vKalc Calculation Editor Examples *(v1.0)*

Dark Valley Software

Calculation Examples

The following pages will demonstrate the capabilities of *vKalc* through a series of short and varied calculations.

The final calculation is much more detailed and demonstrates the complete design of a reinforced concrete beam.

Contents

Compound Interest Calculation

Principal sum;	$P_i = 15000\$$
Annual percentage rate (*APR*);	$r = 4.875\%$
Compound monthly;	$n = 12$; times per year
Full term;	$t_m = 7.5$; years
Total amount accrued over term;	$A_{tm} = P_i \times (1 + r / n)^{(n \times tm)} = \underline{21605}\$$
Total interest accrued over term;	$I_{tm} = A_{tm} - P_i = \underline{6605}\$$

Day Trading Calculation

Trading account fund;	$P_0 = 40000\$$
Maximum risk on this trade;	$risk = 1\%$
Available funds for this trade;	$P_t = P_0 \times risk = \underline{400}\$$
Current stock price;	$sp_{buy} = 15\$$
Target sale price;	$sp_{sell} = 19\$$
Potential win per share;	$win = sp_{sell} - sp_{buy} = \underline{4}\$$
For a 2:1 *win:loss* risk;	$loss = win / 2 = \underline{2}\$$
Set stop loss;	$sp_{stop} = sp_{buy} - loss = \underline{13}\$$
Max share size can trade;	$P_t / loss = \underline{200}$;shares

Terminal Velocity Calculation

Mass of a tennis ball;	$m_{ball} = 58g$
Diameter of a tennis ball;	$D_{ball} = 6.70cm$
Projected cross-sectional area;	$A_{ball} = \pi D_{ball}^2 / 4 = \underline{35.3}cm^2$
Drag coefficient (sphere);	$C_{drag} = 0.47$
Density of air;	$\rho_f = 1.204kg/m^3$
Terminal velocity;	$v_T = \sqrt{(2 \times m_{ball} \times g_o / (C_{drag} \times \rho_f \times A_{ball}))} = \underline{23.9}m/s$

Projectile Motion Calculation

Angle of cannon;	$\theta = 30°$
Initial velocity;	$V_i = 150m/s$
Initial horizontal velocity;	$V_{ix} = V_i \times \cos(\theta) = \underline{130}m/s$
Initial vertital velocity;	$V_{iy} = V_i \times \sin(\theta) = \underline{75}m/s$
Time to reach maximum height;	$t_{max} = V_{iy}/g_o = \underline{7.65}s$
Maximum height reached;	$h_{max} = V_{iy} \times t_{max} - (0.5 \times g_o \times t_{max}^2) = \underline{287}m$
Total time in the air;	$t_{total} = 2 \times t_{max} = \underline{15.3}s$
Range of cannon ball;	$R_{ball} = V_{ix} \times t_{total} = \underline{1987}m$

Length of a Clock Pendulum Calculation

For period;	$T_p = 2.0s$
Pendulum length required;	$L = T_p^2 \times g_o / 4\pi^2 =$ 994mm

Roundabout Calculation

Speed of roundbout;	$v_{max} = 3.0m/s$
Mass of child;	$m_{ch} = 26kg$
Distance of child from center;	$r_{ch} = 3m$
Centripedal acceleration;	$a_{cp} = v_{max}^2 / r_{ch} =$ 3m/s^2
Centripedal force;	$F_{cp} = m_{ch} \times a_{cp} =$ 78N
Weight of child;	$F_{ch} = m_{ch} \times g_o =$ 255N
Ratio;	$F_{cp} / F_{ch} =$ 30.6%

Simple pH Calculations

For a weak acid

Hydrogen ion concentration; $H^+ = 1.4e\text{-}5$;mol

(Note, the semicolon placed between the number and the unit, as the unit is not needed for the subsequent calculation)

$pH = -\log(H^+) =$ 4.85

For a concentrated acid

Hydrogen ion concentration; $H^+ = 0.035$mol

$pH = -\log(H^+ \times mol^{(-1)}) =$ 1.46

Check in reverse from a pH value

pH value of liquid; $pH = 8.48$

Hydrogen ion concentration; $H^+ = 10^{(-pH)} =$ 3.31e-09

(Note, the solver will ignore superscripts ending in '+' or '-')

