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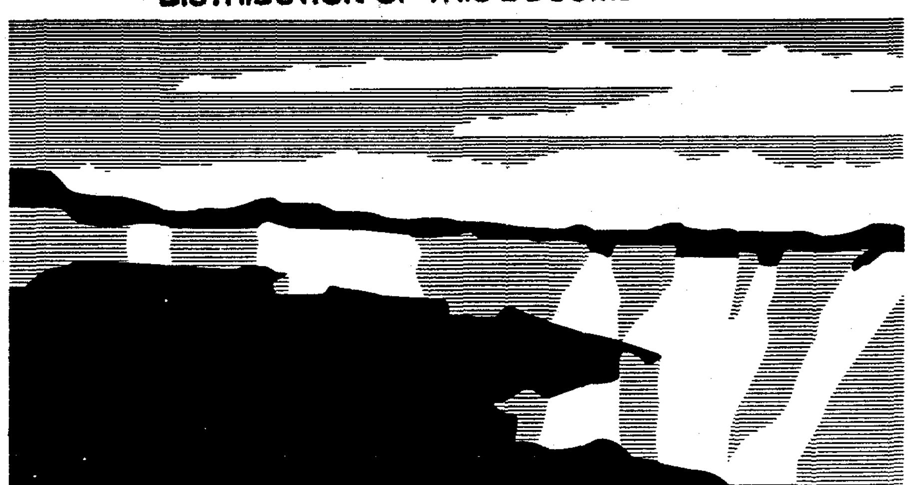

Los Alamos
NATIONAL LABORATORY

ENHANCEMENT OF THE BASIC SEISMIC ASSESSMENT OF THE LOS ALAMOS NATIONAL LABORATORY FACILITIES AND BUILDINGS

by

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ABSTRACT

This paper will present the results of a comparison of values obtained for the seismic security of 479 buildings and facilities at Los Alamos National Laboratory following the methodology adapted from Dr. Otto Fritz's original System, and the requirements contained both in FEMA-154 "Rapid Visual Screening of Buildings for Potential Hazards: A Handbook" and FEMA-187 "NEHRP Handbook for the Seismic Evaluation of Existing Buildings."

In order to comply with DOE Order 5480.28, Executive Order 12941, and Public Law 101-614, engineers from Los Alamos and the Johnson Controls World Services, used the new Screening Assessment Method to screen 479 buildings, comprising more than seven million square feet of floor space in a record short time.

These comparisons were made from five buildings chosen randomly illustrating a wide variety of construction types and building configurations. Each building is divided into sectors, defined as portions of it that are attached additions to the original building, or portions separated by an expansion joint between the structural systems. The five buildings studied contain a total of sixteen sectors.

The paper is divided into the following sections: 1. Introduction; 2. Basic Concepts of the LANL Methodology; 3. Basic Concepts of FEMA-178; 4. Highlights of the Comparison, 5; Comments on the Results; and 6. Final Words.

1. INTRODUCTION

According to the Los Alamos National Laboratory Seismic Program Plan, a Seismic Assessment System was developed to provide a rational, objective,. and uniformly applied methodology for screening buildings at the Los Alamos National Laboratory (LANL) for determining their seismic capacity and potential dynamic hazards.

Following a general procedure proposed by Dr. Otto Fritz, based on his previous experience and results over the past seven years, a screening method in its basic formulation was established by Los Alamos National Laboratory's Engineering Services Team of the Facility Delivery Project Group in collaboration with the Johnson Controls World Services (JCWS) Design Engineering Branch.

2. BASIC CONCEPTS OF THE LANL METHODOLOGY

The basic adapted methodology satisfies the requirement of the Federal Emergency Management Agency FEMA-154 "Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook," also known as ATC-21, which is a speedy screening method that gives pass/fail results on seismic safety.

From the beginning and based on former results, LANL engineers became aware of the deficiencies of the method. First, the FEMA-154 "sidewalk assessment" does not provide sufficient insight into the resisting structure of the building, in order to determine its seismic adequacy. To remove the subjectivity of the collected data based on different points of view of inspection personnel, some unique criteria for the in situ screening were established to take advantage of having construction drawings and calculations for most, if not all, LANL buildings.

