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EJECTOR FEAT

M. Preene · File - Dewatering (ejectors)

Ejector feat

Dr Martin Preene, chief engineer at WJ Engineering Resources, looks at the use of ejector well systems for deep drawdown of groundwater in fine grained soils.

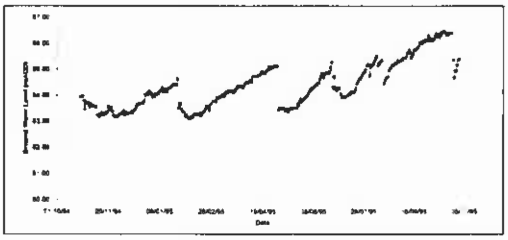

Figure 1. Ejector system long term groundwater level monitoring.

Groundwater control (or construction dewatering) is a fairly commonplace operation whereby groundwater is pumped from an array of wells around an excavation. The aim is to drawdown the groundwater level below formation level to allow excavation in dry and stable conditions. Standard pumping techniques include the use of wellpoints or deepwells with submersible pumps. However, in soils such as silts or silty sands, the standard techniques may be less applicable due to the low flowrates involved. These techniques can be improved by modifications to allow a vacuum to be generated in the well; the vacuum acts to overcome well losses and can improve yields and drawdowns.

Ejector well systems

In recent years ejectors (also known as eductors) have become available as an alternative pumping method capable of developing vacuums of up to 0.95Bar in the well; this high vacuum makes them very effective in low permeability soils. An ejector system operates by circulating clean water at high pressure through a nozzle and venturi arrangement in each well; the water passes through the nozzle at high velocity (typically 40m/s) which generates a low pressure zone which draws groundwater into the well to combine with the circulation water and be lifted out of the well. In simple terms an ejector is a water jet pump; no moving parts are located down the well and although water is injected into the well we get out more water than we put in.

Ejectors have been widely used for groundwater control in the United States since the 1950s but the first large scale use of ejectors in the UK was for the A55 Conwy crossing project in 1987-89.

Theoretical details of ejector systems have been published previously (Miller, 1988; Powrie & Preene, 1994) as have details of US practice (Powers, 1992) but little is available on practical problems and applications of ejector wells in recent practice. This article is based on the author's experience of ejector well projects and highlights some issues which have come to light over the last few years.

Table 1 shows a list of some UK ejector well projects. They have been divided into two groups, low and high ejector yields; in each group the ejector is being used in a different way.

The low yield ejectors are operating as pore pressure control systems in fine soils to prevent instability of excavations. This is how ejectors are primarily used because the high vacuums developed make them more suitable than wellpoints or deepwells. The high yield systems show ejectors used as deep wellpoints (conventional wellpoints are limited to about 6m drawdown, ejectors can achieve much more in more permeable soil).

There is a limit to the pumping rate from ejector systems; even when configured for high flows, capacities of 1 litre/s to 2 litre/s are exceptional. These capacities are much less than for wellpoints or deepwells and are one of the reasons why ejectors are rarely used in very high flowrate situations.

Depth limitations

The published literature indicates a practical depth limit of 25m to 30m for ejector systems. This needs clarifying. It seems to refer to a limit on drawdown of piezometric level (below the level of the supply pump) achievable with standard equipment; ejectors can operate at greater well depths and greater static lifts (well depth minus the ejector submergence). At Conwy and at the Benutan Dam, Brunei (Cole et al, 1994), ejectors were installed at depths of 30m to 40m, although drawdowns were less than 25m. However, on a recent project in Italy, ejectors were operated at depths of 55m and for static lifts of up to 40m. At these depths the equipment had to be modified to operate at higher driving pressures of 1400kPa (compared to 500-1000kPa normally). To date the equipment has been used on a trial basis, but drawdowns in excess of 30m below ground level appear to be achievable.

Ejector wells provided effective drawdown in glacial sands and gravel at Rochdale.

Table 1. Ejector well yields from case records.

	Project	No of ejector wells	Mean ejector flow (litre/min)	Soil type or stratum
Low ejector well yields	Fawley	3	6.0	Barton beds
	Southampton	45	0.4	Bracklesham beds
	Camberley	15	8.0	Bracklesham beds
	Rochdale	5	4.8	Glacial sand and gravel
	Conwy	65	9.2	Glacial lake deposits
	Oldham	8	1.0	Glacial till
	Penygroes	25	0.1	Alluvial silt
	Dartford	24	0.8	Made ground
	Strathclyde	14	6.6	Glacial till
	Preston	100	4.9	Glacial sands
	Wilmslow	101	3.9	Glacial sands
High ejector well yields	Farnborough*	30	15.4	Bracklesham beds
	Rochdale*	5	52.8	Glacial sand and gravel
	Conwy*	80	10.5	Glacial lake deposits
	Rochdale†	21	10.6	Glacial sand and gravel
	Rochdale†	46	15.7	Glacial sand and gravel
	Rochdale†	8	31.5	Glacial sand and gravel
	Conwy†	60	35.0	Glacial lake deposits
	Keighley†	11	20.2	Glacial sands
	Strathclyde†	6	11.0	Glacial deposits
	Bishop Auckland†	20	12.3	Glacial sands
	Weston-super-Mare†	18	45.0	Alluvial sand
	Wrexham†	10	17.4	Glacial deposits

* Ejectors installed in low permeability soil with close source of recharge.
† Ejectors used as deep wellpoints or penetrated more permeable underlying stratum.

Ejector biofouling

When ejectors were first used at Conwy there was a worry that the system would be susceptible to clogging by biofouling deposits inside the wellscreen and ejector; in fact, ejectors have proved no more prone to clogging than deepwells with submersible pumps.

Biofouling occurs where gallionella bacteria ingest naturally occurring dissolved iron and oxygen from the groundwater and excrete a thick brown sludge of insoluble iron oxides and oxyhydroxides which can clog pipework. This is not normally a problem, provided a groundwater monitoring scheme is in place to indicate when biofouling deposits must be cleaned from the wells.

Figure 1 shows long term groundwater level monitoring of an ejector system. After the first few months the groundwater levels rose (and pumped flowrate decreased).The system was cleaned manually or by compressed air) to remove the biofouling; groundwater levels fell immediately.

Over the next few months the system was cleaned periodically when water levels approached trigger levels. Typically, however, each successive cleaning is slightly less effective than the last, resulting in the general upward trend of levels shown. This is often only a problem for very long term projects and can be dealt with by removing and replacing the ejector internal components at suitable intervals.

It is apparent that ejectors are a useful groundwater control tool, but the limits of their use are still to be fully explored. WJ Engineering Resources is currently involved in collaborative ejector research with Southampton University. It is hoped that this research may lead to more efficient ejector systems suitable for practical applications.

References

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