The spray gun and the nozzle shall be electrically earthed. Protection from wind shall be provided for the nozzle, jet and surface to be treated.

Rebound :

Any mortar which does not adhere (known as 'rebound') shall not be worked into the construction, and any which does not fall clear must be removed. All rebound and pockets shall be cut out and made good during the course of the work.

Care must be taken to avoid spraying of sound adjacent areas and rebound falling into drains.

Finishing and Curing :

A wooden or steel float shall be used to finish the sprayed mortar, as soon as practicable after spray application. A smooth, dense surface shall be achieved.

For 14 days after placing, the repair shall be protected against harmful effects of weather.

On completion of a sprayed repair, its soundness can be tested by light tapping with a hand held hammer. In the event of a hollow sounding response, further tests and exploratory work shall be undertaken as directed by the Engineer.

5) Treatment of concrete surfaces following repair

On completion of concrete repairs to a structure, the repaired areas should be protected by impregnation of the surface to extend the life of the repairs. Spraying the surface of a repair with monomeric alkyl (isobutyl)-trialkoxy-silane forms a water-repellant but vapour-permeable layer which protects the concrete from the ingress of water and chlorides.

The silane material must be delivered to site in sealed containers. It must have a minimum active content of 95%; the 5% fraction must not contain hydrocarbon solvents.

Application of the silane must not be carried out until 14 days after the repairs are completed. Two applications are required, at a coverage of $300ml/m^2$, at least six hours apart. Application shall not be undertaken if the air shade temperature is less than 5^0C, or the temperature of the concrete surface is greater than 25^0C. The sprayed surfaces must be protected from rain and traffic spray during application and for six hours after completion.

6.2.4 Installation of Replacement Expansion Joints

1) General

A replacement expansion joint must satisfy the following requirements :

a) The movements to be accommodated must be calculated, taking account of longitudinal expansion/contraction and the rotations of girders at their support. Movements resulting from drying shrinkage and creep of the concrete will generally have taken place prior to joint replacement, and need not be considered. The replacement expansion joint must be capable of accommodating the calculated movements without sustaining any damage.

b) The existing joint gap in the structure should be adequate for the predicted movements, provided it was correctly designed. If not, consideration must be given to widening the existing gap.

c) The running surface of the completed joint must be flat, to ensure driver comfort and to prevent premature deterioration caused by impact loading.

d) The joint must be rigidly fixed to the bridge deck and abutment, where appropriate, or the passage of heavy vehicles will quickly damage it.

e) An important feature of an expansion joint is that it does not permit water to leak onto the bearings and structure below. This can be achieved either by making it waterproof, or by providing a drainage system to carry the water away.

f) A joint should be as simple as possible. The more complex it is, the greater maintenance liability it will become.

The installation of replacement expansion joints should be undertaken by specialists experienced in the use of the materials involved, and the methods of achieving satisfactory results. The following procedures are provided for guidance only.

2) Rubber Slab Joint

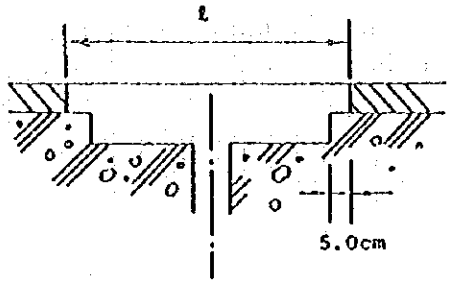
The installation of a rubber slab joint should be undertaken generally in accordance with the following procedure.

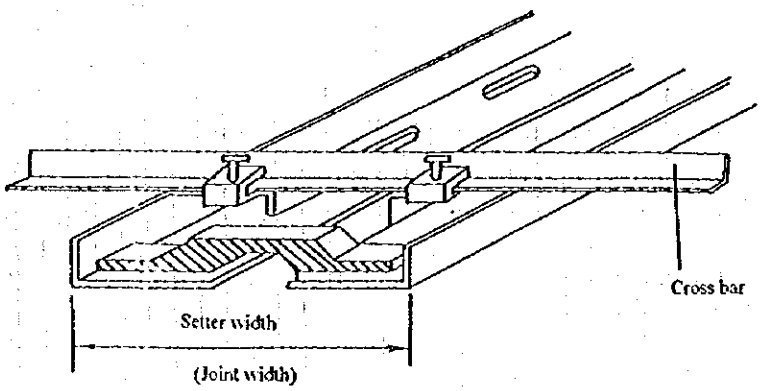
a) Mark out on the carriageway the required width to be cut, and remove the wearing course and concrete over the appropriate widths for the specific joint. Figure - 6.2.1 shows a typical cutting arrangement.

Care must be taken to avoid material falling through the joint gap. It may be necessary to fill the gap temporarily with foam.

b) Surface roughen the concrete surfaces to receive the joint.

c) Set up the steel forms appropriate to the specific joint, so that the anchor bolts are correctly located for the current temperature. Fix plywood forms within the joint gap and install the steel forms, ensuring the top level of the joint will be level with the road surface.





THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED	Figure - 6.2.1 Cutting Arrangement Figure - 6.2.2 Steel Form Arrangement

Figure - 6.2.2 shows a typical steel form arrangement

d) Fix reinforcement and anchor bolts, in accordance with the Engineer's design.

e) Protect the adjacent pavement surface with polythene sheets and boards.

f) Clean out the forms and excavation, using compressed air.

g) Place the concrete to form the base of the expansion joint. Vent holes in the steel forms provide visible evidence of adequate filling beneath the forms.

h) Allow the concrete to cure.

I) Remove the steel and plywood forms and check that a satisfactory bearing surface has been achieved.

j) Spread sealant uniformly over the concrete surface, and install the rubber slab joint before the sealant hardens. Refer to Figure - 6.2.3.

k) Tighten the fixing nuts/bolts to the torque specified by the joint manufacturer.

3) Rubber Seal in Metal Rails

A typical expansion joint comprising a rubber seal supported by metal rails is illustrated by Figure - 6.2.4.

The procedure for installation of such a joint is as follows :

a) Mark the existing carriageway and cut out the appropriate width of pavement.

b) Surface roughen the concrete surfaces to receive the joint, and clean with compressed air.

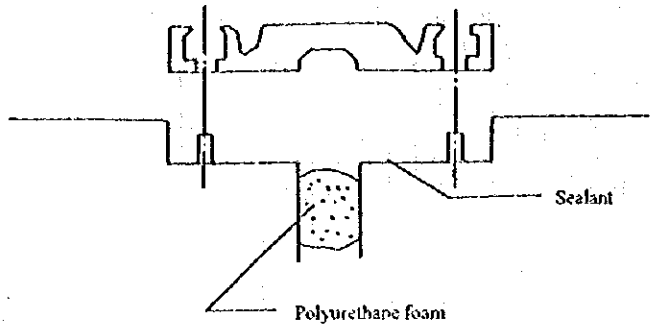
c) Position the metal rails, and restrain them. Fill the gap between the rails with polystrene.

