ENCLOSURE 2

INSPECTION OF 480V ROOM AND VENTILATION EQUIPMENT BUILDING FOR EFFECTS FROM SOIL BACKFILL CONDITIONS AND EVALUATION OF SETTLEMENT MARKERS

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1.0 INTRODUCTION

The purpose of this report is to provide a summary of:

a) The investigation and evaluation of observed cracking of concrete slabs and masonry walls of the safety related structures founded partly on backfill materials. The location and pattern of observed cracking was used to confirm the areal extent of the backfill. Specifically, the 480V Switchgear Room and Ventilation Equipment Building were investigated.

b) The evaluation of the history of the elevations of the settlement markers located in and around major plant structures and equipment at the San Onofre Unit 1 site. Markers of particular interest were those on structures and equipment foundations constructed upon backfill with a relative compaction of less than 95%.

This report is not intended to determine the adequacy of the structures and equipment, but rather to show the correlation that exists between field investigations and postulated fill conditions as presented in references 1, 2 and 3.

This report is comprised of four sections including this introduction. Secton 2 presents a summary of the investigation and evaluation of the observed slab cracking of the 480 V Switchgear Room and the Ventilation Equipment Building. Section 3 presents the review of settlement marker surveys and an evaluation of their results. A list of references is provided in Section 4.

2.0 CONCRETE SLABS/MASONRY WALL CRACKING SURVEY RESULTS

Portions of the 480V Switchgear Room and Ventilation Equipment Building slabs are founded upon fill soil as described in Sections 4 and 5 and Addendum 1 of Reference 3. Field inspections were conducted to examine any evidence of wall and slab cracking in both structures. The observed cracks were then plotted and were evaluated in terms of their relationships to postulated fill conditions. The following sections describe the evaluations and present the conclusions of these evaluations in terms of the previously assumed conditions.

2.1 480V Switchgear Room

A thorough investigation of the 480V room revealed no apparent cracks in the masonry walls. Investigation of the slab revealed several cracks. However, none of the cracks showed any signs of separation. The observed crack pattern and the equipment supported by the slab are shown in Figure 2.1. It should be noted that crack widths were measured from the slab surface and are conservative figures since spalling of the surface concrete at the crack is included.

The observed cracks in the 480 V room floor slab are generally in the southern portion of the room. The absence of cracks on the top surface in the northern 10 feet width indicates the slab is under positive bending (concave upward). The cracking visible in the southern portion indicates that negative moment (convex upward) must exist in this part of the slab.

If a slight amount of settlement were to occur in the northern 10 feet of the slab (the portion over backfill) due to slab self weight and the equipment weights, bending of the slab could occur as shown in Figure 2-2a. The cracking could then be hypothesized to be the result of tension in the top fiber of the slab caused by negative moment. A similar distribution of moments about a north-south axis is shown in Figure 2-2b. The negative moment causing bending about a north-south axis will generally result in cracks with north-south propagation. Cracks deviating from direct north-south or east-west directions can be found to follow the path of maximum resultant moments from orthogonal directions. Cracks adjacent to the switchgear, which are mounted on 4 inch concrete slabs atop the 6 inch building slab, could be caused by localized stress concentrations.

It is therefore concluded that the slab is supported on backfill at the northern portion and on native soil on the southern portion. Since there is general agreement between the observed crack locations and the expected pattern of cracking, the areal extent of the fill as shown in Figure 5-1 of Reference 3 is concluded to be reasonably accurate.

2.2 Ventilation Equipment Building

A thorough investigation of the Ventilation Equipment Building revealed no apparent cracks in the masonry walls. Investigation of the slab disclosed several fine cracks in the eastern portion, as shown in Figure 2-3. The western portion of the slab was not easily accessible due to the equipment in the area. Therefore, a detailed examination could not be done. However, since the depth of backfill is only 4 feet along the west wall, no cracking of any significance is expected in that area. It should be noted that crack widths were measured from the slab surface and are conservative figures since spalling of the surface concrete at the crack is included. Since the walls act as deep beams, no cracks will be apparent for small deflections.

