CHAPTER 76

CALCULATED SAND FILLS AND GROIN SYSTEMS

by

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Abstract

This paper demonstrates the results of the comparison between the calculated alignment of the beach's plan view and the actual alignment that resulted from the natural wave action.

A new groin system was designed to replace an existing one. The new groin system and spacing was designed to hold the beach fill at the required width during average wave conditions as well as changing storm wave conditions. The system was designed for Las Tunas Beach, a beach near Los Angeles, California.

In other words, the energies are tabulated for all storm conditions, and the beach alignment is recalculated for changing storm conditions. As the beach plan view alignment rotates back and forth with changing storm directions, it must always meet the minimum beach width requirements. This may entail changing the groin lengths, heights and spacing several times before the design complied with all requirements.

Surveys from 1929 to 1970 showed that the beach did not have long periods, periods of several years, of constant erosion or constant accretion. If there are no major man made changes, it is safe to assume that nature will provide an adequate sand supply.

Last, but not least, the calculated beach alignments check with the empirical information gathered from years of surveying.

This paper tells of a groin system and sand fill that was calculated by the use of resultant wave energies.

The beach to be studied was widened during 1929 by damming up the littoral drift with five sheet pile groins. We plan to replace the five groins with two long rock groins and fill the groin system with sand. The new groin system and beach alignment was calculated and compared to existing alignments that have been surveyed over the years.

Plate 1 shows the beach as it was seen recently and the way it will look after widening. This beach, called Las Tunas Beach, is located along the Pacific Ocean shoreline, a few miles westerly of the City of Santa Monica in the County of Los Angeles, California. This is, of course, within the United States.

Because of the amount of survey data available over a great number of years, the natural beach has been examined much like it would be if it were a laboratory model. Surveys have been taken at various seasons of the year and during changes of wave climates.

Since the beach's five long groins dammed up the littoral drift, surveys of the natural beach would tell us how the littoral drift was impounded and indicate the plan view alignment changes with different wave climates.

Plate 2 shows the locations of our range lines along which surveys of the ocean bottom were repeated and compared.

See Plate 1 for the location of five groins and the remaining sand fillet.

Our range lines are spaced 250 feet apart along this 1500 feet of proposed shoreline development.

Plate 3 demonstrates our method of plotting and comparing the profiles.

The beach foreshore slopes remain somewhat parallel during seasonal and long term changes.

The groins have deteriorated years ago and allowed the beach to return to its present postion. Since the existing beach has remained in this position, except for seasonal changes, since surveyed during the early 1950's, it is evident that there is adequate nourishment and the beach is stable.

Plate 4 shows the comparison between the calculated alignment and present alignment. The calculated alignment was made for storms coming from south, southeast to west. The shore line on this plate goes east and west and you will note the difference in the resultant inshore wave directions.

The predominant inshore wave direction changes only slightly with different storms, while seaward of the islands the storms varied more than 120° in direction.

A more detailed discussion of what wave statistics are used will be covered later. At this time let's discuss the different alignments. Note the alignments from the westerly

