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DESIGN LIMITS ON CRITICAL FLOAT EMERGENCE IN A TETHERED FLOAT BREAKWATER

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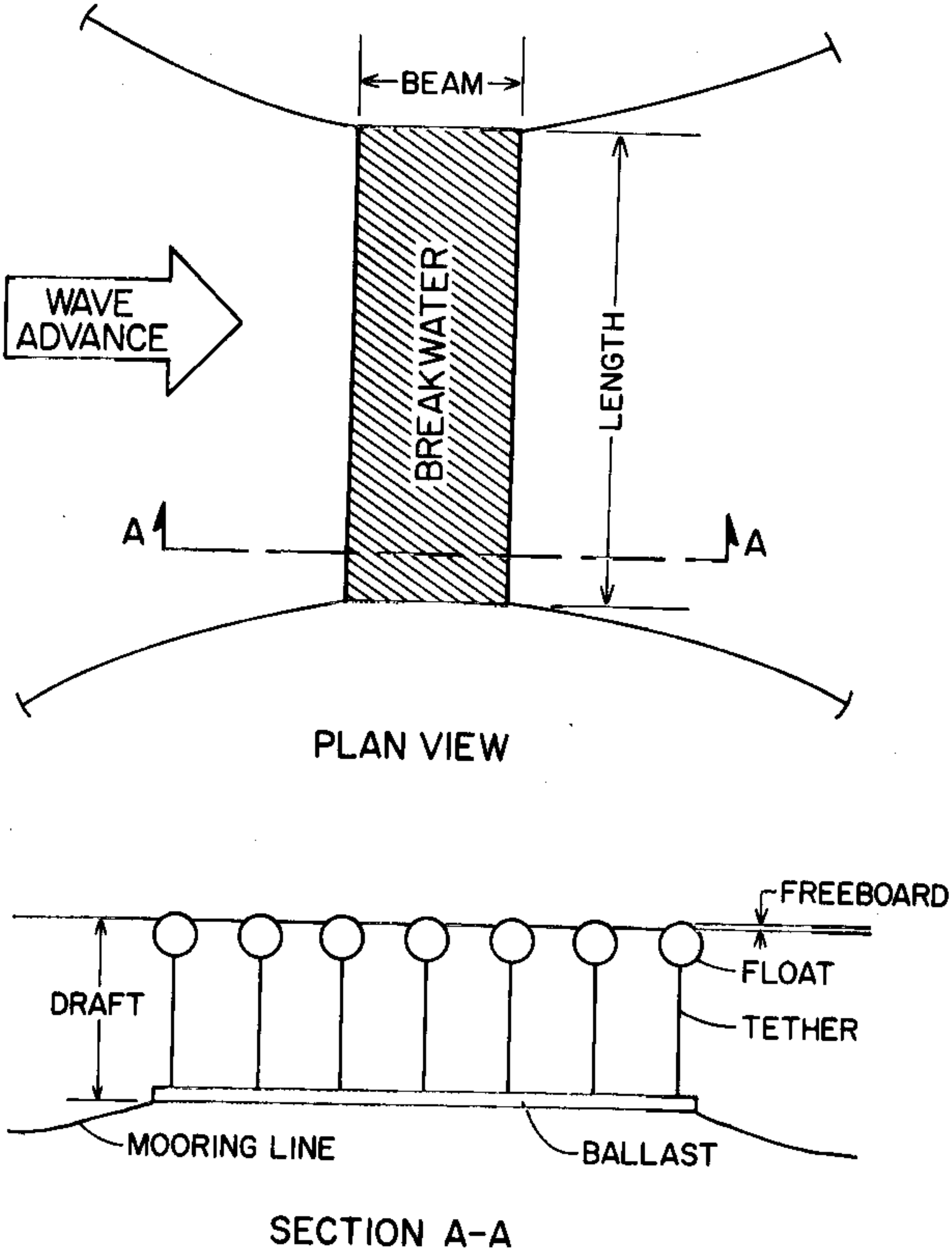
1. INTRODUCTION:

The Tethered Float Breakwater (TFB), described in Seymour and Isaacs (1974), and shown in Figure 1, employs an array of highly buoyant spherical floats to attenuate waves. The floats and the suspended ballast system are moored such that the system is free to follow the sea surface. It is proposed that large arrays be constructed from a number of standard ballast sections, connected by articulated joints. Performance analyses indicate that small float diameters provide an economic advantage. This investigation was undertaken to determine if a limiting relationship exists between the float diameter and the length of the ballast section in the beam direction. The terminology employed in Figure 1 and in the text to describe the breakwater geometry is in accordance with the recommendations of Kowalski (1974).

