CE 415
DESIGN OF STEEL STRUCTURES

LECTURE 12
MIDTERM REVIEW (CONT.)

SEMESTER: SUMMER 2020

COURSE TEACHER: SAURAV BARUA

CONTACT NO: +8801715334075

EMAIL: saurav.ce@diu.edu.bd

OUTLINE

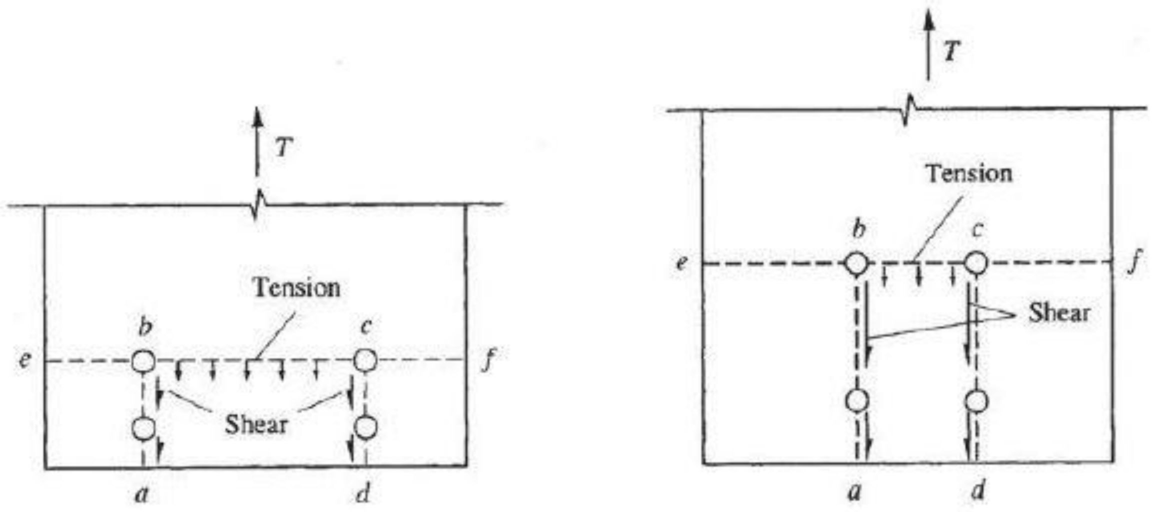
- MIDTERM SYLLABUS

LECTURE 1 (16.5.20) – LECTURE 7 (13.6.20)

MARKS 25 MARKS

  - 2 questions with a (Math), b and c (theory type) segments
  - Time 2hr
  - No alternatives options

Block Shear Failure



Large tension, small shear

Large shear, small tension

AISC-J4.3. defines two block shear failure modes:

1. **Rupture along the tensile plane (b-c** in left fig.) **accompanied by** yielding **along the shear planes** (a-b **and c-d** in left fig.).
2. **Rupture along the** shear planes (a-b and **c-d right fig.) accompanied** by **rupture** along **the tensile** plane **(b-c in right fig.)**.

Block Shear Strength

The tensile failure is defined by *rupture along the net area* in both modes,

The failure along the shear planes can either be
***Rupture along the net shear area* or**
***Yield along the gross shear area*, whichever is smaller.**

Consistent with the limit states discussed earlier, the *gross area* is used for the yielding limit state and the *net area* is used for the fracture limit state.

Following the energy-of-distortion theory,

- **Shear yield stress τ_y is taken as $0.6F_y$**
- **Shear strength/rupture τ_u is taken as $0.6F_u$**

The nominal block shear strength T_n in tension

Shear yielding - tension rupture ($\tau_y A_{gv} < \tau_u A_{nv}$) or ($0.6F_y A_{gv} < 0.6F_u A_{nv}$)

$$T_n = 0.6F_y A_{gv} + F_u U_{bs} A_{nt}$$

Shear fracture - tension rupture ($\tau_y A_{gv} \geq \tau_u A_{nv}$) or ($0.6F_y A_{gv} \geq 0.6F_u A_{nv}$)

$$T_n = 0.6F_u A_{nv} + F_u U_{bs} A_{nt}$$

where

A_{gv} : gross area acted upon by shear
A_n : net area acted upon by tension
A_{nv} : net area acted upon by shear
F_u : specified (ASTM) minimum tensile strength
F_y : specified (ASTM) minimum yield stress

When the tension stress is uniform, use $U_{bs} = 1$, where the tension is non-uniform use $U_{bs} = 0.5$.

