BURSA AREA

Date	Accommodation	Bridge No.	Time Arrangement
10/9 (Monday)	BURSA	SB-200-08-4	
10/10 (Tuesday)	BURSA	SB-200-06-12	
10/11 (Wednesday)	to ANKARA		

JICA Study Team Member : K. Wada and
Cem Budak (team assistant)

b) Environmental and Hydrological Inspection Team

KGM Headquarter : Mr. Ertan Saytt

KGM Division Members :1 Engineer
:1 assistant engineer
:1 driver

JICA Study Team Member : Y. Kobayashi

6.3.5 Work

1) Traffic Regulation

In order to ensure work safety, traffic regulation should be implemented during inspection work as presented in Figure - 6.3.1 for two way carriageway, and Figure - 6.3.2 and 6.3.3 for two lane carriageway.

2) Equipment

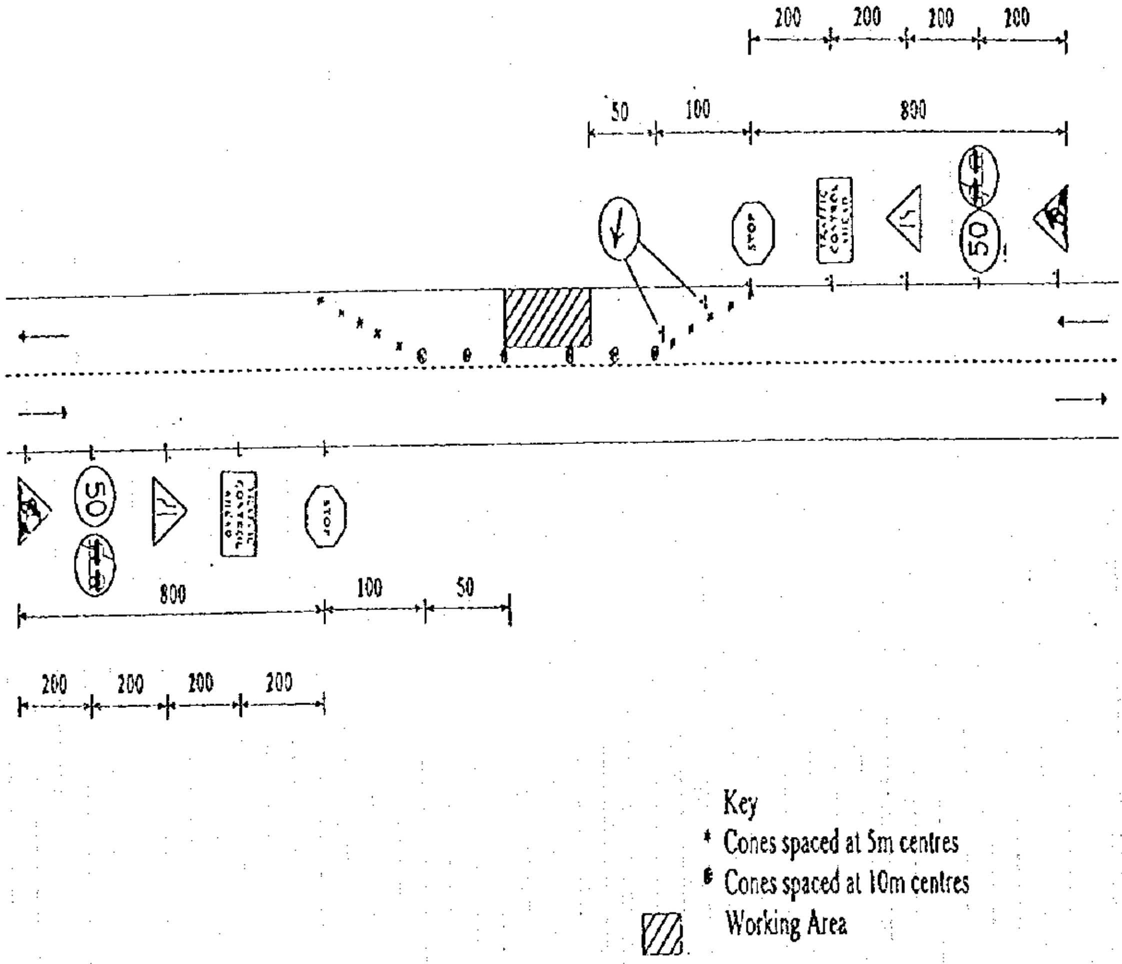
Equipment essential for detailed inspections are presented in Table - 6.3.7, all of which are brought by study team.

In addition to this equipment, a Transit or Level is necessary to survey road height under the highway at collision damage locations. Mortar material is necessary to reinstate drilled holes for neutralization tests.

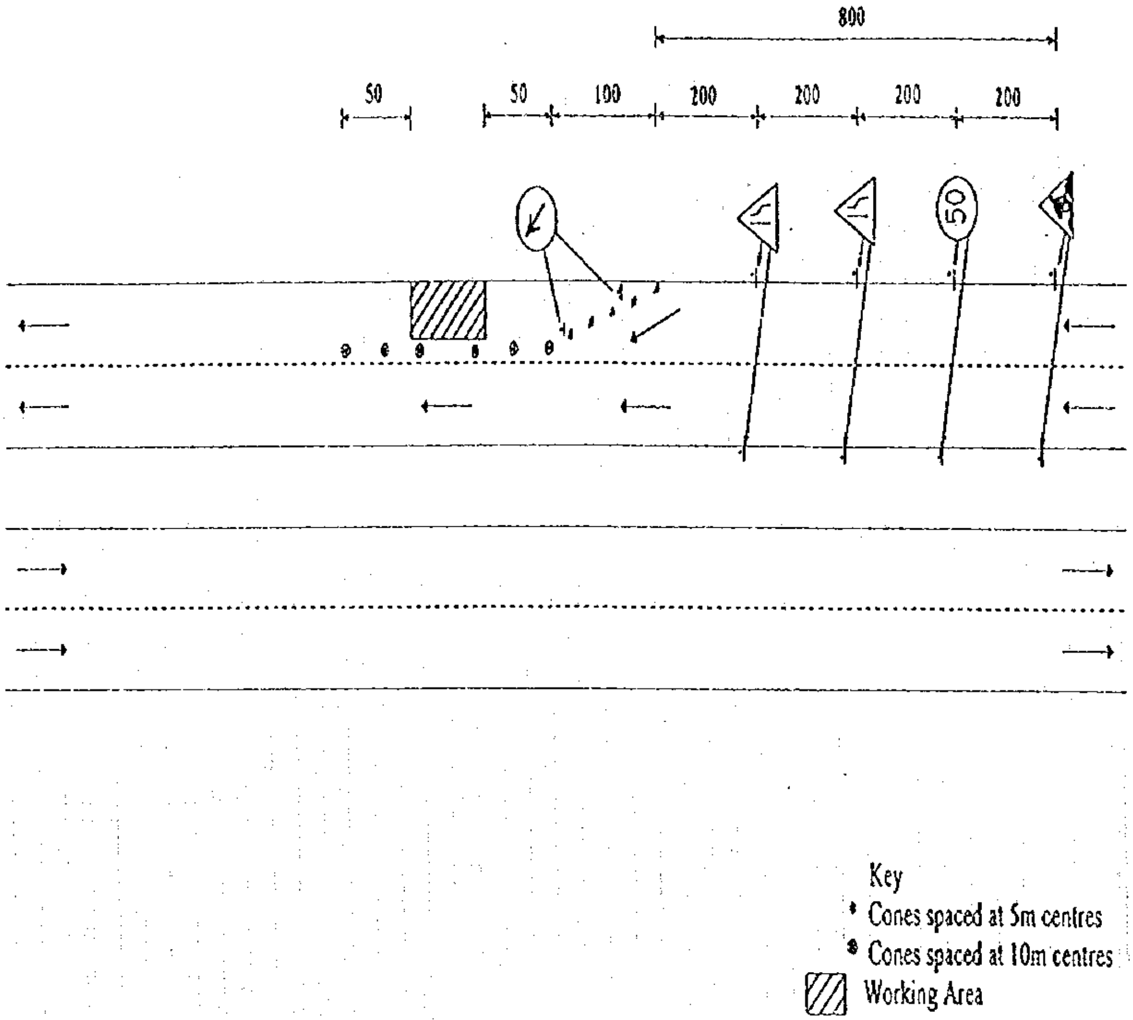
6.4 Structural Investigation

6.4.1 General

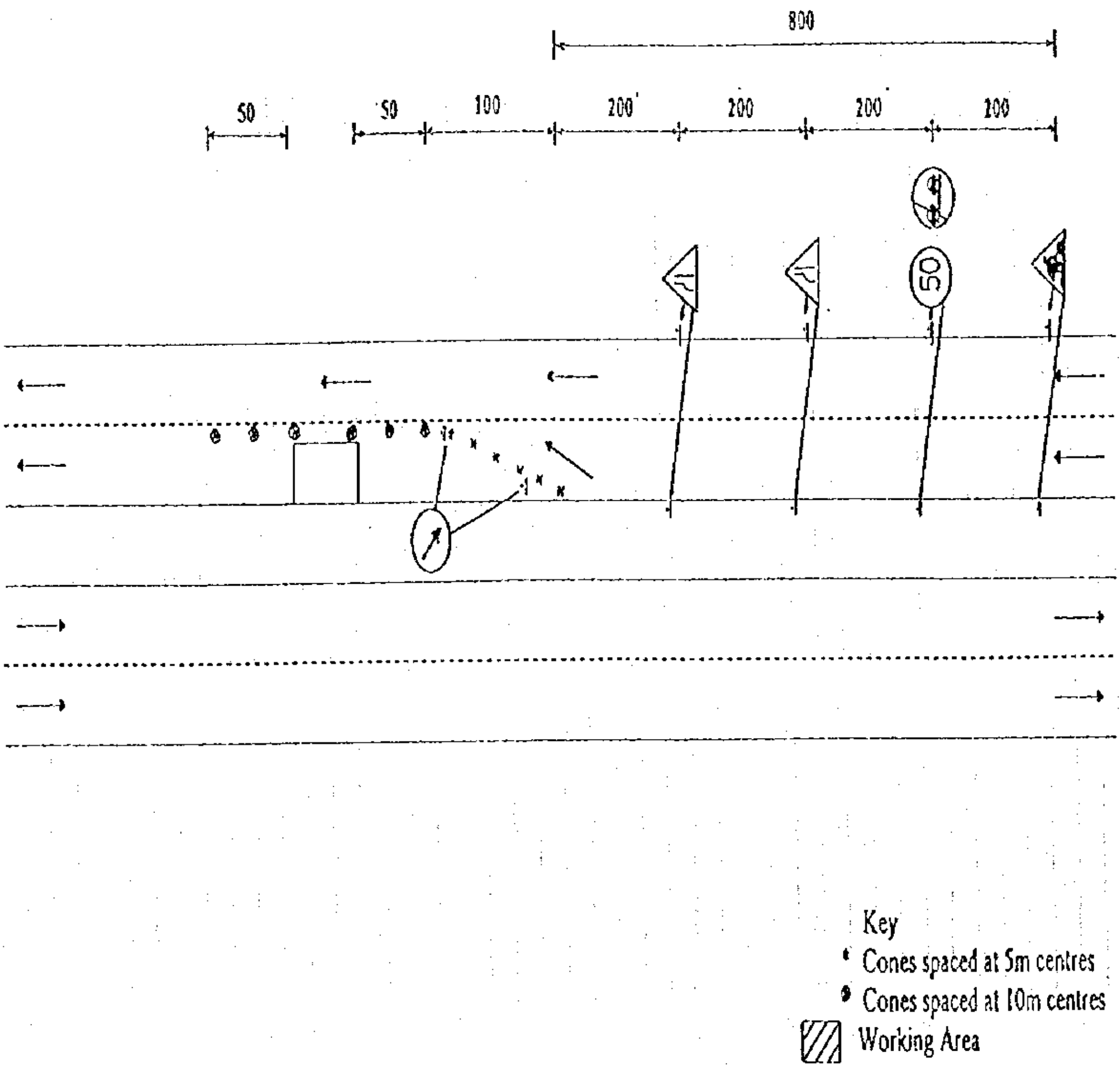
The structural outline for the selected 20 objective bridges for detailed inspection are presented in Table - 6.4.1.



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 LINTED	Figure – 6.3.1 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 LINTED	Figure - 6.3.2 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 - 6.3.3 Traffic Control On Dual Two Lane State Highway (Closing Offside Lane)

Table - 6.4.1 Structural Outline

Bridge Name	Length (m)	Number of Span	Constructed Year	Age
1) BUCA UST GECIT	33.00	3	1972	23
2) HILAL-II	347.80	13	1990	5
3) HUDUT-I	40.40	3	1972	23
4) PORSUK	48.20	4	1973	22
5) BABADAT	25.20	3	1964	31
6) SELYERI	21.70	2	1964	31
7) AKCAY	106.90	5	1961	34
8) MERZIFON	36.25	2	1993	2
9) UST GECIT II	20.50	1	1993	2
10) PASA PINAR	26.60	2	1972	23
11) KOPARAN-II	27.45	2	1977	18
12) HACIMUSA	16.40	2	1972	33
13) ASAGI CAKALLI	71.55	4	1986	9
14) HARSI	248.50	10	1951	44
15) TOPALLI	57.75	4	1975	20
16) DEGIRMENDERE	90.80	4	1961	34
17) GELINCIK	32.50	2	1970	25
18) SOLAKLI	216.90	15	1969	26
19) SARDERE	43.15	3	1985	10
20) CANDIR HASANPASA	113.85	7	1972	23

The extent of Detailed investigation was limited by a worker's strike. Inspection platforms could not be used to approach the higher parts of the bridge (slab and girder) and high water levels prevented investigation in some areas. In addition, the number of points for some investigations were decreased due to the shortage of workers. As a result of the above, actual numbers of investigated points by bridge components are presented in Table - 6.4.2.

Table - 6.4.2 Investigation Items and Points

Bridge Name	Exp.Joint	Deck	Girder	Column	Abutment
1) Buca Ust Gecit		VI(3)	VI(3) CC(1)	VI(2)	CS(1)
2) Hillal II	VI(14)	VI(13)	VI(13)	VI(12) RI(2) CS(2)	VI(2)
3) Hudut-I	VI(4)	VI(3)	VI(3)	VI(2) CS(2)	VI(2)
4) Porsuk		VI(4)		VI(3) RI(2) CS(2) NT(2)	
5) Babadat	VI(2)	VI(3)		VI(2) RI(2) CS(2)	
6) Selyeri	VI(3)	VI(2)	VI(2)	VI(1)	VI(2) CS(2)

					NT(2)
7) Akcay	VI(6)	VI(5)	VI(5) RI(1) CS(2) NT(1)	RI(1) NT(1)	
8) Merzifon	VI(3)	VI(2)	VI(2)	RI(2) CS(2)	
9) Ust Gecit-II			VI(1)		VI(2) RI(1) CS(2)
10) Pasa Pinar	VI(3)	VI(2)	VI(2) RI(2) CS(2) NT(2)		
11) Koparan II	VI(3)	VI(2)	VI(2) RI(2) CS(2) NT(2)	VI(1) CS(1)	VI(2) CS(1)
12) Hacimusa	VI(3)	VI(2)		VI(1) RI(1) CS(1)	VI(2) RI(1) CS(1) NT(1)
13) Asagi Cakalli	VI(5)	VI(4)	VI(4) RI(2) CS(1)	VI(3) CS(1) NT(1)	VI(2) RI(2) CS(1) NT(1)
14) Harsit	VI(11)	VI(10)	VI(10)	VI(9) RI(2) CS(2) NT(2)	
15) Topalli	VI(5)		VI(4)	VI(3) RI(2) CS(1)	
16) Degirmendere	VI(5)		VI(4) CS(2) CC(1) NT(2)	NT(1)	
17) Gelincik	VI(3)	VI(2)	VI(2) RI(2) CS(1) NT(1)		
18) Solakli	VI(16)	VI(15)	VI(14) CS(1)	VI(14) RI(2) CS(2) NT(2)	
19) Sardere	VI(4)	VI(3)	VI(3)	VI(2) CS(1)	VI(2)
20) Candir Hasanapasa	VI(8)	VI(7)	VI(7)	VI(6) RI(2) CS(2) NT(2)	VI(2)

6.4.2 Investigation Results

1) Visual Inspection and Sketches

For all damage items defined in the inspection manual the results shall be presented in the form of confirming surface sketches (some of them have been prepared by KGM engineers) for damaged components for which damage is more serious than rating 'C', for all data collection units such as spans and columns.

Inspection results are written on sketches and damage coding sheets as attached.

2) Concrete Strength

Compressive concrete strength was investigated using a Schmidt Hammer for concrete components for which the damage rating was more serious than rating 'B'. Some locations for investigation were changed to enable testing to be undertaken without a platform. Investigated results are summarized in Table - 6.4.3 and Figure - 6.4.1.

Table - 6.4.3 Concrete Strength by Schmidt Hammer Test

Bridge No.	Bridge Name	Member	Avarage Rebound Value	Concrete Strength	Avarage Concrete Strength
300-02-02	Buca Ust Gecit	Parapet	40	350	350
300-02-08	Hilal-II-Sagust	P7/P5	49/48	495/480	488
300-04-05	Hudut-I	P2/P1	37/29	305/190	248
200-08-04	Porsuk	P1/P1	40/42	350/380	365
200-10-01	Babadat	P1/P1	29/3	190/ 0	190
010-16-04	Selyeri	A2	42 (new)/37 (old)	380/305	343
010-16-12	Akcay	G1/G1	40/47	350/460	405
100-17-01	Merzifon	P1/P1	38/39	320/330	325
100-17-04	Ust Gecit-II	A2/A1	33/35	245/267	256
100-17-05	Pasa pinar	G2	43	400	400
785-05-02	Koparan-II	G2	37	305	305
		A1/P3	41/29	362/190	276
785-05-04	Hacimusa	P1/A1	31/28	220/180	200
795-01-05	Asagi Cakalli	G1	36	290	290
		A2/P1	45/34	430/260	345
010-19-19	Harsit	P6/P7	26/35	150/267	209
010-20-10	Topalli	A2/P3	31/36	220/290	255
010-22-01	Deginnendere	G1	37	305	305
010-22-15	Gelincik	G1	26	150	150
010-22-16	Solakli	G1	45	430	430
		P11/P12	42/42	380/380	380
650-11-03	Sardere	P1	38	320	320
200-06-12	Candir Hasanpasa	P1/P2/P4	38/36/34	320/290/260	290

3) Carbonation Depth

Carbonation (neutralization) of the concrete surface is investigated using Konkit (Phenol Phthalein reaction) for concrete components for which the damage rating is more serious than rating 'B'.

Investigated results are summarized in Table - 6.4.4 and Figure - 6.4.2. Investigated carbonation depth shows that it is progressing approximately 10 mm depth a year in the Black

Sea area, but more slowly in inland areas. In addition to the carbonation of the concrete, low cover to rebar together with salt attack has caused corrosion of rebar and peel-off of the concrete surface.

Table - 6.4.4 Carbonization Depth Investigated

Bridge No.	Bridge Name	Consturcted Year	Age	Member	Carbonization Depth (mm)	Remarks
300-02-02	Buca Ust Gecit	1972	23			
300-02-08	Hilal-II-Sagust	1990	5			
300-04-05	Hudut-I	1972	23			
200-08-04	Porsuk	1973	22	P1	16	
200-10-01	Babadat	1964	31			
010-16-04	Selyeri	1964	31	A2	Old:10 New:3	
010-16-12	Akcay	1961	34		25/45	
100-17-01	Merzifon	1993	2			
100-17-04	Ust Gecit-II	1993	2			
100-17-05	Pasa Pinar	1972	23	G2	40	
785-05-02	Koparan-II	1977	18		35	
785-05-04	Hacimusa	1972	23		70	
795-01-05	Asagi Cakalli	1986	9	A1/P3	15/9	
010-19-19	Harsit	1951	44	P6	7	
010-20-10	Topalli	1975	20	A1	20	
010-22-01	Degirmendere	1961	34	P2	20	
010-22-15	Gelincik	1970	25	G1	10	
010-22-16	Solakli	1969	26			
650-11-03	Sardere	1985	10			
200-06-12	Candir Hasanpasa	1972	23	P4	20	

4) Rebar Investigation

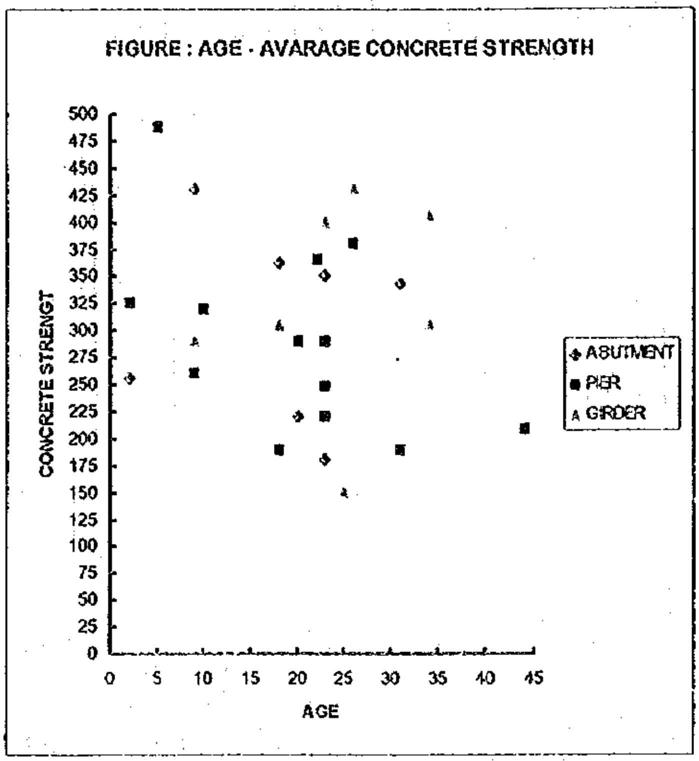
Rebar spacing, cover and diameter were investigated using a Profometer for concrete components for which the damage rating was more serious than rating 'B'. However, KGM possesses drawings on rebar arrangement for all of the selected 20 bridges for detailed inspection.

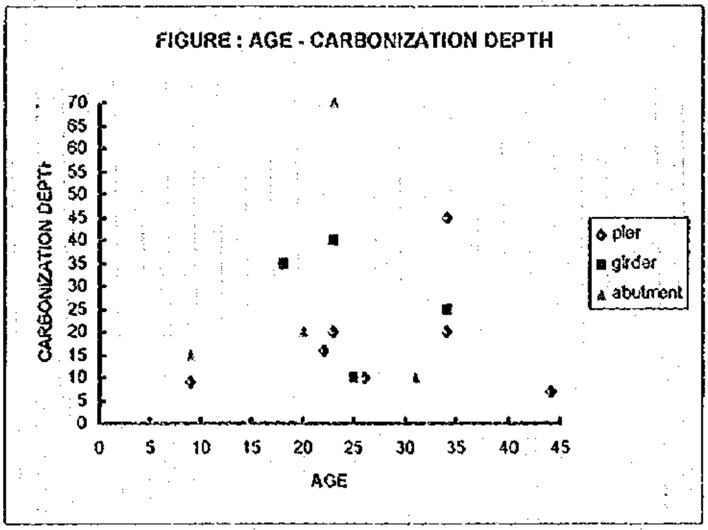
5) Level Survey of Intersecting Road

Three bridges for which the girder bottom has been damaged due to vehicular collision, were surveyed to determine clearance between the girder bottom and road surface beneath the bridge, and to establish the slope situation along the intersecting road. Their conditions under the bridge are presented in Table - 6.4.5 below.

Table - 6.4.5 Under Bridge Conditions

Bridge Name	Clearance	Condition of Intersection Road
1) Buca Ust Gecit	4.2m	Slope at approx. 8 % with heavy traffic in urban area, warning sign states 4.0 m clearance.
9) Ust Gecit-II	4.4m	Horizontal grade with slight local agri. traffic, no warning sign.
16) Degirmendere	4.1m	Valley bottom at bridge, detour for large truck in urban area, no warning sign.





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 - 6.4.1 Concrete Strength of the Bridge Figure - 6.4.2 Carbonation Depth of Concrete

6) Scour Survey

Investigation of damage to foundation stability such as inclination angle, settlement of foundation and height of river bed was planned for damaged columns and abutments for which the damage rating was more serious than rating 'B'. However, lack of access from the water prevented these investigations from being carried out. Instead, the structural elements exposed by scour were examined.

6.4.3 Damage Evaluation

1) Damage Indices

As information on visible damage on the structure surface was collected for each investigation unit, such as span and column, damage indices (Emergency Index (EIDX) and Importance Index (IIDX)) could be calculated for each investigation unit. The same score for damage rating is used to quantify directly damage rating into numerical value as those of using in selecting 20 bridges for detailed inspection as shown in Table - 6.4.6 below.

Table - 6.4.6 Ranking Table of Damage Rating

Damage Rating	Score	
	Case 1	Case 2
Rating 'A'	5	5
'B'	3	3
'C'	1	0
'D'	0	0

The rank of Case 1 is to quantify all the damage suffered on the bridge components, while that of Case 2 is set up to emphasize the serious damage than the rating 'A' and 'B' which are needed to repair anyway. In addition to this, the score of the longer bridge, which has the number of components to be inspected, is apt to get the higher total score according to the much number of damage in rating 'C'. For this reason, score of rating 'C' is changed to zero (1 in initial formula) to emphasize the damages which are rating 'A' and 'B'.

Importance Index (IIDX) is used to evaluate overall damage intensity, since the difference of Emergency and Importance Coefficient for these major five bridge components a slight as shown in Table-6.4.7.

