STRUCTURAL DESIGN REQUIREMENTS (SEISMIC PROVISIONS) FOR EXISTING BUILDING CONVERTED TO JOINT LIVING AND WORK QUARTERS

The purpose of this Information Bulletin is to elaborate on the structural requirements of Chapter 85 of the Los Angeles Building Code (LABC) for strengthening existing industrial/commercial buildings converted to joint living and work quarters. The bulletin provides alternative structural standards for strengthening of existing buildings for which a building permit was issued prior to April 1, 1994. These structural standards are designed to provide a reasonable level of Structural Life-Safety to the building occupants.

APPLICATION

This Information Bulletin provides structural standards for those structural types of buildings for which LABC Chapter 85 does not have standards. These structural types of buildings include:

- Unreinforced Masonry Bearing Wall Buildings (URM)
- Reinforced Masonry and Concrete Bearing Wall Buildings
- Steel Frame Buildings with Semi-rigid, Beam-Column Connections
- Steel Frame Buildings with Steel Bracing
- Steel Frame Buildings with Steel Moment Frames
- Dual Systems, Steel Moment Frames and Concrete Shear Walls

Nothing in this Information Bulletin shall be construed to allow the reduction of the capacity of seismic-force-resisting systems or elements of an existing building unless approved by the Superintendent of Building where such systems or elements provide a greater level of protection than the minimum requirements established by the current building code.

When approved by the Superintendent of Building, alternative standards may be used to comply with the minimum standards of LABC Chapter 85.

I. General requirements

A. **Conversions.** All existing buildings to be converted (Change of Use or Occupancy) to a Joint Living and Work Quarters are required to comply with all structural requirements of the current building code for a new building, except as provided in this Information Bulletin. The entire building shall be analyzed and strengthened in accordance with LABC Section 8502.12.

B. **Alteration.** The conversion of any portion of an existing building to a Joint Living and Work Quarters shall be considered a "substantial alteration." and the entire building shall be required to comply with all structural requirements of the current building code for a new building, except as provided in this Information Bulletin.

C. **Additions.** Additions to existing buildings shall require the entire building to comply with structural requirements of the current building code for a new building.

II. Seismic Design Strengthening Options

A. All existing buildings to be converted in accordance with LABC Chapter 85 shall be analyzed and strengthened for a minimum of 75% of the Design Earthquake Ground Motion per Section 8502.12, but not less than the original base shear the building was designed for, as defined in LABC Section 1613.2 and as specified in LABC Section 1613.5.

EXCEPTIONS:

1. When approved by the Superintendent of Building, a minimum of 75% of the Design Earthquake, as defined by Section 1613 of the LABC 2011 edition, may be used.

2. When approved by the Superintendent of Building, a minimum of 100% of the Design Basis Ground motion, as defined by Section 8502.12 shall be used in the Special Procedure of Appendix A, Chapter A1, Section A111, and the Tier 1 analysis of Appendix A, Chapter A5 , Section A505, of the International Existing Building Code (IEBC) 2009, may be used.

III. Selection of Lateral Analysis Procedure (See Figure 1)

Existing buildings may be analyzed using any of the following procedures:

A. **Nonlinear Analysis** is permitted for all types of building structures. A nonlinear Analysis is required for buildings having vertical or plan irregularity except for buildings of 4 stories or less having plan irregularity only.

EXCEPTIONS:

1. **Performance-based Engineering Analysis**. When approved by the Superintendent of Building, the engineer may be permitted to use performance-based engineering analysis and design procedures per LABC, Section 8502.12 to evaluate the existing building and the design of strengthening of the existing building in lieu of that specified in Section 16.2 of the ASCE 7-05, provided the following requirements are considered in the analysis:

   (I) The Design Response Spectrum used in performance-based procedures shall be not less than that specified in the Seismic Design Strengthening Options, Section II of this Information Bulletin.

   (ii) Buildings shall be analyzed for seismic forces acting simultaneously on the orthogonal axes of the building. The effects of the loading on two orthogonal axes shall be combined by the square root of the sum of the squares (SRSS) methods.

   (iii) All structural elements in the basic-seismic-force -resisting system shall be evaluated as part of the analysis to be determined as adequate by the analysis specified in LABC :

   - Section 8502.12.1 (URM)
   - Section 8502.12.2 (Reinforced Concrete)
   - Section 8502.12.3 (Steel Frame with masonry infill walls)
   - Section 8502.12.4 (Welded Steel Moment-Frame (WSMF) Buildings)

   or new elements of the basic-seismic-force-resisting system shall be added when required. All new structural elements shall meet current LABC detailing requirements.

   (iv) It shall include all irregularities of a building, plan and vertical irregularities, unless these irregularities are eliminated by adding supplemental structural elements prior to analysis. The analysis shall use a 3-dimensional modeling to include all irregularities of a building, plan and vertical irregularities, unless these irregularities are eliminated by adding supplemental structural elements prior to analysis.

2. When approved by the superintendent of Building, a Performance-Based nonlinear analysis may be considered as an expansion of LABC Chapter 95 for structural materials other than reinforced concrete, with and without masonry infill.

3. When approved by the Superintendent of Building, Chapter 8 of FEMA 440-Improvement of Nonlinear Static Seismic Analysis Procedures may be used to include soil-structure interactions effects for modifying the Design Response Spectrum of the Design Earthquake.

B. **Linear Analysis** is permitted for regular buildings or irregular buildings having plan

irregularity only and of not more than 4 stories may be analyzed using Linear Analysis Procedure as follows:

1. **Reinforced Concrete Buildings**

   a. **Equivalent Lateral Force Procedures** (Static Force Analysis) of LABC Section 9510.

   b. **Simplified Analysis Procedure**. Existing regular Reinforced Concrete buildings of not more than 4 stories may be analyzed using the Simplified Analysis method of LABC Section 9511. Simplified Analysis is a strength check comparison using 100% of the code required lateral forces (R=1.0).