2. THEORY:

A single rigid ballast section is shown in Figure 2. The vertical loads from adjacent sections are indicated by F_{c_n} at the connection points. In a random sea, the ballast/float assembly attempts to follow the sea surface variations and to move towards an equilibrium between buoyant and inertial forces. Assuming a large number of floats per rigid ballast section, a fixed ballast length (B), and a constant volume of floats independent of float diameter (D), the attitude of the ballast can be considered to be



DEFINITION SKETCH - TETHERED FLOAT BREAKWATER

FIGURE 1

DEFINITION SKETCH FOR CRITICAL EMERGENCE

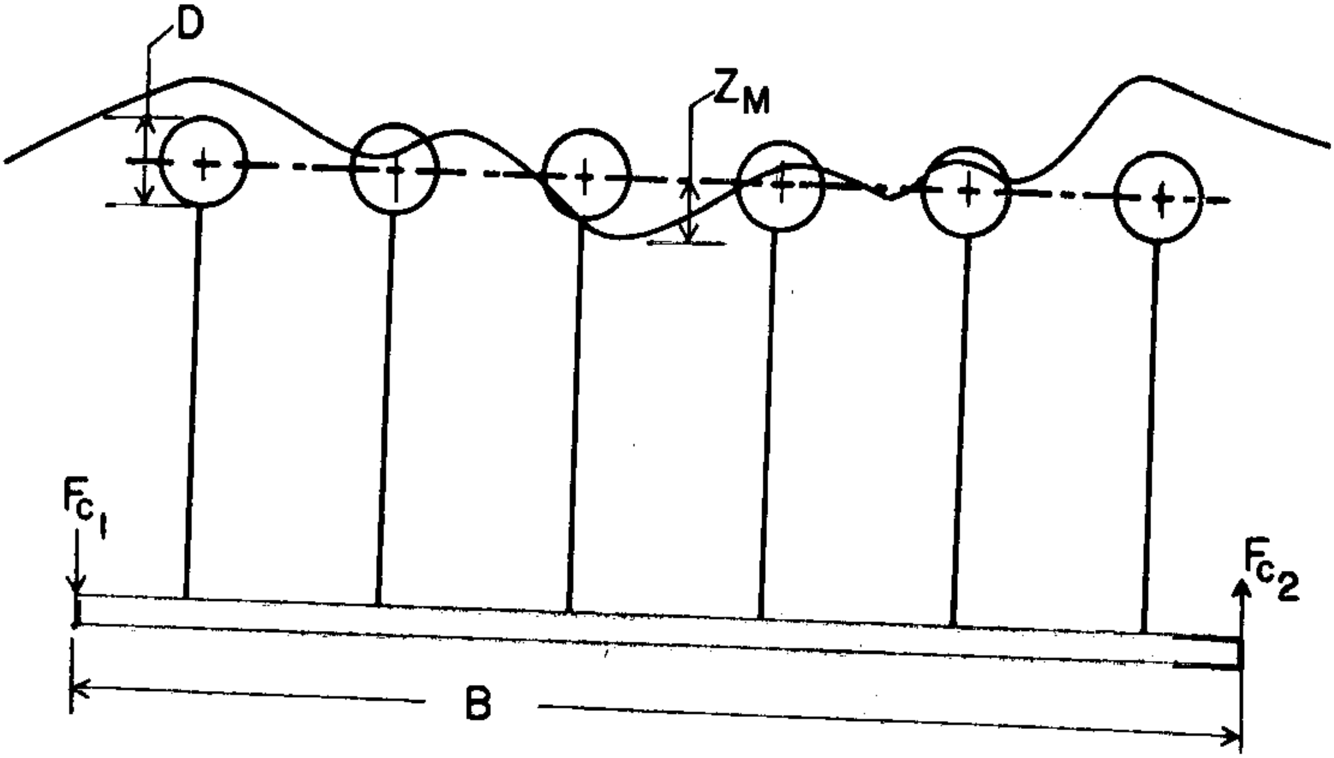


FIGURE 2

nearly independent of float diameter. Therefore, for any given stationary wave process, Z_m, the maximum vertical excursion of the surface from the plane of the float centers, is a function only of B. It is assumed that the float centerline plane can be considered parallel to the ballast plane at all times so that the argument of independence from float diameter holds. Thus, Z_m is determined uniquely for each combination of random sea and baselength, B. However, with fully developed seas in deep water, the statistics of surface elevation scale with some appropriate length such as λ_{peak}, the wave length corresponding to the period of peak energy. Therefore, for a given B/λ_{peak} the ratio Z_m/B can be assumed to be constant.

If Z_m is greater than the radius of the float, the tether will become slack, resulting in shock loading as the float is resubmerged. Since this condition is considered undesireable from an engineering viewpoint, it is of value to be able to predict the limits of its occurence. It can be seen that substituting D/2 for Z_m allows the determination of a limiting D/B ratio for each value of B/λ_{peak} to prevent slack tethers.

