CTCN
CLIMATE TECHNOLOGY CENTRE & NETWORK

AIT
Asian Institute of Technology

CTCN Technical Assistance to Bhutan

Reference Number: 2016000046

"Flood risk assessment for Dungsamchhu Basin in Samdrupjhonkar Municipality"

Deliverable 4: Draft Flood Control Intervention: Scour Protection of Flood Control Dikes and River Banks

CONTEXT

Bhutan has been grappling with flooding problems for years. A combination of steep topography and the projected increase in rainfall in the coming decades due to climate change poses major threats, particularly during the monsoon season. In addition to direct flood damages to life and property, these events also trigger subsequent hazards such as landslides. The Government of Bhutan has recognized the need to urgently manage the recurring flood problems in the country. As a result, it has approved a budget of Nu.728 million in the 11th Five Year Plan for flood protections works throughout the country, and established the Flood Engineering and Management Department (FEMD) to oversee all flood management works in the country. The newly established FEMD, however, lacks the technical capacity to carry out the flood risk assessment studies, which is crucial in developing flood management plans to mitigate the impacts of floods.

In May 2016, FEMD and the National Designated Entity (NDE) of Bhutan, the National Environment Commission Secretariat (NECS), submitted a request for CTCN assistance on "*Capacity development for preparing an integrated flood management plan for Dungsamchhu Basin in Samdrupjongkhar*". The request was accepted by the CTCN, and consortium partner Asian Institute of Technology (AIT) was engaged to provide technical support. After several rounds of interaction between AIT and FEMD, the scope of the technical assistance was defined specifically and deemed to focus on "*Flood Risk Assessment for Dungsamchhu Basin in Samdrupjhonkar District*". The objective of the technical assistance is to enhance the skills of the relevant engineers in FEMD and Samdrupjhonkar municipality to indigenously undertake flood risk assessment and to translate this assessment into flood adaptation interventions.

The last activity under this technical assistance was to develop a draft design of a structural flood alleviation intervention. This document presents the design developed by the FEMD engineers in consultation with experts from AIT.

PROPOSED SOLUTION FOR SCOUR PROTECTION

The flood protection dikes along Samdrup Chu (River) in the Samdrupjhonkar Dzongkhag have been designed by the engineers from FEMD and the Municipality of Samdrupjhonkar. The river dikes stand high enough of about 5 m above the ground with a free board of about 1-1.5 m above the maximum flood level to the dike crest. It was reported that there was no dike overtopping in the past decades, but the toe and the base of the dike and the river banks are facing serious scouring problem at some locations. The causes of scouring are due to:

1. High flood flow velocity (which is likely to increase as a direct impact of climate change)

2. Lack of sufficient protection of loose river bank materials at the banks and base of the dikes.

3. Improper alignment of the dikes with respect to the flow

Therefore, it is intended to provide methods and guidelines to protect the dikes and river banks at the toe and its base as follows:

1) The apron as shown in Figure 1 should be provided at the base of the toe wall **(width of the launching apron= 1.5* maximum scour depth**[1]) to prevent scouring of the base under the toe wall. The bed scour should be measured at site by the designing engineer. Further, it is recommended that the base of the toe wall should be deeper for more efficiency.

