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TECHNICAL INSTRUCTIONS

SEISMIC REVIEW PROCEDURES FOR EXISTING MILITARY BUILDINGS

Headquarters
U.S. Army Corps of Engineers
Engineering and Construction Division
Directorate of Military Programs
Washington, DC 20314

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FOREWORD

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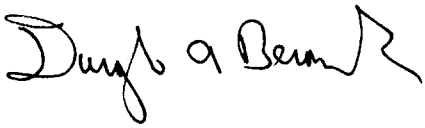

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CHAPTER 1

INTRODUCTION

1-1. Purpose and Scope.

a. Purpose. The purpose of this document is to provide procedures for the assessment of the relative seismic vulnerability of a large inventory of buildings at a military installation. The structural systems of each building or groups of structurally similar buildings in the inventory are reviewed to obtain a numerical score. The scores obtained for all buildings or groups in the inventory are recorded in numerical order in an Installation Report to provide a numerical ranking of the seismic vulnerability of the buildings. This ranked list will provide a basis by which military installations can determine the order for performing seismic evaluations. Other building-specific aspects to consider in conjunction with this review should include: general condition, known site-specific seismic geologic hazards, occupancy type, number of occupants, year built, plans for future use, and availability of alternative buildings (redundancy of function).

b. Scope

(1) Basis of procedures. The seismic review procedures for structural systems were developed by modifying the screening procedures in FEMA 154.

(2) Application. The procedures in this document are intended only for the purposes indicated above, and are not intended to supersede or replace the provisions of TI 809-05 for the evaluation and rehabilitation of military buildings.

(3) Limitations. Review of site-specific seismic geologic hazards and nonstructural components and systems is beyond the scope of these procedures.

1-2. Applicability. These instructions are applicable to all USACE elements and their contractors assessing buildings for seismic vulnerability at military installations.

1-3. References.

- *FEMA 154, Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook.*
- *FEMA 310, Handbook for the Seismic Evaluations of Buildings.*
- *TI 809-05, Seismic Evaluation and Rehabilitation for buildings.*

1-4. Seismic Use Groups. The following Seismic Use Groups are established based on the occupancy or function of a building.

a. Group IIIE. Seismic Use Group IIIE buildings are those containing essential facilities required for post-earthquake recovery, and/or those structures housing mission-essential functions. Mission-essential functions are those absolutely critical to mission continuation of the activity (there is no redundant back-up facility on- or offsite) as determined by the Commanding Officer at the activity and/or the Major Claimant.

b. Group IIIH**.** Seismic Use Group IIIH buildings are those containing substantial quantities of hazardous substances that could be dangerous to the safety of the public, if released.

c. Group II. Seismic Use Group II buildings are those that constitute a substantial public hazard because of the occupancy or use of the building.

d. Group I. Seismic Use Group I buildings are those that are not assigned to Seismic Use Groups II or III.

e. Hazardous Critical Facilities. These facilities (e.g., nuclear power plants, dams, and LNG facilities) are not included within the scope of this document, but are covered by other publications or regulatory agencies. For any facilities housing hazardous items not covered by criteria in this document, guidance should be requested from DAEN-ECE-D (Army), NAVFAC Code 04BA (Navy), or HQ USA/LEEE (Air Force).

Examples of buildings or structures in each of the above groups are provided in table 1-1. Buildings with
with multiple occupancies will be categorized according to the most important occupancy unless the portion of the building that houses the most important occupancy can be shown to satisfy all the requirements for that occupancy.

1-5. Historic Military Buildings. Historic military buildings, in general, are required to meet the same minimum life-safety objectives as all other buildings in the federal inventory.

1-6. Documentation. The forms discussed below document the review procedures prescribed herein. Guidance for preparing these forms is provided in appendix B.

a. Building Review Report

(1) Lateral Load System Data. Form for compilation of pertinent structural data for the seismic review of the building.

(2) Structural Review Score Sheet. Provides a relative numerical rating of a building group based on FEMA 310 Model Building Type, seismicity, and selected structural attributes.

b. Installation Report. A brief report will be prepared to summarize the results of the seismic review of buildings at each installation. Guidance for the completion of the Installation Report is provided in appendix D. The report will include the following information:

(1) Executive Summary

(2) Seismic Vulnerability Ranking

(3) Building List

(4) Exempted Buildings List

(5) Building Group List

(6) Appendices

1-7. QUALIFICATIONS OF INVESTIGATORS. Engineers experienced in the seismic design of building structural systems must implement these procedures.

Table 1-1. Seismic Use Groups

Seismic Use Group	Occupancy or Function of Structure
I. Standard Occupancy Structures	All structures having occupancies or functions not listed above.
II. Special Occupancy Structures	Covered structures whose primary occupancy is public assembly with a capacity greater than 300 persons*.
	Daycare centers with a capacity greater than 150 persons.
	Educational buildings through the 12th grade with a capacity greater than 250 persons or 465 m^2 (5,000 ft^2) classroom space.
	Buildings for colleges or adult education schools with a capacity greater than 500 students or 929 m^2 (10,000 ft^2) of classroom space.
	Medical facilities with 50 or more resident incapacitated patients, but not otherwise designated as Seismic Use Group IIIE facility, or 372 m^2 (4,000 ft^2) of convalescent rooms.
	Jails and detention facilities.
	All structures with occupancy capacity greater than 5,000 persons.
	Structures and equipment in power-generating stations and other public utility facilities not included in Seismic Use Group IIIE, and that are required for continued operation.
	Water treatment facilities required for primary treatment and disinfecting of potable water.
	Wastewater treatment facilities required for primary treatment.
	Facilities having high value equipment, when justification is provided by the using agency.
III H. Hazardous Facilities	Structures housing, supporting or containing sufficient quantities of toxic or explosive substances to be dangerous to the safety of the general public if released.
III E. Essential Facilities[1]	Facilities involved in handling or processing sensitive munitions, nuclear weaponry or materials, gas and petroleum fuels, and chemical or biological contaminants.
	Facilities involved in operational missile control, launch, tracking or other critical defense capabilities.
	Mission-essential and primary communication or data handling facilities.
	Hospitals and other medical facilities having surgery and emergency treatment areas.
	Fire, rescue, and police stations.
	Designated emergency prepared centers.
	Designated emergency operations centers.
	Designated emergency shelters.
	Power-generating stations or other utilities required as emergency back-up facilities for Seismic Use Groups IIIE facilities.
	Emergency vehicle garages and emergency aircraft hangars.
	Designated communications centers.
	Aviation control towers and air traffic control towers.
	Waste treatment facilities required to maintain water pressure for fire suppression.

***ASSSEMBLY AREA GUIDELINES**

Assembly areas, concentrated (without fixed seats) -Single room 195 m^2 (2,100 ft^2) or more.

Auditoriums
Dance floors
Churches and chapels
Lobby accessory to assembly occupancy
Lodge rooms
Reviewing stands
Stadiums
Waiting area – 84 m^2 (900 ft^2) or more

Assembly Areas, less concentrated use – Single room 418 m^2 (4,500 ft^2) or more

Conference rooms
Dining rooms
Drinking establishments
Exhibition rooms
Lounges
Gymnasiums
Stages

[1] Essential facilities are those structures that are necessary for emergency operations subsequent to a natural disaster.

CHAPTER 2

SEISMIC REVIEW OF STRUCTURAL SYSTEMS

2-1. Introduction. This chapter describes the procedures for the seismic review of structural systems in military buildings. The procedures include the compilation of data pertaining to the lateral load system of the building, and the relative scoring of the building as to its seismic vulnerability. Buildings that comply with the exemption criteria defined in appendix A are excluded from the provisions of this document.

2-2. Building Groups. Many military installations contain groups of buildings that are structurally similar (e.g., barracks and other personnel housing units). When this grouping occurs, it is necessary to review only one representative building in the group. The term “group” in this document will therefore denote one or more structurally similar building(s). Parameters considered to determine structural similarity might include comparison of FEMA 310 Model Building Type, plan square footage, the buildings uses or functions, number of stories and the year(s) constructed. Aerial maps may also be helpful in determining structural similarity by comparing building footprints. It is important that building groups are both field-verified and reviewed by individuals who have knowledge of the specific buildings, to confirm the accuracy of the groupings.

2-3. Seismic Review Procedures. Structural review of military buildings includes the activities described below. Figure 2-1 illustrates the overall process. Guidance for the completion of the structural review and summary forms referenced in this chapter is provided in appendix B.

a. Pre-field planning. General issues, such as the seismicity of the site and local soil conditions, should be addressed before any fieldwork is done. This may include interviews with geologists or geotechnical engineers at the USACE District Office responsible for design/ construction at the site to determine if a geotechnical report for the installation has been prepared, and if any site-specific ground motion studies have been performed. Any pertinent information gained from the interviews should be entered on the Lateral Load System Data sheet. Any relevant notes or correspondence related to the interviews should be appended to the data sheet.

b. Travel to building site. Seismic review is primarily a field-oriented activity requiring the reviewer to travel to the building site and perform a visual inspection of the building.

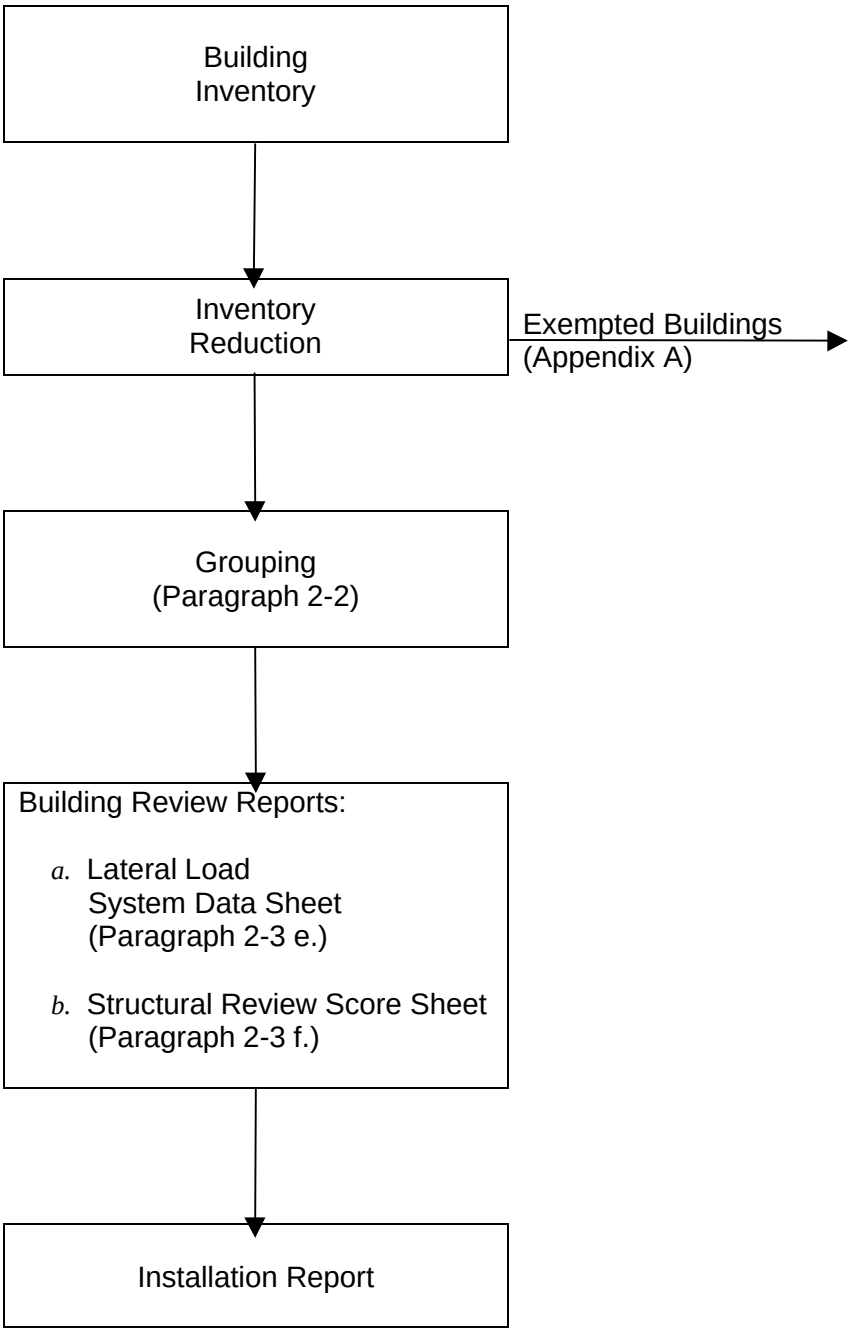


Figure 2-1. Structural Review Flow Chart

c. Review of available data. The review process should begin by reviewing available geotechnical reports, structural drawings, building materials data, and specifications to obtain pertinent information needed to complete the Structural Review Score Sheet. These documents are likely to be kept at the base facility engineering (FE) office. All data obtained from these documents will be confirmed in the field whenever possible. The building Seismic Use Group should be designated on the Lateral Load System Data sheet.

d. Building exemption. If it becomes apparent during the review that one of the parameters listed in appendix A applies, the building may be declared exempt, and no further review will be necessary.

e. Building inspection visit. The objectives of the field survey are to confirm the information obtained at the FE office, and to obtain additional information needed to complete the Lateral Load System Data Sheet and the Structural Review Score Sheet. The general condition of the building should also be noted, including any past damage to structural system elements from fire, earthquakes, wind, lack of maintenance, insect damage to wood, etc. This visit will require access to the facility, but need not be an extensive inspection. Sketches should be made and/or photographs should be taken of significant items related to structural performance.

f. Final structural score. The finalization of the structural review process includes the completion of the Structural Review Score Sheet. In some cases, the quantitative final structural score for the building may be in variance with the qualitative judgment of the reviewer. When this occurs, the reviewer may determine that the quantitative score should not be used, and a different outcome of the review process should be selected. In this case, the reviewer will provide narrative explanation in support of this decision on both the Structural Review Score Sheet and in the Consolidated Review Results Summary Sheet.

2-4. Documentation. The results of the seismic review procedures described in the preceding paragraph shall be summarized for each building group in the Installation Report described in appendix D. Copies of Lateral Load System Data Sheets and the Structural Review Score Sheets will be attached as appendices to the Installation Report, as indicated in paragraph 1-4b.

APPENDIX A

BUILDINGS EXEMPTED BEFORE REVIEW

If any of the following conditions apply to a building under consideration, the building's structural system will be exempted from the seismic review procedures.

