CHAPTER 3

COTENTS OF THE PROJECT

Chapter 3 Contents of the Project

3-1 Basic Concept of the Project

(1) Project Purpose

Since Bhutan is for the most part a mountainous country, roads and bridges provide the only means of transportation. However, the development of rural areas in particular in Bhutan has been hindered by insufficient road maintenance and lack of roads. Therefore, it is essential for the socio-economic development of Bhutan that an efficient and safe network of roads and bridges be developed.

To cope with such problems, the Royal Government of Bhutan defines the renovation of the trunk roads and the construction of the feeder roads (branch roads accessing to trunk roads) as the objectives in "Bhutan 2020" (constituted in 1999), the national development outline of Bhutan, so that all Bhutanese people can access to the trunk roads in half a day. The construction of feeder roads of municipality level is also stated in "Road Sector Master Plan (2007 – 2027)". In addition, it is stated in "the 10th Five-Year Plan (2008 – 2013)" that "Access to the trunk roads shall not be more than 2 hours (the objective has been upwardly revised according to the rapid progress of development)" and that renovation of the trunk roads, reinforcement of feeder roads, maintenance and repair of the existing roads & bridges and replacement etc.

The purpose of the Project is to improve the access for the local residents and to provide solutions for the security of the access in future cyclones.

(2) Project Outline

This project aims to rebuild the two bridges on National Highway No.5 by replacing the present temporary bridges with permanent ones. With respect to the three bridges on the farm road connecting to the National Highway No. 4, temporary bridges will be built, and the substructure works will be implemented by the Japanese side.

Bridges covered by this grant aid project

- Two bridges on National Highway No. 5:
  1) Dolkhola Bridge
  2) Jigmiling Bridge

- Three bridges on the farm road connecting to the National Highway No. 4:
  1) Mandechhu (Reotala) Bridge
  2) Kela Bridge
  3) Jangbi Bridge

(3) Types of Bridges Covered by the Survey

The table below shows the bridges covered by the survey and those ultimately covered by the project.

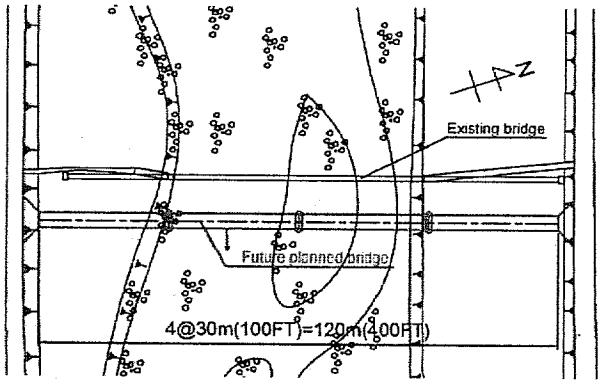
Table 3-1 Bridge Structures

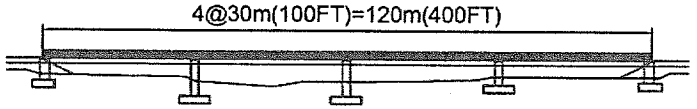
Bridge Name	Covered by the Project	Bridge Structure	Remarks
No.5 Tshendona Bridge	—	Bailey bridge (with 4 spans) L=120m	The length of each span will be 30m, which is longer than the span length of the road bridge downstream.
No.9 Mandechhu (Reotala) Bridge	o	Bailey suspension bridge L=97.6m	Even if the piers are reconstructed, they are likely to be washed out again by flood flow because of the extremely large flood flow. Therefore, a Bailey suspension bridge, whose structure does not require construction of piers, will be constructed.
No.16 Dzongkhachulum Bridge	—	Langer bridge L=70m	The bridge site and span length were decided so that the road can be constructed outside areas of risk of rockfalls and can have good road alignment. From the conditions at the selected site and the selected span length, a Langer bridge was selected as the bridge structure.
No.17 Dolkhola Bridge	o	PC bridge (with 2 spans) L=70m	A PC bridge with two 35m spans was selected as the bridge structure for better cost-efficiency and in consideration of the river width and required span length.
No.18 Jigmiling Bridge	o	PC bridge (with 2 spans) L=70m	
No.19 Kela Bridge	o	Bailey bridge L=48m	A 48m-long Bailey bridge was selected as the bridge structure in consideration of the river width.
No.20 Jangbi Bridge	o	Bailey bridge L=48m	

The outline design of each bridge is shown in the following pages.