      Exception:

      1. When approved by the Superintendent of Building, the similar simplified analysis of Tier 1 check of Appendix A, Chapter A5 of the IEBC 2009 may be used.

   c. **Limited Structural Analysis Method**. Existing reinforced concrete buildings conforming to the requirement of Section 9512 of LABC may be shown to be in conformance with this Information Bulletin by submitting a report per LABC Section 9512.3.

2. **All Other Buildings**

   a. Existing regular buildings of not more than 4 stories may be analyzed using the linear analysis procedure as specified in Sections 12.8, 12.9 or Section 16.1 of the ASCE 7-05.

IV. Symmetry of the Building Lateral Resistance

It is recommended that the lateral load resisting elements added to improve the seismic response of the building are placed at locations so as to minimize the eccentricity between the center of rigidity and the center of mass at all levels.

V. Base Shear for Analysis and Design

A. Reinforced Concrete Frame Buildings with Masonry Infill and all Other Reinforced Concrete Buildings

The base shear shall be determined using 75% of the base shear as determined in accordance with Section 12.8.1 of the ASCE 7-05 with the R values specified in Section

VI of this Information Bulletin. The R value in Table 12.2-1 of the ASCE 7-05 for new building design shall not be used for story drift determination.

B. **All Other Buildings**

The base shear shall be determined per Section II of this Information Bulletin for linear analysis and design of strengthening elements. The base shear for linear analysis procedure may be reduced by R values specified in Table 12.2-1 of ASCE 7-05 for design of new elements.

The existing elements complying with the current Building code detailing requirements are permitted to be designed and checked using the R values specified in Table 12.2-1 of ASCE 7-05 if the structural system can be considered as equivalent to any of the system specified therein.

VI. R values

A. **Reinforced Concrete Frame Buildings with Masonry Infill and all Other Reinforced Concrete Buildings**

R value for analysis and design in conformance with LABC Section 9510 (Equivalent Lateral Force Procedure) is 1.4. R is 1.0 for single story buildings.

B. **All Other Buildings**

When approved by the Superintendent of Building, R values listed in Table 12.2-1 of ASCE 7-05 may be used for linear analysis and strengthening of regular buildings. The selection of the Basic Seismic-Force Resisting system shall be based on conformance of the existing building basic-seismic-force-resisting system in accordance with the detail standards of the listed systems. The sources for the required detail standards are in footnotes to this table.

VII. Story Drift Limitation

The drift or horizontal displacements of the buildings shall be computed per Section 12.8.6 of the ASCE 7-05. A minimum of 75% of the Design Earthquake Ground Motion shall be used to determine the deflection determined by an elastic analysis, δ_{xe}, per Section 12.8.6 of the ASCE 7-05. The Maximum Inelastic Response Displacement, δ_M, shall be determined per LABC Section 1613.6.7 and compared with the limitation specified herein as follows:

A. **Reinforced Concrete Frame Buildings with Masonry Infill and all Other Reinforced Concrete Buildings**

The story drift shall be determined using a minimum of 75% of the Design Basis Ground Motion with the R values specified in Section VI of this Information Bulletin. The R value in Table 12.2-1 of the ASCE 7-05 for new building design shall not be used for story drift limitation.

Story drift limits for existing reinforced concrete buildings and concrete frame buildings with masonry infills are given in LABC Section 9509.7.

B. All Other Buildings

When approved by the Superintendent of Building the story drift limits of Appendix A, Chapter A5, Section A507 of IEBC 2009.

When approved by the Superintendent of Building, story drift limits of Table 12.12-1 of the ASCE 7-05 may be used for Basic-Seismic-Force-Resisting systems listed in IBC Table 12.2-1 of the ASCE 7-05.
The story drift for the Basic-Seismic-Force-Resisting systems not listed in Table 12.2-1 of the ASCE 7-05 shall meet the story drift limits of LABC Section 9509.7.

VIII. STRUCTURAL TYPES OF EXISTING BUILDINGS AND THE REQUIRED STRUCTURAL STANDARDS

A. **Masonry**

1. **Unreinforced Masonry Bearing Wall Buildings (URM), LABC Chapter 88,** See Figure 2.

2. **Reinforced Masonry or Reinforced Concrete Bearing Wall Buildings** See Figure 3.

B. **Reinforced Concrete Buildings and Concrete Moment Frame buildings With or Without Masonry Infills** (See Figure 4)

1. Reinforced Concrete Buildings and Concrete Frame Buildings with or without masonry infills shall comply with Chapter 95 of LABC.

2. When approved by the Superintendent of Building, Appendix A, Chapter A5 of the IEBC 2009 may be permitted as an alternate standard for analysis and design of strengthening of reinforced concrete buildings and concrete frame buildings with and without masonry infill walls.

C. **Structural Steel Frame Buildings** (See Figure 5)

1. Steel Frame Buildings that do not have irregularities as specified in Section 12.3.2 of the ASCE 7-05 and permitted in Table 12.2-1 of the ASCE 7-05 as a basic-seismic-force-resisting system may be analyzed and strengthened by linear analysis.

2. When approved by the Superintendent of Building, the seismic design factors; R, C_d and Ω_o of the basic-seismic-force-resisting system described in the footnotes to Table 12.2-1 of the ASCE 7-05 may be used.

   Acceptance criteria for the linear elastic analysis are:
   - conformance with the minimum strength requirements of the LABC
   - this Information Bulletin
   - the story drift limits of Table 12.12-1 of the ASCE 7-05.

   Building Frame Systems that are not permitted as a basic-seismic-force-resisting system in Table 12.2-1 of the ASCE 7-05 shall be analyzed by Nonlinear Analysis procedures comparable to LABC Section 9509.

