Environmental Protection
Manual

Production of these manuals was made possible through grant assistance from the Millennium Challenge Account – Philippines (MCA-P) through the KALAHI-CIDSS program of the DSWD.

KALAHI-CIDSS
KAPIT-BISIG LABANSA KAHIRAPAN
COMPREHENSIVE AND INTEGRATED
DELIVERY OF SOCIAL SERVICES

Republic of the Philippines
DEPARTMENT OF SOCIAL WELFARE AND DEVELOPMENT

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CHAPTER 1 |

RATIONALE AND BACKGROUND

I. WHAT IS THE CONCEPT OF THE MANUAL?

This manual is intended to provide the Kalahi-CIDSS Deputy Area Coordinator (DAC) with concepts, strategies and alternatives that will help them in designing and implementing environmental protective structure projects such as the development of sea walls, river protection structures, slope protection and flood control drainages in rural areas.

Figure 1 - Example of a Seawall subproject from the KC Risk management enhancement study

In order to provide the end user an appreciation and understanding of these types of structures, this manual encompasses operational procedures and provides an overview of the roles, responsibilities, policies, guidelines and other requirements deemed essential for implementation of the sub-projects. The various sections of this document aim to guide the different implementers, players, and partners in the implementation of the project, particularly the construction and maintenance of small-scale community infrastructure projects.

This manual will also aid project facilitators and stakeholders in gaining a basic understanding of the implementation and maintenance requirements for environmental protection projects.

II. WHAT ARE THE PURPOSE, SCOPE AND LIMITATIONS OF THIS MANUAL?

This manual has been developed to serve as a guide for the Deputy Area Coordinator (DAC) to facilitate the transfer of basic engineering information for environmental protection projects to implementing KC communities.

This manual addresses the basic engineering concepts of application, basis of design, materials, and operations and maintenance (O&M) activities specific to environmental protection subprojects in KC. This manual focuses on the following specific environmental protection subproject types:

a. Slope protection

b. River protection
c. Seawalls
d. Flood control through drainage work (gravity flow only)

This manual also includes preliminary information for additional subprojects that may be considered by the community, such as:

a. Use of plants for riverbank erosion control (i.e. bamboo, vertiver)
b. Use of mangrove planting to mitigate sea wave velocity and beach erosion
c. Use of small-scale water collection infrastructure

The following are the limitations of this manual:

a. This manual has been designed and is intended to be used by a civil engineer with at least two years of experience in the design and construction of similar types of structures. (Typically, a DAC or equivalent with at least two years of experience with the same types of projects)
b. The concepts discussed in this manual require a specific knowledge of engineering theory, principles and practices and the information contained in this manual may be misinterpreted by non-engineering users or by an inexperienced engineer
c. When the user of this manual (Typically the DAC)is not familiar or experienced with the specific subproject under development, the DAC should consult with the Regional Infrastructure Engineer (RIE).
d. This manual is intended to serve as a basic guide and introduction to applicable environmental protection subprojects. Use of this manual is not a substitute for the full engineering investigation, planning and design which is to be undertaken and certified/signed by a registered civil engineer with the appropriate level of experience.

III. WHY ARE ENVIRONMENTAL PROTECTION STRUCTURES IMPORTANT TO KC COMMUNITIES?

According to the United Nations Environment Program (UNEP), the poor are the most to suffer from environmental disasters. This is because the poor depend heavily on their environment for livelihood, have less resilience to environmental disasters and have less access to resources to recover after losses from environmental disasters.

These environmental affects and concerns related to and affecting the poor from natural disasters translate directly to the communities served by Kalahi-CIDSS. Kalahi-CIDSS serves the poorest-of-the-poor communities in the Philippines, communities belonging to the fourth, fifth and sixth class municipalities.

The specific reasons why these Environmental Protection subprojects are important to KC communities are:

First, many KC communities are located in areas near seashores, rivers, flood prone areas, or critical slopes and most of the farming land, fishing communities, and forest product areas are in highly disaster-prone areas. Added to this is the fact that the Philippines has a high rate of incidence of strong typhoons (an average of twenty major occurrences per year) and earthquakes (the Philippines is located in the Pacific Ring of Fire).

Second, there has been a general reduction in the natural defenses in the Philippines against disasters. Examples of this reduction include large-scale losses of forests that absorb rainfall; cutting down of mangroves that provide coastal protection; and removal of vegetation that provides erosion control and prevents landslides.

Lastly, global warming or large-scale environmental events (e.g.. El Nino, La Nina) are expected to increase the incidence of storms, droughts,floods and other extreme weather events in low-lying rural communities, coastal municipalities and effect island communities throughout the Philippines.

The majority of environmental protection structures projects that have been carried out in KC projects can be typically grouped under; slope protection structures, flood control drainage structures, river protection structures, and seawalls. A basic description of these groups of structures is provided below:

IV. WHAT ARE THE MAJOR ISSUES REGARDING ENVIRONMENTAL PROTECTIONS SUBPROJECT IMPLEMENTATION?

Generally, the major issues that can affect the effective implementation of environmental protection projects are:

a. A lack of technical knowledge and an attendant lack of ability to identify the risks of environmental hazards and to identify and design the environmental protection structures to effectively mitigate those risks.
b. Insufficient project funding availability as these types of projects may require a disproportionate amount of the annual income of an entire municipality[1].
c. A lack of technical and/or engineering knowledge for the proper planning, design, implementation and operation & maintenance of these types of projects.

The following list discusses these general issues at the different phases of environmental protective structure project development:

A. PRE-IMPLEMENTATION PHASE

a. Environmental concerns are not highlighted during the orientation and subproject selection stages that would point out the need for environmental protection structures
b. Environmental protective structure designs are not site-specific because insufficient technical investigation is conducted to identify the correct project design requirements.
c. The Barangays/Communities are not provided with the correct approaches and concepts in subproject identification, survey and design of protection structures
d. Design considerations during the feasibility study do not include the possible effects of the environmental protective structure on nearby communities. (e.g. a flood control drainage project may be designed to remove water from a barangay at a higher elevation and may displace the water correctly but also result in the flooding of an adjacent barangay at a lower elevation)
e. Subproject plans do not include sufficient details or may plans may have been developed by insufficiently experienced engineers. Project plan development by inexperienced engineers is a significant concern, as civil

[1] Based on the average cost (2M Php) of KC environmental protection subprojects compared to the annual income of 4th to 6th class municipalities (Maximum of 30M Php to a minimum of less than 10M Php)

engineers with the appropriate skills and experience are not typically found in the Class 4-6 municipalities which Kalahi-CIDSS serves.

B. IMPLEMENTATION PHASE

a. A lack of comprehensive guidelines regarding the process and procedures to be used in subproject construction management, both at the Area Coordination Team (ACT) level (specifically the DAC[2]) and at the community levels.

b. Insufficient technical assistance available during subproject implementation.

c. Insufficient experience in the implementation of environmental protection subproject designs.

d. The project technical specifications do not clearly indicate or suppliers and contractors are not familiar with or experienced with the requirements for the types of material to be used and the construction methods to be adopted

e. Weather disturbances affect subproject construction because they are located in environmental disaster prone areas. Most of the projects are located near rivers, critical/unstable slopes, coastlines and flood plains and construction work will be affected if the site experiences significant weather events prior to completion.

C. POST IMPLEMENTATION PHASE

a. Clear processes and procedures for the operations and maintenance (O&M) of environmental protection structures are not specific and relevant to actual community-level resources.

b. Operations and maintenance (O&M) training may be discontinued due to lack of funding support from the local community

[2] There are training programs provided by Kalahi-CIDSS for the Deputy Area Coordinators (DAC), but actual engineering experience may still be lacking as these are specialized civil engineering projects typically only undertaken by specialty contractors and the Department of Public Works and Highways (DPWH).

V. WHAT GOVERNMENT AGENCIES ARE IMPLEMENTING SIMILAR ENVIRONMENTAL PROTECTION PROJECTS?

Construction and maintenance of environmental protection structures in the Philippines is the concern of several different government agencies. These agencies can be valuable sources of technical information because they implement similar projects and have a larger base of experience with the planning, design, implementation and O&M of these types of structures. The following is a list of several government agencies that have experience implementing environmental protection projects:

a. Department of Public Works and Highways (DPWH) - This government agency is mandated by law to implement different types of public structures all over the country including sea walls, drainages, slope protection and other environmental protection structures.
b. Provincial Local Government Units (PLGUs) – These government units implement environmental protective programs and specific structures upon the request of the concerned municipalities. PLGU's also provide logistical, manpower and equipment support to MLGUs.
c. Municipal Local Government Units (MLGUs) – MLGUs implement environmental structure related projects within their coverage including those projects funded by national government agencies and provincial governments. In some cases, MLGUs request assistance from the DPWH or Provincial Engineer's Office in terms of planning, designing, and implementation of environmental protection structures.
d. Department of Environment and Natural Resources (DENR)– This agency is mandated by the government to be primarily responsible for the protection the country's environment and natural resources. DENR also implements environmental protection structures projects and provide guidelines on the proper planning of these structures when they affect critical ecosystems.
e. Other government agencies such as National Irrigation Authority (NIA) and Philippine Port Authority (PPA) also design and implement environmental protective projects to safeguard their infrastructure and areas of operations.
f. Department of Social Welfare and Development (DSWD) – DSWD has a mandate "*To provide assistance to local government units, non-government organizations, other national government agencies, people's organizations, and other members of civil society in effectively implementing*

programs, projects and services that will alleviate poverty and empower disadvantaged individuals, families and communities for an improved quality of life."

CHAPTER 2 |

APPROACHES TO ENVIRONMENTAL PROTECTION PROJECT IMPLEMENTATION

I. TYPES OF ENVIRONMENTAL PROTECTION PROJECTS

The effective implementation environmental protection subprojects to support programs and projects that address the issue of poverty at the KC community level is a challenging task. The main role of these structures is to protect the community from natural calamities, such as floods, storm surges, typhoons, and landslides.

As described in the introduction, this manual will focus on the following types of environmental protection subprojects:

a. Slope protection
b. Seawalls
c. Flood control structures
    - Drainage
    - Various flood control structures (e.g. dams, levees, small water impounding projects (SWIP) and dredging)

There section of the manual also provides an introduction to the following types of environmental protection projects:

a. Use of plants for erosion control (e.g. bamboo, vertiver)
b. Use of mangrove planting to mitigate sea wave velocity and beach erosion
c. Use of small-scale rain water collection infrastructure

A. WHAT ARE SEAWALL AND REVETMENTS?

Seawalls are vertical or near vertical shoreline/coastal defense structures designed to prevent upland erosion and storm surge flooding. These are generally massive concrete structures placed along a stretch of shoreline and designed parallel to the shore. Seawalls make up the difference in elevation between the shoreline and the intended mainland (area not to be reached by wave action). The purpose of a seawall in KC communities is to protect areas of

Figure 2 – A seawall structure with a distinctive vertical wall shown at low tide (Camarines Sur)

barangay habitation/shelter and conservation of livelihood from the excessive action of tides, waves and storm surges.

Seawalls in KC communities are intended to protect vulnerable areas of the barangay from the excessive and destructive actions and effects of tides, waves and storm surges. Seawalls will also ensure that natural resource bases and sources of livelihood are protected.

Revetments are similar shore parallel structures that also serve the same purposes as seawalls. The main difference between revetments and seawalls is that a revetment is more sloped and a seawall is generally vertical. A revetment is designed with a distinct slope, usually 45% to 65% of slope.

Seawalls and revetments are non-moving structures. Design considerations for these structures should address the consequences of creating a barrier and the effects on biological lifecycles (e.g. laying sea turtles eggs) as a result of these subprojects and how they affect the normal transfer of nutrients from the land to the sea.

Figure 3 - A revetment structure showing a sloped face shown at low tide (Camarines Sur)

Other requirements for seawalls and revetments include the assumption that the coastline is stable during calm weather. The beaches in front of the seawall should not naturally erode and a normal beach is assumed to be present in front of the structures that can be used for socio-economic purposes (e.g. livelihood, leisure, cultural activities). Erosion during storm surges and typhoons is to be expected and included in the design of these structures.

It should also be considered that these structures, if not designed correctly, will have specific weaknesses. First, the actions of waves during typhoons or storm surges may increase beach erosion. Second, seawalls may accelerate coastal shoreline erosion of the adjacent, unprotected coastal areas because these structures affect the transport of sand along the seashore (littoral transport or littoral drift).

The several types of designs for seawalls and revetments that are applicable and appropriate for KC projects are:

a. Curved/vertical faced seawalls are designed to accommodate the impact and run-up of large waves while directing the flow away from the community area being protected. The capacity to accommodate large waves requires a massive structure with an adequate foundation and sturdy toe protection.
b. Stepped-faced seawalls are designed to limit wave run-up and overtopping. They are generally less massive than

curved-face seawalls, but the engineering design requirements for structural stability (foundation) are similar to curved/vertical-faced seawalls. Stepped-faced seawalls are preferred if the beach is extensively used for economic activities that require larger access spaces from the mainland to the beach.

c. Combination seawalls combine both the accessibility of stepped-faced seawalls and the large wave capacity of curved/vertical seawalls. Since this a combination of engineering designs, this approach requires more experienced engineers for the design and construction management.

d. Rubble revetments or a rubble breakwater is placed directly on the beach. The rough surface absorbs and lessens wave action and may minimize scour. The structure consists of a small-size gravel mix base protected by a sloping large gravel/boulder face. This type of design is ideal for KC projects as the technology, design, and materials are available KC coastal barangays. It should be noted however that this design does not have the same capacity to absorb large wave impacts. This type of structure can be improved by replacing the rubble face with reinforced concrete, which is referred to in KC as a "mound-type" structure.

e. Rubble, preformed concrete (i.e. X-blocks, jackstone), and sloped concrete revetments are similar structures that are made of erosion resistant material surface materials. These designs are intended to be built parallel to the shoreline to protect against erosion. These structures are generally made up of an armor layer (protection against wave action), filter (supports the armor layer), and the toe (prevents washout and displacement). The armor layer provides the basic protection against wave action

B. WHAT ARE SLOPE PROTECTION STRUCTURES?

Slope protections are forms of environmental protection structures constructed to support and withstand earth pressure and improve soil stability. The most common failures in slopes of KC communities come from the relatively shallow topsoil in most rural communities, which is further worsened by degradation of vegetation/forest cover and rapid soil saturation during typhoons and rain storms. These conditions contribute to slope collapse.

Figure 4 - Example of a slope protection subproject in KC taken (Iloilo)

Collapsing debris carried by slope failures can move down the slope at relatively fast speeds and travel nearby KC communities, possibly resulting in damage to infrastructure such as roads, houses and livelihood activities (farms, fishponds, etc.)

Suitable slope protection subprojects should be based on a solid understanding of the characteristics of the targeted unstable/critical slopes. Engineering field investigations should start with the collection and evaluation of the general soil conditions (i.e. topography, geology, vegetation, failure history, previous damage caused, climate/rain condition).

The typical types of slope protection measures considered appropriate for KC projects include:

a. Improve water management by increasing the drainage of the area prior to rainwater reaching/accumulating in the critical slope or speeding up removal of water from the critical slope.
b. Slope retention measures such as retaining walls, gabion walls, and stone masonry (riprap walls) will be considered for slope stabilization when failure scales are relatively small and possible landslide movements are relatively low.
c. Shotcrete used for stabilizing, anchoring and preventing collapse of critical slopes.
d. Bio-engineering using various applicable vegetation (i.e. vertiver, trees, bamboo) to anchor loose topsoil or loose materials in critical slopes.

C. WHAT ARE FLOOD CONTROL STRUCTURES?

Flood control structures in rural areas are implemented to protect lives and public/private properties in populated areas (barangays and municipalities) along rivers and streams, flood-prone areas and areas of economic value (i.e. farmlands).

Figure 5 - Example of a river wall or riverbank slope protection used as a flood control structure.

Rural areas have been experiencing increased flooding for the last ten years. The increased incidence of flooding is due to several reasons, ranging from increased precipitation due to climate change, to deforestation that decreases the water storing capacities of forests and watersheds; to siltation and decreased hydraulic capacity of rivers; storm surges (this will be discussed under seawalls and shoreline revetment designs in the next chapter); and to degradation of riverbanks which results in communities being more susceptible to and affected by overflow flooding.

Applicable and appropriate small-scale rural flood control measures for KC communities can be categorized under the following:

a. Increasing river flow capacity through use of dikes, levees, widening of sections of waterways, dredging/excavation, or a combination of these measures .

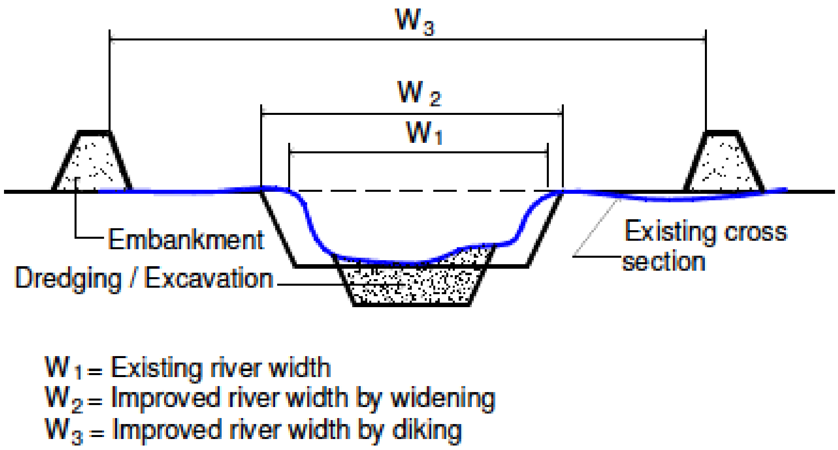

Figure 6 – Several methods for planning and design to increase river flow capacity. (Technical Standards and Guidelines, DPWH JICA)

b. Reduction of peak flood discharge through the use of small-scale dams (although dams are mentioned because they fall specifically under this category, use of dams must be further discussed with the RPMO as they are highly technical and require extensive multi-disciplinary engineering capacity to undertake), retarding basins (these can also be considered as rain collector areas) and floodways (usually termed by KC DACs as high volume drainage structures)

c. Prevention of riverbank collapse by the use of river revetments, spur dikes, bioengineering for riverbank stabilization, and change of waterway/cut-off channels

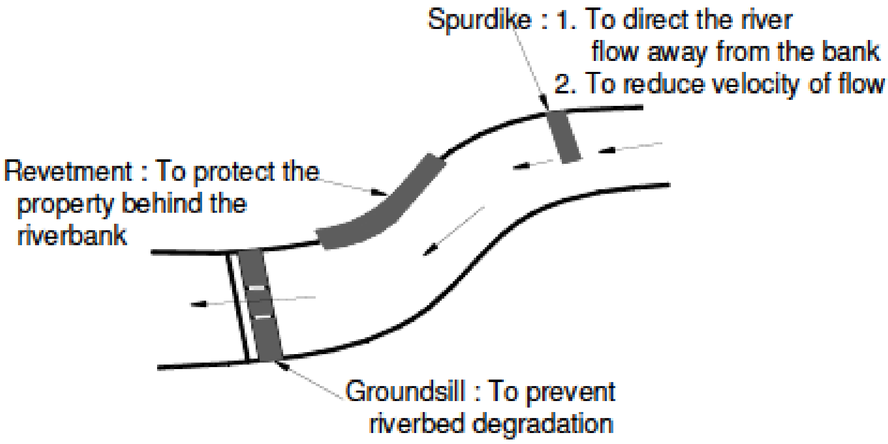

Figure 7 - Several methods for prevention of riverbank collapse (Technical Standards and Guidelines, DPWH JICA)

d. Prevention of obstructions in river flows by using sabo work structures (for sediment control) and regular maintenance (dredging and sedimentation removal)

e. Lateral water transport from flood prone areas to discharge areas through drainage canals

A further explanation of the structures mentioned is provided below:

a. Dikes and levees

Dikes and levees are constructed parallel to the banks of a stream, river, lake or other body of water for the purpose of protecting the land side from inundation by flood water, or to confine the stream flow to its regular channel. These are elevated fill or wall structures that are intended to control a designed maximum water level. These structures can be made from earth, reinforced concrete, or stone masonry (riprap)

b. Dredging

Dredging is the deepening of a riverbed by the removal of targeted materials. This increases the hydraulic capacity of the specific river section and decreases the possibility of rivers bursting their banks. Dredging is usually accomplished by the use of heavy equipment and typically requires earth-moving equipment. There should be particular attention given to disposal sites and the siltation of downstream waters.

c. Small-scale dams

Small-scale dams are man-made structures that are meant to hold back water flow from rivers and streams. They allow for water to be kept and released slowly after the peak flow has subsided. These types of dams are usually made of earthen materials and rock and are designed as gravity dams (other dam types are not considered as they are too large for the small-scale rural context of KC). Dams may also be built as a means of impounding water for irrigation and agricultural purposes.

d. Retarding basins and rain water collectors (SWIP)

Retarding basins for KC projects are typically designed in the form of rainwater collectors or small water impounding projects (SWIP). These are water harvesting and storage subprojects for soil and water conservation, flood control, supplemental irrigation, inland fishery and recreation.

Specific to the Philippines and to KC, the SWIP is an earthen dam or shallow impoundment structure built across a narrow depression or valley to harvest and store rainfall and run-off for multiple uses. A SWIP has a maximum height of 30 meters.

e. River revetments

A river revetment is a sloping structure of stone or concrete surfacing. They are used on riverbanks or vulnerable steep slopes in such a way as to absorb the energy of incoming water and prevent excessive erosion or degradation that may lead to flooding.

f. Spur dikes

Spur dikes are subprojects built at an angle or perpendicular to the riverbank. These structures can be above or below water and have functions of retarding velocity near the riverbank and deflecting the main flow from the levee. Spur dikes reduce the force of storm water and are usually built as part of a system for managing critical riverbanks.

g. Bioengineering for riverbank stabilization

Bioengineering or simply the use of appropriate plant species is a method to stabilize riverbank slopes against excessive erosion and degradation. Bioengineering methods will be discussed further in the TEMS manual for environmental protection structures.

Several of the various species commonly used for riverbank stabilization are vertiver grass, river palm (Sasa), and bamboos.

h. Drainage canals and lateral improvements

Lateral Improvements are structures such as storm drains, main drainages, open canals and ditches. A lateral improvement structure manages the outflow of inland flooding caused by localized torrential rain.

The most frequently used flood control structures in rural areas are artificial diversion channels built to drain water from areas having no natural outlet for precipitation accumulation. Drainage canals are usually routed along the lowest points of the territory being drained.

Figure 8 – An example of a lateral improvement that transports localized flooding in the municipality

The cross section of a canal depends on the purpose of the canal, the structural features of the ground, and the conditions for earthwork.

D. WHAT IS A RAINWATER COLLECTOR (NON-SWIP)?

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land's surface or rock catchments.

There are various types of rainwater harvesting systems, ranging from simple rooftop catchments to land surface catchments. In the KALAHI-CIDDS setting, the most feasible technology that can be adopted will be the simple roof water collection systems.

Recently, the Department of Interior and Local Government released Memorandum Circular No. 2012-02. MC 2012-02, which states that "*consistent with the intent of RA 6716*[3]*, government units from the barangay to the provincial level shall promote the construction of rainwater collectors in all barangays in the Philippines to mitigate the adverse impacts of climate change".*

The roof water collection systems are ideally appropriate for KALAHI-CIDDS as they are simple to install, operate and maintain. Water collected from roof

[3] Republic Act No. 6716 of 1989, also known as the "Rainwater Collector and Springs Development Law" mandate the Department of Public Work and Highways to construct water wells and rainwater collectors, develop springs and rehabilitate existing water wells in barangays nationwide.

catchments usually is of acceptable quality for domestic purposes. As these rooftop catchments are built into existing structures, construction costs are reduced and incremental maintenance costs are minimal. The main components of rooftop based catchment system are the cistern or the storage tank, the piping that leads from the cistern and the fixtures within the cistern.

DPWH, in response to RA 6716, introduced design prototypes for rooftop catchment rainwater collection systems that are available to be used by other government offices/facilities. The technical description and design features are shown in Table 1.

