6.6 Results of Detailed Inspection

6.6.1 Selection of Inspection Section

Since the preliminary road inspection survey carried out in May 1997, several of the inspection sections originally chosen for the detailed inspection have had extensive repairs carried out as a result of ongoing maintenance and highway improvement work. This has occasionally resulted in some substitute section being chosen for the detailed inspection.

The substitute sections were located as near as possible to the original section and were chosen with the assistance of the local Sub Division Chief Engineer. As far as possible similar defects were chosen to maintain the overall damage types for the detailed inspection programme.

6.6.2 Pavement Inspection Results

Of the 43 sections selected for detailed inspection, 30 sections had the condition of the pavement assessed. Of these detailed inspections 17 were carried out on asphaltic concrete surfacing with the remaining 13 inspections being carried out on surface treated roads. Inspection results include sections where little or no damage was observed to sections that will require full reconstruction.

The results of the pavement inspection are summarised in Table 6.6.1

Generally the age of the existing pavement was difficult to determine as records relating to major maintenance such as pavement overlay and reconstruction were not readily available. Where possible local recollection using KGM staff was utilised to determine the date when significant major pavement works had been carried out.

An example of a completed detailed sheet for pavement is given in Fig. 6.6.1 (a) and 6.6.1 (b).

(1) Settlement

Settlement of the pavement to some degree has been recorded in 8 sections that have had detailed inspection carried out. In most instances this settlement has occurred in areas adjacent to pavement that have suffered severe erosion or landslide.

The effect of settlement is a significant contributory factor that affects longitudinal roughness. At least 3 of the sections inspected have significant asphaltic concrete pavement settlement problems. This has contributed in these same 3 sections having the highest longitudinal roughness values for asphalt concrete pavement.

Further details in relation to pavement settlement are discussed in section (5)

Üstyapı İçin Detaylı Muayene Formu

Muayene Tarihi: 30 / 10 / 1997 No:

Genel Bilgiler			Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
	Güzergah: 750-05	Yer : 26+500 km'den 26+600 km'ye	DURSUN ALİ KOÇER	HASAN YILMAZ	CHAI S. CHIEW
	KGM Bölge: 4	Şube: 42			
	Yol Sınıfı: 1	Taşıtyolu Sayısı: 2			
	Şerit Sayısı: 2 x 2	Yön: ANKARA → İSTANBUL			
	Yapım Yılı: 1980	SOL TARAF			

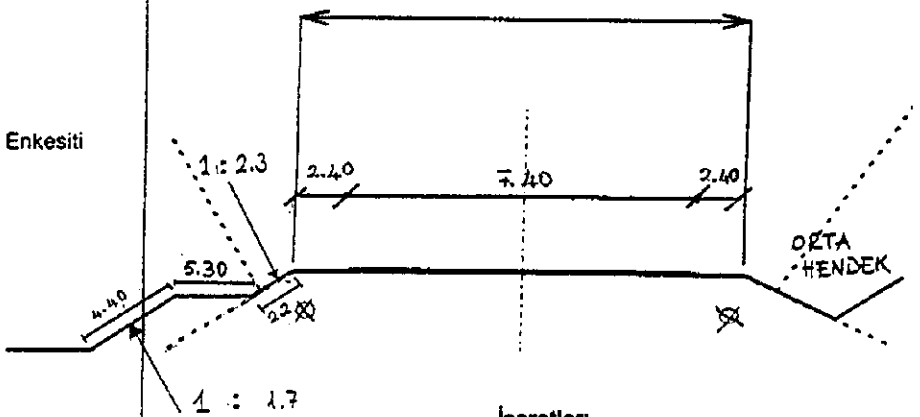
Muayene Elemanları		
	Hasar Cinsi	(1) Oturma (X) Çatlama (3) Çukur (4) Ondüle (5) Tekerlek İzi
	Üstyapı Tipi	(X) Asfalt Beton (2) Sathi Kaplama
	Topografya	(X) Dağlık Ar. (2) Tepelik Ar. (3) Düz Ar. (4) Yumuşak Topraklı Ar. (5) Diğer( )
	Zemin Cinsi	(X) Kaya(Sert veya Yumuşak) (2) Çakıl (3) Kum (X) Silt (5) Kil (6) Diğer( )
	Drenaj Borusu	(1) Var (çapı:.....mm) (X) Yok
	Yeraltı Suyu	(1) Akıntı (2) Sızıntı (3) Islak (X) Yok
	Kar Yağışı	(X) Var (Ortalama Kalınlık: 100 ...mm) (2) Yok
	Zincir Aşınması	(1) Var (Ortalama Derinlik:.....mm) (X) Yok

Çatlama Oranı	C = 35.4	%
Tekerlek İzi Derinliği	D = 12.8	mm
Boyuna Düzgünsüzlük	σ = 12.9	mm
Çukur	Çapı = mm	Derinliği = mm
PSI	PSI = 4.53 - 0.518logσ - 0.371√C - 0.00174D²	= 1.46

PSI indeksi	PSI değeri	Uygulanacak Metod
	PSI<1.0	Yenilden Yapım
	1.1<PSI<2.0	Takviyelendirme ✓
	2.1<PSI<3.0	Onarım
	PSI>3.0	Onarıma gerek yok
	(1)Onarım (2)Takviyelendirme (3)Yeniden Yapım	

Şema — Yol Enkesiti

Araştırma Noktası: .....26... km+ (500..m – 510..m)

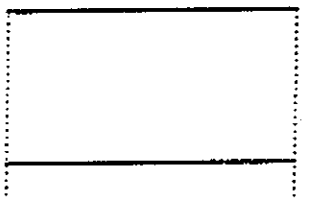


İşaretler:

A: Platform genişliği
B: Taşıtyolu genişliği
C,D: Trafik şerit genişliği
H: Drenaj borusu
E: Banket genişliği
F: Enine eğim
G: Refüj
(O): Araştırma Noktası

Karot Testi Sonuçları

Üstyapı Strüktürü



	Takviye Tabakası	Aşınma Tabakası	Binder Tabakası	Bitümlü Temel	Temel	Alt Temel
Karot No.1						
Karot No.2						
Karot No.3						
Karot No.4						
Karot No.5						
Karot No.6						

Fig. 6.6.1 (a) **Example of Completed Detailed Pavement Inspection Form**

Üstyapı İçin Detaylı Muayene Formu

Muayene Tarihi: 30 /10 /97

Çatlama oranı/yama alanı hesaplanması

	Münferit çatlaklar(c) Birim kare	Alan	Toplam	Bağlantılı çatlaklar ve çukurlar (P) Birim kare	Alan	Toplam
1 çatlak	11	x 0.15	= 1.65	%25 - %75 —	x 0.125	= —
2 veya daha fazla çatlak	98	x 0.25	= 24.50	>%75 1	x 0.25	= 0.25
			c = (26.15			P = (0.25)

Çatlama Oranı (C) =((c+P)/A)x100 =((c+P)/(10x3.5))x100 = %..... 75.4

Tekerlek izi derinliği hesabı

	Derinlik:
No.1	21
No.2	5
No.3	20
No.4	6
No.5	12

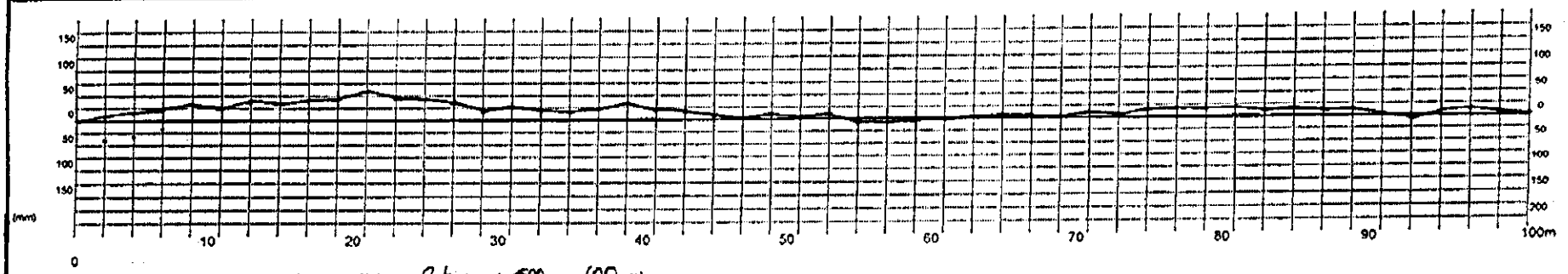
Ortalama Derinlik= 12.8 mm

Çukurlar için veritabanı

	Derinlik:	Boyutlar		Derinlik:	Boyutlar
No.1			No.6		
No.2	50	200 x 200	No.7	—	x
No.3	30	90 x 300	No.8	—	x
No.4	30	80 x 250	No.9	—	x
No.5	—	x	No.10	—	x

Ortalama Derinlik= 36.7 mm

Boyuna Düzgünsüzlük Araştırma Noktası : 26.....km+ (..500.. m - ..600.. m) Düzgünsüzlük Standart Sapması σ = 12.9 mm



Araştırma Noktası : 26..km+ (..500m - ..600 m)

Çatlama oranı/Çukur

	0m					5.0m												10.0m
3.0m			2	2	2	2	2	2	2	2	2	2	2	2	2	2	2			
			2	2	2	2	2	2	2	2	2	X	2	2	2	2	2	2		
2.0m				2	2	2	2	2	1	2	2	2	2	2	2	2	2	2		
				2	1	1	2	2	1	2	2	2	2	2	2	2	2	2	2	
1.0m				2	2	2	2	2	2	20	2	2	2	2	2	2	2	2	2	1
					2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
0m						2	1	1	2	2	2	2	2	2	1	2	2	2		2

2 7 75 10 0 70 60 35 65 20

0+000 40 20 30 40 50 60 70 80 90 100

Fig. 6.6.1 (b) **Example of Completed Detailed Pavement Inspection Form (Continued)**

Table 6.6.1 Summary Cracking Ratio, Rutting Depth, Standard Deviation and PSI

Section . No.	Kilometre Post	Sub Division	Pavement Type	Pavement Results			
				Cracking Ratio %	Rutting Depth mm	Standard Deviation σ	PSI
100-10	40+800	17	As Con	36.2	7.8	14.3	1.59
650-09	17+400	31	Sur Tr	15.1	19.7	17.0	1.77
100-11	41+600	41	As Con	1.3	10.7	70.0	2.95
100-12	9+400	41	As Con	3.8	4.6	10.3	3.25
750-05	26+500	42	As Con	35.4	12.8	12.9	1.46
750-05	31+300	42	As Con	0.0	1.2	16.8	3.89
750-06	5+400	42	As Con	4.0	11.0	23.8	2.86
200-13	35+400	44	As Con	4.5	6.2	49.0	2.80
200-14	21+000	44	As Con	8.0	1.0	34.0	2.69
200-14	27+000	44	As Con	32.0	9.8	19.5	1.60
200-09	50+000	45	As Con	11.4	1.0	5.2	2.90
200-09	23+700	46	As Con	9.7	1.0	16.3	2.75
200-08	13+550	46	As Con	6.9	16.0	11.4	2.56
200-12	49+500	47	As Con	17.5	10.0	42.3	1.96
795-03	10+000	72	Sur Tr	25.0	24.0	14.8	1.07
190-01	11+400	73	Sur Tr	8.0	10.0	17.9	2.66
190-02	13+300	73	Sur Tr	38.0	13.2	8.3	1.46
795-04	15+000	73	Sur Tr	67.0	34.0	25.0	-1.24
795-01	61+500	75	As Con	69.0	14.0	43.7	0.25
010-18	24+950	77	Sur Tr	25.0	17.0	28.3	1.42
010-23	32+000	103	Sur Tr	16.4	21.0	19.7	1.59
010-19	17+600	104	Sur Tr	26.0	21.0	25.5	1.14
010-20	27+500	104	Sur Tr	15.0	8.0	17.8	2.33
010-21	8+750	105	Sur Tr	13.0	18.4	26.0	1.87
650-14	36+650	132	Sur Tr	0.0	12.2	10.1	3.75
650-12	36+200	134	Sur Tr	40.6	10.0	7.3	1.54
650-10	15+500	134	Sur Tr	24.9	14.1	14.6	1.73
200-06	12+100	143	As Con	18.7	10.4	14.0	2.14
200-07	41+700	144	As Con	0.0	48.8	6.9	-0.04
200-06	29+100	147	As Con	29.7	7.0	23.9	1.71

(2) Cracking

In the majority of the detailed inspection sections there was evidence of some form of cracking in over 27 sections. Damage types were recorded for the following main locations:-

- Under the wheel tracks
- At the edge of the carriageway near the hard strip
- Over the full width of the carriageway lane

Cracking over the full width of carriageway was often accompanied by longitudinal roughness either in surface undulations or as a result of localised settlement.

Observed cracks is the major factor in determining the cracking ratio. The other factors which influence the cracking ratio are the patching and pothole areas. There was a significant effect on the cracking ratio from patching and potholes in 6 of the inspected sections.

A summary of the cracking ratio within the inspection sections for different pavement types is presented in Table 6.6.2.

Table 6.6.2 Summary of Cracking Ratio Within Inspection Sections for Different Pavement Types.

Cracking Ratio (CR) %	Pavement Type	
	Asphaltic Concrete	Surface Treated
<25.0	12 (70.6%)	6 (46.2%)
25.0<CR<50.0	4 (23.5%)	5 (38.5%)
>50.0	1 (5.9%)	2 (15.3%)
Total	17 (100%)	13 (100%)

The table is banded according to the repair types likely to be carried out to remedy the observed defects as follows:-

Intervention Level	**Outline Repair Method**
Cracking Ratio <25.0	Sealing of cracks and repair of potholes/minor patching
Cracking Ratio 25.0<CR<50.0	Extensive patching / overlay works
Cracking Ratio>50.0	Overlay / pavement reconstruction

For the asphaltic concrete sections, only 1 section had a cracking ratio above 50% with the vast majority of the sections being below 25%

For surface treated roads, the balance shifts more to the 25% to 50% range.

(3) Potholes

A decrease in the number and extent of potholes was observed during the detailed inspection phase of the study as KGM had deployed maintenance teams over the spring and summer months to carry out repairs in preparation for the winter months. Minimal extensive potholing was observed but where observed appears to be limited to the wearing course. In many instances the existing pavement is heavily cracked and this will soon lead to the formation of potholes either from extensive and heavy vehicular traffic or as a direct effect of water penetrating the pavement layers.
However potholes were evident in over 17 sections of pavement which were subject to detailed inspection. Generally the number of potholes observed was small. The pothole depths in all cases in the asphaltic concrete sections was less than 50mm or less and half were at 25mm or less. Those observed in the surface treated sections were larger and deeper. Recorded pothole information is tabulated in Table 6.6.3.

The results indicate that in almost all sections where potholes were evident, they are of a size that would require some form of repair to be carried out in the near future. In any case, all potholes observed for both pavement types would require attention to prevent the ingress of water which would lead to further deterioration of the damage.

Table 6.6.3 Summary of Pothole Dimensions Within Sample Inspection Section

Section . No.	Kilometre Post	Sub Division	Pavement Type	Pothole Information			
				Number of Potholes	Maximum Size mm	Minimum Size mm	Maximum Depth mm
100-10	40+800	17	As Con	2	200 x 170	250 x 100	25
650-09	17+400	31	Sur Tr	3	310 x 430	290 x 390	28
100-12	9+400	41	As Con	4	360 x 330	200 x 170	50
750-05	26+500	42	As Con	3	300 x 90	250 x 80	50
750-06	5+400	42	As Con	1	900 x 750	---	40
200-13	35+400	44	As Con	2	600 x 700	500 x 300	30
200-14	21	44	As Con	1	110 x 130	---	21
200-09	50+000	45	As Con	1	90 x 100	---	20
200-12	49+500	47	As Con	1	250 x200	---	25
190-01	11+400	73	Sur Tr	5	900 x 450	80 x 200	20
795-04	15+000	73	Sur Tr	4	900 x 350	900 x 90	60
010-23	32+000	103	Sur Tr	5	750 x 300	400 x 350	90
010-19	17+600	104	Sur Tr	1	1000x200	---	30
010-20	27+500	104	Sur Tr	3	450 x 400	300 x 300	25
010-21	8+750	105	Sur Tr	1	2900x500	---	40
200-06	12+100	143	As Con	3	400 x 350	750 x 120	40
200-06	29+100	147	As Con	3	250 x 250	200 x 100	22

** **Note** :- Only inspection sections containing potholes within the inspection section are tabulated.

(4) Rutting

There is some form of rutting in nearly all the sections inspected though in 3 asphaltic concrete sections this is almost negligible. The summary of the average rutting depth within the detailed inspection sections is presented in Table 6.6.4.

Table 6.6.4 Summary of Average Rutting Depth Within Inspection Sections

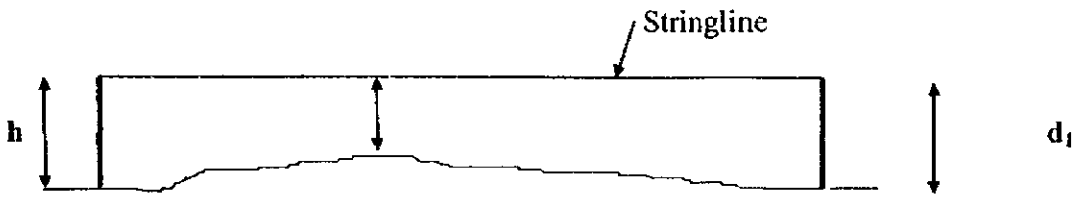
Rutting Depth (RD) mm	Pavement Type	
	Asphaltic Concrete	Surface Treated
<10.0	8 (47.0%)	3 (23.0%)
10.0<RD<20.0	8 (47.0%)	6 (46.0%)
20.0<RD<30.0	0 (0.0%)	4 (30.8%)
>30.0	1 (6.0%)	0 (0.0%)
Total	17 (100%)	13 (100%)

Of the inspected sections, the rutting depth was on average, deeper for surface treated roads than for asphalt concrete roads. This is as expected and is due to the lower axle load carrying properties of the surface treated roads.

Generally rutting was more evident on steeper gradients which accommodate slow moving heavy goods vehicles. This is demonstrated in the result for the largest rut depth recorded during the detailed inspection (48.8 mm) which is located on an incline but with a negligible crack ratio and a small longitudinal roughness value.

In determining rut depth there are some instances, especially on surface treated roads, where the road surface bows out between the wheel tracks. Where the measurement of rutting depth cannot be obtained by the method described in section 6.3.1. In these instances the rut depth is measured as shown below

Rut depth $\mathbf{D_i = h - d_i}$



Rut depth is the greatest value of D_i for each section

Fig. 6.6.2 Alternative Measurement of Rutting Depth On Some Surface Treated Roads Where Transverse Road Section Bows Upwards

(5) Wave

Wave is one of the main factors that affect the longitudinal roughness, together with settlement problems. A summary of the results for longitudinal roughness is presented in Table 6.6.5 and considers separately the two pavement types.

Table 6.6.5 Longitudinal Roughness σ By Inspected Sections, Pavement Type and Severity

Longitudinal Roughness σ	Pavement Type	
mm	Asphalt Concrete	Surface Treated
σ<25	11 (64.7%)	9 (69.2%)
25<σ<35	2 (11.8%)	4 (30.8%)
σ>35	4 (23.5%)	0 (0.0%)
Total	17 (100%)	13 (100%)

With a suggested intervention level in excess of 35 mm for further action, the result indicates that 4 of the 17 sections of the asphaltic concrete pavement require further analysis. In at least

3 of these 4 sections, settlement of part of the pavement is the major factor which has resulted in these high longitudinal roughness values.

(6) Present Serviceability Index (PSI)

The results of the present serviceability index based on the three factors of cracking ratio, rutting depth and longitudinal roughness are presented in Table 6.6.1. The results should be considered separately for the two different pavement types and the range of results by PSI severity are presented in Table 6.6.6.

Once again the results indicate that the asphaltic concrete roads are generally in a better overall condition than surface treated roads with the majority of asphaltic concrete sections requiring either no work or only local patching.

Table 6.6.6 Present Serviceability Index (PSI) By Inspected Sections, Pavement Type and Severity

PSI Value	Pavement Type	
	Asphalt Concrete	Surface Treated
PSI<1.0	2 (11.8%)	1 (7.7%)
1.1<PSI<2.0	5 (23.5%)	9 (69.2%)
2.1<PSI<3.0	7 (52.9%)	2 (15.4%)
PSI>3.0	3 (11.8%)	1 (7.7%)
Total	17 (100%)	13 (100%)

6.6.3 Slope and Embankment Inspection Results

Of the 43 sections selected for detailed inspection, 15 sections had the condition of the slope assessed. Of these detailed inspections 6 were carried out on cutting slope, 6 were carried out on embankment slope and the remaining 3 were carried out on both the cutting and embankment slope.

(1) Slope and Shoulder

The majority of the damage encountered relates to the following problems :-

- Erosion of the slope
- Landslide
- Rock avalanche

There were no recorded instances of collapse to protection wall or cracking to slope.

An example of a completed detailed sheet for slope is given in Fig. 6.6.3.

(2) Embankment Note only one from exists from detailed inspection – four locations are indicated in inspection sheet.

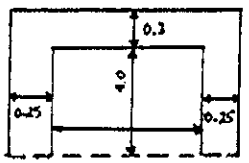
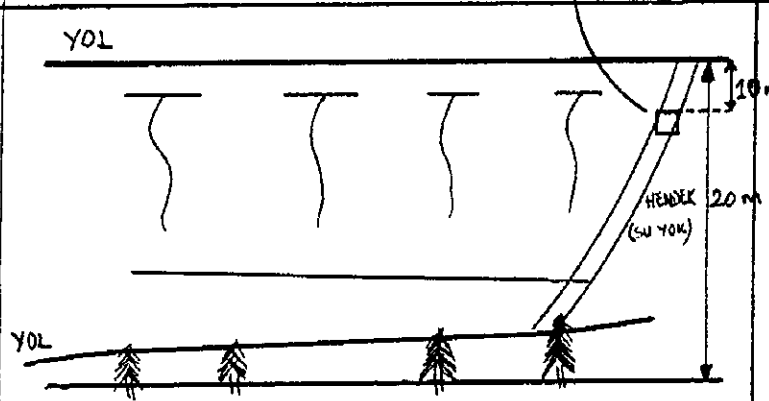
The damage encountered for the embankment detailed inspection is summarised in Table 6.6.7. All damage found relates to the collapse of the embankment.

