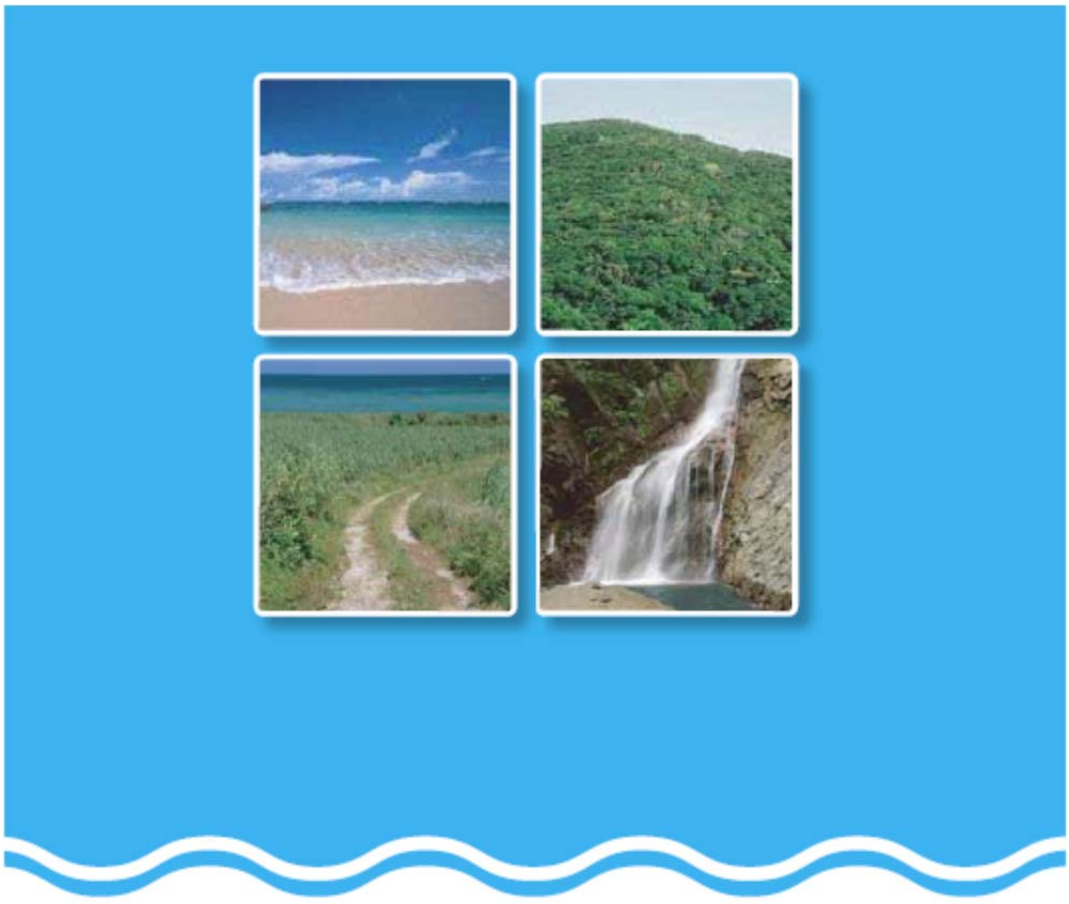
# Handbook for Red Soil Runoff Cntrol



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Okinawa Prefecture, Department of Culture and Environment,
Environment Conservation Section

# How to utilize this handbook

This handbook was made to introduce construction methods for red soil runoff control for the residents of Okinawa Prefecture

Construction methods for control works and technology are continuously upgraded upon implementation and improvements of technology

This hand book introduces the construction methods for red soil runoff control available today.

You can refer to this hand book when you want to know about the types and functions of red soil runoff control works implemented in development projects and farm lands. When you want to check the functions of red soil runoff control works already implemented, this handbook will also be useful.

This handbook is made compact enough to be used in the field.　We hope that many people will come to understand more about the red soil runoff control works

- Table of Contents -

| No | Categories under Red Soil Runoff Control Ordinance | | Categories of Control Measures | | Construction Method | Page to Refer |
|---|---|---|---|---|---|---|
| | Category | Sub category | | | | |
| 1-1-1 | Source Control Devices | Surface Soil Conservation Devices | Surface Conservation Works | Permanent Works | Vegetative Cover | 21 |
| 1-1-2 | | | | | Gravel Laying | 23 |
| 1-1-3 | | | | | Mortar Spray | 25 |
| 1-2-1 | | Temporary Surface Soil Conservation Devices | | Temporary Works | Mulching | 27 |
| 1-2-2 | | | | | Sheet Cover | 29 |
| 1-2-3 | | | | | Gravel Laying | 31 |
| 1-2-4 | | | | | Spray of Chemical Aggregate | 33 |
| 1-2-5 | | | | | Emulsion Spray | 35 |
| 1-2-6 | | | | | Mortar Spray | 37 |
| 1-2-7 | | | | | Roller Compaction | 39 |
| 2-1-1 | Devices For Controlling Turbid Runoff | Runoff Control Devices | Runoff Control Works | Surface Runoff Control Works | Fencing Works | 41 |
| 2-1-2 | | | | | Gabion Baskets | 43 |
| 2-1-3 | | | | | Small Dikes | 45 |
| 2-1-4 | | | | | Furrows | 47 |
| 2-2-1 | | Water Channel Devices | | Water Channel Control Works | On-site Temporary Water Way | 49 |
| 2-2-2 | | | | | Earth Pit | 51 |
| 2-2-3 | | | | | Leaching Pit | 53 |
| 2-2-4 | | | | | Temporary Sand Settling Basin | 55 |
| 2-2-5 | | | | | Embankment | 57 |
| 2-3-1 | | Water Diversion Devices | | | Diversion Channel | 59 |

○Table for Red Soil Runoff Control Works in Development Projects

| No. | Categories under Red Soil Runoff Control Ordinance | | Category of Control Measures | | Construction Method | Page to Refer |
|---|---|---|---|---|---|---|
| | Category | Sub category | | | | |
| 3-1-1 | Devices For Final Treatment of Turbid Water | Final Sedimentation And Drainage Devices | Turbid Water Treatment Works | Turbid Water Storage & Treatment Facility | Natural Settling Basin | 61 |
| 3-1-2 | | | | | Filtering Settling Basin | 63 |
| 3-1-3 | | | | | Coagulation Settling Basin | 65 |
| 3-2-1 | | Turbid Water Dispersion Control Devices | Dispersion Control Works | | Silt Protector | 67 |
| 3-2-2 | | | | | Sheet Piles | 69 |

