attachment 1

TECHNICAL EVALUATION REPORT

MASONRY WALL DESIGN

POWER AUTHORITY OF THE STATE OF NEW YORK

J. A. FITZPATRICK NUCLEAR POWER PLANT

NRC DOCKET NO. 50-333

NRC TAC NO. 42881

NRC CONTRACT NO. NRC-03-81-130

FRC PROJECT C5506

FRC ASSIGNMENT 6

FRC TASK 237

Prepared by

Franklin Research Center
20th and Race Street
Philadelphia, PA 19103

Author: A. K. Le, V. N. Con

FRC Group Leader: V. N. Con

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: N. C. Chokshi

April 24, 1984

8404260163 XA

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

TECHNICAL EVALUATION REPORT

MASONRY WALL DESIGN

POWER AUTHORITY OF THE STATE OF NEW YORK

J. A. FITZPATRICK NUCLEAR POWER PLANT

NRC DOCKET NO. 50-333

NRC TAC NO. 42881

NRC CONTRACT NO. NRC-03-81-130

FRC PROJECT C5506

FRC ASSIGNMENT 6

FRC TASK 237

Prepared by

Franklin Research Center
20th and Race Street
Philadelphia, PA 19103

Author: A. K. Le, V. N. Con

FRC Group Leader: V. N. Con

Prepared for

Nuclear Regulatory Commission
Washington, D.C. 20555

Lead NRC Engineer: N. C. Chokshi

April 24, 1984

Prepared by:	Reviewed by:	Approved by:
A. K. Le	Vu Ngoc Con	D P Carfagno
Principal Author:	Group Leader	Department Director
Date: 4/23/84	Date: 4/24/84	Date: 4/24/84

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

CONTENTS

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 technical evaluations of licensee responses to IE Bulletin 80-11 [1]* with respect to compliance with the Nuclear Regulatory Commission (NRC) masonry wall criteria. In addition, if a licensee has planned repair work on masonry walls, the planned methods and procedures are to be 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 Power Authority of the State of New York (PASNY) provided the NRC with documents [2-4] describing the status of masonry walls at James A. FitzPatrick Nuclear Power Plant. The information in these documents was reviewed, and a request for additional information was sent to the Licensee [5] to which the Licensee responded [6, 7]. Additional questions [8] were sent to the Licensee, to which it has also responded [9].

* Numbers in brackets indicate references, which are cited in Section 5.

The masonry walls at FitzPatrick Nuclear Plant, according to Section 5c of Enclosure 1, Reference 2, provide the following functions:

a. provide personnel barriers and fire protection or radiation shielding
b. serve as removable panels for personnel or equipment access.

There are 86 safety-related masonry walls that required reevaluation [2]. These walls are located in the reactor building, pump house, diesel generator building, emergency generator building, turbine building, battery room, administrative building, cable tunnel, main control room, chiller room, and air condition equipment room. Each masonry wall identified was reviewed and inspected for safety-related piping and equipment and was placed in one of the following classifications in order of descending priority [4]:

"I. Walls with safety related piping 2-1/2 inch diameter or larger attached to, or in proximity of wall, or safety related piping with thermal loads greater than 100 lbs., with a low probability of relocation or providing protective barriers or enclosures.

II. Walls with safety related equipment weighing more than 100 lbs. (as defined in IE Bulletin 80-11) attached to, or in proximity of wall with low probability of relocation or providing protective barriers or enclosures.

III. Walls with safety related equipment weighing more than 100 lbs. (as defined in IE Bulletin 80-11) attached to, or in proximity of wall with high probability of relocation or providing protective barriers or enclosures.

IV. Walls with all other safety related piping or equipment."

All concrete masonry walls identified at the FitzPatrick Nuclear Plant are non-load-bearing. Most of the walls are single wythe and consist of either 6-, 8-, or 12-inch lightweight hollow units. The walls that provide radiation shielding, however, are 12-inch solid units, either single wythe or multiple wythe. All walls have a continuous layer of metal hardware cloth on top of the first course and in every third succeeding course. The walls were considered to be nonreinforced except where vertical reinforcement was used to function as a pier or column.

All masonry walls were constructed in a running bond pattern. Independent laboratory testing was performed on masonry materials to assure compliance with the applicable ASTM specifications.

The materials used in the construction of masonry walls were specified as follows:

Hollow masonry units	C90, Grade P-I
Solid masonry units	C145, Grade P-I
Mortar	C270, Type S
Reinforcement	A615, Grade 40
Structural steel	A36
Reinforcement wires	A82

There are 16 safety-related masonry walls that required modification. Modifications at the FitzPatrick plant typically consist of structural steel members added for lateral support. All the modifications at the FitzPatrick plant have been completed.

2. EVALUATION 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 [10], and ACI 531-79 [11].

The materials, testing, analysis, design, construction, and inspection of safety-related concrete masonry structure 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 11 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, 3, 4] and subsequent responses [6, 7, 9] to the requests for additional information [5, 8]. The Licensee's criteria [2] were evaluated with regard to design and analysis methods, loads and load combinations, allowable stresses, construction specifications, and materials. The Licensee's response to the request for additional information was 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 [11].
- o Load combinations are according to the FSAR.
- o The working stress design method is used.
- o Walls are modeled as beams or plates for hand calculations or as plates for finite element analysis using the ANSYS computer program.
- o Critical damping values of 0.5% and 1.0% were used for the operating basis earthquake (OBE) and the safe shutdown earthquake (SSE), respectively.
- o The typical analytical procedure is summarized below:
  - determine wall boundary conditions
  - calculate the wall's fundamental frequency
  - obtain inertial loading from the floor peak-broadened amplified response spectra (ARS)
  - compare computed stresses with the allowable values in ACI 531-79.

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 response to the request for additional information follows.

Request 1

Provide the boundary conditions and modeling techniques used for the reevaluation of masonry walls at the FitzPatrick plant and indicate how the potential for block pullout was considered.

Response 1

The following generic categories of masonry wall design were identified at the plant:

- o fully bounded by reinforced concrete or steel columns, slabs, etc.
- o bounded on the three sides by reinforced concrete or steel columns, slabs, etc.
- o semi-freestanding supported by reinforced concrete walls and slabs, etc.

Based on the above categories, the boundary condition can be considered pinned, free, or fixed. The Licensee's sample calculations indicated that dowels were used along the bottom boundary of the wall where it was assumed to be fixed. Simple support was assumed for walls that were supported laterally by steel members (see Figure B-1 in Appendix B). Therefore, the boundary conditions assumed in the analysis as pinned, free, or fixed are considered appropriate.

Regarding the potential for block pullout, the Licensee stated that the block pullout strength was determined by the transfer of shear stresses across the bed and head joints and by collar joint strength in a multi-wythe wall. The sample calculations indicated that the shear stresses for collar joint are 0.45 psi and 0.78 psi for OBE and SSE, respectively. It is noted that a number of collar joints were tested for the Trojan Nuclear Power Plant and the accepted NRC allowable was 8 psi and 12 psi for unfactored and factored loads, respectively. A review of the Licensee's response indicated that the local stress resulting from bolt loads on masonry walls is less than the SGEB allowable (shear stress allowable).

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

Request 2

Indicate how earthquake forces in three directions were considered in the seismic analysis of the walls and how the equipment loads were accounted for in the seismic analysis.

Response 2

The Licensee indicated that the earthquake forces used in the reevaluation of the masonry walls are consistent with the FSAR, which states: "The square root of the sum of the square (SRSS) acceleration values for the specific coordinates where the walls are located in the structure are used to compute inertial forces which are applied as static loads to the wall."

The equipment inertial loads were calculated and included in the analysis. In addition, loads resulting from any large bore piping (2 inches and greater) were also accounted for in the analysis. The Licensee also stated that the resulting stresses were obtained by combining the wall inertial loading, with the applicable equipment and piping loads, and interstory drift effects.

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

Request 3

Provide a brief description and a sample calculation to show the analytical approach used for single-wythe and multiple-wythe walls.