The observed cracks in the Ventilation Equipment Building slab are primarily located above the postulated fill envelope as shown in Figure 2-3. The greatest depth of backfill is found below the south wall. Due to the configuration of the fill envelope the primary settlement would be expected to occur in the south eastern portion of the building, specifically the south east corner. Locations of the cracks generally support the premise that slight settlements have occurred in the south eastern section of the building. Crack #2 shown in Figure 2-3 occurs at the interface of the door sill and the wall. Cracks occurring at such discontinuities are common.

It is therefore concluded that the slab is supported on backfill at the southeastern portion of the building. Since there is general agreement between the observed crack locations and the expected pattern of cracking, the areal extent of the fill as shown in Figure 4-1 of Reference 3 is concluded to be reasonably accurate.

3.0 EVALUATION OF SETTLEMENT MARKER SURVEYS

3.1 Introduction

The purpose of this evaluation was to review the history of static settlements of the major plant structures at San Onofre Unit 1 in order to further assess the impact of backfill on the safety related structures and equipment. Facilities constructed upon San Mateo fill with relative compaction less than 95% were of particular interest.

This report also provides up-to-date settlement data pertaining to the safety related structures and equipment which supplement the previous records through 1970. This survey was performed in December 1982.

3.2 SETTLEMENT SURVEY REVIEW AND EVALUATION

Settlement markers were placed on major plant structures during the initial plant construction. Their displacements were monitored by a series of settlement surveys. All major structures at San Onofre Unit 1, are bearing on native San Mateo sand formation with the exception of those facilities as described in Reference 1. The areas where backfill material exists are shown on Figures 2-22, 4-1 and 5-1 of Reference 3.

Settlement surveys were conducted during construction of the original Unit 1 structures between December 1964 and September 1966. Follow-up surveys were conducted in May 1970 and December 1982. Settlement survey records are shown on SCE drawings 567856 and 5102275. The drawings indicate the location of settlement markers, and the requirements for making settlement observations. Marker locations were superimposed upon the soil backfill characterization to outline areas of particular interest. These are shown in Figure 3-1.

The amount of settlement at each marker location for all the surveys is tabulated in Table 3-1. If the marker elevation surveyed is higher than its original record elevation, this is indicated by (+) in the table. An examination of settlement data from 1964 through 1966 indicates a gradual trend of settlements of very small magnitudes.

All the settlement markers surveyed in 1970 indicate that they have risen from their original elevation. The settlement record table for the December 1982 survey indicates a similar condition of the marker elevations rising. These readings are contrary to the field observations at the San Onofre Unit 1 site. Numerous walkdowns have been conducted by engineers to review equipment foundations and structures in the past 3 years during the implementation of the seismic upgrade program. There has been no observation of either soil heaving up or pavement slabs cracking and heaving up. Similarly it is inconceivable that a massive structure like the Turbine/Generator Pedestal that had shown a reasonable trend of settlement from initial construction to 1966, would reverse that trend and start rising.

The discontinuity between the 1964 through 1966 settlement trend and the 1970, 1982 survey readings indicates that the benchmark references of the initial surveys are different from the 1970 or 1982 surveys. An extensive search of the available documents was made to locate past survey notes to determine how the jobsite benchmarks were established. The exact vertical control reference for San Onofre Unit 1 could not be determined. However, it appears to be based on a Coast and Geodetic Survey (CGS) or U.S.G.S. benchmark. Since no field survey notes could be located for the initial plant survey or subsequent settlement surveys prior to December 1982, it is impossible to determine their specific reference benchmarks.

