The Democratic Republic of Timor-Leste
Ministry of Public Works
Directorate of Roads, Bridges and Flood Control

Timor-Leste
The Post-Disaster Survey for New Comoro Upriver Bridge Construction Plan
Post-Disaster Survey Report (Summary)

December 2021

JAPAN INTERNATIONAL COOPERATION AGENCY

INGÉROSEC CORPORATION
IDEA CONSULTANTS, INC

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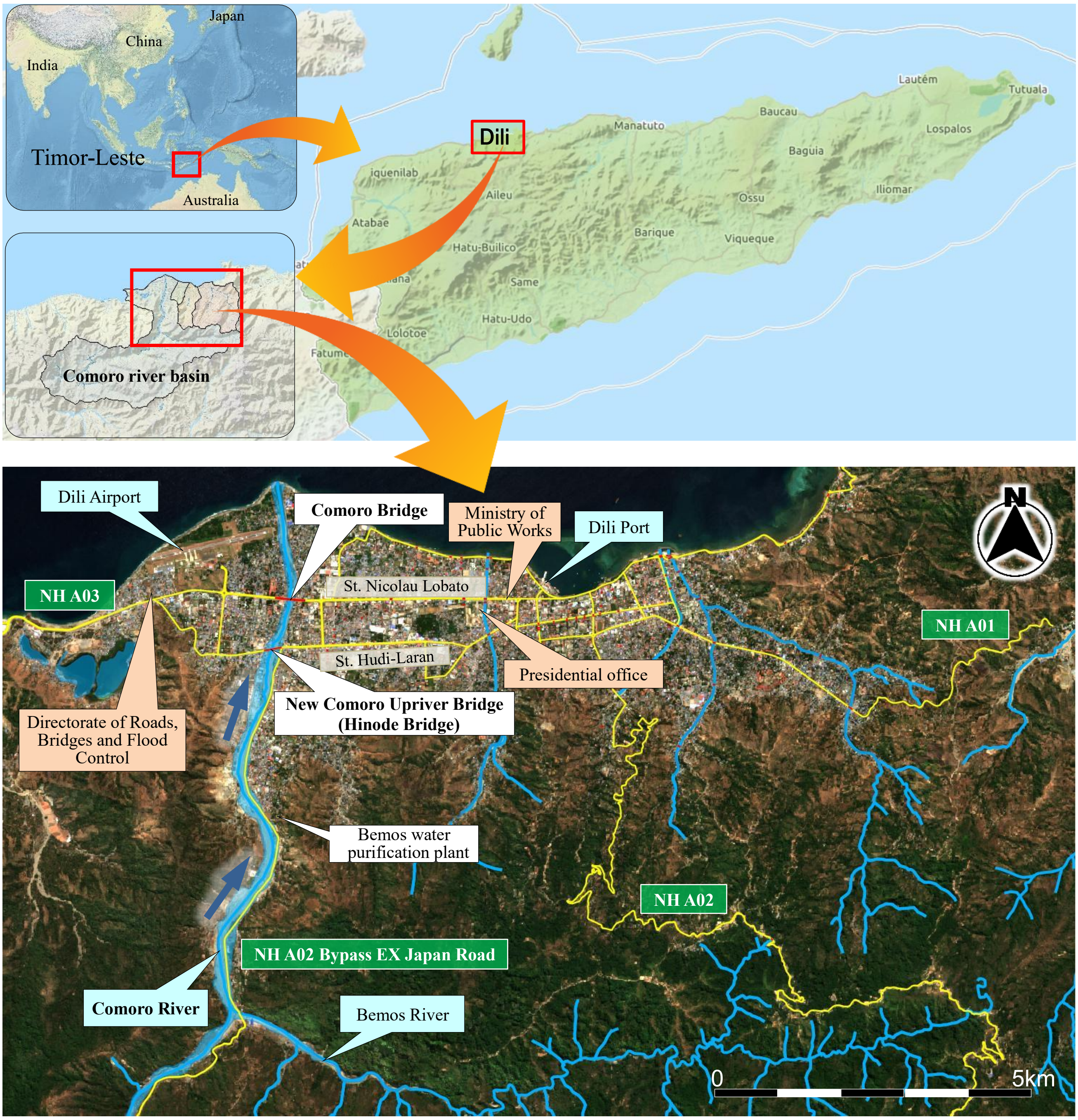
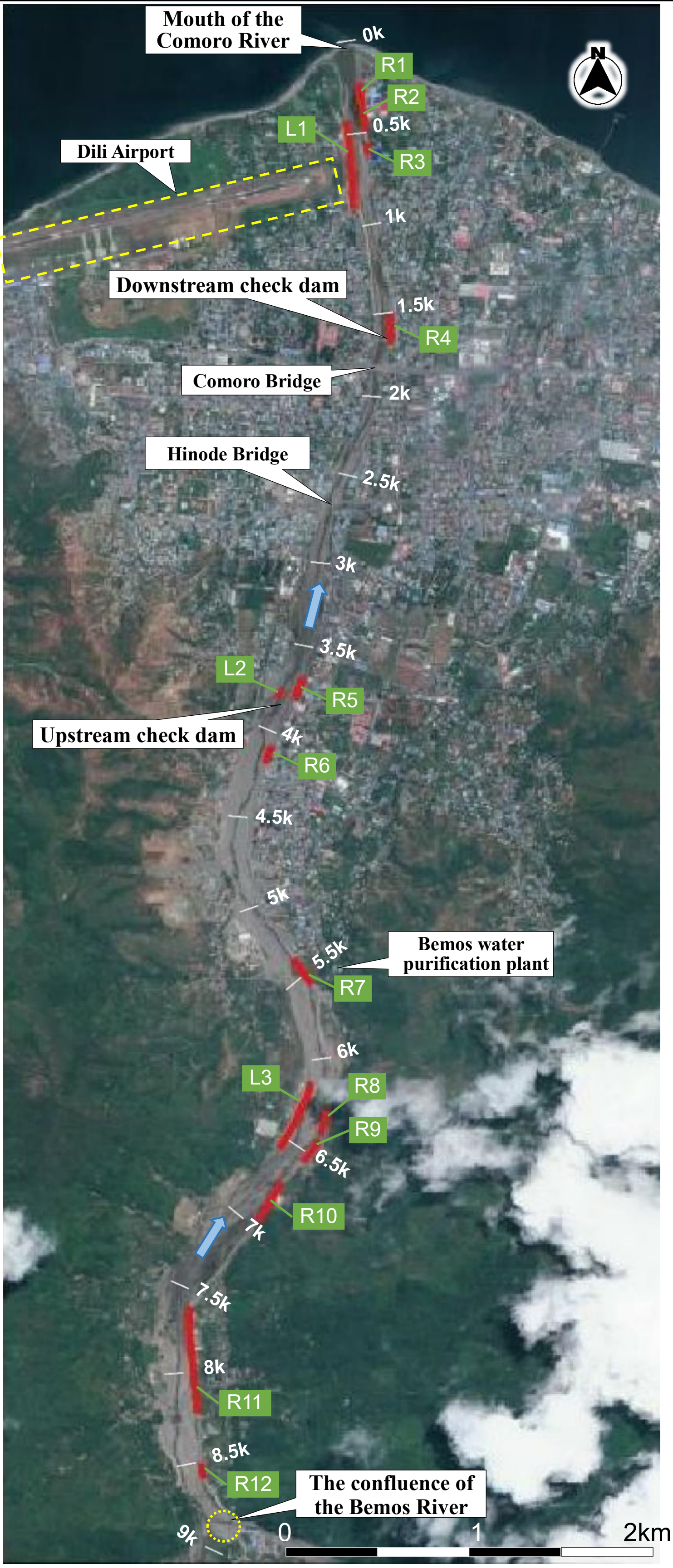


Source: Research team (based on Roads, Bridges and Flood Control Bureau data, Data©OpenStreetMap data, [Top] Maps©Thunderforest data, [Bottom] Sentinel-2 Earth Observation Optical Satellite data [July 19, 2021])

Location map



Downstream check dam

Comoro Bridge

Hinode Bridge

Upstream check dam

R1-12 = damaged areas on the right side, L1-3 = damaged areas on the left side

Survey area

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ADB	Asian Development Bank
ADN	National Development Agency / *Azensia Dezemvolvimentu Nacional*
C/P	counterpart
DRBFC	National Directorate of Roads, Bridges and Flood Control / *Direcção Nacional de Estradas, Pontes e Controlo de Cheias*
EDTL	National Electricity Company
GIS	geographic information system
IPG	Institution of Petroleum and Geology – Public Institute
JICA	Japan International Cooperation Agency
MPW	Ministry of Public Works / *Ministério das Obras Públicas*
ODA	Official Development Assistance
QGIS	geographic information system (GIS) application
UNTL	National University of Timor Lorosa'e
WTP	Water Treatment Plant

Chapter 1 Outline of field survey

1.1.Survey background and purpose

1.1.1.Project background

In response to a request from the Government of Democratic Republic of Timor-Leste ("Timor-Leste"), the Government of Japan ("Japan") decided to implement the Project for Construction of Upriver Comoro Bridge by grant aid in November 2015. The project constructed a 250-m-long road bridge with two abutments and five piers, including revetments, pier protection works and 3.6 km of access roads, on the Comoro River that runs through Dili City, the capital of Timor-Leste. The construction was completed in November 2018 and the grant aid project was completed in November 2019 after the defect inspection. In April 2021, the entire country of Timor-Leste was hit by torrential rainstorms that were said to be the largest since the country's independence in 2002, which drew the attention of the Timorese people. A visual inspection of the bridge site conducted by the JICA office found damage to some of the revetment blocks of the piers, but no major damage to the piers, abutments or revetments was observed. Therefore, it is necessary to confirm the current condition of the bridge and to study countermeasures or preventive measures in case of another disaster.