Table 1 - Sample rainwater collection storage units (DPWH)

PROTOTYPES	DATA DESCRIPTION	VOLUME	REMARKS
A-REINFORCED CONCRETE GROUND STORAGE TANK	DIMENSION: Rectangular Tank Width = 3.00 M Length = 4.00 M Height = 1.50 LIQUID DEPTH = 1.40 FREEBOARD = .10 M	8,000 liters	Permanent, Corrosion free
B- REINFORCED STEEL GROUND STORAGE TANK	DIMENSION: Cylindrical tank Diameter = 1.50 m Length = 2.50m	4,000 liters	Semi-permanent Movable/transferable Prone to corrosion
C. PLASTIC CONTAINER TANK	DIMENSION: Rectangular Tank for one (1) – 1440 liters Width = 1.50 M Length = 2.00 M Height = 1.50	4,000 liters 3 tanks with 144 liters each	Light materials Movable/ Transferable

E. WHAT IS MANGROVE REFORESTATION FOR COASTAL PROTECTION?

Mangroves are being presented in this manual as an alternative to reinforced concrete seawalls. Mangrove planting has been successful in preventing coastal erosion and in acting as a barrier against typhoons and storm surge. As such, mangroves mitigate and minimize damage done to property and life due to seawater-induced

Figure 9 - The figure above illustrates typical mangrove species found in the coastal areas of Samar

flooding. Mangrove tree species that inhabit lower tidal zones can block or buffer wave action with their stems, which can measure three meters in height and several meters in circumference. The trees both shield the land from wind as well as trap sediment in their roots, maintaining a shallow slope on the seabed that absorbs the energy of tidal surges[4].

The role of mangroves in preventing coastal erosion and protecting against typhoons, cyclones and hurricanes, is well documented. The trees both shield the land from wind and trap sediment in their roots, maintaining a shallow slope on the seabed that absorbs the energy of tidal surges. Additionally, analytical models have shown that mangroves can buffer coastlines during tsunami events. Mangrove forests reduce the impact of tsunamis by reducing both the height and the velocity of the incoming waves, and by distributing water among the canals and creeks of the mangroves, thus decreasing the level of inundation.

This manual is only intended to provide an introduction to the use of mangroves as an alternative subproject type for environmental protection structures. The approach, pre-implementation, implementation and post-implementation planning for this type of subproject will require further assistance from the ACT, RPMO and other specialists.

F. WHAT IS BIO-ENGINEERED INFRASTRUCTURE AGAINST SOIL EROSION?

The washing down of the soil during heavy rains causes soil erosion. Erosion can be checked by putting up physical structures and live barriers across the critical slopes, riverbanks and loose soil material.

There are several options for erosion control for both riverbank and soil erosion mitigations. These options may include the use of trees, vertiver grass, bamboo and other applicable vegetation. Bio-engineered infrastructure will be further discussed in the TEMS manuals as alternative measures for climate resilience and as examples of environmental friendly practices.

II. BASIC REQUIREMENTS FOR DEVELOPING ENVIRONMENTAL PROTECTION PROJECTS

A. WHAT ARE THE FACTORS TO BE CONSIDERED IN THE PLANNING AND IMPLEMENTATION OF ENVIRONMENTAL PROTECTION PROJECTS?

[4] Dahdouh-Guebas, F. Mangrove forests and tsunami protection. McGraw-Hill Yearbook of Science & Technology, McGraw-Hill Professional, New York, USA:

Prior to planning any environmental protective projects, it is important to consider the following factors:

a. The needs of the community which specify the purpose of the intended subproject
b. The environmental features of the proposed project location

a. Needs of the community

Construction of environmental protection structures must be responsive to the needs and objectives of the community in order to enhance their quality of life. Being responsive to their needs means, a); the environmental problems that affect the physical and socio-economic progress of the community are fully identified and recognized by the community; b) the types of environmental protection structures needed to address the environmental problems are established through the conduct of thorough surveys and research; and 3) the readiness and availability of all stakeholders, beneficiaries and local government to participate in various phases of project implementation until its sustainability phase is committed.

b. Environmental features of the proposed subproject types

The Philippines' location makes it naturally vulnerable to environmental hazards that lead to natural disasters. This situation plus other developmental factors (i.e., deforestation and mining) compound rural communities' inability to handle such disasters.

The vulnerability of rural communities to hazards refers to their susceptibility to environmental stresses. Recent and major events; i.e., Signal IV typhoons, large scale flooding, and elevated levels of rainfall, as well as the cumulative impacts of these events highlight the importance of identifying the applicable rural infrastructure that can be used as environmental protection infrastructure improvements in order to make communities more resilient to these stresses.

There are complex factors at play, which include the climate/weather, geophysical factors, ecological factors and anthropogenic factors. Identifying vulnerability and risk according to the above mentioned categories will assist in completing scenarios, whether historical or projected, and will enable communities to cope with and adapt to environmental disasters.

According to UNOPS, *"Climate Change is the most critical global challenge of the 21st century; climate change threatens man-made infrastructure, and ecosystems. It has already led to severe, even catastrophic effects, especially to the most vulnerable communities and it will lead to even* *more erratic and extreme weather conditions for decades to come, including floods, droughts, sea-level rise and more.*

This damage to communities and infrastructure stalls the development process. However, when both infrastructure and communities are made more resilient, it is possible to manage risks and foster sustainable development.[5]"

This concept is applied to KC subprojects through the use of environmental protection structures. The main goal of environmental protection structures is for communities that are at high risk from environmental hazards such as floods, landslides, storm surges, beach erosion and river swelling/flooding to be more resilient to these hazards.

A discussion of two most common hazards and possible environmental protection structures as mitigating measures is provided below.

1. Flooding

A flood is an overflow of water that submerges land that is not normally under water; i.e., farms, residence roads, communities, and markets. In the Philippines, floods have become a common occurrence because of the combination of the Philippines' geography and an increase in typhoons /rain intensity.

Floods can occur due to 1); rainwater accumulating in low lying flat areas with inadequate/no drainage and 2); bodies of water such as rivers, streams, or lakes (e.g. the Aklan and Agno rivers) breaching their banks and flooding adjacent areas, or 3); excessive inflow of sea/ocean tides coupled with a typhoon in the form of storm surges.

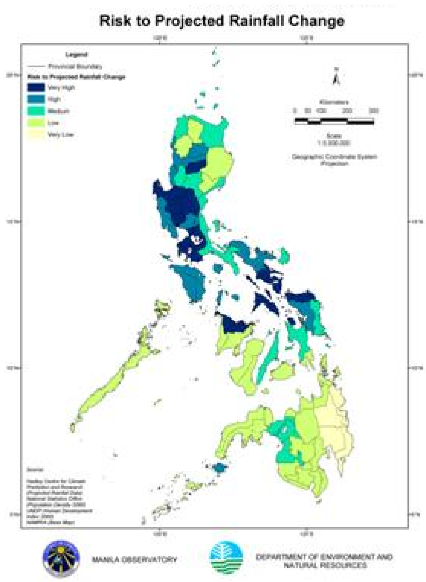

Figure 10 - Areas of the Philippines with high risk of increased rainfall and typhoon occurrence (Map from the Manila Observatory website and PAGASA)

Floods due to rainwater accumulation because of insufficient drainage are the most prevalent source of flooding. This normally occurs as a slow process, typically taking several hours. The rain initially saturates the soil then water builds up when the soil can no longer absorb the rain. Water builds up in the area because there is insufficient drainage capacity to move the water away from the community. There are some instances when this may occur rapidly, such as when hills or mountains funnel water to communities as the rains are deposited in those elevated areas.

[5] PROMOTING SUSTAINABLE DEVELOPMENT BY MAKING COMMUNITIES AND INFRASTRUCTURE CLIMATE-RESILIENT

The common measure to mitigate these effects is the use of high volume drainage subprojects that increase the drainage capacity of the area to move the water to a river or a stream.

Floods due to rivers or streams that breach their banks occur at a faster pace and in a more forceful manner. Since rivers are concentrated bodies of waters that are fed by upstream tributaries, streams and run-off from other land areas, they carry more sediments and debris when strong rains occur. Communities that are in the way of these rivers or people living near these bodies of water may find themselves in the way of a rapidly developing flood, which may damage livelihood activities, homes and infrastructure, or may cause loss of lives. The common measure to mitigate these effects is the use of riverbank protection subprojects or levies to increase the carrying capacity of the river or support the riverbank/lake front from overflowing in that area. These measures will reduce the community's risks from regular flooding by the river/lake/stream due to increase precipitation.

Floods due to storm surges occur due to a combination of an incoming sea/ocean tide coupled with strong storms that increase the height of the incoming tide. These types of floods are very dangerous as they bring a massive amount of fast moving water to coastal communities. In the Philippine setting this may result in catastrophic loss of life as most coastal communities have no early warning mechanisms and are usually situated just above the high-tide level. The damage by a storm surge can usually be mitigated by reducing the energy of the incoming tide through natural barriers such as mangroves and sea grass, or through infrastructure such as seawalls and wave breakers.

2. Landslides

Landslides may be induced by two main factors: rain and earthquakes. The most common type of landslides occurs when steep slopes are saturated by rain and give way due to the increased weight and loosening effect of the water being absorbed by the soil. The other is a shallow landslide induced by earthquakes. Both types happen abruptly and without much warning. Large-scale landslides have been recorded to cause damage to property and infrastructure, as well as to take people's lives.

Figure 11 - An example of rain-induced landslides in Mindanao due to persistent rains in 2008

For the purpose of this manual, the

environmental protective infrastructure will only deal with measures that can mitigate the damage/reduce the occurrence of small-scale landslides in very localized areas. These will be readily identified by the community as regularly occurring events that have previously been identified as a hazard to the community. The common form of subproject type to be applied to mitigate these landslides is slope protection infrastructure in the form of riprap, retaining walls or small-scale shotcrete. The main purpose of these subproject types is to stabilize the slope and increase its resistance to collapse. Large-scale improvements will not be discussed in this manual as these measures exceed the capacity and capability of the KC program to fund and implement. If these large-scale mitigating measures are identified, they should be made known to the mayor's office and directed to the Provincial DPWH office.

III. METHODS OF ENVIRONMENTAL PROTECTION PROJECT IMPLEMENTATION

The methods of implementation to be adopted in the establishment of environmental protective projects include 1); new construction, 2); improvement of existing structures and, 3); spot improvements.

A. NEW CONSTRUCTION

In most cases standard design process for construction should be followed. Environmental protective projects are typically highly technical in nature and generally will require the services of a licensed civil engineer or structural engineer.

B. IMPROVEMENT

Under the KALAHI-CIDSS Project, improvement of existing structures takes into consideration not only the existing structure, but also includes additional work or structures that may enhance the quality of service of any infrastructure project.

C. SPOT IMPROVEMENT

Spot improvements are focused on the restoration of a certain area of the damaged environmental protective structure. Typical activities under this method include, but are not limited to:

a. Application of lean concrete as prevention from small failures at the bottom of the retaining wall slope
b. Placing of a gravity concrete wall on slope protection toes
c. Placing of anchor work

Spot improvements should be carried out to improve the quality of the structure.

Figure 12 - Example of slope protection using riprap methodology

CHAPTER 3 |

PRE-IMPLEMENTATION PHASE

The Pre-Implementation Phase starts from project conceptualization and includes identification of coverage areas, the pre-needs assessment, identification of financial requirements, conducting social investigations and awareness assessments, and performing analysis in determining community desires and enthusiasm for the project pre-engineering activities, social safeguard requirements, project approval, and procurement. The following section of this manual covers the processes of the pre-implementation phase of environmental protection projects.

I. WHAT IS THE SUBPROJECT PRE-IMPLEMENTATION PHASE?

The subproject pre-implementation phase is concerned with the identification of the environmental hazards to be mitigated by the subproject, the identification of the subproject and the planning and design of the subproject. These activities are covered in the activities of the CEAC steps from the PSA through the preparation of detailed design.

The discussion in this section of the manual will focus on engineering pre-implementation. Descriptions of activities for the CEAC stages related to community facilitation are found in the CEAC 2012 manual.

A. WHAT ARE THE ACTIVITIES UNDER THE SUBPROJECT PRE-IMPLEMENTATION PHASE?

Pre-implementation phase covers the following activities:

a. Project identification (SI through subproject ID)
b. Technical validation
c. Pre-engineering activities
    - Engineering surveys
    - Engineering design standards
    - Engineering design (Please note that each design for seawall, river protection, slope protection and drainage structures will be discussed as a separate section)
d. Preparation of project estimates and the program of work (POW)
e. Facilitation of safeguards
f. Project approval

g. Procurement

Only items for engineering pre-implementation will be covered in the discussions that follow. These issues will be for the technical validation, pre-engineering activities and the preparation of the POW. Additional information and discussions regarding project identification, technical validation, facilitation of safeguards, project approvals, and procurement activities can be obtained from the following references:

a. DSWD-KC Environmental and Social Safeguards Manual-2012 (environmental, IP, land, resettlement, social safeguards)
b. DSWD CEAC Manual 2012 manual (project identification, technical validation, project approvals)
c. DSWD-KC KC Procurement Manual (procurement)

II. TECHNICAL VALIDATION

Technical Validation is the process by which environmental and geological information and the ACT and barangay volunteers at the proposed project site initially validate issues associated with the proposed subproject. Validation of information includes the gathering of additional information from other sources that will aid in determining if the proposed subproject is technically eligible for support.

In general, some of the issues that are reviewed during the Technical Validation of proposed Environmental Protection structures project are:

a. Erosion/flood maps leading to the suggestion of the environmental protective sub-project;
b. Elevation and topography of area for the proposed sub-project;
c. Discharge of rivers, creeks and other water bodies along the proposed sub-project or near the community;
d. Agricultural activities (types of crops raised, production data and market) including aquaculture activities;
e. Sources of drinking water for the community including sanitation;
f. Natural and mineral resources;
g. Existence or presence of indigenous people (IP);

h. Other physical data such frequency of earthquakes and tsunami and tide levels of sea water during storm and typhoons for coastal communities and village and other natural calamities in the community.

All of this information will aid in assessing the proposed environmental protection measures when determining the type of structure to be designed and implemented, as well as in validating the proposed projects' technical viability.

A. WHAT ARE THE POSSIBLE RESULTS OF A TECHNICAL VALIDATION?

The following are the expected results of a Technical Validation and appraisal:

a. Determination of the eligibility for project support.
b. Validation of the type of structure to be designed and implemented.
c. Validation of the projects' overall technical feasibility.
d. Validation of the capability of the MLGU and or the Barangay to implement, operate and maintain the sub-project.

B. WHAT CHARACTERISTICS WOULD MAKE A PROPOSED SUBPROJECT INELIGIBLE DURING TECHNICAL VALIDATION?

Proposed environmental protective projects will not be eligible for funding support if:

a. The proposed project will affect protected areas (as identified by the DENR Administrative Order DAO No. 2003-30).
b. Part of the project cost will be for the purchase of land.
c. The project will be for government administration or religious purposes.
d. Part of the material, labor, and equipment will be used for political and religious activities.
e. Activities have alternative prior sources of committed funding.

f. Operations and maintenance of facilities that have been the subject of civil work financed from or previously by loan proceeds.

g. The subproject is under one of the conditions of the KC Negative List

III. PRE-ENGINEERING ACTIVITIES:

Pre-engineering activities are necessary to ensure the subproject design suitability and efficiency for its intended use. Pre-engineering activities should result in an economical project design with appropriate physical quantities and costs for the investors/stakeholders to fund.

Pre-engineering activities include, but are not limited to:

a. Surveys
b. Design criteria and considerations
c. Design process

Pre-engineering activities can only be started on the basis of the results of validation of the identified sites of the proposed sub-projects that indicate the projects' feasibility. From the feasibility documents, an MLGU or the Barangay/community may then commence pre-engineering activities.

A. WHAT INFORMATION AND PLANS/DOCUMENTS SHOULD BE CONSIDERED BEFORE STARTING PRE-ENGINEERING ACTIVITIES?

The following plans and sources of information listed below (as a minimum) should be verified and coordinated prior to selecting the environmental protection structures. These plans may identify existing structures that may be affected (e.g. an existing agricultural irrigation plan may lose its water source if water diversion or drainage is constructed upstream) or that possibly already address the proposed environmental (a municipal river management plan might already have the intended structure as part of its more comprehensive planning) or invalidate the requirement (the CLUP might identify the location being proposed for the location of the subproject as a high risk area not suitable for habitation)

a. Irrigation development plan
b. Road network/bridge plan
c. Sabo plan
d. Environmental Management Plan (EMP)
e. Comprehensive Land Use Plan (CLUP)
f. Disaster/Risk Reduction Management Plan (DRRMP)

It is necessary to consider the effects and influence of other development plans in the formulation of environmental protection structures projects. For example, the location of a drainage control structure must be checked against the comprehensive land use plan to determine if the outflow will possibly affect future communities.

B. WHAT ARE THE PHILIPPINE-BASED CLIMATE TYPES TO BE CONSIDERED DURING PRE-IMPLEMENTATION?

In the Philippines there are four types of climates. These climate types are categorized as Type 1, Type 2, Type 3 and Type 4[6] and described below.

a. Type 1 Climate: Characterized by two pronounced seasons: a dry season from November to April of the following year and a wet season from May until October. This type of climate is prevalent in the western part of the country more notably in the provinces of Region I, the whole provinces of Region III, Metro Manila area, western part of Tagalog Region, Mindoro Occidental, western Palawan, south western part of Panay and Negros Islands, western parts of Cebu, Leyte and Samar Provinces.

b. Type 2 Climate: Characterized by no dry season with a very pronounced rainfall from November to January of the following year. This type of climate is prevalent in the northern part of the provinces of Ilocos Norte and Cagayan, Polilio Island, Camarines Norte Albay, Catanduanes, Sorsogon, Northern and Eastern Samar, Eastern part of Southern Leyte, Surigao Provinces, Davao Oriental Agusan Provinces part of Davao del Norte and parts of Misamis Occidental Provinces.

c. Types 3 Climate: Characterized by weather conditions that are not very pronounced and relatively dry from November to April of the following year and wet from May until October. This type of climate is prevalent in the provinces of Isabela, Ifugao, Quirino, Nueva Viscaya, part of Mountain province, Aurora, Rizal, provinces of Mindoro Oriental, Marinduque southern part of Quezon province, part of, Albay province of Masbate, greater part of the island of Panay, Negros and Cebu, provinces of Basilan, Zamboanga del Sur, North Central part of

[6] As per Philippine Atmospheric Geophysical and Astronomical Services designations.

Mindanao including Lanao provinces, Bukidnon, Maguindanao and North Cotabato.

d. Type 4 Climate: Characterized by rainfall more or less evenly distributed throughout the year. This type of climate is prevalent in the provinces of Cagayan, most of Aurora, Quezon I and II, parts of Albay, greater part of Camarines Norte, parts of Western Samar, greater part of Leyte Island, province of Bohol, northern part of Cebu part of Agusan provinces, Davao Del Norte, Davao del Sur, Sarangani and South Cotabato.

Figure 13 - Map of Philippine Climate Types. Image and description from Philippine Atmospheric, Geophysical and Astronomical Services Administration

Understanding the climate type in an area is important in designing an environmental protective project and in the proper timing of implementation of projects.

a. How do typhoons, flood frequencies and design discharge/wave action/design flow affect the proposed environmental protection structures?

Flood frequencies and design discharges are relevant to environmental protection structures (i.e. flood control, river protection, slope stabilization, seawalls). These factors are more likely to be considered in the design of Flood control Sub-projects. Depending on the data supplied to calculate the design flood frequency and design discharge, the type and dimension of the flood control project is selected.

Initially, the design discharge/design flow/wave action should be assessed considering the existing capacity of each river (design discharge), flood plain or tributary area (design flow), since the frequency levels of target flood for each river are different. The procedure of determination these are as follows:

a. Calculate the discharges corresponding to several flood frequency levels.
b. Calculate the existing river flow capacities on several control points.
c. Investigate the flood damage caused by past major floods and develop the relationship between flood discharge and flood damage.
d. Discuss the possibilities of river improvement.
e. Determine the preliminary river improvement plan.
f. Evaluate the cost to be incurred in the preliminary river improvement plan. If the preliminary river improvement planning is not realistic, back again to 3.
g. Determine the most appropriate plan.

C. ENGINEERING SURVEYS

Surveys for environmental protection projects are conducted to make initial determinations as to the suitability of the proposed location of environmental protective subprojects. These are necessary in order to provide information that will aid in the preparation of designs and plans.

There are several types and forms of surveys, including, but not limited to: Data gathering, information, statistical, physical, and demographic.

Aside from surveys, related documents such as Environmental Management Plans (EMP), Comprehensive Land Use Plans (CLUP), Disaster Risk Reduction Management Programs (DRRMP) of the municipality, or the province can provide additional information to properly design environmental protection structures.

a. Preliminary investigation survey

The main purpose of a preliminary investigation survey is to determine the present conditions and to identify the causes of slope failure.

After a slope failure, engineers should conduct an investigation in order to:

a. Determine the exact location of the affected area and investigate the site using a topographic map (Scale = 1:50,000 or higher resolution).
b. Determine the present conditions of the slope failure from historical accounts and slope characteristics (relevant for slope protection)
c. Determine the hydrologic condition of the river and its relevant tributary streams and rivers (relevant for river flood control)
d. Determine the coastal, tidal and typhoon conditions from historical data (for coastal protection structures)
e. Determine flooding history of location (for lateral drainage structures)
f. Identify the causes of natural disasters (this is relevant for all environmentally protective subprojects). Examples of these may come in the form:
    - Landslides (slope protection)
    - Rock slide (slope protection)
    - Rapid slope erosion (slope protection)
    - River overflow (flood control - river protection)
    - Riverbank degradation (flood control - river protection)
    - Riverbed siltation (flood control - river protection)
    - River overflow into flood plains (flood control - river protection)
    - Coastal erosion (coastal control – seawall/riprap)
    - Storm surge (coastal control – seawall/riprap)
    - Community flooding (flood control - rainwater collection)
g. Collect and correlate available past records or reports of previous disasters (community accounts).

b. Topographic survey

Topographic surveys are relevant to all the subprojects under the environmental subproject protection type. The purpose of this survey is to gather data about the natural and man-made features of the land, as well as its elevations and contours. From this the surveyor may prepare the topographic map in the office after collecting the field data or prepare it right away in the field by plane table. The work usually consists of the following:

a. Establishing horizontal and vertical control that will serve as the framework of the survey
b. Determining enough horizontal location and elevation (usually called side shots) of ground points to provide enough data for plotting when the map is prepared
c. Locating natural and man-made features that may be required by the purpose of the survey
d. Computing distances, angles, and elevations
e. Drawing the topographic map

c. Hydrological data and hydrologic survey (rivers and streams)

Hydrologic data and hydrologic surveys of rivers and inland bodies of water are relevant for flood control (e.g. river walls, dams, dikes, levees, riverbed dredging) environmental protection subprojects. They help identify the environmental risks and the design parameters that need to be considered for a proper design of these structures. The challenges are that these forms of specialized surveys are not usually available in KC communities. The following activities are recommended for facilitation by the ACT (specifically the DAC) to identify the hydrologic data needed for flood control subproject types. The surveys and methods mentioned have been given context and checking for availability of technology in the KC communities. These surveys and information gathering activities should be done in conjunction with the topographic survey.

a. Daily rainfall data of all gauging stations within and around the catchment area throughout the recording period from PAGASA and other related agencies.
b. Hourly rainfall data of all gauging stations within and around the catchment area during the duration of the flood.
c. Hyetographs of past typical floods on all synoptic rainfall gauging stations from PAGASA and other related agencies.

d. Data on the maximum water levels during peak floods at all water level gauging station from BRS and by interview (For rainfall and runoff analysis). This can also be from elderly community members as experiential data of previous floods and disasters.
e. Discharge measurement record for all water level gauging stations.
f. H-Q (Height-Discharge relationship) rating curve for all water level gauging stations (with location, cross-section and flow velocity during flooding time).
g. River dimensions (through physical measurement) and flood prone areas (from DRRMP maps)
h. Ecological profile of the river system (Please refer to TEMS manual for more information)
i. Debris or silt carrying characteristics of the river at normal and flood timelines

d. Coastal survey

Coastal surveys are conducted primarily to identify the required design considerations for the proper construction of coastal defenses. In the KC context these would be surveys that are relevant for seawalls and revetments. The surveys and methods mentioned have been given context and checking for availability of technology in the KC communities. These surveys and information gathering activities should be done in conjunction with the topographic survey.

a. Characterization of beach erosion
b. Histogram of storm surge levels and damage
c. Beach profile
d. Annual timeline for low tide and high tide profiles
e. Storm histogram for frequency and rise of water

e. Slope and soil survey and data

In addition to topographical surveys the following investigations and surveys should be carried out for slope protection subprojects. This information can be gathered by using an appropriate site investigation process. These surveys and methods have been reviewed and determined to be appropriate for the availability of technology in the KC communities. These surveys and information gathering activities should be done in conjunction with the topographic survey.

a. Identifying geological conditions such as the nature and depth of its subsoil and topsoil, degree of decomposition, or location of fracture etc. This data can be obtained by soil investigation.
b. Shear strength of the slope-forming materials. Data can be obtained using appropriate laboratory tests.
c. Surface and ground water condition
d. External loading and surcharges, such as from traffic, nearby structures, possible vibration etc.

