Insight Into Pipe Deflection Predictions

An Interview with Mr. Spangler

Deflection – Does it Matter?

Mr. M.G. Spangler, M.S., was a research professor at Iowa State University. Professor Spangler's investigations into the behavior of buried flexible conduit led to the development of the well known Iowa formula for predicting the deflection of flexible pipe. He is well known internationally as the author of the "Marston-Spangler theory for loads on underground conduits." He also conducted seminal research on pressures on retaining walls and many other topics. Mr. Spangler was a recipient of the Marston Medal at Iowa State University and was an Honorary Member of ASCE. Merlin G. Spangler originally studied under Anson Marston at Iowa State University where both are recognized as international authorities on the design of buried conduits.

Q. Professor, every student of trench loads is familiar with the Marston load equations for rigid conduit. What was your involvement with Dean Marston?

A. I was a student at Iowa State followed by employment at the Iowa Highway Commission as a bridge designer. Marston was conducting his field experiments and needed an Assistant Engineer for these experiments. I don't know how he got my name, but he offered me the job

Q. How long were you associated with Professor Marston?

A. I began in 1924 and he passed away in an auto accident in 1949, so I guess that makes it about 25 years.

Q. Had he already established the first trench load equations?

A. Yes. Before 1910–basically on drainage and sewer pipe.

Q. When did you actually begin to work on the equation to predict the deflection of flexible conduit?

A. In the early days of culvert work, the two materials that were almost universally used, and were competitive with each other, were reinforced concrete pipe and corrugated steel. The performance of a flexible pipe is entirely different from that of a rigid pipe and after thinking about it, I decided that the source of strength of the flexible pipe is not the pipe itself, but is primarily the soil beside the pipe.

Q. Was the flexible pipe formula originally intended to be used for corrugated steel pipe?

A. Yes. That was the only flexible pipe I knew of at that time.

Q. Recent research has indicated that your equation seems to work well with steel pipe, but it does not always correlate well with plastic pipe.

A. Well, at the time that formula for flexible pipe was developed, there weren't any other kinds of flexible pipe except steel. Plastic materials were not introduced as of that time. The most critical feature of a flexible pipe formula is the modulus of passive resistance of the soil at the side. Even a modest deviation in actuality from the design value used could contribute to a difference in the results. I don't know of any way to counteract that except to suggest to the designer that he be careful about the selection of the value of each unit measure, and use a generous factor of safety.

Q. Your equation did not include some parameters which might be considered important today with plastics. For instance, the influence of plastic deformation with time. Plastics do not have a straight line, stress/strain relationship. Where steel has a constant modulus of elasticity up to the elastic limit, the modulus for plastics is a variable. Are the proper parameters being used in the equation?

A. Well, I think the situation that you described can be attributed to the fact that this flexible pipe formula was developed for a steel pipe. Never was it based upon or intended to apply to a plastic pipe.

Q. Would a value of E taken at the point of anticipated deflection rather than an E value instantaneously taken at the beginning of the curve be more useful in design?

A. I think that's right. For instance, if you were designing a plastic pipe that had a deflection of 3%, I think you could use this method of determining the stiffness factor for EI.

12" SDR-35
Deflection Test

Q. The 5% allowable deflection limit that became the standard for corrugated steel pipe is a common requirement in many flexible plastic pipe specifications. Do you have any comments as to the reason why 5% became the standard deflection limit?

A. As I recall, the 5% was derived from corrugated steel pipe. Corrugated steel pipe deforms until the top becomes practically horizontal and that occurs at 20%. After that, the top reverses and deflects downward and the sides pull inward. Failure is imminent. The uncertainties of the soil support at the sides and the uncertainties all through development, justified a safety factor of 4, and the deflection was set at 5%.

12" VCP
3 Edge Bearing Test

"It is the design engineer's responsibility to asses all factors and formulate a design with predicted design life. The cost of the system should be based in life considerations, not just initial cost."

"Government and private agencies cannot afford to replace all the buried pipe infrastructures on a 50-year basis. A 100 year design life should be considered minimum."