1.1.2.Purpose and scope

The purpose of this project is to 1) confirm the damage caused by heavy rain and flooding in April 2021, 2) collect information on the amount of rainfall and river levels during the disaster, 3) identify the causes of damage to roads and bridges, and 4) propose the necessary measures to protect these infrastructure assets.

1.1.3.Project area

The project area is the Hinode Bridge and the surrounding area in the Comoro Suco of Dili Municipality, Timor-Leste, and along the Comoro River from the mouth of the Comoro River to about 10 km upstream.

1.2.Survey process

The preparation for this project started in Japan in late August 2021. The field survey work was conducted in Timor-Leste from mid-September to early November 2021. A draft of the Post-disaster Situation Report was prepared by mid-November 2021. The Post-disaster Situation Report will be submitted to JICA on 6 December 2021.

1.3.Composition of the survey team and main interviewees

The survey was carried out by a team consisting of the four members shown in the Appendix: a Chief of Operations/Bridge Planning Consultant, a Revetment Planning Consultant/River Surveyor, Construction a Planning Consultant・Project Cost Estimator and a Road Planning Consultant/Natural Conditions Surveyor. The team met with key members of the Ministry of Public Works and the National Directorate for Roads, Bridges and Flood Control, which were the counterparts for this survey. A list of the main interviewees is shown in Appendix.

1.4.River conditions at the time of the disaster

In April 2021, heavy rains associated with the approach of tropical cyclone Seroja caused extensive flooding throughout Timor-Leste. There are eight rainfall monitoring stations set up in and around the Comoro River basin (see Figure 1) to observe daily rainfall. The daily rainfall observed at each station from late March to mid-April of the same year peaked on 4 April. In particular, the rainfall recorded at the stations in Dili City (Dili Airport, Dili EDTL Office and WTP Bemos) in the downstream area and at Remexio in the eastern part of the basin were very high, ranging from 305 mm to 466 mm. In the upper Comoro River basin (Railako), 241 mm was recorded.

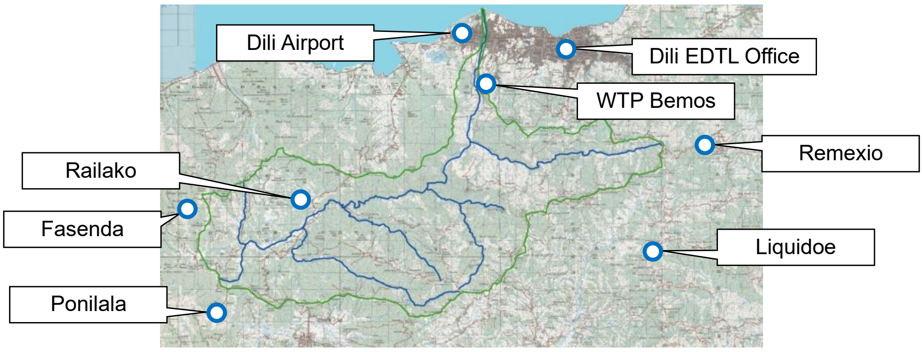


Figure 1 Rainfall monitoring stations

There is a water level monitoring station set up at Railako in the upper reaches of the Comoro River. The observed water level from March to April 2021 is shown in the Figure 2. The station recorded a sustained peak water level for three days before the level began to decline on 8 April.

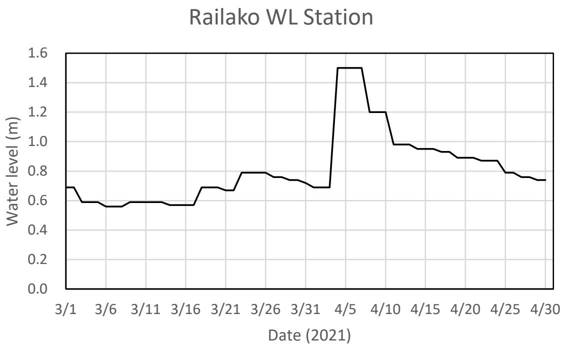


Figure 2 Water level from March to April 2021 (Railako station)

1.5.Damage situation and operation status around the road bridge after the disaster

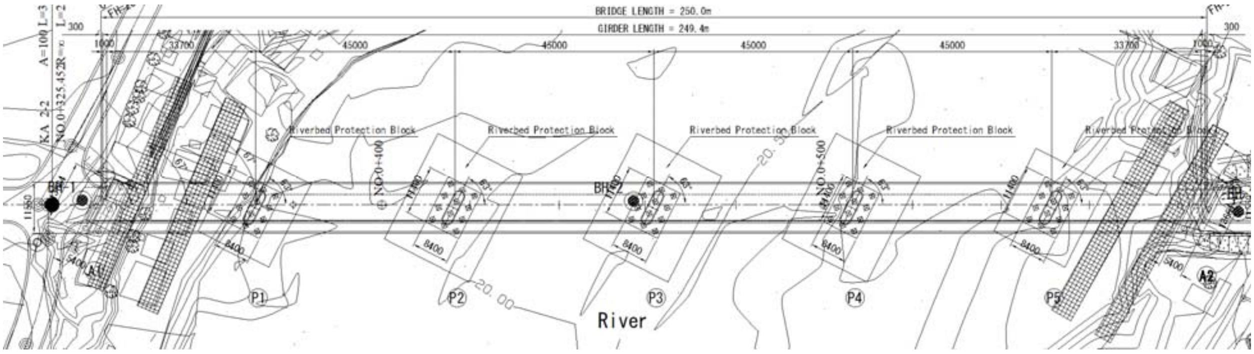
1.5.1.Around Hinode Bridge

The area around the Hinode Bridge, including the access roads, was not affected by the floods this year, and the roads and bridges are in operation without major problems.

However, there are large and small holes caused by gravel mining in the riverbed of the Comoro River as far as the eye can see, and excavation work is also being carried out directly under the Hinode Bridge. These activities have been seen since the time of the preparatory survey, but it appears that the extent of mining is expanding year by year.

In addition, houses have been constructed in the flood channel (inside the river area), since the time of the preparatory survey. In this flood, the buildings in the flood channel on the left bank downstream of Hinode Bridge were damaged by riverbank erosion.

The survey results for bridges and ancillary structures are shown below. The abutments and piers P1 and P5 near the riverbank are almost unaffected by floods. The protective blocks of piers P2, P3 and P4 located in the center of the river have been damaged.



Source：JICA team

Figure 3 Plan of Hinode Bridge

(1)Abutments and revetments

The abutments are protected by revetment blocks (block retaining walls) and no damage due to the flood was observed. No traces made by the water level were found on the revetment blocks. The tops of the revetments were checked with a level measuring device and both banks were found to be level. In addition, gabions were installed at both the left and right ends of each revetment as connections to the existing ground and these were found to be in a healthy condition.

(2)Piers

The Hinode Bridge is a continuous 6-span prestressed-concrete box girder bridge with 5 piers in the river. These piers are named P1 to P5 from east to west. Protection blocks are installed on the riverbed around each pier over an area of approximately 20 m in all directions to prevent scouring.

The conditions of each pier and its surroundings at the time of the site visit (as of September 2021) are as follows.

