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HAY POINT OFF-SHORE BERTH STRUCTURES FORCES AND SCOUR DUE TO WAVE ACTION

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HAY POINT OFF-SHORE BERTH STRUCTURES

FORCES AND SCOUR DUE TO WAVE ACTION

The hydraulic model studies of wave action on the Off-Shore Berth Structures for the extension of the coal loading berth at Hay Point, (Saraji Project - Area 700), were carried out in the Laboratories of the Department of Civil Engineering at the University of Queensland.

The studies were directed by Dr. C.J. Apelt, who also wrote this report on the investigation.

Gordon R McKay

Gordon R. McKay,
Professor of Civil Engineering.

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1. INTRODUCTION

The Saraji Project in Central Queensland, an undertaking of the Utah Development Corporation, requires the construction of off-shore berthing and bulk coal loading facilities at Hay Point, 11 nautical miles south of Mackay. The berth site is approximately 7000 feet off-shore in water 45 feet deep at low water, the tidal range is 20 feet and the berth structures will be subject to substantial wave action. The berth structures, as designed by the Consulting Engineers, Rendel & Partners, are supported on three large concrete caissons which were constructed in dry-dock at Mackay Harbour, towed to the site and sunk into position. The general shape of the main berth caissons is shown in Figure 1. The base of each caisson is 150 feet x 135 feet in plan and 25 feet high. The four columns which support the super-structure are each 40 feet x 40 feet in plan and 51 feet high.

Calculations of wave forces on the berth caisson had been carried out by C.J. Garrison, using linear wave theory, but the accuracy of the mathematical model in this case is impossible to assess. In several important aspects the physical situation differs from the mathematical model significantly, viz:-,

(i) The height of the larger waves, up to 24 feet, is not small compared to the water depth (45 to 65 feet).

(ii) The square shape of the columns causes separation of flow to occur.

(iii) The four columns on each caisson are closely spaced and the patterns of separated flows are likely to be complex.

(iv) The mathematical model cannot predict with confidence the pressures on the underside of the caisson.

Because of the uncertainty concerning the importance of the factors listed above, the Consulting Engineers commissioned a scale model study so that pressures, forces and moments due to wave action might be measured. The model study was carried out in the Hydraulic Model Laboratory of the Department of Civil Engineering at the University of Queensland during the period December 1972 to May 1973, the work being carried out with great urgency and virtually simultaneously with the design of the structures. The data from the model tests were usually required by the design team immediately they were obtained. Under these circumstances, the model tests had to be completed with instrumentation and equipment which was readily available.

2. SCOPE OF MODEL TESTS

The model tests involved two distinct studies.

I. Transient pressures on the surfaces of a berth caisson under wave action were measured for the following cases:-

(a) Cyclone wave at High Water.
(b) Cyclone wave at Low Water.
(c) Design wave at High Water.
(d) Design wave at Low Water.

II. The characteristics of scour at the base of a berth caisson and of an approach caisson due to wave action were studied for the four cases listed above.

The incident wave conditions specified by the Consulting Engineers were as follows:-

Cyclone Wave:- Height (H_{omax}), 24 feet; Period, 8.25 secs.

Design Wave :- Height ($H_{1/3}$), 12 feet; Period, 6.0 secs.

Wave roses obtained at the site indicated that the dominant direction for incident waves is from ESE, but that waves could be expected from virtually any direction within the range SE to NW. The compressed time period in which the model studies had to be carried out made it quite impossible to conduct tests for all possible directions of incident wave. Consequently, the tests were limited to the study of waves approaching normally to the berth line (wave crests parallel to the longer side of the caissons) and of waves approaching from the dominant direction ESE (wave crests at an angle of $52\frac{1}{2}^{o}$ to the longer side of the caissons).

The tide levels used for the tests were R.L. 0 feet for Low Water and R.L. 20 feet for High Water. In all tests on the berth caisson the foundation level of the caisson was taken as R.L. -56 feet.

The berth caissons are founded on four pads, one at each corner, 40 feet x 40 feet in plan. The foundation pads are set on prepared base material and it is considered that the water pressures applied to the under side of the foundation pads will be those corresponding to the current tide level without any significant effect from wave action. However, the cruciform area on the under side of the caisson between the foundation pads will be subjected to pressure variations caused by wave action because it communicates directly to the sea through the gaps between the foundation pads along each side of the caisson. The effects of wave pressures on this region of the underside of the caisson were found to be very significant in overall stability of the caisson. Consequently, wave pressures on the underside of the caisson were measured for two conditions, viz:- (i) the gaps along each side of the base were unobstructed, (ii) 90 percent of each gap was closed, the remaining 10 percent of opening being distributed uniformly over the length of the gap.

3. EXPERIMENTAL DETAILS

3.1 Wave Basin

All of the tests were carried out in a wave basin 10 feet wide and 48 feet long. The wave generator was of paddle type, the throw at top and bottom of the paddle being capable of independent adjustment. A spending beach of crushed rock at a slope of 1 in 10 was placed at the opposite end of the basin from the wave generator in order to eliminate wave reflection. The models were located approximately half way along the basin. The incident waves from the wave generator, as measured at this location, were free of any significant higher harmonics and there was no significant reflection off the spending beach.

3.2 Models

The scale adopted for all models was 1:60. The model of the main berth caisson was constructed from clear perspex (lucite) sheet, ¼ inch thick. Some views of this model can be seen in Plates 1 and 2. A total of 135 pressure tapping points were built into the model, their locations being shown in Figure 2. The large number of tapping points was dictated by the need to measure the pressure distribution over all surfaces of the model in sufficient detail for the purposes of structural design. As can be seen from Figure 2, the pressure tappings were distributed over the surfaces of the model as follows:-

Upper surface of caisson:-	22 tappings over one half of surface
Lower surface of caisson:-	7 tappings over one half of surface
Front face of caisson:-	16 tappings over one half of face
Rear face of caisson:-	16 tappings over one half of face
Side face of caisson:-	28 tappings over full face
Internal diaphragm walls:-	6 tappings
Vertical faces of column:-	10 tappings on each face.

The pressure tappings were 0.062 inch in diameter and they were connected to the pressure recording system through rigid nylon tubing of 0.127 inch internal diameter. The connecting tubing had to be carried out from the model through the tops of the four columns and it was physically impossible to fit more tubes into the columns. Because of this restraint, only one column was fitted with tappings. For tests in which the waves were approaching normally to the structure, it was possible to measure the complete pressure distribution over the base caisson in one set-up, since measurements were needed over only one half of the base on account of symmetry. For this same set-up the pressures were measured on the one instrumented column in the front position and then the model was rotated through 180 degrees so that pressures could be measured on the column in the rear position. For tests in which the waves approached the caisson other than normally, it was necessary to set the model in four orientations in order to obtain the complete pressure distribution over the base caisson and over the four columns. These positions are indicated in Figure 3.

3.3 Instrumentation

3.31 Pressure Measurement

The pressure tappings at the surface of the model were connected through rigid nylon tubing to pressure transducers and the amplified output from the transducers was recorded on chart recorders. The pressure transducers were supplied by ETHER LTD and were type UP1, range ±10 inches of water. They consist essentially of a metal bellows which deflects under pressure and displaces an armature. The movement of the armature induces strain in unbonded strain gauge elements which form the arms of a Wheatstone bridge. The voltage output from the Wheatstone bridge was amplified by carrier amplifiers and the amplified signal was recorded on a pen recorder supplied by Devices Pty Ltd. The model wave periods were 0.775 sec. and 1.065 sec. for the Design wave and Cyclone wave respectively. The natural frequency of the pressure transducers (dry) is in excess of 300 Hz and the response of the pen recorders is flat, up to 40 Hz.

The pressure transducers were of differential type and the case reference pressure used was the ambient atmospheric pressure in order to prevent the occurrence of zero shift, which would otherwise be caused by changes in atmospheric conditions. In order to achieve consistent, repeatable performance over long periods of time it was found necessary to ensure that the air in the cases of the transducers was completely dry. Any humidity in the air caused rapid oxidation of the terminal connections of the unbonded steam gauge elements and erratic performance. This problem was solved by connecting the cases of the transducers to a large plastic bottle, sealed with a flexible polythene bag, which contained dry air over silica-gel drying crystals. The softness of the polythene bag ensured that the pressure of the dry reference air in the bottle was always the same as that of the ambient atmosphere. The reference pressure bottle can be seen in Plate 1.

It was not possible to locate the pressure transducers inside the model in close proximity to the pressure tappings; instead it was necessary to connect the pressure tappings to the transducers through long lengths of tubing. The inertia of the large volume of water in the connecting tube greatly modified the frequency response of the pressure measuring system. A preliminary series of tests established that it was necessary to adjust the length of the connecting tube to achieve satisfactory response characteristics at the different wave periods. For a wave period of 0.775 seconds the optimum length of the connecting tube was found to be 9 feet and for a wave period of 1.065 seconds it was found to be 15 feet. Consequently, in the model used for measurement of wave induced pressures, the connecting tubes were all adjusted to the length which was optimum for the wave period of the test.

3.32 Wave Profile Measurement

The wave profile was recorded by means of a capacitance type wave probe developed at the Civil Engineering Department. The electrical output from the probe was recorded on the Devices pen recorder.

3.4 Experimental Procedure

The instrumentation available for the tests comprised three pressure transducers and associated carrier amplifier systems, one wave recorder and two twin channel pen recorders. One recorder channel was used always to register the incident wave profile and the other three channels were used to record the outputs from the three pressure transducers which were connected to pressure tapping points in groups of three until all had been monitored. Synchronisation of the four separate signals was achieved by activation of the event marker pen on each recorder with a signal generated from a relay on the wave generator. The signal was pulsed once for each period of the wave generator and this provided an accurate time base as well as synchronisation. The pressure history at each tapping point was recorded for at least three successive wave periods in order to average out the effects of any small variations in the incident waves.

All connectors in the pressure transfer tubing were arranged to be kept permanently under water in a tank mounted above the model. This can be seen in Plate 1. The pressures in the tubing were sub-atmospheric and the water in the tank acted as a seal to prevent any entry of air into the system during the switching of the transducers from one set of three tubes to another set and also in the event of a leakage developing at a connector. Provision was made in the circuitry to permit purging of the tubing under pressure in order to clear any air or blockage from the tubes at the beginning of each test and at any other time, if the need arose. The pressure transducers were also connected to a calibrating chamber so that static calibrations of the total pressure recording system could be carried out at the beginning and end of each measurement session. The calibrating chamber was simply a stilling well with a pointer gauge with which the water surface level could be measured. When the well was connected to the wave basin, it registered the mean water level in the basin, and this provided the reference level for all wave pressure measurements. The chamber could be isolated from the wave basin and the water level in it could then be set to any desired level to provide direct static calibration of the pressure recording system.

3.5 Dynamic Calibration of Pressure Recording System

Although the response of the pressure recording system was optimised by the use of the appropriate length of connecting tube, as discussed in Section 3.31, it was not possible in the limited time available to achieve a response which was completely free of amplitude modulation. Consequently, the pressure recording system was calibrated dynamically at the frequencies corresponding to the design wave and to the cyclone wave so that the appropriate conversion factor could be applied to the static calibrations carried out regularly throughout the programme of measurement. This approach was satisfactory in this case because all of the recorded pressure responses showed that the dominant frequency in the dynamic pressure record was identical with the frequency of the incident wave (as would be expected) and that, further, any components at other frequencies, if present, were so small as not to be detectable within the accuracy of resolution of the pressure measurement (approximately 1 to 2 percent).

The dynamic calibration was carried out in an unobstructed wave flume. The mean water level, wave length and wave height were set to be the same as for the model tests. The wave height was measured with the wave probe and checked with a pointer gauge and the pressure at a point on the smooth wall of the clear wave flume was recorded with the pressure recording system. The amplitude of pressure fluctuation at the depth of the pressure tapping was calculated by means of first order wave theory and this amplitude was compared with the result obtained with the pressure recording system. The results of the dynamic calibration, in summary, were:-

(i) Wave period 1.065 secs; Tube length 15 feet:-
The Dynamic response was amplified 1.13 times compared to the static response.

(ii) Wave period 0.775 secs; Tube length 9 feet:-
The Dynamic response was attenuated by a factor of 0.80 compared to the static response.

3.6 Accuracy of Determination of Phase Relationship between Separate Tests

For those pressure histories recorded during the same experimental run, the phase relationship between pressure histories at different locations could be determined accurately from the synchronising event marker generated from the wave machine, described in Section 3.4. However, as was explained in Section 3.2, the complete set of pressure histories over all surfaces of the caisson could be obtained only from two separate runs for those tests in which the waves approached normally to the caisson and from four separate runs for tests in which the waves approached obliquely. The phase relationships between pressure histories from different runs were determined from the event marker also, but the accuracy of determination of phase was reduced because of slight variations in the characteristics of the incident waves in the separate runs. These variations existed because it was impossible to reproduce exactly every test parameter, viz;- water depth, wave height, wave period and location of wave probe, for two separate runs. Relatively small errors in determination of the phase relationship between pressure histories recorded on different parts of the structure can give rise to quite large errors in the results for integrated forces on the caisson as a whole and, consequently, an extensive series of tests was carried out to determine the accuracy which pertains to the measurement of phase relationship for such tests. The results of this investigation led to the conclusion that the accuracy of determination of phase relationship between separate experimental runs is within approximately ± 4 percent of the full wave period.

4. RESULTS OF WAVE PRESSURE MEASUREMENTS

The detailed results from the measurements of pressure on the surfaces of the berth caisson under wave action are presented in the Tables of Appendices 1 to 6. The pressure at each point is given as pressure head in feet of water relative to the pressure head that would be experienced at that point in still water at the appropriate tide level. For example, at a point which is h feet below the level of the tide corresponding to test conditions, wave pressures recorded in the Tables of Appendices 1 to 6 of $\pm \Delta h$ feet correspond to total pressure heads of $h \pm \Delta h$ feet of water, relative to atmosphere. With this convention, at a point which is exposed above the water line as the wave trough passes, the most negative relative pressure head which can be experienced under wave action is $- h$ feet.

It had been anticipated that those pressure sensing holes which were exposed to the air as the wave trough passed would give rise to problems from air entry to the pressure lines. In fact, no such problem was encountered. It was found that the loss of water from the pressure lines during the interval of exposure was not enough to permit any entry of air and the next wetting phase did not entrap any air, even at the entrance of the pressure tapping holes. Of course, the actual output of the pressure recording system during the interval of exposure had no relevance to the wave effects and the relative pressure head during exposure was set at $- h$ feet, as explained above.

The values of pressure heads given in Appendices 1 to 6 have been corrected for the effects of amplitude modulation on the dynamic response of the pressure transducers as described in Section 3.5.

The pressures on the surface of the Caisson due to wave action were integrated to give forces and moments acting on the whole Caisson and also on major elements of it. The co-ordinate and sign conventions used in these integrals are the standard conventions of calculus and are illustrated in Figure 4. The origin of co-ordinates is located at the centre of the Caisson base at foundation level and moments have been computed about this origin. In addition, moments on the columns have been computed about axes in the bases of the columns, i.e. at the level of the upper surface of the Caisson base. All integrals have been computed using the specific weight of fresh water, i.e. 62.4 lbs ft^{-3} in order to avoid a somewhat arbitrary choice for the weight of sea water.

Conversion of results to sea water values is achieved by multiplication by the relative density of sea water. It should be noted that all integrals of forces and moments presented in this Report are the effects due to wave action, relative to those which would be experienced in still water at the corresponding tide level. The total forces and moments applied to the Caisson by water pressures can be obtained by combining the integrals given in this Report with the hydrostatic forces calculated for still water at the corresponding tide level.

The time histories of forces and moments due to wave action on a Berth Caisson through one wave period are presented in the series of Figures numbered 5-1 to 10-8. The various test conditions to which these Figures relate are specified according to the following system:-

CODE	TEST CONDITIONS
H.W./24/normal	High Water: Waves 24 feet high approaching Caisson in direction normal to berthline.
L.W./24/normal	Low Water: Waves 24 feet high approaching Caisson in direction normal to berthline.
H.W./12/normal	High Water: Waves 12 feet high approaching Caisson in direction normal to berthline.
L.W./12/normal	Low Water: Waves 12 feet high approaching Caisson in direction normal to berthline.
H.W./24/E.S.E.	High Water: Waves 24 feet high approaching from E.S.E.

In all tests in which the waves approached in the direction normal to the berthline, there was no neighbouring Caisson present.

For those cases in which the gaps along the lower edges of the Caisson base were left unobstructed, the condition is referred to as "FULL OPENINGS UNDER" and, for cases in which these gaps were closed for 90 percent of their length, the condition is referred to as "TEN PERCENT OPENINGS".

In all of the model tests, water was allowed to enter the space inside each column through two holes, located one in each inward-facing side of the column. Scaled to prototype dimensions, each hole was 0.75 feet in diameter and was located 5 feet above the top surface of the Caisson base, on the centre-line of the face of the column. The depths of water inside the columns were inferred from the pressures recorded at the tappings in the top surface of the Caisson base, numbered 1 and 8, and it was found that the water surface inside each column varied significantly from the still water level throughout the wave period. The contributions to vertical components of forces and to moments due to these variations in water levels within the columns are included in all of the results presented in this Report, except where otherwise noted. Since it should be possible to achieve a virtually constant water level within the columns, corresponding to still water level, by reduction of the size of the openings through the sides of the columns, the effects of such a modification on maxima of forces and moments have been computed and are discussed in Section 4.1. Quantities calculated for the conditions when the water level inside each column is constant at still water level are indicated by a prime ' , i.e., $\Sigma F_Z'$ and $\Sigma My'$.

4.1 Maximum forces and moments due to waves approaching in direction normal to berthline

The maximum forces and moments on the Berth Caisson due to waves approaching in the direction normal to the berthline are set out in Table 1. The largest horizontal and vertical forces are caused by 24 feet high waves at High Water but the largest moments, in most cases, are caused by 12 feet high waves at Low Water.

However, for the latter case the vertical forces are relatively small and the maximum variations in foundation stresses, both positive and negative, are caused by 24 feet high waves at High Water.

The effects produced by maintaining the water level inside the columns constant at still water level can be seen in Table 1. Compared to the results from the model tests, this modification causes reductions in vertical forces but increases in moments for the case of 24 feet high waves at High Water, both for FULL OPENINGS UNDER[+] and for TEN PERCENT OPENINGS. In the case of 12 feet high waves at Low Water, moments are reduced by the modification for both conditions of openings while vertical forces are increased for FULL OPENINGS UNDER. For the other two test conditions in Table 1 the modification results in reductions in most maxima and no increase.

The benefits derived from restriction of the openings along the bottom edges of the Caisson are clearly shown in Table 1. For three

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[+]The largest of all maxima of moments is produced by this combination.

TABLE 1 - Ranges of Forces and Moments on Berth Caisson for Waves approaching in direction normal to berth-line.

Units of Force:- lbs x 10^6

Units of Moment:- lbs-feet x 10^6

WAVE HEIGHT:- TIDE STATE:-	24 feet HIGH WATER	24 feet LOW WATER	12 feet HIGH WATER	12 feet LOW WATER
ΣF_X				
MAX +ve	9.53	7.10	1.28	4.91
MAX -ve	-11.07	-4.94	-1.01	-4.78
FULL OPENINGS UNDER:-				
ΣF_Z				
MAX +ve	7.75	4.59	2.16	2.76
MAX -ve	- 7.93	-4.88	-2.26	-2.86
ΣMy				
MAX +ve	242	224	163	363
MAX-ve	-321	- 97	-141	-342
$\Sigma F'_Z$				
MAX +ve	7.09	4.59	1.66	2.88
MAX -ve	- 6.03	-4.77	-1.88	-2.98
$\Sigma My'$				
MAX +ve	265	219	148	343
MAX -ve	-371	- 92	-115	-328
TEN PERCENT OPENINGS:-				
ΣF_Z				
MAX +ve	5.58	3.63	1.71	0.24
MAX -ve	- 4.43	-3.91	-2.38	-1.33
ΣMy				
MAX +ve	233	112	153	353
MAX -ve	-271	NO NEGATIVE	-136	-326
$\Sigma F'_Z$				
MAX +ve	5.11	3.53	1.22	0.32
MAX -ve	- 2.72	-3.81	-1.99	-1.20
$\Sigma My'$				
MAX +ve	256	112	137	333
MAX -ve	-321	NO NEGATIVE	-110	-306

NOTE (a) $\Sigma F_Z'$ and $\Sigma My'$ are quantities calculated for conditions such that the water level inside each column is constant at still water level.

(b) The largest maximum in each category is under-lined.

of the four test conditions the case of TEN PERCENT OPENINGS has smaller maxima for all forces and moments than does the case of FULL OPENINGS UNDER. The only exceptions occur for the test condition of 12 feet high waves at High Water, for which the case of TEN PERCENT OPENINGS has slightly larger uplift forces than does the case of FULL OPENINGS UNDER.

4.2. Effects of Phase of Components on Maxima of Forces and Moments

For those cases in which integrals have been evaluated from data obtained during separate tests, the effects of the uncertainty in phase relationships (See Section 3.6) on the magnitude of the integrals are set out in Table 2. The quantities affected are the total horizontal force, the total vertical force (but only for the case of TEN PERCENT OPENINGS) and the total moment for both conditions of openings. The pressure records which are subject to uncertainty in their phase relationship to the majority of pressure measurements are those from the sides of the rear column and from the under surface of the Caisson base for the case of TEN PERCENT OPENINGS. The ranges of values shown in Table 2 correspond to the maximum likely error of phase; i.e. ± 0.31 seconds (± 4 percent, approximately) applied simultaneously to all affected components. Only the test conditions of 24 feet high waves at High Water and 12 feet high waves at Low Water are included in Table 2 since these, between them, include all except one of the largest maxima from Table 1.

It can be seen from Table 2 that the effects on the maxima of horizontal forces on the Caisson due to phase shifts amount to approximately ± 10 percent for both test conditons. The largest maximum of moment for the case of 24 feet high waves at High Water is subject to the same uncertainty of ± 10 percent but the range of uncertainty in the largest maximum of moment for the case of 12 feet high waves at Low Water is much smaller. The vertical force for TEN PERCENT OPENINGS is the quantity which is, proportionately, most affected by the phase shifts.

4.3 High Water: 24 feet high waves approaching in direction normal to berthline

The details of forces and moments experienced by a Berth Caisson and by components of it, for the conditions, H.W./24/normal, are shown in Figures 5-1 to 5-7. The total forces and moments for the whole Caisson are shown in Figure 5-1 and the separate contributions of the base

TABLE 2: Effects of Phase of Components on Forces and Moments on Berth Caisson

Units of Force: lbs x 10^6

Units of Moment: lbs-feet x 10^6

WAVE HEIGHT:-	24 Feet			12 Feet		
TIDE STATE:	HIGH WATER			LOW WATER		
	(1)	(2)	(3)	(1)	(2)	(3)
ΣF_x						
MAX +ve	9.53	10.45	8.47	4.91	4.37	5.37
MAX -ve	-11.07	-12.13	-10.04	-4.78	-4.18	-4.94
FULL OPENINGS UNDER:-						
ΣM_y						
MAX +ve	242	294	197	363	353	363
MAX -ve	-321	-352	-263	-342	-338	-345
$\Sigma M_y'$						
MAX +ve	265	317	215	343	333	343
MAX -ve	-371	-406	-313	-328	-324	-324
TEN PERCENT OPENINGS:-						
ΣF_z						
MAX +ve	5.58	7.08	4.08	0.24	0.48	0.14
MAX -ve	- 4.43	-5.40	-3.29	-1.33	-1.25	-1.60
ΣM_y						
MAX +ve	233	275	191	353	342	352
MAX -ve	-271	-293	-221	-326	-318	-340
$\Sigma F_z'$						
MAX +ve	5.11	6.81	3.51	0.32	0.45	0.11
MAX -ve	-2.72	-3.90	-1.58	-1.20	-1.37	-1.47
$\Sigma M_y'$						
MAX +ve	256	298	212	333	321	331
MAX -ve	-321	-347	-271	-306	-303	-320

NOTES: (a) In each case, the column numbers have the following significance:-

(1) Most probable values, as in Table 1.

(2) Components measured separately from main test have had their phase advanced by 0.31 seconds.

(3) Components measured separately from main test have had their phase retarded by 0.31 seconds.

(b) $\Sigma F_z'$ and $\Sigma M_y'$ are quantities calculated for conditions such that the water level inside each column is constant at still water level.

and columns to horizontal and vertical components of force are shown in Figures 5-2 and 5-3 respectively. The significant effects on vertical forces caused by partial closure of the gaps along the bottom edges of the Caisson are evident in Figures 5-1 and 5-3. The columns contribute the largest component to the horizontal force on the Caisson, as can be seen for Figure 5-2.

The details of forces and moments experienced by the columns are shown in Figures 5-4, 5-5 and 5-6. In all cases in which waves approach normally the signs of the forces and moments are correct for the <u>right front</u> column and the <u>left rear</u> column. It can be seen from Figure 5-6 that the columns are subjected to very large moments and, in fact, the columns make the largest contribution to the moments experienced by the Caisson as a whole.

The horizontal force experienced by the left side of the base of the Caisson is shown in Figure 5-7.

The time histories of forces and moments in Figures 5-1 to 5-7 display marked departures from symmetry which are due to a number of effects, including the large wave height (the ratio of wave height to water depth is approximately 1:3), separation of flow past the columns and interactions between the columns. It is of interest to note that, whereas the maximum total horizontal force is larger than the maximum of any partial contribution to it, the maximum of total moment is less than the maximum contribution from the columns, a result of the complex phase relationships between the several contributions to the total effect. The maximum of total vertical force is approximately the same as that on the top surface alone for the case of FULL OPENINGS UNDER but is smaller for the case of TEN PERCENT OPENINGS.

4.4 <u>Low Water: 24 feet high waves approaching in direction normal to berthline</u>

Total forces and moments experienced by the whole Berth Caisson for the conditions, L.W./24/normal, are shown in Figure 6-1. Comparison with Figure 5-1 shows that the maximum forces and moments at Low Water are less than those experienced at High Water. The separate contributions to horizontal and vertical forces are shown in Figures 6-2 and 6-3. It can be seen from Figure 6-2 that the reduction in total horizontal force at Low Water is due largely to reduction in the forces experienced by the columns. The details of horizontal forces and moments experienced by the columns are given in Figures 6-4, 6-5 and 6-6 and comparison with Figures 5-4, 5-5 and 5-6 shows that the maximum forces and moments on a column at Low Water are significantly less than those experienced at High Water.

4.5 High Water: 12 feet waves approaching in direction normal to berthline

The forces and moments experienced by a Berth Caisson for the conditions, H.W./12/normal, are shown in Figures 7-1 to 7-7.

Comparison with the results for the conditions, H.W./24/normal, shows that the maximum forces and moments are much smaller for the smaller wave. Forces on the base of the Caisson due to the action of 12 feet high waves are approximately one tenth to one quarter of those due to the action of 24 feet high waves. However, the ratio increases to more than one half in the cases of forces and moments on the columns and of total moments on the whole caisson. The time histories of forces and moments due to the action of the 12 feet high wave display significant departures from sy mmetry but they are relatively much smaller than those noted for the case of the 24 feet high wave. In the case of the 12 feet high wave, the maxima of total vertical forces and of total moments are each greater than the maxima of individual components contributing to the total but the maximum of total horizontal force is much smaller than the maximum of horizontal forces on the pairs of columns. This pattern is quite different from that noted for the case of the 24 feet high wave in Section 4.3 and the different ways in which the separate components combine, illustrate the great importance of the phase relationships between them.

4.6 Low Water: 12 feet high waves approaching in direction normal to berthline

The forces and moments imposed on a Berth Caisson for the conditions, L.W./12/normal, are shown in Figures 8-1 to 8-7. The maximum total horizontal force in this case is approximately four times as large as that produced by the same waves at High Water; much of this difference results from the different phase relationships between the contributions from the base of the Caisson and from the columns in the two cases. The maximum vertical force for FULL OPENINGS UNDER is somewhat larger for L.W./12/normal than for H.W./12/normal but for TEN PERCENT OPENINGS the maximum vertical force at Low Water is much smaller than that at High Water.

The total moments experienced by the whole Caisson for the conditions, L.W./12/normal,have maxima which are similar in magnitude to and, in some cases, considerably larger than those produced by the conditions, H.W./24/normal, as already noted in Section 4.1. The large total moments for the conditions, L.W./12/normal, are almost entirely the consequence of large moments on the base of the Caisson which, in turn, result from the fact that the contributions from the top and underneath surfaces of the caisson are nearly in phase. In contrast, the large total moments for the conditions, H.W./24/normal,arise from the very large moments experienced by the columns. (See Section 4.3).

4.7 Review of results from tests with waves approaching normally

It is clear from the cases which have been tested that the phase relationships between components are of over-riding importance in determining the magnitude of total forces and moments on the Berth Caisson. It is a tantalising question whether some intermediate condition not tested might give rise to larger effects than those measured and this question points to the desirability of carrying out tests, such as those reported here ,with random waves rather than with regular waves. Unfortunately, no test facility capable of generating random waves exists in Australia at the date of this Report.

4.8 High Water: 24 feet high waves approaching from E.S.E.

In the limited time available for the experimental studies it was not possible to carry out a full set of measurements for cases in which waves approached the Berth Caisson obliquely. The tests which were completed provide details of the effects of wave action on the columns of the Caisson for the conditions, H.W./24/ESE. Each of the four columns is subjected to different conditions in the case of angled waves, as shown in Figure 3. The key to the naming of the faces of the columns is also given in Figure 3.

The details of forces on the faces of each column and of total moments on each column about axes in the base of the column are shown in the two series of Figure 9-1 to 9-8 and 10-1 to 10-8. The results in Figures 9-1 to 9-8 are for the case when no neighbouring Caisson is present, whereas Figures 10-1 to 10-8 show the results for the case when the neighbouring Berth Caissons are present. Comparison between corresponding Figures in the two series shows that the presence of neighbouring Caissons results in changes in the forces and moments experienced by each column. The changes in maxima of moments+ on the columns are probably the best indicators of the magnitude of the effects of neighbouring Caissons. The maximum moment experienced by the Front Leading column is increased by approximately 25 percent in the presence of neighbouring Caissons as can be seen from comparison between Figures 9-2 and 10-2. The presence of neighbours results in only small changes in the maxima of moments on the Rear Trailing Column (see Figures 9-4 and 10-4) and on the Front Trailing Column (see Figures 9-6 and 10-6). This is not surprising since these two columns are down-wave from the other two columns on their own Caisson and the presence of more remote neighbours causes only small additional interference effects. Comparison between Figures 9-8 and 10-8 shows that the Rear Leading Column is the one most affected by the presence of neighbouring Caissons which cause the maxima of moments on that column to be increased almost twofold. This result also is consistent since the Rear Leading Column is the one most directly down-wave from the neighbouring Caisson for waves approaching from ESE.

For the structural design of the columns the stresses resulting from the combined effects of the two components of moment, M_x and M_y, are more important than the individual magnitude of either component. Since the columns are essentially square in plan the magnitude of the maximum stresses produced by the combined action of M_x and M_y is indicated closely by the sum of the magnitudes of M_x and M_y. The maximum magnitude of this sum for each of the various cases involving 24 feet high waves at High Water is set out in Table 3.

TABLE 3: Combined effects of components of moment on Columns of Berth Caissons

TEST CONDITION	COLUMN	MAXIMUM $\lvert M_x \rvert + \lvert M_y \rvert$ lbs-feet $\times 10^6$
H.W./24/normal	Front	92
H.W./24/normal	Rear	94
H.W./24/ESE: No Neighbour	Front Leading	86
H.W./24/ESE: Neighbour Present	Front Leading	90
H.W./24/ESE: No Neighbour	Rear Trailing	71
H.W./24/ESE: Neighbour Present	Rear Trailing	75
H.W./24/ESE: No Neighbour	Front Trailing	97
H.W./24/ESE: Neighbour Present	Front Trailing	94
H.W./24/ESE: No Neighbour	Rear Leading	64
H.W./24/ESE: Neighbour Present	Rear Leading	115

+The discussion in this paragraph relates to the separate components of moment, M_x and M_y

The maximum summation occurs for the rear leading column under conditions of angled waves in the presence of neighbouring Caissons.

5. COMPARISON BETWEEN EXPERIMENT AND THEORY

The forces and moments produced by calculations of C.J. Garrison+ based on linear small wave theory, are compared with the results derived from experimental pressure measurements in Fig. 11. The conditions for which the comparison is possible are those of High Water with cyclone waves approaching in the direction normal to the longer side of the Berth Caisson and, although the conditions used for theoretical calculations and experimental studies are very closely similar, they are not identical, as shown in Table 4.

TABLE 4: Conditions for Theoretical Calculation and for Comparable Experimental Study

	BED LEVEL	TIDE LEVEL	WAVE HEIGHT	WAVE PERIOD
THEORY	- 56 ft.	+ 22 ft.	23.6 ft.	8.25 sec.
EXPERIMENT	- 56 ft.	+ 20 ft.	24.0 ft.	8.25 sec.

The dimensions of the Caisson were the same for the two studies.

The quantities compared in Fig. 11 are total Moment, Horizontal and Vertical forces due to wave action on the exposed surfaces of the Caisson. The effects of wave induced pressure variations on the underside of the Caisson and inside the columns are not included in the comparison. The results obtained from the two approaches display significant differences. Whereas all three curves derived from linear wave theory are very symmetrical, as noted by Garrison, all curves obtained from measured pressure distributions display large departures from symmetry. These departures from symmetry are considered to be due to the significant non-linearity of the incident wave, to the effects of flow separation about the vertical columns and to interactions between the four columns, the spacing of which is not large compared to their dimensions.

Interactions between the columns under wave action were easy to observe during the experimental studies but they are difficult to describe. The phenomena have been recorded on movie film.

+"Report on wave forces on ocean caissons for extension to Hay Point Terminal - UDC" by C.J. Garrison, Naval Postgraduate School, Monterey, Calif., Jan. 1973.

The lack of symmetry in the curves derived from experimental results shows in the different magnitudes for positive and negative peak values. There are also complex effects on phase relationships between the three quantities. The phase shifts between the positive peaks of the three quantities, F_x, F_z and M_y are in good agreement between the two sets of results. However, for the negative values, the peaks in F_X are closely in phase for the two sets of results, the experimental peak for F_z leads that from the theoretical studies by approximately 6 percent of the wave period and the experimental peak of M_y lags that from the theoretical studies by approximately 9 percent of the wave period. The ratios of the peak values of the three quantities are given in Table 5.

TABLE 5: Comparison of Peak Values obtained by Calculation and Experiment

	$\frac{F_x \text{ (experiment)}}{F_x \text{ (theory)}}$	$\frac{F_z \text{ (experiment)}}{F_z \text{ (theory)}}$	$\frac{M_y \text{ (experiment)}}{M_y \text{ (theory)}}$
Positive Maxima	1.60	1.36	0.50
Negative Maxima	1.85	0.81	0.64

The differences are least for vertical force, F_z. The experimental values of horizontal force F_x are much larger than those predicted by linear wave theory but, in spite of this, the experimental values of moments are only approximately one half those predicted by the theory. The explanation of the latter result is that the total moment is the summation of contributions from the four columns, from the vertical faces of the base of the caisson and from its top surface; the combination is considerably smaller in magnitude than some of the individual contributions and the phase relationships between the individual contributions are of very great significance in determining whether effects are additive or whether they cancel each other.

RECOMMENDATION: Since the discrepancies between the experimental and theoretical results are so large it is strongly recommended that the full size Caisson be instrumented for the purpose of recording pressure variations due to wave action. The information so obtained would be of great value.

6. STUDY OF SCOUR NEAR CAISSONS DUE TO WAVE ACTION

The ocean bed at the site of the berth is covered with fine sand. The berth area is dredged to a general depth of 56 feet below low water and the berth caissons are founded on an area of crushed rock, consisting of sizes passing a 6 inch sieve, which has been levelled off to R.L. -56 feet. Scour tests were carried out at a linear scale of 1:60 in order to safeguard the structures against erosion resulting from wave action. The model of the main berth caisson which was used for pressure measurements was also used in the scour tests. At a scale of 1:60 the corresponding maximum size of foundation material for the model is 0.1 inch. The material used to represent the prototype foundation material in the scour studies was prepared from finely crushed rock, by rejection of all sizes not passing a No. 7 sieve and by washing from the remainder the sizes passing a No. 25 sieve. The size analysis of a typical sample is:

Sieve Size	No. 7	No. 14	No. 25
Particle Size (mm.)	2.4	1.2	0.6
% Passing	100	13	1

Interaction between the incident waves and the berth structures will produce significant velocities in the vicinity of the caissons and these induced velocities provide the most important mechanism for erosion of the foundation material. It is very difficult to assess the relative importance of viscous action in the complex phenomena involved in generation of the currents by interaction between incident waves and structures and in movement of the foundation material by these currents. However, the induced velocities are of the same order as the maximum orbital velocities in the incident wave and the Reynolds number based on bed material size is of order 10^3 in the model when the model foundation material has maximum size of 0.1 inch. It is considered that this Reynolds number is large enough to ensure that scale effects in the model will not be so large as to invalidate the general results of the scour studies. The results of the scour studies are considered to be qualitatively correct but no estimate can be made concerning quantitative accuracy.

6.10 Wave Scour near main berth caisson

For studies of wave scour near the main berth caisson, the model of the caisson was mounted at the centre of a layer of the crushed rock fines described in Section 6. The bed material was 2 inches deep over an area 6 feet x 6 feet and at the edges of this square the surface sloped down at a grade of approximately 1 in 6. The mean water depths and wave heights were measured at a location above the horizontal surface of the crushed rock where the incident wave was not significantly affected by the presence of the caisson. Throughout the complete series of tests there was no effect on scour detected which could be attributed to the change in bed level in the wave tank. The only scour observed occurred in the immediate vicinity of the caisson and it was clearly due to the currents resulting from interaction between the incident wave and the caisson.

Unless otherwise noted, all wave scour tests were run continuously for one hour, which corresponds to 7.75 hours of prototype time reckoned according to Froude number scaling. However, as noted in section 6, the uncertainty associated with different viscous effects in model and prototype makes scaling between elapsed times for the model and prototype approximate only. Further, the tide level varies continuously so that a continuous test at low water imposes conditions which are equivalent to a much longer interval of elapsed time with regard to scour development in the prototype.

6.11 Tests on Main Caisson without scour protection

The first scour studies of the main berth caisson were conducted without any scour protection in order to determine the extent of the problem.

Waves 24 feet high at Low Water: As was expected, the most extensive erosion developed for the case of cyclone waves at low water. For these conditions, when the waves approached in a direction normal to the berth-line, deep scour and undermining occurred along each edge of the caisson, as can be seen in Plates 3 and 4. In the test in which the waves approached the caisson at an angle (from E.S.E.), scour holes developed at each corner of the caisson but the scour holes at the two corners which were formed by the diagonal nearly parallel to the wave crests were much deeper and more extensive than those at the other corners, as can be seen in Plates 5 and 6.

Waves 24 feet high at High Water: Cyclone waves at High Water approaching normally to the berth-line caused deep scour along all four edges of the caisson as shown in Plates 7 and 8. The scour patterns are similar to those produced by the same waves occurring at Low Water but are not as deep or extensive.

Waves 12 feet high at Low Water: Design waves approaching normally to the berth-line at low water caused some scour to occur along each edge of the caisson in the region between the columns but not at the bases of the columns. The depth and extent of the scour were much less than for the case of 24 feet waves under similar conditions. Design waves approaching the caisson from the E.S.E. produced no observable scour.

6.12 Tests on Main Caisson with scour protection

The studies described in Section 6.11 demonstrated the need for protection against scour at the base of the berth caissons. The protection proposed consisted of a skirt of woven plastic fabric fixed to the bottom edges of the caisson and extending horizontally for a distance of 15 feet to provide a barrier between the erosive water currents and the foundation material. The fabric was to be held in place by concrete slabs, 7'6" square and having a net weight under water of 50-60 pounds per square foot. The slabs were to cover the fabric completely, and it was planned that they would be linked together at their edges by simple hinged connections. The protective fabric was to be of sufficiently open weave to permit rapid equalisation of pressures above and below it but the weave was to be close enough to prevent loss of any but the finest rock particles through it. In the tests on the model of the main berth caisson, an open weave soft plastic fabric was used to simulate the protective fabric and the slabs were simulated with square sheets of aluminium, 1.5 inch x 1.5 inch x 0.1 inch thick and weighing 0.023 lbs in air. The weight under water of the corresponding full size slabs is 56.8 lbs per sq. ft. and for concrete slabs, the required thickness is 8.25 inches. The small discrepancy in thickness of the slabs because of the use of aluminium for the model slabs is of no significance in the context of these studies. In the model studies the model slabs were not linked together so that any tendencies for the slabs to be moved about would be shown up more readily.

Waves 24 feet high at Low Water: For cyclone waves approaching normally to the berth-line at low water, most of the slabs nearest to the caisson were moved a little by the wave induced currents and some were displaced on to neighbouring slabs. The condition after one hour of model test is shown in Plates 9 and 10. Most of the movement of slabs occurred early in the test and there were only slight movements occurring at the end of the hour. As can be seen from Plates 9 and 10, the greatest movements of the slabs occurred at the front and rear of the caisson in the regions between the columns. There was some displacement of the foundation material underneath the protective fabric along all edges of the caisson in the regions between the columns and also near one rear corner (the right hand corner of Plate 10). This displacement was caused by the pumping action from oscillating currents produced by interaction between waves and caisson, which was strong enough to re-mould the foundation material even though it was protected by the fabric. The effect was to produce depressions in the foundation materials along the edges of the caisson in the regions noted above with depths generally about 1.25 feet but up to 2.5 feet in places and widths generally about 5 feet. No erosion was detected in regions beyond those protected by the fabric.

In the test in which the waves approached the caisson at an angle (from E.S.E.), very little movement of the slabs occurred except at the two outside corners where the slabs were moved about a great deal, as can be seen in Plates 11 and 12. At these corners also the foundation material under and at the edges of the protective fabric was displaced substantially by the pumping action referred to above with the result that the fabric drooped down into hollows about 1.25 feet deep, as can be seen in Plates 11 and 12. No displacement or scour of the foundation material was observed at any other position.

<u>Waves 24 feet high at High Water</u>: Cyclone waves approaching normally to the berth-line at High Water caused movements of slabs and displacement of foundation material under the protective fabric which were very similar to those observed for the same wave condition at low water, but a little less in magnitude. The conditions after one hour of model time are shown in Plates 13 and 14. In the test in which the waves approached the caisson from E.S.E., there was movement of only a few slabs at the two outside corners, as can be seen in Plates 15 and 16, but no movement of foundation material was detected anywhere.

<u>Waves 12 feet high at Low Water</u>: Design waves approaching normally to the berth-line at low water caused only slight movements of a few slabs, as shown in Plates 17 and 18. No scour or movement of foundation material was detected. When the waves approached from E.S.E. no movement of slabs occurred, nor was any scour detected.

Waves 12 feet high at High Water: Design waves at High Water caused no movement of slabs nor any detectable erosion or displacement of foundation material, regardless of the direction of approach of the waves.

6.20 Wave Scour near Approach Caisson

The approach structures linking the off-shore berth to the land are supported on caissons which are considerably smaller than the main berth caissons. The proportions of a typical "approach" caisson are shown in Fig. 12. Two alternative treatments of the foundation for the approach caissons were considered and these also are shown in Fig. 12. In the "lowered" foundation the sea-bed, which is generally at R.L. -45 feet, is dredged to R.L. -50 feet over an area 80-90 feet square and the excavation backfilled with rock (passing 6 inch opening) to a depth of 2 feet. In the "raised" foundation the layer of rock is placed directly on the sea-bed without dredging and the caisson is founded on top of the raised layer of crushed rock. In each case, protective woven plastic fabric attached to the bottom edges of the caisson extends horizontally for a distance of 15 feet and is weighted down with concrete slabs of the same dimensions as those described in section 6.12 in connection with the main berth caissons. As shown in Fig. 12, the approach caissons are supported on four foundation pads, one at each corner, leaving a cruciform space underneath the caisson where there is no contact with the foundation.

6.21 Tests on approach caisson on lowered foundation, with sea bed modelled in loam

In the first set of wave scour studies on the approach caisson set on the lowered foundation, the sea bed was modelled in brick-layer's loam, a material containing fine sand and silt sizes and a small proportion of clay. The layer of crushed rock forming the foundation course was modelled with the same crushed rock fines as used for the tests on the berth caisson and the protective fabric was simulated with the same woven, soft plastic fabric as had been used with the berth caisson. The gaps along the bottom edges of the caisson between the foundation pads were left open. The only test which was conducted with a sea-bed of loam used cyclone waves at low water, the waves approaching in a direction parallel to one diagonal of the caisson. The conditions after one hour of testing are shown in Plates 19 and 20. There was no movement of the slabs and only a small amount of scour of the sea bed occurred at the rear ("down-wave") corner of the protective fabric. The wave motion formed a ripple pattern on the originally smooth loam surface and the wave length of the ripples was approximately 1.75 to 2 inches which corresponds closely to the scaled value of the calculated amplitude of excursion of water particles near the sea bed (9.75 feet at full scale), resulting from the wave motion at these conditions. Interaction between the waves and the caisson modified the movement of bed material, especially in the lee of the caisson; there was significant deposition near the two lee edges of the caisson and a region of general scour of the sea-bed down-wave from the rear corner of the protective fabric, as shown in Plate 20.

6.22 Tests on approach caisson on lowered foundation with sea bed modelled in coarse sand

The loam proved to be an unsatisfactory material for scour tests because the fine silt and clay quickly clouded the water during testing and it was impossible to observe phenomena near the sea bed while testing took place. In the second series of tests on the approach caisson set on the lowered foundation, the sea bed was modelled in coarse river sand. This sand was used, because of a misunderstanding by the technical staff, when it was intended that fine beach sand should be used. The extra set of tests carried out because of this mistake proved to be valuable in that they helped to demonstrate that the erosion patterns developed near the caisson did not depend in any substantial way on the material which was used to model the sea bed.

It had been observed in the tests described in Section 6.21 that the plastic fabric was a little too stiff to take up the contours of erosion patterns under it and, so, in the tests described in this section and for all subsequent tests with the approach caisson a soft, open-weave cotton fabric was used to simulate the protective fabric. This material was found to be satisfactory.

In the first test with the sea-bed of coarse sand, the conditions otherwise were the same as those described in Section 6.21; cyclone waves at Low Water approached the caisson in a direction parallel to one of its diagonals. After one hour of testing the resulting patterns of ripple formation away from the caisson (including the wave-length of the ripples) and of deposition and scour in the lee of the caisson were so similar to those described in Section 6.21 and recorded in Plates 19 and 20, that no photographic record was considered necessary.

For the second test with the sea-bed modelled in coarse sand the conditions were the same as in the first test except that the waves approached the caisson in a direction normal to one face. The conditions after one hour of testing are shown in Plates 21 and 22. During this test many of the slabs were moved about a great deal and some were tossed off the protective fabric, leaving the fabric free to flap in some places, especially on the lee side. There was a strong pumping action on the foundation through the fabric near the gaps along the bottom edges of the caisson and this caused pronounced remoulding of the foundation material, as can be seen in Plate 22. Interaction between the caisson and the wave motion interrupted the general pattern of sediment movement down-wave from the caisson and caused a scour hole to form over extensive areas in the lee of the caisson, as can be seen in Plate 22.

Observations of the phenomena occurring near the base of the caisson while the test was in progress indicated that the currents which caused the greatest displacement of slabs and remoulding of the foundation were associated with the presence of the gaps along the bottom edges of the caisson. Consequently, in all later tests the gaps along the bottom edges of the caisson were closed off completely.

6.23 Tests on approach caisson on lowered foundation, with sea bed modelled in fine sand

The final series of tests on the approach caisson set on the lowered foundation was carried out with the sea-bed modelled in fine beach sand. The soft cotton fabric was used to simulate the protective fabric and the gaps at the bottom edges of the caisson were closed off. The tests described in section 6.21 had shown that, even with the gaps open, 24 ft waves at Low Water approaching in a direction parallel to a diagonal of the caisson did not produce any movement of slabs or scour in the vicinity of the caisson but when, for the same conditions, the wave direction was normal to one face of the caisson, there was severe attack on the foundation near the caisson. Consequently the study was now focussed on the latter set of conditions. The conditions after one hour of testing with 24 ft waves at Low Water, approaching normally to one face of the caisson, are shown in Plates 23 and 24. The general ripple pattern had formed on the sea-bed as in previous tests and the wave length of the ripples was the same as had been noted for the earlier tests with loam and coarse sand beds, i.e. 1.75 to 2 inches.

The beneficial effect of closing the bottom gaps is obvious if comparison is made with Plates 21 and 22. With the gaps closed there was scarcely any movement of the slabs and, at the front and sides of the caisson, substantial quantities of sand were deposited on top of the slabs, which had been clear of sand at the beginning of the test. At the rear of the caisson, the sea bed was eroded over an extensive region in a similar way to that noted for previous tests. More detailed studies carried out at this stage demonstrated that the erosion of the sea bed in the lee of the caisson is caused by a strong streaming motion which occurs in this region and which results from the interaction between the incident waves and the caisson. If the cyclone waves persisted from the same direction for periods in excess of several tidal cycles, then extensive erosion of the sea bed beyond the foundation protection is likely. However, in estimating the probability and seriousness of such an occurrence it should be remembered that changes in direction of the waves are likely to result in previously formed erosion holes being filled up and new erosion patterns being scoured out in a different location.

The case of 12 ft waves at Low Water was also examined for this configuration, the direction of the waves being normal to one face of the caisson. Even after an extended test of 2 hours duration, ripples had not formed on the bed and there was no movement of slabs nor was there any erosion of foundation material.

6.24 Tests on approach caisson on raised foundation with sea bed modelled in fine sand

The first condition examined for the alternative foundation design, the raised foundation, was that of 24 ft waves at Low Water approaching in a direction parallel to a diagonal of the caisson. The gaps along the bottom edges of the caisson were closed off. For the first fifteen minutes of the test nothing untoward was observed but then, quite suddenly, several slabs began to move noticeably and something rather like a chain reaction developed as more and more slabs were shifted bodily over considerable distances. After one hour of testing the foundation protection was in a sorry state, as can be seen in Plates 25 and 26. Consequently the raised type of foundation was judged to be completely unsatisfactory.

7. ACKNOWLEDGEMENTS

Many people contributed to the studies described in this report and several of them deserve special mention. Mr. R. Cowley (presently with the Department of Chemical Engineering, University of Auckland) did most of the developmental work with the instrumentation and, working creatively within severe restrictions of time and of type of instrumentation available, produced a successful system for measurement of dynamic pressures in difficult conditions. Mr. R. Hammer carried out all of the detailed measurements of pressure and maintained a high level of reliability despite stress arising from the urgency with which the results were sought by the design engineers and from the sometimes trying weather conditions. Mr. R. Eaton of the Civil Engineering Department's Workshop displayed skill and speed in constructing the model of the berth caisson.

C. J. Apelt

C.J. APELT, B.E. D.Phil(Oxon)
January 1976.

8. LIST OF FIGURES

9. LIST OF PLATES

Plate No.	Description
15.	Scour test on berth caisson with scour protection installed. Front view after one hour's testing at High Water with 24 ft waves approaching from E.S.E.
16.	Scour test on berth caisson with scour protection installed. Rear view after one hour's testing at High Water with 24 ft waves approaching from E.S.E.
17.	Scour test on berth caisson with scour protection installed. Front view after one hour's testing at Low Water with 12 ft waves approaching in direction normal to berthline.
18.	Scour test on berth caisson with scour protection installed. Rear view after one hour's testing at Low Water with 12 ft waves approaching in direction normal to berthline.
19.	Scour tests on approach caisson; sea-bed of loam; lowered foundation and bottom gaps open. Front view after one hour's testing at Low Water with 24 ft waves approaching at 45^{o} angle.
20.	Scour tests on approach caisson; sea-bed of loam; lowered foundation and bottom gaps open. Rear view after one hour's testing at Low Water with 24 ft waves approaching at 45^{o} angle.
21.	Scour tests on approach caisson; sea-bed of coarse sand; lowered foundation and bottom gaps open. Front view after one hour's testing at Low Water with 24 ft waves approaching in direction normal to berthline.
22.	Scour tests on approach caisson; sea-bed of coarse sand; lowered foundation and bottom gaps open. Rear view after one hour's testing at Low Water witn 24 ft waves approaching in direction normal to berthline.
23.	Scour tests on approach caisson; sea-bed of fine sand; lowered foundation and bottom gaps closed. Front and side view after one hour's testing at Low Water with 24 ft waves approaching in direction normal to berthline.
24.	Scour tests on approach caisson; sea-bed of fine sand; lowered foundation and bottom gaps closed. Rear and side view after one hour's testing at Low Water with 24 ft waves approaching in direction normal to berthline.
25.	Scour tests on approach caisson; sea-bed of fine sand; raised foundation and bottom gaps closed. Front view after one hour's testing at Low Water with 24 ft waves approaching at 45^{o} angle.
26.	Scour tests on approach caisson; sea-bed of fine sand; raised foundation and bottom gaps closed. Rear view after one hour's testing at Low Water with 24 ft waves approaching at 45^{o} angle.

10. LIST OF APPENDICES

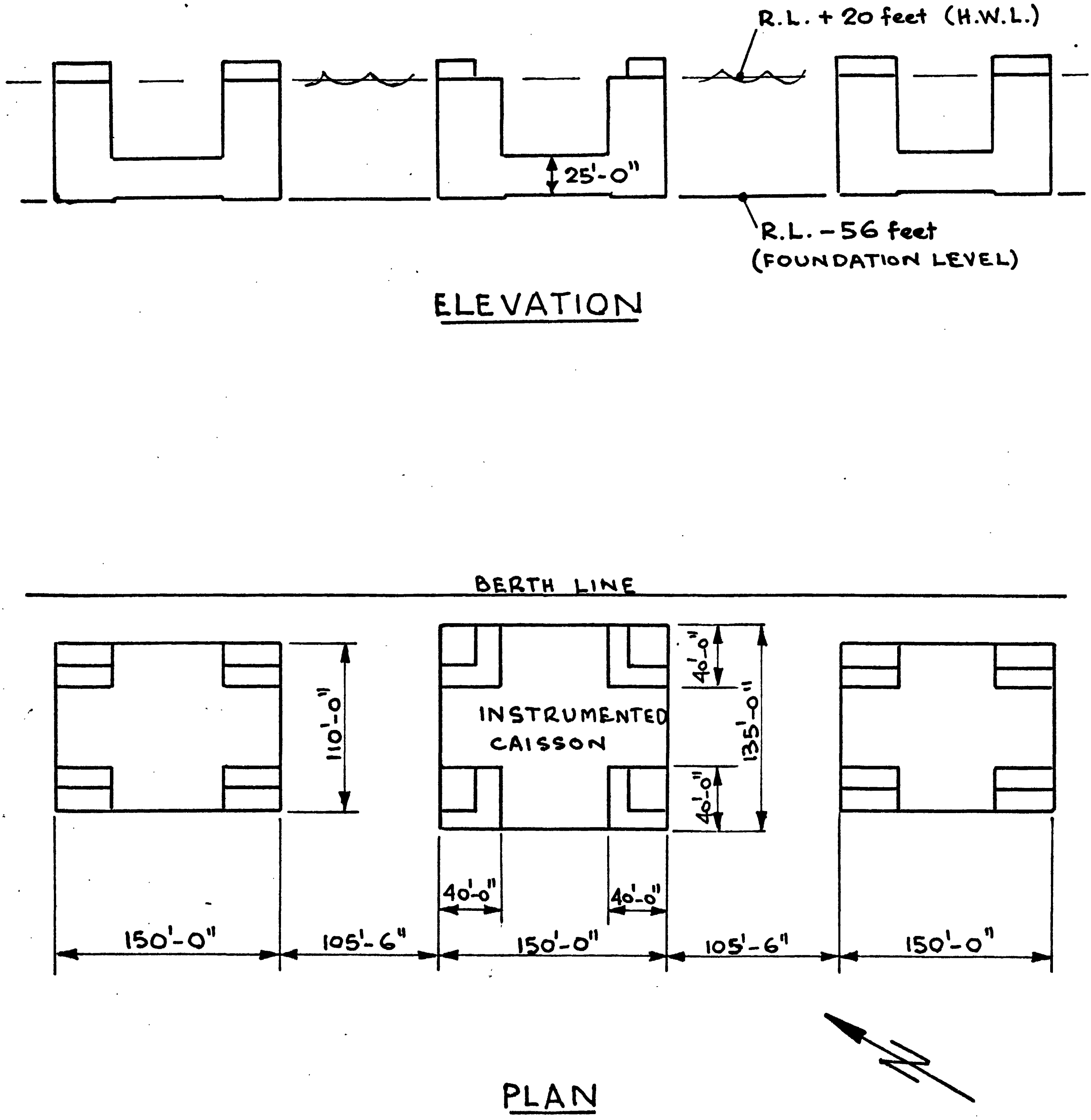
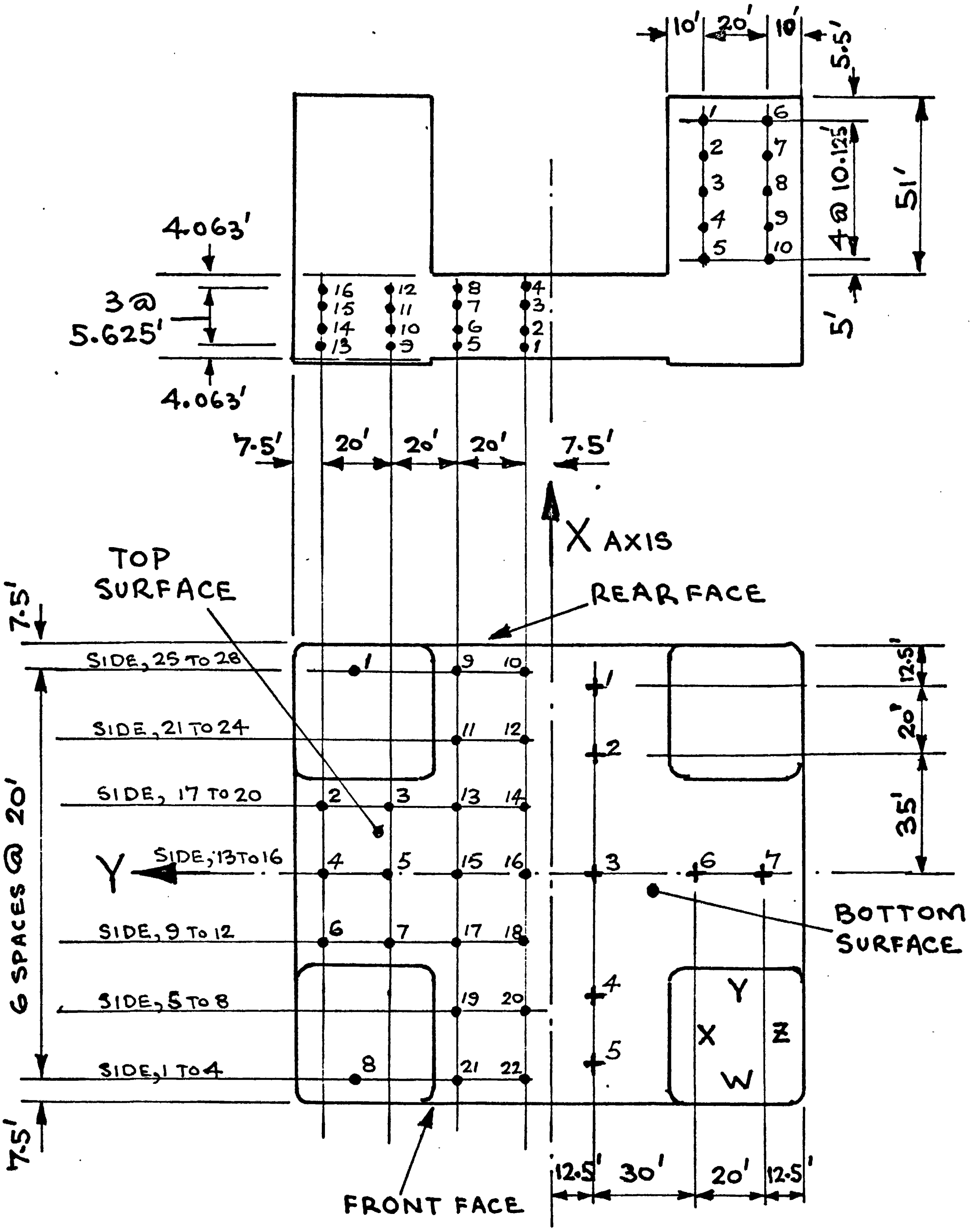


FIGURE 1. BERTH CAISSONS



NOTES :-

1. FRONT FACE AND REAR FACE TAPPINGS ARE NUMBERED IN SAME SEQUENCE.

2. SIDE FACE ;- LOWEST NUMBER OF EACH GROUP OF FOUR TAPPINGS IS IN LOWEST LOCATION.

3. TAPPINGS IN EACH FACE OF INSTRUMENTED COLUMN ARE NUMBERED IN SAME SEQUENCE

4. DIMENSIONS ARE FEET, FULL SIZE

FIGURE 2. LOCATION OF PRESSURE TAPPING HOLES ON MODEL OF BERTH CAISSON.