An example of a completed detailed sheet embankment is given in Fig. 6.6.4

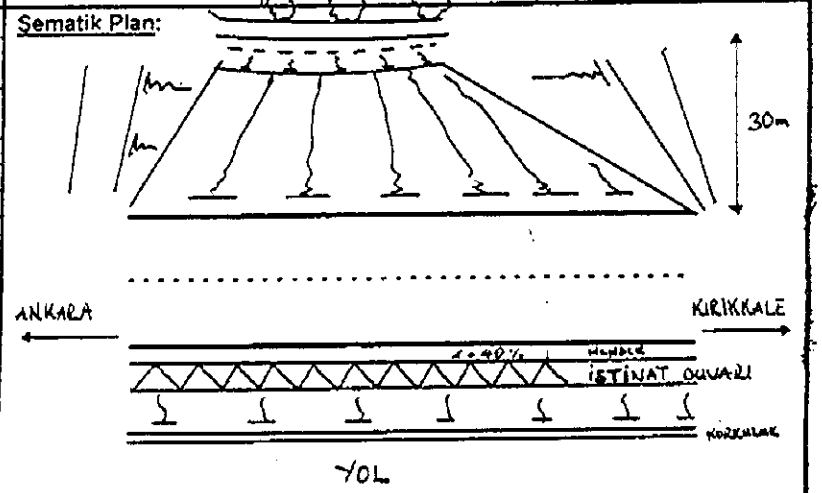
Şev ve Banket İçin Detaylı Muayene Formu

Muayene Tarihi: 27 / 10 / 1997 — No:

Genel Bilgiler			Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
	Güzergah: 200-13	Yer: 35+400 km'den 36 km'ye	DURSUN ALİ KOCER	HASAN YILMAZ	MASATAKA FUJIKUMA HIROMICHI ENOKIDA
	KGM Bölge: 4	Şube: 44			
	Yol Sınıfı: 1	Taşıtyolu Sayısı: 2			
	Şerit Sayısı: 2 x 2	Yön: KIRIKKALE → ANKARA			
	Yapım Yılı: 1980				

Muayene Elemanları	Şev Tipi	(1) Yarma (X) Dolgu
	Hasar Cinsi	(X) Heyelan (2) Kaya Yuvarlanması (3) Tahkimat Duvarının Çökmesi (4) Çatlama (5) Erezyon
	Zemin Cinsi	(1) Kaya(Yumuşak veya Sert) (2) Çakıl (X) Kum (4) Silt (X) Kil (6) Diğer ( )
	Ağaçlandırma	(1) Ağaç (2) Çalı (X) Çim (4) Diğer (5) Yok
	Drenaj	(1) Şev Kademesi Hendeği (2) Kafa Hendeği (X) Yarma Hendeği (4) Yok
	Yeraltı Suyu	(1) Akıntı (2) Sızıntı (X) Islak (4) Yok
	Dren Borusu	(1) Var (çapı: ..... mm) (X) Yok
Şev Koruması	Koruma Tipi	(1)Beton Izgara (2)Harç Püskürtme (3)Gabyon (4)Bitkilendirme(X)Diğer
	Şema	
Şevin Durumu	Şema	

Şematik Plan:



Şematik Enkesit:

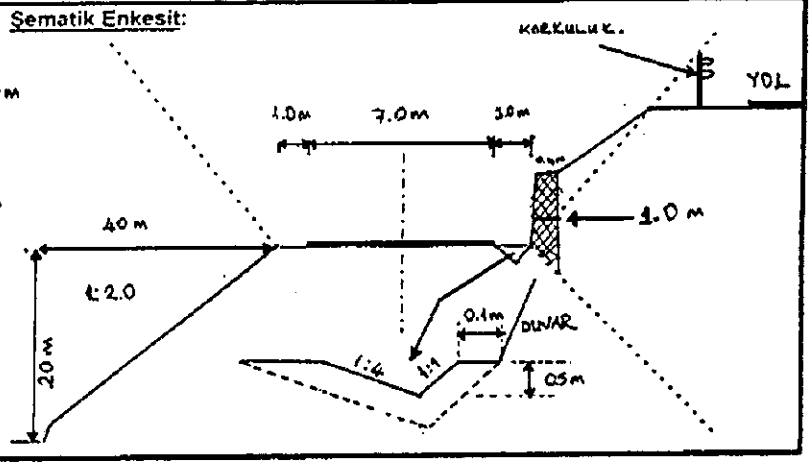


Fig. 6.6.3 Example of Completed Detailed Slope Inspection Form

Dolgu İçin Detaylı Muayene Formu

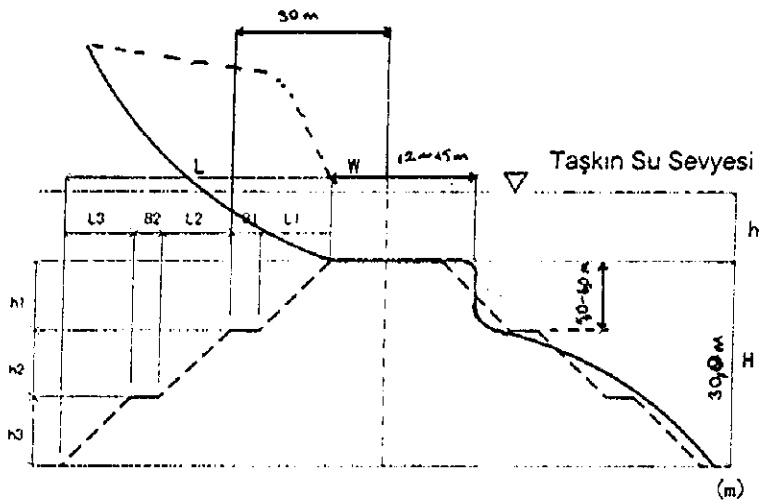
Muayene Tarihi: 30 / 10 / 1997 No:

Genel Bilgiler	Güzergah: 100-17	Yer: 56+900 km'den 57 km'ye	Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
	KGM Bölge: 7	Şube: 72	YUSUF ZİYA YILMAZ	HASAN KAPTAN	MASATA FUJIKURA
	Yol Sınıfı: 1	Taşıtyolu Sayısı: 2			HIROMICHI ENOKIDA
	Şerit Sayısı: 2 x 2	Yön: MERZİFON.. →.. SAMSUN.....			
	Yapım Yılı:				

Muayene Elemanları	Hasar Cinsi	(1) Su Altında Kalma (X) Göçme
	Topografya	(1) Dağlık Arazi (X) Tepelik Arazi (3) Düz Arazi (4) Yumuşak Topraklı Arazi (5) Deniz Kenarı (6) Nehir Kenarı
	Zemin Cinsi	(1) Kaya (2) Çakıl (3) Kum (X) Silt (X) Kil (6) Diğerleri( )
	Su Altında Kalma	(1) Evet (senede ..... kere) (X) Hayır

Şema

Dolgunun Sematik Görünüşü

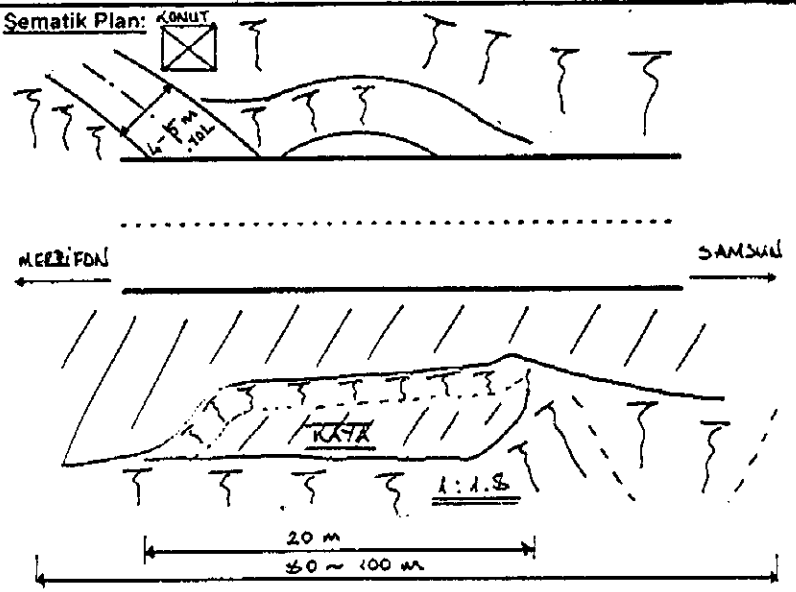


W= L= H= h=

L1= L2= L3= h1= h2= h3=

B1= B2=

Sematik Plan:



Düşünceler:

- KUTU MENDEZ İNŞAASINA BAŞLANMIŞ
- VADİNİN DOLDURULMASI SURETİYLE DOLGUNUN DENGESİ SAĞLANACAK
- TRAFİK KONTROLÜ GEREKLİ

Fig. 6.6.4 Example of Completed Detailed Embankment Inspection Form

Table 6.6.7 (1) **Summary of Slope and Shoulder Damage By Inspected Sections**

Section No.	Kilometre Post	Sub Division	Slope Type	Damage Type	Soil Type	Plantation	Drainage	Ground Water	Drain Hole	Protection Type	Remarks
100 -12	26+750	41	Cutting	Erosion & Rock Avalanche	Rock with Silt Bands	None	Toe	None	None	Masonry Rockfall Wall	Forest above cutting slope
100 - 12	25+700	41	Cutting	Landslide	Rock, Gravel & Silt	Trees & Bushes	Toe	Weeping & Wet	None	None	Landslide due to ponding at the top of slope
100 - 11	41+150	41	Embank-ment	Landslide /Erosion	Earth/ Fill Material	Bushes	None	Wet	None	Mass Concrete Wall	Retaining wall sliding
750 - 05	31+600	42	Embank-ment	Erosion	Gravel & Sand	None	None	Current	None	None	Eroded slope tempor-arily protected by ex-cavated river gravel
750 - 06	5+500	42	Cutting	Erosion	Rock & Silt	Bushes	Toe	None	None	Masonry Rockfall Wall	Winding road
750 - 06	5+600	42	Cutting	Erosion	Gravel & Silt	Bushes	None	None	None	None	Bend in road. 50 m drop to ravine floor
750 - 06	15+600	42	Cutting	Erosion	Gravel & Silt	None	None	None	None	Rockfall Retaining Wall	Debris behind wall nearly to top of wall. Removal urgent
200 - 08	18+500	46	Embank-ment	Erosion	Gravel & Earth	None	None	None	None	None	Erosion partially due to excess use as footpath
785 - 05	15+600	73	Cutting	Rock Avalanche	Rock	None	Toe	Wet	None	None	Continuous rock accumulation in the side ditch

Table 6.6.7 (1) (Continued) Summary of Slope and Shoulder Damage By Inspected Sections

Section No.	Kilometre Post	Sub Division	Slope Type	Damage Type	Soil Type	Plantation	Drainage	Ground Water	Drain Hole	Protection Type	Remarks
200 -13	34+400	44	Embank-ment	Landslide	Sand/ Clay	Grass	Toe	Wet	None	None	Masonry wall supporting higher carriageway
010 - 18	7+60	77	Cutting / Embank-ment	Landslide	Rock	Tree	Toe	Wet	None	Wall on embank-ment	Coastal highway 35m above sea level
010 - 23	40+100	103	Cutting / Embank-ment	Erosion	Rounded Sandy Gravel	None	Toe	Wet	None	None	Due to erosion big cracks have occurred - may cause landslide
010 - 19	15+850	104	Cutting / Embank-ment	Erosion	Gravel & Soil	Trees & Bushes	Toe	Wet	None	Vegetation	Coastal highway
010 - 20	27+750	104	Embank-ment	Erosion	BlackSand & Rock	None	None	Wet	None	None	Coastal highway - sea erosion
200 - 06	34+750	143	Embank-ment	Erosion	Topsoil	None	None	None	None	None	Road construction layers clearly visible on embankment

Table 6.6.7 (2) Summary of Embankment Damage By Inspected Sections

Section No.	Kilometre Post	Sub Division	Damage Type	Topo-graphy	Soil Type	Flooding	Overall Height	Overall Width	Flood Water Level	No.of Berms	Remarks
100 - 17	56 + 900	72	Collapse	Hilly	Silt / Clay	None	30m+	---	None	None	Collapse of embankment immediately below road level

6.6.4 Drainage

The results of the detailed inspection for drainage are summarised in two sections

- Detailed inspection for drainage and culvert
- Detailed inspection for side ditch and gully

No detailed inspection was carried out on drainage for slope.

(1) Drainage and Culvert

Detailed inspection of drainage culverts was carried out in 5 sections. The majority of damage recorded consists of the accumulation of debris resulting in the blockage of these culverts. No instances of collapse or settlement were investigated during the detailed inspection phase. The results of the detailed inspection are summarised in Table 6.6.8.

An example of a completed detailed inspection form is presented in Fig. 6.6.5.

Table 6.6.8 Summary of Drainage Culverts Damage By Inspected Sections

Section No.	Kilometre Post	Sub Division	Culvert Information			
			Type	Number of Cells	Culvert Dimensions mm	Damage Type & Comments
100 - 10	40+900	17	Pipe	1	600 Dia	Downstream blockage (100% full of debris - water weeping up through ground
100 - 12	26+650	41	Pipe	1	800 Dia	Downstream blockage (25% full of debris)
750 - 05	31+500	42	Box	2	2x (2050 x 2050)	Both boxes are over 50% full of rock and soil debris
750 - 06	3+500	42	Box	1	1500 x1500	Partial blockage throughout culvert length - 100 mm deep
750 - 06	15+100	42	Pipe	2	2 x 800 Dia	80% blockage downstream end - upstream clean

Additionally culverts were inspected at each Sub Division to enable training in the use of the inspection forms to be instructed. No damage was recorded in these locations.

(2) Side Ditch and Gully

Detailed inspection of side ditches and gulleys were carried out in 3 sections. The majority of damage recorded consists of an accumulation of debris in the side ditch channels. No instances of side ditch collapse or settlement were recorded during the detailed inspection phase. The results of the detailed inspection are summarised in Table 6.6.9.

Drenaj ve Menfez İçin Detaylı Muayene Formu

Muayene Tarihi: 30 / 10 / 97 — No:

Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
DURSUN ALİ KOGER	HASAN YILMAZ	CHAI S. CHIEW

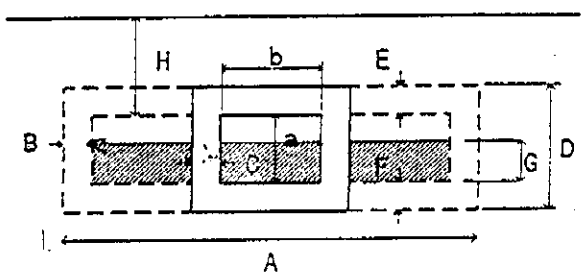
Genel Bilgiler

Güzergah:	750 - 05	Yer:	31 km'den 32 km'ye
KGM Bölge:	4	Şube:	42
Yol Sınıfı:	1	Taşıtyolu Sayısı:	2
Şerit Sayısı:	2x2	Yön:	İSTANBUL → ANKARA
Yapım Yılı:	1980		

Drenaj ve Menfez

Menfez Tipi	(X) Kutu (2) Büz (3) Diğerleri
Hasar Cinsi	(X) Pislik Birikmesi (2) Göçme (3) Oturma
Arazi Kullanımı	(1) Yerleşim Bölgesi (2) Şehirsel Bölge (3) Endüstriyel Bölge (X) Kırsal Bölge (5) Ormanlık Arazi (6) Diğerleri

Yol



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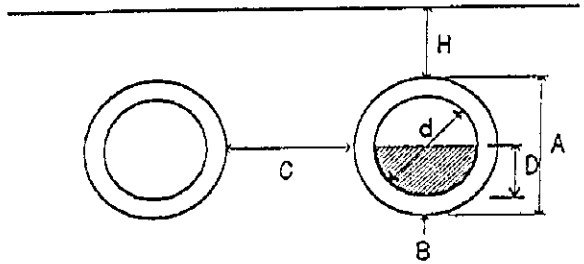

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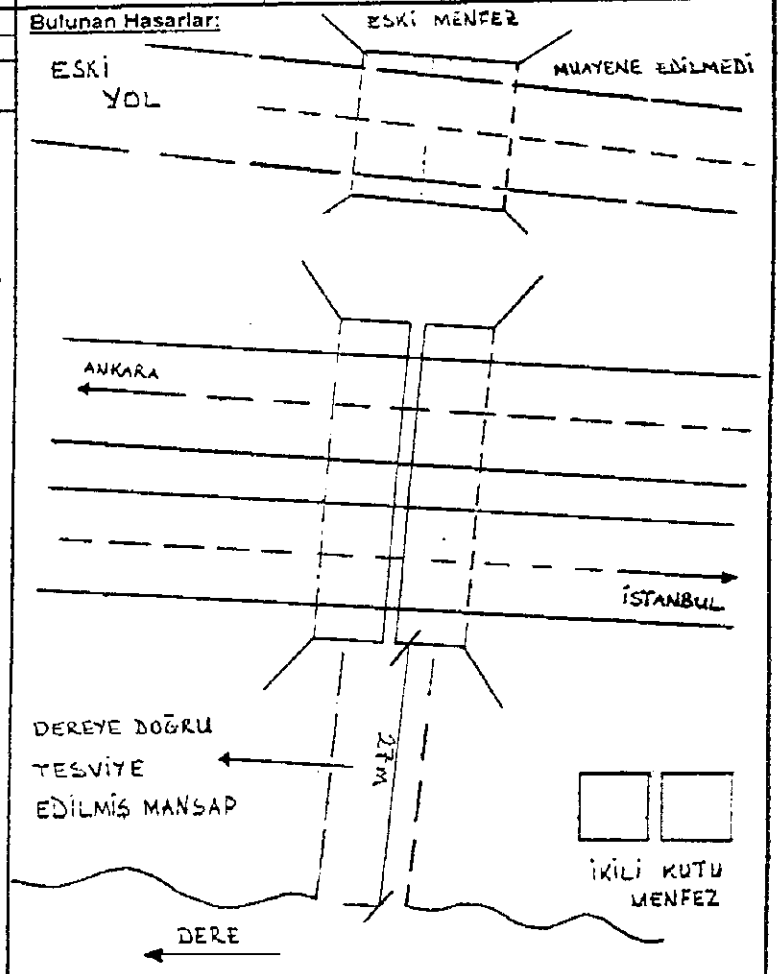


Fig. 6.6.5 (1) **Example of Completed Culvert Inspection Form**

Kenar Hendeği ve Izgara İçin Detaylı Muayene Formu

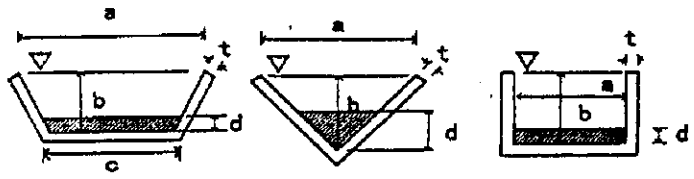
Muayene Tarihi: 29 / 10 / 97. No:

			Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
Genel Bilgiler	Güzergah: 750-06	Yer: 750-06 - [illegible] km'den km'ye	DURSUN ALİ KOÇER	HASAN YILMAZ	CHAI S. CHIEW
	KGM Bölge: 4	Şube: 42			
	Yol Sınıfı: 1	Taşıtyolu Sayısı: 2			
	Şerit Sayısı: 2x2	Yön: Ankara → İstanbul			
	Yapım Yılı: 1980 (Last major reconstruction)				

Kenar Hendeği

Hasar Cinsi: (1) Pislik Birikmesi (2) Göçme (3) Oturma

Boyutlar:



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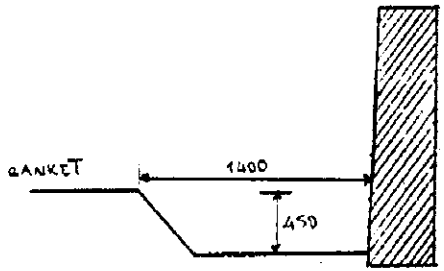
t=			

MEVCUT İSTİNAT DUVARINA KARŞI

Bulunan Hasarlar:

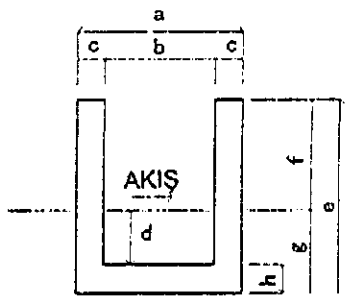


KENAR HENDEĞİNDE TEREsubAT BİRİCİMESİ

Izgara

Hasar Cinsi: (1) Pislik Birikmesi (2) Göçme (3) Oturma

Boyutlar:



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c=
d=
e=
f=
g=
h=

Bulunan Hasarlar:

6 - 40

Fig. 6.6.5 (2) **Example of Completed Side Ditch and Gully Inspection Form**

Table 6.6.9 Summary of Side Ditch and Gully Inspection

Section No.	Kilometre Post	Sub Division	Side Ditch and Gully Information		
			Type	Side Ditch /Gully Dimensions mm	Damage Type & Comments
750 - 06	5+500	42	Side Ditch	Channel with side slope 1450x450 deep	Ditch filled 95% with construction debris from pothole patching.
100 -12	26+400	41	Side Ditch	V Type ditch 1400 wide 390 deep	Ditch filled 25% with debris (including grit from winter maintenance operations.
200 - 12	49+500	47	Central Reserve Ditch	V Type ditch 1400 wide 390 deep	Ditch clean. Minor settlement cracks forming at base of ditch

The results of the detailed inspection indicate a general decrease in cross sectional area of the originally constructed side ditch. In some sections over 95% of the cross section has been lost due to an accumulation of debris. This results in the side ditch and gulleys not performing as designed. In some instances the adequate draining of the carriageway surfacing is affected and creates a hazard during periods of rainfall.

6.6.5 Retaining Wall Inspection Results

The condition of the retaining walls were inspected in 5 sections. The results of the detailed inspection are summarised in Table 6.6.10.

Of the inspected sections the most common damage recorded is from impact; both from vehicles and from rockfall which has caused collapse. In older walls the effect of weathering is causing mortar joints to crumble which in more serious cases is also leading to collapse of the upper courses of the masonry wall.

In instances where the retaining wall acts as a barrier to prevent rock fall from reaching the carriageway the rear of the wall is now full of rock debris. This is now causing a potential hazard as debris can fall directly onto the carriageway.

In coastal regions the effects of sea erosion is having a severs effect on the stability of the retaining walls which has led to the partial collapse of some of these walls.

One case of settlement of the concrete wall retaining the carriageway is leading to severe settlement to the adjacent carriageway pavement.

An example of a completed detailed inspection sheet for retaining wall is given in Fig. 6.6.6.