D. ENGINEERING DESIGN STANDARDS

There are several design standards and references that should be be utilized for the design of environmental protection structures. The most commonly used engineering design standards in the Philippines are:

a. The Building Code of the Philippines
b. DPWH references, especially for flood control, slope stabilization and coastal defenses jointly developed with JICA
c. International Code Council (ICC)-Family of Codes International Building Codes (IBC)
d. American Association of State Highway and Transportation Officials AASHTO Design Manuals
e. American Society for Testing and Materials ASTM Standards

E. ENGINEERING DESIGN (SEAWALLS AND REVETMENTS)

A seawall can be used as a protective structure to defend a shoreline from erosion against wave and current actions. Seawalls may be vertical or sloping. Vertical seawalls have the advantage that they can provide marine frontage for vessel berthing and cargo handling. If necessary, wave absorption units can be included on vertical seawalls to reduce wave agitation inside a harbor. Stepped seawalls are beneficial for rural communities as they provide a way to pull small boats (bankas) behind the seawall when there is an upcoming storm surge.

Seawall design for rural small-scale infrastructure usually falls under sloping or vertical faced design. In both designs, the wave action is perpendicular to the infrastructure as impact or pressure.

a. What are the typical design considerations for a seawall structure

The usual design considerations that the DAC should check as being included in the service provider's design are; run-up, overtopping, transmission and reflection. This manual does not intend to discuss the actual calculations for these considerations. The service provider making the design shall compute these.

1. Exposure

For KC coastal communities that experiences wave height greater than 1.8 meters, utilizing the vertical wall, rubble mound type, or the curved face wall is recommended.

2. Foundation condition

For poor foundations, the more flexible types of seawalls are recommended to account for settlement. Flexible seawall types include the revetment and rubble mound type. Seawalls designs that utilize piles for support are also feasible as these designs depend significantly on soil strength for support as well as not being significantly affected by settlement. For locations where there is a more solid foundation, gravity structures and curved face walls are recommended.

3. Beach scour

Waves breaking on a vertical or slightly sloped face walls are expected to cause scouring at the foot of the wall. Proper scour defenses must be put in place such as the use of a toe blanket cut off walls, or energy dissipaters (please see mangrove reforestation as alternative). Rubble mound, stepped face or similar designs where there is sufficient water depth at the face of the wall to prevent breaking of waves and as such prevents scouring from wave reflection.

4. Wave run-up

Wave action on a structure will cause the water surface to move back and forth over a vertical range generally greater than the incident (wave moving landward) wave height. The maximum high level reached by waves on a structure is the wave run-up.

It is the vertical height above the still water level to which water from an incident wave will run up the face of the structure. In case of vertical structures, the run-up height is that of the top of standing waves. The run-up level can be used to design the required level of the crest of the seawall or as an indicator of the occurrence of wave overtopping.

The engineering and design service provider should indicate the amount of wave run-up ($R_{u2\%}$). This means the run-up level is exceeded by 2% of the incident waves. A rubble slope will dissipate more wave energy and result in fewer run-ups than a smooth slope.

5. Wave overtopping

The usual controlling design requirement in the design of seawalls is wave overtopping. If the crest level of a structure is exceeded by the wave run-up, wave overtopping will occur. Overtopping should not be considered as a continuous inflow but a non-continuous occurrence at times of surge of individual large waves.

Since overtopping is not continuous it is normally measured by the mean rate of overtopped water per meter run of the structure (m3/s/m).

The allowable rate of overtopping water depends on the usage of the top/crest of the structure or the community area behind the structure, the strength of pavement (if applicable) against the impact of falling water mass, and the capacity of drainage facilities. Suggested limits of overtopping are (CIRIA, 1991):

Safety Considerations (m3/s/m)

a. Danger to personnel $3x10^{-5}$
b. Unsafe to vehicle $2x10^{-5}$
c. Damage to unpaved surface $5x10^{-2}$
d. Damage to paved surface $2x10^{-1}$

The above values are mean overtopping rates; peak values can be up to 100 times the average.

6. Wave reflection

All coastal structures reflect some portion of the incident wave energy. The amount of wave reflection is often described by a reflection coefficient; Cr , defined in terms of the incident and reflected wave heights; Hi and Hr , or the incident and reflected wave energies; Ei and Er.

$$C_r = \frac{H_r}{H_i} = \sqrt{\frac{E_r}{E_i}}$$

Figure 14 - Wave Reflection Coefficient

Wave reflection values are important in large harbors where reflected incident waves may disrupt ship traffic. This condition is not seen as affecting much of the performance requirements of KALAHI seawalls.

7. General design considerations of seawalls

The structure and its foundation should be designed so that during the design life, foundation displacements and movements are kept within the limits that the structure can tolerate without affecting its structural integrity and functional capability.

An important consideration in the design of a foundation is the stability of the seabed and the possibility of scour and undermining around the structure resulting from wave and current actions (simply put the waves will washout poorly designed foundations). Advice should be sought from geotechnical specialists, where appropriate.

8. Loading

In seawall design, the live load should be determined according to the designated land use behind the seawall. Temporary surcharge preloading on the seawall may be more critical than the permanent loads or future live loads. This should be checked in the design.

Particular attention should be paid to fill placement behind the structure when clay/silt deposits remain under the foundation as this might make the foundation unstable.

9. Settlement

The settlement expected during the design life of seawalls and breakwaters should be assessed to ensure that it is acceptable to the proposed use of the structures. In general, the residual settlement after completion of construction should be limited to not more than a maximum between 150 mm and 300 mm, depending on the type, importance, stability and usage of the structure and the site condition. For settlement-sensitive installations or facilities, more stringent requirement may be needed and should be determined in consultation with the client and users.[7] This should be checked by the DAC if the service provider has included it.

b. What are common Program of Work (POW) elements for seawalls

1. Foundation

Foundations of seawalls are critical as the seabed or seashore is made of cohesion less soil (sand and silt-clay). Typical foundations in rural small-scale infrastructure are composed of piles, sheet piles, or large and deeply embedded boulders. All of these options are acceptable if they meet the loading, settlement, and scour resistance requirements for seawall design.
The DAC should pay very close attention to the basis of design used by the engineering and design service provider for the foundation and should ask for back-up calculations and reference materials.

2. Under-layer and core

The weight of the under-layer rock should normally be taken as not less than one-tenth of the weight of the armor. The size of individual under-layer rock should be within ± 30% of the nominal weight selected. This applies where the **armor layer is made up of rock**. For concrete armor units, recommendations on the weight of under-layer rock can be found in British Standard BS 6349:Part 7:1991.

3. Slope or face

[7] Guide to Design of Seawalls and Breakwaters, Civil Engineering Department The Government of the Hong Kong Special Administrative Region

The slope angle of the structure depends on hydraulics and geotechnical stability, and should generally be not steeper than 1.5:1 (vertical):(horizontal).

4. Crest[8]

The crest elevation should be determined from wave run-up and overtopping considerations.
An allowance for the settlement that will occur in the design life of the structure may also be included in determining the crest elevation.
The crest width should be sufficient to accommodate any construction, operation and maintenance activities on the structure. For rubble mound breakwaters, the minimum crest width *B* should be sufficient to accommodate at least three crest armor units and may be determined from the following formula:

$$B = 3k_{\Delta}\left(\frac{W_a}{\gamma_a}\right)^{1/3}$$

Figure 15 - Minimum Crest Width

Where:

W_a = Weight of an individual armour unit (N).

k_{Δ}= Layer thickness coefficient.

γ_a= Unit weight of armour unit (N/m3).

5. Toe protection

Wave action in front of the structure can cause severe turbulence at the seabed. In particular, the toe of the structure can be exposed to the action of breaking waves in shallow water, leading to erosion of seabed material and scouring of toe.

The extent of toe protection and the rock size at toe should be determined by the service provider and the DAC should check the design as having the indicated Toe protection before accepting the designs.

[8] Guide to Design of Seawalls and Breakwaters, Civil Engineering Department The Government of the Hong Kong Special Administrative Region

F. ENGINEERING DESIGN (SLOPE PROTECTION)

Designs for slope protection projects depend primarily on the types of slope failure prevalent in the location where the project is being proposed. Slope failure protections are broadly categorized as 1) control work and 2) resistant work.

At a minimum, design considerations for drainage and vegetation should be provided to prevent erosion and eventual slope failure.

Drainage and stabilizing vegetation should be provided not only to slopes prone to failure but also on road sections or gullies, which may be affected by debris and surface runoff. In this case, cross-drains shall be provided.

a. The design should be developed after a thorough investigation as the slope is affected by many factors such as geographical features, geological features, vegetation and springs, etc.
b. Even if the present slope is stable, it is dangerous to cut the foot of the slope during placement of the foundation. Therefore, excavations work for foundation should be minimized.
c. The slope failure countermeasures should avoid using fill materials and the inclination of the slope should be designed as to be as gentle as possible.
d. The slope failure countermeasures should be designed with vegetation matching or adaptive to the surrounding environment as much as possible.
e. In order to minimize the excavation of the foot slope, foundation heights (e.g. for cast-in-place crib works) should not exceed 2.0m

a. What are the parts of a slope protective structure?

The main parts of slope protection structures are:

a. Drainage – drainage for slope protection prevents surface erosion due to slope surface water and failure due to the increase in pore water pressure by scouring and water seepage

b. Collapse Line – expected or current shape of a collapsed slope
c. Weep holes - are small openings on a retaining wall as an outlet for water
d. Original Ground line – the original slope shape prior to any collapse incidents
e. Retaining wall – structure to reinforce the slope in preventing further collapse

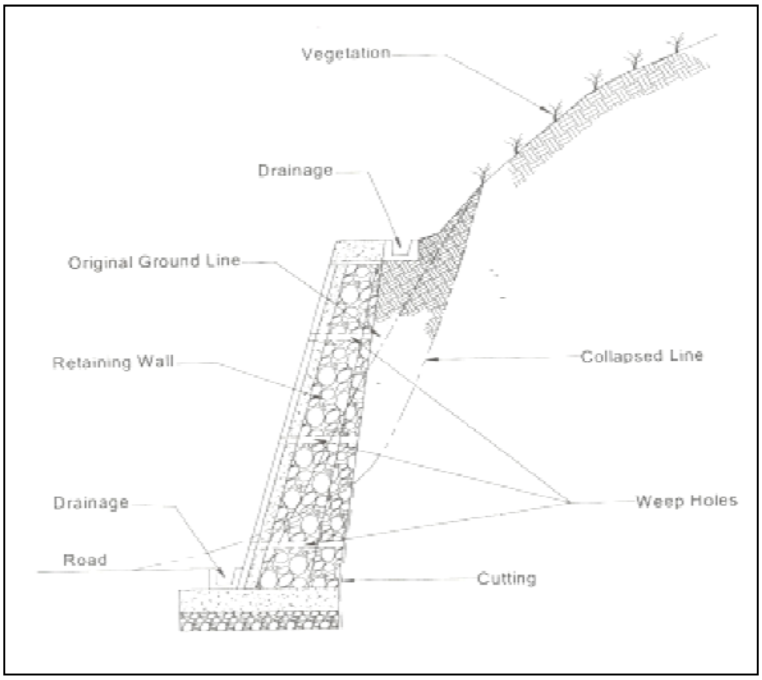

Figure 16 - Part of a Slope Protective structure. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

Each part may vary depending on the type of the slope protective structure. Some types of slope protection require all of the above parts while others do not. Different types of slope protection structures are shown below. A more extensive discussion on these parts can be seen from the DPWH/JICA Technical Standards and guidelines (2010).

b. What are common program of work elements for slope protection

Slope protection structures may be comprised of the following elements of work:

a. Cutting works
b. Drainage works
c. Vegetation works
d. Cast-in-place crib works
e. Retaining wall works

1. Cutting work

In most cases, it is extremely difficult to determine proper design for a slope protective structure by stability calculations alone for the following reasons:

a. The geological formation of the ground is complicated;
b. Soil characteristics vary considerably,
c. Predicting the location of slip surface and the accurate strength of the ground is difficult the strength decreases with time due to weathering after excavation.

Additionally, other factors such as artificial cutting conditions, degree of drainage and protection works, heavy rains and earthquakes overlap in a complicated manner making it difficult to predict slope failures after completion and to plan appropriate countermeasures against them in advance.

Design of cut slopes under such circumstances should be made by an empirical engineering review based on actual examples of works done in the past. This includes:

a. The lithology and geological condition
b. Design and state of execution of work and
c. State of stability (form failure in the event of failure) shall be checked for existing slope.
d. The proper design parameter corresponding to the conditions of (a) should be determined.

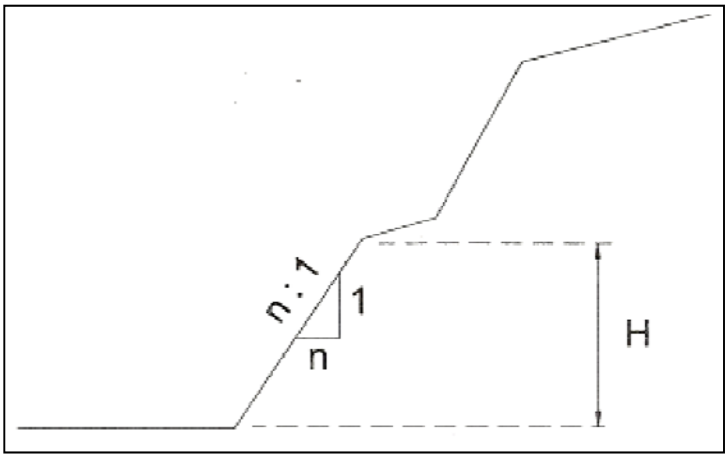

Figure 17 - Gradient of Cut Slope (Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010)

Natural ground is extremely complex and not uniform in its properties, and cut slopes tend to gradually become unstable after the completion of work. Therefore, stability calculations are meaningful only in rare cases when examining the stability of cut slopes. An overall judgment should be made by fully taking into account the requirements for its stability described later by referring to the standard values of the gradient of slope listed in table below. The gradients referred to are those for individual slopes not having berms. See the figure below for the required gradient of cut slope.

Table 2 - Cutting Height, Slope and Gradient

Soil/Rock Properties		Cutting Height, H	Approximate Gradient (Ratio) n : 1
Hard Rock		7.0 m (max)	0.25 : 1 ~ 0.5: 1
Soft Rock		7.0 m (max)	0.5 : 1 ~ 1 : 1
Soil	Cohesive	2.0 m or less over 2.0m	2 : 1 1.5 : 1
	Cohesion-less	2.0 m or less over 2.0m	2 : 1 ~ 4 : 1 1.5 : 1 ~ 2 : 1

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

Notes:

a. Indicated gradient (ratio) is subject to change depending on stability of soil material

b. When the cutting height exceeds 7.0 m for rock materials and 5.0 m for soil, benching is applied

c. Slope rounding: 0~4.5 m = 1.5 m // Over 4.5 m = 2.5 m

The gradient of slope varies depending on the geology and a berm is typically constructed at transition points where the gradient changes.

A berm 1m to 2m wide will generally be constructed in the middle of a cut slope with considerable height.

a. Purpose of Berms – At the lower portion of continuous, long slopes, the discharge and current velocity of the surface water increases, causing the scouring force to increase. In this case, the current velocity can be reduced by providing an almost horizontal berm at the middle of the slope, or the concentration of the surface water at the lower portion of the slope may be prevented by making a ditch in the berm for draining water outside of the slope. The berm can also be used as a sidewalk for inspection or as a scaffold for repair/maintenance work. Berms should be designed by taking into account the difficulty in inspection and repair, gradient of slope, height of cut soils on slope, economy and other conditions.

b. Gradient of Berms – When drainage structures are not provided, about 5% to 10% of transversal gradient is normally provided for the berm to drain water towards the toe of the slope. However, when the slope is easily scaled or when the soil is easily eroded, the gradient of the berm should be made in the reverse direction to drain water toward the ditch of the berm.

c. Location of Berms – On cut slopes, 1m to 2m wide berms are normally provided at every 5m to 7m of height depending on the lithology and scale of the slope. A wider berm is recommended where the slope is long and steep or where rock fall protection fences are to be installed.

2. Drainage work (as slope protection)

Damage on slopes due to water can be roughly divided into, a); surface erosion due to slope surface water and, b); failure due to the increase in pore water pressure or the decrease in shearing strength of the soil forming the slope by scouring and water seepage.

Figure 18 - Example of a small-scale drainage structure that mitigates water flowing onto the road

Slope drainage must be designed to be fully effective in preventing both types of surface erosion failure.

Additionally, even though the drainage structures satisfy all necessary functions, damage may occur in the downstream areas if the drainage outfalls are insufficient. The drainage facilities should be connected to the drainage interceptors with sufficient capacity.

When designing the drainage structure, one should fully first examine rainfall intensity, topography, ground surface conditions, soils, ground water conditions and existing drainage system. However, it is difficult to accurately determine the movement of underground water by surveys, and the presence of groundwater or a permeable layer is often detected for the first time during the construction phase. It is therefore recommended to provide effective drainage structures during the implementation of the necessary work by changing its original design, if necessary. The dimensions of drainage structures during planning should include an allowance of about 20%, taking into account the deposition sediment. A greater allowance may be necessary for slopes from which considerable sediment run-off is likely to occur during heavy rains or for places where the inspection and cleaning of facilities is difficult to perform.

A ditch should be provided along the top of the slope in order to avoid the flowing of surface run-off from the adjacent area onto the slope. The dimension of the ditch along the top of the slope is determined depending upon the volume of surface run-off. Some allowance may be given to the ditch dimensions when taking into account the topography, inclination of the ditch and soil properties. The ditch along the top of slope can be made as an unsupported ditch or by using soil cement mixture, stone pitching, etc. Common types of ditches are:

a. Unsupported Ditch – If water can be easily drained onto impermeable ground and if the amount of water collected is small, then a simple embankment can be built. Sodding should be performed on the embankment.

b. Ditch with soil-cement mixture – Where the amount of water collected by the ditch is relatively large, a ditch is sometimes provided, lined with soil cement mixture (1 cu.m of soil per 40kg-bag of cement). The ditch's minimum thickness should be 5 to 10 cm. Excavated soil can be used as an embankment to attain the required gradient.

c. Vertical Ditch – A vertical ditch is a waterway provided along the slope and is used to guide water from the ditch at the top of a slope or on a berm to a proper channel at the toe of the slope. This longitudinal ditch can be made of a reinforced concrete U-shaped gutter, semi-circular centrifugal reinforced concrete pipes, reinforced concrete pipes, earthen-ware pipes or stone-pitched channel. Concrete or lined waterways can also be utilized as a longitudinal ditch. An example of this is shown in following figure. U-shaped gutters and semi-circular centrifugal reinforced concrete pipes are used as an open ditch on the slope while reinforced concrete pipes and earthen-ware pipes are used as underground drainage embedded in the slope. Of the two, the former can be more easily constructed and maintained. Since the velocity of the running water through a longitudinal ditch can be high, water may often splash out scouring the sides of the ditch. To reduce this effect, it is desirable to slope the surrounding ground towards the external base of ditch with sodding or stone pitching, and then backfill the open space with a soil-cement mixture. At places where the direction of flow changes drastically or where the vertical ditch meets the other waterways, catch basins with covers and simple sediment pits should be installed to reduce the energy of running water.

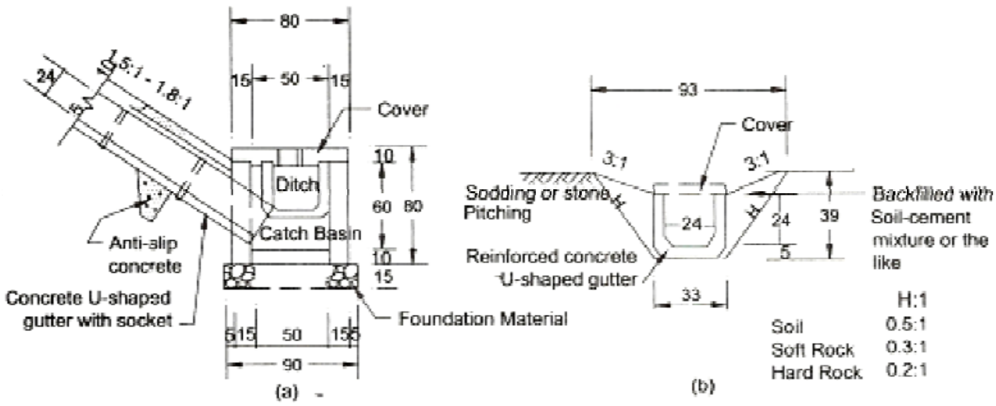

Figure 19 - Vertical ditch using the reinforced concrete U-shaped gutter (in cm). Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

d. Drainage Structure on Berm - For berm drainage, typically employed ditches include those produced by soil cement mixtures, reinforced concrete U-shaped gutters, or unsupported ditches whose construction is similar to those on top of slopes. Berm ditches built with a soil cement mixture or reinforced concrete U-shaped gutters have a similar structure to those of the ditches on the top of slopes and should be installed close to the toe of the slope. In these cases, the water flow on the back or sides of the ditch must be reduced. The width of the berm should be greater than 1.5m.

3. Vegetation work

Vegetation is effective in preventing slope erosion immediately after work completion. One of the features of sodding work is that the face of the slope can be restored naturally, unlike other slope protection works.

Success or failure of vegetation is governed by the growth of the selected plants, so weather and soil conditions on the site should be surveyed. The species suited to the weather and soil should be selected, and the conditions for the complete growth of the species should be assured. Prior to the execution of installing vegetation, the following data should be considered:

a. a. Slope area, gradient and height - Surveying the total surface area, the gradient and total height of the slope requiring vegetation is important to determine the best method by which vegetation should be installed. For large areas with a low gradient, special machinery can be used to help plant the required vegetation. Smaller, steeper, or widely scattered areas may find manual planting to be more economical.

b. Conditions of adjacent land - Spray materials may sometimes scatter and pollute crops, houses or structures. Therefore, protection against scattering and pollution should be made in advance.

c. Soil conditions (physical and chemical composition, water content and consistency of the soil, slope surface condition, presence of spring water, etc.). The condition of the soil to be used should also be checked for appropriateness of use. Soil should not erode away too easily, such as sandy soil, nor should it be too hard, as in clay or mudstone, to allow vegetation to grow roots. The moisture content, acidity, and water availability should also be monitored to ensure optimal growth of vegetation. Additionally, the required compaction and surface texture of the slopes will vary depending upon type of vegetation to be used. For example, a looser soil surface is desirable for seed spraying while a smooth surface is more appropriate for sodding mats. Thus, the degree of finished slope surface should be determined prior to the vegetation work.

d. Weather conditions (air temperature, rainfall, slope direction, degree of sunlight) - Weather data can be gathered from PAG-ASA (DOST) or from observations during the Social Investigation (SI) stage. The yearly daily mean air temperature should be used to determine what type of plants would best grow in the proposed area and in what season their planting would be optimal. The slope direction and degree of exposure to sunlight should also be determined since they are helpful in selecting shade-tolerant grasses. Also, the forecasted weather during the term of the work should be examined to avoid disruption.

e. Others - Other factors to take into consideration while planning vegetation works include the degree of difficulty in securing local materials (such as soil and water), their level of quality, and access road conditions to transport required machinery and materials.

Different types of sodding for slope protection vegetation work are illustrated in the following figure.