RESIDUAL STRESS IN STEEL SECTIONS

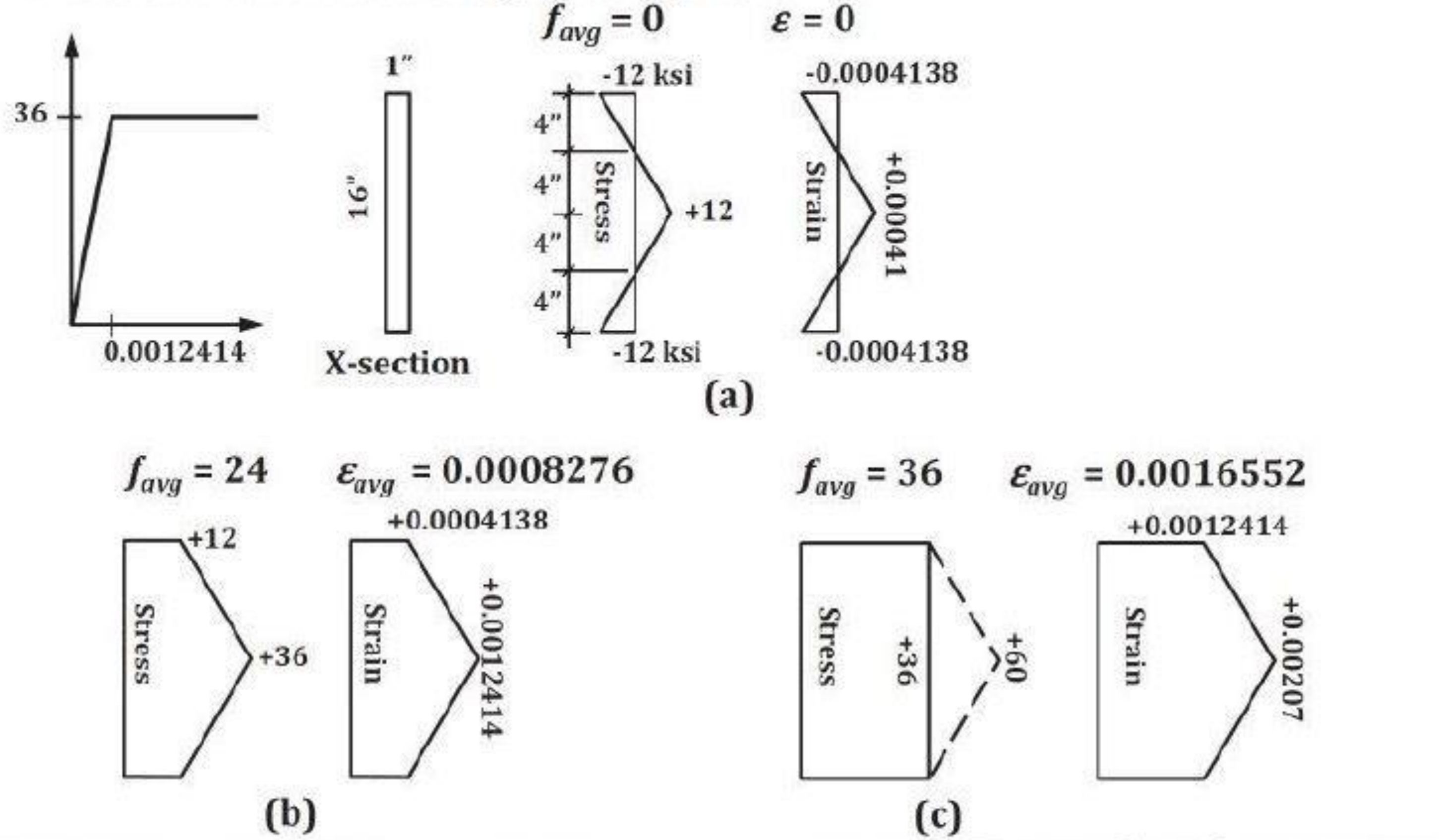
Residual stresses are self balancing stresses that remain in a member without application of load after it has been formed/rolled into a finished product.