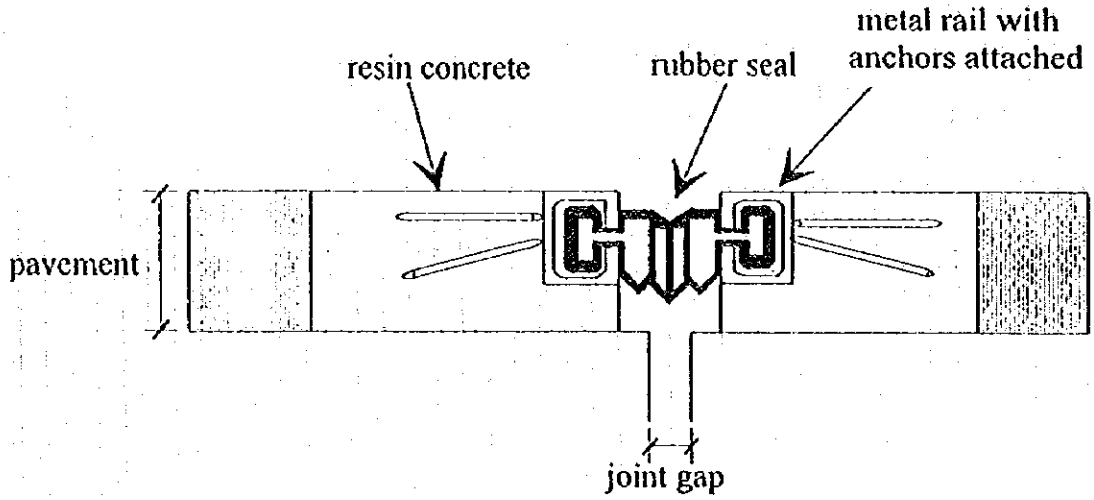
d) Prime the concrete and asphalt surfaces.

e) Mix the resin concrete and pour it into the voids behind the rails. This material is generally self-leveling.

f) Allow the resin concrete to cure.

g) Remove the polystrene form between the rails, and install the rubber-seal.





THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED	Figure - 6.2.3 Joint Installation Figure - 6.2.4 Typical Joint Arrangement

6.2.5 Maintenance Painting of Structural Steelwork

1) Surface Preparation

a) Areas contaminated by oil or grease shall be cleaned down using water and an emulsion cleaner, prior to surface preparation by other specified methods.

b) The required methods and standards of cleaning down and abrading or blast cleaning will depend on the details of the existing deteriorated protective system, and the extent of the proposed remedial painting. Where some existing paint coats or metal coatings are sound, the surface shall be cleaned down by wet cleaning with a stiff bristle brush, water and a cleaning agent, and then rinsed. When all detrimental contamination has been removed by this method, abrasion by scraping and wire brushing or grinding shall be undertaken to remove all unsound paint and unsound metal coating.

c) Where the extent of deterioration is severe, and consequently corrosion of the steel substrate has occurred, blast cleaning shall be used to restore the surface to clean steel.

d) The edges of existing coatings adjacent to abraded or blast cleaned areas shall be stepped back into sound and firmly adhering material.

e) Fasteners shall be prepared to the same standards as adjacent main surfaces.

f) All surfaces shall be dry immediately prior to painting. Compressed air shall be used to remove water from around fasteners and between plies in built up sections.

g) When the surfaces have been dried, if they are affected by embedded metallic grit or other abrasive particles they shall be scraped to dislodge looser particles and then dusted off.

h) When an area has been prepared by blast cleaning, it shall be protected by the application of at least the specified primer and the next two coats of paint (including any stripe coats) prior to the preparation of adjacent areas.

2) Paint and Similar Protective Coatings

a) All paint shall be obtained from a reputable and experienced paint manufacturer approved by the Engineer. Unless otherwise approved by the Engineer, all paints forming part of any one painting system shall be obtained from the same source.

b) All paints shall be supplied in sealed containers of not more than 5 litres capacity and these shall be used in order of delivery. Each container shall be clearly marked on the side. The marking shall include the name of the manufacturer, description of the material (including purpose; whether primer, undercoat or finish), color, manufacturer's reference number, batch number and date of manufacture.

c) On delivery to site the tins of paint shall be unloaded directly into a lock-up paint store of sufficient capacity to hold all deliveries. The store shall be located within 100 metres of the painting area, and its temperature shall be maintained between 4°C and 27°C.

d) Paint which has not been used within the 'shelf life' period recommended by the manufacturer or within 12 months of the date of manufacture, whichever is the lesser, shall be replaced.

e) At the end of each working period, and paint which has been removed from tins but not applied shall be discarded.

f) Paints supplied to a particular site shall be suitable for the climatic conditions prevailing at the time of application.

g) Any addition of thinners to paint shall be made in the store in the presence of the Engineer, and shall not exceed 5 % by volume of the paint.

h) Paint shall only be applied to elements following surface preparation.

j) Each coat of paint in a system shall be applied by one of the following methods :

i. brush
ii. airless spray
iii. air pressure spray

k) Paint shall not be applied under the following conditions :

i. when the ambient temperature falls below 4°C or the relative humidity rises above 90 per cent.

ii. during rain, snow, fog, mist or in a dust laden atmosphere.

iii. where the amount of moisture on the surface to be painted, or that likely to be caused by subsequent condensation or rain, may in the opinion of the Engineer, have a harmful effect on the paint.

iv. when wind borne dust may have a harmful effect on the paint.

l) Before starting any procedure trials the Contractor shall furnish the Engineer with calculated coverage rates (m^2 /litre) for each coat to be used during the works. The calculations shall be based on the volume solids plus an allowance for surface roughness, uneven application and waste.

m) Wet film thickness gauges shall be used where practicable to check that the wet film thickness for each coat is not less than :

$$\frac{\text{min dry film thickness} \times 100}{\text{volume solids \%}}$$

n) Each coat of paint of a specified system shall have satisfactory adhesion as demonstrated by one of the currently accepted adhesion tests specified by the Engineer.

o) Each coat of paint of a specified system shall be generally free from surface defects, particularly cratering, pinholing, blistering, rivelling, sagging, bittiness, dry spray and cissing. The finished system shall have an even and uniform appearance, due allowance being made for the change in film thickness at the edges of patch coats.

p) When required by the Engineer the degree of gloss of a finishing coat shall be agreed before the procedure trials. A painted tinplate reference panel, 150 mm x 100m, shall be provided by the Contractor for this purpose.

q) Unless otherwise specified patch painting shall only be applied over areas of an existing system which have been prepared to sound paint.

r) All coats in a system including the stripe coats (s), but excepting repeat coats of the same patch paint, shall be in contrasting colours to aid identification.

s) Two pack chemically cured paints shall not be applied when the temperature is below 5^{0}C or below the temperature advised by the paint manufacturer, nor shall such paints be applied when the temperature is likely to fall below the minimum temperature during the curing period.

t) Two pack chemically cured paints shall not be used after the expiration of the 'pot life' stipulated by the paint manufacturer and such paints shall not be mixed with the fresh paint.

