1

PICTURE BOOK THE GOOD & THE BAD INFRASTRUCTURE

ROAD & BRIDGE

THE WORLD BANK
Decentralization Support Facility
Social Development
THE WORLD BANK
COMMUNITY DRIVEN DEVELOPMENT

PICTURE BOOK
THE GOOD AND THE BAD INFRASTRUCTURE

Road and Bridge

by :
Ekart Hartmann
Heinz Unger

Picture Book

The GOOD and The BAD Infrastructure

Road and Bridge

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Published by :
World Bank Office, Jakarta
Decentralization Support Facilities (DSF) Office
Jalan Diponegoro No. 8
Jakarta 10310
Phone : (62-21) 3148175 (hunting)
Fax : (62-21) 31903090
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Printed in August 2006

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ISBN : 979-97428-4-6

INTRODUCTION

Development workers new to rural Indonesia are often surprised by how frequently villagers mention that their top development priority is to overcome their isolation. Hamlets want to be joined to villages; and villages want to have access to markets, schools, and hospitals. Ask a gathering of village men who live in remote parts of the country what tops their wish list, and eight times out of ten the answer will be that they would really like help to build a road or a bridge (just as many women will say access to clean water!).

Indonesia is not an easy environment for roads and bridges. Earthquakes and their aftershocks crack their foundations. Landslides cover them in mud. Tropical storms lash them with the most bitter enemy that any road can face: little droplets of water that wash away their foundations. Innocent grasses spring up overnight, sending out roots and tendrils that split road surfaces. Overloaded trucks crack their rocks, leaving behind deep ruts and cracked culverts.

Good engineering can help village roads survive many of the challenges that nature throwns at them. Even without the heavy equipment of modern road-building, simple technologies can produce perfectly good roads. A well-built road can last for ten years or more, even with little maintenance.

If good engineering can produce roads that bring the fruits of development to villagers, bad engineering can subtract years from the life of the roads and bridges built through the hard labor of rural people. Poor drainage means that water will pool, leaching away road surfaces. Badly placed, uncompacted rocks make for weak foundations that soon turn to washboard and mudpits. Soft anchors quickly produce collapsed bridges, even human casulaties. In short, engineering matters.

The purpose of this guide is to help village technical workers build better roads and bridges. It uses examples - both good and bad - drawn from nearly eight years of experience with the Kecamatan Development Program (KDP). Even though all construction done by community, using simple, labour-insentive, it does not mean that the quality is low.

The content of this book is easy to understand because each picture are complimented by simple explanation. Therefore, it can be used as technical training manual.

There is an expectation that this book may benefit not only in KDP but also other agencies, NGOs and community themselves. In order to serve its purpose, critics, inputs and recommendations from the reader would be highly appreciated for better revision in the future.

Finally, we would like to thank to all parties who gave assistance in preparing this book. We wish that this book could give a benefit for better infrastructure development in the community-based development projects.

ACKNOWLEDMENTS

All photographs and text were prepared by Ekart Hartmann and Heinz Unger based on the supervision missions conducted in several KDP locations; West Sumatra, South Sumatra, West Java, Central Java, South Sulawesi, South East Sulawesi, Bali and East Nusa Tenggara (NTT).

Octaviera Herawati oversaw the production of these texts from field survey to publication and provided Indonesian translation, with overall guidance from Victor Bottini. Sentot Satria provided invaluable assistance in selecting field locations.

Scott Guggenheim, Victor Bottini, Enurlaela Hasanah, Sentot Satria, Richard Gnagey and Suroso Yoso Oetomo also contributed comments and input. Field support was also provided by the National Management Consultant (NMC) in Jakarta and the Regional Management Unit (RMU) in the provinces listed above. Field staff facilitated visits to KDP sites.

Special thanks to Scott Guggenheim for his ongoing support.

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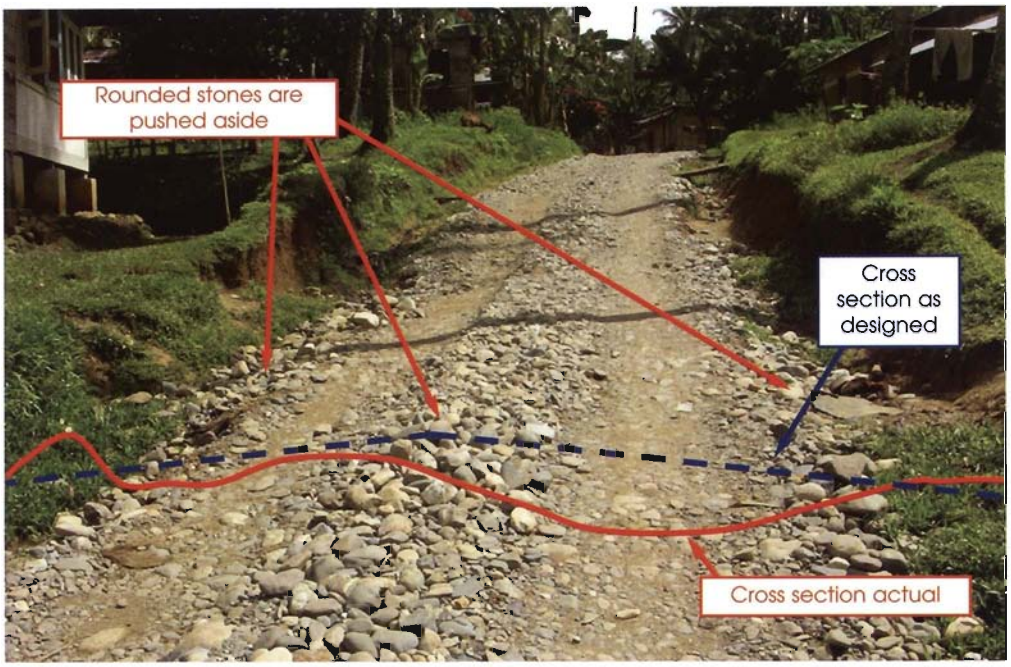
ROAD



River gravel is too round and is generally not suitable for road construction
(Picture shows a road 3 month after completion of construction)

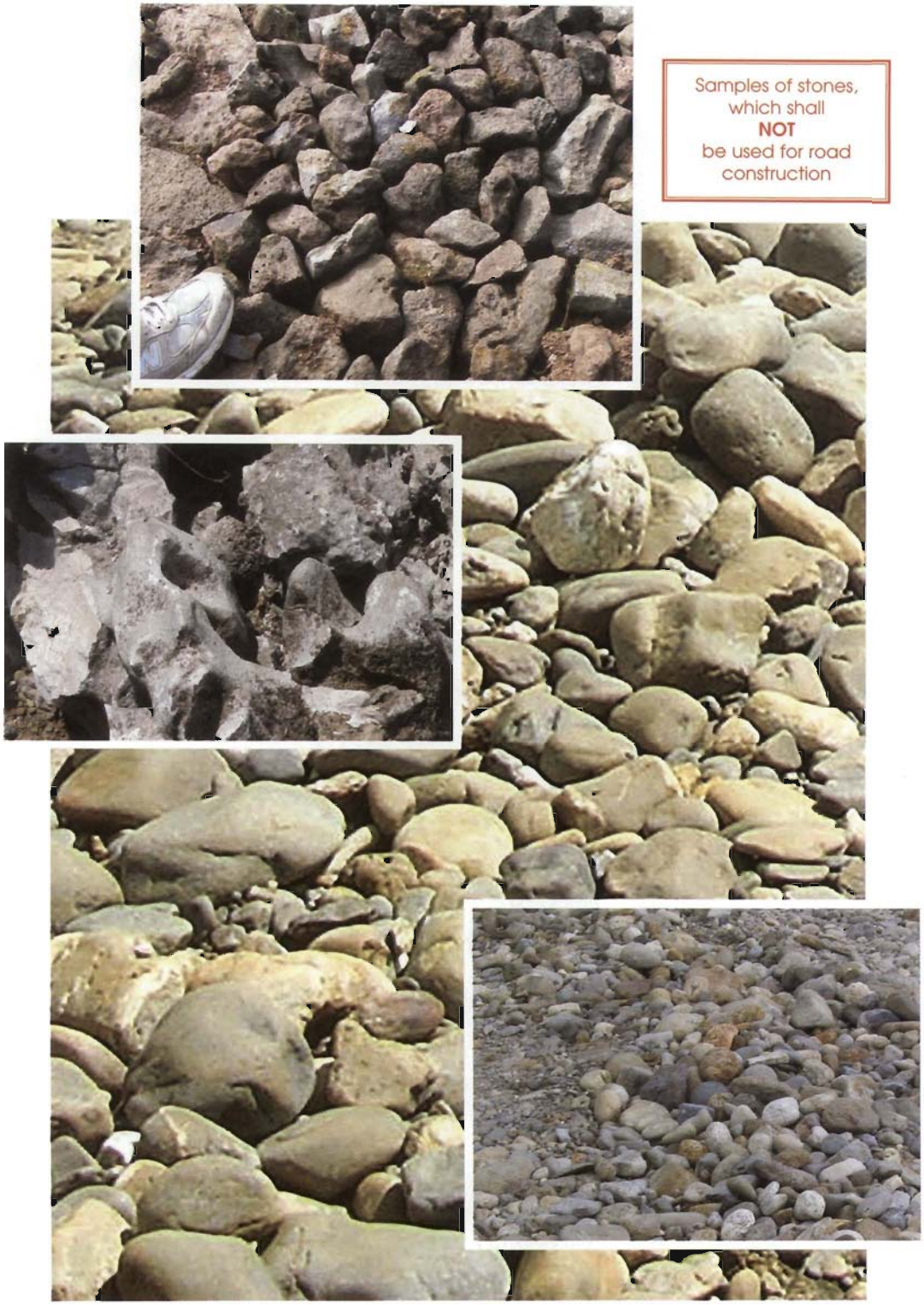
How can I do it better ?

GRAVEL ROAD - Surface Material

- **Compact the material with heavy equipment, and vibration if possible.**
- **Use angular stones with sharp edges.**
- **Check availability of suitable material prior to construction.**

WHY ?

- The stones for the surface layer shall be angular, rough and sharp-edged so that they interlock with each other.
- To make the road withstand traffic loads and minimize O&M work.
- The excavation of gravel from a river bed may cause changes to the flow of the river → Environmental Impact.


Samples of stones,
which shall
NOT
be used for road
construction

The material for the surface layer is too fine, not bound and not well compacted

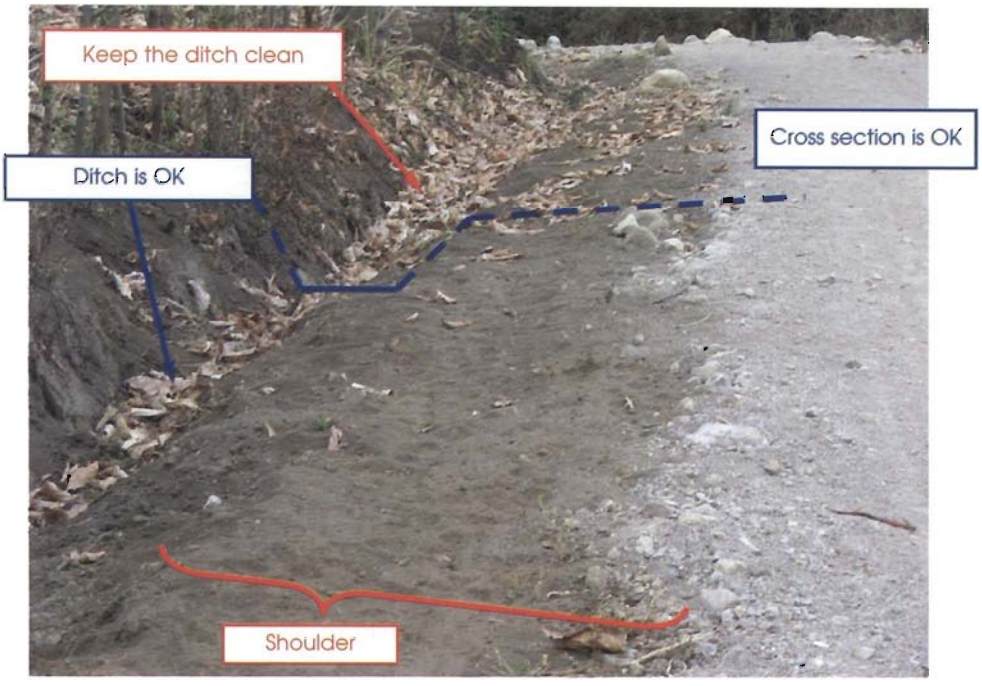
How can I do it better ?

GRAVEL ROAD - Surface Layer

- **Compact again and add a new layer of suitable stones on top.**

WHY ?

- The material for the surface layer shall be angular, rough and sharp-edged so that they interlock with each other.
- To minimize O&M work later on.
- Loosely compacted material will be washed out and driven off quickly.



The material on the shoulder is too fine and not well compacted

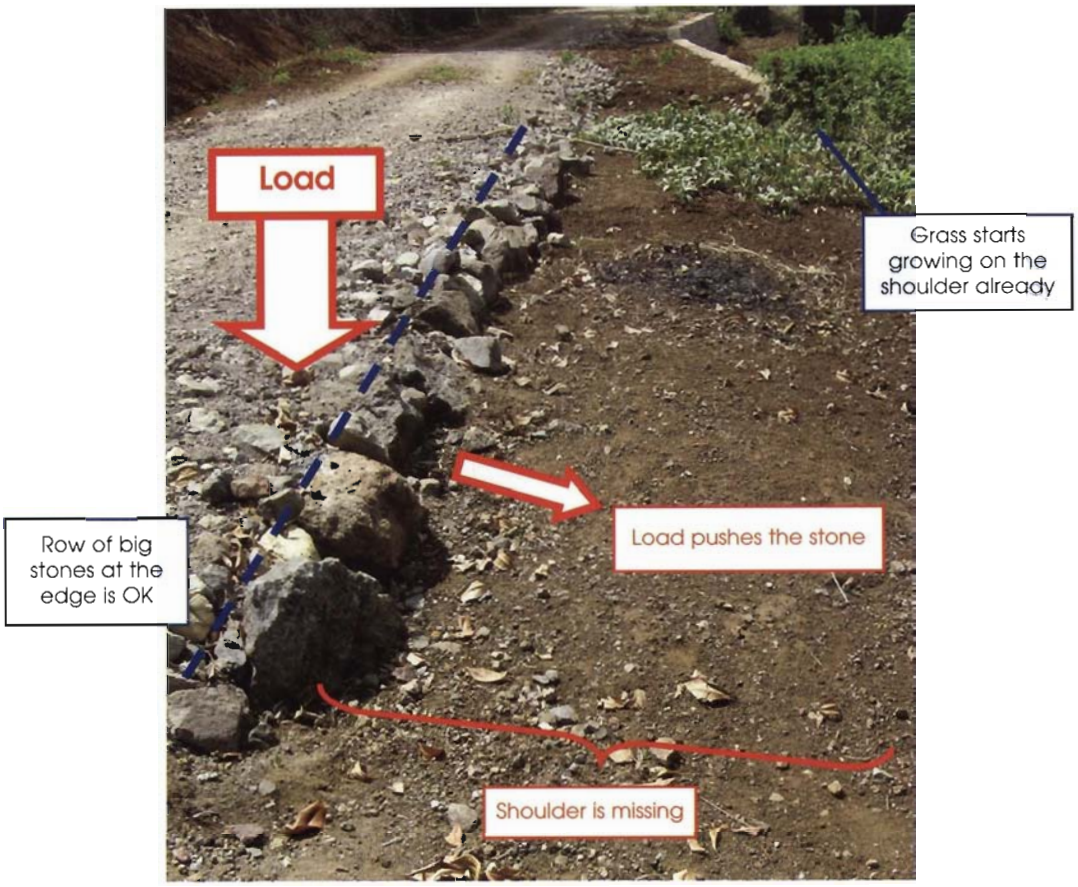
How can I do it better ?

GRAVEL ROAD - Shoulder

- **Compact the shoulder again and add a layer of angular stones on top.**

WHY ?

- The compacted shoulder gives lateral support for the road structure.
- The water flow from the road surface will not erode the shoulder, if the shoulder material is suitable and well compacted.



There is no side support for the big stones
Traffic loads will push the stones aside

How can I do it better ?

GRAVEL ROAD - Shoulder

- **Build a well compacted shoulder.**

WHY ?

- The big stones at the edge of the road must be supported by a solid shoulder, otherwise the stones will be pushed out and the road will fail.

Without O&M the road surface will soon become a lawn.

