

## **Sample Engineering Case Study Seismic Non-structural Retrofitting**

### **Introduction**

In an effort to improve the quality of project applications, engineering case studies have been prepared for several common mitigation measures. The engineering cases studies provide focus on the types of information and data needed to ensure completeness of the sections of the project application affecting engineering feasibility. Of particular importance in the engineering review are:

- Scope of Work, including:
  - Problem Description and Proposed Solution;
  - Description of Existing Condition; and,
  - Work Schedule.
- Cost Estimate, including:
  - Conducting the Benefit-Cost Analysis;
  - Anticipated environmental resource remediation or historic property treatment measures;
  - Engineering schematics, detailed engineering drawings, or engineering designs;
  - Other related construction/demolition/relocation costs, such as survey, permitting, site preparation, material disposal; and,
  - Other related acquisition costs, such as appraisals, legal recordation, displacement costs for renters, maintenance.

For each of these sections in the project sub-application, the engineering case studies describe the general type of information that a Sub-applicant should submit. In order to provide additional guidance, the case studies also include sections of a sample project application that present the kind of specific information that the Sub-applicant would need to include in each engineering-related section to support the proposed project. These engineering case studies are not meant to represent complete project applications. Some relevant project information related to historic and environmental impacts, as well as information regarding the project's cost effectiveness may not be included.

The goal of seismic non-structural retrofitting is to reduce the risk of death, serious injury, and property damage during a future earthquake event. This is typically accomplished by securing, bracing or isolating architectural elements, mechanical equipment, and building contents. Before undertaking a seismic non-structural retrofitting project, sub-applicants should first ensure the structural systems of their facilities are structurally adequate, especially true unreinforced masonry or non-ductile concrete framed buildings. It makes little sense to strap down computer monitors when the structure may be at risk of collapse.

Some common examples of non-structural retrofitting seismic mitigation are providing secure attachments for:

- Exterior facade panels or brick masonry;
- Architectural ornaments, roof parapets and chimneys;
- Heavy interior partition walls;
- Utility and mechanical equipment/systems such as heating, ventilation, air conditioning, water/sewer, gas, electric, ductwork, pipes, motors, pumps, and fans;
- Communication equipment and distribution;
- Drop ceilings and pendant lighting;

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- Lens covers on fluorescent light fixtures;
- Mirrors, paintings, clocks, and similar heavy/fragile wall-mounted objects;
- Computers and monitors; and
- Filing cabinets, bookcases, and lockers.

Other examples of non-structural retrofitting seismic mitigation include:

- Removing heavy ornaments or other features determined not to be needed;
- Replacing or jacketing hollow clay tile walls, especially in stairways and exit corridors;
- Arranging building contents to reduce risk of falling hazards;
- Storing fragile items and equipment on or near floors; and
- Securing all dangerous chemicals to prevent container breakage.

Following is a list of useful references:

- Applicable building code/edition or engineering standard used, including but not limited to International Building Code (IBC), International Existing Building Code (IEBC), and NFPA 5000 Building Construction and Safety Code;
- American Society of Civil Engineers (ASCE) 7-02 *Minimum Design Loads for Buildings and Other Structures*;
- ASCE 31-03, *Seismic Evaluation of Existing* (based on FEMA 310, *Handbook for the Seismic Evaluation of Buildings – a Prestandard*);
- FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (ASCE 41 balloting in process); and
- FEMA 450, National Earthquake Hazards Reduction Program (NEHRP) *Recommended Provisions for New Buildings and Other Structures*

The publication ASCE 31-03, *Seismic Evaluation of Existing Buildings* provides the design professional with a standard methodology for identifying seismic deficiencies in buildings. Non-structural retrofitting elements are covered in Sections 3.9 and 4.8 of this publication.