Stripe Coats

u) Unless otherwise stated in the Contract stripe coats specified shall be applied.

i. over welds and all fasteners including washers and to all external corners excepting those of RHS members.

ii. in areas prepared down to the substrate or a to metal coating the first stripe coat shall be applied over the primer or first undercoat; when a second stripe coat is specified it shall be separated from the first by an undercoat.

iii. in areas prepared down to sound paint, before the priming coat.

iv. by brush on existing paint coats, other than on chlorinated rubber.

v. by airless spray or by brush as appropriate on existing chlorinated rubber paint coats or on new paint.

Exposure times for prepared steel or metal coated surfaces shall be as follows :

v) Exposure times for prepared steel or metal coated surfaces shall be as follows :

i. clean steel prepared by dry blast cleaning or bright steel prepared by abrading or grinding shall be primed within 4 hours.

ii. clean steel prepared by wet blast cleaning only shall be primed within 4 hours of being dry enough for painting.

iii. clean steel prepared by combined wet/dry blast cleaning shall be primed within 4 hours of dry blast cleaning.

iv. bare steel prepared by dry blast cleaning or abrading shall be overcoated within 48 hours.

v. bare steel prepared by wet blast cleaning or combined wet/dry blast cleaning shall be primed within 24 hours of being dry enough for painting or within 48 hours of dry blast cleaning.

vi. steelwork which has been metal sprayed at site shall be etch primed or sealed within 4 hours and in any case before the surfaces have been affected by moisture.

vii. areas prepared down to bright or sound metal spray coating shall be sealed or primed within 4 hours of preparation by dry blast cleaning or abrading and in any case before the surfaces have been affected by moisture.

viii. galvanizing which has been abraded to bright metal prior to painting shall be 'T' washed within 4 hours, or within 4 hours of being dry enough for treatment if wet abraded, and overcoated within 48 hours of 'T' washing.

w) Gaps at joints or plies shall be suitably sealed either before or after the application of the primer as appropriate.

Paint Overcoating Times

x) Unless otherwise specified or agreed by the Engineer ovecoating times shall be as follows :

i. primers on steel or metal sprayed coatings or first coats on 'T' wash shall be overcoated within 7 days and the next coat applied within 14 days.

i. surfaces of existing paint coats which have been prepared to sound paint, cleaned down only or abraded only to remove gloss shall be overcoated within 7 days.

iii. coats following those referred to in i and ii above , excepting for the last two coats of the remedial system, shall be applied within 14 days per coat.

3) Choice of Protective System

Numerous protective systems are available for various applications. The choice of a suitable system for a particular structure will depend on the location, climatic conditions, the levels of airborne pollutants, how difficult it is to gain access to the steelwork, whether physical abrasion is likely, and costs. A protective coatings specialist should be consulted to ensure an appropriate and economical solution is chosen.

6.2.6 Electrochemical Concrete Repair Technology

1) General

In the presence of moisture and oxygen, steel reinforcement will corrode if it is not protected by an alkaline environment. The alkalinity provided by concrete can be destroyed by carbonation and / or chloride attack.

Three techniques exist which can halt, or even reverse, the decay of concrete using electrochemical technology. These methods can remove the need for substantial breaking out.

Specialist advice should be sought when it is considered that electrochemical techniques may offer the best solution.

2) Cathodic Protection

Corrosion can be halted by passing a small direct current to the reinforcement so that no part of the steel can reach an electric potential that would allow it to rust. Every part of the reinforcement is artificially made slightly cathodic with respect to an externally applied anode at or near the concrete surface.

Cathodic Protection can thus avoid the need to remove contaminated but undamaged areas of concrete. Only damaged concrete needs to be cut away and repaired. The technique is therefore particularly useful where access for repairs is difficult.

The anodes used may comprise graphite-based conductive paints, mesh made from corrosion-resistant wire, or discrete anodes in the form of plates or wires fixed to or embedded in the concrete surface.

Cathodic Protection must not be used on prestressed concrete because the generation of hydrogen can cause embrittlement of tendons.

3) Realkalisation

Realkalisation of concrete is achieved by holding a sodium carbonate solution in contact with the concrete surface, and providing an electrical current to transport the solution into the concrete. The effects are to raise the alkalinity and to deposit a buffer solution in the pores to protect against future carbonation.

4) Desalination

The removal of chlorides from concrete can be achieved by holding a flush medium, such as saturated calcium hydroxide, in contact with the concrete surface and providing an electrical current. Negatively charged chloride ions migrate out of the concrete towards the anode where they are dissolved in the flush medium.

6.2.7 Replacement of Bridge Bearings

Many of the bridges on the State Highway Network have some form of rubber bridge bearings. It must be accepted that these elements will not continue to function satisfactorily throughout the life of the main structural members, without periodic replacement.

Removal of the existing bearings, and the installation of replacements, cannot be achieved while these elements are carrying loads. It will therefore be necessary to support the weight of the superstructure using jacks throughout the bearing replacement operation. However to relieve the bearings of load and to facilitate their removal requires the superstructure to be lifted slightly, and this is not always possible. Some types of service mains and cables, carried by bridges, are unable to accommodate even slight movements without sustaining damage. An alternative technique which avoids the need to raise the superstructure is described below.

a) Provide temporary, rigid support to the bridge deck between the existing bearings, using grout bags. These comprise flexible, watertight containers inserted into the gaps between bearings, filled with sand/cement grout under pressure.

b) When the grout has gained sufficient strength to support the bridge deck and any loading applied to it, cut away the bearing shelf beneath the rubber bearings to permit their removal.

c) Clean the deck soffit at the bearing location, and bond the replacement bearing to the soffit using epoxy resin.

d) Install sacrificial hydraulically operated flat-jacks beneath the bearings, and induce appropriate calculated loads into the replacement bearings such that the weight of the deck is supported by the bearings but the deck is not moved significantly.

e) Once the bearing load s are correct, replace the oil in the jacks with epoxy resin, while maintain the pressure. Allow the resin to harden fully.

f) Cut away the top of the bearing shelf, and grout bags, between the replacement bearings.

g) Re-cast the bearing shelf, using a proprietary polymer-modified concrete (refer to section 6.2.3.3), to a suitable profile which will protect the substructure reinforcement and encase the flat-jacks.

6.2.8 Bridge Deck Waterproofing

The provision of an effective waterproof membrane directly on top of a bridge deck slab greatly reduces the deterioration of the structure. Where no such water proofing was provided during construction of a bridge, consideration should be given to its application at the same time as the carriageway surfacing is renewed. Similarly, if waterproofing was provided, the opportunity should be taken during re-surfacing works to investigate its condition and effectiveness, and to replace it if necessary.