Chemical Equation Notation

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

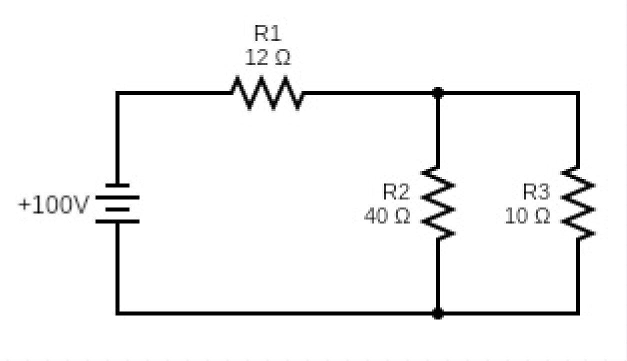
$3Hg(OH)^2 + 2H_3PO_4 \rightarrow Hg_3(PO_4)_2 + 6H_2O$

$H_2O + HCl \rightleftharpoons H_3O^+ + Cl^{(-)}$

$H_2O + NH_3 \rightleftharpoons NH_4{}^+ + OH^{(-)}$

$Al_2O_3 + 6H_30^+ + 3H_2O \rightarrow 2(Al(OH_2)_6)^{3+}$

Electric Circuit Calculation



Source voltage;	$V_s = 100V$
Resistor;	$R_1 = 12\Omega$
	$R_2 = 40\Omega$
	$R_3 = 10\Omega$
For resistors connected in parallel;	$R_{eq} = (1 / R_2 + 1 / R_3)^{(-1)} = \underline{8}\Omega$
Total circuit resistance;	$R_T = R_1 + R_{eq} = \underline{20}\Omega$
Total circuit current;	$I_T = V_s / R_T = \underline{5}A$
Voltage drop across R_1;	$V_{R1} = I_T \times R_1 = \underline{60}V$
Voltage drop across R_2 and R_3;	$V_p = V_s - V_{R1} = \underline{40}V$
Current passing through R_2;	$I_{R2} = V_p / R_2 = \underline{1}A$
Current passing through R_3;	$I_{R3} = I_T - I_{R2} = \underline{4}A$

Electric Circuit Calculation *(cont'd...)*

Voltage drop across R_2;	$V_{R2} = I_{R2} \times R_2 = 40V$
Voltage drop across R_3;	$V_{R3} = I_{R3} \times R_3 = 40V$
Total power consumed;	$P_T = V_s \times I_T = 500W$
Power dissipated by resistor;	$P_{R1} = V_{R1} \times I_T = 300W$
	$P_{R2} = V_{R2} \times I_{R2} = 40W$
	$P_{R3} = V_{R3} \times I_{R3} = 160W$

Electromagnetic Force Calculation

Magnetic constant;	$\mu_0 = 4\pi \times 10^{(-7)}$H/m
Electric current through solenoid;	$I_{sol} = 1.5A$
Number of turns on solenoid;	$N_{sol} = 550$;turns
Diameter of solenoid;	$D_{sol} = 16mm$
Area of solenoid;	$A_{sol} = \pi D_{sol}^2 / 4 = 201mm^2$
Diameter of armature;	$D_{arm} = 12mm$
Gap between solenoid and armature;	$g_{ap} = (D_{sol} - D_{arm}) / 2 = 2mm$
Electromagnetic force *(on armature)*;	$F_{arm} = (N_{sol} \times I_{sol})^2 \times \mu_0 \times A_{sol} / 2g_{ap}^2 = 21.5N$

Reinforced Concrete Beam Design

Material details

Density of concrete; $\gamma_c = 25kN/m^3$

Characteristic strength of concrete; $f'_c = 40N/mm^2$; *(30MPa minimum)*

$f'_{c\_sqrt} = \sqrt{(f'_c)} \times \sqrt{(N/mm^2)} = 6.32N/mm^2$

Elastic modulus; $E_c = ((2500kg/m^3) / (kg/m^3))^{1.5} \times 0.043 \times f'_{c\_sqrt}$

$E_c := 34kN/mm^2$

Characteristic strength of reinf; $f_y = 420N/mm^2$

Elastic modulus; $E_s = 200kN/mm^2$

Modular ratio; $\eta = E_s / E_c = 5.88$

Cover to rebar; $c_{min} = 40mm$

Beam section details

Depth of beam; $h = 600mm$

Width of beam; $b = 300mm$

Span of beam; $L = 5000mm$

Minimum depth as per ACI; $h_{min} = L / 16 = 312mm$

Dead load of beam; $DL_{beam} = h \times b \times \gamma_c = 4.5kN/m$

$DL_{beam\_f} = 1.2 \times h \times b \times \gamma_c = 5.4kN/m$

Reinforced Concrete Beam Design *(cont'd...)*

Floor Loads

Floor loads; $DL_{slab} = 2.45kN/m^2$

$DL_{screed} = 1.75kN/m^2$

$DL_{finishes} = 0.6kN/m^2$

$DL_{services} = 0.3kN/m^2$; *(includes ceilings)*

$DL_{partitions} = 3.0kN/m^2$

Total dead load on floor; $DL_{floor} = sum(DL_{slab}, DL_{screed}, DL_{finishes}, DL_{services}, DL_{partitions})$