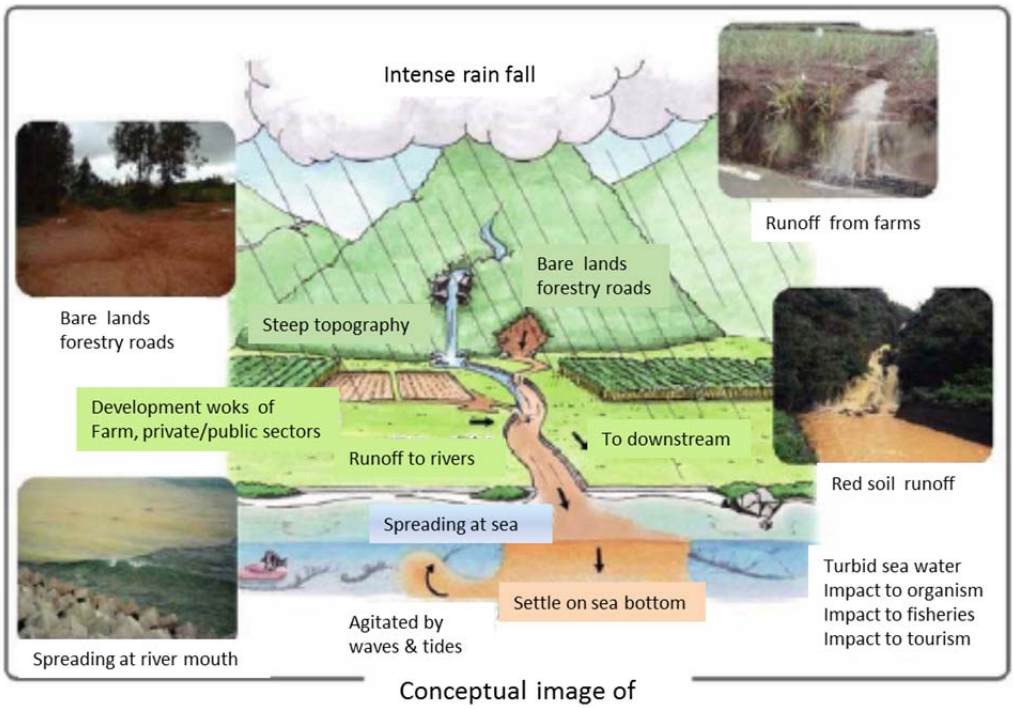
○Table for Red Soil Runoff Control Works in Farm Lands

| No. | Category of Control Works | | Construction Method | Page to Refer |
|---|---|---|---|---|
| | Category | Sub Category | | |
| 4-1-1 | Farm Management Measures | Source Control | Mulching | 73 |
| 4-1-2 | | Farm Slope Lower Border Control | Border Strips | 75 |
| 4-1-3 | | | Green Manure | 77 |
| 4-1-4 | | | Dikes | 79 |
| 4-2-1 | Civil Engineering Measures | Source Control | Reduction of Farm Slope Inclination | 81 |
| 4-2-2 | | Downstream Control | Sand Settling Basin Leaching Pit / Earth Pit | 83 |
| 4-2-3 | | | Drainage Channel | 85 |

## 1. Mechanism of Red Soil Runoff

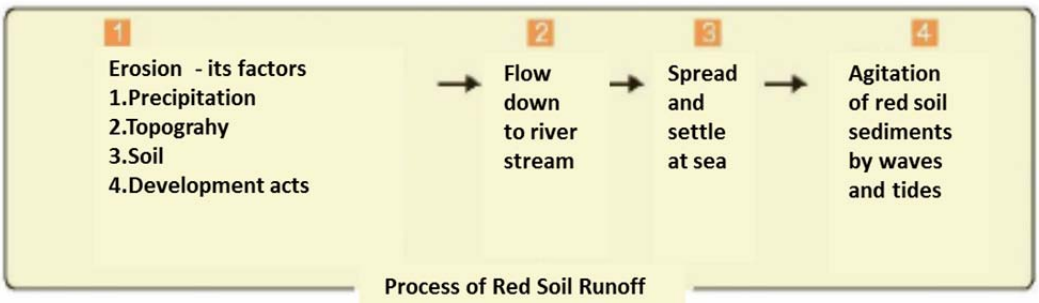
### 1-1. Mechanism

Red soil begins to run off as rainfall erodes soil. Eroded red soil, together with rain, flows into rivers. Runoff continues to travel downstream and reach the sea and disperse. Red soil runoff induces turbidity of sea water, and settles on the ocean floor with the elapse of time. Sedimentation is further disturbed by tidal movement and wave actions, inducing turbidity of sea water again.




Conceptual image of
Red Soil Runoff

There are several factors involved in the red soil runoff such as climate of Okinawa, topography and soil property. Furthermore, additional factors such as alteration of land by private / public development projects and human activities, cause red soil runoff.



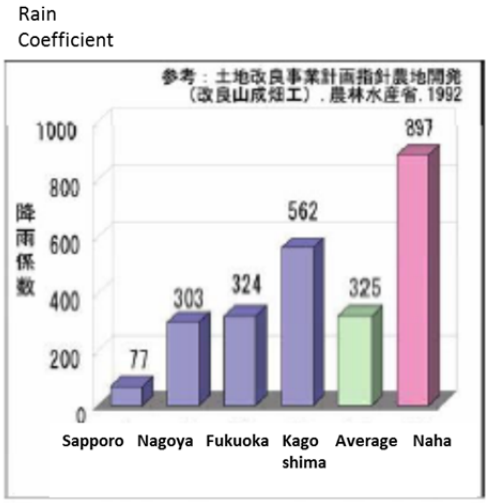

Process of Red Soil Runoff

## (1) On Erosion

### 1) Precipitation

As intensity of rainfall in Okinawa is higher than other regions of Japan, erosive power of rain is stronger as well.

Intensity of rainfall energy is indicated by " rainfall-runoff factor ". The rainfall-runoff factor in Okinawa is 3 times higher than national average. This fact alone indicates that soil erosion in Okinawa is three times more likely to occur than national average.




Intensity of precipitation in Okinawa
Nation-wide comparison

Rainfall-runoff factor is an indicator of how rain falls (volume, size of rain drops, duration of rainfall etc.) in a region. Rainfall-runoff factor is also used to calculate soil runoff.

It is defined as 1/100 of product of total kinetic energy of rainfall event (E) and 60-minute rainfall intensity (I)

Rainfall-runoff factor is calculated using the formula indicated below.

R(rainfall-runoff factor) – (E × I60 / 100 E－(210+89LogI) × r

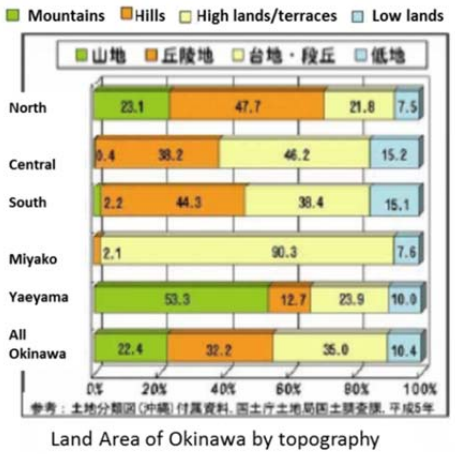
I: rainfall intensity (cm/hour) of 60-minute rainfall read every hour on the hour

r: rainfall (cm) in duration of time

Rainfall event: a period of continuous rainfalls followed by zero rainfall for 6 hours or longer.

### 2) Topography

Steep topography easily induces surface runoff and soil erosion. The central and southern part of main land Okinawa is characterized by gentle hills and undulating topography; however, the northern part of mainland Okinawa and Yaeyama islands are characterized by steep mountains and hills .Thus red soil erosion is more likely to occur. In Okinawa, such topography susceptible for erosion occupies over 50% of the land.




Land Area of Okinawa by topography

### 3) Soil

#### 1. Major Soils Distributed in Okinawa Prefecture

Kunigami Mahji, which shares 55% of soil distributed in Okinawa, is composed of fine particles. Due to its low viscosity and solidity, the soil is highly prone to erosion.

Other soils such as Shimajiri Mahji, Jahgaru, and Kucha, mudstone, readily crumble, and contribute as source of red soil pollution.


When placed into water, fine particles of soil dissolve into water, inducing turbidity.

