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TECHNICAL EVALUATION REPORT

MASONRY WALL DESIGN (B-59)

POWER AUTHORITY OF THE STATE OF NEW YORK
INDIAN POINT NUCLEAR POWER PLANT UNIT 3

NRC DOCKET NO. 50-286

NRC TAC NO. 42863

NRC CONTRACT NO. NRC-03-81-130

FRC PROJECT C5506

FRC ASSIGNMENT 6

FRC TASK 261

Prepared by

Franklin Research Center
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Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: N. C. Chokshi

September 14, 1983

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

APPENDIX B - SKETCH OF WALL MODIFICATIONS

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 AND SCOPE

The purpose of this review is to provide a technical evaluation of the Licensee's 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 PLANT-SPECIFIC BACKGROUND

In response to IE Bulletin 80-11, the Power Authority of the State of New York provided the NRC with documents describing the status of masonry walls at Indian Point Nuclear Power Plant Unit 3 [2]. A review of the status of the masonry walls at this plant was conducted. Following this review, a request for additional information was sent to the Licensee on April 28, 1982 [3]. The Licensee responded to this request on August 5, 1982 [4]. An additional response dated February 4, 1983 was received [5].

A total of 26 safety-related masonry walls have been identified at Indian Point Nuclear Power Plant Unit 3 located in the following buildings:

	No. of Walls
Primary Auxiliary Building	8
Fan House	1
Control Building	17
Total	26

The functions of these masonry walls include fire protection, radiation shielding, and partitioning. The masonry walls for this plant do not act as shear walls [2]. Horizontal reinforcements are provided in all walls; no vertical reinforcement is provided.

Attachments to the walls are extremely light (less than 100 lbs) and they are secured to the walls by anchor bolts.

All walls have running-bond type construction. Eight walls were identified as multi-wythe and the remaining 18 walls are single-wythe.

As will be seen in Response 1. of Section 3.1, metal dovetail anchors are installed at the boundaries beside the mortar joints.

Material construction for masonry walls is as follows:

Hollow block	ASTM C-90, compressive strength (f'_m) = 700 psi
Solid block	ASTM C-145, compressive strength ($'_m$) = 1100 psi
Mortar	Type N, compressive strength (f'_m) = 750 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 [6], and ACI 531-79 [7].

In general, the materials, testing, analysis, design, construction, and inspection of safety-related concrete masonry walls 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 7, 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 submittal [2] and responses [3, 5] to the request for additional information [4]. The Licensee's criteria were evaluated with regard to design and analysis methods, loads and load combinations, allowable stresses, construction specifications, and materials. The Licensee's responses to the request for additional information were also reviewed.

3.1 EVALUATION OF LICENSEE'S CRITERIA

The Licensee has performed the reevaluation of the masonry walls using the following criteria:

- Allowable stresses followed ACI 531-79 [7].
- The loads and load combinations considered were those listed in the FSAR, which include dead, seismic (operating basis earthquake and design basis earthquake) pressure, impact, wind, tornado, and attachment loads. A site survey and a review of system arrangement plans were performed to determine which of the above loads are applicable for each wall. In the majority of the walls, the only acting loads are dead weight and seismic.
- The following damping values were used:

  2% damping for operating basis earthquake (OBE)

  4% damping for design basis earthquake (DBE)
- The working stress design method was used in the analysis.
- No stress increase factors were used for loads involving DBE.
- No composite action was assumed in the analysis.

The Licensee's criteria have been reviewed and found to be adequate and in compliance with the SGEB criteria. Following is the review of the Licensee's responses [3, 5].

Question 1

According to general computation sheets submitted with Reference 2, the masonry walls in the primary auxiliary building (PAB) have no shear transfer mechanism on any of the boundaries and the number of wythes is unknown. Indicate and justify the boundary conditions and the number of wythes assumed in the reevaluation of these walls.

Response 1

The Licensee explained that boundary conditions for all the walls were assumed pinned in both frequency and stress calculations based upon the following information:

- Field inspection indicated that adequate mortar joints existed at the boundaries.
- Design drawings called for metal dovetail anchors at the boundaries.
- Calculated shear stresses at the boundaries were very low. The maximum was 3 psi as compared to the allowable value of 36 psi.

Regarding the multi-wythe walls, no composite action was assumed. They were analyzed as a single wythe [5].

Based on the above information, the Licensee's response is considered reasonably adequate.

Question 2

Using sample calculations, indicate how the effect of higher modes of vibration is included in the analysis.

Response 2

The Licensee referred to a study contained in the "Recommended Guidelines for the Reassessment of Safety-Related Masonry Walls," dated October 6, 1980 and prepared by the Owners and Engineering Firms Informed Group on Concrete Masonry Walls. In this study, walls with different sizes and boundary conditions were analyzed, and the results demonstrated that the first mode moment contributed over 99% of the responses when compared to the square root

of the sum of the squares of the first eight modes. In addition, it has been found, in many cases at other plants, that the first mode usually contributes 95% or more to the total responses. Therefore, the Licensee's approach using the first mode is adequate and satisfactory.

