# **UC Berkeley SEMM Reports Series**

### Title

Structural Model Investigations for Ross High Dam - Model 2, Third Stage as Constructed

## **Permalink**

https://escholarship.org/uc/item/9391j7cd

## **Author**

Raphael, Jerome

# **Publication Date**

1972-09-01

REPORT NO. UC SESM 72-12 STRUCTURES AND MATERIALS RESEARCH

# STRUCTURAL MODEL INVESTIGATIONS FOR ROSS HIGH DAM

MODEL 2
THIRD STAGE AS CONSTRUCTED

ВΥ

JEROME M. RAPHAEL

REPORT TO
INTERNATIONAL ENGINEERING COMPANY, INC.
SAN FRANCISCO, CALIFORNIA

SEPTEMBER 1972

STRUCTURAL ENGINEERING LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY CALIFORNIA

## STRUCTURAL MODEL INVESTIGATIONS

FOR

ROSS HIGH DAM

MODEL 2 - THIRD STAGE AS CONSTRUCTED

Report No.

UC SESM 72-12

INTERNATIONAL ENGINEERING COMPANY, INC.

San Francisco, California

JEROME M. RAPHAEL

Professor of Civil Engineering

UNIVERSITY OF CALIFORNIA

Berkeley, California

September 1972

# TABLE OF CONTENTS

																									Ī	age
INTRODUCTION .		•			•	•	•		•	•	•	•	•	•	•	•			•	•	٠	•,	•	•	•	1
ACKNOWLEDGMENT	• •	•	•	•	•		•		•	•	•	•	•	•		•	•		•	•	•	•		•	•	3
MODEL			•		•			•		•		•	•	•		•		•	•	•	•	•			•	4
SCOPE OF TESTS		•		•			•						•		•	•	•		•	•	•		•	•	•	4
STRESSES		•			•		•	•	•	٠	•	•	•	•	0	•	•	•	•	•			•	•		5
DEFLECTION			•	•		•	•	•	•	•		•	•	•	•	•	•	•		•	•			•	•	8
DISCUSSION		•		•	•	•	٠		•	•	•	•	•	•	•	•	•	•	•	•					•	9
CONCLUSIONS .		•		٠	•		•			•	•	•	•		•	•			•		٠	•	•		•	10
APPENDIX A - D	RAWI	NGS	5	•				•	•		•	•	•	•	•	•	•		•	•	•	•	•			11
APPENDIX B - T	ABLE	S.								•		•	9	•					•	•		•	•			29

# LIST OF ILLUSTRATIONS

Figure	No.	Page
1.	Ross Dam - General Arrangement	12
2.	Ross Dam Model	13
3.	Model 2 - Strain Gage Locations - Downstream Face	14
4.	Model 2 - Strain Gage Locations - Upstream Face	15
5.	Model 3 - Strain Gage Locations - Downstream Face	16
6.	Model 3 - Strain Gage Locations - Upstream Face	17
7.	Model 2 - Orthogonal Stresses - Water Elevation 1600 -	
	Downstream Face	18
8.	Model 2 - Orthogonal Stresses - Water Elevation 1600 - Upstream Face	19
9.	Model 2 - Orthogonal Stresses - Water Elevation 1475 -	
	Downstream Face	20
10.	Model 2 - Orthogonal Stresses - Water Elevation 1475 -	
	Upstream Face	21
11.	Model 2 - Principal Stresses - Downstream Face	22
12.	Model 2 - Principal Stresses - Upstream Face	23
13.	Model 3 - Orthogonal Stresses - Water Elevation 1600 -	
	Downstream Face	24
14.	Model 3 - Orthogonal Stresses - Water Elevation 1600 -	
	Upstream Face	25
15.	Model 3 - Principal Stresses - Downstream Face	26
16.	Model 3 - Principal Stresses - Upstream Face	27
17.	Deflections	28

# LIST OF TABLES

Table	1	-	Comparison	of	Stresses	***	Downstrea	am F	'ace	•	•	•	٠	•	٠	٠	•	•	30
Table	2	point	Comparison	of	Stresses		Upstream	Fac	e.				٠		٠	•	۰		31

# STRUCTURAL MODEL INVESTIGATIONS FOR ROSS HIGH DAM MODEL 2 - THIRD STAGE AS CONSTRUCTED

### INTRODUCTION

Ross Dam, a 661 ft. high by 1500 ft. long arch dam which is the major storage structure of the City of Seattle, Department of Lighting's hydroelectric power project on the Skagit River, Washington, was designed to be constructed in four stages. In the original plan, the first three stages had been constructed essentially as a thin arch dam, and the fourth stage of construction necessitated the addition of a large volume of concrete downstream of this thin arch dam in addition to raising the height. A revised scheme for the fourth stage, based on raising the dam essentially as a thin arch dam with a minimal addition of concrete and thickening only the upper 150 feet of the present dam, was the subject of a model investigation at the University of California which had the objective of determining the structural stresses in the dam under the proposed plan of develop-Since the additional concrete is to be added to the present dam which is ment. already under a state of stress, it was necessary to test a model of the present dam, termed "Ross Dam", in order to determine its stresses prior to construction, and the additional stresses due to raising the dam and increasing the elevation of the reservoir.

This report completes a trilogy of three reports covering all phases of the model tests. Report UCSESM 71-11, Model 1 - Ross High Dam, covered the behavior of a homogeneous model of Ross Dam as raised to its ultimate height with crest elevation 1736. Report UCSESM 72-11, Model 3 - Staged Construction, also studied the dam raised to its ultimate height, but with the additional concrete

assumed more deformable than the old concrete of the low dam, and with a number of assumed structural discontinuities. The work reported here is on Model 2, a homogeneous model which represents the present Ross Dam constructed to elevation 1615 with full water load at elevation 1600, and also with water drawn down to elevation 1475 in preparation for construction of the fourth stage.

In addition, at Stage 10 during the testing of Model 3, the configuration of the lower part of the model corresponded exactly to that of Model 2. Accordingly Model 3 was tested with a load corresponding to that of Model 2, for a direct comparison of stresses.

### ACKNOWLEDGMENTS

Overall supervision of the Ross High Dam Project is by the owner, the City of Seattle, Department of Lighting, under the direction of Chief Engineer R. L. Skone, Chief Civil Engineer C. R. Hoidal, and Engineer E. J. Drobnack.

Engineering studies and layouts for the fourth stage of Ross Dam were carried out by International Engineering Company, Inc., under the direction of Chief Engineer G. S. Sarkaria and Project Manager E. B. Kollgaard assisted by Engineers R. P. Sharma and H. E. Jackson.

Construction and testing of the models were carried out under the direction of Professor Jerome M. Raphael of the University of California.

The testing organization was led by Engineer Charles Mercer, assisted by Research Assistant Otto Fajardo and a staff varying from four to ten technicians.

### MODEL

Figure 1 shows Ross Dam as constructed to elevation 1615. This was modeled at a scale of 1:240 as shown in Figure 2. The plaster-celite model was poured between fiberglass molds on a plaster-celite block foundation cemented into a channel-shaped reinforced concrete test pit. Modulus of elasticity of the model and foundation was 250,000 psi. The structural action of the spillway opening was approximated by slots cut to the shape of the spillway crest. After drying, the model was fitted with 54 SR-4 strain gage rosettes as shown in Figs. 3 and 4. These were coupled to the SESM low-speed scanner for observations at the rate of four per second. Live loading was by means of horizontal air bags controlled by water columns, and dead load was by the method of integration using lead bricks for uniform loads at each horizontal slice. The above summary of the test method is given in greater detail in the first report of this series, "Model 1 - Ross High Dam".

### SCOPE OF TESTS

The purpose for testing a model of Ross Dam constructed to Stage 3 was to provide base stresses by which to determine the incremental stresses in the dam when the fourth stage was added and loaded. Two loading conditions were important: the normal water surface elevation 1600; and the level to which the water would be drawn down prior to construction, elevation 1475. For each of these series of tests, live load was applied to the upstream face in three different load intensities, and the stress results averaged. At the conclusion of the two live load test series, Model 2 was cut down by 100-ft. increments, each stage being loaded with three cycles of uniformly distributed lead bricks to determine the dead load stresses. Finally, at Stage 10 of Model 3, water load was applied to elevation 1600 at three intensities of pressure, to check on the Model 2 tests. Strain gage layout for this last series is shown

on Figs. 5 and 6.

### STRESSES

Stresses reported here are necessarily all surface stresses, as these are the only stresses measurable on structural models. They are reported in two ways, as orthogonal stresses and as principal stresses. The orthogonal stresses, i.e., arch stresses, cantilever stresses, and shears are the most useful for the purposes of this study, as they can most easily be combined algebraically with like stresses from other studies. Five loading cases are reported: water load, dead load, water plus earthquake load, water plus dead load, and water plus earthquake plus dead load. Figs. 7 through 10 show the values of orthogonal stresses on the dam for all these cases with water at the two levels of interest. The magnitude, sense and direction of the principal stresses are useful in visualizing the structural behavior of the dam as a whole under load. These are shown in Figs. 11 and 12 for dead load plus water to elevation 1600 only. Corresponding orthogonal stresses and principal stresses for Model 3 loaded to elevation 1600 are found in Figs. 13 through 16.

Comparison of stresses determined by Models 2 and 3 can be found in Tables 1 and 2 for the orthogonal stresses, for the combination of dead load plus water to elevation 1600.

Considering first Figs. 7 and 8 showing the orthogonal stresses on Model 2 with the maximum water surface elevation 1600, it can be seen that the maximum arch stress due to dead plus water load is 575 psi compression at elevation 1400 on the downstream face at the right abutment. This increases to 697 psi compression when earthquake load is added. Cantilever stresses are more varied. The maximum vertical compressive stress is 528 psi at elevation 1300 on the right abutment, increasing to 591 psi when earthquake is added. Bands of moderate vertical tension are found on the downstream face ranging from elevation 1540 down to one pip at elevation 1400, the

maximum tension being 117 psi at elevation 1500 at the centerline.

On the upstream face, all arch and cantilever stresses are compressive. The maximum arch stress for dead plus water load is 608 psi at elevation 1400 at the centerline, increasing to 722 psi when earthquake is added. Cantilever stresses are everywhere less than that, the maximum being 329 psi at elevation 1400 at station 8+00 under dead plus water load, increasing only slightly to 345 psi adding earthquake.

Corresponding orthogonal stresses for the same water surface elevation 1600 as determined on Model 3 are shown on Figs. 13 and 14, which give the stresses determined for all five loading cases. Maximum downstream stresses shift around a bit, with maximum arch stress at 468 psi compression near the base for dead plus water load, increasing to 569 psi when earthquake is added. Again the cantilever stresses show the band of vertical tension at higher elevations, with a maximum tension of 124 psi at elevation 1500 at the centerline for dead plus water load, increasing to 175 psi tension when earthquake is added. Maximum downstream compression is 516 psi at elevation 1300, right abutment, increasing to 577 psi adding earthquake.

For the upstream face, all stresses are compressive, with a maximum arch stress of 606 psi at elevation 1400 at the centerline, increasing to 719 psi adding earthquake. The maximum cantilever stress occurred at the same location, and was 322 psi, increasing to 341 psi adding earthquake.

Tables 1 and 2 have been prepared so that the orthogonal stresses in Models 2 and 3 can be compared for common locations for one loading case only, dead load plus water load to elevation 1600. Correspondence between stresses determined independently on the two models is fairly good, leading to confidence in the results.

The orthogonal stresses for the low-load case where the water is drawn

down to the construction level of elevation 1475 are shown on Figs. 9 and 10.

As might be expected, stresses are fairly low for this case, everywhere being less than 300 psi compression on the downstream face, and less than 400 psi compression on the upstream face for dead plus water loads. The vertical tensile stresses that were found on the downstream face with the dam fully loaded are not found at all in the drawdown case.

The principal stresses for Ross Dam with dead load and water load to elevation 1600 are shown in Figs. 11 and 12 for Model 2 and in Figs. 15 and 16 for Model 3.

In interpreting the stresses shown, it should be recalled that there were slight but significant differences in the models, that would affect the way in which each would distribute the loads imposed on it. For Model 2, the spillway was modelled as a series of cantilevers that would carry no arch load. For Model 3, the spillway was not modelled, and hence arch action was allowed in the spillway area.

Looking first at the downstream face, maximum compressive principal stress around 730 psi is found at three locations near the abutments of the dam in Model 2. Since this is a region of rapidly varying stress due to its proximity to the foundation, the slightly smaller stresses at these locations in Model 3 may be due to differences in strain gage location. The generally higher arch stresses in Model 3 at elevation 1590 are probably due to the continuous arch in this model. The vertical tension region with a maximum tensile principal stress of 118 psi at the center at elevation 1500 is well shown. Other stresses at locations away from the above-mentioned structural features show fair correspondence.

For the upstream face, the correspondence of stresses found in Model 2 with those of Model 3 is generally good. Maximum compressive principal stress of 690 psi is found at elevation 1540 at the centerline. Minor tension is found at one location, at elevation 1400 at the left abutment.

### DEFLECTION

Downstream radial deflection of the maximum cantilever of Model 2 under water load to elevation 1600 is shown on Fig. 17. The maximum deflection of 1.21 inches is matched by the maximum deflection of 1.15 inches found in Model 3, the crest of which is stiffer than that of Model 2 because of the filled-in spillway section.

