

# Study on Behaviour of MS, CTD & TMT Steel Bars

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**ABSTRACT:** Concrete is very strong in compression but comparatively weak in tension. Steel is very strong in tension and provides tensile strength to concrete. The thermal expansion for both steel and concrete are approximately the same. This along with excellent bendability property makes steel the best material for reinforcement in concrete structures.

Since the invention of R.C.C in 1867, Mild steel was being used as reinforcing material. Plain mild steel (M.S) rebar of grade Fe-250 were used till 1960. Later on the high strength cold twisted deformed (CTD) bars were produced by cold working process.

The yield stress of CTD bars are 415 MPa against 250 MPa of M.S rebars. Though the chemical compositions of M.S & CTD bars are same but the physical strength of CTD bars are 60% higher than the M.S steel bars.

TMT (Thermo mechanically treated) bars were introduced in India during 1980-1985. TMT bars are having an optimum combination of high strength, ductility, bendability and other desirable properties.

Now a days most of steel companies in India like SAIL, TISCO and RINL are producing Fe-500 or 550 grade of TMT bars and not Fe-415 grade of steel bars. If a bridge requires consumption of 1000 tons of M.S. reinforcement for its construction and it is constructed with TMT bars in place of M.S bars, the net consumption will be only 400 tons.

**KEYWORDS:** Material properties, Tensile strength, Mild Steel, TMT, CTD.

## I. INTRODUCTION

It is not exactly known when steel or iron was invented but it is widely believed that they were in use since 2000 B.C. in south west or central Asia. In India the iron pillar near Qutub Minar Delhi a 7.5 meter high and weighing more than 6 metric ton, structure is at least 1600 years old, though some historian believe it to be 2300 years old.

Cement was invented and patented by Joseph Aspdien of Portland, U.K in the years 1824. He burnt ground limestone and clay together, to produce a compound which we know as cement today. With the invention of cement, concrete a mixture of cement, sand stone chips and water came into existence and artificial stone of required shape and strength started to be made.

R.C.C. was invented and patented by Joseph Monier of France in the year 1867. Monier was a gardener who faced problems with flower pots built out of clay and wood. Initially he built flower pots and small water storage tank with concrete reinforced with iron or steel mesh for gardening purposes. Later on he also built pipes, roof slab, water reservoirs, culverts and small bridges out of R.C.C.

He had no formal knowledge of technology behind R.C.C structures. Subsequently knowledge of strength and design procedure was developed gradually by different engineers. Now R.C.C is the most useful and commonly used construction material, as this can be constructed in required strength and shapes in situ. No other construction material such as soil, natural stone, wood, stone or bricks has so much of flexibility, strength and reliability.

Steel is the time proven match for reinforced concrete structures. Reinforced concrete structure is designed on the principle that steel and concrete act together to withstand induced forces. Concrete is very strong in compression but comparatively weak in tension. Steel is very strong in tension and provides tensile strength to concrete. The properties of thermal expansion for both steel and concrete are approximately the same; this along with excellent bendability

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property makes steel the best material for reinforcement in concrete structure. Another reason steel works effectively as reinforcement is that it bonds well with concrete.

Since the invention of R.C.C in 1867, Mild steel was being used as reinforced material. In India, construction of reinforced concrete building structures started about 100 years back when a four storied framed R.C.C building was Constructed for hostel of Victoria jubilee Technical Institute Bombay in year 1907, with mild steel as reinforcement. Plain mild steel (MS) rebars of Grade Fe-250 were used widely till about 1960. As there was demand to raise yield strength of reinforcing bars, the high yield strength was first imparted to the rebars by raising carbon as well as manganese content or by micro alloying which was a costly proposition. Now the high strength cold twisted deformed (CTD) bars are produced by cold working process, which is basically a mechanical process. Red hot M.S bars after passing through the last rolling stand are cut into required length and allowed to cool down at ambient temperature. It is held at both ends and twisted to required increased yield strength. CTD round rebars having yield strength in the range of 415 MPa (Grade Fe-415) were introduced in 1960 since then; there has been an increasing demand for high strength deformed bars.