An attempt was made to normalize the survey data to the initial plant survey reference frame. Assuming that the initial vertical control was based on a C.G.S. benchmark, it was decided that a C.G.S. benchmark be sought and traversed into San Onofre Unit 1 to verify the actual elevation of the San Onofre Unit 1 reference. Coast and Geodetic Survey marker A131 whose elevation was established as 121.621 MSL (124.182 MLLW) in 1978, was used for this study.

Special precautions were taken with the survey instruments to assure the accuracy of the elevations being traversed from the C.G.S. datum. The instrument's calibration was checked prior to the start of the work. It was decided to verify the elevation of the benchmark used in the December 1982 survey. The instruments used for the survey were a Model N12 Zeiss level and a Philadelphia rod with rod bubble. All elevations were the result of the "three wire process," and distances between observed points did not exceed 190 feet. Results of the survey established the San Onofre Unit 1 reference (brass cap on the turning tower footing near column K1) as elevation 20.247 MLLW. The monument is stamped as elevation 20.314 MLLW. Assuming that the reference used for the initial elevations was based on a C.G.S. benchmark, a probable error of -.067 feet is introduced with the 1982 data. An adjustment of -.067 feet of the 1982 data indicates that all markers have settled relative to their initial elevations. Since the records of surveys between 1964 and 1966 are not available, it is not possible to verify if the benchmarks used for those surveys were tied with the C.G.S. benchmark system. Therefore, consistency in the settlement readings taken prior to 1966 and the recent 1982 survey can not be established. Another source of error in this adjustment may arise from the calibration frequency of the C.G.S. benchmarks. Coast and Geodetic benchmarks in the area were adjusted in 1978 and prior to this in 1955, therefore, neither the initial plant survey (1963) or the 1982 adjustment survey were based on a recently calibrated benchmark.

It is therefore concluded that the amount of settlement shown as the 1982 adjusted data may not be the absolute amount of settlement at the marker locations but is the settlement value calculated based on the C.G.S. datum benchmark A131. Because of this, the settlements of the structures and equipment foundations relative to one another cannot be accurately assessed.

An attempt was made to study the settlements recorded for the Refueling Water Storage Tank (RWST) and the Condensate Water Storage Tank (CWST) to determine the relationship of these settlements with the existing backfill. This is discussed further.

3.2.1 Refueling Water Storage Tank

As indicated in Figure 3-1 the northwestern half of the Refueling Water Storage Tank (RWST) is founded upon Category B fill soil. The remainder of the RWST is founded upon undisturbed San Mateo sand. The observed displacements of markers 35, 36, 37, and 38 are shown in Table 3-1. The RWST was surveyed in February 1966 and in 1982. The tank capacity is 250,000 gallons and was filled to the 100,000 gallon level during the 1982 survey. Both surveys indicate the resultant settlement is inclined towards the east. This observed settlement is contrary to that which would be expected from the existing fill conditions. With the existing fill condition the tank foundation would be expected to incline downward towards the northwest.

Considering the weight of the structure, the magnitude of the observed displacements are reasonable. However, the resultant inclined displacement cannot be directly related to the fill material. The settlements have had no effect upon the operation of the RWST and are therefore considered acceptable.

3.2.2 Condensate Water Storage Tank

As indicated in Figure 3-1 the northern two-thirds of the Condensate Water Storage Tank (CWST) is founded upon Category B fill soil. The remainder of the CWST is founded on undisturbed San Mateo sand. This tank has no foundation and resides directly on a 6 inch thick layer of coarse gravel which extends two feet beyond the boundary of the tank shell. The displacements of markers 45, 46, 47 and 48 are shown in Table 3-1. The tank has a history of resultant settlement primarily towards the northeast. The 1982 data indicates a maximum settlement of 1.94 inches at marker 45, and a relative movement of .876 inches between markers 45 and 47. In this case, the historical settlement behavior appears to be consistent with the backfill conditions.

This settlement has had no effect upon the operation of the CWST. Additionally, a new auxiliary feedwater tank is under construction and will be in service prior to startup, thus making the existing condensate water storage tank a non-safety related component.

