Universidad Nacional de Ingeniería

Dirección de Estudios de Posgrado y Educación Continua

UNI-DEPEC

ESPECIALIDAD DE OBRAS VERTICALES

Tesis:

Diseño Sismorresistente De Un Edificio De 10 Plantas Arriostrado Concéntricamente.

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Contenido

1. Introducción

Los sismos, temblores y terremotos son términos usuales para referirse a los movimientos de la corteza terrestre sin embargo técnicamente hablando el nombre se sismo es el más utilizado, estos se originan en el interior de la tierra y se propaga por ella en todas direcciones en forma de ondas, aunque la interacción entre Placas Tectónicas es la principal causa de los sismos no es la única. Cualquier proceso que pueda lograr grandes concentraciones de energía en las rocas puede generar sismos cuyo tamaño dependerá, entre otros factores, de qué tan grande sea la zona de concentración del esfuerzo. Las causas más generales se pueden enumeran según su orden de importancia en: tectónica, volcánica, hundimiento, deslizamientos y explosiones atómicas.

El diseño sismo resistente implica mucho más que la simple consideración de un conjunto de cargas estáticas que se aplican a la estructura; requiere, además y principalmente, la selección de un sistema estructural idóneo y eficiente para absorber los efectos sísmicos y de un cuidado especial en la observancia de requisitos de dimensionamiento y de detalle de los elementos estructurales, y aun de los no estructurales." El objetivo de un sistema estructural es resistir las acciones a las que va a estar sometido, sin recibir grandes daños que lo lleven a un colapso o mal comportamiento. En muchas regiones, los sismos representan la causa mayor de fallas y daños en las estructuras y es necesario tomar precauciones muy especiales en ellas. "En otras, su ocurrencia es mucho más esporádica, pero el riesgo de sismos intensos es suficientemente grande para que sus efectos deban tomarse en cuenta en el diseño de las estructuras comunes." (Meli, 1985)."

En nuestro país hay una marcada actividad sísmica del territorio nicaragüense. Explicamos que la mayoría de los terremotos especialmente los más violentos se han dado en la zona de subducción, en el Océano Pacífico. Estos terremotos son capazas de causar destrucción no solamente en una ciudad sino en todo el litoral del Pacífico. Físicamente menos fuertes, pero no obstantes destructivos por su poca profundidad y cercanía a las poblaciones fueron los que ocurrieron en la zona de la cadena volcánica (León viejo 1610, Diriomo 1739, Granada 1922, Managua 1931, San Cristóbal-Telica 1938, Mateare 1955, Managua 1968, Managua 1972, Rivas 1985).

Por este motivo, la reducción del riesgo sísmico, y en particular de la vulnerabilidad de las construcciones, representa una tarea de gran importancia.

2. Justificación

Nicaragua es un país altamente sísmico que se encuentra ubicado en una zona de interacción de placas tectónicas, cuyo movimiento relativo desarrolla esfuerzos en la corteza terrestre que han derivado un sistema de fallas activas y de alta ocurrencia de terremotos, que a su vez han generado y pueden causar daños en la infraestructura.

La historia geológica del territorio derivó en un intrincado sistema de fallas que atraviesa la ciudad de Managua Muchas de esas fallas se consideran activas y tienen la capacidad de generar terremotos de magnitud importante (del orden de 6 a 6.5), con epicentros directamente dentro del territorio urbano de Managua. El conocimiento de estas condiciones de amenaza, permite establecer posibles escenarios de riesgo, que sean indicativos de los niveles de afectación esperados en futuros eventos, p

La ocurrencia de estos frecuentes eventos sísmicos ha sido una de las razones para el estudio de nuevos sistemas estructurales capaces de funcionar de manera adecuada a dichos requerimientos. Este proyecto contiene el análisis y diseño estructural de sistemas sismo resistentes de un edificio de 10 plantas. Usando Pórticos Arriostrados Concéntricamente.

Los pórticos especiales arriostrados concéntricamente son más económicos que los pórticos ordinarios arriostrados concéntricamente o pórticos especiales a momentos. Esto según se describe en la guía de diseño sísmico 2da edición en la sección 5.3. por esta razón se justifica la importancia de los pórticos especiales arriostrados concéntricamente sobre otro sistema resistente a fuerza sísmica.

3. Objetivos

3.1. Objetivos Generales

Diseñar sísmicamente un edificio de 10 plantas con marcos especiales arriostrado concéntricamente aplicando los criterios descritos en los códigos AISC 360-16, AISC 341-16, AISC - 358-16, AISC Steel Construction Manual 14th Edition, AISC Seismic Disign Manual Second Edition.

3.2. Objetivos Específicos

- Analizar la Edificación con las normas ASCE/SEI 7. haciendo uso de un programa por ordenador (ETABS) para determinas los esfuerzos en los arriostres especiales.
- Diseñar los Elementos de los Arriostres especiales haciendo uso de los procedimientos descritos en el manual de diseño sísmico del AISC segunda edición.
- Diseñar el sistema de cimentación de la edificación según las normas ACI-318-14, ACI SP-17(14).
- Elaborar detalles del diseño.

4. Marco Teórico

4.1. Generalidades del Acero.

Las estructuras de acero han evolucionado a lo largo de más de un siglo como resultado de la experiencia obtenida por la industria de la construcción y de numerosas investigaciones destinadas a optimizar su uso. Este avance ha permitido desarrollar distintos tipos de estructuras sismo resistente, los cuales presentan variaciones no solo en su comportamiento estructural, sino también diferencias constructivas, funcionales y económicas.

Clasificación de los aceros:

Los aceros pueden clasificarse según:

- Su composición química.
- Su contenido de óxidos.
- Sus propiedades mecánicas.
- Su calidad.

De acuerdo con **su composición química**, los aceros pueden ser aceros sin alear, semi-Aleados y aleados. Las aleaciones influyen en las propiedades del acero. Entre los metales de aleación se pueden citar el cobre (Cu), el níquel (Ni), el aluminio (Al), el manganeso (Mn) y el cromo (Cr).

Según **su contenido de óxido**, el grado de desoxidación de los aceros permite clasificarlos en aceros efervescentes, semi-calmados y calmados. Según **sus propiedades mecánicas**, los aceros se clasifican en acero común (acero dulce), acero de alta resistencia y aceros especiales.

4.1.1. Ventajas del Acero

Alta resistencia: La alta resistencia del acero por unidad de peso implica que será poco el peso de las estructuras, esto es de gran importancia para el diseño de vigas de grandes luces y en general en todos los elementos.

Uniformidad: Las propiedades del acero no cambian apreciablemente con el tiempo.

Durabilidad: Si el mantenimiento de las estructuras de acero es adecuado duraran indefinidamente.

Ductilidad: La ductilidad es la propiedad que tiene el acero de soportar grandes deformaciones en el rango no lineal sin llegar a la ruptura. La naturaleza dúctil de los aceros estructurales permite disipar gran cantidad de energía al deformarse plásticamente sin romperse.

Tenacidad: Los aceros estructurales son tenaces, es decir, poseen resistencia y ductilidad. La propiedad de un material para absorber energía en grandes cantidades se denomina tenacidad.

Homogeneidad del material. Posibilidad de reforma de manera más sencilla para adaptarse a **nuevos usos** del edificio, lo cual es más habitual en el caso de equipamientos, edificios de oficinas... que en el caso de viviendas.

Rapidez de montaje, con los consiguientes ahorros en costes fijos de obra.

La **estructura metálica** puede ser preparada en taller, lo que se traduce en que los elementos llegan a obra prácticamente elaborados, necesitando un mínimo de operaciones para quedar terminados.

El acero estructural puede laminarse de forma económica en una gran variedad de formas y tamaños. Además, se puede adaptar a necesidades concretas variando las propiedades mecánicas mediante tratamientos térmicos, termoquímicos…

Reutilización del acero tras desmontar la estructura, lo que supone un ahorro de inversión considerable.

Las vigas reticuladas permiten cubrir grandes luces, con los correspondientes beneficios.

Las **estructuras de acero** son, por lo general, más ligeras que las realizadas con otros materiales; esto supone menor costo **de cimentación.**

La **adaptabilidad del acero** es de especial relevancia en casos de rehabilitación ya sea para reforzar estructuras existentes o para una completa reconstrucción manteniendo las fachadas. El acero se entrega prefabricado en obra; no necesita ser apuntalado y tampoco sufre retracción o fluencia por lo que puede asumir carga de inmediato.

El desarrollo de nuevos sistemas de protección contra la **corrosión,** garantizan con un mantenimiento mínimo, una vida casi ilimitada para las estructuras realizadas con acero.

Cuando termina la vida útil del edificio, la **estructura metálica de acero puede ser desmontada** y posteriormente utilizada en nuevos usos o ser reaprovechada con un fácil reciclaje.

La estructura metálica en acero supone un peso reducido, **segura en caso de sismo**, rendimiento y montaje se controlan visualmente de forma fácil.

4.1.2. Desventajas del acero estructural.

- Corrosión. Este tipo de materiales pueden presentar problemas de corrosión dependiendo del lugar y los agentes corrosivos externos.
- Problemática en caso de incendios. Debido a esto, es conveniente, y en algún caso obligatorio, recubrir este tipo de estructuras con pintura ignífuga o intumescente para evitar el colapso de la misma.
- Pandeo, ya que se utilizan elementos esbeltos sometidos a compresión (soportes metálicos). No obstante, las estructuras se calculan evitando estos fenómenos.
- Coste económico de la estructura y su posterior mantenimiento: pinturas contra la corrosión, paneles de protección frente al fuego.
- Mano de obra especializada.

4.1.3. Propiedades comunes del acero.

- Peso específico (γ): 7850 Kg/m^3
- Módulo de elasticidad longitudinal (E): 2.1 x 10^6 Kg/cm^2
- Módulo de elasticidad transversal o de corte G: $\frac{E}{2((1+v)}$
- Coeficiente de Poisson (v): 0.3 (en el rango elástico)

  0.5 (en rango plástico)
- Coeficiente de dilatación térmica (α): 11.7 x 10^{-6}/°C

Las especificaciones del AISC 360-16 plantea claramente que el acero que se debe usar en las edificaciones debe estar normados según La organización American Society for Testing and Materials (ASTM)

Para perfiles rolados en caliente podemos usar ASTM A36/A36M, ASTM A709/A709M, ASTM A529/A529 M, ASTM A913/A913M, ASTM A572/A572 M, ASTM A992/ A992M, ASTM A588/A588 M, ASTM A1043/A1043M.

Para secciones huecas (HSS), ASTM A500 ASTM, A618/A618M, ASTM A501 ASTM A847/A847M.

Para tubos, ASTM A53/A53M.

Placas, ASTM A36/A36M, ASTM A1043/1043M Gr. 36 (250), A1011/A1011M HSLAS Gr. 55 (380), ASTM A572/A572M Gr. 42 (290),ASTM A572/A572M Gr. 50 (345), Gr. 55 (380), ASTM A588/A588M, ASTM 1043/1043M Gr. 50 (345)

Las provisiones sísmicas AISC 341-16 nos especifica el acero estructural que se debe usar para los sistemas resistentes a fuerzas sísmicas (SFRS, Seismic force Resisting System), estos deben satisfacer los requerimientos de la sección A3.1 del AISC 341-16, en esta sección se define el concepto de resistencia esperada del Acero.

4.1.3.1. Resistencia esperada

La resistencia requerida o esperada se calculará a partir del esfuerzo de fluencia mínima del acero F_y multimplicada por un factor R_y ,donde R_y es la relación de esfuerzo de fluencia esperado entre el esfuerzo de fluencia mínimo especificado.

La resistencia nominal ultima se calculará como $F_y * R_y$ Y para resistencia a tensión esperada $F_u * R_t$, se permite usar en lugar de F_y , F_U el cuál es el esfuerzo a tensión mínima del acero. Rt es la relación del esfuerzo a tensión esperado entre la resistencia a la tensión mínima especificada. A continuación, se presenta la tabla A3.1. Sacada el AISC 341 Sección A.2

TABLE A3.1
R_y and R_t Values for Steel and Steel Reinforcement Materials

Application	R_y	R_t
Hot-rolled structural shapes and bars:		
• ASTM A36/A36M	1.5	1.2
• ASTM A1043/A1043M Gr. 36 (250)	1.3	1.1
• ASTM A992/A992M	1.1	1.1
• ASTM A572/A572M Gr. 50 (345) or 55 (380)	1.1	1.1
• ASTM A913/A913M Gr. 50 (345), 60 (415), 65 (450), or 70 (485)	1.1	1.1
• ASTM A588/A588M	1.1	1.1
• ASTM A1043/A1043M Gr. 50 (345)	1.2	1.1
• ASTM A529 Gr. 50 (345)	1.2	1.2
• ASTM A529 Gr. 55 (380)	1.1	1.2
Hollow structural sections (HSS):		
• ASTM A500/A500M Gr. B	1.4	1.3
• ASTM A500/A500M Gr. C	1.3	1.2
• ASTM A501/A501M	1.4	1.3
• ASTM A53/A53M	1.6	1.2
• ASTM A1085/A1085M	1.25	1.15
Plates, Strips and Sheets:		
• ASTM A36/A36M	1.3	1.2
• ASTM A1043/A1043M Gr. 36 (250)	1.3	1.1
• ASTM A1011/A1011M HSLAS Gr. 55 (380)	1.1	1.1
• ASTM A572/A572M Gr. 42 (290)	1.3	1.0
• ASTM A572/A572M Gr. 50 (345), Gr. 55 (380)	1.1	1.2
• ASTM A588/A588M	1.1	1.2
• ASTM A1043/A1043M Gr. 50 (345)	1.2	1.1
Steel Reinforcement:		
• ASTM A615/A615M Gr. 60 (420)	1.2	1.2
• ASTM A615/A615M Gr. 75 (520) and Gr. 80 (550)	1.1	1.2
• ASTM A706/A706M Gr. 60 (420) and Gr. 80 (550)	1.2	1.2

4.2. Bases del Diseño de Acero.

El Diseño de Acero se realizará de acuerdo con las disposiciones del método Diseño en Base a Factores de Carga y Resistencia (LRFD) o a las disposiciones del método Diseño en Base a Resistencias Admisibles (ASD). El criterio de diseño estructural consiste en seleccionar las secciones óptimas de cada miembro, con sus correspondientes uniones y conexiones, entre un conjunto de alternativas para cada caso.

4.2.1. Diseño por Resistencia Usando Factores de Carga (LRFD).

El diseño de acuerdo con las disposiciones de Diseño en Base a Factores de Carga y Resistencia (LRFD) satisface los requisitos de esta Especificación cuando la resistencia de diseño de cada componente estructural es mayor o igual a la resistencia requerida determinada de acuerdo con las combinaciones de carga LRFD. Se aplican todas las disposiciones de esta Especificación excepto las de la Sección B3.4. del AISC-360-16. El diseño se realizará de acuerdo con la ecuación EC-1:

$$R_u \leq \varphi \cdot R_n \quad \text{EC-10}$$

donde:

R_u = resistencia requerida (LRFD)

R_n = resistencia nominal

ϕ = factor de resistencia.

ϕR_n = resistencia de diseño.

4.2.2. Diseño por Resistencias Admisibles (ASD)

El diseño de acuerdo con las disposiciones de Diseño en Base a Resistencias Admisibles (ASD) satisface los requisitos de esta Especificación cuando la resistencia admisible de cada componente estructural es mayor o igual a la resistencia requerida determinada de acuerdo con las combinaciones de carga ASD. Se aplican todas las disposiciones de esta Especificación excepto las de la Sección B3.3 del AISC-360-16. El diseño se realizará de acuerdo con la ecuación EC-2:

$$Ra \leq Rn / \Omega \qquad \text{EC-2}$$

donde:

R_a = resistencia requerida (ASD)

R_n = resistencia nominal.

Ω = factor de seguridad.

R_n / Ω = Resistencia admisible

4.3. Cargas y combinaciones de cargas

El AISC 360-16 en el capítulo B.2, nos indica que para el diseño de acuerdo con (LRFD), se aplica las combinaciones presentadas en la Sección 2.3 del SEI/ASCE 7-16. Para diseño de acuerdo con (ASD), se aplica las combinaciones Presentadas en la sección 2.4 en el ASCE/ SEI 7.

4.3.1. Combinaciones para Diseño Según el LRFD.

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $0.9D + 1.0W$

4.3.2. Combinaciones para según el ASD

1. D
2. D + L
3. D + (L_r or S or R)
4. D + 0.75L + 0.75(L_r or S or R)
5. D + (0.6W)
6. D + 0.75L + 0.75(0.6W) + 0.75(L_r or S or R)
7. 0.6D + 0.6W

Donde:

D = carga muerta

L = carga viva

L_r = carga viva de techo

R = lluvia

S = nieve

W = carga de viento

4.3.3. Efecto de carga sísmica

Todos los elementos de la estructura, incluyendo aquellas que no son parte del sistema fuerza-resistente sísmico, deben ser diseñado usando los efectos de carga sísmica de la Sección 12.4 ASCE/SEI 7. Los efectos de carga sísmica generan fuerzas en los miembros a axial, cortante y flexión resultando de la aplicación de las fuerzas sísmicas vertical y horizontal a como se establece en la EC-3.

El efecto de carga sísmica, E, debe ser determinado de acuerdo con lo siguiente:

1. E debe ser determinado de acuerdo con la

$$E = E_h + E_v \qquad \text{EC-3}$$

Donde

$E =$ Efecto de carga sísmica

$E_h =$ Efecto de las fuerzas sísmicas horizontales sección 4.3.3.1

$E_v =$ Efecto de las fuerzas sísmicas verticales 4.3.3.2

4.3.3.1. Efecto de Carga Sísmica Horizontal

El efecto de carga sísmica horizontal, E_h, debe ser determinado de acuerdo con la Ec-5 a como se muestra:

$$E_h = \rho Q_E \qquad \text{EC-4}$$

4.3.3.2. Efecto de Carga Sísmica Vertical

El efecto de carga sísmica vertical, E_v, debe ser determinado de acuerdo con la EC-5.

$$E_v = 0.2 S_{DS} D \qquad \text{EC-5}$$

Donde

S_{DS} = Parámetro de diseño de aceleración de respuesta espectral en períodos cortos obtenidos a partir de la Sección 11.4.4 del ASCE/SEI 7

D = efecto de carga muerta

EXCEPCIONES: El efecto de carga sísmica vertical, E_v, se permite sea tomado como cero ya sea para cualquiera de las siguientes condiciones:

1. Para las ecuaciones desde EC-3, EC-4 Y EC-5, donde S_{DS} es igual a ó menor que 0.125.
   En la EC-3. donde se determinan las demandas sobre la interfaz suelo-estructura de las fundaciones.

Combinaciones 8 Y 9 de Carga Sísmica según LRFD considerando el efecto del sismo Horizontal y vertical.

$$(1.2 + 0.2S_{DS})D + \rho Q_E + L \qquad \text{EC-6}$$

$$(0.9 - 0.2S_{DS})D + \rho Q_E + L \qquad \text{EC-7}$$

NOTAS:

El factor de carga sobre L (L= CARGA VIVA) en la combinación se permite igual a 0.5 para todas las ocupaciones en el cual L_o en el que el valor sea menor o igual a 500 $\frac{kgf}{m^2}$, con excepción de los garajes ó áreas ocupadas como lugares de asamblea pública.

Combinaciones 8, 9 y 10 de Carga Sísmica según ASD considerando el efecto del sismo Horizontal y vertical.

$$(1.0 + 0.14S_{DS})D + 0.7\rho Q_E \qquad \text{EC-8}$$

$$(1.0 + 0.105S_{DS})D + 0.525\rho Q_E + 0.75L + 0.75(L_r) \qquad \text{EC-9}$$

$$(0.6 - 0.14S_{DS})D + 0.7\rho Q_E \qquad \text{EC-10}$$

4.3.3.3. El efecto de carga sísmica horizontal con factor de sobre resistencia, E_{mh}.

Debe ser determinado de acuerdo con la EC-12 tal como se muestra:

$$E_{mh} = \Omega_o Q_E \qquad \text{EC-11}$$

Donde:

Q_E = efectos de fuerzas sísmicas horizontales a partir de V, F_{px}, ó F_p como se especifica en las Secciones 12.8.1, 12.10 del ASCE/SEI 7. Donde se requiere por la Sección 2.5.3 o 2.5.4, tales efectos deben resultar de la aplicación de las fuerzas horizontales simultáneamente en dos direcciones en ángulo recto uno respecto del otro.

Ω_o = factor de sobre-resistencia

Excepción: El valor de E_{mh} necesita no exceder la fuerza máxima que pueda desarrollar en el elemento tal como se determina por un análisis racional, de mecanismo plástico o de respuesta no lineal, utilizando valores reales esperados de resistencias de materiales

Combinaciones 8 Y 9 de Cargar con Factor de Sobre resistencia (LRFD).

$$(1.2 + 0.2S_{DS})D + \Omega_o Q_E + L \qquad \text{EC-12}$$

$$(0.9 - 0.2S_{DS})D + \Omega_o Q_E \qquad \text{EC-13}$$

NOTA:

El factor de carga sobre L (L= CARGA VIVA) en la combinación se permite igual a 0.5 para todas las ocupaciones en el cual L_o en el que el valor sea menor o igual a 500 kgf/m^2, con excepción de los garajes o áreas ocupadas como lugares de asamblea pública.

El factor de carga sobre H debe ser establecido igual a cero en la combinación si la acción estructural debido a H contrarresta esa acción debido a E. Donde la presión lateral de tierra proporciona resistencia a acciones estructurales a partir de otras fuerzas, ésta no debe ser la resistencia de diseño.

Combinaciones 11, 12 y 13 para Diseño por Esfuerzos Permisibles (ASD) con Factor de Sobre resistencia.

$(1.0 + 0.14S_{DS})D + 0.7\Omega_o Q_E$ EC-14

$(1.0 + 0.105S_{DS})D + 0.525\Omega_o Q_E + 0.75L$ EC-15

$(0.6 - 0.14S_{DS})D + 0.7\Omega_o Q_E$ EC-16

4.3.3.4. Combinaciones Nocionales

Las combinaciones de integridad, N, serán combinadas con la carga muerta y viva

Para categoría de Diseño sísmico B, C, D, E, o F estas deben de cumplir los requisitos de la sección 1.4.1, 1.4.2, 1.4.3, 1.4.4 y 1.4.5 del ASCE/SEI 7Procedimiento de Análisis Sísmico.

Combinaciones 10 y 11 de carga nocional de diseño de fuerza usando LRFD.

1.2D + 1.0N + L + 0.2S EC-17

0.9D + 1.0N EC-18

Combinaciones 14, 15 y 16 cargas nocionales de diseño por esfuerzos permisibles (ASD)

D 0.7N EC-19

D + 0.75(0.7N) + 0.75L+ 0.75(Or or S or R) EC-20

0.6D + 0.7N EC-21

4.4. PROCEDIMIENTO DE ANALISIS

El Capítulo 12 del ASCE/SEI 7 permite tres tipos de análisis sísmicos planteados en la tabla 1. Basado en la categoría de diseño sísmico de la estructura, sistema estructural, propiedades dinámicas, y regularidad.

para el edificio de 10 niveles de acero con arriostres concéntrico se realizará el análisis Estatico Equivalente y EL análisis modal espectral. El estático equivalente según La sección 7.8 del ASCE/SEI 7 y el Análisis modal espectral según la sección 7.9 del ASCE/SEI 7.

Tabla 1. Procedimientos Analíticos Permitidos

Categoría de Diseño Sísmico	Características Estructurales	Análisis Fuerza Lateral Equivalente	Análisis Modal de Espectro de Respuesta	Procedimiento Historia de Respuesta Sísmica
B, C	Todas las estructuras	P	P	P
D, E, F	Categoría de Riesgo I ó II de edificios que no exceden dos niveles por encima de la base	P	P	P
	Estructuras de construcción de marco liviano	P	P	P
	Estructuras sin irregularidades estructurales ni excediendo 50 mts en altura estructural	P	P	P
	Estructuras excediendo 50 mts en altura estructural sin irregularidades estructurales y con $T<3.5Ts$	P	P	P

	Estructuras sin exceder 50 mts en altura estructural y teniendo solamente irregularidades horizontales de Tipo 2, 3, 4, ó 5 de la Tabla 12.3-1 ó irregularidades verticales de Tipo 4, 5a, ó 5b de la Tabla 12.3-2	P	P	P
	Todas las demás estructuras	NP	P	P
P: Permitido; NP: No Permitido; *Ts:SD1/SDS*				

4.4.1. AMENAZA SÍSMICA

Los mapas de zonificación sísmica, en la mayoría de los países, tienen un periodo de retorno de 475 años correspondientes a los mayores sismos esperados, a través de los cuales se elaboran los espectros de respuesta elásticos, tomando en cuenta el tipo de suelo, tipo de estructura, nivel de importancia y zona sísmica.

A mediados de los años 1970 se realizó el primer estudio de amenaza sísmica en Nicaragua, el cual se publicó en dos partes: Shah et al. (1975) y Shah et al. (1976). Un primer estudio de la amenaza sísmica, usando datos de la red sísmica de Nicaragua, fue realizado por Arellano (1984). Otro estudio más detallado y específico fue realizado doce años más tarde por Segura y Rojas (1996). Ese mismo año se realizó una evaluación probabilista de la amenaza en términos de intensidad macro sísmica por Espinoza (1996). Strauch et al. (2000) efectuaron un estudio de amenaza sísmica para la Ciudad de Managua, que presentó valores de PGA mayores a 4 m/s2, para un periodo de retorno de 475 y además un espectro de amenaza uniforme (UHS). El actual Código Sísmico de Nicaragua, define un periodo de retorno mínimo de 475 años para diseño y construcción de las obras civiles.

En el 2008 se realizó un proyecto llamado RESIS II evaluando la amenaza sísmica en centro América financiado por el Gobierno de Noruega bajo la gestión del CEPREDENAC. Como resultado de este proyecto se definió el espectro de amenaza uniforme.

4.4.1.1. ESPECTROS DE AMENAZA UNIFORME PARA MANAGUA SEGÚN RESIS II.

Las Figuras 1 representan los espectros de amenaza uniforme, de modo que cada figura contiene los tres resultantes para periodos de retorno de 500, 1000 y 2500 años en la capital de Nicaragua. Los resultados numéricos se incluyen en la tabla 2.

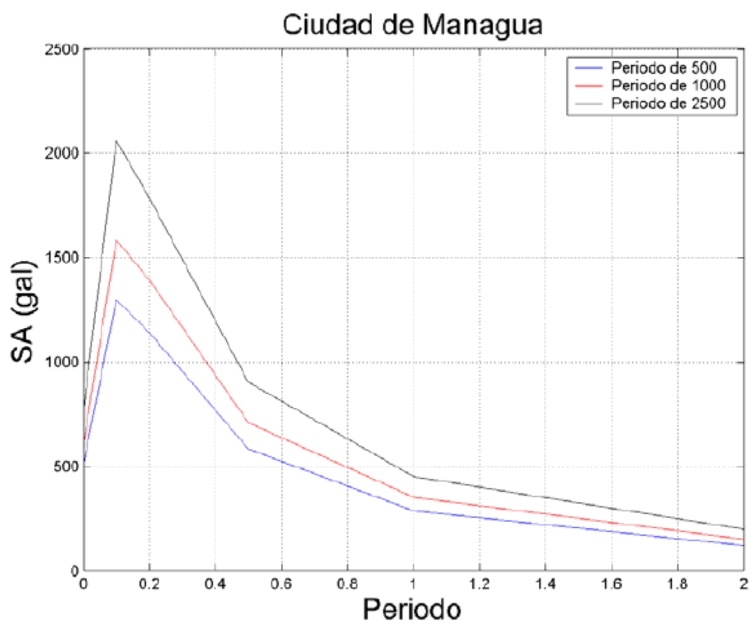


Figura 1. Espectros UHS en ciudad de Managua, para PR =500, 1000 y 2500 años (Fuente: ***RESIS II*** *Evaluación de la Amenaza Sísmica en Centroamérica,2008*).

Managua	PERIODO DE RETORNO (años)		
Aceleración (cm/s²)	500	1000	2500
PGA	507	605	763
SA(0.1s)	1298	1584	2061
SA(0.2s)	1138	1392	1782
SA(0.5s)	586	710	903
SA(1.0s)	288	351	453
SA(2.0s)	122	152	200

TABLA 2. Parámetros resultantes de amenaza para diferentes periodos de retorno en ciudad de Managua (Fuente: ***RESIS II*** *Evaluación de la Amenaza Sísmica en Centroamérica,2008*).

Según el trabajo del Proyecto RESIS II, se muestra en la tabla para un periodo de retorno de 500 años se usará un parámetro de aceleración de respuesta espectral de periodo corto (Ss)=1.138g y un parámetro de aceleración de respuesta espectral de periodo de 1 segundo (Sa)=0.288g. con estos valores podremos definir el espectro de diseño según el ASCE 7.

4.5. DESCRIPCIÓN DEL SISTEMA ESTRUCTURAL DEL EDIFICIO.

Se realizó un modelo con la propuesta de elementos estructurales del edificio, este será construido en la ciudad de Managua, Nicaragua. Cuenta con 10 niveles: el primero para sala de ventas, los siguientes niveles para oficinas y una azotea que funcionara como terraza

El edificio cuenta con sistemas resistentes a cargas laterales y sistema de marcos especiales con arriostramiento concéntrico, lo cual implica que su diseño sea sismo-resistente. En dicho sistema, los marcos arriostrados son diseñados para el 100% de las cargas laterales

En las direcciones X (horizontales) posee marco especial con arriostramientos concéntricos (Special Concentrically Braced Frames) localizados en costados Norte - Sur en todos los niveles.

En la dirección en X posee marco especial con arriostramientos concéntricos (Special Concentrically Braced Frames) localizados en costados Este - Oeste en todos los niveles.

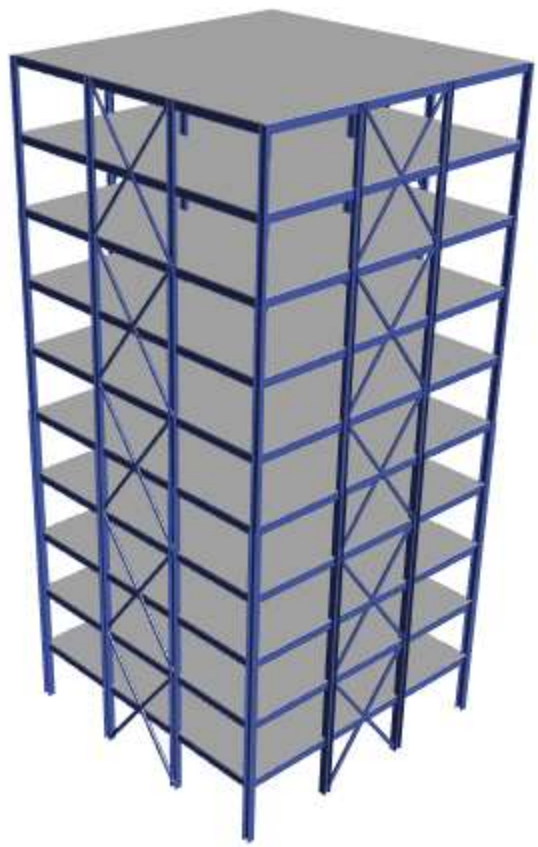


figura 2. Edificio de 10 Niveles usando SCBF.

4.6. Diseño sismorresistente en acero.

En el IBC-2012 en la sección 2205.2.1 y sección 2205.2.2 nos indica que para estructural diseñadas sísmicamente deben ser detalladas y diseñadas según el AISC 341-16.

4.6.1. Filosofía del Diseño Sismorresistente.

Para las estructuras sismorresistente en acero se toman en cuenta los siguientes parámetros que definen el diseño de cada uno de los elementos estructurales presentes en el sistema:

1. Establecer un diseño por capacidad, limitar mecanismos frágiles y propiciar mecanismos dúctiles.
2. Elegir y establecer el patrón de falla adecuado de los elementos “fusibles” que entraran en cedencia durante un evento sísmico.
3. Los elementos “fusibles” deben ser capaces de desarrollar incursiones inelásticas significativas y de disipar energía durante un evento sísmico.
4. Diseñar el resto de los elementos del sistema resistente a sismo con la condición de que permanezcan en el rango elástico al presentarse las fallas dúctiles (rotulas plásticas) esperadas en los “fusibles”.
5. Las conexiones de los elementos “fusibles” deben ser diseñadas en función a la capacidad inelástica esperada de los mismos.
6. Las conexiones del resto de los elementos del sistema resistente a sismo deben ser diseñadas para las fuerzas que se producen al presentarse las fallas dúctiles (rotulas plásticas) esperadas en los “fusibles”.

4.6.2. Pasos a seguir para elaborar un Diseño Sismorresistente en Acero.

Basado en las recomendaciones de la organización FEMA por sus siglas en ingles “Federal Emergency Management Agency” se establecen los siguientes pasos para un adecuado diseño sismorresistente en acero:

1. Seleccionar un Tipo de Sistema Estructural y configuración de pórticos adecuados a la arquitectura presentada.
2. Hacer un redimensionado de los miembros pertenecientes a los pórticos.
3. Determinar los datos para poder llevar a cabo el análisis estructural tales como las cargas gravitacionales y acciones.
4. Llevar a cabo el modelaje y análisis matemático de la estructura.
5. Comprobar el adecuado comportamiento de los miembros seleccionados para el pórtico según las fuerzas, derivas y limitantes de estabilidad adecuadas.
6. Confirmar o revisar las dimensiones de los miembros basado en los requerimientos establecidos para cada uno de los tipos de sistemas estructurales, en caso de no cumplir con dichos requerimientos se deberá redimensionar los elementos y regresar al paso anterior.
7. Completar el diseño de las conexiones, rigidizadores, arriostramientos laterales, entre otros elementos que dependerán del tipo de sistema estructural elegido.

4.7. Clasificación de las estructuras según su tipo, nivel de diseño y tipo de conexiones.

4.7.1. Clasificación según el tipo estructural.

Se clasifican por tipos debido al nivel de ductilidad que logra cada sistema estructural.

Tipo marcos resistente a momentos: son estructuras constituidas por marcos de acero capaces de resistir las acciones mediante deformaciones debidas principalmente a la flexión de sus vigas y columnas de acero.

Según su **nivel de Diseño** pueden ser Ordinarios, intermedios y especiales.

Abreviado como OMF (ordinary moment frames), IMF (intermediate moment frames), SMF (special moment frames).

Figura 2: Sistema de Marcos Resistentes a Momentos. (Fuente: Presentaciones AISC)

Tipo Marcos arriostrados Concéntricos: son pórticos de acero cuya estabilidad o resistencia a las acciones se suministra por medio de diagonales, y en la cual todos sus miembros están solicitados principalmente por fuerzas axiales.

Según su **nivel de diseño** pueden ser Ordinarios con altura limitada, Ordinario con aumento de altura permitido Y especiales. Abreviado Como OCBF (ordinary concentrically braced frame), OCBFI (ordinary concentrically braced frame with permitted height increase), SCBF (special concentrically braced frames)

La configuración de pórticos con diagonales en X corresponde a un par de diagonales que se cruzan aproximadamente en su punto medio. Los pórticos con diagonales simples son aquellos con solo un arriostramiento en los nodos extremos del pórtico. Cuando un par de arriostramientos se conectan en un punto único por encima de la luz de la viga se denominan diagonales en V y cuando se conectan por debajo de la viga se les denomina pórticos con diagonales en V o V invertida.

Figura 3: Sistema de Pórticos con Diagonales Concéntricas. (Fuente: Presentaciones AISC)

Tipo Marcos arriostrados excéntricos: comprende los pórticos de acero con diagonales excéntricas vinculadas a vigas dúctiles, denominadas viga eslabón, capaces de concentrar la absorción y disipación de la energía del sistema. Las diagonales excéntricas pueden disponerse en diversas configuraciones. El eslabón dúctil puede situarse en la longitud media de la viga entre las dos conexiones de las diagonales, o adyacente a una columna, entre la conexión de la viga a la diagonal y la cara de la columna. En los sistemas resistentes a sismos los pórticos con arriostramientos excéntricos corresponden a un nivel de Diseño especiales. **Abreviado como EBF (eccentrically braced frames)**

4.7.2. Clasificación según el nivel de diseño.

Se clasifican por tipos debido al nivel de ductilidad que logra cada sistema estructural.

Nivel de Diseño Ordinario: El diseño en zonas sísmicas no requiere de requisitos adicionales a los establecidos para acciones gravitacionales. En las Normas AISC-360 las edificaciones incluidas en este Nivel de Diseño se les conoce como edificaciones Ordinarias.

Nivel de Diseño Intermedio: Requiere la aplicación de los requisitos adicionales establecidos en las normas AISC -341. Para las Normas AISC-360 las estructuras dentro de este nivel de diseño se les conoce como edificaciones Intermedias.

Nivel de Diseño Especial: Requiere de todos los requisitos adicionales para el diseño en zonas sísmicas establecidos en las normas AISC-341 y AISC-358. En las Normas del AISC-360 a estas estructuras se les conoce como edificaciones Especiales, entre este tipo de pórticos se encuentran los sistemas SMF, SCBF y EBF.

4.7.3. Clasificación según el tipo de conexiones:

Cada uno de los tipos de conexiones controlará de una manera específica el comportamiento y la respuesta tanto de la estructura como de cada una de sus partes, condicionando las dimensiones y resistencia de los miembros y sus conexiones. Los tipos de estructuras en acero según sus conexiones existentes en esta serán:

Tipo FR, estructuración con conexiones totalmente restringidas: este tipo de construcción se designa comúnmente como estructuración con conexiones rígidas (pórtico rígido o continuo) y se supone que durante las deformaciones de las estructuras las conexiones tienen la suficiente rigidez para mantener inalterados los ángulos originales entre los miembros que se interceptan.

Tipo PR, estructuración con conexiones parcialmente restringidas: este tipo de construcción supone que las conexiones no tienen la suficiente rigidez para mantener los ángulos entre los miembros que la interceptan.

Cuando se ignore la restricción de las conexiones, como en la estructuración con conexiones flexibles (sin restricción o de extremos simplemente apoyados), en lo que respecta a cargas gravitacionales, los extremos de las vigas se conectan únicamente para resistir fuerzas cortantes y están libres de girar bajo cargas verticales. Los pórticos con conexiones del tipo PR cumplirán con los siguientes requisitos:

- Las conexiones y los miembros conectados son adecuados para resistir la carga gravitacional mayorada trabajando como vigas simplemente apoyadas.
- Las conexiones y los miembros conectados son adecuados para resistir las solicitaciones mayoradas debidas a las cargas laterales.

- Las conexiones tienen una capacidad de rotación inelásticas suficiente para evitar sobretensiones en los medios de unión bajo las solicitaciones mayoradas producidas por la combinación de cargas gravitacionales y laterales.

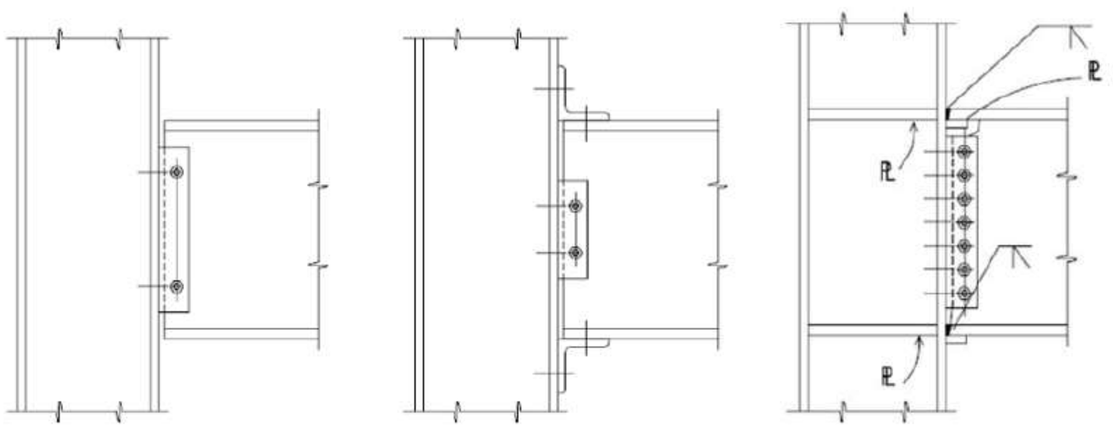


Figura 4: Conexiones en estructuras de acero. De izquierda a derecha Conexión Simple, PR y FR.

(Fuente: AISC LRFD)

4.8. MARCOS ESPECIALES CON ARRIOSTRES CONCÉNTRICOS.

son sistemas capaces de desarrollar incursiones inelásticas moderadas, de manera estable. Estos pórticos serán los que cumplen con el Nivel de Diseño Especial. En las normas AISC-341 son conocidos como *"Special Concentrically Brace Frames"* o SCBF. dispuestos en X, V o V invertida, que solos o en combinación con pórticos forman parte del sistema resistente a sismo. Dentro de las características principales de este tipo de sistemas estructurales están:

1. Sistema de vigas, columnas y arriostramientos concéntricos.

2. Sistemas con desarrollo de deformaciones y fuerzas axiales significativas.

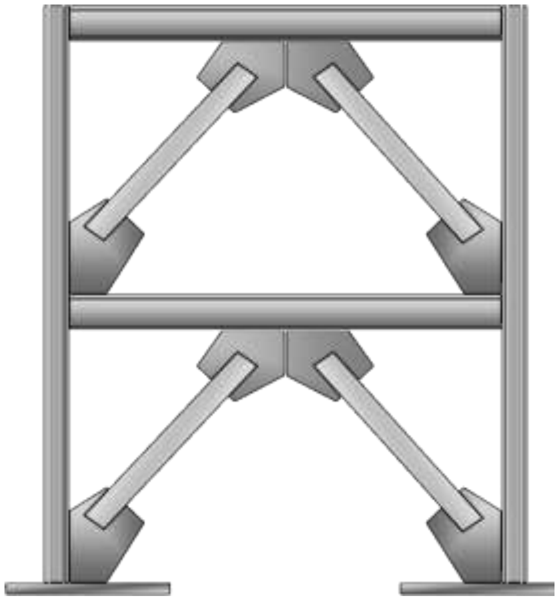


Figura 5: Pórticos con diagonales concéntricas. (Fuente: Presentaciones AISC)

4.8.1. Desempeño Estructural

1. Son sistemas capaces de desarrollar ductilidad, disipación de energía e incursiones significativas en el rango inelástico.
2. Sistema con una gran rigidez elástica.
3. Las columnas y vigas permanecerán en el rango elástico.
4. Los mecanismos que pueden presentarse son:

- Cedencia en los **Arriostramientos** en tensión.
- Pandeo en los **Arriostramientos** en compresión.

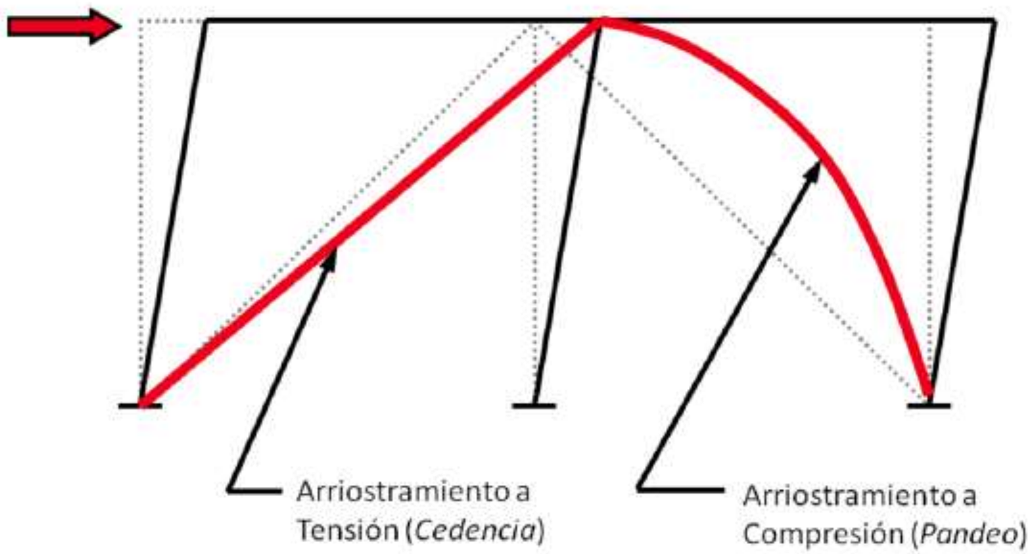


Figura 6: Desempeño estructural de un Pórtico con Diagonales Concéntricas. (Fuente: V Diplomado Estructural CSI Caribe)

4.8.2. Diagrama de Histéresis de un Arriostramiento Concéntrico:

Primera Fase: Se carga axialmente el elemento a compresión.

1. Representa la capacidad a compresión definida por el pandeo del elemento.
2. Representa la resistencia remanente a compresión (Post-pandeo). Se genera una rótula plástica en el centro del elemento (Debido al momento producido por efecto P-Δ en el miembro).

Segunda Fase: Se descarga axialmente el elemento.

3. Representa la deformación (acortamiento) remanente del elemento, generada al superar su capacidad elástica a compresión.

Tercera Fase: Se carga axialmente el elemento a tracción:

4. Representa la capacidad cedente del elemento a tracción.

Cuarta Fase: Se descarga axialmente el elemento.

5. Representa la deformación (alargamiento) remanente en el elemento al superar la capacidad elástica.

Quinta Fase: Se carga axialmente el elemento a compresión en un segundo ciclo.

6. Representa la capacidad a compresión "reducida" por el primer ciclo de carga.
7. Representa la capacidad a compresión para cuando se forma nuevamente la rótula plástica en el medio del elemento.

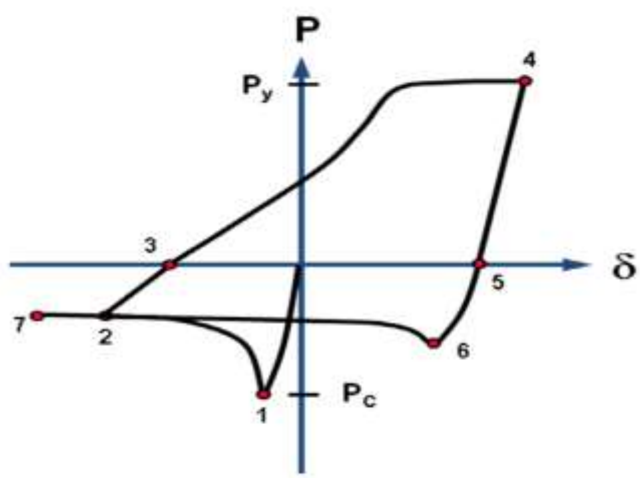
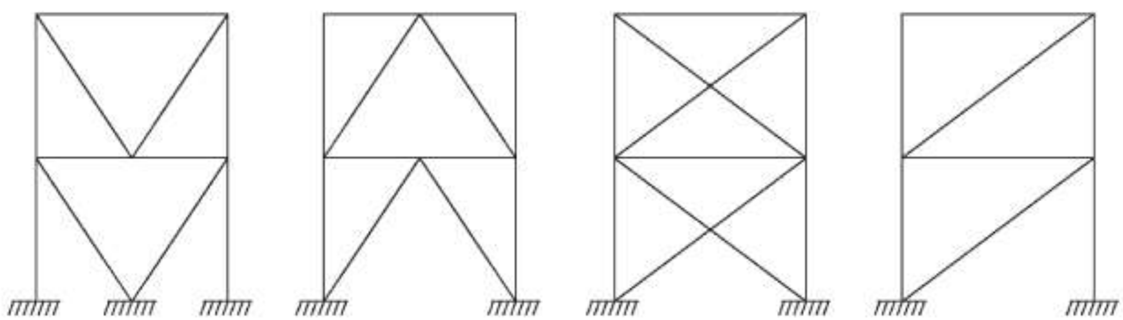


Figura 7: Diagrama de Histéresis de un Arriostramiento Concéntrico. (Fuente: V Diplomado Estructural CSI Caribe)

4.8.3. Clasificación según la disposición de los arriostramientos:

Sistemas con Arriostramientos Simples.

- Sistemas con Arriostramientos dispuestos en V.
- Sistemas con Arriostramientos dispuestos en V Invertida.
- Sistemas con Arriostramientos dispuestos en X de uno o dos pisos.
- Sistemas con arriostres multi-niveles.
- Ssistemas con arriostres dispuestos en K están prohibidos en los sistemas SCBF debido a que generan un mecanismo por la falla de la columna.
- Sistemas de arriostre diagonal, que solo trabaje a tensión no se debe Usar en SCBF



ARRIOSTRE EN ARRIOSTRE-V ARRIOSTRE-X ARRIOSTRE-

Figura 8: Clasificación según la disposición de los arriostramientos (Fuente: ANSI/ AISC-341-16)

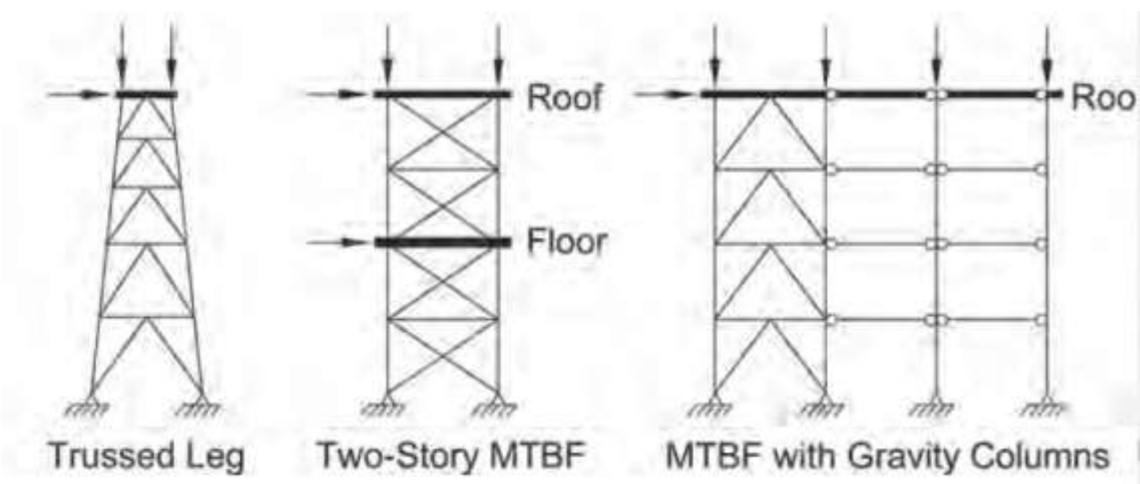


Figura 9: sistema de arriostres multi-nivles (Fuente: ANSI/ AISC-341-16)

4.8.4. Clasificación según su nivel de desempeño sismorresistente:

Pórticos Especiales con Arriostramientos Concéntricos: son sistemas capaces de desarrollar incursiones inelásticas moderadas, de manera estable. Estos pórticos serán los que cumplen con el Nivel de Diseño Especial. En las normas AISC son conocidos como *"Special Concentrically Brace Frames"* o SCBF.

Pórticos Ordinarios con Arriostramientos Concéntricos: son sistemas con una capacidad inelástica muy limitada, su desempeño está basado en el rango elástico. Estos pórticos serán los que cumplen con el Nivel de Diseño En las normas AISC son conocidos como Ordinario. *"Ordinary Concentrically Brace Frames"* u OCBF.

4.8.5. Requisitos en Pórticos Especiales con Arriostramientos Concéntricos:

Los Pórticos Especiales con Arriostramientos Concéntricos o SCBF deberán satisfacer los requerimientos establecidos en el Capítulo F de la Parte F.2 de la Norma AISC 341-16.

4.8.5.1. *Requerimientos de Resistencia de las columnas, vigas y conexiones en SCBF*

1. Se debe determinar la resistencia requerida usando las combinaciones aplicadas en el ASCE/SEI 7 Que incluyan los efectos de amplificación de la carga sísmica Horizontal E_{mh},condicionada por la sobre Resistencia Ω_o, que es igual a 2 para este tipo de sistemas SCBF. Ver figura 7.

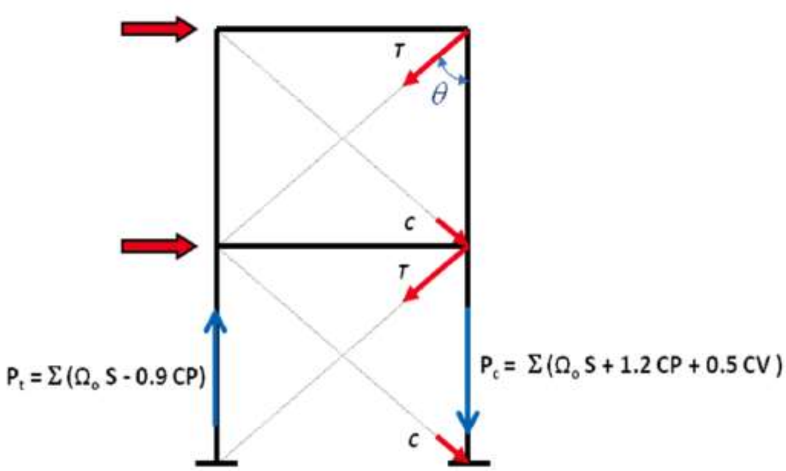


Figura 10: Demanda en columnas para la Condición inciso 1. (Fuente: V Diplomado Estructural CSI Caribe)

2. Se deberá considerar el mayor de las fuerzas de los siguientes análisis:

a) un análisis donde todos los arriostres se asume que resistan la correspondiente **resistencia esperada o requerida** en compresión o en tensión.

b) Un análisis donde todos los arriostres a tensión se asume que resisten la correspondiente **resistencia requerida** y todos los arriostres en compresión la **resistencia requerida post-pandeo**. (Ver figura 8).

c) Para **arriostres multi-niveles**, un análisis que represente progresiva fluencia y pandeo de los arriostres desde el más débil al más fuerte. El análisis debe considerar ambas direcciones de los marcos.

La **resistencia espera en tensión** Se calcula como $R_y F_y A_g$.

La **resistencia esperada a compresión** se calculará como la menor de $R_y F_y A_g$

Y $\left(\frac{1}{0.877}\right) F_{cre} A_g$, Donde F_{cre} , se determina según el capítulo E del AISC-360-16 usando las ecuaciones para determinar F_{cr}. Con la excepción que se usara $R_y F_y$ en lugar de F_y en las ecuaciones

El esfuerzo critico F_{cre}, Se determina como:

a) Cuando $\frac{L_C}{r} \leq 4.71\sqrt{\frac{E}{R_y F_y}}$ $\quad\left(o\ \frac{R_y F_y}{F_e} \leq 2.25\right)$

$$F_{cre} = \left(0.658^{\frac{R_Y F_y}{F_e}}\right) R_Y F_y \qquad \text{EC-22}$$

b) Cuando $\frac{L_C}{r} > 4.71\sqrt{\frac{E}{R_y F_y}}$ $\quad\left(o\ \frac{R_y F_y}{F_e} > 2.25\right)$

$F_{cre} = 0.877 F_e$

Donde el esfuerzo al pandeo elástico $F_e = \frac{\pi^2 E}{\left(\frac{L_c}{r}\right)^2}$ aplicable en ksi. (MPa)

r=radio de giro, in. (mm)

E=módulo de Elasticidad 29000 Ksi, (200000 MPa)

F_y=mínimo esfuerzo de fluencia del acero ksi, (MPa)

La **resistencia esperada post-pandeo** será calculado como el 0.3 veces la resistencia esperada a compresión del arriostre (Hassan and Goel, 1991).

Cuando el radio de esbeltez sea igual a 200 el máximo permitido según la sección F2.5b del AISC-341-16. El pandeo elástico permitido será $0.3F_{cre}$ para este arriostre es 2.1 Ksi (14Mpa). Estos valores deben ser usado según En el análisis mencionado en el inciso 2, sección b)

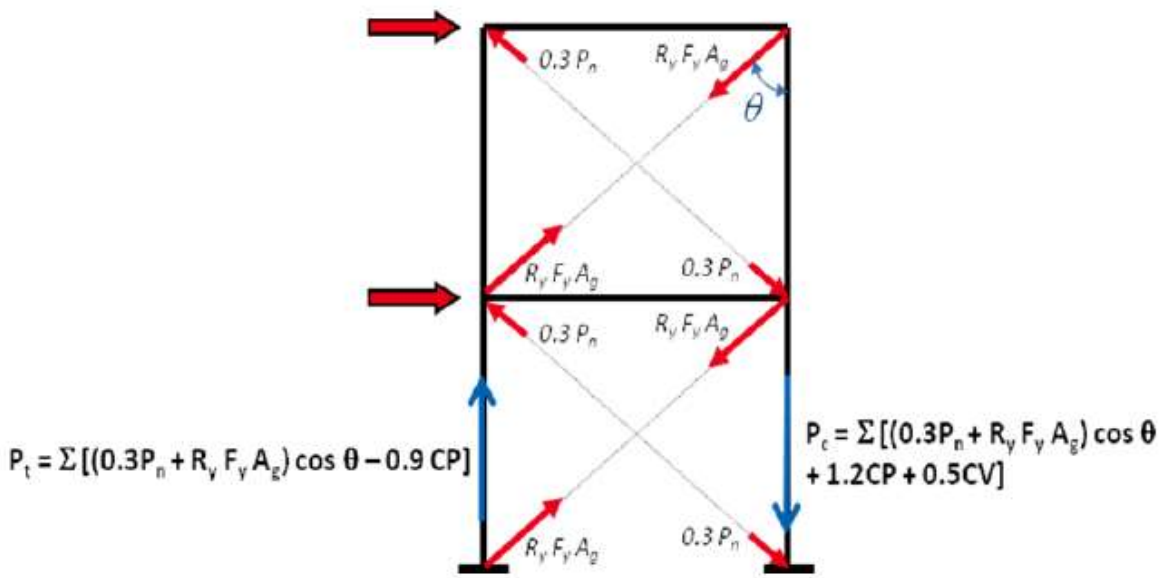


Figura 11: Demanda en columnas para el análisis según inciso 2, sección b). (Fuente: V Diplomado Estructural CSI Caribe)

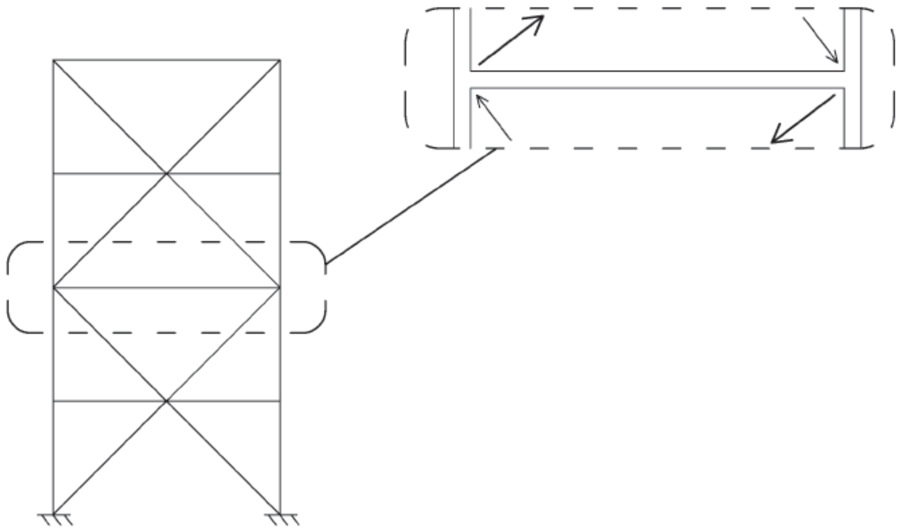


Figura 12: post-elastico flujo de fuerzas en los arriostres en viga. (Fuente: ANSI/ AISC-341-16)

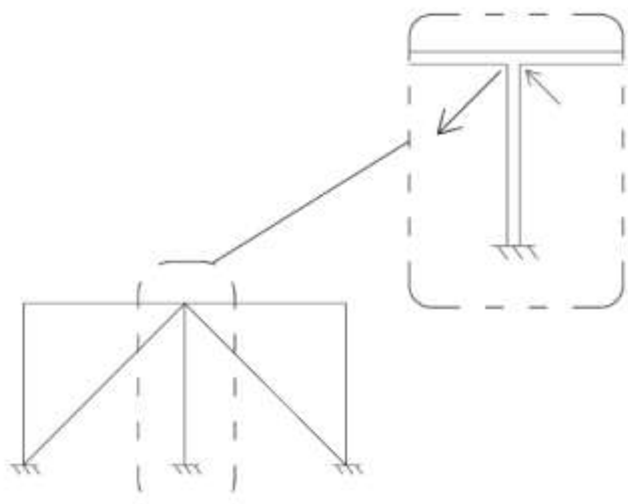


Figura 13: post-elastico flujo de fuerzas en los arriostres en columna. (Fuente: ANSI/ AISC-341-16)

Excepciones:

1. Es permitido despreciar las fuerzas resultantes de la deriva debido al sísmico en esta determinación
2. los requerimientos de resistencia en columnas no necesitan exceder los siguientes requerimientos.

a) Las fuerzas correspondientes a la resistencia de las fundaciones a volcamiento

b) Las Fuerzas determinadas de un análisis no lineal como se define en la sección C3 del AISC-341-16.

3. La resistencia de las conexiones de los arriostres deben de calcularse considerando la sección F2.6c del AISC-341-16

4.8.5.2. *Requerimientos básicos de ductilidad para un SCBF.*

Las columnas, arriostres y vigas deben satisfaces los requerimientos de la sección D1.1 del AISC-341-16 para miembros designados como altamente dúctiles. Los **arriostres multi-niveles** deben cumplir con la siguiente tabla D.1.1 sacada del AISC-341-16 como miembros moderadamente dúctiles

4.8.5.3. Arriostres Diagonales.

Los arriostres deben de cumplir con los siguientes requisitos:

1) Deben de tener un radio de esbeltez de $\frac{L_C}{r} \leq 200$.

   Donde:

   L_C=Longitud efectiva del arriostre =KL. In(mm)

   r= radio de giro que gobierna. In (mm)

2) Proceso constructivo: el espaciado de los conectores (puntos de conexión) debe ser tal que el radio de esbeltez, $\frac{a}{r_i}$, de un elemento individual entre los conectores no exceda 0.4 veces el radio de esbeltez governante en el proceso constructivo del elemento.

   Donde:

   a=la distancia entre conectores, in (mm)

   R_i=mínimo radio de giro de un componente individual. In (mm).

La suma de las resistencias disponible por corte de los conectores debe ser igual o exceder la **resistencia a tensión disponible** de cada elemento. El espaciamiento de conectores debe ser uniforme. No menos se usarán menos de dos conectores in cada **proceso constructivo** del elemento. No se debe localizar conectores dentro de la mitad o cuarta parte de la longitud del arriostre.

Excepción: donde el pandeo del arriostre sobre el eje cargado no cause cortante en el conector, el diseño de los conectores no necesita cumplir con estas especificaciones

(C). el área neta efectiva del arriostre no deberá ser menos que el área gruesa donde el refuerzo en el arriostre fue usado, los siguientes rrequerientos deben ser aplicados

1). la resistencia mínima de fluencia Fy del refuerzo debe ser al menos la misma de la especificada en el arriostre.

2). Los conectores de los refuerzos al arriostre deben tener suficiente resistencia soportar el desarrollo la resistencia esperada reforzada en cada lugar de la sección reducida.

4.8.5.4. Arriostres empotrados y arriostres articulados.

Los arriostres que estén empotrados desarrollaran una rotula plástica en los extremos y el centro del arriostre. Mientras que los arriostre articulados solo desarrollaran una rotula plástica en el centro.

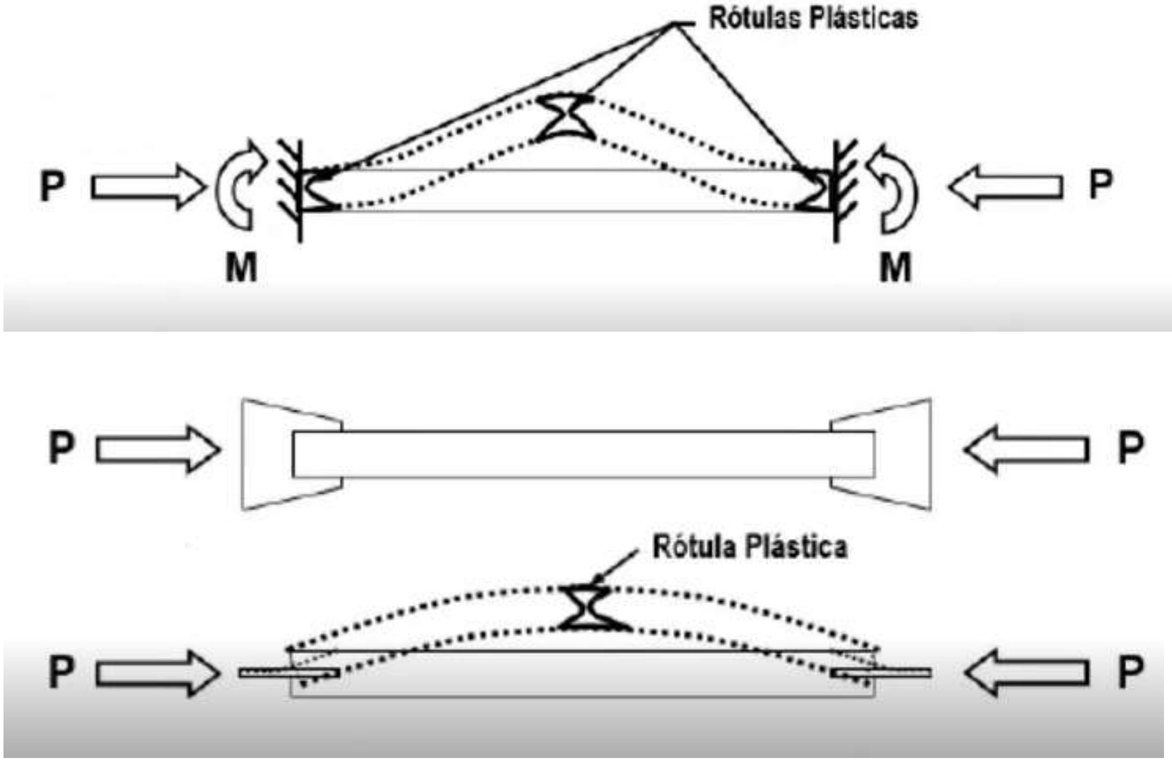


Figura 14: rotula plástica en arriostre empotrado y articulado. (Fuente: ANSI/ AISC-341-16)

4.8.5.5. Zona protegida

Las zonas protegidas para SCBF deben de satisfacer la sección D1.3 del ASCI-341-16, Y se debe incluir los siguientes requisitos:

a) Para los arriostres, se debe considerar zona protegida el centro del arriostre donde se espera un rotula y una distancia de L/4.

b) Los elementos que conectan el arriostre con las vigas y columnas una distancia igual al ancho del arriostre medida a partir del borde de la placa gusset

Soldar o cortar en la zona protegida podría provocar una fractura en las zonas que se espera se plastifique.

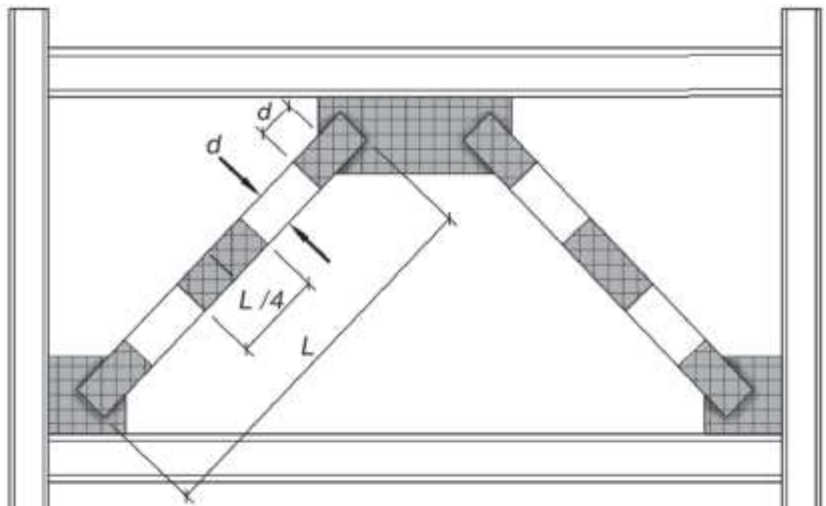


Figura 14: Zonas protegidas en los pórticos con V Invertida. (Fuente: ANSI/ AISC-341-16)

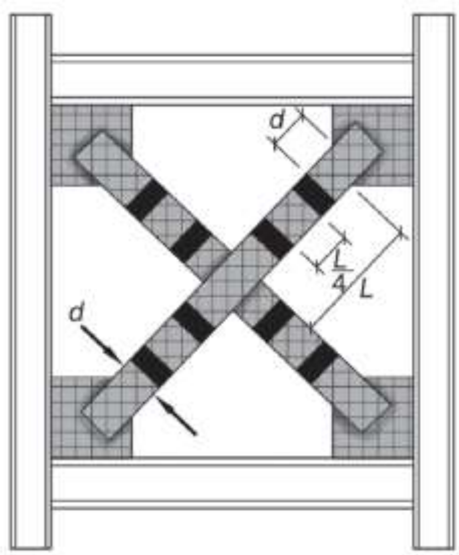


Figura 14: Zonas protegidas en los pórticos con arriostres en x. (Fuente: ANSI/ AISC-341-16).

4.8.5.6. Resistencia Requerida en Conexiones de Arriostramientos:

Requerimientos para soldadura.

La soldadura a usarse debe ser **soldadura de demanda crítica** y debe de cumplir los siguientes requerimientos:

a) Soldadura de relleno para empalmes de columna.
b) Soldadura para la conexión de columna y placa base

Excepciones: la soldadura no necesita ser considerada **soldadura de demanda critica** Cuando se cumpla los siguientes puntos.

1. Columnas articuladas o casi articuladas, la placa base está excluida por condiciones de restricción.
2. No hay tensión neta bajo combinaciones de carga sísmicas que consideren sobre resistencia

c) La soldadura para conexión viga-columna debe estar conforme a la sección F2.6b inciso c) del AISC 341-16. Esta sección nos plantea cumplir con la sección E1.6b inciso c), se debe cumplir la sección E2.6 Y sección E3.6 del mismo AISC-341-16.

conexión viga-Columna.

Las conexiones donde un arriostre o placa Gasset se conecte a la viga y columna deben de cumplir los siguientes requisitos:

a) El ensamble entre viga-columna debe ser **una conexión simple** (Ver figura 4) reuniendo los requisitos de la sección B3. 4a del AISC-360-16, donde la rotación requerida será tomada como 0.025 rad;

b) El ensamble de la conexión viga-columna debe resistir un momento igual al menor de los siguientes:

1. Un momento igual momento por flexión esperado en la viga, $R_y M_p$, multiplicado por 1.1 y dibidio por α_s.

   Donde:

   M_p=momento plástico por flexión.

   α_s=factor por nivel de fuerza, LRFD=1; ASD=1.5.

2. Un momento correspondiente a la suma de resistía esperada por momento de la columna,$\sum(R_y M_p)$, multiplicado por 1 y dividido por α_s.

Estos momentos deben considerarse en combinación con la resistencia requerida del arriostre conectado y la viga conectada. incluyendo el diagrama colector de fuerzas determinado usando carga sísmica se sobre resistencia.

c. la conexión viga columna debe reunir los requisitos de la sección E1.6B inciso c) del AISC 341-16. Este último requisito no aparecía en el AISC 341-10 y se refiere conexiones FR.

Los arriostres están sujetos a derivas inelásticas. Esta conexión tendrá significante rotación. Conexiones con placas gusset puede ser vulnerable a ruptura si no se diseña de acuerdo a esta rotación. Recientemente Un ensayo realizado por (iris and Mahin,2004) indico que el diseño no cuenta con suficiente rigidez y distribución de fuerza

El AISC-341-16 permite usar tres opciones. La primera es usar una conexión simple para esto se requiere una rotación de 0.025 rad. Un ejemplo es la configuración ensayada en la universidad de Illinois (Stoakes andFahnestock, 2010) esta conexión efectivamente cumplió con la rotación. Note que esta conexión no cumple con los requerimientos de zona protegida.

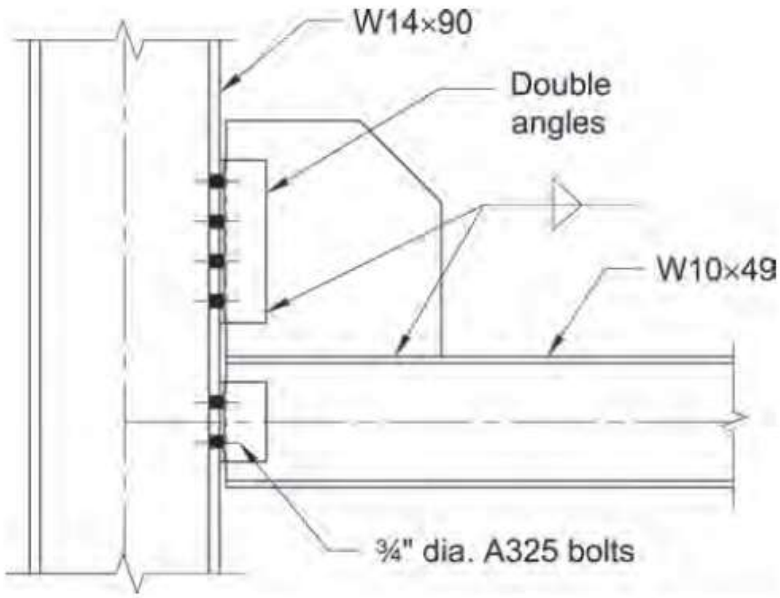
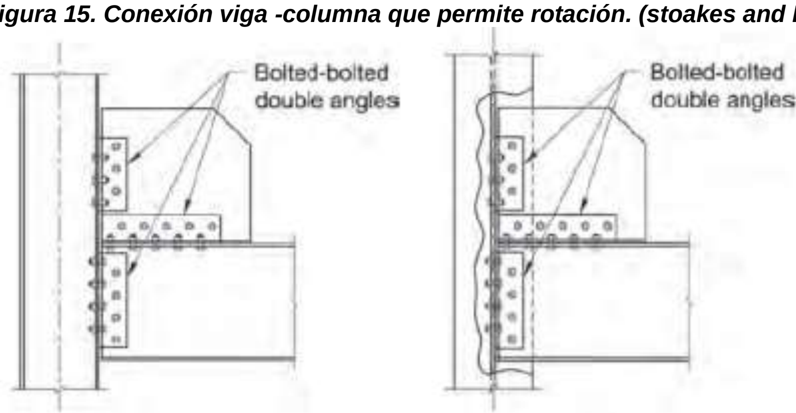


Figura 15. Conexión viga -columna que permite rotación. (stoakes and Fahnestock,2010).



(a) All-bolted unstiffened gusset connection to column flange

(b) All-bolted gusset connection to column web

Fig. C-F2.17. All-bolted beam-to-column connection that allows rotation (McManus et al., 2013).

La conexión a condición se agregó en el manual de diseño símico en la tercera edición y se pretende usar en los cálculos que se realizaran.

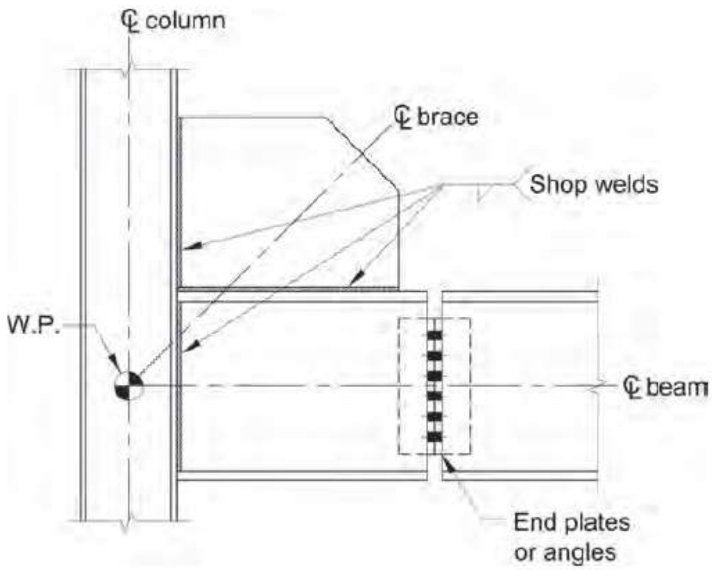


Fig. C-F2.18. Beam-to-column connection that allows rotation (Thornton and Muir, 2008).

La segunda opción es usar una conexión FR, Completamente restringida para la cual se debe encontrar el máximo momento como el momento máximo esperado de la conexión según la sesión E1.6 del AISC 341-16.

Conexión del arriostre

Los requerimientos de resistencia en tensión, compresión y flexión de las conexiones de arriostres deben ser determinados como se especifica a continuación. Estos requerimientos de resistencia están permitidos considerarse independientes.

1. Requerimiento de resistencia a tensión:

a) La resistencia de fluencia esperada en tensión en el arriostre será determinada como $R_y F_y A_g$, dividida por α_s.

Excepto: los arriostres que no cumplan con los requerimientos de las ecuaciones J4-1 y J4-2 del AISC-341-16. Esta excepción aplica a los arriostres con sección neta reducida por pernos.

b) El máximo efecto de la carga, indicada por análisis. Que fue transferida al arriostre por el sistema.

2. Requerimientos de resistencia por compresión.

la conexión del arriostre debe ser diseñado para soportar la resistencia requerida del arriostre. Basado en el límite de pandeo. Esto será igual a la **resistencia a compresión esperada** dividido por α_s

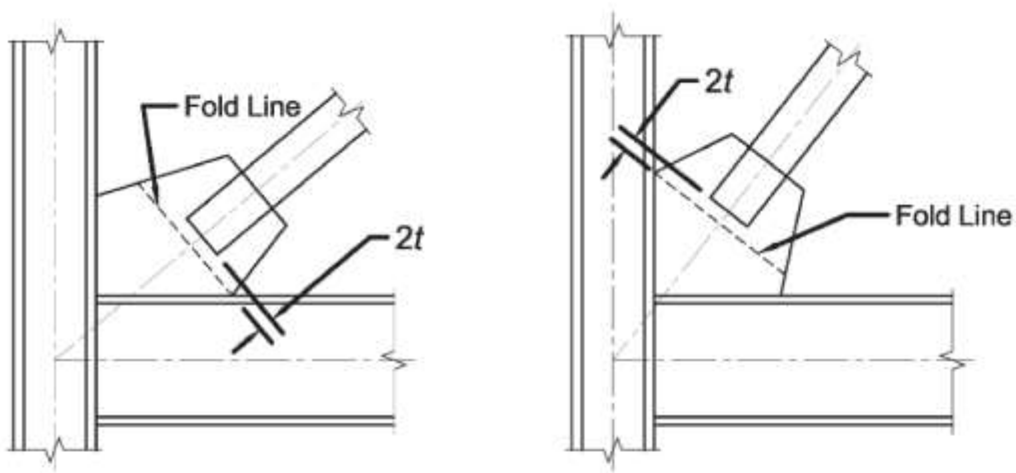
3. Ubicación del pandeo del arriostre.

La conexión del arriostre debe ser diseñada para soportar la fuerza de flexión o rotación impuesta por el pandeo del arriostre. La conexión debe de cumplir las siguientes especificaciones:

a) Requerimiento de resistencia a flexión: la conexión del arriostre debe de soportar las fuerzas de flexión impuestas, deberá tener la resistencia requería a flexión igual a la especificada para el arriostre multiplicada por 1.1 y dividida por α_s. La resistencia requerida por flexión se calculará $R_y M_p$ alrededor del eje de pandeo.

b) Capacidad de Rotación: la conexión del arriostre deberá tener la suficiente capacidad de rotar en función de la deriva del piso. Una rotación inelástica de la conexión es permitida.

Para asegurar una rotación se deberá dejar una distancia de 2t como se muestra en la figura a continuación. Debe ser considerada como la mínima distancia paralela. En la práctica puede usarse 2t +1”. Sabiendo que “t” es el espesor de la placa Gasset



t = thickness of gusset plate

Fig. C-F2.9. Brace-to-gusset plate requirement for buckling out-of-plane bracing system.

Placa Gusset

Para arriostre que se pandean fuera del plano, soldados directamente a la placa gusset y a la viga y columna en sus patines. Deben tener suficiente resistencia a corte igual a

$\mathbf{0.6R_yF_yt_p/\alpha_s}$ veces la longitud de la conexión.

Donde:

F_y=esfuerzo de fluencia mínimo de la placa gusset, Ksi (Mpa)

R_y=relación de esfuerzo esperado a fluencia a esfuerzo de fluencia mínimo. Fy

t_p= espesor de la placa gusset.in(mm)

Excepción: alternativamente, esta soldadura puede ser diseñada para tener la suficiente resistencia para resistir la fuerza del arriostre especificado en la Sección F2.6c.2 del AISC 341-16, Combinado con el momento flexiónante actuando en el eje débil de la placa gosset.

