Annual Meeting of Korean Society of Coastal and Ocean Engineers
Korea Ocean Research and Development Institute, 11-12 October 1996

# Introduction of Characteristics of RUBBER JOINER
## - Durability and Effect of Impact Load Reduction

Katsumasa TOKUBUCHI[1] , Michiya MIKI[2] , Nobuyasu IKOMA[3]
and Hee-Do AHN[4]

## 1. Foreword

RUBBER JOINER, developed by using rubber and chains in combination. It is already applied to many practical use. In this paper, we would like to introduce experimental result about RUBBER JOINER while developing process. And, in recent years, effect of impulsive tension reducing is certified by experiment. We would like to mention the experimental result, too.

## 2. Structure and Static Character of RUBBER JOINER

### 2.1 Structure of RUBBER JOINER

Fig.1 shows basic structure of RUBBER JOINER. It is constituted by two part, rubber and steel chain. Rubber gives springiness to RUBBER JOINER, and steel chain behave as reinforcing bar. And, proof load of steel chain decide using load of RUBBER JOINER.

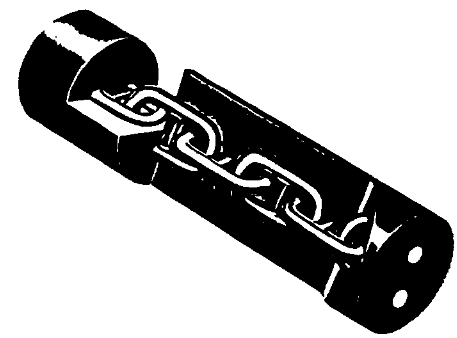

Fig.1 Basic structure of RUBBER JOINER

Chains within RUBBER JOINER buries on loose condition. And, rubber is filled in space between chain links. This rubber gives springiness to RUBBER JOINER. The space is called "nominal space clearance". Generally, nominal space clearance is

[1]Research Engineer, Reseach & Development groupe, Engineering Developping Div., SHIBATA Industrial Co., Ltd.

[2]Head of Engineering Developping Div. , SHIBATA Industrial Co., Ltd.

[3]Chief of Development Planning Section, Engineering Developping Div. , SHIBATA Industrial Co., Ltd.

[4]Principal Researcher, Ocean Engineering Division, Korea Ocean Research & Development Institute

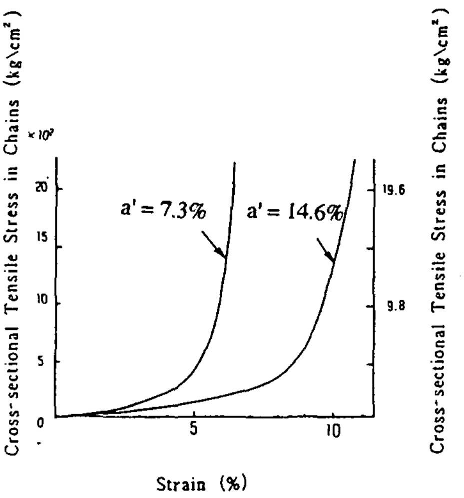


Fig.2 Difference in performance by nominal space clearance

described as percentage to product length. It written by Eq(1).

$$a' = \frac{a(n-1)}{l} \times 100 \cdots (1)$$

Where $a'$ : nominal space clearance, $a$ : distance between chain link, $n$ : number of links, $l$ : product length

The springiness be could regulated by increasing or decreasing nominal space clearance. Fig.2 indicate that difference in performance by nominal space clearance a'. As shown in this figure, when a' is large, the strain is large that for cross sectional tensile strain in chain. In the other hands, the strain is small when a' is small.

## 2.2 Abrasion Resistance

Photo.1 shows condition of RUBBER JOINER and steel chains after comparative test in the sea. The test site is offshore of Rumoi, Hokkaido, and test period is 2 years. The test method is that using a single point mooring buoy. And, RUBBER JOINER and chains were arranged in parallel to make a comparison during a test. As shown in photograph, rubber surface is no abrasion in RUBBER JOINER. But, in steel chains, abrasion occurred due to contacts with rocks and sands on sea bed.