İstinat Duvarı İçin Detaylı Muayene Formu

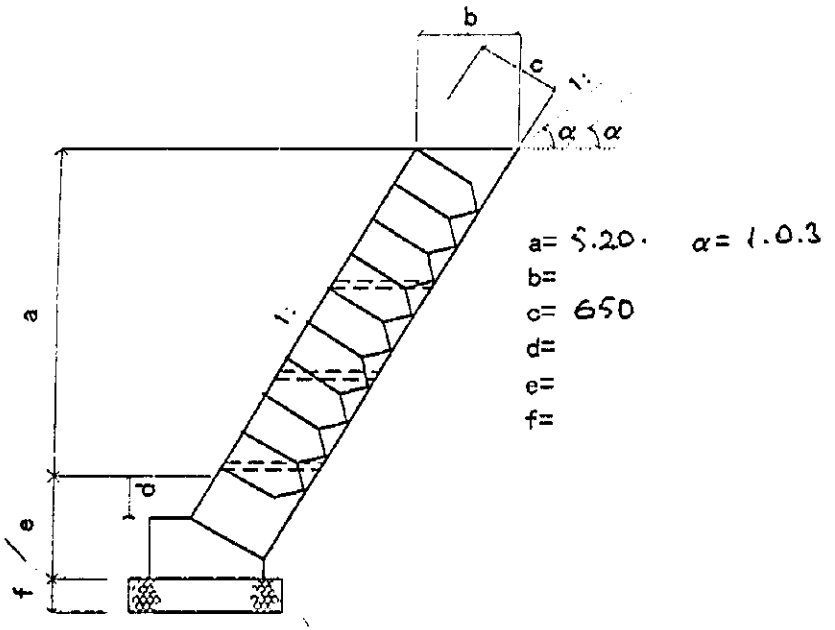
Muayene Tarihi: 1 / 11 / 1997 No:

			Bölge Müdürü	Bakım Baş Müh.	Muayeneyi Yapan
Genel Bilgiler	Güzergah: 100 – 11	Yer: 41+600 km'den 42 km'ye	DURSUN ALİ KOÇER	HASAN YILMAZ	CHAT SENG CHIEW
	KGM Bölge: 4	Şube: 41			
	Yol Sınıfı: 1	Taşıtyolu Sayısı: 1			
	Şerit Sayısı: 3 X 1	Yön: İSTANBUL..→....ANKARA..			
	Yapım Yılı: 1980				

Yapının Cinsi	(1) Taş Kargir (X) İstinat Duvarı(Ağırlık Duvarı, L-şeklinde İs.Dv., Payandalı İs.Dv,Diğer)
Hasar Cinsi	(1) Çatlama (X) Oturma (3) Göçme
Zemin Cinsi	(X) Kaya (Yumuşak veya Sert) (X) Çakıl (3) Kum (4) Silt (5) Kil (6) Diğer( )
Barbakan	(1) Var (çapı.....mm.) (X) Yok Aralıkları = ...m(yatay) X .....m(düşey)

Şema

Taş Kargir Şeması



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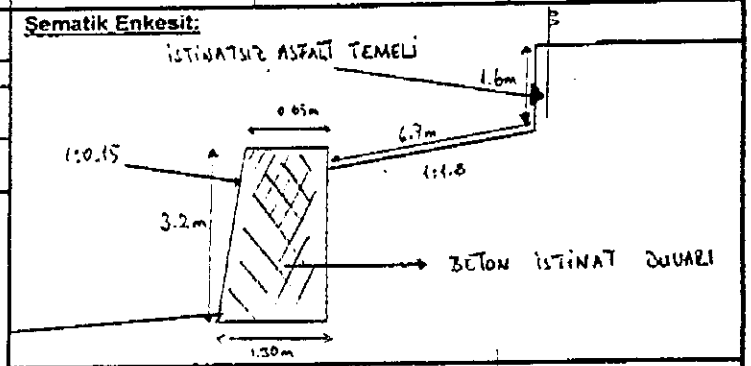

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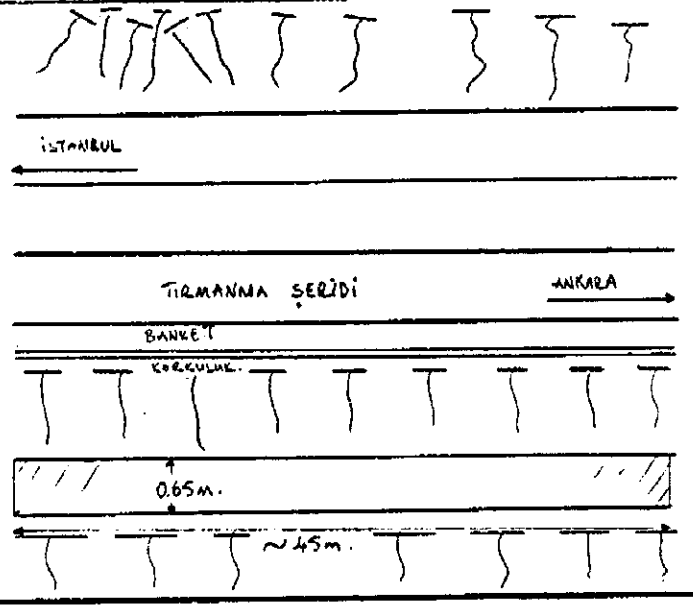


Fig. 6.6.6 **Example of Completed Retaining Wall Inspection Form**

Table 6.6.10 Retaining Wall Damage By Inspected Sections

Section No.	Kilometre Post	Sub Division	Structure Type	Damage Type	Soil Type	Weep Hole (mm)	Overall Height (m)	Wall Slope Gradient	Remarks
100 - 11	41+600	41	Concrete Gravity Wall	Settle-ment / (Sliding)	Rock and Gravel	None	Varies 1.5-3.2	1 : 0.15	Mass concrete wall sections moving over one another. Wall supporting embankment toe. No material against highway construction edge.
750 - 06	5+500	42	Masonry	Collapse	Rock	150 x150	Varies 1.5 - 2.0	1:0.15	Damage caused by a combination of rock fall and vehicle impact.
750 - 06	15+400	42	Masonry	Collapse	Rock and Gravel	100 x200	3.2	1 : 0.3	Collapse caused by vehicle impact. Wall retains rock avalanche debris behind wall. Debris up to wall top and now needs removal.
795 - 02	24+900	75	Masonry	Collapse	Gravel and Sand	250x 100	Varies 1.75-2.75	Varies 1:0to 1:03	Wall retains carriageway from river. Collapse of wall causing pavement settlement.
010 - 19	25+700	104	Masonry	Settle-ment	Rock	None	4.850 above sea level	Vertical	Sea wall with back sloping wave wall. Sub Divsion organised temporary repair works. Repair works to be discussed with KGM.

CHAPTER 7

PRELIMINARY DESIGN OF REPAIR WORK

CHAPTER 7 PRELIMINARY DESIGN OF REPAIR WORK

7.1 Introduction

This Chapter looks at methods for identifying the appropriate repair method for each damage type and for each defect.

The major causes and effects of the damage are listed for each damage type to assist the maintenance engineers to have a better understanding of the issues that they face. The use of supplementary surveys is discussed and recommendations are given as to the suitability of the various surveys for each defect.

The repair methods for each damage type are tabulated for easy reference and flow charts are given for the selection of the most suitable repair method where appropriate.

Construction methods are discussed together with particular points to be aware of during the construction.

For the 20 sections where a detailed inspection was carried out, the design of the repair works has been looked at in more detail and the results are included in Appendix 7.1. The design utilised all the data collected during the detailed inspections and from the supplementary surveys.

7.2 Repair Work Items

The following repair work items are included in this section of the report:-

- Pavement
- Embankment
- Shoulder
- Slope
- Retaining Wall
- Drainage
- Snow and Ice Control Facilities

Each item is discussed in turn looking at the major repair methods and the selection process.

7.3 Pavement

7.3.1 Damage Type

Table 7.3.1 defines each of the damage types and states the major effects of the damage.

Table 7.3.1 Damage Types for Pavement - Definitions and Effects

Items	Damage Type	Effects of Damage
Pavement	Settlement	. poor quality ride for the motorist. . may reduce traffic speed. . water may collect causing an accident risk.
	Cracking	. allows water to enter the pavement causing softening and weakening of the pavement and lower layers. This may cause early failure of the pavement. . in winter, water will freeze and expand to enlarge cracks and cause worsening damage. . if severe, causes uneven ride for the motorist and may reduce traffic speed.
	Potholes	. allows water to enter the pavement causing softening and weakening of the pavement and lower layers. This may cause early failure of the pavement. . in winter, water will freeze and expand to enlarge the pothole and cause worsening damage. . if left unrepaired, can rapidly expand the extent of the damage. . creates poor ride quality for the motorist and may reduce traffic speed. . if large can cause damage to vehicle wheels and tyres. . can create an accident risk.
	Rutting	. causes poor ride quality . water can collect in rut and cause aquaplaning problem for vehicles. This is a serious accident risk. . in winter, water collected in ruts may freeze causing an accident risk due to skidding.
	Wave	. poor ride quality for motorist. . in hot weather, surface stripping can occur.

7.3.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out as shown in Table 7.3.2.

Table 7.3.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey		Remarks
		Core Sampling	CBR	
Pavement	Settlement		■	
	Cracking	■	■	
	Potholes	□		
	Rutting	■	□	
	Wave	□	□	

Notes: ■ essential survey □ optional survey

1. Core Sampling

Core sampling is used to establish the thickness and condition of the existing pavement layers and to establish the extent of the cracking and rutting in the pavement structure. Laboratory tests may be carried out on the sample to provide additional information where required. Core samples vary in size from 50mm for layer depth information only to 150mm where laboratory tests are to be carried out on the sample.

2. CBR Tests

CBR tests are used to get information on the strength of the sub grade. These tests will be required where the design of overlay or reconstruction works is to be done. CBR tests may be carried out in-situ or in the laboratory.

7.3.3 Cause of Damage

The major causes of damage for each of the damage types listed in section 7.3.1 are summarised in Table 7.3.3.

Table 7.3.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Pavement	Settlement	. insufficient compaction of lower layers . differential settlement of sub grade
	Cracking	. poor quality workmanship . poor quality materials . unsuitable compaction temperature . differential settlement at borders of different construction types (pavement/shoulder joint) . reflective cracks from cracks in lower layers . variations in compaction and bearing capacity of lower layers . pavement too thin
	Potholes	. asphalt content too low . excessive heating of asphalt . poor quality mixture . lack of compaction allowing ingress of water
	Rutting	. axle loads in excess of the design loads (pavement too thin) . poor quality materials . lack of compaction of pavement materials . low strength sub grade
	Wave	. poor quality materials . variations in compaction and bearing capacity of lower layers . poor quality or lack of prime coat or tack coat . materials not suited to temperature range

7.3.4 Design of Repair Work

The main pavement repair methods and their definitions are listed below:-

Sealing	Bituminous materials are applied to cracks in the road surface.
Filling	The treatment of isolated potholes to maintain a safe road surface condition.
Patching	Materials are used to fill local depressions in the road surface and to replace areas of the pavement subject to extensive cracking or potholes.
Milling	The road surface is ground down using a machine.
Milling and Overlay	The road surface is ground down using a machine and a new asphaltic concrete layer is placed onto the milled surface.
Overlay	An additional asphaltic concrete layer is placed over the existing surfacing.
Reconstruction	The original pavement layers are fully or partially removed and the pavement is reconstructed to the required level.
Surface treatment	The pavement surface is covered with bituminous material, sand resin based material or epoxy based material.

7.3.4 Design of Repair Work

Table 7.3.4 - Repair Work for Pavement

Damage Type		Repair Method	Purpose
Settlement		- patching - overlay - reconstruction	- temporary repair whilst settlement continues - permanent repair when settlement is not excessive and lower layers are still sound - permanent repair when settlement is excessive and has destroyed the integrity of the pavement
Cracking	Hairline	- sealing - surface treatment	- to prevent the ingress of water and dust - to prevent the ingress of water and dust - to improve the surface texture
	Line	- sealing - surface treatment - milling and overlay	- to prevent the ingress of water and dust - to prevent the ingress of water and dust - to improve the surface texture - longer term repair to remove the cracks and provide a new road surface
	Alligator	- patching - reconstruction	- temporary repair to remove the cracks and provide a new road surface - permanent repair
Potholes		- filling - patching - reconstruction	- used on individual potholes to prevent the ingress of water and improve the ride quality - used where potholes are grouped together to prevent the ingress of water and improve the ride quality - permanent repair
Rutting		- milling - milling and overlay - reconstruction	- used to remove transverse undulation to improve surface condition - long term repair to restore surface ride quality - long term repair to restore surface ride quality
Wave		- patching - overlay	- used to improve the surface ride quality - longer term repair to improve surface ride quality

Selection of Repair Method

The selection of the appropriate repair method will depend on a number of factors:-

- the type and severity of the defect
- the effect on traffic flow during repair works
- the volume of traffic as this will affect the rate of deterioration of the defect
- cost effectiveness considering short and long term options

Urgent repairs may be required in order to reopen a road closed by the damage, or to prevent the damage from developing into a more serious situation.

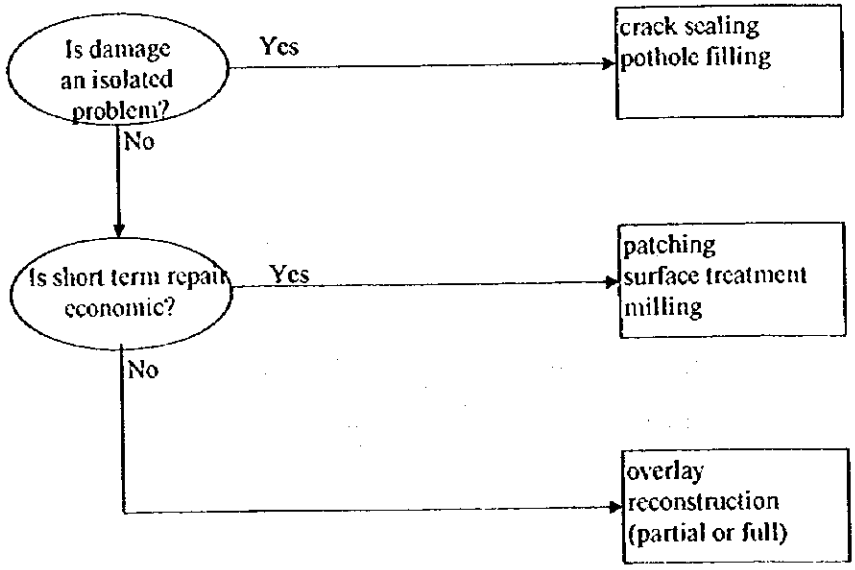
Short term options:-

for isolated defects
- crack sealing
- pothole filling

when defects are more extensive
- patching
- surface treatment
- milling

Long term options:-
- overlay
- partial or full reconstruction

The available budget must be considered. Also the cost effectiveness of different repair options should be considered e.g. repeated short term repairs must be compared with a higher cost long term repair which will have lower ongoing costs (Whole Life Costing). Alternatives such as overlaying and full or partial reconstruction must be evaluated.



Selection of Repair method for Pavement

7.3.5 Construction Method

Pavement

Crack Sealing

The sealing and resealing of cracks in pavements is an important and often underestimated aspect of pavement maintenance. Serviceability and pavement life may be extended through proper resealing by preventing the entry of surface water and debris.

The objective is to fill the cracks as completely as possible with bituminous binder to prevent water entry.

The method and materials used will depend on the equipment available for the work. Viscous binders will need a hand lance with a relatively fine jet capable of getting the binder into the cracks. The use of a watering can or similar may be used when the binder viscosity is suitable.

Work Sequence:-

- the crack should be cleaned by brushing and using a compressed air hose to remove dust and debris from the crack to be sealed.
- the surface must be clean and dry before the application of the sealant.

- sealant is applied to the crack using appropriate equipment
- where necessary, the sealant should be finished with a hand asphalt tool.

- the sealant may be blinded with dry sand or dry fine aggregate to provide a surface texture and to assist with the curing process
- sealant must be allowed to set before allowing traffic to run on the road

Filling

This is used for isolated pothole repairs.

In order to maintain the surface in a safe condition, a rapid repair can be carried out. Loose material should be removed from the hole, the exposed surfaces coated with a tack coat and the hole filled with material, compacting in layers.

However, this type of filling may not last very long. As soon as is possible, the repair should be repeated but the surface should be cut back around the pothole to sound material, the sides squared off and the hole should be cleaned out with a compressed airline. The exposed material should be coated with a tack coat and the hole backfilled with appropriate material, compacting in layers.

Patching

The need for patching is usually the first sign of major pavement deterioration. It may be carried out on a repeat basis or prior to the application of a surface treatment or overlay. The repeat patching process is used to extend the life of the existing pavement and so defer the more expensive overlay or reconstruction works.

The cause of the local failure requiring patching will often be related to problems with drainage both on and off road. It is essential that these problems are identified and remedied before any patching work is carried out.

There are two types of bituminous patching mixtures:-

(a) those mixed hot and compacted while still hot

(b) those mixed and then stockpiled for a period before use

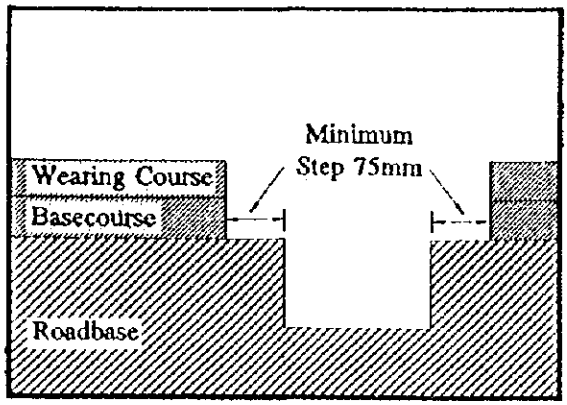
Although cold asphalt mixture is more convenient for transport, storage and placing, its initial stability and durability are inferior to the hot mixture. Hot mix asphalt is therefore preferable for the repairs on heavily trafficked roads.

These mixtures vary widely in quality and costs. The performance of a bituminous patch depends on both the quality of the materials comprising the patching mixture and the quality of the construction in the preparation, placing and compaction of the mixture. The best bituminous patching mixture will only last a short time if good construction practice is not followed.

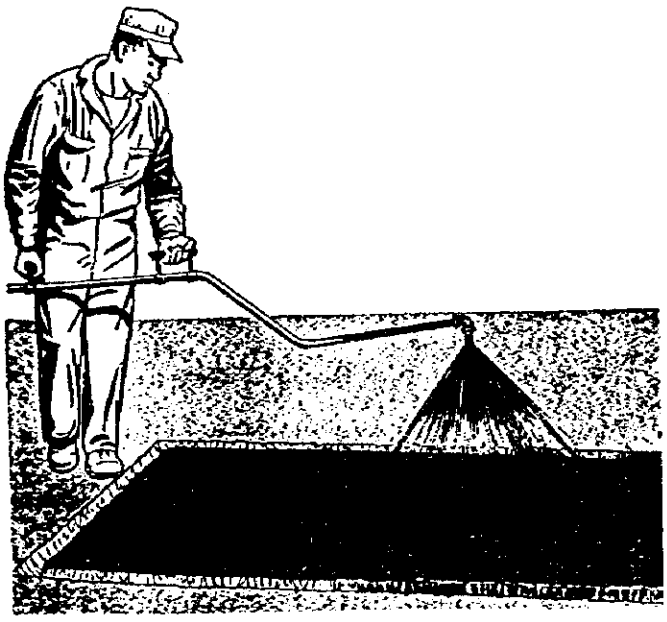
Work Procedure:-

- mark out a square or rectangular area for the patch extending beyond all the unsound material.
- remove all loose and failed material.

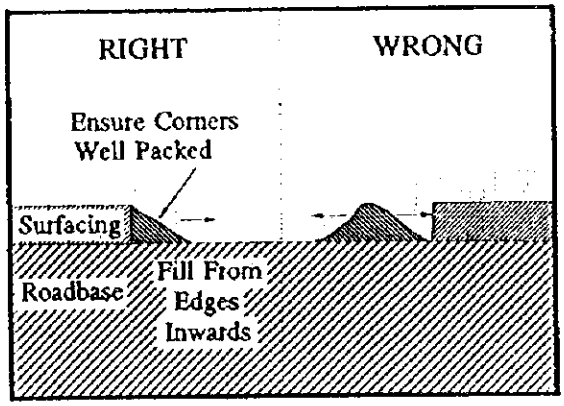
- form the edges of the area by saw cutting on straight lines to a firm undisturbed vertical edge. The depth of the patch excavation will not normally exceed the wearing course depth.
- for deeper excavation, no step is required between the wearing and binder courses, although a minimum of a 75mm step should be made between the binder course and the base course.

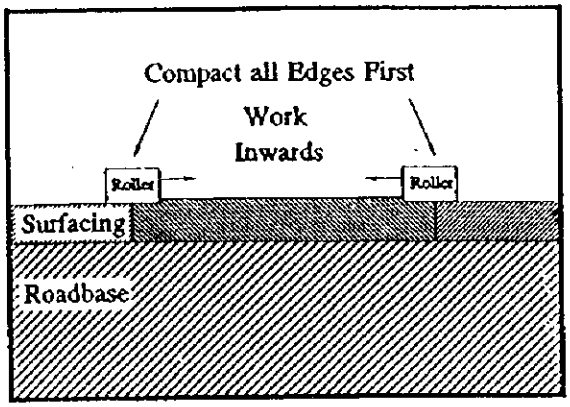


- ensure all edges are trimmed and sweep clean; where possible use a compressed air line.
- paint the edges of the area with asphalt emulsion.
- spray the base of the area with tack coat.

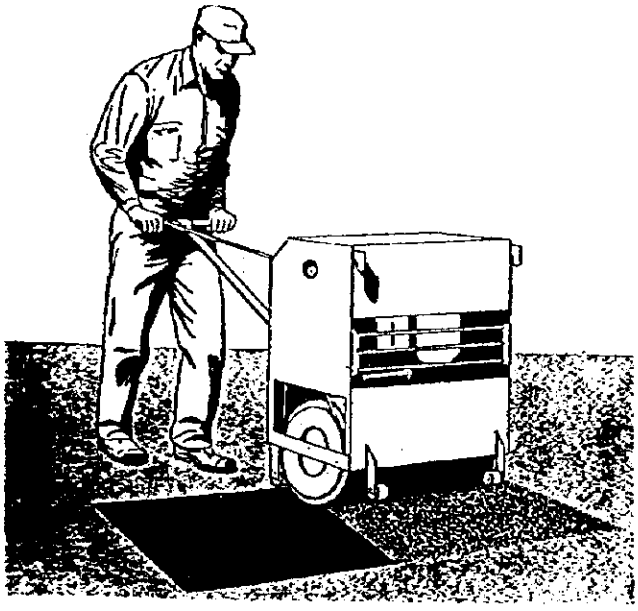


- place patching material in a uniform layer, levelled and shaped to maintain existing carriageway camber /crossfall after compaction. The new material must be flush with all joints, channels and projections and be level or not more than 3mm above adjoining pavement surfaces.





- compact all parts of the patch to refusal using a tamper, hand rammers or a small vibrating roller avoiding roller marks on the surface and damage to adjacent sound material.
- on completion of the operation, clean the site thoroughly.



Milling

Milling has been successful in removing as much as 75mm to 100mm of asphaltic concrete surfacing in a single pass. The major uses are as follows:-

- removing material in readiness for overlays
- removing material to restore surface and cross section profile
- restoring the kerbline area
- restoring the cross slope to improve drainage or to correct drainage inlet cover problems
- improve friction resistance of the surface

After removal of surface material through milling, most pavements are overlaid. Some pavements however, have been milled and opened to traffic without an overlay but tyre noise may generate public complaints so this will generally only be suitable on low traffic volume roads. If the pavement is structurally sound but rough from various non load related distresses, this may be a very cost effective means of delaying overlaying for a few years.