3.3 Conclusion

Evaluation of the historical data has shown that, probably due to different benchmark datums, the settlements of the structures relative to past measurements cannot be accurately assessed. This is demonstrated by the analysis of the two tanks. Therefore, the settlement measurements can not be consistently correlated with postulated fill conditions.

4.0 REFERENCES

1. "Soil Backfill Conditions - San Onofre Nuclear Generating Station, Unit 1", submitted under cover letter from K. P. Baskin, Southern California Edison to D. M. Crutchfield, NRC, dated August 17, 1982, Subject: "In-situ Soil Conditions SEP Topic III-6, Seismic Design Considerations San Onofre Nuclear Generating Station, Unit 1."

2. "Soil Backfill Conditions - San Onofre Nuclear Generating Station, Unit 1," submitted under cover letter from K.P. Baskin, Southern California Edison to D.M. Crutchfield, NRC, dated April 18, 1983.

3. Letter from K. P. Baskin, Southern California Edison, to D. M. Crutchfield, NRC, dated September 1, 1983, Subject: "USNRC Docket No. 50-206, SEP Topic II-4.F, San Onofre Nuclear Generating Station, Unit 1."

SETTLEMENT RECORD TABLE

MARKER		INITIAL		TOTAL SETTLEMENT and OBSERVATION DATES									
LOCATION	NO	ELEV.	DATE	12/4/64	2/1/65 2/3/65	4/20/65	7/1/65 8/31/65	11/18/65 11/19/65	2/18/66 2/23/66	9/1/66 9/2/66	5/29/70 UNADJSTD	12/82 UNADJ	12/82 ADJ
REACTOR	1	14.462	8/23/65						.032				
REACTOR BUILDING	2	14.290	"					.002				.016	.083
	3	12.992	"					.002	.020			.013	.080
	4	13.190	"					.007				.013	.080
	5	14.839	"					.004				.023	.090
CONTAINM'T VESSEL FOUNDATION	6	19.085	11/3/64	.005	.003	.008	.008						
	7	18.962	"	.003	.009	.005	.006						
	8	18.953	"	.009	.019	.021	.017						
	9	19.016	"	.008	.010	.007	(+).004						
NORTH T. PED. EXTEN.	10	15.992	2/24/65			0.00	.015	.013	.017	.025		.005	.072
	11	15.989	"			.005	.014	.015	.020	.025		0.00	.067
TURBINE PEDESTAL	12	16.196	11/4/64		.006	.011	.016	.017	.020	.031		.001	.068
	13	16.122	"		.007	.007	.013	.016	.018			(+).005	.062
	14	10.583	"		.009	.012	.008	.007	.011	.017		(+).010	.057
	15	10.654	"		.010	.013	.016	.026	.027	.027		(+).005	.062
	16	10.599	"		.010	.015	.019	.026	.029	.034		(+).002	.065
	17	16.143	"		.003	.005	.019	.022	.023	.028	(+).009	(+).007	.060
	18	20.196 16.064	8/31/65 11/4/64		.005	DESTROYED		.003	.012	.010		(+).018	.049
SOUTH T. PED. EXTEN.	19	21.991	2/24/65			.007	.016	.019	.019	.022	(+).018	(+).014	.053
	20	21.987	"			.001	.007	.010	.011	.013	(+).025	(+).027	.040
FEEDWATER HEATER PLATFORM EAST	21	15.971	7/22/65				.001	0.00	.002	.010		(+).015	.052
	22	16.061	"				0.00	.002	.004	.011	(+).029		
	23	10.550	"				0.00	.009	.011	.012		(+).032	.038
	24	16.040	"				.006	.009	.011	.021	(+).014	.005	.072
	25	16.066	"				.007	.009	.009	.021	(+).023		
FEEDWATER HEATER PLATFORM WEST	26	16.026	3/15/65			.001	.005	.006	.007	.018			
	27	16.007	"			.002	.002	.007	.011	.010	(+).054	(+).033	.034
	28	16.012	"			.001	.003	.005	.007	.006	(+).049	(+).029	.038
	29	10.473	"			(+).002	(+).002	.008	.009	.008		(+).034	.033
	30	16.006	"			.001	.001	.008	.008	.009	(+).036	(+).012	.055
REACTOR AUX. BLDG	31	16.083	11/9/65										
	32	16.315	"						.005				
FUEL STORAGE BLDG.	33	22.915	1/19/65		.006	.006	.008	.004					
	34	16.164	"		.007	.006	.010	.008	.007			(+).009	.058
REFUELING WATER STORAGE TANK	35	16.094	12/6/65						.015			(+).001	.066
	36	16.270	"						.023			.018	.085
	37	16.425	"						.017			.001	.068
	38	16.251	"						.012			(+).010	.057
MAKE-UP TANK	39	16.910	"						.021			(+).001	.066
COOLING WATER TANK	40	15.026	11/9/65						.005			(+).032	.035
	41	15.202	"						0.00			(+).023	.044
OIL TANK	42	15.905	"						(+).006			(+).052	.015
PUMP WELL	43	14.980	9/1/66					(+).003	(+).003	(+).002	(+).051	(+).034	.038
	44	17.017	"					.009	.010	.018	(+).039	(+).017	.050
CONDENSATE STORAGE TANK	45	21.898	11/9/65						.029	.071	.057	.095	.162
	46	21.425	"						.025	.068	.091	.084	.151
	47	21.182	"						.016	.040	(+).010	.022	.089
	48	21.252	"						.015	.035	.003	.026	.093