### DISCUSSION

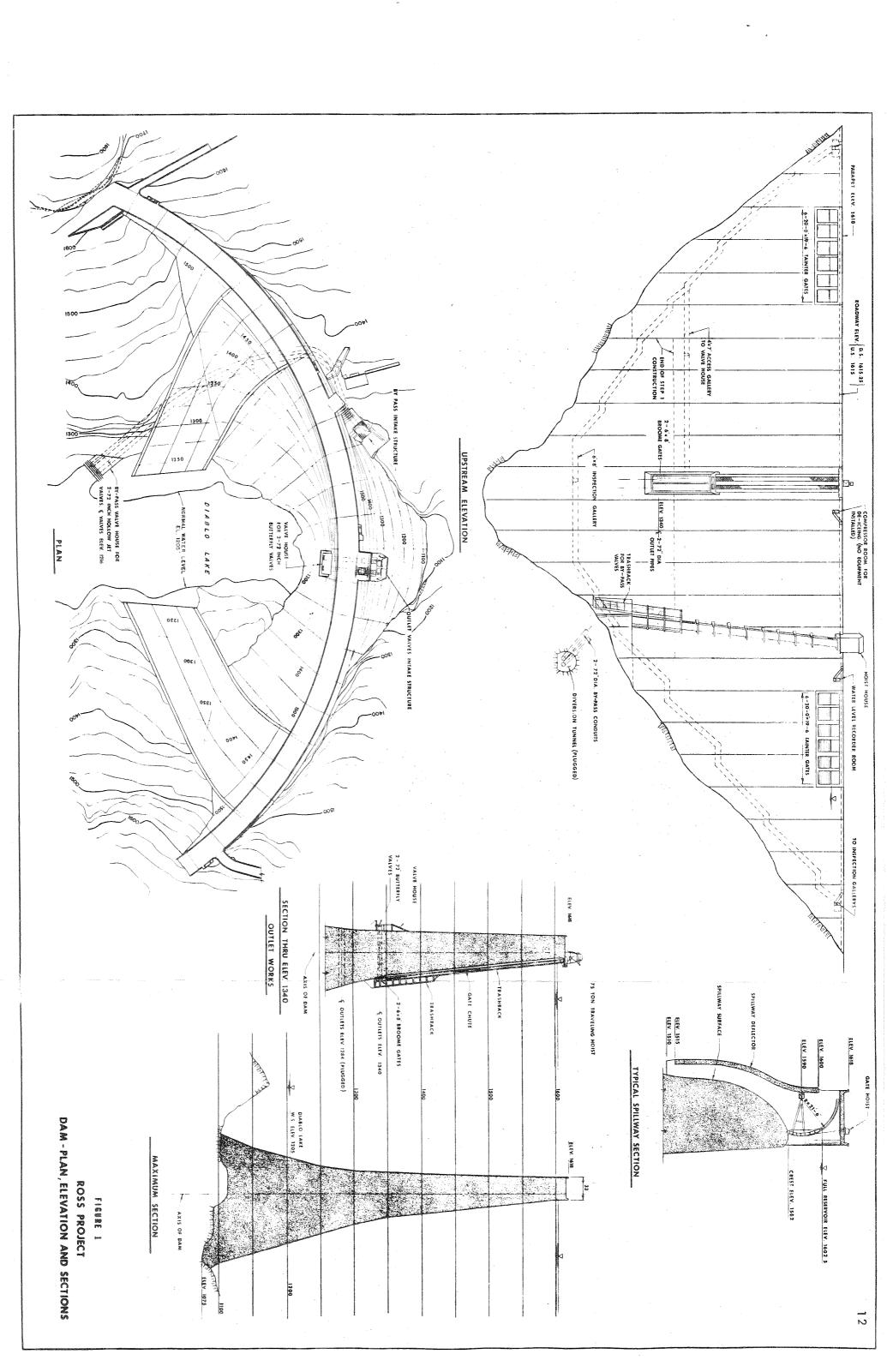
Stresses for the third stage of Ross Dam have been determined on two models, and the question arises, when differences are shown, how to interpret these values: optimistically accept the low stresses; pessimistically accept the higher stresses; or statistically average the different stresses. It will be noted that the highest principal stresses are identical on both models, and neither is cause for concern as to its magnitude. However, keeping in mind that the test on Model 2 most closely approximates the actual structural configurations of the third Stage Ross Dam, it is recommended that the Model 2 results be accepted for study, and that Model 3 results be used only for general corroborations of stresses. It should be noted that deflection which is a fairly sensitive indicator of structural behavior, is nearly identical for the two models.

### CONCLUSIONS

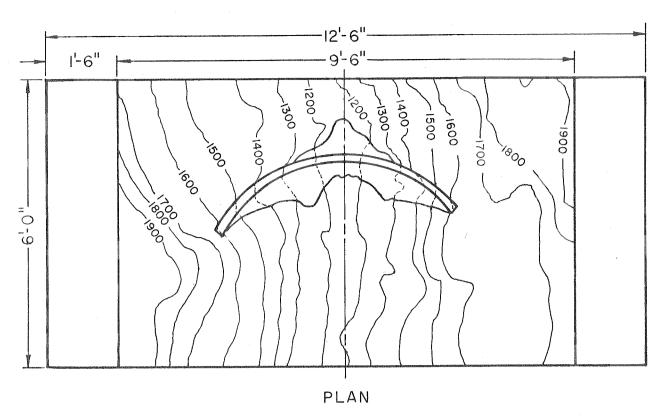
For the third stage of Ross Dam, stresses for dead load plus water load to elevation 1600 are quite moderate, the maximum compression being 608 psi, increasing to 722 psi when the Westergaard horizontal earthquake load for 0.1 g is added. Maximum orthogonal tension was 117 psi. The maximum principal stresses observed during this test were 730 psi compression and 118 psi tension for dead plus water load. While Models 2 and 3 differed somewhat in configuration, maximum stresses of the same magnitude were found in both models.