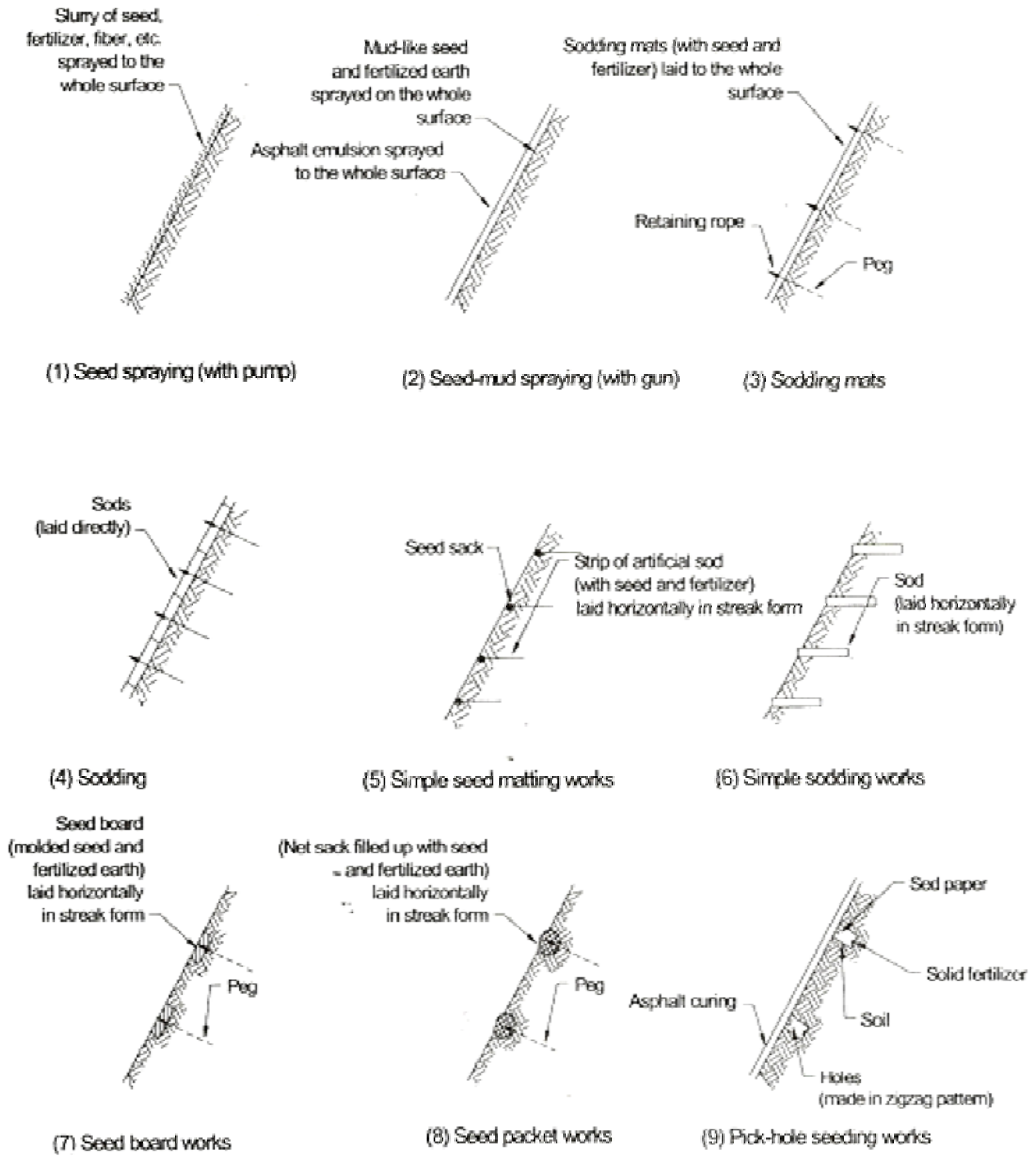

Figure 20 – Various types of sodding work. Source: Technical Standards & Guidelines for Flood Control and Sabo Work, JICA-DPWH, 2010

4. Crib Work

This is used when the long-term stability of the slope is questionable, when the slope is made of weathered rock with spring water, or when the slope is high.

This work is also sometimes applied to produce a support-like function where spalls cannot be fixed by concrete spraying on rocks, joints, or cracks.

Frames are made using cast-in-place reinforced concrete. The spaces inside the frames are filled with and protected by stone pitching, block pitching, concrete pitching, mortar spraying or sodding depending on field conditions. Each intersection of the cribwork frame should be anchored with stakes.

There is a special method of cast-in-place concrete cribwork in which wire mesh and reinforcing bars are formed and placed. The shape of framing follows the irregular face of the slope and concrete spraying completes the cast-in-place concrete framing.

Cast-in-place Slope Crib Works (Sandy Soil, Gravel and Soft Rock). The inclination of the completed slope should be between 0.8:1 and 0.8:1.1

Design factors of the structure of the frame:

a. Shall be reinforced concrete
b. The main bars shall be 16mm diameter with 13mm diameter stirrups at 300mm on center
c. The main frame shall be 300 mm x 400 mm and the middle frame shall be 300 mm x 300 mm.
d. Distance between frames:
    - The main vertical frames shall be spaced at 4.0m on center and 3.0m on center for the main horizontal frames
    - The middle vertical and horizontal frames shall be set at the center of the main frames
e. The frame should be embedded in the ground through excavation.
f. The inside of the frame should be planted with vegetation. However, when the inclination of the slope is 0.8:1, the inside of the frame shall be concreted. In the presence of spring water, drainage and cobblestone shall be emplaced.
g. When the inside of the frame is concrete, two 75mm diameter weep holes shall be installed within the frame.
h. The wall of the foundation shall be connected to the vertical frame with two steel bars of 16mm diameter, 60mm long.
i. During construction, the vertical frames shall be placed at once.
j. The steel bars of the vertical frames shall be interconnected with the topmost horizontal frame.

5. Retaining wall work

Retaining walls are structures that support soils for preventing slope failures and are constructed in places where stability cannot be determined by soil slope alone because of site and topographic conditions. Depending on their shape and mechanical characteristics, retaining walls can be classified into stone or block masonry-type, gravity-type, and leaning concrete-type.

Some of the commonly used types of retaining walls are:

a. Stone or Block Masonry-Type Retaining Wall - Stone or Block Masonry Retaining walls are frequently constructed at the toe portions of cut slopes. The advantages are that the gradient, length and horizontal alignment of slope can be changed easily, so that they can be utilized at the adjoining portions with other structures. The height of these retaining walls is normally less than 5m.

b. Gravity-Type Retaining Wall - These walls can sustain the earth pressure by means of a dead load and can be built more easily than the other types of retaining walls. Gravity-type is often utilized when the height is relatively low (less than 4m) and the ground foundation has a good bearing stratum.

c. Leaning Concrete-type Retaining Wall - These are used to stabilize the cut slope but are able to stand themselves. Calculations are very difficult to perform for these walls, although they are often used as countermeasures for slopes in mountainous areas and narrows sites.

Retaining walls have common requirements that need to be included in their designs. The following items below illustrate some these requirements:

a. Sub-grade Preparation – prepare the sub-grade for riprap and filters to the required grades as shown on the plans. Compact fill required in the subgrade to required density. Remove vegetation and any unnecessary materials in the area. Cut the sub-grade deep to ensure that the finished grade of the riprap will be at the same elevation as the surrounding area. Channels must be sufficiently excavated to have the finished inside dimensions and grade of the riprap meet the design specification.

b. Sand and Gravel Filter Blanket – place the filter blanket immediately after preparation of the ground foundation.

For gravel, spread materials evenly to required depth. If more than one layer of filter material is used, spread the layer with minimal mixing.

c. If synthetic filter fabric is used, place fabric directly on prepared foundation. Overlap the edges by at least 2 feet and space the anchors every 3 feet along the overlap. Bury the upper and lower ends of the fabric a minimum of 12 inches below ground.

d. Stone placement – Placement of the riprap should follow immediately after placement of the filter. Place riprap so that it forms dense, well-graded mass of stone with a minimum number of voids. The desired distribution of stones throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement. Place riprap to its full thickness in one operation. Do not place riprap by dumping through chutes or other methods that cause segregation of stone sizes. Be careful not to dislodge the underlying base or filter when placing the stones.

e. Placement of the Toe - The toe of the riprap should be keyed into a stable foundation at its base. The toe should be excavated to a depth of 0.6m. The design thickness of the riprap should extend a minimum of 1m horizontally from the slope. The finished slope should be free of pockets of small stone or clusters of large stones. Manual placing may be necessary to achieve proper distribution of stone sizes to produce a relatively smooth, uniform surface. The finished grade of the riprap should blend with the surrounding area.

c. How do we select the slope protective structure type applicable and appropriate for the area being proposed?

Deciding on a slope protection type will depend on the existing problem of the area for protection.

The following table shows a guide for selecting the applicable countermeasure needed:

Table 3 - Classification of Slope Failure Countermeasures. Source: DPWH Technical Standards and Guidelines for Planning and Design, Volume IV, March 2002

Classification		Principal Goal	Work Category	Work Sub-category	Purpose or Details of the Work	Application Range and Special Features	
Control Works	Control Works(1)	Protecting the slope from rain	Drainage works	Surface water drainage work	To prevent surface water from flowing over the slope by collecting and draining it quickly. Works includes drainage channels at the top of the slope, berm drainage works, slope toe drainage channels, longitudinal drainage channels, permeation prevention work, and check dams.	One of the most basic methods, it is rarely used alone but almost always with another method.	It is used in almost all works. Its cost is low and it is very cost-effective. This method includes drainage channels used to collect water and drainage channels that drain the collected water out of the slope area.
				Underground water drainage work	To stabilize the slope by draining underground water seepage and lowering the pore water pressure. Works includes culvert work, impervious wall works, collection well etc.		It is used at locations where landslide type failure is predicted or where there is a lot of underground water. It is often used for work smaller than landslide prevention work.
			Slope protection work using vegetation	Sodding work	To prevent rainwater erosion, reduce surface temperature and beautify slopes. Works include spreading seeds, soil dressing, thick layer spraying method, vegetation, network, sand bag works, sodding, vegetation pots, and transplanting.	When the principal method is vegetation, it is a cut slope with little spring water, where in principle, a standard slope gradient can be guaranteed. It is superior because it harmonizes the slope with its surrounding environment	
			Others	Other slope protection works	These works include plastic soil cement works, net works, fluid synthetic resin spray works, mat-covering works, asphalt slope works, etc. and are intended to prevent erosion.	Because of their durability and environmental properties, these works are not appropriate for steep slope failure countermeasures. But they are used for temporary works or partial use.	

Classification	Principal Goal	Work Category	Work Sub-category	Purpose or Details of the Work	Application Range and Special Features
	Excluding slopes where there is a high probability of failure due to rainfall	Cutting unstable soil mass	Cutting work (A)	To eliminate soil layers or rock mass at risk of collapsing by cutting of overhangs and unstable surface soil layers as well as removal of unfixed stones.	One of the most basic countermeasures, it is also one of the most reliable if it is thoroughly implemented. It is often used along with drainage works, vegetation works, and structural protection works using structures.
Restraint Works	Balancing forces to prevent failure even under rainfall.	Cutting work that improves the shape of the slope	Cutting works (B)	To maintain a slope's safety rating by cutting it to an acceptable gradient or height.	It is one of the most basic countermeasures, and one of the most reliable methods when it is executed safely. It is often combined with drainage works, vegetation works, or slope protection works, based on structures. It is often impossible to execute it completely when homes are constructed close to the top or bottom of the slope or when the volume of cut soil would be too large to make it economically feasible to remove, so it is often combined with other safety enhancing methods.
		Retaining wall	Stone masonry or block masonry retaining wall	To prevent small failure at the bottom of the slope	When it is a soil slope with gradient steeper than 1:1.0(normally 0.3:1 to 0.5.:1) and the earth pressure is low because the ground behind it is firm.
			Concrete crib retaining wall	To preventing small failures and to stabilize slopes affected by a lot of spring water or a relatively soft ground.	Because of its good permeability and its flexibility, it is suited for places where there is a lot of spring water and the ground is soft, or to prevent landslide type failure.
		Anchor works	Ground anchor work and rock bolt work	It is used along with cast-in-place concrete grating crib work, concrete retaining wall work, concrete pitching work, or other countermeasures to stabilize these works in order to prevent failure and sliding of severely weathered rock, rock with many cracks, and surface soil. It is also anchors rock that is cracked has joints or bedding stratification to rock that are internally stable to prevent its failure and separation.	It is appropriate for cases where there are dwellings at the top or bottom of the slope, if cutting work, passive retaining wall work, etc. cannot be done, if the slope gradient is steep and the slope is long, and cast-in-place grating crib work concrete pitching work etc. are not stable enough, it is particularly appropriate when the ground or rock to which the anchor is fixed is relatively solid and shallower than the slope surface.
Protective work used during execution of prevention work		Temporary protective work	Temporary protective fence work	To protecting lives and property from collapsed soil and falling rocks during the construction of failure prevention work.	The installation of temporary protective fence work is required when executing steep slope failure prevention work.

The figure bellow shows a flowchart that helps with this decision.

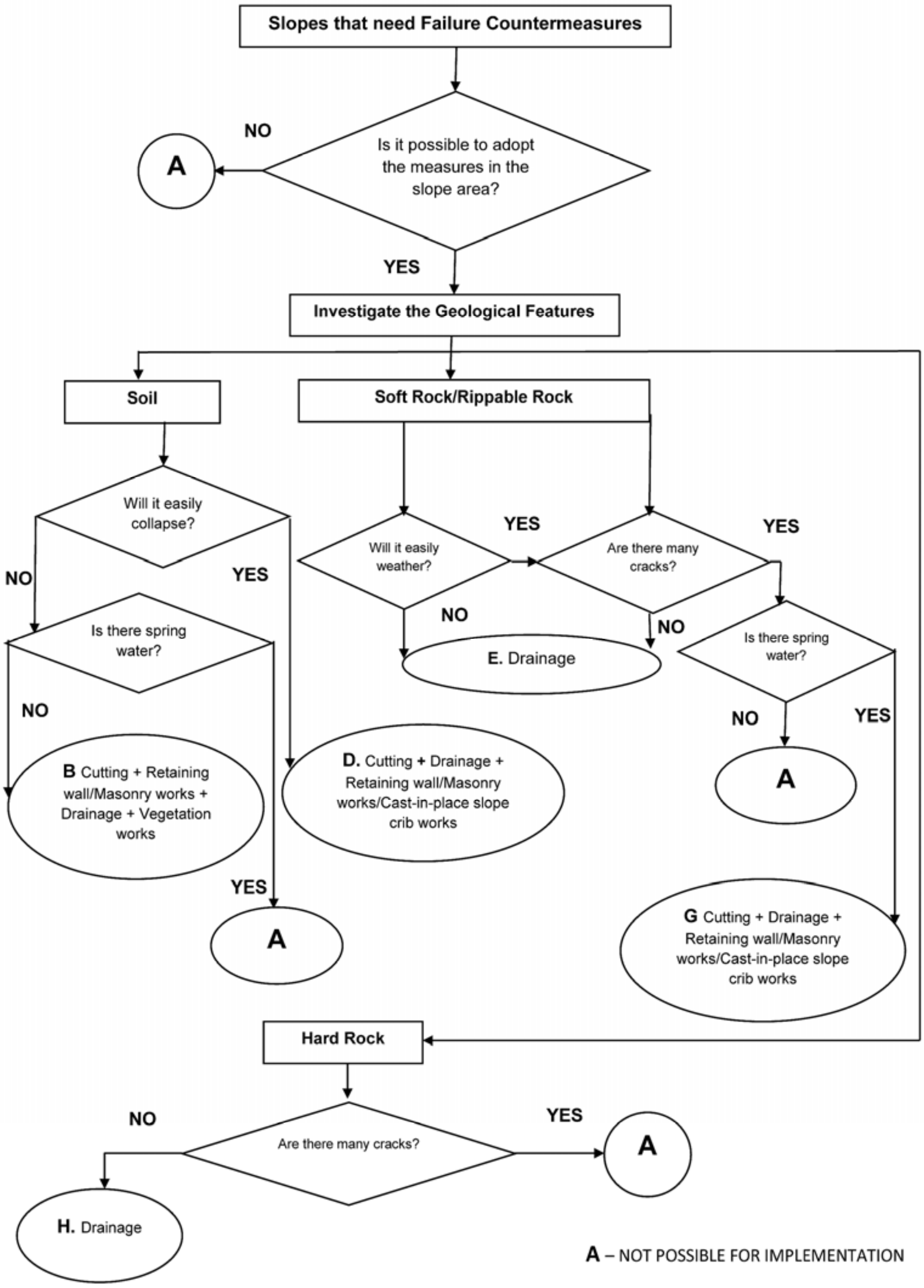

Figure 21 - Slope failure countermeasure identification matrix. Source: DPWH Technical Standards and Guidelines for Planning and Design, Volume IV, March 2002

G. ENGINEERING DESIGN (RIVER PROTECTION – REVETMENTS AND RIVER WALLS)

River protection structures are constructed to mitigate the effects of river overflow and flash flooding from excessive rainy seasons. These structures may consist of revetments[9], dikes, and embankments. The selection of these structures will depend on the municipality Disaster Risk Reduction Management (DRRM) Plan.

a. River protective structure design considerations

The function of river protection structures is to protect the riverbank from collapse due to erosion, scouring and/or riverbed degradation.

River protection designs should take into consideration the river flow velocity, embankment material, topographical, morphological, and geological conditions of the riverbank, flood levels and frequencies and river flow direction. Revetments should be designed to withstand the lateral forces of high velocity flow, flow attack zones, weak geological condition of riverbank, and poor embankment materials.

The river protective structure construction consists of the slope covering works, foundation works and foot projection works.

Figure 22 - Example of the Camarines Sur river protective structure that was developed to stop seasonal flooding resulting from the overflow of the river

Design Flood Level (DFL) - The design floodwater elevation of a river to which the flood will rise in relation to the design flood frequency used (e.g., 1-year, 2-years, 5-years return period, etc) in computing the design discharge

b. What are the parts of a river protective structure?

Although river protection structures have different forms, these are some similar elements that have to be included in the design and pre-engineering work that has to be supervised by the DAC. The following are the more common elements that should be present for the pre-engineering work for river protection structures:

a. Slope covering work directly covers and protects the bank slope from direct attack of floodwaters, boulders and floating debris.
b. Foundation work: constructed at the toe of the slope that supports the slope covering works.

[9] In stream restoration and river control engineering, revetments are sloping structures placed on banks or cliffs in such a way as to absorb the energy of incoming water

c. Foot protection work: constructed to prevent scouring in front of the foundation work. Material typically used from the back of the slope covering work.

d. Shoulder beam work: headwall that is installed at the shoulder of the revetment.

e. Backfilling material: used on the slope covering work to prevent an increase of residual water pressure underneath the slope covering work.

f. Filter material/cloth: installed behind the backfilling material to prevent the erosion of fine materials underneath the revetment due to flow forces or pressure from residual water.

g. Crest work: protection for the crest of the slope covering work.

h. Key: installed at the end portion of the crest work to protect against erosion.

i. Crest protection work: installed at the end portion of the key to join the crest and the original ground in order to protect against erosion.

j. End protection work: installed at the upstream and downstream ends of the slope covering work, to prevent undermining of materials behind the slope covering work.

k. Transition work: installed between the upstream and downstream sides of the end protection work and the natural banks to connect the revetment and natural banks smoothly.

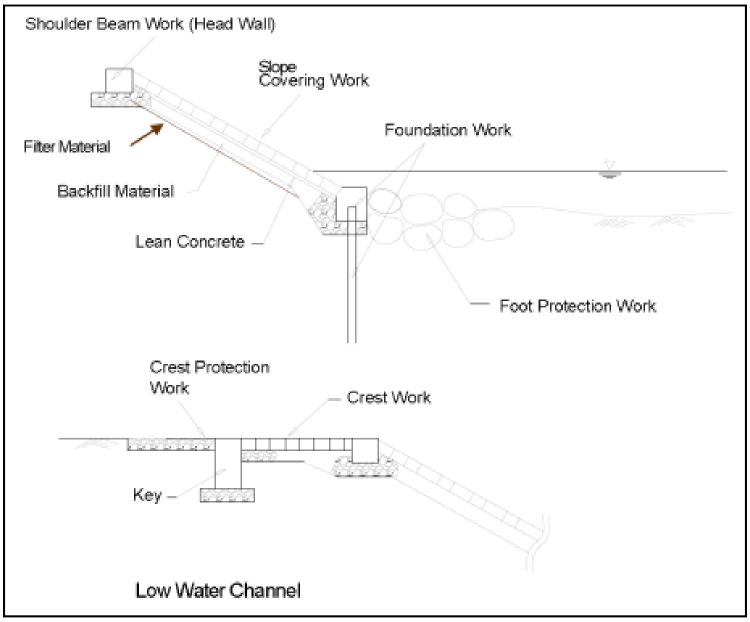

Figure 23- Parts of a Revetment Structure. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

c. What are design considerations for river protection structures?

The following considerations should be addressed by the DAC during the design of river protection structures:

a. Alignment of river protection structures should be as smooth as possible. Structural type of the river protection structures should be determined based on the estimated river flow velocity and characteristics of river.
b. Foot projection works should be considered based on river flow velocities.
c. Transition structures between the river protection structures and the original bank should be provided to prevent erosion and damage to the structure.
d. Other Design Considerations:
    - Drainage Pipe /Weep Hole
    - Backfilling Materials
    - Outflow Prevention Materials
    - Strengthening Upper and Lower Ends
    - Angle of Transition Work
    - Protection of Revetment Crest
    - Bridge Site and Tributary Confluence
    - Structural Change Point (Construction Joint)

d. What are some of the design criteria for river control structures?

The following are common design criteria that should be included in engineering and design for river control structures:

1. Location

River control structures should be prioritized along riverbanks with high velocity river flows. This is often the case along river bends or at the stream attack portion or drift stream sections. The possibility of scouring is very high at these locations. Although the alignment of the revetment depends on the channel plan or the existing alignment of the bank, the bank alignment should be improved through the installation of revetments to make it as smooth as possible, particularly along bends.

2. Height (crest elevation of structure)

The height of revetment is determined by considering the 50-year maximum Design Flood Level (DFL), however, no river protection (revetment) should be designed lower than the top of riverbank.

3. Depth of top of foundation

The depth of the foundation shall be placed deeper than 1.0m from the maximum scouring depth. If it is difficult to calculate the maximum scouring depth, it should be placed deeper than 1.0 m from the deepest riverbed. The determination process of the top elevation of the foundation work is as follows:

a. Plot the elevations 1 meter deeper than the maximum scouring level/deepest riverbed level at the respective cross-sections in the drawing of the longitudinal profile.
b. Draw the circumscribed line of the lowest elevation with the same longitudinal gradient of the top of slope covering work.

In cases where it is difficult to attain the depth of the top of the foundation due to extreme scouring or riverbed degradation, the depth of the top of the foundation can be achieved by use of sheet pile foundation or foot protection work. In this case, the following four cases can be considered for the top elevation of the foundation work:

a. The top elevation of the foundation work is set at the maximum scouring depth, and the minimum foot protection work shall be installed.
b. The top elevation of the foundation is set above the maximum scouring depth, and the foot flexible protection shall be installed to cope with the scouring.
c. The top elevation of the foundation is set above the maximum scouring depth, and the foundation work by sheet pile and the foot protection shall be applied in order to cope with scouring.
d. In cases where it is difficult to secure the adequate depth of embedment for the foundation work, such as high ordinary water levels or tidal rivers, cantilever sheet pile shall be installed as foundation work.

For cases 2 and 3, the top elevation of the foundation work shall be set at 0.5-1.5 m deeper than the average riverbed level.

For a narrow river (less than 50 meters in width) the minimum depth of revetment foundation should be 1.0 meter below the deepest riverbed elevation of the original riverbed or design riverbed, because riverbed materials are subjected to erosion during flood times.

4. Maximum scouring depth/ deepest riverbed level

Bank erosion is attributed primarily to scouring of the near-bank areas of the riverbed during periods of flood. Scouring in front of the bank primarily causes damage to existing revetments. Therefore, predicting the deepest riverbed level in the future is important in determining the foundation work of the revetment. The deepest riverbed level in the future is calculated by use of the scouring depth from the average riverbed level.

Various factors that contribute to scouring include the following:

a. Changes in average riverbed elevation - Channel excavation/dredging lowers the average bed elevation, and the bed elevation in scoured areas becomes lower accordingly. There are also cases where the reduction in sediment transport from the upstream destroys the sediment balance, resulting in a lower bed elevation.

b. River cross-section (change of river width and bend of river) - There are two reasons why the river cross-section directly influences scouring. One is that a change in river width from wide to narrow causes the water depth to increase. The other is that a curved or meandering river causes the flow to move toward one side of the channel, resulting in bank scouring.

c. Constricting structures - A structure located in the path of flowing water increases the velocity of flow around the structure and causes local scouring

d. Sand bar (induced scouring) - Sand bars are deposits in the river, which cause an obstruction to flow. Since the scale of the height of sand bars is roughly equal to the scale of the water depth, the scale of the scouring caused by sand bar is relatively large. The amount of sand bar-induced scouring becomes larger if the influence of the bars occurs at a bend or a meandering spot in the river.