Basic Design Concept (1/4)

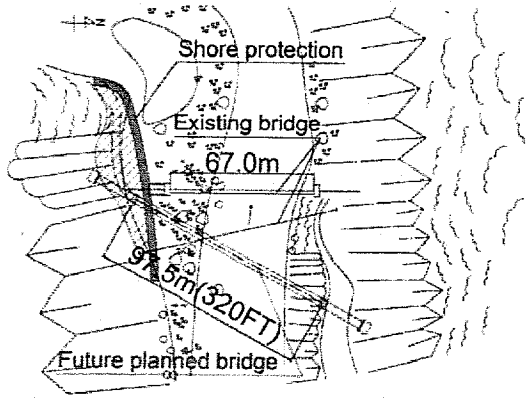
No.5 Tshendona bridge			
Road classification	Farm Road	Jurisdiction	DoA
Existing Size	L=30m	Existing Bridge Type	Suspension Bridge
Beneficiary	-		

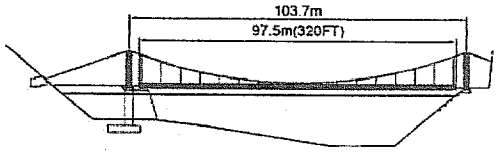




Future Planned Bridge Specifications	
Bridge Length	L=120m(400Ft)
Bridge Type	Bailey Bridge
Carriage Width	W=3.277m
Truck Load	IRC 24R(24ton) / 18R(18ton)
Foundation Type	Spread foundation (T-type)

No.9 Mangdechhu bridge			
Road classification	Farm Road	Jurisdiction	DoA
Existing Size	L=70m	Existing Bridge Type	Bailey Bridge
Beneficiary	210HH (3,000habitants)		

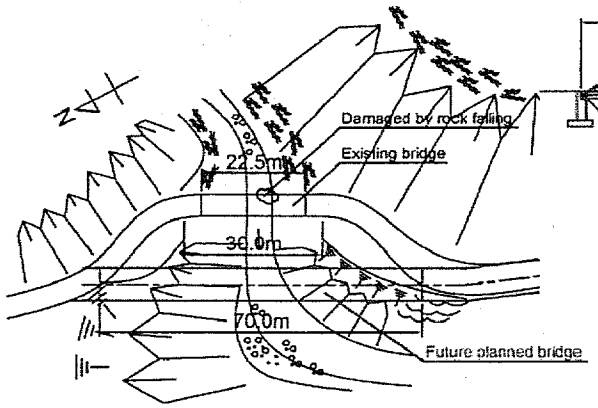


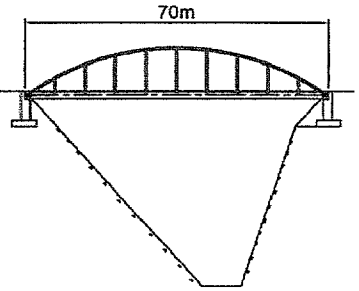


Future Planned Bridge Specifications	
Bridge Length	L=97.5m(320Ft)
Bridge Type	Bailey Suspension Bridge
Carriage Width	W=3.277m
Truck Load	IRC 24R(24ton) / 18R(18ton)
Foundation Type	Spread foundation (T-type) Caisson type pile

Basic Design Concept (2/4)