Both improvements remove the principal defects of FEMA-154. The new LANL/JCWS seismic screening assessment method is an adapted version of Dr. Fritz's original procedure, and permits an inexpensive and accurate way for the assessment of building seismic safety with remarkably consistent results. The basic scoring concepts of the FEMA-154 standard are considered in the enhanced LANL/JCWS methodology. The in situ structural field inspection gives a true account of internal details of the building in which joints, continuity, and connections are evaluated together with the aid of drawings and original basic information. The advantages, in conjunction with the judgement of a professional engineer, eliminate completely the original subjectivity of FEMA-154.

At Los Alamos, the first screening stage (ATC-21) was passed by 75% of the screened sectors. A building is composed by one or more sectors; in Los Alamos National Laboratory, the average was 1.78 sectors for the building. Buildings with no connection to the foundation were also identified (transportable buildings) and a connection was suggested.

For buildings which passed the first screening stage, shear strength determinations were performed to evaluate the base shear resistance of each building. This additional step in the screening process identifies structures which have adequate strength to resist a base shear demand of V=0.2gW. The shear capacities of various types of structural resisting elements are taken from research performed in Mexico under the direction of Dr. Fritz. Using this unique value of the seismic coefficient, 0.2g, 71% of the above sectors passed this second stage of screening. With adequate connection to the foundation, the transportable buildings could also pass the shear requirements, adding 20% to the original second stage passing figure, elevating this value to 91%.

The stipulated Standard in Executive Order 12941 for the seismic assessment of buildings is ICSSC RP 4, "Standards of Seismic Safety for Existing Federally Owned or Leased Buildings." ICSSC RP 4, in turn, references FEMA-178, "NEHRP Handbook for the Seismic Evaluation of Existing Buildings." This manual was studied throughly to determine all possible additional requirements for the seismic evaluation of existing buildings. The gained information gave us a firm basis to believe that the LANL/JCWS Seismic Screening Assessment Method, based on Dr. Fritz's criteria, covers requirements from both FEMA-154 and from FEMA-178, fusing two steps into only one, saving approximately 70% of the time, effort, and money in the complete procedure of evaluating the seismic capacity of existing buildings.

The following comparisons were prepared during the last days of screening of the Los Alamos National Laboratory buildings. The original 459 buildings, to be screened by the September 15, 1995, were finished by August 18. The final figure of screened buildings will be 479, with approximately 850 sectors, to be completed by August 31, 1995. For this comparison, five buildings were chosen, presenting the complete methodology used at LANL and the FEMA-178 requirements.

The compared buildings are:

A. TA-00-0480 Pajarito School (Three Sectors)

B. TA-03-0032 Experimental Material Science Laboratory (Four Sectors)

C. TA-03-0141 Rolling Mill Building (Two Sectors)

D. TA-03-0261 Otowi Building (Two Sectors)

E. TA-46-0016 Component Test Facility Building #1 (Five Sectors).

The comparisons were prepared by Steven Dickson and Jason Caspersen of JCWS Design Engineering in July and August of 1995, and reviewed shortly thereafter. The results are summarized in the conclusions.

3. BASIC CONCEPTS OF FEMA-178

The comparisons that follow are from five buildings at Los Alamos National Laboratory. These five buildings were chosen to illustrate a wide variety of construction types and building configurations. Each building is divided into "Sectors," defined as a portion of a unit attached to another, or portions of a building separated by expansion joints between resisting elements. The five buildings that follow contain a total of sixteen sectors.

The common goal of both FEMA-178 "*NEHRP Handbook for the Seismic* Evaluation of Existing Buildings" and the LANL/JCWS "Seismic Screening Assessment Method" are to provide a simple but rational method to identify potential seismic hazards in existing buildings in order to assess whether an acceptable level of life-safety protection is provided. Both evaluation methods categorize buildings by construction type, use checklists to assess possible configuration and behavior weaknesses, and utilize "quick checks" to determine gross lateral force capacity/demand ratios.

