Improvement of Nb Element on Reinforcement Properties

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ABSTRACT

Reinforcement bar is the main skeleton of building materials. In order to increase the strength and plasticity of reinforcing bar, Nb and V elements are added to reinforcing bar to refine grain size. Fine grain strengthening can improve the strength of reinforcing bar and also improve the plasticity and toughness of reinforcing bar. The strain produced by the external force is very small in the grain interior and grain boundary of fine grains, and the difference of phase transformation is very small, the deformation is relatively uniform, and the chance of cracking caused by stress concentration is small. Tensile test and metallographic, scanning and energy spectrum analysis are carried out on the seismic steel bar. It is concluded that adding Nb and V elements will make the strength of the steel bar. And the plasticity is improved.¹

KEY WORD

Nb And V Elements; Refine Grain Size; Seismic Steel Bar.

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INTRODUCTION

Modern buildings are mainly reinforced concrete structures. Reinforcement is the skeleton structure of reinforced concrete and plays a major role in buildings. In recent years, earthquakes, debris flows, floods and other natural disasters occur frequently in China. The occurrence of natural disasters brings not only economic losses but also a large number of casualties. Therefore, more attention has been paid to the seismic capacity of building structures. In the course of severe ground motion caused by earthquake, brittle concrete cracks, and then the steel bar at the crack of core concrete is subjected to huge local stress and strain. At this time, the fracture of the threaded steel is the cause of the catastrophic collapse of the whole building. Therefore, it is of great significance to systematically study the behavior of reinforcing bars from the perspective of seismic resistance. Mander and anthaki [1] point out that the longitudinal steel bar fracture caused by low cycle fatigue is one of the main failure modes under seismic load. There is an urgent need to improve the ability of buildings to withstand destructive disasters. High strength steel is the primary solution to the current problems. High strength steel bar has the advantages of safe energy storage, high strength and steel saving. The use of seismic reinforcement improves the seismic performance of buildings, and saves the use of steel, better responds to the national energy saving and emission reduction, high-strength seismic reinforcement has a broad development prospects. The yield strength of high strength steel bar is more than 400 MPa[2-3]. Not only the strength of high strength seismic steel bar is higher than that of ordinary steel bar, but also the strength yield ratio, plasticity and elongation of steel bar are better than that of ordinary steel bar.

MECHANICAL PROPERTY ANALYSIS

GB Requirements

The mechanical properties of HRB500E stipulated in GB1499.2-2018 "Steel for Reinforced Concrete Part 2: Hot Rolled Ribbed Bars" are as follows:

1. Yield strength is greater than 500 MPa.
2. Tensile strength is greater than 630 MPa.
3. The ratio of the measured tensile strength to the measured yield strength is not less than 1.25.
4. The ratio of the measured yield strength to the characteristic value of the yield strength specified in the standard is not more than 1.30.
The stress-strain curves of the three specimens are obtained through tensile tests. The analysis shows that the strain and stress of the three specimens are linearly correlated with the increase of stress at first. When the strain exceeds 0.02, a yield platform appears for the first and third specimens. With the increase of strain, the stress does not change significantly. Change. The stress of No. 2 specimen increases with the increase of strain until the steel bar yields completely and breaks.

Strain occurs when steel bars are subjected to stress. With the stress reaching the lower yield strength, the steel bars will have an obvious yield platform, that is, when the strain increases, the stress will not change significantly. This characteristic can effectively prevent the brittle fracture of steel bars, while the steel bars are plastic, it can produce obvious deformation, which can be achieved by deformation. Effective prevention of damage caused by personnel and property losses, play a very good early warning role. However, the No. 2 specimen did not produce a yield platform, and the damage was not symptomatic[4]. When the danger appeared, it did not warn, but fractured directly.

The lower yield strength and tensile strength of the three specimens all meet the requirements of the national standard, and can withstand a great deal of stress, and the tensile strength of No. 2 specimens is greater than that of No. 1 and No. 3 specimens. However, due to the No. 2 sample has no obvious warning effect, there will be a certain risk to the building, and it is an unqualified product[5].

