Transition Width

In the construction of sewer and culvert facilities using round pipe, the two most common types of installations are trench and positive projecting embankment.

TRENCH CONDITION

When concrete pipe is installed in a relatively narrow trench, settlement between the backfill material and the undisturbed soil in which the trench is excavated generates upward frictional forces which effects a load transfer. These frictional forces helps support the backfill material within the trench and results in less load on the pipe than the weight of the prism of backfill material over the pipe.

POSITIVE PROJECTING EMBANKMENT CONDITION

When concrete pipe is installed on the original ground and fill material is placed around and over the pipe, relative settlements between the fill adjacent to the sides of the pipe and the fill directly over the pipe generates downward frictional forces, also effecting load transfer. However, this load transfer results in greater fill load on the pipe than the weight of the prism of fill over the pipe.

TRANSITION CONDITION

The trench and positive projecting embankment conditions represent the limiting loading conditions with the trench being the most favorable and the embankment the most severe. When pipe is installed in a relatively narrow trench, the backfill load is a function of the trench width. As the trench width is increased, for any given size of pipe, type of in situ material and height of backfill, a limiting width is reached beyond which the frictional forces does not help support the weight of the backfill material. The trench width at which this condition occurs is defined as the TRANSITION WIDTH. At trench widths greater than the transition width, the installation simulates a positive projecting embankment condition with the load transfer increasing the weight of the prism of backfill over the pipe. Once the transition width is realized, the backfill load is a maximum and remains constant regardless of any further increase in the trench width. To illustrate the transition condition, and the relationship between trench loads and embankment loads, the frictional forces and resultant load transfer can be depicted as columns of fill or backfill material.

Figure 1 illustrates a positive projecting embankment installation with the pipe installed on a firm, unyielding foundation. Since concrete pipe is relatively rigid
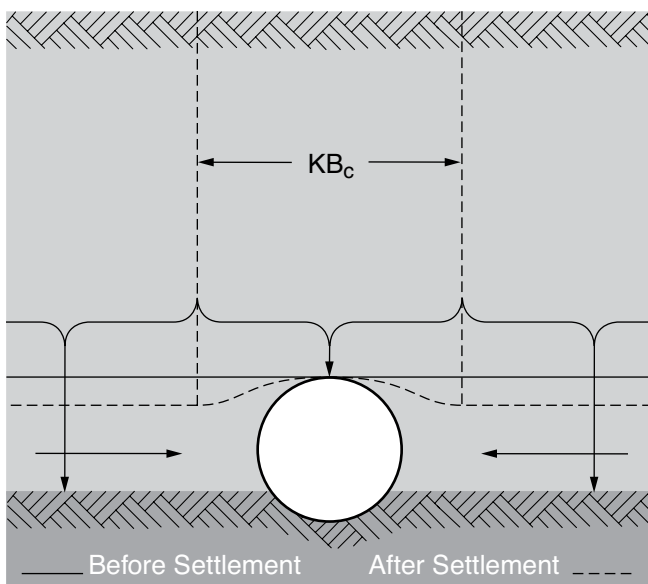
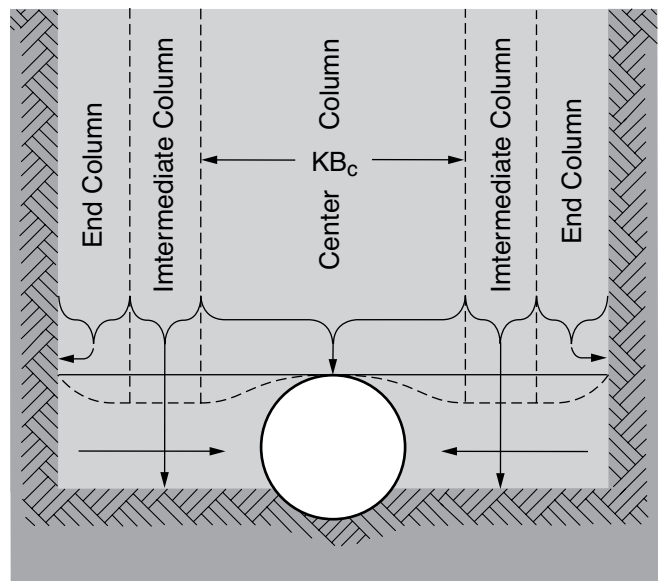### Figure 1 Positive Projecting Embankment

