BEHAVIOR OF BEACH FILL
AT THE COAST OF ALEXANDRIA CITY , EGYPT

BY

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ABSTRACT :

In 1989 , 1990 and 1991 , to restore and stabilize the beaches of the eastern flank shore of Alexandria City , sand was transfered to the beaches of Sidi Bishr , Miami , El-Asafra , Ibrahimiah and El-Shatby from a borrow area by trucks . The beaches were widened and raised , and, in addition , an extra amount of sand was placed on each beach to act as a feeder area . The material from the borrow area proved , to an extent , to be unsuitable beach fill . In 1992, 1993 , and 1994 surveys showed that while the actual net loss of sand from the backshore was slight , losses from the foreshore were major . These losses indicate that maintenance fill is now required and that the construction of several short groins east of the beaches (downdrift) may be desirable . Data , in graphic form , show comparative profiles of the area , changes in beach width , and composite size-distribution curves for sand samples . The study revealed that a natural source of supply of terrestrial material no longer exsited within the area and that improvement of the shore could best be accomplished by artificial replenishment of the beaches . The most logical source of sand for this purpose is deemed to be offshore .

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1- INTRODUCTION :

The most economical method of protecting long reaches of shore is frequently found to be placement of suitable sand to provide a protective beach , and maintaining the required beach dimensions by periodicaly replacing the material eroded from the beach zone . This method of protection is being used at a number of beach sites eleswhere . In the case of the beaches along the coast of Alexandria City,groynes were included in the plan to help stabilize the beaches and reduce replenishment requirements . The fill project for the beaches of Alexandria City is of particular interest as the beach fill material was taken from far distance borrow area from the beach zone .

This paper describes results of sand beach fill placed at some beaches of Alexandria City , in accordance with a plan developed by the Alexandria Shore Protection Board for the protection , restoration and development of beaches . The study reported herein was made under the part of the Board's general investigation programme concerned with the results obtained by work completed under shore protection projects and development of criteria for the design of future beach fill projects . Thus , the purpose of this study was to determine the most suitable method of stabilizing and improving the shore area . Local officials of the Alexandria Governerate had stated that additional beach area was desired and needed for recreational use at Alexandria beaches because of overcrowding of existing beaches during periods of peack use . For this reason , a plan of protection for Alexandria beaches involving placement of a sand beach in front of the seawall was considered preferable to one involving placement of riprap revetment in front of an existing masonry seawall . The recommended plan of improvement involved widening the beaches to a 10-20m. width (above mean high water) by direct placement of sand , and construction of impermeable groynes. The plan provided for additional widening the beaches at the westerly end of the fill , as this sector of the beach fill was expected to be eroded at more rapid rate , and to provide advance nourishment to the widened beaches . Groynes were included in the plan , as the study showed that losses from beach fill would be excessive without these structures . Behavior of sand fill placed on the beaches indicated that the only appreciable loss of fill occured between the high and low water lines . Thus it was believed that short groynes would be required at the beaches under consideration . The short groynes would permit the passage of some sand from the west end of the fill area of each beach to nourish the beaches to the east , and thereby permit more economical maintenance of the entire area of the beaches by periodically placing sand at the west end of each beach . The quantity of sand required for the initial fill to nourish the five study beaches , El-Asafra , Miami and Sidi Bishr, Ibrahimiah and El-Shatby, was about 126415 m^3 . The anticipated percent of losses of the initial fill was estimated at 20% (25283 m^3) for the first year after the fill placement and the average annual loss, i.e. nourishment requirements, was estimated at 5% (6321 m^3) .

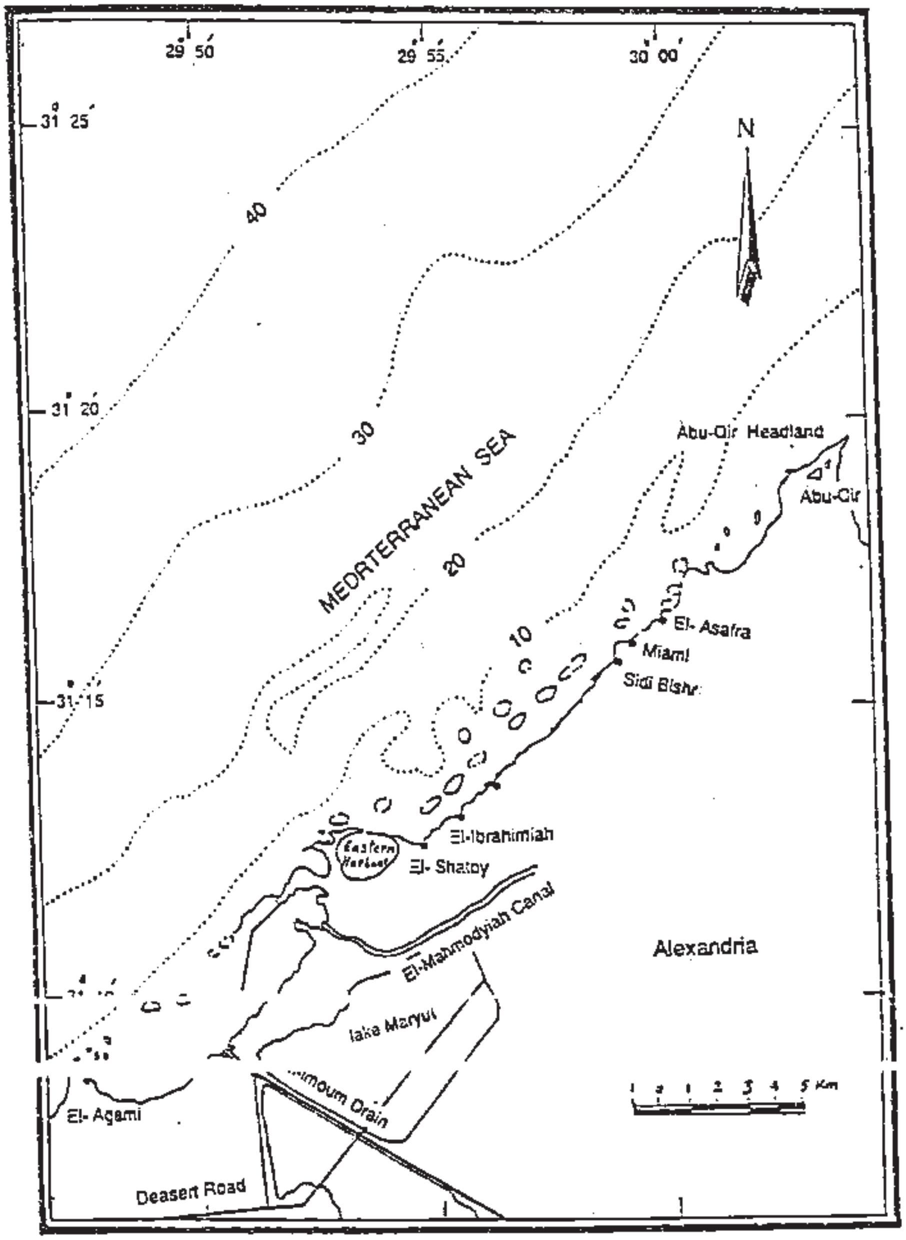
The main objectives of this work are , therefore , to analyse and interprete the changes of the beach profiles located in the shore area of Alexandria , the annual changes of beach area between consecutive surveys , as well as the annual variaton of texture and transportation of sediments covering the beaches under investigation .

2 - AREA OF STUDY

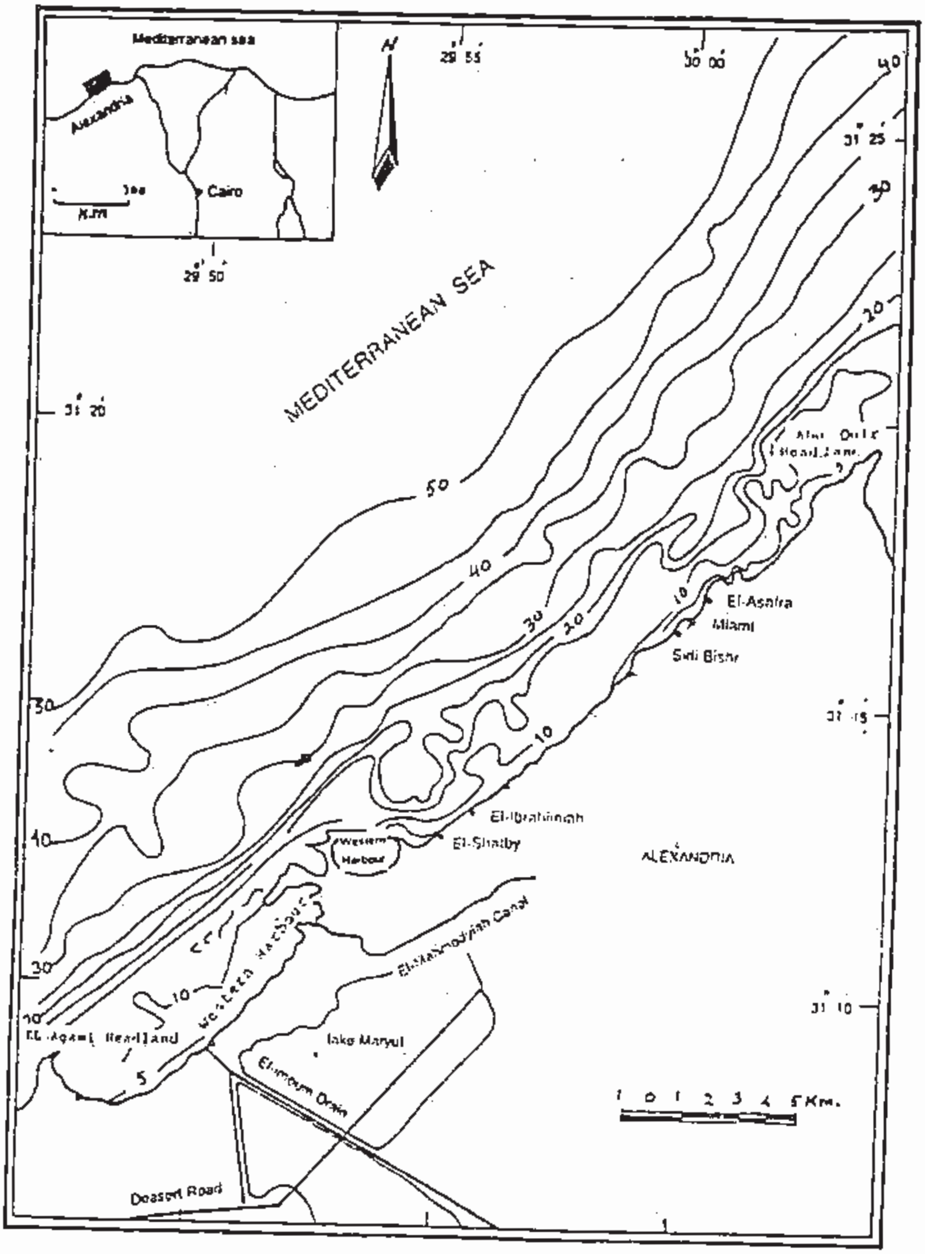
The study beaches of El-Asafra , Miami, Sidi Bishr , Inrahimiah , and El-Shatby are located in the eastern precinct of Alexandria City , and comprise about 6.2 km. of the eastern flank shore along the Alexandria coast , between the Abu-Qir headland in the east and El-Silsila , in the west , a distance of about 25 km. This flank of shore lies between 31^{o} 12.5′- 31^{o} 19.5′ N and 29^{o} 45.5′- 30^{o} 04′ E (Fig. 1) , and extends generally in a south southwesterly - north northeasterly direction . The shoreline of this flank is essentially straight but slightly undulating in some localities forming small embayments .

The beach sands vary , along the eastern flank of the coastal area of Alexandria City , from loose to fairly well indurated deposits of quartz . Shells and shell - fragments as well as heavy minerals are common in beach sands of this part of the Alexandria coast .

Geomorphologically , the shoreline of Alexandria exhibites typical features of a young shoreline and it forms one geomorphological unit that is shaped largely by terrestrial depositional agencies and wave action (Shukri & Philip , 1955) . Submerged hard ground and emerged islets extend more or less parallel and close to the present shoreline ; these probably represent the ancient subsided shoreline (Fig. 2) which was largely affected by the relative rise of sea level (El-Wakeel , et al., 1980 ; El-Sayed, 1991) . The coastal stretch skirting this area is rocky in some places and , in most places , is a low land with narrow



(Fig.1) : Location of the study area,



(Fig.2) : Modern and ancient shorelines of Aledandria.

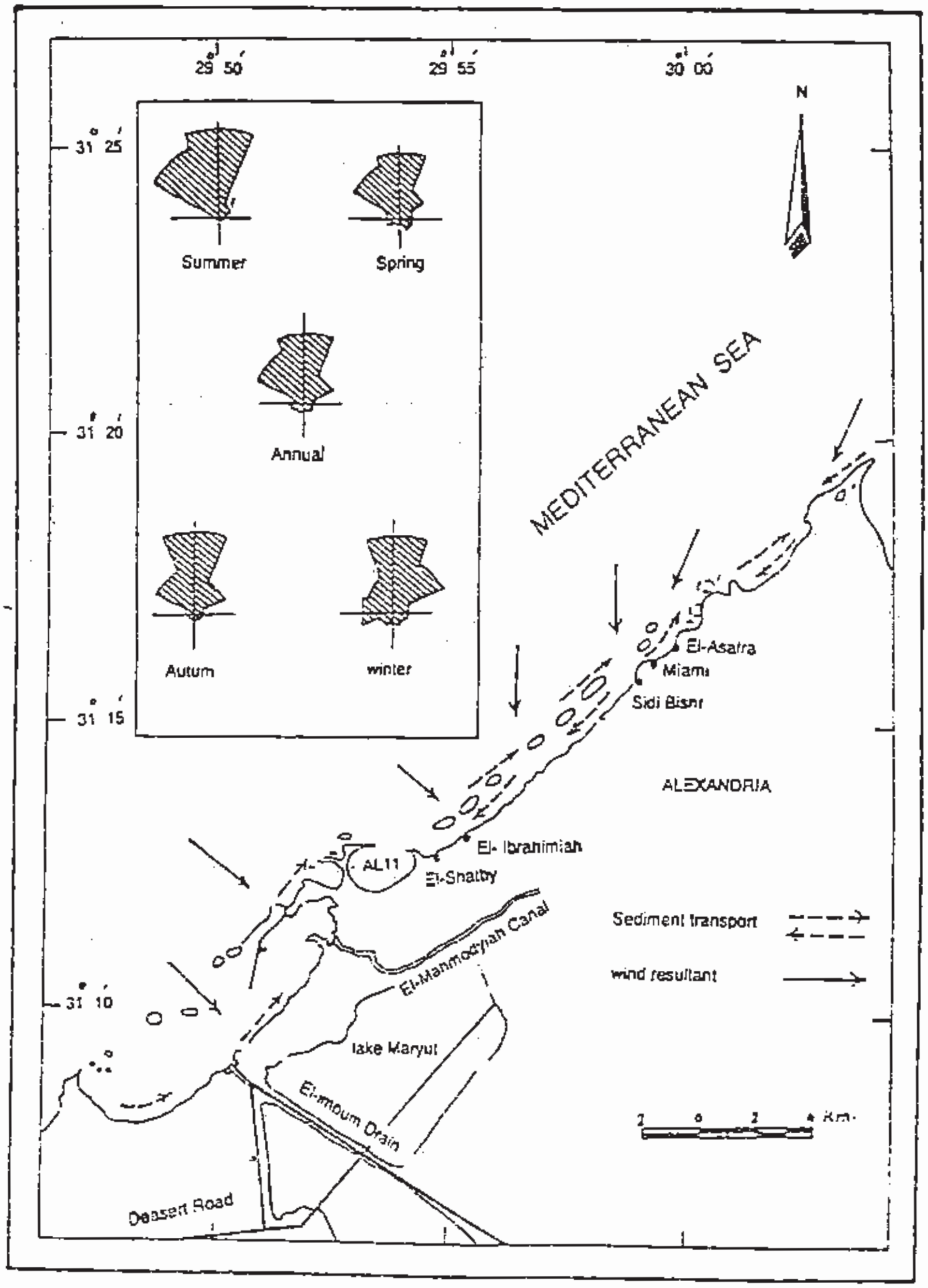
sand beaches in the embayments and relatively wider ones in Sidi Bishr and Maamoura. The beaches have smooth surfaces and slope regularly seaward, at an ever - decreasing.

