CHOOSING RIGHT STEEL

ISSUE 1 :: IS 550 MPa STEEL DESIRABLE?

FACTS ON SCRUTINY

Let us refer to stress – strain behaviour of steel and reiterate our common engineering knowledge that:

(a) Permanent deformation happens in steel only after increase in stress beyond yield point.

(b) When yield point is passed during application of stress (loading), the stress (load) removed, and, the specimen tested again, the specimen shows a behaviour that would be very different from the original one. It would demonstrate a permanent deformation or “permanent set” as if the material has been stretched in comparison to its original configuration. The stress – strain curve would duly reflect this by way of a new yield point when the “set” sample is tested again.

(c) When loading is carried beyond yield, “strain hardening” takes effect. This “strain hardening” or “work hardening” is nothing but the process of loading mild steel beyond its yield point and releasing the deforming load. When reloaded (tested) again, the linear elastic behaviour now extends up to a new yield point, substantially higher than the earlier yield point as may be seen from the graphs.

(d) A fallout of the effect of cold working is loss in ductility, i.e. the material will lose a part of its elasticity. This is expressed by way of lower elongation. The test specimen after cold work displays properties similar to brittle material.

(e) Cold working therefore induces increase in yield and tensile strength while reducing the elongation of steel.

(f) Roll forming (profiling is achieved through roll forming process) happens only when metal is stressed beyond its yield point to impart permanent deformation to achieve the shape of the profile. Every effect of cold working i.e. strain hardening, increase in yield and tensile strength and reduction in ductility (elongation) are therefore all equally applicable through the process of roll forming. In effect, therefore, for already strain hardened steel, like 550 MPa steel, to be effectively roll-formed, the forming stresses need to exceed the yield point i.e. forming stresses need to be in excess of 550 MPa or, rather, exceed the actual yield strength of the material. The actual yield strength has been often found to exceed 700 MPa. The brittle nature of high tensile material is also fraught with danger, as roll forming stress beyond the yield of the material quite often leads to ultimate failure i.e. the material developing cracks in the roll forming line itself. Such cracks, although negligible to the naked eye initially, manifest themselves when erection loads or other imposed loads act upon the sheets.

(g) Check on profiles made of so-called high tensile steel have established beyond doubt that the integrity of profile is conspicuous by its absence i.e. different sheets from same manufacturer and same profile show different geometry for depth, overall and covered width from batch to batch. This is only following laws of physics, as at different points of time, materials of varying yield is available, so also the profiled output will have varying dimensions and will not snugly fit into each other. This is attributable to the different "spring back" effects generated for different strengths leading to varying distortions in the profile after it leaves the shear cut-off when roll forming stresses do not exceed the yield of material and only partial deformation can happen.
THEREFORE, for high tensile steel, one can either have a cracked sheet, or, have different geometry of sheets for the same profile at different times. The second part works as long as one is not required to match sheets from one batch of materials to some other batch at a different point of time.

(h) The nature of the material is accepted and laid down as such in the standards too. That cold work brings about YS and UTS to almost overlap [thereby signifying that the material is nearly brittle] is clear from the strength requirements in the standards themselves.

![Figure 1. The engineering stress-strain curve](image)

<table>
<thead>
<tr>
<th>Steel grade designation</th>
<th>Min. yield strength (Note 1) MPa</th>
<th>Min. tensile strength MPa</th>
<th>Min. elongation, % (Note 2)</th>
<th>Angle of bend degrees</th>
<th>Diameter of mandrel in terms of test piece thickness (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G250</td>
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<td>320</td>
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<td>180</td>
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<td>20</td>
<td>180</td>
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<tr>
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<td>420</td>
<td>15</td>
<td>180</td>
<td>2t</td>
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<td>480</td>
<td>10</td>
<td>90</td>
<td>4t</td>
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<td>G500 (Note 4)</td>
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<td>520</td>
<td>8</td>
<td>90</td>
<td>6t</td>
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<tr>
<td>G550 (Note 5)</td>
<td>550</td>
<td>550</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

NOTES:
1. The yield strength is the lower yield stress. If well-defined yielding is not obvious, the 0.2% proof stress should be determined.
2. Applies to test pieces equal to or greater than 0.6 mm thick. 
   $L_o =$ original gauge length.
3. Applies to hard-rolled material equal to or greater than 1.50 mm thick.
4. Applies to hard-rolled material between 1.00 mm and 1.50 mm thick.
5. Applies to hard-rolled material up to and including 1.00 mm thick; the values of yield strength, 0.2% proof stress and tensile strength are, for practical purposes, the same.

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The requirements for elongation at NIL and 2% significantly denote the brittleness of the material. Overlap of yield and tensile strengths are also significant.
FACTS ON SCRUTINY

The load bearing of sheeting depends not only on strength of material but also on the deflection under load. The cold roll formed steel draws its advantage from the residual stresses developed by the cold work. As we have just investigated, no advantage on roll forming strength is available for 550 MPa steel as it has already been stressed to its maximum limits in imparting the 550 MPa strength.

The properties that determine load bearing capacity and deflection under loading are section modulus and moment of inertia respectively. The calculation for these properties in cold formed section are governed by provisions of IS 801. Here, yield strength of material is a divisor in the property calculations, i.e. the higher the yield strength of input material, the lower will be the section modulus and moment of inertia of the profile. This is as per laws of physics and our findings hereinbefore. The greater the yield of input, the lower will be the effect of further roll forming and hence the residual stresses retained in the section after roll forming will be lower. Therefore, the property of the cold worked section will also be lower compared to more elastic material that can retain cold forming stresses much better.

The properties of one of the most commonly used sheeting profile 32 mm X 195 mm (pitch) may be taken for illustrating this point.

The section modulus for 0.50 mm thick sheet in 350 MPa steel (the world's most commonly used steel for sheeting) is 3.26 cm³ (top) and its deflection moment of inertia is 7.76 cm⁴, both per metre width of sheet.

The same properties for 0.50 mm thick sheet in 550 MPa steel are 2.56 cm³ and 6.30 cm⁴ respectively.

Although theoretically due to higher yield, the load carrying capacity increases, the deflection capacity reduces as allowable deflection is 5/384 times WL³ / EI. With reduction in value of I, the allowable deflection will reduce in proportion to reduction of I value, i.e. we need to in fact reduce spacing for maintaining deflection parameters when using 550 MPa steel.

HENCE, ADDITIONAL LOADING POSSIBILITY WITH 550 MPa STEEL IS MISLEADING.

In fact, except for countries influenced by a particular manufacturer, all enlightened and technically advanced countries 350 MPa is the most commonly used steel for all sheeting, cladding and wall applications.