ATV A127 STANDARD VS. AWWA M55 MANUAL

Main Differences in the Static Calculation Methodology for Flexible Pipes

1. INTRODUCTION

The purpose of this article is to set up the main differences between two popular methods worldwide for performing static verifications of HDPE flexible pipes, i.e. between the method given by the ATV A127 standard ("Guidelines for Static Calculations on Drainage Conduits and Pipelines") and the method established by the American Water Works Association (AWWA) more specifically in its manual M55 ("PE Pipe Design and Installation").

2. BRIEF REVIEW ABOUT THE RELATED METHODOLOGIES

The ATV A127 is a standard of German origin and its latest version dates from the year 2000. It is widely used in Europe and its content exclusively covers the methodology for calculations of all kinds of pipes.

AWWA M55 is not a standard, but rather a design manual according to the recommendations of the American Water Works Association (AWWA) covering all relevant aspects of the design and installation of HDPE pipes. The recommended methodology of structural calculation is one of the ten chapters that the manual contains and is exclusive for HDPE pipes (although the guidelines are common to the AWWA manuals of other types of pipes). The methodology basis used in this manual is the most used, almost exclusively, in the Americas.

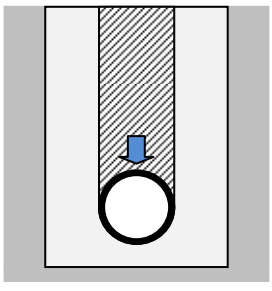
3. COMPARISON

3.1. BASIC DIFFERENCES IN THE METHODOLOGY OF CALCULATION

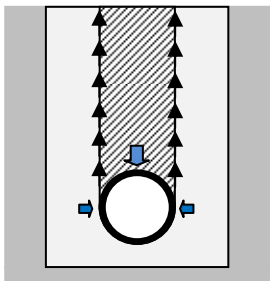
For the main basic differences between both documents, it can be mentioned:

I. The ATV A127 methodology aims to be universal, i.e. for any kind of pipe, regardless of the material or its status as "rigid" or "flexible". The AWWA M55 methodology, on the other hand, stands exclusively for the case of flexible pipes.

II. Soil load calculation is more conservative in AWWA, due to the fact that this manual does not consider, as ATV does, the “arc” effect that usually takes place for flexible pipes (reducing the weight of the soil prism right above the pipe).

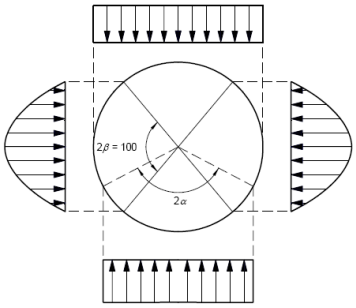


Filling Soil Load for AWWA

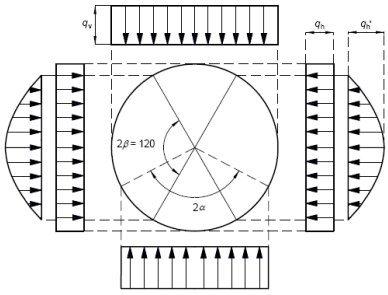


Filling Soil Load for ATV

III. Another important difference is the way in which each methodology analyses the distribution of the filling soil load around the pipe. Both methodologies are based on the theory of M.G. Spangler. However, while the M55 AWWA manual takes this theory without modification assuming, as Spangler, that no horizontal active pressure will develop on the pipe, the A127 ATV standard does take into account the influence of this horizontal active pressure.



Spangler / AWWA M55

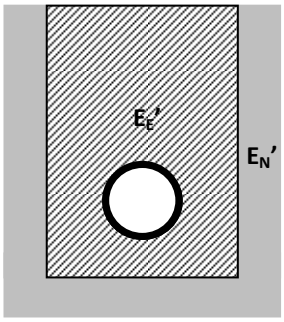


ATV A127

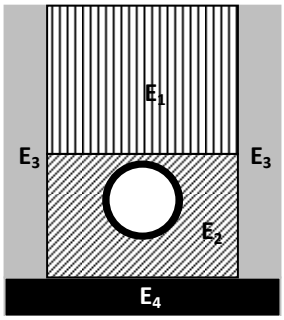
IV. The ATV methodology is much more detailed regarding trench-pipe interaction and does a deeper analysis about the intervention of each of the variables. The main difference in the trench scheme that analyzes each methodology is based on the consideration of the different zones of ground: while AWWA only differences between natural and filling soil (assigning different modules of soil reaction E_N' and E_E' respectively), ATV divides the trench in four areas:

