Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2022.030301
ISSN 2790-2706 Vol. 3, Issue 3: 1-8

High Strength Structural Steel in Ship and Marine Engineering Structures

Ken Lodewyk*

Univ Nairobi, Nairobi, Kenya

**corresponding author*

Keywords: High Strength Structural Steel, Ship Marine, Engineering Structure, Marine Engineering

Abstract: In offshore engineering, structural steel is a very important kind, which can not only improve work efficiency and reduce cost. It also has high safety and reliability. This paper takes ships as the research object, analyzes its application and development, puts forward the application of shipbuilding profiles in the manufacturing mode and service life of sea going ships under new technology, and summarizes the relevant fields. Finally, combined with the concrete example design of structural steel, through the process of theoretical study to practical operation, it expounds how to combine high-strength steel bars with other materials. The experimental results show that the high strength structural steel has excellent yield strength, tensile strength and elongation, and can meet the quality requirements of marine engineering.

1. Introduction

Structural steel is a very important material in ocean engineering. It can be used for ships, waterways and other large facilities. However, due to its own characteristics and high strength requirements, it has strict performance requirements for steel quality, so we need to constantly innovate and improve to meet the new conceptual design requirements of people for high-performance steel components. At the same time, we should also note that China's current national conditions and relevant technical standards are not perfect, resulting in the complex and changeable marine environment, This has brought great difficulties to the construction and manufacturing work of offshore engineering, and there are many potential safety hazards [1-2].

Domestic scholars have conducted in-depth analysis and Exploration on materials and components used in offshore engineering. China has successively developed various types of horizontal gluten plates with different specifications and uses and high strength performance requirements. At that time, ordinary steel structure system was mainly used, that is, light weight and

heavy weight. Construction can be carried out without special manufacturing process and equipment [3-4]. Through comparative analysis, some scholars have found the types and performance characteristics of different types of structural steels and their application effects in offshore engineering. Other scholars use mechanical theoretical knowledge to simulate the whole hull model composed of bow, propeller and blade when the ship deck is simulated, and describe in detail the important components in the ship structure, such as the rudder surface system (hydraulic cylinder), and finally put forward the optimization design method in combination with the actual situation [5-6]. Therefore, this paper studies the application of high strength structural steel in ship and ocean engineering structures.

With the rapid development of China's economy, the construction industry has also made great progress. Steel structure is the most widely used metal material with high strength, high toughness and low deformation temperature. The application of steel in offshore engineering has good comprehensive properties. In this paper, the traditional marine micro aluminum sheet is studied, analyzed, designed and calculated, and combined with the knowledge learned, reasonable suggestions and countermeasures are put forward theoretically. In order to improve the safety of ships working at sea, a ship hull structure model is established by using mechanical methods to simulate its strength, stiffness, deformation and other characteristics.

