Groundwater Simulation-Optimization Modeling using Analytic Element Method and PSO

By

Shishir Gaur

Department of Civil Engineering

Submitted

In fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

July 2009

Dedicated

to

Almighty God…..

CERTIFICATE

This is to certify that the thesis, entitled **"Groundwater Simulation-Optimization Modeling using Analytic Element Method and PSO"**, being submitted by Mr. Shishir Gaur to the Indian Institute of Technology, Delhi for the award of Doctor of Philosophy, is a record of bonafide research work carried out by him under my supervision. The thesis work, in my opinion has reached the standard, fulfilling the requirements for the said degree. Further, I certify that this submission is Mr. Gaur's own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person which to a substantial extent has been accepted for the award of any other degree or diploma of any University or Institute, except where due acknowledgment has been made in the text.

(B. R. Chahar)
Associate Professor
Civil Engineering Department
Indian Institute of Technology Delhi

ACKNOWLEDGEMENTS

With all respects, I express my profound sense of gratitude to my supervisor, Dr. B. R. Chahar, Department of Civil Engineering, Indian Institute of Technology, Delhi for his consistent guidance and supervision during the course of my research work. His graciousness and patience while entertaining any question, no matter how trivial it might be, constructive criticism, unconditional trust and support helped me in successful completion of my research work.

I sincerely acknowledge Prof. Didier Graillot, Head of Centre SITE -Sciences, Information et Technologies pour l'Environnement, Ecole nationale supérieure des Mines de Saint-Etienne, France for his enlightening discussions and utmost cooperation. He helped me at every academic as well as personal level during my stay in France. His continuous motivation and belief in my creditability helped me to complete my research work.

I am grateful to Prof. B. R. Bhattachargi, Prof. A. K. Gosain and Prof. G. Jayaraman for their critical review, valuable suggestions and support to this work.

I also express my sincere thanks to all staff members of the Ecole nationale supérieure des Mines de Saint-Etienne, especially to Dr. Alicja tardy, Dr. Frederic Paran, Dr. Djamel Mimoun and Ms. Zahia Mazer for their kind cooperation during my research work in France.

I would like to acknowledge my friend Mr. Suneet K. Dadheech and Ms. Deepshikha Sharma, my brother Mr. Kostubh Gaur and my wife Priyanka for their kind support and help.

This acknowledgement shall remain incomplete unless I thank my fellow research scholars in IIT Delhi - Mr. D. L. Parmar, Mr. R.K. Prasad, Mr. Amardeep Singh, Mr. Brijesh Yadav, Mr. Debaprakash Satapathy, Mr. Shaliendar jain, Mr. Sumedha Chakma, Dr Pradeep Lodha, Mr. G.P. Vadodariya, Mr. Mahmood, Mr. K. Ravikumar, Mr. Tsewang Thinlas, Ms. Sushmita Dadhich for their help and encouragement during this study. I would like to express my sincere thanks to Mr. Sudheer for his co-operation in my thesis work.

I am highly thankful for Mr. Rajveer Aggarwal, Mr. Bikram and Mr. Gehlot for their help and affection rendered by them during my stay at IIT Delhi.

The author is grateful to his parents without their blessings this study could not have performed.

July 2009 (Shishir Gaur)

ABSTRACT

Groundwater resource management is an important issue at nature, political, scientific and social level. Water demand at industrial, agriculture and domestic level are continuously increasing and subsequently limited fresh water resources are shrinking. Under these circumstances groundwater management is a critical issue for us. Groundwater management deals with management of groundwater resources both in quantity and quality aspect. Groundwater management problems are typically solved by researchers through simulation-optimization approach. The simulation-optimization approach is valuable because it can simulates the complex groundwater flow and/or contamination transport system and helps to identify the optimal solutions by fulfilling the objectives of the problem under the given set of constraints

In this study, Analytic Element Method (AEM) and Particle Swarm Optimisation (PSO) based simulation optimization model has been developed to find out the best management policy for preventing the groundwater resources from critical conditions. AEM model has been developed in MATLAB platform to simulate the groundwater flow in steady state condition and optimization model has been developed to find out the optimal location and discharge for the pumping wells under the constraints imposed by stakeholder and officials of water authorities. Developed AEM model has been applied upon a hypothetical case and real field data. Results obtained from AEM based model have been compared with FDM based model and advantages of AEM model have been measures. In next stage, AEM model has been coupled with PSO based optimization model and applied upon two hypothetical examples. In the first example, results of AEM-

PSO have been compared with other optimization techniques. In the example, model has been applied to identify the location and discharge of unknown wells. Finally AEM-PSO model has been applied on real field problem i.e. Dore river basin, France. Model has been applied to solve the two kind of management problems i.e. identify the maximum groundwater extraction rate for pumping wells and minimizing the cost of pumping wells system. Piping cost, well installation cost and pumping cost have been incorporated in the cost function. Optimal number of wells has also been identified by applying the model for different set of wells.

Artificial Neural Network (ANN) and PSO based simulation-optimization model has also been developed to address the same real field problem. AEM model has been used to generate the data set for the training of neural network. Different ANN models have been developed for each well in each set of well. Results from ANN-PSO model has been compared with AEM-PSO model.

Finally the sensitivity analysis for parameters of cost function and PSO has been performed. Results show that AEM-PSO model is able to effectively solve the groundwater management problems. In some manners, AEM and PSO techniques have been find more efficient than other techniques. ANN-PSO based model excessively reduce the computational burden in comparison of AEM-PSO based model and a good replacement of AEM-PSO model. ANN-PSO based model are also capable to solve the groundwater management problems efficiently. Also proposed wells by developed models are capable to fulfil the water demand of the area without stressing the aquifer.

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