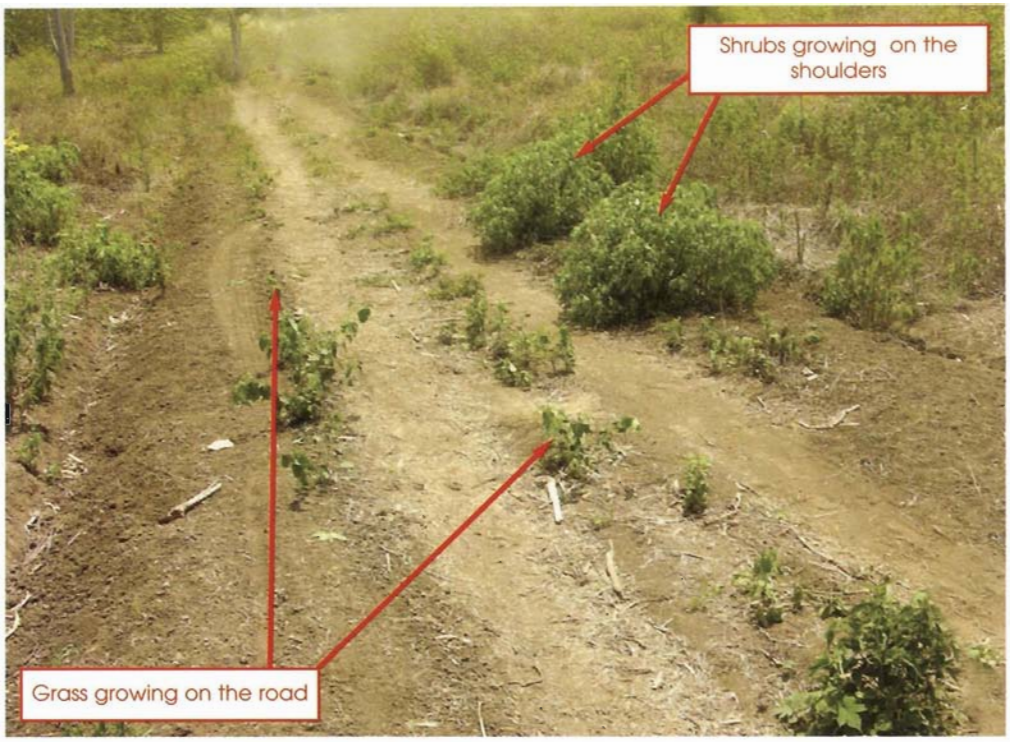
How can I do it better ?

GRAVEL ROAD - Vegetation

- **Cut the grass and remove the roots at least twice a year (O&M).**
- **Make sure that the road surface can drain freely to the ditch(es) by removing earth and vegetation regularly from the shoulders (periodic O&M).**
- **Build a crown for the road with a new gravel layer.**

WHY ?

- Grass is an indicator for poorly organized O&M.
- Without maintenance, grass will grow anywhere, even on a gravel road.
- Grass and plant roots will slowly damage the road.



Without O&M the road surface will soon be overgrown by vegetation
(Picture shows a road 4 month after completion of construction)

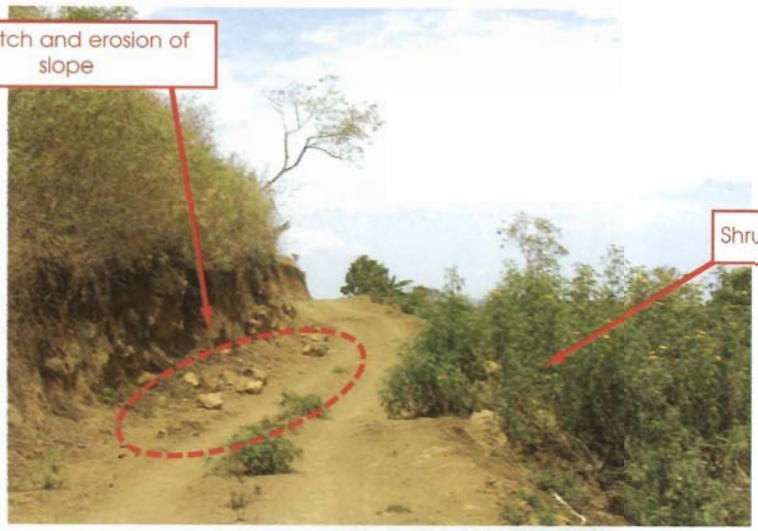
How can I do it better ?

GRAVEL ROAD - Vegetation

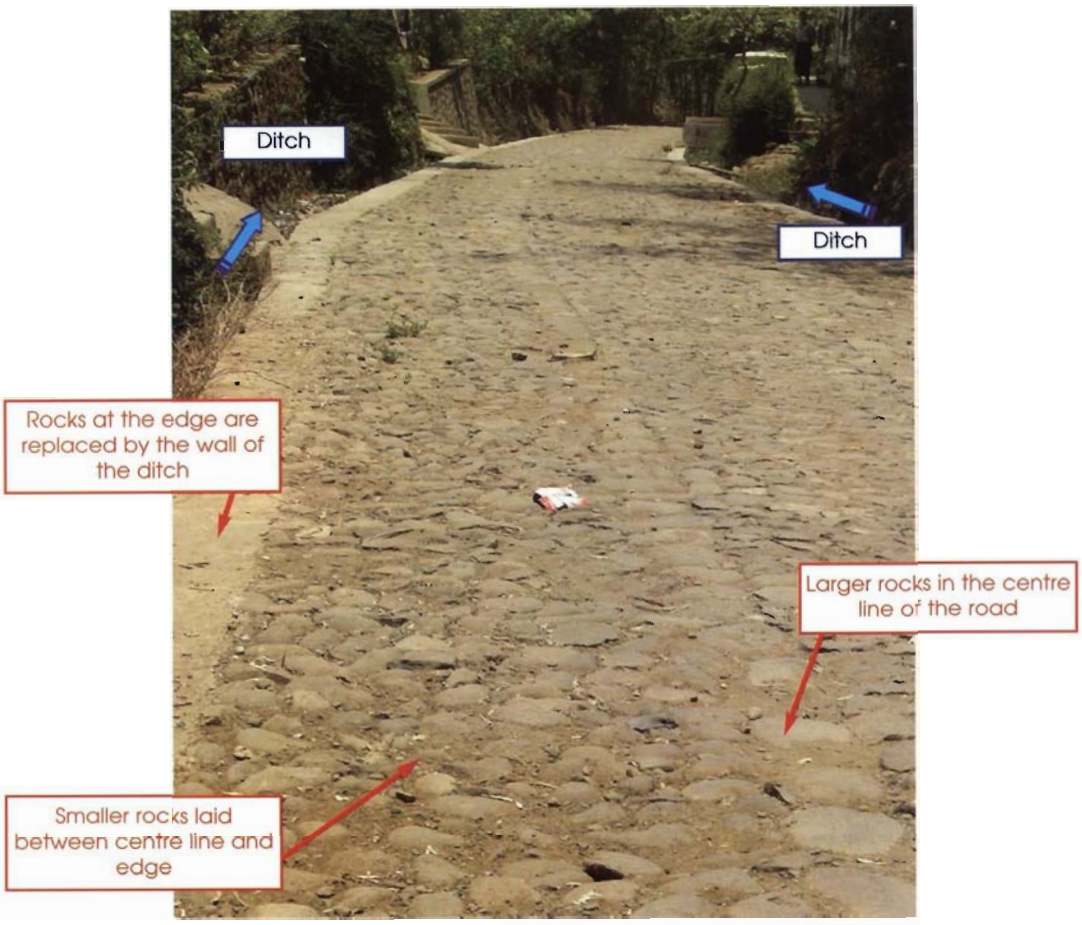
- **Cut all vegetation and remove their roots (O&M).**
- **Make sure that the road surface can drain freely to the ditch(es) by removing topsoil and vegetation regularly (periodic O&M).**
- **Build a crown for the road with a new gravel layer.**

WHY ?

- Grass is an indicator for poorly organized or not executed O&M.
- Grass will grow anywhere, even on a gravel road.
- Grass and plant roots will slowly damage road.



Part of O&M:
Keep the road free of vegetation



Telford road

How can I do it better?

TELFORD ROAD

- **Replace the bigger rocks in the centre line with the rocks which have the same size as in the right and left sides.**
- **Fill the cracks and holes with the sand and gravel mixture to make smoothens the surface of the road.**

WHY ?

- It would be difficult to make a good crown if the larger rocks placed in the centre line.

Alternative:

- A road with a concrete slab.

Construction details of a Telford road

How can I do it better ?

Telford Road

- Place the rock vertically. Larger rocks can be placed in the edge of road while in the middle should be place the rocks which have the same size and shall be angular, rough and sharp-edged.
- Make sure the rocks interlock each other.
- To get good crown, it must be started from the base layer and rocks will follow it.

Alternative :

- No alternative.

Sand layer is less than 10 cm thick and is not according to detailed design

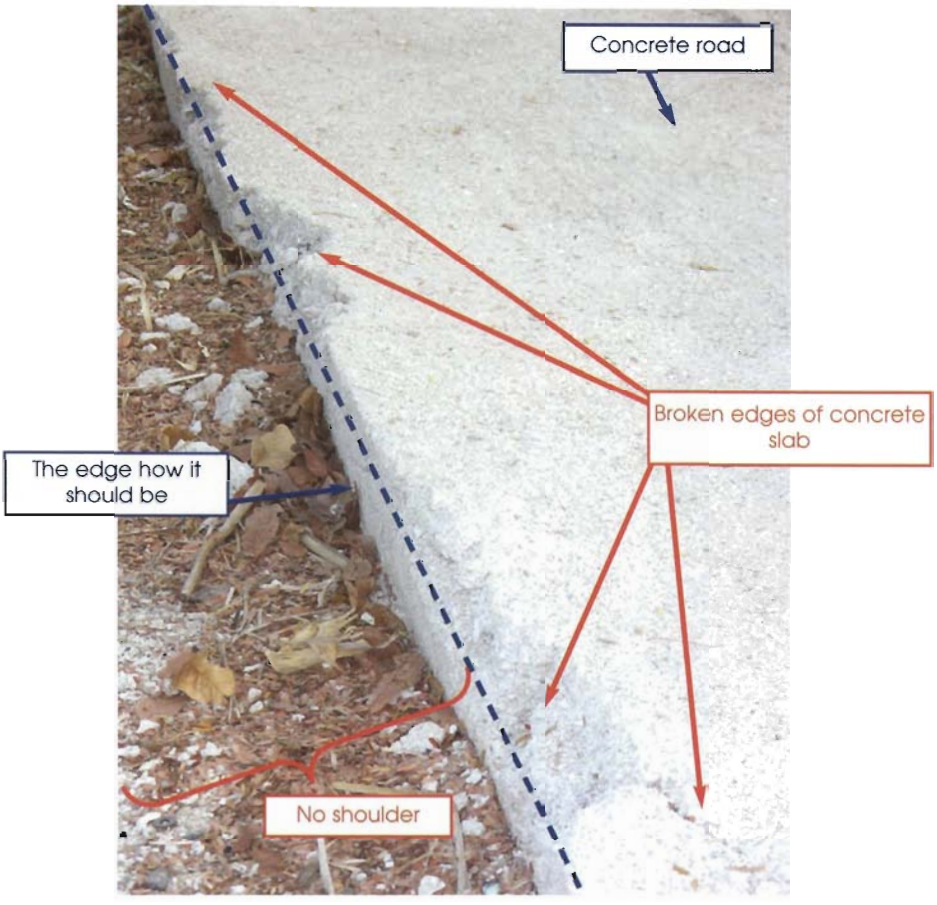
How can I do it better ?

TELFORD ROAD - Details

- **Check the thickness of the different layers against the design.**
- **Excavate more, if the excavation is not deep enough for road sub-base and base layers.**
- **In the case shown above, the sand bed was not thick enough.**

WHY ?

- The depth of the different layers are specified in the cross sections & specifications.
- If the layers are not done as specified, the road surface will break up fast, and will in a lot of repair and O&M work later.



Shoulder is missing and the edge of the road slab is broken

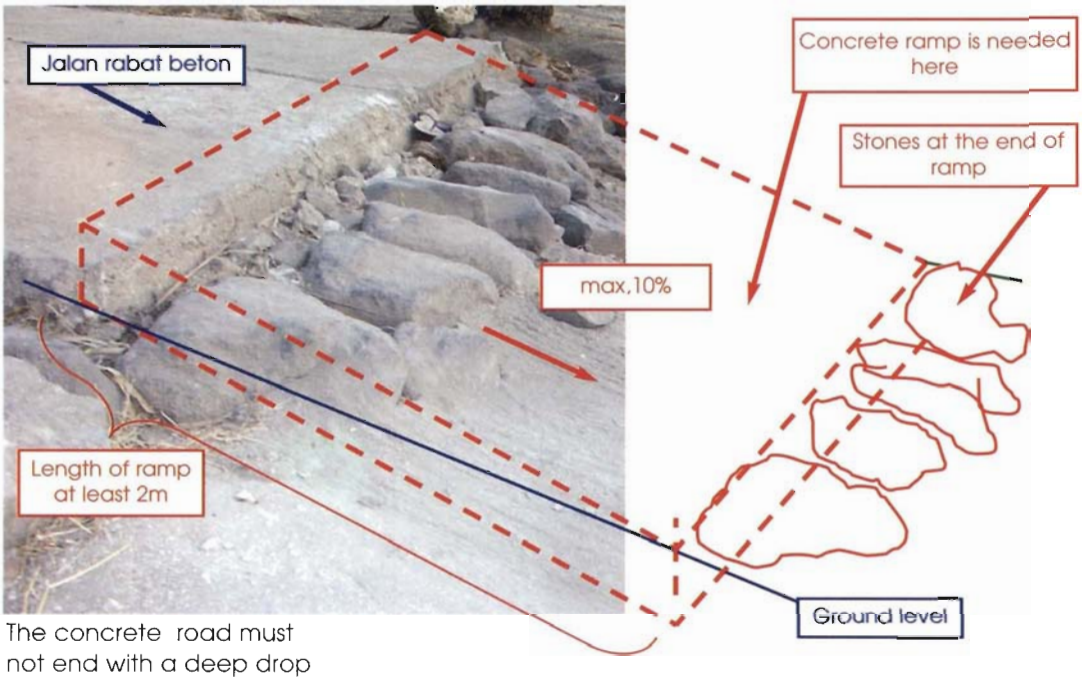
How can I do it better ?

CONCRETE ROAD - Detail

- **A compacted gravel shoulder will protect the edge of the road slab.**
- **Watch for the correct mixture of concrete (gravel / cement/ water) to get good quality concrete which does not chip off easily.**

WHY ?

- A shoulder should support and protect the edge of the road slab.
- Do not remove the formwork of the slab too early.
- Do not save cement - take the right mixture.



The concrete road must not end with a deep drop

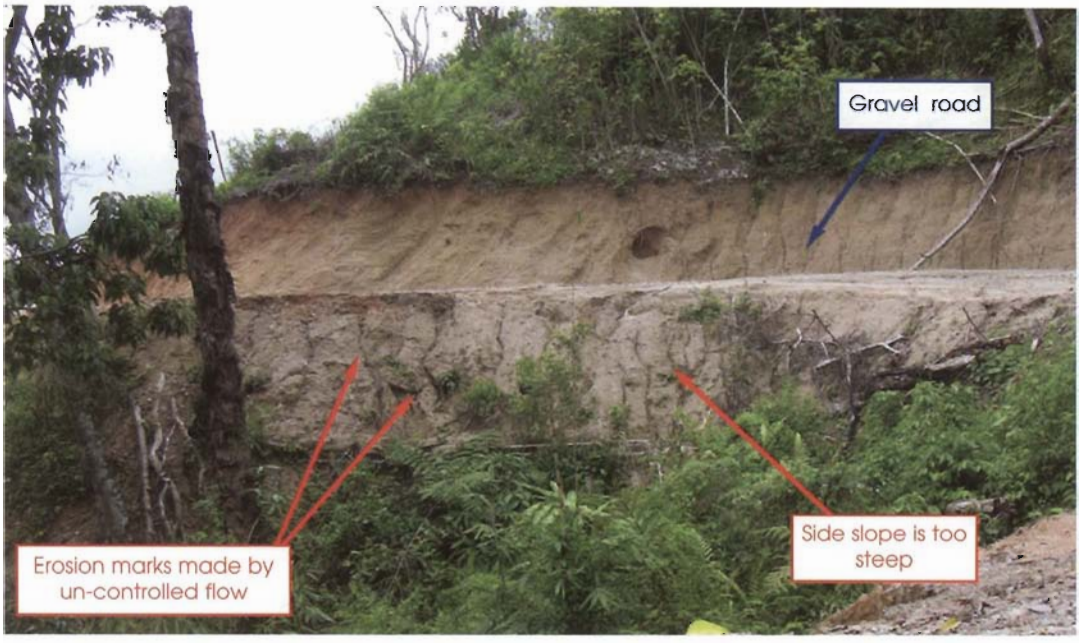
How can I do it better ?

