ICC EVALUATION SERVICE®

ICC-ES Evaluation Report

ESR-4769

Reissued May 2024

Subject to renewal May 2026

This report also contains:

- CBC Supplement

- LABC Supplement

DIVISION: 05 00 00—METALS Section: 05 12 00—Structural Steel Framing	REPORT HOLDER: TAYLOR DEVICES INC.	EVALUATION SUBJECT: TAYLOR DAMPED MOMENT FRAME SYSTEM (TDMF™)	

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021 and 2018 *International Building Code® (IBC)*

For evaluation for compliance with codes adopted by the *Los Angeles Department of Building and Safety (LADBS)*, see ESR-4769 LABC Supplement.

For evaluation for compliance with codes adopted by the California Office of Statewide Health Planning and Development (OSHPD) AKA: California Department of Health Care Access and Information (HCAI) and the Division of State Architects (DSA), see ESR-4769 CBC Supplement.

Property evaluated:

- Structural

2.0 USES

The Taylor Damped Moment Frame System (TDMF™) is used as the main lateral force-resisting system in building structures to resist seismic loads.

3.0 DESCRIPTION

3.1 General:

The Taylor Damped Moment Frame System (TDMF™) consists of a combination of steel special moment frames (SMFs) and supplemental damper frames (DFs) utilizing Taylor Dampers (TDs) (fluid viscous dampers). The SMFs act as the primary lateral load resisting system to resist seismic loads, while the DF dissipates seismic energy and reduces the overall response of the structure.

The DF is designed separately from the SMF, although the two systems may have common elements. There are three types of SMF and DF configurations for the TDMF system, illustrated in Figure 1. In a Type I system, the SMF and DF are located in separate bays and there are no common elements. In a Type II system, the DF is located within the same bay as the SMF. In a Type III system, the SMF and DF are in adjacent bays and share some common elements. Elements common to the DF and SMF are designed for combined demands from the two systems. The DF need not be located along the same line of resistance as the SMFs, as shown in Figure 2. Buildings utilizing the TDMF system may include any combination of Type I, Type II and Type III.

Taylor Dampers are arranged in Diagonal, Chevron, V-type, or Two-story X configurations as shown in Figure 3, where dampers are in-line with the inclined extender braces between work points within a DF, or in modified Chevron or V-type configurations as shown in Figure 4, where dampers are placed horizontally within a DF.

The Taylor Damped Moment Frame System (TDMF™) is evaluated as an alternative structural system in accordance with Section 12.2.1.1 of ASCE/SEI 7 and ICC-ES AC494 Annex C. The design procedure allows the use of Chapter 12 of ASCE/SEI 7 in lieu of Chapter 18.

3.2 Materials:

3.2.1 Damper Frames (DF): Damper frames are beam-column frames and extender braces, as applicable, comprised of structural steel shapes, plates, bolts and welds, with Taylor Dampers (TD) and corresponding hardware.

Structural steel shapes, plates, connectors and welds of beams, columns, extender braces, as applicable, and beam-column joints of the DF must comply with the material and member requirements of AISC 341 for moderately ductile members.

3.2.1.1 Taylor Dampers (TD): TDs are proprietary damping devices that are comprised of the following components, shown numbered in Figure 5, with responsible party in the design indicated.

1. **Piston Rod:** The piston rod is solid 17-4 PH stainless steel, billet machined and through hardened, complying with AMS 5643 or AMS 5659, as applicable.
2. **Piston Head:** The piston head is solid steel construction, billet machined, complying with ASTM A322 or ASTM A108, as applicable, and is typically heat treated 4140 alloy steel. The piston head contains fluid flow channels that provide the orificing for the damping function ($F=CV^{\alpha}$).
3. **Seals/Seal Bearings:** Dynamic seals and seal bearings are manufactured from acetyl resin and virgin Teflon.
4. **Fluid:** Nonflammable and noncombustible silicone fluid complying with Federal Standard VV-D-1078, Sections 4.5.2 Table 3 and 4.5.3.
5. **Cylinder:** The cylinder is heat-treated alloy steel, machined from pierced billet or solid, complying with ASTM A108, ASTM A322, ASTM A519 or ASTM A513, as applicable. The cylinder is painted to protect against corrosion.
6. **End Cap:** The end cap is heat-treated alloy steel, billet machined, complying with ASTM A108 or ASTM A322, as applicable. The end cap is painted to protect against corrosion.
7. **Integral Extender:** The integral extender is carbon steel, machined from wrought billet, tube or pipe, or heat-treated alloy steel and is painted to protect against corrosion. Steels comply with ASTM A519, ASTM A500, ASTM A513, ASTM A108, ASTM A106, ASTM A1085, ASTM A252, CSA G40, AMS 5659, AMS 5629, or ASTM A511, as applicable.
8. **(A) End Clevis:** The end clevis is heat-treated alloy steel, complying with ASTM A322, ASTM A108 or ASTM A829, as applicable, painted for protection against corrosion.

   (B) Base Plate: The base plate is carbon or heat-treated alloy steel, machined from plate, surface ground, complying with ASTM A36, AMS 5604, ASTM A240, ASTM A829, ASTM A572, as applicable, and painted for protection against corrosion.
9. **Spherical Bearing:** Spherical bearings are forged alloy steel or stainless steel.
10. **(A) Outer Sleeve (when included):** Outer sleeves are carbon steel, complying with ASTM A513 or ASTM A519 as applicable, painted for protection against corrosion.

    (B) Bellows: Bellows are nylon reinforced, neoprene rubber boot.
11. **Mounting Pin:** The mounting pin is solid 17-4PH precipitation hardening stainless steel, billet machined, through hardened to condition H-925 complying with AMS 5643 or AMS 5659, as applicable.

    Components designed by the Registered Design Professional (RDP), such as the non-integral extender, end clevis and gusset plates, must comply with Chapter A3 of AISC 341.

3.2.2 Steel Special Moment Frames (SMFs): Steel special moment frames are comprised of structural steel shapes, plates, connectors and welds as required per the design provisions of AISC 341 and AISC 358.

4.0 DESIGN AND INSTALLATION

4.1 Seismic Force Resisting System Requirements:

Taylor Damped Moment Frame System (TDMF™) must be designed and detailed in accordance with the structural *Design Procedure* contained in Annex A of this evaluation report and are subject to the limitations therein. For determining seismic loads, the system seismic performance coefficients and factors for the IBC are permitted to be as follows:

SEISMIC SYSTEM*	RESPONSE MODIFICATION COEFFICIENT, R	OVERSTRENGTH FACTOR, Ω_0	DEFLECTION AMPLIFICATION FACTOR, C_d
SMF	8	3	4.5
DF	N/A	See Annex A	N/A

*Seismic force–resisting system as defined in ASCE/SEI 7, Table 12.2-1, must conform to limitations in IBC and ASCE/SEI 7, including provisions for structural system limitations including structural height noted in Table 12.2-1 of ASCE/SEI 7.

The design procedure is limited to buildings in which each of the following conditions are satisfied:

a) Floor diaphragms must not be considered flexible as defined by ASCE/SEI 7 Section 12.3.1.1 or 12.3.1.3.

b) Buildings must not have horizontal irregularity Type 1b, extreme torsional irregularity, as defined in ASCE/SEI 7 Table 12.3-1.

c) In each principal direction, the damping system must have at least two damping devices in each story above the base, configured to resist torsion.

d) A height limit of 300 ft.

DF members are designed to resist forces generated by the fluid viscous damper overstrength forces as required in Annex A. When DFs include common elements with SMFs, yielding is permitted in certain shared elements of the DF and SMF, as stipulated in AISC 342 for SMF systems, provided that such behavior does not affect DF function.

Beams, columns, and beam-column connections of both SMFs and DFs, and extender braces and connections of the DF, shall be designed to meet the requirements of Chapters 11, 12, and 14 of ASCE/SEI 7, and AISC 360, AISC 341 and AISC 358, as modified by the design requirements in Annex A. This includes but is not limited to member and connection bracing and stiffening, and the definition of protected zones.

Design drift shall satisfy the requirements of Section 12.12 of ASCE/SEI 7.

Welding must comply with the American Welding Society Structural Welding Code—Steel (ANSI/AWS D1.1), Section 2, with modifications as set forth in AISC 360 Section J2.

4.2 Gravity Load Framing Requirements:

Gravity load framing must comply with the requirements of the applicable design standards including ASCE/SEI 7, AISC 360, AISC 341 and the IBC.

Welding must comply with the American Welding Society Structural Welding Code—Steel (ANSI/AWS D1.1), Section 2, with modifications as set forth in AISC 360 Section J2.

4.3 Nonstructural Seismic Design Requirements: The requirements of the IBC and Chapter 13 of ASCE 7/SEI shall be satisfied without modifications.

4.4 Testing and Quality Assurance: All Taylor Dampers must be tested in accordance with Section 12 of the Annex A *Design Procedure*. A sample of Taylor Damper designs, which are subject to testing, is shown on Figure 6.

4.5 Installation: Field installation and adjustments of the Taylor Dampers within the Damper Frame shall be in accordance with the Manufacturer's Printed Installation Instructions for the Pin-Pin Style (Clevis-Clevis) Damper and the Clevis-Base Style Damper.

4.6 Special Inspections:

Special inspections, testing and structural observations are required in accordance with Chapter 17 of the IBC; Chapter N of AISC 360 and Chapter J of AISC 341 for the 2021 and 2018 IBC; applicable portions of AISC 303-16 and Clause 7 of AWS D1.8-2016 for the 2021 and 2018 IBC, and must be specified by a registered design professional, unless the structure qualifies under the exceptions in Section 1704.2 of the 2021 and 2018 IBC and subjected to approval of the code official. When special inspections are required, the inspections must be included in the statement of special inspections prepared by the registered design professional for submittal to the code official.