3. When approved by the Superintendent of Building, the Nonlinear Static Procedure (NSP), pushover analysis of ASCE 41-06 including supplement No. 1, may be used for the nonlinear procedure, provided that:

   a. Meets the performance level of ASCE 41 BSE-1 in the Table 101.5.4.1 of the International Existing Building Code (IEBC) 2009.
   b. All elements of the seismic-force-resisting system shall be considered as primary. Modeling of the structure shall conform to Section 3.2.2 of ASCE 41-06.
   c. Section 3.2.7 of ASCE 41-06, Multidirectional Seismic Effects, shall be considered when applicable.
   d. Section 5.5 of ASCE 41-06, Steel Braced Frames shall be a general reference for steel seismic-force-resisting building frame systems.
   e. Tables 5-6 and 5-7 of ASCE 41-06 shall be used for Modeling Parameters and Acceptance Criteria of elements of the basic-seismic-force-resisting system of building frame systems. The Primary/LS (life safety) Acceptance Criteria in the Tables 5-6 and 5-7 of ASCE 41-06 shall be used occupancy category I and II.

D. **Structural Steel Frame Buildings with Masonry Infill Walls** (see Figure 5)

1. Steel frame buildings with masonry infill walls shall comply with the requirements of this Information Bulletin and all provisions of Division 95 of the LABC except for the following:

a. Item A of LABC Section 9509.6 of this code,
b. Items 1 and 2 of LABC Section 9509.7.2 and LABC Sections 9509.9 and 9511.5.1.

2. Steel frame buildings with masonry infill walls that modify the laterally displaced shape of the existing steel frame are not permitted as a basic-seismic-force-resisting system in Table 12.2-1 of the ASCE 7-05.

   Masonry infill walls confined within the steel frame members, beam and columns, provides resistance to seismic-caused story drifts and shall be considered in the analysis for the determination of the capacity and the stiffness of the as-is seismic force-resisting system.

3. Steel frames with masonry infill shall be analyzed and strengthened in conformance with LABC Chapter 95, modified as described in this Information Bulletin, by the nonlinear analysis and shall comply with the following:

   a. The beam-column connections shall be considered as pinned connections at the face of the column.
   b. The effective stiffness of the infill panel shall be determined by the nonlinear analysis specified in LABC Section 9509.4.
   c. The effective stiffness of the horizontal members of the steel frame may be considered as their elastic stiffness.
   d. If the horizontal members of the steel frame are fully encased in structural concrete cast with the concrete floors the effective stiffness of the horizontal member shall be increased by 30%.
   e. The encasement shall conform to that specified for 3 hour fire protection in the LABC.
   f. The nonlinear analysis of the frame and masonry infill shall include the probability of nonlinear behavior in the column.
   g. The minimum thickness of the masonry infill that is supported on the steel beam and in contact with column or on their concrete encasement, if present, shall be determined.
   h. The nonlinear analysis of the confined masonry infill shall use this minimum thickness for the finite elements analysis to represent the ends of the diagonal compression strut.
   I. The zone of this minimum thickness shall have a ratio of height to length equal to the ratio of the height and length of the infill masonry panel and a diagonal dimension of three times the average thickness of bearing on the column or its concrete encasement if present.

The story lateral load resistance of the infills on each line of resistance shall be taken as the summation of the resistance of all infills having a common displacement on that line of

resistance. The tensile resistance of existing steel column splices shall be determined using the load combinations of LABC Section 1605 and an R factor of 2.5.

E. **Dual Systems, Steel Moment Frame and Concrete Shear Walls**

See Figure 6.

IX. HISTORICAL BUILDINGS

Qualified Historical Buildings may use the State Historic Code.

X. DEFINITIONS

For the purpose of this Information Bulletin, certain terms are defined as follows:

Addition is an extension or increase in floor area or height of a building or structure.

Alteration is any change, addition or modification in construction or occupancy or structural repair or change in primary function to an existing structure other than repair or addition.

Design Earthquake Ground Motion is the earthquake ground motions that are two-thirds of the corresponding MCE ground motion.

Design Response Spectrum is an elastic response spectrum for 5 percent equivalent damping used to represent the dynamic effects of the Design Basis Ground Motion for the design of structures in accordance with Sections 12.9 and 16.2 of the ASCE 7-05. This response spectrum may be either a site-specific spectrum based on the geologic, tectonic, seismological and soil characteristics associated with a specific site or may be a spectrum constructed in accordance with the spectral shape in Sections 11.4.5 of the ASCE 7-05

Drift, see "Story Drift" definition.

Dual System is a structural system with the following features: (1) an essentially complete space frame that provides support for gravity loads; (2) resistance to lateral load provided by concrete shear walls or steel braced frames (EBF,SCBF or OCBF) and moment resisting frames (SMRF, IMRF, MMRWF or steel OMRF). The moment-resisting frames shall be designed to independently resist at least 25 percent of the base shear ; and, (3) each system designed to resist the total lateral load in proportion to its relative rigidity.

Equivalent Lateral Force Procedure can be used to estimate displacement demands for structures where a more sophisticated dynamic analysis will not provide additional insight into behavior. Equivalent Lateral Force Procedure is best suited for structures or individual frames with

well balanced spans and uniformly distributed stiffness where the response can be captured by a predominant translational mode of vibration.

Existing Building is a building for which a building permit was issued prior to April 1, 1994.

Flexible Diaphragms are the roofs and floors including, but not limited to, those sheathed with wood based sheathing and board sheathing (1-by or 2-by) or metal decks without concrete topping slab.

Irregular Structures are structures with significant physical discontinuities in configuration or in their lateral-force-resisting systems. Irregular features include, but are not limited to, those in LABC Tables 12.3-1 and 12.3-2 of the ASCE 7-05.