Table - 6.4.7 Emergency and Importance Coefficient

Bridge Element	Emergency Coef.	Importance Coef.
Expansion Joints	1.00	0.75
Deck Slab	1.00	1.00
Concrete Girder	1.00	1.00
Column and Footing	1.00	1.00
Abutment	1.00	1.00

Table - 6.4.8 presents calculation results in Case 1 (A:B:C:D=5:3:1:0), and Table - 6.4.9 for Case 2 (A:B:C:D=5:3:0:0) as below. IIDX in these tables are sum of all the score of components as much as the bridge has.

Table - 6.4.8 IIDX of 20 Bridges (A:B:C:D=5:3:1:0)

Bridge Name	Exp.Joint	Deck	Girder	Column	Abutment
1) Buca Ust Gecit	--	0	10	0	--
2) Hillal II	20	2	0	37	11
3) Hudut-I	27	10	2	0	0
4) Porsuk	--	4	--	12	--
5) Babadat	0	3	--	22	--
6) Selyeri	4	2	16	2	7
7) Akcay	28	10	17	--	--
8) Merzifon	6	16	4	--	--
9) Ust Gecit-II	--	--	7	--	--
10) Pasa Pinar	0	10	14	--	--
11) Koparan II	3	10	14	6	11
12) Hacimusa	0	12	--	5	10
13) Asagi Cakalli	17	56	46	30	6
14) Harsit	20	5	18	8	--
15) Topalli	0	--	6	7	3
16) Degirmendere	0	--	14	--	--
17) Gelincik	6	5	12	--	--
18) Solakli	59	9	40	31	--
19) Sardere	0	30	16	0	0
20) Candir Hasanapasa	16	51	23	41	1

Note: -- means no detailed investigation conducted

Table - 6.4.9 IIDX of 20 Bridges (A:B:C:D=5:3:0:0)

Bridge Name	Exp.Joint	Deck	Girder	Column	Abutment
1) Buca Ust Gecit	--	0	10	0	--
2) Hillal II	17	0	0	23	6
3) Hudut-I	21	6	0	0	0
4) Porsuk	--	0	--	12	--
5) Babadat	0	0	--	19	--
6) Selyeri	0	0	9	0	0
7) Akcay	21	0	9	--	--
8) Merzifon	0	12	0	--	--
9) Ust Gecit-II	--	--	3	--	--
10) Pasa Pinar	0	0	6	--	--
11) Koparan II	0	0	16	0	0
12) Hacimusa	0	0	--	0	0
13) Asagi Cakalli	4	46	32	18	0
14) Harsit	0	0	0	0	--
15) Topalli	0	--	0	0	0
16) Degirmendere	0	--	10	--	--
17) Gelincik	0	0	9	--	--
18) Solakli	25	0	33	18	--
19) Sardere	0	21	0	0	0
20) Candir Hasanapasa	0	28	3	20	0

Note: -- means no detailed investigation conducted

2) Damage Evaluation

The above IIDX contains the evaluation on the scale of a designated bridge such as bridge length or the number of spans, for IIDX is larger with these value if the damage rating is same level. Table-6.4.10 presents the total score of bridge elements and their divided value by the number of spans to evaluate damage intensity of the bridge.

Table - 6.4.10 Total Score and Damage Intensity

Bridge Name	No of Span (a)	Total (b)	Score (c)	Damage (b/a)	Intensity (c/a)
1) Buca Ust Gecit	3	10	10	3.3	3.3
2) Hillal II	13	46	23	3.5	1.8
3) Hudut-I	3	27	6	9.0	2.0
4) Porsuk	4	12	12	3.0	3.0
5) Babadat	3	19	19	6.3	6.3
6) Selyeri	2	9	9	4.5	4.5
7) Akcay	5	30	9	6.0	1.8
8) Merzifon	2	12	12	6.0	6.0
9) Ust Gecit-II	1	3	3	3.0	3.0
10) Pasa Pinar	2	6	6	3.0	3.0
11) Koparan II	2	16	16	8.0	8.0
12) Hacimusa	2	0	0	0	0
13) Asagi Cakalli	4	100	96	25.0	24.0
14) Harsit	10	0	0	0	0
15) Topalli	4	0	0	0	0
16) Degirmendere	4	10	10	2.5	2.5
17) Gelincik	2	9	9	4.5	4.5
18) Solakli	15	76	51	5.1	3.4
19) Sardere	3	21	21	7.0	7.0
20) Candir Hasanapasa	7	51	48	7.3	6.9

Note b: Total sum of IIDX on all 5 bridge components
c: Sum of IIDX on 3 major components (deck slab, girder, column and footing)

3) Summary Comments on Damages

Comments on damages which may affect the necessity for repairs are given below for each bridge.

<u>BUCA UST GECIT</u>

- Only one damage on the girder bottom, which is rebar exposure and cutting off of rebars along the girder bottom over a length of 4.0m on the outside girder, was detected. It was caused by vehicular collisions. No other remarkable damage was detected.

<u>HILAL-II SAG UST GECIT</u>

- Expansion joints were improved by means of connecting deck slabs in 2 or 4 spans intervals, however, damage to surface was detected. This has contributed to the acceleration of AAR on the substructure.

- Deck slabs and girders are slightly damaged locally, but not seriously.
- Damages to substructures are cracks in vertical direction mainly, with more than 4mm maximum crack width; AAR is suspected.
- Cracks on footing were detected at 0.5m or 1.0m intervals with 1.3mm maximum crack width.

HUDUT-I

- The pavement surfacing and rubber seals were completely missing at the expansion joints.
- Deck of only Span 1 is damaged with honeycomb and rebar exposure due to poor construction.
- No serious damage was detected on girder, column and abutment.

PORSUK

- Cracks with white salt trace were locally detected under the deck, but not serious.
- Cast in situ piles (P1 and P2) were exposed in the stream on the river bed. P3 column is not scoured at present, however it will be vulnerable to scour due to the change of river stream.

BABADAT

- No remarkable damage was detected on expansion joints.
- No serious damage was detected on the deck slab.
- Top of cast in situ piles were exposed on the river bed, however no water in dry season. Concrete strength of exposed pile is less than 100 kg/scm. It is expected that a continuous river flow resulting from a long period of rain will erode the piles.

SELYERI

- Damage to expansion joints is decreased depending on the pavement repair.
- Damage to the deck is concentrated on the cantilever slab, but is not serious.
- Due to the water leakage through the longitudinal girder joints (old and new), damage (peel-off, rebar exposure and corrosion) to girder along and around joints has occurred.
- No serious damage was detected on the substructures.

AKCAY

- Peel-off of pavement surface and joint seal missing causes serious water leakage through the expansion joints.
- Local cracks, water leakage with white trace were found on the deck slab, but were not serious.
- Serious damage in peel off, rebar exposure and corrosion exist at the Gerber joint on the girder, due to water leakage through expansion joints.

MERZIFON

- Potholes (peel-off of pavement) were found locally with cracks along the expansion joints.
- Cracks (suspected) with white trace are found beneath the whole deck area, caused by salt infiltration from the bridge surface.

- No serious damage was detected on the precast girder.

UST GECIT-II

- 2 in 5 main girders are damaged by rebar exposure over a length of 0.7m, at 4.45m clearance under the girder bottom.
- No serious damage was detected on the abutment.

PASA PINAR

- No damage suspected due to surface evenness of Asphalt on the expansion joints.
- Almost all kinds of damages are found on the slab due to poor construction, but not serious in the dry area.
- Honeycombing with rebar exposure exists beneath the girder bottom.

KOPARAN-II

- No serious damage suspected due to overlaid Asphalt on expansion joints.
- Almost all kinds of damage exist on the slab due to poor construction, but none of them are serious.
- Serious and continuous rebar exposure exists under and on the sides of the girders, due to poor concreting and low cover.
- Almost all kinds of damage are found, but each of them is not serious.

HASIMUSA

- No damage suspected due to smooth overlaid Asphalt on the expansion joints.
- Almost all kinds of damage are found on the slab, but none of them is serious.
- Many kinds of minor damage exist on substructures.

ASAGI CAKALLI

- Potholes and peel-off of Asphalt exist locally on the expansion joint lines.
- Serious honeycombing and rebar exposure throughout the deck slab due to poor construction. Some local but serious cracks were found with water leakage trace.
- Much serious honeycombing and rebar exposure exist on the bottom of girder due to poor construction. Clear trace of water leakage on the girder suggests the existence of large cracks or voids in the deck slab.
- Honeycombing and water leakage trace exist on all the columns, and no rebar was detected by Profometer on the column.

HARSIT

- Cracks and peel-off of pavement surface exist on the expansion joint lines, but not serious.
- No serious damage detected on the slab and girder.
- Foundations of piers have in the past settled and inclined. They were repaired by adding concrete at the tops of the columns. The columns appear stable at present.

TOPALLI

- No serious damage detected on the expansion joints.
- Honeycombing and rebar exposure exist, but not serious.
- Scour and water damage to column has not progressed at present, but it is

vulnerableto sea waves in the future.

DEGIRMENDERE

- No remarkable damage detected on the expansion joints.
- Exposure and cutting off of rebars of a girder over a length of 6.0m exists on Span 2 due to vehicular collision, with 4.1m clearance under girder bottom. Municipal office is undertaking under-road construction to achieve 4.5m clearance.

GELINCIK

- Peel-off and crack along expansion joints exist, but not serious.
- Honeycombing and peel-off on the slab deck exist, but only locally.
- Due to poor concreting and low cover, serious honeycombing, rebar exposure and corrosion were detected on the girder. Leaking water is accelerating rebar corrosion.

SOLAKLI

- Peel-off and missing of joint seals are major defects, which allow water to leak through the joints, affecting the slab and girder.
- Rebar exposure and corrosion is a major damage to the slab, but not so serious, caused by low cover together with salt attack. The pavement surface appearance and the exposure of rebar in the deck suggest that a hole is being punched through the deck.
- Peel-off and rebar exposure with corrosion constitute major damage to the girders due to low cover and salt attack. The sea side girders have suffered more serious by than those on the mountain side.
- Low cover with salt attack have caused peel-off and rebar exposure with corrosion, similar to the damage to the girders.

SARDERE

- No remarkable damage detected on the expansion joints as a result of the recent repairs.
- Punched hole with deep void and rebar exposure on the center span slab is very serious, because of its location near to the wheel loading point. Honeycombing and rebar exposure exist extensively due to low cover.
- No serious damage detected on the girder, but almost all kinds of damage exist due to poor construction.
- No remarkable damage detected on the substructures.

CANDIR HASANPASA

- Peel-off of surface Asphalt with voids exists on all expansion joints, but not serious at present.
- Local but serious damage was found on the slab in many areas, with rebar exposure with salt white trace due to water leakage. Extensive white salt trace on Spans 4 and 5 suggests the existence of heavy cracking which probably results in a decrease in loading capacity of the deck.
- Honeycombing and rebar exposure with corrosion exist extensively on the girder due to low cover and poor construction.

- Column on P4 and P5 were seriously scoured with rebar exposure by the stream. Columns other than P4 and P5. Will be vulnerable to scour it the river changes course in the future.

6.4.4 Engineering Considerations on Repairs

1) Bridge Components to be Repaired

According to the results of the detailed inspection, some of the damage ratings have changed since the visual inspection carried out in the previous stage. The necessity of remedial works can be presented on the basis of engineering considerations to secure the loading capacity and a longer service life (durability) for the bridges as shown in Table-6.4.11.

Table - 6.4.11 Bridge Components to be Repaired

Bridge Name	Exp.Joint	Deck	Girder	Column	Abutment
1) Buca Ust Gecit	--	N	I	N	--
2) Hillal II	I	P	N	I	I
3) Hudut-I	I	P	I	N	N
4) Porsuk	--	N	--	I	--
5) Babadat	N	N	--	I	--
6) Selyeri	P	N	I	N	N
7) Akcay	I	P	I	--	--
8) Merzifon	P	I	P	--	--
9) Ust Gecit-II	--	--	I	--	P
10) Pasa Pinar	N	P	I	--	--
11) Koparan II	N	P	I	P	P
12) Hacimusa	N	P	--	N	N
13) Asagi Cakalli	I	I	I	I	P
14) Harsit	P	P	P	P	--
15) Topalli	N	--	P	P	P
16) Degirmendere	N	--	I	--	--
17) Gelincik	N	P	I	--	--
18) Solakli	I	P	I	I	--
19) Sardere	N	I	I	N	N
20) Candir Hasanapasa	I	I	I	I	N

Note: -- means no detailed investigation conducted
I means to be repaired Immediately
P means to be repaired Preferably
N means No remedial work needed

Engineering judgement must be applied when using the above table. Sometimes the repair of components with only slight damage will be desirable in addition to the repair of severely damaged dements, to present rapid deterioration of the main repair.

2) Comments on Repairs

Engineering comments for remedial works are provided taking site conditions into account for tentatively selected 10 bridges as below.

BUCA UST GECIT

- Damaged part is to be repaired to restore the girder strength to that designed.
- Clearance beneath the girder, which is 4.2m at present from the lowest girder soffit to the road surface, is to be raised to 4.5m or more, to provide satisfactory headroom for large vehicles. However, it is impossible to take following measures due to the tight vertical/horizontal alignment at present; lowering under-road profile, raising existing bridge, moving bridges idewards.
- Installation of a warning gate is necessary to show clearly the minimum headroom, and to direct large vehicles through the centre line.
- Traffic regulation to remove traffic from one lane will be is required during repairing.

HILAL-II

- Measures to columns, abutments and footings due to AAR will be clarified after obtaining the results of on-going material tests.
- In order to delay AAR on the substructures, it will be effective to restore the expansion joints to stop water leakage.
- It will be necessary to close one lane for repairing of expansion joints.

BABADAT

- It is necessary to strengthen and stabilise the column to resist greater flows of the stream in the future.
- Temporary additional support may be necessary during repair.
- No traffic control or temporary bridge is required.

SELYERI

- Longitudinal girder joints and related damage to the girders is to be repaired (by injection and patching).
- A water proofing layer on the slab deck is necessary to stop water leakage from the bridge surface. Expansion joints shall be restored for the same reason.
- Closure of vehicular traffic is required during surface work of the bridge. However, it seems that another two lane bridge has enough vehicular capacity at present.

AKCAY

- Expansion joints are to be restored to stop water leakage to improve the function and durability of the half joints.
- The Gerber joints are to be restored to maintain loading capacity and function.
- Closure of vehicular traffic is required during joints repairing, and also half joint repairing if necessary.
- A temporary bridge will be necessary if vehicular traffic is to be stopped for a long time.

KOPORAN-II

- Restoration to peel-off and honeycombing on girder is necessary to improve the durability of bridge.
- At the same time, patching to deck slab, column and abutments can be easily conducted to give better durability.
- No traffic control on temporary bridge will be necessary.

ASAGI CAKALLI

- Expansion joints are to be restored to stop water leakage, to improve the durability of the superstructures and substructures.
- Restoration to damaged deck slab is necessary to maintain the loading capacity and durability (partial replacement and patching).
- Restoration to damaged girder is necessary to maintain the loading capacity and durability (patching).
- It is necessary to confirm the adequacy of the of columns for the possible seismic forces prior to repairing. Restoration (patching) or increasing cross the area of the column is necessary for strength and durability reasons.
- Restoration to abutments is preferable for better durability (patching).
- Closure of vehicular traffic will be required during replacement of the deck slab. However, it seems that another two lane bridge has enough vehicular capacity at present.

GELINCIK

- Restoration to girder, which has suffered serious honeycombing and rebar exposure, is necessary to obtain adequate durability for the bridge (patching).
- At the same time, restoration to slab deck is preferable in the same manner (patching).
- No traffic control or temporary works are necessary.

SARDERE

- In order to maintain the loading capacity of the slab, it is necessary to replace the deck partially, and also to restore the parts which have suffered from rebar exposure (replacement and patching).
- Closure of vehicular traffic will be required during replacing of the deck.
- A temporary bridge is required and can be structured whichever construction is easier.

CANDIR HASANPASA

- Expansion joints are to be restored to stop water leakage to improve durability of the superstructures and substructures.
- Restoration to the damaged deck slab is necessary to maintain loading capacity and durability (partial replacement and patching).
- Restoration to damaged girders is necessary to maintain loading capacity and durability (patching).
- It is necessary to confirm the adequacy of the columns for the possible seismic forces prior to repairing. Strengthening of the columns is necessary to resist seismic and scour effects, and to improve durability.
- A permanent overflow weir is required on the down-stream side of the bridge, in

order to prevent scouring of the bridge foundations by stabilising the flow of the river.

- Temporary supports for the column will be necessary during strengthening of the column, in order to secure the load and to prevent collapse during the reconstruction works.
- A closure of vehicular traffic is required during replacement of the deck slab.
- Temporary bridge is required and can be built on the up-stream side most easily.

6.5 Soil Investigation

6.5.1 Objectives

In order to make an efficient, safe and economic design/construction of highway bridge foundations and also as part of the proper inspection and maintenance of bridges, soil investigation shall be performed to obtain information and data with regard to subsurface conditions. Soil conditions of objective bridges shall be collected wherever possible.

6.5.2 Selection of Location

Soil investigation shall be carried out at levels of rehabilitation and /or reconstruction. There are hundreds of objective highway bridges located on the arterial study roads. The 20 bridges to be urgently improved the were selected by detailed visual inspection based on bridge inspection concepts such as damage rating. Locations were selected among the 20 bridge sites where there is no soil data but the detail investigation such as deep boring and laboratory soil testing requires them. Three locations were proposed and identified as meeting those criteria. Two are in Samson (Division 7) area and one in Trabzon (Division 10) area.

a. Samsun (Division 7)
  1) AR-010-16-4 Selyeri
  2) AR-100-17-5 Pasa Pinar

b. Trabzon (Division 10)
  3) AR-010-20-10 Topalli

6.5.3 Survey Items and Method

Subsurface exploration shall be carried out at each of the proposed 3 bridge sites. Sufficient and adequate information to determine the bearing capacity of the underlying soil must be obtained.

Borings

The deep boring shall be carried out to an obvious bearing stratum. Six successive Standard Penetration Tests per meter depth with the number of blows in excess of 50 is normally considered firm bearing. The boring equipment should be the type that will permit Standard Penetration Tests with the split spoon and thin walled tube sampling.

Sampling

Standard Penetration Tests (AASHTO T206), including sampling shall be made at every change of soil layers or at every 1.0 metre interval. If cohesive soils are encountered, undisturbed samples shall be taken using thin walled tube samplers. Samples obtained shall be carefully transported using a shock-absorbing box for laboratory soil testing.

Records

A boring location plan must be prepared for each bridge site. The data obtained from subsurface exploration shall be recorded. All relevant field observations, such as loss of drilling water, obstructions and difficulties encountered shall be recorded.

Laboratory Soil Tests

The following tests shall be made on the split-spoon samples:

- Visual soil description
- Grain size analysis
- Atterberg Limits
- Group and soil classification

The following tests shall be made on the undisturbed thin walled tube samples:

- Visual soil description
- Grain size analysis
- Atterberg Limits
- Group and soil classification
- Moisture content
- Unit weight
- Specific gravity
- Triaxial compressive strength
- Consolidation

6.5.4 Survey Results

The actual soil investigation on the proposed 3 bridge sites was carried out by a local firm, ERA Geological - Geotechnical Co. Ltd. in the period between 20 Sept. 1995 and 27 Sept. 1995 under the direction of the study team. A Mobile Drill - B 53 Explore Type machine was used for boring and in-situ tests (Standard Penetration Tests). A total of 70 m. boring which is 65.2 m in soil and 4.8 m in rock was made with a total of 62 Nos. of Standard Penetration Tests per one meter interval and disturbed samples. No undisturbed sample was taken due to uncohesive soils. Core samples were taken when the rock basement was encountered and the cores which are totally 4.5 m in length were obtained from these rock portions. Laboratory soil tests were performed on 15 SPT representative samples selected by the study team Engineer. These tests consisted of grain-size distribution, specific gravity, Atterberg limits and water content tests. Based on the factual report data, the investigation results on each bridge site are shown in Figures - 6.5.1 to 6.5.3 Soil Profiles. Each bridge site soil conditions and engineering comments are described below. The detailed boring logs are compiled in Figures - 6.5.4 to 6.5.7.