5.0 CONDITIONS OF USE:

The Taylor Damped Moment Frame System (TDMF™) described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 The Taylor Damped Moment Frame System (TDMF™) design, including structural notes and details, must be in accordance with this report and the applicable code, and must be prepared by a registered design professional and subjected to approval of the authority having jurisdiction.

5.2 Structural design drawings and specifications must comply with Section A4 of AISC 341 under the 2021 and 2018 IBC.

5.3 Installations must be in accordance with Section 4.5 of this report and the approved construction documents, as prepared by a registered design professional and approved by the code official.

5.4 Quality Assurance and special inspections must be in accordance with Sections 4.4 and 4.6 respectively, of this report and the approved construction documents.

5.5 Reduction of wind response due to damper energy dissipation is possible but is outside the scope of this report and may be addressed by a project-specific design prepared by a registered design professional and subject to approval by the code official.

5.6 The Taylor Dampers are manufactured under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Qualification of Building Seismic Performance of Alternative Seismic Force-Resisting Systems (ICC-ES Guidance Document to FEMA P-695) including Annex C Steel Moment Frames with Supplemental Viscous Damper Frames (AC494), Approved February 2022.

The acceptable values of Adjusted Collapse Margin Ratio (ACMR), that were used to evaluate conformance to collapse prevention objectives, of Section 7.5 of FEMA P695 with a total system collapse uncertainty of $\beta_{TOT} = 0.5$ are $ACMR_{10\%} \geq 1.9$ and $ACMR_{20\%} \geq 1.52$.

7.0 IDENTIFICATION

7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4769) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.

7.2 In addition, the Taylor Dampers, part of the Taylor Damped Moment Frame System (TDMF™) are labeled with a part number, serial number and manufacturing date.

7.3 The report holder's contact information is the following:

TAYLOR DEVICES INC.
90 TAYLOR DRIVE
NORTH TONAWANDA, NEW YORK 14120
(716) 964-0800
www.taylordevices.com

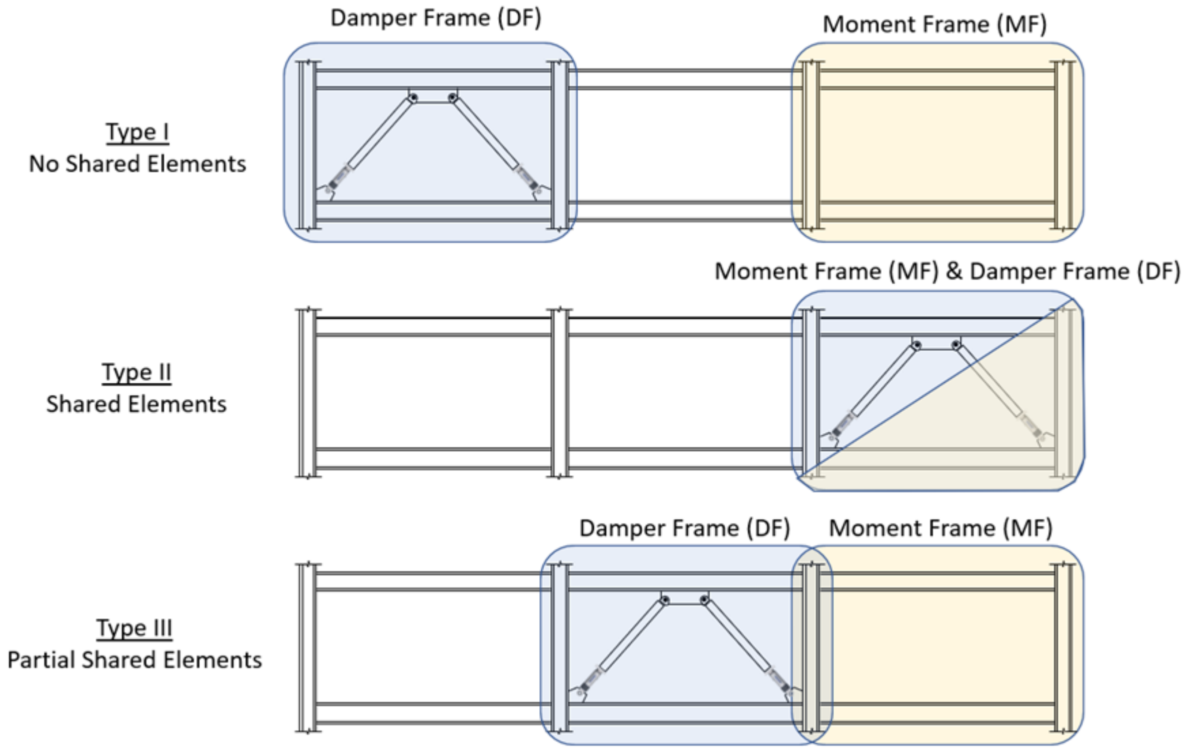


FIGURE 1—SMF AND DF CONFIGURATIONS

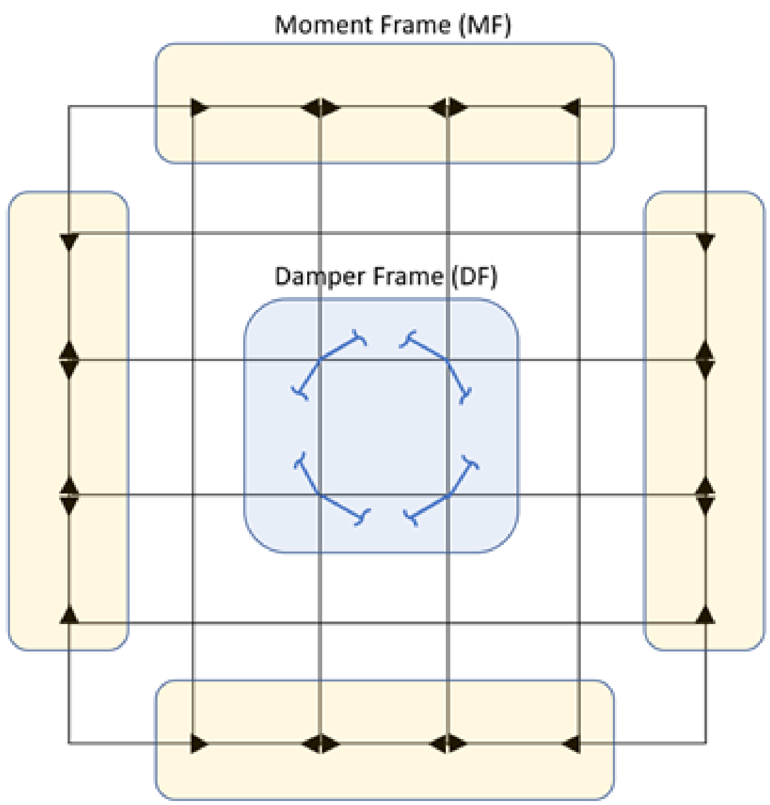
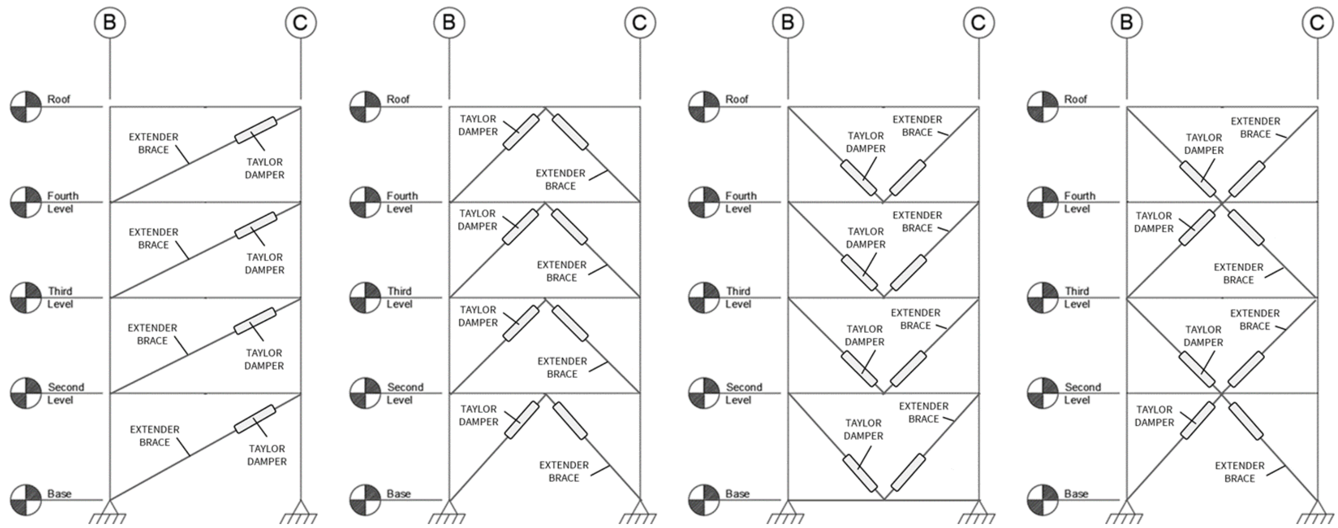
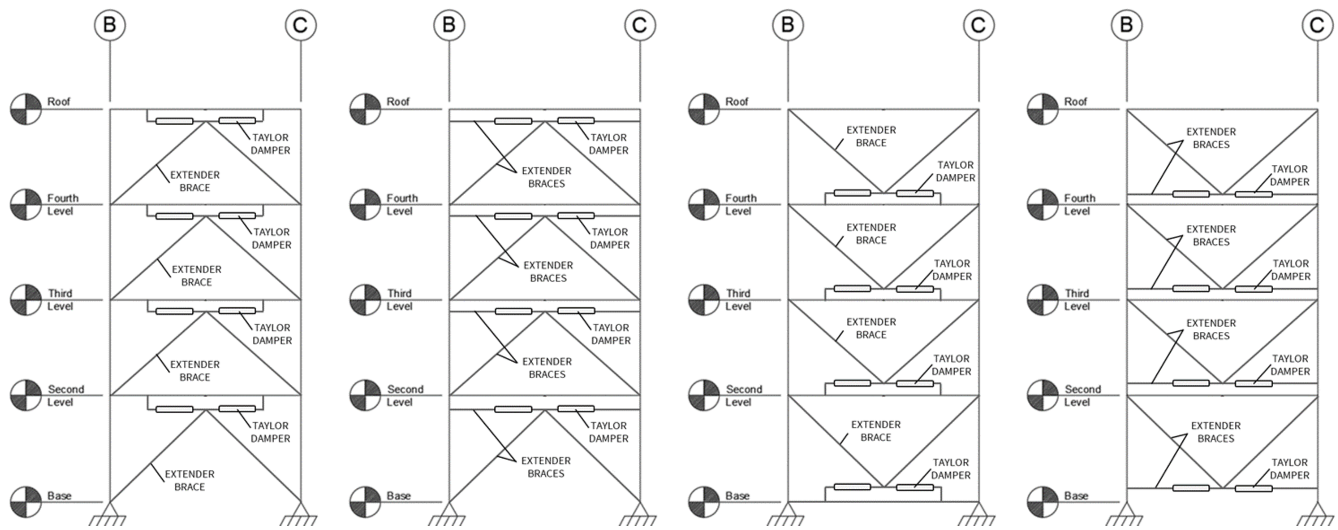