Overlay

For asphaltic concrete, the surface should be prepared by sealing cracks and filling potholes and where necessary, milling the surface. A new surface course is laid to current specifications and should be of sufficient depth to extend the life of the pavement to suit the long term maintenance programme. This might involve a further overlay before reconstruction.

For surface treated roads, surface defects such as cracks and potholes should be repaired prior to the application of a new surface course. Where practical this could be in asphaltic concrete material but this should only be the case where the overall pavement will withstand the expected traffic loading for a number of years to make the repair economic.

Reconstruction

Reconstruction involves the removal of some or all layers of the pavement layers and the replacement with new materials to the current specification allowing for known and projected traffic conditions.

Surface Treatment

Surface treatment involves the application of an asphalt/aggregate to the road surface. The surface treatment provides little or no structural improvement in the pavement but it provides other benefits:-

- provides a new road surface
- seals the surface against water penetration
- seals cracks

This treatment should not be used where the pavement structure is not strong enough to carry the projected traffic load for the next 3 to 5 years. Also if the pavement has any structural problems resulting from poor drainage or an unstable base, this treatment should not be considered.

There are many forms of surface treatments, the most common are as follows:-

- Slurry seal

This consists of the application of a diluted emulsion mixed with a sand sized aggregate. The slurry is spread onto the road surface using squeegee type brushes. The thickness is generally less than 10mm.

- Asphalt-aggregate surface treatment

This consists of sequential application of asphalt and stone chips which can be made either singly or in repetitive layers, sometimes called armour coating.

The use of mechanised surface treatment methods offers important advantages over manual methods. Mechanical bitumen sprayers allow the close adjustment of the rates of application so that these can be accurately controlled and the adverse effects of excessive, insufficient or variable amounts of binder can be avoided. The rate of progress of a mechanised unit is much higher than can be achieved by manual methods.

Chippings

The use of rounded gravel aggregates should be avoided if possible because it is difficult for the binder film to hold them in place and because of their poor surface friction properties. If their use cannot be avoided, adjustments must be made to the rate of spread of the bitumen. The rounded aggregates do not interlock and more bitumen is required to hold particles firmly to the road surface than is required for cubical aggregates.

Binder

The performance and qualities of a surface treatment binder makes the choice of binder critical.

The binder must:-
- be sprayable at a reasonable temperature
- 'wet' the surface of the road and remain in a continuous film waterproofing the road structure
- not run off a steep gradient or cambered road or form pools of binder
- 'wet' and adhere to the stone chippings at road temperature
- be strong enough to resist the traffic forces and retain the chippings even at the highest ambient temperatures
- be flexible at the lowest temperature, neither cracking and allowing water to enter nor brittle thus allowing the chippings to break free
- resist excessive weathering and hardening once the initial hardening has taken place

Modified binders may be considered where chip retention is a problem.

7.4 Embankment

7.4.1 Damage Type

Table 7.4.1 defines each of the damage types and states the major effects of the damage.

Table 7.4.1 Damage Types for Embankments - Definitions and Effects

Item	Damage Type	Effects of Damage
Embankment	Submerge (Flooding)	. risk of scour of embankment as water level lowers . risk of scour of bridge foundations . embankment will be saturated and this may reduce its strength and risk a serious collapse
	Collapse	. road must be closed causing traffic disruption . difficult and expensive reconstruction

7.4.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out. For embankments, the following supplementary surveys may be used:-

Table 7.4.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey			Remarks
		Boreholes	CBR	Cross Section	
Embankment	Submerge	□	□	■	
	Collapse	□	□	■	

Notes: ■ essential survey □ optional survey

1. Boreholes

Boreholes are used to determine ground water levels and to get soil samples to determine design parameters or to check strength characteristics.

2. CBR Tests

CBR tests are used to get information on the strength of the sub grade. CBR tests may be carried out in-situ or in the laboratory.

3. Cross Section

Cross sections should be taken to assist with the evaluation of the problem and the design of remedial works.

7.4.3 Cause of Damage

The major causes of damage for each of the damage types listed in Section 7.4.1 are summarised in Table 7.4.3.

Table 7.4.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Embankment	Submerge (flooding)	. embankment too low for highest flood levels blockage on river or flood channel downstream of embankment . blocked culvert or bridge opening . culvert or flood opening has insufficient capacity for flood flow
	Collapse	. lack of compaction . poor materials . saturation due to lack of drainage or flooding . softening of sub grade due to groundwater or lack of drainage . scouring of toe by water action . earthquakes or other natural disasters

7.4.4 Design of Repair Work

Table 7.4.4 - Repair Work for Embankment

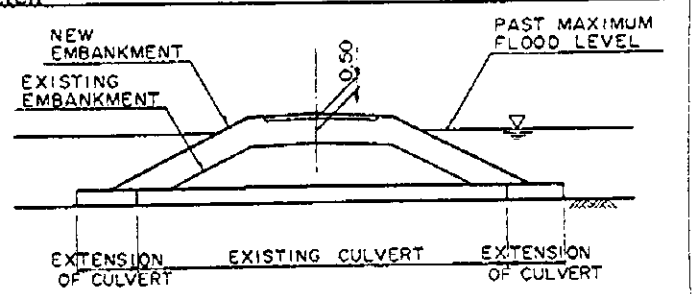
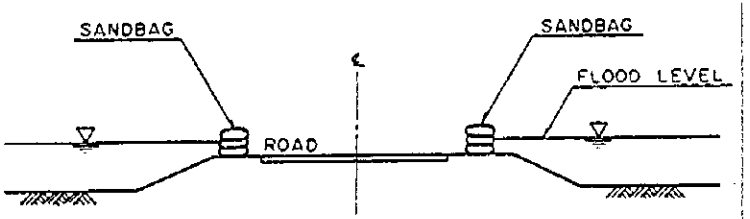
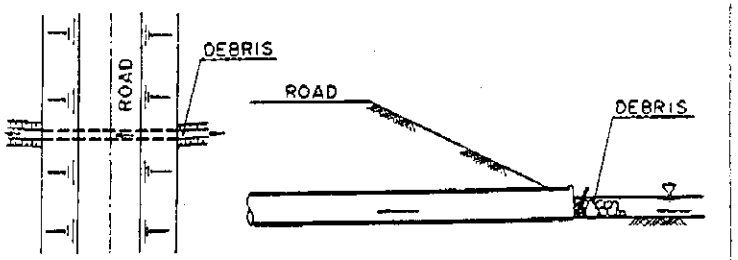
Damage Type	Repair Method	Purpose	Application	Sketch
Submerge (flooding)	Increase height of embankment	- to lift the road surface above the normal flood level	- low embankment in a flood plain	
	Use of sandbags	- to avoid flooding of road	- temporary measure for embankment in flood plain	
	Removal of debris or sediment	- to increase discharge capacity by the removal of debris and sediment from the culvert inlet	- culvert inlets	

Table 7.4.5 Repair Work for Embankment

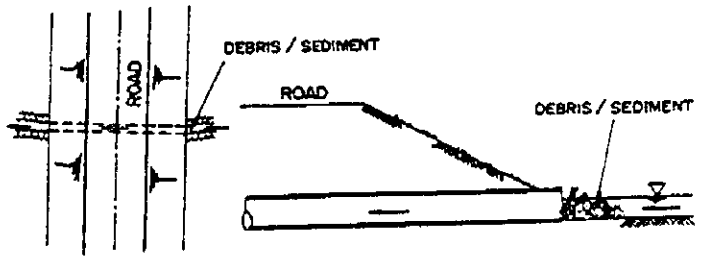
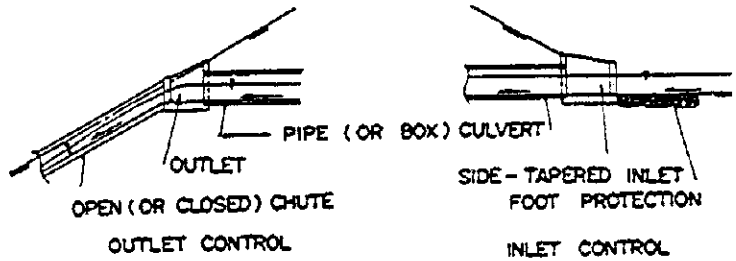
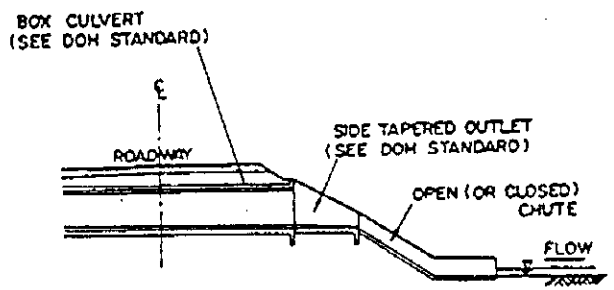
Damage Type	Repair Method	Purpose	Application	Sketch
Submerge (flooding)	Downstream improvements	- increase downstream flow/capacity by the removal of debris or improving the river channel	- downstream river channel	
	Construct additional culverts (consider upstream channelisation)	- to provide a new passage for water through or alongside the embankment	- where regular flooding occurs away from culvert locations	
	Increase cross sectional area of culvert	- to increase the capacity of the flood flow	- where regular flooding occurs at existing culverts that is not caused by debris/sediment or downstream problems	

Table 7.4.6 Repair Work for Embankment

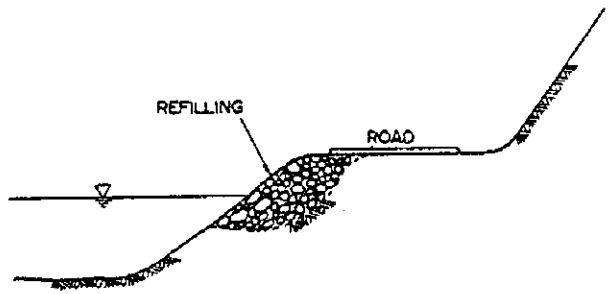
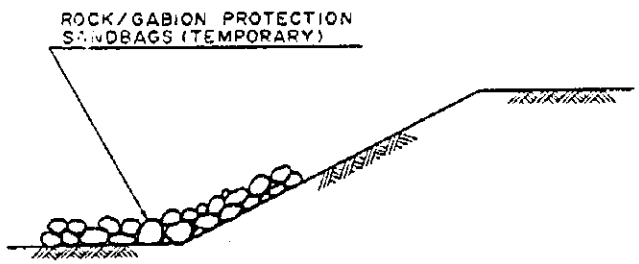
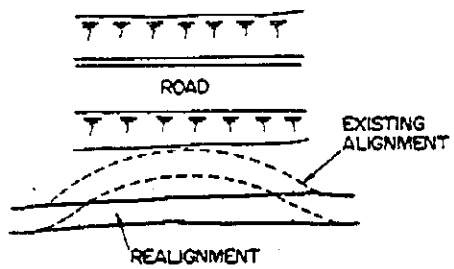
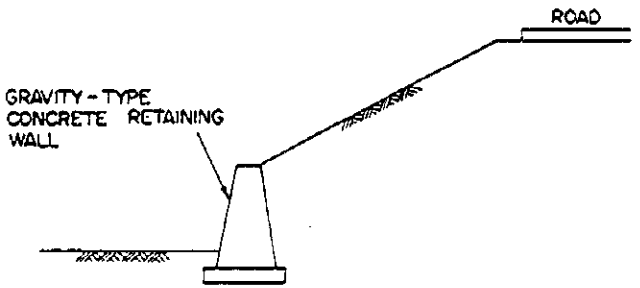
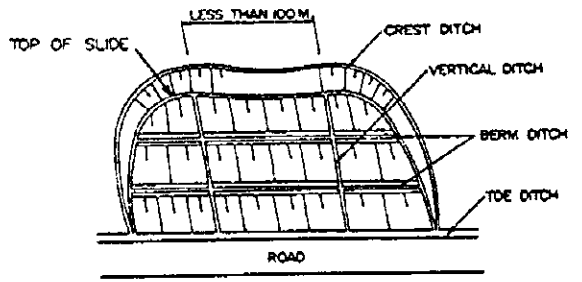
Damage Type	Repair Method	Purpose	Application	Sketch
Collapse	Refill	- to achieve an embankment capable of supporting design loadings	- in all situations and prior to other treatments being applied.	
	Rock protection	- to protect the toe of the slope from scour	- apply to slopes adjacent to water courses	
	Realign river channel	- to prevent erosion and scour of the toe of the embankment	- meandering river adjacent to embankment	

Table 7.4.7 Repair Work for Embankment

Damage Type	Repair Method	Purpose	Application	Sketch
Collapse	Toe retaining wall	- to give extra support in resisting earth pressure	- low height wall, 2m max.	
	Additional drainage measures	- to maintain acceptable sub grade condition - to provide additional flood flow capacity	- where the subgrade is saturated by high ground water levels - where saturation is due to regular flooding of the embankment	

Selection of the Repair Method

For Embankments, consideration must be given to the need for emergency measures to keep the road open to traffic and in a safe condition. In selecting a repair method the cost and implications on traffic flow must be considered very carefully with simple methods being considered first as a quick solution and the methods requiring more major works being considered as part of a longer term solution.

Submerge (flooding)

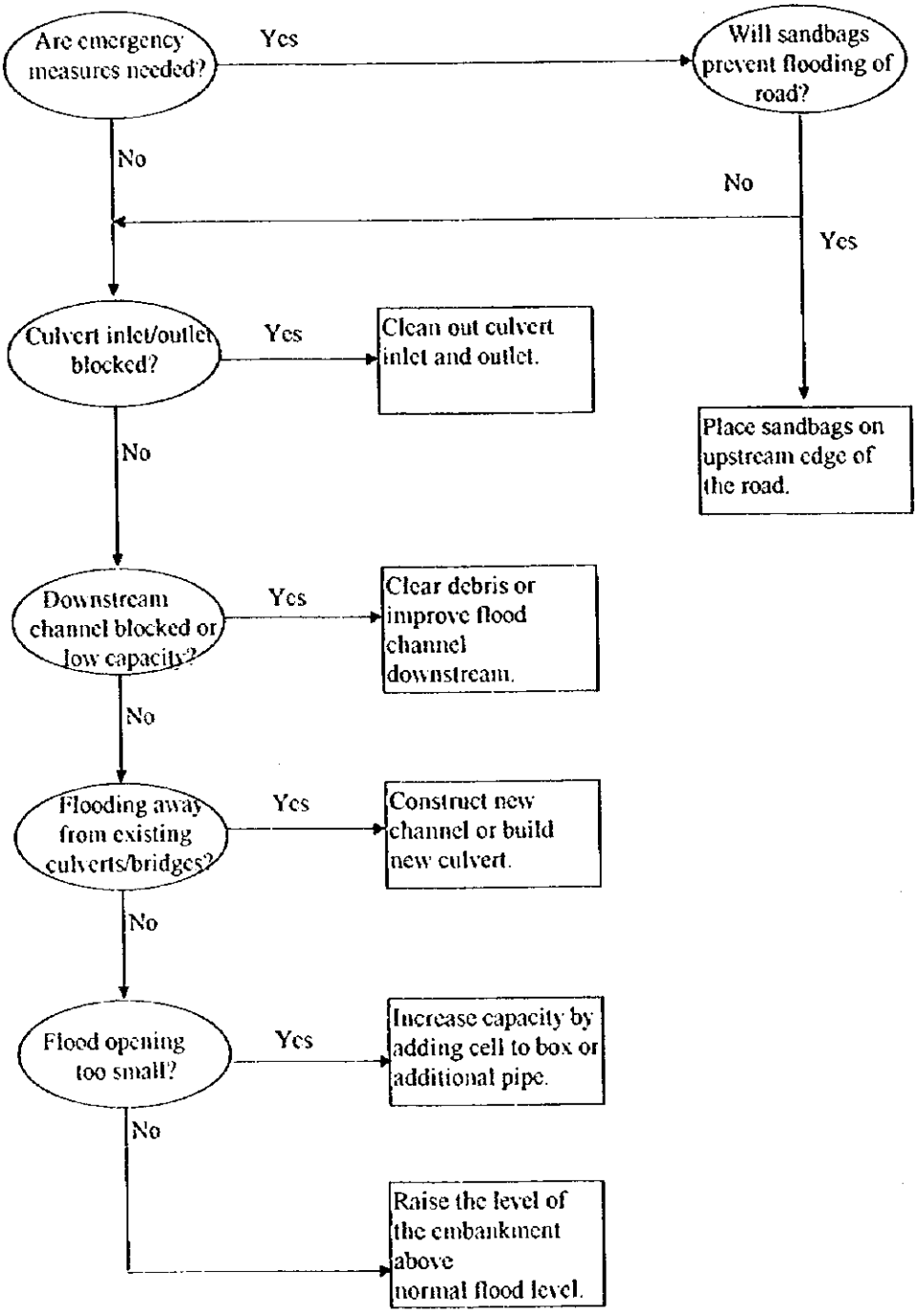


Fig.7.4.1 Selection of Repair Method for Submerged (flooded) Embankment

Collapse of Embankment

There are a number of causes of collapsed embankments and in all cases the damaged section will require to be refilled with suitable material and should be adequately compacted to achieve the design requirements.

Where the collapse has been caused by river scouring, the cost of the permanent solution to realigning the river should be compared with the other alternatives to decide on the optimum solution. This will depend on the budget availability.

Drainage options may be considered both to avoid flooding, preventing saturation of the embankment and also to lower the ground water level to maintain a dry subgrade under the embankment.

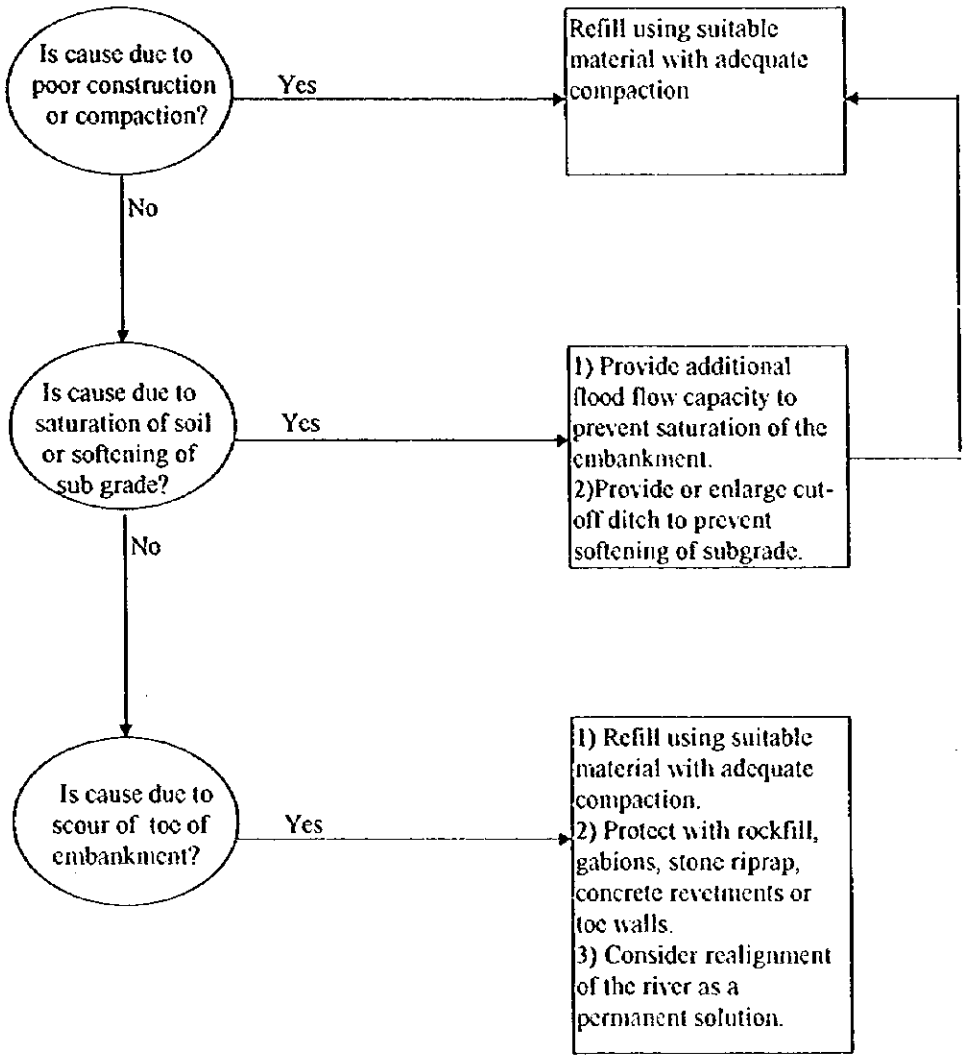


Fig. 7.4.2 Selection of Repair Method for a Collapsed Embankment

7.4.5 Construction Method

Downstream Improvements

This can be used to increase the downstream capacity. The river, stream or flood channel can be widened or regraded to provide additional flow capacity. Where regrading is considered, the design should ensure that adequate gradients can be achieved without extending the regrading to unreasonable lengths and so creating excessive construction costs.

The new works should be designed to prevent excessive scour and suitable scour protection works should be included where necessary.

Additional Culverts

Additional culverts are expensive to construct and may cause traffic disruption and so this method should only be used after careful consideration of all other options.

In general it will be suited where flooding occurs on a regular basis in a location where there is no existing culvert. Alternatives such as creating a flood channel parallel to the road to the nearest discharge point should be considered first.

Where it is decided that an additional culvert is the only solution, then a catchment area calculation should be carried out to confirm the required culvert size.

Increase Cross Section Area

This method is also expensive to construct and may cause traffic disruption and so this method should only be used after careful consideration of the situation.

The method is appropriate where flooding occurs at existing culverts and it has been identified as a lack of flow capacity. A catchment area calculation should be carried out to determine the required flood flow capacity taking account of the existing culvert size.

In some situations it may be possible to thrust bore a pipe or box through the embankment. This requires adequate land for construction of the culvert sections and for the thrust pits for jacks. It also needs a certain depth of cover to avoid major disruption to traffic.

In most circumstances, an additional pipe will be laid in an open trench or new box culvert cell in open excavation. In both cases the construction programme should be phased to minimise the disruption to traffic.

7.5 Shoulder

7.5.1 Damage Type

Table 7.5.1 defines each of the damage types and states the major effects of the damage.

Table 7.5.1 Damage Types for Shoulder- Definitions and Effects

Item	Damage Type	Effects of Damage
Shoulder	Washing Out	. loss of edge support to pavement. Further deterioration likely. . exposes lower pavement layers to possible softening due to water action. . if damage encroaches inside the safety fence, this becomes a safety hazard for motorists.

