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BRIDGE INSPECTOR'S REFERENCE MANUAL

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BRIDGE INSPECTOR'S REFERENCE MANUAL

BACKGROUND

Quite often persons other than bridge engineers have to be asked to inspect the bridges in their jurisdiction to assist the bridge engineers in their inspections. These "other persons" who are called "bridge inspectors" though experienced are not fully qualified engineers. The Bridge Maintenance and Rehabilitation Committee (B-10) of Indian Roads Congress felt that there is a need to prepare reference manual for such bridge inspectors which will in simple terms provide them with information on various components of bridges, the distresses the bridges undergo during the service life time and guidance on what to look for during their inspections and how to record observations made during inspections. The composition of the Committee is as under:

Bridge Maintenance and Rehabilitation Committee (B-10)

A.G. Borkar	...	Convenor
D.K. Kanhere	...	Member-Secretary

Members

P.C. Bhasin	M.V.B. Rao
S.S. Chakraborty	Dr. T.N. Subba Rao
M.K. Chatterjee	S.A. Reddi
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Secretary, IRC	S.C. Sharma, Chief Engineer (Roads), MOST

Corresponding Members

Dr. V.K. Raina	S.R. Tambe
M.K. Saxena	N.G. Thatte

M.R. Vinayak

The Committee set up a small sub-committee with Shri N.V. Merani as the Convenor, the members of this sub-committee were as follows :-

N.V. Merani	...	Convenor
A.G. Borkar	...	Member
S.A. Reddi	...	Member
P.Y. Manjure	...	Member
D.K. Kanhere	...	Member

The draft prepared by the sub-committee was discussed in two meetings by the Bridge Maintenance and Rehabilitation Committee (B-10) before the Manual was approved by the Committee on 29-11-96.

The draft was approved by the Bridge Specifications & Standards Committee on 12.3.1997, the Executive Committee on 29-3-97 and by the Council of the Indian Roads Congress on 17-4-97.

1. INTRODUCTION

1.1 Periodical and a meaningful inspection of highway bridges is an important essential input for any useful and effective bridge management system for ensuring safe and uninterrupted flow of traffic on our highways. Tremendous economic loss and the likely public criticism resulting from any disruption due to the failure of a bridge or its acquiring 'Highly Distressed' status requiring partial closure or load restrictions do not warrant any neglect or laxity in adequate maintenance of bridges and for that purpose regular inspection through well qualified and adequately experienced bridge engineers is essential. It is well understood that all civil engineering structures require regular maintenance and periodical repairs or replacement of some components during their design serviceable life. Considering the astronomical increase in the number of bridges as a result of the rapid development of highways catering to the continuously increasing preference for road transport, the bridge engineer has now far more bridges to inspect than ever before. It has thus become necessary that the bridge inspecting engineer is assisted by a group of sufficiently qualified, properly trained and well experienced bridge inspectors to carry out more frequent inspection though preliminary yet comprehensive enough to include all listed components and sufficiently informative in respect of important details. Report from such reliable inspectors can go a long way in helping the bridge inspecting engineers to plan their priorities and correctly orient their inspections and the means of field inspections. Such purposefully directed timely inspection from the bridge inspecting engineers would ultimately expedite timely and effective removal of defects or rehabilitation measures which is the main aim of the inspection of our bridges.

1.2. While SP:35 of the IRC, published in 1990, contains guidelines on inspection and maintenance of bridges by the bridge inspecting engineers, this manual aims at providing guidance to bridge inspectors so that their resulting inspection reports provide the bridge inspecting engineers directly responsible for the bridge-management in the specified zone of the highway system under their control, a general picture of the present 'Health-Status' of the concerned bridges with broad indicators towards distress-prone areas or already distressed components needing immediate attention.

1.3. Bridge Inspectors are not fully qualified engineers. However, it is essential that they should be selected from the personnel who have certified engineering skills from any approved institution. The selection will depend on the consideration of the position of responsibility or familiarity with the bridges with experience of minimum of 5 years in bridges. This Manual (Bridge Inspector's Reference Manual) is a guideline for such Bridge Inspectors and it provides information needed to be known by them in inspecting the bridges. Using this Manual such persons with experience should be able to carry out routine bridge inspection of a majority of the bridges. The Manual does not cover large and special types of bridges such as suspension bridges, cable stayed bridges, etc., which are considered beyond the scope of the Manual. As far as possible the technical contents and language have been simplified to make the Manual useful for the people whose knowledge of bridge engineering is not highly developed. The State Government will be advised to translate this Manual into local State language. It must be stressed that this Manual is supposed to only support and guide the bridge inspector in how to inspect the bridges on behalf of the Bridge Engineer. The final responsibility, however, must lie with the Bridge Engineer.

1.4. The manual has been organised into the following further Chapters:

Chapter II	:	Salient Components of a Road Bridge
Chapter III	:	Types of Bridges
Chapter IV	:	Usual Problems with different Bridge materials like Masonry, Bricks, Concrete, Steel and Timber

Chapter V : Types of Damages to various Components of Bridges & Protection Measures against them

Chapter VI : Important points for Bridge Inspection and the Format of Bridge Inspector's Report

The Appendices to the Manual include list of equipment to be used during inspection (Appendix-1), safety precautions for Inspectors (Appendix-2) and Bridge Inspection Form (Appendix-3). Any suggestions for improvement of the Manual will be welcome.

2. SALIENT COMPONENTS OF A ROAD BRIDGE

For understanding the methodology of inspection and systematic recording of observations, it is necessary to briefly define major components of a road bridge as per normally accepted common terminology. Format for a bridge inspector's report has been designed accordingly.

2.1. **Superstructure** (Sketches 1 to 7)

The structural system which supports the carriageway for movement of all vehicular traffic and footpaths where required, for use of pedestrians for crossing over the river or other impediments to the free flow of highway traffic is called the superstructure. This structural arrangement sustains all loads and forces coming from the traffic using the bridge and from other causes such as wind, earthquake, temperature changes, (water currents in case of submersible bridges) and transmits the same to the ground (foundation) through the substructure. Important parts of the superstructure are:

a) Roadway decking slab, curbs, footpaths, railing or crash barriers, approach slab.
b) Longitudinal members-beams, girders, arch/arches, cross-girders, box-girders, etc.

2.2. **Substructure** (Sketches 8 to 16)

2.2.1. Superstructure transmits all its loads and forces to a vertical supporting system which is called sub-structure.

2.2.2. Sub-structure is composed of Piers and Abutments.

2.2.3. The vertical support at each end of the bridge is called an Abutment, while other such intermediate supports are called Piers.

2.2.4. This supporting system of Piers and Abutments in addition to carrying loads and forces trasmitted to them from the superstructure, is in itself subjected to forces from wind, earthquakes, water currents, impact from floating trees and barges, (earth pressure in case of abutments, since they retain the approach road embankment), etc.

2.2.5. Piers and Abutments can be solid or hollow and in different shapes. For the case of spill through abutments the approach embankment is allowed to slope in front of the abutment and is protected by proper pitching with an adequate apron.

2.2.6. Abutments normally have return walls at either end constructed at some angle parallel to the approach road to embankment. These are called Wing Walls. These normally have separate foundations when constructed to the full height of the embankment.

2.2.7. In some cases the wing walls are not for the full height and cantilever out from the abutment ends.

These are called flyback returns and allow the earth to spill through on the sides as well. In some bridges R.C.C. box returns are also provided behind the abutments.

2.3. **Foundation** (Sketches 17 to 20)

2.3.1. All loads and forces coming from the superstructure and the sub-structure are ultimately to be safely transmitted to the earth stratum below the river bed or below other natural soil formation in such a manner that there is no unexpected settlement of the piers and abutments or damage due to scour during the design life of the bridge structure. The structural system which enables such a safe load-forces-transference to the soil strata from the substructure components is called foundations. Foundations may be deep foundations or shallow foundations depending upon their depth below the bed being safely below the maximum expected scour or otherwise.

2.3.2. For deep foundations, normally well foundations are adopted while shallow foundations are mostly open foundations duly protected against scour by a suitably designed pucca flooring, cut off walls, upstream and downstream flexible stone aprons. Pile foundations (Bored, precast and driven, and cast in situ) are normally used in situations away from the river flow spread such as for flyovers or viaducts. However use of large-diameter bored piles is quite common for minor and medium bridges (and sometimes for long bridges also,) where scour is not appreciable.

2.3.3. When span openings are small and individual open foundations are likely to either overlap or come too near each other, a combined raft foundation is used e.g. in the case of a box culvert or a multibox type bridge. Such a foundation too is normally protected on u/s and d/s by a pucca flooring, cut off walls and aprons, (Sketch 46).

2.4. **Bearings** (Sketches 21 to 26)

2.4.1. Temperature changes, both day and night variations and seasonal variations, which can be quite large in many parts of India, bring about elongation or contraction of the superstructure as a whole causing longitudinal movements. Due to flexural effects there are rotations at the ends of spans (for superstructure). These movements and rotations if restricted, can produce undesirable large forces on bridge components. To minimise these forces and to judiciously distribute them for an economical solution with better design life serviceability, ends of superstructure of each span are supported on a bearing fixed on the top of the piers and abutments. Bearings can be sliding bearings, reinforced elastomeric pads, roller and rocker bearings in steel and pot bearings. For submersible bridges and for bridges in earthquake prone zones stoppers are provided against any transverse dislodging movement of the superstructure. These are blocks monolithic with the pier or pier cap, steel bars or girders embedded in pier and projecting above.

2.4.2. For a single span or simply supported multi-span system one bearing is a fixed bearing and the other permits movement. For continuous spans system expansion or contraction is allowed with one end fixed in position and movements being allowed at all others.

2.5. **Expansion Joints** (Sketches 43 to 45)

2.5.1. Between simply supported spans or units of a continuous span system and at the ends of the superstructure adjacent to the dirt wall of the abutments, the gaps are bridged by properly designed bridging arrangements which besides protecting the exposed edges of the deck slab and ensuring smoother rideability allow expansion/contraction of the superstructure. These components of the deck-furniture of a bridge are called expansion joints.

2.5.2. Design of the expansion joints varies with the extent of movements. Proper design, adequately strong and leak-proof construction, correct installation and regular maintenance of the expansion gap are essential requirements for ensuring performance of expansion joints. Badly leaking, loose and knocking, dirt clogged or broken or dislodged expansion joints are not desirable for a bridge. Even the best of such joints installed under strict supervision of the suppliers require periodical replacement and hence the need for proper inspection at regular intervals. Leaking expansion joints have been the cause of serious distress due to corrosion of prestressing tendors and mal-functioning of the bearings. Hence, during inspection of bridges, expansion joints and bearings need special attention.

2.6. **Deck Drainage System**

2.6.1. Nothing can be more annoying to the travelling public, whether in vehicles or on foot than a waterlogged carriageway. Worse still is the resulting likely structural distress due to the presence of moisture for long durations.

2.6.2. Riding surface can have in-adequate cross slope or non-functioning drainage outflow system. These problems also need proper identification during inspection.

2.6.3. Again, water flowing out of the drainage spouts (Sketch 27) should not be allowed to fall on the supporting main girders or cross girders but should be led or deflected away from these.

2.6.4. A properly designed drainage system ensures that water from various well-spaced drainage outlets is collected into a longitudinal pipe along the span and then brought down at pier locations so as to discharge into the stream or into the surface drainage system in case of flyovers.

2.7. **Wearing Course**

2.7.1. Deck-slab forming the main structural component of the carriageway is provided with suitable overlay of adequate thickness either in good quality high strength concrete or in layers of graded bituminous construction. This additional covering layer laid in proper longitudinal and transverse profile is called the wearing course and takes on all the frontal attack of the moving heavy vehicles and that of the natural elements. Deteriorating condition of the wearing course affects rideability and can lead to distress in the structural deck slab and main supporting members from water leaking into the deck through cracks and pot holes, especially when there is no waterproof layer interposed.

2.7.2. Therefore proper attention to assess the serviceability of the wearing course during inspection assumes importance. Any water layer locked in between the wearing course and the structural deck-slab is not desirable. Water is constantly pumped in through pressure of heavy moving vehicles and being often contaminated especially in marine environments can be a dangerous source of distress in concrete and reinforcement.

2.8. **Railings/Parapets/Crash Barriers and Footpath (Precast) Slabs and Kerb**

All these items form a part of the carriageway and are normally constructed after the main load bearing structural system of the span has been completed. Since these are essential for the safety of vehicles and pedestrians, their condition requires to be as meticulously inspected as of the main structural components. Railings may have an open design consisting of vertical posts and horizontal members, parapets and crash barriers and solid kerbs which act as an extreme edge guide for the vehicular traffic and is also continuous and made monolithic with the deck slab (except in the case of submersible bridges, where kerbs are discontinuous with gaps in between and railings which are collapsible or removable.)

2.9. **River Protection Works**

Some bridges have to be provided with river protection works like guide bunds which are to be protected with stones of suitable size, protection to banks and protection to bed. These works need to be regularly inspected and damages should be rectified in time.

3. TYPES OF BRIDGES (Sketches 27 to 32)

Bridges can be classified in accordance to their form of structural lay out as well as on the basis of their construction technology or even materials.

3.1. Structural forms normally used and as have been adopted for our bridges, are:

a) Arches
b) Simply-supported spans
c) Continuous spans
d) Rigid frame type with decking integral with substructure
e) Cantilevers or balanced cantilever spans

3.2. Considering construction materials and construction technology, bridges may be in

a) **Masonry:** Brick/Stone/Plain Concrete blocks/plain concrete normally for small and medium span arch bridges.

b) **R.C.C.:** For long span arches and medium span simply supported T-beams and slabs, box-girders, balanced cantilevers and continuous span systems, (Generally not encouraged in severe marine or chemically charged environment) rigid frames.

c) **Prestressed Concrete:** For comparatively longer spans in simply supported, continuous or cantilever construction both in T-beam and box girder cross-sections. Also used in long span arch bridges and segmental construction with precast or cast-in-situ segments. Sometime a bridge may have a combination of RCC and PSC component members.

d) Steel girders bridges with plate girders or triangulated trusses with built-up members, supporting an RCC deck slab.

e) Composite construction for medium spans using plate girders and RCC deck slab.

(f) Timber bridges for temporary crossings and bridges for lighter loads either as cantilevers or in timber truss and timber deck arrangement.

4. USUAL PROBLEMS WITH DIFFERENT BRIDGE MATERIALS LIKE MASONRY, BRICKS, CONCRETE, STEEL AND TIMBER

Problems with different bridge materials: In bridges, timber, masonry, steel and concrete are the materials which are mostly encountered. This chapter enumerates the deficiencies to be watched in each material.

4.1. **Timber**

4.1.1. The main problems with timber are 'decay' and 'Insect Attack'. There are some problems also with joints. Sketch 33 shows a cross-section of a tree trunk. It has three layers. Bark is the outermost and has practically no strength. The central layer is called 'heart-wood' and the Intermediate layer is called 'sapwood'. The sapwood is usually softer and lighter in colour than the heartwood. Sapwood is, prone to decay and insect attack.

4.1.2. The bark usually stays damp and insects live in it. This leads to decay and insect attack. It is, therefore, necessary to remove the bark from the timber in the bridge.

4.1.3. Decay is caused by a fungus which attacks damp wood. It makes the timber go soft and lose strength. Decay is possible at locations where there is ingress for both air and water. Such locations may be:

a. parts in contact with ground (piles, ends of beams, etc.)
b. where dirt, debris and water collect and where, vegetation grows (joints in a truss, bridge deck, etc.)
c. where fixtures are attached with deep bolts, water can get to the centre of the member through bolt-holes. This type of decay is difficult to see.
d. at the location of splits in the timber. Splits are found in all woods. These lead to decay if water gets in and is retained.

4.1.4. To prevent decay and insect attack, timber is treated with chemicals. Chemicals usually cannot penetrate into the middle portion and, therefore, decay may still occur in the middle portion. While inspecting for decay, it is necessary to look for:

a. Stains on the timber caused by water
b. Soft areas on the surface
c. Soft areas split into small blocks separated by cracks - a sign of advanced decay.
d. Fungus growing on surface of timber - a sign of advanced decay deep inside the timber.

4.1.5. A variety of insects can attack timber. The most damaging are termites and borers. Borers may be marine or land-based. Beetles are land-based borers. Marine borers usually cause severe damage and all piers and piles in salt water must be inspected regularly for these.

4.1.6. There are three simple tests for decay and attack by insects:

1. **Spike Test:** A square spike is pushed into wood to find soft spots. Square spike ensures that the resultant hole is not confused with insect bore-holes at a later date.

2. **Hammer Test:** Decayed timber sounds different from solid timber when hit with a hammer. The member is hit at different locations to find weak spots.

3. **Drill Test:** A 5 mm drill is used for this test. If any decay is suspected in the timber, a hole is drilled at such locations. The different feel of drill will then reveal decay. Too many holes near the joints are ill-advised. After using Spike or Drill test, holes should be plugged with wood-plugs after putting in some preservative like creosote.

4.1.7. There are three points to be attended to concerning joints in timber:

1. Vibration caused by traffic or shrinkage can make bolts in the joints loose. Bolts should, therefore, be checked for tightness.
2. Timber trusses are usually joined by nails. It is important to see that no gap is developed at any joint location.
3. Joints in timber are also made with steel-plates and bolts or pins. Corrosion or damage to steel parts and looseness of bolts pins or plates should be checked.
4. Loss of painting or surface protection should be noted.