The coastal zone of Alexandria is susceptible to great changes on application of energy. Most of the energy driving inshore and beach foreshore processes along this coast comes from the Mediterranean Sea, acting as the medium for transfer of energy to the loose material, in the form of waves, currents, tides and winds which are primary agents affecting the coast.

Alexandria area is exposed to a number of storm surges which generally last from October to May, but most frequently between December and February. (Hamid and El-Gindy, 1988). They blow mainly from northwest and southwest, and occur with depressions aproaching from northwest. The wind blows, on shore, generally in a northwesterly direction (Fig. 3) and attains its maximum speed (about 15 km/hr) during winter, and induce during summer months swell which is refracted to produce east-moving longshore drift. Obliquely south - westerly and north - easterly winds are also predominant during winter months, the latter being more frequent and potentially significant in producing west- moving longshore drift (Manohar, 1976). Onshore northerly winds prevail throughout of the year (Climatological Normal, 1980) and give rise to prevailing waves and swells that efficiently transmit energy and momentum to the shore of the study area. On the contrary, contribution by offshore winds is regarded as insignificant considering the general inability of wind to transport coarse sand (Blatt et al., 1972), and because less than one fourth of wind direction for Alexandria Coast has an offshore component.

Wave action along the coast of Alexandria is seaonal in nature with the winter, storm season (October to May) and summer, swell season (May to October). The waves have periods ranging from 7-8 sec. in storm season to 9-10 sec. in swell season. Wave heights of about 0.80m are average. During the storm the average wave heights is 1.3m (with maxima never over 3.0m). The predominant directions of waves during stormy season are usually from NW and NNW, though waves from N, NNE and NE are not uncommon, especially in December and March. (El-Ganainy et al., 1991). Swell approach the coast generally from NNW and NW with an average height of 0.60m.

The coastal area of Alexandria is a microtidal environment (mean range



(Fig.3). Seasonal and annual wind Frequency by direction, and onsore wind resultants and direction of inshore sediment dispersal along the Alexandria Coast.

0.26 m., maximum range 1.17m) . Records from the Western Harbour Tide Gauge Station show that tides are predominately semi-diurnal . The tidal variations are , however , relatively small , and , therefore , constitute significant factor for the mechanisms of sediment transport and shore processes . The average daily variation of the mean sea level along the Mediterranean off Egypt may approch 80 cm (Mobarek et al., 1966) . During storm surges this variation may reach about 120cm. The value of the maximum and minimum annual m.a.s.l. were about 50cm and 40cm respectively (Rady , 1979) .

The prevailing coastal current off Alexandria is mostly directed northeasterly and occasionally southwesterly (Abdallah , 1978 and Eid, 1979) . The current excursions are generally larger and show less directional scatter in summur and fall than in winter . The excursion lengths in the winter reach an offshore limit of about 30km, while they may reach higher values , and therefore have a bigger influence during summur and fall . The average speed of the coastal current is about 28 cm/sec from west to east as deduced from drogue and dye experiments (Gerges , 1978 and Eid, 1979) . On the other hand , the longshore drifts induced within the breaker zone are mainly responsible for longshore transport and movement of the sand load. Eastward current predominate during the summer months , while wesrward currents as well as negligible currents resulting from the perpendicularity of waves are commen features during the monthes (UNESCO , 1973 ; 1976) . Longshore currents with speed up to 100 cm/sec have been measured locally along the Mediterrenean coast of Egypt (Sharaf El-Din , 1974) . The eastward currents are up to 80 cm/sec , over 50% of the time , and this is almost twice as much as the east-west direction (Manohar, 1976) . On the contrary , the tidal current along the coastal area of Alexandria is weak relative to both littoral and coastal currents (UNESCO , 1977) .

Perior to improvement of the study beaches in 1989 , the shore area consisted generally of low land . The shore from El-Shatby to Ibrahimiah consisted of narrow beach (15-20) of mixed shell fragments and coarse sands , while from Sidi Bishr to El-Asafra , the shore is relatively wide (30 - 40 m) and was composed of relatively fine sand admixed with shells and to some extent with Nile deposits . The original beach-face slopes were steep between high and low water and averaged about 1 on 7 , and relatively fllattened in other parts with the majority 1 on 40 .

3- PROJECT CONSTRUCTION

The governerate of Alexandria initiated construction of this project in June 1989 , July 1990 , and May 1991 for the beaches of Miami and Sidi Bishr , El-Asafra , and Ibrahimiah and El-Shatby respectively . The beaches were widened normal to the shoreline length which is a distance of about 6.2 km. A total of 126,415 m^3 (335,000 ton) of sand fill was placed on the study beaches ; at a cost of about LE 3,013,470 ($ 942,715) . Of this quantity , 52,830m^3 were deposited on Miami and Sidi Bishr beaches , 32,075 m^3 were placed on El-Asafra beach , and 41,510 m^3 were deposited on El-Ibrahimia and El-Shatby beaches . The two borrow area , from which the sand fill has been brought to the beaches , were located south west of Alexandria City and lie nearly the 21 km and 120 km on the Desert Road . Samples of fill material had mean sizes ranging from 0.25 ϕ to 2.0 ϕ (Coarse to medium sand) . It was anticipated that about 20% (10565 m^3 , 6415 m^3 , and 8305m^3 for Miami and Sidi Bishr , El-Asafra , and El-Ibrahimiah and El-Shatby beaches respectively) of the initial fill on each beach would move seaward by littoral processes throughout the year after sand fill placement and , thereafter , an average requirement of about 2650 m^3 , 1625m^3 , and 2100 m^3 annually for nourishment of Miami and Sidi Bishr , El-Asafra , and El-Ibrahimiah and El-Shatby beaches respectively . The three impermeable groynes constucted after the fill were placed at location shown on Figure 1 . An average of about 560 tons of stone was required for each groynes , and the average length of the groynes is 65 m . The seaward ends of the groynes terminated at about mean low water on the filled beaches of Miami (2 groynes) and El-Shatby (1 groyne).

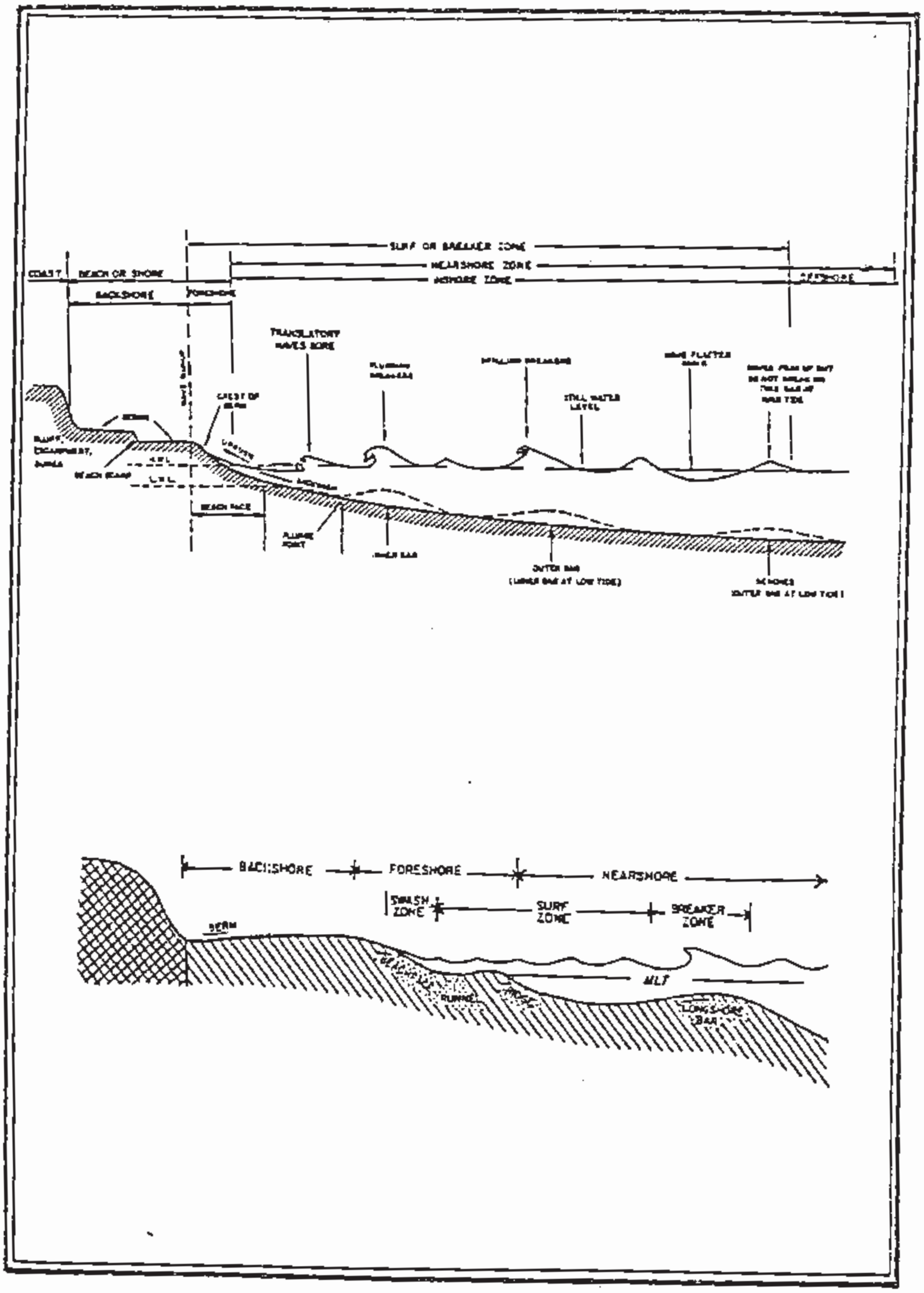
4- MATERIALS AND METHODS

Profiles of the shore were obtained at intervals of approximately 400m (17 profiles ; Ranges P-02 to P-34 inclusive , even numbers only) , along the study shore stretechs in July 1989 , August 1990 , and May 1991 (immediatly after filling) . Condition surveys were made in July 1990 , 1991, 1992 for Miami and Sidi Bishr beaches ; August 1991 , 1992, 1993 , for El-Asafra beach , and May 1992 , 1993 , and March 1994 for Ibrahimiah and El-Shatby beaches . Profile lines are taken perpindicular to the shoreline and extended seaward up to 1.0m depth . The levelling data are adjusted to the MSL datum using beach marks of 2.5 , 2.0 , 2.0 . 1.90 , 1.90 m elevation located behined the beach area of

El-Asafra , Miami , Sidi Bishr , Ibrahimiah and El-Shatby respectively . Distance and corresponding elevations along profiles were measured at 3.0 m interval , to an approximate depth 1.0m below MSL . Beach face slope was measured using a clinometer . Two parameters were calculated for each individual profile survey subsquent to the first survey of July 1989 , August 1990 and May 1991 . (1) The horizontal change of MSL shoreline position between consective survesy of a particular survey line (i.e the changes of beach width) . The shoreline is defined as the point at which the measured beach profile crosses the MSL elevation . (2) The volumetric changes above the MSL shoreline for a unit volume alongshore length of beach . Unit volume is defind as the cross - sectional area under the profile multiplied by a unit length of beach in the longshore direction i.e cubic meters per meter of beach (m^3/m) . The survey data were then stored in the computer for data analysis . It was felt that the selected spacing would furnish sufficient data for significant volumetric computations . Profile locations , a typical as - built beach profile , and plots of profile data are shown in figures 5,6 and 7 , respectively .

Thirty four samples were taken from beach face and inshore zones in 1989 (14 samples) , 1990 (8 samples), 1991 (12 samples) after fill placement on the study beaches of Miami and Sidi Bishr , El-Asafra, and El-Ibrahimiah and El-Shatby respectively . During the resurvey of 1992 , 1993 , 1994 , seventeen surface samples were taken from the beach face , along 17 profiles . The surface sand samples were obtained by conventional procedures , and were collected exclusively from the upper part of the beach foreshore (Fig. 4) , i.e. between the still-water level and ordinary high water mark or somtiemes the limit of wave uprush , including that part of the deposit act upon by the swash waves that have broken near the strand line , of the five study beaches . At each prescribed site , four closely spaced samples , 1m apart , were obtained using a cylindrical tube , 5 cm in diameter , which extended 15 cm normal to the beach-face to obtain more or less average sample over a number of laminae. This was done after the beach-face slope had been measured . The four samples were then combined into a single composite sample . Seventeen inshore sediment samples were also collected from the inshore zone during 1992 , 1993 , 1994 , along 17 profiles . One sample was retrieved from each profile by small grab sampler .

