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# CEMENTED SAND SCREENS

by

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## SUMMARY

### Background

Underground screening of water from boreholes presents considerable difficulty where fine, unconsolidated sediments are encountered. Conventional woven-wire or wedge-wire screens have proved unsatisfactory since they cannot prevent the passage of the fine, clayey sediments.

Earlier work by Amdel investigated the feasibility of producing a porous, cemented sand media suitable for use as a down-the-hole screen, and it was concluded from this work that a cemented sand screen offered a potentially suitable method of restricting the fine sediments from bore-water.

The present programme was undertaken with the following objectives:

(1) Obtain a supply of sand, the grains of which should show the maximum degree of roundness.

(2) Briefly evaluate suitable resin binders which are recommended by suppliers as having strengths superior to that of Epikote 828.

(3) Fabricate four reinforced screens, each 2 ft 6 in. long, 6-in. outside diameter, 1-in. wall thickness, suitable for screwing on to 5-in. bore casing. One screen was to be constructed using minus 8 plus 16 mesh sand, two screens using minus 16 plus 30 mesh sand, and one screen using minus 30 plus 60 mesh sand.

(4) Perform compressive-strength tests on sections cast using each of the various grain size fractions.

### Summary of Work Done

(1) A supply of well-rounded sand was obtained, the sand being of Victorian origin.

(2) Screens were cast using a recently developed epoxy resin, Epirez 133, in combination with a silane pre-treatment for the sand grains to improve the bond strength.

(3) Four reinforced screens were cast in accordance with the stated objectives. In addition to these, four 2 ft 6 in. sections were cast for use as piezometer tubes in observation holes for recording variations in the water-table level.

(4) Compressive-strength tests performed on test sections cast, using sand of each size fraction, indicated an increase in compressive strength

with decreasing grain size. From this it can be inferred that at the point of breakage the failure is due to breakdown of the silica grains and not of the epoxy binder.

## Conclusions

As a result of compressive-strength tests performed on test sections of epoxy-bonded sand, it may be concluded that the cemented sand screens and the piezometer tubes cast during the course of this project are of superior physical strength to the prototype screens of the previous work. This increase in measured bond strength is due jointly to the use of an improved epoxy resin, Epirez 133, and to the use of silane pre-coating agent to pre-treat the sand grains. The physical strength of the sand screens will also have been improved by the use of an increased quantity of reinforcing mesh.

No conclusions can be drawn as to the suitability of the completed sections for their intended uses as down-the-hole screens or as piezometer tubes since, at the date of this Report, the field evaluation by Department of Mines personnel has not been completed.

# 1. INTRODUCTION

Underground screening of water from boreholes presents considerable difficulty where fine, unconsolidated sediments are encountered. Conventional woven-wire or wedge-wire screens have proved unsatisfactory as they cannot prevent the passage of the fine, clayey sediments.

*Amdel Report No.456,* Dec. 1965, describes an investigation into the preparation and evaluation of porous cemented sand media with the objective of producing a material suitable for use as down-the-hole bore screens. Several resins and sand types were evaluated, the optimum materials being found to be Epikote 828 epoxy resin and minus 18 plus 36 mesh rounded sand. Cylindrical screen sections were cast using these materials and were laboratory-tested for water flow under conditions designed to simulate borehole applications. It was concluded from this investigation that the type of screen made offered a potentially suitable method of restricting the fine sediments from bore-water, and it was recommended that field testing be undertaken.

In mid-1974, Amdel further recommended that the initial investigation be continued in the following manner:

(1) Obtain supplies of suitable sand.

(2) Obtain and test suitable resin binders which are recommended by suppliers as having strengths equal to or better than that of Epikote 828.

(3) Produce four prototype screens for down-the-hole testing, screens to be made in 2 ft 6 in. modules.

(4) Subject the prototype screens to field testing, if possible in a location where a direct comparison can be made with conventional screens.

Approval of this programme was given by the Director, Mr B.P. Webb, in his letter of 12 July 1974 outlining the Mines Department sponsored work, approved by the Hon. the Minister of Development and Mines, for 1974-75.