4.2. **Masonry**

4.2.1. The four main problems associated with masonry are:

1. Cracking
2. Bulging
3. Loss of pointing
4. Deterioration of brick, stone or concrete blocks

4.2.2. Masonry is bricks, stone or concrete blocks put together with lime or sand-cement mortar in the joints between them. It is strong in compression but weak in tension. It is used for constructing substructure elements like abutments, piers and retaining or parapet walls. Arches may also be built in masonry. As there is no reinforcing steel, there is no corrosion. Well maintained masonry bridges have lasted for more than a hundred years. Vibrations caused or impact given by very heavy vehicles can cause damage to masonry.

4.2.3. **Cracking** (Sketches 34 to 36)

4.2.3.1. Cracking is an indication of distress in masonry. It can be caused by over-loading, vibration or impact from traffic. Failure or settlement of foundation or change in temperature or alternate wetting and drying can cause cracking.

4.2.3.2. Cracking weakens the masonry and allows ingress of water and soil. Plants and small trees could also grow in cracks. These cause the cracks to further widen. It is not always easy to determine the cause of cracking. Masonry expands and contracts with changes in temperature and moisture content. The resulting cracks normally pass only through mortar joints. Cracks which cross bricks, stones or concrete blocks, are usually serious. These cracks could be caused by either over-loading or by failure in foundation. All large cracks should be meticulously mapped.

4.2.3.3. Cracking is to be considered 'serious' when:

1. Cracking occurs near bearings
2. A step occurs in the face of masonry
3. Cracks are about 5 mm and wider

4.2.4. **Bulging**

Bulging is a change in shape or curving of the face of a masonry wall. It is usually caused due to excessive back-pressure. Bulging of masonry parapets can be caused by vehicular impact. The force exerted by the soil behind a wall can increase due to saturation of fill if drainage is inadequate. For draining a fill, weep-holes are provided in the abutments and returns. These sometimes get choked and cause saturation of the fill. Saturation may also be caused by vibration or compaction caused by heavy vehicles, or by shaking caused by earthquakes. The height of fill may also be increased over the years and the mortar usually goes weaker with age, causing bulging. Bulging should be mapped and measured with the help of a plumb-line, where possible.

4.2.5. **Loss of pointing:** Pointing is the mortar seen exposed between bricks or stones or concrete blocks. The mortar gets worn out by river or rain water. Pointing is usually weaker than stones or bricks and deteriorates with age. Loss or weakening of pointing can cause stones or bricks to move or even fall off. Repointing is required to be done periodically.

4.2.6. **Deterioration of bricks or stones**

4.2.6.1. Many weaker types of brick or stone cannot last for a long time. They can be worn away by rain-water or river flow. 'Peeling Off' or 'De-lamination' could be caused by alternate heating and cooling and changes in moisture content.

4.2.6.2. Tapping the stone or brick face lightly with a hammer can cause pieces to break off. This indicates that there is deterioration or weathering. It may then be necessary to protect the surface with a hard mortar, gunite or shotcrete.

4.3. **Steel**

4.3.1. There are six main problems associated with steel bridges, which need detailed inspection:

1. Deterioration of paint or galvanizing/metallizing
2. Corrosion (Sketch 40)
3. Damage (bends or bulges) to steel parts (Sketch 42)
4. Loose bolts or pins or loss of weld
5. Cracking in plates
6. Loss of grease/oil from contact surfaces.

4.3.2.1. **Deterioration of paint or galvanizing/metallizing:** Steel corrodes when not protected from air or water. Protection is provided by paint, galvanizing or metallizing. Sometimes painting is done after galvanizing or metallizing if risk of corrosion is high. Galvanizing is deposition of zinc on steel by a special process. Metallizing is spraying of zinc on steel by a special gun. In air, galvanizing provides more protection than paint. But in saline water, galvanizing or metallizing can peel off and rusting can occur. Paint or galvanizing does not last for many years and renewal is necessary, after thorough cleaning. When steel starts rusting, spots of rust are seen in the paint surface. Water enters through these spots and moves under the paint, causing peeling. Air pollution and 'holidays' in paint or thin layers of paint can lead to quick deterioration of paint. Galvanizing or metallizing deteriorates due to corrosion of zinc. This is apparent when white spots appear on the surface. Proper record of spots at which paint or galvanizing has deteriorated should be maintained and timely repairs should be carried out.

4.3.2.2. **Corrosion:** In contact with air and moisture, a chemical change occurs in steel and it is called rusting or corrosion. If corrosion progresses and becomes severe, the edge of plates appear to be split into thin layers. This is 'lamination'. This is very serious and steel then looses almost all its strength. Rust has a volume larger than the steel it comes from. Where two or more steel plates are bolted or rivetted or welded together, rust can push them apart due to increased volume and can bend the plates or shear-off bolts, rivets or welds. Worst corrosion usually occurs under the deck where dirt, dust and water tend to accumulate. Bird droppings also cause corrosion. Trough decks and jack arch decks are more prone to corrosion as water can accumulate under the concrete filling above the troughs or over members of jack arch.

4.3.2.3. Vehicle or ship/vessel impact can bend a member of a steel bridge. This may weaken the structure seriously. The location of the bend has to be mapped and the bend measured. Stiffened deck-plates may bend under overload.

4.3.2.4. **Loose or broken fixings:** Steel parts are joined by fixings like rivets, bolts or welds. All rivets and bolts must be tight and not broken. Corrosion can lead to breaking of rivets or bolts. By keeping a finger on one side of a rivet and lightly hammering on the other side, any looseness can be detected by the feel (Sketch 41). There are two basic types of bolts, namely, 'bearing bolts' and 'friction-grip bolts'. Friction-grip bolts can be distinguished by markings on the head. Friction-grip bolts are not likely to work loose and need not be checked. Bolts can be checked for tightness by means of a spanner. Each bolt or rivet on a bridge needs to be checked at every inspection.

4.3.2.5. **Cracking of steel:** It is not a usual occurrence, but, sometimes, steel members crack. Heavy loads frequently crossing the bridge, problems with welds or misfits, and faults in steel can cause cracks. A careful look at all welds and holes is required as cracks can often start there (Sketch 37). A crack only in the paint is not serious, but if there is a thin line of rust along it, the crack is usually serious. Every crack should be mapped and its thickness measured with a crack gauge film.

4.3.2.6. Loss of grease/oil from contact surfaces can sometimes occur, leading to greater frictional forces, loss of metal and protection, and corrosion.

4.4. Concrete

4.4.1. Concrete is made from coarse aggregates, sand, cement and water. It is strong in compression but weak in tension, just like masonry. To carry tension, steel bars are provided as reinforcing material. The steel so provided may be tensioned (as in pre-stressed concrete) or un-tensioned (as in reinforced cement concrete). As concrete dries, it always shrinks. There are three ways in which concrete is used in bridges:

1. **Mass Concrete or Plain Cement Concrete:** It is usually without reinforcement (except may be surface reinforcement to cater to temperature and shrinkage effects). Abutments, piers, retaining walls, footways, parapets, arches, filling, wearing course, etc., may be in mass concrete.

2. **Reinforced Concrete:** It has steel bars as reinforcement, and is used for abutments, piers, deck-slabs, beams, box-girders, arches, caps over piers and abutments, dirt-walls, box-returns, etc.

3. **Prestressed Concrete:** It has tensioned steel bars, wires or strands (prestressing steel) and is used for long spans of slabs, beams and boxes.

4.4.2. Some of the main problems associated with concrete in bridges are:

1. Cracking
2. Spalling
3. Corrosion of tensioned or untensioned steel.
4. Erosion and attrition
5. Chemical attack

4.4.2.1. **Cracking of concrete:** Most concrete usually develops cracks. Fine and short cracks may not pose problems but wide and long cracks can always be dangerous. Shrinkage cracks are usually fine. These need not be mapped.

For mapping cracks, the following guidance should be adequate:

1. Measure the length and the maximum width of important cracks and draw them on a sketch.
2. Cracks 1 mm or wider are usually important. Smaller cracks may be important if they occur in vital parts. A simple metal gauge or crack-gauge film is all that is needed to measure crack widths.
3. Crazing or a large number of cracks in a small area should be mapped even if cracks are less than 1 mm in width.

4. Rust staining or white deposits or discolouration along the line of cracks should be noted.
5. An oil-based coloured pencil should be used to mark the ends of important cracks and the date of inspection should also be marked. Glass tell-tales should preferably be attached across such cracks.
6. During subsequent inspection, it should be ascertained if the cracks have lengthened or the tell-tales cracked. The new ends of the cracks should then be marked alongwith the date of inspection.

4.4.2.2. **Spalling:** If some of the conrete in the structure falls away, it is termed spalling of concrete. It is usually caused by corrosion of reinforcement. When steel corrodes, its volume increases and the resulting pressure breaks away or spalls pieces of concrete. Spalling causes a loss in cross-section of a member and a consequent reduction in strength at the location.

4.4.2.3. **Corrosion of untensioned or tensioned reinforcement :** It is a serious problem and can cause a bridge to fail if neglected. Corrosion is caused by water and air getting into concrete and reaching the reinforcement. It is accelerated by the presence of chemicals like salts carried in with water. Ingress of water and air is facilitated by a break in concrete due to cracking, spalling or honey-combing or due to permeable, poor quality concrete, and/or because of inadequate cover to reinforcement. Tell-tale signs which indicate corrosion of reinforcement are:

a. Exposed reinforcement,
b. Occurrence of spalling, and
c. Cracks or rust-stains (discolouration) or leach-marks along lines of reinforcement.

4.4.2.4. **Poor concrete quality:** Concrete of poor quality could be honey-combed, could be permeable, may be starved of cement, may not have specified construction tolerances, may have reacting aggregates and could, therefore, be susceptible to chemical attack. Usually, tests or cores establish permeability, cement content, reactive aggregates or proneness to chemical attack. But a honey-combed concrete can be detected easily by naked eye and indicates concrete of a poor quality. Water marks, discolouration, leach-marks usually indicate that the concrete is of a poor quality. To prevent further damage, ingress of water should be stopped by improving drainage and providing a less permeable protective coat, as otherwise, there will be profuse corrosion.

4.4.2.5. **Chemical attack:** Even without the presence of moss, if the surface of the concrete feels soft and slippery, and if there are a number of small hollows in the surface of the concrete, it can be inferred that chemicals are damaging the concrete. Tests are required to be conducted to determine the depth of carbonation and the extent of attack by chemicals.

5. TYPES OF DAMAGES TO VARIOUS COMPONENTS OF BRIDGES DUE TO NATURAL CAUSES AND PROTECTION MEASURES AGAINST THEM

5.1. Damage Caused by River

5.1.1. The water flowing in a river can pick up material from the river bed or banks and can carry it away. This is called 'scour'. Scour can form large holes in river beds or can wash away large sections of banks. Scour has destroyed many bridges.

5.1.2. Bridges are damaged either when a river changes its course (Sketch 39) or when it is not able to go through the water-way provided. This occurs when:

a) The water-way provided is inadequate for the discharge in the river,

b) The waterway gets blocked by deposition in bed, parts of old bridges, trees, bunds and other debris, or
c) The river discharge has grown over the years due to some reasons.

5.1.3. If a flood is too big for the waterway provided under a bridge, the following can occur:

i. The river washes away the bridge.
ii. It washes away the road-embankment and may go round the bridge. (This is termed "out flanking").
iii. It washes away fill in front of abutments and may scour larger and deep holes in the river bed (scour is large around piers and abutments). If the provided waterway is not sufficient, additional spans or culverts may be provided to carry the extra flood water.

5.1.4. **Protection against scour:** If a river is causing scour, the road embankment, the abutments and the piers need to be protected. It could be 'bed protection' or 'slope protection'.

5.1.4.1. **Bed protection:** To protect the bed from scour, a part or all of the bed at the bridge site needs to be covered at times. The cover is usually provided with stone or concrete block pitching, concrete flooring or paving with stone filled boxes or crates. It is sometimes necessary to carry this protection beyond the width of the bridge. For example, for fast flowing rivers, a long downstream protection may be needed or for bridges on raft foundation, shorter protection may be needed both on the upstream and downstream. Bed protection carried beyond a bridge is usually termed 'apron'. When the volume of apron provided is sufficient to replace the bed-volume likely to be scoured, it is termed a "launching apron".

5.1.4.2. **Slope protection:** Often, the embankment runs across the water-mass flowing along the river-banks, especially in rivers with flat gorges and large flood-spreads. Such embankments can breach unless protected adequately by stone pitching. Some embankments in backwater zone may have to be designed for sudden draw-down condition, and may need extra slope protection. Slope protection is usually in the form of stone pitching or boulder pitching. Armour of stone may have to be provided for embankments in creeks or sea, where the effect of waves is predominant. Settlement or scour can damage slope protection.

5.1.5. **River training**

5.1.5.1. Rivers can change their course, this change can take place either slowly or suddenly. Change of course, after a time, can damage a bridge. Debris or large logs can cause deposition of the bed material carried in suspension by the river. This leads to formation of new islands. Such an island formed upstream of a bridge can cause scour around piers and or abutments. To prevent a river from changing its course river training works are provided. These works generally keep a river on its course. Four ways commonly used for training rivers are:

1. Walls made of steel or timber, sheet piles or stone filled crates.
2. Embankment protected by boulder pitching (also undressed heavy rock-pieces).
3. Groynes made from crates or boxes filled with stone or from timber or steel piles.
4. Trees protected by stone-filled crates or boxes.

5.1.5.2. Groynes are lines of piles or stone-filled crates placed at an angle and projecting partway across the river from the banks. Trees grown along banks keep the banks in place with the help of their roots. Young trees are usually protected by placing stone-filled crates around them, if the banks are vulnerable. Apart from these, river training works can be made of many different types of materials and with different methods of construction. These need to be identified when encountered.

5.2.1. **Water:** Apart from damage caused by water in the river following are some ways in which water can affect a bridge:

1. Corrosion of steel bridges.
2. Corrosion of reinforcement or prestressing steel in concrete bridges.
3. Decay in timber bridges.
4. Damage caused to masonry or stone pitching by water running down its surface.
5. Bulging of walls caused by excessive pressure exerted by water retained due to blocked weep-holes.
6. Washed embankments due to water running down.

Most of these damages can be prevented by providing good drainage on the approaches and good drainage and water-proofing to the deck of bridges. Badly placed water spouts can cause corrosion and other damages. A good filter medium behind abutments and returns and adequate provision of weep-holes is a must.

5.2.2. **Debris, dirt and vegetation**

5.2.2.1. Dirt or debris hold water if they get collected on a bridge structure. The resultant dampness causes decay or deterioration. Vegetation can grow in these pockets and can damage a bridge.

5.2.2.2. Debris carried by the river sometimes collects against piers or abutments. This can cause blocking of waterway, leading ultimately, to out-flanking.

5.2.2.3. Large amount of debris can sometimes get collected against a pier or a superstructure. Force of water on this debris can badly damage a bridge.

5.2.2.4. Normally vegetation is found growing in areas of the bed not used by river. For many bridges, river is found to flow, most of the time, through only a part of the waterway. Grasses or light vegetation is not bad, as it holds the bed-soil in place. Trees large bushes and large plants are bad, as they block the waterway.

5.2.2.5. Culverts and bridge waterways could be choked in arid areas or where rivers have a tendency to deposit sand. When the river flows in floods, the sand may get washed away but when this happens the structure can get damaged.

5.2.3. **Earthquakes:** Sometimes, bridges can be damaged by earthquakes. Earthquakes can cause two common types of damage:

1. Foundation failure causing abutments or piers to move.
2. Dislodging of superstructures, from their bearings. In earthquake prone areas, measures to hold the superstructure in place are usually provided.

5.2.4. **Landslides:** A landslide occurring directly on a bridge can cause a bridge to collapse. If a Landslide takes place upstream of a bridge, water can build up behind it. After sometime the river can break-through and wash away the bridge along with the debris. This does not occur often but, to be safe, changes in the river on the upstream of a bridge should be watched with the aid of local enquiry during inspection.

6. IMPORTANT POINTS FOR BRIDGE INSPECTION AND FORMAT OF BRIDGE INSPECTOR'S REPORT

6.1. A form of inspection report has been given in Appendix-3. The procedure of filling the form has been explained below. It must be remembered that the report form must be filled into "show what you have seen".

6.2. On page 1 of the report form, the number, name of river and location and the bridge to be inspected should be given. The following checklist should be of help:

(1) Check that "it is really the bridge to be inspected."

(2) Check the bridge number.

(3) Check the name of river/nallah.

(4) Check the kilometerage on the road.

(5) Carefully read any instructions that may have been given by the engineer.

(6) Draw a small sketch. On it, mark the end villages, the flow direction, number of spans, piers abutments.

6.3. It is necessary to give a careful second look to the filled-in report, before leaving the site. The following checklist should be of help:

(1) Have all the sections been filled?

(2) Have all the necessary notes and sketches been completed and properly numbered?

(3) Have any points been noticed which are not listed in the form, but which you feel are important?

(4) Has the form been signed with date?

(5) Has the form been tied together with the total number of pages mentioned?

6.4. On page 2 of the report form, construction details and details of services and signs are to be filled in and the following checklist should be of help:

6.4.1. **Construction details:** Each construction detail should be checked correctly and ticked YES or NO carefully.

6.4.2. **Services:** Services may be electricity or telephone cables or gas, oil, water or sewage pipes. It should be verified if the service mentioned on record drawing is still in place or it has been taken away. If any new services, not mentioned in the form, are noticed, a note should be taken and problems, if any, should be written down. If any damage to services is noticed, a note should be taken, in particular, if it could lead to damage to the bridge, like say a leaking water pipe can cause deterioration. A note should also be taken of any damage caused by the staff or authorities manning the services during installation, removal, maintenance or repairs.

