Sec A Q no 1 ID # 7549

Design Philosophies

A general statment assuming safety in engineering design

Resistance (of material and X-section) ≥ effect of applied load ---(1)

In eq(1) it is essential that both sides are evaluated for same condition e.g if effect of load is to produce compressive stress on soil then it should be compared with bearing capacity of soil

When particular loading reaches its limit failure is the assumed result, i.e the loading condition become failure modes, such a condition is refferred to as limit state and it can be defined as

* A limit state is condition beyond which a structural system or a structural component ceases to fulfill the function for which it is designed

ASD

Safety in the design is obtained by specifying that the effect of the load should produce stresses that is a fraction of the yield stress f_y say one half

This is equivalent to

$$FOS = \text{Resistance},\ R / \text{effect of load } Q$$

$$= f_y / 0.5 f_y$$

$$= 2$$

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Mathematical Description of ASD

$$\frac{\phi R_n}{\gamma} \geq \sum Q_i$$

R_n = Resistance or strength of the component being designed

ϕ = Resistance factor or strength Reduction factor

γ = Overload or load factors

$\frac{\gamma}{\phi}$ = Factor of Safety F_s

Q_i = Effect of applied loads

Advantages of ASD

* elastic analysis for load become Compatible for design

* Old fam book are according to the method

* Experienced engineers are used to this method

* In past It was the any method for design purpose

* This method is included in AISC-05 specification as an alternate method.

Disadvantages of ASD

* Implied the ASD method is the assumption that the stress in the member is zero before any load are applied i-e no residual stress exist from forming the member

LRFD

- To overcome the deficiencies of ASD, the LRFD method is based on : Strength of material
- It consider the variability not only in resistance but also in the effect of load
- It provides measure of safety related to probability of failure.
- Safety in the design is obtained by specifiying that the reduced nominal strength of designed structure is less than the effect of factored loads acting on the structure $\phi R_n \geq n \Sigma \gamma Q_i$

R_n = Resistance or Strength of the Component being designed

Q_i = Effect of Applied load

η = Takes into account ductility, redundancy and Operational imp

Φ = Resistance Factor or Strength Reduction Factor

γ = Overload or load factors

$\frac{\gamma}{\varphi}$ = Factor of Safety.

Advantages:-
- LRFD account for both variability in resistance and load
- It achieves fairly uniform levels of Safety for different limit state

Disadvantages:-

It's disadvantage is change is design Philosophy from previous method

Q no 2

Slip - Critical Connections

- Connection transmits the force by Friction produced between the faying Surface by the clamping of the bolts
- Slip-critical Connection are recommended for joints Subjected to Stress reversal, severe Stress fluctuation, impact, vibration or where slip is objectionable

- Slip critical Connection become bearing type Connection after slip occurs so every slip Critical Connection is essentially a bearing type Connection also.

Bearing type Connections

~~Load type Connection~~ - load is transferred by Shearing and bearing on bolt

- Capacity in Shear depend on whether Shear plan intersects the body of bolt or threaded portion.

- Bearing type Connection is the most widely used general type Connection in which the load is resisted by the bolt body without any Friction btw Faying Surface

Types of failure

Shearing Failure of Bolts

The Shear Stress in the bolt may exceed the working shear stress in the bolt shear stress are generated become the plates slip due to applied force

Bearing Failure of Plate

The plate may be crushed when the bearing stress in the plate exceeds the working bearing stress

Tearing Failure at the edge of Plate

The tensile stress in the plate at the net cross-section may exceed the working tensile stress, tearing failure occurs when bolts are stronger than the plate.

Shearing failure of Plate

Transverse tension Failure

Q no 3

Given Data

Dead load = 130
Live load = 265 k
Section = C10 x 30
Gusset plate = 1 in
Bolt diameter = 3/4 in
A325, A36
three bolt lines

Required

No of bolts = ?

Capacity using ASD = ?

Sol:- ① Finding total service load

= 130 + 265 = 395 kips

② Bolts Design.

For 3/4 dia

Area = 0.4418 in² nominal Area
Fv = 30 ksi (Shear stress of bolt in single Shear table 11)

Rv = 0.4418 x 30

Rv = 13.25 kips / shear surface (resistance offered by a single in shear)

As there are two shear surface per bolt

no of bolt = $\frac{395}{2 \times 13.25}$ = 14.90 ≈ 15 bolt

③ Bearing

$F_p = 1.2 f_u$ (specification allowable stress)

$F_p = 1.2 \times 58$
$F_p = 69.6$ ksi

⇒ $L_e = 1\frac{1}{2} d$
$L = 3d$ [Table 2-9]

Channel

$R_p = d t F_p = \frac{3}{4} \times 0.673 \times 69.6$

$R_p = 35.13$ kips (single bearing surface of channel)

For bolts there are 30 bearing surface so;

Capacity = 30 × 35.13

= 1053 > 395 kips (OK)

Gusset plate:

$R_p = d t F_p$

$R_p = \frac{3}{4} \times 1 \times 69.6$

$R_p = 52.2$ kips

For Gusset plate there are 15 bearing Surface So;

Capacity = 15 x 52.2

= 783 > 395 kips OK

4. Spacing

End distance Sheared Edg = 1 1/4 minimum

End distance = 1 1/2 d = 1.13 in ≤ 1 1/4 in (Table 2-8 and 2-9)

Center to Center = 3d = 2 1/4 in

As we can see that Rp for both Channel and Gusset plate is considerably greater than required Consider minimum end distance of 1 1/4 in and the minimum between connection spacing of 2 in

$$le = \frac{2P}{fut} = 1.25 \quad \left[\begin{array}{l} t = 0.673 \\ \text{from Table 1-5} \\ \text{AISI Manual} \end{array} \right]$$

$$\frac{2P}{58 \times 0.673} = 1.25$$

$$P = 24.41 \text{kips}$$

$$L = \frac{2P}{fut} + \frac{d}{2}$$

$$2 = \frac{2P}{58 \times 0.673} + \frac{3/4}{2}$$

$P = 31.7 \text{ kips}$

Capacity $= 2(3\times(24.4) + 12(31.7))$

Capacity $= 907.2 > 395$ kips (OK)

Gusset

$$L_e = \frac{2P}{F_u t} \Rightarrow 1.25 = \frac{2P}{58\times 1}$$

$P = 36.25$ kips

$L = 36.25$ kips

$$L = \frac{2P}{F_u t} + \frac{d}{2} \Rightarrow 2 = \frac{2P}{58\times 1} + \frac{3/4}{2}$$

$P = 47.13$ kips

Capacity $= 3\times(36.25) + 12(47.13))$

Capacity $= 674.31 > 395$ kips (OK)

So use 15 bolt in 3 rows of five with end distance $1\frac{1}{4}$ in and center to center spacing of 2 in