In the laboratory , the collected samples were washed in distelled water to remove salt which might will have produced aggregates , air-dried ,



(Fig.4) : General profile diagram of beach and nearshore zones using terminologhy of littoral features.

disaggregated then splitted . About 200g from each sample was sieved by hand through the -1.75 ϕ and -150ϕ sieves to remove any coarse shell material . The remainder was then sieved for 15 minutes on a Soiltest Sieve Shaker using a standard set of sieves arranged in a one - half phi class intervals from -1.5 to 4.0ϕ* . The fraction retained on each sieve was weighted to 0.01 g and the weight was converted to percentage of the total sample weight .

The method of moment (Friedman 1961 , 1967 and Griffiths 1962 , 1967) was used to determine the several basic parameters of the Size - Frequency distribution . The mean grain - size (M) , standard deviation , i.e Sorting (S) , skewness (SK) , and kurtosis (K) for all samples were calculated using four computational formulae proposed by Greenwood (1960) . All computations were carried out on a digital personal computer (Mandax M- 109) using a MSX - BASIC computer programmes for standard moment statistics , correlation coeficient, and regression equations of the size parameters of sediments .

5- DATA ANALYSIS AND RESULTS

Comparative profiles abtained from 3 surveys from 1989 - 1992 , 1990 - 1993 and 1991 - 1994 are shown in figures 5 through 7. Volumetric changes were computed for each individual profile survey subsequent to the first survey of 1989 , 1990 , 1991 . To faciliatte volumetric computation and to aintain a more datailed analysis and better definition of the net material movement in the area , beach and inshore were arbitrarly divided into three zones for analysis as follows:

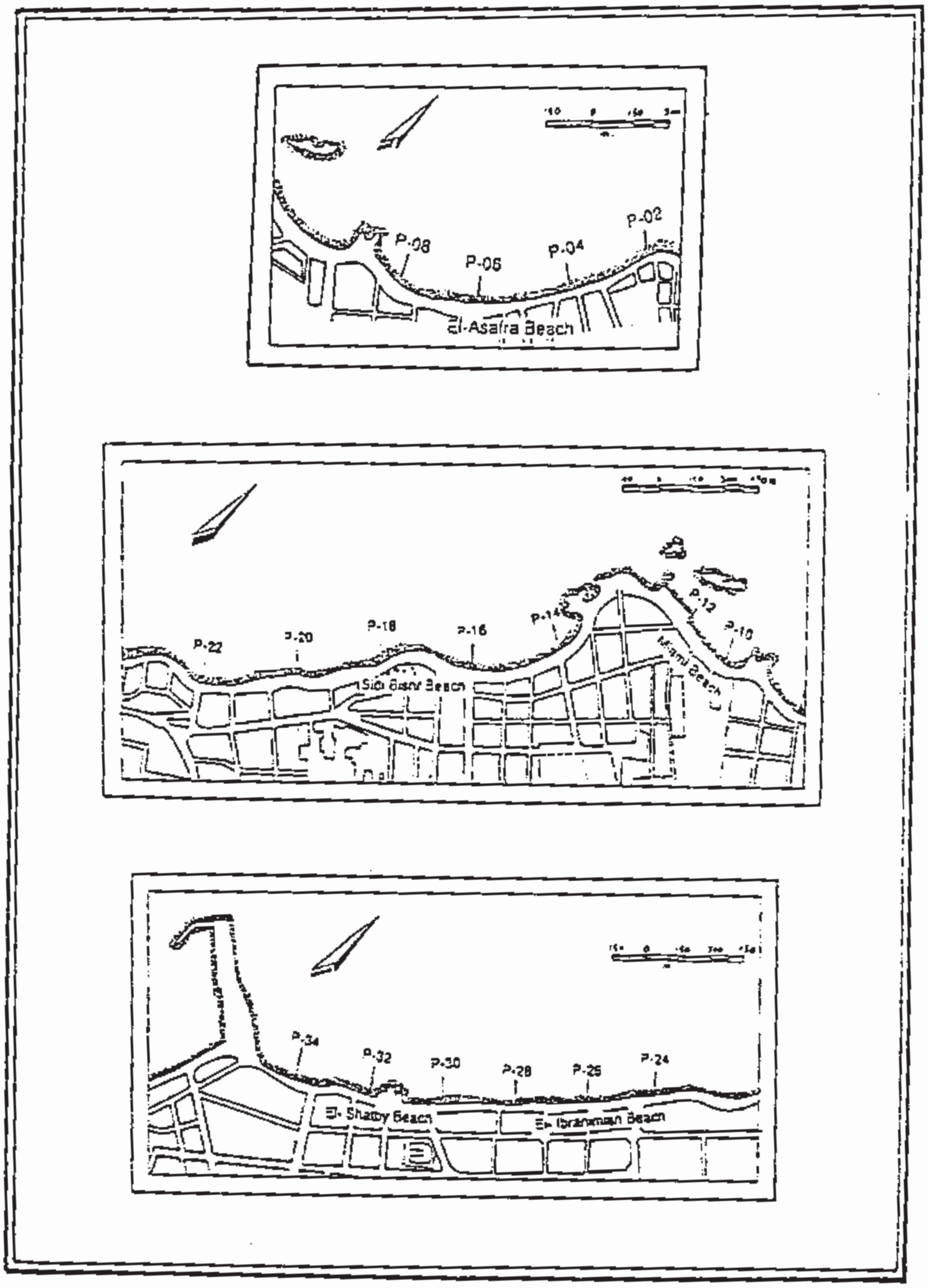
I- Above mean high water (between MHW and baseline) .

II- Between mean high (MHW) and mean low (MLW) water lines .

III- Blow mean low water (between MLW and the point where profiles approximately terminate in the inshore area) .

The volumetric changes computed in each zone for periods between each survey from 1989 to 1992 , 1990 to 1993 , and 1991 to 1994 for the study beaches are given in Table 1 . The computations show that from July 1989 to July 1990 , from August 1990 to August 1991 , and from May 1991 to May 1992

* ϕ = (phi) = - $\log_2$ mm. phi values are more practical than mm and are of standard use in Sedimentology .

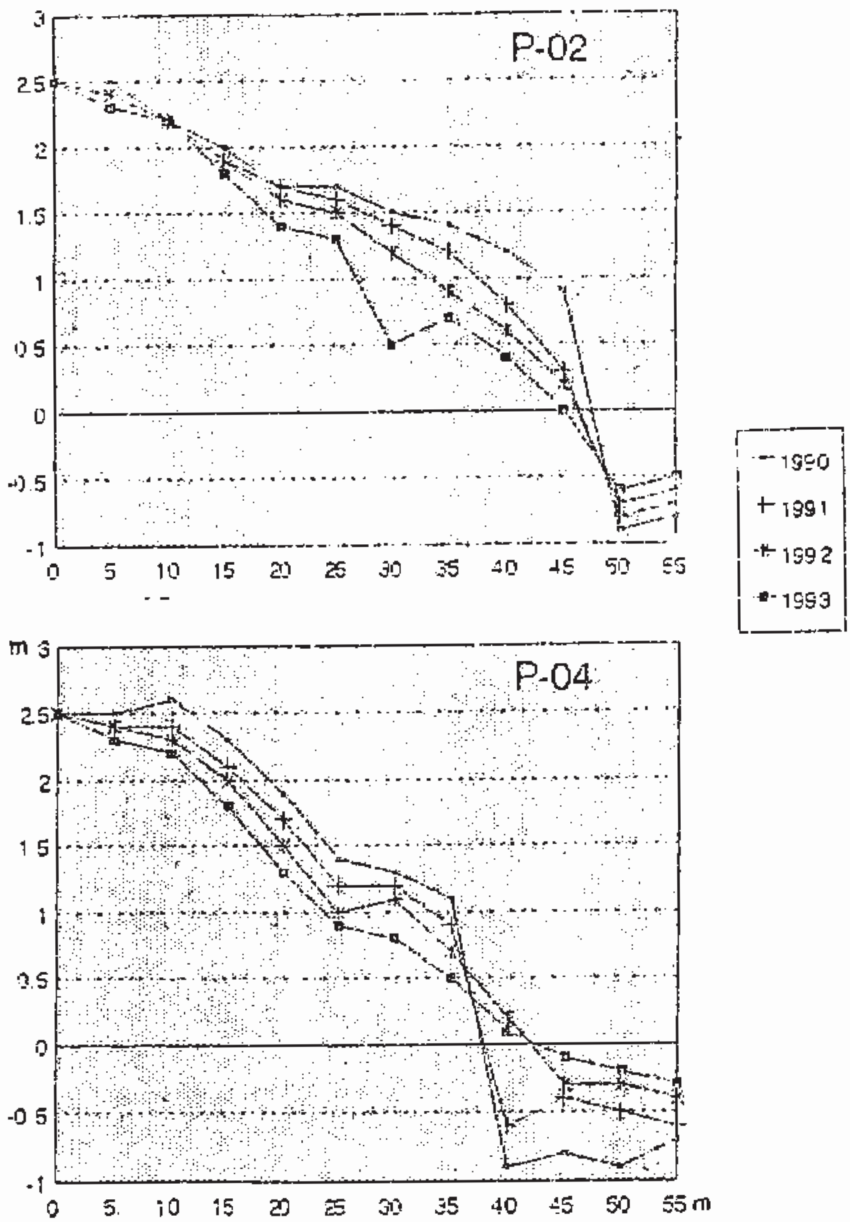


(Fig.5) : Locations of beach profiles along coast of Alexandria.

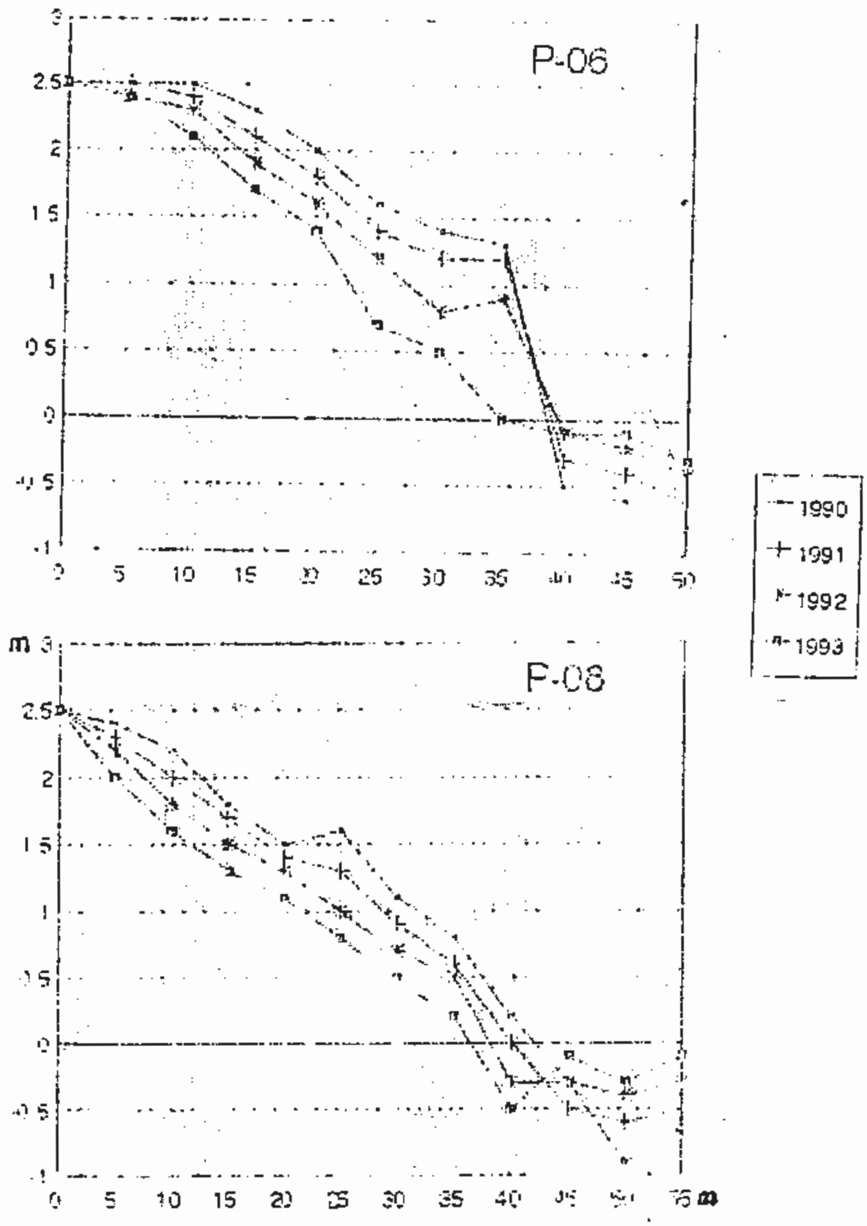
there was a gain of 200 m^3, 500 m^3 and 700 m^3 of material between profiles P-10 and P-22 , profiles P-02 and P-08, and profiles P-24 and P-34 in the zone above mean high water of Miami and Sidi Bishr beaches , El-Asfra beach, and El-Ibrahimiah and El-Shatby beaches respectively. In the zone between mean high and mean low water during this same period there was a material loss of 7800 m^3 between profiles P-02 and P-08 , 13800 m^3 between P-10 and P-22, and 11500 m^3 between P-24 and P-34 . For the zone below mean low water a gain of material throughout the study beaches is indicated . The gain in this latter zone amounted to 200 m^3 , 2500m^3 , and 2100 m^3 at El-Asafra , Miami and Sidi Bishr , and El-Ibrahimiah and El-Shatby beaches respectively . Thus the survey data for the first year after placement of fill indicate a net loss of material the entire study beaches of 26900 m^3.

Between July 1990 and July 1991 , August 1991 and August 1992 , and May 1992 and May 1993 virtually all losses was confines to the zone between planes of mean high and mean low water . Loss of material in this zone along the entire lenght of study beaches amounted to 29400 m^3 . There was a small gain of material in the zone above mean high water amounting to 100 m^3 while the zone below low water gained 5800 m^3 of material at all the study beaches . The net material movement for the three zones between the study limits for the second year was a loss of 23500 m^3 . The general movement of material during the second year after placement of fill was similar to that of that of the first year in that virtually all losses occurred in the zone between mean high and mean low water while the gains were confined almost entirely to the zone below mean low water .

During the period between August 1992 and August 1993 , July 1991 to July 1992 , and May 1993 March 1994 some accretion occured in the zone above mean high water between profiles P-06 and P-08 , and P-10 and P-22 and also in the zone below mean low water for all study beaches ; however , elswhere in the beaches material losses were indicates . In the zone above mean high water there was a gain of 2700 m^3 of material in the area of El-Asafra , and Miami and Sidi Bishr beaches, while in the area of El-Ibrahimiah - El-Shatby losses amounted to 400 m^3 . Between mean high and mean low water, erosion amounted to 6100 m^3, 11300 m^3, and 9100 m^3 at El-Asafra, Miami and Sidi Bishr, and El-Ibrahimiah and El-Shatby beaches respectively . Accretion occurred along the entire length of the zone below mean low water in all the Study beaches , but



(Fig:6) : a- Comparative profiles of El-Asafra beach (P-02 : P-08).