6.4.3. **Signs:** Signs are important indicators giving limits on height, width, speed, weight, number of axles, flow direction, etc. The bridge can fail or get badly damaged if vehicles not permitted on the bridge ply over it. Signs should be easy to read, especially for the drivers. It should be verified that each of the required signs is in place. If any damage to the signs is noticed, it must be reported.

6.5. The main part of the report form covers the list of problems which should be looked for. These problems have been listed under different headings, e.g., under the heading "River", report on scour, blockages in waterway, change in course of river, etc. are covered.

6.6. The report form should be filled-in as the bridge is being inspected and on site itself. It should never be filled from memory subsequently or at a place other than the site. Some additional notes and sketches should also be drawn for clarity, if necessary. Sketches should be drawn on the back pages (If any short note is to be written, it should be done in the same line as the problem as far as possible). The answers to questions "How bad" and "How much" depend on the experience of the Inspector and his judgement. It is always advisable to inspect the first few bridges along with an experienced engineer. It is important to be deliberately careful while filling in each line of the report form. Sometimes, it is difficult to assess the extent of a problem or a problem may be difficult to recognise. In these cases, it is necessary to make a note in the report form. When in doubt, it is better to state that doubt instead of writing something incorrect. When all the questions under each heading have been ticked, the "all checked" box can be ticked as YES. If, due to any reason, it has not been possible to answer any of the questions, it is necessary to tick the "NO" box to show that that a particular part has not been inspected or checked fully.

6.7. **Observations During Inspection**

6.7.1. During Inspection a number of points have to be remembered. The inspection report form covers most of these points. The points to be checked while inspecting and the nature and significance of the problems, in brief, have been indicated in this chapter.

6.7.2. **Road approaches and protection**

6.7.2.1. Slopes of approach embankments become unstable if the base of the embankments is being attacked and washed away by the river flow. It is, therefore, necessary to check for scour at the base of embankment slopes. Where scour takes place, the embankment fill slips down. It is necessary to check for slip of embankment fill.

6.7.2.2. If rain water or in case of submersible bridges, river water, on the approaches to bridges is not drained properly water runs down the face of the embankment. This after some time, may wash the fill away. It can also cause damage to parts of abutments and wing walls. Hence, it is necessary to check for erosion of the fill near the abutments.

6.7.2.3. Cracking of the road or the edge of embankments behind abutments indicates that the wall has moved. Any cracking of the road or edge of embankment has, therefore, to be checked. Failure of embankments may be by formation of slip circles or by 'piping'. In both modes, there is loss of materials from around the abutment.

6.7.2.4. Toe walls are usually provided at the end of embankment slopes to prevent scouring away. Sometimes concrete, steel or timber piles may be provided below toe walls. It is necessary to look for any 'away' movement of the toe wall or piles. Though small movements are common these are not serious. Movement of large sections of the wall are serious.

6.7.2.5. **Stone pitching for slope protection:** One of the ways of protecting the slope surface from being washed away by rain or by water running off the road, is by providing stone pitching. It is necessary to look for cracks in the stone pitching. Cracks wider than 5 mm are serious. The stone pitching breaks up if the mortar pointing is poor. Pitching may crack due to settlements in embankment. It is necessary to observe for any scour or erosion at the edges of stone-pitching. Pieces broken off from stone pitching indicate bad undermining.

6.7.2.6. **Stone filled crates/boxes for slope protection:** Wire or wooden crates or boxes filled with stones are sometimes used to protect slopes from getting washed off in floods or due to water run-off from road. These crates can move considerably, and movement has to be checked. The wires and ties should also be checked to verify that these are in place. When the boxes move excessively the top of the slope gets exposed and the road cracks. There may be scour at the bottom of the slope, resulting in settlement of the boxes.

6.7.2.7. **Boulder pitching for slope protection:** For boulder pitching to be effective, the size and weight of the boulders should be such as to prevent the river or tide from moving these. As the embankment gets scoured at base, the boulder pitching sinks into the river bed. Any sinking or washing away should be carefully noted.

6.7.3. **River bed protection**

6.7.3.1. Rivers can damage the river bed under bridges. It is important to prevent this as it usually leads to major damage to bridges. It is necessary to make a note of large holes in the river bed near or directly under a bridge. If the river flow is fast and if the river bed is soft, protection may have to be provided by:

1. Stone pitching
2. Concrete cover slab or concrete block pitching
3. Stone-filled crates or boxes
4. Boulder pitching.
   (All these come under bed protection or aprons).

6.7.3.2. Scour in the river bed usually occurs at the edge of the bed protection or apron. Small scour holes are usually not important. If any scour holes go below the bed protection the same must be noted and reported. It is preferable to illustrate the note by means of a sketch. Cracks in the surface of the bed protection occur usually due to settlement. It is necessary to report all cracks in reinforced concrete aprons but for mass concrete or stone aprons, only large cracks usually need be reported. To find cracks, a spade should be used to scrape off any soil, sand and debris. If cracks are noticed, a sketch should be prepared. It is necessary to check for any sign of spalling of concrete or missing stones from pitching. It is important to remember that stones carried by the river usually cause erosion of the surface of the concrete aprons. For reinforced concrete aprons, corrosion of reinforcement should be looked for.

6.7.3.3. Stone filled crates or boxes can be advantageously used for river bed protection. These are flexible and when scour takes place, they function as a "launching apron". The protection, therefore, is more effective. It is important to look for signs that the stone filled boxes garlanded around piers or abutments, have broken away. If this occurs, the river can very quickly destroy the bed protection. Damage or corrosion of wires and ties could also result in the destruction of protection work.

6.7.3.4. **Boulder aprons:** Boulder pitching or garlanding is used to prevent scour around piers. It is usually necessary to replenish the boulders lost during floods in filling up the scour holes. It is necessary to look for loss of stones of apron or garlanding during inspection.

6.7.4. **River behaviour and training works**

6.7.4.1. During inspection any changes in the river characteristics should be looked for carefully. Most of the changes and problems can be seen when looking from the bridge deck or when looking from the abutments while standing under the bridge. It may sometimes be necessary to walk along the banks for some distance on both sides to check what is happening to the river.

6.7.4.2. **Obstructions in the waterway:** The waterway under a bridge should be clear. Any obstruction can:

a. Cause scour in the bed or banks.
b. Cause successively larger obstruction due to further deposition and entanglement of debris.

It is, therefore, necessary to look for any debris piled up against piers and abutments or in the bed on the u/s of the bridge. Sometimes, the old bridge is not fully dismantled after a new bridge is built nearby. Parts of the old bridge can arrest debris and lead to scour. Under many bridges, some of the waterway is usually dry, except in floods. Farmers tend to put fences or bunds and may be huts on the dry areas and start cultivation. Large plants or trees and shrubs grown in bed can block waterway. Obstructions like these must be removed, especially when on the u/s of a bridge.

6.7.4.3. **Change of river course:** If a river changes its course, it can destroy a bridge, especially when the change takes place on its upstream. To judge whether a river is changing its course, bends in the river upstream of a bridge and condition of banks on bends should be examined, duly considering information obtained from local people. If the bank is steep with trees at the edge, but with nothing else growing on the bank, then it can be inferred that the river is shifting towards that bank. When a lot of water is seen flowing but the bank is not steep and small plants are seen growing with some mud or pebbles on the bank, then it can be inferred that the river is shifting away from that bank. If new islands are forming on the u/s, it means that the river is likely to change its course.

6.7.5. **Training works:**

6.7.5.1. **The river affects the training works in four ways:**

a. The river can attack the end of the training work by moving beyond the u/s end of the works.
b. The river can wash off or disturb/damage the materials of the river training works.
c. Piles or walls may be moved forward due to scour.
d. The river training works may be damaged by floating logs or trees.

6.7.5.2. Sometimes, trees grown on terraces are used to train rivers. The trees are protected by stone filled crates or boxes till they grow. Damage to trees used in river training works should be noted and dead and damaged trees should be replaced.

6.7.6. **Sub-structure and retaining walls**

6.7.6.1. It is usually found that for a bridge, the sub-structure and retaining wings or returns are made from the same material. However, to enable the inspector to fill in the report form properly, all types of materials are covered in each category. Substructure comprises abutments, returns, wing walls and piers.

6.7.6.2. **Concrete abutments, wing walls and return walls**

6.7.6.2.1. In concrete structures, the inspector should look for any cracking of concrete and indicate the important cracks on a sketch. In concrete, cracks are termed important if 1 mm or wider and/or if water seeps through them. Near the bearings, even fine cracks are important and these should be shown on the sketch.

6.7.6.2.2. Spalling of concrete should be noted and the area indicated on the sketch.

6.7.6.2.3. The inspector should indicate areas where the quality of concrete is poor, as apparent from honey combing and/or chemical attack.

6.7.6.2.4. It is necessary to observe leach marks, rust marks discolouration, leakage, cracks and spalling to infer corrosion of reinforcement. At the location of spalling, the cover to reinforcement and the reduction in diameter of the exposed bar or its stage/state of corrosion should be noted carefully.

6.7.6.3. **Masonry abutments and returns**

6.7.6.3.1. In masonry, it is necessary to map all cracks wider than 3 mm at the widest location and also when there is a step across a crack.

6.7.6.3.2. Any cracks near bearings especially if these go all around the bearings, and cracks which run underneath the bearings are important and should be noted very carefully.

6.7.6.3.3. It must be remembered that bulges noticed in abutments are more serious than those noticed in returns. Specially, when a bulge has horizonal cracks in it, careful noting is needed as this is a serious problem. A sketch showing the location and the extent of bulges should be prepared.

6.7.6.3.4. It is important to observe and note poor quality or loss of pointing.

6.7.6.3.5. Any deterioration of the bricks, stones or concrete blocks should be observed and noted.

6.7.6.4. **Stacked abutments and returns**

Stone filled crates or boxes or wire baskets are at times stacked together to form abutments and returns of simple and often temporary bridges. They could be used as abutments for timber bridges, Bailey bridges and steel beam bridges with timber decks. When these abutments settle or bulge, the deck may be damaged and the road may also be damaged. Any change in shape, cracks or hollows or settlement should be noted. The wires and ties can be cut by debris in the river or corrosion or excessive deformation of the crates or baskets. It is, therefore, necessary to inspect and note the condition of the wires and ties.

6.7.6.5. **Timber abutments and returns**

Abutments and returns are sometimes made of logs tied or spiked together. Usually, these are provided for log bridges. Timber piles topped with timber cross-beam are used as abutments for timber bridges. Timber in contact with ground and water is prone to decay and insect attack. The ties and spikes can corrode and decay. It is necessary to check for the following during an inspection

1. Decay-near beams of spans, near ground and at water level.
2. Insect attack-at the seat of beams on abutments.

6.7.7. **Piers**

6.7.7.1. The different types of piers are shown in Sketches 8 to 12. Boat inspection may be needed to inspect bridges on perennial rivers or on creeks. Ladders or some other arrangement may have to be provided for inspecting piers. In general, piers need to be inspected for the following:

i. Scour near the base of the piers.
ii. Damage near the base or damage to wells or piles including corrosion.
iii. Movement of the piers.
iv. Damage due to impact from boats, vessels, floating logs or trees or vehicles passing under the bridge.
v. Debris resting against piers.
vi. Vegetation growth on the piers.
vii. Leakage of water from expansion joints damaging the piers.

6.7.7.2. Concrete Piers: For piers built in concrete, it is necessary to inspect for the following:

i. Cracking of concrete, especially around bearings, in pile caps, wells and pier caps. Important cracks should be shown on a sketch.
ii. Spalling of concrete: Spalled areas should be shown on a sketch.
iii. Corrosion of reinforcement with special attention given to rust-stains from cracks and areas of spalled concrete. If exposed, the loss in bar diameters should be measured.
iv. Areas of poor concrete especially showing honey combing and chemical attack.

6.7.7.3. **Masonry piers:** For piers built in masonry, it is necessary to remember that cracks can be caused by failure of foundations. These cracks are usually long and go deep into the body of the piers. Overloading may cause cracks around bearings. These may also be caused by free bearings prevented from moving. For piers in masonry, the following points need to be inspected:

i. Cracking of Masonry, especially long and wide cracks and any cracks near bearings.
ii. Poor pointing can lead to problems. Brick or stone masonry piers can be seriously weakened by loss of mortar pointing by erosion due to river flow. The flow of water past a pier and alternate wetting and drying can damage the pier material.
iii. Deterioration of bricks or stones should be tested by hitting the surface with a hammer. If pieces fall off, the indication is that the bricks or stones are in poor condition.

6.7.7.4. **Steel piers:** Steel piers are usually trestle piers and each trestle consists of a number of members jointed together. For steel piers, it is necessary to inspect for:

i. Debris in the joints of the steelwork, leading to corrosion.
ii. Deterioration of paint or galvanizing/metallizing.
iii. Corrosion, especially near water level and in creeks, in the portion between HTL and LTL.
iv. Bends in steel members and joints, usually caused by barges or logs/trees impacting.
v. Loose bolts or rivets and lost welds or cracks near welds and bolt holes.
vi. Cracking especially near bearings.

6.7.7.5. **Timber piers:** Wet timber decays. For timber piers, it is necessary to inspect for:

i. Debris in the joints.
ii. Decay at joints and near water levels.
iii. Insect attack especially below water level in salt water. Attack by marine borers is very common here.
iv. Splits in timber, especially near bolt holes and at or below water-level.
v. Loose bolts or pins at joints.
vi. Bends in timber, which may be caused by impact or overloads.
vii. Corrosion of steel parts especially at water level.

6.7.8. **Superstructure**

6.7.8.1. **General:** Each span of a bridge will have to be inspected and each superstructure will have to be recorded in a separate part of the form. The general inspection should be carried out both from the top of the deck and from under the deck. The points to be checked during general inspection include:

i. Impact damage to beams trusses or bracings caused by vehicles, boats or logs.
ii. Debris and vegetation on beams, trusses, bracings or in joints.
iii. Water coming through the bridge deck, signs of wetness on steel work, on timber and on concrete, respectively in the form of rust marks, water run marks and dark areas with build up of white material on surface, should be noted.
iv. Water from the deck-drainage flowing on the girders, trusses, beams or bracings.
v. Adequate headroom for overbridges exists and is not encroached upon. The actual head room should be noted.

vi. Excessive deflections in superstructure.

vii. Cracking and spalling in superstructure.

6.7.8.2. **Concrete girders:** If cracks are noticed, these should be measured for length and maximum width. A sketch should be included in the report. Date and ends of cracks should be marked and preferably glass tell-tales should be attached. The progress of the cracks already identified in the previous inspections should be observed and noted. For concrete girders, it is important to look for the following:

i. Cracks at ends of beams which spread up from the bearing seat (Sketch 38). It is a serious problem.

ii. Cracks parallel to the beams on the faces of bottom bulbs of beams. These cracks are normally due to corrosion and occur when the concrete in bulb-corners is about to spall. It is necessary, therefore, to tap the concrete here firmly with a hammer.

iii. Spalling of concrete which may be due to external impact or corrosion of reinforcement.

iv. Signs of corrosion of reinforcement. If any reinforcement is visible, a note of the concrete cover and loss in diameter of the bar should be taken in the report.

v. Signs of poor quality of concrete, especially at the corners of bottom bulbs.

6.7.8.3. **Steel girders and bracings:** The parts of a steel girder are shown in Sketch 32.

For steel girders, it is necessary to inspect the following:

i. Deterioration of paint or galvanizing or metallizing on all main and cross girders.

ii. **Corrosion of steel:** Special attention should be given to wet areas and areas where debris accummulates. Ends of beams and girders also get badly corroded. Corrosion causes two very serious problems. These are:

   (a) Lamination &

   (b) Steel sections forced apart by increase in volume due to rusting. This causes rivets, bolts or welds to snap.

iii. Bends in webs and flanges of girders and bends in stiffeners and bracings: Serious overloading could cause bends along the length of girders. These are serious. The size of the bends should be measured by using a string-line and mapped as far as possible.

iv. **Loose bolts, rivets and lost welds:** All these should be marked clearly on the structure with paint and on a sketch. Joints with loose bolts/rivets or lost welds should be shown (Sketch 41)

v. **Cracking:** Cracks at the locations of welds and holes should be sketched and marked on the girder with paint. Cracking can be very dangerous.

6.7.8.4. **Steel trusses:** During inspection of steel trusses, attention has to be given to the following points:

i. Deterioration of paint, galvanizing or metallizing. This should be looked for especially at joints.

ii. **Corrosion:** Corrosion normally starts at joints. The joints of the bottom chord are affected first. Where corrosion is apparent, lamination should be looked for. Signs of forcing apart of plates should also be searched.

iii. **Bends in truss members:** Any bend member should be marked with paint and a sketch drawn. As far as possible, the size of the bend should be measured.

iv. **Bent or damaged joints:** Damaged or bent joints should be marked with paint and a sketch drawn.

v. **Bent or damaged bracings:** The pattern of the bracing system should be sketched and damged members should be clearly shown on the sketch and marking done in paint on the members. The bends should be measured, if possible.

vi. **Loose bolts/rivets and lost welds:** All these should be marked on site with paint also indicating the affected joints. A sketch showing the locations of damage should be drawn. Any bending or displacement of truss as a whole out of plane should be measured and marked and also shown on sketch. Any distress or any displacement in pins of pin-joints should be noted.

vii. **Cracking:** This is serious in trusses as it can lead to sudden collapse as the members are usually small. The cracks should be marked with paint and sketched. Cracks in trusses should be reported to the higher authorities as soon as possible.

