CHAPTER 1

GENERAL

1-1. Purpose

This manual prescribes criteria and furnishes design guidelines, procedures, and strategy to screen, prioritize, evaluate, upgrade, and strengthen existing facilities for seismic resistance. These criteria apply to all elements responsible for the design of military construction in the high seismic regions and will apply to all existing facilities in Seismic Zones 3 and 4, to only existing essential facilities in Seismic Zone 2, and to other facilities designated by the approving agency. These guidelines also provide procedures and guidance for engineers to identify seismically hazardous buildings and to determine the strengthening method to resist the required seismic forces. This manual is a supplement to TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13, referred to herein as the Basic Design Manual (BDM) and TM 5-809-10-1/NAVFAC P-355.1/AFM 88-3, Chapter 13, Section A, referred to herein as the Seismic Design Guidelines (SDG).

1-2. Scope

These guidelines encompass a strategy and method to identify potential seismically hazardous buildings on a priority basis. The guidelines include a step-by-step procedure involving building inventory reduction; preliminary screening; preliminary evaluation; detailed structural analysis; development of design concepts for seismic upgrading/strengthening; cost benefit analysis; final design and preparation of contract documents; and seismic upgrading/strengthening of nonstructural elements. The problems relating to earthquake-induced ground failures and tsunami are stated in the BDM, paragraph 2-7, and will not be covered in this manual. Authorization from HQDA(DAEN-ECE-D) WASH, DC 20314-1000, NAVFAC Code 4BA 200 Stovall Street Alexandria, VA 22332, or HQ USAF/LEEE WASH, DC 20332 is required for the application of the procedures in this manual.

1-3. Definitions, symbols, and notations

Unless otherwise noted in this manual, all definitions, symbols, and notations will be as indicated in chapter 3 of the BDM. Symbols and notations are listed in appendix A.

1-4. Seismic hazard risk levels

The evaluation and upgrading of existing buildings is based on seismic ground motions of two risk levels as specified in chapter 3 of the SDG.

a. The selected risk levels of the two design earthquakes, EQ-I and EQ-II, are based on Department of Defense standards; however, the risk levels may be revised as warranted by approval authorities.

b. As an alternate, the code provisions provided in appendix C may be used for high risk or nonessential buildings in high seismic regions as warranted or deemed appropriate by approval authorities.

1-5. Identification of seismically hazardous buildings

The military has a large inventory of buildings, and an effective strategy method is required to identify potentially hazardous buildings on a priority basis. The objective of this strategy/method is to minimize unnecessary investigations by eliminating buildings of minor importance and low hazard exposure from the large inventory, identifying groups of similar buildings, and prioritizing seismic safety evaluation and hazard mitigation (strengthening) efforts. Since the basic goals of seismic hazard mitigation for existing buildings are to enhance life safety (i.e., protection against collapse) and post-earthquake operational capability, it is essential to identify buildings with post-earthquake operational requirements or high risk (high-loss potential) functions.

a. The essential buildings with post-earthquake operational requirements are:

(1) Hospitals

(2) Fire stations, rescue stations, and structures housing vehicles essential for post-earthquake rescue and relief operations.

(3) Power stations and other utilities required as emergency facilities.

(4) Mission essential facilities. The decision to designate a building as “mission essential” is the responsibility of the operating Command. Since it may be possible to pick up the function of an entire Base at other locations, the decision to designate a structure as mission essential should be confirmed at the major command level or higher.

(5) Primary communications or data-handling facilities. (Some of these may be mission essential, but this category is not limited to mission essential.)

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(6) Facilities involved in operational missile control, launch, tracking, or other critical defense capabilities.

(7) Facilities involved in handling, processing, or storing sensitive munitions, nuclear weaponry, gas and petroleum fuels, and chemical or biological contaminants.

b. High-risk (high-loss-potential) buildings are those whose primary occupancy is for assembling a large number of people, or where services are provided to a large area having many other buildings. Buildings in this category may suffer damage in an earthquake, but are recognized as warranting a higher level of safety than an ordinary building. Typical examples are:

(1) Buildings whose primary occupancy is that of an auditorium, recreation facility, dining hall, or commissary, any of which may have an occupancy of more than 300 persons.

(2) Confinement facilities.

(3) Central utility facilities (power, heat, water, sewage) that are not required as emergency facilities and that serve large areas.

(4) Buildings housing valuable equipment whose justification is provided by the using agency.

c. All other buildings are considered nonessential, ordinary buildings of lesser importance which will require the life safety provision, i.e., against collapse, unless a higher upgrade is warranted by approving authorities.

d. Hazardous critical facilities (e.g., nuclear power plants, dams, and LNG facilities) are not included within the scope of this manual, but are covered by other publications or regulatory agencies. For any facilities housing hazardous items not covered by criteria, advice should be sought from DAEN-ECE-D (Army), NAVFAC Code 04BA (Navy), or HQ USAF/LEEE (Air Force).