Fig. (1) M.S. bars

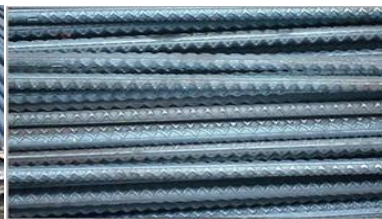


Fig. 2(a) C.T.D. bars



Fig. 2(b) T.M.T. bars

## II. MATERIAL PROPERTIES

Typical stress strain curve of monotonically loaded (tension) mild steel rebar is shown in Fig 3(a). The curves exhibit an initial elastic portion, a yield plateau (that is, a yield point beyond which the strain increases with little or no increase in stress), a strain hardening range in which stress again increases with strain, and finally a range in which the stress drops off until fracture occurs. The slope of the linear elastic portion of the curve represents the modulus of elasticity of steel. The stress at the yield point, referred as the yield strength, is a very important property of steel reinforcement. Reinforcement is generally characterized by its yield strength.

Stress-strain curves of the steel in compression and tension are considered to be the same. In case of mild steel, yielding sometimes is accompanied by an abrupt decrease in stress, and the stress-strain diagram has two stress (yield) levels, which are marked as A and B in Fig 3(a). Points A and B are referred as upper and lower yield strengths respectively. The position of the upper yield point depends on the speed of testing, the shape of the section and the form of the specimen. The lower yield strength is usually considered as the true characteristic of the material and simply referred as yield strength, which is around 250 MPa for mild steel rebars.

In cold working (stretching and twisting) process, the mild steel bar is subjected to repeated loading. The steel will follow a similar linear elastic path, as that of original mild steel till it reaches the point where unloading started, which becomes the new yield point, Fig 3(b). The cold working of steel can cause the shortening of the yield plateau or even eliminating it completely. Desired increase in yield strength is achieved by appropriate selection of unloading point Fig 3(b). This is why high strength bars generally do not exhibit definite yield strength as that in case of mild steel. Fig 3(c) presents a typical stress strain curve of cold twisted high strength rebar. Cold working process is simple, reliable as well as cost effective, but reduces elongation of rebar compared to mild steel. In India most of the high strength deformed bars are manufactured by cold working process. CTD bars does not exhibit specific yield point and 0.2 percent proof stress is taken as yield strength, Fig 3(c).

Stress – strain curve of TMT bars is similar to that for MS bars, Fig 3(d). But in case of TMT bars, there are no distinct yield plateau and two yield points.

The actual yield strength of the rebar is usually some what higher than that considered in design. The specified yield strength normally refers to a guaranteed minimum value of the yield strength–lower yield strength in case of mild steel rebar. Fatigue strength of reinforcement depends on its yield strength and rebars having higher fatigue strength have better capability of withstanding dynamic loads.

