Strength Analysis on Ship Ladder Using Finite Element Method

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Strength Analysis on Ship Ladder Using Finite Element Method

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Abstract. In designing the ship's structure, it should refer to the rules in accordance with applicable classification standards. In this case, designing Ladder (Staircase) on a Ferry Ship which is set up, it must be reviewed based on the loads during ship operations, either during sailing or at port operations. The classification rules in ship design refer to the calculation of the structure components described in Classification calculation method and can be analysed using the Finite Element Method. Classification Regulations used in the design of Ferry Ships used BKI (Bureau of Classification Indonesia). So the rules for the provision of material composition in the mechanical properties of the material should refer to the classification of the used vessel. The analysis in this structure used program structure packages based on Finite Element Method. By using structural analysis on Ladder (Ladder), it obtained strength and simulation structure that can withstand load 140 kg both in static condition, dynamic, and impact. Therefore, the result of the analysis included values of safety factors in the ship is to keep the structure safe but the strength of the structure is not excessive.

1. Introduction

A ship ladder provided especially adapted for shipboard use is safe and comfortable to use for relatively light weight and occupying relatively small floor and overhead space [1]. For example, various means embarking a ship at sea has been proposed, from the simple pilot's ladder hanging down the ship's side to sophisticated devices acting as elevators [4]. In designing the Ladder structure that can withstand a load of 140 kg on a Ferry ship, where the load is derived from the weight of Passenger and Ship Crew.The loading will be charged 140 kg. In designing Ladder (Stairs) on the designed Ferry Ship, it should be reviewed based on the loads occurring during ship operations, either during sailing or at port operations. A further object is to provide a side ladder for ships which may be installed very quickly but when it is installed strongly, it resists accidental displacement in any direction for design arrangement ship ladder [2]. A further object of the ship ladder is the provision of a ladder handrail accomplishing the objectives handrail is extremely simple construction, economical of manufacture, and highly reliable in operation [3]. The rules for the provision of material composition in the mechanical properties of materials should refer to the Classification of ships used. A several further objects of this invention is to provide a ship ladder of this type in which rungs are formed of metal channels through which rails extend and each rung is reinforced by a wood core and rivets extend through flanges of the rungs and through the core and through side rails to lock the rungs in position on the rails [5]. A collapsible ship ladder is provided which may be fabricated defect from standard chains and elongated bars of standard cross-sectional configuration capable of being produced by simple rolling or over extrusion operations, and it makes fail structure [6].Consequently, the shipping of such ladders and their handling during transport confronts the manufacturer and the shipper with a series of problems. Analysis performed on designing and loading of ship ladder structure by using Finite Element method. The outcomes validation with optimal result shows that there is a good correlation between the updated finite element models and the experimental data result [13]. Originally developed to problem specific areas of structural mechanics and elasticity, the finite element method is applicable to problems throughout applied mathematics, continuum mechanics, engineering, and physics. Design analysis in this loading includes loading, among others: static load, dynamic, and impact and included values of safety factors. For safety step ladders of presently known construction –it consists of uprights, steps, handrails and eventually of a platform, all such parts being welded together to form an integral, and rather bulky structure [7]. It aims to anticipate the possibility of failure or damage to structures on the ship ladder that may cause accidents and danger to passengers and crew so it’s checked by strength analysis.

2. Basic Theory

2.1. Definition of Ship *Ladder*

Ship Ladder is a two-storey connecting gear on the vessel that is useful for people access. Ship ladder has several types according to its position; that is oblique ladder and upright ladder. Ship ladder, an object provides a ship ladder which conforms to government requirements or refers to standard Permanent Mean Access Code, it can be easily, safety and quickly installed to the ship to use, or stored on the ship in a relatively small space [9]. The type of ladder is used to analyze the structure. The definition of Ladder tilted is a ladder with a certain slope position adjusted to its displacement; in general, this type of ladder is placed in a large enough room and in accordance with their needs which is impossible to use upright ladder. Examples of stairs in the accommodation room or staircase are out between the deck floors over the top and the engine room. For bulk carriers, a sloping staircase is also contained inside the hatch. This type of ladder is required in certain countries such as Australia. This ladder is necessary because the loading space is large enough so for the safety of the person is made a gradual incline stairs. This type of ladder is also known as the Australian Ladder. Sloping ladder is made of steel or wood construction. For stairs outside the ship building and engine room are made of steel which has a hole, and for the engine room made with anti-skid plate stairs. For the ladder that is in the loading room has a rung made of steel rods. All stairs are equipped with handrails [10]. Tilted ladder type used for boarding down the ship, available winch to lift and lower ladder, staircase also has a special construction arch with anti-skid surface.

