TECHNICAL EVALUATION REPORT

MASONRY WALL DESIGN (B-59)

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT UNITS 1, 2, AND 3

NRC DOCKET NO. 50-259, 50-260, 50-296
NRC TAC NO. Multiple
NRC CONTRACT NO. NRC-03-81-130

FRC PROJECT C5506
FRC ASSIGNMENT 6
FRC TASK 257

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September 26, 1983

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FOREWORD

This Technical Evaluation Report was prepared by Franklin Research Center under a contract with the U.S. Nuclear Regulatory Commission (Office of Nuclear Reactor Regulation, Division of Operating Reactors) for technical assistance in support of NRC operating reactor licensing actions. The technical evaluation was conducted in accordance with criteria established by the NRC.

1. INTRODUCTION

1.1 PURPOSE OF REVIEW

The purpose of this review is to provide a technical evaluation of the Licensee response to IE Bulletin 80-11 [1] with respect to compliance with the Nuclear Regulatory Commission (NRC) masonry wall criteria. In addition, if the Licensee plans repair work on masonry walls, the planned methods and procedures are reviewed for acceptability.

1.2 GENERIC ISSUE BACKGROUND

In the course of conducting inspections at the Trojan Nuclear Plant, Portland General Electric Company determined that some concrete masonry walls did not have adequate structural strength. Further investigation indicated that the problem resulted from errors in engineering judgment, a lack of established procedures and procedural details, and inadequate design criteria. Because of the implication of similar deficiencies at other operating plants, the NRC issued IE Bulletin 80-11 on May 8, 1980.

IE Bulletin 80-11 required licensees to identify plant masonry walls and their intended functions. Licensees were also required to present reevaluation criteria for the masonry walls with the analyses to justify those criteria. If modifications were proposed, licensees were to state the methods and schedules for the modifications.

1.3 PLANT-SPECIFIC BACKGROUND

In response to IE Bulletin 80-11, the Tennessee Valley Authority (TVA) provided the NRC with documents [2-6] describing the status of masonry walls at Browns Ferry Nuclear Plant Units 1, 2, and 3. The information in these documents was reviewed, and a request for additional information was sent to the Licensee on January 28, 1983 [7]. The Licensee responded to this request on April 22, 1983 [8] and June 3, 1983 [9].

TVA identified a total of 119 masonry walls at the Browns Ferry plant. Seventy-one of these walls were classified as safety-related in Units 1, 2, and 3, according to IE Bulletin 80-11.

The masonry walls serve as shield walls and/or partition walls; there are no structural load bearing walls at the plant. According to Reference 5, the only attachments to the walls are non-safety-related conduit and junction boxes, and they do not contribute to the failure of the walls. No attachments can be found on solid shield block walls.

Four types of masonry construction were found: reinforced, unreinforced hollow core, unreinforced solid shield block with mortared joints, and unreinforced solid shield block with non-mortared joints. Masonry wall types and materials for the Browns Ferry Nuclear Plant Units 1, 2, and 3 are given below:

Wall Type

Total number of walls	119
Safety-related walls	71
Walls requiring modification	19

Block

Hollow core, lightweight units conforming to ASTM C-90

Solid shield block, normal weight units conforming to ASTM C-145

Mortar

Type S conforming to ASTM C-270

Grout for cell filling

Structural grade concrete with design compressive strength of 3000 psi

Reinforcing steel

Vertically - No. 6 bar conforming to ASTM A-432 (yield stress = 60,000 psi) spaced at the center of the cell, 16 inches on center

Horizontally - Equal to Blok-Lok, Corner-Lok, and Partition-Lok as manufactured by AA Wire Products Company, Chicago, Illinois, standard grade with No. 9 gauge side rods and No. 9 gauge crossties conforming to ASTM A-82 (yield stress = 70,000 psi).

2. REVIEW CRITERIA

The basic documents used for guidance in this review were the criteria developed by the Structural and Geotechnical Engineering Branch (SGEB) of the NRC (attached as Appendix A to this report), the Uniform Building Code [11], and ACI-531-79 [12].

In general, the materials, analysis, design, construction, and inspection of safety-related masonry structures should conform to the SGEB criteria. For operating plants, the loads and load combinations for qualifying the masonry walls should conform to the appropriate specifications in the Final Safety Analysis Report (FSAR) for the plant. Allowable stresses are specified in Reference 12, and the appropriate increase factors for abnormal and extreme environmental loads are given in the SGEB criteria (Appendix A).

3. TECHNICAL EVALUATION

This evaluation is based on the Licensee's earlier responses [2-6] and subsequent responses [8, 9] to the request for additional information [7]. The Licensee's criteria [3] were evaluated with regard to design and analysis methods, loads and load combinations, allowable stresses, construction specifications, materials, and relevant test data. The Licensee's responses to the request for additional information were also reviewed.

