is required to safeguard the Public.

A Superficial Inspection report form is completed when defects are noted and the report handed to the Divisional Engineer. The report form is only filled out when action is needed. A sample form is given in Appendix C. It may be photocopied for use.

The Superficial Inspection does not use the Department's standard rating system for reporting, as described in this manual. A brief written report is all that is required.

The report form may be in either Naepali or English, as can the actual written report.

2.2 Routine inspections

This type of inspection will be undertaken at least once a year by staff from the Maintenance Divisions. It is essentially a visual inspection, possibly supplemented by a few simple measurements. It should generally be undertaken at a time of low water so that substructures, the river bed and any bed protection can be inspected.

The Routine Inspection is very important. The results of this inspection enable the Divisions to plan the annual bridge maintenance work. Timely inspection and preventative maintenance protect the National assets of Nepal.

Simple access equipment, such as a ladder, will be used from time to time to reach less accessible parts. Binoculars can be used to inspect areas beyond the reach of a ladder. The more inaccessible parts are usually left to more detailed Principal Inspections, unless a problem is suspected. In this case additional access equipment may be called for.

Routine inspections include adjacent earthworks or waterways, damage or other changes to which could affect the stability of the structure. River banks in the vicinity

are examined for evidence of scour or for other conditions, such as deposition of debris, which could cause problems.

Report forms for the Routine Inspection are given in Appendix C. The forms comprise three pages which *summarise* the condition of the bridge component elements, recording where maintenance work is required. The components include associated works, such as embankments and bridge protection works. Not all of the forms are used, this depends on the structure that is being inspected. Site sketches, photographs and notes augment the report forms. Two other forms are included with the Routine Inspection Forms:

- Bridge Inspection Report Form - Bridge Identification
- Bridge Inspection Summary.

The Department's standard rating system for bridges is used for Routine Inspections. This ensures that a uniform system for inspection is applied throughout Nepal, and when staff transfer between Regions and Divisions it is not necessary to learn a new system. The common rating system helps all Departmental staff to perceive the bridge condition without actually seeing the bridge.

The Bridge Unit is available to support all inspections.

The contents of the main body of this manual describe the requirements for this type of inspection.

2.3 Principal inspections

These are planned periodic inspections. They consist of a more detailed inspection of the structure generally from within touching distance, and often involving a certain amount of non-destructive testing. They will normally be undertaken by qualified bridge engineers, either from local consultants or from the DOR Bridge Unit. The frequency of these inspections will probably be between five and eight years. New bridges however should have a Principal Inspection as soon as practicable after completion and again four or five years later. This is to ensure that latent defects are recorded and appropriate action taken within the limitation period.

Comprehensive access equipment may be needed for some bridges, such as scaffolding and/or platforms suspended from the bridge deck.

Report forms for the Principal Inspection are given in Appendix C. The forms comprise fifteen master pages which *detail* the condition of each bridge component element including associated works, such as embankments and bridge protection works. Not all of the forms are used, this depends on the structure that is being inspected, however on occasion extra copies of some of the forms are to be completed, for example on large multi-span bridges. The Bridge Inspection Report Form - Bridge Identification and the Bridge Inspection Summary forms are also filled in.

The Principal Inspection is enhanced by a comprehensive report which will include site sketches, description of structure and inspection, maintenance history, photographs, notes, test results and interpretations of the results and other data.

The Department's standard rating system for bridges is used for Principal Inspections.

Other more specialised equipment such as paint thickness gauge, a depth of cover meter for reinforcement and tell tales may be needed on occasions. Typical special inspection equipment is described in Appendix E, Testing, Methods of Testing, Special Testing Equipment

The Principal Inspection not only forms a basis to determine maintenance activities, but also forms an historical record of the bridge condition at a fixed time in the life of the structure. Analysis of the results help the designer to determine the time related performance of both structural configurations and associated component parts. It is important to rectify those repetitively weak design solutions that are the source of constant maintenance problems.

Analysis of the bridge ratings provide a deterministic means to verify that the unit value of the national bridge assets are being maintained. As such they can form an important guide as to future maintenance investment levels.

2.4 Special inspections

Special inspections may be needed if a structure is at risk, or if there is a problem requiring further investigation. The frequency will therefore vary, and the person undertaking the inspection will vary according to the circumstances. For instance a qualified bridge engineer will be needed to investigate a serious structural defect, but inspection of a flood damaged bridge might be undertaken on a daily basis by an engineer.

The inspection may comprise a close examination of a particular area or defect causing concern. This may be extended to the whole of the structure depending on the condition or level of deterioration.

In some cases access equipment may not be needed. On other occasions it may be necessary to employ specialist inspection firms and equipment.

Examples of times when a Special Inspection shall be carried out are:

- When further detailed examination is needed to investigate a special problem, either found during inspection or already discovered on other similar structures.
- For structures which have weight or other restrictions to reduce traffic loading. These inspections shall be at intervals not exceeding six months.
- When a structure has to carry an abnormal heavy load. The inspection takes place before, during and after the passage of the load if either an assessment has

indicated that the margin of safety is below the current design stansard, or, similar loads are not known to have been carried by the bridge.

- In locations where ground movement is suspected or is taking place. Steps need to be taken to monitor the rate of movement and to assess the urgency of remedial measures.
- If settlement is observed greater than that allowed for in the design. The cause will need to be identified and steps taken to monitor the rate of settlement and to assess the urgency of remedial measures.
- To river bridge foundations and embankments after flooding. Where probing indicates the possibility of scour, further underwater inspection shall be carried out.
- After a major accident, chemical or fuel spillage or fire adjacent to a structure, to investigate possible damage to the structure.
- After a significant earthquake to investigate possible damage to the structure.
- For special bridges, such as Karnali for special circumstances.
- On hoists and winches that are used for access - prior to use and at prescribed intervals - in accordance with HED and inspection manual requirements.

Reporting will vary with the composition and cause of the special inspection. For a simple check after a flood the Superficial Inspection Report Form may be used. For more comprehensive investigations all or part of the Principal Inspection forms may be used augmented where necessary with additional detail and/or specialist reports. Specialist access or equipment inspection may be called for.

2.5 Assessment

If, as a result of any inspection, the load carrying capacity of the bridge is in question, the bridge shall be assessed in accordance with the appropriate assessment standard as specified by the Design Section Bridge Unit.

2.6 Summary

The different types of inspection described above are summarised in the following table.

TYPES OF INSPECTION		
Type	Inspector	Frequency
Superficial	Anyone	Any time
Routine	Divisional staff	Yearly
Principal	Consultants / Bridge Unit	5 - 8 years*
Special	Various	As required

*Initially more frequent for a new structure

3.0 PREPARING FOR BRIDGE INSPECTIONS

It is essential that bridge inspections are properly planned, otherwise they will fail to fulfill their purpose. When preparing for an inspection the following matters need to be addressed.

3.1 Timing

Inspections should generally be carried out during the dry season when water levels are low and rivers may even be completely dry. This will permit easier access to mid-river piers, and will allow the river bed and any bed protection to be inspected. It will also enable scour damage to be inspected.

Inspection by the Maintenance Divisions will need to be coordinated with their general maintenance activities to ensure that the appropriate staff are available to carry out the inspections.

Other seasonal factors need to be considered, for instance avoiding intense midday heat in hot months, and ensuring that there is sufficient daylight available.

Advantage should be taken of any circumstances which will facilitate the work such as scaffolding for repair work on the bridge or the closure of roads or traffic lanes for road works. For the first Principal Inspection on a new structure advantage should be taken of the Contractor's access equipment before it is demobilised.

3.2 Access

The means of access to the bridge needs careful consideration. In many cases access to much of the structure is available on foot, but ladders will normally be required to enable bearings at the tops of piers and abutments to be inspected.

Where bridges are located across permanently flowing rivers it may be necessary to use a boat. If the river is fast flowing strong securing ropes may be necessary, and inspections may need to be carried out in a particular month to take advantage of slower flows.

High level bridges also present difficulties. In some cases it may not be possible to obtain access to the underside of the deck or the tops of the piers without special equipment, and inspections may have to be undertaken from the ground using binoculars until such time as access equipment becomes available.

3.3 Safety

Bridges are potentially hazardous places and safety - of the bridge inspector, road users and local residents - must be given the highest priority. Bridges will normally be inspected while traffic continues to use the bridge, so there is the obvious danger to the inspector due to moving vehicles. There is also the potential danger of tripping and falling from the bridge, or of dropping equipment from the bridge onto people below. Another possible source of injury arises from insect or snake bites.

All of these dangers can be avoided provided suitable precautions are taken. Bridge inspections should not be undertaken alone - the inspector should always take an assistant who can summon help in case of emergency.

Temporary signboards should be used during all bridge inspections to notify drivers and pedestrians using the bridge that inspection work is in progress.

Bridge inspectors should always have a first aid kit available on site.

Please refer to departmental safety guidilies as described

Reading the safety guidelines can save a life.

3.4 Transport

Suitable transport should be arranged to enable the inspector to get to the bridge site, together with all necessary equipment and assistants. Ladders will generally be required and provision needs to be made to carry these.

3.5 Equipment

The following items of equipment should be provided for all inspections apart from Superficial Inspections:-

Traffic warning signs	Penknife
High visibility fluorescent waistcoat	3 m steel tape
Protective clothing	30 m steel tape
Safety helmet	Mirror
Clipboard (waterproof)	Haversack / shoulder bag
Writing materials	Plumb line
Waterproof marker	Ranging rods (for probing depth of scour)
First aid kit	Hammer
Binoculars	Crack width gauge

Camera, flash and film
Ladder
Torch

The following additional items may also be required:-

Jars / plastic bags for samples
Screwdriver
Spirit level
Straight edge
Small boat

The inspection and/or access equipment requirement is enhanced for Principal and Special Inspections. Appendix E gives an indicative guide to specialist inspection equipment that may be used from time to time.

3.6 Bridge data

Before starting the bridge inspection the engineer should look up the data on the Bridge Inventory Record Card held by the Divisions (a copy of which is also held by the Regional Office and the Bridge Unit). This gives basic details of the structure such as size and number of spans and structural form, which will help the engineer to plan the inspection. The engineer should also inspect a copy of the last bridge inspection report and take a copy of the Summary Sheet where appropriate.

3.7 Inspection forms

It is good practice to prepare and collate the inspection forms and to fill in the details from the Inventory Record Card before going to site. This is easier to do in the office and saves time on site.

3.8 Briefing

Before inspecting a bridge the inspecting engineer should check with the Divisional Engineer whether there are any special instructions - for example inspecting previous repair work and reporting on its effectiveness.

4.0 UNDERTAKING THE INSPECTION

In order that the information provided by the inspection is of adequate quality the inspection must be detailed and thorough, and carried out in a systematic way.

At each site the following routine should be carried out:-

- Establish safe working conditions
- Undertake general appraisal of the site
- Carry out detailed inspection

These will now be described in more detail.

4.1 Safety

On arrival at the site vehicles should be parked in a safe place - preferably off the road - and the signboards put in place. These should be sufficiently far back from the structure (say 100 metres) to give approaching traffic adequate warning that there are people working on the bridge.

In some cases there may be a need to establish positive traffic control before the inspection can be safely undertaken - for instance if working on ladders on a truss bridge deck.

Access to difficult areas should not be attempted without appropriate equipment.

Please refer to Part 2: *Procedures for the Inspection and Maintenance of Bridges* for additional advice on safety.

4.2 General appraisal of site

Before starting the detailed inspection of the bridge components, the engineer should first check that it is the right structure. It is surprisingly easy to confuse similar looking bridges with one another.

Having established the identity of the bridge the details from the bridge inventory record should be checked. This will help in understanding the structural principles of the bridge - particularly in relation to how movement is accommodated - and will assist in completing the rest of the inspection forms. Some guidance on the different types of bridges is given in Appendix A.

It is essential at this stage to make sure of the orientation of the bridge, identify which way is north, and the direction of flow of the river.

4.3 The detailed inspection

After completing this preparatory work the detailed inspection of the bridge can start. Each part of the bridge must be inspected thoroughly and its condition recorded using the appropriate inspection report forms which are included in Appendix C. These provide a check list of items to be inspected as well as a standard method of reporting the findings. The condition rating system is explained in Section 5.2 and guidance on some of the defects to be found in bridges is given in Appendix B.

It is essential to fill in the forms at the time of inspection. They should never be filled in afterwards. Additional notes or sketches may be made on the backs of the forms if required.

Sketches should be made to illustrate the location of any defects which are identified. These sketches will be freehand but should be roughly to scale.

Although the inspection is essentially a visual exercise, it may sometimes be useful to take measurements. Examples of these are measurements of crack widths in concrete and of out-of-plumb dimensions in columns.

Occasionally it can be useful to collect samples of items such as broken concrete, corrosion products or paint flakes.

The condition of any previous maintenance or repair work should be carefully examined and reported. This is important as it provides guidance on the most effective materials and techniques to be used for future repair work.

It is important to record the weather conditions at the time of the inspection. Some defects such as leaking joints or defective drainage are much easier to identify in wet weather, whereas narrow cracks in most materials are easier to see when it is dry.

Photographs should be taken to supplement the completed forms as they provide a useful permanent record of the inspector's observations. A general view will help to confirm the identity of the structure, and specific views should be taken of major defects.

Where the inspector identifies the need for maintenance or repair work to be carried out it is useful to make an estimate of the approximate quantity of work involved - for instance the volume of gabions required for abutment protection work - so that budget cost estimates can be prepared.

For Principal and Special Inspections the inspection and reporting format are increasingly detailed. Ratings are attributed to each element on the structure and reporting is comprehensive.

5.0 REPORTING

5.1 Terminology

It is important that the same terminology is used by all bridge inspectors, and guidance on this is given in Appendix A. In particular it should be noted that the left and right banks of the river (and hence the left and right abutments) are defined when looking downstream. Spans and piers should be numbered sequentially starting from the left bank.

5.2 Inspection Report Forms

It is important that a uniform system of reporting the results of the inspections is used, and standard forms have been developed for this purpose. These are reproduced in Appendix C for all types of inspection.

The forms for Routine, and Principal Inspections are divided into the following categories:-

Identification and General details

Ancillary Works	1.	Approach roads, embankment & drainage
	2.	Bridge deck surface, drainage & footpath
	3.	Parapets and signs
	4.	Joints
Superstructure	5.	Reinforced concrete deck
		Steel composite deck
		Steel truss deck
		Timber deck
		Masonry arch and jack arch decks
		Bailey Bridges
	6	Bearings
Substructure	7.	Abutments, wing walls and retaining walls
	8.	Piers
Training Works	9.	Bridge protection works
	10.	River training
Other	11.	Culverts

Summary sheet

Routine Inspection Report Forms (3 No.) are an abbreviated version of those used for Principal Inspections (15 No.) In addition, the 'Identification and General Details' and the 'Bridge Inspection Summary' forms are common to both routine and principal inspections.

The Bridge Identification form should be filled in before going to site with the relevant details from the Bridge Inventory record card. The details are then checked and confirmed (or otherwise amended) on site.

With Routine and Principal Inspections each of the main forms contains three boxes to be completed to describe the condition of the bridge:-

Condition This describes the condition of the particular element on a sliding scale from 0 (no defect) to 4 (severely damaged).

Extent This describes the extent of the damage or deterioration on a sliding scale from 0 (no part of the element affected) to 4 (virtually all of the area affected).

Urgency This indicates the urgency with which any remedial work should be undertaken.

The first column on the left side of each inspection form gives a cross reference to Overseas Road Note 7 Vol.2 - Bridge Inspector's Handbook (the "Blue Book") - where guidance is given on inspection for that particular element or component of the structure. The reference number tells you which page to look at in Part [2] of the "Blue Book". Further information about bridge defects is given in Appendix B.

The last column provides a space for any sketches or notes which the inspector considers necessary to explain his observations.

The Summary Sheet, which will appear in front of the inspection forms in the Inspection Report, is intended to summarise the inspection by providing an overview on a single sheet of the condition of each part of the structure. It will also summarise the recommended repair work and give an approximate cost.

The Divisional Engineer will use the information summarised on this form to assess the maintenance priorities for his division.

The Report for Superficial Inspections is a single form on which is entered general bridge data and a description of the problem. There is an action checklist on the form.

Special Inspections may use either the Superficial Form or all or parts of the Principal Inspection Forms.

With all the forms supplementary information is often called for. This may be a written description, photograph or sketch, specialist assessment report or test results.

5.3 Condition rating

The rating system to be used when filling in the inspection forms is as follows.

(a) Condition Rating

Condition Rating	Condition
4	Serious condition with severe damage. The element or component is not functioning as designed.
3	Poor condition The element or component shows numerous defects of structural significance which may soon prevent it from functioning as designed.
2	Below average. The element or component shows local defects of structural significance but functions as designed.
1	Fair condition. The element or component shows a few non-structural defects.
0	Good condition with no significant defects.
N	Not applicable, or element not accessible for inspection.

Where parts of the bridge are not accesible for inspection - for instance bearings covered in debris - this fact should be noted in the comments column and the designation N used in the condition rating box. In such cases the extent and urgency ratings should be left blank.

(b) Extent Rating

Extent Rating	Area affected by Damage or Deterioration
4	Extensive, most or all of the element affected.
3	Major, highly significant, more than 20% of the element affected
2	Significant, 5% to 20% of length or area of the element affected
1	Minor, less than 5% of length or area of the element affected
0	No defect or insignificant length or area of the element affected

(c) Urgency Rating

Urgency Rating	Time to execute remedial works
4	Immediate attention required.
3	Attention required within 6 months (generally before the monsoon or in the present fiscal year).
2	Attention required within year.
1	Non-urgent, attention required within 2 years.
0	No time limit for action.

A series of tables giving guidance on the condition rating is included in Appendix D. When in doubt the inspector should try to decide to what extent the element or component concerned is functioning as intended, in order to place it at the appropriate place on the sliding scale.

5.4 Recommendations for remedial work.

The inspecting engineer should note any requirements for further action. These will include:-

(i) Minor or routine maintenance items such as clearing of blocked drains, removal of flood debris, repairs to gabion protection, etc. A note of the approximate quantities involved will assist later in the preparation of cost estimates.

(ii) Serious or potentially serious problems requiring major repair work or further investigation. This would include investigation of serious cracks in concrete, settlement or scour damage etc. In the case of Routine or Superficial Inspections undertaken by the division, the Divisional Engineer will decide whether to seek further advice on these matters.

(iii) Where the safety of the bridge is in question, the inspector should inform the Divisional Engineer as a matter of urgency so that appropriate measures to ensure public safety - eg, load restrictions or closure of the bridge - can be put in hand.

