APPENDIX 5–2.1

GUIDELINE FOR CALCULATION OF LOAD OF STEEL ROAD BRIDGES

(Plate girder and truss) (Draft)

Load bearing group, Specification Sub–committee, Bridge Committee, Road Association of Japan

Foreward

More than 60% of the road bridges actually in use are designed with load values smaller than the design live loads in force. How to evaluate the bearing capacity of these bridges with small design bearing capacity is an extremely important problem from the point of view of administration of bridges. The load bearing capacity of the presently existing bridges depends upon factors such as type of material, type of structure, scale of the bridge, design conditions, state of the traffic, state of maintenance, etc., and these conditions differ in accordance with each individual case. Therefore, it is very difficult to draw out an uniform standard for existing bridges by taking into consideration all conditions listed above.

The Bridge Committee of the Road Association of Japan established in 1968 the Load Bearing Capacity Sub-Committee aiming at drawing out the evaluation criteria mentioned above, in spite of the inherent difficulties of the subject. The Load Bearing Capacity Sub-Committee decided to study in the first case the non-composite plate girder bridges and the truss bridges, which are the types whose data and information are relatively easy to collect. Some initial results have been attained after studies carried out for a period of approximately 2 years.

The guidelines (draft) presented below comprise some items where the determination of concrete numerical values is impossible. In such items, the final decision is left to the judgement of the person responsible for the administration of the road. However, the basic orientation regarding the procedure for calculation of the load which can be allowed to pass through the bridges in question is stipulated in these guidelines.

The reinforced concrete bridges, which are the most frequent cases, are not taken into consideration in the present case, because the data and information regarding them are insufficient yet. However, the guidelines regarding them will be established after the collection of more comprehensive data and information.

1 GENERAL RULES

1–1 Scope of Application

The present guidelines (draft) are applicable for the calculation of the allowable load of the superstructure of simply supported non-compsite plate girdger bridges and simply supported truss bridges, among the presently existing road bridges made of steel.

1–2 Definition of Terms

(1) Basic load bearing capacity

The value of P given by the following expression is called basic load bearing capacity.

$$P = 20 \times \frac{\sigma a - \sigma d}{\sigma_{20}}$$

Where

P: Basic load bearing capacity (The symbols T or L are indicated, according to each case, before the numerical value in case of indicating this capacity, i.e., T-P in case of floor and floor structure and L-P in case of main girder and truss main structure).

σ_{20}: Intensity of stress resulting from live loads and impacts, of first class bridges stipulated in the design specifications of road bridges of steel (June of 1964, Road Association of Japan)

σd: Intensity of stress of dead loads.

σa: Allowable intensity of load of the material.

If the structures in question present reduction of cross section due to corrosion, the said fact should be taken into consideration in the calculation of the allowable stress.

(2) Allowable load

Allowable load is the total allowable weight of the vehicles which can arbitrarily pass through the bridge in question, calculated by the person responsible for the administration of the road as a result of the introduction of corrections in the value of the basic load bearing capacity, taking into consideration factors such as the structure of the bridge, the actual state of the bridge, conditions of traffic, etc.

(3) Special allowable load

Special allowable load is the value of the total weight of the vehicle whose traffic through the bridge in question is authorized under special conditions, restricted to the particular case in question, when the authorization for the traffic in question is applied to the person responsible for the administration of the road.

2 PRELIMINARY INVESTIGATION

2–1 Investigation of the Structure and Dimensions of the Cross Section

Details such as the applicable specifications, structure, dimensions of the cross section, etc., of the bridge in question should be known in advance.

2–2 Investigation of Corrosion and Other Defects

If the bridge in question presents defects such as corrosion of the steel materials, deformations and displacements of the members, damages in the floor plates, pavements, expansion joints, etc., which could have any influence in the determination of the allowable load, the said defects should be known in advance.

3 BASIC LOAD BEARING CAPACITY

3–1 Calculation of the Basic Load Bearing Capacity

The basic load bearing capacity should be calculated for all members listed in Table 1.

Table 1

Type	Members whose basic load bearing capacity should be calculated
Simply supported non-composite plate grider bridges	Main grinders, stringers, cross beams, floor plates, etc.
Simply supported truss bridges	Main truss (Upper chord members, lower chord members, vertical members), stringers, cross beams floor plates, etc.

(Remarks)

The basic load bearing capacity should be calculated for all major members. For example, if the bridge in question is a multiple main girder type, the calculation of basic load bearing capacity should be carried out for all main girders. With regard to the stringers of the floor system, the outside stringers and the intermediate stringers should be taken into consideration as subjects of calculation, while with regard to the cross beams those located at the extremities should be taken into consideration as subjects of calculation in the case of the floor system.

On the other hand, in the case of the floor plates, the tensile main reinforcement bar and the compression side concrete should be taken into consideration as subjects of calculation.

3–2 Allowable Stress

With regard to steel materials, the allowable intensity of stress used for calculation of the basic load bearing capacity is determined by taking into consideration the same degree of safety stipulated in the steel road bridge specifications actually in force (established in June of 1964). With regard to concrete, the same value used for the calculation of the bridge in question is assumed to be valid. When the quality of the material used for construction of the bridge in question or when the allowable intensity of stress used for the design is unknown, the value obtained as a result of the test of the material or the value stipulated in the specifications used for the design of the bridge in question should be used as reference data for determination of the desired value.

3–3 Stress of the Dead Load

(1) The value of the dead load w corresponding to each girder of a non-composite girder bridge composed of n main girders is given by the following expression for the calculation of the intensity of stress of the dead load.

$$w = \frac{Wd}{n}$$

Where Wd is the total dead load.

The dead load shared by each main stringer in truss bridges is given by $\frac{Wd}{2}$

(2) The values stipulated in the Paragraph 6 Table 2 of the Steel Road Bridge Design Specifications should be used when the actual weight of the material is unknown.

3–4 Stress of the Live Load

(1) The T-load of 1st class bridges stipulated in the Paragraph 8 of the Steel Road Bridge Design Specifications should be adopted in the floor slab and floor systems, while the L load of 1st class bridges stipulated in the Paragraph 9 of the same specifications should be adopted in the case of main beams and main structure of truss.

(2) The live loads are assumed to generate the impact stipulated in the Paragraph 10 of the Steel Road Bridge Design Specifications.

(3) The method of application of the loads should be in accordance with the stipulations of the Steel Road Bridge Design Specifications. The load shared by each main beam is assumed to be the upward reaction taking place on the main beam, calculated by assuming that the floor plate is a simple beam having an effective span identical to the spacing of the main beams.

Also with regard to the loads shared by the stringers and the cross beams, they are assumed to be the upward reaction taking place in the stringers and/or cross beams, calculated by assuming that the floor plates are simple girders with effective span identical to the spacing of the corresponding members.

(4) Details such as the composition effect of the concrete floor plate on the main girder in non-composite girder bridges are neglected for the calculation of the intensity of stress.

3–5 Registering in the Bridge Register Book

The basic load bearing capacities of the various members should be registered in the bridge register book.

4 ALLOWABLE LOAD

4–1 Determination of the Allowable Load

The minimum value of the TL obtained by multiplying the basic load bearing capacities with the coefficient presented below is assumed to be the allowable load.

(1)	Coefficient related to the intensity of stress	Ks
(2)	Coefficient related to the state of the road	Kr
(3)	Coefficient related to the state of traffic	Kt
(4)	Coefficient related to other elements	Ko

(Remarks)

Calculate the value of P x Ks x Kr x Kt x Ko for each member. The minimum value obtained as a result of the said calculation is the allowable load of the bridge in question. The allowable load of the bridge is in fluenced by the impoverishment of the load bearing capacity due to the aging of the bridge and by the changes in the state of the traffic. Accordingly, it is indispensable to re-calculate the allowable load of the bridge in case of occurrence of clear changes in the traffic conditions or in case of impoverishment of the load bearing capacity.

4–2 Coefficient Related to the Intensity of Load

The coefficient Ks related to the intensity of load are listed in Table 2.

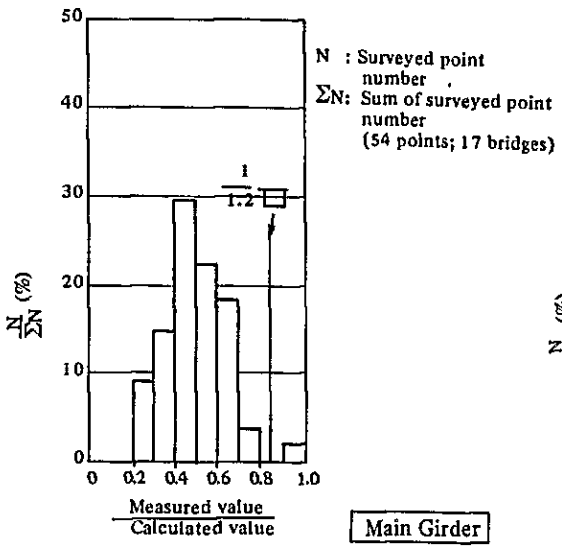
Table 2

Type	Part of the structure	Member	Ks
Non-composite simple plate girder bridge	Main girder	Main girder	1.2
Non-composite simple plate girder bridge	Floor and floor system	Floor plate	1.0
Non-composite simple plate girder bridge	Floor and floor system	Stringer Cross beam	1.6
Simple truss bridge	Main structure	Loaded chord	1.2
Simple truss bridge	Main structure	Non-loaded chord Diagonal member Vertical member	1.0
Simple truss bridge	Floor and floor system	Floor plate	1.0
Simple truss bridge	Floor and floor system	Stringer Cross beam	1.6

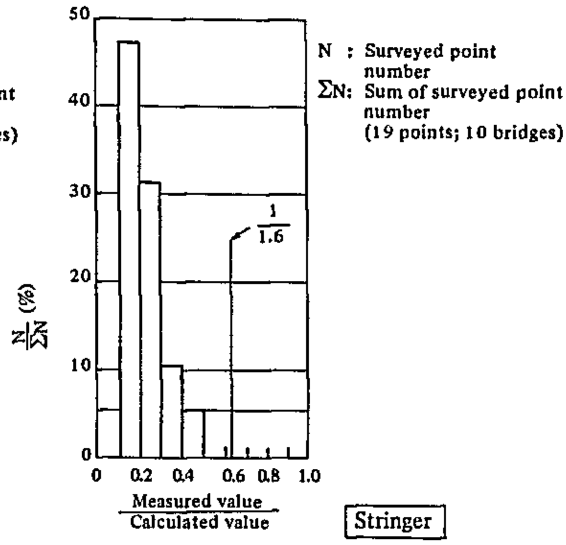
In 1965 and 1966, the Japanese Ministry of Construction carried out the various loading test of existing bridges. The ratios of measured stress as the result of that test and calculated stress in accordance with Paragraph 3-4, for each type of member, are shown on the next page.

The value of the (actually measured intensity of stress)/(theoretically calculated intensity of stress) ratio presents considerable differences depending upon the type of the member, but in most of the cases it is smaller than 1. The fact that the actually occurring stresses are smaller than the calculated values indicates that the actual structure has a margin of safety with regard to the values calculated in accordance with the calculation method described here. The coefficient Ks related to the intensity of stress has the purpose of making practical application of the said margin of safety of the structure.

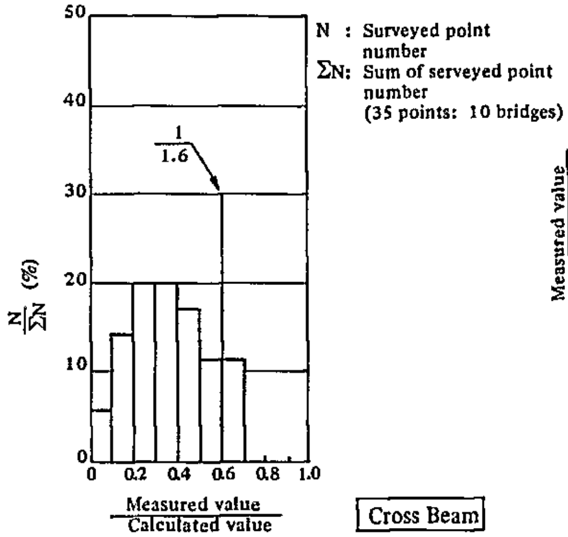
The values presented in Table 2 are determined for each type of member, (based upon the values of the measured intensity of stress) calculating intensity of stress in such a way to ensure the safety in most of the cases.