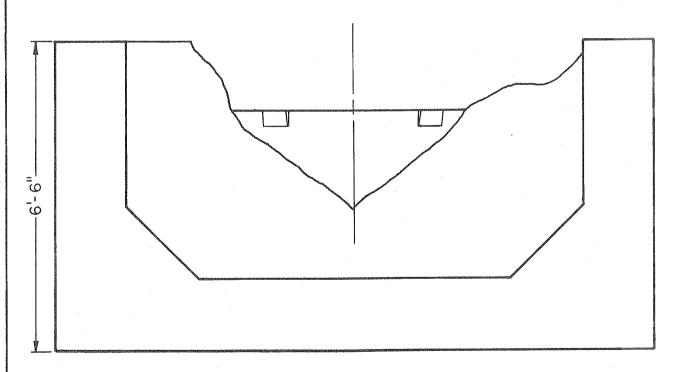
APPENDIX A

DRAWINGS



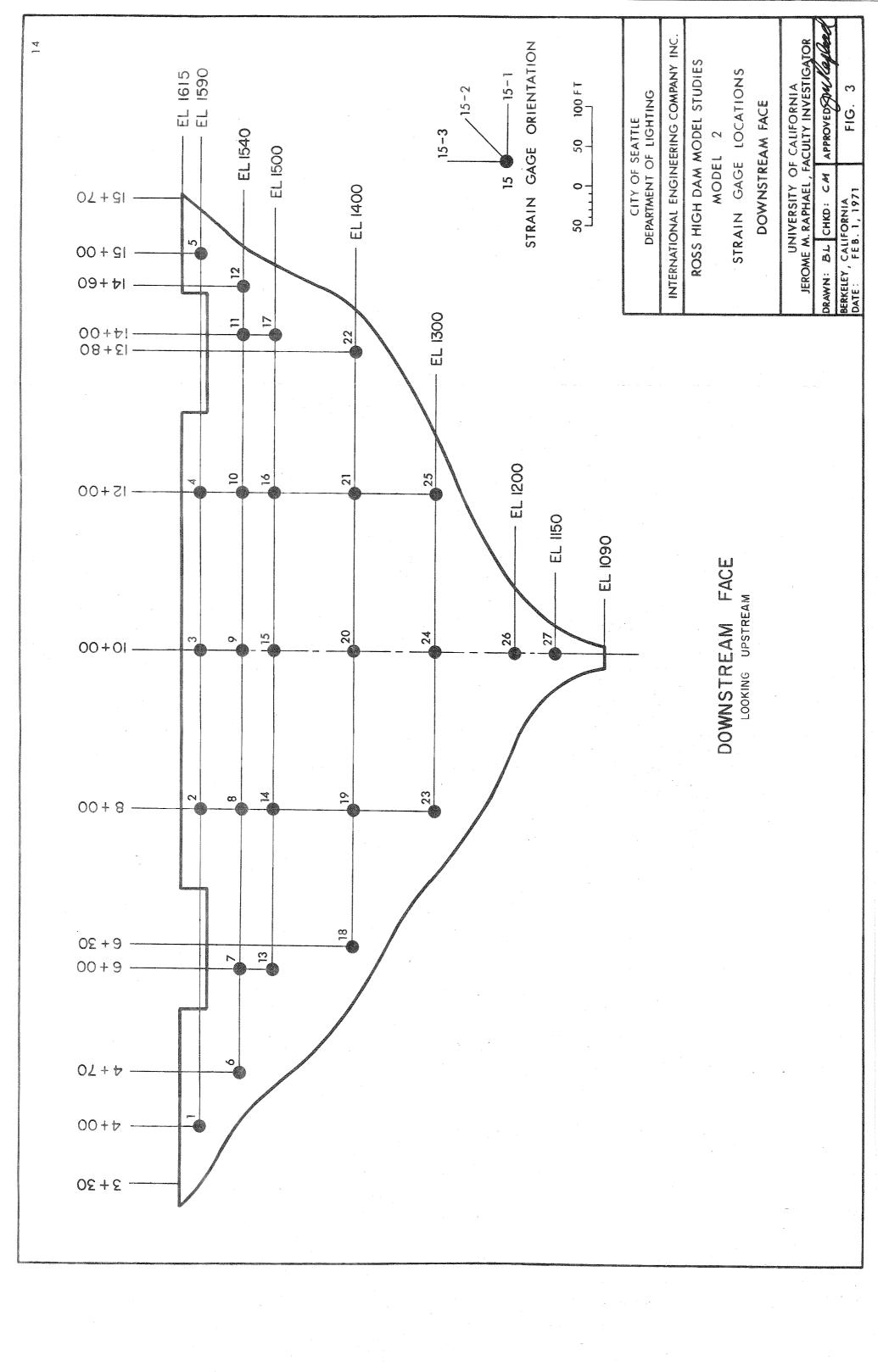


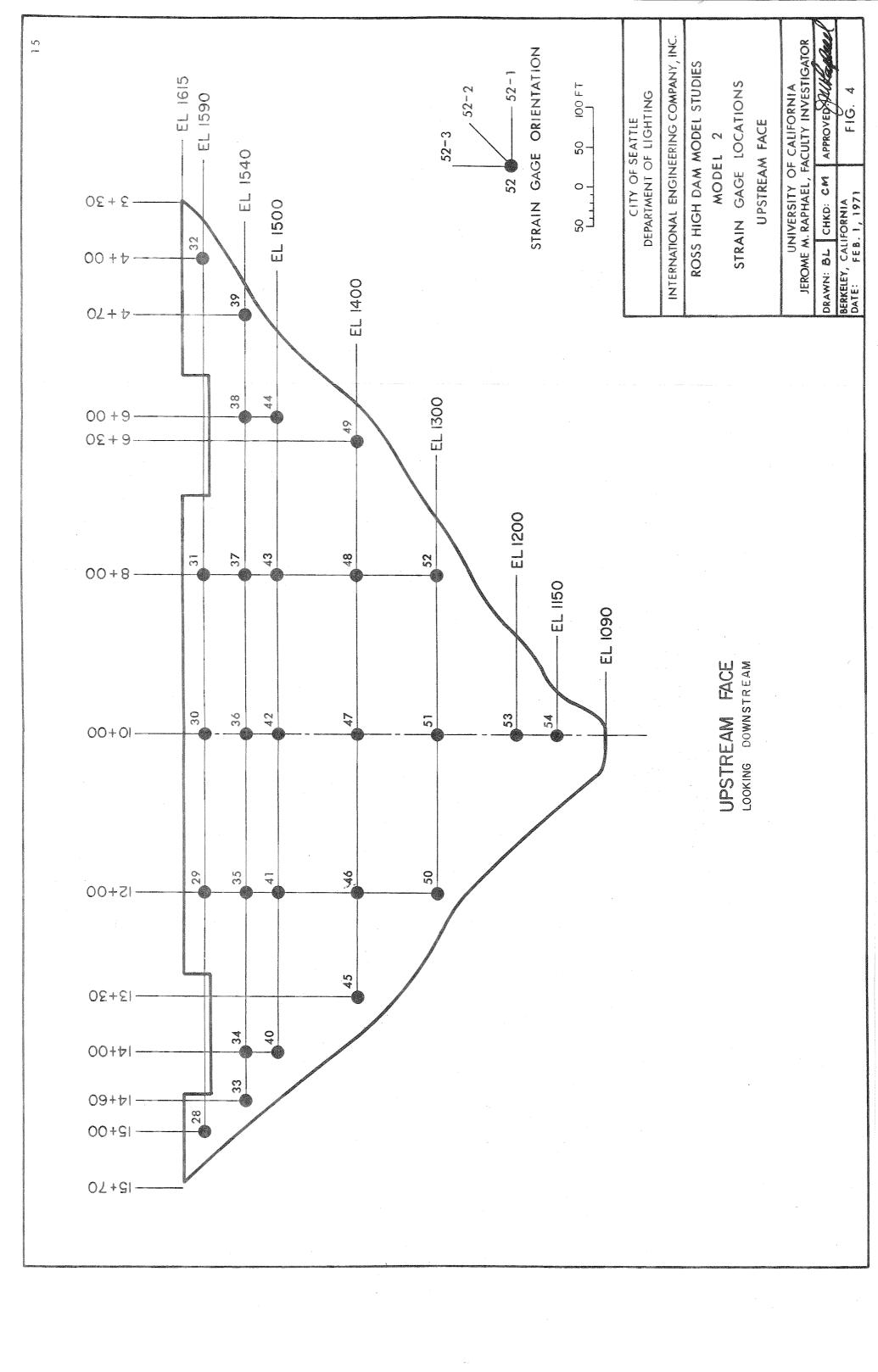


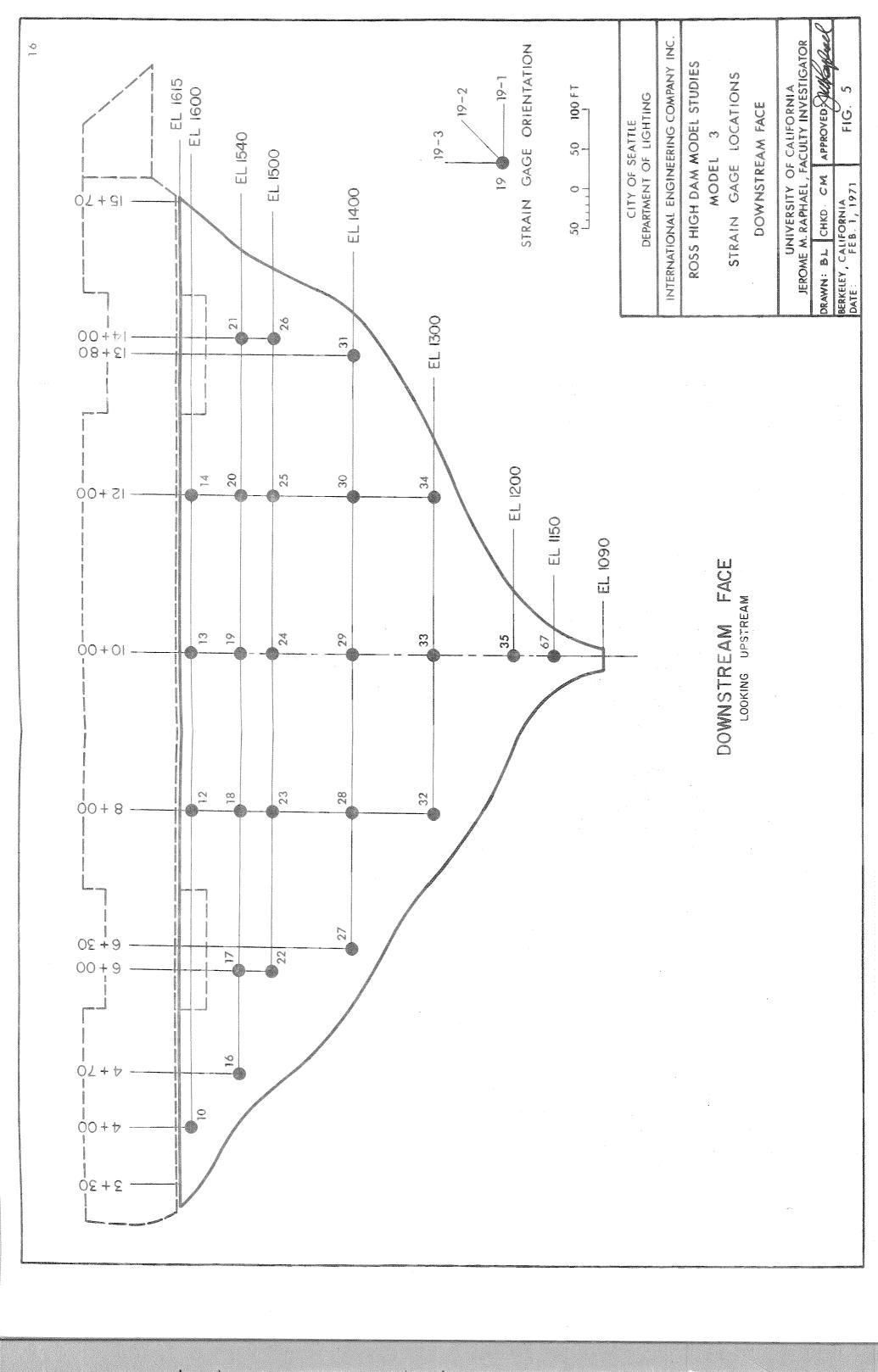


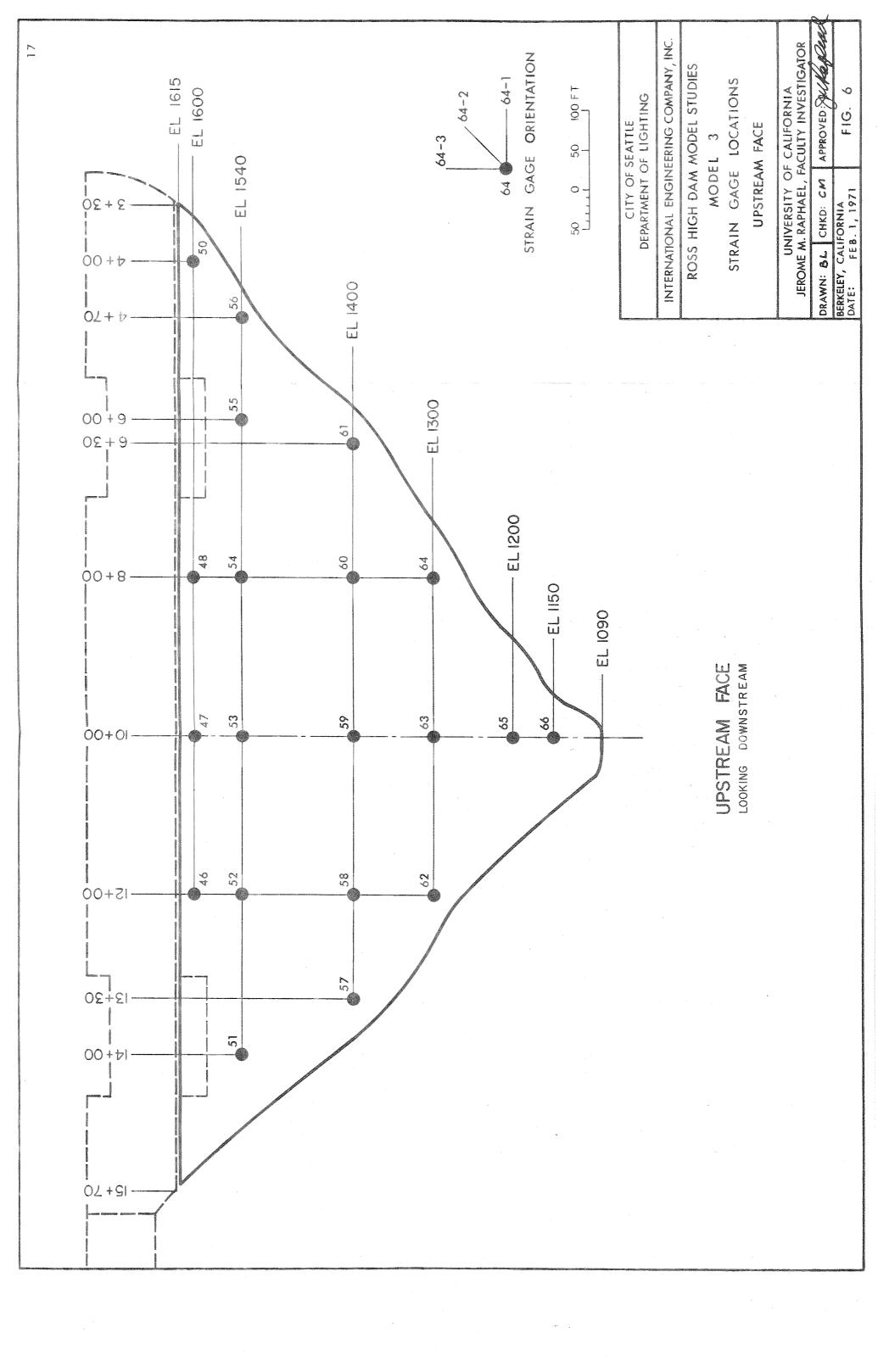
ELEVATION

FIG. 2 MODEL DAM AND TEST PIT









# STAESSES HORIZONTAL, VERTICAL & SHEAR

# DOWNSTREAM FACE

\$41 04 10 4 0 4 0 10 4	λ×,	N	4	0	0	200	80	00	9	5	4	00	romes.	2	9	N	Z	<u>w</u>	200	<u>о</u> ш	In	280	200	20	(D)	4	8	
3			+	1	+	Equipment of the second	-			1	+	+	1	al .	1	50	+	+	1		+	+	ngar		+	ndus.	+	
Z ↓ DC	6	3	2	9	~~~	9	**********	3	3	22	9	യ സ	8	63	entainer) continuel	2	57	<u>7</u>	333	<u> </u>	95	63	2	5	7.20	400	40	
		1	+	+	+	+	n de		+	+	-da	•	1	e e e e e e e e e e e e e e e e e e e	+	4	+	1	Appropriate	1	+	1	Assert	dage		l	l	
111111	Š	2	240	788	- 201	- 387	325	445	355	380	- 283	8	400	505	387	310	303	904	-697	4.34	249	487	200	3	4	39.	3	
Personal Control	na <b>194</b> 9373.jtm	maganistic because consistential	(V)	9	00	L	P	6	3	<u> </u>	<u></u>	w	rU T	<u> </u>	(N)		ru Lu	· O	aleage. eeneman	4			N	N	V	2	+	mto
	×× <sub>2</sub>	- 2	4		T-C-DAVIDSON-TO-CO	4		9		3	W	agenzay	complex	9	S	7	Q	NUMBERS OF STREET	202	9	2	200	-contents	N	$\sim$	2	3	
		10	rU		+		<u> </u>	h	10		+	4	***************************************	<u>س</u>	_	P	3	4	0		0	+	+	<u> </u>	<u>+</u>	4	4	_
	Q,	0		0	W		00	3	35	4	W	00	70	S	5	and the same of th	N	4	290	2	2	58	2	528	25	362	37	
			+	N	4	4	1		+		4	and the second	1		4	+	+	00	1,0	1	+		1	-				
7 - ( * *	ŏ	3	- 202	- 24	12	322	23	- 372	200	33	- 239	32	338	- 424	- 329	253	- 257	333	52	37	7	4	80	200	48	8	2	
DOM/SAND	<u>~~</u>	entropolico	roomontales	Lafr.	3	yerott	00	9	4	2	4	N	Ö	N	4	<u></u>	<u>~</u>	9	3	Lapa mensemen	00	<u>u</u>	NAMES AND ADDRESS OF THE PARTY	 M	[	Currier Currier	-contact	and a
2	7 X		CONTRACTOR	1	(dipline)	10000		Ú00000	+	South States	an De		dame		ennat	and the second	4	Appropriate Approp	+	•	400	+ elimen	+	nfo	10804166	÷	4	and part part than the control of th
	d,	20	7	30	2	24	2	12	03	282	<u>~</u>	50	42	80	38	<u>w</u>	153	<u></u>	5	22	28	(1)	2	200	239	70 TU	237	er e
I		- 1	1	4	1	9	-		1		No.	1	-	-		1	1	l l	l	ı	-	1		a <sub>ppe</sub> dia	1			-
)	b <sup>×</sup>	IO.	N	0	w	Surrectt	macontrols voluntes	N	7	9	2	[-	9	0	34	2	24	0	2	7	9	2	S	2	Z	Ŋ	991	ACA-CACACACACACACACACACACACACACACACACAC
-		-	Mark Street, Control	0000 <del>0000000000</del>	-	-	-po	-ba	1		***************************************		-∳n Mountesman	30000000000000000000000000000000000000	,	ergen	-	e de la companione de l	+	MANAGE CO.	- CONTRACTOR CONTRACTOR		egine Hemesterennen	homos <b>ina</b> ssassassas	25,000,000,000	4-	тин неже нежены	Annual Street, or other
	λ× <sub>2</sub>	Z	\     	9	+	4	<u>C</u>	S	20	2	7	9+	42,0147504 <b>47</b> 14343623			rU	200	4 7	(U)	- 179	2	220	200	200	4	2) 2)	0	management of the contract of
200			<u>w</u>	3%	22	38	In		55	8	and/Wico.	200	managa Kagas	35	<u>a</u>	4	0	+ 5	3	rυ	+	<del>1</del> 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	72		+ 2	<u>+</u>	4	_
- 1	O <sub>\</sub>	rafins	4	+	4	4	ader .	- Age	+	+ 20	allips allips	4	- Annie	+	4 249	+ 304	+ 210	1	7,50		12	(1)	E. Salar	8	1	23	2	THE PERSONAL PROPERTY OF THE PARTY OF THE PA
A &	ь×	226	7,3%	280	204	386	336	450	340	200	271	300	406	496	353	3	279	40	746	387	488	Č	546	220	C-	120	727	
>	нежний.		utmanument.	<del>l</del>	· · · · · · · · · · · · · · · · · · ·	ļ.,,,,,,	l l	NCO TO THE OWNER OF	l Nooren aan aan aan aan aan aan aan aan aan a	1	and the same of th			ĺ	l	l	Deter Informació	i	Ì	١		become	Ì	•	e de la composition della comp	<sub>O</sub> went	4.	Quintotas chart that by factor of an expense
AND ANY CONTRACT AND ANY AND AS AS AS	×	20	4	ru	300 <b>10</b> 0 300 300 300 300 300 300 300 300 300	4	ر ا	īn	Com		(W)	3	0	Ω 00	9	$\overline{\omega}$	4	122	267	77 O	2	8	Emilian Property manager	3	(M)	4	10.2000	gar.
// · · // · · · ·	7	1	ulps	e e e e e e e e e e e e e e e e e e e	+	1200		1	Į		40	+	Dunn	1		ı	+	+	1	-	÷	+	nights	1	+	+	+	-
	6	and and a	2	8	22	2	42	n	38	89	00	9	Militaryo Vetragasa	2	208	255	22	2	23	Q	8	S	3	32	9	9	37	manufacture (control of control o
AA		eder	+	+	4	+	-	n þe	d-	+	- Ages	+	nglan		+	+	+	1		+	afo.	1	1	-	-	-	CORE CO.	-
44	b <sub>×</sub>	0 0	-200	-242		-323	800	377	-282	32	-227	. 32.00	-340	4 5	2007	-26	-233	-343	-624	324	<u>R</u>	394	452	674	9	709	186	Service and a service of the service
أوج <sub>ا</sub> مسار		TOTAL CONTRACTOR AND ADDRESS OF THE PARTY OF		Q	nemmenoscure	Q	THE PERSONS ASSESSED.	2	9	CONCARDON C	0	NATIONAL PROPERTY.	) excession of the state of	SOUTH COMMENTS OF THE	Ö	Ö	Ö	NUMBER OF THE PERSONS	Ö	0	Ö	anakakamenten anaran inda	OR THE PERSON NAMED IN COLUMN	Secretarion de la company de l	MATERIAL CONTRACTOR OF THE PARTY OF THE PART	THE RESERVE OF THE PERSON NAMED IN	kananana <del>ana</del> a	e des
CTA	7	3	8+8	040	2+00	2+5	4+70	90+3	8+00	0010	12+00	14+00	14+60	00-9	8+00	0.0	12+00	00+4	6+30	8+00	0000	00+7	3+88	8+8	9	2+0	85	-
\ <u></u>		065	0 0 0	590	590	0000	540	<u>5</u>	1540	1540	540	5. 0. 1.0. 1.0.	1540	1500	500	500	500	500	400	400	<u> </u>	2004	100年 00年	300	99	300	200	-
and the same of	·····		neoneggy	Date of the second street	manufacture.	montage.	-		*THEORY.	udang.	ONORMANISTRO	- g	end (F statements	SSM SCHOOLSENSON	and the second	Annia de Caractería de Caracte	(	mangaparatan mangaparatan mangaparatan		- September 1		- company	Section of the sectio	September 1997		to the second		
GAGE	#	**************************************	N	(1)	4	Ŋ	9	<u>r</u>	$\infty$	Ø)	0	*Obscuredo	Q.	a	4	rū	9	~	00	<u>a</u>	2	N	22	23	24	72	26	The second secon