FIGURE 2—PLAN VIEW – TYPE 1 – PARALLEL OFFSET



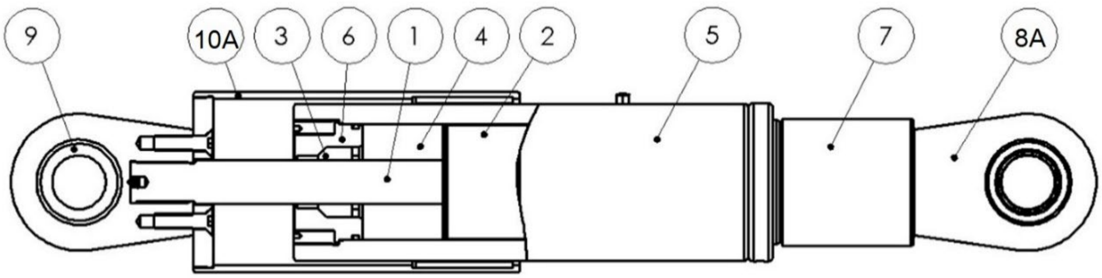
Diagonal Chevron V-Type 2-story X-Type

FIGURE 3—COMMON DF SYSTEM CONFIGURATIONS

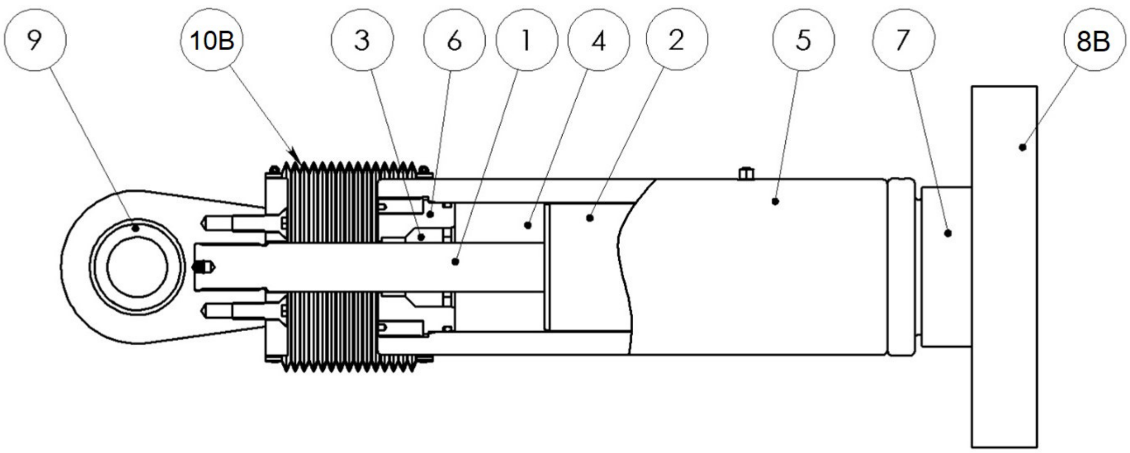


Beam Connected Chevron
Column Connected Chevron
Beam Connected V-Type
Column Connected V-Type

FIGURE 4—MODIFIED CHEVRON WITH HORIZONTAL DAMPERS DF CONFIGURATION



TYPICAL FLUID VISCOUS DAMPER WITH CLEVIS-CLEVIS ARRANGEMENT



TYPICAL FLUID VISCOUS DAMPER WITH CLEVIS-BASE PLATE ARRANGEMENT

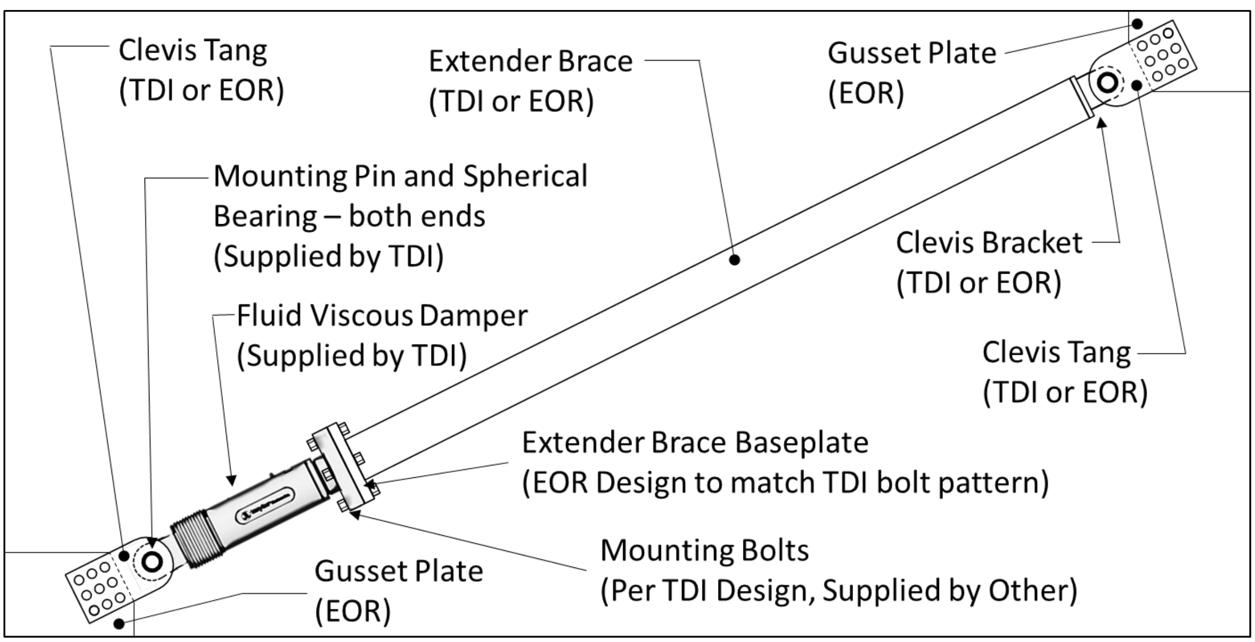
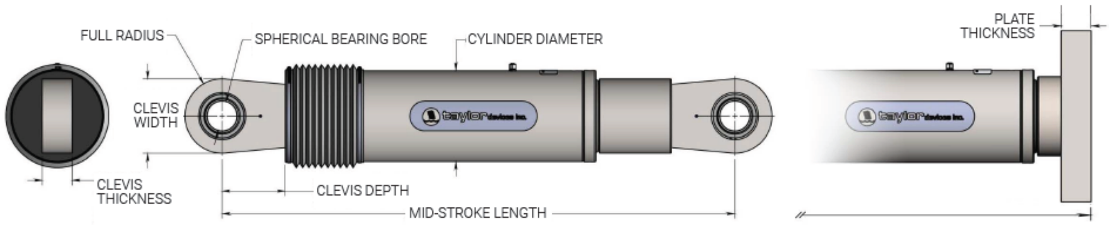


FIGURE 5—TAYLOR DAMPER COMPONENT REFERENCES (SEE SECTION 3.2.1.1) AND RESPONSIBLE DESIGN PARTY

taylor devices inc.