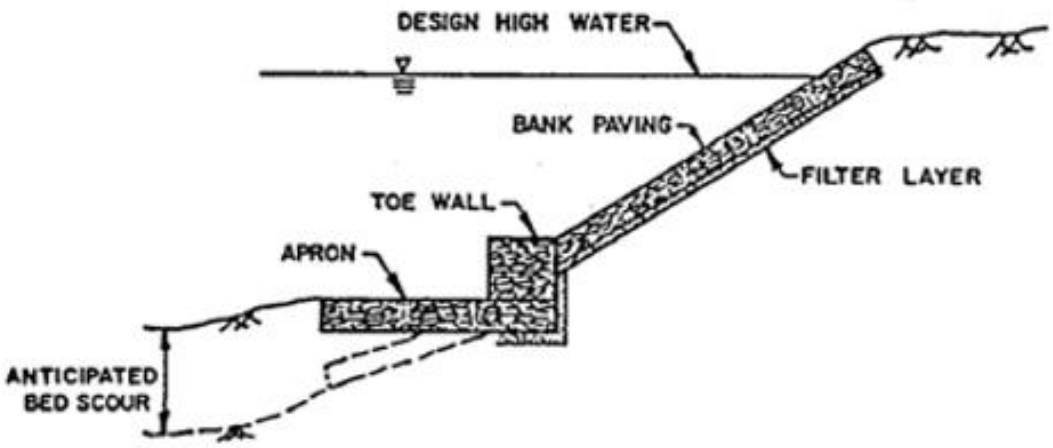

Figure 1: Requirement of apron for scour protection[2]**.**

2) The toe mattress may be designed considering the maximum water level to protect the toe wall from failure due to scouring. It may be provided above the toe wall as depicted in Figure 2.

[1] Handbook for flood protection, anti-erosion and river training works.

[2] Technical Standards and Guidelines for Planning and Design (March 2003).

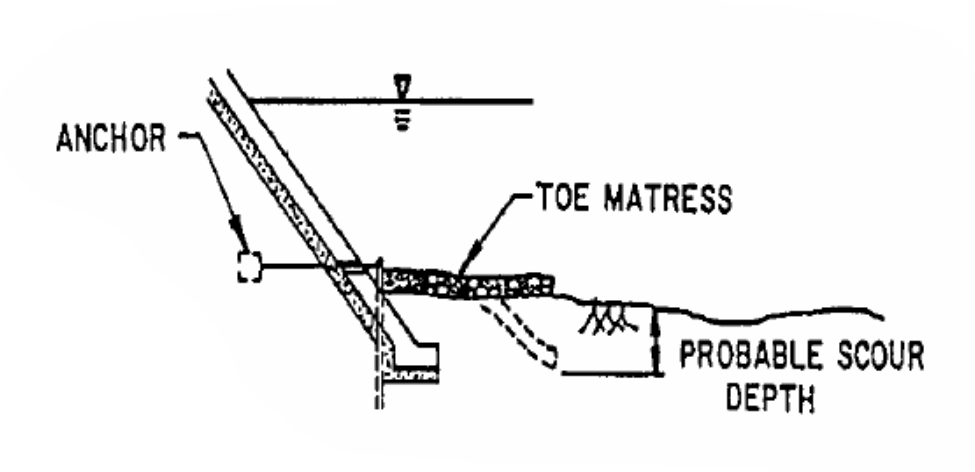

Figure 2: Requirement of toe mattress for toe protection[3].

3) Appropriate counter-measures such as concrete piles or sheet piles may be provided as shown in Figures 3 and 4 to protect the foundation of the revetments and walls during high velocity flow when it is subjected to direct water attack resulting in scouring of the deepest river bed. In addition, the foot protection works should also be placed in front of the revetment foundation to prevent scouring at the base of a loose soil.

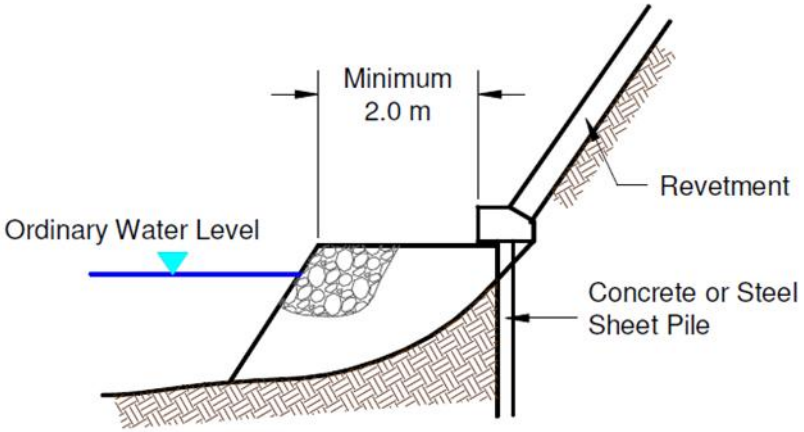

Figure 3: Concrete or steel sheet pile for scour protection[4].