Response 3

The Licensee provided sample calculations for two single-wythe walls and one multiple-wythe wall. A summary of the analysis is provided below:

1. Single-Wythe Wall (hand calculation)

   - The wall is made up of hollow concrete blocks, m_o = 1800 psi.
   - The wall is considered as a rectangular plate, 9 ft 10 in long, 9 ft 3 in high, and 12 in thick.

- o The wall boundary condition is assumed as pinned on four sides.

- o The OBE is 0.08 g and SEE is 0.15 g (the wall fundamental frequency of 81.8 cps is in the rigid range).

- o The wall is located in the reactor building at elevation 272 ft (wall RB-272-1)

The computed stress was found to be 1.25 psi for bending stress perpendicular to bed joints at mid-height of the wall and was less than the Licensee's allowable stress of 28.2 psi for the OBE case (SGEB allowable is 21.21 psi). For the SSE case, the computed stress is 2.32 psi, which is less than the Licensee's allowable stress of 35.42 psi (SGEB allowable is 27.58).

2. Single-Wythe Wall (computer analysis)

- o The wall is made up of solid concrete blocks, m_o = 1800 psi.

- o The wall is considered as a rectangular plate, 8 ft 9 in long, 7 ft high, and 12 in thick.

- o The wall boundary condition is assumed as free for the top and one side of wall, and as pinned for the bottom and opposite side of wall.

- o Floor response spectra are used at fundamental frequency of 16.79 cps.

- o The wall is located in the reactor building at elevation 344 ft (wall RB-344-1).

The results are tabulated below (the results are the SRSS of stresses due to wall inertial, peak pressure, and intestory drift):

Case	Calculated Stress (psi)	SGEB Allowable (psi)	Licensee's Allowable (psi)	Location
OBE	31.48	63.64	84.85	Parallel to bed joint at top
	14.31	42.43	53.32	Perpendicular to bed joint at mid-height
SSE	59.91	95.46	106	Parallel to bed joint at top
	28.79	55.16	66.67	Perpendicular to bed joint at mid-height

3. Multiple-Wythe Wall (hand calculation)

- The wall is made up of solid blocks, m_o = 1800 psi.
- The wall is considered as a rectangular plate, 7 ft long, 11 ft high, and 48 in thick.
- The wall boundary condition is assumed as pinned on four sides.
- OBE is 0.1 g and SSE is 0.2 g. (The wall fundamental frequency of 335.4 cps is in the rigid range.)
- The wall is located in the reactor building at elevation 300 ft (wall RB-300-1).

The results are tabulated below (the results are the SRSS of stresses due to wall inertial, peak pressure, and intestory drift):

Case	Calculated Stress (psi)	SGEB Allowable (psi)	Licensee's Allowable (psi)	Location
OBE Bending	0.67	63.64	84.85	Parallel to bed joint at mid-height
	13.06	42.43	53.32	Perpendicular to bed joint at mid-height
OBE Shear	1.63	40.42	53.89	Vertical strip wall
	1.84	*	8.0	Vertical strip collar joint

Case	Calculated Stress (psi)	SGEB Allowable (psi)	Licensee's Allowable (psi)	Location
SSE Bending	1.16	95.46	106	Parallel to bed joint at mid-height
	15.22	55.16	66.67	Perpendicular to bed joint at mid-height
SSE Shear	1.98	52.54	67.36	Vertical strip wall
	2.22	*	12.00	Vertical strip collar joint

*See Response 1 for the NRC accepted allowables.

The sample calculations indicated that all the stresses are within the SGEB allowables. The Licensee used an increase factor of 1.3 for OBE allowables. Justifications for the increase factor are discussed in Response 4.

The Licensee's response is considered adequate and satisfies the SGEB criteria.

Request 4

With reference to Section 6c, Enclosure 1, Reference 2, justify the proposed 30% increase in allowable stresses for load combinations including OBE loads, for which no increase is allowed in the SGEB criteria [7].

Request 4.1 (Reference 8)

If the wall cannot be qualified without including an increase factor over allowable stresses, identify and explain all conservative measures used in the analysis to justify the proposed increase factor. Identify all affected walls and the actual increase factor associated with each.

Responses 4 and 4.1

In these responses, the Licensee indicated that a 30% increase in the allowables has been used in accordance with Table 12.4.3 of the FSAR.

As will be seen in Response 5, the Licensee's increase factors for load combinations including SSE satisfy the SGEB criteria. It is noted that the Licensee used very low damping values in the analysis: 0.5% for OBE and 1% for SSE as opposed to 4% and 7%, respectively, by the SGEB criteria.

A review of the plant FSAR indicated that, after taking into account the difference in damping for OBE and SSE, the ground response spectrum for SSE is approximately equal to 1.8 OBE. Other load components of the load combination such as normal load and live load (pressure and interstory drift effects) also contributed to the wall response. A review of sample calculations indicated pressure load is not significant. Interstory drift effect is significant in only one calculation, in which it was 20% higher for the SSE case than for the

OBE case. Moreover, interstory drift effect is applicable only in walls with fixed supports.

For the load combination including SSE, the seismic load is 80% higher and interstory drift effects are 20% higher compared to the load combination including OBE. It can be deduced that for the worst possible case, the stress induced by the load combination including OBE would be about 10% higher than the SGEB allowable.

As stated before, the Licensee used 0.5% damping for the OBE as opposed to 4% allowed by the SGEB criteria. Therefore, for all practical purposes, it can be concluded that the Licensee's approach still meets the intent of the SGEB criteria.

Request 5

With reference to Section 6c, Enclosure 1, Reference 2, justify the increase factor of 1.67 applied to allowable stresses for extreme environmental loads (e.g., SSE). The SGEB criteria allow increase factors of only 1.5 for tension parallel to the bed joint and shear in the reinforcement and 1.3 for tension normal to the bed joint and masonry shear.

Request 5.1 (Reference 5)

Justify and identify those masonry walls evaluated by PASNY that have stress factors greater than those specified by the SGEB criteria for extreme environmental conditions (1.5 for tension parallel to the bed joint and 1.3 for tension normal to the bed joint and masonry shear).

Responses 5 and 5.1

In response to this request, the Licensee referred to the National Concrete Masonry Association (NCMA) test results to support the increase factor of 1.67 applied to allowable stresses for extreme environmental loads. For tension normal to the bed joint, NCMA tests indicated an average safety factor of approximately 4, and the minimum factor of safety with respect to the lower bound of static tests for unfactored loads was 2.8. For tension

parallel to the bed joint, NCMA test results on unreinforced walls indicated an average safety factor of 5.3. Therefore, a 1.67 allowable stress increase factor for extreme environmental loads (SSE) is considered reasonable.

In a later response [7], the Licensee stated that only two walls were analyzed using higher increase factors:

- o Wall No. PH-255-3 (pumphouse), stress factor 1.57 (SGEB allows 1.5 for tension parallel to the bed joint): 5% higher than SGEB criteria.
- o Wall No. EB-272-15 (turbine building), stress factor 1.65 (SGEB allows 1.5 for tension parallel to the bed joint): 10% higher than SGEB criteria.

These higher factors were used for only two walls and were 5% and 10% higher than the SGEB allowables. A very conservative damping value of 1% was employed for SSE (as opposed to 7% allowed by the SGEB criteria). For all practical purposes, the small percentage of exceedance can be accepted, and this leads to the conclusion that the Licensee's approach is considered adequate and in compliance with the SGEB criteria.

Request 6

Describe the methodology of any alternative acceptance criteria (i.e., not based on working stress) used to qualify masonry walls. It is the NRC's position at present that the arching theory should not be used in the absence of conclusive evidence of its applicability to masonry structures in nuclear power plants.

Response 6

The Licensee clarified that arching theory has not been used in the analysis and that only working stress design methods have been used. The Licensee's response has resolved this concern.

Request 7

Provide sample calculations to indicate how the effects of higher modes of vibration are accounted for in the masonry wall analysis.

Response 7

For all of the walls being analyzed by finite element procedures using the ANSYS Computer Program [12], the effects of higher modes were accounted for; the participation of higher modes was found to have a negligible effect on the total response of the wall. For this reason, where hand calculations were performed, the participation of higher modes was not included in the analysis.

For all practical purposes, the first mode should adequately cover the total responses of the walls. It has been found, in many cases at other plants, that the first mode usually contributes 95% or more to the total responses. Therefore, it can be concluded that the Licensee's approach is satisfactory and in compliance with the SGEB criteria.