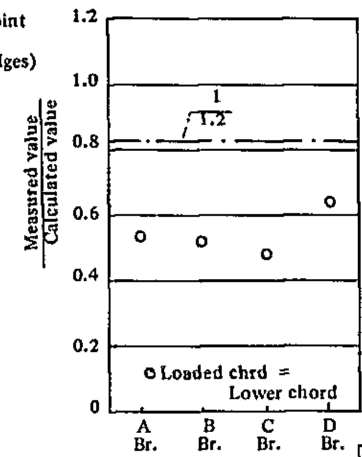
Main Girder



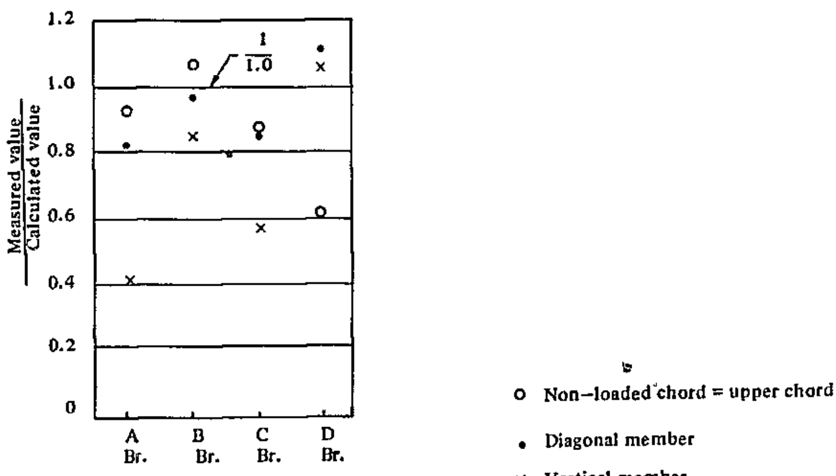
Stringer



Cross Beam



Loaded Chord of Simple Trussed Beam



Non-loaded Chord, Diagonal Member, Vertical Member of Simple Trussed Beam

4–3 Coefficient Related to the Conditions of Road Surface

The coefficient K related to the conditions of road surface are listed in Table 3.

Table 3

Mark	Conditions of road surface	K
A	Normal	1.0
B	Slightly rough on the surface	0.9
C	Remarkable rough on the surface	0.8

4–4 Coefficient Related to the Conditions of Traffic

The coefficient K related to the conditions of traffic are determined by taking into consideration the manner how the load works on the bridge, under normal traffic conditions.

(Remarks)

The basic load bearing capacity of the main girder and main truss is calculated by using the L load of the specifications actually in force, but this L load is determined by assuming the load distribution shown in Fig. 1. Accordingly, the allowable weight can be adequately controlled, according to the more severe or lighter state of the actual traffic load.

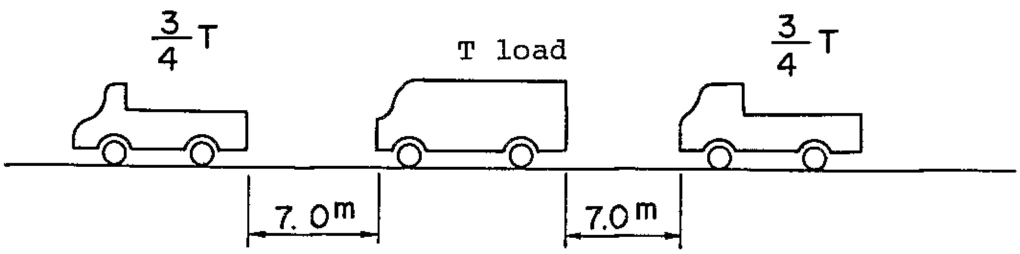


Fig. 1

It is very difficult to determine a unified value of the coefficient related to the state of traffic, by evaluating numerically the state of the actual traffic. Accordingly, the person responsible for the administration of the road is required to determine this coefficient related to the state of traffic, based upon the results of investigation on the actual state of traffic taking place on the bridge.

Examples of reference data for determination of the coefficient related to the state of traffic in the cases of main girder of girder bridge and main truss of truss bridge are presented in Figure 2 and Figure 3.

Figure 3 presents the coefficient Ktw related to the distribution of load in the transversal direction (width direction) of the bridge, while Figure 3 presents the coefficient Ktl related to the distribution of load in the direction of the centerline (longitudinal direction) of the bridge. The coefficient Kt related to the state of traffic is given by the following expression.

$$Kt = Ktw \times Ktl$$

However, it is indispensable to have in mind that these figures (diagrams) give the numerical values of the coefficients based upon the assumption of the premises described below. Accordingly, these figures (diagrams) cannot be used when the state of traffic is different from the said premises (e.g. when there is a high percentage of large-size vehicles).

(1) The hypothesis Ktw for calculation of the coefficient Ktw (Figure 2) related to the distribution of the load in the width direction is calculated by the following expression.

$$Ktw = \frac{[L]s}{[L]r}$$

Where,

[L]s: L load based upon the Steel Road Bridge Design Specifications, i.e., the liner load P and the uniformly distributed load p are assumed to be loaded on the range of width extending up to

5.5 m, of the total width of the bridge, while P/2 and p/2 are assumed to be loaded on the rapaired parts of the bridge.

[L]r: L load taking into consideration the state of traffic taking place actually on the bridge, i.e., the width of the bridge is divided in lanes (2.75 m wide) and only the parts of the bridges corresponding to an integer number of lanes are loaded, assuming that the said lanes are units of loading width.

With regard to the load working on each lane, the linear load P and the uniformly distributed load p are assumed to be applied on the part of the bridge width up to 5.5 m, while the loads P/2 and p/2 are assumed to be acting on the remaining parts of the bridge width.

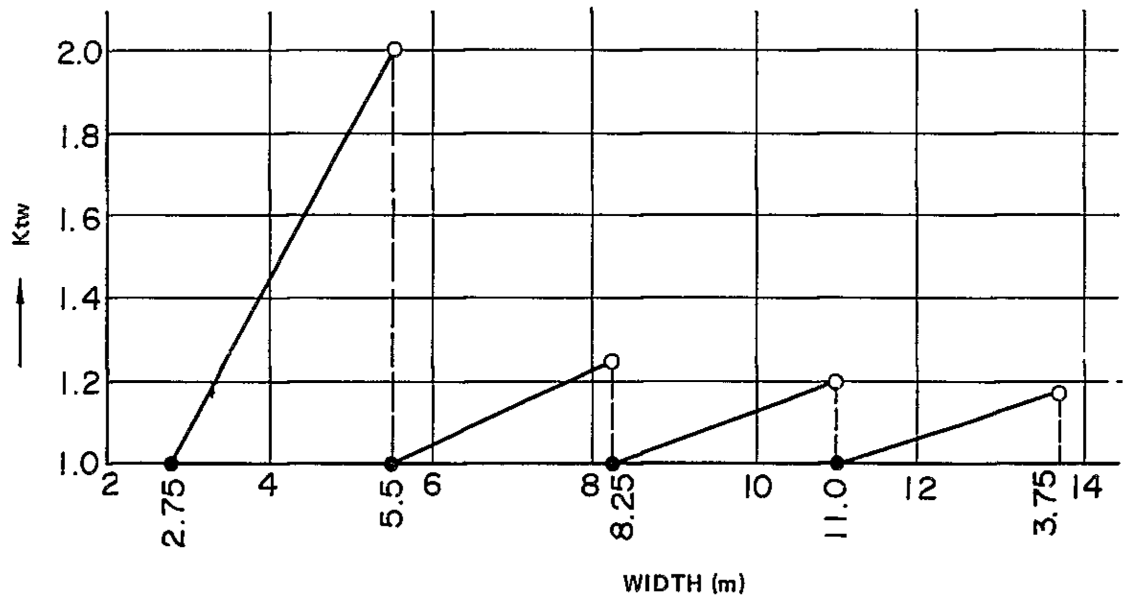


Fig. 2 COEFFICIENT OF CORRECTION RELATED TO THE LOAD DISTRIBUTION IN THE WIDTH DIRECTION

The correction coefficient Kwt is given as follows, when the bridge has a width of X(m).

$$
Ktw = \begin{cases}
\dfrac{X}{2.75} & 2.75 \leqq x < 5.50 \\[2ex]
\dfrac{5.50 \div \frac{1}{2}\cdot(X - 5.50)}{5.50} & 5.50 \leqq x < 8.25 \\[2ex]
\dfrac{5.50 \div \frac{1}{2}\cdot(X - 5.50)}{5.50 \div \frac{1}{2}\cdot 2.75} & 8.25 \leqq x < 11.0 \\[2ex]
\dfrac{5.50 \div \frac{1}{2}\cdot(X - 5.50)}{5.50 \div \frac{1}{2}\cdot 5.50} & 11.0 \leqq x < 13.75
\end{cases}
$$

(2) Hypothesis for calculation of the coefficient Ktl (Figure 3) related to the load distribution in the bridge centerline direction (longitudinal direction). The value of the coefficient Ktl is calculated by the following expression, based upon the bending moment taking place at the center of span of the simple girder of a 1st class bridge with 2.75 m width is given by the following expression.

$$K = \frac{[M]s}{[M]r}$$

Where,

[M]s: Bending moment of the center of effective span of the simple girder with 2.75 m width due to the L load of the Steel Road Bridge Design Specification.

[M]r: Bending moment at the center of effective span of the simple girder with 2.75 m width due to the load which takes into consideration the actual state of traffic on the bridge. In other words, in the case illustrated in Figure 3 , this bending moment is that one taking place at the center of the effective span of the simple girder with 2.75 m width, assuming that there is a high percentage of passenger cars in the traffic, i.e., by locating the rear shaft load of T-20 of the Steel Road Bridge Design Specifications at the center of the effective span and by placing uniformly distributed loads corresponding to passenger cars with total weight of 2t (assuming a car length of 4.6 m) ahead and behind the center of effective span.

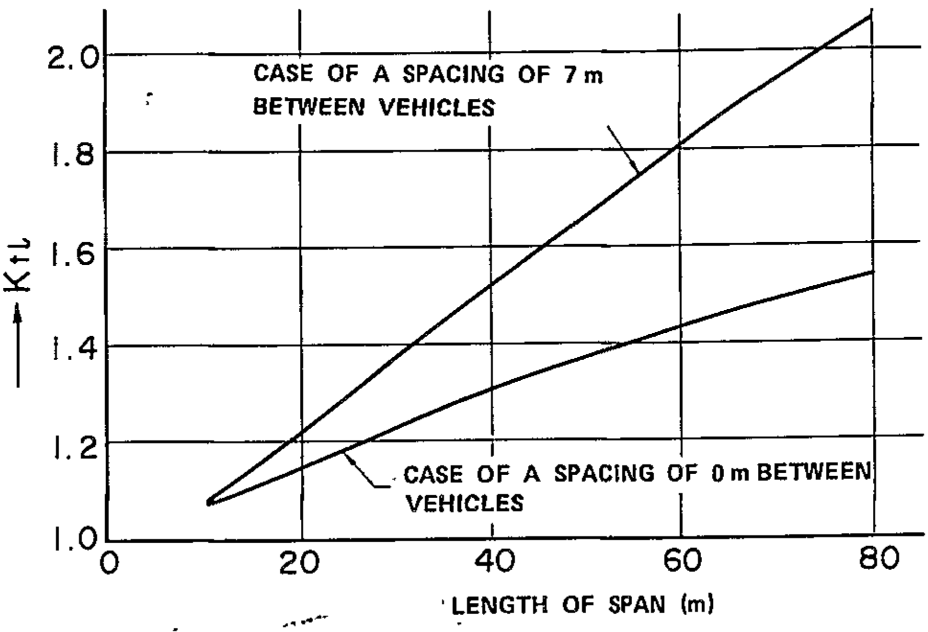


Fig. 3 COEFFICIENT OF CORRECTION RELATED TO THE LOAD DISTRIBUTION THE BRIDGE CENTERLINE (LONGITUDINAL DIRECTION)

Figure 3 presents the coefficient Ktl_1 corresponding to the case when the vehicles are distributed on the bridge with a spacing of 0 m between them and the coefficient Ktl_2 corresponding to the case when the vehicles are arranged on the bridge with a spacing of 7 m between them. The use of either coefficient should be decided in accordance to the state of the actual traffic taking place on the bridge in question.

4–5 Coefficient Related to Other Conditions

The coefficient Ko related to other conditions should be determined by taking into consideration factors such as the expected life of service of the bridge, the importance of the route, the dynamic behaviour of the bridge as a whole, etc.

(Remark)

It is very difficult to present concrete numerical values related to the factors mentioned above. Accordingly, they should be determined by the subjective judgement of the person responsible for the administration of the road.

The expected life of service of the bridge is expected number of years of use of the bridge in question until its replacement or removal. Degree of importance of the route indicates the magnitude of influence on the various sectors in case of impossibility of traffic through the bridge in question due to an important defect or fault taking place therein.

With regard to the dynamic behavior of the bridge, the restrictions imposed upon the bridge may acquire importance, when the deflection and/or vibration becomes abnormally large due to the application of live loads, when the displacements are restricted due to changes of state of the shoes, etc.

4–6 Indication of the Allowable Load

The allowable load should be indicated at both extremities of the bridge. The value to be indicated should be that calculated as described in the Paragraph 4-1, rounded up to the 1st digit after the decimal point. The unit of the allowable load should be tons.