3.1 EVALUATION OF LICENSEE'S CRITERIA

The Licensee reevaluated the masonry walls using the following criteria:

- o Allowable stresses are based on ACI 531-79 [12].
- o Load combinations are according to the FSAR and include dead load, live load, earthquake, and tornado pressure load.
- o The working stress design method is used.
- o Walls were modeled as a beam or a plate. The end conditions are considered as being fixed, simply supported, or free.
- o All walls are to be supported at the top by the use of clip angles if they are not anchored into the ceiling with reinforcing bars.
- o Tensile forces are to be resisted by the vertical reinforcement in reinforced block walls.
- o Seismic loads for reinforced and unreinforced mortared walls are to be evaluated as follows:
  - The wall's natural frequency is calculated using the simple beam formula.
  - The calculated frequency is broadened by 10%.
  - The acceleration selected from floor response spectra curves is multiplied by the weight of the wall to determine the resulting force which is applied as a uniform load to the beam.
- o With respect to the unmortared walls, stability analysis for sliding and overturning (block rotation) was performed using the following criteria:

- The wall was assumed to behave as a simply supported beam.

- The blocks were investigated for sliding by comparing the shear encountered at the joints with the frictional resistance which can be developed in between blocks where the coefficient of friction is $\mu = 0.7$.

- A check for rotation of the blocks was made by evaluating the moment developed by the applied loads and comparing it to the resisting moment of the block itself.

o The analysis procedures for the unmortared walls that have been fixed will be discussed in Response 6.

Other than those areas identified in Section 4, the Licensee's criteria have been reviewed and found to be technically adequate and in compliance with the SGEB criteria. The review of the Licensee's responses to the request for additional information follows.

Request 1

Describe the analytical technique used to determine the seismic accelerations listed in Reference 5, Section 2.2.3 and Section 2.5.2.4.5. Indicate how higher modes of vibration were considered in this analysis. Also, specify how vertical seismic forces were handled in the evaluations.

Response 1

With regard to the analytical technique used to determine the seismic accelerations listed in Section 2.2.3 and Section 2.5.2.4.5 of Reference 5, the Licensee indicated that the natural frequencies of reinforced and unreinforced mortared walls were calculated by the classical deterministic methods in Chapter 4 of J. M. Biggs' "Introduction to Structural Dynamics." Since all calculated modes indicated that the walls' frequencies fall in the rigid range, all tabulated accelerations are zero period accelerations (ZPAs) which are taken from the structural response curves. Consequently, the consideration of higher modes of vibration in the analysis of reinforced and unreinforced mortared walls is no longer a concern. For unmortared walls with steel frame restraints, the spectral accelerations corresponding to the fundamental mode of vibration were used to determine the seismic load. In many cases at other plants, the first mode usually contributes 95% or more to the total responses. Therefore, the fundamental mode should adequately cover the total responses of the walls.

With regard to the consideration of vertical seismic forces, the Licensee stated that compressive stress due to vertical loads was found to be negligible at the base of the highest masonry wall (the 41-ft-high elevator shaft). Consequently, vertical compressive forces in walls of lesser height were not considered. In other plants, the compression loads would increase the capacity of the wall to carry shear. Therefore, by not considering the vertical acceleration, the analysis is still reasonably valid.

The Licensee's response indicated that its approach is adequate and meets the intent of the SGEB criteria.

Request 2

> Regulatory Guide 1.61 allows 4% damping for operating basis earthquake (OBE) and 7% damping for safe shutdown earthquake (SSE). The Licensee does not mention damping in any of its submittals [2-6]. The Licensee should provide any damping values which may have been used in the evaluation of masonry walls, and justify them if they are higher than those given in Regulatory Guide 1.61.

Response 2

The Licensee indicated in Response 1 that all mortared walls are in the rigid range; therefore, damping is no longer a concern in analyzing these walls. For unmortared walls with steel frame restraints, however, 4% and 7% damping were used for OBE and DBE, respectively, to select a peak floor acceleration in the ±10% frequency range of the fundamental frequency of the wall. The Licensee's response is adequate and meets the intent of the SGEB criteria.

Request 3

> Indicate how uncertainties due to variations in mass, materials, and other parameters were accounted for in the evaluation of the fundamental frequency of the wall.

Response 3

The Licensee stated that the modulus of elasticity used in the evaluation of the mortared walls was based on lower bound material properties. Since the calculated fundamental frequency of the walls was greater than 20 Hz, the designated point of rigid responses, a modulus of elasticity higher than that assumed (the lower bound material properties) would shift the frequency to a higher value; therefore, it would not affect the calculated accelerations.

In addition, for the mortared walls, varying boundary conditions were assumed, and the ones yielding the highest response were retained.

For the analysis of unmortared block walls with steel frame restraints, the calculated frequencies are broadened by 10% to account for uncertainties in the analysis.

The Licensee's response is satisfactory and in compliance with the SGEB criteria.

Request 4

> Reference 5 indicates that walls that are required to resist tornado effects also require modifications due to seismic loads, and that these modified designs have been analyzed for the additional tornado loads (pressure loads). Provide sample calculations of this analysis. Also, provide sample calculations of block pullout analysis due to attachments.

Response 4

In response to this request, the Licensee stated that the walls were designed for the loading combinations set forth in Design Criterion BFN-050-709, which does not require seismic loads and tornado loads (pressure loads) to be applied simultaneously and is consistent with the Browns Ferry FSAR, and that no block walls with unmortared joints are subjected to tornado loads (pressure loads). Masonry walls at the Browns Ferry plant, however, were designed to resist seismic and tornado loads (pressure loads). The Licensee provided sample calculations for a reinforced block wall and a non-reinforced hollow core block wall.

