Research on quick dam parameter inversion tool based on ANSYS software using APDL and improved GA

Sun Futing[1,2,a], Zhang Xiuli[1,b]

[1]Large Dam Supervision Center, National Energy Administration of the People's Republic of China, China, Zhejiang Province, Hangzhou 311122

[2]Power China Huadong Engineering Corporation, China, Zhejiang Province, Hangzhou 311122

[a]353936165@qq.com, [b]zhang_xiuli@ecidi.com

Key words: parameter inversion; genetic algorithm; ANSYS; APDL; optimization

Abstract: Dam parameter inversion tool based on ANSYS software and improved Genetic Algorithm is researched. Firstly, traditional GA is improved by introducing power function to rebuilt fitness function; Secondly, quick dam parameter inversion tool based on improved GA is programmed on ANSYS software; Finally, the inversion tool is proved correct and effective by back analyzing dam material parameters.

1 Introduction

As material parameters are important for dam deformation and stress, real parameters during working period are necessary for dam deformation prediction and stress controlling. Now, the most effective method to obtain real parameters is numerical calculating based on dam monitoring data, The method is analogous to a 1: 1 model test of a dam to get real parameters[1].

Until now, many intelligent optimization algorithms are applied to the dam parameter inversion. Deformation parameters of Lijiaxia arch dam are back analyzed based on BP neural network by Lian[2]. GA inversion program based on MAC.Mar and FORTRAN is developed by Xiang[3]. Elastic modulus of Chencun dam is calculated based on Particle Swarm Optimization method by Xu[4]. Chaotic artificial fish swarm algorithm is introduced by Song[5] to the parameter inversion of gravity dam. In summary, the intelligent optimization method represented by genetic algorithm and BP neural network is the most effective and commonly used methods to solve the problem of dam parameters inversion at present.

Therefore, dam parameters inversion tools based on ANSYS software using APDL and improved GA is researched. Dam parameters back analyzing will be convenient using this tool because of the powerful computing power of ANSYS and powerful optimization capabilities of improved GA.

2 Improved Genetic Algorithm

Genetic Algorithm is proposed by professor Holland in 1975, it is a kind of intelligent optimization algorithm based on the idea of survival of the fittest[6]. The basic steps of GA consists of coding, population initialization, decoding, fitness evaluation, generation and variation. However, the optimization efficiency of traditional GA is low, some improvement should be done.

The construction of fitness function is very important for GA. For example, dam deformation is always used for parameter inversion, so the fitness function can be written as formula 1.

$$F_i = 1 / \sum_{i=1}^{n} [(\delta_{i\_cal} - \delta_{i\_mea}) / \delta_{i\_mea}]^2 \tag{1}$$

Where, δ_{i_cal} is calculated displacement, δ_{i_mea} is monitored displacement.

During optimized searching process, the bigger value the fitness function is, the better the result. However, value of fitness function of individuals differs greatly from each other in early period while it has no big difference in later period. Under this situation, some individuals may dominate

the optimization process in early period while dominant individual may difficult to choose in later period. Therefore, power scaling function is introduced to reconstruct the fitness as formula 2.

$$f_i = F_i^T / \sum_{i=1}^{n} F_j^T \tag{2a}$$

$$T = \alpha \cdot \beta^{NG} \tag{2b}$$

Where T is scaling factor similar to temperature in simulated annealing algorithm[7], α and β are constant which can be determined by numerical test. NG is generation number.

When f_i is introduce to replace original fitness function, the optimized efficiency of traditional GA will greatly improve. In addition, during generation process, some individuals whose fitness is large will reserved to next generation to maintain good gene.

3 Quick dam parameter inversion tool

Since ANSYS is a widely used software and its powerful functions is commonly known, it is used as the development platform of parameter inversion tool. APDL is a kind of implanted programming language in ANSYS which is easy and convenient for using, so dam parameter inversion tool can be built based on ANSYS software by using APDL to program the process of FEM calculating and optimization. Back analysis procedure of dam parameters is presented in figure 1.