Empalmes en las Columnas

Se debe diseñar para desarrollar el 50% de la menor de resistencias nominales plásticas a flexión de los miembros conectados.

Resistencia al cortante: $\frac{\sum M_{pc}}{H}$

Donde: $\frac{\sum M_{pc}}{H}$: es igual a la suma de las resistencias nominales plásticas a flexión de las columnas de arriba y debajo del empalme

TABLE D1.1
Limiting Width-to-Thickness Ratios for Compression Elements for Moderately Ductile and Highly Ductile Members

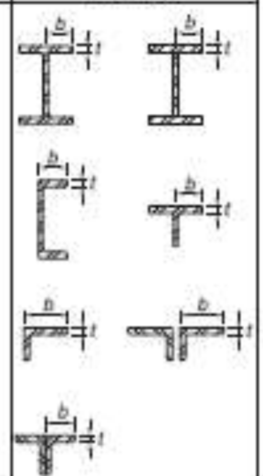
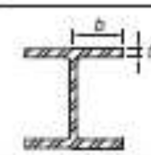
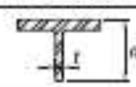
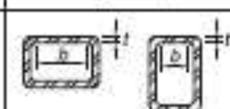
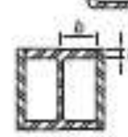
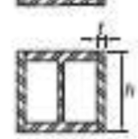
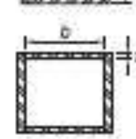
	Description of Element	Width-to-Thickness Ratio	Limiting Width-to-Thickness Ratio: λ_{hd} Highly Ductile Members	Limiting Width-to-Thickness Ratio: λ_{md} Moderately Ductile Members	Example
Unstiffened Elements	Flanges of rolled or built-up I-shaped sections, channels and tees; legs of single angles or double-angle members with separators; outstanding legs of pairs of angles in continuous contact	b/t	$0.32\sqrt{\frac{E}{R_yF_y}}$	$0.40\sqrt{\frac{E}{R_yF_y}}$	
Unstiffened Elements	Flanges of H-pile sections per Section D4	b/t	not applicable	$0.48\sqrt{\frac{E}{R_yF_y}}$	
Unstiffened Elements	Stems of tees	d/t	$0.32\sqrt{\frac{E}{R_yF_y}}$ [a]	$0.40\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Walls of rectangular HSS used as diagonal braces	b/t	$0.65\sqrt{\frac{E}{R_yF_y}}$	$0.76\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Flanges of boxed I-shaped sections	b/t			
Stiffened Elements	Side plates of boxed I-shaped sections and walls of built-up box shapes used as diagonal braces	h/t			
Stiffened Elements	Flanges of built-up box shapes used as link beams	b/t			

TABLE D1.1 (continued) Limiting Width-to-Thickness Ratios for Compression Elements for Moderately Ductile and Highly Ductile Members

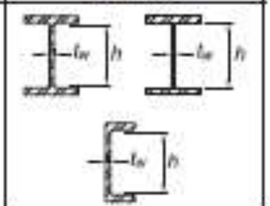
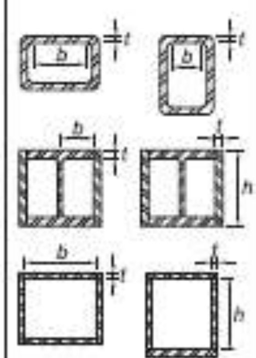
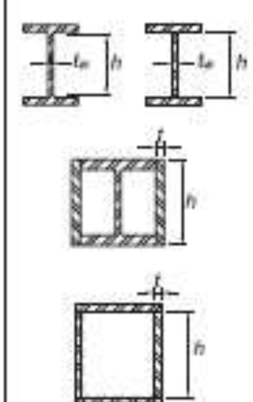
	Description of Element	Width-to-Thickness Ratio	Limiting Width-to-Thickness Ratio: λ_{hd} Highly Ductile Members	Limiting Width-to-Thickness Ratio: λ_{md} Moderately Ductile Members	Example
Stiffened Elements	Webs of rolled or built-up I shaped sections and channels used as diagonal braces	h/t_w	$1.57\sqrt{\frac{E}{R_yF_y}}$	$1.57\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Where used in beams or columns as flanges in uniform compression due to axial, flexure, or combined axial and flexure: 1) Walls of rectangular HSS 2) Flanges and side plates of boxed I-shaped sections, webs and flanges of built-up box shapes	 b/t h/t	$0.65\sqrt{\frac{E}{R_yF_y}}$	$1.18\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Where used in beams, columns, or links, as webs in flexure, or combined axial and flexure: 1) Webs of rolled or built-up I-shaped sections or channels [b] 2) Side plates of boxed I-shaped sections 3) Webs of built-up box sections	 h/t_w h/t h/t	For $C_a \le 0.114$ $2.57\sqrt{\frac{E}{R_yF_y}}(1-1.04C_a)$ For $C_a > 0.114$ $0.88\sqrt{\frac{E}{R_yF_y}}(2.68-C_a)$ $\ge 1.57\sqrt{\frac{E}{R_yF_y}}$ where $C_a=\frac{P_u}{\phi_c P_y}$ (LRFD) $C_a=\frac{\Omega_c P_a}{P_y}$ (ASD) $P_y = R_yF_yA_g$	For $C_a \le 0.114$ $3.96\sqrt{\frac{E}{R_yF_y}}(1-3.04C_a)$ For $C_a > 0.114$ $1.29\sqrt{\frac{E}{R_yF_y}}(2.12-C_a)$ $\ge 1.57\sqrt{\frac{E}{R_yF_y}}$ where $C_a=\frac{P_u}{\phi_c P_y}$ (LRFD) $C_a=\frac{\Omega_c P_a}{P_y}$ (ASD) $P_y = R_yF_yA_g$	

TABLE D1.1 (continued) Limiting Width-to-Thickness Ratios for Compression Elements for Moderately Ductile and Highly Ductile Members

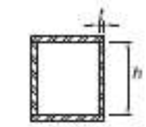
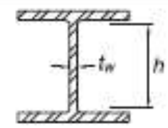
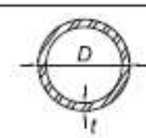
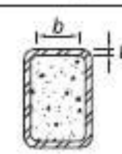
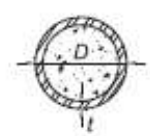
	Description of Element	Width-to-Thickness Ratio	Limiting Width-to-Thickness Ratio: λ_{hd} Highly Ductile Members	Limiting Width-to-Thickness Ratio: λ_{md} Moderately Ductile Members	Example
Stiffened Elements	Webs of built-up box sections used as EBF links	h/t	$0.67\sqrt{\frac{E}{R_yF_y}}$	$1.75\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Webs of H-Pile sections	h/t_w	not applicable	$1.57\sqrt{\frac{E}{R_yF_y}}$	
Stiffened Elements	Walls of round HSS	D/t	$0.053\frac{E}{R_yF_y}$	$0.062\frac{E}{R_yF_y}$ [c]	
Composite	Walls of rectangular filled composite members	b/t	$1.48\sqrt{\frac{E}{R_yF_y}}$	$2.37\sqrt{\frac{E}{R_yF_y}}$	
Composite	Walls of round filled composite members	D/t	$0.085\frac{E}{R_yF_y}$	$0.17\frac{E}{R_yF_y}$	

TABLE D1.1 (continued)
Limiting Width-to-Thickness Ratios for Compression Elements for Moderately Ductile and Highly Ductile Members

[a] For tee-shaped compression members, the limiting width-to-thickness ratio for highly ductile members for the stem of the tee shall be $0.40\sqrt{\frac{E}{R_yF_y}}$ where either of the following conditions are satisfied:

(1) Buckling of the compression member occurs about the plane of the stem.

(2) The axial compression load is transferred at end connections to only the outside face of the flange of the tee resulting in an eccentric connection that reduces the compression stresses at the tip of the stem.

[b] For I-shaped beams in SMF systems, where C_a is less than or equal to 0.114, the limiting ratio h/t_w shall not exceed $2.57\sqrt{\frac{E}{R_yF_y}}$. For I-shaped beams in intermediate moment frame (IMF) systems, where C_a is less than or equal to 0.114, the limiting width-to-thickness ratio shall not exceed $3.96\sqrt{\frac{E}{R_yF_y}}$.

[c] The limiting diameter-to-thickness ratio of round HSS members used as beams or columns shall not exceed $0.077\frac{E}{R_yF_y}$.

where

E = modulus of elasticity of steel = 29,000 ksi (200 000 MPa)
F_y = specified minimum yield stress, ksi (MPa)
P_a = required axial strength using ASD load combinations, kips (N)
P_u = required axial strength using LRFD load combinations, kips (N)
R_y = ratio of the expected yield stress to the specified minimum yield stress
ϕ_c = resistance factor for compression
Ω_c = safety factor for compression

4.9. Distribución de Fuerzas Laterales:

Los arriostramientos se dispondrán a lo largo de cualquier línea resistente en direcciones alternadas, en forma tal que para cualquier dirección de la fuerza, paralela al arriostramiento, por lo menos un 30% pero no más del 70%, de la fuerza horizontal total, sea resistida por los arriostramientos traccionados, a menos que la resistencia teórica (N_t), de cada arriostramiento comprimido sea mayor que la solicitación mayorada que resulta al aplicar las combinaciones que incluyen la carga sísmica amplificada.

Lo que se traduce que la disposición de los arriostramientos debe ser alternante a fin de obtener una respuesta estructural estable y similar, en ambos sentidos de la acción sísmica, tal como se indica en la siguiente figura.

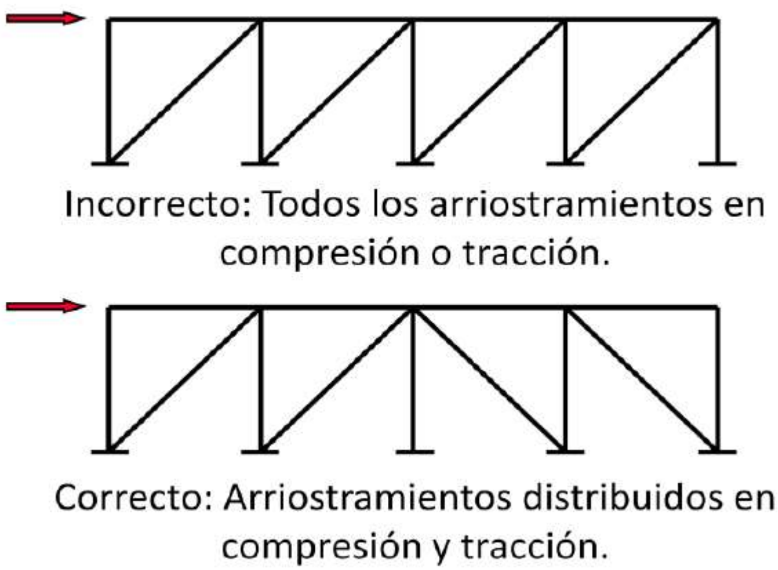


Figura 19: Distribución de Arriostramientos en Pórticos. (Fuente: V Diplomado Estructural CSI Caribe)

Se define como línea de arriostramiento, una línea única o líneas paralelas que no se desvíen en planta más de 10% de la dimensión de la edificación perpendicular a la línea de arriostramiento.

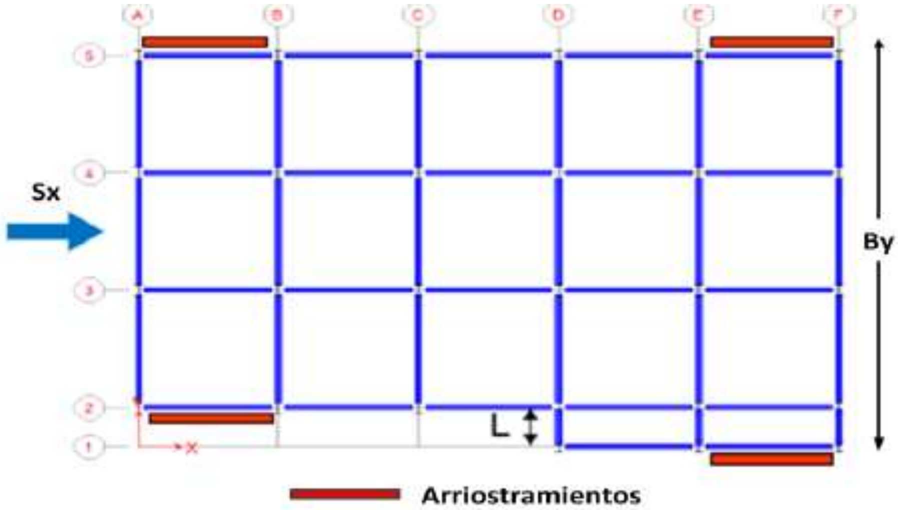


Figura 20: Distribución de Arriostramientos en planta. (Fuente: V Diplomado Estructural CSI Caribe)

Para que el arriostramiento en el eje 1 pertenezca a la misma línea de resistencia que el del eje 2, la longitud L debe ser menor o igual a 0.10By.

4.10. Requerimientos Especiales en Configuraciones con Arriostramientos Tipo V y Tipo V Invertida:

Adicionalmente a las especificaciones anteriormente mencionadas se incorporarán las siguientes condiciones para los sistemas SCBF con arriostramientos Tipo V y Tipo V Invertida.

La resistencia requerida de las vigas interceptadas por los arriostramientos, sus conexiones y miembros de soporte, deberá ser determinada de acuerdo a las combinaciones de carga aplicables para el diseño de edificaciones, considerando que los arriostramientos no generan soporte a las vigas para las cargas gravitacionales (permanentes y variables). Para las combinaciones que incluyen la carga sísmica amplificada, la misma se calculará considerando lo siguiente:

-Fuerza en arriostramientos a tracción: $R_{ey} F_y A_g$

-Fuerza en arriostramientos a compresión: $0.3\ P_n$

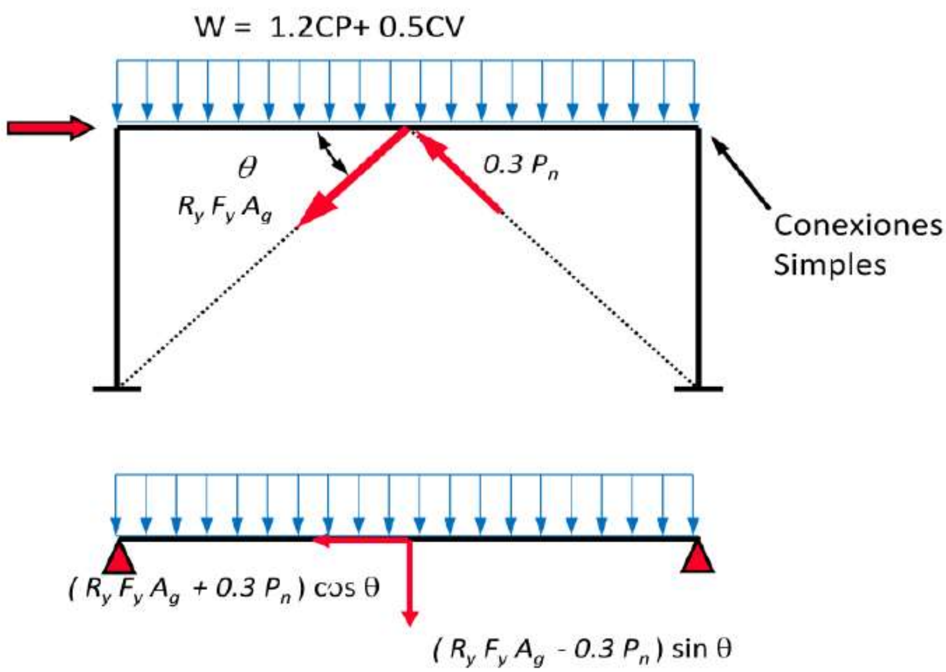


Figura 21: Distribución de fuerzas en el sistema viga-arriostramiento (Fuente: V Diplomado Estructural CSI Caribe)

-Las vigas deben ser continua entre las columnas.

-Ambas alas de la viga deben estar soportadas lateralmente a una distancia menor que el límite L_{pd}.

$$L_{pd} = \left[0.12 + 0.076\left(\frac{M_1}{M_2}\right)\right]\left(\frac{E_s}{F_y}\right) r_y$$

Donde:

L_{pd}=distancia mínima entre soportes laterales.

M_1=menor momento actuando en la viga sin soporte lateral.

M_2=mayor momento actuando en la viga sin soporte lateral.

r_y=radio de giro menor.

-Ambas alas de la viga deben estar soportadas lateralmente en el punto de intersección de los arriostramientos concéntricos.

4.11. Pre dimensionamiento en SCBF

4.11.1. Redimensionado de una viga.

Edificio	Carga	Descripción	Flecha Recomendada
Industrial	CV	Tramos de miembros que soportan techos con recubrimiento no flexibles	L/240
		Tramos de miembros que soportan techos con recubrimiento flexibles	L/180
		Tramos de miembros que soportan pisos	L/300
	P_G	Tramos de miembros que soportan grúas móviles con capacidad:	
		≥ 25 Ton	L/800
		< 25 Ton	L/600
Otros	CV	Tramos de miembros en pisos y techos que soportan acabados susceptibles de agrietarse	L/360
		Tramos de miembros en pisos y techos que soportan acabados no susceptibles de agrietarse	L/300

CV: Carga variables
P_G: Fuerza máxima vertical para el apoyo de grúa móvil.

Tabla 3. Flechas Máximas Verticales Recomendadas. (Fuente: Diseño Estructural de Acero por Estados Límites Prof. A. Güell)

El Predimensionado de vigas se realizará por la condición de servicio de las deflexiones o flechas máximas recomendadas, por la AISC, para dichos elementos:

Tomando en cuenta los valores aproximados de momento (M) y deformación (Δ) máximos, para vigas simplemente apoyadas con cargas uniformes:

$$M = \frac{qL^2}{8}$$

$$\Delta = \frac{5}{384}\frac{qL^4}{EI}$$

Sabiendo que el momento de inercia (I) es igual a:

$$I = S\ \frac{d}{2}$$

Y Asumiendo conservadoramente que:

$$M = 0.5\ F_y S \rightarrow \frac{M}{S} = 0.5F_y$$

Se puede despejar de la ecuación de deflexión máxima:

$$\Delta = \frac{5}{48}\left(\frac{qL^2}{8}\right)\frac{L^2}{ES(d/2)} = \frac{5}{24}\frac{M}{S}\frac{L^2}{Ed} = \frac{5}{24}\left(0.5F_y\right)\frac{L^2}{Ed}$$

$$\Delta = \frac{5}{12}\frac{L^2}{Ed}\ F_y$$

Para el primer caso de deflexión máxima en la Tabla VI.1 se obtiene:

$$\Delta = \frac{L}{240} = \frac{5}{12}\frac{L^2}{Ed}\ F_y$$

$$\Delta = \frac{5x240}{12}\frac{F_y}{E}\ L$$

En la tabla a continuación se muestran los valores recomendados para alturas de vigas (d), haciendo una aproximación, para un valor de $F_y = 2\,530 Kg/cm^2$.

Edificio	Vigas en	$d_{mín}$
Industrial	Tramos de miembros que soportan techos con recubrimiento no flexibles	L/23
	Tramos de miembros que soportan techos con recubrimiento flexibles	L/28
	Tramos de miembros que soportan pisos	L/18
	Tramos de miembros que soportan grúas móviles con capacidad:	
	≥ 25 Ton	L/10
	< 25 Ton	L/12
Otros	Tramos de miembros en pisos y techos que soportan acabados susceptibles de agrietarse	L/16
	Tramos de miembros en pisos y techos que soportan acabados no susceptibles de agrietarse	L/20

Para obtener valores para vigas con otro esfuerzo cedente bastara multiplicar el cociente de L por el valor dado $2\,530/F_{y\ real}$.

4.11.2. Predimensionado de Columnas.

Para las columnas se acostumbra a usar un Predimensionado del área requerida basado en las cargas gravitacionales factorizadas (Q) por el área tributaria (A_t) que recibe cada uno de estos elementos, entre un porcentaje (20-50%) del esfuerzo cedente de la columna

$$A_g = \frac{A_t Q}{\% F_y}$$

A este criterio se le adiciona un método de Predimensionado basado en la esbeltez del elemento:

$$\lambda = \frac{KL}{r_{min}} \leq 200$$

Z_c / Z_{xb}	Relación mínima entre módulos de columna y viga Acero			
Vigas	ASTM - A 36	ASTM - A 572. Gr 42	ASTM - A 572. Gr 50, 55	ASTM - A 913. Gr 50, 55, 65
Una	1,25	1,02	0,87	0,87
Dos	2,50	2,04	1,74	1,74

Z_c / Z_{xb}	Relación mínima entre módulos de columna y viga Acero			
Vigas	ASTM - A 588	ASTM - A 992	ASTM - A 529. Gr 50	ASTM - A 529. Gr 55
Una	0,87	0,87	0,95	0,87
Dos	1,74	1,74	1,90	1,74

Tabla 4. Relación entre módulo plástico de columna y vigas. (Fuente: V Diplomado en Ingeniería Estructural)

Sin embargo, ninguno de estos métodos considera criterios sísmicos, por lo cual se incorpora un Predimensionado, para sistemas SMF, basado en el criterio de columna fuerte viga débil con lo cual se garantiza que la columna permanecerá de pie al momento de fallar la viga. Basado en el material de la exposición *"Diseño Sismo resistente en Acero"* del "*V Diplomado en Ingeniería Estructural"* (México 2009), se pudieron obtener los siguientes valores de relación entre módulo plástico de la columna entre módulo plástico de viga:

El sufijo b significa viga (beam) y el sufijo c indica columna.

El valor de Z_c dependerá de la colocación de la columna, si las vigas llegan al ala de la columna se tomara el módulo del eje fuerte $Z_c = Z_{xc}$, mientras que si llegan al alma de la columna se tomara el módulo del eje débil $Z_c = Z_{yc}$.

Cuando la viga y columna sean de distintos aceros se entra a la tabla con la resistencia de la viga y se deberá multiplicar el valor de la relación dado por el factor F_{yb}/ F_{yc}.

4.11.3. Predimensionado de un arriostramiento.

Es conveniente colocar los arriostramientos de la estructura en forma simétrica para que la fuerza sísmica se distribuya adecuadamente, evitando torsiones de la estructura. Es conveniente más arriostramientos en los pórticos con menor resistencia, es decir, los pórticos con menor cantidad de vigas y columnas resistentes.

La forma en que se elige el tipo de diagonales dependerá del ángulo que su eje forme con la horizontal, ya que, mientras este ángulo sea más cercano a los 45°, el perfil del arriostramiento trabajará mejor ante las cargas laterales.

Para la selección de un perfil adecuado para las diagonales se considera el efecto del pandeo total de la sección o esbeltez, con el fin de determinar el radio de giro adecuado que cumpla con este requisito.

$$\frac{KL}{r_{min}} \leq 4\sqrt{\frac{E}{F_y}} \rightarrow r_{min} \geq \frac{KL}{4}\sqrt{\frac{F_y}{E}}$$

Para los arriostramientos, considerados como libres en los extremos, se toma el factor de longitud efectiva K=1.0 *(Véase Tabla I.2)* para ambos ejes del perfil.

En casos como los arriostramientos dispuestos en X de solo un piso se considera K=0.5 para la longitud total del arriostramiento, solo para el sentido del pandeo total paralelo al eje del elemento, por lo cual se recomienda colocar el perfil con el eje del menor radio de giro (Eje Y-Y) paralelo al eje del arriostramiento, tal

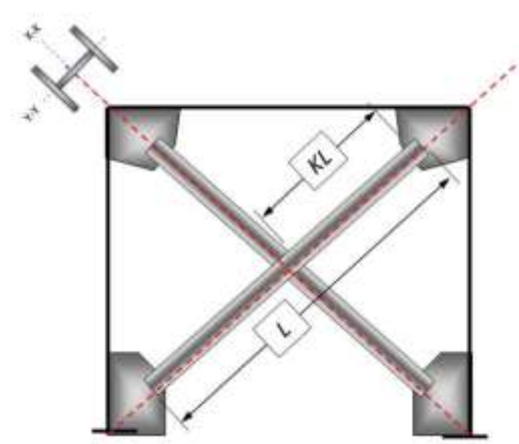


Figura IV.1: Colocación de los arriostramientos en X.

como se indica en la Figura IV.1, en el otro sentido de pandeo el factor K=1.0 y el radio de giro es el de eje mayor (Eje X-X)

4.11.4. Predimensionado del sistema de pisos.

El Predimensionado del sistema de piso no obedece a criterios sísmicos sino a los criterios de cargas gravitacionales y arriostramiento lateral de los elementos resistentes de la estructura. Entre los elementos del sistema de piso se encuentran las correas, vigas de transferencia y losas.

4.11.5. Predimensionado de correas y vigas de Transferencia.

La orientación y número de las correas vendrá dado por la necesidad de arriostramiento de la viga a la que llegan. Una distancia ocasionalmente usada para colocar las correas es un valor entre 1.0 a 1.5 metros, orientadas paralelas a la menor luz de vigas, u ortogonal al pórtico con vigas que requieran una menor longitud no arriostrada

Cuando dichas correas tengan longitudes muy grandes se podrá disponer de una o más vigas de transferencia para que las cargas se distribuyan de manera más eficiente las vigas principales.

Para predimensionar el perfil por su capacidad se debe tomar la acción gravitacional factorizada (Q) por el ancho tributario (a_t) de la correa o viga de transferencia. Donde su capacidad está dada por la sección que resista el siguiente momento:

$$\Phi M_n = 0.9\, Z_x F_y \geq \frac{(Q a_t)L^2}{8}$$

Donde:

L= Longitud de la correa o viga de transferencia.

Q= Carga distribuida por acciones gravitacionales

Para considerar el criterio de flecha máxima se debe respetar el siguiente parámetro:

$$\frac{L}{d} \leq \frac{5600}{F_y}\left(\frac{Z_x}{Z_{req}}\right)$$

Donde:

d= Altura del perfil de la correa o viga de transferencia.

Z_x= Módulo plástico del perfil de la correa o viga de transferencia.

Z_{req}= Módulo plástico mínimo que satisfaga la inecuación (IV-11).

4.11.6. Predimensionado de losa

Típicamente en acero se usa la losa con encofrado colaborante o losa cero, ya que parte de los esfuerzos por flexión los absorbe el sofito metálico que sirve de encofrado. El Predimensionado de la altura (h) este elemento dependerá de la distancia entre apoyos o correas que la sostienen:

Caso:	L/h ≤
En tramos simplemente apoyados	22
En tramos extremos de losas continuas	27
En tramos intermedios de losas continuas	32

Tabla IV.4: Relación L/h para losas en sistemas de piso. (Fuente: COVENIN 1618-98)

Siendo la mínima altura de la losa 90mm y el espesor mínimo del concreto sobre la parte más exterior del sofito metálico 50mm.

5. Marco Metodológico.

A continuación, se enumera la metodología a seguir para realizar la investigación:

1. Iniciar la investigación documental en bibliotecas y archivos electrónicos, así como en publicaciones y revistas que muestran los temas relacionados con marcos arriostrados concéntricos especiales, de la misma manera investigar en los diferentes foros que estén disponibles en internet y recopilar información relevante sobre sistemas.
2. Realizar un modelo matemático del edificio en ETABS 2017. Este modelo será realizado teniendo en cuenta los manuales de CSI structural and earthquake engineering sofware.
3. Realizar hojas de cálculos automatizadas según el manual de Diseño sísmico del AISC, en su tercera edición y el Manual de diseño sísmico volumen 4 del IBC 2012.
4. Realizar planos estructurales donde se detalle los resultados de los cálculos usando Revit 2019.
5. Concluir mediante la investigación cuales son los beneficios del sistema SCBF.

6. RESULTADOS Y ANALISIS

Antes de realizar el modelo matemático en ETABS se debe de resumir los cálculos del análisis sísmico que nos permita considerar los efectos del sismo en el edificio siempre usando el capítulo 11 del ASCE-16 y la amenaza sísmica de managua.

Los diseños de columna, viga y arriostres se calcularon en Excel mientras que las conexiones y fundaciones se calcularon con RAM CONECCTION y RAM Element.

6.1.CRITERIOS DE DISEÑO SISMICOS

Ubicación del Edificio
Departamento: Managua
municipio: Mangua

Ss=	1.138	ordenada espectral periodo corto	sección 4.4.1.1
s1=	0.28	ordenada espectral periodo de 1seg	sección 4.4.1.1

sección 11.4.1 del ASCE07-16

cercanía a falla (10 km) de la proyección de superficie de una conocida
Falla activa capaz de sismos de magnitud 6 o eventos más grandes.

Clasificación de sitio D Usando tabla 20.3-1 del ASCE07-16.
considerando un tipo de suelo S=2 según el RNC-07, con velocidades de onda de 600 a 1200 f

coeficiente de sitio:

Fa=	1.045	Tabla 11.4.1 ASCE-16 Coeficiente de sitio Fa
Fv=	2.04	Tabla 11.4.2 ASCE-16 Coeficiente de sitio Fv

Sms=FaSs=	**1.1889824**	g	Ecuación (11.4–1) ASCE7-1
Sm1= FV*s1=	**0.5712**	g	Ecuación (11.4–2)ASCE7-1

Parámetros de aceleración espectral de diseño

SDs=2/3*SMS=	0.792654933	g	Ecuación (11.4–3) del ASCE7-16:
SD1=2/3*SM1=	0.3808	g	Ecuación (11.4–4) del ASCE7-16:

DISEÑO DE ESPECTRO DE RESPUESTA
Según Sección 11.4.6 ASCE7-16

TL=	4	seg	
Ts=S_{D1}/S_{DS}=	0.48	seg	periodo de transición
To=0.2(S_{D1}/S_{D}	0.10	seg	

FACTOR DE IMPORTANCIA Y CATEGORIA DE RIESGO

CATEGORIA DE RIESGO:	III	Tabla 1.5-1. ASCE7-16
FACTOR DE IMPORTACIA I_e:	1.25	Tabla 1.5-2. ASCE7-16

CATEGORIA DE DISEÑO SISMICO "SDC"

Usando tabla 11.6-1 D
Usando tabla 11.6-2

Las ordenadas espectrales Sa (T) para cualquier período de vibración T, se definen con

S_a(T)=SDS(0.4+0.6(T/T0))	SI T≤T0	Ecuación 11.4-5 ASCE-16
S_a(T)=SDS	si T0≤T≤Ts	
Sa(T)=SD1/T	si TS≤T≤TL	Ecuación 11.4-6 ASCE-16
Sa(T)=SD1*TL/T2	si TL<T	Ecuación 11.4-7 ASCE-16

Respuesta espectral ante un Riesgo máximo de terremoto considerado (MCER)

MCER= 1.5*Sa

SISTEMA PERMITIDO SEGUN EL NIVEL DE PROTECCION

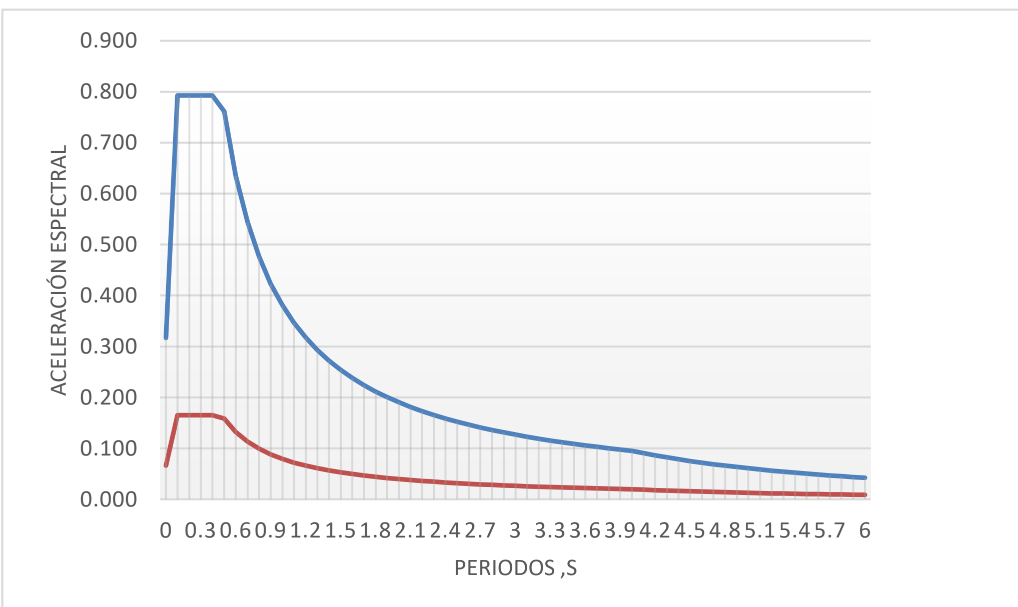
según la tabla 12.2-1 del ASCE7-16.

Marcos Especiales de acero arriostrados concéntricamente

R=	6
Ωr=	2
Cd=	5

Factor de redundancia:

ρ= 1.3 sección 12.3.4.2 factor de redundancia, ρ, para categoría de D
D



Coeficiente sísmico al límite de cedencia Cs

$$c_s = \frac{s_{DS}}{\left(\frac{R}{I_e}\right)}$$

Cs= 0.165136

Valores mínimos de Cs

CS no debe ser menor que 0.04SDS*Ie≥0.01

0.04*SDS*Ie= 0.040 cumple 0.04 es mayor que 0.01
cumple Cs es mayor que valor minimo

Aproximación de Periodo Fundamental.

$$T_a = c_t * h_n^x$$ Ecuación 12.8 ASCE7-16

h_n^x= 32.5 mt altura del edificio en mt.

Los coeficientes Ct y x , se determinan de la tabla 12.8-2 ASCE7-16

ct= 0.0731
x= 0.75 para SCBF
Ta= 0.995 seg

Periodo Máximo permitido

$$T_{max} = c_u * T_a$$

el coeficiente cu , se determina usando la tabla 12.8-1del ASCE7-16

Cu= 1.4
Tmax= 1.393021866

Demandas sísmicas

las combinaciones que consideren sismo tanto para LRFD Y ASD, se debe incluir los efectos del sismo vertical y sismo horizontal.
E=Eh+Ev

Efectos de demandas sísmicas horizontales

Eh=ρ*QE= 1.3 *Qh Ecuación 12.4-3 ASCE7-16

Efectos de demandas sísmicas verticales

Ev=0.2*SDS*D 0.16 *D Ecuación 12.4-4a ASCE7-16
D=Carga muerta

Aplicación de factor de sobre resistencia 1.36

donde se requiera considerar sobre resistencia se deberá determinar según la siguiente formula
Em es el sismo considerando sobre resistencia.
Em=Emh+Ev

Emh=Ωr*QE= 2 *QE Ecuación 12.4-7 ASCE7-16
QE es el efecto Sísmico que se genera del cortante Basal V .

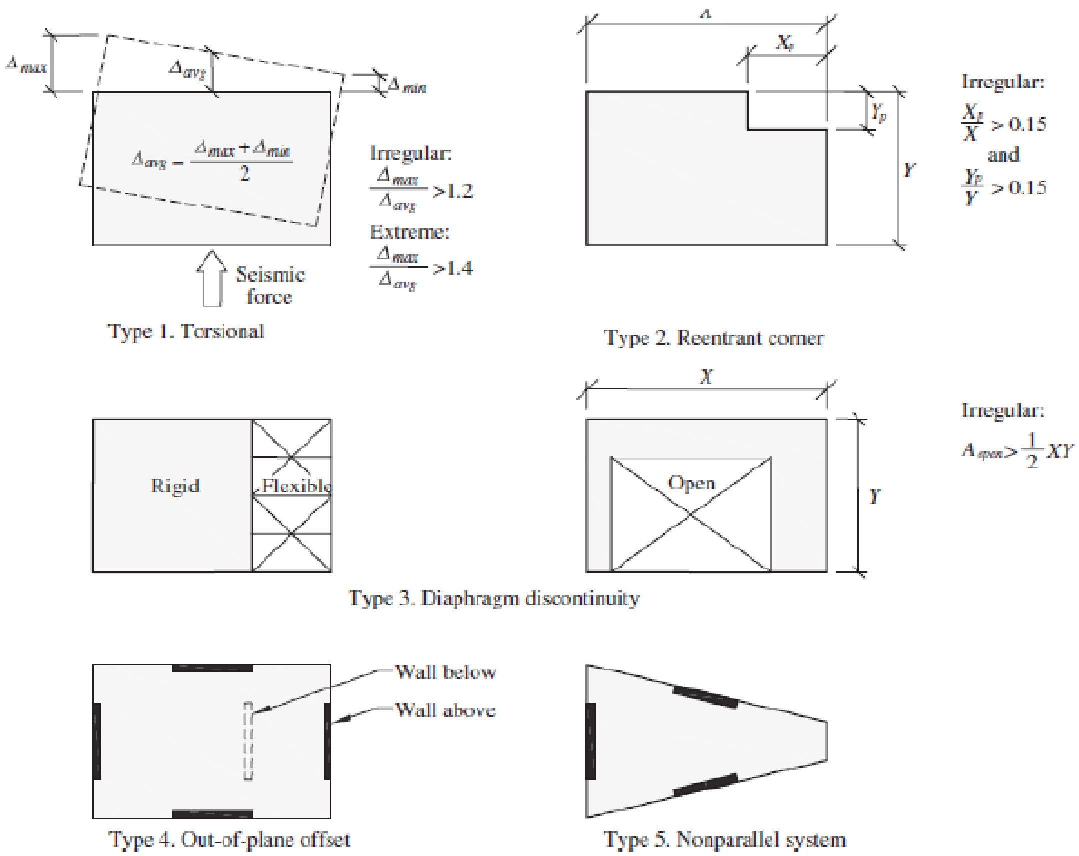
Irregularidades en planta y elevación

A continuación se presentan los tipos de irregularidades en planta
y la manera en la que cada una debe ser considerada en correspondencia
con la categoría de diseño sísmico
en nuestro caso se definió categoría de Diseño (D)

irregularidad en planta

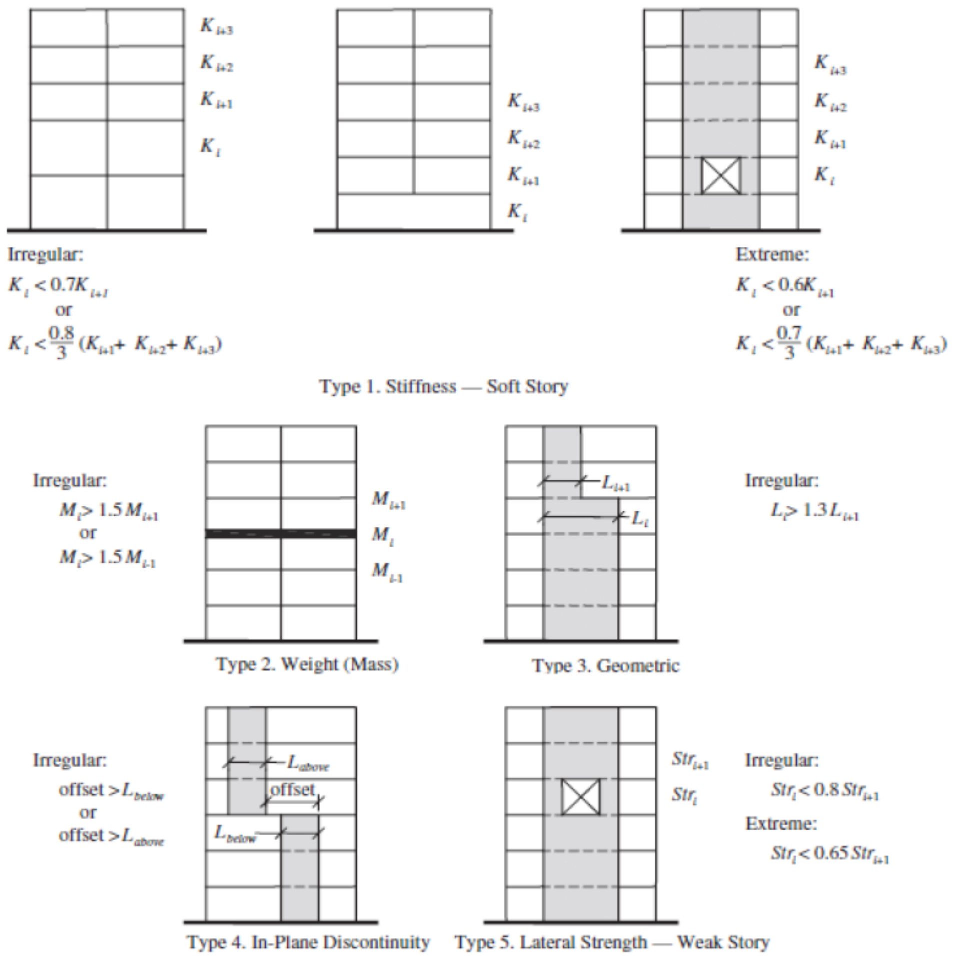
Tipo de irregularidad	Consideración
1a.- Irregularidad torsional. Si el desplazamiento horizontal máximo en un piso en una dirección δ_{max} es mayor que 1,2 veces el promedio de los desplazamientos de las 2 esquinas en la misma dirección δ_{avg}. Los requerimientos aplican para el caso de contar con diafragmas rígidos o semi rígidos.	Las cargas para diseñar la unión entre losa con columnas se deben aumentar un 25%
	El modelamiento debe ser en 3D, con al menos 3 grados de libertad, 2 en planta y 1 de rotación alrededor del eje vertical.
	El momento torsional adoptado para la aplicación de cargas con una excentricidad del 5% se multiplica por un factor de amplificación torsional $A_x = (\frac{\delta_{max}}{1.2\delta_{avg}})^2$.
1b.- Irregularidad torsional extrema. Si el desplazamiento horizontal máximo en un piso en una dirección δ_{max} es mayor que 1,4 veces el promedio de los desplazamientos de las 2 esquinas en la misma dirección δ_{avg}. Los requerimientos aplican para el caso de contar con diafragmas rígidos o semi rígidos.	Todo el efecto de carga sísmica horizontal debe ser multiplicado por un factor $\rho = 1.3$
	Requerimientos citados para irregularidad torsional
2.- Irregularidad de esquina. Si en una esquina existe una porción hueca, y la longitud de dicho espacio hueco es mayor al 15% de la longitud de la planta en esa dirección, se tiene irregularidad de esquina	Las cargas para diseñar la unión entre losa con columnas se deben aumentar un 25%
3.- Irregularidad de discontinuidad de diafragma. Si el diafragma (losa) presenta una variación abrupta de rigidez de más del 50% o existe un área abierta de más del 50% del área del diafragma.	Las cargas para diseñar la unión entre losa con columnas se deben aumentar un 25%

4.- Irregularidad en el eje del sistema lateral. Si a lo largo del eje donde se encuentra conformado el sistema lateral de la estructura existe una irregularidad, como el no alineamiento de al menos un elemento vertical con el eje.	Las cargas para diseñar la unión entre losa con columnas se deben aumentar un 25%
	El modelamiento debe ser en 3D, con al menos 3 grados de libertad, 2 en planta y 1 de rotación alrededor del eje vertical.
5.- Irregularidad de sistema lateral no paralelo. Si existen elementos del sistema lateral que se encuentran alineados de manera no paralela al eje ortogonal del sistema lateral.	Se debe o bien aplicar las cargas sísmicas en ambas direcciones ortogonales, independientemente, y diseñar los elementos del sistema utilizando el 100% de las cargas en el sentido del mismo, más un 30% de las cargas obtenidas para el sistema en dirección ortogonal, o bien aplicar las cargas sísmicas en las dos direcciones ortogonales simultáneamente y aplicar un posterior análisis tiempo historia no lineal
	El modelamiento debe ser en 3D, con al menos 3 grados de libertad, 2 en planta y 1 de rotación alrededor del eje vertical.

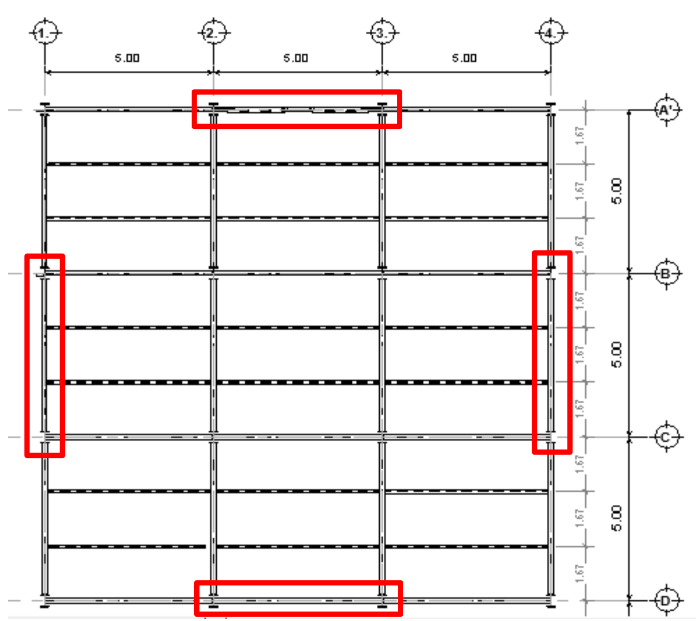


Irregularidad en Elevación.

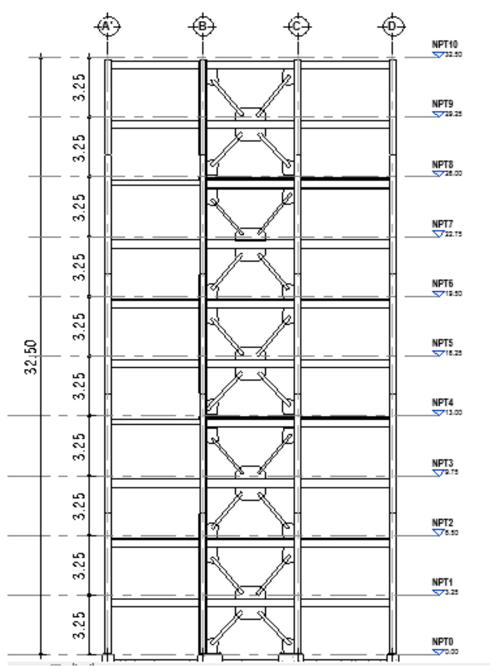
Tipo de irregularidad	Consideración
1a.- Irregularidad leve de rigidez. Si la rigidez lateral de un piso es menor que el 70% de la rigidez lateral del piso superior, o menor que el 80% de la rigidez lateral promedio de los 3 niveles superiores	Si la estructura excede 160 pies de alto (48,8m) no se puede aplicar el método de cargas laterales equivalentes
1b.- Irregularidad extrema de rigidez. Si la rigidez lateral de un piso es menor que el 60% de la rigidez lateral del piso superior, o menor que el 70% de la rigidez lateral promedio de los 3 niveles superiores	
2.- Irregularidad de masa. Si la masa efectiva de un piso es mayor en un 50% de la masa de un piso adyacente. Una cubierta no necesita ser considerada.	
3.- Irregularidad geométrica vertical. Si la longitud horizontal del sistema lateral en un piso es mayor en un 30% que aquella en un piso adyacente.	
4.- Irregularidad de discontinuidad en el plano del sistema lateral. Si existe un desfase de un elemento del sistema lateral en el plano, resultando en cargas de vuelco en los elementos soportantes	Si la estructura excede 160 pies de alto (48,8m) no se puede aplicar el método de cargas laterales equivalentes Las cargas para diseñar la unión entre losa con columnas se deben aumentar un 25%
5a.- Irregularidad débil por discontinuidad del sistema lateral en resistencia lateral de piso. Si la rigidez lateral de un piso es menor que un 80% de aquella del piso superior.	Si la estructura excede 160 pies de alto (48,8m) no se puede aplicar el método de cargas laterales equivalentes
5b.- Irregularidad extrema por discontinuidad del sistema lateral en resistencia lateral de piso. Si la rigidez lateral de un piso es menor que un 65% de aquella del piso superior.	Si la estructura excede 160 pies de alto (48,8m) no se puede aplicar el método de cargas laterales equivalentes Estructuras con este tipo de irregularidad en zonas de categoría de diseño sísmico D no deben ser permitidas



El Edificio que se plantea para el diseño del SCBF no presenta ninguna irregularidad, debido a que se los cálculos se enfocaran en el diseño del marco.



PLANTA



ELEVACION

Ing.Edwin Jose de Jesús peralta Nuñez.
Ing. Johnny Ángel Calero Cuadra

Peso sísmico efectivo W

Se considera la suma de la carga muerta D y el 25% de la carga viga
sección 12.7.2 ASCE7-16

W= 1280142.903 kg sacado del Modelo Etabs

Fuerza lateral Equivalente

V=CS*W
V= 211398.247 kg

Distribución de la Fuerza Sísmica.

$F_X = C_{VX} * V$ Ecuación 12.8-11 ASCE7-16

$C_{VX} = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k}$= Ecuación 12.8-12 ASCE7-16

k= 2 k depende del periodo Sección 12.8-3 ASCE7-16

Tabla 1

Nivel	wi(kg)	hi(mt)	wi*hi^k	Cvx	Fx(kg)
10	122157.65	32.5	4.85E+11	0.170	35885.67
9	124693.34	29.25	4.54792E+11	0.159	33651.84
8	126306.50	26	4.14787E+11	0.145	30691.71
7	127681.17	22.75	3.70881E+11	0.130	27442.99
6	127690.10	19.5	3.17943E+11	0.111	23525.86
5	129716.65	16.25	2.73429E+11	0.096	20232.11
4	131547.98	13	2.24963E+11	0.079	16645.93
3	120991.14	9.75	1.42729E+11	0.050	10561.08
2	129348.68	6.5	1.08752E+11	0.038	8046.99
1	140009.69	3.25	63708821299	0.022	4714.07
Total:	1280142.90		2.85697E+12		211398.25

Los Pesos Wi se obtuvo del modelo en Etabs.

DISTRIBUCION HORIZONTAL DE FUERZA SISMICA DE PISO

La distribución del la fuerza sísmica requiere los cortantes que se generan por torsión
esto se puede aproximar considerando que en la dirección norte-sur solo existen dos arriostres
y toman un 50% del cortante mas un 80% del cortante que se genera por la excentricidad accid

$R_A = 0.5V + 0.8(V[0.05L]/L)$ =0.54V. IBC 2012 sección 3.2
Structural/Seismic Design Manual, vol 4

El marco deberá ser diseñado para resistir la siguientes fuerzas
Fxi y Va

Tabla 2 fuerzas en Marco SCBF

Nivel	Fx(kg)	Vx(kg)	$F_{xi=}$FX*0.54	Vxi=V*0.54
10	35885.67	35885.67	19378.26	19378.26
9	33651.84	69537.51	18171.99	37550.25
8	30691.71	100229.22	16573.52	54123.78
7	27442.99	127672.21	14819.22	68942.99
6	23525.86	151198.07	12703.96	81646.96
5	20232.11	171430.18	10925.34	92572.30
4	16645.93	188076.11	8988.80	101561.10
3	10561.08	198637.18	5702.98	107264.08
2	8046.99	206684.18	4345.38	111609.46
1	4714.07	211398.25	2545.60	114155.05

Combinaciones de Carga

	Método de Resistencia	Método de Esfuerzos de servicio	
	CR1=1.4D	CS1=D	
	CR2=1.2D+1.6L+0.5Lr	CS2=D+L	
	CR3=1.2D+1.6Lr+L	CS3=D+Lr	
	CR4=1.2D+1.0W+L+0.5Lr	CS4=D+0.75L+0.75Lr	
	CR5=0.9D+1.0W	CS5=D+0.6W	
sísmicas	CR6=1.2 D+0.2 S_{Ds} D+ρ*QE+L	CS6=D+0.75L+0.75(0.6W)+0.75Lr	
	CR7=0.9D-0.2 SDs D+ρ*QE+L	CS7=0.6D+0.6L	
	CR8=1.2D+0.2 SDs D+ΩQE +L	CS8=D+0.14*SDs D+0.7ρ*QE	**sísmicas**
	CR9=0.9D-0.2 SDs+Ωqe	CS9=D+0.105*SDs D+0.525ρ*QE+0.75L+0.75L	
		CS10=0.6D-0.14*SDs D+0.70ρ*QE	
		CS11=D+0.14SDs D+0.7*Ω*QE	
		CS12=D+0.105*SDs D+0.525*Ω*QE+0.75L	

6.2. Diseño de Arriostres

Según la sección F2 del AISC 341.

Cargas Gravitacionales

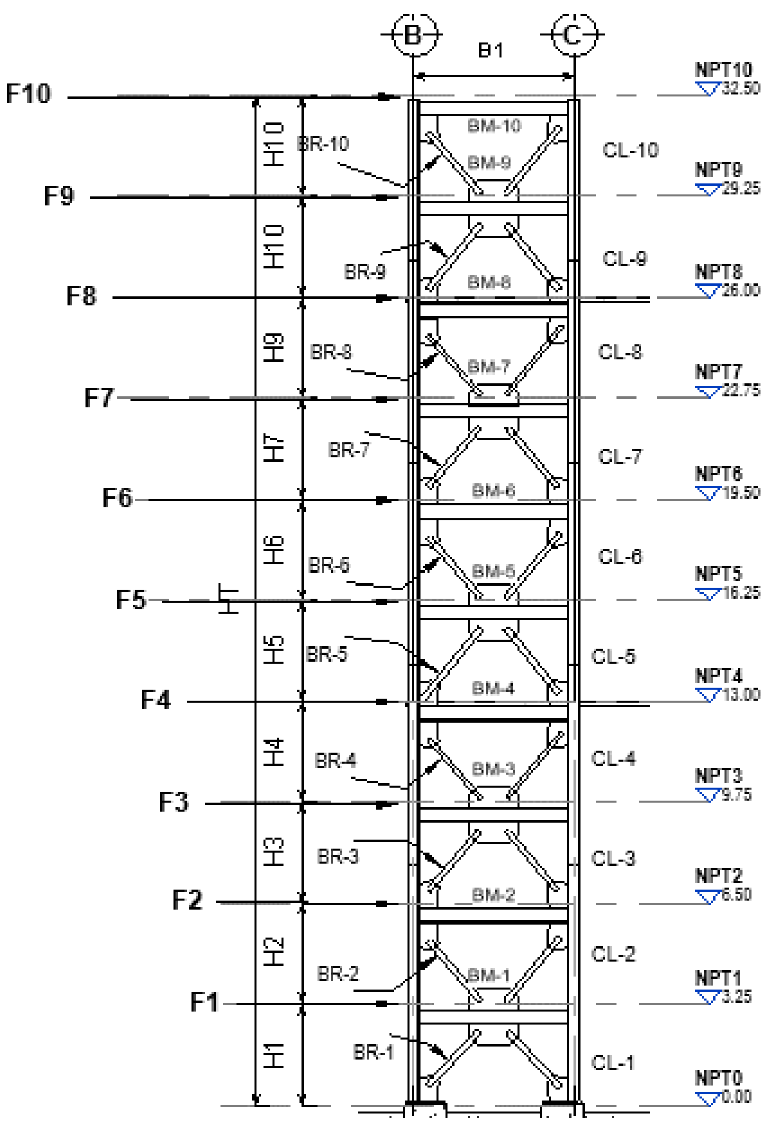
D=	400.00	kg/m²
L=	250	kg/m²
Muro Cortina=	145	kg/m²

a lo largo de viga perimetral en todos los niveles

Del ASCE7

CATEGORIA DE DISEÑO SISMICO "SDC"

	D
Ωr=	2
R=	6
ρ=	1.3
SDs=	0.793



Fuerzas en marco

F10=	19378.26	Kg
F9=	18171.99	Kg
F8=	16573.52	Kg
F7=	14819.22	Kg
F6=	12703.96	Kg
F5=	10925.34	Kg
F4=	8988.80	Kg
F3=	5702.98	Kg
F2=	4345.38	Kg
F1=	2545.60	Kg

Altura de piso(m)

H10=	3.25
H9=	3.25
H8=	3.25
H7=	3.25
H6=	3.25
H5=	3.25
H4=	3.25
H3=	3.25
H2=	3.25
H1=	3.25

longitud de vigas (m)

B1=	5

Fuerza Axial en arriostres

Arriostre	D(ton)	L(ton)	QE(ton)
BR-10	1.15	0.57	15.64
BR-9	3.19	1.56	29.95
BR-8	2.16	1.12	40.27
BR-7	4.15	1.58	56.75
BR-6	2.49	1.26	59.17
BR-5	4.42	2.11	73.93
BR-4	7.02	3.48	72.82
BR-3	9.22	3.55	92.14
BR-2	11.1	4.56	77.64
BR-1	13.08	5.4	104.28

PD=Axial debido a carga muerta; PL=axial debido a carga viva; PQE=Axial debido a sismo
estas fuerzas se obtuvieron del modelo en Etabs como se muestra en las fuerzas axiales por QE

De un análisis de 1er Orden las derivas de Piso son:

NIVEL	hi(m)=	δxt(cm)=
NIVEL 10	3.25	36.08
NIVEL 9	3.25	32.2
NIVEL 8	3.25	27.8
NIVEL 7	3.25	23.48
NIVEL 6	3.25	18.8
NIVEL 5	3.25	14.4
NIVEL 4	3.25	10.48
NIVEL 3	3.25	6.72
NIVEL 2	3.25	3.68
NIVEL 1	3.25	1.264
base	0	0

Considerando que los extremos de los arriostres están liberados a momento.

Propiedades del Arriostre: ASTM A500 grado B

Fy= 2952.84 kg/cm^2 E= 2038865.677 kg/cm^2

Fu= 4077.73 kg/cm^2

Resistencia Requerida del Arriostre a compresión.

LRFD			ASD		
Usando la combinación CR6 de LRFD			usando la combinación CS8 del ASD		
CR6=1.2 D+0.2 SDs D+ρ*QE+L			CS8=D+0.14*SDs D+0.7ρ*QE		
Arriostre	combinación	Pu(ton)	Arriostre	combinación	Pu(ton)
BR-10	CR6	22.46	BR-10	CS8	15.51
BR-9	CR6	44.83	BR-9	CS8	30.80
BR-8	CR6	56.41	BR-8	CS8	39.05
BR-7	CR6	80.99	BR-7	CS8	56.25
BR-6	CR6	81.56	BR-6	CS8	56.61
BR-5	CR6	104.22	BR-5	CS8	72.19
BR-4	CR6	107.68	BR-4	CS8	74.07
BR-3	CR6	135.86	BR-3	CS8	94.09
BR-2	CR6	120.57	BR-2	CS8	82.98
BR-1	CR6	158.73	BR-1	CS8	109.43

Resistencia Requerida del Arriostre a Tensión.

LRFD			ASD		
Usando la combinación CR7 de LRFD			usando la combinación CS8 del ASD		
CR7=0.9D-0.2 SDs D+ρ*QE+L			CS10=0.6D-0.14*SDs D+0.70ρ*QE		
Arriostre	combinación	Pu(ton)	Arriostre	combinación	Pu(ton)
BR-10	CR7	-18.91	BR-10	CS10	-13.67
BR-9	CR7	-35.01	BR-9	CS10	-25.69
BR-8	CR7	-49.63	BR-8	CS10	-35.59
BR-7	CR7	-69.12	BR-7	CS10	-49.61
BR-6	CR7	-73.81	BR-6	CS10	-52.63
BR-5	CR7	-90.72	BR-5	CS10	-65.11
BR-4	CR7	-85.98	BR-4	CS10	-62.83
BR-3	CR7	-109.40	BR-3	CS10	-79.34
BR-2	CR7	-88.14	BR-2	CS10	-65.22
BR-1	CR7	-120.47	BR-1	CS10	-88.50

QE debe evaluarse con el signo (-)

Calculo de longitud del arriostre

$$L = \sqrt{Hi^2 + \left(\frac{B1}{2}\right)^2}$$

Arriostre	Hi	B1	L
BR-10	3.25	5	4.10030487
BR-9	3.25	5	4.10030487
BR-8	3.25	5	4.10030487
BR-7	3.25	5	4.10030487
BR-6	3.25	5	4.10030487
BR-5	3.25	5	4.10030487
BR-4	3.25	5	4.10030487
BR-3	3.25	5	4.10030487
BR-2	3.25	5	4.10030487
BR-1	3.25	5	4.10030487

verificar que 30% a 70% de la fuerza Horizontal es resistido por el arriostre

Arriostre	Vxi=V*0.54	QE	L	B1/2L * QE	%
BR-10	19.38	15.64	2.35030487	16.6361397	85.84948979
BR-9	37.55	29.95	2.35030487	31.8575692	84.83982384
BR-8	54.12	40.27	2.35030487	42.8348685	79.14242208
BR-7	68.94	56.75	2.35030487	60.3645093	87.55713302
BR-6	81.65	59.17	2.35030487	62.9386434	77.08633143
BR-5	92.57	73.93	2.35030487	78.6387343	84.94845424
BR-4	101.56	72.82	2.35030487	77.4580364	76.26742682
BR-3	107.26	92.14	2.35030487	98.0085619	91.37127968
BR-2	111.61	77.64	2.35030487	82.5850309	73.99465389
BR-1	114.16	104.28	2.35030487	110.92178	97.1676477

la longitud del arriostre se reduce por la conexión en 1.75mt

SELECCION DE SECCIONES

Arriostre	Sección	D(in)	t(in)	r(in)	Kl/r	D/t	Observación
BR-10	HSS6.000x0.312	6	0.291	2.02	45.8077662	20.6185567	Cumple
BR-9	HSS6.625x0.312	6.625	0.291	2.24	41.3087891	22.76632302	Cumple
BR-8	HSS6.875x0.312	6.875	0.291	2.33	39.7131707	23.62542955	Cumple
BR-7	HSS6.875x0.375	6.875	0.349	2.31	40.0570076	19.6991404	Cumple
BR-6	HSS7.000x0.312	7	0.291	2.37	39.0429062	24.05498282	Cumple
BR-5	HSS7.000x0.312	7	0.291	2.37	39.0429062	24.05498282	Cumple
BR-4	HSS7.000x0.375	7	0.349	2.35	39.3751862	20.05730659	Cumple
BR-3	HSS7.500x0.375	7.5	0.349	2.53	36.5737896	21.48997135	Cumple
BR-2	HSS7.500x0.500	7.5	0.465	2.49	37.1613203	16.12903226	Cumple
BR-1	HSS8.625x0.500	8.625	0.465	2.89	32.017885	18.5483871	Cumple

revisar que la sección sea altamente dúctil

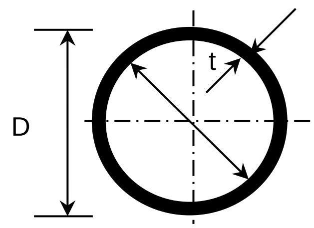
$\frac{D}{t} \leq \lambda_{hd} = 0.053\frac{E}{R_Y F_Y}=$ 26.139456

R_Y=1.4

Revisar la esbeltez del arriostre

$\frac{L_C}{r} \leq 200$

L_C=KL



Efecto de segundo Orden

debido a se considero arriostres liberados a momento. Se debe hacer una aproximación

$P_r = P_{nt} + B_2 P_{lt}$ Ecuación APPENDIX 8 A-8-2. Aisc 360-16

$P_r = resistencia\ axial\ requerida\ por\ efectos\ de\ segundo\ orden$

$P_{nt} = resistencia\ axial\ requerida\ de\ primer\ orden$

$B_2 = coeficiente\ por\ efecto\ P - \Delta$,determinado para cada nivel de la estructura

Calculo de B_2

$$B_2 = \frac{1}{1 - \frac{\alpha p_{story}}{p_{e\ story}}} \geq 1$$

α=1.0(LRFD) ; α= 1.6 (ASD)

P_{story}=carga vertical total soportada por el piso en estudio incluyendo columnas que no sean parte del sistema resistente a fuerzas laterales.

$P_{e\ story}$=resistencia elástica a pandeo del piso en la dirección de traslación

$$P_{e\ story} = RM\frac{HL}{\Delta_H}$$

$RM = 1\ para\ marcos\ arriostrados$

$H = Cortante\ total\ de\ piso$

$\Delta_H = deriva\ de\ piso$

L= $Altura\ de\ piso$

área de piso

Ap: 225 mt^2

usar el área en planta 225 con las carga gravitacional D,L en m^2 en las combinaciones que incluyen el efecto vertical del sismo considerando cero el efecto del sismo Horizontal

LRFD			ASD		
Usando la combinación CR6 de LRFD			usando la combinación CS8 del ASD		
CR6=Ap(1.2 D+0.2 SDs D+L)			CS8=Ap(D+0.14*SDs D)		
	combinación	Pu(kg)		combinación	Pu(kg)
Pstory10	CR6	178518	Pstory10	CS8	99987.45
Pstory9	CR6	357036	Pstory9	CS9	199974.90
Pstory8	CR6	535553	Pstory8	CS10	299962.36
Pstory7	CR6	714071	Pstory7	CS11	399949.81
Pstory6	CR6	892589	Pstory6	CS12	499937.26
Pstory5	CR6	1071107	Pstory5	CS13	599924.71
Pstory4	CR6	1249625	Pstory4	CS14	699912.17
Pstory3	CR6	1428142	Pstory3	CS15	799899.62
Pstory2	CR6	1606660	Pstory2	CS16	899887.07
Pstory1	CR6	1785178	Pstory1	CS17	999874.52

	H(kg)	L(m)	Δ_H (cm)	RM	$P_{e\,story}$
Pe story10	35885.67	3.25	36.08	1	323249.5369
Pe story9	69537.51	3.25	32.2	1	701853.7213
Pe story8	100229.22	3.25	27.8	1	1171744.453
Pe story7	127672.21	3.25	23.48	1	1767183.511
Pe story6	151198.07	3.25	18.8	1	2613796.38
Pe story5	171430.18	3.25	14.4	1	3869083.865
Pe story4	188076.11	3.25	10.48	1	5832512.899
Pe story3	198637.18	3.25	6.72	1	9606709.042
Pe story2	206684.18	3.25	3.68	1	18253358.14
Pe story1	211398.25	3.25	1.264	1	54354770.87

usando AISC 360 Ecuación A-8-6

LRFD		ASD	
α=	1	α=	1.6
$B_2 = \frac{1}{1-\frac{\alpha p_{story}}{p_{e\,story}}} \geq 1$		$B_2 = \frac{1}{1-\frac{\alpha p_{story}}{p_{e\,story}}} \geq 1$	
10 $B_2 =$	1.50	10 $B_2 =$	1.50
9 $B_2 =$	1.50	9 $B_2 =$	1.50
8 $B_2 =$	1.50	8 $B_2 =$	1.50
7 $B_2 =$	1.50	7 $B_2 =$	1.50
6 $B_2 =$	1.50	6 $B_2 =$	1.50
5 $B_2 =$	1.38	5 $B_2 =$	1.50
4 $B_2 =$	1.27	4 $B_2 =$	1.50
3 $B_2 =$	1.17	3 $B_2 =$	1.31
2 $B_2 =$	1.10	2 $B_2 =$	1.16
1 $B_2 =$	1.03	1 $B_2 =$	1.06

Resistencia Requerida del Arriostre a Compresión incluyendo los efectos de segundo orden

LRFD			ASD		
Usando la combinación CR6 de LRFD			usando la combinación CS8 del ASD		
CR6=1.2 D+0.2 SDs D+B_2 ρ*QE+L			CS8=D+0.14*SDs D+0.7ρ*B_2QE		
Arriostre	combinación	Pu(ton)	Arriostre	combinación	Pu(ton)
BR-10	CR7	32.63	BR-10	CS10	22.63
BR-9	CR7	64.30	BR-9	CS10	44.43
BR-8	CR7	82.58	BR-8	CS10	57.37
BR-7	CR7	117.88	BR-7	CS10	82.07
BR-6	CR7	120.02	BR-6	CS10	83.53
BR-5	CR7	141.02	BR-5	CS10	105.82
BR-4	CR7	133.50	BR-4	CS10	107.20
BR-3	CR7	156.77	BR-3	CS10	120.26
BR-2	CR7	130.31	BR-2	CS10	94.57
BR-1	CR7	163.34	BR-1	CS10	114.69

Resistencia Disponible del Arriostre a Compresión

Resistencia nominal a compresión $P_n = F_{cr} A_g$

$el\ \ esfuerzo\ critico\ F_{cr}\ se\ calcula\ como\ se\ muestra$:

a) cuando $\frac{L_C}{r} \leq 4.71\sqrt{\frac{E}{F_y R_y}}$ o $\frac{R_y F_y}{F_e} \leq 2.25$

$$F_{Cr} = \left(0.658^{\frac{R_y F_y}{F_e}}\right) F_y R_y$$ ecuación E3-2 del AISC 360-16

b) cuando $\frac{L_C}{r} > 4.71\sqrt{\frac{E}{R_y F_y}}$ o $\frac{R_y F_y}{F_e} > 2.25$

$$F_{Cr} = 0.0877 F_e$$ ecuación E3-3 del AISC 360-16

$esfuerzo\ a\ pandeo\ elastico\ F_e$ $$F_e = \frac{\pi^2 E}{\left(\frac{L_C}{r}\right)^2}$$

ecuación E3-4 del AISC 360-16

Arriostre	sección	Lc(cm)	r(cm)	F_e	$\frac{R_y F_y}{F_e}$	$\frac{L_C}{r}$	F_{Cr}
BR-10	HSS6.000x0.312	235.03	5.1308	9589.81287	0.43107994	45.81	3451.507
BR-9	HSS6.625x0.312	235.03	5.6896	11792.4334	0.35056174	41.31	3569.808
BR-8	HSS6.875x0.312	235.03	5.9182	12759.0763	0.32400276	39.71	3609.713
BR-7	HSS6.875x0.375	235.03	5.8674	12540.9765	0.32963748	40.06	3601.209
BR-6	HSS7.000x0.312	235.03	6.0198	13200.9166	0.31315825	39.04	3626.134
BR-5	HSS7.000x0.312	235.03	6.0198	13200.9166	0.31315825	39.04	3626.134
BR-4	HSS7.000x0.375	235.03	5.969	12979.0564	0.31851129	39.38	3618.019
BR-3	HSS7.500x0.375	235.03	6.4262	15043.4843	0.27480176	36.57	3684.818
BR-2	HSS7.500x0.500	235.03	6.3246	14571.5613	0.28370165	37.16	3671.118
BR-1	HSS8.625x0.500	235.03	7.3406	19629.2217	0.21060315	32.02	3785.173

$4.71\sqrt{\frac{E}{R_y F_y}} =$ 104.600

Resistencia de Diseño del Arriostre a Compresión

$\Phi_c = 0.9(LRFD)$ $\Omega_C = 1.67\ (ASD)$

			LRFD	ASD	LRFD	ASD	
Arriostre	sección	$A_g(cm^2)$	$\Phi_c P_n$	$P_n\ /\Omega_C$	P_u	P_u	d/c
BR-10	HSS6.000x0.312	33.677352	104613.86	69603.3652	32630.31	22626.217	0.32507361
BR-9	HSS6.625x0.312	37.354764	120014.41	79849.9084	64296.21	44425.750	0.55636569
BR-8	HSS6.875x0.312	38.838632	126176.67	83949.8809	82580.93	57368.249	0.68336308
BR-7	HSS6.875x0.375	46.193456	149717.08	99612.1625	117880.40	82074.283	0.82393837
BR-6	HSS7.000x0.312	39.548308	129066.73	85872.7396	120024.24	83533.370	0.97275771
BR-5	HSS7.000x0.312	39.548308	129066.73	85872.7396	141015.64	105824.945	1.23234621
BR-4	HSS7.000x0.375	47.032164	153146.94	101894.168	133495.64	107198.321	1.05205551
BR-3	HSS7.500x0.375	50.580544	167742.11	111604.864	156774.00	120258.542	1.07753853
BR-2	HSS7.500x0.500	66.45148	219556.09	146078.573	130313.17	94565.291	0.64735909
BR-1	HSS8.625x0.500	76.77404	261542.73	174013.79	163337.12	114689.504	0.65908285

6.3 Análisis de arriostres Especiales concéntricos.

Requerimientos de columnas, vigas y conexiones

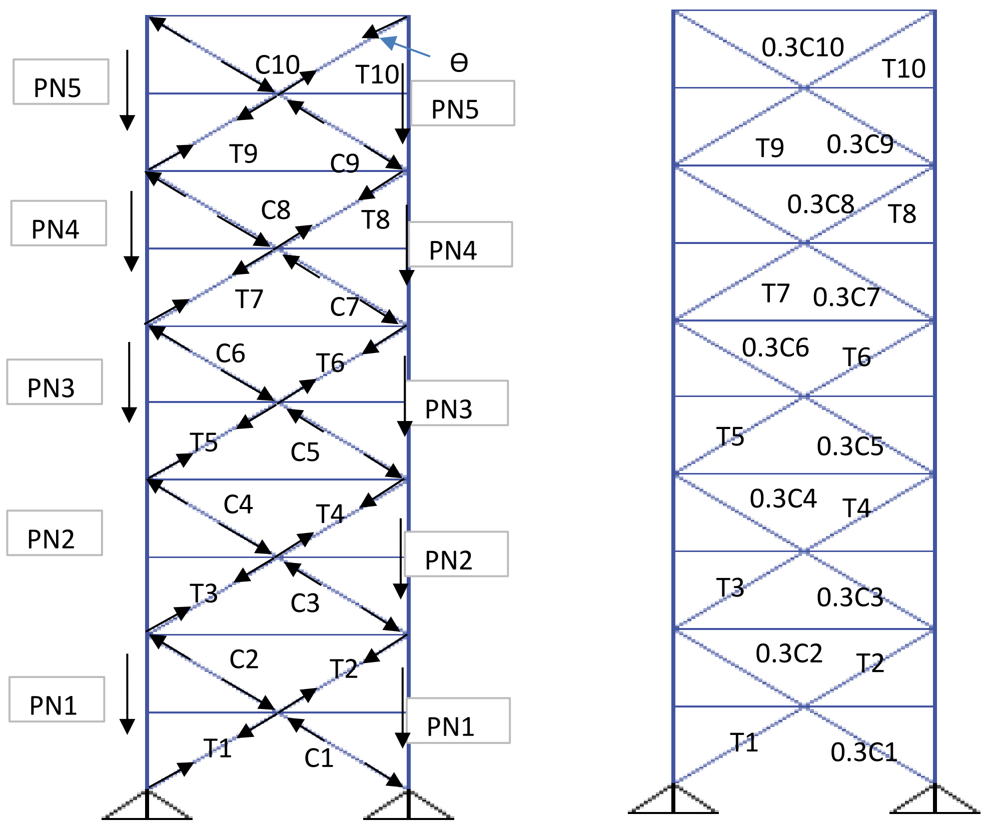
1. Se deberá considerar el mayor de las fuerzas de los siguientes análisis:

a) un análisis donde todos los arriostres se asume que resistan la correspondiente resistencia esperada o requerida en compresión o en tensión.

b) Un análisis donde todos los arriostres a tensión se asume que resisten la correspondiente resistencia requerida y todos los arriostres en compresión la resistencia requerida post-pandeo.

Resistencia Esperada

		Tensión (Kg)	compresión (kg)	post-pandeo(kg)
Arriostres	sección	T=Ry*fy*Ag	C= (1/0.877)*Fcr*Ag	C0.3= 0.3(1/0.877)Fcr*Ag
BR-10	HSS6.000x0.312	139221.36	132540.05	39762.01
BR-9	HSS6.625x0.312	154423.69	152051.71	45615.51
BR-8	HSS6.875x0.312	160557.97	159858.95	47957.69
BR-7	HSS6.875x0.375	190962.63	189683.37	56905.01
BR-6	HSS7.000x0.312	163491.75	163520.50	49056.15
BR-5	HSS7.000x0.312	163491.75	163520.50	49056.15
BR-4	HSS7.000x0.375	194429.83	194028.80	58208.64
BR-3	HSS7.500x0.375	209098.75	212520.10	63756.03
BR-2	HSS7.500x0.500	274708.82	278165.58	83449.67
BR-1	HSS8.625x0.500	317382.03	331360.35	99408.11



caso a) CASO b)

Ing.Edwin Jose de Jesús peralta Nuñez.
Ing. Johnny Ángel Calero Cuadra

Calculo de carga distribuida a la columna por las resistencias esperadas en la diagona

CASO a)

La carga a compresión impuesta sobre la columnas en sentido de la gravedad se tomara como positivo.

$$PN5 = \left(\frac{C10 - T10 + T9 - C9}{2}\right)\cos\Theta$$

PN5=132540.05-139221.36+154423.69-152051.71)*3.25/4.1*1/2=-1707.83866600079

PN5= -1707.838666 kg

$$PN4 = \left(\frac{C8 - T8 + T7 - C7}{2}\right)\cos\Theta$$

PN4=159858.95-160557.97+190962.63-189683.37)*3.25/4.1*1/2=229.960941523347

PN4= 229.9609415 kg

$$PN3 = \left(\frac{C6 - T6 + T5 - C5}{2}\right)\cos\Theta$$

PN3=163520.5-163491.75+163491.75-163520.5)*3.25/4.1*1/2=0

PN3= 0 kg

$$PN2 = \left(\frac{C4 - T4 + T3 - C3}{2}\right)\cos\Theta$$

PN2=194028.8-194429.83+209098.75-212520.1)*3.25/4.1*1/2=-1514.85246041019

PN2= -1514.85246 kg

$$PN1 = \left(\frac{C2 - T2 + T1 - C1}{2}\right)\cos\Theta$$

PN1=278165.58-274708.82+317382.03-331360.35)*3.25/4.1*1/2=-4169.8187966629

PN1= -4169.818797 kg

CASO b)

$$PN5 = \left(\frac{0.3C10 - T10 + T9 - 0.3C9}{2}\right)\cos\Theta$$

PN5=39762.01-139221.36+154423.69-45615.51)*3.25/4.1*1/2=3705.06

PN5= 3705.06 kg

$$PN4 = \left(\frac{0.3C8 - T8 + T7 - 0.3C7}{2}\right)\cos\Theta$$

PN4=47957.69-160557.97+190962.63-56905.01)*3.25/4.1*1/2=8503.8

PN4= 8503.8 kg

$$PN3 = \left(\frac{0.3C6 - T6 + T5 - 0.3C5}{2}\right)\cos \Theta$$

PN3=49056.15-163491.75+163491.75-49056.15)*3.25/4.1*1/2=0
PN3= 0 kg

$$PN2 = \left(\frac{0.3C4 - T4 + T3 - 0.3C3}{2}\right)\cos \Theta$$

PN2=58208.64-194429.83+209098.75-63756.03)*3.25/4.1*1/2=3614.97
PN2= 3614.97 kg

$$PN1 = \left(\frac{0.3C2 - T2 + T1 - 0.3C1}{2}\right)\cos \Theta$$

PN1=83449.67-274708.82+317382.03-99408.11)*3.25/4.1*1/2=10587.39
PN1= 10587.39 kg

FUERZA AXIAL A COMPRESION OPTENIDAS DEL ANALISIS
analizando la columna derecha.. Caso a).

$$P_{Ehm10} = T10 * \cos\theta + PN5$$

$P_{Ehm10} =$ 108642.35 kg

$$P_{Ehm9} = (T10) * \cos\theta + PN5 = P_{Ehm10}$$

$P_{Ehm9} =$ 108642.3529 kg

$$P_{Ehm8} = (T10 + C9 + T8) * \cos\theta + PN5 + PN4$$

$P_{Ehm8} =$ 356654.2427 kg

$$P_{Ehm7} = (T10 + C9 + T8) * \cos\theta + PN5 + PN4 = P_{Ehm8}$$

$P_{Ehm7} =$ 356654.2427 kg

$$P_{Ehm6} = (T10 + C9 + T8 + C7 + T6) * \cos\theta + PN5 + PN4 + PN3$$

$P_{Ehm6} =$ 636589.3139 kg

$$P_{Ehm5} = (T10 + C9 + T8 + C7 + T6) * \cos\theta + PN5 + PN4 + PN3 = P_{Ehm6}$$

$P_{Ehm5} =$ 636589.3139 kg

$$P_{Ehm4} = (T10 + C9 + T8 + C7 + T6 + C5 + T4) * \cos\theta + PN5 + PN4 + PN3 + PN2$$

$P_{Ehm4} =$ 918794.4797 kg

$P_{Ehm3} = (T10 + C9 + T8 + C7 + T6 + C5 + T4) * \cos\theta + PN5 + PN4 + PN3 + PN2 = P_{Ehm3}$

$P_{Ehm3} =$ 918794.4797 kg

$P_{Ehm2} = (T10 + C9 + T8 + C7 + T6 + C5 + T4 + C3 + T2) * \cos\theta + PN5 + PN4 + PN3 + PN2 + PN1$

$P_{Ehm2} =$ 1315571.195 kg

$P_{Ehm2} = P_{Ehm1}$

$P_{Ehm1} =$ 1315571.195 kg

<u>FUERZA AXIAL A TENSION OPTENIDAS DEL ANALISIS</u>
analizando la columna Izquierda. Caso a).