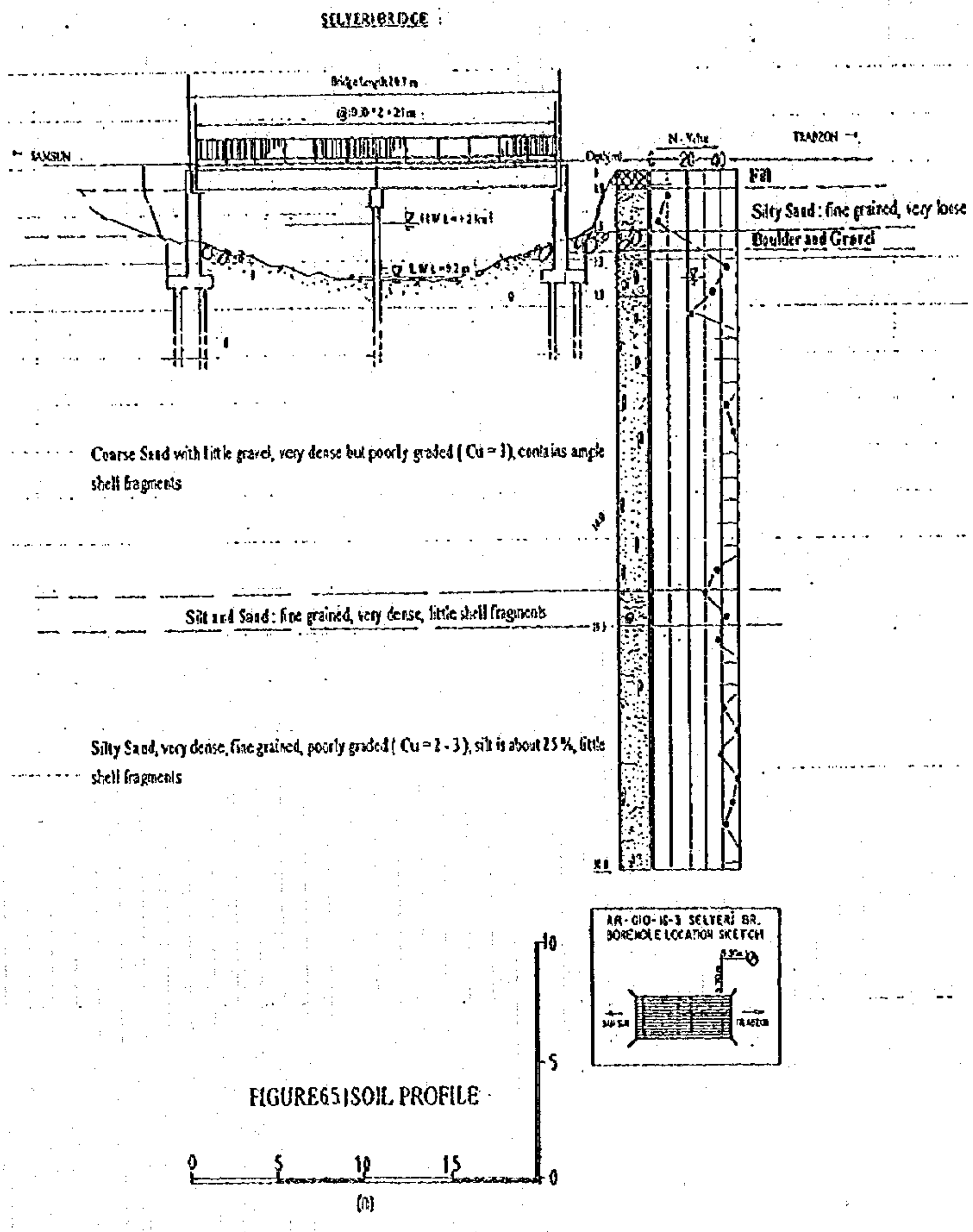


FIGURE6.5.1 SOIL PROFILE

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 - 6.5.1 Soil Profile

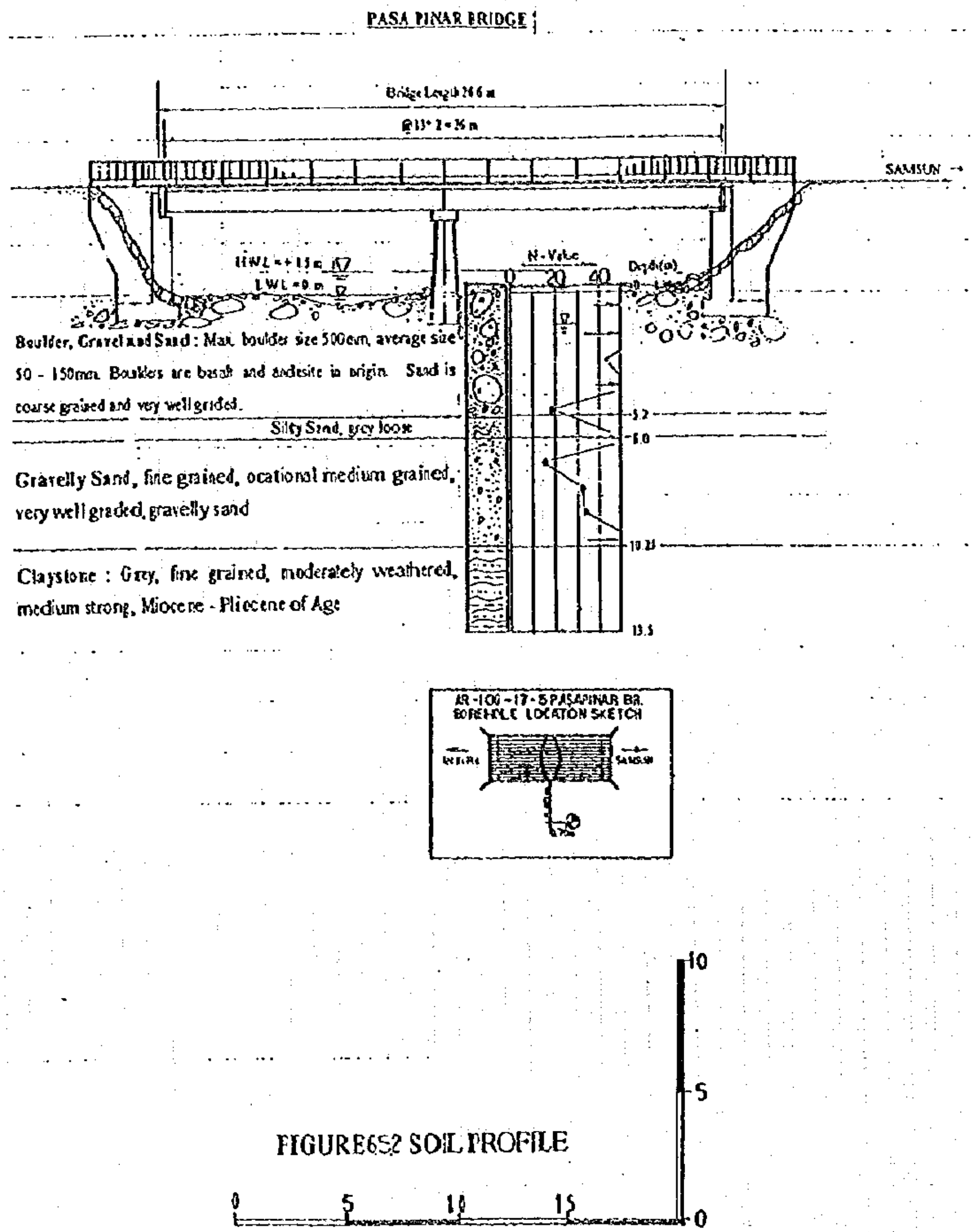


FIGURE6.5.2 SOIL PROFILE

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 - 6.5.2 Soil Profile

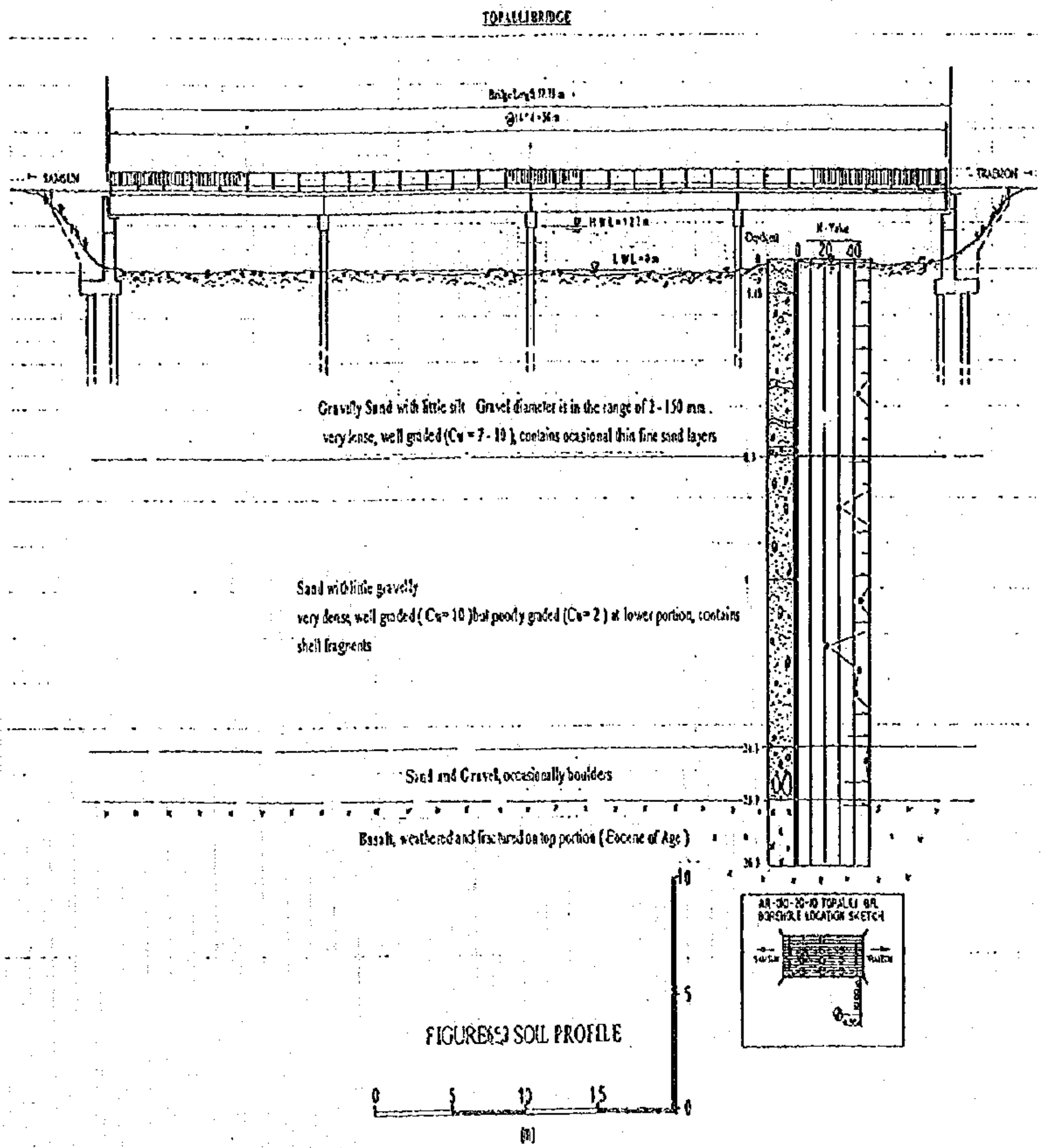


FIGURE6.5.3 SOIL PROFILE

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 LINTED	Figure - 6.5.3 Soil Profile

ERA JEOLOJİ-JEOTEKNİK GEOLOGY-GEOTECHNICS	SOIL SURVEY AT HIGHWAY BRIDGE SITES IN TURKEY SONDAJ LOGU / *BORING LOG*	SAYFA / Sheet NO.: 2/1

SONDAJ NO. / Boring No. : SELYERİ BRIDGE BOREHOLE, SAMSUN
SONDAJ DERİNLİĞİ / Boring Depth : 30 m
MAKİNA TİPİ / Rig Type : Mobile Drill B-63
SONDAJ METODU / Drilling Method : Rotary
MUHAFAZA BORUSU / Casing : Hollow stem O.D. 65.6 mm x 203.2 mm, 15 m
Çap ve Derinlik / Dia & Depth : NW 89/76 mm, 29.55 m

ZEMİN KOTU / Ground EL (m) :
KOORDİNAT / Coordinate Y(E) : Shown in
KOORDİNAT / Coordinate X(W) : Sketch
BAŞLAMA TARİHİ / Start Date : 24.09.1995
BİTİŞ TARİHİ / Finish Date : 25.09.1995

YERALTI SUYU DURUMU / Groundwater Data	DERİNLİK / Depth	TARİH / Date
	-4.60 m	24.09.1995

DERİNLİK Depth (m)	MANEVRA BOYU Run. Depth (m)	NUMUNE TÜRÜ / Sample Type	DARBE SAYISI 15 cm	15 cm	15 cm	N	JEOTEKNİK TANIMLAMA / Geotechnical Description
							FILL : Made Ground ——— 0.80 m
1	1.00–1.45	SPT	5	5	5	10	Silty SAND : Light brown. Fine grained, very loose
2	2.00–2.45	SPT	4	2	2	4	——— 2.50 m
3		NO SPT Made					BOULDER and GRAVEL : Clayey and Sandy ——— 3.30 m
4	4.00–4.45	SPT	10	22	22	44	SAND : Greyish, brown. Coarse, dense, contains shells
5	5.00–5.45	"	9	15	20	35	——— 5.30 m
6	6.00–6.45	"	8	10	11	21	
7	7.00–7.41	"	7	14	50/11	R	
8	8.00–8.45	"	30	50/11	–	R	
9	9.00–9.45	"	15	35	40	75	SAND : Grey-dark grey, coarse, little gravel, very dense, contains ample shells, down to 9.50 m depth. Less shells from here to 18.00 m
10	10.00–10.45	"	16	20	24	44	
11	11.00–11.45	"	18	22	24	46	
12	12.00–12.45	"	20	28	45	73	
13	13.00–13.45	"	30	33	47	80	
14	14.00–14.45	"	17	27	48	75	
15	15.00–15.43	"	30	48	50/13	R	
16	16.00–16.45	"	7	27	50	77	
17	17.00–17.45	"	19	21	27	48	——— 18.00 m
18	18.00–18.45	NO Sample	20	20	20	40	SILT and SAND : Grey fine grained very dense, little shells
19	19.00–19.45	SPT	16	16	27	43	——— 19.50 m Silty SAND : See below
20							

DAYANIMLILIK / Strength
I ÇOK ZAYIF — V. Weak
II ZAYIF — Weak
III ORTA ZAYIF — M. Weak
IV ORTA DAYANIMLI — M. Strong
V DAYANIMLI — Strong

KAYA KALİTESİ TANIMI / RQD
% 0-25 ÇOK ZAYIF — V. Poor
% 25-50 ZAYIF — Poor
% 50-75 ORTA — Fair
% 75-90 İYİ — Good
% 90-100 ÇOK İYİ — Excellent

AYRIŞMA / Weathering
I TAZE — Fresh
II AZ AYRIŞMIŞ — Slightly W.
III ORTA D. AYRIŞ. — Mod. Weath.
IV ÇOK AYRIŞMIŞ — Highly W.
V TAM AYRIŞMIŞ — Comp. Weath.

KIRIKLAR / 30 cm Fractures
< 1 SEYREK — Wide (W)
1-2 ORTA — Moderate (M)
2-10 SIK — Close (Cl)
10-20 ÇOK SIK — Intense (I)
> 20 PARÇALI — Crushed (Cr)

İNCE DANELİ / Fine Grained
N= 0-2 ÇOK YUMUŞAK — V. Soft
N= 3-4 YUMUŞAK — Soft
N= 5-8 ORTA KATI — M. Stiff
N= 9-15 KATI — Stiff
N= 16-30 ÇOK KATI — V. Stiff
N > 30 SERT — Hard

ORANLAR / Proportions
% 5 < PEK AZ — Slightly
% 5-15 AZ — Little
% 15-35 ÇOK — Very
% 35 > VE — And

İRİ DANELİ / Coarse Grained
N= 0-4 ÇOK GEVŞEK — V. Loose
N= 5-10 GEVŞEK — Loose
N= 11-30 ORTA SIKI — M. Dense
N= 31-50 SIKI — Dense
N= > 50 ÇOK SIKI — V. Dense

PLASTİSİTE / Plasticity
PI = 1-5 ÇOK AZ — Slight
PI = 5-10 AZ — Low
PI = 10-20 ORTA — Medium
PI = 20-40 YÜKSEK — High
PI => 40 ÇOK YÜKSEK — Very high

SPT : Standart Pen. Deneyi / Standart Pen. Test
D : Örselenmiş Numune / Disturbed Sample
UD : Örselenmemiş Numune / Undisturbed Sample
K : Karot Numunesi / Core Sample
P : Pressiyometre Deneyi / Pressuremeter Test
VST : Vane Deneyi / Vane Shear Test

	LOGU YAPAN / Logged By	KONTROL / Checked	ONAY / Approved	TARİH / Date
İSİM / Name	EMRULLAH KASIM	AYDOĞAN BORAY		
İMZA / Sign		(signature)		

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 - 6.5.5 (1)

Soil Investigation Result on Selyeri Bridge

ERA
JEOLOJİ - JEOTEKNİK
GEOLOGY - GEOTECHNICS

SOIL SURVEY AT HIGHWAY BRIDGE SITES IN TURKEY

SONDAJ LOGU / *BORING LOG*

SAYFA / Sheet NO.: 2 / 2

SONDAJ NO. / Boring No.	SELYERİ BRIDGE BOREHOLE, SAMSUN	ZEMİN KOTU / Ground El. (m) :	
SONDAJ DERİNLİĞİ / Boring Depth :	30 m	KOORDİNAT / Coordinate Y(E) :	Shown in
MAKİNA TİPİ / Rig Type	: Mobile Drill B-53	KOORDİNAT / Coordinate X(W) :	Sketch
SONDAJ KİE TODU / Drilling Method :	Rotary	BAŞLAMA TARİHİ / Start Date	: 24.09.1995
		BİTİŞ TARİHİ / Finish Date	: 25.09.1995
MUHAFAZA BORUSU / Casing	Hollow stem O.D. 85.6 mm x 203.2 mm, 15 m		
Cap ve Derinlik / Dia & Depth	: NW 89/76 mm, 29.55 m		

YERALTI SUYU DURUMU / Groundwater Data	DERİNLİK / Depth	TARİH / Date
	−4.60 m	24.09.1995

DERİNLİK (m) / Depth	MANEVRA BOYU / Run Dept (m)	NUMUNE / Sample: TÜRÜ / Type	STANDART PENETRASYON DENEYİ / Standard Penetration Test SPT — DARBE SAYISI / Num. of Blows: 15 cm	15 cm	15 cm	N	JEOTEKNİK TANIMLAMA / Geotechnical Description	PROFİL / Profile	DAYANIMLILIK / Strength	AYRIŞMA / Weathering	KIRIK / 30cm Fracture	KAROT % T.C.R	RQD %
	20.00 20.45	SPT	14	16	22	38	Silty SAND: Grey, fine grained, very dense, silt is up to 25 %, little shells						
21	21.00 21.46	"	11	22	43	65							
22	22.00 22.45	"	24	30	45	75							
23	23.00 23.45	"	10	19	22	41							
24	24.00 24.45	"	15	22	27	49							
25	25.00 25.45	"	10	16	22	38							
26	26.00 26.45	"	13	19	30	49							
27	27.00 27.45	"	11	20	25	45							
28	28.00 28.45	"	12	18	24	42							
29													
	29.55	"	21	24	30	54	30.00 m						
30	30.00						END OF BOREHOLE						

GRAFİK / Graph: 10 20 30 40 50 60

DAYANIMLILIK / Strength
- I ÇOK ZAYIF — V. Weak
- II ZAYIF — Weak
- III ORTA ZAYIF — M. Weak
- IV ORTA DAYANIMLI — M. Strong
- V DAYANIMLI — Strong

KAYA KALİTESİ TANIMI / RQD
- % 0-25 ÇOK ZAYIF — V. Poor
- % 25-50 ZAYIF — Poor
- % 50-75 ORTA — Fair
- % 75-90 İYİ — Good
- % 90-100 ÇOK İYİ — Excellent

AYRIŞMA / Weathering
- I TAZE — Fresh
- II AZ AYRIŞMIŞ — Slightly W.
- III ORTA D. AYRIŞ. — Mod. Weath.
- IV ÇOK AYRIŞMIŞ — Highly W.
- V TAM AYRIŞMIŞ — Comp. Weath.

KIRIKLAR / 30cm Fractures
- < 1 SEYREK — Wide (W)
- 1-2 ORTA — Moderate (M)
- 2-10 SIK — Close (Cl)
- 10-20 ÇOK SIK — Intense (I)
- > 20 PARÇALI — Crushed (Cr)

İNCE DANELİ / Fine Grained
- N= 0-2 ÇOK YUMUŞAK — V. Soft
- N= 3-4 YUMUŞAK — Soft
- N= 5-8 ORTA KATI — M. Stiff
- N= 9-15 KATI — Stiff
- N= 16-30 ÇOK KATI — V. Stiff
- N> 30 SERT — Hard

ORANLAR / Proportions
- % 5 < PEK AZ — Slightly
- % 5-15 AZ — Little
- % 15-35 ÇOK — Very
- % 35 > VE — And

İRİ DANELİ / Coarse Grained
- N= 0-4 ÇOK GEVŞEK — V. Loose
- N= 5-10 GEVŞEK — Loose
- N= 11-30 ORTA SIKI — M. Dense
- N= 31-50 SIKI — Dense
- N= >50 ÇOK SIKI — V. Dense

PLASTİSİTE / Plasticity
- PI = 1-5 ÇOK AZ — Slight
- PI = 5-10 AZ — Low
- PI = 10-20 ORTA — Medium
- PI = 20-40 YÜKSEK — High
- PI = > 40 ÇOK YÜKSEK — Very High

SPT : Standart Pen. Deneyi / Standard Pen. Test
K : Karot Numunesi / Core Sample
D : Örselenmiş Numune / Disturbed Sample
P : Pressiyometre Deneyi / Pressuremeter Test
UD : Örselenmemiş Numune / Undisturbed Sample
VST : Vane Deneyi / Vane Shear Test

	LOGU YAPAN / Logged By	KONTROL / Checked	ONAY / Approved	TARİH / Date
İSİM / Name	EMRULLAH KASIM	AYDOĞAN BORAY		
İMZA / Sign		(signature)		

THE STUDY ON
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AUGUST, 1996
ORIENTAL CONSULTANTS COMPANY LIMITED
in association with
JAPAN OVERSEAS CONSULTANTS COMPANY LIMTED

Figure - 6.5.5 (2)

Soil Investigation Result on Selyeri Bridge

ERA
JEOLOJİ - JEOTEKNİK
GEOLOGY - GEOTECHNICS

SOIL SURVEY AT HIGHWAY BRIDGE SITES IN TURKEY

SONDAJ LOGU / *BORING LOG*

SAYFA / Sheet NO.: 1/1

SONDAJ NO. / Boring No.	PAŞAPINAR BRIDGE BOREHOLE, HAVZA
SONDAJ DERİNLİĞİ / Boring Depth	13.50 m
MAKİNA TİPİ / Rig Type	Mobile Drill B-53
SONDAJ METODU / Drilling Method	Rotary
MUHAFAZA BORUSU / Casing — Çap ve Derinlik / Dia & Depth	HW 114/101 mm, 4m; NW 89/76 mm, 10.30m
ZEMİN KOTU / Ground El. (m)	
KOORDİNAT / Coordinate Y(E)	Shown in
KOORDİNAT / Coordinate X(W)	Sketch
BAŞLAMA TARİHİ / Start Date	26.09.1995
BİTİŞ TARİHİ / Finish Date	27.09.1995

YERALTI SUYU DURUMU / Groundwater Data	DERİNLİK / Depth	TARİH / Date
	-1.50 m	27.09.1995

DERİNLİK (m) / Depth	MANEVRA BOYU / Run, Dept (m)	NUMUNE TÜRÜ / Sample Type	SPT 15cm	SPT 15cm	SPT 15cm	N	JEOTEKNİK TANIMLAMA / Geotechnical Description	DAYANIMLILIK / Strength	AYRIŞMA / Weathering	KIRIK /30cm / Fracture	KAROT % / TCR	RQD %
1	1.00 / 1.05	SPT NO Sample	50/5	—	—	R	BOULDER, GRAVEL and SAND: Max. boulder size 50cm. Average boulder size 5-15cm. Boulders are basalt and andesite in origin. Sand is coarse grained. Gravel is polygonic					
2	2.00 / 2.45	SPT	29	26	50	76						
3	3.00 / 3.45	SPT	19	21	23	44						
4	4.00 / 4.10	NO Sample	50/10	—	—	R						
5	5.00 / 5.45	"	21	12	6	18	5.20 m — Silty SAND, Grey loose					
6	6.00 / 6.45	SPT	15	25	40	65	6.00 m					
7	7.00 / 7.45	"	13	7	8	15	Gravelly SAND, Grey, fine grained, occasional medium grained, gravelly sand					
8	8.00 / 8.45	"	8	10	22	32						
9	9.00 / 9.45	"	19	11	22	33						
10	10.00 / 10.32 / 10.50	NO Sample	20	24	50/2	R	10.25 m					
11		K Core					CLAYSTONE: Grey, fine grained, moderately weathered, Medium strong, 10cm thick sandstone intercalated. Miocene - Pliocene of Age	III	III		90	76
12	12.00	K						III	III		95	72
13	13.50						13.50 m — END OF BOREHOLE					

DAYANIMLILIK / Strength		AYRIŞMA / Weathering	
I ÇOK ZAYIF	V. Weak	I TAZE	Fresh
II ZAYIF	Weak	II AZ AYRIŞMIŞ	Slightly W.
III ORTA ZAYIF	M. Weak	III ORTA D. AYRIŞ.	Mod. Weath.
IV ORTA DAYANIMLI	M. Strong	IV ÇOK AYRIŞMIŞ	Highly W.
V DAYANIMLI	Strong	V TAM AYRIŞMIŞ	Comp. Weath.

KAYA KALİTESİ TANIMI / RQD			KIRIKLAR / 30cm Fractures		
% 0-25	ÇOK ZAYIF	V. Poor	< 1 SEYREK	Wide	(W)
% 25-50	ZAYIF	Poor	1-2 ORTA	Moderate	(M)
% 50-75	ORTA	Fair	2-10 SIK	Close	(Cl)
% 75-90	İYİ	Good	10-20 ÇOK SIK	Intense	(I)
% 90-100	ÇOK İYİ	Excellent	> 20 PARÇALI	Crushed	(Cr)

İNCE DANELİ / Fine Grained			İRİ DANELİ / Coarse Grained		
N=0-2	ÇOK YUMUŞAK	V. Soft	N=0-4	ÇOK GEVŞEK	V. Loose
N=3-4	YUMUŞAK	Soft	N=5-10	GEVŞEK	Loose
N=5-8	ORTA KATI	M. Stiff	N=11-30	ORTA SIKI	M. Dense
N=9-15	KATI	Stiff	N=31-50	SIKI	Dense
N=16-30	ÇOK KATI	V. Stiff	N=>50	ÇOK SIKI	V. Dense
N>30	SERT	Hard			

ORANLAR / Proportions			PLASTİSİTE / Plasticity		
% 5 <	PEK AZ	Slightly	PI=1-5	ÇOK AZ	Slight
% 5-15	AZ	Little	PI=5-10	AZ	Low
% 15-35	ÇOK	Very	PI=10-20	ORTA	Medium
% 35 >	VE	And	PI=20-40	YÜKSEK	High
			PI=>40	ÇOK YÜKSEK	Very high

SPT: Standart Pen. Deneyi / Standart Pen. Test
K: Karot Numunesi / Core Sample
D: Örselenmiş Numune / Disturbed Sample
P: Pressiyometre Deneyi / Pressuremeter Test
UD: Örselenmemiş Numune / Undisturbed Sample
VST: Vane Deneyi / Vane Shear Test

	LOGU YAPAN / Logged By	KONTROL / Checked	ONAY / Approved	TARİH / Date
İsim / Name	EMRULLAH KASIM	AYDOĞAN BORAY		
İmza / Sign		AB.		

THE STUDY ON
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AUGUST, 1996
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in association with
JAPAN OVERSEAS CONSULTANTS COMPANY LINTED

Figure - 6.5.6

Soil Investigation Result on Pasapinar Bridge

ERA

JEOLOJİ-JEOTEKNİK
GEOLOGY-GEOTECHNICS

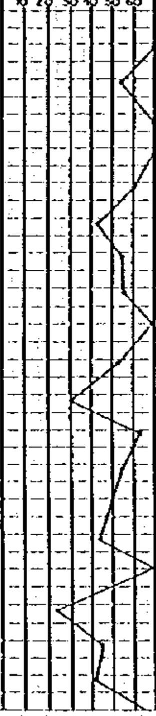
SOIL SURVEY AT HIGHWAY BRIDGE SITES IN TURKEY

SONDAJ LOGU / *BORING LOG*

SAYFA / Sheet NO.: 2/1

SONDAJ NO. / Boring No.	: TOPALLI BRIDGE BOREHOLE, EYNESİL	ZEMİN KOTU / Ground El. (m)	: + 0.50
SONDAJ DERİNLİĞİ / Boring Depth	: 26.50 m	KOORDİNAT / Coordinate Y(E)	: Shown in
MAKİNA TİPİ / Rig Type	: Mobile Drill B-53	KOORDİNAT / Coordinate X(W)	: Sketch
SONDAJ METODU / Drilling Method	: Rotary	BAŞLAMA TARİHİ / Start Date	: 21.09.1995
MUHAFAZA BORUSU / Casing	: Hollow stem O.D. 85.6mm : 203.2mm, 13m	BİTİŞ TARİHİ / Finish Date	: 22.09.1995
Çap ve Derinlik / Dia & Depth	: NW 89/75 mm, 26.50m		

YERALTI SUYU DURUMU / Groundwater Data	DERİNLİK / Depth	TARİH / Date
	-0.20m	22.09.1995



DERİNLİK (m) / Depth	MANEVRA BOYU (m) / Run Depth (m)	NUMUNE / Sample: TÜRÜ / Type	SPT N 15cm	DARBE SAYISI / Num. of Blows 15cm	15cm	N
1	1.00 / 1.27	SPT	8	50/12	—	R
2	2.00 / 2.45	"	7	22	32	54
3	3.00 / 3.38	"	28	35	50/8	R
4	4.00 / 4.45	"	50/12	—	—	R
5	5.00 / 5.45	"	13	25	35	60
6	6.00 / 6.45	"	10	20	22	42
7	7.00 / 7.45	"	10	20	33	53
8	8.00 / 8.45	"	20	21	35	56
9	9.00 / 9.29	"	30	50/14	—	R
10	10.00 / 10.45	"	6	16	36	52
11	11.00 / 11.45	"	10	13	17	30
12	12.00 / 12.45	"	26	26	38	64
13	13.00 / 13.45	"	16	22	33	55
14	14.00 / 14.05	"	50/5	—	—	R
15	15.00 / 15.45	"	18	19	25	44
16	16.00 / 16.45	"	6	16	50/5	R
17	17.00 / 17.45	"	5	10	12	22
18	18.00 / 18.45	"	15	20	23	43
19	19.00 / 19.45	"	10	16	25	41
20						

JEOTEKNİK TANIMLAMA / Geotechnical Description

0.00 – 1.15m	Silty SAND: Grey, fine grained, very dense
1.15m – 8.15m	Gravelly SAND with little silt: Grey-dark grey, very dense. Contains occasional fine sand layers.
8.15m – 8.50m	Sand and Gravel: Grey
8.50m – 14.00m	SAND: Little gravelly, grey, very dense, contains shells
14.00m –	SAND with little gravel and silt: Grey very dense, contains shells

PROFİL / Profile | DAYANIMLILIK / Strength | AYRIŞMA / Weathering | KIRIK /30cm / Fracture | KAROT % / TCR | RQD %

DAYANIMLILIK / Strength		AYRIŞMA / Weathering	
I ÇOK ZAYIF	V. Weak	I TAZE	Fresh
II ZAYIF	Weak	II AZ AYRIŞMIŞ	Slightly W.
III ORTA ZAYIF	M. Weak	III ORTA D. AYRIŞ.	Mod. Weath.
IV ORTA DAYANIMLI	M. Strong	IV ÇOK AYRIŞMIŞ	Highly W.
V DAYANIMLI	Strong	V TAM AYRIŞMIŞ	Comp. Weath.

