SONGS-1 APPROACH
TO
INELASTIC BEAMS

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The work described in this Report was performed in accordance with the Impell Quality Assurance Program. The signatures below verify the accuracy of this Report and its compliance with applicable quality assurance requirements.

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1.0 INTRODUCTION

During the criteria and methodology review of the Long Term Service (LTS) evaluation of Southern California Edison's (SCE) SONGS-1 plant, the NRC raised a licensing issue concerning the effect of inelastic supports on safety-related piping systems. This concern is a result of the SONGS-1 plant having structural steel members which support piping systems and which may exhibit inelastic behavior. A second NRC concern is the type of analysis methodology used to predict the piping systems' safety margins. The name of the analysis methodology used was the "secant stiffness" method.

The secant stiffness method is an approximate method used to analyze piping systems with supports on multiple inelastic beams. The NRC is concerned with the application, the theoretical basis, and the justification of the method.

SCE has addressed this issue through numerous presentations and reports to the NRC [References 1, 2, 3, 4, 5, 6, 7]. However, the NRC and it's consultants still have reservations which need to be addressed. Based upon the time constraints regarding the SONGS-1 plant start-up and the time remaining to resolve the NRC's concerns, SCE has decided to eliminate inelastic beams.

This report describes SCE's plan to address inelastic beams by:

a) reevaluating the beams to determine their elastic state of stress, and

b) modifying the beams to strengthen them.

If a beam is found not to be elastic, then the structural modifications will be performed.

Section 2.0 of this report provides a description of the inelastic beam issue and SCE's program for beam reevaluations, and Section 3.0 describes how the non-qualifying beams will be modified.

2.0 INELASTIC BEAMS

Under the SONGS-1 Return to Service (RTS) and LTS seismic programs, several steel beams, which support piping systems, were shown to be inelastic when evaluated by the force/resistance equation defined in Reference [8]. This equation is based upon the general equation of $F/R = \sqrt{2\mu - 1}$ proposed in [References 9, 10].

The number of inelastic beams under this program is 28, and they are located in five areas of the plant: the Reactor Building (RB), the North Turbine Extension (NE), the North Turbine Extension Mezzanine (NEM), the East Heater Platform (EHP) and the West Heater Platform (WHP). All the beams are identified in Table 1 according to their location in the plant through an area abbreviation in their alpha-numeric description. Figure 1 shows a plan view of these plant areas. A total of eleven safety-related piping systems are supported by either a single inelastic beam or multiple inelastic beams.

To illustrate the building location and piping system on each inelastic beam, a legend (Figure 2) and a partial plan have been developed for each area as follows:

Reactor Building:			Figures 3 and 4
Turbine Building:	•	North Extension	Figure 5
	•	North Mezzanine	Figure 6
	•	East Heater Platform	Figure 7
	•	West Heater Platform	Figure 8

For instance, in Figure 5 there are two piping systems identified on beam NE-B5.2, pipe line SI-51 as a □ and MS-01 as a ◇.

2.1 Inelastic Beam Reevaluations

Most of the 28 inelastic beams were reanalyzed by refined methods to accurately determine the maximum stress in each. The beams were reevaluated by LTS Project Instructions [Reference 11] and LTS criteria [Reference 12], excluding beam ductilities greater than one.

Some of the methods to be used in the beam reevaluations include:

a) using the LTS safety-related piping loads

b) utilizing as-built cross-sectional properties

c) use of "as-installed" support loading mechanisms (load paths) and,

d) use of actual beam end conditions (in lieu of assuming pin-pin ends), i.e., partial or full fixity.

The LTS Project Instructions [Reference 11] have been amended to include the step-by-step details on how to apply each analysis refinement.

2.2 "Secant Stiffness" Method

SCE will not use this method.

3.0 BEAM MODIFICATIONS

Beams which were not qualified to the elastic criteria described in Section 2.1 will be modified. Structural modifications were designed for all remaining inelastic beams. The beams were designed for ductilities less than or equal to one. All connections and new columns are designed per the AISC Specification, Part 1 with a stress allowable of 1.6S per Standard Review Plan requirements, Section 3.8.3, [Reference 13].

Typical examples of the types and locations of the structural steel modifications are shown in Figures 9 through 12.

4.0 CONCLUSIONS

This comprehensive program will resolve all 28 inelastic beams at SONGS-1 through the method of reanalyzing beams to demonstrate that they are elastic, or by structurally modifying the beams to be elastic.

Table 1 contains the status of the beams and girders under this program and the methods used to qualify them.

5.0 REFERENCES

1. Presentation to the NRC and Dr. W. F. Hall at Impell Corporation, Chicago, Ill., May 15, 1984.
2. Letter from D. Crutchfield, NRC, to K. Baskin, SCE, dated August 7, 1984, Docket No. 50-206, "Seismic Evaluations of Structural Elements," with Dr. W. J. Hall May 21, 1984 letter Report, Describing Various Issues and Request for Further Evaluations.
3. Letter Report, M. Medford (SCE) to J. Zwolinski, U.S. Nuclear Regulatory Commission, dated Oct. 25, 1984, Docket No. 50-206, SEP Topic III-6, San Onofre Nuclear Generating Station, Unit 1, and attached Report, "Evaluation of Piping and Structures."
4. Letter Report, M. Medford (SCE) to Z. Zwolinski, NRC, dated June 26, 1985, Docket No. 50-206, SEP Topic III-6, San Onofre Nuclear Generating Station, Unit 1, and attached report, "Summary Report on the Evaluation of Piping and Structures."
5. Letter, Dr. W. J. Hall to L. C. Shieh, LLNL, dated October 30, 1985.
6. Presentation to Dr. W. J. Hall/NRC by SCE/Impell Corporation, December 19, 1985, University of Illinois, Champaign, IL.
7. Presentation to NRC and Consultants by SCE/Impell Corporation, February 18-21, 1986, Impell Corporation, Walnut Creek, CA.
8. Bechtel Power Corp. Project Design Criteria, "Impact of Pipe Support Loads on Structures", Job No. 14000-430/470, Revision 1, dated November 10, 1984.
9. Blume, J. A., "A Reserve Energy Technique for the Earthquake Design and Rating of Structures in the Inelastic Range", Proceedings, Second World Conference on Earthquake Engineering, Tokyo, 1960, Vol. II.
10. Blume, J. A. Newmark, N. M. and Corning, L. "Design of Multi-Story Reinforced Concrete Buildings for Earthquake Motions", Portland Cement Association, Chicago, 1961.