A-1. A building whose occupancy or function is defined in Table 1-1 as Seismic Use Group I, and:

a. Is intended only for minimal human occupancy, or occupied by persons for a total of less than 2 hours a day.

b. Is a detached one- or two-family dwelling, two stories or less, and is located in a region of moderate seismicity as defined by FEMA 310, Table 2-1.

c. Has a gross area of less than 50 square meters (500 square feet).

d. Is a one-story building of wood, FEMA 310 Model Building Type, (MB1&2) or steel light frame (MB5) construction, and has a gross area of less than 280 square meters (3,000 square feet).

e. Is abandoned or scheduled for demolition or replacement within 5 years.

A-2. Buildings in any Seismic Use Group, except as designated in the subparagraphs below, which were designed in accordance with the provisions of the 1982 or later edition of TM5-809-10, or the 1986 or later edition of TM5-809-10-1.

a. Steel braced frame systems (MB4) designed to 1988 UBC or later edition of TM 5-809-10.

EXCEPTION: All steel moment frame systems with welded flange connections shall be reviewed by special criteria not provided in this document.

A-3. All buildings that are either fully or partially leased to the government.

APPENDIX B

COMPLETION OF BUILDING REVIEW REPORT FORMS

B-1. Purpose

This appendix provides guidelines for the completion of forms for the seismic review of structural systems. The Lateral Load System Data Sheet (Figure B-1) is to be used to record pertinent structural data concerning each of the buildings selected for the seismic review process. This sheet should be completed during the field visit to the building to confirm the data obtained from the drawings, and to provide documentation for the Structural Review Score Sheet.

B.2 Lateral Load System Data Sheet

a. Identification data. The data to be entered at the top of the sheet pertains to the identification of the building and the person performing the seismic review. The name and location of the station (e.g., McChord AFB, Washington), the Facility Category Number, and the Building should be consistent with the Department of Defense Real Property Inventory Data. The NEHRP Building Type refers to the 15 common building types described in FEMA 310, Section 2.6. The selection of the building type number that best describes the building will be made by the person performing the review, based on the review of the structural drawings and the visit to the building. The region of seismicity of the building site, represented by the design short-period and one-second period spectral response acceleration parameters, S_{SD} and S_{DI}, shall be determined in accordance with FEMA 310, Section 2.5.

b. Diaphragm data. This section of the form requires a brief description of the floor and roof diaphragms and how they are connected to the vertical lateral-load-resisting elements. The type of diaphragm to be recorded should be the structural element (e.g., cast-in-place concrete slab, horizontal steel bracing, or 2-inch straight-laid wood sheathing) that distributes the seismic inertia forces to the vertical lateral-load-resisting element (e.g., shear walls or braced frames) at each building level. The description of the diaphragm connection to the vertical elements is to be qualitative rather than quantitative. For example, a metal deck diaphragm may be "welded to structural steel framing," and a reinforced concrete slab diaphragm may be "doweled to masonry shear walls."

c. Vertical resisting elements data. The information to be entered in this part of the form is also intended to be primarily a brief description of the structural element, but it should also provide some indication as to distribution of the element. (For example, "Reinforced concrete shear walls in longitudinal and transverse directions in the interior of the building," or "Steel braced frames at building perimeter in longitudinal and transverse directions.") Some buildings may have a different system in each of the orthogonal directions (e.g., moment-resisting frames in the transverse direction, and braced frames or shear walls in the longitudinal direction). The notation "braced or trussed columns" refers to the use of knee braces or trusses to resist lateral-load moments by "fixing" or restraining one or both ends of a column. For infilled frames, it is important to note the type of frame (e.g., structural steel or reinforced concrete) and the type of infill (e.g., unreinforced masonry, reinforced concrete, or hollow clay tile).

d. Site soil profile classification. The applicable soil profile should be noted as one of the six standard site classes described in Table B-2. The identification will be obtained from a site geotechnical report, if available. If a geotechnical report is not available, the reviewer will select a site class based on his review of the soil borings, geologic maps, or other data, and should note the basis of his selection in the space provided on the form.

e. Foundations. The person performing the review should note the basic foundation system features, design, and detailing in the space provided, including the following items:

(1) For wood frame buildings, are the mud plates for the stud walls bolted to the foundation walls or strip footings? Are tension hold-downs provided for slender piers acting as shear walls?

(2) For reinforced concrete frame buildings, are the footings capable of resisting the lateral load moments? If the column vertical reinforcement is spliced at the top of the footing, is the splice capable of developing the tension strength of the bars? If the footing is deeply embedded below grade, is the footing capable of resisting negative moment? (e.g., is there a layer of reinforcement at the top of the footing as well as the bottom?)

(3) For piles or caissons, is the vertical reinforcement adequately anchored into the cap footing to resist lateral load moments? In soft soils, are the pile or caisson cap footings adequately connected with tie beams to preclude lateral displacements?

Lateral Load System Data Sheet

Station _____ Building No. _____

Seismic Use Group_____ NEHRP Building Type _____

Reviewer _____ Date _____

Diaphragms (Describe briefly)

Type	**How connected to vertical elements**
Roof _____	_____
_____	_____
Floor(s) _____	_____
_____	_____

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall _____

Vert. bracing_____

Rigid frames_____

Braced or trussed cols._____

Infilled frames_____

S_A S_B S_C S_D S_E S_F

Mapped Spectral Acceleration

S_s = _____ S_1 = _____ (from 1997 NEHRP MCE Maps 1 to 16)

F_a = _____ F_v = _____ (from FEMA 310, Tables 3-5 and 3-6)

S_{DS} = _____ S_{D1} = _____ ($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)

Soil information source:

Foundations (Circle one or more)

Spread footings

Strip footings

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity _____

Vert. irregularity _____

Diaphragm discontinuity _____

Basement _____

Sidehill site_____

Other _____

Figure B-1. Lateral Load System Data Sheet

f. Unusual features. This portion of the form is to be used to note any unusual structural features that could adversely affect the seismic response of the building. A brief description of these adverse features, as evidenced by the building drawings, should be recorded on the form for use as a basis for the applicable structural modifiers on the Structural Review Score Sheet.

(1) Plan irregularities, for the purpose of this form, include geometric irregularities (e.g., is the building plan symmetrical, "T" shaped, "L" shaped, or other asymmetrical configuration?), and obvious irregularities in the apparent rigidity and location of the vertical lateral-load-resisting elements (e.g., are the shear walls or braced frames symmetrically located with regard to size and extent?).

(2) Vertical irregularities to be noted in this form include significant setbacks in the plan configuration of the building from one story to an adjacent story (e.g., a building that has a "stepped" configuration in elevation), and discontinuities in the vertical lateral-load-resisting system (e.g., are there shear walls or braced frames in upper stories that are discontinued in the lower stories?).

(3) The floor and roof diaphragms should be visually evaluated for obvious discontinuities (e.g., are there large stair or elevator openings that significantly impair the effectiveness of the diaphragm to transmit in-plane story forces to the vertical resisting elements?). Discontinuities can lead to adverse seismic response, particularly for highly stressed diaphragms (e.g., diaphragms required to transfer horizontal shear from a discontinuous vertical element to an offset resisting element).

(4) The presence of a basement should be noted, because an embedded structure subjected to ground motion generally performs better than one founded on shallow foundations.

Table B-1. Site Soil Profile Classification

Class A	Hard rock with measured shear wave velocity, $\bar{v}_s$ > 5,000 ft/sec (1,500 m/s)
Class B	Rock with 2,500 ft/sec < $\bar{v}_s \leq$ 5,000 ft/sec (760 m/s < $\bar{v}_s \leq$ 1,500 m/s)
Class C	Very dense soil and soft rock with 1,200 ft/sec < $\bar{v}_s \leq$ 2,500 ft/sec (360 m/s < $\bar{v}_s \leq$ 760 m/s) or with either $\bar{N}$ > 50 or $\bar{s}_u$ > 2,000 psf (100 kPa)
Class D	Stiff soil with 600 ft/sec $\leq \bar{v}_s \leq$ 1,200 ft/sec (180 m/s $\leq \bar{v}_s \leq$ 360 m/s) or with either 15 $\leq \bar{N} \leq$ 50 or 1,000 psf $\leq \bar{s}_u \leq$ 2,000 psf (50 kPa $\leq \bar{s}_u \leq$ 100 kPa)
Class E	A soil profile with $\bar{v}_s$ < 600 ft/sec (180m/s) or with either $\bar{N} < 15$ $\bar{s}_u <$ 1,000 psf or any profile with more than 10 ft (3 m) of soft clay defined as soil with PI > 20, $w \geq$ 40 percent, and s_u < 500 psf (25 kPa)
Class F	Soils requiring site-specific evaluations: 1. Soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils, quick and highly sensitive clays, and collapsible weakly cemented soils. 2. Peats and/or highly organic clays (H > 10 ft [3 m] of peat and/or highly organic clay where H = thickness of soil). 3. Very high plasticity clays (H > 25 ft [8 m] with PI > 75). 4. Very thick soft/medium stiff clays (H > 120 ft [36 m]).

Exception: When the soil properties are not known in sufficient detail to determine the *Site Class, Site Class* D shall be used. *Site Classes* E or F need not be assumed unless the authority having jurisdiction determines that *Site Classes* E or F could be present at the site, or in the event that *Site Classes* E or F are established by geotechnical data.

(5) The bottom story of a building on a sidehill site will often be a basement with access at grade on one side of the building, and essentially solid walls on the other three sides. If the basement is used to park motor vehicles, the side at grade may have large openings to admit the vehicles, resulting in significant torsional response to seismic forces.

(6) Other unusual features could include structural additions with structural systems or materials that differ from the original construction, or structural alterations that may adversely affect the intended load path for lateral forces.

B-3. Structural Review Score Sheet

The Structural Review Score Sheet (Figures B-2, B-3, and B-4) employs a deterministic matrix of selected structural parameters to arrive at a final structural score that represents the potential vulnerability of the building to seismic damage. This score may be subsequently used to establish a ranking of buildings, based on their relative vulnerability to seismic life-safety hazards. This may be useful as a prioritization tool in selecting buildings for further evaluation and rehabilitation.

Separate score sheets are provided, with applicable basic structural scores and modifiers, for the low, moderate, and high seismic areas. The regions of seismicity shall be defined by using the algorithm presented in FEMA 310, Section 2.5, and using the Maximum Considered Earthquake (MCE) parameters obtained from the 1997 NEHRP *Seismic Map Package.* Most of the data to be entered on this sheet can be extracted from the Lateral Load System Data sheet (Figure B-1), but all of the information on the score sheet, where feasible, should be confirmed during the site visit to the building.

a. Identification data. The basic identification data from the Lateral Load System Data sheet is repeated to allow this score sheet to be used or filed independently of the data sheet. Additional data to be provided include:

(1) The year the building was designed. This information should be obtained from the drawings. If the drawings indicate that the building was modified or expanded in subsequent years, this information should be entered at the bottom of the sheet under

"Comments/Conclusions." The drawing notes may indicate the building codes that governed the design, or may provide a base shear formula that can be used to determine which code governed the seismic design.

(2) The building name. Although the building number may be the primary identification for purposes of inventory, the building name (e.g., Brigade Headquarters Building) is probably the most definitive identification for personnel at the station.

(3) Present or known future use and initial use. The use or occupancy of a building may provide valuable insight as to the initial basis of design. For example, buildings that were not designed for seismic force, but were designed for heavy loads because of their occupancy classification, will have inherent capacity for lateral loads that may be adequate for the lower seismic areas. Since the use of a given building at a military installation may change with time, the current use (or if the building's use is scheduled to be changed at some known date in the near future) or the future use needs to be identified as an important parameter in the assignment of priority for evaluation and retrofit.

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station _____ Building No. _____ Year Designed _____
Facility Cat. No. _____ Building Name _____
Present Use _____
Initial Use _____
No. Stories _____ Total Floor Area _____
Reviewer _____ Date _____

SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS															
Quarters	**No. Persons**	**Building Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Mess																	
Administration		**Basic Score**	**5.0**	**4.5**	**4.5**	**3.0**	**5.5**	**3.5**	**2.5**	**2.0**	**3.0**	**2.5**	**2.0**	**2.5**	**2.5**	**2.0**	**1.0**
Shops	0-10	2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Assembly		Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Hospital	11-100	Details*															
Utility		Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Warehouse	100+	Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Communications		Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Seismic Use Group:		Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
III E		Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
III H		S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
II		S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
I		S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
		Final Score															

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer, as well as comments that may be useful in the evaluation process.

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0. Include explanation for detail modifier.

Figure B-2. Structural Review Score Sheet – High Seismicity Region

Structural Review Score Sheet

Moderate Seismicity Region (0.167g < S_{DS} < 0.500g, 0.067g < S_{D1} < 0.200g)

Station _____ Building No. _____ Year Designed _____
Facility Cat. No. _____ Building Name _____
Present Use _____
Initial Use _____
No. Stories _____ Total Floor Area _____
Reviewer _____ Date _____

SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS															
Quarters	**No. Persons**	**Building Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Mess																	
Administration		**Basic Score**	**6.0**	**5.5**	**5.0**	**3.5**	**6.0**	**4.0**	**3.0**	**2.5**	**3.5**	**3.0**	**2.5**	**3.0**	**3.0**	**2.5**	**2.0**
Shops	0-10	2 to 4 Stories	-0.2	-0.2	-0.2	-0.2	N/A	-0.2	-0.4	-0.2	-0.4	-0.4	-0.8	-0.8	-0.8	-0.8	-0.8
Assembly		Poor Condition	-0.2	-0.2	-0.2	-0.4	-0.2	-0.2	-0.4	-0.4	-0.2	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
Hospital	11-100	Details*															
Utility		Vert. Irregularity	-0.2	-0.2	-0.2	-0.4	N/A	-0.4	-0.4	-0.4	-0.6	-0.4	-0.8	-0.8	-0.4	-0.8	-0.4
Warehouse	100+	Soft Story	-0.4	-0.4	-0.4	-0.6	N/A	-0.6	-0.6	-0.6	-0.6	-0.6	-1.0	-1.0	-0.8	-1.0	-0.6
Communications		Torsion	-0.4	-0.4	-0.5	-0.8	-0.6	-0.6	-0.8	-0.6	-0.6	-0.8	-0.6	-0.8	-0.8	-0.8	-0.4
Seismic Use Group:		Plan Irregularity	-0.4	-0.4	-0.4	-0.6	-0.4	-0.6	-0.8	-0.6	-0.6	-0.8	-0.8	-0.8	-0.6	-0.8	-0.4
III E		Diaphragm Discont.	-0.2	-0.2	-0.4	-0.6	-0.4	-0.6	-0.8	-0.6	-0.6	-0.8	-0.8	-0.8	-0.6	-0.6	-0.5
III H		S_A, S_B	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2
II		S_D	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
I		S_E, S_F	-0.5	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
		Final Score															

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer, as well as comments that may be useful in the evaluation process.