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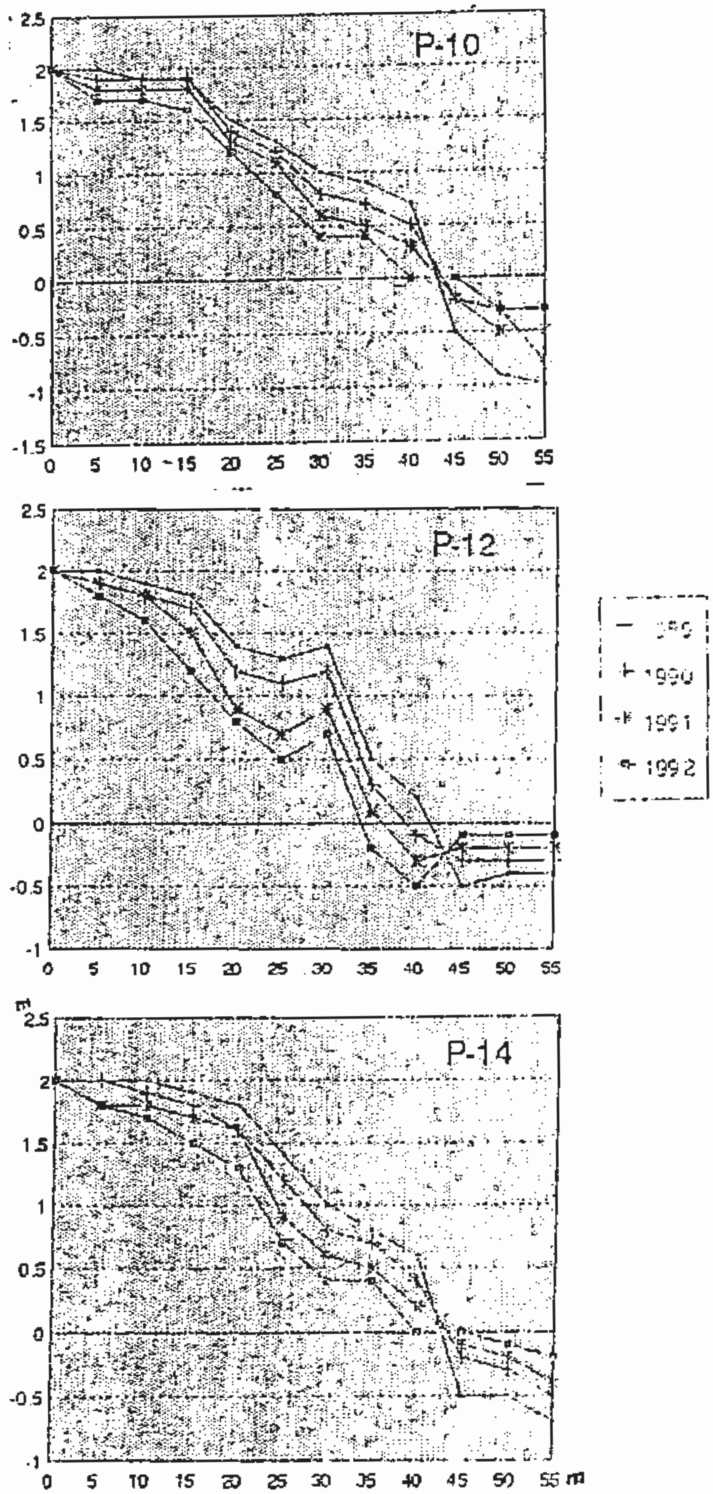
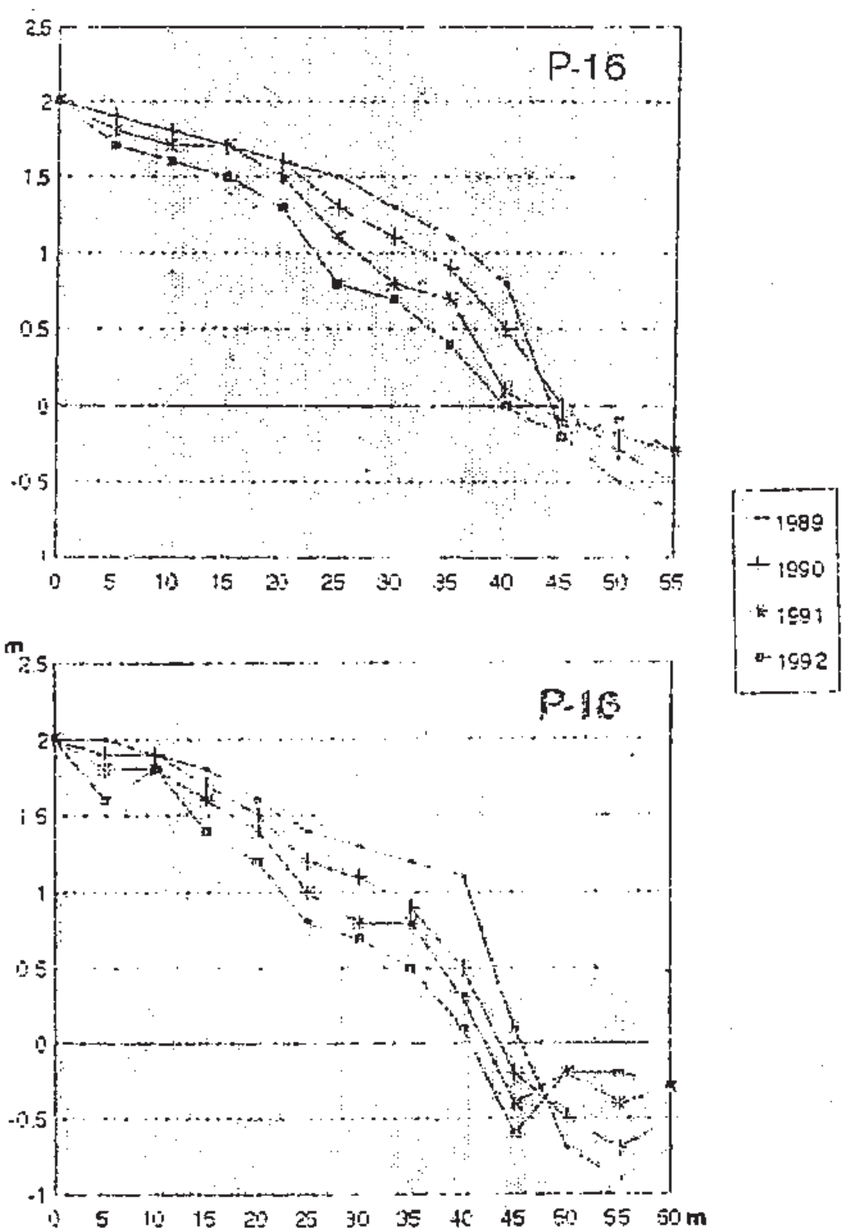
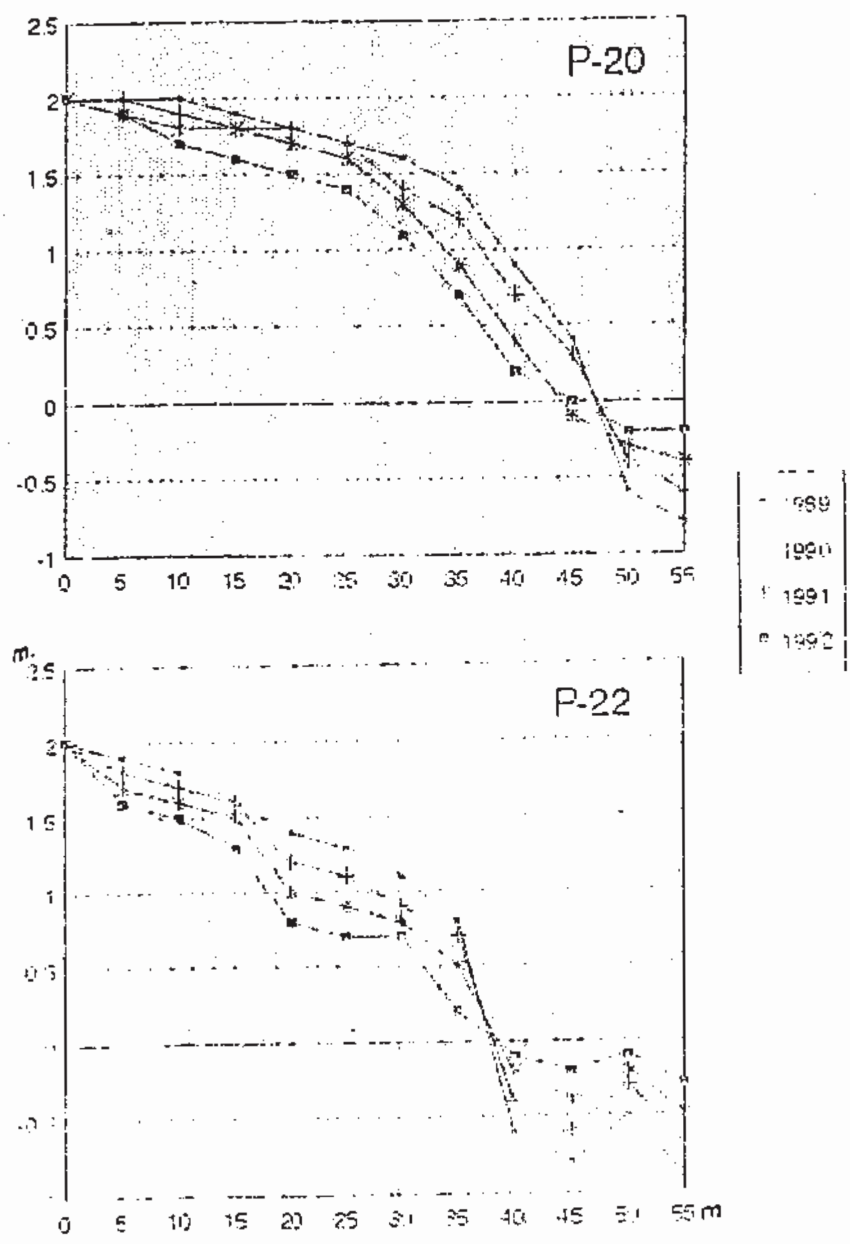


(Fig.6) : b-Comparative profiles of Miami and Sidi Bishr Beaches (P-10 : P-22).