For seismic and tornado analysis of reinforced block walls, the sample calculations present the analysis of the utility elevator Nos. 1 and 2 walls from elevation 519 ft to elevation 562.5 ft. These walls were initially analyzed as a horizontal beam, and it was found that the tension parallel to the bed joints exceeded the allowable stress of 10 psi. Therefore, a subsequent analysis was performed using a plate model and it was found that the calculated stresses are within the allowables.

The results of the sample calculation for reinforced mortared masonry wall are summarized in the following table:

Case	Calculated	Allowable
Tornado (pressure load) (p = 0.501 psi)		
shear force	298 lb	960 lb
flexural stresses	52 psi	405 psi
tensile stresses	7.9 psi	10 psi
SSE (a = 0.344g)		
shear stress	6.8 psi	40.4 psi
axial compression	75 psi	279 psi
tensile stress (steel reinforcement)	19.9 ksi	24 ksi

The sample calculations also indicated that block pullout and punching shear were performed and that the calculated punching shear stress of 29.6 psi is smaller than the allowable of 40 psi.

The Licensee's response is satisfactory and in compliance with the SGEB criteria.

Request 5

Provide any increase factors that may have been used for allowable stresses under abnormal conditions. If they are higher than those listed in the SGEB criteria [10], provide justification. Also indicate the number of walls involved, as well as the actual increase factor used. The SGEB factors are listed below by type of stress:

Axial or flexural compression	2.5
Bearing	2.5
Reinforcement stress except shear	2.0 but not to exceed 0.9 f_y
Shear reinforcement and/or bolts	1.5
Masonry tension parallel to the bed joint	1.5
Shear carried by masonry	1.3
Masonry tension perpendicular to the bed joint	
For reinforced masonry	0
For unreinforced masonry	1.3

Response 5

The Licensee stated that the Licensee's criteria allow only two stress increases for extreme environmental and abnormal loads. The first one is the increase in the allowable flexural compression stress in reinforced walls by a factor of 1.88. However, the SGEB factor is 2.5; therefore, it is not a concern. The second one is the increase in the allowable tension stress in the reinforcement by a factor of 2.25, which is greater than the factor of 2.0 allowed by the SGEB criteria. However, the tension stress in the reinforcement when the allowable ultimate moment is applied is only 0.41 f_y (versus 0.9 f_y allowed by the SGEB criteria); therefore, it is no longer a concern.

Therefore, it can be concluded that the Licensee's response is adequate and in compliance with the SGEB criteria.

Request 6

Reference 5 indicates that there are several walls at the Browns Ferry plant in which solid concrete units are used without mortar and restrained by horizontal members. The Licensee is required to provide details of the horizontal restraining members for these walls, specifying the types of members used, their spacing, and their connections to the masonry walls and surrounding structures. Also, provide sample calculations showing how these walls sustain the loads. It is strongly recommended that modifications be done to all unmortared walls, since without mortar to bond the units together, it would be impossible for these walls to develop the structural strength to resist the anticipated loads.

Response 6

The Licensee provided details of horizontal restraining members for the following unmortared solid block walls: 15, 20, 52, 60, 83, and 87. All six walls are 8 ft high and 2 ft thick (4 wythes). The modifications included steel angles placed back-to-back on both faces of the wall in the horizontal direction at 2-ft intervals. At the ends, steel angles were anchored into concrete columns. The angle size is 4 in x 4 in x 0.5 in and its length is 10 ft 1 in. It can be seen on page B-1 of Appendix B (attached to this report) that each angle will cover two courses of the affected wall (i.e., each angle will carry 1 ft of the uniform load distributed by the wall).

The Licensee also provided sample calculations for the modified walls. The maximum flexural stress due to the inertial load is 8.31 ksi, which was smaller than the allowable of 11.6 ksi for each angle. The shearing force was also obtained and turned out to be smaller than the frictional resistance.

It can be concluded that the horizontal restraining members provided by the Licensee should be adequate to protect the safety-related systems associated with these walls.

The attachment to Reference 2 identifies four other walls as unmortared or partially mortared for which no modification was planned. These walls are discussed in Section 3.2.

Request 7

None of the wall descriptions in the Licensee's submittals [2-6] mention whether the masonry walls at the Browns Ferry plant are stacked or running bond. Indicate whether walls are stacked or running bond. If any stacked bond walls exist, provide sample calculations of the stresses for a typical wall.

Response 7

The Licensee confirmed that there are no stacked bond walls at Browns Ferry Nuclear Plant and that all walls are running bond.

The Licensee's response has resolved this concern.

Request 8

According to Reference 5, page 4, the differential floor displacement was found to be less than 0.01 ft for all floor elevations below the operating floor. Provide the criteria by which this displacement was judged to be insignificant, and justify.

Response 8

The Licensee indicated that the effects of differential floor displacement on masonry walls were evaluated by using the computer program SUPERB to perform a finite element analysis of the wall judged to be the most severely affected by building displacement.

Masonry wall 71B was selected for the analysis because it has a significantly greater width-to-height ratio than any other masonry wall and is located at an elevation in the reactor building having a horizontal displacement due to earthquake per unit height as great as any other level where masonry walls are located. Wall 71B is an unreinforced mortared wall 25 ft high and 22 ft 7 in long in the north-south direction. The differential displacements for which wall 71B was analyzed are less than 0.0026 ft. The stresses due to displacement in the east-west direction were found to be low and, when combined with other stresses caused by the design basis earthquake, did not cause allowable stresses to be exceeded. The shear stress in the mortar was found to be less than the allowable of 40 psi when the wall was subject to the north-south displacement.