KB_c

Before Settlement   After Settlement

Figure 2 Wide Trench Condition

End Column   Imtermediate Column   Center   KB_c   Column   Imtermediate Column   End Column

compared to the semi-elastic soil surrounding the pipe, the columns of fill adjacent to the sides of the pipe will compress or settle more than the prism of fill directly over the pipe. This relative settlement generates downward frictional forces in the soil mass which transfers load onto the pipe so that the pipe carries a load in excess of the weight of material directly above it. This increased load can be represented by a column of fill of width KBc, where K is a load transfer coefficient and Bc is the outside diameter of the pipe. When concrete pipe is installed in this manner, the coefficient K will always be greater than 1.0 and can be as much as 1.45. In addition to the vertical load on the pipe, compression of the fill material on either side of the pipe results in horizontal forces against the sides of the pipe (lateral support) which increase the load carrying capacity of the pipe.

The Figure 2 installation is the same as Figure 1, except the pipe is placed in a wide trench relative to the size of the pipe. When concrete pipe is installed in a wide trench, the backfill material can be considered as five separate but interacting columns; two end columns, two intermediate columns and a center column. The two end columns adjacent to the trench walls will settle relative to the undisturbed soil in which the trench was excavated. This settlement generates upward frictional forces along the trench walls resulting in a load transfer as indicated. This load transfer does not reduce the load on the pipe, since the trench is of sufficient width that the intermediate and center columns still simulate the positive projecting condition illustrated in Figure 1. The intermediate columns of fill on either side of the pipe are not affected by the pipe or trench walls. These columns will settle more than the center column and transfer load onto the pipe such that

the KBc dimension and load on the pipe is the same as the positive projecting embankment condition. The load from the intermediate columns will be transmitted to the trench bottom and, because of compression, horizontal forces will develop against the sides of the pipe.

Figure 3 is the same as Figure 2, except the trench is narrower and of such width that the intermediate columns have been eliminated. The two end columns are now being supported by the trench walls and the pipe. With the elimination of the intermediate columns (Figure 2), the entire backfill load is being supported by the pipe and the trench walls. This is the TRANSITION WIDTH, with the load carried by the pipe being the same as for the "positive projecting embankment installation" and the "wide trench installation". This load is constant for any trench width from the "transition width" to infinity.

If the pipe is installed in a trench narrower than the transition width, as illustrated in Figure 4, the trench walls support as much of the load as in the previous wide trench and transition installations. However, the width of the remaining center column to be supported by the pipe has decreased. The load carried by the pipe is no longer a function of the pipe, but instead is controlled by the width of the trench. Therefore, the narrower the trench, the less the backfill load will be on the pipe. However the trench must be greater than the minimum trench width based on appropriate specifications.

