DEVOTING MAJOR EFFORTS TO APPLICATION & DISSEMINATION OF 400 MPa Ⅲ GRADE REBAR

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1 Research & Production of 400 MPa Ⅲ Grade Rebar

Concrete structural components are widely used in the field of civil building while the rebar concrete is predominant in the domestic household construction. It is imperative to research & produce one kind of high-strength rebar with good comprehensive property. As for 260 MPa Ⅱ Grade rebar, the advanced countries have no longer produced nowadays. Our country is mainly adopting Ⅱ Grade and a small amount of 370 MPa Ⅲ Grade rebar. The countries in Europe and America, etc. are mainly making advantage of the micro-alloying technology to produce high-strength 400 MPa, 500 MPa Grade rebar with good comprehensive property (especially the weldability, including joint and its HAZ). The countries of U.K, Germany, Japan, Russia, etc. have applied tremendously 400 ~ 460 MPa Grade rebar.

From 1972 ~ 1976, in view of the problem that the intensity index of 16 Mn Ⅱ Grade rebar is not able to satisfy the requirement and the performance is not insured, we adjusted its chemical component to increase the element content of C, Si, and changed the steel grade as 20MnSi. More than 400 tons of the product have been used for project trial purpose with which the reaction of usage is not bad at all, and they have been continued to use all the time so far. Rebar of 370 MPa Ⅲ Grade with steel grade 25 MnSi is the original steel grade of the former Soviet Union which the intensity level was originally 40/60 level (YB171 - 69). Because of difficulty to reach the requirement of intensity level of rebar, it was decreased to the level of 38/58 (GB1499 - 79), and it is permissible to be supplied in 2 kg inferior to the standard. In 1983 when the subject of problem tackling of rebar was expounded, the gentlemen of Chinese Construction Scientific Research Institute pointed out that the performance of 25MnSi Ⅲ Grade rebar is not stable, and the intensity difference of Ⅱ, Ⅲ Grade is not varied. The weldability is not good, and also the pressure, tensile strength imposed are not in conformity as result of which rebar of 20MnSi Ⅱ Grade is applied remarkably in the household construction.

During the “Sixth - Five Year Plan” period, the national technology research on low-alloy steel aiming at the fact that the technological process for production of rebar was backward and the technical property could not reach the requirement, the research team had listed the subject of “Post - Rolling Waste Heat Treatment & Research of 410 MPa (42 kg grade) rebar for weldable rebar concrete by way of micro-alloying technique” into the objective of problem tackling. Under the coordination of the General Construction Research
Institute of the former Ministry of Metallurgical Industry and be participated by the companies as Angang, Capital Steel, No. 3 Plant of Shanghai Steel Works, Tanggang, Pangang, etc., the intensity of rebar and the property of product have been enhanced and improved by addition of V, Ti, Nb micro-alloy elements. Over 3 years effort, the steel grade successfully developed are: Angang, 20MnTi; Capital Steel, 20MnSiV; No.3 Plant of Shanghai Steel Works, K20MnSi; Tanggang, 21MnV(N); Pangang, 16MnSiV. When the standards admitted, steel grade of 20MnSiV, 20MnTi were admitted into GB1499-91 while K20MnSi into GB13014-91 standard. When test on trial, for the sake of distinguishing with the other grade rebar, it is called as 410 MPa (42 kg) new grade rebar, however it is named as 400 MPa III Grade rebar. It reached the same technical level of those in the countries of U.K, the United States, Japan, Germany, etc. after trial test on project and expert appraisal. It is also suitable for various kind of constructive process and is easily welded. \[ \frac{\sigma_b}{\sigma_s} \geq 1.15 \sim 1.25 \] where the stipulation of the upper limit value of \( \sigma_s \) is suitable for anti-seismic purpose and is quite advantage for buildings in the earthquake area. If comparing with II Grade rebar in the common rebar concrete structural project, steel product can be saved by 10% ~ 15% with which the safety space of the buildings is enhanced. It is of the notable social & economic benefit and has momentous significance to accelerate the development of the construction industry of our country.