2. Discussion on the Application of High Strength Structural Steel in Ship and Marine Engineering Structures

2.1. Ship and Offshore Engineering Structure

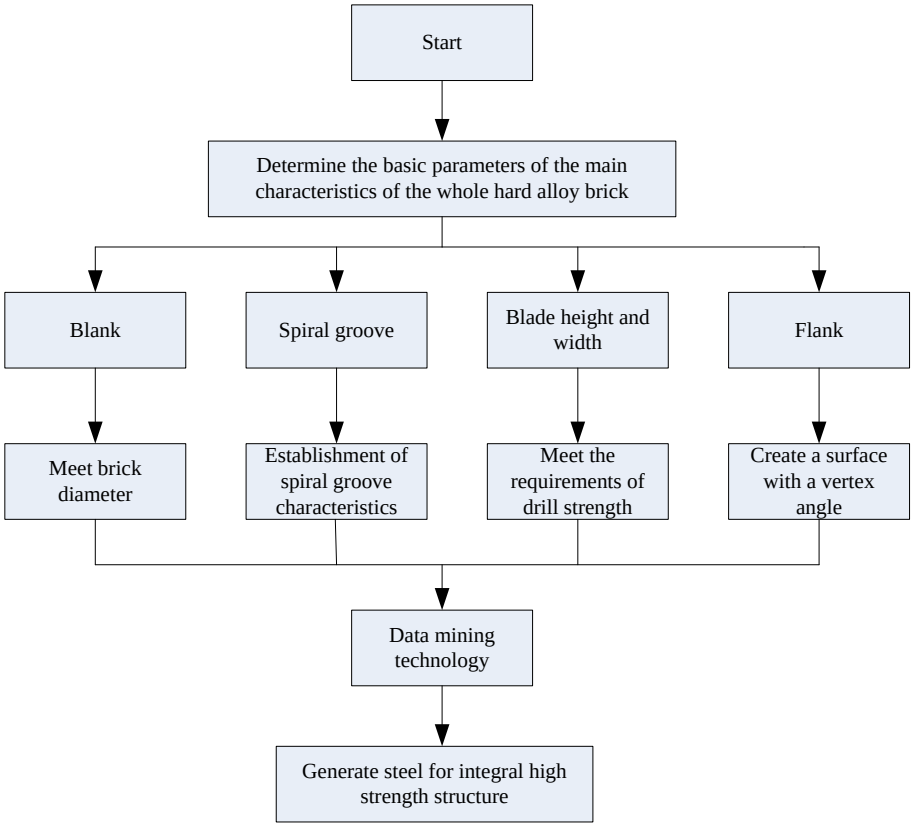

Figure 1. Ships and marine engineering structure

In the ship structure, the most commonly used type is the marine engineering steel made of steel.

It is mainly selected by various specifications and performance standards, and its strength, rigidity and stability shall meet relevant requirements [7-8]. Fig. 1 is a structural diagram of ships and marine engineering. Among them, one of the key factors to be considered in ship type design is the use of different forms of heat insulation panels between the hull and the sea surface to effectively isolate the corrosive impact of seawater on the hull. In addition, the thick and thin steel plates can be used as a part of the load-bearing materials in the ship structure, which greatly reduces the risk factor of fire and explosion in the marine environment. Structural steel is a very important material in ocean engineering. While the traditional marine building structures are mostly of high strength, good toughness and relatively light weight. However, due to the bad seawater environment and the large amount of toxic gases in the seawater, its safety is poor and its service life is short. Therefore, for these problems, we should vigorously promote the application of high-strength silicon carbide steel plate to replace ordinary low-alloy steel for design, manufacturing and processing, so as to meet people's requirements for high-quality life and work. The components built on ships are mainly steel structures, which can also be called plates, beams, columns and trusses. With the continuous improvement of social and economic level and the deepening of human understanding of the marine environment, these are all developed from the shipbuilding industry. The hull is a general term for components formed by supporting the weight of various ship types or deck cargoes and other loads. It not only includes the product of loads on various parts of the hull and the positional relationship between them, but also includes the main components in the ship structure that bear the effects of various forces and motion States, stress and strain changes, bending deformation, vibration and impact [9-10].

2.2. High Strength Structural Steel

In offshore engineering structures, the use of steel is very large. High strength reinforcement is determined by its mechanical properties and processing technology. Therefore, it is necessary to select reasonable materials to meet the design requirements, ensure that the quality meets the standards to achieve the best effect, reduce costs, save resources and improve efficiency, etc. in consideration of economic benefits and environmental protection factors, the selected steel materials are selected and calculated to determine the structure type suitable for the project [11-12]. In marine engineering, steel structure is a common structure. Because it has high strength and rigidity. Therefore, it is widely used on various offshore platforms. This type of ship mainly uses low-carbon and high-strength materials as ship type plates, and it can also be used as components such as large hull, offshore deck and land platform. Therefore, it is also widely used in construction, especially for some large structural steels. With the development of society and the improvement of people's living standards, the requirements for high-intensity shipbuilding are becoming more and more strict. We can see that the current marine environment is relatively special, the coastline is interlaced and complex, and there are a lot of sediment and other substances in the sea water, which lead to serious impact on the marine structure after the sea water enters the land. Therefore, it is necessary to use high-strength steel to replace low-alloy high-strength steel plate as the basic material when building the hull [13-14].