Figures 5, 6, and 7 show the transition widths for ACPA Standard Installations Type 1-4. An explanation of Standard Installations can be found in the ACPA Concrete Pipe Design Manual. For any given size of pipe and height of backfill, the transition width is dependent on the type of in situ material. However, variations in the transition
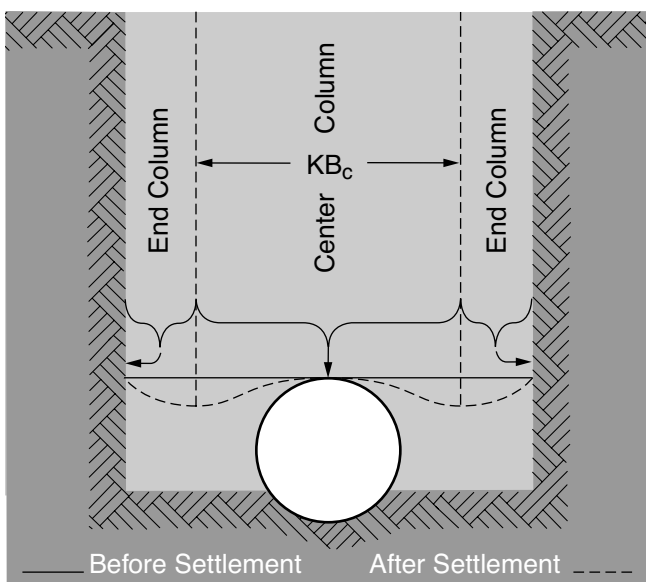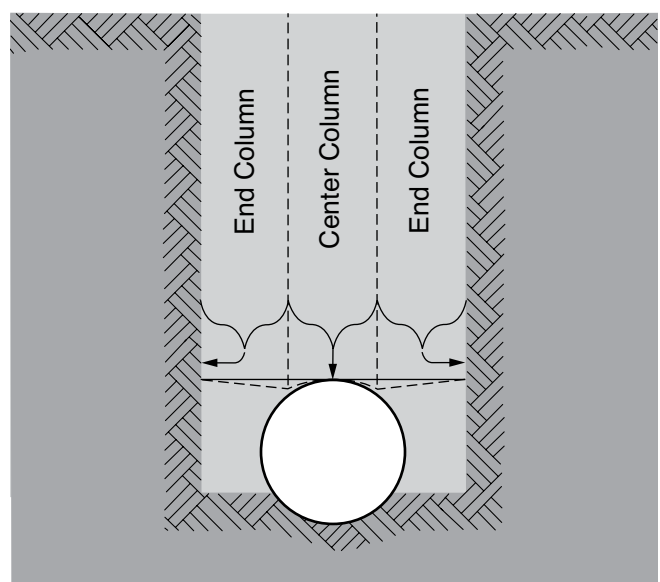

Figure 3   Transition Condition

_____ Before Settlement   After Settlement _ _ _ _

Figure 4   Trench Condition

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Figure 5   Transition Widths for Type 1 Installations Using Sand and Gravel Backfill Material

Heigth of Backfill, H, Top of Pipe (Feet) vs Transition Width, B$_d$ (Feet)

Diameter D in Inches: 12, 15, 18, 21, 24, 27, 30, 33, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114, 120, 126, 132, 138, 144
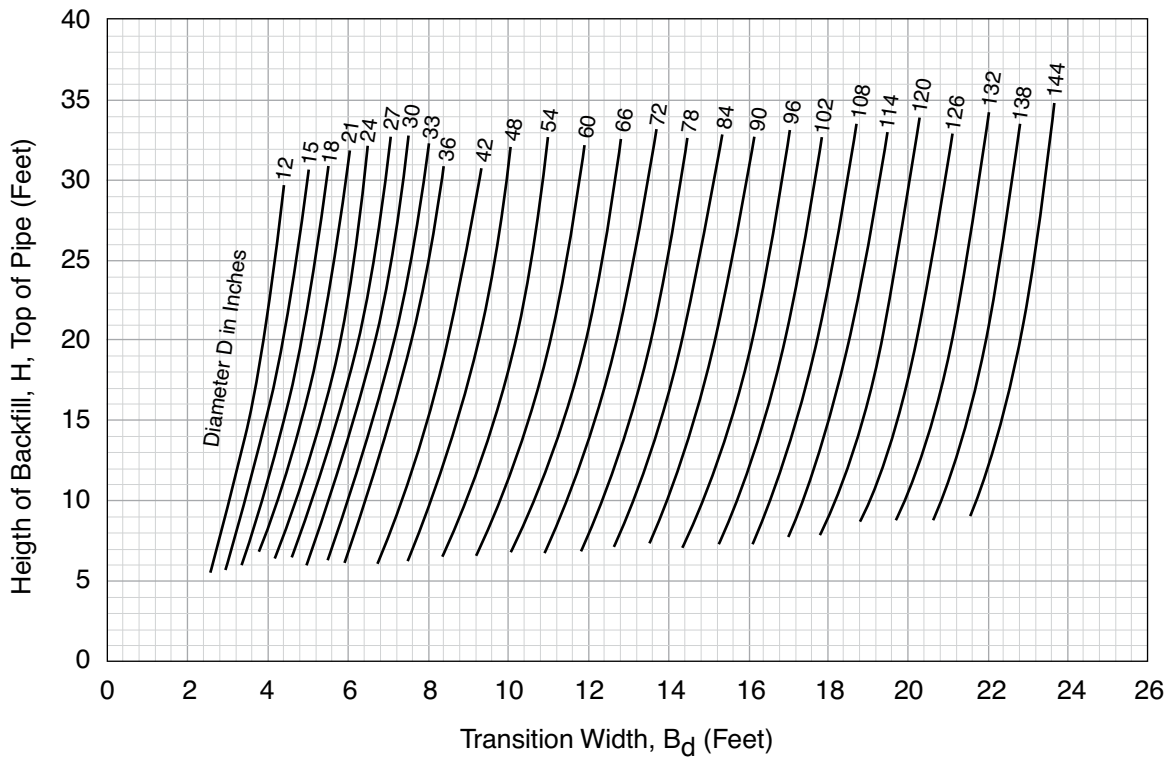
Figure 6   Transition Widths for Type 2 and 3 Installations Using Sand and Gravel Backfill Material