Three types of waterproofing systems are commonly used on bridge decks. They are:

a) Mastic asphalt,
b) Sprayed liquid membrane, and
c) Sheet waterproofing systems.

The latter option cannot be successfully applied in a maintenance situation, although sheet systems are often used at construction stage.

Mastic asphalt is an inexpensive waterproofing material, although its application is very labour-intensive. After priming the clean bridge deck, two 1 cm thick layers of molten mastic asphalt are laid by trowelling. Any blow-holes or other defects in a layer must be made good as the work proceed.

The disadvantages of mastic asphalt for bridge deck waterproofing are:

- a long application period, which may be unacceptable if significant traffic disruption results from the works.
- the materials becomes brittle with age. When this occurs it breaks up under heavy traffic loading, and becomes ineffective.

Sprayed liquid membrane provide the most effective form of bridge deck waterproofing, but they are expensive. They comprise a primer coat sprayed applied acrylic or polyurethane based membrane (2 mm to 3 mm thick) and a tack coat which will react on contact with the applied surfacing or protective layer to provide a bond with the membrane.

6.2.9 River Control Works

1) The need for river control

Where a State Highway crosses a river it is likely that the bridge foundations are vulnerable to scour. Changes to the river flow can drastically increase this risk. Significant changes to the river channel may necessitate works to control the flow of the river.

Scour will be aggravated by the following conditions:

a) if a bridge is located on a bend in the river,
b) failure of a downstream weir, causing the river to flow faster past the bridge,

c) excavation of the river bed downstream, for example the extraction of sand and gravel for use as aggregates.

2) Selection of Appropriate Measures

The selection of appropriate measures to combat scour will depend on the availability of materials, the urgency of the repair, the severity of the problem and aesthetics. The nature of previous scour protection works at the site may also affect the choice.

The following measures can be used to prevent scour:

a) Construction of a concrete revetment
b) Stone rip-rap revetment, mortared
c) Cribwork with stone rip-rap
d) Gabions
e) Dumped rock

The construction of a concrete revetment on the outside of a river bend will provide the best possible protection against scour. However the cost of this option can only be justified where the river flow is particularly fast and rough.

Gabions and dumped rock are only suitable for short-term repairs, such as in emergency situations. Gabions are wire-meshed boxes containing rock fill. Their service life is limited by corrosion of the mesh. Dumped rock is simple to place but crumbles easily; care must be taken not to adopt too steep a slope or it can be unstable.

Chapter 7

Access for Maintenance and Repair Work, and Safety

Chapter 7 Access for Maintenance and Repair Work, and Safety

7.1 Access Requirements

7.1.1 General

Some maintenance and repair operations will require no special access provisions. For example carriageway cleaning, resurfacing works and expansion joint replacement works can all be undertaken directly from the carriageway. However most operations relating to bridge substructures, bearings and deck soffits will require the provision of a working platform of some form. In addition access may be needed for operatives to reach a particular location, such as the entry hatch in a box ginder, even if once there they can work safely from the structure.

Access to many bridges can be gained using simple equipment such as ladders, vertical portable platforms or small lorry mounted hoists (such as lamp cranes), but some operations will require access to a relatively large area and a firm, safe base from which to work. Alternatives must then be considered taking into account the nature of the operation and the number of operatives and supervisors to be accommodated.

All transportation and access equipment including power units should be inspected and maintained regularly. The safe working load of any access equipment must never be exceeded. Advantage should be taken of occupations arranged for other purposes (such as a railway possession), making liaison with other maintenance authorities very important.

7.1.2 Scaffolding

Scaffolding has the advantage that it can provide access for several tasks to be carried out at the same time, or successively. Such tasks may include repair and maintenance work such as weld examination, concrete repairs, painting and drainage maintenance. However these different works must be coordinated.

Scaffolding has the disadvantage of being fairly expensive, time consuming to erect and dismantle. If erected from the ground an inspection of the site should confirm the adequacy of founding strata and the suitability of this type of access. Difficult access erection would include bridges over rivers or railways. Extreme care must be taken in the vicinity of live railway overhead cables and general pole mounted electric cables with firm assurances that the current has been switched off when erecting and dismantling scaffolding. No metal scaffold tube must be within 3 metres of a live electric overhead cable.

Scaffold stagings may also be suspended from the bridge but care must be taken not to infringe the minimum headroom (when erected over a highway) and the scaffolding should also be protected from accidental impact from vehicles.

7.1.3 Fixed Ladders and Walkways

Means of access to bearings, drainage items and parts of the bridge soffit is by the use of fixed ladders and walkways. Steel ladders can be permanently fixed to abutments, piers and

columns in this respect and suspended walkways can be supplemented by staging, cradles and scaffolding to give access to any part of the bridge. In view of the substantial cost and time of erecting scaffolding from the ground, permanent walkways may be a quicker and cost effective long term solution in some situations, yet still preserve the flexibility of scaffolding in providing safe access for a variety of concurrent or successive tasks.

The provision of permanent access ladders and walkways should be coordinated with any military requirements (such as bridge demolition in time of war). Special precautions should be taken to prevent unauthorised access onto the ladders and walkways (such as a locking gate).

7.1.4 Traveling Gantries

Some long span structures have been equipped with purpose built permanent traveling gantries suspended from the structure (most notably on the two Bosphorous Crossing Bridges). Such gantries provide the means for effective and safe access for the maintenance team whilst being secure to prevent unauthorised use. It should be noted the traveling gantry must be inspected annually and this includes the runway beams on which the gantry is likely to be mounted.

7.1.5 Mobile Equipment (Hydraulic Platforms And Lifts)

There is a large range of hydraulic platforms and lifts available in the market which can provide access for bridge maintenance and repair. The following includes details of equipment currently available to KGM and equipment types that can be hired or purchased in the future.

a) For reaching points that are not so high platforms extending in the vertical direction only can be used. These machines should be located immediately adjacent to or below the area to be cleaned or repaired. These types of platforms are generally not self-propelling and need a firm, level surface under the bridge. Scissor lifts are also available with large platform areas which are capable of reaching 12 metres. Additionally small extending boom hoists having a reach up to 10 metres can be towed to site and are useful for working on small structures.

b) Extending and telescopic hoists mounted on trucks have the adaptability to reach low, medium and large heights. These are the commonly available types of access equipment available for KGM as they are normally used to maintain lamp column lighting. However these are usually the extending boom type which are not as maneuverable as the telescopic types. The larger truck mounted hoists tend to have telescopic arms and are capable of reaching in excess of 40 metres. They are heavy vehicles and require a firm base on which to stand but they can reach a large area from one position.