Note: *Subjective Evaluation of structural details varies from –0.8 to +0.8. Include explanation for detail modifier.

Figure B-3. Structural Review Score Sheet – Moderate Seismicity Region

Structural Review Score Sheet

Low Seismicity Region (S_{DS} < 0.167g, S_{D1} < 0.067g)

Station _____ Building No. _____ Year Designed _____
Facility Cat. No. _____ Building Name _____
Present Use _____
Initial Use _____
No. Stories _____ Total Floor Area _____
Reviewer _____ Date _____

SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS																
Quarters	**No. Persons**	**Building Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Mess																	
Administration		**Basic Score**	**8.0**	**6.5**	**6.0**	**5.5**	**6.5**	**5.0**	**4.0**	**4.0**	**5.0**	**4.0**	**4.0**	**3.5**	**3.5**	**3.5**	**3.0**
Shops	0-10	2 to 4 Stories	-0.2	-0.2	-0.2	-0.2	N/A	-0.2	-0.3	-0.2	-0.3	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5
Assembly		Poor Condition	-0.2	-0.2	-0.2	-0.3	-0.2	-0.2	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
Hospital	11-100	Details*															
Utility		Vert. Irregularity	-0.2	-0.2	-0.2	-0.3	N/A	-0.3	-0.3	-0.3	-0.4	-0.3	-0.5	-0.5	-0.3	-0.5	-0.3
Warehouse	100+	Soft Story	-0.3	-0.3	-0.3	-0.4	N/A	-0.4	-0.4	-0.4	-0.4	-0.4	-0.6	-0.6	-0.5	-0.6	-0.4
Communications		Torsion	-0.3	-0.3	-0.3	-0.5	-0.4	-0.4	-0.5	-0.4	-0.4	-0.5	-0.4	-0.5	-0.5	-0.5	-0.3
Seismic Use Group:		Plan Irregularity	-0.3	-0.3	-0.3	-0.4	-0.3	-0.4	-0.5	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4	-0.5	-0.3
III E		Diaphragm Discont.	-0.2	-0.2	-0.3	-0.4	-0.3	-0.4	-0.5	-0.4	-0.4	-0.5	-0.5	-0.5	-0.4	-0.4	-0.3
III H		S_A, S_B	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2
II		S_D	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
I		S_E, S_F	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
		Final Score															

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer, as well as comments that may be useful in the evaluation process.

Note: *Subjective Evaluation of structural details varies from –0.6 to +0.6. Include explanation for detail modifier.

Figure B-4. Structural Review Score Sheet – Low Seismicity Region

b. Sketch and photo. As visual aids in the review process, the form provides spaces for sketches and a photo. At a minimum, a plan of the building and a typical structural section should be sketched. One or more elevations should also be sketched, unless the photo is adequate to show the pertinent features (e.g., approximate size and spacing of window and door openings). The plan should indicate the approximate overall dimensions of the building, and the location and extent of the vertical lateral-load-resisting elements (e.g., shear walls braced frames or rigid frames). If the building has expansion or structural separation joints, the location and size of the joints should be noted. The typical structural section should indicate story height, and should identify the vertical resisting elements and the type of floor or roof diaphragms at each level.

c. Building function. The classification of an existing building regarding its use and function is an important parameter in the assignment of priority for retrofit. The function of the building should be noted by circling the appropriate category(s) that best describes its current use. The occupancy, which is the average number of personnel that occupy the building during the normal work period (assumed to be from 0700 to 1700 hours). The ten classification categories include the following uses:

(1) Quarters. This category includes all buildings used as living quarters. Examples include single-family units; quarters for bachelor officers, enlisted personnel, or contractors (e.g., BOQs, BEQs, BCQs); and barracks for group accommodations.

(2) Mess. Includes all buildings used for the preparation and consumption of food or refreshments. Examples include mess facilities, clubs for officers or enlisted personnel, and cafeterias.

(3) Admin. Includes all buildings used for office or administrative use. Examples include headquarters buildings, personnel offices, and Base Engineer offices.

(4) Shops. This is a broad category characterized by large, open work areas and high overhead space, usually designed for bridge cranes, monorails, or other weight-handling equipment. Examples include aircraft hangars, machine shops, ordnance assembly buildings, and vehicle maintenance facilities.

(5) Assembly. Includes all buildings used for the congregation of groups of personnel. Examples include assembly halls, auditoriums, theaters, chapels, gymnasiums, and recreation buildings.

(6) Hospital. Includes all buildings used for health care. Examples include hospitals, clinics, and dispensaries.

(7) Essential support. Includes buildings that house essential support services, including fire stations, police facilities, security offices, and prisons.

(8) Utility. Includes buildings that are components of utility system. Examples include electric substations, pumping plants, and sewage treatment plants.

(9) Warehouse. Includes buildings that are used for storage. Examples include warehouses, cold storage facilities, and ordnance magazines.

(10) Communications. Includes buildings that house communications facilities. Examples include telephone equipment buildings, aircraft traffic control facilities, and satellite communication centers.

d. Seismic Use Groups. Examples of occupancy types or functions in the various Seismic Use Groups are indicated in Table 1-1. Buildings with multiple occupancies should be categorized according to the most important occupancy, unless the portion of the building that houses the most important occupancy can be shown to satisfy all of the requirements for that occupancy.

e. *Structural scores and modifiers.* This is the most important portion of the review form. The lateral load system data recorded from the drawings and the confirming data observed in the site visit are tempered with the engineering judgment of the engineer to develop a relative score reflecting the seismic vulnerability of the building. For each building type, this portion of the form provides a basic score and 11 structural modifiers. The final score for a specific building will be the total of the basic score plus all applicable modifiers. This scoring system is similar to that described in FEMA 154 (Reference 7), except for revisions to make the descriptions and numerical values more applicable to typical buildings in Department of Defense

installations. Some buildings may have different structural systems in each of the two major orthogonal directions. Separate structural scores should be determined for the structural system in each orthogonal direction.

(1) Basic score. The NEHRP building type for the building being reviewed is identified in Lateral Load System Data Sheet (Figure B-1). As a first step in determining the structural score, the "Basic Score" for the representative building type should be circled and modified by the applicable structural modifiers in that column. The Basic Score for each building type, as developed in FEMA 154, was the negative logarithm of the probability of damage exceeding 60 percent of the building replacement cost. The probabilities of damage were obtained from the ATC-13 data (a probabilistic earthquake damage evaluation study for structures in California based on expert opinion polls), and the basic scores thus derived were intended to be non-arbitrary relative vulnerability assessments for each building type. For purposes of this form, the FEMA 154 basic scores have been reviewed in the light of building damage observed in recent California earthquakes, as well as applicability to typical DOD buildings, and were revised by judgment to represent the relative vulnerability.

(2) Two to four stories. Buildings in this height range are in resonance with the predominant periods (i.e., about 0.2 to 0.4 second) of seismic ground motion in firm soils. These buildings are therefore expected to be subjected to greater damage.

(3) Poor condition. The structural condition of the building should be carefully noted during the field visit. This includes loss of section due to corrosion in steel buildings; excessive cracking of concrete or evidence of staining and spalling due corrosion of reinforcement; fungus (e.g., damp rot) or borer damage in timber structures; cracking, spalling, or weak mortar in masonry buildings; or evidence of past alterations that may have damaged or removed structural members. The indicated modifiers for poor condition should be circled only when the condition is considered to be worse than would be expected for the average building of that type and age. Any unusual conditions should be noted at the bottom of the sheet under "Comments/Conclusions."

(4) Details. This is a subjective assessment of the structural detailing as evidenced in the structural drawings or as noted in the field. The cumulative modifier varies from +1.0 for good details to

-1.0 for poor details in high seismic regions; from +0.8 to -0.8 for moderate seismic regions; and from +0.6 to -0.6 for low seismic regions. A detail modifier of 0.0 denotes average details. The reviewer should determine the details for each building type (e.g., wall openings, connections, or foundations) that will have a significant impact on the capability of the structural system to protect the life safety of the occupants. The reviewer should then assign an approximate judgmental weighting factor to each detail, based on its importance, so that the cumulative modifier falls within the -1.0/-0.8/-0.6 to +1.0/+0.8/+0.6 range (high/moderate/low regions of seismicity). It should also be noted that some detailing features might preempt an otherwise good rating of other details. For example, a shear wall building, with minimal wall openings (i.e., reduced not more than 25 percent by wall openings, and acceptable foundation details) may have minimal connections to floor and roof diaphragms, and in the judgment of the reviewer, should therefore be assigned a cumulative modifier of -0.7/-0.6/-0.4 (high/moderate/low regions of seismicity). The following are examples of qualitatively evaluated details. The values in the parentheses (e.g., +1.0/+0.8/+0.6) are intended to provide a relative range of the modifier for each specific detail in the (high/moderate/low) regions of seismicity.

(a) Concrete or masonry shear walls with the gross cross-sectional area at any story reduced not more than 25 percent by window or door openings (e.g., +1.0/+0.8/+0.6). If reduced by openings more than 75 percent (e.g., -1.0/-0.8/-0.6).

(b) Positive ties at floor and roof diaphragms to resist out-of-plane forces on exterior walls (e.g., +0.5/+0.4/+0.3). If no indication of ties (e.g., -1.0/-0.8/-0.6).

(c) Positive connections to transfer diaphragm shears to vertical resisting elements (e.g., +0.5/+0.4/+0.3). If no indication of connections (e.g., -0.5/-0.4/-0.3).

(d) Anchorage of wood framed buildings to foundation to prevent sliding or uplift (e.g., +0.5/+0.4/+0.3). If no indication of anchorage (e.g., -0.5/-0.4/-0.3)

(e) Diagonal trim bars at openings in concrete walls are desirable to restrain corner cracking under in-plane lateral forces. If trim bars are provided when window or door openings constitute 20% or more of the gross horizontal cross-section of the wall (e.g., +0.3/+0.2/+0.2). If no indication of trim bars (e.g., -0.3/-0.2/-0.2), no modifier is required (0.0) when openings constitute less than 20% of the gross cross-section.

(f) Foundations in soils that may be subjected to settlement or lateral spreading should be connected with the beams. If reasonably well-distributed tie beams are provided (e.g., +0.5/+0.4/+0.3), if no indication of tie beams (e.g., -1.0/-0.8/-0.6). Foundations for cast-in-place concrete columns and walls should have dowels, matching the column or wall reinforcement, with adequate development length in the foundation and in the column or wall above. If number of dowels and development lengths appear to be reasonable (e.g., +0.5/+0.4/+0.3); if not, (e.g., -0.5/-0.4/-0.3). If no information is available (0.0).

A brief explanation of the reasons for the reviewer's chosen cumulative modifier should be noted at the bottom of the sheet under "Comments/Conclusions."

(5) Vertical irregularity. These irregularities may apply to discontinuities of strength, stiffness, geometry, or mass. A significant reduction in stiffness may result in a "soft story," which is evaluated separately in this form. Examples of other vertical irregularities include discontinuous (i.e., offset) columns, "short" columns (e.g., columns in concrete frames with partial height infills), shear walls, or braced frames; significant changes from one story to an adjacent story in size or location of window and door openings in a shear wall; or significant setbacks in the vertical plane of an exterior wall.

(6) Soft story. Generally, in multi-story buildings, a condition where the lateral stiffness of a story is significantly less than that of the story above. This may be the result of higher story height, more or larger openings in the shear walls, or other adverse features, and often occurs at first stories.

(7) Torsion. The quantitative effects of torsion are assessed in the seismic evaluation procedures. For purposes of this form in the review procedure, only the qualitative effects are to be noted (i.e., is the building geometry and/or the location of the lateral-force-resisting elements such that there is obvious eccentricity between the center of mass and the center of rigidity?)

(8) Plan irregularities. This modifier reduces the structural score for buildings with long wings that are "L," "E," or "T" shaped, with sharp re-entrant corners where increased damage is likely to occur. If the plan length of a wing projection, beyond the re-entrant corner, is greater

than 25 percent of the transverse dimension of the wing, the structure can be considered to have plan irregularity.

(9) Diaphragm discontinuities. Significant discontinuities in diaphragm strength or stiffness. Examples include large openings that significantly reduce the strength and/or stiffness of the diaphragm, particularly when the openings are adjacent to a vertical resisting element so as to impair the effective transfer of shear to the element.

(10) S_A, S_B, S_D, S_E, and S_F. These site characteristics pertain to the standardized soil profiles described in Table B-2. Buildings on firm soil (i.e., S_C) are assumed in the basic score and a positive modifier is used for buildings on rock (S_A, S_B), and negative modifiers are used for buildings founded on less favorable soil profiles (S_D, S_E, and S_F).

f. Final score. The numerical total of the basic score and the applicable structural modifiers is the primary structural parameter in the review process. Other parameters noted on this form, (e.g., use, occupancy, and falling hazards) are also important in the assignment of priority for evaluation and retrofit.

g. Comments/Conclusions. This part of the form should be used to record: 1) dates and a brief description of any modifications and/or additions made to the structure; 2) poor condition of the structure, if any; 3) obvious structural deficiencies, if any; 4) a brief explanation to support chosen detail modifier; 5) a narrative explanation provided by the reviewer regarding any discrepancies between the final structural score and the judgement of the reviewer that may affect the outcome of the review results; and 6) any comments that the reviewer believes would be useful for the evaluation process.

APPENDIX C

SEISMIC REVIEW EXAMPLE PROBLEMS

C-1. Introduction. This appendix illustrates the implementation of the guidelines promulgated by this report for the seismic review of existing military buildings. The following example problems represent typical buildings designed for specific functional uses that occur at many military installations:

C1 Reinforced Concrete Frames and Shear Wall Building

C2 Reinforced Brick Masonry Building

C3 Infilled Steel Frame Building

C4 Steel Frame Building

EXAMPLE PROBLEM C1

REINFORCED CONCRETE FRAMES AND SHEAR WALL BUILDING

C1-1. Building Description

The H-shaped barracks (Building 1452) is a three-story cast-in-place reinforced-concrete structure located at Fort Lewis, Washington. According to the available drawings obtained before and during the initial site visit, it was designed as a two-company barracks and mess hall in 1956. It is one of ten similar buildings at the installation.