KAYA KALİTESİ TANIMI / RQD			KIRIKLAR / 30cm Fractures		
% 0-25	ÇOK ZAYIF	V. Poor	< 1 SEYREK	Wide	(W)
% 25-50	ZAYIF	Poor	1-2 ORTA	Moderate	(M)
% 50-75	ORTA	Fair	2-10 SIK	Close	(Cl)
% 75-90	İYİ	Good	10-20 ÇOK SIK	Intense	(I)
% 90-100	ÇOK İYİ	Excellent	> 20 PARÇALI	Crushed	(Cr)

İNCE DANELİ / Fine Grained			İRİ DANELİ / Coarse Grained		
N=0-2	ÇOK YUMUŞAK	V. Soft	N=0-4	ÇOK GEVŞEK	V. Loose
N=3-4	YUMUŞAK	Soft	N=5-10	GEVŞEK	Loose
N=5-8	ORTA KATI	M. Stiff	N=11-30	ORTA SIKI	M. Dense
N=9-15	KATI	Stiff	N=31-50	SIKI	Dense
N=16-30	ÇOK KATI	V. Stiff	N=>50	ÇOK SIKI	V. Dense
N>30	SERT	Hard			

ORANLAR / Proportions			PLASTİSİTE / Plasticity		
% 5 <	PEK AZ	Slightly	PI = 1-5	ÇOK AZ	Slight
% 5-15	AZ	Little	PI = 5-10	AZ	Low
% 15-35	ÇOK	Very	PI = 10-20	ORTA	Medium
% 35 >	VE	And	PI = 20-40	YÜKSEK	High
			PI = >40	ÇOK YÜKSEK	Very High

SPT : Standart Pen. Deneyi / Standard Pen. Test
K : Karot Numunesi / Core Sample
D : Örselenmiş Numune / Disturbed Sample
P : Presiyometre Deneyi / Pressuremeter Test
UD : Örselenmemiş Numune / Undisturbed Sample
VST : Vane Deneyi / Vane Shear Test

	LOGU YAPAN / Logged By	KONTROL / Checked	ONAY / Approved	TARİH / Date
İSİM, Name	EMRULLAH KASIM	AYDOĞAN BORAY		
İMZA, Sign		(signature)		

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AUGUST, 1996
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Figure - 6.5.7 (1)

Soil Investigation Result on Topalli Bridge

ERA JEOLOJİ-JEOTEKNİK GEOLOGY-GEOTECHNICS	SOIL SURVEY AT HIGHWAY BRIDGE SITES IN TURKEY SONDAJ LOGU / *BORING LOG*	SAYFA / Sheet NO.: 2/2

SONDAJ NO. / Boring No.	TOPALLI BRIDGE BOREHOLE, EYNESİL	ZEMİN KOTU/Ground El. (m)	∓ 0.50
SONDAJ DERİNLİĞİ/Boring Depth	26.50 m	KOORDİNAT/Coordinate Y(E)	Shown In
MAKİNA TİPİ/Rig Type	Mobile Drill B-53	KOORDİNAT/Coordinate X(W)	Sketch
SONDAJ METODU/Drilling Method	Rotary	BAŞLAMA TARİHİ/Start Date	21.09.1995
MUHAFAZA BORUSU/Casing	Hollow stem O.D. 85.6 mm x 203.2 mm, 13 m	BİTİŞ TARİHİ/Finish Date	22.09.1995
Çap ve Derinlik/Dia & Depth	NW 89/76 mm; 26.60 m		

YERALTI SUYU DURUMU / Groundwater Data	DERİNLİK / Depth	TARİH / Date
	-0.20 m	22.09.1995

DERİNLİK (m) / Depth	MANEVRA BOYU / Run Depth (m)	NUMUNE TÜRÜ / Sample Type	SPT N 15 cm	SPT N 15 cm	SPT N 15 cm	N	JEOTEKNİK TANIMLAMA / Geotechnical Description	DAYANIMLILIK / Strength	AYRIŞMA / Weathering	KIRIK /30cm / Fracture	KAROT % / TCR	RQD %
	20.00–20.45	SPT	21	30	40	70	Same as above — 21.30 m —					
21	21.00–21.45	NO Sample	12	14	50/4	R	SAND and GRAVEL: Dark grey, very dense, contains occasional boulders					
22	22.00–22.45	"	20	24	24	48						
23	23.00–23.12	"	50/12	—	—	R	— 23.70 m —					
24	24.00–24.08	"	50/8	—	—	R	BASALT: Dark grey, fine grained, glassy, strong, weathered and fractured on top portion. Eocene of Age					
25	24.70	K Core Sample						V	I	W	90	80
26	26.60						— 26.50 m — END OF BOREHOLE					
27												
28												
29												

DAYANIMLILIK / Strength		AYRIŞMA / Weathering	
I ÇOK ZAYIF	V. Weak	I TAZE	Fresh
II ZAYIF	Weak	II AZ AYRIŞMIŞ	Slightly W.
III ORTA ZAYIF	M. Weak	III ORTA D. AYRIŞ.	Mod. Weath.
IV ORTA DAYANIMLI	M. Strong	IV ÇOK AYRIŞMIŞ	Highly W.
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KAYA KALİTESİ TANIMI / RQD			KIRIKLAR / 30cm Fractures		
% 0-25	ÇOK ZAYIF	V. Poor	< 1 SEYREK	Wide	(W)
% 25-50	ZAYIF	Poor	1-2 ORTA	Moderate	(M)
% 50-75	ORTA	Fair	2-10 SIK	Close	(Cl)
% 75-90	İYİ	Good	10-20 ÇOK SIK	Intense	(I)
% 90-100	ÇOK İYİ	Excellent	> 20 PARÇALI	Crushed	(Cr)

İNCE DANELİ / Fine Grained			İRİ DANELİ / Coarse Grained		
N=0-2	ÇOK YUMUŞAK	V. Soft	N=0-4	ÇOK GEVŞEK	V. Loose
N=3-4	YUMUŞAK	Soft	N=5-10	GEVŞEK	Loose
N=5-8	ORTA KATI	M. Stiff	N=11-30	ORTA SIKI	M. Dense
N=9-15	KATI	Stiff	N=31-50	SIKI	Dense
N=16-30	ÇOK KATI	V. Stiff	N=>50	ÇOK SIKI	V. Dense
N>30	SERT	Hard			

ORANLAR / Proportions			PLASTİSİTE / Plasticity		
% 5 <	PEK AZ	Slightly	PI=1-5	ÇOK AZ	Slight
% 5-15	AZ	Little	PI=5-10	AZ	Low
% 15-35	ÇOK	Very	PI=10-20	ORTA	Medium
% 35 >	VE	And	PI=20-40	YÜKSEK	High
			PI=>40	ÇOK YÜKSEK	Very high

SPT: Standart Pen. Deneyi / Standart Pen. Test
K: Karot Numunesi / Core Sample
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İSİM, Name	EMRULLAH KASIM	AYDOĞAN SORAY		
İMZA, Sign		AB		

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Figure - 6.5.7 (2)

Soil Investigation Result on Topalli Bridge

1) Selyeri Bridge

The soil conditions in Figure - 6.5.1 are classified into 3 major layers such as 1. coarse sand, 2. silt and sand, and 3. silty sand from the river bed. Medium to dense sandy soils are predominantly distributed which are fine grained and little gravel with ample shell fragments. Uniformity coefficient is 2 to 3 which means poorly graded. Soil descriptions are as follows:

Coarse Sand with little gravel, very dense but poorly graded (Cu = 3), contains ample shell fragments

Silt and Sand : fine grained, very dense, little shell fragments

Silty Sand, very dense, fine grained, poorly graded (Cu = 2 - 3), silt is about 25 %, little shell fragments

Grain size distribution curves are plotted in Figure 6-5-4 which show poorly graded in comparison with other 2 sites. According to the local seismic map, seismic factors are 4 graded such as 0.1, 0.08, 0.06 and 0.04 in zoning. This location falls on a seismic factor, 0.06 in the region. The seismic factor is not big but it is anticipated liquefaction. Therefore it is recommended that pile foundations for the bridge are preferable. Earthquake-resistant design shall be considered for the proposed pile foundation.

2) Pasa Pinar Bridge

Figure - 6.5.2 Soil Profile shows soil conditions which consist of 4 layers described below. Plenty of boulders and gravels are observed and scattered at the upper layers.

Boulder, Gravel and Sand : Max. boulder size 500mm, average size 50 - 150mm. Boulders are basalt and andesite in origin. Sand is coarse grained and very well graded.

Silty Sand, grey loose

Gravelly Sand, fine grained, occasional medium grained, very well graded, gravelly sand

Claystone : Grey, fine grained, moderately weathered, medium strong, Miocene - Pliocene of Age

Grain size curves show well graded and out of liquefaction critical zone, quite stabilized condition. On the other hand the seismic factor indicates 0.1 in this region according to the local information. However, It is expected that direct foundations such as a spread footing and/or caisson is applicable owing to very dense stabilized gravelly soils condition. Allowable bearing pressure is estimated 50 tons per square metre.

3) Topalli Bridge

Soil conditions are shown in Figure - 6.5.3 Dense to very dense gravelly sandy layers are widely developed in this area. Soil descriptions are as follows:

1. Gravelly Sand with little silt Gravel diameter is in the range of 2-150mm. very dense, well graded (Cu = 7 - 10), contains occasional thin fine sand layers
2. Sand with little gravelly ,very dense, well graded (Cu= 10)but poorly graded (Cu= 2) at lower portion, contains shell fragment
3. Sand and Gravel, occasionally boulders
4. Basalt, weathered and fractured on top portion (Eocene of Age)

Grain size distribution curves are shown in Figure - 6.5.4 which indicate fairly well-graded. Liquefaction potential is low. Because uniformity coefficient is in the range of 7 - 10. The seismic factor shows 0.04 which is the least grade according to the local information. In terms of bridge foundations it is proposed that cast in place piles are applicable on the gravelly sand soils condition.

6.6 Hydrological Survey

6.6.1 Objectives

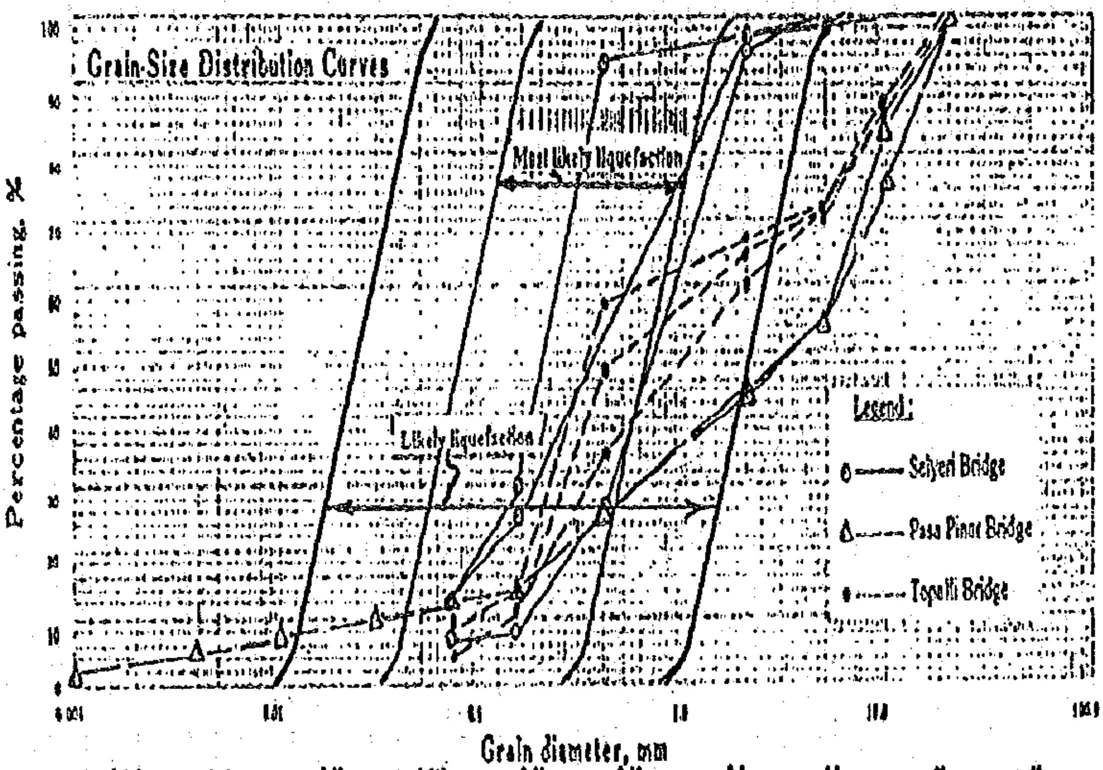
Determination of the design high-water level is essential for design of bridges in order to make a safe and economic design and also a proper maintenance. Hydrological study for estimating flood water level at each bridge site is required to provide empirical data and also engineering approach for determining the elevation of the bridges selected. Therefore, not only existing available data needs to be collected but also a detailed visual inspection on each bridge site shall be carried out in the field to obtain as much hydrological information and data as possible.

6.6.2 Survey Locations

20 bridge sites were selected along the arterial roads to be improved urgently based on the bridge inspection concepts mentioned previously. These 20 bridge sites are geographically deployed in the 5 regions such as 1. Black Sea, 2. Marmara, 3. Aegean, 4. Mediterranean and 5. Central Anatolia Regions. Climatic conditions i.e. annual rainfall and average temperatures are observed to be greatly influenced by each geography. The selected 20 bridges which are classified by geographical regions are summarized in Table - 6.6.1. According to this table, annual rainfall in the Black Sea region is extremely high and reaches 2000mm which is three to five times the other four regions. The least annual rainfall is 382mm in Central Anatolia region. On the contrary average temperatures in difference are found small in the both summer and winter seasons.

6.6.3 Methodology and Schedule

For each selected bridge site, in addition to the preliminary data the detailed visual inspection which consists of high water level prints, width of river and flow, approximate



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	COBBLES
	SILT			SAND			GRAVEL			

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Sample - 1

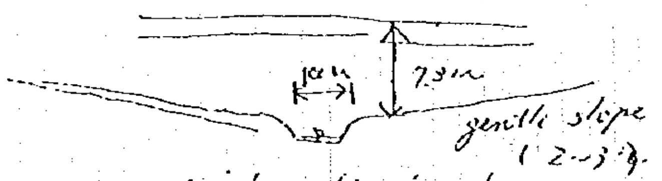
Hydrological Survey

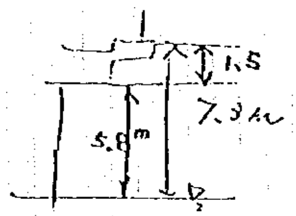
No. 20

Date	10/10/95 Time 10:17 Weather V. Fine
Bridge Name & No.	CANDIR HASANAPASA SB-200-06-12
Division No., KP.Br. Length	Div. 14 . 62+0 . L= 113.85m
River Name	CANDIR
Approx. Distance	km between bridge and river-mouth
Width of river	100m (present 10~20m after scouring)
Width of flow	2.5m
Current velocity	;~ 0.5m/sec. 0.5~1.0m/sec. 1.0m/sec.~; 1.5 m/sec.
Water Level	LWL Depth (0.2)m, LWL Width (4)m
	HWL Depth (2.5)m, HWL Width (13)m
Water Clearness	clear, opaque, muddy, brown, no water — due to washing water of sand quarry.
Riverbed Material	silt and clay, sandy, gravel, rock — mixed
Average grain-size diameter of riverbed soils.	
Past Flood Records by Interview to Local People	Since 1943 no big flood, especially after the present bridge

River Dyke Configuration;

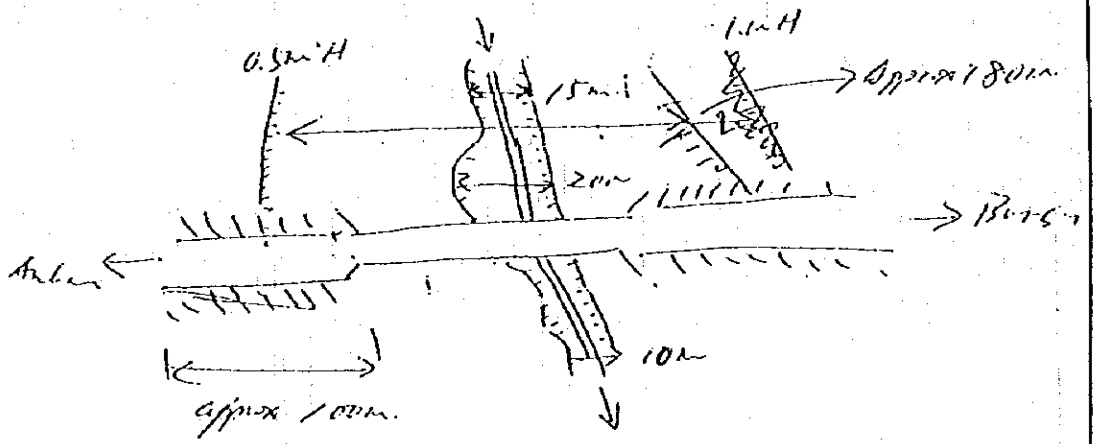
Remarks;





wide flood plain

without natural banks



Photographs Nos.	

TABLE 6-6-1 RESULTS OF HYDROLOGICAL SURVEY BASED ON GEOGRAPHICAL REGION AND CLIMATE

Div. No.	Division Name	Bridge Number	Bridge Name	River Name/ Structure	Geographical Region	Annual Rainfall(mm)	Average Temperature(centigrade)		HWL(m)	
							In the Summer	In the Winter	To Girder Bottom	1*From Riverbed
2	Izmir	AI-300-02-2	Buca Ust Gecit	Fly-over	Aegean	647	27	10	(Fly-over)	
		AI-300-02-8	Hilal-II	Melez Cavi					6.5	3
		AI-300-04--5	Hundut-I	Kurudere					2	2.2
4	Ankara	SB-200-08-4	Porsuk	Porsuk Cayi	Central Anatolia	382	23	0	2	2.9
		AA-200-10-1	Babadat	Babadat N					3.4	0.7
7	Samsun	AR-010-16-4	Selveri 2*	Selveri	Black Sea	2000	22 to 24	5 to 7	1.4	2.3
		AR-100-16-12	Akcay	Akcay					2.4	3.7
		AR-100-17-1	Merzifon	Fly-over					(Fly-over)	
		AR-100-17-4	Ust Gecit-II	Fly-over					(Fly-over)	
		AR-100-17-5	Pasa Pinar 2*	Hacimusa					3.5	1.5
		AR-785-05-2	Koparan-II	Koparan D	Central Anatolia	382	23	0	0.8	2.3
		AR-785-05-4	Hacimusa	Hacimusa					1.2	0.75
		AR-795-01-5	Asagi Cakalli	Cakali					8	4.6
10	Trabzon	AR-010-19-19	Harsit	Harsit Cavi	Black Sea	2000	22 to 24	5 to 7	3.2	4.6
		AR-010-20-10	Topalli 2*	Ogu					0.5	2.2
		AR-010-22-1	Decirmendere	Degirmen D.					5	2.4
		AR-010-22-15	Ivvan Sogukpinar	Sogukpinar					2.5	1.75
		AR-010-22-16	Solakli	Solakli D.					3	3.6
13	Antalya	AA-650-11-3	Sardere	Sarderesi	Mediterranean Sea	777	27	8 to 12	5	1
14	Bursa	SB-200-06-12	Candir Hasanapasa	Candir	Marmara	688	24	5 to 7	5.8	4.1

1*------------ from the lowest river-bed

2*------------ actual geotechnical investigation performed

TABLE 6-6-2 RESULTS OF HYDROLOGICAL SURVEY ON HIGHWAY BRIDGE SITES FOR DETAILED NSPECTION

Div. No.	Bridge Number	Bridge Name	River Name/ Structure	1*Approx. Distance	Width (m) of River	Flow	2*Current Velocity	Water Cleanliness	Riverbed Material	Average Dia.of of Material(mm)	HWL(m) To Girder Bottom	3*From Riverbed
	AI-300-02-2	Buca Ust Gecit	Fly-over					No water			(Fly-over)	
2	AI-300-02-8	Hilal-II	Melez Cayi		33	30	0.5	Dark grey	Silt/gravel	2	6.5	3
	AI-300-04--5	Hundut-I	Kurudere		75	35	2	No water	Sand	1	2	2.2
4	SB-200-08-4	Porsuk	Porsuk Cayi		15	18	2	Clear	Silt	0.05	2	2.9
	AA-200-10-1	Babadat	Babadat N		15	2	0.3	Clean	Silt	0.05	3.4	0.7
	AR-010-16-4	**Selveri 4***	**Selveri**	**2**	**26**	**15**	**1**	**Brown**	**Sand/silt**	**0.05**	**1.4**	**2.3**
	AR-100-16-12	Akcay	Akcay	0.2	110	50	0.3	Brown	Sand/silt	0.1	2.4	3.7
	AR-100-17-1	Merzifon	Fly-over					No water			(Fly-over)	
7	AR-100-17-4	Ust Gecit-II	Fly-over					No water			(Fly-over)	
	AR-100-17-5	**Pasa Pinar 4***	**Hacimusa**		**30**	**5**	**1**	**Muddy**	**Gravel**	**50**	**3.5**	**1.5**
	AR-785-05-2	Koparan-II	Koparan D		9	15		No water	Sand/gravel	30	0.8	2.3
	AR-785-05-4	Hacimusa	Hacimusa		10	5		No water	Silt	0.05	1.2	0.75
	AR-795-01-5	Asagi Cakalli	Cakali		20	10	1.5	Opaque	Sand/gravel	5	8	4.6
	AR-010-19-19	Harsit	Harsit Cayi	0.5	250	140	0.25	Brown	Sand/gravel	30	3.2	4.6
	AR-010-20-10	**Topalli 4***	**Ogu**	**0**	**55**	**40**	**0.5**	**Clear**	**Sand/gravel**	**30**	**0.5**	**2.2**
10	AR-010-22-1	Degirmendere	Degirmen D.	0.2	45	50	1	Muddy	Sand/gravel	2	5	2.4
	AR-010-22-15	Ivyan Sogukpinar	Sogukpinar	0	30	30	2	Brown	Sand	1	2.5	1.75
	AR-010-22-16	Solakli	Solakli D	0	130	120	0.3	Muddy	Sand/gravel	5	3	3.6
13	AA-650-11-3	Sardere	Sarderesi		150	5		No water	Gravel	30	5	1
14	SB-200-06-12	Candir Hasanapas	Candir		180	10	1.5	Muddy	Sand/gravel	10	5.8	4.1

1*---------- from the river-mouth (km)

2*---------- unit : (m/sec)

3*---------- from the lowest river-bed

4*---------- actual geotechnical investigation performed distance from river-mouth, current velocity, water cleanliness, riverbed materials, terrain and past flood records from interviews with local people was carried out for the period 20 September 1995 to 10 October 1995. These survey items in detail are shown in the following page as a sample.

6.6.4 Survey Results

Based on this hydrological survey data and available information, the design high-water level for each bridge site is determined and summarized in the last two columns of Table - 6.6.2. The maximum high water level is in general considered for guidelines in Table - 6.6.3.

Table - 6.6.3 Mini. Clearance Between Girder Bottom and Max. High Water Level (m)

Bridge Length (m)	Mini. Clearance Between Girder Bottom and Max. High Water Level (m)
5 to 100	0.5 to (1.0)
over 100	1.0 to(1.5)

The HWLs for all the bridges in Table - 6.6.2 are cleared by the mini. clearance as a guideline shown in Table - 6.6.3. However, it is recorded that the only Selyeri bridge has experienced floods which means that a past high water reached the girder bottom according to local residents due to high precipitation in the Black Sea region. Precautions should be taken in this region. The other bridges have not ever experienced flooding according to the hydrological suvey results.

It is proposed that the HWL for each bridge indicated in Table - 6.6.2 is the most suitable for the design high-water level.

