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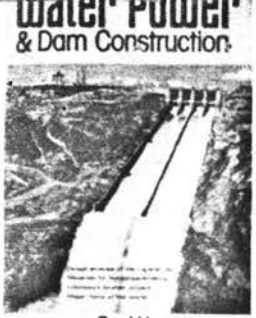

COVER: *Spillway discharge of Emboreaçao dam Brazil. The design and performance of its aerators are described in the article starting on p40.*

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NEXT MONTH: *this issue, published to coincide with the World Energy Conference, carries a world-wide view of hydroelectric development and a description of the present state of, and prospects for, tidal power. We also look at flood routing, and the Bersia and Kenering hydropower project in Malaysia.*

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grouting was carried out in a descending arrangement, in other words the holes are drilled with a 40 mm minimum diameter by diamond drilling equipment up to the depth possible, and then grouted. The grout is allowed to set, the holes are washed and then drilled. The sequence is repeated to achieve the specified depth.

Where there is no tendency for the holes to collapse, grouting is done in an ascending arrangement, in other words, after drilling and washing of the holes of 40 mm minimum diameter to the specified depth, a packer is fixed for the lowest stage depth of 6 m. A water test is conducted and the stage depth is grouted. This sequence is repeated for the next stage depth above it.

The packers used at Salal consist of mechanically manipulated rubber sleeves which can be set tightly in a grout hole, at any depth required, either singly or in pairs to isolate a section of the hole. The grouting progress rate of 40 m/day per unit, comprising a mixer, an agitator tank and a Duplex reciprocating grout pump has been achieved. On average, 35 kg/m depth of cement was consumed.

Guniting

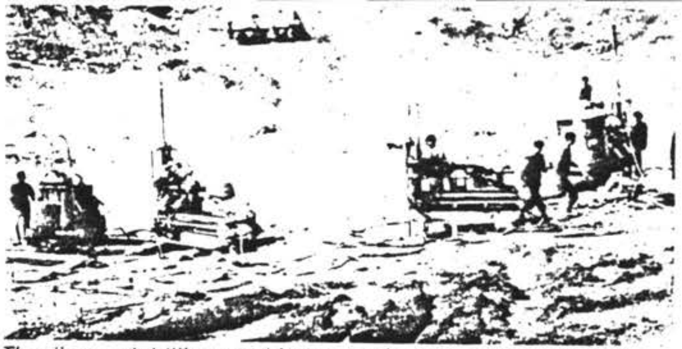
A 50 mm-thick gunite has been applied to the full core base and on the downstream rock face of the core trench. Guniting has been carried out over a standard hard drawn steel wire fabric, of 50×50 mm mesh size, made out of 3.8 mm-diameter wire and secured to the rock surface by dowels. It gives a compressive strength of M-250. No guniting is applied to the concreted surface of the core base.

Concrete cut-off

In the reaches within the core trench where the permeability of the bedrock did not reduce to 10 Lugeons after consolidation grouting, a 6 m deep concrete cutoff has been provided with a 1 m base width and side slopes of 4 V to 1 H and a longitudinal slope of 1 V to 2 H. The excavation of the cutoff trench is carried-out without resorting to blasting. The cutoff trench is provided along the centreline of the core width. During concreting grout pipes are embedded for contact grouting.

Drainage arrangements

Drainage arrangements have been provided to prevent erosion of the embankment materials and to relieve the uplift pressures on the dam. It has been proposed to provide 150 mm-diameter relief wells spaced at 30 m centres along the toe of the dam. The relief wells extend to a depth of 15 m below the rock level. A discharge drain will be provided to connect each relief well for the disposal of water and to measure the amount of seepage through the dam.



The diamond drilling machines used for the grout curtain holes.

Conclusion

The results of grouting in the core base area have shown that the permeability down to a depth of 6 m or so is higher than that in the lower stage depths. Surface leakage has also been observed. Another important conclusion drawn is that the permeability of the rock mass did not improve much even with 1.5 m spacings, and the cement grout could not pass through them because of the fine texture of the dolomite. The grout intake in the shear zones is also not excessive because of the presence of clayey material. The shear zones with gougy seams are not very wide and their influence did not affect the results of permeability. High permeability values in the upper stages could be attributed to leakage through the weathered rock and the opening out of joints to the surface. A positive cutoff is a feasible solution for such situations.