Since the current (structural rules of rebar concrete) is still not fitted into the full play of new III Grade rebar intensity, the customer has not the operative evidence in practice so as that the newly developed product can not be easily applied and disseminated. Due to the fact that the design theory method and structural measure, etc. of how increase the applicable stress of rebar are urgent needed to go deeply into study by focal points, in this reason, in the scientific tackling of national low-alloy steel, the subject “410 MPa applicable technique study of weldable rebar” has been arranged in the tackling task during the “Seventh-Five Year Plan” period. By directing against the technical problems in structural design and application of the newly developed III Grade rebar in scientific research during the “Sixth-Five Year Plan”, the all round and systematic test on material property, weldability, performance of various kind of reinforcing structural parts and its structural measures, etc. have been made. Base upon this, the responsible unit of the task – the General Construction Research Institute under the former Ministry of Metallurgical Industry took a lead to draw up the (Applicable Technique Rules of Concrete Structure 400 MPa III – Grade Rebar) YB9072-93 (hereinafter called as Rules) in the year of 1993. The Rules had reflected the scientific achievement in an all-round way and solved a series of problems in engineering construction. Especially, the stipulation that the max. crevices width calculated based upon the international (Rules of Concrete Structural Design) to the reinforcing structural parts will not multiple the coefficient of 1.1 and make it possible to enhance the applicable stress of a plenty of the structural rebar. For the purpose of bringing the rebar strength into full play, the technical evidence for which 10% ~ 15% of steel product could be saved over the II Grade rebar has been provided. This (Rules) is indeed a effective achievements in scientific research. It evidenced the effective documents for the building structure, structure of high
storey buildings in the earthquake zone so as to change the situation where the appropriate steel product suitable for construction optional directly from the domestic market so far can not be found. Meanwhile, it speed up correspondingly the development of the constructive material industry (e.g. cement, concrete, etc.) to a higher strength (high grade), and play a strong driving role to change the prospects of building construction of our country.

2 Arduous Experience of Application & Dissemination of 400 MPa III Grade Rebar

The new products could not be in usage in long-term way after they were developed. There have been a plenty of reasons for the newly developed products not so easily to be promoted for use. In order to transform the scientific achievements acquired over 10 years tackling into productive forces and expedite the development of V, Ti, Nb steel, and also to speed up the reasonable structural adjustment of low-alloy steel product, as well as to accelerate the replacement with new generation to high technical level, entrusted by the Scientific & technical division of the former Ministry of Metallurgical Industry, the leading team of V – Ti steel of the former Ministry of Metallurgical Industry convened a symposium of application & dissemination as well as how to make connection with international market of 400 MPa III Grade rebar in the city of Chengdu of China in March of 1995. The gentlemen from the different fields had reached a common sense for the superiority of application & dissemination of 400 MPa III Grade rebar and the necessity of replacement with new generation, as well as the reasons why the products had not been yet spread out, etc. It was determined in the symposium that there were two things which must be dealt with.

(1) Try to persuade the two former Ministries, i.e. the Ministry of Metallurgical Industry and the Ministry of Construction Industry to issue jointly the document “Notice of Application & Dissemination of 400 MPa III Grade Rebar”.

(2) Expedite the relevant authorities to revise jointly the related standard and admit 400 MPa III Grade rebar into the national standard (the Rules of Concrete Structural Design) (hereinafter referred to as the Rules), and draw up the corresponding handbook of concrete structural design.