11. "Structural Steel Member Evaluation," Impell Project Instruction No. 01, Job No. 0310-070-1355, Revision 3, Southern California Edison, March 31, 1986.

12. "Seismic Program for Long Term Service," San Onofre Nuclear Generating Station, Unit 1, Southern California Edison, Report No. 01-0310-1368, March 8, 1985.

13. U.S. Nuclear Regulatory Commission. "Standard Review Plan," Section 3.8.3, Rev. 1, July 1981, NUREG 0800.

TABLE 1

[illegible]ASTIC BEAMS

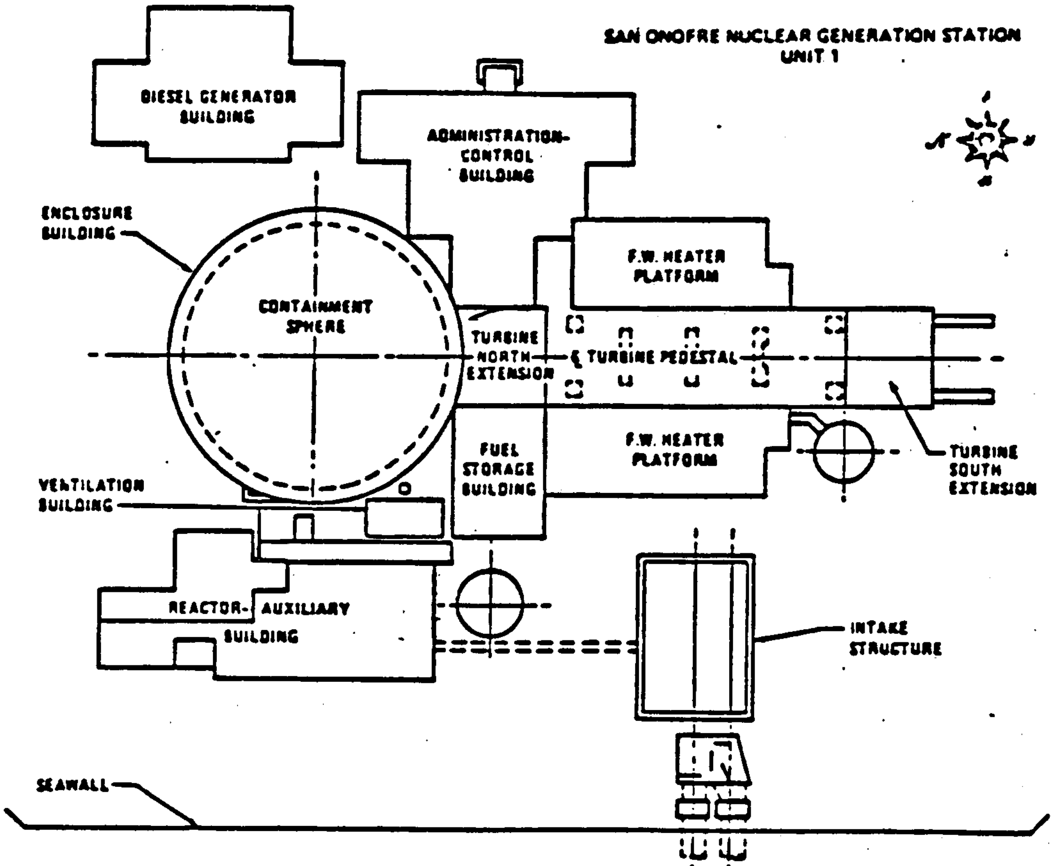
Location	Beam No.	Ductility(2)	Beam Qualification	Qualification Methods(1)	DCP # Modification	Remarks
Reactor Building						
1	RTS-B11	2.19	Elastic	Modified	3016.43 BC	
2	RTS-B18	1.50	Elastic	Modified	3016.43 BC	
T.B. North Extension						
3	NE-B4.3	1.80	Elastic	Modified	3016.44 BC	
4	NE-B4.4	2.72	Elastic	a,c,d	N/A	
5	NE-B4.7	2.21	Elastic	Modified	3016.44 BC	
6	NE-B4.8	2.15	Elastic	a,c	N/A	
7	NE-B5.2	1.30	Elastic	Modified	3016.44 BC	
T.B. North Extension Mezzanine						
8	NEM-B2.9	1.03	Elastic	Modified	3016.42 & .45 BC	
9	NEM-B4	1.36	Elastic	Modified	3016.42 & .45 BC	
10	NEM-B2.10	1.64	Elastic	Modified	3016.42 & .45 BC	
11	NEM-B2.11	1.83	Elastic	Modified	3016.42 & .45 BC	
12	NEM-B2.2	~3	Elastic	Modified	3016.42 & .45 BC	
13	NEM-B2.4	2.82	Elastic	Modified	3016.42 & .45 BC	
14	NEM-B2.5	2.47	Elastic	Modified	3016.42 & .45 BC	
15	NEM-B2.8	~3	Elastic	Modified	3016.42 & .45 BC	
16	NEM-B5	2.60	Elastic	Modified	3016.42 & .45 BC	
17	NEM-B6	1.29	Elastic	Modified	3016.42 & .45 BC	
T.B. East Heater Platform						
18	EHP-B5	1.32	Elastic	a,d	N/A	
19	EHP-B6.2	1.31	Elastic	a,b	N/A	
20	EHP-B7	1.33	Elastic	Modified	3016.46 BC	
22	EHP-B24	1.34	Elastic	a	N/A	
23	EHP-B2	1.91	N/A	N/A	N/A	Spring hangers only
24	EHP-B4	1.70	Elastic	Modified	3016.46 BC	
25	EHP-B22	1.61	Elastic	a	N/A	
26	EHP-B3	2.32	Elastic	Modified	3016.46 BC	
T.B. West Heater Platform						
26	WHP-B4.1	1.08	Elastic	a,b	N/A	
27	WHP-B23.1	1.09	Elastic	Modified	3016.43 BC	
28	WHP-B6	2.06	Elastic	Modified	3016.43 BC	

