NCSEA
National Council of Structural Engineers Associations

STRUCTURAL ENGINEERING SUMMIT

SEISMIC PROVISIONS COMMITTEE

ASCE 7-16 IRREGULARITY GUIDE

ASCE 7-16 Irregularity Guide

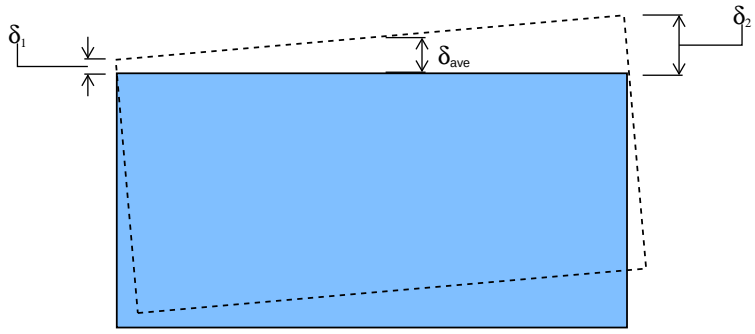
Horizontal Irregularity, Type 1a/1b
Torsional Irregularity

Definition (Table 12.3-1):

1a. Torsional irregularity is defined to exist where the maximum story drift, computed including accidental torsion with , at one end of the structure transverse to an axis is more than 1.2 times the average of the story drifts at the two ends of the structure. Torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.

1b. Extreme torsional irregularity is defined to exist where the maximum story drift, computed including accidental torsion with , at one end of the structure transverse to an axis is more than 1.4 times the average of the story drifts at the two ends of the structure. Extreme torsional irregularity requirements in the reference sections apply only to structures in which the diaphragms are rigid or semirigid.

Graphical Example & Summary



$\delta_{max} = \max(\delta_1, \delta_2)$
$\delta_{ave} = \text{average}(\delta_1, \delta_2)$

No Irregularity: $\delta_{max} < 1.2\delta_{avg}$
Irregularity (1a): $1.2\delta_{avg} \le \delta_{max} \le 1.4\delta_{avg}$
Extreme Irregularity (1b): $\delta_{max} > 1.4\delta_{avg}$

Implications:

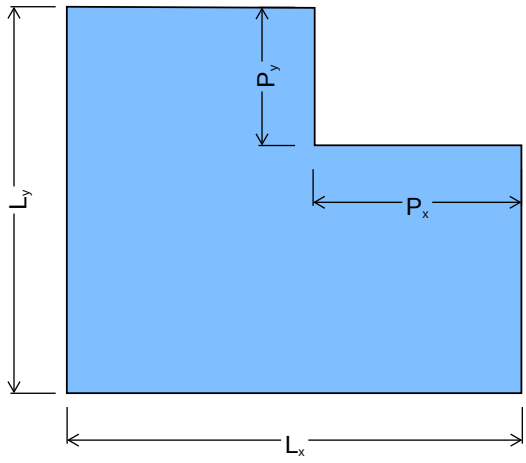
Applicable SDC	Structural Requirements	ASCE Section
B, C, D, E, F	3D Structural model required	12.7.3
B, C, D, E, F	Torsion: Accidental eccentricity required	16.3.4
C, D, E, F	Amplification of accidental torsion	12.8.4.3
C, D, E, F	Story Drift: Largest difference in deflection of vertically aligned points	12.12.1 & 12.8.6
D, E, F	Permitted Analytical Procedure	Table 12.6-1
D, E, F	25% Increase in seismic forces for collectors and connections of diaphragm to vertical elements	12.3.3.4
E, F	For Type 1b (extreme) - Structure prohibited	12.3.3.1

Horizontal Irregularity, Type 2
Reentrant Corner Irregularity

Definition (Table 12.3-1):

Reentrant corner irregularity is defined to exist where both plan projections of the structure beyond a reentrant corner are greater than 15% of the plan dimension of the structure in the given direction.

