A Primary School Teaching Building Aseismic Reinforcement Application Analysis

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Abstract. Xinjiang, as one of the high strength reinforced promote pilot provinces, application in high strength steel has made a lot of data and experience. Based on pilot cities of karamay high-strength steel promote pilot project high strength steel is analyzed, compared with 500 MPa and 400 MPa steel dosage and cost in the same project, this paper applied the advantages of high strength steel, and puts forward the problems existing in the application of high strength steel, are for reference only.

Introduction

In April 2012, the xinjiang uygur autonomous region lived built hall by the autonomous region application implementation scheme of high strength steel; Urumqi, karamay, korla popularization and application of high strength steel for autonomous region demonstration cities. After the three pilot cities, two pilot steel production enterprises, 54 pilot project promotion of production and application of high strength steel, has gained rich experience, achieve the expected goal.

In 2013, out of 235MPa grade light round steel and 335 MPa grade ribbed steel bar, with 300 mpa grade round bar instead of 235 mpa grade light round bar, preferred to use 400 MPa grade high strength ribbed steel bar, actively promote 500 MPa grade high strength ribbed steel bar. By 2015, to realize more than 400 MPa grade and high intensity of ribbed steel bar yield more than 80% of the total ribbed steel bar production, usage in the construction engineering construction ribbed reinforced by more than 65% of the total.

Cannes economy applicable room inside the village primary school is located in the green, is of high strength steel application demonstration project in xinjiang in 2012, one of the project building mechanical reinforcement using HPB500E reinforced, starting from the design, construction and other aspects of no. 1 teaching building of high strength reinforcement application situation carries on the analysis, for your reference.

The Project Summary

Green cannes primary school including 1# floor, 2# floor, and rain playground three parts, reinforced the total amount is 1645 t, among them, the level HRB500E reinforced total amount is 925 t, of reinforcing steel bar, 56.2% of the total consumption (shown in Table 1).

<table>
<thead>
<tr>
<th>Monomer</th>
<th>1 # Teaching building</th>
<th>1 # Teaching building</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction area (m²)</td>
<td>9746.5</td>
<td>15107</td>
<td>24853</td>
</tr>
<tr>
<td>Reinforced total amount (t)</td>
<td>615</td>
<td>1030</td>
<td>1645</td>
</tr>
<tr>
<td>Dosage of unilateral (kg/m²)</td>
<td>63.1</td>
<td>68.2</td>
<td>66.2</td>
</tr>
</tbody>
</table>

Among them, the floor of the 1# floor four, local two, construction area of 9746.5, the main function for the classroom, laboratory, computer room, the office of the report, the office, etc.. The main body is the frame structure, the seismic fortification intensity is 7 degree, the type of earthquake
resistance is the key fortification category, the frame anti earthquake grade is two, among which the big span frame aseismic grade is one class.

**Structural Design Features**

### Table 2. Structural design features.

<table>
<thead>
<tr>
<th>Project name</th>
<th>Main function of building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karamay Cannes Green Primary School of Engineering</td>
<td>Classroom, teaching and research section, office, report hall</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Construction site</th>
<th>Construction area (m²)</th>
<th>Geometry dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karamay District, Karamay City</td>
<td>9746.5</td>
<td>68.8m*67.9m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of main building</th>
<th>On the ground</th>
<th>Height</th>
<th>Reinforced concrete frame structure</th>
<th>Independent foundation under column</th>
<th>The main column(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>17.9m</td>
<td>Basic form</td>
<td>Foundation class</td>
<td>9.0-8.0</td>
</tr>
<tr>
<td></td>
<td>-underground</td>
<td>Height difference between indoor and outdoor</td>
<td>Natural foundation</td>
<td>Maximum span (m)</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6m</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Each layer is high</th>
<th>One-four-storey:4.5m</th>
</tr>
</thead>
</table>

### Main Engineering Materials

1. Concrete: # teaching building in this project the following parts of the ground floor, the foundation, the foundation of the beam, column, wall, slab of concrete grade C40, the ground part of the frame beam, frame column, floor concrete grade C35.

2. Reinforcement: Floor, frame beam, stirrup reinforcement frame column steel grade HPB300 steel frame beam and column, foundation and basement retaining wall, stair board reinforcement grade HRB500E steel.