Chapter 7

Preliminary Design

Chapter 7 Preliminary Design

7.1 Selection of Study Bridges

7.1.1 Selection Criteria

The objective bridges for preliminary design of the maintenance and rehabilitation study were selected from detailed inspection of 20 bridges. The 20 bridges selected (see Figure - 6.2.1) for further repair work were based on the damage ranking or serviceability of the bridge.

To satisfy the objectives, the following criteria are set;

- To have socioeconomic importance,
- To have heavy traffic volume,
- To have remarkable deterioration,
- To have characteristic damages,
- To need immediate remedial work,
- To be able to use typical repair methods, and
- To be from each KGM division. (where possible)

7.1.2 Study Bridges

The bridges selected for this study are not all the damaged bridges that are in existence. They are only representative samples of damages that the Study Team would like to demonstrate for the maintenance and rehabilitation study. From the Study Team's survey, it is noted that approximately 25 % of the 207 bridges inspected will require actual maintenance and rehabilitation work.

The 20 objective bridges, except substitution of other damaged bridges, which are immediately required maintenance and rehabilitation study for repair work, are damaged and deteriorated more seriously than damaged rank B. The number of damaged bridges are summarised in Table - 7.1.1.

Table - 7.1.1 Ratio of Bridge Elements with Serious Damage

Bridge Element	Number of Bridges	Bridge Number Ratio (%)	Whole Ratio (%)
Expansion Joint	5	25	18
Deck Slab	5	25	18
Girder	11	55	39
Column and Footing	6	30	21
Abutment	1	5	4

In this section, the selection criteria of 10 objective bridges are classified into the three categories as follows:

- damage items,

- traffic volume, and
- IRR (Internal Rate of Return).

In chapter 6, the damage intensity was calculated by using the number of span and the damage score. The ratio of the number of span to the damage intensity for each bridge, which comprises the deck slab, girder, column and footing of damaged major components, are shown in Table - 7.1.2.

Table - 7.1.2 Ratio of the Number of span to Damage Intensity

Bridge Name	No. of Span (a)	Damage Score (b)	Damage Intensity (b/a)	Remarks
1) Buca Ust Gecit	3	10	3.3	●
2) Hilal-II	13	23	1.8	O
3) Hudut-I	3	6	2.0	
4) Polsuk	4	12	3.0	
5) Babadat	3	19	6.3	●
6) Selyeri	2	9	4.5	●
7) Akcay	5	9	1.8	O
8) Merzifon	2	12	6.0	●
9) Ust Gecit II	1	3	3.0	
10) Pasa Pinar	2	6	3.0	
11) Koparan-II	2	16	8.0	●
12) Hacimusa	2	0	0	
13) Asagi Cakalli	4	96	24.0	●
14) Harsit	10	0	0	
15) Topalli	4	0	0	
16) Degirmendere	4	19	2.5	
17) Gelincik	2	9	4.5	●
18) Solakli	15	51	3.4	●
19) Sardere	3	21	7.0	●
20) Candir Hasanpasa	7	48	6.9	●

Note ● : Damage Intensity (b/a) > 3.0
O : Characteristic damaged bridge

In Table - 7.1.2, the characteristic damaged bridges, whose damage intensity is less than 2.0, are Hilal II and Akcay. Hilal-II suffers from intensive cracks caused by Alkali-Silica Reaction on the column surface. The shearing cracks on Akcay, is caused by the increased vehicle loading on the Gerber portion of concrete girder. Both the bridges shall be considered by structure and material type for maintenance and rehabilitation study.

As these bridges are situated on the national highway, the traffic volume is to increased every year. The traffic growth is a direct result of the increased socio-economic situation in the country. The relation ship of traffic volume and damage intensity, which are of socio-economic importance and stability of bridge, are shown in Figure - 7.1.1.

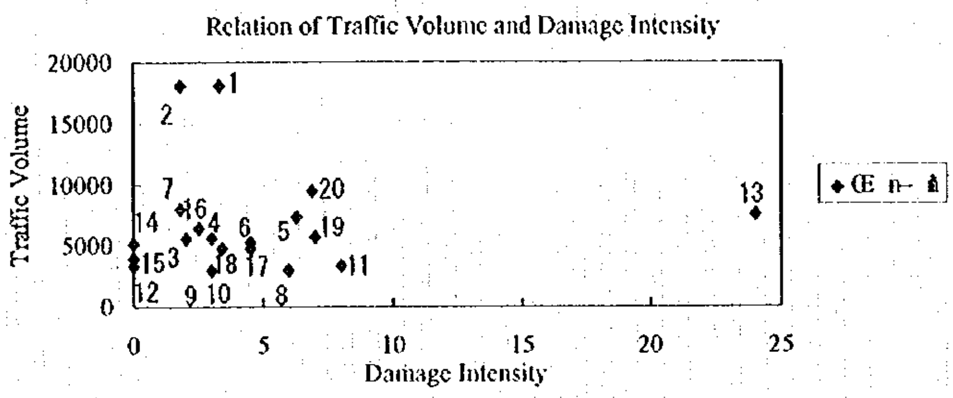


Figure - 7.1.1 Relation of Traffic Volume and Damage Intensity

The value of the Internal Rate of Return (hereinafter referred to as IRR), which is the reference value to select objective bridges in this section, uses the result calculated in chapter 8. Due to the selection of objective bridges using the damage intensity and traffic volume for preliminary design, the following criteria are defined; as:

- The value of damage intensity must be more than 4.5 points, and
- The traffic volume must be greater than 8000 vehicles.

The selection of objective bridges for preliminary design on maintenance and rehabilitation study is shown in Table - 7.1.3.

Table - 7.1.3 Selection of Objective Bridges for Preliminary Design

Bridge Name	Division NO.	Damage Intensity	Traffic Volume	IRR	Objective Bridge
1) Buca Ust Gecit	2	3.3	18,090	--	●
2) Hilal-II	2	1.8	18,090	24.2	●
3) Hudut-I	2	2.0	5,569	20.0	
4) Polsuk	4	3.0	5,638	24.3	
5) Babadat	4	6.3	7,322	28.2	●
6) Selyeri	7	4.5	5,249	19.5	●
7) Akcay	7	1.8	8,003	18.3	●
8) Merzifon	7	6.0	2,964	31.5	○
9) Ust Gecit II	7	3.0	2,964	22.0	
10) Pasa Pinar	7	3.0	2,964	17.5	
11) Koparan-II	7	8.0	3,331	15.8	●
12) Hacimusa	7	0	3,331	23.5	
13) Asagi Cakalli	7	24.0	7,537	100.9	●
14) Harsit	10	0	5,184	50.9	
15) Topalli	10	0	3,955	24.5	
16) Degirmendere	10	2.5	6,413	25.1	
17) Gelincik	10	4.5	4,775	14.8	●
18) Solakli	10	3.4	4,775	16.4	
19) Sardere	13	7.0	5,729	36.0	●
20) Candir Hasanpasa	14	6.9	9,451	26.4	●

In the above mentioned table (mark "O"), the damages on Merzifon bridge are as a result of poor workmanship on deck slab (e.g., peel off and water leakage). Therefore the damages on this bridge, is for the purpose of this study, is adequately represented by the Asagi Cakalli bridge.

The list of objective bridges for preliminary design on maintenance and rehabilitation study are shown in Table - 7.1.4. The Study Team had selected ten (10) bridges for the preliminary design on maintenance and rehabilitation study.

Table - 7.1.4 Objective Bridges for Preliminary Design

Bridge Name	Division No.	Bridge Length (m)	Constructed Year	Damage Items of Bridge Elements			
				Slab	Girder	Column	Abutment
1. Buca Ust Gecit	2	33.00	1972	-	- Peel Off - Rebar	-	-
2. Hilal-II ●	2	347.80	1990	-	-	- Crack - Peel Off	- Crack
3. Babadat	4	25.20	1964	-	-	- Peel Off - Rebar - Scour	-
4. Selyeri	7	21.70	1964	-	- Peel Off - Rebar - Water	-	-
5. Akcay ●	7	106.90	1961	-	- Peel Off - Rebar - Water	-	-
6. Koparan-II	7	27.45	1977	-	- Rebar - Honeycomb	-	-
7. Asagi Cakalli ●	7	71.55	1986	- Crack - Peel Off - Rebar - Honeycomb - Void - Water	- Peel Off - Rebar - Honeycomb - Void	- Peel Off - Rebar - Honeycomb	-
8. Gelincik	10	32.50	1970	-	- Peel Off - Rebar - Honeycomb	-	-
9. Sardere	13	43.15	1985	- Peel Off - Rebar - Honeycomb - Void - Water	-	-	-
10. Candir Hasanpasa	14	113.85	1972	- Crack - Rebar - Water	- Rebar	- Rebar - Scour	-

Note : Mark " ● " along side the Bridge Name means repair work to expansion joint are to be included.

7.2 Study Criteria

7.2.1 General

This section describes the preliminary design on maintenance and rehabilitation study, rehabilitation work planning and cost estimation of the objective bridges for which the detailed inspection was carried out. The maintenance and rehabilitation methods are intended to represent the typical methods to be adopted in Turkey.

The main damages of national highway bridges are a result of poor workmanship of concrete structure, increased vehicle loading and on by scouring of stream or salt attacking the coastline. The selected bridges are generally in on unsatisfactory condition and some of them will actually require replacement with new bridges. However, replacement of bridges will not be considered. This study will be made into methods of rehabilitation of bridges so as to prevent collapse of the bridges that are in particularly dangerous condition and into methods of conducting repair work with a view to keeping the existing bridges functional, and removing the dangers.

The approach of design criteria is presented in chapter 3. The details regarding the design criteria are presented in this chapter.

7.2.2 Material

The strengths of the principal materials used in the repair design are shown in Table - 7.2.1.

Table - 7.2.1 Materials and strength

Material	Strength and other
Cast-in-place concrete	240 kg/cm^2
Patching concrete	240 kg/cm^2
Resin injection (tensile)	200 kg/cm^2 more
Mortar	240 kg/cm^2
Steel Plate	1400 kg/cm^2
Sheet pile	1400 kg/cm^2
Gabion	----
Riprap	diameter 30 cm more

7.2.3 Design

1) Cause of Damages and Deteriorations to Concrete

The deterioration of concrete structures is caused by many factors such as traffic collision damage, structural failures due to over-stress and/or loss of section, freeze and thaw, settlement of foundation, chemical attack, failure of expansion joints, scours, silting, poor design details, construction deficiencies and corrosion of reinforcing steel, as shown in Figure - 7.2.1.

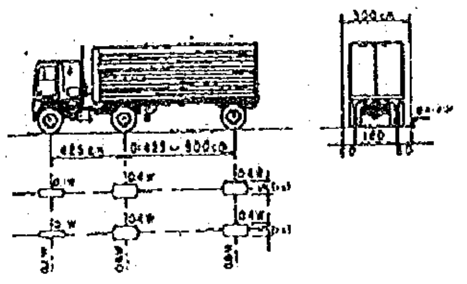
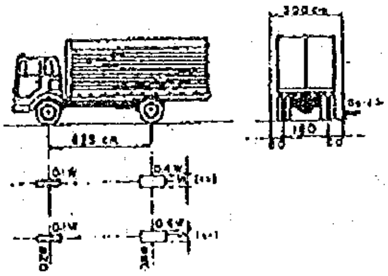
- designing factor
  - unfit structure
    - unfit structure category and type, span, etc.
    - unit sectional shape
  - inadequate calculation
    - mistake in design specification and condition
    - lack of examination of safety ratio
    - mistake in stress analysis
    - mistake and forget of calculation
  - inadequate plan
    - poor arrangement of reinforcement,
    - prestessing tendons
    - lack of additional bars
    - lack of sectional shapes and measurement
    - lack of examination on detailed structure
- construction factor
  - deficiency material
    - poor of quality concrete
    - poor of quality reinforcement.
    - prestressing tendons
    - use of unfit material property
  - deficiency construction
    - error of construction method and order
    - poor quality labour
    - lack of examination of temporary works (formwork, folsework)
    - poor and inadequate execution control
    - in adequate material storage
- external factor
  - increasing and oversizing of traffic volume
  - accident (collision, fall, fire)
  - natural phenomenon (flood, subsidence, etc.)
  - influence of approaches
  - chemical action (sea water, pollution water, sewage)
  - defect of basement structure

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 - 7.2.1 Maintenance and Repair Framework

2) Live Load

In the design work, the specification for all design uses is based on the AASHTO in Turkey. Particularly, the live load uses the HS30 at present in AASHTO. However, at bridge design stage, the live load had used HS20 or HS15. In this study, the live load for preliminary design should be used HS30 for checking up in AASHTO. The type of live load is shown in Table - 7.2.2.

Table - 7.2.2 Live Load Type

Standard figure					
Line Load					
Load Name		H30-S24	H20-S16	H15-S12	H10
Weight (Mp)		30	20	15	10
P (Mp)	Loading Width (m)	13.50	9.00	6.75	9.00
	Uniformed Load	19.50	13.50	9.75	13.00
p (Mp/m)		1.50	1.00	0.75	0.50
s (cm)		75	50	38	25

7.2.4 Manufacturing

It is important during manufacture to comply with the design drawings in the following respects:

- concrete cover to reinforcement,
- spacing of rebar,
- thickness of concrete member,
- material quality,
- embedded depth of basement,
- clearance, and
- range of repair, etc..

7.2.5 Construction

Based on the design drawings, the execution work should be carried out to take account of the following items;

- weather condition,
- environmental condition,
- traffic volume,
- materials,
- construction equipment, and
- cure, etc..

7.2.6 Operation and Maintenance

Maintenance and repair work are categorized as routine maintenance operation and specialized maintenance operation as shown in Figure - 7.2.2.

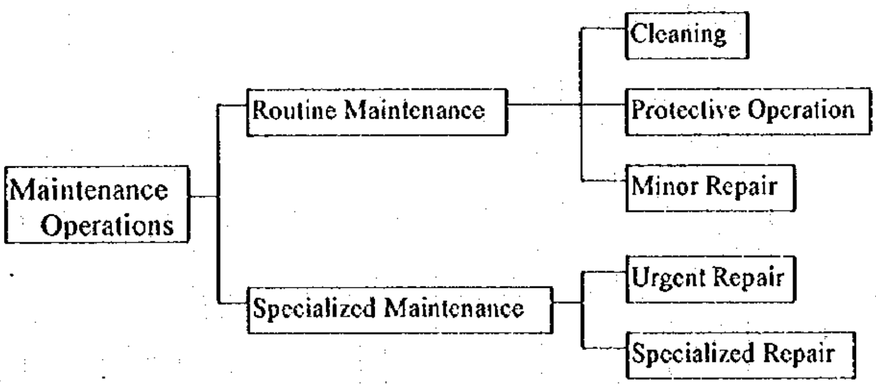


Figure - 7.2.2 Maintenance and Repair Framework

Routine maintenance work is composed of cleaning and minor repairs and is as follows:

- Cleaning
  In order to maintain the function of structures and facilities on the highway in good condition, it is required to clean and remove dirt, debris, and vegetation from pier caps, abutment seats, around bearings, expansion joints, drainage inlets, etc.

- Protective Operations
  Besides cleaning works for structures and facilities, protective operations to secure their function, durability and aesthetics, is essential for structures or facilities, for example periodic repainting for deteriorated paint on steel structures.

- Minor Repairs
  Spot painting or protective coating as required of bearings and exposed portions of steel members; also small-scale repair work for washouts and embankment erosion, and replacement or correction of loose or missing anchor nuts and bolts, etc.

specialized maintenance works comprise urgent repair and special repair for a damaged or deteriorated structure and facility, as follows:

- Urgent Repair

Immediate remedial work is needed to restore a damaged component to a condition for which only routine maintenance is necessary. Work should be scheduled for completion at an early date to prevent further damage to the component or the need for complete reconstruction at a later time.

- Special Repair

Due to the unexpected damage or deterioration discovered from the results of inspection, special remedial work is necessary requiring special skills, equipment, or materials to restore the functions of a damaged component.

Maintenance and repair works, which aim at the above effects, are classified into the following three categories based on the executed work objectives as follows;

- Rehabilitation,

To restore the function of a damaged or deteriorated structure and facility to its initial condition in order to achieve the original loading capacity, durability and aesthetics, etc.

- Reinforcing, and

To strengthen the functions or capacity of a damaged or deteriorated structure or facility in order to cope with initial inferior functions or capacity.

- Improvement.

To provide a damaged or deteriorated structure or facility with better functions or a higher capacity than it originally possessed, in order to cope with an increase in needs.

7.2.7 Natural Condition

The natural condition for preliminary design should consider the following items;

- temperature,
- amount of rainfall,
- effect of earthquake,
- effect of wind,
- effect of snow,
- river condition, and

  river width, ratio of river flow blockade by pier, clearance, scouring of river bed, etc..
- soil condition, etc..

  liquefaction on loose sandy ground, lateral flow on soft ground, etc..

7.2.8 Traffic Volume Projection

1) Design vehicle

Axle load for bridge design is 16 ton/axle in Turkey. The vehicle axle load is over 16 ton is object for this investigation.

2) axle survey

In Turkey, many survey of axle load were conducted on every year. Table - 7.2.3 shows the survey point of axle load after 1990 on the study roads. The results of the survey shown in Appendix 1 for each station. The vehicle axle load over 16 ton/axle ratio are 0%~4.6% and average ratio is 1.8%.

Table - 7.2.3 Outline of axle load survey

point	route	survey year	over 16 ton/axle vehicle ratio
A-1	Afyon-Izmir	1994	3.6%
A-2	Ankara-Antaly	1993	4.6%
A-3	Sivrihisar-Burusa	1991	0.4%
A-4	Ankara-Rize	1994	0.4%
A-5	Ankara-Rize	1994	1.4%
A-6	Afyon-Izmir	1992	2.2%
A-7	Ankara-Antaly	1994	0.9%
A-8	Ankara-Antaly	1992	1.9%
A-9	Ankara-Rize	1990	0.4%
A-10	Ankara-Rize	1991	0.0%
A-11	Ankara-Rize	1994	3.6%

3) axle load

Five study roads are separate two area, east side(Aankara-Rize route) and west side(Ankara-Antalya,Sivrihisar-Burusa,Afyon-Izmir route) so that axle load survey are not conducted on every road on every year.

a) Ankara-Rize route

The result of axle load survey by year shown in Table - 7.2.4 The ratio of vehicles axle load is over 16 ton/axle are grown. And on 1994 , the ratio of vehicle which axle load is over 16 ton/axle are 2.2 % of all vehicle.

Table - 7.2.4 Change of heavy vehicle ratio

year	over 16 ton/axle vehicle ratio	survey station
1990	0.4%	A-9
1991	0%	A-10
1992	1.9%	A-8
1993	-	non
1994	2.2%	A-4, A-5, A-11

b) Ankara-Antalya,Sivrihisar-Burusa,Afyon-Izmir route

The result of axle load survey on three study roads by year shown in Table - 7.2.5. The ratio of vehicles axle load is over 16 ton/axle vary by year. But ratio are over 1% in this three years,and maximum ratio is 4.6% on 1993.

Table - 7.2.5 Change of heavy vehicle ratio

year	over 16 ton/axle vehicle ratio	survey station
1991	0.4%	A-3
1992	2.2%	A-6
1993	4.6%	A-2
1994	1.4%	A-1, A-7

c) Traffic volume

Present and forecasting traffic volume on each 20 bridges are shown in the following. Summary of present and forecasting (2014) traffic volume is shown in Table - 7.2.6 Present traffic volume on each 20 bridges are from 3331 to 13673 per day. For each of the bridges, KGM forecast traffic volume to 2014. After 2015 Study team forecast traffic volume, growth ratio is set half of before 2015. Growth ratio from present to 2014 for each bridges are from 3.5% to 7.6%.

Traffic volume of over 16 ton/axle are forecasted shown in Table - 7.2.6 according to set ratio of over 16 ton/axle vehicle maximum on same study load(Ankara-Rize route : 2.2%,.the other route : 4.6%).

Tble - 7.2.6 Traffic forecast

bridge name	traffic volume present	forecast(2014)	growth ratio	traffic volume of over 16 ton *1
Akcay	8003	49150	3.5%	1081
Asagi	7537	40675	5.2%	895
Candir asanpasa	4052	28944	7.5%	1331
Abadat	7322	35836	7.6%	1648
Hillal 2		236802	5.5%	9472
Koparan 2	3331	14636	5.3%	776
Sardere	4404	27589	5.1%	1269
Selyeri	8003	49150	3.5%	1081
Buca Ustgecití		203933	6.0%	9381
Porsuk	4977	34220	7.1%	1574
Haci Musa	3526	14654	5.3%	322
Merzifon	3595	15158	5.3%	333
Ustgecit 2	3595	15158	5.3%	333
Pasapinar	3595	15158	5.3%	333
Harsit	5471	29378	3.7%	646
Degirmendere	13673	82932	3.6%	1825
Solakli	4835	26195	3.5%	576
Topalli	4141	21225	3.5%	467
Hudut 1	4116	18736	6.0%	412

*1 : traffic volume forecast of over 16 ton/axle per day

7.3 Preliminary Planning

7.3.1 Preliminary Repair Design Alternatives

1) Judgment/Assessment of Damage

The procedure of repair for damaged bridges is shown in Figure - 7.3.1. In Figure - 7.3.1, the evaluation and benefit is presented in Chapter 8.

2) Repair method

Table - 7.3.1 summarizes the inter-relations of damages, repair methods and materials. Cause of damages will have to be considered prior to selecting a suitable method of repair though; the most appropriate one can be found among the ones mentioned here.

3) Repair Work

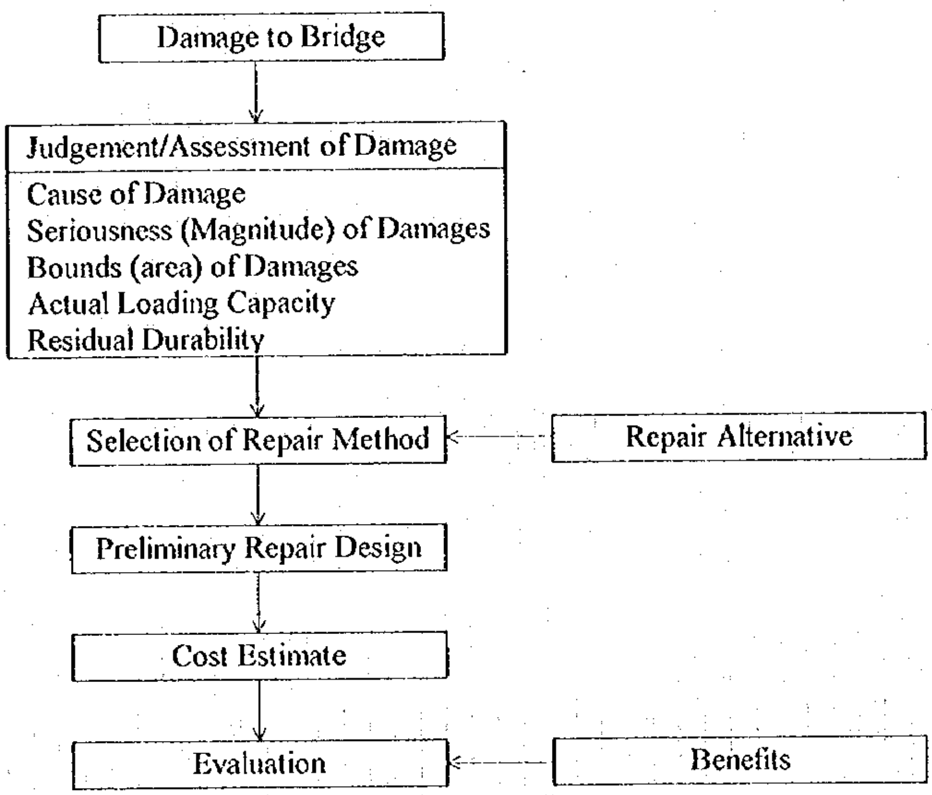
Repair works generally identified as rehabilitation, reinforcing , in kind, or mprovement, in this section deal with three categories of works, namely injection, patching, replacing and others.

a) Injection

Cracks are often filled by either static or pneumatic injection of materials. Method and material for injection shall be selected very carefully to suit the cause and state of damage.

Table - 7.3.1 Concrete Repair Methods and Materials

Defects	Repair Methods	Materials
Cracks (Active)	Pressure injection	Flexible epoxy resin mortar
	Strengthening	Steel plate, post tensioning, stitching
Cracks	Pressure injection	Epoxy grout or mortar
	Coating	Bituminous coating,
	Shotcrete	Cement mortar, fast-setting mortar
	Patching	Cement mortar, or Polymer concrete
	Strengthening	Post tensioning
	Reconstruction	
Voids	Patching	Portland cement grout, mortar,
	Shotcrete	Fast-setting mortar
	Preplaced aggregate	Coarse aggregate and grout
	Replacement	
Scaling	Shotcrete	Fast-setting mortar, Cement mortar
	Coating	Bituminous, Silane treatment
	Replacement	
Spalling	Patching	Concrete, Polymer,
	Shotcrete	Cement mortar, Fast-setting mortar
	Overlay	Latex modified con., Asphalt concrete, Conc.
	Coating	Bituminous, Silane
	Replacement	



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 - 7.3.1 Procedure of Repair to Damaged Bridge

b) Patching

Patching is a surface treatment extending to a depth of a few centimetres. It is used for filling voids on the concrete surface made by various causes such as for repair of cracks, scaling, spalling, popout and honeycombing. Methods and materials for patching also vary to suit the state of damages.

c) Replacing

Concrete can be replaced to any depth by any chosen material theoretically. Most common replacing is the stale concrete to cope with higher live load. Damages caused by fire and vehicle collision are often also repaired by replacement.

d) Others

Other methods include the following:

- Shotcrete (Pneumatically applied mortar or Gunite).
- Epoxy injection, caulking or pressure grouting.
- Protective coating and plaster.
- Strengthening.
    - Reinforcing.

