Three-dimensional inversion analysis of an *in situ* stress field based on a two-stage optimization algorithm

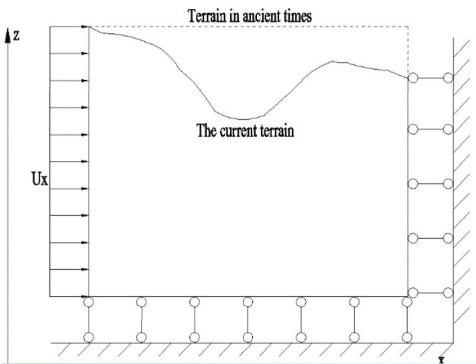
Key words: *In situ* stress, Stepwise regression, Support vector machine, Difference evolution, Finite element, Huangdeng underground cavern

Cite this as: She-rong ZHANG, An-kui HU, Chao WANG, 2016. Three-dimensional inversion analysis of an *in situ* stress field based on a two-stage optimization algorithm. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 17(10):782-802.

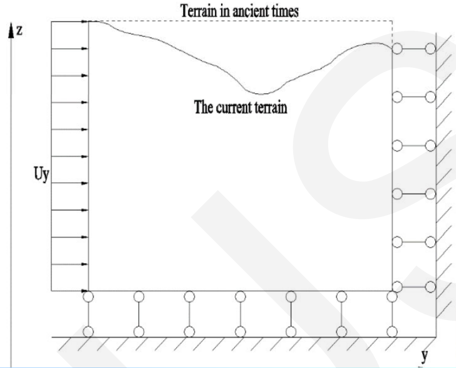
http://dx.doi.org/10.1631/jzus.A1600014

undetermined parameters of boundary conditions

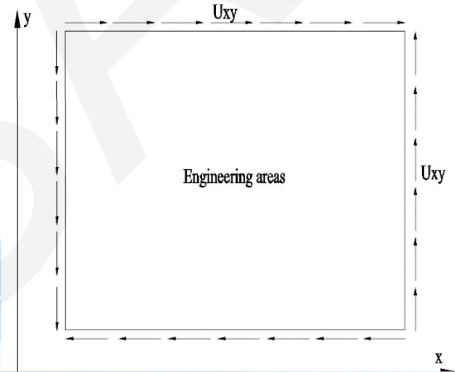
Land surface denudation simulation



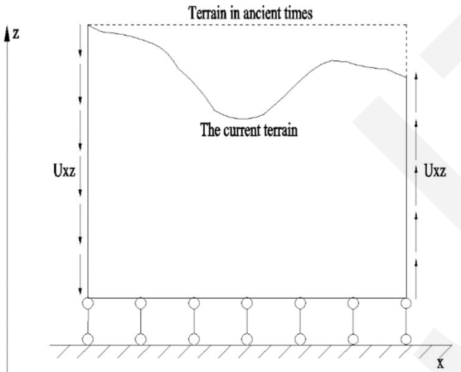
Tectonic movement boundary in the X direction



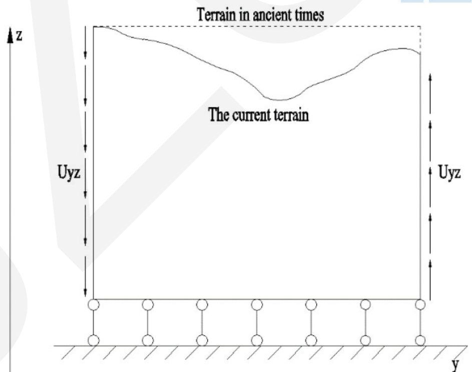
Tectonic movement boundary in the Y direction



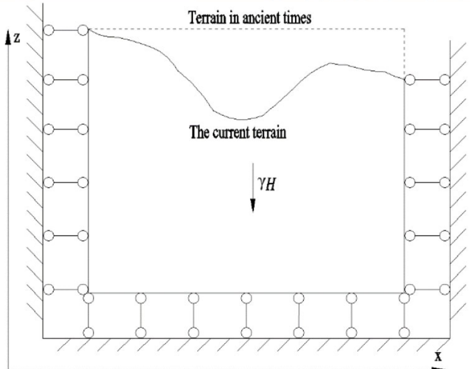
Shear tectonic movement boundary in the XY plane



