PROTOCOL FOR DETERMINING REQUIRED RETROFIT OF EARTHQUAKE DAMAGED BUILDINGS

PURPOSE

This Information Bulletin establishes procedures and provides examples to clarify the Los Angeles Building Code (LABC) regarding retrofit requirements of earthquake damaged buildings, based on Definitions found in this Bulletin, Ordinance 184169, and LABC Section 202 and Section 3405 requirements for evaluation and repair.

The following LABC sections, were revised by Ordinance 184169, effective May 1, 2016, provide requirements for repair of earthquake damaged buildings:

- Section 3405.2 - Substantial structural damage to vertical elements of the lateral force-resisting systems
- Section 3405.3 - Substantial structural damage to gravity load-carrying components
- Section 3405.4 - Less than substantial structural damage

I. DEFINITIONS

COMPLIANT BUILDING is a building originally constructed according to the Code in effect prior to January 1, 2011, with capacity to resist at least 75% of the 2014 LABC Section 1613 for earthquake loads and Section 1609 for wind loads at its pre-damage state. For buildings constructed according to the Code in effect on or after January 1, 2011, if the evaluation establishes compliance of the pre-damage building in accordance with Section 91.3405.2.1.

CONCRETE BUILDING is a building having concrete floors and/or roofs, either with or without beams, supported by concrete walls and/or concrete columns, with or without masonry infills, and any combination thereof.

CURRENT CODE/THIS CODE is the 2014 Los Angeles Building Code.

NONCOMPLIANT BUILDING is a building originally constructed according to the Code in effect prior to January 1, 2011, with capacity to resist less than 75% of the 2014 LABC Section 1613 for earthquake loads and Section 1609 for wind loads at its pre-damaged state. For buildings constructed according to the Code in effect on or after January 1, 2011, if the evaluation does not establish compliance of the pre-damage building in accordance with Section 91.3405.2.1.

NON-DUCTILE CONCRETE BUILDING is a concrete building that was built pursuant to a permit application for a new building submitted before January 13, 1977, or if no permit can be located, is determined by the Department to have been built under building Code standards enacted before January 13, 1977.
SUBSTANTIAL STRUCTURAL DAMAGE, is a condition in the following building types where the building is structurally weakened in a manner described below:

1. Non-ductile Concrete Buildings or Unreinforced Bearing Wall Masonry Bearing Wall Buildings where:
   a. In any story, the vertical elements of the lateral force-resisting system have suffered damage such that the lateral load-carrying capacity of the building in any horizontal direction has been reduced by more than 10 percent from its pre-damage condition; or
   b. The capacity of any vertical gravity load-carrying component, or any group of such components, that supports more than 30 percent of the total area of the structure’s floor(s) and roof(s) has been reduced by more than 20 percent from its pre-damage condition and the remaining capacity of such affected elements, with respect to all dead and live loads, is less than 75 percent of that required by the current Code for new buildings of similar structure, purpose and location.

2. All other Buildings where:
   a. In any story, the vertical elements of the lateral force-resisting system have suffered damage such that the lateral load-carrying capacity of the building in any horizontal direction has been reduced by more than 20 percent from its pre-damaged condition; or
   b. The capacity of any vertical gravity load-carrying component, or any group of such components, that supports more than 30 percent of the total area of the structure’s floor(s) and roof(s) has been reduced by more than 20 percent from its pre-damaged condition and the remaining capacity of such affected elements, with respect to all dead and live loads, is less than 75 percent of that required by the current Code for new buildings of similar structure, purpose and location.

UNREINFORCED MASONRY BEARING WALL BUILDING is a building with at least one masonry wall that relies on the tensile strength of masonry units, mortar and grout in resisting design loads, and in which the area of reinforcement is less than 25 percent of the minimum ratio required by the building Code for reinforced masonry that provides vertical support for the reaction of floor or roof-framing members.