A drainage system has been provided on the downstream side of the core base in view of the shear zones running parallel to the river course and the difficulty in sealing them with cement grout. The use of core bits for drilling and the descending arrangement for grouting has been quite effective for dealing with collapsing strata. □

Degradation of the river Nile

By S. Shalash
Director*

PART TWO

In the concluding part of this article, the author looks at some of the results of research concerning the annual changes in water levels at various points on the Nile.

THE REACH of the Nile investigated, as described last month, extends from downstream of the low Aswan dam to upstream of the Delta barrage. It was found that the maximum drop in water levels varied with the discharge rate, the drops in levels being higher at low discharges.

In general the annual rate of decrease in water levels did not exceed a few centimetres per year downstream of the hydraulic structures and the annual drop in levels decreases gradually with time. The annual changes in water levels downstream of the hydraulic structures are shown diagrammatically before and during construction and after completion of the High Aswan dam until 1982.

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Variation in surface water slope. It is well known that the surface water slope of rivers varies continuously along the course; in the case of the river Nile, the surface slope problem is more complicated for the following reasons:

- the river reach considered for this study is partially controlled by hydraulic structures, and partially controlled by its natural conditions;
- the natural river varies—sometimes the flow runs in one channel and sometimes in two with islands in the middle;
- there is a variation of the formation of bed and banks materials;
- there is a variation of degree of sinuosity along the river course;
- there is continuous variation of water levels downstream of the control points because of the continuous changes in the discharge rates;
- there is continuous variation in natural conditions along the river course;
- there is a variation in the gains and losses along the river channel;
- there is a continuous change in the waterway because of natural and man-made influences; and,
- in addition to the boundary conditions mentioned previously, the river itself was changed after the completion of construction of High Aswan because of the change in the natural hydrological regime.

So as to monitor in the future the annual rate of change in the surface water slope of the Nile, the following methods have been adopted to ensure good basic data for comparison.

- Water level gauges were selected at the beginning and end of reaches affected by degradation downstream of the hydraulic structures.
- Mean annual discharges downstream of each barrage, and water levels for the period 1963-1982, were measured. Some results are in Tables XII and XIII. A relationship between the mean discharges and mean slopes for each reach are shown for the period 1963-1980, see Figs. 8-13.
- To calculate the slopes which correspond to the discharges before construction of the Aswan High dam, the same method was used.
- From the change in surface water slopes during the period 1963-1982, the maximum drop downstream of each structure was as follows:

Low Aswan dam = 89 cm
Esna barrage = 65 cm
N. Hammadi barrage = 104 cm
Asiut barrage = 96 cm

Table XII—Mean annual discharges and water levels at km 7 and km 104 within the Aswan-Esna reach

Year	Mean annual discharges at Low Aswan ($\times 10^6$ m^3/day)	km 7 Mean annual water levels (m)	km 104 Mean annual water levels (m)	Slope (cm/km)
1963	84.95	236	79.61	5.51
1964	85.64	299	80.29	5.52
1965	84.99	227	79.80	5.35
1966	84.01	165	79.22	4.94
1967	84.32	193	79.47	5.00
1968	83.61	147	79.02	4.73
1969	83.62	147	79.07	4.69
1970	83.65	150	79.04	4.75
1971	83.70	153	79.11	4.73
1972	83.67	152	79.13	4.68
1973	83.71	154	79.14	4.71
1974	83.67	154	79.11	4.70
1975	83.63	149	79.06	4.71
1976	83.73	149	79.14	4.73
1977	83.86	158	79.30	4.70
1978	84.08	170	79.47	4.75
1979	83.88	159	79.40	4.62
1980	83.76	155	79.31	4.59
1981	83.82	159	79.37	4.59
1982	83.93	162	79.44	4.63

Table XIII—Mean annual discharges and water levels at gauge km 539 and km 831 within the Asiut-Delta barrage reach

Year	Mean annual discharges LAD ($\times 10^6$ m^3/day)	km 539 Mean annual water levels (m)	km 831 Mean annual water levels (m)	Slope (cm/km)
1963	47.47	185	21.82	8.78
1964	48.14	245	22.53	8.77
1965	47.70	194	21.97	8.81
1966	46.63	102	21.03	8.77
1967	46.86	136	21.32	8.75
1968	46.28	101	21.11	8.62
1969	46.07	95.3	21.04	8.57
1970	46.15	96.9	21.15	8.56
1971	46.11	98	21.18	8.54
1972	46.08	99.7	21.15	8.54
1973	46.00	96.1	21.09	8.53
1974	46.10	96.6	21.17	8.54
1975	45.94	92.4	21.17	8.48
1976	45.94	94.2	21.25	8.46
1977	46.11	103	21.48	8.43
1978	46.30	110	21.74	8.41
1979	46.24	109	21.55	8.46
1980	46.08	97.8	21.44	8.44
1981	46.06	104	21.51	8.41
1982	46.17	110	21.64	8.40