Request 8

Provide details of proposed wall modifications with sketches and indicate, using sample calculations, how these modifications will correct the walls' deficiencies.

Response 8

Modifications at the FitzPatrick plant typically consist of structural steel members added for lateral support. The following general types of modifications are found at the plant:

- o lateral members attached to nearby concrete wall at one end and to the masonry structure at the other end
- o horizontal support members spanning along the face of the masonry wall between existing columns or walls and attached to the masonry wall
- o vertical colunms anchored at top and bottom and attached along their height to the masonry wall
- o knee braces attached to ceiling steel and the upper sections of masonry walls.

Modifications at the FitzPatrick plant typically provided hinge support on top of the walls and/or provided lateral supports to reduce the span length of the walls.

The Licensee has also provided detailed modifications with sketches for five walls. Appendix B illustrates typical modifications to masonry walls. Sample calculations were also given to demonstrate that the modified walls satisfy the SGEB criteria and therefore are considered adequate and in compliance with the SGEB criteria.

Request 9

Provide the status of the proposed wall modifications.

Response 9

The Licensee stated that modifications to block walls started in the plant on or about April 1, 1981 and were completed on or about July 31, 1981. These modifications were reviewed and considered adequate as discussed in Response 8 above.

3.2 EVALUATION OF LICENSEE'S APPROACH TO WALL MODIFICATIONS

There are 16 safety-related masonry walls that require modifications. As described in Response 8 of Section 3.1, the Licensee provided detailed modifications for five walls. These modifications consist of:

- lateral bracing members attached to nearby concrete wall at one end and to the masonry structure at the other end
- horizontal support members spanning along the face of the masonry wall between existing columns or walls and attached to the masonry wall
- vertical columns anchored at top and bottom and attached along their height to the masonry wall
- knee braces attached to ceiling steel and the upper sections of masonry walls.

Appendix B of this report illustrates typical wall modifications for masonry walls at the FitzPatrick plant.

Using sample calculations, the Licensee verified that the modified walls satisfy the SGEB criteria. The Licensee's modification methods have been reviewed and are judged to be structurally adequate.

4. CONCLUSIONS

A detailed study was performed to provide a technical evaluation of the masonry walls at James A. FitzPatrick Nuclear Power Plant. Review 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, indicate that the Licensee's criteria are in compliance with the SGEB criteria except for minor deviations with respect to the increase factors for tension parallel to the bed joint for the loading combination including the SSE (1.67 as opposed to 1.5 by the SGEB criteria) and for the loading combination including the OBE (1.3 as opposed to 1.0 by the SGEB criteria). However, this exception applies to only two walls with increase factors that are 5% and 10% higher than the SGEB allowable for the SSE case (see Responses 5 and 5.1 for further details). As indicated in Responses 4 and 4.1, for the OBE case, the deviation of the increase factor for the worst possible case is only 10% higher than the SGEB criteria. The Licensee used conservative damping values in the analysis: 0.5% and 1% for the OBE and SSE cases, respectively, as opposed to 4% and 7% allowed by the SGEB criteria. It can be concluded that these deviations are minor and that, for all practical purposes, the Licensee's criteria are considered adequate and satisfy the SGEB criteria.

Section 3.2 indicated that 16 walls have been modified, that the Licensee's approach to wall modifications is judged to be satisfactory, and that the modified walls were verified through sample calculations to be structurally adequate and in compliance with the SGEB criteria.

5. REFERENCES

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

2. Stone & Webster Engineering Corp.
   Report on United States Nuclear Regulatory Commission IE Bulletin No. 80-11 (180 Day Response); Masonry Walls - James A. FitzPatrick Nuclear Power Plant, Lycoming, New York
   Power Authority of the State of New York, 03-Nov-80
   J.O. No. 12966.82

3. R. J. Pasternak
   Letter to B. H. Grier, NRC
   Subject: NRC IE Bulletin 80-11, Masonry Wall Design
   Power Authority of the State of New York, 02-Apr-81
   JAFP 81-0300

4. R. Baker for R. J. Pasternak
   Letter to B. H. Grier, NRC
   Subject: IE Bulletin 80-11, Masonry Wall Design; delay of completion of modifications at FitzPatrick Plant
   Power Authority of the State of New York, 29-Jun-81
   JAFP 81-0661

5. D. B. Vassallo, NRC
   Letter to J. B. Bayne, PASNY
   Subject: Request for Additional Information
   IE Bulletin No. 80-11, "Masonry Wall Design"
   April 26, 1982

6. J. P. Bayne, PASNY
   Letter to D. B. Vassallo, NRC
   Subject: IE Bulletin 80-11, Masonry Wall Design
   Power Authority of the State of New York, June 17, 1982
   JPN-81-51

7. J. P. Bayne, PASNY
   Letter to D. B. Vassallo, NRC
   Subject: IE Bulletin 80-11, Masonry Wall Design
   Power Authority of the State of New York, January 26, 1983
   JPN-83-06

8. D. B. Vassallo, NRC
   Letter to J. B. Bayne, PASNY
   Subject: Request for Additional Information
   IE Bulletin No. 80-11, "Masonry Wall Design"
   May 25, 1983

9. J. B. Bayne, PASNY
Letter to D. B. Vassallo, NRC
Subject: IE Bulletin 80-11, Masonry Wall Design
July 21, 1983, JPN-83-69

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

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

APPENDIX A

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

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

CONTENTS

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.

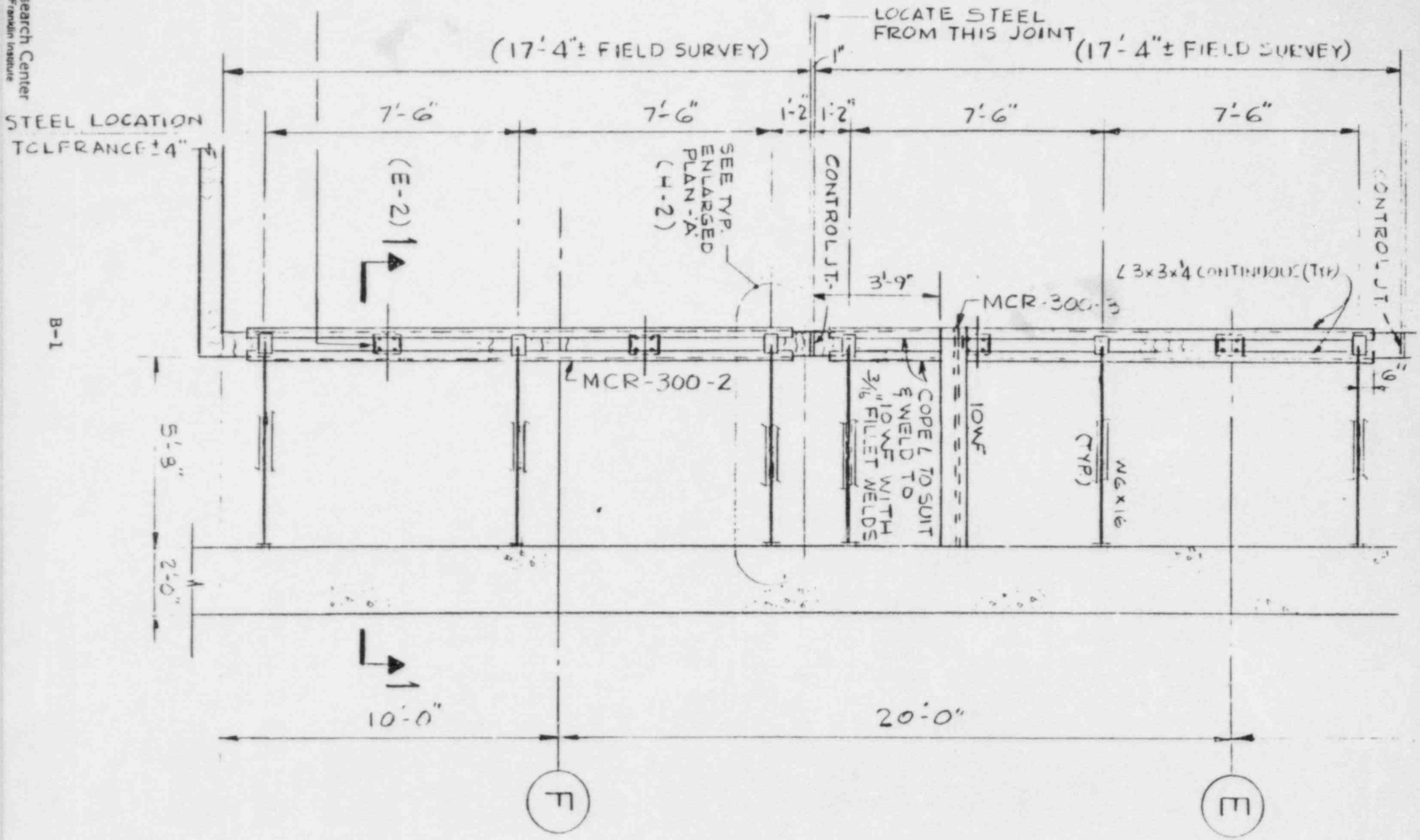
(d) Specification for the Design and Construction of Load-Bearing Concrete Masonry - NCMA August, 1979.