Heigth of Backfill, H, Top of Pipe (Feet) vs Transition Width, B$_d$ (Feet)

Diameter D in Inches: 12, 15, 18, 21, 24, 27, 30, 33, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114, 120, 126, 132, 138, 144

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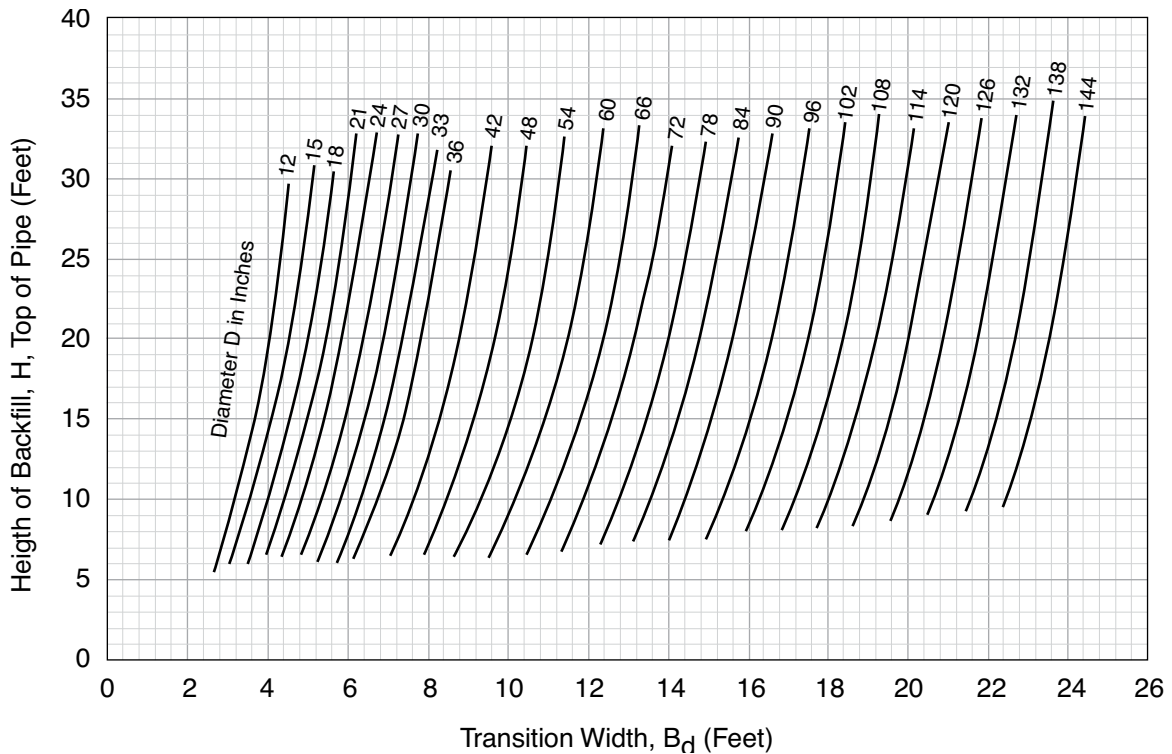
Figure 7   Transition Widths for Type 4 Installations Using Sand and Gravel Backfill Material