# NOTES

- FROM DISTANCES MEASURED ON AXIS I. STATIONS ARE PROJECTED RADIALLY OF DAN
- 2. ALL STRESSES ARE SURFACE STRESS IN PSI
- 3.  $\sigma_{\rm X}$  IS HORIZONTAL OR ARCH STRESS
- 4. OY IS VERTICAL OR CANTILEVER STRESS
- 5. TXY IS SHEAR STRESS
- 6. SIGNS: + IS TENSION IS COMPRESSION

DEPARTMENT OF LIGHTING CITY OF SEATTLE

INTERNATIONAL ENGINEERING COMPANY, INC. ROSS HIGH DAM MODEL STUDIES

ORTHOGONAL STRESSES WATER ELEVATION 1600 DOWNSTREAM FACE MODEL 2

UNIVERSITY OF CALIFORNIA JEROME M. RAPHAEL, FACULTY INVESTIGATOR

DRAWN: BL CHKD: CM APPROVED: SUM BERKELEY, CALIFORNIA DATE: FEB. 1, 1971

# HORIZONTAL, VERTICAL & SHEAR STRESSES

# UPSTREAM FACE

20 20 20 20 20 20 20 20 20 20 20 20 20 2
1 + 24 - 7 - 2 1 + 48 0 - 4 1 - 22 + 2 - 3 4 - 10 + 12 - 11 3 + 76 + 14 - 10
- 1 + 48 0 - 4 - 1 - 22 + 2 - 3 - 44 - 10 + 12 - 11 - 53 + 76 + 14 - 10 - 160 - 39 - 11 - 10
- 44 - 10 + 12 - 1 - 44 - 10 + 12 - 11 - 53 + 76 + 14 - 10 - 160 - 39 - 11 - 10
- 44 - 10 + 12 - 11 - 53 + 76 + 14 - 10 - 160 - 39 - 11 - 10
- 53 + 76 + 14 - 10 - 160 - 39 - 11 - 10
01-11-68-091-
01-11-68-091-
16 - 7 + 48 + 741 -
- 49 - 7 + 19 - 15
- 23 + 36 - 12 - 132
- 75 - 5 + 12 - 163
527-156-47+16-103
666-273-8-29-143
011-18 + 50 + 891-
- 60 - 10 - 10 - 158
+ 14 + 66 - 20 - 265
-101 + 23 + 47 - 41
- 84 + 5 - 27 - 225
-102 + 20 - 3 - 243
- 2 - 63 - 53 - 268
- 8 + 36 - 34 - 289
+251 + 64 - 60 -358
- 17 - 21 - 42 -304
+209 + 4 - 51 - 285
+ 142 - 6 - 128 - 292

# NOTES

- I. STATIONS ARE PROJECTED RADIALLY FROM DISTANCES MEASURED ON AXIS
- 2. ALL STRESSES ARE SURFACE STRESS IN PSI
- 3.  $\sigma_{\rm x}$  is horizontal or arch stress
- 4.  $\sigma_{\gamma}$  IS VERTICAL OR CANTILEVER STRESS
- 5.  $T_{XY}$ IS SHEAR STRESS 6. SIGNS: + IS TENSION - IS COMPRESSION

# CITY OF SEATTLE DEPARTMENT OF LIGHTING

INTERNATIONAL ENGINEERING COMPANY, INC.