The barracks consist of four separate structures with 2-inch separation between adjacent structures. Dimensions of the two end structures (two legs which form the H) are each approximately 39 feet by 117 feet. Dimensions of the structure located between the two wings are approximately 23 feet by 156 feet. These three structures are each 3 stories. The fourth structure that ties into the center structure is a 2-story mess hall with a partial basement. The dimensions are approximately 59 feet by 78 feet. See Figure C1-1 for First Floor Plan and Figure C1-2 for typical structural sections.

a. Vertical-Load-Resisting System. The vertical-load-resisting system consists of reinforced concrete flat slab and columns and is essentially the same for all four structures. The columns are nominally spaced at 19 feet in both directions of building axes. The slab thickness is typically 7 inches at the roof, and at the third- and second-floor levels. The first floor slab is 4-inch-thick concrete on grade. The footings consist of individual spread footings for the columns and strip footings along the perimeter of the structures.

The interior columns are 14-inch square with relatively light reinforcing and #3 ties at 12 inches. The perimeter framing is a beam-column framing system. The columns are 12 inches by 24 inches, with the major axis oriented in the longitudinal axis of the structures. The beams are typically 12 inches wide by 18 inches deep, or 10 inches by 15 or 18 inches deep.

b. Lateral-Load-Resisting System. The primary lateral-force-resisting system consists of the concrete floors acting as diaphragms transmitting lateral forces to the perimeter frames. The lateral-force-resisting frame system consists of rectangular columns and beams. The transverse lateral-force-resisting system of the two end structures consists of 8-inch-thick concrete shear walls at the ends of each structure.

C1-2. Building Review Report

a. Seismic Review of Structural Systems. The review procedure described in Chapter 2 is performed for all four of the structures that comprise Building 1452. A separate Lateral Load System Data Sheet and Structural Review Score Sheet was completed for each structure, except that the data for the two identical wings are combined on each of the two capacity forms. The following forms, along with the recorded data for Building 1452, are included in this section.

b. Lateral Load System Data Sheet (Figures C1-3, C1-5 and C1-7). This form is filled out in accordance with the instructions contained in Appendix B. The information is extracted from the building drawings reviewed in the Base Public Works office, and confirmed by visual

inspection of the building. The applicable FEMA 310 Model Building Type is determined from the description of structural systems given in FEMA 310, Table 2-2. It should be noted that the two dormitory wings have different structural systems in each of the two orthogonal directions.

c. Structural Review Score Sheets (Figures C1-4, C1-6 and C1-8). This form should be completed at the building site using the information entered on the Lateral Load System Data Sheet, and confirmed by visual observation of the building. Note that a +1 has been assigned to the "Details" line for the shear wall system because each shear wall has only a small door opening. A zero has been assigned to the concrete frame systems since the details are typical of nonductile concrete frames. The final scores for the various wings range from -0.2 to 2.9, as shown on the score sheets.

C1-3. Installation Report

The final scores for the structurally separated building wings can then be ranked with other installation building scores to compare the relative seismic vulnerability of all nonexempt buildings at the installation. The procedures for seismic vulnerability ranking of buildings and preparation of the Installation Report that summarizes the seismic review findings are described in appendix D.

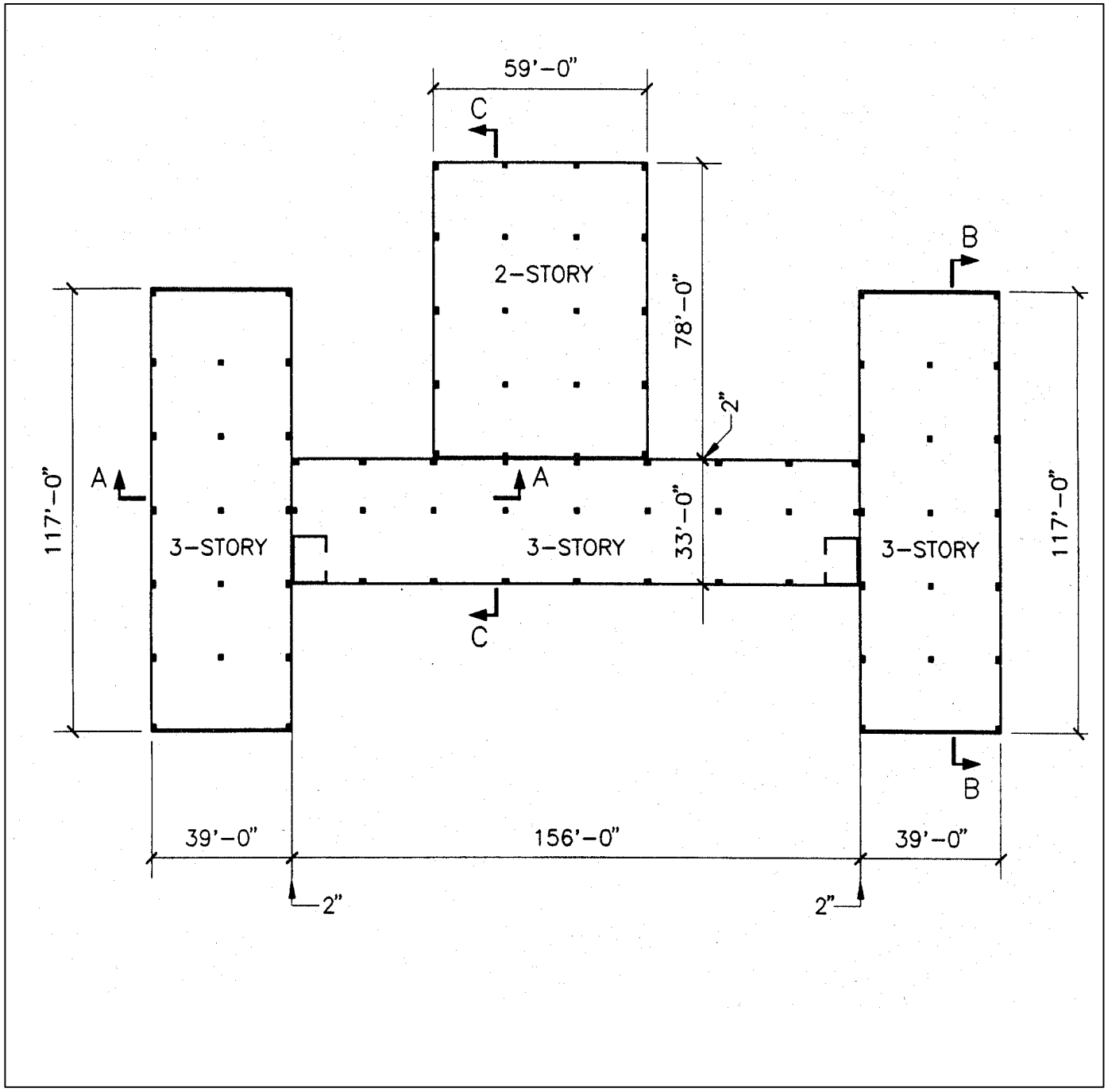


Figure C1-1. First Floor Plan

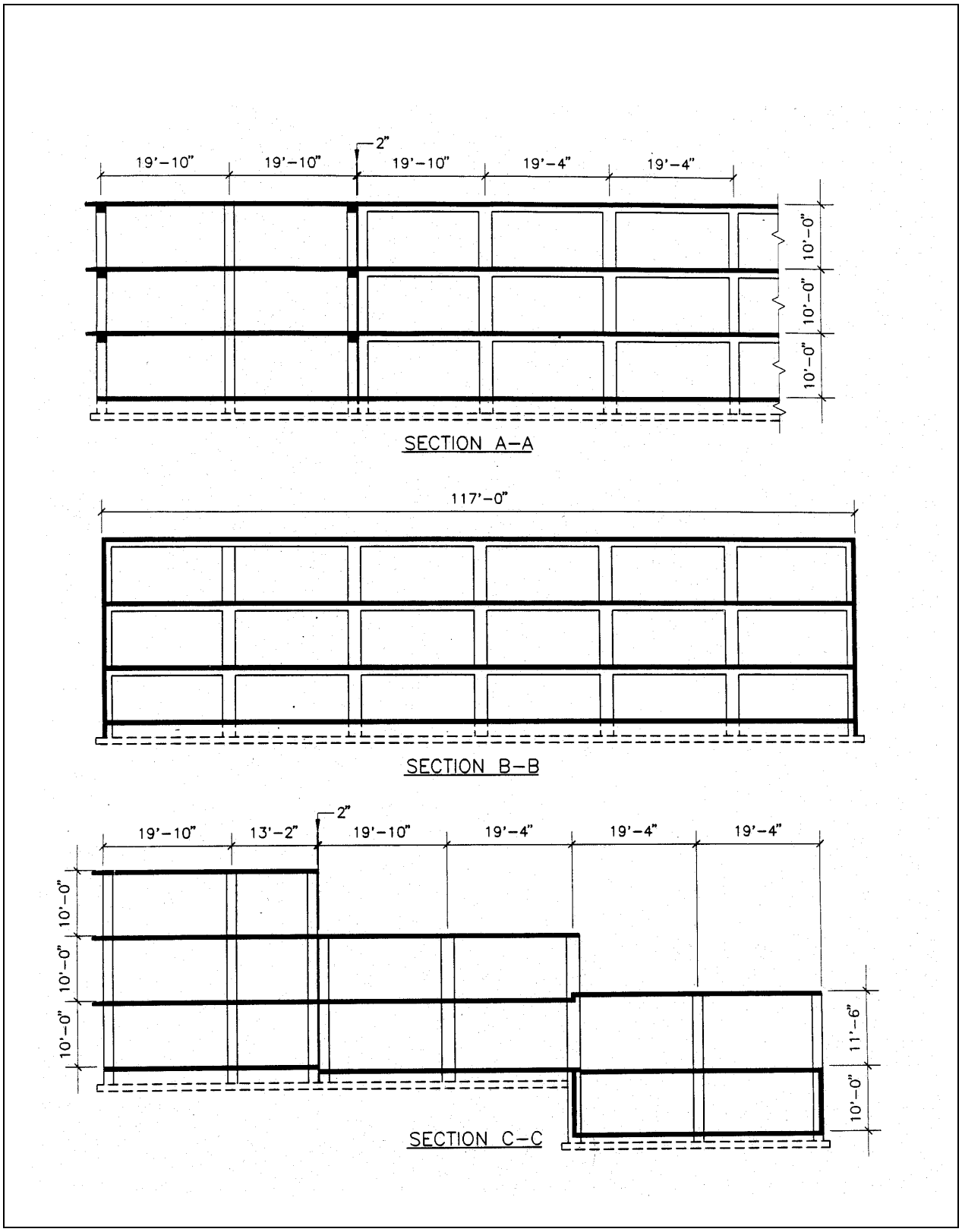


Figure C1-2. Typical Sections

Lateral Load System Data Sheet

Station Fort Lewis, Washington

Building No. 1452*

Facility Cat. No.

NEHRP Building Type 8 & 9

Reviewer K. Honda

Date

* This sheet describes the East and West wings of the H-shaped barracks.

Diaphragms (Describe briefly)

Type	How connected to vertical elements
Roof Cast-in-place R.C. slab	R.C. shear walls at two end in trans. directions & R.C. beam/col. frames in the longitudinal direction with slab reinf. extending into walls and frames.
Floor(s) Cast-in-place R.C. slab at 2nd-3rd Flrs. Slab-on-grade @ 1st Flr.	

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall R.C. at two ends, monolithic with columns in trans. dir'n.

Vert. bracing None

Rigid frames R.C. beam-col. ext. frames & slab-col. interior frames in longit. direction

Braced or trussed cols. None

Infilled frames Nonstructural infill of hollow CMU with flexible caulking at top & sides.

Soil Profile Type (Circle one)

S_A S_B S_C (**S_D**) S_E S_F

source: U.S.G.S. topo. maps

Mapped Spectral Acceleration

S_s = 1.23g	S_1 = 0.40g	(from 1997 NEHRP MCE Maps 1 to 16)		
F_a = 1.0	F_v = 1.6	(From FEMA 310, Tables 3-5 and 3-6)		
S_{DS} = 0.82g	S_{D1} = 0.43g	($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)		

Foundations (Circle one or more)

(Spread footings) below int. columns

(Strip footings) below ext. frames and trans. shear walls

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity No. These wings are regular due to separation joints.

Vert. irregularity No

Diaphragm discontinuity No

Basement No

Sidehill site No

Other 2-inch separation between adjacent buildings.

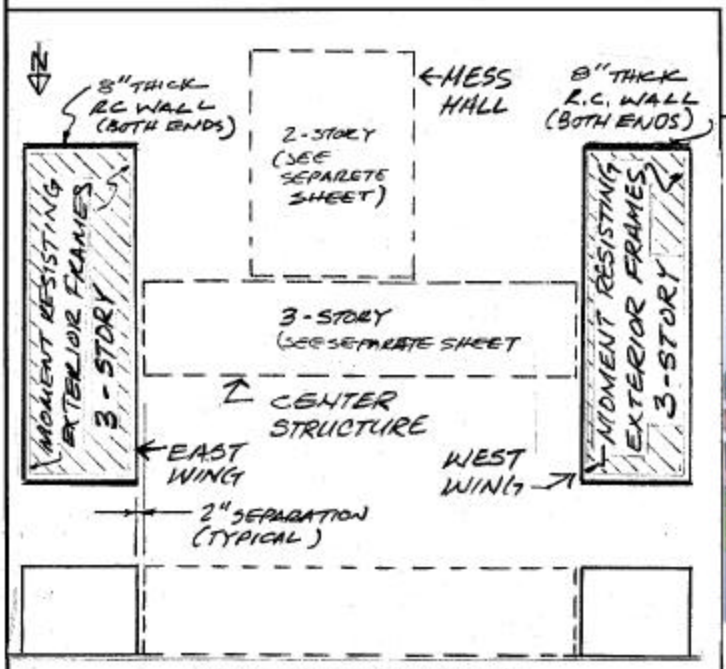
Figure C1-3. Completed Lateral Load System Data Sheet, 1 of 3

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: Fort Lewis, Washington
Facility Cat. No.:

Building No.: 1452* Year Designed: 1956
Building Name: H-Shaped Barracks
Present Use: Quarters
Initial Use: Similar
No. Stories: 3 Total Floor Area: 19,000 ft²/FLR.
Reviewer: K. Honda Date:
* OUTER WINGS



SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION

	No. Persons
(Quarters)	
Mess	
Administration	
Shops	0-10
Assembly	
Hospital	(11-100)
Utility	
Warehouse	100+
Communications	

Seismic Use Group:
III E
III H
II
I ✓

STRUCTURAL SCORES AND MODIFIERS

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								C1	C2						
Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	(2.0)	(3.0)	2.5	2.0	2.5	2.5	2.0	1.0
2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	(-0.3)	(-0.5)	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Details*								0	+1						
Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	(-0.6)	(-0.6)	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Final Score								1.1	2.9						

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process. Structural systems consist of concrete shear walls (C2) transverse and concrete moment frames (C1) longitudinally. Wings are structurally separated by 2" joints. Detail modifiers: Concrete frame details are average (0.0), shear wall system has few openings (+1.0).