5.5 Submission of the Reports.

The Superficial and Routine Inspection Reports will be submitted to the Divisional Engineer, who will forward one copy to the Regional Director and one copy to the Bridge Unit. The information from the reports will enable the Department to monitor the condition of the bridges in all divisions, and to allocate funds to enable each Division to undertake any necessary work on its bridges. The Divisional Engineeer will use the information given in the reports to determine the maintenance level on the bridge stock within the Division.

Special and Principal Inspection Reports are sent to the Divisional Engineer for any necessary action. Where there are serious problems the reports will indicate exactly what aspects are to be referred for action by others. The routine maintenance aspects always remain the responsibility of the Division, unless specifically adopted by a Project.

REFERENCES

The following references give guidance on how to undertake bridge inspections, the many types of defect which can affect bridges and on testing.

1. ORN7 Vol. 1 A guide to bridge inspection and data systems for district engineers (TRL 1988).
2. ORN7 Vol.2 Bridge Inspector's Handbook (TRL 1988). ("The Blue Book")
3. Bridge Inspection Guide (HMSO 1983). ("The Yellow Book")
4. BA63/94 Inspection of Highway Structures, Advice Note (UK Highways Agency, 1994).
5. Manual for maintenance inspection of bridges, (AASHTO, 1983).
6. Manual for Bridge Maintenance, (AASHTO, 1987).
7. Guidelines for inspection and maintenance of bridges, Indian Roads Congress Special Publication 35 (IRC, New Delhi, 1990).
8. Concrete Society Technical Report No.22 (1992).
9. BE13 Fatigue Risk in Bailey Bridges (UK Department of Transport).
10. British Standard 4408. Recommendations for non-destructive methods of testing for concrete.

    Part 1. Electromagnetic cover measuring devices

    Part 3. Gamma radiography for concrete

    Part 4. Surface hardness methods

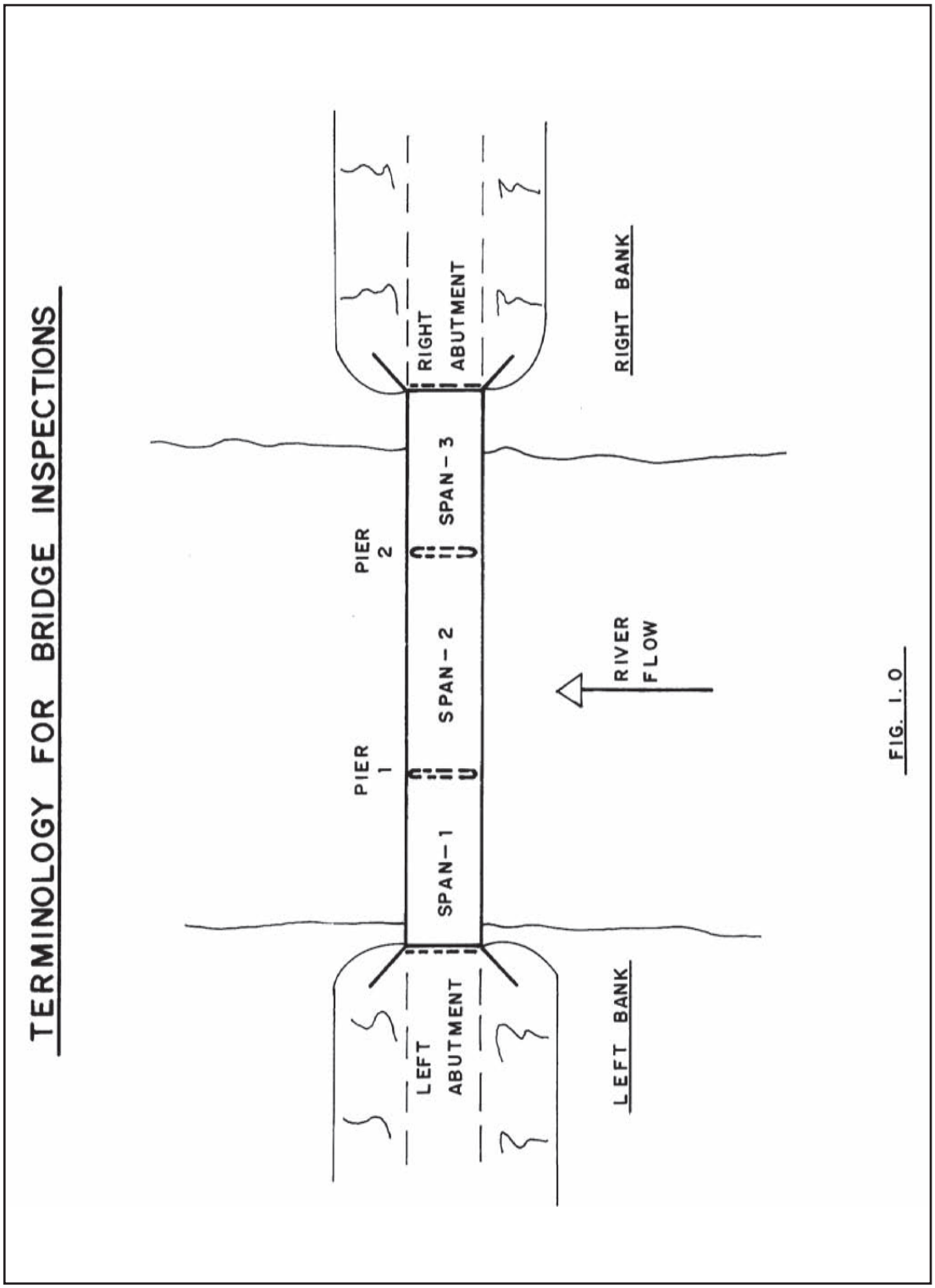
    Part 5. Measurement of the velocity of an ultrasonic pulse in concrete
11. British Standard 1881. Methods of testing concrete

    Part 4. Methods of testing concrete for strength

    Part 6. Analysis of hardened concrete
12. British Standard 4416:1969. Methods of penetrant testing of welded or brazed joints in metals
13. British Standard 4379. Methods magnetic particle testing of welds
14. British Standard 3923. Methods for ultrasonic examination of welds
15. British Standard 4379. Methods magnetic particle testing of welds

APPENDIX A

FEATURES OF BRIDGES


TERMINOLOGY FOR BRIDGE INSPECTIONS
LEFT ABUTMENT
PIER 1
PIER 2
RIGHT ABUTMENT
SPAN – 1
SPAN – 2
SPAN – 3
RIVER FLOW
LEFT BANK
RIGHT BANK
FIG. 1.0