6.7.8.5. **Timber decks:** These include log bridges, timber beam bridges and bridge decks made from laminated timber. Log bridges normally have a short life, being used for temporary bridges. However, these can last for a long time if properly constructed and maintained. For timber bridge decks, it is necessary during inspection, to give attention to the following points:

(i) **Decay any where in the timber:** Areas of dampness and locations around nails and spikes should be closely inspected for decay. If beam ends rest on ground or are likely to come in contact with soil, the ends decay faster. The ends of beams should be carefully inspected for decay. Logs having bark in place should be inspected very carefully and the bark should be removed wherever possible without endangering safety. The extent of decay should be assessed and noted.

(ii) **Insect attack:** The extent of insect attack should be assessed and noted. The spike test, hammer test and/or drill tests should be used. The size and depth of bad area should be ascertained upto a point where good timber is encountered. These should be sketched and recorded.

(iii) **Splitting of timber:** In timber, two types of splits are important and need be noted:

(a) Very large splits, tending to get larger, and

(b) Splits which may allow entry of water into the member but will not allow it to drain. In this context, splits in the top are dangerous as they do not drain. Cracks near the soffit can drain water off. Splits in glue laminated bridges can be serious, but these beams are not used in India.

(iv) Loose or corroded nails, spikes or fixing wires.

6.7.8.6. **Masonry jack-arches:** For masonry jack arches, the following points should be properly inspected:

(i) **Change in shape of arch:** This is usually a result of overloading or failure of arch material. If the change of shape is significant, the arch may have to be rebuilt.

(ii) Cracking or spalling of the bricks or stones,

(iii) **Pointing of arches:** Poor quality pointing or lost pointing can cause serious damage.

6.7.8.**7. Masonry arches**

6.7.8.7.1. For masonry arches, the most important observation is the change in shape of the arch. This could be observed in the following manner:

(i) Standing a long distance away, compare the shape on the left of the arch centre with that on the right. Sometimes, observing the shadow lines reveals a lot of information.

(ii) Look for any shift in the key stone at centre of face walls.

(iii) From underneath the arch look for any change in shape of barrel, even locally.

6.7.8.7.2. The arch barrel should be checked for any cracking. The cracks should be mapped. Cracks across the roadway are usually dangerous signs. Other important crack is due to separation of the face walls from the arch barrel. These cracks run in traffic direction. Alternatively, there may be bulging of the face walls. Any bulge in the face walls should be sketched.

6.7.8.7.3. Spandrel or face wall should not separate from the arch as shown in sketch.

6.7.8.7.4. Any spalling of stones or bricks from the arch or from spandrel walls should be noted.

6.7.8.7.5. Quality and loss of pointing should be noted.

6.7.8.7.6. **Leakage through arch:** With the effects of weather and water, the materials of the arch generally deteriorate. Some water leaks through most arches. Small leakage does not cause problems. If the leakage is large, white stains can be observed near joints and even clear wet areas can be seen. If leakage is excessive, the arch gets damaged.

6.7.8.7.7 **Scour under arch foundation:** This can be observed by pushing a long pole into the ground under the foundation of an arch bridge. If the pole can be pushed in, there is a problem of scour.

6.7.9. **Bearings**

6.7.9.1. **General:** Bearings of some kind or the other are provided under the deck. But it is not possible to inspect all parts of a bearing. The parts not inspected should be recorded as "not inspected". While inspecting bearings it is firstly important to identify which bearings are fixed and which are free. Pedestals and areas under bearings are normally wet places where debris and vegetation collect. During inspection, attention should be given to the following:

(i) Debris and Vegetation around bearings and pedestals, these can damage a bearing and can also lead to malfunction due to obstruction to movement or jamming.
(ii) Poor drainage on top of cap under pedestals and of pedestals themselves: Any signs suggesting continued accumulation of water during rainy season and after floods recede, should be recorded.
(iii) **Prevented/Restricted Movements:** This point is difficult to determine. Small debris accumulation cannot usually lead to this as the weight of the deck is large.
(iv) Bearings not properly seated.
(v) Span or deck not properly seated on bearings.
(vi) Damages to pedestals.
(vii) Damaged or missing grease boxes and missing parts.
(viii) Other extraneous supports inadvertently left in place during construction or inserted later on.
(ix) Cleanliness of the area around bearings.

6.7.9.2. In addition to the above, there are some important points specific to the type of bearings and these are given below:

6.7.9.2.1. **Elastomeric bearings:**

(i) Splitting, tearing or cracking of elastomer

6.7.9.2.2. **Metal bearings**

(i) Fallen cut segmental rollers
(ii) Corrosion.

(iii) Problems in lubrication system.
(iv) Damages to pins, knuckles and sliding or rolling surfaces.
(v) Cracks and bends in metal parts.

6.7.9.2.3. Other types of bearings may include concrete roller bearings, PTFE bearings, pot bearings, dish and knuckle bearings. Any damage to these or any malfunction should be recorded.

6.7.9.2.4. **Restraints:** On bridges in severe earthquake zones or on submersible bridges, deck restraints are usually provided, to prevent the span from falling off. The restraints may be of the following types and any damage or looseness should be recorded:

(i) Large bolt or bolts.
(ii) Concrete or R.C.C. Stoppers.
(iii) Special restraining bearings.

6.7.10. **Expansion joints**

6.7.10.1. Various types of expansion joints may be provided on bridges. The type provided and locations for a particular bridge should be ascertained from records. Physical verification should be done to ensure that the record is correct. Expansion joints can mostly be inspected from above. But sometimes, sound of loose plates or damage or leakage can be noticed from under the deck.

6.7.10.2. For expansion joints, the following points should be inspected:

(i) Damage to the concrete of the superstructure or of the dirt wall.
(ii) Debris or vegetation in the joints-stones or other debris can stop some of the parts from moving.
(iii) Loose or damaged fixtures and fastenings. This is a common problem with bolts and steel parts.
(iv) Damage or corrosion to metal parts of the joints.
(v) Damages to rubber water seals-some joints have a water-seal to prevent water and debris from the deck getting into the joint. Stones rubbing on water-seals can puncture the same.
(vi) Fingers of the finger type expansion joints may deform or snap or debris can arrest their movement.

6.7.11. **Parapets and railings**

6.7.11.1. Railings may be removable or fixed and are usually made of angle iron posts and G.I. Pipe railings. For submersible bridges, collapsible railings are sometimes used. Parapets are usually solid or with patterns and may be made of masonry, concrete, R.C.C. or steel. For some bridges unsurmountable or deflecting crash-barriers may also be provided. Log bridges or culverts may have only guardstones. Parapets and barriers can get damaged by impact from vehicles. Sometimes, this causes damage to the superstructure near parapets.

6.7.11.2. The following points need to be inspected:

(i) **Impact damage to parapets:** A note should be made of any damage to parapets and also to the bridge at that location.
(ii) Loose or damaged fixtures and fastenings.
(iii) **Posts loose at base:** This is relevant when precast R.C.C. or P.C.C. or steel or timber posts are fitted into holes in the concrete runner members.

In addition, some points specific to the material of the parapet also need be considered.

6.7.11.3. **Steel parapets**

(i) Damaged galvanizing or paint
(ii) Corrosion

6.7.11.4. **Concrete parapets**

(i) Cracking
(ii) Spalling of concrete-at corner posts and rails
(iii) Corrosion of reinforcement-especially at corner posts and rails and at locations of spalled concrete
(iv) Poor Concrete and
(v) Vegetation and debris

6.7.11.5. **Timber parapets**

(i) Decay-especially at bases of posts and at joints
(ii) Insect attack
(iii) Splits in timber
(iv) Vegetation and debris

6.7.11.6. **Masonry parapets**

(i) Serious Cracks-Masonry cracks under vehicular impact and gets pushed outwards. Small cracks are usually not important.
(ii) Outward movement or bending of parapets
(iii) Poor Pointing
(iv) Deterioration of brick or stone in parapets

6.7.12. **Wearing course and footpaths**

6.7.12.1. The road surface on a bridge i.e. the wearing course, can be of bituminous materials, concrete, steel or timber. If footpaths are of the same materials, the report can be made for both together. Otherwise, report on road and footpaths should be separate.

6.7.12.2. Bituminous wearing course-where small movements are expected at expansion joints, bituminous wearing course can cover the gap at the joint. The surface often cracks or breaks up over these joints. The following points need attention.

(i) Wearing course breaking up or lifting off the deck concrete-especially at expansion joints and water-spouts.
(ii) Cracked wearing course above buried joints-any damage to or exposure of the water proofing layer, if any, between the deck and wearing coat should be noted.

6.7.12.3. **Concrete wearing course:** The following points need attention:

(i) **Cracking of concrete:** Any cracks which begin in spalled areas of the superstructure could be serious.

Long span bridges especially cantilevers can deflect considerably and induce cracks.

(ii) Spalling of concrete (Sketch 47)

(iii) Exposed and corroded reinforcement

(iv) Poor concrete

(v) Wear of the surface due to small stones on the wearing course and those lodged in tyre surface.

(vi) Loss of filling in bituminous joints

(vii) Potholes in the wearing course

6.7.12.4. Steel and Timber Wearing Course are usually not encountered. However, the basic points as for other wearing course remain the same. Points related to materials themselves should also be given attention.

6.7.13. **Utilities:** Utilities like water pipe lines, electric cables, telephone cables, gas lines, etc., may be provided on the deck or under it. The following points need to be checked:

(i) Whether or not the utility is authorised

(ii) Whether any leakage is seen

(iii) Damage caused by leaking utilities

(iv) Damage caused to utilities themselves

6.7.14. **Electric poles:** On some bridges near cities, electric street lights are provided. The fixing arrangement may be in concrete pedestals, but holding down is usually by bolts. The pedestals also get damaged by vehicular impact. The poles, at times may get bent. The lights may not be functioning. The holding down bolts may corrode and snap. The condition of all these components should be noted and recorded.

6.7.15. **Culverts**

6.7.15.1. As the openings in the culverts are small, blockage by debris and vegetation is often found. At places, people may try to impound water by providing stone slabs or such other obstructions in front of the openings on the upstream of the culverts. Unless these obstructions are removed before monsoons, the culverts are likely to be damaged, and outflanking is also possible.

6.7.15.2. For culverts, the following points need to be inspected:

(i) Debris, vegetation, etc. inside or near the culvert

(ii) Settlement of parts of the culverts.

(iii) Scour at ends of culverts and at edges of aprons. Usually there is silting on the u/s and scour on the d/s.

6.7.15.3. **Concrete culverts:** For these, the following points should be inspected:

(i) Cracking

(ii) Spalling

(iii) Corrosion of reinforcement

(iv) Poor concrete.

6.7.15.4. **Culvert aprons:** Like some bridges, some culverts may be provided with aprons, usually on the d/s. Scour may cause the aprons to settle at the edges. Concrete or stone pitching may crack and break up. Any damage to or loss of material from the aprons should be recorded.

6.7.15.5. **Headwalls:** Embankment at the ends of the culverts is retained by headwalls. These walls may be in masonry or in concrete. If the headwalls settle or get pushed outward, the flow can damage the wall as well as the embankment. It is, therefore, necessary to check for movement of headwalls, especially at the joint between the barrel around waterway opening and the headwall. In addition, depending on the material, the following points need to be inspected:

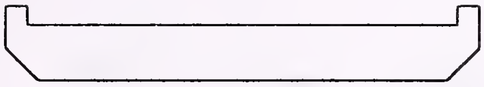
(i) For concrete headwalls, cracking, spalling, corrosion of reinforcement and poor concrete.
(ii) For masonry headwalls, cracking poor pointing, and deterioration of bricks or stone.

6.7.16. **Miscellaneous**

6.7.16.1. **Access:** For any inspection or monitoring, easy and preferably comfortable access to all parts of a bridge or culvert is necessary. The bridges should be inspectable and maintainable and access plays a major role in these operations. It is for this reason that mobile inspection units specially developed for the purpose of detailed inspection are used these days. Older bridges may not have been provided with access arrangements. Newer bridges may have some arrangement for access. Where provided, the condition of the access arrangement should be recorded. The problems encountered due to non-provision of access arrangement or inadequate access arrangement should be recorded. If any hollow component, like a box super-structure or hammer head is found to be without access for going inside the box, the same needs to be recorded and brought to the notice of higher authorities.

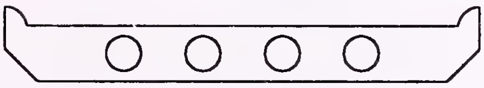
6.7.16.2. **Instrumentation:** Some bridges under distress or some important long span bridges with innovative design may be provided with instrumentation for monitoring stresses, etc. The condition of the instrumentation provided and whether the same is functioning, may be noted, if possible.

SKETCHES



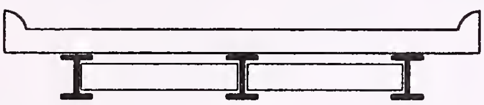
R.C.C./P.S.C. SOLID SLAB

SKETCH 1



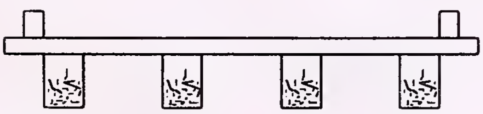
P.S.C/R.C.C. VOIDED SLAB

SKETCH 2



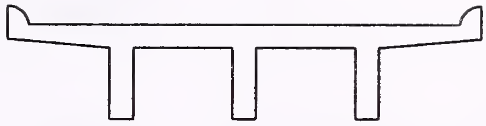
STEEL GIRDER AND CONCRETE DECK SLAB

SKETCH 3



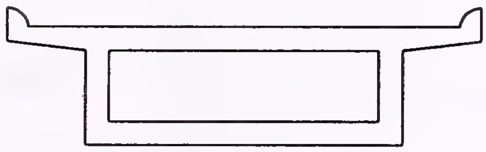
TIMBER BEAMS & DECK

SKETCH 4



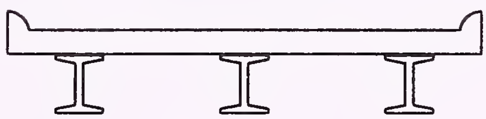
P.S.C./R.C.C. GIRDERS AND DECK SLAB

SKETCH 5



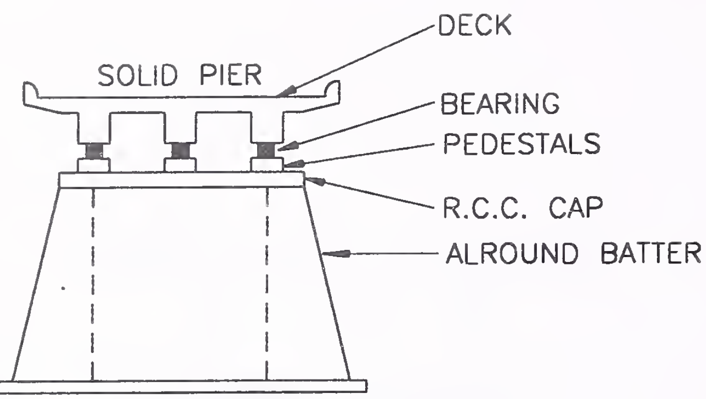
P.S.C./R.C.C.BOX GIRDER

SKETCH 6

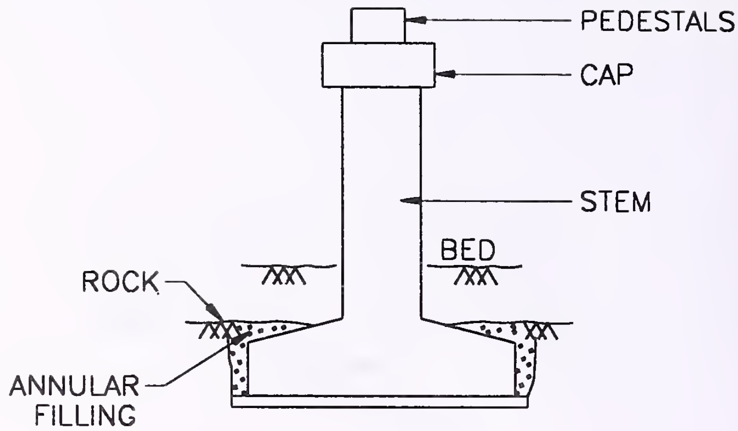


PRECAST GIRDERS AND CAST-IN-SITU DECK SLAB

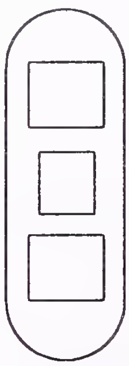
SKETCH 7



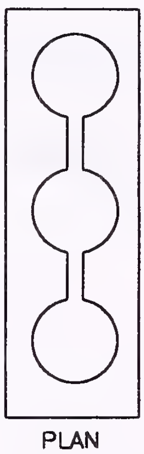
SKETCH 8. SOLID PIER



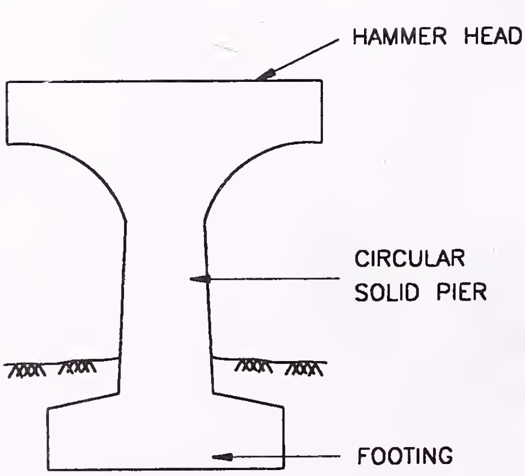
SKETCH 9. C/S R.C.C. WALL TYPE PIER



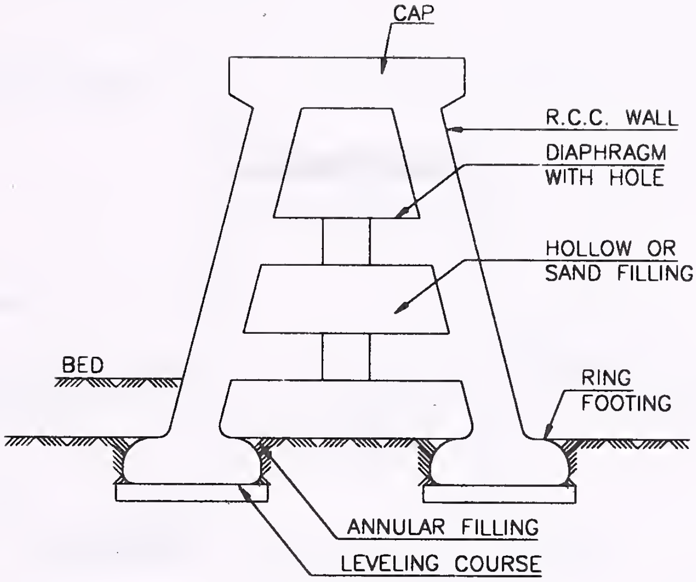
SKETCH 10. CELLULAR R.C.C
/P.C.C. CONCRETE
PIER (PLAN)