Note: *Subjective Evaluation of structural details varies from −1.0 to +1.0 Include explanation for detail modifier.

Figure C1-4. Completed Structural Review Score Sheet, 1 of 3

Lateral Load System Data Sheet

Station Fort Lewis, Washington

Facility Cat. No.

Reviewer K. Honda

Building No. 1452*

NEHRP Building Type 8

Date

* This sheet describes the center structure between the two wings.

Diaphragms (Describe briefly)

Type	How connected to vertical elements
Roof Cast-in-place R.C. slab	R.C. beam-column frames with reinforcing extending into cols.
Floor(s) Same @ 2nd & 3rd Flrs.	

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall None

Vert. bracing None

Rigid frames R.C. beam-col. exterior frames in both directions

Braced or trussed cols.

Infilled frames Nonstructural infill of hollow CMU. Caulking at top and sides.

Soil Profile Type (Circle one)

S_A S_B S_C S_D S_E S_F

source: USGS topo. maps

Mapped Spectral Acceleration

S_s = 1.23g	S_1 = 0.40g	(from 1997 NEHRP MCE Maps 1 to 16)		
F_a = 1.0	F_v = 1.6	(From FEMA 310, Tables 3-5 and 3-6)		
S_{DS} = 0.82g	S_{D1} = 0.43g	($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)		

Foundations (Circle one or more)

Spread footings — footing dowels = 20d (1'-6" min.)

Strip footings — below perimeter frames between columns.

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity No

Vert. irregularity No

Diaphragm discontinuity No

Basement No

Sidehill site No

Other R.C. walls surround stair-well at two ends.

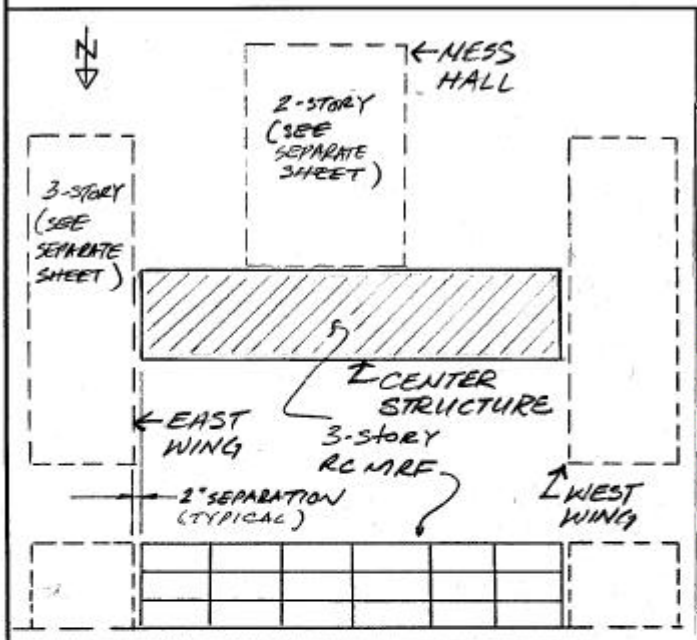
Figure C1-5. Completed Lateral Load System Data Sheet, 2 of 3

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: Fort Lewis, Washington
Facility Cat. No.:

Building No.: 1452* Year Designed: 1956
Building Name: H-SHAPED BARRACKS
Present Use: QUARTERS
Initial Use: SIMILAR
No. Stories: 3 Total Floor Area: 4500 □'/FL.
Reviewer: K. HONDA Date:
* CENTER STRUCTURE



SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS															
Quarters	No. Persons	Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mess										C/							
Administration		Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5	2.0	1.0
Shops	0-10	2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Assembly		Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Hospital	11-100	Details*								0.0							
Utility		Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Warehouse	100+	Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Communications		Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Seismic Use Group:		Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
III E		Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
III H		S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
II		S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
I	✓	S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
		Final Score								1.1							

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process.

See previous comments.

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0 | Include explanation for detail modifier.

Figure C1-6. Completed Structural Review Score Sheet, 2 of 3

Lateral Load System Data Sheet

Station Fort Lewis, Washington

Building No. 1452*

Facility Cat. No.

NEHRP Building Type 8

Reviewer K. Honda

Date

*This sheet describes the 1 and 2 story Mess Hall Wing.

Diaphragms (Describe briefly)

	Type	How connected to vertical elements
Roof	Cast-in-place R.C. slab	beam-column framing with reinforcing extending into framing.
Floor(s)	Same	

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall No

Vert. bracing No

Rigid frames Beam-column exterior and slab-column framing.

Braced or trussed cols. No

Infilled frames Nonstructural CMU at south end.

Soil Profile Type (Circle one)

S_A S_B S_C S_D S_E S_F

source: USGS topo maps

Mapped Spectral Acceleration

S_s = 1.23g S_1 = 0.40g (from 1997 NEHRP MCE Maps 1 to 16)

F_a = 1.0 F_v = 1.6 (From FEMA 310, Tables 3-5 and 3-6)

S_{DS} = 0.82g S_{D1} = 0.43g ($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)

Foundations (Circle one or more)

Spread footings below cols. (dowels = 1'-6")

Strip footings below basement wall

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity 1. North end is open to adjacent structure. 2. Partial 2nd flr. at North end.

Vert. irregularity

Diaphragm discontinuity

Basement Partial basement.

Sidehill site

Other

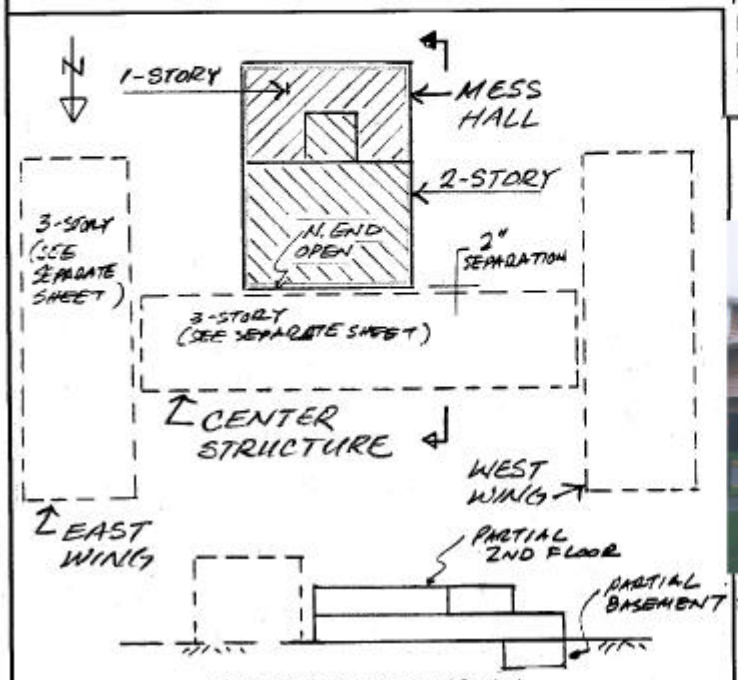
Figure C1-7. Completed Lateral Load System Data Sheet, 3 of 3

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: Fort Lewis, Washington
Facility Cat. No.:

Building No.: 1452*
Year Designed: 1956
Building Name: H-SHAPED BARRACKS
Present Use: LOUNGE & CLASSROOMS
Initial Use: MESS HALL
No. Stories: 2/1
Total Floor Area: 4500 ft²/FL.
Reviewer: K. HONDA
Date:
* MESS HALL WING



SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION	No. Persons
Quarters	
Mess	
Administration	
Shops	0-10
Assembly	
Hospital	11-100
Utility	
Warehouse	100+
Communications	

Seismic Use Group:
III E
III H
II
I ✓

STRUCTURAL SCORES AND MODIFIERS

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
								C1							
Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5	2.0	1.0
2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Details*								0.0							
Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Final Score								-0.2							

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process.

See previous comments.

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0 Include explanation for detail modifier.

Figure C1-8. Completed Structural Review Score Sheet, 3 of 3

EXAMPLE PROBLEM C2

REINFORCED BRICK MASONRY BUILDING

C2-1. Building Description

The Enlisted Men's Barracks at Brigade Headquarters (Building 3733) (Fort Lewis, Washington) is a three-story reinforced brick masonry unit (BMU) structure. According to the as-built drawings, it was designed in 1976.

The building has overall plan dimensions of 80 feet by 48 feet, and consists of three sections. One section on the east end of the building has plan dimensions of 54 feet by 44 feet. The west section has plan dimensions of 16 feet by 42 feet, and is offset 6 feet to the south of the east section. The two are connected by a 10-foot by 31-foot section of corridors and stairs. See Figure C2-1 for floor plans, and Figure C2-2 for elevations.

a. Vertical-Load-Resisting System. The ground floor is a reinforced concrete slab-on-grade. For the second and third floors of the east section, the floor slabs consist of 2½-inch lightweight concrete and 3-inch, 20-gauge composite deck over wide-flange steel beams. For the west and the connecting sections, the floor slabs consist of 8-inch-thick reinforced concrete. The roof consists of built-up roofing and rigid insulation over 20-gauge by 1½-inch steel decking supported by truss joists and steel girders. Vertical loads are supported by steel columns in the interior, and reinforced BMU along the exterior. The footings consist of individual spread footings for the columns, and strip footings along the perimeter of the structures.

b. Lateral-Load-Resisting System. The primary lateral-force-resisting system consists of the roof and floors acting as diaphragms and transmitting lateral forces to the perimeter BMU shear walls. The roof load is transmitted by the steel decking to the walls through steel angles connected to the walls with 5/8-inch-diameter bolts. The BMU walls are reinforced vertically with #4 bars at 24 inches on center. Horizontal bond beams with four #4 bars are provided at each floor level, with intermediate bond beams with two #4 bars at 3-foot, 4-inch centers, and over door and window openings. The lateral force from the floor diaphragm is transmitted to the ground through these BMU shear walls. There are several CMU (concrete masonry unit) walls on the first floor, which also contribute to resisting the lateral loads.

C2-2. Building Review Report

a. Seismic Review of Structural Systems. This form procedure described in Chapter 2 is performed using the Lateral Load System Data Sheet and Structural Review Score Sheet.

b. Lateral Load System Data Sheet. This form (Figure C2-3) is completed in accordance with the guidelines in Appendix B. The information is taken from the building drawings and by visual inspection of the building. The building is categorized as FEMA 310 Model Building Type 13, based on the description of structural systems given in FEMA 310, Table 2-2.

c. Structural Review Score Sheet. This form (Figure C2-4) is completed using the instructions in Appendix B and the information obtained from drawings and other sources, and confirmed by visual inspection of the building.

Although the plan of the building is not purely rectangular, the irregularity does not appear severe enough in the initial review to warrant deduction in the structural score. The basic score of 2.5 for the Model Building Type 13 is modified by -1.0 for having between 2 to 4 stories; +0.5 for better than average detailing; and -0.6 for Soil Type S_D. This results in a final score of 1.4.

C2-3. Installation Report

The final score for the building can then be ranked with other installation building scores to compare the relative seismic vulnerability of all nonexempt buildings at the installation. The procedures for seismic vulnerability ranking of buildings and preparation of the Installation Report that summarizes the seismic review findings are described in Appendix D.

