



**The United Republic of Tanzania**



# **Manual for Farmers' Participatory Repair work of irrigation facilities**

**(Ver.1.0)**

**For**

**Technical Cooperation for Irrigation Scheme Development  
under the District Agriculture Development Plans (DADPs)**



**The United Republic of Tanzania**

**December 2013**

**Irrigation and Technical Services Division, Ministry of Water and Irrigation**

**P.O.Box 9153, Dar Es Salaam, Tanzania**

**Tell: 255-22-2862480**

**Fax: 255-22-2862077**

**Email : [psk@kilimo.go.tz](mailto:psk@kilimo.go.tz)**

# Table of Contents

## List of Abbreviations

	Page
1. Introduction .....	1
1.1 Background .....	1
1.2 Objective .....	1
1.3 Scope of the manual .....	2
1.4 Relation to relevant Guideline and manuals .....	3
2. Working procedure of Farmers' Participatory Repair works.....	4
3. Collection of scheme facilities basic information.....	6
4. Preparation of Inspection works.....	8
5. Inspection of scheme facilities .....	12
6. Grading of deteriorated condition .....	18
7. Summarization of Facilities' Inspection result .....	25
8. Examination and Selection of remedy to repair each deteriorated parts.....	27
9. Repair works Action Plan .....	35
9.1 Cost estimation of each repair works .....	35
9.2 Prioritization of each repair works .....	41
9.3 Examination of repair works implementation by IO.....	42
9.4 Implementation schedule.....	43
10. Follow-ups of Repair works Action Plan.....	44
11. Implementation of repair works .....	46

## APPENDIX

1. Reference for practical repair work Implementation
2. Standard Forms

## Abbreviations

DIDT	:	District Irrigation Development Team
G.L	:	The Comprehensive Guidelines for Irrigation Scheme Development under District Agricultural Development Plan
IO	:	Irrigators' Organization
JICA	:	Japan International Cooperation Agency
NGO	:	Non-Government Organization
O&M	:	Operation and Maintenance
RW	:	Repair Works
Rehabilitation	:	Restoration work that requires technical analysis of damage and the design which is described in Step7 of "G.L. vol2 Section 3: Guidelines for Implementation ". Besides implementation of rehabilitation needs same level of quality control with construction work.
Repair	:	Repair work is part of operation and maintenance activities that IO is supposed to conduct within capacity of IO. Therefore repair work doesn't require design and designated quality control. Generally it is simpler and smaller scale work that IO can handle.
TANCAID	:	Technical Cooperation For The Capacity Development For The Promotion Of Irrigation Scheme Development under the DADPs

# 1. Introduction

## 1.1 Background

Tanzanian government has promoted construction of irrigation facilities nation widely for decades. And now more than 250 irrigation schemes have been established as well as irrigation facilities.

And recently Tanzanian government has been promoting better Operation and Maintenance of irrigation facilities to secure the sustainability of irrigation schemes. And JICA (Japan International Cooperation Agency) has supported O&M training and preparation of manual through TANCAID.

On the other hand it has been found that not small number of irrigation facilities needs repair or rehabilitation works just after short time of handing over. And it is anticipated that this situation will increase cost of repair or rehabilitation works and make it difficult to develop new scheme and expand irrigated area, even sustainability of present condition can be difficult.

Under above mentioned circumstances, Tanzanian government supported with JICA has decided to formulate “Manual for Farmers’ Participatory Repair work of irrigation facilities” to support establishing preventive repair work system that can be conducted by beneficiaries (IO) themselves.

## 1.2 Objective

As it is described in G.L, IO has role and responsibility of Operation & Maintenance activities, including repair works.

Objective of this manual is to support establishing IOs self-reliant preventive repair work system, which shows know-how of inspection of facilities, evaluation of deteriorated condition, preparation of Repair Work Action Plan and implementation.

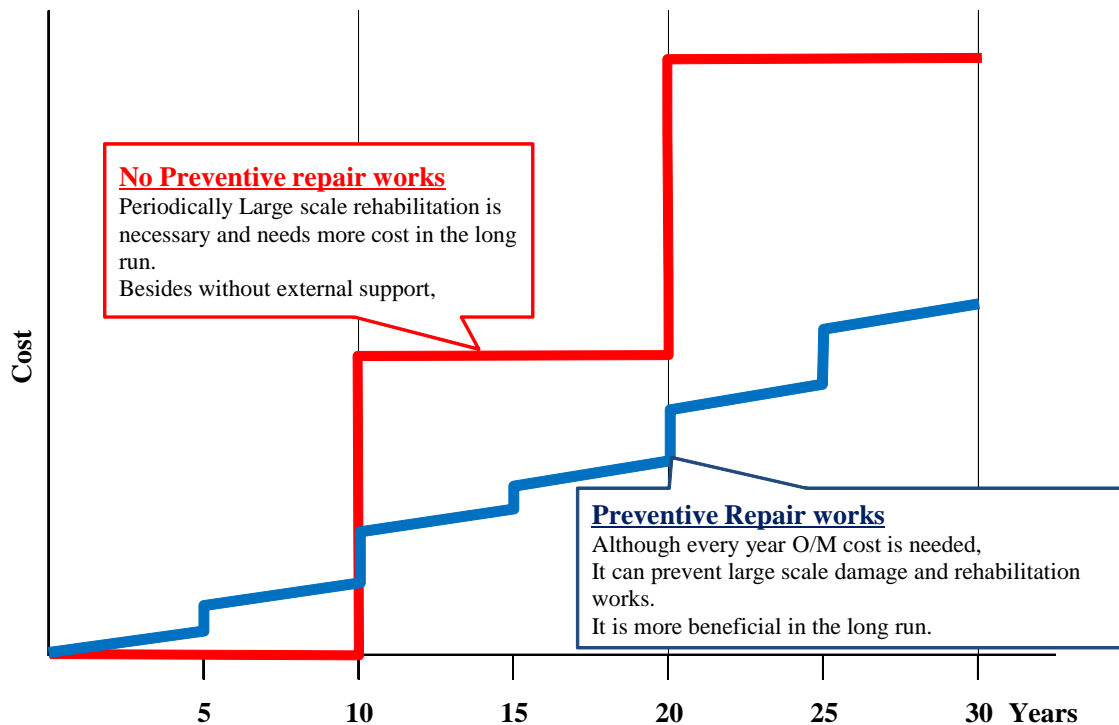
Besides above repair work related activities will improve credibility of IO and make it easy to have external support especially for middle and big scale rehabilitation works that is beyond capacity of IO.



Images of deteriorated irrigation facilities

## Box-1: Importance of Preventive repair works

"Irrigation facility needs preventive and early stage repair works, just like health care"



**Example of canals that need large scale rehabilitation, As No Preventive repair work was conducted**

### 1.3 Scope of the Manual

“**Repair work**” is regarded as part of O&M activities. And items of major maintenance activity are stipulated in **Step5 of “G.L. vol2 Section 4: Operation and Maintenance”**.

For example, followings are major maintenance activities for concrete canal.

- Replacement of joints
- Replacement of damaged slabs
- Weed control at joints and on the surface of concrete slabs
- Control and treatment of filters
- Control and removal of silt
- Repair of damaged lining concrete with cracks

**Box-2 : Difference of meaning between “Repair” and “Rehabilitation” in G.L**

**Rehabilitation :** Restoration work that requires technical analysis of damage and the design which is described in Step7 of “G.L. vol2 Section 3 :Guidelines for Implementation “. Besides implementation of rehabilitation needs same level of quality control with construction work.

**Repair work :** Repair work is part of operation and maintenance activities that IO is supposed to conduct within capacity of IO. Therefore repair work doesn't require design and designated quality control. Generally it is simpler and smaller scale work that IO can handle.

**1.4 Relation to relevant Guideline and manuals**

Overall objective of the manual is to promote the Operation and Maintenance activities which are defined and described in “Section 4 Guidelines for Operation and Maintenance”, focusing on repair work related activities.

As it is shown in below figure, this manual is the part of O/M implementation system to support “Section 4 Guidelines for Operation and Maintenance”, together with “Operation and Maintenance Training Manual” and “Training & Monitoring Framework”.

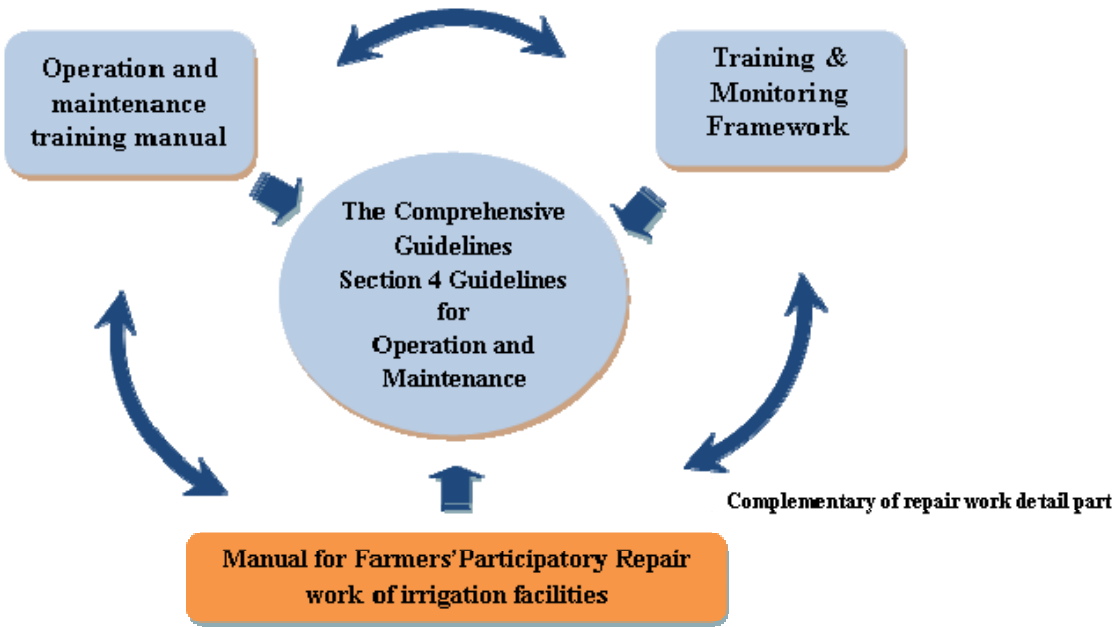


Figure1.4.1: O/M implementation system

## 2. Working procedure of Farmers' Participatory Repair works

Working procedure of Farmers' Participatory Repair works, from inspection to planning and Implementation, composed of 8 steps as is shown below table. And it can be said "Sustainable and self-support Farmers' Participatory Repair work system" is established, after this procedure is to be implemented periodically.

Steps	Items	Filing/ Forms	Reference Page
STEP1	<b>Preparatory works</b>		6
	<ul style="list-style-type: none"> <li>① Collection of basic information about scheme, O&amp;M condition, irrigation facilities.</li> <li>② Preparation of location map of scheme facilities.</li> <li>③ Preparation of Irrigation facilities list and fill the collected information in Form-RW1 by IO.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Scheme facilities layout map</li> <li>✓ Irrigation facilities list (Form-RW1)</li> </ul>	
STEP2	<b>Facilities' Inspection</b>		12
	<ul style="list-style-type: none"> <li>• IO conducts Facilities' Inspection to check the deteriorated condition of each irrigation facilities, filling Filed Inspection sheet at the site.</li> </ul>	Filed Inspection sheet	
STEP3	<b>Grading of deteriorated condition</b>		18
	<ul style="list-style-type: none"> <li>• Each facilities deteriorated parts are classified into four grade in accordance with grading standard which is set in the manual.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Filed Inspection sheet</li> <li>✓ Facilities' Inspection result summery sheet (Form-RW2)</li> </ul>	
STEP4	<b>Summarization of Facilities' Inspection result</b>		25
	<ul style="list-style-type: none"> <li>• Pick up the deteriorated points and result of the inspections is to be summarized in Form-RW2.</li> </ul>	Facilities' Inspection result summery sheet (Form-RW2)	
STEP5	<b>Examination and Selection of remedy to repair each deteriorated parts</b>		27
	<ul style="list-style-type: none"> <li>• IO is to examine and select possible repair methodology for each deteriorations, considering, referring this manual.</li> </ul>	Repair works action plan sheet (Form-RW3)	

STEP6	<b>Repair works Action Plan</b>	Repair works action plan sheet (Form-RW3)	35
	① Cost estimation of each repair works ② Examination of repair works implementation by IO ③ Prioritization of repair works ④ Scheduling plan for repair works and monitoring		
STEP7	<b>Follow-ups of Repair works Action Plan</b>	-	44
	① Confirmation of Action plan by District ② Reutilization of repair related works by IO		
STEP8	<b>Implementation of repair works</b>	-	46
	• IO is to implement highly prioritized repair works, referring to the manual. Basically IO is to be responsible for small scale and preventive repair works.		