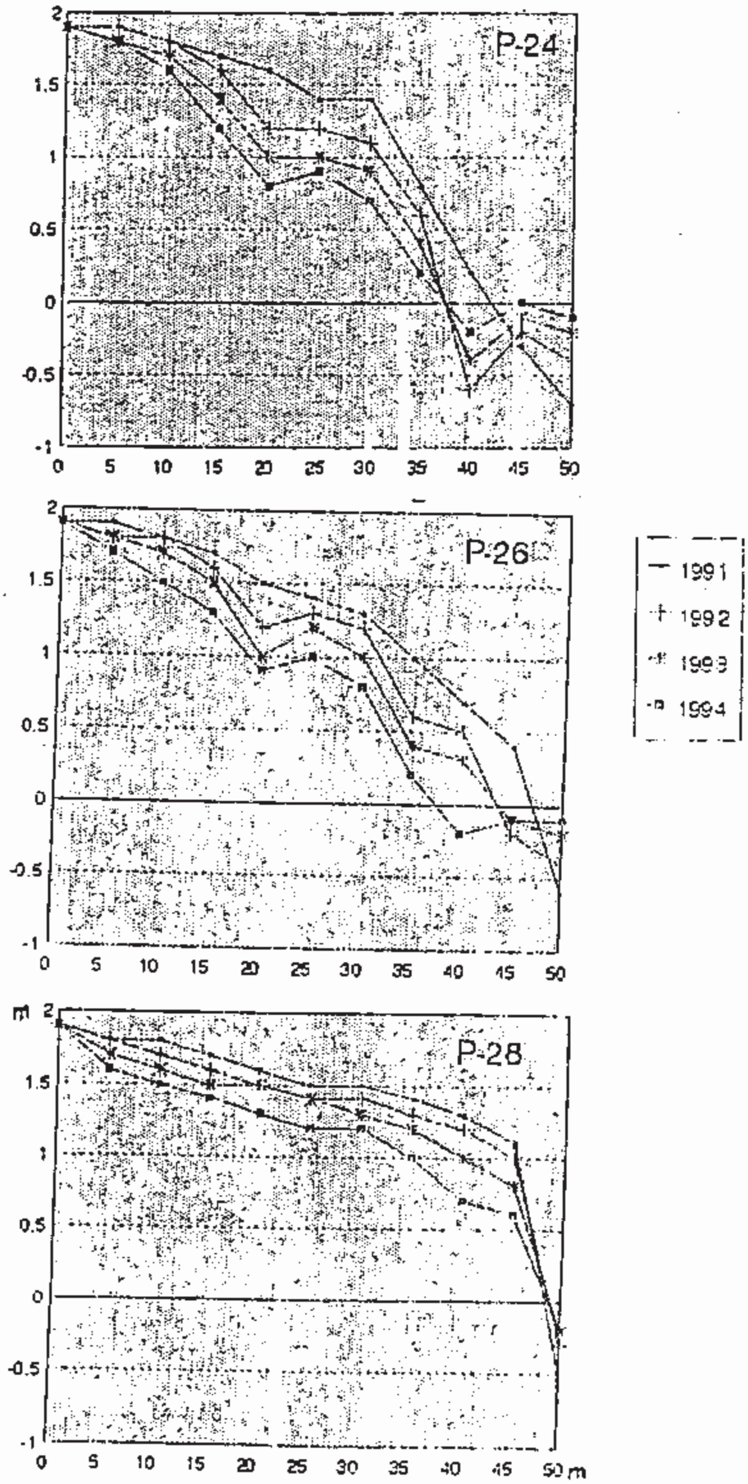


(Fig.6) : b-Comparative profiles of Miami and Sidi Bishr Beaches

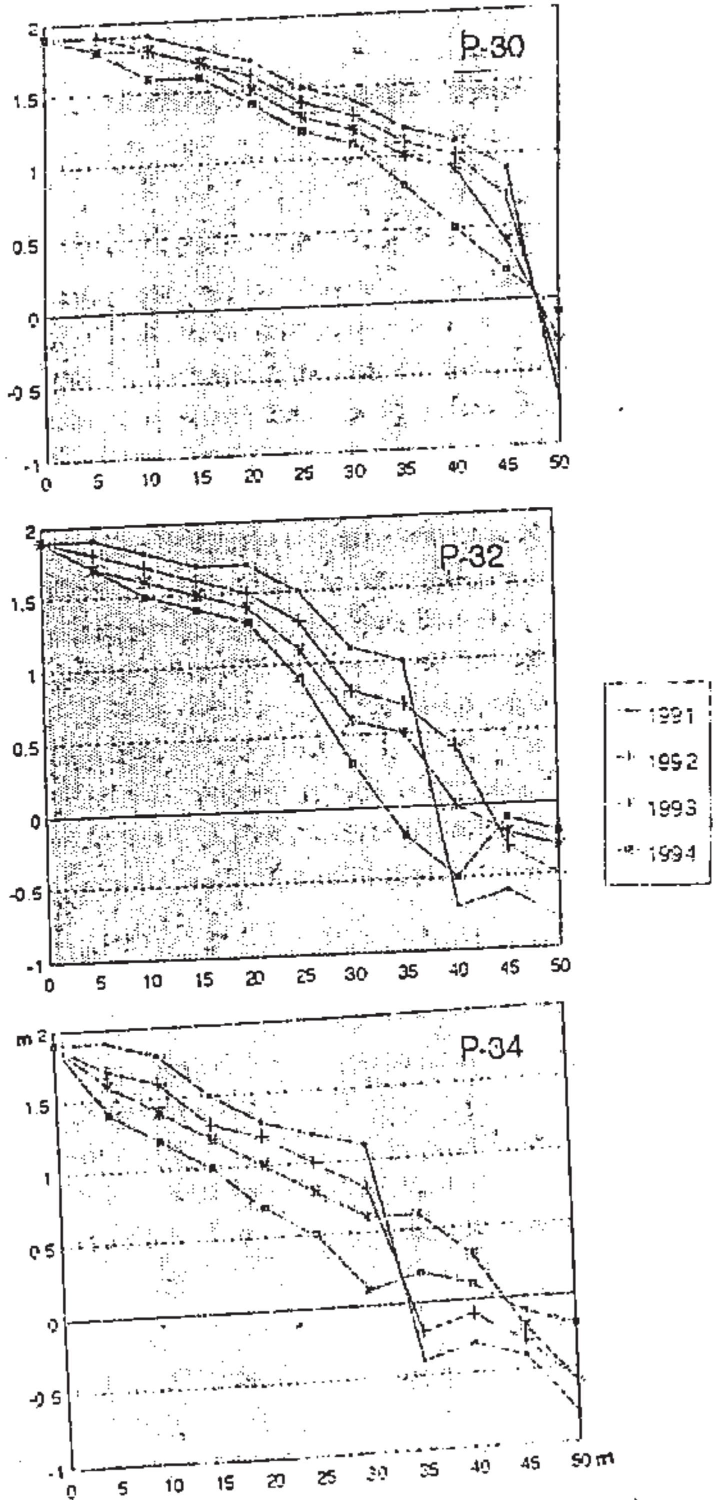
(P-10 : P-22).



(Fig.6) : b-Comparative profiles of Miami and Sidi Bishr Beaches
(P-10 : P-22)



(Fig.7) : a-Comparative profiles of El-Ibrahimiah beach (P-24 : P-28)



(Fig.7) : b-Comparative profiles of El-Shatby Beach (P-30 : P-34).

being greater at the beaches of El-Ibrahimiah and El-Shatby and reducing toward the east at El-Asafra beach . The material gain in this zone amounted to 6600 m^3 and the net loss for all three zones of the study beaches amounted to 17600m^3.

The data in Table 1 indicate also that during the 3-year period since fill placement the trend of shore processes over the project beaches has been accretion and erosion . Accretion was general in all zones except in the tidal zone. At Miami and Sidi Bishr beaches losses amounted to 37800 m^3 in the tidal zone, while in the above mean high water and below mean low water 9300 m^3 of material accreted which produce a net loss of 28500 m^3 at the rate of about 9500 m^3 per year . In the area of El-Asafra beach there was accretion of 2900 m^3 above mean high water and below mean low water, erosion of 20600m^3 between mean high water and mean low water for a net loss of only 17700 m^3 at the rate of about 5900 m^3 per year . At El-Ibrahimiah and El-Shatby beaches the effect of the material movement has been a gain of 8800 m^3 of material above mean high water and below mean low water , loss of 30600 m^3 from the tidal zone , producing a net loss of 21800 m^3 at the rate of about 7270 m^3 per year . The net result of material movement to or from the entire areas of the study beaches , therefore , was erosion amounting to about 68000 m^3 (about 54% of the initial amount of sand fill) , or net loss at the rate of 22700 m^3 per year for all the study beaches .

Since the fill was placed in 1989 , 1990 and 1991 , there has been a landward movement of the shoreline along the entired restored beaches . The greatest movement occured in the area of Miami and Sidi Bishr beaches , where the beaches had been filled to a greater width for added protection . Except in the vicinity of profiles P-06 , P-18, P-20 , P-22 , P-28 , P-30 , P-34 there has been a general advance of the low water line along the shore . This advance was undoubtedly due to seaward movement of the fill as the beach adjusted to a slope flatter than originally estimated .

The sand sample data given in Table 2 show the seive analysis of samples obtained during fill placement in July 1989 , August 1990 and May 1991 (Table 2A) , and samples taken 3 years later in July 1992 , August 1993 and March 1994 (Table 2B) . The beach foreshore sands along the study beaches before fill placement have mean grain size between 1.98 ϕ and 1.18 ϕ at the area form

TABLE 1
Volumetric Changes - Alexandria Beaches
(Volume 10^3 Cubic Metres)

A - El-Asafra

profiles	Aug. 1990 to Aug. 1991				Aug. 1991 to Aug. 1992				Aug. 1992 to Aug. 1993				Aug. 1990 to Aug. 1993			
	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net
p-02	-0.1	-1.9	-0.1	-2.1	0.1	-0.9	0.2	-0.6	-0.8	-1.0	0.5	-1.3	-0.8	-3.8	0.6	-4.0
p-04	0.3	-1.8	-0.2	-1.7	-0.4	-1.8	-0.3	-2.7	-.07	-1.4	0.3	-1.8	-0.8	-5.0	-0.4	-6.2
p-06	0.2	-2.0	0.7	-1.1	-0.3	-2.1	0.5	-1.9	1.8	-1.9	0.2	0.1	1.7	-6.0	1.4	-2.9
p-08	0.1	-2.1	-0.2	-2.2	-0.5	-1.9	0.8	-1.6	0.6	-1.8	0.4	-0.8	0.2	-5.8	1.0	-4.6
Subtotal	0.5	-7.8	0.2	-7.1	-1.1	-6.7	1.0	-6.8	0.9	-6.1	1.4	-3.8	0.3	-20.6	2.6	-17.7

B - Miami and Sidi Bishr

profiles	July 1989 to July 1990				July 1990 to July 1991				July 1991 to July 1992				July 1989 to July 1992			
	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net
p-10	0.3	-2.0	-0.8	-2.5	-0.4	-1.2	0.2	-1.4	0.2	-1.4	0.8	-0.4	0.1	-4.6	0.2	-4.3
p-12	0.0	-1.8	1.2	-0.6	-0.2	-1.5	0.5	-1.2	0.4	-1.6	0.6	-0.6	0.2	-4.9	2.3	-2.4
p-14	-0.4	-1.5	1.1	-0.8	-0.6	-1.0	0.4	-1.2	0.3	-1.5	-0.4	-1.6	-0.7	-4.0	1.1	-3.6
p-16	0.1	-2.2	-0.8	-2.9	0.0	-2.1	0.6	-1.5	0.1	-1.6	-0.5	-2.0	0.2	-5.9	-0.7	-6.4
p-18	-0.3	-2.6	-0.6	-3.5	1.0	-2.3	0.2	-1.1	0.2	-1.8	0.3	-1.3	0.9	-6.7	-0.1	-5.9
p-20	0.3	-1.2	1.0	0.1	0.2	-2.2	0.3	-1.7	0.3	-1.5	0.6	-0.6	0.8	-4.9	1.9	-2.2
p-22	0.2	-2.5	1.4	0.9	0.8	-2.4	0.2	-1.4	0.3	-1.9	0.2	-1.4	1.3	-6.8	1.8	-3.7
Subtotal	0.2	-13.8	2.5	-11.1	0.8	-12.7	2.4	-9.5	1.8	-11.3	1.6	-7.9	2.8	-37.8	6.5	-28.5

C- El-Ibrahimiah and El-Shatby

profiles	May 1991 to May 1992				May 1992 to May 1993				May 1993 to May 1994				May 1991 to May 1994			
	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net	Above MHW	MLW MHW	Below MLW	Net
p-24	-0.3	-1.9	0.7	-1.5	0.4	-0.8	0.3	-0.1	-0.1	-1.6	0.6	-1.1	0.0	-4.3	1.6	-2.7
p-26	-0.2	-1.7	0.2	-1.7	0.2	-1.1	0.5	-0.4	-0.4	-1.7	1.0	-1.1	-0.4	-4.5	1.7	-3.2
p-28	1.0	-2.0	-0.2	-1.2	0.0	-1.3	0.5	-0.8	-0.2	-1.1	0.4	-0.9	0.8	-4.4	0.7	-2.9
p-30	0.5	-1.8	0.6	-0.7	-0.5	-1.0	0.2	-1.3	0.1	-1.3	0.7	-0.5	0.1	-4.1	1.5	-2.5
p-32	-0.8	-1.5	0.5	-1.8	-0.3	-2.7	0.1	-2.9	0.0	-1.2	0.4	-0.8	-1.1	-5.4	1.0	-5.5
p-34	0.5	-2.6	0.3	-1.8	0.6	-3.1	0.8	-1.7	0.2	-2.2	0.5	-1.5	1.3	-7.9	1.6	-5.0
Subtotal	0.7	-11.5	2.1	-8.7	0.4	-10.0	2.4	-7.2	-0.4	-9.1	3.6	-5.9	0.7	-30.6	8.1	-21.8

TABLE 2

Statistical Measures of Sand Samples

Alexandria Beaches

A- Immediately after initial fill placement

(July 1989 , August 1990 , May 1991)

Location	profiles	Beach face zone					Inshore zone				
		Type of Sediment	Grain - Size (ϕ)				Type of Sediment	Grain - Size (ϕ)			
			M	S	Sk	K		M	S	Sk	K
El-Asafra (1990)	p-02	medium	1.92	0.60	+0.49	1.35	medium	1.80	0.74	-0.64	1.29
	p-04	medium	1.98	0.59	-0.29	1.85	medium	1.89	0.65	-0.41	1.19
	p-06	medium	1.16	0.55	+0.18	1.17	fine	2.32	0.46	-0.27	1.25
	p-08	medium	1.95	0.57	-0.27	1.51	fine	2.38	0.42	-0.21	1.27
Miami & Sidi Bishr (1989)	p-10	medium	1.18	0.62	-0.19	1.30	medium	1.06	0.96	-0.08	1.18
	p-12	medium	1.74	0.84	-0.47	2.05	medium	1.41	0.59	-0.06	1.58
	p-14	fine	2.02	0.58	-0.29	1.85	fine	2.13	0.51	-0.37	1.39
	p-16	coarse	0.82	0.61	+0.24	0.79	fine	2.19	0.31	-0.48	1.79
	p-18	medium	1.89	0.79	+0.90	1.15	fine	2.15	0.55	-0.74	1.17
	p-20	fine	2.01	0.92	-0.20	1.62	medium	1.86	0.73	-0.13	1.20
	p-22	medium	1.96	0.57	+0.18	1.17	medium	1.95	0.56	-0.46	1.18
El-Ibrahimia & El-Shatby (1991)	p-24	medium	1.46	0.54	+0.23	1.48	fine	2.39	0.36	-0.15	1.22
	p-26	medium	1.56	0.55	+0.15	1.16	fine	2.31	0.37	-0.25	1.25
	p-28	medium	1.81	0.47	-0.17	2.45	medium	1.89	0.73	-0.13	1.19
	p-30	medium	1.91	0.56	-0.39	1.86	fine	2.20	0.47	-0.41	1.32
	p-32	fine	2.23	0.44	-0.55	2.85	fine	2.34	0.70	-0.12	0.82
	p-34	fine	2.09	0.49	-0.02	2.62	fine	2.14	0.46	-0.24	1.11

B- 3 years after fill placement

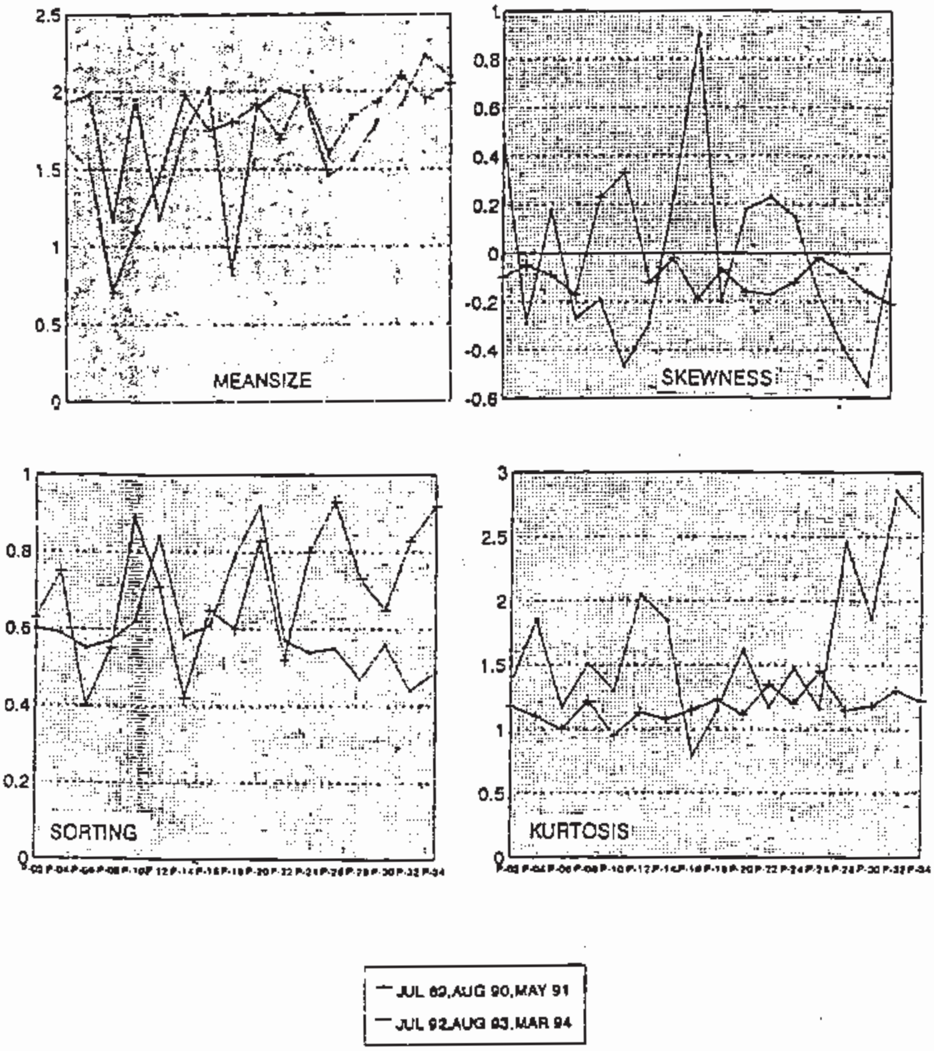
(July 1992 , August 1993 , March 1994)