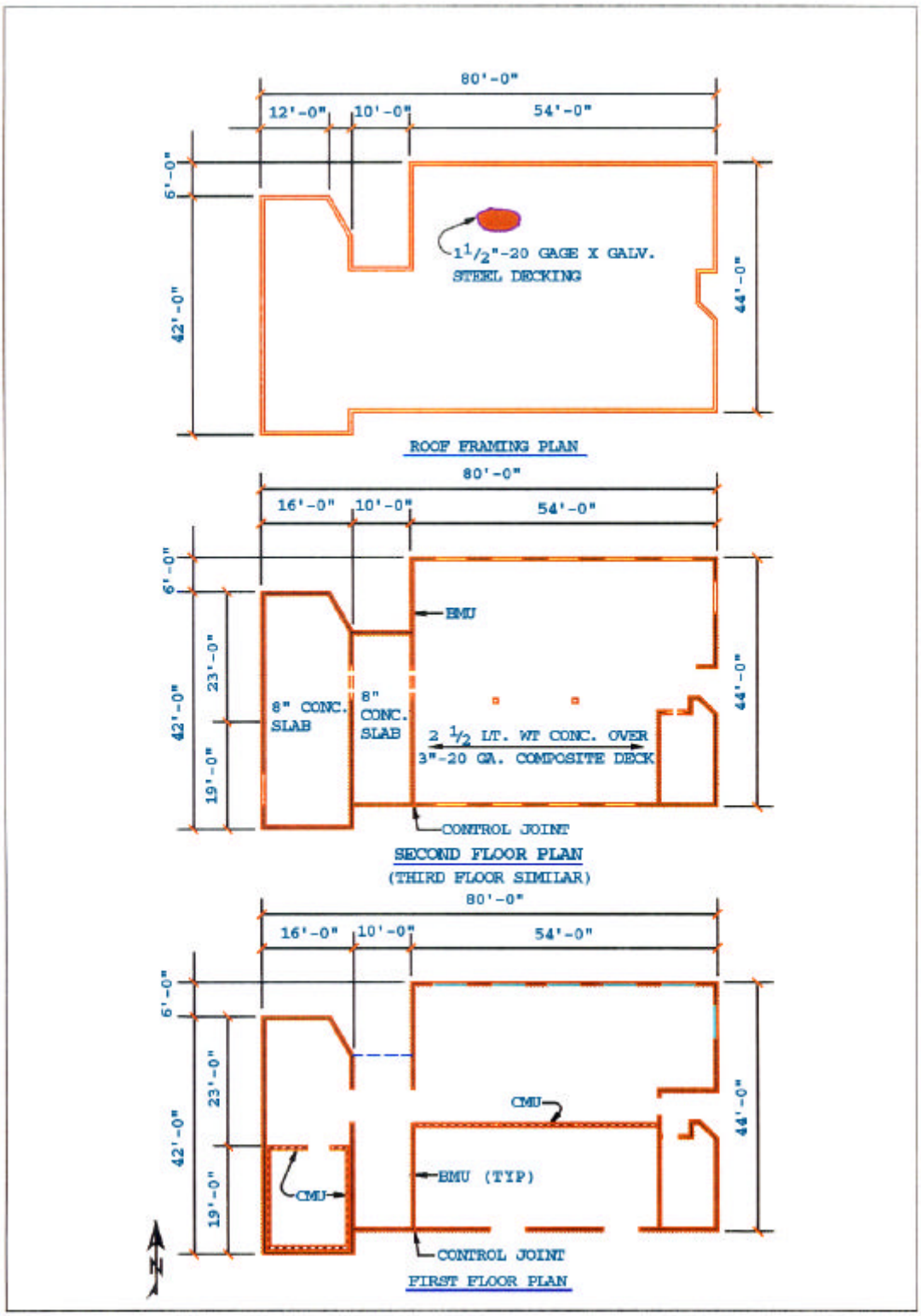


Figure C2-1. Floor Plans

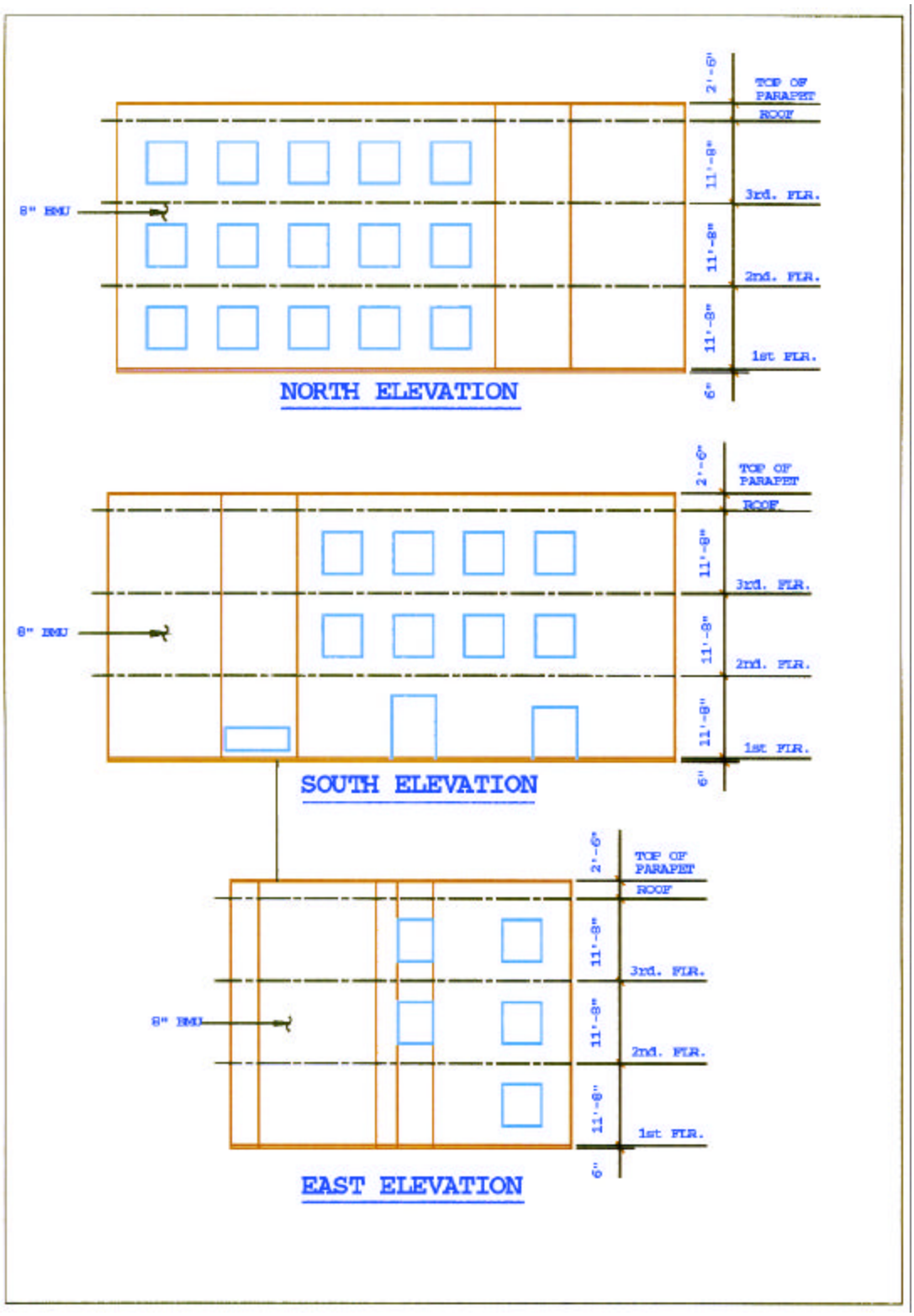


Figure C2-2. Elevations

Lateral Load System Data Sheet

Station FORT LEWIS, WASHINGTON

Building No. 3733

Facility Cat. No.

NEHRP Building Type 13

Reviewer K. HONDA

Date

Diaphragms (Describe briefly)

	Type	How connected to vertical elements
Roof	Rigid insulation over metal deck spot-welded to steel joists	Connected to brick masonry (BMU) walls through bolted 1/4" angles
Floor(s)	L.W. concrete over metal decking and steel joists. Also, partial 8"-thick R.C. structural slab.	SAME

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall BMU with #4 vert. reinf. @ 24" o.c. & horiz. bond beams

Vert. bracing None

Rigid frames

Braced or trussed cols.

Infilled frames

Soil Profile Type (Circle one)

S_A S_B S_C S_D S_E S_F

USGS topo & geologic maps

Mapped Spectral Acceleration

S_s =	1.23g	S_1 =	0.40g	(from 1997 NEHRP MCE Maps 1 to 16)
F_a =	1.0	F_v =	1.6	(From FEMA 310, Tables 3-5 and 3-6)
S_{DS} =	0.82g	S_{D1} =	0.43g	($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)

Foundations (Circle one or more)

Spread footings under interior cols.

Strip footings under walls

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity Building consists of 3 sections that are slightly offset from each other. There are additional CMU walls @ 1st Flr.

Vert. irregularity Slight irregularity due to different wall openings.

Diaphragm discontinuity Yes, at stair openings.

Basement None

Sidehill site

Other

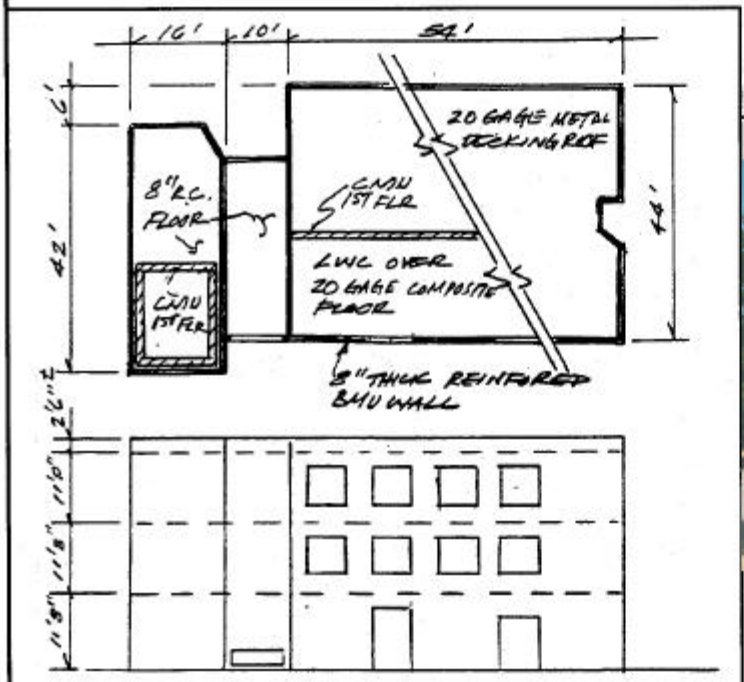
Figure C2-3. Completed Lateral Load System Data Sheet

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: Fort Lewis, Washington
Facility Cat. No.:

Building No.: 3733 Year Designed: 1976
Building Name: E.M. Barracks, Brigade HQ.
Present Use: Quarters
Initial Use: Same
No. Stories: 3 Total Floor Area: 10,000 ft² ±
Reviewer: K. Honda Date:



SKETCH (Plan, Elevation and Section)

PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS															
Quarters	No. Persons	Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mess															RM1		
Administration		Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5	2.0	1.0
Shops	0-10	2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Assembly		Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Hospital	11-100	Details* (well detailed)													+0.5		
Utility		Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Warehouse	100+	Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Communications		Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Seismic Use Group:		Plan Irregularity *	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
III E		Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
III H		S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
II		S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
I	✓	S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
		Final Score													1.4		

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process.

* - Plan irregularity not severe enough for reduction.
Detail modifier: better than average detailing (+0.5).

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0 Include explanation for detail modifier.

Figure C2-4. Completed Structural Review Score Sheet

EXAMPLE PROBLEM C3

INFILLED STEEL FRAME BUILDING

C3-1. Building Description

The French Theater (Building 2004) is a one-story infilled steel frame building located at Fort Lewis, Washington. The steel frames are infilled with unreinforced hollow clay tile walls. According to the available drawings and information, the building was originally built in 1932. It was apparently enlarged in 1940. The drawings reviewed were prepared for the 1940 modification, and generally represent the existing condition of the original building, but do not provide the detailing and reinforcing information of the original building.

The original building had overall plan dimensions of approximately 48 by 120 feet, with the main theater section measuring 48 by 100 feet. The modified building has overall plan dimensions of approximately 80 by 132 feet, consisting of the 80-foot by 100-foot main theater section, and 30-foot by 52-foot entrance and lobby area. See Figure C3-1 for plans, and Figure C3-2 for sections.

a. Vertical-Load-Resisting System. The ground floor is a concrete slab poured on excavated ground to form a sloped surface (reinforcing is unknown). The roof consists of Spanish tile on 2-inch by 6-inch roofing plank supported by a steel joist and truss system. Steel columns support the truss. The steel columns along the exterior are infilled with the hollow clay tile walls. The footings consist of individual spread footings for the columns and strip footings along the perimeter of the structures.

b. Lateral-Load-Resisting System. The primary lateral-force-resisting system consists of horizontal wood sheathing connected to the top flange of the upper chord of the trusses through 3-inch by 6-inch nailer and steel joists. The unreinforced masonry shear walls along the exterior resist the lateral load. The lateral load is transmitted to the walls through the roof diaphragm, with contribution from intermediate collectors and steel framing and X-bracing consisting of angles and rods.

c. The 1940 Modifications. During the 1940 modifications, the auditorium portion was widened and the entrance area was enlarged. The auditorium portion was widened from 49 feet, 4 inches to 80 feet, 4 inches, and the entrance area was enlarged from 39 feet by 20 feet, 2 inches to 52 feet, 8 inches by 30 feet, 8 inches. The transverse framing consists of end shear walls and four interior truss-column frame systems. During the 1940 modifications, the columns of the two interior trusses were removed and a carrying truss was installed to transfer the vertical load to the adjacent columns.

C3-2. Building Review Report

a. Seismic Review of Structural Systems. The review procedure described in Chapter 2 was performed for Building 2004 using the Lateral Load System Data Sheet and Structural Review Score Sheet. The review was performed only on the auditorium section of the building because it appeared to pose the most severe condition.

b. Lateral Load System Data Sheet. The form (Figure C3-3) was completed in accordance with the instructions contained in appendix B. The information was extracted from the available building drawings and by visual inspection of the building. The applicable FEMA 310 Model Building Type was determined from the description of structural systems given in FEMA 310, Table 2-2.

c. Structural Review Score Sheet. This form (Figure C3-4) was completed at the building site using the information entered on the Lateral Load System Data Sheet, and confirmed by visual observation of the building. The building is classified as steel frames with infilled shear wall.

Although the theater is a one-story building, due to its height of approximately 32 feet, and the long 80-foot span of the building, the story modifier of -0.5 was assigned. The building drawings lack information on the original building and some of the key elements are not visible; therefore, a score of -0.5 was assigned for details. The resulting final score for the building is 0.9.

C3-3. Installation Report

The final score for the building can then be ranked with other installation building scores to compare the relative seismic vulnerability of all nonexempt buildings at the installation. The procedures for seismic vulnerability ranking of buildings and preparation of the Installation Report that summarizes the seismic review findings are described in appendix D.