NOTES:

(1) Methods
- a) LTS Safety-Related Piping Loads
- b) As-built Cross-Sectional Properties
- c) End Conditions
- d) Weak Axis Load Paths

(2) Ducility values calculated prior to March, 1986 per RTS/LTS criteria.

GENERAL NOTE:
Beam inertial loadings are based on RTS spectra.
LTS-evaluated pipe loads are based on LTS spectra.
RTS-evaluated pipe loads are based on RTS spectra.



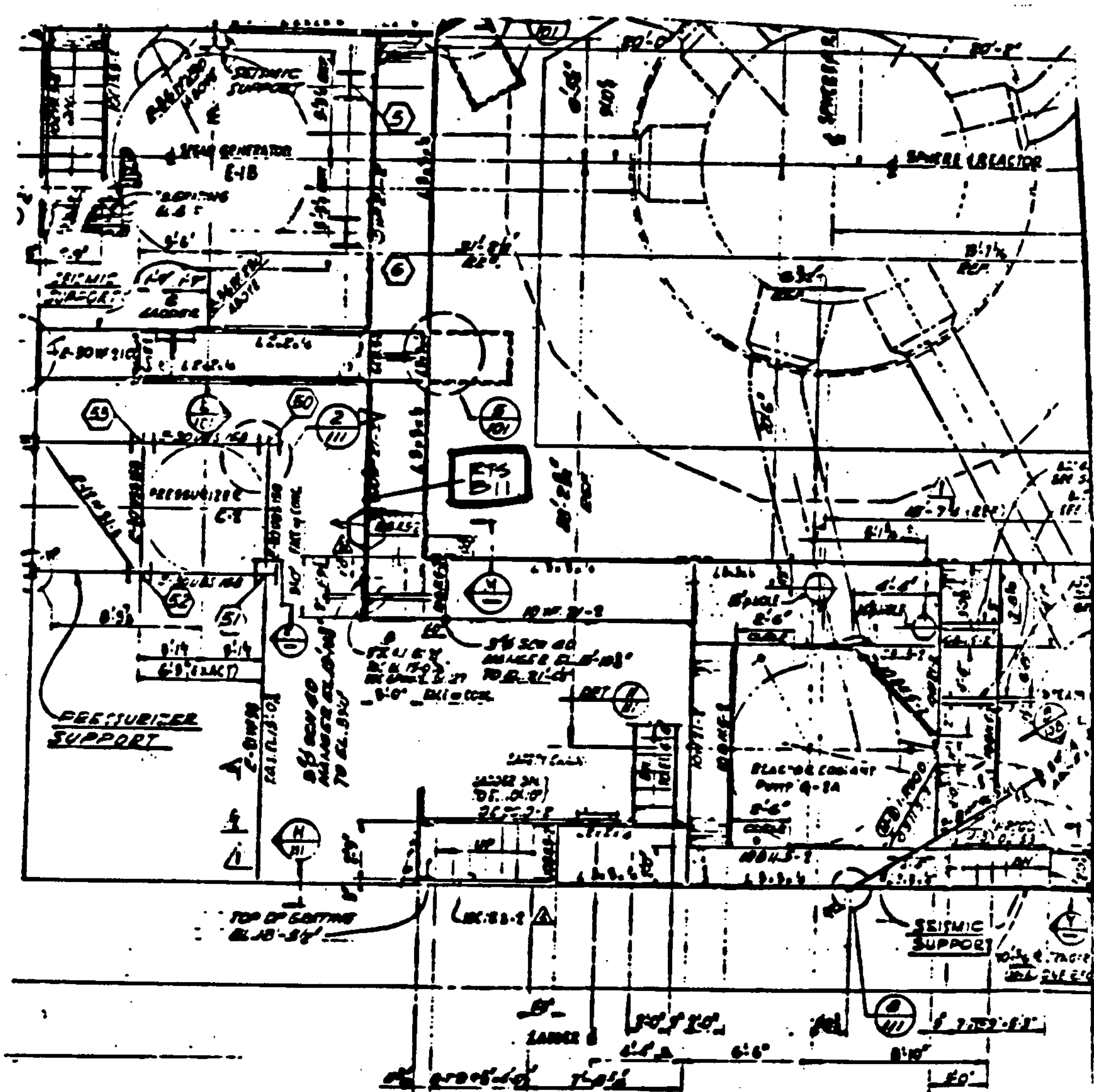
GENERAL SITE PLAN

Figure 1

No.	Symbol	Piping System
1	□	SI-51
2	◁	FW-04
3	○	SI-04
4	◇	MS-01
5	►	FW-06
6	■	MS-03
7	◀	SI-05
8	●	MS-02
9	▷	RC-103
10	⬡	RC-102
11	⬢	AC-108