II. REQUIREMENTS

LABC definition of Substantial Structural Damage involves evaluation of the following, pursuant to the method described in LABC Section 3405.2.1 (as adopted by Ordinance 184169):

- Whether, in the pre-damaged state the building was designed to carry 100% of the gravity loads, current Code drift limits and lateral loads as described in Section 3405.2.1. (compliant Buildings).
• Relative damage level to the vertical elements of the lateral force-resisting systems, according to parts 1.a and 2.a of the substantial structural damage definitions.

• Relative damage level to gravity load-carrying components according to parts 1.b and 2.b of the substantial structural damage definitions.

A. Buildings with Substantial Structural Damage to Vertical Elements of the Lateral Force-Resisting System

Section 3405.2 through 3405.2.3 describes the requirements for damage evaluation and the triggers for seismic retrofit of earthquake damaged buildings:

Section 3405.2 - Substantial Structural Damage to Vertical Elements of the Lateral Force-Resisting System

A building that has sustained substantial structural damage to the vertical elements of its lateral force-resisting system shall be evaluated and repaired in accordance with the applicable provisions of Sections 3405.2.1 through 3405.2.3.

Exceptions:

1. Buildings assigned to Seismic Design Category A, B, or C whose substantial structural damage was not caused by earthquake need not be evaluated or rehabilitated for load combinations that include earthquake effects.

2. One- and two-family dwellings need not be evaluated or rehabilitated for load combinations that include earthquake effects.

Section 3405.2.1 - Evaluation

The building shall be evaluated by a registered design professional, and the evaluation findings shall be submitted to the building official. The evaluation shall establish whether the damaged building, if repaired to its pre-damage state, would comply with the provisions of this Code for wind loads, earthquake loads, and drift.

Wind loads for this evaluation shall be those prescribed in Section 1609. Earthquake loads for this evaluation, if required, shall be permitted to be 75 percent of those prescribed in Section 1613 for buildings built before January 1, 2011. Earthquake loads for this evaluation shall be those prescribed in Section 1613 for buildings designed in accordance with the 2011 Los Angeles Building Code or later edition.

Section 3405.2.2 - Extent of Repair for Compliant Buildings

For buildings originally constructed according to the Code in effect before January 1, 2011, if the evaluation establishes compliance of the pre-damaged building in accordance with Section 3405.2.1, then repairs shall be permitted to restore the building to its pre-damage state, based on material properties and design strengths applicable at the time of original construction. For buildings originally constructed according to the Code in effect on or after January 1, 2011, if the evaluation establishes compliance of the pre-damage building in accordance with Section
91.3405.2.1, then repairs shall be as required by this Code for new buildings of similar structure, purpose and location.

**Section 3405.2.3 - Extent of Repair for Noncompliant Buildings**

If the evaluation does not establish compliance of the pre-damage building in accordance with Section 3405.2.1, then the building shall be rehabilitated to comply with applicable provisions of this Code for load combinations that include wind loads, or seismic loads, and drift. The wind loads for the repair shall be as required by the Code in effect at the time of original construction, unless the damage was caused by wind, in which case the wind loads shall be as required by this Code. Earthquake loads for this rehabilitation design shall be those required for the design of the pre-damage building, which may not be less than 75 percent of the loads prescribed in Section 1613. Any replaced or new structural members and connections required by this rehabilitation design shall comply with the detailing provisions of this Code for new buildings of similar structure, purpose and location.

The attached Flow Charts 1 and 2 and the following simplified example illustrate the application of the LABC definition of Substantial Structural Damage and repair/rehabilitation requirements of earthquake damaged buildings. In general, a detailed evaluation analysis by a California registered design professional is required to justify the post-earthquake lateral capacity of a damaged building compared to its pre-damaged condition.

**Example 1 – Damaged Vertical Elements of the Lateral Load Resisting System:** A 5-story concrete building constructed in 1940 with vertical elements of the lateral load resisting system consisting of a total of 250 concrete columns (50 columns per each of 5 stories). The engineer’s report identified cracked rebar in 40 columns on the first story as the result of a recent earthquake. The 40 damaged columns provide 16% of the lateral load carrying capacity. In addition, the engineer’s evaluation shows that the pre-damaged building strength is noncompliant with the current Code (i.e. original design level for earthquake loads is less than 75% of the current Code).