4) Alternative Repair Work

The repair works are divided up into the following three categories, which have already been explained in the former section, and the repair method should be selected in accordance with the design policies. However, the permanent repair work is presented as reference on this study.

- Urgent repair work,
- Ordinary repair work, and
- Permanent repair work.

The alternative repair works of ten bridges are shown in Table - 7.3.2.

Table - 7.3.2 Alternative Repair Work on Objective Bridges

Bridge name	Damage cause	Repair work		
		Urgent	Ordinary	Permanent
1.Buca Ust Gecit	car collision	installation of warning gate on girder	replacement concrete of girder	use warning gate and replacement concrete together
2.Hillal II	chemical attack	coating on column surface	pressure injection into crack	pressure injection into crack
3.Babadat	scouring	river bank protection by gabions	strengthening by concrete wall and river bank protection	replacement
4.Selyeri	poor workmanship	patching	patching and shotcrete	patching and shotcrete
5.Akcay	aging (Gerber girder)	supporting by scaffolding	replacement by new concrete	replacement by new concrete
6.Koparan II	poor workmanship	patching	patching and shotcrete	patching and shotcrete
7.Asagi Cakalli	poor workmanship	patching and shotcrete	patching , shotcrete and pressure injection into crack	replacement
8.Gelincik	poor workmanship	patching	patching and shotcrete	patching and shotcrete
9.Sardere	poor workmanship	replacement concrete	patching and replacement concrete	patching and replacement concrete
10.Candir Hasanpasa	scouring	river bank protection by gabions	strengthening by concrete wall and river bank protection	replacement

5) Preliminary Repair Design

The repair methods regarding the damage for the objective ten bridges are shown in Table - 7.3.3 and the repair work is presented in the drawings.

Table - 7.3.3 Repair Methods for the Objective Bridges

Bridge Element	Method	Objective Bridge									
		1	2	3	4	5	6	7	8	9	10
Slab	Patching	O			O	O	O	O	O	O	O
	Protective Coating	O			O	O		O	O	O	O
	Shotcrete						O	O	O		
	Pressure Injection							O			O
	Replacement Concrete									O	
	Water Proofing				O			O			O
Girder	Replacement Concrete	O					O	O		O	
	Protective Coating	O					O	O	O	O	O
	New Concrete					O					
	Shotcrete				O			O	O		
	Patching						O	O	O		O
Pier	Pressure Injection		O								
	Protective Coating		O			O					
	strengthening			O							O
	Shotcrete						O	O			
	Patching					O		O			
Abutment	Patching				O	O	O	O			
Other	New Bearing					O					
	Replace Joint	O	O		O	O				O	
	River Control			O							O

The Arabic figures of above mentioned table show the bridge name:

1. Buca Ust Gecit
2. Hillal II
3. Babadat
4. Selyeri
5. Akcay
6. Koparan II
7. Asagi Cakalli
8. Gelincik
9. Sardere
10. Candir Hasanpasa

6) Introduction of Repair Method

i) Injection Method

a) General

Where delamination exists, traffic impact may cause further damage and ultimately produce surface spalls. It is suggested that all delamination from the deck be removed after removal of the chloride contaminated concrete, or all fractures and cracks be sealed by injecting with epoxy grout and then patch the repair area.

Before using epoxy injection, it is necessary to determine the causes of the cracks and to correct the problems. There are two types of crack, one is moving and the other is stabilized. If the crack is moving, the problem should be solved by eliminating the cause.

For example, if a crack occurred due to the over-stress of a girder by loss of the section, the girder should be strengthened before injecting epoxy resin into the cracks.

If the movement of the cracks cannot be corrected then the cracks should be sealed or filled with expandable materials such as neoprene sealer or hot asphalt filler. Once the problem is corrected and the cracks are stabilized, the cracks can be effectively repaired by injection. If the structure has minor movement, the cracks can be repaired by using a flexible type of epoxy resin which has higher viscosity but requires longer curing time.

b) Materials

Injection materials are different for types and sizes of crack. These materials are shown in Table - 7.3.3. Materials generally use Epoxy Resin Mortar, the character of which is described below.

Epoxy resin mortar is generally used for small and shallow patch areas while portland cement mortar is used for larger areas. The cost of epoxy mortar is substantially higher than portland cement but the rapid hardening of the concrete would make it possible to reduce the required curing time, thus the bridge can be open to traffic earlier. This will save user's operational cost and reduce the motorists exposure to the hazard conditions during the construction period.

Table - 7.3.4 Injection Materials

Cracking Scale	Materials	Objection
case of large movements of cracks	polyurethane, gum-asphalt	durability,
case of small movements of cracks	epoxy, polyester, polymer-cement, cement paste, cement mortar (fly ash including expansive admixture) polymer cement mortar	waterproof

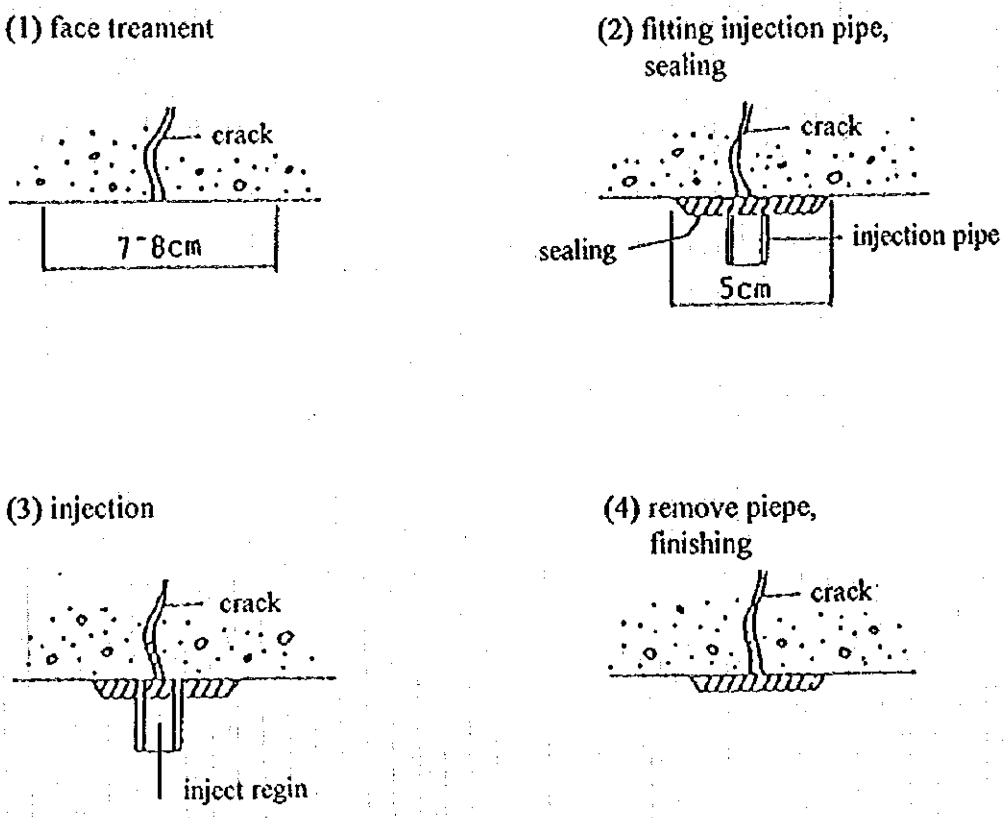
c) Work process

Injection is used generally using three methods. They are the hand manual operation, the stamping manual operation, and the electromotive operation. Other wise the most recently, special method is used, too. Operation process is as follows; and shown in Figure - 7.3.2.

- surface treatment;
  Using a disc sander, wire brush or the like, remove all laitance, dust, etc. from the area along the crack for a width of about 7-8cm. Oil and grease should be cleaned off with a piece of waste cloth dipped into thinner.

- adhesion fitting injection pipe;
  Along the crack, adherent injection pipe with epoxy resin. Table - 7.3.5 shows injection method into cracks.

- sealing;



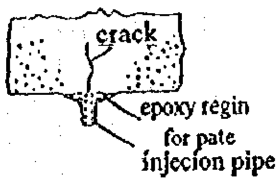
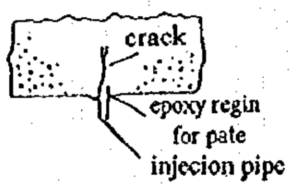
THE STUDY ON THE MAINTENANCE AND REHABILITATION of HIGHWAY BRIDGES in THE REPUBLIC of TURKEY AUGUST, 1996 ORIENTAL CONSULTANTS COMPANY LIMITED in association with JAPAN OVERSEAS CONSULTANTS COMPANY LINTED	Figure - 7.3.2 Operation Process of Injection

Using epoxy resin, seal the areas round the fitting pipe and the front edges of the crack for a width of 7 or 8mm and a thickness of about 3mm then let epoxy resin cure until it hardens. Curing term is usual among 1 day or 2 days.

- injection; and
Pressurize epoxy resin through injection pomp. Confirm out flow from adjoining pomp, defect pipe mouth and cure.

- finishing.
Remove fitting pipe by cutting it off, and finish the repaired portion to a flat surface, using a disc sander.

Table - 7.3.5 Injection Method into Cracks

crack width	case of small	case of large
interval of setting pipe	20cm～30cm	20cm～50cm
pipe type	pipe with washer	usual pipe
V cutting method of crack section	nothing	V cutting (width = 3～5cm) (depth = 3～5cm)
method of fitting pipe		

ii) River Control by Protection of River Bank

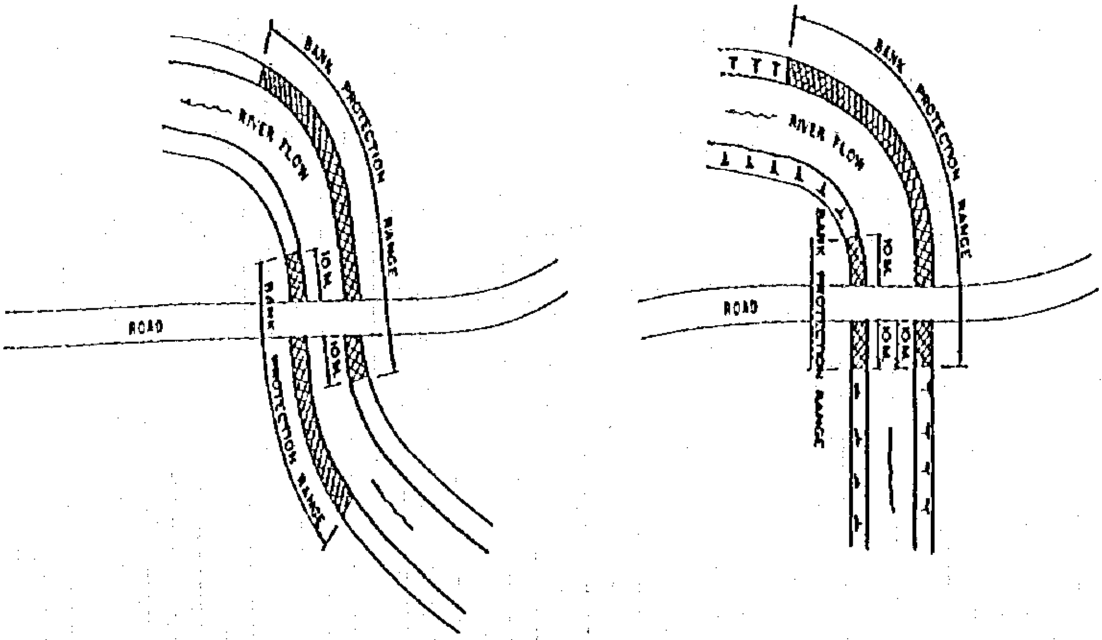
a) General

In the case of a winding river, riverbank protection is installed in order to prevent damage to a bridge from scouring and to rectify river flow. The scope of this protection work, as shown in Figure - 7.3.3, must at least cover the area from where the outside bend of the river begins and ends.

b) Selection of Work

In protecting an approach road, there are the following types of protection work;

- concrete revetment,
- stone riprap revetment with mortar,
- crib work with stone riprap,
- gabion, and



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 LINTED	Figure - 7.3.3 Scope of River Bank Protection

- dumped rock.

Concrete revetments should be applied to areas where the water flow is fast and rough. This means that they should be applied to the outer bend of a river. As for gabions and dumped rock, they should be applied to low places of relative importance, such as a low water channel in an emergency situation. Regarding the types of work, they should be selected taking into consideration material availability, consistency with previous work, esthetics, etc. However, for an articulated concrete revetment, the slope gradient must be shallower than 1.5 : 1 and its height no higher than 3m. The slope gradient of all other work is to shallower than 1.0 : 1.

c) Application

In gabion work, since the corrosion of the wire netting of gabions shortens their service life, they are either applied to locations of low priority or urgent or temporary work is carried out as shown in Figure - 7.3.4.

There are two types of gabions: gabion mat and cynder gabion. Below, these two types are described.

- Gabion Mat
  Gabion mat is applied to slopes with a gradient shallower than 1.5 : 1 that require a change in their configuration. it is especially suitable for machine-baced work.

- Cynder Gabion
  Cynder gabion is applied to a slope gradient shallower than o.5 : 1. It also has a flexible structure and can be applied to an uneven slope. It is especially suitable for manual work.

d) material

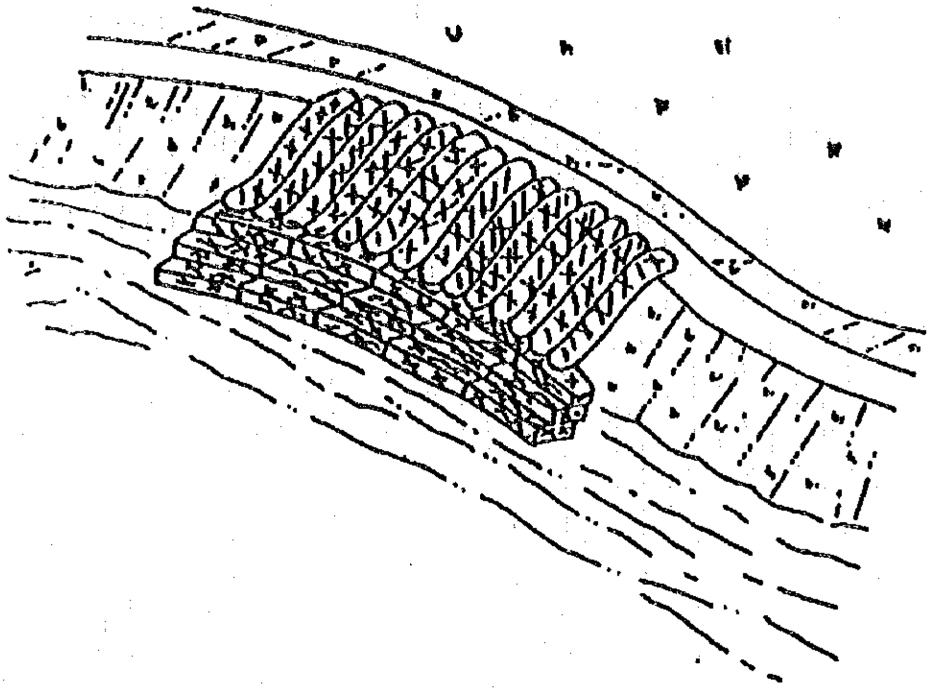
The materials of gabion are the wire net, cobblestone and crushed rock.

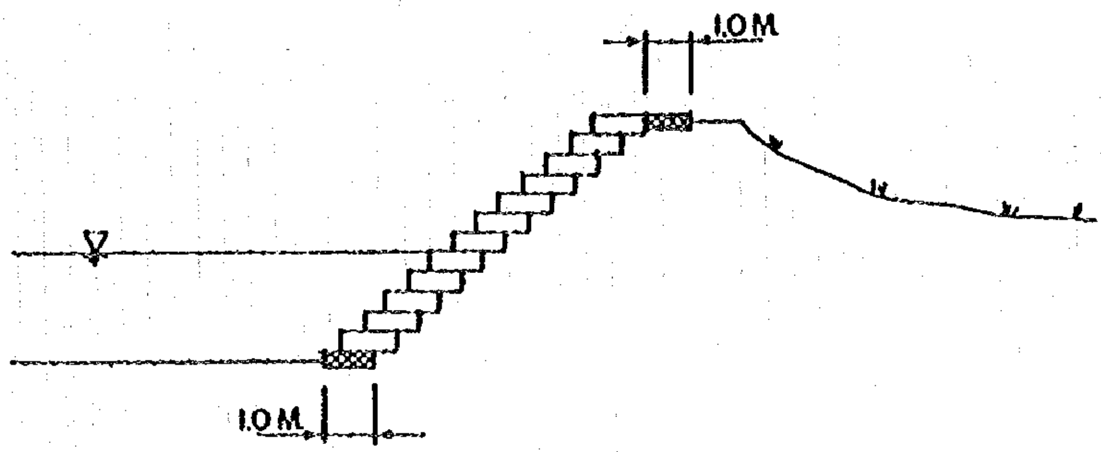
e) Design

The size of the net hole shall be 10cm. However, depending on the cobblestone available, this could vary. In the case of gabion mat, a mat is laid from the toe and the shoulder of a slope as shown in Figure - 7.3.5.

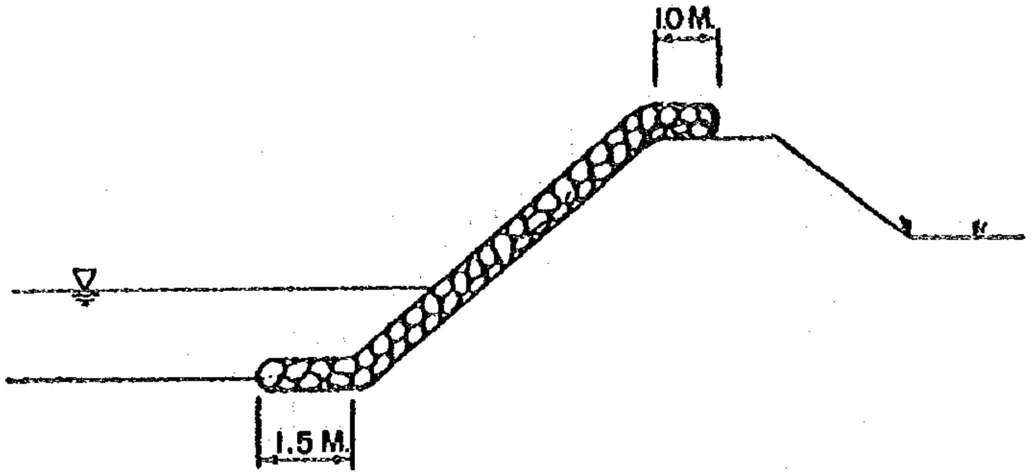
In the case of cynder gabion, it is installed so that it extends 1m out from the shoulder of a slope and 1.5m out from the toe of the slope as shown in Figure - 7.3.6.

The dumped rock structure crumbles rather easily, but it is also easy to implement. It is therefore used at locations of a relatively low priority during urgent and temporary repair work. The slope gradient should be shallower than 1.5 :1 or stability could be adversely affected. The material of dumped rock is cobblestone or crushed rock 150 to 300mm in diameter.





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 LINTED	Figure - 7.3.4 Gabion Work Figure - 7.3.5 Gabion Mat



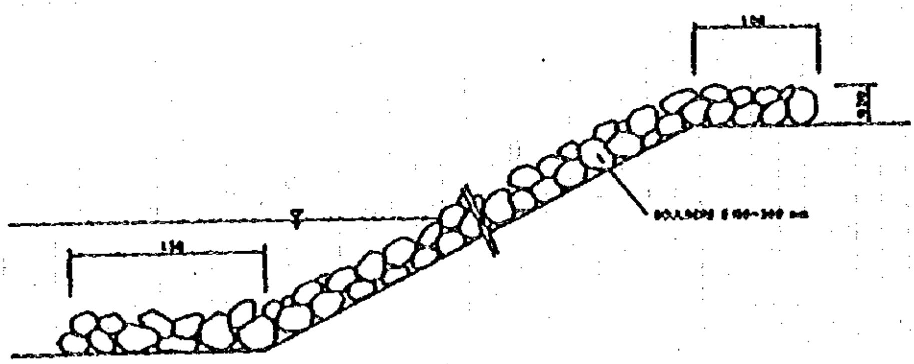


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Figure - 7.3.6 Cynder Gabion

Figure - 7.3.7 Dumped Rock

As shown in Figure - 7.3.7, cobblestone or crushed rock is laid over the entire slope, and extends 1m out from the shoulder of the slope and 1.5m out from the toe of the slope. It is then compacted into the ground.

7.3.2 Preliminary Cost Calculation

1) Unit Cost of Construction Items

The unit costs of each construction item are based on the estimation standards of KGM. However, if the erection method differs regarding the same items of work i.e., scaffolding, etc., these unit costs are calculated by increasing the standard unit costs as shown in Table - 7.3.6.

Table - 7.3.6 Unit Cost of Construction Items

Work Item	Contents	Unit	Cost($)
Excavation	Foundation in the dry	m^3	15.00
	Foundation below water	m^3	34.70
	Surrounding structure by hand	m^3	8.10
	Surrounding structure mechanically	m^3	4.20
Piles	Cast in place piles, 0.8m diameter	m^3	252.00
Reinforcement	Mild steel	ton	784.00
	High yield	ton	826.00
	Prestressing strands	ton	2,030.00
Concrete for	1. Unreinforced insitu		
	foundation etc. grade 15	m^3	64.40
	lean concrete grade 15	m^3	58.80
	2. Reinforced insitu		
	foundation grade 22.5	m^3	82.60
	Beams / slabs grade 30	m^3	168.00
	Piers grade 30	m^3	95.20
	others grade 30	m^3	95.20
	3. Reinforced precast		
	Precast beams and others grade 30	m^3	182.00
	Precast prestressed beams grade 45	m^3	149.80
Expansion Joints	Deck	in m	616.00
Rip Rap	Concrete	m^2	18.90
Bearings	Neoprene	$(dm)^3$	30.80
Waterproofing	Sheet system	m^2	12.60
Parapets	Steel pedestrian	in m	77.00
Stone fill	All sizes less than 0.3m	m^3	15.95
Epoxy	For injection	m^2 **	22.40
Asphalt	Binder	ton	33.60
Diversion	Temporary (all in)	each	70,000.00

Note : ** surface area

2) Justification of Unit Costs

The justification of unit costs is presented in Appendix 5.

7.3.3 Economic Evaluation

1) The Economic Study is concerned with the 'case studies' of ten selected bridges. These bridge are seen as being typical of the problems of bridge maintenance on the State Roads in Turkey. The bridges themselves cover a wide spectrum of :-

- functions (from urban fly over to coastal road)
- lengths (from 21 metres to 348 metres)
- ages (from 5 years old to 34 years old)
- remaining operational life before emergency action will be necessary (from 1 year to 10 years)
- Capacity (from dual carriageway with three lanes each to two lane road bridges).

In addition to the ten 'case study' bridges, a further ten bridges are assessed but in less detail.

2) The methodology used is the cost/benefit analysis. This analysis brings together the capital and maintenance costs, and the traffic disruption cost estimates on the cost side of the equation. On the benefit side, two key elements include:-

- savings in vehicle operating costs (excluding taxes)
- savings in vehicle occupant time, where the vehicle occupant is working

The Costs and Benefits are related together in the standard way with Net Present Values (NPV) and the Economic Internal Rate of Return (EIRR). The present year is taken as 1996. The discount rate (opportunity cost of capital) is taken at 12%. The analysis is internalised to the economy of Turkey.

3) Overall the framework setting for the study is that of:-

- a rapidly growing population in Turkey, meaning that there are more people demanding transport services.

- a rapidly growing economy, which means that there are more people with the income to pay for transport services. Also the greater economic activity means that there is a greater demand to move outputs and inputs around the country.

The implications are:-

- that road capacity will have to be expanded. As a consequence, it is possible to anticipate more motorways and the building of more dual carriageways

- that the costs of traffic congestion are likely to rise significantly. As a result, much greater care will have to be exercised in organising construction and repair activities, as well as more care in planning such activities.

4) The results of the economic analysis of the ten selected bridges indicate that all the projects earn good rates of economic return. (Average - Median - 31% EIRR). But they to not all need to be embarked upon immediately.

The Cost Effectiveness Analysis indicates that repair is more effective than replacement in all cases with the exception of Babadat. However, when taking into account the dynamic situation of traffic in Turkey, the economic solution in two instances is to build a parallel bridge in anticipation of the dual carriageway. (Babadat and Akcay Bridges). This will save the costs of temporary diversion bridges.

The analysis of the other ten bridges also indicates good rates of economic return for the repair of the bridges (Average - Median - 24% EIRR)

5) The most striking observation from the ten 'case study' bridge is that the problems for each of the bridges do not relate to inadequacy of bridge maintenance alone and therefore the focus for future management attention should not be too narrowly confined. The problems stem from:-

- poor workmanship in the original construction (several of the bridges)
- poor design (Buca Ust Gecit slip road)
- lack of traffic management (Buca Ust Gecit)
- materials problem (Hilal II)
- lack of proper management on the river.

Consequently, it is clear that considerable economic benefits could be attained for the Turkish economy by looking at:-

- engineering supervision and acceptance of contractors' work at construction
- specification of materials and their source
- traffic management and transport planning
- river management

6) From a review of the KGM budget for bridge maintenance, the overall implication is that the current KGM budget for bridge maintenance is somewhere between one fifth and one half of what is required.

