## CHAPTER 34

## FIELD OBSERVATIONS OF NEARSHORE CURRENT SYSTEM

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#### ABSTRACT

The two systems based on the principle of photogrammetric surveying have been developed in order to accomplish the field observations of nearshore current system induced by waves, and were applied to the field investigations on the Shonan Coast, Kanagawa Prefecture, Japan (Horikawa, Sasaki et al, 1970). The first is called as the Balloon Camera System and the other is the Synchronized Helicopter System. The main efforts were concentrated to the simultaneous observations of waves and current fields in and out the surf zone. Even there still exist some difficulties to be overcome in applying the present systems, the validity and usefulness of these systems were demonstrated by the obtained data. In this paper are presented the details of the developed systems and a part of the analyzed results by using the data obtained in field.

## INTRODUCTION

The nearshore current system is of very importance in connection with the coastal processes, and the characteristics of the nearshore current have strong influences on the recreational activities and water pollution problems in the coastal area.

Several mathematical models of longshore current and/or of nearshore current system have been proposed very recently by Bowen (1969), and Bowen & Inman (1969, 1971) based on the concept of radiation stress. On the other hand the field measurements of nearshore current have been conducted very actively by Sonu (1972). From the engineering point of views it is of essentially importance that all of the factors taken into the mathematical models of nearshore current system should be determined by the physical parameters such as the height, period, and incident direction of waves, and bottom configuration especially inside the surf zone. The proposed models are at present qualitative ones, and their applicability should be investigated by using the reliable data obtained in field under the numerous conditions.

The principal difficulties in the field observations of nearshore current result from the fact that the phenomena of current system extend to the broad area in and near the surf zone. Therefore the main efforts so far have been devoted to the velocity measurements of longshore current which is a part of the nearshore current system except the pioneering works by Shepard & Inman (1950) and leading works by Sonu (1969, 1972).

Figure 1 is a well-known schematic diagram of nearshore current system drawn originally by Shepard & Inman (1950), and revised by Inman and Bagnold (1962). In order to investigate the whole pattern of this current system, it is desirable to measure the wave characteristics such as height, period, and direction, the current field and the bottom topography in and out of the surf zone simultaneously. From that point of view, the aerial photographic surveying seems to be the most suitable way to accomplish the systematic observations in the nearshore area. Therefore the following two systems were developed and applied to the field observations in order to take successive pictures at certain interval from air. At any rate this is the initial stage of the research project on the nearshore current at the Coastal Engineering Laboratory, University of Tokyo.

#### FIELD OBSERVATION SYSTEMS

Balloon Camera System

Figure 2 is the schematic diagram of the Balloon Camera System which is shortly named as BACS. The Balloon of this system is to hang the capsule in which a motor-drive camera (Hasselbrad 500EL) is contained as shown in Figure 3. The balloon has its inner volume of  $33 \text{ m}^3$  filled with hydrogen gas. The reasons why hydrogen gas is prefered are as follows:

- The cost of hydrogen gas is fairly cheaper in Japan, and its specific gravity is relatively small, therefore the gained buoyancy is relatively large, in comparison with helium gas.
- (2) Although hydrogen gas is easy to detonate in case of mixing with air, it is practically easy to operate with safety under the desired care.

The detailed descriptions of the Balloon Camera System are given in Table 1.

As shown in the table 70 mm film is used instead of 35 mm with the purpose of getting better resolution of pictures. The stability of the photo coverage was practically well in the air. The camera was set for shotting at 6 sec interval and for taking successive 20 frames or more.



Fig. 1 Schematic diagram of nearshore current system. (After Inman & Bagnold)



Fig. 2 Schematic diagram of BACS.



Fig. 11 A part of Fig. 10 enlarged. Two rip channels are seen on left and center of the photograph. (SIHEL-515,,swell)



Fig. 12 An example of velocity field obtained by SIHELS. (cf. Fig. 11, SIHEL-515, swell)

The defects of the present system are as follows:

- (1) The wind speed should be less than 7 8 m/sec.
- (2) The actual distribution of wave height can not be read from successive pictures due to non stereophotogrammetry.
- (3) The area covered by each photograph is relatively small as 100 m x 100 m in horizontal scale.

Synchronized Helicopter System

Figure 4 is the schematic diagram of the Synchronized Helicopter System which is shortly named as SIHELS. The descriptive outline of this system is given in Table 2, from which it is recognized that the area covered by single photograph is pretty large in comparison with the Balloon Camera System. The following facts were the reasons why the helicopter was used. The airplane except helicopter needs at least 5 min. to return to the questioned site, but the helicopter is able to stay for certain period at a defined location with constant altitude owing to its hovering capacity.