Regulations on Chemical Composition of HRB500E Seismic Reinforcement Bar in the New National Standard
By dotting the grain boundaries of the three samples and analyzing the precipitates, the energy spectrum analysis of the three samples shows that niobium elements appear in the energy spectrum of the first and third samples, and niobium compounds can be formed. Because of the strong affinity between Nb and carbon, the stability of carbides formed is very high. It has a certain hindrance effect on the movement of grain boundary. The grain is not easy to grow, and the grain size is relatively small. Under the same force, the hindrance effect of fine grain is greater, and it is not easy to fracture. And there will be better elongation, so there will be obvious yield platforms for No. 1 and No. 3 specimens.
FINE GRAIN STRENGTHENING OF NB

1. The solute atoms adsorbed on the grain boundary can reduce the interfacial energy of the grain boundary, thus reducing the driving force of the interfacial movement and making the grain boundary difficult to move.

2. The most remarkable effect of Nb addition in high strength low alloy steel is the formation of strain-induced fine NbC and Nb (C,N) precipitates during hot deformation. These precipitates delay the recovery and recrystallization of deformed austenite (gamma) and increase the recrystallization stop temperature. During thermomechanical controlled processing, the equiaxed austenite grains are transformed into pancake grains with high density near-plane crystal defects by heavy deformation of austenite below TNR. These defects act as nucleation sites of ferrite and lead to grain refinement of ferrite. The interaction between strain-induced Nb (C,N) precipitation and austenite recrystallization during hot deformation and the subsequent TNR of Nb-containing steel have been extensively studied [6-8].

(1) NbC and Nb (C,N) precipitation during the phase transition from gamma to alpha during cooling treatment can provide precipitation strengthening [9-10].

(2) Nb and its precipitates in solution delay the growth of gamma-grains and inhibit the transformation of gamma to alpha, both of which contribute to grain refinement. Regardless of the deformation temperature and steel composition, the microstructures of the three steels are mainly polygonal ferrite (>70%) and the rest are composed of pearlite and bainite. Among the three steels, pearlite is lamellar with a certain distance between each piece. It can also be noted that for different types of deformation plans, the reduction of final cooling temperature results in the refinement of ferrite grains. Generally, it is predicted that the decrease of C content in Nb-microalloyed steel will reduce strain-induced Nb (C,N) precipitation, thus affecting ferrite grain refinement. However, it is noteworthy that, although the C content is significantly reduced, better ferrite grain refinement has been achieved in Nb microalloyed steel. Energy spectrum analysis of precipitates from the two steels shows that there are Nb peaks, which are expected to precipitate as Nb (C,N) [11] because Nb elements are trace in steel bars.

CONCLUSIONS

(1) The second phase of VN and NbFe precipitated from phase steel at high temperature is rich in N. With the decrease of temperature, the solid solubility of N in molten steel does not change much, but the solid solubility of V in VN steel bar is lower than that of N below 750 C, which greatly promotes the precipitation of V (C,N) particles. The "nose temperature" points of seismic steel bars with VN alloying elements are all around 870 C, while those with NbFe alloying elements are all above 1000 C. The larger the deformation, the higher the N mass fraction, the shorter the incubation period of V(C,N) and Nb(C,N) precipitation and the larger the precipitation amount. A certain proportion of NbFe and VN alloys increases the
precipitation behavior of the second phase. Under 50% deformation, the precipitated particles of VN steel are uniform, dispersive and circular at 870°C. NbFe steel bars have little and no obvious precipitation, so the heating temperature is higher in the steel bars containing Nb element. The precipitation particles of two different alloys are near dislocations.

(2) Due to the high solute and precipitation strengthening of Nb, the rheological stress of two kinds of Nb microalloyed steels is higher than that of ordinary steel bars under the same hot deformation conditions. The addition of Nb can effectively increase peak strain and steady strain, thus significantly delaying the occurrence of dynamic recrystallization. Because Nb mainly forms NbC or Nb(C,N) precipitates in steel, it is necessary to carefully select the carbon (C) content in steel. Generally, from the point of view of pipeline, Navy and structural steel application, low C content in the range of 0.07-0.10 wt% is preferred. However, further reduction of C content can be considered to improve ductility, toughness and weldability, reduce segregation during casting and improve hot workability of steel.

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REFERENCES