7.5.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out. For shoulder damage, the following supplementary surveys may be used:-

Table 7.5.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey		Remarks
		CBR	Cross Section	
Shoulder	Washing Out		❑	

Notes: ■ essential survey ❑ optional survey

1. CBR Tests

CBR tests are used to get information on the strength of the sub grade. These tests will be required where the design of overlay or reconstruction works is to be done. CBR tests may be carried out in-situ or in the laboratory.

2. Cross Section

Cross sections should be taken to assist with the evaluation of the problem and the design of remedial works.

7.5.3 Cause of Damage

The major causes of damage for the damage type listed in section 7.5.1 are summarised in Table 7.5.3.

Table 7.5.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Shoulder	Washing Out	. lack of positive edge drainage . poor edge compaction

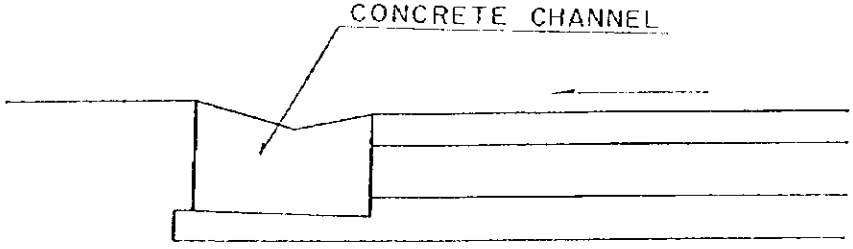
7.5.4 Design of Repair Work

Table 7.5.4 shows the repair methods for the damage type shown in Table 7.5.3.

Table 7.5.4 Repair Work for Shoulder

Damage Type	Repair Method	Purpose	Application
Washing Out	Refill	- to reopen the road by filling the cavity with suitable material, sandbags, rock or gabions	- cavity in shoulder
	Edge Drain with kerb shute or pipe drain	- to collect road surface water in edge drain preventing scour of shoulder	- low side of road
	Kerb with kerb shute or gullies and pipe drain	- to collect road surface water at kerb preventing scour of shoulder	- low side of road

Sketches showing edge drains and kerb details are shown overleaf.


CONCRETE CHANNEL

Selection of Repair Method

Urgent repairs may be considered when the road has been closed to traffic because of the damage. The only rapid repair method is to refill the void with suitable material ensuring proper compaction during the refilling.

If the problem is one that occurs on a regular basis, it may be possible to use positive drainage such as an edge drain or kerb to prevent the surface water from running over the edge of the carriageway and washing out the shoulder.

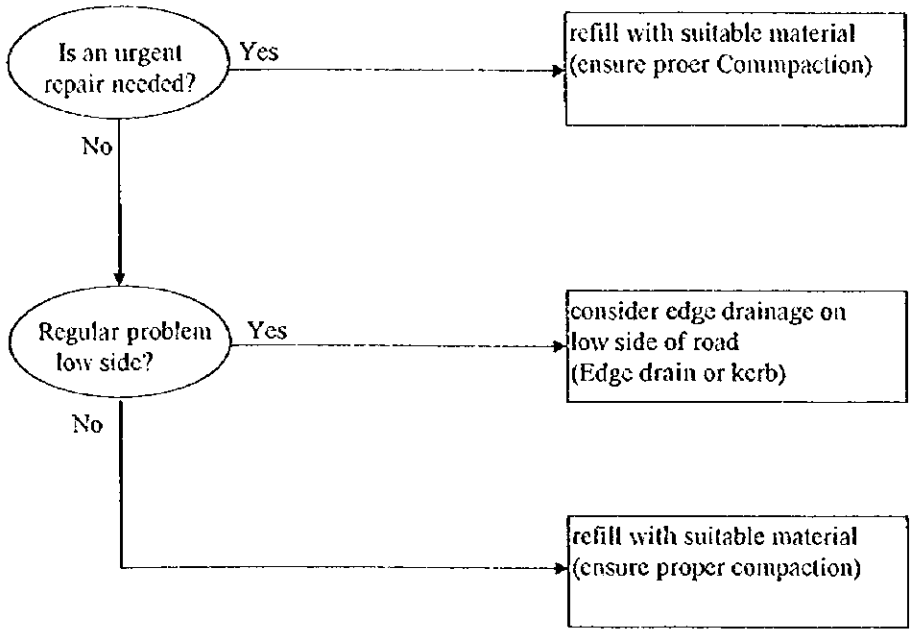


Fig. 7.5.1 Selection of Repair Method for Shoulder

7.5.5 Construction Method

Kerb or edge drain

This method should only be used where the damage occurs on a regular basis on the low side of the road. The positive drainage should be introduced over an adequate length to protect the length of shoulder at risk. The design should allow for discharging the water collected to a suitable river, stream or ditch via a pipe or shute system.

Kerbs may be either precast concrete laid on a mortar bed or an extruded asphalt kerb. The extruded kerb requires good preparation and quality control of materials but is easy to install on an existing pavement provided the equipment is available. The more traditional precast concrete kerb involves more work in a repair situation.

With kerbs, the surface water is carried on the carriageway adjacent to the kerb until it reaches a gully or outfall pipe or gully shute. With a channel, the surface water is carried in the channel adjacent to the dge of the road. The choice of kerb or channel needs to be examined for each situation as it will depend on the capacity requirements which are dependent on the local situation in terms of rainfall, road gradient and crossfall.

7.6 Slope

7.6.1 Damage Type

Table 7.6.1 defines each of the damage types and states the major effects of the damage.

Table 7.6.1 Damage Types for Slope - Definitions and Effects

Items	Damage Type	Effects of Damage
Cut slope	Landslide	• may cause serious problems for third parties • may close road to traffic long term • urgent countermeasures required
	Rock Avalanche	• road may be closed causing traffic disruption • side ditch and other concrete structures may be damaged, and cause drainage problems
	Collapse of Slope Protection	• causes poor countermeasure function for slope defects • rain water causes softening and weakening of the slope • may cause erosion, rock avalanche and landslide
	Cracking	• allows water to enter the slope and cause landslide and rock avalanche
	Slope Erosion	• road may be closed causing traffic disruption • side ditch and other concrete structures may be damaged, and cause drainage problems
Embankment Slope	Landslide	• road may be closed causing traffic disruption • side ditch and other concrete structures may be damaged, and cause drainage problems
	Collapse of Slope Protection	• may close road to traffic or create a hazard and disturb the traffic flow • side ditch and other concrete structures may be damaged, and cause drainage problems
	Slope Erosion	• shoulder and roadbed may collapse • may cause landslide • side ditch and other concrete structures may be damaged, and cause drainage problems

7.6.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out as shown in Table 7.6.2.

Table 7.6.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey		Remarks
		Boreholes	Cross Section	
Cut Slope	Landslide	■	■	
	Rock Avalanche	□	■	
	Collapse of Slope Protection		□	
	Cracking	□	■	
	Slope Erosion	■	■	
Embankment Slope	Landslide	■	■	
	Collapse of Slope Protection		□	
	Slope Erosion	■	■	

Notes: ■ essential survey □ optional survey

1. Boreholes

Boreholes are used to collect the geological information for the slope. This will include the soil types, samples for laboratory tests, Standard Penetration Tests carried out during the drilling and the ground water level. Laboratory tests provide additional information on the soil types, unit weight, cohesion, angle of internal friction which are all needed to carry out an analysis of the slope stability. The number of boreholes depends on needs of the study. For landslides, at least two boreholes should be drilled, whereas for embankment settlement one may be sufficient

2. Cross Section

Cross section surveys are carried out to collect information on the slope dimensions. At least three sections at twenty metre intervals shall be taken in the area of slope damage. The measurements will be drawn out to be used in the slope stability analysis.

7.6.3 Cause of Damage

The major causes of damage for each of the damage types listed in Chapter 7.6.1 are summarised in Table 7.6.3.

Table 7.6.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Cut Slope	Landslide	. too steep slope gradient . lack of drainage system . lack of berm and berm ditch . rain water and underground water runoff between cover soil and foundation rock . dip of rock or weathered rock tends to slide. . in winter seepage water freezes in layer joint causing sliding when it melts
	Rock Avalanche	. dip of rock causes rock fall . poor quality control of construction works . weathering rock causes rock fall . developing joint of rock . seepage water makes rock layer slippery
	Collapse of Slope Protection	. poor quality materials . lack of bearing capacity of structure. . caused by rock fall . lack of proper compaction of the surface allowing slope to crack. . unstable cut slope deforms and causes defects.
	Cracking	. slope too steep . poor quality materials . lack of drainage system on slope
	Slope Erosion	. slope too steep . poor quality materials . no protection of slope surface . runoff water, spring water and seepage water . weathering surface of slope . lack of proper compaction during construction.
Embankment slope	Landslide	. water running between natural ground and fill material . poor construction methodology . on talus cone or landslide area . slope too steep . lack of berm and berm ditch . lack of proper compaction of slope . lack of bearing capacity of lower layers
	Collapse of Slope Protection	. unstable embankment causes slope protection defects . poor quality fill materials . poor quality control of construction . weathering surface of slope . washing out underneath of embankment by river water
	Slope Erosion	. slope too steep . lack of drainage system . poor construction methodology or quality of materials . no protection, no vegetation on slope surface . runoff water, spring water and seepage water . water force of river and sea . weathering surface of slope . lack of proper compaction of surface soil causes surface landslide

7.6.4 Design of Repair Work

(1) Slope Repair Methods

a) Earthworks

- To set up the standard slope gradient, refer to Chapter 4.6 in the Evaluation and Repair Manual.
- When the cut slope gradient is too steep, carry out recutting or refilling to achieve the right gradient.
- When the embankment slope is too steep, make benching on the existing fill slope and refill to the right gradient.
- When the height of the cut slope is more than 15 metres, create a berm or berm ditch.

b) Drainage

- For cut slopes, set up ditches at the top and bottom of the slope and on the berms to collect the runoff water.
- For embankment slopes, set up the ditches at the shoulder to collect the road surface water.
- Table 7.6.4 shows the suitability of drainage provision for different soil types

Table 7.6.4 Suitability of Drainage Provision for Different Soil Types

Location of Drainage Provision	Soil type				Application
	Cutting Slope			Embankment Slope	
	Hard rock	Soft rock	Earth	Earth	
Top of slope	B	A	A	A	
On the berms	C	B	A	A	
Toe of slope	A	A	A	A	

A : very suitable
B : suitable
C : not suitable

c) Vegetation

Slope vegetation is used to prevent defects occurring and also to harmonise with the surrounding environment. However, vegetation is not suitable for the prevention of landslides. In selecting the vegetation method, consideration must be given as to whether the vegetation works efficiently in preventing erosion and collapse and also whether it is compatible with soil type. Table 7.6.5 shows the suitability of the different vegetation methods for each soil type.

Table 7.6.5 Suitability of Vegetation Methods for Different Soil Types

	Soil type				Application
	Cutting Slope			Embankment Slope	
	Hard rock	Soft rock	Earth	Earth	
Block Sodding	D	D	A	A	
Stripe Sodding	D	C	B	A	
Seed Packet Work	D	A	A	D	
Seed Spraying	D	B	A	A	
Tree planting	D	C	A	A	

A : highly recommended
B : recommended
C : difficult to recommend
D : not recommended

d) Structures

If the slope is unsuitable for vegetation and vegetation will not provide long term prevention of erosion, slope structures should be considered for long term countermeasure. Fig. 7.6.6 shows suitability of slope protection methods for each soil type.

Table 7.6.6 Suitability of Slope Protection Methods for Different Soil Types

	Soil type				Application
	Cutting Slope			Embankment Slope	
	Hard rock	Soft rock	Earth	Earth	
Stone riprap revetments	D	C	A	A	
Articulated concrete revetments	D	C	A	A	
Cylinder Gabon Wall	D	D	C	B	
Shotcrete	A	A	C	C	
Concrete Crib	A	A	A	A	

A : highly recommended
B : recommended
C : difficult to recommend
D : not recommended

e) Recutting in Rock Avalanche

Recutting is carried out to stabilize the existing cut slope. Recutting involves cutting back the slope to a flatter gradient to suit the rock structure. Where the instability is isolated, the pockets of unstable rock may be removed without recutting.

f) Protection for slope erosion and weathering

Erosion and weathering may cause a rock avalanche and the slope surface should be protected against them. Suitable slope protection works are as follows:-

- Drainage of surface water
- Vegetation
- Concrete or shotcrete cover

g) Rock Avalanche countermeasures

Countermeasures are as follow:-

- In situ concrete fixes and stabilizes the rock
- Rock net covers the unstable rock slope
- Retaining wall, stone masonry or mat gabion reduces the damage by rock avalanche
- Concrete crib or shotcrete covers the slope surface

The suitability of the countermeasures for different scales of rock avalanche is shown in Table 7.6.7. All loose and unstable rock should be removed before starting any repair works.

Table 7.6.7 Suitability of the Countermeasure for Different Scales of Rock Avalanche

Estimated size of falling rock		Large (1.0m dia.) few tons		Middle(0.4mdia.) few hundred kilos		Small few kilos	
type / Measure		toppling	under-cutting	toppling	under-cutting	toppling	under-cutting
Slope protection from erosion	Surface drainage	♦	♦	♦	♦	□	♦
	Shotcrete	□	-	♦	-	♦	-
	Vegetation	-	□	-	□	-	♦
Structural support	Foot protection	□	♦	-	-	-	-
	Concrete revetments	□	□	♦	♦	♦	♦
	Cribwork	□	□	♦	♦	♦	♦
	Rock Bolts	♦	□	-	-	-	-
Rockfall prevention device	Prevention net	-	-	-	-	♦	♦
	Prevention fence	-	-	-	-	♦	♦
	Retaining wall barrier	-	-	♦	♦	♦	♦

♦ Recommend
□ Suitable
- Not Suitable

Control of discharge water

The following two measures are applicable for controlling discharge water:-

- Prevention of runoff water from permeating into the ground using surface drainage or surface covering of vegetation.
- Lowering of ground water : a temporary repair would be the use of underground drainage by constructing horizontal drain holes.

h) Weight shifting

Weight shifting aims to keep the mechanical balance of a slope by removing or filling in some portion of the slope. Specific measures are given below:-

- Removal of all or part of the slide debris
- Removal of scarp portion
- Apply a counterweight by using earth fill, gabions or concrete walls

i) Structural support

A retaining wall may be used at the foot of a sliding slope or alternatively, a landslide prevention pile may be driven into the ground deeper than the slip surface in the middle of the slope.

j) Application of restoration measures for Landslides

Restoration measures can be selected from the various possible measures in Table 7.6.8.

Table 7.6.8 Restoration Measures for Different Geological Formations

Type of slope	Geology	Surface drainage	Horizontal drain hole	Earth removal	Counter weight	Retaining wall	Prevention pile
Cut slope	Rock	-	□	♦	♦	♦	□
	Weathered Rock	-	□	♦	♦	♦	□
	Alluvium	□	□	♦	♦	♦	♦
	Clayey soil	♦	□	-	♦	♦	□
Fill slope	Alluvium	-	□	-	♦	♦	♦
	Clayey soil	-	-	-	♦	♦	□

♦ Recommend
□ Suitable
- Not Suitable

(2) Selection of Repair Method

(a) Slope Erosion

Fig. 7.6.1 shows the flow chart of selection of repair method.

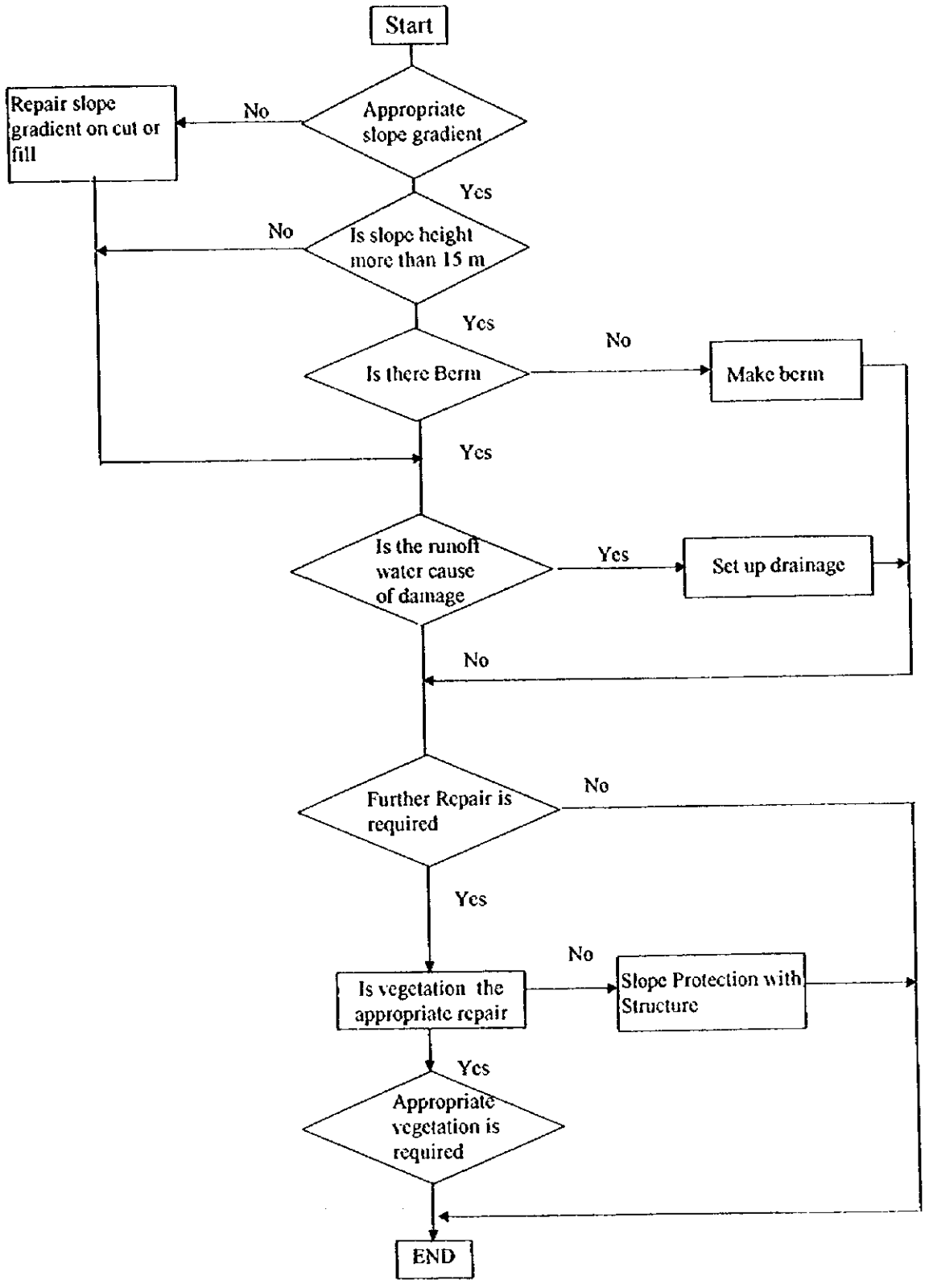


Fig. 7.6.1 Selection of Repair Methods for Erosion

(b) Landslide

Fig. 7.6.2 shows the flow chart for the selection of suitable temporary and permanent repairs for landslides.

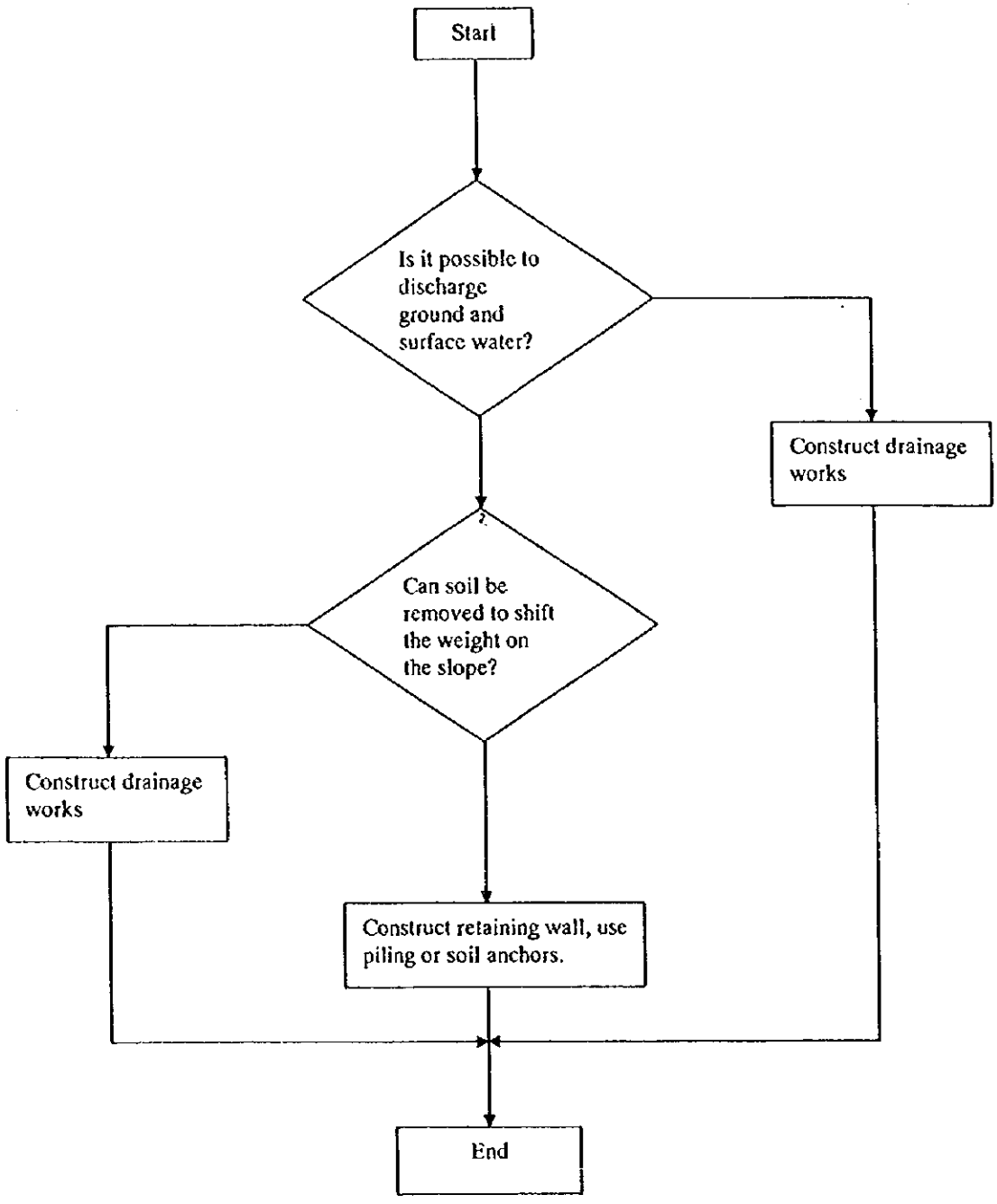


Fig. 7.6.2 Selection of Restoration Measures for Landslides.

7.7 Retaining Wall

7.7.1 Damage Type

Table 7.7.1 defines each of the damage types and states the major effects of the damage.