$T_{Ehm10} = (-C10) * \cos\theta + PN5$

$T_{Ehm10} =$ 226251960.2 kg

$T_{Ehm9} = (-C10) * \cos\theta + PN5 = T_{Ehm10}$

$T_{Ehm9} =$ 226251960.2 kg

$T_{Ehm8} = (-C10 - T9 - C8) * \cos\theta + PN5 + PN4$

$T_{Ehm8} =$ -355640.2629 kg

$T_{Ehm7} = (-C10 - T9 - C8) * \cos\theta + PN5 + PN4 = T_{Ehm8}$

$T_{Ehm7} =$ -355640.2629 kg

$T_{Ehm6} = (-C10 - T9 - C8 - T7 - C6) * \cos\theta + PN5 + PN4 + PN3$

$T_{Ehm6} =$ -636612.0963 kg

$T_{Ehm5} = (-C10 - T9 - C8 - T7 - C6) * \cos\theta + PN5 + PN4 + PN3 = T_{Ehm6}$

$T_{Ehm5} =$ -636612.0963 kg

$T_{Ehm4} = (-C10 - T9 - C8 - T7 - C6 - T5 - C4) * \cos\theta + PN5 + PN4 + PN3 + PN2$

$T_{Ehm4} =$ -921506.319 kg

$T_{Ehm3} = (-C10 - T9 - C8 - T7 - C6 - T5 - C4) * \cos\theta + PN5 + PN4 + PN3 + PN2 = T_{Ehm2}$

$T_{Ehm3} =$ -921506.319 kg

$T_{Ehm2} = (-C10 - T9 - C8 - T7 - C6 - T5 - C4 - T3 - C2) * \cos\theta + PN5$+PN4+PN3+PN2+PN1

$T_{Ehm2} =$ -1307723.719 kg

$T_{Ehm2} = T_{Ehm1}$

$T_{Ehm1} =$ -1307723.719 kg

FUERZA AXIAL A COMPRESION OPTENIDAS DEL ANALISIS
analizando la columna derecha.. Caso b).

$P_{Ehm10} = T10 * \cos\theta + PN5$

$P_{Ehm10} =$ 108642.35 kg

$P_{Ehm9} = (T10) * \cos\theta + PN5 = P_{Ehm10}$

$P_{Ehm9} =$ 108642.3529 kg

$P_{Ehm8} = (T10 + 0.3C9 + T8) * \cos\theta + PN5 + PN4$

$P_{Ehm8} =$ 272290.3613 kg

$P_{Ehm7} = (T10 + 0.3C9 + T8) * \cos\theta + PN5 + PN4 = P_{Ehm8}$

$P_{Ehm7} =$ 272290.3613 kg

$P_{Ehm6} = (T10 + 0.3C9 + T8 + 0.3C7 + T6) * \cos\theta + PN5 + PN4 + PN3$

$P_{Ehm6} =$ 446982.1225 kg

$P_{Ehm5} = (T10 + 0.3C9 + T8 + 0.3C7 + T6) * \cos\theta + PN5 + PN4 + PN3$=$P_{Ehm6}$

$P_{Ehm5} =$ 446982.1225 kg

$P_{Ehm4} = (T10 + 0.3C9 + T8 + 0.3C7 + T6 + 0.3C5 + T4) * \cos\theta + PN5 + PN4 +$

$P_{Ehm4} =$ 638460.1008 kg

$P_{Ehm3} = (T10 + 0.3C9 + T8 + 0.3C7 + T6 + 0.3C5 + T4) * \cos\theta + PN5 + PN4 +$

$P_{Ehm3} =$ 638460.1008 kg

$P_{Ehm2} = (T10 + 0.3C9 + T8 + 0.3C7 + T6 + 0.3C5 + T4 + 0.3C3 + T2) * \cos\theta + PN5 + PN4 + PN3$+PN2+PN1

$P_{Ehm2} =$ 917322.8479 kg

$P_{Ehm2} = P_{Ehm1}$

$P_{Ehm1} =$ 917322.8479 kg

FUERZA AXIAL A TENSION OPTENIDAS DEL ANALISIS
analizando la columna Izquierda. Caso b).

$$T_{Ehm10} = (-0.3C10) * \cos\theta + PN5$$

$T_{Ehm10} =$ 67875588.05 kg

$$T_{Ehm9} = (-0.3C10) * \cos\theta + PN5 = T_{Ehm10}$$

$T_{Ehm9} =$ 67875588.05 kg

$$T_{Ehm8} = (-0.3C10 - T9 - 0.3C8) * \cos\theta + PN5\text{+PN4}$$

$T_{Ehm8} =$ -193406.5409 kg

$$T_{Ehm7} = (-0.3C10 - T9 - 0.3C8) * \cos\theta + PN5\text{+PN4=}T_{Ehm8}$$

$T_{Ehm7} =$ -193406.5409 kg

$$T_{Ehm6} = (-0.3C10 - T9 - 0.3C8 - T7 - 0.3C6) * \cos\theta + PN5\text{+PN4+PN3}$$

$T_{Ehm6} =$ -383651.1867 kg

$$T_{Ehm5} = (-0.3C10 - T9 - 0.3C8 - T7 - 0.3C6) * \cos\theta + PN5\text{+PN4+PN3=}T_{Ehm6}$$

$T_{Ehm5} =$ -383651.1867 kg

$$T_{Ehm4} = (-0.3C10 - T9 - 0.3C8 - T7 - 0.3C6 - T5 - 0.3C4) * \cos\theta + PN5\text{+PN4+PN3+PN2}$$

$T_{Ehm4} =$ -560891.0901 kg

$$T_{Ehm3} = (-0.3C10 - T9 - 0.3C8 - T7 - 0.3C6 - T5 - 0.3C4) * \cos\theta + PN5\text{+PN4+PN3+PN2=}T_{Ehm2}$$

$T_{Ehm3} =$ -560891.0901 kg

$$T_{Ehm2} = (-0.3C10 - T9 - 0.3C8 - T7 - 0.3C6 - T5 - 0.3C4 - T3 - 0.3C2) * \cos\theta + PN5\text{+PN4+PN3+PN2+PN1}$$

$T_{Ehm2} =$ -792771.9905 kg

$$T_{Ehm2} = T_{Ehm1}$$

$T_{Ehm1} =$ -792771.9905 kg

Fuerza Axial en columnas debido a resistencia Esperada en Arriostres

	caso a)		caso b)	
columna	Compresión	Tensión	compresión	Tensión
	P_{Ehm} (Ton)	T_{Ehm} (Ton)	P_{Ehm} (Ton)	T_{Ehm} (Ton)
CL-10	108.64	226251.96	108.64	67875.59
CL-9	108.64	226251.96	108.64	67875.59
CL-8	356.65	-355.64	272.29	-193.41
CL-7	356.65	-355.64	272.29	-193.41
CL-6	636.59	-636.61	-383.65	-383.65
CL-5	636.59	-636.61	-383.65	-383.65
CL-4	918.79	-921.51	638.46	-560.89
CL-3	918.79	638.46	638.46	-560.89
CL-2	1315.57	-1307.72	917.32	-792.77
CL-1	1315.57	-1307.72	917.32	-792.77

Fuerza Axial en Columnas

columna	D(ton)	L(ton)	QE(ton)
CL-10	4.37	1.97	11.787
CL-9	9.97	4.71	11.78
CL-8	15.74	7.24	64.65
CL-7	21.65	10.1	64.65
CL-6	27.87	12.83	152
CL-5	34.11	15.74	152
CL-4	41.04	18.78	262.48
CL-3	47.25	18.87	262.47
CL-2	55.74	22.63	386
CL-1	58.39	23.84	386.86

*fuerzas obtenidas de un análisis estático Equivalente usando Etabs.
QE no considera sobre resistencia

Resistencia Requerida en columnas

la resistencia requerida de las columnas debe ser mayor que la demanda calculada con las combinaciones del ASCE7, Considerando sobre resistencia y la demanda considerando que los arriostres desarrollaran su resistencia esperada en tensión, compresión y Post pandeo.

Resistencia Requerida de la Columna a Compresión
considerar en compresión el máximo valor de los casos a) y caso b) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 D+0.2 SDs D+PEmh+L			CS11=D+0.14*SDs D+0.7PEmh		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-10	CR8	116.55	CL-10	CS11	80.90
CL-9	CR8	126.90	CL-9	CS11	87.13
CL-8	CR8	385.28	CL-8	CS11	267.14
CL-7	CR8	396.17	CL-7	CS11	273.71
CL-6	CR8	687.28	CL-6	CS11	476.58
CL-5	CR8	698.67	CL-5	CS11	483.51
CL-4	CR8	993.33	CL-4	CS11	688.75
CL-3	CR8	1001.86	CL-3	CS11	695.65
CL-2	CR8	1413.93	CL-2	CS11	982.83
CL-1	CR8	1418.74	CL-1	CS11	985.77

Resistencia Requerida de la Columna a Tensión.
considerar en Tensión el mínimo valor de los casos a) y caso b) en el análisis.

LRFD			ASD		
Usando la combinación CR9 de LRFD			usando la combinación CS13 del ASD		
CR9=0.9D-0.2 SDs D+TEmh			CS13=0.6D-0.14*SDs D+0.70TEmh		
columna	combinación	Pu(ton)	columna	combinación	Pu(ton)
CL-10	CR9	67878.83	CL-10	CS13	47515.05
CL-9	CR9	67882.98	CL-9	CS13	47517.79
CL-8	CR9	-343.97	CL-8	CS13	-241.25
CL-7	CR9	-339.59	CL-7	CS13	-238.36
CL-6	CR9	-615.95	CL-6	CS13	-432.00
CL-5	CR9	-611.32	CL-5	CS13	-428.95
CL-4	CR9	-891.08	CL-4	CS13	-624.98
CL-3	CR9	-525.86	CL-3	CS13	-369.52
CL-2	CR9	-1266.39	CL-2	CS13	-888.15
CL-1	CR9	-1264.43	CL-1	CS13	-886.85

Resistencia Requerida de la Columna a Compresión considerando sobre Resistencia

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 D+0.2 SDs D+ΩQE+L			CS11=D+0.14*SDs D+0.7*ΩQE		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-10	CR8	31.48	CL-10	CS11	21.36
CL-9	CR8	41.81	CL-9	CS11	27.57
CL-8	CR8	157.92	CL-8	CS11	108.00
CL-7	CR8	168.81	CL-7	CS11	114.56
CL-6	CR8	354.69	CL-6	CS11	243.76
CL-5	CR8	366.08	CL-5	CS11	250.70
CL-4	CR8	599.49	CL-4	CS11	413.07
CL-3	CR8	608.00	CL-3	CS11	419.95
CL-2	CR8	870.35	CL-2	CS11	602.33
CL-1	CR8	876.88	CL-1	CS11	606.47

Resistencia Requerida de la Columna a Tensión. considerando sobre Resistencia

LRFD			ASD		
Usando la combinación CR9 de LRFD			usando la combinación CS13 del ASD		
CR9=0.9D-0.2 SDs D+ΩQE			CS13=0.6D-0.14*SDs D+0.70*ΩQE		
columna	combinación	Pu(ton)	columna	combinación	Pu(ton)
CL-10	CR9	-20.33	CL-10	CS13	-14.36
CL-9	CR9	-16.17	CL-9	CS13	-11.62
CL-8	CR9	-117.63	CL-8	CS13	-82.81
CL-7	CR9	-113.25	CL-7	CS13	-79.92
CL-6	CR9	-283.34	CL-6	CS13	-199.17
CL-5	CR9	-278.71	CL-5	CS13	-196.12
CL-4	CR9	-494.53	CL-4	CS13	-347.40
CL-3	CR9	-489.91	CL-3	CS13	-344.35
CL-2	CR9	-730.67	CL-2	CS13	-513.14
CL-1	CR9	-730.43	CL-1	CS13	-513.05

Considerar Efecto de segundo Orden

LRFD			ASD		
α=		1	α=		1.6
$B_2 = \dfrac{1}{1 - \dfrac{\alpha p_{story}}{p_{e\,story}}} \geq 1$			$B_2 = \dfrac{1}{1 - \dfrac{\alpha p_{story}}{p_{e\,story}}} \geq 1$		
10	$B_2 =$	1.50		$B_2 =$	1.50
9	$B_2 =$	1.50	9	$B_2 =$	1.50
8	$B_2 =$	1.50	8	$B_2 =$	1.50
7	$B_2 =$	1.50	7	$B_2 =$	1.50
6	$B_2 =$	1.50	6	$B_2 =$	1.50
5	$B_2 =$	1.38	5	$B_2 =$	1.50
4	$B_2 =$	1.27	4	$B_2 =$	1.50
3	$B_2 =$	1.17	3	$B_2 =$	1.31
2	$B_2 =$	1.10	2	$B_2 =$	1.16
1	$B_2 =$	1.03	1	$B_2 =$	1.06

Resistencia Requerida de la Columna a Compresión considerando sobre Resistencia y Efecto de 2do Orden

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 D+0.2 SDs D+B_2ΩQE+L			CS11=D+0.14*SDs D+0.7*B_2*ΩQE		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-10	CR8	43.27	CL-10	CS11	29.61
CL-9	CR8	53.59	CL-9	CS11	35.81
CL-8	CR8	222.57	CL-8	CS11	153.25
CL-7	CR8	233.46	CL-7	CS11	159.82
CL-6	CR8	506.69	CL-6	CS11	350.16
CL-5	CR8	482.46	CL-5	CS11	357.10
CL-4	CR8	742.64	CL-4	CS11	596.80
CL-3	CR8	699.67	CL-3	CS11	534.63
CL-2	CR8	944.86	CL-2	CS11	690.91
CL-1	CR8	903.16	CL-1	CS11	636.51

6.4 Diseño de Columnas.

Propiedades de las Columna ASTM 992

Fy=	3515.29	kg/cm^2	Ry=	1.1	ver tabla A3.1 del AISC 341-16
Fu=	4569.87	kg/cm^2			
E=	2038865.68	kg/cm^2			

SELECCION DE SECCIONES

columna	Sección	bf(cm)	tf (cm)	λhd=bf/2tf	obs
CL-10	**W14x53**	20.4724	1.6764	6.11	cumple
CL-9	**W14x82**	25.654	2.1717	5.91	cumple
CL-8	**W14x132**	37.338	2.6162	7.14	cumple
CL-7	**W14x132**	37.338	2.6162	7.14	cumple
CL-6	**W14x132**	37.338	2.6162	7.14	cumple
CL-5	**W14x132**	37.338	2.6162	7.14	cumple
CL-4	**W14x132**	37.338	2.6162	7.14	cumple
CL-3	**W14x132**	37.338	2.6162	7.14	cumple
CL-2	**W14x145**	39.37	2.7686	7.11	cumple
CL-1	**W14x145**	39.37	2.7686	7.11	cumple

revisar que la sección sea altamente dúctil

revisar pandeo del Patín de la columna.

$$\lambda_{hd} = \frac{bf}{2tf} \leq 0.32\sqrt{\frac{E}{R_Y F_Y}} = \quad 7.34797437$$

revisar pandeo del Alma de la columna

Esta revisión se realiza en función de la máxima carga ultima axial a compresión de la columna.

columna	d(cm)	tw(cm)	hw(cm)	Ag(cm^2)	Pu(ton)	ϕPn=Ag*Fcr	Ca=Pu/ϕPn
CL-10	35.306	0.9398	31.9532	100.64496	43.27	230.12751	0.18801655
CL-9	36.322	1.2954	31.9786	154.8384	53.59	403.23097	0.13291279
CL-8	37.338	1.6383	32.1056	250.32208	222.57	727.661487	0.30587475
CL-7	37.338	1.6383	32.1056	250.32208	233.46	727.661487	0.32083902
CL-6	37.338	1.6383	32.1056	250.32208	506.69	727.661487	0.69632964
CL-5	37.338	1.6383	32.1056	250.32208	482.46	727.661487	0.66302142
CL-4	37.338	1.6383	32.1056	250.32208	742.64	727.661487	1.02057883
CL-3	37.338	1.6383	32.1056	250.32208	699.67	727.661487	0.96152632
CL-2	37.592	1.7272	32.0548	275.48332	944.86	808.12497	1.16920565
CL-1	37.592	1.7272	32.0548	275.48332	903.16	808.12497	1.11759806

columna	hw/tw	λhd	obs
CL-10	34.00	50.3553339	cumple
CL-9	24.69	51.4688117	cumple
CL-8	19.60	47.9737815	cumple
CL-7	19.60	47.6713997	cumple
CL-6	19.60	40.0838872	cumple
CL-5	19.60	40.7569439	cumple
CL-4	19.60	33.5318065	cumple
CL-3	19.60	34.7250764	cumple
CL-2	18.56	30.5285148	cumple
CL-1	18.56	31.5713459	cumple

λhd depende de Ca

Para Ca≤0.114 usar

$$2.57\sqrt{\frac{E}{R_y F_y}}(1-0.114)$$

para Ca>0.114 usar

$$0.88\sqrt{\frac{E}{R_y F_y}}(2.68-Ca)$$

$$\lambda hd \geq 1.57\sqrt{\frac{E}{R_y F_y}} = \quad 36.05$$

Resistencia Disponible de las Columnas a Compresión

Resistencia nominal a compresión $P_n = F_{cr} A_g$

$el\ \ esfuerzo\ critico\ F_{cr}\ se\ calcula\ como\ se\ muestra:$

a) cuando $\frac{L_C}{r} \leq 4.71 \sqrt{\frac{E}{F_y}} \quad o \quad \frac{F_y}{F_e} \leq 2.25$

$$F_{Cr} = \left(0.658^{\frac{F_y}{F_e}}\right) F_y$$

ecuación E3-2 del AISC 360-16

b) cuando $\frac{L_C}{r} > 4.71 \sqrt{\frac{E}{F_y}} \quad o \quad \frac{F_y}{F_e} > 2.25$

$$F_{Cr} = 0.0877 F_e$$

ecuación E3-3 del AISC 360-16

$esfuerzo\ a\ pandeo\ elastico\ F_e$

$$F_e = \frac{\pi^2 E}{\left(\frac{L_C}{r}\right)^2}$$

ecuación E3-4 del AISC 360-16

Columna	sección	Lc(cm)	ry(cm)	F_e	$\frac{F_y}{F_e}$	$\frac{L_C}{r}$	F_{Cr}
CL-10	W14x53	325.00	4.8768	4530.97357	0.78	66.64	2540.587
CL-9	W14x82	325.00	6.2992	7559.48889	0.47	51.59	2893.561
CL-8	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-7	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-6	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-5	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-4	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-3	W14x132	325.00	9.5504	17376.5983	0.20	34.03	3229.890
CL-2	W14x145	325.00	10.1092	19469.5187	0.18	32.15	3259.423
CL-1	W14x145	325.00	10.1092	19469.5187	0.18	32.15	3259.423

$4.71 \sqrt{\frac{E}{F_y}} =$ 113.432

Resistencia de Diseño de la columna a Compresión

$\Phi_c = 0.9 (LRFD)$ $\Omega_C = 1.67\ (ASD)$

Columna	sección	$A_g(cm^2)$	LRFD $\Phi_c P_n$	ASD P_n / Ω_C	LRFD P_u	ASD P_u	d/c
CL-10	W14x53	100.64496	230127.51	153112.116	43267.78	29607.65	0.19
CL-9	W14x82	154.8384	403230.97	268284.079	53594.55	35814.39	0.13
CL-8	W14x132	250.32208	727661.487	484139.379	222573.28	153251.69	0.32
CL-7	W14x132	250.32208	727661.487	484139.379	233462.20	159817.54	0.33
CL-6	W14x132	250.32208	727661.487	484139.379	506692.26	350162.78	0.72
CL-5	W14x132	250.32208	727661.487	484139.379	482455.16	357095.24	0.74
CL-4	W14x132	250.32208	727661.487	484139.379	742635.91	596802.28	1.23
CL-3	W14x132	250.32208	727661.487	484139.379	699665.68	534631.59	1.10
CL-2	W14x145	275.48332	808124.97	537674.631	944864.28	690906.13	1.28
CL-1	W14x145	275.48332	808124.97	537674.631	903158.90	636512.87	1.18

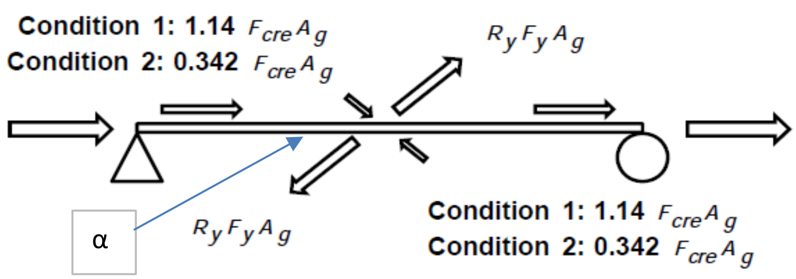
6.5 Diseño de Viga.

DISEÑO DE VIGA BM-9

Cortante y momento por Gravedad. Considerando un simple paso entre columna izquierda y derecha

	FD	FL	VD	VL	MD	ML
viga	kg	kg	kg	kg	kg-m	kg-m
BM-9	0	0	1310	520	550	220
BM-7	0	0	1310	520	550	220
BM-5	0	0	1310	520	550	220
BM-3	0	0	1310	520	550	220
BM-1	0	0	1310	520	550	220

según sección F2.3 341-16



Condición 1

$$P_{y9} = sen\ \alpha\ [T10 + C9 - C10 - T9)]$$

senα=(H9)/L= 0.793

Py9= (senα*(139221.36+152051.71-154423.69-132540.05))

Py9= 3415.677 kg

Condición 2

$$P_{y9} = sen\ \alpha\ [T10 + 0.3C9 - 0.3C10 - T9)]$$

Py9= -7410.110 kg

Esta fuerza de desbalance se considera en el centro de la viga

$V_{Ehm9} = \frac{py}{2}$= 1707.839 Kg

$V_{Ehm9} = \frac{py}{2}$= 3705.055 Kg

$M_{Ehm9} = \frac{pyL9}{4}$= 4269.596665 kg-m

$M_{Ehm9} = \frac{pyL9}{4}$= 9262.63787 kg-m

L=B1

$$F_{Xi} = Cos \propto \left[\frac{\sum arriostres\ abajo\ viga - \sum arriostres\ sobre\ de\ viga}{2}\right]$$

Cos α=(B1/2)/L 0.609710761

$$F_{X9} = Cos \propto \left[\frac{\sum(T9 + C9) - \sum(T10 + C10)}{2}\right]$$

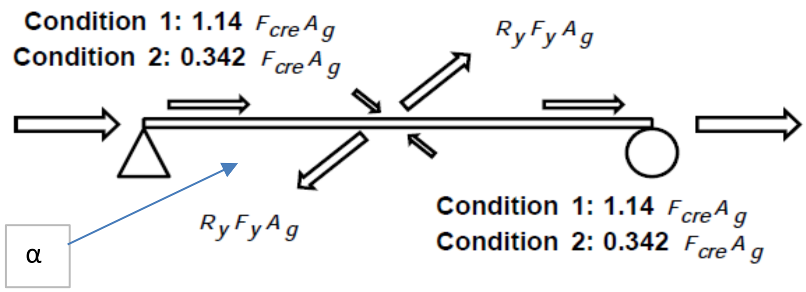
$F_{X9} =$ 10582.74787 kg

$$F_{X9} = Cos \propto \left[\frac{\sum(T9 + 0.3C9) - \sum(T10 + 0.3C10)}{2}\right]$$

$F_{X9} =$ 6418.9834

DISEÑO DE VIGA BM-7

según sección F2.3 341-16



calculo de Fuerza axial requerida

Condición 1

$$P_{y7} = sen\ \alpha\ [T8 + C7 - C8 - T7)]$$

senα=(H7)/L 0.793

Py7= (senα*(160557.97+189683.37-190962.63-159858.95))

Py7= -459.921883 kg

Condición 2

$$P_{y7} = sen\ \alpha\ [T8 + 0.3C7 - 0.3C8 - T7)]$$

Py7= -17007.6036 kg

Esta fuerza de desbalance se considera en el centro de la viga

$$V_{Ehm7} = \frac{py}{2} = \quad 229.9609415 \text{ Kg}$$

$$V_{Ehm7} = \frac{py}{2} = \quad 8503.80178 \text{ Kg}$$

$$M_{Ehm7} = \frac{pyL9}{4} = \quad 270.23916 \text{ kg-m}$$

$$M_{Ehm7} = \frac{pyL9}{4} = \quad 9993.26335 \text{ kg-m}$$

L=B1

$$F_{Xi} = Cos \propto \left[\frac{\sum arriostres\ abajo\ viga - \sum arriostres\ sobre\ de\ viga}{2}\right]$$

Cos α=(B1/2)/L 0.609710761

$$F_{X7} = Cos \propto \left[\frac{\sum(T7 + C7) - \sum(T8 + C8)}{2}\right]$$

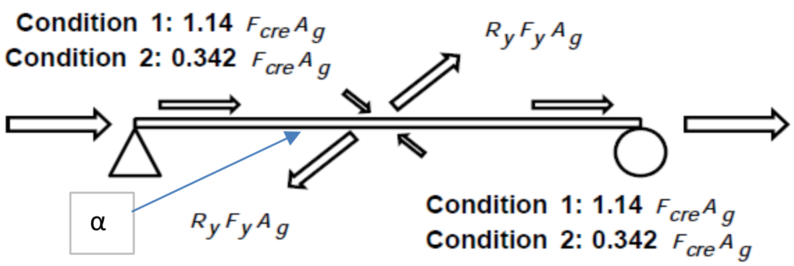
$$F_{X7} = \quad 18361.1586 \text{ kg}$$

$$F_{X7} = Cos \propto \left[\frac{\sum(T7 + 0.3C7) - \sum(T8 + 0.3C8)}{2}\right]$$

$$F_{X7} = \quad 11996.6657 \text{ kg}$$

DISEÑO DE VIGA BM-5

según sección F2.3 341-16



calculo de Fuerza axial requerida

$$P_{y5} = sen\,\alpha\,[T6 + C5 - C6 - T5)]$$

$$P_{y5} = sen\,\alpha\,[T6 + 0.3C5 - 0.3C6 - T5)]$$

senα=(H5)/L 0.793

Py5= (senα*(163491.75+163520.5-163491.75-163520.5))

Py5= 0 kg

Py5= 0 kg

Esta fuerza de desbalance se considera en el centro de la viga

$V_{Ehm5} = \frac{py}{2}=$ 0.000 Kg

$V_{Ehm5} = \frac{py}{2}=$ 0 Kg

$M_{Ehm5} = \frac{pyL5}{4}=$ 0 kg-m

$M_{Ehm5} = \frac{pyL5}{4}=$ 0 kg-m

L=B1

$$F_{Xi} = Cos \propto \left[\frac{\sum arriostres\ abajo\ viga - \sum arriostres\ sobre\ de\ viga}{2}\right]$$

Cos α=(B1/2)/L 0.609710761

$$F_{X5} = Cos \propto \left[\frac{\sum(T5 + C5) - \sum(T6 + C6)}{2}\right]$$

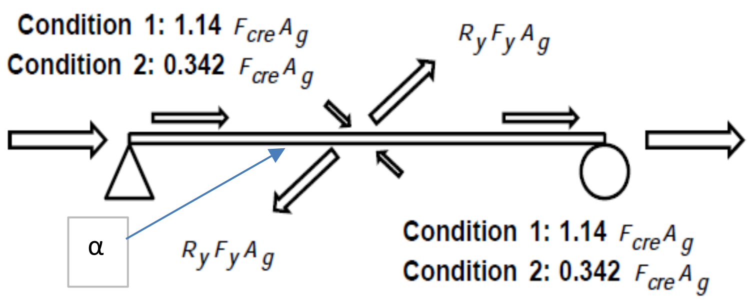
$F_{X5} =$ 0 kg

$$F_{X5} = Cos \propto \left[\frac{\sum(T5 + 0.3C5) - \sum(T6 + 0.3C6)}{2}\right]$$

$F_{X5} =$ 0 kg

DISEÑO DE VIGA BM-3

según sección F2.3 341-16



calculo de Fuerza axial requerida

$$P_{y3} = sen\,\alpha\,[T4 + C3 - C4 - T3)]$$ $$P_{y3} = sen\,\alpha\,[T4 + 0.3C3 - 0.3C4 - T3)]$$

senα=(H5)/L 0.793

Py3= (senα*(194429.83+212520.1-209098.75-194028.8))

Py3= 3029.7 kg Py3= -7229.94 kg

Esta fuerza de desbalance se considera en el centro de la viga

$V_{Ehm5} = \frac{py}{2}$= 1514.850 Kg $V_{Ehm5} = \frac{py}{2}$= 3614.97 Kg

$M_{Ehm5} = \frac{pyL5}{4}$=1780.179664 kg-m $M_{Ehm5} = \frac{pyL5}{4}$=4248.14079 kg-m

L=B1

$$F_{Xi} = Cos \propto \left[\frac{\sum arriostres\ abajo\ viga - \sum arriostres\ sobre\ de\ viga}{2}\right]$$

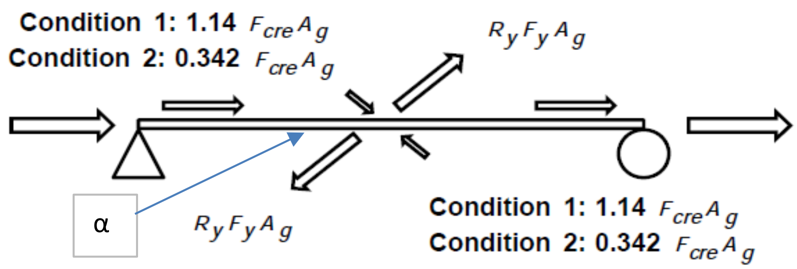
Cos α=(B1/2)/L 0.609710761

$$F_{X3} = Cos \propto \left[\frac{\sum(T3 + C3) - \sum(T4 + C4)}{2}\right]$$ $$F_{X3} = Cos \propto \left[\frac{\sum(T3 + 0.3C3) - \sum(T4 + 0.3C4)}{2}\right]$$

$F_{X3} =$ 10109.06796 kg $F_{X3} =$ 6163.04928 kg

DISEÑO DE VIGA BM-2

según sección F2.3 341-16



calculo de Fuerza axial requerida

$$P_{y1} = sen\,\alpha\,[T2 + C1 - C2 - T1)]$$

$$P_{y1} = sen\,\alpha\,[T2 + 0.3C1 - 0.3C2 - T1)]$$

senα=(H2)/L 0.793

Py1= (senα*(274708.82+331360.35-317382.03-278165.58))

Py1= 8339.64 kg

Py1= -21174.78 kg

Esta fuerza de desbalance se considera en el centro de la viga

$V_{Ehm1} = \frac{py}{2}$= 4169.820 Kg

$V_{Ehm1} = \frac{py}{2}$= 10587.39 Kg

$M_{Ehm1} = \frac{pyL5}{4}$= 4900.17412 kg-m

$M_{Ehm1} = \frac{pyL5}{4}$=12441.7971 kg-m

L=B1

$$F_{Xi} = Cos \propto \left[\frac{\sum arriostres\ debajo\ viga - \sum arriostres\ sobre\ de\ viga}{2}\right]$$

Cos α=(B1/2)/L 0.609710761

$$F_{X1} = Cos \propto \left[\frac{\sum(T1 + C1) - \sum(T2 + C2)}{2}\right]$$

$F_{X1} =$ 29225.871 kg

$$F_{X1} = Cos \propto \left[\frac{\sum(T1 + 0.3C1) - \sum(T2 + 0.3C2)}{2}\right]$$

$F_{X1} =$ 17874.1726 kg

Fuerza en vigas debido a resistencia Esperada en Arriostres

	condición 1			condición 2		
	VEhmi	Mehmi	Fxi	VEhmi	Mehmi	Fxi
viga	kg	kg-m	kg	kg	kg-m	kg
BM-9	1707.839	4269.596665	10582.7479	3705.055	9262.63787	6418.9834
BM-7	229.9609415	270.23916	18361.1586	8503.80178	9993.26335	11996.6657
BM-5	0.00	0.00	0.00	0.00	0.00	0.00
BM-3	1514.850	1780.179664	10109.068	3614.97	4248.14079	6163.04928
BM-1	4169.820	4900.17412	29225.871	10587.39	12441.7971	17874.1726

Resistencia Axial Requerida de la Viga.
casos a) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 FD+0.2 SDsF D+Fxi+FL			CS11=FD+0.14*SDs FD+0.7Fxi		
Columna	combinación	Pu(kg)	Columna	combinación	Pu(kg)
BM-9	CR8	10582.75	BM-9	CS11	7407.92
BM-7	CR8	18361.16	BM-7	CS11	12852.81
BM-5	CR8	0.00	BM-5	CS11	0.00
BM-3	CR8	10109.07	BM-3	CS11	7076.35
BM-1	CR8	29225.87	BM-1	CS11	20458.11

Resistencia a Cortante Requerida de la Viga.
casos a) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 VD+0.2 SDs VD+VEhmi+VL			CS11=VD+0.14*SDs VD+0.7VEhmi		
Columna	combinación	Vu(kg)	Columna	combinación	Vu(kg)
BM-9	CR8	4007.51	BM-9	CS11	2563.19
BM-7	CR8	2529.64	BM-7	CS11	1528.68
BM-5	CR8	2299.68	BM-5	CS11	1367.71
BM-3	CR8	3814.53	BM-3	CS11	2428.10
BM-1	CR8	6469.50	BM-1	CS11	4286.58

Resistencia a Momento Requerida de la Viga.
casos a) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 MD+0.2 SDs MD+MEhmi+ML			CS11=MD+0.14*SDs MD+0.7MEhmi		
Columna	combinación	Mu(kg-m)	Columna	combinación	Mu(kg-m)
BM-9	CR8	5236.79	BM-9	CS11	3599.75
BM-7	CR8	1237.43	BM-7	CS11	800.20
BM-5	CR8	967.19	BM-5	CS11	611.03
BM-3	CR8	2747.37	BM-3	CS11	1857.16
BM-1	CR8	5867.37	BM-1	CS11	4041.16

Resistencia Axial Requerida de la Viga.
casos b) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 FD+0.2 SDsF D+Fxi+FL			CS11=FD+0.14*SDs FD+0.7Fxi		
Columna	combinación	Pu(kg)	Columna	combinación	Pu(kg)
BM-9	CR8	6418.98	BM-9	CS11	4493.29
BM-7	CR8	11996.67	BM-7	CS11	8397.67
BM-5	CR8	0.00	BM-5	CS11	0.00
BM-3	CR8	6163.05	BM-3	CS11	4314.13
BM-1	CR8	17874.17	BM-1	CS11	12511.92

Resistencia a Cortante Requerida de la Viga.
casos b) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 VD+0.2 SDs VD+VEhmi+VL			CS11=VD+0.14*SDs VD+0.7VEhmi		
Columna	combinación	Vu(kg)	Columna	combinación	Vu(kg)
BM-9	CR8	6004.73	BM-9	CS11	3961.24
BM-7	CR8	10803.48	BM-7	CS11	7320.37
BM-5	CR8	2299.68	BM-5	CS11	1367.71
BM-3	CR8	5914.65	BM-3	CS11	3898.18
BM-1	CR8	12887.07	BM-1	CS11	8778.88

Resistencia a Momento Requerida de la Viga.
casos b) en el análisis.

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 MD+0.2 SDs MD+MEhmi+ML			CS11=MD+0.14*SDs MD+0.7MEhmi		
Columna	combinación	Mu(kg-m)	Columna	combinación	Mu(kg-m)
BM-9	CR8	7386.18	BM-9	CS11	7094.88
BM-7	CR8	12963.86	BM-7	CS11	7606.32
BM-5	CR8	967.19	BM-5	CS11	611.03
BM-3	CR8	7130.24	BM-3	CS11	3584.73
BM-1	CR8	18841.36	BM-1	CS11	9320.29

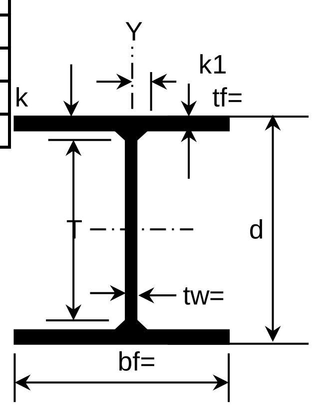
Propiedades de las Vigas:		ASTM 992			
Fy=	3515.29	kg/cm^2	Ry=	1.1	ver tabla A3.1 del AISC 341-16
Fu=	4569.87	kg/cm^2			
E=	2038865.677	kg/cm^2			

VIGA	SECCION	A(in^2)	d(in)	tw(in)	bf	tf	kdes
BM-9	**W24x62**	18.3	23.7	0.43	7.04	0.59	1.19
BM-7	**W24x62**	18.3	23.7	0.43	7.04	0.59	1.19
BM-5	**W24x62**	18.3	23.7	0.43	7.04	0.59	1.19
BM-3	**W24x62**	18.3	23.7	0.43	7.04	0.59	1.19
BM-1	**W24x62**	18.3	23.7	0.43	7.04	0.59	1.19

VIGA	h/tw	Ix(in^4)	Sx(in^3)	rx(in)	zx(in^3)	Iy(in^4)	ry(in)
BM-9	49.58	1560	132	9.24	154	34.5	1.37
BM-7	49.58	1560	132	9.24	154	34.5	1.37
BM-5	49.58	1560	132	9.24	154	34.5	1.37
BM-3	49.58	1560	132	9.24	154	34.5	1.37
BM-1	49.58	1560	132	9.24	154	34.5	1.37

VIGA	J(in^4)	Cw(in^6)	h_0 (in)
BM-9	1.77	4620	23.11
BM-7	1.77	4620	23.11
BM-5	1.77	4620	23.11
BM-3	1.77	4620	23.11
BM-1	1.77	4620	23.11

W, S, M, HP Shapes



revisar que la sección sea altamente dúctil
revisar pandeo del Patín de la viga.

$$\lambda_{hd} = \frac{bf}{2tf} \leq 0.32\sqrt{\frac{E}{R_Y F_Y}} = \quad 7.34797437$$

VIGA	Sección	λhd=bf/2tf	obs
BM-9	W24x62	5.966101695	cumple
BM-7	W24x62	5.966101695	cumple
BM-5	W24x62	5.966101695	cumple
BM-3	W24x62	5.966101695	cumple
BM-1	W24x62	5.966101695	cumple

revisar pandeo del Alma de la viga

Esta revisión se realiza en función de la máxima carga ultima axial a compresión de la columna.

viga	Pu(ton)	ϕPn=Ag*Fy	Ca=Pu/ϕPn	
BM-9	10.58	373.5267022	0.03	
BM-7	18.36	373.5267022	0.05	
BM-5	0.00	373.5267022	0.00	
BM-3	10.11	373.5267022	0.03	
BM-1	29.23	373.5267022	0.08	

λhd depende de Ca

viga	hw/tw	λhd	obs
BM-9	49.58	52.28588934	cumple
BM-7	49.58	52.28588934	cumple
BM-5	49.58	52.28588934	cumple
BM-3	49.58	52.28588934	cumple
BM-1	49.58	52.28588934	cumple

Para Ca≤0.114 usar

$$2.57\sqrt{\frac{E}{R_y F_y}}(1-0.114)$$

para Ca>0.114 usar

$$0.88\sqrt{\frac{E}{R_y F_y}}(2.68-Ca)$$

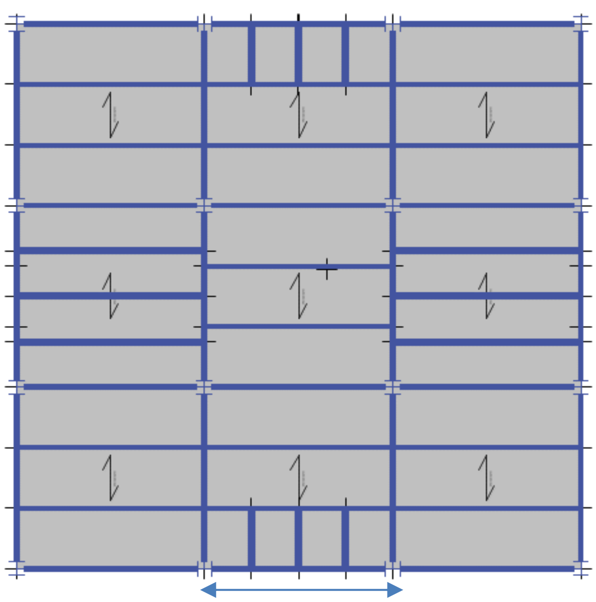
$$\lambda hd \geq 1.57\sqrt{\frac{E}{R_y F_y}} = 36.05$$

Requerimiento de viga altamente dúctil.

Adicional a los requisitos del AISC 341-16. sección D1.2a(a) y(b) los miembros vigas altamente dúctil deberán tener una máxima separación de $L_b = 0.095 r_y E/(R_y F_y)$

viga	L_b(cm)	$usar\ L_b$(cm)	Obs
BM-9	174.31	125.00	cumple
BM-7	174.31	125.00	cumple
BM-5	174.31	125.00	cumple
BM-3	174.31	125.00	cumple
BM-1	174.31	125.00	cumple

se divide en 4 espacios de 125cm cada uno las vigas



L= 5

planta estructural

La resistencia requerida de la viga en el final y a la mitad del punto de arriostre es:

$P_{rb} = 0.02 M_r C_d / h_o$ ecuación A-6-7 del ASCE 360-16

Donde:

$C_d =$ 1.0

usando ecuación D1-1 del AISC 341-16

LRFD				ASD			
$M_r = R_y F_y Z$ =1.1*3515.29*154*(2.54^3)				$M_r = R_y F_y Z/1.5$ =1.1*3515.29*154*(2.54^3)/1.5			
BM-9	$M_{r9} =$	9758334.806	Kg-cm	BM-9	$M_{r9} =$	6505556.54	Kg-cm
BM-7	$M_{r7} =$	9758334.806	Kg-cm	BM-7	$M_{r7} =$	6505556.54	Kg-cm
BM-5	$M_{r5} =$	9758334.806	Kg-cm	BM-5	$M_{r5} =$	6505556.54	Kg-cm
BM-3	$M_{r3} =$	9758334.806	Kg-cm	BM-3	$M_{r3} =$	6505556.54	Kg-cm
BM-1	$M_{r1} =$	9758334.806	Kg-cm	BM-1	$M_{r1} =$	6505556.54	Kg-cm

usando ecuación A-6-7 del AISC 360-16, La resistencia requerida del nodo del arriostre es

LRFD			ASD		
$P_{rb} = 0.02(R_y F_y Z) C_d / h_o$ =0.02*1.1*3515.29*154*(2.54^3)*1/23.11			$P_{rb} = 0.02(R_y F_y Z/1.5) C_d / h_o$ =0.02*1.1*3515.29*154*(2.54^3)*/1.51/23.11		
$P_{rb9} =$	8445.118828	Kg	$P_{rb9} =$	5630.07922	kg
$P_{rb7} =$	8445.118828	Kg	$P_{rb7} =$	5630.07922	kg
$P_{rb5} =$	8445.118828	Kg	$P_{rb5} =$	5630.07922	kg
$P_{rb3} =$	8445.118828	Kg	$P_{rb3} =$	5630.07922	kg
$P_{rb1} =$	8445.118828	Kg	$P_{rb1} =$	5630.07922	kg

Rigidez requerida de los arriostres

Φ= 0.75 Ω= 2

LRFD			ASD		
$\beta_{rb} = \frac{1}{\Phi}\left(\frac{10 M_r C_d}{L_b h_0}\right)$			$\beta_{rb} = \Omega\left(\frac{10 M_r C_d}{L_b h_0}\right)$		
$\beta_{rb9} =$	17732.53297	Kg/cm	$\beta_{rb9} =$	17732.533	Kg/cm
$\beta_{rb7} =$	17732.53297	Kg/cm	$\beta_{rb7} =$	17732.533	Kg/cm
$\beta_{rb5} =$	17732.53297	Kg/cm	$\beta_{rb5} =$	17732.533	Kg/cm
$\beta_{rb3} =$	17732.53297	Kg/cm	$\beta_{rb3} =$	17732.533	Kg/cm
$\beta_{rb1} =$	17732.53297	Kg/cm	$\beta_{rb1} =$	17732.533	Kg/cm

Rigidez Axial de los miembros siempre que los arriostres a la viga sean:

$$k = \frac{AE}{L}$$

$$k \geq \beta_{rb}$$

$$A \geq \beta_{rb} \left[\frac{L}{E}\right]$$

A9 $\geq$ 4.35 cm^2 0.67403854 in^2

A7 $\geq$ 4.35 cm^2 0.67403854 in^2

A5 $\geq$ 4.35 cm^2 0.67403854 in^2

A3 $\geq$ 4.35 cm^2 0.67403854 in^2

A1 $\geq$ 4.35 cm^2 0.67403854 in^2

Proporcione el refuerzo lateral de la viga de ambas bridas en los cuartos de la viga (125 cm)

Área mínima de 0.30 $in.^2$ y con una resistencia de compresión axial de 3779.38 kg.(LRFD) y 2519.59 kg (ASD).

RESISTENCIA A FLEXION DISPONIBLE DE LA VIGA

LRFD	Φ_b= 0.9		ASD	Ω_b= 1.67		LRFD	ASD
	ΦM_P=0.9*fy*Zx			$\frac{M_P}{\Omega}$ =fy*Zx/1.67		M_u	M_u
BM-9	79840.82232	Kg-m	BM-9	53120.9729	Kg-m	7386.18	7094.88
BM-7	79840.82232	Kg-m	BM-7	53120.9729	Kg-m	12963.86	7606.32
BM-5	79840.82232	Kg-m	BM-5	53120.9729	Kg-m	967.19	611.03
BM-3	79840.82232	Kg-m	BM-3	53120.9729	Kg-m	7130.24	3584.73
BM-1	79840.82232	Kg-m	BM-1	53120.9729	Kg-m	18841.36	9320.29

RESISTENCIA A COMPRESION DISPONIBLE DE LA VIGA.

Resistencia nominal a compresión $P_n = F_{cr}A_g$

$el\ esfuerzo\ critico\ F_{cr}\ se\ calcula\ como\ se\ muestra:$

a) cuando $\frac{L_b}{r} \leq 4.71\sqrt{\frac{E}{F_y}} \quad o \quad \frac{F_y}{F_e} \leq 2.25$

$$F_{Cr} = \left(0.658^{\frac{F_y}{F_e}}\right) F_y$$ ecuación E3-2 del AISC 360-16

b) cuando $\frac{L_b}{r} > 4.71\sqrt{\frac{E}{F_y}} \quad o \quad \frac{F_y}{F_e} > 2.25$

$$F_{Cr} = 0.0877F_e$$ ecuación E3-3 del AISC 360-16

$esfuerzo\ a\ pandeo\ elastico\ F_e$ $$F_e = \frac{\pi^2 E}{\left(\frac{L_C}{r}\right)^2}$$ ecuación E3-4 del AISC 360-16

viga	sección	L_{bx}(cm)	rx(cm)	F_e	$\frac{F_y}{F_e}$	$\frac{L_{bx}}{rx}$	F_{Cr}
BM-9	W24x62	500.00	23.4696	44336.3286	0.08	21.30	3400.543
BM-7	W24x62	500.00	23.4696	44336.3286	0.08	21.30	3400.543
BM-5	W24x62	500.00	23.4696	44336.3286	0.08	21.30	3400.543
BM-3	W24x62	500.00	23.4696	44336.3286	0.08	21.30	3400.543
BM-1	W24x62	500.00	23.4696	44336.3286	0.08	21.30	3400.543

$4.71\sqrt{\frac{E}{F_y}} =$ 113.432

Resistencia de Diseño de la viga Compresión

$\Phi_c = 0.9(LRFD)$ $\Omega_C = 1.67\ (ASD)$

			LRFD	ASD	LRFD	ASD
Viga	sección	$A_g(cm^2)$	$\Phi_c P_n$	$P_n\ /\Omega_C$	P_u	P_u
BM-9	W24x62	116.205	355644.141	236622.848	10582.75	7407.92
BM-7	W24x62	116.205	355644.141	236622.848	18361.16	12852.81
BM-5	W24x62	116.205	355644.141	236622.848	0.00	0.00
BM-3	W24x62	116.205	355644.141	236622.848	10109.07	7076.35
BM-1	W24x62	116.205	355644.141	236622.848	29225.87	20458.11

Determinar la resistencia al pandeo crítico para ejes restringidos
pandeo por flexion-torsion
asumiendo
Q= 1

$$F_e = \left\{ \frac{\pi^2 E \left\{ C_W + I_Y \left(\frac{d}{2} \right)^2 \right\}}{(k_z L)^2} + GJ \right\} \left\{ \frac{1}{I_X + I_Y + (d/2)^2 A_g} \right\}$$

						LRFD	ASD
Viga	sección	F_e (kg/cm^2)	F_y/F_e	F_{Cr}	$A_g(cm^2)$	$\Phi_c P_n$	P_n/Ω_C
BM-9	W24x62	19523.64195	0.18	3260.11	116.205	340956.53	226850.65
BM-7	W24x62	19523.64195	0.18	3260.11	116.205	340956.53	226850.65
BM-5	W24x62	19523.64195	0.18	3260.11	116.205	340956.53	226850.65
BM-3	W24x62	19523.64195	0.18	3260.11	116.205	340956.53	226850.65
BM-1	W24x62	19523.64195	0.18	3260.11	116.205	340956.53	226850.65

gobierna la menor capacidad

Se plantea la revisión ante la interacción de la fuerza axial y los momentos

	LRFD	ASD	LRFD	ASD
Viga	$\frac{P_u}{\Phi P_n}$	$\frac{P_u}{P_{n/\Omega}}$	I	I
BM-9	0.031	0.033	0.11	0.14988858
BM-7	0.054	0.057	0.19	0.17151741
BM-5	0.000	0.000	0.01	0.0115027
BM-3	0.030	0.031	0.10	0.08307937
BM-1	0.086	0.090	0.28	0.22054568

LRFD

$$I = si(\frac{P_U}{\Phi P_n} \leq 2, \frac{P_U}{2*\Phi P_n} + \frac{M_u}{\Phi M_n}, \frac{P_U}{\Phi P_n} + \frac{8}{9} * \frac{M_u}{\Phi M_n})$$

Ec C-H1-2a del AISC-360-16

ASD

$$I = si(\frac{P_U}{P_{n/\Omega}} \leq 2, \frac{P_U}{2*P_{n/\Omega}} + \frac{M_u}{M_{n/\Omega}}, \frac{P_U}{P_{n/\Omega}} + \frac{8}{9} * \frac{M_u}{M_{n/\Omega}})$$

Ec C-H1-2b del AISC-360-16

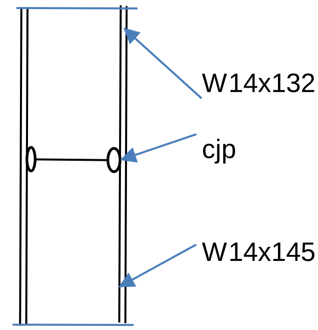
Revisión de Cortante

	LRFD	ASD	$A_w = d * t_w$	h_w/t_w	K_V	C_V	V_b
viga	Vu	Vu	cm^2				
BM-9	6004.73	3961.24	65.75	49.58	5	1	138674.34
BM-7	10803.48	7320.37	65.75	49.58	5	1	138674.34
BM-5	2299.68	1367.71	65.75	49.58	5	1	138674.34
BM-3	5914.65	3898.18	65.75	49.58	5	1	138674.34
BM-1	12887.07	8778.88	65.75	49.58	5	1	138674.34

$\Phi_v = 1.0(LRFD)$ $\Omega_v = 1.50\ (ASD)$

	LRFD	ASD	LRFD	ASD
viga	$\Phi_v V_b$	V_b/Ω_v	d/c	d/c
BM-9	138674.3396	92449.55974	0.04	0.04
BM-7	138674.3396	92449.55974	0.08	0.08
BM-5	138674.3396	92449.55974	0.02	0.01
BM-3	138674.3396	92449.55974	0.04	0.04
BM-1	138674.3396	92449.55974	0.09	0.09

6.6 Diseño de Empalme entre columna



Se diseñara totalmente soldada

Fuerza Axial en Columnas

COLUMNA	D(ton)	L(ton)	QE(ton)
CL-3	47.25	18.87	262.47

asumir que los extremos de las columnas están libres de momento en ambos ejes x-x yy-y.

Propiedades de la columnas ASTM 992

Fy=	3515.29	kg/cm^2	Ry=	1.1	ver tabla A3.1 del AISC 341-16
Fu=	4569.87	kg/cm^2			
E=	2038865.68	kg/cm^2			

columna	Sección	$A(cm^2)$	d(cm)	bf(cm)	tf(cm)	tw(cm)	$Zx(cm^3)$
CL-3	**W14x132**	250.32	37.338	37.338	2.6162	1.6383	234
CL-2	**W14x145**	275.48	37.592	39.37	2.7686	1.7272	260

Fuerza Axial en columnas debido a resistencia Esperada en Arriostres

columna	caso a)		caso b)	
	Compresión	Tensión	compresión	Tensión
	P_{Ehm} (Ton)	T_{Ehm} (Ton)	P_{Ehm} (Ton)	T_{Ehm} (Ton)
CL-3	918.79	638.46	638.46	-560.89

Resistencia Requerida de la Columna a Compresión
considerar en compresión el máximo valor de los casos a) y caso b) en el análisis.

LRFD			ASD		
ombinación CR8 de LRFD			usando la combinación CS11 del ASD		
D+0.2 SDs D+PEmh+L			CS11=D+0.14*SDs D+0.7PEmh		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-3	CR8	1001.85507	CL-3	CS11	695.649548

Resistencia Requerida de la Columna a Tensión.
considerar en Tensión el mínimo valor de los casos a) y caso b) en el análisis.

LRFD			ASD		
Usando la combinación CR9 de LRFD			usando la combinación CS13 del ASD		
CR9=0.9D-0.2 SDs D+TEmh			CS13=0.6D-0.14*SDs D+0.70TEmh		
columna	combinación	Pu(ton)	columna	combinación	Pu(ton)
CL-3	CR9	-525.856679	CL-3	CS13	-369.517175

Resistencia Requerida de la Columna a Compresión considerando sobre Resistencia

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 D+0.2 SDs D+ΩQE+L			CS11=D+0.14*SDs D+0.7*ΩQE		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-3	CR8	608.000589	CL-3	CS11	419.951412

Resistencia Requerida de la Columna a Tensión. considerando sobre Resistencia

LRFD			ASD		
Usando la combinación CR9 de LRFD			usando la combinación CS13 del ASD		
CR9=0.9D-0.2 SDs D+ΩQE			CS13=0.6D-0.14*SDs D+0.70*ΩQE		
columna	combinación	Pu(ton)	columna	combinación	Pu(ton)
CL-3	CR9	-489.905589	CL-3	CS13	-344.351412

Resistencia Requerida de la Columna a Compresión considerando sobre Resistencia y Efecto de 2do Orden

LRFD			ASD		
Usando la combinación CR8 de LRFD			usando la combinación CS11 del ASD		
CR8=1.2 D+0.2 SDs D+B_2ΩQE+L			CS11=D+0.14*SDs D+0.7*B_2*ΩQE		
Columna	combinación	Pu(ton)	Columna	combinación	Pu(ton)
CL-2	CR8	944.864284	CL-2	CS11	690.906126

Usando soldadura de relleno CJP.Seismic Provisiones Section F2.6d, AISC 341-16

Hc=H3-d altura del piso 3 restando el peralte de viga

Hc= 287.662 cm

$$\sum M_{PC} = F_y(Z_{X\ abajo} + Z_{arriba})$$

$$\sum M_{PC} = \quad 1736551.11 \text{ kg-cm}$$

resistencia a corte requerida en el empalme

LRFD (kg)	ASD (kg)
$\frac{\sum M_{PC}}{H_C}$=	$\frac{\sum M_{PC}}{1.5*H_C}$=
= 6036.77618	= 4024.51746

de los estados limites de fluencia a corte de acuerdo al AISC 360-16 sección G2.
Para la columna de arriba
capacidad del empalme a corte

LRFD (kg)	ASD (kg)
$\Phi R_n = \Phi 0.6 F_Y t_W d C_V$	$R_n/\Omega = (\Phi 0.6 F_Y t_W d C_V)/1.5$
= 129019.797	= 86013.198

ok cumple ok cumple

resistencia a flexión disponible en columna mas pequeña

LRFD

$\Phi M_{P=}$0.9*fy*Zx

$\Phi M_{P=}$ 7403.19 Kg-m

ASD

$\frac{M_P}{\Omega_b}$ =fy*Zx/1.67

$\frac{M_P}{\Omega_b} =$ 4925.61 Kg-m

resistencia a flexión requerida en el empalme

LRFD

$M_{u=}$0.5*ΦM_P

$M_{u=}$ 3701.60 Kg-m

ASD

$M_{a=}$0.5*$\frac{M_P}{\Omega_b}$

$M_{a=}$ 2462.80 Kg-m

Suponiendo que todo el momento se toma a través de los empalmes , la resistencia requerida de cada empalme es:

LRFD

$$R_u = \frac{M_u}{d - tf}$$

$R_u =$ 10660.73 kg

ASD

$$R_a = \frac{M_a}{d - tf}$$

$R_a =$ 7092.96 kg

La resistencia disponible de soldadura de relleno con ranura de CJP

ΦR_u =0.9*$F_Y b_f t_f$

$\Phi R_u =$ 309047.421 kg
ok cumple Ru>ΦRn

R_n/Ω =($F_Y b_f t_f$)/1.67

$R_n/\Omega =$ 205620.37 kg
ok cumple Ru>ΦRn

Requisitos adicionales para columnas sujetas a Efecto de carga de tracción neta

AISC Seismic Provisions Section D2.5b

LRFD

T_u= -525856.68 kg

$\frac{T_u}{A_g} =$ 2100.72 kg/cm^2

$0.3F_Y =$ 1054.59 kg/cm^2

No cumple agregar placas

placa			
	bw=	42.338	cm
	tf=	3.2512	cm
	Agplca=	137.649306	cm^2
	por dos	275.298611	cm^2

$\frac{T_u}{A_g + A_{gplaca}} =$ 1000.44897 kg/cm^2

$0.3F_Y =$ 1054.58569

si cumpleTu/Ag<0.3fy

ASD

T_a= -369517.175 kg

$\frac{T_a}{A_g} =$ 1476.16693 kg/cm^2

$0.2F_Y =$ 703.05713 kg/cm^2

No cumple agregar placas

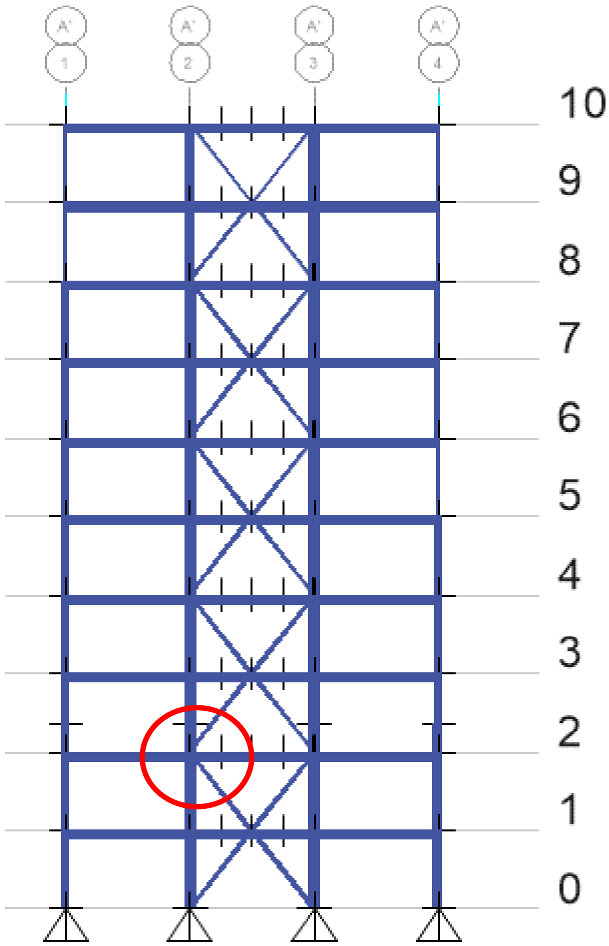
placa			
	bw=	42.338	cm
	tf=	3.2512	cm
	Agplca=	137.649306	cm^2
	por dos	275.298611	cm^2

$\frac{T_u}{A_g + A_{gplaca}} =$ 703.011091 kg/cm^2

$0.2F_Y =$ 703.05713

si cumpleTu/Ag<0.3fy

6.7. DISEÑO DE CONEXION VIGA-COLUMNA CON ARRIOSTRES



Para este diseño se necesita las demanda por carga muerta, carga viva y sismo de las vigas, columnas y arriostres.

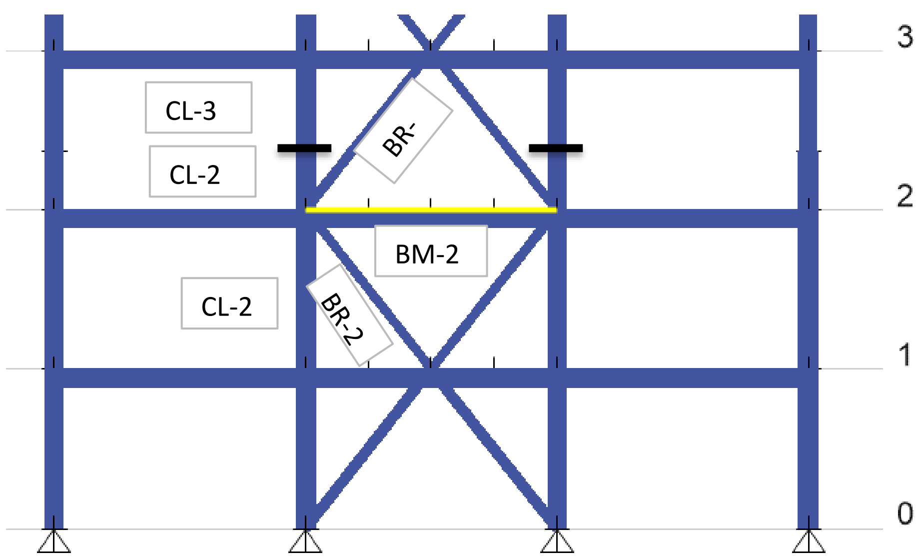


Diagrama de cortante y momento en viga BM-2 debido a carga muerta

Diagrama de cortante y momento en viga BM-2 debido a carga viva

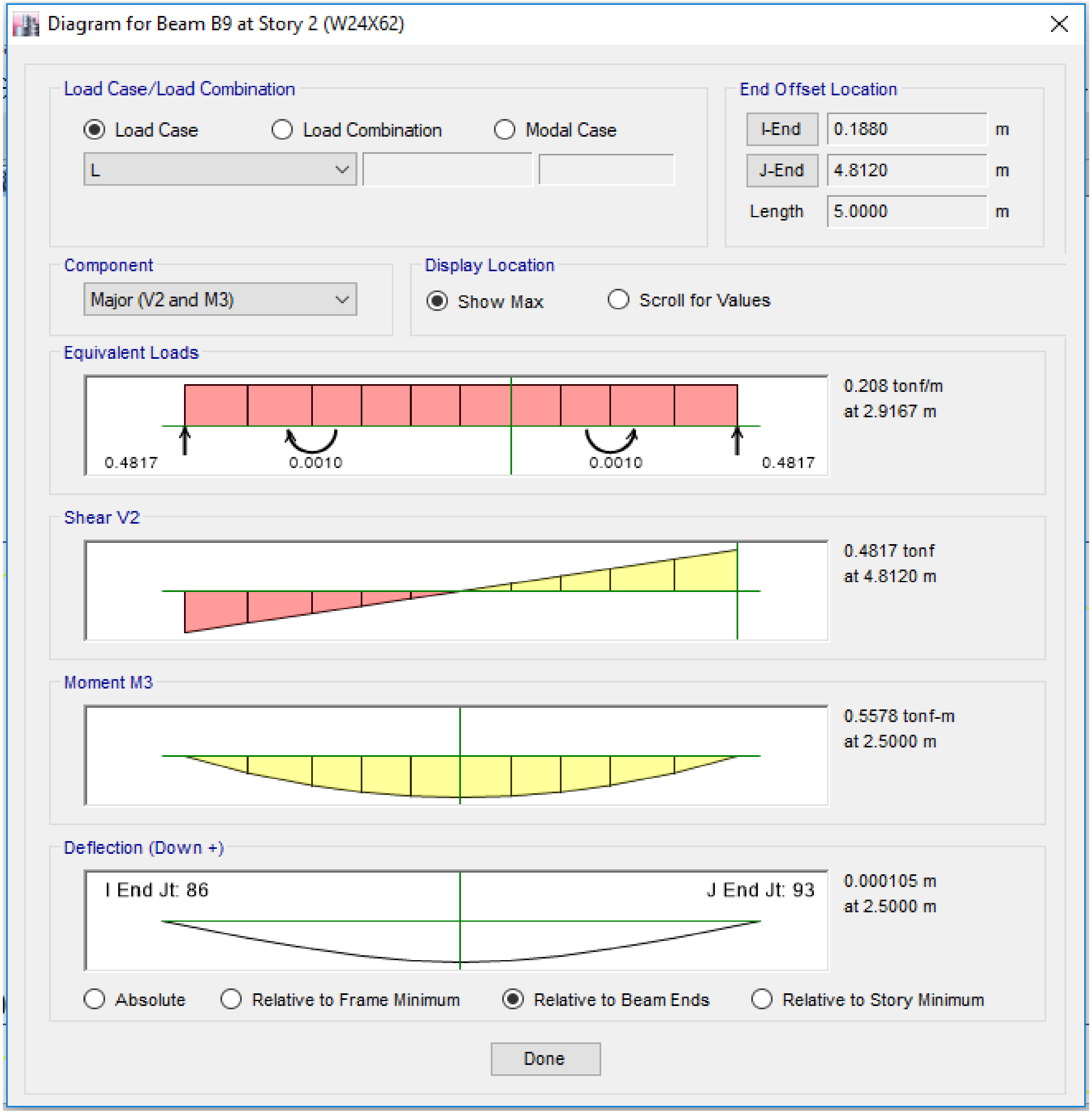


Diagrama de cortante y momento en viga BM-2 debido al sismo

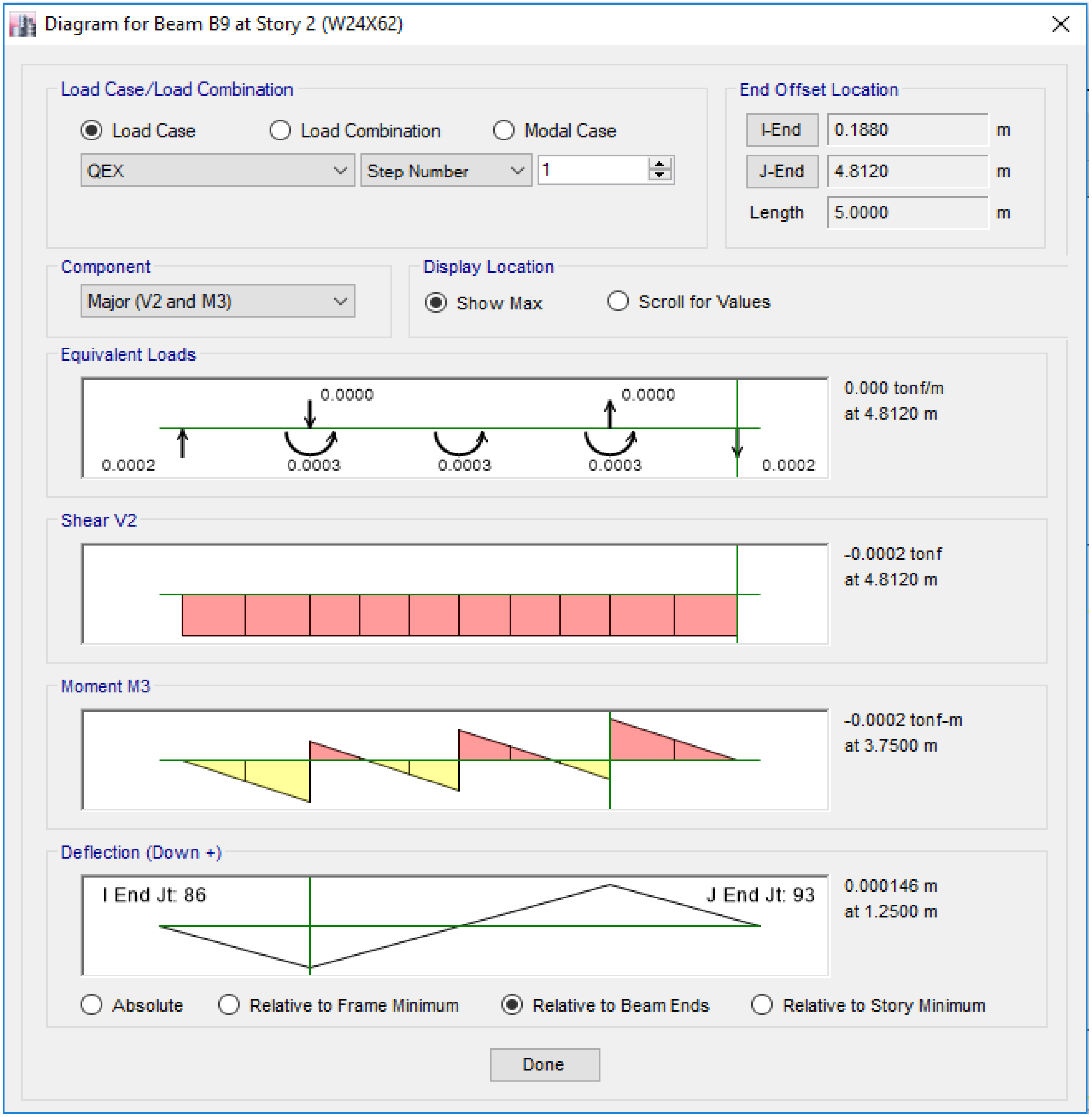


Diagrama de Axial de columna CL-2 debido a carga muerta

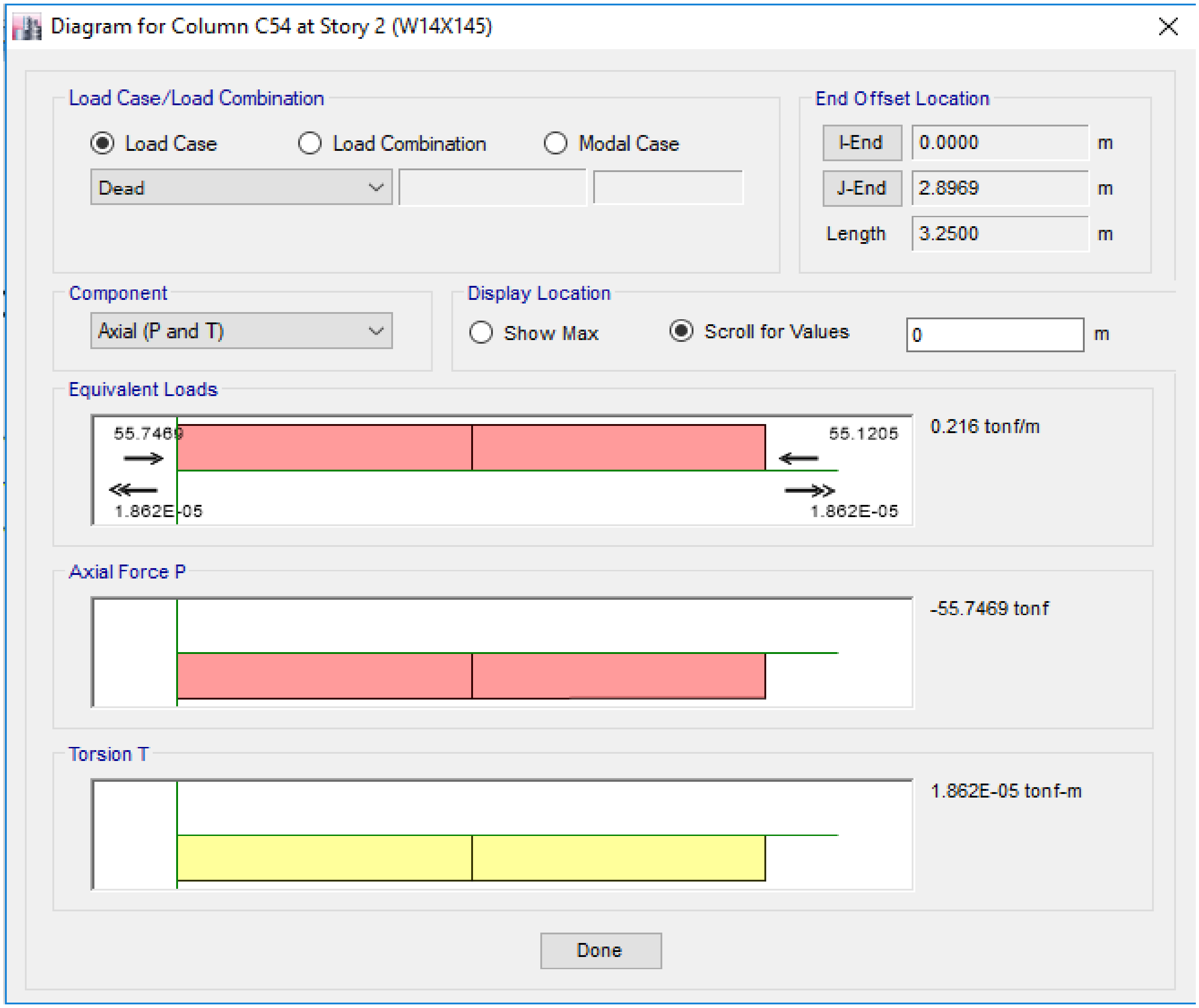


Diagrama de Axial de columna CL-2 debido a carga Viva.

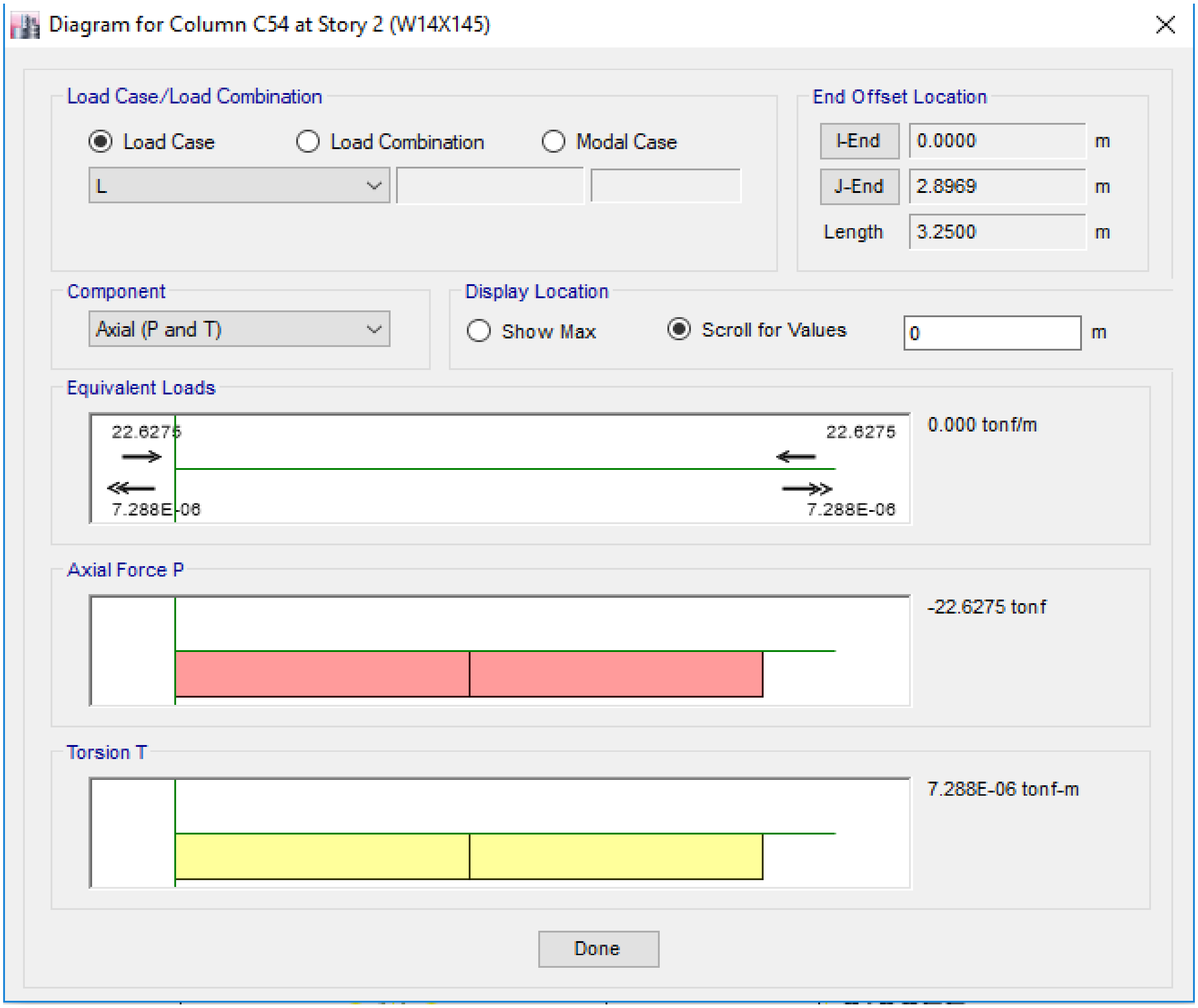


Diagrama de Axial de columna CL-2 debido a carga Sismo.

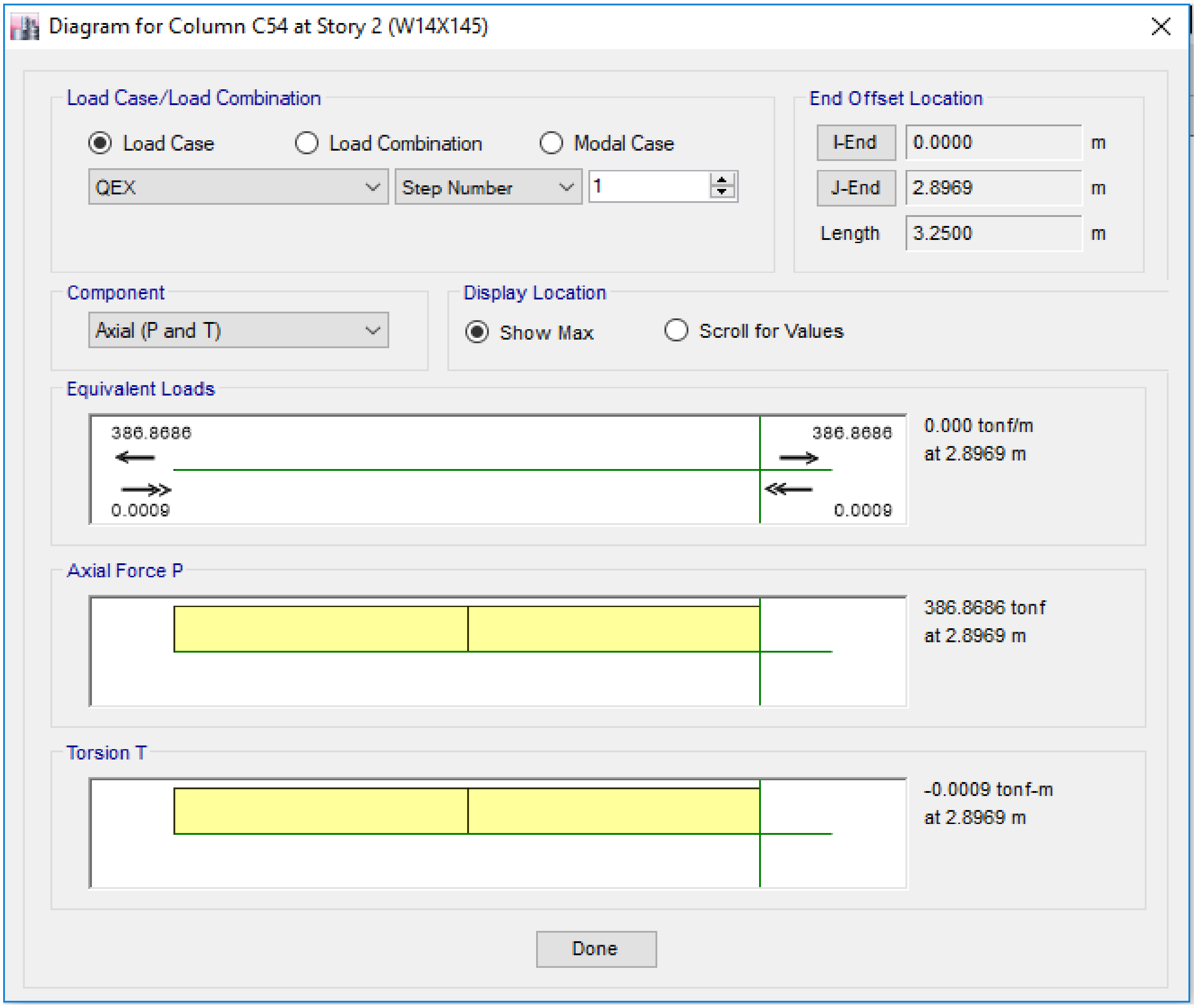


Diagrama de Axial de Arriostre BR-3 debido a carga Muerta.