Question 3

With reference to Table 2 of Reference 2, justify the increase factor of 1.67 applied to allowable shear stress and tensile stresses normal and parallel to the bed joint. The SGEB criteria allow an increase factor of only 1.3 for tension normal to the bed joint and masonry shear and 1.5 for tension parallel to the bed joint.

Response 3

The Licensee explained that the increase factor of 1.67 for shear and for tension normal and parallel to the bed joint, although specified in the original submittal [2], was not used. All safety-related walls were analyzed for the DBE loads and all other applicable loads, and no stress increase factor was used. Therefore, the response is adequate and in compliance with the SGEB criteria.

Question 4

With reference to Table 2 of Reference 2, justify the allowable tensile stress in the grout core and the allowable stresses in the collar joint.

Response 4

The Licensee indicated that there is no grout core at this plant (all walls are unreinforced). Hence, the allowable tensile stresses specified for the grout core in Reference 2 are not applicable.

Regarding the strength of the collar joint, the Licensee explained in Reference 5 that composite action was not assumed in the analysis. Therefore, the Licensee's approach is adequate and in compliance with the SGEB criteria.

Question 5

With regard to the walls which were qualified using plate/beam theory, justify the assumptions for the boundary conditions. Also, indicate how the effect of wall openings was considered.

Response 5

With respect to the boundary conditions, the Licensee provided proper justification in Response 1, and they were found to be adequate.

Regarding the wall openings, the Licensee indicated that the walls were analyzed as beam strips; this is a conservative approach for bending as well as for shear stress computations. It should also be noted that no increase factors were used in the analysis for the DBE loading case, as previously discussed in Response 3. In addition, the damping values were lower than the allowables (2% for OBE as opposed to 4%, and 4% for DBE as opposed to 7%).

Therefore, the response is reasonably conservative and in compliance with the SGEB criteria.

Question 6

Justify the assumption that the OBE stresses are 2/3 of the design basis earthquake (DBE) stresses as summarized in the calculation sheets submitted with Reference 2 (no calculations were presented for the OBE condition).

Response 6

The Licensee's response indicated that, in all cases, OBE accelerations were less than or equal to the DBE accelerations. Response 3 indicated that no stress increase factors were used in the DBE loading cases. Since DBE is the governing case, there is no need to check the stress levels caused by the OBE. Therefore, the Licensee's approach is adequate and in compliance with the SGEB criteria.

Question 7

Provide the results of the analysis for the walls that do not qualify under the working stress criteria, indicating the failure mode. Present the results of the analysis in terms of actual and allowable stresses.

Response 7

The results of the analysis for the walls that do not qualify under the working stress design criteria are summarized below:

	Tension Stress Perpendicular To Bed Joint		Tension Stress Parallel To Bed Joint	
Wall No.	Actual psi	Allowable psi	Actual psi	Allowable psi
46	44.6	13.0	-	27.0
51A	-	13.0	33.6	27.0
52A	52.1	13.0	37.5	27.0
52D	52.1	13.0	37.5	27.0
55B	135.3	13.0	34.7	27.0
57B	169.6	13.0	-	27.0

The Licensee's approach to the wall modifications will be discussed in the next response. The Licensee's response is satisfactory.

Question 8

Provide the details of proposed wall modifications with sketches, and give sample calculations to indicate how these modifications will correct the wall deficiencies. Also, provide legible copies of the plans and elevations of masonry walls attached to Reference 2.

Response 8

The Licensee provided the details of wall modifications and also provided three sample calculations to illustrate that the modifications will correct the wall deficiencies. Appendix B provides drawings illustrating the modifications for Wall 46.

The modification methods consist of:

- o the use of grating to block the collapse of masonry walls
- o the use of intermediate supports to reduce wall spans and, thereby, stresses.

In addition, the Licensee supplied legible copies of plans and elevations attached to Reference 2 as requested.

Wall 57-A was listed in Reference 2 as an unqualified wall. In a conference call on September 22, 1982, the Licensee indicated that Wall 57-A was divided into two portions separated by an existing concrete beam. The upper portion of Wall 57-A satisfied the design criteria. Although the lower portion did not satisfy the design criteria, it does not have any safety-related items attached to it. In Reference 5, the Licensee confirmed that this wall was reevaluated and determined to be non-safety-related.

Review of sample calculations and the modification methods indicated that the modified walls satisfy the SGEB criteria.

Question 9

Provide the status of the proposed wall modifications.

Response 9

According to this response, the wall modifications have been completed.

3.2 EVALUATION OF LICENSEE'S APPROACH TO WALL MODIFICATIONS

Based on Reference 4, the modification methods consist of:

- o the use of grating to block the collapse of masonry walls
- o the use of intermediate supports to reduce wall spans and, thereby, stresses.

With reference to Response 8 in Section 3.1, the Licensee provided the details of wall modifications with drawings (Appendix B).

The Licensee also provided three sets of sample calculations to demonstrate that the modifications will correct the wall deficiencies.

The modification methods as well as sample calculations have been reviewed and are judged to be adequate and in compliance with the SGEB criteria.