7) The economic analysis indicates that, quite aside from safety considerations, the collapse or indeed forced closure of a bridge should always be avoided from the viewpoint of the overall Turkish economy.

8) The economic analysis indicates that the economic savings (to road users) from ensuring that the second bridge for the dual carriageway is in place before repairing the

existing bridge will generally far outweigh the costs to the highway agency (temporary diversions etc.). The recommendation is that planning for dualling and for bridge maintenance should be coordinated.

9) Except where motorways are likely to be built (or indeed where there may be road realignments) the two lane bridge is likely to remain functionally adequate for some considerable time, especially as it is adapted to a single direction in both lanes. This contrasts completely with the early post-war generation of bridges many of which were single lane bridges. In these current circumstances the case for an increased maintenance budget for the road bridges is greatly strengthened.

7.3.4 Environmental Evaluation

In Performing this bridge maintenance and rehabilitation study project, the Environmental Study is to be carried out in accordance with the environmental policy of Turkey and JICA Guideline which provides the following principal objectives:

- identify all possible impacts to be caused
- minimize damages on natural conditions and circumstances
- protect biological resources and eco-system
- prevent or minimize negative effects anticipated, and
- promote sustainable development in the country

All study results are summarized and presented in this section. Details are discussed in Chapter 9.

1) Environmental Impacts Anticipated by the Project

Assessment of effects has been judged based upon the repair and rehabilitation plan of 10 bridges and in accordance with the Forms stipulated by Turkish EIA Regulation (1993), and shown in Table A.

Overall environment impacts have been assessed by JICA Guideline and shown in Table B.

2) Mitigation Measures

As the results of the environmental assessment on the project, the following negative impacts were clarified among 23 items and all are judged to be generated during repair works.

a) Traffic Congestion

The works should be executed side by side in sequence, and one side be always open to traffic controlled by signal except 5 bridge sites where temporary access diversions are to be constructed. In principle, these temporary diversions are to be demolished soonest after repair works are completed.

b) Waste

- Wastes should be treated properly in accordance with the direction of field supervisors or engineers.
- Monitoring should strictly be conducted by the field supervisors to check manners applied to disposal or conditions of wastes at the construction sites.

c) Water Pollution

Monitoring should strictly be conducted by the field supervisors to prevent inflow of soils and disposal of waste and garbage, and drain dirty water into rivers and groundwater.

3) Conclusions and Recommendations

Due to the nature of the project which requires only repair and rehabilitation work without new construction, the potential negative impacts by the works are considered minimal and could be offset by the positive economic and social impacts. Successful performance, however, will bring about benefits to traffic and related industries in the area concerned. It is essential to take precaution measures for maintaining the present environmental condition which is considered favorable in general.

However, it should be noted that environmental parameters marked with small effect may threat project sustainability if adequate countermeasures are no taken. Therefore, continuous and appropriate monitoring shall be required.

Table - 7.3.7 Effects on Control Items-Requirement of Turkey EIA Regulation (1993)

No.	Control Item	Bridge No.										Remarks
		1	2	3	4	5	6	7	8	9	10	
1	New Construction	×	×	×	×	×	×	×	×	×	×	Repair & Rehabilitation
2	Earth Work	×	×	△	×	◎	△	×	×	△	○	For temporary access embankment
3	Effect to Flooding	×	×	×	×	×	×	×	×	×	×	
4	Construction Dust	△	△	△	△	△	△	△	△	△	△	By concrete scraping
5	River Works	×	×	△	×	×	×	×	×	×	△	Rather to be Improved
6	Usage of Water	△	△	△	△	△	△	△	△	△	△	In working hours for dust control mainly
7	Solid Waste	△	△	△	△	△	△	△	△	△	△	Scraped concrete and some soil
8	Construction Noise	△	△	△	△	△	△	△	△	△	△	By concrete breaker in scraping
9	Cutting Trees at Road Sides	×	×	△	×	○	△	×	×	×	△	Mostly inside of KGM Lands except No.5
10	Effect to Firming Land	×	×	×	×	○	×	×	×	×	×	Mostly inside of KGM Lands except No.5
11	Danger in Construction Work	△	△	△	△	△	△	△	△	△	△	Ordinary Work
12	Effect to Flora and Founa	×	×	×	×	×	×	×	×	×	×	
13	others											

◎ Considerable ○ Some △ Minimal × Nil

Table - 7.3.8 Overall Environmental Impacts by the Project

No.	Environmental Item	Impacts	Reason
Social Environment			
1	Resettlement	None	Repair of existing bridges
2	Economic Activities	Positive impact	Temporary benefit by construction workers
3	Traffic/Public Facilities	Minimal	Only during repair work period
4	Split of Communities	None	-
5	Cultural Property	None	Such properties are not observed nor reported nearby
6	Water Rights and Rights of Common	None	Fun fishing by local people only
7	Public Health Condition	None	-
8	Waste	Slight	Small fragments by repair works
9	Hazards (Risk)	None	No slope cut or deep excavation
Natural Environment			
10	Topography and Geology	None	
11	Soil Erosion	Positive Impact	River Control work at Babadat and Candir Hasanpasa Bridge
12	Groundwater	None	No deep excavation
13	Hydrological Situation	Positive Impact	Smooth flow by river control work same as (11)
14	Coastal Zone	None	No earthwork at coastal bridges
15	Fauna and Flora	Negligible	Roads traverse mostly cultivated area. No nearby Natural Reserves etc. except Sardere
16	Meteorology	None	-
17	Landscape	None	-
Pollution			
18	Air Pollution	Positive Impact	Due to smooth running by vehicles
19	Water Pollution	Slight	Only during repair works
20	Soil Contamination	None	
21	Noise and Vibration	Positive Impact	More smooth traffic after repairing
22	Land Subsidence	None	-
23	Offensive Odor	None	-

Chapter 8

Economic Study

Chapter 8 Economic Study

8.1 The Concept of the economic study

8.1.1 The Requirements of the Scope of Work, Inception Report, and Interim Report

The Scope of Work indicates that the following should be covered:

1. *to collect, review and analyse available data, information, reports and plans relevant to the Study*
   - socio-economic and traffic data

3. (4) *to estimate the rehabilitation cost and conduct economic analysis of rehabilitation measures of selected bridges*

As such, the requirements basically relate to the economic assessment of the ten selected bridges. However it has been our intention to try to take this further, and, drawing upon the analysis of the ten 'case study' bridges, try to see if there are general economic guidelines which could assist in establishing a bridge management system(BMS) for KGM. More detail on the Scope of Work is given in Appendix 6.1.

8.1.2 Concept of the Economic Study

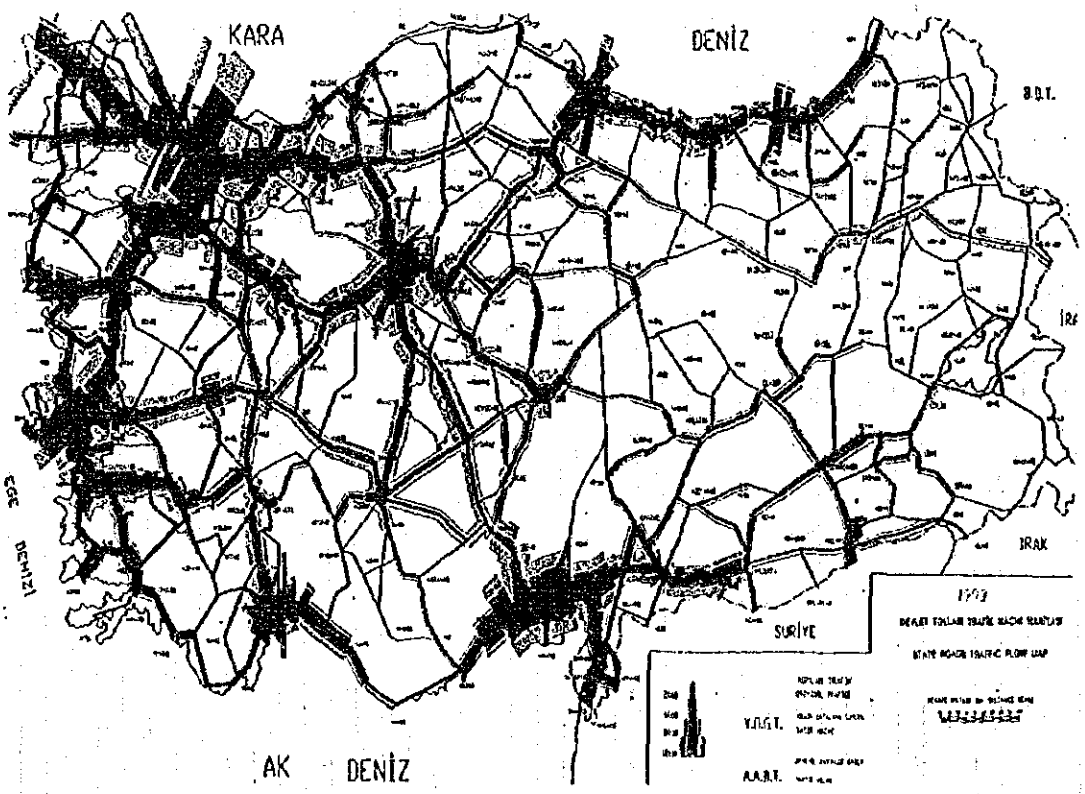
The Inception Report succinctly states the key point:

It is appropriate for Turkey to initiate a program for implementation with a view to systematically maintaining, rehabilitating and strengthening all bridges on state highways in an overall bridge management system.

The General Directorate of Highways, Ministry of Public Works and Settlement (KGM) is in charge of the maintenance and operation of around 31,000 kilometres of national highway network, which includes more than 3,000 bridges. Maintenance of the bridges has been relatively minimal (because of an inadequate level of budget allocation) and this lack of maintenance has led to deterioration in some of the bridges such that more costly repairs will have to be effected. Indeed, replacements will have to be considered in some instances.

So, the aim of this economic study has been to investigate the costs of this lack of maintenance and to try to see what would be the economic benefits of improved maintenance. These economic benefits would then underpin the case for ensuring that there is an appropriate level of budget for such maintenance on a regular basis.

The intention has been to try to make this economic analysis as realistic as possible, drawing upon the 'case studies' of ten selected bridges. (See Figure - 8.1.1). In this way, the conclusions and recommendations should carry a real authority in setting out the economic case for expenditure on bridge maintenance.



Note: Scale is distorted

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 - 8.1.1 Truck Traffic Volume for Study Road

8.2. Methodology of the Economic Analysis

8.2.1 Introduction

The economic analysis has followed the methodology which is now widely accepted. For each of the ten 'case study' bridges it comprised:

a) a cost effectiveness analysis by comparing the estimated costs of repair with the estimated costs of replacement over the whole life of the bridge

b) a cost benefit analysis of the repair project to estimate the Economic Internal Rate of Return (EIRR) of the project.

The costs have comprised the usual capital and maintenance costs, as well as the costs of any temporary diversion works, where these are necessary. In addition, the costs imposed upon road (bridge) users have been estimated by means of delays to such users.

On the benefit side, the principal benefit estimated has been the road user cost savings for the period over which the 'next best alternative' has been avoided. The broad methodology can be illustrated in Figure - 8.2.1.

In order to follow this approach we developed a series of modules which could be used for carrying out the calculations for the economic analysis. These modules were then able to bring together the data so that the usual calculations for Net Present Value (NPV) and Economic Internal Rate of Return (EIRR) could be carried out. The modules include:-

Traffic Module
Capital Cost and Maintenance Module
Traffic Disruption and Delay Module
Cost-Effectiveness Module
Benefits Module
Cost/Benefit Module

The detailed approach in each of these modules is discussed in the following subsections

8.2.2 Traffic Forecasting

For each of the 'case study' bridges, we have used the forecasts prepared by KGM's Cost and Transport Analysis Division. The exception to this is where we have used the base data from the Izmir region for the urban bridges included in this study, namely Buca Ust Gecit and Hilal II. However the same rates of growth as those used by the Cost and Transport Analysis Division have been applied to the new base.

Traffic growth on all the bridges is expected to be considerable. For several of the bridges it is clear that dualling will take place in the relatively near future. On some of the dual carriageways, it is clear that these will have to be widened in the future from 2x2 to 2x3.

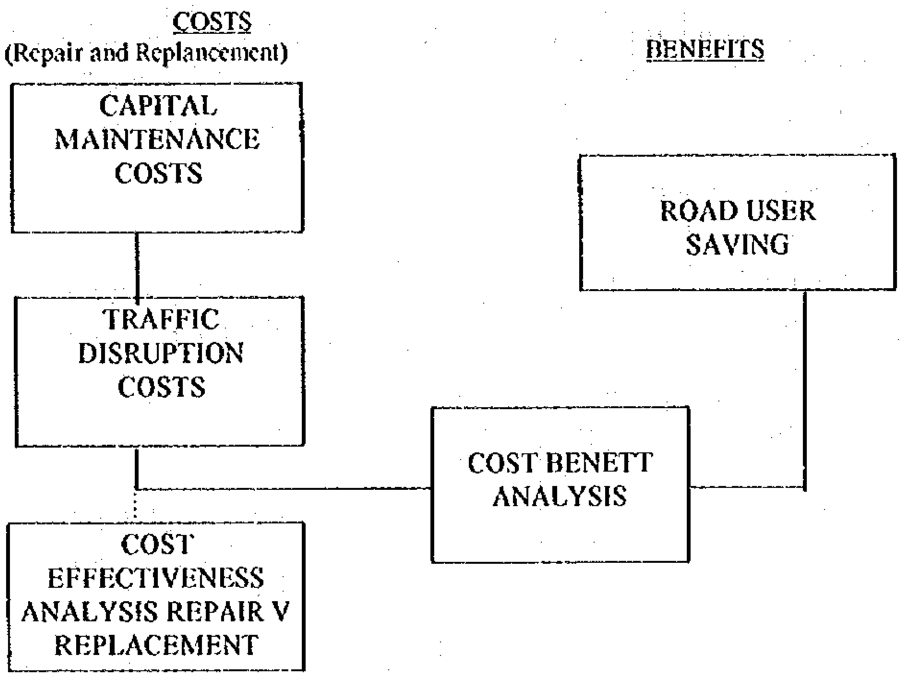


Figure - 8.2.1 Location of Case Study Bridges and Truck Traffic

To assess the need for dualling, we have used the forecasts of KGM's Cost and Transport Analysis Division and combined these with the threshold traffic levels calculated by KGM's Planning Division, based upon the service level concepts developed by the USA Federal Highways Board. (See 6.2). Each of the forecasts for traffic on the individual bridges is shown in the detailed economic analyses for each bridge in the Annexes.

8.2.3 Capital Cost and Maintenance Costs

The capital and maintenance costs for both the repair and the replacement of the ten 'case study' bridges were estimated. (See 6.2.1). The costs of the various repairs to the ten bridges varied considerably as a percentage of the replacement costs (from 2% to 81%). Of course, the higher the repair cost the more likely it is that replacement is the more cost effective option. Indeed, in the case of Babadat bridge, this is the best solution if it is necessary to build the temporary diversion bridge when repair takes place. In fact, in Babadat, it is more cost-effective to first build a new second bridge in anticipation of the needed dual carriageway bridge and then to repair the Babadat bridge using the new bridge as a temporary diversion.

As well as the costs of repair and replacement the time to do the repair jobs are hown in 2.2 of this chapter.

8.2.4 Traffic Disruption and Delay

From the viewpoint of the economy, the time to undertake repairs is a crucial element in the whole cost side of the cost/benefit equation . Whilst the agency may not be paying these costs of disruption due to roadworks (usually road user delays and increased vehicle operating costs), these costs still do have to be met by the road users.

We have attempted to estimate these delays by different means according to the type of delay, of which there are three:-

1) single lane with two way traffic, necessitating control by traffic lights. For the detailed assessments, see Appendix 6 2.3, which have followed the assessments of delay at intersections developed by the USA Federal Highways Board.

2) use of the parallel bridge on a dual carriageway, necessitating training two lanes in one direction into one lane with opposing traffic in the adjacent lane. The change in v/c ratio has been related to an average travelling speed over the affected distance. These average travelling speeds have then been related to vehicle operating costs using the assessments developed by the UK Transport Research Laboratory (TRL) in their COBA programmes.(See Appendix 6 2.4)

3) taking the traffic off the road onto a temporary approach road and bridge (normally two lane)

These delay costs will build up according to the level of traffic and the consequent reductions in travelling speeds. Indeed the disruption costs can far exceed the capital and maintenance costs of the bridge.

The Vehicle Operating Costs (VOC) used in the analyses are those developed by the Planning Division of KGM (See Appendix 6 2.5).

8.2.5 Benefit Estimation

Benefit estimation is one of the more controversial aspects of appraising bridges. Three different approaches tend to be used, as follows:-

1) the savings to road users from not having to use an alternative detour route for the remainder of the life of the project are taken as the benefit of the capital spending on a repair.

2) the savings to the highway agency, because a repair project allows the highway agency to defer capital expenditure on a replacement bridge for a number of years. The savings from this deferral are treated as the benefit of the project in that this capital could be used in the meantime to generate benefits on another project. In effect, the benefits in the use of the alternative project are the benefits accruing to this bridge repair project.

3) the savings to road users from not having to use the 'next best alternative' - usually, a more temporary bridge structure. Often this 'next best alternative' can be notional.

The alternative detour approach

The alternative detour approach is only valid where the detour is genuinely 'realistic'. Often the detour approach is mistakenly used without recognising that the detour route can not possibly cope with the diverted traffic without there being large costs incurred in upgrading the detour route, such that it cannot be a long-term option.

The detour analysis does serve one function in that it does help to focus upon how critical a bridge can be in terms of its lynchpin role in the road network. Whilst the detour may not be a valid long-term measure of benefits against a capital expenditure (unless it also happens to be the 'next best alternative'), it does highlight how crucial the bridge's role is and thus how quickly its role will have to be made good should it have to be closed or indeed collapse.

Our assessments of the detour alternative indicate very high rates of economic return, and basically we have treated these as not realistic, because other less costly alternatives would be introduced. The information on the detour alternative is included in the individual annexes showing the economic analysis on the individual 'case study' bridges.

The deferral of capital expenditure

This approach tends to focus upon the highway agency only, and in effect measures the return on any one project by the returns which the agency can achieve elsewhere. This approach tends to standardise the returns and ignores variations in benefits that any one project can achieve. It is a useful measure for the highway agency but does not reflect the economic impact for the economy. However, the information on this alternative is included in the individual annexes showing the economic analysis on the individual 'case study' bridges.

The 'next best alternative'

Undoubtedly, this approach offers the most sensible assessment of the economic returns associated with a bridge appraisal. The 'next best alternative' is often reflected in what was done before the new bridge was built. It might have been a smaller and less robust structure. It might have been an alternative such as a ferry or a pontoon bridge etc. This 'next best alternative', which can often be 'notional', appears to best reflect the economic returns being generated by the capital expenditure on the repair of the bridge.

8.2.6 Cost/Benefit Analysis

The Cost Benefit Analysis brings together the capital and maintenance costs and the traffic disruption estimates on the cost side of the equation. No attempt has been made to apply any shadow pricing (we assume that market prices reflect economic resource costs) but the costs exclude taxes. On the benefit side, the two key elements include:-

savings in vehicle operating costs (excluding taxes)
savings in vehicle occupant time, where the vehicle occupant is working

No attempt was made to include any changes in the incidence of accidents, because of the lack of clear evidence on this aspect.

The Costs and Benefits were related together in the standard way with Net Present Value (NPV) and the Economic Internal Rate of Return (EIRR). The present year was taken as 1996. The discount rate (opportunity cost of capital) was taken as 12%. The analysis was internalised to the economy of Turkey.

8.3. Economic Analysis of the Ten Selected 'CASE STUDY' Bridges

8.3.1 Introduction

Ten bridges were selected as being typical of the problems of bridge maintenance on the State Roads in Turkey. The locations of these ten bridges are illustrated in Figure 1.1 (Page 4). The bridges themselves cover a wide spectrum of :-

functions (from urban flyover to coastal road)
lengths (from 21 metres to 348 metres)
ages (from 5 years old to 34 years old)
remaining operational life before emergency action will be necessary (from 1 year to 10 years)
capacity (from dual carriageway with three lanes each to two lane road bridges)

The ten 'case study' bridges are listed in Table - 8.3.1. The detailed economic analysis for each of the ten bridges is shown in individual annexes for each of the bridges. The economic findings for each of the ten bridges is briefly discussed in the following subsections.

8.3.2 Framework Setting

<u>Highway Development Prospects</u>

As indicated in the Interim Report (See Section 2.2) the total road network in Turkey approached 400 000 kilometres. The network is being rapidly upgraded rather than being extended. So the key aspects are:-

- introduction of a motorway system
- dualling of existing single carriageway roads
- paving unpaved roads
- general improvements (widening, climbing lanes, realignment, etc.).

The major roads comprise the:-

- motorway system	(1167 km)
- state roads	(31389 km)
- provincial roads	(28443 km)

(Interim Report - 1995 figures).

Table - 8.3.1 Key Features of the Ten' CASE STUDY' Bridges

Name & Division	Length metres	Age (Yrs)	Traffic AADT	Function of Bridge	Years left before emergency
IZMIR					
Buca Ust Gecit (Slip Road only)	33.0	23	50000	Urban Flyover	10
Hilal-II (2x3)	347.8	5	60000	Urban Flyover	7
ANKARA					
Babadat (2 lane)	25.2	31	7322	Main Road	3
SAMSUN					
Selyeri (dual, 2 down, 3 up)	21.7	5	5249	Coastal Road	10
Akcay (2 lane)	106.9	34	8003	Coastal Road	5
Koparan II (2 lane)	27.45	18	3331	Main Road	10
Asagi Cakali (dual, 2x2)	71.55	9	7537	Main Road	3
TRABZON					
Gelincik (2 lane)	32.5	25	4775	Coastal Road	10
ANTALYA					
Sardere (2 lane)	43.15	10	5729	Main Road	1
BURSA					
Candir Hasanpasa (2 lane)	113.9	23	9454	Main Road	1
AVERAGE	82.31	18.3	16140		6

The key implications for the bridge network on state and provincial highways (approximately 173 000 linear metres) are that

- new bridges are being built for the motorway system
- parallel bridges are needed when the main roads are dualled

Traffic growth is very substantial, typically between 5 and 10% per annum. Vehicle ownership continues to grow rapidly.

The overall development prospects for the highway network is that there will be strong pressure to provide more road capacity (mainly through dual carriageways) as demand continues to increase.

Future Projection of Indices (Socio-economic and Traffic)

All the indices point to a strong growth situation through the next few years. Population is expected to increase as follows:-

	Turkish Population (millions)
1900	56.5
2000	70.2
2010	87.2

The population (according to the State Institute of Statistics) will be 54% greater in 2010 than it was in 1990.

Since 1981, real economic growth in the Turkish economy has averaged more than 5% per annum. If this rate can be sustained, then the Turkish economy, as measured by GDP, will be twice the size of 1995 by 2010.

Over the last twenty years, vehicle ownership has grown at more than 11% per annum on average. The increasing numbers of vehicles have inevitably led to increasing traffic levels and a greater demand for road capacity.

Framework for the Study

Overall the framework for the study is that of:-

- a rapidly growing population in Turkey, meaning that there are more people demanding transport services.

- a rapidly growing economy, which means that there are more people with the income to pay for transport services. Also the greater economic activity means that there is a greater demand to move outputs and inputs around the country.

These growth factors translate into rapid increases in traffic, which for the ten case study bridges range as follows:-

	Average Annual Growth Rates in Traffic
Cars	10.0% - 12.0%
Buses	2.9% - 6.0%
Trucks	3.0% - 8.0%
Trailers	2.1% - 7.9%

The implications for bridges and for this study are twofold:-

1) that road capacity will have to be expanded. So, it is possible to anticipate more motorways and the building of more dual carriageways

2) that the costs of traffic congestion are likely to rise significantly. So, much greater care will have to be exercised in organising construction and repair activities, as well asmore care in planning such activities.

8.3.3 Findings for the individual bridges

Buca Ust Gecit (Izmir)

This particular bridge is part of an exceptionally complex road junction within the urban road network of Izmir. Already the junction carries a considerable level of traffic on the over-bridge (50000 vpd), whilst on the underpass, traffic appears to be about (25000 vpd). The damaged bridge is the slip road off the main flyover. This one way slip road (two lanes) takes traffic into the centre of Izmir.

The slip road was a later addition to the original junction and has resulted in a bridge where height clearance on the underpass is inadequate (4 metres) for the southbound, single lane, downhill traffic whilst it is a better clearance, because of the topography, for the northbound, two lane, uphill traffic. The bridge has been hit several times by trucks. The outside girder is damaged with reinforcing rods pulled out and distorted.

The more costly options for repair, such as

raising the deck
lowering the level of the road

are rejected as being unnecessarily costly. The simpler option of a traffic management scheme, such as the use of goalposts, perhaps linked with lights on the bridge to warn truck drivers, is rejected on the grounds of practicality. Consequently the solution is a simple repair costing only about US$9000 (US$7000 repair costs plus US$2000 for traffic control) to make good the girder. The repair should take about 15 days. The difficulty with this simple solution is that probably the bridge will be hit again and the repair will have to be repeated.

The EIRR on this small repair project is estimated to be about 43%.

The problem for Buca Ust Gecit has largely been caused by poor design of the slip road and by inadequate traffic management rather than by failures in maintenance.

