

***“It is a common observation that the theory of elasticity is useful beyond the range of elasticity.”***

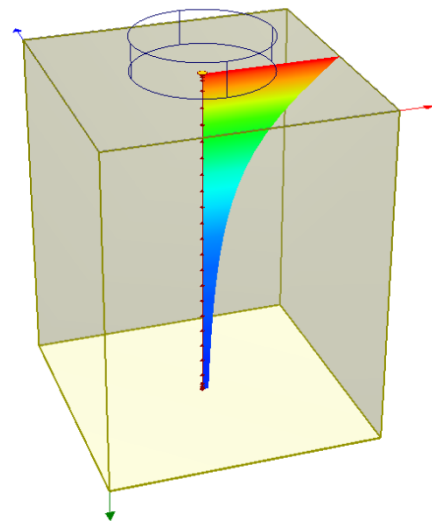
- M. M. Westergaard

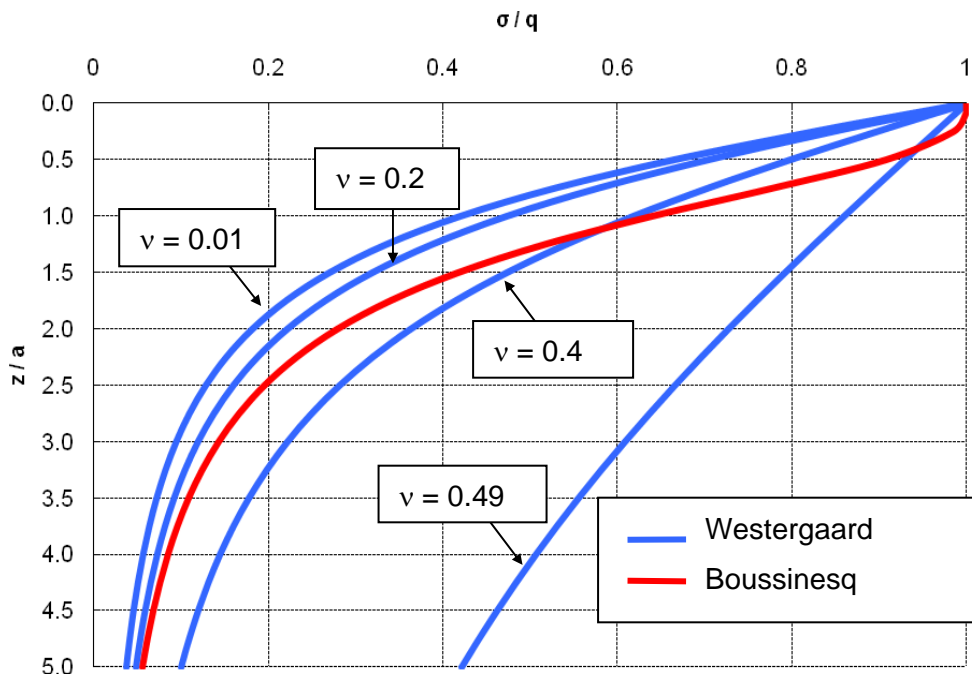
The Boussinesq method is one of the most commonly used methods for obtaining stress distributions in elastic media. It assumes that a medium is elastic, isotropic and homogeneous. However, most soils are neither isotropic nor homogeneous. In fact, at many sites, different soil layers with distinctive characteristics occur.

Casagrande brought to the attention of Westergaard the need for a solution for stresses underneath a foundation that could account for alternating horizontal layers of soft and stiff materials. In such materials, the stress distribution obtained from the Boussinesq solution was incorrect. If, for example, a stiff material layer is underlain by a soft layer, stresses in the soft soil are lower than those indicated by the Boussinesq method. Westergaard formalized the compound material with the following assumptions:

- 1) The stiff layers are spaced very closely such that the compound material has the characteristics of an isotropic homogeneous material.
- 2) The thickness of the stiff layers are negligible compared to that of the soft materials.
- 3) The stiff material is inextensible and thus prevents any horizontal strain in both the soft and stiff layers.

Westergaard’s assumptions mainly reduce the stresses obtained directly below the center of the load as compared to the Boussinesq solution. However, at a certain distance away from the center, stresses obtained from Westergaard begin to exceed those calculated from Boussinesq.





***Westergaard stress profiles with varying Poisson's ratios compared to a Boussinesq stress profile underneath a circular load***

In general, sedimentary soils such as natural clay strata highlight the non-isotropic nature of soil media. As a result, the Westergaard equations better model real problems. In practice, many geotechnical engineers often prefer the Boussinesq approach primarily because it gives more conservative results. However the choice of stress analysis methods should depend on how closely their results match field conditions and observed behaviour.

From the above discussion, and based on valued customer requests, the Westergaard stress solution method was added to *Settle*<sup>3D</sup> version 2.004. A new set of verification examples that compare *Settle*<sup>3D</sup> results to existing analytical solutions were also provided.