No.16 Dzongkhachulum bridge			
Road classification	National Rd No.4	Jurisdiction	DoR
Existing Size	L=23m	Existing Bridge Type	Truss Bridge
Beneficiary	3 dzongkhags		

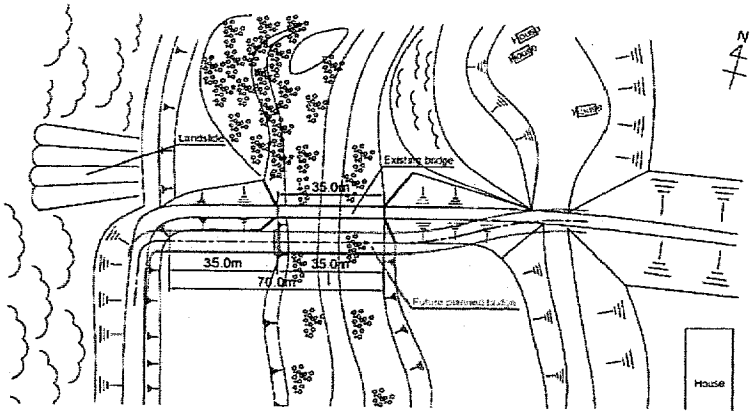


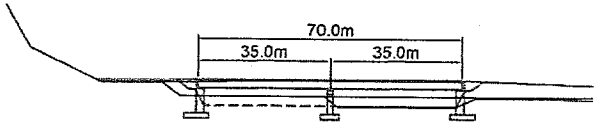


Future Planned Bridge Specifications	
Bridge Length	L=70m
Bridge Type	Langer arch Bridge
Carriage Width	W=7.0m
Truck Load	IRC 70R(70ton) or ClassA(40ton)
Foundation Type	Spread foundation (T-type)

Basic Design Concept (3/4)

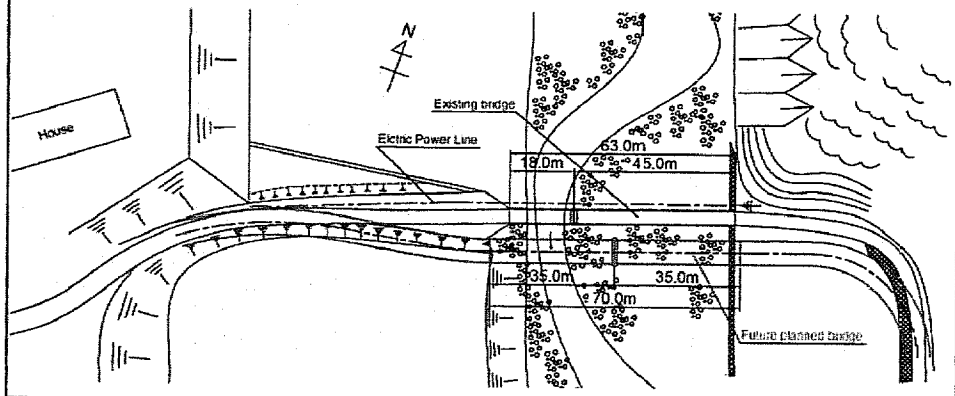
No.17 Dolkhola bridge			
Road classification	National Rd No.5	Jurisdiction	DoR
Existing Size	L=40m	Existing Bridge Type	Bailey Bridge
Beneficiary	5 dzongkhags		

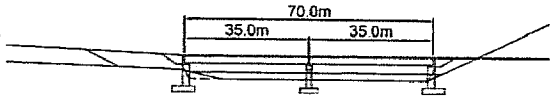




Future Planned Bridge Specifications	
Bridge Length	L=70m
Bridge Type	Prestressed Concrete Bridge
Carriage Width	W=7.0m
Truck Load	IRC 70R(70ton) or ClassA(40ton)
Foundation Type	Spread foundation (T-type)

No.18 Jigmiling bridge			
Road classification	National Rd No.5	Jurisdiction	DoR
Existing Size	L=64m	Existing Bridge Type	Bailey Bridge
Beneficiary	5 dzongkhags		