5 ALLOWABLE LOAD WITH SPECIAL AUTHORIZATION

5–1 Authorization of Special Loads

The judgement related to the authorization of traffic of special loads should be made by the person responsible for the administration of the road, by taking into consideration the state of each individual bridge and each individual case of load.

PHOTOS

Fixed Type Automatic Weighing Machinery of Axle Load for Vehicles

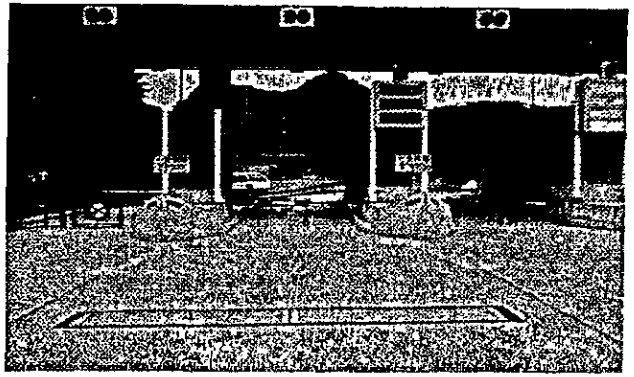


Photo 6–2.1

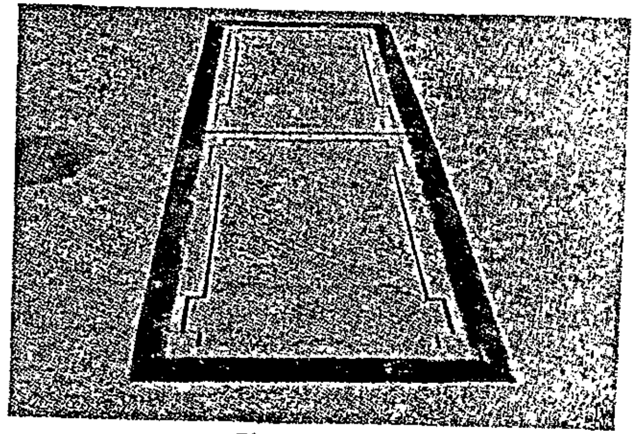


Photo 6–2.2

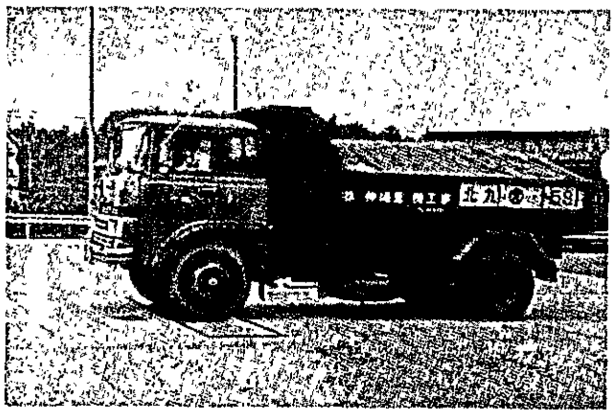


Photo 6–2.3

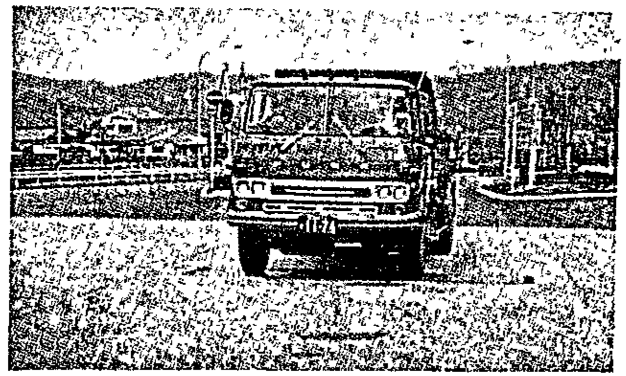


Photo 6–2.4

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Movable Type Automatic Weighing Machinery of Axle Load for Vehicles

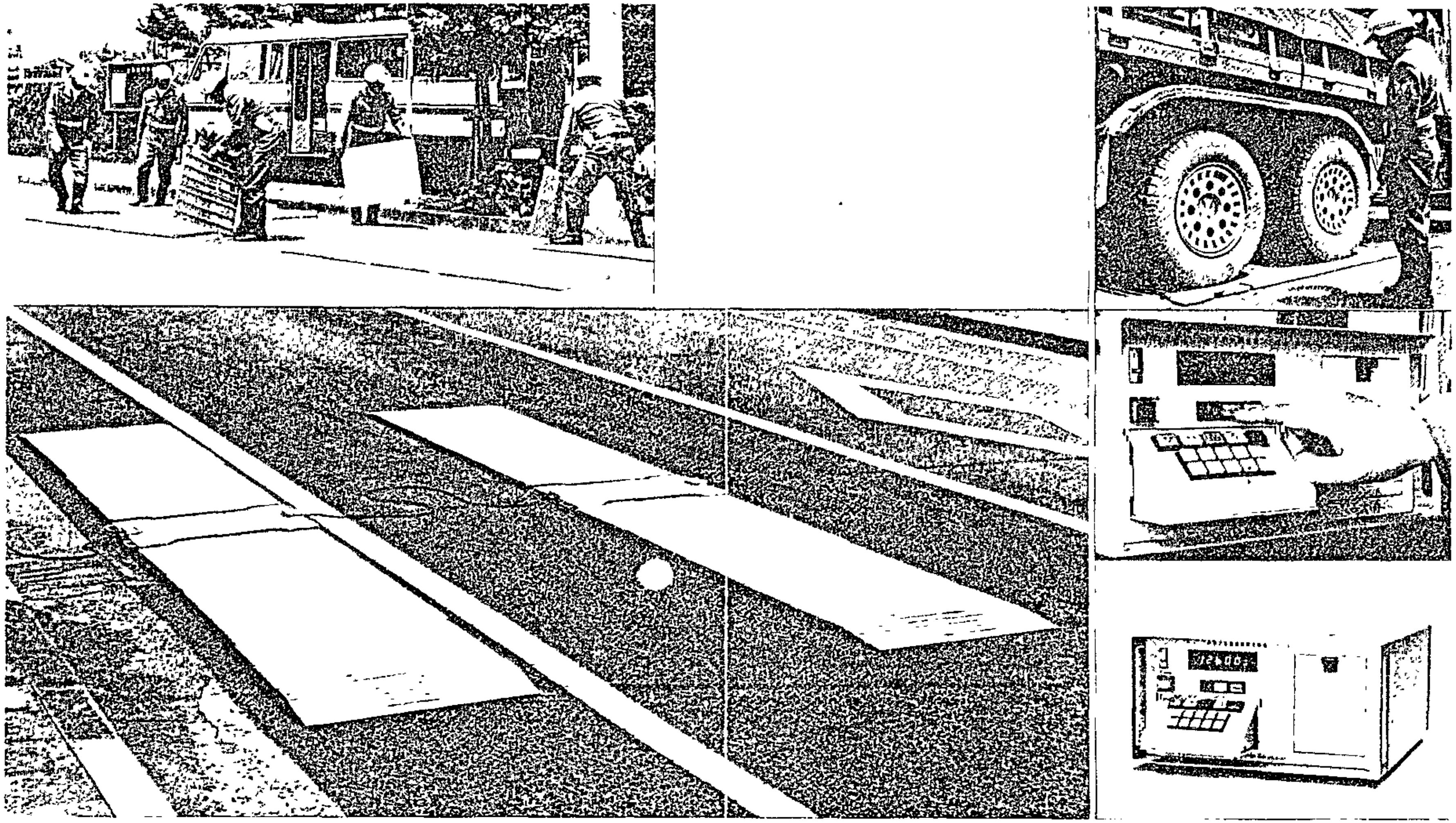

Photo 6–2.5

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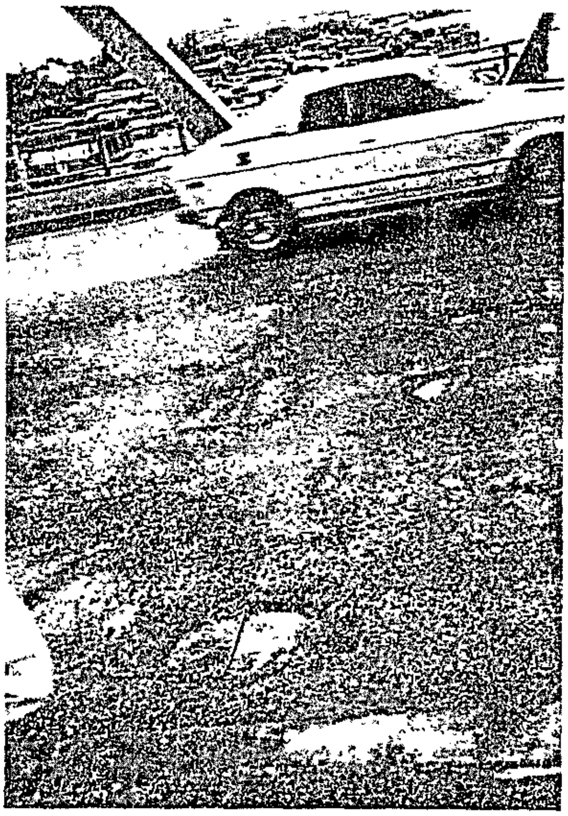