Shear tectonic movement boundary in the XZ plane



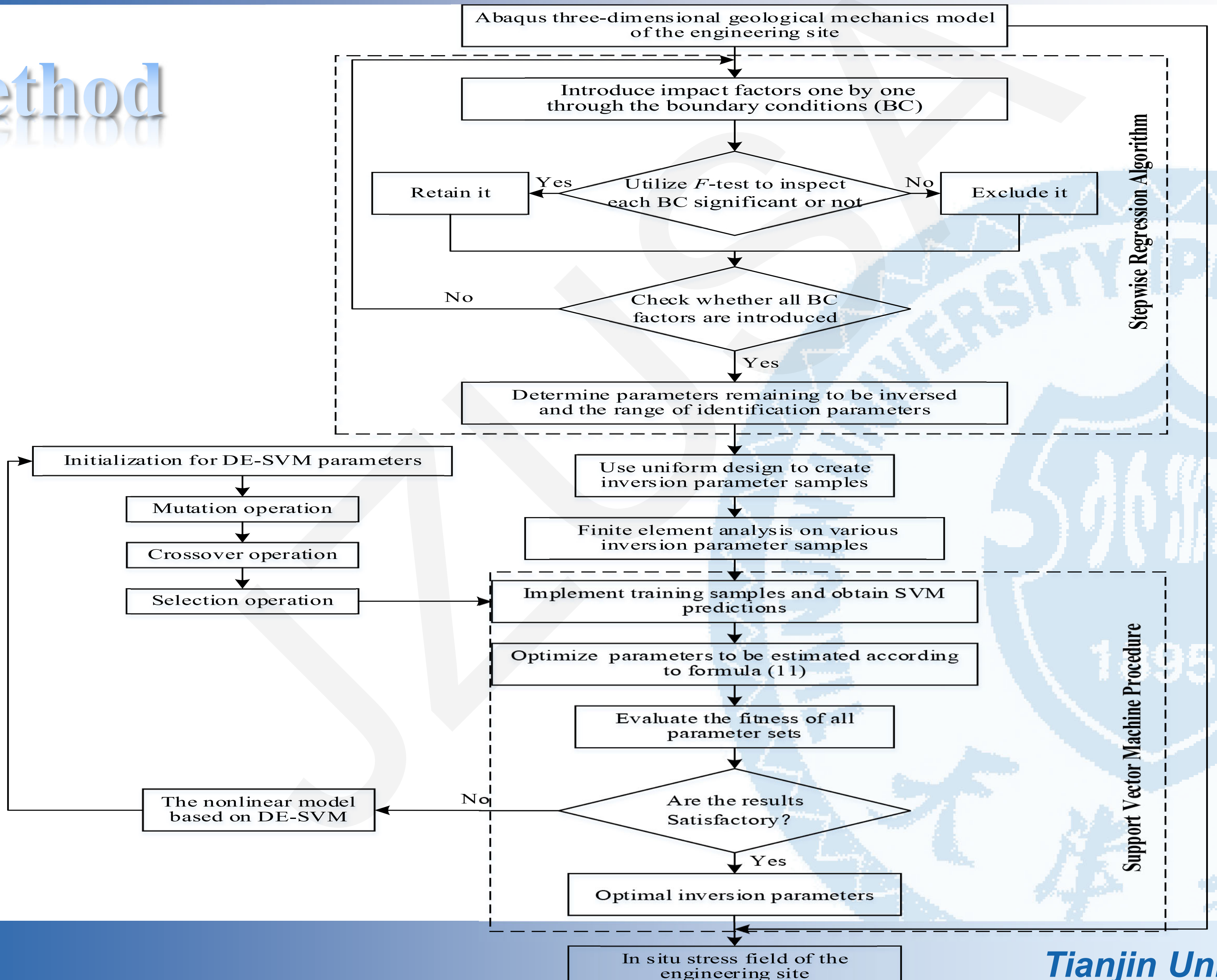
Shear tectonic movement boundary in the YZ plane



