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Soil consolidation analysis with physics-informed neural networks under data-limited conditions

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ABSTRACT

With increasing urbanization, the use of underground space has been expanding, and accordingly, the long-term stability of structures built on soft ground and consolidation behavior have become critical geotechnical issues. In particular, the consolidation in soft ground has a close impact on the structural resilience and sustainable maintenance of infrastructure, and thus technologies capable of accurate and efficient analysis are essential. While conventional numerical analyses rely on soil parameters derived from laboratory tests to predict pore water pressure and consolidation coefficients, their effectiveness is often limited in real-world applications due to incomplete boundary conditions and scarce field data. To overcome these challenges, we propose a physics-informed neural network (PINN) framework to perform reliable consolidation analysis under uncertain conditions and sparse datasets. Through numerical experiments on one-dimensional consolidation problems, the framework was shown to maintain physical coherence and deliver stable performance across a range of uncertain scenarios. These findings demonstrate the potential of PINN as an efficient and robust alternative for consolidation analysis in geotechnical applications where conventional methods face practical limitations.

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REFERENCES

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