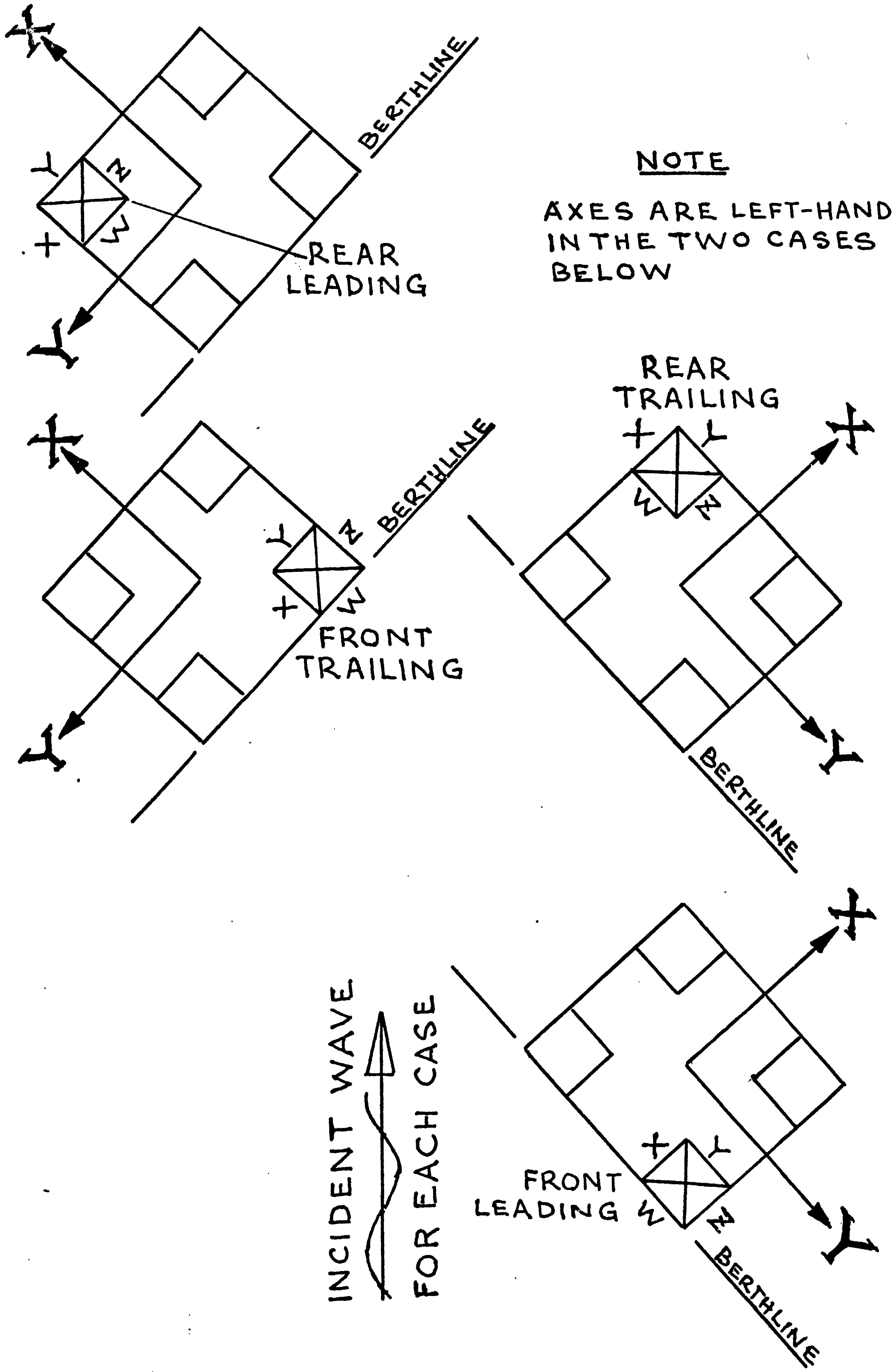


FIGURE 3. ANGLED WAVES; FOUR ORIENTATIONS OF MODEL REQUIRED FOR COMP LETE SET OF PRESSURE MEASUREMENTS.

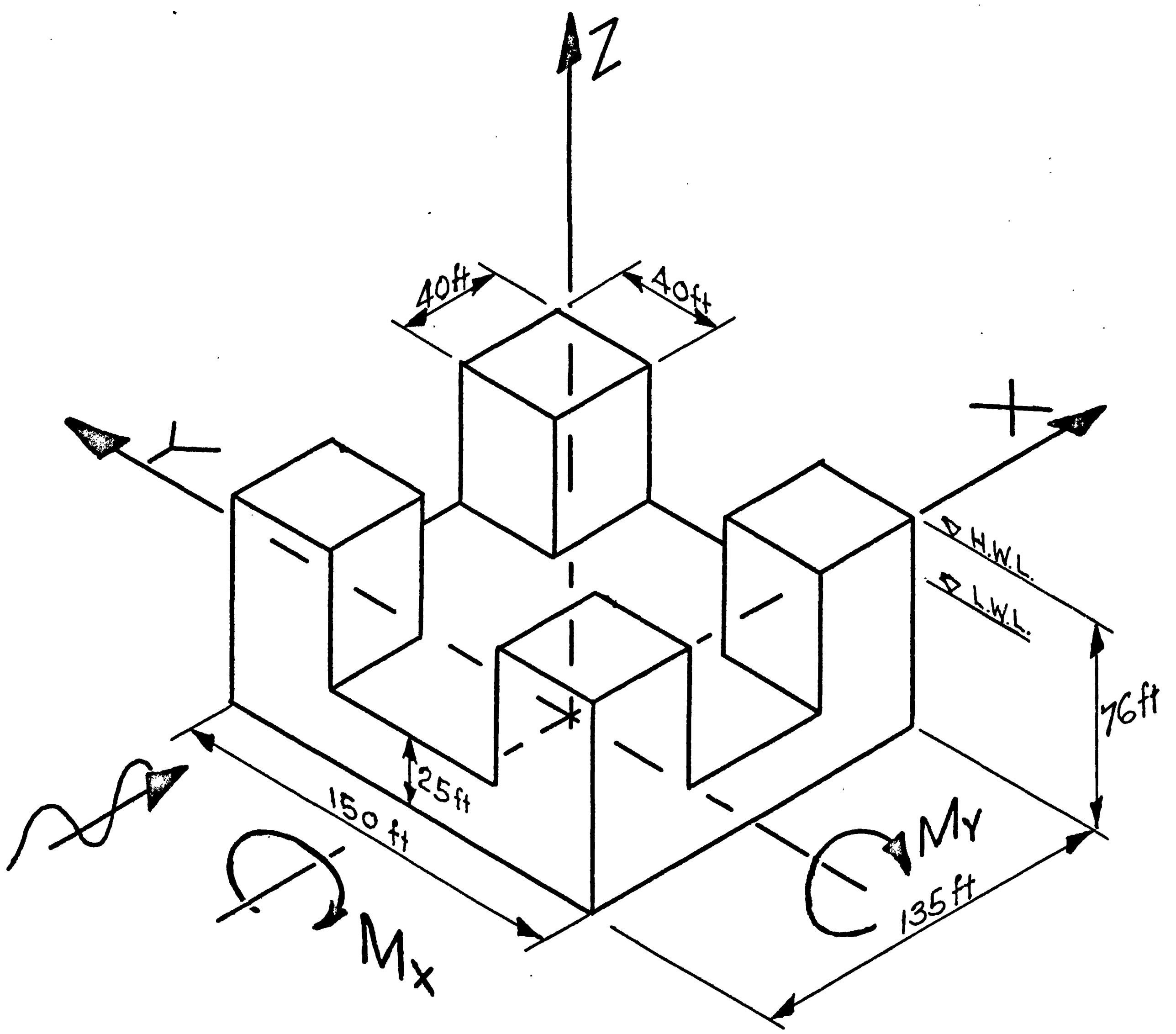


FIGURE 4. COORDINATE AND SIGN CONVENTIONS FOR FORCES AND MOMENTS ON CAISSON DUE TO WAVE ACTION.

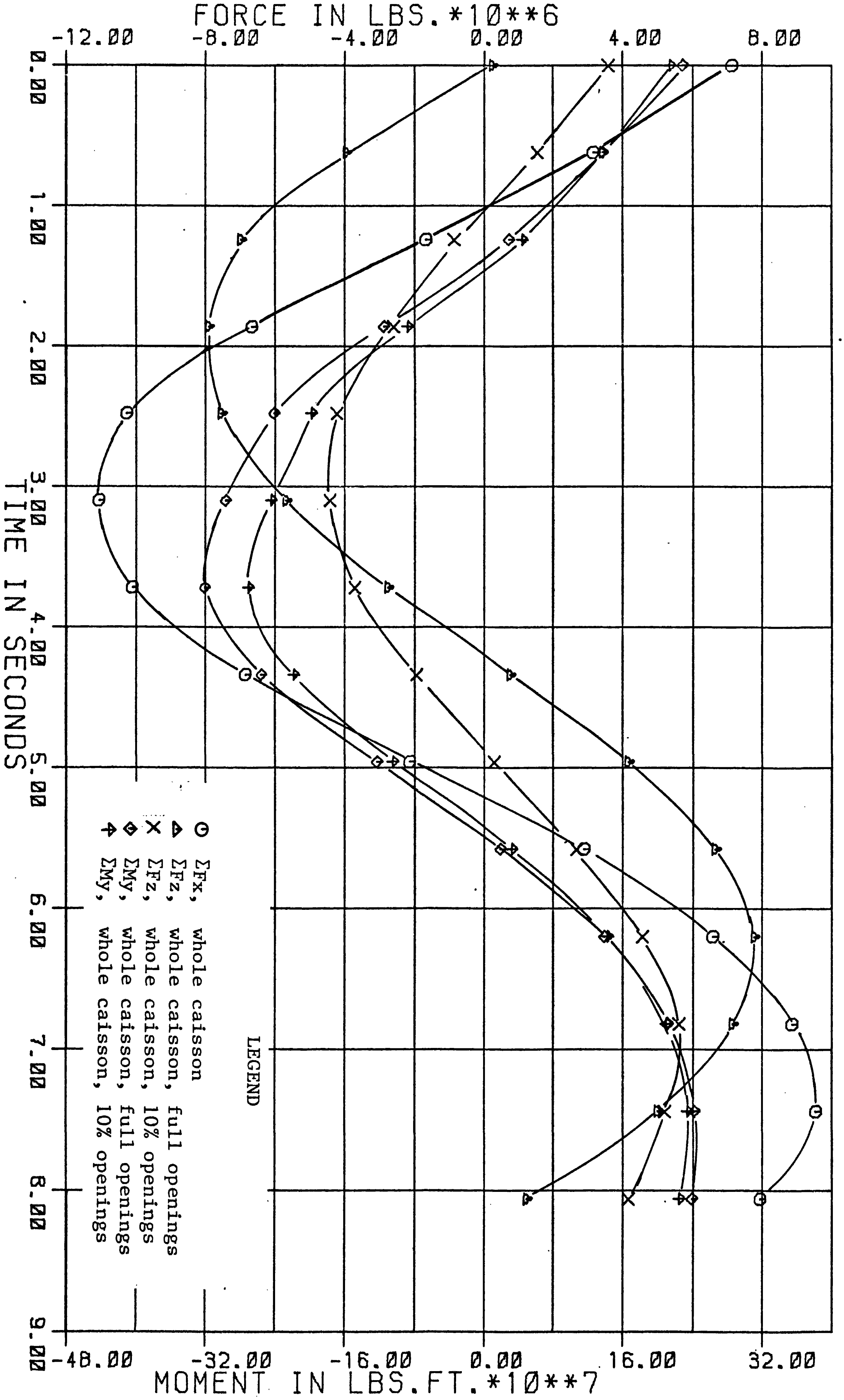


FIGURE 5-1. TOTAL FORCES AND MOMENTS ON BERTH CAISSON FOR CASE, H.W./24/NORMAL.

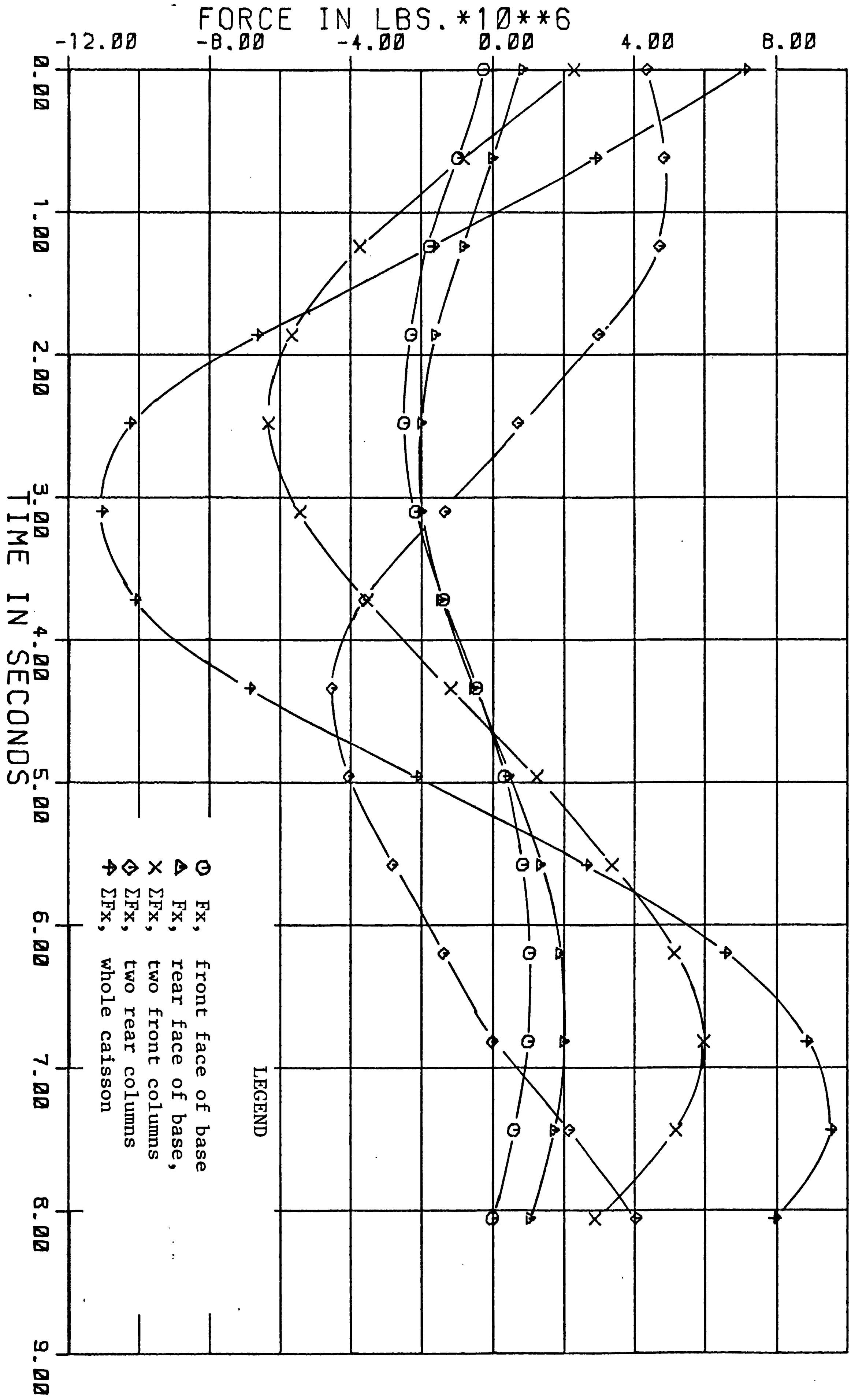


FIGURE 5-2. HORIZONTAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, H.W./24/ NORMAL.

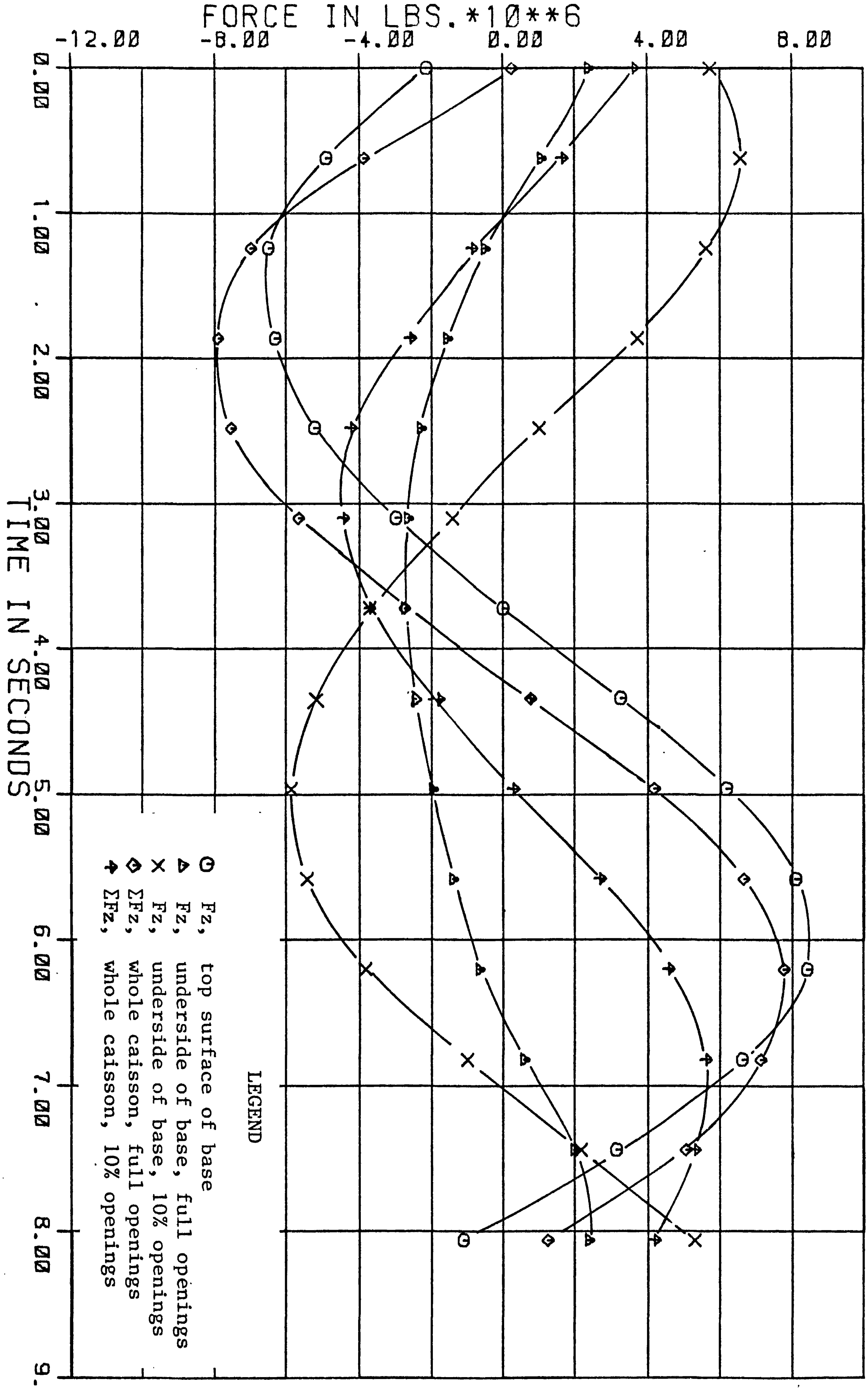


FIGURE 5-3. VERTICAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, H.W./24/ NORMAL.

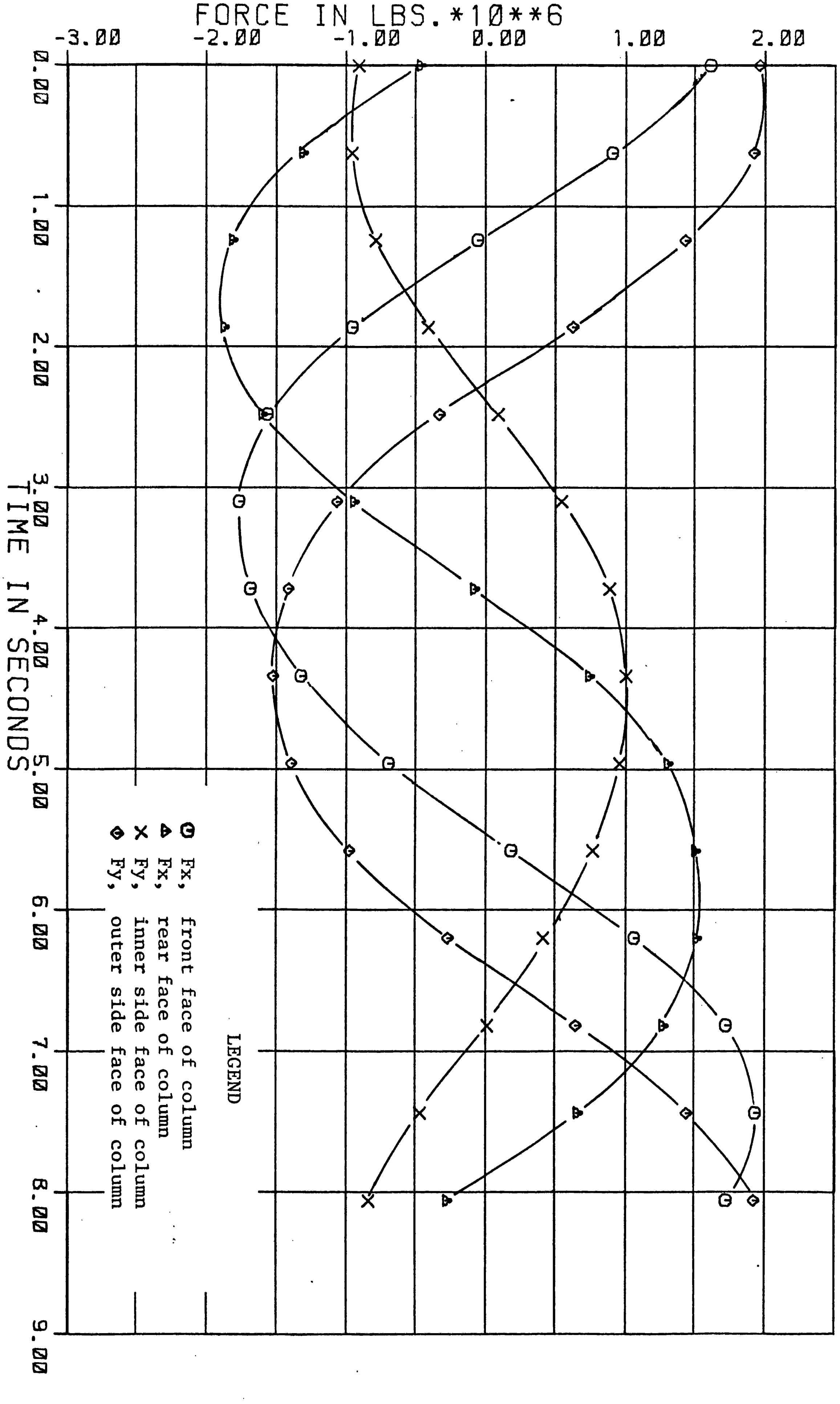


FIGURE 5-4. FORCES ON FRONT RIGHT COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ NORMAL.

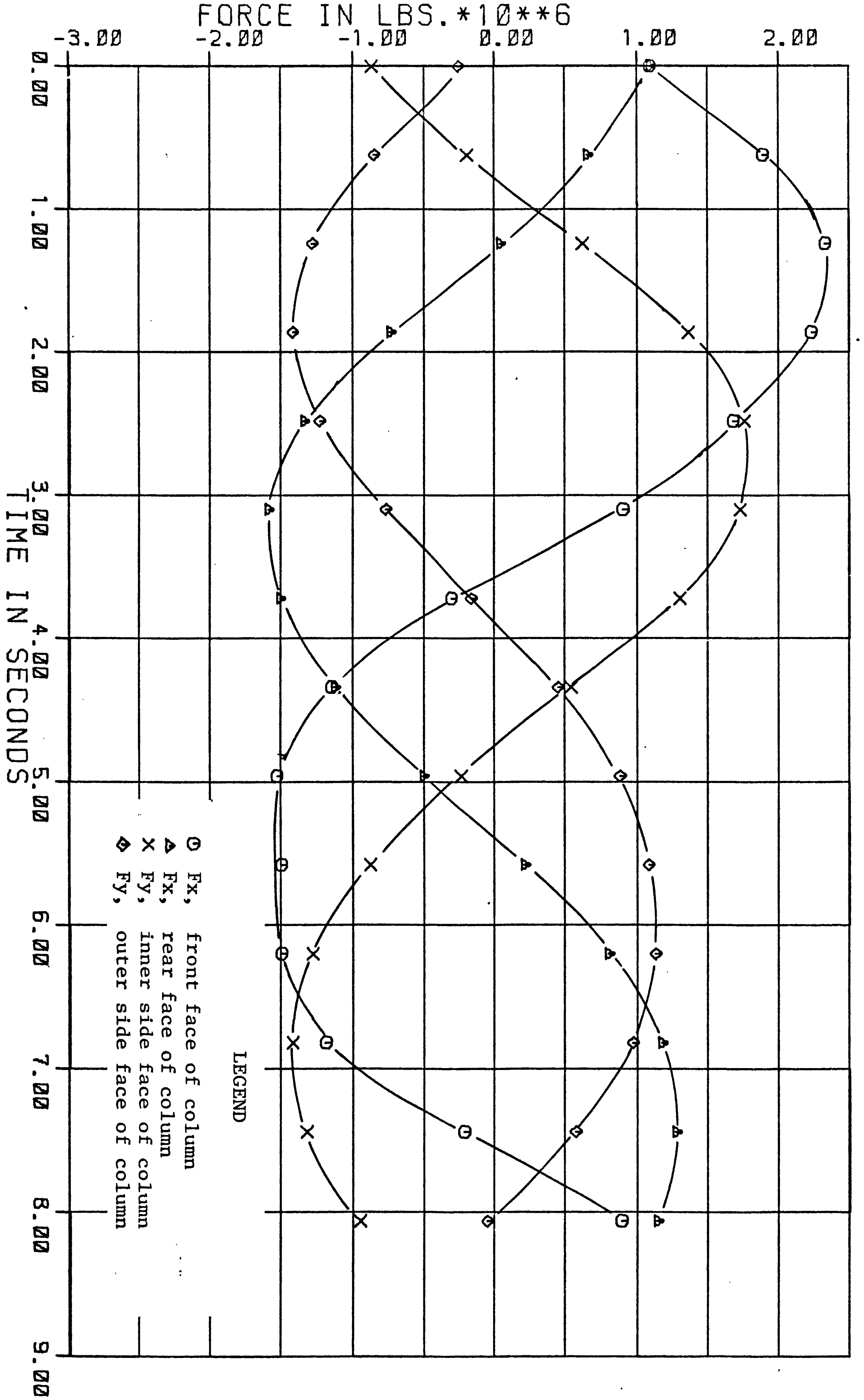


FIGURE 5-5. FORCES ON REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, H.W./24/NORMAL.

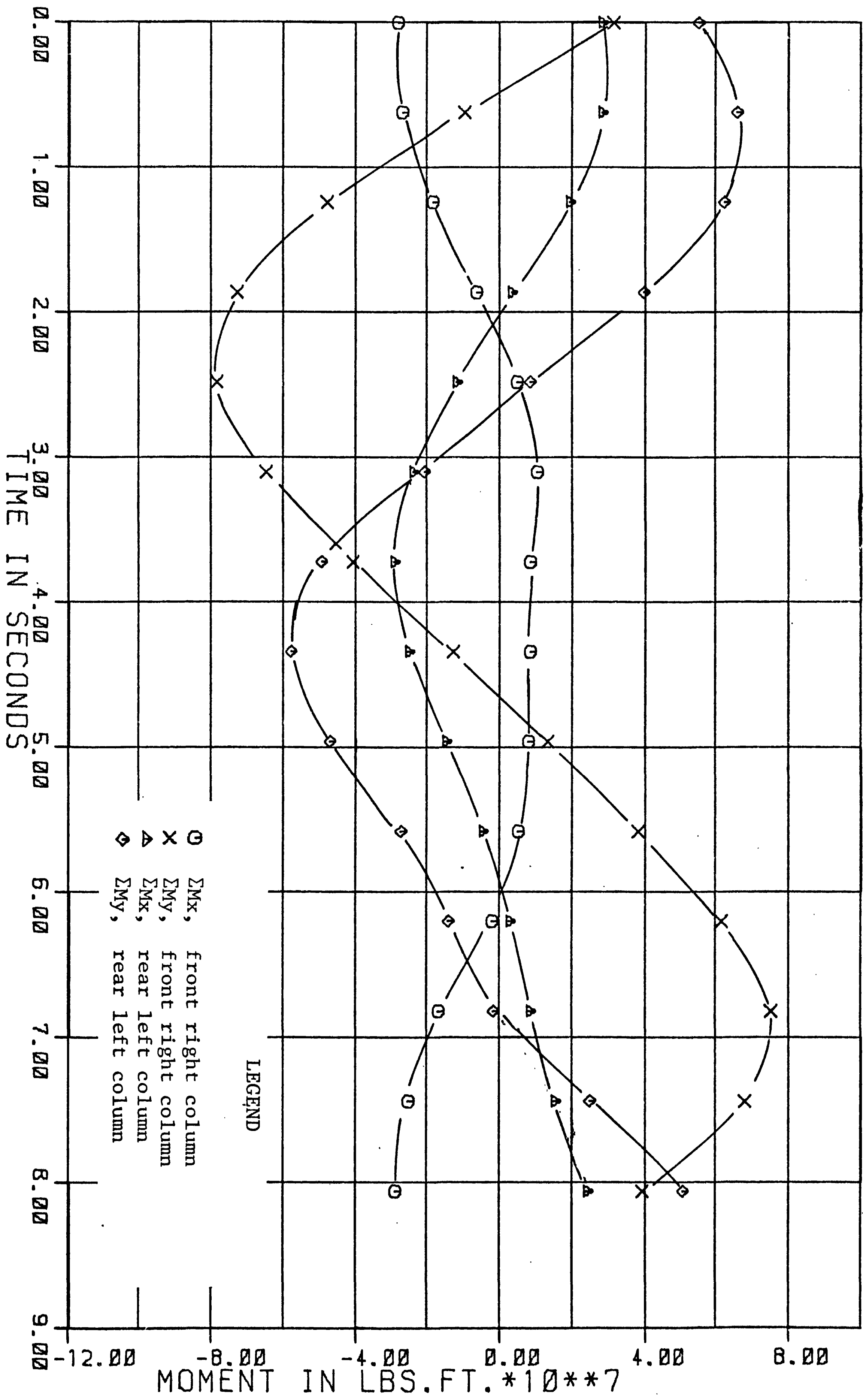


FIGURE 5-6. MOMENTS ABOUT COLUMN BASE ON FRONT RIGHT COLUMN AND REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ NORMAL.

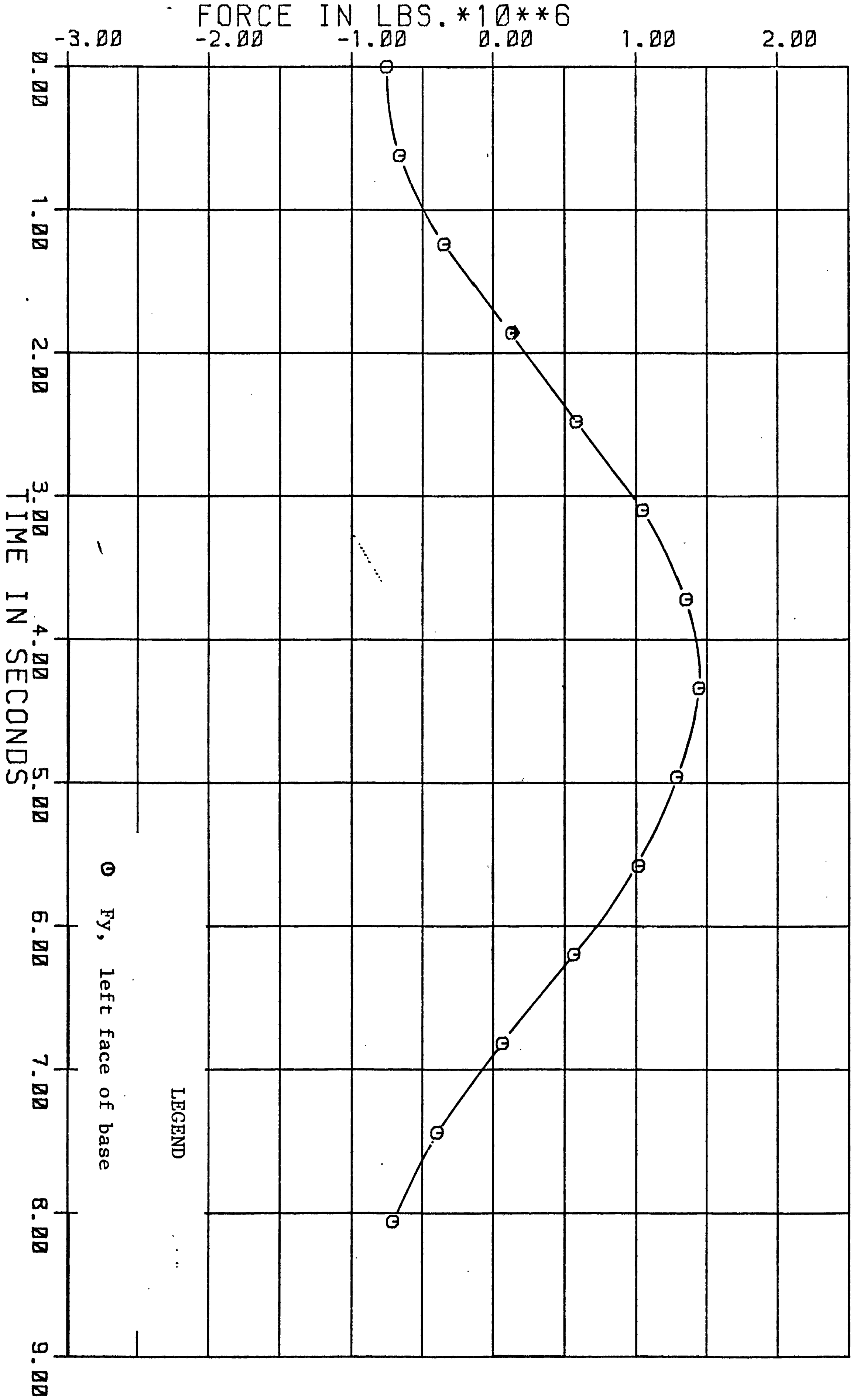


FIGURE 5-7. HORIZONTAL FORCE ON LEFT SIDE OF BASE OF BERTH CAISSON FOR CASE, H.W./24/NORMAL.

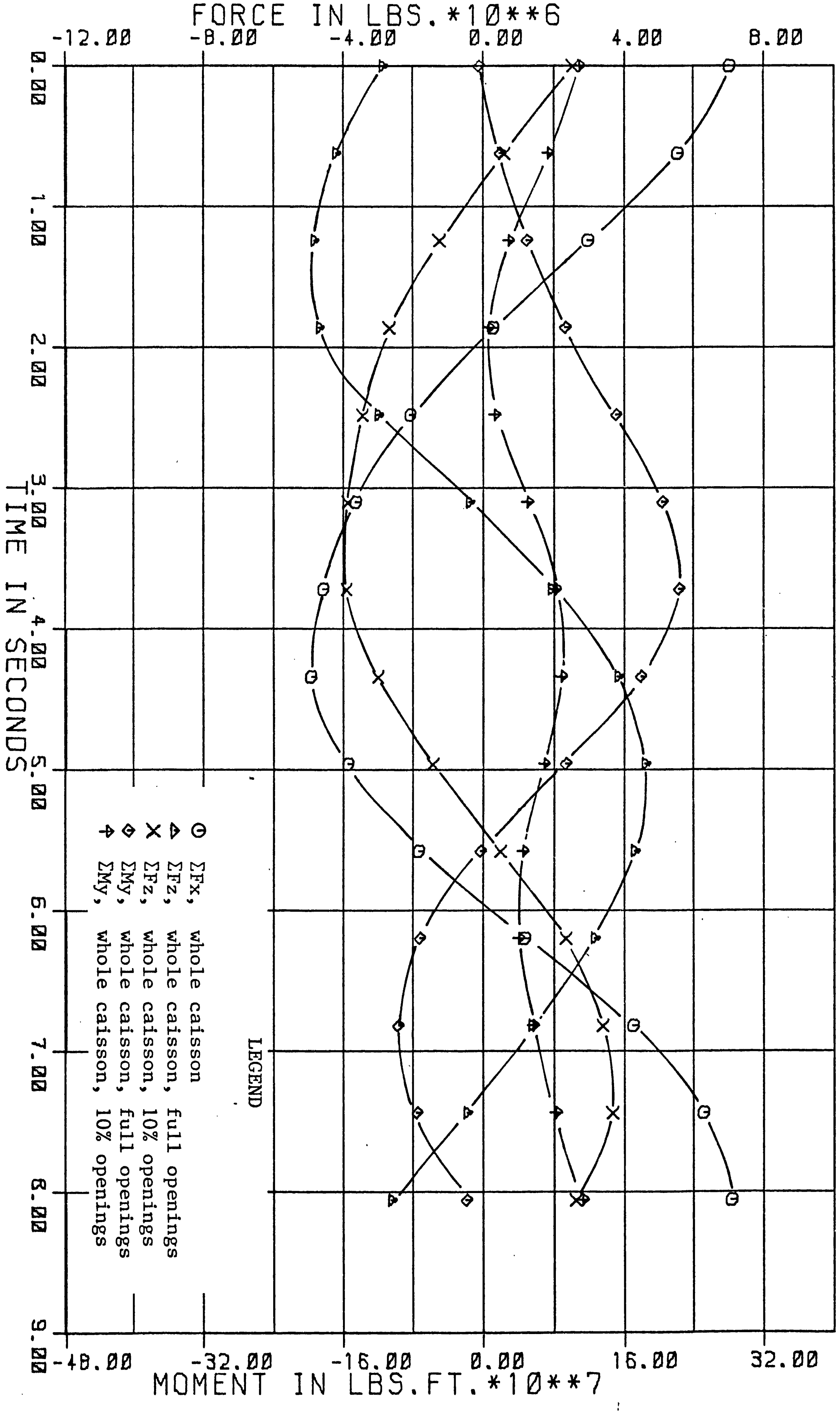


FIGURE 6-1. TOTAL FORCES AND MOMENTS ON BERTH CAISSON FOR CASE, L.W./24/NORMAL.

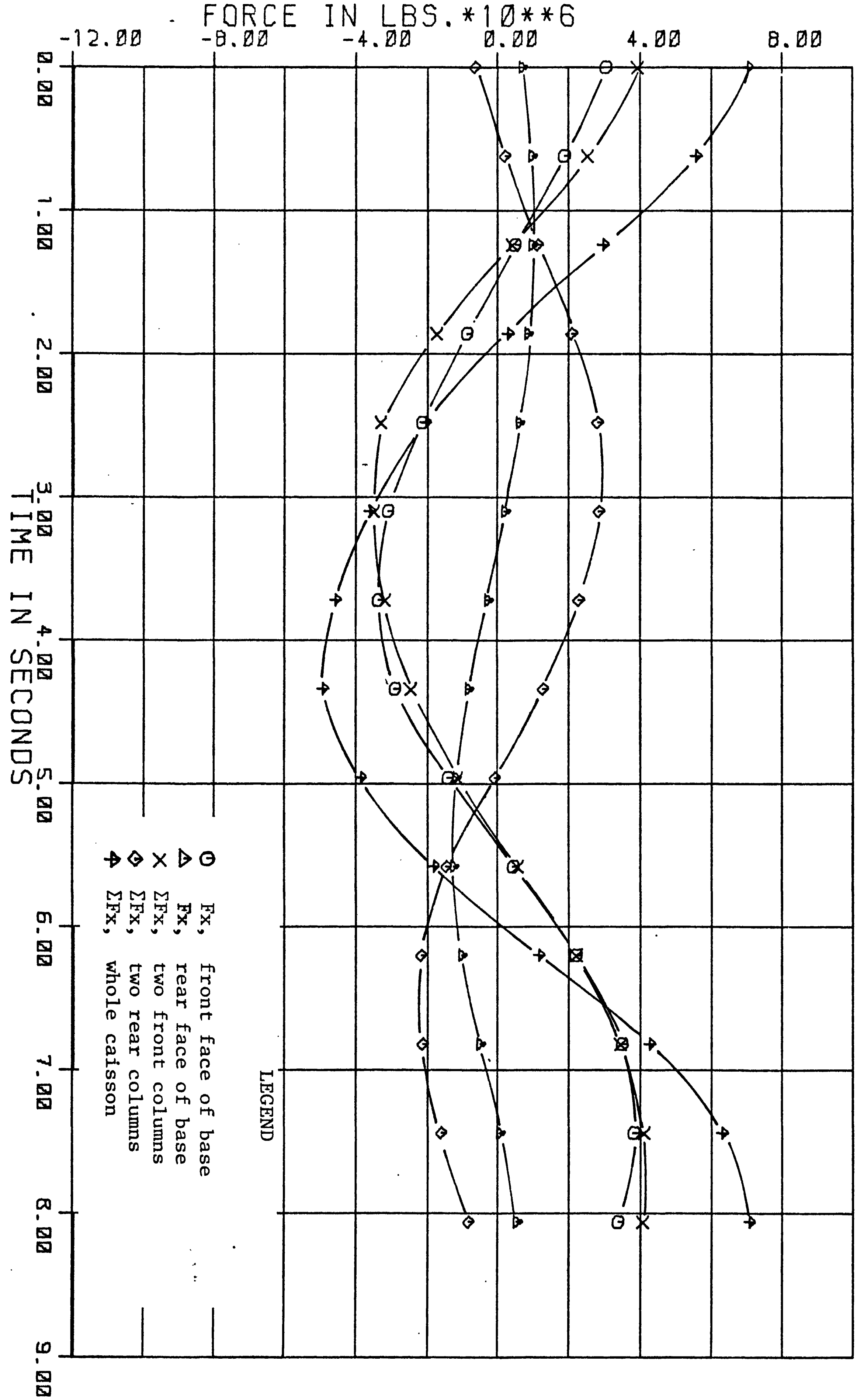


FIGURE 6-2. HORIZONTAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, L.W./24/ NORMAL.

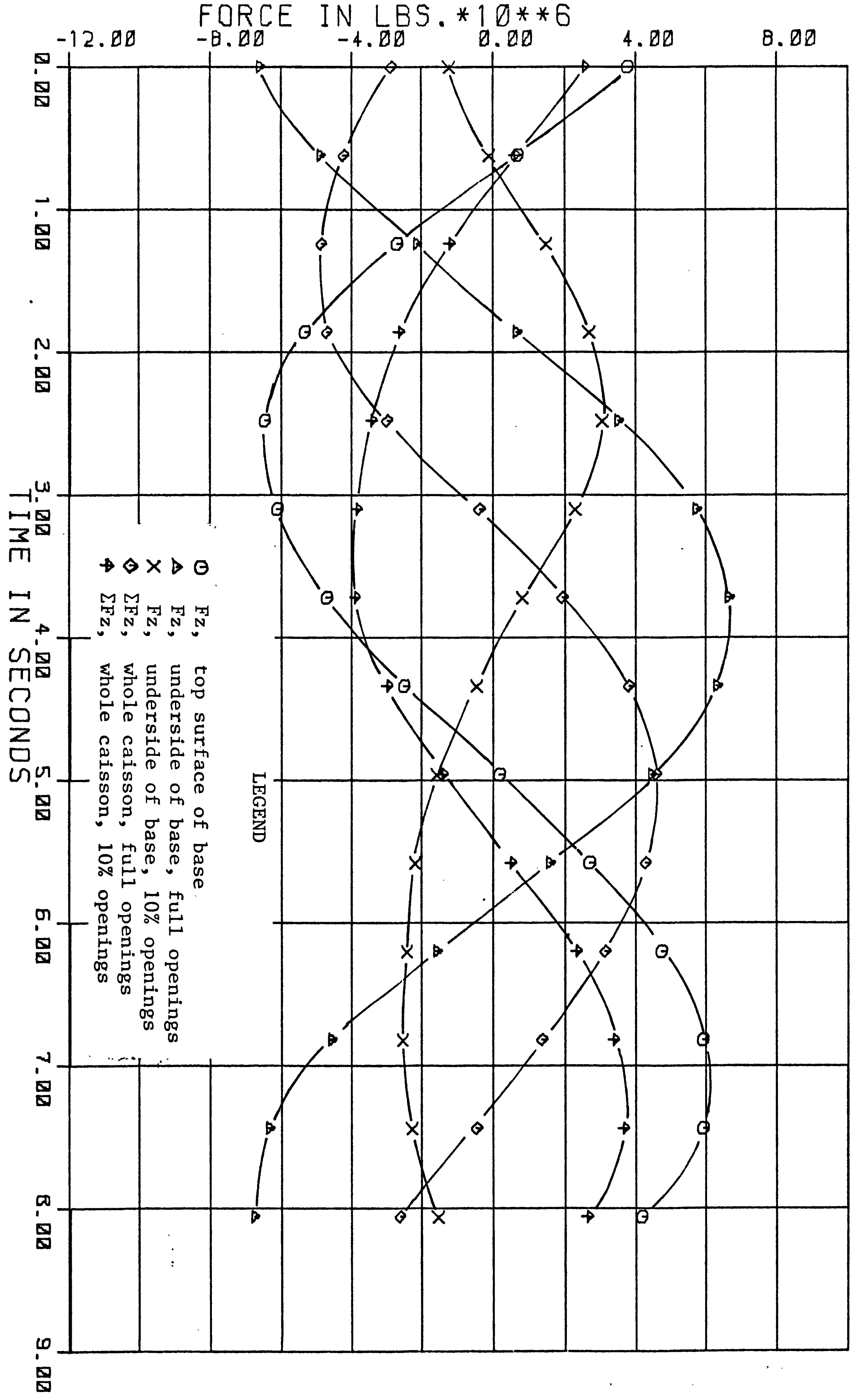


FIGURE 6-3. VERTICAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, L.W./24/ NORMAL.

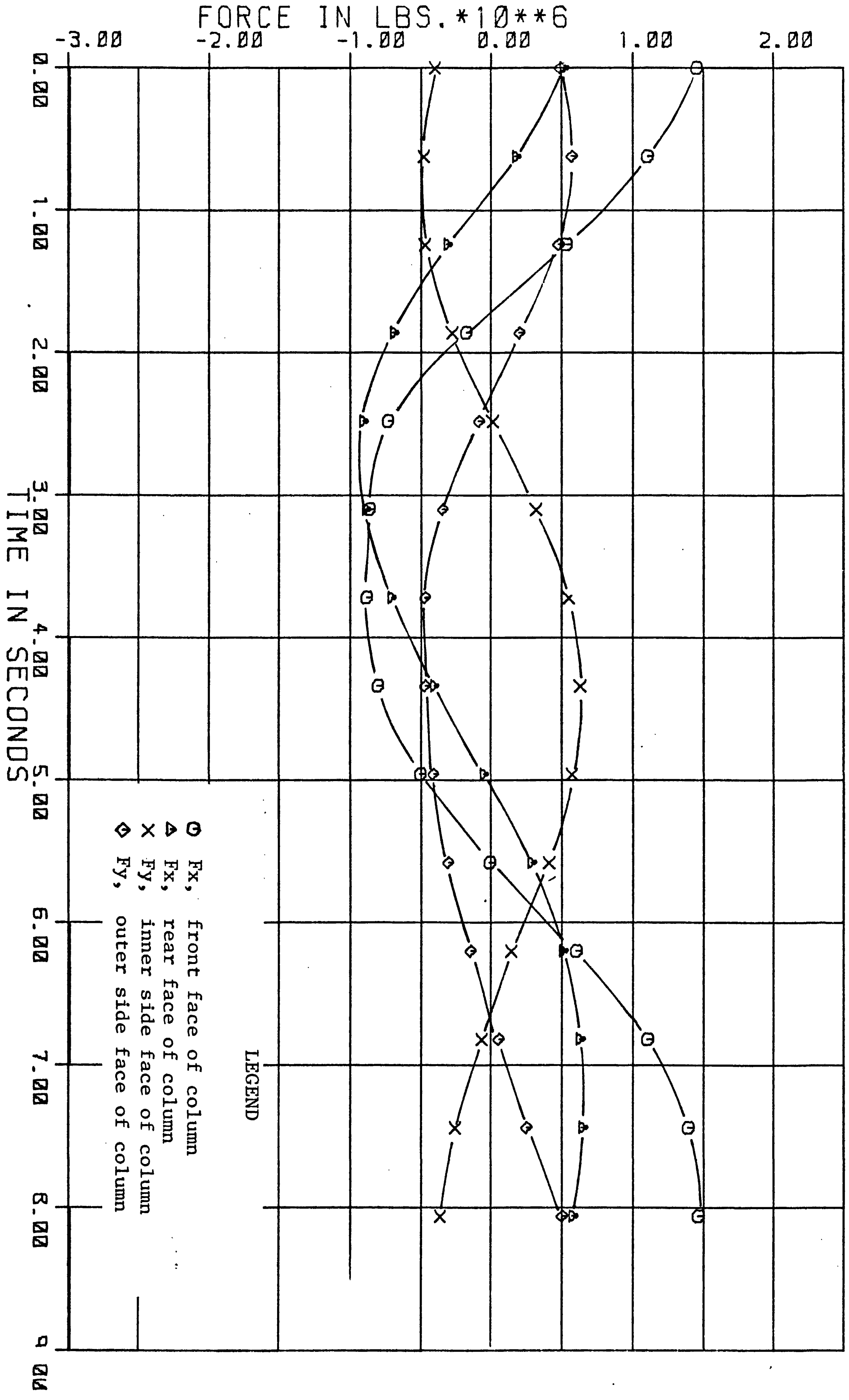


FIGURE 6-4. FORCES ON FRONT RIGHT COLUMN OF BERTH CAISSON FOR CASE L.W./24/ NORMAL.

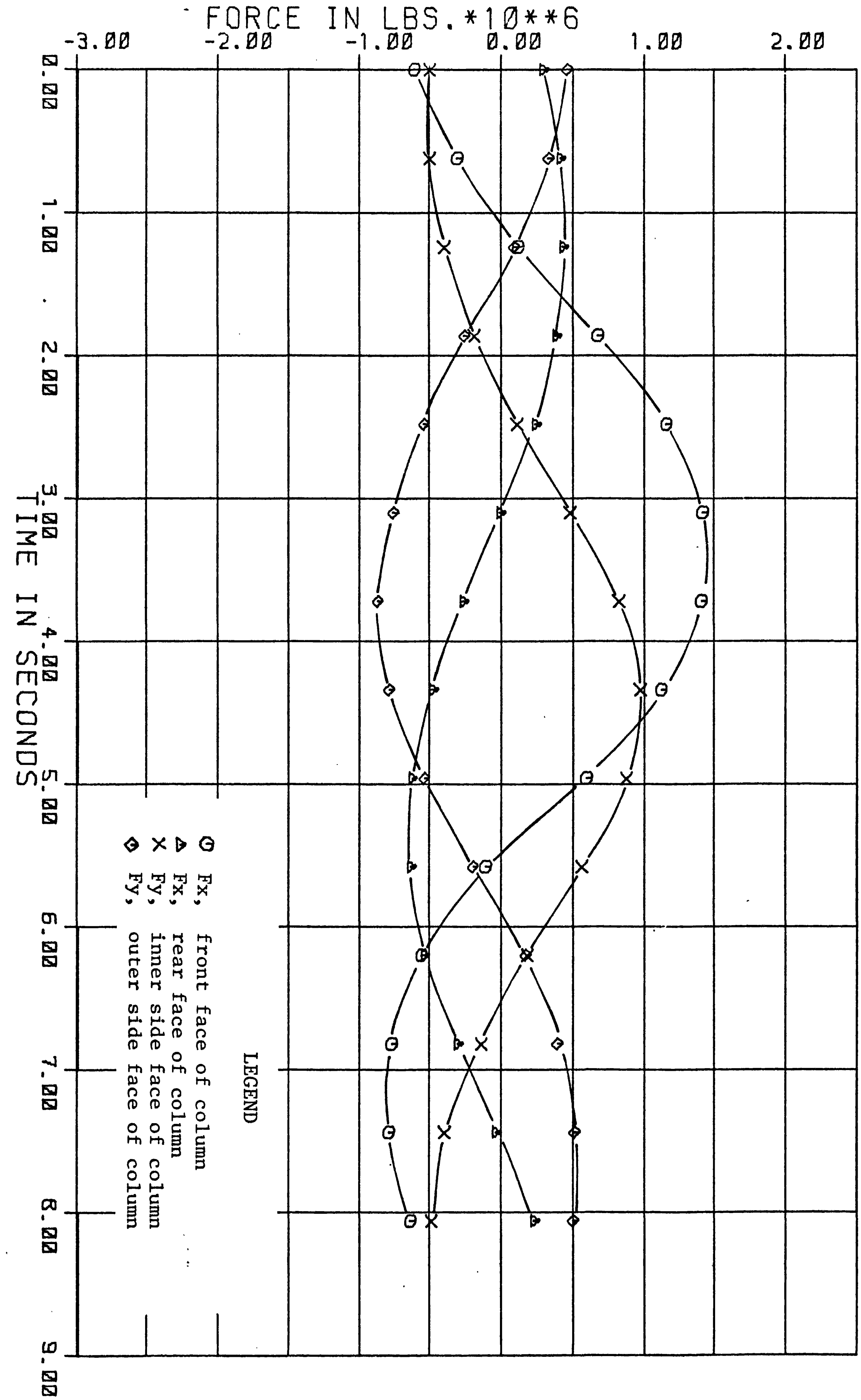


FIGURE 6-5. FORCES ON REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, L.W./24/NORMAL.