(a)Pier P1

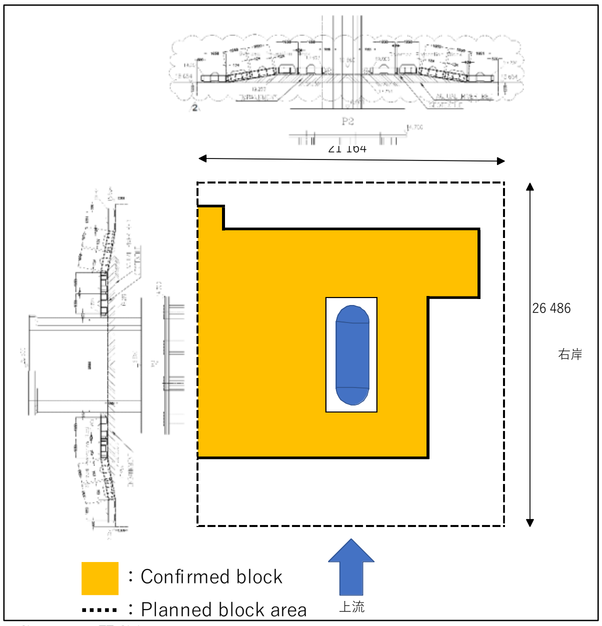
No trace of the flood was seen on the pier. In addition, the inclination of the pier was check and no abnormality was found. No abnormality was found in any of the piers regarding their inclination.

The protection blocks of this pier were designed to be located about 1.5m lower than the current riverbed, so their condition could not be visually confirmed. However, the area around the pier is covered with lush grass, and the inhabitants of the river seem to have been cultivating crops such as corn for a long time, so it is thought that the impact of the flood is not great near the riverbank. Therefore, it is presumed that the protection blocks are in their designated position.

(b)Pier P2

No trace of the flood water level was found on the pier.

Many protection blocks could be visually checked in the riverbed on the side facing pier P3, and the current extent of the protection blocks was determined by measuring the site. Most of the other blocks that could not be confirmed are located in the peripheral area, which is lower in elevation than the others by design, and it is assumed that they are buried in place under sediment deposits.



Source : JICA team

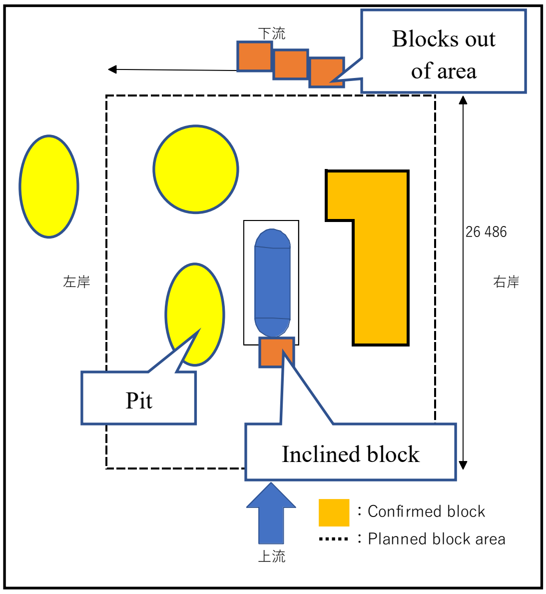
Figure 4 Protection blocks of Pier P2

(c)Pier P3

Traces of the flood water level were seen on the pier column. No noticeable damage was found on the pier.

Pier P3 (P2 side)

The blue line shows the posterior of the stain, and the same position was found in the interview.



Source : JICA team

Figure 5 Pier P3 (left) & Protection blocks of Pier P3 (right)

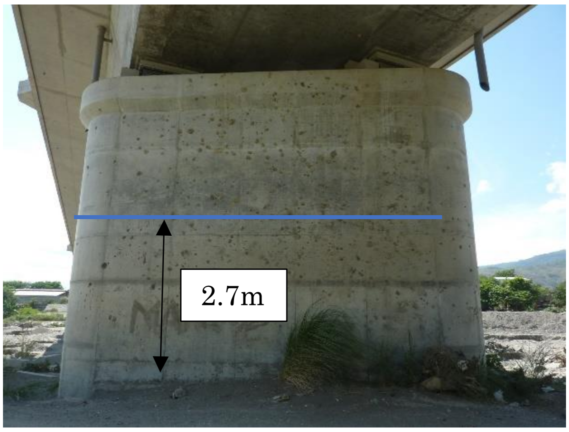
The protection blocks could be confirmed in parts of the planned area for block installation.

Of the five piers, there were particularly many gravel pits near this pier. The size of the holes reaches several meters and the depths are over 1 m.

(d)Pier P4

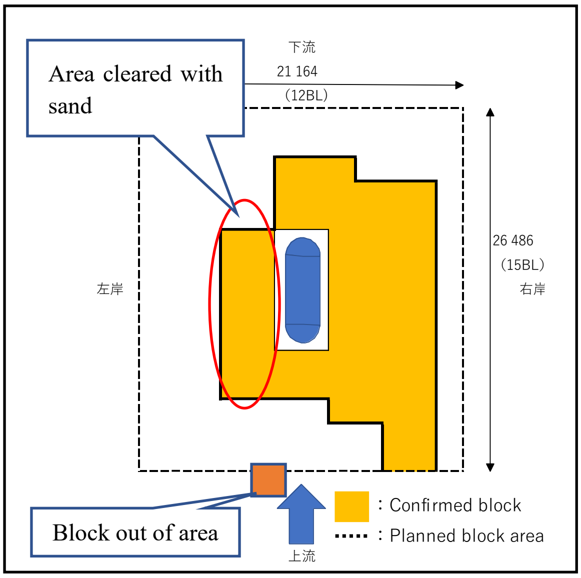
Faint traces of a water level were seen at a height of 2.7 m from the current riverbed height.

The riverbed is leveled with sand to facilitate driving on the protective blocks of this pier in the areas that are frequent used by residents and mining companies. Some metal fittings connecting the blocks were missing in places.



Pier P4 (facing P5)

Traces of water level can be seen at the formwork joints.



Source: JICA team

Figure 6 Pier P4 (left) & Protection block of Pier P4 (right)

(e)Pier P5

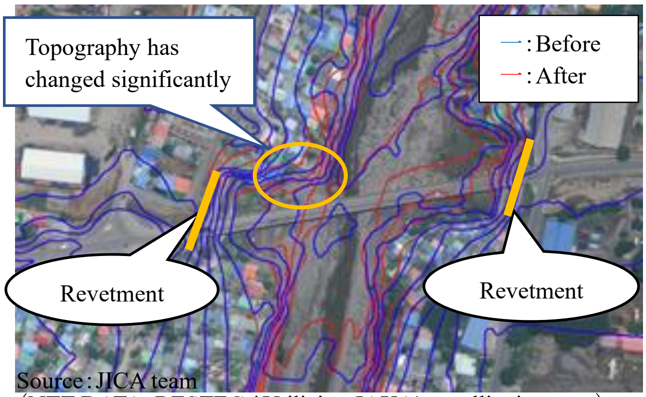
No trace of the flood water level was seen on the pier column.

As with Pier P1, the protection blocks of this pier were placed at a lower elevation (about 2 m below) than the current riverbed, so it is assumed that the protective blocks are in their designated position.

(3)River flood channel

At the location of Hinode Bridge, there are many parts where houses have been built closer to the river center than the revetment on both sides of the river without going through formal procedures. Therefore, the width of the river is narrower than that of the upstream sections.

The Figure 7 shows the contour lines created from satellite elevation data before and after the flood this year superimposed on a satellite image. The field survey confirmed that the embankment gradient became shallower after the flood in the circled location and that the embankment has collapsed due to erosion, despite not being on a curved section or part that would be impacted by the flow.



Source: JICA team
(NTT DATA, RESTEC *Utilizing JAXA's satellite imagery)

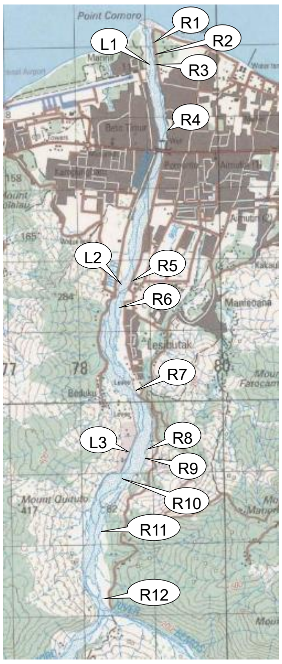
Figure 7 Contour lines before and after the flood near Hinode Bridge

1.5.2.Comoro River

The April 2021 flood caused damage to the Comoro River, including damage to the river walls and resulting riverbank erosion, flooding and loss of houses in the river channel, and loss of protection blocks around the bridge piers of the Hinode Bridge (see Section 1.7.1).

(1)Damage to river walls and resulting riverbank erosion

The location of the damaged sections of the river wall are about 9 km from the mouth of the Comoro River (upstream of the confluence with the Bemos River) as shown in Figure 8. The damaged sections are mainly on the right bank. Especially sections R7 to R12 on the right bank, which are 5.5 km upstream of the river mouth and which were constructed after 2013, have been continuously damaged. The left bank of the same section has not been developed and no revetments have been constructed because the road along that riverbank has been cut off.