ROSS HIGH DAM MODEL STUDIES

MODEL 2

ORTHOGONAL STRESSES

WATER ELEVATION 1600

UPSTREAM FACE

UNIVERSITY OF CALIFORNIA JEROME M. RAPHAEL, FACULTY INVESTIGATOR WN: BL CHKD: CM APPROVED: Quitagle all
---

BERKELEY, CALIFORNIA DATE: FEB. 1, 1971

# HORIZONTAL, VERTICAL & SHEAR STRESSES

# DOWNSTREAM FACE

E - E - E - E - E - E - E - E - E - E		grane anne	por more constants	gosco <del>on and an</del>	(pinanenskaanse	ng monocomments	<b>S</b> iaseennin	<b>April</b> anasas	egonumacuene.	of aurost to secure	oloone contribution	agreement to	tg-wasconamensous	genaneeee	province and	agen and an annual section of the se	gussana. <del>rusa</del> tu	Store Cale	<b>Mark</b>	D-SCHOOL VICTORIA	tracerra enovativo								
ELEV STA WATCH LOAD WATCH FORC LOADS DEAD LOAD WATCH-DEAD LOAD WATCH-CORPORT FORCE LOADS AND LOAD WATCH-CORPORT FOR LOADS AND	OAD	λ×	50		S	0	R	9		-		9	<u>0</u>	27		w		9	NONE TO THE PERSON NAMED IN	7	3	9	<del>\$</del>	<u></u>	9	(4)		27	22
ELEV   STA   WATER LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   STA   $G_X$		2		+	1		1	-	+	+	-	manager of the state of the sta	ļ.	Monte	4	100000	400000	+	-						<b>C</b>	+	Anness .	ĺ	4
ELEV   STA   WATER LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   STA   $G_X$	30 ±3		-		8	24	24	23	52		9	65	96	37	24	74		02	82	83	2		53	<u>@</u>	40	200		-	3
ELEV   STA   WATER LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   STA   $G_X$	EOK			50,000		1	Based						100			Zineazi	***************************************		Commission	0	(III)	amenana	n n	1	3	**********		"	C
ELEV   STA   WATER LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   DEAD LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   WATER FORE LOAD   STA   $G_X$	TER	×		5	4			27	00	9	4	65	0	72	0			8	64	09	52	9		5		9	(4)	57	5
1590   4+00   25 + 3 + 5 - 30 + 3 + 6 - 5 - 20 - 1   -30 - 17 + 1590   24+00   -11 + 2 + 7 + 13 + 2 + 8 - 5 - 20 - 1   -30 - 17 + 1590   24+00   -13 + 2 + 7 + 13 + 2 + 8 - 5 - 20 - 1   -30 - 17 + 1590   24+00   -13 + 1 - 6 - 23 + 1   -7 + 8 - 5 - 20 - 1   -30 - 17 + 1590   24+00   -13 + 1   -6 - 23 + 1   -7 + 3 - 25 - 20 - 4 - 3 - 30 - 17 + 1590   24+00   -13 + 1   -6 - 23 + 1   -7 + 3 - 25 - 3 - 27 - 24 - 1590   25+00   -26 + 16 + 18 + 7   -48 + 21 + 9 + 11   -50 - 18 - 29 - 32 - 1590   25+00   -26 + 18 + 7   -48 + 21 + 9 + 11   -50 - 18 - 29 - 32 - 1590   25+00   25+00   -26 + 18 + 7   -44 + 18 + 21 + 5 - 70 - 9 - 57 - 55 + 18 - 29   25+00	W/A		1				- Contract	- Contraction (Contraction)				1	1	1					THE PERSON NAMED IN	Ī	I					THE PARTY OF THE P	1		]
ELEV   STA	OAD	Zxy	4	9	5	0	ā	eceptotic	0	5	24	12	9	24	す	N	<u>N</u>	N	0			9	30	2		0	0	2	0
FELEY   STA	۵			†		- L		1	<del>                                     </del>		<del>                                     </del>	1			·	1	1	†		1	1				١		-	+	4
FELEY   STA	LLI			-		2	2	32		00		089	20	ω ω	36	8	00	*********	<u></u>			40	9	$\widetilde{\omega}$	80	Z	******		285
FELEY   STA	$\alpha$				1					1	1	1	1		1	1	10		1	1					1	1		ş	1
FELEV   STA	VATE			1	(1)				S	54	30	56	2	9	00	0,	4	8	2		136	75	(4)	4.		2	00	5	200
ELEV   STA   WATER LOAD   WATER FERE LOADS   DEAD LOADS	>			-	1			1				<u> </u>					1		1	1	1	1	homosolessolessoles			201200000000000	<u> </u>	Description (s)	1
FLEV   STA   WATER LOAD   WATER + EOKE LOADS   DEAD     1590   4+00   - 25   + 3   + 5   - 30   + 3   + 6   - 5   - 5     1590   8+00   - 11   + 2   + 7   - 13   + 2   + 8   - 2   - 5     1590   15+00   - 26   + 0   - 1   - 4   + 0   - 1   - 0   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   - 7   - 3   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   + 1   - 7   - 3   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   + 1   - 7   - 3   - 1     1540   15+00   - 26   - 0   - 12   - 3   + 2   + 8   + 2   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 65   + 54   + 11   - 46   + 15   - 15   - 15     1540   15+00   - 65   + 54   + 13   - 65   + 64   + 11   - 34   - 13     1540   15+00   - 65   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 142   + 2   - 70   + 169   + 2   - 16   - 18     1400   15+00   - 59   + 142   + 2   - 70   + 169   + 2   - 16   - 18     1400   12+00   - 196   - 84   - 90   - 234   - 100   - 107   - 22   - 20     1300   12+00   - 24   + 95   + 17   - 29   + 13   + 5   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 13   + 6   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 50   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 50   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 6   - 16   - 18     1500   12+00   - 24   - 47   + 84   - 28   - 57   + 101   + 50   - 10     1500   12+00   - 24   - 47   + 10   - 24   + 10   - 24   - 10     1500	:	λ× <sub>2</sub>			4	689	, maken	0	01	4	2	4	N	9	O	7	7	00	9	3	7	Ø		many				N	ω [~
FLEV   STA   WATER LOAD   WATER + EOKE LOADS   DEAD     1590   4+00   - 25   + 3   + 5   - 30   + 3   + 6   - 5   - 5     1590   8+00   - 11   + 2   + 7   - 13   + 2   + 8   - 2   - 5     1590   15+00   - 26   + 0   - 1   - 4   + 0   - 1   - 0   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   - 7   - 3   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   + 1   - 7   - 3   - 1     1590   15+00   - 26   - 0   - 1   - 4   + 1   + 1   - 7   - 3   - 1     1540   15+00   - 26   - 0   - 12   - 3   + 2   + 8   + 2   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 39   + 10   - 4   - 46   + 12   - 5   + 5   - 1     1540   15+00   - 65   + 54   + 11   - 46   + 15   - 15   - 15     1540   15+00   - 65   + 54   + 13   - 65   + 64   + 11   - 34   - 13     1540   15+00   - 65   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 54   + 3   - 65   + 64   + 11   - 34   - 13     1500   15+00   - 55   + 142   + 2   - 70   + 169   + 2   - 16   - 18     1400   15+00   - 59   + 142   + 2   - 70   + 169   + 2   - 16   - 18     1400   12+00   - 196   - 84   - 90   - 234   - 100   - 107   - 22   - 20     1300   12+00   - 24   + 95   + 17   - 29   + 13   + 5   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 13   + 6   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 50   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 50   - 16   - 18     1500   12+00   - 24   + 95   + 17   - 29   + 11   + 6   - 16   - 18     1500   12+00   - 24   - 47   + 84   - 28   - 57   + 101   + 50   - 10     1500   12+00   - 24   - 47   + 10   - 24   + 10   - 24   - 10     1500	OAD		1			10	- Sembo	<u>                                     </u>	1	<del> </del>		+	-	1		1	1	-		-	-	1		<del></del>		1	<del> </del>	-	+
ELEV   STA   WATER LOAD   WATER + EOKE LOADS   DE     1590   Q+00   - 25 + 3 + 5   - 30 + 3 + 6   - 5     1590   Q+00   - 11 + 2 + 7   - 13 + 2 + 8   - 2     1590   Q+00   - 11   + 2 + 7   - 13 + 2 + 8   - 2     1590   Q+00   - 11   + 2 + 7   - 13 + 2 + 8   - 2     1590   Q+00   - 3   O   - 1   - 4   O   - 1   O     1590   Q+00   - 26   O   - 12   - 3   O   - 14   - 1     1540   Q+00   - 26   O   - 12   - 3   O   - 14   - 1     1540   Q+00   - 39   + 14   + 11   - 46   + 16   + 13   - 15     1540   Q+00   - 39   + 10   - 4   - 46   + 16   + 13   - 15     1540   Q+00   - 39   + 10   - 4   - 46   + 16   + 13   - 15     1540   Q+00   - 39   + 10   - 4   - 46   + 16   + 13   - 15     1540   Q+00   - 39   + 10   - 4   - 46   + 16   + 13   - 15     1540   Q+00   - 55   + 54   + 9   - 65   + 64   + 11   - 34     1500   Q+00   - 55   + 54   + 9   - 65   + 64   + 11   - 34     1500   Q+00   - 55   + 54   + 9   - 65   + 64   + 11   - 34     1500   Q+00   - 55   + 24   + 9   - 65   + 64   + 11   - 34     1500   Q+00   - 55   + 24   + 9   - 65   + 64   + 11   - 34     1400   Q+00   - 55   + 43   - 12   - 10   + 12   - 15     1400   Q+00   - 59   + 14   + 9   - 16   + 11   + 10   + 10     1400   Q+00   - 196   - 194   + 10   - 194   + 10     1400   Q+00   - 196   - 194   - 194   + 10   + 10   + 10     1500   Q+00   - 24   - 95   + 17   - 29   + 113   + 20   - 74     1500   Q+00   - 24   - 95   + 17   - 29   + 113   + 5     1500   Q+00   - 91   - 34   + 5   + 109   - 41   + 6   - 166     1500   Q+00   - 91   - 34   + 5   + 109   - 41   + 6   - 166     1500   Q+00   - 91   - 34   + 5   + 109   - 41   + 6   - 166     1500   Q+00   - 91   - 34   + 5   + 109   - 41   + 6   - 166     1500   Q+00   - 91   - 34   + 5   + 109   - 41   + 6   - 166     1500   Q+00   - 91   - 34   + 5   + 109   - 20   - 100   - 20     1500   Q+00   - 91   - 34   + 5   + 109   - 20   - 100   - 20     1500   Q+00   - 91   - 91   - 91   - 91   - 91   - 91   - 91     1500   Q+00   - 91   - 91   - 91   - 91   - 91   - 91   - 91     1500   Q+00   Q+00   Q+		ď	2	0	3	N		2	12	9	S	00	0		9	8	32	N	1		34				2	(4)	2	3	24
ELEV   STA   WATER LOAD   WATER LOADS     1590   4+00   - 25 + 3 + 5   - 30 + 3 + 6   - 7 \times \text{0.7}	Ш		2	OI I	0	-	emonus	None of the last o	10 10	10	20	01			1	-	0					.0	1	10					
ELEV.   STA.   WATER LOAD   WATER FEOKE LOADS     1590   4+00   - 25 + 3 + 5 - 30 + 3 + 6     1590   8+00 - 11 + 2 + 7 - 13 + 2 + 8     1590   10+00   - 3   0 - 1 - 4   0 - 1     1590   12+00   - 19 + 1 - 6 - 23 + 1 - 7     1590   12+00   - 26   0 - 12 - 31   0 - 14     1590   12+00   - 26   0 - 12 - 31   0 - 14     1590   12+00   - 26   0 - 12 - 31   0 - 14     1540   12+00   - 62 + 15 + 18 - 74 + 18 + 21     1540   12+00   - 39 + 10 - 4 - 46 + 12 - 5     1540   12+00   - 39 + 10 - 4 - 46 + 12 - 5     1540   12+00   - 62 + 13 - 10 - 4 - 46 + 12 - 5     1540   12+00   - 62 + 13 - 10 - 4 - 46 + 15     1500   12+00   - 62 + 13 - 12 - 36 + 74 + 15     1500   12+00   - 62 + 43 - 12 - 36 + 74 + 15     1500   12+00   - 55 + 54 + 9 - 65 + 64 + 16     1500   12+00   - 56 + 43 - 13 - 65 + 64 + 16     1400   12+00   - 59 + 142 + 2 - 70 + 169 + 2 + 140     1400   12+00   - 59 + 142 + 2 - 70 + 169 + 2 + 140     1400   13+80   - 114 + 9 + 25 - 136 + 11 + 30     1300   12+00   - 24 + 95 + 17 - 29 + 113 + 20     1200   12+00   - 24 + 95 + 17 - 29 + 113 + 20     1200   12+00   - 24 + 95 + 17 - 29 + 113 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 95 + 17 - 28 + 11 + 6     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 + 24 + 26     1200   12+00   - 24 +										1			_			w		2	comme.	4	4	Managary .		S	a		N	9	9
ELEV. STA. WATER LOAD WATER + EQKE 1590 4+00 - 25 + 3 + 5 - 30 + 3 1590 8+00 - 11 + 2 + 7 - 13 + 2 1590 8+00 - 11 + 2 + 7 - 13 + 2 1590 12+00 - 26 + 7 - 13 + 2 1590 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 1 - 46 + 12 1540 15+00 - 62 + 15 + 18 - 74 + 18 1540 15+00 - 62 + 15 + 18 - 76 + 16 1540 15+00 - 63 + 7 - 18 - 76 + 16 1540 15+00 - 65 + 4 + 13 - 9 - 65 + 64 1500 10+00 - 44 + 13 - 9 - 65 + 64 1500 10+00 - 80 + 62 + 12 - 96 + 74 1500 10+00 - 55 + 54 + 9 - 65 + 64 1500 10+00 - 56 + 43 - 13 - 66 + 51 1500 10+00 - 59 + 102 - 14 - 107 + 122 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 176 - 84 - 90 - 234 - 100 1300 12+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 10 - 20 - 24 - 20 - 20 - 20 - 20 - 20 - 2	S		0	00	CONTRACTOR OF THE PERSON OF TH	METEROLOGICA CO.	4	-	NAME OF TAXABLE PARTY.	<u>~</u>	(COLUMN TO STATE OF S		CONTRACTOR AND A SECOND	nancucusanini committe	Darmon Mariner		NCOORDINATED IN COLUMN	ın	Section Control Section Control	Market Control	District Control			CHROSPORISES.		OTO COMPANY OF THE PARTY OF THE	+	MERLY ACCORDINATE CO.	S
ELEV. STA. WATER LOAD WATER + EQKE 1590 4+00 - 25 + 3 + 5 - 30 + 3 1590 8+00 - 11 + 2 + 7 - 13 + 2 1590 8+00 - 11 + 2 + 7 - 13 + 2 1590 12+00 - 26 + 7 - 13 + 2 1590 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 6 - 23 + 1 1540 15+00 - 26 + 1 - 1 - 46 + 12 1540 15+00 - 62 + 15 + 18 - 74 + 18 1540 15+00 - 62 + 15 + 18 - 76 + 16 1540 15+00 - 63 + 7 - 18 - 76 + 16 1540 15+00 - 65 + 4 + 13 - 9 - 65 + 64 1500 10+00 - 44 + 13 - 9 - 65 + 64 1500 10+00 - 80 + 62 + 12 - 96 + 74 1500 10+00 - 55 + 54 + 9 - 65 + 64 1500 10+00 - 56 + 43 - 13 - 66 + 51 1500 10+00 - 59 + 102 - 14 - 107 + 122 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 175 - 9 - 42 - 209 - 10 1400 12+00 - 176 - 84 - 90 - 234 - 100 1300 12+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 + 11 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 17 - 29 - 41 1200 10+00 - 24 + 95 + 10 - 20 - 24 - 20 - 20 - 20 - 20 - 20 - 2	OAD	Z X	-de	.l.o	g							7	N	N	шинопъ		- Sellings			N	Witnessen			CU		N	COLUMN TO SERVICE		N
ELEV. STA. WATER LOAD WATER + ECAD    1590	Ш				0	-	0	остоямей			7	9	<u>ر</u>	N			rù		9	0					0	200		COMPANIE OF THE PARIE OF THE PA	7
ELEV   STA.   WATER LOAD   WATER LOAD   WATER LOAD   WATER LOAD   Gx   Txy   Gx     1590   4+00   - 25 + 3 + 5   - 30     1590   8+00   - 11   + 2 + 7   - 13     1590   12+00   - 3   0   - 1   - 4     1590   12+00   - 26   0   - 12   - 31     1590   12+00   - 26   0   - 12   - 31     1540   12+00   - 26   0   - 12   - 31     1540   12+00   - 62   + 15   + 18   - 74     1540   12+00   - 62   + 15   + 18   - 76     1540   14+00   - 62   + 15   + 18   - 76     1540   14+00   - 63   + 7   - 18   - 76     1500   12+00   - 62   + 4   + 12   - 96     1500   12+00   - 55   + 54   + 9   - 65     1500   12+00   - 56   + 43   - 13   - 66     1400   12+00   - 56   + 43   - 13   - 66     1400   12+00   - 56   + 12   - 20     1400   13+80   - 114   + 9   + 25   - 136     1300   12+00   - 24   + 95   + 17   - 29     1200   10+00   - 24   + 95   + 17   - 29     1200   10+00   + 91   - 34   + 5   + 109     1500   10+00   + 91   - 34   + 5   + 109     1500   10+00   + 91   - 34   + 5   + 109     1500   10+00   + 91   - 34   + 5   + 109     1500   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+00   + 91   - 34   + 5   + 109     1100   10+		Ò	+	ala		ala a			-	Commentality.	ammont?	4000phasp		1						1	characters.	emi <b>sse</b> gog		oranies22	0	4001000/00000 40010000000000000000000000	,	4	5
ELEV.   STA.   WATER LOAD   STA			0	(4)	Dp.	3	~~		<del></del>		<del></del>						2		<del></del>	<u>ω</u>	1				4		00	<u>ω</u>	00
ELEV. STA. WATER LOAD   STA.   CX   CX   CX   Txx     1590   4+00   - 25 + 3 + 5     1590   8+00   - 11 + 2 + 7     1590   10+00   - 3   0   - 1     1590   12+00   - 10   + 1   - 6     1590   15+00   - 26   0   - 12     1540   4+70   - 40 + 18 + 7     1540   4+70   - 44 + 13   - 9     1540   12+00   - 39 + 10   - 4     1540   12+00   - 62 + 15 + 18     1540   12+00   - 62 + 15 + 18     1540   12+00   - 62 + 62 + 12     1500   12+00   - 55 + 54 + 9     1500   12+00   - 55 + 54 + 9     1500   12+00   - 56 + 43   - 13     1500   12+00   - 56 + 43   - 13     1300   12+00   - 59 + 142   + 2     1300   12+00   - 24   + 95   + 17     1300   12+00   - 24   + 95   + 17     1200   12+00   - 24   - 47   + 84     1200   12+00   - 24   - 47   + 84     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 34   + 5     1200   12+00   - 24   - 47   + 84     1200   12+00	WAT	b~		ancents	**************************************	1	(1)	7		4	1	l W		£	0)	9	70	9 -		-20	2		100220089	security.	N		- 28	1	<del>2</del>
ELEV. STA. WATER LOAD  1590 4+00 - 25 + 3 + 1  1590 10+00 - 3 0 - 1  1590 12+00 - 11 + 2 + 1 - 1  1590 12+00 - 10 + 1 - 2 + 1  1590 12+00 - 26 0 - 1  1540 4+70 - 40 + 18 + 1  1540 12+00 - 39 + 10 - 1  1540 12+00 - 62 + 15 + 1  1540 12+00 - 63 + 7 - 1  1540 12+00 - 63 + 7 - 1  1500 12+00 - 63 + 7 - 1  1500 12+00 - 63 + 7 - 1  1500 12+00 - 62 + 54 + 1  1500 12+00 - 55 + 54 + 1  1500 12+00 - 56 + 43 - 1  1400 12+00 - 62 + 122 - 1  1400 12+00 - 175 - 9 - 1  1400 12+00 - 196 - 84 - 1  1300 12+00 - 24 + 95 + 1  1200 10+00 - 24 + 95 + 1  1200 10+00 - 24 - 47 + 1	)kupike <del>nstik</del> er	>-	N	-	endalasida entresentación	O	N	r	80	Organización	4	<i>w</i>	00			o,	00	3	4	Ż	4	MATERIAL PROPERTY.	0	In	0	<u></u>	Ż.	announcement)	<u>~</u>
ELEV.   STA.   WATER	aD		+	+	d and	page 1970	guerrican	-4-			day	100 DOI	S. S	errouth.		ado.	***************************************	***	daweg	7	Stromenous	4						4	+
ELEV. STA.   WATER   STA.   Ox   Ox   Ox   Ox   Ox   Ox   Ox   O	707		9	N	0	1008333902	0				0	m	-	7	-		<u></u>	3	2	a	-								44
1590   4+00 - 2   1590   4+00 - 2   1590   4+00 - 2   1590   15+00 - 1   1590   15+00 - 1   1590   15+00 - 2   1540   15+00 - 3   1540   15+00 - 4   1540   15+00 - 6   1540   15+00 - 6   1540   15+00 - 6   1500   15+00 - 6   1500   15+00 - 6   1500   15+00 - 6   1500   15+00 - 6   1500   15+00 - 6   1500   15+00 - 12   1500   15+00 - 12   1500   15+00 - 12   1500   15+00 - 12   1500   15+00 - 24   1500   15+0	TER	Ь	afe	-		4		+					ado	4							GROWING.			4					
1590   4+00   -   1590   4+00   -   1590   4+00   -   1590   8+00   -   1590   15+00   -   1540   15+00   -   1540   15+00   -   1540   15+00   -   1540   15+00   -   1540   15+00   -   1500   15+00   -   1500   15+00   -   1500   15+00   -   1500   15+00   -   1500   15+00   -   1500   15+00   -   1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -     1500   15+00   -       1500   15+00   -       1500   15+00   -       1500   15+00   -       1500   15+00   -       1500   15+00   -         1500   15+00   -	WA	×			3	<u>Q</u> )	56	0		0		-	m			Ŋ		Q		2	-				9				
1590 4+00   1590 4+00   1590 4+00   1590 8+00   1590   15+00   1540   15+00   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1540   1500   1540   1500   1540   1500   1540   1500   1540   1500   1540   1500   1540   1500   1540   1500	all magnerous grant	Ь				١	-		Ī		-		)	1	I		7	1	1	mariumino.	ı		-	эмэнүү	NETONA.		11		50
1590   1590   1590   1590   1590   1590   1590   1540   1540   1540   1540   1500   1500   1500   1500   1500   1400   1400   1300   1300   1300   1200   1500	S	1	Ş	0	00	8	0	2	0	00	00	0	8	09	8	00	8	8	8	30	0	8	PARTICIPATE PROPERTY AND A	0	0	8	8	americans.	
1590   1590   1590   1590   1590   1590   1540   1540   1540   1540   1540   1500	C	n	J	ထ်	2	<u>Ž</u>	10	4	\$	00 +	† 0	7	4	4	\$	$\dot{\phi}$	<u></u>	12+	4	9	$\dot{\phi}$	<u>†</u>	7	4	\$ 00	9	7	<u>\$</u>	5-5
	2	ر د ال	90	90	0	0	00	0	9	5	0				8	Q				0	9				0		-		
	Ī	ח ח	70	50	<u>Š</u>	5.	155	2	Ň	2	15,4	15/2	12/2	2	<u>N</u>	150	150	150	25	140	7	70	<b>4</b>	<u>7</u>	36	3	$\frac{\omega}{\omega}$	2	500
3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	GE	4	Section 200	7	m	- Carpor	LO	10		m	7	0	Officers.	~1	~	4-j-	10	. ^	<b>×vot</b> umenos			<u> </u>	PROFESSIONAL PROFE	Market and the same of the sam	~	Munifors attention	10	,0	
	GA GA	, r	N-826 Day	-	***************************************	*	- CONTRACTOR OF THE PERSON OF		Service de la constante de la		- 1	- Topico	-		***************************************	COLUMN TO SERVICE STATE OF THE	~4 }	~	No.	3		7	N	Ö	Ś	7	2	Ñ	23

# NOTES

- I. STATIONS ARE PROJECTED RADIALLY FROM DISTANCES MEASURED ON AXIS OF DAM
- 2. ALL STRESSES ARE SURFACE STRESS IN PSI
- 3.  $\sigma_{\rm X}$  IS HORIZONTAL OR ARCH STRESS
- 4. OY IS VERTICAL OR CANTILEVER STRESS
- 5. TXY IS SHEAR STRESS
- 6. SIGNS: + IS TENSION - IS COMPRESSION