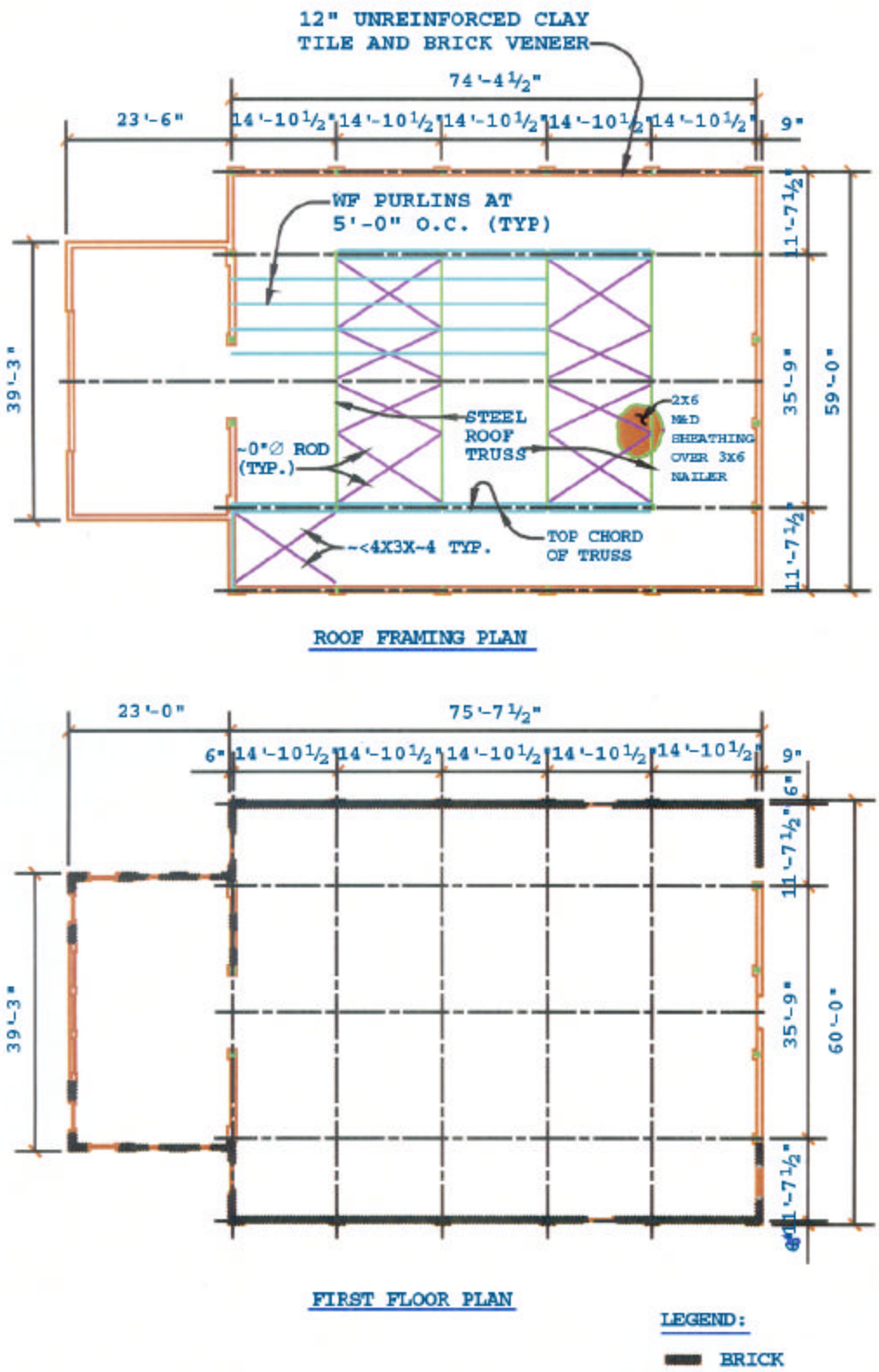
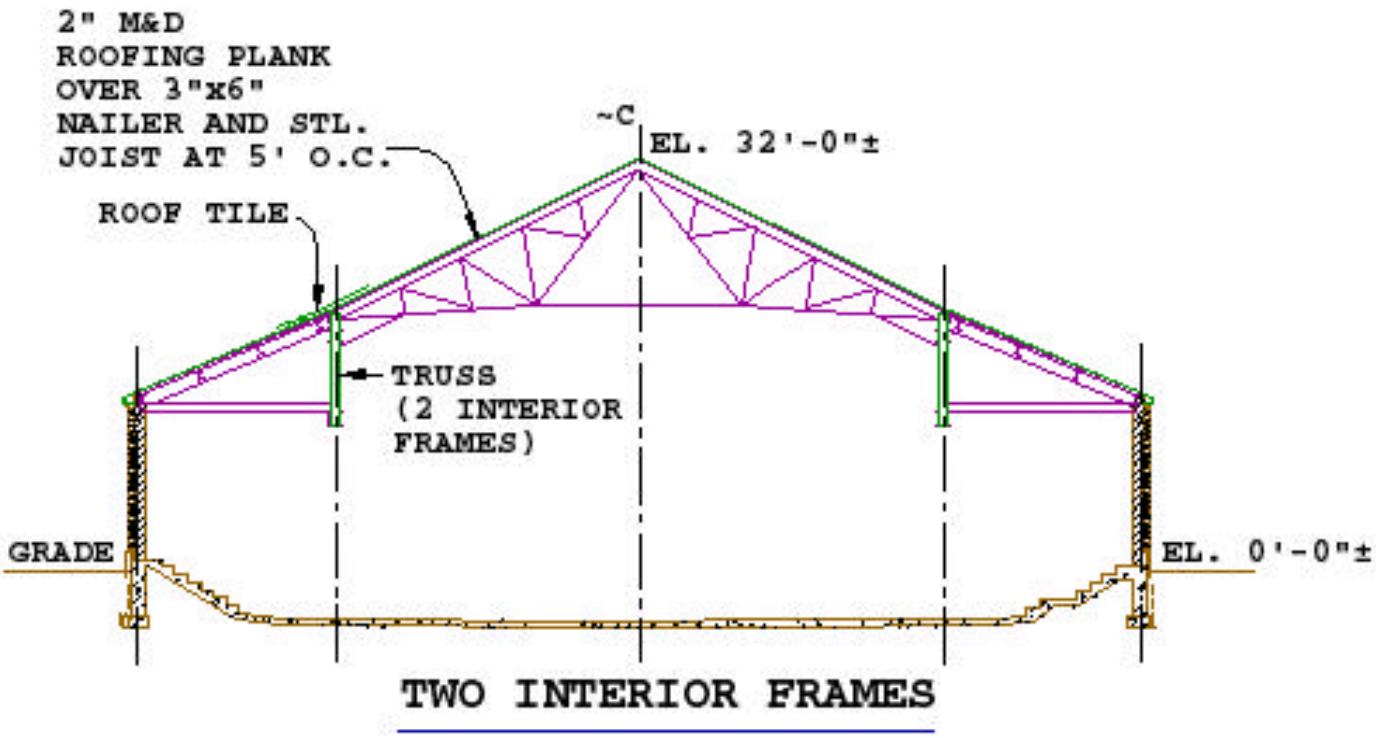


Figure C3-1. Floor Plans



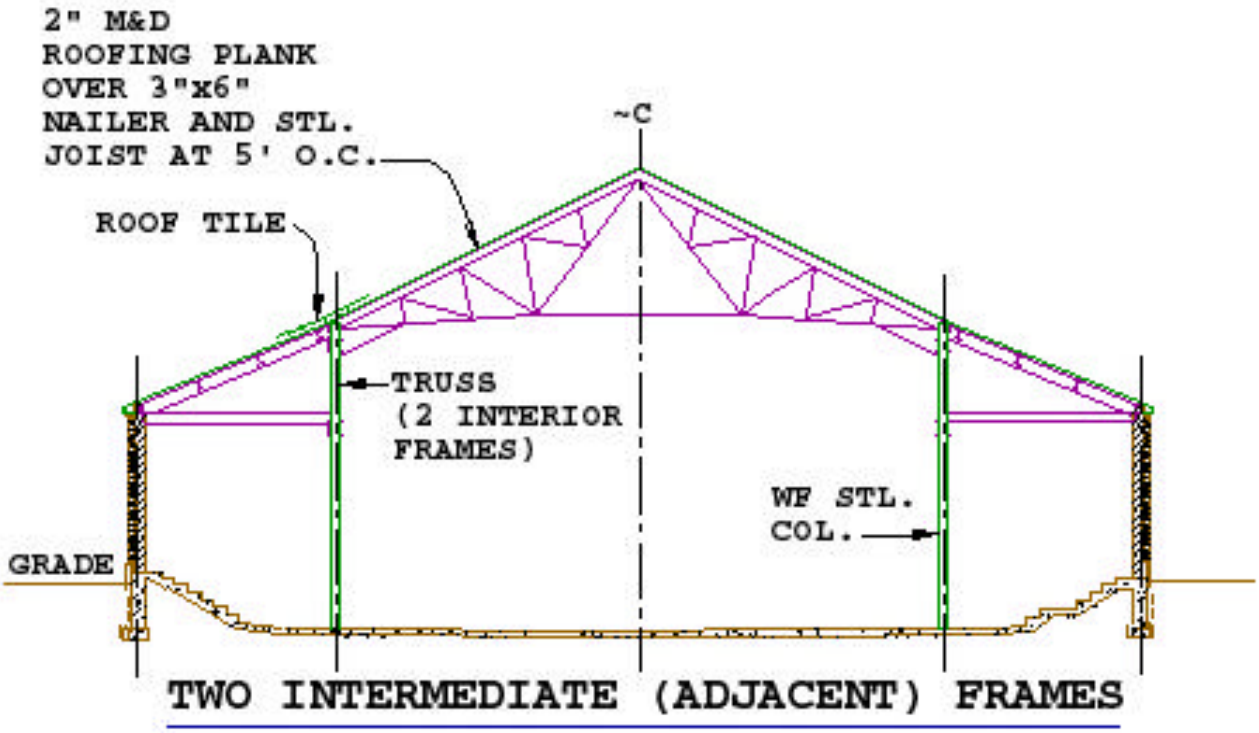


Figure C3-2. Sections

Lateral Load System Data Sheet

Station: Fort Lewis, Washington
Building No.: 2004
Facility Cat. No.:
NEHRP Building Type: 7 (S5A)
Reviewer: K. Honda
Date:

Diaphragms (Describe briefly)

Type	How connected to vertical elements
Roof: 2"-thick straight board sheathing and horizontal steel x-bracing	x-bracing connected to WF collector beams and framing. Exterior steel columns encased in hollow clay tile and brick veneer shear walls.
Floor(s): slab-on-grade	

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall: Hollow clay tile with brick veneer exterior walls.
Vert. bracing: None
Rigid frames: None
Braced or trussed cols.: Truss roof framing with knee braces in trans. direction.
Infilled frames: Steel framing with infilled hollow clay tiles & brick exterior.

Soil Profile Type (Circle one)

S_A S_B S_C S_D S_E S_F

Source: USGS topo. & geologic Maps

Mapped Spectral Acceleration

S_s = 1.23g	S_1 = 0.40g	(from 1997 NEHRP MCE Maps 1 to 16)		
F_a = 1.0	F_v = 1.6	(From FEMA 310, Tables 3-5 and 3-6)		
S_{DS} = 0.82g	S_{D1} = 0.43g	($S_{DS} = 0.67F_aS_s$,	$S_{D1} = 0.67F_vS_1$)	

Foundations (Circle one or more)

- Spread footings below columns
- Strip footings below walls
- Pier footings
- Piles
- Caissons

Unusual Features (Describe briefly)

Plan irregularity: 2-story entrance structure in front end of building.
Vert. irregularity: None
Diaphragm discontinuity:
Basement:
Sidehill site:
Other:

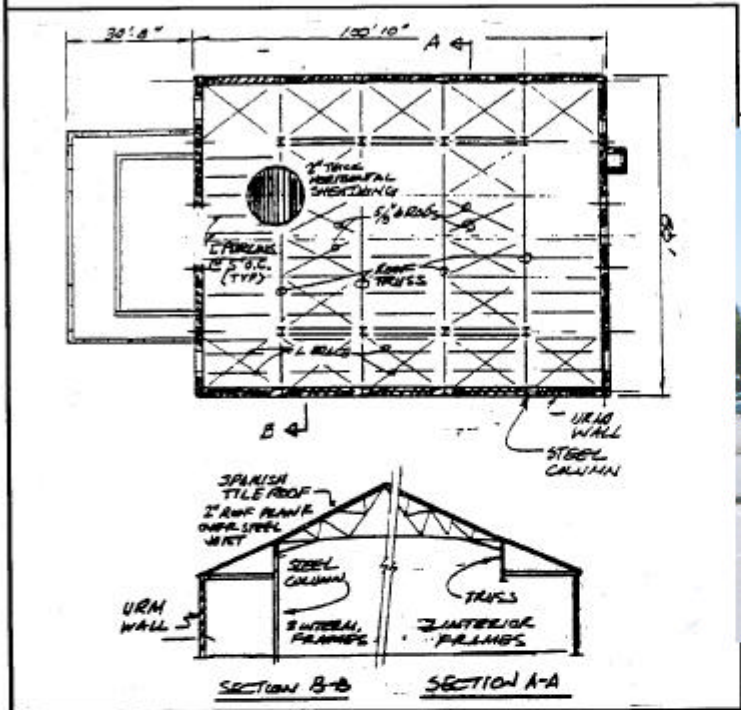
Figure C3-3. Completed Lateral Load System Data Sheet

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: Fort Lewis, Washington
Facility Cat. No.:

Building No.: 2004 Year Designed: 1932
Building Name: French Theater
Present Use: (vacant)
Initial Use: theater
No. Stories: 1 Total Floor Area: 10,000 □'
Reviewer: K. Honda Date:



PHOTO

BUILDING FUNCTION	No. Persons
Quarters	
Mess	
Administration	
Shops	0-10
Assembly	
Hospital	11-100
Utility	
Warehouse	100+
Communications	

Seismic Use Group:
III E
III H
II ✓
I

STRUCTURAL SCORES AND MODIFIERS

Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							S5A								
Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5	2.0	1.0
2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Details*							-0.5								
Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
Final Score							0.9								

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process. 1940 Modification enlarged theater by 4240 □'± by widening the auditorium area from 49'-4" to 80'-4" & enlarging the entrance area from 39'-0" by 20'-2" to 52'-8" by 30'-8". Drawings of the original 1932 structure were not available for review. Detail modifier: drawings lack details of critical elements (-0.5).

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0 | Include explanation for detail modifier.

Figure C3-4. Completed Structural Review Score Sheet

EXAMPLE PROBLEM C4

STEEL FRAME BUILDING

C4-1. Building Description

Building 745 consists of three 1-story structures located at McChord Air Force Base (AFB), Washington. The buildings are used as shops for aircraft engine inspection and repair. One is of timber construction (built in the 1950s), and the other two are steel construction (built in 1961 and 1965), and all are structurally independent of each other. One of the steel structures is used here to demonstrate the structural review procedures.

The example building was constructed in 1965 and consists of a pre-engineered and pre-fabricated gable-framed structure (Figure C4-1). The plan dimensions of the building are approximately 131 feet by 155 feet. The roof framing consists of insulated metal roofing over purlins that are spaced at 5-foot intervals. Steel-gable frames with tapered steel beam-columns at each end span the transverse direction. The beam-columns are 10½-inch by 12-inch built-up steel sections at the base and 10½ inches by about 30 inches at the top, and are spaced at 20-foot intervals. The steel beams are approximately 30 inches deep, and are supported at the midpoint by 12-inch by 12-inch wide-flange steel columns. Two sets of crane rails are suspended from the beams. Each crane has a maximum lift capacity of 8 tons.