[3] Technical Standards and Guidelines for Planning and Design (March 2003).

[4] Technical Standards and Guidelines for Planning and Design (March 2003).

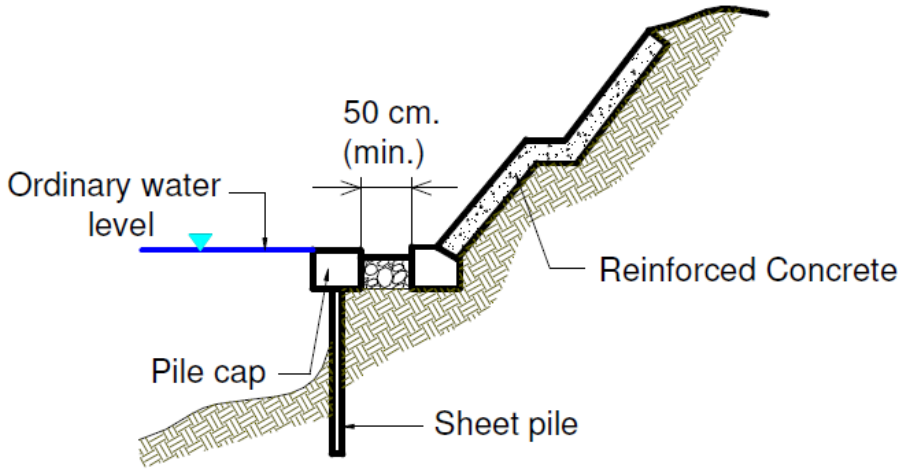

Figure 4: Alternative sheet piling for scour protection[5].

ALTERNATIVE SOLUTION FOR SCOUR PROTECTION AS AN INTERIM MEASURE

The Municipality at present has constructed a lot of flood protection structures along Dungsumchu (River) to reduce the vulnerability of the people and infrastructure to flooding. Presently, the foundation of flood protection structures has weakened over years due to flash floods in the rainy season. However, they are still protecting the settlements along the banks of Dungsumchu. Therefore, there is a need to reinforce existing flood protection walls by providing interim measure on the base of the existing structures as follows:

1)

Figure **5** and Figure 6 show an interim measure to re-strengthen the existing revetment, reinforced cement concrete (RCC) wall and Random Rubble Masonry (RRM) wall for flood protection. The diagram shows that three elements (first gabion panel, second gabion panel and apron) will be constructed in front of the existing walls. The function of the first panel gabion box (height X) provided in front of the toe wall is to prevent the revetment/RCC wall/RRM wall from sliding and it will also provide better stability. Further, the second panel placed below the first panel will make foundation stronger and it will also protect against erosion. The apron provided will be launched in due course of time due to scouring. However, the

[5] Technical Standards and Guidelines for Planning and Design (March 2003)

launching apron will cover the face of the scour and it will protect further scouring, thus retaining the strength of the base of structures.