Two significant differences between these methodologies are the level of effort and technical expertise required to administer them and the relative ease with which the results can be used to screen and prioritize a large number of buildings.

The FEMA-178 evaluation method is addressed to structural engineers and requires extensive and considerable effort to properly administer. Each of the sixteen FEMA-178 evaluations that follow required an average of 23 hours of engineering time to complete, not including drafting time. The CAD drawings are included herein for illustrative purposes but are not typical for this type of work.

The results of each FEMA-178 evaluation would normally include a list of the noted deficiencies, any comments on the relative importance of the deficiencies, and any proposed remedies. This "Final Report" would easily bring the total to 30 hours of engineering time for each evaluation. At $50.00 per hour, the cost of each FEMA-178 evaluation would be $1,500 per sector. Final Reports were not prepared for the sixteen evaluations that follow.

Evaluations of building contents, equipment and furnishing are not within the scope of this phase of LANL's Seismic Program. These non-structural items will be evaluated separately in future phases of the program.

Finally, the results of each FEMA-178 evaluation must "stand alone" as there is no method for comparing the relative seismic safety of several buildings of various construction types. Gross lateral force capacity/demand ratios could be used, but calculating these values for buildings having numerous irregularities or obvious deficiencies would be a waste of time and too simplistic.

The LANL/JCWS "Seismic Screening Assessment Method" is addressed to skilled and trained professionals with general building construction backgrounds, not just to structural engineers. The current LANL Seismic Screening Assessment Program is administered by Johnson Controls World Services (JCWS) Design Engineering Branch. The program has relied on up to fourteen inspectors with backgrounds ranging from structural and mechanical engineering, architectural, and estimating, to structural, architectural, and electrical design and drafting. All inspectors are trained and their work supervised by a structural engineer.

The methodology is presented in the form of an "Inspectors' Handbook," similar to the "NEHRP Handbook," which is used by each inspector as a reference source to assure objectivity and quality control. The LANL/JCWS "Seismic Screening Assessment Method" has been used over the past seven months to evaluate 479 buildings containing 849 "Sectors" at the cost of approximately $350.00 per sector. This translates to approximately eight hours per sector and 4.8 cents per square foot.

The LANL/JCWS "Seismic Screening Assessment Method" consists of an initial screening checklist based on an enhanced version of the FEMA-154 "Rapid Visual Screening of Buildings for Potential Seismic Hazards" methodology, also known as the "ATC-21 Handbook." This initial screening yields a score based on the relative seismic safety of various building types and numerous objectively defined irregularities and deficiencies.

Any sector with an initial screening score (ATC-21 Score) less than 2.0 is identified as requiring a more detailed structural analysis, and no further evaluation is performed.

Any sector with an ATC-21 Score of 2.0 or greater, "passes" the initial screening and is subject to a strength determination. This method uses a seismic coefficient of 0.20 to calculate the gross lateral force demand at the base of the structure. The gross lateral force resistance, or capacity, are calculated using values established from earthquake damage investigations by Dr. Fritz in Mexico and Japan. These capacity values represent an average of capacities from various design, detailing, and construction practices. Thus, they are appropriate for use as a preliminary analysis tool.

The resulting capacity/demand ratio is referred to as the shear score, Sf, the lowest value from the two orthogonal directions controlling. If the shear score is 1.0 or greater, the sector is deemed to have adequate seismic resistance and passes. No further evaluation is performed. Sectors receiving shear score less than 1.0 are identified as requiring a more detailed structural analysis.

Certain make-or-break circumstances identified during the course of the evaluations automatically trigger the requirement for a more detailed seismic analysis. Such circumstances include all DOE Standard 1020-94 Performance Category-3 facilities, buildings known to have suspect gravity load capacities, buildings lacking positive attachment to their foundations, concrete or steel frame structures with masonry infill, and certain underground buildings. Each of these buildings will be dealt with individually in a later phase of LANL's Seismic Program.

The LANL/JCWS "Seismic Screening Assessment Method" assures that no building will be deemed accepted without having undergone a gross lateral force capacity/demand evaluation. It allows buildings having numerous irregularities or obvious deficiencies to be recommended for further analysis without the unnecessary burden of overly simplistic capacity/demand calculations.