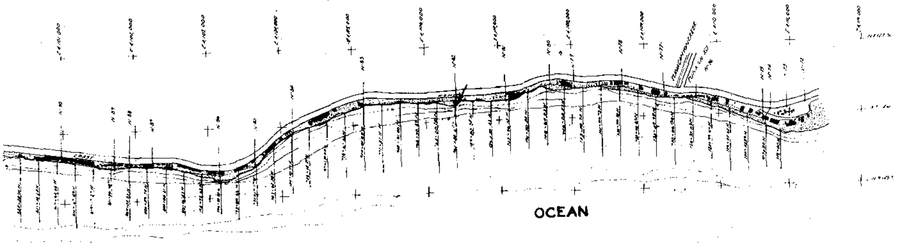
PLATE 1

LAS TUNAS BEACH IMPROVEMENT PROJECT

BEFORE BEACH IMPROVEMENT

AFTER BEACH IMPROVEMENT

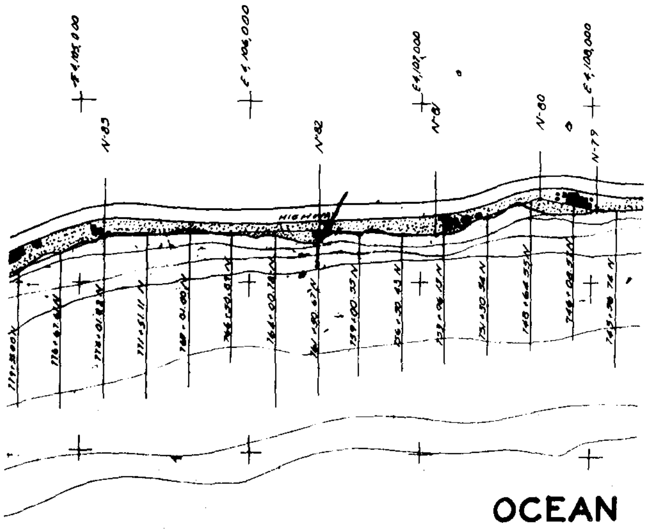
PLATE 2



NUMBER STATION	ADJUSTED STATION	GRID COORDINATES NORTH	EAST	FROM	TO	GRID BEARING	DISTANCE
N-81	754+87.16	4,128,741.11	4,107,085.51				
				N81	N82	N86°12'02"W	684.52
N-82	761+51.68	4,128,762.63	4,106,401.51				
				N82	N83	S88°46'48"W	1,264.27
N-83	774+15.95	4,126,724.69	4,105,137.62				
				N83	N84	S69°13'36"W	1,048.38
N-84	784+64.33	4,126,352.85	4,104,157.39				
				N84	N85	S50°57'58"W	676.74
N-85	791+41.07	4,125,923.61	4,103,634.20				
				N85	N86	S79°30'40"W	498.38
N-86	796+39.45	4,125,[illegible]	4,10[illegible]				
				N86	N87	N80°08'08"W	930.69
N-87	805+70.14	4,125,959.24	4,102,236.00				
				N87	N88	N87°57'58"W	312.24
N-88	808+82.38	4,125,970.35	4,101,923.00				
				N88	N89	S80°32'45"W	247.39
N-89	811+29.77	4,125,929.71	4,101,679.01				
				N89	N90	N77°19'49"W	725.24
N-90	818+55.01	4,126,088.64	4,100,971.53				

NUMBER STATION	FIELD BOOK STATION	GRID COORDINATES NORTH	EAST	FROM	TO	GRID BEARING	DISTANCE
N-72	711+66.51	4,126,661.08	4,111,172.23				
				N72	N73	S70°35'44"W	230.80'
N-73	714+03.31	4,126,584.40	4,110,946.97				
				N73	N74	S83°30'58"W	233.35'
N-74	716+38.66	4,126,555.67	4,110,715.06				
				N74	N75	S34°17'45"W	179.69'
N-75	718+18.35	4,126,407.22	4,110,613.60				
				N75	N76	N70°30'46"W	985.60'
N-76	728+03.95	4,126,734.66	4,109,684.18				
				N76	N77	N87°24'32"W	427.87'
N-77	732+31.82	4,126,754.01	4,109,256.76				
				N77	N78	N74°55'38"W	596.00'
N-78	738+27.82	4,126,908.98	4,108,681.26				
				N78	N79	S89°32'08"W	662.53'
N-79	744+90.35	4,126,903.63	4,108,018.76				
				N79	N80	N79°54'34"W	328.46'
N-80	748+18.81	4,126,961.17	4,107,695.37				
				N80	N81	S70°08'31"W	848.35'
N-81	754+87.16	4,128,741.11	4,107,085.51				