Photo 3-1.1
Pavement on the Construction Joint of RC Slab

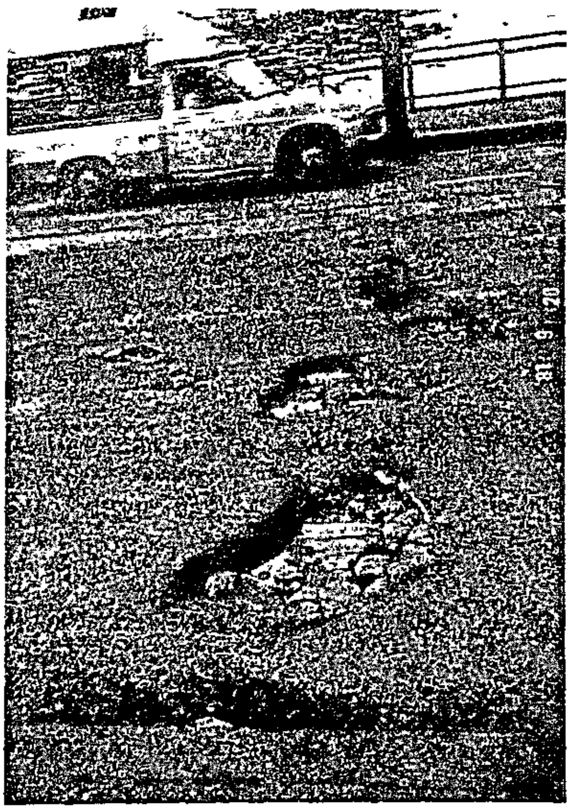

Photo 3-1.2
Pavement around the Expansion Joint

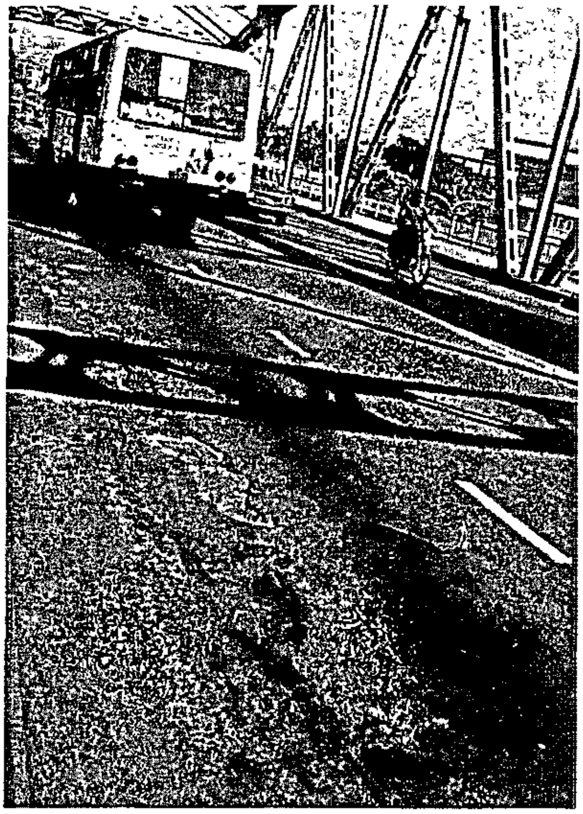

Photo 3–1.3
Pavement on the Construction
Joint of RC Slab

Photo 3–1.4
Pavement on the Carriageway

Krung Thep Bridge

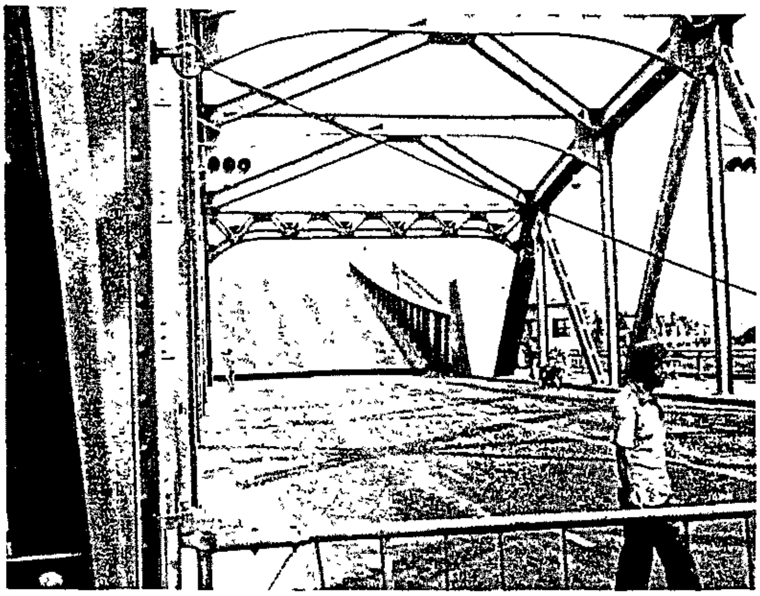

Photo 3–1.5 Pavement on the Construction Joint of the RC Slab

Photo 3–1.6
Pavement on the Trussed Beam and Bascule Bridge

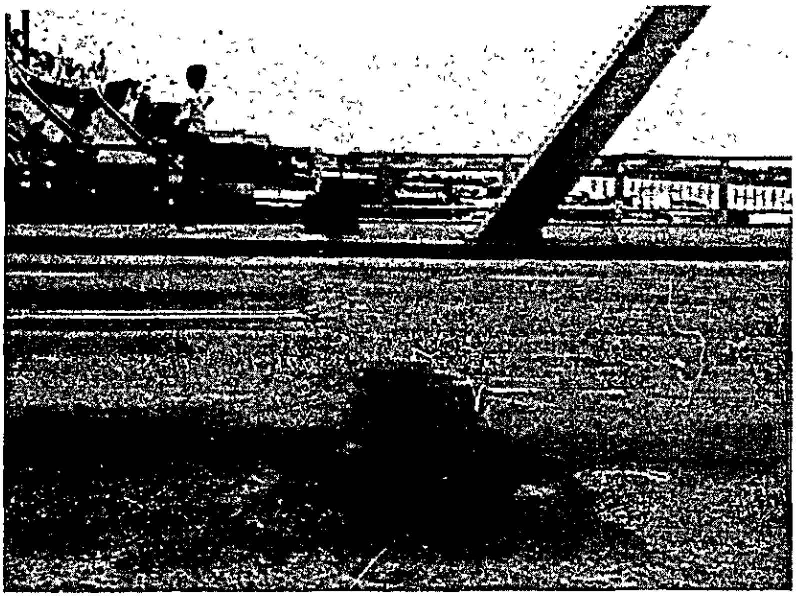

Photo 3–2.1 Expansion Joint on the Foot Path

Photo 3–2.2 Overlaying on the Expansion Joint

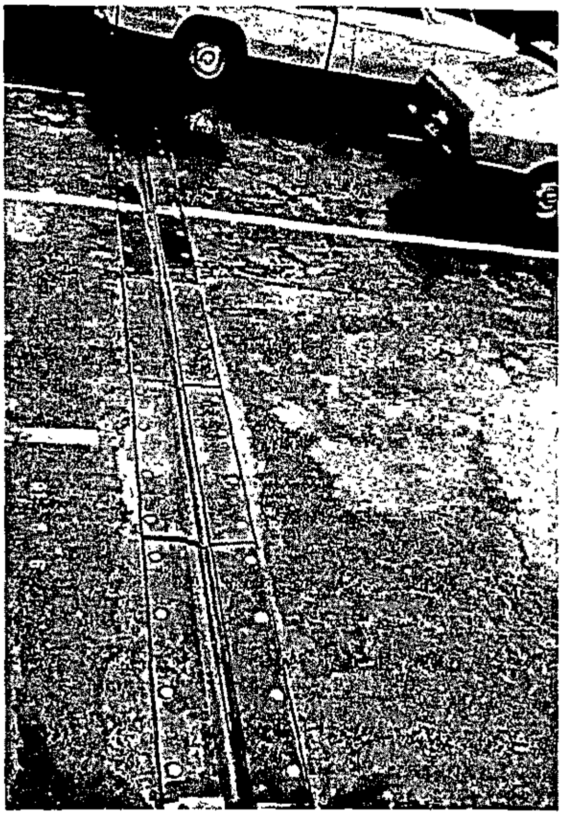

Photo 3–2.3
Expansion Joint at the Center of Bascule Bridge

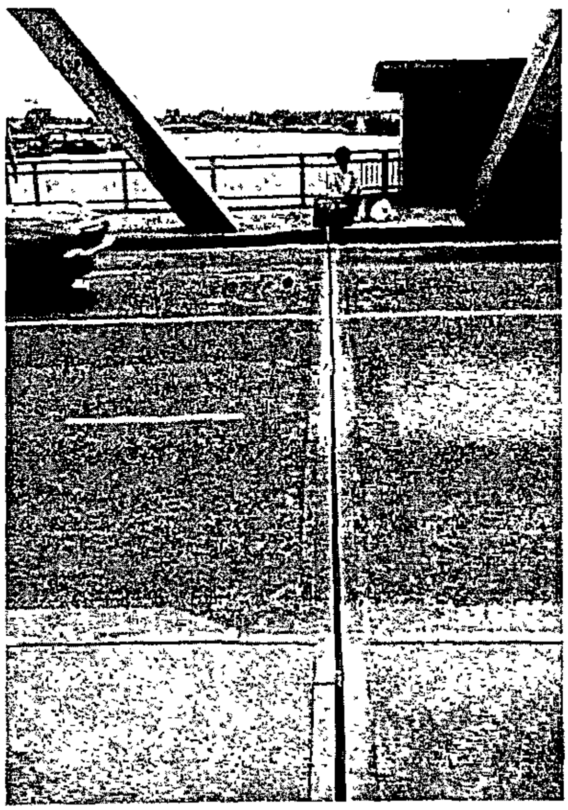

Photo 3–2.4
Expansion Joint between Trussed Beam and Bascule Bridge

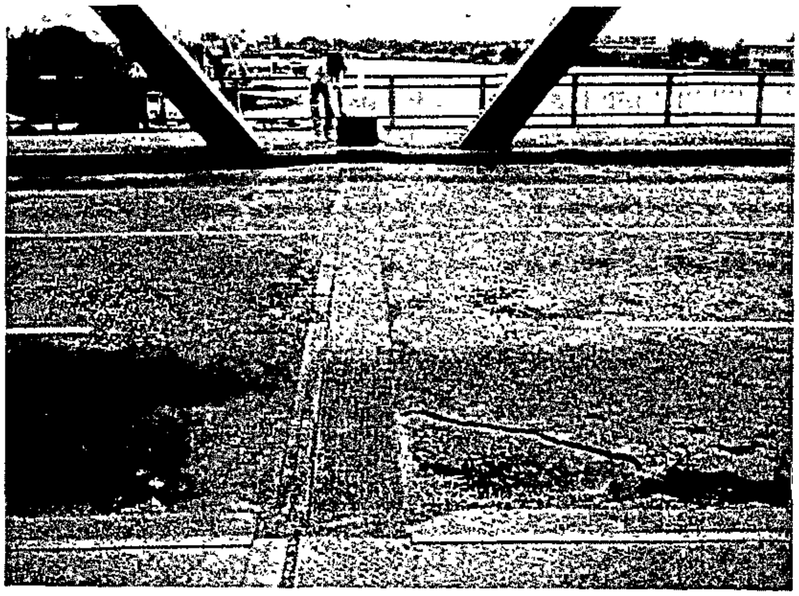

Photo 3–2.5 Expansion Joint between the Ends of Each Trussed Beams

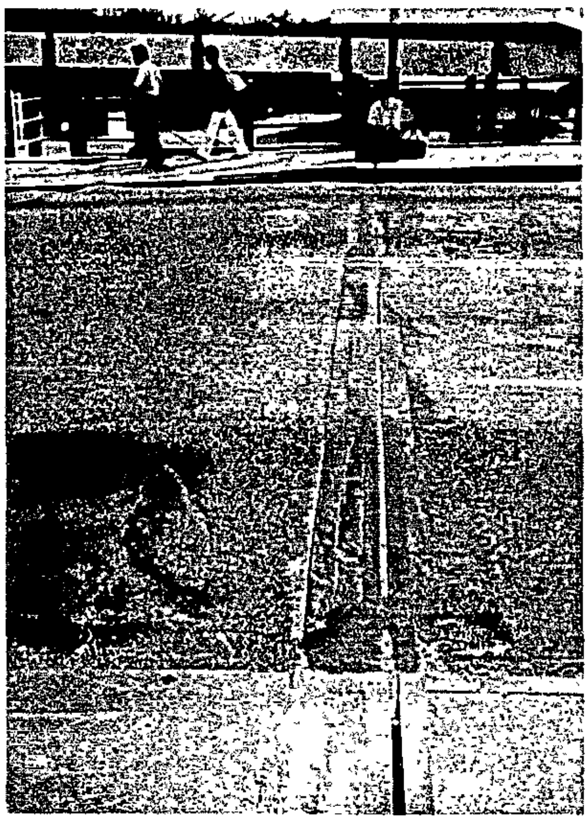

Photo 3–2.6
Expansion Joint between the Ends of each Approach Span

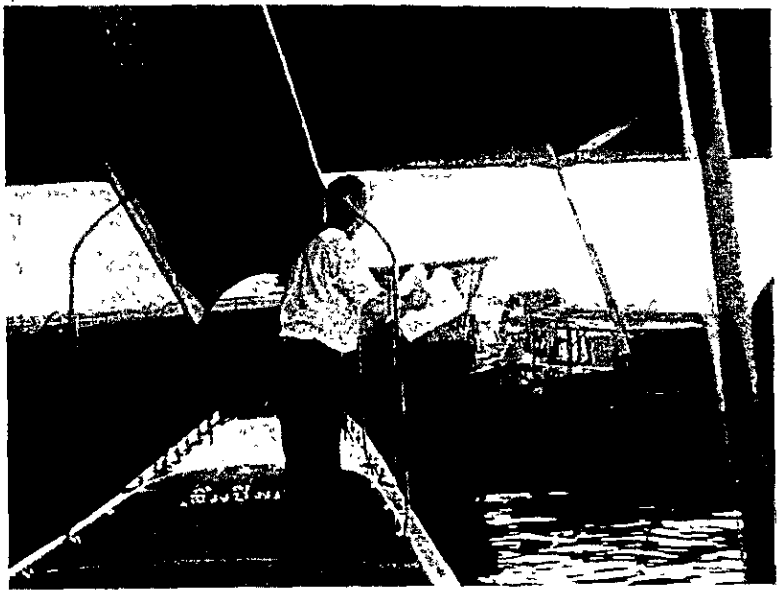

Photo 3–3.1 Vidual Investigation from the Boat

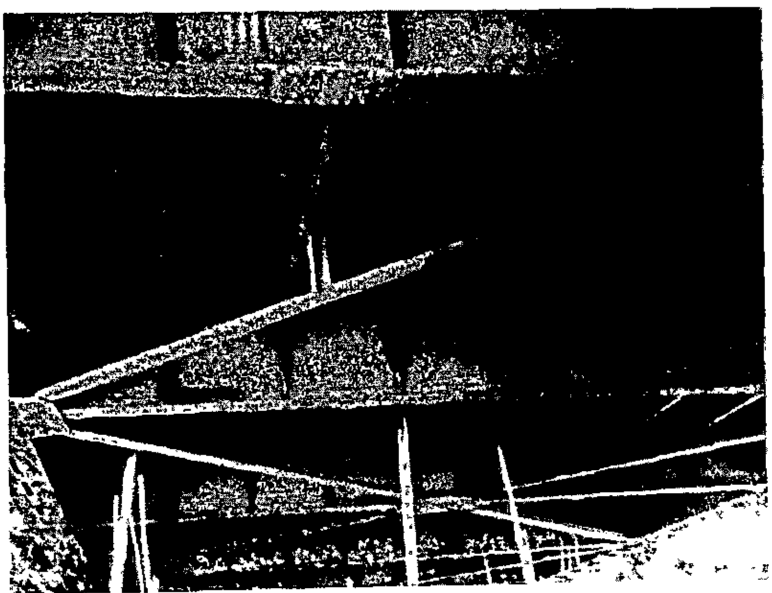

Photo 3–3.2 Vidual Investigation of Floor Slab Cracks and Rustings of Stringers, Cross Beams