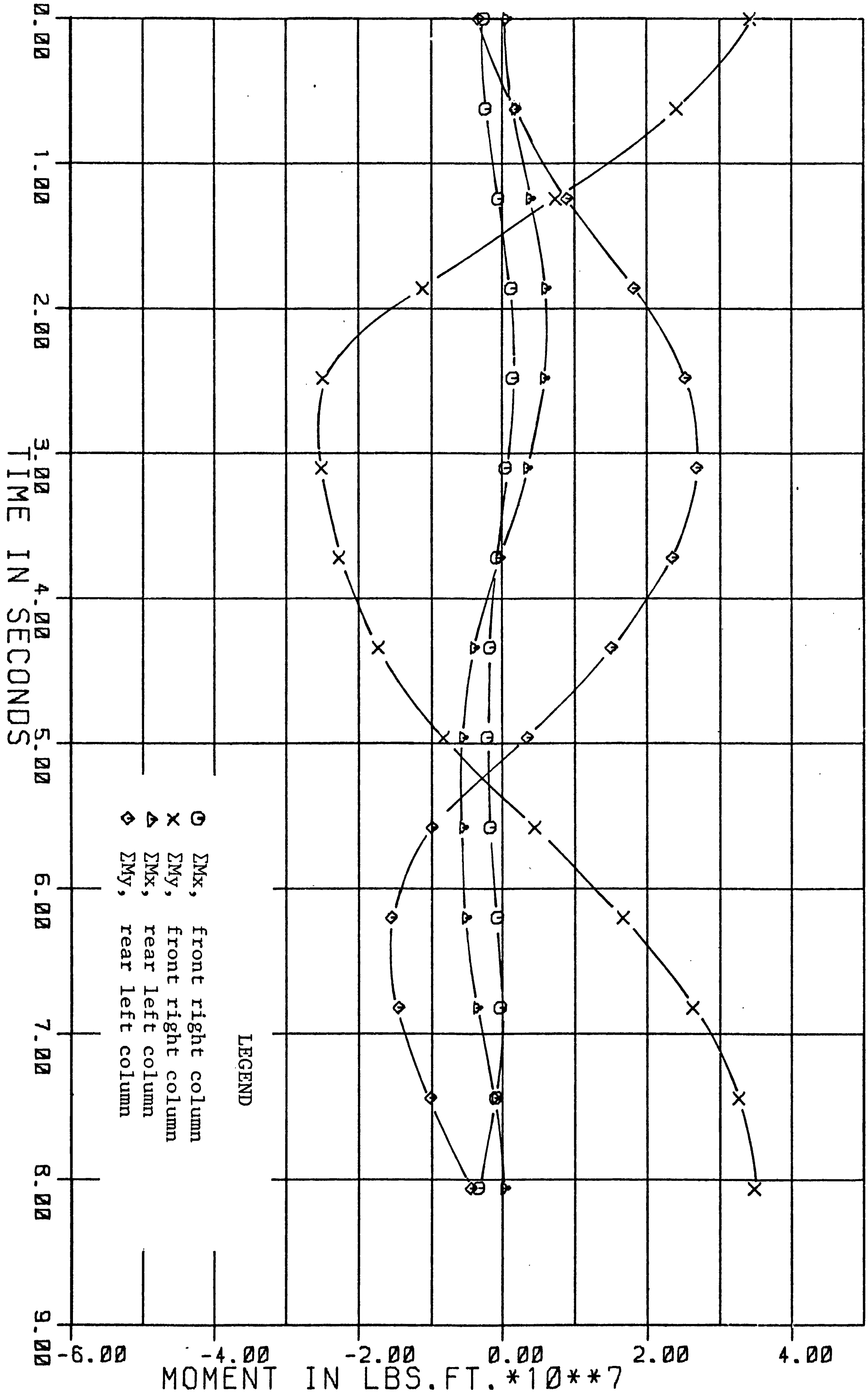


FIGURE 6-6. MOMENTS ABOUT COLUMN BASE ON FRONT RIGHT COLUMN AND REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, L.W./24/ NORMAL.

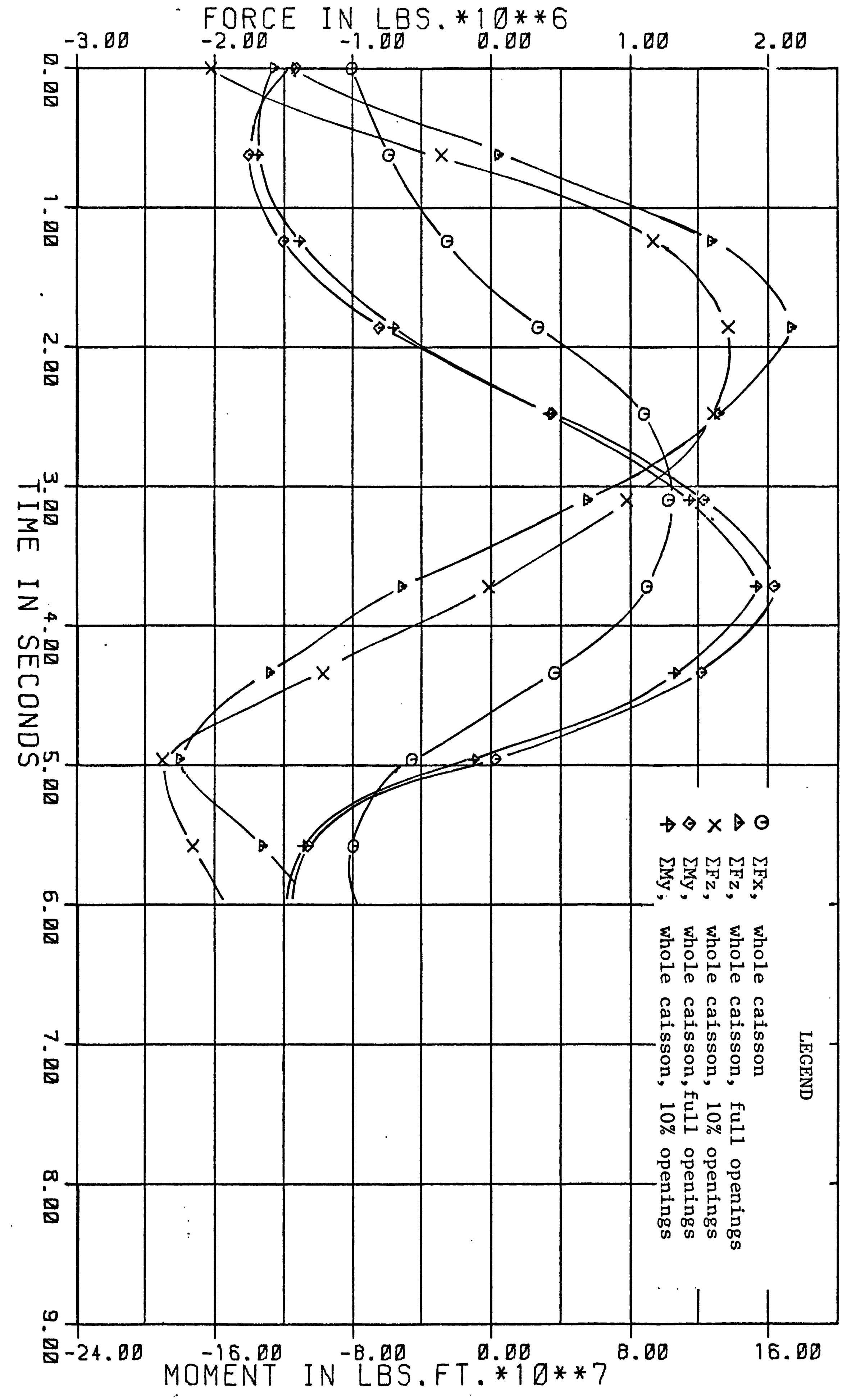


FIGURE 7-1. TOTAL FORCES AND MOMENTS ON BERTH CAISSON FOR CASE, H.W./12/NORMAL.

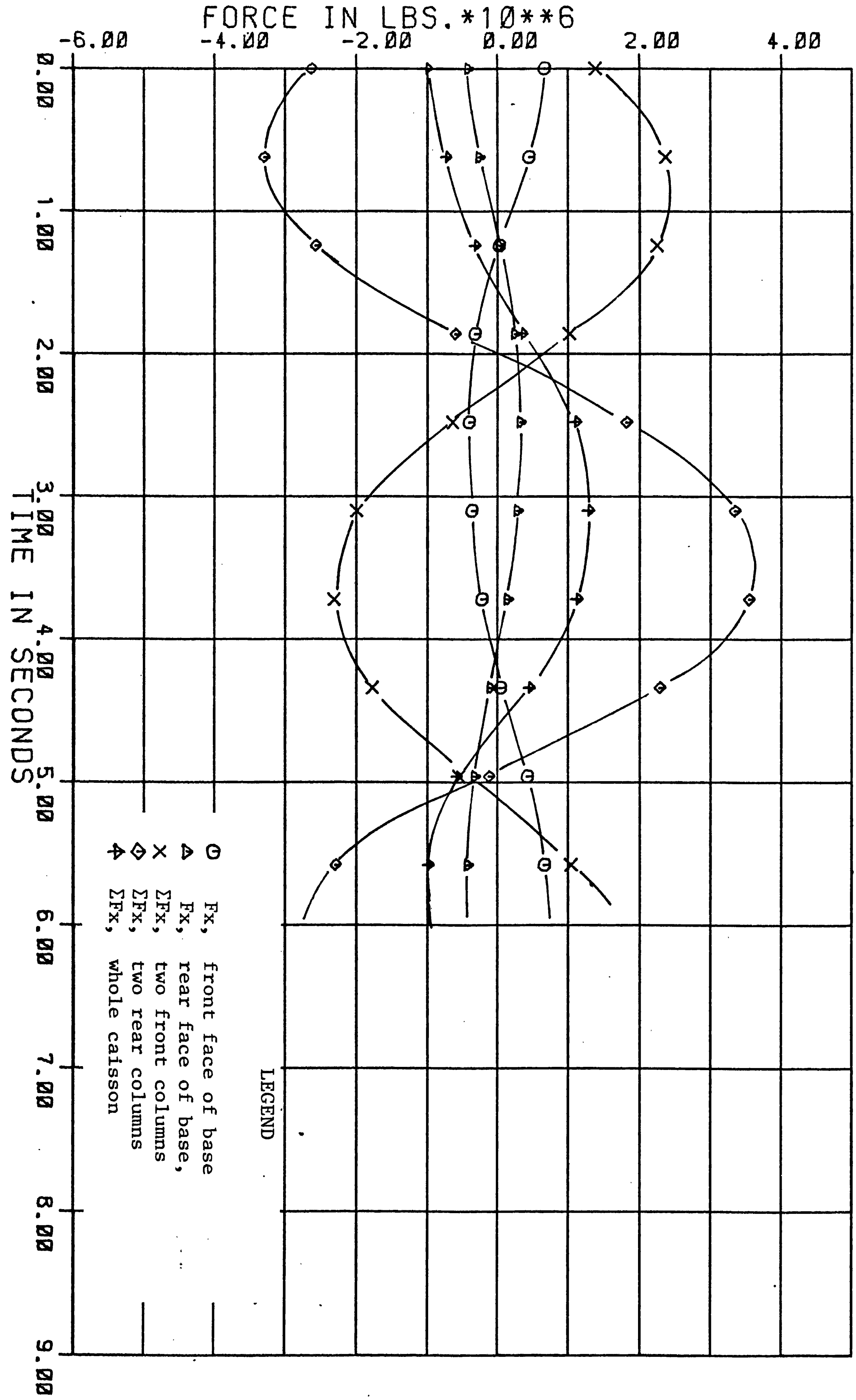


FIGURE 7-2. HORIZONTAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE H.W./12/ NORMAL.

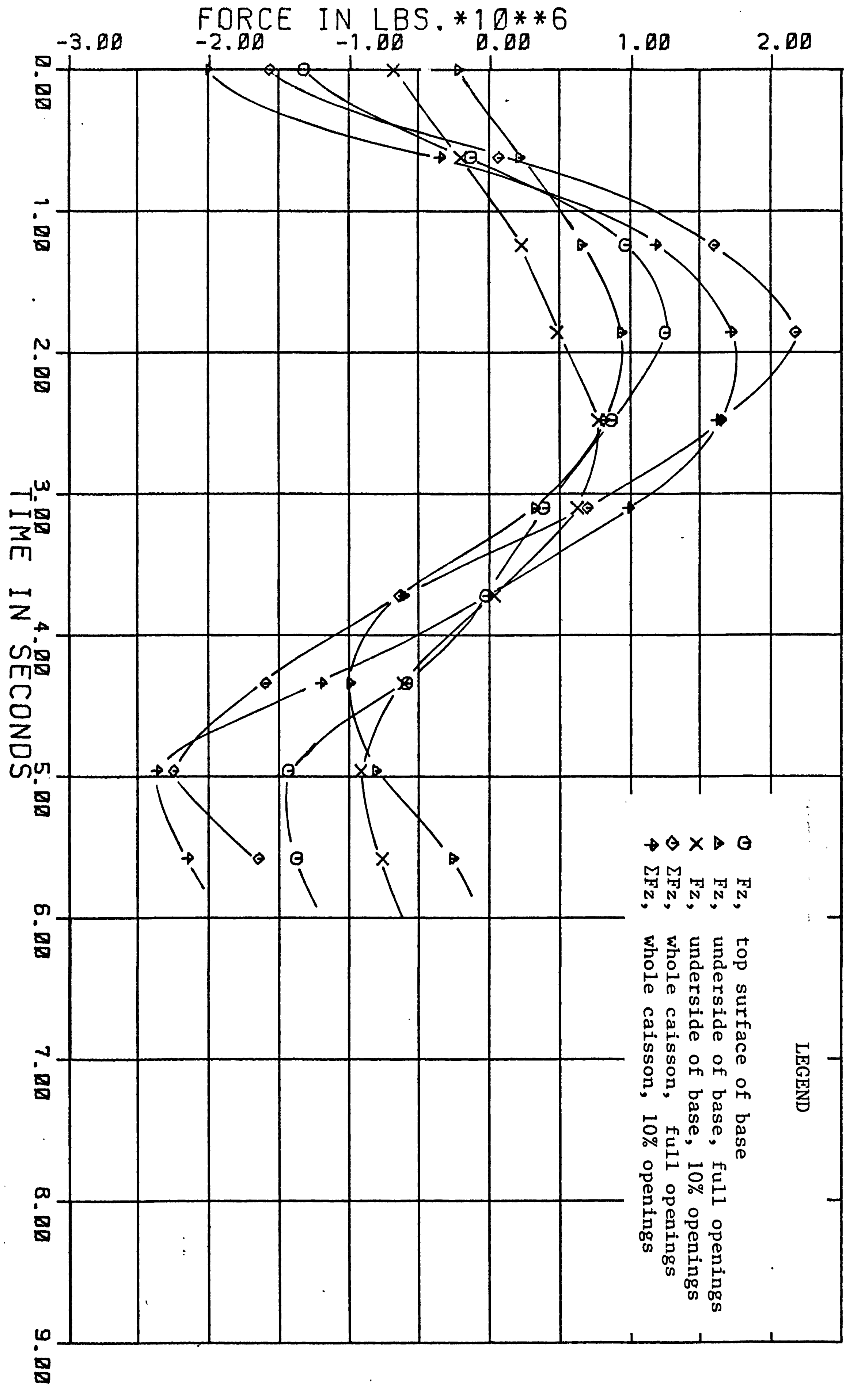


FIGURE 7-3. VERTICAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, H.W./12/ NORMAL.

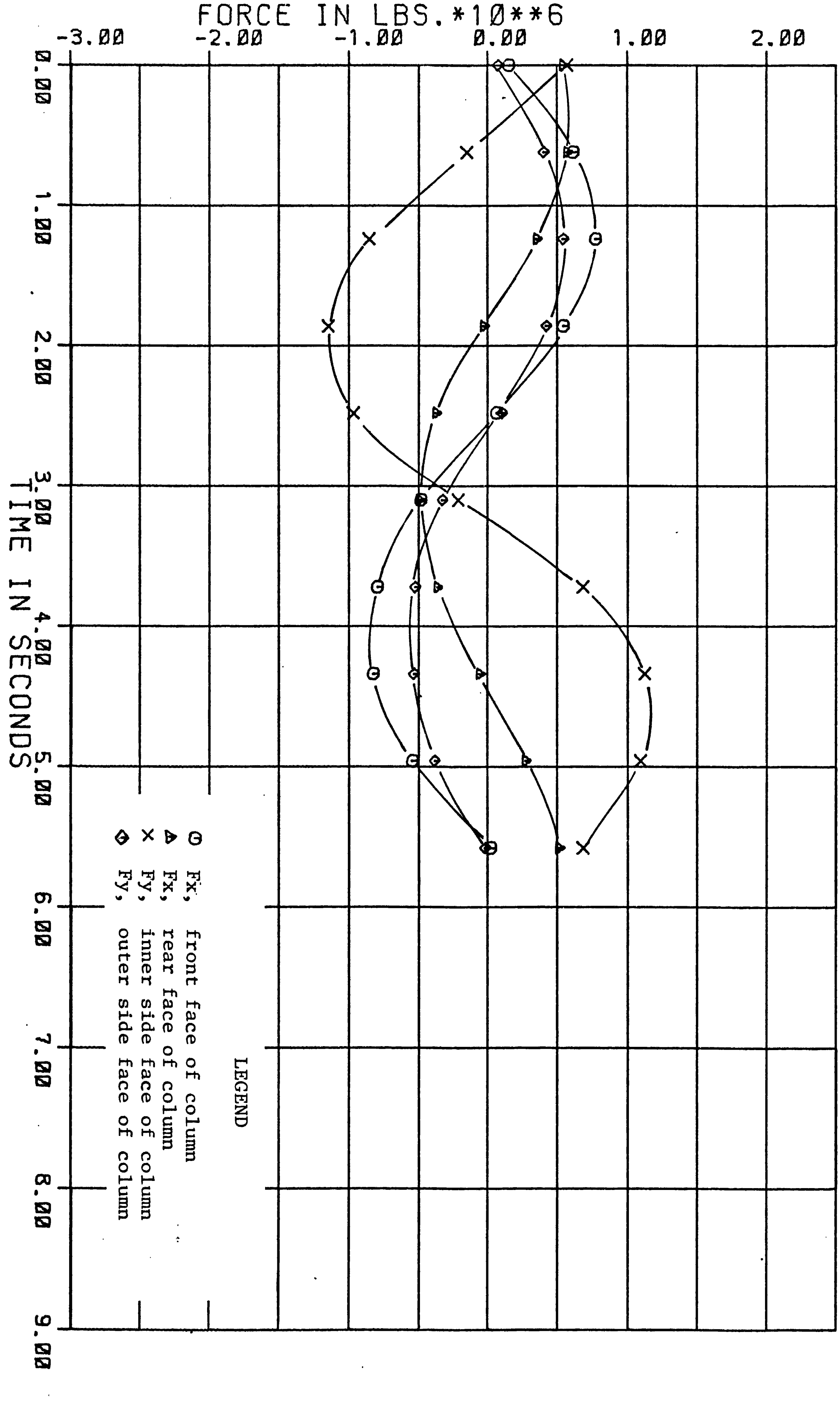


FIGURE 7-4. FORCES ON FRONT RIGHT COLUMN OF
BERTH CAISSON FOR CASE, H.W./12/
NORMAL.

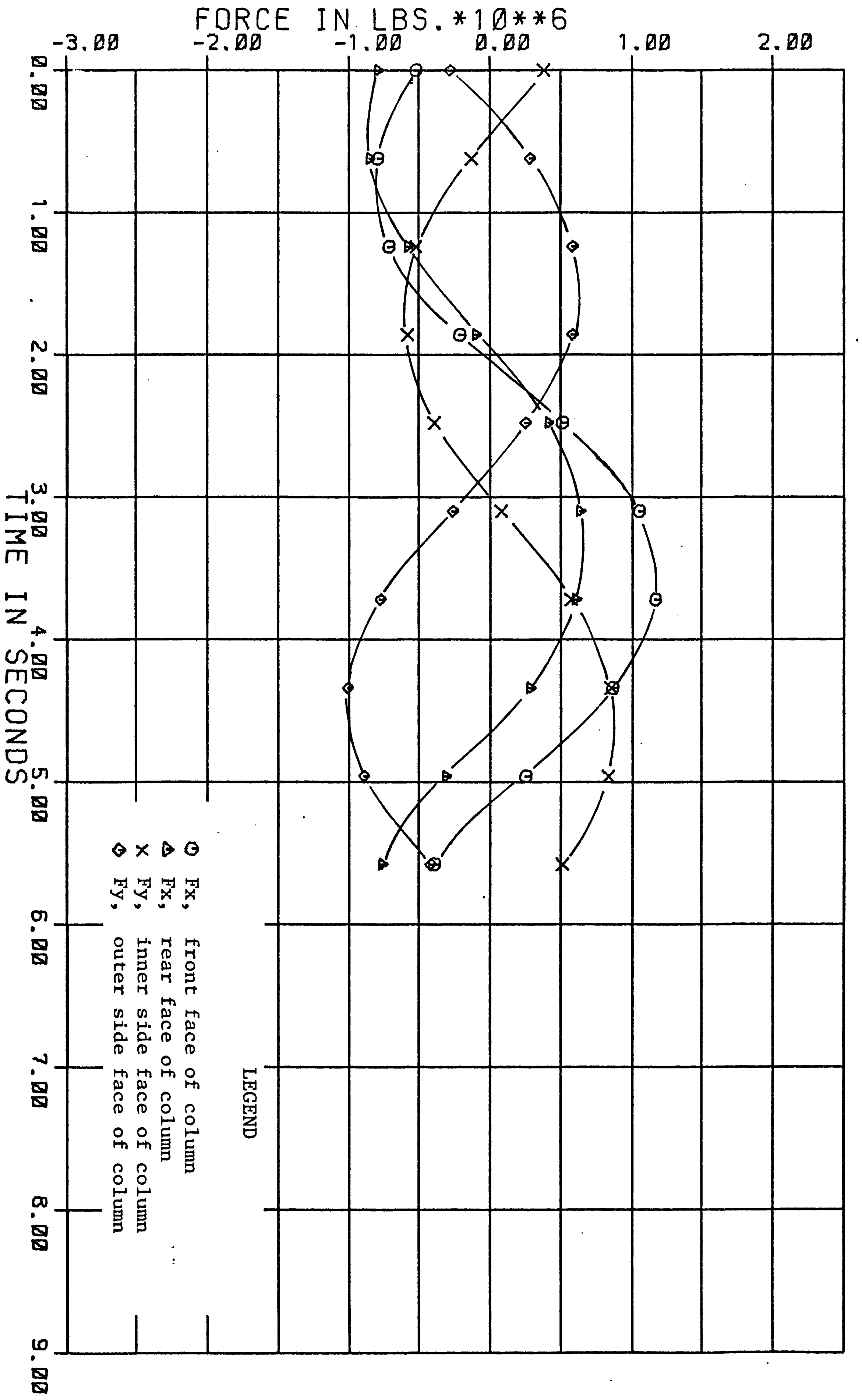


FIGURE 7-5. FORCES ON REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, H.W./12/NORMAL.

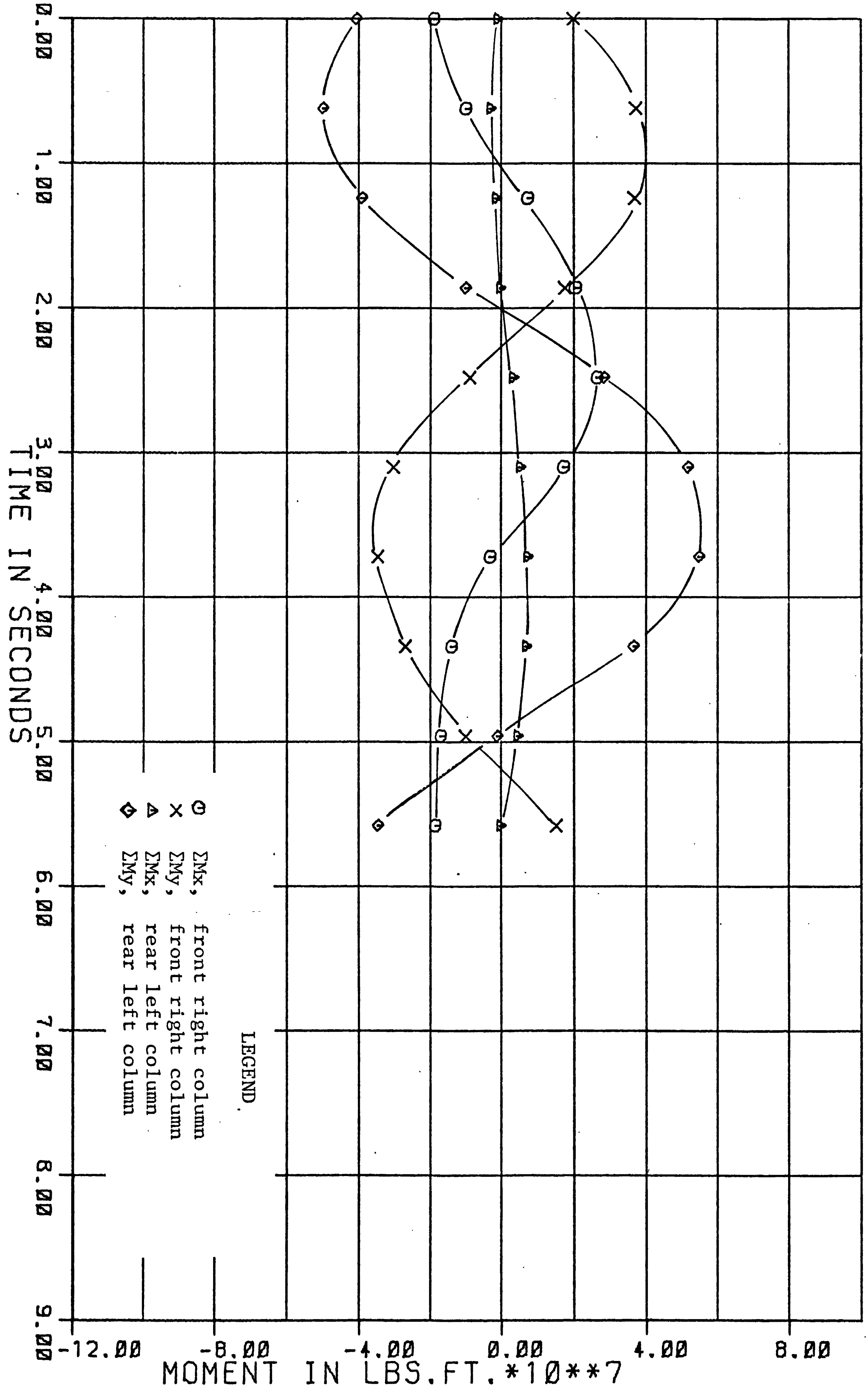


FIGURE 7-6. MOMENTS ABOUT COLUMN BASE ON FRONT RIGHT COLUMN AND REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, H.W./12/ NORMAL.

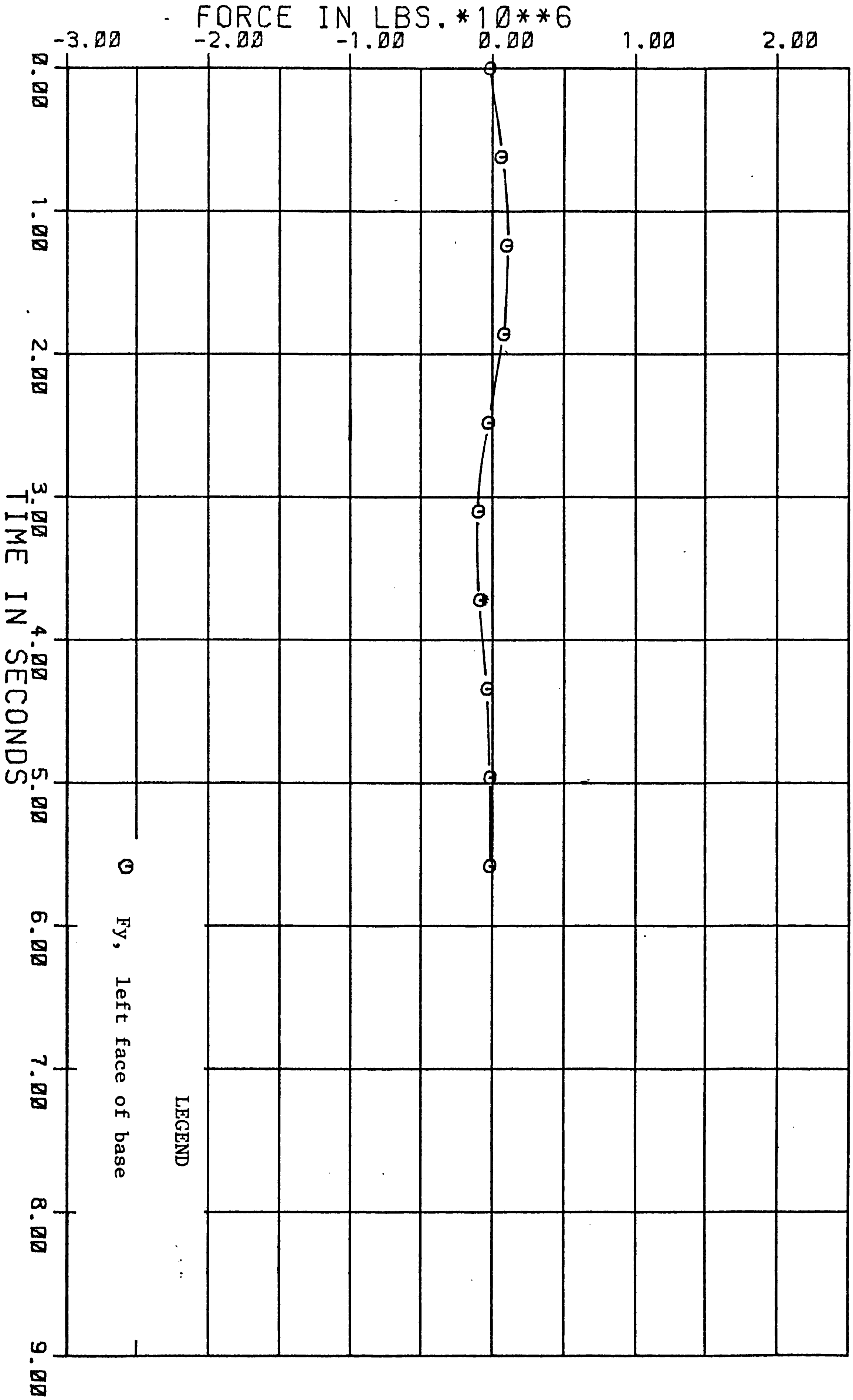


FIGURE 7-7. HORIZONTAL FORCE ON LEFT SIDE OF BASE OF BERTH CAISSON FOR CASE, H.W./12/NORMAL.

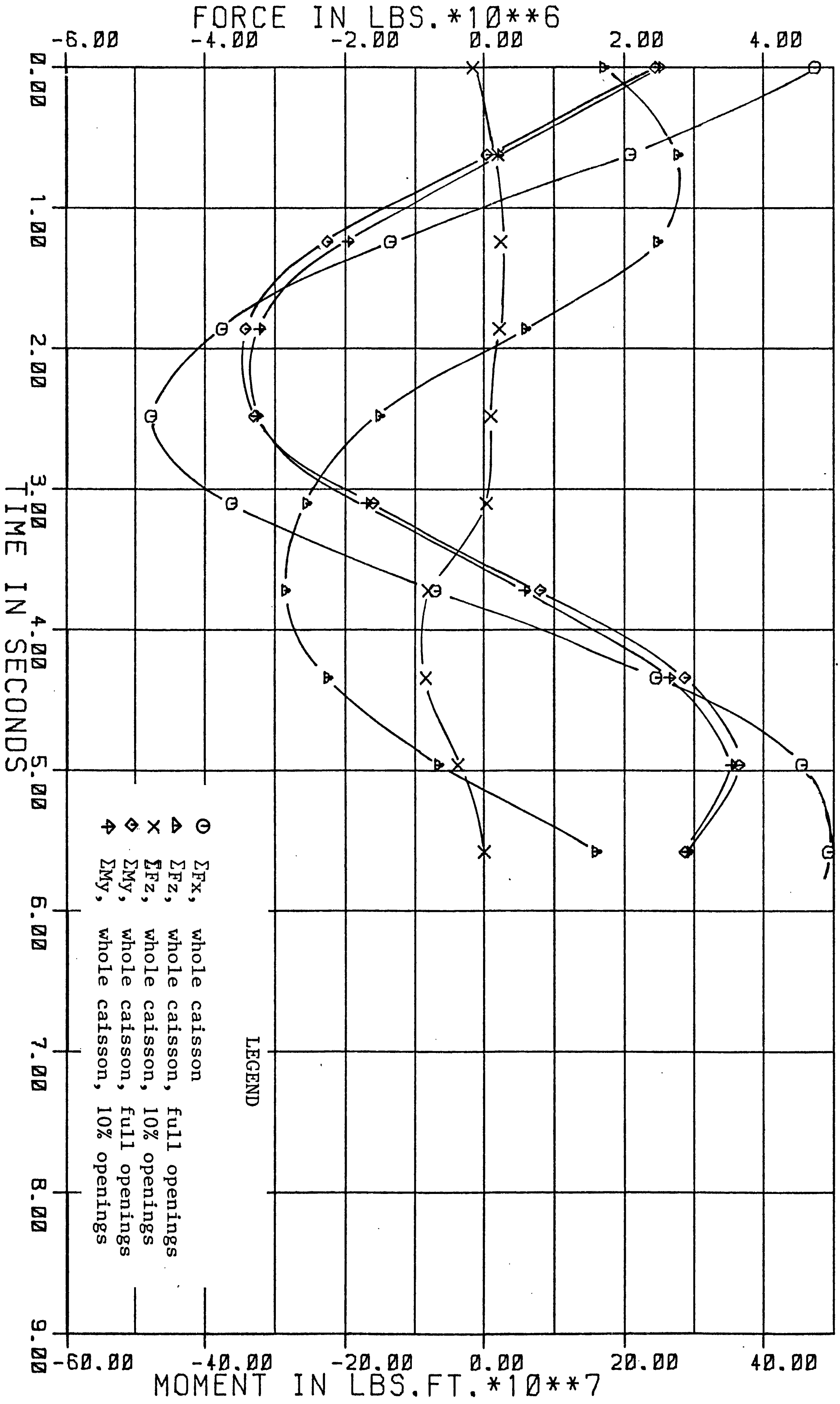


FIGURE 8-1. TOTAL FORCES AND MOMENTS ON BERTH CAISSON FOR CASE, L.W./12/NORMAL.

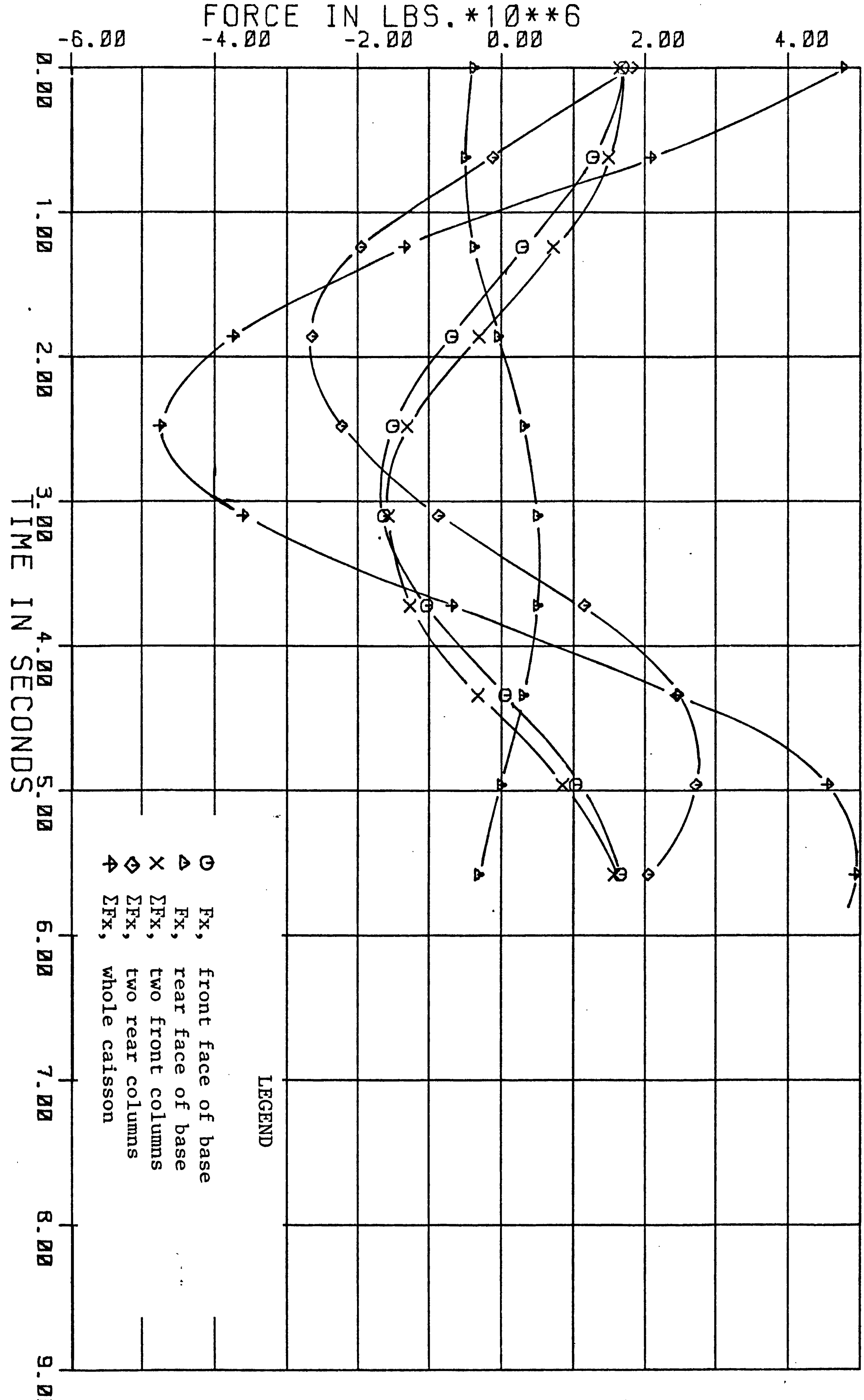


FIGURE 8-2. HORIZONTAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, L.W./12/ NORMAL.

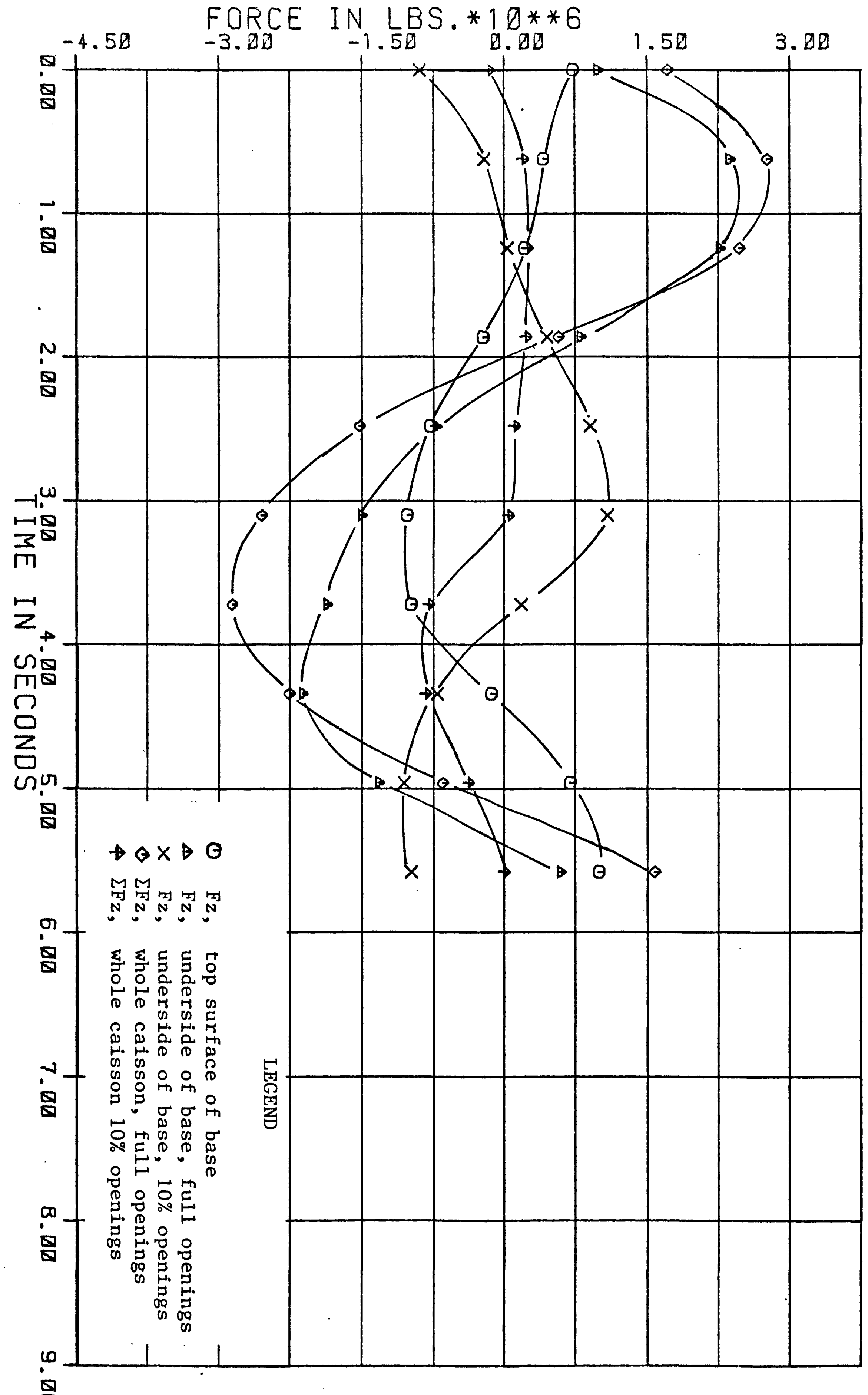


FIGURE 8-3. VERTICAL COMPONENTS OF FORCES ON BERTH CAISSON FOR CASE, L.W./12/ NORMAL.

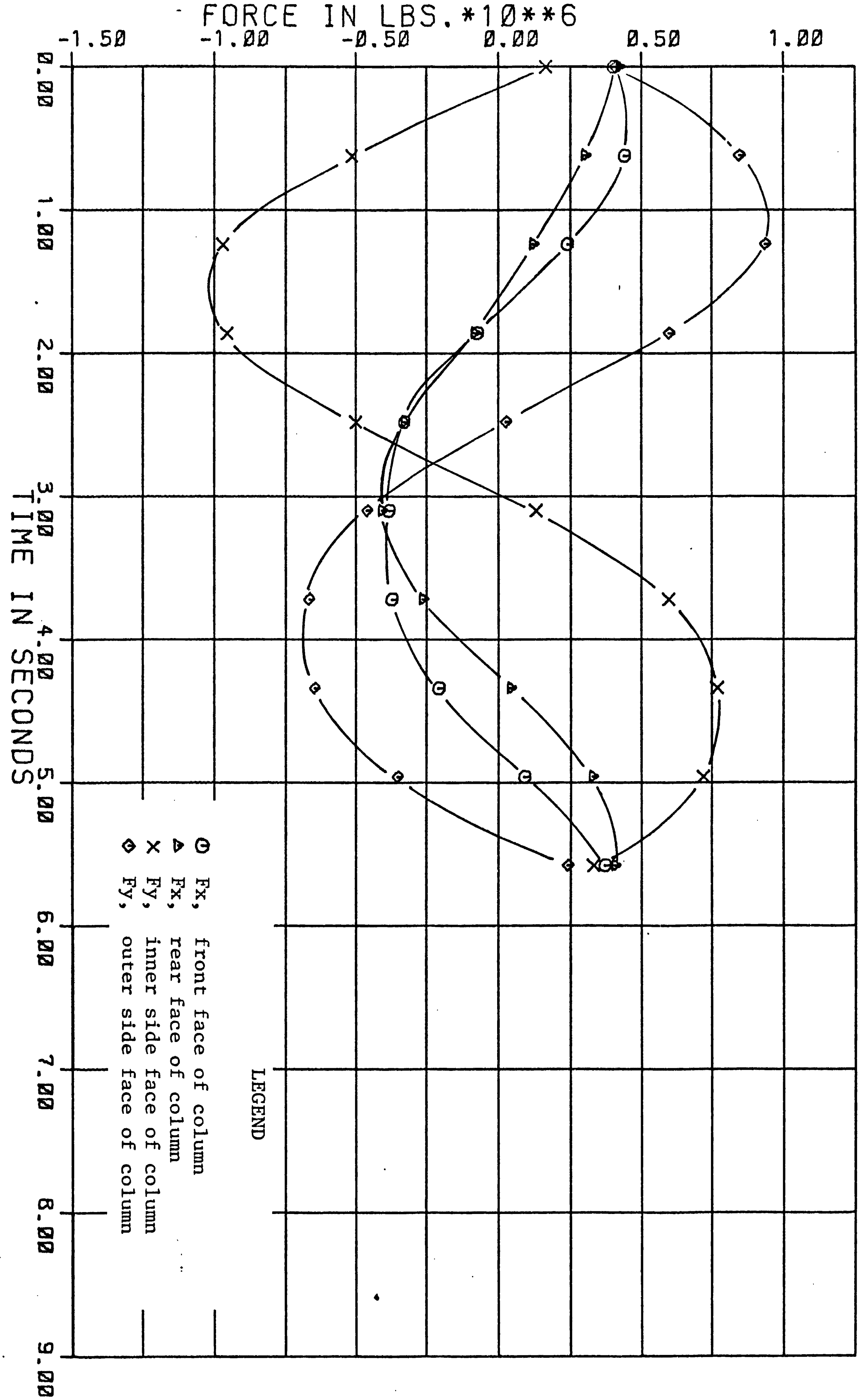


FIGURE 8-4. FORCES ON FRONT RIGHT COLUMN OF BERTH CAISSON FOR CASE, L.W./12/ NORMAL.

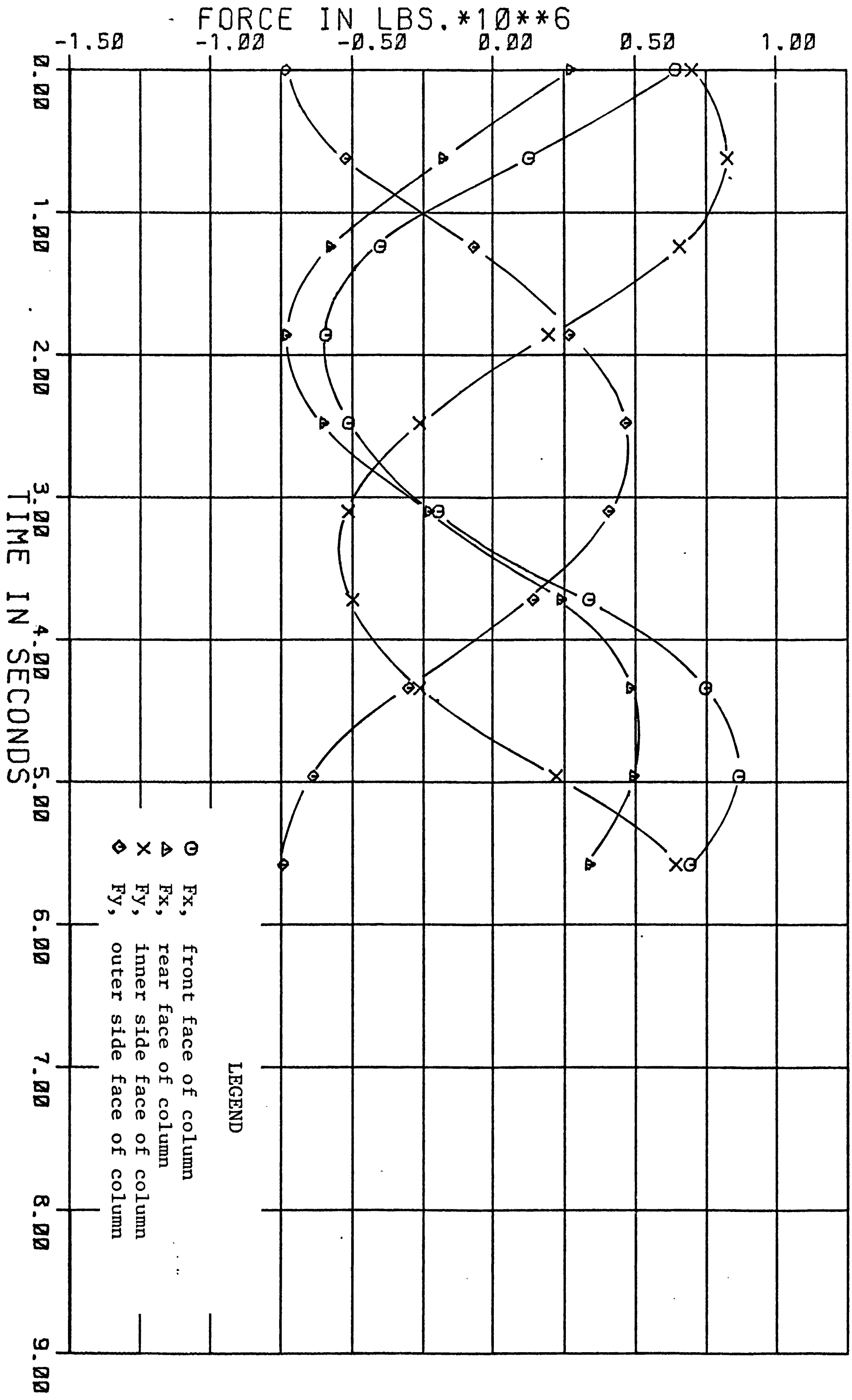


FIGURE 8-5. FORCES ON REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, L.W./12/NORMAL.

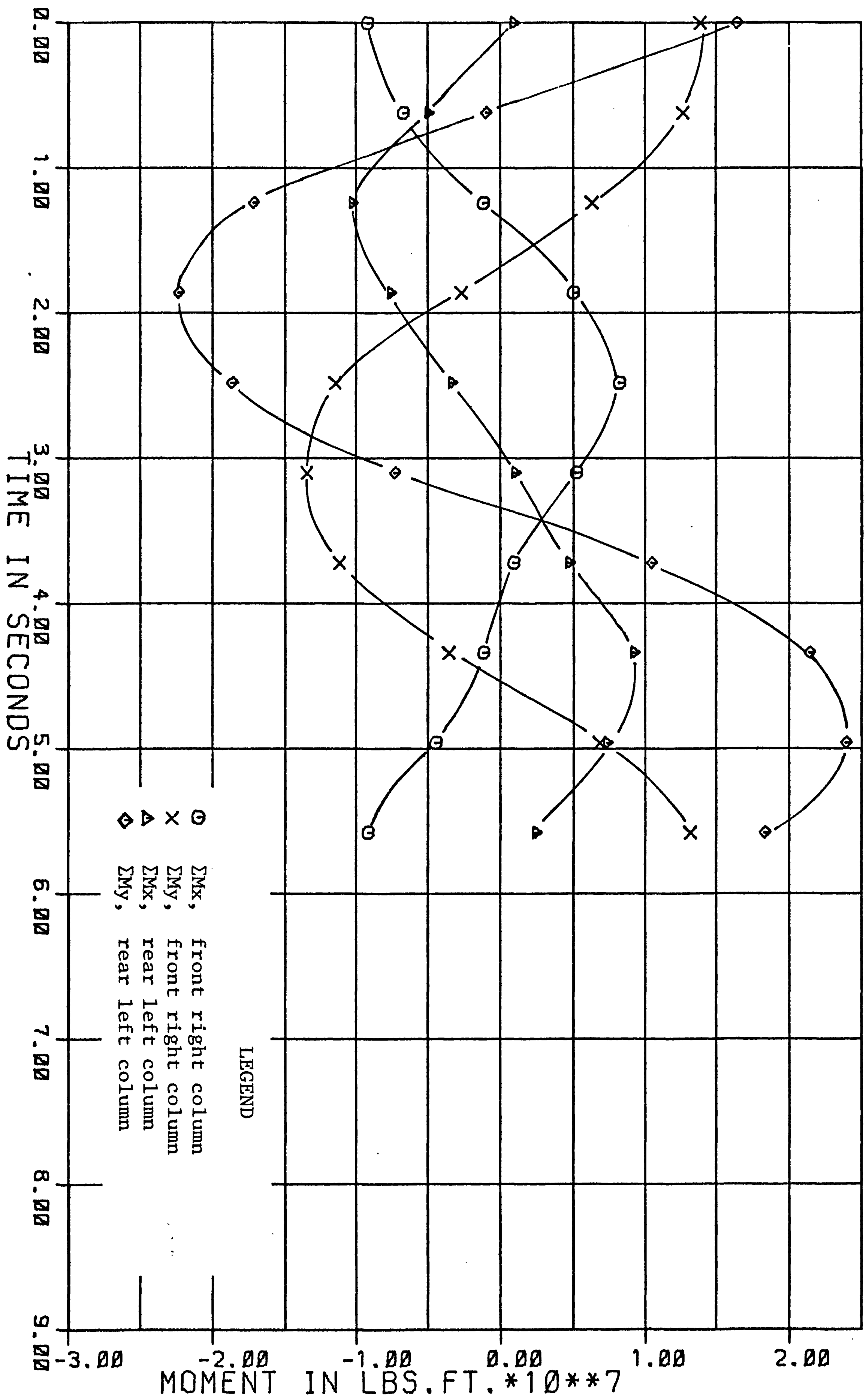


FIGURE 8-6. MOMENTS ABOUT COLUMN BASE ON FRONT RIGHT COLUMN AND REAR LEFT COLUMN OF BERTH CAISSON FOR CASE, L.W./12/ NORMAL.

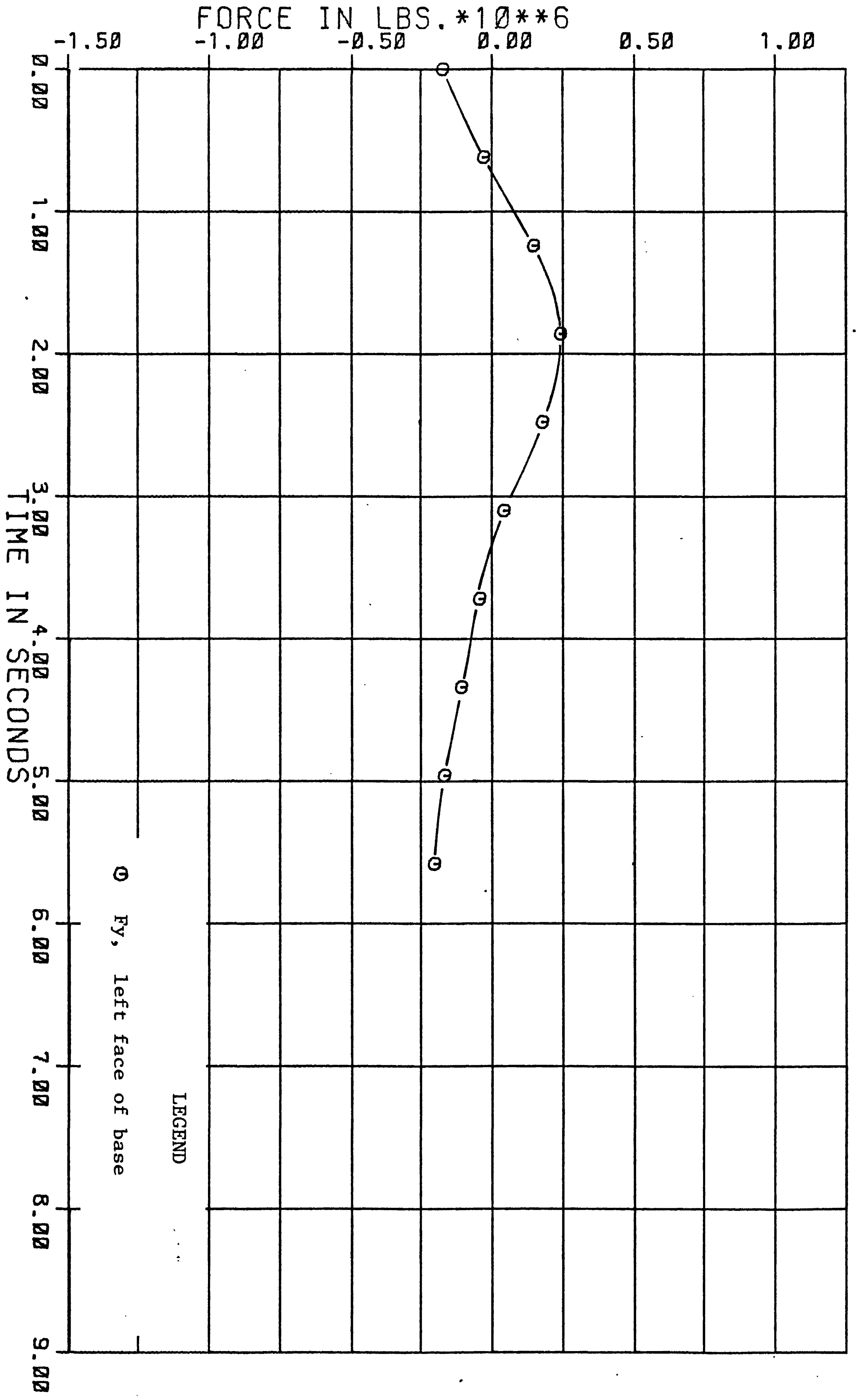


FIGURE 8-7. HORIZONTAL FORCE ON LEFT SIDE OF BASE OF BERTH CAISSON FOR CASE, L.W./12/NORMAL.