This is one of the vigorous measures to promote the above rebar. Having the standards, rules, handbook, the people will get to recognize, admit and eventually use them. Under the unremitting efforts made by the V – Ti steel working team, the former Ministry of Metallurgical Industry and the former Ministry of Construction Industry jointly issued the document on August 4th, 1995, and immediately after that, the symposium acquiring 400 MPa III Grade rebar be admitted into the national standard (the Rules) was held in Beijing on August 9th, 1995. The symposium determined: ① As for partial amendment of the national standard (the Rules) which admit the technical requirement of 400 MPa III Grade rebar, the working team of four persons coming respectively from the Constructive Structure Research Institute of Chinese National Academy of Sciences and the Project Structure Research Division of the General Constructive Research Institute of the former Ministry of Metallurgical Industry jointly undertook the responsibility for partial amendment of (the Rules). ② The detailed time table was that the revised first draft was required to be accomplished in the beginning of 1996 and sent to the related department for opinions. The amendments had to be
fulfilled around March ~ April of 1996, and the relevant experts were invited to attend the examining meeting for the partial revision of 《the Rules》 which was held in Chengdu. ③ Owing to the fact that there has not yet the precedent to subsidize to amend the national standard of 《the Rules》, thus the Ministry of Construction appropriate the expenditure of 20 000 RMB Yuan, the rest insufficient 50 000 RMB Yuan was aided by the awarding funds of V – Ti steel (the awarding funds was provided by Pangang). The working team intensified the amendment work, sent the revised draft to more than 200 units for comments and finished the task in due time. The examining meeting was held in Chengdu on April 7th, 1996. The report was submitted to the Ministry of Construction for approval, and the report was officially approved for issuance on July 29th.

The 《Rules》 which was longed for quite period of time was eventually enacted and this is extremely beneficial to the application & dissemination of this type of rebar. It is thus evident that how long and how much of vitality it is needed for a new type of steel from trial test, production to the application & dissemination! It is thus clear that the work of application & dissemination require the combined operation of the production and consumption units, making joint efforts and cooperating inseparably (the aid of outlay is certainly needed). Only after the corresponding 《Rules》 was established, the newly developed III Grade rebar could be put into the market at an earliest possible time and gave a full play in the constructive projects. It is impossible to have the current situation for application & dissemination of 400 MPa III Grade rebar without the energetic support in terms of manpower and material resources from Pangang.

### 3 Significance of Application & Dissemination of 400 MPa III Grade Rebar

(1) Application & dissemination of 400 MPa III Grade rebar is able to enhance the entire level of rebar used for construction, and benefit the nation and the people.

With the rapid development of construction industry, the requirement of the project structure of high - storey building, etc. for the rebar property is get higher and higher. The problem of anti - seismic work has provoked the common concerns. Presently, the various countries do not use basically the II Grade rebar. What our country used right now at most possible widespread and max. extent is totally the II Grade rebar, accounting for 80% of the total amounts, and the product of 20 MnSi has been owned solely by us. In the symposium of investigation of low - alloy steel, it is the common sense for the drawbacks as the followings: ① big size effect (small specs. good), performance unstable; ② slight higher CEV, bad welding performance; ③ low intensity, unreasonable winding; ④ elongation rate of strain aging ($\delta_s$) decreasing 20% ~ 29%; ⑤ $\sigma_p/\sigma_s$ being insufficient of 1.2. Therefore, it is imperative to vigorously promote the application of 400 MPa III Grade rebar. Comparing with II Grade rebar, the steel products can be saved by 10% ~ 15%, and this would not be an ignored wealth of society.

(2) Expediting the structural adjustment of low - alloy steel product

During the period of the “Ninth – Five Year Plan”, it is one of the important tasks of the former Ministry of Metallurgical Industry to adjust the structure of metallurgical product so as to satisfy the need of national economic development. It
played a decisive role for adjustment of the product structure of low-alloy steel. Why do we say so? Taking an example of how much tonnage of low-alloy steel occupying the total steel production in 1994, 1995, see the table 1.

The low-alloy steel with Chinese characteristics is basically composed of three main parts, namely: low-alloy high strength steel represented by 16Mn; low-alloy steel rebar for construction represented by 20MnSi; low-alloy steel rails represented by 71Mn.