### Engineering Design Analysis

Extension of the application of high-strength steel is: with 500MPa, 400MPa grade reinforcement to replace the HRB335MPa steel; the project adopted by the HRB500E, HRB400E level seismic reinforcement, in accordance with the following requirements:

1. The ratio of the measured value of the tensile strength and the yield strength of the A. longitudinal reinforcement should not be less than 1.25;
2. The ratio of the measured B. yield strength to the strength standard value should not be greater than 1.3;
3. The measured value of the total elongation at the maximum tensile strength of the C. steel bar shall not be less than 9%.

### Application of High Strength Steel Bar

1. Contrast principle: the monomer calculation of steel grade HRB500E steel in the design model, for HRB400 grade steel, other parameters unchanged; then the monomer design calculation model for reinforced HRB400 grade steel, replaced by HRB335 grade steel, other parameters unchanged;
2. Contrast method: only the upper body of the beam and column are compared, excluding the foundation and floor (house); the total beam, column with the longitudinal main reinforcement of steel were analyzed;
4. Contrast results
According to the 1# B area on the ground floor, longitudinal reinforcement by HRB335, HRB400E, HRB500E reinforcement calculation, stirrups are used HPB300 grade steel, beam and column reinforcement (excluding slab reinforcement) are analyzed as follows.

— Alternative comparison results of HRB400 steel bar used in engineering HRB500E

1) The total amount of beam and column reinforcement

\[
\frac{(400 \text{ grade reinforcement} - 500 \text{ grade reinforcement})}{400 \text{ grade reinforcement}} = 13.82\% \quad \text{(Formula 1)}
\]

2) The total amount of longitudinal reinforcement of beam and column

Beam: \[
\frac{(400 \text{ longitudinal reinforcement} - 500 \text{ longitudinal reinforcement})}{400 \text{ longitudinal reinforcement}} = 12\% \quad \text{(Formula 2)}
\]

Column: \[
\frac{(400 \text{ longitudinal reinforcement} - 500 \text{ longitudinal reinforcement})}{400 \text{ longitudinal reinforcement}} = 17.75\% \quad \text{(Formula 3)}
\]

The comparison results are shown in Table 3.

**Cost Analysis of High Strength Steel Bar**

This project is Xinjiang Bayi Iron and steel steel supply manufacturers Limited by Share Ltd, connecting sleeve supplier Hebei Hengshui new machinery equipment Co., Ltd. Zheng connected, can supply timely, meet the demand. According to the Karamay construction engineering cost management information price analysis that, HRB400 steel and HRB500 steel price difference between 100 yuan ~250 yuan, a difference of about 7.5%.

According to Table 2. Statistics, the project B zone HRB500 grade high-strength steel than HRB400 grade steel per square meter of savings of 4.2kg, saving ratio of 13.5%, cost savings of about 10 yuan/m²

**Table 3. Comparison of the dosage of high strength steel bar.**

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Contrast content</th>
<th>500EMPa</th>
<th>400MPa</th>
<th>Reinforcement dosage reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beam and column longitudinal reinforcement (t)</td>
<td>Beam</td>
<td>99.0</td>
<td>112.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Column</td>
<td>36.6</td>
<td>44.5</td>
</tr>
<tr>
<td>2</td>
<td>Total beam and column reinforcement (t)</td>
<td>135.3</td>
<td>157</td>
<td>13.82</td>
</tr>
<tr>
<td>3</td>
<td>Steel capacity per unit of construction area (kg/m²)</td>
<td>26.7</td>
<td>30.9</td>
<td>4.2</td>
</tr>
</tbody>
</table>

**Benefit Analysis of Using High Strength Steel Bar**

(1) Obvious economic benefits, 400MPa, 500 MPa and 1.2 steel strength was 1.45 times higher than 335MPa steel, prices were 1.03 times and 1.06 times of 335MPa steel, the ratio of performance to price is respectively 1.16 times and 1.37 times; the high-strength steel used in concrete structure, can ensure and improve the safety performance of the structure at the same time, reduce the area of reinforcement the amount of construction units. After considering the structural factors can reduce the amount of steel construction area of about 18% to 12%, according to the reinforcement of steel engineering to consider the amount of steel, civil engineering can save 20 yuan per square meter to 38 yuan. Therefore, the promotion and application of high strength steel reinforced its economic interests are very large.
(2) Reducing the rate of structural reinforcement and increasing the safety of the structure. According to the control capacity, can give full play to the benefits of high-strength steel, reduce structural reinforcement ratio, reduce steel row number, improve the efficiency of reinforced concrete beams, especially for large, public, high-rise buildings, large span, large column grid, using 500MPa reinforcement effect is more obvious.