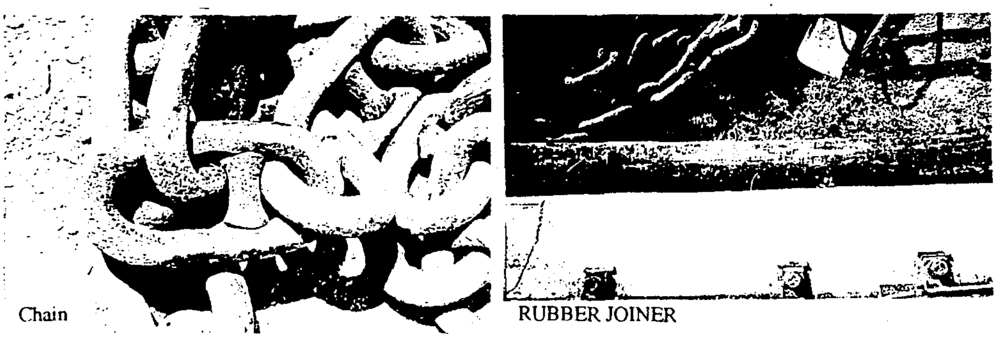


Photo.1 Condition of RUBBER JOINER and steel chains after comparative test

## 3. Dynamic Character of RUBBER JOINER

### 3.1 Impact Test on Acting Initial Load

In this section, result of impact test is described. The sketch of impact test machine is shown in Fig.3. Impact load is acted by weight dropping method on the test. The test carried out under the condition that acting initial load. The initial load conditions are three cases which acting initial load is nothing, 1tf, and 3tf. And the test practiced about steel chains for comparison with RUBBER JOINER, too.

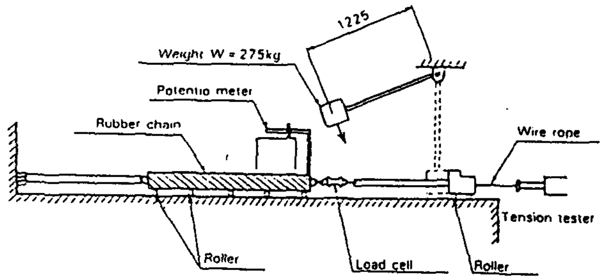


Fig.3 Sketch of impact load test machine

Test results indicated by Fig.4. Vertical axis is occurrence load that measured by loadcell, and horizontal axis represents weight falling speed. That speed decide impact energy for RUBBER JOINER and steel chains. And, Fig.5 is time series data of this test.

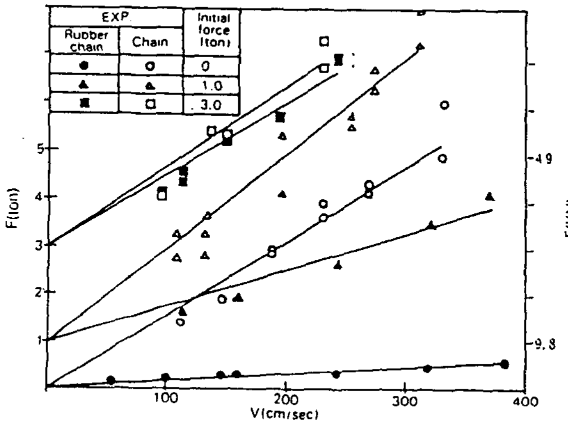


Fig.4 Result of impact load test

According to results, when no initial load applied, occurrence impact load is low level at any weight falling speed. On the same condition, occurrence load is in proportion to weight falling speed for steel chain. But, occurrence load in the case of RUBBER JOINER using is proportional to weight falling speed similarly steel chains. And, in Fig.5, the occurrence load increase on the case of RUBBER JOINER using when initial load acting because of rubber compression between chain links. In the other word, the space clearance is decreased by rubber compression, and the displacement is wanting for needed impact load reduction.

However, initial load to RUBBER JOINER is nothing in any condition of using for one point buoy mooring. Therefor, impact load reduction capacity of RUBBER JOINER is not spoiled.

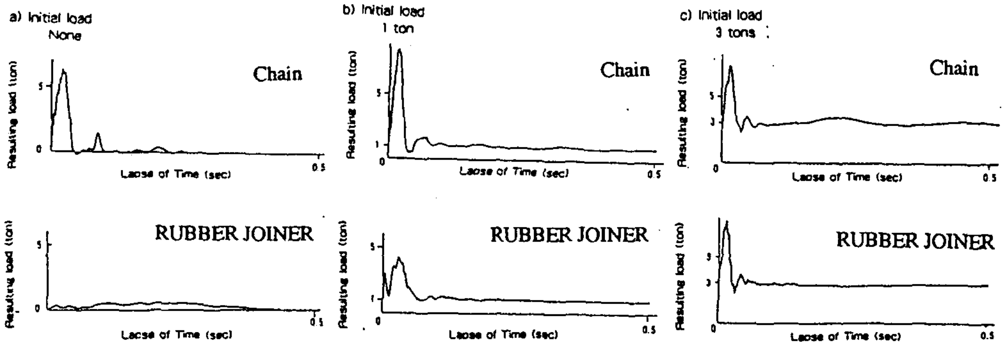


Fig.5 Time series record of occurrence load in impact test

## 3.2 Model Test of Reducing Impulsive Tension[1)]

Next, we would like to introduce one experimental result. This experiment is carried out in Port and Harbor Research Institute (PHRI), MOT, Japan. The purpose is to study for impulsive tension reducing on buoy mooring. Moreover, impulsive tension means "snapping load".

