Forestry Note:

CONSTRUCTING SMALL ROCKED FORDS ON FOREST AND FARM ROADS

This Forestry Note describes construction techniques and cost estimates for small rocked fords for various stream and road conditions.

Introduction

For small stream crossings on forest and farm roads, rocked fords are often preferable to culverts, bridges or concrete slabs (Figure 1). Well-constructed rocked fords are very dependable, very low in maintenance costs and generally low to medium in construction costs.

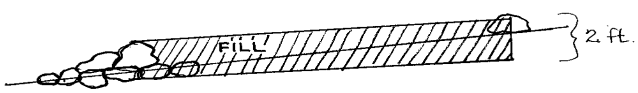

Figure 1. Typical small rocked ford construction with roadway excavation, rock fill, end walls and apron

The principle disadvantages of rocked fords are possible traffic delays during high water, the limitation of the ford low point on vehicle speed and the lack of rock at affordable cost in some locations. Particular advantages of rocked fords are ease of construction, use of local rock where available and ease of repair and reconstruction in case of natural changes in the channel.

Rocked fords can be designed to suit a wide variety of stream and road conditions. Design and costs are affected by differences in stream and channel conditions, expected velocity and depth of flows and planned road use (Table 1).

Commonly encountered road and channel conditions at crossing sites on ephemeral and small intermittent streams include: (1) V-shaped or steep-sided channels, (2) wide flat-bottomed channels with low banks and (3) small channels crossing a sloping road (Figure 2).

For larger fords, a small dozer is likely the most suitable equipment. However, a log skidder or a farm tractor fitted with earth-moving equipment may be suitable for small fords. Where surface rock is available at the site, a small ford can be constructed for little out-of-pocket cost with a farm tractor and hand labor.

On very small channels on rocky or gravelly soil, where local surface rock is available, a satisfactory ford may be constructed by placing a lower end wall with hand labor and a shallow roadway fill of rocky soil or gravel (Fig. 3a).

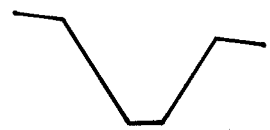

Figure 2-1, V-shaped channel

Figure 2-2. Flat-bottomed channel

Figure 2-3. Small channel on sloping road

Figure 3a. This natural crossing on the Caney Mountain Trail can be improved with hand labor and local rock at very low cost.

Fords on channels with deep soils, like those shown in Figures 3a and 3b, require more rock than fords on rocky channels, like those in Figures 3c and 3d.


Figure 3a


Figure 3b


Figure 3c

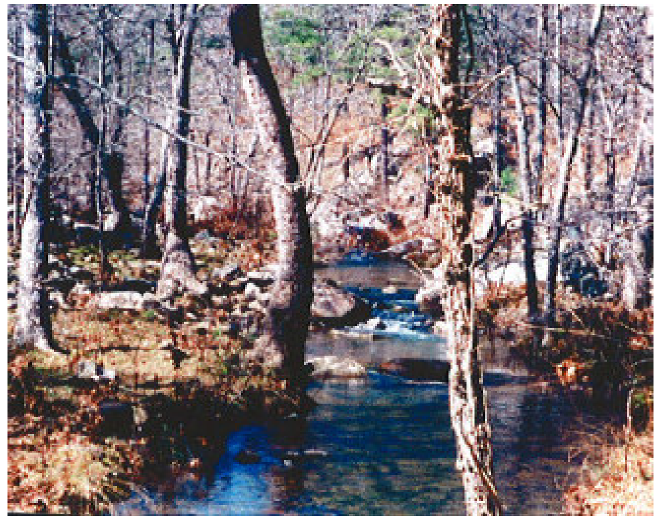
Figure 3d

This publication describes construction techniques and cost considerations for rocked fords designed for the three conditions depicted in Figure 2. The construction details are based on actual installation of small fords on demonstration roads on the Shagbark Ranch in Adair County near Sallisaw, Oklahoma, and the Caney Mountain Trail near Daisy, Oklahoma.