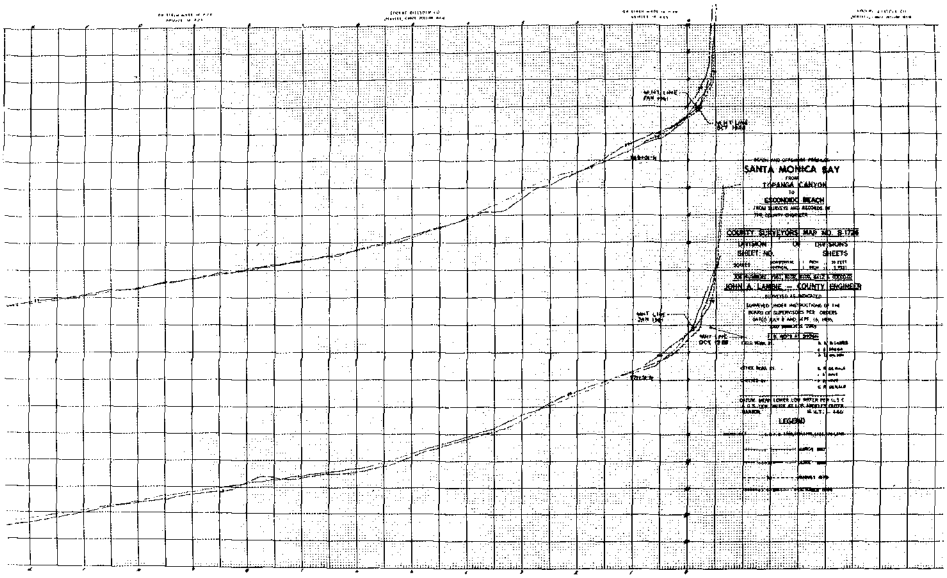
Enlarged Section



This Plate shows the onshore beach control line with "N" monuments and lines extending seaward that formed the paths for the beach profile. Direction and scale can be determined from available survey data.

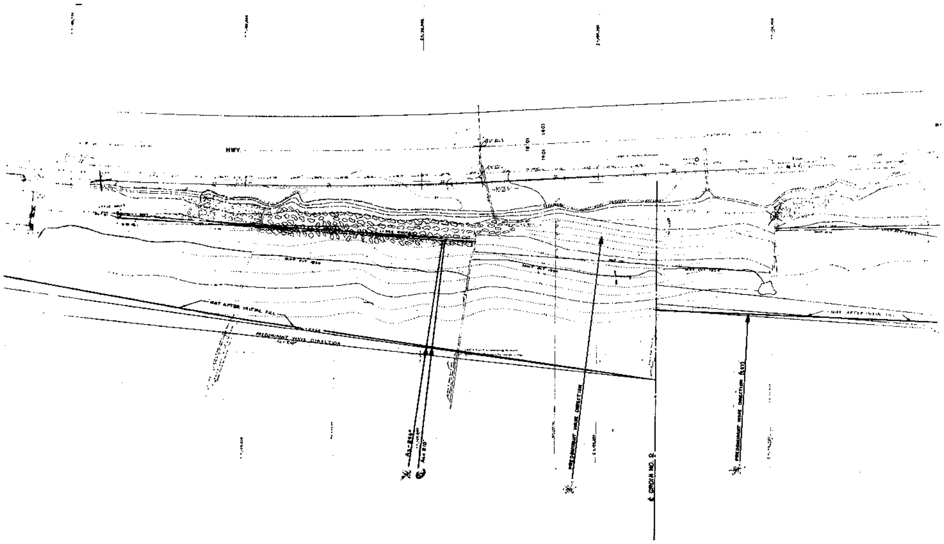
PLATE 3

Beach Profile



Horizontal scale: 1 inch = 365 feet
Vertical scale: 1 inch = 36.5 feet

PLATE 4A



✗ Azimuth 246° is a deep water wave from the west.
● Azimuth 210° is a deep water wave from the south.
✱ Azimuth 232° is the predominant wave direction.