The Licensee's response is adequate and satisfactory.

Request 9

The Licensee indicated in Reference 5 that the design of all modifications would be completed by January 1, 1982, but no commitment was made as to the installation of these modifications. Indicate the current status of the wall modifications and their intended completion date. Provide calculations and detailed drawings of some sample modifications to show how they rectify wall deficiencies. Also, indicate whether a reanalysis was carried out to ensure that these modified walls can be qualified by the working stress design method.

Response 9

The Licensee indicated that restraints have been used to modify the affected walls and that the abilities of these walls to span between supports were evaluated using the working stress design procedures. The Licensee also indicated that in all cases the analysis illustrated that the allowable stresses were less or equal to those allowed by the SGEB criteria.

The Licensee also provided detailed drawings of sample modifications which consist of a grid system with channel steel members in the horizontal direction, and tube steel members on the vertical directions, or angle steel members in both horizontal and vertical directions (see pages B.2 and B.3, Attachment B).

Sample calculations also were provided to show the adequacy of the wall modifications. For wall 71C, vertical steel angles were provided at the edges of the wall and were anchored to the concrete column on both sides of the wall. Horizontal steel angles were also provided and welded to the vertical angle structural members.

The modification methods and sample calculations have been reviewed and judged to be adequate and in compliance with the SGEB criteria. Further discussion on modified walls is given in the next section (Section 3.2).

3.2 EVALUATION OF LICENSEE'S APPROACH TO WALL MODIFICATIONS

The Licensee has identified 19 of the 71 safety-related masonry walls at Browns Ferry Units 1, 2, and 3 as being modified. Two walls have already been fixed (24 and 92). There are three walls in which a shield will be designed to protect the safety-related items (71D, 71E, and 71F). The remaining 14 walls (both mortared and unmortared) will have the following design fixes. (Sketches are provided in Appendix B.)

1. Use a structural steel grid system to contain the wall in the event of failure (mortared walls 5B, 5C, 5D, 71B, and 71C).

2. Use horizontal structural steel restraints at a spacing determined by 10-psi allowable tensile stress in the mortar (mortared walls 6, 72, and 105).

3. Use horizontal structural steel restraints (see Response 6 for more details) at a spacing determined to limit moment and shear (by use of a stability analysis for blocks between restraints) so that the blocks will not fall [unmortared walls 15, 20, 52, 60, 83, and 87. All six walls are 8 ft high and 2 ft thick (4 wythes); their restraints spacing is 2 ft; and all are located at the same floor level, elevation 593 ft.].

The Licensee indicated in Response 9 that the completion date for wall modifications will be submitted in the July 1983 update submittal of the integrated schedule.

Review of the drawings and sample calculations finds the modifications to be adequate and satisfactory and the modified walls are in compliance with the SGEB criteria.

With respect to the unmortared and partially mortared walls which have not been fixed, the attachment to Reference 2 identified the following walls:

Wall 3: 7.33 ft high, 6 in thick, has mortar at every sixth course.

Wall 40: 7.33 ft high, 6 in thick, has mortar at every sixth course.

Wall 74: 8.5 ft high, 4 ft 6 in thick, has no mortar.

Wall 75: 7.33 ft high, 6 in thick, has mortar only at 3 ft 8 in from elevation 565 ft.

All four walls are located at elevation 565 ft of the reactor building. Wall 3 is in Unit 1, Wall 40 is in Unit 2, and Walls 74 and 75 are in Unit 3. These are the only known unmortared or partially mortared walls identified in Reference 2 which have not been fixed.

FRC staff and its consultants have reviewed the Licensee's criteria regarding unmortared walls which have not been fixed, and the following concerns are identified:

- o No masonry codes specify this type of construction. Therefore, the allowable stresses used by the Licensee for these walls are not applicable to the walls in question.

- o The allowable shear was based on the frictional forces developed through static friction where the coefficient of friction used is $\mu = 0.7$ which appears to be high. British and Canadian codes allow only 0.3.

- o In Reference 8, no margin of safety for the stability analysis was provided for the possibility of the wall being overturned. Uncertain behavior due to cyclic dynamic loading suggests a fairly high factor of safety to be used in the analysis.

It is the opinion of FRC staff and consultants that either these walls should be modified to comply with the SGEB criteria or affected safety-related systems associated with these walls should be protected against the possible failure of these walls.

4. CONCLUSIONS

A detailed study was performed to provide a technical evaluation of the masonry walls at Browns Ferry Units 1, 2, and 3. Reivew of the Licensee's criteria and additional information provided by the Licensee led to the conclusions given below.

The criteria used for reevaluation of the masonry walls, along with the additional information provided by the Licensee, indicated that the Licensee's criteria are in compliance with the SGEB criteria [10], except for the stress increase factor for tension in the reinforcement. This factor is 2.25, which is higher than the SGEB allowed factor of 2.0. However, the cross-sectional dimensions, material properties, and reinforcement ratios used in the walls are such that the compressive concrete stress always controls the design. Moreover, the tension stress in the reinforcement when the allowable ultimate moment applied is only 0.41 f_y (the SGEB criteria allowed 0.9 f_y).

The Licensee's approach to wall modifications has been reviewed and is judged to be adequate and in compliance with the SGEB criteria.