LARGE BORE PIPING LEGEND

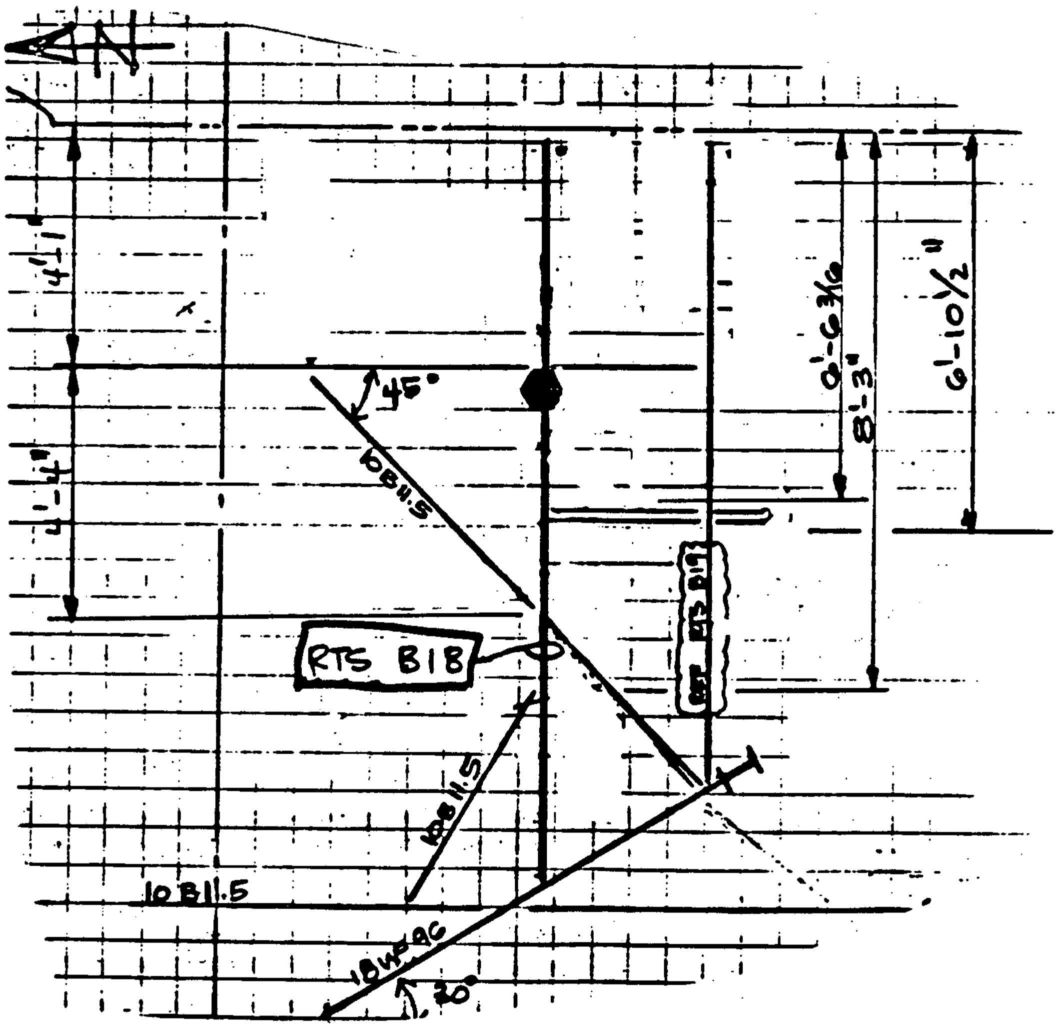
Figure 2



REACTOR BLDG. PARTIAL PLAN

Elev. 14'-0"

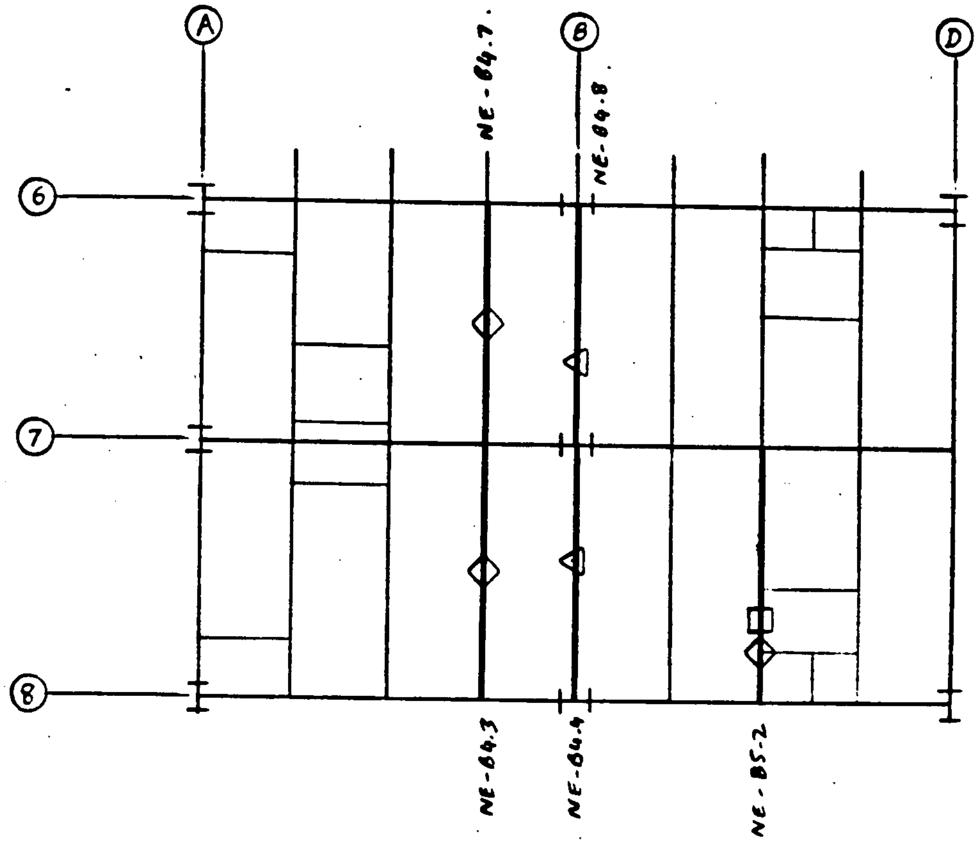
Figure 3



REACTOR BLDG. PARTIAL PLAN

Elev. 14'-0"

