Assignment 10

Q1

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# Design of Tension Member (IS 800:2007)
# ---------------- INPUT SECTION ----------------
Tu = float(input("Enter the value of ultimate tensile load Tu (kN): "))
fy = float(input("Enter the value of yield strength of steel fy (MPa): "))
fu = float(input("Enter the value of ultimate strength of steel fu (MPa): "))
fub = float(input("Enter the value of ultimate strength of bolt fub (MPa): "))
Gamma_m0 = float(input("Enter the value of partial factor of safety Gamma_m0: "))
Gamma_m1 = float(input("Enter the value of partial factor of safety Gamma_m1: "))
Gamma_mb = float(input("Enter the value of partial factor of safety Gamma_mb: "))
# ---------------- GROSS AREA ----------------
print("\n--- Gross Area Required ---")
Agreq = 1.1 * Tu * 1000 / fy
print("The gross area required is:", 1.2 * Agreq)
# Section Selection (example ISA 100x65x8)
Ag = float(input("Enter the value of gross area Ag of steel section (mm^2): "))
Lcl = float(input("Enter the length of connected leg Lcl (mm): "))
Lol = float(input("Enter the length of outstand leg Lol (mm): "))
t = float(input("Enter the thickness t (mm): "))
# ---------------- BOLTED CONNECTION ----------------
print("\n--- Design of Connections ---")
d = float(input("Enter the nominal diameter of bolt d (mm): "))
do = d + 2  # diameter of bolt hole
print("The diameter of bolt hole is:", do)
# Minimum pitch distance as per IS code
pmin = 2.5 * d
print("The minimum pitch is:", pmin)
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# Edge distance as per IS code
e = 1.5 * do
print("The edge distance is:", e)
nn = int(input("Number of shear planes with threads intercepting shear plane: "))
ns = int(input("Number of shear planes without threads: "))
# Net area of bolt
Anb = 0.78 * (3.1416/4) * d * d
print("Threaded area of bolt (Anb):", Anb)
Asb = 0.7854 * d * d
print("Shank area of bolt (Asb):", Asb)
# Shear capacity of bolt
Vdsb = (fub / (1.732 * Gamma_mb)) * (nn * Anb + ns * Asb) * 1e-3
print("Shear capacity of bolt Vdsb (kN):", Vdsb)
# Bearing strength factors
kb1 = e / (3 * do)
print("Kb1:", kb1)
kb2 = (pmin / (3 * do)) - 0.25
print("Kb2:", kb2)
kb3 = fub / fu
print("Kb3:", kb3)
kb4 = 1
print("Kb4:", kb4)
kb = min(kb1, kb2, kb3, kb4)
print("Kb (governing value):", kb)
# Bearing capacity of bolt
Vdpb = (2.5 * kb * d * t * fu * 1e-3) / Gamma_mb
print("Bearing capacity of bolt Vdpb (kN):", Vdpb)
# Design strength of bolt
Vd = min(Vdsb, Vdpb)
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print("Design strength of bolt Vd (kN):", Vd)
# Number of bolts required
N = Tu / Vd
print("Number of bolts required:", N)
N = int(input("Enter the actual number of bolts provided: "))
# ---------- STRENGTH CHECKS ----------
print("\n--- Strength Checks ---")
# 1. Yielding of Gross Section
Tdg = (Ag * fy * 1e-3) / Gamma_m0
print("Tensile strength (Yielding of gross section) Tdg (kN):", Tdg)
# 2. Rupture of Critical Section
Anc = (Lcl - (t/2) - do) * t
print("Net Area of Connecting leg (Anc):", Anc)
Ago = (Lol - (t/2)) * t
print("Gross Area of Outstand leg (Ago):", Ago)
Lc = (N - 1) * pmin
print("Shear Lag distance Lc (mm):", Lc)
bs = 0.6 * Lcl + Lol
print("Shear lag width bs (mm):", bs)
Beta = (fy/fu) * (bs/Lc) if Lc > 0 else 1.0
if Beta > 1.4:
Beta = 1.4
print("Beta factor:", Beta)
Tdn = (0.9 * fu * Anc / Gamma_m1) * 1e-3 + (Beta * Ago * fy / Gamma_m0) * 1e-3
print("Tensile strength due to rupture of critical section Tdn (kN):", Tdn)
# 3. Block Shear
Avg = (pmin * (N - 1) + e) * t
print("Shear area Avg (mm^2):", Avg)
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Avn = ((pmin * (N - 1) + e) - (N - 1) * do + 0.5 * do) * t
print("Net shear area Avn (mm^2):", Avn)
Atg = Lcl * t
print("Gross tension area Atg (mm^2):", Atg)
Atn = (Lcl - 0.5 * do) * t
print("Net tension area Atn (mm^2):", Atn)
Tb1 = (((Avg * fy) / (1.732 * Gamma_m0)) + (0.9 * fu * Atn) / Gamma_m1) * 1e-3
print("Block shear strength (mode 1) Tb1 (kN):", Tb1)
Tb2 = ((0.9 * Avn * fu) / (1.732 * Gamma_m1) + (Atg * fy) / Gamma_m0) * 1e-3
print("Block shear strength (mode 2) Tb2 (kN):", Tb2)
Tb = min(Tb1, Tb2)
print("Block shear strength Tb (kN):", Tb)
# Governing Strength
Td = min(Tdg, Tdn, Tb)
print("Design tensile strength of section Td (kN):", Td)
# ---------- SAFETY CHECK ----------
if Td > Tu:
print("\n ✅ SAFE: Section is adequate")
else:
print("\n ❌ NOT SAFE: Revise the Section")
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output-