#### 2. Soil Distributions

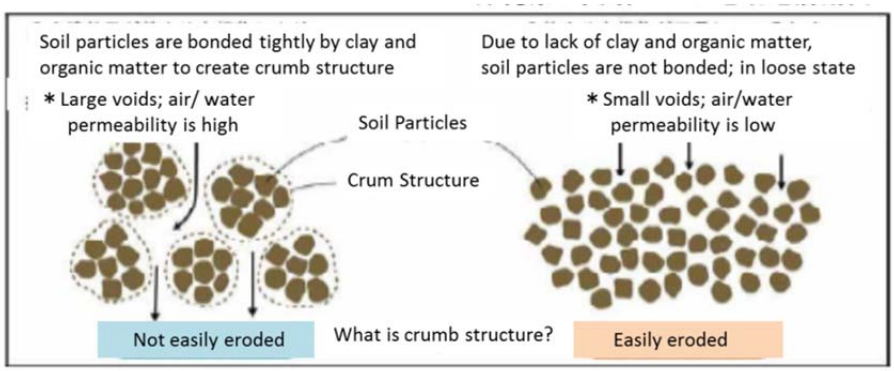
Very erosive soil of Kunigami Mahji (indicated in red in the graph below) is distributed in the central to northern part of mainland Okinawa and the extensive area of Ishigaki and Iriomote Islands. Soil layer of Kunigami Mahji can be as thick as 20~30 m in some location. This indicates that due to the high temperature and precipitation, weathering process has reached deeper layers of soil. Not only the steep topography in the northern part of mainland Okinawa, but also the soil structure contributes to the environment that is very susceptible to red soil runoff.

#### 3. Weakly-Developed Crum Structure

On forest soil surface, litters and corps of dead animals will accumulate. In the decomposition process of organic matters in soil, humus which is not readily decomposed by microorganism is formed in the soil. The materials excreted from humus, microorganisms and vegetation roots, act as a bonding material to bring soil particles together and form crumb structure.

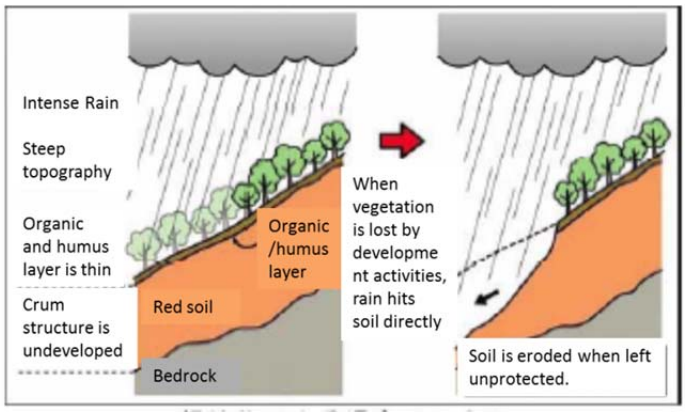
In temperate regions of mainland Japan, black soil, which is rich in organic matters and humus are exposed on the ground surface. However, in Okinawa where subtropical climate induces vigorous activities of soil animals and microorganism, the rate of organic matter decomposition is much faster than that of temperate regions. Due to this fact, volume of humus is small and crumb structure of soil is not well developed. When crumb structure is not well developed, soil is easily crumbled and eroded under the rain as runoff once surface soil is exposed by development works.


Soil Profile of Kunigami Mahji Area




## 4. Alteration of Topography

Under natural topography with little human impact, trees and vegetation grow well on soil, preventing red soil runoffs. Branches and leaves of vegetation prevent rainfall from directly hitting the soil surface; thus, mitigating the soil erosion.




Mechanism of Erosion in Bare Soil

The roots of vegetation also blocks runoff and control soil erosion.

Therefore, the bare soil without vegetation created by logging is left unprotected, positive effects of vegetation to control soil erosion are lost, causing red soil runoff. The major causes for the progression of bare soil are development activities and farming practices.

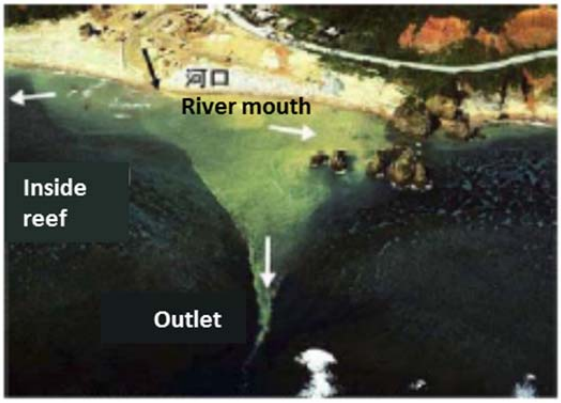
### (1) Runoff through River to Downstream

Due to rough topography of mainland north, Kumejima and Yaeyama , rivers in the regions are steep and short, creating a condition more susceptible to quick soil runoff all the way to the sea.


Red soil runoff to a river

### (2) Inflow, Dispersion and Accumulation

Red soil runoffs flow from the river mouth and glide over the river water surface and dispersing into the sea area. At low tide, a small amount of red soil sediments escape through the outlet of the leaf; however, most of the red soil sediments continue to accumulate within the leaf area.




Red soil runoff spread into the sea and settle.
(Sediment is partially flowing out from outlet.)

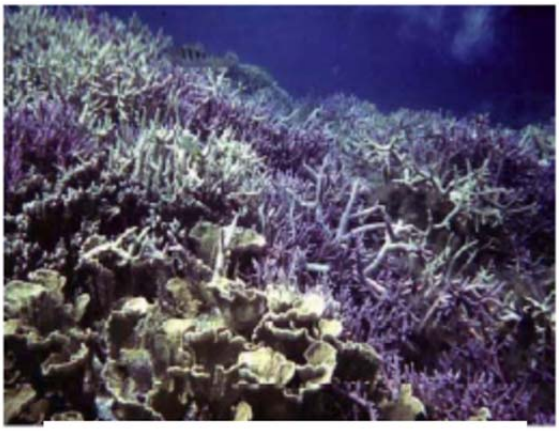
### (3) Turbid Sea Water induced by agitation of bottom sediments.

Red soil sediments are agitated by tidal movements and rough wave actions, inducing turbidity within the reef. As red soil runoffs from the land continue to flow into the sea, turbidity of the sea water continue to remain inside the reef.

## 1-2. Impact of Red Soil Runoff

### (1) Pristine Condition of Coral Reefs

Okinawa prefecture consists of many island surrounded by shallow water where beautiful coral reef is well developed. Branching coral provides a good habitat for small animal such as crabs and shrimps, which in turn attract fishes, creating a rich coral reef ecosystem. Coral reefs not only serve as natural breakwater to protect the islands but also bring big blessings to the lives of people.



Sea area with a dense *Acropora* colony

### (2) Impact to Coral Reefs

Not only the coral reefs but also tidal flats, sea grass beds extend in the area along with sandy beaches and mangrove forest. This rich natural environment provides scenic sites and recreational areas.

When red soil sediments accumulate in coral reefs, population of live coral will decrease. As small animals lose their habitats in the branching *acropora*, fishes feeding on the small animals also disappear.

Sea grass polluted by red soil

In addition, red soil runoff dispersing into the sea and beaches will cause red soil pollution. The pollution leads to deterioration of scenic landscape which has an impact to the tourism and recreational activities such diving and other marine sports.

In fisheries, turbid water cause decline of cultured mozuku sea weeds; red soil particles clog set nets. In head waters, turbidity presents possible deterioration of water quality

## 4. Okinawa Prefecture Red Soil Runoff Control Ordinance

### 2-1. Overview of Okinawa Prefecture Red Soil Runoff Control Ordinance

The purposes of this ordinance which became effective in October 1995 are the containment of red soil erosion caused by development project activities and promotion of control measures for water quality deterioration in rivers and sea by red soil runoff.