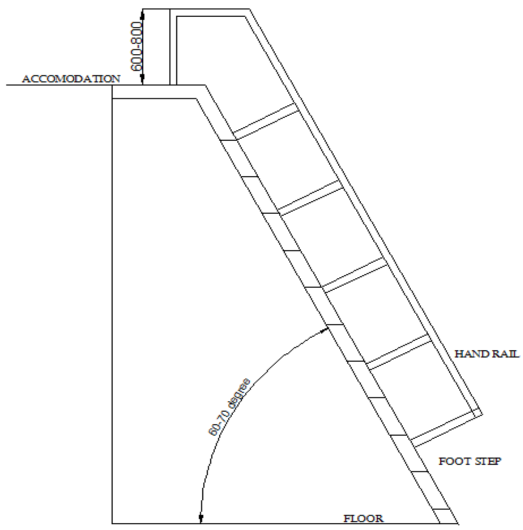

Figure 1.Ship ladder

2.2. Assorted Loads

Various types of loading that occur in the structure of ships ladder are as follow:

1. Dinamic Load
   Dynamic loads are loads of magnitude that change over time in the presence of certain incentives of cultivation generating reaction responses to the ship structures. In behavioral analysis on Ladder Ships structure is subject to Passenger or Ship crew. When the ship is not in a static state, it is causing in a loading action responded by the ship's structure. The failure criteria for dynamic loading are defined and based on the description of failure Slow crack growth in brittle materials under dynamic loading conditions [11].

2. Static Load
   Static load, especially to impact loads, is the burdens that occur due to a sudden impact force that has a force response to the structure. In behavioral analysis on the ships ladder structure, it is assumed that the load loading is assumed to be loaded from the fall of the altitude. Statistical ship structure response, immediate and cumulative, over the life of the ship is demonstrated in relation to the prediction of long-term bending moment trends stresses and the distribution of the extremes is observesed [12].

2.3. Strains and stresses

Uniform loading and tension loading that occur in the Ship Ladder structure on this Ferry ship when analysed by the calculation of the structure components can be seen in the formula diagram listed below.

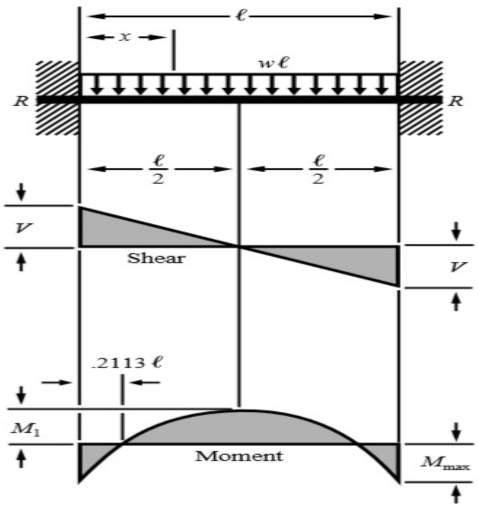

Figure 2. Moment diagram

The diagram, to calculate the value of the maximum bending moment that occurs, is as follows:

$$M\ max = \frac{1}{12}\, q\, \ell^2 \quad (1)$$

The maximum bending moment is used to calculate the maximum stress value that occurs in the structure with the following formula:

$$\sigma = M.y / Ixx \quad (2)$$

While Strain relative is changed by the size or shape of objects that experience stress. The figure above shows a rod that is stretched by the pull force F. The length of the stem is Lo. After obtaining a tensile force of F, the bar changes its length to L. Thus, the rod obtains a length increase of, with ΔL = L-Lo.

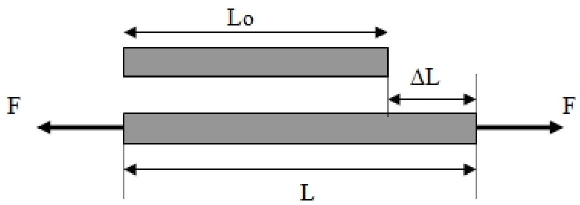

Figure 3.Strain

Therefore, strain is defined as the ratio between the length of the object and the length of the starting object. The expression stress and strain relation is useful for the design and numerical modeling of stainless steel members and elements which reach stresses beyond the 0.2% proof stress in their ultimate limit state [14].

