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# Ultimate Longitudinal Strength of Ship Hull Girder: Historical Review and State of the Art

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## ABSTRACT

This paper introduces the historical matters and state of the art regarding the research works on the ultimate longitudinal strength of a ship hull girder. At first, it is described how the longitudinal strength assessment started, and past experimental works on full-scale and small-scale hull girders applying longitudinal bending load are introduced. Then, it is explained how the yielding and buckling affect the progressive collapse behaviour of cross-section of a ship's hull under longitudinal bending, showing the results of example calculations. After this, the methods of analyses as well as research works on ultimate longitudinal strength and progressive collapse behaviour of a ship's hull are reviewed, and some important results are introduced. At the end, bench mark calculation on progressive collapse behaviour under longitudinal bending is described.

**Keyword:** ultimate longitudinal strength, ship hull girder, buckling/plastic collapse, progressive collapse, historical review, state of the art

## PREFACE

A ship's hull is a box girder structure composed of stiffened plating, and is subjected to longitudinal bending load produced by distributed hull weight, cargo weight, buoyancy force and wave force. The ship hull strength against longitudinal bending/shearing loads is called *longitudinal strength*, which may be the most fundamental strength of a ship structure. This is because buckling/plastic collapse of deck and/or bottom structure takes place and a ship's hull may break if the woking longitudinal bending moment exceeds the capacity of the cross-section.

It can be said that ship structures do not undergo buckling/plastic callapse if the working load is below the design load. However, a ship's hull may be exposed to an extreme load in some occasions when the ship fails to escape from a storm or when the cargo and/or ballast is unduely loaded. It should be noticed that an ordinary load below the design load can also be an extreme load for a ship's hull suffering from corrosion damage or fatigue cracking.

On the other hand, the thickness of plating in ship structures is recently decreasing because of the introduction of rational design by analysis and the wide use of high tensile strength steel. Upon this fact, it has become more important to accurately assess the ultimate longitudinal strength of a hull girder from the safety viewpoint.

In the present paper, at the beginning, it is introduced how the research works on ultimate longitudinal strength started, and the past collapse tests on full-scale ship hulls in early days are reviewed. Later tests on small-scale models and girders are also introduced.

Then, the influences of yielding and buckling on progressive collapse behaviour of the cross-section of a ship's hull under longitudinal bending are explained based on the results of example calculations.

After this, recent research works on methods of analyses to evaluate ultimate longitudinal strength and to simulate progressive collapse behaviour are reviewed. In this connection, results of progressive collapse analysis on existing ship hull girders are introduced.

At the end, results of bench mark calculation on progressive collapse behaviour of 1/3-scale welded steel frigate model are introduced.

## START OF LONGITUDINAL STRENGTH ASSESSMENT

Thomas Young, who is well-known by *Young's modulus*, was the first person who had calculated the longitudinal strength of a ship's hull (Timoshenko, 1953). He considered a ship's hull as a beam, and calculated shear force and bending moment diagrams assuming the distributions of weight and buoyancy forces along a shup's hull. The buoyancy force was calculated based on the