1-6. Background

a. Seismic design criteria. In recent years, developments in earthquake engineering have resulted in substantial changes in seismic design criteria. In the 1960's, major changes began to occur in the seismic design codes. In 1966, the first edition of the "Seismic Design for Buildings" was introduced (TM 5-809-10/NAVDOCKS P-355/AFM 88-3, Chapter 13, March 1966). In 1973, a new revised and expanded edition of the manual was published (TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13, April, 1973) which included ductility provisions for moment resisting space frames. In the February, 1982 edition (i.e., the BDM) substantial changes were made in force levels and seismic detailing requirements. Many of these changes were in response to experiences from the 1971 San Fernando, California earthquake. In the late 1970's, areas in the United States outside of California and the Pacific Coast area began to be aware of the need for earthquake-resistant design requirements for their facilities. In 1978, "Tentative Provisions for the Development of Seismic Regulations for Buildings" was published by the National Bureau of Standards (NBS SP-510; Applied Technology Council, ATC 3-06; and National Science Foundation, 78-8). These provisions were developed through a nationwide effort to improve seismic design and construction building practices and are currently being evaluated by a national committee. In addition to the static force approach used in codes and manuals, there was a need for a dynamic analysis approach to seismic design for essential buildings. In 1986, the tri--Services published the SDG to provide guidelines for the design of essential buildings, as well as other structures, by means of a two-level dynamic analysis procedure.

b. Existing buildings. Major changes in structural criteria based upon building failures in past earthquakes naturally raise the question of the adequacy of existing buildings. A building designed and constructed prior to the recent changes in seismic design criteria, especially those in high seismic areas, will probably not conform to the requirements of today's criteria. In some cases, the general structural system does not conform, and there are some cases where the new lateral force levels can be 3 or more times greater than forces used in the original design. This does not necessarily mean that all these buildings are unsafe or will not be able to perform adequately when subjected to a major or moderate earthquake. Some of the older buildings may actually perform better than new ones that conform to the latest provisions. Many of the performance capabilities of buildings depend on configuration, details, and ability to act in a tough, ductile, energy absorbing manner rather than on conformance to the minimum standards of the code provisions.

c. Evaluation and upgrading. Current codes are developed for new construction and are not necessarily applicable to existing buildings. An existing building should be evaluated on the basis of its actual performance characteristics, as best as they can be determined, when subjected to a realistic postulated earthquake. Modifications of existing buildings shall take into account the performance characteristics of the existing materials interacting

with the new materials used to upgrade the structure.

1-7 Methodology for seismic evaluation and upgrading existing facilities

The various steps in the methodology which are outlined below and graphically in figure 1-1, are presented in detail in the following chapters of this manual. It should be noted that the methodology as shown is applicable to a military installation with a large inventory of buildings. The approval authority may direct the omission of one or more steps in the methodology. For example, for an installation with a limited number of buildings (e.g., 25 or less) that are in use, the inventory reduction may not be required. If only essential buildings at a given facility are to be considered for seismic upgrading, the inventory reduction, preliminary screening, and preliminary evaluation may be omitted and the upgrading evaluation would directly begin with the detailed structural analysis, with or without the cost/benefit analyses.

a. Inventory reduction (chapter 2). Prior to beginning the phased seismic evaluation procedure, the overall inventory of the installation is reviewed to select buildings that will be included in the evaluation program. The purpose of reducing the total inventory to a select group is to eliminate unnecessary investigations and to keep the scope of work within reasonable limits.

b. Preliminary screening (chapter 3). A site survey is made to visually inspect all the buildings on the select inventory list. A screening process is used to reduce the number of buildings that require the preliminary evaluation.

c. Preliminary evaluation (chapter 4). A structural analysis of each selected building from the preliminary screening is made using simplified techniques. The purpose of the evaluation is to estimate the vulnerability of the buildings (i.e., damage when subjected to site specific seismic ground motion) and to establish a priority listing for more detailed structural analysis.

d. Detailed structural analysis (chapter 5). Buildings are selected for the detailed analysis on the basis of the priority listing resulting from the preliminary evaluation or by direct request by the authorized agency. The purpose of the detailed structural analysis is to determine if the existing building will satisfy the acceptance criteria, to identify deficiencies, and, if required, to recommend alternatives for seismic upgrading.

e. Development of design concepts for seismic upgrading (chapter 6). On the basis of the detailed structural analysis, methods of seismic strengthening are studied. A general concept is developed as recommended in the detailed structural analysis for seismic upgrading. In some cases, an alternate concept may be included.

f. Cost-benefit analysis (chapter 7). The costs of seismic upgrading are compared to the risk of doing nothing and to the costs of a new building. An evaluation may also be made for various levels of rehabilitation in comparison to the risk of future damage. The results of the cost-benefit analysis will be used for setting priorities in relation to other buildings.