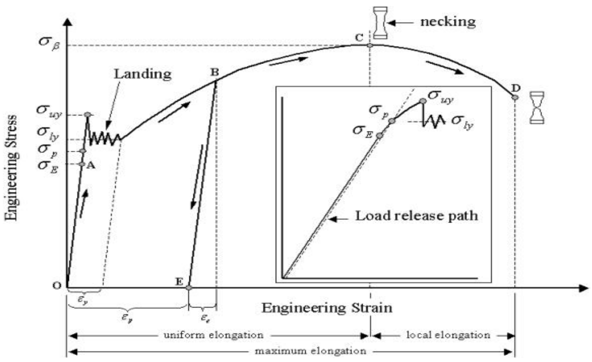

Figure 4. Graph of stress-strain relationship on tensile test results

In the plastic stretch εp (plastic strain), Strain is caused by the plastic changes. Unstable fracture is found to be consistent with the attainment of a stress intensification close to the tip such that the maximum principal stress σyy exceeds σf over a characteristic distance, determined as twice the grain size [8]. At the time the load is released this strain remains as a permanent change of the material. The normal stress is the stress that occurs when the force applied perpendicular to the cross-sectional area of the material. Principal stress is the extreme value of the normal stresses that occur in the material. If it is supposed a cube, the direction of the tension is in the direction of the cube, it ignores the shear stress.Von Misses stress is the resultant of all stresses that are derived from the principal axes and associated with principal stress. This will lead to a structural response to the value of existing loading on the modulus of the structure.

2.4. Material

In this research, the construction is analyzed using standard material of BKI grade A marine used which has mechanical properties as follows.The material in table above is the material for hull structures on the ship. The determination of yield strength from hardness measurements, it shows that the 0.2 pct offset yield strength of a material (in kg per sq mm) can be obtained from simple hardness measurements, where H is the Diamond pyramid hardness and m is Meyer's hardness coefficient [15]. The elastic modulus and yield strengths were obtained at different strain levels, and the ultimate strength and thermal elongation were evaluated at different temperatures. It shows that the reduction factors of yield strength and elastic modulus of high strength steel and mild steel are quite similar for the temperature ranging from 22 to 540°C [16]. See Table below is showed by requirement steel grade of BKI Rule [17].

Table 1. Steel Grade Properties

Steel grade	*Yield Stress (N/mm²) min.*	*Tensile Strength (N/mm²)*	*Elongation (%)*
A	235	400/520	22
B	235	400/520	22
D	235	400/520	22
E	235	400/520	22

2.5. *Safety Factor*

The safety factor is a number to get the allowable stress. The factors that determine the allowable stress of a construction material are:

- Factors relating to properties, those are; quality of materials, way of working and construction forms include material elasticity, material type, climate and concurrent cross-sectional changes.
- Factors of planner expertise, quality control of materials, and planning.
- Factors related to the way of loading, ie the type of material (dead, live, wind and others), dynamic or static, tensile, flexural, press and others.

For structural design, the allowable stress level is made lower than the yield strength in order to enter into the elastic design range.

Table 2. Safety factor

Partial safety factors covering unvertainies regarding	*Partial safety factor*		
	Symbol	*Plat-ing*	*Stiffeners*
Still water pressure	γs2	1,00	1,00
Wave pressure	γw2	1,10	1,10
Material	Γm	1,02	1,02
Resistance	γR	1,30	1,05

At the view point of the table of safety factors taken from the Indonesian Bureau of Classification for steel vessel construction, the safety factor used according to the material used is 1.02 for the plates as well as the pens. So the safety factor used to analyze the behavior of Ladder Ships structure is with the value of 1.02. The application of the long-term and short-term design criteria on a Mariner ship is illustrated as an example, and compared with the conventional safety factor of the deterministic approach [18].

3. Methodology

The use of Element Method Up to the structure of the analysis is the most common tool for analyzing stres that occurs in the structure, the steps are:

1. Design Modeling
   The design analysed was made of advance with a certain size. It would be analysed on the Ladder Ships structure on the Ferry ship.
2. Determination of the type of design by study
   Before the analysis process was done, it must determine the name of the problem (study), the type of analysis required (analysis type).
3. Determination of material type
   The material used was BKI grade A marine used.
4. Meshing
   The simulation was made in the form of three dimensions, then given a solid mesh form which has the recommended meshing type.
5. Load determination
   Loading should be determined according to the actual circumstances. In behavioral analysis of Ladder Ships structure, the load would be analyzed was dynamic load, and impact. The load was assumed to be uniform and centralized load.
6. Analysis
   In the behavioral analysis of Ship Ladder structure, post-processing analysis was performed with dynamic loading simulation, and impact occurs.