A large number of components for structural reinforcement (such as seismic structural requirements, the basic structural requirements of members), according to the structural reinforcement, due to the use of high-strength steel, the increase in the structure of the safety reserve.

(3) reduction in the construction process of steel processing and transportation and installation.

1) per unit area of reinforcement ratio decreased, not only improves the efficiency of steel works, including (straightening, cutting, forming, thread processing (for mechanical connection), or welding, steel banding)

2) effectively reduce the number of people consumed and reinforced;
3) reduce on-site hoisting and installation, improve the efficiency of Jixietaiban

(4) to ensure the quality of rebar and the concrete pouring quality

1) is conducive to improve the quality of beam column joints of reinforced banding

2) is conducive to the concrete casting, to ensure the quality of concrete construction. At present a large number of beam column joints due to steel strength grade the low nodes caused by intensive steel, rebar difficult, concrete pouring can lead to concrete vibrator, the leader is not dense and affect the quality of the project.

Application of High Strength Reinforcement Should Pay Attention to the Problem

(1) With the increase of strength, the ductility of high strength steel is decreased accordingly. Ductility of steel bar is to ensure that an important aspect of structure and the seismic performance of steel concrete; at the same time, high strength steel with strength increases, the strong cuby decreases (especially the RRB), decreased in the seismic performance, seismic design, on the one or two, three frame aseismic grade and slope design support member, must meet the requirements of seismic performance of reinforced:

(2) The new requirements for the processing and connection of steel bars and the anchoring technology are put forward. The higher the procurement and quality inspection of steel, construction enterprises to improve the level of processing technology of high strength steel, high strength reinforced connection should actively use the mechanical connection technology, in order to reduce the anchorage length of steel bar should actively research and development and application of high strength reinforced mechanical anchoring technology. Advocate the reinforcement of professional processing and distribution, improve the processing efficiency of reinforcing steel bar, improve the processing quality, reduce the consumption of the construction site personnel, improve the utilization rate of steel bar, and reduce the waste of the site construction.

(3) The use of 500MPa reinforcement is not equal to improve the seismic performance. When the strength of reinforcement is increased, the ductility is reduced accordingly. While the ductility is an important aspect to ensure the seismic performance of concrete structural components, such as plastic hinge Liang Duan must rely on the ductility of steel bar. The seismic performance requirements, using 400MPa grade steel is the most appropriate, not simply that the high-strength steel can be put on the seismic performance of high concrete structure, seismic performance for the 500MPa reinforcement has yet to be studied.

(4) No occasion to blindly use 500MPa steel. 500MPa grade high strength steel should be applied to the member stress large, high-rise buildings, large span and heavy load column beam, control by member reinforcement bearing capacity, but also can be used for the large room floor.

500MPa grade high strength steel bars should not be used in the normal span frame structure of the longitudinal stress reinforcement, the ordinary span floor, the house in the shear wall. 500MPa grade
high strength steel should not be used as ordinary stirrup, but can be used for high-rise building column hoops (continuous spiral hoop, hoop welding).

(5) The new version of "concrete structure design code" advocate 400MPa as the main reinforcement, the promotion of 500MPa grade steel, 300MPa grade as auxiliary reinforcement. HRB, HRBF, RRB, -E reinforced concrete structure with the use of steel policy. Requirements of steel products standard with revision, the formation of 300MPa, 400MPa and 500MPa grade ribbed steel bar as the main body of reasonable reinforcement strength grading.

Conclusion

400MPa grade reinforced concrete structure of the main reinforcement, give full play to the characteristics of 400MPa grade high-strength steel, in the guarantee and improve the structural safety, can significantly reduce the amount of reinforcement than 335MPa steel. In the design, consideration should be given to give full play to the efficiency of high-strength steel, reduce the reinforcement ratio in ensuring the safety performance and reduce the original large component multi row steel reinforcing bars dense rows, improve the efficiency of reinforcement, for large public construction, high-rise building column, large column beam reinforced by 500MPa, the effect is very good.

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Wen-Ling Zhang, female, 1966, Xinjiang, Associate professor/Registered cost engineer, Research direction: Engineering cost and management.

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