Also self propelled hoists, controlled from the inspection cage are available for inspection heights of up to 15 metres. These are often available with 4 wheel drive for areas of rough uneven ground. The most important disadvantage is that a separate vehicle is required to transport the inspection vehicle to site adding to the cost.

For all types of hydraulic access equipment the load carrying capacity of the structure shall not be exceeded and in such cases it may be necessary to restrict live loading of the deck by coning off one carriageway. Again sufficient carriageway must be coned off when the vehicles are maneuvered. Often it is advisable to park another vehicle in a position that protects the access vehicle and personnel (see section 7.3)

7.1.6 Roped Access

The use or roped access provides a cost effective method of undertaking some limited repairs where the cost of scaffolding of other forms of access would be prohibitive in relation to the task to be carried out. The technique has evolved from mountaineering with most of the equipment used being taken from climbing. The technique however involves a very high degree of training and should only be undertaken by trained specialist personnel with a background in undertaking this type of work.

7.1.7 Confined Spaces

Some repairs to structural members such as steel and concrete box girders, hollow abutments and towers will involve internal work. Access to such confined spaces should be strictly controlled and the following guidelines adopted in addition to the safety guidelines referred to in Section 7.2. Hazards associated with confined spaces include oxygen deficiency, flammable gases or liquids, toxis fumes, fungal or bacterial organisms and dust.

These confined spaces can usually be entered through manholes without much disruption to traffic flows. When working the manhole cover should be secured to prevent closure and all openings adequately protected to prevent anyone from falling in.

The following guidelines are recommended to be implemented for entry into confined spaces :

- The maintenance team members should be of suitable stature and should not have psychological problems such as fear of height or enclosed spaces.

- There should be sufficient light for the works and for preventing accidents such as running into obstacles.

- A detailed briefing by the Maintenance Team Leader shall be carried out prior to entering the confined space,

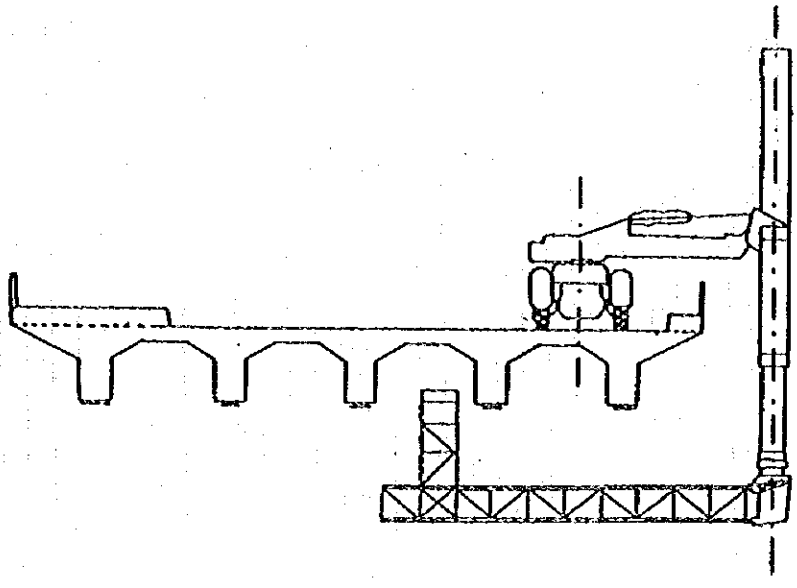
- The biological danger from such items as mould growth and bird droppings shall be assessed. If it is detected that mould is growing within the structural member, the local health directorate of the province should be urgently informed and the effects on health checked. Entry to the confined space should be avoided until samples of the mould have been analysed. If it is very urgent to enter the structural member this can only be done through the use of breathing apparatus.

- Persons should check the ventilation within the confined space before entering.

Small self propelled all terrain vehicles with telescopic hoists are also useful on rough ground sites. The reach is generally limited to 10 metres and the machines rely on outriggers for stability. They also require frequent changes of position to cover a large repair area.

c) When it is difficult or impossible to provide access from below, proprietary underbridge platforms can be used.

These are either lorry or trailer mounted platforms and the larger platforms can be used for up to 20 metres under the bridge soffit, For these types of vehicles care must be taken to ensure that the bridge structure including the verges is capable of withstanding vehicle wheel and outrigger loads which can be considerable. Attention has to be given to the amount of space needed to mobilise the vehicle and it is necessary to check for any obstructions such as high kerbs or parapet which may prevent the use of this type of platform. Presently KGM has one such vehicle based at 17th Division Headquarters in Istanbul and two additional vehicles are likely to become operational soon, to be based in Erzurum. Shown in Figure - 7.1.1.



THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST. 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED	Figure - 7.1.1. Underbridge Platform

Adequate through ventilation shall be ensured by opening additional manhole covers or by pumping in fresh air.

7.1.8 Underwater Access

The method to be applied for underwater repair of bridge elements, partially or wholly submerged in water, is different than for bridge elements on land. Underwater work shall only be undertaken by qualified persons specialising in this type of work. For access to site by means of either diving from the shoreline or in the case of strong currents diving from a standby boat, appropriate safety lines need to be established.

In extreme cases where extensive repair works are required to be carried out, a caisson should be constructed and water pumped out. This will then provide the appropriate conditions to allow access for repairs works.

7.2 Personnel Safety

7.2.1 Basic Safety Rules

Prior to the commencement of works a suitable and sufficient assessment of the risks for the particular situation and techniques involved needs to be carried out. The assessment should cover the risks to the workforce and public, with particular attention to vehicular traffic, passengers and pedestrians

The importance of safety throughout the works cannot be emphasised strongly enough on maintenance personnel. Each maintenance team member shall ensure their own personal safety and that of the other team members. Adequate knowledge and training in the appropriate maintenance or repair procedure is required as is the use of the specialised equipment such as access hoists, breathing apparatus etc. These are general guidelines only and do not cover any specific situation. Specific safety legislation may be required in the future.

7.2.2 Safety Rules For The Maintenance Team

a) Approach To Site

Prior to approaching the site arrangements will have been made to implement the appropriate traffic control measures necessary to carry out the works safely (See Section 7.3).

Personnel should be aware of the layout of any traffic control measures as these may change as the works proceed, any area partially restricted by traffic control measures may subsequently be open to traffic as the working area changes.

If possible maintenance personnel should be transported to the site in official vehicles equipped with flashing beacons. This will alert the traveling public to any unusual maneuvers the vehicles may make in approaching the coned off areas.