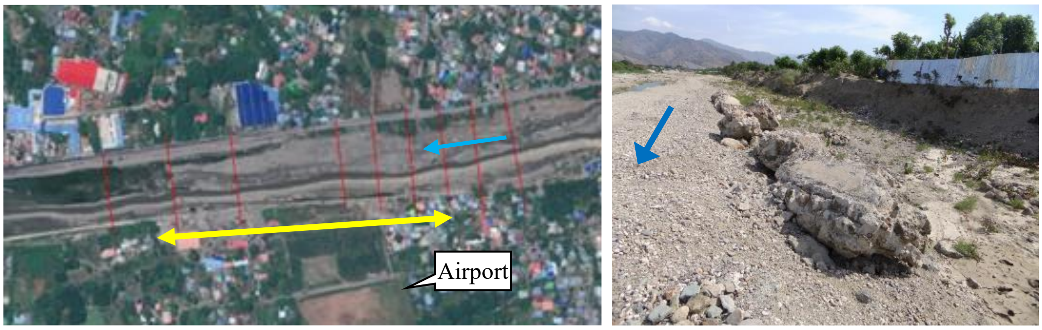


Source：JICA team

Figure 8 Locations of damaged river walls

(a)L1（Approximately 0.7 km from the mouth of the river, 460 m in length）

It is thought that the 3.5-to-4-m-high stone revetment collapsed due to scouring caused by the current flood and due to a reduced the embedment depth of the revetment caused by the level of the riverbed becoming lower over time. Since the revetment does not contain any lateral strips, the collapse at one point is thought to have adversely affected the adjacent revetments. The riverbank is close to the airport runway, so the restoration of this section is a high priority.



Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 9 Damage to river wall (L1)

(b)L2（Approximately 3.8 km from the mouth of the river, 23 m long）

A low-water revetment (about 2m high) on the left bank 100 m downstream of the check dam has been washed away. The structure is made of masonry and the surface is finished with mortar. With the construction of the check dam 100m upstream in 2019, it is feared that sediment transport from upstream during floods will be inhibited and the level of the riverbed will become lower. The check dam was constructed in 2017 to prevent riverbed degradation due to the erosion of gravel.

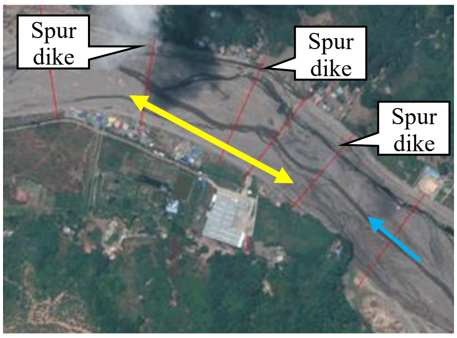
Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 10 Damage to river wall (L2)

(c)L3 (about 6.3 km from the river mouth, 374 m long)

There is a mixture of sections where the entire revetment has been washed away and sections where only the upper part of the revetment has been left and the lower part has been washed away. The structure is a masonry retaining wall. There are spur dikes on the right bank on the outside of the bend in the river. The spur dikes may have caused the mainstream floodwaters to hit the left bank and scour the edge of the river wall, leading to the collapse of the river wall.

These three spur dikes were constructed around 2013. Their purpose is to protect the riverbank by directing the flow during floods toward the center of the river channel.

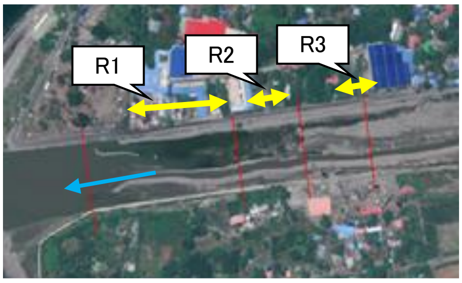


Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 11 Damage to river wall (L3)

(d)R1 (0.3 km from the mouth of the river, 168 m long), R2 (0.5 km from the mouth of the river, 39 m long) and R3 (0.6 km from the mouth of the river, 38 m long)

The satellite image of before the flood shows that there are water routes near the riverbank, which suggests that the foundation of the riverbank was washed away during the flood and collapsed. After the flood, a small embankment with a width of 5 to 10 meters has been constructed at the edge of the riverbank.



R1

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 12 Damage to river wall (R1, R2, R3)

(e)R4 (about 1.6 km from the mouth of the river, 141 m long)

The alignment of the river channel changes direction to the left near the check dam, and the affected section is located on the outer bank of the bend. Although a 4-to-5-m-wide embankment has been placed at the edge of the riverbank to stabilize the slope, which is currently covered with earth, it is desirable to restore the embankment as soon as possible or to place protection blocks on the embankment.

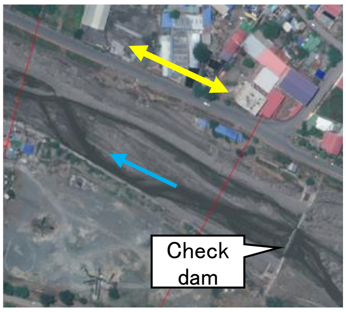
The check dam had been severely damaged since around 2017 and it was repaired in 2019 because the missing section was causing sediment to be washed away on the upstream side and there was a risk that the riverbed scour could extend to the Comoro Bridge.

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 13 Damage to river wall (R4)

(f)R5 (3.8 km from the river mouth, 100 m long)

The gabions have collapsed near the middle of the 570-m-long gabion revetment section. Ten tiers of gabions were piled up on the riverbank to a height of about 10 meters. In the remaining section, the shape of the bottom gabions are deformed. The slope up to the road on the riverbank has collapsed and the road is currently one-sided, so restoration is urgently needed.



Source：(Left) Compiled by the research team from NTT DATA satellite images,
(Right) Taken by the research team

Figure 14 Damage to river wall (R5)

(g)R6 (4.1 km from the mouth of the river, 110 m long)

A retaining wall about 7 m high collapsed, and gravel was piled up in front of the riverbank to protect the slope as an emergency measure. The width of the river narrowed from 140 m to 115 m at a point 230 m upstream of this section, which may have led to the collapse of the riverbank due to a higher flow velocity of the river. The road on the riverbank is cracked and caved in, which has restricted traffic to one side of the road, so the restoration of this section is highly urgent.

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 15 Damage to river wall (R6)

(h)R7 (about 5.5 km from the mouth of the river, 142 m long)

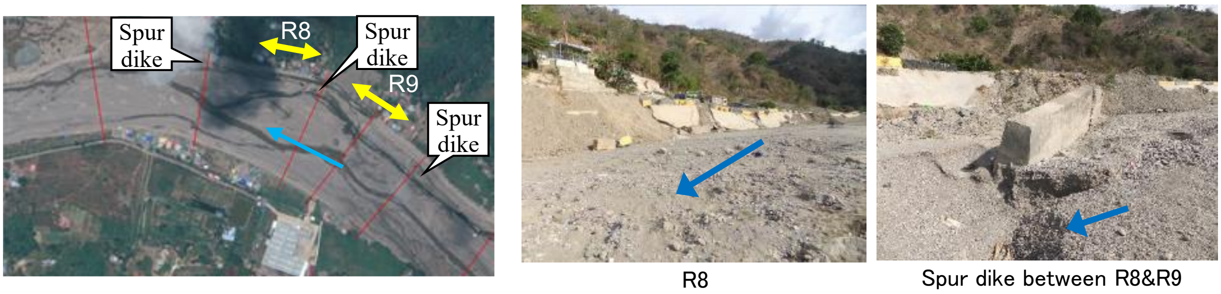
The floodwaters directly hit the section because of the land reclamation in the river by a gravel mining company on the right bank upstream of this section. The collapse of the revetment is thought to have been caused the scouring of the revetment foundation and the removal of sediment from the behind the revetment. The road surface of both lanes of the riverside road have been washed out, and vehicles are driving on the road surface about 2 meters lower than the original surface. Although the urgency of reconstruction is high, countermeasures need to be considered in conjunction with measures to deal with the land reclamation activities upstream.

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 16 Damage to river wall (R7)

(i)R8 (approx. 6.3 km from the mouth of the river, 100 m long) and R9 (approx. 6.5 km from the mouth of the river, 121 m long)

There are three spur dikes on the outer bank of the bend. The angle of the spur dikes is downstream (i.e., not at a right angle to the revetment), so it is possible that the flow over the spur dikes directly hit the revetment during the flood and scoured the revetment foundation. Two of the three spur dikes on the downstream side were severely damaged, so repairs to the spur dikes when restoring the revetments are recommended.



Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 17 Damage to river wall (R8, R9)

(j)R10 (6.8 km from the river mouth, 223 m long)

The bedding area (about 1.5 m) of the remaining river wall in this vicinity was exposed and floating. In this section, sediment was deposited in front of the riverbank before the flood, but it was eroded during the flood and the flow reached the river wall, lifted the foundation and caused the wall collapse.

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 18 Damage to river wall (R10)

(k)R11 (7.8 km from the mouth of the river, 560 m long) and R12 (8.6 km from the mouth of the river, 53 m long)

Gravel was piled up on the riverbank as a first measure, but the gravel was collected from the riverbed near the damaged area that resulted in the formation of a channel near the riverbank. The length of the damaged section on R11, 560 m, is the largest among the surveyed sections in this study. For the restoration, it is recommended that the revetment be reinforced with lateral strips at regular intervals to prevent displacement and damage from spreading to other areas, and that protection blocks be laid in front of the revetment.

Source: (Left) Compiled by the research team from NTT DATA satellite images, (Right) Taken by the research team

Figure 19 Damage to river wall (R11, R12)

1.5.3.Road

There was no damage to the road pavement, drainage, sidewalk facilities and hand railings of the Hinode Bridge due to heavy rains. Furthermore, there have been no traffic restrictions or other road operations after the heavy rains. However, due to the aforementioned damage to the river wall of the Comoro River, the access road to Hinode Bridge that is located on the riverbank was damaged in the following locations.

(a)Damage to the road at 1.6 km (R4) from the mouth of the river

The unpaved shoulder at the edge of the road on the riverbank of the Comoro River is partially damaged due to the partial collapse of the retaining wall of the bank at points R1, R2 and R3 near the check dam, which is located 1.7 km from the mouth of the river. The road itself has not been damaged.

(b)Road damage at 3.8 km (R5) and 4.1 km (R6) from the river mouth

As mentioned above, no road damage was observed in the Hinode Bridge area, but the foundation of a masonry retaining wall upstream of the Hinode Bridge was washed away causing the retaining wall to collapse and the sidewalk and pavement of the road on the embankment collapsed along with it. The damaged retaining wall was upstream and downstream of the check dam that is located 3.9 km from the mouth of the river and it was constructed to a height of 7-10 m from the riverbed. As a result, the road has been reduced to a single lane, which is not only a hindrance to vehicular traffic, but also affects the houses that are in the vicinity. If left unattended, the damage to the road will continue to interfere with traffic and may also increase the risk of flooding for nearby residents.

The restoration structure of this river wall will be described later.

Source: JICA team

Figure 20 Road damage at 3.8 km (left, R5) & at 4.1 km (right, R6)

(c)Road damage at the point 5.5 km (R7) to 6.3 km (R8) from the mouth of the river

There is road damage near the Bemos Water Treatment Plant at the point where the alluvial fan of the Comoro River begins at 5.5 km from the mouth of the river. In this location, the revetment had been damaged in the past, causing overflow and flooding of the city downstream. Therefore, the current ground near the embankment had been raised in the past to prevent the overflow from occurring, but the reinforced concrete revetment collapsed because the foundation was washed away and the road collapsed along with the embankment.

This section of the road was blocked by a private stone quarrying factory and the road overhang was damaged by the muddy water caused by heavy rain. In addition, there are many bare areas in this section because the hills are close together and the vegetation in the valleys has been stripped by the crushed stones. As a result, counterpart organizations have been removing mud and stones from the roads immediately after the disaster to allow the passage of traffic.

However, the intrusion into the river area and damage to the revetment caused by the blockage of road facilities by the private sector is a problem that should be addressed by the maintenance of revetments and roads in the original river area. As for Japan's measures to deal with the current damage, since this is a domestic issue, it is recommended that the local government improve the location of the river and the structure of the riverbank, and restore the existing riverbank road or the original road position.

Source：JICA team

Figure 21 Road damage at 5.5 km (left, R7), Mudslide at 6.3 km (center, R8) & Road plan for 5.5-6.3 km (right)

(d)Road damage from 6.8 km (R10) to 7.8 km (R11) from the river mouth

A four-lane paved road has been completed, but the foundation of the revetment along the river has been washed away, causing the road embankment to slip away and the pavement to crack and collapse. However, the masonry retaining wall in this section is only about 3-4m above the riverbed, so there are few technical problems in reconstruction. It is recommended that foundation protection works be constructed and the damaged road facilities be reconstructed from the roadbed.

(e)Damaged road at 12.2 km from the mouth of the river

A four-lane paved road has been constructed up to 8.9 km from the mouth of the river, which is the junction of the Comoro River and the Bemos River. From this point on, the road upstream of the Comoro River becomes a two-lane paved road that passing through mountainous areas.

At the crossing box culvert 12.2 km from the mouth of the river after the junction, heavy rains from the mountains have washed away the road and river side retaining walls, resulting in the road being reduced to a single lane and the unpaved lower subbase is severely scoured. The section upstream of this point is under construction up to the lower subbase, but since two lanes of traffic are maintained in the section before and after this point, it is recommended that restoration work be carried out as soon as possible.

(f)Damaged roads at 14.6 km and 15.4 km from the mouth of the river

At the 14.6 km and 15.4 km points from the mouth of the river as well as at the 12.2 km point, heavy rains from the mountain side have washed away the road and retaining wall, reducing the road to a single lane, so it is recommended that restoration work be carried out as soon as possible.

Source: JICA team

Figure 22 Cross culvert and road damage at 12.2 km (left) & Road damage at 15.4 km (right)

(g)After the above-mentioned sections, there is little damage to the road and only erosion of the lower subbase by rainwater. The construction of the lower subbase under construction should proceed. The upper subbase of the section connecting to National Highway No.2 from further upstream has been completed, and a wide two-lane road has been completed.

(h)Status of National Highway No. 2 (NH2)

NH2, which connects the southern part of the country, is undergoing a complete renovation of the existing drainage facilities and embankment retaining walls along almost the entire route. In addition, the road is muddy because it is only one lane and is made of earth road, which significantly hinders the safe passage of vehicles and motorcycles, resulting in low traffic volume. The Ex-Japan Road along the Comoro River is used as a bypass for NH2.


Source: JICA team

Figure 23 Construction of subbase on Ex-Japan Road (left)
& Cross culvert / retaining wall on NH2 (right)

For this reason, the rehabilitation of the three narrowed sections of the unpaved Ex-Japan Road is expected to be completed as soon as possible, as the road is still functioning as a bypass for NH2 and will also be important as a distribution route for large cargo vehicles to the southern region of the country as the Port of Tibar develops into an international cargo port.

1.6.Confirmation of the cause of the damage

This section will assess the possibility that the protection blocks were washed away by the flood flow.
As described in "1.7.1(d)", the trace water level during the current flood was found to be 2.7 m above the riverbed at pier P4. The flow rate of the trace water level at the bridge site was approximately 650-750 m3/s and the velocity was 3-4 m/s according to a back-calculation of the flow rate using a non-uniform flow calculation and a river channel cross section created from AW3D data. The evaluation including the flow rate of this year's flood will be discussed based on the latest survey results from the Post Situation Data Collection Survey for the Flood Countermeasures in Dili (hereafter the "Collection Survey in Dili") which is being conducted separately.
In comparison to the design hydraulic capacity of the weight of protection blocks, the severity of this year's flood was small and, according to calculations, the 3tf of protection blocks should be sufficient.
The reason for the absence of the blocks is assumed to be because of the behavior of the flowing water during the flood, the following may be considered.
In section "2.1 River wall restoration policy and measures to prevent recurrence based on revised design conditions," the following points will be taken into consideration and measures will be proposed to prevent another disaster.

- As the metal fittings that connect the blocks to each other were removed, the blocks lost their resistance as a group and were washed away,
- As the riverbed was in contact with the blocks at the edge of the laying area, the flow was disturbed by the sudden change in roughness, and the blocks were washed away by local scouring at the edge.
- A circular hole dug during gravel extraction near the protection block was enlarged by the flood current and reached the protection block, causing the block to slide and be washed away.

1.7.Counterpart emergency repair and full-scale repair policy

In response to the recent flood damage, a survey was conducted to investigate whether there were any repair measures for bridges and roads carried out by counterpart organizations. The survey found that the Hinode Bridge has not been repaired since there was no major damage and no operational problems. As for roads and especially the NH2 bypass, several landslides occurred about 6 km upstream from the mouth of the Comoro River and the landslides blocked the road. Other than that, there are some damaged areas as shown in the results of the field survey of the road, but no repairs have been carried out so far. The necessary repair measures are being studied by the Flood Damage Assessment Task Force (Chairperson: Dr. Benjamin), which includes the DRBFC, ADN, IPG and other related organizations, and the Ad Hoc Team (Coordinator: Mr. Vital, Advisor of the DRBFC), which is studying the technical aspects. A close coordination between these teams and the Collection Survey in Dili survey teams will be necessary. Based on the results of these studies, emergency repair measures will be compiled.