Table 7.7.1 Damage Types for Retaining Wall - Definitions and Effects

Items	Damage Type	Effects of Damage
Retaining Wall	Cracking	. risk of collapse if left
	Settlement	. risk of collapse . risk of retained material spilling onto the road
	Collapse	. wall and retained material may block road . if material is left unsupported, risk to retained slope

7.7.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out as shown in Table 7.7.2.

Table 7.7.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey			Remarks
		Boreholes	CBR	Cross Section	
Retaining Wall	Cracking		□	□	
	Settlement		■	□	
	Collapse	□	□	■	

Notes: ■ essential survey □ optional survey

1. Boreholes

Boreholes are used to determine ground water levels and to get soil samples to determine design parameters or to check strength characteristics.

2. CBR Tests

CBR tests are used to get information on the strength of the sub grade. CBR tests may be carried out in-situ or in the laboratory.

3. Cross Section

Cross sections should be taken to assist with the evaluation of the problem and the design of remedial works.

7.7.3 Cause of Damage

The major causes of damage for each of the damage types listed in section 7.7.1 are summarised in Table 7.7.3.

Table 7.7.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Retaining Wall	Cracking	. vehicle impact . insufficient wall thickness . excessive build up of water behind wall due to lack of or blocked weep holes/drainage
	Settlement	. softening of sub grade due to ground water, flood or lack of drainage . lack of compaction below foundations
	Collapse	. vehicle impact . insufficient wall thickness . inadequate foundations . landslide, major slip or rockfall . excessive build up of water behind wall due to lack of or blocked weep holes/drainage

7.7.4 Design of Repair Work

Table 7.7.4 shows the major repair methods for each of the damage types shown in Table 7.7.3.

Table 7.7.4 Repair Methods for Retaining Walls

Damage Type	Repair Method	Purpose	Application
Cracking	Sealing/filling	- to prevent water penetration and regain structural integrity	- minor cracking with minimal displacement
	Demolish and rebuild	- to regain adequate wall strength to support the retained material	- where wall thickness is too thin - large cracking unsuitable for sealing/filling
	Clear/renew drainage	- to prevent the build up of water pressure behind the wall	- minor cracking caused by blocked or lack of weepholes/ drainage material behind the wall
	Strengthen wall with additional material	- to regain adequate wall strength to support the retained material	- where wall thickness is too thin
Settlement	Strengthen sub grade	- to provide a subgrade capable of supporting the wall	- localised problem where this method is the best economic option
	Demolish and rebuild	- to regain adequate wall strength to support the retained material	- long lengths effected; extensive ground treatment or drainage works may be necessary
Collapse	Demolish and rebuild	- to regain adequate wall strength to support the retained material	- collapsed sections where the wall can no longer support the retained material

Selection of Repair Method

For retaining walls there are a limited number of repair methods and the choice is usually fairly clear having established the severity and cause of the defect.

Cracking

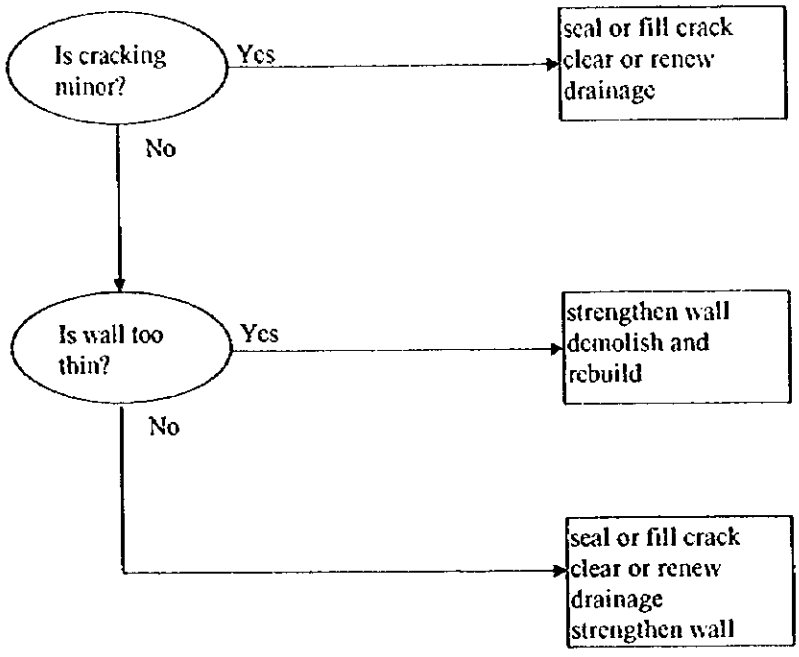


Fig. 7.7.1 Selection of Repair Method for a Retaining Wall with Cracking

Settlement

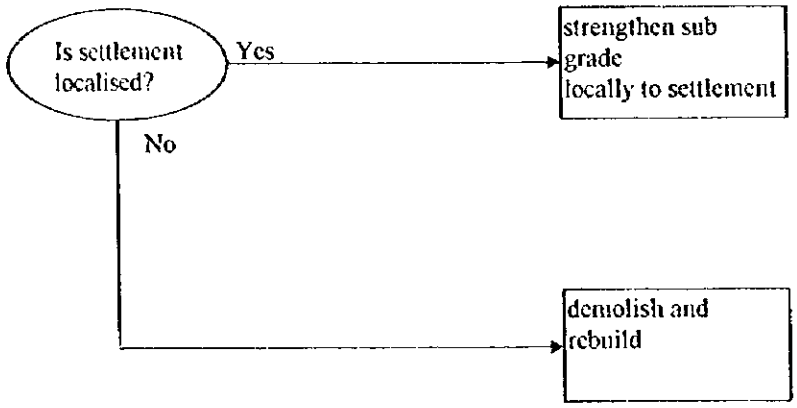


Fig. 7.7.2 Selection of Repair Method for a Retaining Wall with Settlement Problems

Collapse

For a wall that has collapsed, the only solution is to rebuild the collapsed section. Where the cause is other than vehicle impact, additional measures may be needed in addition to rebuilding to avoid another collapse e.g. additional drainage, stabilisation of the retained material.

7.7.5 Construction Method

Sealing and Filling

This is only suited to situations with minor cracking and minimal displacement. Cracks should be sealed or filled with material in keeping with the original construction materials. Cement mortars may be used in many situations.

Strengthen Subgrade

Before this method is used, any subgrade problems should be identified from supplementary surveys. Where water is softening the subgrade, suitable drainage measures should be introduced to prevent further deterioration.

The subgrade material should be removed in short sections so as not to introduce excessive stress on the wall foundation. Suitable material should then be placed under the foundation and compacted in layers up to the underside of the foundation. Where compaction is unlikely to be achieved under the foundation, consideration should be given to replacing the softened subgrade with concrete which can be placed and vibrated to prevent voids forming under the foundation. The base of the excavated subgrade should be firm and free from loose material.

Where practical, pressure grouting may be considered as a quick method to improve the subgrade strength.

Demolish and rebuild

All loose material should be removed so that the remaining sections of wall are in a sound structural condition. It is important that the new section of wall is keyed into the old sections to provide structural continuity in the finished wall.

Wherever possible, identical materials should be used to rebuild the wall both from an aesthetic and a structural integrity point of view.

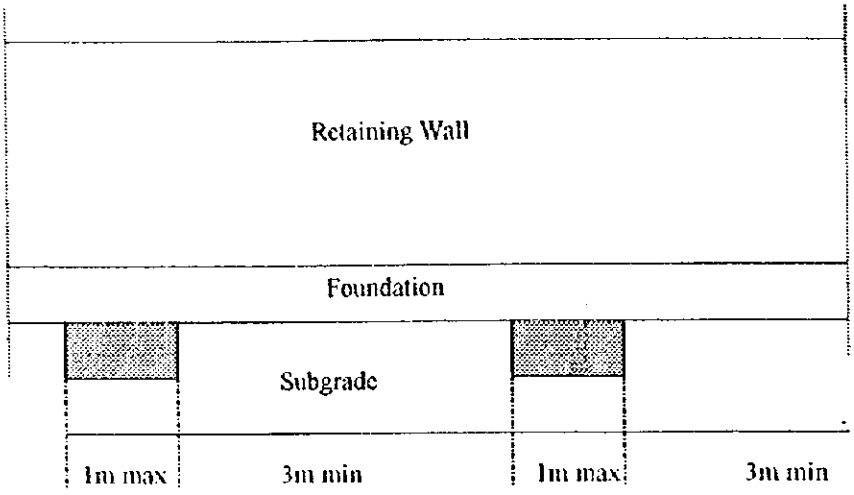


Fig. 7.7.3 Replacement of Weak Sub Grade

7.8 Drainage

7.8.1 Damage Type

Table 7.8.1 defines each of the damage types and states the major effects of the damage.

Table 7.8.1 Damage Types for Drainage - Definitions and Effects

Item	Damage Type	Effects of Damage
Side Ditch	Accumulation of debris	. decreases the section area and reduces drainage capacity . overflow water occurs weakening road bed, and causes reduction in bearing capacity . causes washing out of shoulder and slope
	Settlement	. causes accumulation of debris and collapse . reduced drainage capacity
	Collapse	. reduced drainage capacity . allows water to enter cracks and causes weakening of the road bed, shoulder and slope . may cause traffic accident
Gully	Accumulation of debris	. overflow water may cause traffic accident . overflow water may cause landslide . reduces drainage capacity
	Settlement	. cause of collapse . may cause traffic accidents
	Collapse	. may cause traffic accidents . allows water to enter cracks and causes weakening of the road bed . runoff water causes landslide . reduce drainage capacity
Culvert	Accumulation of debris	. disturbs the flow of water in culvert . lack of cross section area; overflow water may cause landslide . reduce drainage capacity
	Settlement	. cause of accumulation of debris . may cause traffic accidents
	Collapse	. may cause traffic accidents . allows water to enter cracks and causes weakening of the road bed . runoff water causes landslide . reduces drainage capacity

7.8.2 Supplementary Surveys

In order to confirm the cause of the damage and to collect data to assist with the design of the repair, supplementary surveys may be carried out. For drainage, the following supplementary surveys may be used:-

Table 7.8.2 Supplementary Surveys

Item	Damage Type	Supplementary Survey		Remarks
		Boreholes	Cross Section	
Side Ditch				
Gully				
Culvert	Accumulation of debris		□	
	Settlement	□	□	
	Collapse	□	□	

Notes: ■ essential survey □ optional survey

1.Boreholes12

Boreholes are used to determine the ground water levels and to get soil samples to determine design parameters or to check strength characteristics.

2.Cross Section

Cross sections is used to check the incline of the culvert and the depth of soil cover above the culvert. It will also be used to calculate the drainage capacity and design the repair method.

7.8.3 Cause of Damage

The major causes of damage for each of the damage types listed in Chapter 7.8.1 are summarised in Table 7.8.3.

Table 7.8.3 Major Causes of Damage for each Damage Type

Item	Damage Type	Major Causes of Damage
Side Ditch, Gully and Culvert	Accumulation of debris	. lack of frequent maintenance to clean the debris . additional inspections required where traffic numbers increase at holiday season, where windy or swampy area creates quick earth movement.
	Settlement	. lack of bearing capacity
	Collapse	.excessive load by heavy traffic .damaged by rock fall .poor materials .weak foundation

7.8.4 Design of Repair Work

(1) Repair Methods

Table 7.8.3 shows the repair methods for each damage type.

Table 7.8.3 Drainage Damage and Repair Method

Damage Type	Damage items		Repair Method
Accumulation of debris	Side ditch Drain pipe Gully	Muddy Accumulation of debris	■ Removal of debris by jet washer and sucker vehicle ■ Removal of debris by workman
	Slope ditch	Muddy Accumulation of debris	■ Removal of debris by jet washer and sucker vehicle ■ Removal of debris by workman
	Culvert	Muddy Accumulation of debris	■ Removal of debris by back-hoe and belt-conveyer ■ Removal of debris by jet washer ■ Removal of debris by workman ■ Dam or screen stops debris flowing out
Settlement			■ Relining of drainage base concrete ■ Cement mortar grouting works ■ Partial Reconstruction works
Collapse	Crack	Small scale affect to the structure	■ Coating (Cement Paste, Synthetic Resin)
		Medium scale affect to the structure	■ V shape cutting into crack and sealing / filling
		Large scale affect to the structure	■ Partial concrete works required ■ Reinforcement works help to increase the strength
	Gap Collapse		■ Filling by use of synthetic resin or cement mortar to prevent water leakage ■ Cement mortar grouting and chemical grouting
	Overall Collapse		■ Reinforcement works help to increase the strength ■ Relining by reinforced concrete ■ Construction of alternative culvert

(2) Selection of Repair Method

(a) Accumulation of Debris

Fig. 7.8.1 shows the flow chart for the selection of repair method for accumulation of debris.

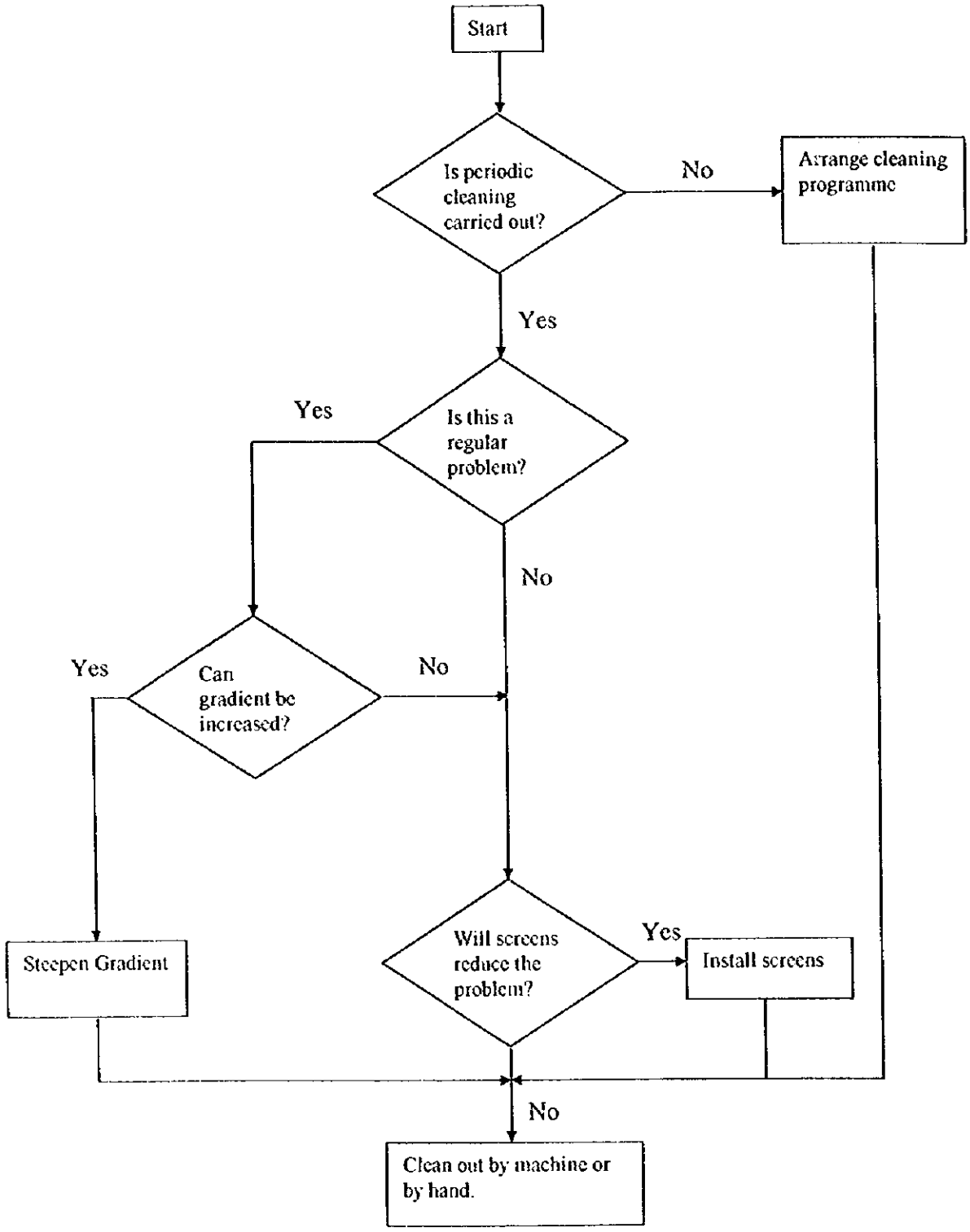


Fig. 7.8.1 Selection of Repair Method for Accumulation of Debris

(b) Cracking

Fig. 7.8.2 shows the flow chart for the selection of a repair method for cracking.

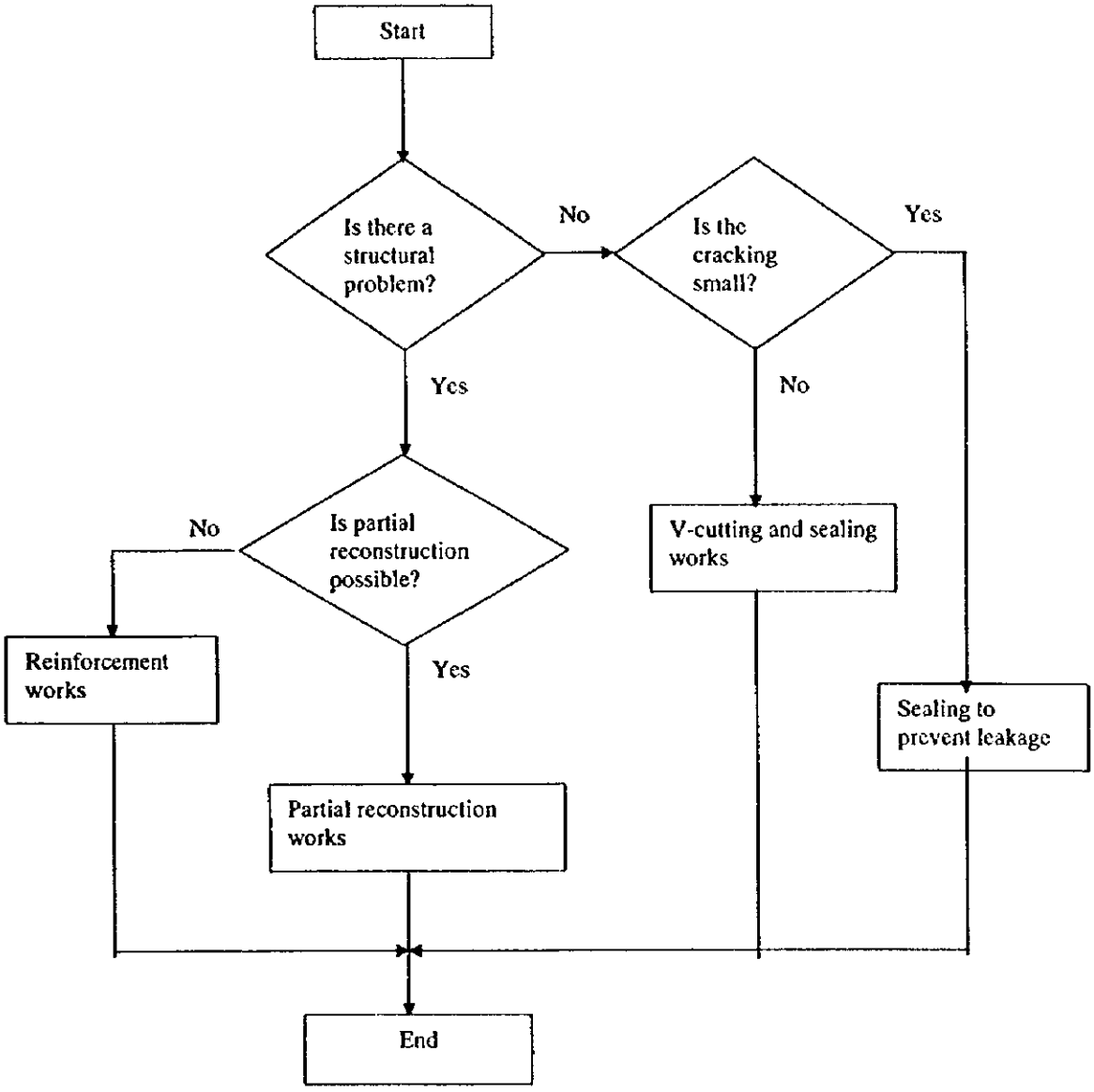


Fig. 7.8.2 Selection of Repair Methods for Cracking

Settlement and Collapse

Fig. 7.8.3 shows the flow chart for the selection of repair methods for settlement and collapse.

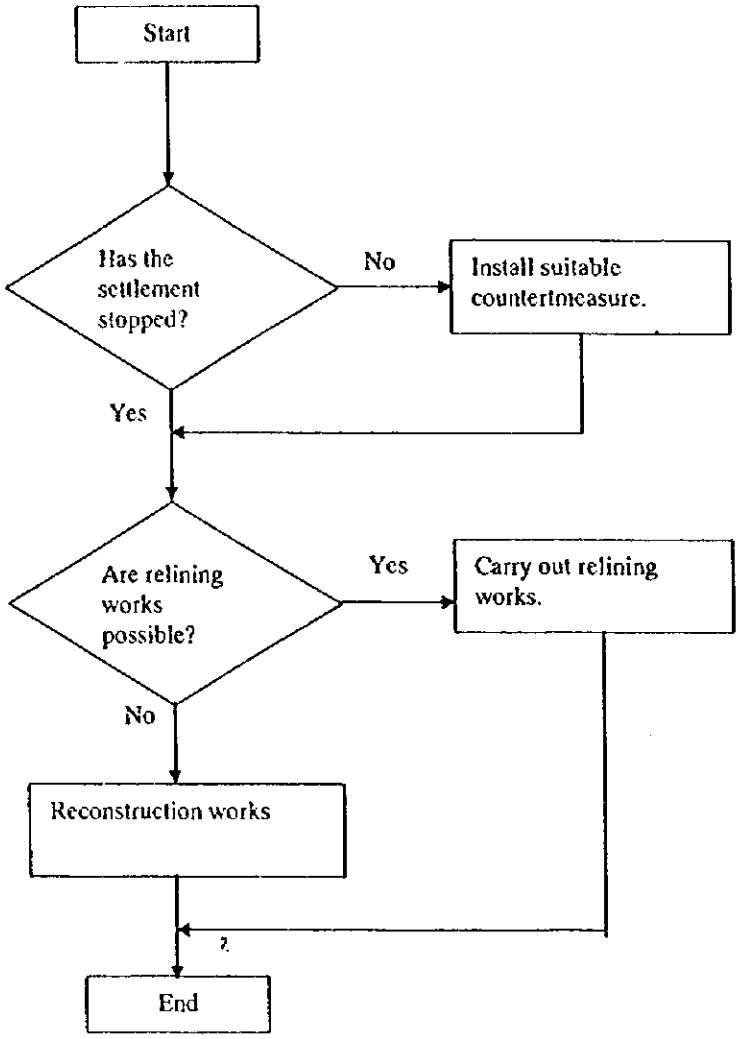


Fig. 7.8.3 Selection of a Repair Method for Settlement and Collapse

7.8.4 Construction Methods

1) Repair Method for Accumulation of Debris

- It is important to remove the accumulation of debris periodically to suit the regional weather conditions and seasons of the year.