**Has Substantial Structural Damage Been Observed?**

Since the building is a non-ductile building and due to damage to the first story columns the lateral load-carrying capacity of the structure has been reduced by more than 10% of its pre-damaged condition, the damage to the building is of the level of Substantial Structural Damage.

**What type of repair is required?**

Since the original building design is based on lateral forces less than 75% of the current Code, the building is considered to be noncompliant with the current Code and pursuant to LABC Section 3405.2.3 the building shall be retrofitted. (see Flow Chart 1)

**What level of retrofit is required?**

Since, the evaluation established that the pre-damaged building strength for earthquake loads is noncompliant with the current Code (i.e. original design level less than 75% of the current Code), the building shall be retrofitted to resist at least 75% of the current Code seismic requirements according to Sections 3405.3 and 3405.2.3.

**B. Buildings with Substantial Structural Damage to Gravity Load-Carrying Components**
LABC Sections 3405.3 and 3405.3.1 describe the repair/rehabilitation requirements and evaluation for substantial structural damage to gravity load-carrying components:

**Section 3405.3 - Substantial structural damage to gravity load-carrying components**
Gravity load-carrying components that have sustained substantial structural damage shall be rehabilitated to comply with the applicable provisions of this Code for dead and live loads. Snow loads shall be considered if the substantial structural damage was caused by or related to snow load effects. Existing gravity load-carrying structural elements shall be permitted to be designed for live loads approved prior to the damage. Non-damaged gravity load-carrying components that receive dead, live or snow loads from rehabilitated components shall also be rehabilitated or shown to have the capacity to carry the design loads of the rehabilitation design. New structural members and connections required by this rehabilitation design shall comply with the detailing provisions of this Code for new buildings of similar structure, purpose and location.

**Section 3405.3.1 - Lateral force-resisting elements**
Regardless of the level of damage to vertical elements of the lateral force-resisting system, if substantial structural damage to gravity load-carrying components was caused primarily by wind or earthquake effects, then the building shall be evaluated in accordance with Section 3405.2.1 and, if noncompliant, rehabilitated in accordance with Section 3405.2.3.

**Exceptions:**
1. One- and two-family dwellings need not be evaluated or rehabilitated for load combinations that include earthquake effects.
2. Buildings assigned to Seismic Design Category A, B, or C whose substantial structural damage was not caused by earthquake need not be evaluated or rehabilitated for load combinations that include earthquake effects.

The following example illustrates the determination of whether a building needs retrofitting in addition to repair.

**Example 2 – Damaged Gravity Load Elements:** A 3-story unreinforced masonry bearing wall building constructed in 1910 was damaged by an earthquake wherein repair to the timber interior load bearing system is being evaluated. The engineer’s report identified damage to interior bearing walls located only on the second and third story. This group of damaged walls support more than 30% of the total area of the building’s floors and roof. The observed damage to the bearing walls were that walls are out-of-plumb with cracked plaster and a few cracked studs. The damaged walls represent a loss of more than 20% of the capacity of their vertical gravity load-carrying from its pre-damaged condition. The engineer’s report shows that these columns cannot support the combined dead load plus the live load required by the current Code.

**Is there Substantial Structural Damage?**
Since the gravity load carrying capacity of these bearing walls carry more than 30% of the total gravity load from the roof and floors has been lost by more than 20% of their pre-damaged capacity,
the damage to the building fits the definition of Substantial Structural Damage to gravity load carrying members.

**What level of retrofit is required?**
Pursuant to LABC Section 3405.3, the damaged bearing walls shall be repaired to support the dead and live load combinations of the current Code. Other floor joists, walls, and foundations that support loads from the repaired bearing walls are required to be repaired and replaced when not capable of supporting the dead plus current live load combination.