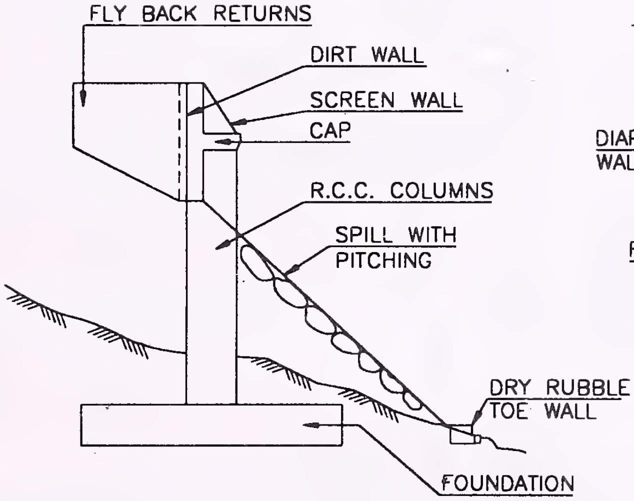
SKETCH 11. R.C.C. TRESTLE PIER



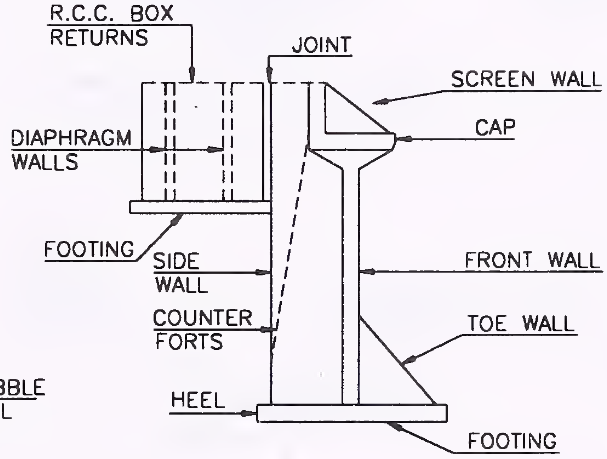
SKETCH 12. SINGLE CIRCULAR SOLID
R.C.C. PIER WITH HAMMER HEAD



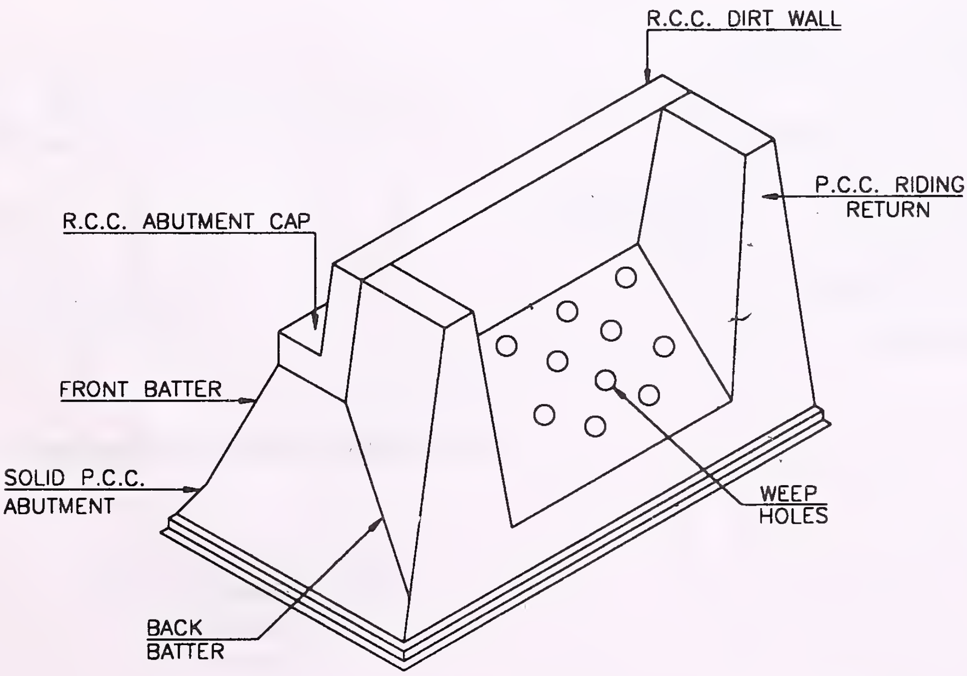
HOLLOW CIRCULAR R.C.C. PIER
SKETCH 13



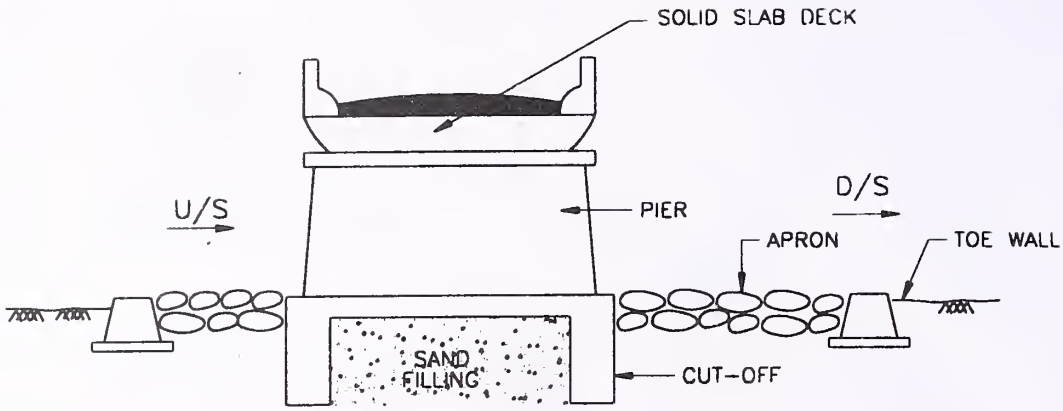
R.C.C. SPILL-THROUGH ABUTMENT WITH FLY-BACK TYPE RETURNS
SKETCH 14



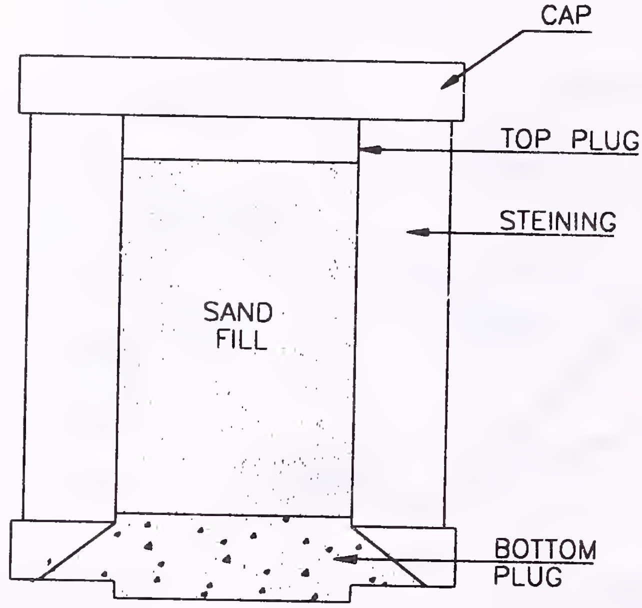
P.C.C. COUNTERFORT ABUTMENT
SKETCH 15



SKETCH 16

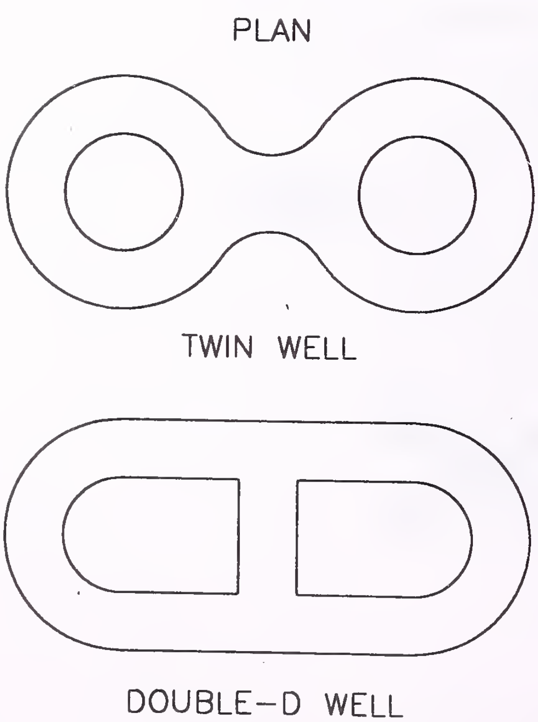


SKETCH 17. C/S OF RAFT FOUNDATION

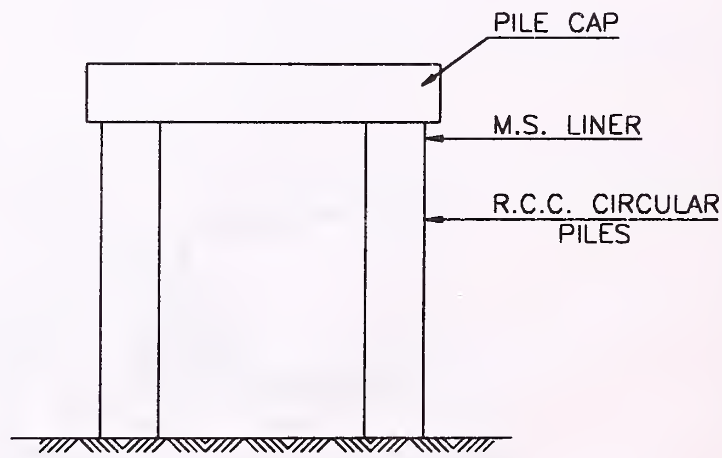


C/S OF SINGLE CIRCULAR WELL

SKETCH 18

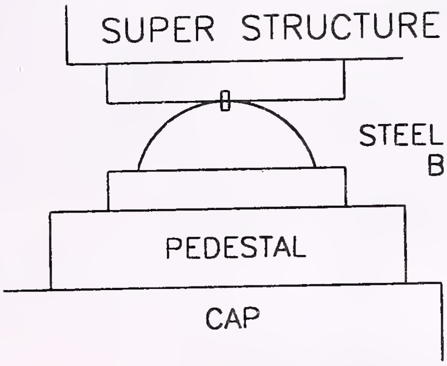


SKETCH 19

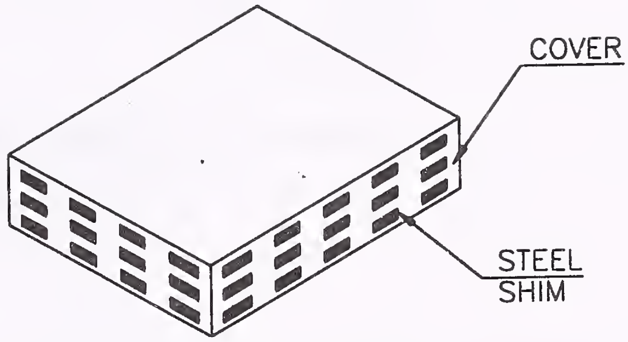


C/S OF TYPICAL END BEARING PILE FOUNDATION

SKETCH 20

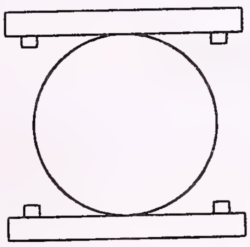


SKETCH 21



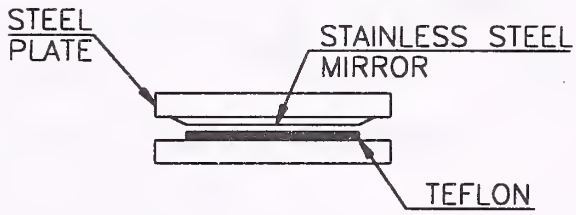
MOULDED RESTRAINED NEOPRENE BEARING