The accuracy of the results is very high and satisfactory in the quantitative sense for the present purpose, but the largest defect is the operation cost being extremely high.

The helicopters used are too small to stay for longer time at the specified locations accurately (Figure 5). The accuracy is requested to get stereophotographic pictures. Owing to the above limitation, 40 sec period was selected for the operation of taking pictures.

The method for synchronization of taking pictures was as follows. The trigger signal was transmitted from "MASTER" camera mounted on the commanding helicopter to "REMOTE" camera mounted on the other helicopter at the initiation of operation, ever since then the timing mechanism installed in each camera was operated to take the following successive 5 - 7 frames at interval of 6 - 8 sec.

## Floats

The principle of both systems stated above is basically the same as follows: numerous floats throwing by hand along the specified lines from shore to breaker line were traced by the successive pictures taken at a certain interval. Various kinds of floats were tested in order to find out the adequate type of floats for tracing the velocity field of nearshore current as accurately as possible. The float of cube made from polyurethane foam with 25 cm or 33 cm in edge length was finally selected. The outer surface was coated by membrane of vinyl with yellow and/or orange colour. This kind of device was successful to distinguish the location of float on colour film under the white foamed surf zone condition.



Fig. 4 Schematic diagram of SIHELS.

Table 2 Outline of SIHELS.

HELICOPTER	Bell KH-4
CAMERA	Zeiss RMK 15/23
FILM	Kodak Aerocolour – N
PHOTO SCALE	1/3000
ALTITUDE	450 m
COVERAGE	690m X 410m (stereo)
	690 m X 970 m (mono)



Fig. 5 Helicopters used for SIHELS.



Fig. 6 Polyurethane floats for nearshore current observations.

## FIELD INVESTIGATIONS AND ANALYZED RESULTS

#### Test Sites and Wave Climates

The two systems stated above were practically applied to the field observations on the Shonan Coast near Enoshima Island in Kanagawa Prefecture, Japan. This is one of the busiest summer health resorts in Japan owing to the relatively short distance from the Tokyo Metropolitan Area, namely the distance from Tokyo to Enoshima Island is about 50 km. The survey area is divided into two, one is named as Area A, and the other Area B as shown in Figure 7.

Table 3 gives the available information about the date and time of observations, the wind conditions, the wave characteristics of breakers, and the width of surf zone. The classification of wave climate was also indicated as wind wave or swell condition. The hydrographic surveying could not be conducted at the time when the stated field observations were done, but the hydrographic chart made by the Kanagawa Prefecture in 1969 was available to be used. According to this chart the foreshore slope was in the range of 1/20 through 1/40. Here the authors wish to mention that has been observed the flow field under the rather rough sea condition such as the maximum breaker height being over 2.5 m in comparison with most of the previous data which were obtained under the relatively small wave condition.

#### Some Results of Field Observations

Figure 8 gives one example of photographs taken by the Balloon Camera System. Analysis of these successive photographs gives the velocity field in the surf zone as demonstrated in Figure 9. In this diagram the solid line arrows indicated the actual trace of floats, while the dotted line arrows indicate the interpreted flow pattern. The wave climate, when the field investigation was conducted, was swell condition with its breaker height of about 0.6 m, and the spacing between two neighbouring rip channels was about 100 m.

Figure 10 is one example of photographs taken by the Synchronized Helicopter System. It is needless to say that the original one was colour picture. The existence of many rip channels was clearly taken in this photograph. In order to make much more clear picture of rip channels and rip heads, the right hand half of the original photograph was enlarged as shown in Figure 11, where the rip channels, the targets ship and numerous floats were indicated. The wave climate at that time was swell with breaker height of 0.5 - 0.8 m. The wave steepness was relatively small, hence the breaker was classified into plunging breaker type with rather long wave crest. The analyzed diagram is given in Figure 12, where the flow pattern and the rip head were interpreted. The shape of the rip head is quite similar to a cauliflower. At any rate the flow pattern is surprisingly similar to the illustration given in Figure 1. The synchronization was unsuccessful at this operation, hence the stereoscopic analysis could not be applied.

On the other hand, under the wind wave condition the situation of flow



Fig. 7 Location map of field boservation site.