#### (1) Contents of Main Ordinance

**1) Requirement for Red Soil Runoff Control (Article 3)**

Project operators are required to take counter measures deemed necessary to prevent red soil erosion from the project site.

**2) Application and Reporting of Project Operations (Article 6 and Article 9)**

Project operators (private/public) who plan to develop an area of 1,000 ㎡ or more, must report the details of project and red soil runoff control countermeasures to the Governor for reviewing.

**3) Consultation and Orders to Change Plans (Article 9 Item 3, Article 10)**

When necessary, the Governor is authorized to issue an order to change project plan after reviewing the contents of project plan based on the Standard for Okinawa Prefecture Red Soil Runoff Control Facility.

#### (4) Designation of Chief Officer Responsible for Red Soil Runoff Control (Article 12)

The specified project operators should appoint a person responsible for implementation of red soil runoff control measures.

#### (5) Orders for Improvements (Article 14)

When project operators do not comply with Governor's order to change the plan, the Governor may issue an order for necessary improvement, or temporary suspension.

**Discontinuance of Development Acts (Article 15)**

When project development work is terminated /suspended, the project operator must notify the Governor. The Governor can issue an order for the project operator to implement necessary measures when he/she finds that the red soil runoff control measures taken are not sufficient.

#### (6) Suspension Order for Unlicensed Development Works (Article 16)

The Governor can issue an order to terminate/suspend the project operation when such operation was implemented without proper notification to the Governor.

#### (7) Management of Farmland and others (Article 17~19)

Manager of farmland and vacant lot, must make efforts to implement red soil runoff control measures. When red soil runoff form such areas is found, the Governor can give directions the land/farm manager to control such runoff.

### 9) On-Site Inspection (Article 20)

The Governor shall have the authority to direct on-site inspection by official staff.

### 10) Penalties (Article 25, Article 26)

When a person/staff violates the government order, the employer (sub-contractor) of the staff as well as the contractor of the project shall be subject to penalty of fine.

## 2-2. Flow of Repot/Notification Procedures

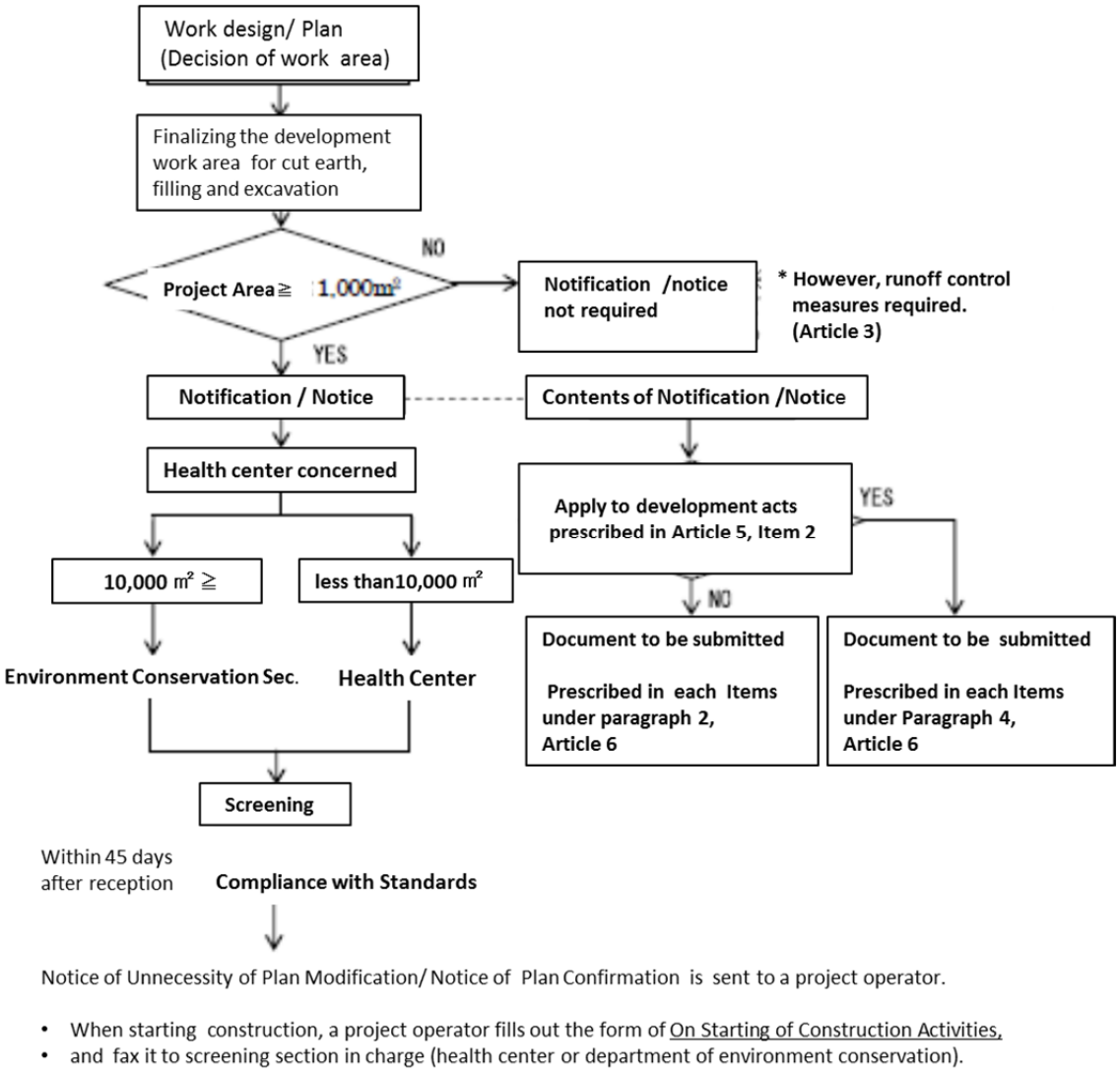



**Fig. 2-2-1 Flow of Report/Notice Procedure for Okinawa Prefecture Red Soil Runoff Control Ordinance**

## 3 The Basic of Red Soil Runoff Control

### 3-1. The basic concept of Red Soil Runoff Control Measures

Turbid water is generated by a series of actions such as infiltration of rain water to soil, destruction of soil structure by rain drops, and dispersion of soil particles into water, followed by erosion/transportation by surface runoff.

Red soil runoff control requires measures specific to a series of runoff process from generation of turbid water to drainage to outside of construction area as indicated in fig.3-1-1. The basic concept of control measures includes 4 basic methods indicated below.