If the operations to be undertaken require no traffic control measures then the highway bridge should be approached, whenever possible, from the road which crosses over or under the state highway or from the ground below an underbridge. Whenever maintenance vehicles are parked they must be left so that they are not a danger to other road users. Care must be taken when approaching the structure on foot via an embankment or cutting as the slopes can be slippery in dry as well as in frosty and wet weather.

b) Access

At the site, the maintenance staff must satisfy themselves that the access facilities provided by others are adequate and safe. For example scaffolds and stagings should be secure and have handrails, and confined spaces should be adequately ventilated beforehand (See 7.1.7). The maintenance team must always have a communication system when entering confined spaces or areas away from the public.

c) Precautions

Maintenance staff should remain alert and safety conscious at all times. All necessary precautions must be taken by maintenance team members in advance to minimise the potential for accidents on site. Protective clothing including hard hat and safety boots should be worn, especially when using mobile access equipment. Where maintenance workers are on or adjacent to a trafficked carriageway they must wear a high visibility reflective jacket or waistcoat.

When working in confined spaces or using high or deep ladders workers should ensure they have the appropriate physical and mental requirements needed,. It must be stressed that confined spaces may be attractive to children, vandals or others. It is therefore essential that precautions are taken as far as reasonably practicable to prevent unauthorised entry.

d) Equipment

Care must be taken when carrying or using tools and equipment in high places. Tools should be transported from one level to another using a securely fastened rope or in the cradle of a hoist, rather than being carried up ladders.

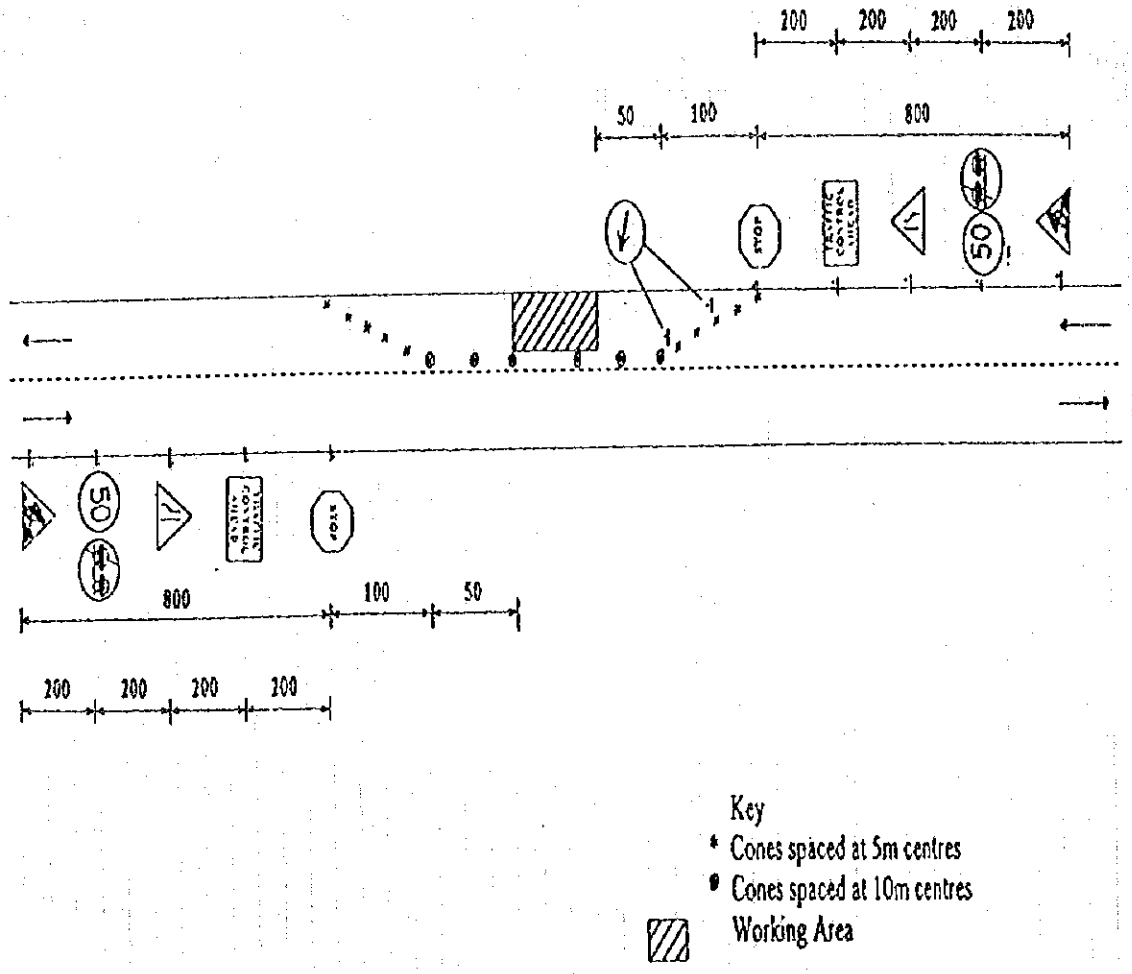
Specialist equipment for roped access and diving must be used in the manner recommended by the equipment manufacturer.

7.3 Traffic Control Measures

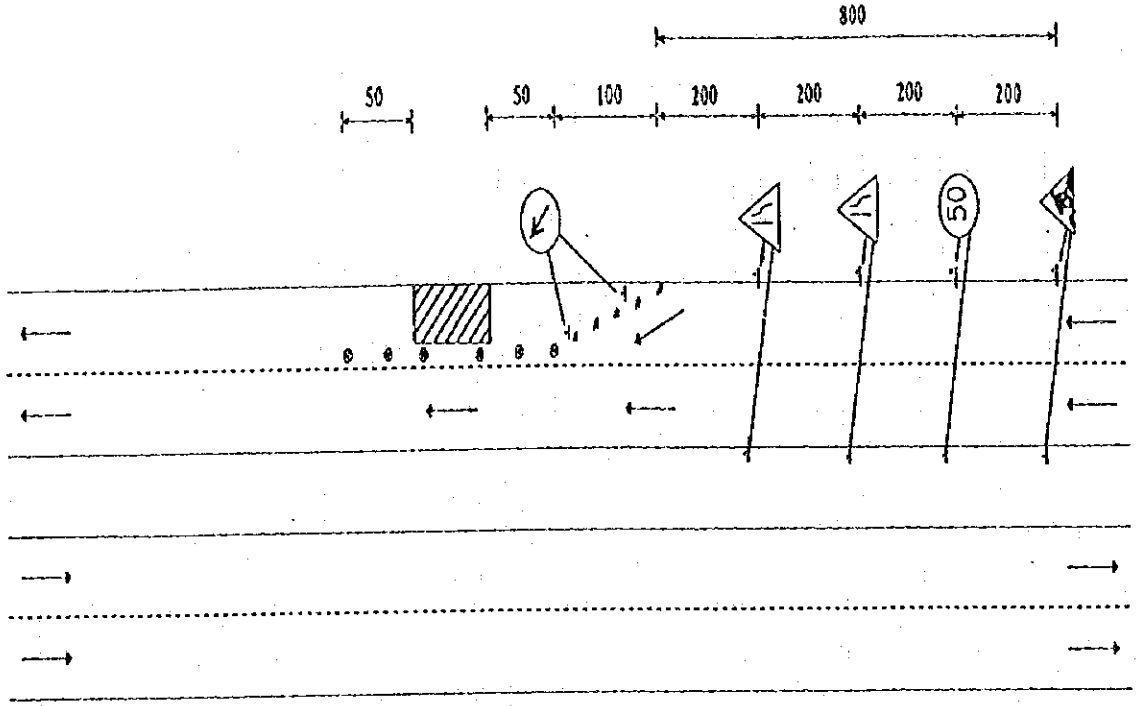
Traffic control measures will always need to be implemented whenever the type of bridge maintenance or repair requires partial closure of the carriageway. This is particularly so when long term maintenance or repair work requires the use of road traveling inspection platforms/hoists and underbridge platforms or when equipment, such as scaffolding, needs to be erected or distmantled.