Constructing Fords on V-Shaped Channels

Design and construction steps consist of:

A. Proper location
B. Sloping banks where needed
C. Excavation for rock fill where needed
D. Placement of the end walls
E. Placement of the roadway rock fill
F. Placement of rock surfacing on steep approaches where necessary
G. Leveling and sloping the roadway rock fill
H. Placing and leveling additional gravel surfacing where needed.

Location

The ford should be located in a riffle area to minimize fill and ponding of water above the ford. The approaches to the ford should be at right angles to the channel, such as those shown in Figures 4a and 7a.

Bank Sloping

Where needed, the banks should be sloped, to a slope not exceeding 20 percent where feasible. In deep V-channels, short approach segments of greater slope may be necessary. Steep approaches (greater than 20 percent) should be surfaced with rock and gravel.

Table 1. Rock size recommendations based on the various fords in the two demonstration locations

Demonstration Road Location	Watershed Size (Acres)	Watershed Steepness	Channel Slope	*Rock or Gravel Used:* Rock or Channel Fill	Lower End Wall & Apron	Upper End Wall
Caney Mountain Trail (Heavy truck use)						
1	9	Low to Steep	Low	Crusher-run 8” max. dia.	6-8” dia.	None
2	40	Mod. to Steep	Moderate	Crusher-run 8” max. dia.	Local rock 12-18” dia.	6-8” dia.
3	13	Low to Mod.	Low	Crusher-run 8” max. dia.	6-8” dia.	6-8” dia.
4	11	Steep	Steep	8” max. dia.	Local rock 12-18” dia.	None
5	9	Steep	Steep	Crusher-run 8” max. dia.	Local rock 12-18” dia.	None
Shagbark Ranch Road (Auto and pickup use)						
6	11	Low to Mod.	Low	Gravel 1½ max. dia.	Local rock 6-12” dia.	None
7	10	Low to Mod.	Low	Gravel 1½ max. dia.	Local rock 6-12” dia.	None

Excavation for Roadway Fill

In most cases, the channel should be excavated and filled with rock (Figures 4c and 4d). On six of the seven demonstration road fords, the channel bottoms consisted of deep soils that become soft in wet weather. These channels were excavated and rock or gravel fills provided. Where the bottom is clay soil, excavation and rock or gravel fill are always necessary.

Excavation may not be needed where the bottom consists of firm sandy, gravelly or rocky soil with no clay, and a roadway fill of at least one foot of rock is provided.

Where excavation is needed, it should normally be about 1½ feet in maximum depth and 4 to 8 feet of roadway length, the length depending on channel size. In cases where the fill is on clay subsoil and heavy truck use is expected, the excavation should be deeper. Excavated soil (other than clay) can be spread on the roadway approaches. The excavation should be extended to include the end wall sites. This will allow water to seep through the rock fill and minimize water standing on the ford roadway and ponding in the channel above the ford.

Roadway Rock Fill

Size of rock needed in the roadway fill depends on the ability of high flows to move the rock. This ability increases as flow velocity and depth increase. Flow depth and velocity increase with channel slope and watershed size and steepness. The watersheds of the seven fords ranged from 6 to 40 acres in size and differed widely in steepness and channel slope (Table 1).

Size of rock in the roadway fill and depth of the fill needed are also dependent on frequency of road use, likelihood of frequent use during wet conditions and weight of vehicles. Based on the experience of the seven fords constructed, crusher-run rock of 8 inches maximum diameter is recommended as fill for all fords that will receive heavy truck use (Figure 4d).

At locations that receive heavy truck use and where the fill must be placed on clay subsoil, larger rock should be used. In fords for light vehicle use only, fills of gravel of 1½-inch maximum diameter or larger may be satisfactory (Figure 5).


Figure 4a. This channel bottom is on deep soil and became a mud hole during log truck use


Figure 4b. Small boulders were pushed to build the lower end wall


Figure 4c. The channel was excavated, then filled with rock


Figure 4d. Additional fill in channel


Figure 4e. A dozer leveled and shaped the rock fill to form the roadway surface


Figure 4f. The ford two years following completion and with heavy log truck use

Figure 5. Placing a gravel fill in a ford on a light-use road

Crusher-run rock of 8 inches maximum diameter can be spread easily with a small dozer to form a usable surface (Figure 4e). The ford surface should be sloped about 3 percent to help prevent water from standing in the ford.

An alternative for the roadway fill is to use Geoweb© with small rock or gravel fill, rather than the larger rock as recommended. Where a gravel surface is provided, the Geoweb© has the advantage of holding the gravel in place during use (Figure 6).

Figure 6. A Geoweb© and gravel fill surfaced ford

End Walls and Apron

Use a wall of larger rock at the lower end of the roadway fill to prevent high flows from washing out the fill (Figure 4b). Base the size of the rock to be used in the end wall on expected stream flow, velocity and depth, which are determined by the watershed and channel characteristics noted above. End wall rock sizes used in the seven fords varied considerably (Table 1).

Based on the demonstration examples, end wall rock sizes in fords on steep watersheds in the general size range of 10-50 acres should be 12-18 inches in average diameter or larger. Most rocks of this size can be moved by hand. Rocks of this size may also be suitable for somewhat larger watersheds with moderate slopes. To aid the choice in rock size, the channel above and below the ford location should be examined to determine the larger sizes of rock typically moved by the stream.

On fords where the rock size in the end wall should be larger than the maximum size in the rock fill, the lower end wall should normally be placed prior to the rock fill. Where the end wall is to be constructed of the larger rocks in the fill material, the wall can be constructed by hand labor as the fill material is dumped and spread.

On fords where fast and deep flows are expected, and where the channel is not naturally armored with rock, an apron of rock of the same size used in the lower end wall should be placed below the wall.

An upper end wall should be placed where expected high flows may dislodge the roadway surface fill materials. An upper end wall may not be needed where the ford surface over the channel is not elevated above the channel bottom. Using these criteria, upper end walls were installed on only two of the seven demonstration fords.

Rock size in the upper end wall can be smaller than what is required for the lower wall. On watersheds of the sizes and conditions represented in the examples, the larger pieces in crusher-run rock of 8 inches maximum diameter can be used for the upper end wall. Where local surface rock is available, an upper wall can be constructed for most fords of this size range with one-half hour of hand labor or less.

Fords on Wide Flat-bottomed Channels

Design and construction steps on fords across wide, flat-bottomed channels are generally the same as for V-shaped channels. Usually, gently-sloping approaches can be provided with little or no bank sloping. Figures 7a and 7b present pre-construction conditions and placement of the rock fill and end wall on one of the flat-bottomed crossings on the Caney Mountain Trail demonstration road.

The channel bottom at this location was firm, consisting of rock and sandy soil. No excavation was needed. A fill of about one foot of rock 8 inches in maximum diameter was placed across the channel.

The watershed above this crossing is about 9 acres, with moderate to steep slopes. The channel slope is gentle. These conditions allowed the use of larger pieces of the rock fill material to form the lower end wall. No upper end wall was needed.

Figure 7a. Rock fill on a wide, flat crossing on an old road. The end wall is being placed by hand.

Figure 7b. Dozer leveling rock fill. Lower end wall and apron have been completed.

Constructing Fords on Sloping Roads

Guidelines for proper location, excavation and fill, end walls and surfacing in constructing a ford on a sloping road are the same as for V-shaped channel crossings. However, this type of structure differs from the ford crossings described above, in the need for a berm immediately below the channel to prevent high water from flowing down the road. The crossing is in fact a ford-dip combination. Construction is illustrated in Figures 8a-d. The watershed above the ford is small but steep, with a steeply sloping channel immediately above the ford. Large boulders were placed in the channel to serve as flow-energy dissipaters to reduce the velocity of high flows across the ford (Figure 8e).

The alternative to the combination ford-dips constructed on the two demonstration roads would have been to install pipe or box culverts. Some BMP publications in other areas make a general recommendation against using a dip as a stream crossing. However, we have found this type of structure preferable where limited to small ephemeral channels, and where the guidelines described were applied.

The two ford-dip combinations installed on the demonstration roads replaced pipe culverts that had become plugged with soil. The ford-dips as constructed will handle larger flows without damage and will require less maintenance than culverts.

Ford Construction Costs

Costs for the five examples on the heavy-use road ranged from 1/4 to 2 dozer hours, 1/4 to 1/2 hand-labor hours and 8 to 14 tons of rock. Inputs for the two light-use ford examples were 1/2 hour each for dozer, 1/4 to 1/2 hours for the farm tractor and 1/4 hour to 1/2 hour hand labor time, and 4 to 5 tons of gravel.

Costs of construction vary considerably, depending on the watershed and channel conditions, the expected use of the ford, the type of equipment used, operator experience, cost of rock or gravel and availability of hand labor.

In the examples presented, machine costs for the two light-use fords were relatively high because of the equipment used. The dozer was too large and did not have an adjustable blade. Additional work with a farm tractor was necessary.

In the first five fords described, the rock fills ranged from 8 to 14 tons. These fords were designed for frequent use in all seasons by heavy log trucks and fire control transports. On a light-use road with infrequent heavy truck use, the volume of the fill could be satisfactorily reduced by fifty percent or more.

Where rock or gravel must be purchased and delivered, the cost of the delivered material will usually be the major cost item. Rock or gravel costs are variable among locations because of large differences in delivered costs due to the distance from the source and road conditions to the site. Where rock delivery involves transport over a rough, low-standard mountain road, hauling costs will be high. Building the road to meet Oklahoma BMP guidelines would be the first step to reducing high haul rates.

Where rock purchase and delivery costs are prohibitive, use of local surface rock may be an alternative in some areas where hand labor is available. Local rock could have been used in all of the examples described.

Figure 8a. Dozer removing old culvert and excavating channel

Figure 8b. Dozer filling channel with rock

Figure 8c. Dozer pushing small boulder for end wall

Figure 8d. Rock fill in channel and berm

Figure 8e. Dozer placing large boulder flow dissipaters in channel above ford

Figure 8f. Completed ford and berm

Figure 8g. Ford two years following completion

Based on the cost inputs for the first five rocked fords listed and estimated machine and labor cost rates, most heavy-use rocked ford installation costs that involve excavation and rock fill are likely to be in the general range of 200 to 500 dollars. The range is due mainly to differences in the cost of delivered rock.

Where loose local surface rock is available at the site, small fords can be constructed at quite low rates. In smaller fords requiring less than two tons of rock, the rock can be collected and placed with 10 hours of hand labor or less.

Maintenance Costs

Maintenance costs and risk of washout are primary considerations in choice of types of stream crossing. Differences in maintenance requirements should be considered as being very important from the standpoint of road usability and water quality, as well as repair costs. Properly designed rock fords are usually easier and cost less to maintain than culverts or bridges. Well-constructed fords are very low in maintenance costs.

The five fords on the Caney Mountain Trail received exceptionally high flows and heavy log truck use soon after construction without damage or the need for maintenance (Figures 4f, 8f and 8g). The two fords on the Shagbark Ranch road have been in service for several years with no repairs needed.

Other Information Sources

This Forestry Note is one in a series on stream crossings and forest road Best Management Practices (BMPs) produced by the Oklahoma Department of Agriculture, Food, & Forestry - Forestry Services Division. Other Forestry Notes include:

- Introduction to Road Stream Crossings
- How to Install a Forest Road Culvert
- Designing and Constructing Large Rocked Fords on Forest Streams
- A Handy Gauge for Forest and Farm Road Construction Measurements

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Additional information on this and other forest road BMPs is available in videos produced by Forestry Services and in the OSU Extension handbook *Best Management Practices for Forest Road Construction and Harvesting Operations in Oklahoma* and a publication by the USDA Natural Resources Conservation Service, *Woods Roads*. These materials may be available at local offices of Forestry Services, the OSU Cooperative Extension Service and the Conservation Districts.

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Forestry Services Division
Oklahoma Department of Agriculture, Food, & Forestry
2800 North Lincoln Boulevard
Oklahoma City, OK 73105-4298
405-522-6158

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