2.3. High Strength Design Process

When designing, it should be reasonably selected according to the structural performance and characteristics in the marine environment under different environments. For example, for ships, it has the disadvantages of large body weight and low hull stiffness. Therefore, we need to improve and perfect these shortcomings. For offshore waters, high-strength reinforced concrete should be used as the foundation and the material to ensure the stability and durability of components. For the

sea areas with shallow water depth during offshore operations, the deep buried thin steel plate structure or composite steel should be selected as the design basis. Select appropriate materials according to the given parameter calculation results and actual requirements [15-16]. In order to improve the overall quality of ship components, composite materials can be used to improve their durability, and the synergy between them should be fully utilized when welding to avoid structural performance degradation or fracture due to weld problems. After the preliminary design is completed, check whether there is any irrationality according to the calculation table. If problems are found, modify and improve the scheme in time and restart the next step (for example, figure 2 shows the modification process). If there is no need to change, continue until the structure meets the requirements, and ensure the safety and reliability of the project [17-18].

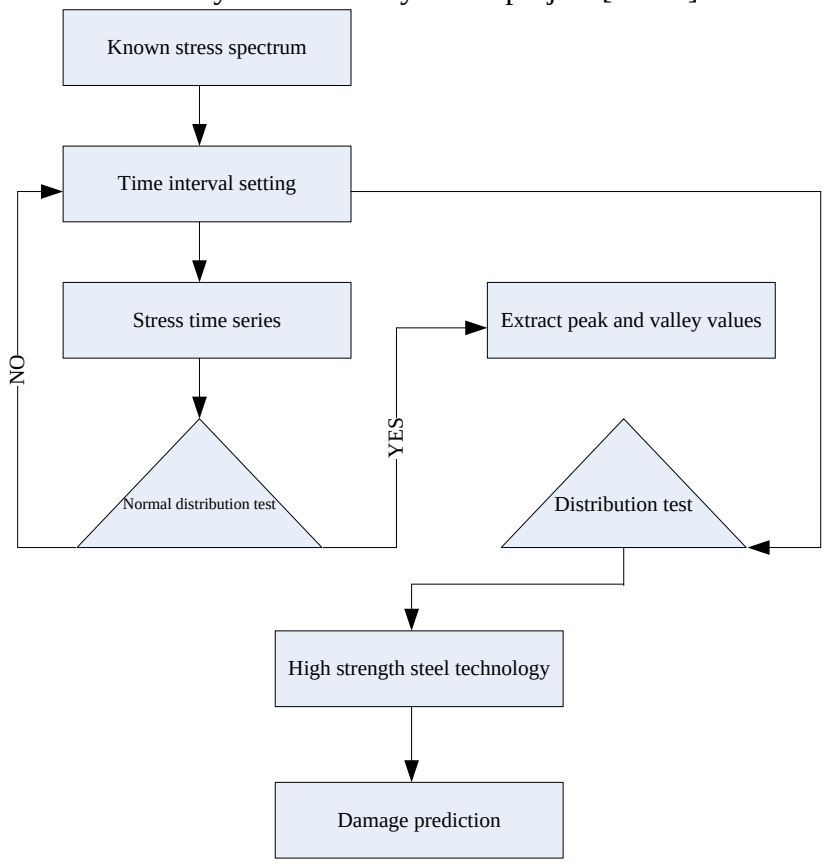

Figure 2. High-strength structure modification process

In the process of accounting for the basic elements of the hull structure, the minimum modulus of the static section of the hull girder at the deck and bottom of the cross section is:

$$Z_v\text{-}\min = 0.9C_u k2B\ (\ C_b + 0.7\ )\times 10^{-6}\,m^3 \tag{1}$$

Where: CW is the wave coefficient; H is the highest stiffness steel coefficient; B is the profile width; CB is the square strength ratio. In the project of large-scale use of high-strength steel, it is also necessary to adjust the ratio of vertical rotational inertia to ih32 / ih40 according to the design standard. That is to say, in the project of large-scale use of high-strength steel with grade ratio of H 40, the weight level borne by ship components in the same scale is more than 30% higher than that of high-strength steel with grade H 32. It can be seen that the volume of building components can be effectively reduced on the basis of improving the shipbuilding size and design level by using a large number of high-strength steels of H 40. However, in order to make the ship structures of all

levels including steel, matching profiles and main supporting members have better stability, it is also necessary to control the size characteristics of building members reasonably. For the ship plate bearing in-plane axial load, the buckling limit calculation formula is as follows:

$$\sigma C = k_S \frac{\pi^2 Et^2}{12(1-\gamma^2)S^2} \ N/mm^2 \tag{2}$$

Where: KS is the boundary condition coefficient; E is the elastic modulus of the material; T is the thickness of the plate; γ is the Poisson's ratio of the material; S is the panel width.