CONCRETE ROAD - End of road

- **Build a concrete ramp at the end of the road slab.**
- **The last element of the slab must have a slope and is dug into the natural ground to get ramped transition.**
- **Place some larger rocks at the end of the ramp - top edge at the same level as the concrete.**

WHY ?

- Vehicles cannot drive over a deep drop without getting damaged.
- The rocks at the end of the ramp will protect the concrete edge.



No erosion protection of the fill (embankment) section
Side slope is too steep

How can I do it better ?

EARTH WORK - Fill Section

- **Consider the natural angle of repose of the material.**
- **Fill sections have to be compacted very well using heavy equipment.**
- **For steep slopes consider to build a stepped embankment for greater stability.**
- **Prevent uncontrolled water discharge from the road surface by sufficiently large drainage ditches and drain away from the down slope.**
- **Plant vegetations (shrubs, trees) on the steep slopes to increase stability.**
- **O&M has to keep an eye on the embankment until natural settlement has consolidated the fill.**

WHY ?

- The natural angle of repose of the fill embankment must be considered and the slope of the embankment must not be steeper.
- Flowing water causes erosion which will wash out steep.
- Roots of shrubs and trees can strengthen the fill section.

Consider the natural angle of repose of the material in the cut

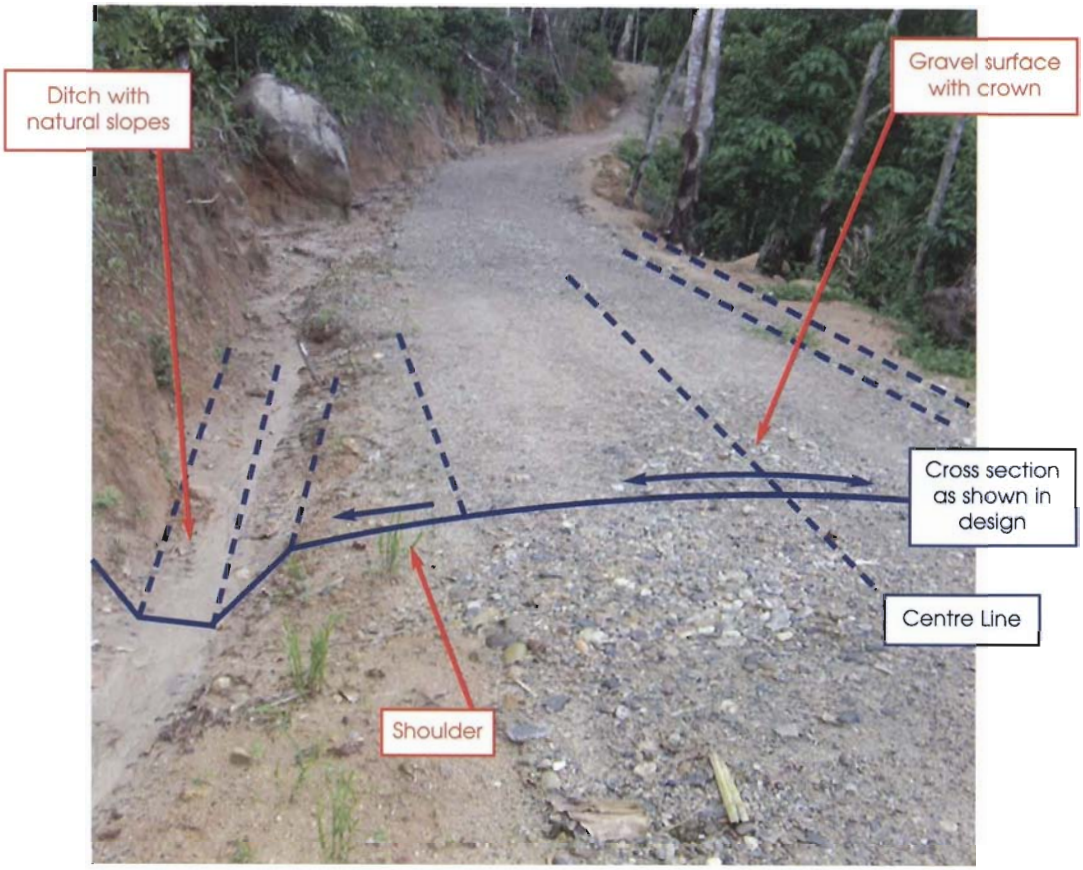
How can I do it better ?

EARTH WORK - Cut Section

- **Consider the natural angle of repose of the material in the cut section.**
- **Consider constructing a stepped embankment (terracing) to make steep slopes more stable.**
- **Make sure water can drain easily → sufficiently large ditches are needed.**
- **Plant vegetation (shrubs, trees) on the steep slopes to increase slope stability.**

Why ?

- Consider the natural angle of repose of the slope material.
- The slope of the cut must not be steeper than the natural angle of repose.
- On steeper slopes the material is unstable and will collapse slowly.
- Flowing water causes erosion - washing out the slopes.
- Roots of shrubs and trees increase the stability of a cut / fill section.



Gravel road

Why is it better ?

GRAVEL ROAD

- **The angular stones of the surface layer ensure a smooth and durable surface.**
- **The shoulders support the gravel surface and prevent washing out of the road surface.**
- **The natural slopes of the ditch will not cause erosion.**

Alternative:

- No.
- A Telford road maybe, but this type is better used on steep sections only.

Gravel road with a good surface layer

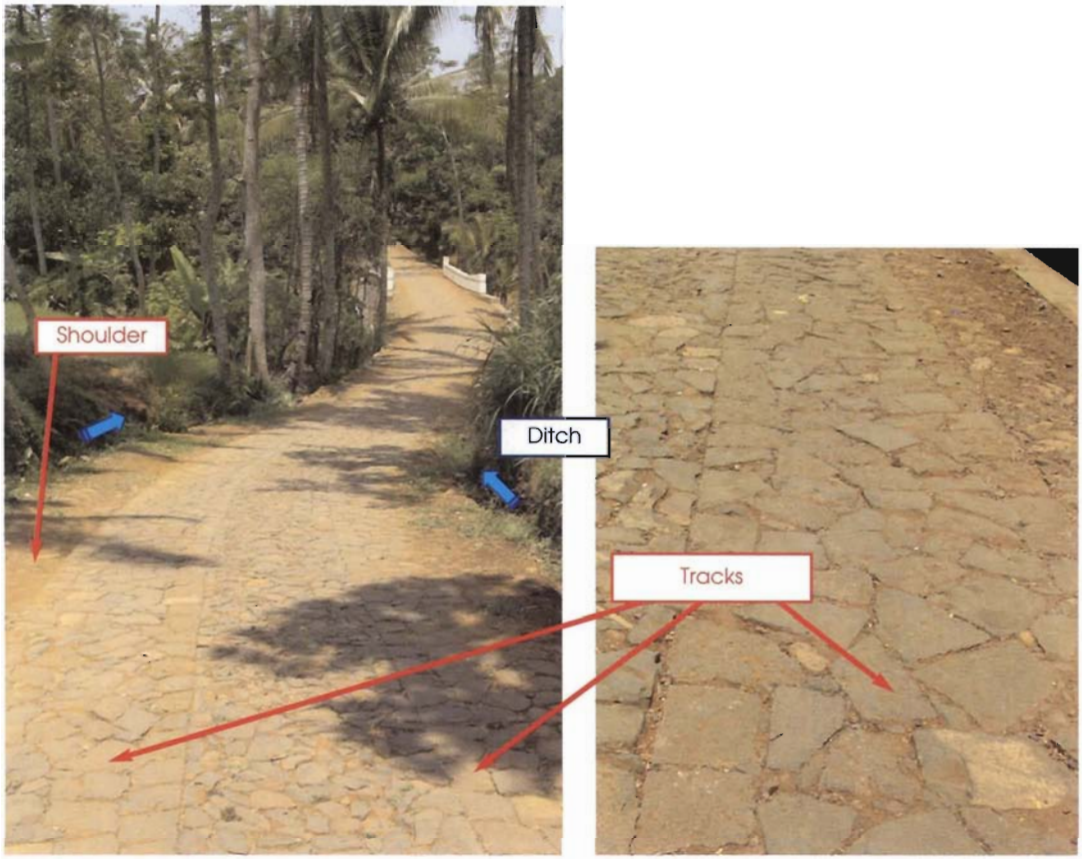
Why is it better ?

GRAVEL ROAD - Surface

- **The stones of the gravel layer are broken and compacted by a roller (heavy equipment), which ensure a smooth and durable surface.**
- **The wall of the ditch supports the gravel surface and prevents washing out of the road surface.**

Alternative:

- There is no alternative to a good surface layer with angular stones and a good mixture of stone sizes.
- A Telford road maybe, but this type is better used on steep sections only.



Well-built Telasah road

Why is it better ?

TELASAH ROAD

- **Flat stones are well arranged to form a smooth surface and still provide good friction.**

Alternative:

- A Telford road, but the surface is not so smooth.
- A road with a concrete slab.
- A asphalt road which is much more expensive.

Economical construction of a concrete road

Why is it better ?

CONCRETE ROAD

- **Concrete surface should be used on steep sections or when flooding of the road is likely to happen.**
- **The distance between the two tracks shall not exceed 80cm because of the average distance of the wheels of the cars.**
- **The permeable sand and gravel mixture between the tracks must be compacted, but shall also drain away the water flowing from the tracks.**
- **A complete concrete slab (not separate tracks) is preferable in curves.**

Alternative:

- A road with a complete concrete slab.

Road with a concrete slab

Why is it better ?

CONCRETE ROAD

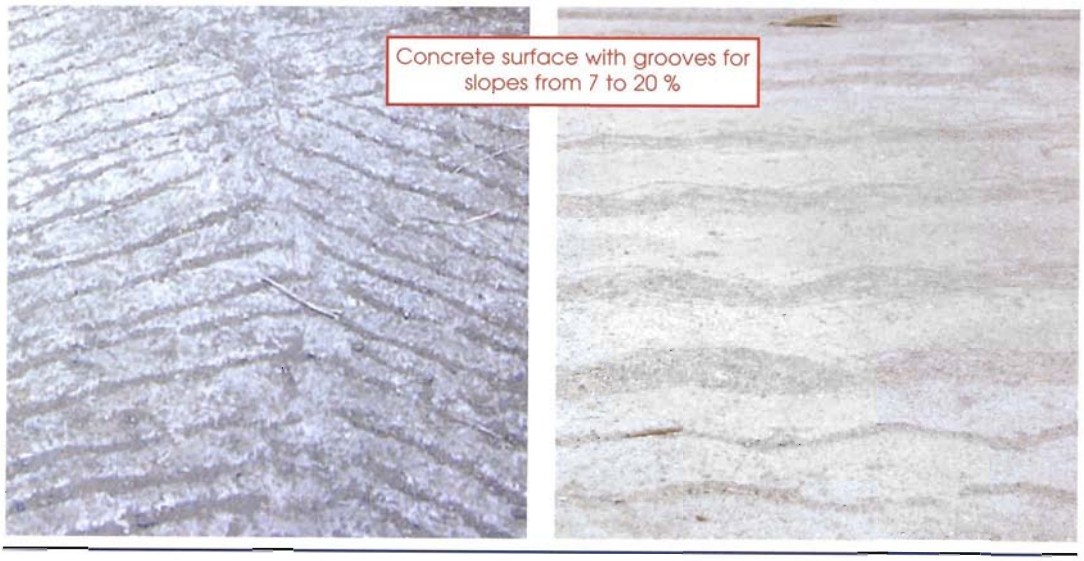
- **Concrete surface shall be used on steep sections or when flooding of the road is likely to happen.**
- **Grooves in the surface increase the roughness for better friction.**

Alternative:

- A road with two concrete tracks.
- The pattern of the grooves can vary (see next page).


Smooth concrete surface
for slopes up to 3 %


Rough concrete surface
for slopes from 3 to 7 %


Concrete surface with grooves for
slopes from 7 to 20 %

Road with a concrete slab on steeper road section
Good transition from gravel surface to concrete slab

Why is it better ?

CONCRETE ROAD

- **Concrete surface should be used on steeper sections.**
- **Grooves in the surface increase roughness and friction for vehicles.**

Alternative:

- A Telford road on steeper sections.

Retaining wall along a gravel road

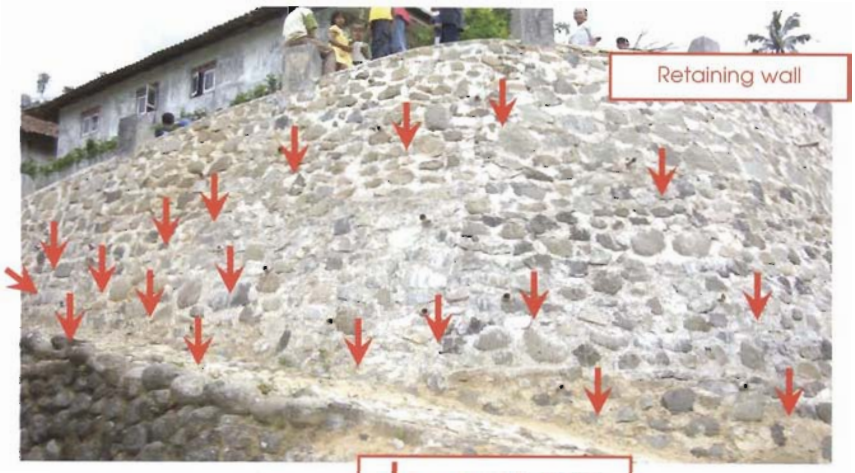
Why is it better ?

RETAINING WALL

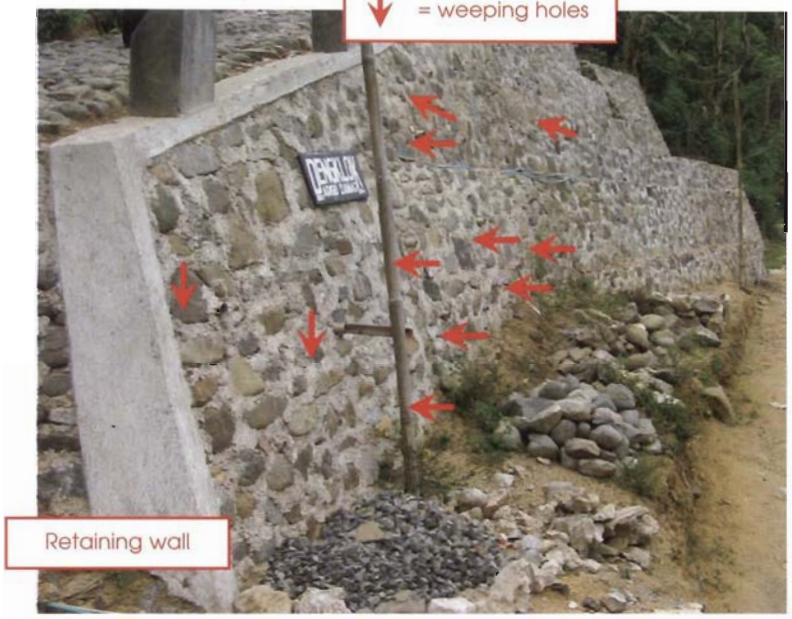
- **A retaining wall needs not so much space, but is much more expensive than a road on an embankment with natural slopes.**
- **Weeping holes in the retaining wall (especially the in the lower portions) for drainage of the road sub-base are essential for a dry road.**

Alternative:

- Road on filled embankment.



= weeping holes



Discharge water drained from behind a retaining wall

Why is it better ?

RETAINING WALL

- **If the drained water cannot discharge from behind the wall, the water pressure will rise and will put pressure on the wall. The wall could break or fall over !**
- **Place the pipes in a regular pattern, with more in the lower portions of the wall.**

Alternative:

- No.

Replanting the bare slopes of fill section

Why is it better ?

EARTH WORK - Fill Section

- **New fill sections have to be planted with shrubs and trees to increase slope stability.**
- **The natural angle of repose of the material has been considered.**

Alternative:

- A retaining wall can shorten the length of the side slope, but it is more expensive.

No protection against erosion on the far side of the drainage ditch.

How can I do it better ?

DITCH

- **Smoothen the sides, if possible.**
- **Lay stones on the sides of the drain.**
- **Build a masonry (or concrete) wall.**

WHY ?

- Erosion material will fill the drain with soil after heavy rains and the force of flowing water will destroy the sides of the drain.
- Blocked drains stop the flow of water.
- Dammed up water will damage the road's sub-base and base, and it can overflow and wash out the road surface.

Water cannot run into the drain because the top edge is higher than the shoulder of the road.