1.8.Review of planning conditions at the outline design stage

The outline design is developing a channel plan for the 3.6 km section of the Comoro River from its mouth to accommodate the 50-year probability flow rate (2,500 m3/s) for the basic design of the Hinode Bridge (which is located 2.6 km from the river mouth). In the ongoing Collection Survey in Dili, the river channel plan is being reviewed with a wider scope up to approximately 10 km from the mouth of the river.

Chapter 2 Study to resolve inconveniences

2.1.Policy for river wall restoration and measures to prevent recurrence

The policy for restoration of the river wall and recurrence prevention measures based on revised design conditions are as follows.

(a) The river channel plan is being reviewed and developed using the latest survey data and climate models as part of the Collection Survey in Dili. The restoration plan will be based on the plan reviewed in that study.

(b) The following measures are proposed for the protection blocks around the piers of the Hinode Bridge.

- Although the existing 3tf blocks are stable against the flow according to calculations, it is recommended that the weight of the additional blocks should be 3tf or more to prevent another disaster;
- The protection blocks should be laid between the piers to prevent gravel extraction in the vicinity of the protection blocks and to prevent the riverbed against erosion in that section;
- The upstream and downstream ends of the protection blocks should be covered with gabion mats within around 10 m of the ends to improve the fit with the surrounding riverbed;
- The blocks should be connected to each other in such a way that they cannot be detached easily.

(c) The following measures are proposed for the restoration of the river wall.

- In addition to securing a sufficiently safe embedment length against scouring, protection blocks should be placed in front of the river wall to prevent local scouring of the edge of the river wall;
- Lateral strips should be laid across the length of the river wall to separate certain sections of the river wall and prevent any effects of shifting or damage in one section from spreading to others;
- When the riverbank height is high, a step should be provided in the middle of the slope to stabilize the slope. However, if the width of the step is large, it may be used as a site for housing construction, which should be taken into consideration when determining the width of the step;
- Upstream of 6.6 km, development has not progressed because the left bank is mountainous and roads have been cut off;

- When restoring the right bank revetment upstream of 6.6 km, spur dikes (groynes) will be considered to defend the riverbank.

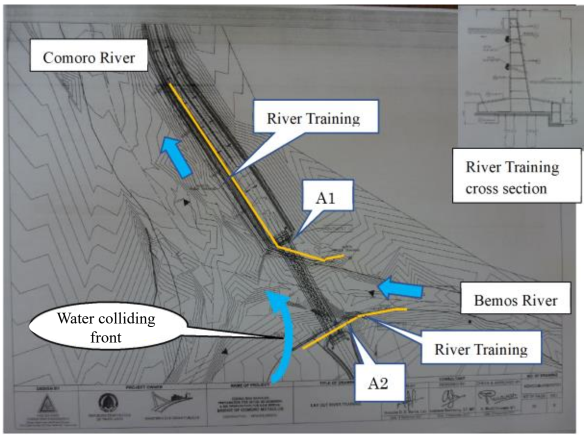
2.2.Recommendations for the Bemos River Bridge Plan

A survey of the Bemos River Bridge Project, which is being planned by the government of Timor-Leste, was carried out.

[Outline of the Bemos River Bridge Project]

- Location of the bridge: at the confluence of the Bemos and Comoro rivers (about 8.9 km upstream from the mouth of the Comoro River)
- Bridge width: (2 lanes) 8m
- Bridge structure: (superstructure) steel Nielsen arch bridge, bridge length 120 m
- (substructure) inverted T abutment
- (foundation) Steel pipe piles φ700 mm
- Approach roads: (North side) approx. 400 m, (South side) approx. 250 m
- Riverbank: Reverse T-type retaining wall, (right bank side) approx. 270 m, (left bank side) approx. 90 m

The basic concept of the bridge plan is to cross the Bemos River by using the existing NH2 bypass road. The bridge straddles the Bemos River with a single span. A single span is desirable to avoid installing bridge piers in the river, because the confluence of rivers with different river characteristics causes large-scale eddies, scouring and sedimentation of the riverbed, and it is a weak point for flood control. In addition, the following recommendations are made based on the plans prepared by the government.



Source: Processed from drawings prepared by DRBFC
Figure 24 River training construction plan

- ➢ There is an indication of the 50-year and 100-year probable flood levels. Obviously, these levels are low and do not seem to take into account the volume of water in the Comoro River, which joins the Bemos River. It is necessary to review the river plan in the future based on the results of the recommendations made in the information gathering survey.
- ➢ The back of the abutment may be eroded because the southern abutment (A2 abutment) is at the water colliding front on the outside of the bend of the Comoro River. However, since river training is not sufficiently planned for the flow and water level of the Comoro River, it is important to review the location of the revetment to protect the back of the abutment from erosion, taking into account the above water level and the flow speed of the river. It is also necessary to take measures against erosion of the approach road embankment slopes.
- ➢ In contrast to the above, the revetment of the north abutment (A1 abutment) is arranged to protect the abutment and approach road extensively.

2.3.Outlined design and estimated construction cost for emergency bridge repair

2.3.1 Emergency restoration

Based on the survey of the damage, it was found that the areas around the bridge that needed to be restored were the protection works around piers P2, P3 and P4. The bridge piers will be scoured during flood without the protection blocks, which will have a negative impact on the piers, so immediate restoration is desirable. The restoration policy is to reuse the remaining blocks as much as possible and to manufacture the missing blocks on site to restore the bridge to its original condition. The approximate construction cost is calculated as follows.

Table 1 Approximate construction cost

Protection block on Piers P2, P3, P4	Indirect construction costs	General management costs	Total (1000USD)
179	164	61	404

Source: JICA team

2.3.2 Full-scale restoration

During the meeting with the counterparts, it was reported that the construction of the second Hinode Bridge was underway in the vicinity of the current Hinode Bridge. Therefore, in addition to the above emergency restoration, the measures proposed in 2.1 to prevent recurrence, such as the addition of protection blocks between the piers and the installation of gabions around the blocks, should be considered in conjunction with the construction plan for the second Hinode Bridge.

2.4.Outlined design and estimated construction quantities for rehabilitation of river wall

2.4.1. Emergency restoration

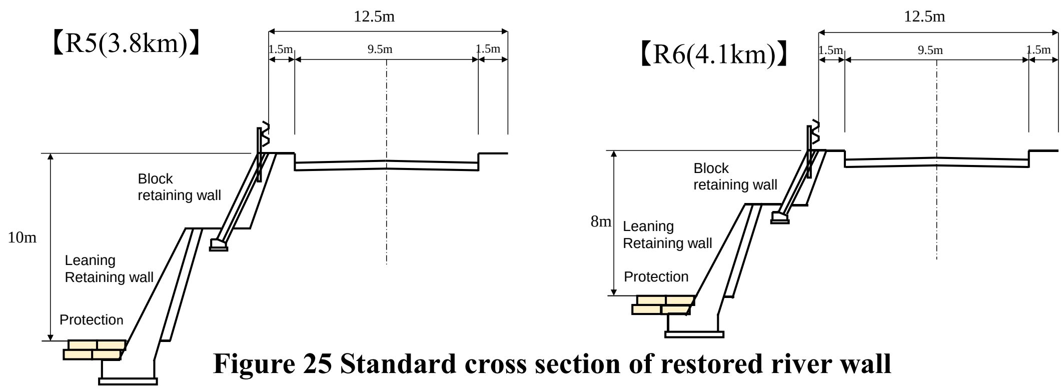


Figure 25 Standard cross section of restored river wall

The restoration of 110 m and 120 m of revetments (R5 and R6 as discussed in 1.7.2(1)) upstream and downstream of the upstream check dam are necessary. Furthermore, the associated road rehabilitation works will necessitate the removal of the damaged parts of the concrete revetments, gabions, pavement, subbase and embankment, and then the restoration of the lower subbase, upper subbase and pavement. In addition, ancillary facilities such as guardrails, curbs and road marking should be installed where necessary. The Figure 25 shows the proposed restoration structure for the river wall and road, and the restoration quantities for R5 and R6 were calculated based on this idea.

Table 2 Main construction quantities

	Leaning and block retaining wall	Riverbed protection	Pavement (subbase, asphalt)	Guardrails	Removal of concrete / gabions
R5	110m	440m	935m2	110m	800m3
R6	120m	480m	1020m2	120m	1210m3

Source: JICA team

2.4.2.Full-scale restoration

Of the 15 damaged sections of the river wall shown in Figure 8, R5 and R6 on the right bank will be restored as a Japanese grant aid project as described in 2.4.1. The restoration of the other 13 locations (total length of 2,442 m) is described below.