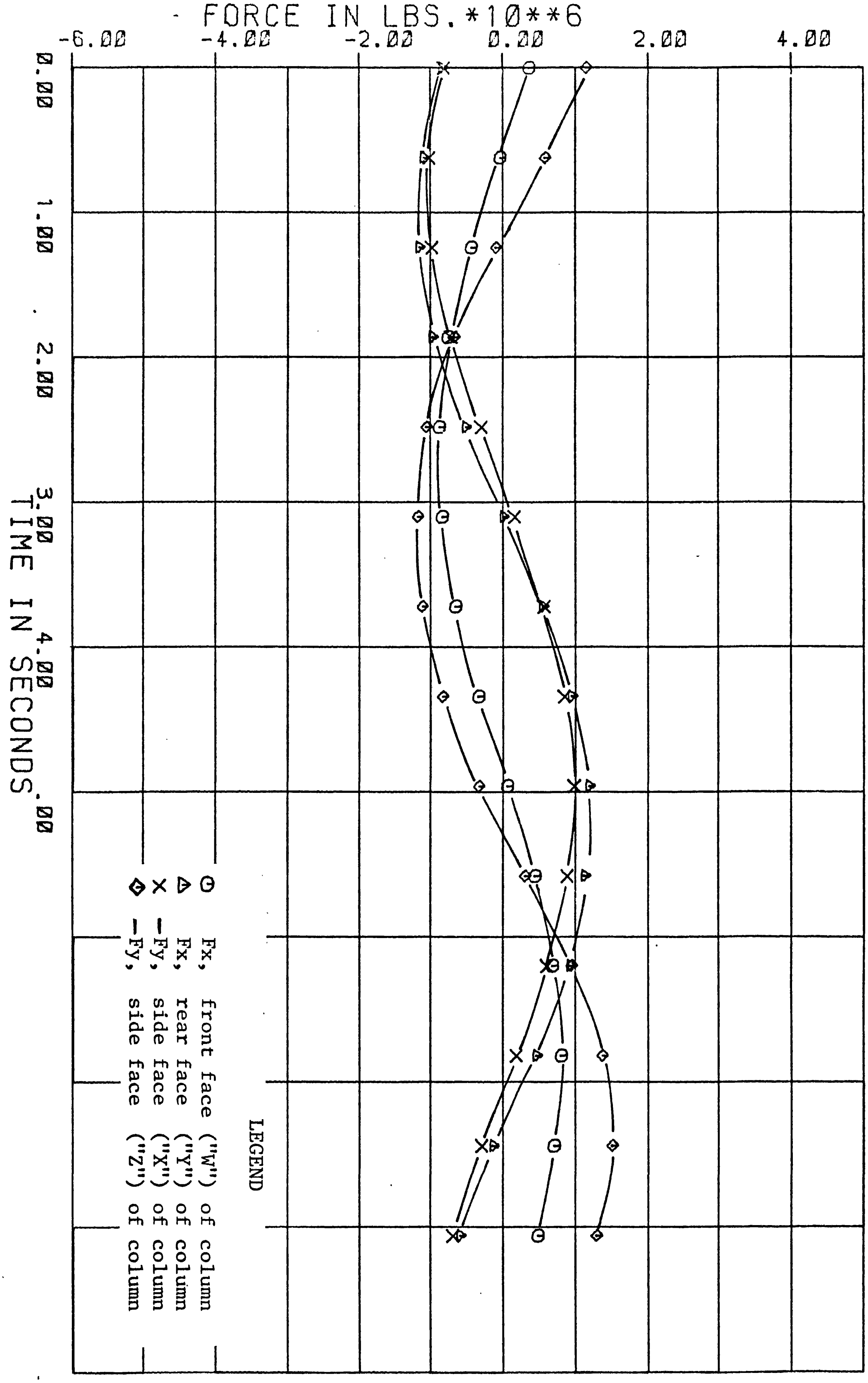


FIGURE 9-1. FORCES ON FRONT LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

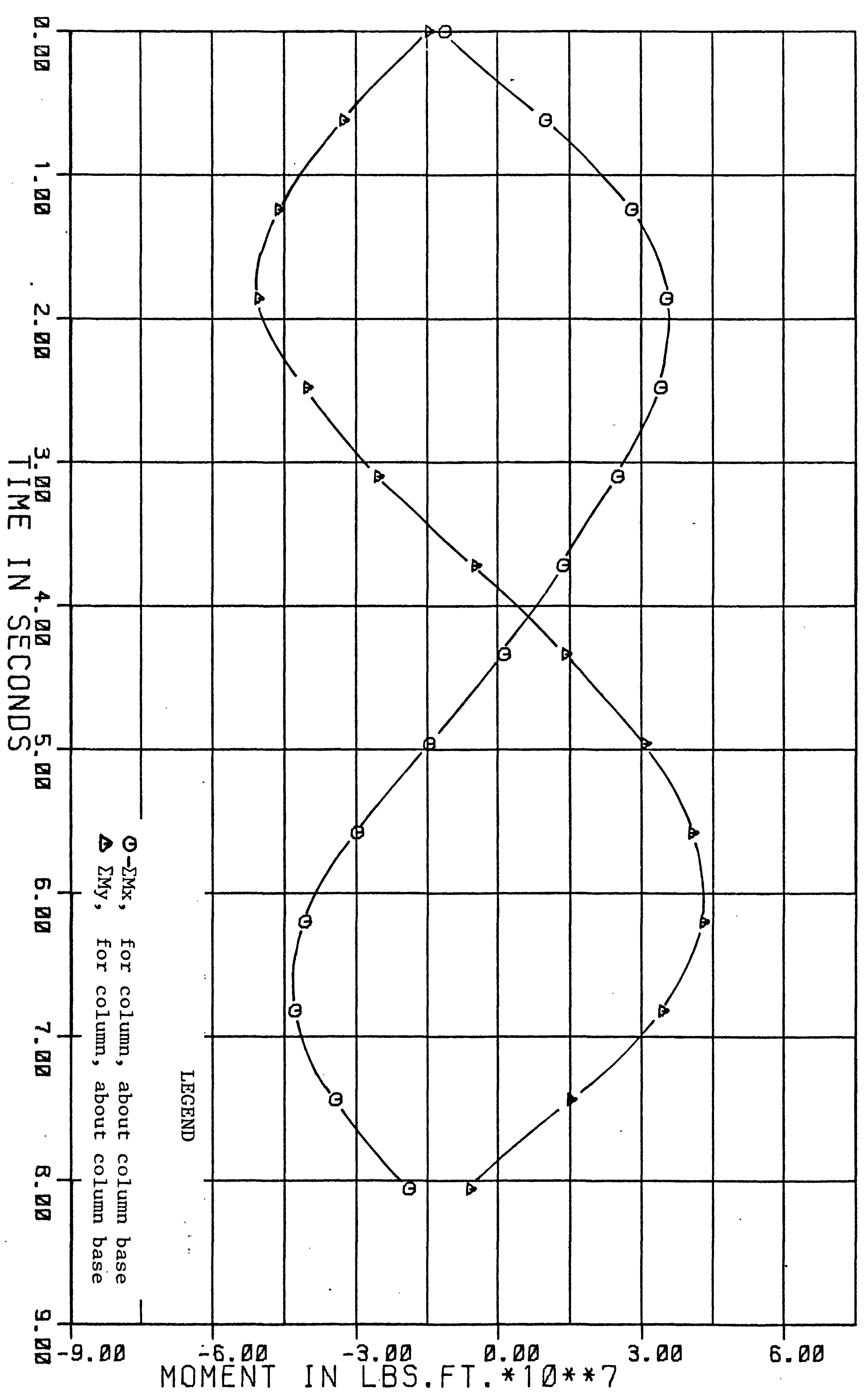


FIGURE 9-2. MOMENTS ON FRONT LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

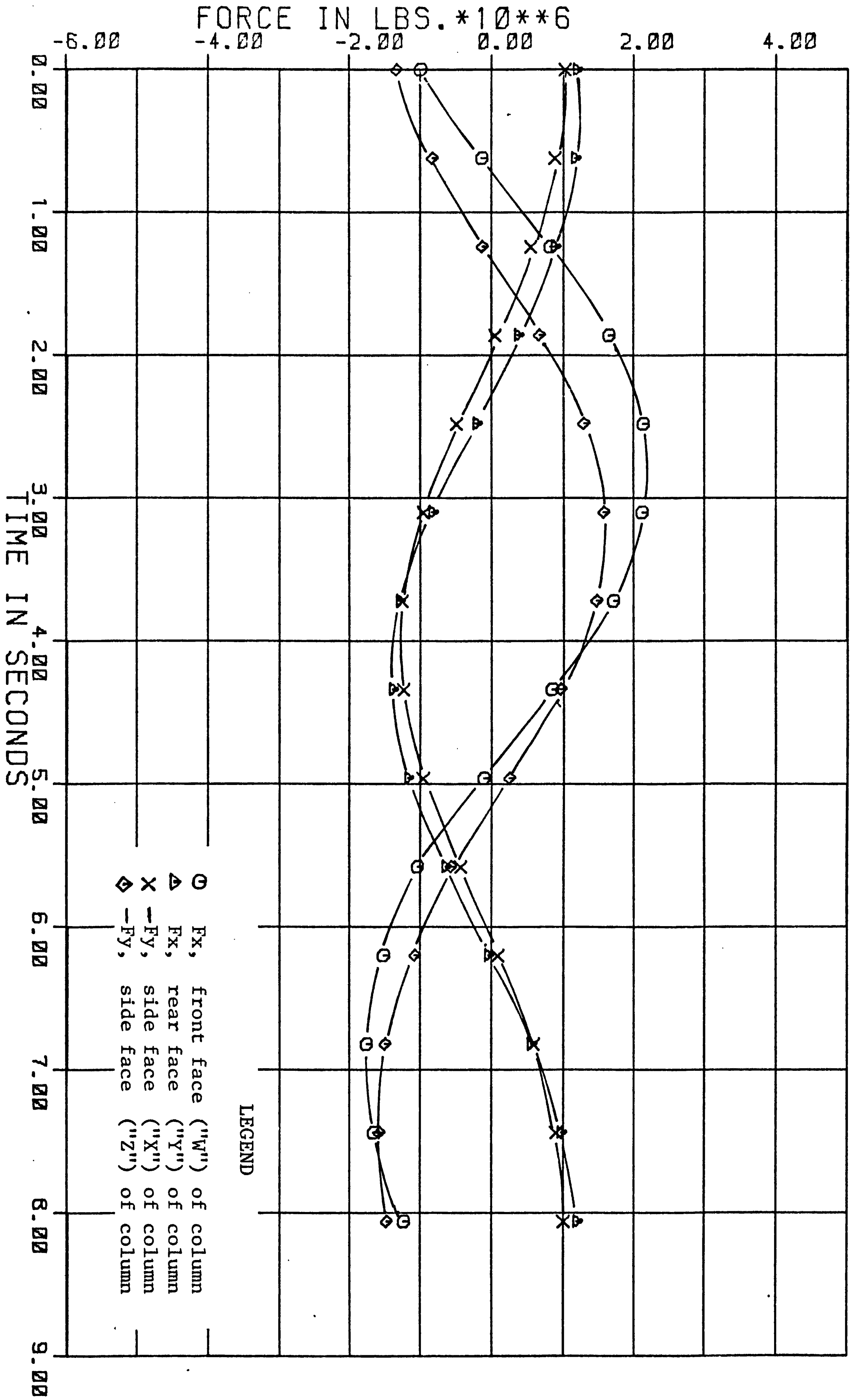


FIGURE 9-3. FORCES ON REAR TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

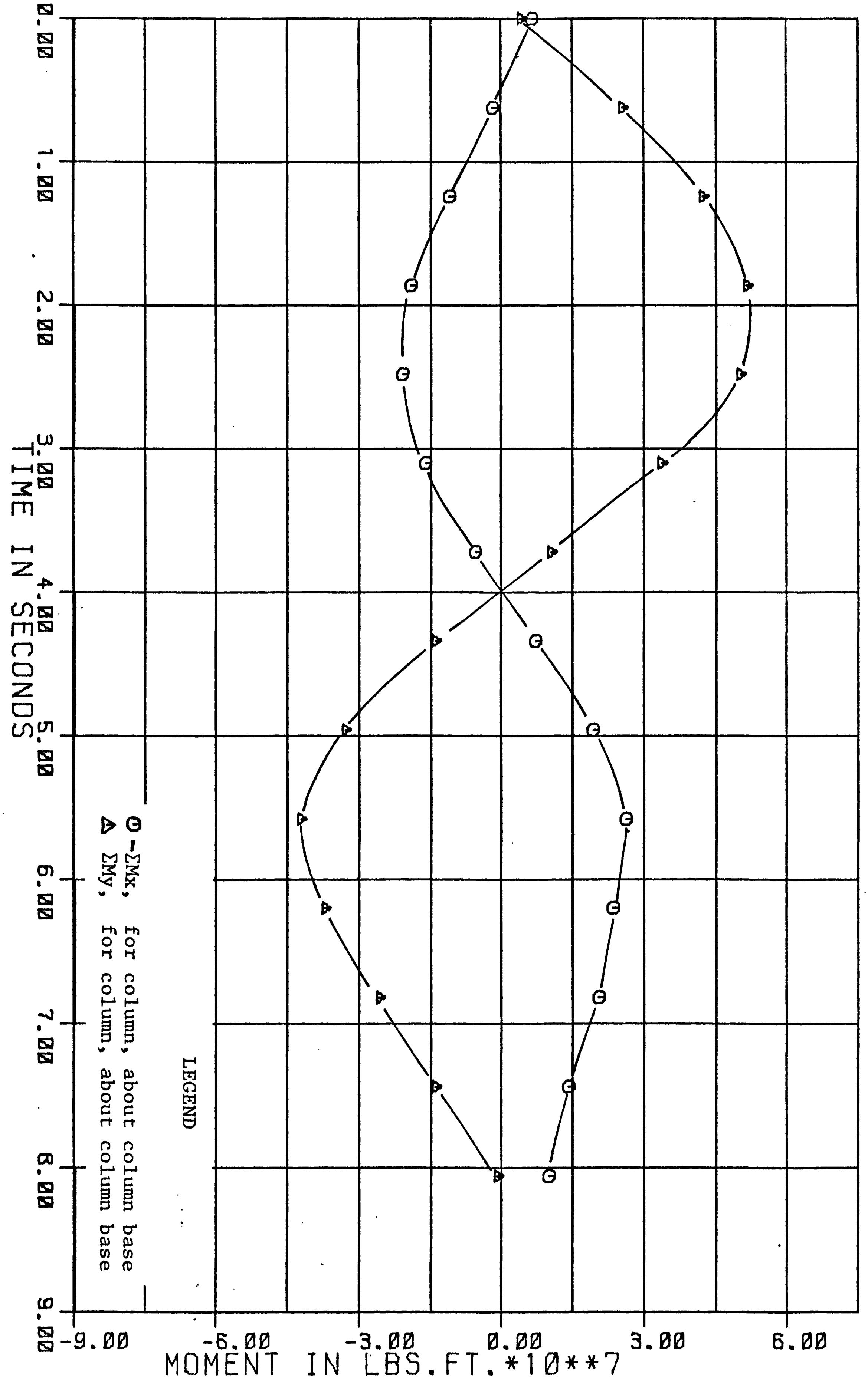


FIGURE 9-4. MOMENTS ON REAR TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

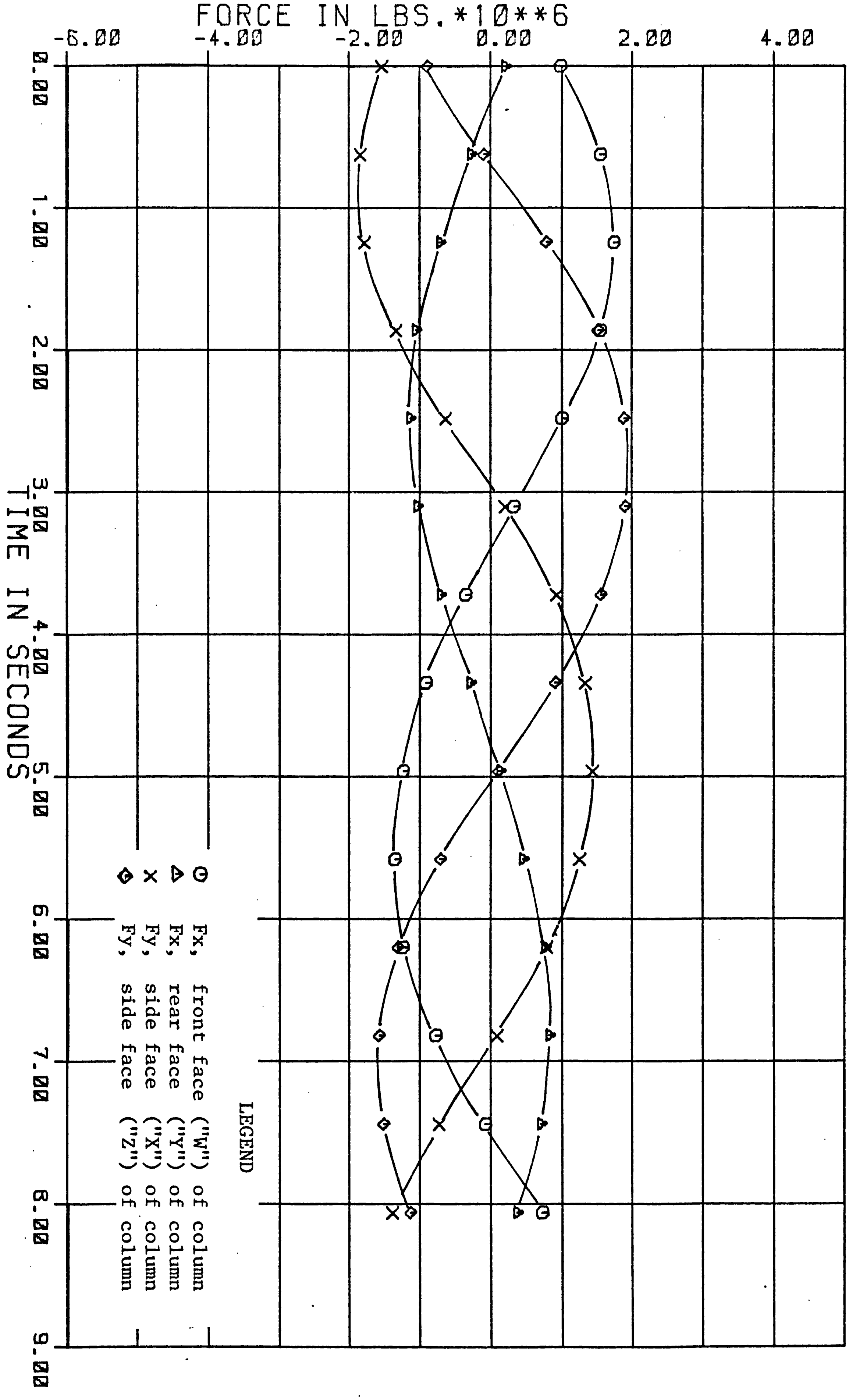


FIGURE 9-5. FORCES ON FRONT TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./23/ESE. NO NEIGHBOUR CAISSON.

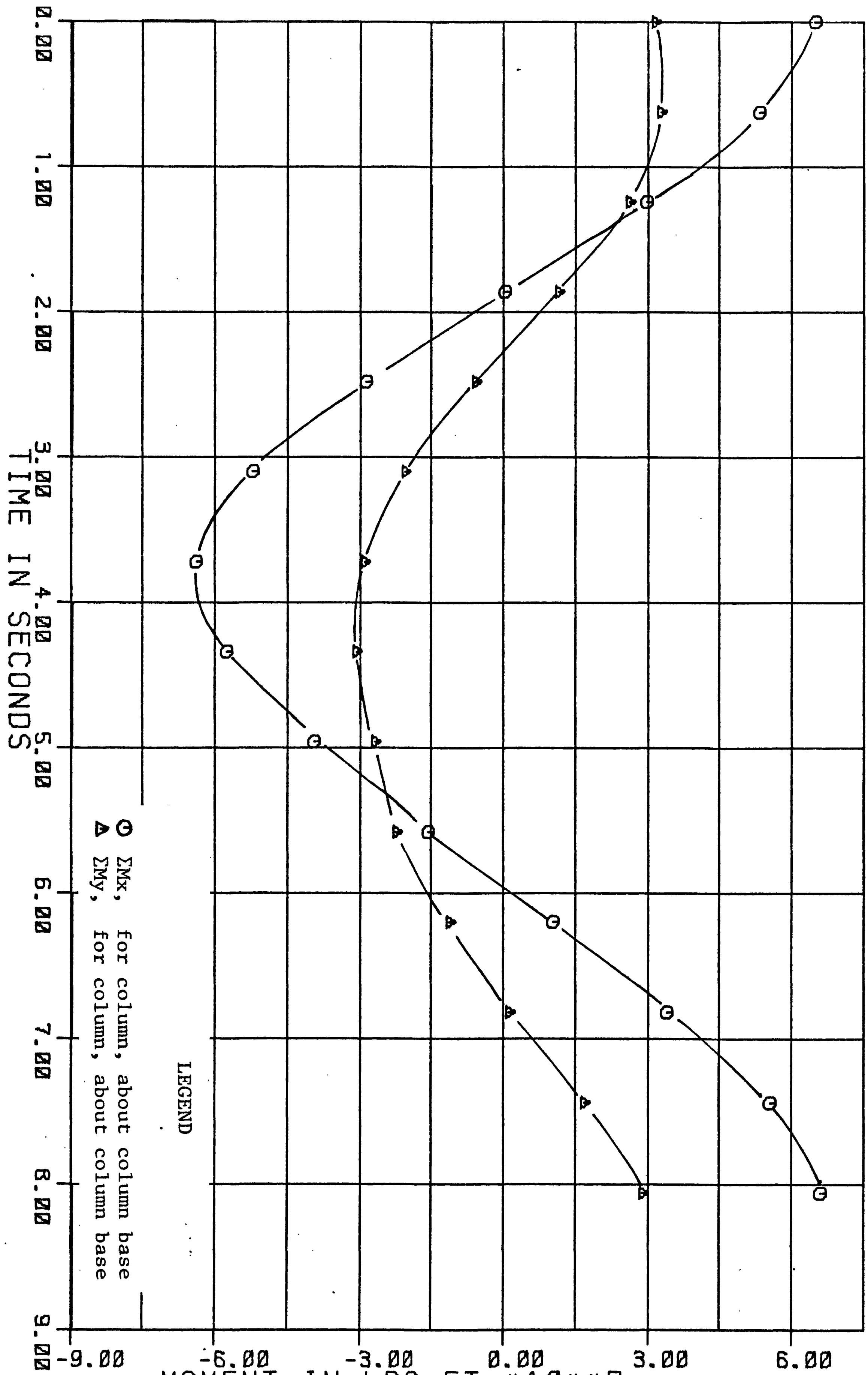


FIGURE 9-6. MOMENTS ON FRONT TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

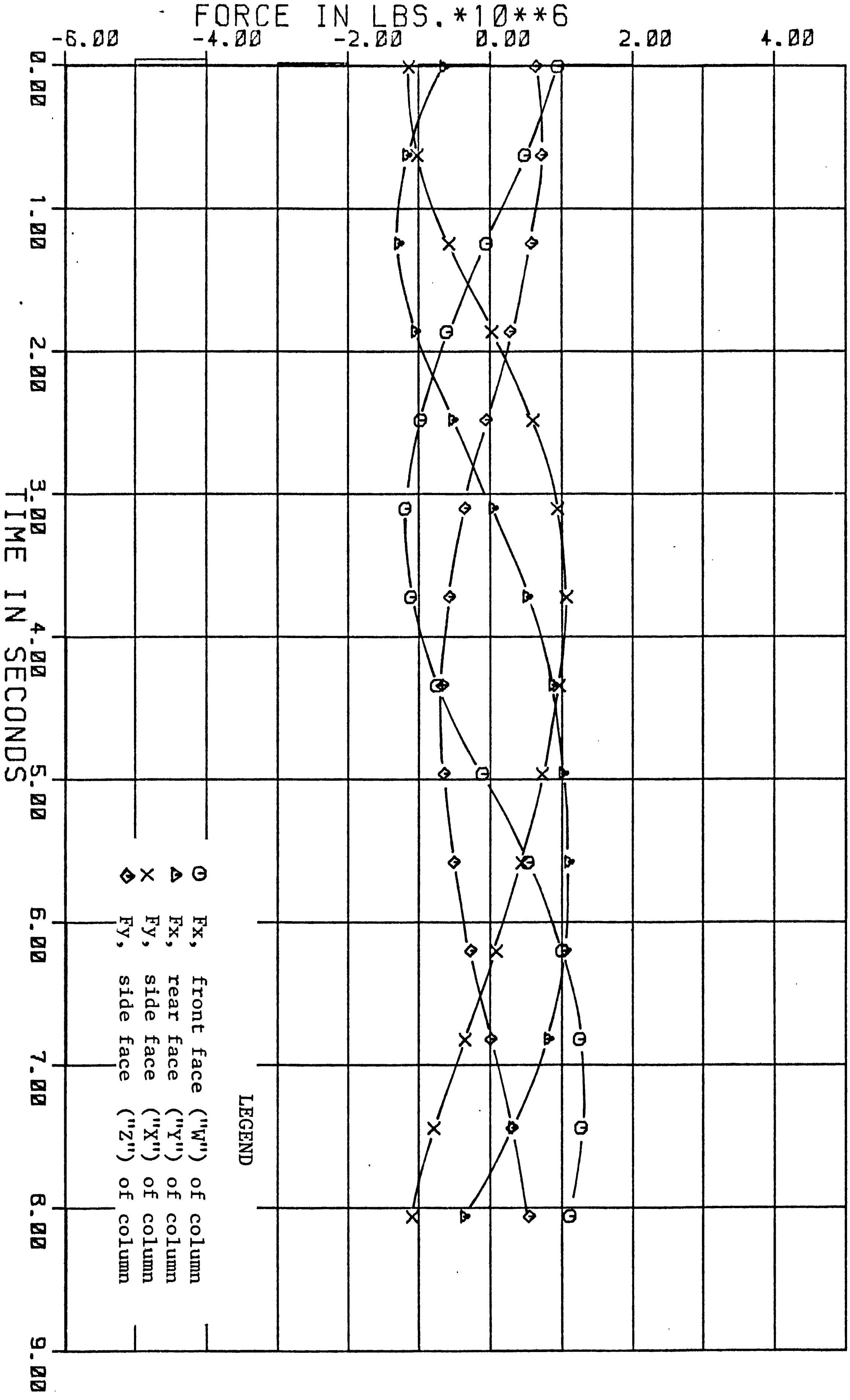


FIGURE 9-7. FORCES ON REAR LEADING COLUMN OF
BERTH CAISSON FOR CASE, H.W./24/ESE.
NO NEIGHBOUR CAISSON.

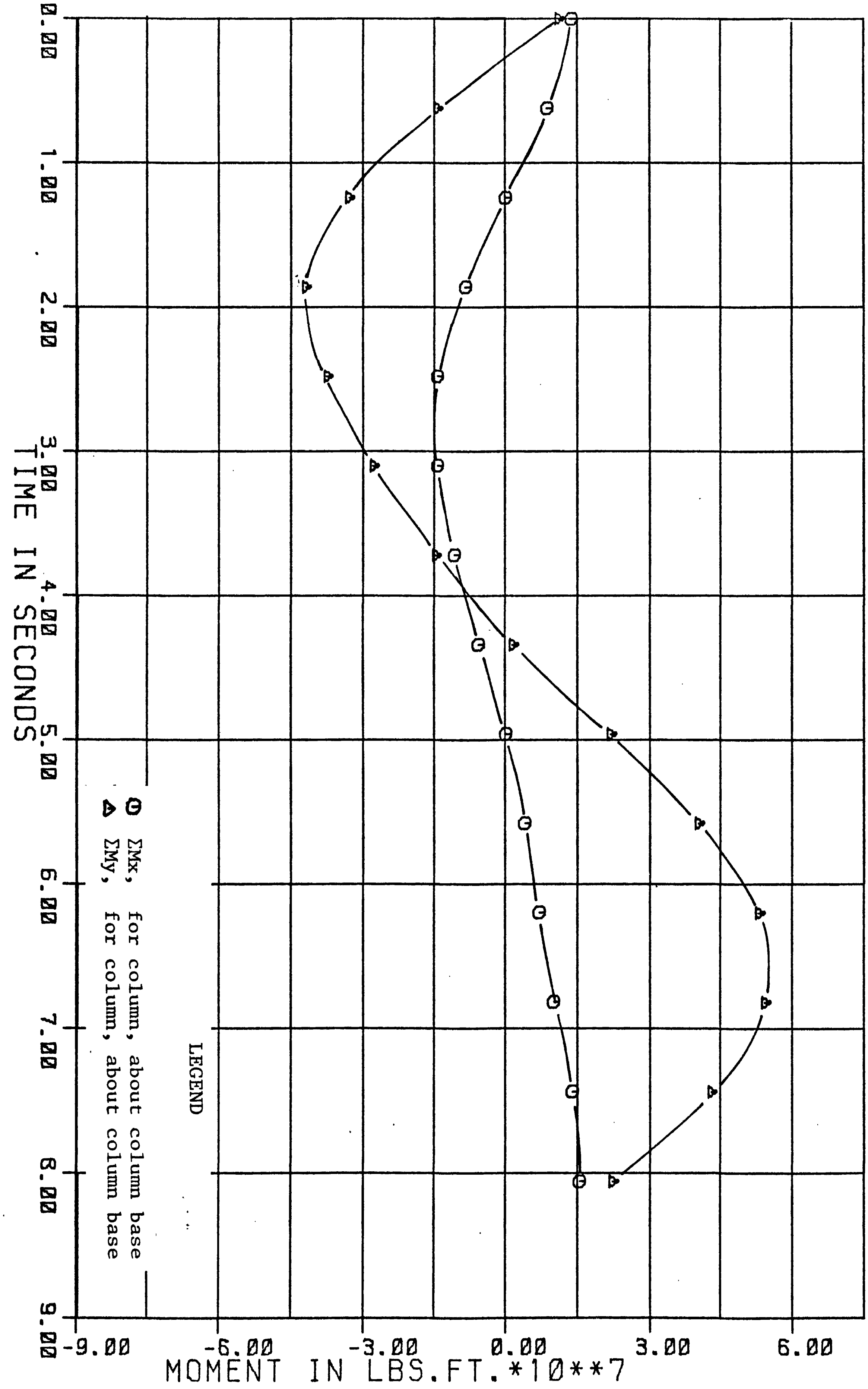


FIGURE 9-8. MOMENTS ON REAR LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NO NEIGHBOUR CAISSON.

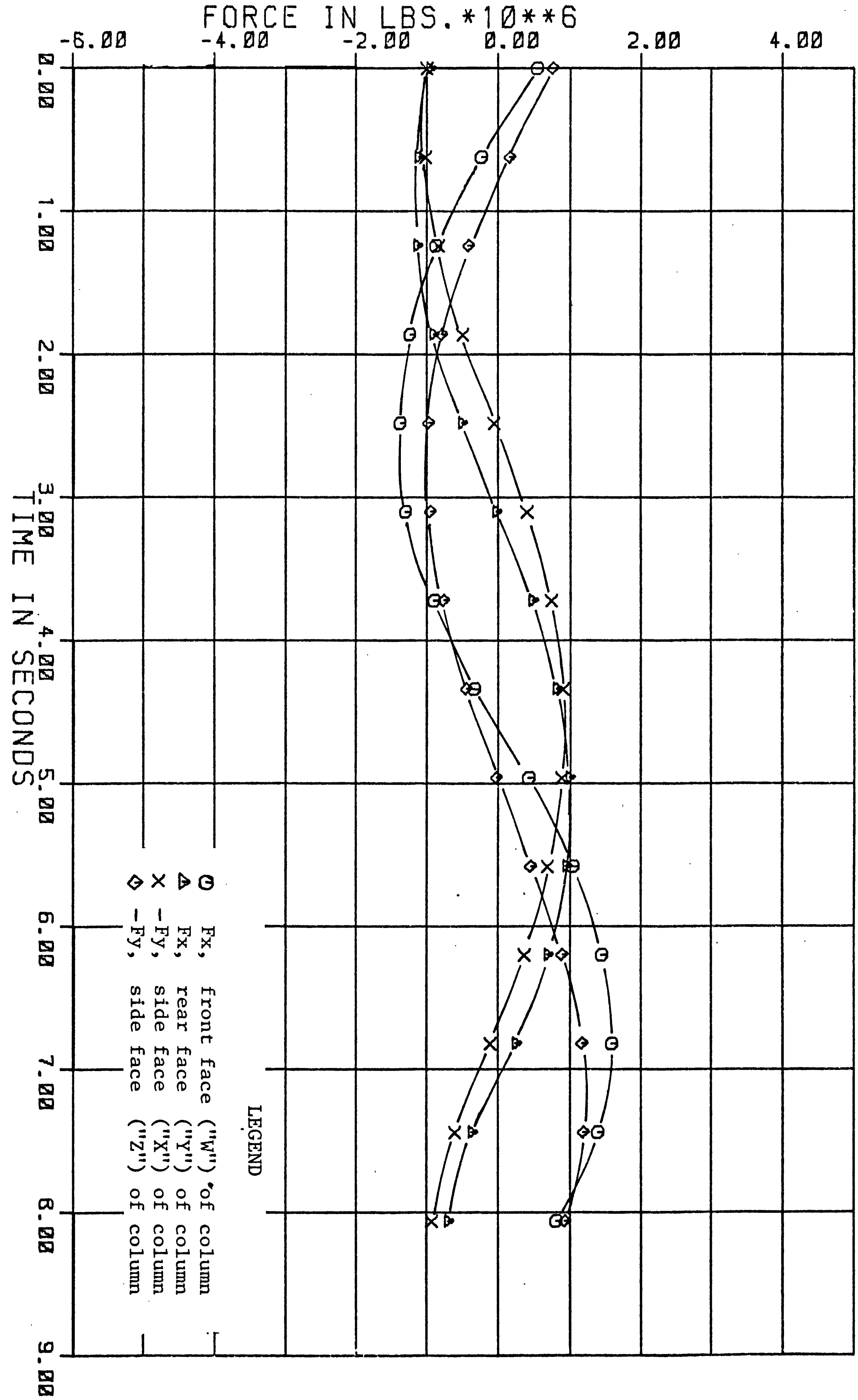


FIGURE 10-1. FORCES ON FRONT LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOUR CAISSONS PRESENT.

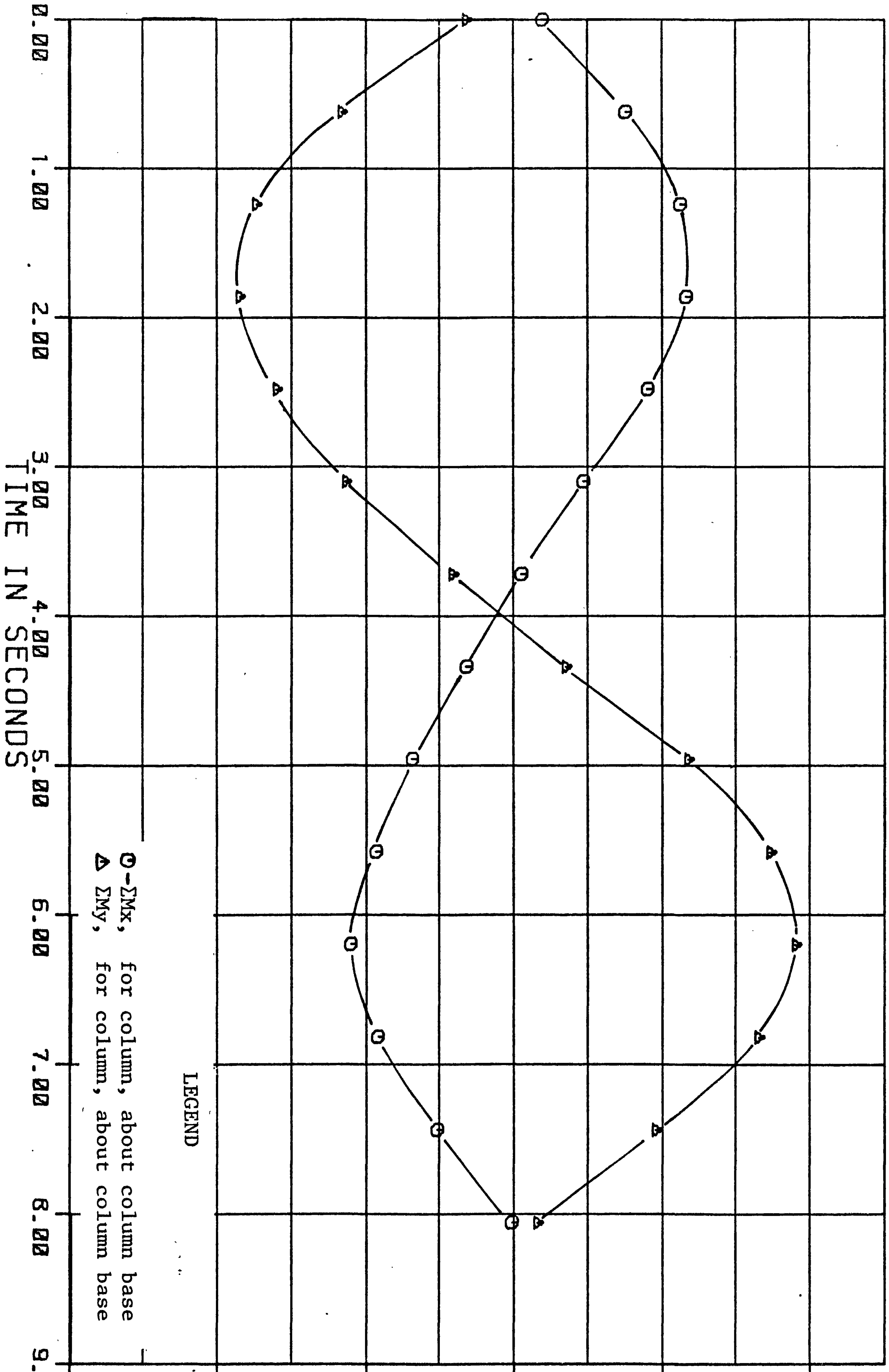


FIGURE 10-2. MOMENTS ON FRONT LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOUR CAISSONS PRESENT.

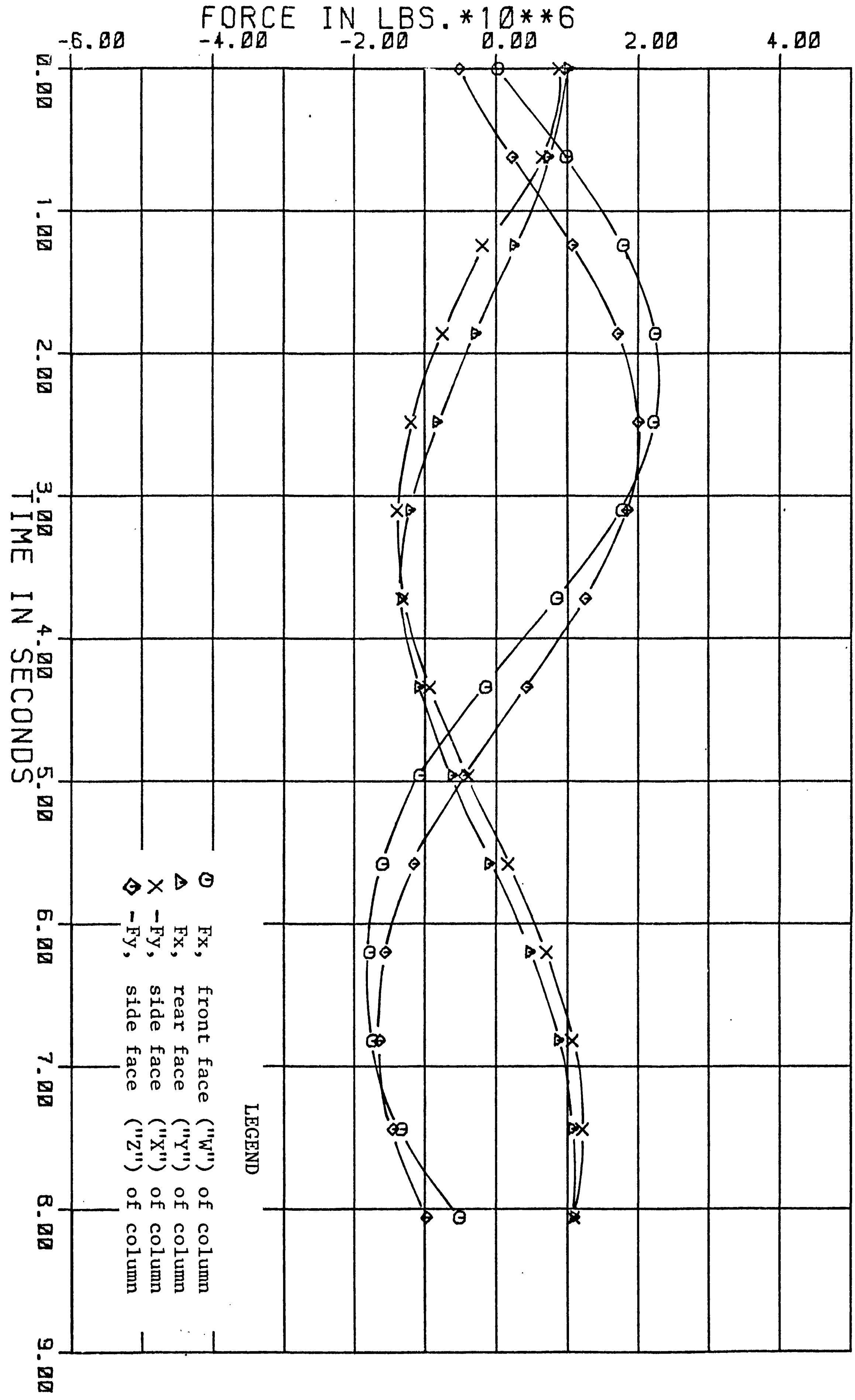


FIGURE 10-3. FORCES ON REAR TRAILING COLUMN OF
BERTH CAISSON FOR CASE, H.W./24/ESE.
NEIGHBOUR CAISSONS PRESENT.

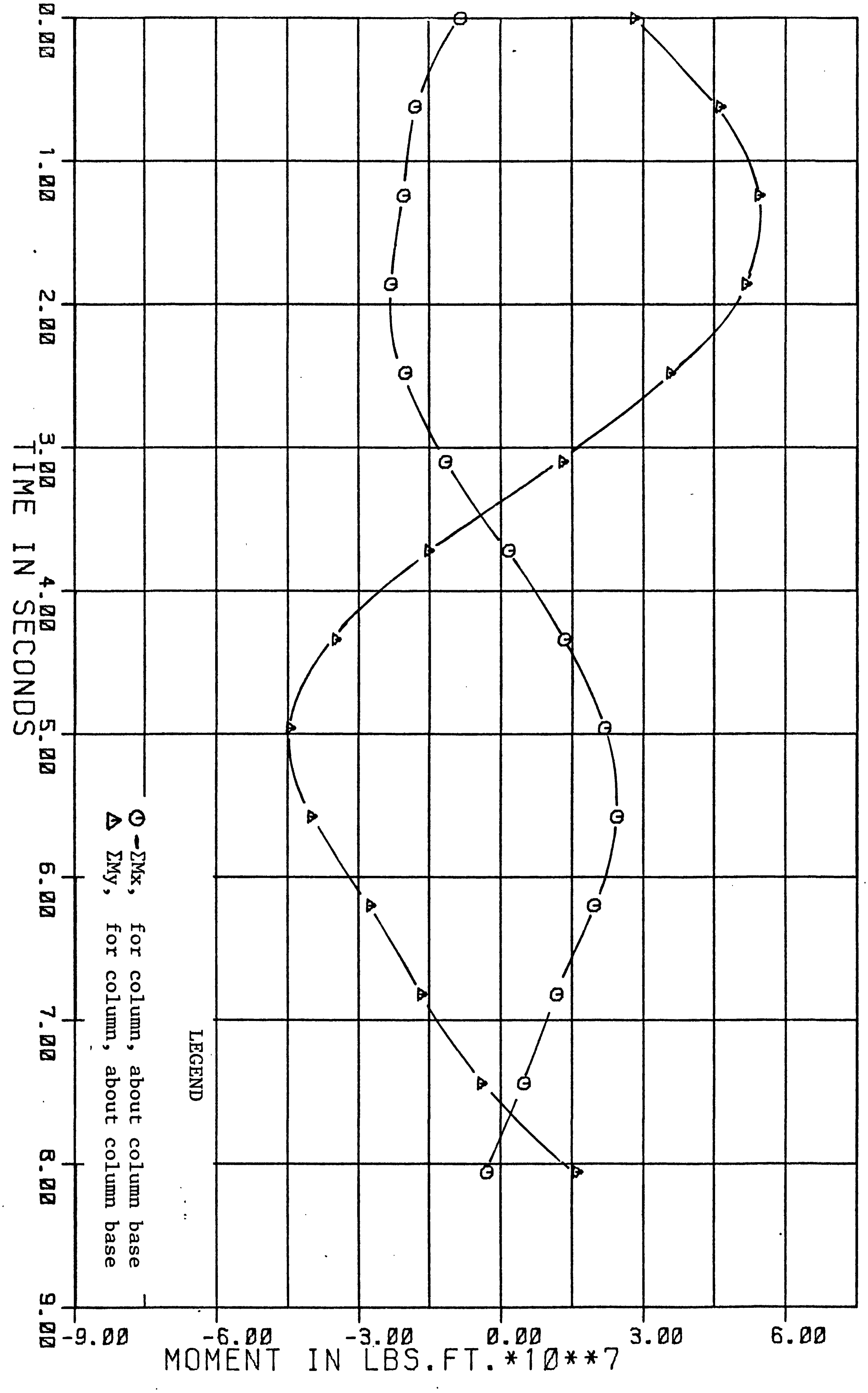


FIGURE 10-4. MOMENTS ON REAR TRAILING COLUMN OF
BERTH CAISSON FOR C ASE, H.W./24/ESE.
NEIGHBOUR CAISSONS PRESENT.

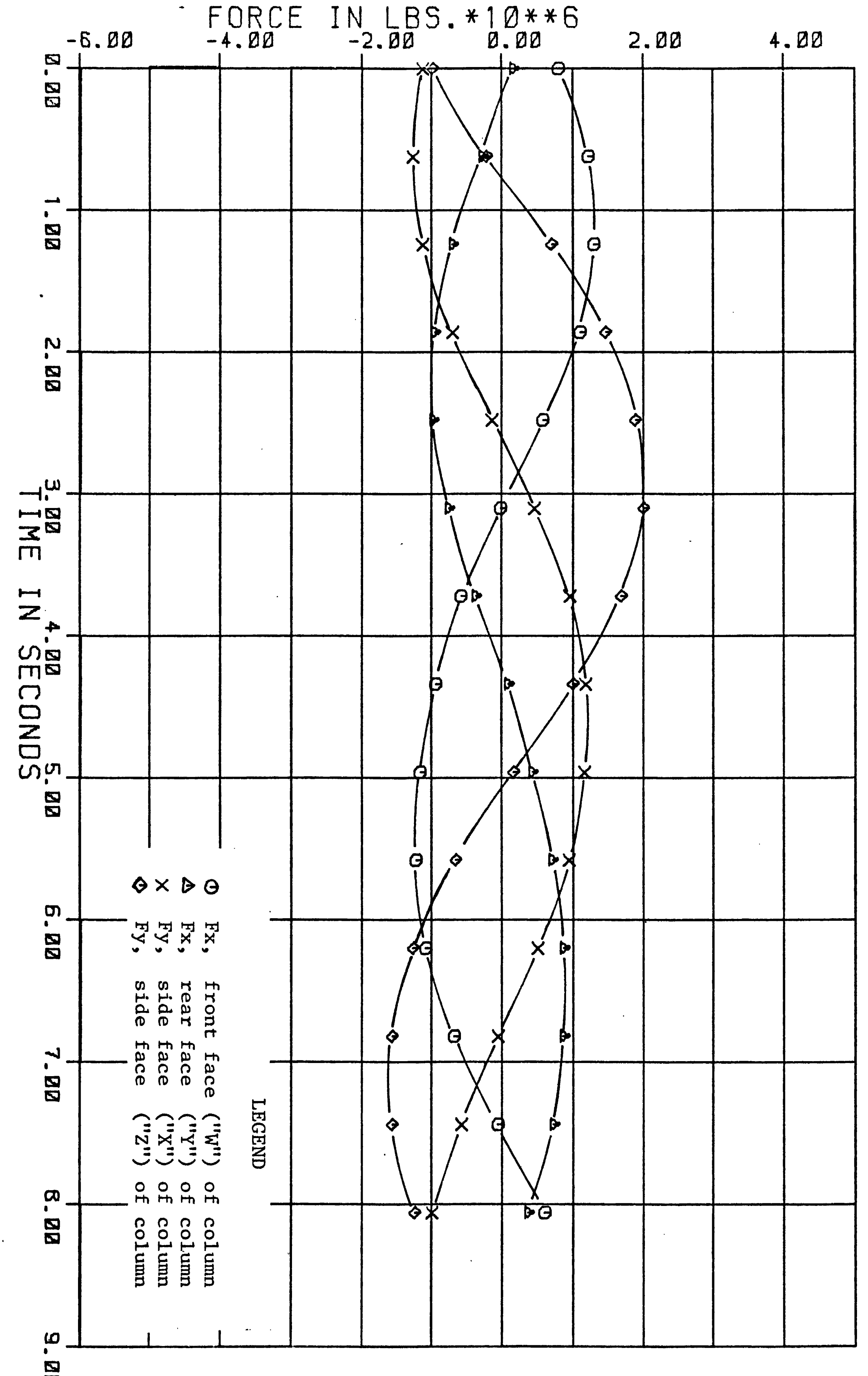


FIGURE 10-5. FORCES ON FRONT TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOUR CAISSONS PRESENT.

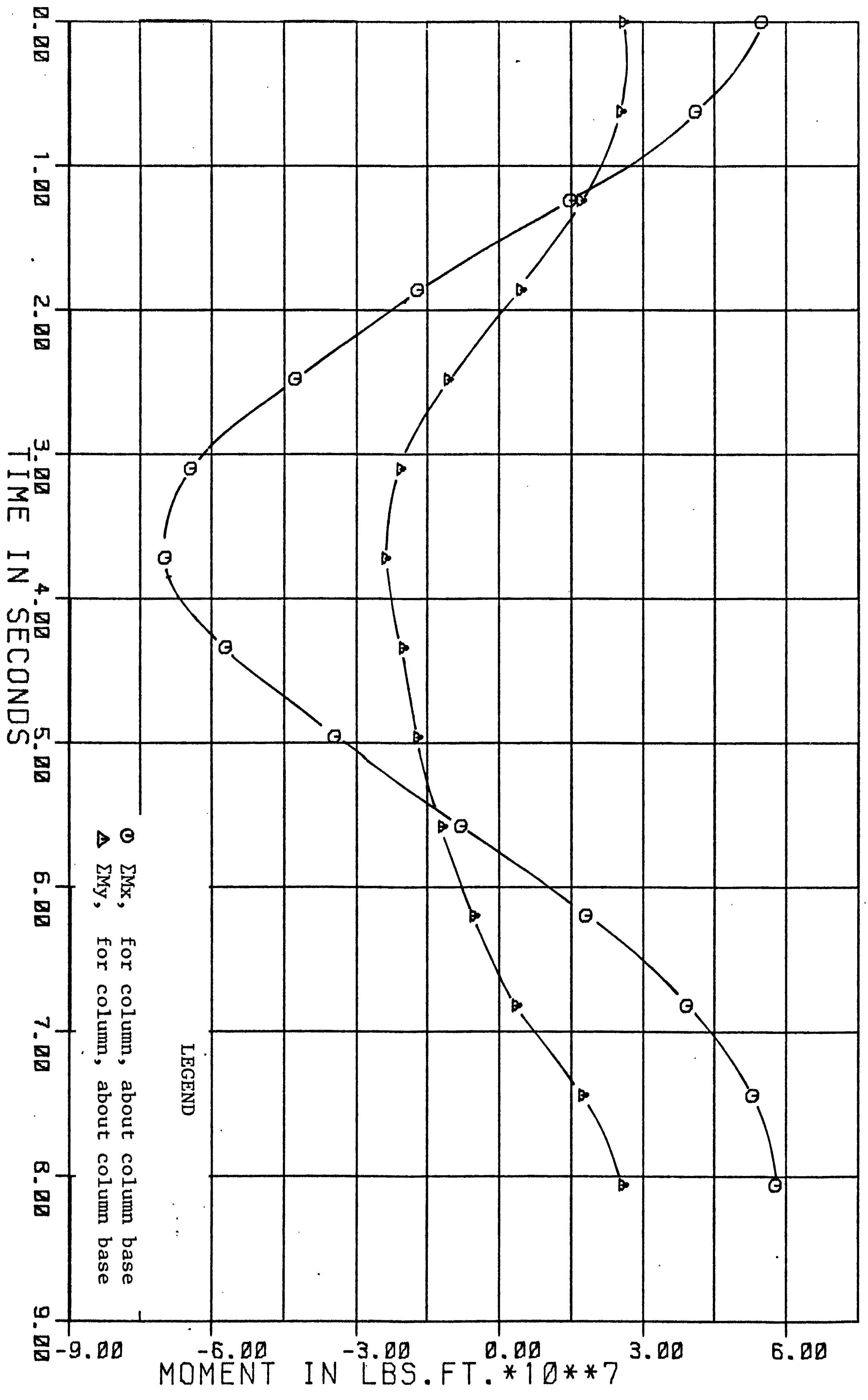


FIGURE 10-6. MOMENTS ON FRONT TRAILING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOUR CAISSONS PRESENT.

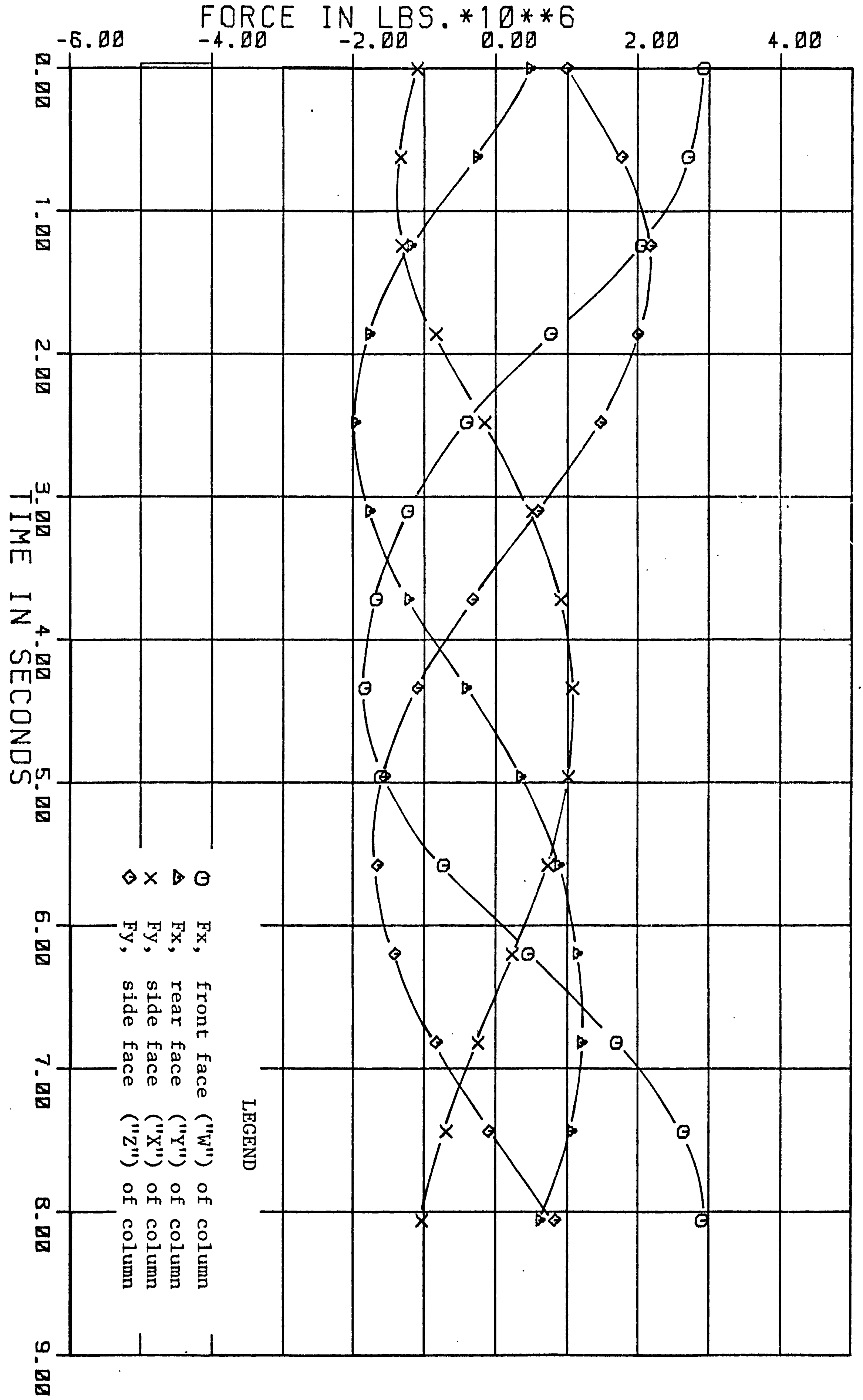


FIGURE 10-7. FORCES ON REAR LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOUR CAISSONS PRESENT.