TYPES OF BRIDGES

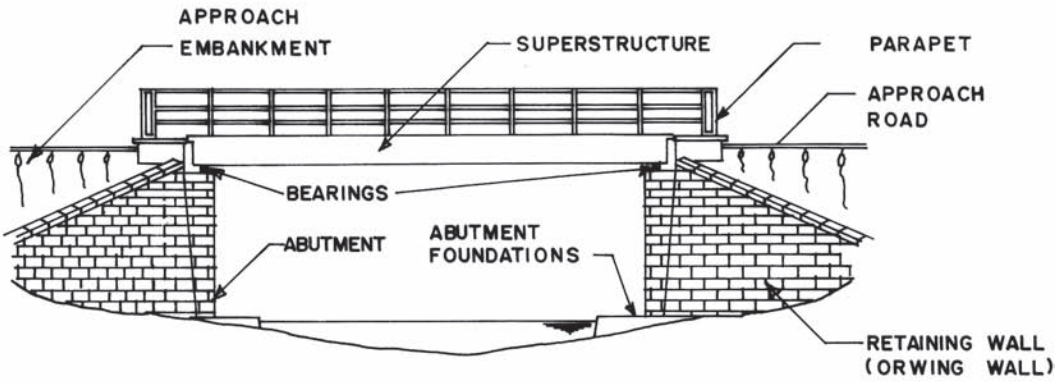


FIG.2.1 SINGLE SPAN BRIDGE

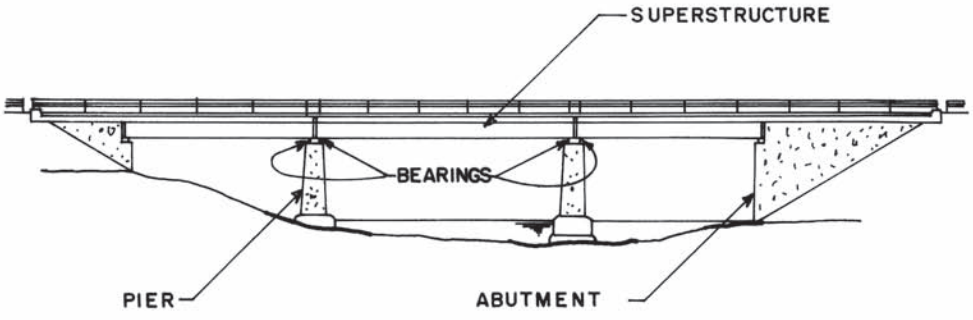


FIG.2.2 MULTI-SPAN SIMPLY SUPPORTED BRIDGE

TYPES OF BRIDGES

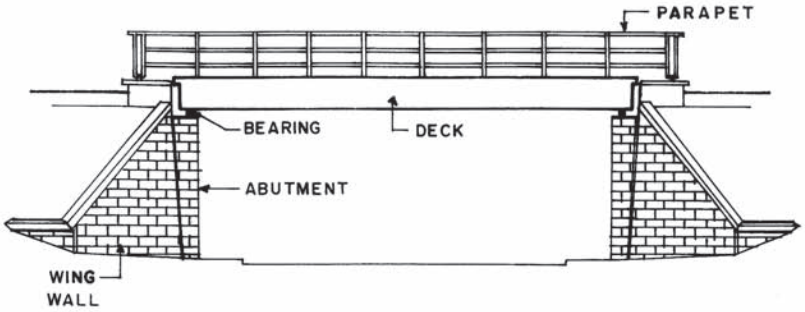


FIG. 2.3 SIMPLY SUPPORTED CONSTRUCTION

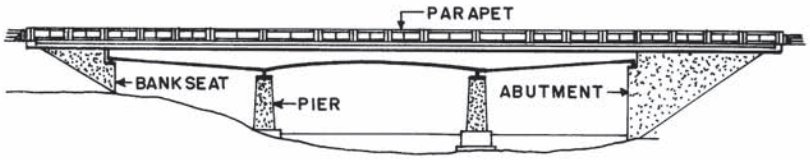


FIG. 2.4 CONTINUOUS CONSTRUCTION

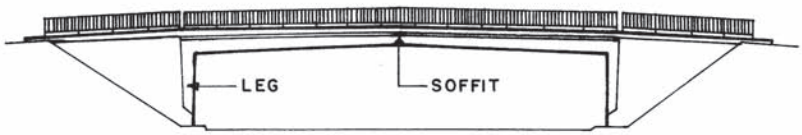


FIG. 2.5 PORTAL FRAME

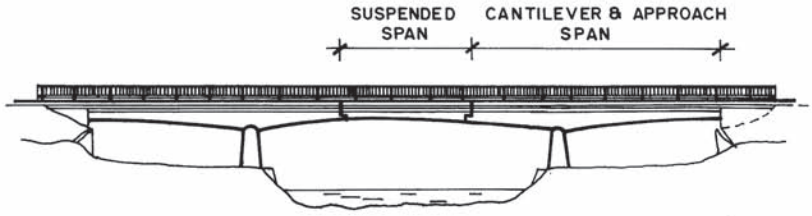


FIG. 2.6 CANTILEVER & SUSPENDED SPAN

TYPES OF BRIDGES

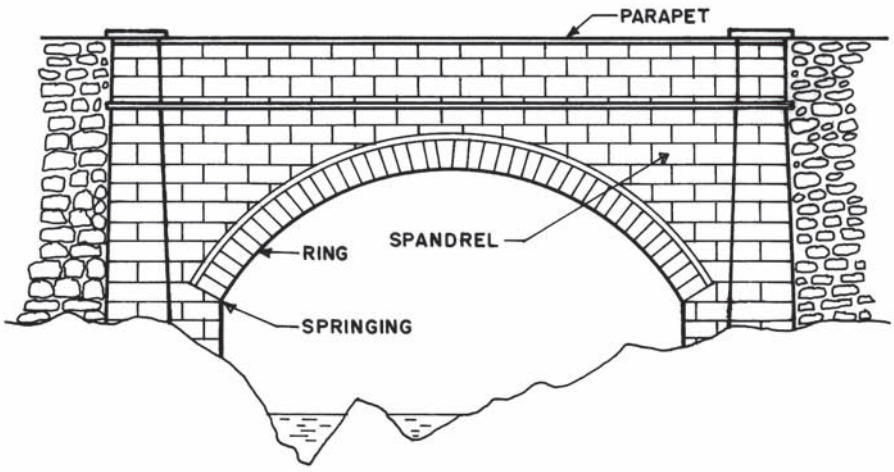


FIG. 2.7 ARCH

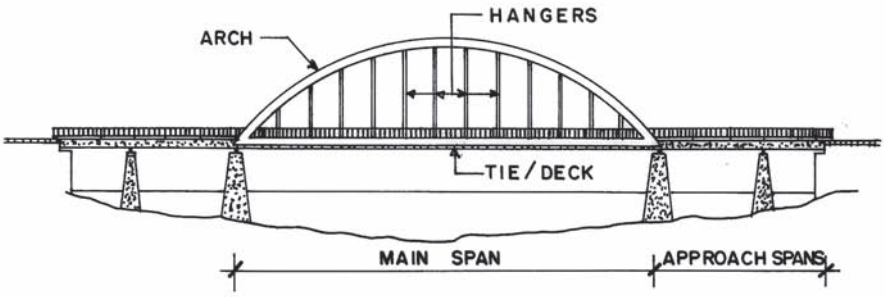


FIG. 2.8 TIED ARCH

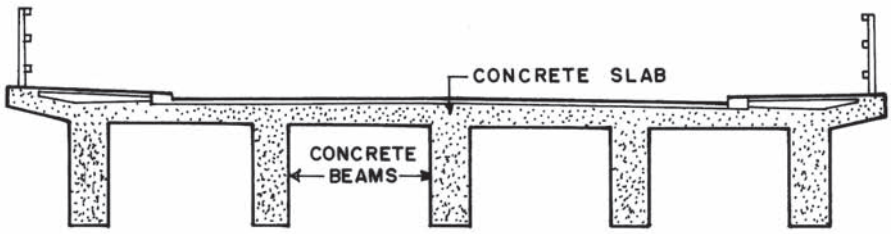


FIG. 2.9 BEAM AND SLAB CONSTRUCTION

TYPES OF BRIDGES

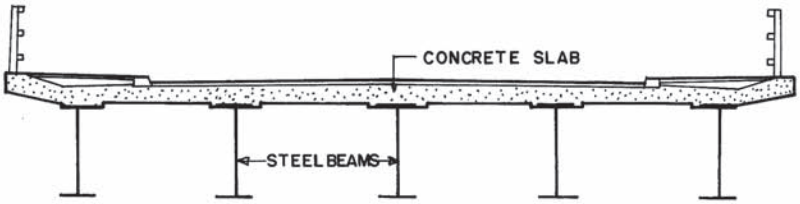


FIG. 2.10 **COMPOSITE CONSTRUCTION**

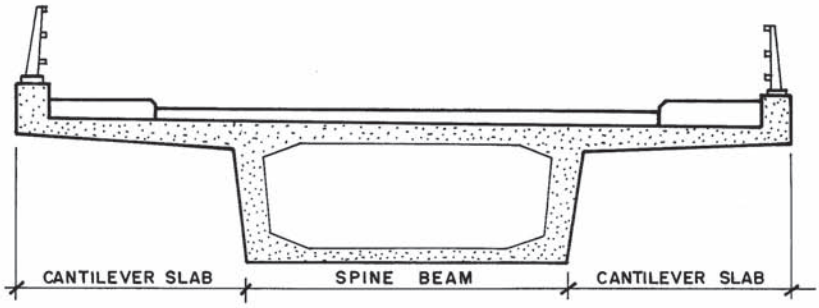


FIG.2.11 **SPINE BEAM CONSTRUCTION**

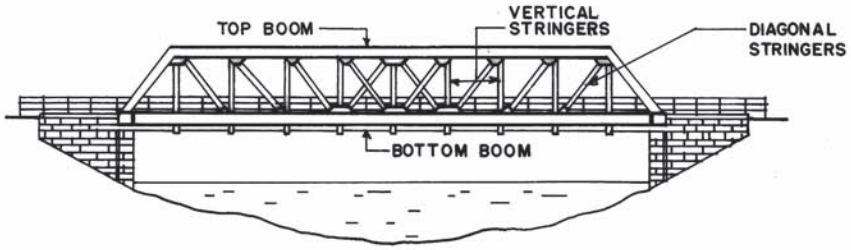


FIG.2.12 **TRUSS BRIDGE**

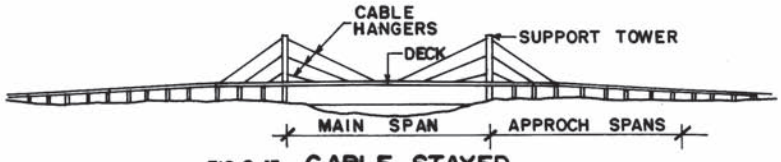


FIG.2.13 **CABLE STAYED**

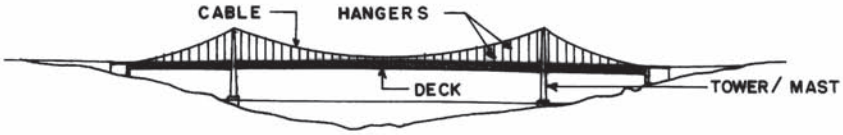


FIG.2.14 **SUSPENSION BRIDGE**

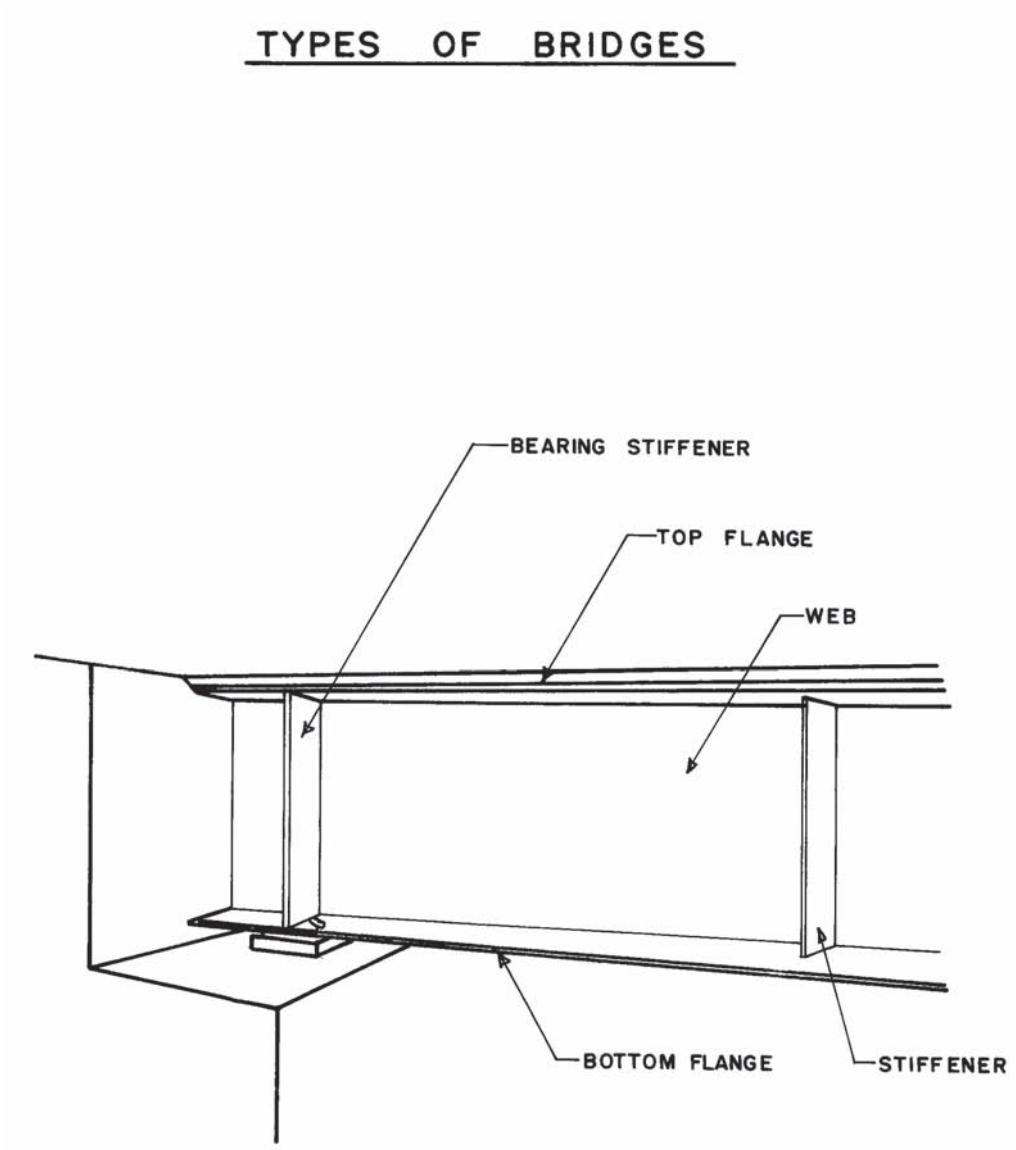


FIG. 2.15 STEEL GIRDERS AND BRACINGS

BAILEY BRIDGES

The drawing below shows most of the parts of a typical Bailey bridge and gives their names. Not all Bailey bridges are exactly like this.

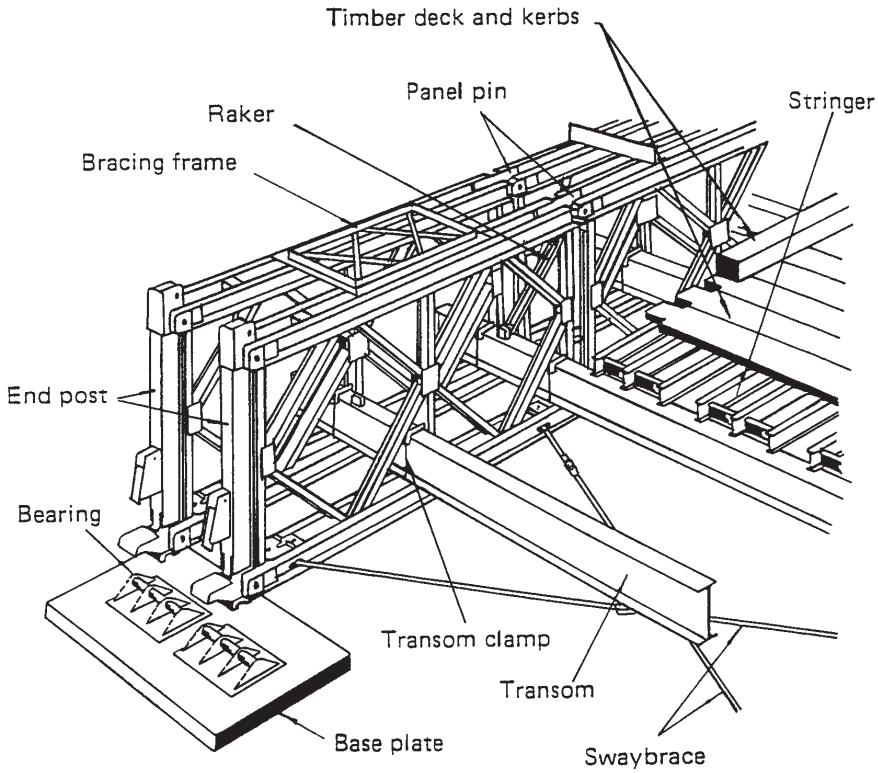


FIG. 3.0 TYPICAL DETAILS

ABUTMENTS, PIERS, WING WALLS & RETAINING WALLS

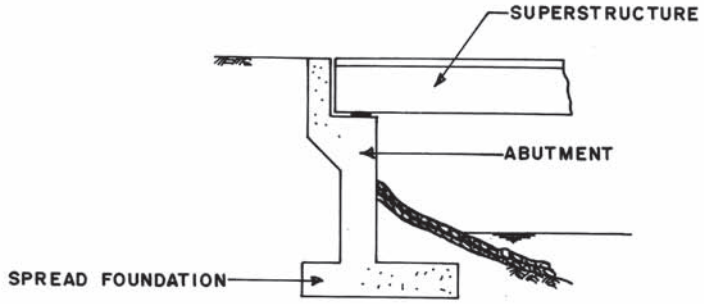


FIG. 4.1 ABUTMENT ON SPREAD FOUNDATION

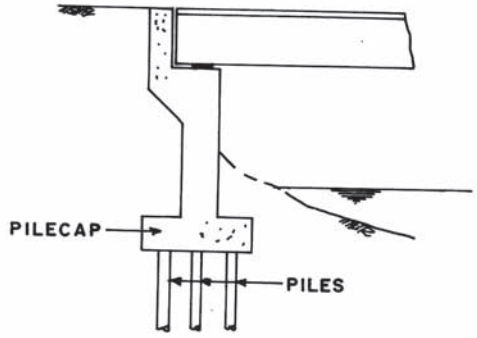


FIG.4.2 ABUTMENT ON PILES

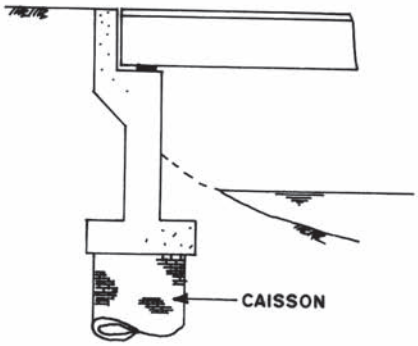


FIG.4.3 ABUTMENT ON CAISSON

ABUTMENTS, PIERS, WING WALLS & RETAINING WALLS

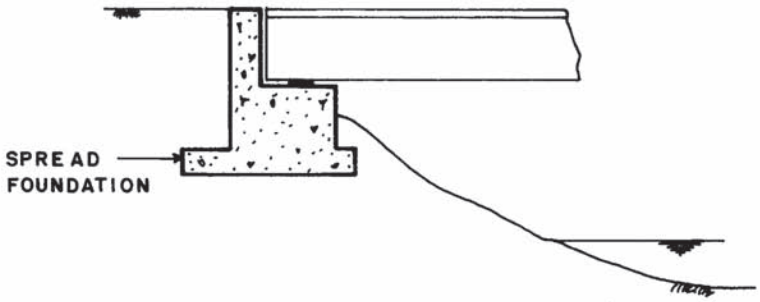


FIG. 4.4 BANK SEAT ABUTMENT ON SPREAD FOUNDATION

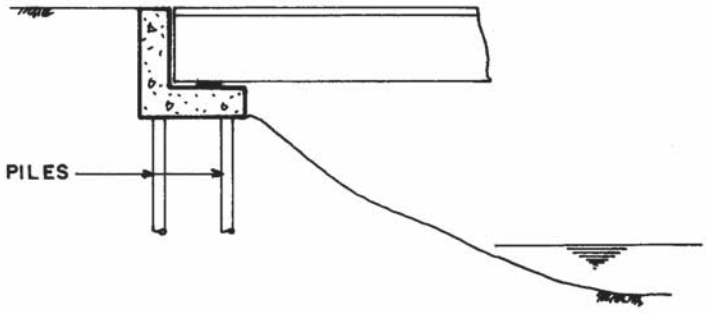


FIG. 4.5 BANK SEAT ABUTMENT ON PILES

ABUTMENTS, PIERS, WING WALLS & RETAINING WALLS

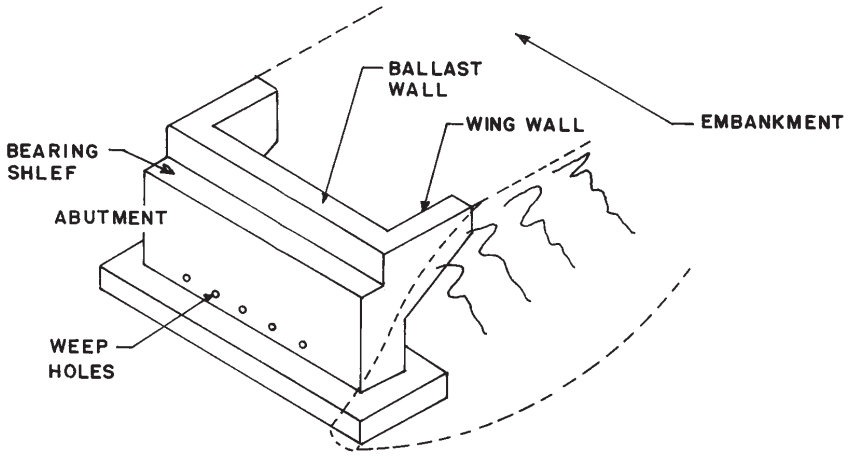


FIG. 4.6

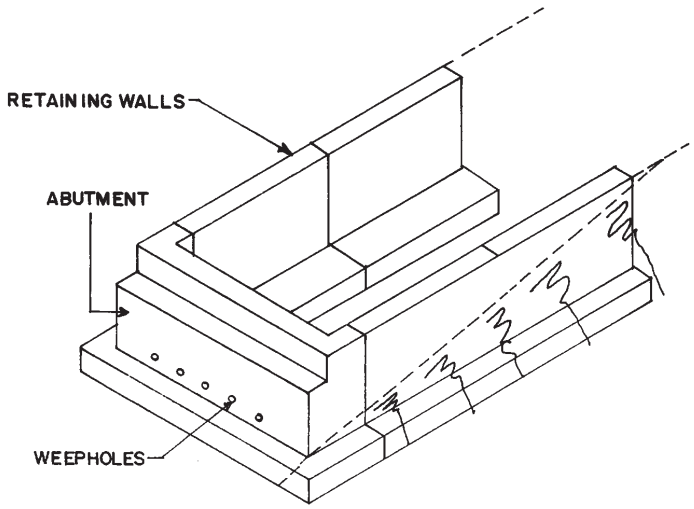


FIG. 4.7

ABUTMENTS, PIERS, WING WALLS & RETAINING WALLS

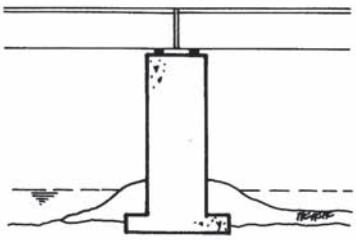


FIG. 4.8 CONCRETE PIER ON SPREAD FOUNDATION

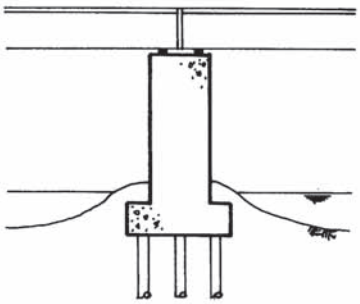


FIG. 4.9 CONCRETE PIER ON PILES

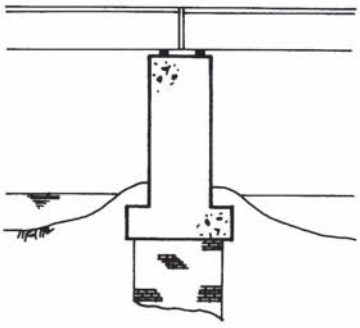


FIG. 4.10 CONCRETE PIER ON CAISSON

APPENDIX B

TYPICAL BRIDGE DEFECTS

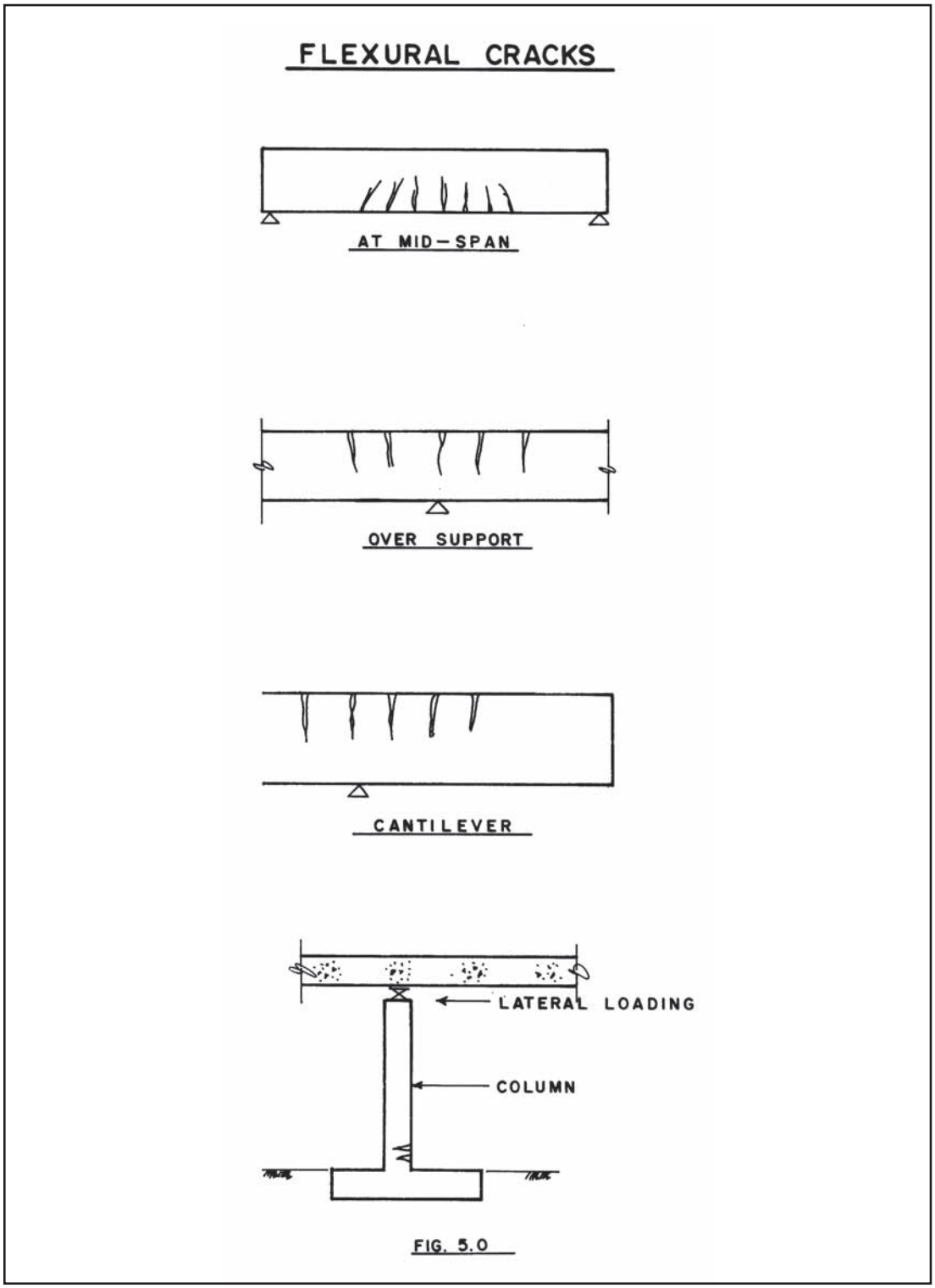
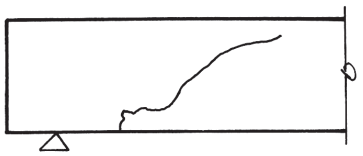