# CITY OF SEATTLE DEPARTMENT OF LIGHTING

INTERNATIONAL ENGINEERING COMPANY, INC.
ROSS HIGH DAM MODEL STUDIES
MODEL 2

ORTHOGONAL STRESSES WATER ELEVATION 1475 DOWNSTREAM FACE

JEROME M. RAPHAEL, FACULTY INVESTIGATOR

DRAWN: BL CHKD: CM APPROVED APPLACE

BERKELEY, CALIFORNIA

DATE: FEB. 1, 1971

FIG. 9

# STRESSES SH TA TA UPSTREAM FACE HORIZONTAL, VERTICAL &

DEAD LOAD

6A61

30 20 8

39 40 42

4

47 45

46 4 <del>2</del>

 $\chi_{\chi}$ 

9

n

0 (1)

	× 7	*				(Contrary Standard)						1		1-4-40		and 1			60 ************************************	Succession .		101	90	5.00		,	-	1
EA		L.	grafia	gond.	+		1	+	<u>-</u>	9	+	4	4	729	<i>v</i>	5	+	4	+	S	+	+	7	-	+		4	4
WATER+EQKE+DEAD L	ď	Ñ	34	24	94	32	123	7	104	2	9=	_	Ī	8	32	79	53	2	328	à	353	370	328	367	407	3%	249	264
Ę		<u> </u>	1		<u> </u>			1	1		1				1	1			١	1		-	1	1		1	1	
YTER-	o Z	क्र	28	58	39	N	ā	0	2	2	84	3	53	7	8	34	8	4	<u>0</u>	97	20	<u>N</u>	82	20	395	146	292	434
2		Insure Transmiss	1							l l	1		ı	- (		١			1	١	december	Without	1	1	١	and the same of th	•	Ì
LOAD	Σχγ	N	4		4		7	33	$\frac{1}{\omega}$	63	-	-		Q	മ	43	5	26	173	00	Ŋ	4	82	79	73	23	7	23
		+	1		+		1	+		+	+	+	+		900	1	+	+	+	1	+	-fr	+	· September	+	POPULATION		+
R+DEAD	$\sigma_{\gamma}$	25	34	24	04	32	22	2	2		<u>_</u>	<u></u>	143	93	33	2	53	88	318	78	332	350	314	354	399	381	255	269
1 +		-	1		d'antière :	to one	-	e.	١	-		1		gracore	0000	44				-				ì	-			
WATER	ď	28	24	50	33	00	a	૭	2	0	20	ALFRACIO	47	0	99	33	17	35	88	250	248	33	77	33	340	29	533	384
3					-	Decore	440	alasonia.		-		+	D) compa		directly.	884000	an and a second			1	, ,					ı	2	
	Z <sub>X</sub> Y	77	Ŋ	3	- Constitution of Constitution	N	-	2	22	3	7	4	00	W	0	7	4	80	83	78	7	3	84	00	35	N	4	2
AD	7	1	+	and the same of th	1		+	-	+	+	+	+	+	+	+	+			- Annual Control		n de	+	+	400				+
107		$\bar{\omega}$	38	22	42	32	5	80	104	02	50	n	N	3	3	3	0)	58	65	National Property Control	In	W	89	٥	58	4	J.	8
i	b				1		Output.		$ \simeq$	2	01	CONTORNAL DESCRIPTION OF THE PERSON OF THE P	3	9	0	4	2	3	N	4	22	2	26	289	35	304	285	20
DEAD			-	1	<u> </u>	-	<del>                                     </del>		-		1	1	ı		1			-	1	1	and an analysis	1	1		1	1	1	
	b×	2	S		0	2	2	4	7	outerests.	N	0	2	2	9	29	00	0	20	47	27	W	53	34	09	42	ī	128
	a de la constanta de la consta				-	1	4	4	ner comme		+	+		+	+		+	l										
LOADS	λ× <sub>2</sub>	9		2	9	7	0	onestable	42	39	ā	9	MODERNIA GEORGIA	4	23	59	watering .	0	2	37	4	25	2	- Capellon	45	8	N	7
19	-			+	+	+	-	+	1	+	+	+	+	Consulta			+	+			+	j.	+	September 1	+	١	4	+
EOKE	Ω <sup>ζ</sup>	4	7		N	0	9	$\overline{\omega}$	0	4	$\overline{\varrho}$	4	5	36	36	22	40	36	63	44	28	127	54	200	49	35	36	28
+		1	+	÷	+			-		9	١	1	1	the second	manufai manufai		1	1	1	ra-		ı			-	-	+	+
WATER	b×	36	26	S	30	23	25	24	0	108	98	22	4	0	9	Ŋ	102	30	$\overline{\omega}$	23	264	N	29	25	335	104	24	306
Ø.		1			1		Book	E-course		dition.	a de la composição de l	9	d Paresta.			o o o o o o o o o o o o o o o o o o o		t to the second			- 4	•		1		-	7	(1)
	×	S	Q	S	N	۰	9	9	35	32	0		Ø	Q	۵	50	o)	00	0	(n)	W	on.	· Stranger	ennyas	38	N	7	N
19	2	+		-de-		+	À	+	-	+	+	+	+	00000	ales to		+	+	1		+	+	+		+	1	+	+
LOAD		N	2	*diagrams	N	0	S	Watterns sometime	0	7	9	4	copporato	30	30	<u>∞</u>	34	30	533	2			25-	62			1	9
WATER	b	-	4	+	+	Mantham Continues Laboratory		-				9		(4)	(4)	-	W	9	rU	37	- 107	107	4	9	4	- 77	30	2
NAT		30	22	3	m	0	нарт		0	90	N	3	2	~	<u>'</u>	4	2		00	3	constant	0	(Separa	10			4	+
	b×	1 W	7	4	m	7	2	- 20		Q)	- 72	<u> </u>	3	- 22	- 82	7	8	- 25	- 68	- 103	- 22	- 30	- 24	0	-280	- 87	-202	-256
No.		O	0	O	0	0	0	Ö	0	Ö	Ö	0	Ó	<u></u>	6	0	<u>_</u>	0	5	0	0	0		6	0	0	0	4
1	<u>1</u> 0	5400	2+00	10+00	8+00	4+00	14+60	4-00	12+00	00+01	8+00	00+9	4+00	4.00	12+00	00±0	8+00	00+9	13+30	12+00	10+00	8+00	6+30	2+60	00+01	8+00	10+00	00+0
	>	590	90	590	590	590				540	540					0		0	00	00	00		<del> </del>	<del> </del>	00			0
	- L E V.	Š	ro o	5,	5	55	540	540	540	25	54	540	540	500	500	20	500	50	0	5	9	400	400	300	90	300	00	20

<u>a</u>

 $\overline{\omega}$ 

 $\overline{Q}$ 

3 20 5

- FROM DISTANCES MEASURED ON AXIS OF DAM I. STATIONS ARE PROJECTED RADIALLY
- ALE STRESSES ARE SURFACE STRESS IN PSI તં
- 3.  $\sigma_{\chi}$  IS HORIZONTAL OR ARCH STRESS
- 4.  $\sigma_{\gamma}$  IS VERTICAL OR CANTILEVER STRESS