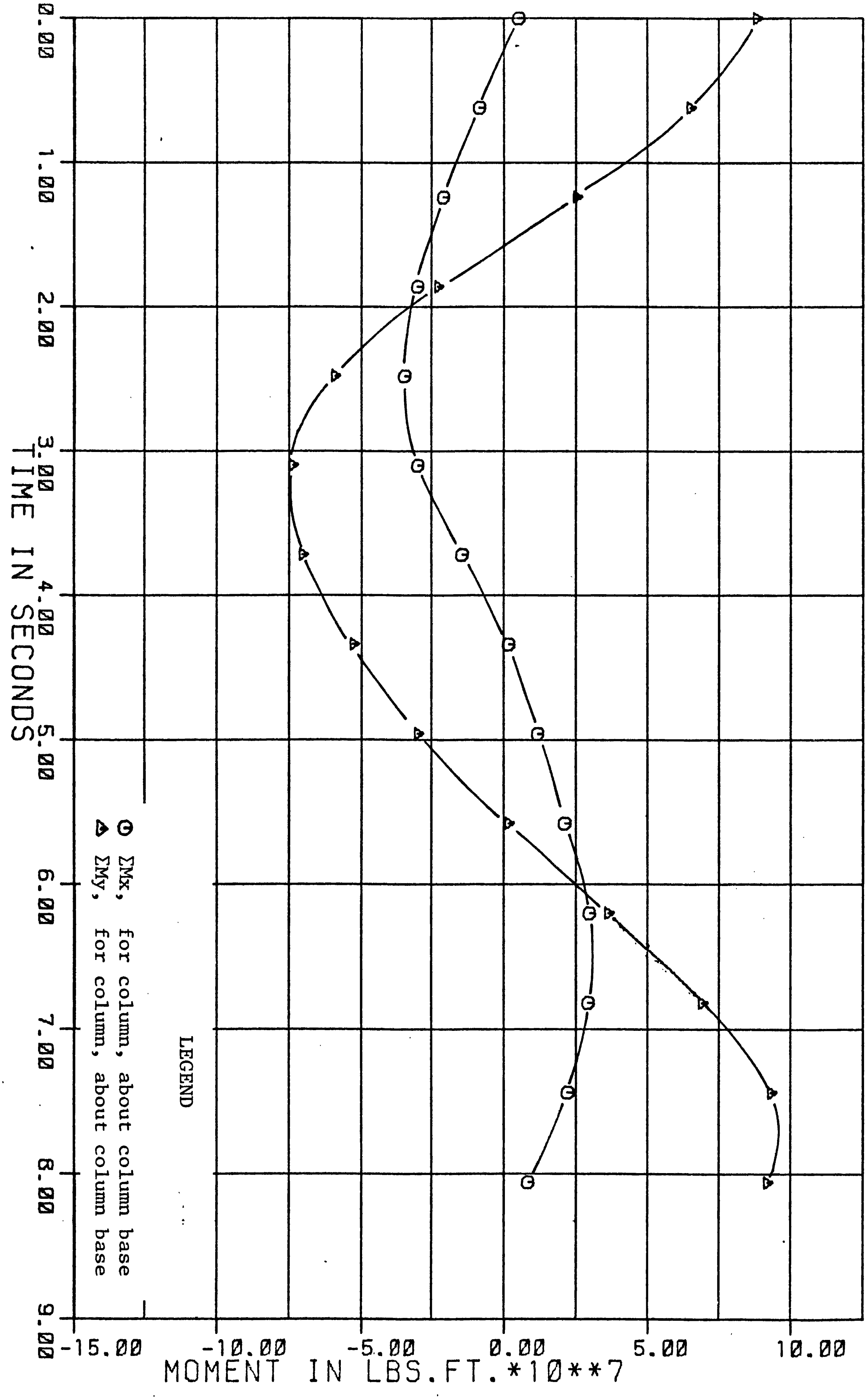


FIGURE 10-8. MOMENTS ON REAR LEADING COLUMN OF BERTH CAISSON FOR CASE, H.W./24/ESE. NEIGHBOURING CAISSONS PRESENT.

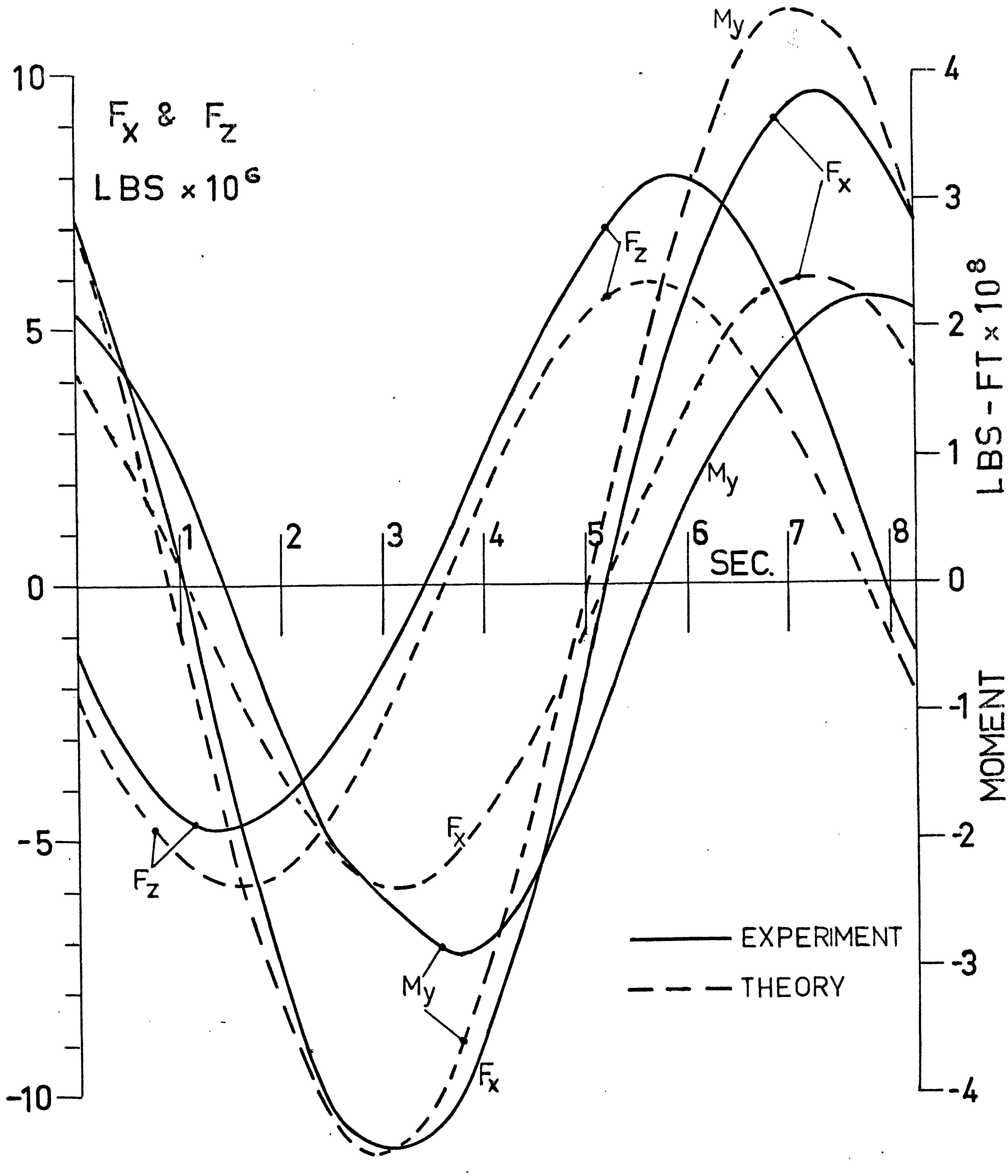


FIGURE 11. COMPARISON BETWEEN EXPERIMENTAL AND THEORETICAL VALUES OF FORCES AND MOMENTS ON BERTH CAISSON FOR CASE, H.W./24/NORMAL.

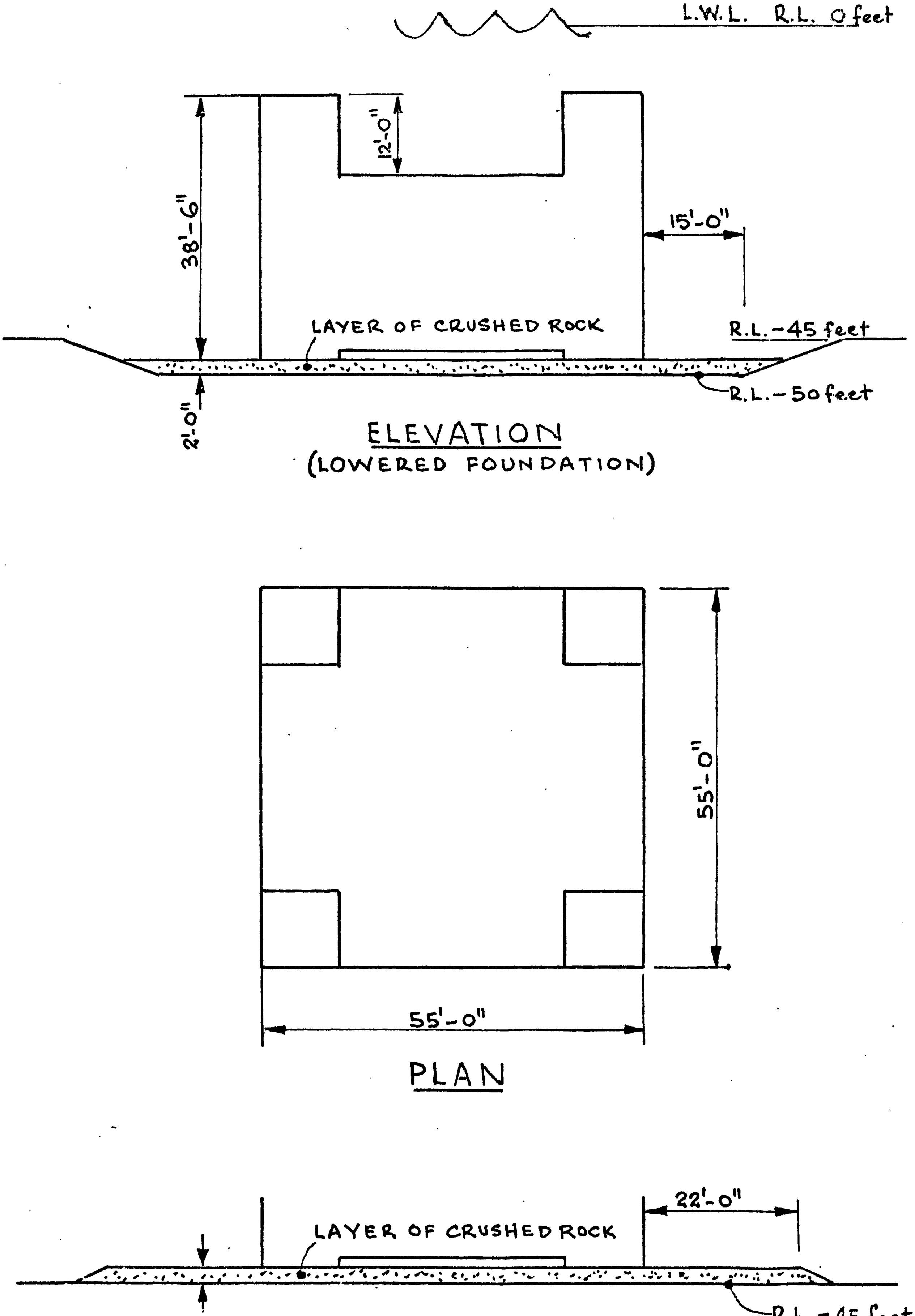


FIGURE 12. APPROACH CAISSON

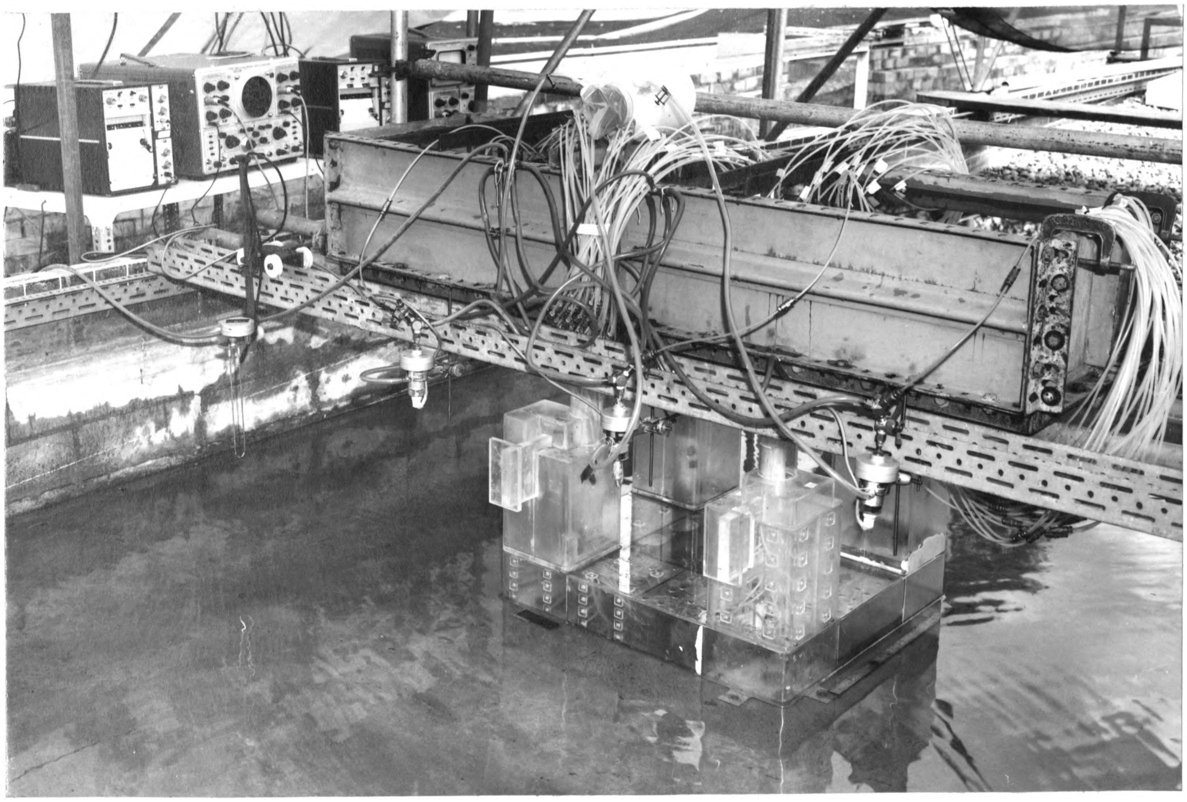


PLATE 1. GENERAL VIEW OF MODEL OF BERTH CAISSON INSTRUMENTED FOR PRESSURE MEASUREMENT. FRONT VIEW, SHOWING WAVE PROBE, PRESSURE TRANSDUCERS, DRY AIR REFERENCE RESERVOIR AND RECORDING INSTRUMENTS.

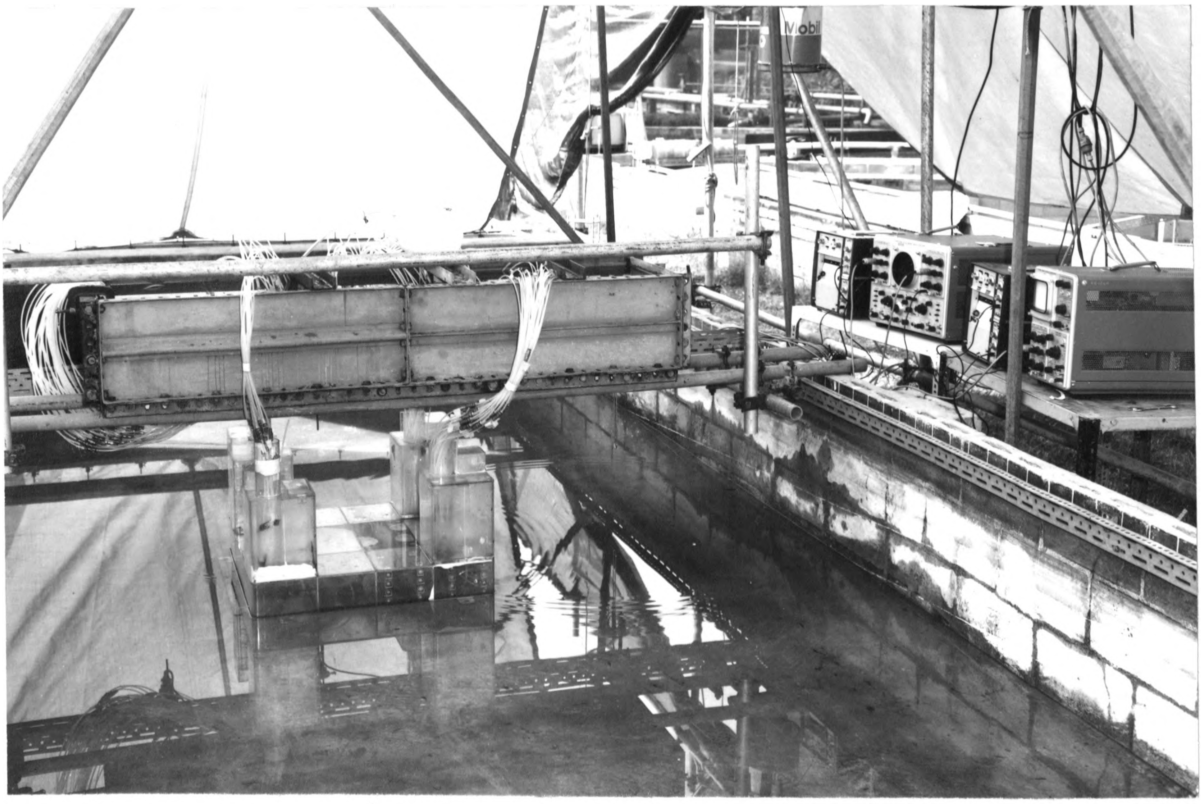


PLATE 2. GENERAL VIEW OF MODEL OF MAIN BERTH CAISSON FROM REAR.

PLATE 3. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 ft WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

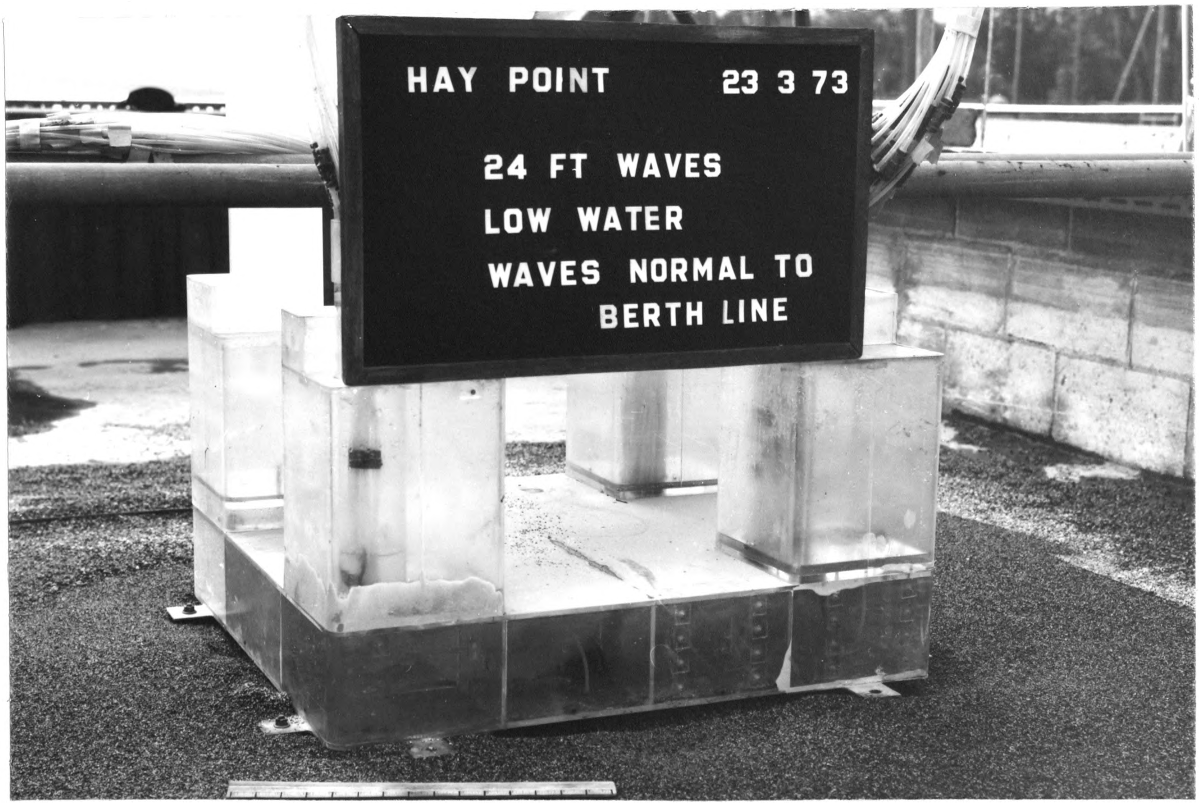


PLATE 4. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

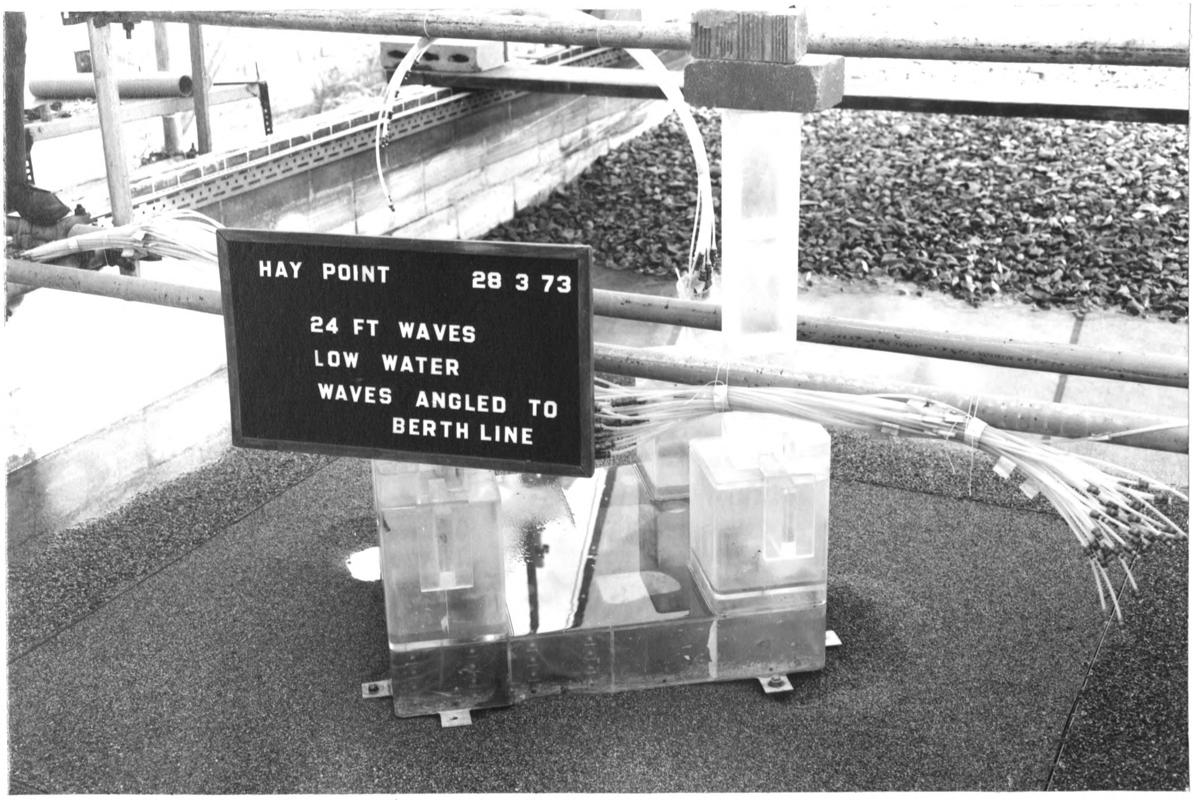


PLATE 5. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

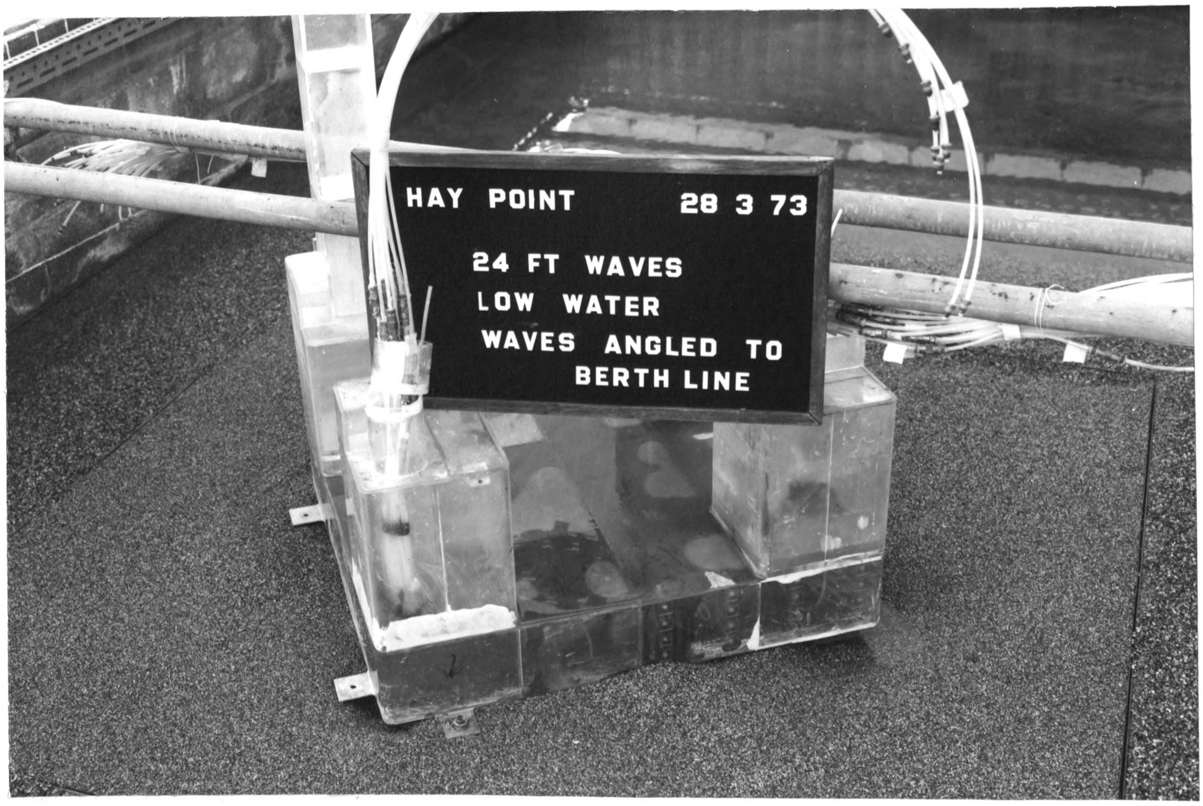


PLATE 6. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

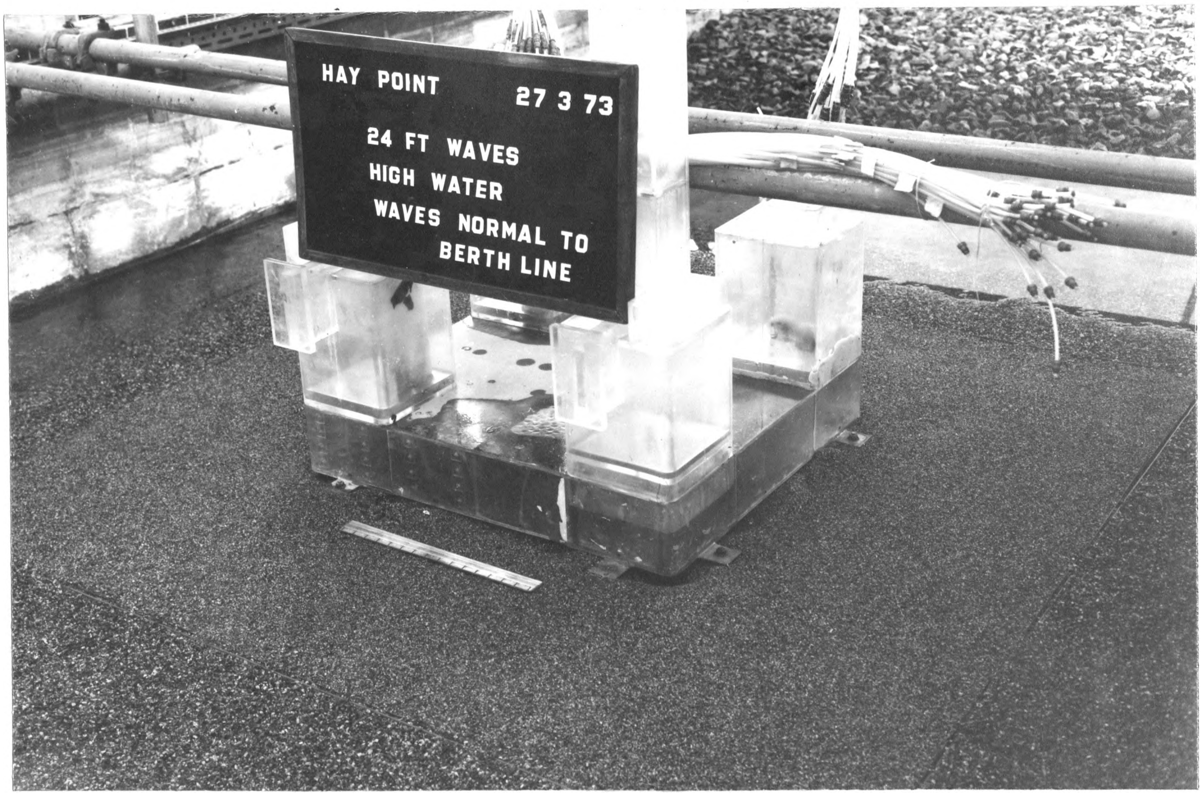


PLATE 7. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. FRONT VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

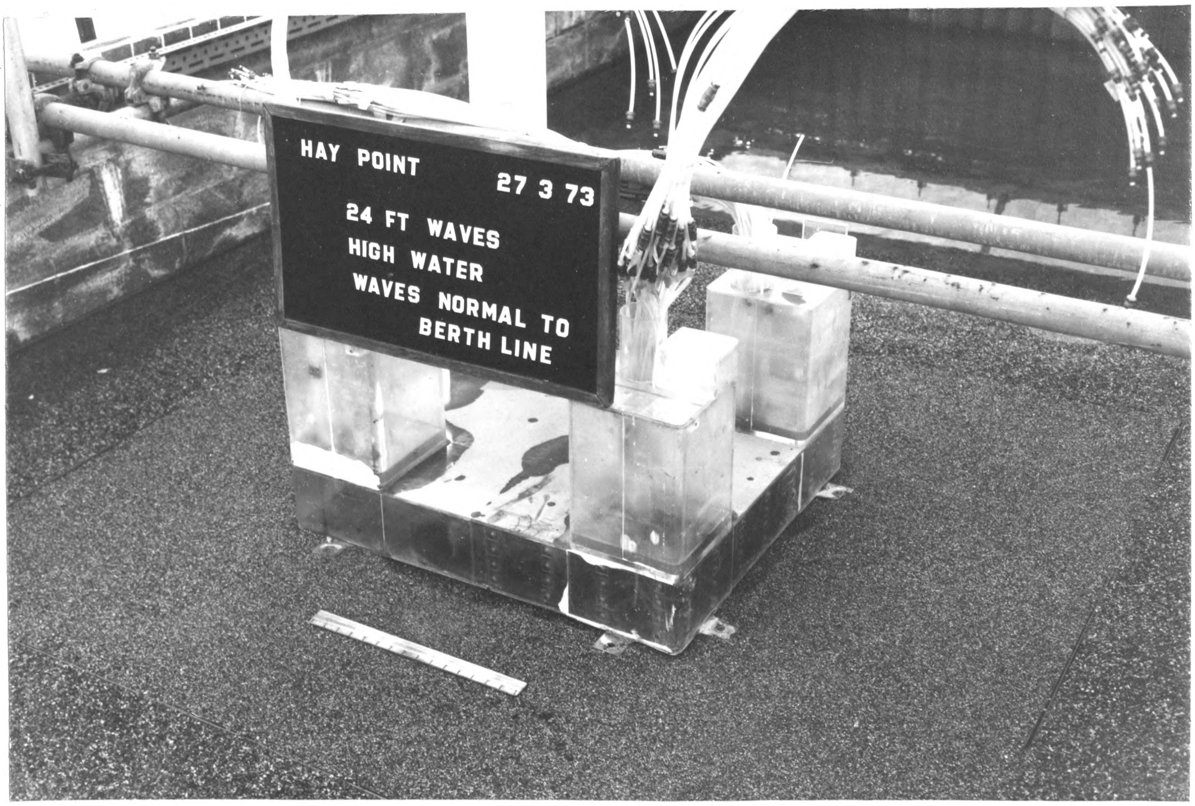


PLATE 8. SCOUR TESTS ON BERTH CAISSON WITHOUT PROTECTION. REAR VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

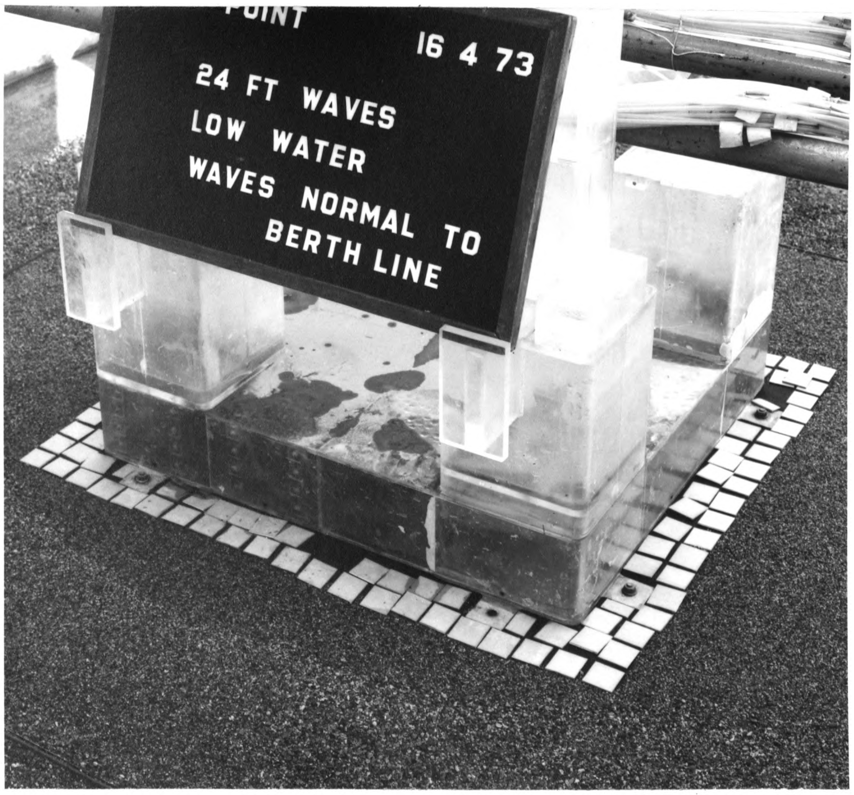


PLATE 9. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

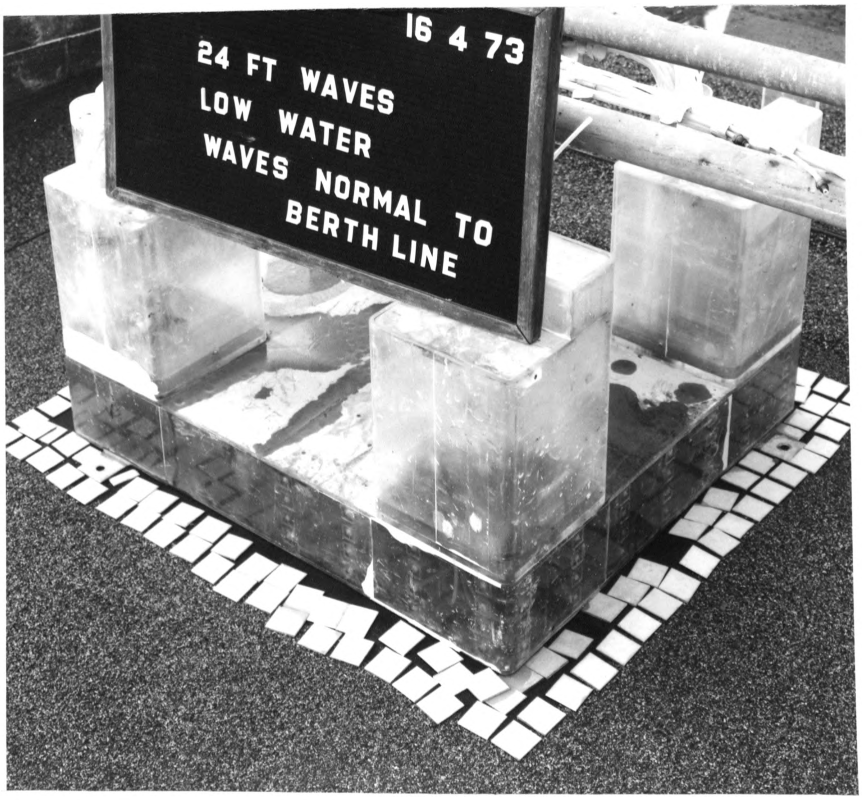


PLATE 10. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

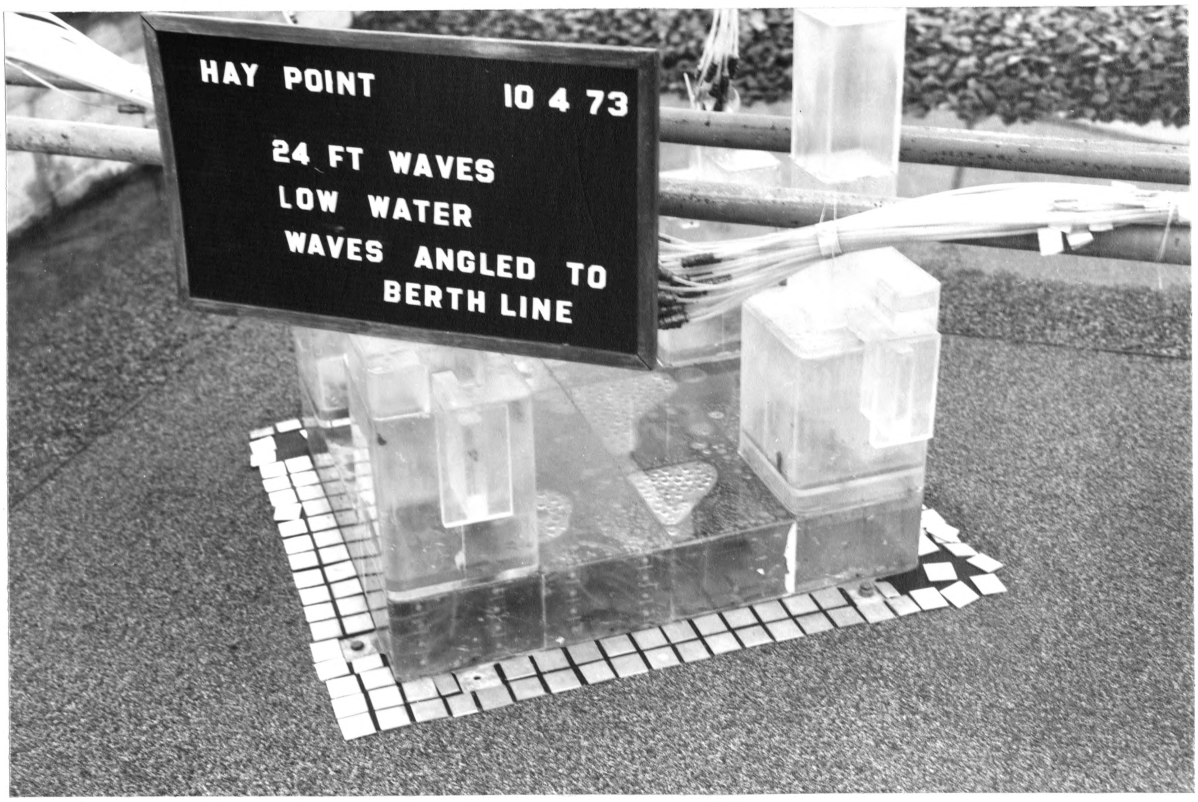


PLATE 11. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

PLATE 12. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

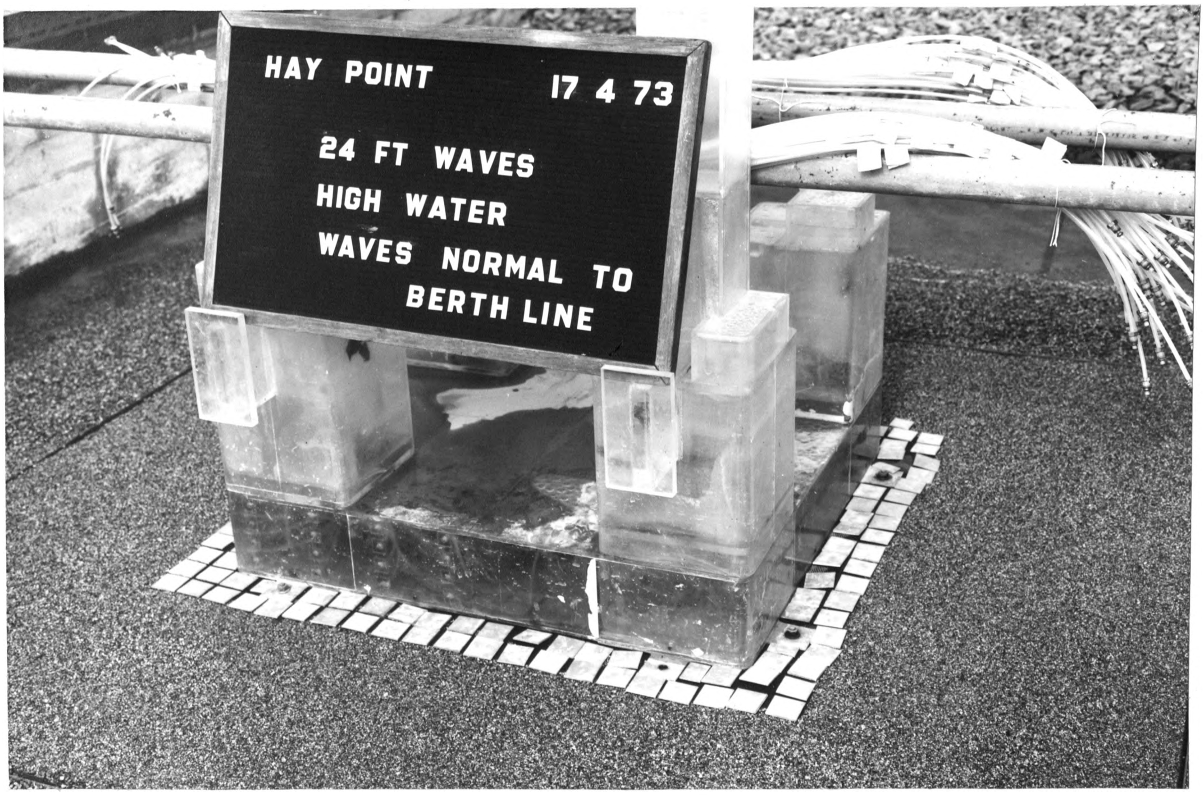


PLATE 13. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. FRONT VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

PLATE 14. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. REAR VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

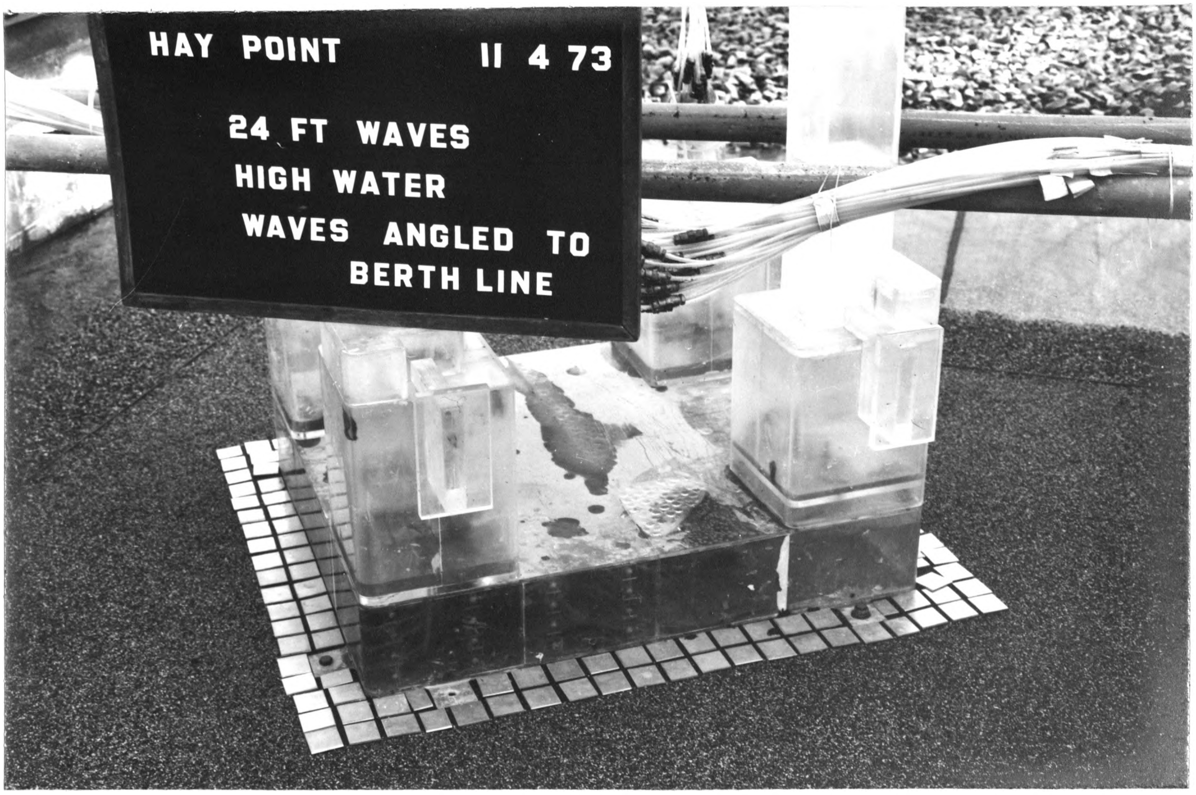


PLATE 15. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. FRONT VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

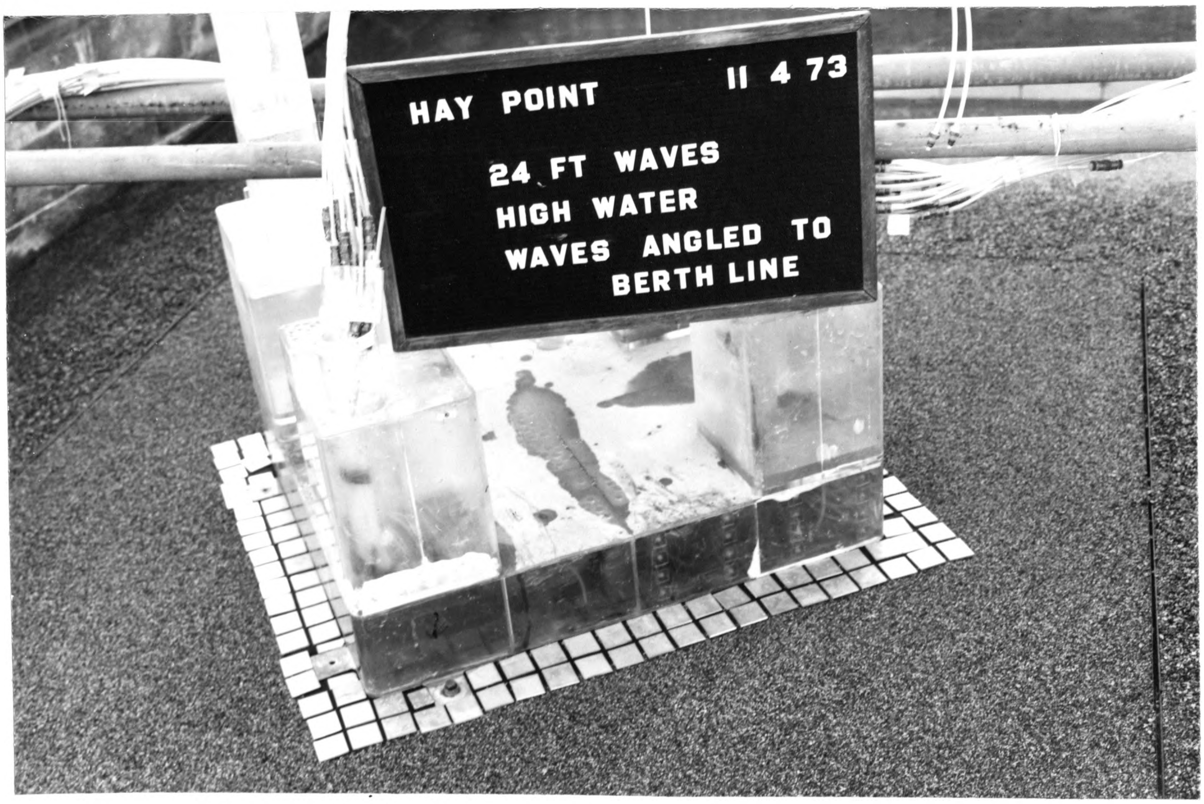


PLATE 16. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. REAR VIEW AFTER ONE HOUR'S TESTING AT HIGH WATER WITH 24 FT WAVES APPROACHING FROM E.S.E.

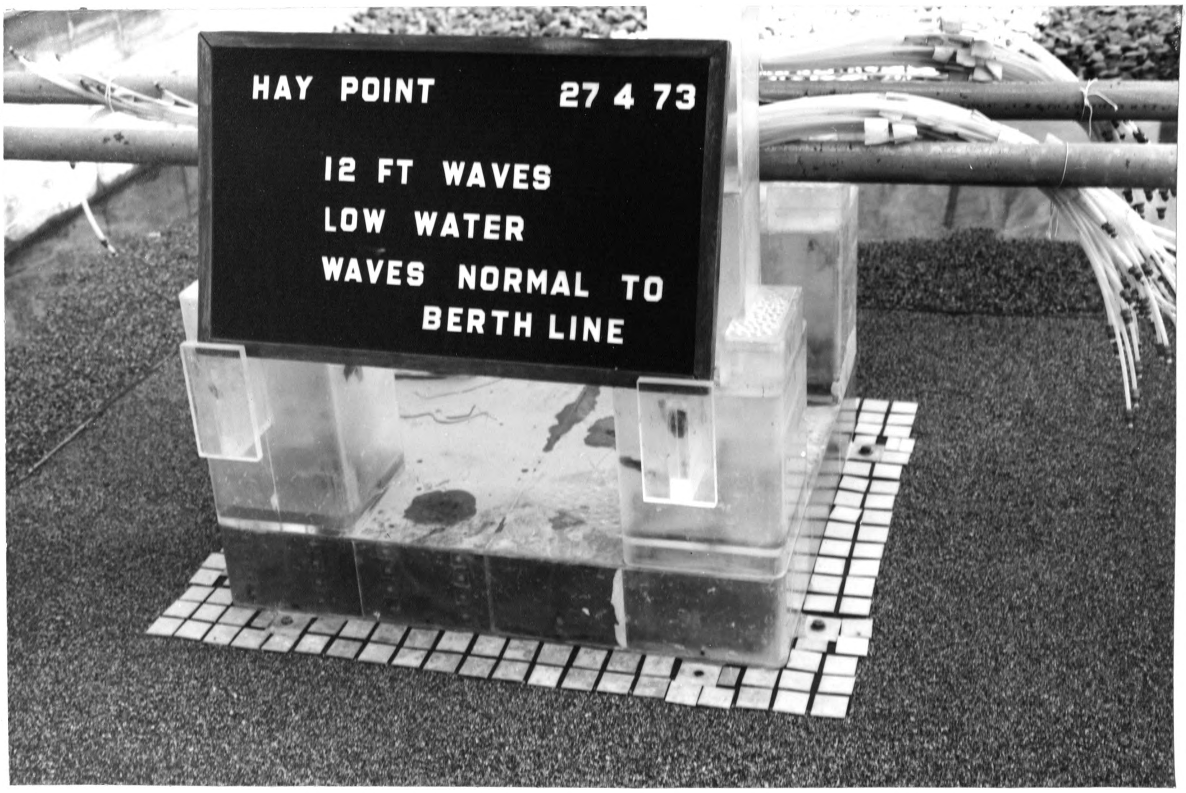


PLATE 17. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 12 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

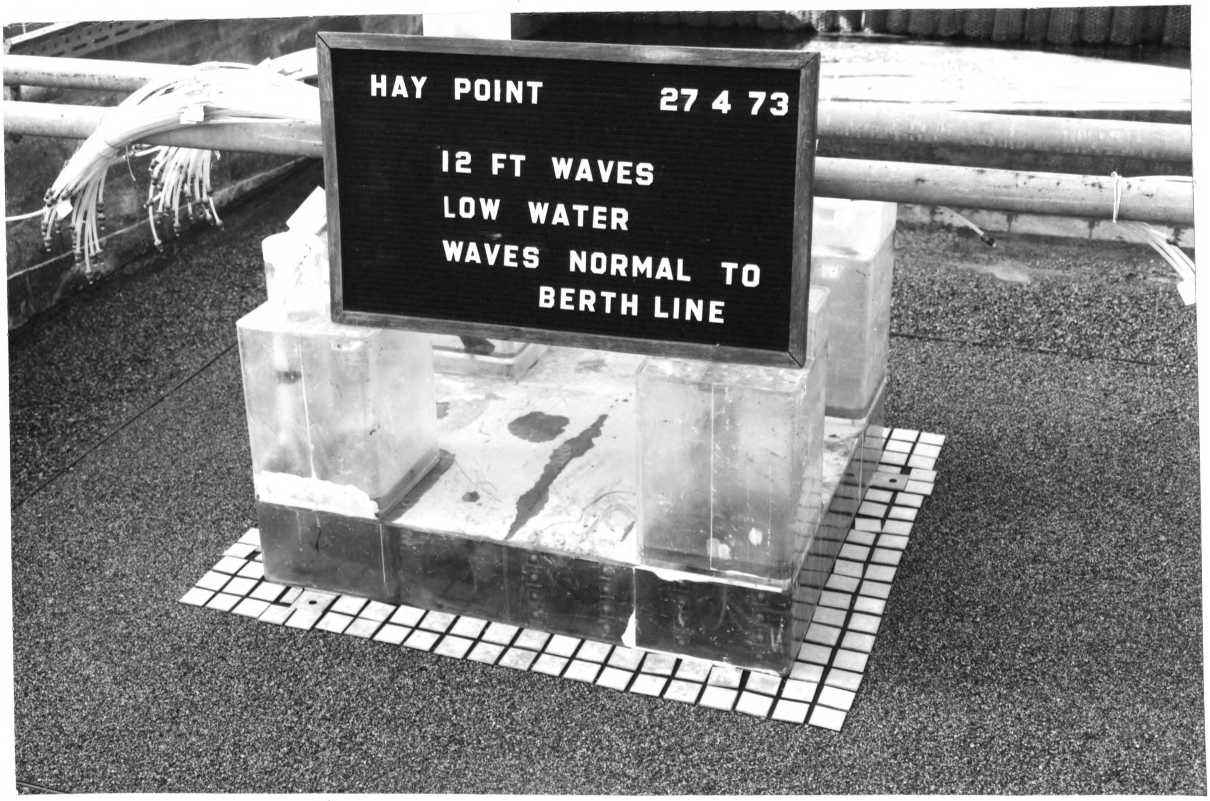


PLATE 18. SCOUR TEST ON BERTH CAISSON WITH SCOUR PROTECTION INSTALLED. REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 12 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

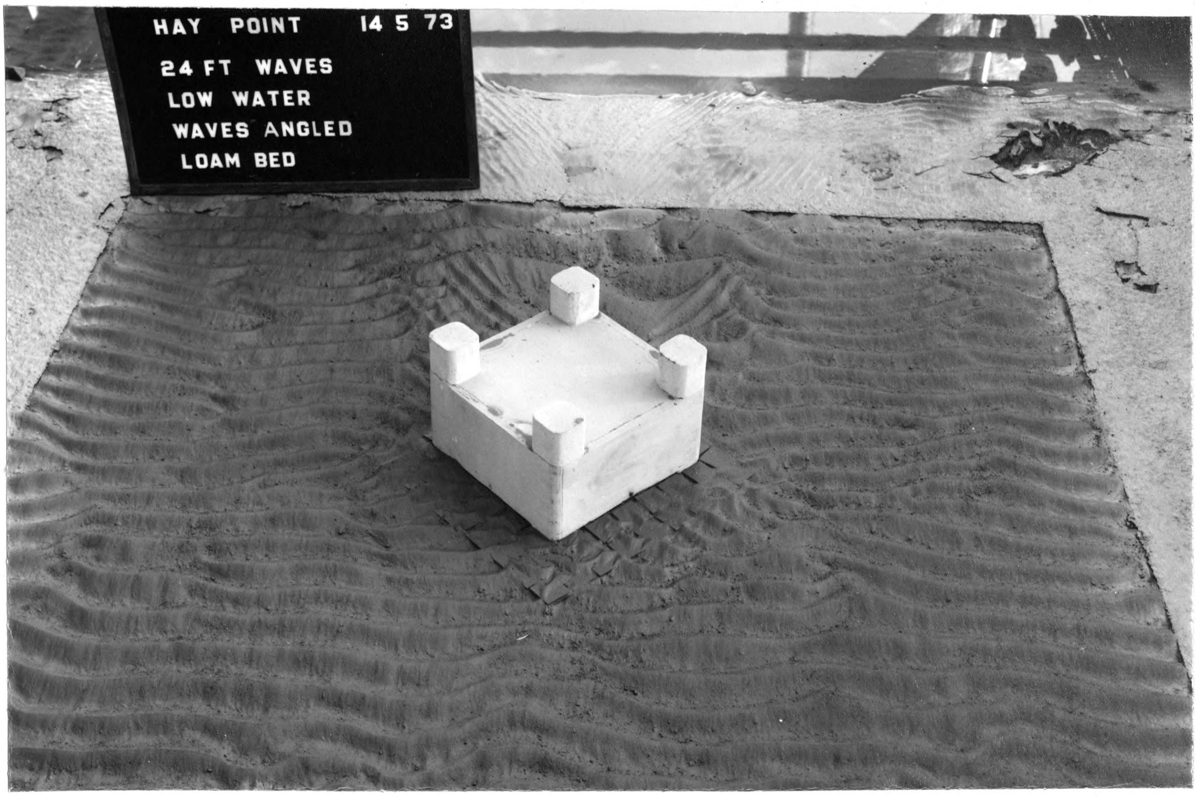


PLATE 19. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF LOAM; LOWERED FOUNDATION AND BOTTOM GAPS OPEN.
FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING AT 45^{o} ANGLE.