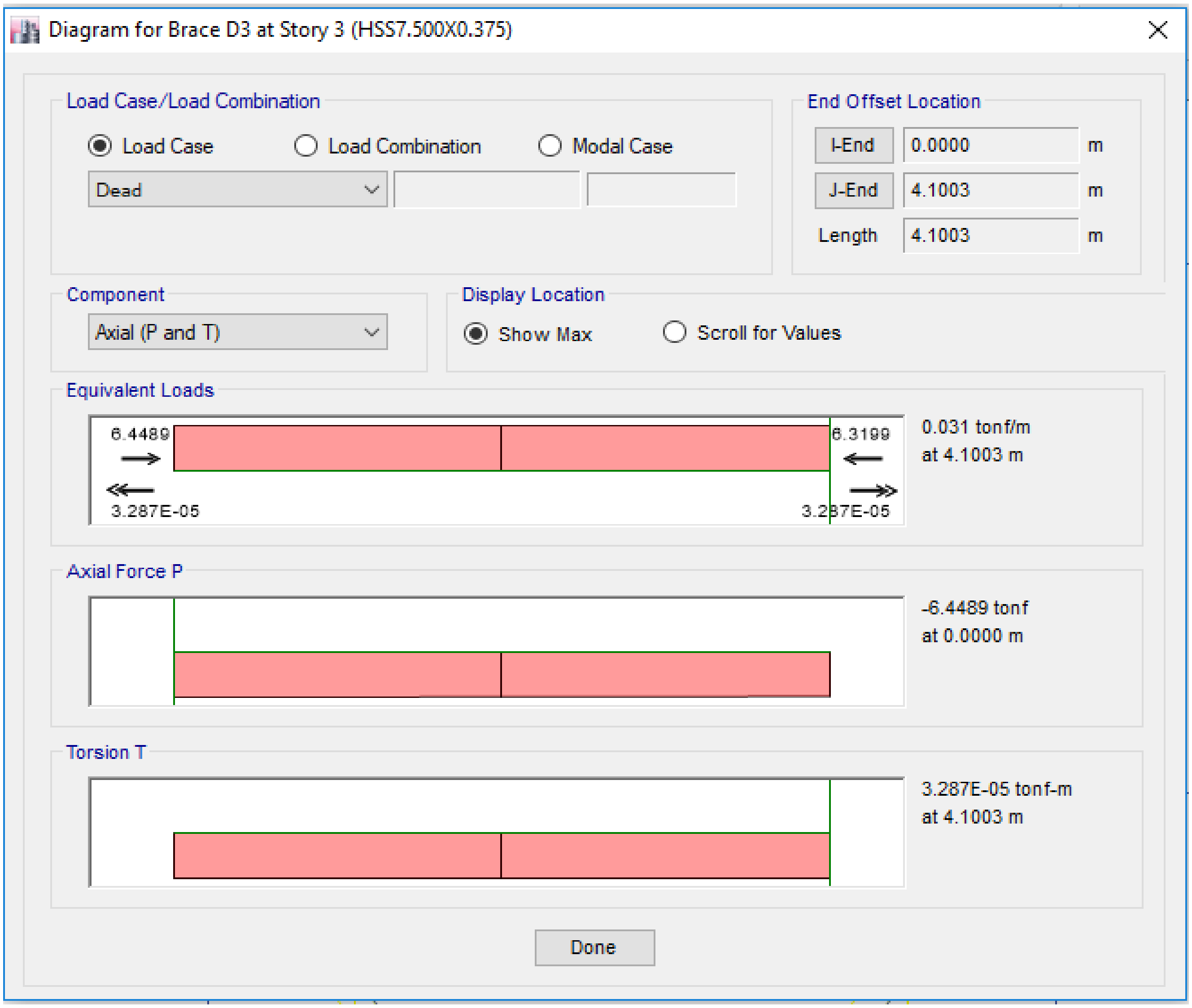
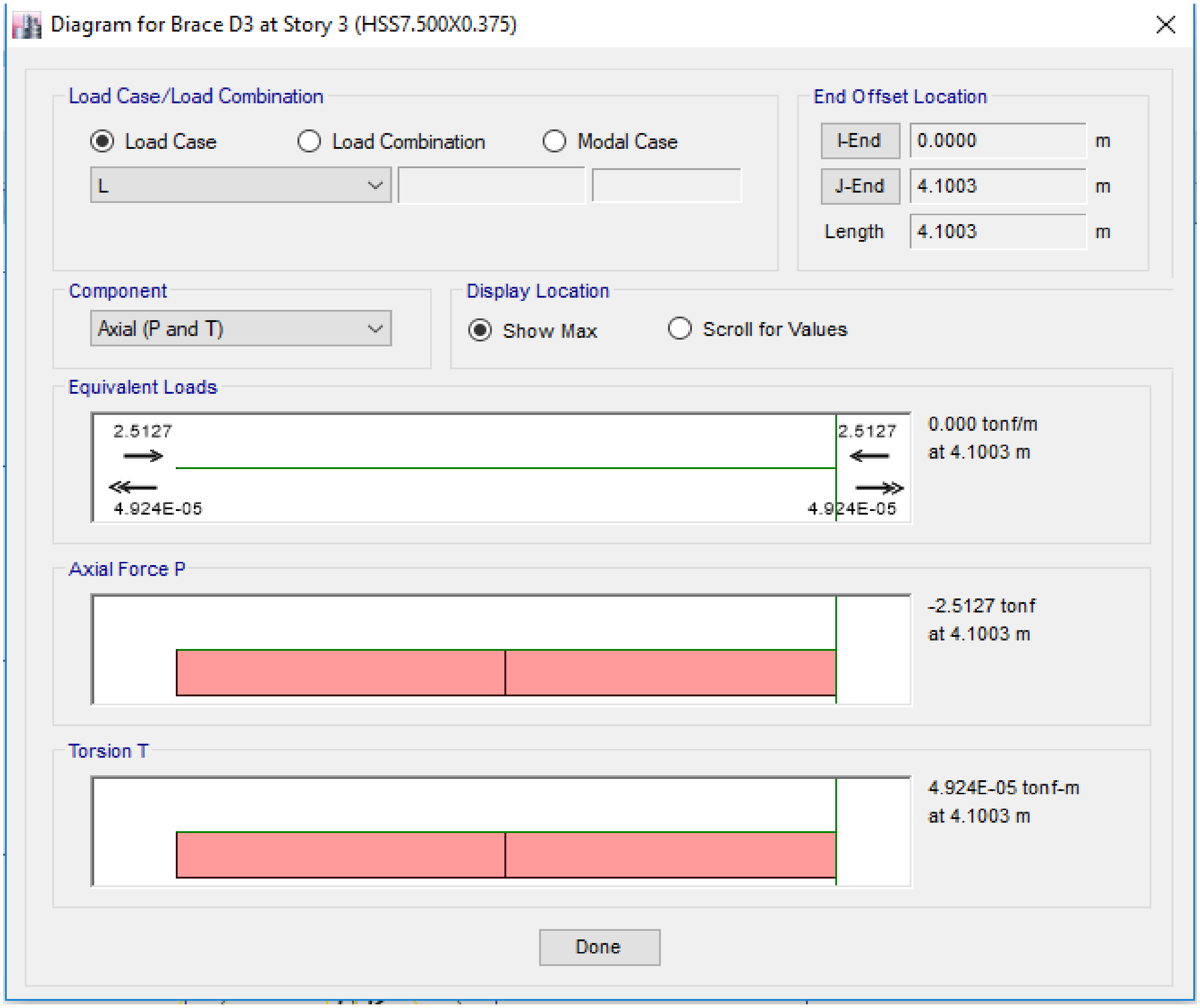


Diagrama de Axial de Arriostre BR-3 debido a carga Viva.



<u>Diagrama de Axial de Arriostre BR-3 debido a carga Sismo.</u>

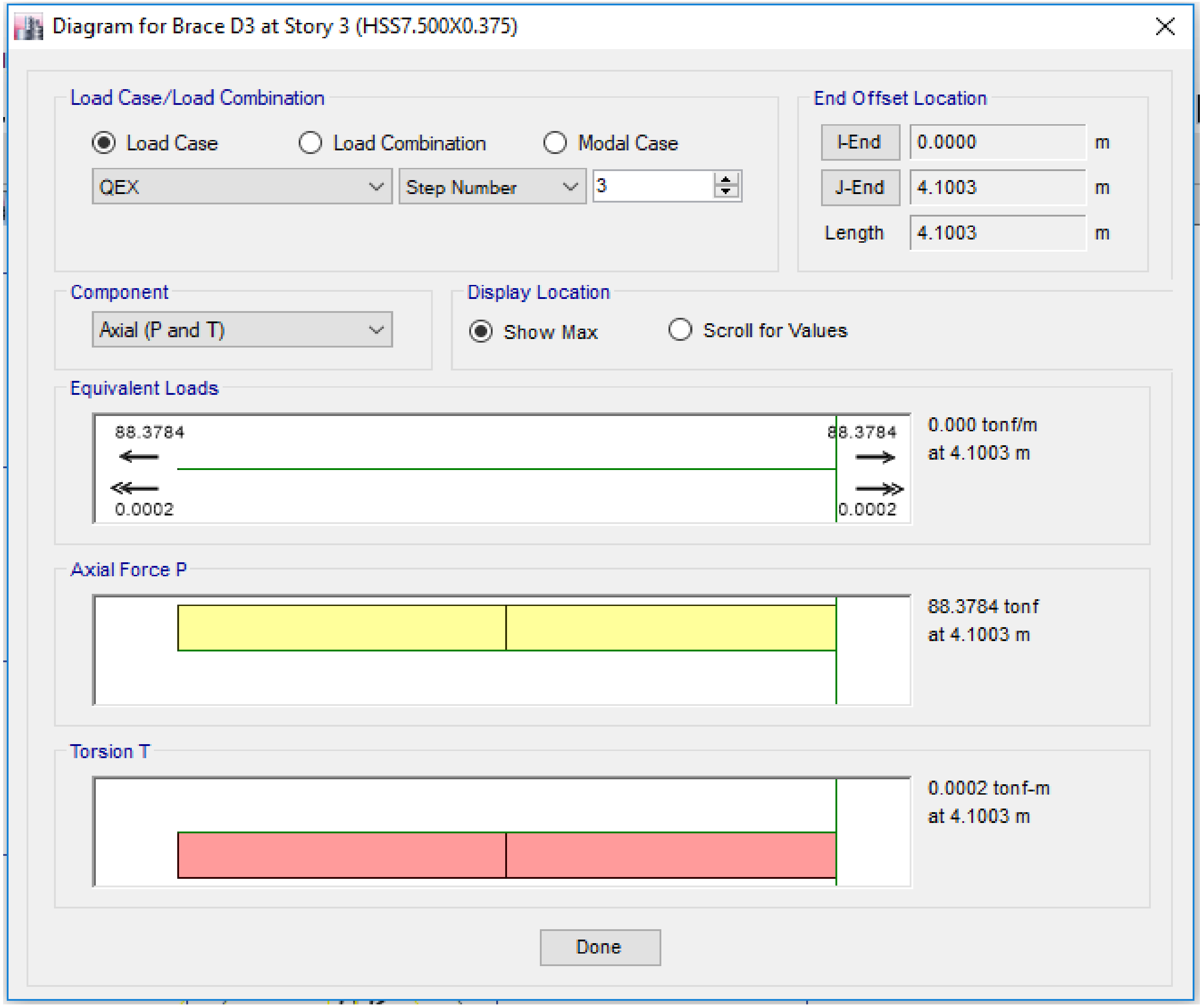


Diagrama de Axial de Arriostre BR-2 debido a carga Muerta.

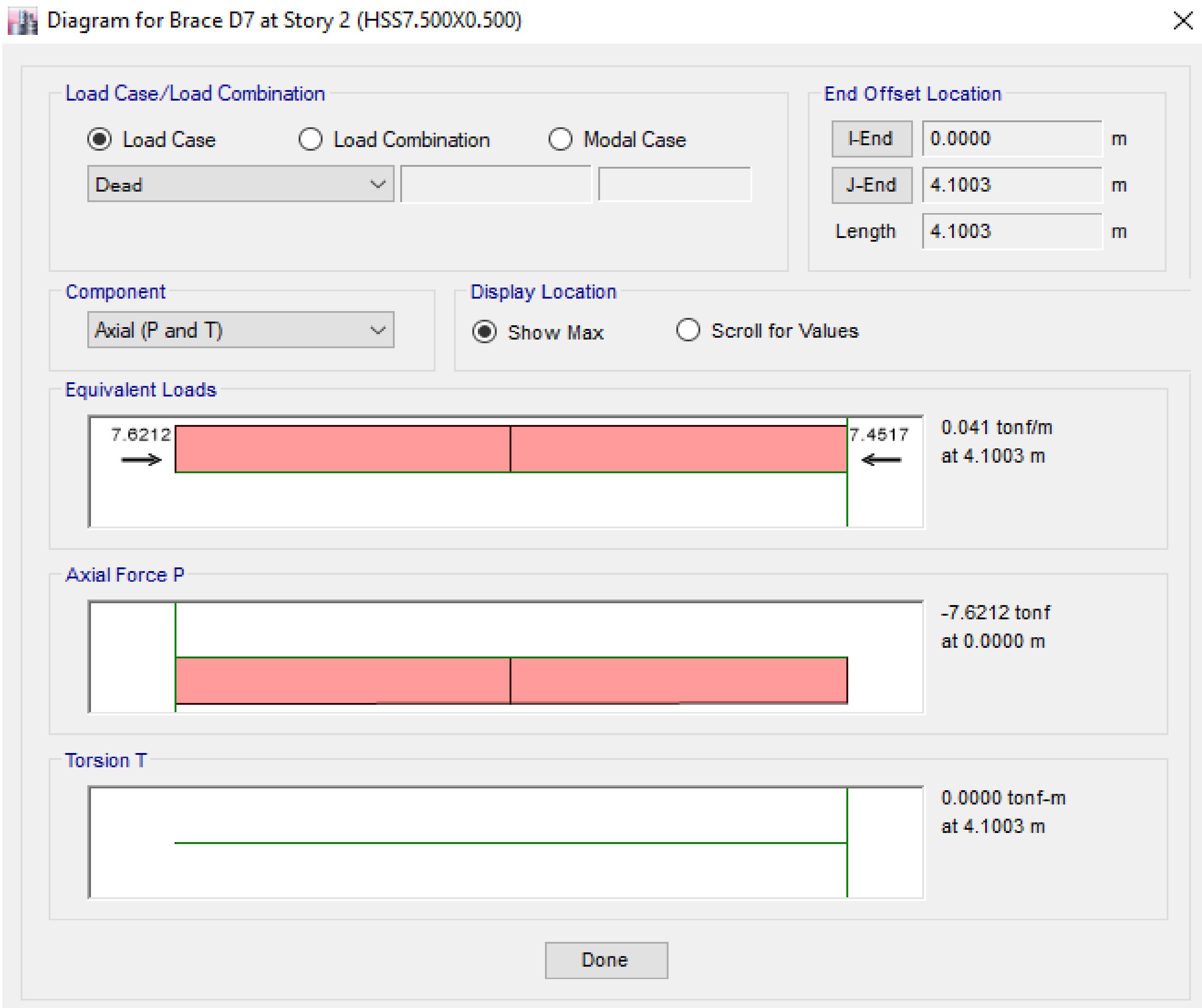


Diagrama de Axial de Arriostre BR-2 debido a carga Viva.

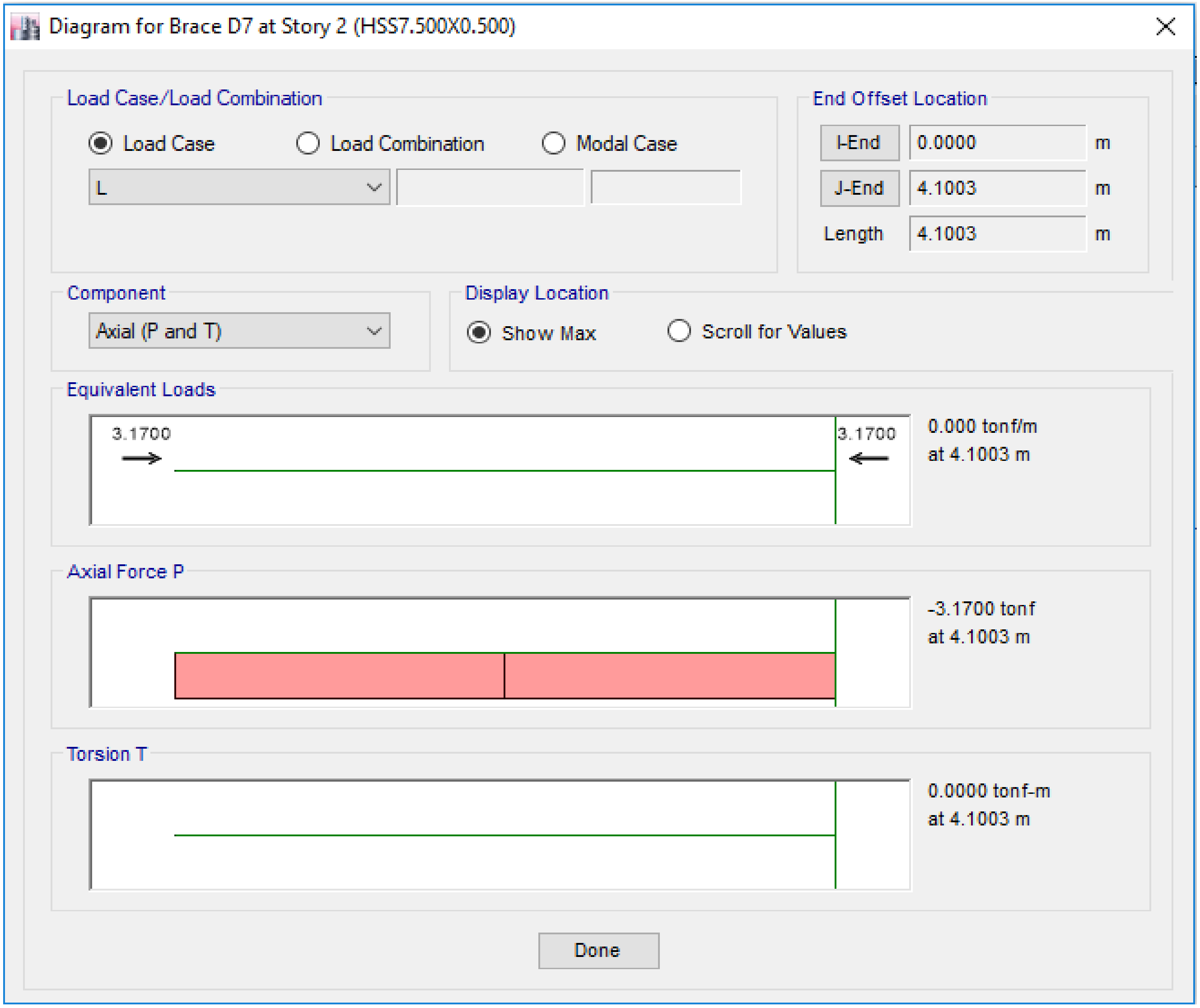
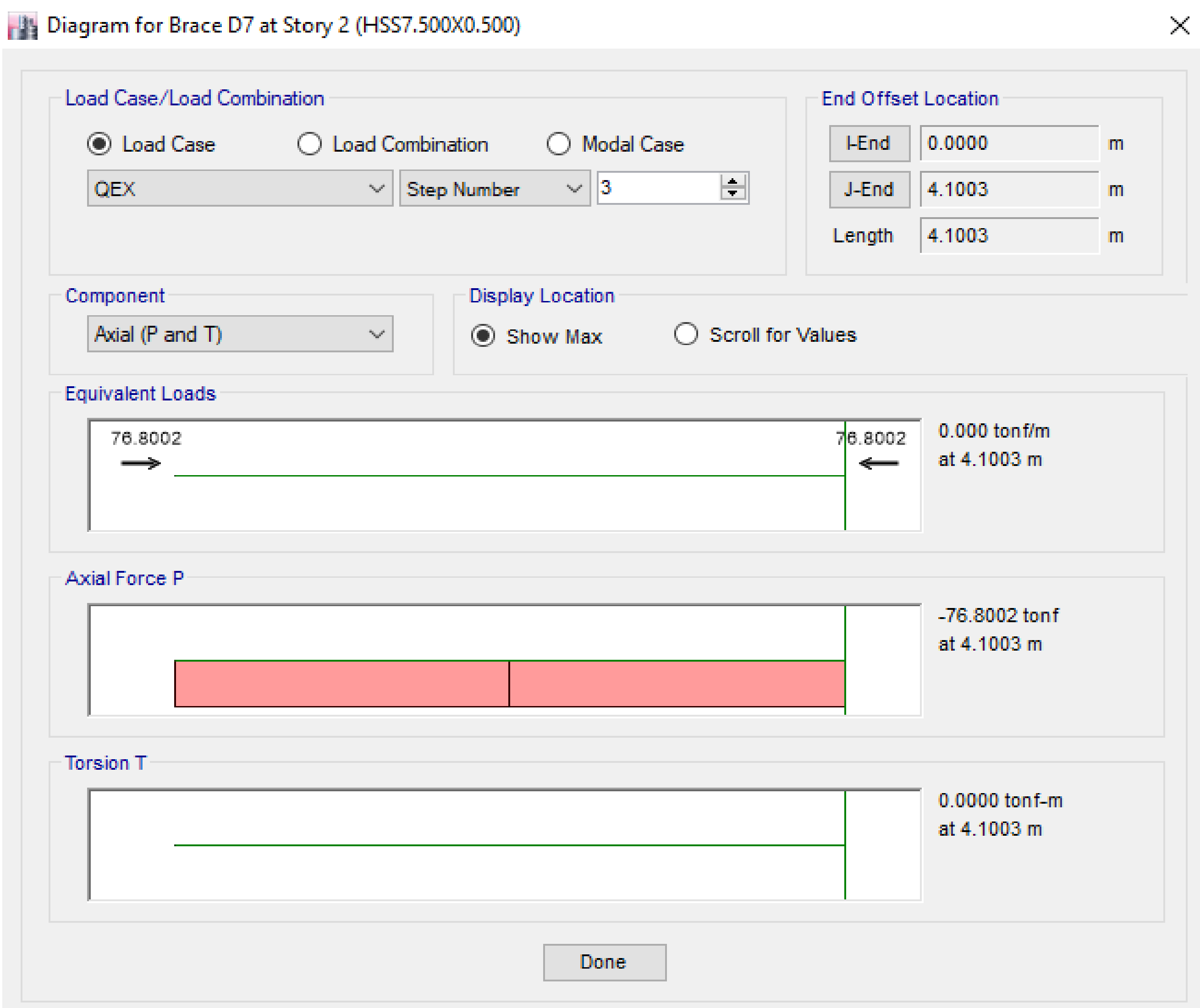
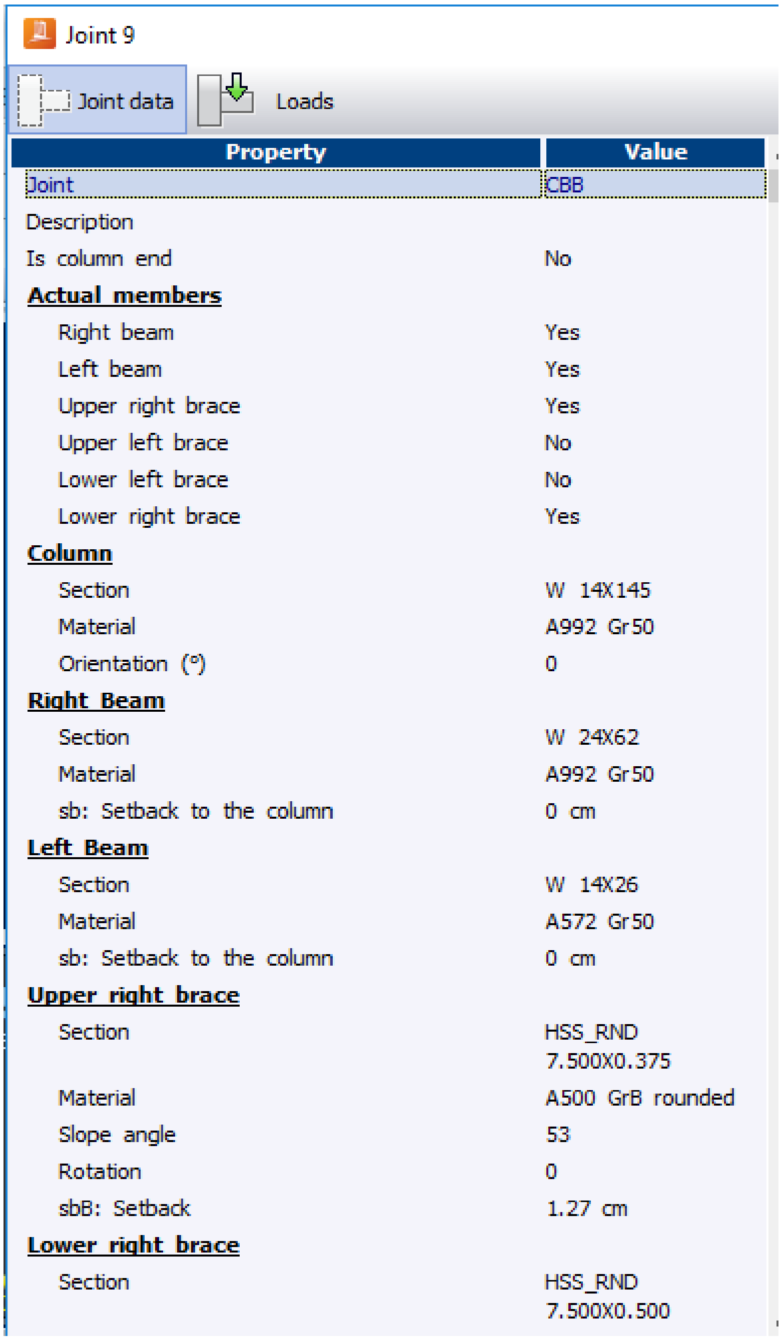


Diagrama de Axial de Arriostre BR-2 debido a carga Sismo.



Usando una conexión CBB
se usaron las secciones que resultaron del diseño de columna y vigas.

BM-2	W24X62
BR-3	HSS_RND 7.5X0.375
BR-2	HSS_RND 7.5X0.50
CL-2	W 14X155


Joint 9

Joint data | Loads

Property	Value
Joint	CBB
Description	
Is column end	No
Actual members	
Right beam	Yes
Left beam	Yes
Upper right brace	Yes
Upper left brace	No
Lower left brace	No
Lower right brace	Yes
Column	
Section	W 14X145
Material	A992 Gr50
Orientation (°)	0
Right Beam	
Section	W 24X62
Material	A992 Gr50
sb: Setback to the column	0 cm
Left Beam	
Section	W 14X26
Material	A572 Gr50
sb: Setback to the column	0 cm
Upper right brace	
Section	HSS_RND 7.500X0.375
Material	A500 GrB rounded
Slope angle	53
Rotation	0
sbB: Setback	1.27 cm
Lower right brace	
Section	HSS_RND 7.500X0.500

Ingresamos las cargas muertas, vivas y sismo obtenidas del análisis.

Joint 9

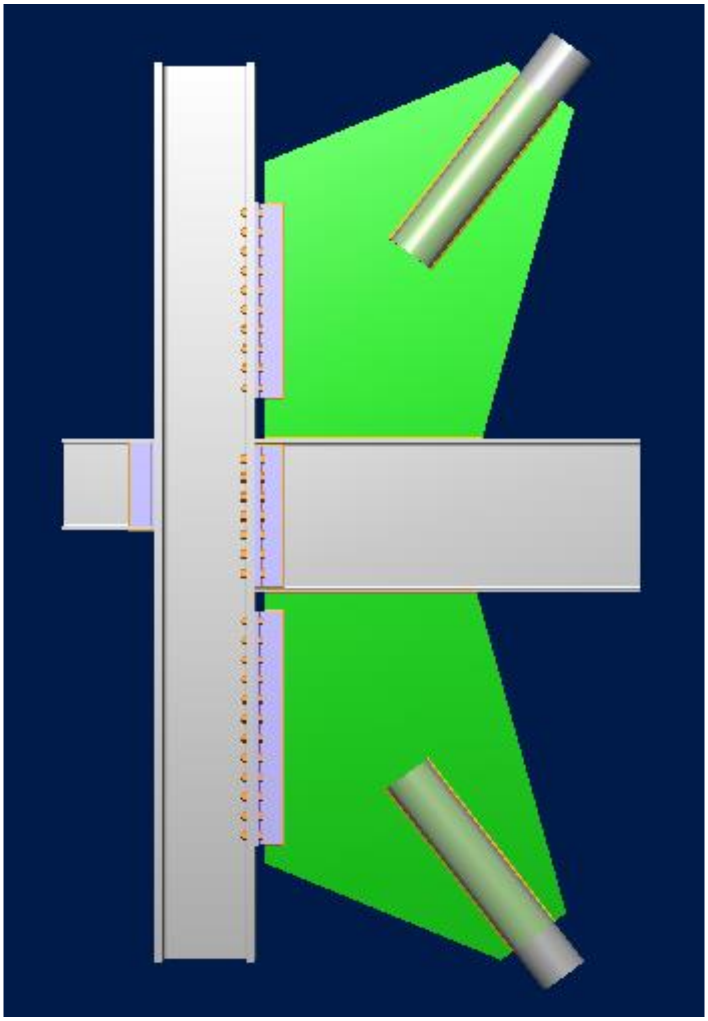
Joint data | Loads

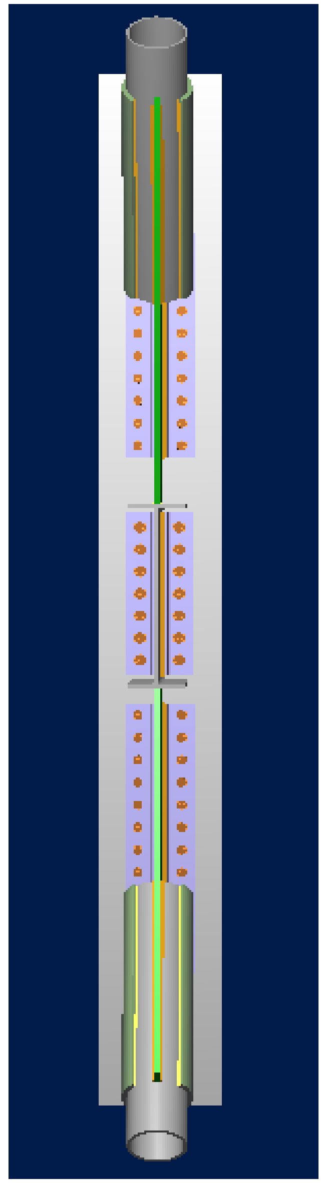
Beam(s) - Column(s)

		Column		Right Beam			Left Beam		
Num	Condition	V2	Axial	V2	Axial	M33	V2	Axial	M33
1	C1	0	55.74	1.24	0	0	1.19	0	0
2	C2	0	22.62	0.48	0	0	0.48	0	0
3	C3	0	386.86	0.002	0	0	0.002	0	0
4	C4	0	0	0	0	0	0	0	0
5	C5	0	0	0	0	0	0	0	0
6	C6	0	0	0	0	0	0	0	0

Braces

		(1) Top right	(2) Top left	(3) Bottom left	(4) Bottom right
Num	Condition	Axial	Axial	Axial	Axial
1	C1	-6.44	0	0	-7.62
2	C2	-2.51	0	0	-3.17
3	C3	88.38	0	0	-76.8
4	C4	0	0	0	0
5	C5	0	0	0	0
6	C6	0	0	0	0





Modelo 3D en RAM CONECTTION

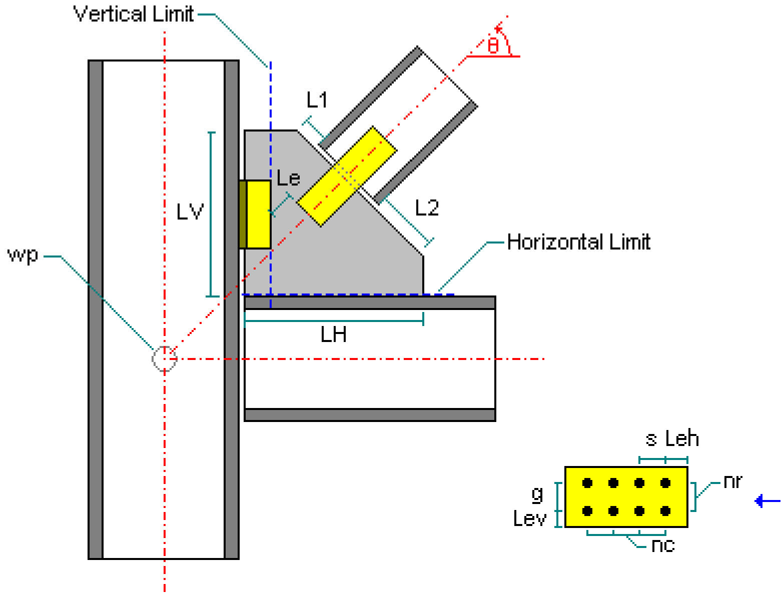
Datos

Connection name	**:**	**CBB_DW**
Connection ID	**:**	**9**

Family: Column - Beams - Braces (CBB)
Type: Gusset

GENERAL INFORMATION

Connector



MEMBERS

Actual members

Right beam	:	Yes
Left beam	:	Yes
Upper right brace	:	Yes
Upper left brace	:	No
Lower left brace	:	No
Lower right brace	:	Yes
Align beams to top edge	:	Yes

Column

General

Column section	:	W 14X145
Column material	:	A992 Gr50
Column orientation	:	Longitudinal
Is column end	:	No

Right beam

General

Section	:	W 24X62
Material	:	A992 Gr50

Coped

dct: Top cope depth	:	0 cm
ct: Top-flange cope length	:	0 cm
dcb: Bottom cope depth	:	0 cm

cb: Bottom-flange cope length	:	0 cm
Left beam		
General		
Section	:	W 14X26
Material	:	A572 Gr50
Coped		
dct: Top cope depth	:	0 cm
ct: Top-flange cope length	:	0 cm
dcb: Bottom cope depth	:	0 cm
cb: Bottom-flange cope length	:	0 cm
Upper right brace		
General		
Section	:	HSS_RND 7.500X0.375
Material	:	A500 GrB rounded
Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm
Lower right brace		
General		
Section	:	HSS_RND 7.500X0.500
Material	:	A500 GrB rounded
Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm

INTERFACES

Right beam		
Beam-to-Column connection		
Connection type to column	:	Angles
sb: Setback to column	:	0 cm
Angles		
Angle section	:	L 4X4X1_2
Material	:	A572 Gr50
Angle long leg side on column	:	Yes
Eccentricity	:	0 cm
L: Angle length	:	52 cm
Column side		
Connection type to the column	:	Bolted
gc: Bolt group spacing	:	12.5 cm
Bolts	:	7/8" A325 N
Hole type	:	Standard (STD)
nr: Rows of Bolts	:	7
nc: Bolt columns	:	1
s: Pitch - longitudinal center-to-center spacing	:	7 cm
Lev: Longitudinal distance to the edge	:	5 cm
Leh: Transversal distance to the edge	:	4.46 cm
Beam side		
Connection type to the beam	:	Welded
Weld to beam	:	E70XX
D: Weld size (1/16 in)	:	6
Left beam		
Beam-to-Column connection		
Connection type to column	:	Angles

sb: Setback to column	:	0 cm
Angles		
Angle section	:	L 4X4X1_2
Material	:	A36
Angle long leg side on column	:	Yes
Eccentricity	:	0 cm
Column side		
Connection type to the column	:	Welded
Weld to column	:	E70XX
D: Weld size (1/16 in)	:	5
Beam side		
Connection type to the beam	:	Welded
Weld to beam	:	E70XX
D: Weld size (1/16 in)	:	5
L: Connection length	:	30 cm
Upper right brace		
Gusset		
General		
tp: Thickness	:	2 cm
Material	:	A36
LV: Length on column	:	108.77 cm
LH: Length on beam	:	82.12 cm
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1.5 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	3
Gusset-to-Brace connection		
General		
Lt: Length on toe	:	80 cm
Lh: Length on heel	:	80 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	6
dp: Distance between weld and plate end	:	2.54 cm
Gusset-to-Column connection		
General		
Connection type to column	:	Angles
sc: Setback	:	3.81 cm
Angles		
Angle section	:	L 4x4x1_2
Material	:	A36
Angle long leg side on column	:	Yes
Eccentricity	:	0 cm
L: Angle length	:	76.2 cm
Column side		
Connection type to the column	:	Bolted
gc: Bolt group spacing	:	13.97 cm
Bolts	:	3/4" A325 N
Hole type	:	Standard (STD)
nr: Rows of Bolts	:	10
nc: Bolt columns	:	1
s: Pitch - longitudinal center-to-center spacing	:	7.62 cm
Lev: Longitudinal distance to the edge	:	3.81 cm
Leh: Transversal distance to the edge	:	4.17 cm
Gusset side		
Connection type to the gusset	:	Welded
Gusset weld	:	E70XX
D: Weld size (1/16 in)	:	6
Gusset-to-Beam connection		
General		
Connection type to beam	:	Directly welded
Directly welded		

Welding electrode to beam	:	E70XX
D: Weld size to beam (1/16 in)	:	5
Lower right brace		
Gusset		
General		
tp: Thickness	:	2 cm
Material	:	A36
LV: Length on column	:	106.07 cm
LH: Length on beam	:	80.08 cm
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1.5 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	3
Gusset-to-Brace connection		
General		
Lt: Length on toe	:	80 cm
Lh: Length on heel	:	80 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	0 cm
Gusset-to-Column connection		
General		
Connection type to column	:	Angles
sc: Setback	:	3.81 cm
Angles		
Angle section	:	L 4x4x1_2
Material	:	A36
Angle long leg side on column	:	Yes
Eccentricity	:	0 cm
L: Angle length	:	91.44 cm
Column side		
Connection type to the column	:	Bolted
gc: Bolt group spacing	:	13.97 cm
Bolts	:	3/4" A325 N
Hole type	:	Standard (STD)
nr: Rows of Bolts	:	12
nc: Bolt columns	:	1
s: Pitch - longitudinal center-to-center spacing	:	7.62 cm
Lev: Longitudinal distance to the edge	:	3.81 cm
Leh: Transversal distance to the edge	:	4.17 cm
Gusset side		
Connection type to the gusset	:	Welded
Gusset weld	:	E70XX
D: Weld size (1/16 in)	:	6
Gusset-to-Beam connection		
General		
Connection type to beam	:	Directly welded
Directly welded		
Welding electrode to beam	:	E70XX
D: Weld size to beam (1/16 in)	:	5

Resultado

Connection name : CBB_DW
Connection ID : 9

Family: Column - Beams - Braces (CBB)
Type: Gusset
Design code: AISC 360-10 LRFD, AISC 341-10 LRFD

DEMANDS

	Right beam			Left beam			Column		Pu				
Description	**Pu** [Ton]	**Vu** [Ton]	**Mu33** [Ton*m]	**Pu** [Ton]	**Vu** [Ton]	**Mu33** [Ton*m]	**Pu** [Ton]	**Vu** [Ton]	**Brace1** [Ton]	**Brace2** [Ton]	**Brace3** [Ton]	**Brace4** [Ton]	**Load type**
D1	0.00	1.74	0.00	0.00	1.67	0.00	78.04	0.00	-9.02	0.00	0.00	-10.67	Design
D2	0.00	2.26	0.00	0.00	2.20	0.00	103.08	0.00	-11.74	0.00	0.00	-14.22	Design
D3	0.00	1.49	0.00	0.00	1.43	0.00	66.89	0.00	-7.73	0.00	0.00	-9.14	Design
D4	0.00	1.49	0.00	0.00	1.43	0.00	66.89	0.00	-7.73	0.00	0.00	-9.14	Design
D5	0.00	1.49	0.00	0.00	1.43	0.00	66.89	0.00	-7.73	0.00	0.00	-9.14	Design
D6	0.00	1.49	0.00	0.00	1.43	0.00	66.89	0.00	-7.73	0.00	0.00	-9.14	Design
D7	0.00	1.97	0.00	0.00	1.91	0.00	89.51	0.00	-10.24	0.00	0.00	-12.31	Design
D8	0.00	1.97	0.00	0.00	1.91	0.00	89.51	0.00	-10.24	0.00	0.00	-12.31	Design
D9	0.00	1.49	0.00	0.00	1.43	0.00	453.75	0.00	80.65	0.00	0.00	-85.94	Seismic
D10	0.00	1.49	0.00	0.00	1.43	0.00	66.89	0.00	-7.73	0.00	0.00	-9.14	Design
D11	0.00	1.97	0.00	0.00	1.91	0.00	476.37	0.00	78.14	0.00	0.00	-89.11	Design
D12	0.00	1.97	0.00	0.00	1.91	0.00	89.51	0.00	-10.24	0.00	0.00	-12.31	Design
D13	0.00	1.12	0.00	0.00	1.07	0.00	50.17	0.00	-5.80	0.00	0.00	-6.86	Design
D14	0.00	1.12	0.00	0.00	1.07	0.00	50.17	0.00	-5.80	0.00	0.00	-6.86	Design
D15	0.00	1.12	0.00	0.00	1.07	0.00	437.03	0.00	82.58	0.00	0.00	-83.66	Seismic
D16	0.00	1.12	0.00	0.00	1.07	0.00	50.17	0.00	-5.80	0.00	0.00	-6.86	Design
D17	0.00	1.24	0.00	0.00	1.19	0.00	55.74	0.00	-6.44	0.00	0.00	-7.62	Design
D18	0.00	1.72	0.00	0.00	1.67	0.00	78.36	0.00	-8.95	0.00	0.00	-10.79	Design
D19	0.00	1.60	0.00	0.00	1.55	0.00	72.71	0.00	-8.32	0.00	0.00	-10.00	Design
D20	0.00	1.24	0.00	0.00	1.19	0.00	55.74	0.00	-6.44	0.00	0.00	-7.62	Design
D21	0.00	1.24	0.00	0.00	1.19	0.00	55.74	0.00	-6.44	0.00	0.00	-7.62	Design
D22	0.00	1.24	0.00	0.00	1.19	0.00	326.54	0.00	55.43	0.00	0.00	-61.38	Seismic
D23	0.00	1.24	0.00	0.00	1.19	0.00	55.74	0.00	-6.44	0.00	0.00	-7.62	Design
D24	0.00	1.60	0.00	0.00	1.55	0.00	72.71	0.00	-8.32	0.00	0.00	-10.00	Design
D25	0.00	1.60	0.00	0.00	1.55	0.00	72.71	0.00	-8.32	0.00	0.00	-10.00	Design
D26	0.00	1.24	0.00	0.00	1.19	0.00	258.84	0.00	39.96	0.00	0.00	-47.94	Seismic
D27	0.00	1.24	0.00	0.00	1.19	0.00	55.74	0.00	-6.44	0.00	0.00	-7.62	Design
D28	0.00	0.74	0.00	0.00	0.71	0.00	33.44	0.00	-3.86	0.00	0.00	-4.57	Design
D29	0.00	0.74	0.00	0.00	0.71	0.00	33.44	0.00	-3.86	0.00	0.00	-4.57	Design
D30	0.00	0.75	0.00	0.00	0.72	0.00	304.25	0.00	58.00	0.00	0.00	-58.33	Seismic
D31	0.00	0.74	0.00	0.00	0.71	0.00	33.44	0.00	-3.86	0.00	0.00	-4.57	Design

Interface between Gusset - Top right brace

Connection: Directly welded

DEMANDS

Pu [Ton]	**Description**	**Load type**
-9.02	D1	Design
-11.74	D2	Design
-7.73	D3	Design
-7.73	D4	Design
-7.73	D5	Design

-7.73	D6	Design
-10.24	D7	Design
-10.24	D8	Design
209.10	D9	Seismic
-7.73	D10	Design
78.14	D11	Design
-10.24	D12	Design
-5.80	D13	Design
-5.80	D14	Design
209.10	D15	Seismic
-5.80	D16	Design
-6.44	D17	Design
-8.95	D18	Design
-8.32	D19	Design
-6.44	D20	Design
-6.44	D21	Design
209.10	D22	Seismic
-6.44	D23	Design
-8.32	D24	Design
-8.32	D25	Design
209.10	D26	Seismic
-6.44	D27	Design
-3.86	D28	Design
-3.86	D29	Design
209.10	D30	Seismic
-3.86	D31	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace - Directly welded Connection						
Total weld design strength	[Ton]	477.32	209.10	D9	0.44	Eq. J2-4, Eq. J2-6

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*6/16$ [in]*80[cm] = **53.88**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*53.88[cm2]) = **238.66**[T] — Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*6/16$ [in]*80[cm] = **53.88**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*53.88[cm2]) = **238.66**[T] — Eq. J2-4

$\phi R_n = \phi R_{w1} + \phi R_{w2} = 238.66$[T] + 238.66[T] = **477.32**[T] — Eq. J2-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Maximum weld force that brace can develop	[Ton]	520.53	209.10	D9	0.40	Eq. J4-4

$L_e = L_t + L_h = 80$[cm] + 80[cm] = **160**[cm]

$A_{nv} = L_e*t_p = 160$[cm]*0.886[cm] = **141.83**[cm2] — Sec. J4-2

$\phi R_n = 2 * (\phi*0.60*F_u*A_{nv}) = 2 * (0.75*0.60*4077.78$[kg/cm2]*141.83[cm2]) = **520.53**[T] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset						
Maximum weld force that gusset can develop	[Ton]	587.20	209.10	D9	0.36	Eq. J4-4

$L_e = L_t + L_h = 80$[cm] + 80[cm] = **160**[cm]

$A_{nv} = L_e*t_p = 160$[cm]*2[cm] = **320**[cm2] — Sec. J4-2

$\phi R_n = \phi*0.60*F_u*A_{nv} = 0.75*0.60*4077.78$[kg/cm2]*320[cm2] = **587.2**[T] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear on gusset	[Ton]	492.56	209.10	D9	0.42	Eq. J4-5

$L_{max} = \max(L_t, L_h) = \max(80$[cm], 80[cm]) = **80**[cm]

$L = L_{max} + d_w = 80$[cm] + 2.54[cm] = **82.54**[cm] — Sec. J4.3

$A_{gv} = 2*L*t_p = 2*82.54$[cm]$*2$[cm] $=$ **330.16**[cm2] Sec. J4.3
$A_{nv} = A_{gv} =$ **330.16**[cm2] Sec. J4.3
$A_{nt} = b*t_p = 19.05$[cm]$*2$[cm] $=$ **38.1**[cm2] Sec. J4.3
$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*$
$\min(0.6*4077.78$[kg/cm2]$*330.16$[cm2] $+ 1*4077.78$[kg/cm2]$*38.1$[cm2], $0.6*2531.04$[kg/cm2]$*330.16$[cm2] $+ 1*$
4077.78[kg/cm2]$*38.1$[cm2]$)$ $=$ **492.56**[T] Eq. J4-5

Ratio	**0.44**

Checks for gusset and brace

REQUIRED RESISTANCE OF BRACED CONNECTIONS

Requirement	Value [Ton]
Required tensile strength	209.10
Required compressive strength	201.20

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Slenderness		46.68	--	200.00	✔	AISC 341-10 Sec. F2.5b.

$\lambda_{max} = 200$ AISC 341-10 Sec. F2.5b.

$\lambda_b = L/r = 300$[cm]$/6.43$[cm] $=$ **46.68**

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Local buckling		21.49	0.00	26.24	✔	Seismic Manual Table I-8-1, Seismic Manual Table D1.1

$\lambda = D/t_p = 19.05$[cm]$/0.886$[cm] $=$ **21.49** Seismic Manual Table I-8-1

$\lambda_{hd} = 0.038*(E/F_y) = 0.038*(2.04E+06$[kg/cm2]$/2952.88$[kg/cm2]$) =$ **26.24** Seismic Manual Table D1.1

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Gusset plate plastic hinge length (2t)	[cm]	4.00	4.00	8.00	✔	
Weld size	[1/16in]	3	3	5	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.004763** table J2.4
$t_p<1/4$ [in] $\rightarrow 0.886$[cm]$<1/4$ [in] $\rightarrow$ **False**
$w_{max} = t_p - 1/16$ [in] $= 0.886$[cm] $- 1/16$ [in] $=$ **0.007277** Sec. J2.2b

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Brace</u>						
Yielding strength due to axial load	[Ton]	134.42	78.14	D11	0.58	Eq. J4-1

$\phi R_n = \phi*F_y*A_g = 0.9*2952.88$[kg/cm2]$*50.58$[cm2] $=$ **134.42**[T] Eq. J4-1

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Tension rupture	[Ton]	345.72	209.10	D9	0.60	Seismic Manual p.3-54

$A_n = A_g - 2*(t_p + 1/8$ [in]$)*t = 50.58$[cm2] $- 2*(2$[cm] $+ 1/8$ [in]$)*0.886$[cm] $=$ **46.47**[cm2] Sec. D3.2
$U = 1 - x/l = 1 - 6.69$[cm]$/80$[cm] $=$ **0.916** Table D3.1

$A_e = A_n*U$ = 94.89[cm2]*0.916 = **86.96**[cm2] — Eq. D3-1

$\phi R_n = \phi*R_t*F_u*A_e$ = 0.75*1.3*4077.78[kg/cm2]*86.96[cm2] = **345.72**[T] — Seismic Manual p.3-54

Compression [Ton] 117.59 11.74 D2 0.10 Eq. E3-1

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2$*2.04E+06[kg/cm2]/(1*300[cm]/6.43[cm])^2 = **9236.48**[kg/cm2] — Eq. E3-4

F_e>=0.44*$Q*F_y$ → 9236.48[kg/cm2]>=0.44*1*2952.88[kg/cm2] → **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y$ = 0.658$^{(1*2952.88[kg/cm2]/9236.48[kg/cm2])}$*2952.88[kg/cm2] = **2583.05**[kg/cm2] — Eq. E7-2

$\phi P_n = \phi*F_{cr}*A_g$ = 0.9*2583.05[kg/cm2]*50.58[cm2] = **117.59**[T] — Eq. E3-1

Weld capacity for reinforcement plate [Ton] 238.66 192.51 D9 0.81 Eq. J2-4

$F_w = 0.6*F_{EXX}$ = 0.6*4921.46[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}$/2*3/16 [in]*80[cm] = **26.94**[cm2] — Sec. J2.4

$\phi R_n = 4 * (\phi*F_w*A_w)$ = 4 * (0.75*2952.88[kg/cm2]*26.94[cm2]) = **238.66**[T] — Eq. J2-4

Gusset

Tension yielding on the Whitmore section [Ton] 476.23 209.10 D9 0.44 Eq. J4-1

$A_g = L_w*t_p$ = 104.53[cm]*2[cm] = **209.06**[cm2]

$\phi R_n = \phi*F_y*A_g$ = 0.9*2531.04[kg/cm2]*209.06[cm2] = **476.23**[T] — Eq. J4-1

Ratio **0.81**

Calculation of the brace interface forces

Load condition :D1

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (44.87[cm]/54.39[cm])^2 = **1.25** — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] — p. 13-10

$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] — p. 13-5

$H_b = \alpha*P/r$ = 44.87[cm]*-9.02[T]/105.79[cm] = **-3.82**[T] — p. 13-5

$H_c = e_c*P/r$ = 18.8[cm]*-9.02[T]/105.79[cm] = **-1.6**[T] — p. 13-5

$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.02[T]/105.79[cm] - 0[T] = **-2.57**[T] — p. 13-5

$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-9.02[T]/105.79[cm] + 0[T] = **-4.64**[T] — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.57[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.6[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] — p. 13-10

Load condition :D2

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (44.87[cm]/54.39[cm])^2 = **1.25** — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] — p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{54.39}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)^{1/2} = \mathbf{105.79}[cm]$ p. 13-5

$H_b = \alpha*P/r = 44.87[cm]*-11.74[T]/105.79[cm] = \mathbf{-4.98}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-11.74[T]/105.79[cm] = \mathbf{-2.09}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-11.74[T]/105.79[cm] - 0[T] = \mathbf{-3.34}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[cm]*-11.74[T]/105.79[cm] + 0[T] = \mathbf{-6.04}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-3.34[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.09[T]*(54.39[cm] - 54.39[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D3

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = \mathbf{70.83}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = \mathbf{44.87}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{54.39}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)^{1/2} = \mathbf{105.79}[cm]$ p. 13-5

$H_b = \alpha*P/r = 44.87[cm]*-7.73[T]/105.79[cm] = \mathbf{-3.28}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-7.73[T]/105.79[cm] = \mathbf{-1.37}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-7.73[T]/105.79[cm] - 0[T] = \mathbf{-2.2}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[cm]*-7.73[T]/105.79[cm] + 0[T] = \mathbf{-3.97}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.37[T]*(54.39[cm] - 54.39[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D4

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = \mathbf{70.83}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = \mathbf{44.87}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{54.39}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)^{1/2} = \mathbf{105.79}[cm]$ p. 13-5

$H_b = \alpha*P/r = 44.87[cm]*-7.73[T]/105.79[cm] = \mathbf{-3.28}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-7.73[T]/105.79[cm] = \mathbf{-1.37}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-7.73[T]/105.79[cm] - 0[T] = \mathbf{-2.2}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[cm]*-7.73[T]/105.79[cm] + 0[T] = \mathbf{-3.97}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.37[T]*(54.39[cm] - 54.39[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D5

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\text{[cm]}*0.754 + 3.89\text{[cm]}*(44.87\text{[cm]}/54.39\text{[cm]})^2)/1.25 = \mathbf{44.87}\text{[cm]}$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{54.39}\text{[cm]}$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\text{[cm]} + 18.8\text{[cm]})^2 + (54.39\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{105.79}\text{[cm]}$ — p. 13-5

$H_b = \alpha*P/r = 44.87\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} = \mathbf{-3.28}\text{[T]}$ — p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} = \mathbf{-1.37}\text{[T]}$ — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} - 0\text{[T]} = \mathbf{-2.2}\text{[T]}$ — p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} + 0\text{[T]} = \mathbf{-3.97}\text{[T]}$ — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2\text{[T]}*(44.87\text{[cm]} - 44.87\text{[cm]})) + abs(0\text{[T]}*44.87\text{[cm]}) = \mathbf{0}\text{[T*m]}$ — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.37\text{[T]}*(54.39\text{[cm]} - 54.39\text{[cm]})) = \mathbf{0}\text{[T*m]}$ — p. 13-10

Load condition :D6

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\text{[cm]}*0.754 + 3.89\text{[cm]}*(44.87\text{[cm]}/54.39\text{[cm]})^2)/1.25 = \mathbf{44.87}\text{[cm]}$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{54.39}\text{[cm]}$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\text{[cm]} + 18.8\text{[cm]})^2 + (54.39\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{105.79}\text{[cm]}$ — p. 13-5

$H_b = \alpha*P/r = 44.87\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} = \mathbf{-3.28}\text{[T]}$ — p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} = \mathbf{-1.37}\text{[T]}$ — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} - 0\text{[T]} = \mathbf{-2.2}\text{[T]}$ — p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\text{[cm]}*-7.73\text{[T]}/105.79\text{[cm]} + 0\text{[T]} = \mathbf{-3.97}\text{[T]}$ — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2\text{[T]}*(44.87\text{[cm]} - 44.87\text{[cm]})) + abs(0\text{[T]}*44.87\text{[cm]}) = \mathbf{0}\text{[T*m]}$ — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.37\text{[T]}*(54.39\text{[cm]} - 54.39\text{[cm]})) = \mathbf{0}\text{[T*m]}$ — p. 13-10

Load condition :D7

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\text{[cm]}*0.754 + 3.89\text{[cm]}*(44.87\text{[cm]}/54.39\text{[cm]})^2)/1.25 = \mathbf{44.87}\text{[cm]}$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{54.39}\text{[cm]}$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\text{[cm]} + 18.8\text{[cm]})^2 + (54.39\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{105.79}\text{[cm]}$ — p. 13-5

$H_b = \alpha*P/r = 44.87\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} = \mathbf{-4.34}\text{[T]}$ — p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} = \mathbf{-1.82}\text{[T]}$ — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} - 0\text{[T]} = \mathbf{-2.91}\text{[T]}$ — p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} + 0\text{[T]} = \mathbf{-5.26}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.91\text{[T]}*(44.87\text{[cm]} - 44.87\text{[cm]})) + abs(0\text{[T]}*44.87\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.82\text{[T]}*(54.39\text{[cm]} - 54.39\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D8

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\text{[cm]}*0.754 + 3.89\text{[cm]}*(44.87\text{[cm]}/54.39\text{[cm]})^2)/1.25 = \mathbf{44.87}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{54.39}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\text{[cm]} + 18.8\text{[cm]})^2 + (54.39\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{105.79}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 44.87\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} = \mathbf{-4.34}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} = \mathbf{-1.82}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} - 0\text{[T]} = \mathbf{-2.91}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\text{[cm]}*-10.24\text{[T]}/105.79\text{[cm]} + 0\text{[T]} = \mathbf{-5.26}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.91\text{[T]}*(44.87\text{[cm]} - 44.87\text{[cm]})) + abs(0\text{[T]}*44.87\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.82\text{[T]}*(54.39\text{[cm]} - 54.39\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D9

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g = 1*1.4*2952.88\text{[kg/cm2]}*50.58\text{[cm2]} = \mathbf{209.1}\text{[T]}$ AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\text{[cm]}*0.754 + 3.89\text{[cm]}*(44.87\text{[cm]}/54.39\text{[cm]})^2)/1.25 = \mathbf{44.87}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{54.39}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\text{[cm]} + 18.8\text{[cm]})^2 + (54.39\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{105.79}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 44.87\text{[cm]}*209.1\text{[T]}/105.79\text{[cm]} = \mathbf{88.69}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*209.1\text{[T]}/105.79\text{[cm]} = \mathbf{37.15}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*209.1\text{[T]}/105.79\text{[cm]} - 0\text{[T]} = \mathbf{59.49}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\text{[cm]}*209.1\text{[T]}/105.79\text{[cm]} + 0\text{[T]} = \mathbf{107.5}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(59.49\text{[T]}*(44.87\text{[cm]} - 44.87\text{[cm]})) + abs(0\text{[T]}*44.87\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(37.15\text{[T]}*(54.39\text{[cm]} - 54.39\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D10

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\text{[cm]}*(0.754 + 44.87\text{[cm]}/54.39\text{[cm]}) = \mathbf{70.83}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\text{[cm]}/54.39\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83$[cm]$*0.754 + 3.89$[cm]$*(44.87$[cm]$/$
54.39[cm]$)^2)/1.25 =$ **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+$
30.1[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*-7.73$[T]$/105.79$[cm] $=$ **-3.28**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*-7.73$[T]$/105.79$[cm] $=$ **-1.37**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-7.73$[T]$/105.79$[cm] $- 0$[T] $=$ **-2.2**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*-7.73$[T]$/105.79$[cm] $+ 0$[T] $=$ **-3.97**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*$
44.87[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.37$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D11

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87$[cm]$*(0.754 + 44.87$[cm]$/54.39$[cm]$) =$ **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87$[cm]$/54.39$[cm]$)^2 =$ **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83$[cm]$*0.754 + 3.89$[cm]$*(44.87$[cm]$/$
54.39[cm]$)^2)/1.25 =$ **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+$
30.1[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*78.14$[T]$/105.79$[cm] $=$ **33.14**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*78.14$[T]$/105.79$[cm] $=$ **13.88**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*78.14$[T]$/105.79$[cm] $- 0$[T] $=$ **22.23**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*78.14$[T]$/105.79$[cm] $+ 0$[T] $=$ **40.17**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(22.23$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*$
44.87[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(13.88$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D12

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87$[cm]$*(0.754 + 44.87$[cm]$/54.39$[cm]$) =$ **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87$[cm]$/54.39$[cm]$)^2 =$ **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83$[cm]$*0.754 + 3.89$[cm]$*(44.87$[cm]$/$
54.39[cm]$)^2)/1.25 =$ **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+$
30.1[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*-10.24$[T]$/105.79$[cm] $=$ **-4.34**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*-10.24$[T]$/105.79$[cm] $=$ **-1.82**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-10.24$[T]$/105.79$[cm] $- 0$[T] $=$ **-2.91**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*-10.24$[T]$/105.79$[cm] $+ 0$[T] $=$ **-5.26**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.91$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*$
44.87[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.82$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D13

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/ 54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5

$H_b = \alpha*P/r$ = 44.87[cm]*-5.8[T]/105.79[cm] = **-2.46**[T] p. 13-5

$H_c = e_c*P/r$ = 18.8[cm]*-5.8[T]/105.79[cm] = **-1.03**[T] p. 13-5

$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-5.8[T]/105.79[cm] - 0[T] = **-1.65**[T] p. 13-5

$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-5.8[T]/105.79[cm] + 0[T] = **-2.98**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.65[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]* 44.87[cm]) = **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.03[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D14

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/ 54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5

$H_b = \alpha*P/r$ = 44.87[cm]*-5.8[T]/105.79[cm] = **-2.46**[T] p. 13-5

$H_c = e_c*P/r$ = 18.8[cm]*-5.8[T]/105.79[cm] = **-1.03**[T] p. 13-5

$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-5.8[T]/105.79[cm] - 0[T] = **-1.65**[T] p. 13-5

$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-5.8[T]/105.79[cm] + 0[T] = **-2.98**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.65[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]* 44.87[cm]) = **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.03[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D15

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g$ = 1*1.4*2952.88[kg/cm2]*50.58[cm2] = **209.1**[T] AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/ 54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] +

$30.1[\text{cm}])^2)^{1/2} = \mathbf{105.79}[\text{cm}]$ p. 13-5

$H_b = \alpha*P/r = 44.87[\text{cm}]*209.1[\text{T}]/105.79[\text{cm}] = \mathbf{88.69}[\text{T}]$ p. 13-5

$H_c = e_c*P/r = 18.8[\text{cm}]*209.1[\text{T}]/105.79[\text{cm}] = \mathbf{37.15}[\text{T}]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[\text{cm}]*209.1[\text{T}]/105.79[\text{cm}] - 0[\text{T}] = \mathbf{59.49}[\text{T}]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[\text{cm}]*209.1[\text{T}]/105.79[\text{cm}] + 0[\text{T}] = \mathbf{107.5}[\text{T}]$ p. 13-5

$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha) = \text{abs}(59.49[\text{T}]*(44.87[\text{cm}] - 44.87[\text{cm}])) + \text{abs}(0[\text{T}]*$
$44.87[\text{cm}]) = \mathbf{0}[\text{T*m}]$ p. 13-10

$M_c = \text{abs}(H_c*(\beta - \beta_{bar})) = \text{abs}(37.15[\text{T}]*(54.39[\text{cm}] - 54.39[\text{cm}])) = \mathbf{0}[\text{T*m}]$ p. 13-10

Load condition :D16

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[\text{cm}]*0.754 - 18.8[\text{cm}] = \mathbf{3.89}[\text{cm}]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87[\text{cm}]*(0.754 + 44.87[\text{cm}]/54.39[\text{cm}]) = \mathbf{70.83}[\text{cm}]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[\text{cm}]/54.39[\text{cm}])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83[\text{cm}]*0.754 + 3.89[\text{cm}]*(44.87[\text{cm}]/$
$54.39[\text{cm}])^2)/1.25 = \mathbf{44.87}[\text{cm}]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83[\text{cm}] - 3.89[\text{cm}]*0.754)/1.25 = \mathbf{54.39}[\text{cm}]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87[\text{cm}] + 18.8[\text{cm}])^2 + (54.39[\text{cm}] +$
$30.1[\text{cm}])^2)^{1/2} = \mathbf{105.79}[\text{cm}]$ p. 13-5

$H_b = \alpha*P/r = 44.87[\text{cm}]*-5.8[\text{T}]/105.79[\text{cm}] = \mathbf{-2.46}[\text{T}]$ p. 13-5

$H_c = e_c*P/r = 18.8[\text{cm}]*-5.8[\text{T}]/105.79[\text{cm}] = \mathbf{-1.03}[\text{T}]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[\text{cm}]*-5.8[\text{T}]/105.79[\text{cm}] - 0[\text{T}] = \mathbf{-1.65}[\text{T}]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[\text{cm}]*-5.8[\text{T}]/105.79[\text{cm}] + 0[\text{T}] = \mathbf{-2.98}[\text{T}]$ p. 13-5

$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha) = \text{abs}(-1.65[\text{T}]*(44.87[\text{cm}] - 44.87[\text{cm}])) + \text{abs}(0[\text{T}]*$
$44.87[\text{cm}]) = \mathbf{0}[\text{T*m}]$ p. 13-10

$M_c = \text{abs}(H_c*(\beta - \beta_{bar})) = \text{abs}(-1.03[\text{T}]*(54.39[\text{cm}] - 54.39[\text{cm}])) = \mathbf{0}[\text{T*m}]$ p. 13-10

Load condition :D17

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[\text{cm}]*0.754 - 18.8[\text{cm}] = \mathbf{3.89}[\text{cm}]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87[\text{cm}]*(0.754 + 44.87[\text{cm}]/54.39[\text{cm}]) = \mathbf{70.83}[\text{cm}]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[\text{cm}]/54.39[\text{cm}])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83[\text{cm}]*0.754 + 3.89[\text{cm}]*(44.87[\text{cm}]/$
$54.39[\text{cm}])^2)/1.25 = \mathbf{44.87}[\text{cm}]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83[\text{cm}] - 3.89[\text{cm}]*0.754)/1.25 = \mathbf{54.39}[\text{cm}]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87[\text{cm}] + 18.8[\text{cm}])^2 + (54.39[\text{cm}] +$
$30.1[\text{cm}])^2)^{1/2} = \mathbf{105.79}[\text{cm}]$ p. 13-5

$H_b = \alpha*P/r = 44.87[\text{cm}]*-6.44[\text{T}]/105.79[\text{cm}] = \mathbf{-2.73}[\text{T}]$ p. 13-5

$H_c = e_c*P/r = 18.8[\text{cm}]*-6.44[\text{T}]/105.79[\text{cm}] = \mathbf{-1.14}[\text{T}]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[\text{cm}]*-6.44[\text{T}]/105.79[\text{cm}] - 0[\text{T}] = \mathbf{-1.83}[\text{T}]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39[\text{cm}]*-6.44[\text{T}]/105.79[\text{cm}] + 0[\text{T}] = \mathbf{-3.31}[\text{T}]$ p. 13-5

$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha) = \text{abs}(-1.83[\text{T}]*(44.87[\text{cm}] - 44.87[\text{cm}])) + \text{abs}(0[\text{T}]*$
$44.87[\text{cm}]) = \mathbf{0}[\text{T*m}]$ p. 13-10

$M_c = \text{abs}(H_c*(\beta - \beta_{bar})) = \text{abs}(-1.14[\text{T}]*(54.39[\text{cm}] - 54.39[\text{cm}])) = \mathbf{0}[\text{T*m}]$ p. 13-10

Load condition :D18

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[\text{cm}]*0.754 - 18.8[\text{cm}] = \mathbf{3.89}[\text{cm}]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5
$H_b = \alpha*P/r$ = 44.87[cm]*-8.95[T]/105.79[cm] = **-3.8**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-8.95[T]/105.79[cm] = **-1.59**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-8.95[T]/105.79[cm] - 0[T] = **-2.55**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-8.95[T]/105.79[cm] + 0[T] = **-4.6**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.55[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.59[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D19

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5
$H_b = \alpha*P/r$ = 44.87[cm]*-8.32[T]/105.79[cm] = **-3.53**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-8.32[T]/105.79[cm] = **-1.48**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-8.32[T]/105.79[cm] - 0[T] = **-2.37**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-8.32[T]/105.79[cm] + 0[T] = **-4.28**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.37[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.48[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D20

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (44.87[cm]/54.39[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5
$H_b = \alpha*P/r$ = 44.87[cm]*-6.44[T]/105.79[cm] = **-2.73**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-6.44[T]/105.79[cm] = **-1.14**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-6.44[T]/105.79[cm] - 0[T] = **-1.83**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-6.44[T]/105.79[cm] + 0[T] = **-3.31**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.83[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*

$44.87\mathrm{[cm]}) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.14\mathrm{[T]}*(54.39\mathrm{[cm]} - 54.39\mathrm{[cm]})) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

Load condition :D21

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\mathrm{[cm]}*0.754 - 18.8\mathrm{[cm]} = \mathbf{3.89}\mathrm{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\mathrm{[cm]}*(0.754 + 44.87\mathrm{[cm]}/54.39\mathrm{[cm]}) = \mathbf{70.83}\mathrm{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\mathrm{[cm]}*0.754 + 3.89\mathrm{[cm]}*(44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2)/1.25 = \mathbf{44.87}\mathrm{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\mathrm{[cm]} - 3.89\mathrm{[cm]}*0.754)/1.25 = \mathbf{54.39}\mathrm{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\mathrm{[cm]} + 18.8\mathrm{[cm]})^2 + (54.39\mathrm{[cm]} + 30.1\mathrm{[cm]})^2)^{1/2} = \mathbf{105.79}\mathrm{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 44.87\mathrm{[cm]}*-6.44\mathrm{[T]}/105.79\mathrm{[cm]} = \mathbf{-2.73}\mathrm{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\mathrm{[cm]}*-6.44\mathrm{[T]}/105.79\mathrm{[cm]} = \mathbf{-1.14}\mathrm{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\mathrm{[cm]}*-6.44\mathrm{[T]}/105.79\mathrm{[cm]} - 0\mathrm{[T]} = \mathbf{-1.83}\mathrm{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\mathrm{[cm]}*-6.44\mathrm{[T]}/105.79\mathrm{[cm]} + 0\mathrm{[T]} = \mathbf{-3.31}\mathrm{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.83\mathrm{[T]}*(44.87\mathrm{[cm]} - 44.87\mathrm{[cm]})) + abs(0\mathrm{[T]}*44.87\mathrm{[cm]}) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.14\mathrm{[T]}*(54.39\mathrm{[cm]} - 54.39\mathrm{[cm]})) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

Load condition :D22

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g = 1*1.4*2952.88\mathrm{[kg/cm2]}*50.58\mathrm{[cm2]} = \mathbf{209.1}\mathrm{[T]}$ AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c = 30.1\mathrm{[cm]}*0.754 - 18.8\mathrm{[cm]} = \mathbf{3.89}\mathrm{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\mathrm{[cm]}*(0.754 + 44.87\mathrm{[cm]}/54.39\mathrm{[cm]}) = \mathbf{70.83}\mathrm{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\mathrm{[cm]}*0.754 + 3.89\mathrm{[cm]}*(44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2)/1.25 = \mathbf{44.87}\mathrm{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83\mathrm{[cm]} - 3.89\mathrm{[cm]}*0.754)/1.25 = \mathbf{54.39}\mathrm{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87\mathrm{[cm]} + 18.8\mathrm{[cm]})^2 + (54.39\mathrm{[cm]} + 30.1\mathrm{[cm]})^2)^{1/2} = \mathbf{105.79}\mathrm{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 44.87\mathrm{[cm]}*209.1\mathrm{[T]}/105.79\mathrm{[cm]} = \mathbf{88.69}\mathrm{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\mathrm{[cm]}*209.1\mathrm{[T]}/105.79\mathrm{[cm]} = \mathbf{37.15}\mathrm{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\mathrm{[cm]}*209.1\mathrm{[T]}/105.79\mathrm{[cm]} - 0\mathrm{[T]} = \mathbf{59.49}\mathrm{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39\mathrm{[cm]}*209.1\mathrm{[T]}/105.79\mathrm{[cm]} + 0\mathrm{[T]} = \mathbf{107.5}\mathrm{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(59.49\mathrm{[T]}*(44.87\mathrm{[cm]} - 44.87\mathrm{[cm]})) + abs(0\mathrm{[T]}*44.87\mathrm{[cm]}) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(37.15\mathrm{[T]}*(54.39\mathrm{[cm]} - 54.39\mathrm{[cm]})) = \mathbf{0}\mathrm{[T*m]}$ p. 13-10

Load condition :D23

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\mathrm{[cm]}*0.754 - 18.8\mathrm{[cm]} = \mathbf{3.89}\mathrm{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87\mathrm{[cm]}*(0.754 + 44.87\mathrm{[cm]}/54.39\mathrm{[cm]}) = \mathbf{70.83}\mathrm{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83\mathrm{[cm]}*0.754 + 3.89\mathrm{[cm]}*(44.87\mathrm{[cm]}/54.39\mathrm{[cm]})^2)/1.25 = \mathbf{44.87}\mathrm{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+ 30.1$[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*-6.44$[T]$/105.79$[cm] $=$ **-2.73**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*-6.44$[T]$/105.79$[cm] $=$ **-1.14**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-6.44$[T]$/105.79$[cm] $- 0$[T] $=$ **-1.83**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*-6.44$[T]$/105.79$[cm] $+ 0$[T] $=$ **-3.31**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.83$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*44.87$[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.14$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D24

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87$[cm]$*(0.754 + 44.87$[cm]$/54.39$[cm]$) =$ **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87$[cm]$/54.39$[cm]$)^2 =$ **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83$[cm]$*0.754 + 3.89$[cm]$*(44.87$[cm]$/54.39$[cm]$)^2)/1.25 =$ **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+ 30.1$[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*-8.32$[T]$/105.79$[cm] $=$ **-3.53**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*-8.32$[T]$/105.79$[cm] $=$ **-1.48**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-8.32$[T]$/105.79$[cm] $- 0$[T] $=$ **-2.37**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*-8.32$[T]$/105.79$[cm] $+ 0$[T] $=$ **-4.28**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.37$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*44.87$[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.48$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D25

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87$[cm]$*(0.754 + 44.87$[cm]$/54.39$[cm]$) =$ **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87$[cm]$/54.39$[cm]$)^2 =$ **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83$[cm]$*0.754 + 3.89$[cm]$*(44.87$[cm]$/54.39$[cm]$)^2)/1.25 =$ **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D = (70.83$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87$[cm] $+ 18.8$[cm]$)^2 + (54.39$[cm] $+ 30.1$[cm]$)^2)^{1/2} =$ **105.79**[cm] p. 13-5
$H_b = \alpha*P/r = 44.87$[cm]$*-8.32$[T]$/105.79$[cm] $=$ **-3.53**[T] p. 13-5
$H_c = e_c*P/r = 18.8$[cm]$*-8.32$[T]$/105.79$[cm] $=$ **-1.48**[T] p. 13-5
$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-8.32$[T]$/105.79$[cm] $- 0$[T] $=$ **-2.37**[T] p. 13-5
$V_c = \beta*P/r + \Delta V = 54.39$[cm]$*-8.32$[T]$/105.79$[cm] $+ 0$[T] $=$ **-4.28**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.37$[T]$*(44.87$[cm] $- 44.87$[cm]$)) + abs(0$[T]$*44.87$[cm]$) =$ **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.48$[T]$*(54.39$[cm] $- 54.39$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D26

General case DG29 p. 24-33

$\phi R_n = \phi * R_y * F_y * A_g$ = 1*1.4*2952.88[kg/cm2]*50.58[cm2] = **209.1**[T] AISC 341-10 Sec. F2.6.c

$K = e_b * tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2$ = **1.25** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5

$H_b = \alpha * P/r$ = 44.87[cm]*209.1[T]/105.79[cm] = **88.69**[T] p. 13-5

$H_c = e_c * P/r$ = 18.8[cm]*209.1[T]/105.79[cm] = **37.15**[T] p. 13-5

$V_b = e_b * P/r - \Delta V$ = 30.1[cm]*209.1[T]/105.79[cm] - 0[T] = **59.49**[T] p. 13-5

$V_c = \beta * P/r + \Delta V$ = 54.39[cm]*209.1[T]/105.79[cm] + 0[T] = **107.5**[T] p. 13-5

$M_b = abs(V_b * (\alpha - \alpha_{bar})) + abs(\Delta V * \alpha)$ = abs(59.49[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10

$M_c = abs(H_c * (\beta - \beta_{bar}))$ = abs(37.15[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D27

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2$ = **1.25** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5

$H_b = \alpha * P/r$ = 44.87[cm]*-6.44[T]/105.79[cm] = **-2.73**[T] p. 13-5

$H_c = e_c * P/r$ = 18.8[cm]*-6.44[T]/105.79[cm] = **-1.14**[T] p. 13-5

$V_b = e_b * P/r - \Delta V$ = 30.1[cm]*-6.44[T]/105.79[cm] - 0[T] = **-1.83**[T] p. 13-5

$V_c = \beta * P/r + \Delta V$ = 54.39[cm]*-6.44[T]/105.79[cm] + 0[T] = **-3.31**[T] p. 13-5

$M_b = abs(V_b * (\alpha - \alpha_{bar})) + abs(\Delta V * \alpha)$ = abs(-1.83[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10

$M_c = abs(H_c * (\beta - \beta_{bar}))$ = abs(-1.14[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D28

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2$ = **1.25** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5

$H_b = \alpha * P/r$ = 44.87[cm]*-3.86[T]/105.79[cm] = **-1.64**[T] p. 13-5

$H_c = e_c*P/r$ = 18.8[cm]*-3.86[T]/105.79[cm] = **-0.687**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-3.86[T]/105.79[cm] - 0[T] = **-1.1**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-3.86[T]/105.79[cm] + 0[T] = **-1.99**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.1[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-0.687[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D29

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2$ = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5
$H_b = \alpha*P/r$ = 44.87[cm]*-3.86[T]/105.79[cm] = **-1.64**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-3.86[T]/105.79[cm] = **-0.687**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-3.86[T]/105.79[cm] - 0[T] = **-1.1**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*-3.86[T]/105.79[cm] + 0[T] = **-1.99**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.1[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-0.687[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D30

General case DG29 p. 24-33
$\phi R_n = \phi*R_y*F_y*A_g$ = 1*1.4*2952.88[kg/cm2]*50.58[cm2] = **209.1**[T] AISC 341-10 Sec. F2.6.c
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 44.87[cm]*(0.754 + 44.87[cm]/54.39[cm]) = **70.83**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87[cm]/54.39[cm])^2$ = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (70.83[cm]*0.754 + 3.89[cm]*(44.87[cm]/54.39[cm])^2)/1.25 = **44.87**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (70.83[cm] - 3.89[cm]*0.754)/1.25 = **54.39**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((44.87[cm] + 18.8[cm])^2 + (54.39[cm] + 30.1[cm])^2)$^{1/2}$ = **105.79**[cm] p. 13-5
$H_b = \alpha*P/r$ = 44.87[cm]*209.1[T]/105.79[cm] = **88.69**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*209.1[T]/105.79[cm] = **37.15**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*209.1[T]/105.79[cm] - 0[T] = **59.49**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 54.39[cm]*209.1[T]/105.79[cm] + 0[T] = **107.5**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(59.49[T]*(44.87[cm] - 44.87[cm])) + abs(0[T]*44.87[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(37.15[T]*(54.39[cm] - 54.39[cm])) = **0**[T*m] p. 13-10

Load condition :D31

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 44.87_{[cm]}*(0.754 + 44.87_{[cm]}/54.39_{[cm]}) = \mathbf{70.83}_{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (44.87_{[cm]}/54.39_{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (70.83_{[cm]}*0.754 + 3.89_{[cm]}*(44.87_{[cm]}/54.39_{[cm]})^2)/1.25 = \mathbf{44.87}_{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (70.83_{[cm]} - 3.89_{[cm]}*0.754)/1.25 = \mathbf{54.39}_{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((44.87_{[cm]} + 18.8_{[cm]})^2 + (54.39_{[cm]} + 30.1_{[cm]})^2)^{1/2} = \mathbf{105.79}_{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 44.87_{[cm]}*-3.86_{[T]}/105.79_{[cm]} = \mathbf{-1.64}_{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8_{[cm]}*-3.86_{[T]}/105.79_{[cm]} = \mathbf{-0.687}_{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1_{[cm]}*-3.86_{[T]}/105.79_{[cm]} - 0_{[T]} = \mathbf{-1.1}_{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 54.39_{[cm]}*-3.86_{[T]}/105.79_{[cm]} + 0_{[T]} = \mathbf{-1.99}_{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.1_{[T]}*(44.87_{[cm]} - 44.87_{[cm]})) + abs(0_{[T]}*44.87_{[cm]}) = \mathbf{0}_{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-0.687_{[T]}*(54.39_{[cm]} - 54.39_{[cm]})) = \mathbf{0}_{[T*m]}$ p. 13-10