- Zone 1: filling soil above the pipe (E_1)
- Zone 2: filling soil below and to the sides of the pipe (E_2)
- Zone 3: natural soil on the trench sides (E_3)
- Zone 4: natural soil below the trench (E_4)

In both cases an influence of the native soil in the global pipe-trench structural package is considered, but the way of analysis for each methodology is different.



Trench scheme for AWWA



Trench scheme for ATV

V. While AWWA methodology does not distinguish between vertical or sloping trench walls, in the ATV methodology the inclination angle of the walls of the trench is an important variable.

VI. In the ATV the use of sheet piling or coatings to contain the walls of the trench, and its removal methodology once installed the trench fill, acquires importance. However, these considerations are not taken into account by AWWA at any time.

VII. The ATV A127 methodology is more conservative when coming to the treatment of the "long term" analysis, especially in the case of thermoplastic materials, as it considers that the pipe will be permanently loaded in time and, therefore, it has to be always verified for every long term load using the materials long term properties (creep module, ultimate stresses).

The methodology of the AWWA M55 manual, on the other hand, considers that, against the external vertical loads, the pipe will not always be requested in the long term, but only when the stiffness of the pipe exceeds 25% of the rigidity of the filling soil of the trench. This is based on the theory that, if the pipe behaves like flexible and it is well installed (i.e. has a good soil filling around, compacted to an adequate density) it shall transmit the vertical loads to the lateral filling soil and will therefore not be requested permanently, but rather by "discrete" load pulses, against which, the material of the pipe will always respond with its short term resistance. However, if the stiffness of the pipe is close to the rigidity of the filling soil, it will behave more like a rigid pipe and will have to withstand the burdens in its own structure on an ongoing basis, responding, as a result, with material's long term parameters.

VIII. ATV's treatment of buckling verification is more conservative, especially in the case of existing groundwater, as it adopts the criteria that the pipe's confinement due to the filling soil will never have any influence in the pipe's resistance. On the other hand, AWWA only considers that the pipe's confinement does not fully act when the cover depth is low, because it cannot develop properly, but it's help on pipe's buckling resistance is always considered for cover depths equal or greater than 1.20 meters.

3.2. DIFFERENCES IN THE APPLICATION OF EACH METHOD

When applying each method in performing static calculations of pipes, the following differences can be observed:

I. The ATV requires a prior knowledge and/or definition of a large number of installation parameters (many of them of difficult definition in advance). On the other hand, AWWA requires less and easier to estimate data.

II. The ATV methodology is more complex to understand and to apply than the AWWA methodology.

III. The ATV methodology presents a strong dependence of the results with some variables (such as the methodology of installation of the filling soil and/or the slope angle of the trench walls) that the AWWA methodology has directly no consideration of.

IV. In the ATV methodology there's a great variation in the results when varying the pipe's bedding angle. This does not happen in AWWA, where, despite the fact that the bedding angle is actually considered, its real influence on the final results is very low.

V. In all cases, especially in the cases where there´s groundwater above the pipe, ATV's required ring stiffness is far superior to the one required by AWWA. Generally this is because of the differences in the treatment of buckling verification between both methodologies.

4. EXAMPLE ANALYSIS

A priori, given the great variability existing between the parameters considered by each methodology, it's virtually impossible to make a detailed theoretical comparison between the two. However, what can be analyzed are the results that occur in one or another case.