3

 $\overline{\omega}$ 

5. Txy IS SHEAR STRESS

78

-

<u>万</u>

- IS COMPRESSION 6. SIGNS: + IS TENSION

# DEPARTMENT OF LIGHTING CITY OF SEATTLE

8

98 5

0

INTERNATIONAL ENGINEERING COMPANY, INC. ROSS HIGH DAM MODEL STUDIES ORTHOGONAL STRESSES WATER ELEVATION 1475 MODEL 2

> 8 2

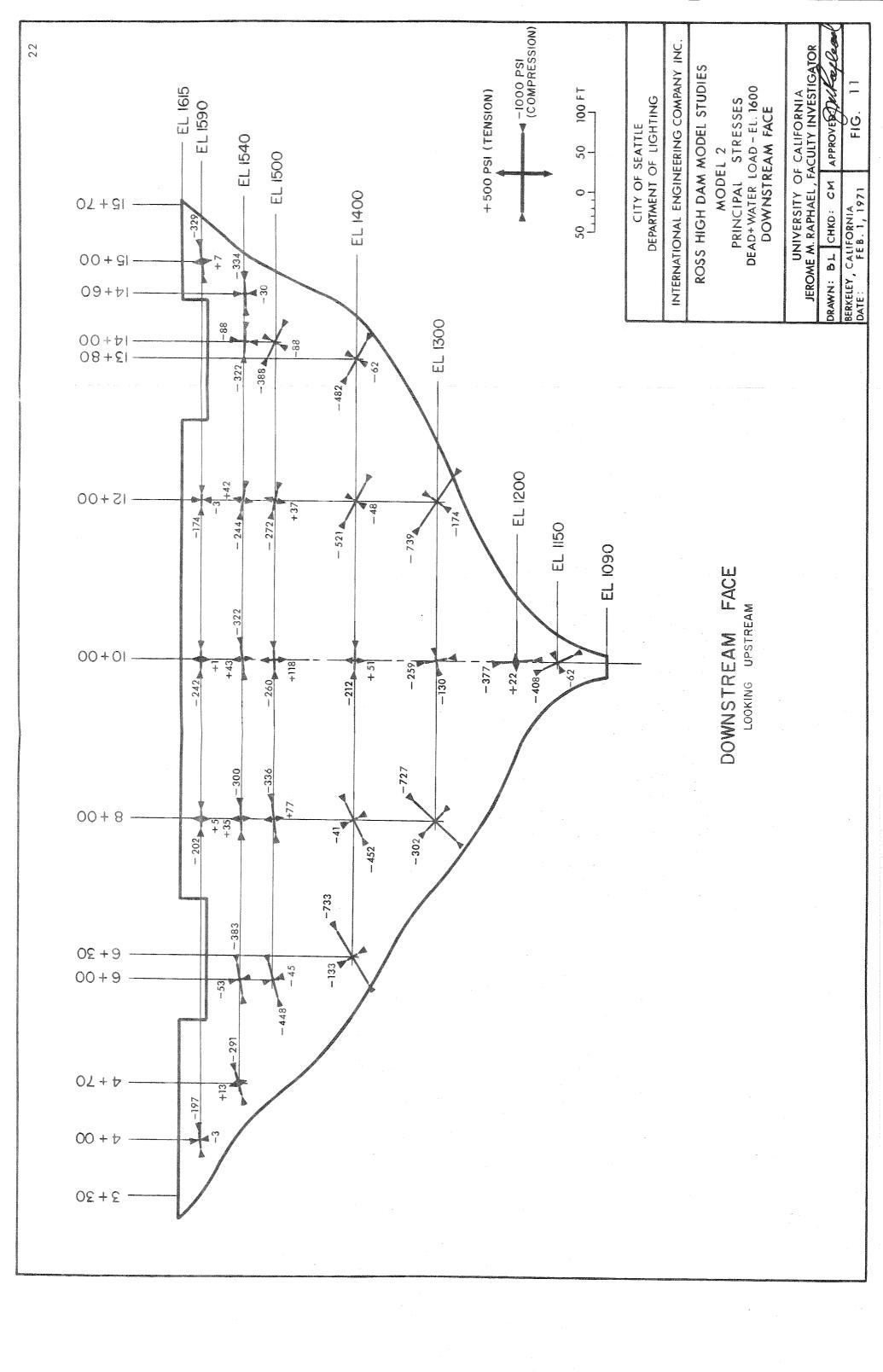
UNIVERSITY OF CALIFORNIA JEROME M. RAPHAEL, FACULTY INVESTIGATOR

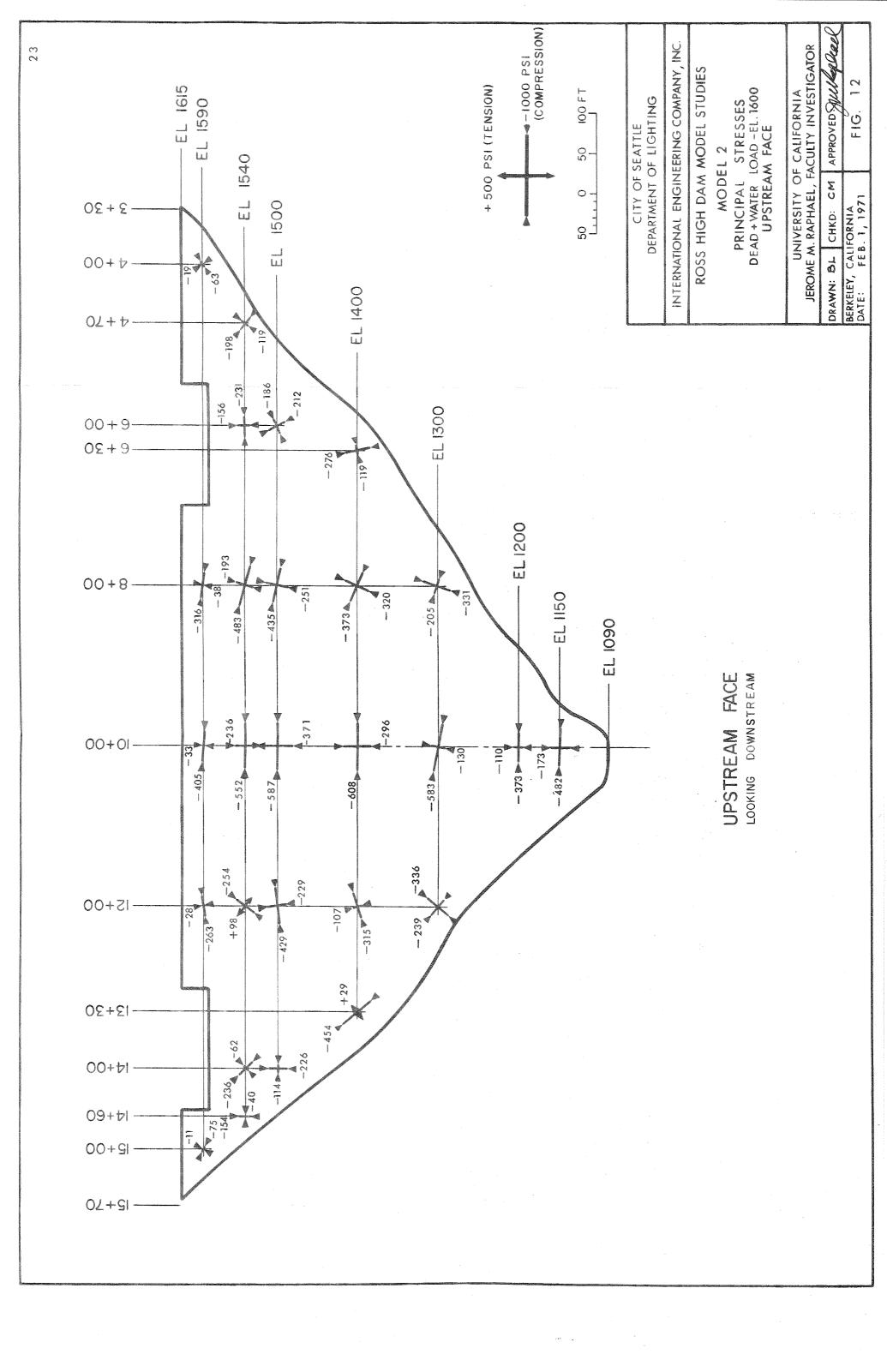
23

2

UPSTREAM FACE

DRAWN: BL CHKD: CM APPROVED WILL SIGNED BERKELEY, CALIFORNIA DATE: FEB. 1, 1971





# HORIZONTAL, VERTICAL & SHEAR STRESSES DOWNSTREAM FACE

		kalatorii badana q	TOXAN MARK	Name of the last o	Charles Street, Street	Sometiment	Tree-respondent	ionesonesia ionesonesia		SOMUTON MAN	<b>Sec</b> tions of	y	professional and the second	pioni il interna	gronistissause T	74000000000000000000000000000000000000	grammon.	Smean or com-	en e warreng	paramong.	DENG AND THE PERSON NAMED IN	uzan seren eren ere	Section Chammed .	- - -	omaniones of the second	sasawezeeeusany	na n	azzacina egele
WATER+EOKE+DEAD LOAD	λ× <sub>2</sub>	0	<u>00</u>	**************************************	7		99		W	2	4			72	19	4	1 2	100 +	Z	38	4 4.0	487	747	788	4	12 15 15 15	4	
730+3	7	4	63	22	9	and the state of t	-1		30	50	ō			20	63	75	77	5	ru Fu	02	40	50	10 4	2	82	<b>4</b> 50	34	011.00 <del>2</del> 70.000
+EQK	<b>b</b>		+	+	+		Management		- fr	-4	+				+	de .	nijes.		7	1	+	HOMEON .		7	7	7	7	
WATER	,×	-254	-309	-296	-252	NAMES OF THE PROPERTY OF THE P	- 45	management of the state of the	-394	-241	-334			-379	-433	-232	386	-368	447	-373	-287	4.92	8	32	<u> </u>	- 569	78	
LOAD	Σχγ	N	70	0	0		83	***************************************	7	0	20	SERVICE PROPERTY.	•	42	8	9	9	2	4	00	32	2	2	23	ANALES POR PERSON	217	2	na estatología
a t		15	4 の +	4	62		4		00	78	707			2	30	24+	(L)	+ 50	42	02	<b>ひ</b>	<del>+</del>	4	9	2	32+	8	-
+	у Д		+	+	+		1		4	4	+				da	+	4	1	-2	-	+	Marie Constant	40000000	15	7	Q'	4	
WATER	ď	23	-259	-248	7		- 120		-332	-202	-282			-319	-368	- - - - - - - - - - - - - - - - - - -	-327	-306	-366	-320	243	014-	283	4 10 10 10 10 10 10 10 10 10 10 10 10 10	130	-468	TO +	
	≿	The state of the s	M GALLERY	Q.	9	OUTS COLUMN TO THE	<u>Ø</u>	C SCHOOL STATE OF	4	2	4	) III II JAJANINO RANO	27-909-244-14-0	N	4	[ -	<u></u>	j	<u>(U</u>	4	00	<u> </u>	Metaconstr.	i m	C	Q	<u>~</u>	ANDONOS
	X	l	au and a	III.	ADD TO SERVICE OF THE PARTY OF		1		wļa.		+			+	62,0349	cacore	+		+		de action	-	s de la constante de la consta	+	augunod	+	+	
AD LOAD	ď	- 20	2	30	- 25		5		- 103	-128	00			0	- 38 - 38	38	- 53	<u>-</u>	- 73	134	182	-133	00	-204	-239	100 T	-237	
DEAD	×	5	d	0	3		rappacto wereget		70	W	2			Q)	34	S	24	0	2	4	9	2	70 TU	22	74	25	99	
	0		1				edu Mariane	Construence program	1	-þs		-	areases consequences	- de-	200	+	-		-la			Existing in the contract of th	-de-			+		-
LOADS	XX <sub>2</sub>	******	+	+	4		4		7	4	<u>+</u>			721	53	9 +	+ 52	4		- 24	48	+ 78	7	325	<u> </u>	+234	9 +	
关 (天)	Ž,	٥	24	52	40		43		333	00	<u>v</u>			78	200	4. 6. 6.	+227	w 4	-202	32	† 77,00 77	78	+ 79	373	AMERICANA REPRESENTA	000	<u>ن</u> د	
$\alpha$	ь× b	249	307 +	4 967	404		56 +		379 +	244 +	322 +			388	390	234 +	362 +	86	364	-326 +	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	4 78 +	9 4	1 8 10	67	- 179	+260	
W W		1	1		7	STANGE GROUPS AND	1	- Parameter (1980)		a consumer consumer	-	paratoristanting	in the second second					2	СРОКО ОЗВИТИНИК	ENGINEERING STATE		<b>TPAN</b> INCOME	in the second	exmechine actor.	-	NAMES AND ADDRESS OF THE PARTY	incompany was	om equi
0	XX Z	gamen (	9	4	1 W		40		9 -	1	9 +			44	4	T W	+ 43	+ 78	- م	104	40	+ 2	2 +	727	2	40%	00	
ER LOAD	b	٠ In	22	44	00.7		. 36			+ 50 -	09			23	89	202 +	<u>0</u>	8	00	72	<u>+</u>	N	25	2	0	2	4 10 9	
WATER	ر ک	708	-257 +	248 +	708 +		<u>_</u>		317 +	205	7/20 +			328	334 +	300	303 +	7 978	70	273 +	227 +	4004	34.8	433	50 50 4	28	1 2 2 +	
	~~~	errene et constant	CONTRACTOR DESCRIPTION		-	On with the second second	0	0	COMP. POR CALIFORNIA	1	-	0				-			1	1		ARTHRONOUS (STATEMENT	apanemento#s	l l	0	inguis service de la constante	A THE OWNER OF THE OWNER OWNER OF THE OWNER OWNER OF THE OWNER OWNE	
STA	7	4+00	8+00	00.0	12+00		4+70	8000	8+00	00+0	12+00	4-00		0+0	8+00	00 +01	12+00	4+00	28	00+8	950	2+00	88.8	00.48	0010	2+00	0000	
\ \ \ !	,    -  -	1600	1600	0091	009		1540	540	1540	1540	540	1540		500	1500	1500	1500	1500	<b>7</b> 50 <b>4</b> 50 <b>5</b>	400	400	400	400	1300	200	300	200	
GAGE	#	0	2	3	4		2		8	0	20	7	ouspe <mark>tations in</mark> 400	2	2	42	20	7.0	7	28	53	8	7	7	8	4	8	

# NOTES

- I. STATIONS ARE PROJECTED RADIALLY FROM DISTANCES MEASURED ON AXIS OF DAM
- 2. ALL STRESSES ARE SURFACE STRESS IN PSI
  - 3.  $\sigma_{\rm X}$  IS HORIZONTAL OR ARCH STRESS
- 4.  $\sigma_{\gamma}$  is vertical or cantilever stress 5.  $\mathcal{I}_{\chi\gamma}$  is shear stress
  - 6. SIGNS: +IS TENSION
     IS COMPRESSION

8

DEPARTMENT OF LIGHTING	INTERNATIONAL ENGINEERING COMPANY, INC.	ROSS HIGH DAM MODEL STUDIES
		OK.

MODEL 3 ORTHOGONAL STRESSES WATER ELEVATION 1600 DOWNSTRFAM FACE

CONTROL OF THE PARTY OF		
UNIVERSITY OF CALIFORNIA	JEROME M. RAPHAEL, FACULTY INVESTIGATOR	BL CHKD: CM APPROVED: SUNLAPPERP
	<	=
$  \ge $		0
IZ	5	-
]5	WE /	ವ
	JERO	DRAWN: 00L
Q.	6	

<u>.</u>

BERKELEY, CALIFORNIA DATE: FEB. 1, 1971

# HORIZONTAL, VERTICAL & SHEAR STRESSES

# UPSTREAM FACE

GAGE	i i	···	3	WATER	LOAD	Q	WATER	+	EQKE		LOADS	<b>Make</b> and wee	DEA	9 0	AD		WATE	R+DEA	0	LOAD	WATER+EQKE+DEAD	+EQKE+	DEA	0	LOAD
	ГГГ V.	1 n	b	þ		XX Z	ρ×		Qγ	7	XX <sub>Z</sub>	6	×	Ç	7	×	ď	ò	<u> </u>	L <sub>X</sub> X	ь×	٥٨		λ× <sub>2</sub>	
			Paris i richinanza a																						
46	1600	12+00	-253	1	67	+ 3	3 - 303	(D)	80	+	10	ļ.	3	- 36	+	in	-255	9	4	$\overline{\omega}$	-305	-	4	N	0
47	1600	00+01	-353	-	00	-	6 -422	01	9	1	00	1	7	200	auges .	3	-360	- 33		മ	-429		34	***************************************	
48 8	1600	8+00	-347	1	22 -	+ 36	4 4 4	-	26	+	43		0	- 42	41.00	**************************************	-347	20 1	+	35	7414	9	00	4	Ö