Upper right gusset interface - beam
Directly welded

DEMANDS

	Beam			Column			
Description	**Ru** [Ton]	**Pu** [Ton]	**Mu** [Ton*m]	**Pu** [Ton]	**Mu22** [Ton*m]	**Mu33** [Ton*m]	**Load type**
D1	-3.82	-2.57	0.00	0.00	0.00	0.00	Design
D2	-4.98	-3.34	0.00	0.00	0.00	0.00	Design
D3	-3.28	-2.20	0.00	0.00	0.00	0.00	Design
D4	-3.28	-2.20	0.00	0.00	0.00	0.00	Design
D5	-3.28	-2.20	0.00	0.00	0.00	0.00	Design
D6	-3.28	-2.20	0.00	0.00	0.00	0.00	Design
D7	-4.34	-2.91	0.00	0.00	0.00	0.00	Design
D8	-4.34	-2.91	0.00	0.00	0.00	0.00	Design
D9	88.69	59.49	0.00	0.00	0.00	0.00	Seismic
D10	-3.28	-2.20	0.00	0.00	0.00	0.00	Design
D11	33.14	22.23	0.00	0.00	0.00	0.00	Design
D12	-4.34	-2.91	0.00	0.00	0.00	0.00	Design
D13	-2.46	-1.65	0.00	0.00	0.00	0.00	Design
D14	-2.46	-1.65	0.00	0.00	0.00	0.00	Design
D15	88.69	59.49	0.00	0.00	0.00	0.00	Seismic
D16	-2.46	-1.65	0.00	0.00	0.00	0.00	Design
D17	-2.73	-1.83	0.00	0.00	0.00	0.00	Design
D18	-3.80	-2.55	0.00	0.00	0.00	0.00	Design
D19	-3.53	-2.37	0.00	0.00	0.00	0.00	Design
D20	-2.73	-1.83	0.00	0.00	0.00	0.00	Design
D21	-2.73	-1.83	0.00	0.00	0.00	0.00	Design
D22	88.69	59.49	0.00	0.00	0.00	0.00	Seismic
D23	-2.73	-1.83	0.00	0.00	0.00	0.00	Design
D24	-3.53	-2.37	0.00	0.00	0.00	0.00	Design
D25	-3.53	-2.37	0.00	0.00	0.00	0.00	Design
D26	88.69	59.49	0.00	0.00	0.00	0.00	Seismic
D27	-2.73	-1.83	0.00	0.00	0.00	0.00	Design
D28	-1.64	-1.10	0.00	0.00	0.00	0.00	Design
D29	-1.64	-1.10	0.00	0.00	0.00	0.00	Design
D30	88.69	59.49	0.00	0.00	0.00	0.00	Seismic
D31	-1.64	-1.10	0.00	0.00	0.00	0.00	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Gusset</u>						
Beam yielding (normal stress)	[Ton]	374.11	59.49	D9	0.16	Eq. B-1, Appendix B, DG29, Eq. J4-1
$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 59.49$[T] $+ ((4*0$[T*m]$)/82.12$[cm]$) = \mathbf{59.49}$[T]						Eq. B-1, Appendix B, DG29
$A_g = L_p*t_p = 82.12$[cm]$*2$[cm] $= \mathbf{164.23}$[cm2]						Sec. D3-1
$\phi R_n = \phi*F_y*A_g = 0.9*2531.04$[kg/cm2]$*164.23$[cm2] $= \mathbf{374.11}$[T]						Eq. J4-1
$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 59.49$[T] $+ ((4*0$[T*m]$)/82.12$[cm]$) = \mathbf{59.49}$[T]						Eq. B-1, Appendix B, DG29
Shear yielding	[Ton]	249.41	88.69	D9	0.36	Eq. J4-3
$A_g = L_p*t_p = 82.12$[cm]$*2$[cm] $= \mathbf{164.23}$[cm2]						Sec. D3-1
$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*2531.04$[kg/cm2]$*164.23$[cm2] $= \mathbf{249.41}$[T]						Eq. J4-3
Gusset edge tension stress	[kg/m2]	2.277934E07	3622534.00	D9	0.16	J4-1
$\phi F_n = \phi*F_y = 0.9*2531.04$[kg/cm2] $= \mathbf{2277.93}$[kg/cm2]						J4-1
$f_{ua} = V_b/(t_p*l) = 59.49$[T]$/(2$[cm]$*82.12$[cm]$) = \mathbf{362.25}$[kg/cm2]						9
Gusset edge shear stress	[kg/m2]	1.518622E07	5400096.00	D9	0.36	J4-1
$\phi F_n = \phi*0.6*F_y = 1*0.6*2531.04$[kg/cm2] $= \mathbf{1518.62}$[kg/cm2]						J4-1
$f_{uv} = H_b/(t_p*l) = 88.69$[T]$/(2$[cm]$*82.12$[cm]$) = \mathbf{540.01}$[kg/cm2]						9
Weld capacity	[Ton]	246.59	133.49	D9	0.54	Tables 8-4 .. 8-11
$\phi R_n = 2 * (\phi*C*C_1*D*L) = 2 * (0.75*0.4$[T/cm]$*1*5*82.12$[cm]$) = \mathbf{246.59}$[T]						Tables 8-4 .. 8-11
$f_{ua} = V_b/l = 59.49$[T]$/82.12$[cm] $= \mathbf{0.725}$[T/cm]						9
$f_{uv} = H_b/l = 88.69$[T]$/82.12$[cm] $= \mathbf{1.08}$[T/cm]						9
$f_{ub} = M_b/(l^2/6) = 0$[T*m]$/(82.12$[cm]$^2/6) = \mathbf{0}$[T/cm]						9
$f_{uPeak} = ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2} = ((0.725$[T/cm] $+ 0$[T/cm]$)^2 + 1.08$[T/cm]$^2)^{1/2} = \mathbf{1.3}$[T/cm]						9
$f_{uAve} = 0.5*(((f_{ua} - f_{ub})^2 + f_{uv}^2)^{1/2} + ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2}) = 0.5*(((0.725$[T/cm] $- 0$[T/cm]$)^2 + 1.08$[T/cm]$^2)^{1/2} + ((0.725$[T/cm] $+ 0$[T/cm]$)^2 + 1.08$[T/cm]$^2)^{1/2}) = \mathbf{1.3}$[T/cm]						9
$f_{uWeld} = l*\max(f_{uPeak}, 1.25*f_{uAve}) = 82.12$[cm]$*\max(1.3$[T/cm]$, 1.25*1.3$[T/cm]$) = \mathbf{133.49}$[T]						9
<u>Beam</u>						
Weld block shear	[Ton]	240.79	88.69	D9	0.37	Eq. J4-5
$A_{gv} = l*t_w = 82.12$[cm]$*1.09$[cm] $= \mathbf{89.69}$[cm2]						Sec. J4.3
$A_{gt} = (A_g - t_w*T)/2 = (117.42$[cm2] $- 1.09$[cm]$*54.66$[cm]$)/2 = \mathbf{28.86}$[cm2]						8
$A_{nv} = A_{gv} = \mathbf{89.69}$[cm2]						Sec. J4.3
$A_{nt} = A_{gt} = \mathbf{28.86}$[cm2]						Sec. J4.3
$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*\min(0.6*4569.93$[kg/cm2]$*89.69$[cm2] $+ 1*4569.93$[kg/cm2]$*28.86$[cm2]$, 0.6*3515.33$[kg/cm2]$*89.69$[cm2] $+ 1*4569.93$[kg/cm2]$*28.86$[cm2]$) = \mathbf{240.79}$[T]						Eq. J4-5
Local web yielding	[Ton]	341.86	59.49	D9	0.17	Eq. J10-3,

Eq. B-1, Appendix B, DG29

$IsBeamReaction \rightarrow$ **False**

$l_b = N =$ **82.12**[cm] — Sec. J10-2

$IsMemberEnd \rightarrow$ **True**

$\phi R_n = \phi*(2.5*k + l_b)*F_{yw}*t_w = 1*(2.5*2.77$[cm] $+ 82.12$[cm]$)*3515.33$[kg/cm2]$*1.09$[cm] $=$ **341.86**[T] — Eq. J10-3

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 59.49$[T] $+ ((4*0$[T*m]$)/82.12$[cm]$) =$ **59.49**[T] — Eq. B-1, Appendix B, DG29

Ratio	**0.54**

Upper right gusset interface - column

Angles

DEMANDS

Description	Ru [Ton]	Pu [Ton]	Load type
D1	-4.64	-1.60	Design
D2	-6.04	-2.09	Design
D3	-3.97	-1.37	Design
D4	-3.97	-1.37	Design
D5	-3.97	-1.37	Design
D6	-3.97	-1.37	Design
D7	-5.26	-1.82	Design
D8	-5.26	-1.82	Design
D9	107.50	37.15	Seismic
D10	-3.97	-1.37	Design
D11	40.17	13.88	Design
D12	-5.26	-1.82	Design
D13	-2.98	-1.03	Design
D14	-2.98	-1.03	Design
D15	107.50	37.15	Seismic
D16	-2.98	-1.03	Design
D17	-3.31	-1.14	Design
D18	-4.60	-1.59	Design
D19	-4.28	-1.48	Design
D20	-3.31	-1.14	Design
D21	-3.31	-1.14	Design
D22	107.50	37.15	Seismic
D23	-3.31	-1.14	Design
D24	-4.28	-1.48	Design
D25	-4.28	-1.48	Design
D26	107.50	37.15	Seismic
D27	-3.31	-1.14	Design
D28	-1.99	-0.69	Design
D29	-1.99	-0.69	Design
D30	107.50	37.15	Seismic
D31	-1.99	-0.69	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Gusset side)						

Weld size	[1/16in]	6	3	7	table J2.4, Sec. J2.2b

$w_{min} = w_{min} = \mathbf{0.004763}$ — table J2.4

t_p<1/4 [in] → 1.27[cm]<1/4 [in] → **False**

$w_{max} = t_p$ - 1/16 [in] = 1.27[cm] - 1/16 [in] = **0.0111** — Sec. J2.2b

Angle (Column side)

Vertical edge distance	[cm]	3.81	2.54	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] — Tables J3.4, J3.5

Horizontal edge distance	[cm]	4.17	2.54	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] — Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[cm]	7.62	5.08	30.48	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1.9[cm] = **5.08**[cm] — Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*1.27[cm], 12 [in]) = **30.48**[cm] — Sec. J3.5

Column

Horizontal edge distance	[cm]	12.33	2.54	--	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] — Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Gusset side)						
Weld capacity	[Ton]	279.99	113.74	D9	0.41	Tables 8-4 .. 8-11

ϕR_n = 2 * (ϕ*C*C_1*D*L) = 2 * (0.75*0.408[T/cm]*1*6*76.2[cm]) = **279.99**[T] — Tables 8-4 .. 8-11

Shear yielding	[Ton]	293.93	107.50	D9	0.37	Eq. J4-3

$A_g = L_p$*t_p = 76.2[cm]*1.27[cm] = **96.77**[cm2] — Sec. D3-1

ϕR_n = 2 * (ϕ*0.60*F_y*A_g) = 2 * (1*0.60*2531.04[kg/cm2]*96.77[cm2]) = **293.93**[T] — Eq. J4-3

Leg tensile yielding	[Ton]	440.89	37.15	D9	0.08	Eq. J4-1

ϕR_n = 2 * (ϕ*F_y*A_g) = 2 * (0.9*2531.04[kg/cm2]*96.77[cm2]) = **440.89**[T] — Eq. J4-1

Angle (Column side)

Bolts shear	[Ton]	162.40	107.50	D9	0.66	Tables (7-1..14)

ϕR_n = ϕ*F_{nv}*A_b = 0.75*3796.58[kg/cm2]*2.85[cm2] = **8.12**[T] — Eq. J3-1

ϕR_n = 2 * (C*ϕR_n) = 2 * (10*8.12[T]) = **162.4**[T] — Tables (7-1..14)

Bolt bearing under shear load	[Ton]	345.54	107.50	D9	0.31	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.81[cm] - 2.06[cm]/2) = **2.78**[cm] — Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0,\ s - d_h) = \mathrm{Max}(0.0,\ 7.62\text{[cm]} - 2.06\text{[cm]}) = \mathbf{5.56}\text{[cm]}$ Sec. J4.10

$\phi R_n = 2 * (\phi*(C/(n_c*n))*(\min(k_1*l_c,\ k_2*d) + \min(k_1*L_{c\text{-}spa},\ k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.75*(10/(1*10))*(\min(1.2*2.78\text{[cm]},\ 2.4*1.9\text{[cm]}) + \min(1.2*5.56\text{[cm]},\ 2.4*1.9\text{[cm]})*(10 - 1))*1.27\text{[cm]}*4077.78\text{[kg/cm2]}*1) = \mathbf{345.54}\text{[T]}$ p. 7-18, Sec. J3.10

Shear yielding [Ton] 293.93 107.50 D9 0.37 Eq. J4-3

$A_g = L_p*t_p = 76.2\text{[cm]}*1.27\text{[cm]} = \mathbf{96.77}\text{[cm2]}$ Sec. D3-1

$\phi R_n = 2 * (\phi*0.60*F_y*A_g) = 2 * (1*0.60*2531.04\text{[kg/cm2]}*96.77\text{[cm2]}) = \mathbf{293.93}\text{[T]}$ Eq. J4-3

Shear rupture [Ton] 251.57 107.50 D9 0.43 Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 2.06\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.22}\text{[cm]}$ Sec. D3-2

$L_e = L - n*L_h = 76.2\text{[cm]} - 10*2.22\text{[cm]} = \mathbf{53.98}\text{[cm]}$ DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 53.98\text{[cm]}*1.27\text{[cm]} = \mathbf{68.55}\text{[cm2]}$ Sec. J4-2

$\phi R_n = 2 * (\phi*0.60*F_u*A_{nv}) = 2 * (0.75*0.60*4077.78\text{[kg/cm2]}*68.55\text{[cm2]}) = \mathbf{251.57}\text{[T]}$ Eq. J4-4

Block shear [Ton] 233.22 107.50 D9 0.46 Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 2.06\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.22}\text{[cm]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 2.06\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.22}\text{[cm]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (4.17\text{[cm]} + (1 - 1)*7.62\text{[cm]} - (1 - 0.5)*2.22\text{[cm]})*1.27\text{[cm]} = \mathbf{3.89}\text{[cm2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (3.81\text{[cm]} + (10 - 1)*7.62\text{[cm]})*1.27\text{[cm]} = \mathbf{91.94}\text{[cm2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (3.81\text{[cm]} + (10 - 1)*(7.62\text{[cm]} - 2.22\text{[cm]}) - 2.22\text{[cm]}/2)*1.27\text{[cm]} = \mathbf{65.12}\text{[cm2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$\phi R_n = 2 * (\phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt},\ 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.75*\min(0.6*4077.78\text{[kg/cm2]}*65.12\text{[cm2]} + 1*4077.78\text{[kg/cm2]}*3.89\text{[cm2]},\ 0.6*2531.04\text{[kg/cm2]}*91.94\text{[cm2]} + 1*4077.78\text{[kg/cm2]}*3.89\text{[cm2]})) = \mathbf{233.22}\text{[T]}$ Eq. J4-5

Resulting tension capacity due prying action [Ton] 88.77 37.15 D9 0.42 p. 9-11, p. 9-10

$f_v = F/(A_b*N_{bolts}) = 107.5\text{[T]}/(2.85\text{[cm2]}*20) = \mathbf{1884.93}\text{[kg/cm2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/(\phi*F_{nv}),\ 0.0),\ F_{nt}) = \min(\max(1.3*6327.63\text{[kg/cm2]} - 6327.63\text{[kg/cm2]}*1884.93\text{[kg/cm2]}/(0.75*3796.58\text{[kg/cm2]}),\ 0.0),\ 6327.63\text{[kg/cm2]}) = \mathbf{4037.18}\text{[kg/cm2]}$ Eq. J3-3

$\phi R_n = \phi*F'_{nt}*A_b = 0.75*4037.18\text{[kg/cm2]}*2.85\text{[cm2]} = \mathbf{8.63}\text{[T]}$ Eq. J3-2

$f_v = F/(A_b*N_{bolts}) = 107.5\text{[T]}/(2.85\text{[cm2]}*20) = \mathbf{1884.93}\text{[kg/cm2]}$ Sec. J3.7

$F'_{nt} = \min(\max(1.3*F_{nt} - F_{nt}*f_v/(\phi*F_{nv}),\ 0.0),\ F_{nt}) = \min(\max(1.3*6327.63\text{[kg/cm2]} - 6327.63\text{[kg/cm2]}*1884.93\text{[kg/cm2]}/(0.75*3796.58\text{[kg/cm2]}),\ 0.0),\ 6327.63\text{[kg/cm2]}) = \mathbf{4037.18}\text{[kg/cm2]}$ Eq. J3-3

$\phi R_n = \phi*F'_{nt}*A_b = 0.75*4037.18\text{[kg/cm2]}*2.85\text{[cm2]} = \mathbf{8.63}\text{[T]}$ Eq. J3-2

$p_{inner} = \min(p,\ s,\ 2*b) = \min(7.62\text{[cm]},\ 7.62\text{[cm]},\ 2*5.35\text{[cm]}) = \mathbf{7.62}\text{[cm]}$ p. 9-11

$p_{outer} = \min(p,\ s,\ 2*b) = \min(7.62\text{[cm]},\ 7.62\text{[cm]},\ 2*5.35\text{[cm]}) = \mathbf{7.62}\text{[cm]}$ p. 9-11

$a' = \mathrm{Min}(a + d/2,\ 1.25*b + d/2) = \mathrm{Min}(4.17\text{[cm]} + 1.9\text{[cm]}/2,\ 1.25*5.35\text{[cm]} + 1.9\text{[cm]}/2) = \mathbf{5.13}\text{[cm]}$ p. 9-12

$b' = b - d/2 = 5.35\text{[cm]} - 1.9\text{[cm]}/2 = \mathbf{4.4}\text{[cm]}$ p. 9-12

$\rho = b'/a' = 4.4\text{[cm]}/5.13\text{[cm]} = \mathbf{0.858}$ p. 9-12

$\delta = 1 - d'/p = 1 - 2.06\text{[cm]}/7.62\text{[cm]} = \mathbf{0.729}$ p. 9-11

$t_c = ((3.33*B*b')/(\phi*p*F_u))^{0.5} = ((3.33*8.63\text{[T]}*4.4\text{[cm]})/(0.75*7.62\text{[cm]}*4077.78\text{[kg/cm2]}))^{0.5} = \mathbf{2.33}\text{[cm]}$ p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 0.858)))*((2.33\text{[cm]}/1.27\text{[cm]})^2 - 1) =$

1.75 p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (1.27$[cm]/2.33[cm]$)^2*(1 + 0.729) =$ **0.514** p. 9-13

$T_{avail} = 20 * (B*Q) = 20 * (8.63$[T]*0.514) = **88.77**[T] p. 9-10

Gusset

Welds rupture	[Ton/m]	489.33	161.58	D9	0.33	p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*4077.78$[kg/cm2]*2[cm] = **4.89**[T/cm] p. 9-5

$D_{min} = P/(\phi*C*C_1*L) = 56.87$[T]/(0.75*0.408[T/cm]*1*76.2[cm]) = **2.44** tables 8-4..11

HasWeldsOnBothSides → **False**

$R_u = 2 * (0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in]) = 2 * (0.6*4921.46[kg/cm2]$*(2)^{1/2}/2*2.44/16$ [in]) =
1.62[T/cm] p. 9-5

Shear yielding	[Ton]	330.37	107.50	D9	0.33	Eq. J4-3

$A_g = L_p*t_p = 108.77$[cm]*2[cm] = **217.55**[cm2] Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*2531.04$[kg/cm2]*217.55[cm2] = **330.37**[T] Eq. J4-3

Tear out under axial load	[Ton]	495.02	37.15	D9	0.08	Eq. J4-5

$A_{gv} = 2.0*(b - c)*t_p = 2.0*(10.16$[cm] - 3.81[cm])*2[cm] = **25.4**[cm2] Sec. J4-3

$A_{nv} = A_{gv} =$ **25.4**[cm2] Sec. J4-3

$A_{nt} = L*t_p = 76.2$[cm]*2[cm] = **152.4**[cm2] Sec. J4-3

$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*$
min(0.6*4077.78[kg/cm2]*25.4[cm2] + 1*4077.78[kg/cm2]*152.4[cm2], 0.6*2531.04[kg/cm2]*25.4[cm2] + 1*
4077.78[kg/cm2]*152.4[cm2]) = **495.02**[T] Eq. J4-5

Column

Bolt bearing under shear load	[Ton]	867.69	107.50	D9	0.12	Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0,$ 1.00E+32[cm] - 2.06[cm]/2) = **1.00E+32**[cm] Sec. J4.10

$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0,$ 7.62[cm] - 2.06[cm]) = **5.56**[cm] Sec. J4.10

$\phi R_n = 2 * (\phi*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*$
$n_c)$ = 2 * (0.75*(min(1.2*1.00E+32[cm], 2.4*1.9[cm]) + min(1.2*5.56[cm], 2.4*1.9[cm])*(10 - 1))*2.77[cm]*
4569.93[kg/cm2]*1) = **867.69**[T] Eq. J3-6

Ratio **0.66**

Interface between Gusset - Bottom right brace

Connection: Directly welded

DEMANDS

Pu [Ton]	**Description**	**Load type**
-10.67	D1	Design
-14.22	D2	Design
-9.14	D3	Design
-9.14	D4	Design
-9.14	D5	Design
-9.14	D6	Design
-12.31	D7	Design
-12.31	D8	Design
-263.20	D9	Seismic
-9.14	D10	Design
-89.11	D11	Design
-12.31	D12	Design

-6.86	D13	Design
-6.86	D14	Design
-263.20	D15	Seismic
-6.86	D16	Design
-7.62	D17	Design
-10.79	D18	Design
-10.00	D19	Design
-7.62	D20	Design
-7.62	D21	Design
-263.20	D22	Seismic
-7.62	D23	Design
-10.00	D24	Design
-10.00	D25	Design
-263.20	D26	Seismic
-7.62	D27	Design
-4.57	D28	Design
-4.57	D29	Design
-263.20	D30	Seismic
-4.57	D31	Design

DESIGN CHECK

Verification	**Unit**	**Capacity**	**Demand**	**Ctrl EQ**	**Ratio**	**References**
Brace - Directly welded Connection						
Total weld design strength	[Ton]	397.76	263.20	D9	0.66	Eq. J2-4, Eq. J2-6

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] $=$ **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*80$[cm] $=$ **44.9**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]$*44.9$[cm2]$)$ $=$ **198.88**[T] — Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] $=$ **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*80$[cm] $=$ **44.9**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]$*44.9$[cm2]$)$ $=$ **198.88**[T] — Eq. J2-4

$\phi R_n = \phi R_{w1} + \phi R_{w2} = 198.88$[T] $+ 198.88$[T] $=$ **397.76**[T] — Eq. J2-6

Maximum weld force that brace can develop	[Ton]	693.54	263.20	D9	0.38	Eq. J4-4

$L_e = L_t + L_h = 80$[cm] $+ 80$[cm] $=$ **160**[cm]

$A_{nv} = L_e*t_p = 160$[cm]$*1.18$[cm] $=$ **188.98**[cm2] — Sec. J4-2

$\phi R_n = 2 * (\phi*0.60*F_u*A_{nv}) = 2 * (0.75*0.60*4077.78$[kg/cm2]$*188.98$[cm2]$)$ $=$ **693.54**[T] — Eq. J4-4

Gusset						
Maximum weld force that gusset can develop	[Ton]	587.20	263.20	D9	0.45	Eq. J4-4

$L_e = L_t + L_h = 80$[cm] $+ 80$[cm] $=$ **160**[cm]

$A_{nv} = L_e*t_p = 160$[cm]$*2$[cm] $=$ **320**[cm2] — Sec. J4-2

$\phi R_n = \phi*0.60*F_u*A_{nv} = 0.75*0.60*4077.78$[kg/cm2]$*320$[cm2] $=$ **587.2**[T] — Eq. J4-4

Ratio **0.66**

Checks for gusset and brace

REQUIRED RESISTANCE OF BRACED CONNECTIONS

Requirement	**Value** [Ton]
Required tensile strength	274.71
Required compressive strength	263.20

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Slenderness		47.42	--	200.00	✔	AISC 341-10 Sec. F2.5b.

$\lambda_{max} = 200$ AISC 341-10 Sec. F2.5b.

$\lambda_b = L/r = 300[cm]/6.33[cm] = \mathbf{47.42}$

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Local buckling		16.13	0.00	26.24	✔	Seismic Manual Table I-8-1, Seismic Manual Table D1.1

$\lambda = D/t_p = 19.05[cm]/1.18[cm] = \mathbf{16.13}$ Seismic Manual Table I-8-1

$\lambda_{hd} = 0.038*(E/F_y) = 0.038*(2.04E+06[kg/cm2]/2952.88[kg/cm2]) = \mathbf{26.24}$ Seismic Manual Table D1.1

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Gusset plate plastic hinge length (2t)	[cm]	4.00	4.00	8.00	✔	
Weld size	[1/16in]	3	3	6	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} = \mathbf{0.004763}$ table J2.4

$t_p < 1/4\ [in] \rightarrow 1.18[cm] < 1/4\ [in] \rightarrow \mathbf{False}$

$w_{max} = t_p - 1/16\ [in] = 1.18[cm] - 1/16\ [in] = \mathbf{0.0102}$ Sec. J2.2b

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DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace						
Compression	[Ton]	153.82	89.11	D11	0.58	Eq. E3-1

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06[kg/cm2]/(1*300[cm]/6.33[cm])^2 = \mathbf{8949.16}[kg/cm2]$ Eq. E3-4

$F_e >= 0.44*Q*F_y \rightarrow 8949.16[kg/cm2] >= 0.44*1*2952.88[kg/cm2] \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}*2952.88[kg/cm2] = \mathbf{2571.98}[kg/cm2]$ Eq. E7-2

$\phi P_n = \phi*F_{cr}*A_g = 0.9*2571.98[kg/cm2]*66.45[cm2] = \mathbf{153.82}[T]$ Eq. E3-1

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Weld capacity for reinforcement plate	[Ton]	238.66	192.51	D9	0.81	Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46[kg/cm2] = \mathbf{2952.88}[kg/cm2]$ Sec. J2.4

$A_w = (2)^{1/2}/2*D/16\ [in]*L = (2)^{1/2}/2*3/16\ [in]*80[cm] = \mathbf{26.94}[cm2]$ Sec. J2.4

$\phi R_n = 4 * (\phi*F_w*A_w) = 4 * (0.75*2952.88[kg/cm2]*26.94[cm2]) = \mathbf{238.66}[T]$ Eq. J2-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset						
Buckling on the Whitmore section	[Ton]	392.45	263.20	D9	0.67	Eq. E3-1

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06[kg/cm2]/(0.65*52.18[cm]/0.577[cm])^2 = \mathbf{5830.66}[kg/cm2]$ Eq. E3-4

$F_e >= 0.44*Q*F_y \rightarrow 5830.66[kg/cm2] >= 0.44*1*2531.04[kg/cm2] \rightarrow \mathbf{True}$

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2531.04[kg/cm2]/5830.66[kg/cm2])}*2531.04[kg/cm2] = \mathbf{2110.53}[kg/cm2]$ Eq. E7-2

$\phi P_n = \phi*F_{cr}*A_g = 0.9*2110.53[kg/cm2]*206.61[cm2] = \mathbf{392.45}[T]$ Eq. E3-1

Ratio **0.81**

Calculation of the brace interface forces

Load condition :D1

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-10.67[T]/104.1[cm] = \mathbf{-4.49}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-10.67[T]/104.1[cm] = \mathbf{-1.93}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-10.67[T]/104.1[cm] - 0[T] = \mathbf{-3.08}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-10.67[T]/104.1[cm] + 0[T] = \mathbf{-5.44}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-3.08[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.93[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D2

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-14.22[T]/104.1[cm] = \mathbf{-5.99}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-14.22[T]/104.1[cm] = \mathbf{-2.57}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-14.22[T]/104.1[cm] - 0[T] = \mathbf{-4.11}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-14.22[T]/104.1[cm] + 0[T] = \mathbf{-7.24}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-4.11[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.57[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D3

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-9.14[T]/104.1[cm] = \mathbf{-3.85}[T]$ p. 13-5

$H_c = e_c*P/r$ = 18.8[cm]*-9.14[T]/104.1[cm] = **-1.65**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.14[T]/104.1[cm] - 0[T] = **-2.64**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-9.14[T]/104.1[cm] + 0[T] = **-4.66**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.64[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.65[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D4

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-9.14[T]/104.1[cm] = **-3.85**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-9.14[T]/104.1[cm] = **-1.65**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.14[T]/104.1[cm] - 0[T] = **-2.64**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-9.14[T]/104.1[cm] + 0[T] = **-4.66**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.64[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.65[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D5

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-9.14[T]/104.1[cm] = **-3.85**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-9.14[T]/104.1[cm] = **-1.65**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.14[T]/104.1[cm] - 0[T] = **-2.64**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-9.14[T]/104.1[cm] + 0[T] = **-4.66**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.64[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.65[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D6

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-9.14[T]/104.1[cm] = **-3.85**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-9.14[T]/104.1[cm] = **-1.65**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.14[T]/104.1[cm] - 0[T] = **-2.64**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-9.14[T]/104.1[cm] + 0[T] = **-4.66**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.64[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.65[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D7

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-12.31[T]/104.1[cm] = **-5.19**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-12.31[T]/104.1[cm] = **-2.22**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-12.31[T]/104.1[cm] - 0[T] = **-3.56**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-12.31[T]/104.1[cm] + 0[T] = **-6.27**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-3.56[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.22[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D8

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-12.31[T]/104.1[cm] = **-5.19**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-12.31[T]/104.1[cm] = **-2.22**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-12.31[T]/104.1[cm] - 0[T] = **-3.56**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-12.31[T]/104.1[cm] + 0[T] = **-6.27**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-3.56[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.22[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D9

General case	DG29 p. 24-33
$F_e = \pi^2 * E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(1*300$[cm]$/6.33$[cm]$)^2$ = **8949.16**[kg/cm2]	Eq. E3-4
F_e>=0.44*Q*F_y → 8949.16[kg/cm2]>=0.44*1*2952.88[kg/cm2] → **True**	
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}*2952.88$[kg/cm2] = **2571.98**[kg/cm2]	Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.4*170.91[T] = **263.2**[T]	AISC 341-10 Sec. F2.6c.
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm]	p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm]	p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25**	p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = **43.85**[cm]	p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm]	p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm]	p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-263.2[T]/104.1[cm] = **-110.88**[T]	p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-263.2[T]/104.1[cm] = **-47.52**[T]	p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-263.2[T]/104.1[cm] - 0[T] = **-76.1**[T]	p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-263.2[T]/104.1[cm] + 0[T] = **-134.1**[T]	p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-76.1[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = **0**[T*m]	p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-47.52[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m]	p. 13-10

Load condition :D10

General case	DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm]	p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm]	p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25**	p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = **43.85**[cm]	p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm]	p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm]	p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-9.14[T]/104.1[cm] = **-3.85**[T]	p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-9.14[T]/104.1[cm] = **-1.65**[T]	p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-9.14[T]/104.1[cm] - 0[T] = **-2.64**[T]	p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-9.14[T]/104.1[cm] + 0[T] = **-4.66**[T]	p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.64[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = **0**[T*m]	p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.65[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m]	p. 13-10

Load condition :D11

General case	DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm]	p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm]	p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25**	p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/	

$53.04\text{[cm]})^2)/1.25 = \mathbf{43.85}\text{[cm]}$ p. 13-10

$\beta = (K' - K{*}tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}{*}0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha{*}P/r = 43.85\text{[cm]}{*}{-89.11}\text{[T]}/104.1\text{[cm]} = \mathbf{-37.54}\text{[T]}$ p. 13-5

$H_c = e_c{*}P/r = 18.8\text{[cm]}{*}{-89.11}\text{[T]}/104.1\text{[cm]} = \mathbf{-16.09}\text{[T]}$ p. 13-5

$V_b = e_b{*}P/r - \Delta V = 30.1\text{[cm]}{*}{-89.11}\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-25.77}\text{[T]}$ p. 13-5

$V_c = \beta{*}P/r + \Delta V = 53.04\text{[cm]}{*}{-89.11}\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-45.4}\text{[T]}$ p. 13-5

$M_b = \mathrm{abs}(V_b{*}(\alpha - \alpha_{bar})) + \mathrm{abs}(\Delta V{*}\alpha) = \mathrm{abs}(-25.77\text{[T]}{*}(43.85\text{[cm]} - 43.85\text{[cm]})) + \mathrm{abs}(0\text{[T]}{*}43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = \mathrm{abs}(H_c{*}(\beta - \beta_{bar})) = \mathrm{abs}(-16.09\text{[T]}{*}(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D12

General case DG29 p. 24-33

$K = e_b{*}tan\theta - e_c = 30.1\text{[cm]}{*}0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}{*}(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85\text{[cm]}{*}(0.754 + 43.85\text{[cm]}/53.04\text{[cm]}) = \mathbf{69.3}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85\text{[cm]}/53.04\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'{*}tan\theta + K{*}(\alpha_{bar}/\beta_{bar})^2)/D = (69.3\text{[cm]}{*}0.754 + 3.89\text{[cm]}{*}(43.85\text{[cm]}/53.04\text{[cm]})^2)/1.25 = \mathbf{43.85}\text{[cm]}$ p. 13-10

$\beta = (K' - K{*}tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}{*}0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha{*}P/r = 43.85\text{[cm]}{*}{-12.31}\text{[T]}/104.1\text{[cm]} = \mathbf{-5.19}\text{[T]}$ p. 13-5

$H_c = e_c{*}P/r = 18.8\text{[cm]}{*}{-12.31}\text{[T]}/104.1\text{[cm]} = \mathbf{-2.22}\text{[T]}$ p. 13-5

$V_b = e_b{*}P/r - \Delta V = 30.1\text{[cm]}{*}{-12.31}\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-3.56}\text{[T]}$ p. 13-5

$V_c = \beta{*}P/r + \Delta V = 53.04\text{[cm]}{*}{-12.31}\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-6.27}\text{[T]}$ p. 13-5

$M_b = \mathrm{abs}(V_b{*}(\alpha - \alpha_{bar})) + \mathrm{abs}(\Delta V{*}\alpha) = \mathrm{abs}(-3.56\text{[T]}{*}(43.85\text{[cm]} - 43.85\text{[cm]})) + \mathrm{abs}(0\text{[T]}{*}43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = \mathrm{abs}(H_c{*}(\beta - \beta_{bar})) = \mathrm{abs}(-2.22\text{[T]}{*}(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D13

General case DG29 p. 24-33

$K = e_b{*}tan\theta - e_c = 30.1\text{[cm]}{*}0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}{*}(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85\text{[cm]}{*}(0.754 + 43.85\text{[cm]}/53.04\text{[cm]}) = \mathbf{69.3}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85\text{[cm]}/53.04\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'{*}tan\theta + K{*}(\alpha_{bar}/\beta_{bar})^2)/D = (69.3\text{[cm]}{*}0.754 + 3.89\text{[cm]}{*}(43.85\text{[cm]}/53.04\text{[cm]})^2)/1.25 = \mathbf{43.85}\text{[cm]}$ p. 13-10

$\beta = (K' - K{*}tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}{*}0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha{*}P/r = 43.85\text{[cm]}{*}{-6.86}\text{[T]}/104.1\text{[cm]} = \mathbf{-2.89}\text{[T]}$ p. 13-5

$H_c = e_c{*}P/r = 18.8\text{[cm]}{*}{-6.86}\text{[T]}/104.1\text{[cm]} = \mathbf{-1.24}\text{[T]}$ p. 13-5

$V_b = e_b{*}P/r - \Delta V = 30.1\text{[cm]}{*}{-6.86}\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-1.98}\text{[T]}$ p. 13-5

$V_c = \beta{*}P/r + \Delta V = 53.04\text{[cm]}{*}{-6.86}\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-3.49}\text{[T]}$ p. 13-5

$M_b = \mathrm{abs}(V_b{*}(\alpha - \alpha_{bar})) + \mathrm{abs}(\Delta V{*}\alpha) = \mathrm{abs}(-1.98\text{[T]}{*}(43.85\text{[cm]} - 43.85\text{[cm]})) + \mathrm{abs}(0\text{[T]}{*}43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = \mathrm{abs}(H_c{*}(\beta - \beta_{bar})) = \mathrm{abs}(-1.24\text{[T]}{*}(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D14

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-6.86[T]/104.1[cm] = \mathbf{-2.89}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-6.86[T]/104.1[cm] = \mathbf{-1.24}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-6.86[T]/104.1[cm] - 0[T] = \mathbf{-1.98}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-6.86[T]/104.1[cm] + 0[T] = \mathbf{-3.49}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.98[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.24[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D15

General case DG29 p. 24-33

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06[kg/cm2]/(1*300[cm]/6.33[cm])^2 = \mathbf{8949.16}[kg/cm2]$ Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 8949.16[kg/cm2]>=0.44*1*2952.88[kg/cm2] \rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}*2952.88[kg/cm2] = \mathbf{2571.98}[kg/cm2]$ Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n = 1*1.1*1.4*170.91[T] = \mathbf{263.2}[T]$ AISC 341-10 Sec. F2.6c.

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-263.2[T]/104.1[cm] = \mathbf{-110.88}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-263.2[T]/104.1[cm] = \mathbf{-47.52}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-263.2[T]/104.1[cm] - 0[T] = \mathbf{-76.1}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-263.2[T]/104.1[cm] + 0[T] = \mathbf{-134.1}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-76.1[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-47.52[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D16

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/$

53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-6.86[T]/104.1[cm] = **-2.89**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-6.86[T]/104.1[cm] = **-1.24**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-6.86[T]/104.1[cm] - 0[T] = **-1.98**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-6.86[T]/104.1[cm] + 0[T] = **-3.49**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.98[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.24[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D17

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-7.62[T]/104.1[cm] = **-3.21**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-7.62[T]/104.1[cm] = **-1.38**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-7.62[T]/104.1[cm] - 0[T] = **-2.2**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-7.62[T]/104.1[cm] + 0[T] = **-3.88**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-2.2[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.38[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D18

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-10.79[T]/104.1[cm] = **-4.55**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-10.79[T]/104.1[cm] = **-1.95**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-10.79[T]/104.1[cm] - 0[T] = **-3.12**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-10.79[T]/104.1[cm] + 0[T] = **-5.5**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-3.12[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.95[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D19

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ — p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-10[T]/104.1[cm] = \mathbf{-4.21}[T]$ — p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-10[T]/104.1[cm] = \mathbf{-1.81}[T]$ — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-10[T]/104.1[cm] - 0[T] = \mathbf{-2.89}[T]$ — p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-10[T]/104.1[cm] + 0[T] = \mathbf{-5.09}[T]$ — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.89[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.81[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ — p. 13-10

Load condition :D20

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ — p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-7.62[T]/104.1[cm] = \mathbf{-3.21}[T]$ — p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-7.62[T]/104.1[cm] = \mathbf{-1.38}[T]$ — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1[cm]*-7.62[T]/104.1[cm] - 0[T] = \mathbf{-2.2}[T]$ — p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04[cm]*-7.62[T]/104.1[cm] + 0[T] = \mathbf{-3.88}[T]$ — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]*43.85[cm]) = \mathbf{0}[T*m]$ — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.38[T]*(53.04[cm] - 53.04[cm])) = \mathbf{0}[T*m]$ — p. 13-10

Load condition :D21

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1[cm]*0.754 - 18.8[cm] = \mathbf{3.89}[cm]$ — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = \mathbf{69.3}[cm]$ — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = \mathbf{1.25}$ — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/53.04[cm])^2)/1.25 = \mathbf{43.85}[cm]$ — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3[cm] - 3.89[cm]*0.754)/1.25 = \mathbf{53.04}[cm]$ — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)^{1/2} = \mathbf{104.1}[cm]$ — p. 13-5

$H_b = \alpha*P/r = 43.85[cm]*-7.62[T]/104.1[cm] = \mathbf{-3.21}[T]$ — p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-7.62[T]/104.1[cm] = \mathbf{-1.38}[T]$ — p. 13-5

$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-7.62[T]/104.1[cm] - 0[T] = **-2.2**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-7.62[T]/104.1[cm] + 0[T] = **-3.88**[T] p. 13-5
$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha)$ = abs(-2.2[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = \text{abs}(H_c*(\beta - \beta_{bar}))$ = abs(-1.38[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D22

General case DG29 p. 24-33
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2$*2.04E+06[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
F_e>=0.44*$Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*2952.88[kg/cm2] $\rightarrow$ **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y$ = 0.658$^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}$*2952.88[kg/cm2] = **2571.98**[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.4*170.91[T] = **263.2**[T] AISC 341-10 Sec. F2.6c.
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-263.2[T]/104.1[cm] = **-110.88**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-263.2[T]/104.1[cm] = **-47.52**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-263.2[T]/104.1[cm] - 0[T] = **-76.1**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-263.2[T]/104.1[cm] + 0[T] = **-134.1**[T] p. 13-5
$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha)$ = abs(-76.1[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = \text{abs}(H_c*(\beta - \beta_{bar}))$ = abs(-47.52[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D23

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 30.1[cm]*0.754 - 18.8[cm] = **3.89**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 43.85[cm]*(0.754 + 43.85[cm]/53.04[cm]) = **69.3**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = (0.754)^2 + (43.85[cm]/53.04[cm])^2 = **1.25** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (69.3[cm]*0.754 + 3.89[cm]*(43.85[cm]/ 53.04[cm])^2)/1.25 = **43.85**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (69.3[cm] - 3.89[cm]*0.754)/1.25 = **53.04**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((43.85[cm] + 18.8[cm])^2 + (53.04[cm] + 30.1[cm])^2)$^{1/2}$ = **104.1**[cm] p. 13-5
$H_b = \alpha*P/r$ = 43.85[cm]*-7.62[T]/104.1[cm] = **-3.21**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-7.62[T]/104.1[cm] = **-1.38**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 30.1[cm]*-7.62[T]/104.1[cm] - 0[T] = **-2.2**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 53.04[cm]*-7.62[T]/104.1[cm] + 0[T] = **-3.88**[T] p. 13-5
$M_b = \text{abs}(V_b*(\alpha - \alpha_{bar})) + \text{abs}(\Delta V*\alpha)$ = abs(-2.2[T]*(43.85[cm] - 43.85[cm])) + abs(0[T]* 43.85[cm]) = **0**[T*m] p. 13-10
$M_c = \text{abs}(H_c*(\beta - \beta_{bar}))$ = abs(-1.38[T]*(53.04[cm] - 53.04[cm])) = **0**[T*m] p. 13-10

Load condition :D24

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$)$ = **69.3**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25$ = **43.85**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3$[cm] $- 3.89$[cm]$*0.754)/1.25$ = **53.04**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85$[cm] $+ 18.8$[cm]$)^2 + (53.04$[cm] $+ 30.1$[cm]$)^2)^{1/2}$ = **104.1**[cm] p. 13-5

$H_b = \alpha*P/r = 43.85$[cm]$*-10$[T]$/104.1$[cm] = **-4.21**[T] p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-10$[T]$/104.1$[cm] = **-1.81**[T] p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-10$[T]$/104.1$[cm] $- 0$[T] = **-2.89**[T] p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04$[cm]$*-10$[T]$/104.1$[cm] $+ 0$[T] = **-5.09**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.89$[T]$*(43.85$[cm] $- 43.85$[cm]$)) + abs(0$[T]$*43.85$[cm]$)$ = **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.81$[T]$*(53.04$[cm] $- 53.04$[cm]$))$ = **0**[T*m] p. 13-10

Load condition :D25

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$)$ = **69.3**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25$ = **43.85**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3$[cm] $- 3.89$[cm]$*0.754)/1.25$ = **53.04**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85$[cm] $+ 18.8$[cm]$)^2 + (53.04$[cm] $+ 30.1$[cm]$)^2)^{1/2}$ = **104.1**[cm] p. 13-5

$H_b = \alpha*P/r = 43.85$[cm]$*-10$[T]$/104.1$[cm] = **-4.21**[T] p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-10$[T]$/104.1$[cm] = **-1.81**[T] p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-10$[T]$/104.1$[cm] $- 0$[T] = **-2.89**[T] p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04$[cm]$*-10$[T]$/104.1$[cm] $+ 0$[T] = **-5.09**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.89$[T]$*(43.85$[cm] $- 43.85$[cm]$)) + abs(0$[T]$*43.85$[cm]$)$ = **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.81$[T]$*(53.04$[cm] $- 53.04$[cm]$))$ = **0**[T*m] p. 13-10

Load condition :D26

General case DG29 p. 24-33

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(1*300$[cm]$/6.33$[cm]$)^2$ = **8949.16**[kg/cm2] Eq. E3-4

$F_e>=0.44*Q*F_y \rightarrow 8949.16$[kg/cm2]$>=0.44*1*2952.88$[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}*2952.88$[kg/cm2] = **2571.98**[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n = 1*1.1*1.4*170.91$[T] = **263.2**[T] AISC 341-10 Sec. F2.6c.

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] = **3.89**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$)$ = **69.3**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2$ = **1.25** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25$ = **43.85**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 43.85\text{[cm]}*-263.2\text{[T]}/104.1\text{[cm]} = \mathbf{-110.88}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-263.2\text{[T]}/104.1\text{[cm]} = \mathbf{-47.52}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-263.2\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-76.1}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04\text{[cm]}*-263.2\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-134.1}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-76.1\text{[T]}*(43.85\text{[cm]} - 43.85\text{[cm]})) + abs(0\text{[T]}*43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-47.52\text{[T]}*(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D27

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85\text{[cm]}*(0.754 + 43.85\text{[cm]}/53.04\text{[cm]}) = \mathbf{69.3}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85\text{[cm]}/53.04\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3\text{[cm]}*0.754 + 3.89\text{[cm]}*(43.85\text{[cm]}/53.04\text{[cm]})^2)/1.25 = \mathbf{43.85}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 43.85\text{[cm]}*-7.62\text{[T]}/104.1\text{[cm]} = \mathbf{-3.21}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-7.62\text{[T]}/104.1\text{[cm]} = \mathbf{-1.38}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-7.62\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-2.2}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04\text{[cm]}*-7.62\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-3.88}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.2\text{[T]}*(43.85\text{[cm]} - 43.85\text{[cm]})) + abs(0\text{[T]}*43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.38\text{[T]}*(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D28

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{3.89}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85\text{[cm]}*(0.754 + 43.85\text{[cm]}/53.04\text{[cm]}) = \mathbf{69.3}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85\text{[cm]}/53.04\text{[cm]})^2 = \mathbf{1.25}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3\text{[cm]}*0.754 + 3.89\text{[cm]}*(43.85\text{[cm]}/53.04\text{[cm]})^2)/1.25 = \mathbf{43.85}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 43.85\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} = \mathbf{-1.93}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} = \mathbf{-0.826}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-1.32}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-2.33}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.32\text{[T]}*(43.85\text{[cm]} - 43.85\text{[cm]})) + abs(0\text{[T]}*43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-0.826\text{[T]}*(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D29

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$) =$ **69.3**[cm] — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2 =$ **1.25** — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25 =$ **43.85**[cm] — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **53.04**[cm] — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85$[cm] $+ 18.8$[cm]$)^2 + (53.04$[cm] $+ 30.1$[cm]$)^2)^{1/2} =$ **104.1**[cm] — p. 13-5

$H_b = \alpha*P/r = 43.85$[cm]$*-4.57$[T]$/104.1$[cm] $=$ **-1.93**[T] — p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-4.57$[T]$/104.1$[cm] $=$ **-0.826**[T] — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-4.57$[T]$/104.1$[cm] $- 0$[T] $=$ **-1.32**[T] — p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04$[cm]$*-4.57$[T]$/104.1$[cm] $+ 0$[T] $=$ **-2.33**[T] — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.32$[T]$*(43.85$[cm] $- 43.85$[cm]$)) + abs(0$[T]$*43.85$[cm]$) =$ **0**[T*m] — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-0.826$[T]$*(53.04$[cm] $- 53.04$[cm]$)) =$ **0**[T*m] — p. 13-10

Load condition :D30

General case — DG29 p. 24-33

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(1*300$[cm]$/6.33$[cm]$)^2 =$ **8949.16**[kg/cm2] — Eq. E3-4

$F_e >= 0.44*Q*F_y \rightarrow 8949.16$[kg/cm2]$>=0.44*1*2952.88$[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*2952.88[kg/cm2]/8949.16[kg/cm2])}*2952.88$[kg/cm2] $=$ **2571.98**[kg/cm2] — Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n = 1*1.1*1.4*170.91$[T] $=$ **263.2**[T] — AISC 341-10 Sec. F2.6c.

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$) =$ **69.3**[cm] — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2 =$ **1.25** — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25 =$ **43.85**[cm] — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3$[cm] $- 3.89$[cm]$*0.754)/1.25 =$ **53.04**[cm] — p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85$[cm] $+ 18.8$[cm]$)^2 + (53.04$[cm] $+ 30.1$[cm]$)^2)^{1/2} =$ **104.1**[cm] — p. 13-5

$H_b = \alpha*P/r = 43.85$[cm]$*-263.2$[T]$/104.1$[cm] $=$ **-110.88**[T] — p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-263.2$[T]$/104.1$[cm] $=$ **-47.52**[T] — p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1$[cm]$*-263.2$[T]$/104.1$[cm] $- 0$[T] $=$ **-76.1**[T] — p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04$[cm]$*-263.2$[T]$/104.1$[cm] $+ 0$[T] $=$ **-134.1**[T] — p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-76.1$[T]$*(43.85$[cm] $- 43.85$[cm]$)) + abs(0$[T]$*43.85$[cm]$) =$ **0**[T*m] — p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-47.52$[T]$*(53.04$[cm] $- 53.04$[cm]$)) =$ **0**[T*m] — p. 13-10

Load condition :D31

General case — DG29 p. 24-33

$K = e_b*tan\theta - e_c = 30.1$[cm]$*0.754 - 18.8$[cm] $=$ **3.89**[cm] — p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 43.85$[cm]$*(0.754 + 43.85$[cm]$/53.04$[cm]$) =$ **69.3**[cm] — p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (43.85$[cm]$/53.04$[cm]$)^2 =$ **1.25** — p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (69.3$[cm]$*0.754 + 3.89$[cm]$*(43.85$[cm]$/53.04$[cm]$)^2)/1.25 =$ **43.85**[cm] — p. 13-10

$\beta = (K' - K*tan\theta)/D = (69.3\text{[cm]} - 3.89\text{[cm]}*0.754)/1.25 = \mathbf{53.04}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((43.85\text{[cm]} + 18.8\text{[cm]})^2 + (53.04\text{[cm]} + 30.1\text{[cm]})^2)^{1/2} = \mathbf{104.1}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 43.85\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} = \mathbf{-1.93}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} = \mathbf{-0.826}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 30.1\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} - 0\text{[T]} = \mathbf{-1.32}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 53.04\text{[cm]}*-4.57\text{[T]}/104.1\text{[cm]} + 0\text{[T]} = \mathbf{-2.33}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.32\text{[T]}*(43.85\text{[cm]} - 43.85\text{[cm]})) + abs(0\text{[T]}*43.85\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-0.826\text{[T]}*(53.04\text{[cm]} - 53.04\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Lower right gusset interface - beam

Directly welded

DEMANDS

	Beam			Column			
Description	**Ru** [Ton]	**Pu** [Ton]	**Mu** [Ton*m]	**Pu** [Ton]	**Mu22** [Ton*m]	**Mu33** [Ton*m]	**Load type**
D1	-4.49	-3.08	0.00	0.00	0.00	0.00	Design
D2	-5.99	-4.11	0.00	0.00	0.00	0.00	Design
D3	-3.85	-2.64	0.00	0.00	0.00	0.00	Design
D4	-3.85	-2.64	0.00	0.00	0.00	0.00	Design
D5	-3.85	-2.64	0.00	0.00	0.00	0.00	Design
D6	-3.85	-2.64	0.00	0.00	0.00	0.00	Design
D7	-5.19	-3.56	0.00	0.00	0.00	0.00	Design
D8	-5.19	-3.56	0.00	0.00	0.00	0.00	Design
D9	-110.88	-76.10	0.00	0.00	0.00	0.00	Seismic
D10	-3.85	-2.64	0.00	0.00	0.00	0.00	Design
D11	-37.54	-25.77	0.00	0.00	0.00	0.00	Design
D12	-5.19	-3.56	0.00	0.00	0.00	0.00	Design
D13	-2.89	-1.98	0.00	0.00	0.00	0.00	Design
D14	-2.89	-1.98	0.00	0.00	0.00	0.00	Design
D15	-110.88	-76.10	0.00	0.00	0.00	0.00	Seismic
D16	-2.89	-1.98	0.00	0.00	0.00	0.00	Design
D17	-3.21	-2.20	0.00	0.00	0.00	0.00	Design
D18	-4.55	-3.12	0.00	0.00	0.00	0.00	Design
D19	-4.21	-2.89	0.00	0.00	0.00	0.00	Design
D20	-3.21	-2.20	0.00	0.00	0.00	0.00	Design
D21	-3.21	-2.20	0.00	0.00	0.00	0.00	Design
D22	-110.88	-76.10	0.00	0.00	0.00	0.00	Seismic
D23	-3.21	-2.20	0.00	0.00	0.00	0.00	Design
D24	-4.21	-2.89	0.00	0.00	0.00	0.00	Design
D25	-4.21	-2.89	0.00	0.00	0.00	0.00	Design
D26	-110.88	-76.10	0.00	0.00	0.00	0.00	Seismic
D27	-3.21	-2.20	0.00	0.00	0.00	0.00	Design
D28	-1.93	-1.32	0.00	0.00	0.00	0.00	Design
D29	-1.93	-1.32	0.00	0.00	0.00	0.00	Design
D30	-110.88	-76.10	0.00	0.00	0.00	0.00	Seismic
D31	-1.93	-1.32	0.00	0.00	0.00	0.00	Design

DESIGN CHECK

Verification	**Unit**	**Capacity**	**Demand**	**Ctrl EQ**	**Ratio**	**References**
<u>Gusset</u>						
Shear yielding	[Ton]	243.23	110.88	D9	0.46	Eq. J4-3

$A_g = L_p*t_p = 80.08\text{[cm]}*2\text{[cm]} = \mathbf{160.16}\text{[cm2]}$ Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*2531.04$[kg/cm2]$*160.16$[cm2] = **243.23**[T] — Eq. J4-3

Gusset edge tension stress	[kg/m2]	2.277934E07	4751635.00	D9	0.21	J4-1

$\phi F_n = \phi*F_y = 0.9*2531.04$[kg/cm2] = **2277.93**[kg/cm2] — J4-1

$f_{ua} = V_b/(t_p*l) = -76.1$[T]$/(2$[cm]$*80.08$[cm]$)$ = **-475.16**[kg/cm2] — 9

Gusset edge shear stress	[kg/m2]	1.518622E07	6922613.00	D9	0.46	J4-1

$\phi F_n = \phi*0.6*F_y = 1*0.6*2531.04$[kg/cm2] = **1518.62**[kg/cm2] — J4-1

$f_{uv} = H_b/(t_p*l) = -110.88$[T]$/(2$[cm]$*80.08$[cm]$)$ = **-692.26**[kg/cm2] — 9

Weld capacity	[Ton]	241.46	168.10	D9	0.70	Tables 8-4 .. 8-11

$\phi R_n = 2 * (\phi*C*C_1*D*L) = 2 * (0.75*0.402$[T/cm]$*1*5*80.08$[cm]$)$ = **241.46**[T] — Tables 8-4 .. 8-11

$f_{ua} = V_b/l = -76.1$[T]$/80.08$[cm] = **-0.95**[T/cm] — 9

$f_{uv} = H_b/l = -110.88$[T]$/80.08$[cm] = **-1.38**[T/cm] — 9

$f_{ub} = M_b/(l^2/6) = 0$[T*m]$/(80.08$[cm]$^2/6)$ = **0**[T/cm] — 9

$f_{uPeak} = ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2} = ((0.95$[T/cm] $+ 0$[T/cm]$)^2 + 1.38$[T/cm]$^2)^{1/2}$ = **1.68**[T/cm] — 9

$f_{uAve} = 0.5*(((f_{ua} - f_{ub})^2 + f_{uv}^2)^{1/2} + ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2}) = 0.5*(((0.95$[T/cm] $- 0$[T/cm]$)^2 + 1.38$[T/cm]$^2)^{1/2} + ((0.95$[T/cm] $+ 0$[T/cm]$)^2 + 1.38$[T/cm]$^2)^{1/2})$ = **1.68**[T/cm] — 9

$f_{uWeld} = l*\max(f_{uPeak}, 1.25*f_{uAve}) = 80.08$[cm]$*\max(1.68$[T/cm], $1.25*1.68$[T/cm]$)$ = **168.1**[T] — 9

Beam

Weld block shear	[Ton]	237.28	110.88	D9	0.47	Eq. J4-5

$A_{gv} = l*t_w = 80.08$[cm]$*1.09$[cm] = **87.47**[cm2] — Sec. J4.3

$A_{gt} = (A_g - t_w*T)/2 = (117.42$[cm2] $- 1.09$[cm]$*54.66$[cm]$)/2$ = **28.86**[cm2] — 8

$A_{nv} = A_{gv}$ = **87.47**[cm2] — Sec. J4.3

$A_{nt} = A_{gt}$ = **28.86**[cm2] — Sec. J4.3

$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*\min(0.6*4569.93$[kg/cm2]$*87.47$[cm2] $+ 1*4569.93$[kg/cm2]$*28.86$[cm2], $0.6*3515.33$[kg/cm2]$*87.47$[cm2] $+ 1*4569.93$[kg/cm2]$*28.86$[cm2]$)$ = **237.28**[T] — Eq. J4-5

Web crippling	[Ton]	247.23	76.10	D9	0.31	Eq. J10-4, Eq. B-1, Appendix B, DG29

IsBeamReaction → **False**

$l_b = N$ = **80.08**[cm] — Sec. J10-2

$\phi R_n = \phi*0.80*t_w^2*(1 + 3*(N/d)*(t_w/t_f)^{1.5})*(E*F_{yw}*t_f/t_w)^{1/2} = 0.75*0.80*1.09$[cm]$^2*(1 + 3*(80.08$[cm]$/60.2$[cm]$)*(1.09$[cm]$/1.5$[cm]$)^{1.5})*(2.04E+06$[kg/cm2]$*3515.33$[kg/cm2]$*1.5$[cm]$/1.09$[cm]$)^{1/2}$ = **247.23**[T] — Eq. J10-4

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = -76.1$[T] $+ ((4*0$[T*m]$)/80.08$[cm]$)$ = **-76.1**[T] — Eq. B-1, Appendix B, DG29

Local web yielding	[Ton]	334.04	76.10	D9	0.23	Eq. J10-3, Eq. B-1, Appendix B, DG29

IsBeamReaction → **False**

$l_b = N =$ **80.08**[cm] — Sec. J10-2

$IsMemberEnd \rightarrow$ **True**

$\phi R_n = \phi^*(2.5^*k + l_b)^*F_{yw}{}^*t_w = 1^*(2.5^*2.77$[cm] + 80.08[cm])*3515.33[kg/cm2]*1.09[cm] = **334.04**[T] — Eq. J10-3

$N_{eq} = V_{ub} + ((4^*M_{ub})/L_p) = -76.1$[T] + ((4*0[T*m])/80.08[cm]) = **-76.1**[T] — Eq. B-1, Appendix B, DG29

Ratio	**0.70**

Lower right gusset interface - column

Angles

DEMANDS

Description	Ru [Ton]	Pu [Ton]	Load type
D1	-5.44	-1.93	Design
D2	-7.24	-2.57	Design
D3	-4.66	-1.65	Design
D4	-4.66	-1.65	Design
D5	-4.66	-1.65	Design
D6	-4.66	-1.65	Design
D7	-6.27	-2.22	Design
D8	-6.27	-2.22	Design
D9	-134.10	-47.52	Seismic
D10	-4.66	-1.65	Design
D11	-45.40	-16.09	Design
D12	-6.27	-2.22	Design
D13	-3.49	-1.24	Design
D14	-3.49	-1.24	Design
D15	-134.10	-47.52	Seismic
D16	-3.49	-1.24	Design
D17	-3.88	-1.38	Design
D18	-5.50	-1.95	Design
D19	-5.09	-1.81	Design
D20	-3.88	-1.38	Design
D21	-3.88	-1.38	Design
D22	-134.10	-47.52	Seismic
D23	-3.88	-1.38	Design
D24	-5.09	-1.81	Design
D25	-5.09	-1.81	Design
D26	-134.10	-47.52	Seismic
D27	-3.88	-1.38	Design
D28	-2.33	-0.83	Design
D29	-2.33	-0.83	Design
D30	-134.10	-47.52	Seismic
D31	-2.33	-0.83	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Angle (Gusset side)</u>						
Weld size	[1/16in]	6	3	7	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} =$ **0.004763** — table J2.4

t_p<1/4 [in] $\rightarrow$ 1.27[cm]<1/4 [in] $\rightarrow$ **False**

$w_{max} = t_p$ - 1/16 [in] = 1.27[cm] - 1/16 [in] = **0.0111** Sec. J2.2b

Angle (Column side)

Vertical edge distance	[cm]	3.81	2.54	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] Tables J3.4, J3.5

Horizontal edge distance	[cm]	4.17	2.54	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] Tables J3.4, J3.5

Vertical center-to-center spacing (pitch)	[cm]	7.62	5.08	30.48	✔	Sec. J3.3, Sec. J3.5

s_{min} = 8/3*d = 8/3*1.9[cm] = **5.08**[cm] Sec. J3.3

IsCorrosionConsidered → **False**

s_{max} = min(24*t_p, 12 [in]) = min(24*1.27[cm], 12 [in]) = **30.48**[cm] Sec. J3.5

Column

Horizontal edge distance	[cm]	12.33	2.54	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2$ = 2.54[cm] + 0[cm] = **2.54**[cm] Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Angle (Gusset side)

Weld capacity	[Ton]	329.96	142.27	D9	0.43	Tables 8-4 .. 8-11

ϕR_n = 2 * (ϕ*C*C_1*D*L) = 2 * (0.75*0.401[T/cm]*1*6*91.44[cm]) = **329.96**[T] Tables 8-4 .. 8-11

Shear yielding	[Ton]	352.71	134.10	D9	0.38	Eq. J4-3

$A_g = L_p$*t_p = 91.44[cm]*1.27[cm] = **116.13**[cm2] Sec. D3-1

ϕR_n = 2 * (ϕ*0.60*F_y*A_g) = 2 * (1*0.60*2531.04[kg/cm2]*116.13[cm2]) = **352.71**[T] Eq. J4-3

Angle (Column side)

Bolts shear	[Ton]	194.87	134.10	D9	0.69	Tables (7-1..14)

ϕR_n = ϕ*F_{nv}*A_b = 0.75*3796.58[kg/cm2]*2.85[cm2] = **8.12**[T] Eq. J3-1

ϕR_n = 2 * (C*ϕR_n) = 2 * (12*8.12[T]) = **194.87**[T] Tables (7-1..14)

Bolt bearing under shear load	[Ton]	416.57	134.10	D9	0.32	p. 7-18, Sec. J3.10

$L_{c\text{-}end}$ = Max(0.0, L_e - d_h/2) = Max(0.0, 3.81[cm] - 2.06[cm]/2) = **2.78**[cm] Sec. J4.10

$L_{c\text{-}spa}$ = Max(0.0, s - d_h) = Max(0.0, 7.62[cm] - 2.06[cm]) = **5.56**[cm] Sec. J4.10

ϕR_n = 2 * (ϕ*(C/(n_c*n))*(min(k_1*l_c, k_2*d) + min(k_1*$L_{c\text{-}spa}$, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.75*(12/(1*12))*(min(1.2*2.78[cm], 2.4*1.9[cm]) + min(1.2*5.56[cm], 2.4* 1.9[cm])*(12 - 1))*1.27[cm]*4077.78[kg/cm2]*1) = **416.57**[T] p. 7-18, Sec. J3.10

Shear yielding	[Ton]	352.71	134.10	D9	0.38	Eq. J4-3

$A_g = L_p*t_p = 91.44\text{[cm]}*1.27\text{[cm]} = \mathbf{116.13}\text{[cm2]}$ — Sec. D3-1

$\phi R_n = 2 * (\phi*0.60*F_y*A_g) = 2 * (1*0.60*2531.04\text{[kg/cm2]}*116.13\text{[cm2]}) = \mathbf{352.71}\text{[T]}$ — Eq. J4-3

Shear rupture | [Ton] | 301.89 | 134.10 | D9 | 0.44 | Eq. J4-4

$L_h = d_h + 1/16\text{ [in]} = 2.06\text{[cm]} + 1/16\text{ [in]} = \mathbf{2.22}\text{[cm]}$ — Sec. D3-2

$L_e = L - n*L_h = 91.44\text{[cm]} - 12*2.22\text{[cm]} = \mathbf{64.77}\text{[cm]}$ — DG4 Eq. 3-13

$A_{nv} = L_e*t_p = 64.77\text{[cm]}*1.27\text{[cm]} = \mathbf{82.26}\text{[cm2]}$ — Sec. J4-2

$\phi R_n = 2 * (\phi*0.60*F_u*A_{nv}) = 2 * (0.75*0.60*4077.78\text{[kg/cm2]}*82.26\text{[cm2]}) = \mathbf{301.89}\text{[T]}$ — Eq. J4-4

Block shear | [Ton] | 277.31 | 134.10 | D9 | 0.48 | Eq. J4-5

$dh_h = d_h + 1/16\text{ [in]} = 2.06\text{[cm]} + 1/16\text{ [in]} = \mathbf{2.22}\text{[cm]}$ — Sec. D3-2

$dh_v = d_h + 1/16\text{ [in]} = 2.06\text{[cm]} + 1/16\text{ [in]} = \mathbf{2.22}\text{[cm]}$ — Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (4.17\text{[cm]} + (1 - 1)*7.62\text{[cm]} - (1 - 0.5)* 2.22\text{[cm]})*1.27\text{[cm]} = \mathbf{3.89}\text{[cm2]}$ — Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (3.81\text{[cm]} + (12 - 1)*7.62\text{[cm]})*1.27\text{[cm]} = \mathbf{111.29}\text{[cm2]}$ — Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (3.81\text{[cm]} + (12 - 1)*(7.62\text{[cm]} - 2.22\text{[cm]}) - 2.22\text{[cm]}/2)*1.27\text{[cm]} = \mathbf{78.83}\text{[cm2]}$ — Sec. J4-3

$IsStressUniform \rightarrow \mathbf{True}$

$U_{bs} = 1$ — Sec. J4-3

$\phi R_n = 2 * (\phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) = 2 * (0.75*\min(0.6*4077.78\text{[kg/cm2]}*78.83\text{[cm2]} + 1*4077.78\text{[kg/cm2]}*3.89\text{[cm2]}, 0.6*2531.04\text{[kg/cm2]}* 111.29\text{[cm2]} + 1*4077.78\text{[kg/cm2]}*3.89\text{[cm2]})) = \mathbf{277.31}\text{[T]}$ — Eq. J4-5

Resulting tension capacity due prying action | [Ton] | 106.52 | 0.00 | D1 | 0.00 | p. 9-11, p. 9-10

$\phi R_n = \phi*F_{nt}*A_b = 0.75*6327.63\text{[kg/cm2]}*2.85\text{[cm2]} = \mathbf{13.53}\text{[T]}$ — Eq. J3-1

$\phi R_n = \phi*F_{nt}*A_b = 0.75*6327.63\text{[kg/cm2]}*2.85\text{[cm2]} = \mathbf{13.53}\text{[T]}$ — Eq. J3-1

$p_{inner} = \min(p, s, 2*b) = \min(7.62\text{[cm]}, 7.62\text{[cm]}, 2*5.35\text{[cm]}) = \mathbf{7.62}\text{[cm]}$ — p. 9-11

$p_{outer} = \min(p, s, 2*b) = \min(7.62\text{[cm]}, 7.62\text{[cm]}, 2*5.35\text{[cm]}) = \mathbf{7.62}\text{[cm]}$ — p. 9-11

$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(4.17\text{[cm]} + 1.9\text{[cm]}/2, 1.25*5.35\text{[cm]} + 1.9\text{[cm]}/2) = \mathbf{5.13}\text{[cm]}$ — p. 9-12

$b' = b - d/2 = 5.35\text{[cm]} - 1.9\text{[cm]}/2 = \mathbf{4.4}\text{[cm]}$ — p. 9-12

$\rho = b'/a' = 4.4\text{[cm]}/5.13\text{[cm]} = \mathbf{0.858}$ — p. 9-12

$\delta = 1 - d'/p = 1 - 2.06\text{[cm]}/7.62\text{[cm]} = \mathbf{0.729}$ — p. 9-11

$t_c = ((3.33*B*b')/(\phi*p*F_u))^{0.5} = ((3.33*13.53\text{[T]}*4.4\text{[cm]})/(0.75*7.62\text{[cm]}*4077.78\text{[kg/cm2]}))^{0.5} = \mathbf{2.92}\text{[cm]}$ — p. 9-12

$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.729*(1 + 0.858)))*((2.92\text{[cm]}/1.27\text{[cm]})^2 - 1) = \mathbf{3.15}$ — p. 9-13

$Q = (t_p/t_c)^2*(1 + \delta) = (1.27\text{[cm]}/2.92\text{[cm]})^2*(1 + 0.729) = \mathbf{0.328}$ — p. 9-13

$T_{avail} = 24 * (B*Q) = 24 * (13.53\text{[T]}*0.328) = \mathbf{106.52}\text{[T]}$ — p. 9-10

<u>Gusset</u>

Welds rupture | [Ton/m] | 489.33 | 171.51 | D9 | 0.35 | p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*4077.78\text{[kg/cm2]}*2\text{[cm]} = \mathbf{4.89}\text{[T/cm]}$ — p. 9-5

$D_{min} = P/(\phi*C*C_1*L) = 71.14\text{[T]}/(0.75*0.401\text{[T/cm]}*1*91.44\text{[cm]}) = \mathbf{2.59}$ — tables 8-4..11

$HasWeldsOnBothSides \rightarrow \mathbf{False}$

$R_u = 2 * (0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16\text{ [in]}) = 2 * (0.6*4921.46\text{[kg/cm2]}*(2)^{1/2}/2*2.59/16\text{ [in]}) = \mathbf{1.72}\text{[T/cm]}$ — p. 9-5

Shear yielding | [Ton] | 322.17 | 134.10 | D9 | 0.42 | Eq. J4-3

$A_g = L_p * t_p = 106.07$[cm]$*2$[cm] $=$ **212.15**[cm2] Sec. D3-1

$\phi R_n = \phi * 0.60 * F_y * A_g = 1*0.60*2531.04$[kg/cm2]$*212.15$[cm2] $=$ **322.17**[T] Eq. J4-3

Column

Bolt bearing under shear load	[Ton]	1041.23	134.10	D9	0.13	Eq. J3-6

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 1.00E+32$[cm] $- 2.06$[cm]$/2) =$ **1.00E+32**[cm] Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 7.62$[cm] $- 2.06$[cm]$) =$ **5.56**[cm] Sec. J4.10

$\phi R_n = 2 * (\phi*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*$
$n_c) = 2 * (0.75*(\min(1.2*1.00E+32$[cm]$, 2.4*1.9$[cm]$) + \min(1.2*5.56$[cm]$, 2.4*1.9$[cm]$)*(12 - 1))*2.77$[cm]$*$
4569.93[kg/cm2]$*1) =$ **1041.23**[T] Eq. J3-6

Web crippling	[Ton]	1456.60	47.52	D9	0.03	Eq. J10-4

IsBeamReaction → **False**

$l_b = N =$ **167.64**[cm] Sec. J10-2

$\phi R_n = \phi*0.80*t_w^2*(1 + 3*(N/d)*(t_w/t_f)^{1.5})*(E*F_{yw}*t_f/t_w)^{1/2} = 0.75*0.80*$
1.73[cm]$^2*(1 + 3*(167.64$[cm]$/37.59$[cm]$)*(1.73$[cm]$/2.77$[cm]$)^{1.5})*(2.04E+06$[kg/cm2]$*3515.33$[kg/cm2]$*$
2.77[cm]$/1.73$[cm]$)^{1/2} =$ **1456.6**[T] Eq. J10-4

Ratio **0.69**

Calculation of the brace interface forces

Load condition :D1

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.6$[T] $+ -1.93$[T] $=$ **-3.53**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.74$[T] $- -2.57$[T] $+ -3.08$[T] $=$ **1.22**[T]

Load condition :D2

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -2.09$[T] $+ -2.57$[T] $=$ **-4.65**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 2.26$[T] $- -3.34$[T] $+ -4.11$[T] $=$ **1.49**[T]

Load condition :D3

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.37$[T] $+ -1.65$[T] $=$ **-3.02**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49$[T] $- -2.2$[T] $+ -2.64$[T] $=$ **1.04**[T]

Load condition :D4

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.37$[T] $+ -1.65$[T] $=$ **-3.02**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49$[T] $- -2.2$[T] $+ -2.64$[T] $=$ **1.04**[T]

Load condition :D5

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.37$[T] $+ -1.65$[T] $=$ **-3.02**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49$[T] $- -2.2$[T] $+ -2.64$[T] $=$ **1.04**[T]

Load condition :D6

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.37$[T] $+ -1.65$[T] $=$ **-3.02**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49$[T] $- -2.2$[T] $+ -2.64$[T] $=$ **1.04**[T]

Load condition :D7

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.82$[T] $+ -2.22$[T] $=$ **-4.04**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.97$[T] $- -2.91$[T] $+ -3.56$[T] $=$ **1.32**[T]

Load condition :D8

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0$[T] $+ -1.82$[T] $+ -2.22$[T] $=$ **-4.04**[T]

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.97$[T] $- -2.91$[T] $+ -3.56$[T] $=$ **1.32**[T]

Load condition :D9

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 37.15[T] + -47.52[T] = \mathbf{-10.37}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49[T] - 59.49[T] + -76.1[T] = \mathbf{-134.11}[T]$

Load condition :D10

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.37[T] + -1.65[T] = \mathbf{-3.02}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.49[T] - -2.2[T] + -2.64[T] = \mathbf{1.04}[T]$

Load condition :D11

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 13.88[T] + -16.09[T] = \mathbf{-2.21}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.97[T] - 22.23[T] + -25.77[T] = \mathbf{-46.03}[T]$

Load condition :D12

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.82[T] + -2.22[T] = \mathbf{-4.04}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.97[T] - -2.91[T] + -3.56[T] = \mathbf{1.32}[T]$

Load condition :D13

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.03[T] + -1.24[T] = \mathbf{-2.27}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.12[T] - -1.65[T] + -1.98[T] = \mathbf{0.782}[T]$

Load condition :D14

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.03[T] + -1.24[T] = \mathbf{-2.27}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.12[T] - -1.65[T] + -1.98[T] = \mathbf{0.782}[T]$

Load condition :D15

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 37.15[T] + -47.52[T] = \mathbf{-10.37}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.12[T] - 59.49[T] + -76.1[T] = \mathbf{-134.48}[T]$

Load condition :D16

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.03[T] + -1.24[T] = \mathbf{-2.27}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.12[T] - -1.65[T] + -1.98[T] = \mathbf{0.782}[T]$

Load condition :D17

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.14[T] + -1.38[T] = \mathbf{-2.52}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - -1.83[T] + -2.2[T] = \mathbf{0.869}[T]$

Load condition :D18

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.59[T] + -1.95[T] = \mathbf{-3.54}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.72[T] - -2.55[T] + -3.12[T] = \mathbf{1.15}[T]$

Load condition :D19

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.48[T] + -1.81[T] = \mathbf{-3.28}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.6[T] - -2.37[T] + -2.89[T] = \mathbf{1.08}[T]$

Load condition :D20

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.14[T] + -1.38[T] = \mathbf{-2.52}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - -1.83[T] + -2.2[T] = \mathbf{0.869}[T]$

Load condition :D21

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.14[T] + -1.38[T] = \mathbf{-2.52}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - -1.83[T] + -2.2[T] = \mathbf{0.869}[T]$

Load condition :D22

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 37.15[T] + -47.52[T] = \mathbf{-10.37}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - 59.49[T] + -76.1[T] = \mathbf{-134.36}[T]$

Load condition :D23

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.14[T] + -1.38[T] = \mathbf{-2.52}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - -1.83[T] + -2.2[T] = \mathbf{0.869}[T]$

Load condition :D24

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.48[T] + -1.81[T] = \mathbf{-3.28}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.6[T] - -2.37[T] + -2.89[T] = \mathbf{1.08}[T]$

Load condition :D25

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.48[T] + -1.81[T] = \mathbf{-3.28}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.6[T] - -2.37[T] + -2.89[T] = \mathbf{1.08}[T]$

Load condition :D26

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 37.15[T] + -47.52[T] = \mathbf{-10.37}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - 59.49[T] + -76.1[T] = \mathbf{-134.36}[T]$

Load condition :D27

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -1.14[T] + -1.38[T] = \mathbf{-2.52}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.24[T] - -1.83[T] + -2.2[T] = \mathbf{0.869}[T]$

Load condition :D28

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -0.687[T] + -0.826[T] = \mathbf{-1.51}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.744[T] - -1.1[T] + -1.32[T] = \mathbf{0.521}[T]$

Load condition :D29

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -0.687[T] + -0.826[T] = \mathbf{-1.51}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.744[T] - -1.1[T] + -1.32[T] = \mathbf{0.521}[T]$

Load condition :D30

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 37.15[T] + -47.52[T] = \mathbf{-10.37}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.745[T] - 59.49[T] + -76.1[T] = \mathbf{-134.85}[T]$

Load condition :D31

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + -0.687[T] + -0.826[T] = \mathbf{-1.51}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.744[T] - -1.1[T] + -1.32[T] = \mathbf{0.521}[T]$

Right beam interface - column
Angles

DEMANDS

Description	Ru [Ton]	Pu [Ton]	Load type
D1	1.22	-3.53	Design
D2	1.49	-4.65	Design
D3	1.04	-3.02	Design
D4	1.04	-3.02	Design
D5	1.04	-3.02	Design
D6	1.04	-3.02	Design
D7	1.32	-4.04	Design
D8	1.32	-4.04	Design
D9	-134.11	-10.37	Seismic
D10	1.04	-3.02	Design
D11	-46.03	-2.21	Design

D12	1.32	-4.04	Design
D13	0.78	-2.27	Design
D14	0.78	-2.27	Design
D15	-134.48	-10.37	Seismic
D16	0.78	-2.27	Design
D17	0.87	-2.52	Design
D18	1.15	-3.54	Design
D19	1.08	-3.28	Design
D20	0.87	-2.52	Design
D21	0.87	-2.52	Design
D22	-134.36	-10.37	Seismic
D23	0.87	-2.52	Design
D24	1.08	-3.28	Design
D25	1.08	-3.28	Design
D26	-134.36	-10.37	Seismic
D27	0.87	-2.52	Design
D28	0.52	-1.51	Design
D29	0.52	-1.51	Design
D30	-134.85	-10.37	Seismic
D31	0.52	-1.51	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[cm]	52.00	27.33	54.66	✔	p. 10-8

$L_{min} = T/2 = 54.66$[cm]$/2 = \mathbf{27.33}$[cm] — p. 10-8

$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 60.2$[cm] $- \max(2.77$[cm]$, 0$[cm]$) - \max(2.77$[cm]$, 0$[cm]$) = \mathbf{54.66}$[cm] — p. 10-8

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Beam side)						
Weld size	[1/16in]	6	3	7	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} = \mathbf{0.004763}$ — table J2.4

$t_p < 1/4$ [in] $\rightarrow 1.27$[cm]$<1/4$ [in] $\rightarrow$ **False**

$w_{max} = t_p - 1/16$ [in] $= 1.27$[cm] $- 1/16$ [in] $= \mathbf{0.0111}$ — Sec. J2.2b

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle (Column side)						
Vertical edge distance	[cm]	5.00	2.86	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 2.86$[cm] $+ 0$[cm] $= \mathbf{2.86}$[cm] — Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Horizontal edge distance	[cm]	4.46	2.86	--	✔	Tables J3.4, J3.5

$L_{emin} = e_{dmin} + C_2 = 2.86$[cm] $+ 0$[cm] $= \mathbf{2.86}$[cm] — Tables J3.4, J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Vertical center-to-center spacing (pitch)	[cm]	7.00	5.93	30.48	✔	Sec. J3.3, Sec. J3.5

$s_{min} = 8/3 * d = 8/3 * 2.22$[cm] $= \mathbf{5.93}$[cm] — Sec. J3.3

$IsCorrosionConsidered \rightarrow$ **False**

$s_{max} = \min(24 * t_p, 12$ [in]$) = \min(24 * 1.27$[cm]$, 12$ [in]$) = \mathbf{30.48}$[cm] — Sec. J3.5

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Column						
Horizontal edge distance	[cm]	12.15	2.86	--	✔	Tables J3.4,

$L_{emin} = e_{dmin} + C_2 = 2.86\text{[cm]} + 0\text{[cm]} = \mathbf{2.86}\text{[cm]}$ J3.5 Tables J3.4, J3.5

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Weld capacity	[Ton]	224.31	135.25	D30	0.60	Tables 8-4 .. 8-11

$\phi R_n = 2 * (\phi * C * C_1 * D * L) = 2 * (0.75*0.479\text{[T/cm]}*1*6*52\text{[cm]}) = \mathbf{224.31}\text{[T]}$ Tables 8-4 .. 8-11

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Ton]	278.58	134.85	D30	0.48	Eq. J4-3

$A_g = L_p * t_p = 52\text{[cm]}*1.27\text{[cm]} = \mathbf{66.04}\text{[cm2]}$ Sec. D3-1