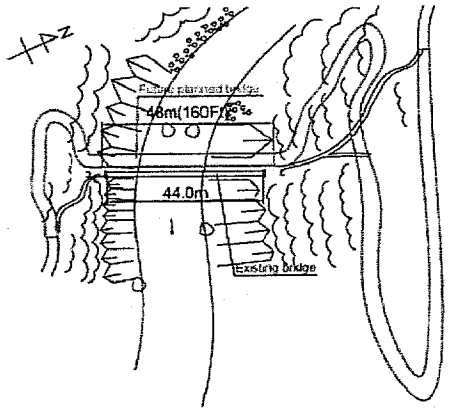


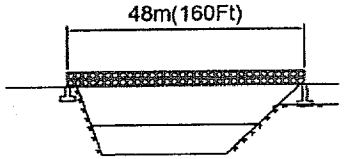


Future Planned Bridge Specifications	
Bridge Length	L=70m
Bridge Type	Prestressed Concrete Bridge
Carriage Width	W=7.0m
Truck Load	IRC 70R(70ton) or ClassA(40ton)
Foundation Type	Spread foundation (T-type)

Basic Design Concept (4/4)

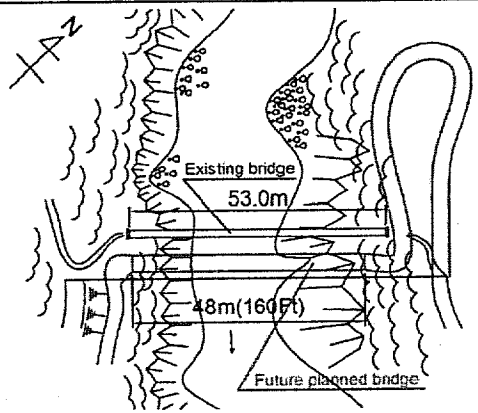
No.19 Kela bridge			
Road classification	Farm Road	Jurisdiction	DoA
Existing Size	L=45m	Existing Bridge Type	Suspension Bridge
Beneficiary	2villages,57HH		

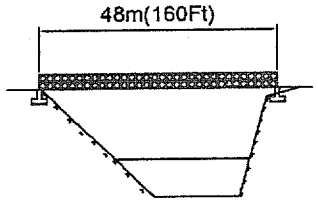




Future Planned Bridge Specifications	
Bridge Length	L=48m(160Ft)
Bridge Type	BaileyBridge
Carriage Width	W=3.277m
Truck Load	IRC 24R(24ton) / 18R(18ton)
Foundation Type	Spread foundation (T-type)

No.20 Jangbi bridge			
Road classification	Farm Road	Jurisdiction	DoA
Existing Size	L=53m	Existing Bridge Type	Suspension Bridge
Beneficiary	5villages,64HH		





Future Planned Bridge Specifications	
Bridge Length	L=48m(160Ft)
Bridge Type	Bailey Bridge
Carriage Width	W=3.277m
Truck Load	IRC 24R(24ton) / 18R(18ton)
Foundation Type	Spread foundation (T-type)

3-2 Outline Design of Japanese Assistance

3-2-1 Design Policy

3-2-1-1 Basic Policy

(1) Bridges on National Highway No.5

National Highway No.5, on which the bridges covered by this survey are located, is an important route running through the area of development in the southern plain of the country. On National Highway No. 5, "Wakleytar Bridge" has been reconstructed under the grant aid program of Japan (The Project for Reconstruction Bridges Phase III) to replace the temporary Bailey suspension bridge with a permanent bridge. In addition, under the The Project for Reconstruction of Bridges Phase III that is currently being implemented, reconstruction work is under way for Lawaka Bridge, Basochu Bridge, Bhurichu Bridge, Narachu Bridge, Chanchey Bridge and Loring Bridge. Five bridges 30 m or less in length are also being rebuilt on the same route by the Bhutanese side. However, Dolkhola Bridge and Jigmiling Bridge, located between Gelephu and Sarpang in the southern part of the same route, are still Bailey bridges. These bridges are highly likely to be washed away in the event of a similar disaster as Cyclone Aila. Therefore, it is very important to include them in the project. The survey revealed that these bridges have a maximum load limit of 18 t and a width of only 3.27 m. Due to the damage caused by the distortion as well as the abrasion and the corrosion of the structures, their condition does not allow the safe and smooth passage of vehicular traffic. Also, traces of the erosion are observed in the foundations of the bridge abutments.