The scoring schemes presented in the LANL/JCWS "Seismic Screening Assessment Method" are well suited for management and prioritization of a large building inventory within a database format. Scoring criteria proposed by the " Draft DOE/DP Screening Methodology for Seismic Hazard Mitigation of DOE Existing Buildings" can be used directly by adapting the scores from the LANL/JCWS "Seismic Screening Assessment Method."

Finally, the data collected as part of the LANL/JCWS Seismic Screening Assessment Method" will be valuable in later analysis. Most of the information required for more detailed analyses has already been collected, and specific deficiencies have been identified.

The FEMA-178 evaluation process was followed in the comparisons carefully and included the following steps:

A. A visit to the site and data collection (previously done by the LANL/JCWS Method).

B. Selection of either the general set of evaluation statements or one or more of the sets for 15 common building types and review of the statements. (previously done almost entirely by the LANL/JCWS Method).

C. Conduct the follow-up field work. (previously done by the LANL/JCWS Method).

D. Performance of the analysis required for the evaluation statements that have been found to be false. (Partially done before by the LANL/JCWS Method).

E. Final evaluation. (Done with much better values, taking into account the responding stresses in dynamic conditions, by the LANL/JCWS Method).

F. Preparation of the evaluation report. (previously done with better results by LANL/JCWS Method).

4. HIGHLIGHTS OF THE COMPARISON

After careful consideration of the results of the unitarian comparisons, the following points can be stated:

A. TA-00-0480 PAJARITO SCHOOL

SECTOR A

FEMA-178: Sector A is judged to have adequate seismic resistance. (SSC = 4.48)

LANL/JCWS: Sector A is judged to have adequate seismic resistance. (SSC=8.8)

REMARKS: Results in the same direction. Methods are in good agreement.

SECTOR B

FEMA-178: Sector B is judged to have inadequate seismic resistance. (SSC=0.23)

LANL/JCWS: Sector B is judged to have inadequate seismic resistance. (SSC=0.87)

REMARKS: Results in the same direction. Methods are in good agreement.

SECTOR C

FEMA-178: Sector C is judged to have adequate seismic resistance. Shortcoming of this method as a direct screening tool is shown.

LANL/JCWS: Due to the fact that this sector did not pass the initial FEMA-154, (ATC-21) screening, shear resistance was not calculated. This wing should be subjected to a more detailed analysis to determine its seismic capacity.

REMARKS: In this example the power of the LANL/JCWS Method can be seen: It identifies modifiers that affect the seismic behavior of buildings. The FEMA-178 result is questionable.

B. TA-03-0032 EXPERIMENTAL MATERIAL SCIENCE LABORATORY

SECTOR A

FEMA-178: Sector A is judged to have adequate seismic resistance. (SSC=15.57)

LANL/JCWS: Sector A is judged to have adequate seismic resistance. (SSC=9.5)

REMARKS: The results are in the same direction. The LANL/JCWS requirements are more rigid. Methods are in good agreement.

SECTOR B

FEMA-178: Sector B is judged to have adequate seismic resistance. (SSC=21.22)

LANL/JCWS: Sector B is judged to have adequate seismic resistance. (SSC=9.7)

REMARKS: The results are in the same direction. LANL/JCWS requirements are more rigid.

SECTOR C

FEMA-178: Sector C is judged to have adequate seismic resistance (SSC=1.09)

LANL/JCWS: Sector C is judged to have adequate seismic resistance. (SSC=1.7)

REMARKS: The results are in the same direction. In this case the seismic shear capacity is larger in the LANL/JCWS Methodology, due to the fact that the shear stresses used as permissible are extracted from the real performance of materials in seismic conditions, according to Dr. Fritz's research. Methods are in good agreement.

SECTOR D

FEMA-178: Sector D is judged to have adequate seismic resistance. (SSC=10.84).

LANL/JCWS: Sector D is judged to have adequate seismic resistance. (SSC=1.4)

REMARKS: The results are in the same direction. LANL/JCWS is more rigid. Methods are in good agreement.