With regard to the unmortared and partially mortared walls, it is recommended (in Section 3.2) that the Licensee either provide modifications for walls 3, 40, 74, and 75 or the affected safety-related systems associated with these walls should be adequately protected against the possible failure of these walls. It should be noted that these four walls are the only known unmortared walls identified in Reference 2 which have not been fixed.

5. REFERENCES

1. IE Bulletin 80-11
   Masonry Wall Design
   NRC, 08-May-81

2. J. L. Cross
   Letter to J. P. O'Reilly (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant
   Tennessee Valley Authority, 08-Jul-80

3. J. L. Cross
   Letter to J. P. O'Reilly (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant - Response to Item 2B, and Results of Reevaluation Program
   Tennessee Valley Authority, 07-Nov-80

4. L. M. Mills
   Letter to J. P. O'Reilly (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant; Interim Response on Additional Applicable Loadings
   Tennessee Valley Authority, 07-Apr-81

5. L. M. Mills
   Letter to J. P. O'Reilly (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant; (Final Response Attached)
   Tennessee Valley Authority, 01-Oct-81

6. L. M. Mills
   Letter to J. P. O'Reilly (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant; Copy of Page 2 from Response of October 1, 1981
   Tennessee Valley Authority, 13-Nov-81

7. D. B. Vassallo (NRC)
   Letter to Tennessee Valley Authority. Subject: Additional Information Required by IE Bulletin 80-11
   January 28, 1983

8. L. M. Mills
   Letter to H. R. Denton (NRC)
   Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant Responses to Request for Additional Information
   April 22, 1983

9. L. M. Mills
Letter to H. R. Denton (NRC)
Subject: IE Bulletin 80-11 - Browns Ferry Nuclear Plant
Responses to Request for Additional Information
June 3, 1983

10. SGEB Criteria for Safety-Related Masonry Wall Evaluation
Structual Engineering Branch (SGEB) of the NRC
00-Jul-81

11. Uniform Building Code
International Conference of Building Officials, 1979

12. Building Code Requirements for Concrete Masonry Structures
Detroit: American Concrete Institute, 1979
ACI 531-79 and ACI 531-R-79

APPENDIX A

SGEB CRITERIA FOR SAFETY-RELATED MASONRY WALL EVALUATION (DEVELOPED BY THE STRUCTURAL AND GEOTECHNICAL ENGINEERING BRANCH [SGEB] OF THE NRC)

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1. General Requirements

The materials, testing, analysis, design, construction, and inspection related to the design and construction of safety-related concrete masonry walls should conform to the applicable requirements contained in Uniform Building Code - 1979, unless specified otherwise, by the provisions in this criteria.

The use of other standards or codes, such as ACI-531, ATC-3, or NCMA, is also acceptable. However, when the provisions of these codes are less conservative than the corresponding provisions of the criteria, their use should be justified on a case-by-case basis.

In new construction, no unreinforced masonry walls will be permitted. For operating plants, existing unreinforced walls will be evaluated by the provisions of these criteria. Plants which are applying for an operating license and which have already built unreinforced masonry walls will be evaluated on a case-by-case basis.

2. Loads and Load Combinations

The loads and load combinations shall include consideration of normal loads, severe environmental loads, extreme environmental loads, and abnormal loads. Specifically, for operating plants, the load combinations provided in the plant's FSAR shall govern. For operating license applications, the following load combinations shall apply (for definition of load terms, see SRP Section 3.8.4II-3).

(a) Service Load Conditions

(1) D + L

(2) D + L + E

(3) D + L + W

If thermal stresses due to T_o and R_o are present, they should be included in the above combinations as follows:

(1a) $D + L + T_o + R_o$

(2a) $D + L + T_o + R_o + E$

(3a) $D + L + T_o + R_o + W$

Check load combination for controlling condition for maximum 'L' and for no 'L'.

(b) Extreme Environmental, Abnormal, Abnormal/Severe Environmental, and Abnormal/Extreme Environmental Conditions

(4) $D + L + T_o + R_o + E$

(5) $D + L + T_o + R_o + W_t$

(6) $D + L + T_a + R_a + 1.5 P_a$

(7) $D + L + T_a + R_a + 1.25 P_a + 1.0 (Y_r + Y_j + Y_m) + 1.25 E$

(8) $D + L + T_a + R_a + 1.0 P_a + 1.0 (Y_r + Y_j + Y_m) + 1.0 E'$

In combinations (6), (7), and (8) the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, should be used unless a time-history analysis is performed to justify otherwise. Combinations (5), (7), and (8) and the corresponding structural acceptance criteria should be satisfied first without the tornado missile load in (5) and without Y_r, Y_j, and Y_m in (7) and (8). When considereing these loads, local section strength capacities may be exceeded under these concentrated loads, provided there will be no loss of function of any safety-related system.

Both cases of L having its full value or being completely absent should be checked.

3. Allowable Stresses

Allowable stresses provided in ACI-531-79, as supplemented by the following modifications/exceptions, shall apply.

(a) When wind or seismic loads (OBE) are considered in the loading combinations, no increase in the allowable stresses is permitted.

(b) Use of allowable stresses corresponding to special inspection category shall be substantiated by demonstration of compliance with the inspection requirements of the SEB criteria.