Photo 3–3.3 Investigation of Cracks at the RC Floor Slabs

Photo 3–3.4 Vidual Investigation of Rusting at the Stringers and Cross Beams

Krung Thon Bridge

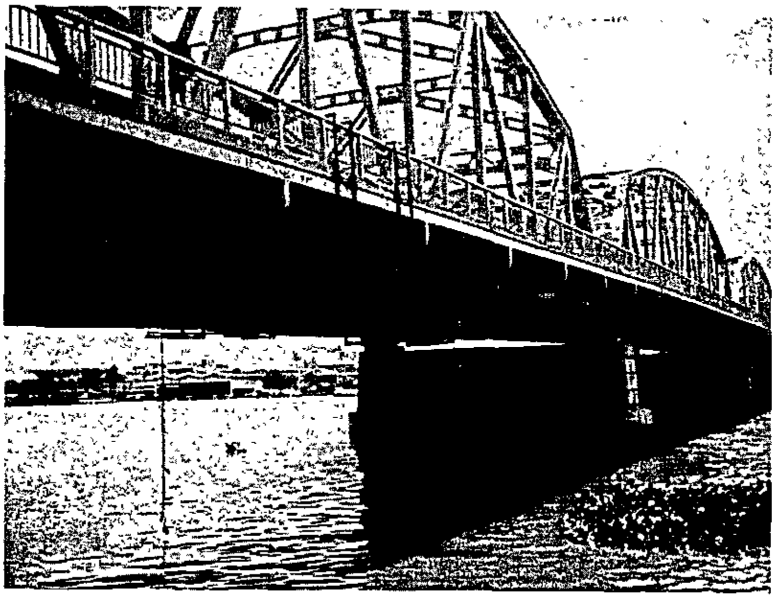

Photo 3–4.1 Hang Scaffolding

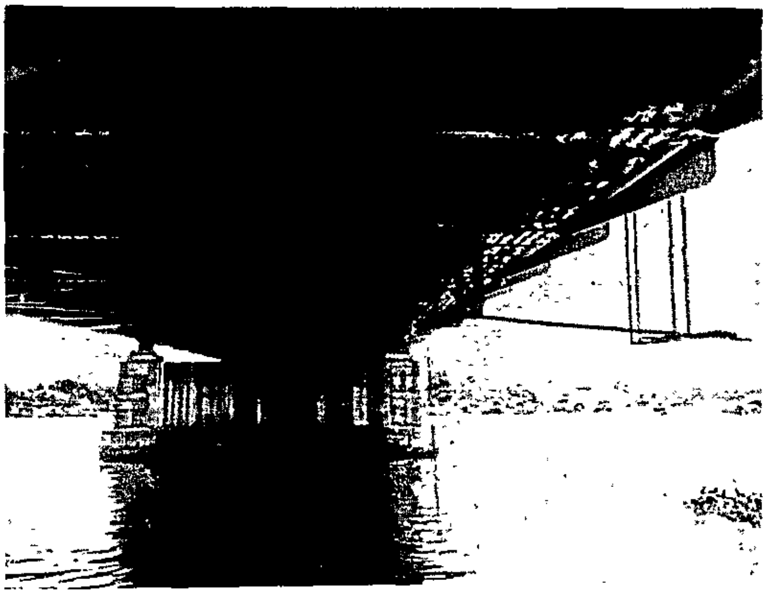

Photo 3–4.2 Hang Scaffolding

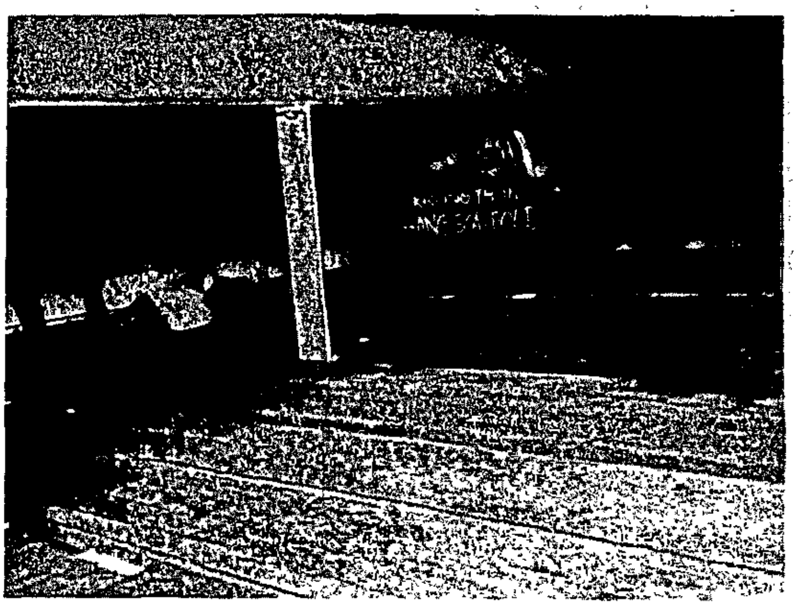

Photo 3—4.3 Stringer and Hang Scaffolding

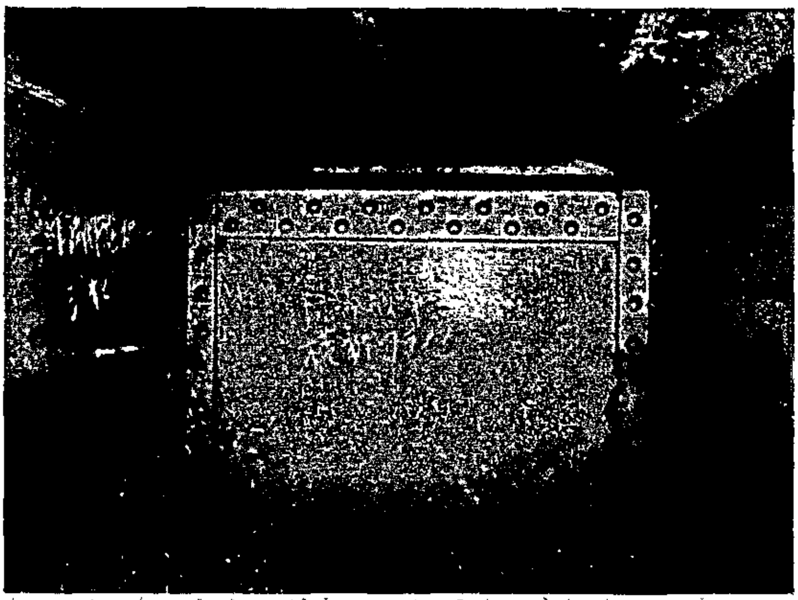

Photo 3—4.4 Rusting of Stringers and Cross Beam under the Construction Joint of the RC Floor Slabs

Photo 3–4.5 Investigation of Cracks at the RC Floor Slabs

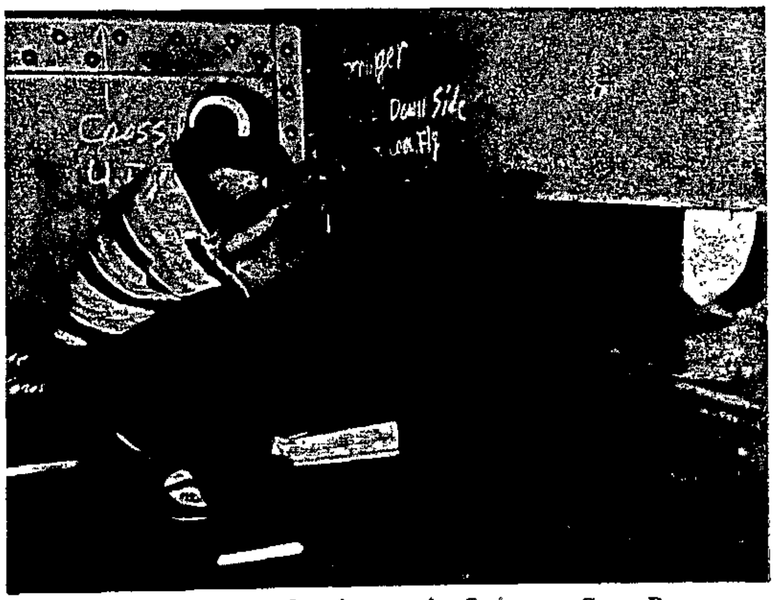

Photo 3–4.6 Rustings at the Stringers, Cross Beams and Lower Chords under the Construction Joint of the RC Floor Slabs