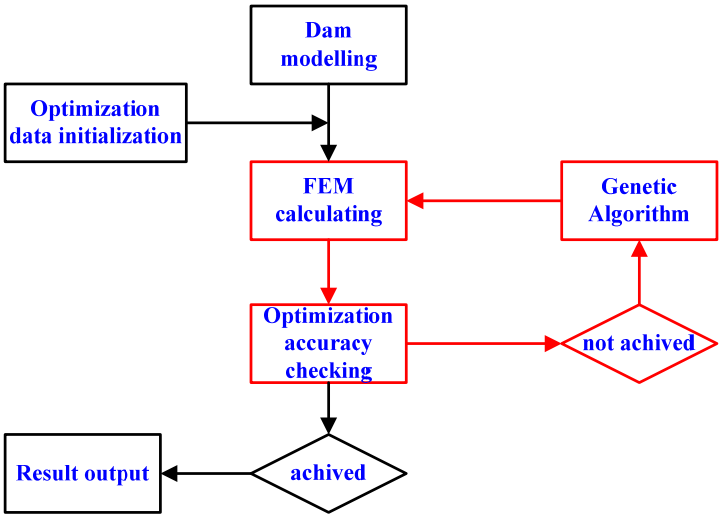

Fig.1 Dam parameters inversion process

According to parameter inversion tool, when input data is given to the program, parameter inversion process will run automatically to complete the inversion. The specific steps are as follows:

a. Modelling 3D FEM model based on dam geometry and geological information;
b. Inputting load condition, boundary condition, monitoring deformation data and initial parameter range, completing calculation initialization;
c. Driving ANSYS solver to complete FEM calculating;
d. Checking optimization accuracy by fitness function: if accuracy achieved, go to step f;
e. Generating new individuals using GA, go to step c;
f. Outputting optimization calculation result.

4 Examples

In order to checking the correctness and effectiveness of dam parameter tool built in this paper, two

examples of deformation material parameters inversion are used for verification. Considering the purpose, monitored displacement of the examples are firstly calculate by ANSYS. Some calculating parameters in GA are as follows: population number *NP* is set to 35, hybridization probability p is set to 0.6, mutation probability p_m is set to 0.05, power function scaling parameter α is set to 0.35 and β is set to 1.15, maximum interaction number is set to 30, and termination condition of optimization is the root mean square of error is less than 0.25%.

Finite element models of two examples are showed in figure 2. 5 monitored points are selected as checking points for each model. Two groups of water level are selected for each model to back calculating elastic modulus, model information and calculating conditions are listed in table 1.

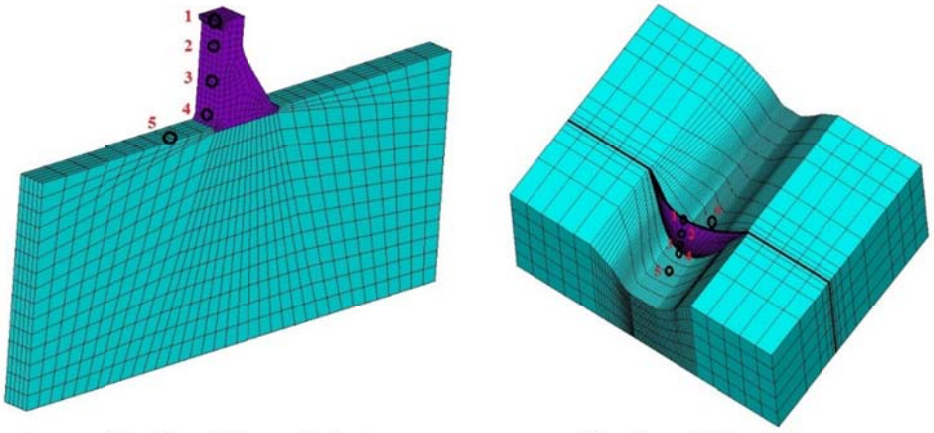

Fig.2 FEM models of examples

Table 1 Model information and calculating condition

	Model information		Water depth 1 (m)		Water depth 2 (m)		Ranges of elastic modulus (GPa)	
	Element number	Node number	up	down	up	down	Dam	Foundation
Model 1	3125	4182	73	9	52	6	10~50	5-25
Model 2	10680	13146	227	38	207	35	10~50	10~40