Height of Backfill, H, Top of Pipe (Feet) vs Transition Width, B$_d$ (Feet)

Diameter D in Inches: 12, 15, 18, 21, 24, 27, 30, 33, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114, 120, 126, 132, 138, 144
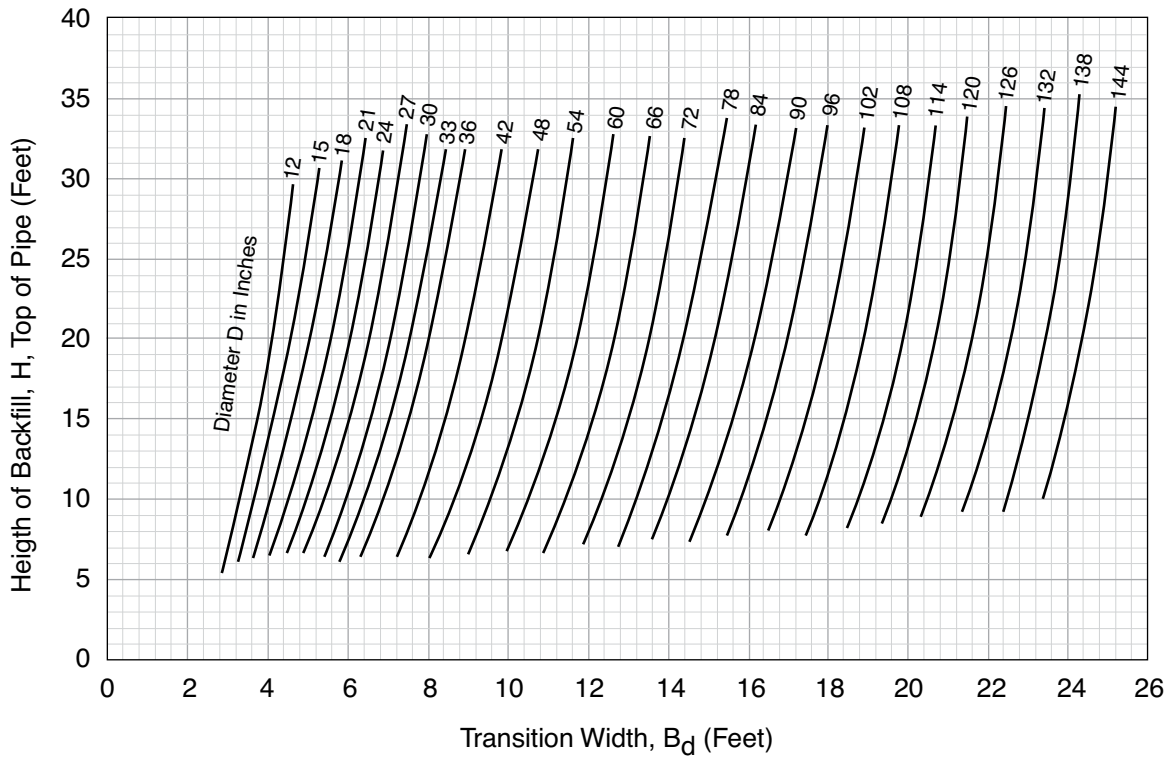
Figure 8   Transition Loads on Circular Pipe (Type 1)

Height of Backfill, H, Above Top of Pipe (Feet) vs Backfill Load, W(Pounds Per Linear Foot)

Diameter D in Inches: 12, 15, 18, 21, 24, 27, 30, 33, 36, 42, 48, 54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114, 120, 126, 132, 138, 144

Loads based on positive projection embankment installations with 100 pounds per cubic foot backfill. For fill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds, increase loads 20%; etc.