<u>Hilal-II (Izmir)</u>

Hilal II performs a critical function in the urban road network carrying 60000 vpd over both the river and the railway line. It also comprises a junction, firstly, taking traffic further round what is in effect an inner ring road for Izmir, and, secondly, allowing traffic on and off a connection into the commercial centre of Izmir.

The problem for Hilal II arises from a problem of material selection for the concrete (the sand) which during the coarse of the has been confirmed as aggregate silica reaction.

With traffic growing so fast in Izmir, closure for Hilal II is unthinkable, in that the congestion costs imposed on road users will be very large. Whilst there are new roads being built which will help the urban traffic situation (the motorway to Aydin, the inner freeway by Izmir Bay), it seems likely that traffic growth (demand) will continue to stay ahead of road supply for the foreseeable future. Consequently Hilal II will continue to play a vital role.

The repair project is estimated to cost US$350000 (US$340000 for repairs and US$10000 for traffic control). Traffic will have to be trained into two lanes instead of three lanes and repair work is estimated to take about 100 days. The traffic disruption costs imposed upon users will easily exceed US$ 1 million. The economic returns (EIRR) from the repair are estimated at around 24%.

Babadat (Ankara)

Babadat is a simple two lane road bridge carrying a substantial truck, trailer and bus traffic between Ankara and key centres such as Eskisehir, Izmir and Antalya. Poor workmanship in the original construction has left the substructure as inadequate and indeed now dangerous.

The economic analysis indicates that replacement is more cost-effective than repair, because it will be necessary to close the bridge and build a temporary bridge whilst repair work takes place. However, the road shortly will need dualling, consequently it is best to build the dual carriageway bridge first and then repair the existing bridge. The repair cost is about US$52000 plus US$73000 for diversion costs. The repair will take about 100 days.

The EIRR even from repairing the existing bridge is nearly 31%. Avoiding the costs of building a temporary diversion bridge will increase the rate of return on the project.

Selyeri (Samsun)

The westbound two lane downhill carriageway has a separate and much older bridge than the three lane uphill eastbound carriageway. Lack of maintenance and poor workmanship have contributed to the current situation . Some US$ 37000 needs to be spent on repair, plus US$10000 for traffic controls. The repair project will take about 35 days and this spending is likely to achieve an EIRR of around 26%. Traffic disruption costs are kept relatively low because traffic is not so high, and the parallel bridge allows the disruption to be confined to pushing two lanes of traffic into one.

Akcay (Samsun)

The bridge at Akcay performs a key function as a two lane coastal road running alongside the Black Sea, where the opportunities for diversions are very few because of the topography. The road connects Samsun and Trabzon. It is the only Gerber bridge in the ten 'case studies'. Whilst repair is a more cost-effective solution than replacement, the forthcoming need for dualling means that it is better to build a new bridge in anticipation of the dualling, and then repair the existing bridge.

Poor workmanship and the lack of maintenance have contributed to the current situation. The cost of repair is estimated at US$78000 plus US$73000 for the diversion. The repair will take about 80 days. Even as a repair project including the costs of a temporary diversion bridge the project earns an EIRR of 31%.

Koparan II (Samsun)

Koparan II is on a two lane highway connecting Ankara with Samsun. Poor orkmanship has been the main factor in the current situation. Costs of repair are estimated at US$32000 but it will be necessary to build a temporary diversion bridge (US$73000). The project earns an EIRR of nearly 17%.

Asagi Cakali (Samsun)

Asagi Cakalli is the newer of the parallel two lane bridges of the main road between Ankara and Samsun and is on the northbound carriageway. Despite being the newer bridge (built 1986), exceptionally poor workmanship in construction has contributed to the current situation.

These two bridges provide a considerable level of economic benefit because they cross quite a deep valley ravine. The 'next best alternative' would involve a flimsier structure which would increase the distance needing to be driven as the road makes its way down the valley.

Using the parallel bridge allows the traffic disruption costs to be reduced but they are still considerable because two lane traffic is pushed into one lane and that one lane has to face opposing traffic in the adjacent lane. This parallel bridge can be used as the temporary diversion only within the next four years or so. After that, the costs of traffic disruption become excessive and it would be necessary to build a temporary bailey bridge.

The repair costs total US$163000. The EIRR on the repair project exceeds 100%. This high rate of return reflects the high rate of user benefits being generated by the bridge because it crosses a substantial valley ravine, and it also reflects the long economic life which the bridge should enjoy after repair, since it is currently only nine years old.

Gelincik (Trabzon) - formerly known as Ivyan Sogukpinar

The bridge at Gelincik performs a key function as a two lane coastal road running alongside the Black Sea, where the opportunities for diversions are very few because of the topography. The road connects Trabzon and Rize.

It is a difficult project which will take some 250 days, because it is not possible to close the bridge. The costs of repair total US$59000. The EIRR on the project is some 15%. Traffic disruption costs are considerable because it will be necessary to operate traffic lights with one direction at any one time.

Sardere (Antalya)

Sardere is near to the point of being unusable because one of the slabs is near to disintegration. Some US$ 36000 needs to be spent upon repair. In addition a temporary diversion bridge will be necessary (US$88000). Poor workmanship at the time of construction is to blame for the current situation. The repair project should earn an EIRR of nearly 41%.

Whilst the river quarrying of aggregates does not appear to have affected the bridge, nonetheless there is such an operation there upstream of the bridge. The impact of these quarrying operations upon the river regime should be investigated and monitored, as necessary.

Candir Hasanpasa (Bursa)

Candir Hasanpasa is near the point of collapse. Inadequate attention appears to have been paid to river management with the result that the downstream weir has collapsed and this has accelerated the speed of river flow. Upstream there are all types of river quarrying of aggregates but no attention appears to have been paid to how this affects the velocity and ferocity of the river and its course. The result is that after 23 years some of the bridge columns are dangerously exposed and scoured to the point of collapse.

Some US$117000 has to be spent on making good the bridge, taking some 100 days. In addition it will be necessary to build a temporary diversion bridge and approach roads (US$73000). The EIRR from the project is nearly 33%.

8.3.4 Summary of Results

The results of the economic analysis are summarised in Table - 8.3.2 and 8.3.3. All the projects earn good rates of economic return. They do not all need to be embarked upon immediately.

When disruption costs to road users are taken into account,

- it is sometimes better to build a parallel bridge in anticipation of dualling, and then repair the existing bridge (for example, Akcay)

- or, it is sometimes better to advance the repair, when a parallel bridge on a dual carriageway can cope with the diversion. If it is left too long, the disruption costs are so great as to necessitate building a very costly temporary diversion bridge (for example, Asagi Cakalli)

The Cost Effectiveness Analysis indicates that repair is more effective than replacement in all cases with the exception of Babadat. However, when taking into account the dynamic situation of traffic in Turkey, the economic solution in two instances is to build a parallel bridge in anticipation of the dual carriageway. This will save the costs of temporary diversion bridges.

Table - 8.3.2 The Economic Solutions

Bridge Name	The Solution	The Disruption to Road Users	Economic Comment
Buca UG(Izmir) (slip road westbound only)	Repair	Close slip road and divert over-traffic; traffic lights for under-traffic. One lane-one way.	The bridge is part of the overall urban road network. Full capacity is nearly reached.
Hilal-II (Izmir) Dual Carriageway (westbound only)	Repair	Repair using traffic control - two lanes into one to reduce vibration.	Part of the overall urban road network. Full capacity is nearly reached.
Babadat (Ankara) (Two lane)	Build new parallel bridge.	Minimal, as new bridge will be diversion when repairing existing bridge.	Dualling already required at service level 'D', and by 2001 at 'E'.
Selyeri (Samsun) (West bound carriageway)	Repair	Parallel bridge as diversion - two lanes into one.	Already dualled, but 3 lanes downhill required by 2004.
Akcay (Samsun) (2 lane Gerber Bridge)	Build new parallel bridge.	Minimal, as new bridge will be diversion when repairing existing bridge.	Dualling already required at service level 'D', and by 2001 at 'E'.
Koparan II (Samsun) (2 Lane)	Repair	Temporary 'culvert' bridge as diversion.	Dualling required in 2008 at 'D' service level.
Asagi Cakalli (Samsun) (Northbound carriageway)	Repair	Use parallel bridge as diversion - two lanes into one.	After 1999, traffic is too high to use parallel bridge effectively.
Gelincik (Trabzon) (2 lane)	Repair	Traffic lights for one lane-one way.	Dualling required in 2003 at 'D' service level.
Sardere (Antalya) (Two Lane)	Repair	Temporary 'culvert' bridge as diversion.	Dualling required in 2004 at 'D' service level.
Candir Hasanpasa (Bursa) (Two Lane)	Repair	Temporary 'culvert' bridge as diversion.	Dualling required by 2003 at service level 'D', and 2009 at 'E'.

Table - 8.3.3 The Results of the Economic Analysis
(FIGURES APPLY TO REHABILITATION IN 1996)

Bridge Name	EIRR with 'next best alternative'	EIRR with detour alternative	Repair or Replace	Comment
Buca UG(Izmir) (slip road westbound only)	43.1%	53.8%	Repair by 2004.	
Hilal-II (Izmir) Dual Carriageway (westbound only)	24.5%	39.7%	Rehabilitate in 1990s	
Babadat (Ankara) (Two lane)	30.6%	166.7%	Replace in 1998. But better is to build dual bridge in 1997 and Repair in 1998	Dualling is a key factor
Selyeri (Samsun) (West bound carriageway)	26.3%	55.4%	Repair 2004	
Akcay (Samsun) (2 lane Gerber Bridge)	30.8%	92.1%	Put in dual bridge by 1999 and repair in 2000	Dualling is a key factor
Koparan II (Samsun) (2 Lane)	16.9%	79.8%	Repair in 2004	
Asagi Cakalli (Samsun) (Northbound carriageway)	106.9%	284.2%	Repair in 1998	After 1999 traffic will enforce costly diversions
Gelincik (Trabzon) (2 lane)	15.0%	45.4%	Repair in 2000	If delay to 2001 then better to replace
Sardere (Antalya) (Two Lane)	40.8%	632.0%	Repair 1996	Closure will enforce repair
Candir Hasanpasa (Bursa) (Two Lane)	32.7%	617.2%	Repair 1996	Without repair collapse will force replacement
Average Median	30.7%	86.0%		

8.3.5 General Observations from the Economic Analysis

Focus for future management attention

The most striking observation from the ten 'case study' bridges is that the problems for each of the bridges do not relate to inadequacy of bridge maintenance alone (See Table - 8.3.4). The problems stem from

- poor workmanship in the original construction (several of the bridges)

- poor design (Buca Ust Gecit slip road)
- lack of traffic management (Buca Ust Gecit)
- materials problem (Hilal II)
- lack of proper management on the river.

Consequently the focus for future management attention should not be too narrowly confined. It is clear that considerable economic benefits could be attained for the Turkish economy by looking at:-

engineering supervision and acceptance of contractors' work at construction
specification of materials and their source
traffic management and transport planning
river management

Integrating bridge management and road planning

Turkey has reached the stage of very rapid growth in traffic, with the consequent need for dualling many of the major arterial roads and indeed the need for building motorways for carrying the traffic. Whereas many of the first generation road bridges (single lane bridges) built after World War II were quickly overtaken by the unforeseen growth in traffic, now, by contrast, many of the two lane bridges could see a considerable economic (service) life as the arterial roads are dualled and the two lane bridge built for two way traffic becomes a two lane bridge catering for traffic in one direction. This dualling results in more than a doubling of road capacity; it results in a near a tripling of capacity because of the benefits of being one direction.

The need to dual opens up the opportunity for building a new second bridge for the dual carriageway and then using that bridge as the diversion bridge whilst repairs are undertaken for the original bridge. It is clear that the

- information on plans for dualling and increasing the number of lanes for roads, and
- information on the condition and likely deterioration of bridges

should be coordinated and continually updated. The opportunities for gaining economic benefits for the Turkish economy are considerable when it is possible to avoid the costs of diversion bridges , and the costs of traffic disruption. Even in these 'case studies' of ten bridges, two of them (20%) offered this opportunity.

Table - 8.3.4 The Critical Problem Areas

Bridge Name	The key reason for the problem	Focus for management attention
Buca UG(Izmir) (slip road westbound only)	Poor design and inadequate traffic management measures.	Traffic Management.
Hilal-II (Izmir) Dual Carriageway	Materials and their source.	Specifications for materials and source of such.
Babadat (Ankara) (Two lane)	Poor workmanship at original construction.	Supervision of Construction.
Selyeri (Samsun) (West bound carriageway)	Poor workmanship at original construction. Lack of bridge maintenance.	Bridge Maintenance. Supervision of Construction.
Akcay (Samsun) (2 lane Gerber Bridge)	Lack of bridge maintenance. Poor workmanship at original construction.	Bridge Maintenance. Supervision of Construction.
Koparan II (Samsun) (2 Lane)	Poor workmanship at original construction.	Supervision of Construction.
Asagi Cakalli (Samsun) (Northbound carriageway)	Poor workmanship at original construction.	Supervision of Construction.
Gelincik (Trabzon) (2 lane)	Poor workmanship at original construction.	Supervision of Construction.
Sardere (Antalya) (Two Lane)	Poor workmanship at original construction. Lack of bridge maintenance. No control on the river regime.	River Management. Bridge Management. Supervision of Construction.
Candir Hasanpasa (Bursa) (Two Lane)	Lack of maintenance for river structures (weir) and lack of management on the use of the river bed (aggregate mining). Lack of bridge maintenance.	River Management. Bridge Management.

Obtaining information on Traffic Disruption Costs

In common with most other areas of the world, the costs of traffic disruption to the economy in Turkey, through increased road user costs, often turn out to be higher than the costs of the actual engineering works to repair the bridge, a cost which is met by the highway authority. Indeed in some instances the costs are such that it is better to plan the timing of the repair works such that traffic disruption costs can be reduced. Such an approach might even mean bringing forward the repair by as much as some years terms of years.

In order to make these kinds of decisions, it is essential to have information on the likely costs of traffic disruption at any bridge. An example of the way in which traffic disruption costs can escalate as time passes and as traffic grows is illustrated by Gelincik Bridge, as shown in Figure - 8.3.1 below.

Box 2A -Economic Life

It is difficult to assess the economic life of a bridge, even after assuming that the bridge will not be made obsolete by some change in any of the following - the road system, the transport system, the economic system, - and even after assuming that the bridge will not be rendered inadequate by the growth in traffic volume. The difficulties arise because the bridge is subject to varying factors which cannot easily be foreseen, namely

- occasional, exceptional overloading by trucks, and accidents
- action by the river (flood)
- general environment (weather and pollution)
- exceptional events, such as earthquakes

Of course, there are also other factors which can deteriorate the bridge, including
design subsequently judged to be inappropriate
poor construction (inadequate supervision)
poor quality materials

The shorter the economic life, the fewer the benefits delivered by the bridge. However, judging the future economic life can not be a precise judgement. Another difficulty with economic life is that the various elements of a bridge have different lives in themselves, along the following lines:-

STRUCTURAL ITEMS	50 years
NON-STRUCTURAL ITEMS	2-15 years

Prior to the 1980s, KGM did not pay substantial attention to the concept of designing to a particular economic life, but since the 1980s, bridge design has taken into account the concepts of designing for the 1 in 100 year flood and similarly for the earthquake. In this exercise we have taken the view that the economic life of the road bridges is 50 years. This may be considered a conservative estimate. Also best 'engineering/planning' judgements have been made in order to indicate the likely year when urgent emergency action will have to be taken, i.e. the year when the bridge will become unusable.

Table - 8.3.5 Economic Returns for The Other Ten Bridges

Bridge Name	Next Best Alternative	Alternative Detour	Deferral of Capital Expenditure
Hudut I (Izmir)	20.0%	57.9%	12.2%
Porsuk (Ankara)	24.3%	77.5%	19.1%
Merzifon (Samsun)	31.5%	163.2%	25.4%
Ust Gecit II (Samsun)	22.0%	61.0%	14.6%
Pasa Pinar (Samsun)	17.5%	53.5%	7.8%
Hacimusa (Samsun)	23.5%	82.8%	8.6%
Harsit (Trabzon)	50.3%	238.6%	148.7%
Topalli (Trabzon)	24.5%	77.6%	20.0%
Degirmendere (Trabzon)	25.1%	56.1%	19.3%
Solakli (Trabzon)	16.4%	61.0%	20.2%
Average Median	23.9%	68.2%	19.2%

8.3.6 The Other Ten Bridges of The Twenty

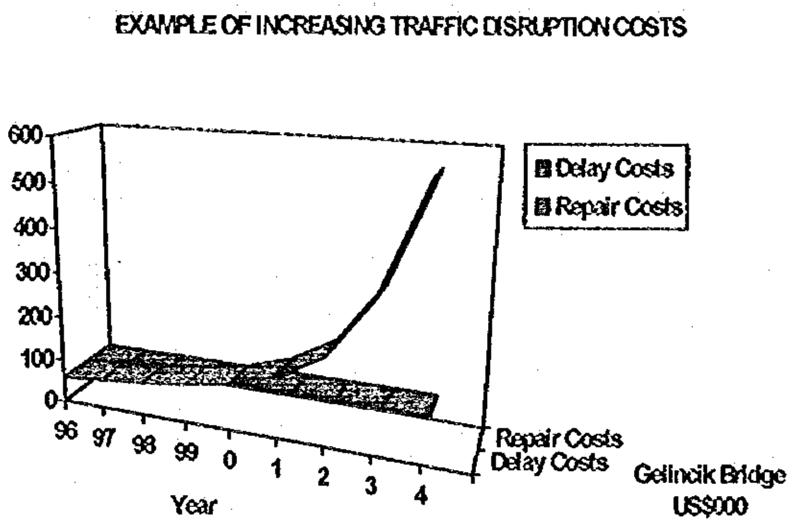
The Economic Analysis was extended to the other ten bridges of the twenty. The results were found to be similar in that the median EIRR was around 23.9% compared with 30.7% using the 'next best alternative' approach. The 'Alternative Detour' approach gave results that were 2.8 times higher than the 'next best alternative' (See Table - 8.3.5) for both the original ten and the other ten.

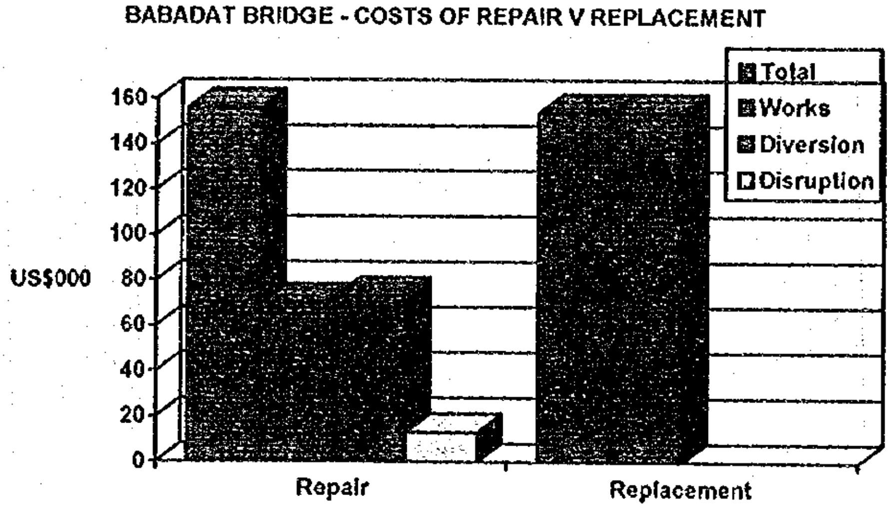
Again, with the other ten bridges, as with the original ten, repair was always a better option than replacement. The only exception to this situation was the Babadat Bridge, as illustrated in Figure - 8.3.2 below.

8.3.7 Prioritising the Ten Selected Bridges from the 'Economic Viewpoint'

All the ten selected bridges require repairs, as indeed do the other ten bridges. They cannot all be repaired together, nor need they be. From the 'economic viewpoint' the use of resources for repairs should not be viewed independently from

- the use of resources for investments in dual carriageways and hence investments in parallel bridges





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 - 8.3.1 Example of Increasing Disruption Costs Figure - 8.3.2 Babadat Bridge - Cost of Repair V Replacement

- the use of other resources, notably road user resources.

In addition to the 'economic viewpoint', a programme of bridge repairs must take into account

- the 'logistic viewpoint' (i.e. it is not possible to mobilise for one small repair)
- the 'political viewpoint'.

Probably, a principal factor driving bridge repair is the impending date of when the bridge will become unusable. Largely, the bridge maintenance programme has to anticipate when this will occur.

From our small sample of ten bridges, the appropriate programme for repair would be along the following lines:-

Year	Bridge	Cost of Repair US$	Total US$
1996	Candir Hasanpasa Sardere	190 000 124 000	314 000
1997	New Parallel Bridge for Babadat Hilal II	155 000 350 000	505 000
1998	Asagi Cakalli Babadat	163 000 52 000	215 000
1999	New Parallel Bridge for Akcay	648 000	648 000
2000	Gelincik Akcay	59 000 151 000	210 000
2001	Buca Ust Gecit Koparan II Selyeri	9 000 105 000 47 000	161 000
TOTAL		2053000	2053000

8.4 Conclusions and Recommendations

8.4.1 The Economic Aspects of A Bridge Management System (BMS)

General Background

The current situation in Turkey is that KGM is responsible for more than 3000 bridges on the State Roads. When comparison is made with some of the developed countries in Europe, Turkey's road bridge stock is relatively young in age and as yet there are not the same pressures for bridge maintenance as is occurring in developed countries. The maintenance work that is carried out by KGM is generally of good quality and appropriate to the needs of the bridge.

However, the allocation of resources in Turkey to bridge maintenance tends to be driven by two factors. Either the funds are allocated because (1) they are divided evenly (fairly) between the regions, without real economic or engineering assessment of priority, or (2) the need is clearly pressing in that the bridge has become dangerous. This study has highlighted the fact that some of the bridges are potentially near the point of collapse (for examples, Candir Hasanpasa, Sardere, Babadat).

Forward planning of maintenance expenditure on bridges is difficult because there is no system for evaluating the condition of the bridge stock and for assessing how much money has to be allocated to maintaining the condition of that stock.

The Bridge Network

The main road bridge network in Turkey on the State and Provincial Highways in 1994 was as follows:-

State Roads	3088	123199 metres,	so, average 40 metres
Provincial Roads	1511	49493 metres ,	so, average 33 metres

(Source: KGM Planning Division)

This State Roads bridge network at an average cost of TL 350 million per linear metre (US$7000 per linear metre, based on a typical cost of US$ 700 per m2 and 10 metre typical width) has a replacement value of around TL 43 trillion (US $ 0.9 billion). On the assumption of a fifty year economic life it would be necessary to spend TL 860 billion per year (US$ 17 million) merely to replace the state road bridge network, not allowing for any necessary upgradings such as strengthening to take heavier trucks or dualling to take increases in traffic volumes etc. The above figures also exclude motorway bridges and the Bosphorus bridges as well as the provincial roads.

In fact, road bridge construction has been a significant activity within KGM, with road bridge construction on the state roads typically varying between 1000 and 2000 linear metres per year, and on provincial roads typically varying between 400 and 600 linear metres per year.

Bridge Maintenance in KGM

The KGM Budget for bridge maintenance in 1995 is TL 114 billion (approx US$ 2,5 million). This figure can be compared with typical ratios for routine maintenance of bridges of 0.5% of capital costs, which would imply an annual need for a budget of TL 215 billion.(US$ 4.3 million). In fact, the KGM budget is used for replacements rather than routine maintenance. Again typical ratios would be up to 1.5% for rehabilitation and routine maintenance as a percentage of capital cost , implying a need for a budget of TL 645 billion (US$ 13 million).

The overall implication is that the current KGM budget for bridge maintenance is somewhere between one fifth and one half of what is required.

8.4.2 Economic Factors to take into account in a possible BMS

There are a large variety of Bridge Management Systems (BMS), all relatively similar in general scope and aims. Examples of such management systems include ETAMS, SPEA, PONTIS, HISMIS, NATS, BRIDGIT, INCBEN, PENNDOT, UBMS etc. Possibly the most interesting of these is the SPEA system (See Box 4A) because of its long history of data about the deterioration of reinforced concrete road bridges.

From the economist's viewpoint the critical need is to know what is the impact through time of the allocation (or not) of resources to bridge maintenance. It is necessary to know the following

1) the expected development of traffic, because not only does this signal the future benefits being delivered by the bridge but also it signals when further inputs are needed to the road bridge system. A further supply of bridges has a strong impact upon the role any one bridge plays in the system. The most notable impact of further supply is upon the use of parallel bridges on dual carriageways when undertaking maintenance. There needs to be a regular forecast of traffic on the bridge and leading from that a regular forecast of the dates for dualling or widening.

2) an assessment of the costs of maintenance against an assessment of the deterioration of the bridge. In short, costs of a maintenance project will increase as the project is delayed. There needs to be a regular assessment of such costs.

3) an assessment of the costs of traffic disruption when maintenance takes place. Traffic disruption costs can exceed the costs of maintenance, and indeed can exceed the costs of the replacement of a bridge. Again such costs need to be forecast on a regular basis as they can greatly affect the optimum timing for a maintenance project.

4) an assessment of the costs of the alternative to using the bridge, if it became necessary to close the bridge. These costs apply not only to the costs for the agency (KGM) but also the costs for road users. In part, this signals how critical the bridge is to the overall road network. A very critical bridge is usually generating a high level of benefits to the economy through the savings over alternatives enjoyed by the road users.

All the above are key economic factors which ought to be brought into the operation of a bridge management system. These factors (together with the engineering factors) would then go into an analysis which would aim to maximise certain conditions, or minimise other conditions, all within the context of imposed budgetary constraints.