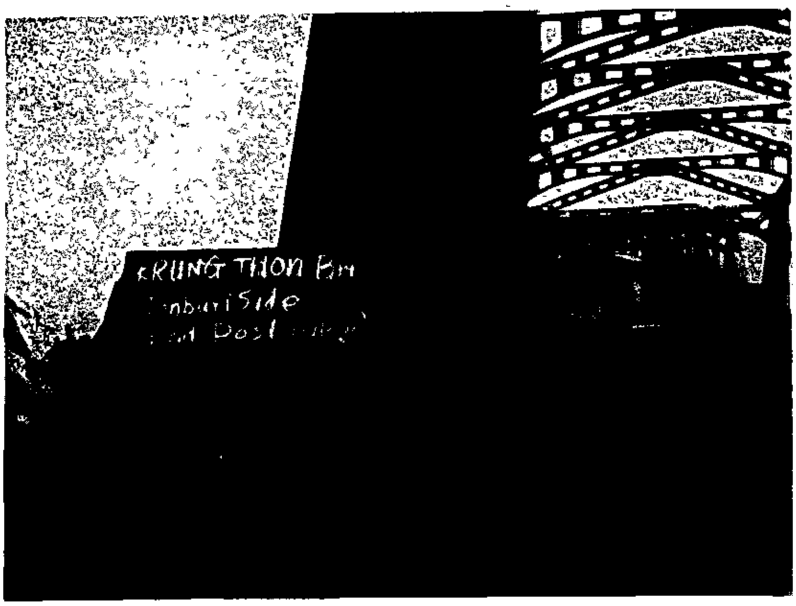

Photo 3–5.1 Clashed Signs of Cars at the End Post of the Trussed Beams

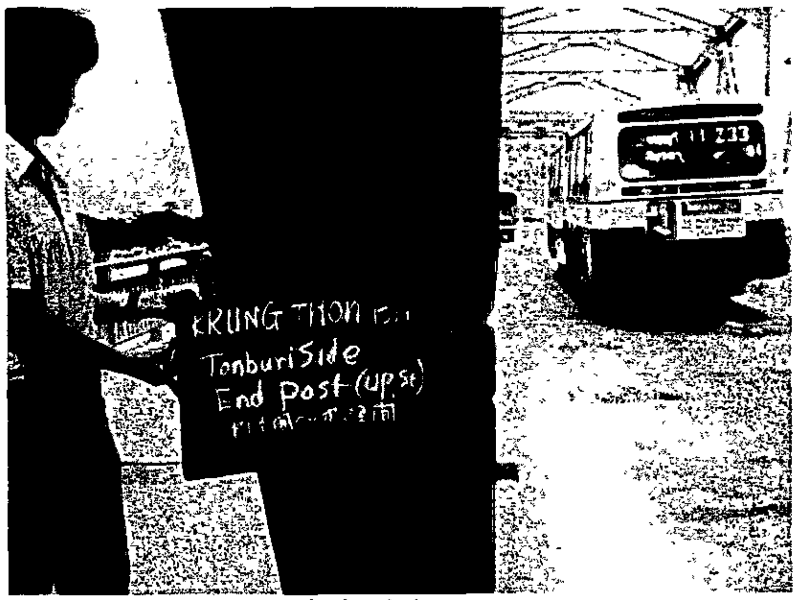

Photo 3–5.2 Clashed Signs of Cars at the End Post of the Trussed Beams

Photo 3–5.3 Clashed Signs of Cars at the Vertical Member of the Truss Bridge

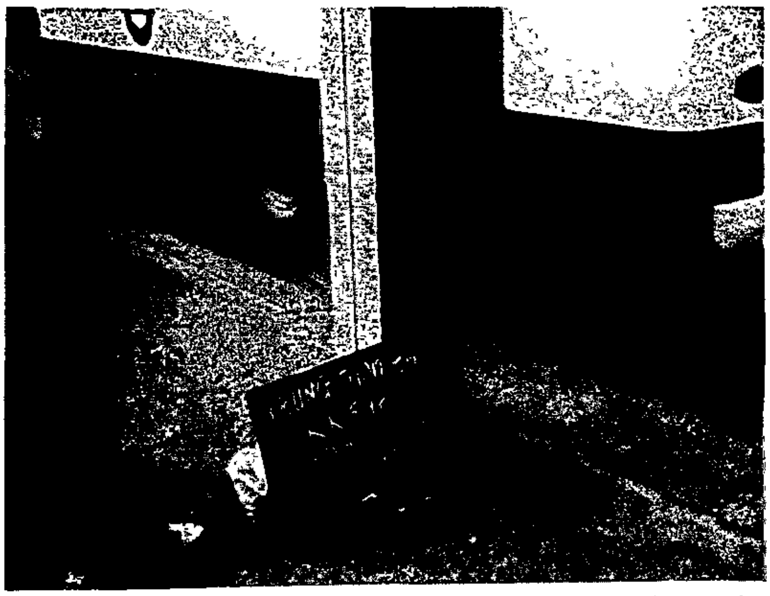

Photo 3–5.4 Clashed Signs of Cars at the Vertical Member

Krung Thon Bridge

Photo 3–5.5 Clashed Signs of Cars

Photo 3–5.6 Clashed Signs of Cars

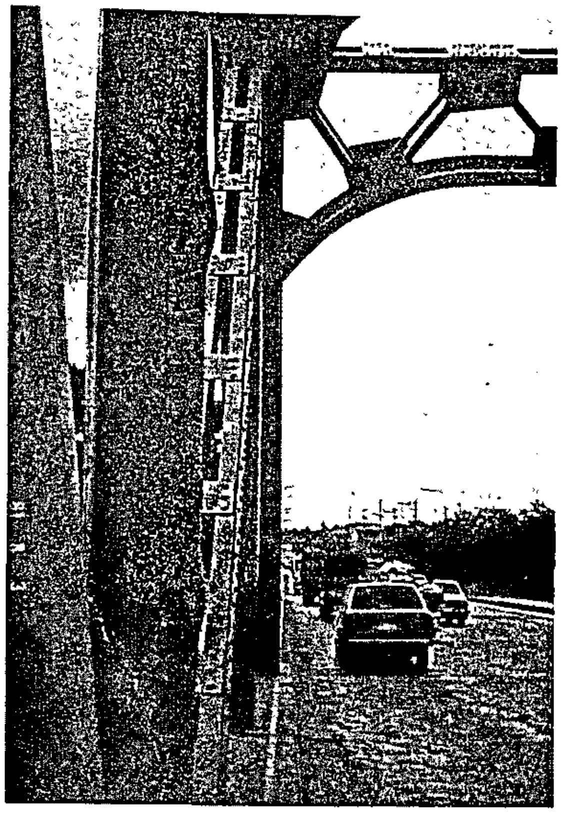

Photo 3–5.7
Clashed Signs of Cars

Photo 3–5.8 Corrosion of the Lower Chord at the Trussed Beam

Photo 3–5.9 Corrosion of the Lower Chord at the Trussted Beam

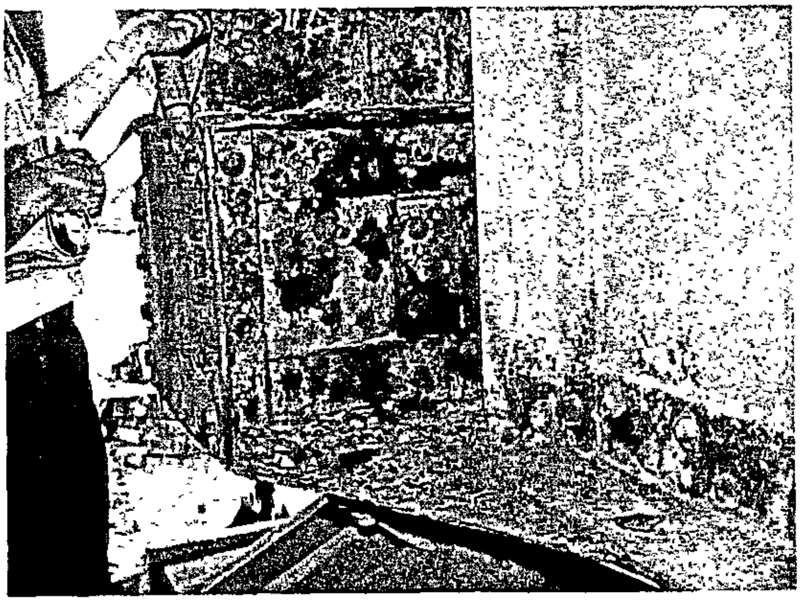

Photo 3–5.10 Corrosion of the Lower Chord at the Trussed Beam

Photo 3–6.1
Asphalt Coverings on the RC Slab

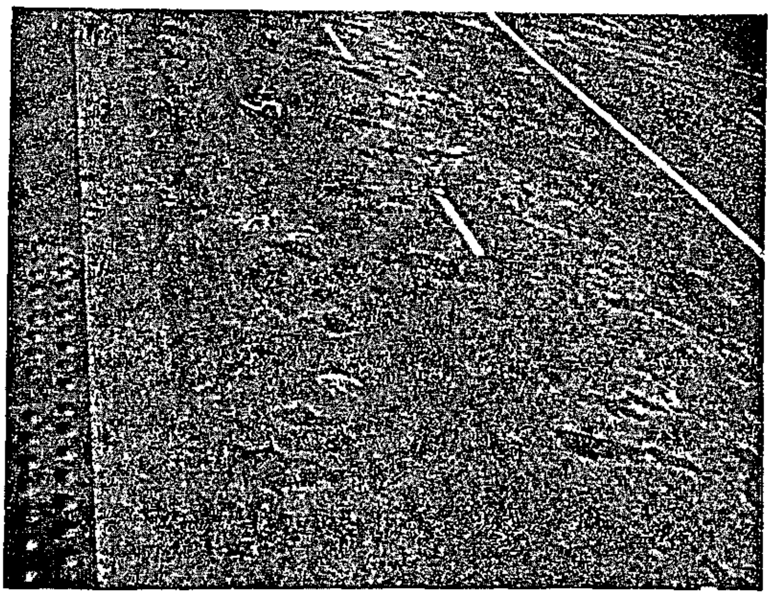

Photo 3–6.2 Asphalt Coverings on the RC Slab

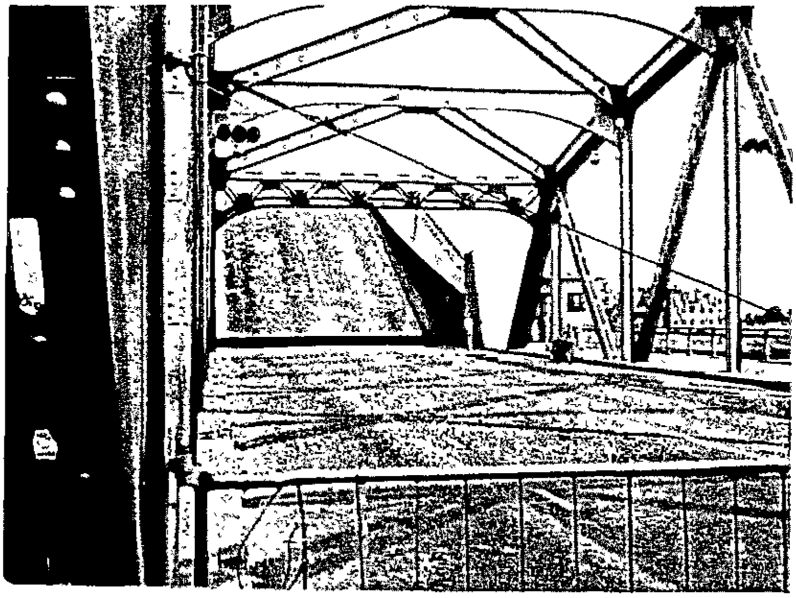

Photo 3—6.3 The Opened Situation of the Bridge

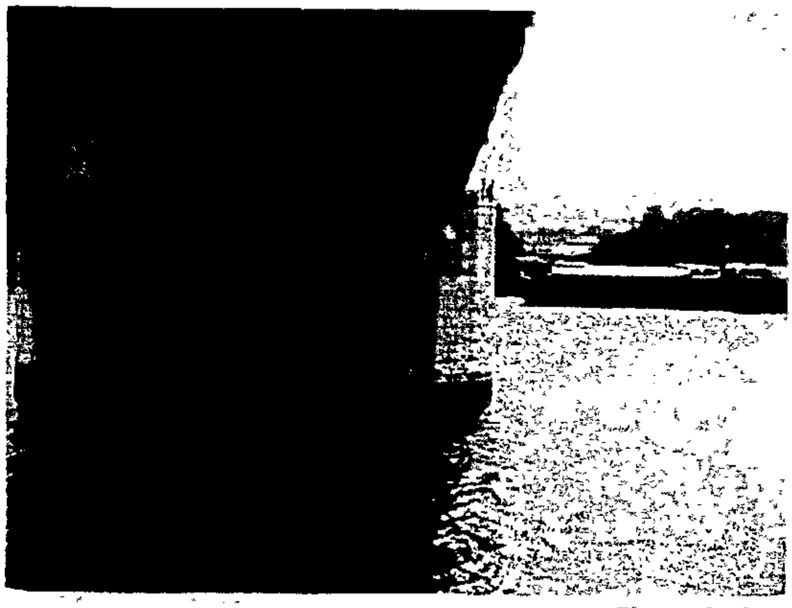

Photo 3—6.4

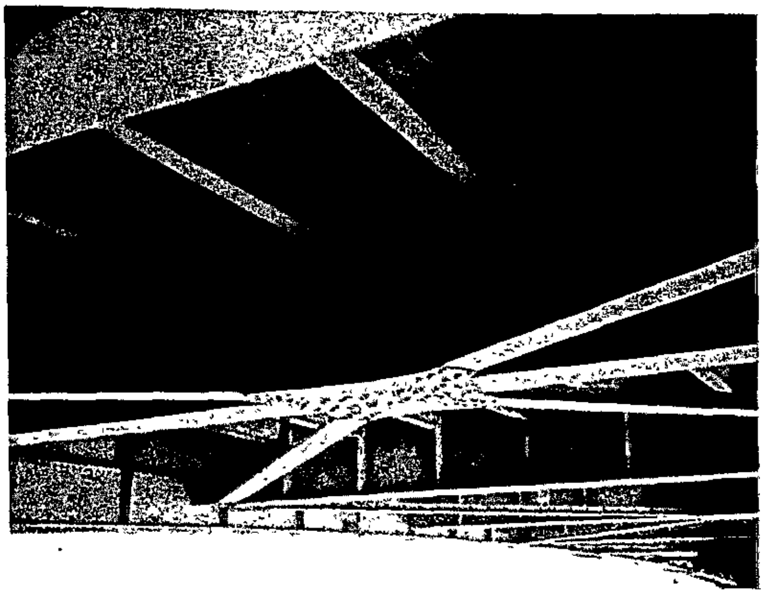

Photo 3–6.5 Stringer, Cross Beam and Lower Lateral

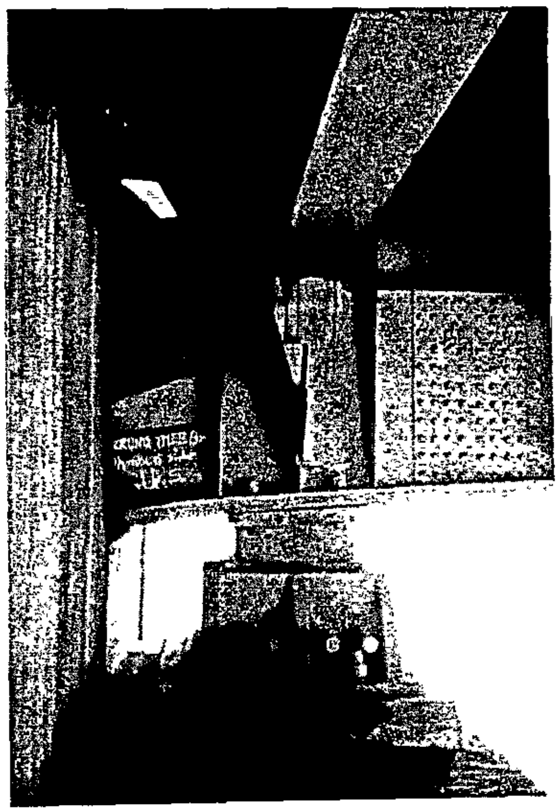

Photo 3–6.6
Lower Flange Plate of the Cross Beam and Inside of Main Girder on the Live Load Shoe