FLUID VISCOUS DAMPERS DIMENSIONS

CLEVIS END CONDITION **BASE PLATE END CONDITION**



RATED DAMPER FORCE (Kips)	TAYLOR DEVICES MODEL NUMBER	MAXIMUM CYLINDER DIAMETER (IN)	MAXIMUM CLEVIS WIDTH (IN)	CLEVIS DEPTH (IN)	CLEVIS THICKNESS (IN)	SPHERICAL BEARING BORE (IN)
55	17120	4 1/2	4	3.25	1.67	1.50
110	17130	5 3/4	5	4.00	2.16	2.00
165	17140	7 1/4	6	5.10	2.31	2.25
220	17150	8 1/4	7 1/4	5.88	2.78	2.75
330	17160	9 1/2	8	6.38	3.03	3.00
440	17170	11 1/4	9 1/4	7.50	3.56	3.50
575	20860	12 3/4	10 1/4	7.50	4.40	4.00
750	17180	13 3/4	11 1/4	8.25	4.60	4.00
975	17190	16 3/4	12 3/4	8.25	5.56	5.00
1350	17200	20 1/4	13 3/4	12.00	6.00	6.00
1800	17210	22 1/4	16 1/4	13.50	7.00	7.00

Suggested C Values for TDMF Applications, kip-(sec/in)$^{\alpha}$

1,316	1,144	995	865	752	654	569	495	430	374	325	283	246	214	186	162	141	123	107	93	81	70	61	53	46	40	35	30	26	23

NOTES:
1. The Rated Damper Force corresponds to the MCE level demands per the TDMF design procedure.
2. Dampers are available for any stroke capacity, manufactured with integer values in ±1" increments. Each damper type has a minimum provided stroke of ±3". Damper weight and mid-stroke length are dependent upon the required stroke, so consult Taylor Devices for exact quantities on specific applications.

MADE IN USA

FIGURE 6—EXAMPLE OF TAYLOR DAMPER DESIGNS

Annex A: Design Procedure

1. NOTATIONS

A_1 = amplification factor for first story yielding

A_g = gross area

A_v = velocity amplification factor for higher modes and yielding

BF = base shear correction factor—removes the effect of the base shear scaling from the DE damper displacement

C_d = deflection amplification factor, ASCE/SEI 7

$C_{ji(L)}$ = linear damper constant computed for the j^{th} damper in the i^{th} story

$C_{ji(NL)}$ = required nonlinear damper constant computed for the j^{th} damper in the i^{th} story

$C_{ji(NL)spec}$ = specified nonlinear damping constant for the j^{th} damper in the i^{th} story

$C_{s,d}$ = minimum base shear for drift checks

CD_i = center of damping location in the i^{th} story

$CF1_{ji}$ = column axial load reduction factor, option 1

$CF2_{ji}$ = column axial load reduction factor, option 2

DE = design earthquake (2/3 of MCE_R)

DF = damper frame

d, d_{ji} = DE level damper displacement measured from the maximum displacement stage analysis

d_M = MCE_R device displacement

d_T = the maximum total stroke requirement for the damper under design loads for the 50-year mean return interval (MRI) wind event, which is defined in Figure CC 2-3 of ASCE/SEI 7 Commentary to Appendix C

d_w = displacement amplitude for wind testing

E = seismic load effect, ASCE/SEI 7; or modulus of elasticity

E_h = effect of horizontal seismic load, ASCE/SEI 7

E_{loop} = area of damper hysteresis loop (i.e., energy dissipation)

E_v = effect of vertical seismic load, ASCE/SEI 7

ELF = equivalent lateral force procedure, ASCE/SEI 7

ESR = evaluation service report

$e_{TD,i}$ = damping eccentricity, defined as the distance between center of mass and center of damping (CD_i) in the direction of interest

F_{ji} = Overstrength TD force in the j^{th} damper in i^{th} story

f_{ji} = design force in the j^{th} damper in the i^{th} story

$f_{MCE}, f_{MCE,ji}$ = MCE_R damper force

f = frequency in cycles per second

f_1 = fundamental frequency of the structure in cycles per second in direction of analysis.

$h_{s,i}$ = story height of story i

I_e = Importance factor, ASCE/SEI 7

K_E = extender brace stiffness

$K_{EM,ji}$ = minimum extender brace stiffness for the j^{th} damper extender brace in the i^{th} story

K_{SM} = minimum allowable DF bay stiffness

k_i = linear stiffness of the i^{th} story in the principal direction of interest

L = plan dimension perpendicular to the direction of interest; or pin-to-pin length of the damper and brace assembly

MCE_R = risk targeted maximum consider earthquake, ASCE/SEI 7

MRSA = modal response spectrum analysis

M_{ta} = accidental torsion moment, ASCE/SEI 7

$M_{ta,TDMF}$ = modified accidental torsion moment, with added torsion due to damping eccentricity

n = number of dampers in a DF bay; or number of cycles for windstorm testing

n_{ai} = number of consecutive columns taking damper forces above story *i* of interest

$n_{local,ai}$ = number of consecutive columns taking damper forces above story *i* of interest for which $CF2_{ji}$ is computed

n_i = number of dampers in story *i*

n_s = number of above grade TDMF™ stories

$P_{ETD,ji}$ = reduced damper-induced column axial load for the *j*th column in the *i*th story

$P_{ETD1,ji}$ = reduced damper-induced column axial load for the *j*th column in the *i*th story, option 1

$P_{ETD2,ji}$ = reduced damper-induced column axial load for the *j*th column in the *i*th story, option 2

P_{ji} = damper-induced column axial load at story *i* and column line *j,* from simultaneous application of maximum forces considering damper overstrength at all stories above

$P_{local,ji}$ = local damper-induced column axial load considering damper overstrength acting at story *i* and column line *j*

P_n = nominal axial strength

Q_{MD} = maximum displacement stage load effect

Q_{TD} = maximum velocity stage load effect, i.e., from design earthquake TD forces

R = response modification coefficient, ASCE/SEI 7

R_v = factor for determining the upper bound value of the damping constant

RDP = registered design professional

$r_{TD,i}$ = radius of gyration of damping at story i in the direction of interest

S_1 = mapped MCE_R, 5% damped, spectral response acceleration parameter at a period of 1 second, ASCE/SEI 7

S_{D1} = design, 5% damped, spectral response acceleration parameter at a period of 1 second, ASCE/SEI 7

SMF = steel special moment frame

$s_{req,ji}$ = minimum required damper stroke capacity

T_1 = fundamental translational period in the principal direction of interest

TD = Taylor Damper

TDMF™ = The Taylor Damped Moment Frame system

$V_{MD,i}$ = earthquake story shear in story i for the maximum displacement stage analysis for strength design

$V_{TD,i}$ = damping system story shear at story *i*, based on the design earthquake TD load effect from maximum velocity stage analysis

V_i = seismic shear force acting between levels *i* and *i* − 1 based on the ELF

V_t = modal base shear, ASCE/SEI 7 section 12.9.1.4.2

v_{ji} = damper velocity of the *j*th damper in the *i*th story for computing the target nonlinear damping constant

v^*, v^*_{ji} = DE damper velocity for computing the design earthquake TD force

v_M = MCE_R device velocity

W = effective seismic weight of building, ASCE/SEI 7

x_{ji} = horizontal location of the *j*th damper in the *i*th story measured perpendicular to the direction of interest

α = velocity exponent, 0.4

β_v = target viscous damping ratio, 0.25

Δ_i = design story drift between levels *i* and *i* -1 occurring simultaneously with V_i, computed from a static ELF analysis

θ_{ji} = angle of inclination of the *j*th damper in the *i*th story measured from horizontal

θ_{max} = maximum allowable stability coefficient

λ = Parameter computed with equation 4-14 of MCEER report 00-0010, used for determining the nonlinear damping constant based on the linear damping constant. For the TDMF™ system, it is 3.582.

$\lambda_{(max)}$ = factor for maximum design properties of the specified damper

$\lambda_{(min)}$ = factor for minimum design properties of the specified damper ρ = redundancy factor, ASCE/SEI 7

τ_{ji} = ratio of the specified nonlinear damping constant to the required nonlinear damping constant for the j^{th} damper in the i^{th} story

φ_{ji} = angle of DF containing the j^{th} damper on i^{th} story measured from the principal direction (zero degrees when the DF aligns with the principal direction)

ϕ = strength reduction factor for LRFD design

ψ_{ji} = angle of the j^{th} damper on i^{th} story measured from the principal direction of motion under consideration. For DFs aligned with the principal direction, ψ_{ji} is equal to the damper angle of inclination, θ_{ji}

Ω_d = overstrength factor on viscous damper stroke required

Ω_F = overstrength factor for damper forces

Ω_v = overstrength factor on design velocity for determining overstrength damper force demands

ω = angular frequency in radians per second.

2. Basis of Design

This Annex A defines the requirements for design of the Taylor Damped Moment Frame System (TDMF™), consisting of steel special moment frames (SMFs) and damper frames (DFs) utilizing Taylor dampers (fluid viscous dampers) connected to beams and columns of the DF. Eccentricities at the joints in the DF are permitted if the resulting member and connections forces are computed and the members and connections resist those forces as specified in Section 7 of this Annex A and if the eccentricities do not alter either the viscous energy dissipation in the DF or the expected inelastic deformation in the SMF.

The peak displacements and velocities at the risk-targeted maximum consider earthquake (MCE_R) intensity are specified to be 1.5 times the peak displacements and velocities at the design earthquake (DE) intensity.

SMFs act as the primary lateral force resisting system for both wind and seismic excitation. The DF is included to dissipate seismic energy and reduce the overall response of the structure. The DF will also reduce structure oscillation during windstorms, but wind response is not addressed in this ICC-ES evaluation service report; no exception is taken to the requirements of ASCE/SEI 7 for wind load design.

The SMF must be designed in accordance with AISC 341 Section E3.

The DF is designed separately from the SMF, although the two systems may have common elements. There are three types of SMF and DF configurations for the TDMF system, illustrated in Figure 1. In a Type I system, the SMF and DF are located in separate bays and there are no common elements. In a Type II system, the DF is located within the same bay as the SMF. In a Type III system, the SMF and DF are in adjacent bays and share some common elements. Elements common to the DF and SMF are designed for combined demands from the two systems. The DF need not be located along the same line of resistance as the SMFs.