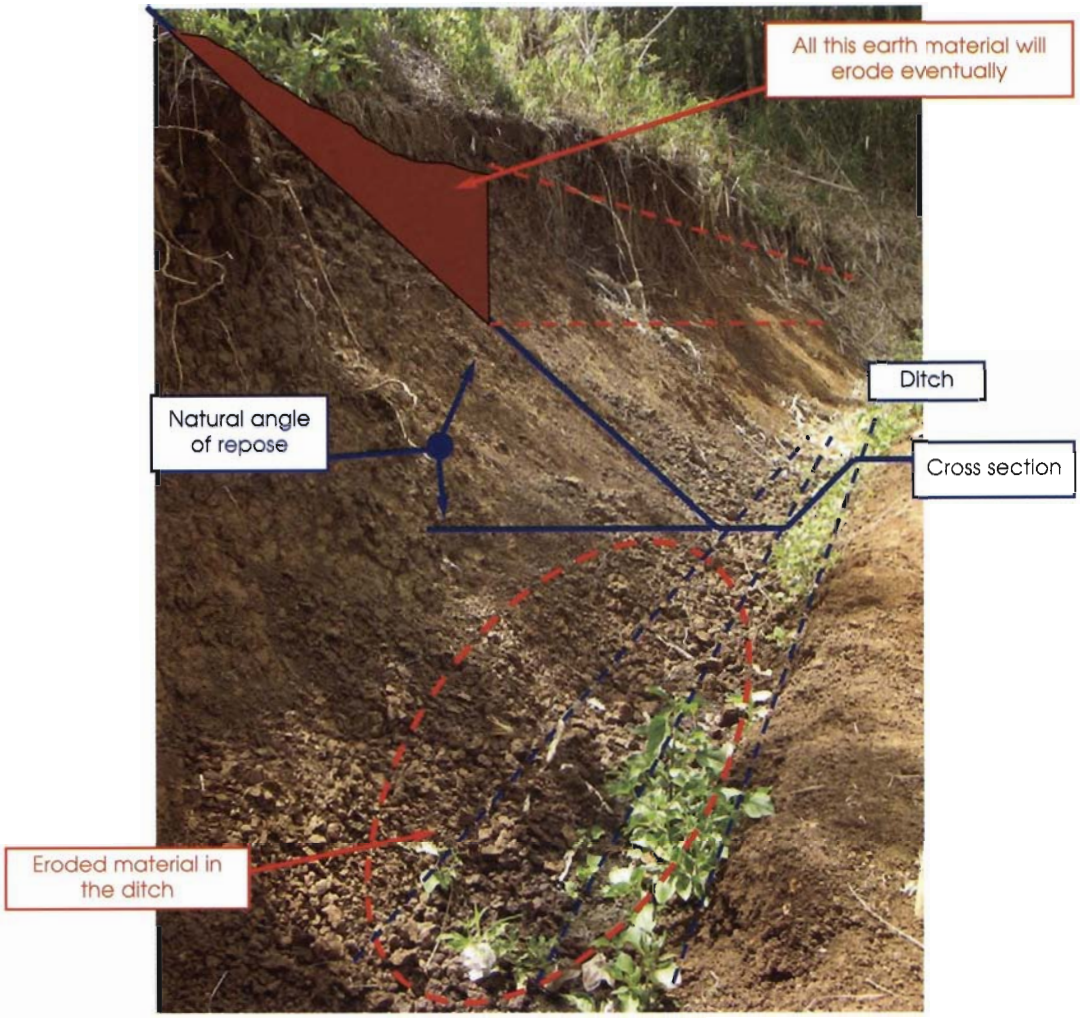
How can I do it better ?

DITCH

- Cut notches (length about 30cm) in the top of the drain, spaced about 5m apart.
- Extend the asphalt surface all the way to the ditch. Watch the slope of the road surface, making sure there is a crown in the center.
- Clear vegetation from shoulder so water can flow into the drain (O&M).

WHY ?

- If the water cannot flow into the roadside drain, it will flood the road and shoulder, and damage them by washing out the surface.



Erosion material dams up the water flow in the ditch
Standing water causes vegetation growth in the ditch

How can I do it better ?

DITCH - Excavation

- **Remove all material steeper than the natural angle of repose.**
- **If this is not possible a retaining wall should be built.**
- **Ensure that the water can flow in the roadside ditch → O&M work must clean the ditch periodically.**

WHY ?

- The natural angle of repose must not be ignored.
- Water cannot flow if roadside ditch is blocked by eroded material.

Water cannot drain away - it will flow on the road surface and will damage it

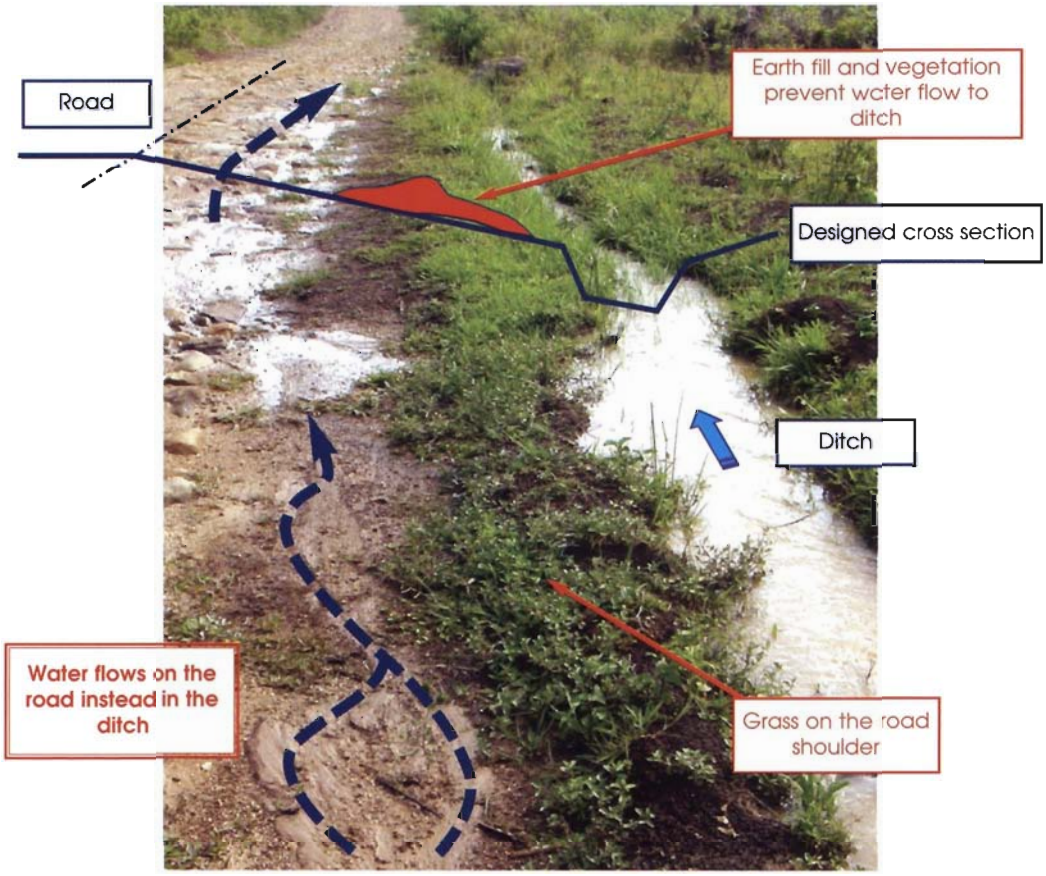
How can I do it better ?

DITCH - Road Surface

- **Remove the high ridge on the left side so the water can drain over the shoulder.**
- **Build a ditch on the right side.**
- **Make sure that the water can flow over the shoulder and to the roadside ditch.**
- **Cut back the excavated slope to the natural angle of repose.**
- **O&M must remove the eroded material.**

WHY ?

- If water cannot drain away, it will flood the road and wash out the surface.
- Water should be moved away from the road surface as fast as possible.



Water cannot flow into the drain because the shoulder is overgrown with vegetation and higher than the ditch

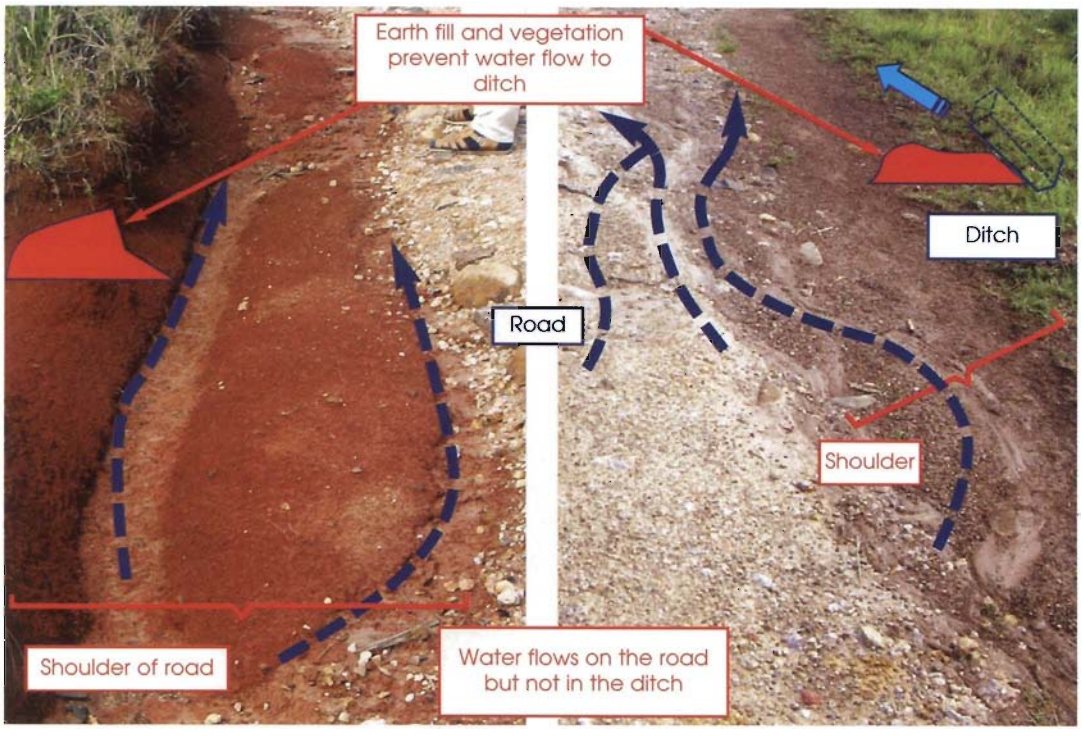
How can I do it better ?

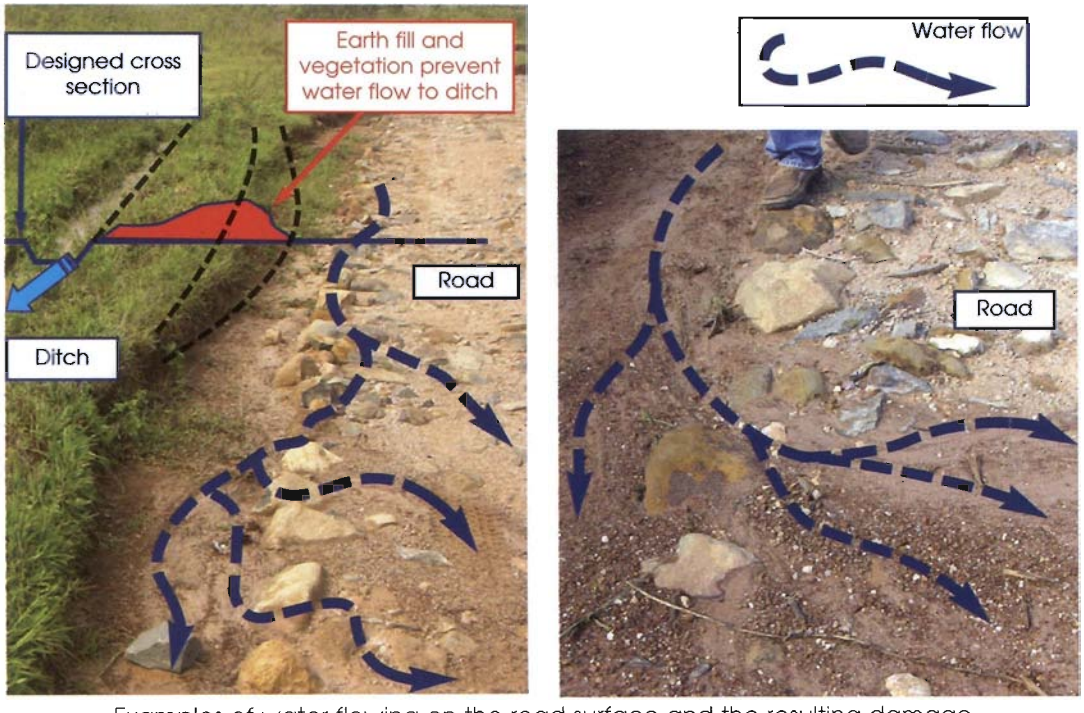
DITCH - Road Surface

- **Remove earth and vegetation on the road shoulder.**
- **Deepen the ditch.**
- **O&M has to keep the shoulder free of grass and the ditch clean.**

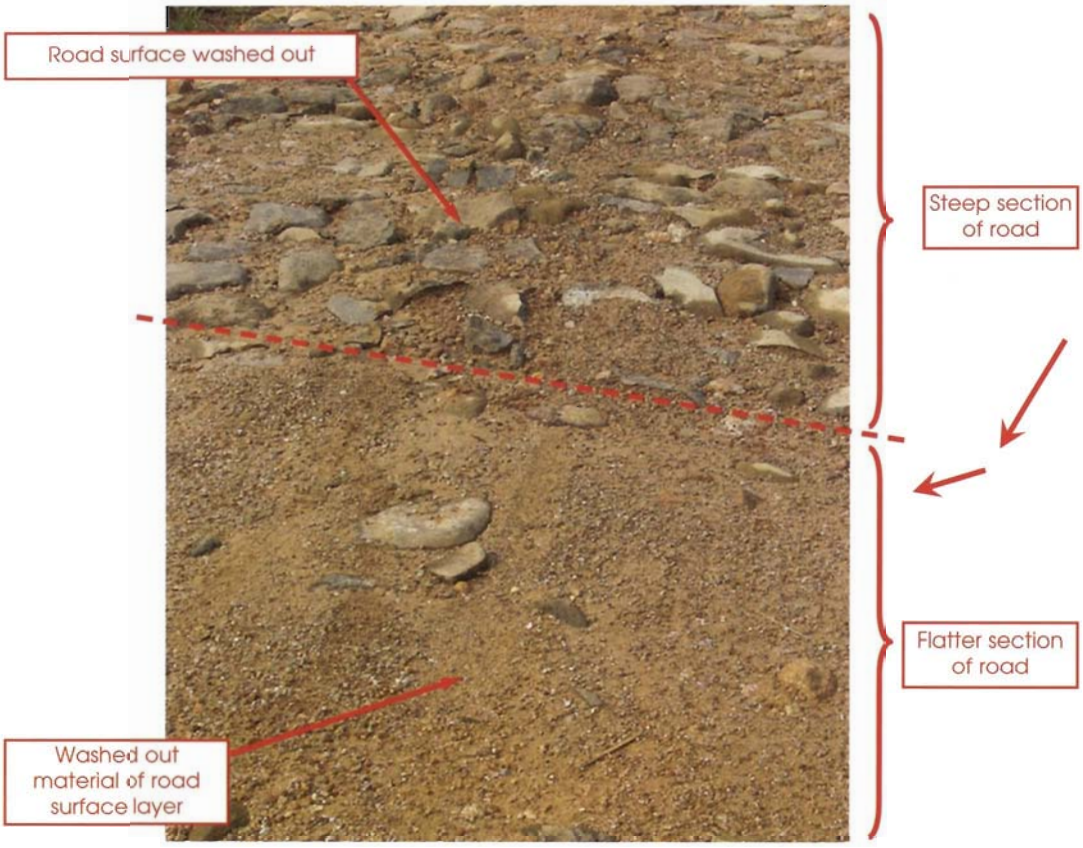
WHY ?

- If the water cannot flow into the roadside ditch, it will saturate the road base and damage the surface (see following page).





Examples of water flowing on the road surface and the resulting damage



Water cannot run into the drain - the surface road layer will be washed out

How can I do it better ?