### **Scope of Work**

The Scope of Work (SOW) must contain sufficient detail to evaluate effectiveness in reducing the identified seismic hazards. It must also be detailed enough to develop a reasonably accurate cost estimate. Technical documentation (including sketches and engineering calculations) should be provided with the sub-application to demonstrate that the proposed work will successfully mitigate against future earthquake damage. The SOW should include the following as well as applicable references and supporting documentation:

- Dimensions, locations, and material properties for all connectors, braces, isolators, straps and other devices to be installed;
- Description of any work required due to compliance with any Federal, state and local laws, regulations, and ordinances, such as historic preservation issues or accessibility requirements;
- References to all design provisions consulted including Federal, state and local building codes and standards.

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- Proposed schematic or detailed engineering drawings, or engineering design, including calculations demonstrating the effectiveness of the proposed solution in mitigating the seismic hazards.
- Applicable building code/edition or engineering standard used;
- Level of protection provided by the proposed project
- Any residual risk to the structure from all hazards after project implementation;
- Proposed project details
  - Description of the proposed activity to correct the identified seismic non-structural deficiencies including a discussion of any alternative schemes considered;
  - Description of design criteria; and
  - Description of any work required due to compliance with any Federal, state and local laws, regulations, and ordinances, such as historic preservation issues or accessibility requirements.

### ***Sample Scope of Work***

*The Richter County Sheriff's Department contracted with ABC Consultants to evaluate non-structural retrofitting seismic hazards in their 3-story Administration Building. ABC was also asked to recommend mitigation measures for these conditions. Using the Non-structural Checklists provided in Sections 3.9 and 4.8 of ASCE 31-03, Seismic Evaluation of Existing Buildings, ABC was able to identify several hazardous conditions in the building. These conditions as well as corrective measures are described in detail in ABC's 16-page report entitled "Nonstructural Seismic Hazards – Richter County Sheriff's Department Administration Building", dated August 14, 2005. This report has been attached as backup documentation to this sub-application. Design calculations for the precast tiebacks were based on the provisions of the 2003 International Building Code using an MCE for the building's exact location.*

*The scope of work consists of the following items:*

1. *Provide 24 tiebacks at exterior precast panel sections adjacent to building entrance on Elm Street. Tiebacks shall be 3/4" diameter stainless steel threaded rod, double nutted to structural steel spandrel beams with plate washers. Epoxy grout holes in precast panels to 1/2" from surface. Patch surface hole to match panel. See Sketch S-1.*
2. *Provide bracing for light fixtures in 3<sup>rd</sup> floor cafeteria, 32 locations. See Sketch S-2.*
3. *Secure chemical storage in basement Crime Lab per Sketches S-3 and S-4. Provide seismic straps for office equipment as follows (See Sketch S-5):*
  - *Type A (48 locations) – strap computer monitors to desks*
  - *Type B (17 locations) – strap computer monitors to desks, attach 4-drawer file cabinets to walls, attach bookcases to walls*
4. *Regroup and gang connect filing cabinets in records storages areas in Basement, 2<sup>nd</sup> floor and 3<sup>rd</sup> floor. See Sketch S-6.*

*Note: The attached sketches are preliminary and have been provided for cost estimating purposes only.*

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### **Problem Description and Proposed Solution**

At a minimum, be sure to include the following items:

- Site specific seismic hazard data for the Maximum Considered Earthquake (MCE) spectral response accelerations for periods of 0.2 second ( $S_S$ ) and/or 1.0 second ( $S_1$ );
- Description of any damage sustained in past earthquakes; and
- Descriptions of all identified of non-structural seismic deficiencies.

The current engineering practice is to design for a MCE used for collapse prevention. Except in near-fault areas, it is equivalent to the earthquake having a 2 percent chance of occurrence in 50 years. For new construction, it is generally multiplied by a factor of 2/3 to produce life safety level design. Site specific seismic hazard data is required for both evaluation and design. This data consists of the MCE spectral response accelerations for periods of 0.2 second ( $S_S$ ) and 1.0 second ( $S_1$ ). Values for these parameters can be obtained from the USGS website <http://earthquake.usgs.gov/hazmaps> as well as ASCE 7-02. This data is also available in the 2003 IBC and may be available in the sub-applicant's local building code.