PLATE 4B

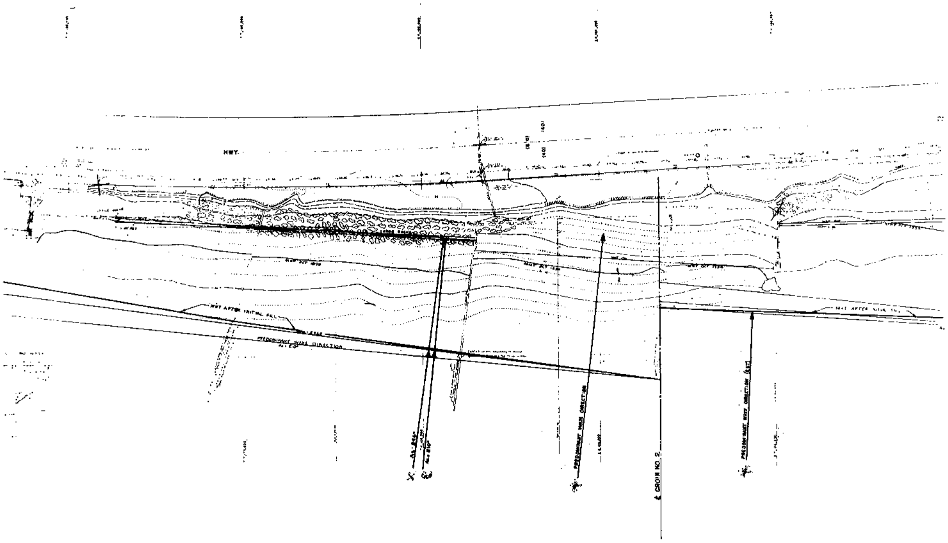
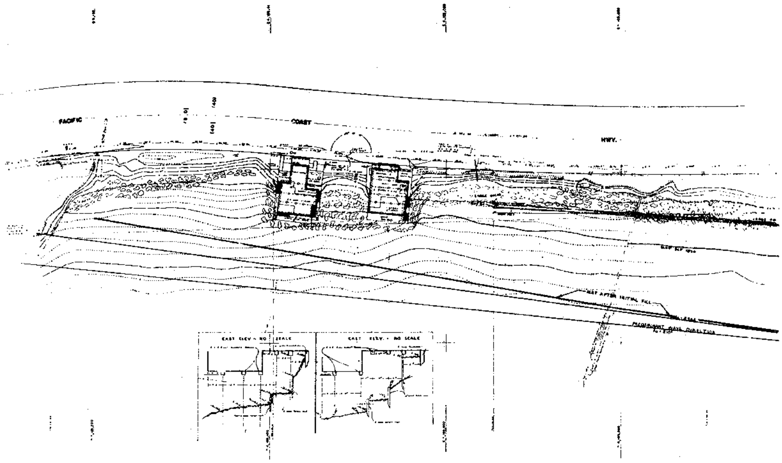

HWY.
MHT AFTER INITIAL FILL
PREDOMINANT WAVE DIRECTION
PREDOMINANT WAVE DIRECTION
℄ GROIN NO. 2
PREDOMINANT WAVE DIRECTION (EST.)

PLATE 4C


PACIFIC
COAST
HWY.
MLT AFTER INITIAL FILL
PREDOMINANT WAVE DIRECTION
EAST ELEV. - NO SCALE
EAST ELEV. - NO SCALE

waves as they compare to those from the south and the predominant wave direction of all waves.

Since the sand fillet will attempt to align itself normal to the wave orthogonals from these predominant wave directions, we can calculate the alignment of the shoreline by knowing the inshore direction of the orthogonals.

The next question is how did we calculate these different shoreline alignments and where did we get the wave statistics to do it with.

Plate 5 shows the crux of the problem. The hindcasted wave statistics must he brought through the island maze, refraction and resultant wave directions must be calculated.