g. Final design and preparation of contract documents (chapter 8). The proposed upgrading concepts will be used as a basis for the development of the final design for seismic upgrading. The final design will include a complete analysis of the modified building to confirm the adequacy of the strengthening measures in accordance with the detailed structural analysis procedure. Contract documents will include drawings and specifications.

h. Nonstructural elements (chapter 9). A qualitative evaluation is made on the basis of available documents and an on-site inspection. Elements identified as being susceptible to damage are subjected to a detailed analytical evaluation by a static or dynamic approach. Recommendations for seismic upgrading are made if required.

i. Evaluation of existing structural materials (appendix E). Where necessary data or information of the existing materials are not available, the materials and structural elements will be tested. Testing procedures and methods for materials and structural elements are provided.

1-8. References and bibliography

Publications that are referenced in the text and are required reading for use of this manual are listed in appendix B. Publications for suggested reading are listed in the bibliography.

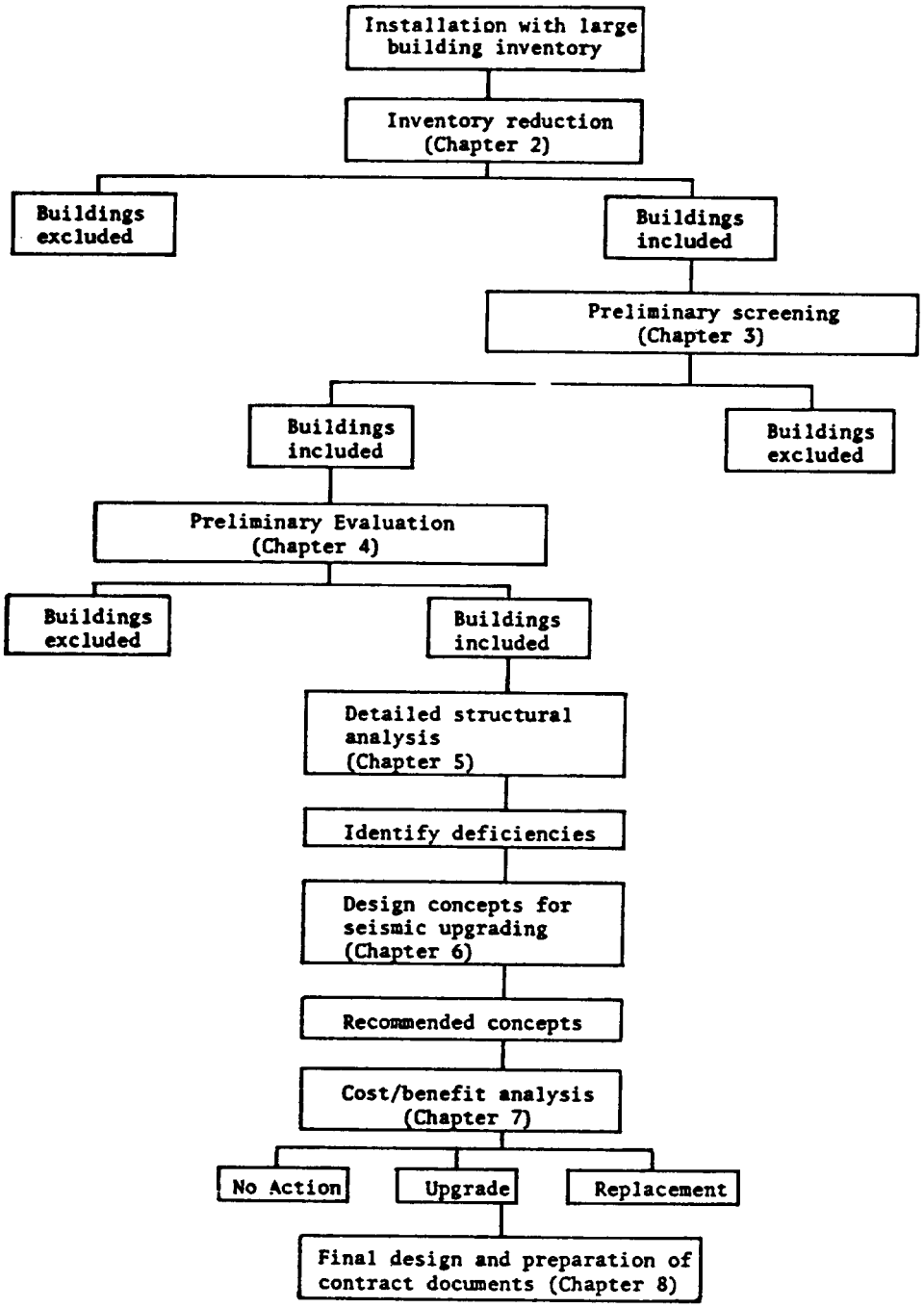

Figure 1–1. Methodology for seismic evaluation and upgrading