20	1600	4+00	-103		0		3 - 23	W	0	1	4	4	2	32	1	N	0	- 32	1	S	2	3	7	١.	0
				-			PORETA CALCUMA					pokry laterings w gazza													1
2	1540	14+00	<u> </u>	ŀ	- 89	-	7 - 18,7		$\overline{\infty}$	Special	7	4	4	108	+	72	43		+ 9	F	1.33	8	9		3
52	1540	12+00	-353	1 49	9	42	2 -422	01	<u>7</u>	١	20	1	7	104	+	22	-374	-253	1	20	443	-283	8	~	000
53	1540	10+00	-491	1 2 2	-	4	1 - 586	1	78	+	9			-102	+	8	-502	-25	+	45	- 597	- 280	0		C d
54	1540	8+00	-446	etzepop)	48 4	+ 68	8 - 533	3	177	+	$\overline{\omega}$	+	7	76.	+	1	-444	-245	+	75	- 531	-27	74	00	89
55	1540	00+9	-186		777 +	+ 45	72	7	92	+	54	4	<u>@</u>	<u>-</u>	+	4	191-	192	+	45	-203	-20	+		83
25	540	4+00	<u>n</u>	9	supplication	+ 24		1	73	+	80		7	.132	4	00	7	   <u> </u>   <u> </u> <u> </u>	+	32	- 83	1 20	<del>†</del>	w	0
	70.00										-														
									A not continue a laboratoria de la continue de la c					Property and the second			Average of the state of the sta				acrano pri andra arranda arranda especial de la constanta de l	***			I
							essetta conourse,																	**CONTRACTOR OF THE CONTRACTOR	
						nessessipatoreanii appini oose	<b>300</b> a 134 2 1 4 1 1 4 1					bit fra use a sign									niceter circle rigores en conservation en				
			04830 OMBA									and and an													
57	1400	3+30	2 - -	and the second	7	<del>م</del>	<u>1</u>		<u>n</u>	+	08	<i>'V</i>	20  -	265	+	83	- 149	-277	+	274	72	7	- 0 0	29	estration contracts
	1400	12+00	-337	- 83	<i>w</i>	0	5 -402	1	9	-	2	+	471-	7	Acquit	78	-290	- 124		88	-355	- 140	0	8	0
	4.00	10+00	-573	100	+ 1	- 26	6-692	1	9	+	3	7	7	-225	+	7	909-	-322	. +	78	7 - 0	-34			33
09	1400	8+00	-36	7 46	9	3	-432	1	2	-	37		3	243	+	3	-364	-289	1	80	-435	- 29	1	w	32
	400	6+30	1	+ 527	1	43	4 07	+	3	1	2/2		53	268	+	400	- 142	7	+	20	091 -	0			00
23	1300	12+00	791 -	+ 42	4	* 29	9 – 193	+	20	+	35	111	34	289	deserve	29	30	-247	1	<del>4</del>	-227	- 239	<u></u>	Q-	3
	1300	00+01	-527	+ 57	+		9 629	+	88	+	**************************************	7	09	358	+	35 10	-587	-28	+	Ages Ages	689-	5	0		3
29	1300	8+00	- 163	= 1	N I		\\ \frac{1}{5} \]		_		9	7	42	304		7	- 205	-319		26	-236	-32		. 2	27
65	1200	10+00	-352	+245	52		2 - 421	+	293	g and a	9	5 1	-	285		T	-403	- 40		9	72.4-	*	00		
99	1150	10+00	-294	+212	<u></u>	0	-35	+	254	1	2		28	292	+	7	-422	08	+		-479	7	4	o constant of	<i>σ</i> /

# NOTES

- I. STATIONS ARE PROJECTED RADIALLY FROM DISTANCES MEASURED ON AXIS OF DAM
- 2. ALL STRESSES ARE SURFACE STRESS IN PSI
- 3.  $\sigma_{\rm X}$  IS HORIZONTAL OR ARCH STRESS
- 4.  $\sigma_{\gamma}$  IS VERTICAL OR CANTILEVER STRESS
- 5. TXY IS SHEAR STRESS
- 6. SIGNS: +IS TENSION - IS COMPRESSION

	بنا	HOHING
	-	$^{\circ}$
	-	_
	⋖	S. Balance
Name of the last o	SEATTLE	
	CITY OF	DEPARTMENT OF
	>	w
	-	5
	-	h
	$\cup$	04
ě		⋖
100		Ω.
		LL.
2		ل

INTERNATIONAL ENGINEERING COMPANY, INC.

ROSS HIGH DAM MODEL STUDIES

MODEL 3

ORTHOGONAL STRESSES

WATER ELEVATION 1600

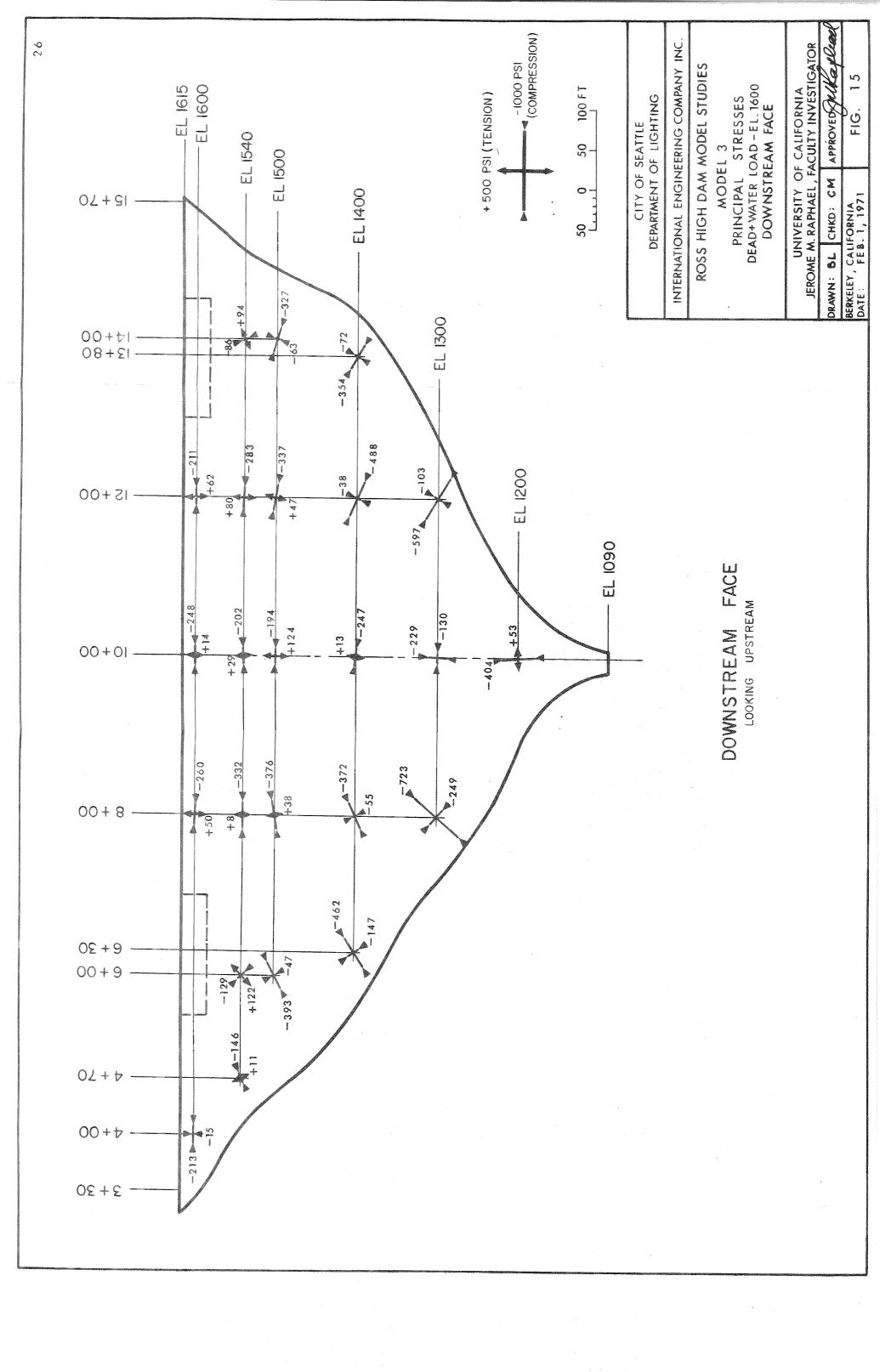
UNIVERSITY OF CALIFORNIA JEROME M.RAPHAEL, FACULTY INVESTIGATOR

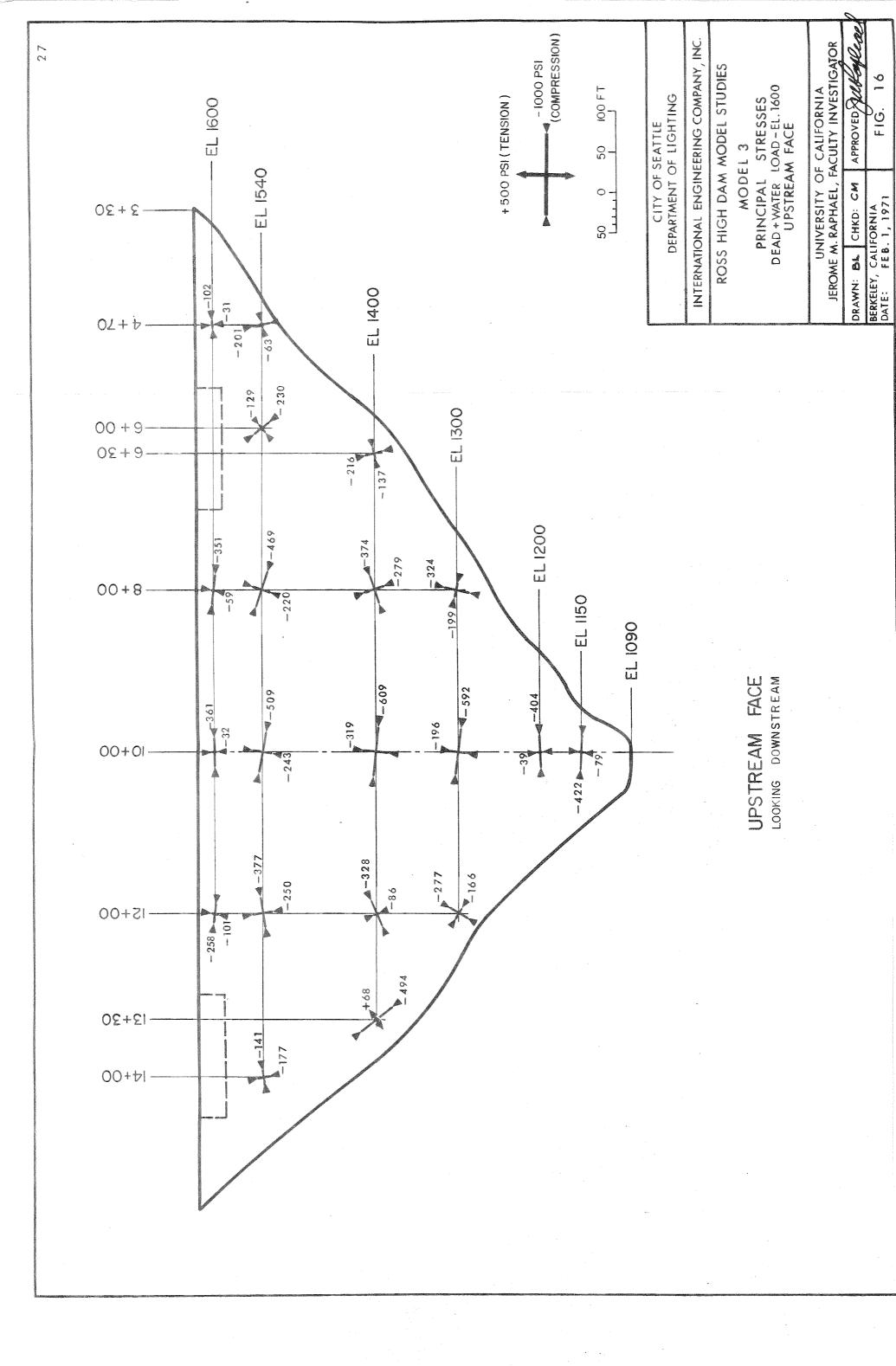
UPSTREAM FACE

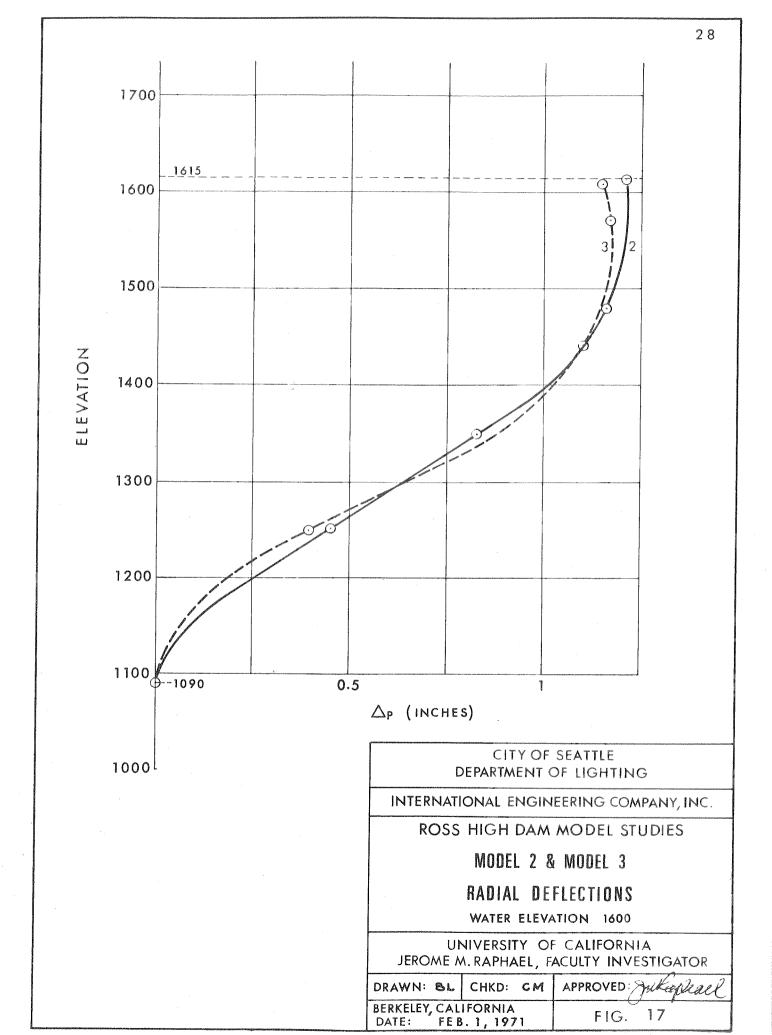
DRAWN: BL CHKD: CM APPROVEDS WARDER BERKELEY, CALIFORNIA

FIG. 14

DATE: FEB. 1, 1971







APPENDIX B

TABLES

TABLE 1

COMPARISON OF STRESSES

DEAD PLUS WATER LOAD TO ELEVATION 1600

DOWNSTREAM FACE

G/	\GE	1	EV.	STATION	ARCH S	TRESSES	CANT	ILEVER	STRE	ESSES
MODEL 2	MODEL 3	MODEL 2	MODEL 3	STATION	MODEL 2	MODEL 3	MOD	EL 2	MOD	EL 3
l	10	1590	1600	4+00	- 194	- 213	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	6	Appendix Commence of the Comme	15
2	12	1590	1600	8+00	- 202	- 259	+	5	+	49
3	13	1590	1600	10+00	- 242	- 248		0	+	14
4	14	1590	1600	12+00	- 174	- 211		3	+	62
5		1590		15+00	- 324		+	Î		
6	16	15	40	4+70	- 270	- 120	Money	8		14
7		15	40	6+00	- 372			65	,	
8	18	15-	40	8+00	- 299	- 332	+	35	-	8
9	19	154	40	10+00	- 318	- 202	-4-	40	4-	28
10	20	154	40	12+00	- 239	- 282	+	37	+	79
		154	40	14+00	- 321		- Spires	89		
12		154	40	14+60	- 334			31		
13	22	150	00	6+00	- 424	- 319	epres	69	ssandings	121
14	23	150	00	8+00	- 329	- 368	+	70	4-	30
15	24	150	00	10+00	- 259	- 194	en fina	117	+	124
16	25	150	00	12+00	- 257	- 327	+	23	+	37
17	26	150	00	14+00	- 333	- 306	questg	142	**************************************	85
18	27	140	00	6+30	- 575	- 366	*****	290	uggestion.	242
19	28	14(	00	8+00	- 371	- 320	- Carriery	122	- Paring	107
20	29	140	00	10+00	- 211	- 243	-4-	50	+	9
21	30	140	00	12+00	-410	- 416	ggyerd#	58	ativingsing	110
22	31	140	0	13+80	- 392	- 283	gogania.	152	· gastraddd	144
23	32	130	0(	8+00	- 501	- 455		528		516
24	33	130	00	10+00	- 134	- 130	queire	255	Motoracy	229
25	34	130	00	12+00	- 550	- 468		362		232
26	35	120	00	10+00	+ 20	+ 51		374	gyconie	402
27		115	50	10+00	- 125		and a	345		

# TABLE 2 COMPARISON OF STRESSES DEAD PLUS WATER LOAD TO ELEVATION 1600 UPSTREAM FACE

GA	\GE	ELEV.		VDCH C	TRESSES	CANTILEVER	CTDECCEC
		MODEL MODEL	STATION		<u> </u>		
A CONTRACTOR OF THE PROPERTY OF THE PARTY OF	MODEL 3			MODEL 2	MODEL 3	MODEL 2	MODEL 3
28		1590 1600	15+00	- 62		- 24	
29	46	1590 1600	12+00	- 257	- 255	- 34	- 103
30	47	1590 1600	10+00	- 404	- 360	- 34	- 33
31	48	1590 1600	8+00	-310	- 347	- 43	- 64
32	50	1590 1600	4+00	- 50	- 101	- 32	- 32
33		1540	14+60	- 40	·	- 154	
34	51	1540	14+00	- 146	- 143	- 152	- 176
	52	1540	12+00		- 374		- 253
36	53	154 <i>0</i>	10+00	- 552	- 502	- 236	- 251
37	54	1540	8+00	- 461	- 444	- 216	- 245
38	55	1540	6+00	- 231	- 167	156	- 192
39	56	1540	4+00	- 166	- 71	- 151	- 193
40		1500	14+00	-114		- 226	
41		1500	12+00	- 425		- 234	
42	·	1500	10+00	- 587		- 371	
43		1500	8+00	- 427		- 259	
44		1500	6+00	- 191		- 208	
45	57	1400	13+30	- 171	-149	- 253	- 277
46	58	1400	12+00	- 296	- 290	- 125	- 124
47	59	1400	10+00	- 608	- 606	- 296	- 322
48	60	1400	8+00	- 364	- 364	- 329	- 289
49	61	1400	6+30	- 125	- 142	- 270	- 211
50	62	1300	12+00	- 279	- 196	- 295	- 247
51	63	1300	10+00	- 565	- 587	- 148	- 201
52	64	1300	8+00	- 219	-205	- 318	- 319
53	65	1200	10+00	- 373	-403	- ///	- 40
54	66	1150	10+00	- 481	-422	- 174	- 80