In some dry areas, dust will accumulate such that when it does rain, the capacity of the drainage system is inadequate. In other areas, the rainfall is sufficient to allow the drainage to

be self cleaning, provided the sizing and gradient were correctly designed and constructed. The frequency of cleaning needs to be adjusted to suit these climatic variations.

- A sediment trap shall be set at the entrance of drainage works to prevent the flow of sediment into the permanent works.

Alternative ways of removing the mud and debris are as follows:-

- Manual Labour

Where labour is available, the amount of debris is not too great and the size of the pipe or culvert is accessible, this can be an effective way of clearing debris.

- Small Machine

Where the amount of debris is large and the size of the pipe or culvert will allow access, a small machine such as a back hoe will be more efficient than manual labour.

- Gully Sucker and Jet Spray

This machine is ideally suited to cleaning gullies, ditches, small pipes and kerb channels. It is clean, fast and efficient. Independent jet spraying equipment may also be used where the combined vehicle cannot gain access to ditches and small pipes.

The above points are summarised in Table 7.8.4.

Table 7.8.4 Methods for Cleaning the Accumulation of Debris

Item	Shape of Cross Section (w x h)	Manual Labour	Combined Gully Sucker and Jet Spray	Jet Spray	Small Machine
Side Ditch		♦	♦	♦	♦
Gully		♦	♦	♦	□
Culvert	<1.0m x 1.0m	□	♦	♦	□
	1.0m x 1.0m - 3m x 2.5m	♦	□	♦	♦
	>3m x 2.5m	□	□	♦	♦

♦ Suitable □ Not Suitable

- Cleaning Programme

The frequency and timing of the cleaning of drainage facilities shall be based on the following conditions:

- The climatic conditions in the region can greatly affect the amount of debris collecting at the drainage facilities. Local knowledge of the seasonal variations, the rainfall, snow and dry conditions shall be used to determine the frequency of the cleaning programme. Areas where high rainfall or high surface run off from snow is expected, should be cleaned out before the wet season to prevent the risk of flooding or scour. On occasions, they may need cleaning out during the wet season as well.

- The road conditions and traffic flow volume should also be taken into account, particularly where the traffic volume increases seasonally.

- Areas where severe winds are known to blow sediment and exposed coastal areas need to be monitored carefully.

The recommended minimum frequency for cleaning the drainage facilities is shown in Table 7.8.5.

Table 7.8.5 Minimum Frequency for Cleaning Drainage

Item	Frequency
Side ditch	More than once per year
Gully	2 times per year or as required because of climatic conditions
Culvert	1 time per year or as required by climatic conditions

Countermeasures against the Accumulation of Debris:-

- Scour Protection Works
  At the inlet area of a culvert, this will prevent the accumulation of the scoured material in the culvert or at the inlet and so avoid the risk of flooding. At the outlet areas for culverts or on bends in ditches, such works will prevent the channel from blockage and again will prevent the risk of flooding.

- Weirs and Screens
  Preventing the flow of debris by the construction of weirs or screens will keep the downstream sections clear. The locations of such works need to be carefully selected in relation to the topography and geology. This method requires careful monitoring of the amount of debris being collected at the weir or screen and regular cleaning out to maintain full flow capacity.

- Channel Works
  Channel improvements should always be considered to maintain or improve flow capacity or to increase the channel gradient to increase the water velocity and hence the self cleaning ability. These works can be expensive and should be considered very carefully in terms of the benefits they will bring in relation to the cost of the works.

(2) Repair Methods for Settlement

- Where the foundations of drainage facilities are washed away by water erosion, the cavity shall be filled with cement mortar or concrete.
- Where the bearing capacity of a footing is insufficient, the ground shall be strengthened using cement mortar or chemical grouting.
- Where the settled structure can be reinstated this should be done using materials in accordance with the original design.
- Where reinstatement is not possible, the structure shall be reconstructed.

(3) Repair Methods for Cracks and Spalling

- Where there are small cracks, the cracks shall be coated with cement paste or synthetic resin to prevent water leakage.
- Where there are large cracks, the cracks shall be cut into a V-shape and shall be filled with resin mortar.
- Where concrete is spalling from the structure, the spalled area should be cut back to sound concrete, and depending on the size of the works, resins or concrete will be applied to the surface and used to fill the void.

(4) Repair Method of Damaged Concrete Culvert

- Where the damaged concrete can be repaired and the cross section can be reduced without affecting the operation of the culvert, additional concrete is constructed inside the existing culvert to form a new lining and to give additional strength
- Where it is not possible to reduce the cross section and hence the flow capacity, the concrete may be strengthened by the addition of steel plates to the inside of the culvert.
- Where strengthening is not possible, the structure must be reconstructed.

(5) Repair Method at a Construction Joint

- Where a construction joint is open, the gap shall be filled with cement mortar, concrete, synthetic resin or cement mortar with synthetic resin.
- Where there is difference in level at the construction joint and the foundation needs to be improved, ***the parts are repaired by mortar or chemical grouting***.
- ***Reconstruction by jointing or water-proofing.***

Table 7.8.6 shows a summary of the repair methods for each type of drainage facility.

Table 7.8.6 Summary of Repair Methods for the Different Drainage Facilities

Drainage Item / Repair Method	Side Ditch	Gully	Culvert
Cracking			
- coating			
- cement paste	♦	♦	♦
- synthetic resin	♦	♦	♦
- v cut and synthetic resin and mortar	♦	♦	♦
Spalling			
- partial replacement with concrete	♦	♦	♦
Damaged Concrete			
- additional reinforced concrete			♦
- steel plate			♦
- reconstruction	♦	♦	♦
Filling			
- mortar	♦	♦	♦
- synthetic resin			♦
Difference in Level			
- mortar grouting			♦
- chemical grouting			♦

♦ Suitable Not Suitable

CHAPTER 8

ENVIRONMENTAL STUDY

CHAPTER 8 ENVIRONMENTAL STUDY

8.1 General

In this road maintenance study project, a preliminary road survey by visual inspection was, at first, conducted for the national roads of approximately 2 000km in total. Based on the results of the preliminary survey, 40 detailed survey sections approximately 40km long were chosen for further study. Then, 20 typical sections were selected for maintenance and repair design. The Environmental Study was performed for the 20 sections in accordance with the environmental policy of Turkey and the JICA Guideline, which provide the following principal objectives:

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

8.2 Environmental Laws and Administration in Turkey

8.2.1 Laws and Regulations

The Environmental Law was enacted in 1983 for prevention of air and water quality contamination as well as providing fundamental regulations to control noise and solid waste. Following the enactment of the Environmental Law, the following regulations were passed in turn:

- The Environmental Pollution Prevention Fund Regulation (1985)
- The Air Quality Regulation (1986)
- The Noise Control Regulation (1986)
- The Regulation concerning the Establishment of Guilt in Fines to be Levied on Ships and other Marine Vessels
- The Procedures for Levying Fines and Receipts to be Issued (1987)
- The Water Pollution Control Regulation (1988)

And in February 1993, the Environmental Impact Assessment (EIA) Regulation was enacted, which placed all projects under an obligation to implement environmental studies and obtain MOE's approval. The Regulation stipulates that a Preliminary EIA and EIA is to be performed depending on size and nature. Meantime, a Bill has been submitted to Parliament to further strengthen the Environmental Law enacted in 1983, imposing severer penalties. Turkish may need changing.

In June 1997, the Regulation was further revised on various points as follows;

- It is now required to hold one public participation meeting during the course of the

Preliminary EIA as required in EIA.

- Sensitive Area List for EIA is deleted in the revised regulation.
- A Public Participation meeting shall be announced in one local and one national newspaper at least 3 days before the meeting is to be held.
- In submission , approval and validity of EIA reports, a more precise programme is stipulated.

The Air Quality Protection Regulation shows the guideline for controlling exhaust gas of every kind. The Turkish Standards TS-4236 and TS-5648 stipulate the standard values of exhaust gas from vehicles and the testing methods. All vehicles registered are now required to receive an examination of exhaust gas emission in a car safety test at specified stations once every one to two years. In case of Ankara Municipality, the Ankara City Environmental Foundation issues the certificate. If any car fails a heavy fine will be levied on the offender.
For noise control in the case of residential areas, the basic criterion are set at 35-45 dBA depending on the location of the residential area and the time of day, for which the Regulation stipulates zone definitions and a time range:

		35~45 dB (A)
Day Time	06:00---19:00	±0
Evening Time	19:00---22:00	-5
Night Time	22:00---06:00	-10

The maximum noise level is decided for each vehicle type and definitive standards are available for the methods of measurement and evaluation in TS-4236.

8.2.2 Administration

In Turkey, the Department of Environment was first established in 1978 as an undersecretariate to the Prime Ministry. It functioned as a simple coordination body but was upgraded to the Ministry of Environment (MOE) in 1991. MOE has now about 600 staff with 3 General Directorates; Environmental Protection, EIA and Pollution Control and Prevention. Moreover, 33 Area Directorates of Environment are established under the jurisdiction of Governors.

The General Directorate of Highways (KGM) has the Environment Impact Assessment (EIA) Division (EIAD) under the Department of Survey and Design responsible for the environment An Environment Committee was set up within KGM 5 years ago but EIAD was officially established in April 1995. At present, EIAD is operating with staff in the fields of environmental engineering, agriculture, archaeology and biology under the control of the Division Director. In the future, it will be composed of 42 staff to operate under the Director.

8.2.3 EIA Procedure

By the Environmental Impact Assessment Regulation enacted in 1993 and revised in 1997, all the departments responsible for projects are obliged to conduct an environmental study and obtain

approval from MOE. For KGM which is responsible for highway and bridge projects, however, there are some differences between new construction and, repair and rehabilitation as shown in Fig. 8.1. Direct application to MOE is required for new construction and for implementation of the EIA regardless of its size, and for repair and rehabilitation, basically only the Preliminary EIA is required to be implemented according to the procedures as stipulated by the EIA Regulation as shown in Fig. 8.2 and Fig. 8.3 respectively. In the revised Regulation, it is stipulated that one public hearing shall be performed during both the Preliminary EIA and EIA processes. Projects can be commenced in principle after obtaining approval of the Provincial Directorates.

In a few years time, a Qualification system may be adopted to perform and submit the official EIA study reports for governmental approval, by which only qualified and registered agencies and bodies are allowed to prepare EIA reports.

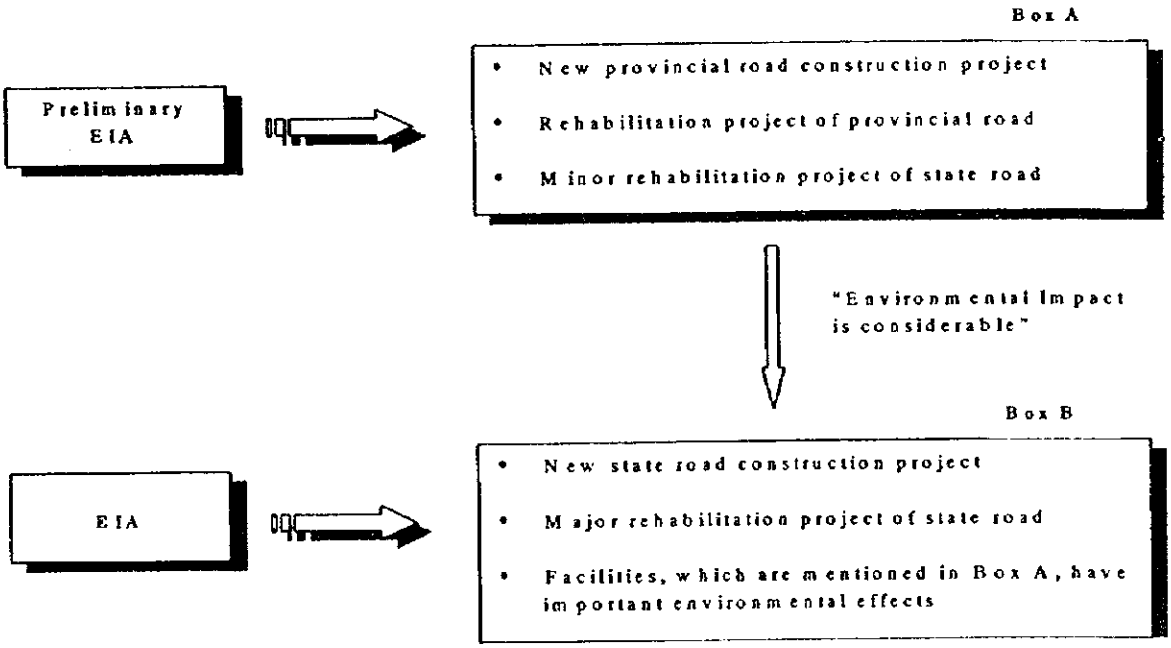


Fig. 8.1 Application of Preliminary EIA and EIA

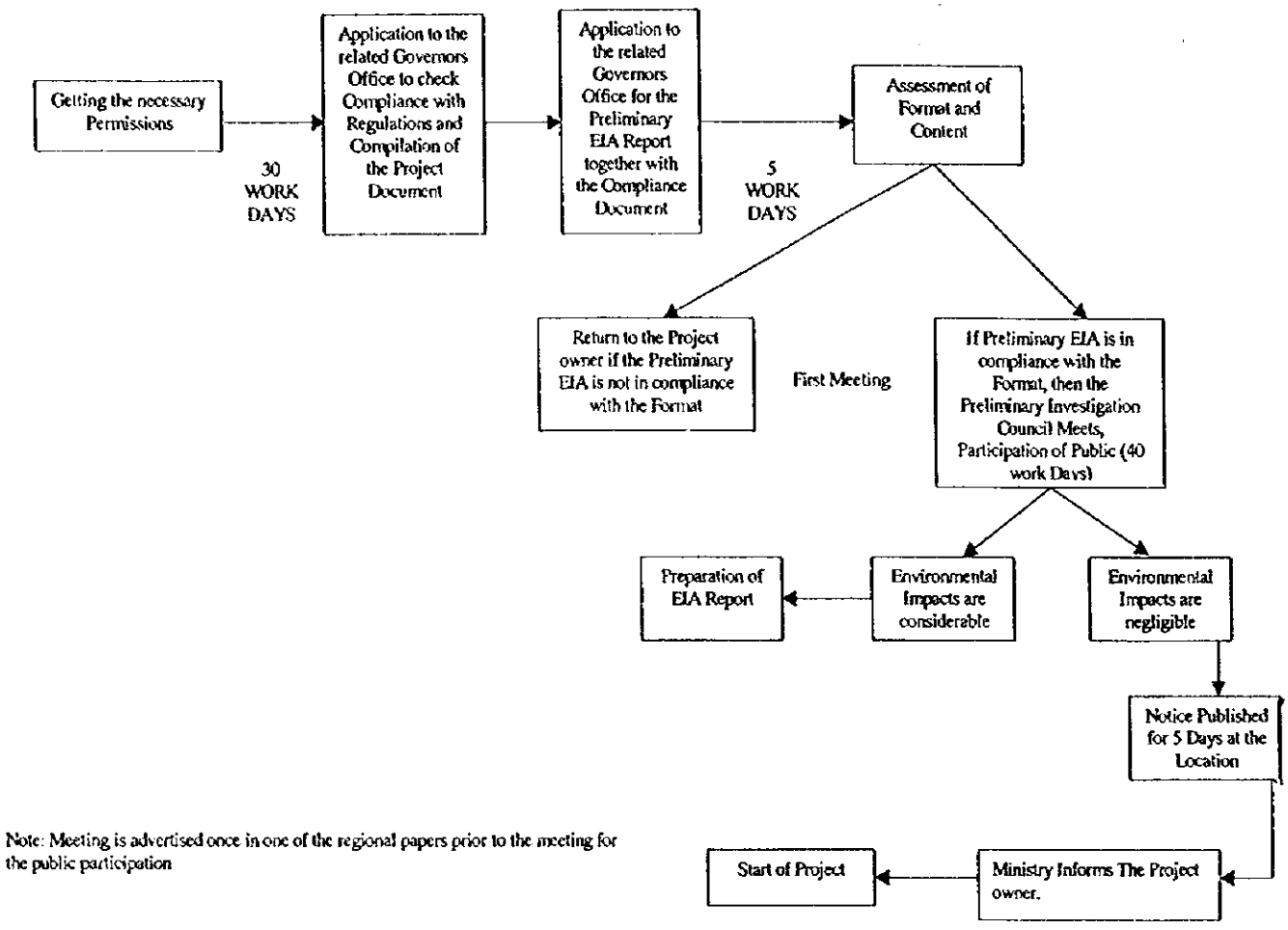


Fig. 8.2 Preliminary EIA (Environmental Impact Assessment) Procedure (4-6 Months)

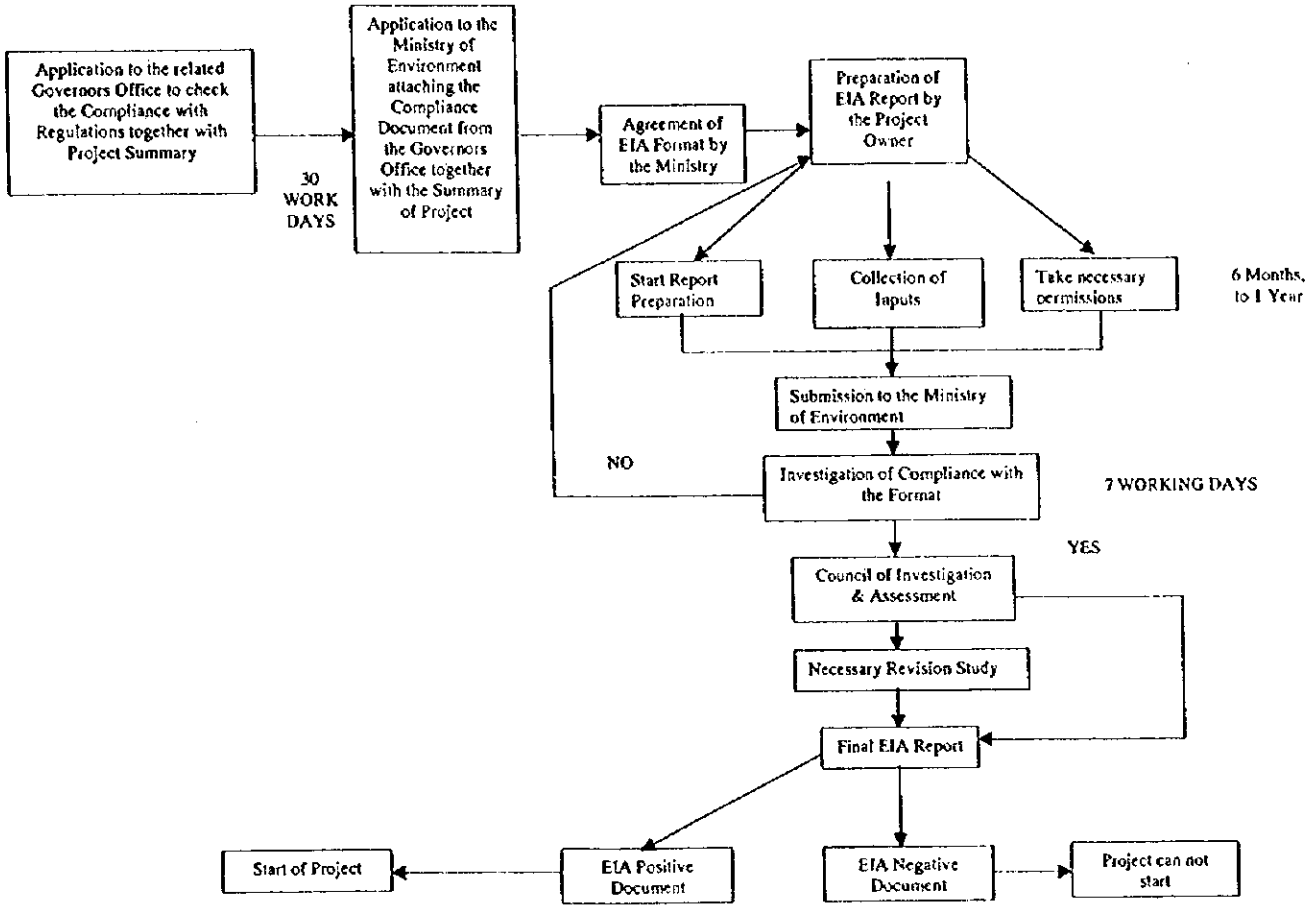


Fig. 8. 3 EIA (Environmental Impact Assessment) Procedure (6-8 Months)

8.3 General Environmental Characteristics of Turkey

8.3.1 Geographic Conditions

Turkey comprises some 779 000 square kilometers, located between Europe and Asia, which serves as a bridge between three continents, and is surrounded on three sides by seas with substantially different characteristics. A large variety of climatic zones co-exist due to its topography.
In today's Anatolia there exist 5 main climatic regions. That is; a rainy, humid and mild climate in the North, especially north of the Black Sea mountain range; a type of Siberian climate with cold and dry winters in the East; a hot and dry, desert-like climate in the Southeast; a climate with hot and dry summers and cold and snowy winters in the interior regions; and a Mediterranean climate with hot and dry summers and rainy winters in the West and Southwest.

Turkey is, and has been for a long time, located in the Palearctic zone. For this reason, its current bio-geographic composition and structure may be seen as representative of Palearctic flora and

fauna. However, especially in the Southeast and East, the influence of oriental and Ethiopic (African) elements are observable although this influence diminishes as one goes north.
In the Northeast, there are examples of cold steppe and even Siberian species. Mountains are traversing Anatolia and give the impact of this geography on the evolution of living things:
There are a number of mountain ranges in Anatolia, which constitute effective barriers against the geographical diffusion of living things, which therefore become significant in geo-zoological analyses.
The most important of such barriers are the eastern Taurus mountains, which separate the southeastern Anatolia region from eastern Anatolia, with its cold and dry steppe characteristics; the western Taurus Mountains which separate the Mediterranean littoral with its Mediterranean climate from the interior region of Anatolia with its dry, steppe climate; the Black Sea range which separates the mild and rainy Black Sea coastline from the dry region of the interior and from the cold and dry eastern Anatolian steppes; a series of mountains which cut across Anatolia laterally (Binbo-ga, Munzur, Kargasekmez Mountains, etc.) that constitute the Anatolian diagonal and separate eastern Anatolia from western and Central Anatolia, and, in fact, divide the European continent at its southern limit from all of Asia and Africa.

The Bosphorus and the Dardanelles also constitute effective obstacles to the diffusion of land and fresh water animals. Of secondary importance are the partial barriers constituted by Dinar Baba Dag, etc. which divide the Aegean region with its Mediterranean climate and Central Anatolia characterized by its dry steppe climate.