For this, a brief analysis was performed based on Krah's profiled wall pipes offer, making structural verification of buried pipelines using both methodologies, for pipe's diameters from 400 to 1600 mm, varying the cover height between 1 and 9 meters and in the 2 following conditions: a) without groundwater and b) with a groundwater level at a 0.5 meters depth below ground surface. In both cases, a native cohesive soil (with medium to low stiffness), a granular filling soil compacted up to 90% of normal Proctor Density and the heavier vehicular traffic considered by each methodology (AASHTO H20 truck for AWWA and HGL60 truck for ATV) with rigid pavement were adopted. In each case the most appropriate Krah pipe (the one that verified all conditions) was selected and its ring stiffness was registered, observing the following:

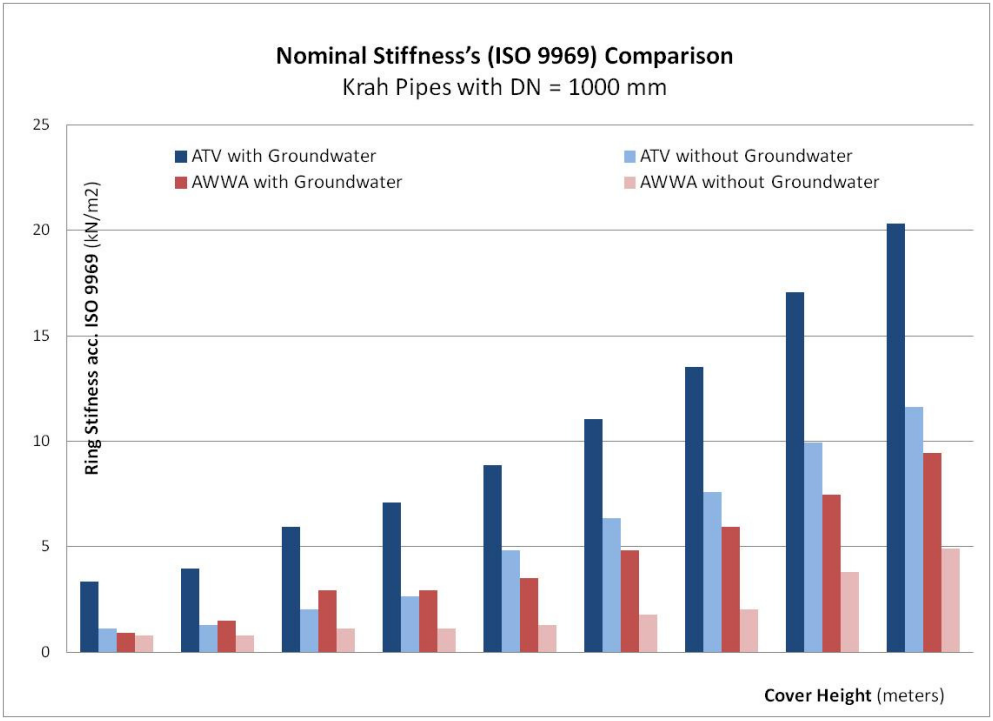
a) The pipes that verified ATV's conditions required a much higher ring stiffness (in the order of 40 to 260 % higher) than the pipes that verified AWWA's conditions.

b) The influence of groundwater, especially for long term buckling verification, probed to be very important in the ATV, resulting pipes of a very high ring stiffness for big cover depths in the presence of groundwater pressures. AWWA methodology verification for long term buckling in the presence of

groundwater was also defining in most cases, but without reaching the magnitudes of ring stiffness of ATV.

In the figure below an example can be seen of the obtained results (i.e. the required nominal stiffness according to ISO 9969) for DN = 1000 mm pipes, with the following color references:

- Light blue: ATV's verifications without groundwater
- Dark blue: ATV's verifications with groundwater
- Light red: AWWA's verifications without groundwater
- Dark red: AWWA's verifications with groundwater



5. FINAL CONCLUSIONS

The ATV presents as a more complete and detailed calculation methodology, but is also more conservative, it's difficult to get all the required data for its implementation and the results penalize the pipe much more than AWWA. Therefore, from the point of view of the economy of a project, the choice of AWWA's methodology seems more appropriate.

However, what should be the choice of one or another methodology for calculating is the accuracy of each in terms of its correlation with reality. And that's the big question that is still matter of vigorous discussions up to this date, without a clear or definitive conclusion, because pipes being calculated by one or the other method had presented in both cases very good field performances over the last decades. So nowadays, unless there's an obligation to attend to a specific standard, the election is at the discretion of the professional in charge of each project in particular.