Fig.6 is sketch of model for the experiment. Model RUBBER JOINER is used for model buoy mooring. For this experiment, model RUBBER JOINERs is prepared four kinds as indicated in Table.1. And, tensile meter is installed in the joint points chain-buoy and chain-anchor.

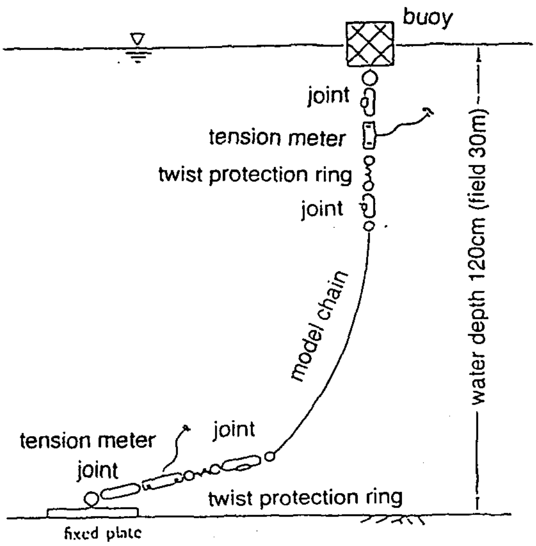


Fig.6 Sketch of experiment model

Fig.7 is comparison of average peak

mention. Vertical axis is tension in chain-anchor, and horizontal axis is tension of πbuoy-anchor. And, the indicated tension is converted to real scale load from model scale. As shown in Fig.7, for steel chain, occuremce tension scatter at high tensile reasion (40~60tf), and large tensile load appear at upper the anchor comparison with tension in chain-buoy. In Fig.7, when using model RUBBER JOINER, occurrence tension in buoy-chain point is lower than steel chain using. And, effect of impulsive tension reducing depend on springiness of RUBBER JOINER. In the other word, soft RUBBER JOINER (L2 and S2) is effective against impulsive tension.

Fig.8 is indicate that relation between attribute of RUBBER JOINER to maximum tension. From this figure, maximum tension is reduced at the rate of 20~30% to normal steel chain by RUBBER JOINER. And, Type2 RUBBER JOINER (springiness is soft) is superior to reducing tension. In the other word, effect of reducing tension is influenced by springiness of RUBBER JOINER rather than length.

As mentioned above, RUBBER JOINER has effect of impulsive tension reducing. Therefore, it is keep chains from cutting due to impulsive tension in buoy mooring.

Table.1 Attribute of model RUBBR JOINER

| | S1 | L1 | S2 | L2 |
|---|---|---|---|---|
| springness | hard | hard | soft | soft |
| length | short | long | short | long |

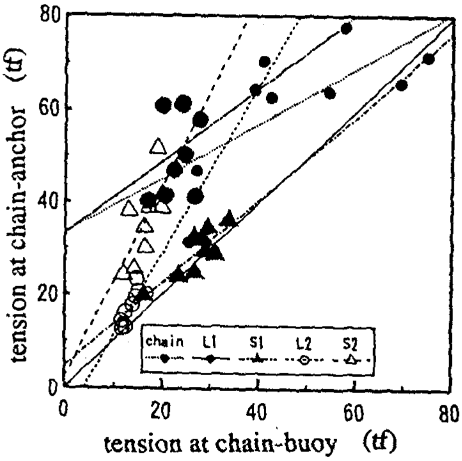


Fig.7 Measured load at tension meter

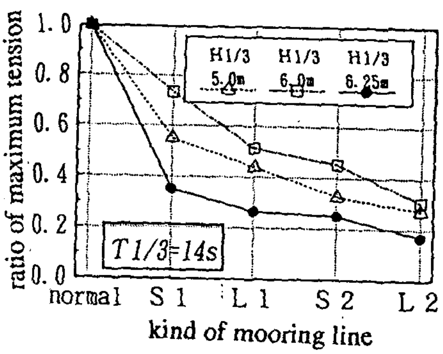


Fig.8 Relation about kind of mooring line

## 5. Conclusion

Characteristics of RUBBER JOINER is described in below. Namely,

1)*Springiness*

Springiness is appeared by rubber between chain links. And the springness is controlled by space clearance of chain links.

2)Abrasion resistance

Rubber material is superior to abrasion. RUBBER JOINER resist against abrasion due to sands and rocks in sea bed.

3)Impact load reduction

RUBBER JOINER has effect of impact load reduction. And, on buoy mooring, RUBBER JOINER keep chains from cutting due to impulsive tension.


## Acknowledgment

Lastly, the authors would like to express sincerely thanks to Dr. Tetsuya HIRAISHI, senior research engineer, Hydraulic Engineering division, Port and Harbour Research Institute, Ministry of Transportation, Japan who permit us to introduce his experimental result and to make this report.


## Reference


1)Tetsuya HIRAISHI, Yasuhiro TOMITA (1995): Model Test on Countermeasure to Impulsive Tension of Mooring Buoy, Technical Note of Port and Harbour Research Institute, No. 816