Sub-standard rebars in the Indian market: An insight*

C.S. Viswanatha, L.N. Prasad, Radhakrishna and H.S. Nataraja

The use of sub-standard rebars has far-reaching repercussions as far as the quality and durability of a reinforced concrete structure is concerned. The authors, who had tested about 18,000 rebar samples during last two-and-a-half years, present some selected case studies of sub-standard rebars that are classified into six specific categories. It is concluded that since the standard and sub-standard rebars look alike, proper verification of the source and requisite properties of the rebars are highly essential.

Rebars and cement are the two vital components in any reinforced concrete (RC) construction. The safety and durability of concrete structures is directly dependent on the quality of rebars and/or concrete. Quite often, in the Indian market, we come across sub-standard rebars. The problem today has become acute with sub-standard rebars causing considerable anxiety.

The products in rebar market today include the following main varieties.

(i) Cold twisted deformed (CTD) rebars
(ii) Thermo-processed (TMT) rebars
(iii) Torsteel rebars
(iv) TOR-KARI rebars
(v) Corrosion resistant (CRS) rebars
(vi) Stainless steel rebars, and
(vii) Coated rebars — either galvanised or epoxy coated

The first two obviously form the major portion of the rebar market and hence the present discussion is confined to these varieties.

The thermo processing technique (TMT) is essentially “controlled water cooling” of rebars by passing them through specially-designed quenching tubes. To get optimum benefits, the quenching is precisely controlled by appropriate adjustments in temperature and volume of water in the quenching tubes. The strength of rebars, after they are quenched, increases from about 250 to 420 N/mm². In contrast to this, in case of CTD rebars, the rebars are twisted to predetermined pitch, wherein the strength level again gets enhanced from about 250 to 420 N/mm².

There have been continuous attempts by many concerned to ensure that defective and sub-standard rebars do not find a place in the market. However, these have not been totally successful.

The defects which are generally observed in rebars from the market are:

(i) underweight
(ii) defective geometry (over sized ribs and lugs or worn out ribs and lugs)
(iii) rolling defects
(iv) twisting defects, and
(v) defects due to production from defective raw material (pipings and inclusions).

Either by visual observation or by a bit of experience, one can easily identify such rebars. Such rebars can be addressed as ‘Defective rebars’.

While producing rebars, if standard methods of production are not adopted, whatever the reasons may be, it results in sub-standard rebars. Such rebars are distinctively

*First published in the The Indian Concrete Journal, January 2004, Vol. 78, No. 1, pp. 52-55. Republished for reader interest with the kind permission of The Indian Concrete Journal.
different from defective rebars. It is generally not possible to make out by mere physical observations whether any rebar is standard or sub-standard. Both standard and sub-standard rebars look alike, thus misguiding the users.

Sub-standard rebars

In the course of last two and a half years, about 18,000 rebar samples, sent by various consumers, have been tested in Torsteel laboratories at Bangalore, Chennai and Hyderabad in accordance with stipulations in Indian Standards — IS 1608 : 1995 and IS 1786 : 1985 (reaffirmed 2000). The physical and chemical properties assessed included:

(i) 0.2 percent proof stress,
(ii) tensile strength
(iii) percentage elongation
(iv) type of fracture, and
(v) carbon content.

A statistical analysis showed that about 8 percent of the tested rebars came under the category of defective and sub-standard rebars, and about 1/3 of this 8 percent, were sub-standard rebars. This is considered to be very high percentage in view of the structural risks encountered in constructions with such rebars. Even about 0.5 percent is considered to be a very high and risky figure, since every rebar in a structure is directly responsible for the safety and/or durability of the structure.

In TMT rebars, generally, it is the strength that suffers on sub-standard production, whereas in CTD rebars, it is the ductility.

The sub-standard rebars that were tested can be classified into six specific categories. These categories are:

(i) TMT rebars with low carbon content
(ii) TMT rebars (?) quenched in water tank
(iii) TMT rebars with inadequate quenching in cooling tubes