The river plan for the Comoro River is being studied in the Collection Survey in Dili. The plane alignment, height, channel cross-section, etc. of the river wall will be studied based on this plan. In addition, it is appropriate to consider the Hinode Bridge and the Ex-Japan Road as critical infrastructure in order to maintain logistical functions in the event of a flood.

Table 3 Restoration of 13 other locations

Left/right bank	Symbol	From mouth of river	Length	Restoration concept
Left bank	L1	0.7 km	460 m	Because of the proximity to the critical infrastructure (the airport runway), the structure needs to be a more stable form than just an L-shaped retaining wall, and repairs should be prioritized.
	L2	3.8 km	23 m	For localized damage, the structure should be the same as the existing river walls (masonry retaining walls) upstream and downstream. Where the foundation is exposed on the existing revetment, fill it with gravel to prevent scouring in front of the foundation.
	L3	6.3 km	374 m	The riverbank has been eroded by about 30 meters before and after the flood. Further erosion needs to be prevented, but there are not that many resources to protect the riverbank.
Right bank	R1	0.3 km	168 m	Since it is a continuous section, these 3 sections should be repaired at the same time. A large excavation is being done in front of bottom of the bank, leaving a flat area of 4 m to 10 m wide. First, reclamation should be carried out to maintain a certain width (20 m or more) from the bottom of the bank, and then the river wall should be repaired.
	R2	0.5 km	39 m	
	R3	0.6 km	38 m	
	R4	1.6 km	141 m	Since the height of riverbank is more than 7m, it should be designed as a two-stage revetment structure with a small step as shown in 2.4.1.
	R7	5.5 km	142 m	The width of the two lanes has been restored through emergency works. However, the road surface has been lowered by about 1.5 m, and there is a risk of flooding in the event of a water outflow from the river, so restoration is a high priority.
	R8	6.3 km	100 m	This is a continuous section and the 2 sections should be repaired at the same time. Since the riverbank is high (7-8 m), a two-stage revetment structure should be used. As it is located on the outer bank of the bend, spur dikes (groynes) should be used proactively and on a trial basis.
	R9	6.5 km	112 m	
	R10	6.8 km	232 m	Since the riverbank is as high as 7-8m, a two-stage revetment structure should be used.
	R11	7.8 km	560 m	Since it is a straight line and a long distance, an embankment with a slope of about 20% should be considered instead of a revetment. In such a case, there is a concern that it might be used as a way for trucks and other vehicles to enter the river.
	R12	8.6 km	53 m	
Total			2,442 m	

Chapter 3 Summary and recommendations of the field survey

In this survey, the post-disaster situation of the Hinode Bridge on the Comoro River, its surrounding areas and the area about 10 km from the mouth of the Comoro River were confirmed. Although the damage around the Hinode Bridge was limited to the protection blocks of the bridge piers, the Comoro River and the Ex-Japan Road along the bridge were damaged in many places by the collapse of the river wall, subsidence of the road and cracks in the pavement.

As for the protection of the bridge piers, many protection blocks remained in the planned locations even after the heavy rains, which indicates a good level of durability. However, the gravel mining in the river, especially around the bridge piers, has been continuously carried out and the resulting mining pits are estimated to be the cause of riverbed lowering and turbulent flow. As for the river revetments, they are thought to have collapsed because the revetments are a gravity-type masonry structure even though the structural height is over 5 meters, because of multiple stacking of gabions, because the footing of the revetments were washed away, or a combination of these causes. This collapse and overturning of the river revetments caused the subsidence of the roadsides and cracks in the pavements.

Based on the results of the above survey and analysis, countermeasures are proposed in Chapter 2.

For the implementation of the countermeasure works, it is recommended that the local government restore the protection blocks around the bridge piers to their original state as soon as possible, since the technical level of the country is sufficient and the construction cost is not significant. As for measures to prevent recurrence, it is recommended that improvement measures be considered in conjunction with the construction plan for second Hinode Bridge. As for the restoration of river revetments and riverside roads, prioritization of the works is recommended based on urgency as well as cost, because the damaged areas are scattered and the scale of each damaged area varies. However, the road between the Hinode Bridge and the upstream check dam (R5, R6) has been narrowed due to damage to the road surface, which affects vehicle traffic and requires urgent attention. Also, this section of road is crowded with buildings, and it is recommended that the road be restored as soon as possible through grant aid.

The Ex-Japan Road, which branches off from the Hinode Bridge and connects to NH2, is a paved road from the bridge to the cross culvert (12.2 km from mouth of Comoro River), except for some damaged sections. However, upstream of this point, there is a section where the lower subbase is under construction and there are three sections where the road is severely damaged. We recommend that the counterpart organizations urgently repair the section that has been reduced to one-lane to ensure the function of the national highway bypass.

In addition, the result of the traffic volume survey conducted by the counterpart organizations during the outline design stage are required for the post evaluation after the completion of the Hinode Bridge. However, Timor-Leste has yet to conduct regular traffic volume monitoring surveys on major roads such as national highways. For this reason, a two-day traffic survey was conducted with counterparts at the Comoro Bridge and the Hinode Bridge during the current survey as on-the-job training. A TOR for conducting traffic surveys by private sector orders was presented as a reference for future implementation of regular traffic observation. The result of traffic volume observation/evaluation and TOR are shown in the Appendix.

At the same time, it was confirmed that the roadside blocks were removed by the stores on the access road towards the airport. Since the paving of the sidewalk had been re-laid after the removal, the counterpart organizations were requested to instruct Dili City, the road management authority, to properly maintain the road facilities provided to them.

Appendix

1 Composition of the survey team

Composition of the survey team

Responsibility	Member name	Affiliation
Chief of Operations／Bridge Planning Consultant	NAGANO Seishi	INGEROSEC
Revetment Planning Consultant／River Surveyor	USUI Yosuke	IDEA
Construction Planning Consultant・ Project Cost Estimator	OGAWA Fujio	INGEROSEC
Road Planning Consultant／Natural Conditions Surveyor	MUTO Hisashi	INGEROSEC

2 Main Interviewees

Main Interviewees

Department	Position	Position	Person	Note
Directorate General	Director General		Mr. Rui Hernani F. Guterres	
National Directorate of Road, Bridge and Flood Control (DRBFC)	National Director		Mr. Nene Lobato	
	Advisor of DRBFC		Mr. Vital Naique	Coordinator for Ad Hoc team
	Planning and Inspection Dept.	Chief of Department	Mr. Rogerio Freitas	New Bemos bridge
	Construction and Maintenance Dept.	Chief of Construction Section	Mr. Nazario de JesusFrette	Ex-Japan road
	Construction and Maintenance Dept.	Maintenance Section	Mr. Antonio Araujo	Person in charge for the project
	Construction and Maintenance Dept.	Maintenance Section	Mr. Emidio Daniel S Alves	Civil engineer
	Construction and Maintenance Dept.	Maintenance Section	Mr. Zebedeu de Araujo	Civil engineer
	Cooperation Dept.		Mr. Cipriano da Silva Guterres	Civil engineer

3 Traffic Survey Results and Post Project Evaluation

A. Traffic Survey

A.1 Sample Traffic Counting

For the post evaluation of the construction project of the Hinode Bridge and Access Road, Traffic Volume on both bridges across the Comoro River is the key element of the project evaluation.

But there is no official traffic survey conducting on both of the bridges.

Therefor sampling traffic counting has been conducted by direct force of the two members of the planning section of DRBFC starting from 01 PM to 06 PM on 26th October 2021 and from 8AM to 01 PM on 27th October 2021 at Hinode bridge and Comoro bridge

Survey time was about 20 to 15 minutes sampling within each survey one hour.

After the traffic counting, normal hourly traffic volume, 12-hour traffic volume and then 24 hour traffic volume have also been calculated as shown in below table.

At the original period of the project, Traffic counting had been conducted in 2013 on Comoro bridge by the JICA study team and after the construction of the Hinode bridge second time traffic counting had been conducted by the Supervision Consultant.

And also traffic estimation on both of the bridge has also been conducted by the JICA study team.

Therefor evaluation of the construction project of the Hinode bridge can be conducted through the comparison between the actual traffic volume and the estimated traffic volume as shown in table XX.

The Table shows that the existing traffic volume on Comoro bridge is about 38,000 in 2013, 30,000 in 2018 and 55,000 pcu par day in 2021 and the estimated traffic volume is about 40,000 in 2018 and 45,000 pcu par day in 2021. Therefore, the actual traffic volume is only lower than the estimation on just opening of the project and the existing traffic volume growing than that of estimation.