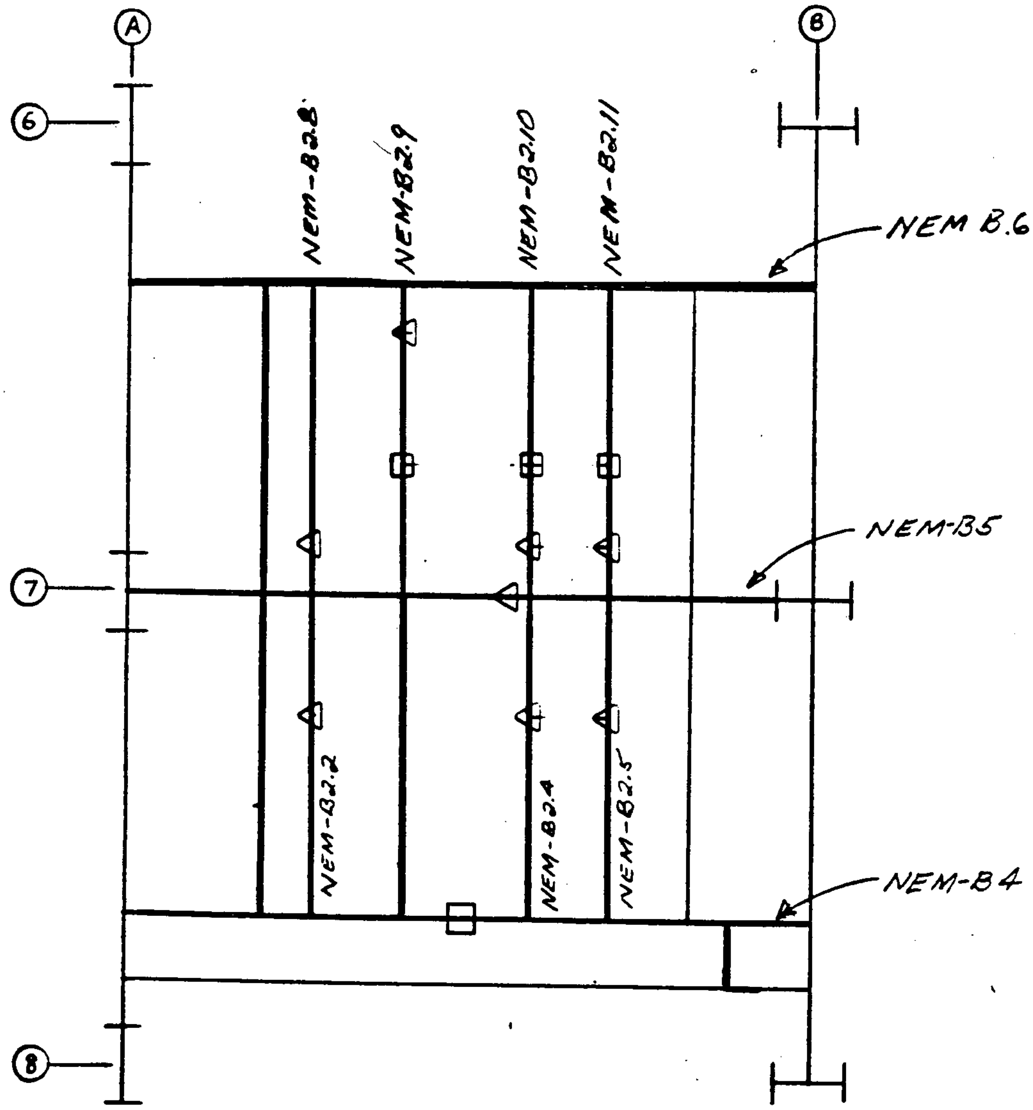
Figure 4



NORTH EXTENSION PLAN

Elev. 42'-0"

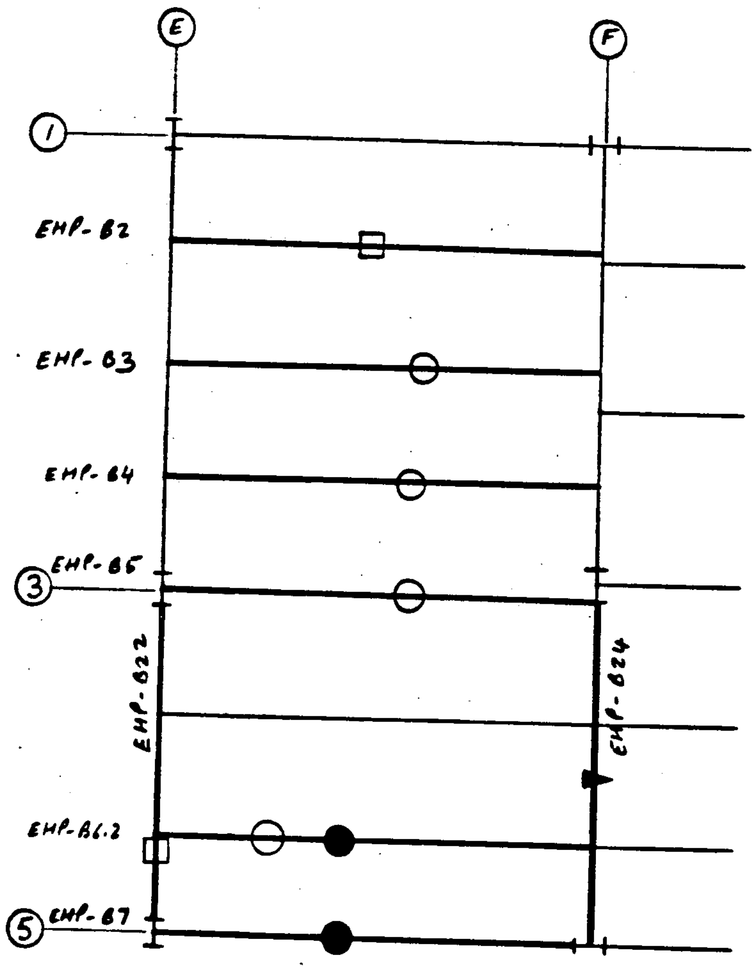
Figure 5



NORTH EXTENSION MEZZANINE PLAN

Elev. 30'-0"