$DL_{floor} := 8.1kN/m^2$

Total live load on floor; $LL_{floor} = 1.5kN/m^2$

Total loading on 150mm floor; $UDL_{floor} = DL_{floor} + LL_{floor} = 9.6kN/m^2$

$UDL_{floor\_f} = 1.2 \times DL_{floor} + 1.6 \times LL_{floor} = 12.1kN/m^2$

From Analysis

Loaded width of beam; $b_L = 5000mm$

Ultimate design moment; $M_u = (DL_{beam\_f} + b_L \times UDL_{floor\_f}) \times L^2 / 8 = 206kNm$

Ultimate design shear; $V_u = (DL_{beam\_f} + b_L \times UDL_{floor\_f}) \times L / 2 = 165kN$

Reinforced Concrete Beam Design *(cont'd...)*

Check Bending

Design moment;	M_u := 206kNm
Area of steel provided;	A_s = 4T25 = 1963mm^2
	Φ_{main} = 25mm; Φ_{link} = 10mm
Depth to tension steel;	$d = h - c_{min} - \Phi_{link} - \Phi_{main} / 2$ = 538mm
Min area of steel;	$A_{s\_min} = \max(b \times d \times f'_{c\_sqrt} / 4f_y, 1.4N/mm^2 \times b \times d / f_y)$
	A_{s_min} := 607mm^2
Steel ratio;	$\rho = A_s / (b \times d)$ = 0.0122
Depth of compression block;	$a = \rho \times f_y \times d / (0.85 \times f'_c)$ = 80.8mm
Ratio;	$\beta_1 = \max(0.65, 0.85 - (0.05 \times (f'_c - 30N/mm^2) / 7N/mm^2))$ = 0.779
Depth to neutral axis;	$c = a / \beta_1$ = 104mm
Net tensile strain;	$\varepsilon_t = 0.003 \times (d - c) / c$ = 0.0125
	Net tensile strain in tension controlled zone
Strength reduction factor;	$\Phi = \min(\max(0.65 + (\varepsilon_t - 0.002) \times (250 / 3), 0.65), 0.9)$ = 0.9
Nominal bending capacity;	$M_n = A_s \times f_y \times (d - a / 2)$ = 410kNm
Permissable bending capacity;	$\Phi M_n = \Phi \times M_n$ = 369kNm
	if($\Phi M_n < M_u$, Bending = "Fail", Bending = "Pass")
	Bending := Pass

Reinforced Concrete Beam Design *(cont'd...)*

Check Shear

Design shear force; $V_u := 165\text{kN}$

For normal weight concrete; $\lambda = 1.0$

Shear reduction factor; $\Phi = 0.75$

Nominal concrete shear strength; $V_c = 0.17 \times \lambda \times f'_{c\_sqrt} \times b \times d = 173\text{kN}$

Nominal rebar shear strength; $V_s = \max((V_u - (\Phi \times V_c)) / \Phi, 0\text{kN}) = 46.6\text{kN}$

Max allowable rebar shear strength; $V_{s\_max} = 4 \times V_c = 693\text{kN}$

Where V_s exceeds $2V_c$ reduce the maximum link spacing by one-half

$V_{s\_limit} = 2 \times V_c = 347\text{kN}$

Max link spacing; $s_{v\_max} = 1.0 \times \min(d / 2, 600\text{mm}) = 269\text{mm}$

Try spacing; $s_v = 200\text{mm}$

Min area of shear steel required; $A_{sv\_min} = \max(0.062 \times f'_{c\_sqrt}, 0.35\text{N/mm}^2) \times b / f_y = 280\text{mm}^2/\text{m}$

Area of shear steel required; $A_{sv\_reqd} = \max(V_s / (f_y \times d), A_{sv\_min}) = 280\text{mm}^2/\text{m}$

Area of shear steel provided; $A_{sv\_prov} = 2\text{T}10@200\text{mm} = 785\text{mm}^2/\text{m}$

if($A_{sv\_reqd} > A_{sv\_prov}$, Shear = "Fail", Shear = "Pass")