FLEXURAL CRACKS
AT MID-SPAN
OVER SUPPORT
CANTILEVER
LATERAL LOADING
COLUMN

FIG. 5.0

SHEAR CRACKS



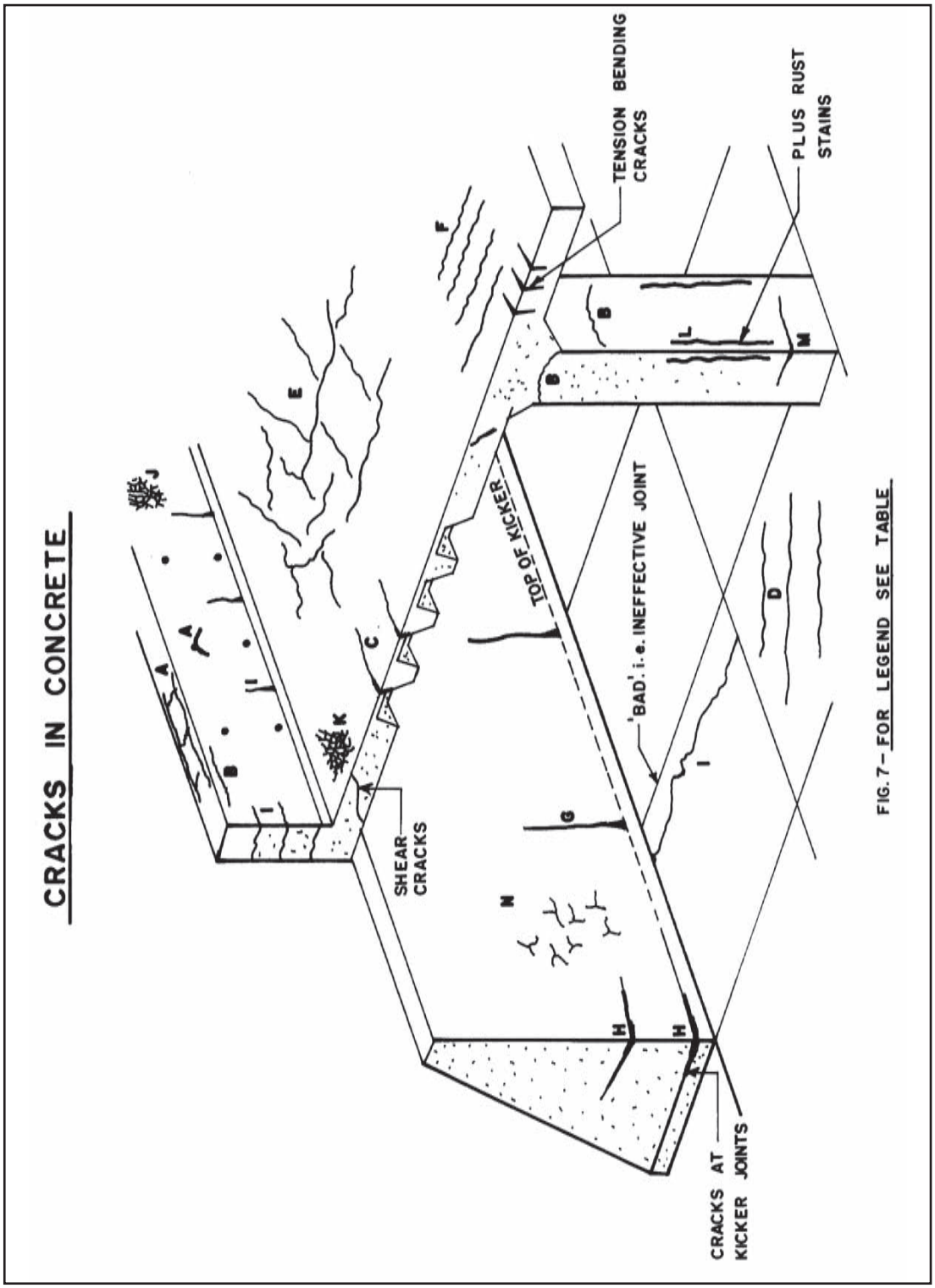


FIG. 7 – FOR LEGEND SEE TABLE

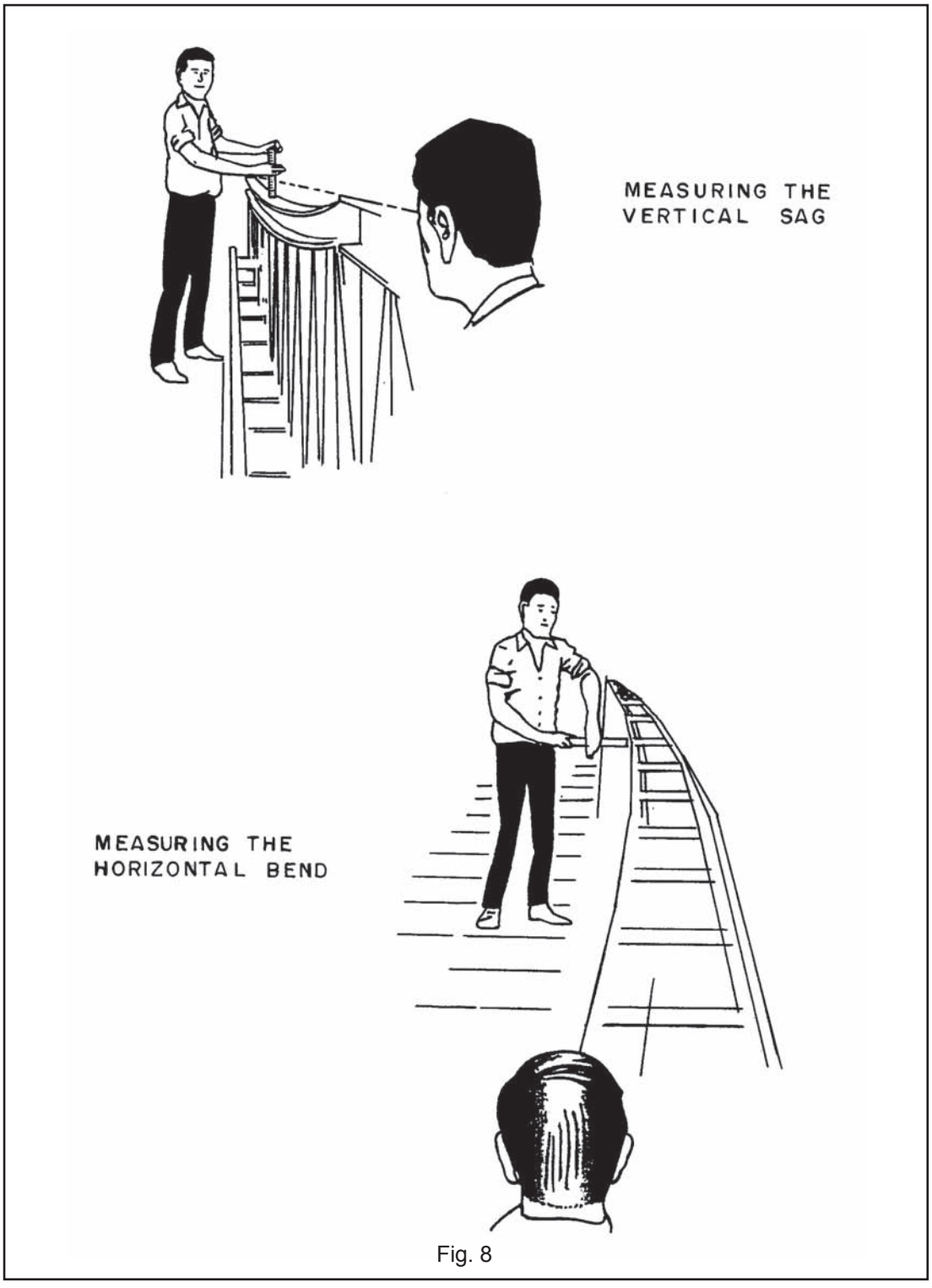
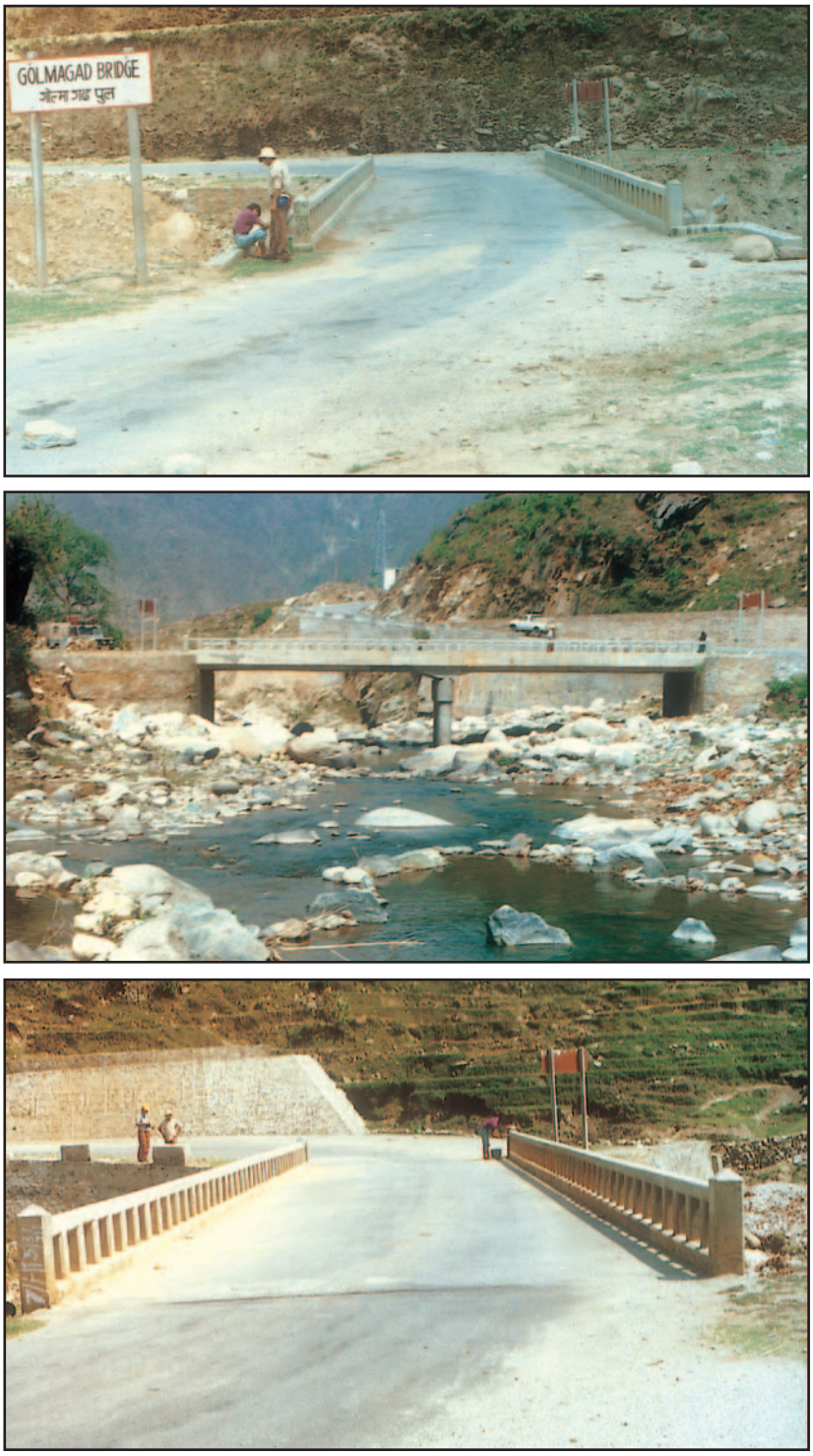


Fig. 8

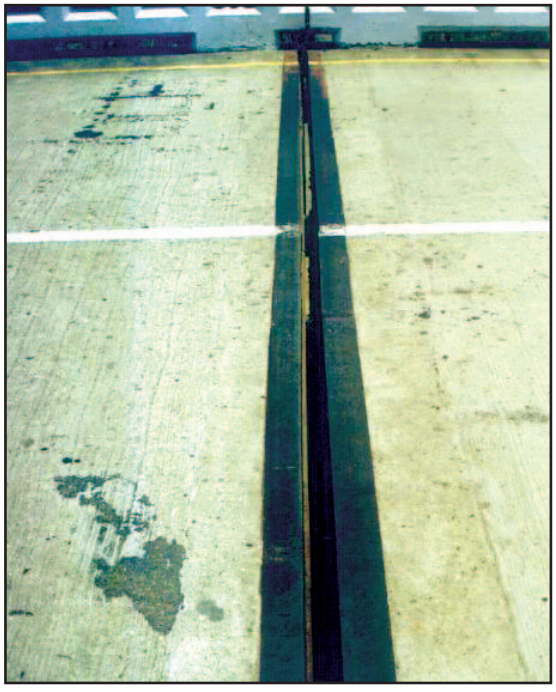


Fairly maintained Bridge signs, substructures and superstructures

Properly maintained bearings and bearing shelves

Bearings and bearing shelves should be cleaned free of debris and vegetations


Expansion joints needed for reporting and awaiting repair




Adequately maintained Expansion joints

Drainage holes should be always clean as above

Waterway needs to be cleared, this shall be reported to Division Chief

Fairly maintained waterway

EXTRACT FROM GONCRETE SOCIETY TECHNICAL REPORT NO 22

Non structural cracks in concrete

Type of cracking	See letters in fig. 7	Subdivision	Most common location	Primary cause (excluding resiraunt)	Secondary causes/factors	Remedy (Assuming basic redesian is impossible in all cases reduce resitraint)	Time of appearance
Plastic settlement	A	Over reinforcement	Deep section	Excess bleeding	Rapid early grying conditions	Reduce bleeding(air entrainment) or revibrate	Ten minutes to three hours
	B	Arching	Top of columns				
	C	Change of depth	Trough and wattle slabs				
Plastic shrinkage	D	Diogonal	Roads and slabs	Rapid early drying	Low rate of bleeding	Improve early curing	Thirty minutes to six hours
	E	Random	Rreinforced concrete slabs				
	F	Over reinforcement	Rreinforced concrete slabs	Diffo plus steel near surface			
Early thermal contraction	G	External restraint	Thick walls	Excess heat generation	Rapid cooling	Reduce heat and /or insulate	One day to two or three weeks
	H	Internal restraint	Thick slabs	Excess temperature gradients			
Long term drying shrinkage	I		Thin slabs (and walls)	Inefficient joints	Excess shrinkage insufficient curing	Reduce water content improve curing	Several weeks or months
Crazing	J	Against formwork	Fair faced concrete	Impermeable formwork	Rich mixes poor curing	Improve curing and finishing	One to seven days, sometimes much later
	K	Floated concrete	Slabs	Over trowelling			
Corrosion of reinforcement	L	Natural	Columns and beams	Lack of cover	Poor quality concrete	Eliminate causes listed	More than two years
	M	Calcium chioride	Precast concrete	Excess calcium chloride			
Aika-liaggregate reaction	N		(Damo locations)	Reactive aggregate plus high-aikali cement		Eliminate causes listed	More than five years

APPENDIX C

INSPECTION FORMS

CONTENTS

Items 1 and 2 are always used with Items 4 and 5.

BRIDGE INSPECTION REPORT FORM

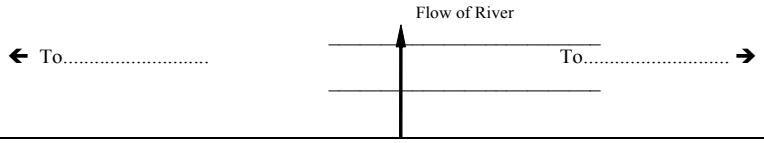
BRIDGE IDENTIFICATION

Bridge Number	Name
Division	Road Link Identification

BRIDGE DESCRIPTION

No' of Spans x length			m	Total length	m
Carriageway width	m	Footpath width	m	Overall width	m
Posted load restriction	tonnes	Height restriction			m

DIAGRAMMATIC SKETCH



INSTRUCTIONS FROM ENGINEER

NOTES FROM INSPECTOR

Inspector:	No. of pages in this report:	Date:

WEATHER:

CONSTRUCTION DETAILS (from the inventory)	Correct	
	Yes	No
Span		
Running surface		
Deck		
Pier(s)		
Abutments		
Foundation type		
Articulation		

Services	Details of services on bridge card	Services still there?		Services Damaged?	
		Yes	No	Yes	No
Telephone					
Electricity					
Watermain					
Others					

Details of signs on bridge card	Sign still there?		Sign damaged?		Notes
	Yes	No	Yes	No	

Comments:

BRIDGE INSPECTION SUMMARY

BRIDGE IDENTIFICAITON	
Bridge Number:	Name:
District	Road Link Identification:

INSPECTION SUMMARY	
Date of Inspection: Inspection Type:	Inspected By: Division:

INSPECTION SUMMARY					
Item	Description	Condition	Extent	Urgency	Comments
1	Approach road, embankments, drainage				
2	Bridge deck surface, drainage and footpath				
3	Parapet, railing and guardrail				
4	Expansion joints				
5	Deck				
6	Bearings				
7	Abutment				
8	Pier				
9	Bridge protection works				
10	River training				

RECOMMENDATIONS FOR REMEDIAL WORK

Signed …….. Date ……..

Superficial Bridge Inspection Report

Division:	District:	Road:

Bridge Number:	Bridge Name:	Reported by:	Date:

Description of Problem

ACTION CHECKLIST

Action by Division	Yes/No	Action Officer	Details
Further Inspection			
Urgent Work			
Routine Work			
Repair Estimate*			
Repair Completed			
Request Bridge Unit support			

*Please attach estimate

Divisional Engineer: ..... **Date:** .....