Story numbering in this procedure begins with the first above-grade story of TDMF™ framing. TDMF™ may be constructed over a podium using the two-stage design procedure, as allowed by ASCE/SEI 7, in which case the top of the podium is considered the base of the TDMF™.

The horizontal seismic load effect, E_h, for the TDMF™ system is a combination of the maximum displacement stage load effect (QMD, Section 3) and the maximum velocity stage load effect (QTD, Section 5). Since maximum displacement and maximum velocity are out of phase, Q_{MD} and Q_{TD} are combined using the equations in Section 9. The vertical seismic load effect, E_v, is computed according to ASCE/SEI 7 without exceptions.

3. Maximum Displacement Stage Analysis

The maximum displacement stage load effect, Q_{MD}, is determined with ASCE/SEI 7 Chapter 12, but with some modifications to account for the reduction in seismic response due to the DF. Modifications to ASCE/SEI 7 Chapter 12 are given in this section.

3.1 SMF Analysis

The required strength and stiffness of SMF for the DE must be determined using Modal Response Spectrum Analysis (MRSA) of the SMF, using the 5% damped design spectrum without consideration of the supplemental damping provided by the DF, in accordance with ASCE/SEI 7 Section 12.9.1, except with the following modifications:

a. *Table 12.2-1 – Design Coefficients and Factors for Seismic Force-Resisting Systems:*

For steel special moment frames, deflection amplification factor, C_d, shall be 4.5.

b. *Section 12.3.4 – Redundancy:*

The redundancy factor, *ρ,* shall be 1.0.

c. *Section 12.8.7 P-Delta Effects:*

θ_{max} = 0.25 (Eqn. 12.8-17, modified)

d. Section 12.8.4.2 Accidental Torsion

When the damping eccentricity, $e_{TD,i}$, is greater than 0.02L, the accidental torsion moment calculation shall be modified to include damping eccentricity:

$$M_{ta,TDMF} = 0.05V_{MD,i}L + 0.7e_{TD,i}V_{TD,i}\left(1 - \frac{r_{TD,i}}{L}\right)^2 \qquad \text{(EQ A-3.1)}$$

$V_{MD,i}$ = Earthquake story shear in story i for the maximum displacement stage analysis of this section for strength design

L = Plan dimension perpendicular to the direction of interest

$e_{TD,i}$ = damping eccentricity, defined as the distance between center of mass and center of linear damping (CD_i) in the direction of interest.

$r_{TD,i}$ = radius of gyration of linear damping at story i in the direction of interest.

$V_{TD,i}$ = damping system story shear at story i, based on the design earthquake TD load effect (f_{ji} in Section 5.2) from maximum velocity stage analysis in Section 5.

Where all lines of damping in a given direction have identical configurations and dampers, the center of damping (CD_i) is the average of their locations. Otherwise, CD_i is computed with the following equation:

$$CD_i = \frac{\sum_{j=1}^{n_i} x_{ji}\tau_{ji}C_{ji(L)}cos^2\psi_{ji}}{\sum_{j=1}^{n_i} \tau_{ji}C_{ji(L)}cos^2\psi_{ji}} \qquad \text{(EQ A-3.2)}$$

n_i = number of dampers in story i

x_{ji} = horizontal location of the j^th damper on the i^th story measured perpendicular to the direction of interest.

τ_{ji} = The ratio of the specified nonlinear damping constant to the required nonlinear damping constant for j^th damper on i^th story, defined in Section 4.4.

$C_{ji(L)}$ = Linear Damper Constant computed for j^th damper on i^th story in Section 4.1

ψ_{ji} = angle of the j^th damper on i^th story measured from the principal direction of motion under consideration. For DFs aligned with the principal direction, ψ_{ji} is equal to the damper angle of inclination measured from horizontal (θ_{ji}). For DFs not aligned with the principal direction:

$\psi_{ji} = cos^{-1}(cos\theta_{ji}cos\varphi_{ji})$

θ_{ji} = angle of inclination of the j^th damper on i^th story measured from horizontal

φ_{ji} = angle of DF containing the j^th damper on i^th story measured from the principal direction (zero degrees when the DF aligns with the principal direction)

The radius of gyration of damping at the i^th story, $r_{TD,i}$, is computed using only the dampers' contributions to damping in the direction of interest. For two identical lines of damping that are parallel to the direction of interest, this quantity is half the perpendicular distance between them. Otherwise, it is given by the following Equation:

$$r_{TD,i} = \sqrt{\frac{\sum_{j=1}^{n_i}\left[(x_{ji} - CD_i)^2 \tau_{,ji}C_{ji(L)}cos^2\psi_{ji}\right]}{\sum_{j=1}^{n_i}\left[\tau_{ji}C_{ji(L)}cos^2\psi_{ji}\right]}} \qquad \text{(EQ A-3.3)}$$

e. Section 12.9.1.4.1 Scaling of Forces

The combined response for the modal base shear (V_t) shall be scaled to 75% of the ELF base shear (V) computed in Section 12.8. This scaling may be upward or downward.

f. Section 12.9.1.4.2 Scaling of Drifts

Replace C_s from Equation 12.8-6 with $C_{s,d}$ for scaling of drifts. Do not take the 25% reduction that is used for strength checks. This scaling shall apply for any design in which the combined modal base shear V_t is less than $C_{s,d}W$, where $C_{s,d}$ is from the following equation, regardless of the controlling ASCE/SEI 7 equation for scaling strength:

$$C_{s,d} = 0.35S_{D1}/(R/I_e) \leq 0.5S_1/(R/I_e) \qquad \text{(EQ A-3.4)}$$

3.2 Diaphragms, chords, and collectors

Diaphragm forces for the maximum displacement stage analysis shall be determined according to ASCE/SEI 7 Section 12.10, with the following exception:

a. *Sections 12.10.1.1 and 12.10.3.2 Diaphragm Inertial Forces*

Limiting equations for diaphragm inertial forces (Equations 12.10-2, 12.10-3, 12.10-5) may be reduced by 25%.

4. Viscous Damper Constant for Target Viscous Damping

4.1 Target Linear Damper Constant determination for j^th damper in i^th story, $C_{ji(L)}$

$$C_{ji(L)} = \boldsymbol{\beta_v} \frac{k_i}{\sum_{j=1}^{n_i} \cos^2\varphi_{ji}} \frac{T_1}{\pi} \frac{1}{cos^2\theta_{ji}} \quad \text{(EQ A-4.1)}$$

β_v = 0.25 (Target Viscous Damping Ratio)

θ_{ji} = angle of inclination of the j^th damper on i^th story measured from horizontal

φ_{ji} = angle of DF containing the j^th damper on i^th story measured from the principal direction (zero degrees when the DF aligns with the principal direction)

T_1 = fundamental translational elastic period in the principal direction of interest computed from the structural model. Alternatively, T_1 can be computed using Equation 18.7-22 of ASCE/SEI 7.

k_i = i^th story linear stiffness in principal direction of interest

$k_i = (C_d V_i)/\Delta_i$

Δ_i = design story drift between levels i and i -1 occurring simultaneously with V_i, computed from a static ELF analysis

V_i = seismic shear force acting between levels i and i − 1 based on ELF

n_i= number of dampers in story *i*

Exception: Alternative values of $C_{ji(L)}$ may be determined by satisfying the following equation for the dampers in story i that are used for damping in the principal direction of interest:

$$\sum_{j=1}^{n_i} C_{ji(L)} cos^2\psi_{ji} = \beta_v k_i \frac{T_1}{\pi} \quad \text{(EQ A-4.2)}$$

ψ_{ji} = angle of the j^th damper in i^th story measured from the principal direction of motion under consideration.

$\psi_{ji} = cos^{-1}(cos\theta_{ji} cos\varphi_{ji})$

If a damper is not aligned with a principal direction of interest, and its contribution to system level damping is relied upon in both principal directions, $C_{ji(L)}$ shall be calculated for each principal direction and the maximum value of $C_{ji(L)}$ shall be used for the target.

4.2 Damper Velocity for Target Nonlinear Damping Constant, v_{ji}

Taylor Dampers (TD) with velocity exponent of α = 0.4 shall be utilized and TD velocities are required for transforming the linear damping constant to a nonlinear damping constant via equivalent energy dissipation. Determination of individual TD velocities requires TD displacement results from the MRSA as modified by C_d and a correction factor (BF) to offset the effect of the base shear scaling requirement.

$$v_{ji} = \omega d_{ji} BF \quad \text{(EQ A-4.3)}$$

$$\omega = \frac{2\pi}{T_1}$$

d_{ji} = displacement of j^th damper in i^th story measured from the Maximum Displacement Stage Analysis of Section 3.1, accounting for the orientation of the damper.

BF = Base shear correction factor—removes the effect of the base shear scaling from the DE damper displacement.

$BF = \min\,(1.0, V_t/(C_{s,d}W)$

V_t = Modal base shear from ASCE/SEI 7 section 12.9.1.4.2

$C_{s,d}$ = minimum base shear for drift checks in accordance with section 3.1.

4.3 Target Nonlinear Damping Constant of j^th damper in i^th story

$$C_{ji(NL)} = c_{ji(L)} \frac{\pi}{\lambda} (v_{ji})^{(1-\alpha)} \quad \text{(EQ A-4.4)}$$

$\lambda = 3.582$ for velocity (v_{ji}) units of inches per second

α = velocity exponent, 0.4

4.4 Specified Nonlinear Damping Constant of j^th damper in i^th story

The nonlinear damping constant $C_{ji(NL)spec}$ for each damper specified for installation shall satisfy the following criterion:

The ratio of the specified nonlinear damping constant to the target nonlinear damping constant (τ_{ji}) shall be greater than 0.9 and less than 1.3:

0.9 < τ_{ji} < 1.3

$$\tau_{ji} = \frac{C_{ji(NL)spec}}{C_{ji(NL)}} \quad \text{(EQ A-4.5)}$$

5. Maximum Velocity Stage Analysis

Additional analyses are required to determine the TD load effect, Q_{TD}, based on peak TD velocities created in the system by the DE ground motion. TD load effects in elements of the DF shall be determined from an analysis in which all TD's simultaneously resist forces as determined by Sections 5.2-5.4.