5. Estimation method for maximum scouring depth, ΔZ

The scouring depth is measured from the average riverbed level. Principally, maximum scouring depth (ΔZ) at the proposed structure site is estimated as the larger value between the computed maximum scouring depth (ΔZc) and surveyed maximum scouring depth (ΔZs).

Calculated maximum scouring depth (ΔZc) is an empirical value that considers the relationship among the width of a waterway, depth, the riverbed material, and the radius of curve.
Surveyed maximum scouring depth (ΔZs) is the deepest riverbed determined from actual field survey (cross sectional survey).

Scouring phenomena occur along the entire river stretch with different effects for straight line and bend or curved waterway. The primary factors that contribute to scouring based on the alignment of rivers are:

a. Straight–line waterway: sand bar height
b. Curve waterway: bend of river alignment

According to DPWH Technical Standards and Guidelines for Planning and Design for Flood Control Structures, scouring depth can be estimated in three cases and requires additional calculations. The stakeholders will need to consult a design engineer in estimating the scouring depth value to be used in the design.

6. Segment length

The length of one segment of river protection in the longitudinal direction should be less than 50 meters in order to reduce the extension of damage in case one section of river protection collapses. The edge of the segment end shall be adequately filled with joint material (mortar) to connect with the adjoining structure.

The structure of the partition works shall be the same as the end protection work.

7. Slope

After the determination of height of the slope covering work, the slope should be planned based on the following factors:

a. The slope of the river protective structure should be the same or lower as that of the dike - 2:1 (horizontal to vertical, respectively). In cases when the slope of river protective structure is required to be steeper than the dike, it should be based on the natural slope of the adjacent bank.

b. In cases of stretches with a high velocity flow that contains large quantities of boulders or gravel, the slope should be lower than 0.5:1.

c. In portions where the structure must joint with a natural slope, the slope of structure should gradually change to smoothly connect with the natural slope.

d. For a retaining wall type river protective structure, a maximum slope of 0.3:1 should be observed considering stability and the resulting residual hydraulic pressure.

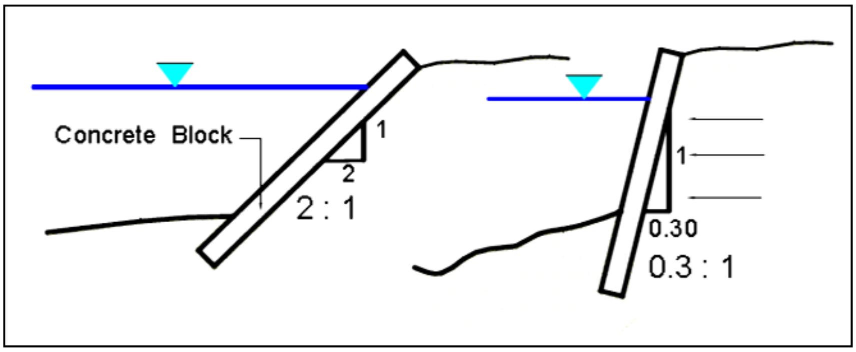

Figure 24 - Types of river protective structure depending on the slope. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

8. Berm arrangement

a. If the height of river protective structure is more than 5.0 meters, a berm (banquette) must be provided and designed in order to separate the river protective structure into segments.

b. The berm is provided for stability and construction convenience of the river protective structure. The berm shall be at least 1.0 meter in width.

9. Thickness

The thickness of river protective structure is generally decided based on the flow velocity, sediment runoff, soil and groundwater pressure at the back of river protective structure, and other associated factors. Minimum overall thickness should be 300 mm for all types of river protective structure, except for reinforced concrete type.

10. Calculation of design velocity for river protective structures

a. Design velocity for river protective structure[10]

The velocity of flow is a critical factor in the selection of the type of slope covering work.

The mean velocity derived by uniform flow calculations is not equal to the velocity of flow in front of the river protective structure. The effects of the sand bar, bend and foot projection work, and other factors influence the velocity of flow in front of the river protective structure. In designing the river protective structure, it is recommended to mitigate excessive velocity to make it match the he design velocity of the river protective structure. Details of mitigations are described below.

In case where there will be no correction, it is recommended that the maximum value in the mean velocities of the representative cross sections of the design flood is adopted.

b. Mitigation of mean velocity for design

The design velocity (VD) is estimated based on the average value of the mean velocities of the representative cross sections (Vmave) at the design flood, as follows:

$$VD = \alpha \, Vmave$$

Figure 25 - Design Velocity

Where:

VD = Design velocity (m/s)

Vmave = Average value of the mean velocities of the representative cross sections at the design flood.

α = Correction coefficient

[10] This section is repeated from Typical Design of Flood Control Structures, JICA-DPWH (2005).

Considering the effects of the bend or scouring and the installation of effective foot projection work, the correction coefficient is estimated as follows:

c. Mitigation for the straight stretch and without foot protection work

Considering the decrease of the stream area due to sand bar, the correction coefficient is as follows:

$\alpha = 1 + \Delta Z / 2Hd$; $(\alpha \leq 2.0)$

Figure 26 - Correction Coefficient

Where :

ΔZ = Maximum scouring depth (m) (refer to 2.4.3)

Hd = Average design water depth (m)

d. Mitigation for the bend stretch and without foot protection work

Inner bank of the bend:

$$\alpha = 1 + \frac{B}{2r}$$

Figure 27 - Correction Coefficient (Inner Bank)

Outer bank of the bend:

$$\alpha = 1 + \frac{B}{2r} + \frac{\Delta Z}{2H_d}$$

Figure 28 - Correction Coefficient (Outer Bank)

Where:

α = Correction coefficient (Segment 1: $\alpha \leq 2$, Segment 2 and 3: $\alpha \leq 1.6$)

B = River width (m)

r = Radius of the bend (m)

ΔZ = Maximum scouring depth (m)

Hd = Average design water depth (m)

e. In cases with foot projection work

In case of structure with the adequate foot protection works (crest width of 2 m or more), the correction coefficient of above (Figure 26) or (Figure 27) is revised as follows:

bw/ HI > 1.0: $\alpha^1 = 0.9\ \alpha$

bw/ HI ≤ 1.0: $\alpha^1 = 1.0\ \alpha$

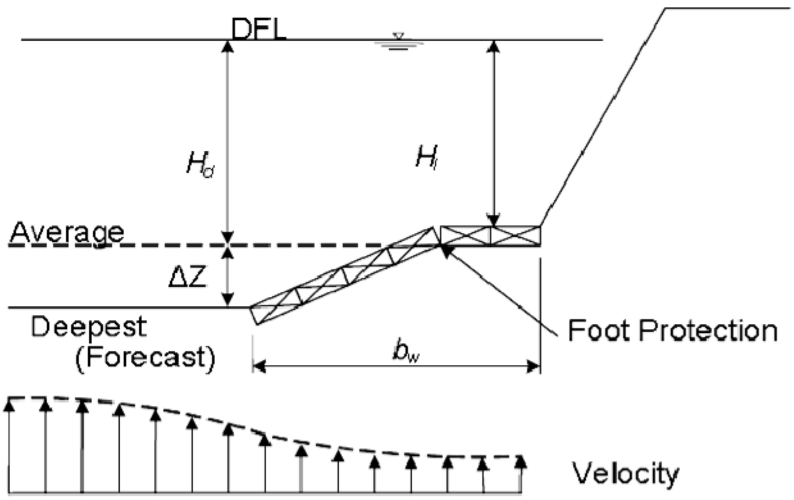

Figure 29 - Cross-sectional Distribution of Velocity. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

e. What are the different types of river protection structures and how do we select the appropriate type?

The table below depicts design standards to be consulted when deciding on which type of river protective structure to select.

Table 4 - Criteria for Selection of Slope Covering Work

Type of River protective structure	Allowable Design Velocity (m/s)	Slope (H:V)	Remarks
Dry Boulder Riprap	3.0	Less than 2:1	Diameter of boulder shall be determined using the thickness of river protective structure in the Standard Drawings in Appendix C Height shall not exceed 3m
Grouted Riprap (Spread Type)	5.0	Less than 1.5:1	Use Class "A" boulders for grouted riprap and loose boulder apron.
Grouted Riprap (Wall type)	5.0	1.5:1 to 0.5:1	Use class "A" boulder for grouted riprap.
Reinforced Concrete	As per design	As per design	Minimum thickness of 20 cm

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

f. What is foot protection/toe protection in a river protective structure project?

Foot protection work is planned in order to protect the river protective structure foundation from local riverbed scouring and/or the degradation of riverbed. Foot protection reduces the force of flow at the foundation, thus reducing the abrupt scouring of riverbed. The upper surface level of foot protection is set below the original riverbed or designed riverbed. However, in cases where foot protection is given a function as a spur dike, or where there is a difficulty in providing foot protection below the riverbed due to high water levels, the foot protection can be placed on the original riverbed or designed riverbed with due consideration to the regimen of the stream, river cross-sectional area, river flow direction and type of river protective structure.

Types of foot protection:

- Wooden stockade

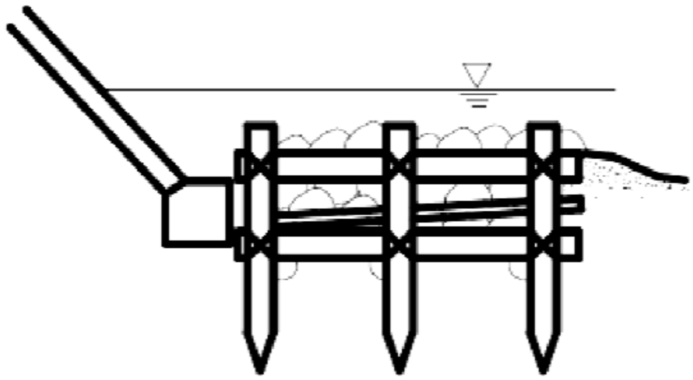

Figure 30 - Wooden stockade

- Boulder

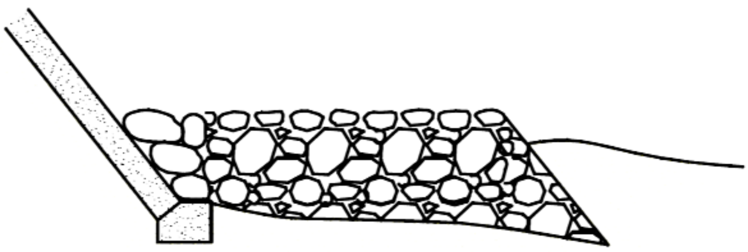

Figure 31 - Boulder footing protection

Table 5 – Minimum Boulder Diameter of Foot Protection Work

Type of Foot Protection	Water Depth (m)	Design Velocity (m/s) 1.0					
		1.0	2.0	3.0	4.0	5.0	6.0
		Diameter of Boulder (cm)					
Wooden stockade type	1.0	1.0	5	10	30	-	-
	2.0	2.0	5	10	15	35	65
	3.0	3.0	5	10	15	25	45
	4.0	4.0	5	5	15	25	40
	5.0	5.0	5	5	10	20	35
	6.0	6.0	5	5	10	20	30

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

Table 6 - Boulder Size by Design Velocity

	Design Velocity (m/s)	Diameter (cm)
Boulder	2	-
	3	30
	4	50
	5	80
	6	120

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

H. ENGINEERING DESIGN RIVER PROTECTION (DIKES)[11]

A dike is an embankment or levee constructed along the banks of a stream, river, lake or other body of water for the purpose of protecting the landside from overflowing with floodwater by confining the stream flow to the regular channel. The dike prevents drainage water from the inland to flow naturally into the river. Inland drainage improvement (non-dike system) is provided to address inland flooding.

a. What are the parts of dike structures?

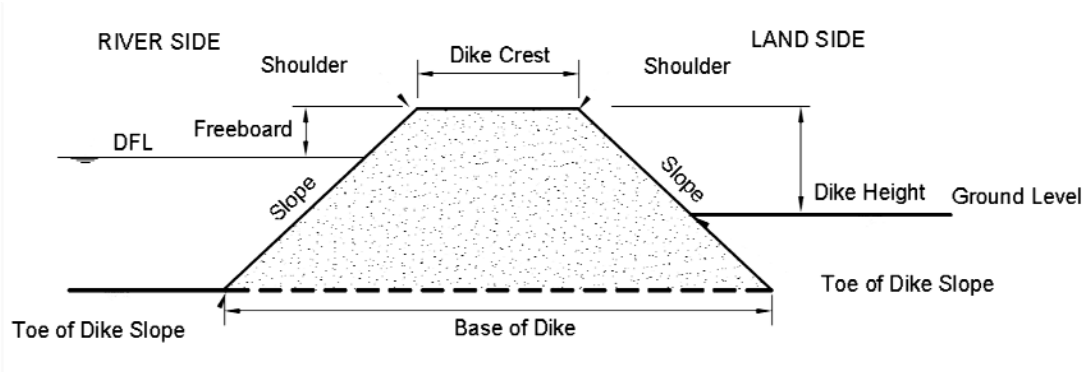

Figure 32 - Parts of a Dike. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

b. What are the design considerations for Dike Structures?

a. Flood Level – can either refer to planned flood design height or the maximum flood level recorded.
b. Ground height – the dike itself will need to be higher than the flood level. The actual ground height or elevation where the structure will be placed will help in designing the required height of the dike.
c. Ground Condition – Weak and permeable foundations are major issues that need to be addressed on the pre-implementation stages via surveys and investigation. A weak foundation can cause damage in and around the dike such as sliding failure and large areas of subsidence,

[11] The dike design guidelines is being segregated from the general river control/protection write up because it required a lengthy discussion.

which may decrease functionality and increase deformation of nearby foundations and structures.

d. Alignment – dike structures will be aligned with the river flow and the natural riverbed orientation.

The following factors should be considered when designing alignments:

a. Reduction of the existing stream area should be kept to a minimum.
b. The alignment should be as straight as possible. Sharp curves should be avoided since these portions are subject to direct attack of flow.
c. Where there is sufficient space, the dike is recommended to be located not too close to the river channel or riverbanks to prevent undermining/scouring.
d. Valuable land, historical or religious structures, and weak/permeable foundation should be avoided.

c. What are the design criteria of dike structures?

1. Height

The height of a dike is based on the design flood level plus the required freeboard. The calculated flow capacity should be used as the Design Flood Discharge for establishing the freeboard.

Dike height = Design flood level + Freeboard

2. Freeboard

Freeboard is the margin from design flood level up to the elevation of the dike crest. It is the margin of the height, which does not allow overflow. The freeboard should be based on the design flood discharge, which should not be less than the value given in Table 8.

Table 7 - Minimum Freeboard and Crest Width Requirement

Design Flood Discharge Q (m2/s)	Freeboard (m)	Crest Width (m)
Less than 200	0.6	3
200 and up to 500	0.8	3
500 and up to 2,000	1.0	4
2,000 and up to 5,000	1.2	5
5,000 and up to 10,000	1.5	6

Design Flood Discharge Q (m2/s)	Freeboard (m)	Crest Width (m)
10,000 and over	2.0	7

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

For the backwater effect in a tributary, the height of the dike in the transition stretch should not be lower than that of the main river or even higher at the confluence in order to prevent inundation in the subject areas. In general, the dike's height of the main river at the confluence point is based on the design flood level.

3. Crest width

The crest width of the dike, especially for a wide river, should be based on the design flood discharge, and should not be less than the values given in Table 8. When the landside ground level is higher than the design flood level, the crest width shall be 3m or more regardless of the design flood discharge. Crest width should be designed with multiple uses in mind, such as for patrolling during floods and emergency flood prevention works.

The base of the dike is fixed by the width of its crest and slope. Likewise, the dike shall be designed to prevent from possible collapse due to seepage, which is also dependent on the width of the dike's crest.

For backwater effect on the affected tributary, the crest width of the dike shall be designed such that it is not narrower than the dike crest width of the main river.

4. Maintenance road

The dike may be provided with a maintenance road for patrolling the river during emergency flood prevention activities. When a permanent road is to be built and when the difference in height between the dike crest and the landside is below 0.6 meters, a maintenance road is no longer necessary. However, the dike's crest itself can be used as a maintenance road. The maintenance road shall be 3.0 meters or more.

5. Slope

In principle, the slope of a dike shall be low as possible, ideally less than 2:1. When the crest height from riverbed is more than 6 meters, the slope of dike shall be less than 3:1.

A slope of 4:1 is usually used for dikes consisting of sand and shall be protected by providing a cover of good soil sodded at least 300 mm thick. When the surface of a dike is covered with a river protective structure, the slope of the dike could be steeper than 2:1.

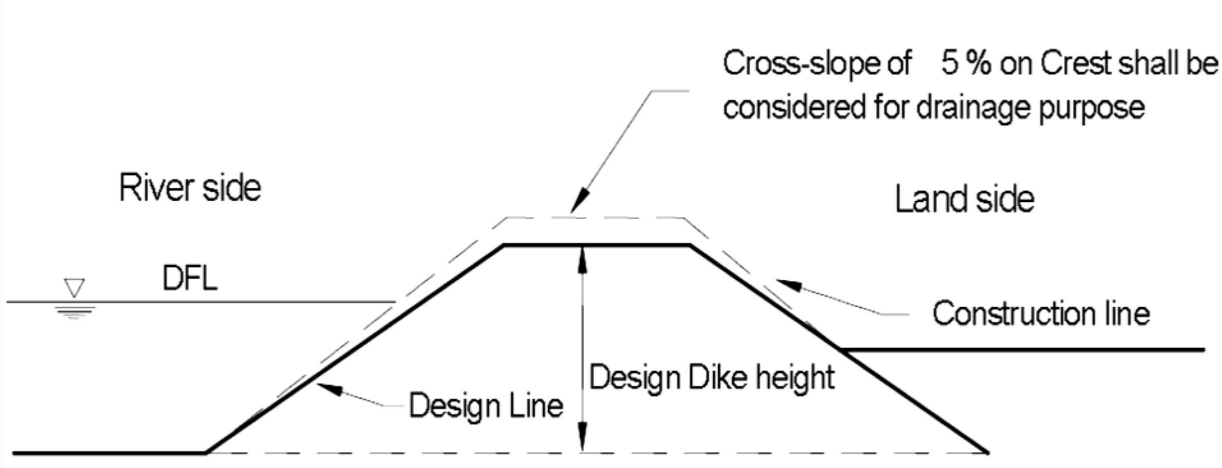

Figure 33 - Height of Embankment

Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

6. Extra-embankment

An extra-embankment should be planned due to settlement of the dike. The standard for extra-embankment height is shown below:

Table 8 - Standard Height of Extra Embankment. Source: Technical Standards & Guidelines for Flood control and Sabo Work, JICA-DPWH, 2010

Dike Height	Dike Foundation Materials			
	Ordinary Soil		Sand/Sand & Gravel	
	Extra Embankment Materials to be added to dike foundation materials			
	Ordinary Soil (cm)	Sand/Sand& Gravel (cm)	Ordinary Soil (cm)	Sand/Sand& Gravel (cm)
≤ 3m	20	15	15	10
3m – 5m	30	25	25	20
5m – 7m	40	35	35	30
≥ 7 m	50	45	45	40

d. What are the design considerations in heightening/widening a dike project?

In cases where the existing dike project requires heightening or widening, the expansion is ideally constructed on the 'landside' of the structure.

Expansion can be made on the 'riverside' if there the expansion does not conflict with waterway right-of-way. This option may entail more problems because the toe of the dike is close to the lower water channel.

I. PLAN PREPARATION

a. What are engineering plans?

Engineering plans are the graphical representation of the structure to be constructed. Plans should include details and other important information that conforms both to the design requirements and project specifications.

b. What are the requirements of engineering plan?

Design criteria and requirements must be first established including the project's quantity computations and specifications. A complete and clear plan, drawings, quantity computations, and clear specifications will help the project implementers execute the design to standards.

c. What measuring system is used and how are engineering plans presented?

Engineering plans are prepared using the metric system for measurements and computation. All design, quantity computation and other information, as support to the plan should be presented on A4 bond paper with size 29.7cm X 21.0cm. All engineering plans should be prepared in a tracing paper or cross section paper or mix of the tow with paper size of 59.4cm X 76.20cm. Engineering plans should be prepared in a manner to prevent inconsistencies between the design, drawing details, specification and plans.

d. Plans for environmental protective subprojects

Below are the required contents of engineering plans for environmental protective subprojects.

1. Cover Sheet
2. Title of the environmental protection subproject
3. Location Map
4. Drawing Index
5. Legend, Abbreviations & General Notes
6. Channel, river, seashore, slope (as appropriate)
7. Longitudinal Plan
8. Typical structure design drawings
9. Summary of Quantities
10. Drainage Drawing & Schedules (applicable for dike and slope protection) and quantities
11. Right-of-Way Straight-Line Diagram (typical for drainage plans only)

e. What is the cover sheet of the plan?

Cover Sheet of the Plan is a plain tracing paper with no marks or writing on it. This is the cover of the project plans.

f. How about the title of the project?

The title of the project goes on the second page of the plan. It is presented on tracing paper indicating the name of the project, the type of flood control structure, and its encompassing stations. It is written in the following format: Construction of river protective structure from Barangay {Name of barangay} from —Sta. {x+xxx} to Sta. {x+xxx}. This page will include the length of the project in kilometers, the agency co-financing the project (with its logo), the barangay, municipality and province where the proposed project is located.

g. What about the location map?

The location map of the plan is the third sheet. This sheet indicates the map of the Philippines, Province Municipality and the Barangay(s) where the proposed environmental protective project is located. On these maps the location of the flood control project should be indicated. All the maps mentioned should be drawn on a tracing paper and do not have to be drawn to scale.

Figure 34 - Example of a typical location map

h. How about the drawing index, legend, abbreviations and general notes?

The Drawing Index, Legend, Abbreviation and General Notes are the fourth sheet of the plan. The fourth sheet consists of the title of each page in the Drawing, meanings of the Legends and Abbreviation as indicated in the Drawings and General Notes. This is also presented on a tracing paper.

i. What about the channel plans?

Channel plans use the topographic map as its base in plotting the information it presents. The topographic map will be acquired in developing this plan. The topographic map will need to include the location where the project will be constructed. The following information will be plotted on the map:

1. Existing river area
2. Delineation of flood control area
3. Planned structure alignment
4. Main property to be protected by flood control structure
5. Existing condition of sedimentation and vegetation

j. What about the longitudinal plans?

Longitudinal plans use the information based from the cross section surveys and the following information is indicated:

1. Deepest riverbed
2. Average riverbed
3. Design Water level
4. Existing bank overflow levels
5. Design crest level
6. Design riverbed
7. Ground level behind the dike (for dike project only)
8. Planned river gradient by different sketch/segment

k. What are the typical structure design drawings?

This is the part of the plan that contains typical structural design drawings like foundations, floor plans, elevation and section views of the structure complete with corresponding details, dimensions, elevations, material, material sizes and any information that will be needed during the construction of the sub-project.

l. How is the summary of quantities presented?

The summary of project quantities is the sixth sheet in the plan. In this sheet, quantities of every work item that is part of the work are presented. These quantities are the same work quantities in the detailed estimates and the project program of work. This should be presented on tracing paper in table form indicating the work item number, description of work items, units and quantities.

m. What is the importance of Right-of-Way Straight Line Diagram? When is it prepared and what is its importance to the other plans?

The Right-of-Way Straight Line Diagram is attached to the plans for presentation and verification purposes. This diagram should be prepared prior to the negotiation with the lot owners affected by the project. The diagram should include the name of the lot owners and the approximate area covered by the project. This will also guide the implementers in the marking the new boundaries of the affected private lots with corner posts.

IV. DETAILED ESTIMATES AND PROGRAM OF WORK

Detailed estimates are the basis for the preparation of project program of work and also a requirement for public bidding and project implementation. This is prepared on the basis of the prepared project plans and design with reference to project specification and mode of implementation.

A. DETAILED ESTIMATES

The DAC assists the barangays in the preparation of the detailed estimates on the basis of the project or agency requirements and procedures and from the results of the completed plans, designs, specifications, present market prices, and acceptable standards and procedures in quantity derivation and computation. The detailed estimates are checked, reviewed and approved by the DAC.

Preparation of detailed estimates starts after the completion of the computation of project quantities.

a. How are project quantities prepared?