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

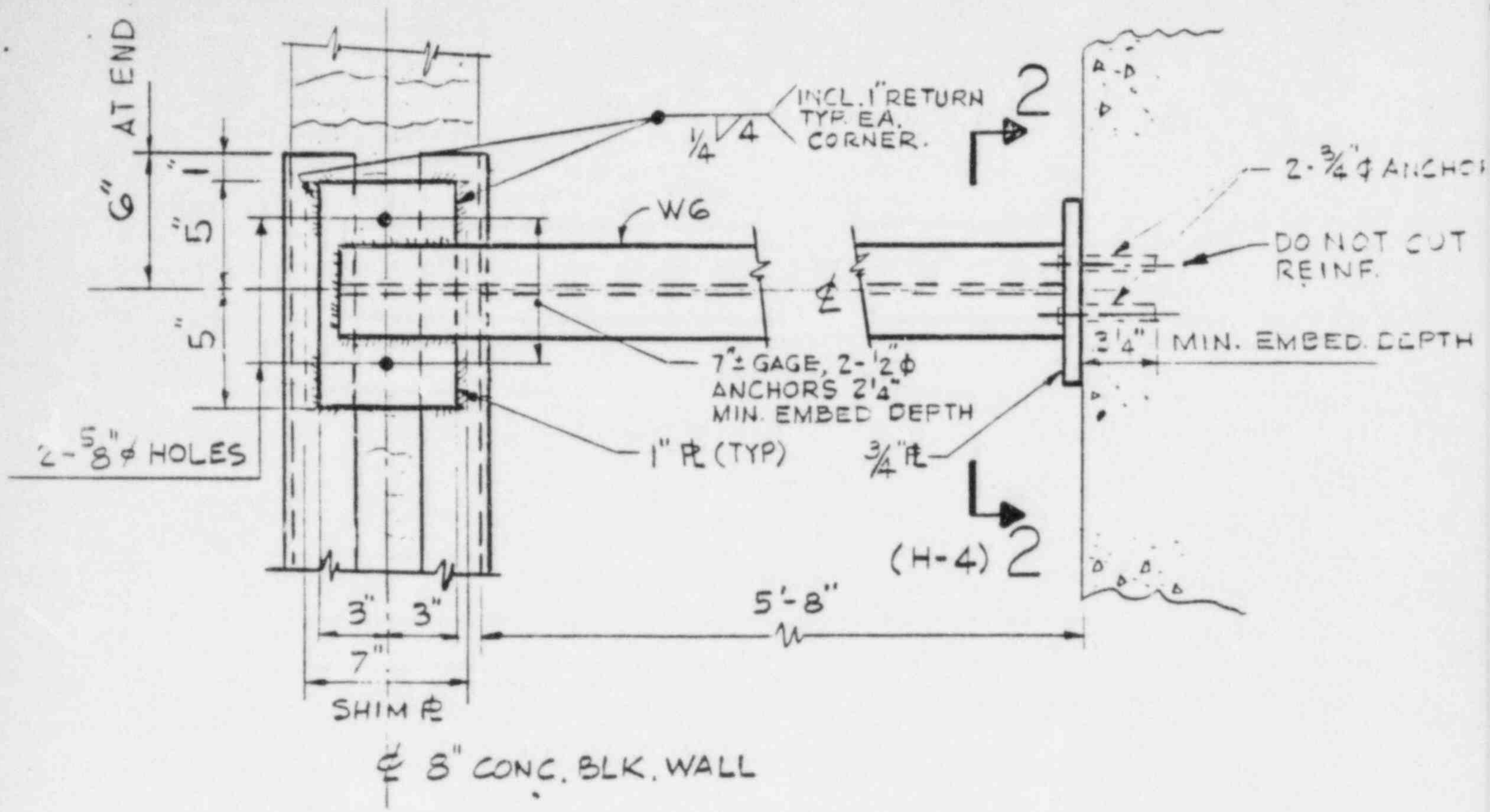
APPENDIX B

SKETCHES OF WALL MODIFICATIONS

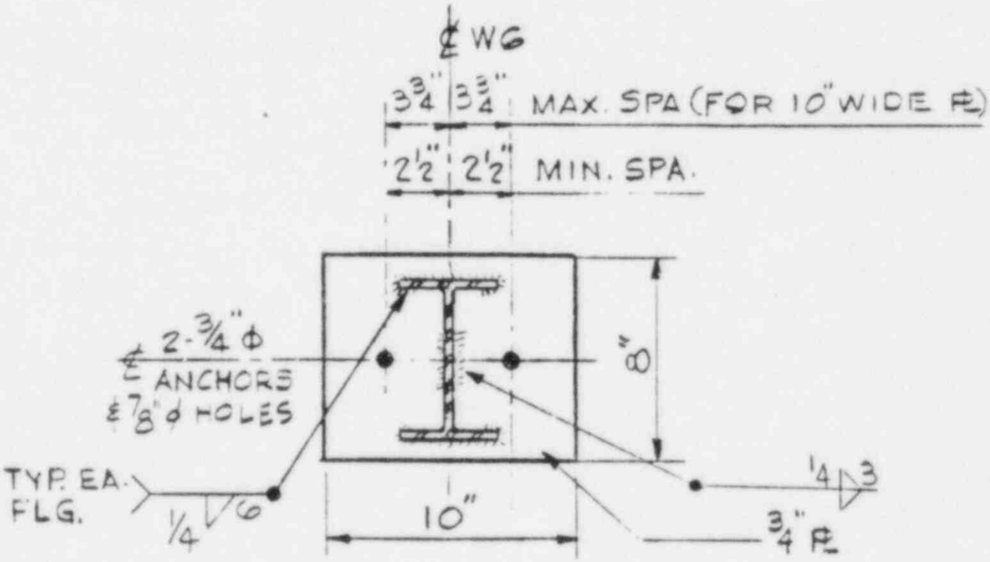
Franklin Research Center
A Division of The Franklin Institute
The Benjamin Franklin Parkway, Phila., Pa. 19103 (215) 448-1000



Lateral bracing members (WF, TS) attached to nearby concrete wall at one end and to the masonry structure at the other end.