(c) When tension perpendicular to bed joints is used in qualifying the unreinforced masonry walls, the allowable value will be justified by test program or other means pertinent to the plant and loading conditions. For reinforced masonry walls, all the tensile stresses will be resisted by reinforcement.

(d) For load conditions which represent extreme environmental, abnormal, abnormal/severe environmental, and abnormal/extreme environmental conditions, the allowable working stress may be multiplied by the factors shown in the following table:

Type of Stress	Factor
Axial or Flexural Compression[1]	2.5
Bearing	2.5
Reinforcement stress except shear	2.0 but not to exceed 0.9 fy
Shear reinforcement and/or bolts	1.5
Masonry tension parallel to bed joint	1.5
Shear carried by masonry	1.3
Masonry tension perpendicular to bed joint	
for reinforced masonry	0
for unreinforced masonry[2]	1.3

Notes

(1) When anchor bolts are used, design should prevent facial spalling of masonry unit. .

(2) See 3(c).

4. Design and Analysis Considerations

(a) The analysis should follow established principles of engineering mechanics and take into account sound engineering practices.

(b) Assumptions and modeling techniques used shall give proper considerations to boundary conditions, cracking of sections, if any, and the dynamic behavior of masonry walls.

(c) Damping values to be used for dynamic analysis shall be those for reinforced concrete given in Regulatory Guide 1.61.

(d) In general, for operating plants, the seismic analysis and Category I structural requirements of FSAR shall apply. For other plants, corresponding SRP requirements shall apply. The seismic analysis shall account for the variations and uncertainties in mass, materials, and other pertinent parameters used.

(e) The analysis should consider both in-plane and out-of-plane loads.

(f) Interstory drift effects should be considered.

(g) In new construction, grout in concrete masonry walls, whenever used, shall be compacted by vibration.

(h) For masonry shear walls, the minimum reinforcement requirements of ACI-531 shall apply.

(i) Special constructions (e.g., multiwythe, composite) or other items not covered by the code shall be reviewed on a case-by-case basis for their acceptance.

(j) Licensees or applicants shall submit QA/QC information, if available, for staff's review.

In the event QA/QC information is not available, a field survey and a test program reviewed and approved by the staff shall be implemented to ascertain the conformance of masonry construction to design drawings and specifications (e.g., rebar and grouting).

(k) For masonry walls requiring protection from spalling and scabbing due to accident pipe reaction (Y_r), jet impingement (Y_j), and missile impact (Y_m), the requirements similar to those of SRP 3.5.3 shall apply. However, actual review will be conducted on a case-by-case basis.

5. References

(a) Uniform Building Code - 1979 Edition.

(b) Building Code Requirements for Concrete Masonry Structures ACI-531-79 and Commentary ACI-531R-79.

(c) Tentative Provisions for the Development of Seismic Regulations for Buildings - Applied Technology Council ATC 3-06.

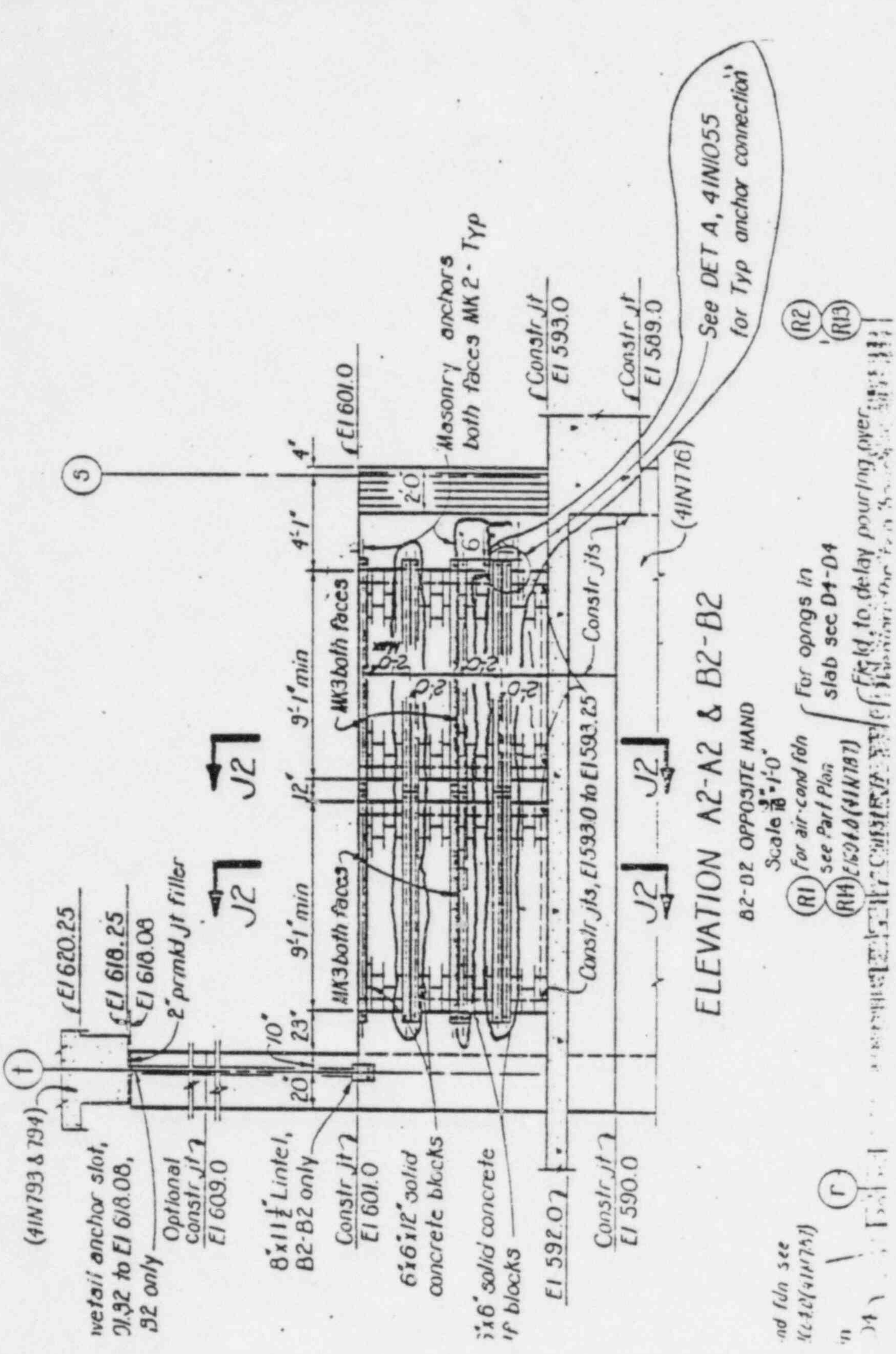
(d) Specification for the Design and Construction of Load-Bearing Concrete Masonry - NCMA August, 1979.