The east end wall and both side walls consist of 6-inch-thick by 4-foot-high precast concrete wainscot and insulated metal siding over steel girders spaced at approximately 4-foot intervals above (except for door and window openings). The west wall is an 8-inch-thick CMU firewall, and is connected to the steel columns with metal clips.

a. Vertical-Load-Resisting System. Steel framing and concrete columns carry the vertical loads. The footings of the steel frames consist of 3-foot, 6-inch-square spread footings for each column, with strip footings between the columns. The interior columns are 12-inch-square, with reinforcing of four #6 bars and #3 ties at 12 inches. The footings below the center columns are 2-foot, 6-inch-square spread footings.

b. Lateral-Load-Resisting System. The lateral forces in the transverse direction are transmitted through the gable-frame system to the foundation. The lateral forces in the longitudinal direction are transmitted to the foundation by three sets of ¾-inch rod X-bracing in the roof and two sets of 3-inch by 3-inch angle X-bracing in the side walls (one leg of the angle is notched at the intersection).

C4-2. Building Review Report

a. Seismic Review of Structural Systems. The review procedure described in Chapter 2 is performed using the Lateral Load System Data Sheet and Structural Review Score Sheet. The information is extracted from the building drawings (made available by the Base Master Planning office), and by visual inspection of the building. For this building, there were no fabrication drawings showing the frame sizes and bracing locations. It was necessary to obtain this information by field measurement where they were accessible, and by estimation where they were not. The completed forms are shown in Figures C4-2 and C4-3.

b. Lateral Load System Data Sheet (Figure C4-2). This form is completed in accordance with the instructions contained in Appendix B. The building is categorized as FEMA Building Type 5, based on the description of structural systems given in FEMA 310, Table 2-2. Based on the information obtained from topographic maps and logs of soil profiles, the site is assigned Soil Profile Type S_D.

c. Structural Review Score Sheet (Figure C4-3). This form is completed using the information obtained from drawings and confirmed by visual observation of the building.

The building is rectangular in plan. There is a firewall on the east side of the building that is not expected to contribute to the overall building stiffness because the wall is connected to the framing with clips, which do not transfer lateral forces. Therefore, no reduction is taken for possible torsion.

The basic score for Model Building Type 5 is 5.5. With the -0.6 reduction for Soil Type S_D, the final score is 4.9.

C4-3. Installation Report

The final score for the building can then be ranked with other installation building scores to compare the relative seismic vulnerability of all nonexempt buildings at the installation. The procedures for seismic vulnerability ranking of buildings and preparation of the Installation Report that summarizes the seismic review findings are described in appendix D.

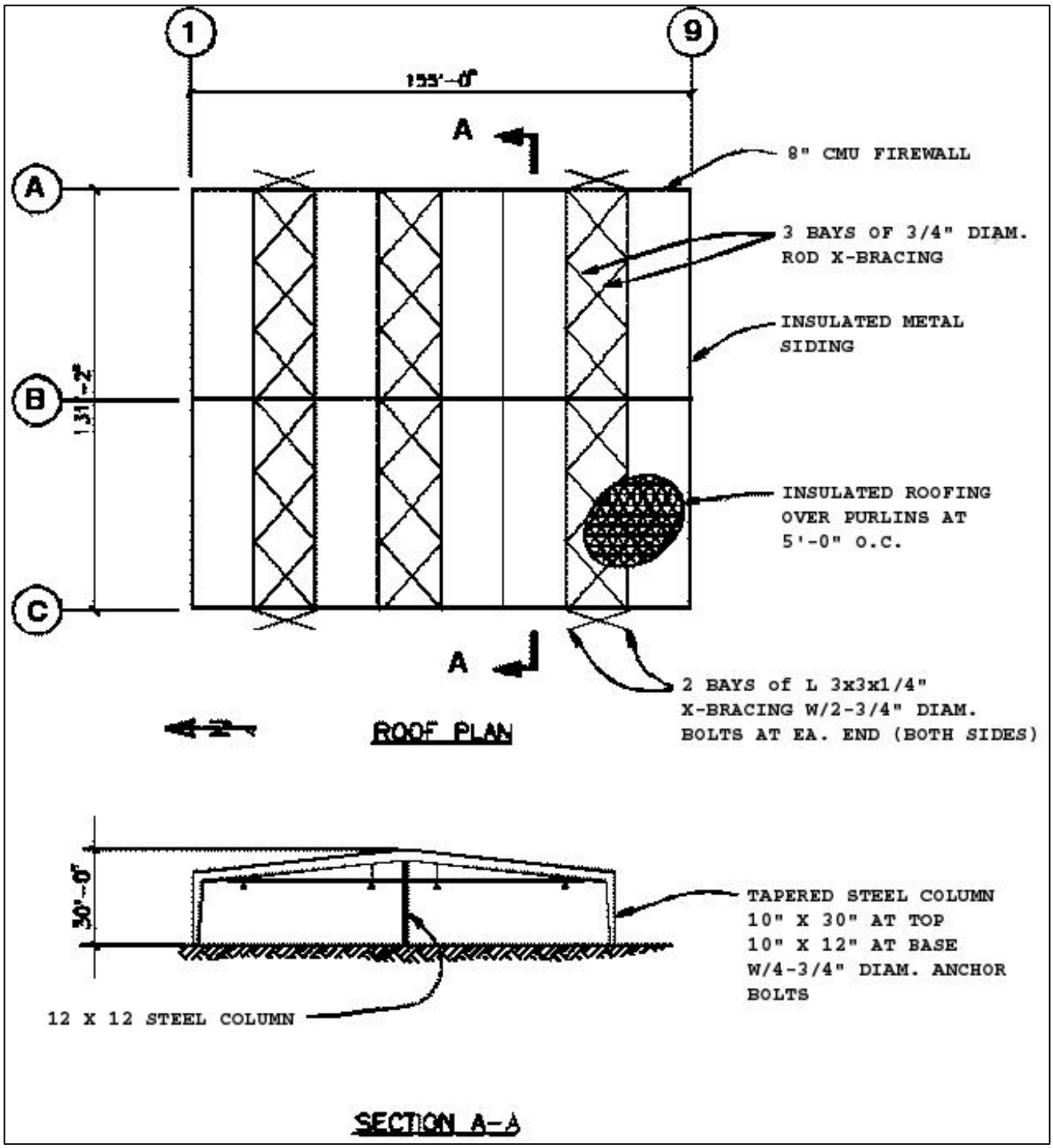


Figure C4-1. Plan and Section

Lateral Load System Data Sheet

Station McChord AFB, Washington

Building No. 745

Facility Cat. No.

NEHRP Building Type 5 (S3)

Reviewer K. Honda

Date

Diaphragms (Describe briefly)

	Type	How connected to vertical elements
Roof	Insulated metal deck	welded to purlins which are supported by steel frames.
Floor(s)		

Vertical Resisting Elements (Describe briefly as applicable)

Shear wall None

Vert. bracing Steel angle x-bracing in the longitudinal direction

Rigid frames Steel frames in transverse direction

Braced or trussed cols. None

Infilled frames None

Soil Profile Type (Circle one)

S_A S_B S_C S_D S_E S_F

source: USGS topo. maps

Mapped Spectral Acceleration

S_s = 1.23g S_1 = 0.40g (from 1997 NEHRP MCE Maps 1 to 16)

F_a = 1.0 F_v = 1.6 (From FEMA 310, Tables 3-5 and 3-6)

S_{DS} = 0.82g S_{D1} = 0.43g ($S_{DS} = 0.67F_aS_s$, $S_{D1} = 0.67F_vS_1$)

Foundations (Circle one or more)

Spread footings below cols.

Strip footings below interior walls between columns

Pier footings

Piles

Caissons

Unusual Features (Describe briefly)

Plan irregularity No

Vert. irregularity No

Diaphragm discontinuity No

Basement No

Sidehill site No

Other No

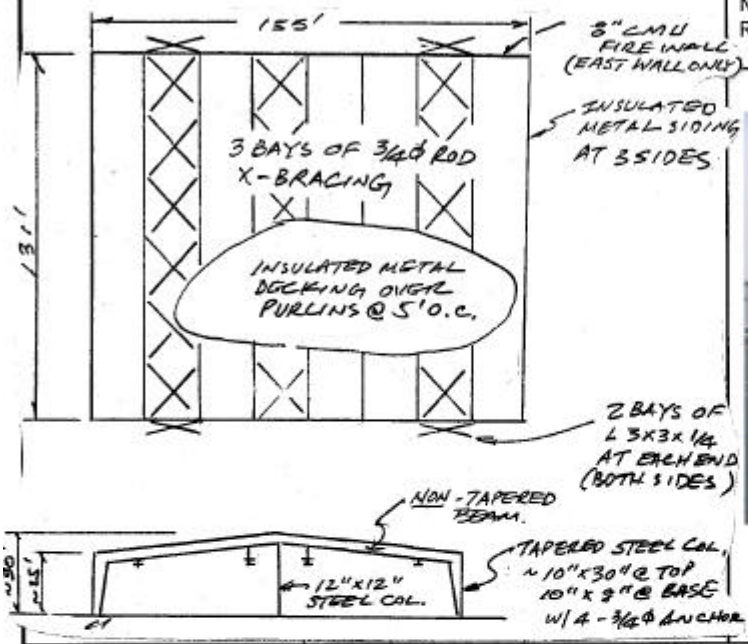
Figure C4-2. Completed Lateral Load System Data Sheet

Structural Review Score Sheet

High Seismicity Region (S_{DS} > 0.500g, S_{D1}>0.200g)

Station: McChord AFB, Washington
Facility Cat. No.:

Building No.: 745 Year Designed: 1965
Building Name: Aircraft Inspection & Repair
Present Use: Same
Initial Use: Same
No. Stories: 1 Total Floor Area: 20,000 SF
Reviewer: K. Honda Date:



PHOTO

BUILDING FUNCTION		STRUCTURAL SCORES AND MODIFIERS															
Quarters	No. Persons	Building Type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mess							93										
Administration		Basic Score	5.0	4.5	4.5	3.0	5.5	3.5	2.5	2.0	3.0	2.5	2.0	2.5	2.5	2.0	1.0
Shops	0-10	2 to 4 Stories	-0.3	-0.3	-0.3	-0.3	N/A	-0.3	-0.5	-0.3	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0
Assembly		Poor Condition	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-0.5	-0.5	-0.3	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Hospital	11-100	Details*					0.0										
Utility		Vert. Irregularity	-0.3	-0.3	-0.3	-0.5	N/A	-0.5	-0.5	-0.5	-0.8	-0.5	-1.0	-1.0	-0.5	-1.0	-0.5
Warehouse	100+	Soft Story	-0.5	-0.5	-0.5	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	-0.8	-1.2	-1.2	-1.0	-1.2	-0.8
Communications		Torsion	-0.5	-0.5	-0.6	-1.0	-0.8	-0.8	-1.0	-0.8	-0.8	-1.0	-0.8	-1.0	-1.0	-1.0	-0.5
Seismic Use Group:		Plan Irregularity	-0.5	-0.5	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-1.0	-0.5
III E		Diaphragm Discont.	-0.3	-0.3	-0.5	-0.8	-0.5	-0.8	-1.0	-0.8	-0.8	-1.0	-1.0	-1.0	-0.8	-0.8	-0.6
III H		S_A, S_B	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3	+0.3
II		S_D	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
I	✓	S_E, S_F	-0.6	-0.6	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8
		Final Score					4.9										

COMMENTS/CONCLUSIONS: Record dates and a brief description of additions and/or modifications (if any), poor condition or obvious structural deficiencies (if any), narrative explanation of any discrepancies between the final structural score and the judgement of the reviewer as well as comments that may be useful in the evaluation process.

Detail modifier: average details (0.0).

Note: *Subjective Evaluation of structural details varies from –1.0 to +1.0 Include explanation for detail modifier.

Figure C4-3. Completed Structural Review Score Sheet

APPENDIX D

INSTALLATION REPORT

D-1. Purpose. This appendix defines the key components of the Installation Report that summarize the results of the seismic review of buildings at a given military installation.

D-2. Installation Report Components

a. Executive Summary. The following items shall be summarized in the front of the report:

(1) The total number of buildings designated for review

(2) The number of buildings exempted by the criteria defined in Appendix A

(3) The total number of structurally similar building groups reviewed.

b. Seismic Vulnerability Ranking. A listing of the structurally similar building groups reviewed, ranked in ascending numerical order based on their structural scores. This will result in the ranking of the building groups from highest seismic vulnerability (lowest structural scores) to lowest seismic vulnerability (highest structural scores). The listing shall include:

(1) Building Group number

(2) The building number of the representative building reviewed in each group

(3) The structural score for each group

(4) The FEMA 310 Model Building Type of the building reviewed

(5) The number of stories of the building reviewed

(6) The construction date of the building reviewed

(7) The Seismic Use Group (Table 1-1) of the building reviewed.

c. Building List. A listing of the buildings designated for review arranged numerically by building number, with the following information for each building:

(1) Building number

(2) Building title

(3) Building group number

(4) The number of stories

(5) Gross area

(6) The FEMA 310 Model Building Type

(7) The year of construction

(8) The Seismic Use Group (Table 1-1).

d. Exempted Buildings List. A listing of buildings exempted by the criteria defined in Appendix A during the Inventory Reduction Phase (Figure 2-1).

(1) Building number

(2) Building title

(3) Paragraph reference from Appendix A as the basis for exemption.

e. Building Group List. A listing of building groups and the buildings within each group. The representative building reviewed for each group shall be identified, and the assigned FEMA 310 Model Building Type shall be indicated.

(1) Groups of buildings determined to be structurally similar based on the following parameters:

- Year Built
- Number of Stories
- Seismic Use Group
- Gross Area
- FEMA 310 Model Building Type
- Building Footprint.

(2) A number for each group based on largest (Group 1) to smallest (last Group) gross building areas.

f. Appendices. The Appendices to the Installation Report shall consist of the individual Building Review Reports arranged in ascending numerical order by either building number or group number. Installations have preferred the Building Review Reports listed by building number in the past. Each Building Review Report shall consist of the Structural Review Score Sheet and the Lateral Load Systems Data Sheet for each building or group. For building groups of structurally similar buildings, only the Building Review Reports of the representative buildings for each group need be included.

APPENDIX E

BIBLIOGRAPHY

E-1. Government Publications

Departments of the Army, Navy, and Air Force

Draft TI 809-04, 1998, November 1998
Seismic Design for Buildings

Draft TI 809-05, November 1998
Seismic Evaluation and Rehabilitation for Buildings

Federal Emergency Management Agency

FEMA 156, July 1988
Typical Costs for Seismic Rehabilitation of Existing Buildings, Volume I - Summary

FEMA 157, September 1988
Typical Costs for Seismic Rehabilitation of Existing Buildings, Volume II - Supporting Documentation

FEMA 172, June 1992
NEHRP Handbook for Seismic Rehabilitation of Existing Buildings

FEMA 302, 1997 Edition
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