SKETCH 24



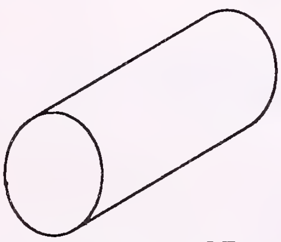
SINGLE STEEL ROLLER BEARING

SKETCH 22



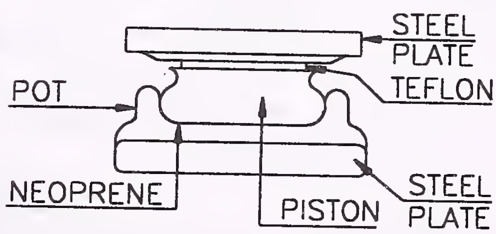
SLIDING PTFE BEARING

SKETCH 25



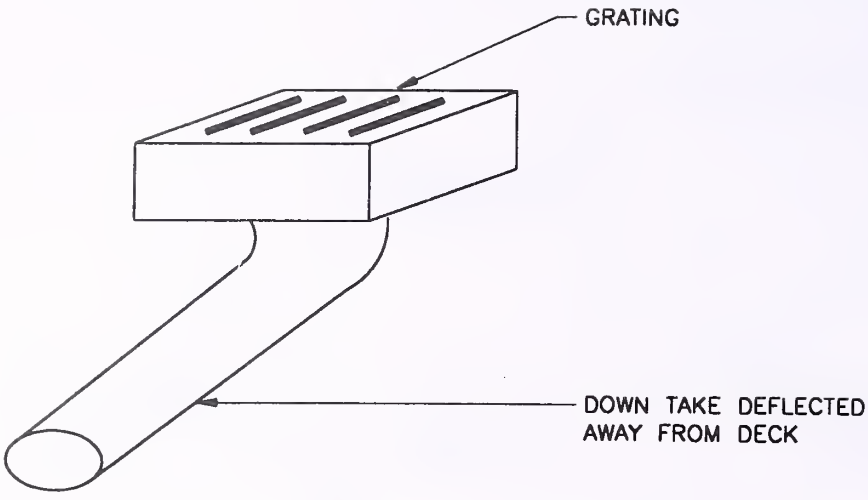
CONCRETE ROLLER BEARING

SKETCH 23

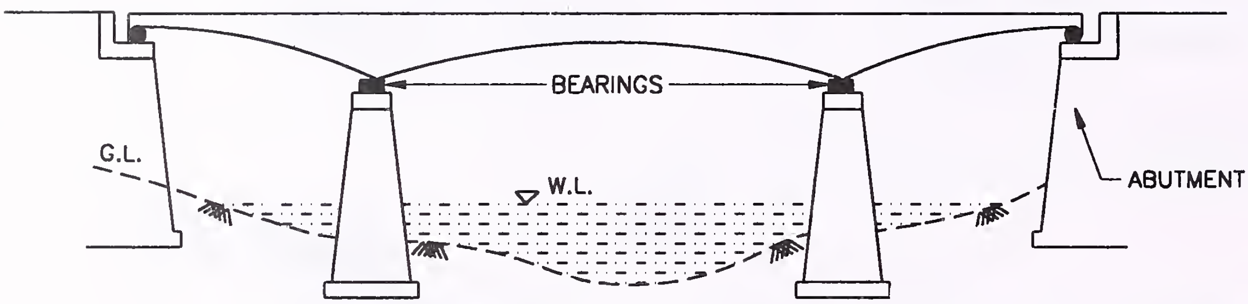


POT PTFE BEARING

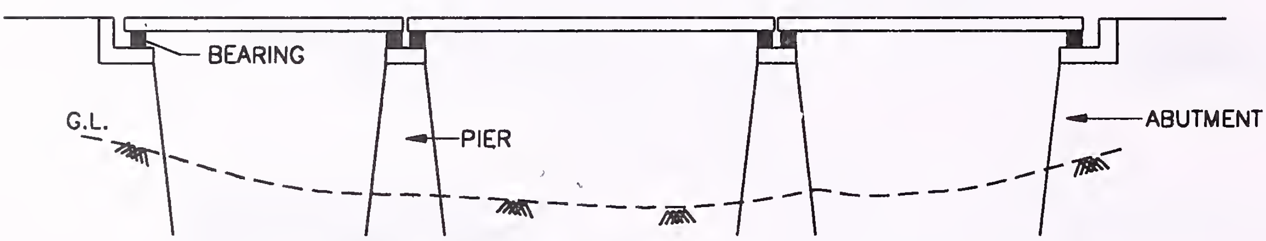
SKETCH 26



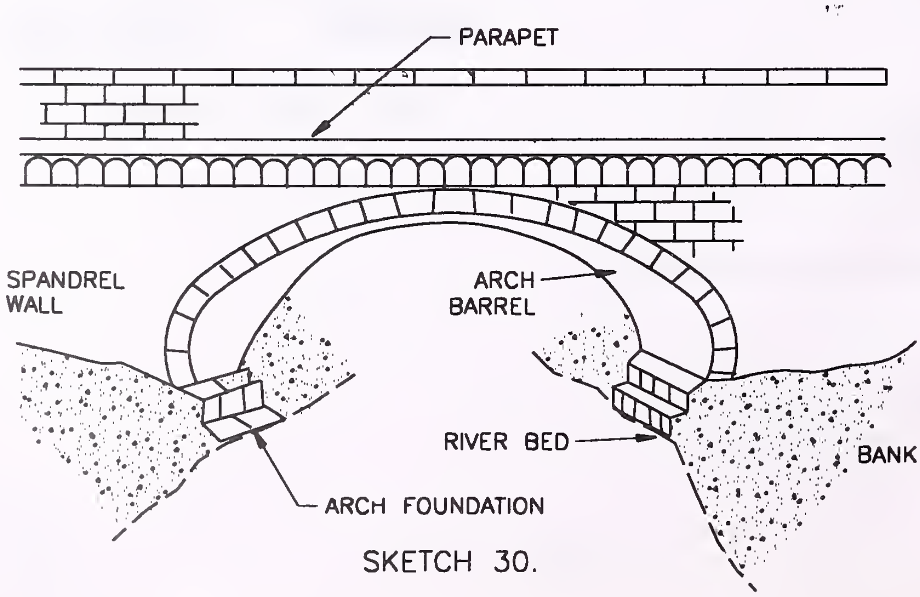
SKETCH 27. A TYPICAL WATER-SPOUT



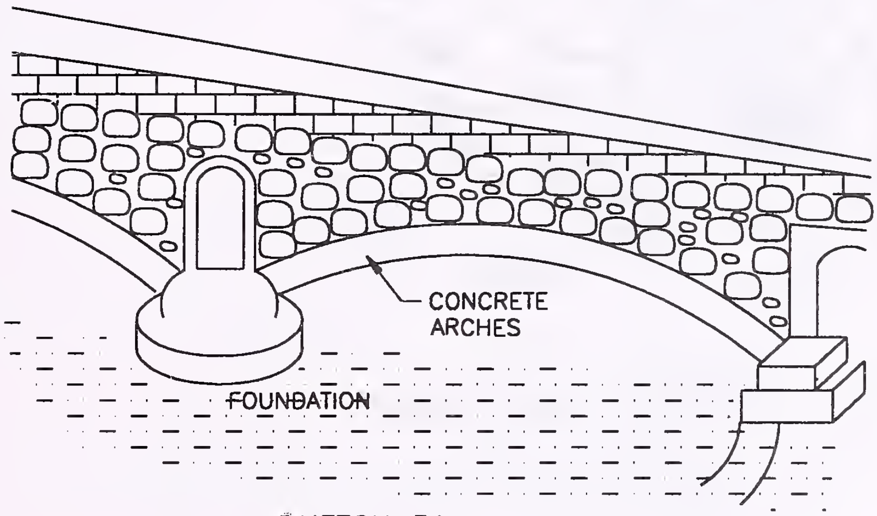
SKETCH 28. A THREE SPAN CONTINUOUS BRIDGE



SKETCH 29. A MULTI-SPAN SIMPLY SUPPORTED BRIDGE

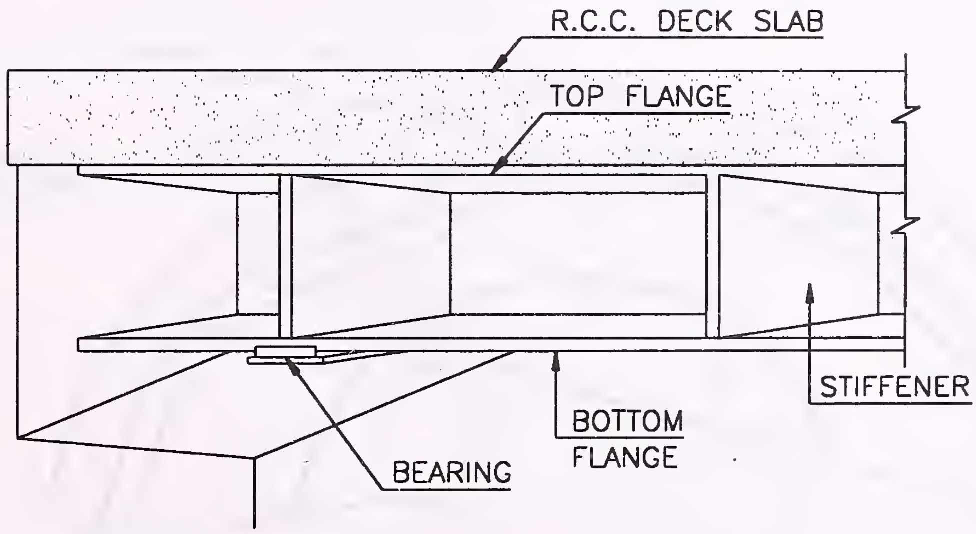


SKETCH 30.

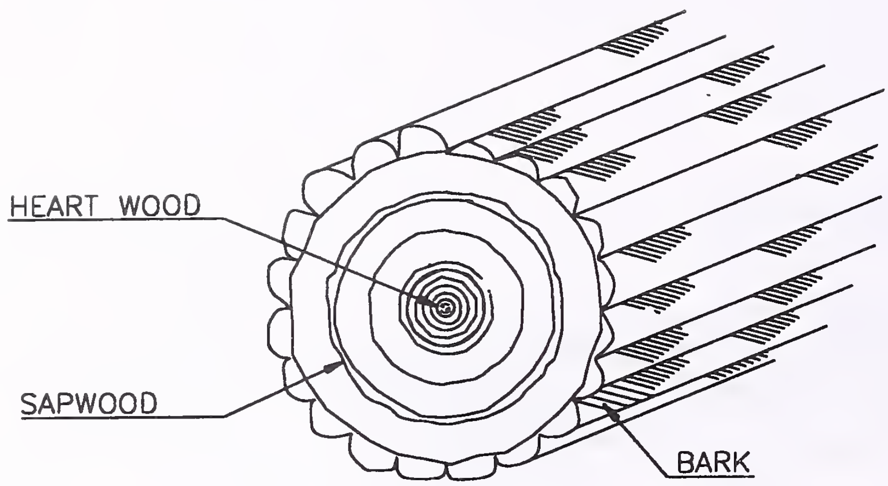


SKETCH 31.

FIG30.DWG

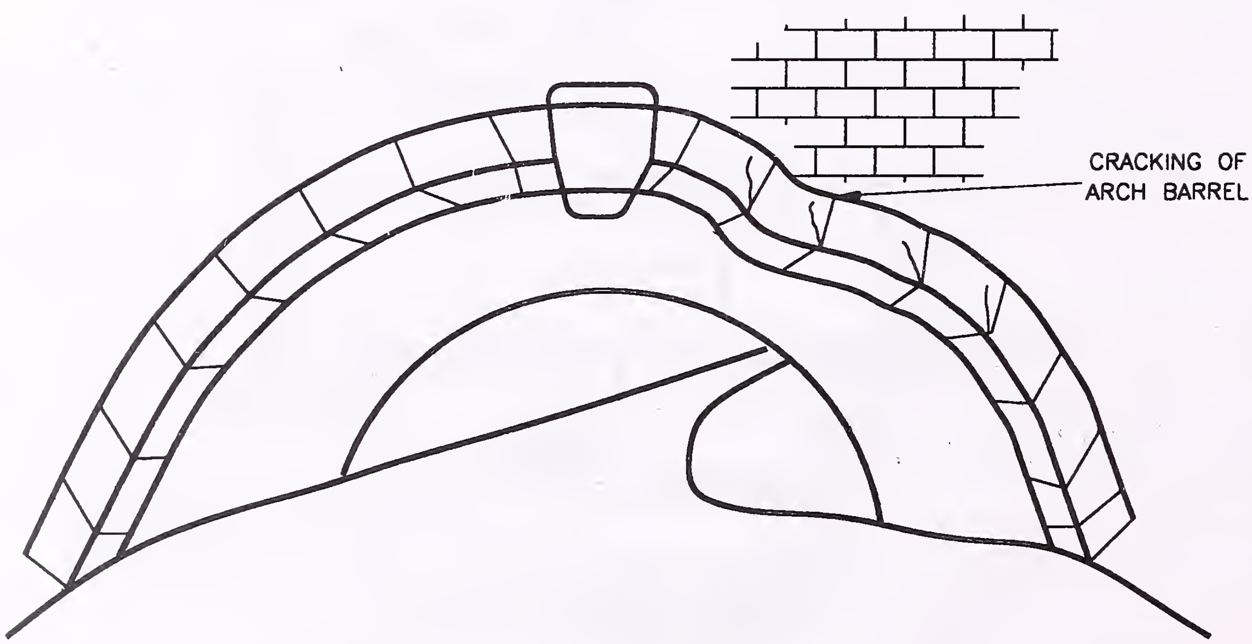


STEEL GIRDER
SKETCH 32



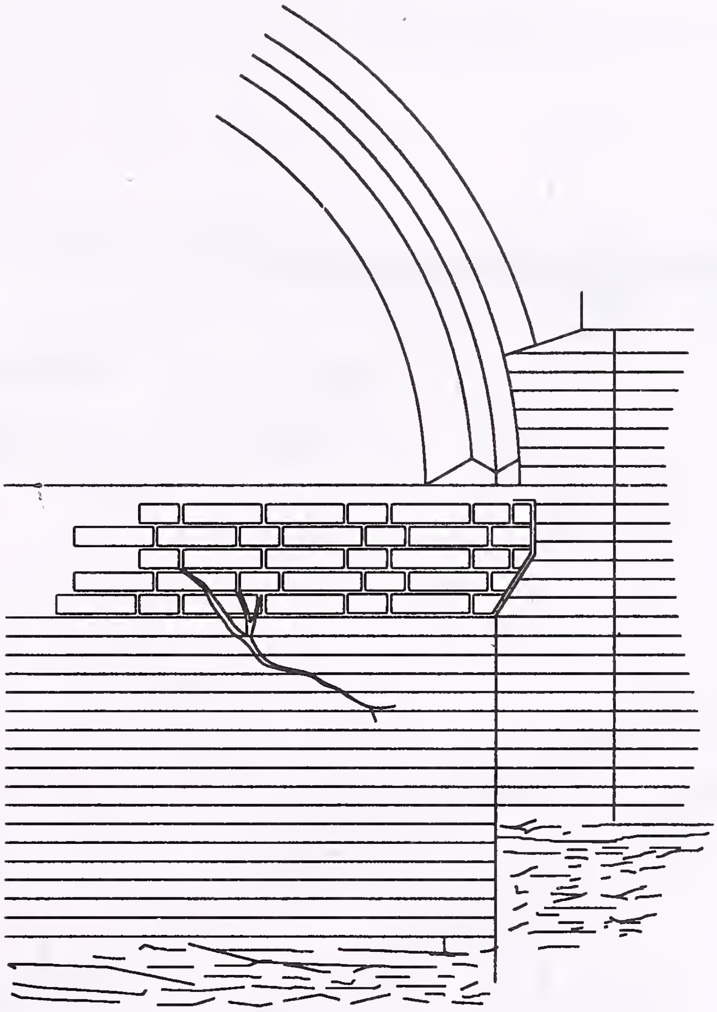
SECTION THROUGH A TREE TRUNK

SKETCH 33

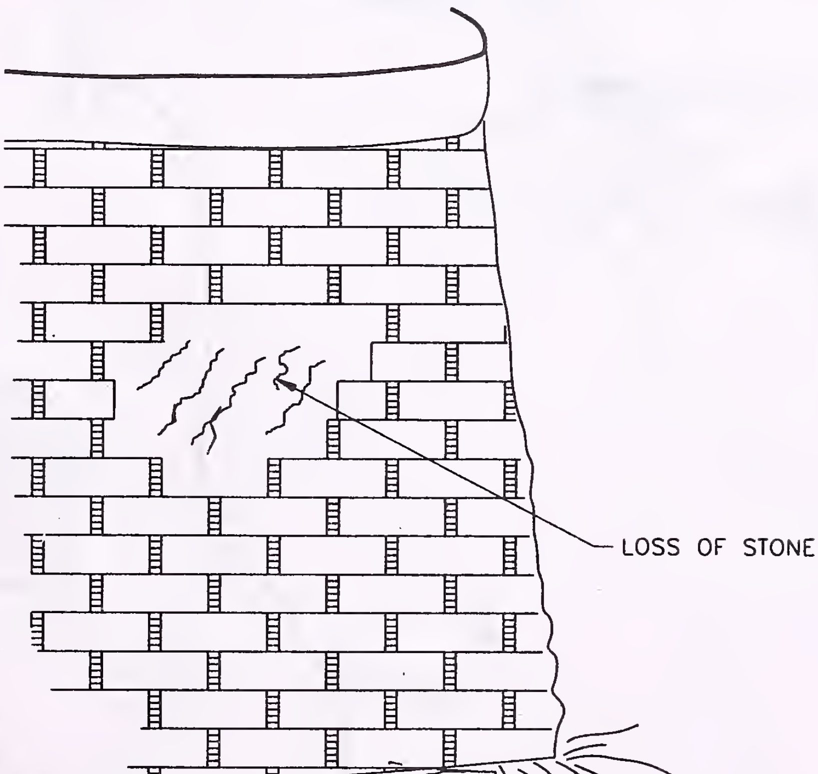


SKETCH 34.