3. ARRANGEMENT OF THE EXPERIMENT:

To limit the experimental effort, one float diameter, two beam lengths and four wave climates were employed. A single column of 10.16 cm diameter floats was secured to a variable length ballast with 82 cm long tethers. This array was subjected to a variety of random seas in a 40 meter long wave channel at the Hydraulics Laboratory, SIO. A description of the characteristics of these model random seas and the methods for obtaining them in the laboratory is contained in Seymour (1975).

During each run, the array was observed visually for float emergence and recorded by a series of still photographs and cinematography. Since the onset of fully slack tethers was assumed to be difficult to observe, a criterion was established in which critical emergence was defined as the appearance of more than half of the volume of any float. Figure 3 shows floats exceeding the critical emergence.

4. RESULTS:

The results for eight experiments are shown in Table I.

TABLE I

Survey of Critical Emergence at Various Ratios of D/B and B/λ_{peak}.

f_{peak} (hz)	λ_{peak} (m)	Beam (m)	B/λ_{peak}	D/B	*Observed Emergence
0.883	2.00	4.88	2.44	0.021	NC
		7.32	3.66	0.014	NC
0.675	3.43	4.88	1.42	0.021	NC
		7.32	2.13	0.014	NC
0.510	6.00	4.88	.813	0.021	NC
		7.32	1.22	0.014	NC
0.375	9.35**	4.88	.522	0.021	NC
		7.32	.783	0.014	C

*NC = Not Critical, C = Critical
** - Corrected for water depth (1.78 m)