Note where the hindcasted wave statistics were compiled, Station A and Station 7, and where the wave statics were tabulated inside the island maze, lat. 33°56, long. 118° 37'.

Plate 6 shows a summary nf the work, and an explanation of the various steps that were followed.

Column No. 1 shows the wave directions at Station A, Station 7 and those used to tabulate the local winds.

The waves at Stations A and 7 were compiled within 22½ degrees arcs, of which the directions shown are the center. The local waves or those called sea, are recorded within ten degree arcs, and the directions shown are the center of these arcs.

Column No. 2 shows the resultant wave directions, based on energy calculation, of those waves shown in Column No. 1.

The first calculations were to change the wave statistics to deep water wave energy. Since relative energy was all that was needed, we calculated the total storm wave energy by the use of significant wave heights. You will note, I used the word "total". In other words, we calculated the wave energy for the total average annual time that given storms would occur during the year.

The next step was to calculate the resultant energy for all the storms within the 22½ degree segments represented in Column No. 1.

The resultant can be calculated by vector analysis. The length of the vector represents total annual energy for storms and the vector direction represents the direction of these storm waves. By joining these vectors end for end the resultant energy and direction can be calculated.

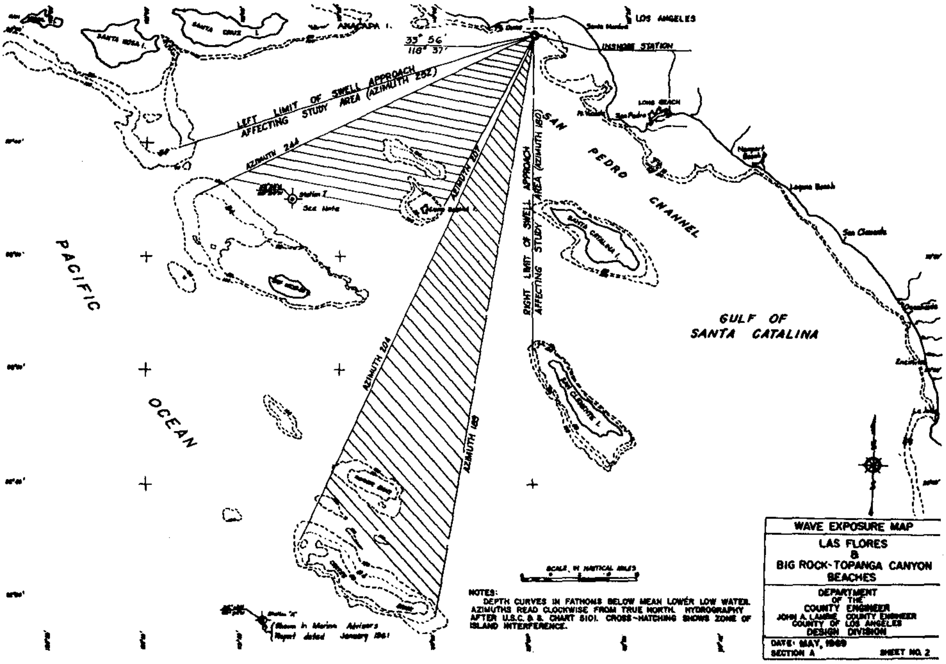
Column No. 3 shows a tabulation of the shift in the direction of the resultant of wave energy when the point of observation is moved from Station 7 or A to the deep water area just off Las Tunas Beach. This shift will be explained in a later plate.

Column No. 4 is a summation of Columns 2 and 3.

Column No. 5 shows the resultant relative energy that has been calculated for different storm conditions at Station A or Station 7.

Column No. 6 shows a coefficient that indicates the decimal part of this energy that gets through the island maze.

PLATE 5



Note stations where wave statistics were compiled "⌖".