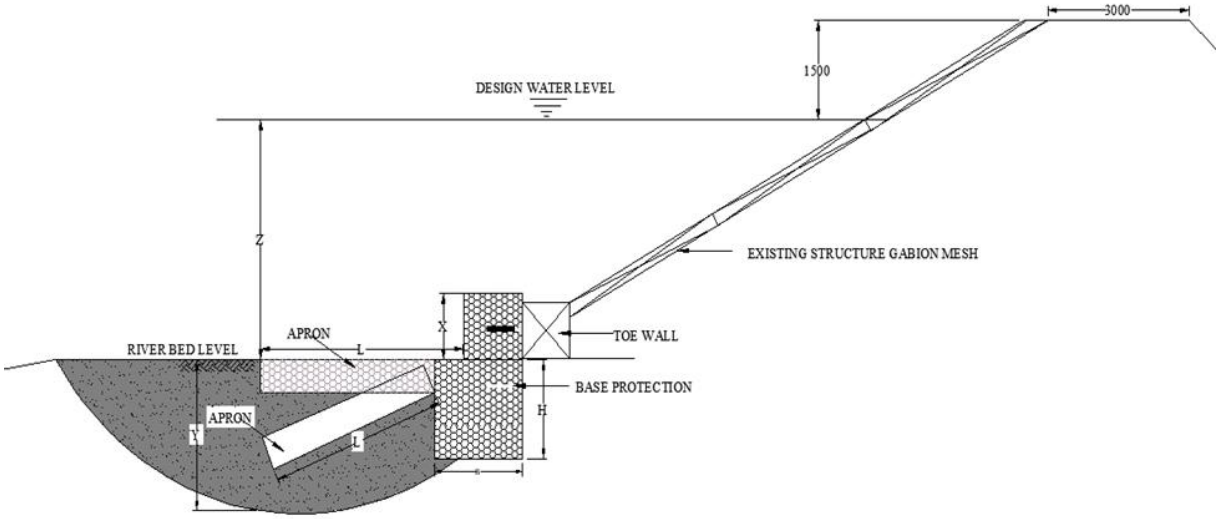

Figure 5: Apron for existing revetment.

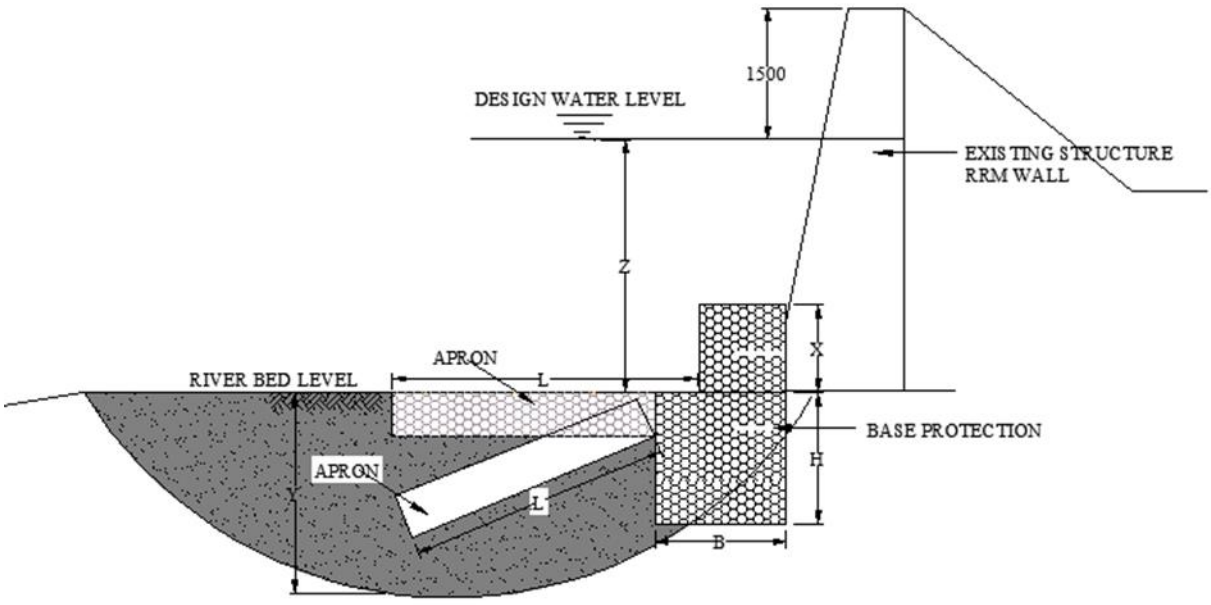

Figure 6: Apron for existing RRM/RCC wall.