Project quantities are prepared based on work required on the structures as shown on the plan. The following are the procedures:

a. Prepare lists of works and activities required in the implementation of the project based on structures and type of work required.
b. From the cross section plan of the slope, earthwork quantities for area cut and fill of earth materials along the proposed drainage system can be calculated by using plan meter or ordinary computation. Area cut and area fill for a certain drainage section shall be initially written at the bottom of the slope station cross-section.
c. After completing the calculation of cut and fill areas for the entire length of the slope, the quantities shall be entered in the bill of quantities.
d. Summarize all volume computations. Separate summaries should be provided for volume of cut and volume of fill.

e. For the volume of cut, the computed volume will be the quantity to be use in preparing the detailed estimates for slope excavation.

f. For the volume of fill, the computed volume will be the in-place quantities. However, to properly accomplish the in-place quantities, a larger volume of loose material is required to cover the shrinkage of earth materials when compacted. A 15% increase in volume is necessary to attain the required quantity of volume in-place. This new quantity is now the working quantity to be use in the embankment or fill section. Other that the shrinkage factors no other allowance is necessary.

b. After preparation of the project quantities, what are the other activities that follow?

Other activities include, but are not limited to:

a. Canvas prices of construction materials (with and without delivery charges to the project site, plus taxes), equipment rentals rates, labor rates (skilled, unskilled and professional) and labor contracts. These prices shall be calculated from the nearest source area from the project site.

b. Utilize the rate of equipment to be use in the project and the production rate of skilled and unskilled workers in every type of work.

c. Review project specifications and determine the type of materials required in each work and the required quality of work output.

c. How are project detailed estimates prepared?

Project estimates are prepared as per the following:

a. Based on the quantity estimates of every work, identify the item number and the description of work in the specifications and adopt the item number and the corresponding description. Example: Item No. 1 Excavation for Structures.

b. From the quantities of work, estimate the number of days to complete the work using the production rate of the number of cubic meters that a single laborer can accomplish. Likewise also consider the ideal number of laborers required to accomplish the work. The results are number of workers to be utilized to excavate the required quantities and the number of days to complete the work.

c. The detailed estimates should show the materials, equipment and labor utilization per item of work.

d. Labor costs should show the number of laborers to be utilized multiplied by the rate per day times the number of days required to execute the work. This will be the total cost for the laborers. Also provide the cost of wages for one foreman and one engineer that will supervise the work. They will have the same number of working days with the laborers but different rates per day. The combined costs of the laborers (which includes the wages of laborers), foreman and engineer are the total labor cost of the item of work. This is called the subtotal.

e. Using the subtotal amount calculate 1% for OCM (overhead, contingencies and management), 10% profit for projects undertaken by contract (0% for works undertaken by Force Account), and 12% for taxes.

f. The sum of the subtotal, OCM, profit and taxes is the total cost of the item of work.

g. Divide the total cost over the estimated quantities and the result is the unit cost of the item of work for the project. This process should be repeated for the other items of work of the project. The output is the detailed estimate of the project including its construction cost.

h. The detailed estimates shall be reviewed both on the derivation and mathematical computation before preparing the project Program of Work.

d. How are mistakes and errors avoided in the preparation of quantity estimates?

To achieve good results in preparing quantities, the following practices should be adopted:

a. Plans and drawings should be carefully studied by the estimator to familiarize himself with the project

b. Crosscheck the dimensions between the design and plans. Any inconsistencies should be brought to the attention of the designer and draftsman

c. Document every structure that has been quantified and verify in the plan that other similar structures have different assigned numbers or letters to avoid duplication of the computation of quantities

d. In the computation of structural excavation, no allowances should be allowed.

e. In steel reinforcement computation allow only overlap length of steel bars and do not consider full length in the computation.

f. Quantity computations for earth works shall be carefully executed. No allowance for excavation and embankment should be allowed. Review and recheck the areas of the cross-section and its volumes.

g. Final computation of quantities should be indicated in one sheet of the plan. Separate documents should contain the back-up computations.

B. PROGRAM OF WORK (POW)

The Project Program of Work is a project document that summarizes all the costs attributed to the implementation of a project. This is the final document to be approved by MLGU and signals that the work of the project is about to be started. The POW is also submitted as part of the proposal prior to approval of the subproject.

a. Who prepares the Project Program of Work?

The community volunteers prepare the Project POW with the assistance of the DAC and the ACT.

b. What are the contents of the Project POW?

The Project POW is generally structured as follows:

1. Heading

a. Country
b. Name of the Executing Agency
c. Name of the Project

d. Province
e. Municipality
f. Name of Implementing Agency (MLGU/ Barangay/ Community)

2. General information of the project

a. Name of the Project
b. Title of the document
c. Category
d. Physical Target
e. Total Project Cost
f. Project Number (if any)

3. General description of the project

a. General statement of the Project
b. Mode of Implementation
c. Project Duration
d. Equipment Required
e. Technical Personnel Required

4. Scope of work of the project

a. Item No. (based on the Project Specification)
b. Scope of Work of the Project
c. Percentage weight of the Items of Work of the Project against the total Direct Cost
d. Unit measure of every item of work
e. Unit cost of each item of work based on the detailed estimates
f. Total cost per line item
g. Total Direct Cost/Construction Cost

5. Breakdown of total direct cost/construction cost into

a. Equipment rental
b. Materials and
c. Labor indicating
    - Skilled and
    - Unskilled labor with the following
d. Cost sharing:
    - Project
    - National Government
    - MLGUs
    - Barangay
    - Community/Other (to be specified)
    - Total cost of line items such as labor (skilled and unskilled), materials and equipment rental
    - Subtotal (should be the same as item 5.g)

6. Indirect cost

Note: With cost assignment for cost sharing such as the Project, National Government, MLGUs, Barangay/Community and others.

a. Pre-Engineering
b. Preparation of plans
c. Engineering supervision
d. Management Cost
e. Other cost associated to the type of mode of implementation
f. Total Cost for indirect cost with cost sharing arrangement
g. Total cost for direct and indirect cost with cost sharing arrangements

7. Percentage of cost sharing arrangements

For the Project, National Government, MLGUs, Barangay, Community and others to that of the total cost for direct and indirect cost. This will arrive to the total cost of the project.

c. Who approves the project Program of Work (POW)?

The Project Program of Work will be approved by the authorized official of the BSPMC and reviewed by the ACT (DAC). The POW is a technical project document. The person who reviews the POW must have proper technical/ engineering background knowledge and expertise to do so.

V. FACILITATION OF SAFEGUARD REQUIREMENTS

Environmental and Social safeguard requirements should be facilitated to ensure smooth project implementation. Project safeguards are policies to be complied by all government agencies implementing government projects and are necessary to prevent legal and environment problems during and after project implementation. These activities should be implemented in parallel with physical surveys and must be completed before all subprojects are submitted for project approval. Full discussion of safeguards can be found in your KC Environmental and Social Safeguards Manual (ESSM 2012).

A. WHAT ARE THE SAFEGUARD REQUIREMENTS THAT THE PROJECT MUST COMPLY WITH?

a. Land Acquisition Resettlement and Rehabilitation (LARR)
b. Environment
c. Indigenous People's Concerns
d. Gender Concerns

These safeguards are facilitated through securing of clearances and permits, such as, ECC or CnC, EMPs, ESS checklist and other forms, and attached to the proposals for DENR compliance and approval. The gender concerns are taken into consideration during the Social Investigation (SI) and PSA discussion of problems and issues. Their participation is also accounted for through the subproject and CEAC life cycle. During social investigations, women should be included in the research and PSA team. During subproject implementation, women participation in rendering labor should be encouraged. They should be also be given opportunities to join in all sub-committees for operation and maintenance of subprojects. It should be a practice to include at least one female member in the implementation and post-implementation committees/groups.

The IP concern is also considered from the social preparation stage by securing FPIC from the provincial NCIP. This serves as an agreement or approval for the project to conduct investigation, consultation with the IPs and implementation of projects in the ancestral domain or IP natural habitat/areas. The ACT also ensures their involvement from the planning stage through implementation stage, so that their voices in decision-making are also heard.

VI. **PROCUREMENT**

Procurement activities should follow the procedures and policies of the KC Procurement manual.

CHAPTER 4 |

IMPLEMENTATION PHASE

This is the portion of the project implementation process that involves the construction management and project management activities.

I. CONSTRUCTION MANAGEMENT

The following activities have been aligned with the KC Infrastructure manuals manual that are presently being utilized in the field by KC ACTs.

A. PRE-CONSTRUCTION CONFERENCE

Before the actual implementation/construction, it is important to set the direction of activities to be undertaken. The Deputy Area Coordinator (DAC) or the Municipal Engineer should lead the Project Implementation Team and other ad hoc committees involved during implementation stage in a workshop or meeting. Discussions will focus on explaining the work items and its subsidiary works to be accomplished including but not limited to:

a. Duration to complete the work items (including sequence of work)
b. Manpower and equipment utilization requirements,
c. Timing of delivery of materials and storage facilities,
d. Quality control program and materials testing requirements,
e. Safety measures during construction stage
f. Effects of the weather and the terrain (hauling)

For sub-projects to be undertaken by Contract, it is important that the Project Engineer and the Proprietor (or the authorized representative of the Contractor) be present during the conference. Important provisions of the contract should be discussed including the corresponding attachments for payment of progress billings. The Sub-project Physical Accomplishment Report needs to be discussed with the PIT and AIT for their understanding and appreciation.

a. Duration to complete the work items (including sequence of work)

The DAC should discuss in the preconstruction meeting the planned duration and sequence of work using the KC schedule spreadsheet.

Particular attention should be given to weather conditions because the environmental protection subprojects are specifically located in areas where weather-related natural disasters frequently occur. Items to be considered are:

a. Anticipated weather delays based on known annual weather events in the locality
b. Alternative work (if applicable) to concrete placement during rainy periods
c. Schedule and tracking of long lead items
d. Importance of preparatory work, inspection, and horizontal/vertical controls to be in place before actual work
e. Discussion of critical path activities that should be prioritized
f. Schedule of anticipated testing
g. Updating completed and/or delayed activities on a weekly basis

b. Manpower and equipment utilization requirements

The DAC shall discuss in the preconstruction meeting the planned manpower and equipment for the subproject. This will utilize POW document approved with the proposal.

Particular attention shall be given to the quantity and quality of manpower as well as the capacity of the equipment to be utilized. Environmental protection projects are hardened structures built to make the communities more resilient to natural calamities. This means that there are several skill sets that are needed to ensure that the structures are built in accordance with the approved specifications and designs. These are the common manpower and equipment requirements for this subproject type:

a. Supervision and construction management – this resource must be checked as adequate because the construction methodology of environmental protection structures is heavily technical. This resource is important in interpreting the engineering drawings and specifications. This position is given a 5% portion of the subproject budget. The municipal engineering office or a service provider usually takes this position. The DAC oversees the activities of this resource.
b. Heavy equipment – this resource is primarily for earthmoving and movement of large stones/boulders. Environmental equipment (i.e. seawalls, rip raps, gabions, revetments) has components made up of large amounts of earth and/or boulders. Some structures even require specialized equipment to drive sheet piles for their foundations. The understanding of the capacity required to complete the subproject in good quality has to be explained to the community volunteers, as they are not familiar with these types of equipment.
c. Skilled workforce (i.e. rebar worker, mason, formwork carpenter) are essential for strengthened structures that require good quality workmanship to resist environmental impacts such as floods, storm surges and slope collapse. The DAC shall identify the minimum experience these skilled workers are required to have.

c. Timing of delivery of materials and storage facilities

The DAC should discuss in the preconstruction meeting the planned material delivery and storage requirements for the subproject. This should be done alongside the discussion of the schedule.

Particular attention should be given to the materials that may spoil or waste, are long lead items, or are resources needed in a critical path activity. Some of the common items that should be covered are:

a. Cement and the requirements of keeping it moist free or else it will harden
b. Reinforcing bars can rust if delivered too early and will develop less bonding to concrete because of the rust covering its surface
c. Fuel for heavy equipment, because it is a hazardous/flammable substance

d. Quality control program and materials testing requirements

The DAC should discuss in the preconstruction meeting and throughout the subproject implementation (as needed) the requirements for quality control. This should be done with the discussion of the specifications and the acceptable quality description of the subproject.

Particular attention should be given to the quality control for structural integrity, material quality and subproject dimensions/controls (e.g. horizontal and vertical control, length, height). Some of the common items that should be covered are:

a. Gravel and soil quality
b. Compaction test
c. Concrete slump test
d. Concrete compressive test
e. Steel strength test or availability of a mill certificate
f. Formwork and false-work inspection (dimensions, alignment and strength)

e. Safety measures during construction stage

Environmental protection structures have similar safety concerns because most of them are large and are placed in natural disaster prone locations. The DAC shall discuss in the preconstruction meeting and throughout the subproject implementation (as needed) the requirements for safety measures in the construction area.

Particular attention should be given to the following safety practices:

1. Excavation and trenching

Most environmental protection subprojects require deep foundations (e.g. seawalls, riprap, river protection) or trenching (large drainage) that if not properly and adequatley shored can collapse and cause injuries or even fatalities to workers. Excavations over 1.2m deep should have readily available exit ladders and sloped excavation walls to prevent collapse of cohesive soils. The risk of collapse is further increased when working on foundations of seawalls that have sand walls (non-cohesive soils) that can collapse easily if not properly sloped or shored.

2. Fall (general) injuries and falling object-related injuries

Falls are one of the greatest safety risks in these subprojects as many of the subprojects entail construction activities at heights above 3m. The risks increase as the projects are completed due to the height of the workspace and because the local materials (mainly coco-lumber) used for scaffolding may deteriorate during the construction of the subprojects.

Additionally, as the subproject nears completion, more loose materials are typically placed and available at the top of the structure. These materials may include light tools, rubble and other materials. The DAC should inform the community volunteers regarding the proper use of hard hats and PPE.

3. Ladders and scaffolding related injuries

Ladder and scaffolding related injuries are primarily fall-related. This safety risk is highlighted because ladders and scaffolds in rural construction tend to be makeshift ladders built from formwork wood or bamboo. Most such ladders are usually sturdy enough for normal work, but environmental protection structures typically utilize heavy stones and other heavy materials which may lead to collapse of ladders in the workplace if these are not strengthened adequately when they are built.

4. Heavy equipment related injuries

Often rural communities are not familiar with the dimensions and reach of heavy equipment required to implement environmental protection structures. Also, children in communities tend to watch their relatives during construct and are likely to play around parked heavy equipment. The DAC should identify and orient the community volunteers and other stakeholders to the dangers of typical heavy equipment used in rural environmental protection structures. A few of these dangers from heavy equipment are:

a. Backhoes – possibility of getting hit by excavation arm
b. Dump trucks – danger of being backed into and caught under dumping load
c. One-bagger mixer – danger of hands getting caught in the gears, belts, chains or other moving parts

5. Ergonomic related injuries (back injuries)

The wide use of riprap structures, mound-type seawalls, gabions and boulder foundations increases the risk environmental protection structures pose for increased ergonomic injuries caused by improper lifting or too excessive loads.

The DAC should inform the community on proper lifting techniques and the recommended maximum limit of 40kg lifting weight (same weight as 1 cement bag) for manual laborers.

6. Drowning

Because the seawalls and river protection structures are situated at the edges of the sea or rivers, there are inherent risks of drowning when working during storm conditions. The supervising engineer or foreman should assess the risks of a sudden storm surge or a flash flood before starting work in these conditions.

f. Effects of the weather and the terrain (hauling)

Hauling has become one of the largest challenges for subproject implementation. The effects of weather and rain on roads and hauling costs can significantly increase the resource requirements for a subproject. In consideration of this, construction management approaches should be discussed between the DAC and the implementing community volunteers before actual project implementation.

B. IMPLEMENTATION PERIOD (CONSTRUCTION)

a. Planning the work and assigning people to do the tasks

This involves identifying and documenting the specific activities that must be performed in order to deliver the completed subproject. The available labor force should be maximized and employment opportunities provided at the community level. Supervising engineers should have the work ready and manpower schedules developed in order to manage the distribution of workers. Matching of available skilled workers to the work requirements should be analyzed by the Supervising Engineers. If required skills are not available at the village, the management committee may decide to explore obtaining such other skills and resources from other barangays. Facilitators can assist the implementing committees and Supervising Engineers by mobilizing the interested volunteers/workers during implementation.

b. Organizing the work

Construction activities must be accurately sequenced in order to support to develop a realistic and achievable construction schedule. In most cases, several items or elements of work will be performed simultaneously to optimize labor resources and meet the desired timeline for completion. It is important for the supervisor to manage the level of complexity during this period. Ensuring that required resources and manpower are available will expedite completion of the work. The timing and effects of weather conditions must also be considered during the scheduling in order to come up with a realistic completion date.

c. Directing activities

This is a critical aspect of project implementation. Community volunteers and project workers must have clear instructions and completely understand technical requirements and activities they are assigned to undertake. Supervising Engineers must provide instruction and be very explicit in explaining the possible outcomes, implications of the work and as well as expected completion dates.

d. Controlling project execution

This process provides the project with necessary inputs for updating schedules, making revisions, corrective actions and documenting the lessons or experiences-learned. Implementing committees and project supervisors should learn to exercise control of the time of implementation, the cost of investment, the quality of the execution and managing the risks involved. The implementing committees and project supervisors must remain aware of continuing risks during the procurement process, from financial transactions or environmental impacts from the work activities. Risk mitigation measures must be executed properly and in a timely manner to minimize impacts from these risks.

e. Work suspension

During the course of project construction and implementation, unforeseen events and situations will occur. When appropriate, the Project Engineer through the BSPMC will issue a Suspension Order and state the reasons for suspension including the duration of the suspension. A Weather Chart is a very important part of the project documentation and may be necessary in case there is a need to justify work suspension due to unfavorable weather conditions.

When conditions allow the work to resume, the Project Engineer through the BSPMC will issue a Resume Order. For work under contract, the number of days covered by the approved suspension order should not be counted towards the total duration for contract period and necessary adjustments to the contract completion date may be required.

f. Tracking progress and reporting system

Tracking the project's progress and using an effective and regular reporting system is an important part of effective project management. In KC projects, simple progress and monitoring reports are submitted regularly as required. Posting of these reports at the ACT and BSPMC offices are essential for monitoring the project's performance during implementation. Project progress monitoring and reporting implements and reinforces the principle of transparency and fosters the sharing of responsibility among community members. In addition to the project's progress reports, the project's financial status must also be readily available at the community level.

To further ensure that subprojects are implemented according to plans, several transparency mechanisms may adopted by the project. Community volunteers through various ad hoc committees should conduct regular meetings and assemblies to report the status of the subproject physical progress and financial status.

1. Monthly physical accomplishment report

This report should reflect the activities conducted for the period of report coverage and the progress attained in terms of weighted value, as a percentage of the entire project. Problems encountered including delays should be properly documented and reported. The DAC should provide the BSPMC with analysis of the report, to include his recommendations for appropriate actions to address any issues.

2. Variation order (VO)

Variation Orders (VO) are issued by the procuring entity to cover any increase and/or decrease in quantities, including the introduction of new work items that were not included in the original contract. A VO also includes reclassification of work items that may be the result of a change of plans, design or alignment to suit actual field conditions that result in a disparity between the preconstruction plans and the "as staked plans" (construction drawings prepared after a joint survey by the contractor and the Government after award of the contract). The Variation Order should not exceed ten percent (10%) of the original project cost. The addition or deletion of work should be within the general scope of the project, as bidded and awarded. A Variation Order may either be in the form of a change order or extra work order.

Any changes that may occur at the project site must be supported by shop drawings, cost estimates and the corresponding approved Variation Orders. The technical staff at the LGU and PIT will request the proposed changes to be reviewed by the DAC. Before the BSPMC signs the approval, the request must pass the final review of the Regional Infrastructure Engineer (RIE) for concurrence and notation. The RPMT is expected to notify the BSPMC through a letter of approval/disapproval on the merits of the proposed Variation Order. In no instance shall work that is the subject to proposed changes commence without the approved Variation Orders and notation of the proposal. Administrative sanctions may be imposed on technical staff failing to follow procedures.

g. Analyzing the project progress results

Progress reports should be analyzed to determine whether the level of accomplishment or performance is within the expected timelines and parameters of the project plan. Once a subproject incurs delays, the causes should be analyzed and solutions and corrective actions should be developed and agreed upon. A common cause of delay is the timing of delivery and releases of project funds. This type of delay should be anticipated and addressed with appropriate actions during the pre-construction conference.

Additionally, one of the transparency and accountability mechanisms of the project is the Barangay Assembly (BA). The Executive Council of the BSPMC reports the status of subproject implementation to the Barangay Assembly. Issues are presented and collective resolutions are agreed upon for action.

h. Accountability reporting

Members and representative of barangays report before the end of the cycle the actual engagement of the prioritized barangays during the subproject implementation. Problems encountered and strategies to address these problems and issues should to be shared with others as lessons-learned in implementing CDD projects.

II. PROJECT MANAGEMENT

Project Management is the discipline of using management techniques to meet the requirements of the project scope. Project Management deals with plans, systems, and procedures to ensure that agreed costs, schedules, and quality requirements are achieved.

A. PROJECT MANAGEMENT CONSIDERATIONS

a. How does project management differ from construction management when both are dealing with the same project?

Construction Management refers only to the methods and strategies specific to achieving project construction goals, whereas project management deals with the greater project requirements, to include coordination with stakeholders and securing of additional funding sources.

b. What are some typical project management actions?

Some typical project management actions include, but are not limited to, the following:

a. Identification and clarification of project deliverables to understand client expectations
b. Ensuring quality standards, schedules, and budgets are being met.
c. Facilitation of project progress by assisting implementers in resolving project issues through reviews of policy, contract agreements, specifications and guidelines.
d. Ensuring that projects are executed safely and without accidents.
e. Continuous coordination with stakeholders to maintain desired levels of participation, support, and funding.
f. Ensuring that adequate resources are available to complete the project.

c. Who are some of the members of the project management team?

a. The Regional and Provincial Offices of the Executing Agency
b. Representative of the National Agency at the Project level (ACT)
c. Municipal representatives
d. Community volunteers

d. What aspects of project management are most relevant in the Kalahi-CIDSS context?

While project management encompasses a wide variety of applications, tasks, processes, procedures and actions, the aspects of project management most relevant to Kalahi-CIDSS can be grouped into two main categories:

a. Adherence to the project time and schedule requirements (Time Control)
b. Adherence to the project quality requirements (Quality Control)

B. TIME CONTROL

Adherence to the project schedule and time requirements means ensuring that the project implementation is completed within the planned or contracted time period. This process in project management is called Time Control. Some of the strategies to ensure the completion of a project within the specified time period include the following:

a. A project time frame should include allowances for unworkable days due to poor weather conditions.
b. Handover of project site to the Contractor or the Site Engineer (MLGU) should be accomplished prior to the actual start date of the project.
c. The start of pakyaw or subcontract work activities should be prior to the official project starting date.
d. Construction plans should be reviewed carefully to minimize revisions and changes.
e. Material testing should be conducted prior to the actual start of the project.
f. Materials, equipment and workers should be at the job site before works starts.
g. Quality control testing for works should be scheduled based on the materials quality test program. Continuous monitoring of the quality

control program will help implementers forecast possible project delays.

h. Catch-up plans and project recovery plans should be created prior to any forecasted delays.

i. Approval of time suspension and extension requests should be handled at the project level and should not ordinarily be elevated to a higher management level. However, for purposes of transparency, regional or provincial offices of the National Agency co-financing the project should review all approved time suspension and extensions. Time suspension and extension requests may be disapproved if they are not in accordance with project policy.

C. QUALITY CONTROL

a. What are some measures and strategies for quality control?

To ensure that the project is implemented in accordance with the quality requirements of the project, a quality control process or program should be established. Quality control is a set of measures implemented during the project to ensure that the quality standards of materials and workmanship are met.

Technical staff should explain to the community the importance of a quality control program in order to achieve compliance with quality requirements and objectives. The community should be helped to understand that a quality control program will reduce operations and maintenance risks for completed subprojects

For work performed by contract, no progress payments should be made if materials testing is not conducted or if the contractor does not produce and present satisfactory material testing results. In the interest of transparency, the technical staff should accompany the community volunteers to testing centers to witness materials testing activities.

Table (9) below provides minimum recommended quality control tests required per item of work.