Following discussions between Messrs R.G. Shepherd of the Department and D.W. Fox of Amdel, the work programme was defined with the following objectives:

(1) Obtain a supply of sand, the grains of which should show the maximum degree of roundness.

(2) Briefly evaluate suitable resin binders which are recommended by suppliers as having strengths superior to that of Epikote 828.

(3) Fabricate four reinforced screens, each 2 ft 6 in. long, 6-in. outside diameter, 1-in. wall thickness, suitable for screwing on to 5-in. bore casing. One screen was to be constructed using minus 8 plus 16 mesh sand, two screens using minus 16 plus 30 mesh sand, and one screen using minus 30 plus 60 mesh sand.

(4) Perform compressive-strength tests on sections cast, using each of the various grain size fractions.

# 2. MATERIAL EXAMINED

## 2.1 Sand

The sand used in the initial investigation was a rounded sand obtained from Price on the Yorke Peninsula. Samples of the three current products, coarse, medium and fine sand, were obtained from Price and were microscopically examined to determine the degree of roundness of the grains. Whilst the grain shape of the current products was observed to be comparable to that of the original material, the grains were considerably more angular than those used in a similar type of screen of American manufacture. A search was therefore initiated to locate a local source of sand of improved grain shape.

Samples were obtained from local sand pits, from beaches and from sand suppliers. Approximately thirty samples were collected and microscopically examined, the optimum material selected being a sand of Victorian origin, supplied by Steetley Australasia Pty Ltd., Minerals Division. This material is comprised of well rounded, dominantly silica grains, and is supplied in three size fractions, namely, minus 8 plus 16 mesh, minus 16 plus 30 mesh, and minus 30 plus 60 mesh. The screens were constructed using these three size fractions.

## 2.2 Resin

During the course of the initial investigation, the bonding effect of several different resin types was evaluated. The resins investigated included phenolic resin, polyvinyl acetate, sodium silicate, lime, soda ash and epoxy resin. Test sections were constructed using the various binders and were submitted to porosity and compressive-strength tests. The best results were obtained using Epikote 828 and Epicure U, an epoxy resin and an amine resin-hardener supplied by the Shell Chemical Company.

Based on this initial work, it was decided that the only binders worthy of further consideration were the epoxy resins.

Discussions with resin suppliers indicated that the only new resin likely to have a significantly higher compressive strength than the Epikote 828 was Epirez 133. Since the manufacturer could not quantify the likely improvement in bond strength, a sample of the resin was supplied by Epirez Adelaide Pty Ltd for evaluation.

During the search for an improved resin it was learned that a range of surface coating reagents, 'silanes', were available. The silanes most appropriate for pre-coating the silica grains were the organosilane esters, these being reagents which substantially improve the physical bonding between the inorganic substrate and the organic epoxy resin. Samples of the two most appropriate silanes, A187 (gamma-glycidoxypropyltrimethoxysilane) and A1100 (gamma-aminopropyltriethoxysilane), were supplied by Union Carbide Australia Ltd for evaluation.

# 3. EXPERIMENTAL PROCEDURE AND RESULTS

## 3.1 Evaluation of Resins and Silanes

It was considered that, provided the addition-rate of resin of 4% by weight was observed, the only method of evaluation necessary was compressive strength. Since the variation in specific gravity of different epoxy resins is minimal, the volume occupied by the resin, and hence the porosity of the screen, was unlikely to be significantly affected.

Cylindrical test sections, 4-cm high × 3.8-cm diameter, were cast using minus 16 plus 30 mesh sand, and their compressive strengths were determined using an Avery Universal testing machine. These tests showed the following results:

| Resin | Surface Agent | Comp. Strength (megapascals) |
|---|---|---|
| Epikote 828 | Nil | 6* |
| Epirez 133 | Nil | 28 |
| Epirez 133 | Silane A187 | 29 |
| Epirez 133 | Silane A1100 | 34 |

* See *Amdel Report No.456* - Cemented Sand Screens.

The Epirez 133 resin can be seen to impart a considerably higher compressive strength than the Epikote 828, whilst the silane A1100 surface coating agent further increases this effect. On the basis of these results it was decided to cast all screens using Epirez 133 resin and hardener, and silane A1100 surface agent.

