U. S. Department of Agriculture
Soil Conservation Service
Engineering Division
Design Branch

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Design Note No. 17 *

Subject: Some Comments on the Location of Riser-Conduit Articulation Joints

This design note is occasioned by a known instance of distress in a drop inlet spillway riser. The riser included a special elbow and transition, all constructed as a monolithic unit.

In pipe conduit drop inlet spillways where flow velocities are sufficiently low and pressures are sufficiently high, it has been standard practice for many years to employ an articulation joint between the drop inlet riser and the pipe conduit. This close-in articulation joint, located immediately downstream of the riser, consists of two components: a spigot wall fitting set in the downstream endwall and the adjacent pipe bell section. This practice grew from the recognition that it is desirable, especially when the riser is situated within the embankment, to permit essentially free relative rotation and longitudinal translation between the riser and the most upstream pipe conduit length. The ability of both elements to displace independently with their surrounding environments is beneficial in that this behavior tends toward minimum possible loadings on the elements. Service publications contain references to, and illustrations of, this feature of design. (See the list of relevent references at the end of the design note.)

When velocities in the spillway are too high, the standard square-edged conduit entrance used with the spigot wall fitting is no longer satisfactory. High velocities and square-edged entrances are associated with flow separation, objectionable vibrations, and cavitation problems. Thus with a high velocity structure it becomes necessary to incorporate a special elbow and transition in the drop inlet spillway design.

The provision of a special elbow and transition to meet hydraulic requirements does not negate the structural desirability of an articulation joint placed as close to the plane of the downstream endwall of the riser as is physically reasonable. The following discussion is primarily pertinent to a riser within an embankment. Nevertheless, benefits also exist when the riser is located out in the reservoir area.

Risers with special elbows and transitions have sometimes been designed and/or constructed as monolithic units with the first articulation joint located at the downstream end of the transition. It should be recognized that such monolithic construction results in riser resistance to rotation

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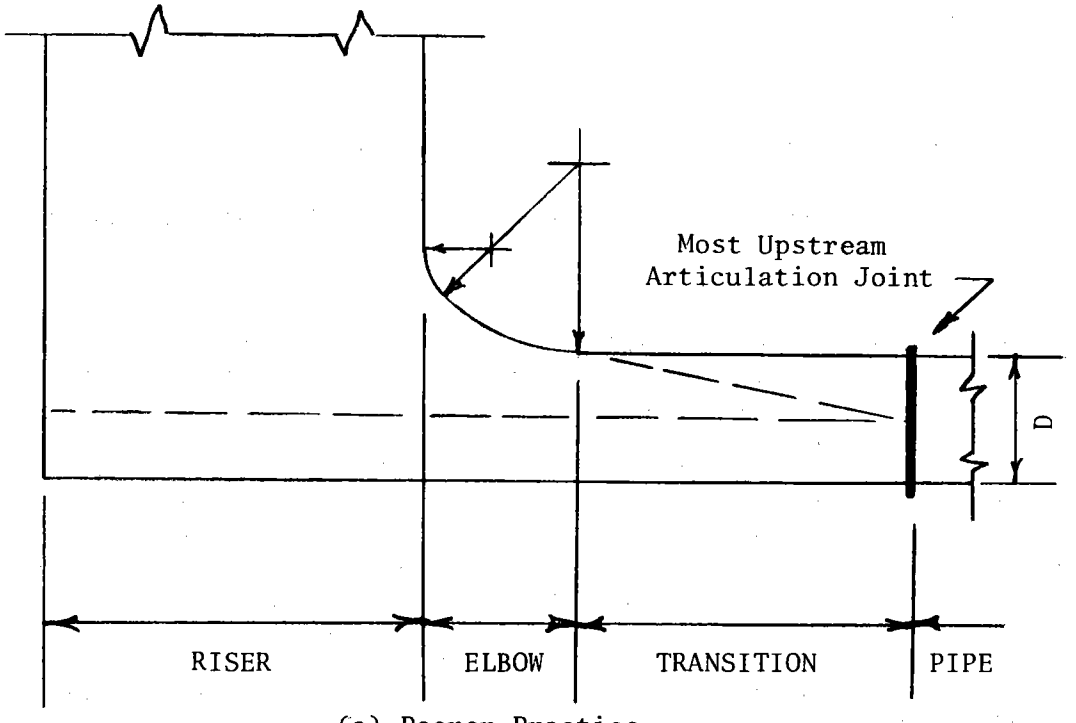
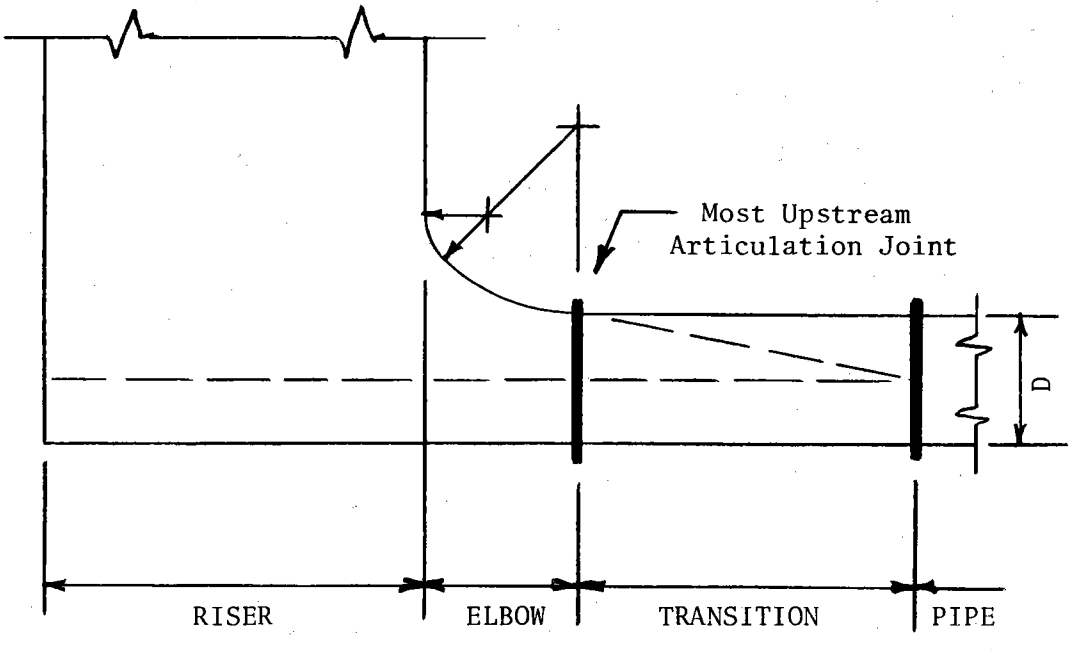