Joint Living And Work Quarter (Quarter) is a residential occupancy of one or more rooms or floors in a building originally designed for industrial or commercial occupancy which includes (1) cooking space and sanitary facilities and (2) adequate working space reserved for, and regularly used by, one or more persons residing therein pursuant to Health and Safety Code (H&SC) Section 17958.11 (a).

Life Safety is a code-level seismic evaluation where the building and nonstructural component are expected to experience some damages. The Life-Safety level design earthquake is taken as an event having a 10% probability of being exceeded in 50 years (475 year return period). The purpose of these analysis to check the strength and stiffness of structural members, their connections, and nonstructural components meet or exceed the corresponding demands. As implicit in building codes, damage is permitted as long as Life-Safety is not compromised.

Linear Dynamic Analysis shall be used to estimate the displacement demands for structures where Linear Static Analysis does not provide an adequate level of sophistication to estimate the dynamic behavior. A linear elastic multi-modal spectral analysis utilizing the appropriate response spectrum shall be performed. The number of degrees of freedom and the number of modes considered in the analysis shall be sufficient to capture at least 90% mass participation in the longitudinal and transverse directions.

Sources of nonlinear response that are not captured by Linear Dynamic Analysis include the effects of the surrounding soil, yielding of structural components, opening and closing of expansion joints, and nonlinear restrainer and abutment behavior.

Masonry Infill is the unreinforced or reinforced masonry wall construction within a reinforced concrete frame or steel frame.

Maximum Considered Earthquake (MCE) is the most severe earthquake effects considered by the code as defined in Section 11.4 of ASCE 7-05

Nonlinear Analysis is the seismic analysis in which a mathematical model directly incorporating the nonlinear load-deformation characteristics of individual components and elements of the building is subject to ground motions.

Nonlinear Static Analysis, commonly referred to as "push over" analysis, shall be used to determine the reliable displacement capacities of a structure or frame as it reaches its limit of structural stability.

It shall be performed using expected material properties of modeled members. Nonlinear static analysis is an incremental linear analysis, which captures the overall nonlinear behavior of the elements, including soil effects, by pushing them laterally to initiate plastic action. Each increment pushes the frame laterally, through all possible stages, until the potential collapse mechanism is achieved.

Because the analytical model accounts for the redistribution of internal actions as components respond inelastically, nonlinear static analysis is expected to provide a more realistic measure of behavior than can be obtained from elastic analysis procedures.

Regular Structures are structures with no significant physical discontinuities in plan or vertical configuration or in their lateral-force-resisting systems such as the irregular features described for irregular structures.

Story Drift is the horizontal displacement of one level relative to the level above or below calculated by using the lateral design force as specified in this Information Bulletin and the appropriate effective stiffness.

Performance - Based Engineering Analysis Structural design should be capable of providing a high level of confidence that damage will not exceed certain limits (such as rehabilitation objective of basic safety (BSO) as referenced in ASCE 41-06. The BSO in ASCE 41-06 requires a life safety performance level for BSE-1 and a collapse prevention performance level for BSE-2) given that the design ground motions, as specified in this Information Bulletin, are experienced and are not lower than the requirement.

The permissible level of damage is termed a performance level while the combined specification that the performance level not be exceeded for a specific ground shaking hazard is termed a performance objective.

Performance-based engineering analysis refers to methodology in which structural criteria are expressed in terms of achieving a performance objective. This is in contrast to a conventional method in which structural criteria are defined by limits on member forces resulting from a prescribed level of applied base shear force.

Pushover Analysis is an nonlinear static analysis which involves applying horizontal loads, in a prescribed pattern, to a computer model of the structure, incrementally; i.e., “pushing” the

structure; and plotting the total applied load shear force and associated lateral displacement at each increment, until the structure reaches a limit state or collapse condition.

Semi-rigid, Beam-Column Connection is a semi-rigid framing (partially restrained) as defined by AISC, 13th Edition.

XI. REFERENCES

ASCE 7-05, MINIMUM DESIGN LOADS FOR BUILDINGS AND OTHER STRUCTURES

ASCE 41-06, SEISMIC REHABILITATION OF EXISTING BUILDINGS published by American Society of Civil Engineers.

ATC-40, SEISMIC EVALUATION AND RETROFIT OF CONCRETE BUILDINGS

FEMA 351 "RECOMMENDED SEISMIC EVALUATION AND UPGRADE CRITERIA FOR EXISTING WELDED STEEL MOMENT-FRAME BUILDINGS" is the July 2000 edition prepared by the partnership of the Structural Engineers Association of California, the Applied Technology Council, and the California Universities for Research in Earthquake Engineering (SAC) Joint Venture for the Federal Emergency Management Agency, Washington, DC.

FEMA 352, "RECOMMENDED POST-EARTHQUAKE EVALUATION AND REPAIR CRITERIA FOR WELDED STEEL MOMENT-FRAME BUILDINGS" is the July 2000 edition prepared by the partnership of the Structural Engineers Association of California, the Applied Technology Council, and the California Universities for Research in Earthquake Engineering (SAC) Joint Venture for the Federal Emergency Management Agency, Washington, DC.

INTERNATIONAL EXISTING BUILDING CODE (IEBC) 2009 published by International Council Code.

