Numerical Modelling

Numerical modelling is the process of solving the equations describing a physical process using a step-wise approximation. Solutions are obtained by performing iterations (successively improved approximations) at each step until the numerical answer satisfies all the equations being used. The approximation is improved by decreasing the size of the steps, much like drawing a curve using a series of short, straight lines. Decreasing step size, however, increases the amount of labour. With the rapid advances in computer processing speed, this is becoming less of a concern.

The advantage of numerical modelling is that, once the model is set up and established, a range of scenarios may be investigated with relatively little effort, and complex problems may be solved using numerical models. Nevertheless, numerical models should be viewed with caution as their complexity and their 'black box' appearance may promote errors of judgement in their application.

Numerical models were developed in the early 1960s and are now well established tools. Finite difference (FD) and finite element (FE) models are currently popular. These subdivide the physical area of interest into small fragments which are each treated in a simplified manner. FE models are more adaptable to complicated boundaries, but the methods of solution are slightly more complex than FD models. Other models which have limited use are boundary integral and method-of-characteristics formulations, but these presently lack the practical applicability of FD and FE methods.

Numerical models may be applied to a wide range of problems in hydrology, flood flow and groundwater flow. In recent times, advances in the understanding of contaminant transport, sediment transport and complex boundary conditions have resulted in a generation of problem-specific models. Before choosing a model, its applicability to a specific problem must be questioned in depth.

The process of 'calibration' and verification is an integral part of numerical modelling. Because a numerical model may operate using several parameters describing the physical processes (eg. frictional stresses, soil-water conductivity) a historical event for which cause-and-effect data exists should always be simulated. This allows the modeller to 'tune' the parameters against an observed event.

The complexity of the model chosen should realistically reflect the extent to which the relevant parameters may be measured or inferred with accuracy, as well as required accuracy of modelled answers in a particular project. The sensitivity of the model to prime parameters should always be investigated and quantified. The use of models as decision making tools often have greater value in sensitivity analysis than in absolute predictions.

The applicability of simpler (one dimensional) models should be investigated first before adopting complex (eg. three dimensional) models under the philosophy that complicated models have a greater opportunity for errors, both judgemental and numerical. Finally, the limitations of the model should always be clearly understood.