### 3. Collection of basic information of scheme facilities

Steps	Items	Filing/ Forms
STEP1	<b>Preparatory works</b>	✓ Scheme facilities layout map ✓ Irrigation facilities list (Form-RW1)
	① <u>Collection of basic information about scheme, O&amp;M condition, irrigation facilities.</u> ② Preparation of location map of scheme facilities. ③ Preparation of Irrigation facilities list and fill the collected information in Form-RW1 by IO.	

#### **【Supplementary Explanation】**

In the past huge budget and labors has been spent for construction and rehabilitation of scheme irrigation facilities.

However many IO doesn't keep basic information document of scheme facilities, like information of construction, facilities description, records of repair and rehabilitation works and etc.

It is important for IO to keep these basic information documents as preparatory work for effective and systematic repair work procedures.

IO is to request District to provide above basic information, as District usually keeps the relevant document. Example of basic information summary sheet is attached in following page.

## Scheme facilities basic information ; **Tentative Example**

### Survey Sheet (Status of each Scheme by DIDF)

Date (21/June/2013)

Zone	Region	District	Scheme
Morogoro	Morogoro	Mvomero	Msufini

#### 1. Study and Detailed Design

F/S	D/D

#### 2. Irrigated, Potential and Planned Area

Area (ha)		Irrigated Area	Potential Area	Planned Area	Main Crops
	Rainy season	100	1459	150	paddy
	Dry season	50		100	vegetables

	Irrigation type	Source name	Source type
Irrigation			

#### 3. Irrigation Facilities and Construction (Rehabilitation)

	name (number, size, length)	Constructed		Facilities Condition			Reason for selection
		Funds	year	good	fair	poor	
Main facilities	Dam (0) H=0m, L=0m						
	Weir (1) H=2m, L=20m	2008, 2009	DADP, DADP		v		weir completed; silts exist on the weir
	Main canal (L=750m) (lining: 500m, earth: 1,000m)	2010	DADP				completed
	Sec. canal (L=0m) (all earth canal)	2011	DIDF				8677 m sec canal, 4000m drains, 5809 m farmroad and 1350m river training need to be done, Tshs 1,500,000,000 needed

\*Facilities Condition include the situation such as sit sedimentation into irrigation facilities and damaged facilities.

#### 4. Operation & Maintenance

Irrigation organization	IO type	IO establishment	Member of IO		
			male	female	total
	Association	2010	180	140	320

Water permit	permitted year	water quantity
	exists	good

Status of O&M by IO	Good	Fair	Poor	Reason for selection
			v	

Collection of O&M cost (Tsh/year)	***,****
Collection ratio (%)	100%
Collection basis (area, volume)	area

(Please select)

O&M sub-committee	1. exist	2. none		1
IO bank account	1. exist	2. none		1
Water distribution method	1. flow sharing	2. time sharing	3. both	traditional
Scheme manager	1. exist	2. none		2
Gate keeper	1. exist	2. none		2

Attach the latest version of Monitoring Results of Irrigation Scheme

#### 4. Preparation of Inspection works

Steps	Items	Filing/ Forms
STEP1	<b>Preparatory works</b>	
	① Collection of basic information about scheme, O&M condition, irrigation facilities.	✓ Scheme facilities layout map
	② <u>Preparation of location map of scheme facilities.</u> ③ <u>Preparation of Irrigation facilities list and fill the collected information in Form-RW1 by IO.</u>	✓ Irrigation facilities list (Form-RW1)

#### 【Supplementary Explanation】

Basically Inspection work is to be conducted every six month (at least once a year) together with periodical monitoring activity. And the recording should be done concretely and measurably so that inspection result will not be influenced by personal view of inspector.

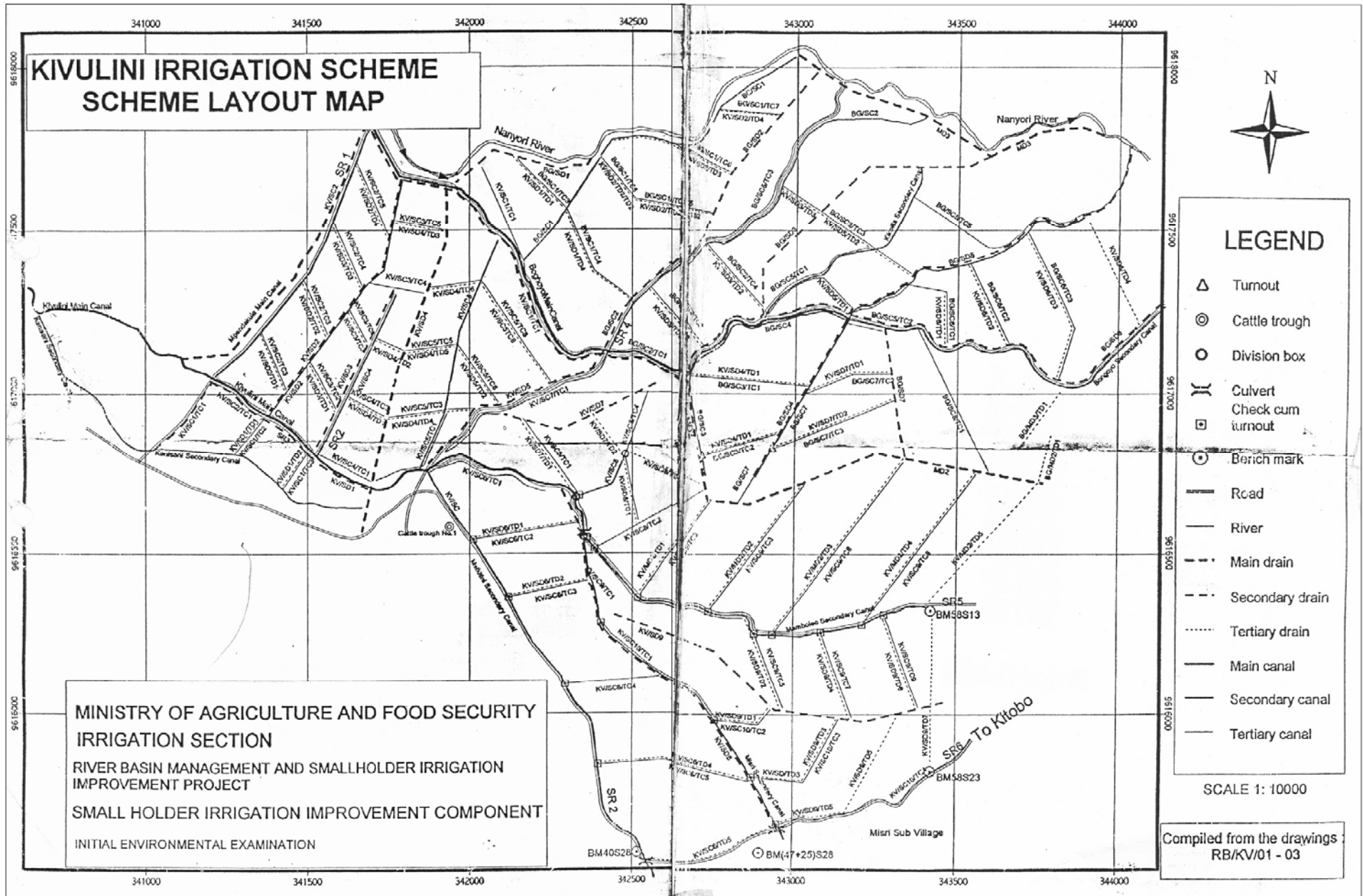
Therefore here in the step, IO is to prepare scheme facilities layout map and list of scheme facilities as Preparation of Inspection works.

Target scheme facilities are Intake facilities, Main canal, lined canal, gate and farm road. Tertiary canals, earth canal and drainage can be also included, considering the importance of the facility.

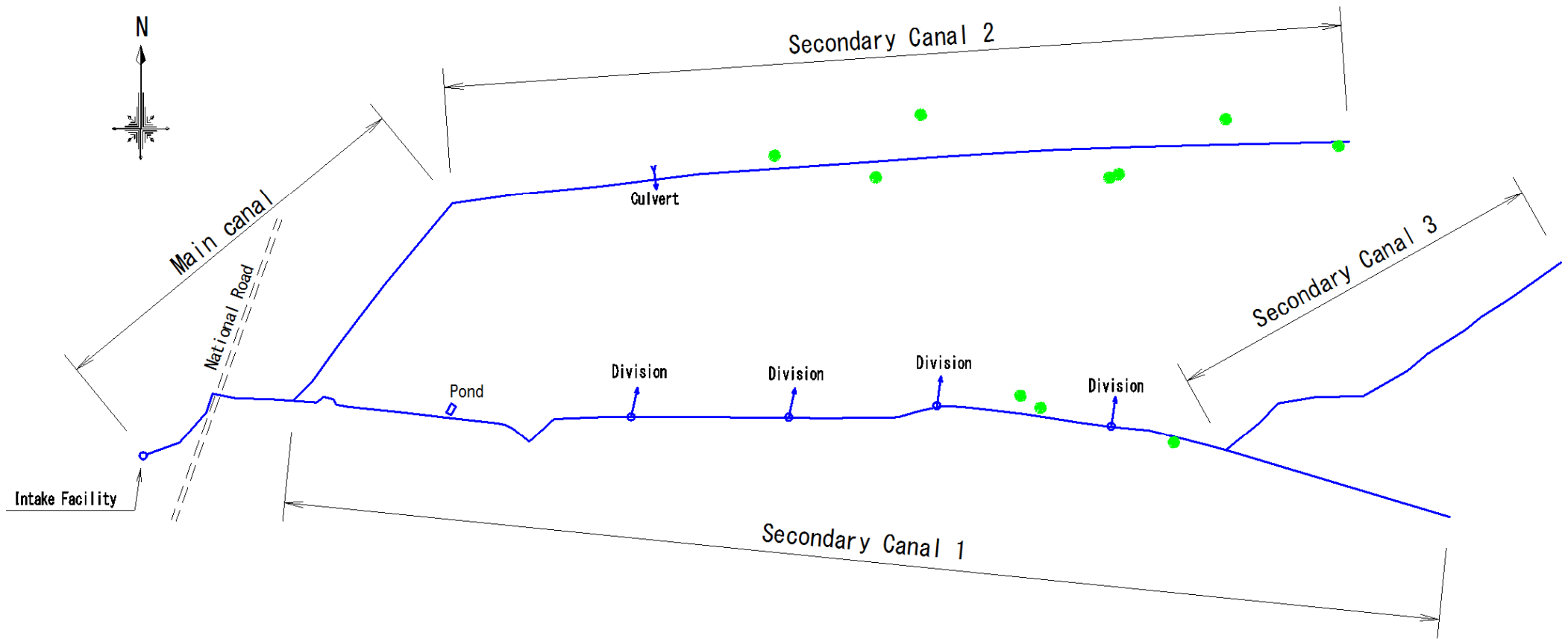
In case IO keeps existing layout map like construction time layout map, No need to prepare new layout map. (Refer to following page for example)

In case IO doesn't keep, IO is to prepare handmade simplified layout map of scheme facilities. (Refer to page-10 for example)

**Scheme facilities layout map Example 1 ; Existing map can be used for repair related works**



**Scheme facilities layout map Example 2 ; Handmade Map is to be prepared by IO in case of no existing map**



**List of Scheme major facilities (Form-RW1) ; Example of filling**

<b>District</b>	*****
<b>Scheme</b>	*****

Date ;     /     /

<b>Facility Name</b>	<b>Structure / type</b>	<b>Description</b>	<b>Constructed Year</b>	<b>Rehabilitated Year</b>	<b>Remark</b>
Head work	Reinforced Concrete/ River	W=10.0m, H=3.0m 5 main gates 1 intake gate	1987	2009	
Pump station	River	Q=0.2 m <sup>3</sup> /s Two Pumps renewed with DIDT in 2011	1987	2011	
No1. Main canal	Block masonry	L= 1000m Rectangular section W=0.5, H=0.5m 2002 rehabilitated with NGO fund	1987	2002	
No2. Main canal	Stone masonry	L= 1000m Rectangular section W=0.5, H=0.5m 2002 rehabilitated with NGO fund	1987	2002	
No1. Secondary canal	Con slab & Block masonry	L= 500m Trapezoid section Bottom W=0.4, H=0.4m 2005 lining works done	1987	2005	
No2. Secondary canal	Con slab & Block masonry	L= 800m Trapezoid section Bottom W=0.4, H=0.4m 2005 lining works done	1987	2005	

## 5. Inspection of scheme facilities

Steps	Items	Filing/ Forms
STEP2	<b>Inspection of scheme facilities</b>	Filed Inspection sheet
	• IO conducts Facilities' Inspection to check the deteriorated condition of each irrigation facilities, filling Filed Inspection sheet at the site.	