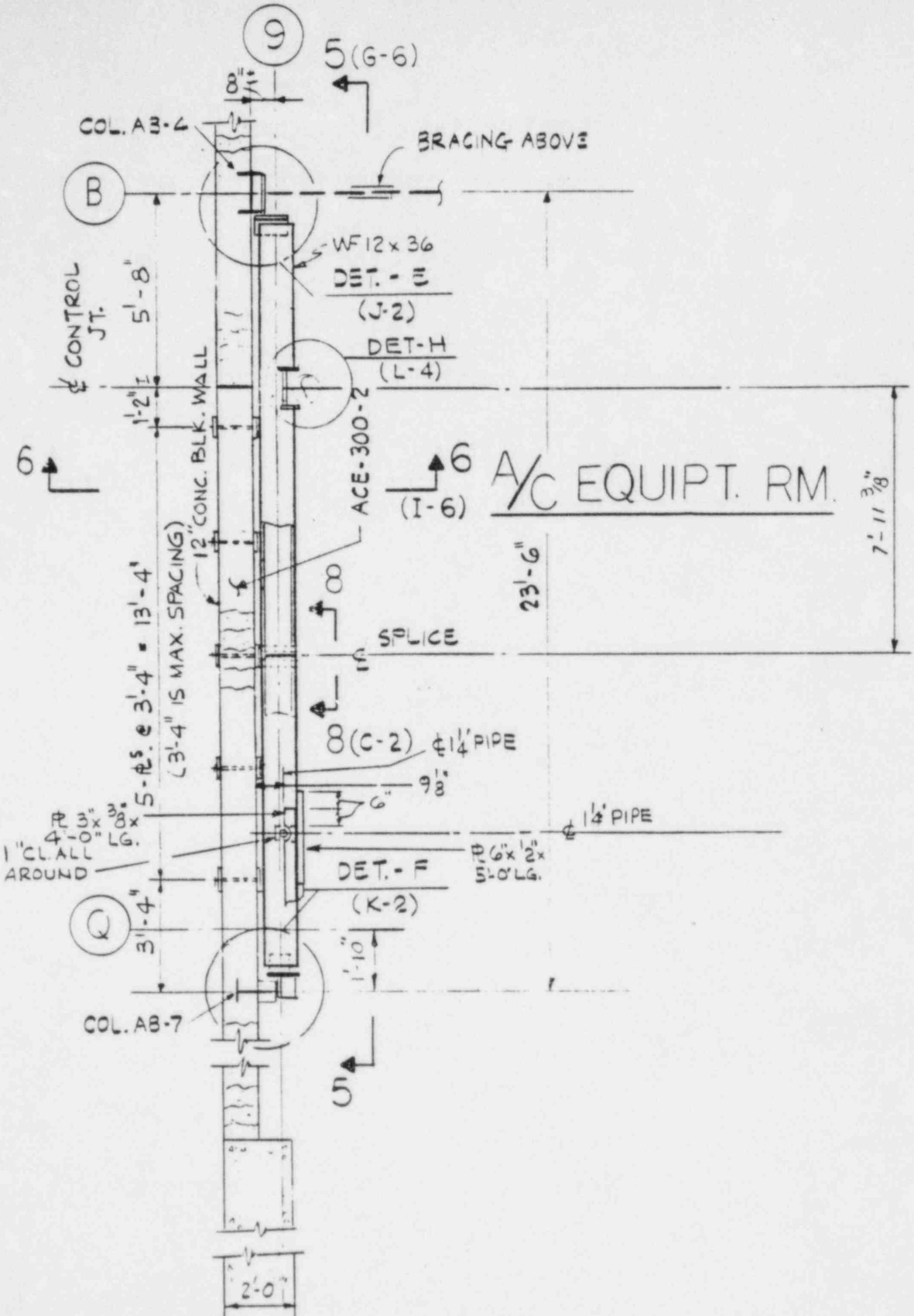


ENLARGED PLAN-'A' (D-7)

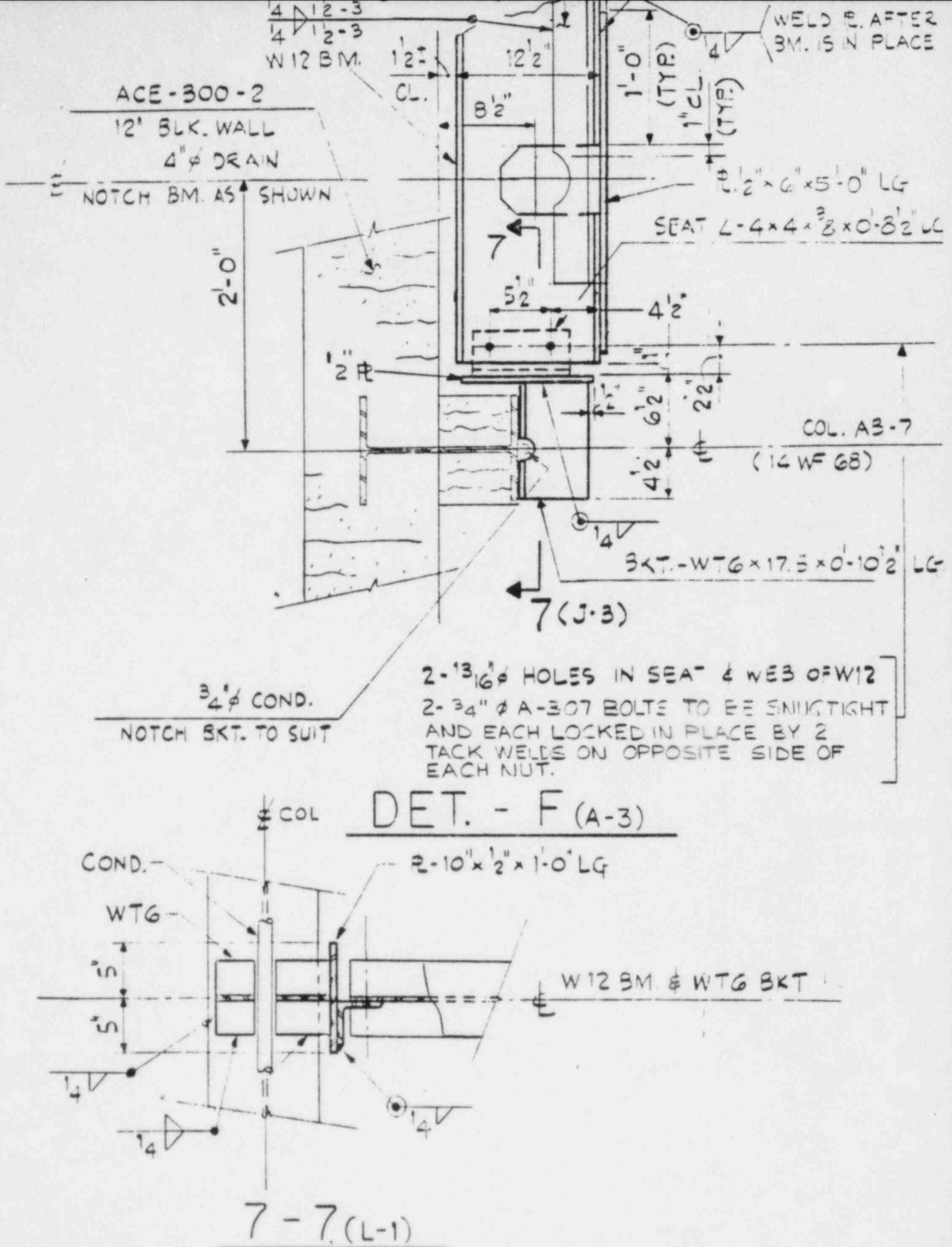


2 - 2 (H-2)