3. Experimental Process of High Strength Structural Steel in Ship and Marine Engineering Structures

3.1. Model Composition of High Strength Structural Steel in Ship and Offshore Engineering Structure

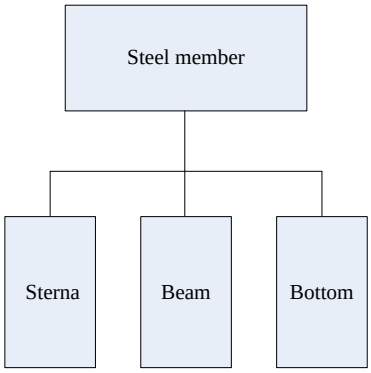

Figure 3. Steel member

The steel members in the ship structure are mainly composed of three parts (as shown in Fig. 3), namely, web, beam and bottom. In practical application, we need to design according to different specific situations. The hull is caused by the propeller. When the diesel engine works, it cannot be used normally due to factors such as high power or increased fuel pressure due to the influence of air resistance. At the same time, there are a series of problems such as a large amount of exhaust gas discharged into the atmosphere, which will cause adverse damage to the surrounding ecological environment and irreversible damage to the ship structure, which will cause deformation and damage to the steel members. In the ship structure, the connection between steel and steel plate is mainly realized by welding, and this method also has many disadvantages. For example, the welding needs to be operated with the help of the weld, and the surface quality of the workpiece is required to be high. Due to the use of ordinary low-carbon high-strength steel materials and special engineering plastic plates as marine profiles, such problems as poor adaptability to the environment, poor corrosion resistance and unstable wear resistance are caused. In the ship structure, steel is the main component, which has good tensile strength and good toughness. In addition, it can ensure that the hull can bear a certain weight and have enough space. High strength metal materials are widely used in offshore engineering structures due to their excellent performance, excellent mechanical properties and good weldability. At the same time, they also have some disadvantages, such as very low yield limit and toughness and brittleness. In use, it is necessary to improve its plastic deformation ability by strictly controlling the stress to meet the steel requirements and hull stiffness of ships and marine environment.

3.2. Quality Test of High Strength Structural Steel

When testing the steel quality, the main purpose is to understand the mechanical properties of the steel structure. First of all, we should check whether the materials of the selected specifications can meet the design requirements and test standards; Secondly, it is necessary to judge whether the component is reasonable and reliable by detecting its strength, yield and other indicators. Finally, it is also necessary to check whether the connector related to the test results meets the specified requirements. During the measurement, the most important thing is to test the quality control points and other relevant parameters. For example, the quality of steel is determined by the materials of the selected specifications. At the same time, it is necessary to strengthen the inspection of special equipment and the data recording and archiving management system related to the formulation and implementation of relevant technical specifications to ensure that all performance indicators of high-strength structural steel can meet the corresponding regulations and requirements, and effectively supervise and test the accuracy of the test results.

4. Experimental Analysis of High Strength Structural Steel in Ship and Marine Engineering Structures

4.1. Quality Test and Analysis of High Strength Structural Steel

Table 1 is the quality test data of high-strength structural steel.

Table 1. Steel quality test for high-strength structure

Test times	Extensibility (%)	Yield strength	Tensile strength
1	98	3	5
2	95	4	4
3	90	5	4
4	98	4	5
5	95	4	4