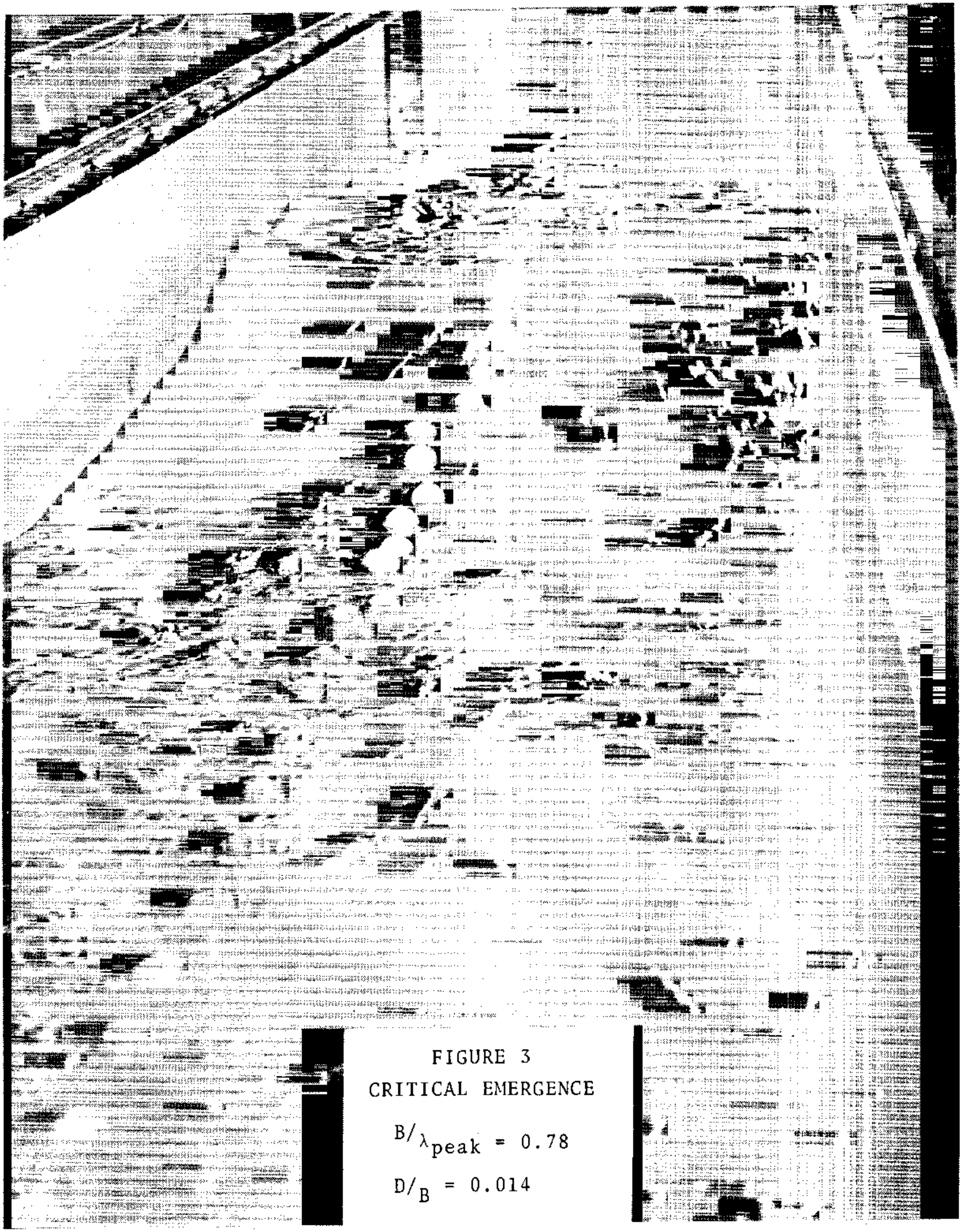


FIGURE 3
CRITICAL EMERGENCE

$B/\lambda_{peak} = 0.78$

$D/B = 0.014$

The Table I results are shown graphically in Figure 4. In addition, values for full model arrays using D = 15.24 cm and B = 3.35 m, as described in Seymour (1975) are also displayed. From these data, a zone of acceptable combinations of D/B and B/λ_{peak} can be deduced. There is a degree of conservativism in the assumed boundaries in that critical emergence was defined at less than the slack tether condition.

5. CONCLUSIONS:

The ratio D/λ_{peak}, a parameter of a specific TFB application, defines the possible combinations of D/B and B/λ_{peak} which will satisfy this ratio. The range of D/λ_{peak} of interest covers the span from 0.005 to 0.05. Three curves of constant D/λ_{peak} have been drawn on Figure 4. It can be seen that only the combinations of the lowest values of D/B and D/λ_{peak} fall in the critical zone.

Under conditions of limited fetch and short wave lengths, selection of small float diameters and reasonable ballast lengths could result in a critical condition. Under ocean wave conditions, with the float diameters presently anticipated, the ballast section lengths required to yield a critical condition would far exceed the limits imposed by bending strength, handling and logistics. Therefore, it can be concluded that D/B ratio does not present a realistic design restraint on the tethered float breakwater except for smaller scale applications.

