Highland Engineering P.C. 700 Industrial Drive Suite A Cary, IL 60013	Project				Job Ref.	
	Section				Sheet no./rev. 1	
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Reinforced Masonry Wall Out-of-Plane Axial, Bending and Shear Forces;

Referance and notes: Reinforced Masonry Handbook use static equilibrium and strain compatiblity. Enter forces per length of wall then use length of wall as center to center spacing of reinforcement. Reinforcement must be tied to be considered effective in carrying vertical load or compressive stress from bending. Because the reinforcement is not tied it will not be considered effective in for axial load.

Wall Geometry and Forces;

Height of wall;	H=12.0ft;	
Center to Center spacing of reinforcement;	b=48in;	
Reinforcment size (bar number);	b_{num} =5;	A_s=pi/4*(b_{num} *1in/8)^2=**0.307**in^2;
Axial Load (per foot of wall);	P=2kip/ft;	
Moment (per foot of wall);	M=0.56kip_ft/ft;	
Shear;	V=0.5kip/ft;	

Wall Properties (compare to Table GN-8b) Geometry;

(assumes face shells, cell at bar and webs each side of bar are grouted)

Nominal thickness of unit (height of x-section);	h=7.625in;	
Depth to reinforcement;	d=3.81in;	
Flange thickness;	t_f=1.25in;	
Web thickness;	t_w=1.0in;	
Width of unit and width of grout;	b_{unit}=15.625in;	b_{grout}=0.375in;
Nominal width of unit;	b_{nunit}=b_{unit}+b_{grout}=**16.000**in;	
Width of web cell;	b_{cell}=(b_{unit}-3*t_w)/2=**6.313**in;	
Width of web;	b_w=b_{cell}+2*t_f=**8.813**in;	
Height of web;	h_w=h-2*t_f=**5.125**in;	
Total area based on rebar spacing;	A=2*b*t_f+h_w*b_w=**165.164**in^2;	
Total moment of inertia based on rebar spacing;	I=b*h^3/12-(b-b_w)/2*$h_w{}^3$/12*2=**1333.699**in^4;	
Radius of gryation;	r=(I/A)$^{0.5}$=**2.842**in;	
Shear Area (disregard kd as max shear will not occur at max moment);	A_v= b*t_f+b_w*(d-t_f)=**82.560**in^2;	

Wall Properties Material (See Tbl 2.2B or IBC 2105.2.2.1.2);

Allowable 1/3rd increase;	i=1.33;	
Maximum masonry compressive stress;	f'$_m$'=1500psi;	f'$_m$=f'$_m$'*i=**1995.000**psi;
Rebar yeild stress;	F_y=60ksi;	
Modulus of Elasticity – steel;	E_s=29000ksi;	ε_y=F_y/E_s=**0.002**in/in
Modulus of Elasticity – masonry;	E_m=900*f'$_m$=**1795.500**ksi;	(use 700 for clay)
Modular ratio;	n=E_s/E_m=**16.151**;	
Allowable rebar stress;	F_s'=max(F_y /2.5,24ksi);	F_s=F_s'*i=**31920.000**psi;
Allowable compressive stress;	F_m=f'$_m$/3=**665.000**psi;	
Slenderness Ratio;	γ=H/r=**50.675**	
Reduction factor for slenderness;	R1=1-(γ/140)^2=**0.869**;	R2=(70/γ)^2=**1.908**;
	R=if(γ<=99,R1,R2)=**0.869**;	
Allowable axial stress;	Fa=0.25*f'$_m$*R=**433.405**psi;	

Allowable shear stress; $F_v=\min(1psi*(f'_m/1psi)^{0.5},50psi*i)=$**44.665**psi;

Eccentricity required from loads; $e_d=M/P=$**3.360**in;

<u>Analysis of Stesses;</u>

Assume location of NA; kd=2.0 in;

Assume allowable compressive stress of masonry controls; $f_m=F_m$;

Effective flange thickness; $t'_f=\min(t_f,kd)=$**1.250**in;

Effective height of web; $y_{cw}=\max(0in,kd-t'_f)$

Stress at flange/web intersection; $f_{cw}=f_m*(kd-t'_f)/kd=$**249.375**psi;

Stress in steel based on compatibility; $f'_s=n*f_m/kd*(d-kd)=$**9.720**ksi;

Usable steel stress; $f_s=\min(F_s,f'_s)=$**9.720**ksi;

Compressive force on flange; $C_f=0.5*(f_m+f_{cw})*t'_f*b=$**27.431**kip;

Compressive force on web; $C_w=0.5*y_{cw}*f_{cw}*b_w=$**0.824**kip;

Tension force; $T=\max(0kip,A_s*f_s)=$**2.982**kip;

Momemt Arm – Flange; $X_{cf}=h/2-t'_f*(2*f_{cw}+f_m)/(3*(f_{cw}+f_m))=$**3.282**in;

Moment strength; $M_{cf}=X_{cf}*C_f=$**7.503**kip_ft;

Moment Arm – Web; $X_{cw}=h/2-(t'_f+y_{cw}/3)=$**2.312**in;

Moment strength – Web; $M_{cw}=X_{cw}*C_w=$**0.159**kip_ft;

Moment Arm – Steel; $X_{s1}=h/2-d=$**0.002**in;

Moment strength – steel; $M_{s1}=X_{s1}*T=$**0.001**kip_ft;

Compressive force based on assumed kd location and “fm=Fm”; $P_{ns}=C_f+C_w-T=$**25.273**kip;

Moment stength of section based on assumed kd location and “fm=FM”; $M_{ns}=M_{cf}+M_{cw}-M_{s1}=$**7.661**kip_ft;

Eccentricity of section; $e_s=M_{ns}/P_{ns}=$**3.638**in;

Compare to Eccentricity of Required; $e_d=$**3.360**in;

<u>Checks;</u>

Loads on effective wall length; $P_r=P*b=$**8.000**kip; $M_r=M*b=$**2.240**kip_ft; $V_r=V*b=$**2.000**kip;

Axial Stress; $f_a=P_r/A=$**48.437**psi;

Shear Stress; $f_v=V*b/A_v=$**24.225**psi

Check Axial Stress; ChAx=if(f_a<Fa,”OK”,”NG”)=**"OK"**;

Check Shear stress; ChV=if(f_v<Fv,”OK”,”NG”)=**"OK"**;

Check Axial Strength; ChP=if($P_{ns}>P_r$,”OK”,”NG”)=**"OK"**;

Check Moment Strength; ChM=if($M_{ns}>M_r$,”OK”,”NG”)=**"OK"**;