Table 9 - Recommended minimum QC tests for subproject work activities

Work Item/Material	Minimum Laboratory Test Required	Field Test
1. Embankment (Item 104) Material which is acceptable and which can be compacted. It can be common or rock.	Grading – 1 Soil of such gradation that all particles will pass a sieve with 75mm (3 in) square openings and not more than 15% will pass the 0.075mm (No. 200) sieve.	Field Density test (FDT) should meet the minimum compaction of 95%.
	Plasticity Index – 1 (not more than 6)	
2. Sub base Materials (Items 200 and 201) Aggregate sub base shall consist of hard, durable particles or fragments of crush stone, crushed slag or natural gravel and filler of natural sand.	Grading – 1 The fraction passing the 0.075mm (no.200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425mm (No. 40) sieve.	Field Density test (FDT) should meet the minimum compaction of 100%.
	Plasticity Index – 1 (the fraction passing No. 40 sieve shall not be more than 12)	
3. Concrete Works (Item 311) (Item 405)	Beam sample (150mm x 150mm x 525mm) Compression Test. Cylinder sample (150mm x 300mm) Minimum compressive strength of 20.7 MN/m^2 or 3000Psi at 28 days for class "A"	
4. Steel Reinforcing (Item 404)	Bending – 1 for every size of rebar.	
	Tensile Stress – 1 for every size of rebar.	
5. RCPC	Compression test per batch of culverts if fabricated on site.	Certification from the supplier that materials delivered passed the test.

b. Joint inspection report

A Joint Inspection Report is submitted to support the release of the final tranche of project funds. A Joint Inspection is conducted when the subproject has reached "substantial completion" (at least 90% physical accomplishment). This report is prepared to check the acceptability of the work, to assess the remaining work and to provide time for correction of unacceptable work.

c. Final inspection report

The Final Inspection Report is submitted together with the Subproject Completion Report (SPCR) to signify that the entire project was completed in accordance with the plans and specifications. All "Work In Place" including the approved Variation Orders should be reflected on the Final Inspection Report, signifying that the subproject is 100% complete in accordance with the approved plans and specifications.

d. Subproject completion report (SPCR)

Project milestones, important undertakings and important information regarding the subproject are captured in this document. The SPCR must be prepared prior to the date of the project inauguration to serve as the key document for the event, together with the Mutual Partnership Agreement (MPA).

e. How is material identification and selection conducted?

Identification and selection of materials to be used in the project is a critical activity of the quality control process. Materials to be used in the project shall be identified based on the approved plans and project specifications. The materials selected must yield the same quality as required in the specifications when tested.

The following is a general process for material identification and selection:

a. Regardless of implementation mode, either by contract or through Force Account, stakeholders should agree on the materials to be used on the project. This should be discussed during the pre-construction conference.

b. Once the materials are identified and selected, they should be presented to the MLGU Project Engineer and the Project Officer of the National Agency co-financing the project for approval and quality testing.
c. All material samples presented should be recorded for verification and validation purposes.
d. If the material sample presented fails the quality test, the materials should be rejected and new material should be sourced for replacement. New materials must also be tested.
e. The Project Officer, representative of the National Agency, the Project Engineer of the MLGU should ensure that materials to be used in the project are those materials that pass the appropriate quality tests. All stakeholders and project implementers should observe and witness the laboratory testing process.

In cases where a change of materials is necessary, the same materials identification and selection process should be followed. Any changes of materials during the course of project implementation should be with the consent of the Project Officer, the representative of the National Agency co-financing the project, and the Project Engineer of the MLGU. The Project Officer of the National Agency should ensure that correct materials are incorporated into the project and also has the responsibility to reject materials that have not passed the quality test.

CHAPTER 5 |

POST IMPLEMENTATION PHASE

I. WHAT IS OPERATIONS AND MAINTENANCE?

Operations and maintenance (O&M) activities ensure that the completed subproject is maintained in a serviceable condition for the designed project life span. Operation and maintenance activities must take into consideration available technology, resources, and cultural sensitivities as needed.

A. WHEN WILL THE OPERATION AND MAINTENANCE OF A COMPLETED STRUCTURE START?

The operations and maintenance of environmental protection structures should start immediately after project turnover or during the operation and maintenance step of the CEAC cycle. If contractors were employed, O&M starts after the contractor's warranty period has expired.

The community should prepare an Annual Maintenance Program and assign community members to every activity. An example of an annual barangay maintenance program implementation calendar is shown on Appendix D.1.

II. OPERATION AND MAINTENANCE STRATEGY

Various O&M arrangements can be agreed upon for every barangay. For road and bridge access, it is recommended that an environmental protective structure operations and maintenance (EPSOM) group be organized, to be headed by the Barangay Councilor in-charge of the Infrastructure Committee. The Barangay Council could be the lead organization in the O&M function of the environmental protective structure.

In order to minimize the cost of unnecessary repairs, the operations and maintenance plan should be fully observed by the O&M group and community members . A tariff or a user's fee can be collected to augment the maintenance fund set aside by the BLGU and MLGU. The Barangay Council should pass an ordinance to operationalize and legalize the fee collection.

A Sustainability Evaluation of O&M activities should be conducted regularly by the Municipal Inspectorate Team (MIT), organized at the local level, to assess the level of compliance with the operations and maintenance plan and the sustainability performance of the subproject.

Sustainability Evaluations should be conducted every six months from the date of the project's inauguration. The Mutual Partnership Agreement (MPA) will also serve as source document during the evaluation.
During the conduct of the Sustainability Evaluation, ratings of "Satisfactory" are the lowest expected ratings to be received by the barangay once they follow their operation and maintenance plan. Benefits monitoring can be established throughout the course of these evaluations and are expected to reflect the improved the economic and social status of the communities from the subproject.

A. WHAT ARE SOME OF THE O&M STRATEGIES THAT CAN BE UNDERTAKEN AT BARANGAY/COMMUNITY LEVEL?

Other O&M actions that can be taken by the barangay are indicated below.

a. Formation of a barangay level committee to formulate annual O&M plans and monitors implementation.
b. Monthly barangay inspection of the subproject for structural defects.
c. Assignment of community maintenance volunteers to remove debris and maintain regular upkeep.
d. Inclusion of funds and a budget for maintenance of equipment into overall barangay annual budget.
e. When appropriate, the collection of tolls and other user fees to fund O&M budget.
f. Inclusion of O&M activities as part of a barangay development plan.

B. WHAT ARE SOME OF THE O&M STRATEGIES THAT CAN BE UNDERTAKEN AT THE MUNICIPAL LEVEL?

a. Inclusion of subproject monitoring tasks within the municipal engineering office.
b. Inclusion of counterpart municipal funds to partially fund subproject O&M.
c. Utilization of municipal technical staff for engineering support as needed for O&M activities.

d. Inclusion of a memorandum of agreement between KC, the barangay, and the municipality that indicates the municipality's commitment to support the sustainability of the subproject after turnover.

e. Integration of the subproject into the municipal development plan and the Comprehensive Land Use P Plan (CLUP) to ensure the subprojects' beneficial effects are monitored alongside the development efforts of the municipality.

C. WHAT OTHER STRATEGIES CAN BE UNDERTAKEN?

If the subproject was executed through a contractor or service provider, the community should perform an inspection prior to the expiration of the warranty period. The community should instruct the contractor or service provider to repair any damage or correct any deficiencies prior to the expiration of the warranty period.

III. WHAT ARE SOME OF THE MAINTENANCE PROCEDURES FOR ENVIRONMENTAL PROTECTION STRUCTURES?

Environmental protection structures can quickly deteriorate if not well maintained. Continuous observation and maintenance is essential to prevent physical and performance degradation.

Inspections should be carried out regularly to determine the conditions of these structures. These inspections can be subdivided into three typical categories:

a. Routine Inspections; these can be performed by a non-technical individual (e.g. a member of the barangay appointed by the barangay chairman) armed with a few general visual guidelines. Routine Inspections should be performed every six months and immediately after a large typhoon or natural disaster in the location of the subproject.
b. Engineering Inspections; conducted by a professional engineer, these inspections are more thorough and usually require the engineer to study the guiding standards, specifications, and guidelines. A professionally licensed engineer should perform this inspection if the

routine inspection comes up with a significant finding (e.g. structural damage).

c. Regular Monitoring Inspections; performed by the municipal engineering team or a qualified engineer. These should be scheduled and performed annually as a minimum.

As a preliminary inspection to ensure the sustainability of the environmental protective structure, a routine inspection is recommended. The following should be observed when performing a routine inspection:

a. Ensure that the structure is free from debris
b. Damaged or cracked protective surfaces and drainage system should be repaired immediately and kept in good condition.
c. Unblock weep holes and drains from time to time (where applicable)
d. Remove over-grown vegetation that may damage/crack the surface of the structure
e. Observe any damage appearing on the slope or other retaining structure
f. Observe any irregularity appearing on or nearby the slope, erosion at the foundation or deformation of the structure and its parts

A. TYPICAL ROUTINE MAINTENANCE WORK FOR ENVIRONMENTAL PROTECTIVE STRUCTURE:

a. Surface drainage system, drainage channels and catch pits (applicable for slope protection, river protection and drainage structures)

    - Clear debris, undesirable vegetation and other obstructions
    - Repair minor cracks with concrete mortar or flexible sealing compound
    - Rebuild severely cracked channels

b. Weep holes and surface drainage pipes (applicable for slope protection)

    - Clear obstructions like weeds and debris in weep holes and pipe ends.
    - Probe with rods for deeper obstruction.

c. Rigid surface cover (applicable for seawall, revetments, river protection, slope protection and drainage)

- Remove undesirable vegetation growth
- Repair cracks or spalling
- Re-grade and repair eroded areas
- Replace surface cover that has separated from underlying soil or core

d. Vegetation surface cover (applicable for bio-engineered soil protection and river protection)

- Re-grade eroded areas with compacted soil followed by re-planting
- Re-plant vegetation in areas where the vegetated surfacing has died

e. Rock slopes, boulder mounds, and earth dikes (applicable for seawall, revetments, river protection, and slope protection)

- Remove undesirable vegetation growth
- Seal up open joints or provide local surfacing to prevent ingress of water
- Remove loose rock debris

f. Structural facings

- Re-point deteriorated mortar joints on masonry face
- Repair cracking or spalling of concrete surface and replace missing or deteriorated joint fillers and sealants

g. Structural Damage

- For extensive foundation damage have an assessment by a qualified engineer
- For damage to structural portions (i.e. excessive riprap failure, deterioration of gabion stack, excessive seawall erosion) coordinate with municipal engineer's office and the provincial DPWH for assistance.

IV. FACTORS THAT CAUSE PROTECTION STRUCTURES TO FAIL OR HAVE EXCESSIVE O&M REQUIREMENTS

There are many reasons or causes that contribute to why environmental protection subprojects sometimes fail or require excessive O&M. The following are some of the more common causes of failures that should be taken into consideration by the community and the ACT:

a. Design error – minimal site investigation has been carried out and the factor of safety is inadequate. Other factors included in design error are the lack of understanding of soil mechanics and design errors such as inadequate surface and sub-surface drains.

b. Construction error – the construction methodology was not followed, such as a lack of details in the drawings provided, specified and required materials were not used, over-excavation, etc.

c. Lack of maintenance – no inspection or monitoring plan was been developed therefore, inspections were not performed to identify defects and/or deterioration and to develop a maintenance plan to mitigate the identified defects.

d. Inadequate vegetation – trees in the surrounding areas are cut. Improper vegetation, not suitable for the type of soil in the area is planted.

V. WHAT ARE SOME OF THE PROCEDURES TO BE PERFORMED BEFORE OPERATION AND MAINTENANCE ACTIONS ARE IMPLEMENTED?

Prior to the implementation of operation and maintenance activities for environmental protection structures, the organization tasked to implement sustainability activities should perform the following:

a. Prepare informational materials to be posted in the barangay on how to operate and maintain the completed environmental protective project.

b. Dissemination information to all barangay residents regarding the proper use of completed environmental protection projects. This should be performed during a Barangay Assembly (BA).

c. Prepare proper and adequate signs and install them in locations as previously identified.

d. Prepare a draft of a barangay ordinance regarding the proper operation and maintenance of completed environmental protection projects.

e. Prepare an operation and maintenance program showing O&M activities or items to be maintained and a complete schedule for its implementation.

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ANNEX FOR ENVIRONMENTAL PROTECTION PROJECT IMPLEMENTATION MANUAL

APPENDIX A – EXAMPLE ILLUSTRATION FOR SLOPE PROTECTION (RUBBLE MASONRY)

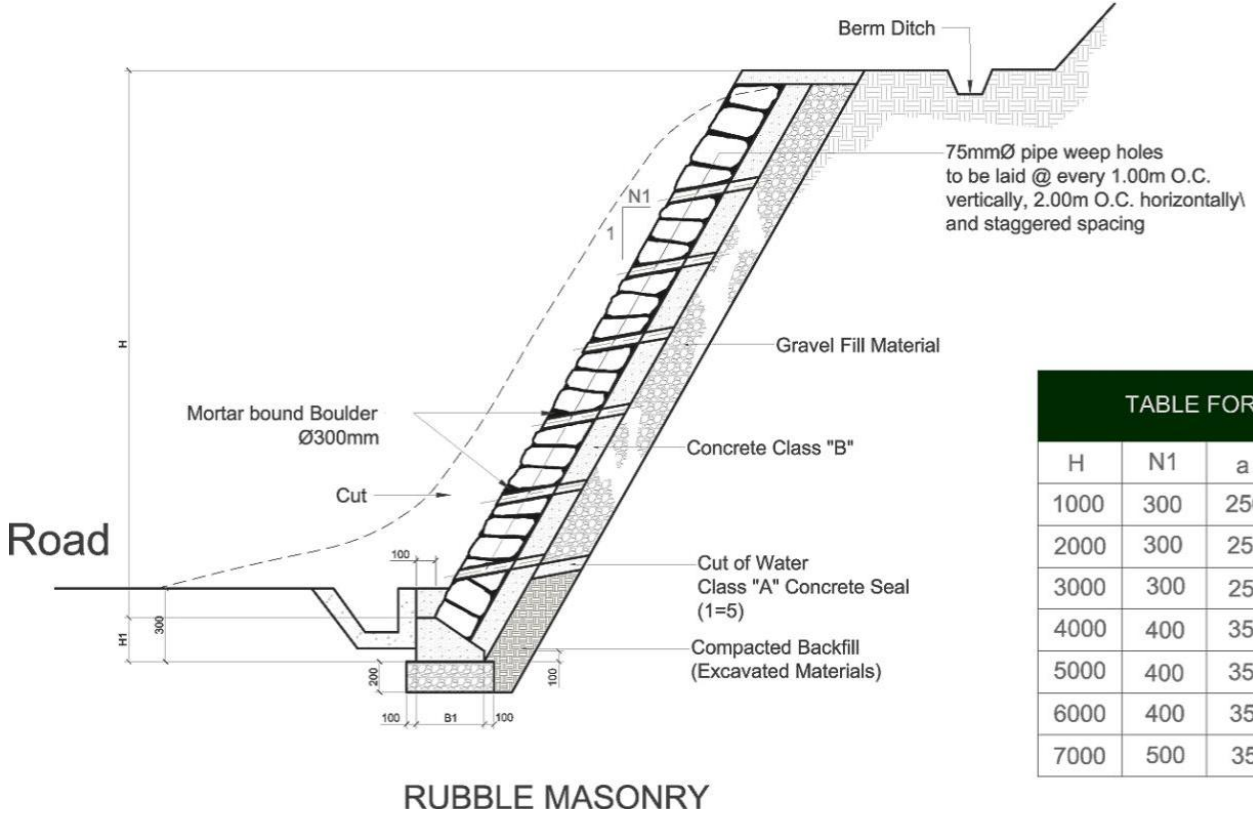
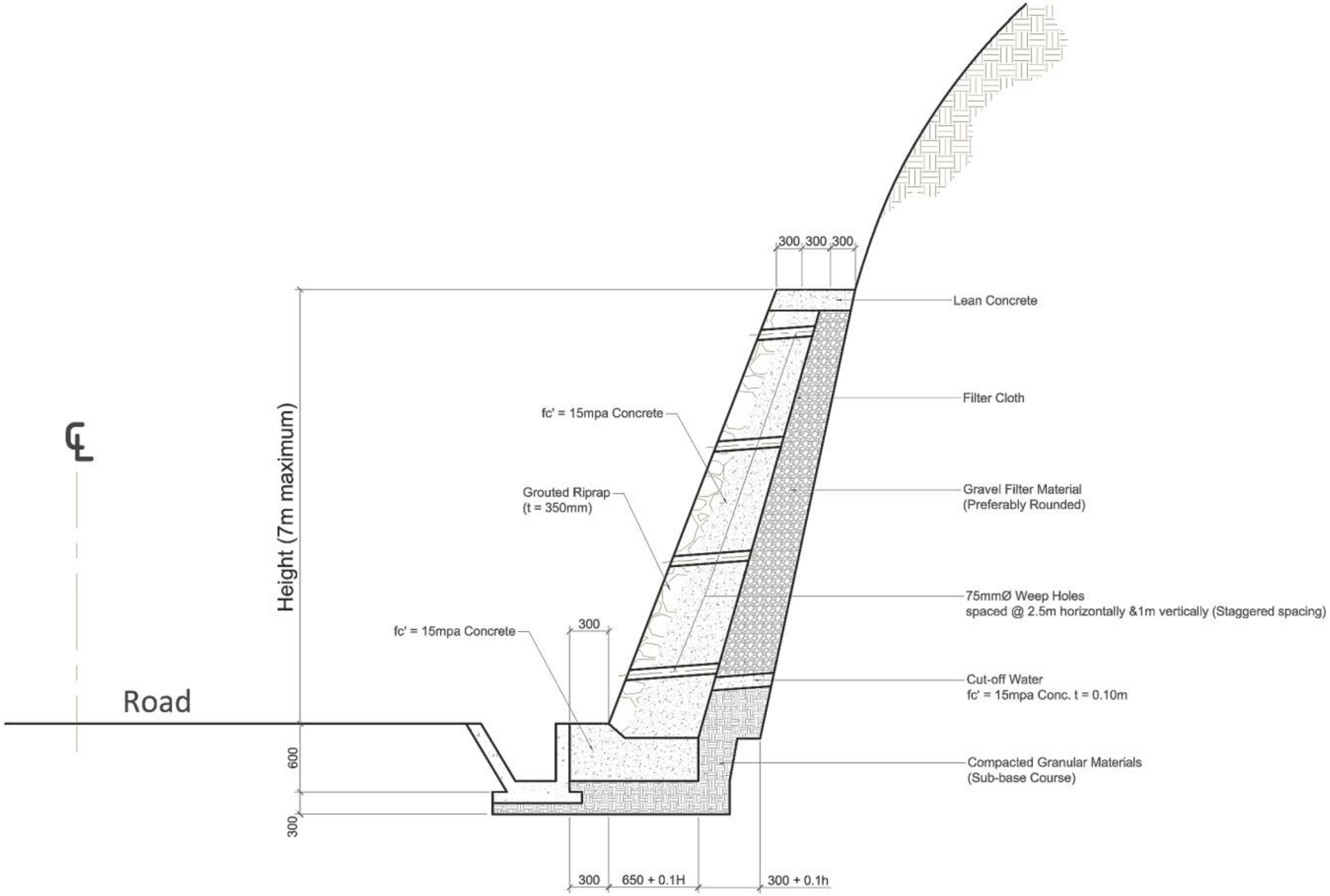


TABLE FOR CUT SLOPE (Millimeter)						
H	N1	a	b	c	B1	H1
1000	300	250	50	300	520	300
2000	300	250	100	300	520	300
3000	300	250	100	300	520	300
4000	400	350	150	300	550	350
5000	400	350	150	300	550	350
6000	400	350	200	300	550	350
7000	500	350	200	300	550	350

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

APPENDIX B - EXAMPLE ILLUSTRATION FOR SLOPE PROTECTION (GROUTED RIPRAP)



GROUTED RIPRAP RETAINING WALL

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

APPENDIX C - EXAMPLE ILLUSTRATION FOR SLOPE PROTECTION (CRIB RETAINING WALL)

Note:

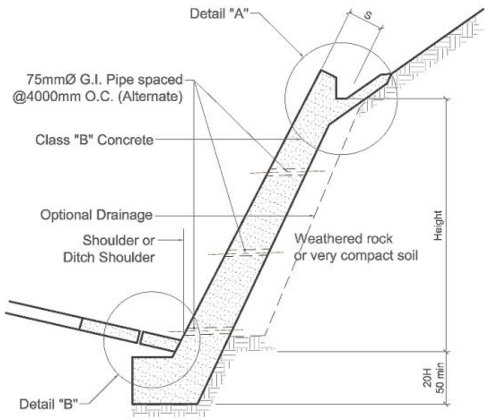
The depth of the foundation is for preliminary estimating only and its depth will be determined accurately according to the soil characteristics at the time of construction.

All dimensions are in millimeters unless otherwise noted and specified

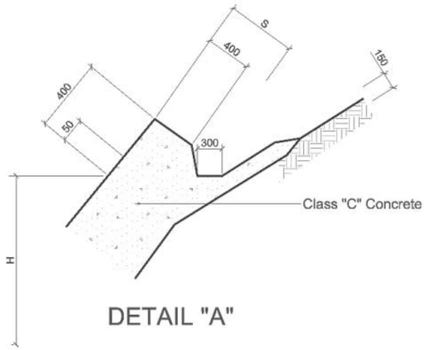
S = 10H (Minimum 5000)
The thickness may vary according to the nature of the ground

H = Maximum 6000

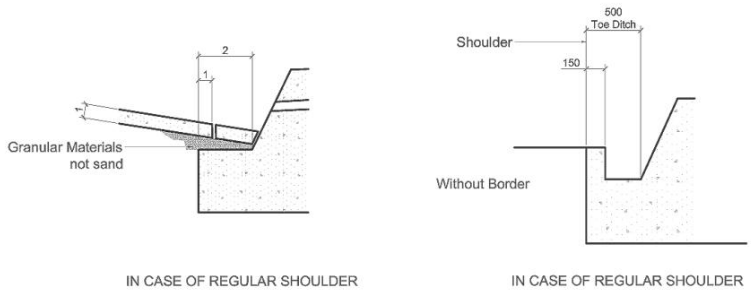
ESTIMATED QUANTITIES			
H	Concrete Volume Cu M./M		
	Class "B" Concrete	Class "C" Concrete	
		Top Ditch	Toe Ditch
1000	106	35	75
2000	168		
3000	237		
4000	343		
5000	447		
6000	558		



SECTION



DETAIL "A"