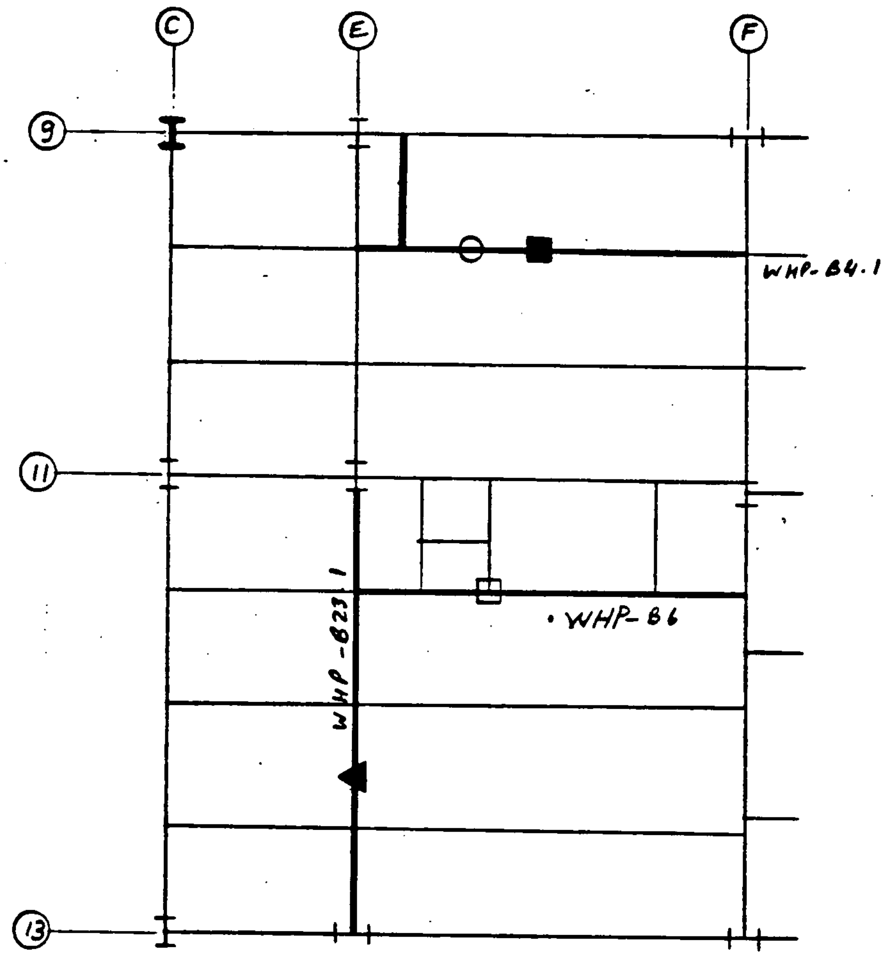
Figure 6



EAST HEATER PLATFORM PLAN

Elev. 35'-6"

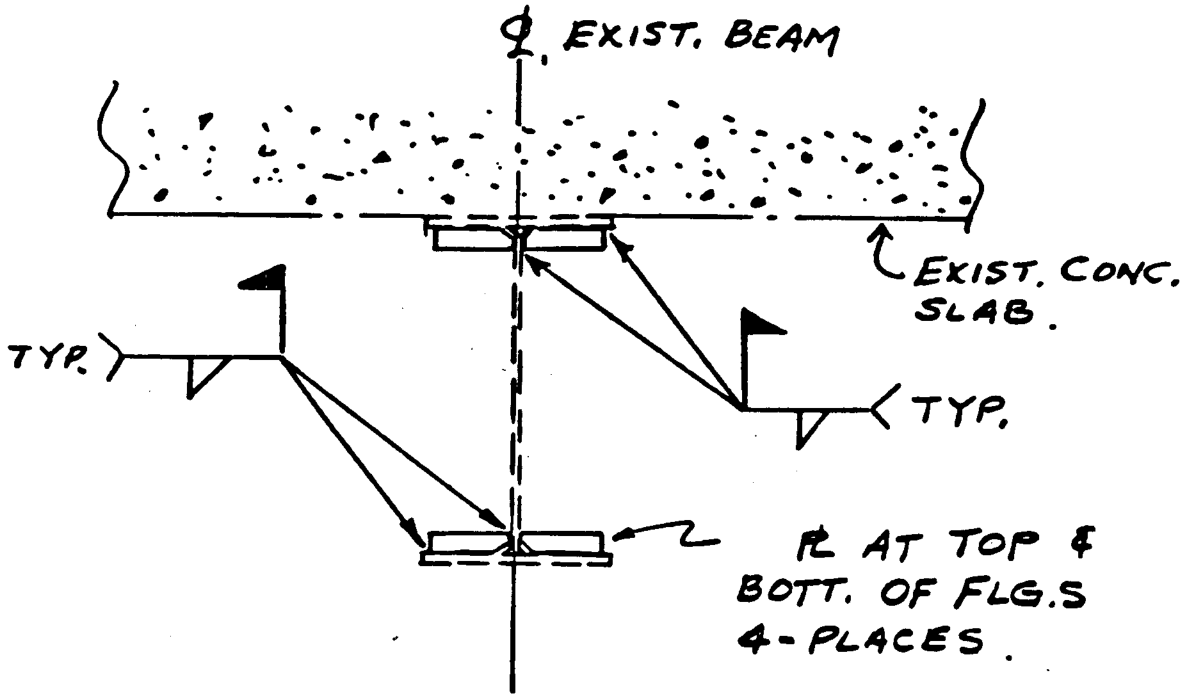
Figure 7



WEST HEATER PLATFORM PLAN

Elev. 35'-6"