<u>Sources of residual stresses:</u>

- ❑ Uneven cooling which occurs after hot rolling of structural shapes
- ❑ Cold bending or cambering during fabrication
- ❑ Punching of holes and cutting operations during fabrication
- ❑ Welding

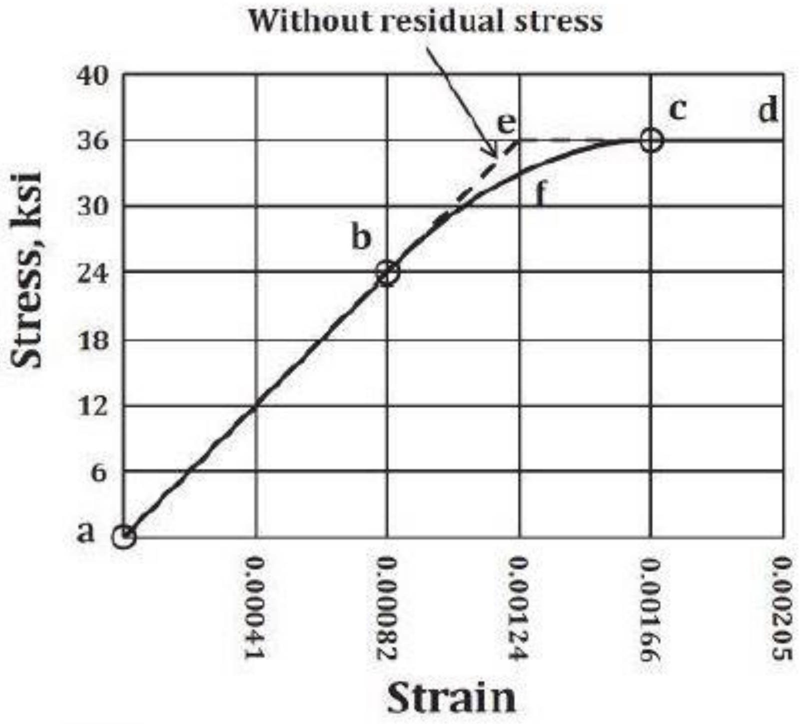
Average tensile stress-strain relation of a 16"x1" x-section flat bar having residual stress.

Distribution of residual stress and stain are shown in Fig. (A) when no external force acts. The bar is then gradually pulled.



RESIDUAL STRESS IN STEEL SECTIONS

Average tensile stress-strain relation of a 16"x1" x-section flat bar having residual stress.



Due to presence of residual stress/strain the average stress-strain behavior follows path a-b-f-c-d

If there was no residual stress then the path would be a-b-e-c-d

How calculate strain at 12 ksi stress?

Equation of Stress-Strain Curve:

Up to point b, the stress-strain relation is linear. After c, the curve is flat. The transition from b to c can be covered by one parabolic curve as follows:

$f = k_1\varepsilon^2 + k_2\varepsilon + k_3$ Here, f is stress and ε is strain.

The constants k_1, k_2 and k_3 can be found from three conditions:

1) At b, $df/d\varepsilon = E = 29000$, when $\varepsilon = 0.0008276$ where E is the Young's modulus.
2) At b, $f = 24$ when $\varepsilon = 0.0008276$
3) At c, $f = 36$ when $\varepsilon = 0.0016552$

Now, $df/d\varepsilon = 2k_1\varepsilon + k_2$, $\therefore$ from (1), $2k_1(0.0008276) + k_2 = 29000$ ----(1)

From (2), $k_1(0.0008276)^2 + k_2(0.0008276) + k_3 = 24.0$ -----(2)

From (3), $k_1(0.0016552)^2 + k_2(0.0016552) + k_3 = 36.0$ ------(3)

Solving the above three,

$k_1 = -17520833.3$, $k_2 = +58000.48$, $k_3 = -12$

Therefore,

$f = +29000\varepsilon$ for $0 \le \varepsilon \le 0.008276$ [portion a-b]

$f = -17520833.3\varepsilon^2 + 58000.48\,\varepsilon - 12$ for $0.008276 \le \varepsilon \le 0.0016552$ [portion b-f-c]

$f = +36$ for $\varepsilon \ge 0.0016552$

Check: ideally at c, $df/d\varepsilon = 0$

Check at e, $df/d\varepsilon = 2(-17520833.3)(0.0016552) + 58000.48$

$= -0.49 \rightarrow$ very small compared to $E = 29000 \rightarrow$ OK.