5.1 DE Damper Velocity, v_{ji}^*

$$v_{ji}^* = A_v A_1 \omega d_{ji} \quad \text{(EQ A-5.1)}$$

A_v = Velocity Amplification Factor for higher modes and yielding

A_1 = Amplification Factor for first story yielding

5.1.1 Velocity Amplification Factor for higher modes and yielding, A_v

$$A_v = 1.1 + 0.1n_s \quad \text{(EQ A-5.2)}$$

n_s = Number of above grade TDMF™ stories.

5.1.2 Amplification Factor for first story yielding, A_1

At the bottom TDMF™ story:

$$A_1 = 0.85\left(\frac{\Delta_2/h_{s,2}}{\Delta_1/h_{s,1}}\right) \geq 1.0 \quad \text{(EQ A-5.3)}$$

Δ_i = Story drift in story i

$h_{s,i}$ = Story height of story i

At all stories above the bottom TDMF™ story:

$A_1 = 1.0$

5.2 Design Earthquake TD Force, f_{ji}

$$f_{ji} = C_{ji(NL)spec}(v_{ji}^*)^{\alpha} \quad \text{(EQ A-5.4)}$$

$C_{ji(NL)spec}$ = Specified nonlinear damping constant from Section 4.4 for the j^th damper in the i^th story.

5.3 Force at MCE$_R$, $f_{MCE,ji}$ in the Specified Damper

$$f_{MCE,ji} = C_{ji(NL)spec}(1.5v_{ji}^*)^{\alpha} = 1.18f_{ji} \quad \text{(EQ A-5.5)}$$

5.4 Overstrength TD Force, F_{ji}

Certain elements shall be designed for overstrength damper forces, in accordance with Section 9, using upper bound damping demands.

$$F_{ji} = R_v C_{ji(NL)spec}(\Omega_v v_{ji}^*)^{\alpha} \quad \text{(EQ A-5.6)}$$

Overstrength Factor on Design Velocity for Maximum Considered Demands

$\Omega_v = 2.5$

Expected Properties for Damping (Upper bound damping constant)

$R_v = 1.15$

NOTE: if the final design utilizes dampers with properties exceeding normal testing limits, as permitted by Section 11.5, R_v shall be adjusted upwards in proportion to the accepted damping constant.

Overstrength factor for damper forces

$$\Omega_F = R_v(\Omega_v)^{\alpha} \quad \text{(EQ A-5.7)}$$

6. Steel Special Moment Frame (SMF) Design Requirements

6.1 Beams, Columns, and Connections

6.1.1 Seismic Load Effect, *E*: The seismic load effect shall be determined according to ASCE/SEI 7, but with the alternative horizontal load effect E_h in Section 9 of this Annex.

6.1.2 Design Criteria: AISC for Special Moment Frames, AISC 341, Chapters A through D, Section E3, and Chapters I through K, which also reference pertinent provisions of AISC 360 and AISC 358.

7. Damper Frame (DF) Design Requirement

7.1 Beams and Columns

7.1.1 Seismic Load Effect, *E*: The seismic load effect, *E*, shall be determined according to ASCE/SEI 7, but with the alternative horizontal load effect E_h in Section 9 of this Annex.

7.1.2 Beams shall satisfy the requirements of AISC 341 Section D1.1 for moderately ductile members.

7.1.3 Columns shall satisfy the requirements of AISC 341 Section D1.1 for highly ductile members.

7.1.4 For determining TD load effects on the DF, Beam to Column Connections may be treated as pinned for analysis.

7.1.5 Demand critical welds shall be designed to satisfy Section F4.6a of AISC 341.

7.1.6 The beam to column connections shall be designed to satisfy Section F4.6b of AISC 341, except the minimum rotation for option (a) shall be 0.050 radians.

7.1.7 Column splices shall be designed to satisfy Section F4.6d of AISC 341.

7.2 TD Design Requirements

TD shall be specified in accordance with the following criteria. All TD are subject to prototype and production testing, as defined by in Section 12 of this Annex.

TD test results and design reports shall be approved by the Engineer of Record in accordance with project specifications using verification criteria defined by Sections 11 and 12 of this Annex.

7.2.1 Velocity Exponent, α; α = 0.4

7.2.2 Damper Force Capacity Requirement: Viscous dampers shall be designed to resist the force at MCE_R developed by the specified damper, $f_{MCE,ji}$, (Section 5.3) and shall have a minimum factor of safety of 1.6 considering all relevant failure modes.

7.2.3 Minimum Required Damper Stroke, $s_{req,ji}$

The minimum required damper stroke, $s_{req,ji}$, is computed with the following equation:

$$s_{req,ji} = A_1 I_e \Omega_d d_{ji} \qquad \text{(EQ A-7.1)}$$

Ω_d = Overstrength Factor on viscous damper stroke required

$s_{req,ji}$ shall not be less than the stroke capacity required to accommodate a 3% inter story drift ratio.

7.2.3.1 Overstrength factor for viscous damper stroke, Ω_d

The overstrength factor for determining viscous damper stroke, Ω_d, depends on the total number of TDMF™ stories, n_s, and Seismic Design Category (SDC).

For building structures in SDC D and lower:

$$\Omega_d = \begin{cases} 3.5 & \text{for } n_s \le 4 \\ 4.0 - 0.125 n_s & \text{for } 5 < n_s < 12 \\ 2.5 & \text{for } n_s \ge 12 \end{cases}$$

For building structures in SDC E and higher:

$$\Omega_d = \begin{cases} 3.5 & \text{for } n_s \le 8 \\ 4.5 - 0.125 n_s & \text{for } 8 < n_s < 14 \\ 2.75 & \text{for } n_s \ge 14 \end{cases}$$

7.3 Extender Brace Design Requirements

The required strength of extender braces and connecting elements between the extender brace and TD shall be based on overstrength viscous damper demands as determined in Section 5.4. Nominal strength (P_n), strength reduction factor (φ), and detailing of the extender brace shall be determined according to AISC 360 for axial members with pinned ends, and the cross-section shall qualify as non-slender for axial compression.

Extender braces shall be sufficiently stiff to drive the damping device without significant stroke loss due to axial deformation. Minimum extender brace stiffness shall be in accordance with Section 7.3.2.

7.3.1 Extender Brace Stiffness, K_E for DF with concentric connections

$$K_E = \frac{A_g E}{L}$$

$E =$ 29,000 ksi (Modulus of Elasticity)

$A_g =$ Gross Area of Steel Section

$L =$ Pin to pin length

7.3.2 Minimum Extender Brace Stiffness, $K_{EM,ji}$

$$K_{EM,ji} = \frac{5 f_{ji}}{d_{ji}BF}$$

$f_{ji} =$ DE Damper Force in accordance with section 5.2

$d_{ji}BF =$ DE Damper Displacement in accordance with section 4.2

$d_{ji}BF > 0.015 h_i \cos\theta_{ji}$ shall be used as a minimum for extender brace stiffness calculations, where h_i is the vertical distance between work points of the brace/damper assembly.

7.4 Stiffness for DF with Eccentric Connections

For the modified chevron or modified V with horizontal damper DF configuration (as in Figure 4) or for any DF configuration with connection eccentricities greater than half the beam depth, the lateral story stiffness of the combined extender brace, beams and columns of the DF bay shall be computed assuming the columns are pinned at the top and bottom of the story and including the eccentricities of the connections. The minimum allowable DF bay stiffness shall be K_{SM}

$$K_{SM} = \frac{5 \sum_{j=1}^{n} f_j \cos\theta_j}{\sum_{j=1}^{n} d_j BF \cos\theta_j} \qquad \text{(EQ A-7.2)}$$

where *n* is the number of dampers in the DF bay in the story being designed.

7.5 Connection Design Requirements

Required strength of connections for damping devices and extender braces to beams and columns shall be based on overstrength damper load effects as determined in Section 5.4. Design strengths shall be established per AISC 360.

Connections of dampers and extender braces shall be detailed to accommodate in-plane and out-of-plane drift of the SFRS.

8. Optional Reduction of Damper-Induced Column Axial Loads for Continuously Damped Bays

For column elements receiving damper-induced axial loads, the axial load corresponding to the Q_{TD} loading may be reduced based on the number of continuously damped stories directly above the column of interest (n_{ai}). The resulting damper-induced column axial load for the *jth* column in the *ith* story ($P_{ETD,ji}$) is given by the following relationships:

$$P_{ETD,ji} = max(P_{ETD1,ji}, P_{ETD2,ji}) \qquad \text{(EQ A-8.1)}$$

$$P_{ETD1,ji} = CF1_{ji} \cdot P_{ji} \qquad \text{(EQ A-8.2)}$$

$$CF1_{ji} = 1/[1 + 0.06(n_{ai} - 3)] \qquad 0.5 \le CF1_{ji} \le 1.0 \qquad \text{(EQ A-8.3)}$$

$P_{ji} =$ Damper-induced column axial load considering damper overstrength at story *i* and column line *j* from maximum forces at all stories above

$n_{ai} =$ Number of consecutive columns taking damper induced axial forces of the same sign (i.e., all compression or all tension) above story i of interest

$$P_{ETD2,ji} = \sum_{i}^{n_s} CF2_{ji} P_{local,ji} \qquad \text{(EQ A-8.4)}$$

$P_{local,ji}$ = Local damper-induced column axial load considering damper overstrength acting at story *i* and column line *j*

$CF2_{ji} = 1 - [(n_{ai,local} - 2)0.15] \quad 0.25 \le CF2_{ji} \le 1.0$ (EQ A-8.5)

$n_{local,ai}$ = Number of consecutive columns taking damper forces above story i for which $CF2_{ji}$ is computed

Exception: For the column under consideration, $P_{ETD2,ji}$ can be taken as equal to $P_{ETD1,ji}$, if there is no story above in which the story stiffness is less than 85% of the stiffness of the story below. The 85% limit does not apply for the story supporting the roof.