Where, X= Height of the first panel
Y=Maximum scour depth
Z=Design water level

H= height of the second panel
L= Length of the apron
Therefore, L=2H

2) Figure 7 and Figure 8 show an interim measure to re-strengthen the existing revetment, reinforced cement concrete (RCC) wall and Random Rubble Masonry (RRM) wall for flood protection. The diagram shows riprap with varying size of boulders to be used as apron for protection of existing structures. The uniformly graded boulder is to be in front of the toe wall with slope of 1:3 towards the center of the river. The apron provided will be launched in due course of time due to scouring. However, the launching apron will cover the face of the scour and it will protect further scouring, thus retaining the strength of the base of structures. These methods are cheaper and it can be adopted for Dungsumchu. But, when the velocity of the river is high during flash floods, smaller boulders may be washed away.

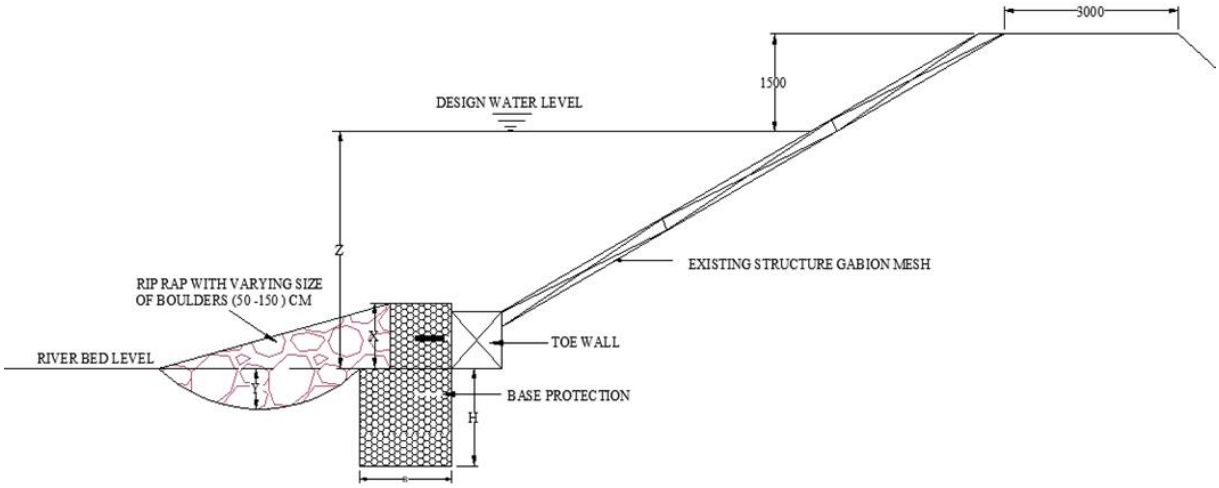

Figure 7: Rip rap to protect the base of the existing revetment.

