229 AE

ANDREW PHASE II

JOINT INDUSTRY PROJECT

PROGRESS MEETING NUMBER 1

NOVEMBER 16, 1994

PMB ENGINEERING, INC.

ANDREW PHASE II JOINT INDUSTRY PROJECT
PROGRESS MEETING NUMBER 1
NOVEMBER 16

AGENDA

INTRODUCTION & OVERVIEW OF PROJECT (R. L. SMITH)	9:00
UPDATE RECIPE (R.W. LITTON)	9:30
BREAK	10:30
MSL PRESENTATION ON JOINTS & CONTINUE UPDATE RECIPE	10:45
ANDREW STORM CONDITIONS UPDATED (R.W. LITTON)	11:45
LUNCH	12:00
PLATFORM SELECTION (D.K. DOLAN)	1:00
BAYESIAN CALIBRATION (RAJIV AGGARWAL)	2:00
DISCUSSION (R. L. SMITH)	3:30
REVISIT WORK PLAN (R. L. SMITH)	4:00
ADJOURN	4:30

ANDREW PHASE II

LIST OF PARTICIPANTS

- AMOCO PRODUCTION COMPANY
- CHEVRON PETROLEUM TECHNOLOGY COMPANY
- EXXON PRODUCTION RESEARCH COMPANY
- MINERALS MANAGEMENT SERVICES
- MOBIL RESEARCH AND DEVELOPMENT CORPORATION
- PHILLIPS PETROLEUM COMPANY
- SHELL OIL COMPANY
- UNOCAL CORPORATION

ANDREW PHASE I

OBJECTIVES AND RESULTS

- DEVELOPED A DATABASE OF PLATFORMS AFFECTED BY ANDREW
- DEVELOPED AN ULTIMATE CAPACITY ANALYSIS RECIPE & PROCEDURE
- IDENTIFIED DEFICIENCIES IN ULTIMATE CAPACITY ANALYSIS PROCESS
- DEVELOPED A BAYESIAN UPDATING PROCEDURE
- ESTABLISHED A GLOBAL BIAS FACTOR FOR PLATFORMS
- PROVIDED EXAMPLES FOR THE USE OF THE BIAS FACTOR

ANDREW PHASE II

PROJECT OBJECTIVES

- **UPDATE MODELING AND ANALYSIS RECIPE**
  - **JOINTS**
  - **BRACES**
  - **WAVE PROFILE**
  - **FOUNDATIONS**
  - **CONDUCTORS**
- **ANALYZE PLATFORMS USING UPDATED RECIPE**
  - **PLATFORMS SELECTED FROM FAMILY OF EXISTING STRUCTURES USED IN PHASE I**
  - **POSSIBLE REPLACEMENT IF MORE MEANINGFUL PLATFORM(S) FOUND**
- **EXPAND BAYESIAN CALIBRATION**
  - **TWO BIAS FACTORS DEVELOPED – JACKET AND FOUNDATION**
  - **UTILIZE RESULTS OF THE API/MMS FOUNDATION PROJECT**
  - **PRODUCE EXAMPLE USING EXPANDED PROCEDURE**

SUBSEQUENT PROJECTS

- MMS INSPECTION PROJECT
- API/MMS CAISSON PROJECT
- API/MMS FOUNDATION PROJECT
- TRIALS/BENCHMARK JIP

ANDREW PHASE II

PROJECT TEAM

■ R. L. SMITH	PROJECT MANAGER
■ F. J. PUSKAR	PROJECT ADVISOR
■ R. W. LITTON	TECHNICAL MANAGER
■ R. AGGARWAL	TECHNICAL DEVELOPER
■ D. K. DOLAN	TECHNICAL ADVISOR
■ C. A. CORNELL	RELIABILITY CONSULTANT
■ F. MOSES	RELIABILITY CONSULTANT
■ MSL ENGINEERING, LTD	TUBULAR JOINT CONSULTANT

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UPDATE MODELING AND ANALYSIS RECIPE