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Enter the value of ultimate tensile load Tu (kN): 225
Enter the value of yield strength of steel fy (MPa): 250
Enter the value of ultimate strength of steel fu (MPa): 410
Enter the value of ultimate strength of bolt fub (MPa): 400
Enter the value of partial factor of safety Gamma_m0: 1.1
Enter the value of partial factor of safety Gamma_m1: 1.25
Enter the value of partial factor of safety Gamma_mb: 1.25
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--- Gross Area Required ---

The gross area required is: 1188.0

Enter the value of gross area Ag of steel section (mm^2): 1257

Enter the length of connected leg Lcl (mm): 100

Enter the length of outstand leg Lol (mm): 65

Enter the thickness t (mm): 8

--- Design of Connections ---

Enter the nominal diameter of bolt d (mm): 20

The diameter of bolt hole is: 22.0

The minimum pitch is: 50.0

The edge distance is: 33.0

Number of shear planes with threads intercepting shear plane: 1

Number of shear planes without threads: 0

Threaded area of bolt (Anb): 245.0448

Shank area of bolt (Asb): 314.16

Shear capacity of bolt Vdsb (kN): 45.273866050808316

Kb1: 0.5

Kb2: 0.5075757575757576

Kb3: 0.975609756097561

Kb4: 1

Kb (governing value): 0.5

Bearing capacity of bolt Vdpb (kN): 65.6

Design strength of bolt Vd (kN): 45.273866050808316

Number of bolts required: 4.969754510195687

Enter the actual number of bolts provided: 5

--- Strength Checks ---

Tensile strength (Yielding of gross section) Tdg (kN): 285.6818181818182

Net Area of Connecting leg (Anc): 592.0

Gross Area of Outstand leg (Ago): 488.0

Shear Lag distance Lc (mm): 200.0

Shear lag width bs (mm): 1.0

Beta factor: 0.38109756097560976

Tensile strength due to rupture of critical section Tdn (kN): 217.0255840354767

Shear area Avg (mm^2): 1864.0

Net shear area Avn (mm^2): 1248.0

Gross tension area Atg (mm^2): 800.0

Net tension area Atn (mm^2): 712.0

Block shear strength (mode 1) Tb1 (kN): 454.776143439009

Block shear strength (mode 2) Tb2 (kN): 394.525803065295

Block shear strength Tb (kN): 394.525803065295

Design tensile strength of section Td (kN): 217.0255840354767

❌ NOT SAFE: Revise the Section