6.2.4.1 Types of Drilled Shafts

The five categories of drilled shaft foundations are defined by their diverse methods of load transfer. Generally, the load-carrying capacity is obtained from load transfer to the soil from the shaft or the base or a combination of both, as described below.

1. Straight shaft, end-bearing drilled shaft. Load is transferred by base resistance only.
2. Straight shaft, side-wall-shear or friction drilled shaft. Load is transferred by shaft resistance only.
3. Straight shaft, side-wall-shear and end-bearing drilled shaft. Load is transferred by a combination of shaft and base resistance.
4. Belled or under-reamed drilled shaft. Load is transferred by the bell in end-bearing. Shaft resistance may be considered, depending on the dimensions of the drilled shaft and overburden material.
5. Straight or belled drilled shaft on hard soil or rock. Shaft resistance may be considered under some circumstances, with the approval of the Bridge Design Engineer.

6.2.4.2 Application of Drilled Shafts

The drilled shaft is usually employed as a deep foundation to support heavy loads or to minimize settlement. Because of the methods of construction, it is readily applied to soil above the water table, or soil that is nearly impermeable, and to profiles where rock or hard soil is overlaid by a weak stratum. With suitable construction techniques and equipment, the drilled shaft can be used in less favorable conditions. Casing or bentonite slurry can be employed to prevent caving or deformation of loose or permeable soils.

The methods of construction can be adapted to severely restricted conditions using specialized equipment. Often drilled shafts are used where piles cannot be driven due to physical overhead restrictions. Drilled shafts also have applications under certain environmentally sensitive conditions.

The geometry of the drilled shaft will be determined by the soil conditions and the performance requirements. If lateral forces have to be resisted, modifications to the structural stiffness must be made for the bending stress. The load capacity of drilled shafts is such that a single, large-diameter drilled shaft can take the place of a group of driven piles.

The flexibility of this type of foundation is such that axial and lateral loads can be resisted in a variety of soil conditions. The final decision as to whether drilled shafts are better applied to a foundation problem than driven piles must be based on the performance requirements and economic considerations. Refer to the *FHWA Drilled Shaft Manual*.

6.3 SEISMIC DESIGN AND RETROFITTING

All bridge structures in Delaware must be designed with consideration of seismic (earthquake) motion. Seismic design is not required for culverts. Each bridge will be designed considering the Seismic Performance Zone and the Acceleration Coefficient. Every bridge in Delaware must have an Importance Classification assigned.

The boundary between Seismic Performance Zone "1" and "2" is Delaware