### **【Supplementary Explanation】**

- Inspection team from IO members is to be formed and the team should be authorized by IO committee.
- IO is to prepare Scheme facilities layout map and Filed Inspection sheet for each facility at hand, before conducting the Inspection.
- Objective of the Inspection is to identify the deteriorated parts, type of deterioration, locations, degree of deterioration and possible cause of deterioration.
- Inspection will be conducted, walking along the facilities and recording.
- Walking Inspection is to be conducted two times by inspectors. First time inspectors are to grasp overall deteriorated condition of targeted facilities. Second time inspectors are to check carefully with recording and grading the deteriorated parts.
- Inspectors are to pay attention not only to facility itself but also surrounding conditions, like hollows of ground and wet of ground.
- Basically Inspection is to be conducted every 6 month. Besides it is recommendable to conduct special Inspection after flooding.

### **How to fill out Inspection Filed Inspection sheet**

#### Example of Field Inspection Sheet; Secondary Canal-1

S/N		SCI- 1/1			Date		20/ 11/ 2013	
District/ Scheme		**** / ****			Inspector Name		**** , ****	
Facility Name		Secondary Canal-1			Inspector Name		**** , ****	
1	2	3	4		5	6	7	Remarks
Location Map reference	Facility Name	structure type like Con slab, Masonry, etc	Description of Deterioration (Scale, detail location, existing condition )		Possible Cause of deterioration	When first detected	Grading of deterioration	
A	Secondary canal-1	Cement Brick masonry	8 expansion Joint parts	Leakage & washing from Expansion Joints	Loss of Filling material	8/2012	2	
B	Secondary canal-1	Concrete Slab	L=10m	Collapse and broken of bank	Wash out of soil from behind of slab	7/2013	3-4	Big leakage
C	Secondary	Concrete Slab	L=400m	Slight deform and Wash out	Ditto	7/2011	2	

- IO is to prepare Filed Inspection sheet for each facilities separately to avoid confusion of filling. For example, In case Scheme has two main canals, two sheets should be

prepared for main canal inspection work.

- Filling Part “1 Location Map reference” is corresponding with the deteriorated point shown in Location Map (refer to P.16)
- Filling Part “4 Description of deterioration” front space is to be filled with scale of deterioration and detailed location information if needed.
- Filling Part “4 Description of deterioration” behind space is to be filled with type and situation of deterioration. Typical types of deterioration are shown below.

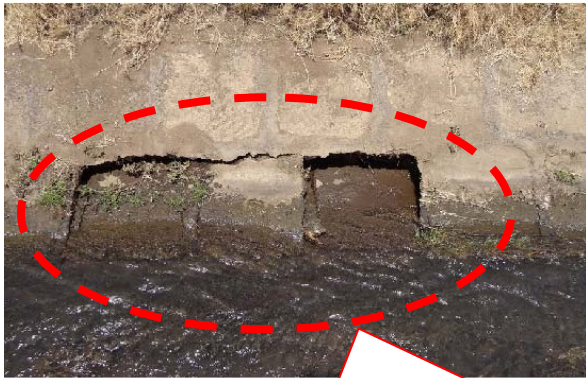
Facility	Typical types of deterioration
Canal Intake	Collapse, Deform, Sinking, Gap, Crack, Leakage, Abrasion wear, Washout, Erosion, silting, thick weeds and etc.
Gate	Rusting, Deformed, un-functioning,
Farm Road	Erosion, Deep Wheel rut, Muddy surface

- Filling Part “6 When detected” is to be filled appreciate date when the deterioration was first detected. ( For Example, 8/ 2010, 2008)
- Inspection team is expected to consider and fill out possible cause of the deterioration in Inspection sheet. Because estimation of the cause is important to consider and select repair work methodology.
- Common causes of the deterioration are “Wash out of soil”, “Soil problem”, “Abrasion wear” and “Construction time problem”. Besides “flooding”, “design mistake” and “artificially broken” can be found commonly. Refer to following page for images of Common causes.
- Filling Part “7 Grade of deterioration” is to be referred to Page 18.

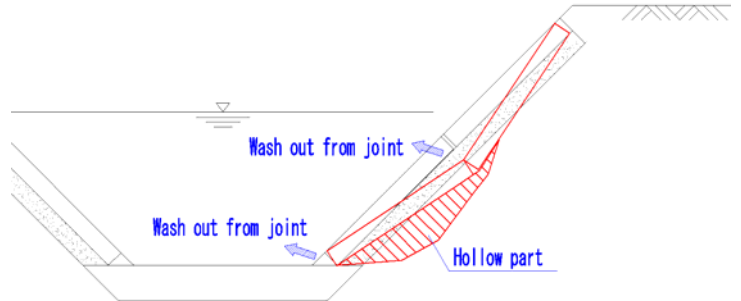


### **Typical cause 1. Wash out of soil**

Canal water flow damages weak joint mortar and lost, then soil washout from behind of slab and collapsed



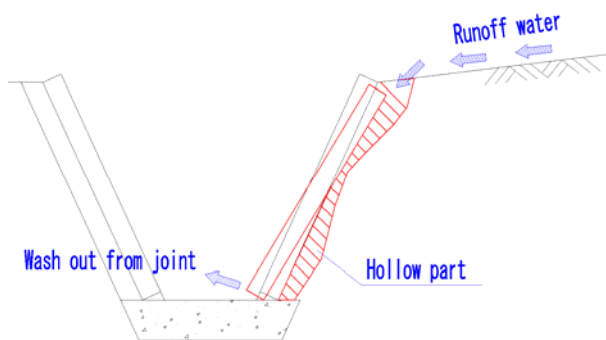
Soil washout from behind of slab and collapsed



Runoff water from around area penetrates behind of slab and washed out soil.



Runoff water penetrates behind of slab and washed out



### **Typical cause 2. Soil condition**

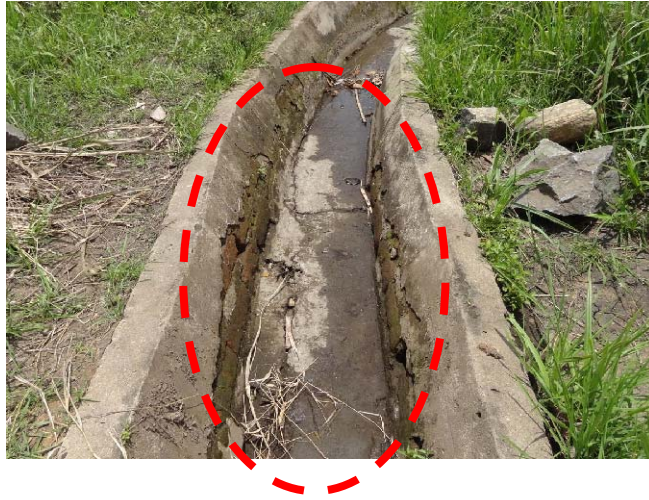
Settlement of soft foundation, deformation of black cotton soil



Settlement of soft foundation

### **Typical cause 3. Abrasion wear**

Abrasion wears of plastering cover and its extension



### **Typical cause 4. Artificially broken facilities**



#### **Box-2**

**Checking Methodology of hollows behind slab or stones**

**: Hammering Test**

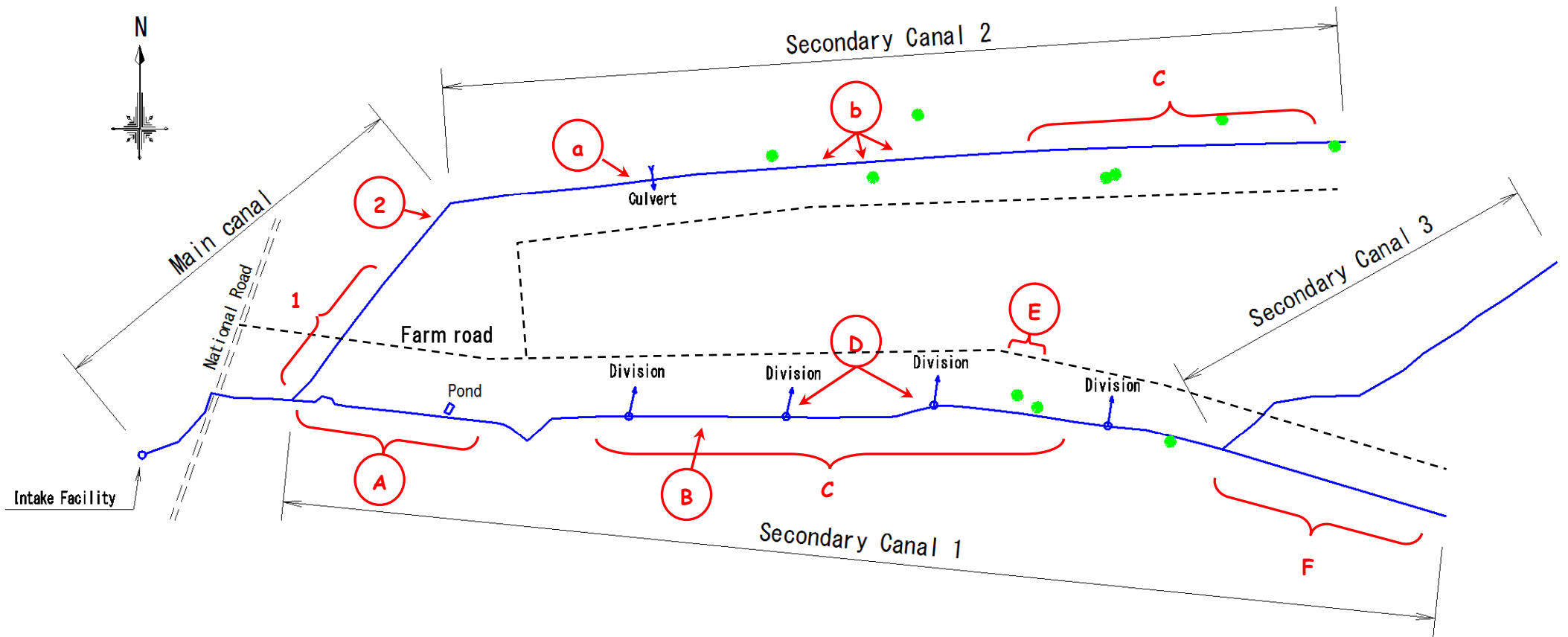
- Hammering Test is easy test to identify hollows behind concrete, slab, stones or tile, with tapping surface of the wall and listening the tapping sound.
- Hollows behind slab is one of most common factor to cause collapse of slab canal (refer to previous page) and it is important to find and fill the hollow in early stage to prevent further development. Therefore, it is recommendable to conduct Hammering Test at the time of Inspection.



**Example of Field Inspection Sheet; Secondary Canal-1**

S/N		SC1- 1/1		Date	20/ 11/ 2013			
District/ Scheme		***** / *****		Inspector Name	***** , *****			
Facility Name		Secondary Canal-1		Inspector Name	***** , *****			
1	2	3	4		5	6	7	Remarks
Location Map reference	Facility Name	structure type like Con slab, Masonry,etc	Description of Deterioration (Scale,detail location,existing condition )		Possible Cause of deterioration	When first detected	Grading of deterioration	
A	Secondary canal-1	Cement Brick masonry	8 expansion Joint parts	Leakage & washing from Expansion Joints	Loss of Filling material	8/2012	2	
B	Secondary canal-1	Concrete Slab	L=10m	Collapse and broken of bank	Wash out of soil from behind of slab	7/2013	3-4	Big leakage
C	Secondary canal-1	Concrete Slab	L=400m	Slight deform and Wash out	Ditto	7/2011	2	
D	Secondary canal-1	Concrete	division gate	gate handle broken	Artificially?	7/2011	2	

## Example of Inspection map



## 6. Grading of deteriorated condition

Steps	Items	Filing/ Forms
STEP3	<b>Grading of deteriorated condition</b>	✓ Filed Inspection sheet
	• Each facilities deteriorated parts are classified into four grade in accordance with grading standard which is set in the manual.	✓ Facilities' Inspection result summery sheet (Form-RW2)

### **【Supplementary Explanation】**

- Objectives of Grading of deteriorated condition :
  - ✓ It will clarify the existing deteriorated condition of facilities from objective point of view (Not from personal view).
  - ✓ It will help to take repair actions in early stage of deterioration. And preventive measures can be taken.
  - ✓ It will clarify basic role and responsibility of IO and relevant organizations.
- Grading of deteriorated condition is classified into Four Grading (1 to 4), as it is shown in next page.
- Basically Inspection team is to assess grade of deteriorated condition, when Inspection team is conducting inspection work at the site. And the grade should be decided by inspection team, not individually.
- In case it is difficult to clarify into designated four grades. Inspection team can note 2 grades. For example : 2or3, 3or4.
- District is to check and confirm the result of Inspection works and visit targeted facilities, in case technical support or judgment is necessary.
- Example of Grading for each facility is shown from Page20.