9. Horizontal Seismic load Effect, E_h

For DF beams and columns, SMF elements, transfer elements, and all elements making up the SFRS load path, such as diaphragms, collectors, and foundations, the horizontal seismic load effect (E_h) shall be the maximum load effect resulting from Q_{MD} and Q_{TD} as follows:

For portions of foundations that do not require overstrength design forces according to ASCE/SEI 7, ACI, and AISC:

$$E_h = max(Q_{MD}, Q_{TD}, Q_{MD} \pm 0.7Q_{TD}) \quad \text{(EQ A-9.1)}$$

For elements that do not normally require overstrength:

$$E_h = max(Q_{MD}, \Omega_F Q_{TD}, Q_{MD} \pm 0.7\Omega_F Q_{TD}) \quad \text{(EQ A-9.2)}$$

Where overstrength is normally required, such as for collectors:

$$E_{mh} = max(\Omega_0 Q_{MD}, \Omega_F Q_{TD}, \Omega_0 Q_{MD} \pm 0.7\Omega_F Q_{TD}) \quad \text{(EQ A-9.3)}$$

10. Orthogonal Load Combinations

Where the orthogonal combination of earthquake load effects requires simultaneous application of 30% of the orthogonal seismic load effect, the portion of the orthogonal load effect due to damper forces (Q_{TD}) shall be 60% rather than 30%.

11. Damping Devices

11.1 Device Design

The design, construction, and installation of damping devices shall be based on forces, velocities, and displacements determined in accordance with this ESR and consideration of all of the following:

a. Low-cycle, large-displacement degradation caused by seismic loads.

b. High-cycle, small-displacement degradation caused by wind, thermal, or other cyclic loads, where applicable.

c. Forces or displacements caused by gravity loads.

d. Adhesion of device parts caused by corrosion or abrasion, biodegradation, moisture, or chemical exposure.

e. Exposure to environmental conditions, including, but not limited to, temperature, humidity, moisture, radiation (e.g., ultraviolet light), and reactive or corrosive substances (e.g., saltwater).

Devices using bimetallic interfaces subject to cold welding of the sliding interface shall be prohibited from use in a damping system.

Damping devices subject to failure by low-cycle fatigue shall resist wind forces without slip, movement, or inelastic cycling.

The design of damping devices shall incorporate the range of thermal conditions, device wear, manufacturing tolerances, and other effects that cause device properties to vary during the design life of the device in accordance with Section 11.4.4.

Ambient temperature shall be the normal in-service temperature of the damping device. The design temperature range shall cover the annual minimum and maximum in-service temperatures of the damping device. An ambient temperature range of 50 to 90 degrees Fahrenheit may be assumed for the operating temperature of the dampers in most enclosed climate controlled buildings.

11.2 Multiaxis Movement.

Connection points of damping devices shall provide sufficient articulation to accommodate simultaneous longitudinal, lateral, and vertical displacements of the damping system.

11.3 Inspection and Maintenance

Means of access for visual inspection shall be provided.

The unit shall be constructed to be maintenance-free. Each Taylor Damper shall be designed and constructed such that installation, removal, and replacement, if necessary, shall be a simple process not requiring any special tools or methods. The use of fluid seals that require fluid weepage for lubrication is prohibited. Dampers shall be designed for a service life of 50 years and shall be maintenance-free over the course of that service life.

11.4 Specified Design Properties

Specified design properties (damper constant and velocity exponent) for energy-dissipation devices shall be established from the design procedure and damper performance within the allotted bounds (maximum and minimum damper properties below) shall be confirmed through either project-specific prototype test data or prior prototype tests on devices of similar type and size.

11.5 Maximum and Minimum Damper Properties

Maximum and minimum design properties for each device shall be determined in accordance with the following equations, where λ_{max} is 1.15 and λ_{min} is 0.85:

$$Maximum\ Design\ Property = Specified\ Design\ Property * \lambda_{(max)} \quad \text{(EQ A-11.1)}$$

$$Minimum\ Design\ Property = Specified\ Design\ Property * \lambda_{(\min)} \quad \text{(EQ A-11.2)}$$

Exception: At the discretion of the Engineer of Record and damper provider, λ_{max} and λ_{min} may be taken greater than 1.15 and less than 0.85, respectively, for project conditions with expected temperature exposure greater than 120 degrees and/or less than 30 degrees Fahrenheit. In such cases, R_v used in Section 5.4 shall be equal to the alternative λ_{max} and Ω_F shall be adjusted accordingly.

12. Damping Device Testing

The force-velocity-displacement relationships and damping properties assumed as the specified design properties, $C_{(NL)spec}$ and α, shall be confirmed by the tests conducted in accordance with Section 12.1 or shall be based on prior tests of devices meeting the similarity requirements of Section 12.1.3.

The prototype tests specified in Section 12.1 shall be conducted to confirm the force-velocity-displacement properties of the damping devices assumed for analysis and design and to demonstrate the robustness of individual devices under cyclic excitation.

The production testing requirements are specified in Section 12.2.

Device force-velocity-displacement relationship and damper properties (C and α) determined from the prototype testing of Section 12.1 and the production testing of Section 12.2 shall meet the acceptance criteria established using $\lambda_{(max)}$ and $\lambda_{(min)}$ from Section 11.5.

The fabrication and quality control procedures used for all prototype and production devices shall be identical.

12.1 Prototype Tests

The following tests shall be performed separately on two full-size damping devices of each type and size used in the design, in the order listed as follows.

Representative sizes of each type of device are permitted to be used for prototype testing, provided that both of the following conditions are met:

a. Fabrication and quality control procedures are identical for each type and size of device used in the structure.

b. Prototype testing of representative sizes is approved by the Registered Design Professional (RDP) responsible for design of the structure.

Test specimens shall not be used for construction, unless they are approved by the RDP responsible for design of the structure and meet the requirements for prototype and production tests.

12.1.1 Data Recording

The force-deflection relationship for each cycle of each test shall be recorded electronically.

12.1.2 Sequence and Cycles of Testing

For all of the following test sequences, each damping device shall be subjected to thermal environments representative of the installed condition.

Prior to the sequence of prototype tests defined in this section, a production test in accordance with Section 12.2 shall be performed, and data from this test shall be used as a baseline for comparison with subsequent tests on production dampers.

1. Design Windstorm Testing: Each damping device shall be subjected to a minimum of *n* continuous fully reversed cycles at an amplitude equal to or greater than d_w and frequency (f) equal to or greater than the fundamental frequency of the structure (f_1), where:

   $n = f_1 * 1800\ seconds$

   $f_1 = 1/T_1$

   $d_w = 0.5 * (0.5 d_T)$

   d_T = the maximum total stroke requirement for the damper under design loads for the 50-year mean return interval (MRI) wind event, which is defined in Figure CC.2-3 of ASCE/SEI 7 Commentary to Appendix C.

   It is permitted to use alternate loading protocols, representative of the design windstorm, that apportion the total wind displacement into its expected static, pseudo static, and dynamic components.

   Exception: Damping devices need not be subjected to these tests if they are not subject to wind-induced forces or displacements or if the design wind force is less than the device slip force.

2. MCE_R Seismic Testing: Each damping device shall be brought to ambient temperature and loaded with the following sequence of fully reversed, sinusoidal-like cycles at a frequency, f, equal to ω/2π, where:

   ω = the angular frequency = v_M/d_M

   v_M = MCE_R device velocity = $1.5 * v^*$

   v^* = DE damper velocity from section 5.1

   d_M = MCE_R device displacement = $1.5 * d$

   d = device displacement measured from the Maximum Displacement Stage Analysis of Section 3.1

   a. Ten fully reversed cycles at a displacement in the energy-dissipation device corresponding to 0.33 times d_M;

   b. Five fully reversed cycles at a displacement in the energy-dissipation device corresponding to 0.67 times d_M;

   c. Three fully reversed cycles at a displacement in the energy-dissipation device corresponding to 1.0 times d_M; and

   d. Where test (c) produces a force in the energy-dissipation device that is less than the MCE_R device force, f_{MCE} from Section 5.3, test (c) shall be repeated at a frequency that produces a force equal to or greater than the f_{MCE}.

   The damping device may be brought to ambient temperature between each test, a-d.

3. Temperature-Effect Testing: When the expected temperature range for the dampers is outside of 50 to 90 degrees Fahrenheit, the tests of Section 12.1.2, 2(a) to 2(d) shall be conducted on at least one device, at a minimum of two additional temperatures (minimum and maximum), that bracket the design temperature range.

Exception: Damping devices are permitted to be tested by alternative methods provided that all of the following conditions are met:

a. Alternative methods of testing are equivalent to the cyclic testing requirements of this section.

b. Alternative methods capture the dependence of the damping device response on ambient temperature, frequency of loading, and temperature rise during testing.

c. Alternative methods are approved by the RDP responsible for the design of the structure.