4. CONCLUSIONS

A detailed study was performed to provide a technical evaluation of the masonry walls at Indian Point Nuclear Power Plant Unit 3. Review of the Licensee's criteria and additional information provided by the Licensee led to the conclusions given below.

The Licensee's criteria are found to be adequate and in compliance with the SGEB criteria.

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

5. REFERENCES

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

2. J. P. Bayne
   Letter to B. H. Grier, NRC. Subject: Indian Point Nuclear Power Plant Unit 3 180-Day Response to IE Bulletin 80-11
   Power Authority of the State of New York, 20-Nov-80
   IPN-80-109

3. S. A. Varga (NRC)
   Letter to Power Authority of the State of New York
   Subject: NRC Request for Additional Information Concerning Masonry Wall Design
   April 28, 1982

4. J. B. Bayne
   Letter to S. A. Varga (NRC)
   Subject: Request for Additional Information Concerning Masonry Wall Design
   August 5, 1982

5. J. B. Bayne
   Letter to S. A. Varga (NRC)
   Subject: Request for Additional Information Concerning Masonry Wall Design
   February 4, 1983

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

7. 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)
July 1981

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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 considering 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

SKETCH OF WALL MODIFICATIONS

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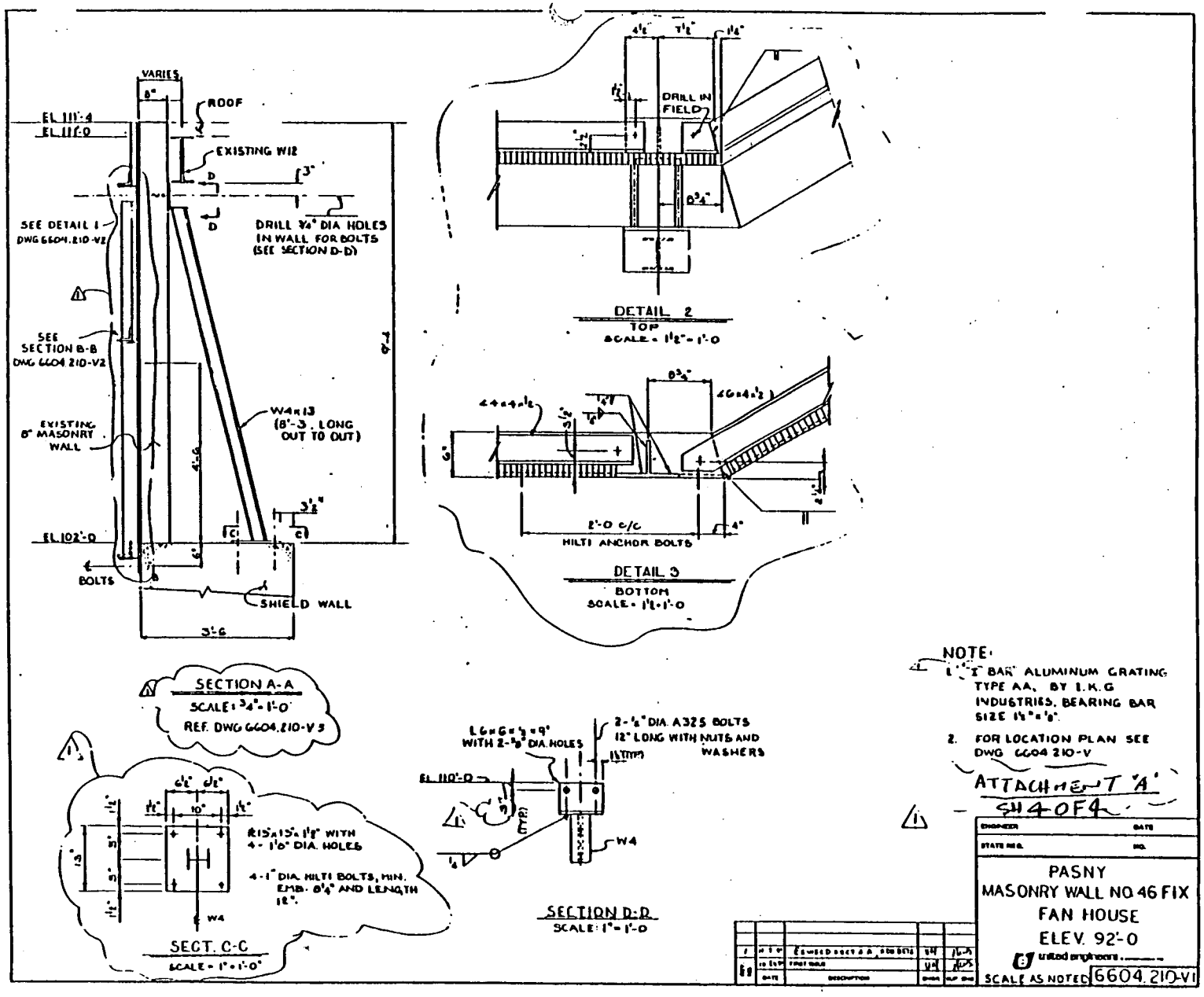

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