Many of the most critical water supply pipelines in cities across North America are large diameter cast iron pipes installed from 50 to 100 years ago. While public utilities have limited resources to replace these, failure can lead to substantial water damage and can increase the risks associated with fire and economic loss. Rational procedures were therefore developed to calculate the factor of safety against rupture considering the impact of different geometrical, structural, hydraulic, environmental factors.

The physical model estimates both the time-dependent factor of safety and probability of failure of large-diameter cast-iron water mains. Failure for these large diameter pipes is assumed to occur by longitudinal cracking caused by tensile hoop stress and a reduction in the strength of the pipe due to corrosion pitting. Six different load sources were considered associated with the earth load, live load, frost load, internal water pressure, and the curvature caused by the live load.

The model was then used in a two-part sensitivity analysis to determine the influence of each input of the model outputs. The first part of the analysis was deterministic and considered all 28 input variables. This identified six variables as having a high impact: the pipe wall thickness, corrosion rate, and the constants used to calculate the residual tensile strength, but were relatively insensitive to pipe diameter.

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Wall of a large diameter cast iron water pipe showing extensive corrosion damage

Daniel completed his work by undertaking assessments of 20 large diameter cast iron water mains in the City of Hamilton, and 4 in Kingston. These assessments provide input on the factors that control calculated factors of safety, and so the likelihood of failure over time. While the analysis still requires experimental evaluation, an assessment of different water pipe assets facilitates rankings to identify which pipes are most vulnerable, which are expected to have the longest remaining service lives, and what additional information could be collected to improve these assessments.