

GENERALIZED METHOD FOR DESIGNING
RETRACTABLE FENDER SYSTEM

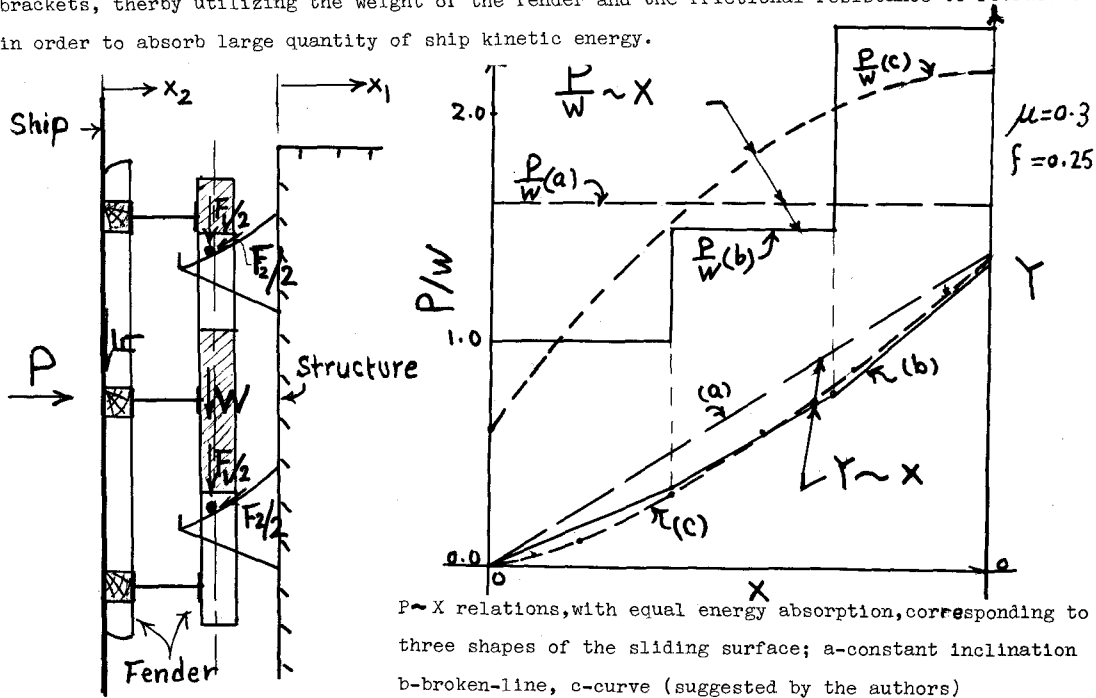
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Introduction

This type of fender usually consists of a frame with a front surface composed of vertical timber members fixed to horizontal wales. The frame is suspended by bars sliding on supporting brackets built in the berthing structure. The fender frame with its own weight W , or with other auxiliary weight, moves, under the ship impact P , inward and upward on the supporting brackets, thereby utilizing the weight of the fender and the frictional resistance to retraction in order to absorb large quantity of ship kinetic energy.



The Existing Methods of Retractable Fender System Design

Some designers select the sliding surface to have a constant inclination through the whole retraction. Others, select it in the form of a broken-line. In the first case the outside acting load will be of a constant value, while in the second, stepped-load-displacement relation will result. To the authors, both solutions may create resonance response in the structure during retraction. As regards the frictional resistance to retraction, F_1 , F_2 ,

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some designers consider F_2 but overlook F_1 . Neglecting of such force, which actually exists, is neither on the safe side in designing the berthing struct., nor on the economic side for fender design. On the view of the preceding informations, the authors present two modifications. First, selecting the sliding surface to be curved in shape, which permits the load P to increase gradually. Second, consideration of the dynamic behaviour of the berthing system.

At any displacement x the relation linking the outside acting load P with the retractable weight W, the surface inclination $G(x)$, and the coefficients of friction f and μ between the hull and the front surface of the fender, and between the suspending bars and the sliding surface respectively, is given by the following equation;

$$P(x) = \frac{\mu + G(x)}{1 - \mu f - (\mu + f) G(x)} W \quad . . . (a)$$

the recommended values of $G(x)$ are; $G(x)$ at the beginning of retraction is equal $\mu + 0.5$ and at the end of retrac. = $(0.5 \sim 0.6)G(x)_{cr.}$ in which $G(x)_{cr.} = \frac{1 - \mu f}{\mu + f}$

Dynamic Behavior Of The Berthing System

After the ship contacts the fender, the system will undergo the three following stages of motion:

1) The First Stage: After time of contact till the fender starts to retract, all the system move together, $(M_1 + M_2 + m) \ddot{X}_1 + K_1 X_1 = 0.0 \quad . . . (b)$

2) The Second Stage: In time when the fender is in action, Struct. motion is $M_1 \ddot{X}_1 - P(x) = 0.0$ } ..(c) (K_1 Spring const. of Struct.)
 Ship and fender $(M_2 + m) \ddot{X}_2 + P(x) = 0.0$

3) The Third Stage: After the time when the fender weight reached its max. displacement, all the system move together, eq.(b) is valid. As for the velocity for the beginning of each stage, it is taken the ship approach velocity in the first stage, and evaluated for the second and third stages by considering the momentum and Kin. energy conservation during retraction.

Design Procedure

For economic design of a berth the following procedure is recommended:

- 1) The sliding surface shape, designated by $y=G(x)$, is first assumed, taking into consideration the recommended values of $G(x)_{max.}$ and $G(x)_{min.}$.
- 2) Substituting $G(x)$, with an assumed value of the weight W in eq.(a), the $P(x)$ relation will be obtained.
- 3) By substituting $P(x)$ in the dynamic equations and solving by numerical integration methods and the help of the digital computer, the max. value of the dynamic load P acting on the berthing struc. and the energy stored by the structure will be evaluated.
- 4) For making these values as less as possible, other sliding surface shape, $G(x)$ or the weight W is tried and the steps 1) to 4) are repeated.