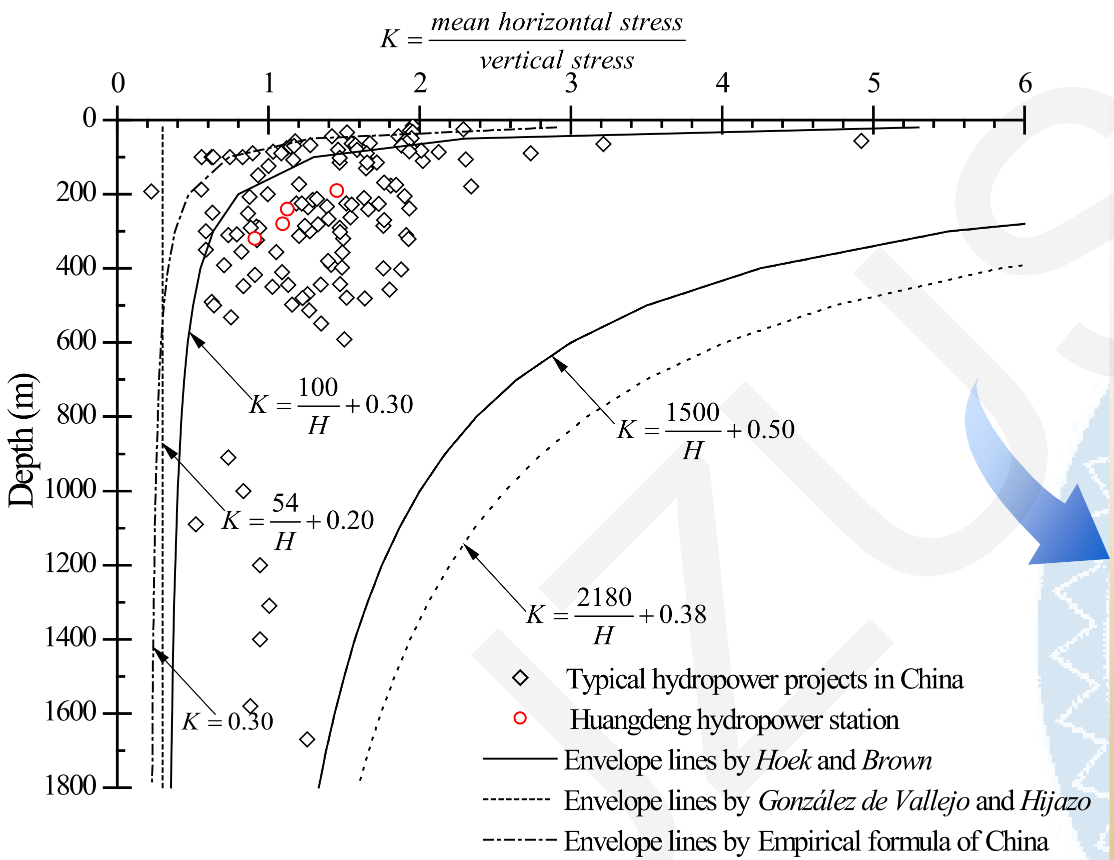
Boundary condition under a gravity function