### ***Sample Problem Description and Proposed Solution***

*The ABC Consultants report "Nonstructural Seismic Hazards – Richter County Sheriff's Department Administration Building" discusses the ASCE 31-03 procedure used to evaluate the nonstructural elements of this building. The report goes on to recommend corrective measures. Sketches and engineering calculations for the precast tiebacks are included. Also provided are site specific MCE spectral response accelerations to establish the seismicity of the building's location. For details, see the ABC Consultants report attached as backup to this sub-application.*

*The most serious condition identified by ABC was the inadequacy of the precast connections at the building's entrance on Elm Street. Existing connections were found to be seriously overstressed by MCE loading. Refer to page 4 the ABC report for discussion. ABC's corrective measures call for the installation of additional tiebacks for these panels. Tiebacks were designed per the provisions of the 2003 IBC. ABC also reviewed the original precast shop drawings for loads imposed on the panels by their new connections.*

*Besides bracing light fixtures and strapping down computers, filing cabinets, and bookcases, ABC is also recommending the reorganization of all chemicals stored in the Basement Crime Laboratory. Currently these materials are kept on open shelves and in unsecured cabinets. ABC's revised storage scheme provides compartmentalized storage in lower height secured cabinets.*

### **Description of Existing Conditions**

The following information regarding the building should be included in the property description of the application:

- Age of structure (year built) (enter data into Property section (Part 2 of 3) Property Information);
- Date of any upgrades or additions;
- Structure type (ASCE 31-03, Table 2-2) (enter data into Property section (Part 2 of 3) Property Information);

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- Site Classification (ASCE 7-02, Table 9.4.1.2);
- Occupancy Category (ASCE 7-02, Table 1-1);
- Seismic Use Group (ASCE 7-02, Table 9.1.3);
- Foundation type (enter data into Property section (Part 2 of 3) Property Information);
- Number of floors, including basement and dimensions including inter-story heights (enter data into Property section (Part 2 of 3) Property Information);
- Floor and roof diaphragm construction (to evaluate flexibility);
- Location of any seismic isolation joints; and
- Description of architectural finishes (floors, walls, and ceilings) and glazing.

### ***Sample Description of Existing Conditions***

*The Richter County Sheriff's Department Administration Building is a 24,650 SF 3-story plus basement office building, completed in 1990. It is classified as Building Type 4 – S2 Steel Braced Frame (Table 2-2 in ASCE 32-02). The building is rectangular in plan measuring 102'-8" by 62'-4". Floor to floor heights are typically 11'-8". The façade consists of 8"-thick precast concrete panels with punch windows. Interior finishes consist of vinyl tile floors, gypsum board and metal stud walls and acoustical drop ceilings. Lobby finishes are marble. Restroom finishes are ceramic tile on both floors and walls. Offices are located on Floors 1, 2 and 3. The basement contains a crime lab, records storage, and utility rooms. Stairs are located at the north-west and south-east corners with elevators located in the lobby area.*

*The building's structure consists of composite steel floor beams (typically W16s and W21s) supported by W12 steel columns spaced at 25'-3". Floor and roof slabs are 5-1/2" thick normal weight concrete on metal deck. Lateral load resistance is provided by steel braced frames on column lines A, C, E, 1 and 3. The basement floor is a 6" thick concrete slab on grade. Typical foundation elements are 2'-6" thick by 6'-6" square reinforced concrete footings. Foundation walls are reinforced concrete 12" thick, supported on 2'-0" wide concrete wall footings.*

### **Work Schedule**

The sub-application should contain a schedule for accomplishing the proposed mitigation activity. Care should be taken to include all activities necessary for completing the work. The following project elements should be included in the Work Schedule:

- Architectural/engineering design including schematic, design development and contract document phases;
- Materials testing or other anticipated studies;
- Advertising, bid, and award of contract(s);
- Permitting;
- Temporary relocation of occupants and contents;
- Contractor mobilization;
- Construction, including milestones; and
- Reoccupy facility.