Figure 8



TYP. MODIFICATION

OPTION No. 1

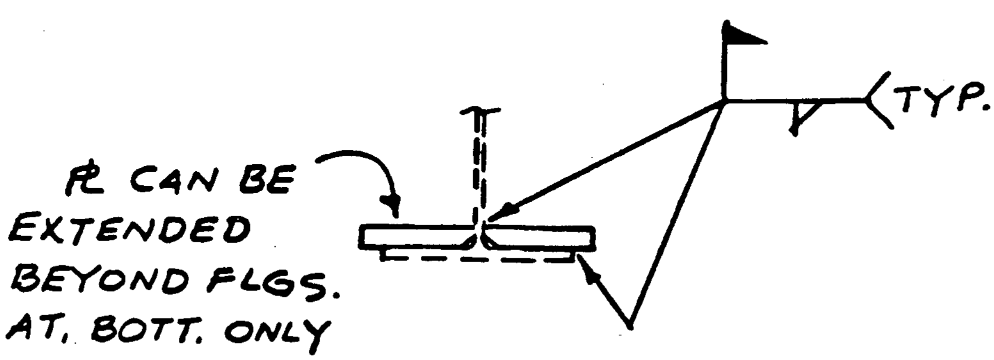
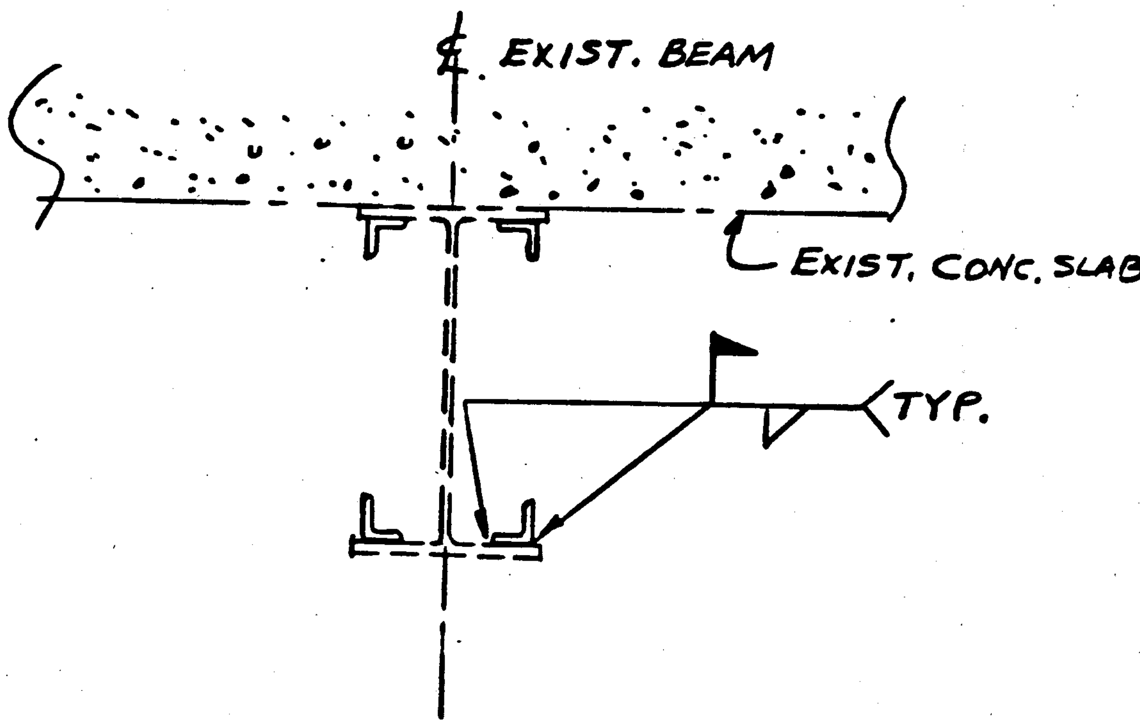