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SELECTION OF LATERAL ANALYSIS PROCEDURE CHART

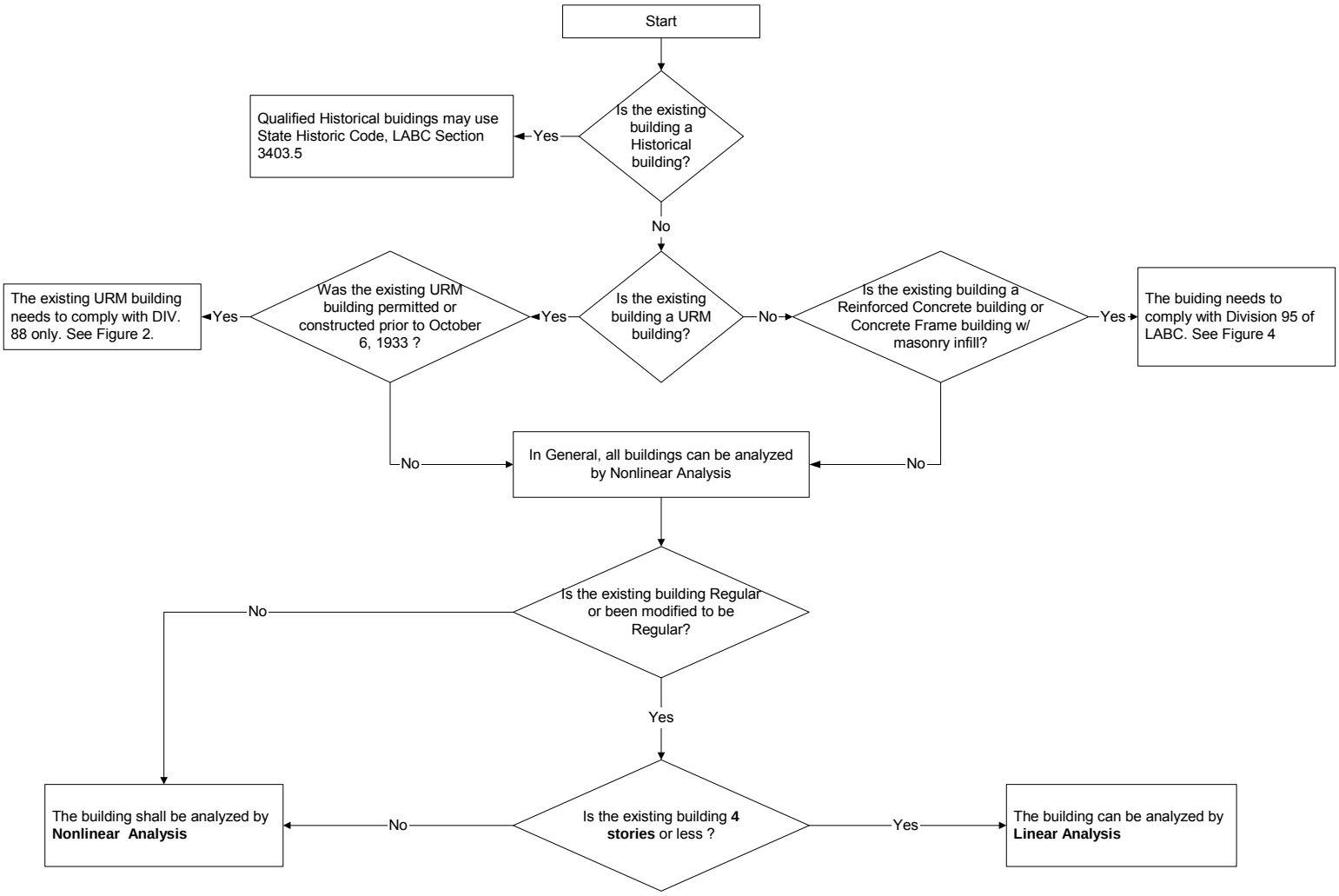

FIGURE 1

LABC DIVISION 88 , URM BUILDINGS