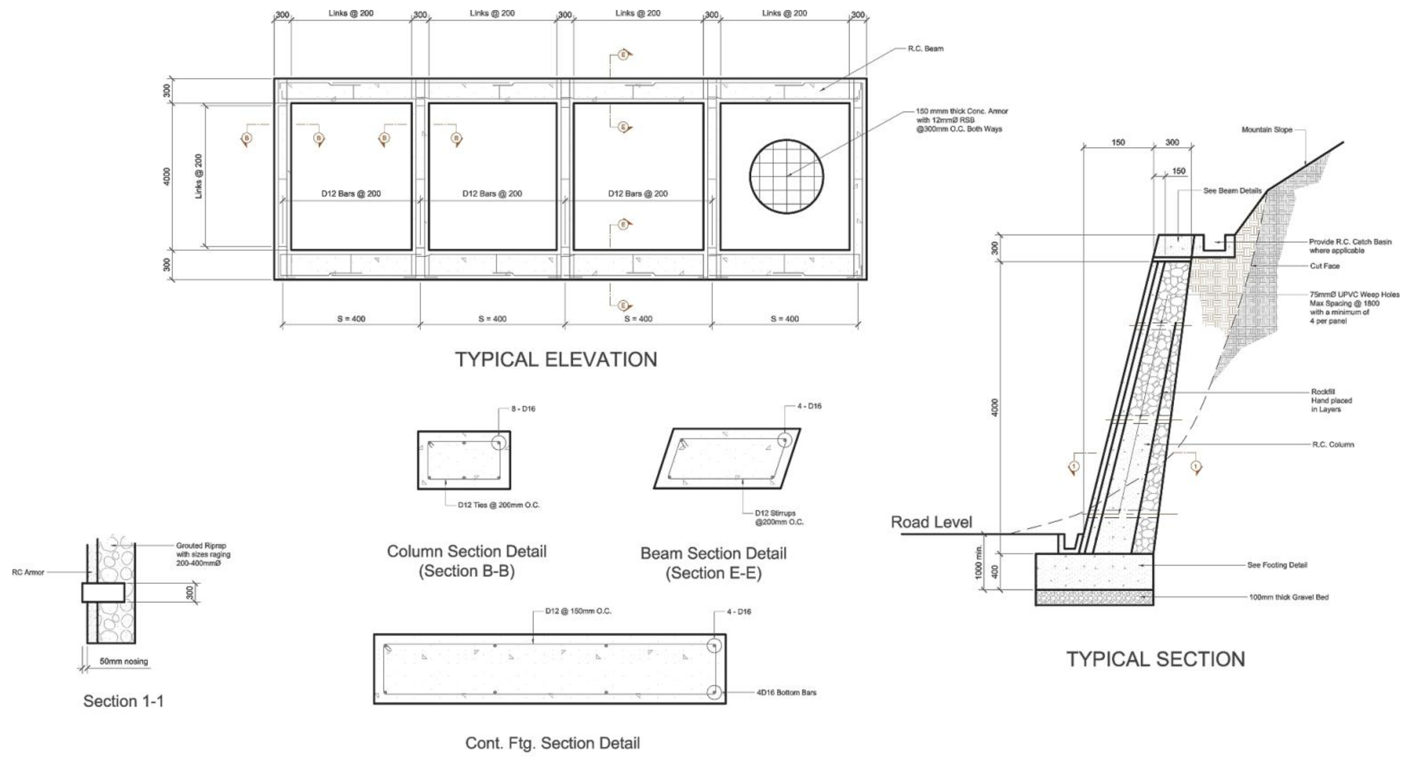


DETAIL "B" SHOULDER DETAIL

LEANING WALL

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

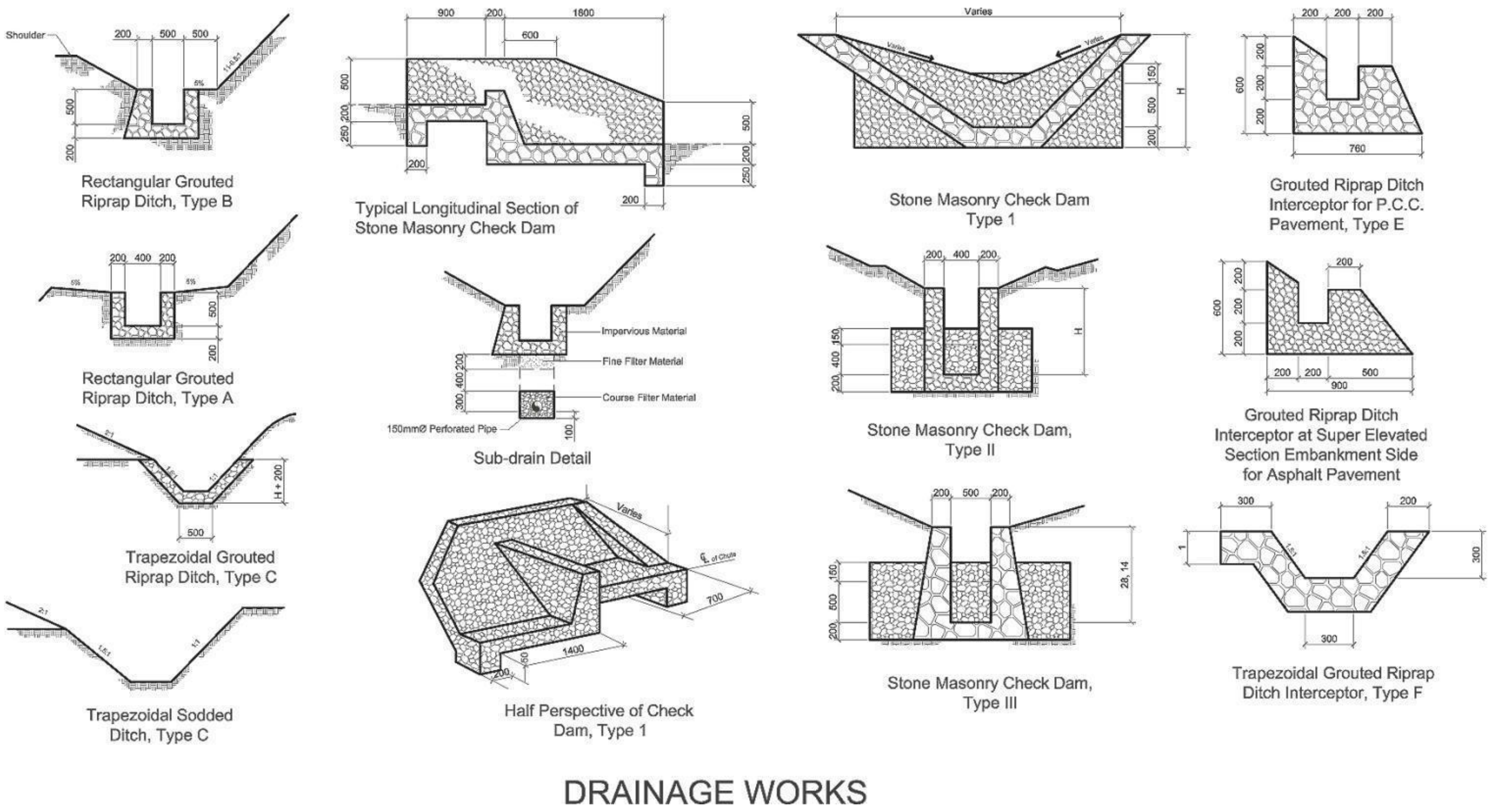
APPENDIX D - EXAMPLE ILLUSTRATION FOR SLOPE PROTECTION (LEANING WALL)



CRIB RETAINING WALL

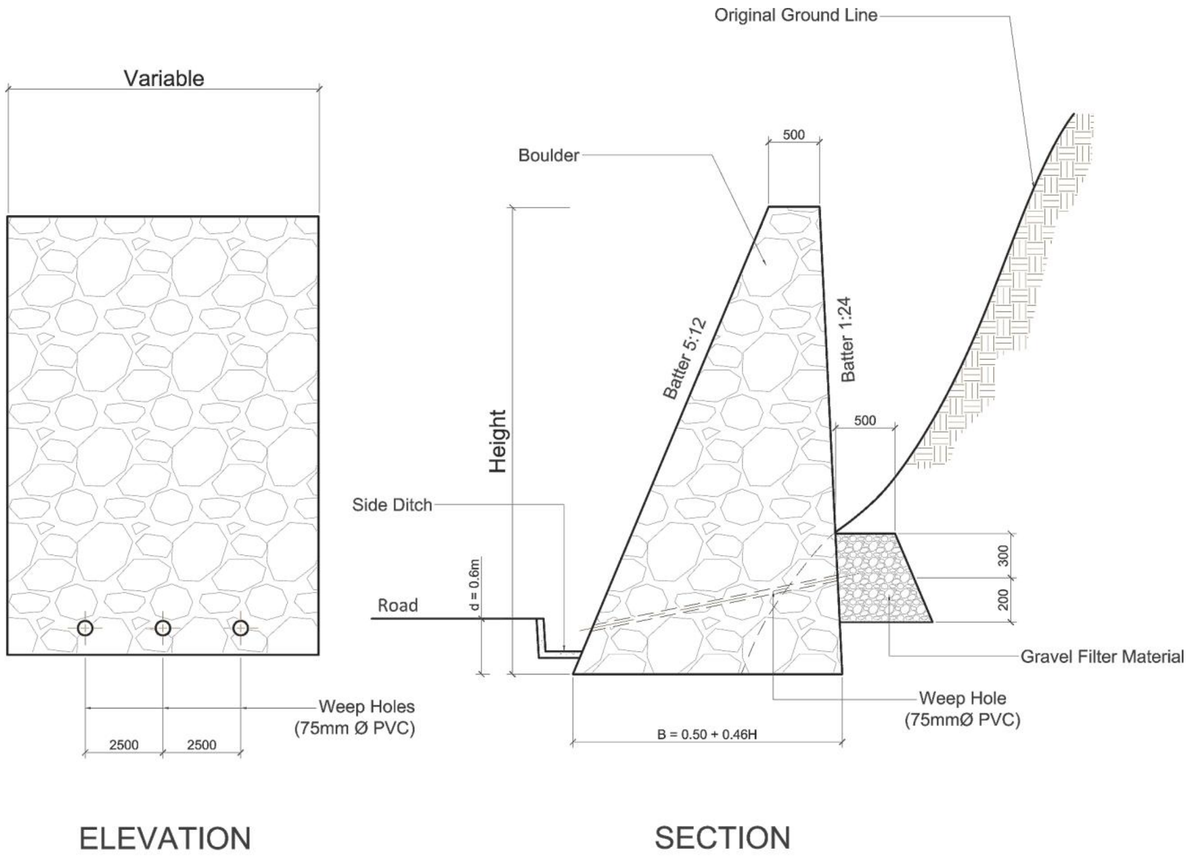
(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

APPENDIX E – DRAINAGE WORK



(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

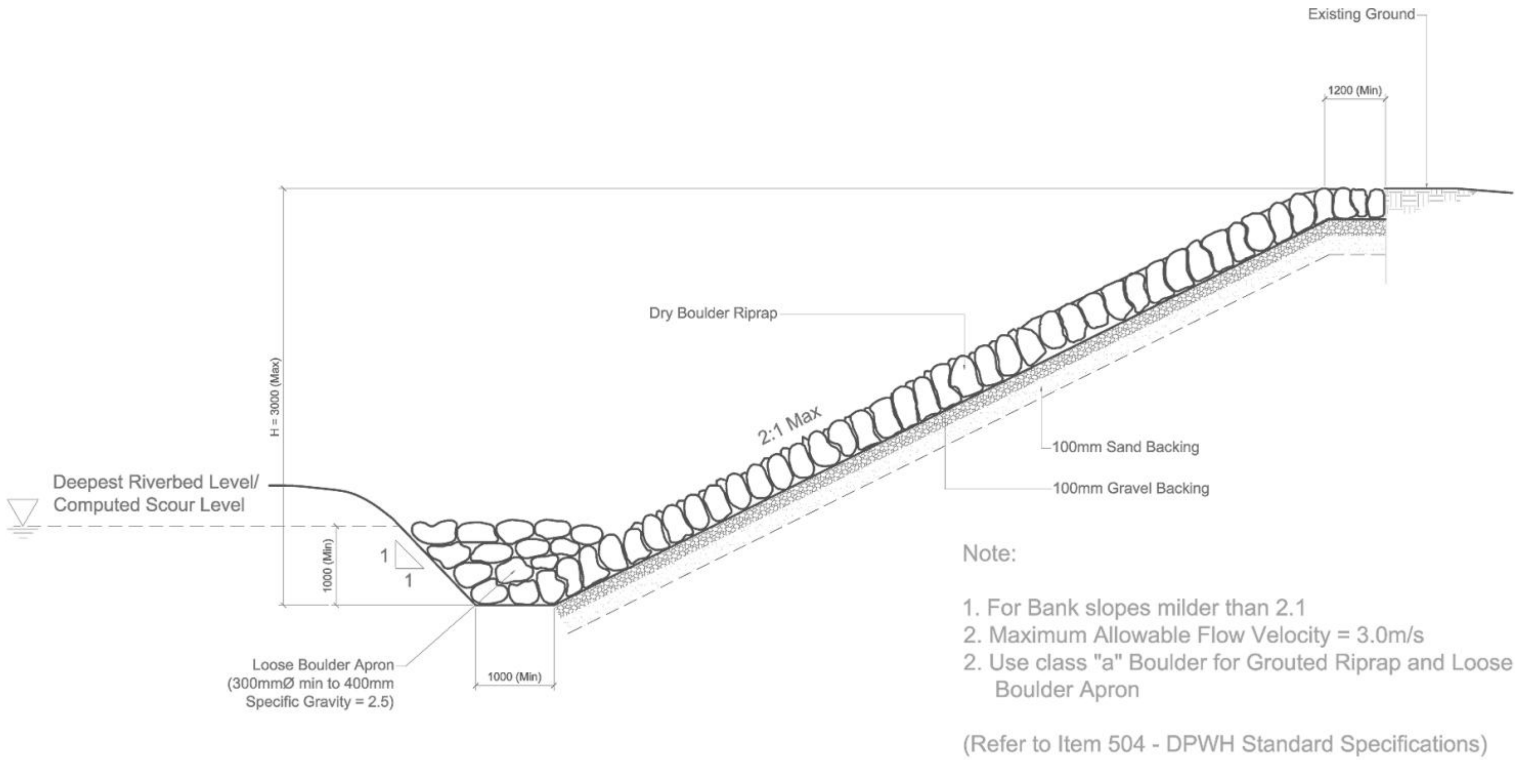
APPENDIX F - EXAMPLE ILLUSTRATION FOR SLOPE PROTECTION (STONE MASONRY)



STONE MASONRY RETAINING WALL

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

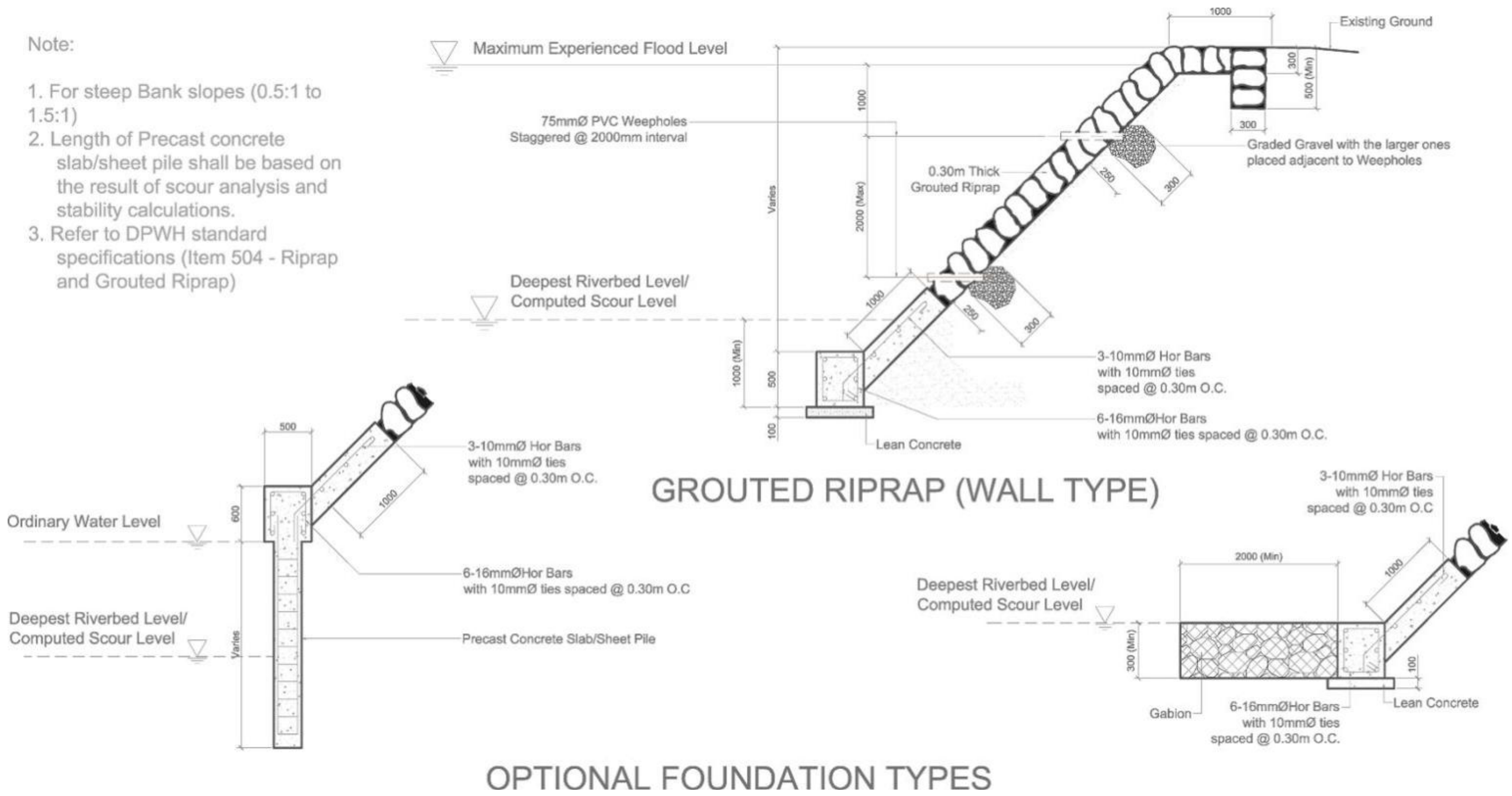
APPENDIX G – RIVER PROTECTION BOULDER RIPRAP



DRY BOULDER RIPRAP

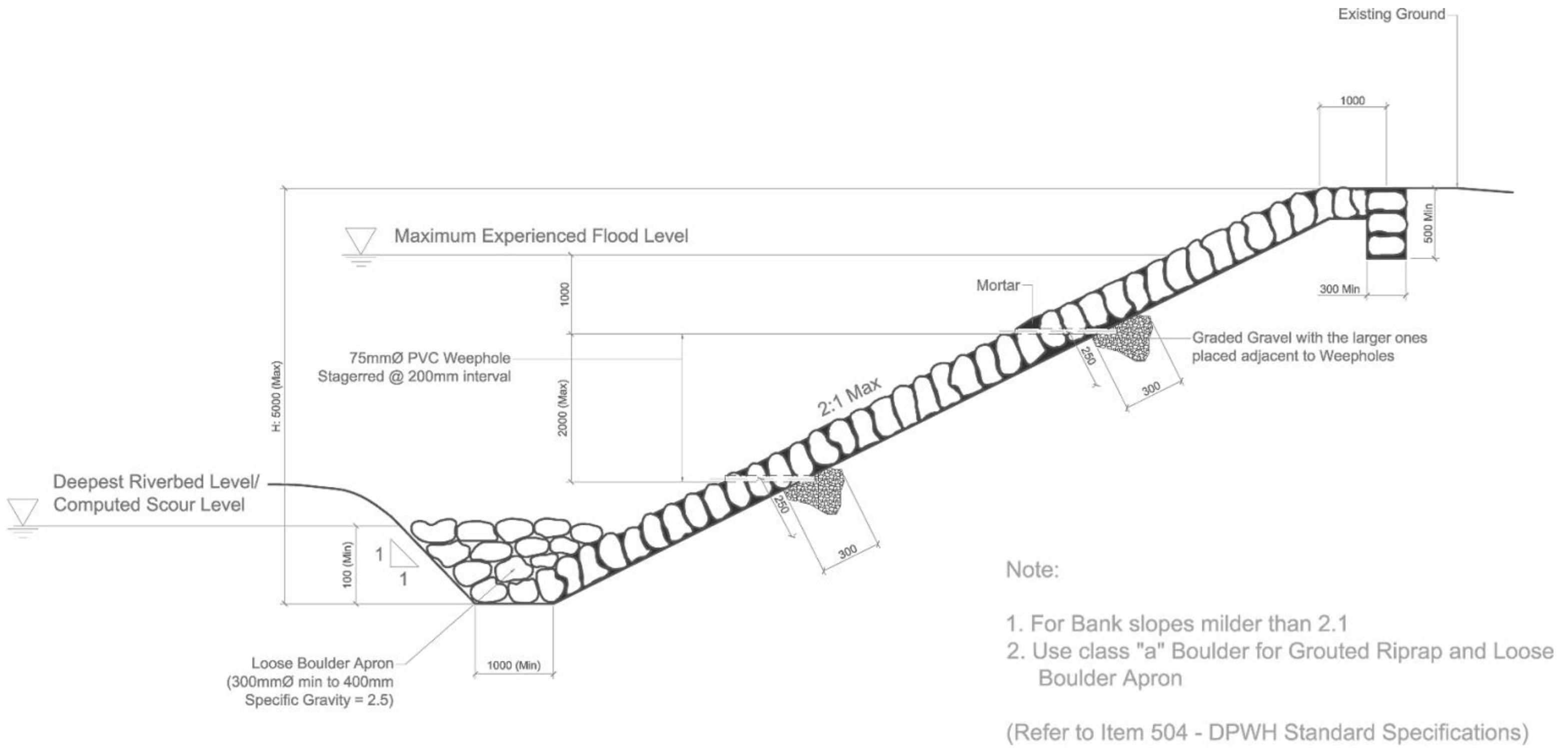
(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

APPENDIX H – RIVER PROTECTION (OPTIONAL FOUNDATION TYPES)



(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

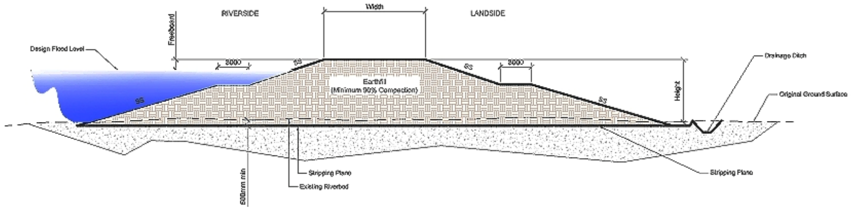
APPENDIX I – RIVER PROTECTION GROUTED RIPRAP (SPREAD TYPE)



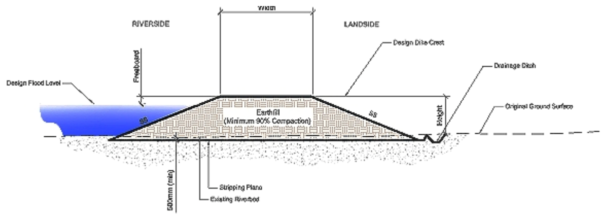
GROUTED RIPRAP (SPEAD TYPE)

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

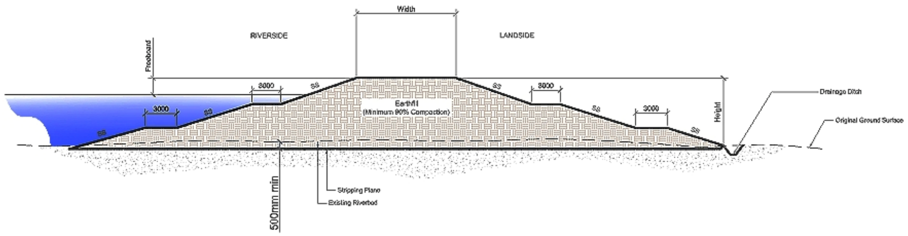
APPENDIX J – RIVER PROTECTION EARTH FILL DIKE



TYPE II (H < 4.0m)



TYPE I (H < 4.0m)



TYPE III (H < 4.0m)

Recommended Side Slope for Earthfill Dike			
	(H ≤ 4.0m)	(H < 4.0m)	
		With Berm	Without Berm
Recommended Slope	Milder than 2:1	Milder than 2:1	Milder than 3:1

Note:

1. Embankment should be constructed with "suitable material" as described in the DPWH standard specifications.
2. Slope protection works shall be provided on the riverside of the dike when scouring/erosion is present. Sodding shall be done at the landslide of the dike.

EARTHFILL DIKE

(Source: JICA-DPWH (2005). Typical Design of Flood control Structures)

APPENDIX K – SAMPLE O&M PROGRAM

Republic of the Philippines
BARANGAY MAINTENANCE PROGRAM
IMPLEMENTATION CALENDAR
Environmental Protective Structure)

Year _______________

MAINTENANCE ACTIVITIES	FREQUENCY OF IMPLEMENTATION PER YEAR																																																
Name of Protective Subproject	Monthly	Jan				Feb				March				Apr				May				Jun				Jul				Aug				Sept				Oct				Nov				Dec			
	Quarterly																																																
	Weekly																																																
A. MAINTENANCE INSPECTION																																																	
i) Maintenance inspection		■				■				■				■				■				■				■				■				■				■				■				■			
ii) Regular cleaning and brushing				■				■								■				■				■				■				■				■				■				■				■	
iii)Monitor structure usage		■				■				■				■				■				■				■				■				■				■				■				■			
B. REPAIR WORKS	ALL REPAIR WORKS SHALL BE DONE AS REQUIRED																																																
Structure																																																	
Foundation																																																	
i) Restoration of damage structure																																																	
ii) Provide item 104 at Back wall																																																	
ii) Concrete pavement in accordance with drawings																																																	
iv) Monitor repair works																																																	
C. PROVIDE SIGNAGE		REPLACEMENT OF SIGNAGE SHALL BE DONE AS REQUIRED																																															
D. TRAININGS						■																				■																							
E. ENVIRONMENT ENHANCEMENT & BEAUTIFICATION	This activity shall be done every 3 months starting last week of January of the year																																																