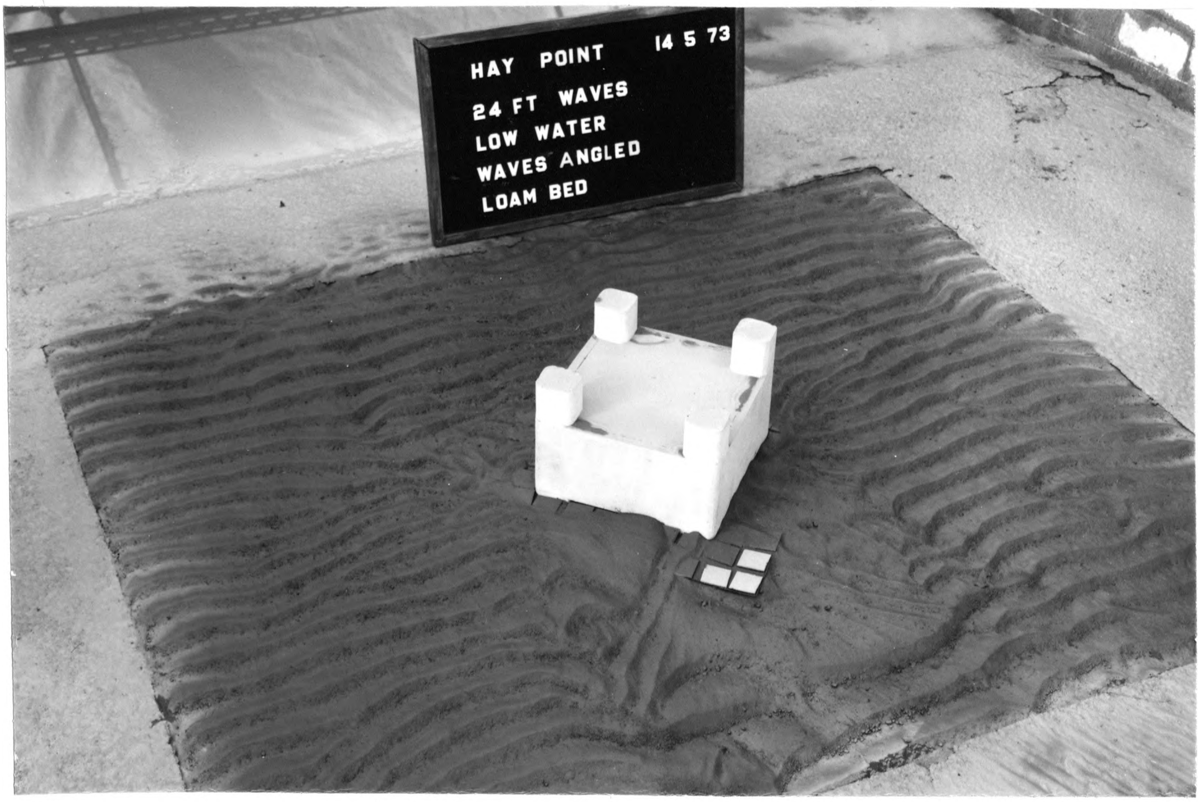


PLATE 20. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF LOAM; LOWERED FOUNDATION AND BOTTOM GAPS OPEN.
REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING AT 45^{o} ANGLE.

PLATE 21. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF COARSE SAND; LOWERED FOUNDATION AND BOTTOM GAPS OPEN.
FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

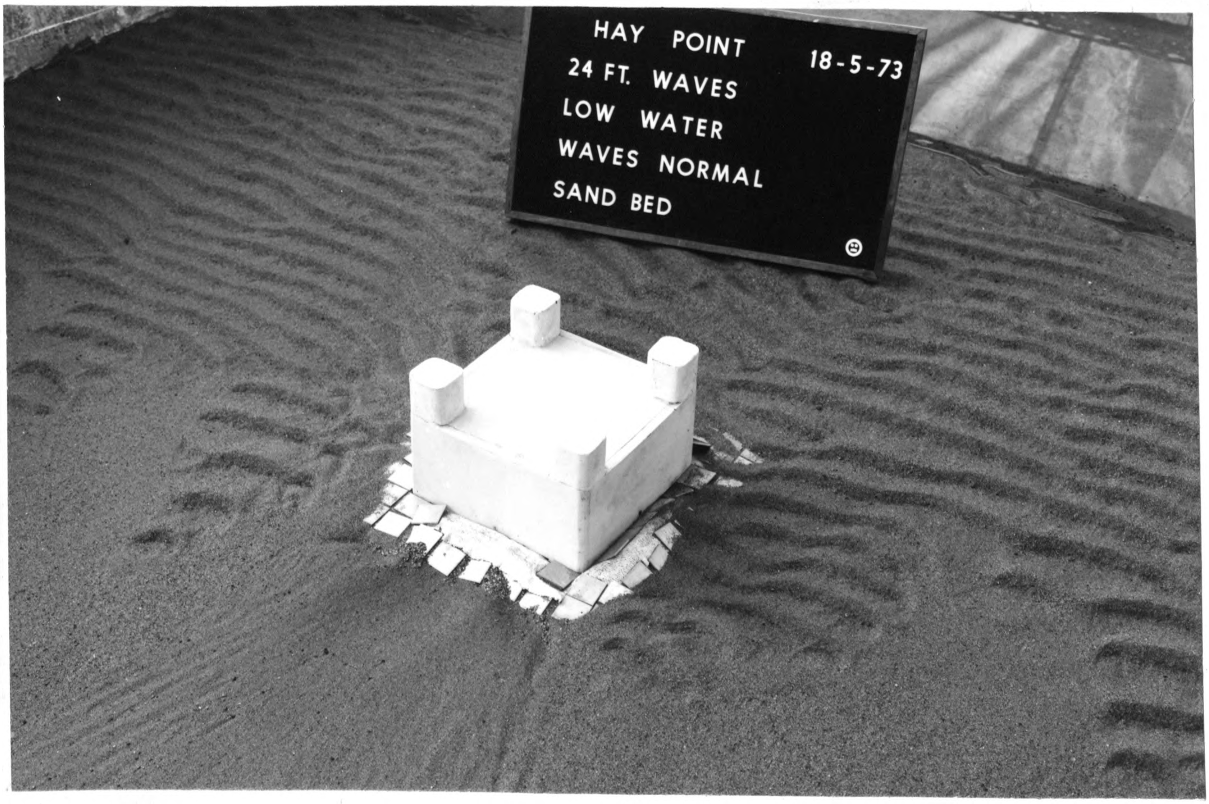


PLATE 22. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF COARSE SAND; LOWERED FOUNDATION AND BOTTOM GAPS OPEN.
REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

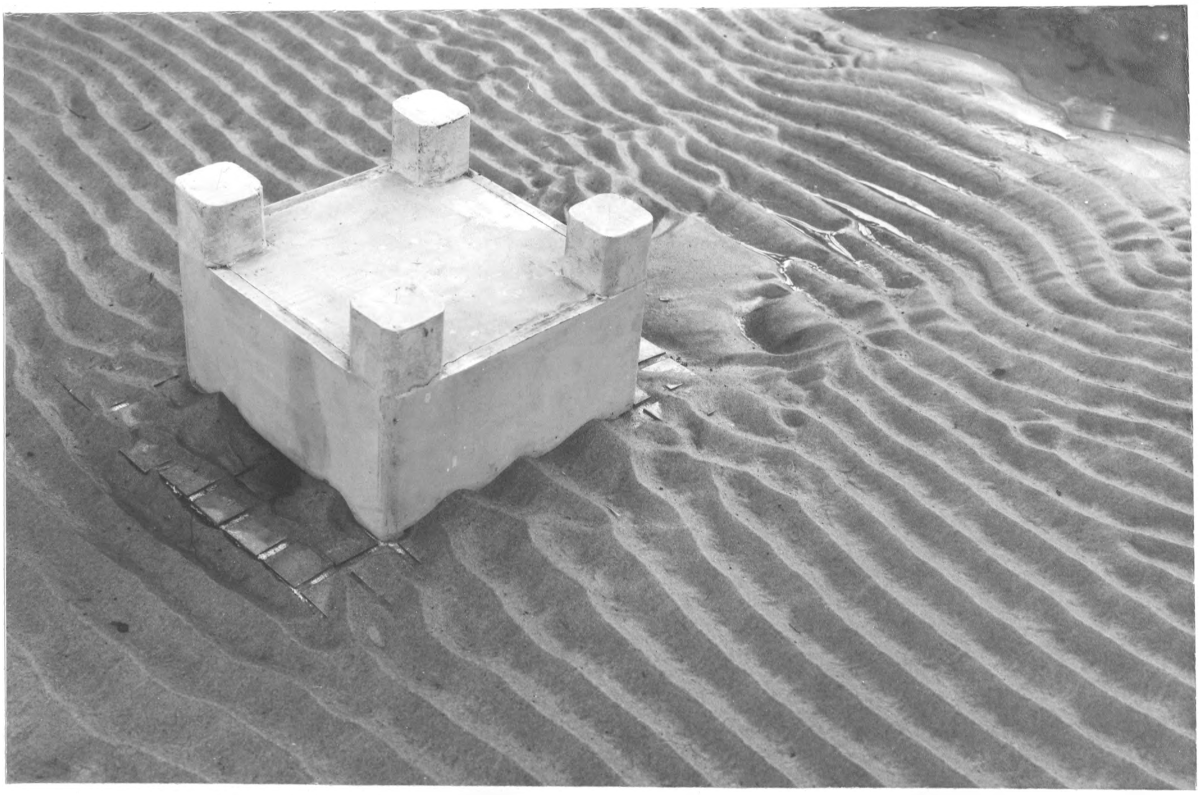


PLATE 23. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF FINE SAND; LOWERED FOUNDATION AND BOTTOM GAPS CLOSED.
FRONT AND SIDE VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

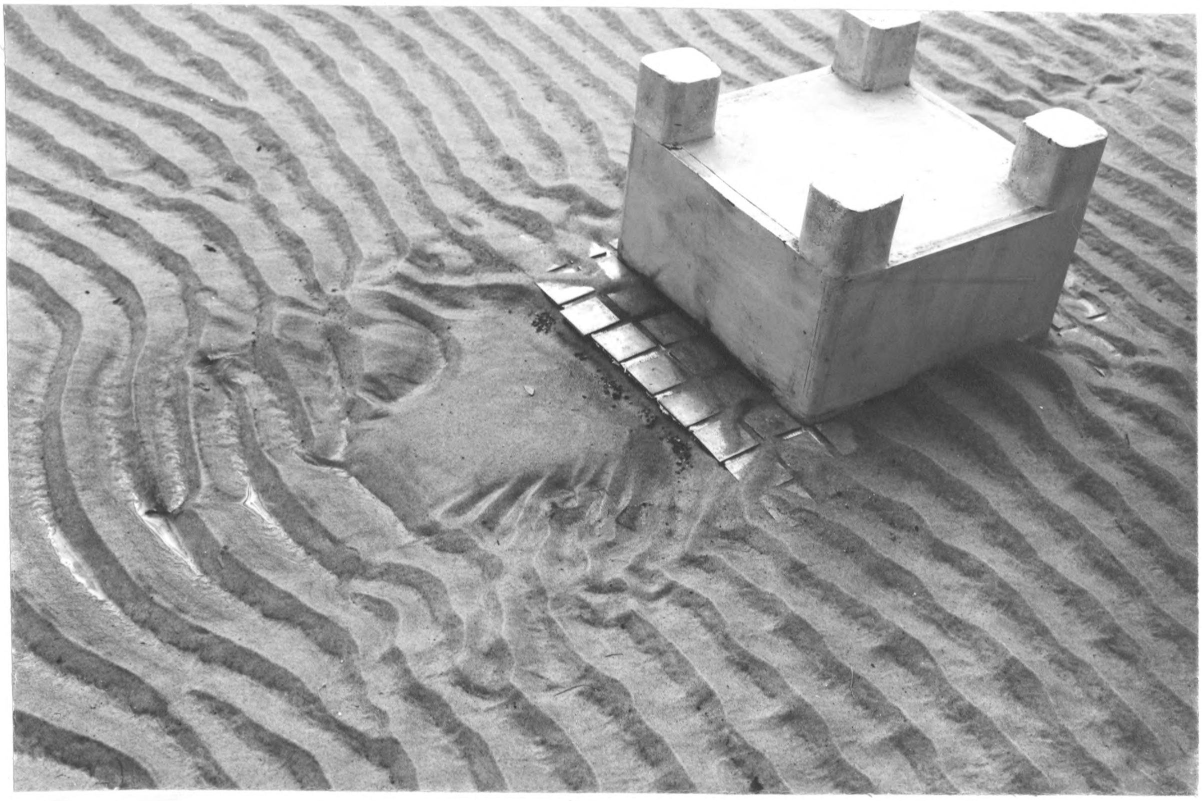


PLATE 24. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF FINE SAND; LOWERED FOUNDATIONS AND BOTTOM GAPS CLOSED.
REAR AND SIDE VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING IN DIRECTION NORMAL TO BERTHLINE.

PLATE 25. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF FINE SAND; RAISED FOUNDATION AND BOTTOM GAPS CLOSED.
FRONT VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING AT 45° ANGLE.

PLATE 26. SCOUR TESTS ON APPROACH CAISSON; SEA-BED OF FINE SAND; RAISED FOUNDATION AND BOTTOM GAPS CLOSED.
REAR VIEW AFTER ONE HOUR'S TESTING AT LOW WATER WITH 24 FT WAVES APPROACHING AT 45° ANGLE.

APPENDIX 1

PRESSURES ON BERTH CAISSON DUE TO 24 FEET HIGH WAVES APPROACHING IN THE DIRECTION NORMAL TO BERTHLINE AT HIGH WATER.

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER

TOP SURFACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
1.9	-2.9	-4.3	0.0	0.0	10.3	1.9	2.9	-10.9	-12.2
2.5	1.9	3.5	5.7	6.7	9.1	7.1	3.3	-6.8	-6.1
5.2	5.2	5.2	9.5	10.9	6.3	9.5	3.3	2.0	-2.7
6.7	7.1	8.6	10.5	12.4	1.8	10.0	2.9	4.1	2.7
7.6	7.1	9.5	10.5	12.4	-1.8	8.6	2.4	8.1	7.5
7.1	5.2	3.6	7.1	8.6	-5.4	5.2	1.4	3.8	8.6
5.7	1.9	5.2	2.9	2.9	-8.2	0.2	0.5	8.1	8.1
3.3	-1.9	0.5	-2.4	-2.9	-9.1	-4.9	-1.0	4.1	4.1
1.9	-6.7	-4.3	-6.7	-6.6	-9.1	-9.0	-1.9	-1.4	-1.4
0.2	-9.5	-8.6	-10.5	-12.8	-6.3	-11.9	-1.9	-6.8	-6.8
-1.4	-11.4	-11.4	-10.9	-14.3	-2.7	-12.4	-1.9	-10.9	-10.9
-1.9	-11.4	-11.9	-9.5	-12.8	1.8	-10.0	-1.2	-13.6	-14.3
-1.4	-8.6	-10.0	-5.7	-8.1	7.3	-5.2	1.0	-14.9	-14.9
0.5	-3.8	-5.7	0.0	-1.9	10.9	0.0	2.4	-12.2	-13.6

11	12	13	14	15	16	17	18	19	20
-5.4	-4.8	0.0	-2.7	12.7	10.9	12.7	11.8	7.3	7.3
0.0	1.4	4.1	2.7	15.4	12.7	12.7	11.8	5.4	5.4
5.4	5.4	6.8	6.6	14.5	10.9	12.0	8.2	1.8	2.7
8.3	7.5	8.1	8.8	10.0	6.3	4.5	2.7	-3.6	0.0
9.5	7.5	6.8	8.8	3.6	0.0	-1.8	-2.7	-6.3	-2.7
8.1	5.4	4.1	6.6	-2.7	-6.3	-6.3	-7.3	-8.2	-3.6
3.[illegible]	1.4	-0.7	[illegible]	-8.2	-11.8	-9.1	-9.1	-8.2	-4.1
-2.7	-4.1	-5.4	-2.7	-11.8	-15.4	-10.9	-10.0	-7.3	-4.5
-8.1	-9.5	-9.5	-8.1	-13.6	-16.3	-11.3	-10.0	-5.9	-4.5
-13.6	-12.2	-12.9	-12.2	-13.6	-16.3	-10.0	-8.2	-4.1	-3.6
-16.3	-14.3	-13.6	-14.3	-10.0	-12.7	-6.3	-5.4	-1.8	-0.9
-16.3	-13.6	-12.2	-13.6	-3.6	-4.5	0.0	0.9	1.8	1.5
-13.6	-10.9	-8.1	-11.9	4.5	3.6	6.3	6.3	5.4	5.4
-8.1	-5.4	-2.7	-4.1	11.8	10.9	10.9	10.9	7.3	7.3

21	22
-[illegible]	-0.5
-1.[illegible]	-3.6
-5.9	-6.3
-7.7	-7.3
-8.2	-7.3
-6.3	-4.5
-3.6	-1.8
0.[illegible]	0.9
2.7	2.7
3.6	3.2
3.7	2.7
3.1	2.3
3.[illegible]	1.9
0.[illegible]	0.0

APPENDIX 1-3

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 24 FT PERIOD 8.25 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

FRONT FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
-2.[illegible]	-1.4	-1.4	-1.4	-2.0	-1.4	-2.0	-1.4	-2.0	-1.4
-5.4	-4.1	-4.1	-2.7	-5.4	-4.1	-4.1	-4.1	-4.1	-5.4
-8.1	-6.8	-7.5	-5.4	-6.8	-6.1	-6.8	-6.8	-6.8	-9.5
-9.[illegible]	-9.5	-9.5	-8.1	-8.1	-8.1	-8.1	-8.1	-8.1	-12.2
-10.2	-9.5	-10.2	-8.8	-8.1	-8.8	-8.8	-8.8	-8.8	-13.6
[illegible]	-8.1	-6.8	-8.1	-6.8	-6.1	-7.5	-6.8	-8.1	-12.9
-4.8	-5.4	-5.4	-6.1	-2.7	-4.1	-4.8	-4.1	-4.8	-6.8
-0.7	-1.4	-2.0	-2.7	0.0	-1.4	-1.4	-1.4	-1.4	-2.7
2.[illegible]	1.4	1.4	0.0	1.4	1.4	0.7	1.4	1.4	1.4
4.[illegible]	4.1	3.4	1.4	2.7	2.7	1.4	2.0	2.7	4.1
4.[illegible]	4.8	4.1	2.[illegible]	2.7	3.4	2.0	2.7	2.7	5.4
[illegible]	4.1	4.1	[illegible]	2.0	3.4	2.0	2.7	2.7	5.4
1.4	2.7	2.7	1.4	0.7	1.4	1.4	1.4	1.4	2.7
-1.4	0.0	0.0	0.0	-1.4	0.0	-0.7	-0.7	-0.7	0.0

11	12	13	14	15	16
-1.4	0.0	0.0	-1.4	0.0	-1.4
-5.4	-4.1	-4.1	-4.1	-4.1	-4.1
-1[illegible]	-9.5	-8.1	-7.5	-6.8	-8.1
-12.[illegible]	-13.6	-12.2	-9.5	-9.5	-10.9
-13.[illegible]	-14.3	-12.9	-10.9	-10.9	-12.2
-12.[illegible]	-12.2	-12.2	-12.2	-10.9	-10.9
-7.[illegible]	-8.1	-8.1	-6.8	-6.8	-8.1
-2.7	-2.7	-4.1	-3.4	-2.7	-3.4
2.7	2.7	0.[illegible]	0.[illegible]	0.7	0.0
5.4	6.8	4.1	2.7	2.7	3.4
[illegible]	8.1	5.4	3.4	4.1	4.1
6.[illegible]	8.1	5.4	3.4	4.1	4.1
4.[illegible]	5.4	4.1	2.7	2.7	2.7
0.[illegible]	1.4	0.7	0.0	0.0	0.0

UNDER SURFACE OF CAISSON - FULL OPENINGS

1	2	3	4	5	6	7
-2.[illegible]	1.0	5.2	4.8	0.7	4.3	3.8
-2.[illegible]	0.2	3.8	1.9	-4.1	2.9	3.8
-1.[illegible]	-1.0	[illegible]	-1.4	-7.5	1.0	2.9
[illegible]	-1.0	-1.0	-3.8	-9.5	-1.0	1.0
1.[illegible]	-0.5	-1.4	-5.7	-10.9	-2.9	-1.0
[illegible]	-0.5	-1.9	-6.7	-9.5	-4.3	-3.3
3.[illegible]	0.5	-1.9	-6.2	-6.8	-5.2	-5.2
2.[illegible]	0.0	-1.4	-4.8	-2.7	-5.7	-6.7
1.[illegible]	-0.5	-1.0	-2.9	1.4	-5.2	-7.1
[illegible]	-1.[illegible]	[illegible]	-1.[illegible]	2.7	-3.8	-6.7
-1.[illegible]	-1.[illegible]	1.[illegible]	1.[illegible]	4.1	-2.4	-4.8
-2.[illegible]	[illegible]	2.9	[illegible]	4.8	0.[illegible]	-2.4
-2.9	1.0	4.8	4.8	4.1	2.9	0.5
-2.9	1.0	5.2	4.8	1.4	4.3	3.3

APPENDIX 1-4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 5.25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNIT FEET OF WATER

REAR FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
-3.6	-2.7	-4.5	-3.6	-3.6	-4.5	-3.6	-3.6	-3.6	-3.6
0.0	0.0	-0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.6	3.6	2.7	4.5	3.6	3.6	4.5	3.6	3.6	3.6
7.3	7.3	6.3	7.3	7.3	7.3	7.3	7.3	8.2	7.3
9.5	10.0	8.2	8.2	9.1	9.1	9.1	10.0	9.5	9.1
9.5	11.3	8.2	7.3	9.5	10.0	9.1	10.0	9.5	9.1
7.3	10.0	5.4	4.5	7.3	8.2	6.3	7.3	7.3	6.8
2.7	7.3	1.8	0.9	3.6	4.5	2.7	3.6	3.6	2.7
-1.8	3.6	-2.7	-4.5	-0.9	0.0	-2.7	-1.8	-0.9	-1.8
-5.4	-2.9	-6.3	-8.2	-5.4	-4.5	-6.3	-5.4	-5.4	-5.9
-8.2	-4.5	-9.1	-9.5	-8.2	-7.3	-8.6	-8.2	-7.3	-8.2
-8.6	-5.4	-9.1	-9.5	-8.6	-8.6	-9.1	-8.6	-8.2	-9.1
-7.3	-5.4	-8.2	-7.3	-7.3	-8.2	-7.3	-7.3	-7.3	-7.7
-4.5	-3.6	-5.4	-4.1	-4.5	-5.4	-4.1	-4.5	-4.5	-4.5

11	12	13	14	15	16
-4.1	-3.2	-1.8	-2.3	-2.7	-2.7
0.0	0.0	0.9	0.9	0.0	0.9
3.6	3.6	3.6	3.6	3.6	3.2
6.8	7.3	6.3	6.3	5.9	6.3
9.1	9.1	7.5	7.7	7.3	8.2
8.6	8.6	7.3	7.3	6.8	7.3
6.3	6.5	5.4	5.4	4.5	5.4
1.8	1.4	1.8	2.3	1.4	1.8
-2.7	-3.6	-1.4	-1.4	-2.3	-1.8
-6.3	-7.3	-4.1	-4.5	-5.4	-5.4
-8.6	-9.1	-6.3	-6.3	-7.3	-7.3
-9.1	-9.5	-6.3	-7.3	-7.7	-7.7
-8.2	-8.2	-5.4	-5.9	-6.3	-6.3
-5.2	-4.5	-2.7	-3.6	-3.6	-3.6

UNDER SURFACE OF CAISSON - 10 PERCENT OPENINGS

1	2	3	4	5	6	7
3.7	4.6	7.8	5.6	6.5	8.4	9.3
6.2	6.0	7.4	6.0	6.0	9.8	10.2
[illegible]	5.6	5.6	5.6	3.7	8.4	8.6
6.5	4.6	3.7	3.3	0.9	5.1	5.6
4.6	2.5	0.5	0.9	-1.9	1.4	0.9
2.3	0.9	-2.3	-2.3	-3.7	-2.3	-3.3
[illegible]	-1.9	-4.6	-4.6	-4.6	-5.6	-6.5
-4.2	-3.7	-6.0	-5.6	-5.1	-7.4	-6.8
-6.5	-5.6	-6.5	-6.0	-4.6	-7.9	-9.3
[illegible]	-6.0	-5.6	-5.1	-3.3	[illegible]	-8.4
-7.4	-5.6	-3.7	-3.7	[illegible]	-4.6	-5.1
-5.6	-3.3	[illegible]	[illegible]	1.9	-0.9	-0.9
-1.9	[illegible]	3.7	2.8	4.2	3.3	4.2
[illegible]	4.2	6.5	5.6	6.0	7.4	8.8

APPENDIX 1-5

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER

SIDE FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
5.4	3.4	4.8	2.7	5.4	5.4	6.1	8.1	8.1	8.1
1.4	1.4	1.4	-1.4	2.7	2.7	2.7	4.1	7.5	6.8
-2.7	-2.7	-4.1	-5.4	0.0	-1.4	0.0	0.0	4.1	2.7
-6.8	-5.4	-8.1	-9.5	-4.1	-5.4	-4.1	-5.4	0.0	-1.4
-9.5	-8.1	-10.9	-10.9	-6.8	-8.1	-6.8	-8.1	-3.4	-5.4
-10.9	-9.5	-11.5	-10.9	-8.8	-9.5	-8.1	-10.2	-6.8	-9.5
-10.2	-8.1	-9.5	-8.8	-8.8	-9.5	-8.8	-9.5	-8.1	-10.9
-6.8	-6.8	-6.8	-5.4	-7.5	-7.5	-7.5	-8.1	-8.1	-10.2
-2.7	-2.7	-2.7	0.0	-5.4	-5.4	-5.4	-4.1	-6.8	-8.1
0.0	0.0	1.4	4.1	-1.4	-1.4	-1.4	0.0	-2.7	-4.8
4.1	2.7	5.4	6.8	1.4	1.4	1.4	4.1	0.0	0.0
6.1	4.1	7.5	7.5	4.1	4.1	4.1	6.8	4.1	4.1
6.8	4.8	8.1	6.8	5.4	5.4	6.8	8.8	6.8	6.8
6.1	4.1	6.1	4.1	5.4	5.4	6.1	8.1	8.1	8.1

11	12	13	14	15	16	17	18	19	20
9.5	9.5	3.4	4.1	4.8	4.1	4.8	4.1	2.0	2.7
8.1	6.8	4.8	4.8	6.1	5.4	6.1	6.1	2.7	3.4
4.1	2.7	4.1	4.1	5.4	5.4	5.4	5.4	2.7	2.7
0.0	-2.7	1.4	1.4	4.1	2.7	4.1	4.1	1.4	1.4
-4.1	-6.8	-1.4	-1.4	0.0	-1.4	1.4	0.0	0.7	0.0
-8.1	-9.5	-4.1	-4.1	-3.4	-5.4	-2.7	-2.7	-2.7	-2.7
-10.2	-12.2	-6.8	-6.8	-6.8	-9.5	-5.4	-6.1	-4.8	-4.1
-10.9	-12.2	-8.1	-8.1	-9.5	-12.9	-7.5	-8.1	-6.1	-5.4
-9.5	-9.5	-8.8	-9.5	-10.2	-14.3	-8.8	-9.5	-6.8	-6.8
-5.4	-5.4	-8.1	-10.2	-9.5	-13.6	-8.1	-9.5	-6.8	-6.1
-1.4	0.0	-6.8	-6.8	-8.1	-10.9	-6.1	-6.8	-5.4	-4.1
4.1	4.1	-2.7	-3.4	-4.1	-6.8	-2.7	-4.1	-2.7	-2.7
6.8	8.1	0.0	0.0	0.0	-1.4	1.4	0.0	0.0	0.0
9.5	9.5	2.7	2.7	3.4	3.4	4.1	4.1	1.4	2.7

21	22	23	24	25	26	27	28
0.7	0.0	0.7	0.7	0.0	-2.7	-1.4	-3.8
1.4	1.4	2.0	2.0	1.4	0.0	0.0	-1.9
1.4	2.0	2.7	2.7	2.0	1.4	1.4	0.5
1.4	1.4	2.0	2.7	2.7	2.0	1.4	2.4
0.7	0.7	1.4	1.4	2.7	2.0	1.4	3.8
0.0	-1.4	-1.4	-1.4	1.4	1.4	0.0	3.8
-1.4	-3.4	-2.7	-4.1	0.0	0.0	-1.4	1.9
-2.7	-5.4	-4.8	-6.1	-1.4	-2.7	-2.7	-1.0
-3.4	-6.8	-6.1	-7.5	-2.7	-4.1	-4.8	-2.9
-3.4	-6.8	-6.8	-8.1	-3.4	-6.1	-6.1	-4.8
-2.7	-6.1	-6.1	-7.5	-4.1	-6.8	-6.8	-5.7
-2.0	-4.1	-4.8	-5.4	-3.4	-6.8	-6.1	-6.7
-1.4	-2.7	-2.7	-2.7	-2.0	-5.4	-4.8	-6.2
0.0	0.0	0.0	0.0	0.0	-3.4	-2.7	-3.8

APPENDIX 1-6

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER

FRONT COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
9.5	9.5	13.3	8.6	6.7	14.3	21.9	16.2	14.3	12.4
5.7	3.8	7.6	2.9	2.9	8.6	15.2	8.6	8.6	6.7
1.9	-4.8	0.0	-3.8	-3.8	1.0	4.8	-1.0	1.0	0.0
-1.9	-12.4	-6.7	-10.5	-9.5	-4.3	-6.7	-10.5	-6.7	-6.7
-4.3	-13.3	-14.3	-15.2	-14.3	-4.3	-13.3	-18.1	-14.3	-12.4
-4.3	-13.3	-17.1	-17.1	-15.7	-4.3	-13.3	-20.9	-18.1	-15.2
-4.3	-13.3	-16.6	-15.2	-14.3	-4.3	-13.3	-20.0	-17.6	-14.3
-3.8	-11.4	-12.4	-11.4	-10.9	-4.3	-13.3	-14.3	-13.3	-9.5
-1.0	-3.8	-6.7	-4.8	-5.7	-4.3	-12.4	-5.7	-7.6	-2.9
3.8	2.9	1.0	1.9	0.0	-1.0	-1.9	2.9	1.0	3.8
7.6	9.5	8.6	6.7	4.8	6.7	9.5	11.9	8.6	9.5
10.9	13.8	13.8	10.5	8.6	13.3	18.1	17.6	14.3	14.3
11.4	13.8	15.7	11.4	9.0	16.2	22.8	19.5	16.6	15.2
10.5	10.9	14.3	9.5	7.6	14.7	22.8	17.1	14.3	13.3

FRONT COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
5.7	5.7	4.8	4.8	5.7	10.5	11.4	9.0	7.6	6.2
8.1	8.6	8.6	7.6	7.6	7.6	9.5	7.6	5.7	4.8
8.6	9.5	9.5	8.6	8.6	2.9	5.7	3.8	1.9	2.9
7.1	8.1	8.6	7.6	6.7	-1.9	0.0	-1.0	-1.9	-1.0
3.8	4.8	5.7	4.8	3.8	-6.7	-6.7	-5.7	-5.7	-4.8
-1.0	0.0	1.4	1.0	0.0	-9.5	-10.5	-9.0	-8.6	-6.7
-4.3	-4.8	-2.9	-2.9	-3.8	-10.5	-12.8	-10.5	-9.0	-7.6
-4.3	-8.6	-6.7	-6.7	-6.7	-9.5	-12.4	-9.5	-7.6	-6.7
-4.3	-11.4	-9.5	-8.6	-8.1	-6.7	-9.5	-7.6	-4.8	-4.3
-4.3	-11.4	-10.5	-9.0	-8.6	-2.4	-5.7	-3.8	-1.9	-1.9
-4.3	-10.5	-9.5	-8.1	-6.7	2.4	0.0	1.0	1.9	1.4
-4.3	-6.7	-6.7	-5.2	-3.8	6.7	5.7	4.8	4.8	3.8
0.0	-1.4	-1.9	-1.0	1.0	10.5	9.5	7.6	7.1	5.7
4.8	4.8	2.9	3.8	4.8	10.5	11.4	9.0	7.6	6.2

FRONT COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
7.6	4.8	5.7	3.8	3.8	0.0	1.9	2.9	3.8	2.9
12.4	12.4	12.4	10.5	7.6	7.6	10.5	10.5	10.5	9.5
14.3	17.1	15.2	13.3	9.5	14.3	16.2	15.2	14.3	13.3
13.8	17.1	15.2	13.3	9.5	16.6	17.1	16.2	14.3	14.3
10.5	14.3	12.4	11.4	7.6	16.2	15.2	14.3	12.4	12.4
5.7	8.6	5.7	5.7	3.8	11.4	9.5	9.0	7.6	7.6
0.0	0.0	-1.9	0.0	-1.0	4.8	1.0	2.4	1.0	1.0
-4.3	-7.6	-8.6	-6.7	-5.7	-2.9	-6.7	-4.8	-5.7	-4.8
-4.3	-13.3	-13.3	-11.4	-9.5	-4.3	-13.3	-10.9	-11.4	-10.5
-4.3	-13.3	-15.7	-13.8	-10.9	-4.3	-13.3	-14.3	-14.3	-13.8
-4.3	-13.3	-14.7	-13.3	-10.5	-4.3	-13.3	-15.2	-15.2	-14.3
-4.3	-13.3	-10.5	-10.0	-7.6	-4.3	-13.3	-12.4	-12.4	-11.4
-1.9	-6.7	-2.9	-4.8	-2.9	-4.3	-9.5	-6.7	-5.7	-5.7
5.7	2.9	4.8	2.9	2.9	-1.0	0.0	1.0	1.9	1.0

APPENDIX 1-7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER

FRONT COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
17.1	19.0	17.1	15.2	13.3	15.2	18.1	14.3	12.4	12.4
16.2	16.2	16.2	12.4	11.4	16.6	20.0	16.2	13.3	12.4
10.5	9.5	11.4	6.7	7.6	14.3	17.1	13.3	11.4	10.5
3.8	0.0	2.9	0.0	1.9	8.6	10.5	7.6	6.7	6.7
-3.8	-8.6	-5.7	-6.7	-4.8	1.9	1.0	1.0	0.0	0.0
-4.3	-13.3	-13.3	-12.4	-9.5	-4.3	-7.6	-6.7	-6.7	-5.7
-4.3	-13.3	-17.1	-14.3	-12.4	-4.3	-11.4	-12.4	-11.4	-10.5
-4.3	-13.3	-17.6	-13.8	-12.4	-4.3	-13.3	-16.2	-13.3	-11.9
-4.3	-13.3	-14.3	-9.5	-9.5	-4.3	-13.3	-16.2	-13.3	-11.9
-4.3	-5.7	-8.6	-3.8	-4.8	-4.3	-13.3	-13.3	-10.5	-8.6
0.0	3.8	0.0	2.9	1.9	-4.3	-10.5	-6.7	-4.8	-3.8
8.6	11.4	7.6	9.5	6.7	1.9	0.0	1.0	1.9	1.9
15.2	17.1	14.3	14.3	11.4	8.6	9.5	7.6	7.6	7.6
17.1	19.0	17.1	15.2	13.3	14.3	17.1	14.3	12.4	11.4

REAR COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
9.7	11.6	10.7	8.7	8.7	8.7	7.8	6.8	4.8	7.8
15.5	18.4	11.6	14.5	13.6	14.5	17.4	14.5	13.6	14.5
16.5	20.3	18.4	16.5	15.5	19.4	23.3	19.4	16.5	17.4
14.5	18.4	15.5	14.5	14.5	19.4	24.2	20.3	17.4	16.5
8.7	12.6	10.7	8.7	10.7	15.5	19.4	18.4	14.5	12.6
1.9	3.9	2.9	1.9	5.8	7.8	9.7	12.6	17.4	6.8
-4.4	-5.8	-5.8	-6.8	0.0	-1.9	-1.9	3.9	0.0	-1.0
-4.4	-13.1	-12.6	-12.6	-6.8	-4.4	-12.6	-5.8	-8.7	-9.7
-4.4	-13.1	-16.5	-16.5	-10.7	-4.4	-13.1	-11.6	-14.5	-15.5
-4.4	-13.1	-7.8	-16.5	-11.6	-4.4	-13.1	-13.6	-17.4	-16.5
-4.4	-13.1	-14.5	-12.6	-10.2	-4.4	-13.1	-13.6	-16.5	-15.5
-4.4	-10.7	-17.4	-6.8	-5.8	-4.4	-13.1	-9.7	-11.6	-9.7
0.0	-1.0	0.0	1.0	0.0	0.0	-5.8	-3.9	-4.8	-1.9
7.8	9.7	8.7	8.7	7.8	6.8	5.8	4.8	2.9	6.8

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER

REAR COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
-2.9	-7.8	-5.8	-3.9	-2.9	-4.4	-11.6	-10.7	-8.7	-9.7
1.9	-1.0	0.0	1.9	1.0	-3.9	-3.9	-4.8	-1.9	-3.9
7.8	6.8	6.8	7.8	5.8	1.9	2.9	1.9	3.9	2.9
12.6	12.6	11.6	10.7	8.7	8.7	11.6	9.7	10.7	9.7
14.5	15.5	13.6	11.6	10.2	12.6	16.5	15.5	14.5	13.6
12.6	15.5	11.6	10.7	9.7	12.6	17.4	16.5	14.5	14.5
7.8	11.6	5.8	6.8	6.8	9.7	13.6	14.5	11.6	13.6
1.0	4.8	0.0	1.0	2.9	3.9	6.8	8.7	5.8	7.8
-3.9	-1.0	-6.8	-4.8	-1.0	-2.9	0.0	1.0	0.0	1.0
-4.4	-7.8	-12.6	-9.7	-4.8	-4.4	-7.8	-5.8	-5.8	-5.8
-4.4	-12.6	-15.5	-11.6	-6.8	-4.4	-12.6	-11.6	-10.7	-10.7
-4.4	-13.1	-15.5	-11.6	-7.8	-4.4	-13.1	-14.5	-13.6	-13.6
-4.4	-13.1	-12.6	-8.7	-6.8	-4.4	-13.1	-14.5	-12.6	-13.6
-4.4	-8.7	-7.8	-4.8	-3.9	-4.4	-11.6	-10.7	-8.7	-9.7

REAR COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
-4.4	-11.6	-10.7	-9.7	-8.7	-4.4	-11.6	-8.7	-7.8	-8.2
-4.4	-5.8	-6.8	-5.8	-4.8	-3.9	-6.8	-3.9	-3.9	-4.8
-1.0	0.0	-1.9	-1.9	0.0	1.0	-1.0	1.0	1.0	0.0
4.8	7.8	4.8	3.9	4.8	5.8	6.8	6.8	6.8	5.8
10.7	14.5	9.7	8.7	9.7	10.7	11.6	10.7	9.7	9.7
13.6	17.4	11.6	11.6	11.6	11.6	13.6	11.6	11.1	10.7
12.6	16.5	11.6	11.1	10.7	10.7	13.6	11.6	10.7	9.7
8.7	12.6	9.7	8.7	7.8	7.8	9.7	8.7	7.8	7.8
3.9	5.8	3.9	3.9	3.9	2.9	4.8	3.9	3.9	2.9
-1.9	0.0	-1.9	-1.9	-1.9	-1.9	-1.0	-1.9	-1.9	-1.9
-4.4	-7.8	-6.8	-6.8	-6.8	-4.4	-6.8	-6.8	-6.8	-5.8
-4.4	-11.6	-10.7	-10.7	-9.7	-4.4	-11.6	-10.7	-9.7	-8.7
-4.4	-13.1	-12.1	-11.6	-10.2	-4.4	-13.1	-11.6	-9.7	-9.7
-4.4	-11.6	-11.6	-10.7	-9.2	-4.4	-12.6	-9.7	-7.8	-7.8

REAR COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	-1.0	0.0	-1.0	0.0	2.9	5.8	4.8	2.9	4.8
4.8	4.8	4.8	3.9	2.9	7.8	11.6	10.7	7.8	7.8
9.7	9.7	8.7	6.8	5.8	10.7	15.5	13.6	10.7	9.7
11.6	12.6	10.7	8.7	6.8	10.7	16.5	13.6	10.7	9.7
11.6	12.6	10.2	7.8	6.8	8.7	13.6	9.7	8.7	6.8
7.8	9.7	7.8	5.8	5.3	3.9	7.8	4.8	4.8	2.9
2.9	4.8	2.9	1.9	2.9	-1.9	0.0	-1.0	1.0	-1.0
-2.9	-1.0	-1.9	-1.9	-1.0	-4.4	-6.8	-6.8	-3.9	-4.8
-4.4	-5.8	-5.8	-5.8	-4.8	-4.4	-12.6	-10.7	-6.8	-7.8
-4.4	-9.7	-9.2	-7.8	-6.8	-4.4	-13.1	-12.1	-8.7	-8.7
-4.4	-11.6	-10.7	-8.7	-7.8	-4.4	-13.1	-11.6	-8.7	-8.2
-4.4	-11.6	-9.7	-8.7	-6.8	-4.4	-10.7	-7.8	-6.8	-5.8
-4.4	-8.7	-6.8	-5.8	-4.8	-3.9	-4.8	-1.9	-2.9	-1.0
-1.9	-2.9	-1.9	-1.9	-1.0	1.0	2.9	3.9	1.9	3.9

APPENDIX 2

PRESSURES ON BERTH CAISSON DUE TO 24 FEET HIGH WAVES APPROACHING IN THE DIRECTION NORMAL TO BERTHLINE AT LOW WATER.

APPENDIX 2-2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	LOW WATER
WAVE HEIGHT	24 FT PERIOD 8,25 SECS
DIRECTION	NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER

TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

TOP SURFACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
0,0	-5,8	-7,4	-3,2	-4,2	-3,3	-4,2	0,0	-5,6	-6,4
0,0	0,0	-2,7	2,1	1,1	0,0	1,1	0,5	-5,6	-6,4
0,0	5,8	4,2	6,4	6,4	3,3	7,4	0,5	-4,0	-4,8
0,5	10,6	10,1	9,0	10,1	5,0	10,6	0,5	-1,6	-3,2
0,5	12,7	13,8	9,0	11,2	5,0	11,7	0,5	0,8	-0,8
0,5	12,2	14,9	7,4	9,6	3,3	9,6	0,5	3,2	2,0
0,5	9,6	12,7	4,2	6,4	1,1	5,3	0,0	6,0	6,0
0,5	3,2	7,4	0,0	1,1	-1,1	0,0	0,0	8,5	8,9
0,0	-1,1	0,0	-4,2	-3,7	-3,3	-4,2	0,0	8,9	9,7
0,0	-7,4	-7,4	-7,4	-8,0	-5,0	-8,5	0,0	7,2	7,6
-0,5	-10,6	-11,7	-10,1	-10,1	-6,6	-10,1	0,0	3,6	3,6
-0,5	-12,2	-13,3	-10,6	-10,6	-7,2	-10,6	0,0	-0,8	-1,2
-0,5	-11,2	-11,7	-8,5	-9,0	-6,6	-9,6	0,0	-3,6	-4,8
0,0	-6,9	-8,0	-5,3	-5,3	-4,4	-5,3	0,0	-5,6	-6,4

11	12	13	14	15	16	17	18	19	20
-7,6	-6,0	-8,5	-8,9	-7,7	-11,6	-6,1	-6,6	2,2	2,2
-4,8	-2,5	-5,2	-5,6	-2,8	-6,1	-1,1	-2,2	5,5	5,0
-1,2	0,4	0,0	0,0	3,3	2,2	4,4	3,9	7,2	5,5
2,4	3,6	6,0	5,2	8,3	9,4	9,4	8,8	6,6	4,4
6,0	7,2	10,5	10,5	11,1	13,8	11,1	10,5	3,3	0,6
8,5	10,5	13,7	13,3	11,1	14,9	10,0	8,8	-0,6	-4,4
10,5	12,5	14,1	13,7	8,8	12,7	6,6	6,1	-4,4	-7,7
10,9	13,3	11,7	11,7	4,4	7,7	2,2	2,2	-7,2	-8,8
7,6	11,3	6,4	7,2	-1,1	2,2	-2,2	-1,7	-8,8	-8,3
2,4	7,2	0,8	2,4	-5,5	-3,9	-5,5	-4,4	-8,3	-6,6
-2,4	2,0	-4,8	-2,8	-9,4	-8,8	-8,3	-6,6	-6,1	-4,4
-6,8	-2,8	-9,7	-6,8	-11,1	-12,2	-8,8	-7,7	-3,3	-2,8
-8,5	-5,6	-10,9	-9,3	-11,1	-13,8	-8,8	-8,3	-1,1	-1,1
-7,6	-5,2	-8,5	-9,3	-7,7	-12,2	-7,2	-7,2	2,2	1,7

21	22
7,2	7,7
6,1	6,1
3,3	3,3
-0,6	-0,6
-4,4	-5,5
-7,7	-10,0
-9,4	-13,3
-9,4	-13,3
-6,6	-10,5
-2,2	-5,5
2,2	0,0
5,5	4,4
7,7	6,6
7,7	7,2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 24 FT PERIOD 8,25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

FRONT FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
12,5	13,7	15,3	16,1	13,7	13,7	13,7	14,5	12,1	12,5
8,0	8,9	10,5	11,3	8,0	8,9	8,0	10,5	6,4	6,8
2,4	3,2	4,0	5,6	2,4	2,4	1,6	4,8	0,0	0,8
-4,0	-3,2	-0,8	-0,8	-4,0	-4,0	-3,2	-1,6	-5,6	-4,8
-8,9	-8,9	-7,2	-6,4	-9,7	-9,7	-8,9	-7,2	-11,3	-10,5
-12,9	-12,9	-12,1	-11,3	-13,7	-13,7	-13,7	-11,3	-14,5	-14,5
-14,5	-14,5	-14,5	-12,9	-14,5	-15,3	-15,7	-13,7	-15,7	-14,9
-13,3	-12,9	-13,3	-11,3	-12,1	-13,7	-15,3	-12,1	-12,9	-12,1
-7,2	-7,2	-8,5	-4,8	-5,6	-8,0	-9,7	-6,4	-6,4	-5,6
0,8	1,6	0,0	4,0	3,2	0,0	0,0	1,6	0,8	2,4
8,2	8,9	8,0	12,1	11,3	8,0	8,9	9,7	9,7	10,5
14,1	15,3	14,5	17,7	16,1	14,5	14,5	15,3	15,3	15,3
15,7	16,9	17,3	18,9	17,3	16,1	16,1	17,3	16,1	16,1
14,5	15,3	16,1	17,7	15,3	14,9	14,9	16,1	13,7	13,7

11	12	13	14	15	16
11,7	12,9	11,3	12,1	10,9	12,9
6,8	7,2	6,4	8,0	6,4	8,0
0,0	0,0	1,6	2,4	0,8	2,4
-5,6	-6,4	-4,0	-2,4	-4,8	-3,2
-10,5	-11,3	-8,9	-8,0	-9,7	-8,9
-14,5	-15,3	-12,1	-12,1	-13,7	-13,3
-14,9	-15,7	-12,5	-12,9	-14,5	-14,9
-11,3	-12,1	-10,5	-11,3	-12,1	-13,3
-4,0	-3,2	-4,8	-5,6	-6,4	-8,0
4,7	5,6	1,6	0,8	0,8	-0,8
10,5	12,1	8,0	7,2	8,0	7,2
15,3	16,9	12,9	12,9	12,9	12,9
16,5	16,9	15,3	14,9	14,1	14,5
12,9	12,9	12,9	12,9	12,9	13,7

UNDER SURFACE OF CAISSON - FULL OPENINGS

1	2	3	4	5	6	7
0,0	-1,6	-9,6	-10,6	-11,2	-9,6	-9,6
-0,5	-2,7	-8,0	-5,3	-5,3	-8,0	-8,0
-1,1	-3,2	-4,8	2,1	1,1	-4,8	-4,8
-1,6	-3,2	-1,1	7,4	7,4	-1,1	-1,1
-2,1	-2,7	3,2	11,7	12,7	3,2	3,2
-2,1	-1,6	7,4	13,3	13,8	7,4	7,4
-1,6	0,5	9,6	11,7	12,7	9,6	9,6
0,0	3,2	9,6	7,4	9,6	9,6	9,6
1,1	4,8	7,4	2,1	3,2	7,4	7,4
2,1	5,8	3,2	-3,2	-3,2	3,2	3,2
2,7	5,3	-1,6	-7,4	-9,6	-1,6	-1,5
2,7	4,2	-6,4	-10,6	-13,8	-6,4	-6,4
1,6	2,1	-9,0	-12,2	-14,9	-9,0	-9,0
[illegible]	-0,5	-9,6	-11,7	-12,7	-9,6	-9,5

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE LOW WATER

WAVE HEIGHT 24 FT PERIOD 8,25 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

REAR FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
-1,1	-0,6	-1,7	-2,2	-1,7	-2,2	-2,2	-2,8	-3,3	-3,9
-2,2	-1,1	-2,2	-2,2	-3,3	-4,4	-4,4	-3,9	-5,0	-5,0
-2,2	-1,7	-2,2	-2,2	-3,3	-5,0	-5,0	-4,4	-5,5	-5,0
-1,7	-1,7	-2,2	-2,8	-3,3	-5,5	-5,0	-4,4	-5,0	-3,9
-1,1	-1,7	-2,2	-2,2	-3,3	-4,4	-4,4	-3,9	-3,3	-2,2
0,0	0,0	-1,1	-1,1	-1,7	-2,2	-2,2	-2,2	-1,7	0,0
2,2	2,2	1,1	1,1	0,6	0,0	0,0	0,0	0,6	0,6
4,4	4,4	3,3	3,3	3,3	3,3	3,3	3,9	3,3	4,4
6,1	6,6	4,4	4,4	5,5	6,1	5,5	5,5	5,5	6,1
6,6	6,6	4,4	4,4	6,6	7,2	6,6	5,5	6,1	6,1
5,5	5,5	2,8	2,8	6,1	6,6	6,6	4,4	5,5	4,4
3,3	3,9	1,1	1,1	3,9	4,4	4,4	2,2	3,3	2,2
1,1	1,7	-0,6	-1,1	1,1	1,7	1,7	0,0	0,6	-0,6
-0,6	0,0	-1,1	-2,2	-1,1	-1,1	-1,1	-2,2	-2,2	-3,3

11	12	13	14	15	16
-3,3	-4,4	-4,4	-4,4	-3,9	-3,9
-5,0	-5,5	-5,0	-5,0	-4,4	-4,4
-5,5	-5,5	-4,4	-4,4	-4,4	-3,3
-5,0	-5,0	-3,3	-3,3	-3,3	-2,2
-3,9	-3,3	-1,1	-1,7	-1,7	-0,6
-2,2	-1,1	1,1	0,6	0,0	1,1
0,0	1,1	3,3	2,2	2,2	2,8
2,2	3,9	4,4	3,9	3,9	3,3
3,9	5,5	5,0	4,4	4,4	3,9
5,0	6,1	4,4	4,4	4,4	3,3
4,4	4,4	2,8	2,8	3,3	1,7
2,8	2,2	0,0	0,0	1,1	-0,6
0,0	-1,1	-2,2	-2,2	-1,1	-2,2
-2,2	-3,3	-3,9	-3,9	-2,8	-3,3

UNDER SURFACE OF CAISSON - 10 PERCENT OPENINGS

1	2	3	4	5	6	7
-1,9	-1,4	-0,9	0,0	0,5	-1,9	-3,7
-0,9	-0,5	0,5	0,9	1,4	0,0	-1,9
0,5	1,4	2,3	2,3	1,9	1,9	1,4
1,9	2,8	3,7	2,8	2,3	3,7	3,7
2,3	3,3	3,7	2,8	2,3	4,7	4,7
1,9	2,3	2,8	1,4	0,5	3,7	4,7
0,9	1,4	0,9	-0,9	-1,4	1,9	2,8
0,5	0,0	-0,9	-1,9	-2,3	0,0	0,5
-0,5	-0,9	-1,9	-2,8	-3,3	-1,9	-1,9
-0,9	-1,4	-2,3	-2,3	-2,8	-3,3	-3,7
-1,4	-1,9	-2,8	-2,3	-1,9	-3,7	-4,7
-1,9	-2,3	-2,8	-1,9	-1,9	-4,2	-5,6
-1,9	-2,3	-2,3	-1,4	-0,5	-3,7	-5,1
-1,9	-1,9	-1,4	-0,5	0,5	-2,3	-4,2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 24 FT PERIOD 8,25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

SIDE FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
9,3	8,0	10,5	8,0	5,6	5,6	6,0	6,0	1,6	2,4
8,0	6,8	8,9	6,4	6,4	6,0	6,4	6,8	4,0	4,8
5,6	4,4	5,6	3,2	6,4	6,0	6,0	6,4	5,6	5,6
2,0	1,2	0,8	-0,8	4,4	3,6	3,2	3,2	5,2	5,2
-1,6	-2,0	-2,8	-4,8	1,2	0,0	-0,4	-0,8	2,8	2,4
4,4	5,6	5,6	-7,6	-2,4	-3,6	-4,0	-4,0	0,0	-0,8
-5,6	-7,2	-6,8	-8,9	-4,8	-6,0	-5,6	-6,4	-3,6	-3,2
-5,2	-6,8	-6,0	-8,0	-5,2	-6,8	-6,0	-6,4	-5,6	-4,8
-2,4	-4,4	-2,4	-4,8	-4,4	-5,6	-4,8	-4,8	-5,6	-5,6
1,6	0,0	1,6	-0,8	-2,0	-3,2	-1,6	-2,4	-4,8	-4,8
5,6	3,6	5,6	4,0	0,8	-0,4	0,8	0,8	-3,6	-3,2
8,0	6,4	8,9	7,2	2,8	1,6	2,8	2,4	-2,4	-2,0
9,3	8,0	10,5	8,5	4,0	3,6	4,0	4,0	-0,8	-0,8
9,7	8,0	10,5	8,5	5,6	5,2	5,2	5,6	1,6	1,6

11	12	13	14	15	16	17	18	19	20
1,6	2,4	0,0	-0,8	0,0	0,0	-2,4	-4,0	-2,4	-3,2
3,6	4,6	3,2	3,2	4,8	4,6	1,2	-0,8	1,6	0,4
4,8	6,0	6,4	6,4	7,2	8,0	4,8	3,2	5,6	4,8
4,4	5,6	8,0	8,5	8,9	9,7	7,2	6,4	8,0	8,0
2,4	3,2	7,6	8,5	8,9	9,7	7,6	7,2	8,9	8,9
0,2	0,0	4,8	6,4	5,6	6,4	6,0	7,2	7,2	8,0
-2,4	-2,4	1,6	2,4	1,6	2,4	2,8	4,8	4,0	4,8
-4,0	-4,0	-1,6	-1,2	-1,6	-2,4	-0,4	1,6	0,0	0,8
-4,4	-5,2	-4,0	-3,6	-4,0	-5,2	-3,2	-1,6	-3,2	-3,2
-4,0	-4,8	-5,2	-5,6	-5,6	-6,8	-4,8	-4,0	-6,0	-6,4
-3,6	-4,4	-5,6	-6,0	-6,0	-7,2	-6,4	-6,0	-7,2	-8,0
-2,8	-3,2	-5,2	-6,0	-5,6	-6,8	-6,4	-6,8	-7,6	-8,9
-1,6	-1,2	-4,0	-4,8	-4,0	-4,8	-6,0	-6,8	-6,4	-7,2
0,4	1,6	-1,6	-2,4	-1,2	-1,6	-3,2	-4,8	-3,2	-4,0