PLATE 6
WAVE STATISTICS
AT
NORTH LATITUDE 33° 55.9'
AND
WEST LONGITUDE 118° 36.7'

(ANNUAL ENERGY IN MILLIONS OF FOOT POUNDS)

(1) DIRECTION (AZIMUTH)	(2) RESULTANT DIRECTION (AZIMUTH NORTH)	(3) SHELTERING CORRECTION TO DIRECTION	(4) DIRECTION AT THE ABOVE LOCATION	(5) ENERGY AT STATION A or 7	(6) ISLAND SHELTERING COEFFICIENT (C)		(7) RESULTANT ENERGY AT THE ABOVE LOCATION
					C	C^2	
			SWELL STATION A				
157.5	157.3°	+29.9	187.2°	10,400	.33	.109	1,140
180.0	174.8°	+21.9	196.7°	8,400	.47	.221	1,850
202.5	204.6°	+ 6.0	210.6°	9,500	.60	.360	3,420
225.0	226.0°	+ 3.5	229.5°	29,200	.71	.504	14,900
			STATION 7				
247.5°	247.5°	- 8.5	239.0°	5,600	.62	.384	2,130
270.0°	270.0°	-24.0	246.0°	48,500	.54	.292	14,060
			SEA				
120	145	Waves are the result of local winds blowing towards the main-land from the islands --no sheltering correction needed.	145				22
130	148		148				7
140	157		157				53
150	167		167				84
160	175		175				46
170	182		182				78
180	187		187				50
190	194		194				137
200	204		204				217
210	213		213				190
220	217		217				65
230	219		219				180
240	226		226				120

RESULTANT - WAVE DIRECTION
(For all Waves Listed) = 231° 50'
AVERAGE WAVE PERIOD = 11.8"
NOTE: Waves from west north west have no effect on this area.

We call this the island sheltering coefficient.

Column No. 7 shows the fractional part of the energy that reaches the deep water area just off Las Tunas Beach.

Three important beach forming wave resultants exist, wave resultants from westerly waves, southwesterly waves and southerly waves.

Other waves considered in the tabulation are as follows:

The waves from the southwest have a very high energy value but are so close to the predominant wave direction that no special consideration need be given them.

The local wind wave energies are tabulated at the bottom of the plate under the term sea. None of these waves have significant quantities of energy in the study area. Furthermore, the waves from 226° to 145° occur over a wide range of months and involve many small storms during the year. Thus, the energy for any individual storm will be quite small and will not be very effective in shaping the study area coastline.

Plate 7 shows the way the island blocking is handled. The details of this type of blocking can not be completely covered here, but in general the area under the curve shown represents total energy from the average storms and the area under the curve and not crosshatched shows the part of the energy that gets through the islands.

Because of the irregularities of wind waves within the island maze, it was expedient to divide the problem into two parts --energy resulting from deep water swells, and energy resulting from fetch, wind and local conditions.

Since little wave decay exists between Station A or 7 and Las Tunas Beach, the plate shows how the island sheltering affected a wave with an azimuth of 175° from Station A.

In the formula $i d\theta = K(1+\cos 2\theta)d\theta$, θ is the angle on either side of the center of the waves formed and $i d\theta$ is the energy for a small sector of θ. The K and $d\theta$ can be chosen to be unity without significant error. Because this wave is a deep water swell, a path of 45° on eether side of 175° is considered and the blocking effect is shown. The energy will be reduced by 22% of the energy at Station A and the resulting wave azimuth will increase from 175° to 197°--this direction change is achieved by calculating the resultant of the energy in the open windows.