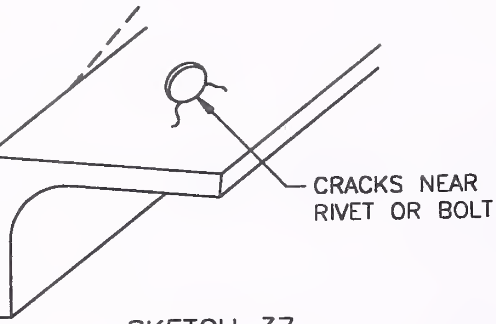
FIG34.DWG



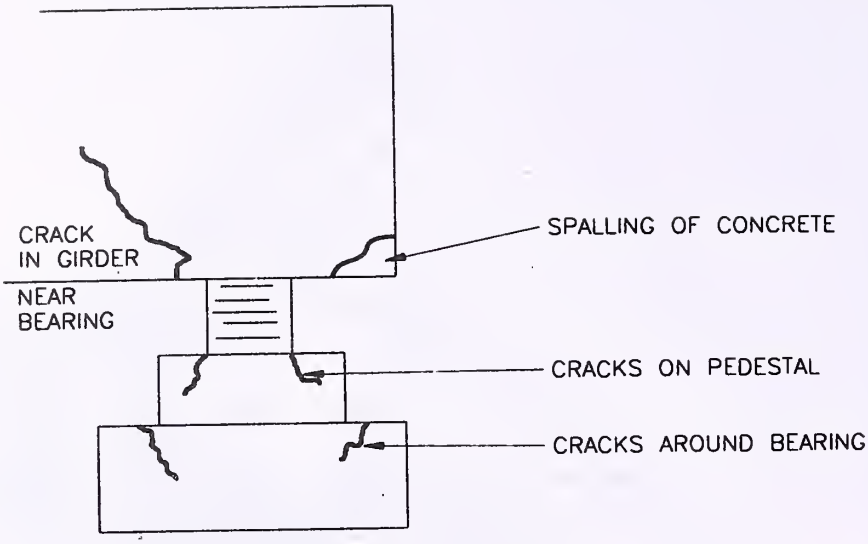
CRACKS IN MASONRY
SKETCH 35



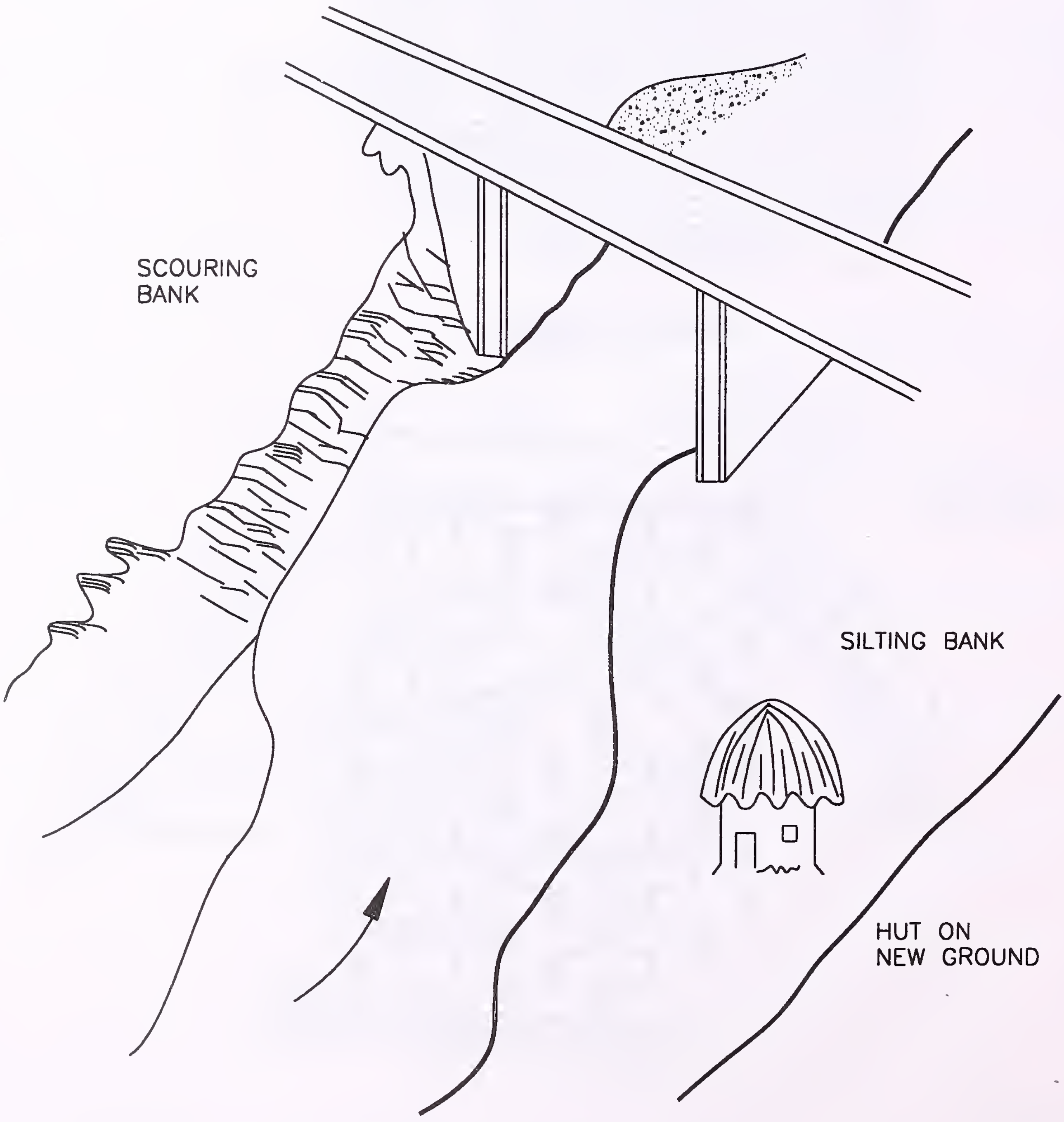
SKETCH 36. MASONRY PIER



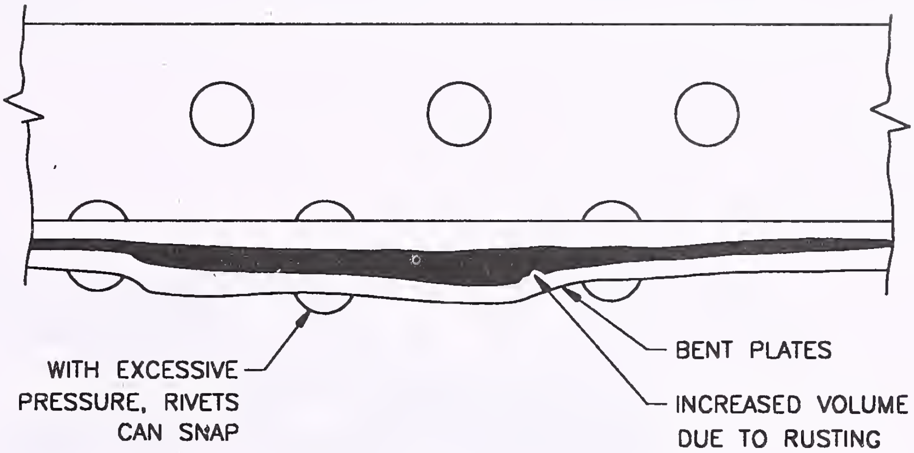
SKETCH 37.



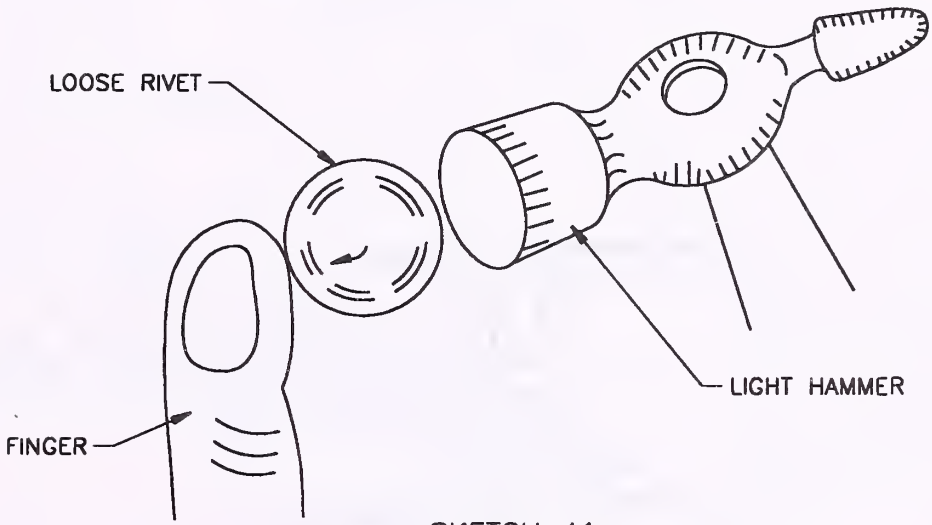
SKETCH 38.



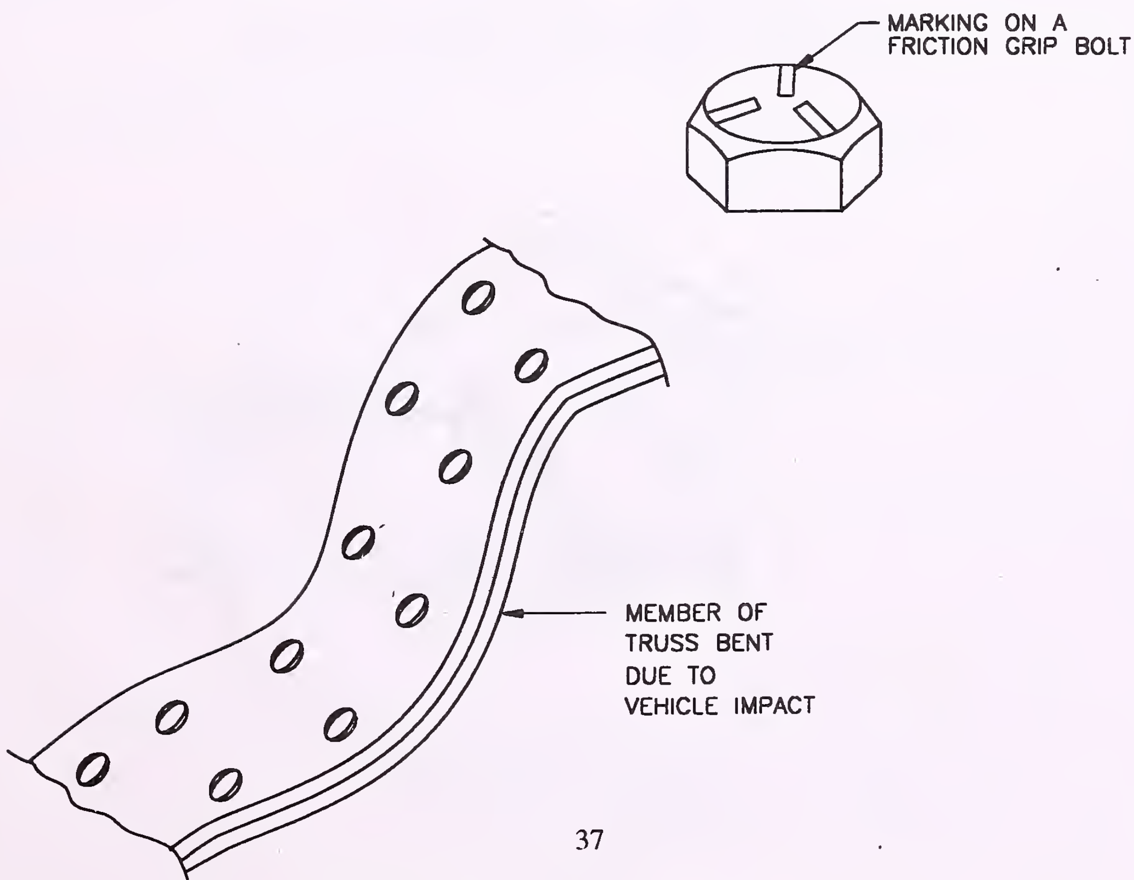
SKETCH 39. CHANGE IN RIVER – COURSE



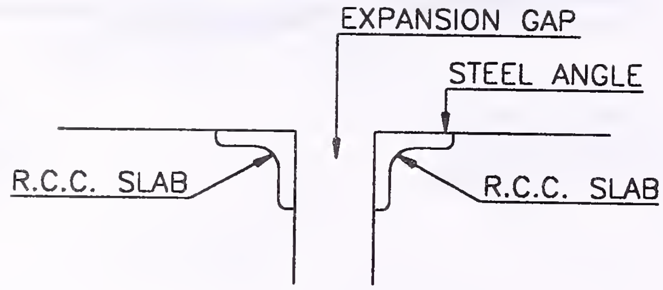
SKETCH 40.



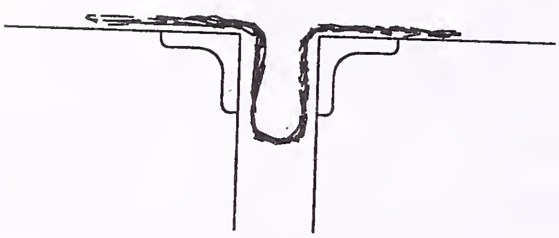
SKETCH 41.



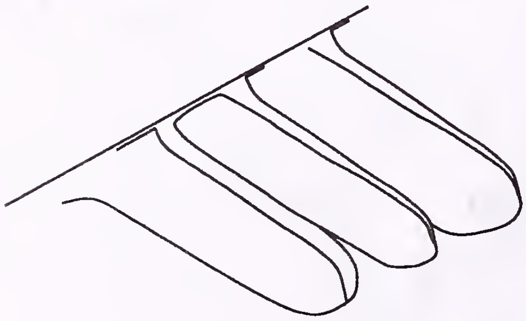
SKETCH 42.



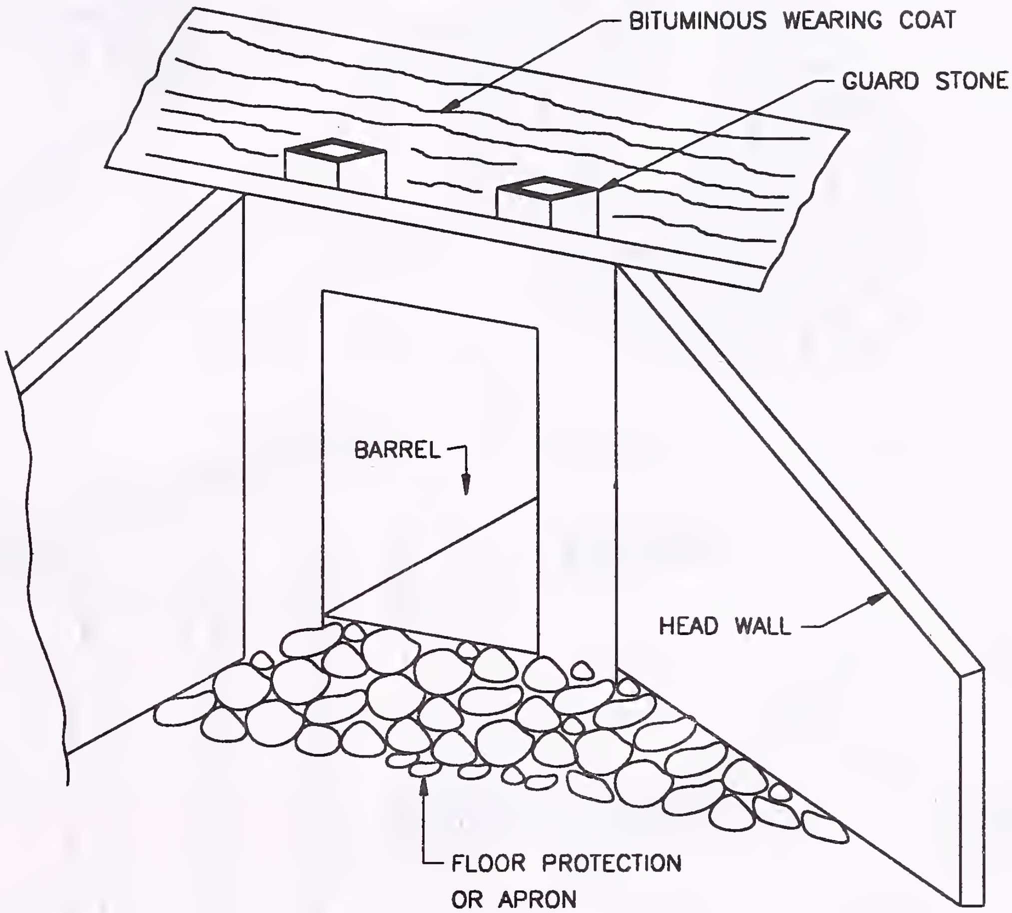
SKETCH 43



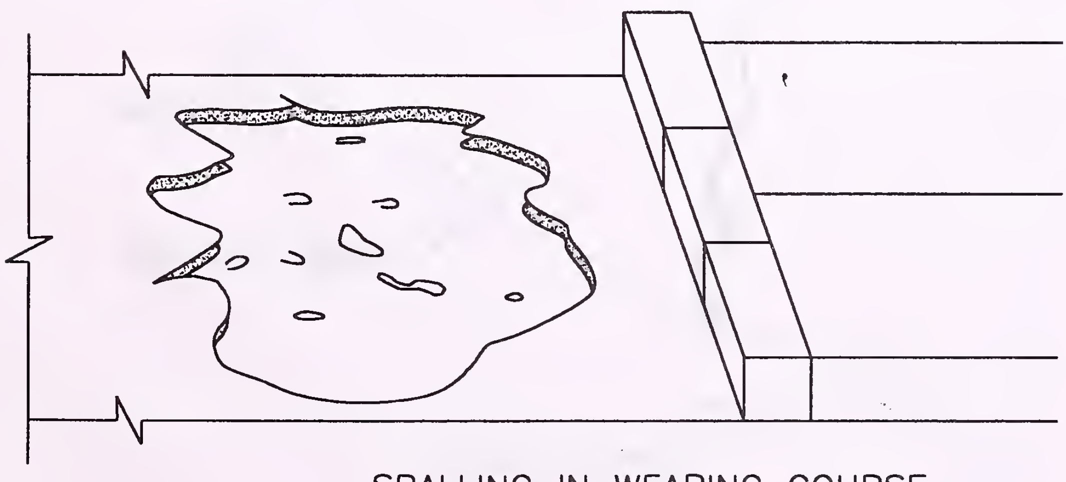
COPPER PLATE JOINT
SKETCH 44



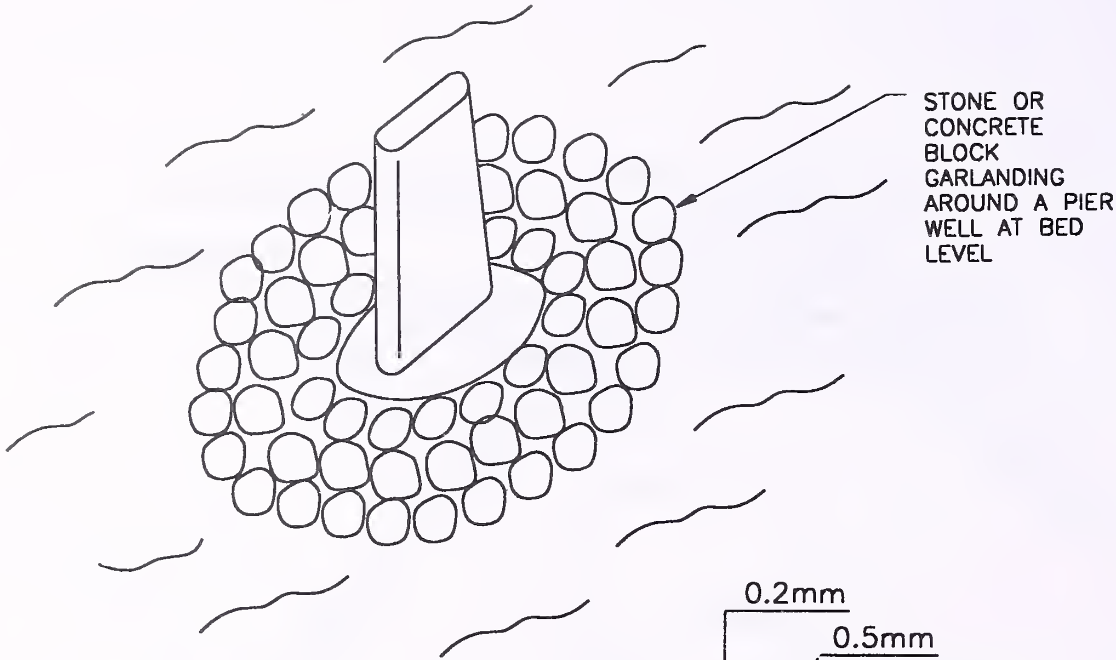
FINGER TYPE
EXPANSION JOINT
SKETCH 45



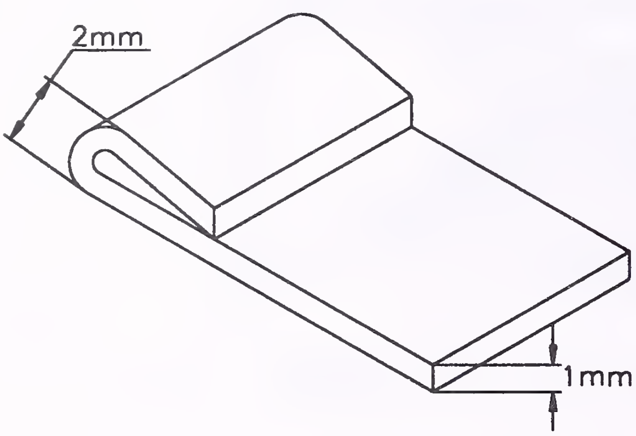
SKETCH 46 R.C.C. SINGLE CELL BOX-CULVERT