Notes and Special Instructions:

ORN7 H 'BOOK PG. NO.'	ROUTINE INSPECTION MAINTENANCE REPORT	Condition	Extnt	urgency	Remarks, Sketch Reference No. Bridge No. ..... Page No. ..... of .....
	ANCILLARY WORKS				
	1. APPROACH ROAD EMBANKMENT & DRAINAGE				
15	Approach road embankment				
16	Approach Road drainge				
	2. BRIDGE DECK SURGACE. DRAINAGE & FOOTHPATH				
16	Bridge deck drainage				
19	Bitumen Surface				
20	Concrete surface				
22	Steel surface				
24	Timber surface				
25	Timber running strips				
26	Footpath				
27	**3. PARAPET, RAILING, GAURD-RAIL AND SIGN**				
28	Metallic parapet				
29.	Corcrete parapet				
30	Timber parapet				
31	Masonry parapet				
26	footpath				
32	**4. JOINTS**				
32	Joint (left abutment)				
	Joint (at pier No. .....)				
	Joint (at pier No. .....)				
	Joint (at pier No. .....)				
	Joint (Right abutment)				

ORN7 H 'BOOK PG. NO.'	ROUTINE INSPECTION MAINTENANCE REPORT	Condition	Extnt	urgency	Remarks, Sketch Reference No. Bridge No. ..... Page No. ..... of ..... Span No. ..... of .....
	SUPERSTRUCTURE				
	5. RENFORCED CONCRETE DECK				
42	General surface condition of underside				
44	Concrete beam				
59	Concrete slab soffit				
	5. STEEL COMPOSITE DECK				
42	General surface condition of underside				
47	Steel girders and bracing				
59	Concrete slab soffit				
	5. STEEL TRUSS AND DECK				
42	General surface condition of underside				
50	Steel truss members				
59	Concrete slab soffit				
60	Steel deck				
61	Timber deck				
	5. TIMBER DECK				
42	General surface condition of underside				
53	Timber beams				
56	Timber trusses				
61	Timber deck				
	5. MASONRY ARCH AND JACK ARCH DECKS				
42	General surface condition of underside				
44	Concrete beam				
47	Steel girders and bracing				
63	Concrete/masonry jack arch decks				
70	arches				
	5. BAILEY BRIDGES				
42	General surface condition of underside				
60	Steel deck soffit				
61	Timber deck soffit				
75	Bailey bridge trusses				
	6. BEARINGS				
64	General condition				
66	Elastomeric bearings				
67	Metal bearing				
69	Earthquake restrints				
	Speical bearings				

ORN7 H 'BOOK PG. NO.'	ROUTINE INSPECTION MAINTENANCE REPORT	Condition	Extnt	urgency	Remarks, Sketch Reference No. Bridge No. ..... Page No. ..... of ..... Span No. ..... of .....
SUB STRUCTURE					
7. ABUTMENTS, WINGWALLS AND RETAINING WALLS					
82	General condition				
87	Drainage system				
89	Concrete abutments, Wing/retaing walls				
91	Masonry abutments, Wing/retaing walls				
93	Gabion abutments, Wing/retaing walls				
94	Timher abutements, Wing/retaing walls				
8. PIERS					
110	General Condition				
113	Concrete piers				
114	Masonry piers				
116	Steel piers				
117	Timber pires				
TRAINING WORKS					
9. BRIDGE PROTECTION WORKS					
96	Embarnkment and fill				
99	Piled walls				
100	Stone nitching slone protection				
102	Gobion slope protection				
104	Rin-ran slone protection				
105	Bed protection				
106	Stone pitching, concrete bed protection				
109	Rip rap bed protection				
10. RIVER TRAINING CHANNEL CONTROL					
34	Blockage in waterway				
39	River Bank Protection				
37	Change of river pathe				
	Other				
11. CULVERTS (Also use other bridge inspection forms as required)					
119	General				
121	Concrete culvert barrel				
122	Corrugated metal pipe culverts (CMP)				
123	Culvert aprons				
124	Headwalls				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**Condition**	**Extent**	**Urgency**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	ANCILLARY WORKS				
	1. APPROACH ROAD EMBANKMENT & DRAINAGE				
15	Bumpy road surface ?				
	Erosion on approach embankment ?				
16	Badly built road drainage near bridge ?				
16	Blocked or damaged road drains ?				
	2. BRIDGE DECK SURFACE, DRAINAGE & FOOTPATH				
16	**BRIDGE DECK DRAINAGE**				
	Water on the deck ?				
	Blocked or damaged deck drains ?				
19	**BITUMEN SURFACE**				
	Surface breaking up or lifting off ?				
	Cracking above joints ?				
20	**CONCRETE SURFACE**				
	Cracking ?				
	Spalling ?				
	Reinforcement exposed ?				
	Poor concrete ?				
	Wear of surface?				
22	**STEEL SURFACE**				
	Fixings loose or damaged ?				
	Bends in panels and/or sections?				
	Corrosion ?				
24	**TIMBER SURFACE**				
	Dirt or plants between boards ?				
	Decay ?				
	Insect attack ?				
	Splitting of timbers ?				
	Loose or damaged fixings ?				
25	**TIMBER RUNNING STRIPS**				
	Damage to running strips ?				
	Loose or damaged fixings ?				
26	**FOOTPATH**				
	Damaged footpath, damaged or loose kerbs?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C o n d i t i o n**	**E x t e n t**	**U r g e n c y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	ANCILLARY WORKS				
27	**3. PARAPET, RAILING , GUARD-RAIL AND SIGNS**				
	Impact damage ?				
	Loose or damaged fixings ?				
	Loose post base ?				
28	**METALLIC PARAPET**				
	Damaged galvanising or paint ?				
	Corrosion ?				
29	**CONCRETE PARAPET**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
30	**TIMBER PARAPET**				
	Decay ?				
	Insect attack ?				
	Splitting of timbers ?				
31	**MASONRY PARAPET**				
	Cracking ?				
	Movement or bending of parapet ?				
	Poor pointing ?				
	Deterioration of the bricks or stonework ?				
	BRIDGE SIGNS				
	Bridge identification ?				
	Post damaged ?				
	Signboard damaged ?				
	Signboard unreadable ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**Condition**	**Extent**	**Urgency**	**Remarks, Sketch Reference No.** **Bridge No. ....** **Page No........of.........**
	ANCILLARY WORKS				
32	**4. JOINT (at Left Abutment)**				
	Damage to concrete of deck end or ballast wall near joint ?				
	Debris or vegetation in joint ?				
	Loose or damaged fixings ?				
	Damage or corrosion to metal parts ?				
	Damage to rubber water-bars/sealant?				
32	**4. JOINT (at Pier No. ....)**				
	Damage to concrete of deck end or ballast wall near joint ?				
	Debris or vegetation in joint ?				
	Loose or damaged fixings ?				
	Damage or corrosion to metal parts ?				
	Damage to rubber water-bars/sealant?				
32	**4. JOINT (at Pier No. ....)**				
	Damage to concrete of deck end or ballast wall near joint ?				
	Debris or vegetation in joint ?				
	Loose or damaged fixings ?				
	Damage or corrosion to metal parts ?				
	Damage to rubber water-bars/sealant?				
32	**4. JOINT (at Pier No. ....)**				
	Damage to concrete of deck end or ballast wall near joint ?				
	Debris or vegetation in joint ?				
	Loose or damaged fixings ?				
	Damage or corrosion to metal parts ?				
	Damage to rubber water-bars/sealant?				
32	**JOINT (at Right Abutment)**				
	Damage to concrete of deck end or ballast wall near joint ?				
	Debris or vegetation in joint ?				
	Loose or damaged fixings ?				
	Damage or corrosion to metal parts ?				
	Damage to rubber water-bars/sealant?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C o n d i t i o n**	**E x t e n t**	**U r g e n c y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. REINFORCED CONCRETE DECK				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water coming through the deck ?				
	Water from the deck drainage flowing onto girders, trusses, beams or bracing ?				
	Water from damaged services flowing onto deck members				
	MAIN BEAMS, GIRDERS, TRUSSES AND BRACING				
44	**CONCRETE BEAMS**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
	Not enough cover to reinforcement?				
	UNDERSIDE OF DECK				
59	**CONCRETE**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
	Not enough cover to reinforcement?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. STEEL COMPOSITE DECK				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water coming through the deck ?				
	Water from the deck drainage flowing onto girders, trusses, beams or bracing ?				
	Water from damaged services flowing onto deck members				
	MAIN BEAMS, GIRDERS, TRUSSES AND BRACING				
47	**STEEL GIRDERS AND BRACING**				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in webs, flanges, stiffeners or bracing ?				
	Loose bolts or rivets ?				
	Cracking ?				
	UNDERSIDE OF DECK				
59	**CONCRETE**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
	Not enough cover to reinforcement?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. STEEL TRUSS DECK				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water coming through the deck ?				
	Water from the deck drainage flowing onto girders, trusses, beams or bracing ?				
	Water from damaged services onto member				
	MAIN BEAMS, GIRDERS, TRUSSES AND BRACING				
50	**STEEL TRUSSES**				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in truss members ?				
	Bent or damaged joints ?				
	Bent or damaged bracing ?				
	Loose bolts or rivets ?				
	Cracking of steel members ?				
	UNDERSIDE OF DECK				
59	**CONCRETE**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
	Not enough cover to reinforcement?				
60	**STEEL**				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in stringers or plates ?				
	Loose bolts or rivets ?				
	Cracking ?				
61	**TIMBER**				
	Decay ?				
	Insect attack ?				
	Split timbers ?				
	Loose or corroded bolts or pins ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. TIMBER DECK				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water coming through the deck ?				
	Water from the deck drainage flowing onto girders, trusses, beams or bracing ?				
	Water from damaged services onto member				
	MAIN BEAMS, GIRDERS, TRUSSES AND BRACING				
53	**TIMBER BEAMS**				
	Decay ?				
	Insect attack ?				
	Splitting of timbers ?				
	excessive deflection?				
	Loose / corroded nails, spikes or fix wires ?				
56	**TIMBER TRUSSES**				
	Decay ?				
	Insect attack ?				
	Splitting of timber ?				
	Loose deck to truss connection ?				
	Loose or corroded bolts or pins at joints ?				
	Bends in truss timbers ?				
	Damaged or corroded steel parts ?				
	UNDERSIDE OF DECK				
61	**TIMBER**				
	Decay ?				
	Insect attack ?				
	Split timbers ?				
	Loose or corroded bolts or pins ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. MASONRY ARCH AND JACK ARCH DECKS				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water coming through the deck ?				
	Water from the deck drainage flowing onto girders, trusses, beams or bracing ?				
	Water from damaged services onto member				
	UNDERSIDE OF DECK				
44	**CONCRETE BEAMS**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
	Not enough cover to reinforcement ?				
	Precast blocks damaged or deformed?				
47	**STEEL GIRDERS AND BRACING**				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in webs, flanges, stiffeners or bracing ?				
	Loose bolts or rivets ?				
	Cracking ?				
63	**CONCRETE/MASONRY JACK ARCH DECKS**				
	Change of shape of arch ?				
	Cracking or spalling ?				
	Poor pointing ?				
70	**ARCHES**				
	Change of shape of arch ?				
	Cracking of arch barrel ?				
	Cracking or bulging of spandrel walls ?				
	Spandrel walls separating from arch ?				
	Spalling of stones or bricks ?				
	Poor pointing ?				
	Water leaking through the arch ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**Condition**	**Extent**	**Urgency**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span No.....of.....**
	SUPERSTRUCTURE				
	5. BAILEY BRIDGES				
42	**GENERAL** (from below the deck - above and below for a through truss)				
	Impact damage to beams, girders, trusses or bracing or in joints ?				
	Debris or vegetation on beams, girders, trusses or bracing ?				
	Water from the deck drainage or services flowing onto deck members?				
	UNDERSIDE OF DECK				
60	**STEEL**				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in stringers or plates ?				
	Loose bolts?				
	Cracking ?				
61	**TIMBER**				
	Decay ?				
	Insect attack ?				
	Split timbers ?				
	Loose or corroded bolts or pins ?				
75	**BAILEY BRIDGE TRUSSES** (NB separate sheet required to show location of defects)				
	Missing safety pins ?				
	Missing panel pins ?				
	Missing or loose bolts ?				
	Missing rakers or tie plates ?				
	Missing or loose sway braces ?				
	Missing,, loose or damaged horizontal bracing frames ?				
	Missing or loose transom clamps ?				
	Wear at stringer or transom seating ?				
	Cracking ?				
	Bend in members ?				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Settlement of bearings ?				
	Damage to bearings or base plate ?				
	Maximum vertical sag ?				
	Maximum horizontal bend ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Span/Pier No.....of.....**
	6. BEARINGS				
64	**ALL BEARINGS**				
	Debris or vegetation around bearings ?				
	Bad drainage to bearing shelf ?				
	Not enough room for the bridge span to move ?				
	Bearing not seated properly ?				
	Bridge span not seated properly on bearing?				
	Damaged bedding mortar ?				
66	**ELASTOMERIC BEARINGS**				
	Splitting , tearing or cracking of elastomere ?				
	Damaged/loose bolts or pins at fixed bearings?				
67	**METAL BEARINGS**				
	Parts not seated properly ?				
	Parts not free to move ?				
	Problem with the lubrication system ?				
	Sliding surfaces damaged ?				
	Cracks or bends in metal parts ?				
	Corrosion of metal parts ?				
69	**EARTHQUAKE RESTRAINTS**				
	Damaged or loose earthquake restraints ?				
	OTHER				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	SUBSTRUCTURE				
	7. ABUTMENTS, WINGWALLS AND RETAINING WALLS				
82	**GENERAL**				
	Erosion or scour near abutment ?				
	Damage to caissons or piles ?				
	Movement of abutment ?				
	Debris against abutment ?				
	Vegetation growing on/in abutment ?				
	Scour near to retaining walls ?				
	Water leaking down through the expansion joint ?				
87	**DRAINAGE SYSTEM**				
	Not enough weepholes ?				
	Weepholes not working ?				
	Water leaking through the abutment ?				
89	**CONCRETE ABUTMENTS, WING WALLS AND RETAINING WALLS**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
91	**MASONRY ABUTMENTS AND RETAINING WALLS**				
	Cracking ?				
	Bulging ?				
	Poor pointing ?				
	Deterioration of bricks or stones ?				
93	**GABION ABUTMENTS AND RETAINING WALLS**				
	Settlement or bulging of gabions ?				
	Damage to gabion wires or ties ?				
94	**TIMBER ABUTMENTS AND RETAINING WALLS**				
	Decay ?				
	Insect attack ?				
	Splitting of timber ?				
	Loose or corroded binding cables ?				
	Loose or corroded fixing spikes ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....** **Pier No.....of.....**
	SUBSTRUCTURE				
	8. PIERS				
110	**GENERAL**				
	Scour near base of pier ?				
	Damage to caissons or piles ?				
	Movement of pier ?				
	Impact damage ?				
	Debris against pier ?				
	Vegetation growing on pier ?				
	Water leaking past expansion joint ?				
113	**CONCRETE PIERS**				
	Cracking ?				
	Spalling ?				
	Corrosion of reinforcement ?				
	Poor concrete ?				
114	**MASONRY PIERS**				
	Cracking ?				
	Poor pointing ?				
	Deterioration of masonry ?				
116	**STEEL PIERS**				
	Debris in joints ?				
	Deterioration of paint or galvanising ?				
	Corrosion ?				
	Bends in steel members or at joints ?				
	Loose bolts or rivets ?				
	Cracking ?				
117	**TIMBER PIERS**				
	Debris in joints ?				
	Decay ?				
	Insect attack ?				
	Splitting of timber ?				
	Loose bolts or pins at joints ?				
	Bends in pier timbers ?				
	Damaged or corroded steel parts ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**C** **o** **n** **d** **i** **t** **i** **o** **n**	**E** **x** **t** **e** **n** **t**	**U** **r** **g** **e** **n** **c** **y**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	TRAINING WORKS				
	9. BRIDGE PROTECTION WORKS				
96	**EMBANKMENT AND FILL**				
	Scour at base of slopes ?				
	Slip of fill ?				
	Erosion of fill ?				
	Cracking of road or embankment edge ?				
	Piping failure of fill ?				
99	**PILED WALLS**				
	Forward movement ?				
	Deterioration of piles ?				
100	**STONE PITCHING SLOPE PROTECTION**				
	Cracking ?				
	Poor pointing ?				
	Scour or erosion at edge ?				
	Pieces broken off ?				
102	**GABION SLOPE PROTECTION**				
	Too much movement of gabions ?				
	Damage to gabion wires or ties ?				
104	**RIP-RAP SLOPE PROTECTION**				
	Rip-rap being washed away ?				
	Bed settlement ?				
105	**BED PROTECTION**				
	Large holes in the river bed near /under bridge				
106	**STONE PITCHING OR CONCRETE BED PROTECTION AND APRONS**				
	Scour at edge ?				
	Cracking ?				
	Spalling or stones missing ?				
	Erosion of surface ?				
	Corrosion of reinforcement ?				
108	**GABION BED PROTECTION AND APRONS**				
	Gabion broken away from pier or abutment ?				
	Damage to gabion wires or ties ?				
109	**RIP-RAP BED PROTECTION**				
	Loss of rip-rap ?				
	Damage to checkdams ?				

ORN 7 H'book Pg No'	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**Condition**	**Extent**	**Urgency**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	TRAINING WORKS				
	10. RIVER TRAINING				
	CHANNEL CONTROL				
34	**BLOCKAGES IN WATERWAY**				
	Debris against piers or abutments ?				
	Remains of old bridges near to bridge ?				
	Fencing, road or buildings under bridge ?				
	Trees or bushes growing under bridge ?				
	Siltation?				
39	**RIVER BANK PROTECTION**				
	River attack beyond the upstream end of the river training works ?				
	Damage to sheet piled walls ?				
	Loss of rip-rap ?				
	Damage to gabion, timber, fencing etc. ?				
	Damage to groynes ?				
	Damage to trees ?				
37	**CHANGE OF RIVER PATH**				
	River changing path upstream from bridge				
	New islands forming upstream from bridge ?				
	OTHER				

ORN 7 H'book Pg No.	**PRINCIPAL INSPECTION** IN-DEPTH SURVEY, OR SPECIAL INSPECTION POSSIBLE PROBLEM	**Condition**	**Extent**	**Urgency**	**Remarks, Sketch Reference No.** **Bridge No. .....** **Page No.....of.....**
	11. CULVERTS (Also use other bridge inspection forms as required)				
119	**GENERAL**				
	Debris, vegetation etc. in or near culvert?				
	Settlement of parts of the culvert?				
	Scour at ends of the culvert or at edge of apron?				
121	**CONCRETE CULVERT BARRELS**				
	Cracking?				
	Spalling?				
	Corrosion of reinforcement?				
	Poor concrete?				
122	**CORRUGATED METAL PIPE CULVERTS (CMP)**				
	Change of shape of culvert barrel?				
	Damage or deterioration to paint or galvanising?				
	Corrosion of steel?				
	Loose, missing or corroded bolts?				
123	**CULVERT APRONS**				
	Cracking and damage to concrete or stone pitching?				
	Damage to gabion protection?				
124	**HEADWALLS**				
	Movement of headwall?				
	Concrete: cracking, spalling, corrosion of reinforcement or poor concrete?				
	Masonry: cracking, poor pointing or deterioration of bricks or stones?				

APPENDIX D

RATING GUIDE

Condition Rating	Condition
4	Serious condition with severe damage. The element or component is not functioning as designed.
3	Poor condition The element or component shows numerous defects of structural significance which may soon prevent it from functioning as designed.
2	Below average. The element or component shows local defects of structural significance but functions as designed.
1	Fair condition. The element or component shows a few non-structural defects.
0	Good condition with no significant defects.
N	Not applicable, or element not accessible for inspection.

Extent Rating	Area affected by Damage or Deterioration
4	Extensive, most or all of the element affected.
3	Major, highly significant, more than 20% of the element affected
2	Significant, 5% to 20% of length or area of the element affected
1	Minor, less than 5% of length or area of the element affected
0	No defect or insignificant length or area of the element affected

Urgency Rating	Time to execute remedial works
4	Immediate attention required.
3	Attention required within 6 months (generally before the monsoon or in the present fiscal year).
2	Attention required within year.
1	Non-urgent, attention required within 2 years.
0	No time limit for action.