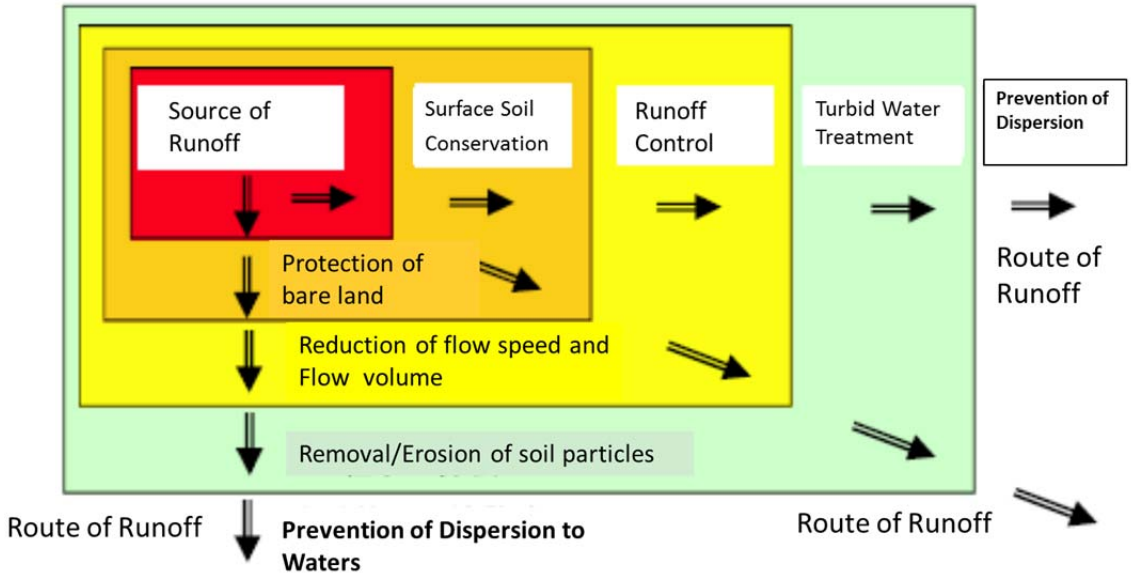



Fig. 3-1-1 Basic Concept of Red Soil Runoff Control Measures

**(1) Surface Conservation: Control of Turbid Water Generation**

Surface is conserved by reduction of bare soil, which is the source of turbid water, minimization of bare soil exposure duration, and conservation of bare soil at early stage.

**(2) Runoff Control: Control of Surface Runoff**

Measures are implemented to reduce surface runoff speed, to promote infiltration for reduction of surface runoff energy and to reduce the volume of turbid water by diverting surface runoff from in/out of construction plot.

**(3) Turbid Water Treatment:**

Turbid water is stored temporarily for settling and filtering of soil particles and discharged at a below the required standard level.

### (4) Dispersion Control: Dispersion of Red Soil to Sea

When implementing works near rivers, seashores and ports, contractors are required to provide measures to control dispersion of turbid water from work area .

The figure below is a summary of red soil control system and classification.

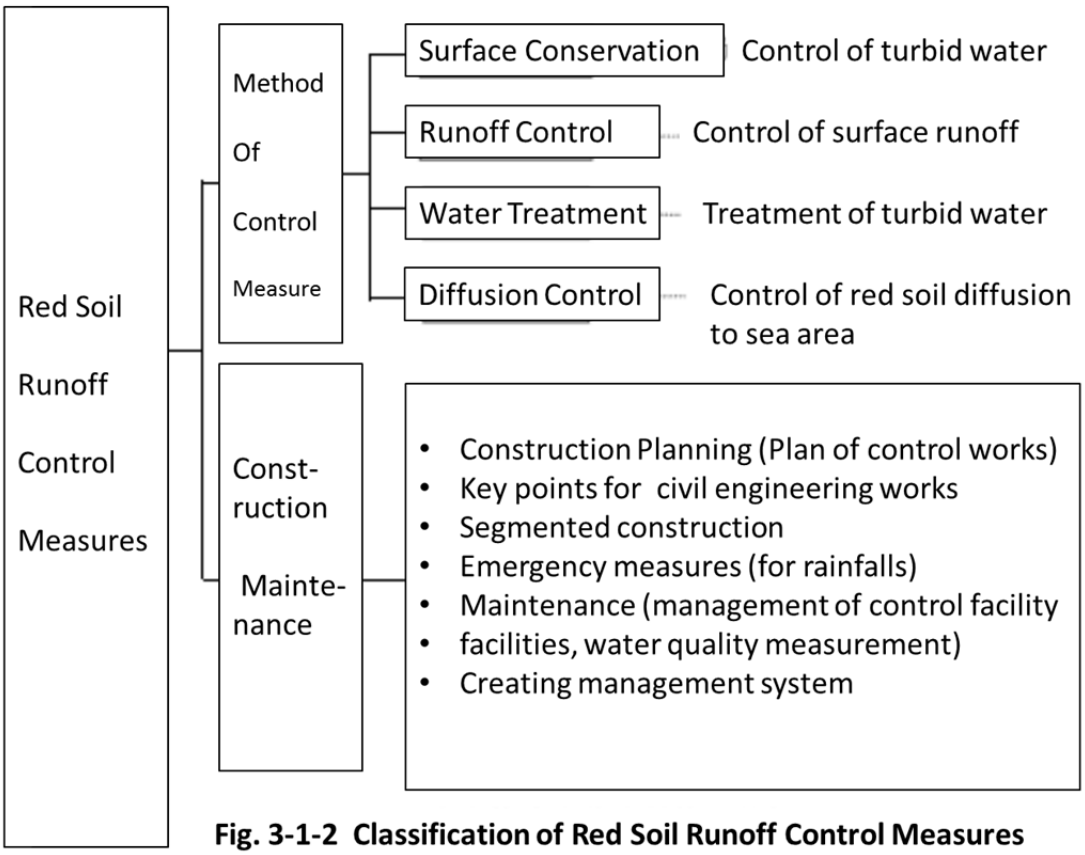
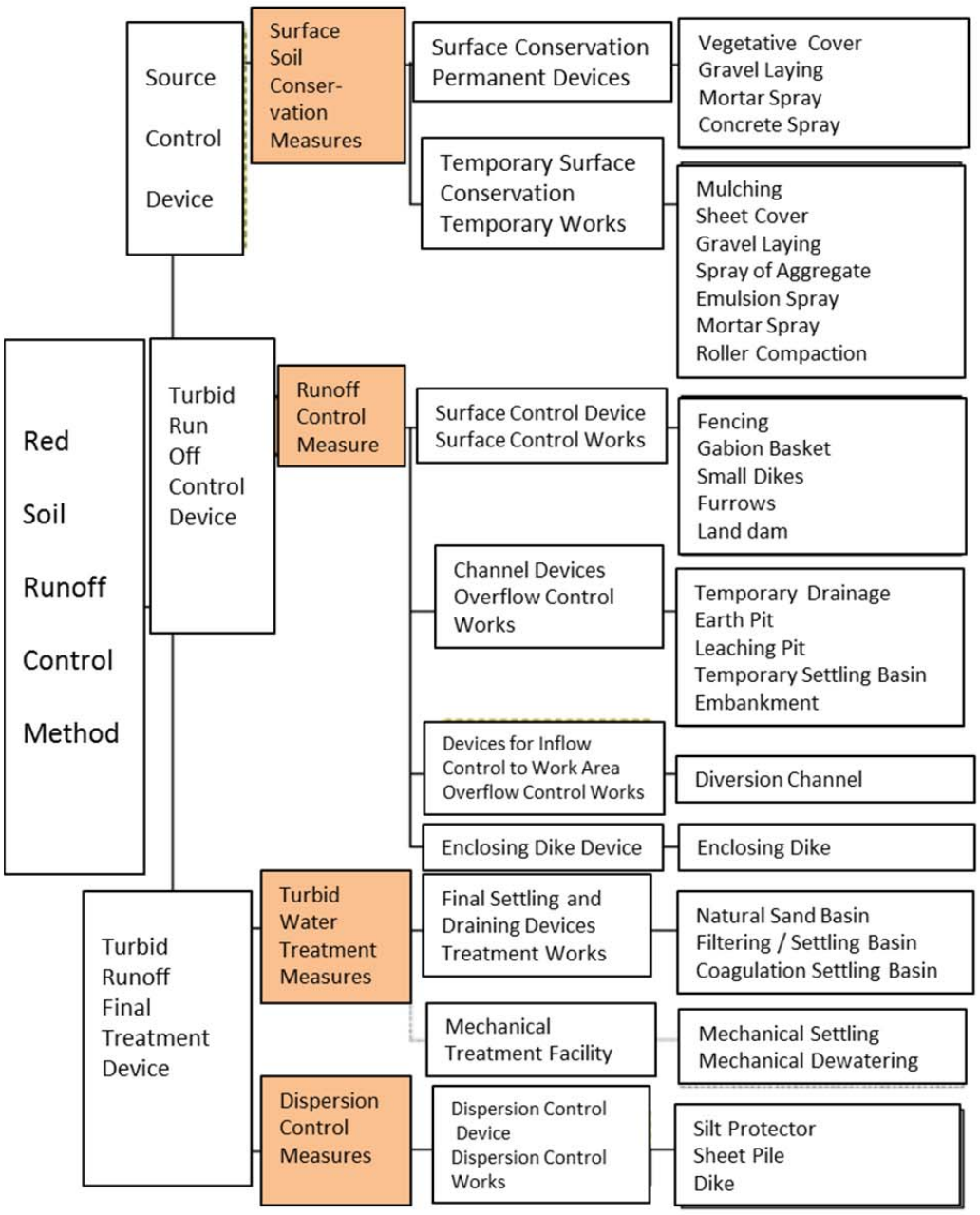