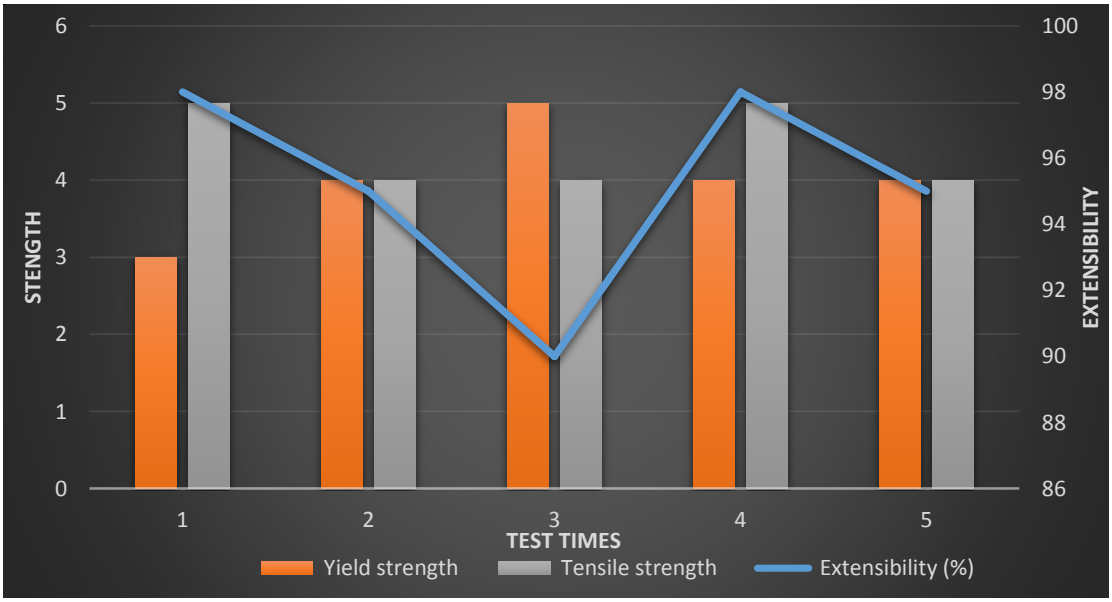

Figure 4. Quality of steel in ship and marine engineering structures

The quality inspection of high-strength structural steel is to comprehensively check its

performance and determine whether the materials used meet the design requirements, so as to ensure that the high-strength reinforcement has good mechanical properties on the ship deck. The hull and various components used in marine engineering are welded by high-quality steel plates. Therefore, when building the ship type, we should consider the actual situation and needs of the shipyard and select appropriate, advanced and reliable process methods that are easy to manufacture, assemble and weld for quality inspection. As for structural steel, it is mainly affected by corrosion environmental factors. It can be seen from Fig. 4 that the yield strength, tensile strength and elongation of high-strength structural steel are excellent and can meet the quality requirements of marine engineering.

5. Conclusion

In offshore engineering, structural steel is an important material, which is also the most widely used, mature and large-scale building material in China. This paper mainly introduces the problems of tight welding, bite and splicing between high-strength reinforcement and ship body. Through the comparative analysis of two different types of metals used by ships, it is concluded that with the increasing number of uses, bridges need to use more steels with better performance and higher quality. In the structure, it is necessary to ensure the corrosion resistance and hardness of components, and at the same time meet the requirements of the hull structure, with good economic benefits.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Slawomir Konrad Tadeja, Yupu Lu, Maciej Rydlewicz, Wojciech Rydlewicz, Tomasz Bubas, Per Ola Kristensson:Exploring gestural input for engineering surveys of real-life structures in virtual reality using photogrammetric 3D models. Multim. Tools Appl. 80(20): 31039-31058 (2021). https://doi.org/10.1007/s11042-021-10520-z

[2] Enrique Garc á-Mac ás, Rafael Castro-Triguero, Erick I. Saavedra Flores, Sergio J. Yanez, Karen Hinrechsen:An interactive computational strategy for teaching the analysis of silo structures in civil engineering. Comput. Appl. Eng. Educ. 27(4): 821-835 (2019). https://doi.org/10.1002/cae.22112

[3] Feng Tao, Tijun Fan, Kin Keung Lai:Inventory Management Under Power Structures With Consignment Contract Subject to Inventory Inaccuracy. IEEE Trans. Engineering Management 66(4): 763-773 (2019). https://doi.org/10.1109/TEM.2018.2850003

[4] Yichi Zhang, Denghua Zhong, Binping Wu, Tao Guan, Pan Yue, Han Wu:3D Parametric Modeling of Complex Geological Structures for Geotechnical Engineering of Dam Foundation

Based on T-Splines. Comput. Aided Civ. Infrastructure Eng. 33(7): 545-570 (2018). https://doi.org/10.1111/mice.12343