### Grading of deteriorated condition of Irrigation facility

Deteriorated Grade	Deteriorated Condition (General)	Example of Deteriorated Condition (each facility)		Remedy
1	<ul style="list-style-type: none"> <li>• Little or small deterioration</li> <li>• No problem for normal operation and function of facilities</li> </ul>	Gate	<ul style="list-style-type: none"> <li>• No remarkable deterioration</li> <li>• No problem for normal operation</li> <li>• Small rust on gate</li> </ul>	Routine monitoring
		Canal Turnout	<ul style="list-style-type: none"> <li>• Little or small deterioration</li> <li>• Small cracks or abrasion wear on concrete structure</li> <li>• Small erosion</li> <li>• Small deformation on/around canals</li> </ul>	
		Intake Facility	• Ditto	
		Road	• Passable without trouble	
2	<ul style="list-style-type: none"> <li>• Not so seriously deteriorated as to damage normal operation and function of facilities</li> <li>• Repairable with small scale repair works.</li> <li>• Part of facility functions is lost but usable.</li> </ul>	Gate	<ul style="list-style-type: none"> <li>• Deterioration, like rust and deform, can be found. But gate can be used and operated.</li> <li>• Remarkable rust can be found on gate</li> </ul>	Routine monitoring or Small scale repair work
		Canal Turnout	<ul style="list-style-type: none"> <li>• Small and acceptable leakage</li> <li>• Deterioration, like Cracks, abrasion wear on concrete structure, joint part gaps, can be found. But function of the facility is not heavily damaged.</li> <li>• Structure of the facility is still stable.</li> <li>• O&amp;M works, like weeding and deposits removal, needed. But still normal operation is possible.</li> </ul>	
		Intake Facility	• Deterioration, like Cracks, abrasion wear on concrete structure, joint part gaps, can be found. But normal operation is possible and no structural problem.	
		Road	• Shallow wheel rut/ muddy surface. But possible to pass with slow speed	
3	<ul style="list-style-type: none"> <li>• Seriously deteriorated as to damage normal operation and function of facilities and needs early repair works.</li> <li>• Partially damaged but still repair work or Partial renewal works can be applied</li> </ul>	Gate	<ul style="list-style-type: none"> <li>• Deterioration, like rust and deform, is so serious as to damage normal operation and function of facilities.</li> <li>• Partial Repair can be applied to recover the function of the gate.</li> </ul>	Repair work or Partial renewal work
		Canal Turnout	<ul style="list-style-type: none"> <li>• Remarkable leakage</li> <li>• Structure of the facility is getting unstable.</li> <li>• Partially damaged but still repair work or Partial renewal works can be applied</li> <li>• Damage of facility is reaching the ground or road around the canals.</li> <li>• O&amp;M works, like weeding and deposits removal, needed. And normal operation is difficult.</li> </ul>	
		Intake Facility	<ul style="list-style-type: none"> <li>• Rusting of reinforcement bar can be found.</li> <li>• Partial structural damage can be found and Partial repair works can be applied.</li> </ul>	
		Road	<ul style="list-style-type: none"> <li>• Difficult to pass for Deep wheel rut/ muddy surface</li> <li>• Need diversion for passing</li> </ul>	
4	<ul style="list-style-type: none"> <li>• Seriously deteriorated enough to make normal operation impossible and unusable.</li> <li>• Large scale rehabilitation or renewal is needed</li> </ul>	Gate	<ul style="list-style-type: none"> <li>• Operation impossible</li> <li>• Renewal or replacement of the gate is needed.</li> </ul>	Renewal or Large scale rehabilitation
		Canal Turnout	• Facility is seriously deteriorated enough to make normal operation impossible. And Renewal or large scale repair works are needed.	
		Intake Facility	• Ditto	
		Road	• Impossible to pass	

## Example of Deteriorations and Grading; Canal



Grade -1: No serious deterioration  
No remarkable deterioration.  
Keep periodical monitoring.



Grade -1or2 : Segregation of surface concrete  
Segregation of cover surface can be identified. But little problem for normal operation and function of facilities. Keep periodical monitoring.



Grade-2: Gap of expansion joints  
Repair of joint is needed to stop leakage and wash out of soils.



Grade-2: Abrasion wear of plastering cover  
Repair of plastering is needed to stop development of damages.



Grade-2: Hollow behind slabs  
Filling of hollow behind slab is needed to prevent development of damages.



Grade-2: Loss of joint mortar  
Repair of joint mortar is needed to prevent development of damages.



**Grade-3: Deform of slabs**  
 Partial section damage and Partial section repair works can be applied.



**Grade-3or4 : Collapse of stone wall**  
 In case of partial section damage, then Grade3.  
 In case of long section damage, then Grade 4



**Grade-3: Loss of corner plastering cover**  
 Deterioration of corner part and leakage.  
 Repair with new hunching concrete is needed.



**Grade-3 : Collapse of slabs**  
 Partial section damage and Partial section repair works can be applied.



**Grade- 4 : Collapse of slabs**  
 Long section damage, large scale rehabilitation needed.



**Grade-4 :Collapse of stone wall**  
 Long section damage, large scale rehabilitation needed.



**Grade-4: Washout of division point**  
 Normal operation impossible and unusable.  
 Rehabilitation is needed



**Grade- 4: Washout of division point**  
 Normal operation impossible and unusable.  
 Rehabilitation is needed



## Example of Deteriorations and Grading; Gate



Grade-1or2 ; Small rust of gate  
Normal operation possible. Keep periodical maintenance works



Grade- 1or2 ; Small rust of gate ;  
Normal operation possible. Keep periodical maintenance works



Grade- 3 : Deform of gate  
Normal operation difficult.  
Repair of handle is needed



Grade- 3 : Deform of spindle  
Normal operation difficult.  
Repair of spindle is needed



Grade- 4 ; Broken metal frame  
Frame of gate is completely broken  
Renewal of gate is needed.



Grade- 4 ;Deform of gate plate  
Plate of gate is completely bent  
Renewal of gate is needed.

## Example of Deteriorations and Grading; Farm Road



Grade- 2 ; Shallow wheel rut  
Shallow wheel rut/ muddy surface. But possible to pass with slow speed.



Grade- 2or3 ; Deep wheel rut  
Getting difficult to pass for Deep wheel rut/ muddy surface. Need diversion for passing



Grade- 3 ; Deep wheel rut/ muddy surface  
Difficult to pass for Deep wheel rut/ muddy surface. Damaged section needs repairing.



Grade- 4 ; Muddy and drainage problem  
Impossible to pass.  
Large scale rehabilitation necessary

## Example of Deteriorations and Grading; Intake Facility



Grade- 2 ; Thickly weeded intake  
Normal operation is possible. But weeds may disturb intaking of water in near future. Cleaning is needed.



Grade-3 ; Heavy deposits around intake  
Normal operation is impossible.  
Cleaning is needed as soon as possible.



Grade-:2or3 : Crack on wall  
Repair of cracks is needed to prevent development of damages.



Grade- 4 ; Damaged head work  
Large scale rehabilitation is needed.

## 7. Summarization of Facilities' Inspection result

Steps	Items	Filing/ Forms
STEP4	<b>Summarization of Facilities' Inspection result</b>	Facilities' Inspection result summery sheet (Form-RW2)
	• Pick up the results of Inspection from Filed Inspection sheet. And result of the inspections is to be summarized in Form-RW2.	

### **【Supplementary Explanation】**

- Here in this step IO is to pick up the results of Inspection from Filed Inspection sheet. And result of the inspections is to be summarized in Form-RW2.
- Example of “ Facilities' Inspection result summery sheet (Form-RW2)” is attached in following page.

**Facilities' Inspection result summary (Form-RW2) ; Example of filling**

**District/ Scheme Name; \* \* \* \* \* / \* \* \* \* \* \* \* \* \* \***

**Date of Inspection; / /**

1	2	3	4		5	6	7	Remarks
Location Info	Facility Name	structure type like Con slab, Masonry,etc	Description of Deterioration (Scale,detail location,existing condition )		Possible Cause of deterioration	When first detected	Grading of deterioration	
-	Intake facility	Stone masonry & Reinforced con	Left side Bank Gate	Small cracks Small Leakage from gate	Construction	10/2010	1	No problem for Normal operation
1	Main canal	Cement Brick masonry	several joints	Small Leakage from Expansion Joints	Short of Filling material	8/2012	1-2	
2	Main canal	Cement Brick masonry	L=8m	Wearing of plastering	Mixture of Cement	8/2012	2	Ditto
A	Secondary canal-1	Cement Brick masonry	Joint parts	Leakage & washing from Expansion Joints	Loss of Filling material	8/2012	2	
B	Secondary canal-1	Concrete Slab	L=10m	Collapse and broken of bank	Wash out of soil from behind of slab	7/2013	3-4	Big leakage
C	Secondary canal-1	Concrete Slab	L=400m Several parts	Slight deform and Wash out	Ditto	7/2011	2	
D	Secondary canal-1	Concrete	division gate	gate handle broken	Artificially?	7/2011	2	
E	Farm road	Unpaved	L=20m	Wheel rut & Muddy surface	No drainage	3/2010	3	

**Note ; Refer to page 17 for Location map**

## 8. Examination and Selection of remedy to repair each deteriorated parts

Steps	Items	Filing/ Forms
STEP5	<b>Examination and Selection of remedy to repair each deteriorated parts</b>	Repair works action plan sheet (Form-RW3)
	• IO is to examine and select possible repair methodology for each deteriorations, referring this manual.	

### 【Supplementary Explanation】





#### Basic remedy for Grading of deterioration






Grading of deterioration	Basic remedy for deterioration
1	IO is to monitor and inspect the targeted facilities periodically and record the conditions. If possible, picture of the deterioration should be taken and attached with the record.
2	Basically IO is to take responsibility of Grade2 parts repair works and conduct preventive repair works positively, as Grade2 deterioration is not in serious stage and small scale repair works can be applied. Even if early repair work is difficult for financial reason, IO has to monitor and inspect the targeted facilities periodically.
3	IO or District is to take responsibility of Grade2 parts repair works. In case the repair work is beyond capacity of IO. IO is to organize result of Inspection and repair works action plan (refer to chapter 9), and report it to District level.
4	Generally rehabilitation of Grade 4 is beyond capacity of IO. IO is to prepare result of Inspection and report it to District.

#### Examination of suitable repair methodology for deterioration




- IO is to examine and select possible repair methodology for each deteriorated parts, referring following attached list.
- In case big scale repair work or rehabilitation is necessary, IO can fill “8 Selected Remedy” of Form-RW3 as “Responsibility of District”.
- Initially it is important to clarify the cause of the deterioration and point of improvement. Then next proceed to selection of repair methodology. In case unsuitable methodology is selected, same deterioration can happen again soon. Then the repair work will be wasted.
- Usually several methodologies can be candidate of repair works. In that case, IO is to select most suitable methodologies, considering cost and technical difficulty.