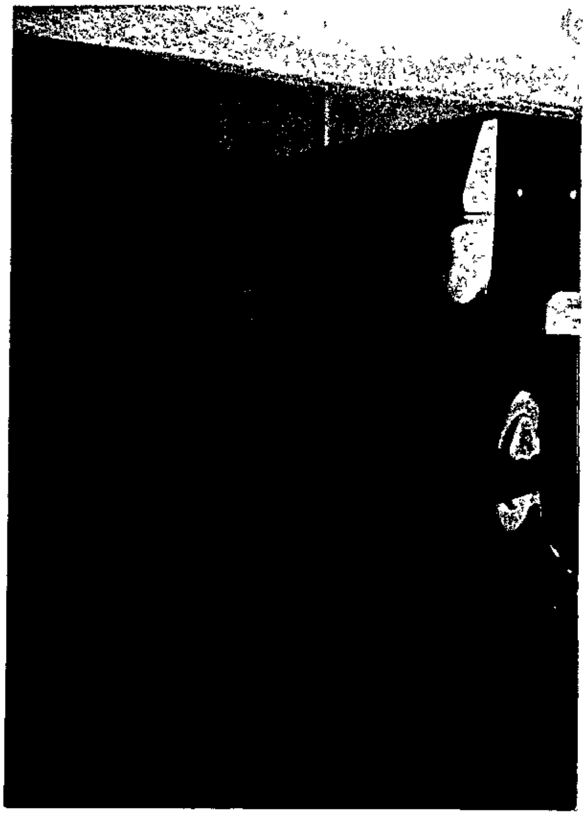

Photo 3–6.7
Corrosion on the Splice Plate of the Main Girder

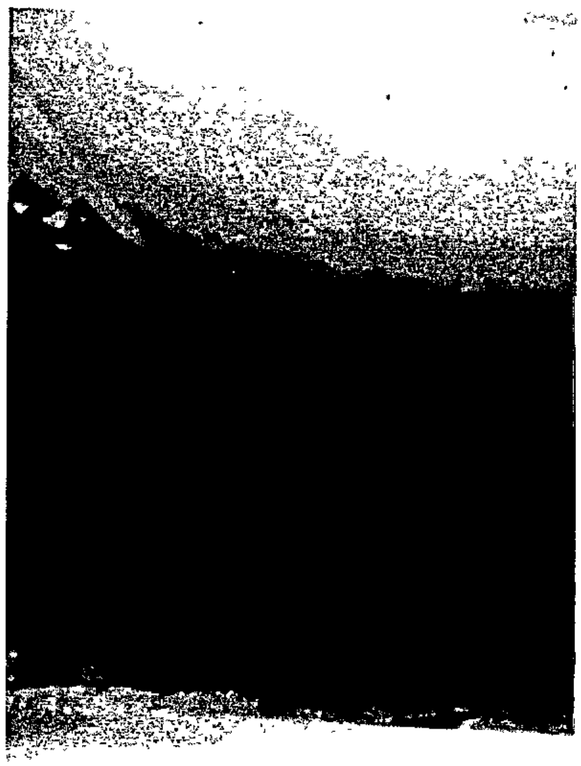

Photo 3–6.8
Corrosion on the Splice Plate of the Main Girder

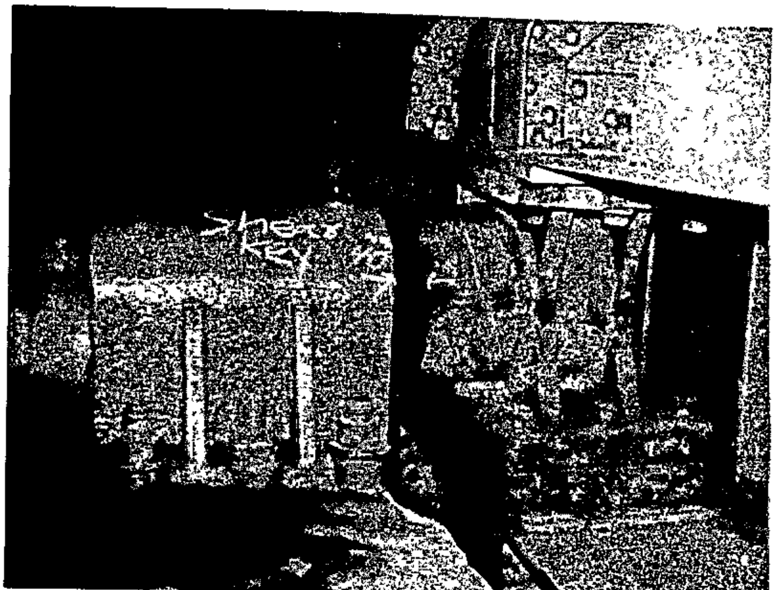

Photo 3–6.9 Different Spacings at the Rear Key
(At Up Stream of B.K.K Side)

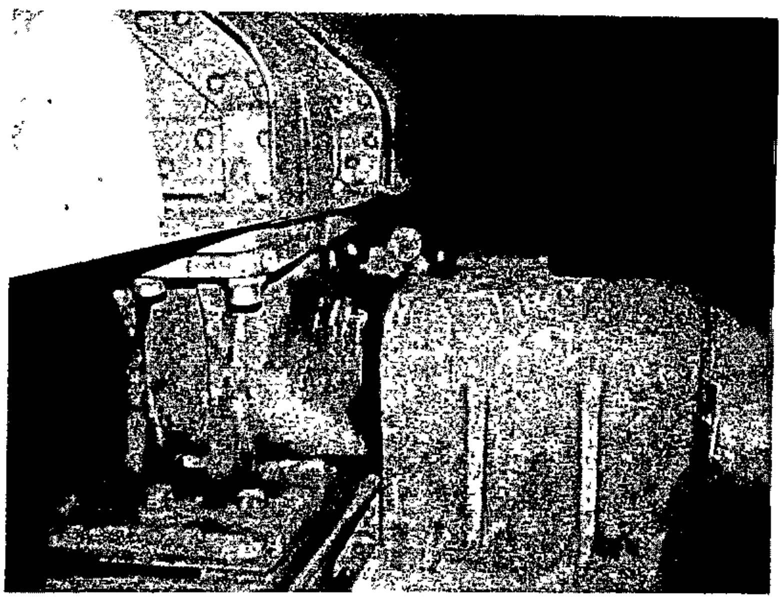

Photo 3–6.10 Different Spacings at the Rear Key
(At Down Stream of B.K.K Side)

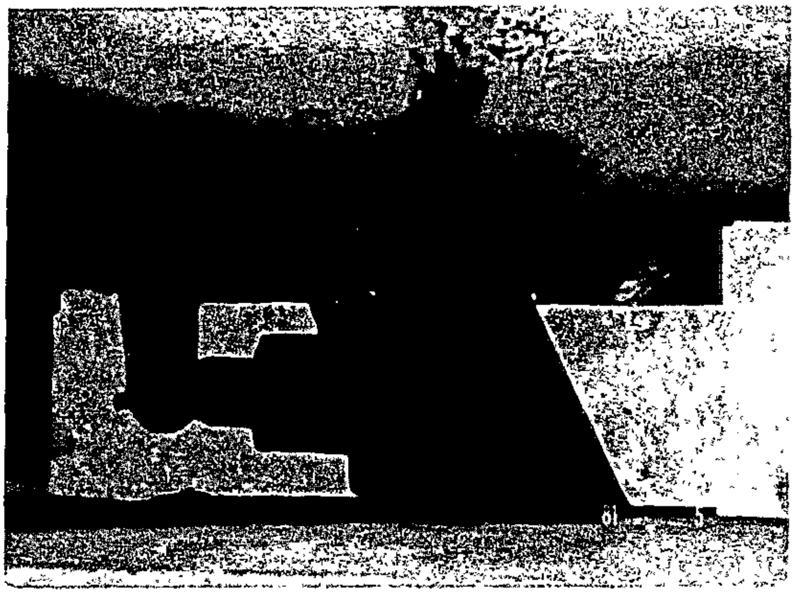

Photo 3–6.11 Different Spacings of the Shear Key at the Cantilever End (Down stream side)

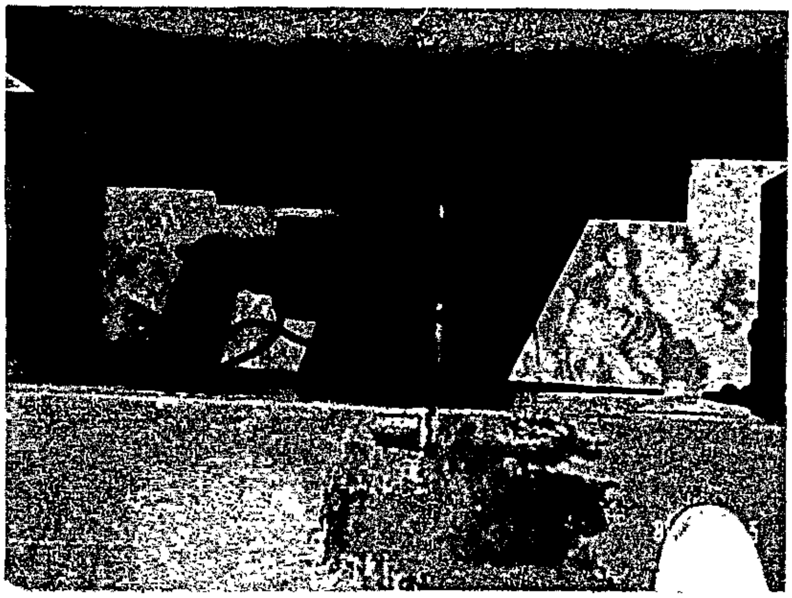

Photo 3–6.12 Different Spacings of the Shear Key at the Cantilever End (Up stream side)

Krung Thon Bridge

Photo 3–7.1 Movable and Fixed Shoes

Krung Thep Bridge

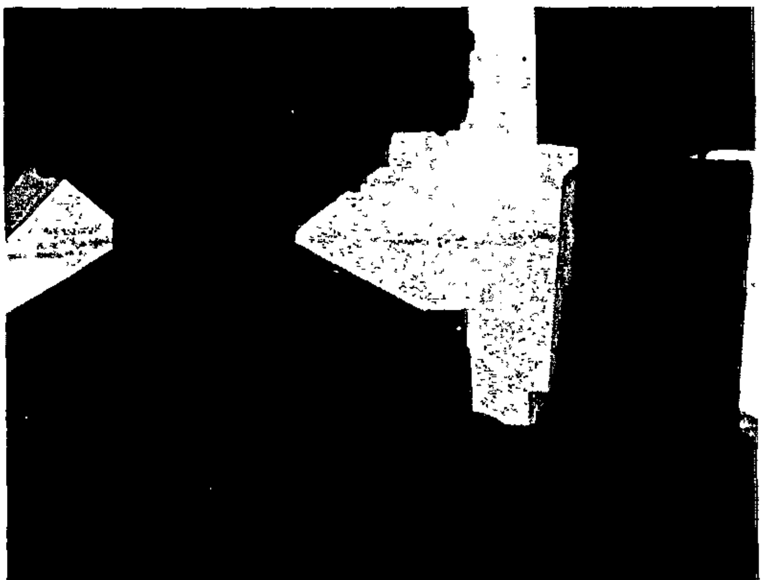

Photo 3–7.2 Movable Shoe

Krung Thon Approach Bridge

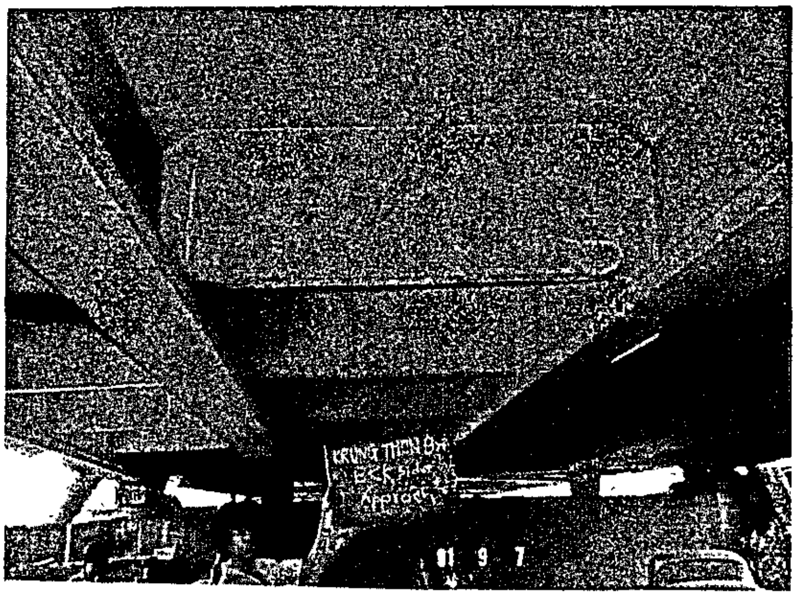

Photo 3–8.1 PC Composite Girder (B.K.K. Side)