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***Sample Work Schedule***

*ABC Consultants was asked to develop the following Work Schedule for their proposed non-structural retrofitting seismic mitigation work on the Richter County Sheriff's Department Administration Building.*

<b>RICHTER COUNTY SHERIFF'S DEPARTMENT ADMINISTRATION BUILDING SEISMIC NON-STRUCTURAL RETROFITTING PROJECT</b>	
<b>ACTIVITY</b>	<b>DURATION</b>
<b><i>Architectural &amp; Engineering Design</i></b>	
<i>Develop Final Mitigation Details and Drawings</i>	<i>3 weeks</i>
<b><i>Bid Phase</i></b>	
<i>Advertise, Review Bids and Award Contract</i>	<i>6 weeks</i>
<i>Obtain Permits</i>	<i>1 weeks</i>
<b><i>Construction Phase</i></b>	
<i>Contractor Mobilization</i>	<i>1 week</i>
<i>Precast Panel Tie-Backs</i>	<i>2 weeks</i>
<i>Brace Cafeteria Lights</i>	<i>1 week</i>
<i>Reorganize Chemical Storage</i>	<i>1 week</i>
<i>Office Equipment &amp; Records Storage</i>	<i>1 week</i>
<b><i>TOTAL</i></b>	<b><i>16 weeks</i></b>

**Cost Estimate**

The Cost Estimate describes all anticipated and potential costs associated with the proposed project activity, and represents the Sub-applicant's best estimate of the total value of the proposed activity. Sufficient detail should be provided regarding various cost items. Back-up documentation for all costs, including the basis for each should be provided (e.g., bids from qualified professionals, nationally published or local cost estimating guides). Also, reference the base year for all cost data used. Costs should be provided for the following tasks:

- Architectural/engineering design;
- Materials testing or other anticipated studies;
- Permits;
- Installation of non-structural retrofitting seismic mitigating measures;
- Any additional work required including the demolition /restoration of architectural finishes as well as work to the building's utility systems;
- Temporary relocation including rental and moving expenses (out and back); and
- Compliance with Federal, state, and local laws, regulations, and ordinances, such as historic preservation issues or required accessibility upgrades.

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**Sample Cost Estimate**

ABC Consultants developed the following Cost Estimate for proposed non-seismic structural retrofitting project on the Richter County Sheriff's Department Administration Building.

<b>DESCRIPTION</b>	<b>SOURCE</b>	<b>QTY</b>	<b>UNIT</b>	<b>UNIT PRICE</b>	<b>COST (Note 1)</b>
<b>Architectural &amp; Engineering Design</b>					
1 A&E Fee	Consultant Quote (Note 3)	1	LS	\$10,000	\$10,000
<b>Contractor General Conditions and Contingency</b>					
2 Standard Cost	Engineer's Est (Note 2)	1	LS	\$7,000	\$7,000
<b>Construction</b>					
3 Tie-Back PC Panels	Contractor Quote (Note 3)	24	EA	\$985	\$23,640
4 Lighting	Engineer's Est (Note 2)	1	LS	\$8,750	\$8,750
5 Lab Chemicals	Engineer's Est (Note 2)	1	LS	\$19,450	\$19,450
6 Office Equip Type A	Contractor Quote (Note 3)	48	EA	\$23	\$1,104
7 Office Equip Type B	Contractor Quote (Note 3)	17	EA	\$167	\$2,839
8 Records Storage	Contractor Quote (Note 3)	1	LS	\$8,450	\$8,450
<b>TOTAL</b>					<b>\$81,233</b>

Note 1. Costs are based on 2005 data.

Note 2. See ABC Consultants Report for details of lump sum costs.

Note 3. Contractor quotes are attached to this sub-application.