## List of Canal repair work methodologies


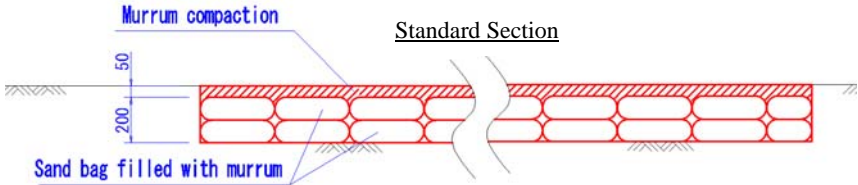


S/N	Remedy	Content	Image
C-1	Monitoring & Inspection	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• All</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• from 1 to 4</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Basically IO is to monitor and inspect the targeted facilities periodically and record the conditions. And special inspection should be conducted after flooding.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Monitoring &amp; Inspection is very important methodology and it can be very effective and positive remedy , in case IO conduct properly.</li> </ul>	
C-2	Mortar/ Concrete Filling	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• hollow of lining and joints, etc</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 1,2</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Low cost and simple repair work, and effective as preventive repair work.</li> <li>• Filling materials has to be filled deeply without hollow. And careful curing is needed to avoid cracks.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• In case hollow is detected behind lining, first the hollow has to be filled completely.</li> </ul>	 
C-3	Plastering	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Abrasion wear, cracks</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 1, 2</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Low cost and simple repair work, and effective as preventive repair work.</li> <li>• Deteriorated parts and dirt has to be cleaned beforehand. And careful curing is needed to avoid cracks.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Cause of surface segregation usually comes from construction time problem, like poor mixture of materials. Therefore repair needed area have to be identified and clarified through monitoring before Implementation.</li> </ul>	

C-4	Sand bag	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Erosion, Wash out of soil, repair of earth canal</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 1,2</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Low cost and simple repair work, and effective as preventive repair work.</li> <li>• Sand bags should be installed without gaps each other and well compacted.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Sand bag facing water flow can be reinforced with double use of sand bags.</li> </ul>	 
C-5	Filling of termark sand	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• gap of canal joint, cracks</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 1,2</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Low cost and simple repair work, and effective as preventive repair work.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Termark sand can be washed out after several years. It should be applied together with C-4 to prevent soil washout from behind.</li> </ul>	
C-6	Protection of crown part of slabs	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Wash out, Erosion, Hollow behind lining</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 1,2,3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Without coverage concrete, sometime Runoff water from around area penetrates behind of slab and washed out soil to damage.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Surrounding drainage condition should be taken care and improved, if necessary.</li> </ul>	
C-7	Installation of Haunch Concrete	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Abrasion wear of corner/bottom, leakage</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 2,3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Canal inner plastering usually start deterioration from corner and bottom. These parts need to be reinforced with haunch concrete.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Deteriorated parts needs to be removed before installation of haunch concrete.</li> </ul>	



C-8	Renewal of damaged section with Cement block	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• all kinds of damages</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 2,3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• most recommendable repair methodology. Long durability, stable and strong against washout problem.</li> <li>• However relatively cost is higher than other.</li> <li>• Rectangular section can be fitted with existing trapezoid section, with wing wall at both side of section.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Burnt brick is not suitable and weak against water.</li> <li>• C-4,C-5 can be applied as expansion joint.</li> </ul>	
C-9	Renewal of damaged section with stone masonry	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• all kinds of damages</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 2,3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• In case stone materials can be purchased cheaper than slabs. This method can be applied.</li> <li>• However installation of stone needs experience and technique. In case IO doesn't have experience, support is necessary.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Sufficient concrete filling between stones is needed, not just surface mortar. Otherwise joint hollow will be made in near future and washout of soil will start.</li> </ul>	
C-10	Renewal of damaged section with concrete slab	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• all kinds of damages</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• 2,3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• This repair work is easier than stone. But materials are more costly.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Basically this method should not be applied for the section which water flow velocity is more than 0.8 m/s. In case needed, sand behind slab should be replaced with concrete.</li> </ul>	

## List of Farm Road repair work methodologies

S/N	Remedy	Content	Image
R-1	Drainage	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Wheel rut, Muddy surface, Erosion</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• from 1 to 4</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Drainage is easy but most effective repair methodology.</li> <li>• Usually bad drainage condition section is to be damaged. Therefore it is important to make drainage and drain water from targeted section.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• Usually Drainage is used together with R-2 or R-3.</li> </ul>	
R-2	Sandbag & Murrum surface	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Wheel rut, Muddy surface,</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• from 1 to 3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Soft and muddy base is to be reinforced with sand bags and Murrum surface. Refer to standard section below.</li> <li>• This methodology is more durable than R-3.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• This methodology should be applied together with R-1.</li> <li>• Muddy surface has to be removed.</li> <li>• This methodology was applied a lot in Kenya and Uganda through JICA project.</li> </ul> <div style="text-align: center;">  </div>	
R-3	Marrum filling	<p><b>Deterioration type</b></p> <ul style="list-style-type: none"> <li>• Wheel rut, Muddy surface, Erosion</li> </ul> <p><b>Applicable grade</b></p> <ul style="list-style-type: none"> <li>• from 1 to 3</li> </ul> <p><b>Description of remedy</b></p> <ul style="list-style-type: none"> <li>• Good for filling hollow part and repair for initial stage damage.</li> </ul> <p><b>Special Note</b></p> <ul style="list-style-type: none"> <li>• This methodology should be applied together with R-1.</li> <li>• Muddy surface has to be removed.</li> </ul>	

## Gate repair and Maintenance work methodologies

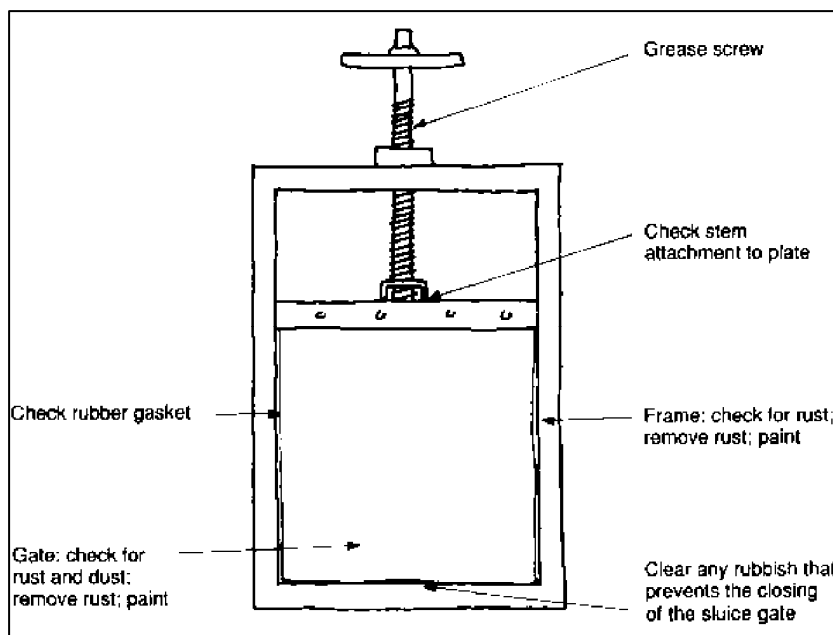
Generally Repair work of gate can't be handled only by IO. In case partial repair work is still possible, the work should be supported by local craft man. Below picture shows example of handle repair work by local craft man.



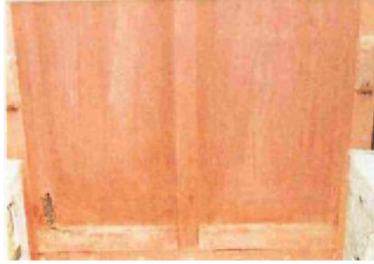





However, in case damage of the gate is more serious and need renewal, then order to factory is needed.

Besides, IO is expected to conduct periodical maintenance of gate for smooth operation. Followings are basic periodical maintenance.

- Plates and guide channels in the frame should be checked.
- Rust and old paint should be removed with a steel brush.
- Any holes should be patched by welding a steel plate over them.
- The gate and frame should be painted with three or four coats of an epoxy or other equally durable type of paint.
- The stem and guide plates should be well greased.



### Reference picture when to repaint gate

	Plate	Frame
Monitoring		
Monitoring		
Repainting Needed		

## Intake Facility repair and Maintenance work methodologies

Intake Facility is most important facility and deterioration of the facility will make big negative impact to total irrigation system and sometime make agricultural activities difficult.

Therefore preventive repair and maintenance works by IO is also crucial to the scheme operation.

As the repair work cost of intake facility is more than other facility generally, middle or large scale works should be supported by District.

IO main activities is to be preventive repair works just like same with canal facility, like repair of cracks, gaps, abrasion wear, etc. and periodical maintenance works for smooth operation, as it is shown below table. (Below table quoted from “Operation and Maintenance Manual”)

Element of irrigation system	Major maintenance activities
Intake weirs	<ul style="list-style-type: none"><li>▪ Removal of large pieces of floating debris or dangerous materials especially large floating woods to protect trash racks, weir bodies and associated structures</li><li>▪ Cleaning of the scouring sluice gates</li><li>▪ Maintenance of the flow measuring facilities to obtain accurate records</li><li>▪ Cleaning of all sites and areas adjacent to the facilities</li><li>▪ Removal of weeds and any other foreign materials at the trash racks and the scouring sluice gates</li><li>▪ Keeping all gates, accessories and metal works in workable conditions - lubrication (oiling or greasing) and anticorrosion treatment (painting)</li><li>▪ Monitoring of water quality (pH, EC, salt content and biological standpoint) of the river</li><li>▪ Removal of solid deposition - silt and stones</li></ul>

## 9. Repair works Action Plan

- Situation or condition of the irrigation facility systems varies from scheme to scheme. This means that Repair works Action Plan has to be formulated for each individual scheme. And Repair works Action Plan includes following items.

- Targeted Facility
  - Location of deteriorated part
  - Grade of deterioration
  - Selected repair work for each deterioration parts
  - Cost estimation of each repair works
  - Examination of repair works implementation by IO
  - Prioritization of each repair works
  - Working schedule
- } Facilities' Inspection result summery sheet (Form-RW2)

- After formulation of above Action plan by IO, the plan is to be checked technically by District and Zonal office, and the finalized plan should be kept in three parties.

### 9.1 Cost estimation of each repair works

Steps	Items	Filing/ Forms
STEP6	<b>Repair works Action Plan</b>	Repair works action plan sheet (Form-RW3)
	① <b>Cost estimation of each repair works</b> ② Examination of repair works implementation by IO ③ Prioritization of repair works ④ Scheduling plan for repair works and monitoring	

- The maintenance cost, including repair cost, is normally disbursed from O&M fee collected from irrigators. IO need to know how to estimate repair works cost to make practical Repair Works Action Plan.
- This step includes reference materials that IO can use for cost estimation.
- Basically small scale repair works is to be conducted by IO members, contributing labour forces. Therefore repair cost is mainly composed of materials and transportation.
- Cost of materials can be calculated “ Quantity × unit price rate”
- Quantity of repair works can be calculated “ standard section Quantity × Length ”
- Basically each scheme IO should consult with District for standard unit price of materials and technical support, in case necessary.

- Following table shows example of material costs that were used at time of Practical Repair works training, which was held in November 2013.

Item /Description	Unit	Rate(Tsh)		
		Mwanga	Kilombero	Rufiji
Sand bags	ps	500		
Murram	Trip (3CuM) Backfilling soil	50,000	100,000	90,000
	CuM	-	33,000	30,000
Sand	Trip (3CuM)	120,000	120,000	100,000
	CuM	40,000	40,000	33,000
Aggregates	Trip (3CuM)	280,000	200,000	110,000
	CuM	93,000	67,000	37,000
Cement (50kg/bag)	bag	20,000	15,000	15,000
Con slab; 37x45x5 cm	ps	-	-	5,000
Con slab; 45x45x5 cm	ps	7,500	-	-
Lorry(Truck) hiring for transportation	Day	150,000		
Cement Block ( 80mmx150mmx300mm)	ps	-	-	1,200
Cement Block ( 150mmx250mmx450mm)	ps	-	1,100	
Hand Hoe	pc	6,500		
Hammer	pc	7,500		
Shovel	pc	10,000		
Plastics (10Lt)	lt	2,000		
Wooden dumper	pc	10,000		
Wheelbarrow	pc	150,000		
Timbers for form work	Ls	30,000		
Wood saw	pc	6,000		
Trowel	pc	3,000		
Nail	kg	4,000		
Wire brush	pc	10,000		
Glove	pc	6,000		
Spirit level (pima maji)	pc	10,000		

- Necessary materials to make 1.0m<sup>3</sup> Concrete (1;2;4)  
(Concrete (1;2;4) is used for structure like wall )

Item	Unit	Quantity	Rate(Tsh)	Amount(Tsh)
Cement	bags	6.9	20,000	138,000
Sand	m3	0.45	50,000	22,500
Aggregates	m3	0.89	67,000	59,630
Total				220,130

- Necessary materials to make 1.0m<sup>3</sup> concrete (1;3;6)  
(Concrete (1;3;6) is used for Blinding concrete and thick foundation)