$\phi R_n = 2 * (\phi * 0.60 * F_y * A_g) = 2 * (1*0.60*3515.33\text{[kg/cm2]}*66.04\text{[cm2]}) = \mathbf{278.58}\text{[T]}$ Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Column side)						
Bolts shear	[Ton]	154.57	134.85	D30	0.87	Tables (7-1..14)

$\phi R_n = \phi * F_{nv} * A_b = 0.75*3796.58\text{[kg/cm2]}*3.88\text{[cm2]} = \mathbf{11.04}\text{[T]}$ Eq. J3-1

$\phi R_n = 2 * (C * \phi R_n) = 2 * (7*11.04\text{[T]}) = \mathbf{154.57}\text{[T]}$ Tables (7-1..14)

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Bolt bearing under shear load	[Ton]	318.41	134.85	D30	0.42	p. 7-18, Sec. J3.10

$L_{c\text{-}end} = \text{Max}(0.0, L_e - d_h/2) = \text{Max}(0.0, 5\text{[cm]} - 2.38\text{[cm]}/2) = \mathbf{3.81}\text{[cm]}$ Sec. J4.10

$L_{c\text{-}spa} = \text{Max}(0.0, s - d_h) = \text{Max}(0.0, 7\text{[cm]} - 2.38\text{[cm]}) = \mathbf{4.62}\text{[cm]}$ Sec. J4.10

$\phi R_n = 2 * (\phi*(C/(n_c*n))*(\min(k_1*l_c, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*n_c) = 2 * (0.75*(7/(1*7))*(\min(1.2*3.81\text{[cm]}, 2.4*2.22\text{[cm]}) + \min(1.2*4.62\text{[cm]}, 2.4*2.22\text{[cm]})*(7 - 1))*1.27\text{[cm]}*4569.93\text{[kg/cm2]}*1) = \mathbf{318.41}\text{[T]}$ p. 7-18, Sec. J3.10

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Ton]	278.58	134.85	D30	0.48	Eq. J4-3

$A_g = L_p * t_p = 52\text{[cm]}*1.27\text{[cm]} = \mathbf{66.04}\text{[cm2]}$ Sec. D3-1

$\phi R_n = 2 * (\phi * 0.60 * F_y * A_g) = 2 * (1*0.60*3515.33\text{[kg/cm2]}*66.04\text{[cm2]}) = \mathbf{278.58}\text{[T]}$ Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear rupture	[Ton]	178.75	134.85	D30	0.75	Eq. J4-4

$L_h = d_h + 1/16\ \text{[in]} = 2.38\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.54}\text{[cm]}$ Sec. D3-2

$L_e = L - n * L_h = 52\text{[cm]} - 7*2.54\text{[cm]} = \mathbf{34.22}\text{[cm]}$ DG4 Eq. 3-13

$A_{nv} = L_e * t_p = 34.22\text{[cm]}*1.27\text{[cm]} = \mathbf{43.46}\text{[cm2]}$ Sec. J4-2

$\phi R_n = 2 * (\phi * 0.60 * F_u * A_{nv}) = 2 * (0.75*0.60*4569.93\text{[kg/cm2]}*43.46\text{[cm2]}) = \mathbf{178.75}\text{[T]}$ Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear	[Ton]	187.00	134.85	D30	0.72	Eq. J4-5

$dh_h = d_h + 1/16\ \text{[in]} = 2.38\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.54}\text{[cm]}$ Sec. D3-2

$dh_v = d_h + 1/16\ \text{[in]} = 2.38\text{[cm]} + 1/16\ \text{[in]} = \mathbf{2.54}\text{[cm]}$ Sec. D3-2

$A_{nt} = (L_{eh} + (n_c - 1)*spa - (n_c - 0.5)*dh_h)*t_p = (4.46\text{[cm]} + (1 - 1)*6\text{[cm]} - (1 - 0.5)*2.54\text{[cm]})*1.27\text{[cm]} = \mathbf{4.05}\text{[cm2]}$ Sec. J4-3

$A_{gv} = (L_{ev} + (n - 1)*s)*t_p = (5\text{[cm]} + (7 - 1)*7\text{[cm]})*1.27\text{[cm]} = \mathbf{59.69}\text{[cm2]}$ Sec. J4-3

$A_{nv} = (L_{ev} + (n - 1)*(s - dh_v) - dh_v/2)*t_p = (5\text{[cm]} + (7 - 1)*(7\text{[cm]} - 2.54\text{[cm]}) - 2.54\text{[cm]}/2)*1.27\text{[cm]} = \mathbf{38.72}\text{[cm2]}$ Sec. J4-3

$IsStressUniform \rightarrow$ **True**

$U_{bs} = 1$ Sec. J4-3

$\phi R_n = 2 * (\phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt})) =$
$2 * (0.75*\min(0.6*4569.93\text{[kg/cm2]}*38.72\text{[cm2]} + 1*4569.93\text{[kg/cm2]}*4.05\text{[cm2]}, 0.6*3515.33\text{[kg/cm2]}*59.69\text{[cm2]} +$
$1*4569.93\text{[kg/cm2]}*4.05\text{[cm2]})) = \mathbf{187}\text{[T]}$ Eq. J4-5

Resulting tension capacity due prying action [Ton] 68.23 0.00 D1 0.00 p. 9-11, p. 9-10

$\phi R_n = \phi*F_{nt}*A_b = 0.75*6327.63\text{[kg/cm2]}*3.88\text{[cm2]} = \mathbf{18.4}\text{[T]}$ Eq. J3-1
$\phi R_n = \phi*F_{nt}*A_b = 0.75*6327.63\text{[kg/cm2]}*3.88\text{[cm2]} = \mathbf{18.4}\text{[T]}$ Eq. J3-1
$p_{inner} = \min(p, s, 2*b) = \min(7\text{[cm]}, 7\text{[cm]}, 2*5.07\text{[cm]}) = \mathbf{7}\text{[cm]}$ p. 9-11
$p_{outer} = \min(p, s, 2*b) = \min(8.5\text{[cm]}, 7\text{[cm]}, 2*5.07\text{[cm]}) = \mathbf{7}\text{[cm]}$ p. 9-11
$a' = \mathrm{Min}(a + d/2, 1.25*b + d/2) = \mathrm{Min}(4.46\text{[cm]} + 2.22\text{[cm]}/2, 1.25*5.07\text{[cm]} + 2.22\text{[cm]}/2) =$
$\mathbf{5.57}\text{[cm]}$ p. 9-12
$b' = b - d/2 = 5.07\text{[cm]} - 2.22\text{[cm]}/2 = \mathbf{3.96}\text{[cm]}$ p. 9-12
$\rho = b'/a' = 3.96\text{[cm]}/5.57\text{[cm]} = \mathbf{0.711}$ p. 9-12
$\delta = 1 - d'/p = 1 - 2.38\text{[cm]}/7\text{[cm]} = \mathbf{0.66}$ p. 9-11
$t_c = ((3.33*B*b')/(\phi*p*F_u))^{0.5} = ((3.33*18.4\text{[T]}*3.96\text{[cm]})/(0.75*7\text{[cm]}*4569.93\text{[kg/cm2]}))^{0.5} = \mathbf{3.18}\text{[cm]}$ p. 9-12
$\alpha' = (1/(\delta*(1 + \rho)))*((t_c/t_p)^2 - 1) = (1/(0.66*(1 + 0.711)))*((3.18\text{[cm]}/1.27\text{[cm]})^2 - 1) =$
$\mathbf{4.67}$ p. 9-13
$Q = (t_p/t_c)^2*(1 + \delta) = (1.27\text{[cm]}/3.18\text{[cm]})^2*(1 + 0.66) = \mathbf{0.265}$ p. 9-13
$T_{avail} = 14 * (B*Q) = 14 * (18.4\text{[T]}*0.265) = \mathbf{68.23}\text{[T]}$ p. 9-10

Beam

Welds rupture [Ton/m] 299.48 239.83 D30 0.80 p. 9-5

$R_n = 0.6*F_u*t_p = 0.6*4569.93\text{[kg/cm2]}*1.09\text{[cm]} = \mathbf{2.99}\text{[T/cm]}$ p. 9-5
$D_{min} = P/(\phi*C*C_1*L) = 67.63\text{[T]}/(0.75*0.479\text{[T/cm]}*1*52\text{[cm]}) = \mathbf{3.62}$ tables 8-4..11
HasWeldsOnBothSides → **False**
$R_u = 2 * (0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16\text{ [in]}) = 2 * (0.6*4921.46\text{[kg/cm2]}*(2)^{1/2}/2*3.62/16\text{ [in]}) =$
$\mathbf{2.4}\text{[T/cm]}$ p. 9-5

Shear yielding [Ton] 138.68 134.85 D30 0.97 Eq. J4-3

$A_g = L_p*t_p = 60.2\text{[cm]}*1.09\text{[cm]} = \mathbf{65.75}\text{[cm2]}$ Sec. D3-1
$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*3515.33\text{[kg/cm2]}*65.75\text{[cm2]} = \mathbf{138.68}\text{[T]}$ Eq. J4-3

Column

Bolt bearing under shear load [Ton] 708.62 134.85 D30 0.19 Eq. J3-6

$L_{c\text{-}end} = \mathrm{Max}(0.0, L_e - d_h/2) = \mathrm{Max}(0.0, 1.00E{+}32\text{[cm]} - 2.38\text{[cm]}/2) = \mathbf{1.00E{+}32}\text{[cm]}$ Sec. J4.10
$L_{c\text{-}spa} = \mathrm{Max}(0.0, s - d_h) = \mathrm{Max}(0.0, 7\text{[cm]} - 2.38\text{[cm]}) = \mathbf{4.62}\text{[cm]}$ Sec. J4.10
$\phi R_n = 2 * (\phi*(\min(k_1*L_{c\text{-}end}, k_2*d) + \min(k_1*L_{c\text{-}spa}, k_2*d)*(n - 1))*t_p*F_u*$
$n_c) = 2 * (0.75*(\min(1.2*1.00E{+}32\text{[cm]}, 2.4*2.22\text{[cm]}) + \min(1.2*4.62\text{[cm]}, 2.4*2.22\text{[cm]})*(7 - 1))*2.77\text{[cm]}*$
$4569.93\text{[kg/cm2]}*1) = \mathbf{708.62}\text{[T]}$ Eq. J3-6

Web crippling [Ton] 825.59 10.37 D9 0.01 Eq. J10-4

IsBeamReaction → **False**
$l_b = N = \mathbf{84}\text{[cm]}$ Sec. J10-2
$\phi R_n = \phi*0.80*t_w^2*(1 + 3*(N/d)*(t_w/t_f)^{1.5})*(E*F_{yw}*t_f/t_w)^{1/2} = 0.75*0.80*$
$1.73\text{[cm]}^2*(1 + 3*(84\text{[cm]}/37.59\text{[cm]})*(1.73\text{[cm]}/2.77\text{[cm]})^{1.5})*(2.04E{+}06\text{[kg/cm2]}*3515.33\text{[kg/cm2]}*$
$2.77\text{[cm]}/1.73\text{[cm]})^{1/2} = \mathbf{825.59}\text{[T]}$ Eq. J10-4

Ratio **0.97**

Calculation of the brace interface forces

Load condition :D1

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.67[T] - 0[T] + 0[T] = \mathbf{1.67}[T]$

Load condition :D2

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 2.2[T] - 0[T] + 0[T] = \mathbf{2.2}[T]$

Load condition :D3

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D4

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D5

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D6

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D7

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.91[T] - 0[T] + 0[T] = \mathbf{1.91}[T]$

Load condition :D8

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.91[T] - 0[T] + 0[T] = \mathbf{1.91}[T]$

Load condition :D9

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D10

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.43[T] - 0[T] + 0[T] = \mathbf{1.43}[T]$

Load condition :D11

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.91[T] - 0[T] + 0[T] = \mathbf{1.91}[T]$

Load condition :D12

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.91[T] - 0[T] + 0[T] = \mathbf{1.91}[T]$

Load condition :D13

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.07[T] - 0[T] + 0[T] = \mathbf{1.07}[T]$

Load condition :D14

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.07[T] - 0[T] + 0[T] = \mathbf{1.07}[T]$

Load condition :D15

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.07[T] - 0[T] + 0[T] = \mathbf{1.07}[T]$

Load condition :D16

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.07[T] - 0[T] + 0[T] = \mathbf{1.07}[T]$

Load condition :D17

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D18

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.67[T] - 0[T] + 0[T] = \mathbf{1.67}[T]$

Load condition :D19

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.55[T] - 0[T] + 0[T] = \mathbf{1.55}[T]$

Load condition :D20

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D21

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D22

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D23

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D24

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.55[T] - 0[T] + 0[T] = \mathbf{1.55}[T]$

Load condition :D25

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.55[T] - 0[T] + 0[T] = \mathbf{1.55}[T]$

Load condition :D26

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D27

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 1.19[T] - 0[T] + 0[T] = \mathbf{1.19}[T]$

Load condition :D28

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.714[T] - 0[T] + 0[T] = \mathbf{0.714}[T]$

Load condition :D29

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.714[T] - 0[T] + 0[T] = \mathbf{0.714}[T]$

Load condition :D30

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.715[T] - 0[T] + 0[T] = \mathbf{0.715}[T]$

Load condition :D31

$H_{BeamToColumn} = H_{Beam} + H_{Top} + H_{Bot} = 0[T] + 0[T] + 0[T] = \mathbf{0}[T]$

$V_{BeamToColumn} = V_{Beam} - V_{Top} + V_{Bot} = 0.714[T] - 0[T] + 0[T] = \mathbf{0.714}[T]$

Left beam interface - column

Angles

DEMANDS

Description	Ru [Ton]	Pu [Ton]	Load type
D1	1.67	0.00	Design
D2	2.20	0.00	Design
D3	1.43	0.00	Design
D4	1.43	0.00	Design
D5	1.43	0.00	Design
D6	1.43	0.00	Design
D7	1.91	0.00	Design
D8	1.91	0.00	Design
D9	1.43	0.00	Seismic
D10	1.43	0.00	Design
D11	1.91	0.00	Design
D12	1.91	0.00	Design
D13	1.07	0.00	Design
D14	1.07	0.00	Design
D15	1.07	0.00	Seismic
D16	1.07	0.00	Design
D17	1.19	0.00	Design
D18	1.67	0.00	Design
D19	1.55	0.00	Design
D20	1.19	0.00	Design
D21	1.19	0.00	Design
D22	1.19	0.00	Seismic
D23	1.19	0.00	Design
D24	1.55	0.00	Design
D25	1.55	0.00	Design
D26	1.19	0.00	Seismic
D27	1.19	0.00	Design
D28	0.71	0.00	Design
D29	0.71	0.00	Design
D30	0.72	0.00	Seismic
D31	0.71	0.00	Design

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Angle						
Length	[cm]	30.00	15.57	31.14	✔	p. 10-8
$L_{min} = T/2 = 31.14$[cm]$/2 =$ **15.57**[cm]						p. 10-8
$L_{max} = d - \max(k, d_{ct}) - \max(k, d_{cb}) = 35.31$[cm] - max(2.08[cm], 0[cm]) - max(2.08[cm], 0[cm]) = **31.14**[cm]						p. 10-8
Angle (Beam side)						
Weld size	[1/16in]	5	3	7	✔	table J2.4, Sec. J2.2b
$w_{min} = w_{min} =$ **0.004763**						table J2.4
t_p<1/4 [in] → 1.27[cm]<1/4 [in] → **False**						
$w_{max} = t_p$ - 1/16 [in] = 1.27[cm] - 1/16 [in] = **0.0111**						Sec. J2.2b
Angle (Column side)						
Weld size	[1/16in]	5	3	7	✔	table J2.4, Sec. J2.2b
$w_{min} = w_{min} =$ **0.004763**						table J2.4
t_p<1/4 [in] → 1.27[cm]<1/4 [in] → **False**						
$w_{max} = t_p$ - 1/16 [in] = 1.27[cm] - 1/16 [in] = **0.0111**						Sec. J2.2b
Weld length	[cm]	30.00	3.18	--	✔	Sec. J2.2b
$L_{min} = 4.0*w = 4.0*0.794$[cm] = **3.18**[cm]						Sec. J2.2b

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Angle (Beam side)						
Weld capacity	[Ton]	123.22	1.43	D9	0.01	Tables 8-4 .. 8-11
$\phi R_n = 2 * (\phi*C*C_1*D*L) = 2 * (0.75*0.548$[T/cm]*1*5*30[cm]) = **123.22**[T]						Tables 8-4 .. 8-11
Shear yielding	[Ton]	115.72	1.43	D9	0.01	Eq. J4-3
$A_g = L_p*t_p = 30$[cm]*1.27[cm] = **38.1**[cm2]						Sec. D3-1
$\phi R_n = 2 * (\phi*0.60*F_y*A_g) = 2 * (1*0.60*2531.04$[kg/cm2]*38.1[cm2]) = **115.72**[T]						Eq. J4-3
Angle (Column side)						
Weld capacity	[Ton]	47.30	1.43	D9	0.03	p. 10-11
$\phi R_n = \phi*2*0.6*F_{EXX}*(2)^{1/2}/2*D/16$ [in]$*L/(1 + 12.96*e^2/L^2)^{1/2} = 0.75*2*0.6*4921.46$[kg/cm2]$*(2)^{1/2}/2*5/16$ [in]*30[cm]/(1 + 12.96*10.16[cm]^2/30[cm]^2)$^{1/2}$ = **47.3**[T]						p. 10-11
Shear yielding	[Ton]	115.72	1.43	D9	0.01	Eq. J4-3
$A_g = L_p*t_p = 30$[cm]*1.27[cm] = **38.1**[cm2]						Sec. D3-1
$\phi R_n = 2 * (\phi*0.60*F_y*A_g) = 2 * (1*0.60*2531.04$[kg/cm2]*38.1[cm2]) = **115.72**[T]						Eq. J4-3
Beam						
Welds rupture	[Ton/m]	177.60	3.85	D9	0.02	p. 9-5
$R_n = 0.6*F_u*t_p = 0.6*4569.93$[kg/cm2]*0.648[cm] = **1.78**[T/cm]						p. 9-5
$D_{min} = P/(\phi*C*C_1*L) = 0.715$[T]/(0.75*0.548[T/cm]*1*30[cm]) = **0.058**						tables 8-4..11
HasWeldsOnBothSides → **False**						
$R_u = 2 * (0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16$ [in]) = 2 * (0.6*4921.46[kg/cm2]$*(2)^{1/2}/2*0.058/16$ [in]) =						

0.0385[T/cm] p. 9-5

Shear yielding	[Ton]	48.23	1.43	D9	0.03	Eq. J4-3

$A_g = L_p * t_p$ = 35.31[cm]*0.648[cm] = **22.87**[cm2] Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g$ = 1*0.60*3515.33[kg/cm2]*22.87[cm2] = **48.23**[T] Eq. J4-3

Column

Welds rupture	[Ton/m]	759.14	5.01	D9	0.01	p. 9-5

$R_n = 0.6*F_u*t_p$ = 0.6*4569.93[kg/cm2]*2.77[cm] = **7.59**[T/cm] p. 9-5

$D_{min} = P*(1 + 12.96*e^2/L^2)^{1/2}*16/(1\text{ [in]})/(\phi*2*0.6*F_{EXX}*(2)^{1/2}/2*L)$ = 1.43[T]*(1 + 12.96*10.16[cm]^2/30[cm]^2)$^{1/2}$*16/(1 [in])/(0.75*2*0.6*4921.46[kg/cm2]*(2)$^{1/2}$/2*30[cm]) = **0.151** p. 10-11

HasWeldsOnBothSides → **False**

$R_u = 0.6*F_{EXX}*(2)^{1/2}/2*D_{min}/16\text{ [in]}$ = 0.6*4921.46[kg/cm2]*(2)$^{1/2}$/2*0.151/16 [in] = **0.0501**[T/cm] p. 9-5

Ratio	**0.03**

Global critical strength ratio **0.97**

NOTATION

- a: Plate depth
- A_b: Nominal bolt area
- A_e: Effective net area
- A_g: Gross area
- A_{gt}: Gross area subject to tension
- A_{gv}: Gross area subject to shear
- A_n: Net area
- A_{nt}: Net area subject to tension
- A_{nv}: Net area subjected to shear
- A_w: Effective area of the weld
- a': Distance for prying action
- α: Distance from the face of the column flange or web to the centroid of the gusset to beam connection
- α': Value that either maximizes the bolt available tensile strength for a given thickness or minimizes the thickness required for a given bolt available tensile strength
- α_{bar}: Centroid of the gusset to beam connection
- B: Available tensile strength per bolt
- b: Plate, connector or member width
- B: Available strength of all bolts
- b': Distance for prying action
- N: Bearing length
- β: Distance from the face of the beam flange to the centroid of the gusset to column connection
- β_{bar}: Centroid of the gusset to column connection
- b: Distance from bolt centerline to the face/centerline of tee stem/angle leg.
- C: Bolt group coefficient
- C_1: Electrode strength coefficient
- C_2: Edge distance increment
- c: Setback
- C: Weld group coefficient
- $cos\theta$: Cosine of the brace with the horizontal angle
- d: Nominal bolt diameter
- D: Outside section diameter
- d_{cb}: Bottom cope depth
- d_{ct}: Top cope depth
- d_h: Nominal hole dimension

D: Uniform force method factor
d_w: Distance between weld and the end of the plate
d': Width of the hole along the length of the fitting
δ: Ratio of the net area at bolt line to gross area at face of the stem or leg of angle
ΔV: Arbitrary shear
d: Beam depth
dh_h: Horizontal hole dimension
dh_v: Vertical hole dimension
D: Number of sixteenths of an inch in the weld size
D_{min}: Number of sixteenths of an inch in the minimum weld size
E: Elastic modulus
e: Width of the leg of the connection angle attached to the support
e_b: One half the depth of the beam
e_c: One half the depth of the column
F: Required shear force for combined tension and shear
F_{cr}: Critical stress, flexural stress buckling
F_e: Elastic critical buckling stress
F_{EXX}: Electrode classification number
F_{nt}: Nominal tensile stress
F_{nv}: Nominal shear stress
F_u: Specified minimum tensile strength
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{uAve}: Average weld stress on welds along gusset-beam or gusset-column interface
f_{ub}: Bending stress on welds along gusset-beam or gusset-column interface
f_{uPeak}: Peak weld stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
f_{uWeld}: Design weld force on welds along gusset-beam or gusset-column interface
f_v: Required shear stress
F_w: Nominal strength of the weld metal per unit area
F_y: Specified minimum yield stress
F_{yw}: Specified minimum yield stress of web
F'_{nt}: Nominal tensile stress modified to include the effects of shear stress
H_b: Required shear force on the beam to gusset connection
H_{Beam}: Beam horizontal force
$H_{BeamToColumn}$: Beam to column interrface total horizontal force
H_{Bot}: Bottom horizontal component of the gusset forces
H_c: Required axial force on the column to gusset connection
H: Brace axial force horizontal component
H_{Left}: Left brace axial force horizontal component
H_{Right}: Right brace axial force horizontal component
H_{Top}: Top horizontal component of the gusset forces
HasWeldsOnBothSides: Has welds on both sides
IsBeamReaction: Is beam reaction
IsCorrosionConsidered: Is corrosion considered
IsMemberEnd: Is member end
IsStressUniform: Is the stress uniform
K: Effective length factor
k_1: Bearing factor
k_2: Bearing factor
k: Distance from outer face of flange to the web toe of fillet
k: Outside corner radius
K: Uniform force method factor
K': Uniform force method factor
l: Length
L: Length
L: Angle length
l_b: Bearing length
$L_{c\text{-}end}$: Clear distance
l_c: Clear distance
L_e: Effective length
L_e: Edge distance

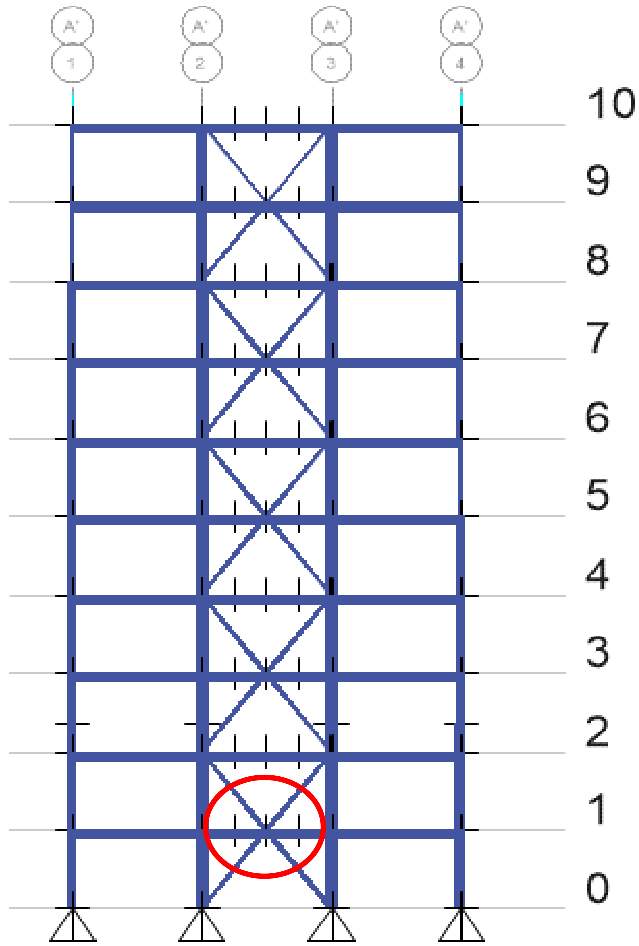
L_{eh}: Horizontal edge distance
L_{emin}: Minimum edge distance
L_{ev}: Vertical edge distance
L_h: Hole dimension for tension and shear net area
L_h: Weld length on heel
L_{max}: Maximum length
L_{min}: Minimum length
L_p: Plate length
L_t: Weld length on toe
L: Length of weld
L_w: Width of Whitmore section
λ_b: Brace Slenderness
λ_{max}: Maximum slenderness
λ: Width-thickness ratio
λ_{hd}: Limiting Width-Thickness ratio (highly ductile)
M: Bending required
M_b: Required moment on the beam to gusset connection
M_c: Required moment on the column to gusset connection
e_{dmin}: Minimum edge distance
n: Bolts rows number
N: Bearing length
N_{bolts}: Number of bolts
n_c: Number of bolt columns
P: Required axial force
P_n: Nominal Compressive strength
ϕ: Design factors
ϕP_n: Design or allowable strength
ϕR_n: Design or allowable strength
ϕR_{w1}: Fillet weld capacity of the weld element 1
ϕR_{w2}: Fillet weld capacity of the weld element 2
p: Tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
p_{inner}: Inner tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
p_{outer}: Outer tributary length per pair of bolts, which should preferably not exceed the gage between the pair of bolts
Q: Prying action coefficient
Q: Prying action coefficient
r: Radius of gyration
R_n: Nominal strength
R_t: Ratio of the expected tensile strength to the specified minimum tensile strength
R_u: Required strength
r: Uniform force method parameter
R_y: Ratio of the expected yield stress to the specified minimum yield stress
ρ: Prying distances ratio
s_{max}: Maximum spacing
s_{min}: Minimum spacing
$sin\theta$: Sine of the brace with the horizontal angle
spa: Transversal spacing between bolts or welds
s: Longitudinal bolt spacing
$L_{c\text{-}spa}$: Distance between adjacent holes edges
t_p: Thickness of the connected material
T: Clear distance between web fillets
T_{avail}: Available tensile strength per bolt including effects of prying action
t_c: Flange or angle thickness required to develop the available strength of the bolt with no prying action
t: Design wall thickness of HSS member
t_f: Thickness of the loaded flange
t_p: Plate thickness
t_w: Web thickness
$tan\theta$: Tangent of the brace with the vertical angle
U: Shear lag factor

U_{bs}: Stress index
V_b: Required axial force on the beam to gusset connection
V_{Beam}: Beam vertical force
$V_{BeamToColumn}$: Beam to column interrface total vertical force
V_{Bot}: Bottom vertical component of the gusset forces
V_c: Required shear force on the column to gusset connection
V: Brace axial force vertical component
V_{Left}: Left vertical component of the gusset forces
V_{Right}: Right vertical component of the gusset forces
V_{Top}: Top vertical component of the gusset forces
w_{max}: Maximum weld size required
w_{min}: Minimum weld size required
w: Weld size
x: Connection eccentricity
x_{Left}: Distance from the gusset center to the left vertical force
x_{Right}: Distance from the gusset center to the right vertical force
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
ϕF_n: Design or allowable tension/shear yielding stress
N_{eq}: Equivalent normal force
V_{ub}: Shear applied to the interface
M_{ub}: Moment applied to the interface

REFERENCES

{9} AISC 2005, Design Examples Version 13.0, pp. IIC-26 - IIC-27
{8} Dowswell, B., 2003, Connection Design For Steel Structures, Structural Design Solutions, LLC. Chapter 13, p. 14

6.8. DISEÑO DE CONEXION VIGA-ARRIOSTRES



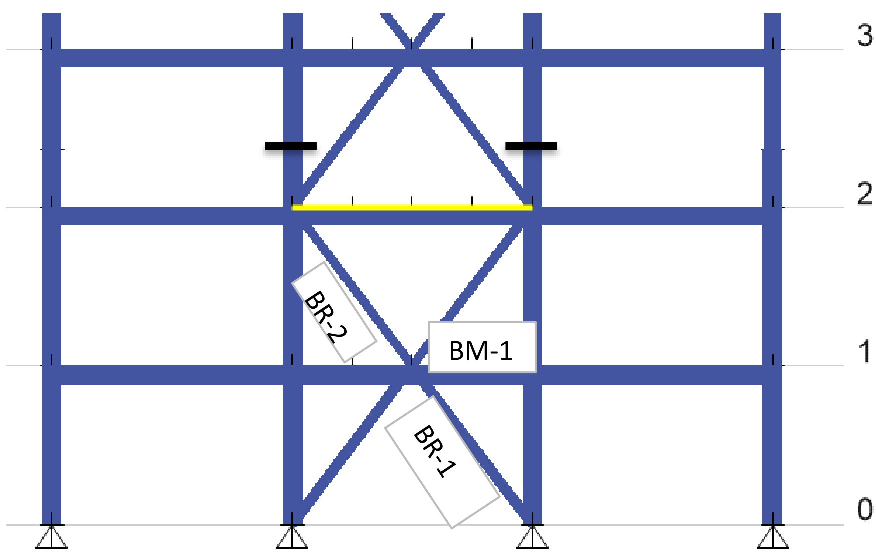


Diagrama de cortante y momento en viga BM-1 debido a carga muerta

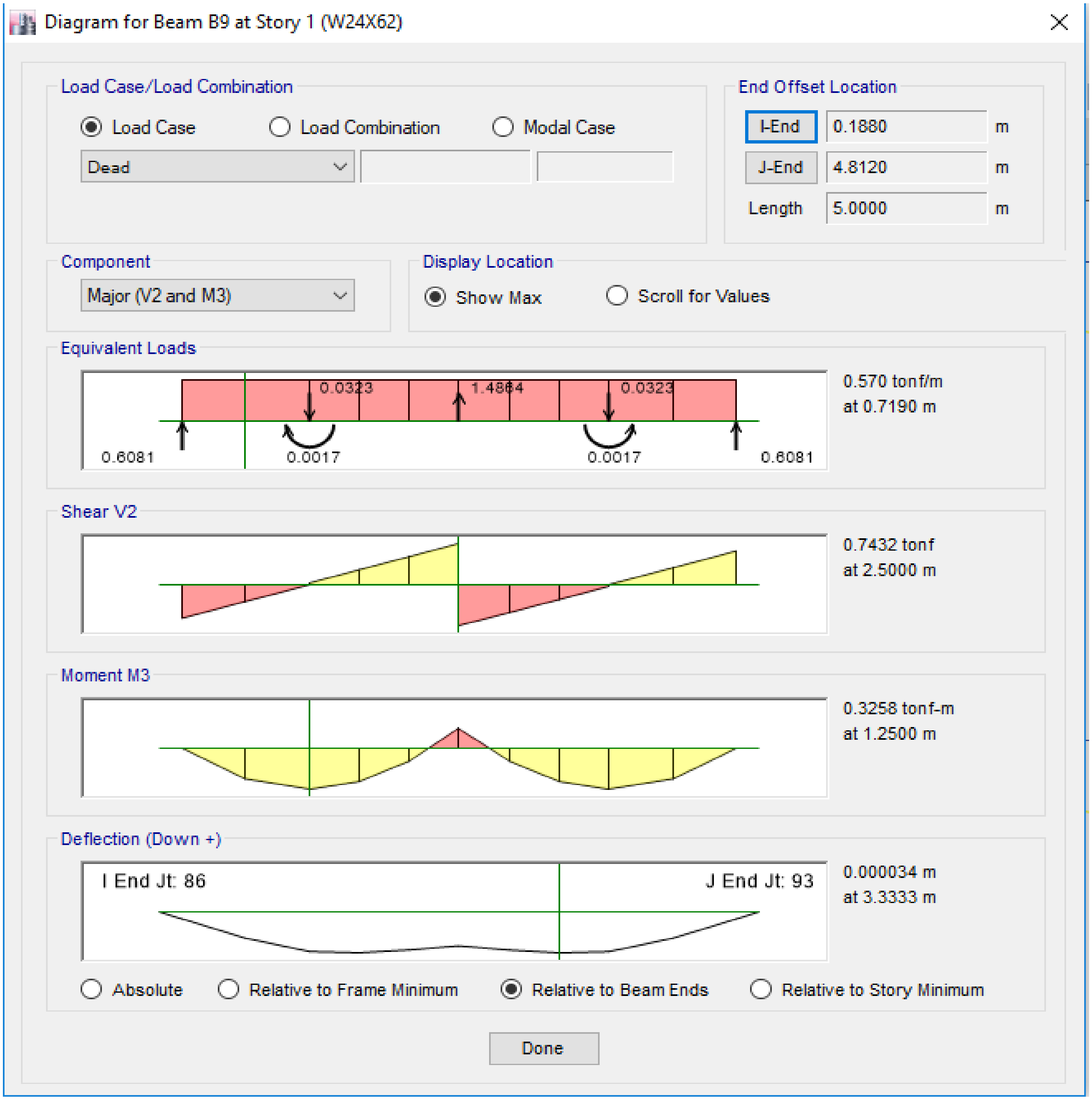


Diagrama de cortante y momento en viga BM-1 debido a carga viva.

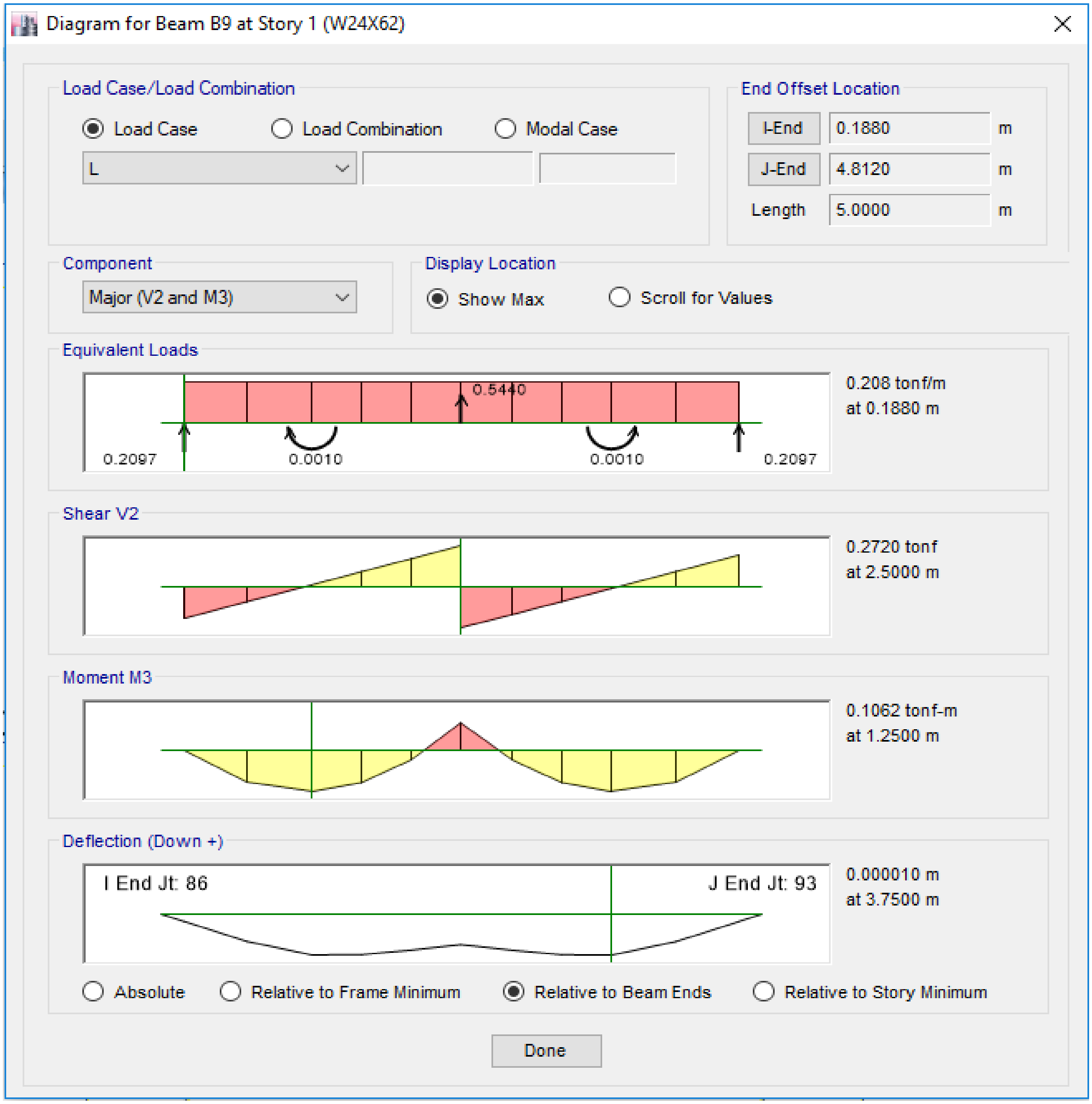


Diagrama de cortante y momento en viga BM-1 debido a Sismo.

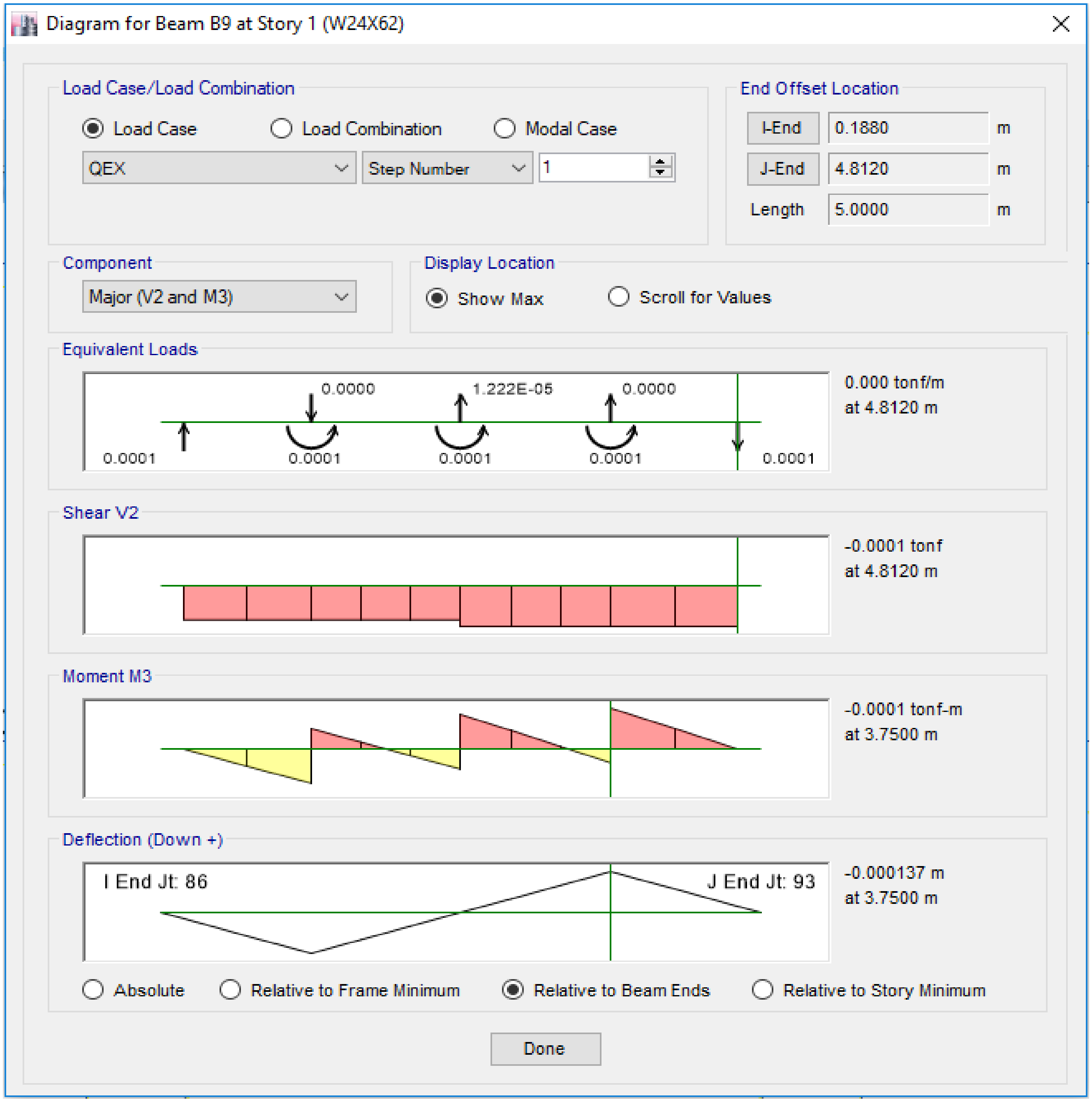


Diagrama de Axial en arriostre BR-1 carga muerta

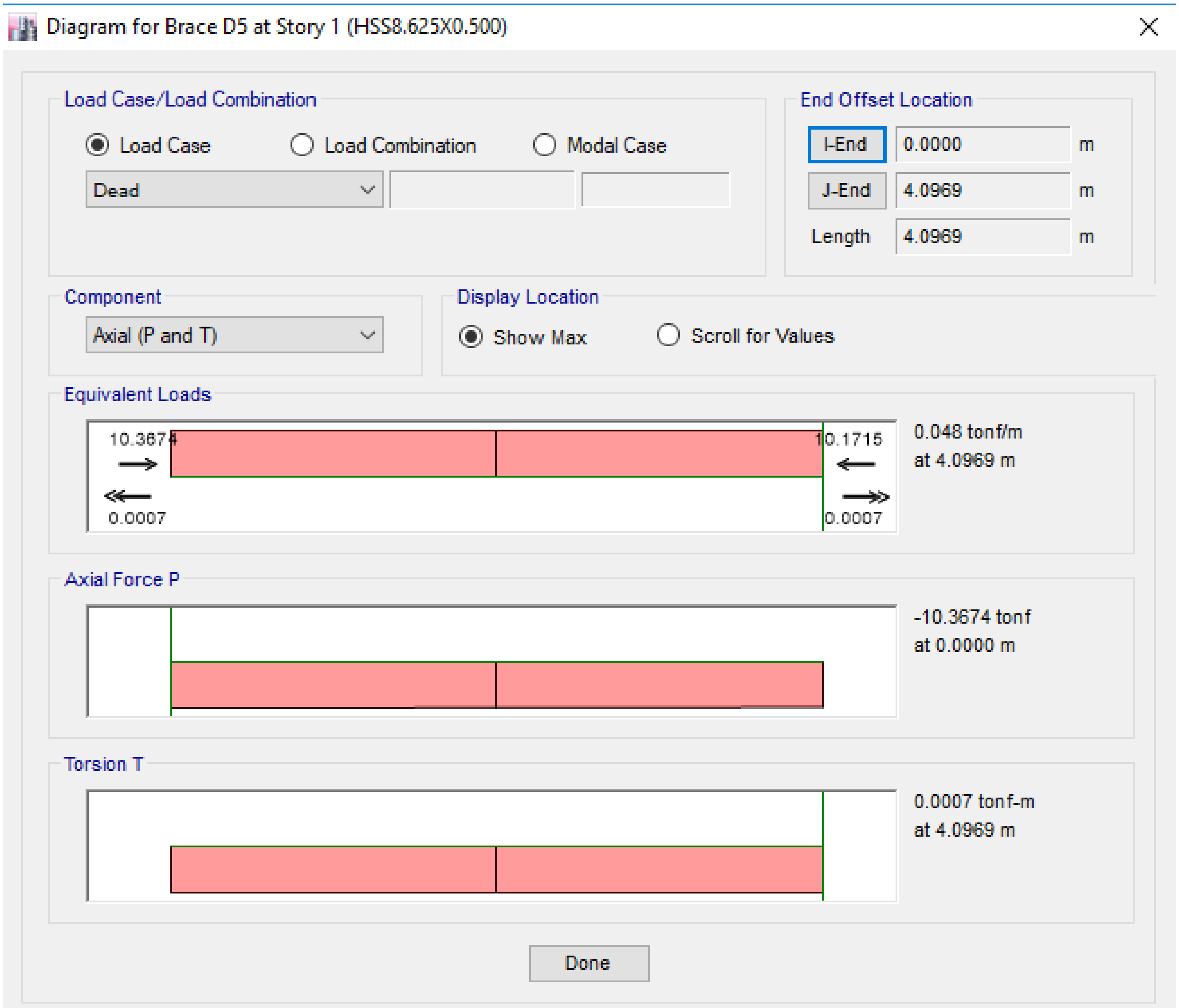


Diagrama de Axial en Arriostre BR-1 por carga Viva

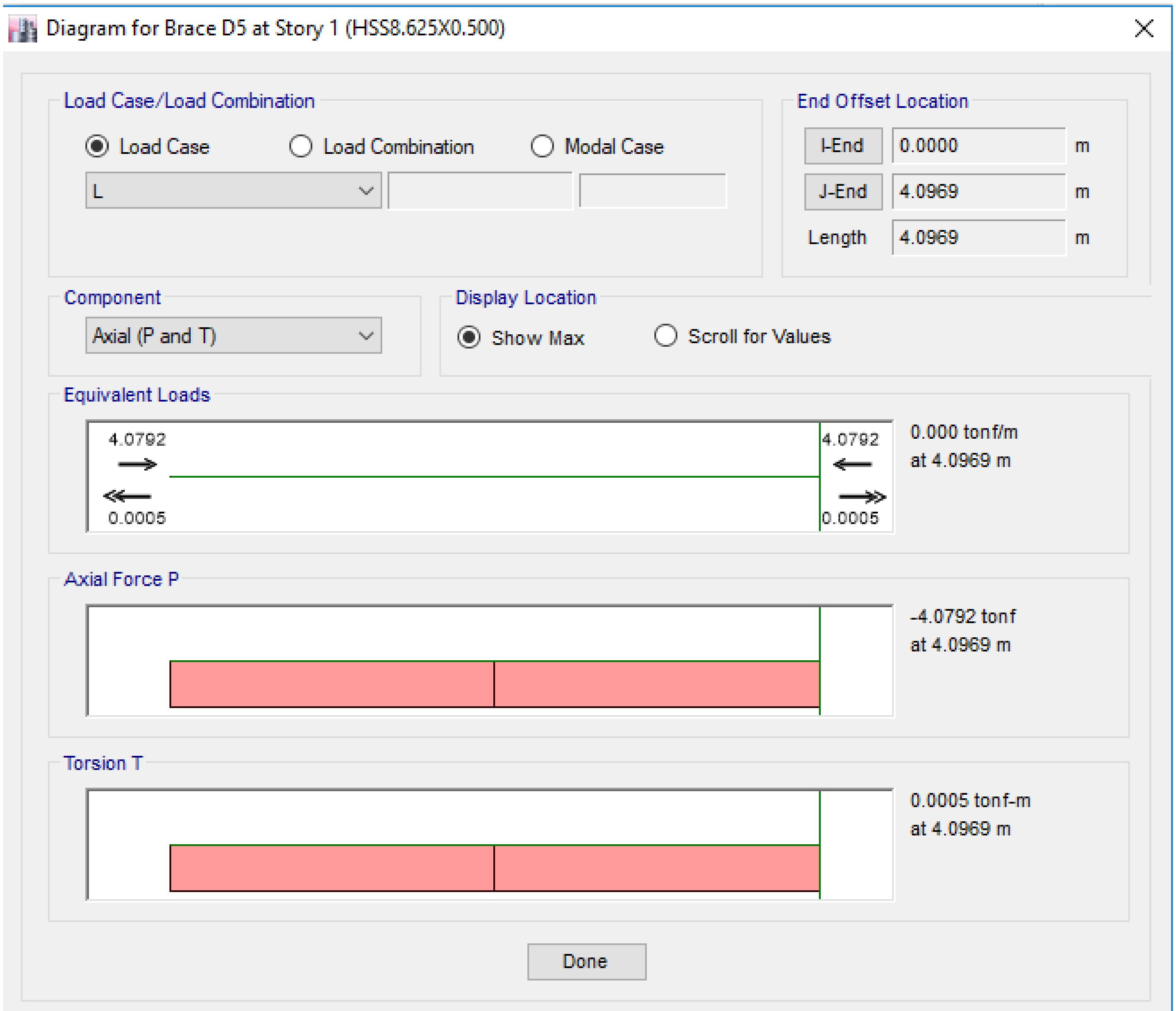


Diagrama de Axial en arriostre BR-1 debido a sismo

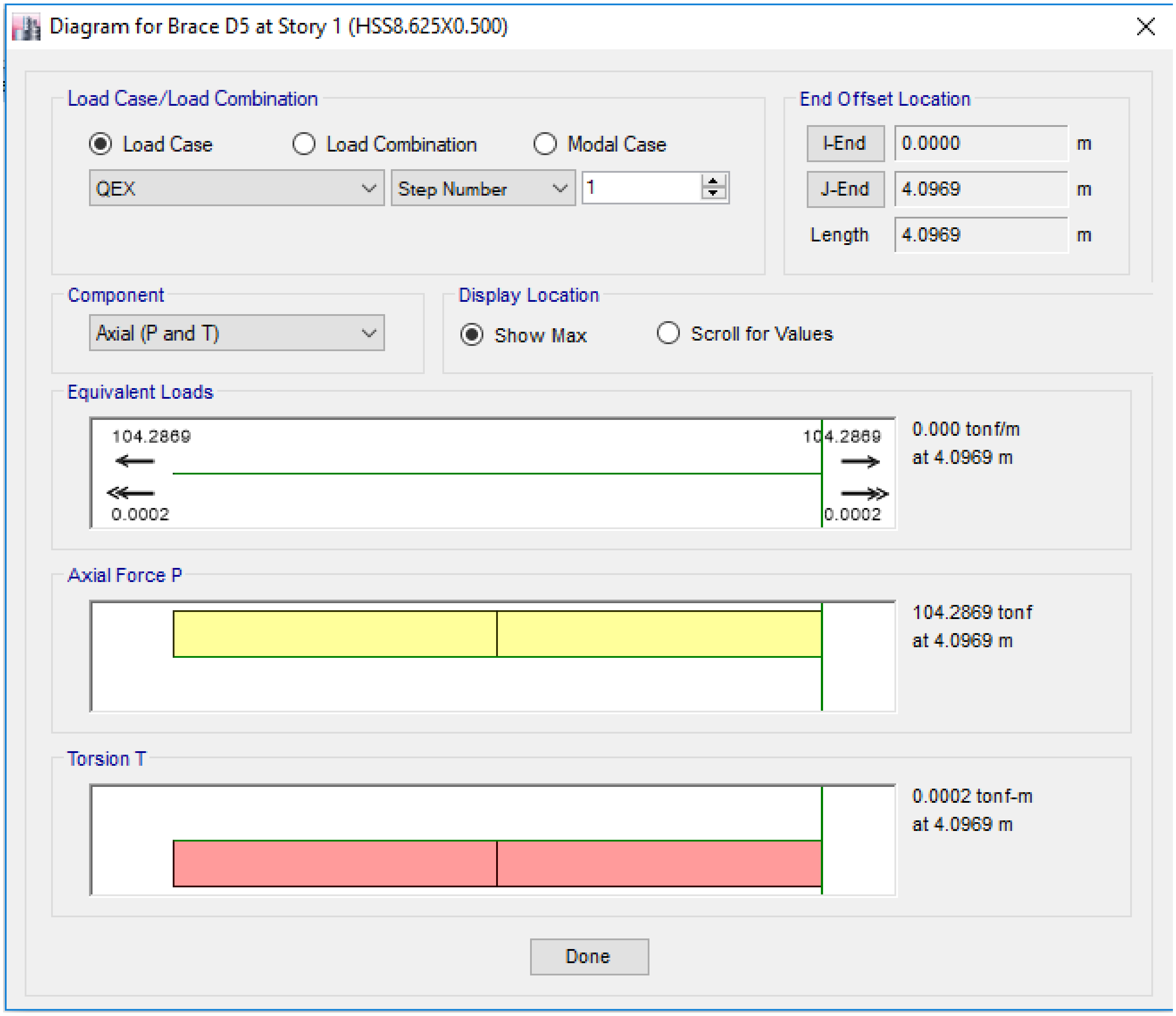


Diagrama de Axial en arriostre BR-2 carga muerta

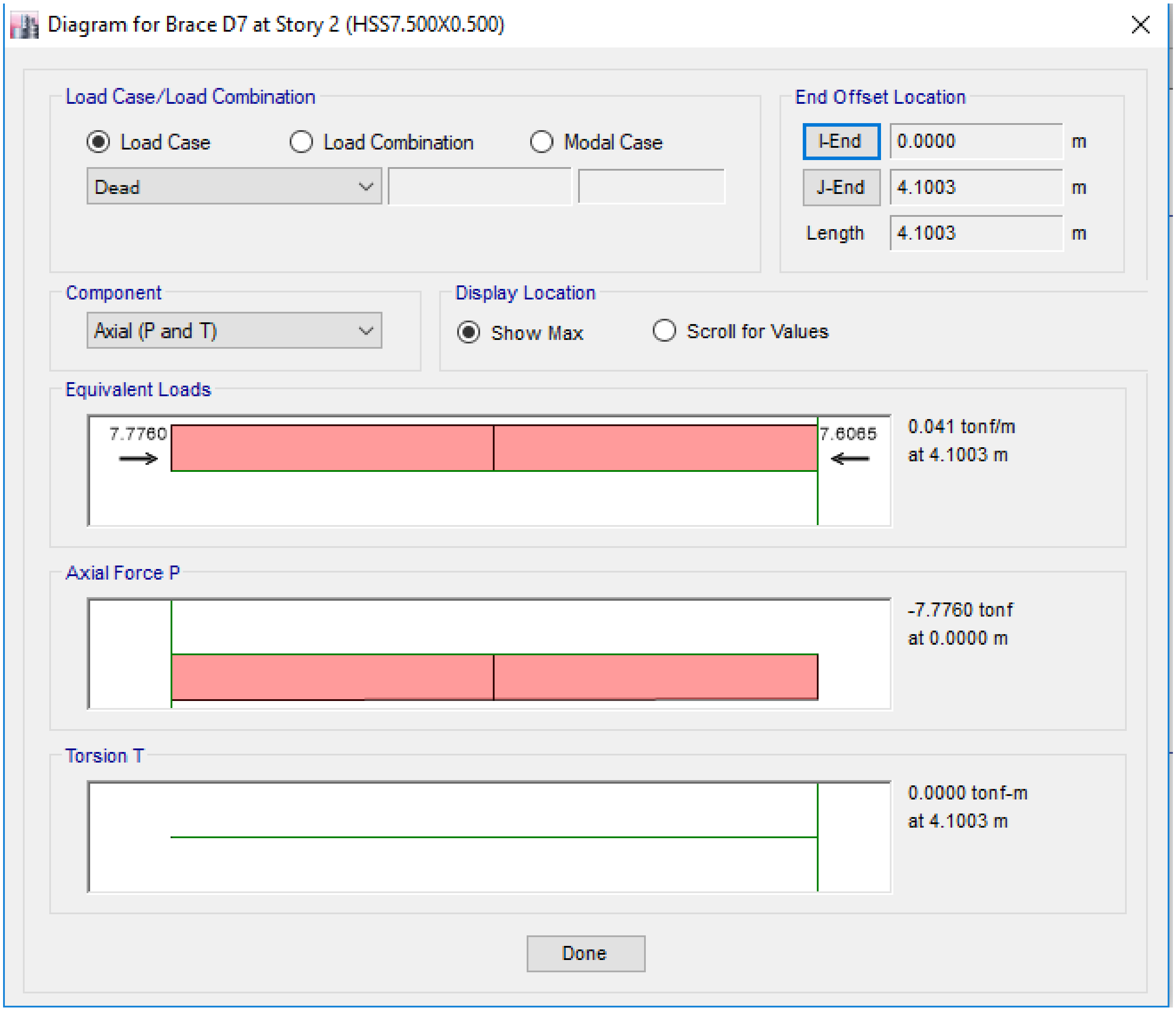


Diagrama de Axial en arriostre BR-2 carga Viva.

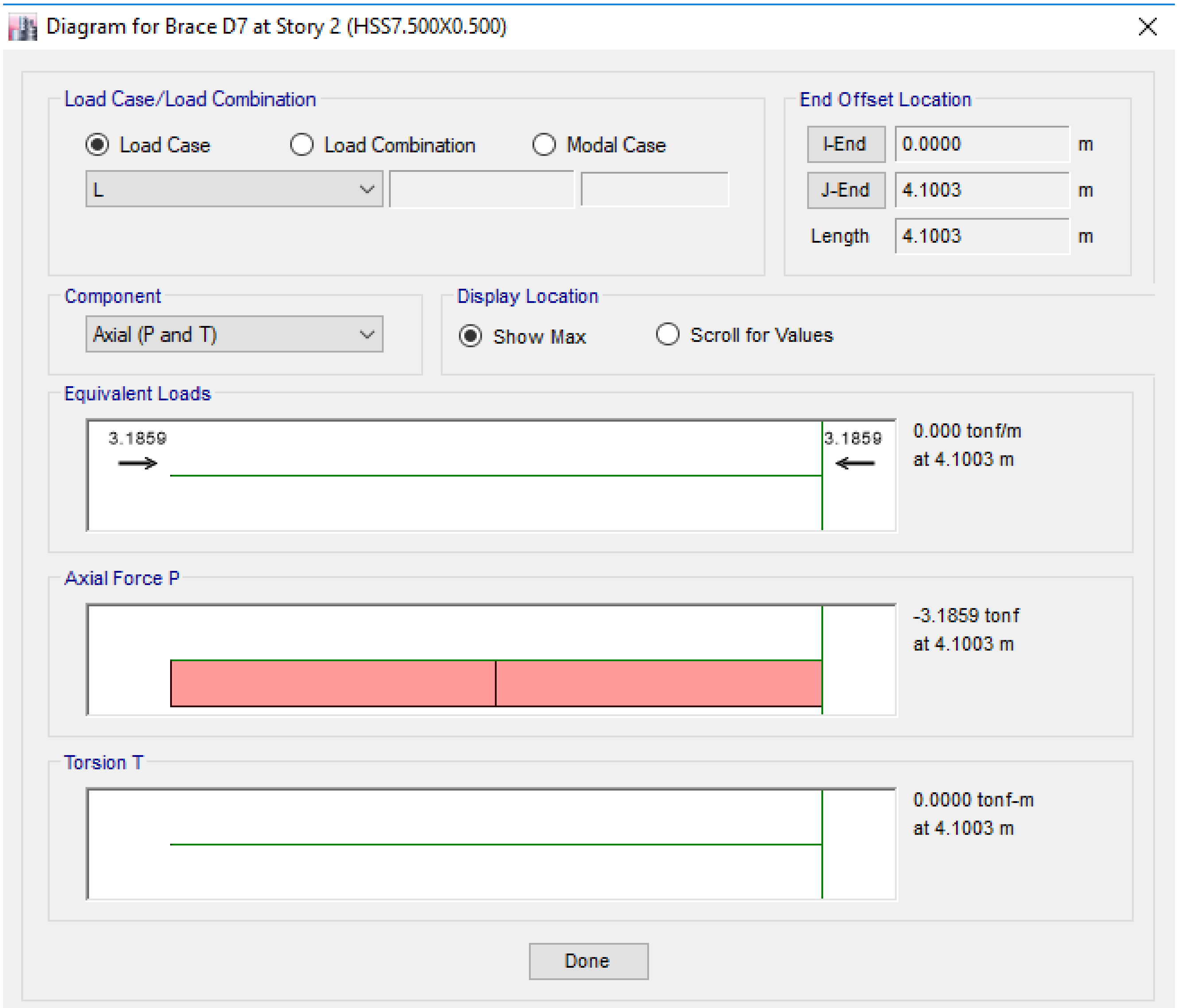
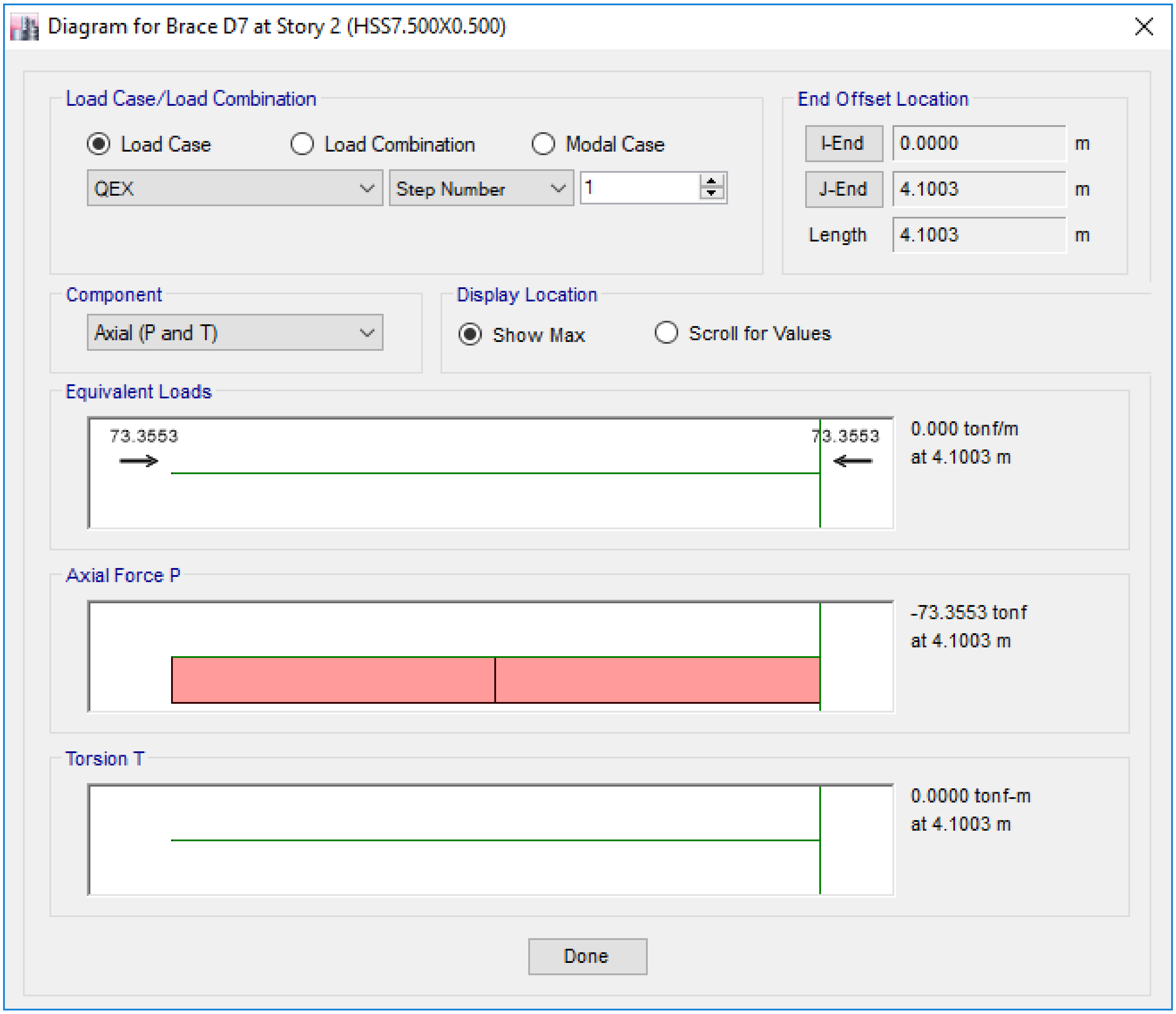


Diagrama de Axial en arriostre BR-2 debido a Sismo.



Usando una conexión CVR
se usaron las secciones que resultaron del diseño de columna y vigas.

BM-2	W24X62
BR-2	HSS_RND 7.5X0.5
BR-1	HSS_RND 8.625X0.50

Joint 8

Joint data Loads

Property	Value
Joint	CVR
Description	PB-1
Actual members	
Upper gusset	Yes
Lower gusset	Yes
Beam	
Section	W 24X62
Material	A992 Gr50
Upper right brace	
Section	HSS_RND 7.500X0.500
Material	A992 Gr50
Slope angle	53
Rotation	0
sbB: Setback	1.27 cm
Upper left brace	
Section	HSS_RND 7.500X0.500
Material	A992 Gr50
Slope angle	53
Rotation	0
sbB: Setback	1.27 cm
Lower left brace	
Section	HSS_RND 8.625X0.500
Material	A992 Gr50
Slope angle	53
Rotation	0
sbB: Setback	1.27 cm
Lower right brace	
Section	HSS_RND 8.625X0.500

Ingresamos las cargas muertas, vivas y sismo obtenidas del análisis.

Joint 8

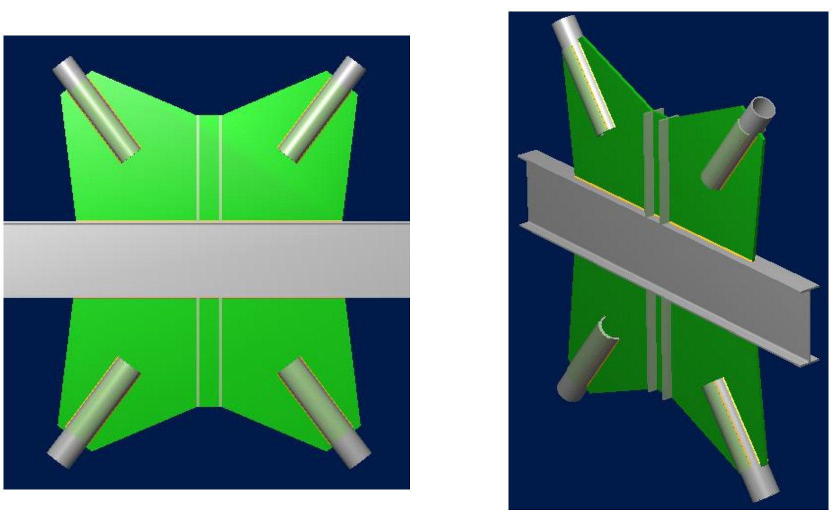
Joint data | Loads

Beam(s) - Column(s)

		Beam		
Num	Condition	V2	Axial	M33
1	C1	0.74	0	0.32
2	C2	0.27	0	0.11
3	C3	0.001	0	0.001
4	C4	0	0	0
5	C5	0	0	0
6	C6	0	0	0

Braces

		(1) Top right	(2) Top left	(3) Bottom left	(4) Bottom right
Num	Condition	Axial	Axial	Axial	Axial
1	C1	-7.77	-7.77	-9.04	-9.04
2	C2	-3.18	-3.18	-3.55	-3.55
3	C3	-73.35	73.35	104	-104
4	C4	0	0	0	0
5	C5	0	0	0	0
6	C6	0	0	0	0



Modelo 3D en RAM CONECTTION

Datos:

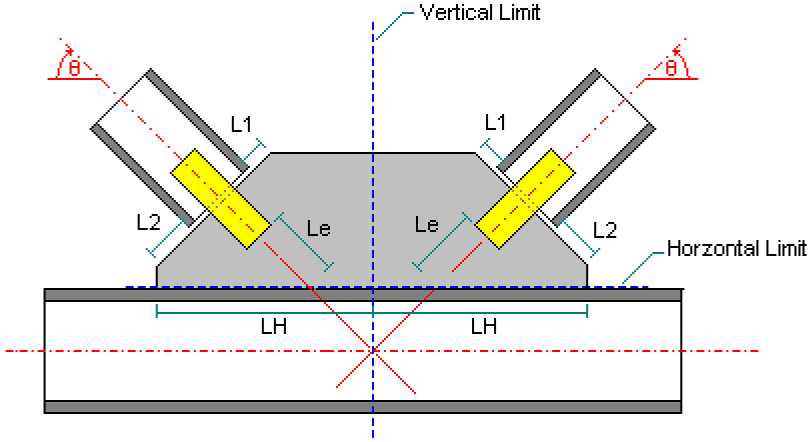
Connection name : CVR

Connection ID : 8

Family: Chevron - Braces (CVR)
Type: Gusset
Description: PB-1

GENERAL INFORMATION

Connector



MEMBERS

Actual members

Upper gusset	:	Yes
Lower gusset	:	Yes
Stiffen gusset	:	Yes
Stiffeners thickness	:	1 cm
Distance between stiffeners	:	20 cm
Beam		
General		
Section	:	W 24X62
Material	:	A992 Gr50
Upper right brace		
General		
Section	:	HSS_RND 7.500X0.500
Material	:	A992 Gr50
Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm
LH: Length on beam	:	61.5 cm
LV: Length on stiffener	:	45.89 cm
Upper left brace		
General		
Section	:	HSS_RND 7.500X0.500
Material	:	A992 Gr50

Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm
LH: Length on beam	:	61.5 cm
LV: Length on stiffener	:	45.89 cm
Lower left brace		
General		
Section	:	HSS_RND 8.625X0.500
Material	:	A992 Gr50
Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm
LH: Length on beam	:	63.84 cm
LV: Length on stiffener	:	46.57 cm
Lower right brace		
General		
Section	:	HSS_RND 8.625X0.500
Material	:	A992 Gr50
Brace slope angle (degrees)	:	53
L: Length	:	3 m
Additional geometric data		
wpx: WP horizontal displacement	:	0 cm
wpy: WP vertical displacement	:	0 cm
Le: Minimum distance to other members	:	5.08 cm
L1: Left distance	:	5.08 cm
L2: Right distance	:	5.08 cm
LH: Length on beam	:	62.99 cm
LV: Length on stiffener	:	47.81 cm

INTERFACES

Upper gusset		
General		
tp: Thickness	:	2.5 cm
Material	:	A992 Gr50
LV: Length over vertical limit	:	83.15 cm
LH: Length on beam	:	94.78 cm
Top gusset-to-beam connection		
Connection type to beam	:	Directly welded
Directly welded		
Welding electrode to beam	:	E70XX
D: Weld size to beam (1/16 in)	:	6
Upper right brace		
General		
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	5
Gusset-to-Brace connection		

Lt: Length on toe	:	70 cm
Lh: Length on heel	:	70 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	2.54 cm
Upper left brace		
General		
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	5
Gusset-to-Brace connection		
Lt: Length on toe	:	70 cm
Lh: Length on heel	:	70 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	2.54 cm
Lower gusset		
General		
tp: Thickness	:	2.5 cm
Material	:	A572 Gr50
LV: Length over vertical limit	:	85.52 cm
LH: Length on beam	:	96.99 cm
Bottom gusset-to-beam connection		
Connection type to beam	:	Directly welded
Directly welded		
Welding electrode to beam	:	E70XX
D: Weld size to beam (1/16 in)	:	6
Lower left brace		
General		
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	5
Gusset-to-Brace connection		
Lt: Length on toe	:	70 cm
Lh: Length on heel	:	70 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	2.54 cm
Lower right brace		
General		
Reinforce brace section	:	Yes
Brace reinforcement data		
Reinforcement plate thickness	:	1 cm
Reinforcement plate length	:	80 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	5
Gusset-to-Brace connection		
Lt: Length on toe	:	70 cm
Lh: Length on heel	:	70 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	2.54 cm

Results

Connection name : CVR
Connection ID : 8

Family: Chevron - Braces (CVR)
Type: Gusset
Description: PB-1
Design code: AISC 360-10 LRFD

DEMANDS

	Beam			Pu				
Description	**Pu** [Ton]	**Vu** [Ton]	**Mu33** [Ton*m]	**Brace1** [Ton]	**Brace2** [Ton]	**Brace3** [Ton]	**Brace4** [Ton]	**Load type**
D1	0.00	1.04	0.45	-10.88	-10.88	-14.50	-14.50	Design
D2	0.00	1.32	0.56	-14.41	-14.41	-18.90	-18.90	Design
D3	0.00	0.89	0.38	-9.32	-9.32	-12.43	-12.43	Design
D4	0.00	0.89	0.38	-9.32	-9.32	-12.43	-12.43	Design
D5	0.00	0.89	0.38	-9.32	-9.32	-12.43	-12.43	Design
D6	0.00	0.89	0.38	-9.32	-9.32	-12.43	-12.43	Design
D7	0.00	1.16	0.49	-12.50	-12.50	-16.47	-16.47	Design
D8	0.00	1.16	0.49	-12.50	-12.50	-16.47	-16.47	Design
D9	0.00	0.89	0.39	-82.67	64.03	91.85	-116.71	Seismic
D10	0.00	0.89	0.38	-9.32	-9.32	-12.43	-12.43	Design
D11	0.00	1.16	0.50	-85.85	60.85	87.81	-120.75	Seismic
D12	0.00	1.16	0.49	-12.50	-12.50	-16.47	-16.47	Design
D13	0.00	0.67	0.29	-6.99	-6.99	-9.32	-9.32	Design
D14	0.00	0.67	0.29	-6.99	-6.99	-9.32	-9.32	Design
D15	0.00	0.67	0.29	-80.34	66.36	94.96	-113.60	Seismic
D16	0.00	0.67	0.29	-6.99	-6.99	-9.32	-9.32	Design
D17	0.00	0.74	0.32	-7.77	-7.77	-10.36	-10.36	Design
D18	0.00	1.01	0.43	-10.95	-10.95	-14.40	-14.40	Design
D19	0.00	0.94	0.40	-10.16	-10.16	-13.39	-13.39	Design
D20	0.00	0.74	0.32	-7.77	-7.77	-10.36	-10.36	Design
D21	0.00	0.74	0.32	-7.77	-7.77	-10.36	-10.36	Design
D22	0.00	0.74	0.32	-59.12	43.58	62.64	-83.36	Seismic
D23	0.00	0.74	0.32	-7.77	-7.77	-10.36	-10.36	Design
D24	0.00	0.94	0.40	-10.16	-10.16	-13.39	-13.39	Design
D25	0.00	0.94	0.40	-10.16	-10.16	-13.39	-13.39	Design
D26	0.00	0.74	0.32	-46.28	30.74	44.39	-65.11	Seismic
D27	0.00	0.74	0.32	-7.77	-7.77	-10.36	-10.36	Design
D28	0.00	0.44	0.19	-4.66	-4.66	-6.22	-6.22	Design
D29	0.00	0.44	0.19	-4.66	-4.66	-6.22	-6.22	Design
D30	0.00	0.44	0.19	-56.01	46.68	66.78	-79.21	Design
D31	0.00	0.44	0.19	-4.66	-4.66	-6.22	-6.22	Design

Interface between Gusset - Top right brace

Connection: Directly welded

DEMANDS

Pu [Ton]	Description	Load type
-10.88	D1	Design
-14.41	D2	Design
-9.32	D3	Design
-9.32	D4	Design
-9.32	D5	Design
-9.32	D6	Design
-12.50	D7	Design
-12.50	D8	Design
-239.80	D9	Seismic
-9.32	D10	Design
-239.80	D11	Seismic
-12.50	D12	Design
-6.99	D13	Design
-6.99	D14	Design
-239.80	D15	Seismic
-6.99	D16	Design
-7.77	D17	Design
-10.95	D18	Design
-10.16	D19	Design
-7.77	D20	Design
-7.77	D21	Design
-239.80	D22	Seismic
-7.77	D23	Design
-10.16	D24	Design
-10.16	D25	Design
-239.80	D26	Seismic
-7.77	D27	Design
-4.66	D28	Design
-4.66	D29	Design
-56.01	D30	Design
-4.66	D31	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace - Directly welded Connection						
Total weld design strength	[Ton]	348.04	239.80	D9	0.69	Eq. J2-4, Eq. J2-6

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]*70[cm] = **39.29**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*39.29[cm2]) = **174.02**[T] — Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]*70[cm] = **39.29**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*39.29[cm2]) = **174.02**[T] — Eq. J2-4

$\phi R_n = \phi R_{w1} + \phi R_{w2} = 174.02$[T] + 174.02[T] = **348.04**[T] — Eq. J2-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Maximum weld force that brace can develop	[Ton]	680.09	239.80	D9	0.35	Eq. J4-4

$L_e = L_t + L_h = 70$[cm] + 70[cm] = **140**[cm]

$A_{nv} = L_e * t_p = 140$[cm]*1.18[cm] = **165.35**[cm2] Sec. J4-2

$\phi R_n = 2 * (\phi * 0.60 * F_u * A_{nv}) = 2 * (0.75*0.60*4569.93$[kg/cm2]*165.35[cm2]) = **680.09**[T] Eq. J4-4

Gusset

Maximum weld force that gusset can develop	[Ton]	719.76	239.80	D9	0.33	Eq. J4-4

$L_e = L_t + L_h = 70$[cm] + 70[cm] = **140**[cm]

$A_{nv} = L_e * t_p = 140$[cm]*2.5[cm] = **350**[cm2] Sec. J4-2

$\phi R_n = \phi * 0.60 * F_u * A_{nv} = 0.75*0.60*4569.93$[kg/cm2]*350[cm2] = **719.76**[T] Eq. J4-4

Ratio **0.69**

Checks for gusset and brace

REQUIRED RESISTANCE OF BRACED CONNECTIONS

Requirement	Value [Ton]
Required tensile strength	256.96
Required compressive strength	239.80

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Slenderness		47.42	--	200.00	✔	AISC 341-10 Sec. F2.5b.

$\lambda_{max} = 200$ AISC 341-10 Sec. F2.5b.

$\lambda_b = L/r = 300$[cm]/6.33[cm] = **47.42**

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Local buckling		16.13	0.00	22.04	✔	Seismic Manual Table I-8-1, Seismic Manual Table D1.1

$\lambda = D/t_p = 19.05$[cm]/1.18[cm] = **16.13** Seismic Manual Table I-8-1

$\lambda_{hd} = 0.038*(E/F_y) = 0.038*(2.04E+06$[kg/cm2]/3515.33[kg/cm2]) = **22.04** Seismic Manual Table D1.1

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Gusset plate plastic hinge length (2t)	[cm]	5.00	5.00	10.00	✔	
Weld size	[1/16in]	5	3	5	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min}$ = **0.004763** table J2.4

t_p<1/4 [in] → 1[cm]<1/4 [in] → **False**

$w_{max} = t_p$ - 1/16 [in] = 1[cm] - 1/16 [in] = **0.008413** Sec. J2.2b

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DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace						
Compression	[Ton]	178.37	56.01	D30	0.31	Eq. E3-1
$F_e = \pi^2 * E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(1*300$[cm]$/6.33$[cm]$)^2 = \mathbf{8949.16}$[kg/cm2]						Eq. E3-4
$F_e >= 0.44*Q*F_y \rightarrow 8949.16$[kg/cm2]$>=0.44*1*3515.33$[kg/cm2] $\rightarrow$ **True**						
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}*3515.33$[kg/cm2] $= \mathbf{2982.38}$[kg/cm2]						Eq. E7-2
$\phi P_n = \phi * F_{cr} * A_g = 0.9*2982.38$[kg/cm2]$*66.45$[cm2] $= \mathbf{178.37}$[T]						Eq. E3-1
Weld capacity for reinforcement plate	[Ton]	397.76	118.74	D9	0.30	Eq. J2-4
$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] $= \mathbf{2952.88}$[kg/cm2]						Sec. J2.4
$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*80$[cm] $= \mathbf{44.9}$[cm2]						Sec. J2.4
$\phi R_n = 4 * (\phi * F_w * A_w) = 4 * (0.75*2952.88$[kg/cm2]$*44.9$[cm2]$) = \mathbf{397.76}$[T]						Eq. J2-4
Gusset						
Buckling on the Whitmore section	[Ton]	620.67	239.80	D9	0.39	Eq. E3-1
$F_e = \pi^2 * E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(0.65*63.77$[cm]$/0.722$[cm]$)^2 = \mathbf{6099.66}$[kg/cm2]						Eq. E3-4
$F_e >= 0.44*Q*F_y \rightarrow 6099.66$[kg/cm2]$>=0.44*1*3515.33$[kg/cm2] $\rightarrow$ **True**						
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/6099.66[kg/cm2])}*3515.33$[kg/cm2] $= \mathbf{2761.89}$[kg/cm2]						Eq. E7-2
$\phi P_n = \phi * F_{cr} * A_g = 0.9*2761.89$[kg/cm2]$*249.7$[cm2] $= \mathbf{620.67}$[T]						Eq. E3-1

Ratio	**0.39**

Calculation of the brace interface forces

Load condition :D1

$H = P*cos\theta = -10.88$[T]$*0.602 = \mathbf{-6.55}$[T]

$V = P*sin\theta = -10.88$[T]$*0.799 = \mathbf{-8.69}$[T]

Load condition :D2

$H = P*cos\theta = -14.41$[T]$*0.602 = \mathbf{-8.67}$[T]

$V = P*sin\theta = -14.41$[T]$*0.799 = \mathbf{-11.51}$[T]

Load condition :D3

$H = P*cos\theta = -9.32$[T]$*0.602 = \mathbf{-5.61}$[T]

$V = P*sin\theta = -9.32$[T]$*0.799 = \mathbf{-7.45}$[T]

Load condition :D4

$H = P*cos\theta = -9.32$[T]$*0.602 = \mathbf{-5.61}$[T]

$V = P*sin\theta = -9.32$[T]$*0.799 = \mathbf{-7.45}$[T]

Load condition :D5

$H = P*cos\theta = -9.32$[T]$*0.602 = \mathbf{-5.61}$[T]

$V = P*sin\theta = -9.32$[T]$*0.799 = \mathbf{-7.45}$[T]

Load condition :D6

$H = P*cos\theta$ = -9.32[T]*0.602 = **-5.61**[T]

$V = P*sin\theta$ = -9.32[T]*0.799 = **-7.45**[T]

Load condition :D7

$H = P*cos\theta$ = -12.5[T]*0.602 = **-7.53**[T]

$V = P*sin\theta$ = -12.5[T]*0.799 = **-9.99**[T]

Load condition :D8

$H = P*cos\theta$ = -12.5[T]*0.602 = **-7.53**[T]

$V = P*sin\theta$ = -12.5[T]*0.799 = **-9.99**[T]

Load condition :D9

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4

F_e>=0.44*$Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.