Dam parameter inversion tool is used for back analyzing elastic modulus of dam concrete and foundation rock mass. Displacement of monitoring points and water depth are input for calculating, ranges of elastic modulus is input to produce initial population for GA through random function, and inversion tool will complete back analyzing process automatically and results will be output. Back analyzing convergence process of two examples are presented in figure 3.

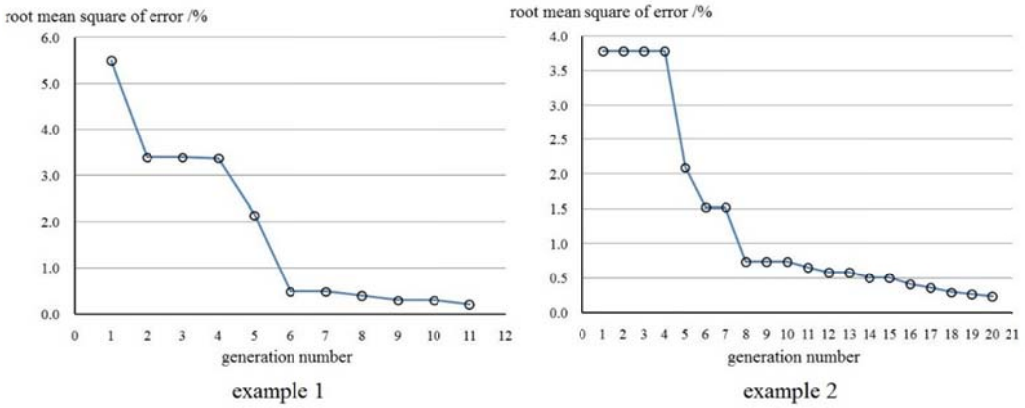

Fig.3 Convergence of back analyzing

It can be seen from figure 3 that: the error is less than 1.0% when generation number is 6 and converge is achieved when generation is 11 for example 1; the error is less than 1.0% when

generation number is 8 and converge is achieved when generation is 20 for example 2. Elastic modulus back analyzed by parameter inversion tool is listed in table 2 compared with its exact value.

Table 2 Optimized parameters

	Elastic modulus of dam (GPa)		Elastic modulus of foundation (GPa)	
	Optimized value	Exact value	Optimized value	Exact value
Example 1	23.04	23.0	11.95	12.0
Example 2	24.91	25.0	21.11	21.0

It can be concluded from table 2 that elastic modulus back analyzed by parameter inversion tool built in this paper is very close to the exact value, so the parameter inversion tool is capability to use for dam parameters inversion.

5 Conclusions

Dam parameter inversion tool based on ANSYS software using APDL and improved Genetic Algorithm is researched, some conclusions are as follows:

(1) The optimization efficiency of traditional Genetic Algorithm is low, so power function is introduced to reconstruct fitness function to improve the searching efficiency of GA.

(2) Powerful calculation capability of FEM and optimization capability of improved GA is combined and dam parameters inversion tool is established relying on ANSYS software platform. Dam parameters inversion can be achieved automatically with this inversion tool.

(3) Two examples are used to check the correctness and effectiveness of parameter inversion tool. Elastic modulus value of these two dams back analyzing by this tool are very close to its exact value by several iterations, thus the tool is proved correct and effective for dam parameters inversion.

Acknowledgements

This work is financially supported by China Postdoctoral Science Foundation(2016M591969)

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