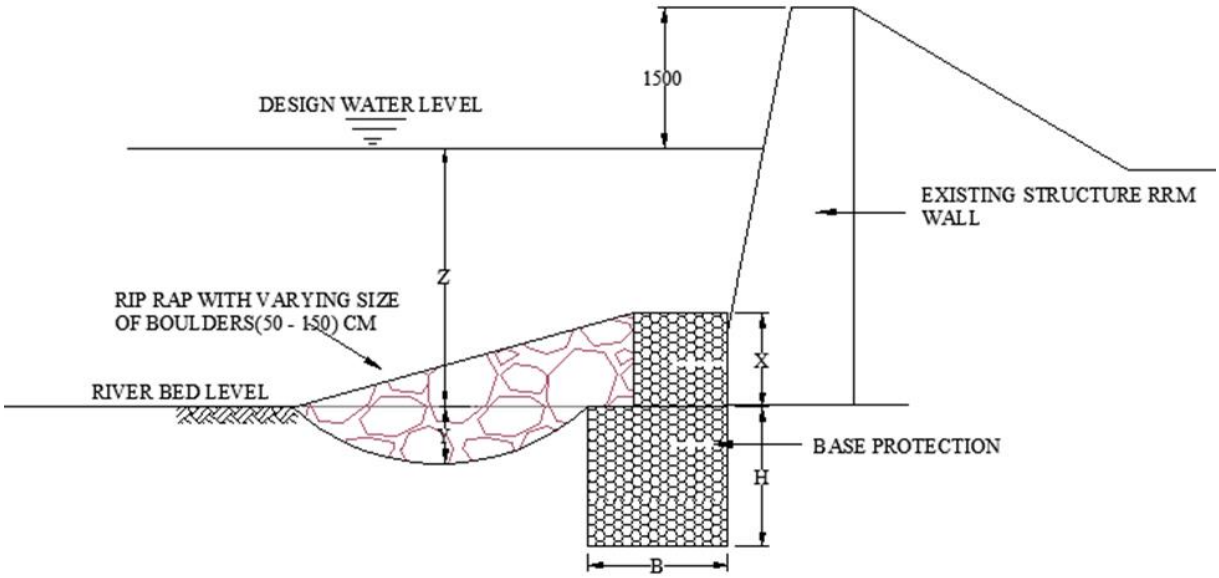

Figure 8: Rip rap to protect the base of the existing RCC/RRM wall.

REFERENCES

JICA (2002): Technical Standards and Guidelines for Planning and Design, Project for the Enhancement of Capabilities in Flood Control and Sabo Engineering of the Department of Public Works and Highways, Japan.

International Cooperation Agency, Volume I, Flood Control, March, website https://www.jica.go.jp/project/philippines/0600933/04/pdf/Technical_Standards_and_Guidelines_for_Planning_and_Design.pdf

Jansen, P.Ph. et al (1979): Principles of River Engineering, Pitman Publishing Co. Ltd., London, U.K.

N.V. Maddukuri, N.V.N.Ravali, A. D. Vasudeo (2015): Design of embankments and bank protection works for hilly rivers, Journal of Civil Engineering and Environmental Technology, Volume 2, Number 9; April – June, pp 58-62, Krishi Sanskriti Publications, India.

IMPLEMENTATION OF THE INTERVENTIONS

1. Cost of the interventions and interim solutions: This particular deliverable under the CTCN technical assistance is related to addressing the scouring problem in dikes because of increased flow velocity (attributable to climate change in future). The FEMD has already designed the structural features of the dikes. The CTCN assistance helped FEMD to incorporate the scouring aspects in the design, given that this problem is likely to be more pronounced in light of climate change. It is understood that, hence forth, all the dikes that are constructed in the country will be based on this scoring design. The cost of the interventions and interim solutions will depend on the length of the structure to be placed in critical locations as well as the length of existing walls requiring the maintenance respectively. In context of Samdrupjhonkar, the expected costs are USD 148,000 for the critical areas.

2. Equipment and materials needed: The equipment and material needed are mostly for construction of the dikes, and its related features. The major equipment required are: excavators, dumper trucks, concrete mixers, wooden/steel formwork, road rollers for developing access roads, concrete vibrators, water pumps and tankers. The major materials required include: Gabion mattress, gabion boxes, boulders, cement, sand, aggregates, sheet piles, concrete piles, steel rods and non-woven geotextiles.

3. Implementation time and timeline for implementation: The implementation time for the dike in Samdrupjhonkar should take around 1 year. However, for larger dikes in other parts of the country, this time period can extend up to 3 years. The FEMD will now liaise with the Royal Government of Bhutan for a blanket funding, based on which the timelines for the appropriate interventions will be identified.

4. Institutions in charge: The FEMD will be responsible for providing technical backstopping in terms of providing technical design, drawing, estimates and specifications. Further, FEMD will be responsible for timely monitoring during the implementation phase. The Samdrupjongkhar Municipality will be responsible for execution of the interventions and interim measures.

5. Funding source: The FEMD is currently looking for funding from Royal Government of Bhutan (RGOB), and other funding agencies.