$H = P*cos\theta$ = -239.8[T]*0.602 = **-144.32**[T]

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4

F_e>=0.44*$Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.

$V = P*sin\theta$ = -239.8[T]*0.799 = **-191.51**[T]

Load condition :D10

$H = P*cos\theta$ = -9.32[T]*0.602 = **-5.61**[T]

$V = P*sin\theta$ = -9.32[T]*0.799 = **-7.45**[T]

Load condition :D11

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4

F_e>=0.44*$Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.

$H = P*cos\theta$ = -239.8[T]*0.602 = **-144.32**[T]

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4

F_e>=0.44*$Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.

$V = P*sin\theta$ = -239.8[T]*0.799 = **-191.51**[T]

Load condition :D12

$H = P*cos\theta$ = -12.5[T]*0.602 = **-7.53**[T]
$V = P*sin\theta$ = -12.5[T]*0.799 = **-9.99**[T]

Load condition :D13

$H = P*cos\theta$ = -6.99[T]*0.602 = **-4.21**[T]
$V = P*sin\theta$ = -6.99[T]*0.799 = **-5.58**[T]

Load condition :D14

$H = P*cos\theta$ = -6.99[T]*0.602 = **-4.21**[T]
$V = P*sin\theta$ = -6.99[T]*0.799 = **-5.58**[T]

Load condition :D15

$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
F_e>=0.44*Q*F_y → 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] → **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.
$H = P*cos\theta$ = -239.8[T]*0.602 = **-144.32**[T]
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
F_e>=0.44*Q*F_y → 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] → **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.
$V = P*sin\theta$ = -239.8[T]*0.799 = **-191.51**[T]

Load condition :D16

$H = P*cos\theta$ = -6.99[T]*0.602 = **-4.21**[T]
$V = P*sin\theta$ = -6.99[T]*0.799 = **-5.58**[T]

Load condition :D17

$H = P*cos\theta$ = -7.77[T]*0.602 = **-4.68**[T]
$V = P*sin\theta$ = -7.77[T]*0.799 = **-6.21**[T]

Load condition :D18

$H = P*cos\theta$ = -10.95[T]*0.602 = **-6.59**[T]
$V = P*sin\theta$ = -10.95[T]*0.799 = **-8.75**[T]

Load condition :D19

$H = P*cos\theta$ = -10.16[T]*0.602 = **-6.11**[T]
$V = P*sin\theta$ = -10.16[T]*0.799 = **-8.11**[T]

Load condition :D20

$H = P*cos\theta$ = -7.77[T]*0.602 = **-4.68**[T]
$V = P*sin\theta$ = -7.77[T]*0.799 = **-6.21**[T]

Load condition :D21
$H = P*cos\theta$ = -7.77[T]*0.602 = **-4.68**[T]
$V = P*sin\theta$ = -7.77[T]*0.799 = **-6.21**[T]

Load condition :D22
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
$F_e>=0.44*Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] =
2982.38[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.
$H = P*cos\theta$ = -239.8[T]*0.602 = **-144.32**[T]
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
$F_e>=0.44*Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] =
2982.38[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.
$V = P*sin\theta$ = -239.8[T]*0.799 = **-191.51**[T]

Load condition :D23
$H = P*cos\theta$ = -7.77[T]*0.602 = **-4.68**[T]
$V = P*sin\theta$ = -7.77[T]*0.799 = **-6.21**[T]

Load condition :D24
$H = P*cos\theta$ = -10.16[T]*0.602 = **-6.11**[T]
$V = P*sin\theta$ = -10.16[T]*0.799 = **-8.11**[T]

Load condition :D25
$H = P*cos\theta$ = -10.16[T]*0.602 = **-6.11**[T]
$V = P*sin\theta$ = -10.16[T]*0.799 = **-8.11**[T]

Load condition :D26
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
$F_e>=0.44*Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] =
2982.38[kg/cm2] Eq. E7-2
$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.
$H = P*cos\theta$ = -239.8[T]*0.602 = **-144.32**[T]
$F_e = \pi^2*E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]/(1*300[cm]/6.33[cm])^2 = **8949.16**[kg/cm2] Eq. E3-4
$F_e>=0.44*Q*F_y \rightarrow$ 8949.16[kg/cm2]>=0.44*1*3515.33[kg/cm2] $\rightarrow$ **True**
$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}$*3515.33[kg/cm2] =
2982.38[kg/cm2] Eq. E7-2

$\phi R_n = \phi*1.1*R_y*P_n$ = 1*1.1*1.1*198.18[T] = **239.8**[T] AISC 341-10 Sec. F2.6c.

$V = P*sin\theta$ = -239.8[T]*0.799 = **-191.51**[T]

Load condition :D27

$H = P*cos\theta$ = -7.77[T]*0.602 = **-4.68**[T]

$V = P*sin\theta$ = -7.77[T]*0.799 = **-6.21**[T]

Load condition :D28

$H = P*cos\theta$ = -4.66[T]*0.602 = **-2.81**[T]

$V = P*sin\theta$ = -4.66[T]*0.799 = **-3.72**[T]

Load condition :D29

$H = P*cos\theta$ = -4.66[T]*0.602 = **-2.81**[T]

$V = P*sin\theta$ = -4.66[T]*0.799 = **-3.72**[T]

Load condition :D30

$H = P*cos\theta$ = -56.01[T]*0.602 = **-33.71**[T]

$V = P*sin\theta$ = -56.01[T]*0.799 = **-44.73**[T]

Load condition :D31

$H = P*cos\theta$ = -4.66[T]*0.602 = **-2.81**[T]

$V = P*sin\theta$ = -4.66[T]*0.799 = **-3.72**[T]

Interface between Gusset - Top left brace

Connection: Directly welded

DEMANDS

Pu [Ton]	Description	Load type
-10.88	D1	Design
-14.41	D2	Design
-9.32	D3	Design
-9.32	D4	Design
-9.32	D5	Design
-9.32	D6	Design
-12.50	D7	Design
-12.50	D8	Design
256.96	D9	Seismic
-9.32	D10	Design
256.96	D11	Seismic
-12.50	D12	Design
-6.99	D13	Design
-6.99	D14	Design
256.96	D15	Seismic
-6.99	D16	Design
-7.77	D17	Design
-10.95	D18	Design
-10.16	D19	Design
-7.77	D20	Design
-7.77	D21	Design

256.96	D22	Seismic
-7.77	D23	Design
-10.16	D24	Design
-10.16	D25	Design
256.96	D26	Seismic
-7.77	D27	Design
-4.66	D28	Design
-4.66	D29	Design
46.68	D30	Design
-4.66	D31	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Brace - Directly welded Connection</u>						
Total weld design strength	[Ton]	348.04	256.96	D9	0.74	Eq. J2-4, Eq. J2-6

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]*70[cm] = **39.29**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*39.29[cm2]) = **174.02**[T] — Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]*70[cm] = **39.29**[cm2] — Sec. J2.4

$\phi R_n = 2 * (\phi*F_w*A_w) = 2 * (0.75*2952.88$[kg/cm2]*39.29[cm2]) = **174.02**[T] — Eq. J2-4

$\phi R_n = \phi R_{w1} + \phi R_{w2} = 174.02$[T] + 174.02[T] = **348.04**[T] — Eq. J2-6

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Maximum weld force that brace can develop	[Ton]	680.09	256.96	D9	0.38	Eq. J4-4

$L_e = L_t + L_h = 70$[cm] + 70[cm] = **140**[cm]

$A_{nv} = L_e*t_p = 140$[cm]*1.18[cm] = **165.35**[cm2] — Sec. J4-2

$\phi R_n = 2 * (\phi*0.60*F_u*A_{nv}) = 2 * (0.75*0.60*4569.93$[kg/cm2]*165.35[cm2]) = **680.09**[T] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Gusset</u>						
Maximum weld force that gusset can develop	[Ton]	719.76	256.96	D9	0.36	Eq. J4-4

$L_e = L_t + L_h = 70$[cm] + 70[cm] = **140**[cm]

$A_{nv} = L_e*t_p = 140$[cm]*2.5[cm] = **350**[cm2] — Sec. J4-2

$\phi R_n = \phi*0.60*F_u*A_{nv} = 0.75*0.60*4569.93$[kg/cm2]*350[cm2] = **719.76**[T] — Eq. J4-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Block shear on gusset	[Ton]	736.99	256.96	D9	0.35	Eq. J4-5

$L_{max} = \max(L_t, L_h) = \max(70$[cm], 70[cm]) = **70**[cm]

$L = L_{max} + d_w = 70$[cm] + 2.54[cm] = **72.54**[cm] — Sec. J4.3

$A_{gv} = 2*L*t_p = 2*72.54$[cm]*2.5[cm] = **362.7**[cm2] — Sec. J4.3

$A_{nv} = A_{gv}$ = **362.7**[cm2] — Sec. J4.3

$A_{nt} = b*t_p = 19.05$[cm]*2.5[cm] = **47.62**[cm2] — Sec. J4.3

$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*$
min(0.6*4569.93[kg/cm2]*362.7[cm2] + 1*4569.93[kg/cm2]*47.62[cm2], 0.6*3515.33[kg/cm2]*362.7[cm2] + 1*
4569.93[kg/cm2]*47.62[cm2]) = **736.99**[T] — Eq. J4-5

Ratio **0.74**

Checks for gusset and brace

REQUIRED RESISTANCE OF BRACED CONNECTIONS

Requirement	Value [Ton]
Required tensile strength	256.96
Required compressive strength	239.80

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Slenderness		47.42	--	200.00	✔	AISC 341-10 Sec. F2.5b.

$\lambda_{max} = 200$ AISC 341-10 Sec. F2.5b.

$\lambda_b = L/r = 300[cm]/6.33[cm] = \mathbf{47.42}$

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Local buckling		16.13	0.00	22.04	✔	Seismic Manual Table I-8-1, Seismic Manual Table D1.1

$\lambda = D/t_p = 19.05[cm]/1.18[cm] = \mathbf{16.13}$ Seismic Manual Table I-8-1

$\lambda_{hd} = 0.038*(E/F_y) = 0.038*(2.04E+06[kg/cm2]/3515.33[kg/cm2]) = \mathbf{22.04}$ Seismic Manual Table D1.1

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Gusset plate plastic hinge length (2t)	[cm]	5.00	5.00	10.00	✔	
Weld size	[1/16in]	5	3	5	✔	table J2.4, Sec. J2.2b

$w_{min} = w_{min} = \mathbf{0.004763}$ table J2.4

$t_p<1/4\ [in] \rightarrow 1[cm]<1/4\ [in] \rightarrow \mathbf{False}$

$w_{max} = t_p - 1/16\ [in] = 1[cm] - 1/16\ [in] = \mathbf{0.008413}$ Sec. J2.2b

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Brace</u>						
Yielding strength due to axial load	[Ton]	210.24	46.68	D30	0.22	Eq. J4-1

$\phi R_n = \phi*F_y*A_g = 0.9*3515.33[kg/cm2]*66.45[cm2] = \mathbf{210.24}[T]$ Eq. J4-1

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Tension rupture	[Ton]	315.49	256.96	D9	0.81	Seismic Manual p.3-54

$A_n = A_g - 2*(t_p + 1/8\ [in])*t = 66.45[cm2] - 2*(2.5[cm] + 1/8\ [in])*1.18[cm] = \mathbf{59.8}[cm2]$ Sec. D3.2

$U = 1 - x/l = 1 - 5.84[cm]/70[cm] = \mathbf{0.917}$ Table D3.1

$A_e = A_n*U = 91.29[cm2]*0.917 = \mathbf{83.68}[cm2]$ Eq. D3-1

$\phi R_n = \phi*R_t*F_u*A_e = 0.75*1.1*4569.93[kg/cm2]*83.68[cm2] = \mathbf{315.49}[T]$ Seismic Manual p.3-54

Compression	[Ton]	178.37	14.41	D2	0.08	Eq. E3-1

$F_e = \pi^2 * E/(K*L/r)^2 = \pi^2*2.04E+06$[kg/cm2]$/(1*300$[cm]$/6.33$[cm]$)^2 = \mathbf{8949.16}$[kg/cm2] Eq. E3-4

$F_e >= 0.44*Q*F_y \rightarrow 8949.16$[kg/cm2]$>=0.44*1*3515.33$[kg/cm2] $\rightarrow$ **True**

$F_{cr} = 0.658^{(Q*Fy/Fe)}*F_y = 0.658^{(1*3515.33[kg/cm2]/8949.16[kg/cm2])}*3515.33$[kg/cm2] = **2982.38**[kg/cm2] Eq. E7-2

$\phi P_n = \phi * F_{cr} * A_g = 0.9*2982.38$[kg/cm2]$*66.45$[cm2] = **178.37**[T] Eq. E3-1

Weld capacity for reinforcement plate	[Ton]	397.76	118.74	D9	0.30	Eq. J2-4

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*80$[cm] = **44.9**[cm2] Sec. J2.4

$\phi R_n = 4 * (\phi * F_w * A_w) = 4 * (0.75*2952.88$[kg/cm2]$*44.9$[cm2]$)$ = **397.76**[T] Eq. J2-4

Gusset

Tension yielding on the Whitmore section	[Ton]	789.99	256.96	D9	0.33	Eq. J4-1

$A_g = L_w * t_p = 99.88$[cm]$*2.5$[cm] = **249.7**[cm2]

$\phi R_n = \phi * F_y * A_g = 0.9*3515.33$[kg/cm2]$*249.7$[cm2] = **789.99**[T] Eq. J4-1

Ratio **0.81**

Calculation of the brace interface forces

Load condition :D1

$H = P*cos\theta = -10.88$[T]$*0.602$ = **-6.55**[T]

$V = P*sin\theta = -10.88$[T]$*0.799$ = **-8.69**[T]

Load condition :D2

$H = P*cos\theta = -14.41$[T]$*0.602$ = **-8.67**[T]

$V = P*sin\theta = -14.41$[T]$*0.799$ = **-11.51**[T]

Load condition :D3

$H = P*cos\theta = -9.32$[T]$*0.602$ = **-5.61**[T]

$V = P*sin\theta = -9.32$[T]$*0.799$ = **-7.45**[T]

Load condition :D4

$H = P*cos\theta = -9.32$[T]$*0.602$ = **-5.61**[T]

$V = P*sin\theta = -9.32$[T]$*0.799$ = **-7.45**[T]

Load condition :D5

$H = P*cos\theta = -9.32$[T]$*0.602$ = **-5.61**[T]

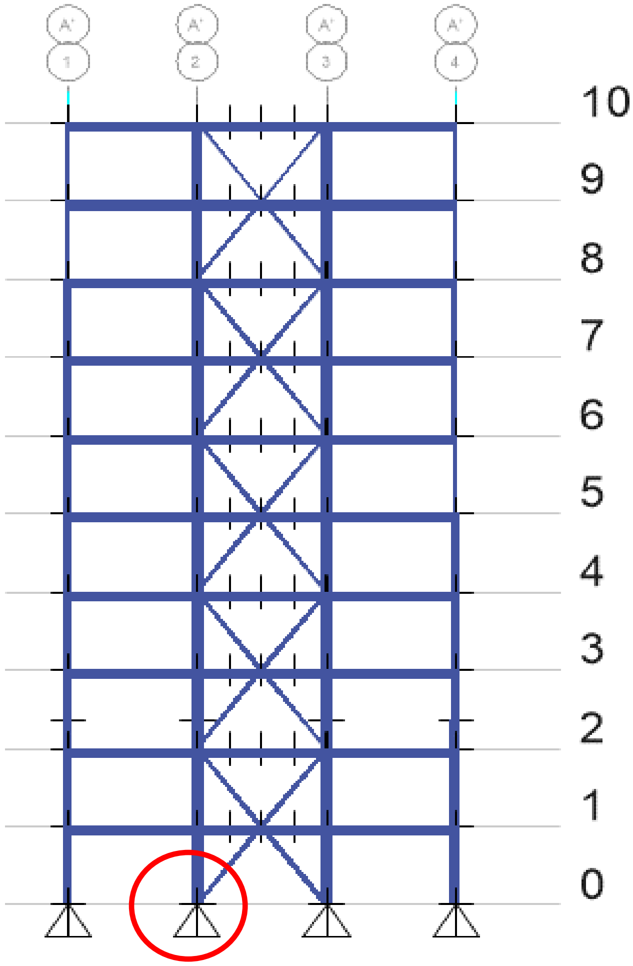
$V = P*sin\theta = -9.32$[T]$*0.799$ = **-7.45**[T]

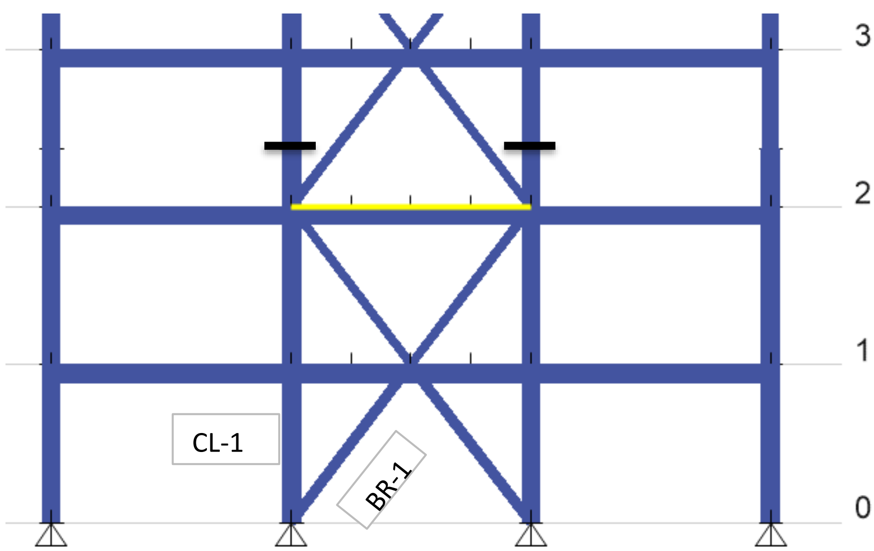
Load condition :D6

$H = P*cos\theta = -9.32$[T]$*0.602$ = **-5.61**[T]

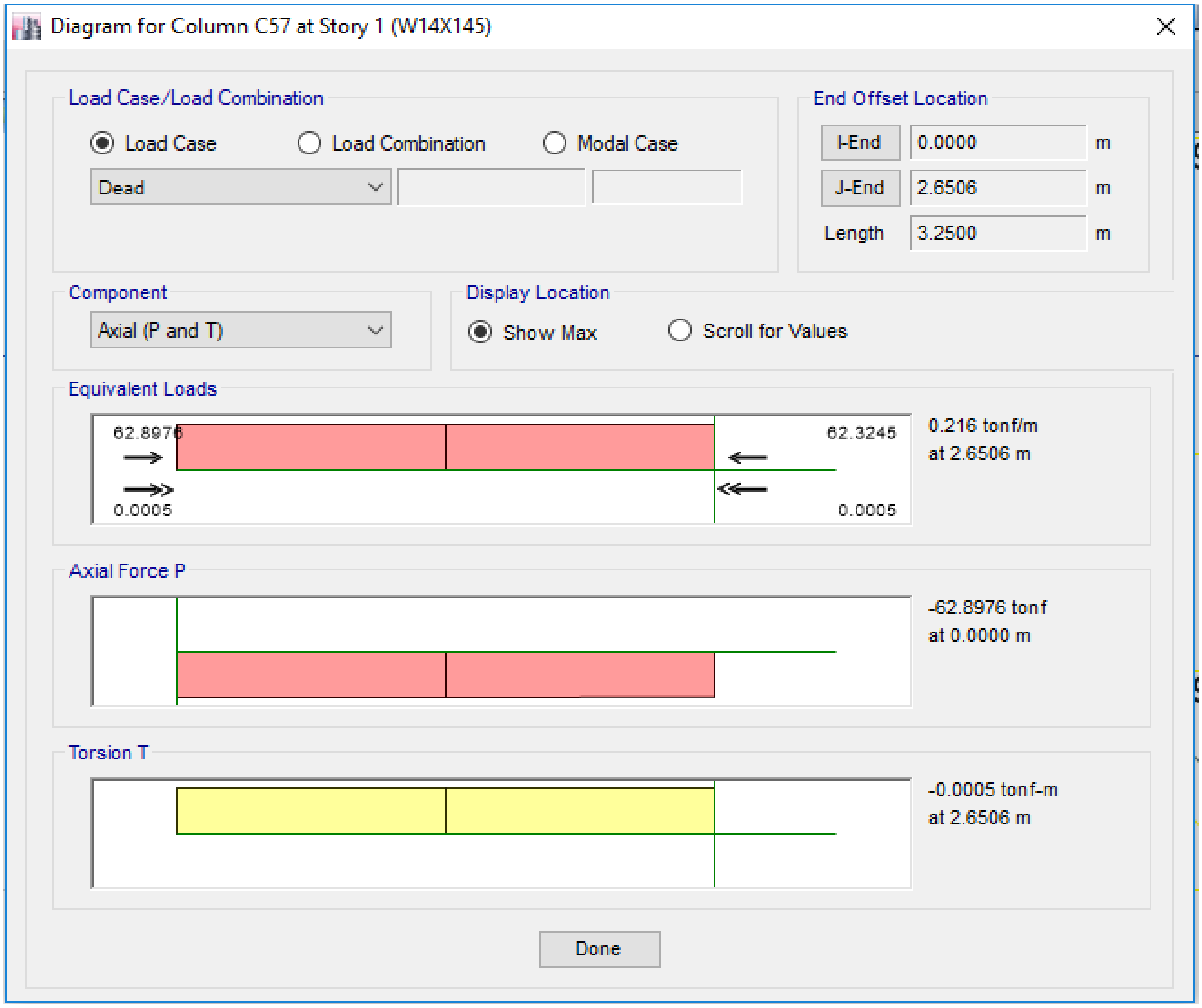
$V = P*sin\theta = -9.32$[T]$*0.799$ = **-7.45**[T]

6.9. DISEÑO DE CONEXION PLACA BASE-ARRIOSTRE.

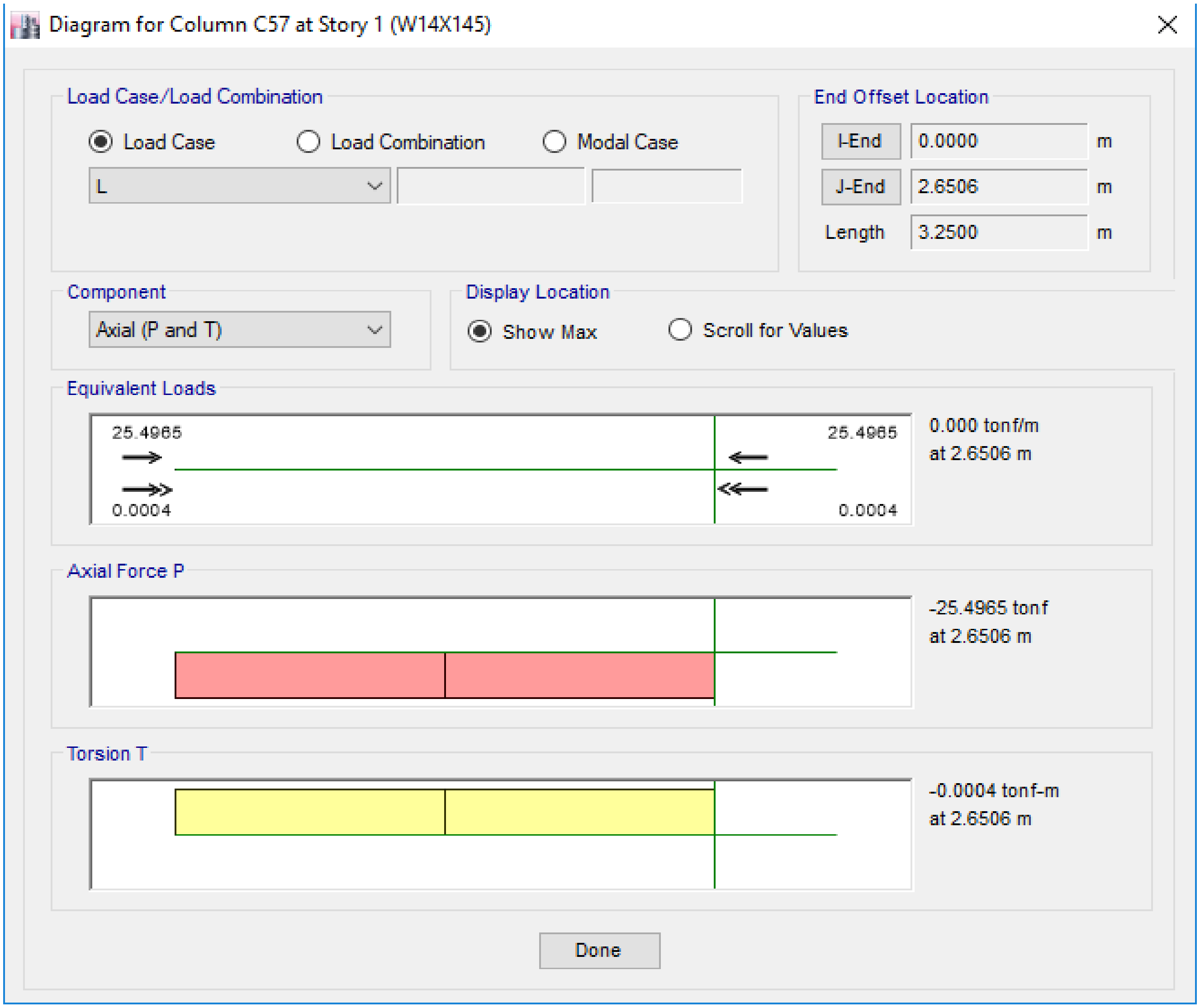




<u>Diagrama de Axial de columna CL-1 debido carga muerta</u>



<u>Diagrama de Axial de columna CL-1 debido carga viva.</u>



<u>Diagrama de Axial de columna CL-1 debido a Sismo.</u>

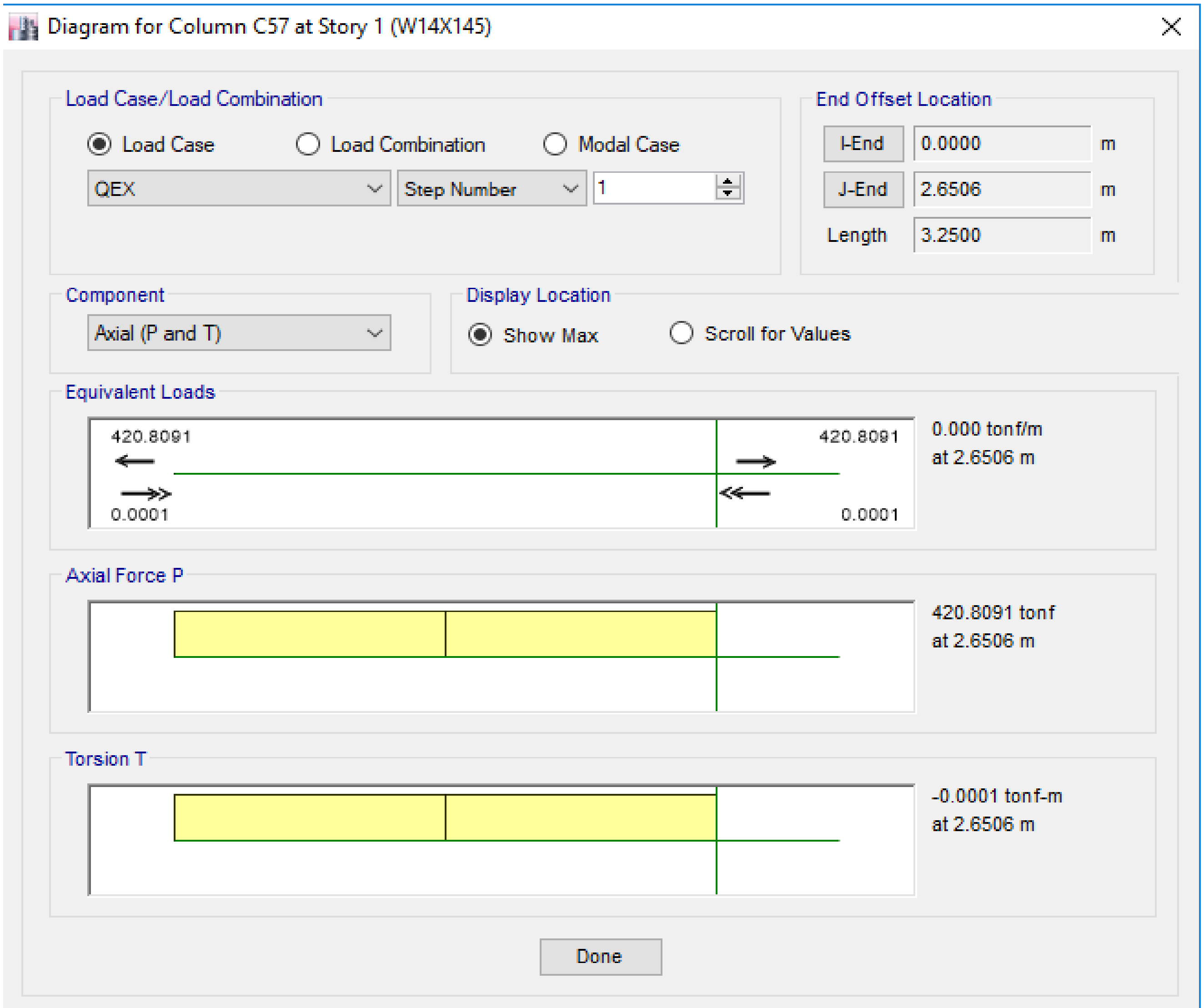


Diagrama de Axial de Arriostre BR-1 debido carga muerta

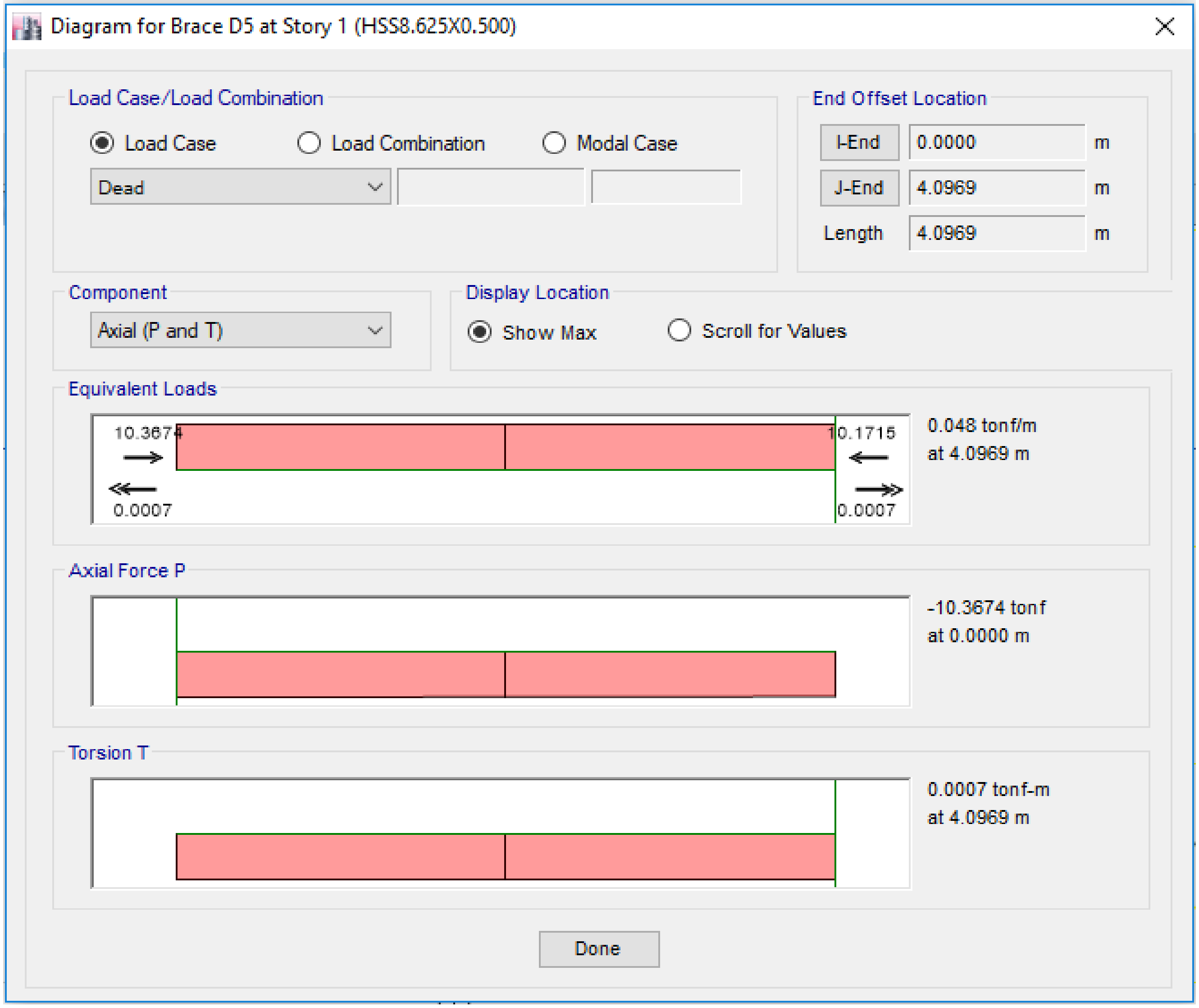


Diagrama de Axial de Arriostre BR-1 debido carga Viva.

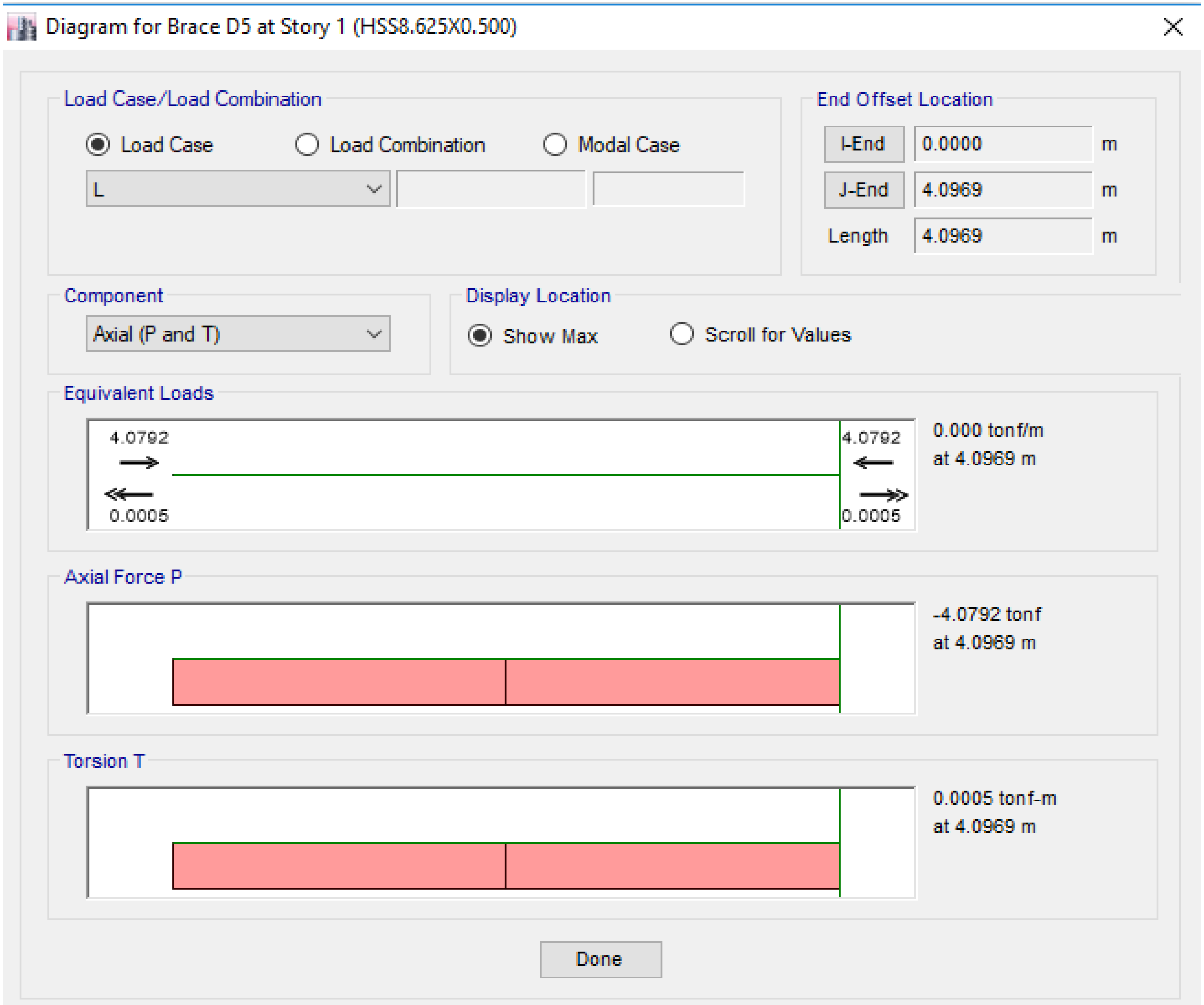
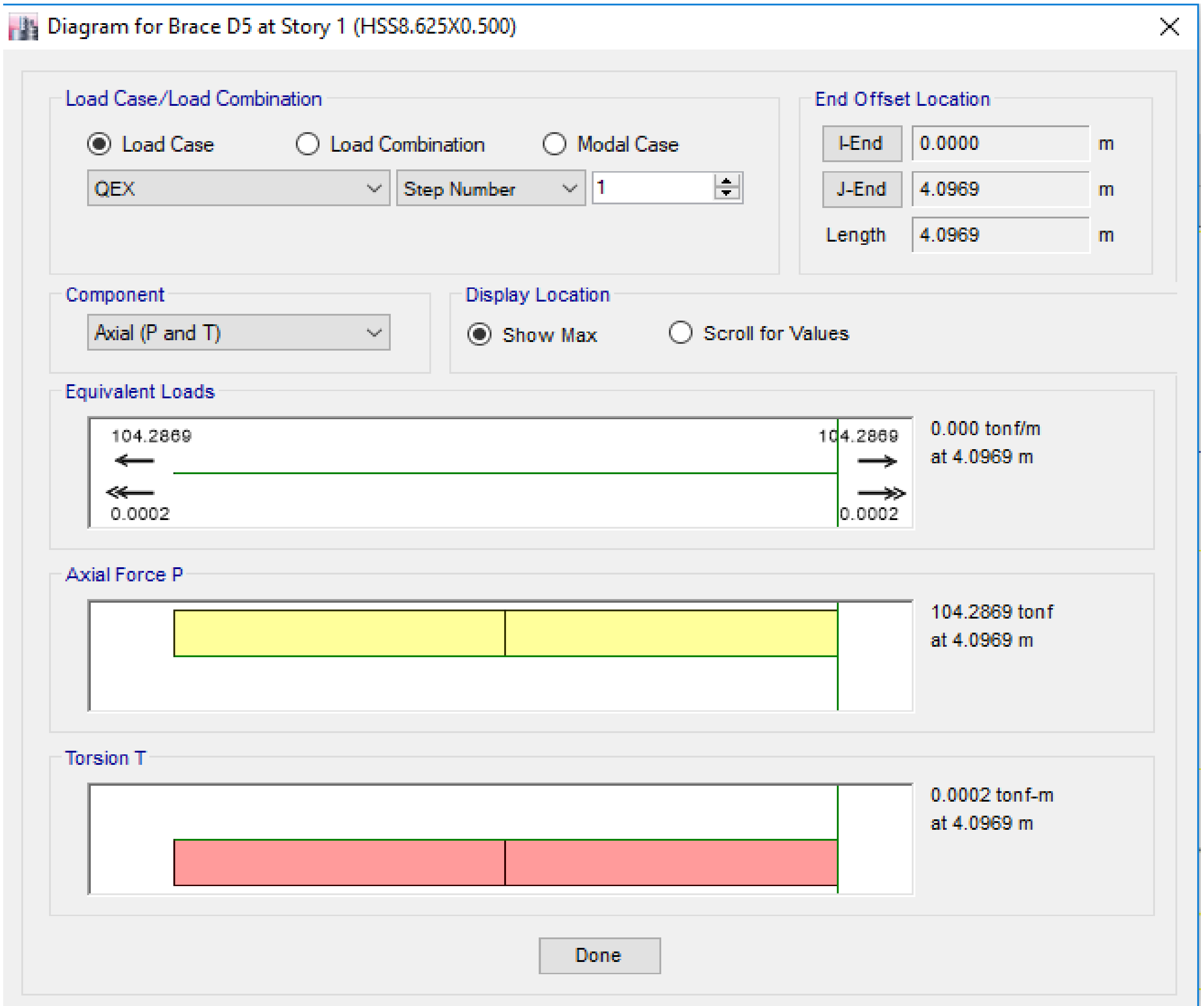


Diagrama de Axial de Arriostre BR-1 debido a Sismo.

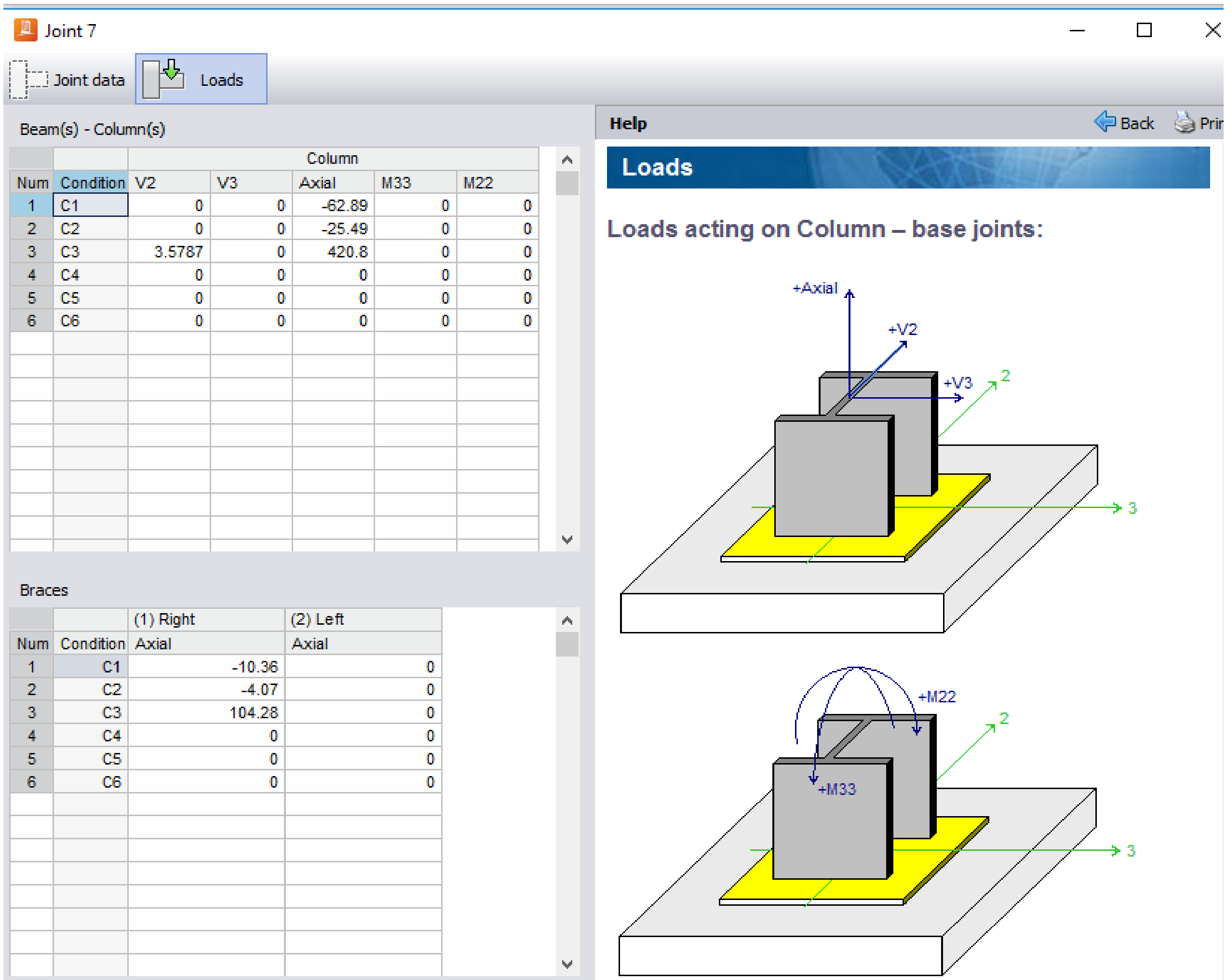


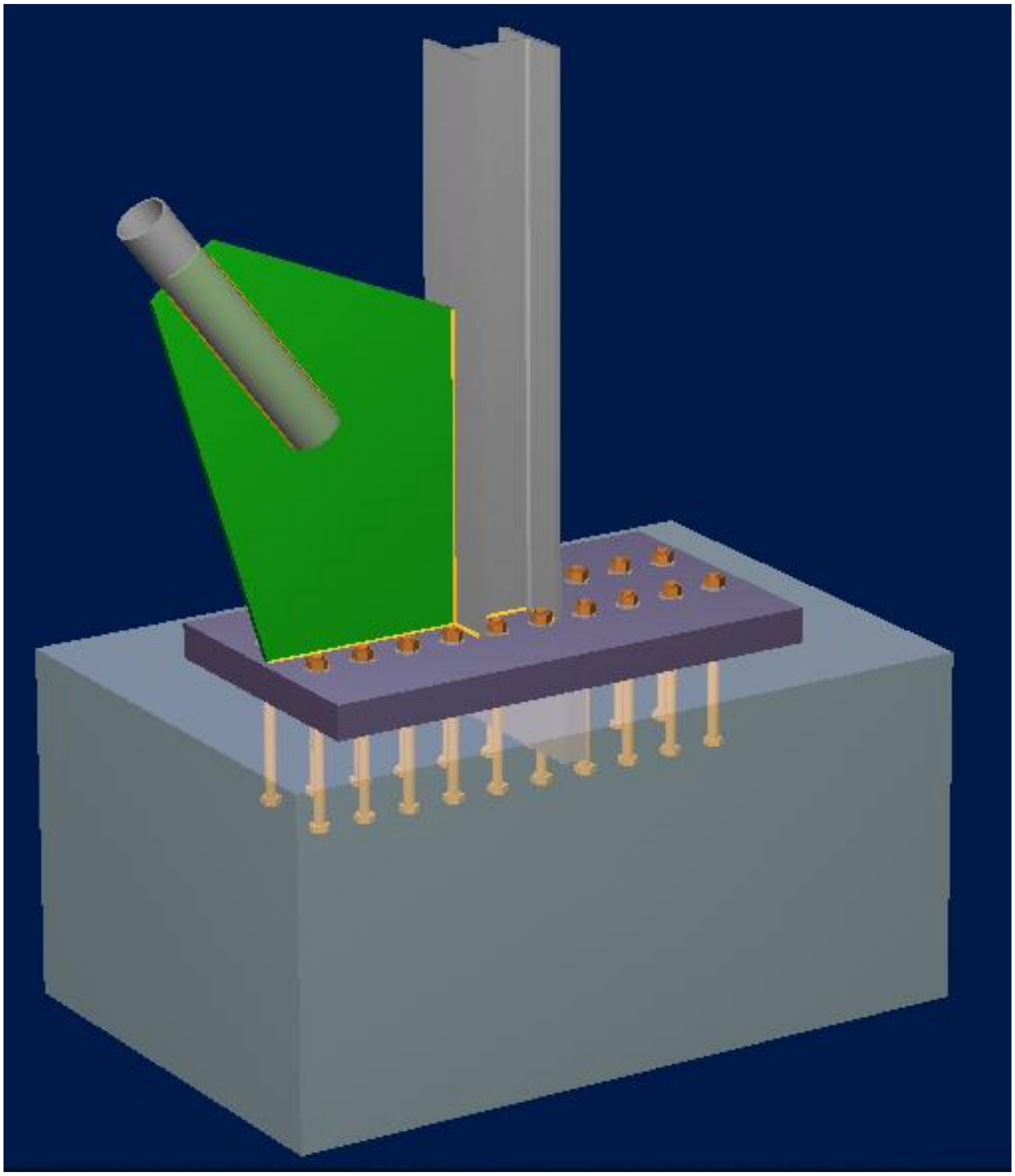
Usando una conexión CB
se usaron las secciones que resultaron del diseño de columna y vigas.

CL-1	W14X145
BR-1	HSS_RND 8.625X0.50

Property	Value
Joint	CB
Description	PB-1
Right brace	Yes
Left brace	No
Column	
Type	Prismatic member
Section	W 14X145
Material	A992 Gr50
Orientation (°)	0
Right brace	
Section	HSS_RND 8.625X0.500
Material	A992 Gr50
Slope angle	53
Rotation	0
sbB: Setback	1.27 cm

Ingresamos las cargas muertas, vivas y sismo obtenidas del análisis.





Modelo 3D en RAM CONECTTION

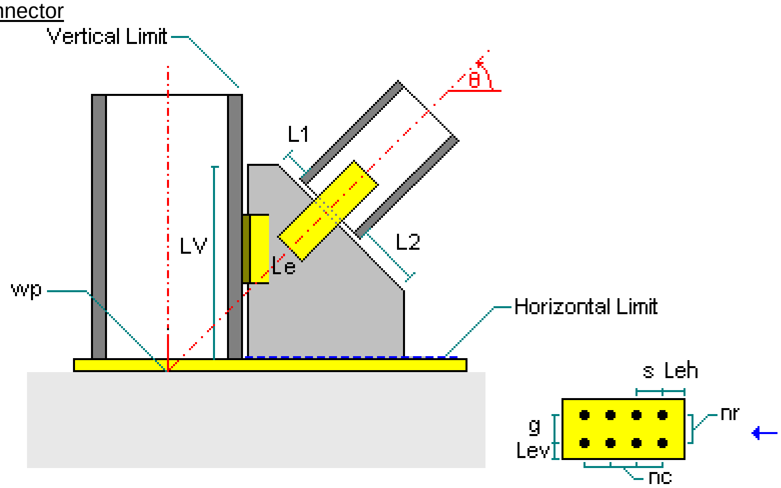
Datos

Connection name : Gusset BP
Connection ID : 7

Family: Column - Base (CB)
Type: Gusset
Description: PB-1

GENERAL INFORMATION

Connector



MEMBERS

Actual members

Right brace : Yes
Left brace : No

Column

General

Section : W 14X145
Material : A992 Gr50
Column orientation : Longitudinal
Longitudinal offset : 0 cm
Include opposite stiffener : No

Right brace

General

Section : HSS_RND 8.625X0.500
Material : A992 Gr50
Brace slope angle (degrees) : 53
L: Length : 3 m

Additional geometric data

wpx: WP horizontal displacement : 0 cm
wpy: WP vertical displacement : 0 cm
Le: Minimum distance to other members : 66.19 cm
L1: Left distance : 5.08 cm
L2: Right distance : 6.22 cm

BASE PLATE

Base plate

Position on the support : Center
N: Longitudinal dimension : 213.36 cm
B: Transversal dimension : 116.84 cm
Thickness : 15 cm
Material : A36

Column weld	E70XX
Outer welds flanges only	No
D: Column weld size (1/16 in)	7
Override A2/A1 ratio	Yes
Value for A2/A1 ratio	1
Include shear lug	Yes
<u>Shear lug</u>	
Orientation	Transversal direction
Consider same width as base plate	Yes
Depth	30 cm
Thickness	10 cm
Weld type	Fillet
Base plate weld	E70XX
Base plate weld size	7
Consider friction	Yes
Coefficient of friction	0.5
<u>Support</u>	
With pedestal	Yes
Longitudinal dimension (pedestal)	300 cm
Transversal dimension (pedestal)	200 cm
Thickness	150 cm
Material	C 4-60
Include grouting	No
<u>Anchor</u>	
Anchor position	Longitudinal position
Rows number per side	1
Anchors per row	10
Longitudinal edge distance on the plate	15 cm
Transverse edge distance on the plate	40 cm
Anchor type	Headed
Head type	Hexagonal
Include lock nut	No
Anchor	1 3/4"
Effective embedment depth	50 cm
Total length	70.87 cm
Material	A36 (anchor)
Fy	2.53 T/cm2
Fu	4.08 T/cm2
Cracked concrete	No
Brittle steel	No
Anchors welded to base plate	No
<u>Anchor reinforcement</u>	
Type of reinforcement	Primary
Tension reinforcement	Yes
Tension bar size	no. 8
Tension bar grade	4.22 T/cm2
Tension number of bars	40
Shear reinforcement	Yes
Shear bar size	no. 4
Shear bar grade	2.81 T/cm2
Shear number of bars in major axis direction	10
Shear number of bars in minor axis direction	10

INTERFACES

Right brace - Gusset

<u>General</u>	
tp: Thickness	3 cm
Material	A572 Gr50
LH: Length over plate	84.81 cm
LV: Length on column	132.44 cm
Reinforce brace section	Yes
<u>Brace reinforcement data</u>	
Reinforcement plate thickness	1.5 cm

Reinforcement plate length	:	100 cm
Weld	:	E70XX
D: Weld size (1/16 in)	:	5
Right brace - Gusset/Brace connection		
General		
Lt: Length on toe	:	90 cm
Lh: Length on heel	:	90 cm
Brace weld	:	E70XX
D: Weld size (1/16 in)	:	5
dp: Distance between weld and plate end	:	2.54 cm
Right brace - Gusset/Column connection		
General		
Connection type to column	:	Directly welded
Directly welded		
Column weld	:	E70XX
D: Weld size to column (1/16 in)	:	5
Right brace - Gusset/Base plate connection		
Directly welded		
Base plate weld	:	E70XX
D: Plate weld size (1/16 in)	:	5

Connection name : Gusset BP
Connection ID : 7

Family: Column - Base (CB)
Type: Gusset
Description: PB-1
Design code: AISC 360-10 LRFD, AISC 341-10 LRFD, ACI 318-08

Interface between Gusset - Top right brace

Connection: Directly welded

DEMANDS

Pu [Ton]	Description	Load type
-14.50	D1	Design
-18.94	D2	Design
-12.43	D3	Design
-12.43	D4	Design
-12.43	D5	Design
-12.43	D6	Design
-16.50	D7	Design
-16.50	D8	Design
296.87	D9	Seismic
-12.43	D10	Design
296.87	D11	Seismic
-16.50	D12	Design
-9.32	D13	Design
-9.32	D14	Design
296.87	D15	Seismic
-9.32	D16	Design
-10.36	D17	Design
-14.43	D18	Design
-13.41	D19	Design
-10.36	D20	Design
-10.36	D21	Design
296.87	D22	Seismic
-10.36	D23	Design
-13.41	D24	Design
-13.41	D25	Design
296.87	D26	Seismic
-10.36	D27	Design
-6.22	D28	Design
-6.22	D29	Design
296.87	D30	Seismic
-6.22	D31	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Brace - Directly welded Connection						
Total weld design strength	[Ton]	447.48	296.87	D9	0.66	Eq. J2-4, Eq. J2-6

$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] $=$ **2952.88**[kg/cm2] Sec. J2.4

$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*90$[cm] $=$ **50.51**[cm2] Sec. J2.4

$\phi R_n = 2 * (\phi * F_w * A_w) = 2 * (0.75*2952.88$[kg/cm2]$*50.51$[cm2]$) =$ **223.74**[T] Eq. J2-4
$F_w = 0.6*F_{EXX} = 0.6*4921.46$[kg/cm2] = **2952.88**[kg/cm2] Sec. J2.4
$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*5/16$ [in]$*90$[cm] = **50.51**[cm2] Sec. J2.4
$\phi R_n = 2 * (\phi * F_w * A_w) = 2 * (0.75*2952.88$[kg/cm2]$*50.51$[cm2]$) =$ **223.74**[T] Eq. J2-4
$\phi R_n = \phi R_{w1} + \phi R_{w2} = 223.74$[T] + 223.74[T] = **447.48**[T] Eq. J2-6

Maximum weld force that brace can develop	[Ton]	874.40	296.87	D9	0.34	Eq. J4-4

$L_e = L_t + L_h = 90$[cm] + 90[cm] = **180**[cm]
$A_{nv} = L_e * t_p = 180$[cm]$*1.18$[cm] = **212.6**[cm2] Sec. J4-2
$\phi R_n = 2 * (\phi * 0.60 * F_u * A_{nv}) = 2 * (0.75*0.60*4569.93$[kg/cm2]$*212.6$[cm2]$) =$ **874.4**[T] Eq. J4-4

<u>Gusset</u>

Maximum weld force that gusset can develop	[Ton]	1110.49	296.87	D9	0.27	Eq. J4-4

$L_e = L_t + L_h = 90$[cm] + 90[cm] = **180**[cm]
$A_{nv} = L_e * t_p = 180$[cm]$*3$[cm] = **540**[cm2] Sec. J4-2
$\phi R_n = \phi * 0.60 * F_u * A_{nv} = 0.75*0.60*4569.93$[kg/cm2]$*540$[cm2] = **1110.49**[T] Eq. J4-4

Block shear on gusset	[Ton]	1103.59	296.87	D9	0.27	Eq. J4-5

$L_{max} = \max(L_t, L_h) = \max(90$[cm], 90[cm]$) =$ **90**[cm]
$L = L_{max} + d_w = 90$[cm] + 2.54[cm] = **92.54**[cm] Sec. J4.3
$A_{gv} = 2*L*t_p = 2*92.54$[cm]$*3$[cm] = **555.24**[cm2] Sec. J4.3
$A_{nv} = A_{gv} =$ **555.24**[cm2] Sec. J4.3
$A_{nt} = b*t_p = 21.91$[cm]$*3$[cm] = **65.72**[cm2] Sec. J4.3
$\phi R_n = \phi*\min(0.6*F_u*A_{nv} + U_{bs}*F_u*A_{nt}, 0.6*F_y*A_{gv} + U_{bs}*F_u*A_{nt}) = 0.75*$
min(0.6*4569.93[kg/cm2]*555.24[cm2] + 1*4569.93[kg/cm2]*65.72[cm2], 0.6*3515.33[kg/cm2]*555.24[cm2] + 1*
4569.93[kg/cm2]*65.72[cm2]) = **1103.59**[T] Eq. J4-5

Ratio **0.66**

Checks for gussset and brace

REQUIRED RESISTANCE OF BRACED CONNECTIONS

Requirement	**Value** [Ton]
Required tensile strength	296.87
Required compressive strength	289.24

GEOMETRIC CONSIDERATIONS

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Slenderness		40.74	--	200.00	✔	AISC 341-10 Sec. F2.5b.

$\lambda_{max} = 200$ AISC 341-10 Sec. F2.5b.
$\lambda_b = L/r = 300$[cm]$/7.36$[cm] = **40.74**

Dimensions	**Unit**	**Value**	**Min. value**	**Max. value**	**Sta.**	**References**
Local buckling		18.55	0.00	22.04	✔	Seismic Manual Table I-8-1, Seismic Manual Table D1.1

$\lambda = D/t_p = 21.91$[cm]$/1.18$[cm] = **18.55** Seismic Manual Table I-8-1

λ_{hd} = 0.038*(E/F_y) = 0.038*(2.04E+06[kg/cm2]/3515.33[kg/cm2]) = **22.04** Seismic Manual Table D1.1

Gusset plate plastic hinge length (2t)	[cm]	6.00	6.00	12.00	✔	
Weld size	[1/16in]	5	3	6	✔	table J2.4, Sec. J2.2b

w_{min} = w_{min} = **0.004763** — table J2.4

t_p<1/4 [in] → 1.18[cm]<1/4 [in] → **False**

w_{max} = t_p - 1/16 [in] = 1.18[cm] - 1/16 [in] = **0.0102** — Sec. J2.2b

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DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Brace</u>						
Tension rupture	[Ton]	431.16	296.87	D9	0.69	Seismic Manual p.3-54

A_n = A_g - 2*(t_p + 1/8 [in])*t = 76.77[cm2] - 2*(3[cm] + 1/8 [in])*1.18[cm] = **68.94**[cm2] — Sec. D3.2

U = 1 - x/l = 1 - 7.06[cm]/90[cm] = **0.922** — Table D3.1

A_e = A_n*U = 124.09[cm2]*0.922 = **114.36**[cm2] — Eq. D3-1

ϕR_n = ϕ*R_t*F_u*A_e = 0.75*1.1*4569.93[kg/cm2]*114.36[cm2] = **431.16**[T] — Seismic Manual p.3-54

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Compression	[Ton]	215.13	18.94	D2	0.09	Eq. E3-1

F_e = π^2*E/(K*L/r)^2 = π^2*2.04E+06[kg/cm2]/(1*300[cm]/7.36[cm])^2 = **12121.93**[kg/cm2] — Eq. E3-4

F_e>=0.44*Q*F_y → 12121.93[kg/cm2]>=0.44*1*3515.33[kg/cm2] → **True**

F_{cr} = 0.658$^{(Q*Fy/Fe)}$*F_y = 0.658$^{(1*3515.33[kg/cm2]/12121.93[kg/cm2])}$*3515.33[kg/cm2] = **3113.52**[kg/cm2] — Eq. E7-2

ϕP_n = ϕ*F_{cr}*A_g = 0.9*3113.52[kg/cm2]*76.77[cm2] = **215.13**[T] — Eq. E3-1

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Weld capacity for reinforcement plate	[Ton]	497.20	207.94	D9	0.42	Eq. J2-4

F_w = 0.6*F_{EXX} = 0.6*4921.46[kg/cm2] = **2952.88**[kg/cm2] — Sec. J2.4

A_w = (2)$^{1/2}$/2*D/16 [in]*L = (2)$^{1/2}$/2*5/16 [in]*100[cm] = **56.13**[cm2] — Sec. J2.4

ϕR_n = 4 * (ϕ*F_w*A_w) = 4 * (0.75*2952.88[kg/cm2]*56.13[cm2]) = **497.2**[T] — Eq. J2-4

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
<u>Gusset</u>						
Tension yielding on the Whitmore section	[Ton]	1087.20	296.87	D9	0.27	Eq. J4-1

A_g = L_w*t_p = 114.55[cm]*3[cm] = **343.64**[cm2]

ϕR_n = ϕ*F_y*A_g = 0.9*3515.33[kg/cm2]*343.64[cm2] = **1087.2**[T] — Eq. J4-1

Ratio **0.69**

Calculation of the brace interface forces

<u>Load condition :D1</u>

General case — DG29 p. 24-33

K = e_b*$tan\theta$ - e_c = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] — p. 13-10

K' = α_{bar}*($tan\theta$ + α_{bar}/β_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] — p. 13-10

D = ($tan\theta$)^2 + (α_{bar}/β_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = **0.978** — p. 13-10

α = (K'*$tan\theta$ + K*(α_{bar}/β_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] — p. 13-10

β = (K' - K*$tan\theta$)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] — p. 13-10

r = ((α + e_c)^2 + (β + e_b)^2)$^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/}$

^{2} = **101.7**[cm] p. 13-5
$H_b = \alpha * P/r$ = 42.41[cm]*-14.5[T]/101.7[cm] = **-6.05**[T] p. 13-5
$H_c = e_c * P/r$ = 18.8[cm]*-14.5[T]/101.7[cm] = **-2.68**[T] p. 13-5
$V_b = e_b * P/r - \Delta V$ = 15[cm]*-14.5[T]/101.7[cm] - 0[T] = **-2.14**[T] p. 13-5
$V_c = \beta * P/r + \Delta V$ = 66.22[cm]*-14.5[T]/101.7[cm] + 0[T] = **-9.44**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V * \alpha)$ = abs(-2.14[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.68[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D2

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha * P/r$ = 42.41[cm]*-18.94[T]/101.7[cm] = **-7.9**[T] p. 13-5
$H_c = e_c * P/r$ = 18.8[cm]*-18.94[T]/101.7[cm] = **-3.5**[T] p. 13-5
$V_b = e_b * P/r - \Delta V$ = 15[cm]*-18.94[T]/101.7[cm] - 0[T] = **-2.79**[T] p. 13-5
$V_c = \beta * P/r + \Delta V$ = 66.22[cm]*-18.94[T]/101.7[cm] + 0[T] = **-12.34**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V * \alpha)$ = abs(-2.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-3.5[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D3

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha * P/r$ = 42.41[cm]*-12.43[T]/101.7[cm] = **-5.18**[T] p. 13-5
$H_c = e_c * P/r$ = 18.8[cm]*-12.43[T]/101.7[cm] = **-2.3**[T] p. 13-5
$V_b = e_b * P/r - \Delta V$ = 15[cm]*-12.43[T]/101.7[cm] - 0[T] = **-1.83**[T] p. 13-5
$V_c = \beta * P/r + \Delta V$ = 66.22[cm]*-12.43[T]/101.7[cm] + 0[T] = **-8.09**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V * \alpha)$ = abs(-1.83[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.3[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D4

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r = 42.41[cm]*-12.43[T]/101.7[cm] = \mathbf{-5.18}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-12.43[T]/101.7[cm] = \mathbf{-2.3}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15[cm]*-12.43[T]/101.7[cm] - 0[T] = \mathbf{-1.83}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22[cm]*-12.43[T]/101.7[cm] + 0[T] = \mathbf{-8.09}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.83[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.3[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D5

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r = 42.41[cm]*-12.43[T]/101.7[cm] = \mathbf{-5.18}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-12.43[T]/101.7[cm] = \mathbf{-2.3}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15[cm]*-12.43[T]/101.7[cm] - 0[T] = \mathbf{-1.83}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22[cm]*-12.43[T]/101.7[cm] + 0[T] = \mathbf{-8.09}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.83[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.3[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D6

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r = 42.41[cm]*-12.43[T]/101.7[cm] = \mathbf{-5.18}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-12.43[T]/101.7[cm] = \mathbf{-2.3}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15[cm]*-12.43[T]/101.7[cm] - 0[T] = \mathbf{-1.83}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22[cm]*-12.43[T]/101.7[cm] + 0[T] = \mathbf{-8.09}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.83[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.3[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D7

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15$[cm]$*0.754 - 18.8$[cm] $=$ **-7.49**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41$[cm]$*(0.754 + 42.41$[cm]$/66.22$[cm]$) =$ **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41$[cm]$/66.22$[cm]$)^2 =$ **0.978** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11$[cm]$*0.754 + -7.49$[cm]$*(42.41$[cm]$/66.22$[cm]$)^2)/0.978 =$ **42.41**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11$[cm] $- -7.49$[cm]$*0.754)/0.978 =$ **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41$[cm] $+ 18.8$[cm]$)^2 + (66.22$[cm] $+ 15$[cm]$)^2)^{1/2} =$ **101.7**[cm] p. 13-5

$H_b = \alpha*P/r = 42.41$[cm]$*-16.5$[T]$/101.7$[cm] $=$ **-6.88**[T] p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-16.5$[T]$/101.7$[cm] $=$ **-3.05**[T] p. 13-5

$V_b = e_b*P/r - \Delta V = 15$[cm]$*-16.5$[T]$/101.7$[cm] $- 0$[T] $=$ **-2.43**[T] p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22$[cm]$*-16.5$[T]$/101.7$[cm] $+ 0$[T] $=$ **-10.75**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.43$[T]$*(42.41$[cm] $- 42.41$[cm]$)) + abs(0$[T]$*42.41$[cm]$) =$ **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-3.05$[T]$*(66.22$[cm] $- 66.22$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D8

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15$[cm]$*0.754 - 18.8$[cm] $=$ **-7.49**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41$[cm]$*(0.754 + 42.41$[cm]$/66.22$[cm]$) =$ **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41$[cm]$/66.22$[cm]$)^2 =$ **0.978** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11$[cm]$*0.754 + -7.49$[cm]$*(42.41$[cm]$/66.22$[cm]$)^2)/0.978 =$ **42.41**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11$[cm] $- -7.49$[cm]$*0.754)/0.978 =$ **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41$[cm] $+ 18.8$[cm]$)^2 + (66.22$[cm] $+ 15$[cm]$)^2)^{1/2} =$ **101.7**[cm] p. 13-5

$H_b = \alpha*P/r = 42.41$[cm]$*-16.5$[T]$/101.7$[cm] $=$ **-6.88**[T] p. 13-5

$H_c = e_c*P/r = 18.8$[cm]$*-16.5$[T]$/101.7$[cm] $=$ **-3.05**[T] p. 13-5

$V_b = e_b*P/r - \Delta V = 15$[cm]$*-16.5$[T]$/101.7$[cm] $- 0$[T] $=$ **-2.43**[T] p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22$[cm]$*-16.5$[T]$/101.7$[cm] $+ 0$[T] $=$ **-10.75**[T] p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.43$[T]$*(42.41$[cm] $- 42.41$[cm]$)) + abs(0$[T]$*42.41$[cm]$) =$ **0**[T*m] p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-3.05$[T]$*(66.22$[cm] $- 66.22$[cm]$)) =$ **0**[T*m] p. 13-10

Load condition :D9

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g = 1*1.1*3515.33$[kg/cm2]$*76.77$[cm2] $=$ **296.87**[T] AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c = 15$[cm]$*0.754 - 18.8$[cm] $=$ **-7.49**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41$[cm]$*(0.754 + 42.41$[cm]$/66.22$[cm]$) =$ **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41$[cm]$/66.22$[cm]$)^2 =$ **0.978** p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11$[cm]$*0.754 + -7.49$[cm]$*(42.41$[cm]$/66.22$[cm]$)^2)/0.978 =$ **42.41**[cm] p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11$[cm] $- -7.49$[cm]$*0.754)/0.978 =$ **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41$[cm] $+ 18.8$[cm]$)^2 + (66.22$[cm] $+ 15$[cm]$)^2)^{1/2} =$ **101.7**[cm] p. 13-5

$H_b = \alpha*P/r$ = 42.41[cm]*296.87[T]/101.7[cm] = **123.79**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*296.87[T]/101.7[cm] = **54.87**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*296.87[T]/101.7[cm] - 0[T] = **43.79**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*296.87[T]/101.7[cm] + 0[T] = **193.31**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(43.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D10

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2$ = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-12.43[T]/101.7[cm] = **-5.18**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-12.43[T]/101.7[cm] = **-2.3**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-12.43[T]/101.7[cm] - 0[T] = **-1.83**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-12.43[T]/101.7[cm] + 0[T] = **-8.09**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.83[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.3[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D11

General case DG29 p. 24-33
$\phi R_n = \phi*R_y*F_y*A_g$ = 1*1.1*3515.33[kg/cm2]*76.77[cm2] = **296.87**[T] AISC 341-10 Sec. F2.6.c
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2$ = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*296.87[T]/101.7[cm] = **123.79**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*296.87[T]/101.7[cm] = **54.87**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*296.87[T]/101.7[cm] - 0[T] = **43.79**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*296.87[T]/101.7[cm] + 0[T] = **193.31**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(43.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D12

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10
$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5
$H_b = \alpha*P/r = 42.41[cm]*-16.5[T]/101.7[cm] = \mathbf{-6.88}[T]$ p. 13-5
$H_c = e_c*P/r = 18.8[cm]*-16.5[T]/101.7[cm] = \mathbf{-3.05}[T]$ p. 13-5
$V_b = e_b*P/r - \Delta V = 15[cm]*-16.5[T]/101.7[cm] - 0[T] = \mathbf{-2.43}[T]$ p. 13-5
$V_c = \beta*P/r + \Delta V = 66.22[cm]*-16.5[T]/101.7[cm] + 0[T] = \mathbf{-10.75}[T]$ p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-2.43[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-3.05[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D13

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10
$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5
$H_b = \alpha*P/r = 42.41[cm]*-9.32[T]/101.7[cm] = \mathbf{-3.89}[T]$ p. 13-5
$H_c = e_c*P/r = 18.8[cm]*-9.32[T]/101.7[cm] = \mathbf{-1.72}[T]$ p. 13-5
$V_b = e_b*P/r - \Delta V = 15[cm]*-9.32[T]/101.7[cm] - 0[T] = \mathbf{-1.38}[T]$ p. 13-5
$V_c = \beta*P/r + \Delta V = 66.22[cm]*-9.32[T]/101.7[cm] + 0[T] = \mathbf{-6.07}[T]$ p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.38[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.72[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D14

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10
$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5
$H_b = \alpha*P/r = 42.41[cm]*-9.32[T]/101.7[cm] = \mathbf{-3.89}[T]$ p. 13-5
$H_c = e_c*P/r = 18.8[cm]*-9.32[T]/101.7[cm] = \mathbf{-1.72}[T]$ p. 13-5
$V_b = e_b*P/r - \Delta V = 15[cm]*-9.32[T]/101.7[cm] - 0[T] = \mathbf{-1.38}[T]$ p. 13-5
$V_c = \beta*P/r + \Delta V = 66.22[cm]*-9.32[T]/101.7[cm] + 0[T] = \mathbf{-6.07}[T]$ p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.38[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

M_c = abs(H_c*(β - $β_{bar}$)) = abs(-1.72[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D15

General case DG29 p. 24-33

$\phi R_n = \phi * R_y * F_y * A_g$ = 1*1.1*3515.33[kg/cm2]*76.77[cm2] = **296.87**[T] AISC 341-10 Sec. F2.6.c

$K = e_b * tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = $(0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5

$H_b = \alpha * P/r$ = 42.41[cm]*296.87[T]/101.7[cm] = **123.79**[T] p. 13-5

$H_c = e_c * P/r$ = 18.8[cm]*296.87[T]/101.7[cm] = **54.87**[T] p. 13-5

$V_b = e_b * P/r - \Delta V$ = 15[cm]*296.87[T]/101.7[cm] - 0[T] = **43.79**[T] p. 13-5

$V_c = \beta * P/r + \Delta V$ = 66.22[cm]*296.87[T]/101.7[cm] + 0[T] = **193.31**[T] p. 13-5

M_b = abs(V_b*(α - $α_{bar}$)) + abs(ΔV*α) = abs(43.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10

M_c = abs(H_c*(β - $β_{bar}$)) = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D16

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = $(0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5

$H_b = \alpha * P/r$ = 42.41[cm]*-9.32[T]/101.7[cm] = **-3.89**[T] p. 13-5

$H_c = e_c * P/r$ = 18.8[cm]*-9.32[T]/101.7[cm] = **-1.72**[T] p. 13-5

$V_b = e_b * P/r - \Delta V$ = 15[cm]*-9.32[T]/101.7[cm] - 0[T] = **-1.38**[T] p. 13-5

$V_c = \beta * P/r + \Delta V$ = 66.22[cm]*-9.32[T]/101.7[cm] + 0[T] = **-6.07**[T] p. 13-5

M_b = abs(V_b*(α - $α_{bar}$)) + abs(ΔV*α) = abs(-1.38[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10

M_c = abs(H_c*(β - $β_{bar}$)) = abs(-1.72[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D17

General case DG29 p. 24-33

$K = e_b * tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10

$K' = \alpha_{bar} * (tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = $(0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10

$\alpha = (K' * tan\theta + K * (\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10

$\beta = (K' - K * tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/}$

^{2} = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-10.36[T]/101.7[cm] = **-4.32**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-10.36[T]/101.7[cm] = **-1.91**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-10.36[T]/101.7[cm] - 0[T] = **-1.53**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-10.36[T]/101.7[cm] + 0[T] = **-6.75**[T] p. 13-5
M_b = abs($V_b*(\alpha - \alpha_{bar})$) + abs($\Delta V*\alpha$) = abs(-1.53[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
M_c = abs($H_c*(\beta - \beta_{bar})$) = abs(-1.91[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D18

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-14.43[T]/101.7[cm] = **-6.02**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-14.43[T]/101.7[cm] = **-2.67**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-14.43[T]/101.7[cm] - 0[T] = **-2.13**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-14.43[T]/101.7[cm] + 0[T] = **-9.4**[T] p. 13-5
M_b = abs($V_b*(\alpha - \alpha_{bar})$) + abs($\Delta V*\alpha$) = abs(-2.13[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
M_c = abs($H_c*(\beta - \beta_{bar})$) = abs(-2.67[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D19

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2$ + (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-13.41[T]/101.7[cm] = **-5.59**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-13.41[T]/101.7[cm] = **-2.48**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-13.41[T]/101.7[cm] - 0[T] = **-1.98**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-13.41[T]/101.7[cm] + 0[T] = **-8.73**[T] p. 13-5
M_b = abs($V_b*(\alpha - \alpha_{bar})$) + abs($\Delta V*\alpha$) = abs(-1.98[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
M_c = abs($H_c*(\beta - \beta_{bar})$) = abs(-2.48[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D20

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} = \mathbf{-4.32}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} = \mathbf{-1.91}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{-1.53}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{-6.75}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.53\text{[T]}*(42.41\text{[cm]} - 42.41\text{[cm]})) + abs(0\text{[T]}*42.41\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.91\text{[T]}*(66.22\text{[cm]} - 66.22\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D21

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{-7.49}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41\text{[cm]}*(0.754 + 42.41\text{[cm]}/66.22\text{[cm]}) = \mathbf{59.11}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} = \mathbf{-4.32}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} = \mathbf{-1.91}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{-1.53}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*-10.36\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{-6.75}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.53\text{[T]}*(42.41\text{[cm]} - 42.41\text{[cm]})) + abs(0\text{[T]}*42.41\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.91\text{[T]}*(66.22\text{[cm]} - 66.22\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D22

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g = 1*1.1*3515.33\text{[kg/cm2]}*76.77\text{[cm2]} = \mathbf{296.87}\text{[T]}$ AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c = 15\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{-7.49}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41\text{[cm]}*(0.754 + 42.41\text{[cm]}/66.22\text{[cm]}) = \mathbf{59.11}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} = \mathbf{123.79}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} = \mathbf{54.87}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{43.79}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{193.31}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(43.79\text{[T]}*(42.41\text{[cm]} - 42.41\text{[cm]})) + abs(0\text{[T]}*$

$42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D23

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r = 42.41[cm]*-10.36[T]/101.7[cm] = \mathbf{-4.32}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-10.36[T]/101.7[cm] = \mathbf{-1.91}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15[cm]*-10.36[T]/101.7[cm] - 0[T] = \mathbf{-1.53}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22[cm]*-10.36[T]/101.7[cm] + 0[T] = \mathbf{-6.75}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.53[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.91[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D24

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r = 42.41[cm]*-13.41[T]/101.7[cm] = \mathbf{-5.59}[T]$ p. 13-5

$H_c = e_c*P/r = 18.8[cm]*-13.41[T]/101.7[cm] = \mathbf{-2.48}[T]$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15[cm]*-13.41[T]/101.7[cm] - 0[T] = \mathbf{-1.98}[T]$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22[cm]*-13.41[T]/101.7[cm] + 0[T] = \mathbf{-8.73}[T]$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-1.98[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = \mathbf{0}[T*m]$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-2.48[T]*(66.22[cm] - 66.22[cm])) = \mathbf{0}[T*m]$ p. 13-10

Load condition :D25

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15[cm]*0.754 - 18.8[cm] = \mathbf{-7.49}[cm]$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = \mathbf{59.11}[cm]$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41[cm]/66.22[cm])^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = \mathbf{42.41}[cm]$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11[cm] - -7.49[cm]*0.754)/0.978 = \mathbf{66.22}[cm]$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)^{1/2} = \mathbf{101.7}[cm]$ p. 13-5

$H_b = \alpha*P/r$ = 42.41[cm]*-13.41[T]/101.7[cm] = **-5.59**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-13.41[T]/101.7[cm] = **-2.48**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-13.41[T]/101.7[cm] - 0[T] = **-1.98**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-13.41[T]/101.7[cm] + 0[T] = **-8.73**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.98[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-2.48[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D26