12.1.3 <u>Testing Similar Devices</u>

Prototype tests need not be performed on a particular damping device if there exists a previously prototype-tested unit that meets all of the following conditions:

1. It is of similar dimensional characteristics, internal construction, and static and dynamic internal pressures (if any) to the subject damping device; and
2. It is of the same type and materials as the subject damping device; and
3. It was fabricated using identical documented manufacturing and quality control procedures that govern the subject damping device; and
4. It was tested under similar maximum strokes and forces to those required of the subject damping device.

12.1.4 Determination of Force-Velocity-Displacement Characteristics

The force-velocity-displacement characteristics of the prototype damping device shall be based on the cyclic displacement tests specified in Section 12.1.2 and all of the following requirements:

1. The maximum force (absolute value of tension and compression) and the area of hysteresis loops (E_{loop}) shall be calculated for each cycle of deformation.
2. For each cycle of prototype and production testing, the maximum force and area of the hysteresis loop shall fall within the range of λ_{min} and λ_{max} from the theoretical values (force and loop area) corresponding to the specified damper properties. If temperature variation is a component of the testing requirements, values at various temperatures shall also meet this requirement.

12.1.5 Device Adequacy

The performance of a prototype damping device shall be deemed adequate if all of the conditions listed below are satisfied. The $\lambda_{(max)}$ and $\lambda_{(min)}$ limits specified in the following text are permitted to be increased by the RDP responsible for the design of the structure provided that the increased limit has been demonstrated by analysis not to have a deleterious effect on the response of the structure.

The performance of the prototype velocity-dependent damping devices shall be deemed adequate if all of the following conditions, based on tests specified in Section 12.1.2, are satisfied:

1. For Test 1, no signs of damage including leakage, yielding, or breakage.
2. For Tests 2, 3, and 4, the maximum force (absolute value of tension and compression) for a damping device for any one cycle does not differ by more than $\lambda_{(max)}$ and $\lambda_{(min)}$ from the theoretical force as calculated based upon the specified damper properties and peak velocity.
3. For Tests 2, 3, and 4, the area of hysteresis loop (E_{loop}) of a damping device for any one cycle does not differ by more than $\lambda_{(max)}$ and $\lambda_{(min)}$from the theoretical hysteresis loop based upon the specified damper properties and peak velocity.
4. The average maximum force and average area of the hysteresis loop (E_{loop}), calculated for Test 2(c), shall fall within the limits specified in Section 11.5.

12.2 Production Tests

Prior to installation in a building, damping devices shall be tested in accordance with the requirements of this section.

The test program shall validate the performance of each damper to be used in construction based upon the specified properties of the damper by testing the device for three cycles at 0.67 times d_M at the frequency determined in Section 12.1.2 for MCE_R seismic testing. The measured values of the properties (defined as the average of three cycles) shall fall within $\lambda_{(max)}$ and $\lambda_{(min)}$ provided in the project specifications. These limits shall be consistent with the tolerances on specified design properties established in Section 11.5 of this ESR.

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DIVISION: 05 00 00—METALS
Section: 05 12 00—Structural Steel Framing

REPORT HOLDER:

TAYLOR DEVICES INC.

EVALUATION SUBJECT:

TAYLOR DAMPED MOMENT FRAME SYSTEM (TDMF™)

1.0 REPORT PURPOSE AND SCOPE

Purpose:

The purpose of this evaluation report supplement is to indicate that the Taylor Damped Moment Frame System (TDMF™), described in ICC-ES evaluation report ESR-4769, has also been evaluated for compliance with the codes noted below as adopted by the Los Angeles Department of Building and Safety (LADBS).

Applicable code editions:

- 2023 *City of Los Angeles Building Code* (LABC)

2.0 CONCLUSIONS

The Taylor Damped Moment Frame System (TDMF™), described in Sections 2.0 through 7.0 of the evaluation report ESR-4769, complies with the LABC Chapter 22 and is subject to the conditions of use described in this supplement.

3.0 CONDITIONS OF USE

The Taylor Damped Moment Frame System (TDMF™) described in this evaluation report supplement must comply with all of the following conditions:

- All applicable sections in the evaluation report ESR-4769.
- The design, installation, conditions of use and identification of the Taylor Damped Moment Frame System (TDMF™) are in accordance with the 2021 *International Building Code®* (IBC) provisions noted in the evaluation report ESR-4769.
- The design, installation and inspection are in accordance with additional requirements of LABC Chapters 16, 17, 22 and City of Los Angeles Information Bulletin P/BC 2023-098, as applicable.
- Special inspection by Deputy Inspectors shall be provided during the installation of the TDMF™.
- The Taylor Dampers shall be produced in the shop of an approved City of Los Angeles fabricator, in accordance with LABC Section 202 "Fabricated Item" and LABC Section 96.203.

This supplement expires concurrently with the evaluation report, reissued May 2024.

ICC-ES Evaluation Report

ESR-4769 CBC Supplement

Reissued May 2024

This report is subject to renewal May 2026.

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DIVISION: 05 00 00—METALS
Section: 05 12 00—Structural Steel Framing

REPORT HOLDER:

TAYLOR DEVICES INC.

EVALUATION SUBJECT:

TAYLOR DAMPED MOMENT FRAME SYSTEM (TDMF™)

1.0 REPORT PURPOSE AND SCOPE

Purpose:

The purpose of this evaluation report supplement is to indicate that the Taylor Damped Moment Frame System (TDMF™), described in ICC-ES evaluation report ESR-4769, has also been evaluated for compliance with the code*(s)* noted below.

Applicable code edition*(s)*:

- *2022 California Building Code* (CBC)

For evaluation of applicable Chapters adopted by the California Office of Statewide Health Planning and Development (OSHPD) AKA: California Department of Health Care Access and Information (HCAI) and the Division of State Architect (DSA), see Sections 2.1.1 and 2.1.2 below.

2.0 CONCLUSIONS

2.1 CBC:

The Taylor Damped Moment Frame System (TDMF™), described in Sections 2.0 through 7.0 of the evaluation report ESR-4769, complies with CBC Chapter 22, provided the design and installation are in accordance with the 2021 *International Building Code®* (IBC) provisions noted in the evaluation report and the additional requirements of CBC Chapters 16, 17 and 22 as applicable.

2.1.1 OSHPD:

The Taylor Damped Moment Frame System (TDMF™), described in Sections 2.0 through 7.0 of the evaluation report ESR-4789, complies with CBC amended Chapter 22, and Chapter 22A, provided the design and installation are in accordance with the 2021 *International Building Code®* (IBC) provisions noted in the evaluation report and the additional requirements in Sections 2.1.1.1 and 2.1.1.3 of this supplement:

2.1.1.1 Conditions of Use:

- All loads applied must be determined by a registered structural engineer and comply with applicable loads from Chapter 16 [OSHPD 3] and its applicable amendments [OSHPD 1R, 2 and 5] and Chapter 16A [OSHPD 1 and 4].
- Structural steel connection design for restrained welded connections and column base plate shall comply with the requirements of Sections 2204.1.1 and 2204.4 [OSHPD 1R, 2 and 5], respectively, and Sections 2204A.1.1 and 2204A.4 [OSHPD 1 and 4], respectively, and as applicable.
- Structural steel design of members in tension and compression shall comply with the exception requirements of Section 2205.1 [OSHPD 1R, 2 and 5] and 2205A.1 [OSHPD 1 and 4], as applicable.
- AISC 341 and AISC 358 must be modified as indicated in Sections 2205.3 and 2205.4 [OSHPD 1R, 2 &5] and Sections 2205A.4 and 2205A.5 [OSHPD 1 and 4], respectively and as applicable.
- Structural steel seismic force-resisting systems are not permitted to be assigned to Seismic Design Categories B and C as indicated in Section 2205A.2.1.1 [OSHPD 1 and 4].

2.1.1.2 Verification Test Requirements: Testing and field verification of high strength bolts, nuts and washer shall be in accordance with Section 2213.1 [OSHPD 1R, 2 and 5] and Section 2213A.1 [OSHPD 1 and 4].

2.1.1.3 Special Inspection Requirements: Special inspection of structural steel elements in buildings shall be in accordance with Section 1705.2.1 [OSHPD 1R, 2 and 5] and Section 1705A.2.1 [OSHPD, 1 and 4], as applicable.

2.1.2 DSA:

The Taylor Damped Moment Frame System (TDMF™), described in Sections 2.0 through 7.0 of the evaluation report ESR-4769, complies with CBC amended Chapter 22, and Chapter 22A, provided the design and installation are in accordance with the 2021 *International Building Code*® (IBC) provisions noted in the evaluation report and the additional requirements in Sections 2.1.2.1 and 2.1.2.3 of this supplement:

2.1.2.1 Conditions of Use:

- All loads applied shall be determined by a registered structural engineer and comply with applicable loads from Chapter 16 and its applicable amendments [DSA-SS/CC] and Chapter 16A [DSA-SS].
- Structural steel connection design for column base plate shall comply with the requirements of Section 2212.1 [DSA-SS/CC] and 2204A.4 [DSA-SS] as applicable.
- Structural steel seismic force-resisting systems are not permitted to be assigned to Seismic Design Categories B and C as indicated in Section 2205A.2.1.1 [DSA-SS].
- AISC 341 shall be modified as indicated in Section 2212.2 [DSA-SS/CC] and Section 2205A.3 [DSA-SS], as applicable.

2.1.2.2 Verification Test Requirements: Testing and field verification of high strength bolts, nuts and washer shall be in accordance with Section 2212.6.1 [DSA-SS/CC].

2.1.2.3 Special Inspection Requirements: Special inspection of structural steel elements in buildings shall be in accordance with Section 1705A.2.1 [DSA-SS and DSA-SS/CC], as applicable.

This supplement expires concurrently with the evaluation report, reissued May 2024.