These two bridges have a high possibility to become bottlenecks obstructing the steady transportation of people and commodities as the traffic volume, particularly of large vehicles, is expected to increase as the development program of the areas in the south progresses. Therefore, the reconstruction will be significant in ensuring safe and smooth traffic on National Highway No. 5.

The basic design policies are as follows:

- Since the two bridges covered by the project were found in the field survey to be more than 30 m in length, there are some difficulties for the Bhutanese side to reconstruct them, given Bhutan's experience in similar projects, topographical conditions, procurement situation, etc. Therefore, reconstruction should be carried out as a grant aid project of Japan.
- According to the "Road Survey & Design Manual", which is the road standard in Bhutan, the width of National Highway No. 5 should be 7.0 m. Thus the effective width should not be less than 7.0 m, in order to ensure ease of passage, safety and continuity.
- As it is assumed that there will be large-vehicle traffic on National Highway No. 5 for the transportation of materials and equipment for the Punatshangchu hydropower project, in addition to Class A as prescribed by the Indian Roads Congress (IRC) standard, the Royal Government of Bhutan has established a new standard, 70R (wheeled), as the live load intensity for the design of bridges on the National Highway, taking into account large-vehicle traffic. Therefore, the standards "Class A live load" and "70R (wheeled)" should be used in designing the bridges.
- The design and construction plan should be examined so as to obtain maximum benefit for minimum cost.

(2) Bridges on the Farm Road along National Highway No. 4

Out of the three bridges on the farm road along National Highway No.4 on which the bridges covered by this survey are located, Mandechhu (Reotala) Bridge was washed away by Cyclone Aila and a pedestrian suspension bridge has been constructed. Both Kela Bridge and Jangbi Bridge are pedestrian suspension bridges and they are not fit to take vehicular traffic at present. All three bridges, i.e., Mandechhu (Reotala) Bridge, Kela Bridge and Jangbi Bridge, provide the only route connecting the agricultural villages on the opposite bank with the arterial road and market. Consequently, reconstruction of these bridges will greatly contribute to the restoration and improvement of the people's lives, helping them in the acquisition of daily commodities and transportation of agricultural produce. It will also significantly contribute to the achievement of one of the objectives of the 10th Five-Year Plan, namely, to make arterial roads accessible within two hours.

The basic design policies are as follows:

- With respect to the superstructure of the three bridges, taking into consideration the length of the bridges, it was decided to adopt a Bailey bridge design for Kela Bridge and Jangbi Bridge and a Bailey suspension bridge design for Mandechhu (Reotala) Bridge. Former achievements in Bhutan suggest that it has an adequate track record and capability in building Bailey bridges and Bailey suspension bridges. The superstructures should be built by the Bhutanese side.
- Collapsed bridge abutments and bridge piers remained at the target sites. The results of the survey showed that the quality of the substructure (concrete construction) built by the contractor in Bhutan was improper. Therefore, it was decided that the substructure work should be carried out by the Japanese side.
- According to the design standards for Bailey bridges in Bhutan, the width should be 3.277 m and the design load should be Class 24R. This project also adopts these standards. If the materials currently used for Bailey bridges are diverted, the allowable load should be Class 18R.
- An appropriate margin was set of the vertical clearance in view of the possibility of damage by flooding caused by Cyclone Aila, etc. Also, revetment work was designed so as to protect the bridge abutments. A request was sent to the Bhutanese side to take the design of Mandechhu (Reotala) Bridge into account in the construction of new bridges over the Wandigang River, which merges with another river at a point downstream of Mandechhu (Reotala) Bridge.