Guide to condition rating

Item	Good 0	Fair 1	Below Average 2	Poor 3	Serious 4
ANCILLARY WORKS					
1	**Approach Roads, embankments, drainage**				
Road Surfacing	Sound. Little wear	Poor texture, some wear. Minor crazing, cracking, fretting	Very open textured. Slippery Small areas crazed, fretted. Average tracking	Large areas cracked or top layer missing. Heaved/subsided. Bad tracking. some potholes	Deep cracks/potholes. Complete break-up. Dangerous
Embankments	Sound. No deformation	Minor subsidence Minor deformation	Minor slip Settlement causing carriageway cracks	Major slip Major settlement	Critical slip or settlement
Drainage	Free draining	Drainage paths restricted by debris or vegetation. Slight ponding	Drainage paths blocked by debris or vegetation. Ponding	Poor crossfall with standing water. Water flows onto road with large areas of ponding Some rainwater scour	No drainage Road floods consistently with major loss of road and embankment material
2	**Bridge deck surface, drainage and footpath**				
Bridge deck surface	**Bitumen** Sound little wear	**Bitumen** Poor texture, some wear. Minor crazing, cracking, fretting. Slight cracking above joints	**Bitumen** Very open textured. Slippery Small areas crazed, fretted. Average tracking. Noticeable cracking above joints	**Bitumen** Large areas cracked or top layer missing. Heaved/subsided. Bad tracking. some potholes. Wide cracks above joints, break-up	**Bitumen** Deep cracks/potholes. Complete break-up. Dangerous. Broken up at joints
	Concrete: Minor weathering. No cracks or spalling	**Concrete:** Minor cracks or spalling, slight honeycombing	**Concrete:** Cracks easily seen, average spalling, Honeycombed. Minor deformation. Reinf't blown	**Concrete:** Major cracks and spalling. Major deformation and sagging. Reinf't exposed	**Concrete:** Disintegrating or collapsing
	Steel: Intact	**Steel:** Some fixings loose or missing	**Steel:** Fixings loose, missing and damages **Minor corrosion**	**Steel:** Major loss of fixings, panel loose, Deformation and corrosion	**Steel:** Panels loose, missing deformed broken or badly corroded
	Timber: Sound structurally with little wear	**Timber:** Minor section loss, rotting, shakes. Fixings rusting, some pultruding	**Timber:** Some section loss/rotten timber. Timber loose but safe. Minor deformation, fixings loose Timber shakes average	**Timber:** Significant section loss/rotten timber. Major shakes. Major deformation/sagging Timber loose and unsafe. Fixings missing.	**Timber:** Decking missing or disintegrating

Guide to condition rating

Item	Good 0	Fair 1	Below Average 2	Poor 3	Serious 4
ANCILLARY WORKS					
2	**Bridge deck surface, drainage and footpath (continued)**				
Superstructure drainage	Functioning	Mostly functioning. Minor clearing needed	Clearing needed Outlets blocked. Some vegetation. Part functioning with some adjacent minor structural damage	Little function. Blocked or broken with debris and vegetation. Causing structural damage	Non functioning or non existent Totally blocked or broken with heavy vegetation. Causing serious structural damage
3	**Parapet, railing, guardrail and signs**				
Parapet, railing and guardrail	Minor weathering Structurally sound	Slight surface rusting of steel. Some cracks in concrete Slight section loss/rot in timber Minor deformation/dents	Surface rusting with some corrosion and section loss. Vehicle damage but intact Rail/post loose/bent Fixings loose, or starting to rot	Corrosion with significant section loss. Major vehicle damage Rail/post broken or missing. Fixings missing/rotten	Disintegration, missing. Critical vehicle damage
Signs	All signs present and correct, inc. bridge number, name and any load ration.	Damage to posts, signs slightly misplaced.	Damage to posts and signs making signs slightly illegible.	Significant damage to signs but bridge in good condition with no restriction.	No signs where bridge should have load limit posted.
4	**Expansion Joints**				
Expansion Joints	Reasonably sound	Minor surface cracks at joint and/or sealant missing. Some debris, vegetation in joints.	Surfacing cracked at joint. Compression seal dropped/worn. Induced crack sealant missing. Bolt sealer missing. Nosing to surfacing joint missing. Strip sealant loose/poor. Debris and vegetation in joints.	Patched/cracked/loose. Plates/angles/fixings loose, few missing. C/way sealant missing. Compression seal u/s, strip sealant missing. Debris and vegetation disrupting joints.	Dangerous. Deck flashing showing. Nosing missing or disintegrated. All sealant missing. Debris and vegetation causing break-up of joints.

Guide to condition rating

Item	Good 0	Fair 1	Below Average 2	Poor 3	Serious 4
SUPERSTRUCTURE					
5	**Deck**				
General	Good clean condition Structurally sound. Good headroom clearance.	Minor weathering. Scrapes and scratches from impact. Some vegetation. Light water staining Acceptable headroom clearance	Average weathering. Some light damage from vehicular impact, flood or earthquake. Some debris and vegetation. Some restriction to headroom. Minor deformation, sagging	Significant weathering. Broken and/or deformation of structure from flood, vehicular impact or earthquake.Disruption from vegetation and debris. Headroom restriction. Major deformation, sagging Disruption from debris and vegetation.	Disintegration due to weathering, vegetation and debris. Headroom blocked. Severe accident/impact damage from vehicle, flood or earthquake. Movement of the structure following earthquake, exceptional floods, slides. Collapsed or close to collapse.
Concrete deck main members and cross girders	No noticeable cracks or spalling Cracks in concrete < 0.3 mm	Minor cracks or spalling, slight honeycombing Concrete cracks > 0.3mm <1mm	Cracks easily seen, average spalling, Honeycombed. Minor deformation. Reinf't blown Concrete cracks>1mm	Major cracks and spalling. Major deformation and sagging. Spalling in reinforced concrete with main reinforcement bars exposed and rusting	Disintegrating or collapsing
Steel deck main members and cross girders	Intact. Sound structurally with little wear Paint system or/and galvanising sound	Some fixings loose or missing Start of breakdown of coating system in local areas.	Fixings loose, missing and damages Minor corrosion due to breakdown of protective system particularly in local areas. Paint lifting, cracking or blistering. Some missing. Some lamination between joints and in section.	Major loss of fixings, panel loose, Deformation and corrosion Major breakdown of protective system with paint or/and galvanising missing. Lamination of steel especially with section loss	Panels loose, missing deformed broken or badly corroded
Timber deck and main members	Sound structurally with little wear	Minor section loss, rotting, shakes. Fixings rusting, some pultruding	Some section loss/rotten timber. Timber loose but safe. Minor deformation, fixings loose Timber shakes average	Significant section loss/rotten timber. Major shakes. Major deformation/sagging Timber loose and unsafe. Fixings missing.	Decking missing or disintegrating
Arches	Minor weathering. No cracks. Slight pointing loss.	Weathered. Minor cracks/spalls. Moderate pointing loss. No deformation.	Few bricks/stone missing/loose. Cracks easily visible. Minor deformation. Slight separation from spandrels or barrel. Significant pointing loss.	Many bricks/stones missing. Major cracks. Major deformation/sagging. Total separation from spandrels or barrel.	Disintegrating. Large areas of bricks/stone missing. Collapsing.
6	**Bearings**				
	Minor weathering Minor rusting	Average weathering, rusting, scaling. External crazing. Slightly offset.	Heavy rusting. Cracked, loose. perished. External breakdown. Offset, tilted.	Major breakdown (PTFE, laminations, rubber etc.) Dislodged	Missing, seized. Completely dislodges. Complete breakdown.

Guide to condition rating

Item	Good 0	Fair 1	Below Average 2	Poor 3	Serious 4
SUBSTRUCTURE					
7	**Abutment, Wing Walls and Retaining Walls**				
	No settlement, scour or cracks. Appear sound. Minor wear, weathering, rust staining, pointing loss	No visible settlement. Minor cracks, scour, faults. Weathered, some rust staining, scaling, minor section loss, pointing loss	Minor settlement and deformation. Average scour. Cracks easily visible. Few bricks, stone missing or loose. Reinf't blown, significant faults and pointing loss.	Major settlement or scour. Many bricks or stones missing. Major cracks, section loss, deformation.	Disintegration, missing. Completely scoured. Critical settlement. Large areas missing or rotten.
8	**Piers and Columns**				
	No settlement, scour or cracks. Appear sound. Minor wear, weathering, rust staining, pointing loss	No visible settlement. Minor cracks, scour, faults. Weathered, some rust staining, scaling, minor section loss, pointing loss	Minor settlement and deformation. Average scour. Cracks easily visible. Few bricks, stone missing or loose. Reinf't blown, significant faults and pointing loss.	Major settlement or scour. Many bricks or stones missing. Major cracks, section loss, deformation.	Disintegration, missing. Completely scoured. Critical settlement. Large areas missing or rotten.
TRAINING WORKS					
9	**Bridge Protection Works**				
	Sound, well defined embankments. No settlement or scour. No movement of gabions, no stone loss or build up of debris or vegetation.	No visible settlement. Slight scour. Some weathering and wear. Some deformation of gabions, some loss of stone. Vegetation appearing	Major weathering. Deformation of protection structure. Settlement and scour developing. Cracks and stone loss. Gabion baskets wires breaking up. Vegetation established.	Major settlement and scour affecting bridge structure as well as protection works. Break up and stone loss from baskets and riprap. Totally silted, overgrown. Increasing risk to structure.	Disintegrating. Dangerous scour. Totally blocked
10	**River Training Works**				
	Well established and controlled river channel with no obstructions. No settlement or scour. No movement of gabions, no stone loss or build up of debris or vegetation.	Minor defects in river training works. Slight encroachment, scour or siltation.. Vegetation appearing. No visible settlement. Slight scour. Some weathering and wear. Some deformation of gabions, some loss of stone. Vegetation appearing	Developing meander pattern. Scour from 0.5 to 1 m Vegetation established and starting to disrupt flow. Major weathering. Deformation of protection structure. Settlement and scour developing. Cracks and stone loss. Gabion baskets wires breaking up.	Major settlement and scour affecting bridge structure as well as protection works. Break up and stone loss from baskets and riprap. Totally silted, overgrown. Increasing risk to structure.	Large scour (more than 1 m Movement of the structure following earthquake, exceptional floods, slides Disintegrating. Dangerous scour. Totally blocked

APPENDIX E

TESTING, METHODS OF TESTING, SPECIAL TESTING EQUIPMENT

Testing, Methods of Testing, Special Testing Equipment

Introduction

Of the tests described in this Appendix, only a few are likely to be suitable for use in Nepal. Some will need the employment of specialist organizations.

Non-destructive testing is a means of measuring various properties without destroying the parent material or damaging it to any great extent. In the context of this Appendix non-destructive testing is taken to include tests involving the removal of small samples by drilling or cutting, but on a minor scale which will not impair the effectiveness of the structure.

Probably the most common reason for carrying out non-destructive testing is to assess concrete strength. In doing so it is important for the Engineer to bear two things in mind:

- With the exception of core testing no other non-destructive technique will give a direct measure of strength.
- The strength of a concrete in a structure would not normally be as high as that from a standard BS 1881 cube made from the same concrete.

There are a number of reasons why the engineer may wish to undertake testing:

- To discover the cause of distress or deterioration.
- A routine inspection as part of preventative maintenance, or for records
- As part of a correct and comprehensive diagnosis.
- To help determine appropriate remedial action
- Compliance with Specification:

As a back up or alternative to standard control specimens at the time of construction (e.g. to measure in-situ strength,. cover, density, permeability etc.) Following non-compliance or loss of standard control specimens In cases where deterioration has occurred.

- Assessment of Insitu Quality (This may relate either to the properties of the concrete such as strength or density etc., or the performance of the structural members as a whole. The most likely situations are:

Proposed change of use or extensions of a structure Assessment of structural integrity or safety following suspected material deterioration, structural damage, fire damage, chemical action or overload etc., Serviceability of members with design faults or suspected to contain material which does not meet specifications Monitoring of strength development

Planning a Test Programme

The cost of initial investigations and precise diagnosis is minimal in relation to the cost of many repairs contracts. Planning an investigation must consider the:

- Requirements of the investigation, the scope and purpose.
- Suitability of the test methods to provide the information.
- Practicality of the methods (access, safety, damage, disruption. Cost of the methods.
- Availability of the test method.

Preliminary Considerations

- Reviewing the preliminary considerations can help to determine the test regime:
- Is it a routine or specific inspection?
- Is the integrity of the structure, or any element, in doubt (i.e. after collision)?
- Historical data
- Identify survey objectives
- Identify access difficulties and determine a cost/time effective approach.
- Identify requirement for any specialist inspectorate/equipment.
- Where the structure is in use, is there a need for restrictions to be applied?
- Check the availability of water and power.
- Is the extent of deterioration to be defined in precise terms or in general terms for further investigative study?
- Are recommendations or repair options required?
- Required remnant life of structure, predictions on latent defects? Location of structure, location of test.
- Setup system of pro-forma sheets, report format
- Site and laboratory specifications and work programmes.
- Environmental assessment.

Historical Background data

- Historical background data includes:
- Drawings, general arrangement, details, as-built.
- Records of previous inspections.
- Original design parameters and loading, present loading.

- Original materials, other specifications.
- Construction details, foundations, bearings, joints.
- Age and details of previous remedial work

Location of tests

When deciding on the location of a test within a structure it is important to realise that the strength of concrete can vary significantly within that structure. Fig.II. The reason for the variation is related to the migration of water towards the top of the lift during compaction. Note that Specification Compliance Testing will require, in general, that results reflect the average insitu conditions. On the other hand, Serviceability or Adequacy Testing will require results for weakest, most severely damaged or critically stressed regions.

Test and Inspection Techniques

Test and inspection techniques are briefly reviewed under the following headings and in the table at the end of the Appendix.

Visual Surveys

Useful aids include photography, notes, tapes, computer data recorders, pro-forms sheets, check lists.

Sounding surveys

To detect incipient spalls and delaminations over reinforcement in concrete, loose bolts in steel fabrication. Techniques vary from simple hammer to proprietary flails (chains) for concrete decks. Although primarily an aural method the US Federal Highway Authority have developed a method of doing this electronically for bridge decks with a trolley mounted apparatus. May have depth limitations, only detecting surface defects 75 mm to 100 mm deep.

Covermeter Surveys (BS 1881)

Situations often arise on site where it becomes necessary to check the location and cover to the reinforcement in an existing structure. Gamma radiography is one method used to locate reinforcement, however a much cheaper and simpler alternative is to use an electromagnetic covermeter. This test is covered in BS 4408 Pt. 1 and consists essentially of an electromagnet powered by a 9- volt battery. The search head is passed over the concrete and the magnitude of the reading on the galvanometer indicates the depth of cover to the steel. Although the test is simple to carry out, care is required with operation and interpretation of results. Cover to reinforcement is one of the main parameters in concrete durability. Covermeter surveys can:

- Locate main and secondary reinforcement, bar size spacing and cover.
- Determine minimum cover and variability.
- Locate reinforcement or pre-stressing strand for either purpose of assessment calculations, or for avoidance during core sampling.

Gamma Radiography

This method, covered by BS 4408 Pt. 3 is performed by placing a radioactive source on one side of a concrete member and a photographic plate on the other. Its use is restricted to locating reinforcement or areas of poor compaction or for locating voids in concrete and grouted tendon ducts. This is a specialist technique needing stringent safety precautions with little scope in Nepal.

Thermography, Acoustic Emission, Radar

Specialist investigative techniques yield information on structural integrity. Refer to BS 1881 Pt. 201 for advantages and disadvantages.

Dynamic Response/Vibration Technigaues

Used for testing integrity of insitu piles or whole structures. With piles this usually involves striking the head of a pile with a hammer and measuring the dynamic response. Where structures are concerned excitation is normally provided using vibrators clamped to relevant parts of the structure. The dynamic structural response is then monitored using sensitive accelerometers. Both techniques require the use of sophisticated expensive equipment together with skill and care in carrying out the tests and interpreting the results.

Rebound Hammer

The test method is covered by BS 4408 Pt. 4 and essentially it works by measuring the rebound of a spring controlled hammer. Fig.12. The test is sensitive to orientation of the hammer, Fig. 13. and to local variations within the concrete. To overcome this it is recommended to take the average of a number of readings (between 9 and 25 over an area not exceeding 300mm by 300mm). The test only measures the surface properties of the concrete and it is therefore very difficult to derive a relationship between strength and rebound number. Apart from surface characteristics the test is also sensitive to other factors such as:

- Aggregate type and content. Fig. 14.
- Cement content
- Moisture content of concrete
- Degree of carbonation (It is not recommended to perform this test on concrete more than 3 months old where high results are likely due to hardening of the surface as a result of carbonation.

The only realistic way to establish a relationship between strength and rebound is to take readings on cubes and crush them. The test has the advantage of being simple to carry out and a large number of readings can be obtained in a short space of time. The equipment is cheap and portable. As a comparative test the accuracy is rated as ± 25%.

Internal Fracture or Pull-out Test

This test was developed by the British Research Establishment in England and measures the force required to pull-out a wedge anchor bolt which has been inserted into a pre-drilled hole. Fig. 5. The procedure involves drilling a 6mm diameter hole into the surface and tapping a 6mm wedge anchor bolt with expanding sleeve into the hole to a depth of 20mm. A load is applied to the bolt through a torque meter and reaction frame until failure occurs by internal fracture of the concrete when the maximum torque reading is recorded. Fig. 6. The mean of six results is usually taken. Calibration specimens should be prepared in the Laboratory (using the same materials as the site concrete) to give the relationship between torque and compressive strength. Fig. 17. An accuracy of ± 28% is claimed, the reasons for the high variability including:

- Localised nature of test
- Imprecise load transfer mechanism
- Variations due to drilling
- Location of large pieces of aggregate near to the bolt.

The test is fairly easy to carry out but does damage the surface of the concrete. Other tests in this category include:

- Windsor Probe -An American test in which the bolt is fired into the concrete and the depth of penetration measured.
- Lok- Test -Similar to the BRE internal fracture test except that the bolt is cast into the concrete. Fig. 18. (i.e. no drilling required)
- Pull-Off Test -A steel probe is glued onto the concrete surface by an epoxy resin and the force required to pull the piece of concrete off the surface measured. Fig. 19.

Ultrasonic Technigaues

This method measures the speed of an ultrasonic pulse traveling through the concrete from one transducer to another. Fig. 20 gives the relationship between pulse velocity and cube strength. Unless cubes are available which can be crushed after test reading have been taken it is not possible to get direct readings for strength. It is possible to take a large number of readings fairly quickly, the equipment is fairly cheap, easily portable and the test does not damage the concrete in any way. Rather than use the test to assess strength it is perhaps better used to detect voids, crack depth or areas of poor compaction. As with most non-destructive methods it is best used as a comparative tool.

Core Drilling

Core sampling is used to determine concrete quality. Core diameters vary from 40mm to over 200mm. Generally 3 times the aggregate size is specified, however a diameter of not less than 100mm is usually required for strength tests. As well as compressive strength cores can be used for expansion tests for alkali-silica reaction, carbonation and chloride testing, density, porosity concrete composition analysis and information on cracks. (BS 1881). It is important to keep full and complete records of core samples

taken from the structure for later analysis. Core drilling can weaken the structure and should be carried out only on the authority of the Engineer.