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Figure 9   Transition Loads on Circular Pipe (Type 2 & 3)

Diameter D in Inches

Loads based on positive projection embankment
installations with 100 pounds per cubic foot backfill.
For fill weighing 110 pounds per cubic foot, increase
loads 10%; for 120 pounds, increase loads 20%; etc.

Heigth of Backfill, H, Above Top of Pipe (Feet)

Backfill Load, W(Pounds Per Linear Foot)
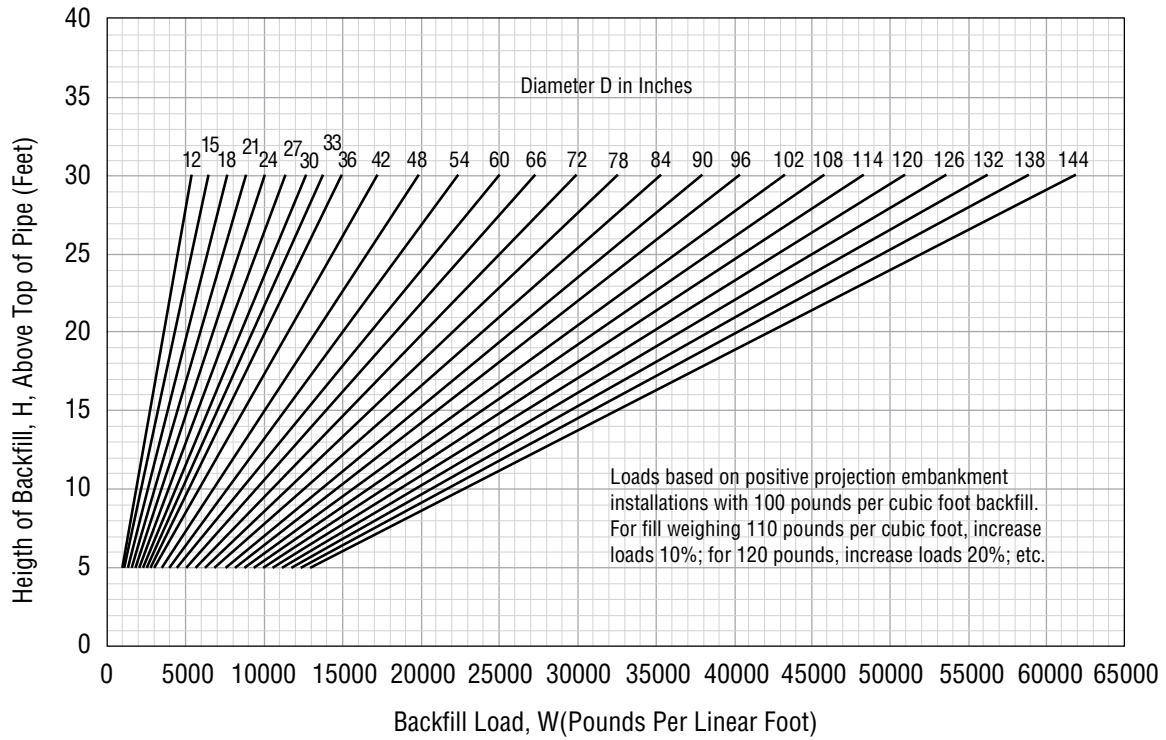
Figure 10   Transition Loads on Circular Pipe (Type 4)

Diameter D in Inches

Loads based on positive projection embankment
installations with 100 pounds per cubic foot backfill.
For fill weighing 110 pounds per cubic foot, increase
loads 10%; for 120 pounds, increase loads 20%; etc.