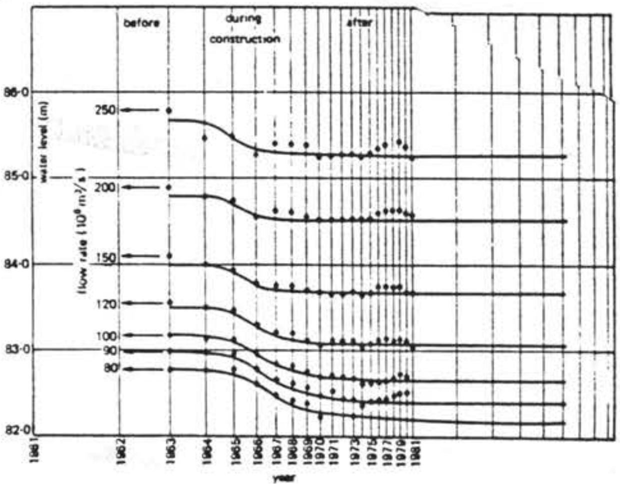

Fig. 8. Water levels for discharges downstream of low Aswan.

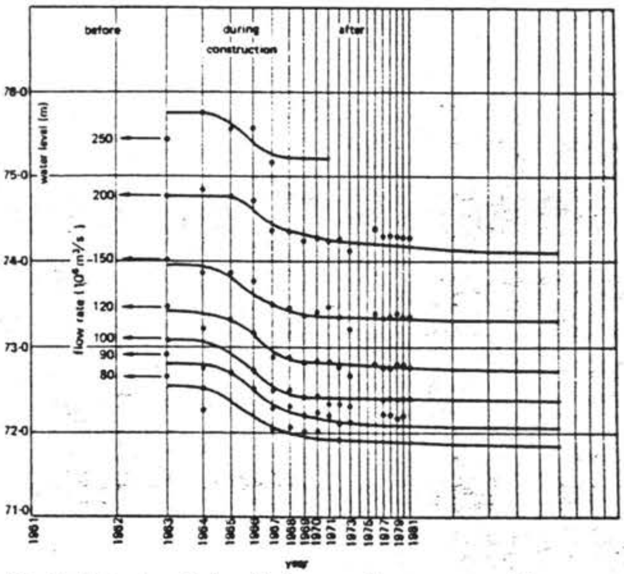

Fig. 9. Water levels for discharges downstream of Esna.

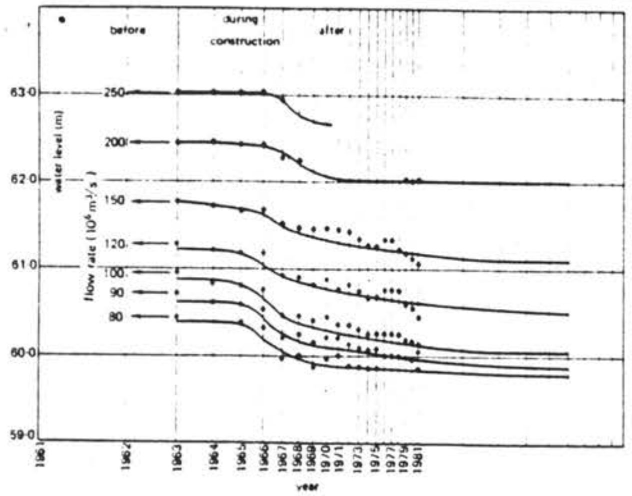

Fig. 10. Water levels for discharges downstream of N. Hammadi.

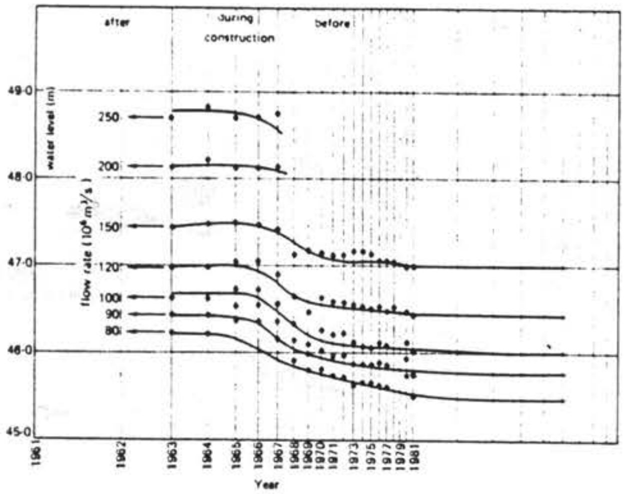

Fig. 11. Water levels for discharges downstream of Asiut.