Figures - 7.3.1 to 7.3.3 inclusive show typical examples of lane closures to provide a safe working area. The layouts shown are minimum requirements and should be adapted to take account of the traffic condition including speed and number of passing vehicles.

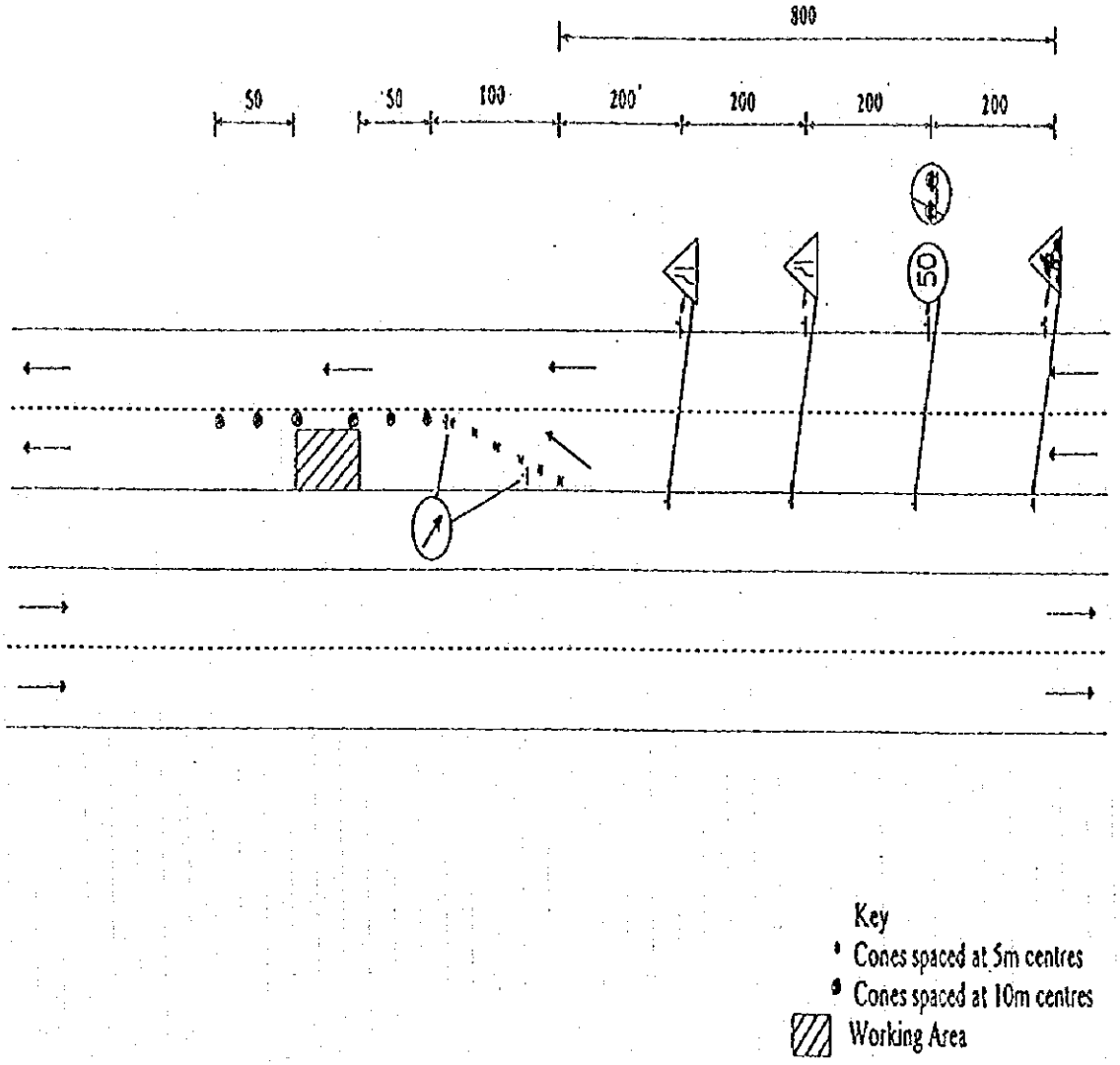
On some occasions it will be appropriate for a traffic team vehicle to be parked in front of a maintenance vehicle to provide additional protection to workers. Flagmen should be used if this is considered advantageous. Flagmen will be required to control traffic at side of working are when traffic control measures shown in Figure - 7.3.1 to 7.3.3 are implemented. An alternative to flagmen is the introduction of temporary traffic signals.



THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1998 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED	Figure - 7.3.1 Traffic Control On Two Way Single Carriage Way Highway (Reversed For Closing Other Side Of Carriage Way)



THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMITED	Figure - 7.3.2 Traffic Control On Dual Two Lane State Highway (Closing Nearside Lane)



THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED	Figure - 7.3.3 Traffic Control On Dual Two Lane State Highway (Closing Offside Lane)