The actual traffic volume on the Hinode Bridge is about 15,000 in 2018 and 33,000 pcu par day in 2021 and the estimated traffic volume is about 13,000 in 2018 and 14,000 pcu par day in 2021. Therefor the actual traffic volume on the Hinode bridge is larger than that of the estimated traffic and the actual across traffic of the Comoro River of about 88,000 pcu par day in 2021 is also increased than that of the estimation volume of 57,000 pcu par day in 2021.

And also actual truck and trailer traffic volume on both bridge is about 5,700 vehicles par day is larger than that of the estimated truck volume of 4,700 vehicle par day.

But the traffic congestion rate on Comoro bridge was 0.68 in 2013 and the existing congestion rate become 1.18 on both bridges due to dramatical increase of the cross river traffic and city expansion toward west area of the city and need widening of the facilities will be considered.

This is showing that the purpose of the construction bridge project is successfully achieved and the city expansion toward the west area of the city has streamline by the opening of new access bridge and access road development

A.2 Annual Traffic survey

Annal traffic survey on certain points on each of the national road is the basic information both for traffic characteristics and socio-economic index. Therefor many country conducting such annual traffic survey on national road and it is recommended that DRBFC should consider to introduced annual traffic counting.

The recommendable annual traffic counting is also consisting not only count 12 hour traffic count the main purpose of the survey is to define the average annual daily traffic (AATD). Therefor seasonal variation, weekly variation and daytime and nigh time variation should also be conducted on certain point of the national road.

Actual traffic counting will be on average weekday and average season and counting place will not be changed at each of the survey time.

In case of the 12hour traffic counting on one point, minimum 3 person will be required for the survey consisting of 2 persons for counting for each direction and one person will be supporting.

In case of the Traffic counting by the private, following Terms of Reference and the contract will be considerable.

Table XX Traffic Survey Results and Comparison with estimated traffic volume

Bridge name	Comoro Bridge													Hinode Bridge										Comoro +Hinode Bridge							
passed /future traffic volume	Full scale surveyed traffic in 2013 (A)			Full scale survryed traffic in 2018(B)	Estimated traffic in 2018 (C)	Estimated traffic in 2021 (D)	sample survey traffic in 2021 (E)					Evaluated 2018 traffic Value (B/C)	Evaluated 2021 traffic Value (E/D)	Full scale survryed traffic in 2018 (F)	Estimated traffic in 2018 (G)	estimated traffic in 2021 (H)	sample survey traffic in 2021 (I)					Evaluated 2018 traffic Value (F/G)	Evaluated 2021 traffic Value (I/H)	Estimated traffic in 2018 (J)	Full scale survey traffic in 2018 (K)	Evaluated traffic Value (K/J)	2018 Traffic Increase from 2013 (J/A)	Estimated traffic in 2021 (L)	Sample survey traffic in 2021 (M)	Evaluated 2021 traffic Value (M/L)	2021 Traffic Increase from 2013 (M/A)
Type of traffic	12 hrs traffic	24/12 rate	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	6 hrs morning traffic	6 hrs evening traffic	12hrs traffic	24/12 rate	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	6 hrs morning traffic	6 hrs evening traffic	12hrs traffic	24/12 rate	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic	24 hrs traffic
Type of vehicles																															
M/C	25,142	1.18	29,668	30,207	30,787	33,154	20,708	15,414	36,122	1.18	42,624	0.98	1.29	12,952	10,700	11,520	11,880	10,482	23,400	1.18	27,612	1.21	2.40	41,487	43,159	1.04	1.45	44,674	70,236	1.57	2.37
Passenger Car/4WD	9,842	1.29	12,696	4,670	14,114	16,339	11,056	8,587	19,643	1.29	25,339	0.33	1.55	2,717	4,520	5,240	3,396	3,503	8,636	1.29	11,140	0.60	2.13	18,634	7,387	0.40	0.58	21,579	36,480	1.69	2.87
Bus	2,688	1.21	3,252	6,874	3,515	4,069	1,676	1,846	3,522	1.21	4,262	1.96	1.05	1,770	930	1,080	436	537	1,516	1.21	1,834	1.90	1.70	4,445	8,644	1.94	2.66	5,149	6,096	1.18	1.87
Truck	2,176	1.49	3,242	1,649	3,084	3,370	844	931	1,775	1.49	2,645	0.53	0.78	1,162	780	840	724	728	1,564	1.49	2,330	1.49	2.77	3,864	2,812	0.73	0.87	4,210	4,975	1.18	1.53
Trailer	81	1.49	121	285	356	412	60	84	144	1.49	215	0.80	0.52	393	150	180	164	226	344	1.49	513	2.62	2.85	506	678	1.34	5.62	592	727	1.23	6.02
Total traffic	39,929	-	48,979	43,685	51,856	57,344	34,344	26,862	61,206		75,084	0.84	1.31	18,994	17,080	18,860	16,600	15,476	35,460		43,430	1.11	2.30	68,936	62,679	0.91	1.28	76,204	118,514	1.56	2.42
Total Traffic in PCU			37,508	29,713	39,903	44,549					55,443	0.74	1.24	14,728	12,670	14,120					33,061	1.16	2.34	52,573	44,441	0.85	1.18	58,669	88,504	1.51	2.36
Traffic Capacity of Road Section (Qpcu)			55,000	55,000	55,000	55,000					55,000			20,000	20,000	20,000					20,000			75,000	75,000			75,000	75,000		
Congestion Rate (T/Q)			0.68	0.54	0.73	0.81					1.01			0.74	0.63	0.71					1.65			0.70	0.59			0.78	1.18		

(Sample)

TERMES OF REFERENCES (TOR) for Traffic Survey

<u>in accordance with</u>

<u>the Comoro and Hinode bridges and access roads across the Comoro River in Dili</u>

1. General

These specifications shall be applied on the Traffic Survey for the post evaluation of the construction project of the Hinode Bridge and Access Road, Traffic Volume on Comoro and Hinode bridges across the Comoro River.
Under this evaluation, a qualified local consultant shall be engaged to execute the traffic surveys.

2. Traffic Count Survey

The objective of traffic count survey is to understand traffic volume that passes through the survey point by each vehicle type. Traffic count survey shall be conducted as follows:

(1) Survey Point

The survey point is shown as figure-**

(2) Date and Duration

- Date : weekday 1 day
- Duration : 12 hours from 7h 00 to 19h 00

(3) Vehicle type Classification

- The vehicles passing the survey point shall be counted by 4 vehicle types, “Motorcycle”, “Passenger car & Taxi“, “Bus“, “Truck & Trailer”
- The unusual traffic flow caused by traffic accident or event or disaster shall be noted in the survey form.

Table-1 Example of vehicle type

Vehicle type	Example
Motorcycle	
Passenger car & Taxi	 

Bus	 
Truck	 

(4) Method

- Counting by each vehicle type and each direction,
- Recording the survey result in the survey sheet by every hour.

(5)Preparation

- Contractor should prepare all the survey instruments by himself,
- Survey form and input form will be provided by the Client.

3. Materials

3.1 Materials to be submitted

The Contractor shall input the survey result in the input form provided by the Client.

Annex-1

BILL OF QUANTITIES
FOR
TOPOGRAPHIC SURVEY

Currency Unit: US$

No.	Work Items	Unit	Q'ty	Unit Price	Amount	Remark
Sub-Total(Topographic Survey)						
1	**Traffic Survey**					
1-1	Preparation of Survey	LS				
1-2	Traffic Count Survey(12h/ 1day)	Point				
1-3	Data Input	LS				
Subtotal						
Tax (%)						
Total Amount						

Note:

1. Contractor shall acquire all necessary approvals and permissions from the relevant authorities to conduct the survey.
2. Contractor shall provide all equipment, materials, personnel which are necessary to perform the survey work.
3. Contractor shall provide all transportation to/from the survey site for all personnel, equipment and materials. In addition, Contractor shall provide all accommodation and other allowance for all personnel, if any.

Annex-2

PAYMENT SCHEDULE

The First Party will pay to the Second Party in compliance with the following payment schedule:

1) An advance payment, USD ***** (***** USD only) equivalent to forty percent (**%) of the total contracted amount, will be paid to the Second Party within five (*) days after signing the contract by remittance from the First Party to the bank account mentioned below of the Second party.

2) The final payments, USD ***** (***** USD only) equivalent to sixty percent (**%) of the total contracted amount, will be paid by the First Party within five (*) days after the approval of the fulfillment of Services by the First Party by remittance from the First Party to the bank account of the Second party.

3) As for modifications to the ordinances in the site of work, these will be performed multiplying the unit price by the quantity; such amount will be credited in the final payment (Contract by unit price.)

Bank Account of the Second Party

Consultant:

Banker's Name:

Address:

BSB:

Account No:

Swift Code: