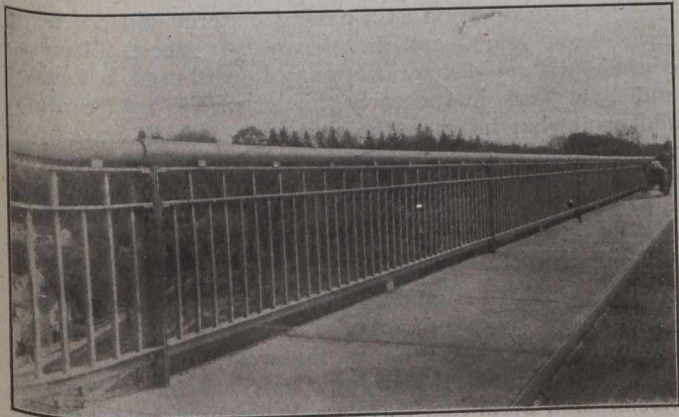


the pier secure against displacement. The entire design of a pier should be carried out so that it will have a stability factor of at least two under all possible conditions.

Roadway Embankments.—The embankments of the approaches to a bridge should be made in thin layers and thoroughly compacted. Each layer should be built out to the full width required, with its sides constructed to the true slope, and not widened with loose material dumped from the top. All side slopes of the embankment should be constructed to a batter of 1½ feet horizontal to 1 foot vertical.

Where washing of the embankment may be expected during times of high water, the outside slopes should be protected with a rip rap of large stones properly laid to protect the filling. Such rip rap should extend from a solid bottom up to a height of several feet above high water mark.

Surface and Subsurface Drainage.—Wherever possible water shall be kept off the roadbed. This may be accomplished by a properly crowned roadway surface, and by having the ditches always in proper condition to drain water away. Water should not be allowed to remain in side ditches, and to prevent such condition the



Handrail Should be of Such Height as to Give Confidence.

ditches should be properly graded to the natural outlet. To protect embankments built upon saturated soils a satisfactory procedure is to provide intercepting ditches or pipe drains. In cuts, the side ditches should be excavated through whatever class of material is met with. In wet cuts or in wet and soft hills or side hills a tile drain or drains should be provided. The wet spots appearing in the roadway on a hill should have a tile drain run into such wet spot, and any soft material removed and replaced with crushed stone or gravel.

Breaking and sliding away of the shoulder of a roadway is best cured by flattening the slope away from the shoulder. This should be accomplished by filling in material against the embankment. The old surface of the embankment should be ploughed before any new material is placed, so that a satisfactory bond may be secured.

Where a roadway is in a cutting and material from the sloping banks continues to slide in on to the road, the best method of securing relief is to remove the bank on each side of the road till a flatter slope is secured.

Pipe Culverts.—Pipe culverts are circular in cross-section, and vary from 8 to 48, and even 60 inches in diameter. The materials used in their manufacture are vitrified clay, corrugated sheet metal, cast-iron and concrete. Culverts should be permanent; should be large enough to easily pass the largest flood flow of water;

should, if possible, be self-cleaning, and should be of such a size as to permit cleaning.

It is important that they be large enough to enable proper cleaning, and with this fact in view it is recom-

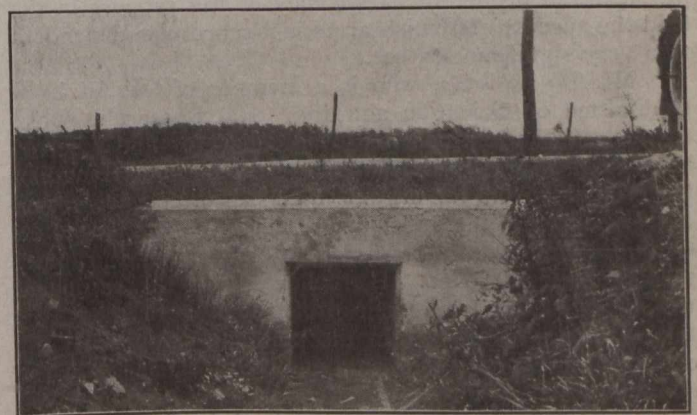


What Happens when Good Endwalls are not Used and Pipe not Properly Located.

mended that pipes less than 15 inches in diameter be not used, and that the opening of box culverts be not less than 2 feet square. The amount of material required for these sizes is not a very great increase over those of smaller dimensions, and the ease with which they may be maintained fully warrants their construction. Where conditions permit, culverts should be laid with a fall of about 1 foot in 20 feet, and care should be taken to see that the ditch above and below the culvert is properly graded to deliver and carry away the water.

Care should be taken to construct a substantial head-wall of concrete or rubble-stone at each end of the pipe, and to see that the footings of this wall extend to a depth of not less than 3 feet. All joints in the pipe should be carefully made and thoroughly tight.

The foundation upon which the pipe rests is very important, and a solid bottom should be secured before laying the pipe. If earth is the material upon which the pipe is laid a satisfactory foundation may be secured by trimming off the bottom of the trench to a firm and even bearing. After the pipe is placed great care should be taken to thoroughly tamp and pack the backfilling around



Well Built and Properly Drained.

the pipe, as otherwise unequal settlement may occur and the earth will crack or crush the pipe. Backfilling should be placed in layers 6 inches thick and well tamped. In soft or marshy soils a trench should be excavated one