**Fig. 3-1-2 Classification of Red Soil Runoff Control Measures**

### 3-2. Classification of Red Soil Runoff Control Methods

Red soil runoff control methods are indicated in fig.3-2-1.

Under the 4 basic concept of red soil runoff control methods, 4 major works are identified such as surface conservation works, runoff control works, and turbid runoff treatment works, and dispersion control works. The basic principle is that these 4 control methods are systematically implemented in each construction area.




注 2. 4 basic concept to control red soil runoff

3-3. Layout of Red Soil Control Works

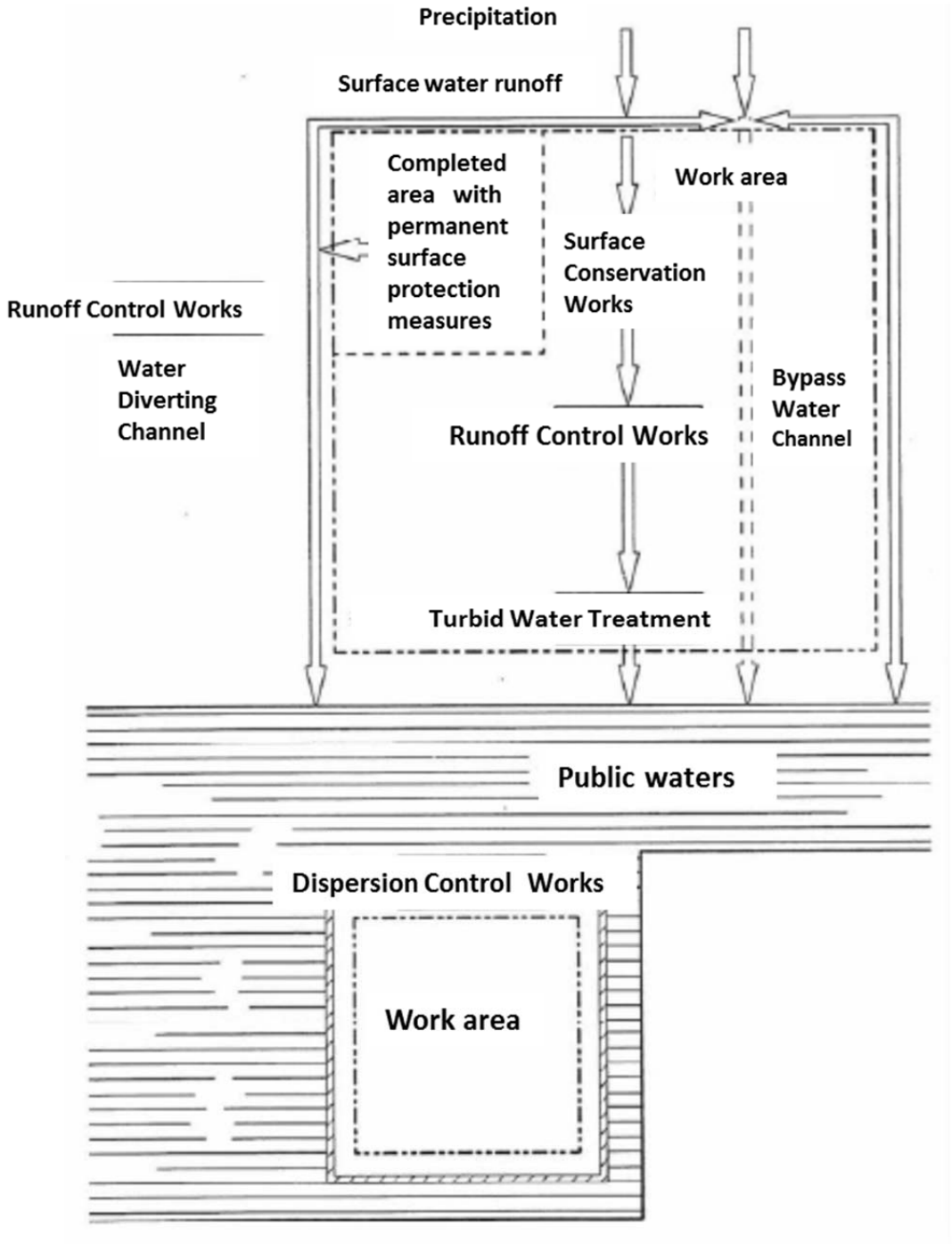



Fig. 3-3-1 Layout Plan for Red Soil Runoff Control Works

### 3-4.1 Facility Standards on Red Soil Runoff Control Ordinance (1)

<table>
<tr><th colspan="4">Category</th><th>Facility Standard</th></tr>
<tr><td rowspan="2">Source Control Devices</td><td rowspan="2">Surface Conservation Works</td><td>Surface Conservation Devices</td><td>Vegetative Cover, Sawing, Soil Aggregating Chemical, Spray of seed, mortar, concrete</td><td rowspan="2">*Bare soil exposed by construction work should be quickly covered.<br>*Unfinished surface is covered immediately by temporary devices.<br>*For farmland with enclosing dike, use of mulching is sufficient.</td></tr>
<tr><td>Temporary Surface<br><br>Conservation</td><td>Sheet Cover, Mulching, Asphalt Emulsion, Aggregating Chemical, Seed Spray</td></tr>
<tr><td rowspan="2">Turbid Runoff Control Devices</td><td rowspan="2">Runoff Control Works</td><td>Runoff control And Water Channel Devices</td><td>Small Dike, Water Channel, Fence, Gabion Basket</td><td>*A combination of these devices is used according to the progress of civil engineering works.<br>*Small dike is made every 40m when slope inclination is less the 2 degree, every 30me when inclination is 2~3 degree, and add more when the inclination is over 3 .<br>*Small dikes are made on the shoulder and bottom of the slope.<br>*Slopes are made of bare soil surface to direct runoff to diversion channel</td></tr>
<tr><td>Devices to control inflow of water to the plot</td><td>Diversion Channel</td><td>* Diversion channels should be constructed prior to civil engineering works.</td></tr>
</table>

**Table 3-4-2 Facility Standard on Red Soil Runoff Control Ordinance (1)**

| Category | | | | Facility Standard |
|---|---|---|---|---|
| Turbid runoff Control Devices | Runoff Control Works | Enclosing Dike Devices | Enclosing Dikes | This is used in farmland where storage and underground infiltration are relatively easy, in lime stone area, or in temporary work site for small-scale development. |
| Turbid water Final Treatment Devices | Turbid Water Treatment Works | Final Settling and Draining Devices | | Turbid water storage capacity should be 150 ㎥ or more per 1,000 ㎡. This capacity can be reduced when discharge standard is cleared by additional use of filtering devices. |
| | Turbid Water Dispersion Control Works | Dispersion Control Devices | Sheet Pile Silt Protector | These devices are used when civil engineering work is done underwater or near water. |

4 basic control works identified under the red soil runoff control measures.