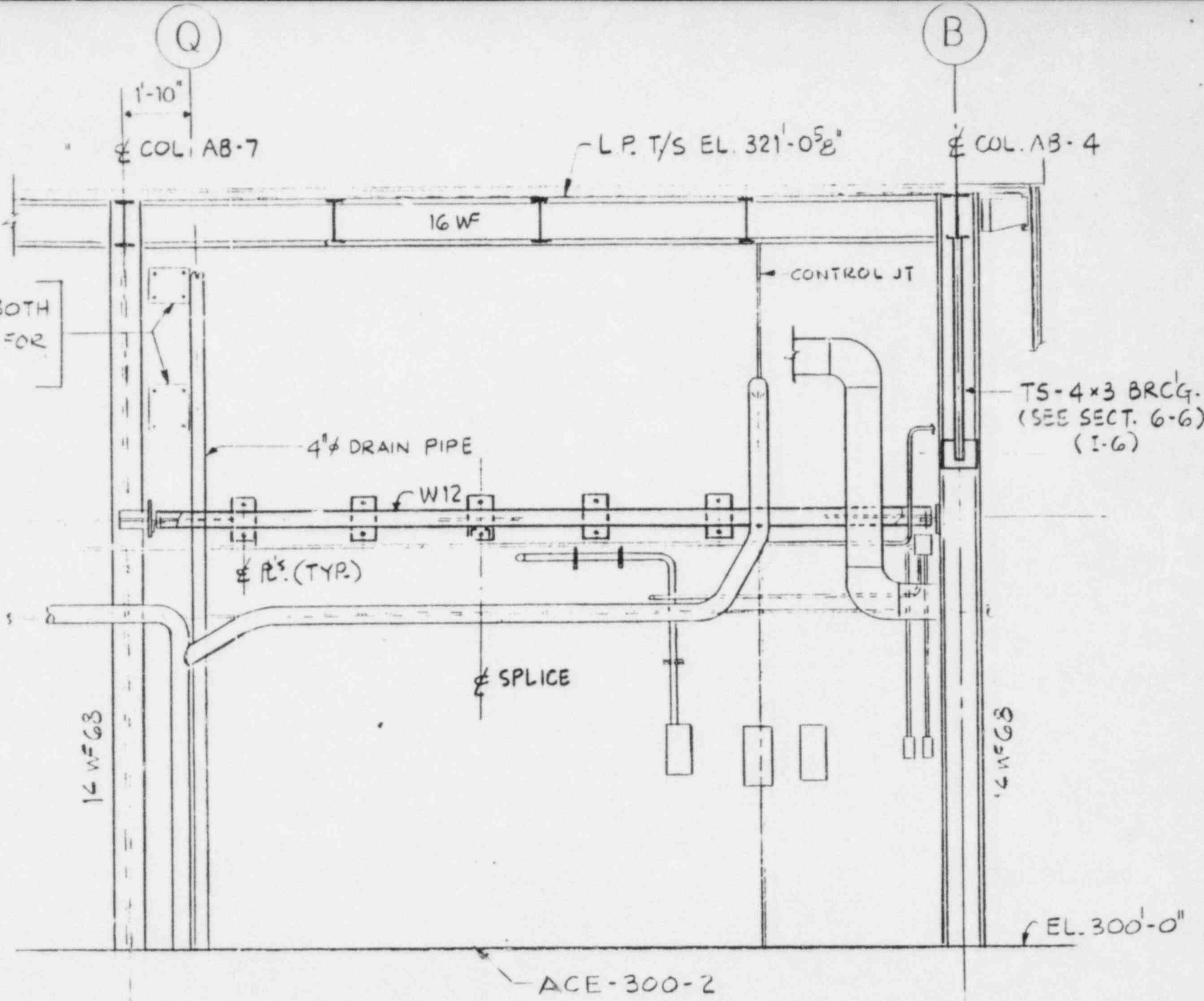
Lateral bracing members (WF, TS) attached to nearby concrete wall at one end and to the masonry structure at the other end.



Horizontal support members (WF) spanning along the face of the masonry wall between existing columns or walls and attached to the masonry wall.



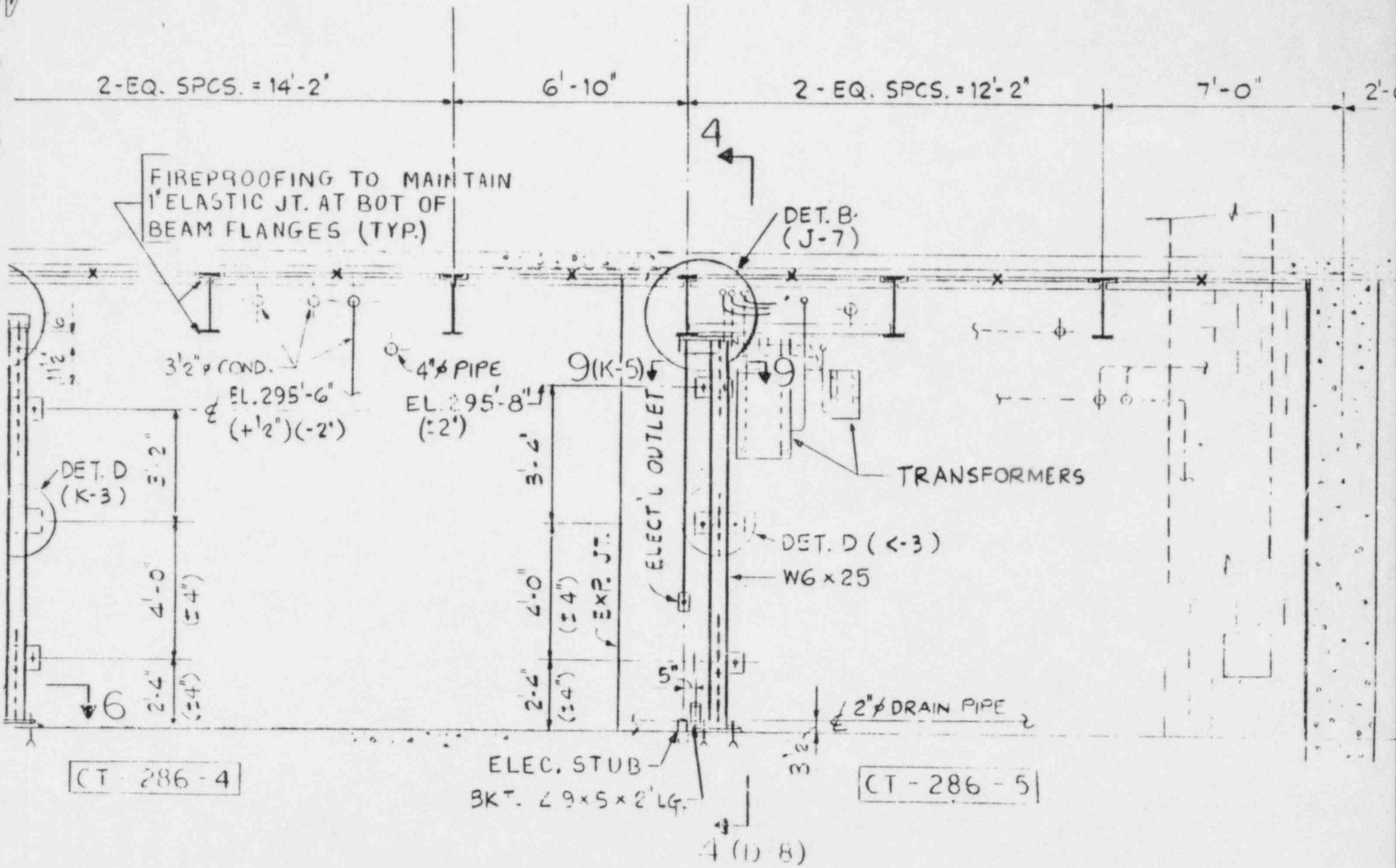
Horizontal support members (WF) spanning along the face of the masonry wall between existing columns or walls and attached to the masonry wall.