Item	Unit	Quantity	Rate(Tsh)	Amount(Tsh)
Cement	bags	4.8	20,000	96,000
Sand	m3	0.47	50,000	23,500
Aggregates	m3	0.94	67,000	62,980
Total				182,480

- Necessary materials to make 1.0m<sup>3</sup> Mortar (1;3)

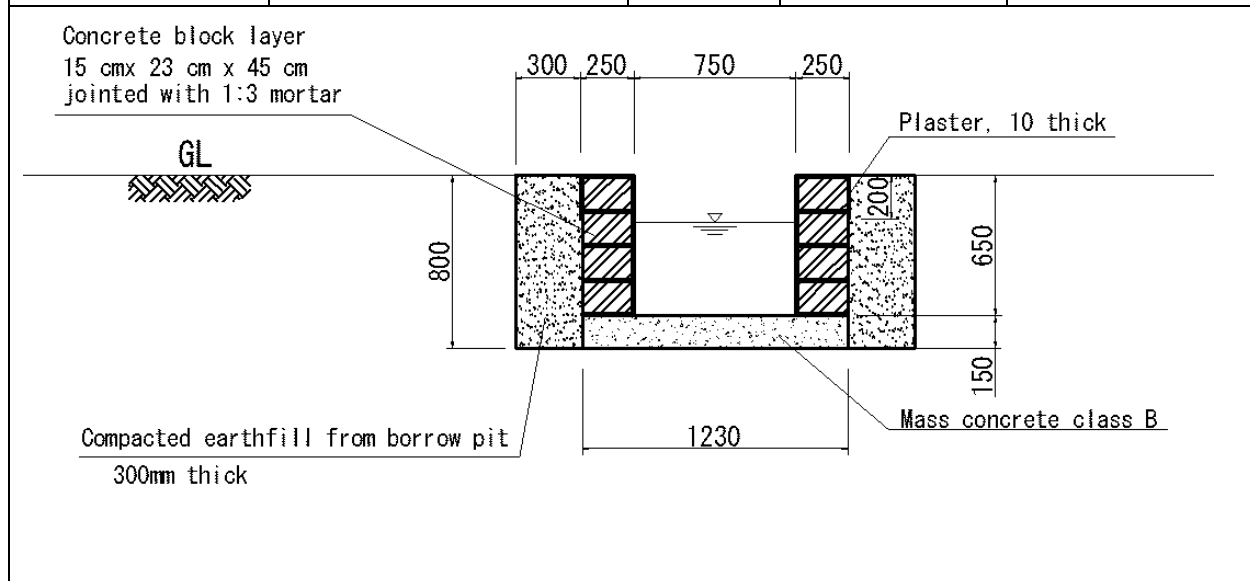
Item	Unit	Quantity	Rate(Tsh)	Amount(Tsh)
Cement	bags	17.8	20,000	356,000
Sand	m3	1.06	50,000	53,000
Total				409,000



### Example of cost estimation (Block Type canal)

L=10m

Item	Quantity	Unit	Rate	Amount
Mass Concrete	$1.23 \times 0.15 \times 10$ =1.85 m <sup>3</sup>	m <sup>3</sup>	220,130	407,241
Concrete Block	$10 \div 0.46 \times 8$ =175	Ps	1,000	175,000
Soil from borrow pit	$0.3 \times 0.8 \times 2 \times 10$ =4.80 m <sup>3</sup>	m <sup>3</sup>	20,000	96,000
Sub Total				678,241
Mortal	15	%	678,241	101,736
Total				779,977 Round $\approx$ 780,000



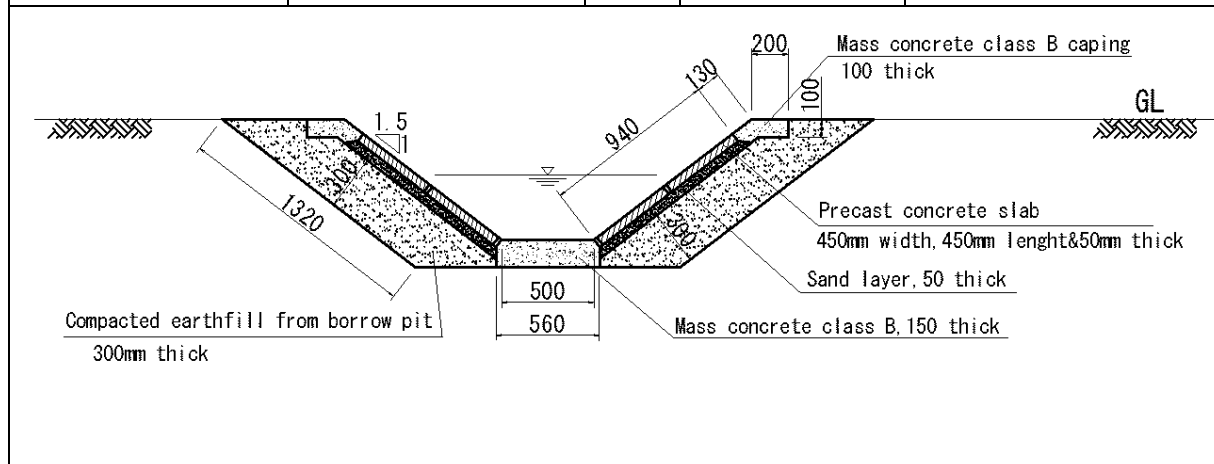
Note : IO is to confirm minimum selling quality of materials.

For example, sometime it is difficult to purchase only 1 m<sup>3</sup> quality of sand and aggregate.

### Example of cost estimation (Slab Type canal)

L=10m

Item	Quantity	Unit	Rate	Amount
Mass Concrete (base)	$0.53 \times 0.15 \times 10$ = 0.80m <sup>3</sup>	m <sup>3</sup>	220,130	176,104
Mass Concrete (capping)	$(0.2+0.13) \times 0.1 \times 10 \times 2$ = 0.66m <sup>3</sup>	m <sup>3</sup>	220,130	145,286
Slabs	$10 \div 0.46 \times 4$ =87	Ps	6,500	565,500
Soil from borrow pit	$0.3 \times 1.32 \times 2 \times 10$ =7.92	m <sup>3</sup>	20,000	158,400
Sub Total				1,045,290
Mortal	5	%	1,045,290	52,265
Total				1,097,555 Round $\approx$ 1,100,000



Note : IO is to confirm minimum selling quality of materials.

For example, sometime it is difficult to purchase only 1 m<sup>3</sup> quality of sand and aggregate.

## Example of gate minor repair work cost

Gate minor repair work was conducted in Kivulini Scheme in Mwanga district by local craft man to repair bent un-functioning gate, as the picture is shown below.



The repair work include following works. And it needed about two days work.

- initial checking of existing condition
- Removing of handle and plate.
- Repairing of deformed parts.
- Repainting
- Re-installation of gate.

This kind of Gate minor repair work cost about 50,000 to 60,000 Tsh.



## 9.2 Examination of repair works implementation by IO

Steps	Items	Filing/ Forms
STEP6	<b>Repair works Action Plan</b>	Repair works action plan sheet (Form-RW3)
	① Cost estimation of each repair works ② <b>Examination of repair works implementation by IO</b> ③ Prioritization of repair works ④ Scheduling plan for repair works and monitoring	

- Basically preventive repair works of Grade-1,2 deterioration should be conducted by IO, as Scheme managing organization.
- In case of Grade-3 deterioration, IO is to examine if the repair work can be handled within capacity of IO. And if not, IO is to note down what kind of support is needed and why needed in Form-RW3.
- If the internal resources and capacity are not enough, the public sector that provides the governmental budget like District Irrigation Development Fund (DIDF) and private sector including NGOs can be alternative external resources for the maintenance. But over external dependency must be avoided.
- In case of Grade-4 deterioration, Generally rehabilitation of Grade 4 is beyond capacity of IO. IO is to organize result of Inspection and repair works action plan, and report it to District level.
- To mobilize the external resources, IO has to prepare and show the credibility to the outside that may be financial records, constitution and Inspection result and this repair plan can be also convincing document to show existing conditions and necessary repair works.
- The government, especially the district level, can be a partner and facilitator with IO to implement repair works.

### Box-3: Importance of Financial Management of IO

The O&M fee is indispensable to proper operation and maintenance of the irrigation scheme. But incentive of payment by the IO members is not so high. This results in deterioration of facilities.

IO members who are the beneficiaries of the irrigation scheme have responsibility for O&M of irrigation systems after being handed over from the government.

☞ Refer to " OPERATION AND MAINTENANCE TRAINING MANUAL " Module 4 and Step1 of "G.L. vol2 Section 4: Operation and Maintenance " for more detail of Financial Management



### 9.3 Prioritization of each repair works

Steps	Items	Filing/ Forms
STEP6	<b>Repair works Action Plan</b>	Repair works action plan sheet (Form-RW3)
	① Cost estimation of each repair works ② Examination of repair works implementation by IO ③ <b>Prioritization of each repair works</b> ④ Scheduling plan for repair works and monitoring	

- Each of the repair works needs does not have the same degree of priority. For example, a failure of an intake facility causes serious consequences to the scheme hence the priority is high. Other routine maintenance can be scheduled months later.
- Purpose of this prioritization step is to decide orders which repair works should be conduct earlier.
- Initial prioritization should be conducted by IO members and should be approved by IO committee.
- IO is to prioritize all selected repair works candidate one by one (from 1 to end). And in case it is difficult to differentiate two or three repair works, IO can give same prioritization for two or three repair works.
- When IO is to decide prioritization of each repair works, following factors should be taken into consideration.

Items	Description
Impact & Influence	- Impact & Influence of the deterioration - In case repair of the deterioration delayed, how big negative impact and influence is expected to happen. - Generally deterioration impact of intake and main canal will be bigger.
Grade of deterioration	- Generally the more Grade of deterioration, the more prioritized. - However at the same time, repair works should be conducted before it become serious in preventive manner. Just like human disease.
Emergency	- In case IO think emergency repair work is needed, the part can be highly prioritized, like leakage to stop soon, broken of gate which is causing problems within beneficiaries.
• Preventive effect • Development speed of damage	- As it is mentioned before, early stage repair works is important before the deterioration become serious. - In case IO can identify the development of deterioration, comparing with previous inspection result, the targeted parts should be repair in early stage.

## 9.4 Implementation schedule

Steps	Items	Filing/ Forms
STEP6	<b>Repair works Action Plan</b>	Repair works action plan sheet (Form-RW3)
	① Cost estimation of each repair works ② Examination of repair works implementation by IO ③ Prioritization of each repair works ④ <b><u>Scheduling plan for repair works and monitoring</u></b>	

- IO is to make repair works implementation schedule.
- Basically highly prioritized work should be implemented earlier. However in case IO can't prepare budget of repair works enough, prioritized order and schedule needed to be adjusted.
- Scheduling of big scale repair works or rehabilitation, which is beyond capacity of IO, should be decided in consultation with District.
- Besides IO also needs to consider season of repair, diversion of water, mobilization of members, besides budget.
- Prepared repair works schedule should be added and reflected to existing Maintenance Schedule Plan. Example of the schedule is shown below.