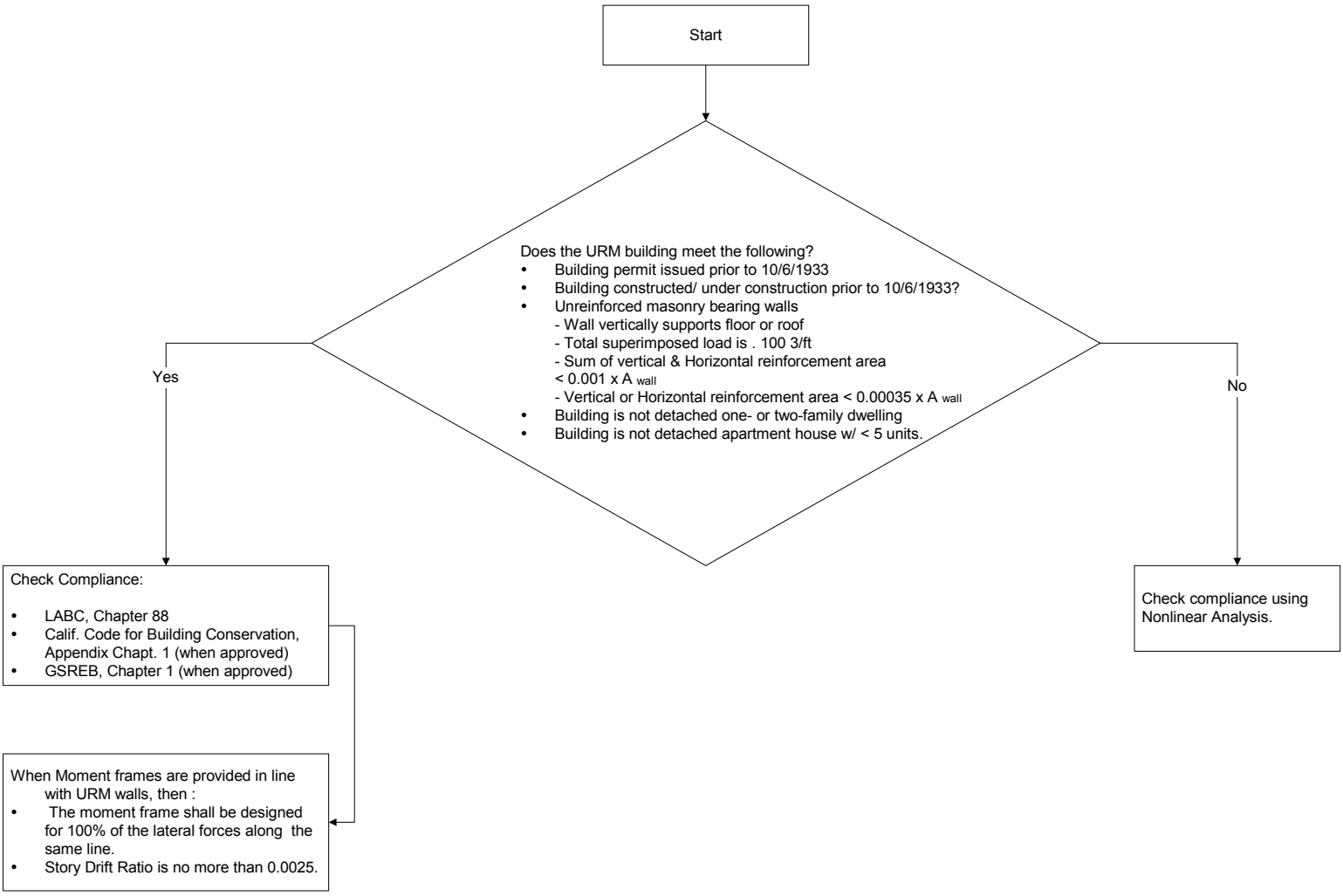

FIGURE 2

REINFORCED MASONRY AND CONCRETE BEARING WALL BUILDINGS

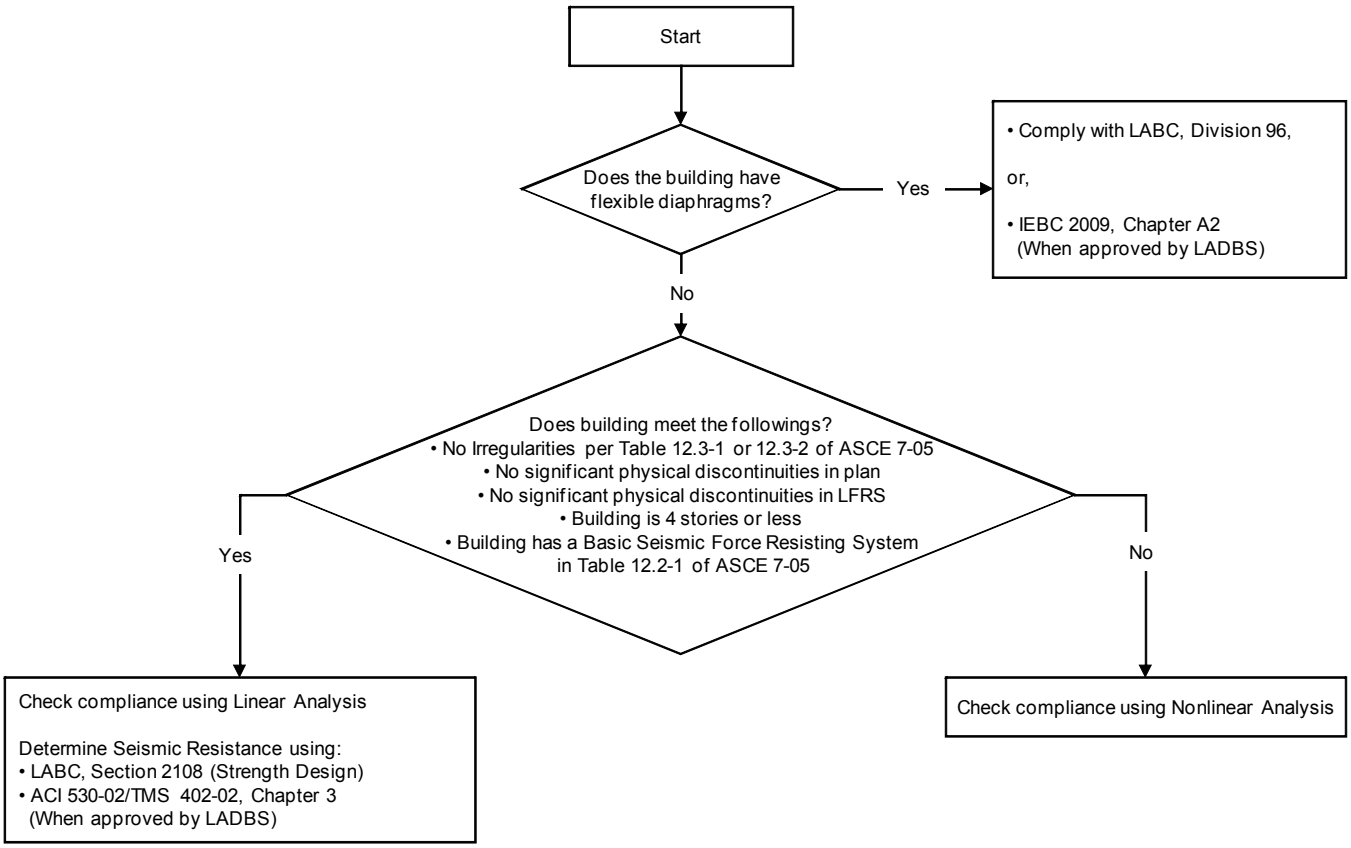

FIGURE 3