(e) Trojan Nuclear Plant Concrete Masonry Design Criteria Safety Evaluation Report Supplement - November, 1980.

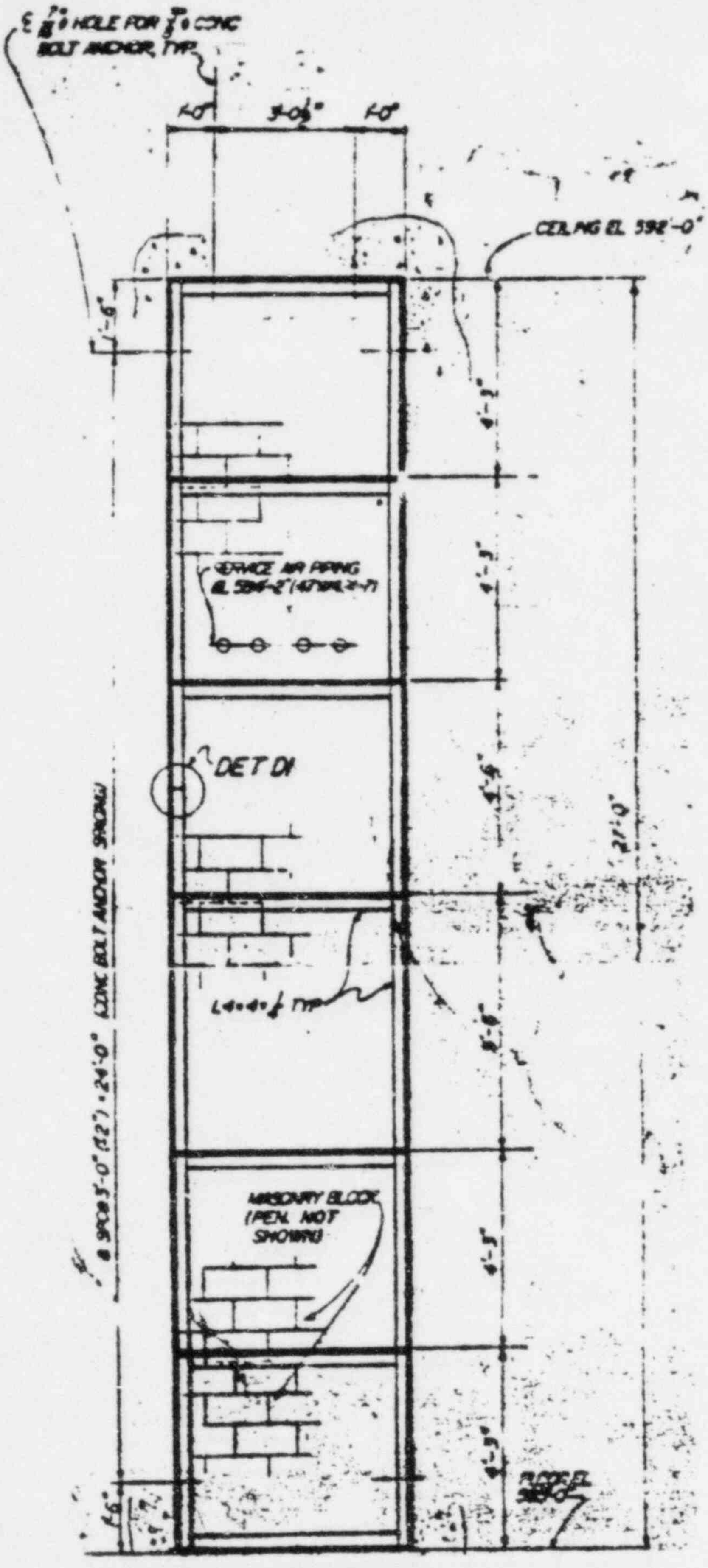
APPENDIX B

SKETCHES OF WALL MODIFICATIONS

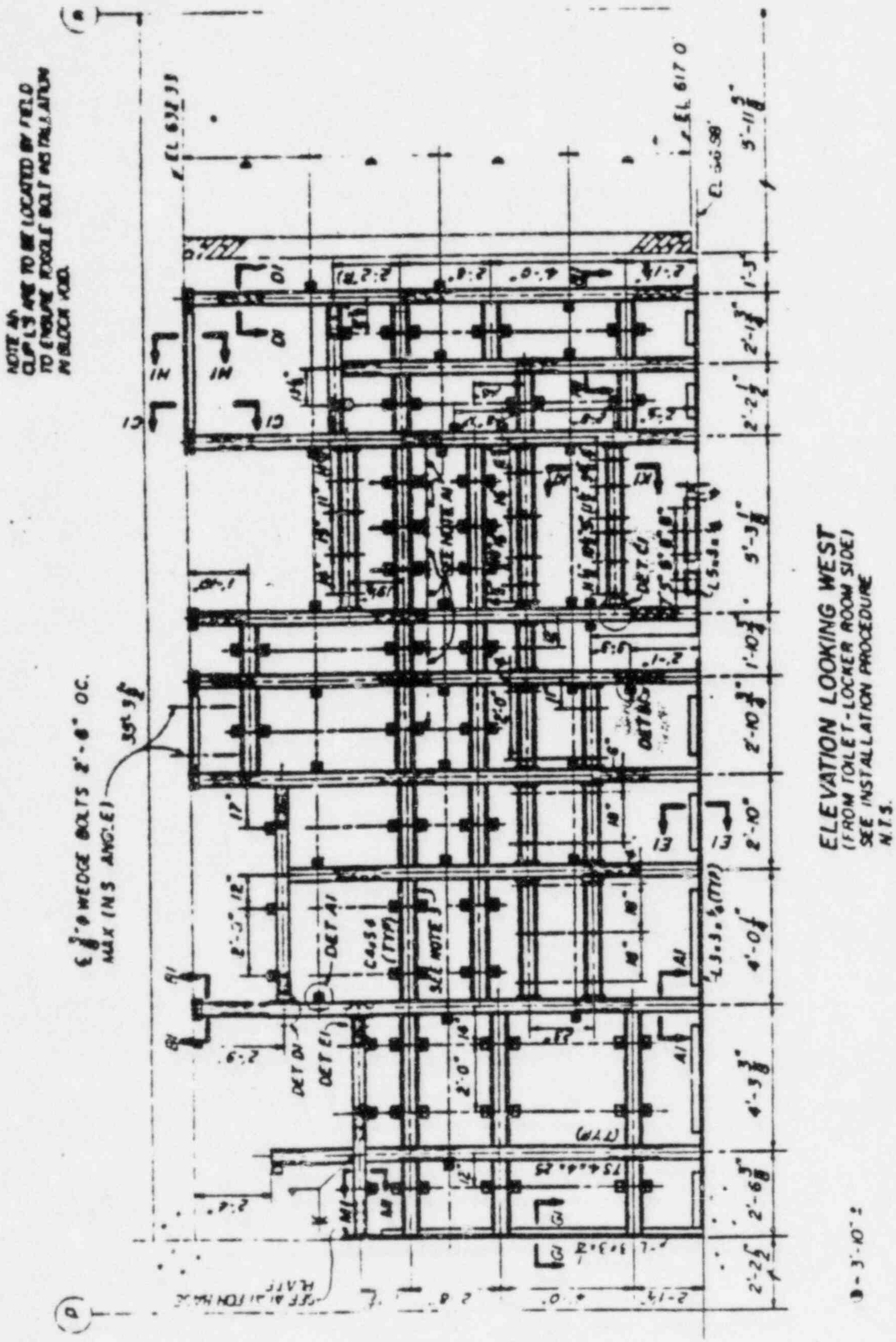
Franklin Research Center
A Division of The Franklin Institute
The Benjamin Franklin Parkway, Phila., Pa. 19103 (215) 448-1000



ELEVATION A2-A2 & B2-B2
B2-D2 OPPOSITE HAND
See DET A, 41N1055 for Typ anchor connection
Masonry anchors both faces MK 2 - Typ
MK3 both faces
Constr jts
Constr jts, El 593.0 to El 593.25
El 601.0
El 620.25
El 618.25
El 618.08
2" prmld jt filler
(41N793 & 794)
Optional Constr jt El 609.0
Constr jt El 601.0
6"x6"x12" solid concrete blocks
El 592.0
Constr jt El 590.0
Constr jt El 593.0
Constr jt El 589.0
(41N776)
J2
9'-1" min
4'-1"
For opngs in slab see D4-D4
For air-cond fdn See Part Plan



1'-0"
3'-0½"
1'-0"
CEILING EL 592'-0"
SERVICE AIR PIPING
DET D1
L4×4×¼ TYP
MASONRY BLOCK (PEN. NOT SHOWN)
27'-0"


NOTE A1:
CLIP L3 ARE TO BE LOCATED BY FIELD
TO ENSURE TOGGLE BOLT INSTALLATION
IN BLOCK VOID.
EL 617 0
ELEVATION LOOKING WEST
(FROM TOILET-LOCKER ROOM SIDE)
SEE INSTALLATION PROCEDURE
N.T.S.