SIGN		STHEL	5-515	STHELS	-611	BACS-624	STHELS	-705
		311EC3 313				0000 024	3m223 703	
DATE		1971.	5. 15.	1971.	<b>6.</b> 11.	1971. 6. 24.	1971.	7. 05.
AREA		A	В	A	B	A	A	В
TIME		12:35	14:23	13:47	15:26	11:40	14 : 10	15:40
VE	LOCITY(m/sec)	(8)	(8)	6.6	4.3	2.5	5.3	6.7
DIRECTION	RECTION	(NNE)	(NE)	sw	ssw	NNW	ssw	ssw
	HEIGT (m)	0.8	0.8	1.4 ~ 1.7	13~2.5	0.6	1.4 ~ 1.7	1.2 ~ 1.5
WAVE	ANGLE (deg.)	7	7	9	0	10	4	2
(breaker)	LENGTH (m)	15~30	20	15~25	20~30	20 ~ 30	6~12	10~25
	PERIOD(sec.)		-			7.0	(4	~ 5)
	CONDITION	SWELL		WIND WAVE		SWELL	WIND WAVE	
SURF ZON	E WIDTH (m)	50	50	100	90	60	40	50

Table 3	Wave and cli	mate condition	associated	with	field
	observations	executed.			

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Fig. 8 An example of photograph taken by BACS.



Fig. 9 An example of velocity field by 8ACS. (BACS-624, swell)

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Fig. 10 An example of photographs taken by SIHELS. (SIHELS-515, swell)



Table 1 Outline of BACS.

BALLOON	Ovoid type gas balloon volume : 33 m³
CAMERA	Hasselbrad 500EL
	70 mm moter drive
LENS	Distagon 50 mm
TETHER	ø5mm polyester
ALTITUDE	100 ~ 150 m
FLOAT	Polyurethane foam



Fig. 13 An example of photographs taken by SIHELS. (SIHELS-611, wind wave)





pattern seems to be really complicated. Figure 13 is one example of photographs taken during the wind waves, the breaker height of which was approximately 2.5 m.

The distributed pattern of floats was unfortunately not adequate to catch the whole flow pattern of nearshore circulation system as shown in the analyzed diagram of Figure 14. The main reason of this situation was that the handling of floats was extremely limited in the technical sense due to the rough sea. In spite of this limitation stated above, it was successful to figure the successive configuration of water surface as shown in Figure 15. By using these successive diagrams the contour map for the maximum elevation of water surface above the estimated mean water level is shown in the following fugures. Figure 16 is for the wind waves corresponding to Figures 13, 14, and 15. That is to say the breaker height for Figure 16 was as large as 2.5 m, while the breaker height for Figure 17 was about 1.0 m. From these diagrams it is easily recognized the existence of the periodical distribution of highs and lows along the shoreline. Following the hypothesis presented by Bowen (1969), that is the rip current appeares at the site of the lowest breaker height, the location of rip current was assumed as indicated in Figures 16 and 17. The generation theory of rip current proposed by Bowen & Inman (1969) is as well-known based on the interaction of edge waves with incoming waves.

On the other hand Sonu (1972) stresses that the bottom undulation existed in the surf zone is also to be the cause of nearshore circulation even in the case of uniform breaker height of the waves coming normaly to the shoreline. He stresses also the existence of meandering current in the case of oblique incident waves. In the case of Sonu's hypothesis it must be essentially needed to solve the problem by what reason such an undulation of bottom contour was caused.

In order to clarify the actual phenomena occurred in nature, further field observation data is highly requested.

#### CONCLUSIONS

The conclusions of the present investigations are as follows:

- (1) Yhe two systems developed at the Coastal Engineering Laboratory, University of Tokyo, were verified in field to be successful measures to observe the nearshore current system.
- (2) The pattern of the current system described by the previous researchers is characterized only in the case of swell condition, while the pattern generated by wind waves seems to be more complex due to the existence of numerous circulations with vertical axis.
- (3) The Synchronized Helicopter System is the most suitable one at present, but the Balloon Camera System must be also very effective due to its simplicity and mobility in the operation provided with an additional camera





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Fig. 16 Maximum water surface distribution above the estimated mean water level. (SIHEL-611-B, wind wave)



Fig. 17 Maximum water surface distribution above the estimated mean water level. (SIHEL-705-B, wind wave)

to make the pictures stereographic.

- (4) The floats presently used are useful to trace the flow pattern in the case of plunging breaker and also in the case of spilling breaker with its height less than 1 m.
- (5) The following two problems should be solved in the near future in order to obtain the valuable data under the stormy wave conditions; the first is to find a new type of float which is effective to the spilling breaker, and the second is to apply one more helicopter for throwing a number of floats in a short tim e in an interested broad area.

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