REINFORCED CONCRETE BUILDINGS AND CONCRETE MOMENT FRAME BUILDINGS WITH OR WITHOUT MASONRY INFILLS

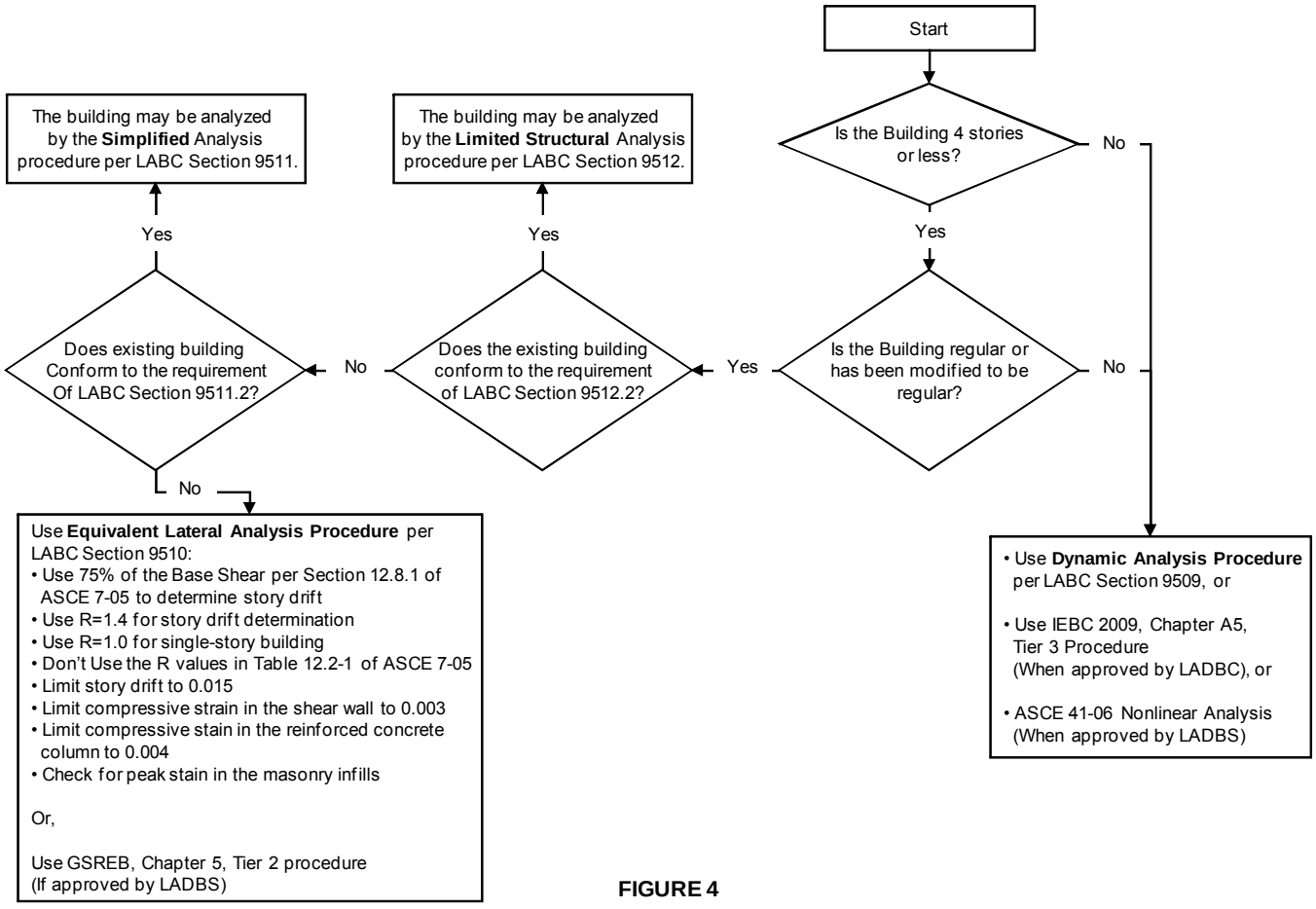

FIGURE 4

STEEL MOMENT FRAMES WITH OR WITHOUT INFILLS