One major advantage claimed for the silanes is that they improve the bonding of the epoxy resins when the bonded material has been subjected to prolonged immersion in water. This property was felt to be very useful for the present application, however to evaluate and quantify the improvement in bond strength further test sections were cast, 3 with no silane, 3 with silane A187 and 3 with silane A1100. These sections have been immersed in water and will be left for a further 5 months, after which time they will be subjected to compressive-strength tests. The results of these tests will be reported at that time.

## 3.2 Casting of Sand Screens

Four screen sections were cast, one using minus 8 plus 16 mesh sand, two using minus 16 plus 30 mesh sand and one using minus 30 plus 60 mesh sand. The fabrication method was identical in each case.

A piece of 6-in. I.D. bore casing was used as the outer mould casing, and a piece of 4-in. diameter oregon with a ½° longitudinal taper was used as the inner mould.

The screens were cast onto a 6-in. diameter mild-steel collar to which was welded a cylindrical reinforcing mesh (2 in. × 1-in aperture) cage. This cage was 33 in. long × 5-in diameter. The collar was machined with a female thread suitable for attaching to 5-in. bore casing.

For each screen, 25 kg of sand was weighed out and thoroughly mixed with sufficient hydrolysed silane A1100 to form a mono-molecular layer on each grain. The treated sand was oven-dried at 105°C for 12 hours to drive-off the excess water and to set the silane.

After the treated sand had cooled it was thoroughly mixed with 1 kg of Epirez 133 resin and hardener, the resin:hardener ratio being 3:1 by weight. The screen was then cast and allowed to set at ambient temperature for 24 hours before being removed from the mould.

As each screen was cast, test sections were cast using the excess sand/resin mixture, and subjected to compressive-strength tests. The results are shown tabulated below:

| Sand Size (mesh BSS) | Compressive Strength (megapascals) |
|---|---|
| - 8+16 | 14 |
| -16+30 | 21 |
| -30+60 | 25 |

## 3.3 Casting of Piezometer Tubes

On 16 January 1975, following discussions between Messrs R. Hancock, Chief Drilling and Mechanical Engineer of the Mines Department, and D.W. Fox, Amdel was requested to fabricate 4 screen sections for use as piezometer tubes in observation holes for measuring sub-surface water-level variations.

Four sections were cast, each 2 ft 6 in. long, 3⅜-in. O.D., and 1½-in. I.D. Silane-coated minus 8 plus 16 mesh sand was used, with epoxy resin addition of 3% by weight. The lower resin addition was used to increase the porosity of the screen.

Sections were cast with a mild-steel collar at each end, one with a 2-in. BSP male thread and the other with a 2-in. BSP female thread; this was to enable the sections to be screwed together to form a 10-ft tube. The two collars on each section were connected with three $^{5}/_{16}$-in. mild-steel rods embedded in the wall of the tube.

The sand preparation method and the casting procedure was as used in casting the sand screens.

The completed piezometer tubes were delivered to the Department of Mines Thebarton Works Depot on 29 January 1975 and the completed sand screens were collected by Department of Mines personnel on 6 February 1975.

Field testing of the completed piezomater tubes and sand screens will be undertaken by Department of Mines personnel.

## 4. CONCLUSIONS

As a result of compressive-strength tests performed on test sections of epoxy-bonded sand, it may be concluded that the cemented sand screens and the piezometer tubes cast during the coarse of this project are of superior physical strength to the prototype screens of the previous work. This increase in measured bond strength is due jointly to the use of an improved epoxy resin, Epirez 133, and to the use of silane pre-coating agent to pre-treat the sand grains. The physical strength of the sand screens will also have been improved by the use of an increased quantity of reinforcing mesh.

No conclusions can be drawn as to the suitability of the completed sections for their intended uses as down-the hole screens or as piezometer tubes since, at the date of this Report, the field evaluation by Department of Mines personnel had not been completed.

## 5. ACKNOWLEDGEMENT

The author wishes to acknowledge the advice and assistance given by the Amdel engineering and machine shop staff, during design of the casting moulds and in overcoming the problems encountered during casting.