C. **Buildings with less than Substantial Structural Damage**

LABC Section 3405.4 describes the requirements for damage evaluation and how to determine that seismic retrofit is not required for earthquake damaged buildings:

**Section 3405.4 - Less Than Substantial Structural Damage**

For damage less than substantial structural damage, repairs shall be allowed that restore the building to its pre-damage state, based on material properties and design strengths applicable at the time of the original construction. Any replaced or new structural members and connections used for this repair shall comply with the detailing provisions of this Code for new buildings of similar structure, purpose and location.

The following example illustrates how to determine if the earthquake damaged building has sustained less than substantial structural damage and determine repair requirements for earthquake damaged building. The building does NOT require retrofitting.

**Example 3 – Less Than Substantial Structural Damage:** A 3-story apartment building built in 1970 with timber, plaster and gypsum over wood shear walls experienced cracking of stucco and gypsum plaster in only one wall on the first floor. The engineer’s report identified the damaged wall will reduce the lateral load resisting elements by 10%. This wall supports only 5% of the total floor and roof area and the vertical capacity of the wall has not been diminished. The engineer’s evaluation shows that the pre-damaged building strength is non-compliant with the current Code.

**Is there Substantial Structural Damage?**

Part 2 of the definition of Substantial Structural Damage for “All Other Buildings” needs to be used for a timber building. The report concluded the damaged wall constitutes less than 20% of the pre-damaged condition of the lateral force resisting system. The damaged wall supports less than 30% of the total load from the roof and floors and has not lost capacity, the damage to the building is Less Than Substantial Structural Damage.

**Is retrofit required?**

As per LABC Section 3405.4 no retrofit is required for buildings with less than substantial structural damage. Therefore, repairs shall be done to restore the building to the pre-damaged status.

**What design criteria may be used for repairs?**

Repairs are permitted to restore the building to its pre-damage state, using material properties and design strengths applicable at the time of the original construction. All new structural members,
connections and detailing used for this repair shall comply with provisions of this Code for new buildings of similar structure, purpose and location. (See flow Chart 2)

The following example illustrates how to determine if a newer building, constructed to the current Code, has sustained substantial structural damage and determine repair requirements for earthquake damaged building. The building does NOT require retrofitting.

**Example 4 – Modern Building with Substantial Structural Damage:** A timber single-family-dwelling built in 2015 wood shear walls experienced structural cracking of several plywood shear walls on the first floor. The engineer’s report identified the damaged wall will reduce the cumulative strength of the lateral load resisting system by 25%. The engineer’s evaluation shows that the pre-damaged building strength was compliant with the current Code.

**Is there Substantial Structural Damage?**
Part 2 of the definition of Substantial Structural Damage for “All Other Buildings” needs to be used for a timber building. The report concluded the damaged walls constitutes more than 20% of the pre-damaged condition of the lateral force resisting system in the first story. Therefore, the damage to the building is Substantial Structural Damage.

**Is retrofit required?**
As per LABC Section 3405.2.2 repairs shall be done to restore the building to the pre-damaged status. Strengthening beyond the current Code is not required.

**What design criteria may be used for repairs?**
Repairs are permitted to restore the building to its pre-damage state, using material properties and design strengths applicable at the time of the original construction. All new structural members, connections and detailing used for this repair shall comply with provisions of this Code for new buildings of similar structure, purpose and location. (See flow Chart 2)
Flow Chart 1 - Required Repair Level for Damaged Non-Ductile Concrete Buildings & Unreinforced Bearing Wall Buildings

1. Damaged Buildings

2. Compliant Building Section 3405.2.1

3. Is the damage more than:
   * a. 10% or
   ** b. 30%/20%
   *** c. Survey

4. Yes → 1) Repair to pre-damaged state based on code levels in original design per Section 3405.2.2
   2) Detailing of new members per current code

5. No → 3) Non-damaged gravity load-carrying components receiving load from rehabilitated components shall be rehabilitated to carry rehabilitated design load.