**Table 3-4-3 Management Standard on Red Soil Runoff Control Ordinance**

| Category | Management Standard |
|---|---|
| Effluent Standard For Turbid water | Turbid water is promptly discharged when SS reaches 200mg/L or below and reading value should be recorded. |
| Maintenance of Facilities | Visual patrols of facilities are implemented and results are recorded. When alert is found in the facilities, immediate measures should be taken to improve the situation. |
| Removal and Disposal of Red Soil Sediment | Red soil sedimentation in the facilities should be removed and adequately disposed. |

## 4. Planning and Maintenance of Red Soil Runoff Control Measures

### 4-1. Planning of Control Measures

In planning of red soil control measures, information gathering and on-site survey to assess the conditions of location and surrounding environment become crucial so that appropriate measures to the site condition can be implemented. Table 4-1-1 can serve as a check sheet to assess the conditions of location and surrounding environment.

(1) **Conditions of Location:** Downstream monitoring points such as topography (runoff routes and end), drainage routes, spring water, soil, rainfall.

(2) **Conditions of Surrounding Environment:** Use of catchment area (intake stations, fishing grounds, resorts and so on), land use of surrounding area, rare fauna and flora.

(3) **Others:** Activities of catchment area coordination council, information on other red soil runoff control facilities in surrounding areas.

**Table 4-1-1 Check Parameters for Survey**

| Category | Sub Category |
|---|---|
| Construction Title | |
| Location | |
| Soil & Geology | |
| Rivers within work site (When bypass channel is required) | Upstream Catchment area |
| | Flood discharge (recurrence interval) |
| Status of downstream | Utilization for leisure activities (camping sites and the like) |
| | Water intake (types/management) |
| | Existing red soil control facilities |
| | Red soil monitoring facilities in the vicinity |
| Red Soil Runoff Status | Status of upstream land use |
| | Status of rivers for discharge (photos(distant/near view) |
| | Status of red soil sedimentation (photos, water quality( SS )) |
| Status of Downstream Sea Area | Runoff routes and sea area. |
| | Fishing rights and fishing ports concerned |
| | Status of sea farming |
| | Utilization for fishing and swimming |
| | Resort Facilities |
| Remarks | Distribution status of rare fauna & flora on site and its vicinity |

### 4-2. Construction Planning / Maintenance

In creating a construction plan, one needs to assess key points of required measures according to the stages of construction and its progress. Key points for making a construction plan is indicated below.

#### (1) Segmented Construction within Work Area

In order to minimize bare soil area on site, construction is implemented in segments according to the construction plan. After surface conservation works are completed in a segment, construction work in other segment should begin as a basic principle.

#### (2) Preparation of Quarterly Red Soil Control Plan

Based on construction progress plan every quarter, forecast is made for generation of turbid water and runoff routes in every stage of construction. According to the forecast made, construction time table is made for planning layout of runoff control facilities and drainage channels. Key points for maintenance are described below.

#### (3) Clarification of Roles and Assignment of Chief Officer

As indicated in fig.4-2-1, A chief officer for red soil runoff control management (on-site agent) is assigned and persons in charge are designated for each task.

#### (4) Preparation of Suspended Solids Measurement Log and others

As stipulated in Red Soil Runoff Control Ordinance, the forms for 1) suspended solids measurement log, 2) a check sheet for site patrol in rainy weather, and 3) emergency report should be prepared for management of the site, and submitted according to the regulation.

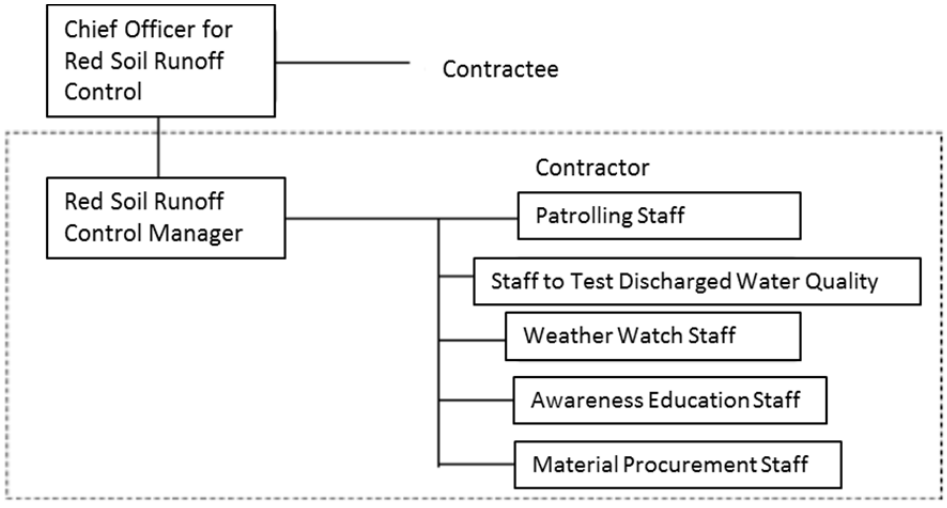



Fig. 4-2-1 Management System for Red Soil Runoff Control

## 5. Outline of Red Soil Runoff Control Methods

### 5-1. Outline of red soil runoff Control in Development Works

#### (1) Overview

##### 1) Measures Against the Sources of Runoff

Turbid red soil runoff is caused by erosion when rainfall hits bare soil surface (source of runoff) exposed by landslides and developments. This runoff can be controlled by covering the bare soil surface so that rain fall will not hit the soil surface directly. Thus surface conservation works are identified as a countermeasure against the source of runoff by covering the soil surface.

Various types of surface conservation works are available such as artificial cover works with various cover materials such as earth work sheets, and vegetative cover works with seed spraying and turf. Controlling the sources of runoff is the primary measure and applicable to all scale of development works regardless of the scale requirement of Okinawa Prefecture Red Soil Runoff Control Ordinance (development area of 1,000 or more).

##### 2) Measures Against Turbid Runoff

In order to control turbid runoff to the outside of construction area (or inflow to the work area), diverting channels, small banks and soil runoff control embankments are constructed around the work area when needed. These measures basically control the movement of turbid water of red soil, and direct to final treatment devices. As for the soil runoff control fences and weirs, filtering function is added to the structure by using materials such as sand, tree branches and grass, chemical non-woven fibers, and coconut fibers, in order to reduce the flow volume of turbid water.

##### 3) Measures for Final Turbid Water Treatment

Okinawa Prefecture Red Soil Runoff Control Ordinance basically requires construction of sand settling basin for a development area of 1,000 ㎡ or more. This basin with capacity to store a continuous rainfall of 150 mm will allow turbid matter to settle after the rainfall and then to discharge a clear surface water (natural settling basin).

When enough basin capacity cannot be secured, filtering settling basin or coagulating settling basin is constructed.

### (2) Details

Outline of engineering works to Control red soil runoff is indicated in table 5-1-1~12.