Location	profiles	Beach face zone					Inshore zone				
		Type of Sediment	Grain - Size (ϕ)				Type of Sediment	Grain - Size (ϕ)			
			M	S	Sk	K		M	S	Sk	K
El-Asafra (1990)	p-02	medium	1.65	0.63	-0.30	1.18	medium	1.74	0.85	-0.49	1.08
	p-04	medium	1.50	0.75	-0.05	1.10	medium	1.53	0.79	-0.58	1.01
	p-06	coarse	0.70	0.40	-0.09	1.00	medium	1.38	0.49	-0.23	1.64
	p-08	medium	1.10	0.55	-0.17	1.22	medium	1.15	1.14	0.10	0.57
Miami & Sidi Bishr (1989)	p-10	medium	1.45	0.59	0.23	0.95	medium	1.78	0.85	-0.46	1.09
	p-12	medium	1.98	-0.71	0.33	1.13	medium	1.13	0.67	-0.48	1.10
	p-14	medium	1.75	0.42	-0.12	1.08	medium	1.74	0.17	-0.56	1.19
	p-16	medium	1.80	0.65	-0.07	1.15	coarse	0.75	0.94	-0.61	1.67
	p-18	medium	1.92	0.60	-0.19	1.23	fine	2.10	0.52	-0.47	1.13
	p-20	medium	1.70	0.83	-0.07	1.11	medium	1.39	0.47	-0.22	1.60
	p-22	fine	2.01	0.52	-0.16	1.35	fine	2.05	0.44	-0.02	0.95
El-Ibrahimia & El-Shatby (1991)	p-24	medium	1.60	0.80	-0.17	1.20	fine	2.07	0.53	-0.12	1.19
	p-26	medium	1.85	0.93	-0.12	1.45	fine	2.15	0.59	-0.13	1.07
	p-28	medium	1.93	0.73	.019	1.15	medium	1.90	0.79	-0.51	1.18
	p-30	fine	2.10	0.65	-0.08	1.18	medium	1.95	0.51	-0.23	1.07
	p-32	medium	1.95	0.83	-0.16	1.30	fine	2.03	0.57	-0.06	1.03
	p-34	fine	2.05	0.92	-0.21	1.32	fine	2.17	0.37	-0.02	1.10

El-Asafra to Sidi Bishr , and between 1.46 ϕ and 1.16 ϕ at the area from El-Ibrahimiah to El-Shatby . The dispersion of sand paricle size (i.e. sorting) is between 0.62 ϕ to 59 ϕ at El-Asafra - Sidi Bishr , and between 57 ϕ to 55 ϕ at El-Ibrahimiah - El-Shatby , which means that the native beach material of the study beaches is moderately well sorted . Most beach foreshore sands have asymmetrical size distribution about the mean . Skewness of beach foreshore sands of the study beaches ranges from -0.29 ϕ to 0.19 ϕ and from +1.25 ϕ to +0.18 ϕ , while kurtosis varies from 1.85 ϕ to 1.30 ϕ , and from 1.46 ϕ to 1.17ϕ (Abou - Raddy , 1988) .

The samples obtained in 1989 , 1990 and 1991 from the beach zone immediately after the fill placement had mean size ranging from 2.01 ϕ to 0.82 ϕ at El-Asafra - Sidi Bishr and from 2.23 ϕ to 1.46 ϕ at El-Ibrahimiah - El-Shatby ; however , this values are the extreme limites and the average mean - size for the 17 samples was 1.74 ϕ . The mean size of the 1992 , 1993 and 1994 samples taken from the beach zone ranged from 2.01 ϕ to 0.70 ϕ at El-Asafra - Miami-Sidi Bishr , and from 2.10 ϕ to 1.60 ϕ at El-Ibrahimiah - El-Shatby , and the average mean size was 1.71 ϕ . The similarity in the values of the average mean size of the 1989 , 1990 and 1991 , and 1992 , 1993 and 1994 samples and the fact that both these values are not in the same order as the mean size of the native material , are indications that unsuitably sized beach fill material was placed on the study beaches . A comparison of mean size of beach samples after 3 years shows that the mean size is much larger (Fig. 8) . This would indicate that there had been mixing of the fill material with the coarser material composing the original native beaches and that also much of the finer size material may have been lost from the fill during placement or by subsequent action of littoral forces . Normally , when entire class fractions are removed from size - class distribution of mixture of material , the remaining material exhibits better sorting . For the 1992 , 1993 and 1994 beach samples , the indicated poor sorting , as well as coarseness (in some degree) , are believed to be derived from the mixing of fill material with the relatively coarser moderately sorted native beach material .

The skewness of the 1989 , 1990 and 1991 samples taken from the beach face zone had values ranging from -0.17 ϕ to +0.49ϕ , while skewness of the 1992, 1993 and 1994 samples ranged from -0.02 ϕ to -.033 ϕ . Skewness is an expression of the symmetry of a cumulative size distribution curve . The small values for the skewness of both sets of samples indicates that the peak of the size



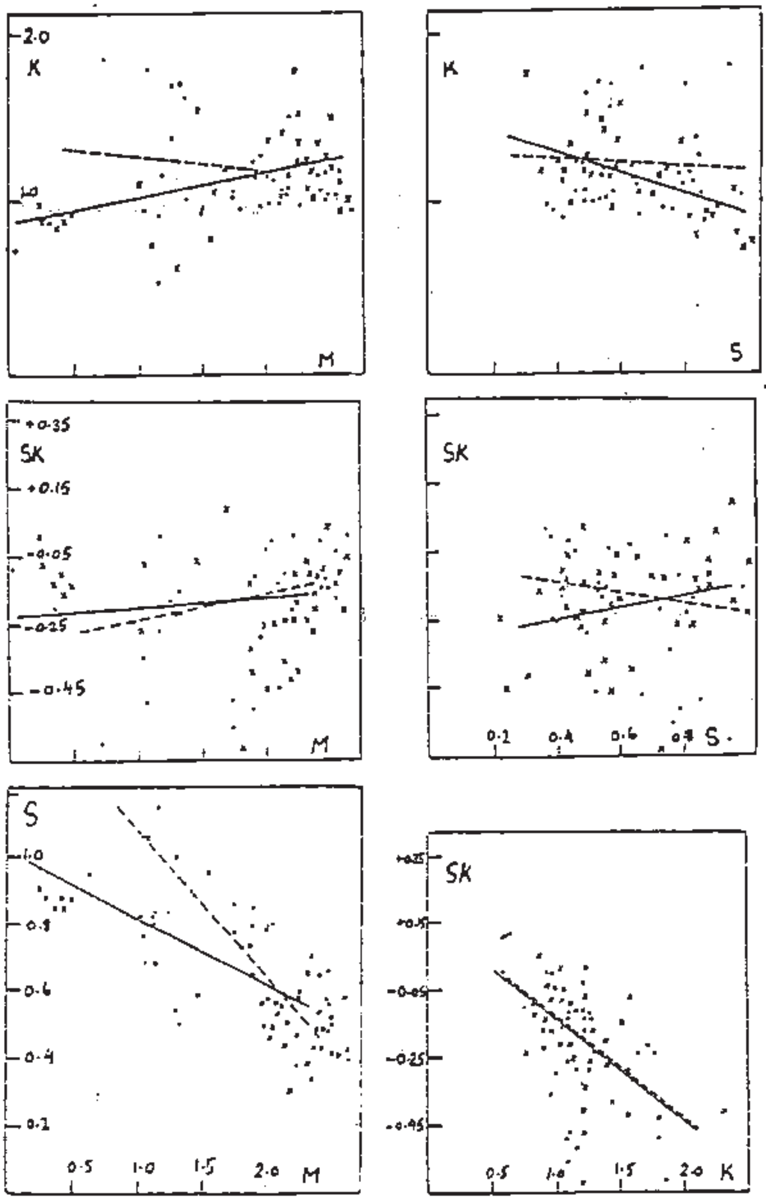
(Fig.8) : Comparison of the grain-size parameters of study beach sands during the period from 1989 to 1994 .

distribution in both cases lies very near the mean size . The peak of the size distribution for the 1989 , 1990 and 1991 lies on the relatively fine side of the mean size , whereas it is on the coarse side for the 1992 , 1993 and 1994 samples. The majority of 1989 , 1990 and 1992 samples have high values of kurtosis than the 1992 , 1993 and 1994 samples . Kurtosis is a measure of the concentration of frequencies within the central part of the distribution relative to the concentration in the tails . The high kurtosis values (more leptokurtic) on the study beach faces in 1989 , 1990 and 1991 (i.e. immediately after initial fill placement) indicate that sorting in the central part of the grain - size distribution is better than in the tails , whereas it is less better for the 1992 , 1993 and 1994 samples since their values of kurtosis are decreased .

The regression equations and correlation coefficient values among the grain size parameters for the beach face samples collected in 1989 , 1990 , 1991 and 1992 , 1993 , 1994 are presented in tables 3 and 4 respectively . The highest correlation coefficient values between the grain size parameters in sediments collected in 1989 , 1990 , 1991 are obtained between the mean size and sorting , followed by that between the mean size and kurtosis . On the other hand , the mean size and sorting is still highly correlated in sediments collected in 1991 , 1993 , 1994 , followed by that of kurtosis and skewness (Fig. 9)

Table 3 : Regression equations of the size parameters birelation of sediments in the years (1989, 1990, 1991) & (1992, 1993, 1994)

Parameters	(1989, 1990, 1991)	(1992, 1993, 1994)
M / S	y = 1 + (-0.4) X	y = 1.3 + (-0.34) X
M / SK	y = -0.35 + 0.4 X	y = -0.4 + 0.08 X
M / K	y = 0.87 + 0.19 X	y = 1.32 + (-0.06) X
S / SK	y = -0.33 + 0.19 X	y = -0.16 + (-0.05) X
S / K	y = 1.71 + (-0.72) X	y = 1.3 + (-0.16) X
K / SK	y = 0.18 + (-0.28) X	y = 0.13 + (-0.29) X



(Fig.9) : Intrrelation of the statistical measures of the beach sediments in1989,1990,1991,and 1992,1993,1994(the regression lines for 1989,1990,1991 are continous,whereas for 1992,1993,1994 are dashed).

Table 4: Correlation coefficient matrices of the statistical measures of the foreshore sediments in the years (1989, 1990, 1991) & (1992, 1993, 1994)

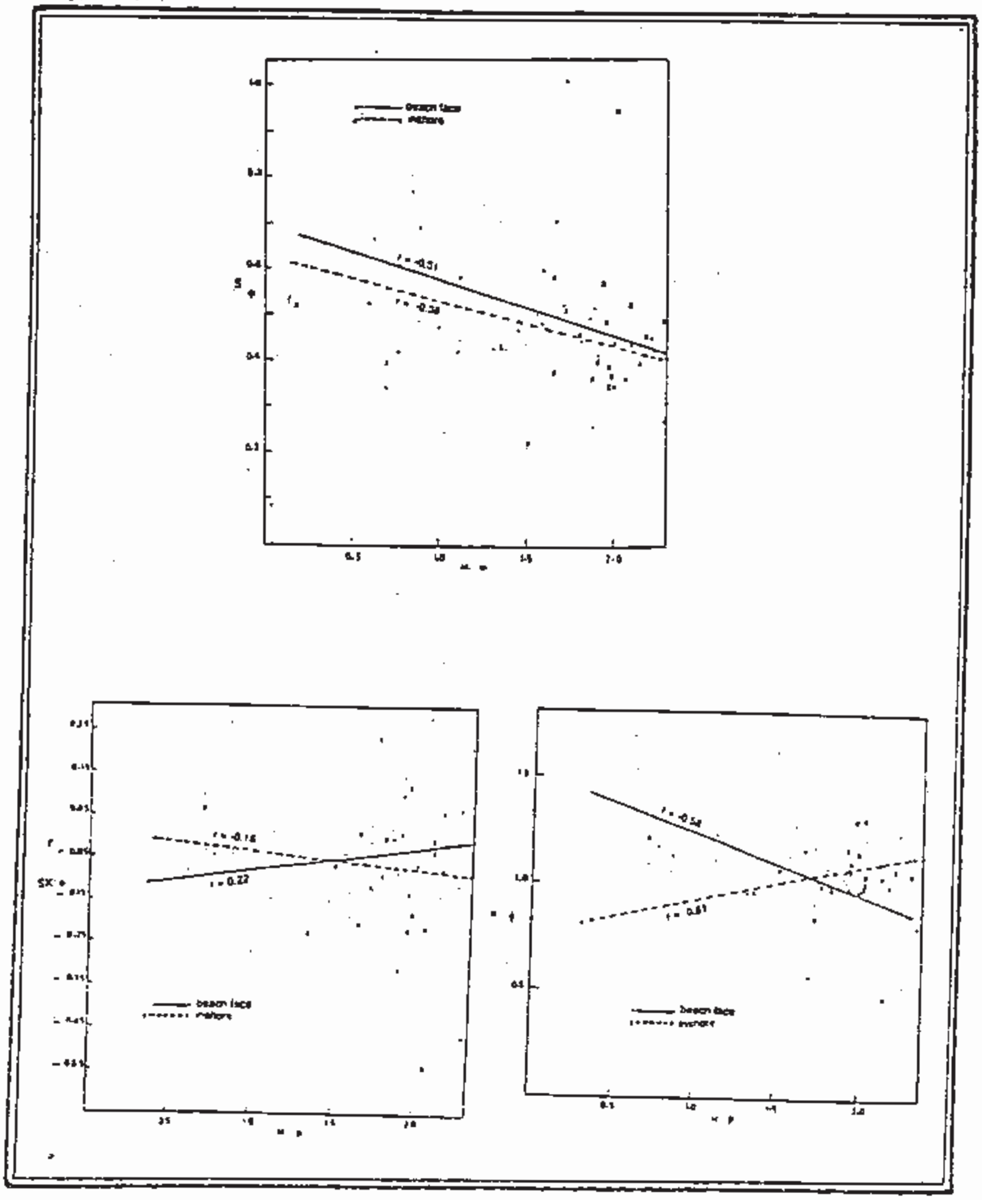
Parameters	(1989, 1990, 1991)				(1992, 1993, 1994)			
	M	S	SK	K	M	S	SK	K
M	1.00				1.00			
S	-0.73	1.00			-0.68	1.00		
SK	0.08	0.22	1.00		0.19	0.09	1.00	
K	0.59	-0.68	0.35	1.00	-0.19	-0.17	0.45	1.00