6. Is the damage more than:
   * a. 10% or
   ** b. 30%/20%

7. No → 1) Repair gravity load system for current code load combinations per Section 3405.2.3
   2) Rehab entire building, but not less than 75% lateral load levels of current code per Section 3405.2.3
   3) New members, connections & detailing per current code

8. Yes → 1) Rehabilitated gravity load system to comply with current code for dead and live loads per Section 3405.3, if required
   2) Evaluate and Rehab entire building per Section 3405.2.3
   3) New members, connections & detailing per current code

9. Notes:
   * a. In any story, the vertical elements of the lateral force-resisting system have suffered damage such that the lateral load-carrying capacity of the building in any horizontal direction has been reduced by more than 10 percent from its pre-damaged condition; or
   ** b. The capacity of any vertical gravity load-carrying component, or any group of such components, that supports more than 30 percent of the total area of the building’s floors and roofs has been reduced by more than 20 percent from its pre-damaged condition and the remaining capacity of such affected elements, with respect to all dead and live loads, is less than 75 percent of that required by the current code for new buildings of similar structure, purpose and location.
   *** c. Survey should be performed per one of the two detailed evaluation procedures outlined in Chapter 4 of FEMA 352

10. Less than substantial structural damage, restore damaged area to pre-damaged state.
    For damage less than substantial structural damage, repairs shall be allowed that restore the building to its pre-damaged state, based on material properties and design strengths applicable at the time of original construction. Any replaced or new structural members and connections used for this repair shall comply with the detailing provisions of current code for new buildings of similar structure, purpose and location. Section 3405.4
Flow Chart 2 - Required Repair Level for All Other Damaged Buildings

1. Damaged Buildings
   - 2. Compliant Building
     - Section 3405.2.1
     - Is the damage more than:
       - * a. 20% or
       - ** b. 30%/20%
       - *** c. Survey
     - Yes
     - 3. Substantial Structural Damage to Vertical elements of lateral force-resisting system
       - (a)
       - 4. 1) Repair to pre-damaged state based on code levels in original design per Section 3405.2.2
         - 2) Detailing of new members per current code
     - No
     - 5. 1) Evaluate & Rehab damaged components to comply with the current code per Section 3405.3 & 3405.3.1
         - 2) New structural members, connections and detailing per current code
         - 3) Non-damaged gravity load-carrying components receiving load from rehabilitated components shall be rehabilitated to carry rehabilitated design load.
   - 7. Is the damage more than:
     - * a. 20% or
     - ** b. 30%/20%
     - No
     - 6. 1) Repair gravity load system for current code load combinations per Section 3405.2.3
         - 2) Rehab entire building, but not less than 75% lateral load levels of current code per Section 3405.2.3
         - 3) New members, connections & detailing per current code
     - Yes
     - 8. 1) Rehabilitated gravity load system to comply with current code for dead and live loads per Section 3405.3, if required
         - 2) Evaluate and Rehab entire building per Section 3405.2.3
         - 3) New members, connections & detailing per current code
         - 4) Non-damaged gravity load-carrying components receiving load from rehabilitated components shall be rehabilitated to carry rehabilitated design load.
   - 10. Less than substantial structural damage, restore damaged area to pre-damaged state.
     - Notes:
       - * a. In any story, the vertical elements of the lateral force-resisting system have suffered damage such that the lateral load-carrying capacity of the building in any horizontal direction has been reduced by more than 20 percent from its pre-damaged condition; or
       - ** b. The capacity of any vertical gravity load-carrying component, or any group of such components, that supports more than 30 percent of the total area of the building’s floors and roofs has been reduced by more than 20 percent from its pre-damaged condition and the remaining capacity of such affected elements, with respect to all dead and live loads, is less than 75 percent of that required by the current code for new buildings of similar structure, purpose and location.
       - *** c. Survey should be performed per one of the two detailed evaluation procedures outlined in Chapter 4 of FEMA 352.