### Example) Maintenance Schedule Plan

Facilities	Activities	Responsible persons	Necessary resources	budget	Jan.			
					1	2	3	4
Headworks	Removal of silt	All members	Shovels buckets		●	●		
	Cutting grasses	All members	Pangas Rakes			●	●	
	Painting	O&M committee	Paints Brushes Thinner	20,000 10,000	●	●		
Main canal	Removal of silt	All members	Shovels buckets					
	Cutting grasses	All members	Pangas Rakes					
	Repair work-1	All members	Repairing materials	150,000		●	●	

## 10. Follow-ups of Repair works Action Plan

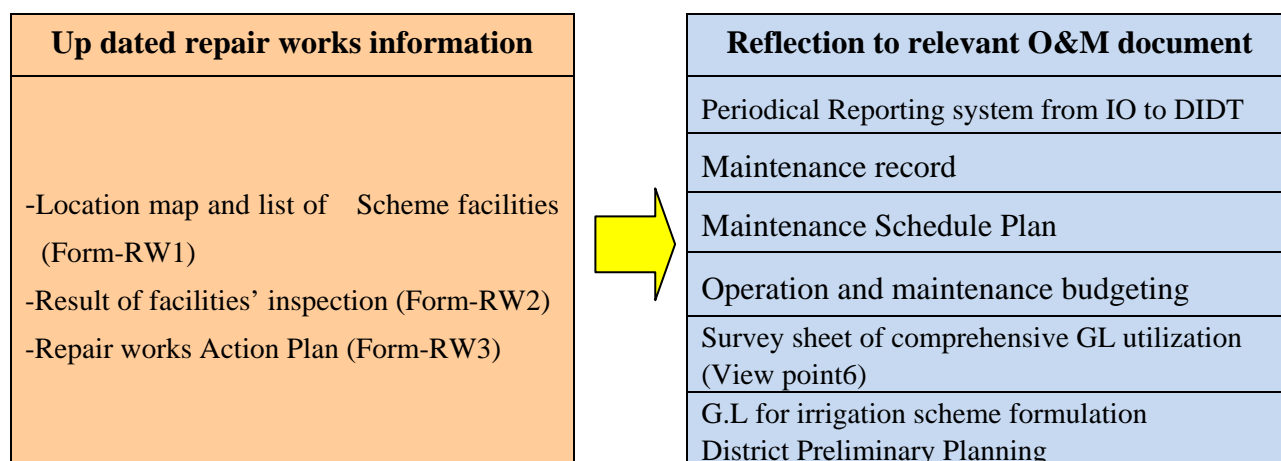
Steps	Items	Filing/ Forms
STEP7	<b>Follow-ups of Repair works Action Plan</b>	-
	<ul style="list-style-type: none"> <li>① <u>Check and Confirmation of Action plan by District</u></li> <li>② <u>Reutilization of repair related works by IO</u></li> </ul>	

### 1). Check and Confirmation by District/ Zonal engineer

- All filled forms, which were prepared through Inspection and Planning procedures, should be submitted to District and District is to check through technically and financially and confirm the action plan is practical and realistic.
- In case needed, District is to visit the site and confirm physically and take pictures of deteriorated conditions.
- In case needed, District is to give technical support and revise the documents, especially cost calculation, prioritization and responsibility of District.
- Whenever District revise the prepared document, District need to explain the reason and contents of revision.
- Finalized and approved document forms should be kept in IO, District and Zonal office.

### 2). Reutilization of repair related works by IO

- Basically Inspection of scheme facilities is to be conducted every 6 months and update result of inspection and repair works action plan.
- Special inspection should be conducted after flooding.
- Every time repair work related forms updated, updated information should be reflected to relevant document. (refer to following figure)



**Repair works Action Plan form; (Form-RW3) : Example of filling**

**District/ Scheme Name; \* \* \* \* \* / \* \* \* \* \* \* \* \* \***

**Date ; 15 / 11 / 2013**

1	2	7	8	9	10	11.	12	13	Remarks & Challenges
Location Info	Facility Name	Grading of deterioration	Selected Remedy	Approximate Cost	Priority	Main implementer	Needed support from outside And the reason	Work Schedule	
-	Intake facility	1	Monitoring	-	-	IO	-	Every 6 month Next: 5/2013	
1	Main canal	1-2	Monitoring	-	-	IO	-	Every 6 month Next: 5/2013	
2	Main canal	2	Plastering	150,000	4	IO	-	Repair work of 2015	This year no budget
A	Secondary canal-1	2	Filling of gaps	100,000	3	IO	-	2/2014	Repair work of 2014
B	Secondary canal-1	3-4	Renewal of damaged section	1,000,000	1	District	Technical and financial support needed/ beyond IO capacity	10/2014	
C	Secondary canal-1	2	Filling of hollow parts	300,000	3	IO	-	2/2014	Repair work of 2014
D	Secondary canal-1	2	Repair of gate handle/ Monitoring	100,000	5	IO	-	Every 6 month Next: 5/2013	
E	Farm road	3	Sandbag& Murrum surface	600,000	2	IO	-	Repair work of 2015	This year no budget

**Note: Location map and Facilities' Inspection result summery (Form-RW2) should be compiled together.**



## 11. Implementation of repair works

Steps	Items	Filing/ Forms
STEP8	<b>Implementation of repair works</b>	-
	• IO is to implement highly prioritized repair works, referring to the manual. Basically IO is to be responsible for small scale and preventive repair works.	

- Basically IO is to implement repair works within the capacity.
- In case necessary, IO request District for support of facilitation.
- "Reference for practical repair work Implementation" is attached in APPENDIX- 1.  
IO can refer the document for the help of implementation.

## **APPENDIX– 1;**

### **Reference Materials**

#### **for practical repair work Implementation**

S/N ; C-6	Name of Repair work ; Protection of crown part of slabs
S/N ; C-7	Name of Repair work ; Installation of Haunch Concrete
S/N ; C-10	Name of Repair work ; Renewal of damaged section with concrete slab & backfill concrete
S/N ; R-2	Name of Repair work ; Sandbag & Murrum surface coverage
S/N ; C-4 C-5	Name of Repair work ; Filling gap of canals
S/N ; -	Name of Repair work ; Hand mixing of concrete

### 1. Applicable Deterioration type

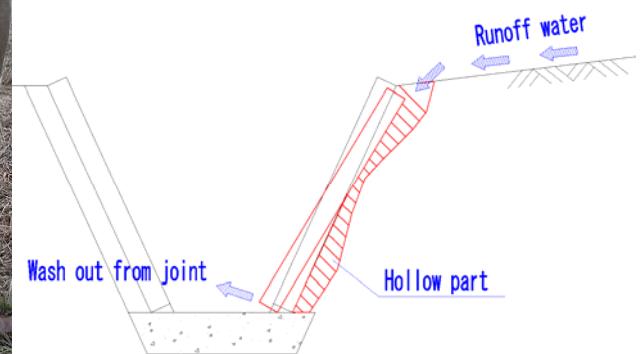
- Determination of canal
- Wash out, Erosion, Hollows behind lining

### 2. Applicable Deterioration Grade

- from 1 to 3

### 3. Description of the work

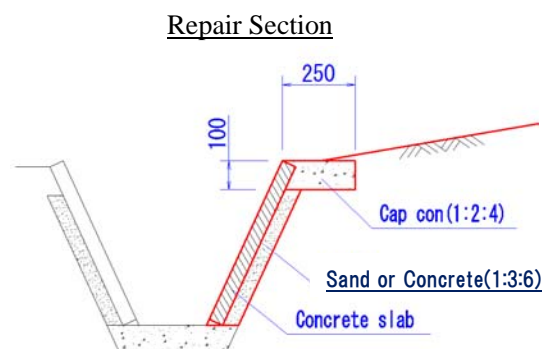
- Without crown part concrete, often Runoff water from around area penetrates behind of slab and washed out soil to damage. This damage were seen where elevation of canal is lower than ground around.



- Two remedies can be taken for this problem. One is to stop run-off water coming to canal side like drainage. The other is to prevent run-off water entering behind walls with capping concrete.
- In case the targeted facility is main canal, it is recommendable to use backfilling concrete instead of sand as materials behind slabs.

### 4. Necessary Materials

- Concrete (1:2:4)
- Mortar (1:3)
- Sand or Concrete (1:3:6)
- Slab (If necessary)



- Compaction tool
- Spade

## 5. How to Implement

- ① Check existing run-off water flow and where water comes from.
- ② If possible, try to stop run-off water coming to canal side with diversion drainage or change slope of ground.
- ③ Remove deformed slab and clear dirt and weeds. If slab itself is not damaged, the slab can be reused.
- ④ Check if additional foundation concrete is needed. If so, cast additional concrete and cure.
- ⑤ Prepare sand compacted slope and install slab, with filling joint mortar.
- ⑥ Prepare forms and cast capping concrete.
- ⑦ Backfilling and slope the surface for drainage.



Removing deformed slab and clear dirt and weeds



Re-installation of removed slabs



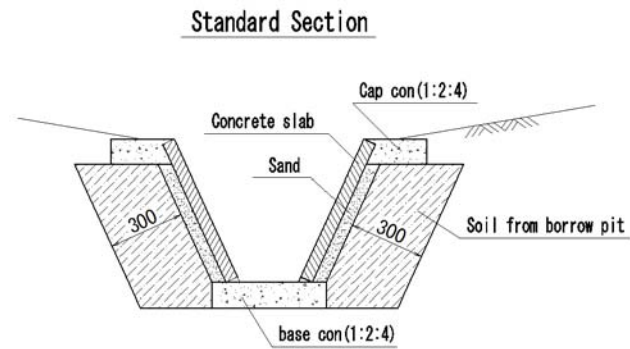
Casting capping concrete



Backfilling and slope the surface for drainage.

## 6. Special Note

- Surrounding drainage condition should be taken care and improved, if necessary.
- In case soil around canal is not good like black cotton soil, soil from borrow pit should be used for backfilling around canal.



- IO should consider reuse of existing materials like slab to minimize repair cost. Below picture shows example of reuse of existing slab.



S/N ; C-7

Name of Repair work ; Installation of Haunch Concrete

**1. Applicable Deterioration type**

- Repair of Canal
- Abrasion wear of corner/bottom, leakage

**2. Applicable Deterioration Grade**

- 2, 3

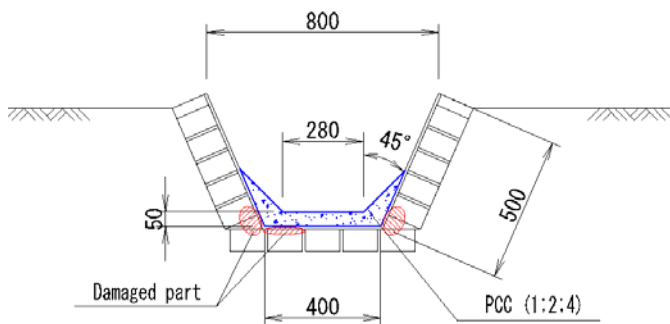


**3. Description of the work**

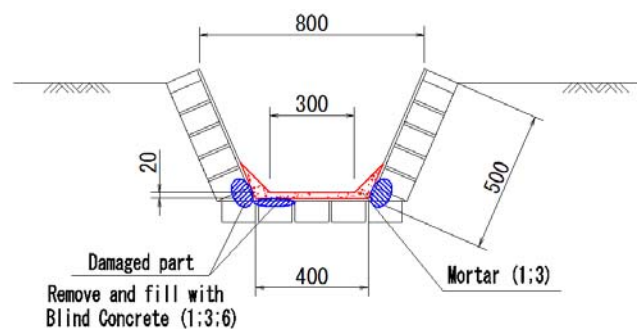
- Canal inner plastering usually start deterioration from corner and bottom. These parts need to be reinforced with haunch and bottom concrete.
- This methodology is more durable than R-3.
- In case aggregate material cost is more expensive than sand, Mortar can be used instead. (refer to two type of sections)



**Haunch**



Concrete haunch type



Mortar haunch type

**Example of Repair Section**

#### 4. Necessary Materials

- Haunch Concrete (1:2:4) or Haunch Mortar(1:3)
- Blinding Concrete (1:3:6) or Blind mortar(1:6)
- Chisel and hammer
- Brush for cleaning

#### 5. How to Implement (Example of Kilonbero training)

- ① Clean the surface of repair part
- ② Remove deteriorated parts with chiseling and hummer.
- ③ Fill blinding mortar in hollow and removed parts and finish surface with trowel.
- ④ Cast base mortar (20mm) and finish surface with trowel.
- ⑤ Cast haunch mortar and finish surface with trowel.
- ⑥ Curing of mortar parts.



Removing deteriorated parts with chiseling and hummer



Filling blind mortar in hollow and removed parts



Casting base mortar (20mm) and finishing surface



Casting haunch mortar and finishing surface with trowel

## 6. Special Note

- Water flow level and extra of freeboard should be examined at the time of planning.
- Size of aggregate to mix concrete should be small, like less than 20mm.
- Deteriorated parts needs to be removed before installation of haunch concrete.



S/N ; C-8

Name of Repair work ; **Renewal of damaged section with Cement blocks**

### 1. Applicable Deterioration type

- Repair of Canal
- All kinds of damages

### 2. Applicable Deterioration Grade

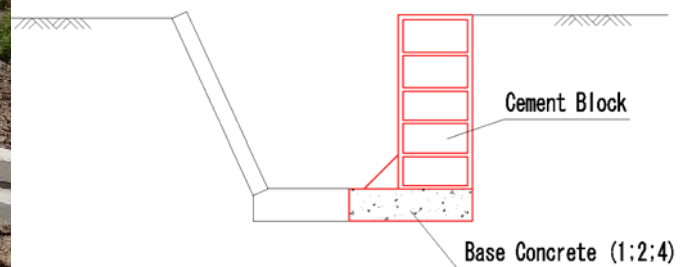
- 2, 3,4

### 3. Description of the work

- Generally Cement Block structure is more durable and stable than slab structure. And in case canal is to be newly rehabilitated, Cement Block structure is more recommendable.
- Repair work with Cement Blocks can be applied even partially within slab type canal. Besides the Block type repair work can be applied even to one side of canal, as the section is shown below.
- Cement Block structure can be more economical than slab type repair, Especially when existing slabs is damaged and new slabs need to be purchased.