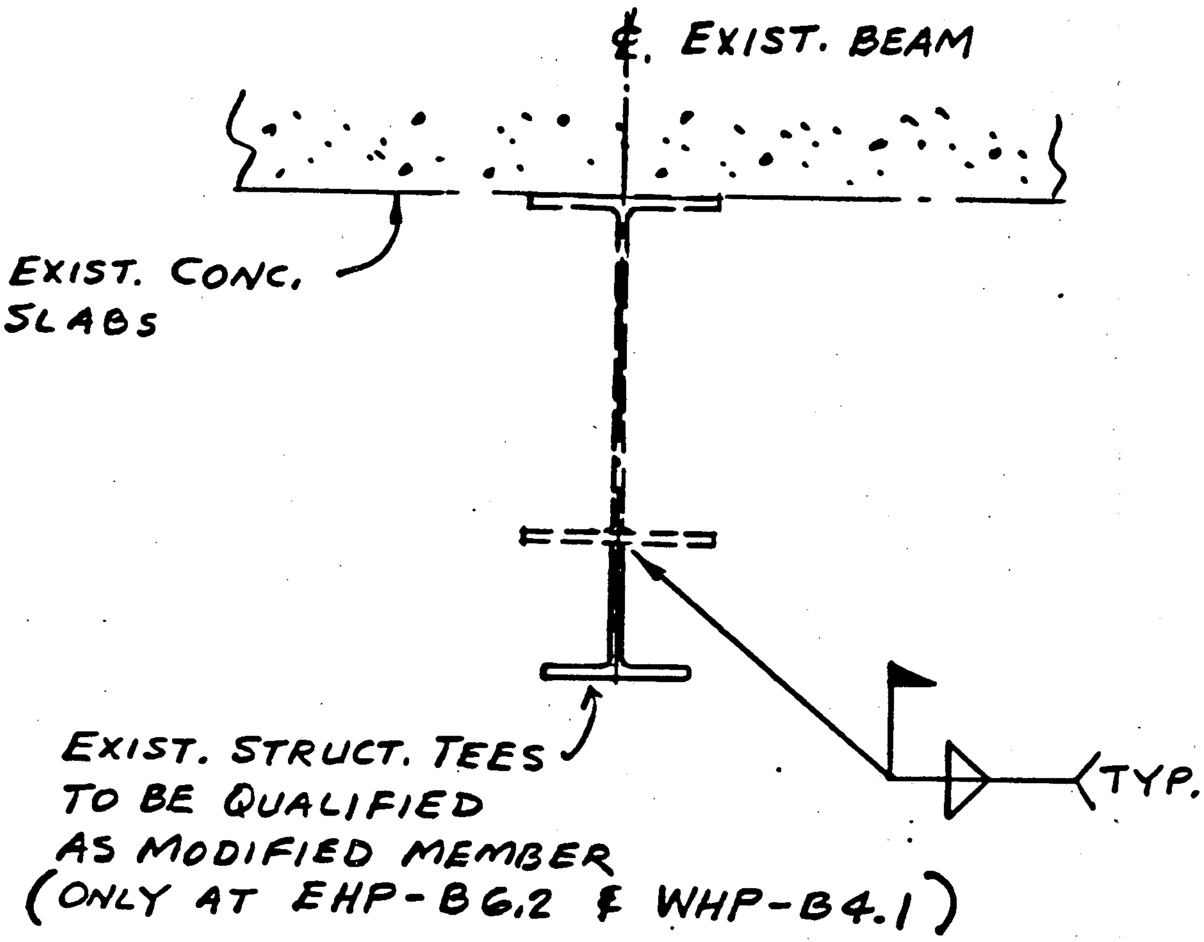
Figure 9



TYP. MODIFICATION

OPTION NO. 2

Figure 10



TYP. MODIFICATION

OPTION No 3

Figure 11

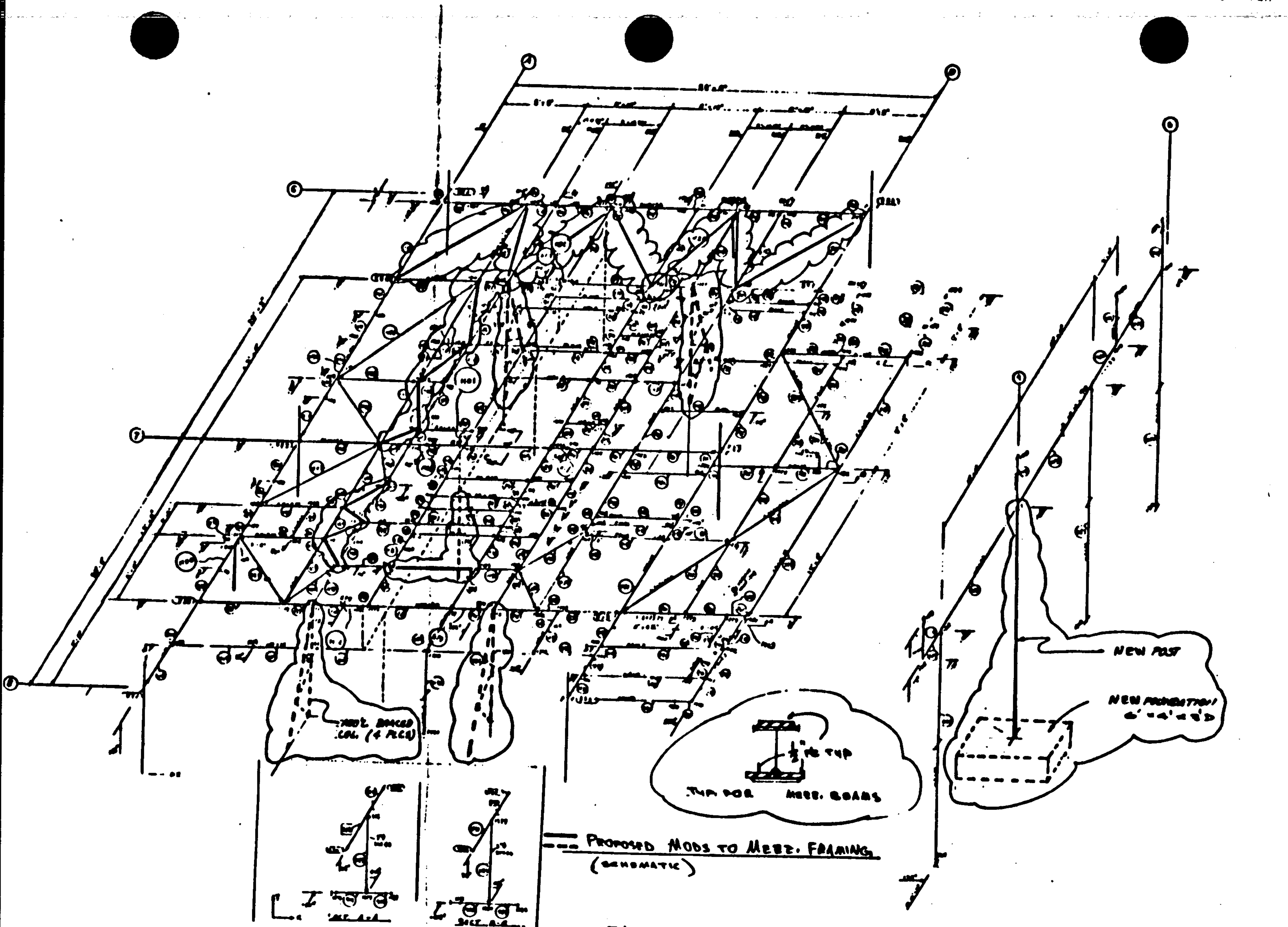

NEW POST
NEW FOUNDATION
TYP FOR MEZZ. BEAMS
PROPOSED MODS TO MEZZ. FRAMING
(SCHEMATIC)

Figure 12