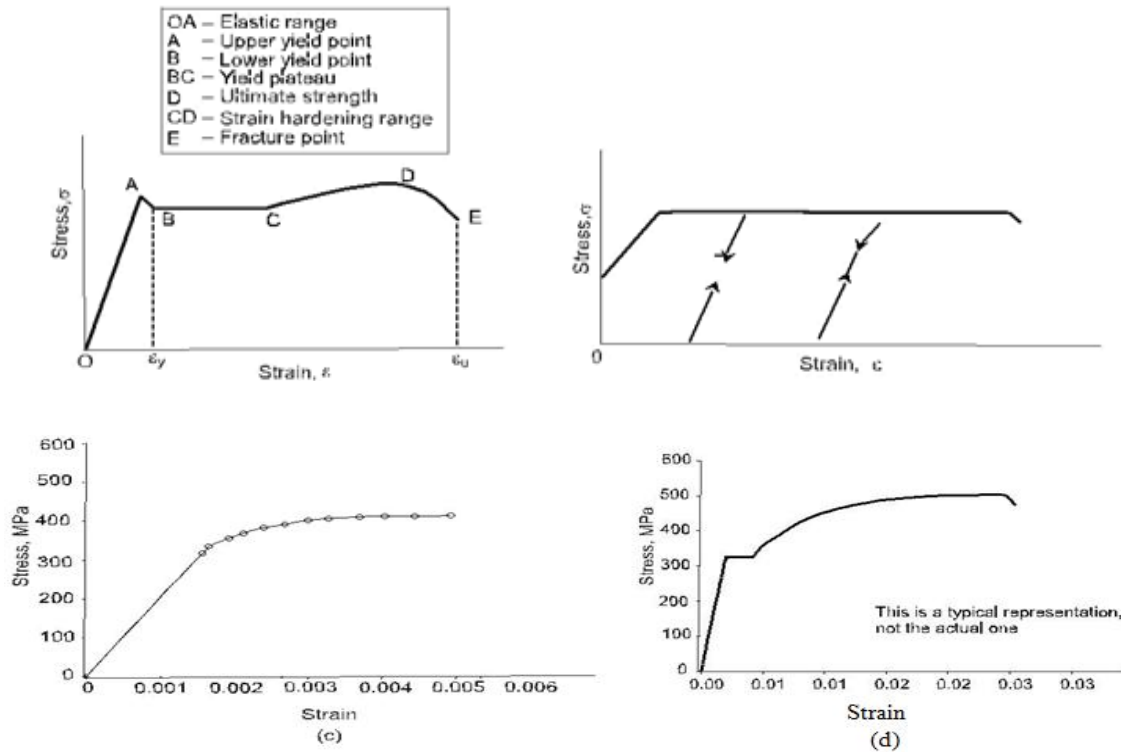
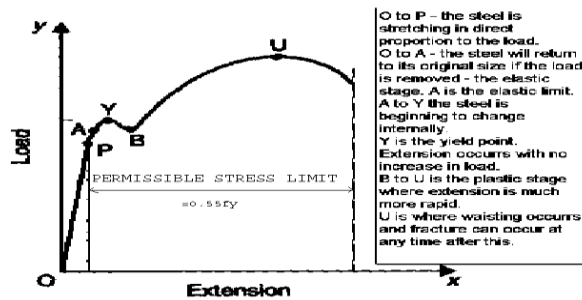


Fig 3: Typical stress strain curve for (a) mild steel (c) CTD bar (d) TMT bar.

### III. RESULT & DISCUSSION

Minimum yield stress of CTD bars are 415 MPa against 250 MPa of M.S rebars. Through the chemical composition of M.S and CTD bars are same, physical strength of CTD bars are 60% higher than the M.S. steel bars. Permissible tensile stress of reinforcing steel bars as per IS 456-2000 is adapted as  $0.55f_y$ . Hence permissible stress of M.S bars work out to  $0.55 \times 250 = 137.5$ , which is adapted as 140. Permissible stress of CTD bars work out to  $0.55 \times 415 = 228.5$  which is rounded off and adapted as  $230 \text{ N/mm}^2$ .

Permissible stress of TMT bars for Fe 415 grade, work out to  $0.55 \times 415 = 228.5$  which is rounded off and adapted as  $230 \text{ N/mm}^2$ .



Typical load - extension graph for mild steel.

From above it can be seen that permissible stress of CTD bars increased to 230 MPa from 140 MPa of chemically same M.S bars. This ensured an increase of more than 60% in permissible stress of reinforcing bars. In physical term, use of

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CTD bars ensured 60% less consumption of steel as compare to M.S bars. This was a great advantage and use of CTD bars became an instant hit. It almost completely replaced use of M.S reinforcing bars in Reinforced concrete construction.

As the tensile strength of rebars increased in comparison to M.S bars, it required more bond strength between concrete and steel to prevent slippage. To meet these requirement producers of CTD and TMT bars introduced raised projection as cross ribs on transverse side of steel bars. This ensured high bond strength between steel and concrete. For this end IS-456 stipulated 25% more bond stress in case of use of high yield strength rebars as compared to plain M.S bars

CTD bars however suffered from one disability as it became harder than mildsteel during twisting operation and its ductility property reduced. Elongation at breaking point of CTD bars reduced to 14% as compared to 24% of Mild steel. Many times cracks appeared on outer surface of CTD bars while making hooks. It was considered not very suitable to face reversal of stresses an in case of machine foundation or high rise structures subjected to earthquake or strong wind. In such situation it was likely to develop cracks, as such scientists and engineers were trying to find a method to increase yield stress of mild steel without twisting. Development of TMT bars are result of such research and requirement.

TMT steel bars are a new generation of steel bars for concrete reinforcement which is very widely used in present day construction work. Earlier CTD bars i.e cold twisted deformed bars were being used. Prior to that M.S or mild steel bars were in use for R.C.C (reinforced cement concrete) construction works.

#### IV. CONCLUSION

Thermo mechanically treated (TMT) bars were introduced in India during 1980-1985. Thermo mechanical treatment is an advance heat treatment process in which red hot bars coming out of last rolling mill stand are rapidly quenched through a series of water jets. Rapid quenching provides intensive cooling of surface resulting in the bars having hardened surface at top, while core remained red hot. The rebars are then allowed to cool in ambient conditions. During the course of such slow cooling, the heat released from core tempers the hardened surface while core is turned into ferrite-pearlite aggregate composition. TMT process thus changes the structure material to a composite structure of ductile ferrite-pearlite composition with tough surface rim of tempered marten site providing an optimum combination of high strength, ductility, bendability and other desirable properties. Ductility of TMT bars are same as that of mild steel Hence it is very suitable for making hooks, vibrating structures subjected to reversible stresses as in case of machine foundation and for high rise structures subjected to strong earthquake and wind forces. TMT bars of grade Fe-415, Fe500 and Fe550 are now available in India. Most of steel companies in India like SAIL, TISCO and RINL are now a days producing Fe500 or 550 grade of TMT bars and not Fe-415 grade of steel bars. Design Engineers should accordingly make calculations and drawings taking actual strength of steel into account. If a bridge requires consumption of 1000 tons of M.S reinforcement for its construction, and it is constructed with TMT bars in place of M.S bars, the net saving in consumption of steel shall be 600tons. In terms of money the saving will be around Rs: 3,00,00,000 taking steel prices as Rs:50,000/t. This way lot of economy is achieved in construction.



Fig 4: Vidya sagar setu at kolkatta used tmt bars for construction

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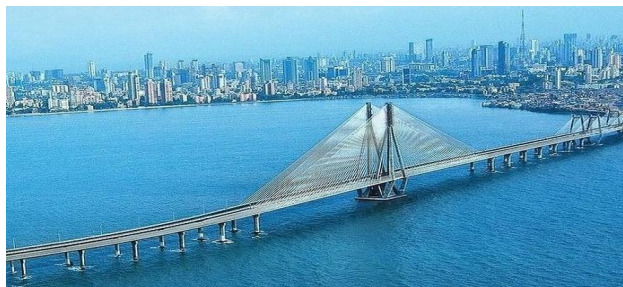


Fig 5: Bandra worli sea link in mumbai used tmt bars for construction

## V. FUTURE SCOPE

It is expected that in coming days, big steel bar producing company may go further for high grade TMT bars like Fe-600 to Fe-650, which will be having high strength, ductility, bendability and other desirable properties.

## REFERENCE

- [1] Stuart tapping, 1940. The early use of Reinforced concrete in India, April 1940.
- [2] Prof. Joseph S. Spoeri, A brief history of Iron and Steel production.
- [3] Dr. Prabir C. Basu, Ms. Shyalmoni P, Mr. Roshan. D Brief overview of Mechanics of R.C. structures, 2004. Indian concrete Journal-January 2004.
- [4] Prof. P.C Varghese, 2005. Building Materials-2005.
- [5] Bureau of Indian standard Codes IS 456-2000, IS 1786-1985.
- [6] Iron Pillar at Delhi, Retrieved by Wikipedia.