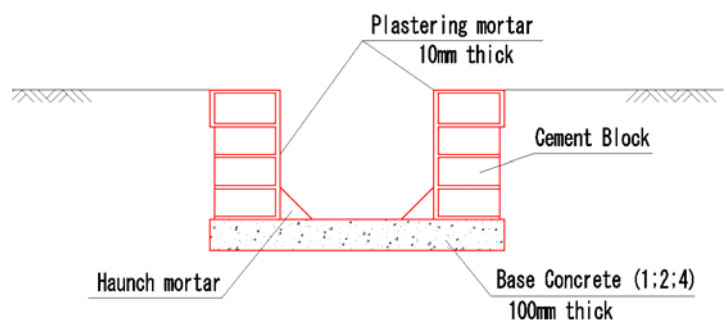


Example of partial repair with Cement Block



### 4. Necessary Materials

- Cement blocks
- Mortar (1:3)
- Base Concrete (1:2:4)
- Plastering tools



Standard section

## 5. How to Implement

- ① Remove deteriorated parts and excavation for foundation.
- ② Casting base concrete and cure.
- ③ Installation cement blocks.
- ④ Plastering surface of cement blocks.



Excavation and casting base concrete



Installation of cement blocks



Plastering surface of cement blocks.



After Plastering

## 6. Special Note

- In case existing canal is burnt brick structure, existing brick materials can be reused in above part of canal, as it is shown in left picture.



S/N ; C-10

Name of Repair work ;

Renewal of damaged section with  
concrete slab & backfill concrete

---

### 1. Applicable Deterioration type

- Repair of Canal
- all kinds of damages, especially washout

### 2. Applicable Deterioration Grade

- 2, 3

### 3. Description of the work

- Concrete slab type Canals are easy to be damaged for washout, especially where water flow velocity is high and water flows long period within a year, as the damage steps are shown in below pictures. In that case, if damaged section is repaired as before, Same washout problem will happen again and again.



1<sup>st</sup> stage washout damage



2<sup>nd</sup> stage washout damage

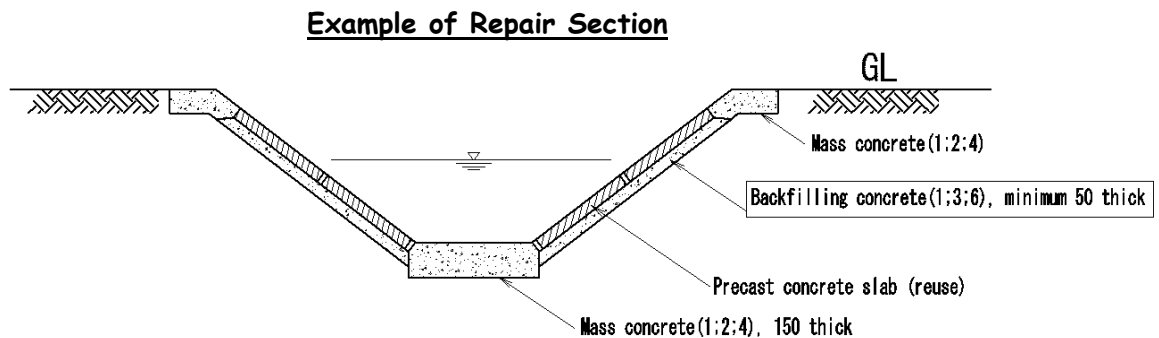


3<sup>rd</sup> stage washout damage



4<sup>th</sup> stage washout damage

- Repair section is to install backfilling concrete instead of sand to reinforce weak part of concrete slab structure, as Example of Repair Section is shown below.



#### 4. Necessary Materials

- Mass Concrete (1:2:4)
- Back filling Concrete (1:3:6)
- Precast concrete slabs (if possible, reuse existing slabs)
- Mortar for joints
- backfilling soil, if needed.

#### 5. How to Implement

- ⑤ Remove deteriorated parts
- ⑥ Preparation of foundation and installation slope with good compaction.
- ⑦ Cast backfilling concrete and cure.
- ⑧ Install precast concrete slab and fill joints with mortar.
- ⑨ Cast capping concrete



Deterioration Before repair work



Remove of deteriorated slabs and filling soil.



Casting backfilling concrete



Re-installation of slabs (reused slabs)



Re-installation of slabs (reused slabs)



After repair works

## 6. Special Note

- Basically this method should not be applied for the section which water flow velocity is more than 0.8 m/s. In case needed, sand behind slab should be replaced with concrete.

### 1. Applicable Deterioration type

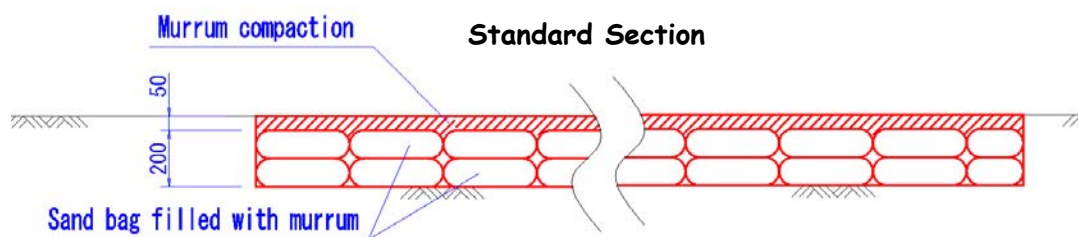
- Wheel rut, Muddy surface,

### 2. Applicable Deterioration Grade

- from 1 to 3

### 3. Description of the work

- Soft and muddy base is to be reinforced with sand bags and Murram surface. Refer to standard section below.
- This methodology is more durable than R-3.



### 4. Necessary Materials

- Sand bag
- Sisal Strings
- Murram
- Compaction tool
- Spade

### 5. How to Implement

- ① Make drainage not to get wet and muddy around targeted area
- ② Remove weeds and muddy and soft soil
- ③ Excavate the area with 25 cm deep and compact foundation.
- ④ Prepare sandbag filling materials. Murram or sand or aggregates is preferred. Clay or organic soil is not suitable.



- ⑤ Put above materials in sandbags and tie up the mouse of sandbag firmly with Sisal Strings.
- ⑥ Install sandbag uniformly and compact installed sandbags
- ⑦ Put covering murrum soil on sandbags and give Compaction, and make 5cm deep coverage layer



Excavation of targeted area. (25cm deep.)



Installation of sandbags and compaction. (1<sup>st</sup> layer)



Filling spaces with murrum and compaction.  
(Two layers sandbags)



Put covering murrum soil (5cm deep) on sandbags and give Compaction, and make 5cm deep coverage layer

## 6. Special Note

- This methodology should be applied together with R-1.
- Muddy surface has to be removed.
- This methodology was applied a lot in Kenya and Uganda through JICA project.

S/N ; C-4  
C-5

Name of Repair work ; **Filling gap of canal joints**

---

### 1. Applicable Deterioration type

- Gap of canal joints, cracks, prevention of washout

### 2. Applicable Deterioration Grade

- from 1 to 3

### 3. Description of the work

• Gaps of canals, like expansion joints and wide cracks, is to cause not only leakage but also washout of soil behind canal. The gap is to be repaired before it become serious.

• Filling of gaps can be done in two ways. One is filling gap part directly by turmac sand. And the other is sandbag filling.



### 7. Necessary Materials

- turmac
- sand
- pan
- form work timebers
- Sand bag
- Sisal Strings
- Compaction tool

### 8. How to Implement

#### Filling tarmac sand

- ① Excavate and Clear around the targeted part.
- ② Formwork around the targeted part to receive tarmac sand filling



materials.

- ③ Heat tarmac in pan and mix with sand (ratio 1:1) , after the tarmac heated and liquidized.
- ④ Fill the gap with tarmac sand with stick and tapping forms so that the gap will be filled well.



### Sand bag filling

- ① Excavate and Clear around the targeted part.
- ② Put empty sandbag behind the slab with covering the gap parts.
- ③ Backfilling the excavated space with filled sandbags, compacting well.
- ④ Put covering soil on sandbags



### 9. Special Note

- In case leakage from gap is main problem, filling with mortar can be applied together with sandbag filling.

## Introduction

Before you can mix your concrete, you need to:

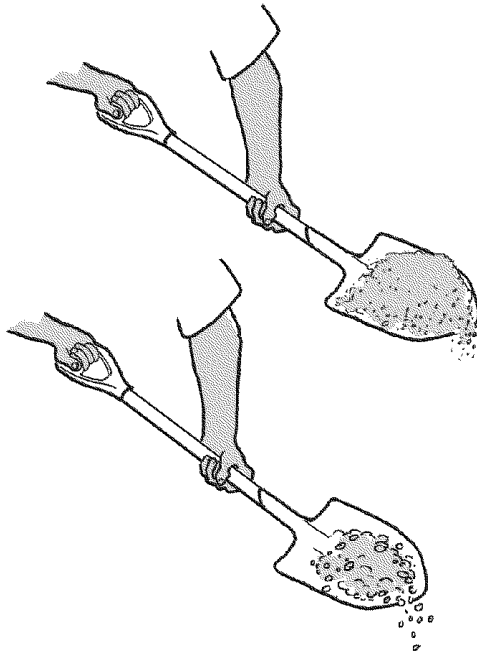
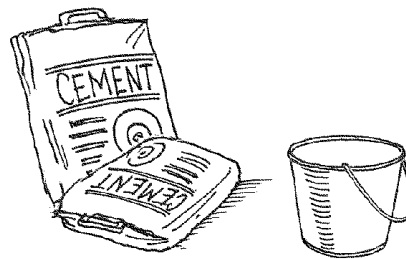
- Know the type of concrete you are making and the right amounts of water, cement, sand and rock you need
- Know the amount of concrete you need
- Get all the material and equipment together.

## Measuring materials

Use a bucket or a box to measure

It is important to get the *right* amounts of cement, sand, rock and water.

A shovel is *not good* for measuring.



A shovel of cement is not the same size as a shovel of rock

### ! Safety note

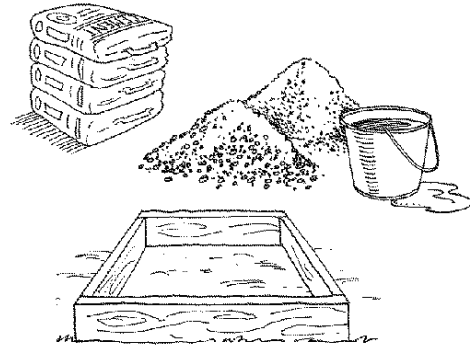
- Avoid getting cement or wet concrete on your skin if you can. The cement will dry your skin and can cause alkaline 'burns'.

Wear boots and gloves if at all possible.



Also avoid breathing cement dust — it can harm your lungs.

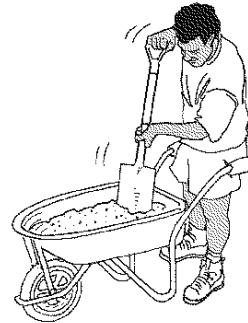
# Mixing by hand



1. Measure all the sand, cement and rock/stone into a wheel-barrow or onto a board.



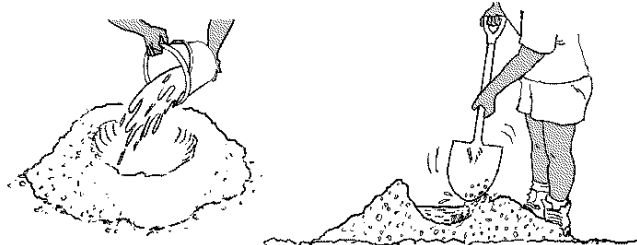
2. Mix them together until it all looks the same colour.



3. Gather it all into a heap and make a hollow in the middle.



4. Add the water slowly into the hollow and mix in the material.



5. Make into a heap again, add more water and mix.

6. Do this until you have a mix that is workable but not too wet.

7. Keep turning and mixing for about 2 minutes.



8. Use the concrete and make the next batch.

## Image Pictures of Hand mixing concrete

- Strength of concrete is greatly influenced by mixing water volume.
- Mixing water volume for one cement bag (50kg) should be about 26 - 30 liters.
- Following pictures shows bad and good example of mixed concrete. Bad concrete should not be used.



**NO !**



**NO !**



**OK !**

## **APPENDIX– 2; FORMS**