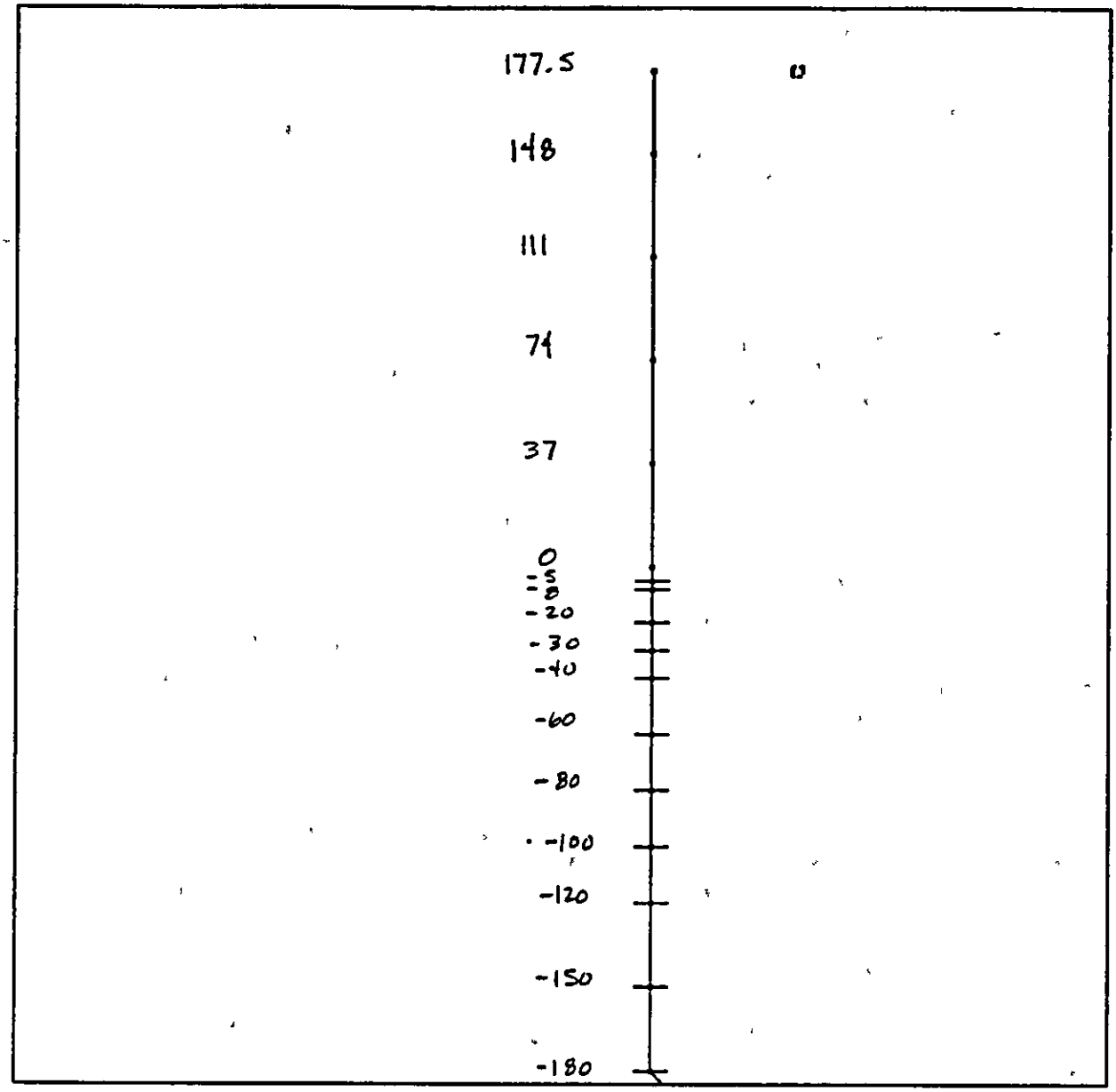
- CONDUCTOR RESISTANCE
- WAVE FORCE PROFILE
- BRACE MODELING
- FOUNDATIONS
- JOINT MODELING