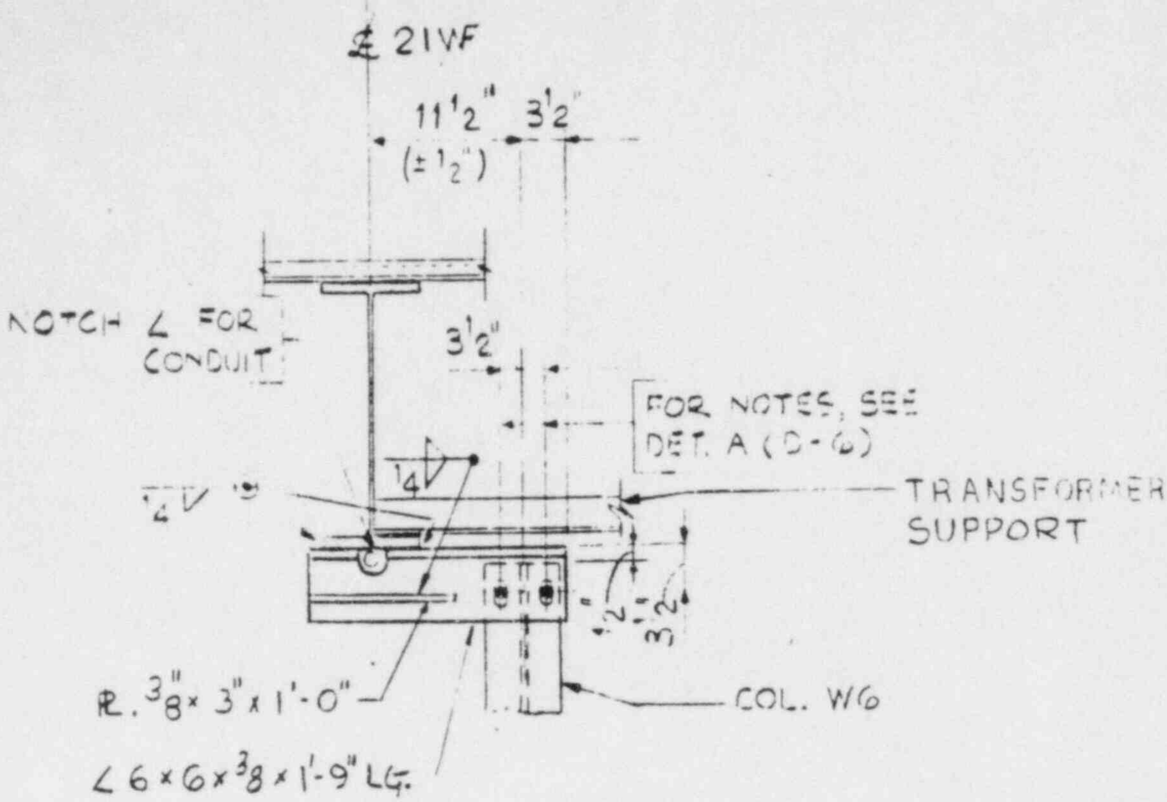
5 - 5 (A-1)

Horizontal support members (WF) spanning along the face of the masonry wall between existing columns or walls and attached to the masonry wall.

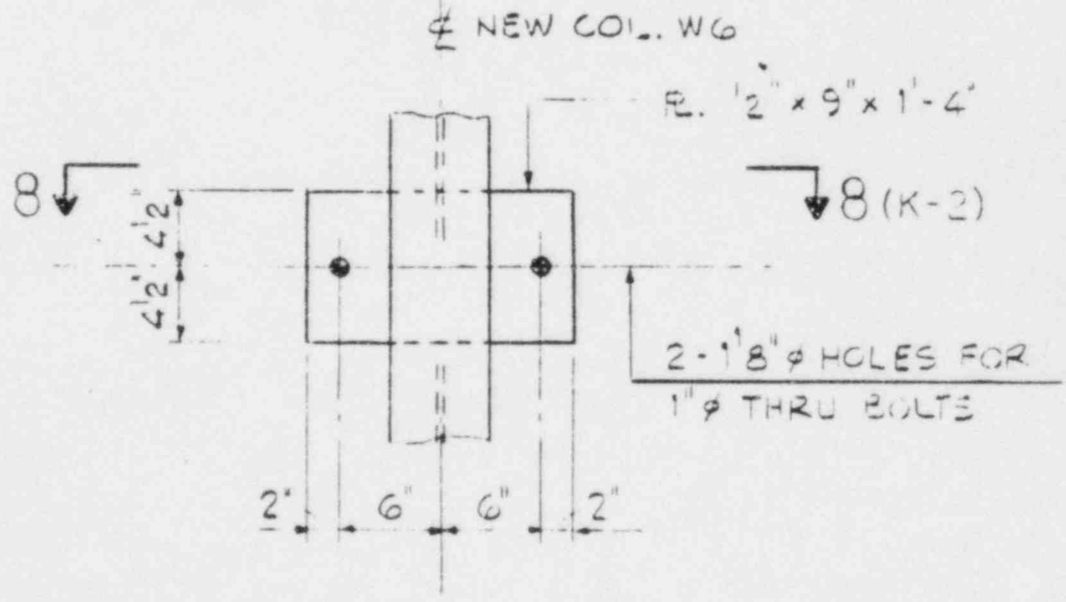
Franklin Research Center
A Division of The Franklin Institute



Vertical columns (WF) anchored at top and bottom and attached along their height to the masonry wall.

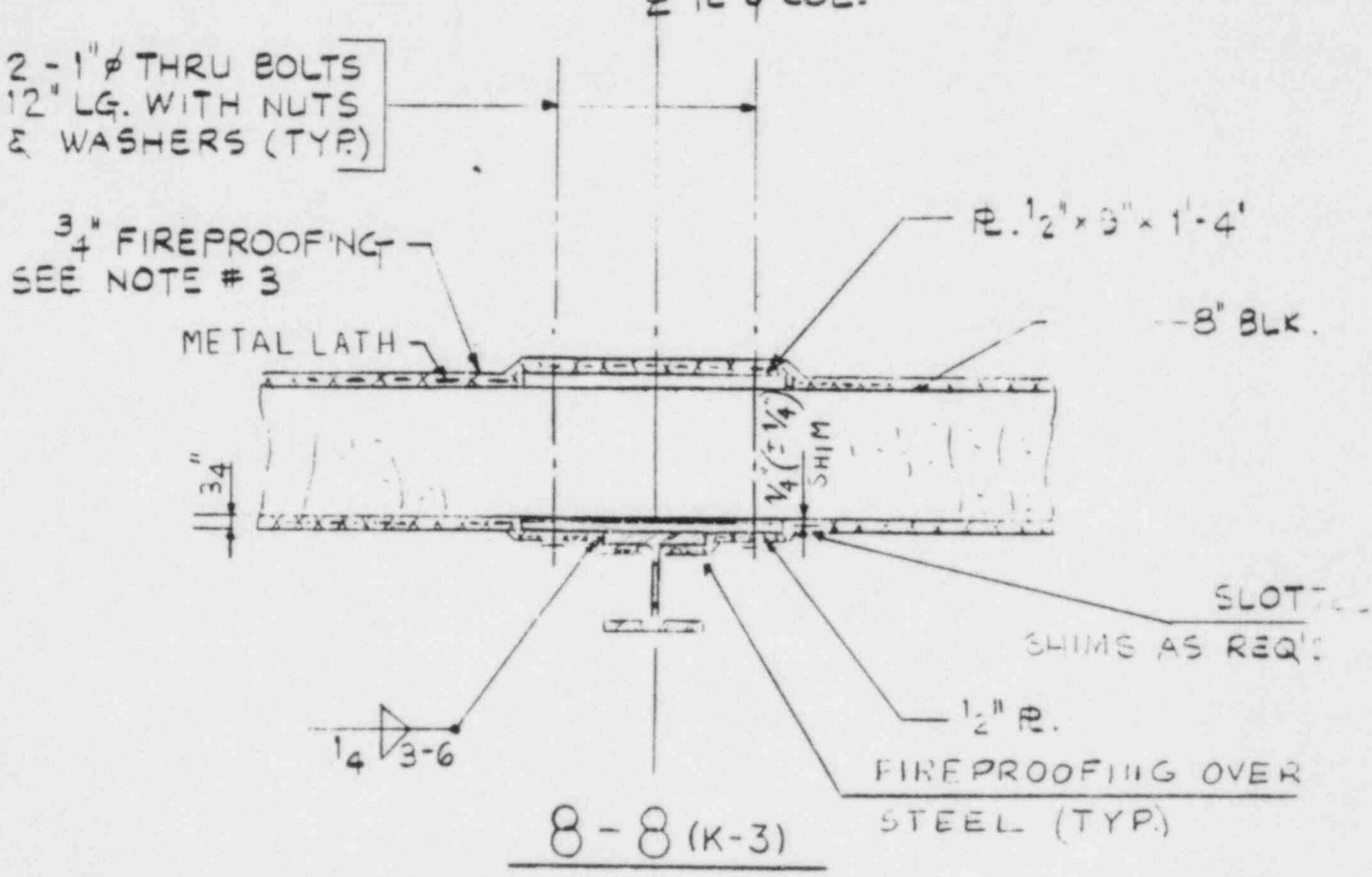


DET. B (G-4)