[5] Massimo Donelli, Federico Viani:Remote Inspection of the Structural Integrity of Engineering Structures and Materials With Passive MST Probes. IEEE Trans. Geosci. Remote. Sens. 55(12): 6756-6766 (2017). https://doi.org/10.1109/TGRS.2017.2734042

[6] Alan Smith, Rodrigo Sarlo:Automated extraction of structural beam lines and connections from point clouds of steel buildings. Comput. Aided Civ. Infrastructure Eng. 37(1): 110-125 (2022). https://doi.org/10.1111/mice.12699

[7] Paolo Cicconi, Vincenzo Castorani, Michele Germani, Marco Mandolini, Alessio Vita:A multi-objective sequential method for manufacturing cost and structural optimization of modular steel towers. Eng. Comput. 36(2): 475-497 (2020). https://doi.org/10.1007/s00366-019-00709-0

[8] Shahrin Mohammad, Tan Cher Siang, Sharifah Osman, Nurdiana Yasmin Jamaluddin, Nur Afiqah Mohamed Alfu, Lee Yeong Huei:A Proposed Heutagogy Framework for Structural Steel Design in Civil Engineering Curriculum. Int. J. Emerg. Technol. Learn. 14(24): 96-105 (2019). https://doi.org/10.3991/ijet.v14i24.12091

[9] P. P. Kapse, M. T. Telsang:Parametric investigation and optimisation of plasma arc cutting of structural steel St.52-3 using grey-based fuzzy algorithm. Int. J. Manuf. Res. 14(2): 179-197 (2019). https://doi.org/10.1504/IJMR.2019.100020

[10] Christopher John Steele, M. Mallar Chakravarty:Gray-matter structural variability in the human cerebellum: Lobule-specific differences across sex and hemisphere. NeuroImage 170: 164-173 (2018). https://doi.org/10.1016/j.neuroimage.2017.04.066

[11] Serdar Çarbas:Optimum structural design of spatial steel frames via biogeography-based optimization. Neural Comput. Appl. 28(6): 1525-1539 (2017). https://doi.org/10.1007/s00521-015-2167-6

[12] Vaughn R. Steele, Vikram Rao, Vince D. Calhoun, Kent A. Kiehl:Machine learning of structural magnetic resonance imaging predicts psychopathic traits in adolescent offenders. NeuroImage 145: 265-273 (2017). https://doi.org/10.1016/j.neuroimage.2015.12.013

[13] Nadia Pérot, Nicolas Bousquet:Functional Weibull-based models of steel fracture toughness for structural risk analysis: estimation and selection. Reliab. Eng. Syst. Saf. 165: 355-367 (2017). https://doi.org/10.1016/j.ress.2017.04.024

[14] Burak Efe, Ömer Faruk Efe, Alessio Ishizaka:A model proposal to examine the effects of ships to marine pollution in terms of internal and external factors. Soft Comput. 26(5): 2121-2134 (2022). https://doi.org/10.1007/s00500-021-06626-z

[15] Hiroyasu Kifune, Mehdi Karbalaye Zadeh, Hidetsugu Sasaki:Efficiency Estimation of Synchronous Generators for Marine Applications and Verification With Shop Trial Data and Real Ship Operation Data. IEEE Access 8: 195541-195550 (2020). https://doi.org/10.1109/ACCESS.2020.3033404

[16] Cagatay Kandemir, Metin Celik:A human reliability assessment of marine auxiliary machinery maintenance operations under ship PMS and maintenance 4.0 concepts. Cogn. Technol. Work. 22(3): 473-487 (2020). https://doi.org/10.1007/s10111-019-00590-3

[17] Soroush Azizi, Mohammad Hassan Asemani, Navid Vafamand, Saleh Mobayen, Afef Fekih:Adaptive Neural Network Linear Parameter-Varying Control of Shipboard Direct Current Microgrids. IEEE Access 10: 75825-75834 (2022). https://doi.org/10.1109/ACCESS.2022.3191385

[18] Simon Blindheim, Tor Arne Johansen:Electronic Navigational Charts for Visualization, Simulation, and Autonomous Ship Control. IEEE Access 10: 3716-3737 (2022). https://doi.org/10.1109/ACCESS.2021.3139767