4. Analysis and Discussion

The value of Equivalent Stress loading occurred on the Ladder structure apply on the Ferry ship for loading conditions is shown as follows:

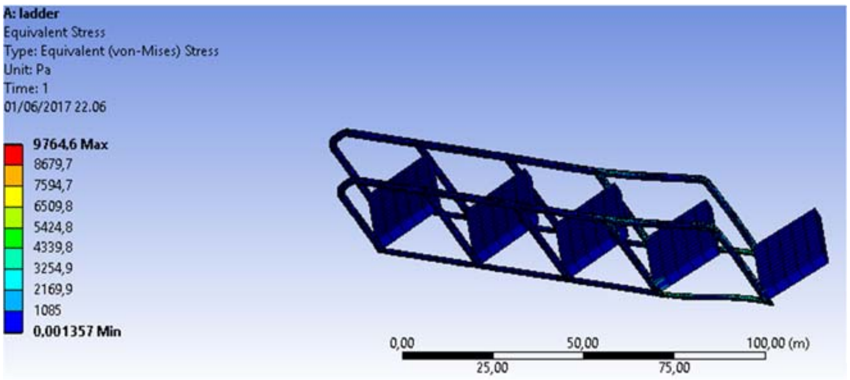

Figure 5. Equivalent Stress

From the figure above analysis can be seen that Von Mises the maximum stress that occurred is 9764,6 Pa.

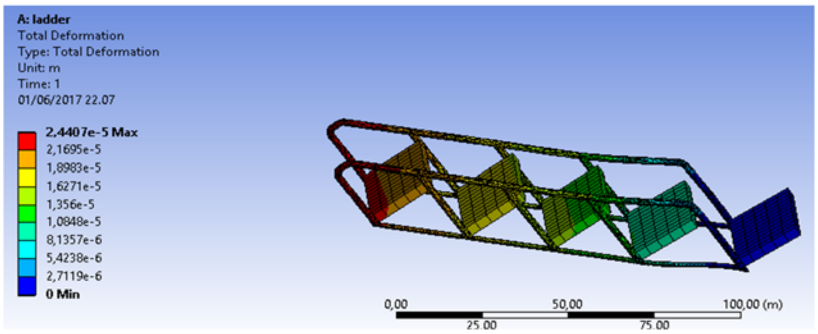

Figure 6. Total Deformation

From the figure above analysis can be seen that deformation maximum that occurs is 2.4407e-5 m.

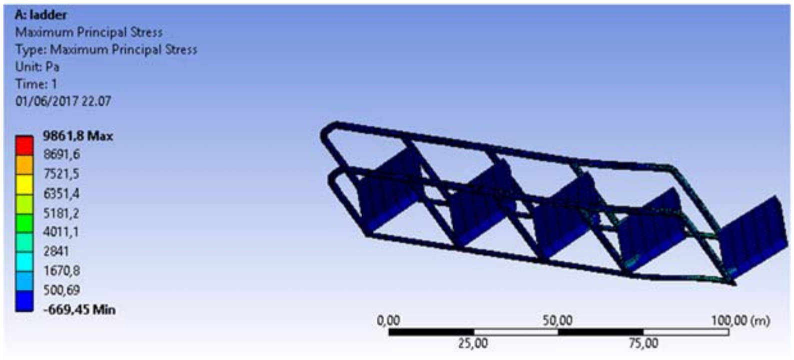

Figure 7. Maximum Principal *Stress*

From the figure above analysis can be seen that von Mises the maximum stress that occurred is 9861.8 Pa.

5. Conclusion

From the result of behavioral analysis structure of Ladder Ships using structure program of analysis based on finite element method, it can be concluded as follows:

1. Ladder structure design on Ferry ship by given static load is in accordance with the Classification standard.
2. The value of the load (Equivalend Stress, Total Deformation, Maximum Principal Stress) is still acceptable allowable standard.

6. Acknowledgements

Thanks to lectures in PPNS for supporting and sharing knowledge in Campus.

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