Job site report on diaphragm wall blasting

An unusual drilling and blasting operation was recently successfully completed at the Cityplaza Extension site of Icos Vibro Ltd.

As part of their foundation contract, Icos Vibro have to construct diaphragm walls, which entail excavating to depths of up to 40m through varying ground conditions, where boulders and rock intrusions have to be removed during the excavation. The normal method of breaking up boulders and rock is by the use of heavy lift cranes operating steel chisels, followed by the use of grabs to excavate the broken material.

The chiselling in particular is an expensive and time-consuming method, and Mr. Jonathan Craft, manager of Icos Vibro, decided to investigate other potentially more efficient methods, in particular the use of explosives to preshatter all boulders and rock prior to inserting the grabs.

Mr. Craft called on Blasting Consultants (Asia) Ltd. to advise on whether the use of explosives was feasible, and if so, whether the resultant fragmentation would be sufficiently small to be handled by the normal grab.

The investigation and method study was carried out by Mr. Bob Lloyd of Blasting Consultants (Asia) Ltd., who eventually decided that not only was it feasible to use explosives, but also, within the limits of accuracy of drilling, that guarantees could be given that fragmentation would indeed be such that the broken rock could be handled by a grab of a specific size. In addition, however, it was known that vibration levels would have to be kept low because of the proximity of high rise apartment blocks (16m from the blast area).

Because of the nature of the ground conditions, drilling would of necessity have to utilise casings to avoid hole collapse, and the finished holes themselves would have to be cased with PVC tubing to avoid collapse and to facilitate charging with explosives. At the same time, extremely accurate drilling and location and logging of the incidence of all types of boulders and rock would form a prerequisite to successful blasting, so it was imperative to find a drilling contractor with sufficient experience and expertise, and the right type of equipment to meet the exacting standards required.

Colcrete Ltd., new to Hong Kong but with a long and successful record in the U.K. and worldwide in all types of drilling, were approached and discussions with Dr. Donald Bruce, managing director of Colcrete Ltd. Hong Kong, confirmed that his company could undertake all work to the required standard. It was agreed that Colcrete should do the drilling under the aegis of Blasting Consultants, who would undertake the actual blasting.

The width of the diaphragm wall is 1.2m, and it was specified by Blasting Consultants that two rows should be drilled 1.3m apart, with a staggered spacing of 1m, and to whatever depth was necessary to blast boulders/rock to conform with the design of the diaphragm wall.

Colcrete Ltd. deployed a fleet of diesel hydraulic track rigs consisting of the Casagrande SCM5006 and Krupp DHR 80 models. Each rig was fitted with a Krupp HB 103 hydraulic top hammer, giving a maximum torque output of 4000Nm at 40 rpm and 1,800 blows per minute. Given the adverse ground conditions the first choice of these high powered machines was clear: each is powered by a 6-cylinder Deutz diesel rated at 105 hp, and has a pull out capacity of over 6 tonnes. However, this choice was further vindicated by their manoeuv-

Overall view of the Icos Vibro site. Blasting took place in the area at left of photo.

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rability and self-contained operation (i.e. no compressor required), both factors being of great value in such an intensive site.

All rigs operated a percussive duplex system of drilling, wherein drill rods and casings were simultaneously advanced. Upon reaching full depth the inner rods were extracted prior to insertion of the PVC lining tube and retrieval of the steel casing. The position of boulders requiring blasting was logged on the basis of flush returns, rate of penetration, and by close monitoring of the rigs' hydraulic systems governing thrust and torque.

In order to reduce vibration to acceptable levels, the Mines Department stipulated that no more than 30 holes should be fired at any one time, and restricted to 1 lb. the amount of explosive which could be used with each detonator delay period. This meant that, in order to obtain maximum fragmentation, a medium density explosive with an acceptable velocity of detonation would need to be used, and, depending on the number and size of boulders/rock encountered, multiple detonators would have to be used in any one hole.

The diameter of holes drilled was 65mm, and because this reduced to 40mm on insertion of the PVC tubing, Blasting Consultants decided to use a watergel explosive from DuPont, Tovex 210, in 16" x 1" catridges, combined with downlines of detonating fuse, with milli-second electric delay detonators from ICI connected to the downlines outside the hole. Virtually every hole contained water in varying degrees, and sand stemming was used only in sufficient quantities that the detonator and protruding lengths of detonating fuse could be buried to reduce noise levels.