The sediment samples taken from the inshore zone in 1989, 1990 and 1991 show that the area off the El-Asafra and Miami and Sidi Bishr beaches is covered by fine and medium sands, which grade seawards to medium and coarse sands. Westwards, in front of El-Ibrahimiah and El-Shatby beaches the sediments are mostly of fine sands (Table2 A). In 1992, 1993 and 1994, sediments covering the area off the former beaches have changed to medium and coarse sands, while in front of the western beaches sediment size remained as in 1989, 1990 and 1991. The relation between the mean size and sorting shows that the majority of the samples collected immediately after initial fill placement in 1989, 1990 and 1991 are clustered in the range of fine grains (2.38 ϕ), and are well to moderately well sorted (0.31 - 0.65 ϕ). However, few samples are relatively coarse (1.06 ϕ) and moderately sorted (0.70 - 0.96 ϕ). Samples taken 3 years later in 1992, 1993 and 1994 show sediment bimodality which is distinguished on the basis of the size and sorting values. The fine sands (2.17 ϕ) are well to moderately well sorted (0.37 - 0.57 ϕ), while the medium sands (1.0 - 2.0 ϕ) are moderately sorted (0.6 - 1.14 ϕ). The relation between the mean size and skewness reveals that most of the sediments collected in 1989, 1990 and 1991 are fine to coarse skewed (-0.46), while few samples are medium to nearly symmetrically skewed (-0.37 to -0.06). The fine and medium sediments collected in 1992, 1993 and 1994 are generally coarse skewed (-0.23 to -0.1); exceptionally some are strongly coarse. Most of the fine, medium and relatively coarse in 1989, 1990 and 1991 are leptokurtic (1.3), where the medium and fine sands of 1992, 1993 and 1994 fall in the mesokurtic and leptokurtic range (0.5 - 1.6). The relation of sorting with both skewness and kurtosis shows that most of the well, moderately well and moderately sorted sands of the initial fill placement are coarse skewed (-0.70) and leptokurtic (1.3), while few samples are nearly symmetrically skewed (-0.06) and mesokurtic (0.82). Three years after fill placement, most of the leptokurtic and mesokurtic sediments are moderately well and well sorted (0.4-1ϕ) and coarse skewed; however very few samples are fine skewed, or nearly symmetrically skewed.

The interrelationship between the statistical parameters (Fig.10) shows an obvious difference in the grain - size characteristics for the samples from foreshore and inshore zones of the study beaches (Table 2 A and B). This difference could be largely attributed to the effect of currents and waves acting separately on each zone. The undertow currents would winnow out the relatively fine particles leaving the coarser sands on the foreshore or beach face area. On the other hand, the coarse sands would piled on the inshore zone due to the direct action of wave transported sands.

6- DISCUSSION

During the 3-year period immediately following placement of beach fill, 17700 m^3 of material were eroded from approximately 1000 linear meters of shore under study at El-Asafra, 28500 m^3 were transported out of the 3200 - meters sector of shore at Miami and Sidi Bishr, and 21800 m^3 were eroded from 1800-meters sector of shore at El-Ibrahimiah and El-Shatby. If the data are examined over various segment of the profile, deficits created by movement of beach material are indicated to be predominantly between mean high and mean low water. Most of the losses can be accounted for by accretion in the zone above mean high water and below the tidal zone. However, the loss of approximately 89000 m^3 of material from tidal zone of the project beaches extremity indicates that at least 70% of the original 126415 m^3 of beach fill placed in 1989, 1990 and 1991 has been repositiones by wave forces from its initial zone of placement. Analysis of the data indicates that the quantity of material deposited below the mean low water line was about equal to that eroded from the beach and even though losses from the upper beach face have been more or less constant along the full lengths of the project beaches. Actually only 68000 m^3 of fill is indicated as having been entirely removed from the project



(Fig.10): Interrelation of the grain-size parameters of beach foreshore and inshore sands.

areas , which would represent net losses of only a little more than 50% for the 3-year period or an average annual loss of about 22700 m^3 . While presumably accretion offshore of the mean low water line will cause the future rate of erosion to diminish , it is probable that losses will continue to be heavier than initially estimated due to the relative alignment of the projecting beaches with the adjacent shores . Undoubtedly quantities of material substantially greater than those indicated by available survey have been moved from the study beaches to the inshore underwater bottom or to the zone below the low water line and redistributed within the study beach areas by littoral forces .

Immediately prior to placement of the beach fill in 1989 , 1990 and 1991 the width of the study beaches above mean high water was about 15m at El-Asafra , 25 m at Miami and Sidi Bishr and 10m at El-Ibrahimiah El-Shatby . After placement of the fill the maximum beach width was about 30m 50m , and 25m at El-Asafra , Miami and Sidi Bishr and El-Ibrahimiah and El-Shatby beaches respectively. The analysis of shore processes did indicate , however , that the direction of littoral drift is easward (Hilmy , 1951 ; Gerges , 1978 ; Eid , 1979) and therefore material placed in the area of El-Shatby and El-Ibrahimiah beaches at the western sector of the shore could be expected to move eastward and help nourish the other beaches at the eastern sector of the shore. Throughout the remainder of the beaches , widths greater than project dimensions were achieved with the initial fill . In 1992 , 1993 , 1994 the beach width reduced to about 25 m at El-Asafra , 30- 35 m at Miami and Sidi Bishr, and 12 - 20 m at El-Ibrahimiah and El-Shatby . In the 3-year period there was an average reduction in width about 5m , 8m and 12m , or an average reduction of about 1.7m , 3m and 4m annually at El-Asafra , Miami and Sidi Bishr , and Ibrahimiah and El-Shatby respectively . The rate of reduction of beach width at the westerly end , El-Ibrahimiah and El-Shatby beaches , was twice the average reduction for the entire other study beaches . A higher rate of erosion for this sector was expected because the fill extended into deeper water , and hence was subjected to more direct wave attack . Based on the rate of recession for the 3-year period after placement of fill , and if no additional fill is placed on the study beaches , the width of the beaches would be reduced below the recommended project width by about the year 1999 or 2000 .

The volumetric computations indicate that the greatest adjustment of fill material occurred in the first year after the fill was placed . The losses from between the planes of mean high and mean low water from 1990 - 1991 , 1991 - 1992 , 1992 - 1993 and 1993 - 1994 were significantly less than from 1989 - 1990 , 1990 - 1991 , 1991 - 1992 and 1992 - 1993 . These data tend to indicate the littoral processes of the areas have or will reach a more stable condition and the data may reflect the average annual losses from this zone that may be expected in the immediate future . Requirement for average annual maintenance of the beach fill could be based on the analysis of the data collected to date . Therefore , annual sand maintenance requirement is presently estimated at 6870 m^3 for El-Asafra , 12600m^3 for Miami and Sidi Bishr , and 10200 m^3 for El-Ibrahimiah and El-Shatby , which is 3670 m^3 , 7300 m^3 , and 6150 m^3 greater than originally estimated for the study beaches respictively . This represents an increase in the estimated annual cost of LE 408,580 ($ 120,525) , resulting in a total estimated annual cost of LE 948,900 ($ 279,913) for only the sector of the study beaches . These costs indicate that under the above conditions for estimation , a beach of project dimensions can be established and maintained along 6200 m of shoreline at El-Asafra , Miami and Sidi Bishr , and El-Ibrahimiah and El-Shatby for a cost of LE 153 ($ 45) per linear metre per year . Even though a beach of project width existed along most of the study sector of shore in 1992 , 1993 and 1994 , the foreshore slopes have greatly steepned and material losses from between mean high and mean low water have been much greater than anticipated . Although there had been no programme of periodic maintainance of the study beaches as of that date , a nourishment programme should soon be initiated if the annual cost per linear metre to maintain of the desired beach dimensions is to be kept as low as estimated . If erosion is allowed to continue the backshore will be exposed to wave action and maintainance costs will increase .

The data do not show the net effectiveness of the three groynes, installated in Miami and El-Shatby beaches . They were apparently constructed to suitable dimensions , as no area within the system or downdrift thereof shows recession by reason of a reduced supply of littoral drift . Since none of the annual surveys showed the study beaches to have dimensions less then recommended project dimensions , it may be reasoned that the groynes have tended to minimize short - term fluctuations in the beach widths , particularly during of storm conditions . And , possibly the installation of the three groynes to retard movement from the zone between mean high and mean low water would reduce the erosion rate to a degree more than sufficient to justify their construction. The groynes envisioned at this time were terminated at about mean low water line and be high enough to prevent the passage of some sand down drift as well as to retain beach sediment on their western sides. It seems reasonable to assume from data available at this time that suitably designed groynes for all the beaches could reduce the rate of erosion by a much greater amount. As the losses are principally moved eastward along the coast of Alexandria City, groynes located east of the beach would probably most effictive.

Analysis of the sand samples taken from the beach zone in 1989 , 1990 and 1991. and 1992. 1993 and 1994 show a very close relation between the mean size of the composite samples. The 1989. 1990 and 1991 samples represent the characteristics of the original fill and the 1992 , 1993 and 1994 represent the characteristics of the beach material after being subjected to natural sorting and other littoral processes . The composite plots (Fig.8) of the two sets of samples show that extensive sorting of the sediments composing the outer layers of the fill has taken place over the 3-year period. This would be additional evidence that the bottom slopes off the study beaches have reached some degree of stability and that the overall rate of material movement in the littoral zone has reached relative stability. These plots also demonstrate that a significant eastward coarsening trend in grain-size, took place during the study period . This coarsening trend would thus indicate the direction of sand transport along the Alexandria shoreline . This finding coincides with that given by McCave (1978) who found that the direction of sand transport along the northern East Anglia (England) appears to be indicated by the coarsening of the beach sediment in the net direction of wave-driven . The eastward coarsening trend of the study beaches is attributed to the effect of the longshore current having a general eastward direction and used to drift the eroded sand.

The comparative size analysis data of the sand samples taken along profites from the inshore zone during the 3 - year period of investigation indicated that the relation between the mean size and sorting is the most sensitive measure to delineate the inshore sediment types . Accordingly the sediment in the inshore zone were generally finer and better sorted during 1989, 1990 and 1991. On the other hand, nearly similar skewness and kurtosis values characterise the sediments all over the period of study . In the inshore environment, the surf and the breaker zones are very sensitive to the precesses affecting the coastal area, namely erosion and accretion. The inshore bottom sediments are moved to the beaches along the coast of Alexandria under the influence of shoreward drift. The fine sand thrown into suspension, as wave crest passes, tends to be moved seaward by the mid depth return flow associated with mass transport (Ippen & Engelson, 1955). However, the long period flat swells which approach the beach have an extremely assymmetrical pattern of surges ; landward crestal surges are much stronger than seaward trough surges, and the coarse sands move landwards as bedload onto the plunge point bar and across it to the beach (Inman & Nasu , 1956). This finding would explain the relative coarseness of beach sands in the study sector of shore compared to the inshore sediments. The storm surges over Alexandria have generally a distructive effect on the beaches , where they remove different particle size from the beach face . Cook & Grosline (1972) suggested that surges of varying strengths are competent to move all available sand size particles with equal facility on a rippled bottom. According to the method used by Passega (1957) to characterise the depositional agents and to study the dynamics of sand transport in the nearshor zone , the sediments collected in 1989, 1990 and 1991 are mainly transported by rolling or graded suspension of a moderate turbulance deposition type, whereas sediments taken in 1992, 1993 and 1994 are transported by rolling. The dominant grain size in the sediments of the inshore area off the study beaches is the medium sands . These sediments type is most likely transported by rolling, particularly during the period of accretion . However, fine particles might also be transported in suspension under certain conditions as during the storm periods affecting the shore of Alexaudria City . The longshore current is dominant in the inshore area off the study beaches , as waves approach the shore in oblique path . The enstward drift of longshore currents use to transport sediments paraller to the shoreline (Fig.3). When beach sands are shifted offshore from the foreshore by action of undertow currents , it generally deposits to form the longshore bar with a trough on its shoreward side (Abdullah, 1978; Eid, 1979; El-Sayed, 1979) . It is worth to mention that the wave induced longshore currents is the main reason for the sand movement . Other marine currents are effective only under exceptional conditions (Komar,1976) . On the other hand, Hjulstiom (1955) suggests that the minimum velocity needed for erosion, 10.8 cm/sec, is capable for eroding a particle having a diameter of 1.05ϕ, Smaller particles would remain in suspension until carried to deeper water or until the motion of the water subsided and permitted them to settle . In the inshore off the study beaches , as off the overall shore of Alexandria, where the average current volocity is 28 cm/sec (Eid, 1979)., the sediments of grain-size ranging between 3.3ϕ and 0.0ϕ are possibly continuously eroded , whereas those of the size ranging between - 1.59 ϕ and 0.0 ϕ are easily transported . Consedering the range of size for the study inshore sediments , it is presumed that these sediments are continuously eroled or transported .

7- CONCLUSION

Based on the analysis and discussion of the results , just mentioned , it is possible to make some concluding remarks about the behavior of sand fill at some beaches along the coast of Alxandria City . However , concluding remarks presented herein need to be subjected to repeat testing by field study and statistical analysis to permit more accurate conclusions to be drawn .

The fill placed under the improvement project for some beaches along the coast of Alexandria City initially provided protective beaches of project dimensions . Although actual net loss of material from the project beaches was about 7550 m^3 per year , losses from the tidal zone , i.e between mean high and mean low water , averaged about 9880 m^3 per year . Consideration could be given to the construction of several short stone groynes to retard the erosion rate at the project beaches . A maintenance programme should be initiated to replenish losses from the tidal zone if project beach widths above mean high water are to retained , and to protect the narrow beaches which well be eroded entirely during the next ten years , assuming that the present rate of erosion continues . The annual cost to provide and maintain the beaches of the improvement project will apparently be about LE 153.0 ($ 45.0) per linear metre of shore when considered over an estimated 15 - year amortization period .

The initial beach fill material had unsuitable grain-size distribution characteristics . The borrow area was located sufficiently far hinterland and its material was , therefore , unsuitable far wave conditions which have existed in the coastel area of Alexandria City . Hence , it is suggested that the borrow area should be located far enough seaward , from which sand would be pumped to the shore by a hydraulic pipeline dredge , to preclude inducement of the beach fill to move back into the borrow pits .