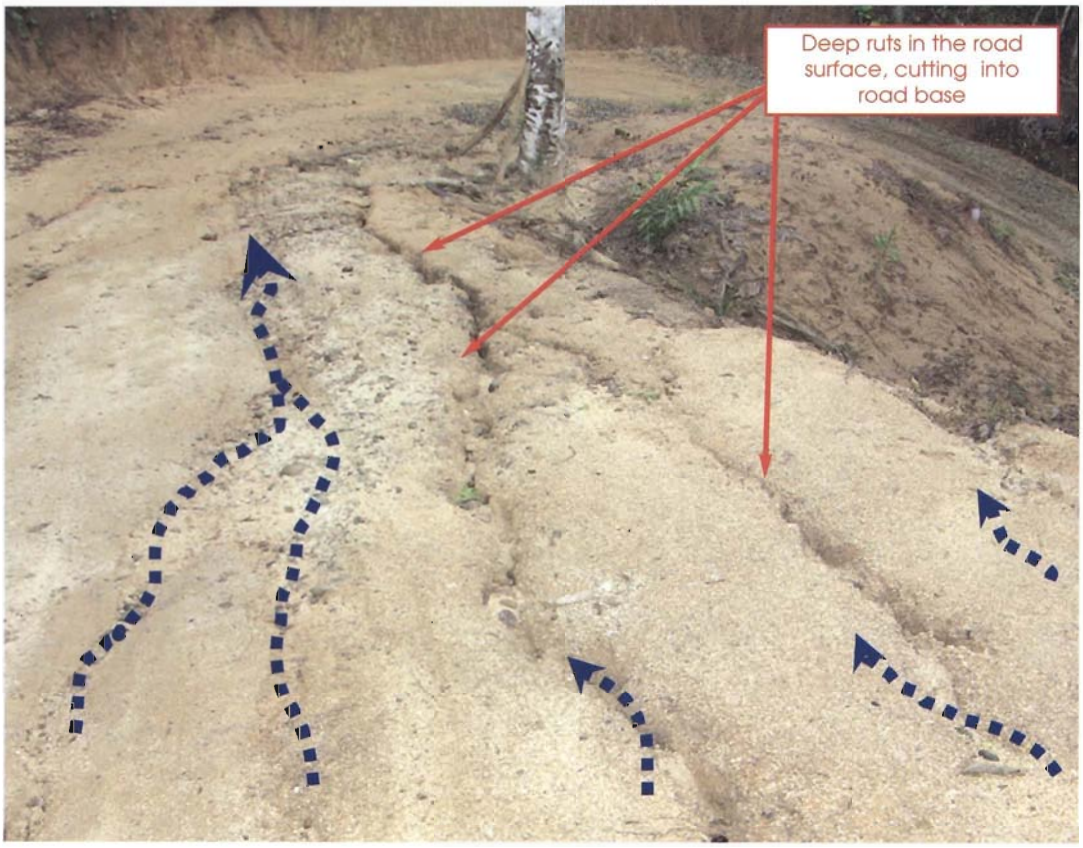
DITCH - Road Surface

- **Ensure that the water can flow into the roadside ditch.**
- **Compact the surface layer with a roller again.**
- **O&M must deal with this problem.**

WHY ?

- If the water cannot flow into the roadside ditch, it will flood the road and damage the surface by washing out.

Examples of washed out road surfaces


Deep ruts in the road surface, cutting into road base


Shoulder - badly damaged by flowing water - starting to slide away


Deep ruts in the road surface - cutting into the road base

Formwork that is not removed can block the culvert making it useless

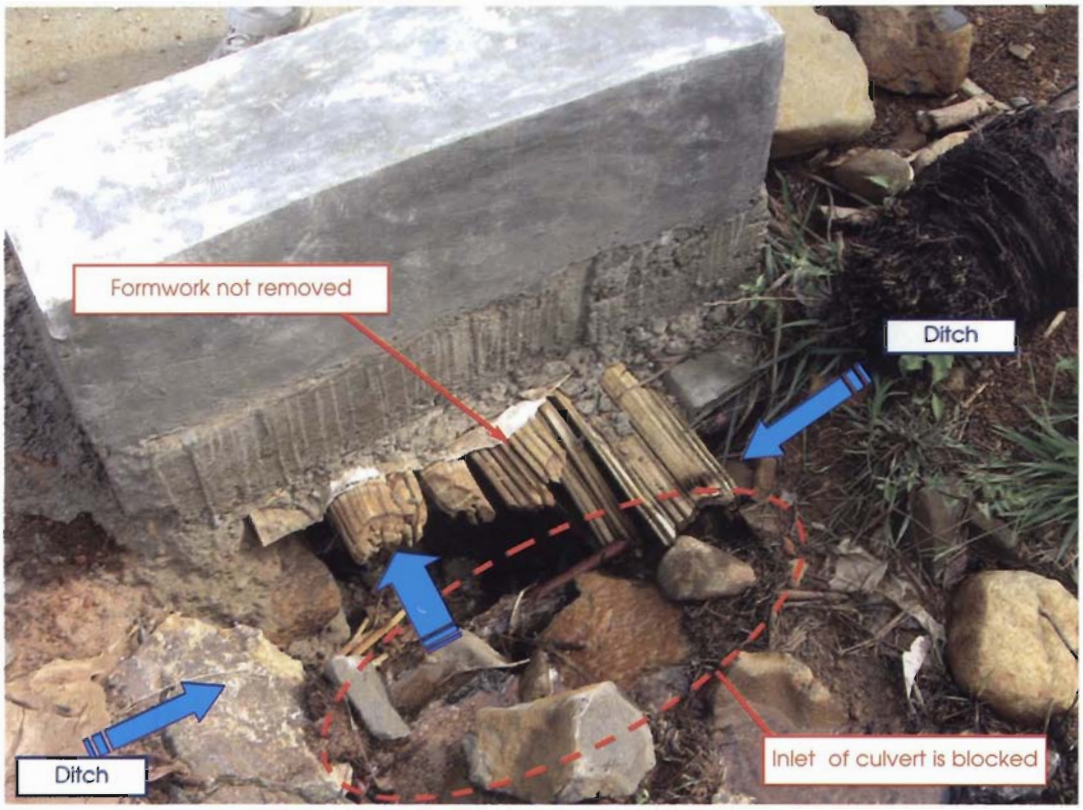
How can I do it better ?

CULVERT

- **Remove all formwork from inside the culvert (after concrete has reached full strength).**
- **Place large stones the outlet of the culvert to prevent erosion.**

WHY ?

- Formwork that is not removed will rot eventually, drop down and obstruct the free flow of water.



The inlet area of the culvert is blocked by formwork that has not been removed

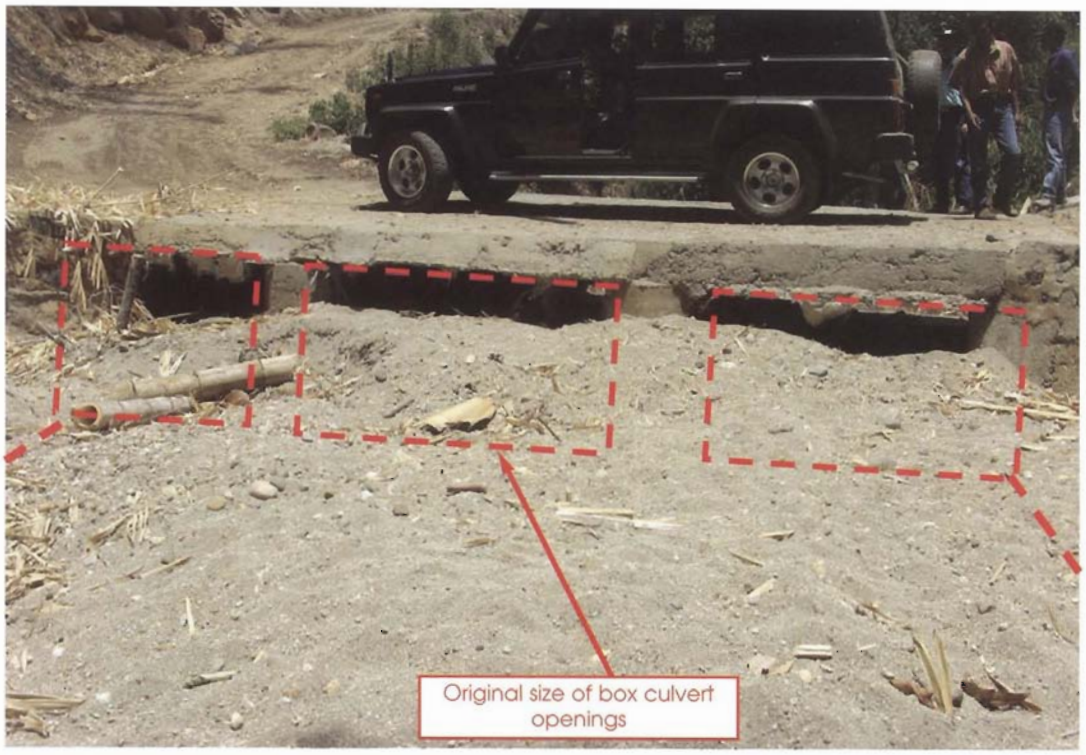
How can I do it better ?

CULVERT

- **Remove all formwork, also from the inside and outside of the culvert (after concrete has reached full strength).**
- **Excavate around and deepen the inlet of the culvert → see inlet box**
  (→ see Good Examples).

WHY ?

- Formwork that is not removed will block the culvert.
- The free water flow has not be obstructed.



Gravel and sand block the culvert inlets and will dam up the water

How can I do it better ?

CULVERT

- **Keep the culvert inlets free from sand and gravel - the water must flow through the culvert → O&M.**
- **Build a sand trap upstream of the culvert to prevent accumulation at culvert inlets (sand trap will have to be cleaned periodically).**
- **Make the necessary provisions during the design phase already.**

WHY ?

- When water is dammed up in front of the blocked culvert it overtop the road and wash out the surface or do even more damage.

Damage caused by poor water management on road and around culvert
Culvert pipes are broken

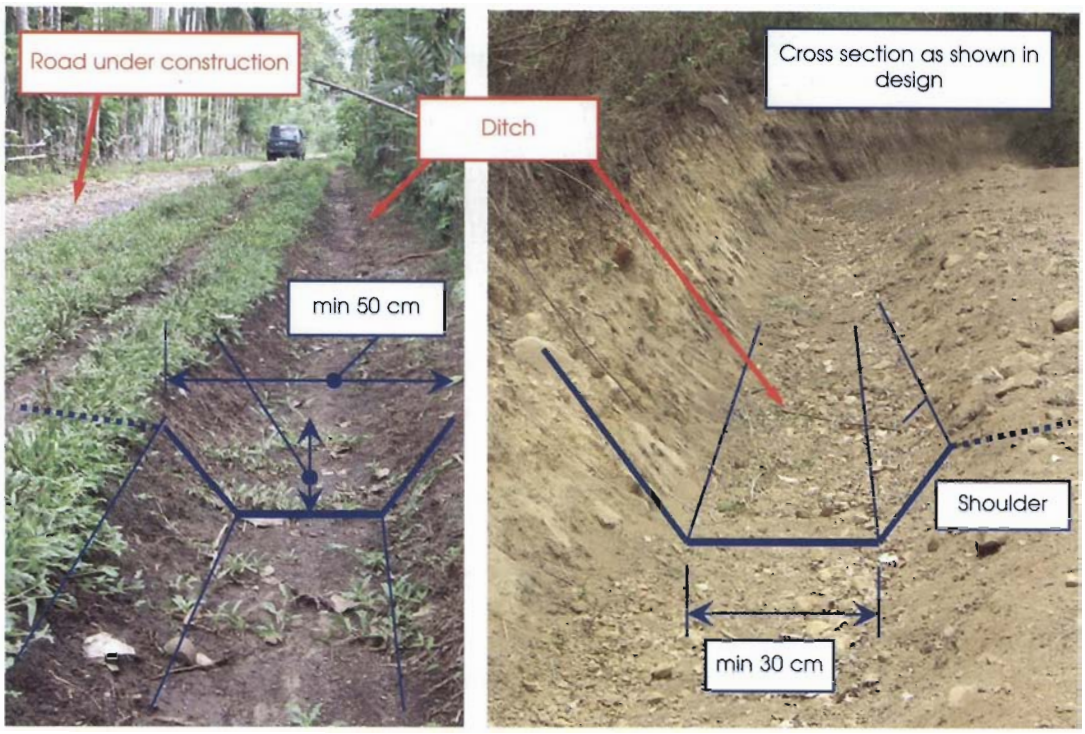
How can I do it better ?

DITCH - Water Discharge

- **Cover culvert pipes with concrete (minimum 15 cm cover).**
- **Add soil/gravel mixture layer on top and compact properly.**
- **Ensure that the water of the adjacent road sections can flow freely into the roadside ditch ⟶ O&M has to clean the ditches periodically.**

WHY ?

- Flowing water can easily erode a gravel road surface or even the base of a road.
- Make sure that the water can flow the shortest route to the roadside ditch.
- When water is dammed up in the ditch, it will flood the road, especially when in cut, and will destroy the road surface or even the base (see picture).



Well shaped earth ditch with natural slopes

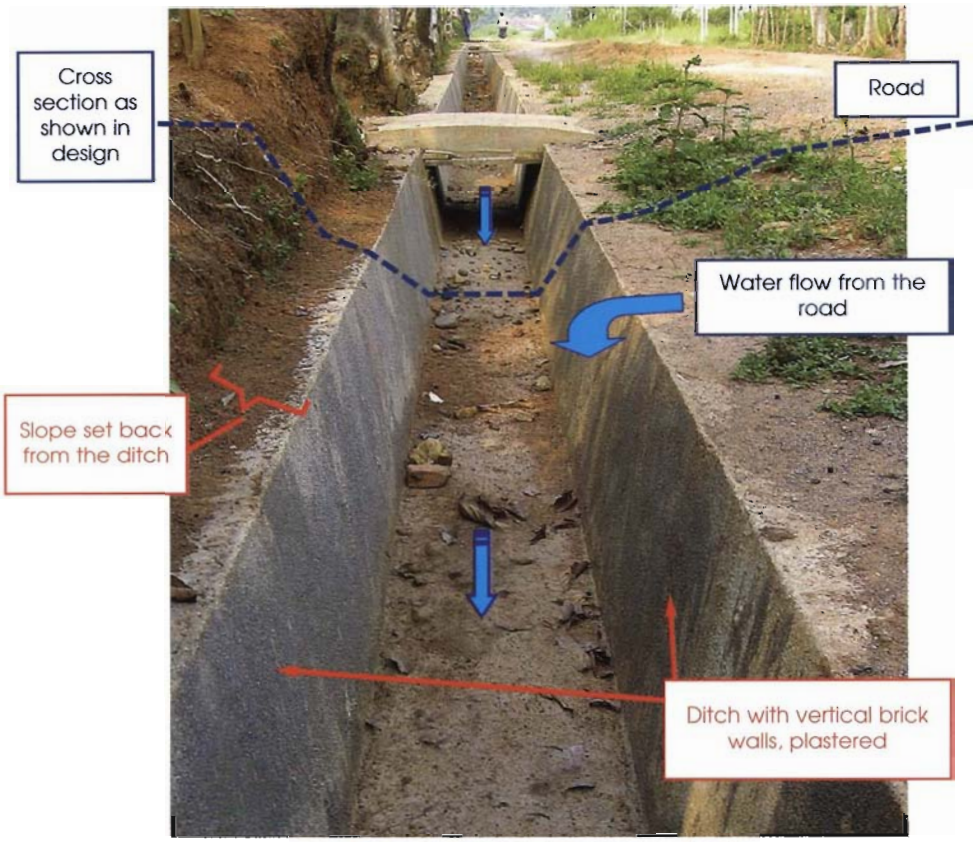
Why is it better ?

DITCH

- **The natural slopes of an earth drain hold up well against erosion.**
- **A ditch with natural slopes reduces erosion and that means less O & M.**
- **Always respect the minimum width (top & bottom) and minimum depth of a ditch.**

Alternative:

- Stone masonry or concrete ditch (more expensive, but easier for O&M.



Ditch walls made of masonry

Why is it better ?

DITCH

- **Water is quickly transported away.**
- **Road and shoulder are protected by the masonry walls from the eroding force of flowing water.**

Alternative:

- Earth drains, but they need much more space and are less stable; earth ditches also need a lot of more maintenance.