C. TA-03-0141 ROLLING MILL BUILDING

SECTOR A

FEMA-178: Sector A is judged to have adequate seismic resistance. (SSC=2.44)

LANL/JCWS: Sector A is judged to have adequate seismic resistance. (SSC=1.80)

REMARKS: The results are in the same direction. The LANL/JCWS Method is more rigid. Methods are in good agreement.

SECTOR B

FEMA-178: Sector B is judged to have adequate seismic resistance. (SSC=2.44)

LANL/JCWS: Sector B is judged to have adequate seismic resistance. (SSC=2.12)

REMARKS: Results are in the same direction. In this case the seismic shear capacity is in the

LANL/JCWS Method, due to the fact that the shear stresses used as permissible are extracted from the real performance of the concrete columns. (Dr. Fritz's research) The methods are in good agreement.

D. TA-46-0016 OTOWI BUILDING

SECTOR A

FEMA-178: Sector A is judged to have adequate seismic resistance. (SSC=4.16)

LANL/JCWS: Sector A is judged to have adequate seismic resistance. (SSC=1.6)

REMARKS: Results in the same direction LANL/JCWS Method is more rigid. The methods are in good agreement.

SECTOR B:

FEMA-178: Sector B is judged to have adequate seismic resistance. (SSC= 4.27)

LANL/JCWS: Sector B is judged to have adequate seismic resistance. (SSC=1.6)

REMARKS: Results are in the same direction. LANL/JCWS Method is more rigid. The methods are in good agreement.

E. TA-46-0016 COMPONENT TEST FACILITY BUILDING # 1

SECTOR A

FEMA-178: Sector A is judged to have adequate seismic resistance. (SSC= 12.8)

LANL/JCWS: Sector A is judged to have adequate seismic resistance. (SSC= 1.6)

REMARKS: Results are in the same direction. LANL/JCWS seismic resistance is based on real material stresses under seismic conditions Methods are in good agreement.

SECTOR B

FEMA-178: Sector B is judged to have adequate seismic resistance. (SSC=1.8)

LANL/JCWS: Sector B is judged to have adequate seismic resistance. (SSC=1.6)

REMARKS: Results are in the same direction. LANL/JCWS Method is more rigid. The methods are in good agreement.

SECTOR C

FEMA-178: Sector C is judged to have adequate seismic resistance. (SSC=5.6)

LANL/JCWS: Sector C is judged to have adequate seismic resistance. (SSC=1.9)

Results are in the same direction. Our method is more rigid, taking into account the real, by research, capacity in the connection between super and infra structures. The methods are in good agreement.

SECTOR D

FEMA-178:	Sector D is judged to have adequate seismic capacity. (SSC= 3.1)
LANL/JCWS:	Sector D is judged to have adequate seismic capacity. (SSC=2.9)
REMARKS:	Results are in the same direction. Our method is more rigid. The methods are in good agreement.

SECTOR E

FEMA-178:	Sector E is judged to have adequate seismic resistance. (SSC= 24.8)
LANL/JCWS:	Sector E is judged to have adequate seismic resistance. (SSC=6.9)
REMARKS:	Results are in same direction. Our method is more rigid. The methods are in good agreement.

5. COMMENTS ON THE RESULTS

In five buildings taken randomly, we have compared two different methodologies for measuring seismic resistance. The final results were all in the same direction; the numerical differences in the Seismic Shear Coefficient (SSC) were primary caused by the Los Alamos National Laboratory use of the real material stresses, in seismic conditions, for the resisting structural elements and a conservative unique value of 0.2g for the seismic coefficient.

From our own experience in doing both Methods, we can conclude that the cost and time used for the FEMA methods, FEMA-154 plus FEMA-178, are 4.4 times greater than the cost and time of the LANL/JCWS "Seismic Screening Assessment Method."

Therefore, we highly recommend the use of the LANL/JCWS "Seismic Screening Assessment Method" for the integral screening of buildings to determine their seismic safety.

6. FINAL WORDS

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Professor Dr. Gustavo Otto Fritz-de la Orta.