UNADJUSTED DATA

ADJUSTED DATA

NOTES:

(+) INDICATES A MEASURED ELEVATION GREATER THAN THE INITIAL MARKER ELEV.

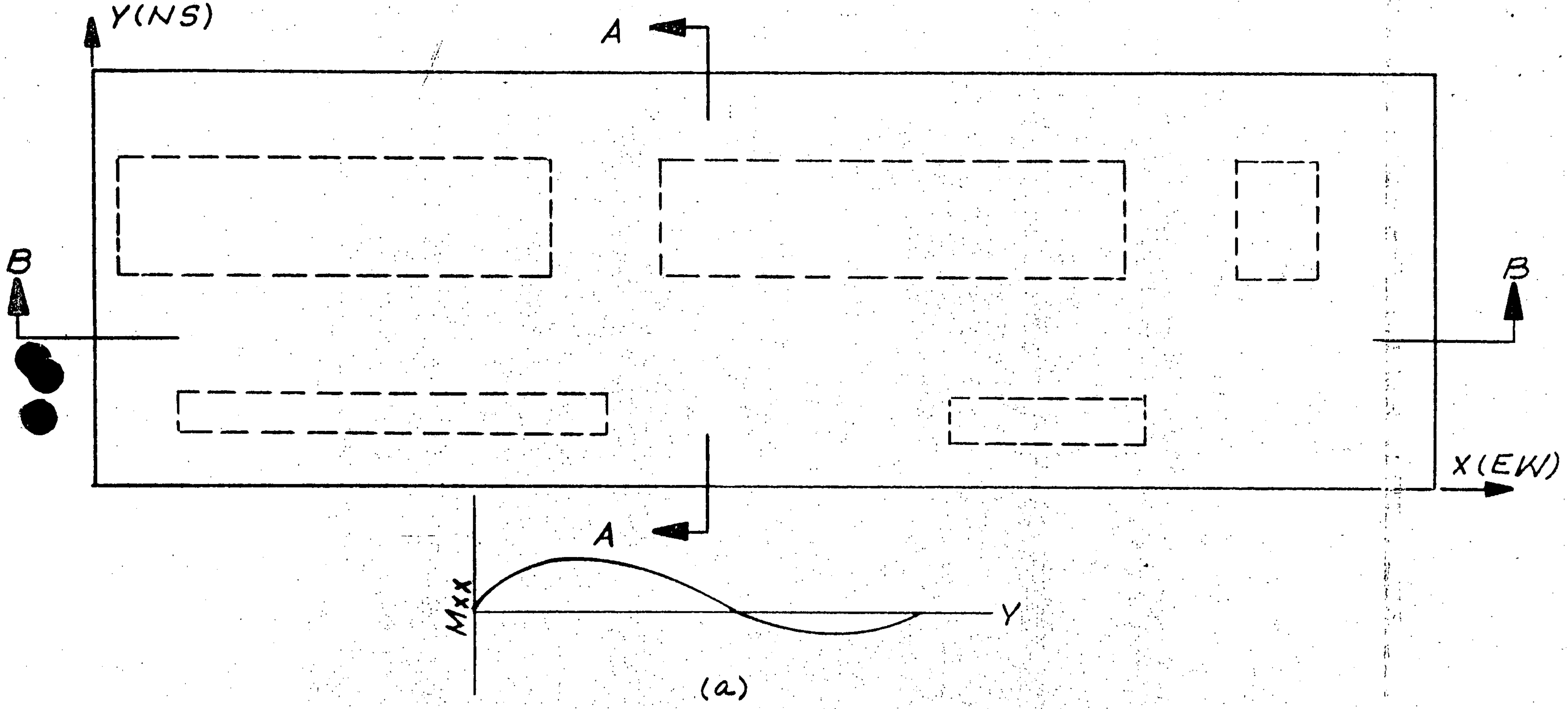
ELEVATIONS ARE BASED ON MEAN LOWER LOW WATER (MLLW) DATUM

TABLE WAS PREPARED FROM SCE DRAWINGS, 5102275 and 567856