Powder Sample Drilling

Normally taken for the determination of the chloride content of hardened concrete. Powder gradients are taken at various depths when it is suspected that contamination is from an external source, and at depth to give the background level of chlorides. It is also used in determining sulphate profiles, alkali content etc.

Depth of Carbonation

The normal method is to spray a fresh fractured sample of concrete with the inductor. (1% phenolphthalein in alcohol-water base). Phenolphthalein changes colour over the pH range 8.3 to 10 with the red colour visible on concrete above a pH of 9 to 9.5 indicating passivity. Laboratory analysis should be used for an accurate determination of depth of carbonation.

Measurement of Electrical Potentials

Electrical methods for inspection of concrete bridge components include resistance and potential measurements. These methods are particularly useful to detect corrosion of reinforcement.

Crack Meters

These may be in the form of simple comparagauges or more intricate vernier microscopes. The later may be used to inspect the concrete surface inside the crack. The simple crack gauge is an essential inspector's tool.

Measurement of Strains and Deflections

Strains are usually measured by acoustic gauges or electrical resistance gauges. For deflection there are a variety of methods including visual reading dial gauges, precise leveling, electrical transducers or laser techniques. Some equipment is sensitive to thermal strains and care may be needed in the interpretation of the results.

Thickness Testing of Steel Members

Testing for the thickness of steel members can be carried out either by direct measurement or special ultrasonic thickness testing instruments. the latter being accurate down to 0.lmm. This can be particularly useful to determine corrosion loss in a member when assessing remnant strength. Even with no corrosion present the equipment can help to size steel members for records or assessment.

Weld Sizes

A weld fillet gauge can confirm the weld size. Usually this is combined with visual inspection of weld quality.

Flatness Testing of Steel Members

To check distortions and deviation from flatness the normal method is to apply a

straight edge to the surface and record distortion and location of test. Steel wire is used over longer gauge lengths.

Bolts and Rivets

Looseness and movement can be identified by tapping with a hammer. When the bolt is tight the sound penetrates into the full member however the sound is dull when the bolt is loose. A visual inspection identifies corrosion or other deterioration.

High-strength Friction Grip Bolts

These bolts will not be loose. Any check on insitu torque setting will require eventual removal and replacement of the test bolt. A new bolt is always used to replace a test bolt. HSFG bolts are not reused. Bolts must only be removed under engineering supervision and only one bolt at a time removed. Old bolts are inspected for corrosion.

Magnetic Crack Detection

There are a number of different forms of magnetic crack detection which amount to different methods of producing the magnetic field in a test area. All methods indicate the presence of defects on the surface by a magnetic powder which is influenced by the magnetic fields.

Dye Penetration Testing

Used to identify surface defects and cracks in steelwork, particularly welds, the test method is covered by BS4416. Paint is removed and the surface cleaned then sprayed with a low viscosity red dye. This penetrates into cracks or other open defects. After some twenty minutes the dye is cleaned from the surface using a solvent. A dusting of chalk powder is applied which indicates the presence of cracks as a dark stain on the surface.

Hardness Testing

A portable hardness testing apparatus can be used to indicate the approximate strength of steel in a particular area. The surface is prepared to a polished finish and, depending on the type of unit used, a calibrated indentation mark impressed on the steel surface. The relative size of the impressions enable the hardness number to be determined. In the structural steel range hardness numbers below 150 HV are typical of mild steel to BS 4360 Grade 43. Hardness numbers in the range 160 to 200 are typical of higher yield steels to BS 4360 Grade 50.

Ultrasonic Testing of Steelwork

General techniques of ultrasonic testing, described in BS 3923 and BS 4336, normally comprise pulse echo methods in which signals returned from internal flaws are monitored. In particular the technique is used for detection of defects in butt welds and for delaminations in steel plate. There are other variations of ultrasonic testing but all require specialist equipment and skilled operators.

Radiographic Methods of Testing Steelwork

Radiographic methods of testing steelwork are specialist techniques, particularly when used on sites. A more common application is in the laboratory testing of specimens for the approval of welders or weld procedures.

Chemical Analysis of Steelwork

This is used to determine the chemical composition of steel for identification of type or for weld compatibility. Drillings, scrapings or small coupons are cut from an area approved by the engineer for spectrographic analysis.

Load Testing of Structures and Elements

This method entails the assessment of structural response to known applied loading conditions. It can be used either to compare actual behaviour under load with the theoretical predicted performance, or to compare recovery of a structure or element with deflection under load. (i.e. a test pile is a common application of the latter). The loading may be applied to elements, superstructure, substructure foundations or bearings. Applied loading can consist of certified dead weights, water, bagged sand, kentledge, hydraulic jacks or vehicles. (London Busses were used to load test the Tower Bridge in London in 1991- RPT). Water has a number of advantages including cost, accuracy, uniformity of loading and availability.

Response can be measured by deflection dial gauges, load cell, linear voltage displacement transducers, electrical resistance and vibrating wire strain gauge, plastic vernier strain gauge and demec gauge.

Table: In situ test and inspection techniques

Test method	Principal reference	Application	Property assessed	Remarks
Structural integrity and layout				
Visual survey including (a) crack mapping (b) endoscope survey (c) photography, video (d) stareo pairs	Bridge inspection Panel (1984) AC: (1968) Manning and Bye (1983) Cement and Concrete Association (1988)	All elements and All elements and structures	Condition and monitoring Condition and monitoring	Simplest but most important inspection method Include scales and colour charts as appropriate Close-ups and general views
Hammer testing Chain drags etc.	Moore at al. (1973) Savage (1985) Manning and Bye (1983) Cantor (1984)	All elements and structures	Presence of cracks, spalls and delaminations	Hammer test or chain drag may only detect surface laminations to 75-100mm deep
Covermeter surveys to locate reinforecement, prestressing ties etc.	BSI (1988b) BSI (1986a)	All elements and structures	Location and concrete cover Bar sizes also determined	Influenced by magnetic aggregates and difficulties with lapped or closely spaced bars or layers of bars: modern instruments much more effective at locating steel up to 300 mm deep
Termography	Manning (1985) BSI (1986a) Manning and Holt (1980) Kunz and Eales (1985)	Principally bridge decks (asphalt and plain concrete) and other elements	Presence of laminations	Influenced by water on deck and prevailing weather: rapid scan system
Radar	Manning (1985) Cantor (1984) BSI (1986a)	Principally bridge decks	Voidage etc. on large scale including reinforcement, dusts etc.	Bulky equipment: signals can be difficult to interpret
Acoustic emission	Mkalar et al. (1984) Hendry and Roy (1985) Manning (1985) BSI (1986a)	All structures during load testing	Determination of initiation and origin of cracks	Specialist Inspection equipment and interpretation
Dynamic response e.g. sonic echo continuous vibration	Stain (1982) Manning (1985) BSI (1986a)	Principally pile testing	Pile integrity	Specialist Inspection equipment and interpretation
Load testing of structures	BSI (1986c) Manzies(1978) Jones and Oliver (1978) ACI (1985a)	Structures/elements	Deflection under loads against structural analysis	Expensive but informative

Determination of concrete quality and composition				
Core and lump samples	Concrete society (1987) BSI (1981) ASTM (1987a)	All elements and structures	Used in physical chemical and petrographic analysis of quality	Required for almost all Laboratory testing; restricted by access, to certain in members; can be expensive
Power drilled samples	Building research establishment (1977)	All elements and structures	Chloride, sulphate and moisture content of concrete	Simple subject to errors of depth/cross contamination and sampling
Partially non-destructive assessment of strength i.e. Windsor probe, internal fracture, pull-out testing, Schmidt Hammer etc.	BSI (in preparation) BSI (1981) Keiller (1982)	All elements and structures	Strength usually converted to equivalent compressive	Varying in simplicity, often wide margin of error (15%-30%) depending on method and availability of calibration information on cover concrete only often operator and equipment sensitive can damage concrete.
Ultrasonic pulse velocity testing	BSI (1986a) BSI (in preparation) ASTM 91987c)	All elements and structures	Concrete quality uniformity presence of cracks voids weak layers etc.	Rapid scan technique through thickness of concrete can be correlated with strength
In situ permeability tests e.g. ISAT Figg test. Clam	Concrete society (1988) Lawrence (1981) Montgomery and Adams (1985)	All elements and structures	Concrete quality and permeability generally restricted to cover	Can be difficult to use in situ and slow; may only give a perme-ability index measure-ment not true intrinsic permeability and can be influenced by moisture content of concrete surface condition etc.
Half-ceil potential mapping	ASTM (1987) Figg and Marsden (1985) ASTM (1983) Baker (1986)	Steel serviceability and condition All elements and structures	Likelihood of corrosion of rein-forcement and possible rate	Single cell and two cell methods used with copper, silver reference electrodes Requires in situ calibration
Resistivity of cover	Manning (1985) Vassie (1980) Figg and Marsden (1985) Wenner (1915)	All elements and structures	Electrical resistance of cover concrete	Four-probe method used with either embedded or surface contact electrodes Measurement of circuit resistance may also be valuable

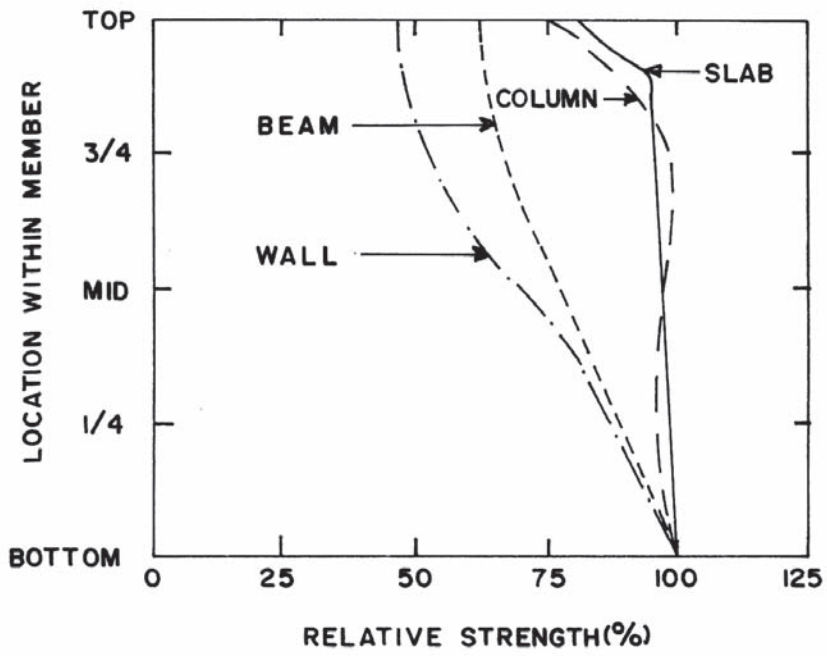


FIG. 11 **TYPICAL CONCRETE STRENGTH VARIATIONS WITHIN DIFFERENT STRUCTURAL MEMBERS**

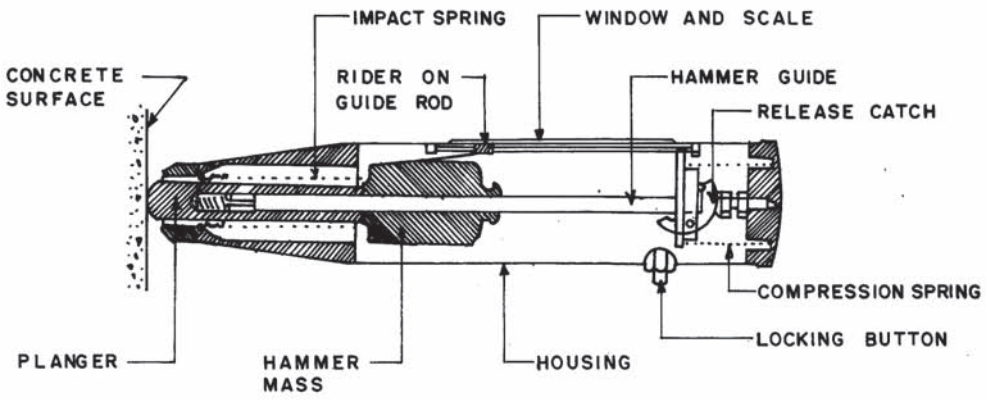


FIG. 12 SECTION THROUGH REBOUND HAMMER

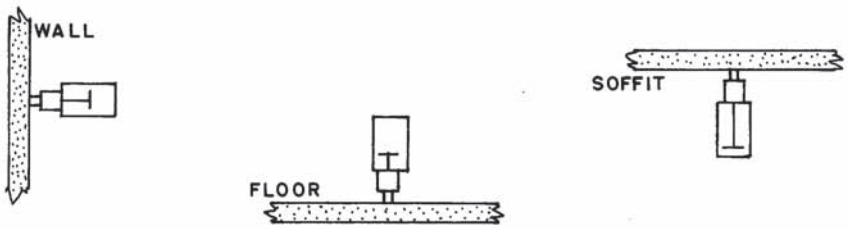


FIG.13 INFLUENCE OF ORIENTATION IN REBOUND READING

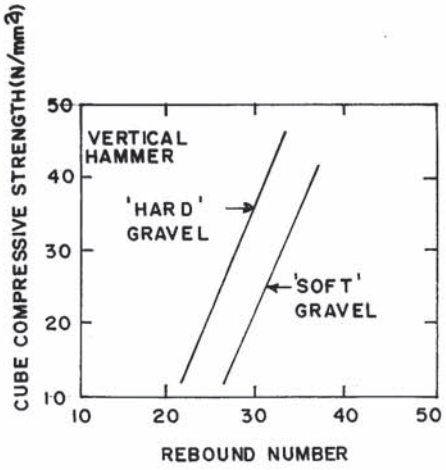


FIG. 14 RELATIONSHIP BETWEEN REBOUND NUMBER AND AGGREGATE TYPE

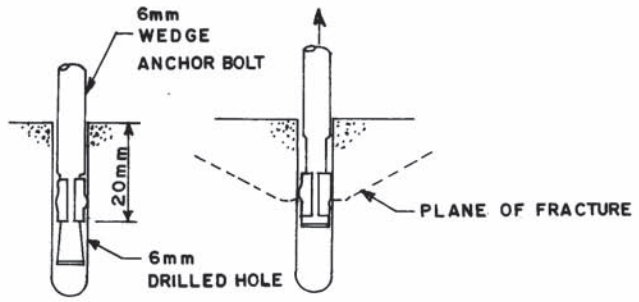


FIG. 15 WEDGE ANCHOR BOLT FOR "PULL-OUT TEST"

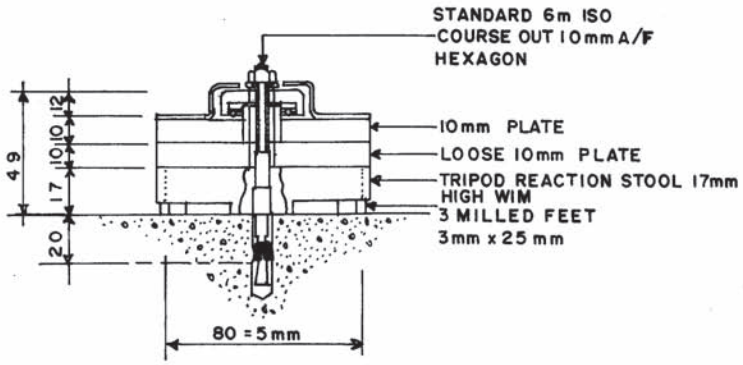


FIG. 16 REACTION FRAME FOR "PULL-OUT TEST"

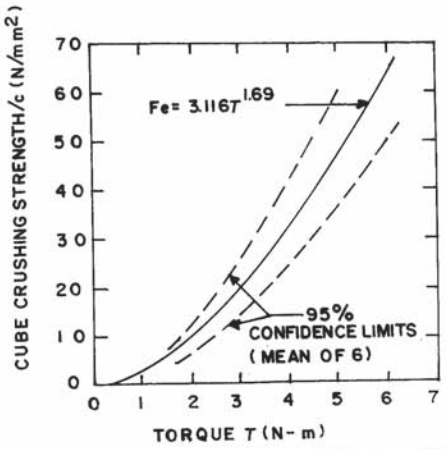


FIG. 17 RELATIONSHIP BETWEEN PULL-OUT FORCE AND CONCRETE STRENGTH

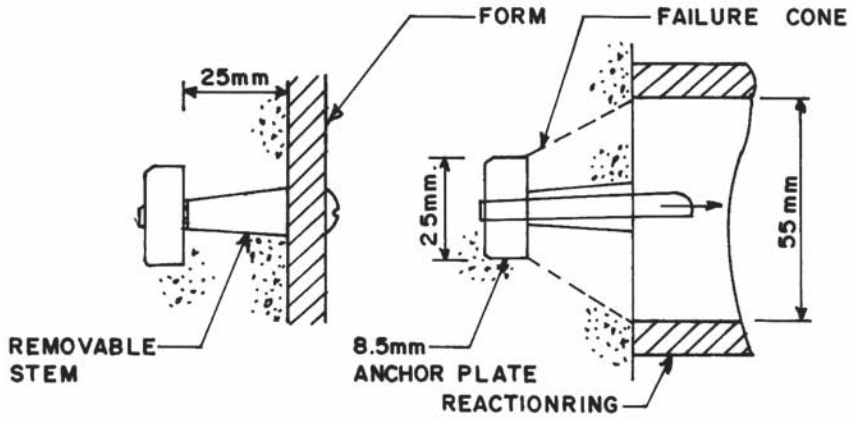


FIG. 18 LOK – TEST

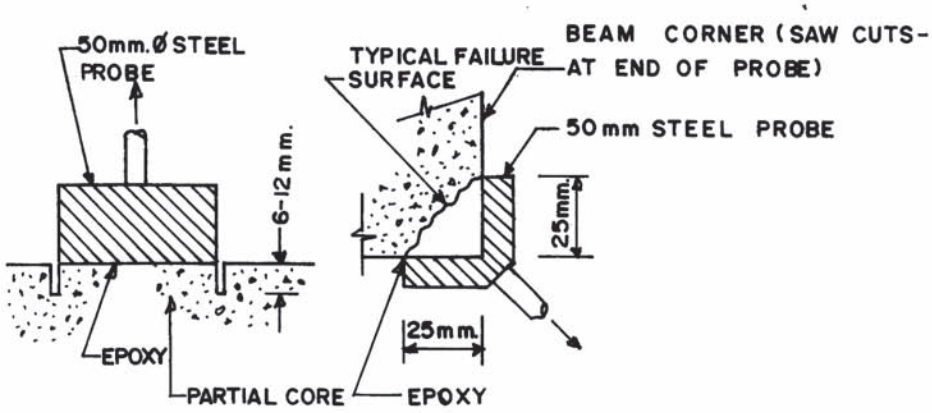


FIG. 19 PULL – OFF TEST

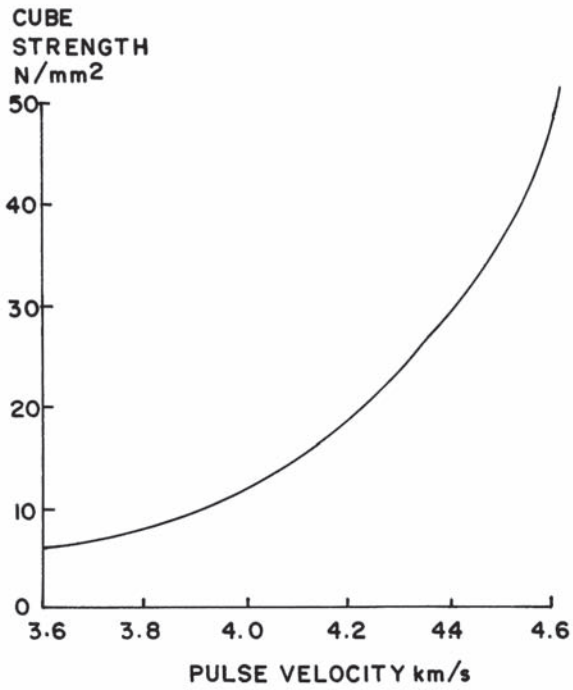


FIG. 20 RELATIONSHIP BETWEEN ULTRA- SONIC PULSE VELOCITY AND CONCRETE STRENGTH

Part 3
Guidlines for routine maintenance of Bridges

CONTENTS

Part 3
Guidelines for Routine Maintenance

1. INTRODUCTION

1.1 This guideline has been introduced in order to formalize the procedures for routine maintenance to ensure that vital maintenance functions are carried out regularly.