It is clear that the principle of "drill and blast" is an attractive diaphragm wall construction technique whose value should be noted by specialist foundation contractors.

Borehole logs indicated a great variety of ground conditions: even with the close spacing of holes, different conditions were encountered hole to hole. Materials varied from soft fill, fill, marine mud, marine sand, and slightly and completely decomposed granite, to boulders and fresh granite, and were either part or full water returning during the drilling operations.

The size of single boulders encountered ranged from 0.5m to 4m. Multiple boulders covered lengths of 1.75m up to 13m in varying degrees of cementation. Although most boulders encountered were 4m or more below ground level, some were located only 1.5m – 2.5m below ground level. Often the softer material between boulder clusters was only 0.5m – 1m deep, so that the placing of explosive charges accurately to position them within the boulder or rock, and not in the softer material, assumed great importance.

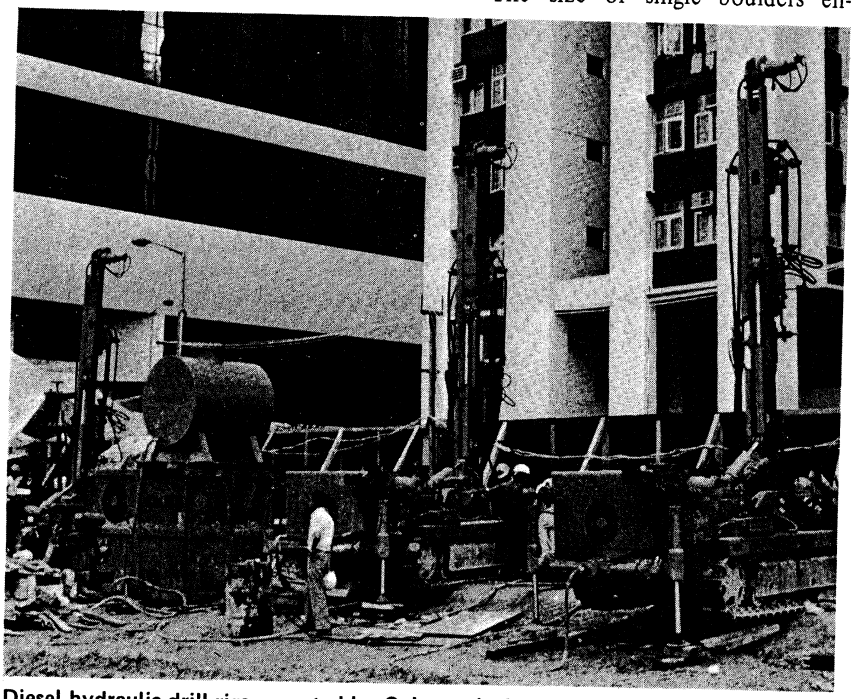
Equally, because of the limitation on charge per delay, related to the actual amount of explosive required to shatter boulders to the specified degree of fragmentation, the use of part-cartridges and multi-delays per hole became obligatory.

All calculations and measurements were prepared before each blast by Blasting Consultants, and implemented by the company's staff under the direct supervision and control of Mr. Lloyd.

A total of 126 holes were drilled by Colcrete, of which 89 contained considerable quantities of boulders, and a "rockhead" which had to be blasted. Eleven holes were actually left unfired because of their proximity to existing caisson work. The results of the blasting have been such that work has proceeded much more quickly than was estimated using the chisel method; in particular, the "rockhead", which would have taken an average of 19 days to chisel, was completed in only four days.

While in underground confined blasting vibration levels can increase by five times their "normal" level when blasting above ground to a free face, the maximum P.P.V. recorded at Taikoo Shing was 36.45 mm/sec., and the minimum 19.54 mm/sec., using the Sprengnether VS1600 Seismograph. The average reading was 24.41 mm/sec.

It is clear that the principle of "drill and blast" has been successfully proven as a very attractive construction technique. Bearing in mind the considerable volume of diaphragm walling and bored piling work being conducted in Hong Kong, often through similarly awkward conditions, the value of the technique should be carefully noted by specialist foundation contractors.



Diesel hydraulic drill rigs operated by Colcrete Ltd. at the Icos Vibro site.

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