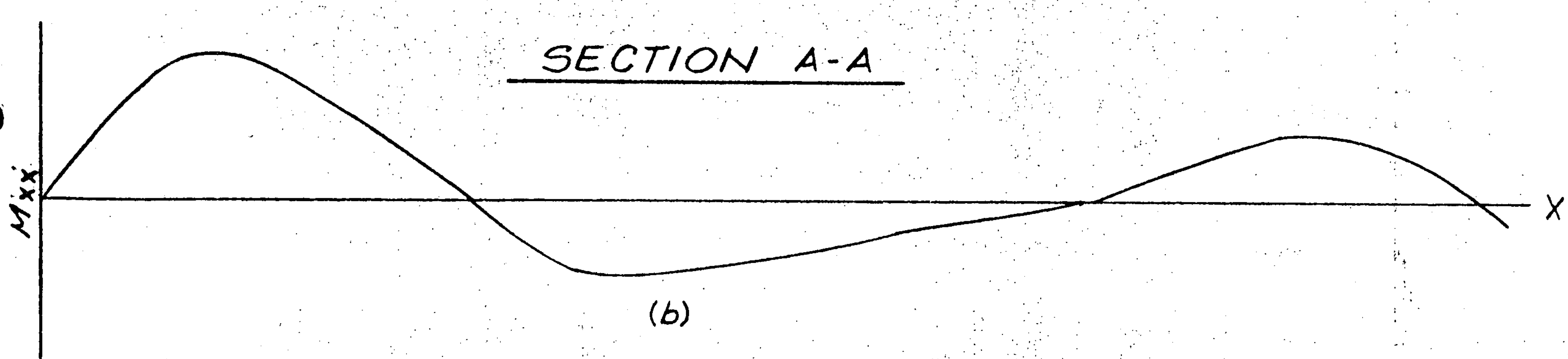
THE ENTRIES ARE DIFFERENTIAL DISPLACEMENTS FROM THE INITIAL ELEVATION

UNITS ARE IN FEET

TABLE 3-1



SECTION A-A



SECTION B-B

FIGURE 2.2 MOMENT DISTRIBUTION IN 480V SLAB