It sets out those operations, and their frequency, which are to be undertaken as Routine Maintenance.

Many of the tasks listed in this guidelines are fairly minor in themselves, but failure to carry them out may lead to deterioration of the structure, and the need for more serious repair operations in the future.

1.2 The items of routine maintenance work described in the guideline should be regarded as those which relate to bridge servicing rather than bridge repair and the work will be undertaken regularly at pre-determined intervals : 2 to 3 times a year.

1.3 Routine maintenance does not cover the renewal of structural elements or components which have become unserviceable because of general wear and tear or have deteriorated for other reasons. Such work should be identified during the regular inspection process, and should be included in a planned structural maintenance programme.

1.4 An interim norms for the Routine Maintenance Works has been approved by Department of Roads. This norms may be used as a trial, subsequent corrections will be made after feedback from the Division Offices, and the final norms shall be approved.

1.5 This guidelines prescribes the frequencies with which routine maintenance operations are to be carried out and in some cases the manner in which they are to be performed for given elements and components of structures. They may not be appropriate in all circumstances and may need to be modified to take account of local conditions and the needs of individual structures e.g. by reducing maintenance intervals.

1.6 Maintenance Divisions should identify those items of routine maintenance which are appropriate for each particular structure, and prepare a schedule of operations. This schedule should be either appended to the Maintenance Manual or filed within a Divisional Bridge Data Base.

1.17 These guidelines will cover for routine maintenance of works for the bridges as specified by Nepal Road Standard.

Superficial Inspection Report form

1.8 During the Routine Maintenance activity a Superficial Inspection Report Form shall be completed. Anything noticed of serious nature should be reported immediately. A separate form is used for each structure and is returned to the Divisional Engineer who will take action. The Divisional Engineer will then either instruct the necessary works or send the report to the Bridge Unit for further detailed investigation by the Bridge Unit. Minor Repair Works, if needed can be carried out as mentioned elsewhere in the guidelines. A sample superficial inspection report form is attached as Section 8.

Routine Maintenance Schedule

1.9 A Routine Maintenance Schedule is filed on each bridge every twelve months by the Division. The Routine Maintenance Schedule can be used by the Division as a basis for preparing the Budget application for recurrent maintenance within the Division for the next financial year. A sample Routine Maintenance Schedule is attached as Section 9.

2. ROUTINE MAINTENANCE OPERATIONS : WATERWAY

River Channel, Stream-Bed and Banks

2.1 Requirements for Maintenance

i. Remove accumulation of debris and vegetation, especially tree trunks and branches, especially around and between piers and abutments.

ii. Note new erosion and scour on superficial inspection report forms.

iii. Note deposition of river bed material on superficial inspection report forms.

iv. Note change of river direction on superficial inspection report forms.

v. Note any extraction of sand or gravel within 200 metres upstream or downstream of the structure on the superficial inspection report forms.

vi. Clear any encroachments in the area of the bridge site.

2.2 Maintenance Interval

3 – 4 times a year.

2.3 Time of Maintenance

Before start of the monsoon season. (July). During the dry season after the monsoon season when the rivers are low. (October). After large floods during the monsoon season.

3. ROUTINE MAINTENANCE OPERATIONS: SUB STRUCTURES

Reinforced Concrete, Mass Concrete, Masonry and Timber - Piers and Abutments

3.1 Requirements for Maintenance

i. Remove Graffiti

ii. Remove any vegetation from the structure.

iii. Clear debris including animal and fecal deposits from bearing shelves and bridge surfaces.

iv. Clean drainage channels.

v. Clean out drainage pipes and remove silt and debris. Test on completion

vi. Report damaged or missing gap sealant to movement joints on superficial inspection report form

3.2 Maintenance interval

3 – 4 times a year.

3.3 Time of Maintenance

(Ideally) all drains to be cleared after leaf fall and working properly before the monsoon starts (July). All vegetation to be cleared before the growing season (April).

Reinforced Concrete, Mass Concrete and Masonry - Wing-Walls, Retaining Walls. Reinforced Earth Walls and Gabion Walls.

3.4 Requirements for Maintenance

i. Remove Graffiti

ii. Clean out weep pipes and remove silt and debris.

iii. Remove any vegetation from the Structure.

iv. Remove all debris including animal and fecal deposits and clean drainage channels.

v. Clean outlet pipes and test on completion.

vi. Report damaged or missing gap sealant to movement joints on superficial inspection report form

3.5 Maintenance interval

3 – 4 times a year.

3.6 Time of Maintenance

All drains to be cleared after leaf fall and working properly before the monsoon starts. (July). All vegetation to be cleared before the growing season (April).

3. ROUTINE MAINTENANCE OPERATIONS: SUB STRUCTURES

Steel, Concrete and Timber Columns and Frames

3.7 Requirements for Maintenance

i. Remove Graffiti

ii. Remove debris, bird droppings, animal and fecal deposits from all surfaces

3.8 Maintenance Interval

3 – 4 times a year.

4. ROUTINE MAINTENANCE OPERATIONS: SUPERSTRUCTURES

Steel , Concrete and Timber Beams, Trusses and Decks, Concrete Slabs

4.1 Requirements for Maintenance

i. Remove Graffiti

ii. Remove any vegetation from the structure.

iii. Clear debris and stones including animal and fecal deposits from bridge deck and surfaces.

iv. Clean drainage channels.

v. Clear drainage outlet pipes to ensure effective operations. Test on completion.

vi. Clear weep pipes and remove silt and debris.

vii. Check all bolts and nuts for tightness, report missing or loose bolts on superficial inspection report forms.

viii. Report cracks, deformation and potholes in bridge deck surfacing on superficial inspection report forms.

ix. Report damaged or missing gap sealant to movement joints on superficial inspection report form

4.2 Maintenance interval

3 – 4 times a year.

4.3 Time of Maintenance

(Ideally) all drains to be cleared after leaf fall and working properly before the monsoon starts (July). All vegetation to be cleared before the growing season (April).

5. ROUTINE MAINTENANCE OPERATIONS: COMPONENTS

Expansion Joints and Bridge Joint Systems

5.1. Requirements for maintenance

i. Clean out stones, debris and vegetation. (For large movement joints with access provision from below this may require low pressure water washing.)

ii. Check condition of joint sealant where applicable. Report damaged or missing gap sealant to movement joints on superficial inspection report form

iii. Clear drainage systems.

iv. Check all bolts and nuts for tightness. Report loose or missing bolts on the superficial inspection report form.

v. Replace gaskets etc. where this is a requirement of the specific maintenance manual.

vi. Report wear, damage and deformation in joint, lack of freedom of movement, jamming of joint due to debris, lack of proper clearance or incorrect vertical or horizontal alignment on superficial inspection report form.

vii. Report cracks in adjacent surfacing and wearing course on superficial inspection report form.

5.2 Maintenance Interval

3 – 4 times a year.

Metal Parapets, Concrete Parapets, Timber Railings and Safety Fences

5.3 Requirements for Maintenance

i. Check all bolts and nuts for tightness. Report loose or missing bolts on the superficial inspection report form.

ii. Clear hollow section drain holes.

iii. Remove graffiti, vegetation and debris.

iv. Report any damage on superficial inspection report form.

5.4 Maintenance Interval

3 – 4 times a year.

5. ROUTINE MAINTENANCE OPERATIONS: COMPONENTS

Bearings

5.5 Requirements for Maintenance - General

i. Remove any vegetation from the bearing shelf and/or bearing plinth.

ii. Clear debris and stones including animal and fecal deposits from bearing shelf and/or bearing plinth.

5.6 Requirements for Maintenance - Elastomeric

i. Remove general debris and dirt.

ii. Report any damage including tearing, bulging, deterioration, flattening, other abnormal deformation, loose bearings and mortar, stress cracks in structure, on superficial inspection report forms.

5.7 Maintenance Intervals

3 – 4 times a year.

5.8 Requirements for maintenance - Sliding

i. Clean to ensure sliding surfaces perform satisfactorily.

ii. Remove general debris and dirt.

iii. Clear and clean contact surfaces where accessible and re-grease/lubricate in accordance with manufacturer's instructions, in the maintenance manual.

iv. Report damaged, loose bearings, bolts and mortar bedding, stress cracks in structure

v. Report corrosion of bearing surfaces

5.9 Maintenance Intervals

3 – 4 times a year.

5.10 Requirements for Maintenance - Roller

i. Remove general debris and dirt

ii. Clear and clean roller surfaces where accessible and re-grease if necessary. (Identify Manufacturers instructions in maintenance manual).

iii. Report damaged, loose bearings, bolts and mortar bedding, stress cracks in structure

iv. Report corrosion of bearing surfaces

5.10 Maintenance Intervals

3 –4 times a year.

5.11 Requirements for Maintenance - Special Bearings, PTFE etc.

Refer to manufacturers instructions and maintenance manual.

Earthquake Restraints

5.12 Requirements for Maintenance

i. Check all bolts and nuts for tightness. Report loose or missing bolts on the superficial inspection report form.

ii. Check steel sections for deformation.

iii. Check for missing or damaged bearing parts, such as vertical or horizontal elastomeric pads.

iv. Report corrosion of earthquake restraints.

v. Report any damage on superficial inspection report form.

5.13 Maintenance Interval

3– 4 times a year.

6. ROUTINE MAINTENANCE OPERATIONS: PROTECTIVE SYSTEMS

6.1 Requirements for Maintenance

i. Clean surfaces of debris, animal and fecal contamination.

ii. Report damage and/or corrosion, breakdown of protective system on superficial inspection report form.

6.2 Maintenance interval

3 – 4 times a year.

7. ROUTINE MAINTENANCE OPERATIONS: BRIDGE SIGNS

Bridge Signs

7.1 Requirements for Maintenance

i. Clean surfaces of all signs including chevrons.

ii. Remove all notices and advertisements from signs.

iii. Report all damage to signs, including chevrons on superficial inspection report form

7.2 Maintenance Interval

3 – 4 times a year.

8. Responsibilties and Reporting Authority of Routine Maintenance Activities

Activity / Task Summary	Responsibilities	Reporting to
1. River Channel, Stream Bed and Banks		
• Removal accumulation of debris and vegetation	Supervisor / Or	
• New erosion and scour	Supervisor /Or	
• Deposition of river bed material	Overseer	
• Change of river direction	Engineer	Div. Chief
• Extraction of sand or gravel in the vicinity of bridge	Engineer	Div. Chief
2. Sub Structures		
• Remove graffiti and vegetation	Supervisor	
• Clear debris including animal and fecal deposits	Supervisor	
• Clean out drainage pipes and remove silt and debris	Supervisor	
• Clean out weep pipes and remove silt and debris	Supervisor	
• Damage or missing gap sealant to movement joints	Overseer	Engineer
3. Super Structures		
• Clear hollow section drain holes	Supervisor	
• Refix timber fences	Overseer	
• Remove graffiti, vegetation and debris	Supervisor	
• Check all bolts and nuts for tightness	Overseer	Engineer
• Missing or loose bolts	Overseer	Engineer/DC
4.1 Components: Expansion joints and Bridge Joint Systems		
• Clean out stones, debris and vegetation	Supervisor	
• Clear drainage systems	Supervisor	
• Check all bolts and nuts for tightness	Supervisor/Or	
• Missing or loose bolts	Overseer	Engineer
• Missing or damaged joint sealant	Overseer	Engineer
• Wear, damage and deformation in joint, lack of freedom of movement, jamming of joint due to debris, lack of proper clearance or incorrect vertical or horizontal alignment	Overseer	Engineer
• Cracks in adjacent surfacing and wearing course	Overseer	Engineer/DC
4.2 Components: Bearings		
• Remove debris, dirt, vegetations from bearing or bearing plinth	Supervisor	
• Damage to bearing such as tearing, bulging, deterioration, flattening, other abnormal deformation, loolse bearings and mortars etc. in Elastomeric bearing	Overseer	Engineer
• Damage to bearing such as loose of bearing, bolts and mortar bedding, stress cracks in structure and corrosion of bearing surfaces etc. in Sliding bearing, Roller bearing	Overseer	Engineer/DC
• Damage to Earthquake restraints.	Engineer	Div. Chief
4.3 Components: Bridge Signs		
• Clean surfaces of all signs including chevrons	Supervisor	
• Remove all notices and advertisements from signs	Supervisor/Or	Engineer
• Any damage to signs including chevrons	Overseer	Engineer/DC

Note Or and DC stand for Overseer and Division Chief respectively.

9. SUPERFICIAL INSPECTION REPORT FORM (SAMPLE):

Superficial Bridge Inspection Report

Division:	District:	Road:	
Bridge Number:	Bridge Name:	Reported	Date: by:

Description of Problem

ACTION CHECKLIST

Action by Division	Yes/No	Action Officer	Details
Further Inspection			
Urgent Work			
Routine Work			
Repair Estimate*			
Repair Completed			
Request Bridge Unit support			

*Please attach estimate

Divisional Engineer: ..... Date: .....

Notes and Special Instructions:

10. ROUTINE MAINTENANCE - SCHEDULE

Given below is a *completed sample* Routine Maintenance Schedule. A schedule is drawn up for each bridge by the Division after referring to the Guidelines for Routine Maintenance. This would then form part of the Divisional Bridge Inventory Record for the Bridge.

Routine Maintenance - Schedule

Division:

Bridge Number: H04/97.6		**Bridge** Name: Muglin	**Contractor** Supershift Ltd	**Maintenance Interval** 12 months	**Maintenance Date** 27 July 1995
Item No′	Code No′	Activity	Cost of Work	Remarks: Condition before maintenance	
1	2.1	Remove debris from waterway		Wreaked bus dumped in river,	
2	3.1	Remove graffiti from sub-structure pier			
3	4.1	Clean drainage channel - deck		Much sand and silt washed from hillside	
4	4.1	Deck truss, loose bolts		Reported. Located upstream Muglin side	
5	5.3	Loose timber handrail		Refixed	
6	5.5	Abutment bearing shelf		Cleaned down - fecal deposits	
7	5.10	Bearings		Roller greased	
8	7.1	Signs		Sign missing - reported	

ACTION CHECKLIST

Action by Division	**Date**	**Officer**	**Details**
Schedule prepared			
Estimate prepared (Recurrent maintenance)			
Funding available			
Instructions to contractor			
Work completed			
Total cost			
Additional work required			
Funding requested			

Note: The code number refers to the paragraph number in the Guidelines for Routine Maintenance

Divisional Engineer: **Date:**

11. INTERIM NORMS FOR ROUTINE BRIDGE MAINTENANCE

12. MODALITY OF IMPLEMENTATION OF ROUTINE MAINTENANCE ACTIVITIES

Routine maintenance has been introduced DoR SMD programme III recently in the fiscal year 2061/62. An interim norms has been approved by the Department which will be developed to final norms with the necessary corrections after receiving suggestion from division offices.

The number and total length of bridges vary in each division. The distances between the two bridges vary from few meters to several kilometers. There seem practical difficulties to implement routine bridge maintenance works in the same manner of routine road maintenance works. Thus an effective modality of implementation of routine maintenance works shall be developed. Following modalities are proposed at the starting which may be reviewed and updated.

(1) Form groups of 2 (at least) to 4 labourers as allowed by the approved norms. Assign these group THROUGHOUT the year in cyclic order to various locations of the division so that each bridge is attempted 4 to 5 times a year. This modality is suitable for the divisions having bridges at close distances and having more lengths of bridges.

(2) Total mandays allowed by the norms is calculated. Hire a group of 2 to 4 labourers, for required time, locally and assign the group for the works on the bridges with a workable stretch of road length. Another group is formed for another site accordingly and maintenance works are carried out such that each bridge is attempted 3 to 5 times a year. This modality is suitable for the divisions having bridges at longer distances and having lesser total lengths of bridges.

(3) Divisions may submit any other implementation modalities which are suitable to the respective divisions and discussed with BU/SMD.

(4) The same supervisors from the routine road maintenance works will be used for the supervision works.

Equipment list:

The following equipments are proposed for carrying out the works

1) Safety jackets 2) Gloves 3) Safety helmet 4) Rain coat 5)Bicycle 6) Ladders 7) Other tools such as First aid kit, Axe, Hasiaya, Knife, Hammer, Gainti, Saw, Traffic cones. The equipment list from part 2: Bridge Inspection Manual shall also be referred.

The above equipment are as guidelines, the divisions shall propose other equipment if needed. For the year 2061/62, the divisions should purchase a new set of tools and equipment. SMD has agreed to supplement equipment to those divisions where the assigned budget for the tools and plants are inadequate for the year 2061/62.

As a guide following set of major equipment and services are suggested be provided:

1. One to two bicycles for 2 man-days as per site requirements.
2. Safetywares and raincoat for each man-day labour as per the norms.
3. Ladders and tool sets as following:

up to 1000 m bridge length	1 set
from 1000 m to 5000 m bridge length	additional 1 set
from 5000 m above	additional 1 set