Very well built Telford road and masonry ditches

Note : *Road shoulder is not finished yet. It should be filled in to protect edge of the road and to allow drainage into the ditch*

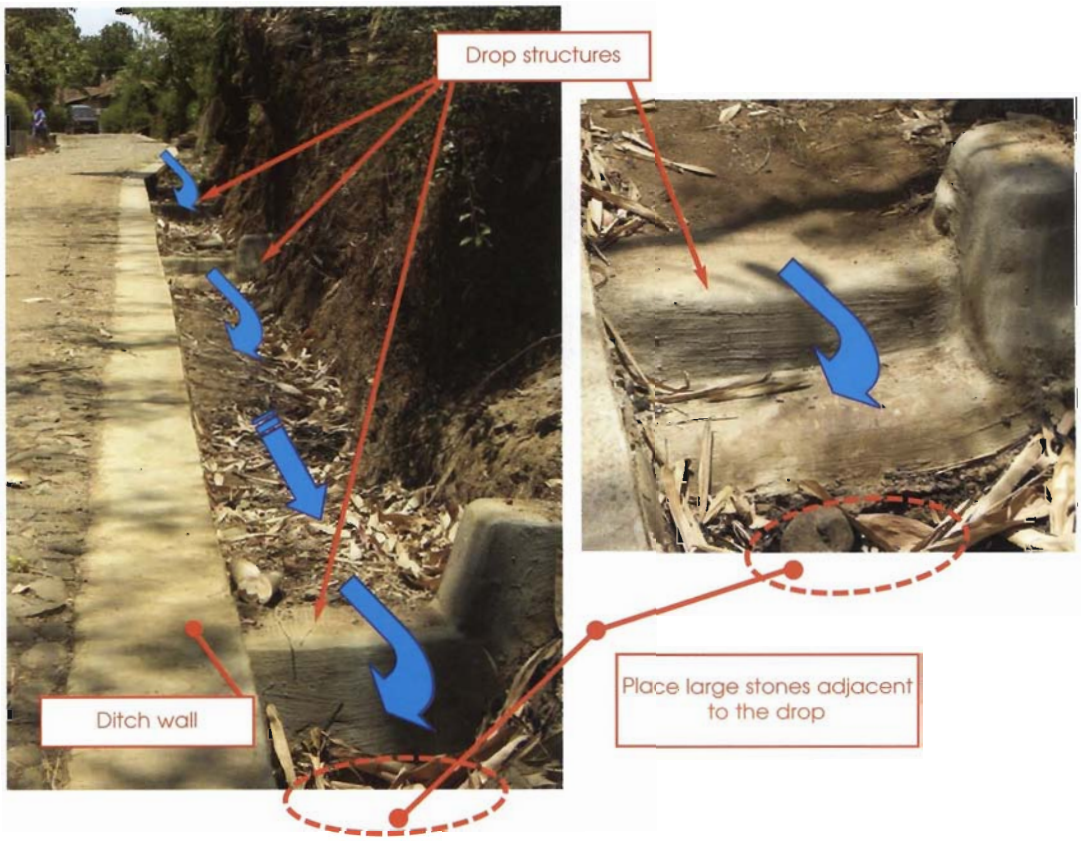
Why is it better ?

DITCH

- **Ditches with a hard surface have large flow capacity.**
- **Road shoulders are protected against the force of flowing water by the masonry walls of the ditches.**
- **Ditches with a hard surface are easier to clean → less maintenance.**

Alternative:

- Earth drains, but they need much more space and are less stable; earth ditches also need a lot of more maintenance.



Drop structures are required in a steep ditch

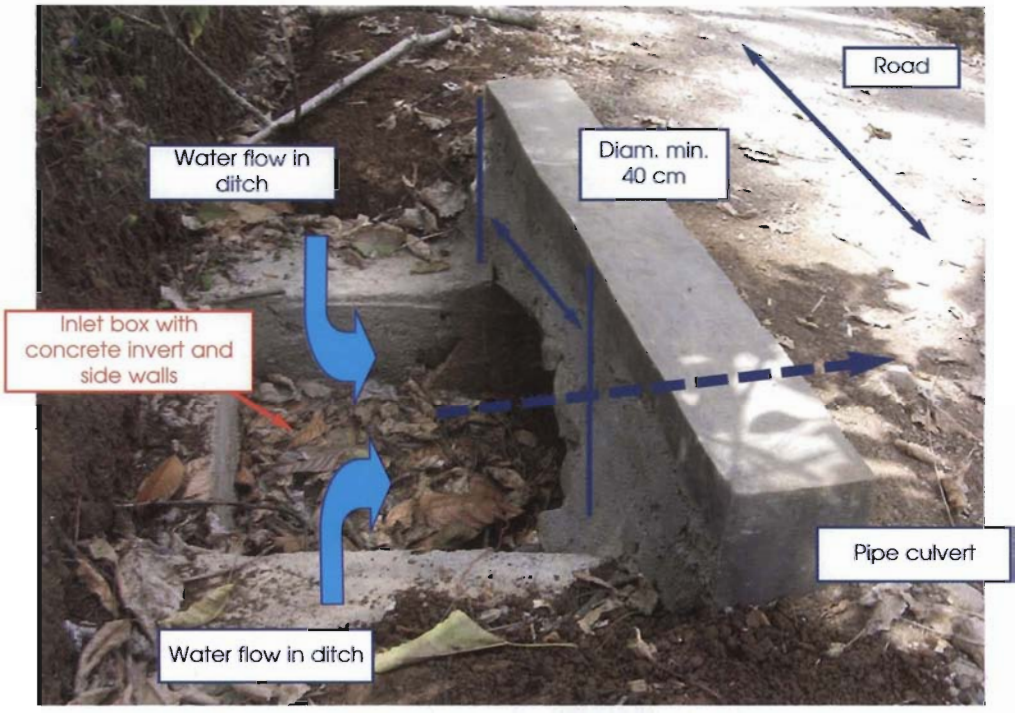
Why is it better ?

DITCH

- **Drop structures in a steep ditch (larger than 2% slope) reduce the force of water and that means less erosion of the invert of the ditch.**

Alternative:

- Invert of ditch made of concrete or stone rip rap.



Inlet box for a pipe culvert

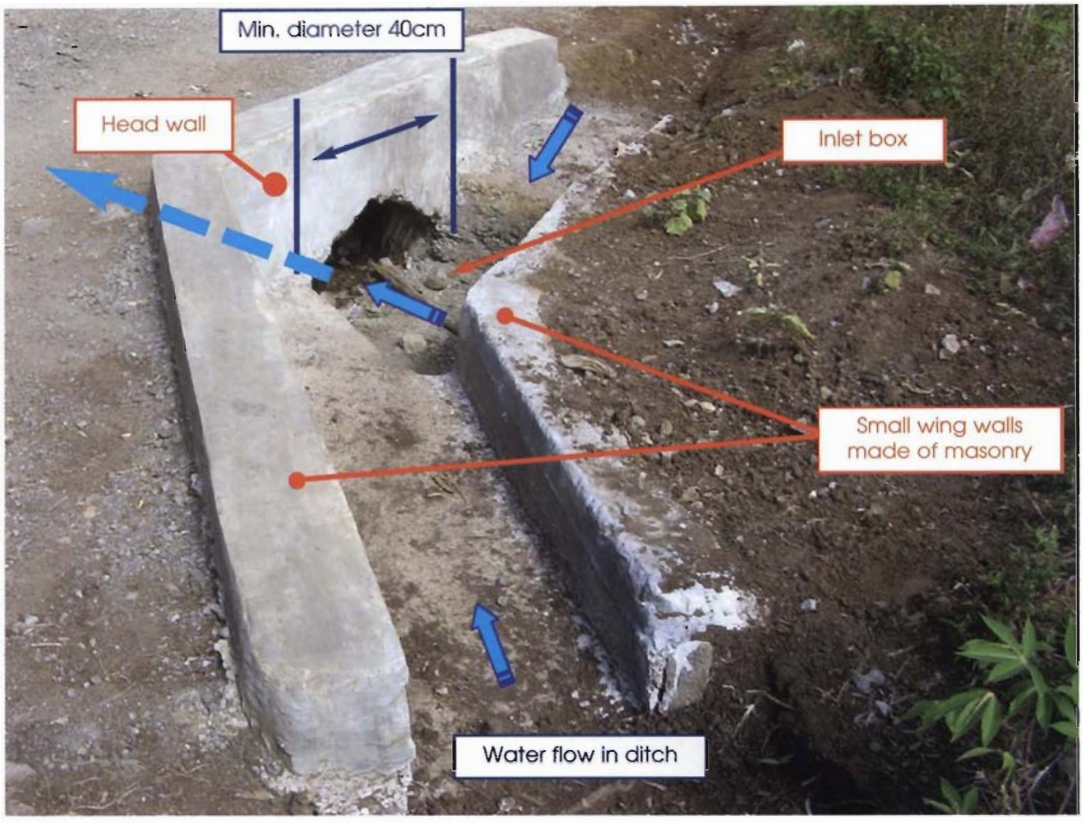
Why is it better ?

CULVERT - Inlet

- **Inlet box traps erosion material from entering and blocking the culvert.**
- **The minimum diameter of a pipe culvert should not be less than 40 cm.**
- **Maintenance must keep the inlet box clean.**

Alternative:

- Instead of concrete for the walls - masonry or stones could be used.



Effective inlet of a pipe culvert

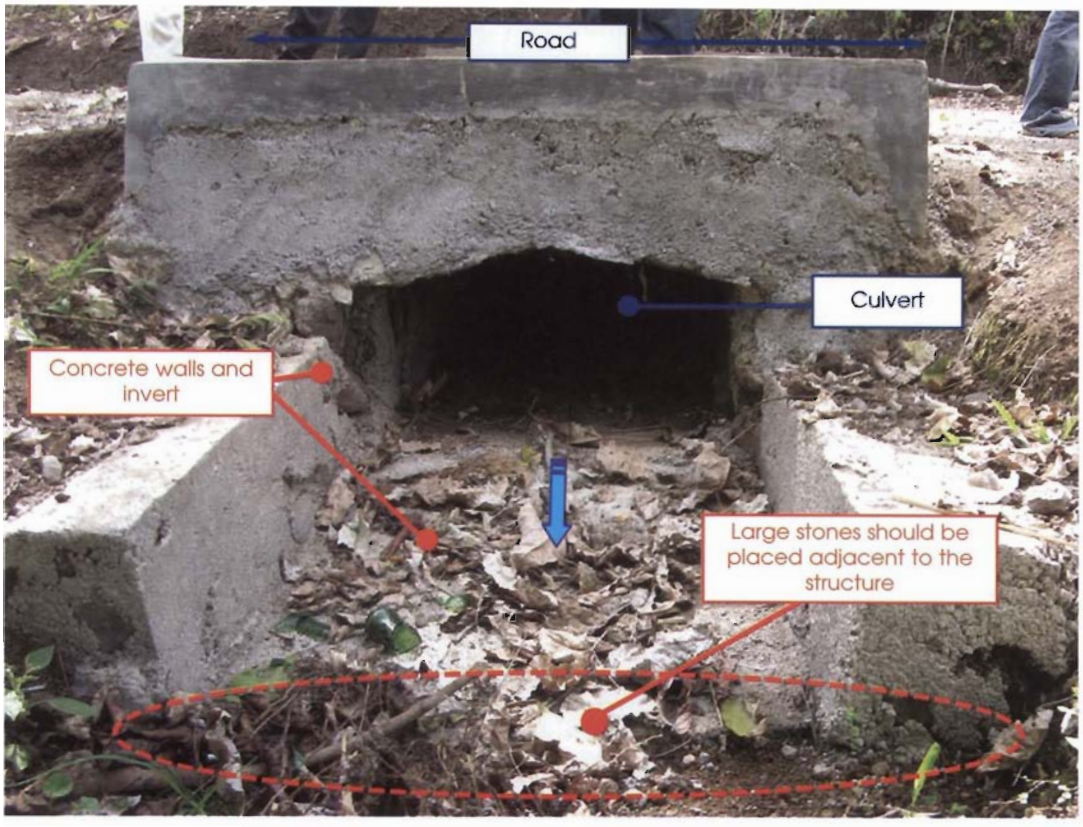
Why is it better ?

CULVERT - Inlet

- **Ditch runs into an inlet box before entering the culvert.**
- **Diameter of the culvert has to be big enough (min. diameter 40 cm).**
- **Maintenance must keep the inlet box clean.**

Alternative:

- Concrete walls.



Culvert outlet

Why is it better ?

CULVERT - Outlet

- **Water is channelled away from the culvert.**
- **Large stones adjacent to the concrete outlet structure prevent washing out or undercutting of the structure.**
- **Length of protection depends on the maximum flow but should be at least 1 meter.**

Alternative:

- Instead of concrete for the walls and bottom - masonry or stone riprap could be used.

Effective water discharge away from a culvert outlet

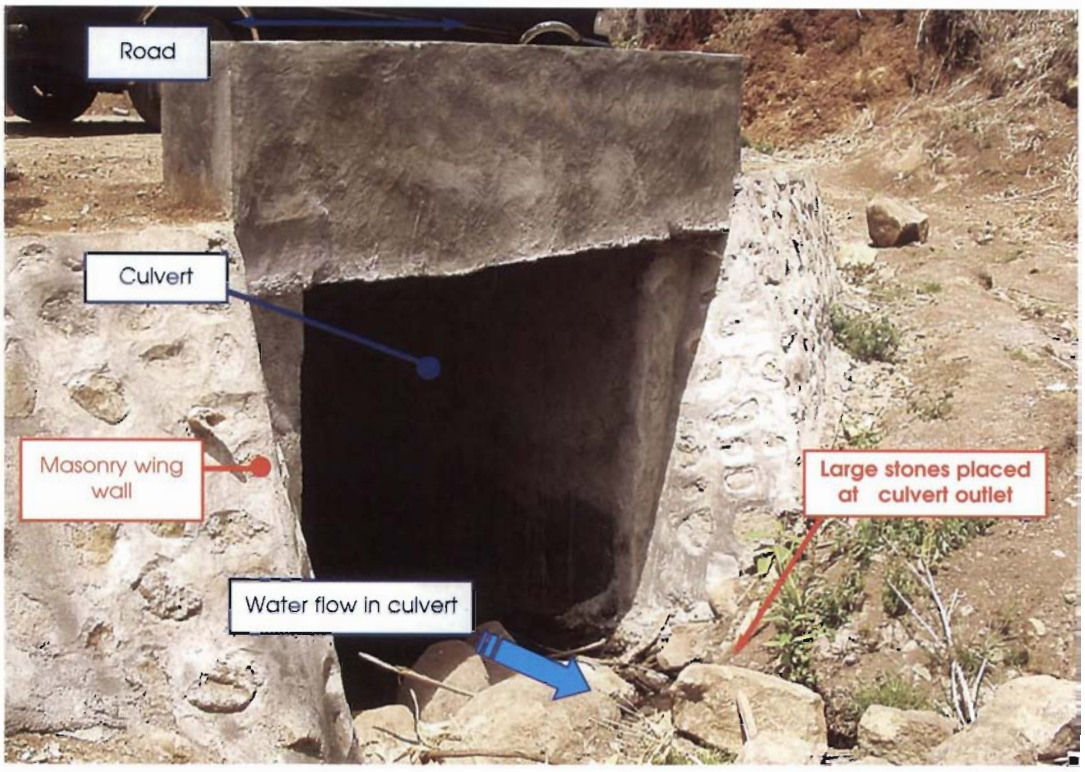
Why is it better ?

CULVERT - Outlet

- **Flow from the culvert outlet is channelled away from the road.**
- **Large stones adjacent to the concrete structure angular stones have to be laid to prevent a washing out or undercutting of the structure.**
- **Length of stone protection depends on maximum flow but should be at least 1 meter.**

Alternative:

- Concrete walls.



Outlet of a culvert

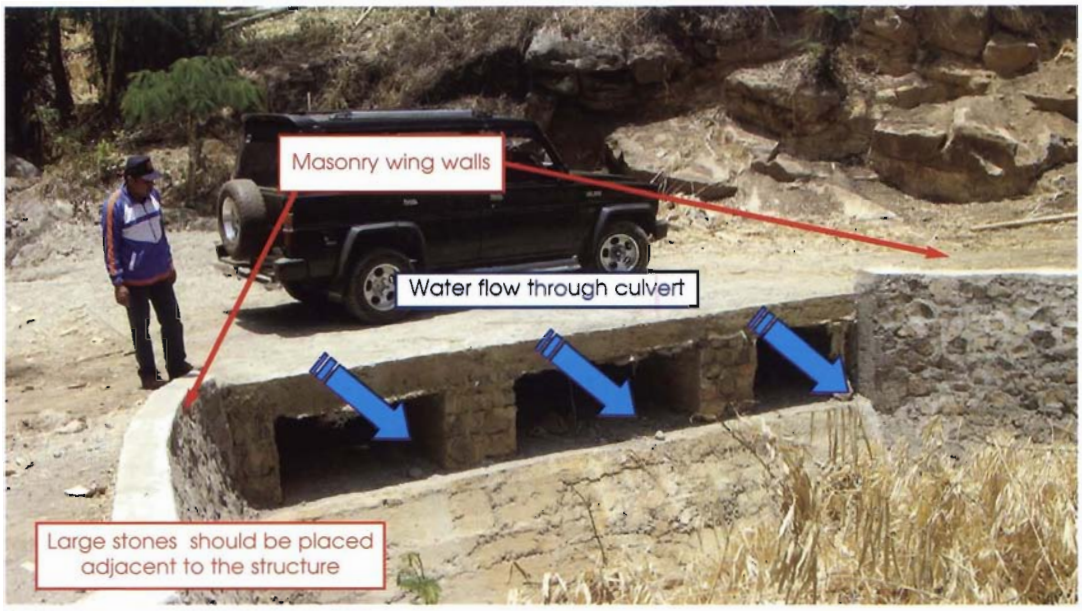
Why is it better ?