Graphical Example & Summary



Largest notch on diaphragm
$P_y > 0.15L_y$ AND $P_x > 0.15L_x$

Implications:

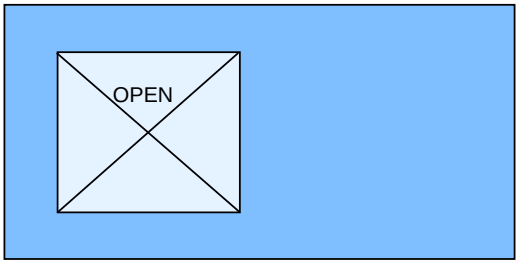
Applicable SDC	Structural Requirements	ASCE Section
D, E, F	25% Increase in seismic forces for collectors and connections of diaphragm to vertical elements	12.3.3.4
D, E, F	Permitted Analytical Procedure	Table 12.6-1

Horizontal Irregularity, Type 3
Diaphragm Discontinuity Irregularity

Definition (Table 12.3-1):

Diaphragm discontinuity irregularity is defined to exist where there is a diaphragm with an abrupt discontinuity or variation in stiffness, including one that has a cutout or open area greater than 50% of the gross enclosed diaphragm area, or a change in effective diaphragm stiffness of more than 50% from one story to the next.

Graphical Example & Summary



Opening in Diaprhragm

a) Cutout, open > 50% gross area, or
b) Changes in effective diaphragm stiffness >50% from one story to next.

Implications:

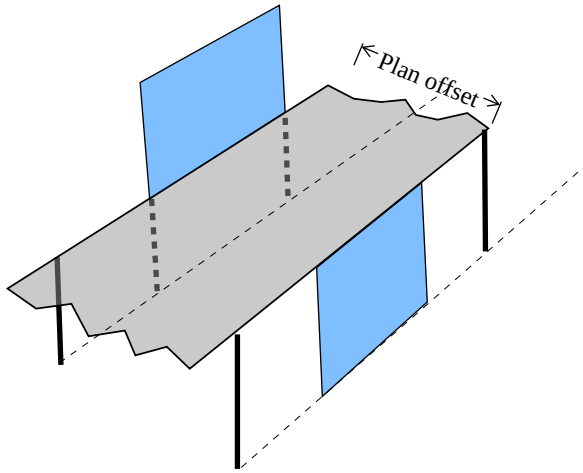
Applicable SDC	Structural Requirements	ASCE Section
D, E, F	25% Increase in seismic forces for collectors and connections of diaphragm to vertical elements	12.3.3.4
D, E, F	Permitted Analytical Procedure	Table 12.6-1

Horizontal Irregularity, Type 4
Out-of-Plane Offset Irregularity

Definition (Table 12.3-1):

Out-of-plane offset irregularity is defined to exist where there is a discontinuity in a lateral force-resistance path, such as an out-of-plane offset of at least one of the vertical elements.

Graphical Example & Summary



Horizontal discontinuities in a lateral force-resistance path by offsets of the vertical elements perpendicular to the axis of the vertical element.

Implications:

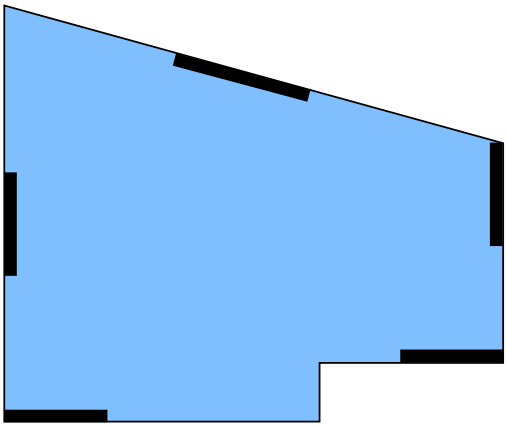
Applicable SDC	Structural Requirements	ASCE Section
B, C, D, E, F	Amplified axial using load combinations with over-strength for elements supporting discontinuous vertical elements	12.3.3.3
B, C, D, E, F	3D Structural model required	12.7.3
B, C, D, E, F	Torsion: Accidental eccentricity required	16.3.4
D, E, F	25% Increase in seismic forces for collectors and connections of diaphragm to vertical elements	12.3.3.4
D, E, F	Permitted Analytical Procedure	Table 12.6-1

Horizontal Irregularity, Type 5
Non-Parallel System Irregularity

Definition (Table 12.3-1):

Nonparallel system irregularity is defined to exist where vertical lateral force-resisting elements are not parallel to the major orthogonal axes of the seismic force-resisting system.