Table 1: Properties of various rebars

<table>
<thead>
<tr>
<th>Sample</th>
<th>A TMT rebar with low carbon content</th>
<th>B TMT rebar quenched in water tank</th>
<th>C TMT rebar with improper quenching</th>
<th>D TMT rebar without quenching</th>
<th>E CTD rebar with hot twisting</th>
<th>F High carbon CTD rebar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Fe 415 TMT rebar</td>
<td>rerolling unit</td>
<td>rerolling unit</td>
<td>rerolling unit</td>
<td>rerolling unit</td>
<td>rerolling unit</td>
</tr>
<tr>
<td>Diameter, mm</td>
<td>12 10 16</td>
<td>10 12 12</td>
<td>10 12 12</td>
<td>8 10 12</td>
<td>25</td>
<td>16 20 28</td>
</tr>
<tr>
<td>Weight/kg, m</td>
<td>0.864 0.595 1.543</td>
<td>0.596 0.857 0.871</td>
<td>0.601 0.900 0.860</td>
<td>0.386 0.584 0.887</td>
<td>3.786</td>
<td>1.559 2.464 4.838</td>
</tr>
<tr>
<td>0.2 percent proof stress, N/mm²</td>
<td>340 352 366</td>
<td>595</td>
<td>363 375 390</td>
<td>278 291 270</td>
<td>365</td>
<td>587 550 590</td>
</tr>
<tr>
<td>Tensile strength, N/mm²</td>
<td>451 462 475</td>
<td>710 694 645</td>
<td>468 487 480</td>
<td>462 450 430</td>
<td>460</td>
<td>665 610 684</td>
</tr>
<tr>
<td>Elongation percent (over 5d)</td>
<td>36 34 32</td>
<td>2.5 3.9 4.7</td>
<td>38 40 32</td>
<td>44 40 38</td>
<td>18</td>
<td>11.0 8.5 9.3</td>
</tr>
<tr>
<td>Type of fracture</td>
<td>Ductile Ductile Ductile</td>
<td>Brittle Brittle Brittle</td>
<td>Ductile Ductile Ductile</td>
<td>Ductile Ductile Ductile</td>
<td>Ductile Brittle Brittle</td>
<td></td>
</tr>
<tr>
<td>Carbon content, percent</td>
<td>0.12 0.12 0.14</td>
<td>0.20 0.22 0.23</td>
<td>0.21 0.19 0.23</td>
<td>0.17 0.20 0.19</td>
<td>0.20</td>
<td>0.32 0.34 0.32</td>
</tr>
</tbody>
</table>

*PS: Proof stress; *TS: Tensile strength

Fig 1 Close-up of two sub-standard TMT rebars tested

Fig 2 TMT rebar quenched in water tank: Typical brittle fracture
TMT rebars with low carbon content

Case studies

The reduction in proof and tensile strengths is essentially due to the low carbon content. The thermo-mechanical treatment has not been totally effective. These rebars are classified as sub-standard rebars in view of the fact that the proof and tensile strengths are not up to the desired levels. But the rebars looked like standard rebars.

TMT rebars quenched in water tank

Table 1(B) and Fig 2 illustrate the results of the testing of three samples in this category.

Remarks

The brittle fracture and very low percent elongation were conspicuous. It could be ascertained that at the manufacturing sources, thermo-mechanical treatment facility had not been installed and information revealed that rebars were being led directly to water tank after the finishing stand.

TMT rebars with inadequate quenching in cooling tubes

Table 1(C) and Fig 3 illustrate three samples in this category.

Remarks

The proof and tensile strengths are not up to the desired levels. But, the rebars looked like standard rebars. At the manufacturing unit itself.

Whenever there was a doubt about quality, attempts were made with all seriousness to identify the source of the problem.

(iv) TMT rebars (?) with no quenching at all

(v) CTD rebars – hot twisted, and

(vi) CTD rebars with high carbon content.

**Fig 3 TMT rebars that are inadequately quenched**

**Fig 4 Stress strain diagram (normal and sub-standard TMT bars)**

**Fig 5 TMT rebars with very low proof and tensile strengths**

**Fig 6 Typical hot-twisted rebar**
manufacturing sources, it could be ascertained that, thermo-
mechanical treatment facility was available, but was not totally func-
tional.

*Fig 4* shows typical stress-strain curves of the above men-
tioned sub-standard TMT rebars.

**TMT rebars with no quenching at all**

*Table 1(D)* and *Fig 5* illustrate three samples in this category.

**Remarks**

The proof and tensile strengths are very low compared to the desired levels. Investigation revealed that untwisted deformed rebars or non-treated bars were being marketed as TMT rebars by the manufacturing units. The rebars looked like standard TMT rebars.

**CTD rebar – hot twisted**

*Table 1(E)* and *Fig 6* illustrate one sample in this category.

**Remarks**

Inspite of the carbon content and degree of twisting being ideal, the 0.2 percent proof stress has dropped down. An examination at the manufacturing source revealed that hot rebars were being twisted due to excessive demand. The rebar looked like a standard rebar inspite of being sub-standard. Only when cold rebars are twisted, the desired strength levels can be realised.

**CTD rebars with high carbon content**

*Table 1(F)* and *Fig 7* illustrate three samples in this category.

**Remarks**

The insignificant difference between 0.2 percent proof stress and tensile strength, low elongation and brittle fracture were causes of concern. The problem could be traced to the high carbon content in the rebars. But at the outset, the rebars looked like standard rebars. Use of such rebars in structures is risky.

**Concluding remarks**

Sub-standard rebars are a matter of serious concern. Safety and durability of structures with such rebars are in doubt.

Reinforcing bars are elusive. Standard or sub-standard, they look alike.

It is advisable that any engineer should accept rebars only after proper verification of the source and the requisite properties, however big or small, the consignments are. This is of greater relevance today than yesterday.

**References**

1. ______Internal reports from Torsteel Research Foundation In India, Bangalore

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