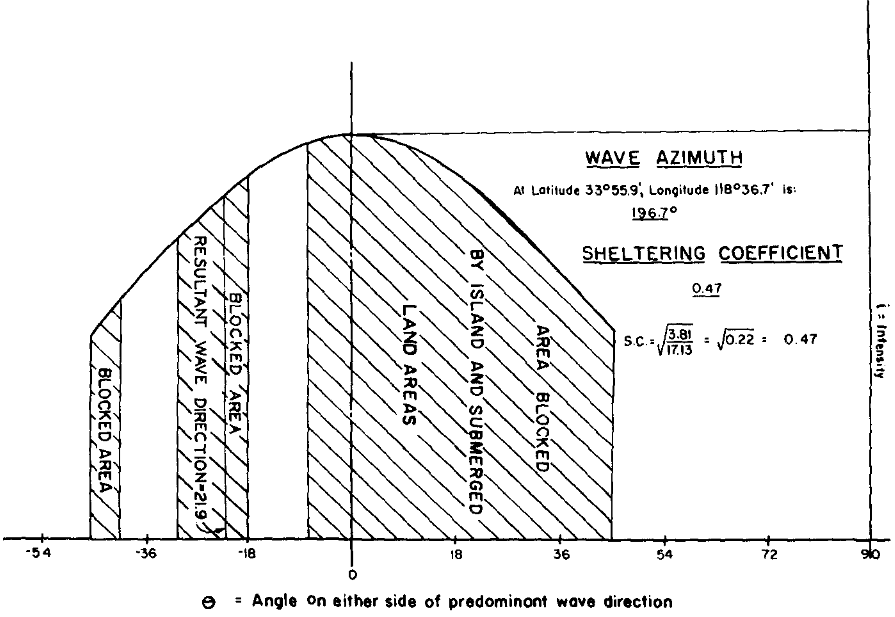
The unblocked energy is represented by the figure 17.13 which is the area under the total curve, and 3.81 represents the area of the open windows. Therefore, the energy just off Las Tunas Beach equals energy calculated at Station A, times ($3.81 \div 17.13$) and equals 22% of the total energy.

During sea conditions in which the sheltering land masses are within the fetch area, a wave path of 90° on either side of the fetch directions is considered to be good. Decayed swell conditions can lead to overestimating the effects of island sheltering. The variability of wave direction for swells can be less than 45° and may be only a few degrees for very distant storms. Remember, the island windows are based on the average

PLATE 7

WAVE DIRECTION 174.8° AT STATION "A"

Chart for Computing Island Sheltering Coefficient $i = K(1 + \cos 2\theta)\,d\theta$



Predominant wave direction =

wave period for all swells, and the long period swells will not get through windows as large as those shown. Forty-five degrees probably represents an average figure. Beaches in Los Angeles County are developed, primarily by the mid-range wave conditions and not the unusual rare occuring large wave conditions.

Investigating island sheltering necessitates considering the depth to which this island blocking will take place.

This was accomplished by determining the average wave period and taking 50 percent of the resultant deep water wave lengths as the depth to which the offshore islands will block continental bound waves.

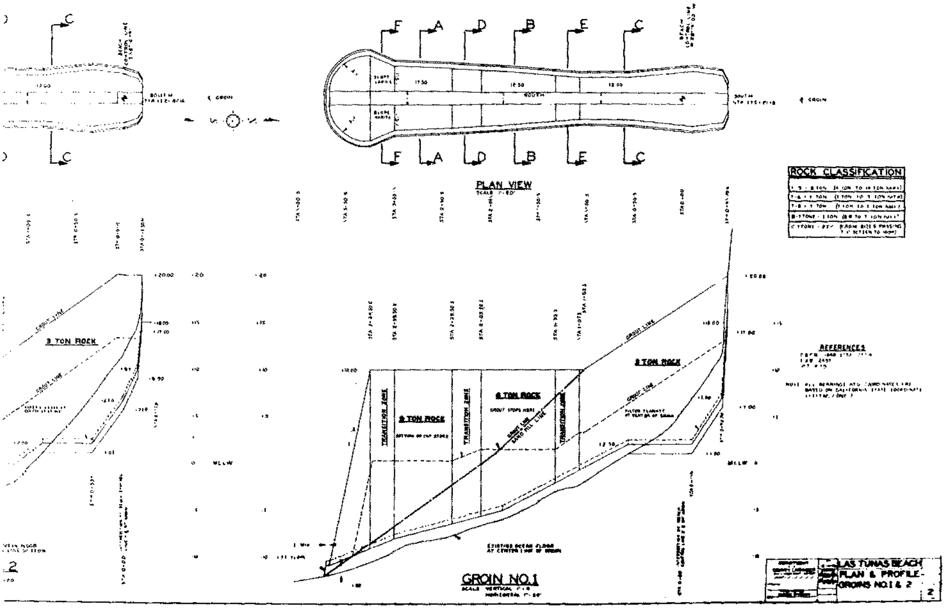
The refraction diagrams were calculated and used to determine the resultant inshore energies.