The SR-DE-SVM algorithm

- **Method**



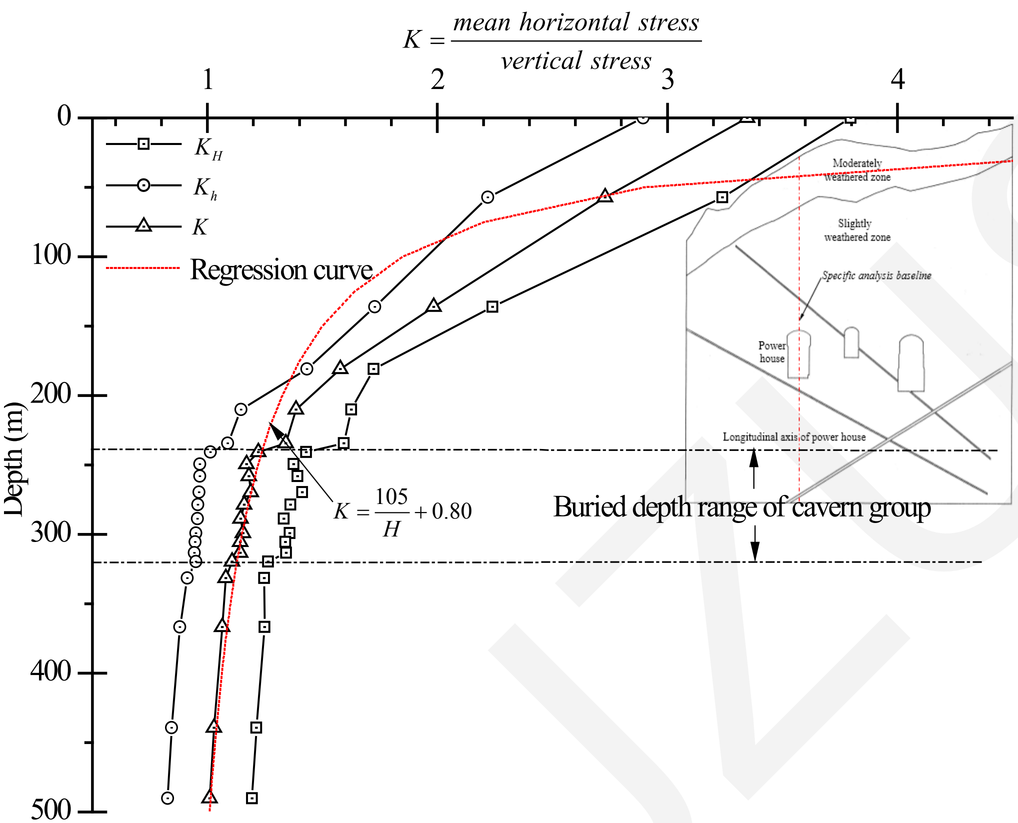
Application to the Huangdeng hydropower station



K-depth relationships based on national data for China

- The maximum envelope lines are generally similar, with less data scatter for depths greater than 1000 m, with K tending toward 1.0 with depth.
- The minimum envelope lines show greater discrepancies for depths below 500 m.
- These results show that at typical depths for most underground excavations, K-depth relationships cannot be used in practice.

Application to the Huangdeng hydropower station



Distribution of K in the area of the power house along its depth

The influence mechanism of the tectonic movements to the in situ stress field is more complicated closer to the surface of the rock-mass, which ultimately results in the instability of K. Therefore, prioritizing K for a rock-mass whose buried depth exceeds 200 m, the function of the optimum regression curve is reason-ably expressed by the formula $K=150/H+0.80$, which is highly consistent with the relevant research results (Zhao, et al., 2007).

Results and Conclusions

NO.1

Through the example of the Huangdeng hydropower station, the SR-DE-SVM approach was shown to maintain a consistently high solution accuracy for *in situ* stress estimation, particularly compared to two contemporary approaches, namely, the MLR method and the ANN surrogate direct inversion approach.

NO.2

In the Huangdeng underground cavern group, the in situ stress is moderate and originates mainly from gravity and the geological tectonic stress field. According to finite element analysis, the category of the surrounding rocks does not have a serious effect on the in situ stress field at the engineering site.

NO.3

With increasing rock-mass depth, the normal stresses increase linearly in the area of the underground rock-mass without geological faults and tuff interlayers crossed over in areas.

NO.4

This method can clarify the dominant cause of the formation of in situ stress specific to various practical projects to obtain an approximate solution that can provide in situ stress information for the design of dams and tunnels.