21	22	23	24	25	26	27	28
-4,4	-3,6	-2,8	-2,4	-4,4	-4,0	11,7	0,0
-1,6	-0,8	0,0	0,8	-2,4	-2,8	8,0	0,0
2,0	3,2	4,0	4,4	0,0	-0,4	2,8	0,0
5,2	6,0	6,8	7,6	2,4	2,4	-2,4	0,0
6,8	7,6	8,5	8,9	4,4	4,8	-7,2	0,0
7,6	8,0	8,5	9,3	5,6	6,8	-11,7	0,0
5,6	6,4	7,6	8,0	5,6	7,2	-12,9	0,0
3,2	4,0	4,8	5,6	4,8	6,8	-11,7	0,0
0,0	1,2	1,6	2,4	2,8	5,2	-6,8	0,0
-2,4	-1,6	-1,6	-1,2	0,8	2,8	0,0	0,0
-4,0	-4,0	-4,0	-3,6	-2,0	0,0	6,4	0,0
-6,0	-5,6	-5,6	-5,2	-4,0	-2,4	12,1	0,0
-6,4	-6,0	-5,6	-5,6	-4,8	-4,0	13,7	0,0
-4,8	-4,8	-3,6	-4,0	-4,8	-4,4	12,1	0,0

APPENDIX 2-6

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	LOW WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER

TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

FRONT COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
0.0	8.5	18.1	16.5	14.9	0.0	9.6	16.5	15.9	13.8
0.0	8.5	14.9	10.6	9.6	0.0	9.6	12.7	10.6	9.6
0.0	8.5	8.5	2.1	2.7	0.0	7.4	6.4	3.2	3.2
0.0	6.4	0.0	-6.4	-4.8	0.0	3.2	-2.1	-6.4	-4.2
0.0	0.0	-4.2	-13.3	-12.2	0.0	0.0	-4.2	-13.3	-10.6
0.0	0.0	-4.2	-13.3	-17.0	0.0	0.0	-4.2	-13.3	-15.9
0.0	0.0	-4.2	-13.3	-18.1	0.0	0.0	-4.2	-13.3	-16.5
0.0	0.0	-4.2	-13.3	-14.9	0.0	0.0	-4.2	-13.3	-13.8
0.0	0.0	-4.2	-8.5	-7.4	0.0	0.0	-4.2	-7.4	-8.5
0.0	1.1	0.0	1.1	0.0	0.0	0.0	-1.1	0.0	-2.1
0.0	2.7	6.4	10.6	9.0	0.0	0.5	4.2	8.5	5.3
0.0	4.2	12.7	15.9	14.9	0.0	2.1	10.6	14.3	11.7
0.0	6.4	15.9	19.1	16.5	0.0	5.3	14.9	17.0	14.3
0.0	8.5	18.1	17.5	15.4	0.0	9.0	16.5	15.9	13.8

FRONT COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	1.1	0.0	1.1	0.0	0.0	9.6	11.2	9.0
0.0	0.0	4.2	3.2	4.2	0.0	0.0	9.6	9.6	7.4
0.0	0.0	6.4	5.8	5.8	0.0	0.0	8.5	6.4	4.8
0.0	0.0	6.4	6.4	5.3	0.0	0.0	2.1	1.1	1.1
0.0	0.0	4.2	3.7	3.2	0.0	0.0	-3.7	-4.2	-3.7
0.0	0.0	-1.1	0.0	-1.1	0.0	0.0	-4.2	-10.6	-8.5
0.0	0.0	-4.2	-5.3	-4.2	0.0	0.0	-4.2	-13.3	-11.7
0.0	0.0	-4.2	-8.5	-6.9	0.0	0.0	-4.2	-13.3	-12.2
0.0	0.0	-4.2	-9.0	-7.4	0.0	0.0	-4.2	-11.7	-8.5
0.0	0.0	-4.2	-8.5	-6.4	0.0	0.0	-4.2	-5.3	-3.2
0.0	0.0	-4.2	-6.9	-4.2	0.0	0.0	0.0	1.1	3.2
0.0	0.0	-4.2	-5.3	-2.7	0.0	0.0	4.2	6.4	7.4
0.0	0.0	-2.1	-3.2	-1.1	0.0	0.0	7.4	10.1	9.6
0.0	0.0	0.0	-1.1	0.5	0.0	0.0	9.0	11.2	9.6

FRONT COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	-4.2	-7.4	-8.0	0.0	1.1	-4.2	-10.1	-7.4
0.0	0.0	-2.1	-2.1	-3.2	0.0	1.6	1.1	-5.3	-3.2
0.0	0.5	3.2	4.2	2.7	0.0	2.1	6.4	3.2	3.2
0.0	0.5	6.4	9.0	6.9	0.0	3.2	10.6	9.6	8.5
0.0	1.1	9.0	11.7	9.6	0.0	3.7	12.7	13.8	10.6
0.0	1.1	9.6	11.2	9.6	0.0	3.2	12.2	13.8	10.1
0.0	2.1	9.0	8.5	7.4	0.0	2.7	9.0	10.6	7.4
0.0	2.1	6.4	4.2	5.3	0.0	1.1	4.8	5.3	3.7
0.0	1.6	2.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0
0.0	0.5	-2.7	-5.3	-3.2	0.0	0.0	-4.2	-4.2	-3.2
0.0	0.0	-4.2	-9.6	-6.9	0.0	0.0	-4.2	-8.5	-5.8
0.0	0.0	-4.2	-11.2	-10.1	0.0	0.0	-4.2	-10.6	-8.0
0.0	0.0	-4.2	-11.7	-10.6	0.0	0.5	-4.2	-11.7	-8.5
0.0	0.0	-4.2	-8.5	-9.6	0.0	1.1	-4.2	-10.6	-8.5

APPENDIX 2-7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 24 FT PERIOD 8,25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

FRONT COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0,0	4,2	10,6	9,6	8,5	0,0	0,0	2,1	1,6	1,6
0,0	4,2	9,6	9,6	7,4	0,0	0,0	4,8	4,8	4,2
0,0	3,7	5,8	6,4	5,3	0,0	0,0	5,3	6,4	4,8
0,0	2,1	-1,1	1,1	0,0	0,0	0,0	3,7	5,3	4,2
0,0	1,1	-4,2	-4,2	-4,2	0,0	0,0	0,5	2,1	1,6
0,0	0,0	-4,2	-9,6	-8,5	0,0	0,0	-2,1	-1,6	-1,6
0,0	0,0	-4,2	-11,2	-9,6	0,0	0,0	-4,2	-4,2	-4,2
0,0	0,5	-4,2	-10,6	-8,5	0,0	0,0	-4,2	-5,3	-5,3
0,0	1,1	-4,2	-7,4	-6,4	0,0	0,0	-4,2	-5,8	-5,8
0,0	1,6	-3,2	-4,2	-3,2	0,0	0,0	-4,2	-5,8	-5,3
0,0	2,1	0,0	0,0	1,1	0,0	0,0	-4,2	-6,4	-4,2
0,0	2,1	3,2	4,2	5,3	0,0	0,0	-3,2	-5,3	-2,7
0,0	3,2	6,9	7,4	7,4	0,0	0,0	-1,1	-3,2	-1,1
0,0	4,2	9,6	9,6	8,5	0,0	0,0	1,1	5,3	1,1

REAR COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
0,0	0,0	-4,4	-8,8	-8,3	0,0	0,0	-4,4	-9,7	-12,2
0,0	1,5	-4,4	-2,9	-2,4	0,0	1,0	-4,4	-4,9	-7,8
0,0	1,9	0,0	3,4	3,9	1,5	2,4	-2,4	1,0	-1,9
0,0	3,4	5,8	9,7	10,7	2,9	4,4	3,9	6,8	4,9
0,0	4,9	11,7	15,1	14,6	3,4	7,3	10,7	12,6	10,7
0,0	5,8	14,6	17,0	15,6	3,9	9,2	15,6	15,6	14,6
0,0	5,8	14,6	15,6	12,6	3,9	10,2	17,5	15,6	15,1
0,0	4,4	11,7	11,7	7,8	3,4	9,2	15,6	11,7	12,6
0,0	2,9	4,9	5,8	1,0	2,4	6,8	9,7	5,8	6,8
0,0	1,0	-2,9	-1,9	-6,3	1,0	3,4	0,0	-2,9	0,0
0,0	0,0	-4,4	-8,8	-11,7	0,0	1,0	-3,9	-8,8	-7,8
0,0	0,0	-4,4	-12,6	-14,1	0,0	0,0	-3,9	-13,1	-12,6
0,0	0,0	-4,4	-13,1	-13,6	0,0	0,0	-3,9	-13,1	-14,1
0,0	0,0	-4,4	-9,7	-9,2	0,0	0,0	-3,9	-10,7	-12,6

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 24 FT PERIOD 8,25 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT INTERVALS OF ONE-FOURTEENTH OF TIDAL PERIOD

REAR COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0,0	0,0	-4,4	-10,7	-8,8	0,0	0,0	-4,4	-6,3	-4,9
0,0	0,0	-4,4	-8,8	-7,8	0,0	0,0	-4,4	-7,3	-6,8
0,0	0,0	-1,9	-5,8	-5,4	0,0	0,0	-4,4	-6,8	-7,3
0,0	2,4	1,0	-1,0	-1,0	0,0	0,0	-4,4	-5,4	-6,8
0,0	3,9	4,9	3,9	3,9	0,0	1,5	-3,4	-1,9	-3,9
0,0	5,4	9,2	9,2	8,8	0,0	2,9	0,5	2,4	-1,0
0,0	6,3	12,6	12,6	12,6	0,0	4,4	4,9	6,8	3,9
0,0	5,8	12,6	13,6	13,6	0,0	4,4	8,8	10,2	6,8
0,0	4,4	8,8	10,2	11,7	0,0	4,4	9,2	11,2	8,3
0,0	2,9	2,9	4,9	6,8	0,0	3,4	6,8	8,8	7,3
0,0	1,9	-2,4	-1,9	1,0	0,0	1,9	3,9	5,4	4,4
0,0	1,0	-4,4	-6,8	-3,9	0,0	1,0	0,0	1,0	1,0
0,0	0,0	-4,4	-10,2	-7,3	0,0	0,0	-3,9	-2,9	-2,4
0,0	0,0	-4,4	-10,7	-8,8	0,0	0,0	-4,4	-5,8	-4,4

REAR COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
0,0	0,0	-3,9	-2,9	-4,9	0,0	0,0	-4,4	-3,4	-3,4
0,0	0,0	-4,4	-5,8	-7,3	0,0	0,0	-4,4	-5,4	-4,9
0,0	0,0	-4,4	-6,3	-7,8	0,0	0,0	-4,4	-5,8	-5,4
0,0	0,0	-4,4	-5,8	-6,8	0,0	0,0	-4,4	-4,4	-3,9
0,0	0,0	-3,9	-3,9	-4,9	0,0	0,0	-1,9	-1,9	-1,9
0,0	0,0	-1,0	-1,0	-1,9	0,0	0,0	1,9	1,9	1,0
0,0	0,0	2,9	1,9	1,9	0,0	0,0	5,4	4,9	3,9
0,0	0,0	6,8	4,9	4,9	0,0	0,0	7,8	7,8	5,8
0,0	0,0	8,8	7,8	6,8	0,0	0,0	9,2	8,8	7,8
0,0	0,0	9,2	8,8	6,8	0,0	0,0	8,8	8,8	7,8
0,0	0,0	8,3	7,8	5,8	0,0	0,0	6,8	6,3	6,8
0,0	0,0	5,8	4,9	2,4	0,0	0,0	3,4	3,9	3,9
0,0	0,0	1,0	1,9	-1,0	0,0	0,0	0,0	0,0	1,0
0,0	0,0	-2,9	-2,4	-3,9	0,0	0,0	-3,9	-2,9	-1,9

REAR COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0,0	0,0	-4,4	-8,3	-6,8	0,0	0,0	-4,4	-5,8	-6,8
0,0	0,0	-4,4	-6,8	-5,4	0,0	0,0	-4,4	-2,4	-2,9
0,0	0,0	-3,4	-3,9	-2,9	0,0	0,0	0,0	1,9	1,5
0,0	0,0	0,0	0,0	1,0	0,0	1,9	4,9	6,8	5,8
0,0	0,0	3,9	3,9	3,4	0,0	2,9	8,8	10,7	8,8
0,0	0,0	8,3	6,8	5,8	0,0	3,9	11,7	12,6	10,7
0,0	0,0	10,7	9,2	7,8	0,0	4,4	12,2	13,1	10,7
0,0	0,0	10,2	9,7	7,8	0,0	4,4	9,7	11,2	8,8
0,0	0,0	7,8	7,8	5,8	0,0	3,4	5,8	7,3	4,9
0,0	0,0	3,9	3,9	2,9	0,0	2,9	0,0	1,9	0,0
0,0	0,0	-1,0	-1,0	-1,0	0,0	1,9	-4,4	-2,9	-4,9
0,0	0,0	-4,4	-4,9	-4,4	0,0	0,5	-4,4	-5,4	-7,8
0,0	0,0	-4,4	-7,8	-6,8	0,0	0,0	-4,4	-7,8	-8,8
0,0	0,0	-4,4	-8,3	-7,3	0,0	0,0	-4,4	-6,8	-7,8

APPENDIX 3

PRESSURES ON BERTH CAISSON DUE TO 12 FEET HIGH WAVES APPROACHING IN THE DIRECTION NORMAL TO THE BERTHLINE AT HIGH WATER.

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	12 FT PERIOD 6.0 SECS
DIRECTION	NORMAL TO BERTH LINE
FRIG DOOR CAISSONS	ABSENT
UNITS	FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

TOP SURFACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
[illegible]	-0.3	0.5	-3.3	0.0	-1.4	-0.8	0.8	1.9	2.3
-1.9	-3.3	-2.2	-3.0	-0.8	-0.8	-0.8	0.8	0.4	1.2
-3.0	-4.4	-4.1	-1.5	-1.1	0.0	-0.5	0.5	-1.2	-0.4
-3.[illegible]	-3.8	-4.4	1.5	-0.3	1.1	0.0	0.5	-1.9	-1.5
-2.[illegible]	-1.4	-2.[illegible]	3.5	[illegible].5	2.2	0.5	0.3	-1.9	-1.9
-0.3	1.4	0.0	4.0	1.1	1.6	0.8	-0.3	-0.8	-0.8
1.[illegible]	3.[illegible]	2.2	3.5	1.4	0.3	0.3	-0.5	[illegible].4	0.4
1.6	3.6	3.6	2.0	1.4	-0.8	-0.3	-0.5	1.5	1.9
1.[illegible]	2.5	3.5	-1.0	1.1	-1.4	-0.5	0.3	2.3	2.7
0.3	0.0	1.1	-2.5	0.3	-1.1	-0.8	0.5	1.9	2.3

11	12	13	14	15	16	17	18	19	20
1.5	0.4	0.[illegible]	-1.2	-1.4	-0.5	2.2	2.8	6.9	2.5
-1.[illegible]	-2.3	-3.[illegible]	-3.1	-2.2	-0.[illegible]	3.0	4.7	9.0	3.8
-3.8	-3.8	-3.8	-3.8	-1.9	-0.3	2.3	4.4	6.0	3.8
-4.[illegible]	-3.8	-3.1	-2.7	-0.5	0.3	1.9	3.3	2.8	2.8
-3.1	-1.5	-0.4	0.0	1.4	1.6	0.8	0.8	-0.8	0.8
[illegible]	0.8	2.3	1.9	2.2	2.2	-1.1	-2.5	-4.4	-2.5
2.3	2.7	3.8	3.5	1.6	1.6	-3.3	-4.9	-6.0	-4.9
3.[illegible]	3.5	4.[illegible]	3.1	[illegible].3	-0.3	-3.6	-4.9	-4.1	-5.2
3.8	3.1	3.1	1.5	-0.5	-0.3	-1.4	-1.6	0.5	-1.9
1.[illegible]	[illegible].4	[illegible]	-1.2	-1.4	-0.5	1.9	2.8	6.6	1.9

21	22
8.[illegible]	3.5
7.[illegible]	6.0
2.[illegible]	1.9
-1.9	-1.9
-5.[illegible]	-5.5
-7.[illegible]	-6.9
-6.[illegible]	-4.7
-1.[illegible]	0.5
4.[illegible]	6.3
8.[illegible]	8.5
[illegible]	[illegible]
0.[illegible]	0.0
0.[illegible]	0.0
0.0	0.0

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 12 FT PERIOD 6.0 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

FRONT FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
3.1	3.1	2.7	3.8	2.7	2.3	3.1	3.1	3.1	1.9
2.7	2.3	2.7	3.8	1.5	1.5	1.9	2.3	1.5	0.8
[illegible]	0.8	1.2	2.3	-0.8	0.3	0.0	0.4	-0.4	-1.2
-0.8	-1.2	-0.8	0.0	-1.5	-1.5	-1.5	-0.8	-1.2	-1.9
-1.2	-1.5	-1.5	-1.5	-1.9	-1.5	-1.5	-1.5	-0.8	-1.9
-1.9	-1.9	-2.3	-2.3	-1.5	-1.5	-1.2	-1.2	-0.4	-1.2
-1.2	-1.5	-2.3	-2.7	-0.8	-1.2	-0.8	-0.8	0.8	-0.4
-0.4	-0.4	-1.5	-1.5	0.4	-0.4	0.4	0.8	1.9	0.4
1.2	1.5	0.8	1.2	1.9	0.8	1.9	2.3	3.1	1.5
3.1	3.1	2.7	3.8	2.7	1.9	3.1	3.5	3.1	1.9

11	12	13	14	15	16
2.3	3.1	2.3	1.9	3.1	3.8
[illegible]	1.2	1.2	0.8	2.3	3.5
-0.3	-1.2	-0.8	-0.8	0.4	1.5
-1.9	-2.3	-2.3	-1.9	-1.2	-0.4
-1.5	-2.3	-2.7	-2.3	-1.9	-1.5
[illegible]	-1.5	-2.3	-1.9	-1.9	-1.9
0.0	-0.8	-1.5	-1.2	-1.2	-1.2
1.2	0.8	-0.4	0.8	0.4	0.4
2.3	2.3	1.5	1.5	1.5	2.3
2.3	3.1	2.3	1.9	3.1	3.8

UNDER SURFACE OF CAISSON - FULL OPENINGS

1	2	3	4	5	6	7
2.3	-1.1	-0.5	0.5	0.8	-0.8	-0.5
[illegible]	2.5	0.5	1.4	-0.4	-0.5	-0.3
[illegible]	1.9	1.6	1.6	-0.8	0.2	-0.3
[illegible]	2.5	2.5	1.6	-1.5	0.6	0.3
0.3	1.6	2.2	1.1	-1.2	1.1	0.3
[illegible]	0.2	1.1	1.0	0.0	0.8	0.3
-0.3	-2.2	-0.8	-1.6	0.8	-0.3	-0.3
[illegible]	-3.	-1.6	-2.2	1.2	-1.1	-0.5
0.	-2.8	-1.6	-1.1	1.2	-1.1	-0.5
[illegible]	-1.4	-0.5	0.3	0.8	-0.6	-0.5

APPENDIX 3-4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 12 FT PERIOD 6.0 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

REAR FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
2.5	1.4	1.9	1.4	2.2	1.6	1.5	1.6	1.9	2.5
1.4	1.1	1.1	0.3	1.4	1.1	1.1	1.1	1.4	1.6
[illegible]	[illegible]	[illegible]	-1.1	0.0	0.3	0.3	0.3	0.5	0.5
-1.4	-1.1	-0.8	-1.9	-1.1	-0.8	-0.8	-0.8	-0.8	-0.5
-1.[illegible]	-1.4	-1.4	-1.9	-1.6	-1.4	-1.1	-1.4	-1.6	-1.1
-1.6	-1.6	-1.1	-1.4	-1.6	-1.6	-1.1	-1.1	-1.6	-1.4
[illegible]	-1.1	-0.5	-0.3	-1.1	-1.1	-0.5	-0.5	-1.4	-0.8
0.5	-0.3	0.5	0.8	0.3	-0.3	0.5	0.3	0.0	0.3
1.[illegible]	0.5	1.6	1.4	1.6	0.5	1.4	1.1	1.1	1.6
2.2	1.4	1.9	1.4	2.5	1.4	1.6	1.6	1.9	2.5

11	12	13	14	15	16
1.9	2.2	0.8	1.1	1.6	2.2
[illegible]	1.4	[illegible]	0.3	1.1	1.4
-0.3	-0.3	-0.5	-0.5	-0.3	0.3
-1.[illegible]	-1.1	-0.8	-0.8	-0.5	-0.5
-1.6	-1.6	-0.8	-1.1	-0.5	-0.3
-1.1	-1.6	-0.5	-0.5	-0.5	-0.3
-0.3	-0.5	-0.3	-0.3	0.3	0.3
[illegible]	[illegible]	[illegible]	0.3	0.8	1.1
1.6	1.9	0.8	1.1	1.4	1.9
1.[illegible]	2.2	0.3	1.1	1.6	2.2

UNDER SURFACE OF CAISSON - 10 PERCENT OPENINGS

1	2	3	4	5	6	7
-0.7	-1.3	-0.7	-0.7	0.0	-0.7	-1.3
[illegible]	[illegible]	[illegible]	[illegible]	0.0	0.[illegible]	-0.7
[illegible]	0.3	0.7	0.0	0.0	0.7	0.0
0.3	1.3	1.3	0.0	0.0	0.7	0.0
0.7	2.0	1.3	0.0	0.0	1.3	0.7
0.7	1.3	1.3	[illegible]	0.0	0.7	0.7
[illegible]	0.0	0.7	-0.7	0.0	0.0	0.0
[illegible]	-0.7	-0.7	-1.3	-0.7	-0.7	-0.7
-0.7	-1.3	-1.3	-1.3	-0.7	-0.7	-1.3
-0.7	-1.3	-0.7	-1.3	0.0	-0.7	-1.3

APPENDIX 3-5

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 12 FT PERIOD 6.Ø SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

SIDE FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
1.5	1.9	1.9	2.3	1.1	1.2	Ø.8	1.5	Ø.Ø	-Ø.4
1.5	1.5	2.3	2.3	1.1	1.5	1.5	2.3	Ø.4	Ø.Ø
Ø.4	Ø.8	1.2	1.5	Ø.8	1.2	1.5	2.3	[illegible]	Ø.4
-Ø.8	Ø.Ø	-Ø.4	Ø.Ø	Ø.5	Ø.8	1.2	1.5	1.2	Ø.8
-1.[illegible]	[illegible].4	-1.5	-1.5	Ø.3	Ø.Ø	Ø.4	Ø.4	1.2	1.2
-1.[illegible]	-Ø.8	-2.7	-2.3	Ø.Ø	-Ø.4	-Ø.8	-Ø.8	Ø.4	Ø.8
-1.[illegible]	-[illegible].4	-2.7	-2.3	-Ø.5	-1.2	-1.5	-1.9	-Ø.8	-Ø.4
-1.2	Ø.Ø	-1.9	-1.5	-Ø.3	-Ø.8	-1.9	-2.3	-1.2	-1.2
Ø.4	1.2	Ø.Ø	Ø.4	Ø.3	Ø.Ø	-1.5	-Ø.8	-1.2	-1.2
1.5	1.9	1.9	2.3	Ø.8	1.2	Ø.4	1.2	Ø.Ø	-Ø.4

11	12	13	14	15	16	17	18	19	20
-Ø.8	-Ø.8	-Ø.8	-1.2	-Ø.8	-2.3	-1.5	-1.5	-1.2	-Ø.8
[illegible]	-Ø.4	-1.2	-1.9	-1.5	-2.7	-1.9	-2.3	-2.3	-1.9
Ø.4	Ø.4	-1.2	-1.9	-1.2	-2.3	-2.3	-2.7	-2.3	-1.9
1.2	Ø.8	Ø.Ø	-1.2	-Ø.4	-Ø.8	-1.2	-1.5	-1.9	-Ø.8
1.5	1.2	1.5	Ø.Ø	Ø.8	1.2	Ø.8	Ø.4	Ø.Ø	1.5
1.9	Ø.8	2.3	1.2	1.5	2.3	1.5	1.9	1.9	3.1
Ø.4	Ø.Ø	1.9	1.5	1.5	1.9	1.9	2.3	2.7	3.5
-1.2	-1.2	1.2	Ø.8	Ø.8	Ø.8	1.2	1.5	2.3	2.7
-1.2	-1.5	Ø.Ø	Ø.8	-Ø.4	-Ø.8	Ø.Ø	Ø.4	Ø.8	1.5
-Ø.[illegible]	-Ø.8	-Ø.[illegible]	-1.2	-Ø.8	-1.9	-1.2	-1.5	-Ø.8	Ø.Ø

21	22	23	24	25	26	27	28
[illegible]	Ø.3	Ø.Ø	-1.2	Ø.Ø	Ø.8	1.5	1.1
-1.2	-1.5	-1.2	-2.3	-Ø.8	-Ø.4	1.9	Ø.3
-1.[illegible]	-1.5	-1.[illegible]	-2.7	-1.2	-1.2	1.2	-Ø.5
-1.5	-1.2	-1.5	-1.5	-1.5	-1.5	Ø.4	-1.6
-Ø.4	Ø.Ø	Ø.Ø	Ø.4	-Ø.8	-Ø.8	-Ø.4	-1.6
Ø.8	1.5	1.5	1.5	Ø.Ø	Ø.4	-1.5	-1.4
1.5	1.9	1.9	2.3	Ø.8	1.2	-1.9	-Ø.5
1.9	1.9	1.9	1.9	Ø.8	1.5	-2.3	Ø.5
1.2	1.2	1.2	Ø.8	Ø.8	1.5	-Ø.8	Ø.8
Ø.Ø	Ø.Ø	Ø.Ø	-1.2	Ø.Ø	1.2	1.2	1.1

<u>APPENDIX 3-6</u>

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	12 FT PERIOD 6.1 SECS
DIRECTION	NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD	

FRONT COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	1Ø
-3.3	-7.Ø	-Ø.5	Ø.Ø	Ø.5	6.Ø	3.8	4.1	3.3	1.6
6.3	4.Ø	2.8	1.9	2.2	12.6	7.7	5.5	3.6	1.6
8.8	12.Ø	4.7	3.3	2.8	13.7	7.7	3.8	2.5	Ø.8
7.1	13.Ø	4.7	3.3	2.5	8.3	3.3	Ø.5	Ø.5	-Ø.5
1.1	Ø.2	2.5	1.6	1.4	-Ø.5	-2.8	-3.3	-1.6	-2.2
-5.5	-2.2	-Ø.5	-1.1	-Ø.5	-6.3	-9.3	-6.6	-3.3	-3.6
-6.7	-13.3	-4.4	-3.8	-2.2	-6.3	-11.5	-7.1	-3.8	-3.8
-6.3	-19.5	-6.Ø	-4.9	-3.Ø	-6.3	-9.3	-4.9	-2.2	-2.8
-6.3	-17.Ø	-4.9	-3.6	-1.6	-5.5	-3.3	-Ø.5	Ø.5	-Ø.5
-2.2	-8.Ø	-1.9	-1.1	-Ø.3	3.8	3.3	3.3	3.Ø	1.4

FRONT COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	1Ø
-6.3	-7.7	-4.9	-3.3	-3.Ø	-5.5	-7.1	-3.8	-1.6	-1.1
-1.6	Ø.2	1.1	Ø.5	Ø.Ø	2.2	2.8	2.2	2.2	2.8
7.1	7.7	6.Ø	4.4	3.3	11.Ø	1Ø.4	7.1	5.5	4.9
12.1	11.Ø	8.Ø	6.3	4.9	15.4	12.9	8.3	6.Ø	5.5
12.1	9.3	8.8	5.5	4.9	13.2	9.3	6.Ø	3.8	3.3
5.5	2.5	4.Ø	2.Ø	3.Ø	2.4	Ø.5	Ø.Ø	-Ø.5	-Ø.5
-3.3	-6.6	-6.Ø	-3.3	-1.6	-6.3	-9.9	-6.Ø	-5.5	-4.4
-6.4	-13.2	-1Ø.4	-6.6	-4.9	-6.3	-15.4	-1Ø.4	-7.7	-6.6
-6.3	-14.Ø	-9.9	-6.6	-5.5	-6.3	-15.4	-9.9	-6.Ø	-5.5
-6.3	-8.8	-6.Ø	-3.8	-3.8	-6.3	-8.3	-5.5	-2.2	-2.2

FRONT COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	1Ø
-6.Ø	-4.4	-4.9	-2.8	-2.2	-6.3	-6.Ø	-4.1	-3.3	-2.5
-6.3	-6.3	-4.9	-3.6	-3.Ø	-6.Ø	-4.9	-4.1	-2.8	-2.8
-5.5	-5.5	-2.8	-3.Ø	-2.5	-2.2	-1.6	-2.2	-Ø.8	-1.6
-1.1	-2.5	Ø.5	-1.1	-Ø.5	2.8	2.2	Ø.5	1.6	Ø.Ø
3.Ø	1.6	2.8	1.4	1.4	5.5	4.9	3.3	3.3	2.2
6.Ø	4.4	3.6	2.8	2.2	4.9	4.9	4.4	3.Ø	3.Ø
5.5	4.9	2.8	2.5	2.2	1.6	2.2	3.Ø	1.1	2.5
2.8	3.2	Ø.3	1.1	1.1	-2.2	-1.6	Ø.3	-1.1	Ø.8
-1.1	-Ø.5	-2.3	-Ø.8	-Ø.5	-5.5	-4.4	-2.2	-2.8	-Ø.8
-4.9	-3.8	-4.7	-2.9	-1.9	-6.3	-6.Ø	-3.8	-3.3	-2.2

APPENDIX 3-7.

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIME HIGH WATER

WAVE HEIGHT 12 FT PERIOD 6.0 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

FRONT COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
3.3	3.3	1.6	2.2	1.6	-2.8	-1.6	-1.1	-1.1	0.0
10.4	7.7	4.4	3.3	2.2	1.4	0.9	0.5	[illegible]	0.5
12.1	8.8	5.2	3.3	2.2	4.4	3.0	1.6	0.8	0.8
[illegible]	6.[illegible]	3.3	1.4	1.1	4.9	3.6	2.2	1.1	0.8
1.6	1.1	0.0	-1.1	-0.5	2.2	2.2	1.4	0.5	0.5
-6.3	-4.9	-4.1	-3.3	-1.9	-2.2	-0.5	-0.5	-[illegible].8	-3.5
-6.3	-8.3	-6.3	-4.4	-2.5	-4.9	-2.9	-2.2	-2.2	-1.4
-6.3	-7.1	-5.[illegible]	-3.6	-2.2	-6.3	-4.1	-3.0	-2.8	-1.4
-6.3	-3.3	-2.8	-1.1	-0.5	-6.3	-4.1	-2.8	-2.5	-1.1
1.[illegible]	2.2	1.6	1.6	1.4	-4.4	-2.5	-1.6	-1.5	-0.3

REAR COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
-6.2	-3.4	-4.1	-5.5	-2.7	-5.5	-5.5	-4.1	-2.1	-2.1
-6.2	-8.2	-6.6	-6.8	-4.1	-6.2	-9.6	-6.8	-4.1	-3.4
-6.2	-8.2	-5.5	-5.5	-3.4	-6.2	-8.9	-6.2	-3.4	-2.7
-2.7	-2.7	-[illegible].7	-2.1	-1.7	-1.4	-3.4	-2.7	[illegible]	0.0
5.5	4.8	5.5	2.1	2.1	6.8	4.1	2.7	2.7	3.4
12.3	11.[illegible]	8.2	4.1	4.1	13.7	11.0	6.8	5.5	5.5
13.7	13.0	8.2	4.8	4.1	15.7	12.3	8.2	6.2	5.5
[illegible]	9.6	5.5	2.1	2.1	12.3	10.3	6.8	4.8	4.1
2.7	4.1	1.4	-1.4	-0.7	4.1	4.1	2.7	2.1	0.7
-4.1	-2.7	-3.4	-4.8	-2.7	-2.7	-4.1	-2.7	-1.4	-2.1

APPENDIX 3-8

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 12 FT PERIOD 6.0 SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

REAR COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
[illegible]	0.0	0.0	1.4	2.1	8.9	5.5	4.8	4.8	2.7
-6.[illegible]	-2.7	-5.5	-2.1	-1.4	1.4	1.4	1.4	2.7	0.7
-6.2	-5.5	-8.9	-4.1	-2.1	-5.5	-2.7	-2.7	-1.4	-2.1
-6.[illegible]	-4.[illegible]	-6.[illegible]	-4.[illegible]	-2.1	-6.2	-4.1	-4.1	-2.7	-3.4
-2.7	-2.1	-3.4	-1.4	-1.4	-6.2	-4.1	-3.4	-3.4	-2.7
[illegible]	2.1	2.1	2.7	1.4	-2.7	-2.1	0.0	-1.4	-1.4
12.3	5.5	5.5	5.5	4.1	4.1	2.1	2.7	1.4	1.4
13.7	6.8	6.8	6.8	5.5	9.6	5.5	5.5	4.1	2.7
9.6	4.8	4.8	5.5	4.8	12.3	6.8	6.8	5.5	4.1
[illegible]	1.4	[illegible]	2.7	2.7	11.6	6.8	4.8	4.8	3.4

REAR COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
11.[illegible]	8.2	5.5	2.7	4.1	11.6	8.2	4.8	3.4	2.7
11.6	8.9	6.2	3.4	4.8	13.0	8.2	4.8	3.4	2.7
6.2	5.5	4.8	2.1	3.4	9.6	4.1	2.7	2.7	2.1
2.1	0.7	1.4	0.0	1.4	2.7	0.0	0.0	-1.4	0.7
-4.[illegible]	-5.5	-2.7	-2.[illegible]	-0.7	-4.[illegible]	-5.5	-2.7	-2.7	-1.4
-6.2	-8.2	-5.5	-3.4	-2.1	-6.2	-7.5	-4.1	-4.1	-2.1
-5.[illegible]	-7.5	-5.[illegible]	-3.4	-2.1	-6.2	-6.8	-3.4	-4.1	-2.7
-0.7	-3.4	-2.7	-2.1	-0.7	-4.8	-2.7	-1.4	-2.1	-1.4
7.[illegible]	2.7	3.4	0.7	2.1	2.7	3.4	2.1	[illegible].7	1.4
11.0	8.2	4.8	3.4	4.1	10.3	7.5	4.8	2.7	2.7

REAR COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
6.2	5.5	3.4	1.4	1.4	1.4	2.7	0.0	0.0	0.0
-1.[illegible]	1.4	[illegible]	-0.7	-0.7	-5.5	-3.4	-5.5	-4.1	-2.1
-6.2	-4.1	-2.7	-2.[illegible]	-1.4	-6.2	-6.8	-7.5	-5.5	-2.7
-6.[illegible]	-6.2	-3.4	-2.7	-2.1	-6.2	-5.5	-6.2	-5.5	-2.1
-6.2	-4.8	-2.1	-1.4	-1.4	-0.7	0.0	-1.4	-2.1	0.0
-2.7	-1.4	[illegible].7	[illegible]	0.0	8.2	6.8	4.1	2.7	2.1
5.5	4.1	4.1	2.1	1.4	13.7	12.3	8.2	5.5	3.4
11.[illegible]	8.2	6.[illegible]	2.7	2.1	15.1	13.7	9.6	6.8	3.4
12.[illegible]	8.9	7.[illegible]	2.7	2.1	11.0	11.0	6.8	5.5	2.1
7.	6.8	4.1	2.1	1.4	4.1	4.1	1.4	1.4	0.0

APPENDIX 4

PRESSURES ON BERTH CAISSON DUE TO 12 FEET HIGH WAVES APPROACHING IN THE DIRECTION NORMAL TO THE BERTHLINE AT LOW WATER.

APPENDIX 4-2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

TOP SURFACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
1.0	-5.9	-5.[illegible]	-4.3	-4.0	-3.0	-5.9	-0.3	7.4	7.4
0.6	-9.3	-8.7	-5.9	-4.3	-2.7	-3.7	0.0	4.4	4.4
-[illegible]	-9.3	-8.7	-5.3	-3.1	-1.6	0.0	0.2	-0.5	-1.0
-1.2	-4.3	-4.3	-1.9	0.0	0.5	3.7	0.3	-4.9	-5.9
-1.[illegible]	3.1	1.9	2.2	3.1	2.7	5.9	0.3	-7.1	-7.9
-1.6	8.1	7.5	5.6	4.7	3.2	5.6	0.2	-5.9	-6.4
-[illegible]	9.9	9.9	5.9	3.7	2.4	2.5	0.0	-2.0	-1.7
0.6	6.8	9.7	3.7	1.2	0.0	-1.9	-0.5	3.0	3.5
1.[illegible]	1.2	3.1	3.6	-1.9	-1.9	-5.6	-0.5	6.4	6.9
1.6	-5.0	-3.1	-3.7	-3.7	-3.0	-6.2	-0.6	7.4	7.9

11	12	13	14	15	16	17	18	19	20
5.4	5.9	-9.5	1.5	-3.2	-1.4	-6.0	-6.5	-1.6	-2.7
-[illegible]	1.3	-3.9	-2.5	-2.7	0.2	-0.5	0.5	7.6	2.2
-6.4	-4.4	-6.4	-5.4	-1.6	1.1	4.3	7.6	11.9	5.4
-[illegible]	-6.4	-9.7	-6.[illegible]	-[illegible].3	1.4	7.5	10.5	11.4	6.5
-8.4	-8.6	-3.0	-4.9	1.6	1.6	7.8	10.3	6.5	7.8
-3.[illegible]	-4.9	2.[illegible]	[illegible]	2.7	1.[illegible]	5.1	6.0	[illegible].0	3.8
3.[illegible]	1.8	6.4	4.4	2.4	1.4	0.0	0.0	-7.6	-0.5
7.[illegible]	6.4	6.[illegible]	5.[illegible]	[illegible].3	0.0	-6.0	-7.[illegible]	-11.9	-4.9
8.9	8.6	4.4	5.4	-2.2	-1.6	-8.4	-10.3	-11.9	-6.2
[illegible]	5.9	0.5	2.[illegible]	-3.2	-1.4	-7.0	-8.7	-4.9	-3.6

21	22
2.7	1.1
6.7	8.7
1[illegible].5	12.4
7.[illegible]	11.9
2.[illegible]	6.5
-4.9	-4.3
-[illegible]	-1[illegible].3
-9.7	-13.[illegible]
-[illegible]	-9.2
0.[illegible]	-1.1
7.[illegible]	7.0
[illegible]	3.[illegible]
[illegible]	4.[illegible]
[illegible]	0.0

APPENDIX 4-3

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

FRONT FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
4.7	4.4	4.4	5.4	6.2	6.2	6.9	6.9	7.1	7.9
4.2	4.4	5.2	6.2	4.4	5.4	5.9	6.4	4.4	4.9
[illegible]	1.5	[illegible]	3.9	0.5	[illegible]	1.7	3.0	[illegible]	0.0
-3.5	-2.5	-1.0	-0.5	-3.9	-2.5	-2.5	-2.0	-3.9	-4.4
[illegible]	-4.4	-3.9	-4.4	-6.2	-5.4	-5.9	-6.4	-6.7	-7.9
-4.4	-4.4	-4.7	-6.2	-5.7	-6.2	-5.9	-7.4	-6.7	-7.9
[illegible]	-2.5	-3.9	-5.4	-2.5	-3.5	-3.0	-5.4	-3.5	-3.9
[illegible]	0.0	-2.0	-3.2	1.2	0.0	1.5	-1.0	1.5	1.5
[illegible]	2.5	0.5	1.2	4.4	3.7	4.9	3.0	5.9	6.4
4.4	4.2	3.5	5.2	5.9	6.2	6.9	6.4	6.9	8.1

11	12	13	14	15	16
8.9	11.3	7.1	7.1	6.1	9.9
5.4	7.4	4.9	5.9	4.9	5.4
2.5	1.5	0.5	2.0	0.0	-1.0
[illegible]	-3.9	-3.9	-2.0	-4.4	-5.9
-8.4	-8.9	-6.9	-5.4	-7.4	-8.6
[illegible]	-11.1	-7.4	-6.9	-7.6	-8.7
-4.9	-8.9	-5.2	-5.9	-4.4	-4.4
[illegible]	-2.0	-3.2	-0.5	1.0	[illegible]
6.9	6.9	4.4	4.4	6.4	3.5
[illegible]	10.8	6.9	6.9	8.1	9.9

UNDER SURFACE OF CAISSON - FULL OPENINGS

1	2	3	4	5	6	7
1.9	1.9	1.2	1.6	2.0	0.0	0.2
3.7	3.7	3.7	3.4	0.5	3.1	0.9
3.7	3.7	3.7	2.8	-1.2	4.7	0.6
[illegible]	1.2	1.9	[illegible]	-2.2	3.7	-0.3
[illegible]	-1.6	-0.6	-2.5	-2.0	1.2	-0.3
[illegible]	-2.8	-2.2	-3.4	-0.7	-1.2	0.2
[illegible]	-3.7	-2.8	-3.4	0.7	-2.8	-0.3
[illegible]	-3.7	-3.4	-3.1	1.7	[illegible]	-1.2
-0.9	-2.2	-2.5	-1.6	2.2	-3.7	-1.2
[illegible]	0.9	0.5	0.9	2.0	-0.6	0.2

APPENDIX 4-4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE LOW WATER

WAVE HEIGHT 12 FT PERIOD 6.Ø SECS

DIRECTION NORMAL TO BERTH LINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

REAR FACE OF CAISSON

1	2	3	4	5	6	7	8	9	1Ø
1.[illegible]	2.2	2.7	2.7	1.6	1.4	1.9	1.9	1.1	1.6
2.4	2.4	2.4	2.2	2.2	2.2	2.2	1.9	1.9	2.7
2.[illegible]	1.6	1.6	Ø.5	1.9	1.4	1.4	Ø.8	1.6	2.2
Ø.5	-Ø.3	-Ø.8	-1.4	Ø.5	Ø.Ø	Ø.3	-Ø.8	Ø.5	1.1
-1.[illegible]	-1.6	-2.4	-2.7	-1.1	-1.4	-1.4	-1.9	-[illegible].8	-Ø.8
-2.4	-2.4	-2.7	-2.4	-2.4	-2.2	-1.6	-2.2	-1.6	-2.2
-2.4	-2.2	-2.2	-1.4	-2.4	-2.2	-1.4	-1.6	-1.6	-2.2
-1.6	-Ø.8	-Ø.3	Ø.3	-1.6	-1.4	-Ø.5	-Ø.5	-1.4	-1.9
[illegible]	Ø.5	1.4	1.6	-Ø.5	Ø.Ø	Ø.5	Ø.8	-Ø.5	-Ø.5
1.4	1.9	2.4	2.4	1.1	1.4	1.4	1.9	1.1	1.1

11	12	13	14	15	16
2.2	1.9	1.1	1.4	Ø.8	1.6
2.7	3.2	1.6	2.4	1.1	2.2
2.7	2.7	1.1	2.2	Ø.8	1.6
1.1	1.4	Ø.[illegible]	Ø.5	Ø.[illegible]	Ø.5
-Ø.5	-1.1	-1.1	-1.1	-Ø.5	-Ø.5
-2.[illegible]	-2.7	-1.6	-2.4	-Ø.8	-1.4
-2.4	-3.Ø	-1.6	-3.Ø	-1.1	-1.6
-1.[illegible]	-2.4	-1.1	-2.2	-Ø.8	-1.1
-Ø.[illegible]	-Ø.5	Ø.3	-Ø.6	Ø.Ø	Ø.Ø
[illegible]	1.4	1.1	1.[illegible]	Ø.5	1.4

UNDER SURFACE OF CAISSON - 1Ø PERCENT OPENINGS

1	2	3	4	5	6	7
-1.3	-1.3	-Ø.7	-Ø.7	-Ø.7	-1.3	-1.3
[illegible]	Ø.7	[illegible]	Ø.[illegible]	Ø.[illegible]	-Ø.7	-1.3
Ø.7	Ø.Ø	Ø.Ø	Ø.Ø	Ø.7	Ø.Ø	-Ø.7
1.3	Ø.7	Ø.7	Ø.[illegible]	Ø.7	Ø.7	Ø.Ø
1.3	1.3	1.3	Ø.7	Ø.7	1.3	Ø.7
1.[illegible]	1.3	1.3	1.3	Ø.7	1.3	1.3
Ø.[illegible]	Ø.Ø	Ø.Ø	Ø.Ø	Ø.Ø	Ø.7	Ø.7
-1.[illegible]	-1.3	-Ø.7	-Ø.7	-Ø.7	-Ø.7	-Ø.7
-2.[illegible]	-1.3	-1.3	-Ø.7	-Ø.7	-1.3	-1.3
-[illegible]	-1.3	-1.3	-Ø.7	-Ø.7	-1.3	-1.3

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

SIDE FACE OF CAISSON

1	2	3	4	5	6	7	8	9	10
[illegible]	4.4	5.4	6.4	2.5	2.7	2.0	1.5	0.2	0.0
4.4	4.9	5.4	6.2	3.2	3.2	2.7	1.7	0.5	0.2
[illegible]	2.5	3.5	3.9	2.5	2.5	2.2	1.5	0.5	0.5
-0.5	-0.5	0.2	0.5	1.0	0.7	1.0	0.5	0.5	0.7
-2.7	-3.[illegible]	-3.[illegible]	-3.5	-1.0	-1.2	-0.7	-0.5	0.5	0.7
-4.4	-4.9	-4.9	-5.9	-2.2	-3.0	-2.2	-1.5	0.0	0.5
-4.4	-4.9	-5.4	-6.4	-3.2	-3.5	-3.2	-2.0	-0.5	-1.2
-2.2	-2.7	-3.2	-3.9	-2.7	-3.0	-2.5	-1.2	-0.7	-0.7
1.2	1.0	1.[illegible]	0.5	-0.5	-0.5	-0.5	0.5	-2.7	-0.7
4.4	4.4	4.9	5.7	2.0	2.0	1.7	2.0	0.0	0.0

11	12	13	14	15	16	17	18	19	20
-0.5	-0.7	-1.0	-1.5	-1.2	-2.0	-0.5	-1.0	-1.5	-2.7
-0.2	-0.2	-2.[illegible]	-2.0	-2.0	-2.7	-2.2	-2.7	-3.0	-4.9
[illegible]	0.0	-2.0	-2.0	-2.0	-2.2	-3.2	-3.2	-3.9	-5.2
[illegible]	0.5	-1.2	-1.2	-1.0	-0.5	-2.5	-2.5	-2.7	-2.5
0.5	1.0	0.5	0.5	1.0	2.0	-0.5	0.0	0.0	1.5
[illegible]	1.[illegible]	2.[illegible]	2.0	2.2	2.7	2.0	2.5	3.0	4.9
0.[illegible]	0.5	2.0	2.2	2.5	2.5	3.2	3.7	4.4	5.7
[illegible]	-0.5	1.[illegible]	1.2	1.5	1.7	3.0	3.5	3.9	4.4
-0.7	-1.0	0.0	0.0	0.5	0.2	1.5	1.5	2.0	1.5
[illegible]	[illegible]	-1.[illegible]	-1.2	-1.0	-1.5	0.0	-0.2	-0.5	-1.5

21	22	23	24	25	26	27	28
[illegible]	-0.2	-0.2	0.0	1.5	1.[illegible]	2.7	1.9
-2.5	-2.5	-2.5	-2.7	0.2	0.2	4.2	0.9
-3.7	-3.[illegible]	-4.[illegible]	-4.4	-0.5	-1.[illegible]	3.0	-1.2
-3.5	-3.9	-3.9	-4.4	-1.0	-2.0	-0.5	-2.5
-1.5	-2.2	-1.5	-2.[illegible]	-1.2	-1.7	-3.5	-2.5
1.5	1.0	1.5	1.5	0.0	-0.5	-4.4	-1.6
[illegible]	3.5	3.5	3.9	0.5	1.[illegible]	-4.2	0.3
3.2	3.7	3.7	4.4	1.0	1.7	-3.0	1.9
2.[illegible]	3.0	2.9	3.0	1.5	2.2	-1.0	2.2
0.0	0.7	0.5	0.5	1.2	1.7	2.5	2.5

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

FRONT COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	6.[illegible]	4.3	2.5	0.0	0.0	8.7	5.6	3.4
0.0	0.0	7.1	6.2	2.5	0.0	0.0	8.4	6.2	4.0
0.0	0.0	3.7	4.3	[illegible].6	0.0	0.0	5.0	3.1	2.2
0.0	0.0	-1.9	0.3	-1.6	0.0	0.0	-0.6	-1.6	-0.6
0.0	0.0	-6.2	-3.7	-2.2	0.0	0.0	-6.2	-5.[illegible]	-2.8
0.0	0.0	-6.2	-5.6	-2.2	0.0	0.0	-6.2	-6.5	-3.4
0.0	0.0	-6.2	-5.6	-1.6	0.0	0.0	-6.2	-6.2	-3.7
0.0	0.0	-3.7	-3.7	-0.9	0.0	0.0	-2.5	-3.4	-2.2
0.0	0.0	1.2	3.[illegible]	[illegible].3	0.0	0.0	4.3	1.2	0.0
0.0	0.0	5.6	4.3	2.2	0.0	0.0	8.7	5.3	3.1

FRONT COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	-5.6	-4.3	-3.7	0.0	0.0	-0.6	0.0	1.2
0.0	0.3	2.5	6.2	5.6	0.0	0.3	8.7	9.3	7.5
0.0	1.9	10.9	13.7	11.2	0.0	1.6	14.3	12.7	9.9
0.0	3.1	13.7	14.3	11.2	0.0	2.5	13.7	9.3	7.5
0.0	1.9	10.6	9.3	6.2	0.0	1.2	6.2	2.5	1.6
0.0	0.0	2.[illegible]	[illegible]	[illegible]	0.0	0.0	-4.3	-5.6	-3.7
0.0	0.0	-6.2	-8.7	-6.2	0.0	0.0	-6.2	-11.2	-8.7
0.0	0.0	-6.2	-13.7	-11.2	0.0	0.0	-6.2	-13.4	-9.9
0.0	0.0	-6.2	-14.3	-11.2	0.0	0.3	-6.2	-11.2	-7.5
0.0	0.0	-5.[illegible]	-6.[illegible]	-3.2	0.0	0.0	-3.1	-2.5	-1.2

FRONT COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	-5.[illegible]	-4.7	-4.0	0.0	0.0	-6.2	-7.1	-5.9
0.0	0.2	-4.7	-4.0	-3.1	0.0	0.2	-3.7	-4.3	-3.7
0.0	[illegible]	-2.[illegible]	-2.[illegible]	-1.9	0.0	0.7	0.0	-[illegible].9	-0.9
0.0	0.0	0.6	0.0	0.0	0.0	0.0	2.5	1.9	1.9
0.0	0.0	3.7	3.7	2.2	0.0	0.0	6.2	5.6	4.3
0.0	0.0	5.[illegible]	4.[illegible]	3.4	0.0	0.0	7.5	6.8	5.6
0.0	0.0	4.7	1.9	1.9	0.0	0.0	5.0	3.7	3.7
0.0	0.0	2.5	-1.6	-1.6	0.0	0.0	0.0	-1.9	-0.6
0.0	0.0	-1.9	-3.7	-3.7	0.0	0.0	-5.0	-6.2	-5.0
0.0	0.0	-4.7	-4.3	-4.0	0.0	0.0	-6.2	-6.8	-5.9

APPENDIX 4-7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

FRONT COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.3	9.3	8.7	7.5	0.0	0.0	0.0	3.7	2.2
[illegible]	2.2	14.9	13.7	9.3	0.0	0.2	9.3	9.9	7.1
0.0	3.4	14.3	11.8	7.5	0.0	2.2	14.9	12.9	8.4
[illegible]	2.2	6.5	4.3	2.5	0.0	2.8	14.9	7.5	6.2
0.0	0.0	-3.7	-4.3	-3.1	0.0	1.9	7.5	1.9	1.9
[illegible]	0.0	-6.2	-11.2	-7.1	0.0	0.3	-4.3	-5.0	-2.5
0.0	0.0	-6.2	-14.0	-9.3	0.0	0.0	-6.2	-9.9	-6.8
[illegible]	0.0	-6.2	-11.8	-8.1	0.0	0.0	-6.2	-10.9	-8.1
0.0	0.0	-3.7	-3.7	-2.5	0.0	0.0	-6.2	-6.2	-5.6
[illegible]	[illegible].3	6.8	5.2	4.3	0.0	0.0	-1.2	1.9	0.6

REAR COLUMN FRONT FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	8.9	3.4	2.8	0.0	4.1	11.0	11.3	9.6
[illegible]	0.0	1.4	-2.8	-1.4	0.0	2.8	1.4	2.8	5.5
0.0	0.0	-4.8	-8.9	-4.8	0.0	0.0	-6.2	-5.5	-1.4
[illegible]	[illegible]	-6.9	-11.0	-6.2	0.0	0.0	-6.2	-11.0	-5.5
0.0	0.0	-4.1	-8.3	-4.1	0.0	0.0	-6.2	-11.0	-6.9
[illegible]	0.0	2.0	-1.4	0.0	0.0	0.0	-6.2	-8.2	-4.0
0.0	0.0	9.5	5.5	4.1	0.0	2.8	1.4	1.4	1.4
[illegible]	0.0	13.3	3.9	6.2	0.0	4.1	9.6	5.9	6.9
0.0	0.0	13.8	8.3	5.5	0.0	4.8	13.8	12.4	9.6
[illegible]	0.0	9.6	5.5	3.4	0.0	4.1	11.0	11.0	9.6

APPENDIX 4-8

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE LOW WATER
WAVE HEIGHT 12 FT PERIOD 6.0 SECS
DIRECTION NORMAL TO BERTH LINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
TIME HISTORIES AT ONE-TENTH OF TIDAL PERIOD

REAR COLUMN INNER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	13.8	13.1	10.3	0.0	0.0	8.3	5.5	4.1
0.0	0.0	13.8	12.4	9.6	0.0	0.0	13.8	8.3	6.9
0.0	0.0	8.3	8.3	5.5	0.0	0.0	13.8	8.3	7.6
[illegible]	0.0	-1.4	1.4	-1.4	0.0	0.0	8.3	4.1	4.1
0.0	0.0	-6.2	-4.8	-6.2	0.0	0.0	0.0	-2.1	-1.4
[illegible]	0.0	-6.2	-7.6	-7.6	0.0	0.0	-6.2	-6.9	-6.2
0.0	0.0	-6.2	-5.5	-5.5	0.0	0.0	-6.2	-8.3	-7.6
0.0	0.0	-2.8	0.7	0.0	0.0	0.0	-6.2	-6.2	-6.2
0.0	0.0	6.9	8.3	6.2	0.0	0.0	-1.4	-1.4	-1.4
[illegible]	0.0	12.4	12.4	10.3	0.0	0.0	6.9	4.1	4.1

REAR COLUMN REAR FACE

1	2	3	4	5	6	7	8	9	10
[illegible]	0.0	-4.8	-6.9	-5.5	0.0	0.0	-3.4	-1.4	0.7
0.0	0.0	5.5	0.7	0.0	0.0	0.0	2.8	2.8	3.4
[illegible]	0.0	13.8	7.6	5.5	0.0	0.0	8.3	6.2	4.1
0.0	0.0	16.5	11.0	8.3	0.0	0.0	10.3	7.6	4.1
[illegible]	0.0	12.4	9.6	6.9	0.0	0.0	9.6	6.2	2.8
0.0	0.0	4.1	2.8	2.8	0.0	0.0	5.5	2.8	0.7
[illegible]	0.0	-6.2	-4.8	-3.4	0.0	0.0	-1.4	-1.4	-1.4
0.0	0.0	-6.2	-11.0	-7.6	0.0	0.0	-6.2	-4.1	-2.8
[illegible]	0.0	-6.2	-11.7	-3.3	0.0	0.0	-6.2	-4.1	-2.1
0.0	0.0	-5.5	-8.3	-5.5	0.0	0.0	-4.8	-2.1	0.0

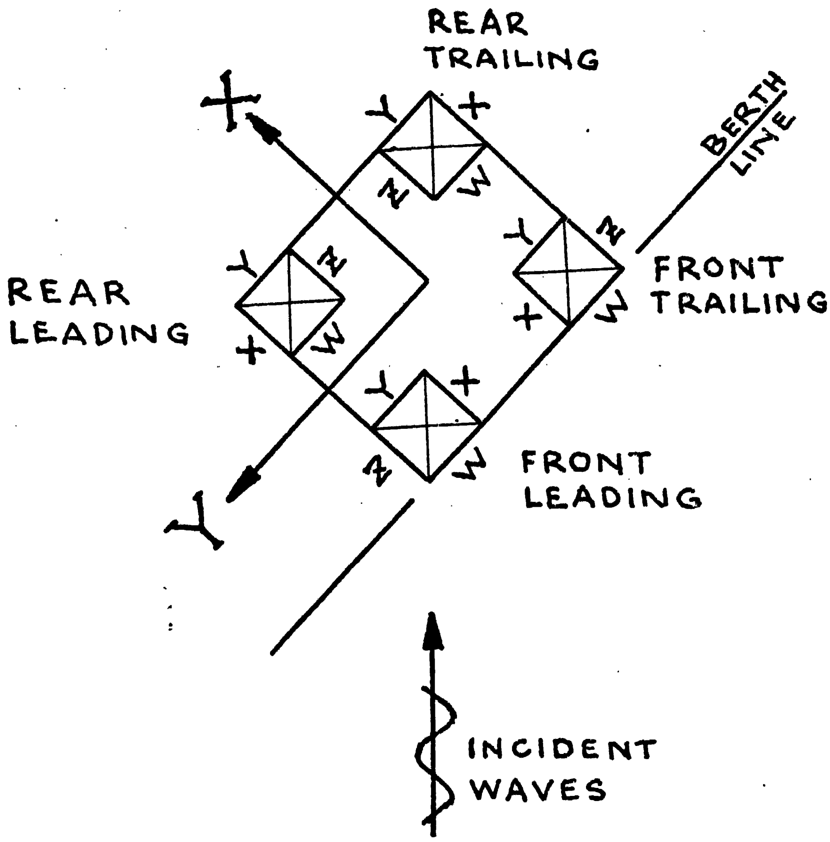
REAR COLUMN OUTER SIDE FACE

1	2	3	4	5	6	7	8	9	10
0.0	0.0	9.6	6.2	4.1	0.0	0.0	15.1	12.4	10.3
[illegible]	0.0	9.6	5.2	3.4	0.0	0.0	8.3	6.9	6.9
0.0	0.0	5.5	3.4	1.4	0.0	0.0	-4.1	-2.1	1.4
[illegible]	0.0	0.0	0.7	-1.4	0.0	0.0	-6.2	-9.6	-4.1
0.0	0.0	-5.5	-2.8	-3.4	0.0	0.0	-6.2	-11.7	-6.9
[illegible]	0.0	-6.2	-2.8	-2.8	0.0	0.0	-6.2	-8.3	-5.5
0.0	0.0	-4.1	-1.4	-1.4	0.0	0.0	-2.8	-1.4	0.0
[illegible]	0.0	0.0	2.1	1.4	0.0	0.0	8.3	6.9	5.5
0.0	0.0	5.5	4.1	3.4	0.0	0.0	15.1	12.4	9.6
[illegible]	0.0	9.6	6.2	4.1	0.0	0.0	15.8	12.4	10.3

<u>APPENDIX 5</u>

PRESSURES ON THE COLUMNS OF BERTH CAISSON DUE TO 24 FEET HIGH WAVES APPROACHING FROM E.S.E. AT HIGH WATER, WITH NO NEIGHBOURING CAISSON.