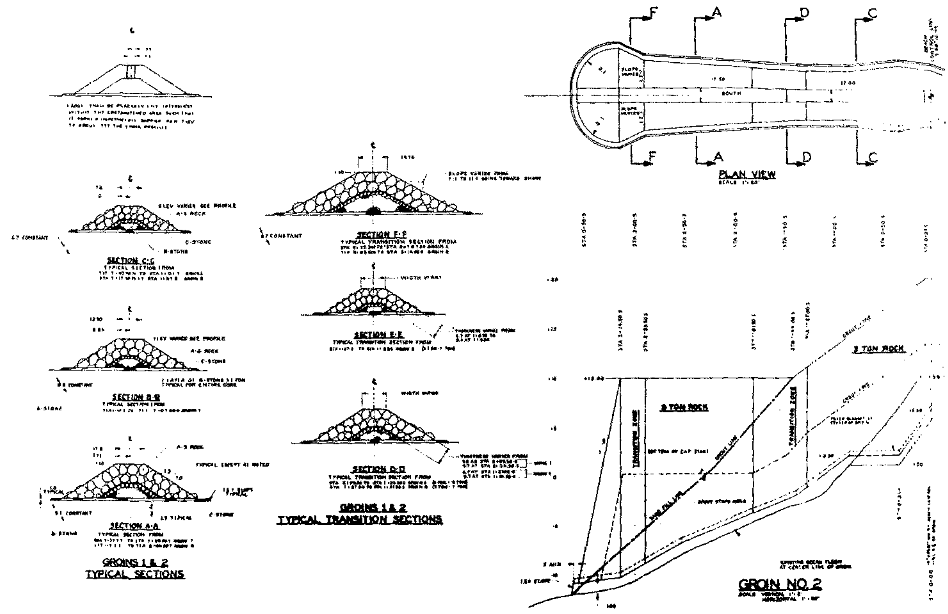
Plate 8 shows the plotted profiles and the grouted groin area. The grout is placed on the porous cap stone to make it impermeable far enough seaward to maintain the beach at a minimum width.

The last ingredient is the question of an adequate, continuous sand supply. Surveying the beach over a great many years also gives us the answer to this question. Surveys from 1929 to 1970 showed that the beach did not have long periods--periods of several years of constant erosion and constant accretion. If there are no major man made changes, it is safe to assume that nature will provide an adequate sand supply.

Last, but not least, the calculated beach alignments check with the empirical information gathered from years of surveying.

PLATE 8


PLAN VIEW
ROCK CLASSIFICATION
3 TON ROCK
8 TON ROCK
TRANSITION ZONE
GROUT LINE
SAND FILL LINE
EXISTING OCEAN FLOOR AT CENTER LINE OF GROIN
REFERENCES
MLLW
GROIN NO.1
LAS TUNAS BEACH
PLAN & PROFILE-
GROINS NO.1 & 2


SECTION C-C
SECTION B-B
SECTION A-A
GROINS 1 & 2
TYPICAL SECTIONS
SECTION F-F
SECTION E-E
SECTION D-D
GROINS 1 & 2
TYPICAL TRANSITION SECTIONS
PLAN VIEW
3 TON ROCK
TRANSITION ZONE
GROUT LINE
SAND FILL LINE
GROIN NO.2

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