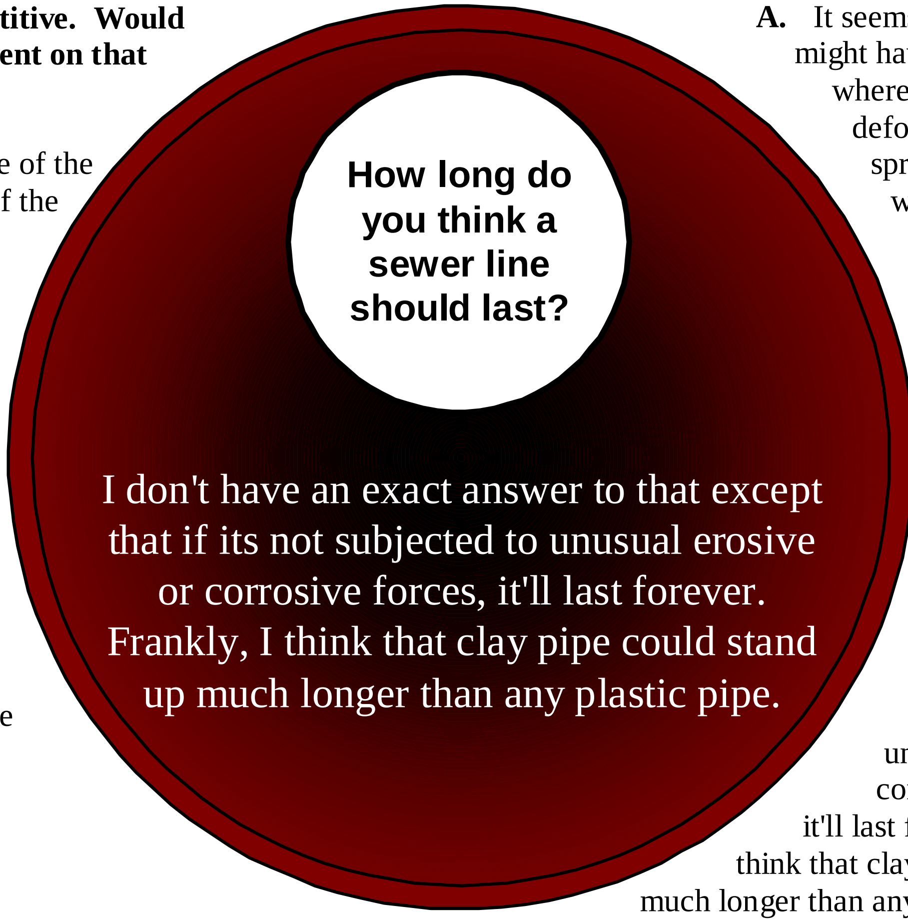
SOURCE: A.P MOSER, Author, Buried Pipe Design, 2nd Edition

Q. While clay pipe derives most of its supporting strength from its I inherent strength and from the bedding reaction at the bottom of the pipe, plastic pipe gets most of its supporting strength at the sides. Some manufacturers are trying to reduce the quantity and the quality of the embedment in order to be more competitive. Would you care to comment on that point.

A. Well, that's one of the tactical problems of the real world.

Q. Many believe clay pipe is the best product for sanitary sewers, and if properly designed and installed, a clay pipe line has no determinant life span.

A. I have the same impressions.



Q. There is a trend with some flexible conduits to bring good bedding materials up to the spring line of the pipe and neglect the area above it. Do you see any problem with this practice?

A. It seems to me that you might have a situation where you get a greater deformation above the spring line than you would below the spring line, assuming the soil above is less resistant.

Q. How long do you think a sewer line should last?

A. I don't have an answer to that except that if it is not subjected to unusual erosive or corrosive forces, it'll last forever. Frankly, I think that clay pipe could stand up much longer than any plastic pipe.

"Deformation is a problem for plastic pipes because of their inherent flexible behavior and creep properties which result in a loss of strength under load of 50% after two years and 80% after fifty years buried in the ground. The structural integrity of a plastic sewer is derived almost exclusively from properly installed bedding and backfill materials surrounding the pipe."

Source: Technical Note Number 1, Clay Pipe Development Association Limited, Europe.

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