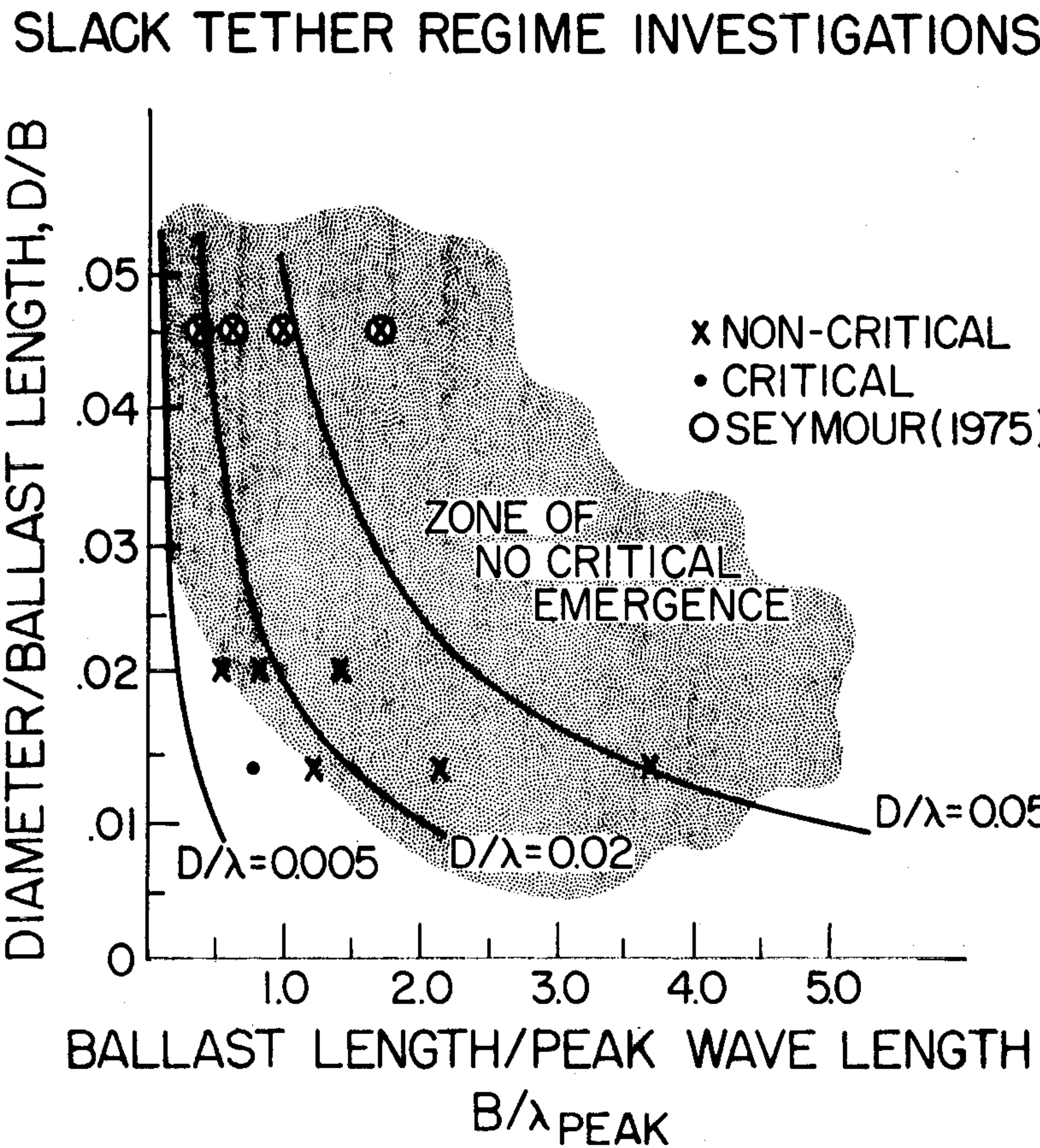

SLACK TETHER REGIME INVESTIGATIONS
DIAMETER/BALLAST LENGTH, D/B
.05
.04
.03
.02
.01
0
x NON-CRITICAL
• CRITICAL
O SEYMOUR(1975)
ZONE OF
NO CRITICAL
EMERGENCE
D/λ=0.005
D/λ=0.02
D/λ=0.05
1.0
2.0
3.0
4.0
5.0
BALLAST LENGTH/PEAK WAVE LENGTH
B/λ PEAK

FIGURE 4

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