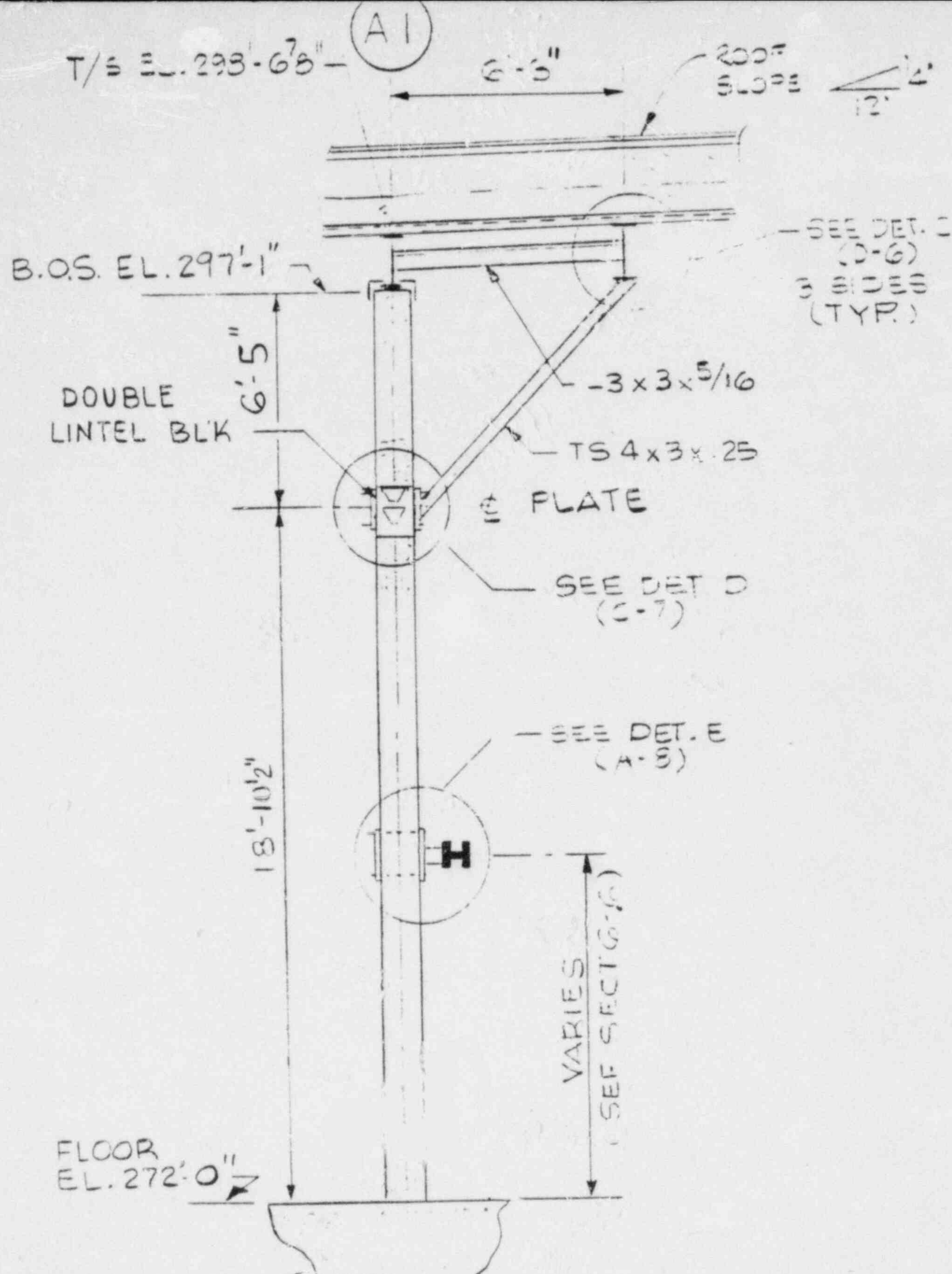
DET. D (E-4)(G-4)

Vertical columns (WF) anchored at top and bottom and attached along their height to the masonry wall.



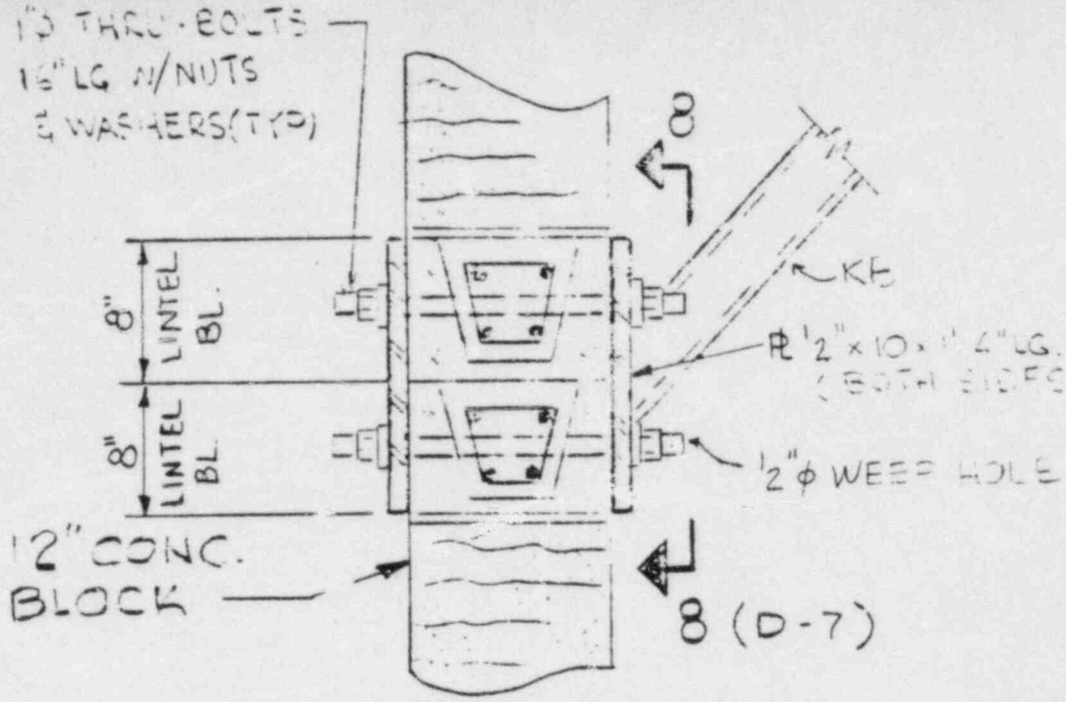
8 - 8 (K-3)

Vertical columns (WF) anchored at top and bottom and attached along their height to the masonry wall.

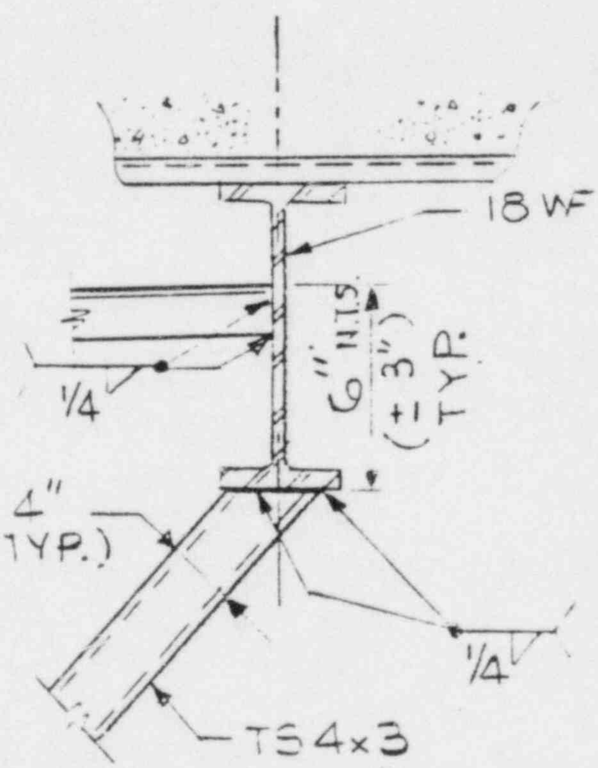


7-7 (D-4)

Knee braces (TS) attached to ceiling steel and the upper sections of masonry walls.



DET. - D (A-5)



(TYPICAL)

Knee braces (TS) attached to ceiling steel and the upper sections of masonry walls.