<table>
<thead>
<tr>
<th>Year</th>
<th>Output (10,000t)</th>
<th>Ration of low-alloy/%</th>
<th>Ration of HSLA/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>9,561.27</td>
<td>20.95</td>
<td>3.7</td>
</tr>
<tr>
<td>1995</td>
<td>9,300</td>
<td>25</td>
<td>3.94</td>
</tr>
</tbody>
</table>

Let us take an example which shows the percentage of low-alloy high strength steel occupying in the total steel production in the foreign countries in 1994: the U.S.A 15%; Japan 12.8%; Germany 14.2%; Russia 13.4%; however, China less than 4%. It obviously differentiated greatly. It is thus clear that the tasks of adjustment of product structure are both arduous and formidable.

The rebar used for construction in our country is accounting for over 70% of the total low-alloy steel production, while the II Grade rebar is accounting for more than 80% of the total rebar production. It is said that the consumption of rebar for construction (excluding those used for bridges, ports, etc.) is 14 million tons, among them the gloss round rebar (including wire rod, etc.) amounting to 2.5 ~ 3.0 million tons; II Grade hot-rolling rebar 11 ~ 11.5 million tons; 370 MPa III Grade rebar with steel grade of 25 MnSi accounting very few for 5%.

Should it is possible to replace 50% of the II Grade rebar with 400 MPa III Grade rebar, as a consequence of that the product of V, Ti, Nb micro-alloying steel would be accounted for 30% of the low-alloy steel and undertook 6% of the total steel production of the country (currently the micro-alloying steel of V, Ti, Nb accounting for 2% of the total steel production as a whole). It is thus evident that it plays an important role for application & dissemination of 400 MPa III Grade rebar in the steps of speeding up of adjustment for the product structure of low-alloy steel and also in the structure adjustment of the metallurgical product.

(3) Application & dissemination of the 400 MPa III Grade rebar making possible to full play of V, Ti, Nb resources enriched in our country

There are famous iron ores like Baiyun Erbo iron ore (containing Nb, Re, . . . . . .) and Panzhihua V/Ti magnetite ore (containing V, Ti, . . . . . .) in our country. They are all the rare poly-metal associated ore. Currently, our country has become the export country of V product from the V importing country, while the metals of V, Ti, Nb, etc. are mainly used in the iron & steel industry. The application & dissemination of 400 MPa III Grade rebar will definitely require plenty of the metals like V, Ti, Nb, and certainly give impetus to the development of iron & steel industry.

(4) Adopting the 400 MPa III Grade rebar to speed up the connection with the international market and to accelerate the steps for blending the products into the international market

Even though it is not very rational for application & dissemination of 400 III Grade V - contained rebar in the domestic market, however, the exporting amount of V - contained slab and rebar is unceasing increased. The main export compa-
nies are: Pangang, Capital Steel, Chengde Steel Works, Hangzhou Steel Works, etc. The annual export amounts have reached above 100,000 tons over recent years. In 1995, Pangang exported billet for V-contained rebar up to 170,000 tons, while Hangzhou Steel Works exported more than 30,000 tons V-contained rebar. They have been all well accepted by the various countries in the Southeast Asia and the customers in Taiwan Province of P.R. China.

4 Conclusions

In a word, it should promote energetically the application of the 400 MPa III Grade rebar in such a manner that it would not only bring the resources of our country into full play so as to speed up the adjustment of metallurgical products, to stimulate the steel product for construction industry to higher level and the development of constructive material industry, but also realize truly the connection with the international market of our rebar products. This is a great work which is benefiting immediately while merits are in the centuries, and also benefit the nation and the people as well as bring benefit to the future generations.

Having the Rules in practice, hopefully it can be used boldly by the construction engineering department and make it to be substantial practiced at the earliest possible time. To bring the 400 MPa III Grade rebar into full play for application & dissemination, the perspectives mainly depends upon as well the followings: homogeneousness of material, excellent weldability, good plasticity and appropriate price, etc.. Hence, it is hoped that the producer will supply the qualified products with low cost so as to fit the demand of the construction industry.

Should we treat it actively and seriously, it is deeply believed that the application of the 400 MPa III Grade rebar will be surely used for the projects over the century.