8.3.2 Present Conditions of Environmental Conservation in Turkey

Seas surround Turkey on three sides. The Black Sea to the north, which had until recently been a rich environment for sea life, is unfortunately in the process of rapid decay, due in part to the pollution from the less developed littoral countries, but especially because of the industrial waste deriving from central European discharges into the Danube, which deposits into the Black Sea.
The Marmara Sea, which connects the Black Sea with the Mediterranean, is also rapidly losing its viability due to the urbanization and industrialization on its coastline.
The Aegean Sea to the West continues to remain clean despite some local pollution in the Izmir area.
The Eastern Mediterranean Sea still preserves its environmental cleanness and species diversity, although this diversity is not as great as in other regions.

Turkish Governments have come to the understanding that the preservation of the natural ecology in Anatolia, and thereby the environmental conservation of many species such as animals, birds, natural forests, other vegetation and etc., in their natural habitat is most important.
For the said purpose the following laws and treaties have been enacted;

* National Parks Law
* Forest Law
* Land Hunting Law
* Aquatic Products Law
* Law to Protect Cultural and Natural Resources

* Decree-Law on Special Environmentally Protected Area
* International Treaty concerning the Protection of Birds
* Treaty to Protect European Wild life and its Habitats
* RAMSAR Convention

8.3.3 Nature Preservation

The followings are the main categories to protect biological diversity in Turkey.

(1)National Parks

The first national park in Turkey was established in 1958. Since then their numbers have increased to twenty-one. Some of these parks, which were initially established for archeological and historical purposes are at the same time rich habitats where biological diversity is being protected. The regional distribution of national parks is as follows: Mediterranean-6, Central Anatolia-5, Marmara-3, Black Sea-3, Aegean-2, Eastern Anatolia-2. Their surface areas vary from 64 hectares (Kuscenneti National Park) to 69 800 hectares (Olympos-Bey) and the total areas reach 400 000 hectares. Within a year 8 new national parks will be nominated. The number of national parks will go up from 21 to 29 with 555 000 hectares.
Although the majority of the national parks are found in forestlands, there are also a number, which are established in areas where steppe-type vegetation predominates.

(2)Nature Reserves

In addition to national parks, 23 nature reserves were designated between 1987 and 1991.
Most of these nature reserves are smaller in area than national parks, which allows for their enclosure and leads to more effective protection. All the nature reserves have been designated as such due to various biological characteristics.

(3) Special Areas of Environmental Protection

By means of legislation adopted in 1990 the Turkish Government has taken under protection twelve areas and has granted these the status of Special Areas of Environmental Protection. These areas have been selected not so much for their biological characteristics but in order to prevent tourism and construction from encroaching on their natural beauty. Among these the Mugla-Koycegiz-Dalyan area has been brought under protection because it is the habitat where Caretta caretta (sea turtle), which has recently become the focus of world public attention, lay their eggs. Pamukkale is under protection because of its world famous calcareous sediment; the Ihlara Valley, due to its historical significance as one of the earliest dwelling places of Christians and because of the presence of churches and temples containing paintings and frescoes.

(4) Wetland

Wetlands are of enormous importance both in ensuring the ecological balance and in preserving

biological diversity.
Turkey is the richest country in Europe and the Middle East as far as wetlands are concerned as These wetlands have a crucial importance for the water birds as they are on the birds' migrating route between the continents of Europe, Asia and Africa.
According to the International Criteria, there are 19 A Class Type wetlands in Turkey. Eleven of the 19 A Class type wetlands which contain more than 25 000 birds at the same time are under the protection of the Ministry of Forest and there is a great increase in the bird population.

(5) Other Protection Measures

In addition to the various areas of environmental protection cited above, there are also enclosed zones of smaller scale, which are under protection. These serve to protect some animal species which are either rare in Turkey or in the world, or face the danger of extinction. These animals are preserved and bred under special care and some are released into nature when their populations reach a certain level. There are forty such areas of animal protection and they are located in all regions of Turkey. Below is a partial list of the animals, which are under protection in these areas.

Fallow Deer, Roe Deer, Bald Ibis, Pheasant, Frankolin, Partridge, Deer, Wild Goat, Waterfowl, and Wild Sheep (mouflon)

8.4 Methodology for Environmental Consideration

8.4.1 Basic Concept of JICA the Guideline

JICA's basic principles with regard to environmental consideration, are to promote sustainable development aimed at improving the living standard of the residents, and harmonizing the development with a desirable environment based on the country's willingness.
If the environmental consideration is not sufficiently undertaken for implementing a development project and, if careful attention is not paid to the management of the surrounding natural resources, the base of the development might be jeopardized and the development might be halted. The base of the people's livelihood or even their subsistence can be also threatened. It is necessary, therefore, to try to ensure the sustainable development by harmonizing the development project with natural resources and the base of same meaning of the residents in the area.
When undertaking the environmental consideration, it is necessary to take account of the developing country's policies and structures and to understand the country's awareness of environmental problems, while holding sufficient discussions with the people concerned in a flexible manner.
The process of environmental consideration in a project cycle is shown in Fig. 8.4.
A development project begins with its finding and formulation. At each stage of the cycle, a series of environmental considerations, such as a preliminary environmental survey, an initial environmental examination (IEE), environmental impact assessment (EIA), and the design of environmental protection measures takes place. Environmental monitoring is then conducted

during the project implementation. Through this process, sustainable development can be attained.

Definition of the environmental management plan mentioned here is limited to the monitoring system, which handles the environmental impacts caused by the project.

Table 8.1 illustrate the time flows corresponding to the project implementation stages and the environmental consideration stages. The process starts with an environmental survey, followed by the EIA, the examination of environmental conservation measures, and then the monitoring stage. It is necessary to understand the relationships between the environmental items and the project related activities during the construction and operation periods. Table 8.2 shows a comprehensive matrix covering 13 sections of social and economic infrastructure development projects.

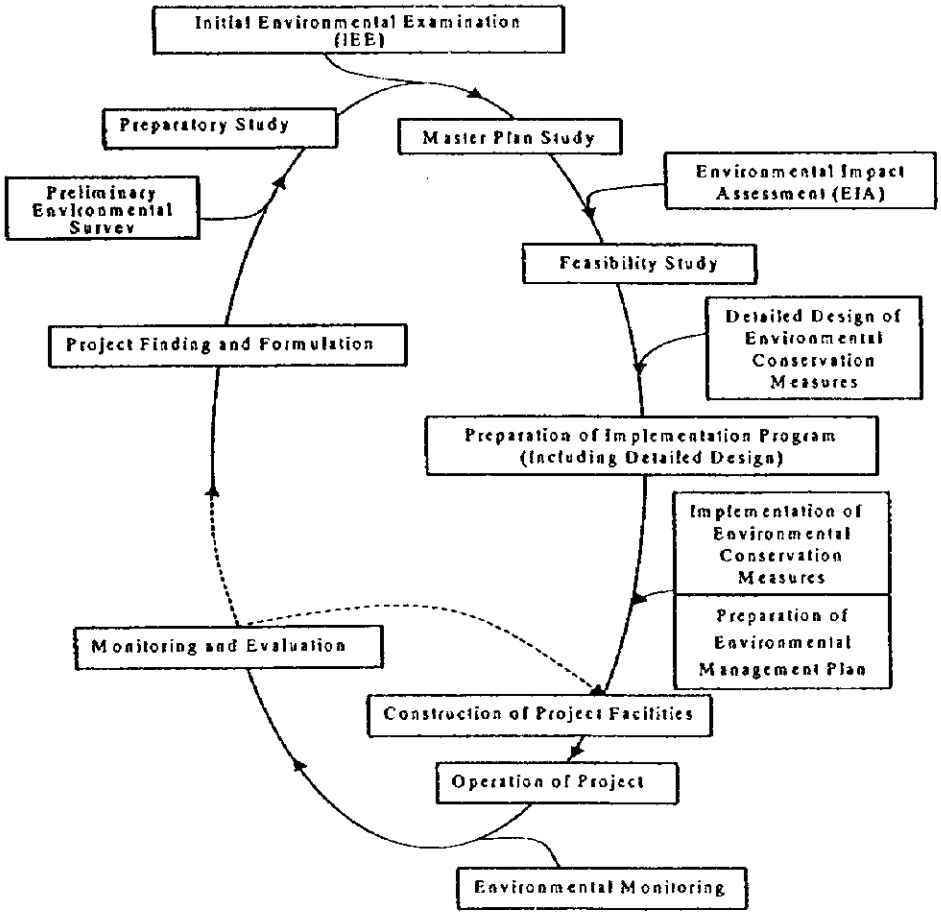


Fig.8.4 Flow of Environmental Consideration in Project Cycle

Table 8.1 Project Implementation Stage and Corresponding Environmental Consideration Stage

<table>
<tr><td colspan="4">Project Implementation Stages</td><td>Environmental Consideration Stages</td></tr>
<tr><td colspan="4">Preparatory Study</td><td>Preliminary Environmental Survey</td></tr>
<tr><td rowspan="2">Implementation by JICA</td><td rowspan="2">Full-scale Study</td><td>Master Plan Study</td><td rowspan="2">Feasibility Study</td><td>Initial Environmental Examination (IEE)</td></tr>
<tr><td>Feasibility Study</td><td>Environmental Impact Assessment (EIA)</td></tr>
<tr><td rowspan="3">Implementation by Executing Agency</td><td colspan="3">Preparation of Project Implementation Plan (Including Detailed Design)</td><td>Examination of Environmental Conservation Measures</td></tr>
<tr><td colspan="3">Project Construction</td><td>Implementation of Environmental Conservation Measures</td></tr>
<tr><td colspan="3">Project Facility Operation</td><td>Environmental Monitoring</td></tr>
</table>

Notes: 1. This table does not indicate strict correspondence
2. Some projects do not require IEE or EIA
3. Preparation of the project implementation plan includes the detailed design of the environmental conservation facilities and their construction
4. The item enclosed in a separate box indicates the major boundary for the guidelines

Table 8.2 Comprehensive Matrix

Project Type			Sectoral Development									Comprehensive Development			
Sectors / Environment Items			1. Ports and Harbors	2. Airports	3. Roads	4. Railways	5. River and Erosion control	6. Solid Waste Management	7. Sewerage	8. Groundwater Development	9. Water Supply	10. Regional Development	11. Tourism Development	12. Transportation Development	13. Urban Transportation Development
Social Environment	1	Resettlement	◎	◎	◎	◎	◎	○	○		○	○	○	○	○
	2	Economic Activities	○	○	○	○						○	○	○	○
	3	Traffic and Public Facilities	○	○	○	○	○	○				○	○	○	○
	4	Split of Communities		○	○	○	○					○	○	○	○
	5	Cultural Property	○	○	○	○	○					○	○	○	○
	6	Water Rights/Rights of Common	◎	○	○	○	◎			○	○	○	○	○	
	7	Public Health Condition				○		○				○	○	○	
	8	Waste	○	○	○	○	○	○	○			○	○	○	○
	9	Hazards (Risk)	○	○	○	○						○	○	○	○
Natural Environment	10	Topography and Soil Condition	○	○	○	○	○					○	○	○	
	11	Soil erosion		○	○	○						○	○	○	
	12	Groundwater			○	○		○		◎		○			
	13	Hydrological situation	○	○	○	○	◎	○			○	○	○	○	○
	14	Coastal Zone	◎	○	○	○	○	○				○	○	○	
	15	Fauna and Flora	◎	◎	◎	◎	◎	○	○		○	○	○	○	○
	16	Meteorology										○		○	
	17	Landscape	○	○	○	○	○	○	○		○	○	○	○	○
Pollution	18	Air Pollution	○	○	◎			◎	○			○		○	○
	19	Water Pollution	○	○	○	○	○	◎	○	○	○	○	○	○	
	20	Soil Contamination	○		○			○						○	○
	21	Noise and Vibration	○	◎	◎	◎	○	○	○	○	○	○	○	○	○
	22	Ground Subsidence								◎					
	23	Offensive Odor	○					◎	○			○		○	

Note: ◎: The environmental items to which special attention has to be paid
They might cause serious impacts that may affect the project formulation depending on the magnitude of the impacts and the possibility of the measures.

○: The environmental items which may have a significant impact depending on the scale of project and site conditions

No mark: The environmental items requiring no impact assessment since the anticipated impacts are, in general, not significant.

8.4.2 Environmental Consideration for Road Projects

* Definition of Road Projects in the Guidelines

  Road projects in the guidelines deal with the construction and operation of the roads for vehicular traffic and the large-scale rehabilitation and operation of existing roads.

* Typical Possible Impacts and the Points of Environmental Consideration

  Typical impacts caused by road projects are described below. Particular consideration of these impacts is necessary.

Resettlement

People living on the project site would be relocated due to land acquisition for road construction. Loss of livelihoods of inhabitants, difficulty in social and cultural adaptation in the resettled site may occur.

The condition of the inhabitants to be resettled and the resettlement site should be investigated in the environmental consideration.

Fauna and Flora

Animals habitats would be lost by the removal of vegetation for road construction. Breeding, plant life and animals would be affected by exhaust gas and noise caused by vehicles after construction. Migration routes and habitat areas could be interrupted by road facilities. Also, reduction of water area, and stemming and diversion of water courses by construction of revetment banks and piers for bridges are possible impacts on the water system for ecology. Commencement of road operations would bring an increase in immigrants who would change the forest along the route into cultivated land thereby disrupting the habitats and environment.

The above impacts would cause a decrease in the number of valuable species or the extinction of predatory species that would result in the degradation of biodiversity. The decrease and extinction of predatory species and other species could result in an outbreak of other species, especially pests and pathogenic insects.

The value of plants and animals and the ecological features of the site, as well as the social concern for plants and animals, should be studied thoroughly.

Air Pollution

Exhaust gas and dust from construction equipment and vehicles during the construction equipment and vehicles during the construction stage and exhaust gas from vehicular traffic after the commencement of operations would cause air pollution.

The health of inhabitants and plants and animals would be affected. If the volume of exhaust gas is large, sulfur oxides and nitrogen oxides may contribute to acid rain; carbon monoxide and dioxide may contribute to global warming.

In urban areas, the effect of soot, carbon monoxide, nitrogen oxides and sulfur oxides must be considered carefully.

Noise and Vibration

During the construction stage, the operation of construction equipment and detonations

would create noise and vibration. During the operational stage, vehicles could cause noise and vibration. Noise would affect facilities requiring particular tranquillity, such as hospitals and schools, disturb sleep at night, interfere with the breeding of livestock and cause the dispersion of wildlife.
Highly populated areas, e.g., urban areas, and areas having specific religious facilities, need special consideration.

8.5 Environmental Impact Assessment

8.5.1 Introduction

The Environmental Assessment for the Study on Arterial Highway Maintenance in Turkey was performed between November, 1997 and February 1998.
The work has been carried out in line with the Environmental Guidelines for Infrastructure Projects-III Road prepared by JICA together with consideration of the environmental rules in Turkey. The work is based on site visits to the project locations and related areas, meetings and discussions with representatives of related sectors, a review of documents, regulation and data concerning the project.

8.5.2 Description of the Project (PD)

(1) Background

The General Directorate of Highways within the Ministry of Public Works and Settlement of the Republic of Turkey (hereinafter referred to as "KGM") is responsible for the construction, maintenance and operation of around 60 000 km of motorway, state roads and provincial roads.

(2) Study Objectives

The study objectives are:

- to develop road maintenance manuals, and
- to formulate an implementation plan for a road maintenance management system

Study roads consist of state and provincial road, excluding bridges and tunnels. These roads are dealt with by the study in the following way:

① Development of the road maintenance manuals	: all state and provincial roads
② Preliminary road inspection and evaluation	: approx. 2 000km
③ Detailed inspection and evaluation	: 40 road sections (approx. 40km)
④ Design of repair work	: 20 road sections (approx. 20km)
⑤ Implementation plan	: approx. 2 000km

Accordingly, the environmental assessment was performed for the selected 20 road sections for which the design of repair works was made.

8.5.3 Description of the Site (SD)

Detailed inspection was carried out for 20 sections whose site conditions are largely classified into the Black Sea coastal area and inland area. In a narrow belt zone between the Black Sea and the North Anatolia high mountains, a high density of population and settlement could be found along the coast. The inland area is flat except some parts with sparse population. Table 8.3 shows the environmental conditions for the 20 sections.

8.5.4 Screening of Potential Environmental Impact

After the site survey and detailed inspection for the selected 20 sections, the results of screening with respect to potential environmental impact are shown in Table 8.4 in the format of the JICA Guideline.

8.5.5Results of Environmental Assessment

Overall environment impacts have been assessed by the JICA Guideline and shown in Table 8.5

8.6 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 precautionary measures for maintaining the present environmental condition, which in general is considered favorable.
However, it should be noted that the environmental parameters marked with small effect may threat projecten sustainability if adequate countermeasures are not taken. Therefore, continuous and appropriate monitoring shall be required.

Table 8.3 Environmental Conditions of 20 Sections

	Section No	Sub Div.	Km.	Location	Land Use	Topography	Building Houses	Natural Growth	Farming	Site Conditions	Roadside Space	Damages to be repaired
1	100-10	17	40-41	Sakarya	Suburban	Plain	A few	Trees	Wheat		Flat	Pavement cracks
2	300-07	31	35-36	Afyon	Rural	Plain	-	-	Wheat	Partly on embankment	Flat	Slope erosion
3	100-12	41	25-27	To Bolu	Rural	Hilly	-	Trees	-	Cut & fill slope, pond on upper terrace	Slopes	Slope failure by seepage
4	750-05	42	31-32	To Bolu	Rural	Hilly	-	Barren	-	Riverside road	Hill & river	River erosion
5	200-13	44	33-34	Krikkale	Rural	Mountainous	-	Barren	-		Steep slopes	Failure by erosion
6	200-09	45	50-51	Near Ankara	Rural	Plain	-	-	Wheat		Flat	Pavement
7	200-08	46	18-19	Near Ankara	Suburban	Plain	Many	Trees	-	On embankment	Flat	Slope erosion
8	200-14	44	27-28	Near Ankara	Suburban	Plain	Many	Trees	-		Flat	Pavement
9	100-17	72	56-57	Corum	Rural	Mountainous	-	-	Wheat	Cut & fill slope	Steep slopes	Huge landslide downslope
10	190-01	73	11-12	Corum	Rural	Plain	-	Trees	Wheat		Flat	Pavement
11	795-01	75	61-62	Samsun	Rural	Hilly	A few	Trees	Wheat	N-S road in shallow valley w/ gentle slopes	Gentle slopes	Pavement damage due to landslide
12	10-18	77	7-8	Ordu	Rural	Mountainous Coastal	A few	Trees	-	High & steep cliff seaside,house hillside	Vertical slopes w/space above	Steep slope safety
13	10-23	103	47-48	Rize	Rural	Hilly/Coastal	-	Trees	-	Seaside road	No space	Sea protection
14	10-20	104	25-26	Gireson	Suburban	Hilly/Coastal	A few	Trees	-	Seaside road	No space	Retaining wall
15	10-21	105	5-6	West Trabson	Urban	Plain/Coastal	Many	-	-	Seaside road	No space	Retaining wall
16	650-14	132	36-37	Antalya	Rural	Hilly/Plain	-	Trees	Wheat	Fill on slope	Gentle terrain	Pavement & retaining wall
17	650-12	134	36-37	Antalya	Rural	Plain	-	-	Wheat	Fill on slope	Flat	Retaining wall
18	200-06	143	12-13	Bursa	Urban	Plain	Dense	-	-	In town	Center zone	Pavement
19	200-07	144	41-42	East Bursa	Rural	Plain	-		Wheat	On slope	Flat	Pavement
20	200-06	147	29-30	East Bursa	Rural	Hilly	-	Trees	-	On slope	Gentle terrain	Pavement

Table 8.4 Format for Screening

No.	Environmental Item	Description	Road Section																			Remarks
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Social Environment																							
1	Resettlement	Resettlement due to land occupancy (transfer of rights of residence/land ownership)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	No new construction nor widening
2	Economic Activities	Loss of bases of economic activities, such as land, and change of economic structure	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
3	Traffic and Public Facilities	Impacts on schools, hospitals and present traffic conditions, such as the increase of traffic congestion and accidents	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
4	Split of Communities	Community split due to interruption of area traffic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
5	Cultural property	Damage to or loss of the value of churches, temples, shrines, archaeological remains or other cultural assets	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
6	Water Rights and Rights of Common	Obstruction of fishing rights, water rights, rights of common	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
7	Public Health Condition	Deterioration of public health and sanitary conditions due to generation of garbage an the increase of vermin	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
8	Waste	Generation of construction and demolition waste, debris and logs	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Minimal volumes only
9	Hazards (Risk)	Increase in risk of landslides, cave-ins and accidents	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Natural Environment																							
10	Topography and Geology	Changes of valuable topography and geology due to excavation or filling work	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	
11	Soil Erosion	Topsoil erosion by rainfall after reclamation and vegetation removal	–	○	○	–	○	–	–	–	○	–	○	–	–	–	–	–	–	–	–	–	No wide vegetation removal made
12	Groundwater	Change of distribution of groundwater by large-scale excavation	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	No deep excavation
13	Hydrological Situation	Changes of river discharge and riverbed condition due to landfill and drainage inflow	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
14	Coastal Zone	Coastal erosion and sedimentation due to landfill or change in marine condition	–	–	–	–	–	–	–	–	–	–	–	○	○	○	○	–	–	–	–	–	
15	Fauna and Flora	Obstruction of breeding and extinction of species due to changes of habitat conditions	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
16	Meteorology	Changes of temperature, precipitation, wind, etc. due to large-scale land reclamation and building construction	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
17	Landscape	Change of topography and vegetation due to reclamation. Deterioration of aesthetic harmony by structures	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Pollution																							
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
19	Water Pollution	Pollution by inflow of silt, sand and effluent into rivers and groundwater	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
20	Soil Contamination	Continuation of soil by dust and chemicals, such as herbicides	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
21	Noise and Vibration	Noise and vibration generated by vehicles	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	By Repair Work
22	Land Subsidence	Deformation of land and land subsidence due to the lowering of groundwater table	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	
23	Offensive Odor	Generation of exhaust gas and offensive odor by facility construction and operation	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	No change of road gradient
Overall Evaluation:			–	–	–	–	–	–	–	–	○	–	–	○	–	–	–	–	–	–	–	–	

Table 8.5 Overall Environmental Impacts

No.	Environmental Item	Impacts	Reason
Social Environment			
1	Resettlement	None	-
2	Economic Activities	None	-
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	-
7	Public Health Condition	None	-
8	Waste	Slight	Small fragments by repair works
9	Hazards (Risk)	None	-
Natural Environment			
10	Topography and Geology	None	-
11	Soil Erosion	Positive Impact	-
12	Groundwater	None	No deep excavation
13	Hydrological Situation	None	-
14	Coastal Zone	Positive Impact	-
15	Fauna and Flora	Negligible	Roads traverse mostly cultivated area. No nearby Natural Reserves etc.
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	Except No.9 at Corum
23	Offensive Odor	None	-