General case DG29 p. 24-33
$\phi R_n = \phi*R_y*F_y*A_g$ = 1*1.1*3515.33[kg/cm2]*76.77[cm2] = **296.87**[T] AISC 341-10 Sec. F2.6.c
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 +$ (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*296.87[T]/101.7[cm] = **123.79**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*296.87[T]/101.7[cm] = **54.87**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*296.87[T]/101.7[cm] - 0[T] = **43.79**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*296.87[T]/101.7[cm] + 0[T] = **193.31**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(43.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D27

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 +$ (42.41[cm]/66.22[cm])^2 = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-10.36[T]/101.7[cm] = **-4.32**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-10.36[T]/101.7[cm] = **-1.91**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-10.36[T]/101.7[cm] - 0[T] = **-1.53**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-10.36[T]/101.7[cm] + 0[T] = **-6.75**[T] p. 13-5
$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha)$ = abs(-1.53[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
$M_c = abs(H_c*(\beta - \beta_{bar}))$ = abs(-1.91[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D28

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41\text{[cm]}*(0.754 + 42.41\text{[cm]}/66.22\text{[cm]}) = \mathbf{59.11}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} = \mathbf{-2.59}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} = \mathbf{-1.15}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{-0.917}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{-4.05}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-0.917\text{[T]}*(42.41\text{[cm]} - 42.41\text{[cm]})) + abs(0\text{[T]}*42.41\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.15\text{[T]}*(66.22\text{[cm]} - 66.22\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D29

General case DG29 p. 24-33

$K = e_b*tan\theta - e_c = 15\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{-7.49}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41\text{[cm]}*(0.754 + 42.41\text{[cm]}/66.22\text{[cm]}) = \mathbf{59.11}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} = \mathbf{-2.59}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} = \mathbf{-1.15}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{-0.917}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*-6.22\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{-4.05}\text{[T]}$ p. 13-5

$M_b = abs(V_b*(\alpha - \alpha_{bar})) + abs(\Delta V*\alpha) = abs(-0.917\text{[T]}*(42.41\text{[cm]} - 42.41\text{[cm]})) + abs(0\text{[T]}*42.41\text{[cm]}) = \mathbf{0}\text{[T*m]}$ p. 13-10

$M_c = abs(H_c*(\beta - \beta_{bar})) = abs(-1.15\text{[T]}*(66.22\text{[cm]} - 66.22\text{[cm]})) = \mathbf{0}\text{[T*m]}$ p. 13-10

Load condition :D30

General case DG29 p. 24-33

$\phi R_n = \phi*R_y*F_y*A_g = 1*1.1*3515.33\text{[kg/cm2]}*76.77\text{[cm2]} = \mathbf{296.87}\text{[T]}$ AISC 341-10 Sec. F2.6.c

$K = e_b*tan\theta - e_c = 15\text{[cm]}*0.754 - 18.8\text{[cm]} = \mathbf{-7.49}\text{[cm]}$ p. 13-10

$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar}) = 42.41\text{[cm]}*(0.754 + 42.41\text{[cm]}/66.22\text{[cm]}) = \mathbf{59.11}\text{[cm]}$ p. 13-10

$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2 = (0.754)^2 + (42.41\text{[cm]}/66.22\text{[cm]})^2 = \mathbf{0.978}$ p. 13-10

$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D = (59.11\text{[cm]}*0.754 + -7.49\text{[cm]}*(42.41\text{[cm]}/66.22\text{[cm]})^2)/0.978 = \mathbf{42.41}\text{[cm]}$ p. 13-10

$\beta = (K' - K*tan\theta)/D = (59.11\text{[cm]} - -7.49\text{[cm]}*0.754)/0.978 = \mathbf{66.22}\text{[cm]}$ p. 13-10

$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2} = ((42.41\text{[cm]} + 18.8\text{[cm]})^2 + (66.22\text{[cm]} + 15\text{[cm]})^2)^{1/2} = \mathbf{101.7}\text{[cm]}$ p. 13-5

$H_b = \alpha*P/r = 42.41\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} = \mathbf{123.79}\text{[T]}$ p. 13-5

$H_c = e_c*P/r = 18.8\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} = \mathbf{54.87}\text{[T]}$ p. 13-5

$V_b = e_b*P/r - \Delta V = 15\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} - 0\text{[T]} = \mathbf{43.79}\text{[T]}$ p. 13-5

$V_c = \beta*P/r + \Delta V = 66.22\text{[cm]}*296.87\text{[T]}/101.7\text{[cm]} + 0\text{[T]} = \mathbf{193.31}\text{[T]}$ p. 13-5

M_b = abs(V_b*(α - α_{bar})) + abs(ΔV*α) = abs(43.79[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
M_c = abs(H_c*(β - β_{bar})) = abs(54.87[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Load condition :D31

General case DG29 p. 24-33
$K = e_b*tan\theta - e_c$ = 15[cm]*0.754 - 18.8[cm] = **-7.49**[cm] p. 13-10
$K' = \alpha_{bar}*(tan\theta + \alpha_{bar}/\beta_{bar})$ = 42.41[cm]*(0.754 + 42.41[cm]/66.22[cm]) = **59.11**[cm] p. 13-10
$D = (tan\theta)^2 + (\alpha_{bar}/\beta_{bar})^2$ = $(0.754)^2$ + $(42.41\text{[cm]}/66.22\text{[cm]})^2$ = **0.978** p. 13-10
$\alpha = (K'*tan\theta + K*(\alpha_{bar}/\beta_{bar})^2)/D$ = (59.11[cm]*0.754 + -7.49[cm]*(42.41[cm]/66.22[cm])^2)/0.978 = **42.41**[cm] p. 13-10
$\beta = (K' - K*tan\theta)/D$ = (59.11[cm] - -7.49[cm]*0.754)/0.978 = **66.22**[cm] p. 13-10
$r = ((\alpha + e_c)^2 + (\beta + e_b)^2)^{1/2}$ = ((42.41[cm] + 18.8[cm])^2 + (66.22[cm] + 15[cm])^2)$^{1/2}$ = **101.7**[cm] p. 13-5
$H_b = \alpha*P/r$ = 42.41[cm]*-6.22[T]/101.7[cm] = **-2.59**[T] p. 13-5
$H_c = e_c*P/r$ = 18.8[cm]*-6.22[T]/101.7[cm] = **-1.15**[T] p. 13-5
$V_b = e_b*P/r - \Delta V$ = 15[cm]*-6.22[T]/101.7[cm] - 0[T] = **-0.917**[T] p. 13-5
$V_c = \beta*P/r + \Delta V$ = 66.22[cm]*-6.22[T]/101.7[cm] + 0[T] = **-4.05**[T] p. 13-5
M_b = abs(V_b*(α - α_{bar})) + abs(ΔV*α) = abs(-0.917[T]*(42.41[cm] - 42.41[cm])) + abs(0[T]*42.41[cm]) = **0**[T*m] p. 13-10
M_c = abs(H_c*(β - β_{bar})) = abs(-1.15[T]*(66.22[cm] - 66.22[cm])) = **0**[T*m] p. 13-10

Right gusset interface - base plate

Directly welded

DEMANDS

Description	Beam Ru [Ton]	Beam Pu [Ton]	Beam Mu [Ton*m]	Column Pu [Ton]	Column Mu22 [Ton*m]	Column Mu33 [Ton*m]	Load type
D1	-6.05	-2.14	0.00	0.00	0.00	0.00	Design
D2	-7.90	-2.79	0.00	0.00	0.00	0.00	Design
D3	-5.18	-1.83	0.00	0.00	0.00	0.00	Design
D4	-5.18	-1.83	0.00	0.00	0.00	0.00	Design
D5	-5.18	-1.83	0.00	0.00	0.00	0.00	Design
D6	-5.18	-1.83	0.00	0.00	0.00	0.00	Design
D7	-6.88	-2.43	0.00	0.00	0.00	0.00	Design
D8	-6.88	-2.43	0.00	0.00	0.00	0.00	Design
D9	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D10	-5.18	-1.83	0.00	0.00	0.00	0.00	Design
D11	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D12	-6.88	-2.43	0.00	0.00	0.00	0.00	Design
D13	-3.89	-1.38	0.00	0.00	0.00	0.00	Design
D14	-3.89	-1.38	0.00	0.00	0.00	0.00	Design
D15	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D16	-3.89	-1.38	0.00	0.00	0.00	0.00	Design
D17	-4.32	-1.53	0.00	0.00	0.00	0.00	Design
D18	-6.02	-2.13	0.00	0.00	0.00	0.00	Design
D19	-5.59	-1.98	0.00	0.00	0.00	0.00	Design
D20	-4.32	-1.53	0.00	0.00	0.00	0.00	Design
D21	-4.32	-1.53	0.00	0.00	0.00	0.00	Design
D22	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D23	-4.32	-1.53	0.00	0.00	0.00	0.00	Design
D24	-5.59	-1.98	0.00	0.00	0.00	0.00	Design
D25	-5.59	-1.98	0.00	0.00	0.00	0.00	Design
D26	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D27	-4.32	-1.53	0.00	0.00	0.00	0.00	Design

D28	-2.59	-0.92	0.00	0.00	0.00	0.00	Design
D29	-2.59	-0.92	0.00	0.00	0.00	0.00	Design
D30	123.79	43.79	0.00	0.00	0.00	0.00	Seismic
D31	-2.59	-0.92	0.00	0.00	0.00	0.00	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset						
Beam yielding (normal stress)	[Ton]	805.01	43.79	D9	0.05	Eq. B-1, Appendix B, DG29, Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 43.79$[T] $+ ((4*0$[T*m]$)/84.81$[cm]$) = \mathbf{43.79}$[T] — Eq. B-1, Appendix B, DG29

$A_g = L_p*t_p = 84.81$[cm]$*3$[cm] $= \mathbf{254.44}$[cm2] — Sec. D3-1

$\phi R_n = \phi*F_y*A_g = 0.9*3515.33$[kg/cm2]$*254.44$[cm2] $= \mathbf{805.01}$[T] — Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 43.79$[T] $+ ((4*0$[T*m]$)/84.81$[cm]$) = \mathbf{43.79}$[T] — Eq. B-1, Appendix B, DG29

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Ton]	536.67	123.79	D9	0.23	Eq. J4-3

$A_g = L_p*t_p = 84.81$[cm]$*3$[cm] $= \mathbf{254.44}$[cm2] — Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*3515.33$[kg/cm2]$*254.44$[cm2] $= \mathbf{536.67}$[T] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset edge tension stress	[kg/m2]	3.163797E07	1720932.00	D9	0.05	J4-1

$\phi F_n = \phi*F_y = 0.9*3515.33$[kg/cm2] $= \mathbf{3163.8}$[kg/cm2] — J4-1

$f_{ua} = H_c/(t_p*l) = 43.79$[T]$/(3$[cm]$*84.81$[cm]$) = \mathbf{172.09}$[kg/cm2] — 9

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset edge shear stress	[kg/m2]	2.109198E07	4865319.00	D9	0.23	J4-1

$\phi F_n = \phi*0.6*F_y = 1*0.6*3515.33$[kg/cm2] $= \mathbf{2109.2}$[kg/cm2] — J4-1

$f_{uv} = V_c/(t_p*l) = 123.79$[T]$/(3$[cm]$*84.81$[cm]$) = \mathbf{486.53}$[kg/cm2] — 9

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Weld capacity	[Ton]	231.15	164.14	D9	0.71	Tables 8-4 .. 8-11

$\phi R_n = 2 * (\phi*C*C_1*D*L) = 2 * (0.75*0.363$[T/cm]$*1*5*84.81$[cm]$) = \mathbf{231.15}$[T] — Tables 8-4 .. 8-11

$f_{ua} = V_c/l = 43.79$[T]$/84.81$[cm] $= \mathbf{0.516}$[T/cm] — 9

$f_{uv} = H_c/l = 123.79$[T]$/84.81$[cm] $= \mathbf{1.46}$[T/cm] — 9

$f_{ub} = M_c/(l^2/6) = 0$[T*m]$/(84.81$[cm]$^2/6) = \mathbf{0}$[T/cm] — 9

$f_{uPeak} = ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2} = ((0.516$[T/cm] $+ 0$[T/cm]$)^2 + 1.46$[T/cm]$^2)^{1/2} = \mathbf{1.55}$[T/cm] — 9

$f_{uAve} = 0.5*(((f_{ua} - f_{ub})^2 + f_{uv}^2)^{1/2} + ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2}) = 0.5*(((0.516$[T/cm] $- 0$[T/cm]$)^2 + 1.46$[T/cm]$^2)^{1/2} + ((0.516$[T/cm] $+ 0$[T/cm]$)^2 + 1.46$[T/cm]$^2)^{1/2}) = \mathbf{1.55}$[T/cm] — 9

$f_{uWeld} = l*\max(f_{uPeak}, 1.25*f_{uAve}) = 84.81$[cm]$*\max(1.55$[T/cm]$, 1.25*1.55$[T/cm]$) = \mathbf{164.14}$[T] — 9

Ratio **0.71**

Upper right gusset interface - column

Directly welded

DEMANDS

	Beam			Column			
Description	**Ru**	**Pu**	**Mu**	**Pu**	**Mu22**	**Mu33**	**Load type**

	[Ton]	[Ton]	[Ton*m]	[Ton]	[Ton*m]	[Ton*m]	
D1	-9.44	-2.68	0.00	-88.05	0.00	0.00	Design
D2	-12.34	-3.50	0.00	-116.25	0.00	0.00	Design
D3	-8.09	-2.30	0.00	-75.47	0.00	0.00	Design
D4	-8.09	-2.30	0.00	-75.47	0.00	0.00	Design
D5	-8.09	-2.30	0.00	-75.47	0.00	0.00	Design
D6	-8.09	-2.30	0.00	-75.47	0.00	0.00	Design
D7	-10.75	-3.05	0.00	-100.96	0.00	0.00	Design
D8	-10.75	-3.05	0.00	-100.96	0.00	0.00	Design
D9	193.31	54.87	0.00	345.33	0.00	0.00	Seismic
D10	-8.09	-2.30	0.00	-75.47	0.00	0.00	Design
D11	193.31	54.87	0.00	319.84	0.00	0.00	Seismic
D12	-10.75	-3.05	0.00	-100.96	0.00	0.00	Design
D13	-6.07	-1.72	0.00	-56.60	0.00	0.00	Design
D14	-6.07	-1.72	0.00	-56.60	0.00	0.00	Design
D15	193.31	54.87	0.00	364.20	0.00	0.00	Seismic
D16	-6.07	-1.72	0.00	-56.60	0.00	0.00	Design
D17	-6.75	-1.91	0.00	-62.89	0.00	0.00	Design
D18	-9.40	-2.67	0.00	-88.38	0.00	0.00	Design
D19	-8.73	-2.48	0.00	-82.01	0.00	0.00	Design
D20	-6.75	-1.91	0.00	-62.89	0.00	0.00	Design
D21	-6.75	-1.91	0.00	-62.89	0.00	0.00	Design
D22	193.31	54.87	0.00	231.67	0.00	0.00	Seismic
D23	-6.75	-1.91	0.00	-62.89	0.00	0.00	Design
D24	-8.73	-2.48	0.00	-82.01	0.00	0.00	Design
D25	-8.73	-2.48	0.00	-82.01	0.00	0.00	Design
D26	193.31	54.87	0.00	158.03	0.00	0.00	Seismic
D27	-6.75	-1.91	0.00	-62.89	0.00	0.00	Design
D28	-4.05	-1.15	0.00	-37.73	0.00	0.00	Design
D29	-4.05	-1.15	0.00	-37.73	0.00	0.00	Design
D30	193.31	54.87	0.00	256.83	0.00	0.00	Seismic
D31	-4.05	-1.15	0.00	-37.73	0.00	0.00	Design

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset						
Beam yielding (normal stress)	[Ton]	1257.03	54.87	D9	0.04	Eq. B-1, Appendix B, DG29, Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 54.87$[T] $+ ((4*0$[T*m]$)/132.44$[cm]$) =$ **54.87**[T] — Eq. B-1, Appendix B, DG29

$A_g = L_p*t_p = 132.44$[cm]$*3$[cm] $=$ **397.32**[cm2] — Sec. D3-1

$\phi R_n = \phi*F_y*A_g = 0.9*3515.33$[kg/cm2]$*397.32$[cm2] $=$ **1257.03**[T] — Eq. J4-1

$N_{eq} = V_{ub} + ((4*M_{ub})/L_p) = 54.87$[T] $+ ((4*0$[T*m]$)/132.44$[cm]$) =$ **54.87**[T] — Eq. B-1, Appendix B, DG29

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Shear yielding	[Ton]	838.02	193.31	D9	0.23	Eq. J4-3

$A_g = L_p*t_p = 132.44$[cm]$*3$[cm] $=$ **397.32**[cm2] — Sec. D3-1

$\phi R_n = \phi*0.60*F_y*A_g = 1*0.60*3515.33$[kg/cm2]$*397.32$[cm2] $=$ **838.02**[T] — Eq. J4-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Gusset edge tension stress	[kg/m2]	3.163797E07	1380995.00	D9	0.04	J4-1

$\phi F_n = \phi*F_y = 0.9*3515.33$[kg/cm2] $=$ **3163.8**[kg/cm2] — J4-1

$f_{ua} = H_c/(t_p*l) = 54.87$[T]$/(3$[cm]$*132.44$[cm]$) =$ **138.1**[kg/cm2] — 9

Gusset edge shear stress	[kg/m2]	2.109198E07	4865319.00	D9	0.23	J4-1

$\phi F_n = \phi * 0.6 * F_y = 1*0.6*3515.33$[kg/cm2] = **2109.2**[kg/cm2] J4-1

$f_{uv} = V_c/(t_p * l) = 193.31$[T]/(3[cm]*132.44[cm]) = **486.53**[kg/cm2] 9

Weld capacity	[Ton]	352.73	251.18	D9	0.71	Tables 8-4 .. 8-11

$\phi R_n = 2 * (\phi * C * C_1 * D * L) = 2 * (0.75*0.355$[T/cm]*1*5*132.44[cm]) = **352.73**[T] Tables 8-4 .. 8-11

$f_{ua} = V_c/l = 54.87$[T]/132.44[cm] = **0.414**[T/cm] 9

$f_{uv} = H_c/l = 193.31$[T]/132.44[cm] = **1.46**[T/cm] 9

$f_{ub} = M_c/(l^2/6) = 0$[T*m]/(132.44[cm]^2/6) = **0**[T/cm] 9

$f_{uPeak} = ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2}$ = ((0.414[T/cm] + 0[T/cm])^2 + 1.46[T/cm]^2)$^{1/2}$ = **1.52**[T/cm] 9

$f_{uAve} = 0.5*(((f_{ua} - f_{ub})^2 + f_{uv}^2)^{1/2} + ((f_{ua} + f_{ub})^2 + f_{uv}^2)^{1/2})$ = 0.5*(((0.414[T/cm] - 0[T/cm])^2 + 1.46[T/cm]^2)$^{1/2}$ + ((0.414[T/cm] + 0[T/cm])^2 + 1.46[T/cm]^2)$^{1/2}$) = **1.52**[T/cm] 9

$f_{uWeld} = l * \max(f_{uPeak}, 1.25 * f_{uAve})$ = 132.44[cm]*max(1.52[T/cm], 1.25*1.52[T/cm]) = **251.18**[T] 9

Column

Local web yielding	[Ton]	934.44	54.87	D9	0.06	Eq. J10-2, Eq. B-1, Appendix B, DG29

IsBeamReaction → **False**

$l_b = N$ = **132.44**[cm] Sec. J10-2

IsMemberEnd → **False**

$\phi R_n = \phi * (5 * k + l_b) * F_{yw} * t_w$ = 1*(5*4.29[cm] + 132.44[cm])*3515.33[kg/cm2]*1.73[cm] = **934.44**[T] Eq. J10-2

$N_{eq} = V_{ub} + ((4 * M_{ub})/L_p)$ = 54.87[T] + ((4*0[T*m])/132.44[cm]) = **54.87**[T] Eq. B-1, Appendix B, DG29

Ratio **0.71**

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interface between Column - base plate

DEMANDS

Description	**Pu** [Ton]	**Mu22** [Ton*m]	**Mu33** [Ton*m]	**Vu2** [Ton]	**Vu3** [Ton]	**Load type**
D1	-99.63	0.00	-1.31	8.73	0.00	Design
D2	-131.38	0.00	-1.71	11.40	0.00	Design
D3	-85.40	0.00	-1.12	7.48	0.00	Design
D4	-85.40	0.00	-1.12	7.48	0.00	Design
D5	-85.40	0.00	-1.12	7.48	0.00	Design
D6	-85.40	0.00	-1.12	7.48	0.00	Design
D7	-114.14	0.00	-1.49	9.93	0.00	Design
D8	-114.14	0.00	-1.49	9.93	0.00	Design
D9	582.43	0.00	26.80	-175.08	0.00	Seismic
D10	-85.40	0.00	-1.12	7.48	0.00	Design
D11	556.94	0.00	26.80	-175.08	0.00	Seismic
D12	-114.14	0.00	-1.49	9.93	0.00	Design
D13	-64.05	0.00	-0.84	5.61	0.00	Design
D14	-64.05	0.00	-0.84	5.61	0.00	Design
D15	601.29	0.00	26.80	-175.08	0.00	Seismic
D16	-64.05	0.00	-0.84	5.61	0.00	Design
D17	-71.16	0.00	-0.94	6.23	0.00	Design

D18	-99.90	0.00	-1.30	8.68	0.00	Design
D19	-92.72	0.00	-1.21	8.07	0.00	Design
D20	-71.16	0.00	-0.94	6.23	0.00	Design
D21	-71.16	0.00	-0.94	6.23	0.00	Design
D22	468.76	0.00	26.80	-176.16	0.00	Seismic
D23	-71.16	0.00	-0.94	6.23	0.00	Design
D24	-92.72	0.00	-1.21	8.07	0.00	Design
D25	-92.72	0.00	-1.21	8.07	0.00	Design
D26	395.12	0.00	26.80	-176.78	0.00	Seismic
D27	-71.16	0.00	-0.94	6.23	0.00	Design
D28	-42.70	0.00	-0.56	3.74	0.00	Design
D29	-42.70	0.00	-0.56	3.74	0.00	Design
D30	493.92	0.00	26.80	-176.16	0.00	Seismic
D31	-42.70	0.00	-0.56	3.74	0.00	Design

Design for major axis
Base plate (AISC 360-10 LRFD)

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Base plate						
Distance from anchor to edge	[cm]	12.78	0.64	--	✔	
Weld size	[1/16in]	7	4	--	✔	table J2.4
$w_{min} = w_{min} = \mathbf{0.00635}$						table J2.4
Shear lug						
Weld size	[1/16in]	7	5	--	✔	table J2.4
$w_{min} = w_{min} = \mathbf{0.007938}$						table J2.4
Right gusset						
Weld size	[1/16in]	5	5	--	✔	table J2.4
$w_{min} = w_{min} = \mathbf{0.007938}$						table J2.4

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Pedestal						
Axial bearing	[kg/m2]	1553776.00	53353.24	D2	0.03	DG1 3.1.1;
$f_{p,\,max} = \phi*\min(0.85*f'_c*(A_2/A_1)^{1/2}, 1.7*f'_c) = 0.65*\min(0.85*281.23\text{[kg/cm2]}*(1)^{1/2}, 1.7*281.23\text{[kg/cm2]}) = \mathbf{155.38}\text{[kg/cm2]}$						DG1 3.1.1
Base plate						
Flexural yielding (bearing interface)	[Ton*m/m]	128.13	20.01	D2	0.16	DG1 Eq. 3.3.13, DG1 Sec 3.1.2
$\phi M_n = \phi*F_y*t_p^2/4 = 0.9*2531.04\text{[kg/cm2]}*15\text{[cm]}^2/4 = \mathbf{128.13}\text{[T*m/m]}$						DG1 Eq. 3.3.13
$m = m = \mathbf{88.82}\text{[cm]}$						DG1 Sec 3.1.2
$n = n = \mathbf{42.67}\text{[cm]}$						DG1 Sec 3.1.2
$M_{pl} = \max(M_{pM}, M_{pN}) = \max(20.01\text{[T*m/m]}, 4.86\text{[T*m/m]}) = \mathbf{20.01}\text{[T*m/m]}$						
Flexural yielding (tension interface)	[Ton*m/m]	128.13	97.53	D15	0.76	DG1 Eq. 3.3.13
$\phi M_n = \phi*F_y*t_p^2/4 = 0.9*2531.04\text{[kg/cm2]}*15\text{[cm]}^2/4 = \mathbf{128.13}\text{[T*m/m]}$						DG1 Eq. 3.3.13
$M_{pT} = M_{strip}/B_{eff} = 113.96\text{[T*m]}/116.84\text{[cm]} = \mathbf{97.53}\text{[T*m/m]}$						
Right gusset						

Weld capacity	[Ton/m]	186.45	99.45	D15	0.53	p. 8-9, Sec. J2.5, Sec. J2.4, DG1 p. 35

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} = \mathbf{1.5}$ — p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor = 0.6*4921.46[kg/cm2]*1.5 = \mathbf{4429.32}[kg/cm2]$ — Sec. J2.5

$A_w = (2)^{1/2}/2*D/16\ [in]*L = (2)^{1/2}/2*5/16\ [in]*100[cm] = \mathbf{56.13}[cm2]$ — Sec. J2.4

$\phi R_w = \phi*F_w*A_w/L = 0.75*4429.32[kg/cm2]*56.13[cm2]/100[cm] = \mathbf{1.86}[T/cm]$

$b_{eff} = 2*L = 2*16.92[cm] = \mathbf{33.84}[cm]$ — DG1 p. 35

$Maximum\ weld\ load = T/b_{eff} = 33.65[T]/33.84[cm] = \mathbf{0.994}[T/cm]$

Shear lug

Bearing on the concrete	[Ton]	832.96	176.78	D26	0.21	DG1 Sec 3.5.2

$d = D_{lug} - G = 30[cm] - 0[cm] = \mathbf{30}[cm]$ — DG1 Sec 3.5.2

$A_l = d*b = 30[cm]*116.84[cm] = \mathbf{3505.2}[cm2]$ — DG1 Sec 3.5.2

$\phi P_{ubrg} = \phi*1.3*f'_c*A_l = 0.65*1.3*281.23[kg/cm2]*3505.2[cm2] = \mathbf{832.96}[T]$ — DG1 Sec 3.5.2

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

Shear on the concrete	[Ton]	353.43	176.78	D26	0.50	DG1 Sec 3.5.2, DG1 p. 42

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

$d = D_{lug} - G = 30[cm] - 0[cm] = \mathbf{30}[cm]$ — DG1 Sec 3.5.2

$B_v = \min(B_{cs}, b + 2*c_{lug}) = \min(200[cm], 116.84[cm] + 2*145[cm]) = \mathbf{200}[cm]$ — DG1 p. 42

$D_v = \min(d + c_{lug}, t_{cs}) = \min(30[cm] + 145[cm], 150[cm]) = \mathbf{150}[cm]$ — DG1 p. 42

$A_v = B_v*D_v - d*b = 200[cm]*150[cm] - 30[cm]*116.84[cm] = \mathbf{26494.8}[cm2]$ — DG1 p. 42

$V_u = 4*\phi*(f'_c/(1\ [psi]))^{1/2}\ [psi]*A_v = 4*0.75*(281.23[kg/cm2]/(1\ [psi]))^{1/2}\ [psi]*26494.8[cm2] = \mathbf{353.43}[T]$ — DG1 Sec 3.5.2

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

Flexural yielding	[Ton*m]	66.54	26.52	D26	0.40	DG1 p. 43, DG1 Sec 3.5.2

$M_{lgu} = (\phi*F_y*b*t^2)/4 = (0.9*2531.04[kg/cm2]*116.84[cm]*10[cm]^2)/4 = \mathbf{66.54}[T*m]$ — DG1 p. 43

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

$d = D_{lug} - G = 30[cm] - 0[cm] = \mathbf{30}[cm]$ — DG1 Sec 3.5.2

$M_{lg} = V*(G + d/2) = 176.78[T]*(0[cm] + 30[cm]/2) = \mathbf{26.52}[T*m]$ — DG1 p. 43

Weld capacity	[Ton/m]	261.03	224.44	D26	0.86	p. 8-9, Sec. J2.5, Sec. J2.4, DG1 Sec 3.5.2, DG1 p. 43

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} = \mathbf{1.5}$ — p. 8-9

$F_w = 0.6*F_{EXX}*LoadAngleFactor = 0.6*4921.46[kg/cm2]*1.5 = \mathbf{4429.32}[kg/cm2]$ — Sec. J2.5

$A_w = (2)^{1/2}/2*D/16\ [in]*L = (2)^{1/2}/2*7/16\ [in]*100[cm] = \mathbf{78.58}[cm2]$ — Sec. J2.4

$\phi R_w = \phi*F_w*A_w/L = 0.75*4429.32[kg/cm2]*78.58[cm2]/100[cm] = \mathbf{2.61}[T/cm]$

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

$V = \max(V - \mu*P, 0) = \max(176.78[T] - 0.5*0[T], 0) = \mathbf{176.78}[T]$

$d = D_{lug} - G = 30[cm] - 0[cm] = \mathbf{30}[cm]$ — DG1 Sec 3.5.2

$M_{lg} = V*(G + d/2) = 176.78[T]*(0[cm] + 30[cm]/2) = \mathbf{26.52}[T*m]$ — DG1 p. 43

$s = t + 2*w/3 = 10[cm] + 2*1.11[cm]/3 = \mathbf{10.74}[cm]$ — DG1 p. 43

$f_c = M_{lgu}/(s*b) = 26.52[T*m]/(10.74[cm]*116.84[cm]) = \mathbf{2.11}[T/cm]$ — DG1 p. 43

$f_v = V/(2*b) = 176.78$[T]/(2*116.84[cm]) = **0.757**[T/cm] DG1 p. 43
$f_r = (f_c^2 + f_v^2)^{1/2} = (2.11$[T/cm]^2 + 0.757[T/cm]$^2)^{1/2}$ = **2.24**[T/cm] DG1 p. 43

Column

	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Weld capacity	[Ton/m]	261.03	260.78	D15	1.00	p. 8-9, Sec. J2.5, Sec. J2.4, DG1 p. 35

$LoadAngleFactor = 1 + 0.5*(\sin(\theta))^{1.5} = 1 + 0.5*(\sin(1.57))^{1.5} =$ **1.5** p. 8-9
$F_w = 0.6*F_{EXX}*LoadAngleFactor$ = 0.6*4921.46[kg/cm2]*1.5 = **4429.32**[kg/cm2] Sec. J2.5
$A_w = (2)^{1/2}/2*D/16$ [in]$*L = (2)^{1/2}/2*7/16$ [in]*100[cm] = **78.58**[cm2] Sec. J2.4
$\phi R_w = \phi*F_w*A_w/L$ = 0.75*4429.32[kg/cm2]*78.58[cm2]/100[cm] = **2.61**[T/cm]
$b_{eff} = 2*L$ = 2*5.84[cm] = **11.68**[cm] DG1 p. 35
$Maximum\ weld\ load = T/b_{eff}$ = 30.46[T]/11.68[cm] = **2.61**[T/cm]

Ratio **1.00**

Major axis
Anchors

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
Anchors						
Anchor spacing	[cm]	20.37	17.78	--	✔	Sec. D.8.1
Concrete cover	[cm]	56.10	5.08	--	✔	Sec. 7.7.1
Effective length	[cm]	52.89	--	147.11	✔	

Anchor spacing: $s_{min} = 4*d_a$ = 4*4.45[cm] = **17.78**[cm] Sec. D.8.1

Concrete cover: $IsConcreteCastAgainstEarth \rightarrow$ **False**
$Cover = 2$ [in] Sec. 7.7.1

Ratio **0.93**

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Anchor tension	[Ton]	37.48	33.65	D15	0.90	Eq. D-3

$A_{se} = \pi/4.0*(d_a - 0.9743$ [in]$/n_t)^2 = \pi/4.0*(4.45$[cm] - 0.9743 [in]/5$)^2$ = **12.25**[cm2] Sec. D.5.1.1, D.6.1.2
$f_{uta} = \min(f_{uta}, 1.9*f_{ya}, 125$ [ksi]) = min(4077.78[kg/cm2], 1.9*2531.04[kg/cm2], 125 [ksi]) = **4077.78**[kg/cm2] Sec. D.5.1.2
$\phi N_{sa} = \phi*n*A_{se,N}*f_{uta}$ = 0.75*1*12.25[cm2]*4077.78[kg/cm2] = **37.48**[T] Eq. D-3

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References
Pullout of anchor in tension	[Ton]	44.11	33.65	D15	0.76	Sec. D.3.3.3

$A_{brg} = 0.866025*F^2 - A_g = 0.866025*6.98$[cm]^2 - 15.52[cm2] = **26.68**[cm2]
$IsHeadedBolt \rightarrow$ **True**
$N_p = 8*A_{brg}*f_c$ = 8*26.68[cm2]*281.23[kg/cm2] = **60.02**[T] Eq. D-15
$CrackedConcrete \rightarrow$ **False**
$\psi_{c,P} = 1.4$ Sec. D.5.3.6
$N_{pn} = \psi_{c,P}*N_p$ = 1.4*60.02[T] = **84.03**[T] Eq. D-14

$HighSeismicDesignCategory \rightarrow$ **True**

$\phi N_{pn} = 0.75*\phi*N_{pn} = 0.75*0.7*84.03$[T] = **44.11**[T] Sec. D.3.3.3

Group of Anchors reinforcement in tension	[Ton]	644.94	601.29	D15	0.93	Sec. D.5.2.9, D.6.2.9

$\phi N_{sar} = 0.75*n*A_s*F_y = 0.75*40*5.1$[cm2]*4218[kg/cm2] = **644.94**[T] Sec. D.5.2.9, D.6.2.9

Anchor shear	[Ton]	19.49	0.00	D1	0.00	Eq. D-20

$A_{se} = \pi/4.0*(d_a - 0.9743$ [in]$/n_t)^2 = \pi/4.0*(4.45$[cm] - 0.9743 [in]$/5)^2$ = **12.25**[cm2] Sec. D.5.1.1, D.6.1.2

$f_{uta} = \min(f_{uta}, 1.9*f_{ya}, 125$ [ksi]) = min(4077.78[kg/cm2], 1.9*2531.04[kg/cm2], 125 [ksi]) = **4077.78**[kg/cm2] Sec. D.5.1.2

$HasGroutPad \rightarrow$ **False**

$\phi V_{sa} = \phi*0.6*n*A_{se,V}*f_{uta} = 0.65*0.6*1*12.25$[cm2]*4077.78[kg/cm2] = **19.49**[T] Eq. D-20

Pryout of anchor in shear	[Ton]	71.72	0.00	D1	0.00	Eq. D-4, Sec. D.3.3.3

$h_{ef}<2.5$ [in] $\rightarrow$ 50[cm]<2.5 [in] $\rightarrow$ **False**

$k_{cp} = 2$ Sec. D.6.3.1

$c_{a1Left}<1.5*h_{ef} \rightarrow$ 81.58[cm]<1.5*50[cm] $\rightarrow$ **False**

$c_{a1Left} = 1.5*h_{ef} = 1.5*50$[cm] = **75**[cm] Sec. D.5.2.1

$c_{a1Right}<1.5*h_{ef} \rightarrow$ 118.42[cm]<1.5*50[cm] $\rightarrow$ **False**

$c_{a1Right} = 1.5*h_{ef} = 1.5*50$[cm] = **75**[cm] Sec. D.5.2.1

$c_{a2Top}<1.5*h_{ef} \rightarrow$ 241.68[cm]<1.5*50[cm] $\rightarrow$ **False**

$c_{a2Top} = 1.5*h_{ef} = 1.5*50$[cm] = **75**[cm] Sec. D.5.2.1

$c_{a2Bot}<1.5*h_{ef} \rightarrow$ 58.32[cm]<1.5*50[cm] $\rightarrow$ **True**

$c_{a2Bot} = c_{a2Bot}$ = **58.32**[cm] Sec. D.5.2.1

$IsCloseToThreeEdges \rightarrow$ **False**

$h_{ef} = h_{ef}$ = **50**[cm] Sec. D.5.2.3

$A_{Nc} = (c_{a1Left} + c_{a1Right})*(c_{a2Top} + c_{a2Bot})$ = (75[cm] + 75[cm])*(75[cm] + 58.32[cm]) = **19998**[cm2] Sec. RD.5.2.1

$A_{Nco} = 9*h_{ef}^2 = 9*50$[cm]^2 = **22500**[cm2] Eq. D-6

$c_{a,min}<1.5*h_{ef} \rightarrow$ 58.32[cm]<1.5*50[cm] $\rightarrow$ **True**

$\psi_{ed,N} = 0.7 + 0.3*c_{a,min}/(1.5*h_{ef})$ = 0.7 + 0.3*58.32[cm]/(1.5*50[cm]) = **0.933** Eq. D-11

$CrackedConcrete \rightarrow$ **False**

$\psi_{c,N} = 1.25$ Sec. D.5.2.6

$IsCastInPlaceAnchor \rightarrow$ **True**

$\psi_{cp,N} = 1$ Sec. D.5.2.7

$IsCastInPlaceAnchor \rightarrow$ **True**

$k_c = 24$ Sec. D.5.2.2

($IsCastInPlaceAnchor$) and ($IsHeadedBolt$) and (h_{ef}>=11 [in]) and (h_{ef}<= 25 [in]) $\rightarrow$ (True) and (True) and (50[cm]>=11 [in]) and (50[cm]<= 25 [in]) $\rightarrow$ **True**

$N_b = 16*\lambda*(f_c/(1$ [psi]$))^{1/2}*(h_{ef}/(1$ [in]$))^{(5/3)}$ [lb] = $16*1*(281.23$[kg/cm2]$/(1$ [psi]$))^{1/2}*(50$[cm]$/(1$ [in]$))^{(5/3)}$ [lb] = **65.87**[T] Eq. D-8

$N_{cb} = (A_{Nc}/A_{Nco})*\psi_{ed,N}*\psi_{c,N}*\psi_{cp,N}*N_b$ = (19998[cm2]/22500[cm2])*0.933*1.25*1*65.87[T] = **68.3**[T] Eq. D-4

$V_{cp} = k_{cp}*N_{cb} = 2*68.3$[T] = **136.6**[T] Eq. D-30

$HighSeismicDesignCategory \rightarrow \mathbf{True}$

$\phi V_{cp} = 0.75*\phi*V_{cp} = 0.75*0.7*136.6[T] = \mathbf{71.72}[T]$ Sec. D.3.3.3

Pryout of group of anchors in shear	[Ton]	189.40	0.00	D9	0.00	Eq. D-5, Sec. D.3.3.3

$h_{ef}<2.5 [in] \rightarrow 50[cm]<2.5 [in] \rightarrow \mathbf{False}$

$k_{cp} = 2$ Sec. D.6.3.1

$A_{Nco} = 9*h_{ef}^2 = 9*50[cm]^2 = \mathbf{22500}[cm2]$ Eq. D-6

$A_{Nc} = \min(A_{Nc}, n*A_{Nco}) = \min(56052[cm2], 20*22500[cm2]) = \mathbf{56052}[cm2]$ Sec. D.5.2.1

$\psi_{ec,Ny} = \min(1/(1 + 2*e'_N/(3*h_{ef})), 1) = \min(1/(1 + 2*4.6[cm]/(3*50[cm])), 1) = \mathbf{0.942}$ Eq. D-9

$\psi_{ec,Nx} = \min(1/(1 + 2*e'_N/(3*h_{ef})), 1) = \min(1/(1 + 2*0[cm]/(3*50[cm])), 1) = \mathbf{1}$ Eq. D-9

$\psi_{ec,N} = \psi_{ec,Nx}*\psi_{ec,Ny} = 1*0.942 = \mathbf{0.942}$ Eq. D-9

$c_{a,min}<1.5*h_{ef} \rightarrow 58.32[cm]<1.5*50[cm] \rightarrow \mathbf{True}$

$\psi_{ed,N} = 0.7 + 0.3*c_{a,min}/(1.5*h_{ef}) = 0.7 + 0.3*58.32[cm]/(1.5*50[cm]) = \mathbf{0.933}$ Eq. D-11

$CrackedConcrete \rightarrow \mathbf{False}$

$\psi_{c,N} = 1.25$ Sec. D.5.2.6

$IsCastInPlaceAnchor \rightarrow \mathbf{True}$

$\psi_{cp,N} = 1$ Sec. D.5.2.7

$IsCastInPlaceAnchor \rightarrow \mathbf{True}$

$k_c = 24$ Sec. D.5.2.2

$(IsCastInPlaceAnchor)$ and $(IsHeadedBolt)$ and $(h_{ef}>=11 [in])$ and $(h_{ef}<= 25 [in]) \rightarrow$ (True) and (True) and $(50[cm]>=11 [in])$ and $(50[cm]<= 25 [in]) \rightarrow \mathbf{True}$

$N_b = 16*\lambda*(f_c/(1 [psi]))^{1/2}*(h_{ef}/(1 [in]))^{(5/3)} [lb] = 16*1*(281.23[kg/cm2]/(1 [psi]))^{1/2}*(50[cm]/(1 [in]))^{(5/3)} [lb] = \mathbf{65.87}[T]$ Eq. D-8

$N_{cbg} = (A_{Nc}/A_{Nco})*\psi_{ec,N}*\psi_{ed,N}*\psi_{c,N}*\psi_{cp,N}*N_b = (56052[cm2]/22500[cm2])*0.942*0.933*1.25*1*65.87[T] = \mathbf{180.38}[T]$ Eq. D-5

$V_{cpg} = k_{cp}*N_{cbg} = 2*180.38[T] = \mathbf{360.75}[T]$ Eq. D-31

$HighSeismicDesignCategory \rightarrow \mathbf{True}$

$\phi V_{cpg} = 0.75*\phi*V_{cpg} = 0.75*0.7*360.75[T] = \mathbf{189.4}[T]$ Sec. D.3.3.3

Minor axis
Anchors

GEOMETRIC CONSIDERATIONS

Dimensions	Unit	Value	Min. value	Max. value	Sta.	References
<u>Anchors</u>						
Anchor spacing	[cm]	20.37	17.78	--	✔	Sec. D.8.1
$s_{min} = 4*d_a = 4*4.45[cm] = \mathbf{17.78}[cm]$						Sec. D.8.1
Concrete cover	[cm]	56.10	5.08	--	✔	Sec. 7.7.1
$IsConcreteCastAgainstEarth \rightarrow \mathbf{False}$						
$Cover = 2 [in]$						Sec. 7.7.1
Effective length	[cm]	52.89	--	147.11	✔	

Ratio	**0.93**

DESIGN CHECK

Verification	Unit	Capacity	Demand	Ctrl EQ	Ratio	References

Anchor tension	[Ton]	37.48	30.06	D15	0.80	DG1 3.1.1

$f_{p,\ max}$ = ϕ*min(0.85*f'_c*(A_2/A_1)$^{1/2}$, 1.7*f'_c) = 0.65*min(0.85*281.23[kg/cm2]*(1)$^{1/2}$, 1.7* 281.23[kg/cm2]) = **155.38**[kg/cm2] DG1 3.1.1

Pullout of anchor in tension	[Ton]	44.11	30.06	D15	0.68	Sec. D.3.3.3

A_{brg} = 0.866025*F^2 - A_g = 0.866025*6.98[cm]^2 - 15.52[cm2] = **26.68**[cm2]

IsHeadedBolt → **True**

N_p = 8*A_{brg}*f_c = 8*26.68[cm2]*281.23[kg/cm2] = **60.02**[T] Eq. D-15

CrackedConcrete → **False**

$\psi_{c,P}$ = 1.4 Sec. D.5.3.6

N_{pn} = $\psi_{c,P}$*N_p = 1.4*60.02[T] = **84.03**[T] Eq. D-14

HighSeismicDesignCategory → **True**

ϕN_{pn} = 0.75*ϕ*N_{pn} = 0.75*0.7*84.03[T] = **44.11**[T] Sec. D.3.3.3

Group of Anchors reinforcement in tension	[Ton]	644.94	601.29	D15	0.93	Sec. D.5.2.9, D.6.2.9

ϕN_{sar} = 0.75*n*A_s*F_y = 0.75*40*5.1[cm2]*4218[kg/cm2] = **644.94**[T] Sec. D.5.2.9, D.6.2.9

Anchor shear	[Ton]	19.49	0.00	D1	0.00	Eq. D-20

A_{se} = π/4.0*(d_a - 0.9743 [in]/n_t)^2 = π/4.0*(4.45[cm] - 0.9743 [in]/5)^2 = **12.25**[cm2] Sec. D.5.1.1, D.6.1.2

f_{uta} = min(f_{uta}, 1.9*f_{ya}, 125 [ksi]) = min(4077.78[kg/cm2], 1.9*2531.04[kg/cm2], 125 [ksi]) = **4077.78**[kg/cm2] Sec. D.5.1.2

HasGroutPad → **False**

ϕV_{sa} = ϕ*0.6*n*$A_{se,V}$*f_{uta} = 0.65*0.6*1*12.25[cm2]*4077.78[kg/cm2] = **19.49**[T] Eq. D-20

Pryout of anchor in shear	[Ton]	71.72	0.00	D1	0.00	Eq. D-4, Sec. D.3.3.3

h_{ef}<2.5 [in] → 50[cm]<2.5 [in] → **False**

k_{cp} = 2 Sec. D.6.3.1

c_{a1Left}<1.5*h_{ef} → 58.32[cm]<1.5*50[cm] → **True**

c_{a1Left} = c_{a1Left} = **58.32**[cm] Sec. D.5.2.1

$c_{a1Right}$<1.5*h_{ef} → 241.68[cm]<1.5*50[cm] → **False**

$c_{a1Right}$ = 1.5*h_{ef} = 1.5*50[cm] = **75**[cm] Sec. D.5.2.1

c_{a2Top}<1.5*h_{ef} → 81.58[cm]<1.5*50[cm] → **False**

c_{a2Top} = 1.5*h_{ef} = 1.5*50[cm] = **75**[cm] Sec. D.5.2.1

c_{a2Bot}<1.5*h_{ef} → 118.42[cm]<1.5*50[cm] → **False**

c_{a2Bot} = 1.5*h_{ef} = 1.5*50[cm] = **75**[cm] Sec. D.5.2.1

IsCloseToThreeEdges → **False**

h_{ef} = h_{ef} = **50**[cm] Sec. D.5.2.3

A_{Nc} = (c_{a1Left} + $c_{a1Right}$)*(c_{a2Top} + c_{a2Bot}) = (58.32[cm] + 75[cm])*(75[cm] + 75[cm]) = **19998**[cm2] Sec. RD.5.2.1

A_{Nco} = 9*h_{ef}^2 = 9*50[cm]^2 = **22500**[cm2] Eq. D-6

$c_{a,min}$<1.5*h_{ef} → 58.32[cm]<1.5*50[cm] → **True**

$\psi_{ed,N}$ = 0.7 + 0.3*$c_{a,min}$/(1.5*h_{ef}) = 0.7 + 0.3*58.32[cm]/(1.5*50[cm]) = **0.933** Eq. D-11

CrackedConcrete → **False**

$\psi_{c,N}$ = 1.25 Sec. D.5.2.6

IsCastInPlaceAnchor → **True**

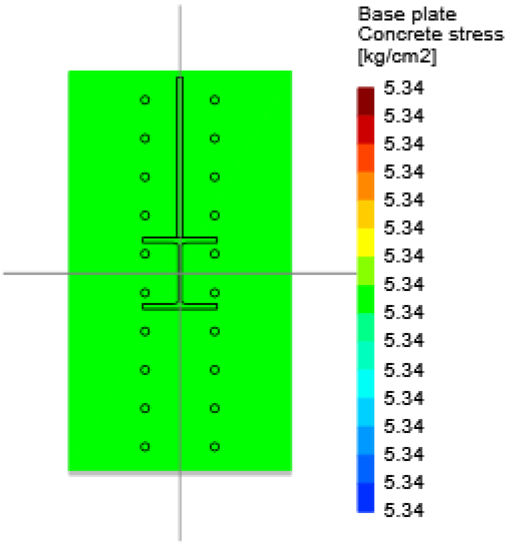
$\psi_{cp,N} = 1$	Sec. D.5.2.7
$IsCastInPlaceAnchor \rightarrow$ **True**	
$k_c = 24$	Sec. D.5.2.2
$(IsCastInPlaceAnchor)$ and $(IsHeadedBolt)$ and $(h_{ef}>=11$ [in]$)$ and $(h_{ef}<=25$ [in]$) \rightarrow$ (True) and (True) and (50[cm]>=11 [in]) and (50[cm]<=25 [in]) $\rightarrow$ **True**	
$N_b = 16*\lambda*(f_c/(1\text{ [psi]}))^{1/2}*(h_{ef}/(1\text{ [in]}))^{(5/3)}$ [lb] = 16*1*(281.23[kg/cm2]/(1 [psi]))$^{1/2}$*(50[cm]/(1 [in]))$^{(5/3)}$ [lb] = **65.87**[T]	Eq. D-8
$N_{cb} = (A_{Nc}/A_{Nco})*\psi_{ed,N}*\psi_{c,N}*\psi_{cp,N}*N_b$ = (19998[cm2]/22500[cm2])*0.933*1.25*1*65.87[T] = **68.3**[T]	Eq. D-4
$V_{cp} = k_{cp}*N_{cb}$ = 2*68.3[T] = **136.6**[T]	Eq. D-30
$HighSeismicDesignCategory \rightarrow$ **True**	
$\phi V_{cp} = 0.75*\phi*V_{cp}$ = 0.75*0.7*136.6[T] = **71.72**[T]	Sec. D.3.3.3

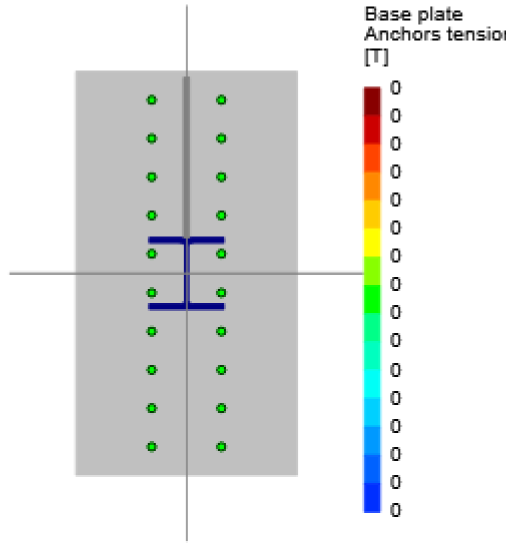
Pryout of group of anchors in shear	[Ton]	201.01	0.00	D9	0.00	Eq. D-5, Sec. D.3.3.3

$h_{ef}<2.5$ [in] $\rightarrow$ 50[cm]<2.5 [in] $\rightarrow$ **False**	
$k_{cp} = 2$	Sec. D.6.3.1
$A_{Nco} = 9*h_{ef}^2$ = 9*50[cm]^2 = **22500**[cm2]	Eq. D-6
$A_{Nc} = \min(A_{Nc}, n*A_{Nco})$ = min(56052[cm2], 20*22500[cm2]) = **56052**[cm2]	Sec. D.5.2.1
$\psi_{ec,Ny} = \min(1/(1 + 2*e'_N/(3*h_{ef})), 1)$ = min(1/(1 + 2*0[cm]/(3*50[cm])), 1) = **1**	Eq. D-9
$\psi_{ec,Nx} = \min(1/(1 + 2*e'_N/(3*h_{ef})), 1)$ = min(1/(1 + 2*0[cm]/(3*50[cm])), 1) = **1**	Eq. D-9
$\psi_{ec,N} = \psi_{ec,Nx}*\psi_{ec,Ny}$ = 1*1 = **1**	Eq. D-9
$c_{a,min}<1.5*h_{ef} \rightarrow$ 58.32[cm]<1.5*50[cm] $\rightarrow$ **True**	
$\psi_{ed,N} = 0.7 + 0.3*c_{a,min}/(1.5*h_{ef})$ = 0.7 + 0.3*58.32[cm]/(1.5*50[cm]) = **0.933**	Eq. D-11
$CrackedConcrete \rightarrow$ **False**	
$\psi_{c,N} = 1.25$	Sec. D.5.2.6
$IsCastInPlaceAnchor \rightarrow$ **True**	
$\psi_{cp,N} = 1$	Sec. D.5.2.7
$IsCastInPlaceAnchor \rightarrow$ **True**	
$k_c = 24$	Sec. D.5.2.2
$(IsCastInPlaceAnchor)$ and $(IsHeadedBolt)$ and $(h_{ef}>=11$ [in]$)$ and $(h_{ef}<=25$ [in]$) \rightarrow$ (True) and (True) and (50[cm]>=11 [in]) and (50[cm]<=25 [in]) $\rightarrow$ **True**	
$N_b = 16*\lambda*(f_c/(1\text{ [psi]}))^{1/2}*(h_{ef}/(1\text{ [in]}))^{(5/3)}$ [lb] = 16*1*(281.23[kg/cm2]/(1 [psi]))$^{1/2}$*(50[cm]/(1 [in]))$^{(5/3)}$ [lb] = **65.87**[T]	Eq. D-8
$N_{cbg} = (A_{Nc}/A_{Nco})*\psi_{ec,N}*\psi_{ed,N}*\psi_{c,N}*\psi_{cp,N}*N_b$ = (56052[cm2]/22500[cm2])*1*0.933*1.25*1*65.87[T] = **191.44**[T]	Eq. D-5
$V_{cpg} = k_{cp}*N_{cbg}$ = 2*191.44[T] = **382.89**[T]	Eq. D-31
$HighSeismicDesignCategory \rightarrow$ **True**	
$\phi V_{cpg} = 0.75*\phi*V_{cpg}$ = 0.75*0.7*382.89[T] = **201.01**[T]	Sec. D.3.3.3

Ratio **1.00**

Major axis
Maximum compression (D2)



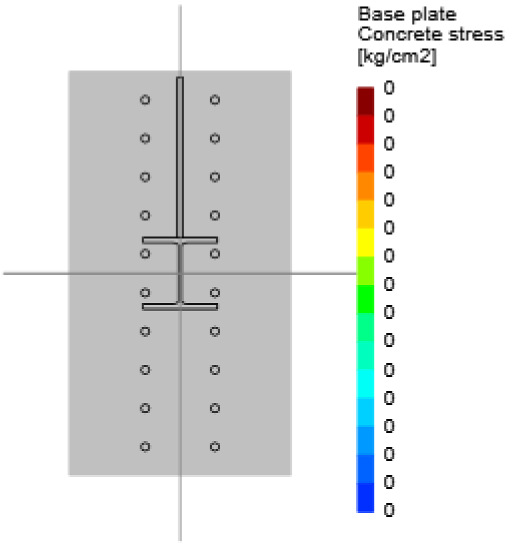


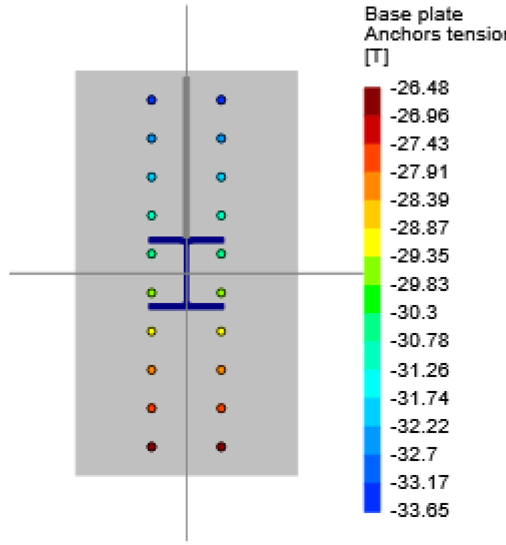
Maximum bearing pressure	5.34	[kg/cm2]
Minimum bearing pressure	5.34	[kg/cm2]
Maximum anchor tension	0.00	[Ton]
Minimum anchor tension	0.00	[Ton]
Neutral axis angle	0.00	
Bearing length	210.76	[cm]

Anchors tensions

Anchor	Transverse [cm]	Longitudinal [cm]	Shear [Ton]	Tension [Ton]
1	-18.42	-91.68	0.57	0.00
2	-18.42	-71.31	0.57	0.00
3	-18.42	-50.93	0.57	0.00
4	-18.42	-30.56	0.57	0.00
5	-18.42	-10.19	0.57	0.00
6	-18.42	10.19	0.57	0.00
7	-18.42	30.56	0.57	0.00
8	-18.42	50.93	0.57	0.00
9	-18.42	71.31	0.57	0.00
10	-18.42	91.68	0.57	0.00
11	18.42	91.68	0.57	0.00
12	18.42	71.31	0.57	0.00
13	18.42	50.93	0.57	0.00
14	18.42	30.56	0.57	0.00
15	18.42	10.19	0.57	0.00
16	18.42	-10.19	0.57	0.00
17	18.42	-30.56	0.57	0.00
18	18.42	-50.93	0.57	0.00
19	18.42	-71.31	0.57	0.00
20	18.42	-91.68	0.57	0.00

Maximum tension (D15)





Maximum bearing pressure	0.00	[kg/cm2]
Minimum bearing pressure	0.00	[kg/cm2]
Maximum anchor tension	33.65	[Ton]
Minimum anchor tension	26.48	[Ton]
Neutral axis angle	0.00	
Bearing length	-661.63	[cm]

Anchors tensions

Anchor	Transverse [cm]	Longitudinal [cm]	Shear [Ton]	Tension [Ton]
1	-18.42	-91.68	-8.75	26.48
2	-18.42	-71.31	-8.75	27.27
3	-18.42	-50.93	-8.75	28.07
4	-18.42	-30.56	-8.75	28.87
5	-18.42	-10.19	-8.75	29.67
6	-18.42	10.19	-8.75	30.46
7	-18.42	30.56	-8.75	31.26
8	-18.42	50.93	-8.75	32.06
9	-18.42	71.31	-8.75	32.85
10	-18.42	91.68	-8.75	33.65
11	18.42	91.68	-8.75	33.65
12	18.42	71.31	-8.75	32.85
13	18.42	50.93	-8.75	32.06
14	18.42	30.56	-8.75	31.26
15	18.42	10.19	-8.75	30.46
16	18.42	-10.19	-8.75	29.67
17	18.42	-30.56	-8.75	28.87
18	18.42	-50.93	-8.75	28.07
19	18.42	-71.31	-8.75	27.27
20	18.42	-91.68	-8.75	26.48

Global critical strength ratio **1.00**

NOTATION

A_e: Effective net area
A_g: Gross area
A_{gv}: Gross area subject to shear
A_l: Embedment area of the shear lug

A_n: Net area
A_{nt}: Net area subject to tension
A_{nv}: Net area subjected to shear
A_v: Project area of the failure plane at the face of the pier excluding the area of the lug
A_w: Effective area of the weld
α: Distance from the face of the column flange or web to the centroid of the gusset to beam connection
α_{bar}: Centroid of the gusset to beam connection
A_2/A_1: Ratio between the concrete support area and the base plate area
b: Plate, connector or member width
B_{cs}: Width of the concrete supporting surface or pier perpendicular to moment design direction
b_{eff}: Effective width of the compression block
B_{eff}: Controlling ffective width
b: Width of the shear lug
B_v: Width of the projected failure plane at the face of concrete support
N: Bearing length
β: Distance from the face of the beam flange to the centroid of the gusset to column connection
β_{bar}: Centroid of the gusset to column connection
C_1: Electrode strength coefficient
c_{lug}: Distance from the face of the shear lug to the concrete support edge parallel to shear load direction
C: Weld group coefficient
D: Outside section diameter
D_{lug}: Depth of the shear lug
d: Embedment depth of the shear lug
D: Uniform force method factor
D_v: Depth of the projected failure plane at the face of the concrete support
d_w: Distance between weld and the end of the plate
ΔV: Arbitrary shear
D: Number of sixteenths of an inch in the weld size
E: Elastic modulus
e_b: One half the depth of the beam
e_c: One half the depth of the column
f'_c: Specified compressive strength of concrete
F_{cr}: Critical stress, flexural stress buckling
f_c: Load on weld due cantilever moment
F_e: Elastic critical buckling stress
F_{EXX}: Electrode classification number
$f_{p,\ max}$: Maximum uniformly bearing stress under base plate
f_r: Resultant load on weld that attach the shear lug to base plate
F_u: Specified minimum tensile strength
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{uAve}: Average weld stress on welds along gusset-beam or gusset-column interface
f_{ub}: Bending stress on welds along gusset-beam or gusset-column interface
f_{uPeak}: Peak weld stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
f_{uWeld}: Design weld force on welds along gusset-beam or gusset-column interface
f_v: Vertical shear force on weld
F_w: Nominal strength of the weld metal per unit area
F_y: Specified minimum yield stress
F_{yw}: Specified minimum yield stress of web
G: Thickness of the grout bed
H_b: Required shear force on the beam to gusset connection
H_{Beam}: Beam horizontal force
$H_{BeamToColumn}$: Beam to column interrface total horizontal force
H_{Bot}: Bottom horizontal component of the gusset forces
H_c: Required axial force on the column to gusset connection
H_{Top}: Top horizontal component of the gusset forces
IsBeamReaction: Is beam reaction
IsMemberEnd: Is member end
K: Effective length factor
k: Distance from outer face of flange to the web toe of fillet
K: Uniform force method factor

K': Uniform force method factor
l: Length
L: Length
L: Distance from the anchor rod to the column
l_b: Bearing length
L_e: Effective length
L_h: Weld length on heel
L_{max}: Maximum length
L_p: Plate length
L_t: Weld length on toe
L: Length of weld
L_w: Width of Whitmore section
λ_b: Brace Slenderness
λ_{max}: Maximum slenderness
λ: Width-thickness ratio
λ_{hd}: Limiting Width-Thickness ratio (highly ductile)
LoadAngleFactor: Load angle factor
M_b: Required moment on the beam to gusset connection
M_c: Required moment on the column to gusset connection
m: Base plate bearing interface cantilever direction parallel to moment direction
M_{lg}: Required cantilever end moment for the shear lug
M_{lgu}: Cantilever end moment strength for the shear lug
M_{pl}: Plate bending moment per unit width
M_{pM}: Plate bending moment per unit width at bearing interface for the cantilever m
M_{pN}: Plate bending moment per unit width at bearing interface for the cantilever n
M_{pT}: Plate bending moment per unit width at tension unstiffened strip interface
M_{strip}: Maximum bending moment at the strip
Maximum weld load: Maximum weld load
μ: Coefficient of friction
n: Base plate bearing interface cantilever direction perpendicular to moment direction
P: Required axial force
P_n: Nominal Compressive strength
ϕ: Strength reduction factor
ϕ: Design factors
ϕM_n: Design or allowable strength per unit length
ϕP_n: Design or allowable strength
ϕR_n: Design or allowable strength
ϕR_w: Fillet weld capacity per unit length
ϕR_{w1}: Fillet weld capacity of the weld element 1
ϕR_{w2}: Fillet weld capacity of the weld element 2
ϕP_{ubrg}: Concrete bearing limit for the shear lug
Q: Prying action coefficient
r: Radius of gyration
R_t: Ratio of the expected tensile strength to the specified minimum tensile strength
r: Uniform force method parameter
R_y: Ratio of the expected yield stress to the specified minimum yield stress
s: Transversal length of the weld for the shear lug
t_p: Thickness of the connected material
T: Anchor rod tensile strength required
t_{cs}: Thickness of the concrete support or height of the pier
t: Design wall thickness of HSS member
t: Thickness of the shear lug
t_p: Plate thickness
t_w: Web thickness
$tan\theta$: Tangent of the brace with the vertical angle
θ: Load angle
U: Shear lag factor
U_{bs}: Stress index

V: Shear load
V_b: Required axial force on the beam to gusset connection
V_{Beam}: Beam vertical force
$V_{BeamToColumn}$: Beam to column interrface total vertical force
V_{Bot}: Bottom vertical component of the gusset forces
V_c: Required shear force on the column to gusset connection
V_u: Strength in shear of the concrete in front of the lug
V_{Top}: Top vertical component of the gusset forces
w_{max}: Maximum weld size required
w_{min}: Minimum weld size required
w: Weld size
x: Connection eccentricity
f_{ua}: Axial stress on welds along gusset-beam or gusset-column interface
f_{uv}: Shear stress on welds along gusset-beam or gusset-column interface
ϕF_n: Design or allowable tension/shear yielding stress
N_{eq}: Equivalent normal force
V_{ub}: Shear applied to the interface
M_{ub}: Moment applied to the interface
A_{brg}: Net bearing area of the head of stud or anchor bolt
A_g: Gross area of anchor
A_{Nc}: Projected concrete failure area of a single anchor or group of anchors, for calculation of strength in tension
A_{Nco}: Projected concrete failure area of a single anchor, for calculation of strength in tension if not limited by edge distance or spacing
A_s: Effective cross-sectional area of anchor reinforcement
A_{se}: Effective cross-sectional area of anchor
$A_{se,N}$: Effective cross-sectional area of anchor in tension
$A_{se,V}$: Effective cross-sectional area of anchor in shear
c_{a1}: Distance from the anchor center to the concrete edge
c_{a1Left}: Distance from the anchor center to the left edge of the concrete base
$c_{a1Right}$: Distance from the anchor center to the right edge of the concrete base
c_{a2Bot}: Distance from the anchor center to the bottom edge of the concrete base
c_{a2Top}: Distance from the anchor center to the top edge of the concrete base
$c_{a,min}$: Minimum distance from center of an anchor shaft to the edge of concrete
Cover: Concrete cover
CrackedConcrete: Cracked concrete at service loads
d_a: Outside diameter of anchor or shaft diameter of headed stud, headed bolt, or hooked bolt
e'_N: Distance between resultant tension load on a group of anchors loaded in tension and the centroid of the group of anchors loaded in tension
F: Distance between head flat sides
f_c: Specified compressive strength of concrete
f_{uta}: Specified tensile strength of anchor steel
F_y: Specified minimum yield stress
f_{ya}: Specified yield strength of anchor steel
h_{ef}: Effective embedment depth of anchor
HasGroutPad: Has grout pad
HighSeismicDesignCategory: High seismic design category (i.e. C, D, E or F)
IsCastInPlaceAnchor: Is cast in place anchor
IsCloseToThreeEdges: Anchor is close to three or more edges
IsConcreteCastAgainstEarth: Is concrete cast against and permanently exposed to earth
IsHeadedBolt: Is anchor headed stud
k_c: Coefficient for concrete pry out basic strength
k_{cp}: Coefficient for pry out strength
λ: Lightweight concrete modification factor
n: Number of anchors in the group
N_b: Basic concrete breakout strength in tension of a single anchor in cracked concrete
N_{cb}: Nominal concrete breakout strength in tension of a single anchor
N_{cbg}: Nominal concrete breakout strength in tension of a group of anchors
N_p: Pullout strength in tension of a single anchor in cracked concrete
N_{pn}: Nominal pullout strength of a single anchor in tension
n: Number of anchor reinforcement bars
n_t: Number of threads per inch
ϕ: Strength reduction factor
ϕN_{pn}: Pullout strength in tension of a single anchor

ϕN_{sa}: Strength of a single anchor or group of anchors in tension

ϕN_{sar}: Strength of a single anchor reinforcement or group of anchors reinforcements in tension

ϕV_{cp}: Concrete pryout strength of a single anchor

ϕV_{cpg}: Concrete pryout strength of a group of anchors

ϕV_{sa}: Strength in shear of a single anchor or group of anchors as governed by the steel strength

$\psi_{c,N}$: Factor used to modify tensile strength of anchors based on presence or absence of cracks in concrete

$\psi_{c,P}$: Factor used to modify pullout strength of anchors based on presence or absence of cracks in concrete

$\psi_{cp,N}$: Factor used to modify tensile strength of postinstalled anchors intended for use in uncracked concrete without supplementary reinforcement

$\psi_{ec,N}$: Factor used to modify tensile strength of anchors based on eccentricity of applied loads

$\psi_{ec,Nx}$: Factor used to modify tensile strength of anchors based on eccentricity in x axis of applied loads

$\psi_{ec,Ny}$: Factor used to modify tensile strength of anchors based on eccentricity in y axis of applied loads

$\psi_{ed,N}$: Factor used to modify tensile strength of anchors based on proximity to edges of concrete member

s_{min}: Center-to-center anchor minimum spacing

SideFaceBlowoutApply: Side-face blowout apply

V_{cp}: Nominal pryout strength of a anchor in shear

V_{cpg}: Nominal pryout strength of a group of anchor in shear

REFERENCES

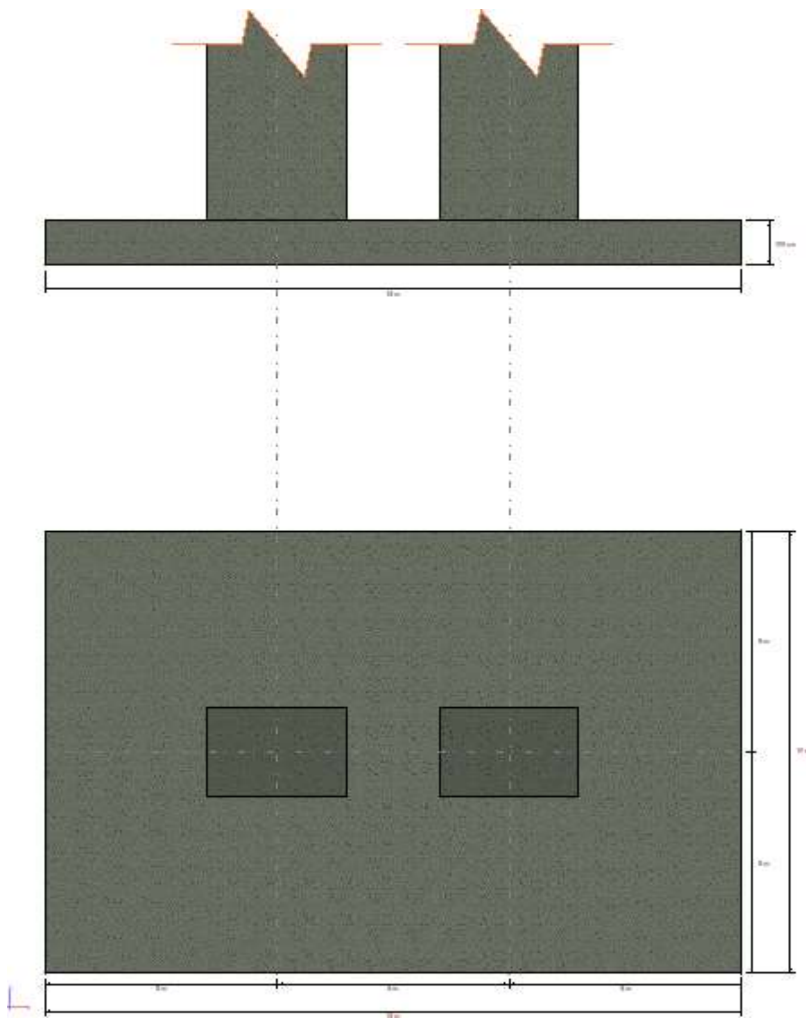
{9} AISC 2005, Design Examples Version 13.0, pp. IIC-26 - IIC-27

6.10. Diseño de Funcaciones-zapata Combinada

GENERAL INFORMATION:

Global status	:	OK
Design Code	:	ACI 318-2011
Footing type	:	Combined
Column type	:	Concrete

Geometry



Length	:	15.00 [m]
Width	:	10.00 [m]
Thickness	:	1.00 [m]
Base depth	:	4.00 [m]
Base area	:	150.00 [m2]
Footing volume	:	150.00 [m3]
Column length 1	:	300.00 [cm]
Column width 1	:	200.00 [cm]

Column length 2	:	300.00 [cm]
Column width 2	:	200.00 [cm]

Distance between columns	:	5.00 [m]
Column location relative to footing g.c.	:	Centered

Materials

Concrete, f'c	:	0.28 [Ton/cm2]	Steel, fy	:	4.22 [Ton/cm2]
Concrete type	:	Normal	Epoxy coated	:	No
Concrete elasticity modulus	:	253.46 [Ton/cm2]	Steel elasticity modulus	:	2038.89 [Ton/cm2]
Unit weight	:	2.40 [Ton/m3]			

Soil

Modulus of subgrade reaction	:	3203.68 [Ton/m3]	Cohesion	:	0.00 [kg/m2]
Unit weight (wet)	:	1.76 [Ton/m3]	Internal friction angle	:	30.00 [º]
Saturated unit weight	:	2.24 [Ton/m3]	Depth of water level	:	30.48 [m]
Slope of ground from base	:	0.00 [º]			

Footing reinforcement

Free cover	:	7.62 [cm]
Maximum Rho/Rho balanced ratio	:	0.75
Bottom reinforcement // to L (xx)	:	91-#5 @ 10.16cm
Top reinforcement // to L (xx)	:	91-#5 @ 10.16cm
Bottom reinforcement // to B (zz)	:	30-#5 @ 10.16cm (Zone 1)
Bottom reinforcement // to B (zz)	:	17-#5 @ 20.32cm (Zone 2)
Bottom reinforcement // to B (zz)	:	15-#5 @ 10.16cm (Zone 3)
Bottom reinforcement // to B (zz)	:	31-#5 @ 10.16cm (Zone 4)
Bottom reinforcement // to B (zz)	:	30-#5 @ 10.16cm (Zone 5)
Top reinforcement // to B (zz)	:	15-#5 @ 22.86cm

Dowel bar size

Rebar 1	:	56-#8
Free cover	:	2.54 [cm]
Development length calculated	:	in tension
Bars number // to x axis	:	20
Bars number // to z axis	:	10
Stirrups	:	#4 @ 20.00cm
Legs number // to x axis	:	10
Legs number // to z axis	:	10

Rebar 2	:	56-#8
Free cover	:	2.54 [cm]
Development length calculated	:	in tension
Bars number // to x axis	:	20
Bars number // to z axis	:	10
Stirrups	:	#4 @ 20.00cm
Legs number // to x axis	:	10
Legs number // to z axis	:	10

Load conditions to be included in design

Service loads:

SC1	:	DL
D5	:	0.9DL+EQx
D6	:	DL
D7	:	DL+LL
D8	:	DL+0.75LL
D9	:	DL+0.7EQx
D10	:	DL+0.525EQx
D11	:	0.6DL+0.7EQx

Design strength loads:

DC1	:	1.4DL
D1	:	1.4DL
D2	:	1.2DL+1.6LL
D3	:	1.2DL+EQx
D4	:	1.2DL+LL+EQx

Loads

Condition	**Column**	**Axial** [Ton]	**Mxx** [Ton*m]	**Mzz** [Ton*m]	**Vx** [Ton]	**Vz** [Ton]
DL	1	71.16	0.00	0.00	-6.25	0.00
LL	1	28.73	0.00	0.00	-2.48	0.00
EQx	1	-503.54	0.00	0.00	59.91	0.00
DL	2	69.30	0.00	0.00	6.19	0.00
LL	2	27.89	0.00	0.00	2.46	0.00
EQx	2	510.29	0.00	0.00	60.43	0.00

RESULTS:

Status : OK

Soil.Foundation interaction

Soil stress due to the footing self weight and su...	:	9.13E03 [kg/m2]
Min. safety factor for bearing capacity	:	2.50
Min. safety factor for sliding	:	1.25
Min. safety factor for overturning	:	1.25
Initial effective stress (qef)	:	7.05E03 [kg/m2]
Controlling condition	:	D5

Condition	**qu** [kg/m2]	**qnmax** [kg/m2]	**qnav** [kg/m2]	**FS B. Cap.**	**Δmax** [cm]	**Area** comp(%)	**Overturning** **FSx**	**FSz**	**FS slip**
D5	1.46E04	7.5E03	757	1.01	0.454	100	1000.00	3.47	7.08

Bending

Factor ϕ	:	0.90
Min rebar ratio	:	0.00180

Development length

Axis	**Pos.**	**Id** [cm]	**Ihd** [cm]	**Dist1** [cm]	**Dist2** [cm]
zz	Bot.	60.24	21.08	392.38	392.38
xx	Bot.	59.58	20.85	342.38	342.38
zz	Top	30.48	15.24	392.38	392.38
xx	Top	34.58	15.24	342.38	342.38

Axis	**Pos.**	**Condition**	**Mu** [Ton*m]	**ϕ*Mn** [Ton*m]	**Asreq** [cm2]	**Asprov** [cm2]	**Asreq/Asprov**	**Mu/(ϕ*Mn)**
zz	Top	D3	-277.23	-621.74	80.35	182.00	0.441	0.446
zz	Bot.	D4	443.23	621.74	129.07	182.00	0.709	0.713

Zone 1 xx	Top	DC1	0.00	0.00	0.00	0.00	0.000	0.000	
Zone 1 xx	Bot.	DC1	0.00	201.36	59.53	60.00	0.992	0.000	
Zone 2 xx	Top	D3	-98.80	101.61	29.16	30.00	0.972	0.972	
Zone 2 xx	Bot.	D2	31.04	115.03	31.78	34.00	0.935	0.270	
Zone 3 xx	Top	DC1	0.00	0.00	0.00	0.00	0.000	0.000	
Zone 3 xx	Bot.	DC1	0.00	100.64	29.06	30.00	0.969	0.000	
Zone 4 xx	Top	DC1	0.00	0.00	0.00	0.00	0.000	0.000	
Zone 4 xx	Bot.	D4	146.82	208.04	60.94	62.00	0.983	0.706	
Zone 5 xx	Top	DC1	0.00	0.00	0.00	0.00	0.000	0.000	
Zone 5 xx	Bot.	DC1	0.00	201.36	59.53	60.00	0.992	0.000	

Shear

Factor ϕ	:	0.75
Shear area (plane zz)	:	9.16 [m2]
Shear area (plane xx)	:	13.50 [m2]

Plane	Condition	Vu [Ton]	Vc [Ton]	Vu/(ϕ*Vn)	
xy	D2	80.33	1200.56	0.089	
yz	D4	254.02	814.49	0.416	

Punching shear

Factor ϕ	:	0.75
Perimeter of critical section (b...	:	13.63 [m]
Punching shear area	:	12.38 [m2]
Perimeter of critical section (b...	:	13.63 [m]
Punching shear area	:	12.38 [m2]

Column	Condition	Vu [Ton]	Vc [Ton]	Vu/(ϕ*Vn)	
column 1	D4	-381.46	2200.30	0.231	
column 2	D4	578.24	2200.30	0.350	

Notes

* Soil under the footing is considered elastic and homogeneous. A linear soil pressure variation is assumed.

* The required flexural reinforcement considers at least the minimum reinforcement

* The design bending moment is calculated at the critical sections located at the support faces

* Only rectangular footings with uniform sections and rectangular columns are considered.

* The nominal shear strength is calculated in critical sections located at a distance d from the support face

* The punching shear strength is calculated in a perimetral section located at a distance d/2 from the support faces

* Transverse reinforcement is not considered in footings

* Values shown in red are not in compliance with a provision of the code

*qef = Initial effective stress at foundation level prior to loading.

*qu = Meyerhof, Hansen or Vesic ultimate soil bearing capacity.

*qnmax = Maximum pressure at foundation base. qnmax=qmax-qef

SF (bearing) = Safety factor for bearing capacity, SF= (qu-qef)/qnmax

SF (sliding) = Safety factor for sliding

*Δmax = maximum total settlement (considering an elastic soil modeled by the subgrade reaction modulus).

* Mn = Nominal moment strength.

* Mu/(ϕ*Mn) = Strength ratio.

* Vn = Nominal shear or punchure force (for footings Vn=Vc).

* Vu/(ϕ*Vn) = Shear or punching shear strength ratio.

7. Conclusión y recomendación.

Esta investigación preliminar plantea solucionar los problemas de falta de información sobre el tema. Haciendo de este documento un material de consulta para el diseño de un edificio de varios niveles de acero con arriostres concéntricos especiales.

Se pretende Aclarar todas las dudas y desconocimientos de los ingenieros que se dedican al diseño de estructuras.

Los marcos especiales con arriostres concéntrico tiene la capacidad de disipar energía inelástica y concentrar los daños provocados durante un sismo de máxima intensidad en los arriostres. Estos posteriormente podrían ser remplazados sin comprometer la integridad de las columnas ni las vigas y proteger las vidas de las personas que se encuentren dentro del edificio.

Actualmente hay pocos edificios altos en Nicaragua, en su mayoría no sobre pasan los 10 niveles esto debido al miedo del inversionista de construir en una zona de alta sismicidad y la falta de ingenieros capacitados en la materia de edificios diseñados símicamente.

Se recomienda consultar este documento ya que está considerando los últimos códigos existentes a la fecha, y contiene las modificaciones realizadas al AISC-360 y AISC- 34.

No se pretende abordar los diseños de columnas, vigas, fundaciones y conexiones de los elementos del edificio que no formen parte del sistema SCBF.

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9. Cronograma.

Tema/avance	Febrero	marzo	Abril	mayo	junio
Introducción Primer capitulo					
Segundo capitulo Tercer capitulo					
Cuarto capitulo					
Quinto capitulo					
Sexto capítulo y Séptimo capitulo					