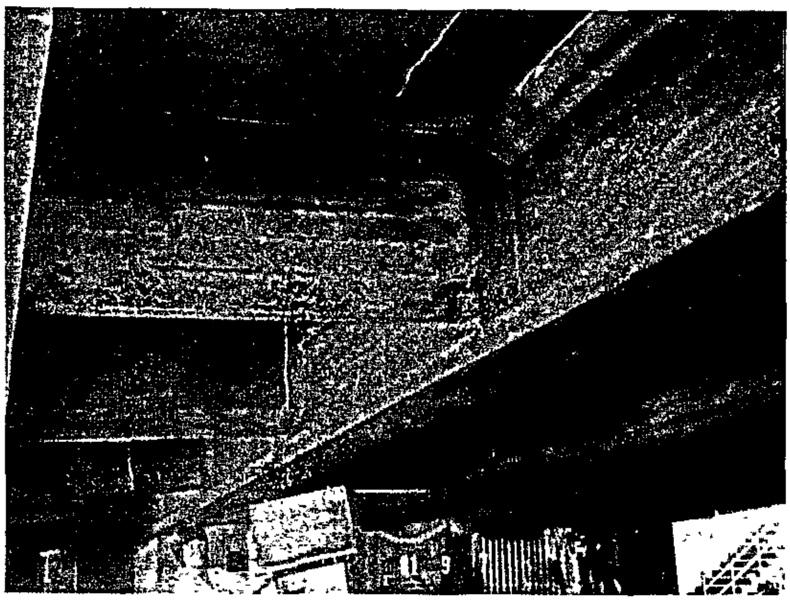

Photo 3–8.2 PC Composite Girder (Thonburi Side)

Photo 3—8.3 2 Span Continuous RC Rigid Bridge

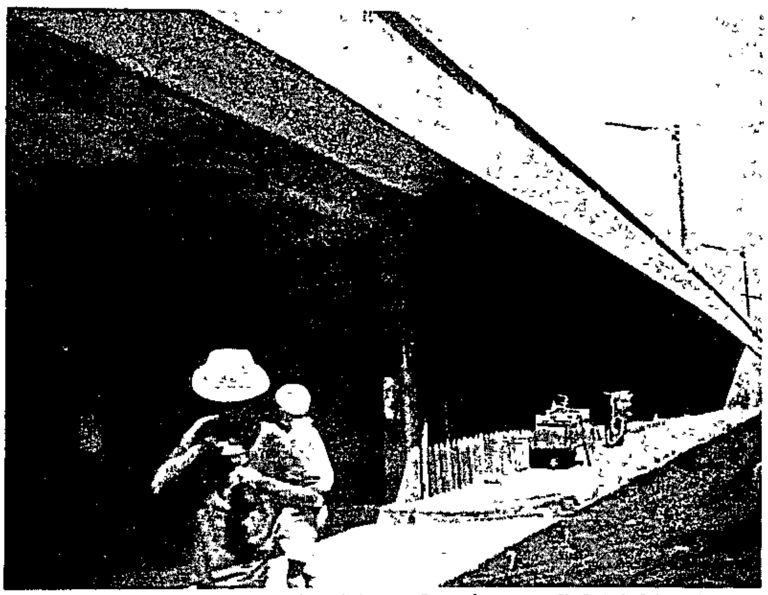

Photo 3—8.4 6 Span Continuous RC Rigid Bridge

Photo 3—8.5 Cracks and Timberings under the RC Slab at the 6 Spans Continuous RC Rigid Bridge (B.K.K Side)

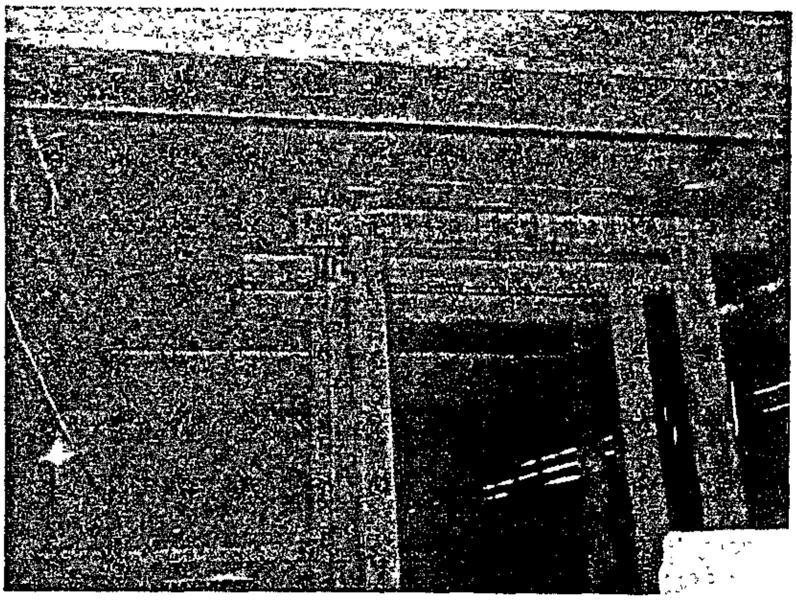

Photo 3—8.6 6 Spans Continuous RC Rigid Bridge Timber of RC Slab (B.K.K Side)

Krung Thep Approach Bridge

Photo 3–8.7 Cracks and Timbering under the RC Slab at the PC Composite Girder (B.K.K Side)

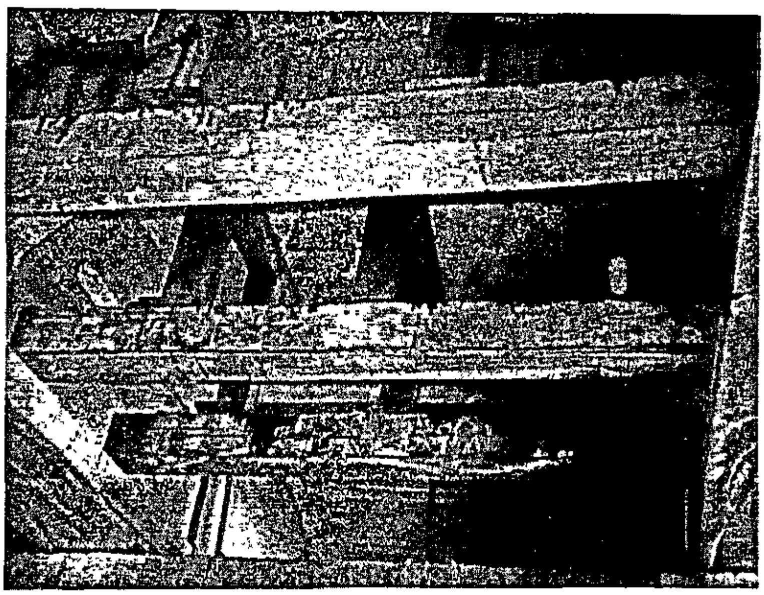

Photo 3–8.8 Timberings under the RC Slab at the PC Composite Girder (B.K.K Side)

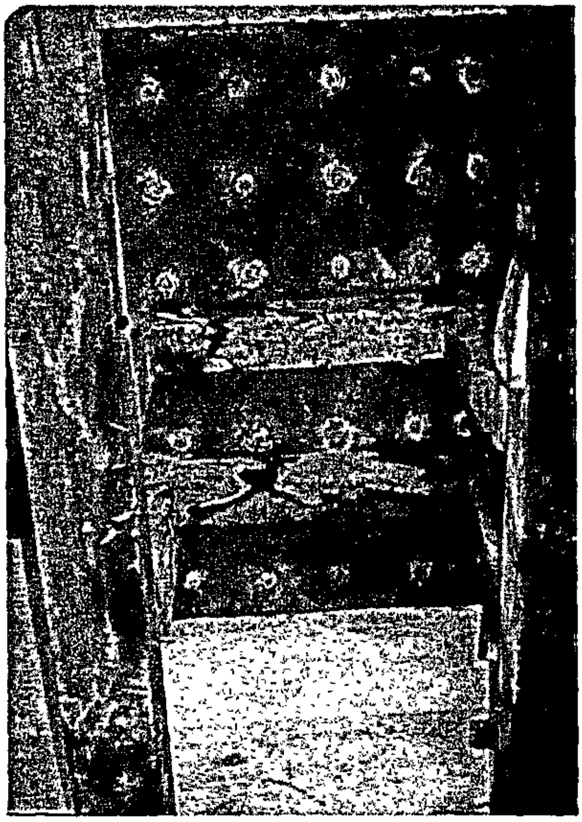

Photo 3–8.9
Strengthening by Steel Plates and Timberings under the RC Slab (B.K.K Side)

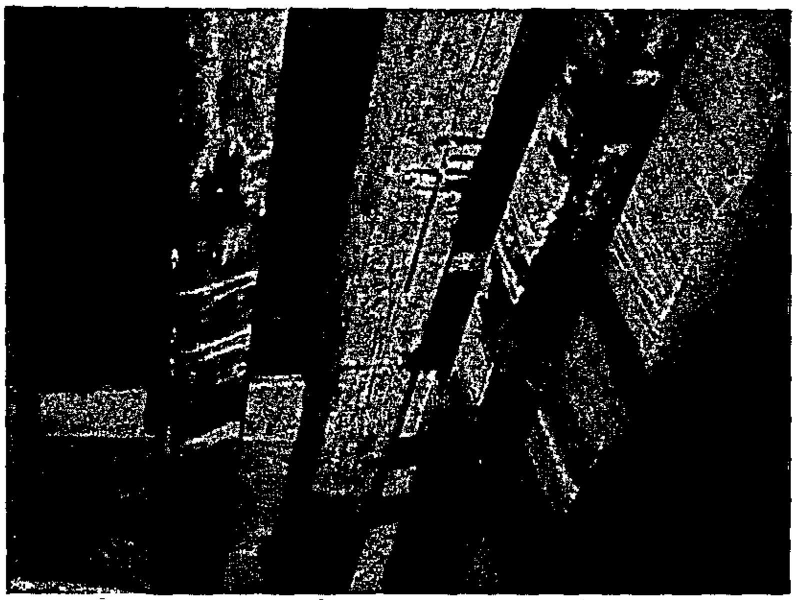

Photo 3–8.10 Strengthening by Timberings under the RC Slab (B.K.K Side)

Photo 3–9.1
Visual Investigation at the Pier

Photo 3–9.2
Visual Investigation at the Pier

Photo 3–9.3
Visual Investigation at the Pier

Photo 3–9.4
Visual Investigation at the Pier

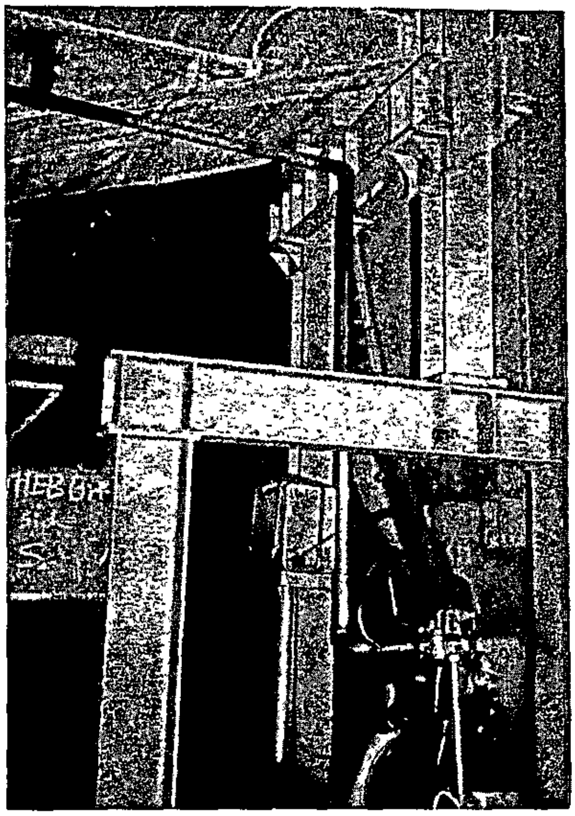

Photo 3–9.7
Cracks at the under Side of the Cantilever Slab in which Seted the Rear Key

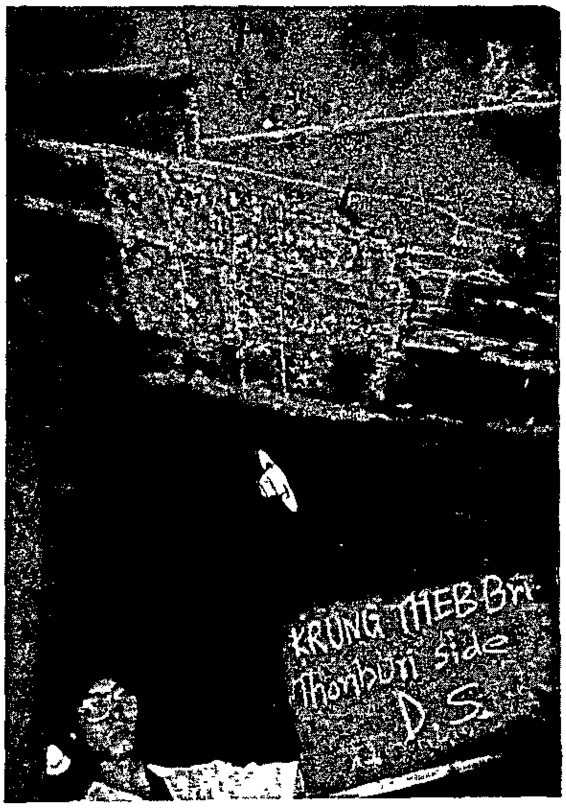

Photo 3–9.8
Strengthening against the Uplift Pressure at the Rear Key