Appendix 1 Database Output Sheet

	Key Identifier	Route		200	Chainage	3,200	Sub-Division	from	Work Category	IS:Inspection		Date of Work	5/2/95												Sketch of Site View	
INVENTORY	Bridge General	Bridge Name		BALABAN			Span Composition																			
		KGM-Division		4			Carriageway Width		8.5																	
		Division					Side Walk Width		1																	
		Name of River		KUSCALI D.			Skew Angle		45																	
		Design Spec. & Load		AASHTO H20-S16			Contractor		Intest																	
		Bridge Length		49.50-			Construction Year		1977																	
	Superstructure	Bridge Type		RC (Reinforced Concrete)			Type of Deck Slab		RC (Reinforced Concrete)																	
		Type of Support		Simple			Type of Surface		Asphalt Pavement																	
		Type of Structure		Beam			Type of Railing		ST (Steel)																	
		Number of Beam		4																						
	River Condition	Low Water Level		0.5			High Water Level		35			Current Velocity	2.5													
		Low Water Level Width		5			High Water Level Width		35			Bridge Height from River Bed	3.6													
	Site Condition	Topography		Flat			Geology		Rocks			Land Use	Pasture													
	Traffic Volume in AADT		Bus	1872		Lorry	714		Pick-up		5035	Passenger Car	5106	Total	12727											
INSPECTION	Work Category	(none)		Conducted Date			File Number																			
	Evaluation	Pavement	Wave	D	Wheel Indent	C	Crack	C	Potholes	C																3
		Kerb & Railing	Crack	D	Peel Off	C	Rebar Explosure	D	Deformed	D	Corrosion	D	Missing	D												1
		Expansion Joint	Crack	D	Water Leakage	C	Deformed	C	Peel Off	B	Missing	D														5
		Deck Slab	Noise	B	Peel Off	D	Rebar Exposure	D	Honeycomb	C	Void	D	Water Leakage	B							Overall Ranks					7
		Steel Girder	Deformed		Crack		Corrosion		Worn		Bolt Missing		Paint-Damage													
		Concrete Girder	Crack	D	Peel Off	D	Rebar Exposure	C	Honeycomb	C	Void	D	Water Leakage	D												2
		Bearing	Main-Damage	D	Parts Missing	D	Anchor Damage	D	Bed-Damage	D	Unusual Movement	D														
		Drainage	Pipe-Damage	D	Blocked	C	Inlet-Damage	D																		1
		Column & Foot	Crack	D	Peel Off	C	Rebar Exposure	C	Honeycomb	D	Void	D	Water Damage	C	Displacement	D	Scour	D								3
		Abutment	Crack	C	Peel Off	D	Rebar Exposure	D	Honeycomb	D	Void	D	Water Damage	D	Displacement	D	Scour	C								2
		Embankment	Depression	C	Erosion	D																				1
		Riprap	Missing	D	Erosion	D	Displacement	D																		
	Damage Indices	Emergency Index		25																						
		Importance Index		21.5																						

REPAIR	Work Record	Items	Conducted Date	Work Category	Repair Method	Cost x 1,000,000 TL.	File Number
		Pavement					
		Kerb & Railing					
		Expansion Joint					
		Deck Slab					
		Steel Girder					
		Concrete Girder					
		Bearing					
		Drainage					
		Column & Foot					
		Abutment					
		Embankment					
		Riprap					

Comments	Capbeams peel off due to the leakage on Exp. joints.
	Scour occuring to Çorum abutment.
	Span 1 and 2 silted up.

Photographs

Appendix 2 ROUTINE MAINTENANCE SCHEDULE

STRUCTURE NAME:SOLAKLI **STRUCTURE NO:AR-010-22-16**

MAINTENANCE DUE:1995

ROUTINE MAINTENANCE INTERVAL:12 MONTHS

Activity No	Chapter	Activity	Date Carried Out	Remarks
		ABUTMENTS PIERS		
1		Remove vegetation	27/10/1995	None present
2		Clear debris from bearing shelves	27/10/1995	Little debris present
3		Clean drainage channels	27/10/1995	Systems checked and working
4		Rod outlet pipes and check operation	27/10/1995	
5		Rod weep pipes and remove silt and debris	27/10/1995	
		CONCRETE BEAMS		
6		No routine maintenance required		All clear
		DECK CARRIAGEWAY		
7		Remove grass and weeds from verges and channels	1st: 4/4/1995 2nd:15/10/1995	Little debris present
		EXPANSION JOINTS		
8		Clean out debris and vegetation		
		DECK DRAINAGE		
9		Remove silt ,vegetation around gullies and rod	1st: 4/4/1995 2nd: 15/10/1995	Little debris Severe debris. 2 no. gullies blocked
10		Rod subsurface drainage outlet	15/10/1995	
		METAL PARAPETS/VEHICLE SAFETY FENCE		
11		Tighten any loose nuts		Severe rusting to south barrier over span 2
		BEARINGS		
12		Remove general debris and dirt		No debris present

Appendix 3 Measures to control alkali silica reaction

a) The contractor shall either use non-reactive aggregates (as defined in sub-clauses (b) or (c) below) or restrict the content of equivalent sodium oxide in the mix.

b) Coarse aggregates and fine aggregates that each contain at least 95% (by weight) of one or more of the rock or artificial types in Table - 2.1, shall be considered to be non-reactive, provided they are not contaminated with any opal, tridymite or cristobalite or contain a total of more than 2% (by weight) of chert, flint or chalcedony taken together.

Table -2.1 Aggregate Types

Air cooled blast furnace slag	Granite
Andesite	Limestone
Basalt	Marble
Diorite	Microgranite
Dolerite	Quartz
Dolomite	Schist
Expanded blast furnace slay/clay/shale/slate	Sintered pulverised fuel ash (pfa)
Feldspar	Slate
Gabbro	Syenite
Gneiss	Trachyte
	Tuff

In the case of quartz it shall not contain quartzite or more than 30% (by weight) highly strained quartz. The quartz shall be classified as highly strained if the petrological examination of thin sections of grains give an average undulatory extinction angle of more than 25 degrees. The extinction angle shall be measured on at least 20 separate grains.

c) When the proportion of chert or flint is greater than 60% (by weight) of the total aggregate it shall be considered to be non-reactive provided that it contains no opal, tridymite or cristobalite.

d) Feldspar, quartz, chalcedony and opal, tridymite or cristobalite are minerals.

e) The petrolgraphical examination of aggregates for alkali silica reaction shall be carried out by the specialist consultant engineer.

f) When the coarse and fine aggregates are not accepted as wholly non-reactive the amount of equivalent sodium oxide shall not exceed 3.0 kg in any cubic metre of concrete.

g) The equivalent sodium oxide content of the cement shall be taken as that of the proposed quantity of cement in the mix, with 10 kg of cement added for each cubic metre of concrete to allow for tolerances in batching. For Portland cement the acid-soluble alkali content shall be used and for slag and pulverised fuel ash the water-soluble alkali content.

h) The acid-soluble alkali content of the portland cement shall be taken as the average of 25 daily determination of equivalent sodium oxide, plus twice the standard deviation for the period in which the cement was manufactured. The specialist contractor shall submit to the sepcialist consultant engineer test certificates furnished by the cement manufacturer giving the results of these tests.

i) The specialist contractor shall submit to the specialist consultant engineer test certificates giving the water-soluble alkali content of any slag or pulverised fuel ash to be used.

j) The equivalent sodium oxide (Na_2O) in the mix shall be calculated from the equivalent sodium oxide ($Na_2O + 0.66\ K_2O$) in the cement (including slag and pulverised fuel ash), the chloride ion (Cl ion) in the aggregate and the amount equivalent sodium oxide (Na_2O) in any admixtures or water to be used in the mix as follows:

Eq. Na_2O (Concrete) = Eq. acid soluble Na_2O (cement, admixtures and water) +

Eq. water soluble Na_2O (slag and pfa) +

0.76 Cl ion (aggregates).

k) The equivalent sodium oxide content of the coarse and fine aggregate shall be calculated from the quantity of chloride ion present.