3-2-1-2 Policies concerning the Natural Conditions

(1) Topography and Geology

The two bridges on National Highway No.5 (Dolkhola Bridge and Jigmiling Bridge) are located on the road running through the plain in the southern part of the country. The river is wide, and gravel, sand, cobbles and boulders are observed in the riverbank deposits. As the geological survey revealed that the bearing stratum has a sufficient soil bearing capacity, gravity-spread foundations should be adopted for the bridge abutment. The construction plan should be developed so as to include cut-off of water and unwatering to deal with the outflow of subsoil water that is anticipated in the construction work.

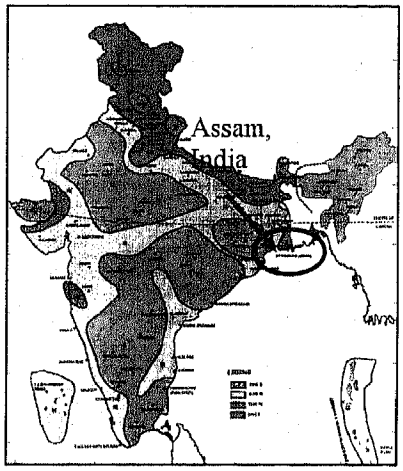
The three bridges on the farm road along National Highway No. 4 (Mandechhu (Reotala) Bridge, Kela Bridge and Jangbi Bridge) are located on steeply-sloping land. Excavation of 2-3m exposes the bearing stratum. Therefore, gravity-spread foundations should be adopted for the bridge abutment. It is anticipated that during the rainy season the flow rate and water level of the river will rise significantly at the point where the bridge is to be constructed. Adequate measures should be taken to prevent the occurrence of water-related accidents.

(2) Climate

The climate of Bhutan is as described in 2-2-3 Natural Conditions. The possibility of construction work being carried out during the rainy season should be considered with the climate in mind, and the results should be reflected in the design, construction plan and work schedule.

(3) Earthquake

As Bhutan does not have any clear standards regarding earthquake condition classification in the design of structures, it was decided to apply the earthquake conditions of Assam, India ("zone V," Very High Damage Risk Zone), in accordance with the IRC standards.



(source: IRC)

Figure 3-1 Earthquake Conditions of Assam, India

3-2-1-3 Policies Concerning Socio-Economic Conditions

National Highway No. 5 is the arterial road in the area covered by the project. It provides access to Thimphu, the capital city, and is also used for travelling to major cities in the area, such as Wangdi Phodrang, Damphu, Sarpang and Gelephu. It is an important road for the transportation of people and commodities by truck and bus.

The major industries in the area along National Highway No. 5 are forestry in the northern part that is mostly covered with forests, and agriculture in the plains in the south. National Highway No. 5 is used for the transportation of the produce from these industries to Thimphu, Wangdi Phodrang and other cities.

The topography of Punatshangchu River along National Highway No. 5 is suited to the construction of hydroelectric power plants because the flow rate is high and the area slopes steeply. Basochu Hydroelectric Power Plant has already started operations and the construction of Punatshangchu Hydroelectric Power Plant is currently under way near Wangdi Phodrang.

There are projects in the plains in the south for the planned construction of Jigmiling Industrial Park and Greenfield International Airport. National Highway No.5 will be the main route for the transportation of materials and equipment when these projects are implemented in the future.

The major industries along the farm roads providing access to National Highway No. 4 are forestry in the north and agriculture in the south. Fruit cultivation is particularly vigorous. Used for the transportation of timber and delivery of agricultural equipment and produce, these farm roads link the farms with the markets.