Shear := Pass

Reinforced Concrete Beam Design *(cont'd...)*

Check Deflection

Area of tension reinforcement; $A_{s\_tens} = A_s = 1963\text{mm}^2$

Tension reinforcement ratio; $\rho := 0.0122$

Depth to compression steel; $d' = 60\text{mm}$

Area of compression reinforcement; $A_{s\_comp} = 0\text{mm}^2$

Compression reinforcement ratio; $\rho' = A_{s\_comp} / (b \times d) = 0$

Moment of inertia (gross); $I_g = b \times h^3 / 12 = 540000\text{cm}^4$

$y_t = h / 2 = 300\text{mm}$

For normal weight concrete; $\lambda = 1.0$

Modulus of rupture; $f_r = 0.62 \times \lambda \times f'_{c\_sqrt} = 3.92\text{N/mm}^2$

Cracking moment; $M_{cr} = f_r \times I_g / y_t = 70.6\text{kNm}$

Neutral axis depth factor; $x_{na} = -\eta \times (\rho + \rho') + \sqrt{}(\eta^2 \times (\rho + \rho')^2 + 2 \times \eta \times (\rho + d' \times \rho' / d))$

$x_{na} := 0.314$

Moment of inertia (cracked); $I_{cr} = (x_{na}^3 / 3 + \eta \times \rho \times (1 - x_{na})^2 + \eta \times \rho' \times (x_{na} - d' / d)^2) \times b \times d^3$

$I_{cr} := 205132\text{cm}^4$

Service dead load moment; $M_D = (DL_{beam} + b_L \times DL_{floor}) \times L^2 / 8 = 141\text{kNm}$

Service live load moment; $M_L = (b_L \times LL_{floor}) \times L^2 / 8 = 23.4\text{kNm}$

Reinforced Concrete Beam Design *(cont'd...)*

Instantaneous deflections

Moment factor; $f_m = M_{cr} / M_D = 0.502$

Moment of inertia (effective); if($f_m > 1$, $I_e = I_g$, $I_e = f_m^3 \times I_g + (1 - f_m^3) \times I_{cr}$)

$I_e := 247474\text{cm}^4$

Deflection due to dead load; $\delta_{dead} = 5 \times L^2 \times M_D / (48 \times E_c \times I_e) = 4.35\text{mm}$

Moment factor; $f_m = M_{cr} / (M_D + M_L) = 0.43$

Moment of inertia (effective); if($f_m > 1$, $I_e = I_g$, $I_e = f_m^3 \times I_g + (1 - f_m^3) \times I_{cr}$)

$I_e := 231796\text{cm}^4$

Deflection due to dead plus live; $\delta_{total} = 5 \times L^2 \times (M_D + M_L) / (48 \times E_c \times I_e) = 5.42\text{mm}$

Movement after installation; $\delta_{install} = \delta_{total} - \delta_{dead} = 1.07\text{mm}$

Movement after installation limit; $\delta_{limit} = L / 480 = 10.4\text{mm}$

if($\delta_{limit} < \delta_{install}$, Deflection = "Fail", Deflection = "Pass")

Deflection := Pass

Reinforced Concrete Beam Design *(cont'd...)*

Long term deflections

Moment factor; $f_m = M_{cr} / (M_D + 0.25 \times M_L) = 0.482$

Moment of inertia (effective); if$(f_m > 1, I_e = I_g, I_e = f_m^3 \times I_g + (1 - f_m^3) \times I_{cr})$

$I_e := 242593\text{cm}^4$

Defl'n due to dead plus sust live; $\delta_{sust} = 5 \times L^2 \times (M_D + 0.25 \times M_L) / (48 \times E_c \times I_e) = 4.63\text{mm}$

Load duration coefficients; $\xi_{5years} = 2.0$

$\xi_{12months} = 1.4$

$\xi_{6months} = 1.2$

$\xi_{3months} = 1.0$

Time dependant multipliers; $\lambda_{5years} = \xi_{5years} / (1 + 50 \times \rho') = 2$

$\lambda_{12months} = \xi_{12months} / (1 + 50 \times \rho') = 1.4$

$\lambda_{6months} = \xi_{6months} / (1 + 50 \times \rho') = 1.2$

$\lambda_{3months} = \xi_{3months} / (1 + 50 \times \rho') = 1$

Long term movement; $\delta_{LT} = \delta_{install} + (\lambda_{5years} \times \delta_{sust}) = 10.3\text{mm}$

Movement after install limit; $\delta_{limit} = L / 480 = 10.4\text{mm}$

if$(\delta_{limit} < \delta_{LT}$, Deflection = "Fail", Deflection = "Pass")

Deflection := Pass