Graphical Example & Summary



Vertical lateral force-resisting elements not parallel to or symmetric about the major orthogonal (x, y) axes.

Implications:

Applicable SDC	Structural Requirements	ASCE Section
B, C, D, E, F	3D Structural model required	12.7.3
B, C, D, E, F	Torsion: Accidental eccentricity required	16.3.4
C, D, E, F	Orthogonal load combination required	12.5.3
D, E, F	Permitted Analytical Procedure	Table 12.6-1

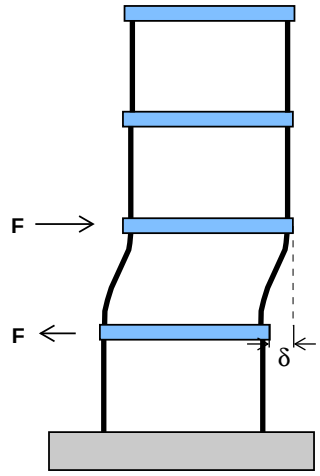
Vertical Irregularity, Type 1a/1b
Soft story irregularity

Definition (Table 12.3-2):

1a) Stiffness–Soft Story Irregularity: Stiffness–soft story irregularity is defined to exist where there is a story in which the lateral stiffness is less than 70% of that in the story above or less than 80% of the average stiffness of the three stories above.

1b) Stiffness–Extreme Soft Story Irregularity: Stiffness–extreme soft story irregularity is defined to exist where there is a story in which the lateral stiffness is less than 60% of that in the story above or less than 70% of the average stiffness of the three stories above.

Graphical Example & Summary



Lateral Story Stiffness (k)
$k = F/\delta$

1a) Lateral stiffness <70% story above or <80% average stiffness of 3 stories above

1b) Lateral stiffness <60% story above or <70% average stiffness of 3 stories above

Implications:

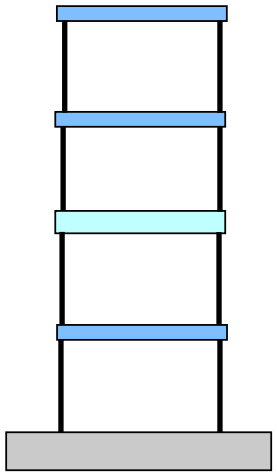
Applicable SDC	Structural Requirements	ASCE Section
D, E, F	Permitted Analytical Procedure	Table 12.6-1
E, F	Extreme (1b) irregularity structural configurations prohibited	

Vertical Irregularity, Type 2
Mass Irregularity

Definition (Table 12.3-2):

Weight (mass) irregularity is defined to exist where the effective mass of any story is more than 150% of the effective mass of an adjacent story. A roof that is lighter than the floor below need not be considered.

Graphical Example & Summary



Mass of any story >150% of mass of an adjacent story.

Exception: Roof lighter than floor below

Implications:

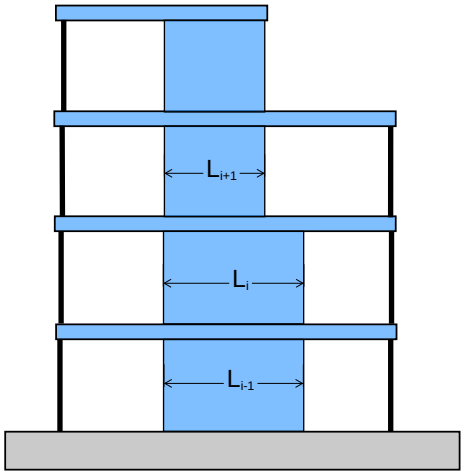
Applicable SDC	Structural Requirements	ASCE Section
D, E, F	Permitted Analytical Procedure	Table 12.6-1

Vertical Irregularity, Type 3
Geometric Irregularity

Definition (Table 12.3-2):

Vertical geometric irregularity is defined to exist where the horizontal dimension of the seismic force-resisting system in any story is more than 130% of that in an adjacent story.

Graphical Example & Summary



Checking each level, horizontal dimension of the seismic force–resisting system >130% of adjacent story.

$L_i > 1.3 * L_i/L_{i+1}$ or
$L_i > 1.3 * L_i/L_{i-1}$

Implications:

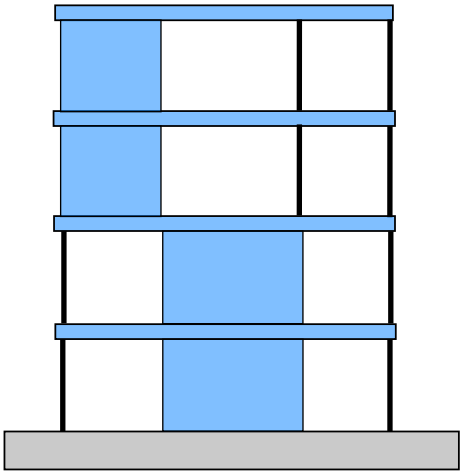
Applicable SDC	Structural Requirements	ASCE Section
D, E, F	Permitted Analytical Procedure	Table 12.6-1

Vertical Irregularity, Type 4
In-Plane Discontinuity in Vertical LFRS Irregularity

Definition (Table 12.3-2):

In-plane discontinuity in vertical lateral force-resisting element irregularity is defined to exist where there is an in-plane offset of a vertical seismic force-resisting element resulting in overturning demands on supporting structural elements.

Graphical Example & Summary



In-plane offset of lateral force-resisting elements resulting in overturning loads being supported by a different element (i.e. column, transfer beam) below.

Implications:

Applicable SDC	Structural Requirements	ASCE Section
B, C, D, E, F	Amplified axial using load combinations with over-strength for elements supporting discontinuous vertical elements	12.3.3.3
D, E, F	Permitted Analytical Procedure	Table 12.6-1
D, E, F	25% Increase in seismic forces for collectors and connections of diaphragm to vertical elements	12.3.3.4

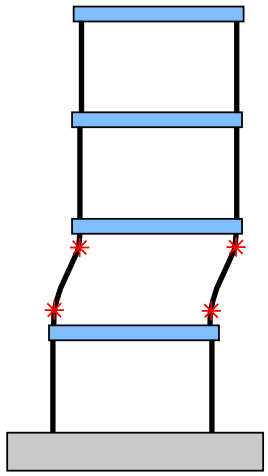
Vertical Irregularity, Type 5
In-Plane Discontinuity in Vertical LFRS Irregularity

Definition (Table 12.3-2):

5a) Discontinuity in Lateral Strength–Weak Story Irregularity: Discontinuity in lateral strength–weak story irregularity is defined to exist where the story lateral strength is less than 80% of that in the story above. The story lateral strength is the total lateral strength of all seismic-resisting elements sharing the story shear for the direction under consideration.

5b) Discontinuity in Lateral Strength–Extreme Weak Story Irregularity: Discontinuity in lateral strength–extreme weak story irregularity is defined to exist where the story lateral strength is less than 65% of that in the story above. The story strength is the total strength of all seismic-resisting elements sharing the story shear for the direction under consideration.

Graphical Example & Summary



Irregularity occurs where story lateral strength < 80% story above.

Extreme irregularity occurs where story lateral strength < 65% story above.

Implications:

Applicable SDC	Structural Requirements	ASCE Section
B, C, D, E, F	Extreme (5b) Weak Story: Cannot exceed 2 stories or 30ft unless the weak story can resist the seismic forces multiplied by omega	12.3.3.2
D, E, F	Permitted Analytical Procedure	Table 12.6-1
D, E, F	Extreme (5b) weak story irregularity structural configurations prohibited	12.3.3.1
E, F	Weak Story irregularity (5a/5b) structural configurations prohibited	12.3.3.1

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