**Table 5-1-1 Construction Method for Red Soil Runoff Control (1)**

| No. | Category | Sub Category | Construction Method | Outline of Method |
|---|---|---|---|---|
| 1-1-1 | Source Control Devices | Surface soil Conservation Devices | Vegetative cover | Control runoff by covering bare soil surface with vegetation |
| 1-1-2 | | | Gravel laying | Control runoff by laying relatively larger size of gravels |
| 1-1-3 | | | Mortar spray | Control runoff by spraying mortar to bare soil surface |
| 1-2-1 | | Temporary Surface Soil Conservation Devices | Mulching | Control runoff by covering bare soil surface with dry grass such as silver grass |
| 1-2-2 | | | Sheet cover | Control runoff by covering bare soil surface with sheets |
| 1-2-3 | | | Gravel laying | Control runoff by laying relatively large gravels |
| 1-2-4 | | | Spray of Chemical Aggregates | Surface red soil particles are aggregated to prevent erosion |
| 1-2-5 | | | Spray of emulsion | Control runoff by spraying emulsion to cover bare surface |
| 1-2-6 | | | Mortar Spray | Control runoff by spraying mortar to cover bare surface. |
| 1-2-7 | | | Roller Compaction | Control unfinished bare construction surface by compaction with roller. |

Table 5-1-2 Construction Method for Red Soil Runoff Control (2)

| No. | Category | Sub Category | Construction Method | Outline of Method |
|---|---|---|---|---|
| 2-1-1 | Devices For Controlling Turbid Runoff | Runoff Controlling Devices | Fencing Works | Control erosion by reducing runoff speed by fences made of bamboo, net and brushwood |
| 2-1-2 | | | Gabion Basket Works | Control slope collapse and erosion by reducing runoff speed with wire basket filled with stones |
| 2-1-3 | | | Small Dikes | Control runoff by spraying mortar to bare soil. |
| 2-1-4 | | | Furrows | Furrows are set at an angle to the slope to slow down runoff and direct it to a temporary drainage |
| 2-2-1 | | Water Channel Devices | On-site Temporary Water Channel | This will direct turbid runoff to final water treatment devices, or discharge clear runoff to outside of work area. |
| 2-2-2 | | | Earth Pit | This will slow down runoff speed, facilitate leaching in to the earth, and settle a coarse sediment |
| 2-2-3 | | | Leaching Pit | To control surface runoff, this pit will reduce total volume of runoff in a catchment area |
| 2-2-4 | | | Temporary Sand Settling Basin | Reduce the total volume of runoff in the work area |
| 2-2-5 | | | Embankment | This will contain surface runoff inside the construction site |
| 2-3-1 | | Water Diverting Devices | Diversion Channel | This diverts surface water to outside the work area to prevent inflow to the work area |

Table 5-1-3 Construction Method for Red Soil Runoff Control (3)

| No. | Category | Sub Category | Construction Method | Outline of Method |
|---|---|---|---|---|
| 3-1-1 | Devices For Final Treatment of Turbid Water | Final Settling and Draining Devices | Natural Settling Basin | Remove red soil particles by letting the turbid water to flow in for natural settling. |
| 3-1-2 | | | Filtering Settling Basin | Remove red soil particles by letting the turbid water to flow in for filtering & settling. |
| 3-1-3 | | | Coagulation Settling Basin | Remove red soil particles by adding coagulant to turbid water to settle |
| 3-2-1 | | Turbid Water Control Devices | Silt Protector | Control diffusion of turbid water by setting silt protector |
| 3-2-2 | | | Sheet Pile | Control diffusion of turbid water by setting sheet piles |

In the following pages, key points for various countermeasures on site are discussed.

## 5-2. Outline of Red Soil Runoff Control in Farm Lands

### (1) Overview

#### 1) Countermeasures in farm land

Consistent implementation of countermeasures in farm lands is difficult in some cases due to an additional cost for farmers, shortage of labors, and occasional drop in crop quality. However, since surface runoff from the farm lands leads to decline in farm productivity, implementing measures against runoff is not always a negative factor to farmers.

For farmlands, seasons for postharvest, regeneration, and seeding present problems when farmlands are in bare condition. Therefore, consideration of relatively easy measure becomes necessary. It is desirable to implement measures that will not only control soil runoffs but also promote growth of crops. (Fig.5-2-1)

2) Major methods of red soil run-off control in farm land

From the viewpoint mentioned above, methods such as intercropping (cultivation other crop between ridges thus leaves no bare land), reduced tillage farming (tillage is done for planting section only) to control emergence of bare land, and use of mulching, green manure, and green belt are being studied and implemented.

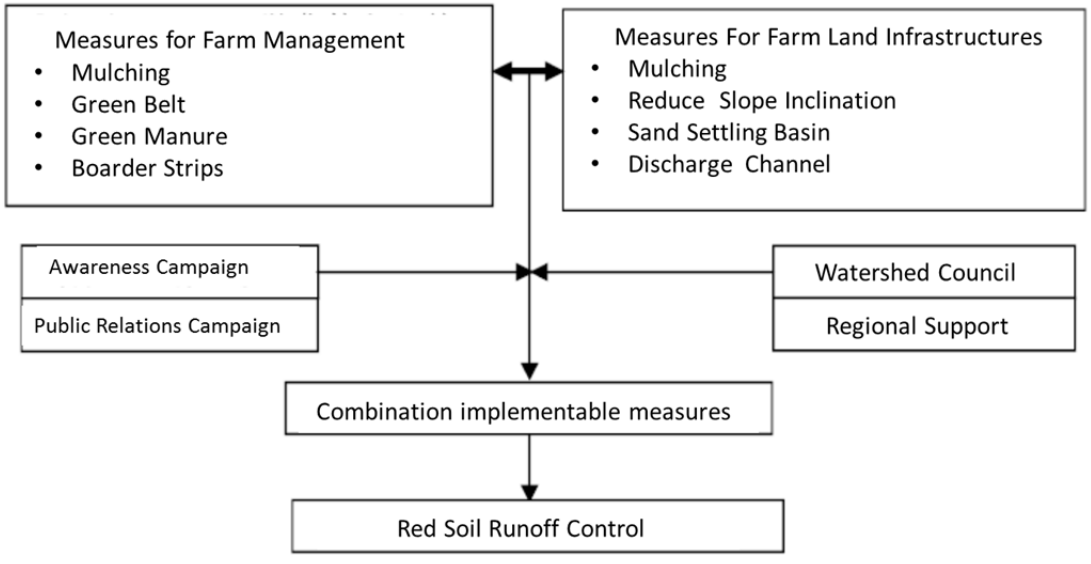



**Fig. 5-2-1 Concept of Red Soil Runoff Control in Farm Lands**

Additionally, in land improvement projects, reduction of farm slope inclination is implemented. (Tale 5-2-1)

### (2) Details

As implementing a single method is not enough to control turbid runoff of red soil, a combination of method that is suitable for the site becomes necessary. In table 5-2-1, outline of measures to control red soil runoff in farm lands is indicated.

| No. | Category | Sub Category | Construction Method | Outline of Method |
|---|---|---|---|---|
| 4-1-1 | Farm Management Measures | Source Control | Mulching | Control red soil runoff by covering bare soil with some some leaves such as cropped cane leaves. |
| 4-1-2 | | Farm Slope Lower Border Control | Border Strips | Control red soil runoff by planting vegetation such as ginger around farm boarder. |
| 4-1-3 | | | Green Manure | Minimize a bare soil during furrow period by plating cover vegetation. |
| 4-1-4 | | | Dikes | Control soil runoff by placing bundles of cane leaves on dikes |
| 4-2-1 | Civil Engineering Measures | Source Control | Reduction of Farm Slope Inclination | By reducing slope inclination, speed of runoff is reduced. |
| 4-2-2 | | Downstream Control | Sand Settling Basin Earth Pit | Turbid runoff from farm is directed to a pit or basin. After settling of red soils, clear surface water is discharged. |
| 4-2-3 | | | Drainage Channel | Diverting channel is created to divert runoff from outside of farm; drainage is constructed to drain turbid runoff from farmland. |

In the following pages, key points for various measures on site and guidelines are illustrated.