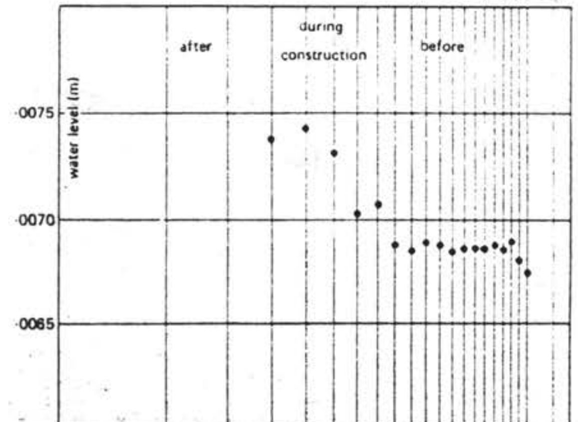

Fig. 12. Changes in surface water slope: (above) Aswan-Esna reach; and, (below) Esna- N. Hammadi reach.

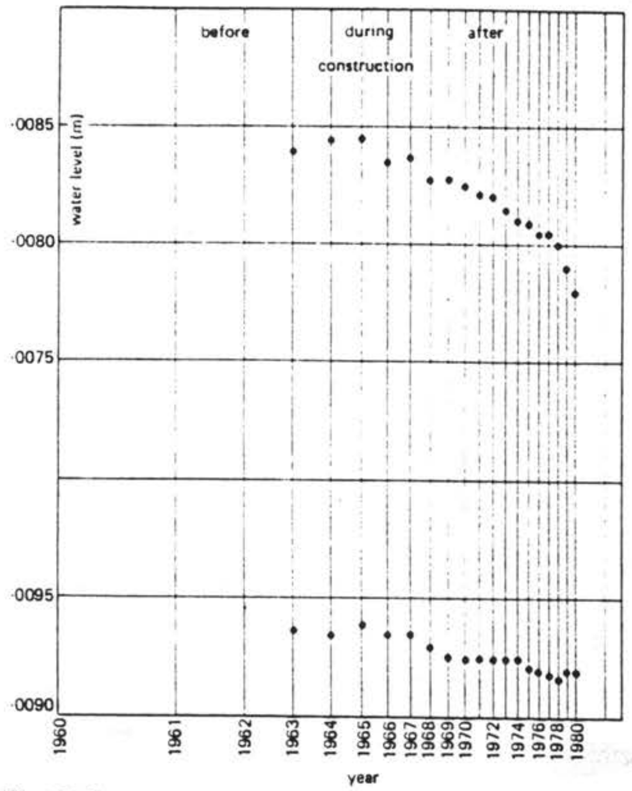

Fig. 13. Changes in surface water slope: (above) N. Hammadi-Asiut reach; and, (below) Asiut-Delta reach.

Table XIV—Comparison of the results of field experience and theory

Researcher or organization	Downstream of High Aswan	Downstream of Esna barrage	Downstream of N. Hammadi barrage	Downstream of Asuit barrage
Results of drop In water levels from research				
A. Fathy (1956)				
G. Mestafa (1957)	8.50	8.00	7.00	6.50
VBB (1960)	3.0-4.0	3.0-4.0	3.0-4.0	3.0-4.0
S. Shalash (1965)	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
D. B. Simons (1965)		3.50		
Hydro project (1973)	3.00	3.50	3.50	3.00
S. Shalash (1974)	1.37	1.01	1.37	2.90
Hydro project (1976)	5.30	7.00	11.00	
Hydro project (1977)	3.00	2.50	4.00	8.00
Field results drop in water levels up to 1982				
	0.61	0.80	0.99	0.73
Field results drop in bed levels up to 1982				
	0.25	0.38	0.48	0.70

Conclusion

Eighteen years have elapsed since the High Aswan dam began to have an effect on the hydrological regime of the river Nile. It is therefore interesting to evaluate the actual effect of the dam. with respect to degradation and from the points of view of both theory and practice.

Table XIV summarizes the results of degradation on drops in both the river bed and water levels along the reach between Aswan and the Delta barrage. The Table shows the large difference between some of the theoretical forecasting and the actual results, as regards the rate, maximum magnitude and time taken for the complete degradation process. □