Optimisation of Dewatering Systems

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Dewatering (also known as groundwater control) is often required to allow excavations to be made in dry and stable conditions below groundwater level. Dewatering can involve pumping methods where groundwater is pumped from an array of wells or sumps to temporarily lower groundwater levels. Alternatively, exclusion methods can use low permeability cut-off walls to exclude groundwater from the excavation. Pumping and exclusion methods may be used in combination.

WHY OPTIMISE?

Groundwater control is one of first geotechnical processes required on a project, and is often the first that must be proven to allow work to proceed. If groundwater control does not work effectively, or causes delays, these problems will occur at the start of the project, and can critically affect later stages of construction.

In contrast to many other forms of geotechnical processes, dewatering design is not covered in detail by geotechnical design codes. For example the dewatering section in Eurocode 7 is only one page long, and there is no corresponding execution standard for dewatering. Dewatering guidance documents do exist in the UK (Preene et al 2000), United States (Unified Facilities Criteria 2004) and the Middle East (Abu Dhabi City Municipality 2014), but tend not to be prescriptive and are typically in the form of 'toolkits' of design methods and construction techniques. Therefore, at the start of a project the designer can be faced with a bewildering arrangement of design and implementation options, and a rational optimisation approach can look attractive.

METHODS OF OPTIMISATION

There are several possible approaches to dewatering design and optimisation:

Empirical optimisation: A design based largely on experience, local knowledge and 'rules of thumb'. Optimisation by empirical methods has been successfully used on many simple projects.

Analytical and numerical optimisation: Use of hydrogeological design equations, either manually or by spreadsheet or use of 2 or 3 dimensional numerical groundwater flow models. Numerical modeling is used far more in dewatering design and optimisation than it was 10 years ago. This popularity is because the necessary investments in software, hardware and training have reduced dramatically, and also because modern software can easily demonstrate results visually for non-technical project clients. Numerical modelling offers the flexibility to take into account known or inferred variations in the aquifer within the range of influence. This might include assessing the effects of a nearby river, another dewatering project, or a natural barrier in the aquifer.

Observational optimisation: Use of construction observations to design and refine the dewatering system. Construction observations (for example pumped flow rates and groundwater drawdown levels) are used to guide optimisation of the system. Occasionally, dewatering systems are not effective when initially installed, and a 'troubleshooting' investigation is needed. This approach takes place during construction, and so has access to field data (e.g. dewatering well logs, pumped flow rates, drawdown water levels) that were not available to the original designer.

POTENTIAL PROBLEMS WITH OPTIMISATION

A wide range of problems affect optimisation:

Lack of clarity in objectives of optimisation: A fundamental problem is failure to set clear objectives for optimisation, and failure to recognise that optimising in one aspect may require compromises in other aspects.

Data quality and quantity: Data from site investigation and previous projects are the foundation of the conceptual hydrogeological model and all subsequent calculations, modelling or analysis, and dewatering system design. If these data are inadequate in quality or quantity everything after this step will be of limited value. A valid part of dewatering optimisation may ultimately be to recommend additional ground investigation to plug any identified data gaps.

Errors in conceptual model: Getting the conceptual hydrogeological model correct is fundamental to the design and optimisation of dewatering systems. Many significant dewatering problems can ultimately be traced back to an inappropriate conceptual model that either leads the designer down the wrong design avenue, or causes the designer to ignore a design condition that is, in fact, important.

Inappropriate dewatering method: Each type of pumped dewatering method is applicable to a finite range of ground conditions. If an unsuitable dewatering method is selected at the outset of design then even extensive and detailed optimisation measures are likely to be futile.

POSSIBLE PRIORITIES FOR OPTIMISATION

There are several different strategies that can be adopted for optimisation, as shown in the table below.

Optimisation priority	Comments
Lowest pumping rate	Risk that system will not have sufficient spare capacity to handle modest increases in flow rate above design values.
Lowest energy usage	Will tend to favour lowest pumping rate solutions, with the same risks. May involve use of smaller pumps for steady state pumping, once initial drawdown has been achieved.
Minimal impacts	May favour groundwater exclusion solutions that use low permeability cut-off walls to avoid or minimise pumping.
Minimal capital cost	Will tend to favour lowest pumping rate solutions, with the same risks.
Minimal operating cost	Will tend to favour lowest pumping rate solutions, with the same risks.
Shortest dewatering period	May be appropriate for emergency dewatering systems to recover a project after a failure or inundation, or for projects where the dewatering costs are small relative to project weekly on-costs
Maximum certainty of outcome	May be appropriate for projects where programme certainty is a key factor, and the dewatering must be fully effective without time consuming modifications.

CONCLUSION

It is important to realise that there is no perfect optimisation method that will address all the possible priorities for a dewatering system. In reality, different aspects of optimisation may conflict, and there will need to be trade offs between different priorities of design. The required conditions for effective optimisation of dewatering systems include: clarity of the objectives of optimisation; adequate site investigation data; development of a valid hydrogeological conceptual model; and, selection of the most appropriate dewatering method at the earliest possible stage of optimisation.

REFERENCES

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