(a) Poorer Practice
Most Upstream Articulation Joint at Transition-Pipe Section



(b) Preferred Practice
Most Upstream Articulation Joint at Elbow-Transition Section

Figure 1. Special Elbow and Transition

in excess of that associated with risers without special elbows. Therefore a riser having a substantial monolithic downstream projection will probably induce embankment loading, that is, net loading tending to cause overturning of the riser, in excess of that normally associated with risers having close-in articulation joints. In this case, provision for moment from embankment loading may become a principal design consideration.

The selection of the proper magnitude of embankment loading to be assumed in design is always difficult. The Service normally treats the difference between the downstream and the upstream lateral earth pressures on standard risers as roughly equivalent to the active pressure case on the downstream face only. On the proposition that this is reasonable practice for risers with close-in articulation joints, the ratio of the increased embankment loading for risers with monolithic special elbows and transitions to the embankment loading for risers with close-in articulation joints may range up to something on the order of the ratio of "at rest" lateral pressures to active lateral pressures.

There is a better approach than that of designing monolithic units for such increased loadings with the concomitant problems. Make the layout conform as nearly as possible to that of standard risers with their close-in articulation joints. Therefore, design for the more normal loadings and provide an articulation joint at the vertical section common to the downstream end of the special elbow and the upstream end of the transition.* This joint can be the same as those ordinarily used in rectangular conduit layouts. If felt desirable, short tangent lengths can be provided each side of the joint. The joint at the downstream end of the transition would have the usual transition-to-pipe conduit configuration. The smallest length elbow consistent with hydraulic needs should be used. This would usually mean the compound quarter curve shown in Figure 2 of Design Note No. 8, "Entrance Head Losses in Drop Inlet Spillways," would be selected.

Figure 1 shows two layouts of a riser-elbow-transition configuration in a pipe conduit drop inlet system. Sketch (a) shows the most upstream articulation joint located at the downstream end of the transition. The embankment over the special elbow and transition serves as an anchor tending to prevent the riser from rotating. Sketch (b) shows the most upstream articulation joint located at the section common to the downstream end of the special elbow and the upstream end of the transition. This layout permits riser rotation essentially independent of the transition.

No mention has been made thus far of rectangular conduit drop inlet spillways. The preceding comments apply to these spillways also, but not to the same extent since transitions are not involved. Here also, the smallest length elbow consistent with hydraulic needs should be used. This would usually mean either the simple quarter curve "rounded" or the compound quarter curve "special" elbows shown in Figure 4 of DN-8 would be selected. The articulation joint can then be located at, or close to, the point of tangency.

*This basic concept, in the context of risers with special elbows and transitions, was recently suggested by Quinton K. Milhollin, Civil Engineer, Design Section, STSC.

Relevant SCS references:

ES-150	Drop Inlet Spillways, Standard for Covered Top Riser
ES-151	Drop Inlet Spillways, Standard for Rectangular Open Top Riser
ES-152	Drop Inlet Spillways, Standard for Square Open Top Riser
DN-8	Entrance Head Losses in Drop Inlet Spillways
TR-18	Computation of Joint Extensibility Requirements
TR-29	Hydraulics of Two-way Covered Risers
TR-30	Structural Design of Standard Covered Risers
TR-60	Earth Dams and Reservoirs.