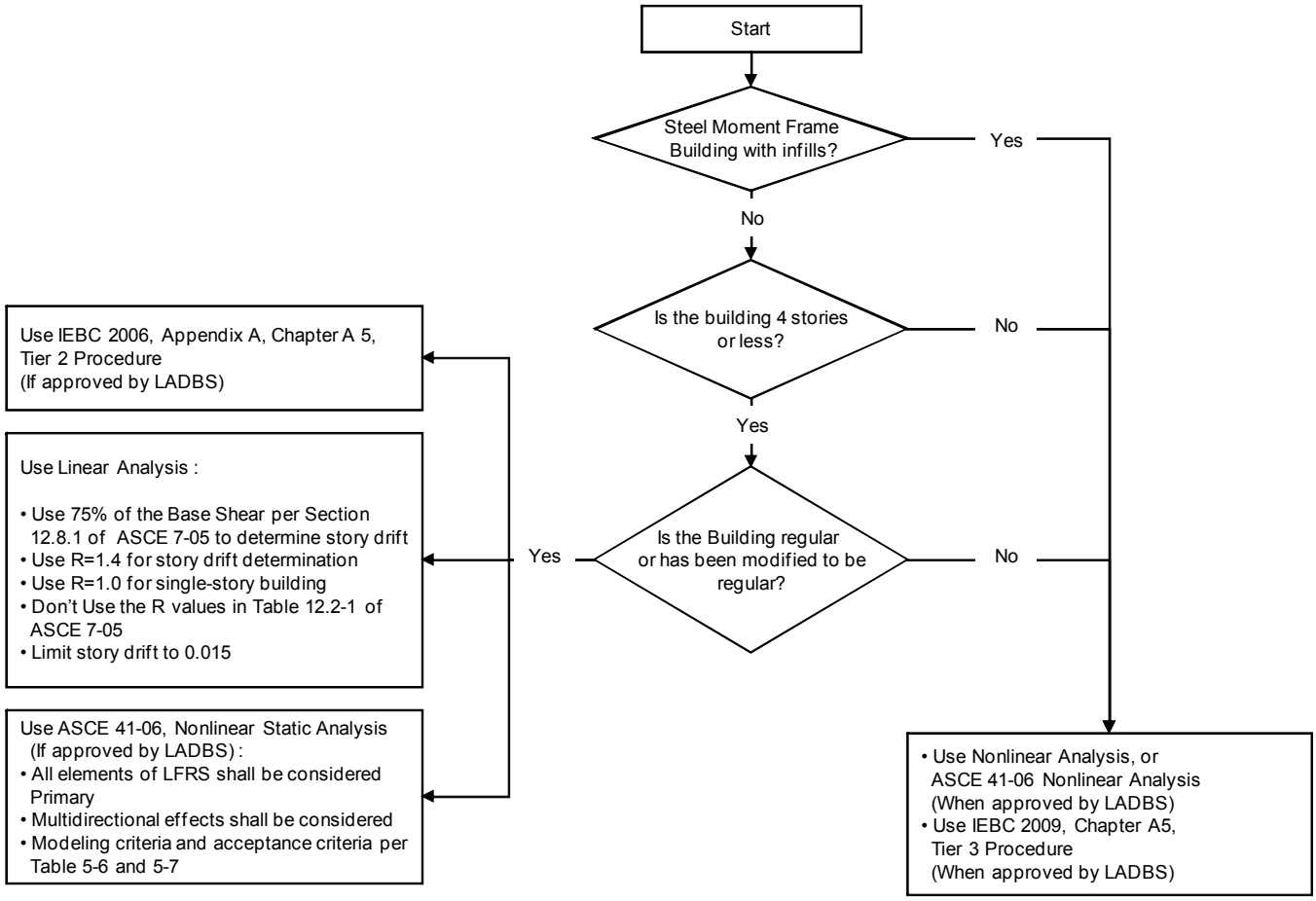

FIGURE 5

DUAL SYSTEMS, STEEL MOMENT FRAMES AND CONCRETE SHEAR WALLS

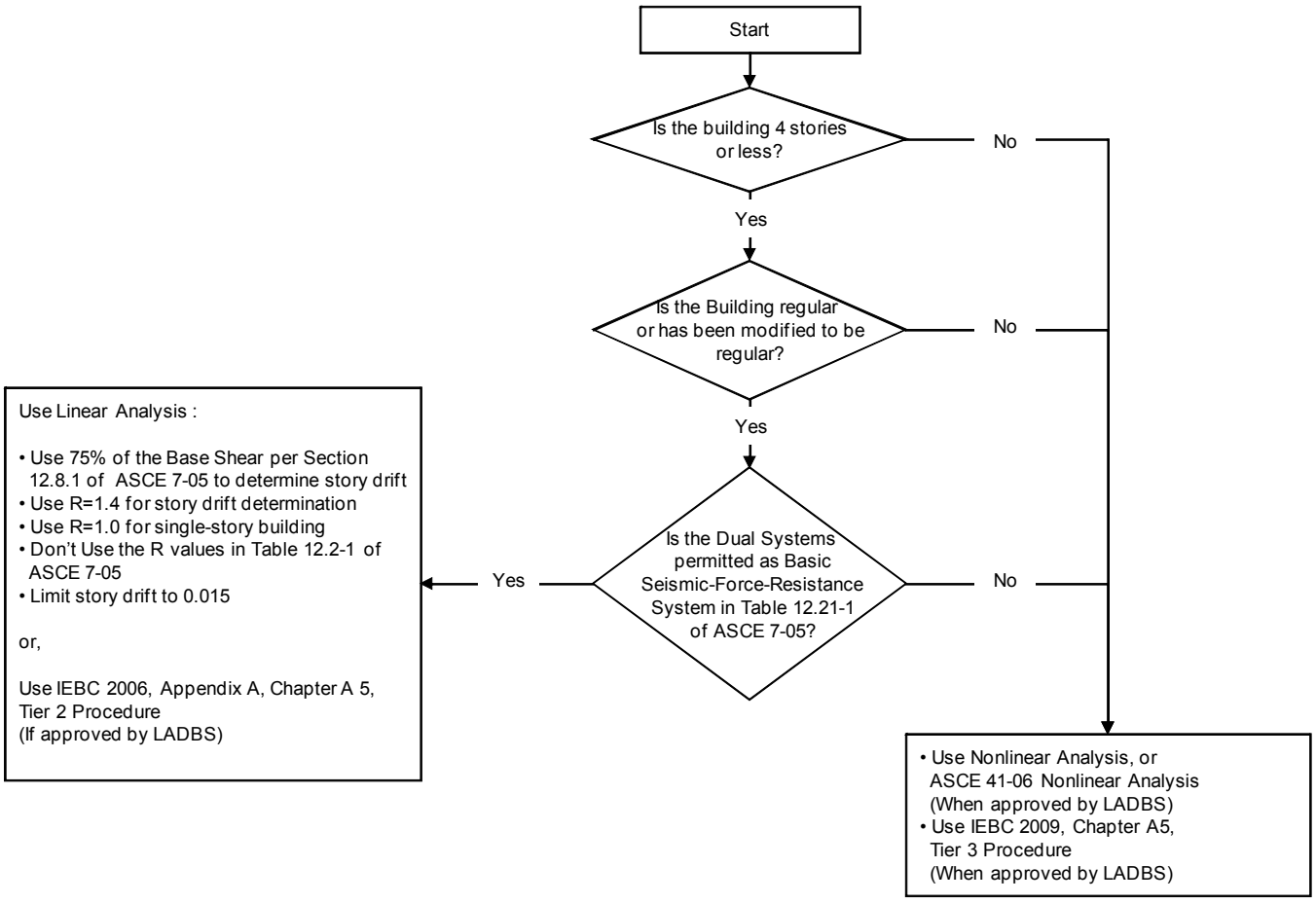

FIGURE 6