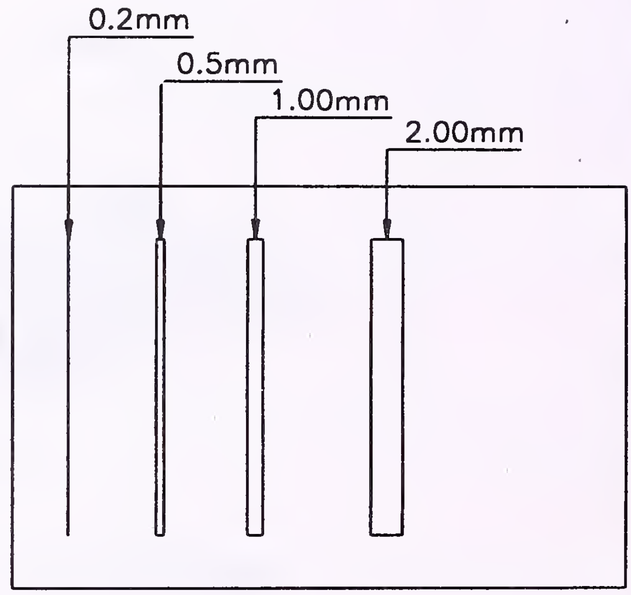
SPALLING IN WEARING COURSE
SKETCH 47



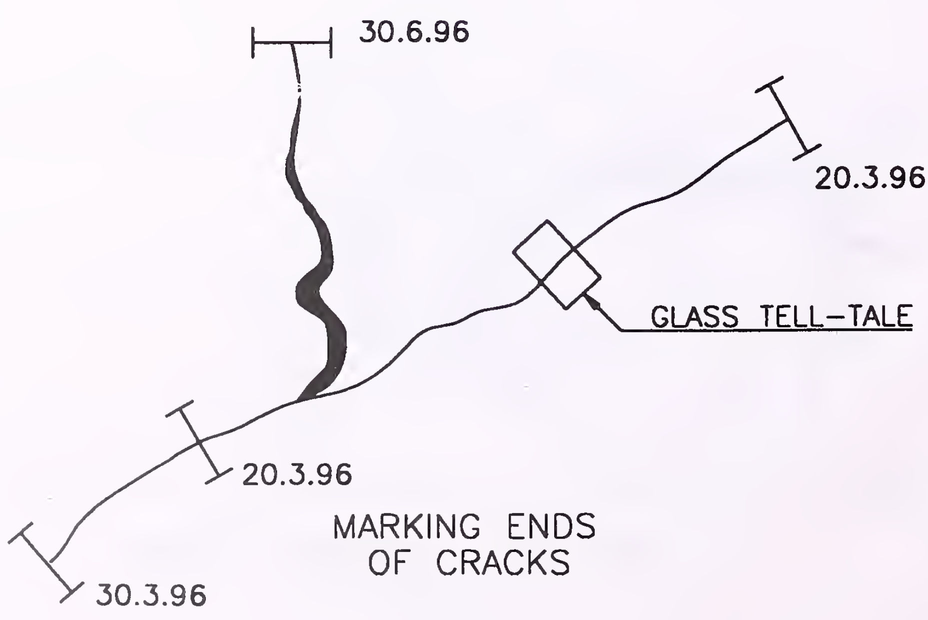
SKETCH 48



CRACK GAUGE
SKETCH 49



CRACK FILM
SKETCH 50



MARKING ENDS OF CRACKS

APPENDICES

Appendix-1

LIST OF EQUIPMENTS

1. Water proof clipboard
2. Marking pencil, pen, paint and brush
3. Torch
4. Straight edge
5. Small tape with level tube and 30m tape
6. String and plumb-bob
7. Knife
8. Hammer
9. Wire brush
10. Trowel
11. Set of spanners
12. Crack measuring guage/film (Sketches 49, 50)
13. Square Spike
14. Hand Drill
15. Saw
16. First Aid Box
17. Road Cones and Signs
18. Reflective Helmet and reflective yellow rain-coat/Jacket
19. Long rope
20. Long rod
21. Ladder and Boat

Appendix-2

"SAFETY ASPECTS FOR INSPECTORS"

The bridge inspector has to be careful during inspections to prevent accidents to himself. He has to keep in mind, all along the following, to plan his work:

1. **Traffic:**

a. While walking on the bridge and its approaches, it is necessary to keep an eye on the traffic.

b. It is better to carry warning signs like DANGER, WORK IN PROGRESS, SLOW, etc., and place them so as to warn drivers.

c. It is better to wear bright coloured uniform and helmet, preferably yellow.

d. It is better to protect work area with cones and ask the assistant to control traffic. Traffic may be stopped for a short while, if required.

2. **Dangerous Spots:**

a. Small bridges over shallow water could be inspected alone. Otherwise always take someone with you to make sure that you are safe.

b. Always a rope and a safety harness should be carried with you.

c. Never go into dangerous places without assistance.

d. Keep a watch on insects, reptiles or animals or birds which can cause harm. This is especially so after floods.

e. Before going into closed spaces like inside of a box-girder, keep the manhole covers off for a long time before you enter. Poisonous gases can cause death. Always keep somebody standing outside, ready to help.

3. **Chemicals:**

Most chemicals are toxic and proper care must be taken while using those.

APPENDIX 3

BRIDGE INSPECTION FORM

Bridge across river/nallah/road/rail ____

____

in kilometre no ____________ on the ____________ to ____________ road

Instructions from the engineer to the inspector

____

____

____

View of bridge looking from above

d/s down stream

Left bank ____ Right bank

u/s up stream

(Town or village) (Town or village)

Notes from the inspector to the engineer :

____

____

____

Inspected by ____________________________________ Date ____________

Number of pages in report
(including sketches, notes, photos, etc.) ____________________________

Report accepted by ______________________________ Date ____________

CONSTRUCTION DETAILS (FROM THE INVENTORY) CORRECT?

Span ____

Running Surface ____

Deck ____

Pier(s) ____

Abutments ____

Foundation Type ____

Expansion Joints ____

Services	Details of service on bridge	Service there?		Services damage?	
		Yes	No	Yes	No
Telephone					
Electricity					
Gas					
Watermain					
Sewer drain					
Oil pipeline					

Notes

____

____

____

Signs on Bridge (details)	Sign still exist?		Sign damaged?		Notes
	Yes	No	Yes	No	

Previous inspection

By ______________________________

Comments ______________________________

____

____

____

ROAD APPROACHES AND DECK	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

1. ROAD SURFACE NEAR BRIDGE

Bumpy road surface?									
				All checked		Yes		No	

1.1. DRAINAGE

Badly built road drainage near bridge									
Blocked or damaged road drains?									
Water on the deck?									
Blocked or damaged deck drains?									
				All checked		Yes		No	

1.2. BITUMEN WEARING COURSE BRIDGE SURFACE AND FOOTPATHS

Surface breaking up or lifting off?									
Cracking above joints									

1.3. CONCRETE WEARING COURSE

Cracking?									
Spalling?									
Reinforcement exposed?									
Poor concrete?									
Wear of surface due to small stones									

1.4. STEEL WEARING COURSE

Fixings loose or damaged?									
Bonds in panels?									
Corrosion?									
				All checked		Yes		No	

1.5. TIMBER WEARING COURSE

Dirt or Plants between boards?									
Decay?									
Insect attack?									
Splitting of timbers									
Loose or damaged fixing?									

ROAD APPROACHES	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

1.6. KERBS

Loose railing fixtures?									

1.7. FOOTPATHS

Damaged or loose kerbs?									
				All checked		Yes		No	

2. PARAPETS, RAILINGS AND CRASH BARRIERS

Impact damaged?									
Loose or damaged fixings?									
Loose base of posts?									

2.1. STEEL OR ALUMINIUM PARAPETS

Damaged coating or paint?									
Corrosion?									
				All checked		Yes		No	

2.2. TIMBER PARAPETS

Decay?									
Insect attack?									
Splitting of timbers?									

2.3. MASONRY PARAPETS

Cracking?									
Movement or bending of parapet?									
Poor pointing?									
Deterioration of bricks or stones?									
				All checked		Yes		No	

ROAD APPROACHES	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

3. EXPANSION JOINT AT ABUTMENTS & PIERS

Damage to concrete of deck end or dirt wall near joint?									
Debris or vegetation in joint?									
Loose or damaged fixtures?									
Damage or corrosion to metal parts?									
Damage to rubber waterseals?									
				All checked		Yes		No	

4. RIVER

4.1. BLOCKAGES IN WATERWAY

Debris against piers or abutments?									
Remains of old bridge under or upstream of the bridge?									
Fencing or buildings under bridge?									
Trees or bushes growing under bridge?									

4.2. CHANGE IN RIVER COURSE

River changing path upstream of bridge?									
New islands forming upstream of bridge?									

4.3. RIVER TRAINING WORKS

River attack beyond the upstream end of river training works?									
Damage to walls?									
Loss of pitching?									
Damage to crates, timber, fencing, etc.?									
Damage to trees?									
				All checked		Yes		No	

SUPERSTRUCTURE SPAN No......	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

5. **SUPERSTRUCTURE**
(From below the deck..above & below for a through truss)

5.1. **GENERAL**

Impact damage to girders, trusses or bracings?									
Debris or vegetation on beams, girders, trusses bracings or joints?									
Water coming through the deck?									
Water from the deck drainage flowing on to girders, trusses, beams or bracings?									
Not enough vertical & horizontal clearances?			If the road has been resurfaced MINIMUM HEADROOM=						
			All checked		Yes		No		

5.2. **MAIN BEAMS, GIRDERS, TRUSSES AND BRACINGS**

5.2.1. **CONCRETE BEAMS**

Cracking?									
Spalling?									
Corrosion of reinforcement?									
Poor concrete?									

5.2.2. **STEEL GIRDERS AND BRACINGS**

Deterioration of paint or galvanising									
Corrosion?									
Bends in webs, flanges, stiffeners or bracings?									
Loose bolts or rivets?									
Cracking									
			All checked		Yes		No		

SUPERSTRUCTURE SPAN No......	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

5.2.3 STEEL TRUSSES

Deterioration of paint or galvanising?									
Corrosion?									
Bends in members?									
Bent or damaged joints?									
Bent or damaged bracing?									
Loose bolts or rivets?									
Cracking of steel members?									

5.2.4. TIMBER BEAMS

Decay?									
Insect attack?									
Splitting of timber?									
Separation of laminations?									

5.3. UNDERSIDE OF DECK

5.3.1. CONCRETE

Cracking?									
Spalling?									
Reinforcement corrosion?									
Poor concrete?									
Less cover to reinforcement?									

5.3.2. STEEL

Deterioration of paint or galvanising?									
Corrosion?									
Bends in stringers or plates?									
Loose bolts or rivets?									
Cracking?									

SUPERSTRUCTURE SPAN No......	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

5.3.3. TIMBER

Decay?									
Insect attack?									
Split timbers?									
Loose or corroded bolts or pins?									

5.3.4. 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?									
				All checked		Yes		No	

5.3.5. MASONRY JACK ARCH DECKS

Change of shape of arch?									
Cracking or spalling?									
Poor pointing?									

6. ALL BEARINGS

Debris or vegetation around bearings									
Bad drainage?									
Not enough room for the bridge span to move?									
Bearing not seated properly?									
Bridge span not seated properly on bearing?									
Damaged bedding mortar?									

BEARING	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

6.1. RUBBER BEARINGS

Splitting, tearing or cracking of rubber?									
Damaged or loose bolts or pins at fixed bearing?									

6.2. METAL BEARINGS

Parts not properly seated?									
Parts not free to move?									
Problem with the lubrication system?									
Sliding surfaces damaged?									
Cracks or bends in metal parts? Bearing?									
Corrosion of metal parts?									

6.3. EARTHQUAKE RESTRAINTS

Damaged or loose earthquake restraints?									
				All checked		Yes		No	

7. MASONRY 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 arch?									
Scour under arch foundations?									
				All checked		Yes		No	

ABUTMENT, WING WALLS & RETAINING WALLS ABUTMENT NAME:	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

8. GENERAL

Erosion or scour at abutment?									
Damage to foundation?									
Movement of abutment?									
Debris against abutment?									
Vegetation growing on or in abutment?									
Scour near to retaining walls?									
Movement of retaining walls?									
Water leaking down through the expansion joint?									

8.1. DRAINAGE SYSTEM

Not enough weepholes									
Weepholes not working?									
Water leaking through the abutment									

8.2. CONCRETE ABUTMENT, WING WALLS AND RETAINING WALLS

Cracking?									
Spalling?									
Corrosion of reinforcement?									
Poor concrete?									
				All checked		Yes		No	

8.3. MASONRY ABUTMENTS AND RETAINING WALLS

Cracking?									
Bulging?									
Poor pointing?									
Deterioration of bricks or stones?									

ABUTMENT, WING WALLS & RETAINING WALLS ABUTMENT NAME:	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

8.4. ABUTMENTS AND RETAINING WALLS

Settlement or bulging of crates?									
Damage to crates or ties?									

8.5. TIMBER ABUTMENTS AND RETAINING WALLS

Cracking?									
Insect attack?									
Splitting of timber?									
Loose or corroded bindings?									
Loose or corroded fixing spikes?									
				All checked		Yes		No	

8.6. EMBANKMENTS AND FILL IN FRONT OF ABUTMENT

GENERAL

Scour at base of slopes?									
Slippage of fill?									
Erosion of fill?									
Cracking of road or embankment edge?									
Piping failure of fill?									

PILED WALLS

Forward movement?									
Deterioration of piles?									

EMBANKMENT	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

9.1. STONE PITCHING SLOPE PROTECTION

Cracking?									
Poor pointing?									
Scour or erosion at edge?									
Pieces broken off?									

9.2. SLOPE PROTECTION WITH CRATES

Not much movement of crates?									
Damage to crates or ties?									

9.3. PITCHING SLOPE PROTECTION WITH CONCRETE BLOCKS

Slope getting washed out?									
Settlement?									
				All checked		Yes		No	

9.4. BED PROTECTION

Large holes in the river bed?									

9.5. STONE PITCHING OR CONCRETE BED PROTECTION AND APRONS

Scour at edge?									
Cracking?									
Spalling or stones missing?									
Erosion of surface?									
Corrosion of reinforcement?									

9.6. BED PROTECTION AND APRONS

Crates broken away from pier or abutment?									
Damage to wires or ties?									

THE RIVER BED	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	v. bad	not much	some	a lot	

9.7. BED PROTECTION

Loss of material									
				All checked		Yes		No	

10. PIERS

10.1. GENERAL

Scour near base of pier?									
Damage to foundations?									
Movement of pier?									
Impact damage?									
Vegetation growing on pier?									
Water Leaking past expansion joint									

10.2. CONCRETE PIERS

Cracking?									
Spalling?									
Corrosion of reinforcement?									
Poor concrete?									

10.3. MASONRY PIERS

Cracking?									
Poor pointing?									
Deterioration of masonry									

10.4. STEEL PIERS

Debris in joints?									
Deterioration of paint or coating?									
Corrosion?									
Bends in steel members or at joints?									
Loose bolts or rivets?									
Cracking?									

PIERS/ PIER NO.	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	very bad	not much	some	a lot	

10.5. TIMBER PIERS

Debris in joints?									
Decay?									
Insect attack?									
Splitting of timber?									
Loose bolts or pins?									
Bends in pier timber?									
Damaged or corroded steel parts?									
				All checked		Yes		No	

11. CULVERTS

CULVERTS	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	very bad	not much	some	a lot	

11.1. GENERAL

Debris, vegetation etc., in or near culvert?									
Settlement of parts of the culvert?									
Scour at ends of culvert or at edge of apron?									

11.2. CONCRETE CULVERT BARRELS

Cracking?									
Spalling?									
Corrosion of reinforcement?									
Poor concrete?									

11.3. CULVERT APRONS

Cracking and damage to concrete or stone or brick									
Damaged or corroded crates?									

CULVERTS	Problem		How bad?			How much?			Note or sketch reference
POSSIBLE PROBLEM	yes	no	not so bad	bad	very bad	not much	some	a lot	

11.4. HEADWALLS

Movement of headwall									
Concrete: Cracking, spalling, corrosion or poor concrete?									
Masonry: Cracking, poor pointing or deterioration of brick or stones?									

11.5. CORRUGATED STEEL CULVERTS

Change in shape of culvert barrel?									
Damage or deterioration to paint or coating									
Corrosion of steel									
Loose or corroded bolts?									
				All checked	Yes		No		