<u>IDENTIFICATION OF FACES OF COLUMNS</u>



APPENDIX 5-2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS ABSENT
UNIT FEET OF WATER
FRONT LEADING COLUMN IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
3.[illegible]	3.5	5.9	2.5	3.0	3.0	5.9	0.0	1.0	[illegible]
0.0	1.0	3.0	0.0	1.0	-1.0	0.0	-3.0	-1.5	-2.0
-3.5	-1.5	-1.[illegible]	-2.5	-2.0	-3.9	-7.9	-5.9	-3.5	-3.5
-5.5	-4.4	-4.9	-4.9	-3.5	-5.5	-12.8	-7.9	-4.9	-4.9
-5.[illegible]	-5.9	-7.4	-5.9	-4.9	-5.5	-14.[illegible]	-8.4	-5.4	-4.9
-5.5	-6.9	-8.4	-6.4	-4.9	-5.5	-13.3	-5.9	-4.9	-4.4
-5.5	-6.4	-7.9	-4.9	-3.5	-3.[illegible]	-8.9	-4.9	-3.5	-3.0
-5.4	-5.4	-4.9	-2.5	-1.5	0.0	-3.0	-1.5	-1.0	-1.0
-3.[illegible]	-3.0	-1.5	0.5	1.5	3.0	3.0	1.5	1.0	1.0
0.[illegible]	0.5	3.0	3.5	3.5	5.4	8.9	3.9	3.0	2.5
2.[illegible]	3.[illegible]	5.9	4.9	5.4	6.9	12.8	4.9	3.9	3.0
4.4	4.4	7.9	5.9	5.9	7.9	13.3	4.9	4.4	3.0
4.9	4.9	8.4	5.4	4.9	5.9	11.8	3.9	3.5	2.0
3.9	4.4	7.9	3.5	3.5	3.0	7.9	1.5	1.5	0.0

FACE X

1	2	3	4	5	6	7	8	9	10
3.9	7.9	5.9	5.9	4.9	10.4	7.4	6.9	5.4	5.4
5.4	11.8	9.9	8.4	7.9	10.4	7.9	7.4	5.4	5.9
5.4	12.8	11.8	8.9	8.4	8.4	5.9	5.9	4.9	4.9
3.9	11.4	10.9	7.4	[illegible].4	4.9	2.0	3.0	1.5	3.0
2.[illegible]	7.4	7.9	4.4	4.4	1.5	-2.0	-0.5	-1.5	0.0
0.[illegible]	2.0	3.5	0.5	1.0	-2.0	-6.9	-3.5	-3.9	-3.[illegible]
-2.[illegible]	-2.5	-1.0	-3.0	-3.0	-4.9	-10.4	-5.9	-5.9	-5.4
-3.9	-7.4	-4.4	-5.9	-5.9	-5.4	-12.3	-7.4	-6.4	-6.4
-4.9	-10.9	-7.9	-7.9	-7.9	-5.4	-12.3	-7.4	-5.4	-6.4
-4.[illegible]	-11.8	-8.9	-7.9	-8.4	-3.5	-9.9	-5.9	-3.0	-4.9
-3.9	-9.9	-7.9	-6.4	-6.9	-0.5	-5.9	-3.0	-0.5	-2.5
-2.[illegible]	-5.4	-4.9	-3.5	-3.9	3.0	-1.[illegible]	0.5	2.5	[illegible].0
1.[illegible]	0.[illegible]	[illegible]	0.5	0.0	6.9	3.9	3.9	4.4	3.0
3.5	6.4	2.5	4.9	3.9	9.9	6.9	6.4	5.4	4.9

FACE Y

1	2	3	4	5	6	7	8	9	10
8.9	10.9	7.4	4.4	3.0	7.9	7.9	6.9	3.9	4.4
8.[illegible]	11.4	8.4	4.9	3.5	10.9	13.8	10.9	7.4	6.4
7.[illegible]	10.9	7.4	4.4	3.0	12.3	15.8	12.3	9.9	6.9
6.4	9.9	4.4	2.5	1.5	11.4	14.3	11.4	9.4	4.9
1.5	4.9	1.0	0.0	-1.5	7.9	9.9	8.4	5.9	2.0
-2.[illegible]	1.0	-3.0	-3.5	-2.5	3.0	3.5	3.9	2.0	-2.0
-5.[illegible]	-3.9	-6.[illegible]	-6.4	-4.4	-2.[illegible]	-4.9	-1.0	-3.0	-4.9
-5.5	-8.9	-8.9	-7.9	-5.4	-5.5	-10.9	-5.9	-7.4	-7.9
-5.9	-12.8	-9.4	-8.4	-5.9	-5.5	-15.6	-9.4	-1[illegible].9	-9.4
-5.[illegible]	-11.8	-7.[illegible]	-6.9	-4.4	-5.5	-15.6	-9.9	-11.4	-9.4
-4.4	-7.9	-4.9	-4.4	-3.0	-5.5	-15.6	-8.9	-1[illegible].4	-7.9
[illegible]	-1.5	-1.5	-1.5	-0.5	-4.4	-11.4	-4.9	-6.9	-4.9
4.[illegible]	4.9	3.5	1.5	1.5	1.[illegible]	-3.[illegible]	0.0	-2.5	-1.0
7.9	9.4	6.9	3.5	2.5	5.9	4.9	5.4	3.0	-3.0

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 24 FT PERIOD 8.25 SECS

DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

FRONT LEADING COLUMN IN THIS ANGLED CASE

FACE Z

1	2	3	4	5	6	7	8	9	10
9.9	8.9	6.9	3.9	3.9	14.8	11.8	12.3	9.9	7.9
3.0	3.5	2.0	0.0	0.0	9.9	7.9	8.4	6.9	3.9
-3.9	-3.0	-3.9	-3.5	-3.5	3.0	1.5	2.5	3.0	-0.5
-5.5	-7.9	-8.9	-6.4	-6.4	-3.0	-4.4	-3.5	-2.0	-5.4
-5.5	-10.4	-11.8	-7.9	-7.9	-5.5	-9.4	-9.4	-6.4	-9.9
-5.5	-10.9	-12.3	-7.4	-7.4	-5.5	-12.3	-11.8	-8.9	-11.4
-5.5	-8.4	-9.9	-4.9	-5.4	-5.5	-14.3	-12.8	-9.4	-11.4
-5.5	-4.4	-5.9	-2.0	-2.0	-5.5	-13.3	-10.9	-7.9	-8.9
-2.0	1.5	-0.5	2.0	2.0	-4.9	-8.9	-6.4	-4.4	-4.9
4.4	6.4	4.9	5.4	5.9	1.0	-5.0	-1.0	2.0	0.0
10.9	11.4	9.9	7.9	8.4	6.9	3.9	5.4	4.9	4.9
14.8	13.8	11.8	8.4	8.9	12.8	9.9	10.4	8.9	7.9
15.8	13.8	11.4	7.4	7.9	16.3	12.8	12.8	10.9	8.9
12.8	10.9	8.9	4.9	4.9	16.3	12.8	12.3	10.9	6.4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER
REAR TRAILING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
-5.5	-6.7	-7.2	-7.2	-7.2	-5.5	-11.4	-11.4	-9.3	-7.8
-2.1	0.5	-0.5	-0.5	-1.6	0.0	-2.1	-2.1	-1.0	-1.6
3.1	8.3	6.2	5.7	4.7	7.2	8.3	6.2	7.2	7.2
8.3	14.5	11.9	10.9	10.4	14.5	16.6	14.5	14.0	13.5
12.4	18.1	15.0	13.5	12.9	19.1	22.3	19.7	17.6	17.1
12.9	17.6	14.5	12.9	12.4	19.7	22.3	19.7	17.6	17.1
10.9	14.0	11.4	9.3	10.4	15.5	18.6	15.5	13.5	14.0
5.2	6.7	5.2	3.6	5.2	8.3	10.4	8.3	6.2	7.8
-0.5	-2.1	-2.6	-3.1	-0.5	0.0	0.0	0.0	-1.0	1.0
-5.5	-9.3	-9.8	-9.3	-6.2	-5.5	-11.4	-9.3	-9.3	-6.7
-5.5	-14.5	-14.5	-13.5	-10.9	-5.5	-15.6	-16.6	-15.0	-7.2
-5.5	-15.6	-16.0	-15.0	-12.9	-5.5	-15.6	-19.7	-17.1	-15.0
-5.5	-14.0	-14.5	-13.5	-12.4	-5.5	-15.6	-18.6	-16.0	-14.5
-5.5	-9.3	-9.8	-9.3	-8.8	-5.5	-14.5	-12.9	-11.4	-10.4

FACE X

1	2	3	4	5	6	7	8	9	10
-5.5	-10.9	-9.3	-8.3	-7.2	-5.5	-8.8	-9.8	-8.8	-6.7
-5.5	-10.4	-8.8	-7.8	-6.7	-4.1	-6.7	-7.2	-6.7	-4.7
-5.2	-7.2	-6.2	-5.7	-4.7	-2.1	-2.6	-3.1	-3.6	-1.6
-2.6	-2.6	-2.6	-2.1	-2.1	1.6	2.6	1.0	0.5	2.6
1.6	2.6	2.1	2.1	2.1	5.7	7.8	6.2	4.1	5.7
6.7	7.2	6.7	5.7	5.2	9.3	11.4	9.3	7.2	7.2
10.9	11.4	10.4	8.8	7.8	10.4	12.4	10.4	8.3	7.8
11.9	12.4	11.4	9.3	8.3	8.8	11.4	8.8	7.8	6.7
10.4	10.9	10.9	8.8	7.8	4.7	7.2	5.2	5.2	4.7
6.2	6.7	7.2	5.2	5.2	-0.5	2.1	0.0	1.6	1.6
2.1	1.6	3.1	1.6	1.6	-5.2	-3.6	-4.7	-2.1	-1.0
-2.6	-4.1	-2.1	-2.6	-2.6	-5.5	-7.2	-7.8	-6.2	-4.7
-5.5	-8.8	-6.2	-6.2	-5.2	-5.5	-8.8	-9.8	-8.3	-6.7
-5.5	-10.9	-8.3	-7.8	-6.7	-5.5	-8.8	-9.8	-8.8	-6.7

FACE Y

1	2	3	4	5	6	7	8	9	10
-5.5	-15.0	-10.9	-10.9	-11.4	-5.5	-10.4	-8.3	-8.8	-6.7
-5.5	-14.0	-10.9	-10.9	-10.4	-5.5	-10.4	-8.3	-8.8	-6.7
-2.6	-10.4	-8.3	-7.8	-7.8	-5.5	-7.8	-6.2	-7.8	-4.7
0.5	-4.7	-2.6	-2.6	-2.6	-3.6	-4.1	-2.6	-4.7	-2.1
5.2	1.6	2.6	2.6	2.6	0.0	0.0	1.6	0.0	1.0
9.8	8.8	8.3	7.8	7.8	4.7	6.2	5.2	3.6	4.1
11.4	14.0	12.9	11.9	10.9	8.8	9.8	8.8	6.7	6.7
9.8	15.0	14.0	12.4	11.4	10.4	11.4	9.8	8.3	7.8
5.7	12.4	11.9	10.4	8.8	9.3	9.8	8.8	7.8	7.2
0.5	5.7	7.2	6.2	4.1	5.2	6.2	5.7	5.2	5.7
-3.6	0.0	2.6	1.0	-1.6	0.0	1.0	1.6	1.6	2.1
-5.5	-6.7	-3.6	-4.1	-6.2	-4.1	-4.1	-2.6	-3.1	-1.6
-5.5	-11.9	-7.8	-8.8	-9.8	-5.5	-8.3	-6.2	-6.2	-4.7
-5.5	-15.0	-10.9	-10.9	-11.9	-5.5	-10.4	-8.3	-8.3	-6.2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS ABSENT
UNITS FEET OF WATER
REAR TRAILING COLUMN IN THIS ANGLED CASE

FACE Z

1	2	3	4	5	6	7	8	9	10
-5.2	-12.4	-12.9	-10.9	-10.9	-5.5	-14.5	-12.4	-11.4	-9.3
-2.1	-6.2	-6.2	-5.2	-5.7	-4.7	-11.4	-9.3	-8.3	-6.2
2.6	2.1	0.5	1.0	0.0	-2.1	-5.7	-3.6	-3.6	-1.6
8.8	11.4	8.3	7.2	5.7	2.6	1.0	2.1	1.6	3.1
13.5	17.6	13.5	10.9	9.3	6.7	7.8	7.2	6.2	7.2
15.5	19.1	15.0	11.9	10.9	10.4	11.9	9.8	8.8	8.8
13.5	16.6	13.5	10.4	9.3	10.9	12.9	9.8	8.8	8.8
8.3	9.8	8.3	5.7	5.7	7.8	9.8	7.2	6.7	6.2
1.0	1.6	1.0	0.0	0.0	2.6	4.1	2.6	3.1	2.1
-4.7	-7.2	-6.7	-6.7	-6.2	-2.6	-3.1	-3.6	-2.1	-2.1
-5.5	-13.5	-7.8	-11.9	-11.4	-5.5	-9.3	-8.3	-6.2	-6.2
-5.5	-15.6	-16.6	-15.0	-14.5	-5.5	-14.0	-11.9	-9.8	-9.8
-5.5	-15.6	-17.1	-15.0	-14.5	-5.5	-15.6	-13.5	-11.4	-10.9
-5.5	-14.5	-14.5	-12.4	-12.4	-5.5	-15.0	-13.5	-11.9	-10.4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER
FRONT TRAILING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
10.6	12.8	11.9	9.7	9.7	8.0	3.1	4.4	3.5	3.5
12.8	16.8	14.6	12.8	11.5	12.4	10.6	10.6	9.3	8.9
12.4	16.8	13.7	13.3	11.1	14.2	16.4	14.2	12.4	11.9
8.0	12.8	10.2	10.6	8.4	12.8	18.1	15.0	12.8	12.8
1.8	5.8	4.0	4.4	4.0	8.4	16.4	12.4	10.6	11.1
-4.0	-1.8	-2.2	0.4	-1.3	3.1	10.6	7.5	6.2	7.1
-5.5	-9.3	-8.4	-5.3	-6.2	-1.6	4.0	1.8	0.9	2.2
-5.5	-14.6	-12.8	-9.7	-9.7	-5.5	-2.7	-4.0	-4.4	-2.7
-5.5	-15.6	-14.6	-11.5	-10.6	-5.5	-9.3	-8.9	-8.9	-7.1
-5.5	-15.6	-13.3	-11.5	-9.7	-5.5	-14.2	-11.5	-11.5	-9.3
-5.5	-11.5	-9.3	-8.9	-7.1	-5.5	-15.6	-12.4	-11.5	-9.7
-2.7	-4.4	-3.1	-3.5	-1.8	-4.4	-15.0	-9.7	-9.3	-8.0
2.7	3.5	3.1	2.2	3.5	0.0	-9.3	-4.0	-4.4	-3.5
8.9	11.1	10.2	8.0	8.0	5.3	-1.3	2.7	1.8	1.8

FACE X

1	2	3	4	5	6	7	8	9	10
9.7	11.9	10.6	8.9	8.9	15.0	17.7	14.2	11.9	12.4
13.7	15.9	13.7	10.6	9.7	17.3	19.9	15.9	13.7	13.3
15.0	16.8	14.2	10.6	9.3	16.8	18.1	14.6	12.4	11.5
13.7	15.5	11.5	8.0	6.6	12.8	11.5	9.7	8.4	7.5
8.9	8.9	6.6	4.0	3.1	7.1	3.5	2.7	2.7	2.2
2.2	1.3	0.4	-0.9	-1.8	0.0	-5.3	-4.0	-4.0	-3.1
-3.1	-5.8	-5.8	-6.2	-6.2	-5.3	-13.3	-10.6	-8.9	-7.1
-5.5	-11.9	-10.6	-9.7	-8.9	-5.5	-15.6	-14.2	-11.9	-9.7
-5.5	-15.5	-12.4	-11.1	-9.7	-5.5	-15.6	-15.0	-11.9	-8.9
-5.5	-15.5	-11.5	-9.7	-8.4	-5.5	-15.0	-11.9	-9.3	-5.3
-5.5	-11.9	-8.0	-6.6	-4.9	-3.5	-8.0	-6.2	-4.4	-1.8
-2.2	-5.8	-2.7	-2.2	-0.9	2.2	0.0	0.4	1.8	3.5
2.7	5.8	3.5	3.1	3.5	8.0	8.9	7.5	7.1	8.4
8.0	11.9	8.9	8.0	7.1	13.3	15.9	13.3	11.5	11.9

FACE Y

1	2	3	4	5	6	7	8	9	10
-1.8	-7.1	-2.2	-2.7	-4.4	1.8	-0.9	1.3	0.0	0.4
2.2	-1.3	1.8	1.3	-0.9	5.3	3.5	4.0	3.1	3.5
6.2	4.4	6.2	5.3	3.1	7.5	7.1	6.6	5.3	5.3
10.2	9.7	10.6	8.9	6.2	8.0	9.3	8.0	6.6	5.8
11.9	12.4	12.4	10.6	8.0	6.2	8.9	7.5	6.6	5.3
11.9	12.4	13.3	11.1	8.0	3.5	6.2	5.8	5.3	4.0
10.6	9.7	11.5	8.9	6.6	0.3	2.2	3.1	2.7	1.8
6.6	5.3	8.0	5.8	3.5	-2.7	-1.8	0.0	-0.4	-1.3
2.7	0.0	4.0	1.8	0.0	-4.4	-5.3	-2.7	-3.1	-3.1
-1.3	-0.6	0.0	-2.2	-4.0	-5.3	-8.0	-4.4	-4.9	-4.4
-3.5	-10.2	-3.5	-5.3	-6.2	-5.5	-8.9	-5.3	-5.8	-4.9
-4.4	-12.4	-5.3	-6.2	-8.0	-4.9	-8.9	-5.3	-5.3	-4.4
-4.4	-11.9	-5.8	-6.2	-7.5	-3.1	-6.6	-3.1	-4.4	-2.7
-2.7	-8.9	-3.5	-4.0	-5.3	0.0	-2.7	0.0	-1.3	0.0

APPENDIX 5-7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 24 FT PERIOD 8.25 SECS

DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE

NEIGHBOUR CAISSONS ABSENT

UNITS FEET OF WATER

FRONT TRAILING COLUMN IN THIS ANGLED CASE

FACE Z

1	2	3	4	5	6	7	8	9	10
-4.4	-8.4	-7.5	-5.3	-3.5	-5.3	-11.5	-9.7	-7.5	-7.5
0.9	-1.3	0.0	1.3	1.3	-0.9	-3.5	-2.7	-1.3	-1.8
6.6	6.2	8.9	8.0	7.1	5.8	4.9	4.4	4.9	4.9
10.2	11.9	14.2	13.3	11.5	11.5	12.8	11.9	10.2	10.2
11.5	15.0	15.9	15.0	13.3	15.5	17.7	15.9	13.7	13.3
11.1	15.5	15.0	15.0	12.4	16.8	18.6	16.4	14.2	13.7
9.3	12.8	11.5	10.2	9.3	15.5	15.9	13.7	11.5	11.9
4.9	7.5	4.9	4.9	4.4	11.1	10.2	9.7	7.1	6.6
0.0	2.2	-2.7	-1.3	-0.9	4.9	2.2	1.3	1.3	0.9
-4.9	-4.9	-9.7	-7.5	-5.8	-1.3	-6.2	-5.8	-4.9	-5.3
-5.5	-10.6	-15.0	-11.9	-9.7	-5.5	-13.3	-11.9	-9.7	-10.2
-5.5	-14.2	-17.3	-13.7	-11.1	-5.5	-15.6	-15.5	-12.4	-12.8
-5.5	-14.2	-15.5	-11.9	-10.2	-5.5	-15.6	-15.9	-12.4	-12.8
-5.5	-10.2	-9.7	-7.5	-6.2	-5.5	-13.3	-12.4	-9.3	-9.7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER
REAR LEADING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
8.8	9.2	7.4	5.3	4.6	9.2	13.1	6.4	4.6	5.0
5.3	3.5	2.8	1.8	1.1	6.7	9.9	2.8	1.4	1.8
0.0	-1.4	-1.4	-2.1	-2.5	2.5	4.6	-1.1	-1.8	-1.4
-5.5	-6.4	-6.4	-6.4	-6.4	-2.8	0.0	-5.3	-5.3	-4.6
-5.5	-10.6	-9.9	-9.2	-8.5	-5.5	-5.3	-8.5	-7.4	-7.1
-5.5	-13.1	-12.0	-10.6	-9.6	-5.5	-8.8	-11.0	-9.2	-8.5
-5.5	-12.0	-11.0	-9.2	-8.1	-5.5	-9.6	-10.6	-8.5	-7.8
-5.5	-7.1	-6.0	-5.7	-4.6	-5.5	-7.1	-7.8	-5.3	-5.0
-1.1	0.0	0.4	-0.7	0.0	-1.8	-1.4	-2.5	-1.4	-1.1
2.8	7.1	5.3	3.9	4.2	1.4	6.4	2.8	2.8	3.5
5.3	13.1	9.6	7.1	7.1	5.3	12.4	6.7	6.4	6.4
9.6	13.5	12.0	8.8	8.5	7.8	13.1	9.2	7.8	7.8
9.2	13.5	12.0	8.8	8.1	9.6	13.1	9.6	7.8	7.8
8.8	12.0	9.9	6.7	6.0	9.6	13.1	7.8	6.4	5.7

FACE X

1	2	3	4	5	6	7	8	9	10
9.2	9.9	9.9	8.8	7.8	9.6	13.5	8.1	6.7	6.4
9.6	11.0	9.9	8.5	8.1	8.5	10.6	5.7	4.2	4.6
6.7	7.8	6.4	5.7	6.4	4.2	4.6	1.4	0.7	1.4
2.1	1.4	1.4	1.4	2.8	-1.8	-0.7	-3.2	-3.2	-2.1
-3.5	-5.0	-3.2	-2.8	-1.1	-5.5	-6.4	-7.4	-6.7	-5.0
-5.5	-9.6	-7.1	-6.0	-5.0	-5.5	-9.9	-10.3	-8.5	-7.1
-5.5	-11.7	-8.5	-7.8	-7.1	-5.5	-9.9	-10.6	-8.5	-7.4
-5.5	-12.0	-8.8	-7.8	-7.4	-5.5	-6.7	-8.5	-6.4	-6.0
-5.5	-11.3	-8.1	-6.7	-7.1	-2.1	-3.2	-5.3	-3.2	-3.5
-3.5	-11.0	-7.1	-5.0	-5.7	0.7	0.7	-2.1	0.0	-1.4
-1.1	-8.5	-4.2	-2.8	-3.2	2.5	4.2	2.1	3.2	1.8
1.8	-3.2	-0.4	0.7	0.0	4.6	8.5	5.7	5.7	5.0
5.7	3.2	4.6	4.6	4.2	7.4	11.7	7.4	7.1	6.4
8.5	9.2	8.8	7.8	7.4	9.6	13.1	8.5	7.1	6.7

FACE Y

1	2	3	4	5	6	7	8	9	10
5.0	0.0	5.0	3.9	4.2	6.4	7.1	7.8	6.0	6.7
8.5	5.7	9.2	7.8	7.4	9.6	12.7	11.7	10.3	9.6
10.3	7.8	10.3	9.2	8.5	9.6	14.2	12.4	10.6	9.6
9.9	7.1	8.5	8.1	7.8	6.4	10.6	9.2	8.5	7.1
6.4	2.5	5.0	5.3	5.0	2.1	5.0	4.2	4.2	2.8
2.1	-2.8	0.0	1.1	1.4	-1.1	-0.7	0.0	-0.7	-1.4
-1.4	-7.8	-3.5	-2.8	-2.5	-2.8	-5.3	-4.2	-5.0	-4.2
-5.0	-11.3	-6.4	-5.7	-5.3	-3.9	-8.1	-7.1	-7.1	-7.1
-5.5	-12.7	-7.8	-7.1	-6.7	-4.6	-9.6	-8.5	-8.5	-8.1
-5.5	-13.8	-8.5	-7.8	-7.4	-4.2	-10.6	-9.6	-9.2	-8.5
-5.5	-14.2	-8.1	-6.7	-7.1	-3.9	-11.0	-9.6	-8.5	-7.4
-3.5	-13.1	-5.7	-5.7	-5.0	-2.8	-9.6	-7.1	-5.7	-5.0
-1.1	-9.2	-1.4	-2.1	-1.8	-0.7	-3.5	-1.8	-1.4	0.0
2.1	-2.8	3.5	2.1	2.1	4.6	4.2	5.0	3.5	5.0

APPENDIX 5-9

PRESSURES DUE TO WAVE ACTION - RELATIVE TO-STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8,25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	ABSENT
UNITS	FEET OF WATER
REAR LEADING COLUMN	IN THIS ANGLED CASE

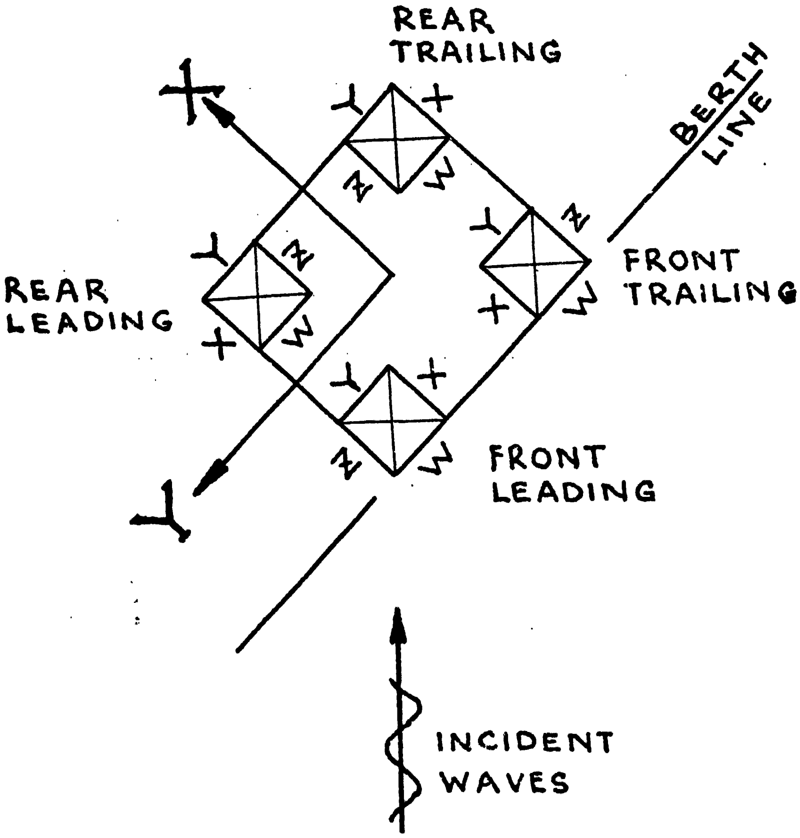
FACE Z

1	2	3	4	5	6	7	8	9	10
6.0	7.1	5.3	5.3	4.2	5.0	5.7	4.6	3.9	3.5
5.7	6.7	5.0	4.2	3.5	6.7	8.1	6.4	5.0	4.6
2.8	4.2	3.2	2.5	2.1	7.1	8.1	6.4	5.0	4.2
-1.4	1.1	0.4	0.7	0.0	5.3	5.7	4.6	3.5	2.8
-4.6	-2.5	-2.5	-1.8	-2.1	2.5	1.8	2.1	1.4	1.1
-5.3	-5.0	-4.6	-3.9	-3.5	-1.1	-1.8	-1.1	-1.1	-1.4
-5.3	-6.0	-5.7	-5.0	-4.2	-4.2	-5.0	-3.5	-3.2	-3.2
-5.5	-6.4	-6.0	-5.3	-4.2	-5.5	-6.7	-5.3	-4.6	-4.2
-4.2	-5.7	-5.7	-3.9	-3.2	-5.5	-7.3	-6.0	-5.3	-4.6
-2.8	-3.9	-3.2	-1.8	-1.4	-5.5	-7.8	-5.7	-5.0	-4.2
-0.7	-1.4	-0.7	0.7	1.1	-3.9	-6.4	-4.2	-4.2	-2.5
1.4	1.8	2.1	2.5	2.8	-1.4	-3.5	-2.1	-1.8	-1.1
3.5	4.6	3.9	4.2	3.9	0.7	0.4	0.7	2.7	1.1
5.7	6.4	5.3	5.0	4.2	3.5	3.9	3.2	2.8	3.2

APPENDIX 6

PRESSURES ON THE COLUMNS OF BERTH CAISSON DUE TO 24 FEET HIGH WAVES APPROACHING FROM E.S.E. AT HIGH WATER, WITH NEIGHBOURING CAISSONS PRESENT.

IDENTIFICATION OF FACES OF COLUMNS



PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	**PRESENT**
UNITS	FEET OF WATER
FRONT LEADING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
8.2	8.2	6.2	4.6	4.1	3.6	1.5	2.6	1.5	2.1
2.1	2.6	0.0	-1.0	0.0	-3.6	-6.7	-5.1	-3.6	-3.6
-4.1	-4.1	-5.1	-5.6	-5.1	-5.5	-13.9	-10.3	-8.7	-7.2
-5.5	-9.8	-9.8	-9.8	-8.2	-5.5	-15.6	-13.4	-10.8	-9.8
-5.5	-12.8	-12.3	-11.8	-9.8	-5.5	-15.6	-13.4	-11.3	-10.3
-5.5	-13.4	-13.4	-11.8	-9.8	-5.5	-13.9	-10.8	-9.2	-8.7
-5.5	-11.3	-11.3	-9.2	-7.2	-3.6	-6.7	-5.6	-5.6	-4.6
-4.1	-9.2	-7.2	-5.1	-2.6	1.5	1.0	0.0	0.0	-0.5
0.0	-1.0	-1.0	0.0	2.1	6.7	8.7	6.7	5.6	4.6
6.2	5.6	4.1	5.1	6.2	10.8	13.9	11.3	9.8	8.7
10.8	10.8	8.7	8.7	9.2	13.4	16.4	13.4	11.8	10.3
13.4	13.4	11.8	9.8	10.3	13.9	15.9	13.4	11.8	10.3
13.4	13.4	11.8	9.2	9.2	11.8	11.8	10.3	8.7	8.2
9.8	9.8	8.2	6.2	6.2	5.6	4.6	4.6	4.1	3.6

FACE X

1	2	3	4	5	6	7	8	9	10
7.7	8.2	8.2	6.2	6.7	10.8	9.8	8.7	7.2	5.6
9.2	10.8	9.8	8.2	8.2	8.7	7.7	7.7	5.6	4.1
9.2	11.3	9.8	8.2	8.2	5.1	4.6	4.6	3.1	2.1
7.7	9.2	8.2	6.7	6.2	1.0	0.0	1.0	0.0	-0.5
4.1	5.1	4.1	3.1	2.6	-2.6	-3.1	-3.1	-3.1	-3.1
0.0	0.0	0.0	-1.0	-1.5	-5.5	-7.2	-6.2	-5.6	-5.1
-4.6	-4.1	-4.1	-4.6	-5.1	-5.5	-9.2	-8.2	-6.7	-6.2
-5.5	-8.2	-6.7	-7.2	-7.2	-5.5	-9.2	-8.2	-6.7	-6.2
-5.5	-10.8	-8.2	-8.2	-8.2	-5.1	-7.7	-6.7	-5.1	-4.1
-5.5	-10.8	-8.2	-8.2	-7.2	-2.6	-4.6	-3.1	-2.1	-1.5
-5.5	-8.2	-5.6	-6.2	-5.1	-1.5	1.0	0.5	1.0	1.5
-1.5	-4.1	-2.1	-3.1	-2.1	5.6	4.1	4.1	4.1	3.6
3.6	2.1	3.1	1.5	2.1	9.8	7.7	7.2	6.2	5.1
7.2	7.2	6.7	5.1	5.6	10.8	9.2	8.7	7.2	5.6

FACE Y

1	2	3	4	5	6	7	8	9	10
8.2	10.3	9.2	9.2	5.6	6.7	5.6	7.7	6.2	7.2
7.2	10.8	9.8	9.2	6.2	9.2	9.8	9.8	7.7	8.7
6.2	10.3	8.7	8.2	5.6	10.8	10.3	10.8	8.7	9.2
4.1	6.7	6.2	5.6	3.6	10.3	10.8	9.8	7.7	8.2
2.1	2.1	2.6	2.1	0.5	7.7	7.2	6.7	4.6	5.1
0.0	-2.6	-1.0	-1.5	-2.6	3.6	2.6	2.6	0.5	1.5
-2.1	-6.7	-4.1	-4.6	-3.6	-1.0	-2.6	-2.6	-3.6	-2.6
-3.1	-10.3	-5.6	-6.2	-7.2	-4.6	-6.7	-6.2	-6.7	-5.6
-3.6	-12.8	-6.2	-6.2	-7.7	-5.5	-10.3	-8.2	-8.7	-7.2
-3.1	-12.3	-5.6	-4.6	-6.2	-5.5	-11.8	-8.7	-8.7	-7.2
-1.0	-8.2	-3.1	-2.1	-3.6	-5.5	-10.3	-6.7	-7.2	-5.6
2.6	-2.6	2.1	2.1	-0.5	-4.6	-6.7	-3.6	-4.1	-3.1
6.2	4.1	6.2	6.2	3.6	0.5	-1.0	1.5	0.5	1.5
8.2	9.2	9.2	8.7	5.6	5.6	-4.6	4.1	4.6	5.1

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD 8.25 SECS
DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS **PRESENT**
UNIT FEET OF WATER
FRONT LEADING COLUMN IN THIS ANGLED CASE

FACE #

1	2	3	4	5	6	7	8	9	10
6.2	5.1	3.6	2.6	3.1	10.3	9.8	7.7	5.6	6.2
0.5	-1.0	-2.6	-1.5	-1.0	5.1	5.1	3.6	2.1	2.6
-4.1	-6.7	-7.2	-5.6	-4.1	-0.5	-0.5	-1.5	-1.5	-0.5
-5.9	-10.3	-9.8	-3.2	-6.2	-5.1	-4.5	-4.6	-4.6	-3.6
-5.5	-10.8	-10.8	-8.7	-6.7	-5.5	-8.2	-7.7	-6.7	-6.2
-5.5	-9.2	-9.2	-7.7	-5.6	-5.5	-9.2	-6.7	-7.7	-6.7
-4.1	-5.6	-6.2	-5.1	-3.1	-5.5	-9.8	-6.7	-7.2	-6.7
-1.5	-1.0	-2.1	-1.0	0.0	-5.5	-9.2	-6.7	-4.6	-4.6
2.1	3.6	3.1	3.1	3.1	-4.1	-6.2	-3.6	-2.1	-1.5
5.6	7.7	6.7	5.7	6.2	[illegible]	-2.1	[illegible]	1.5	1.5
9.2	10.8	9.8	8.7	6.2	5.1	3.6	4.1	5.1	4.6
11.3	11.8	10.3	9.2	8.7	9.2	8.2	7.7	7.2	7.2
11.3	10.8	8.7	7.7	7.7	12.3	10.8	8.7	7.7	7.7
7.7	6.7	4.6	4.6	4.6	11.8	11.3	8.2	6.7	6.7

APPENDIX 6-4

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES
TIDE HIGH WATER
WAVE HEIGHT 24 FT PERIOD [illegible].25 SECS
DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS PRESENT
UNITS FEET OF WATER
REAR TRAILING COLUMN IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
-2.1	-2.1	0.0	-1.6	-1.6	6.2	1.2	0.4	1.0	0.5
4.7	6.2	7.3	6.2	5.2	12.5	11.4	9.4	6.2	7.8
11.4	13.5	13.0	12.0	10.9	16.6	19.8	16.6	12.0	14.6
16.6	18.7	16.1	14.6	13.5	18.7	23.9	20.8	15.1	18.2
17.2	19.2	15.6	14.6	13.5	17.7	22.9	22.3	15.1	17.7
14.6	16.1	12.0	10.4	10.9	12.5	19.8	15.6	12.5	14.0
7.3	9.4	5.2	4.7	5.7	5.2	7.3	7.3	6.2	7.3
0.0	0.0	-2.1	-2.1	0.0	-2.1	-5.2	-1.0	0.0	0.0
-5.5	-8.3	-9.4	-9.4	-6.2	-5.5	-15.1	-9.9	-7.3	-7.8
-5.5	-15.6	-15.1	-14.0	-11.4	-5.5	-15.6	-16.1	-13.0	-14.0
-5.5	-15.6	-16.6	-16.1	-13.5	-5.5	-15.6	-18.7	-16.6	-16.6
-5.5	-15.6	-15.6	-15.1	-14.0	-5.5	-15.6	-17.7	-16.1	-16.1
-5.5	-13.5	-10.9	-10.9	-10.9	-4.2	-13.5	-12.5	-12.0	-12.0
-5.2	-6.8	-4.2	-4.7	-5.2	2.1	-3.6	-4.2	-5.2	-4.7

FACE X

1	2	3	4	5	6	7	8	9	10
-5.8	-10.9	-8.3	-7.8	-7.8	-2.6	-8.3	-7.3	-4.2	-6.2
-2.6	-6.8	-4.7	-4.7	-5.2	1.0	-2.6	-2.1	-21.3	-2.1
1.0	-3.5	0.0	0.0	-1.0	5.2	3.1	4.2	0.0	3.1
4.7	5.2	5.2	4.7	3.1	8.3	9.4	9.4	2.1	7.3
7.8	10.4	9.4	8.8	5.7	12.5	13.5	13.0	3.6	9.4
10.4	13.5	12.0	10.4	8.8	12.0	14.6	13.5	4.7	9.9
10.9	14.0	12.5	10.4	9.4	8.3	13.0	11.4	5.2	8.3
9.9	12.0	10.4	7.8	7.8	2.1	8.3	6.8	4.2	4.2
7.3	7.3	6.8	4.2	4.7	-4.2	1.6	1.6	2.6	0.0
3.1	2.1	1.6	-0.5	3.5	-5.5	-5.2	-4.7	2.0	-4.7
-1.0	-5.2	-3.6	-5.2	-3.6	-5.5	-9.9	-9.4	-2.6	-3.3
-4.7	-10.4	-7.8	-8.8	-6.8	-5.5	-13.0	-12.0	-4.2	-10.4
-5.5	-13.5	-9.9	-10.4	-8.8	-5.5	-13.0	-12.0	-5.2	-10.4
-5.5	-13.0	-9.4	-9.9	-8.8	-5.2	-10.4	-9.9	-4.7	-8.3

FACE Y

1	2	3	4	5	6	7	8	9	10
-5.5	-10.9	-4.2	-6.3	-6.8	-5.5	-13.0	-10.9	-8.3	-6.8
-5.2	-7.3	-1.6	-4.2	-3.6	-5.2	-8.8	-9.4	-6.2	-4.7
-1.0	-2.6	2.1	-0.5	-0.5	-2.1	-4.2	-5.2	-3.1	-2.1
5.2	3.1	6.2	3.6	2.6	1.0	1.0	-0.5	0.0	1.6
10.9	7.8	9.9	6.8	6.2	5.2	6.8	4.2	3.6	4.2
14.0	11.4	12.5	8.8	8.3	9.4	10.4	8.3	6.8	6.8
13.5	12.0	11.4	9.4	8.8	11.4	12.0	10.4	8.3	7.3
9.9	7.8	9.4	7.3	6.8	10.4	10.4	9.9	7.3	6.8
3.1	3.1	5.7	3.6	3.6	7.3	6.8	7.3	6.2	4.2
-2.1	-2.1	2.1	0.0	-0.5	2.6	2.1	3.1	3.1	1.0
-5.5	-7.3	-2.1	-4.2	-4.2	-2.6	-4.2	-2.1	-1.0	-2.6
-5.5	-10.9	-4.7	-6.3	-6.8	-5.5	-9.9	-6.8	-4.7	-5.7
-5.5	-12.5	-5.7	-7.8	-7.8	-5.5	-13.0	-10.4	-7.3	-7.3
-5.5	-12.0	-5.7	-7.8	-7.3	-5.5	-13.5	-11.4	-8.3	-7.8

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 24 FT PERIOD 8,25 SECS

DIRECTION AT ANGLE OF 37,5 DEGREES TO BERTHLINE

NEIGHBOUR CAISSONS PRESENT

UNIT FEET OF WATER

REAR TRAILING COLUMN IN THIS ANGLED CASE

FACE 2

1	2	3	4	5	6	7	8	9	10
-2.6	-2.6	-3.1	-1.6	-1.0	-2.6	-8.3	-7.8	-6.2	-5.2
2.6	4.7	3.1	5.2	5.2	0.5	-1.6	-1.6	-0.5	0.0
9.4	12.5	13.9	12.0	10.4	5.7	5.7	5.2	5.7	6.2
14.[illegible]	17.7	16.1	15.6	14.0	10.9	12.0	11.4	13.9	10.9
17.7	19.2	17.7	15.6	14.0	15.1	16.1	15.1	14.0	13.0
16.1	16.6	15.1	12.5	11.4	15.6	16.1	15.1	14.0	12.0
9.9	9.9	9.4	6.8	6.2	11.4	12.5	12.0	12.9	8.6
2.1	1.0	1.6	0.0	1.0	6.8	5.2	5.7	5.7	3.6
-5.2	-7.3	-7.3	-6.8	-5.2	0.5	-1.6	-1.6	0.0	-1.6
-5.5	-13.5	-14.[illegible]	-13.[illegible]	-10.4	-4.2	-9.9	-6.3	-6.2	-6.8
-5.5	-15.6	-17.7	-15.6	-13.0	-5.5	-14.6	-13.0	-10.4	-10.9
-5.5	-15.6	-17.7	-15.6	-13.5	-5.5	-12.6	-15.1	-12.5	-12.5
-5.5	-13.[illegible]	-14.6	-12.0	-10.4	-5.5	-15.1	-14.0	-12.0	-12.0
-4.7	-7.3	-8.8	-6.2	-5.2	-4.2	-11.4	-10.9	-5.8	-8.8

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	PRESENT
UNITS	FEET OF WATER
FRONT TRAILING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
7.9	9.8	9.8	8.4	6.5	6.5	3.7	3.3	3.7	3.7
9.8	13.1	11.2	9.3	7.9	10.7	10.3	8.4	7.9	6.5
8.9	12.6	10.3	8.4	7.5	12.1	14.5	11.2	9.3	7.9
4.7	8.9	7.0	5.6	5.1	11.2	14.9	11.7	9.3	7.9
-0.9	2.3	1.9	0.9	1.4	6.5	11.2	9.3	7.0	6.1
-5.5	-3.7	-3.7	-3.3	-2.8	0.9	5.6	5.1	3.3	2.8
-5.5	-9.3	-8.4	-7.0	-6.5	-4.2	-0.9	-0.5	-1.4	-1.4
-5.5	-13.1	-11.2	-9.3	-8.9	-5.5	-6.5	-4.7	-5.1	-4.2
-5.5	-14.0	-12.1	-9.8	-9.3	-5.5	-11.7	-8.9	-7.9	-7.0
-5.5	-13.1	-11.2	-8.4	-8.4	-5.5	-15.4	-11.2	-9.3	-7.9
-5.5	-9.3	-7.5	-5.6	-6.1	-5.5	-15.6	-11.7	-9.3	-7.9
-3.7	-2.8	-2.3	-0.9	-1.9	-5.5	-14.0	-9.8	-6.5	-6.1
1.4	3.7	3.3	3.7	2.3	-0.5	-7.5	-5.1	-2.8	-2.8
6.5	9.8	8.4	7.5	5.6	4.7	0.0	0.9	2.3	1.4

FACE X

1	2	3	4	5	6	7	8	9	10
7.9	10.3	8.4	6.5	6.1	10.3	13.1	9.8	7.5	7.5
10.3	12.1	9.8	7.0	6.5	13.1	14.0	10.7	7.9	7.5
9.8	11.7	8.9	6.5	6.1	13.1	11.7	8.9	6.1	5.6
7.0	7.9	6.1	3.7	4.2	9.8	6.5	5.1	2.3	2.3
2.3	2.3	1.9	0.5	0.9	5.1	0.0	0.0	-1.9	-0.9
-2.8	-3.3	-3.3	-3.3	-2.3	0.0	-7.5	-4.7	-5.6	-4.2
-5.5	-10.3	-7.5	-6.5	-5.1	-4.2	-12.6	-8.9	-8.4	-7.0
-5.5	-13.5	-9.8	-7.9	-7.0	-5.5	-14.9	-10.7	-9.3	-7.9
-5.5	-14.0	-10.3	-8.9	-7.5	-5.5	-14.0	-10.3	-8.9	-7.0
-5.5	-11.2	-7.9	-8.9	-6.1	-5.5	-10.3	-7.5	-6.5	-4.7
-4.2	-6.1	-4.7	-5.6	-3.3	-2.3	-5.1	-3.3	-2.8	-1.9
-0.5	-0.5	0.0	-2.3	0.0	1.4	1.9	1.4	0.9	1.9
3.3	5.1	4.2	1.9	2.8	5.1	7.5	6.1	4.7	5.1
7.0	9.3	7.0	5.6	5.6	8.9	12.1	8.9	7.0	7.0

FACE Y

1	2	3	4	5	6	7	8	9	10
-2.8	-3.7	-2.3	-4.2	-4.2	0.9	0.5	0.5	1.4	1.9
0.5	0.0	1.4	-0.5	-0.9	4.7	5.1	4.2	3.7	3.7
3.7	4.2	5.6	3.7	2.8	8.4	7.9	7.0	6.1	5.1
6.1	6.5	9.3	7.0	5.6	9.8	9.8	8.4	6.5	5.6
7.0	7.5	10.7	8.9	7.0	7.9	8.9	7.5	6.5	4.7
6.1	6.5	10.7	8.4	7.0	3.7	5.6	4.7	4.2	2.3
3.7	3.7	8.4	6.5	4.7	-0.9	0.5	1.4	1.9	0.0
0.5	0.0	5.1	2.8	1.9	-5.5	-4.2	-2.8	-1.9	-2.3
-2.8	-3.7	1.4	0.9	-1.4	-5.5	-7.5	-6.1	-3.7	-4.2
-5.1	-6.5	-2.3	-3.3	-4.7	-5.5	-9.8	-7.9	-4.7	-5.1
-5.5	-8.4	-5.1	-6.1	-7.0	-5.5	-10.3	-8.4	-6.1	-5.1
-5.5	-8.9	-6.5	-8.4	-7.9	-5.5	-8.9	-7.0	-5.1	-3.7
-5.5	-7.5	-6.1	-8.4	-7.5	-5.5	-5.6	-4.7	-3.3	-1.9
-4.2	-5.1	-3.7	-7.5	-5.6	-0.9	-1.4	-0.5	0.0	0.9

APPENDIX 6-7

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE HIGH WATER

WAVE HEIGHT 24 FT PERIOD 8.25 SECS

DIRECTION AT ANGLE OF 37.5 DEGREES TO BERTHLINE

NEIGHBOUR CAISSONS PRESENT

UNITS FEET OF WATER

FRONT TRAILING COLUMN IN THIS ANGLED CASE

FACE 2

1	2	3	4	5	6	7	8	9	10
-3.3	-5.6	-7.5	-7.9	-3.7	-5.5	-13.5	-11.2	-9.8	-8.4
2.8	1.9	0.0	-0.5	1.9	-3.3	-6.1	-5.6	-4.2	-3.7
8.4	8.9	8.4	6.5	7.9	4.2	1.9	2.3	3.3	2.8
13.1	14.5	14.5	12.1	12.1	11.7	10.3	8.9	9.3	8.4
14.9	16.8	17.3	14.9	14.5	16.3	12.1	13.5	13.5	13.1
14.9	16.3	16.3	14.9	14.5	17.7	19.6	15.4	14.5	13.5
12.1	12.6	12.1	11.2	12.1	15.9	18.2	13.1	12.6	12.1
7.0	6.5	5.1	5.6	7.9	10.3	12.6	8.4	7.9	7.5
0.9	0.0	-2.3	-1.4	2.8	3.7	4.2	1.4	1.4	1.9
-4.2	-6.5	-9.3	-7.9	-2.8	-3.3	-4.2	-5.1	-4.7	-3.7
-5.5	-11.7	-14.9	-12.6	-6.5	-5.5	-11.7	-11.7	-10.3	-8.9
-5.5	-14.0	-17.3	-14.9	-8.9	-5.5	-15.6	-15.4	-13.5	-12.1
-5.5	-13.1	-15.9	-14.5	-8.9	-5.5	-15.6	-16.3	-14.5	-13.1
-5.5	-7.5	-10.3	-10.3	-6.1	-5.5	-15.6	-13.5	-11.7	-11.2

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	PRESENT
UNITS	FEET OF WATER
REAR LEADING COLUMN	IN THIS ANGLED CASE

FACE W

1	2	3	4	5	6	7	8	9	10
15.1	26.1	27.3	19.8	17.7	23.1	26.9	28.2	23.5	21.9
14.7	21.9	24.0	15.1	13.9	25.2	26.9	28.2	21.9	19.8
9.3	12.6	19.3	8.2	10.1	23.1	26.9	22.7	13.9	14.7
0.0	0.8	5.9	-0.4	-1.3	11.4	19.3	12.6	5.0	6.7
-5.5	-10.1	-3.8	-8.8	-8.8	0.4	6.7	2.5	-5.0	0.0
-5.5	-15.6	-10.9	-14.7	-14.7	-5.5	-5.0	-5.9	-11.8	-7.6
-5.5	-15.6	-15.6	-18.1	-17.2	-5.5	-12.6	-12.6	-17.7	-12.2
-5.5	-15.6	-16.8	-17.2	-16.8	-5.5	-15.6	-16.8	-20.2	-14.3
-5.5	-15.6	-10.5	-10.1	-15.6	-5.5	-15.6	-16.8	-18.5	-13.5
-5.5	-4.2	0.0	-0.4	-2.9	-5.5	-11.4	-10.1	-9.7	-8.4
-2.5	8.4	11.8	8.8	6.3	0.0	0.8	0.0	0.8	0.8
4.6	19.3	21.4	17.2	13.9	8.0	13.5	12.6	11.8	9.3
10.5	25.2	27.3	21.4	18.5	16.4	25.7	26.1	20.2	16.0
15.1	26.5	28.2	19.3	18.1	22.3	26.9	28.6	23.1	20.2

FACE X

1	2	3	4	5	6	7	8	9	10
5.5	4.2	7.1	3.4	4.2	12.2	14.3	14.3	10.5	10.1
10.1	9.7	10.5	6.7	6.3	14.7	13.9	14.3	10.5	9.3
12.6	13.5	12.6	7.6	7.1	14.7	9.3	10.9	8.0	6.7
11.4	12.6	10.9	5.9	5.5	8.4	1.3	5.0	2.5	2.5
5.9	8.4	7.1	2.5	2.1	-0.8	-5.9	-0.8	-3.4	-2.1
-1.3	1.7	2.5	-1.7	-1.3	-5.5	-14.3	-6.3	-8.0	-5.9
-5.5	-4.2	-0.8	-4.6	-4.2	-5.5	-15.6	-10.1	-11.4	-8.8
-5.5	-7.6	-2.9	-6.7	-5.9	-5.5	-15.6	-10.9	-12.2	-9.7
-5.5	-8.4	-3.8	-7.6	-6.3	-5.5	-14.7	-8.4	-10.5	-8.0
-5.5	-7.6	-3.8	-6.7	-6.3	-3.8	-7.6	-4.2	-6.7	-4.2
-2.5	-6.3	-2.1	-5.0	-4.2	0.4	0.0	2.5	-0.8	0.8
0.0	-5.0	0.4	-2.5	-1.7	4.6	6.7	7.6	4.6	5.5
2.5	-1.7	3.4	0.8	1.3	8.0	11.8	12.2	8.4	8.8
5.0	3.4	6.3	3.4	3.8	11.8	14.3	13.9	10.1	10.1

FACE Y

1	2	3	4	5	6	7	8	9	10
-1.7	-6.7	-2.9	-1.3	-3.4	-2.5	-7.6	-3.4	-3.4	-3.4
2.5	0.0	2.9	3.8	2.5	3.4	0.0	2.5	2.5	1.7
9.3	9.3	10.5	10.1	8.4	10.5	9.3	10.1	9.3	7.6
13.5	16.4	16.0	15.1	12.6	13.0	14.3	14.3	13.0	11.4
15.6	19.3	18.1	16.8	14.3	12.6	16.0	16.0	14.3	12.6
13.9	17.2	16.4	15.6	12.6	11.4	14.3	14.3	12.6	10.9
9.3	15.1	11.8	10.5	7.6	8.4	9.7	9.7	8.4	6.7
2.9	2.5	5.5	5.0	1.7	4.6	4.2	4.2	2.9	1.3
-2.9	-5.0	-0.8	-1.3	-4.2	-0.4	-2.5	-0.8	-2.5	-3.8
-5.5	-10.9	-5.9	-5.0	-8.4	-4.6	-7.6	-5.5	-5.9	-8.0
-5.5	-13.5	-8.4	-7.6	-10.5	-5.5	-10.9	-7.6	-8.4	-10.1
-5.5	-13.9	-8.8	-8.0	-10.9	-5.5	-12.6	-8.4	-8.4	-10.5
-5.5	-13.0	-7.6	-6.3	-8.4	-5.5	-12.2	-7.6	-7.6	-8.8
-2.5	-8.4	-3.8	-2.9	-4.2	-3.8	-8.8	-4.2	-4.2	-4.6

APPENDIX 6-9

PRESSURES DUE TO WAVE ACTION - RELATIVE TO STILL WATER PRESSURES

TIDE	HIGH WATER
WAVE HEIGHT	24 FT PERIOD 8.25 SECS
DIRECTION	AT ANGLE OF 37.5 DEGREES TO BERTHLINE
NEIGHBOUR CAISSONS	PRESENT
UNITS	FEET OF WATER
REAR LEADING COLUMN	IN THIS ANGLED CASE

FACE Z

1	2	3	4	5	6	7	8	9	10
10.5	12.6	13.0	12.6	11.8	5.0	0.0	3.4	3.8	3.8
16.0	20.2	18.1	16.8	15.1	11.4	10.1	10.5	10.9	8.8
19.3	22.7	18.1	17.2	15.1	16.4	19.3	15.6	15.1	12.6
17.2	18.5	12.6	13.9	11.4	16.8	22.3	16.4	15.6	13.0
10.5	9.3	4.6	8.4	6.3	16.4	19.3	14.3	13.5	11.4
0.8	0.0	-3.8	1.3	0.4	11.8	11.8	8.4	8.3	6.7
-5.5	-9.3	-11.8	-5.5	-5.5	4.2	2.1	0.4	2.9	1.3
-5.5	-15.6	-16.8	-11.4	-10.9	-4.6	-6.7	-7.6	-2.9	-4.6
-5.5	-15.6	-19.3	-17.7	-13.5	-5.5	-13.5	-13.9	-8.4	-9.3
-5.5	-15.6	-18.5	-18.1	-13.9	-5.5	-15.6	-16.0	-10.9	-11.4
-5.5	-15.6	-12.6	-9.3	-10.1	-5.5	-15.6	-15.1	-10.9	-10.9
-1.7	-8.4	-4.2	-2.1	-2.9	-4.2	-15.6	-11.8	-8.0	-7.6
3.4	0.8	4.6	5.0	4.2	-0.8	-12.6	-5.9	-3.4	-2.5
9.3	10.9	12.2	12.6	10.1	4.2	-2.5	1.7	2.5	2.9