Heigth of Backfill, H, Above Top of Pipe (Feet)

Backfill Load, W(Pounds Per Linear Foot)

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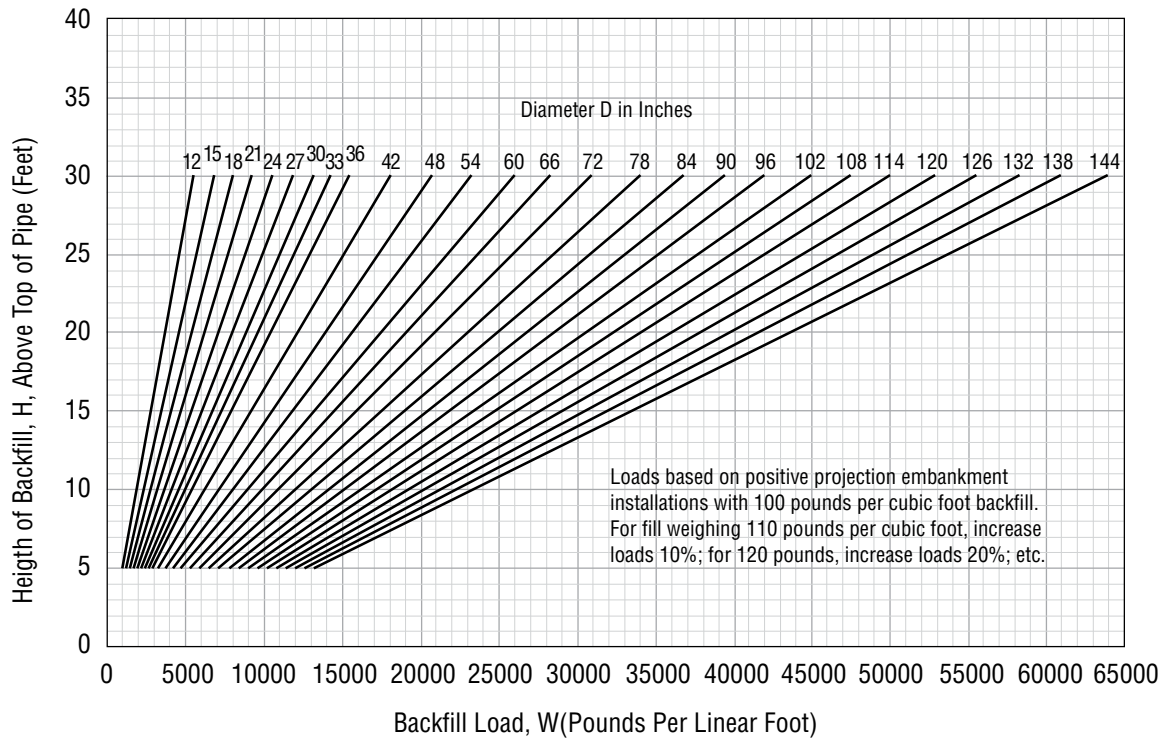
width for different types of backfill material is such that in normal design work, it is sufficiently accurate to use sand and gravel backfill material for the evaluation of transition widths.

Figures 8, 9, and 10 present maximum backfill loads for pipe installed in a trench where the trench width is equal to or greater than the transition width loads based on positive projection embankment installations with 15.7 kN per cubic meter backfill density. The maximum backfill loads are based on the embankment loading condition. For embankment installations the load transfer coefficient, K, varies between 1.35 and 1.45 for Standard Installation Types 1, 2, 3, and 4. The value of this coefficient and resultant load increase is dependent on:

   a. The type of foundation on which the pipe is placed.
   b. Compaction of the fill material adjacent to the sides of the pipe.
   c. The vertical height of the pipe projecting above the original ground.

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Technical data herein is considered reliable, but no guarantee is made or liability assumed.