CULVERT - Outlet

- **Large stones adjacent to the culvert prevent erosion and washing out of the structure (length depends on max. flow but should be at least 1 meter).**
- **Wing walls made of masonry.**

Alternative:

- Lengthen the concrete invert of the culvert (see previous page).



Box culvert outlet

Why is it better ?

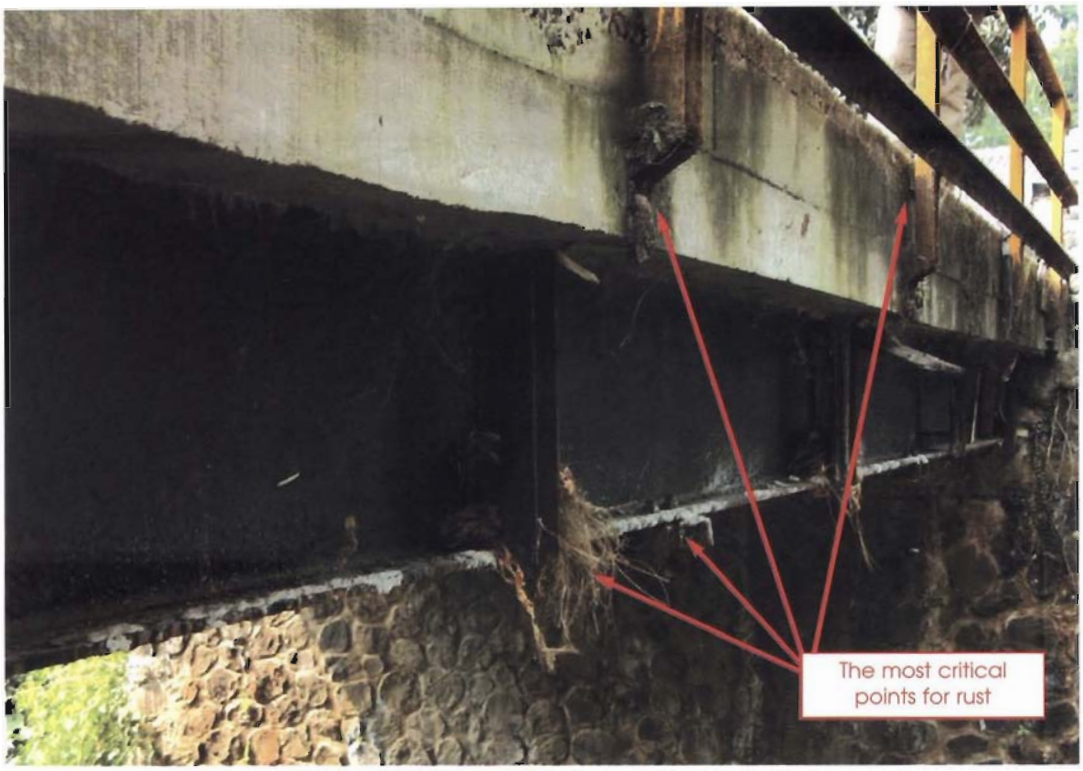
CULVERT - Outlet

- **Box culvert is a good alternative to a small bridge.**
- **Construction is more simpler and cheaper.**
- **Large stones should be placed adjacent to the drop structure to prevent a washing out or undercutting of the structure.**
- **Length of protection depends on maximum flow but should be at least 3 meter for larger structures.**

Alternative:

- Small bridge, but it is much more expensive.

BRIDGE



Water left on steel causes rusting

How can I do it better ?

BRIDGE - Rust

- **Make the necessary provisions during the design phase already, so that water will not be trapped or sit on steel surfaces.**
- **Periodically check all critical points where rust can establish itself (O&M).**
- **Remove all rust with a steel brush and paint with rustproof paint.**

WHY ?

- Rusty steel loses its strength.

Formwork from under the concrete slab must be removed

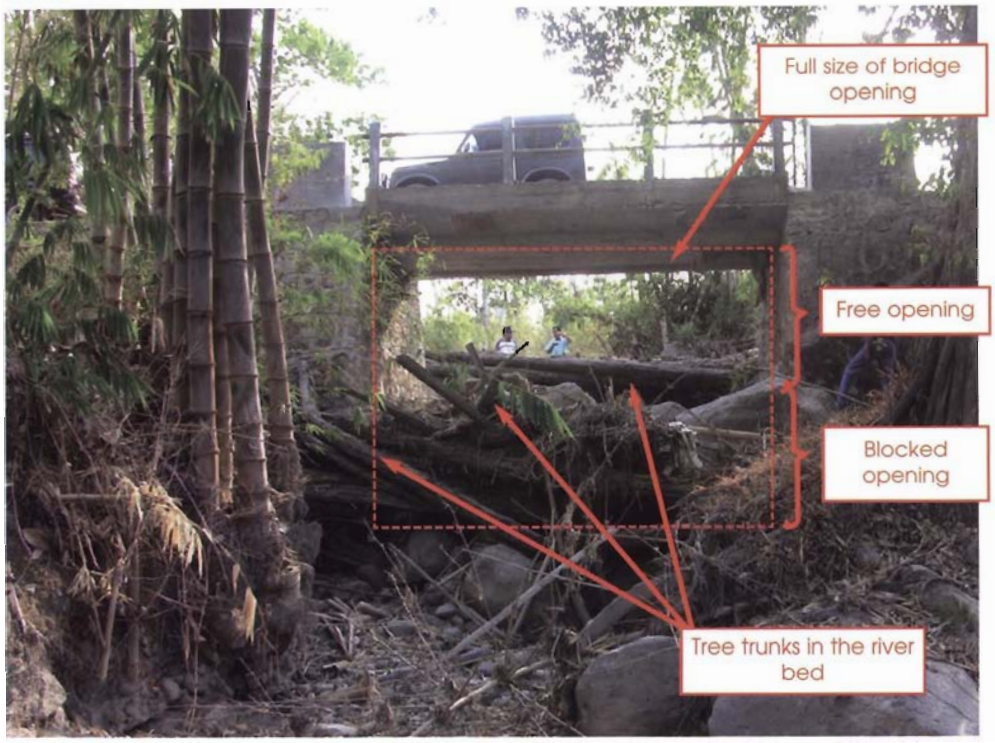
How can I do it better ?

BRIDGE - Formwork

- **Remove all formwork (after concrete has reached full strength).**

WHY ?

- When the wooden boards rot, they will fall down.
- Wood absorbs and holds moisture, and this may cause the steel beams to rust quickly.



Tree trunks in the river block and dam up the water

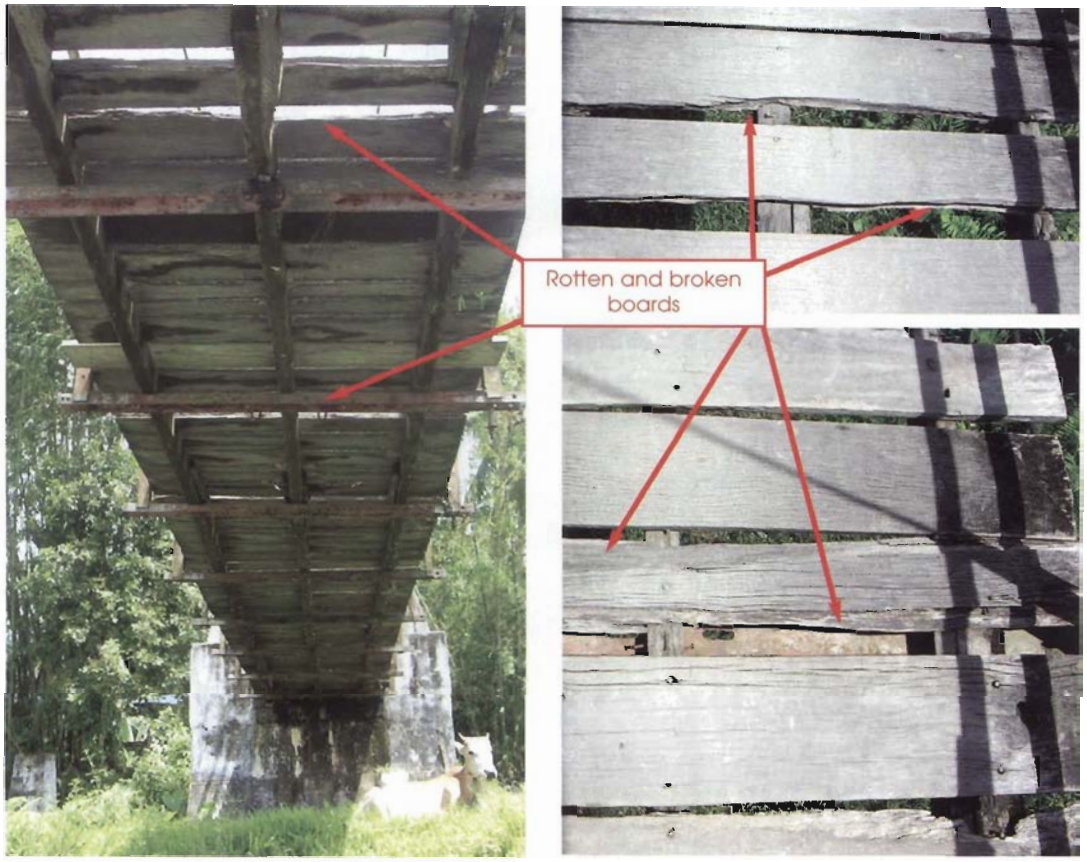
How can I do it better ?

BRIDGE - Clear Opening

- **Keep the opening free of any material - the water must be able to flow freely under the bridge → O&M.**

WHY ?

- When water is dammed up in front of a blocked bridge it will become a hazard for the bridge itself.
- The dammed up water may overtop the road and could cause serious damage to the road and surroundings.
- Environmental impacts, i.e. flooding could arise.



Pedestrians can break through rotten and broken boards of the decking

How can I do it better ?

DECK

- **Check the condition of the decking boards periodically.**
- **Replace any rotten boards and use good quality hardwood.**
- **Paint the boards with protective coating.**

WHY ?

- Risk of accident for the users.
- The stability and structural integrity of the bridge are potentially affected.

Damaged and missing and rotten decking and beams illustrate poor O & M

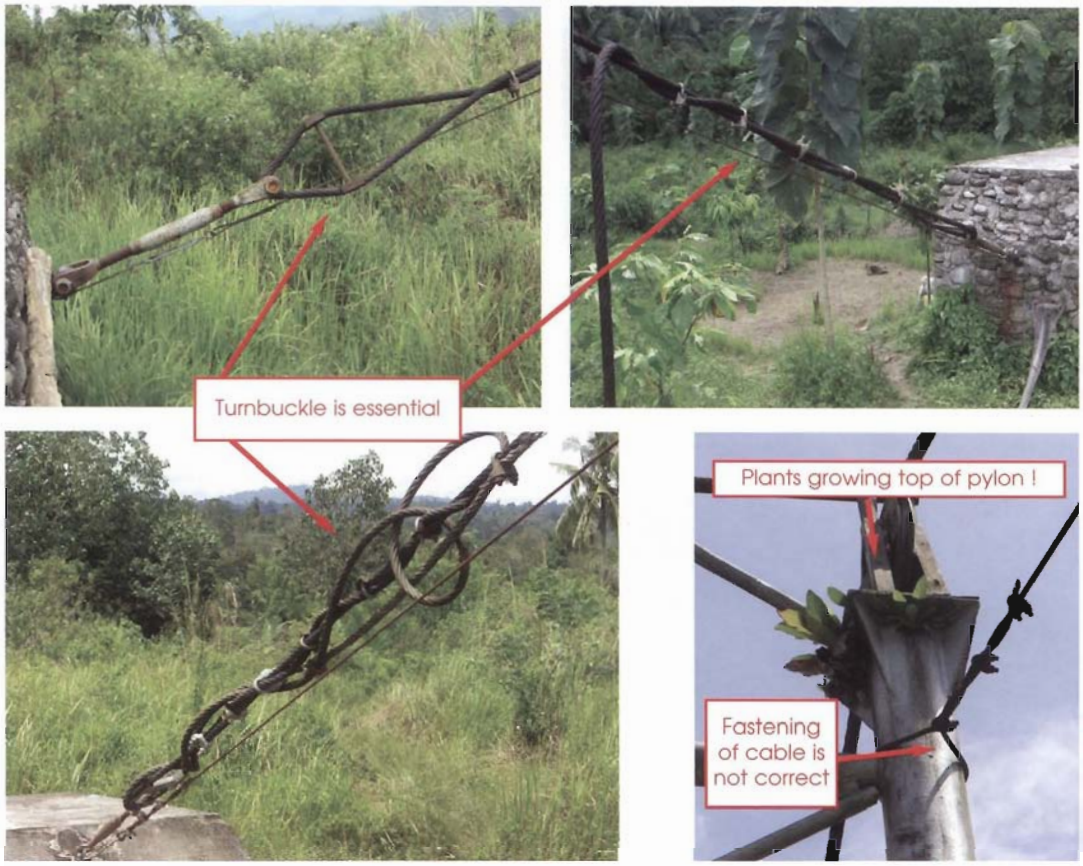
How can I do it better ?

DECKING

- **Check the condition of railings, boards and supports of the decking periodically.**
- **Replace the damaged parts without delay.**

WHY ?

- Risk of accident for the users.
- The stability and structural integrity of the bridge are potentially affected.



Good maintenance is essential to keep
a suspension bridge safe and in good shape

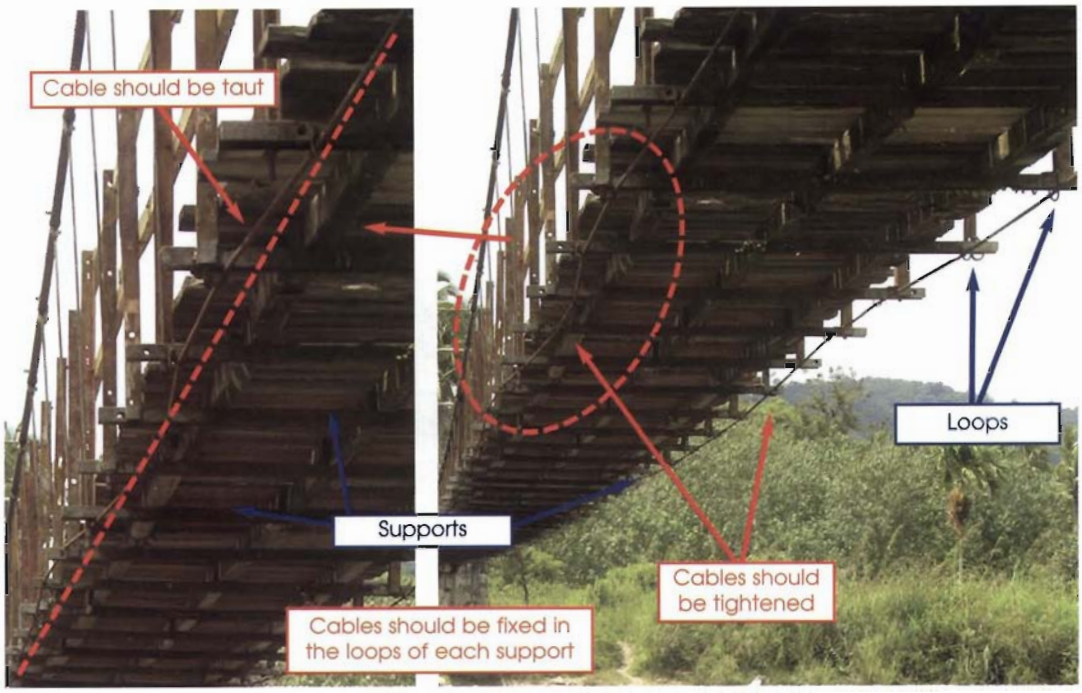
How can I do it better ?

CABLE

- **Turnbuckles are essential to keep the cable at the right tension.**
- **Clean and oil the cable periodically.**
- **Keep water and wet mud away from all steel parts ' danger of rust !**

WHY ?

- The cable is the load bearing element of the bridge - keep it in good condition.
- Avoid rust → it will destroy the steel elements of the bridge.