Considering the situations stated above, it is necessary to make study on designs of the bridges and the access roads that will secure safe and smooth traffic. The factors such as the increase of commodity transport and the large vehicles traffic brought by the development of the regional economy shall specifically be taken into account in determining the road width and the design load.

3-2-1-4 Policies Concerning the State of the Construction Industry

(1) State of the Construction Industry

11.4% of the GDP of Bhutan comes from the construction sector, which ranks third after the electric power and agricultural sectors (2009 Annual Report). 4.5% of the working population works for the construction sector (2009 Annual Report). The construction sector is a critical sector, contributing not only to the construction of hydroelectric power plants, which produce the country's primary export item, electricity, but also to the construction and maintenance of roads and bridges, which are the lifeline of a mountainous country. To be more specific, the construction industry is engaged in the construction of new roads, the improvement of existing roads and the construction of small temporary bridges. On the other hand, the local construction industry has the following problems, which has been taken into consideration in the development of the project plan.

i) Materials Management

During the field survey, it was observed that management of the construction materials at some construction sites was substandard, as shown in the following pictures.

ii) Shortage of Construction Workers and Civil Engineers

The number of construction projects in Bhutan has grown year on year. However, there has been a chronic

shortage of construction workers because the number of new young construction workers has not kept pace with the increase in construction projects. There is also a shortage of experienced and skilled civil engineers capable of supervising and managing young workers. For this reason, field management is substandard, causing inferior quality and work delays.

iii) Substandard Construction Methods

In the survey of the damage to the bridges, it was confirmed that bridge abutments had broken at the joints due to substandard construction work.

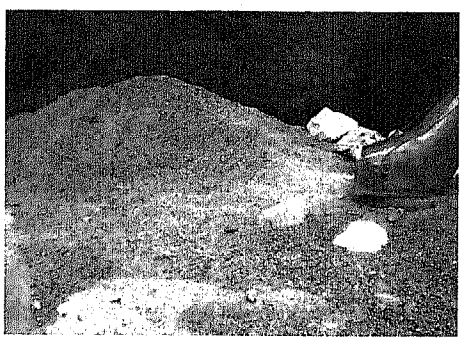


Photo – Unorganized storage of aggregate

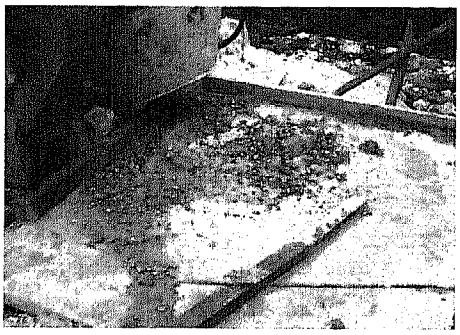


Photo – Equipment not cleaned before storage

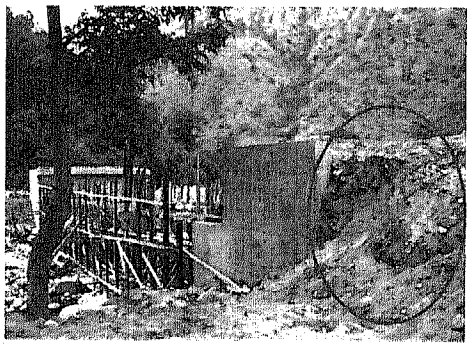


Photo - Insufficient rolling compaction of back-filling (inadequate supervision)

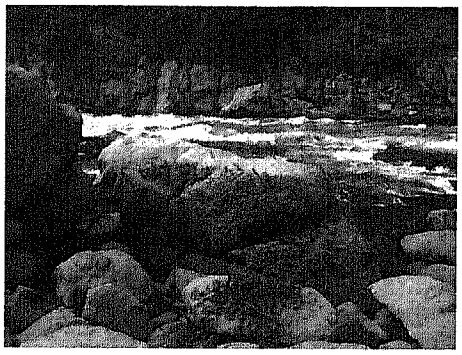


Photo - Structure Broken at the Joint