The present study reveals that the beach sands in project beaches , have an eastward coarsening trend which could be attributed to the effect of longshore current having a general eastward direction and used to drift the eroded sands. Clearly, although the high rate of erosion that the project beaches undergo, the supply of bottom sediments to the beaches is limited owing to the erosion and transportation of such deposits in the inshore area. The offshore - onshore transportation of the eroded sediments took place by action of waves, whereas transporattion along the study beaches is most likely resulted by action of currents.

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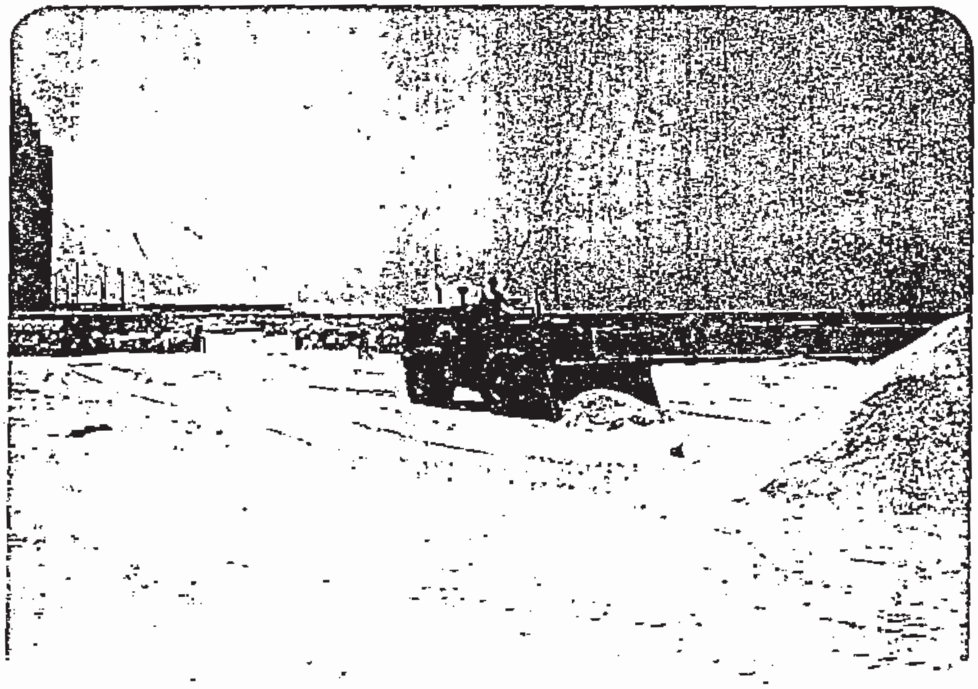
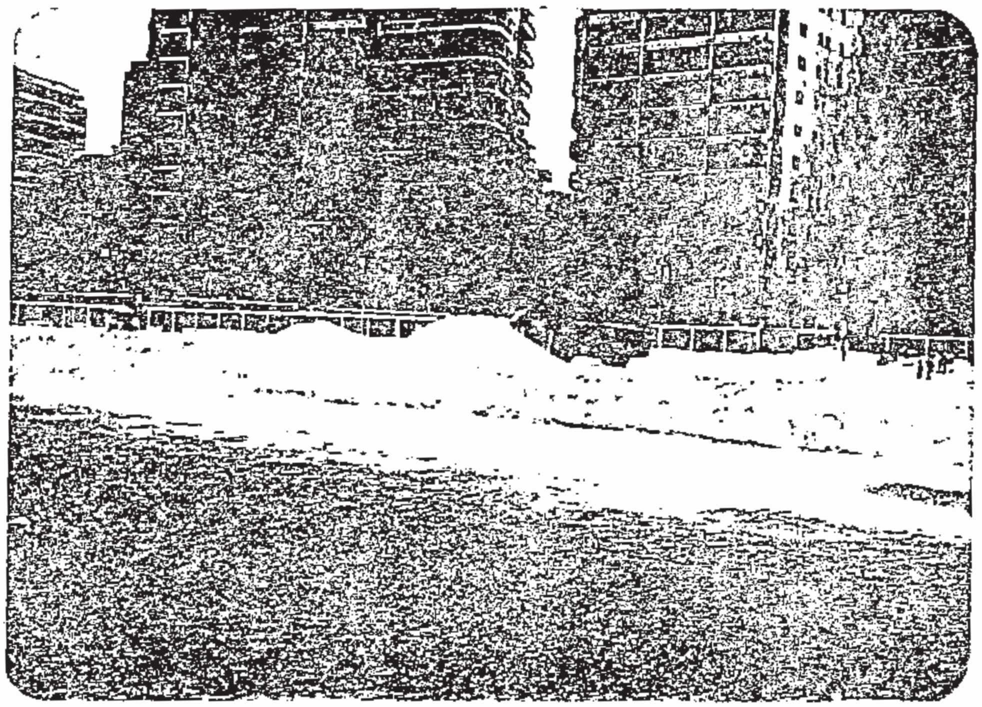
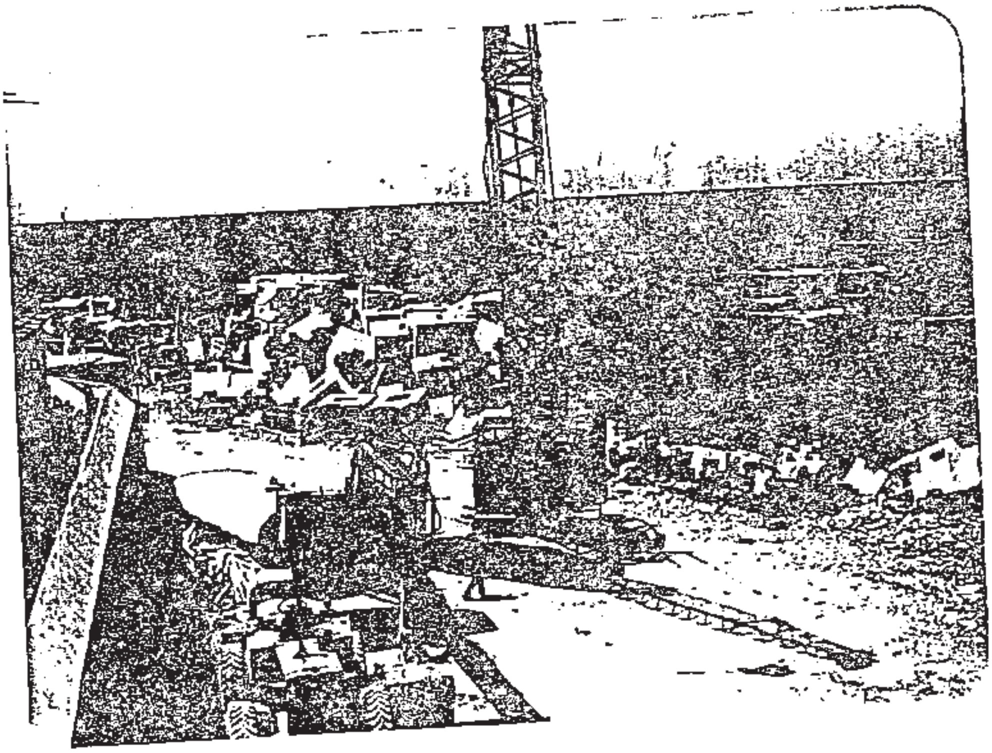


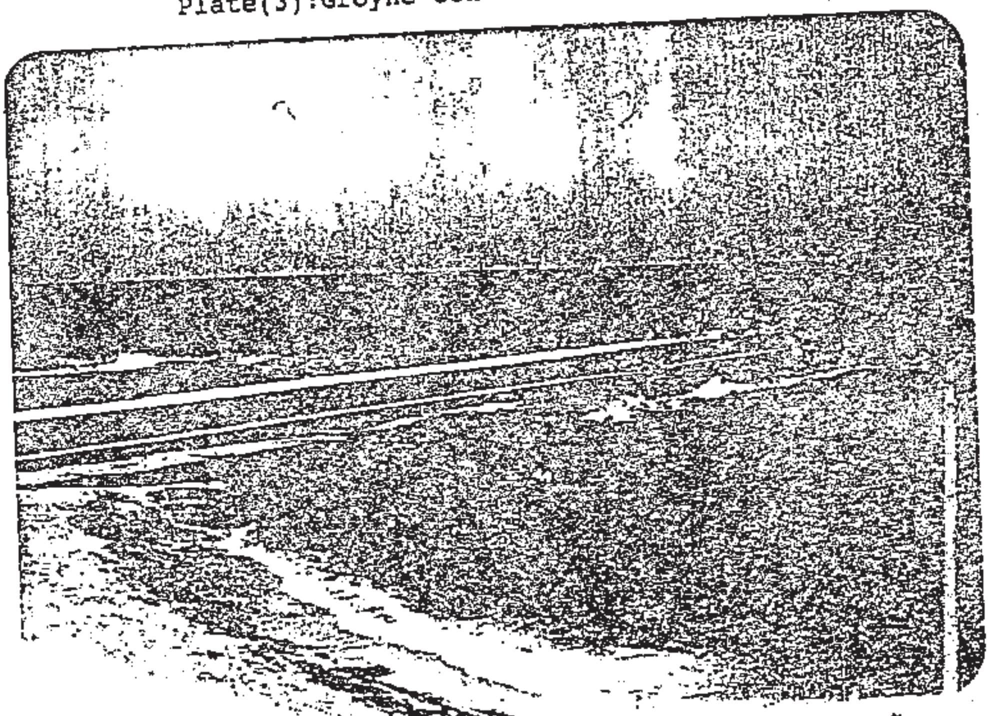
Plate(1):Mechanical process of widing the beach by placing an extra amount of terrestrial sand.



Plate(2):beach raising by artificial replenshment.



Plate(3):Groyne construction.



plate(4):Extension of the groyne into the sea to prevent the passage of sand eastwarde.

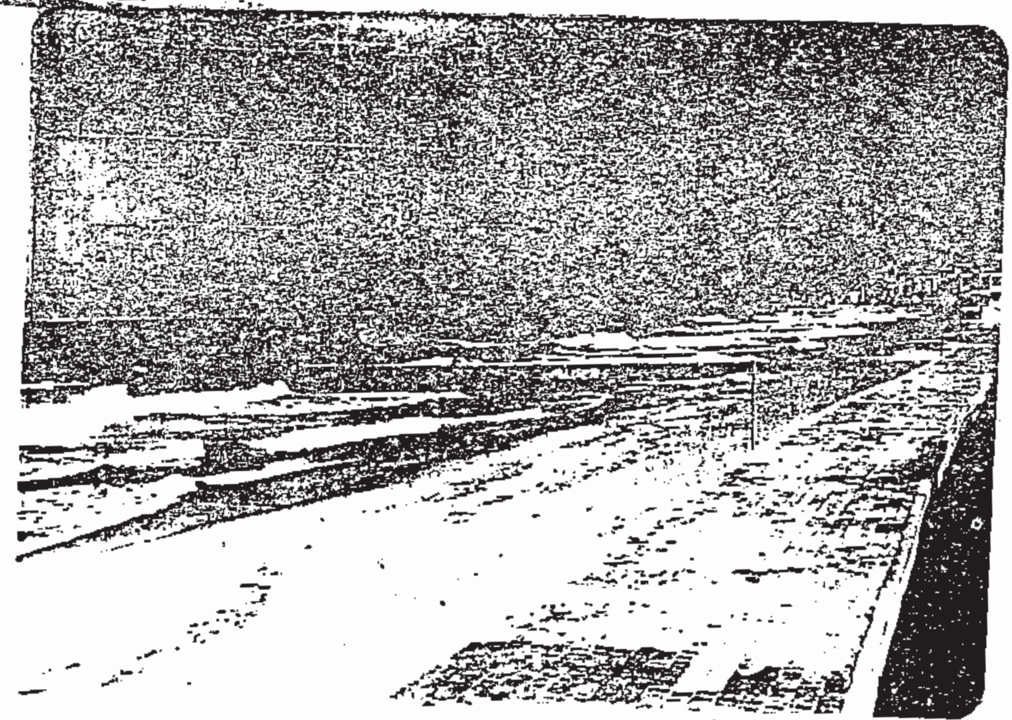
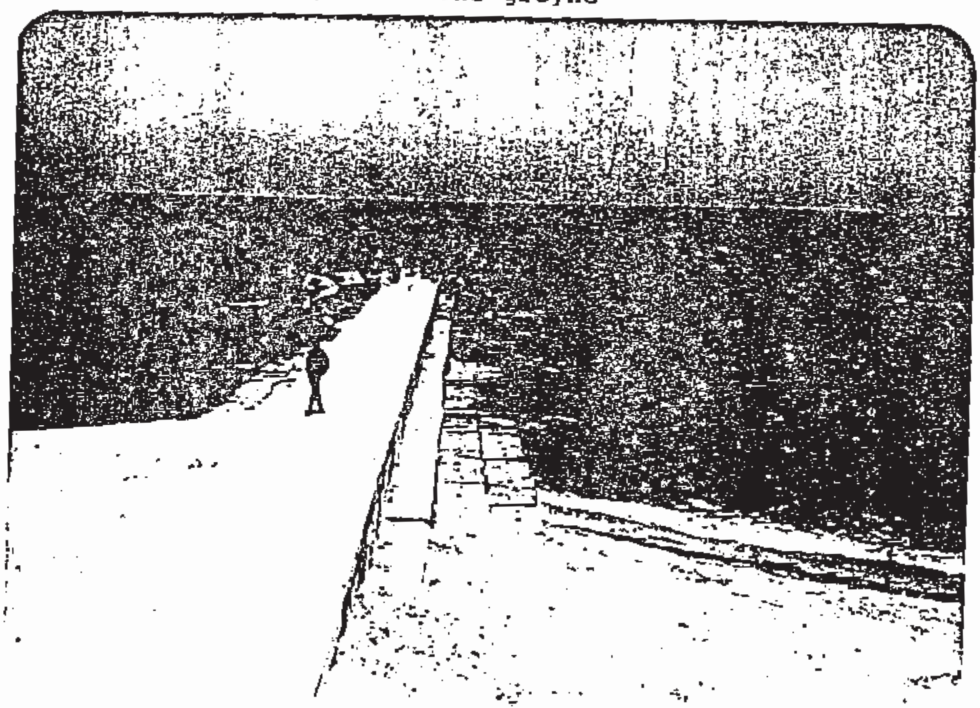


Plate (5):Deposition(inthe west)and erosion(in the east)around the groyne



Plate(6)The effectiveness of the groyne instsllated between El-Shatby &El-Ibrahimiah beaches on reducing the longshore drift

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