A slack cable is useless

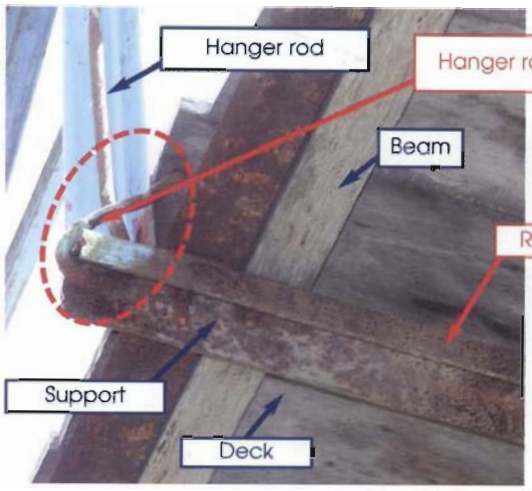
How can I do it better ?

CABLE

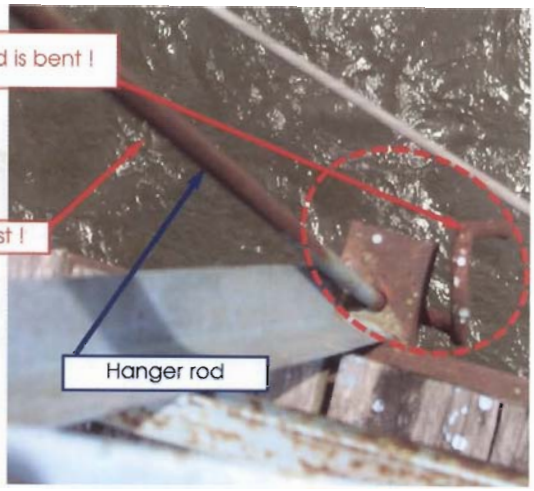
- **Check the loops and replace the broken ones.**
- **Check the cable running through the loops and it.**
- **Protect the steel elements against rust.**

WHY ?

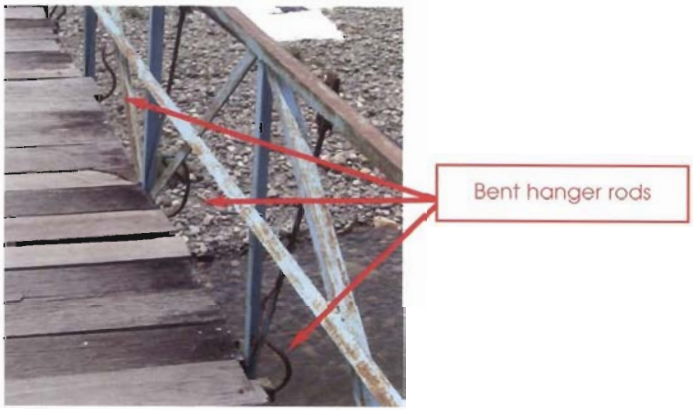
- The cable must be to connected to all supports for greater stability of the bridge.



View from the bottom



View from the top



The hanger rods should be screwed to the supports, NOT bent !

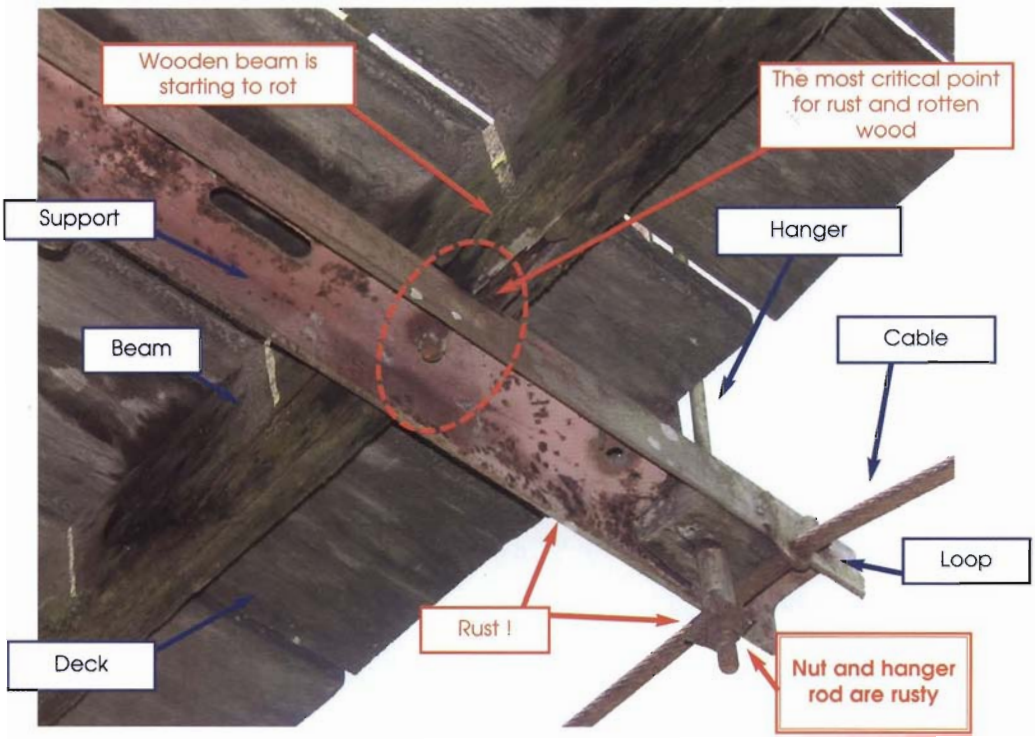
How can I do it better ?

HANGER

- **Replace hanger rods and use threaded connections to the supports**
- **Protect the steel elements against rust coating.**

WHY ?

- The hanger rods transfer the load of the bridge to the suspension cable - keep them in good condition.
- Use of a threaded connection allows adjustment of hanger rod length - use two nuts for each hanger rod to prevent loosening of the connection.
- Avoid rust ⟶ it will destroy the steel elements of the bridge.



View from the bottom

Watch out for the critical points for rust and rotting wood

How can I do it better ?

SUPPORT

- **Keep the critical points clean and protect them with water resistant coatings**
- **Use two nuts for each hanger rod.**

WHY ?

- The supports are carrying the load of the bridge - keep them in good condition.
- Avoid rust → it will destroy the steel elements of the bridge.

Bridge with a concrete slab

Why is it better ?

CONCRETE SLAB BRIDGE

- **A concrete slab bridge shall not exceed 6m span.**
- **Longer bridge over a deep valley avoids steep approach sections.**
- **The abutments are made of stone masonry with a height of more than 8 m.**

Alternative:

- "Dutch-style" arch bridge.

"Dutch-style" arch bridge

Why is it better ?

CONCRETE ARCH BRIDGE

- **This type of bridge is suitable for spans up to 10 m.**
- **The arch and the abutments are made of concrete.**
- **The walls are made of stone masonry and rock fill in between.**
- **The appearance of the bridge is very nice.**
- **Not suitable for rivers with high flood flows.**

Alternative:

- A steel girder bridge.

Steel girder bridge

Why is it better ?

STEEL BEAM BRIDGE

- **For larger span, i.e. more than 6 m, a steel girder bridge is most suitable.**
- **The abutments are made of stone masonry.**
- **BUT good maintenance is needed to prevent rust formation.**

Alternative:

- None.

Suspension bridge

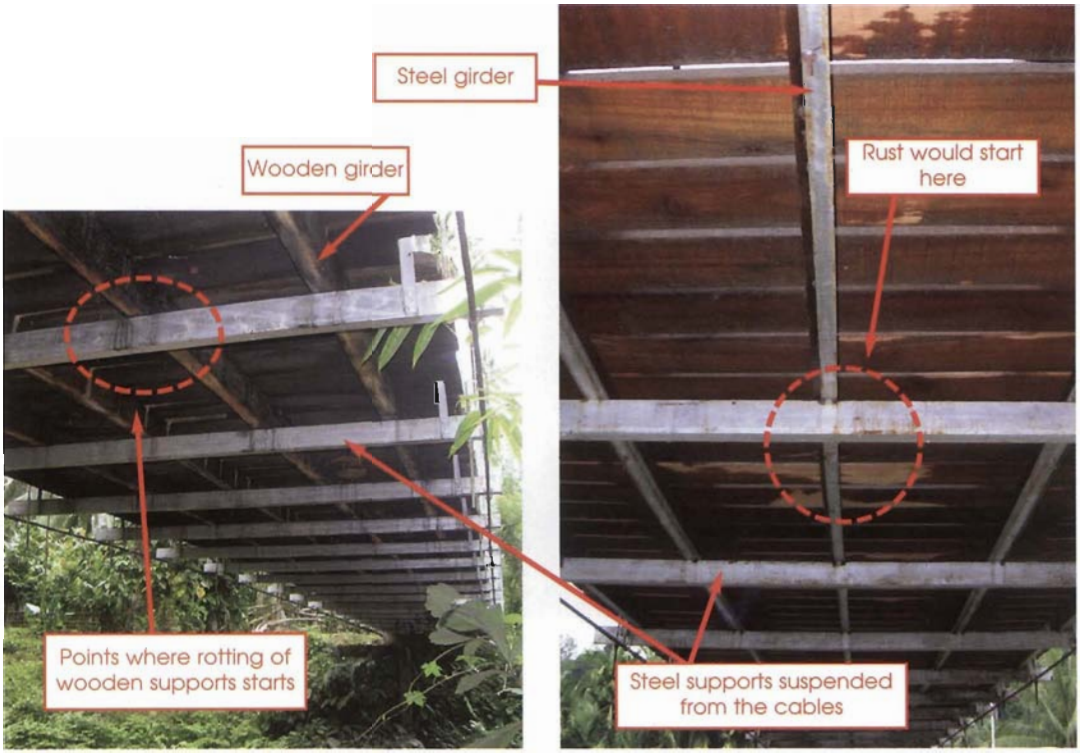
Why is it better ?

SUSPENSION BRIDGE

- **This type of bridge is suitable for spans up to 100 m.**
- **This bridge is for pedestrians and motorcycles only.**
- **Good O & M is essential, especially to prevent rusting.**

Alternative:

- No.



Construction details of a suspension bridge

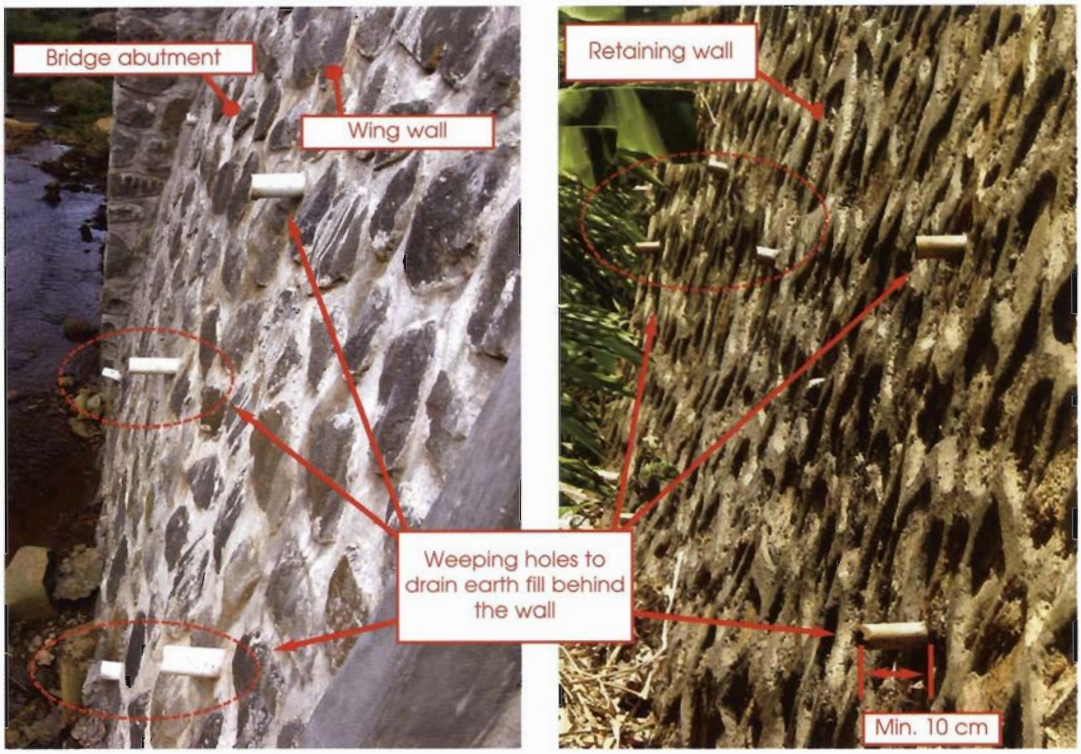
Why is it better ?

SUSPENSION BRIDGE, Details

- **Steel cross supports are preferable because of they last longer.**
- **Decking boards should be painted with weather resistant coating.**
- **Good O & M is essential.**

Alternative:

- No.



Drainage of retaining walls, abutments and wing walls

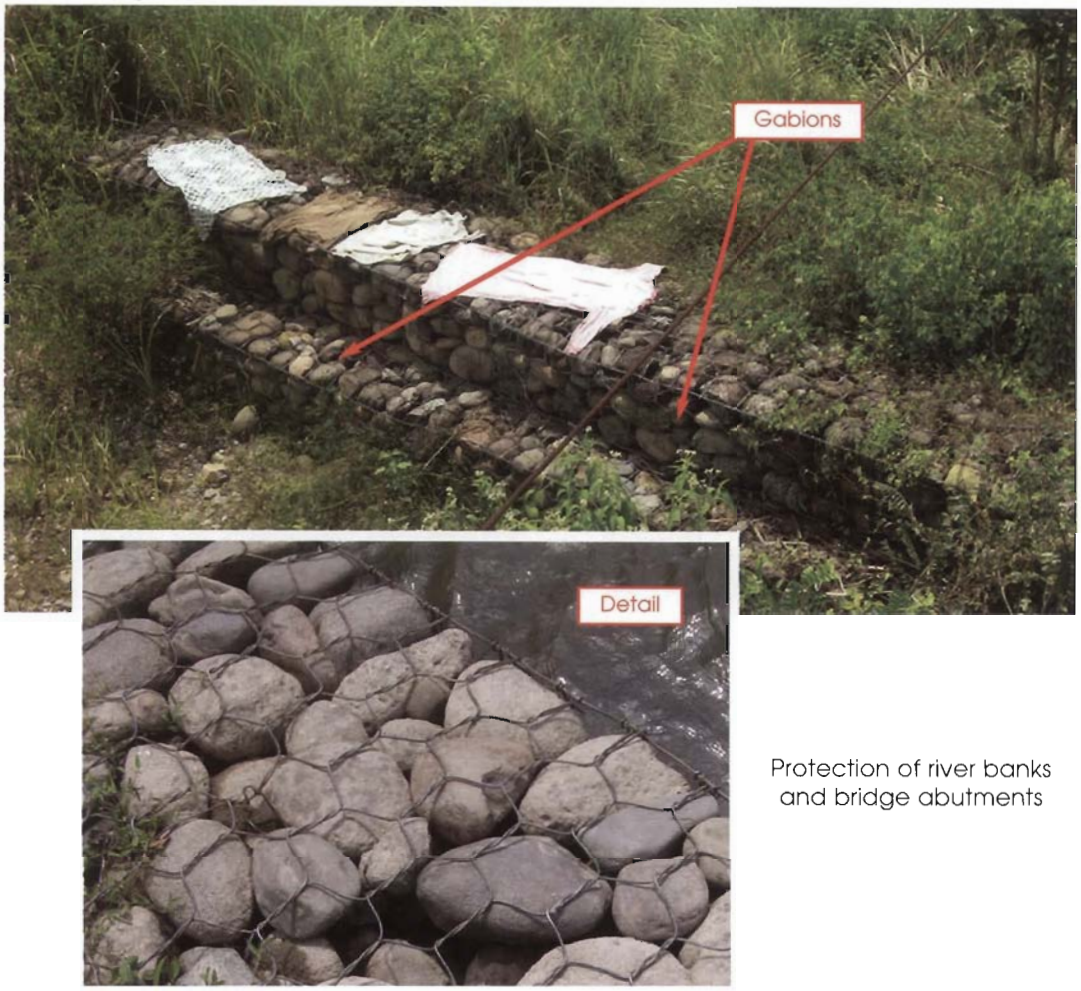
Why is it better ?

ABUTMENT or RETAINING WALL

- **If the sucked water cannot discharge from behind the wall, the water pressure will rise and exert pressure on the wall. The wall could fail, i.e. develop cracks or topple over.**
- **Weeping holes use PVC pipes, but bamboo or other materials could be used as well.**

Alternative:

- No.



Protection of river banks
and bridge abutments

Why is it better ?

RIVER BANK PROTECTION

- **Gabions consist of rocks or iver stones in a galvanized wire mesh cage - a simple but very effective construction element.**
- **Use gabions as protection for bridge abutments and for adjacent river banks.**

Alternative:

- Wing walls of masonry or concrete.
- Stone riprap.

PROGRAM PENGEMBANGAN KECAMATAN (PPK)

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9 789799 742841

ISBN 979-97428-4-6