ANDREW PHASE II

CONDUCTOR RESISTANCE

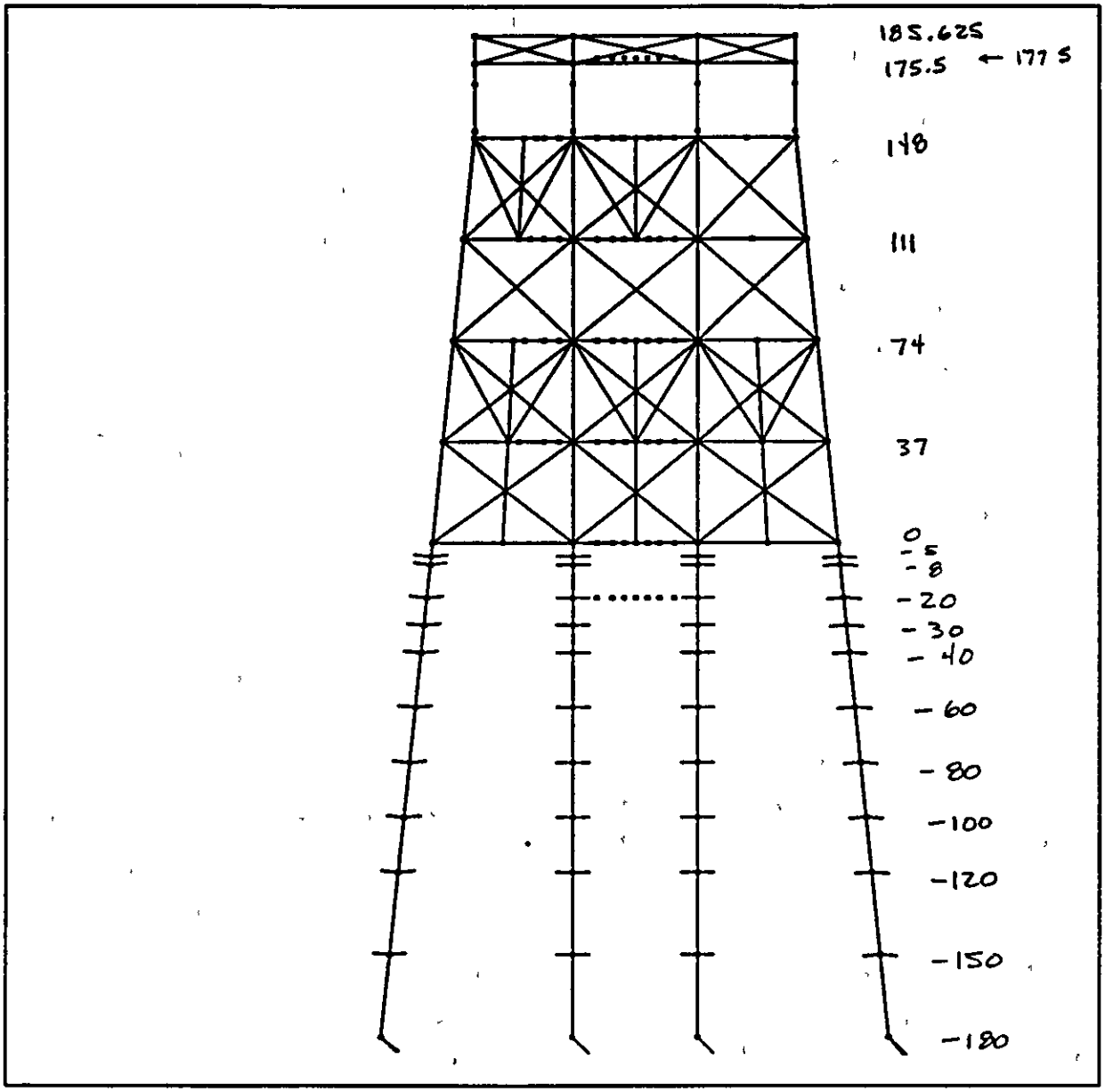
- **RESISTANCE NOT INCLUDED IN PHASE I**
- **CONTRIBUTION TO OVERALL RESISTANCE A PHASE II STUDY ISSUE**
- **COMPARE FOR 4-LEG AND 8-LEG PLATFORM**
- **CONSIDER CONDUCTOR POSITION IN GUIDES**
  - **1/3 LEFT, 1/3 CENTER, 1/3 RIGHT**

Project: ST151K Model: Conductor Version: 1 Mon Nov 14 14:31:40 1994 *



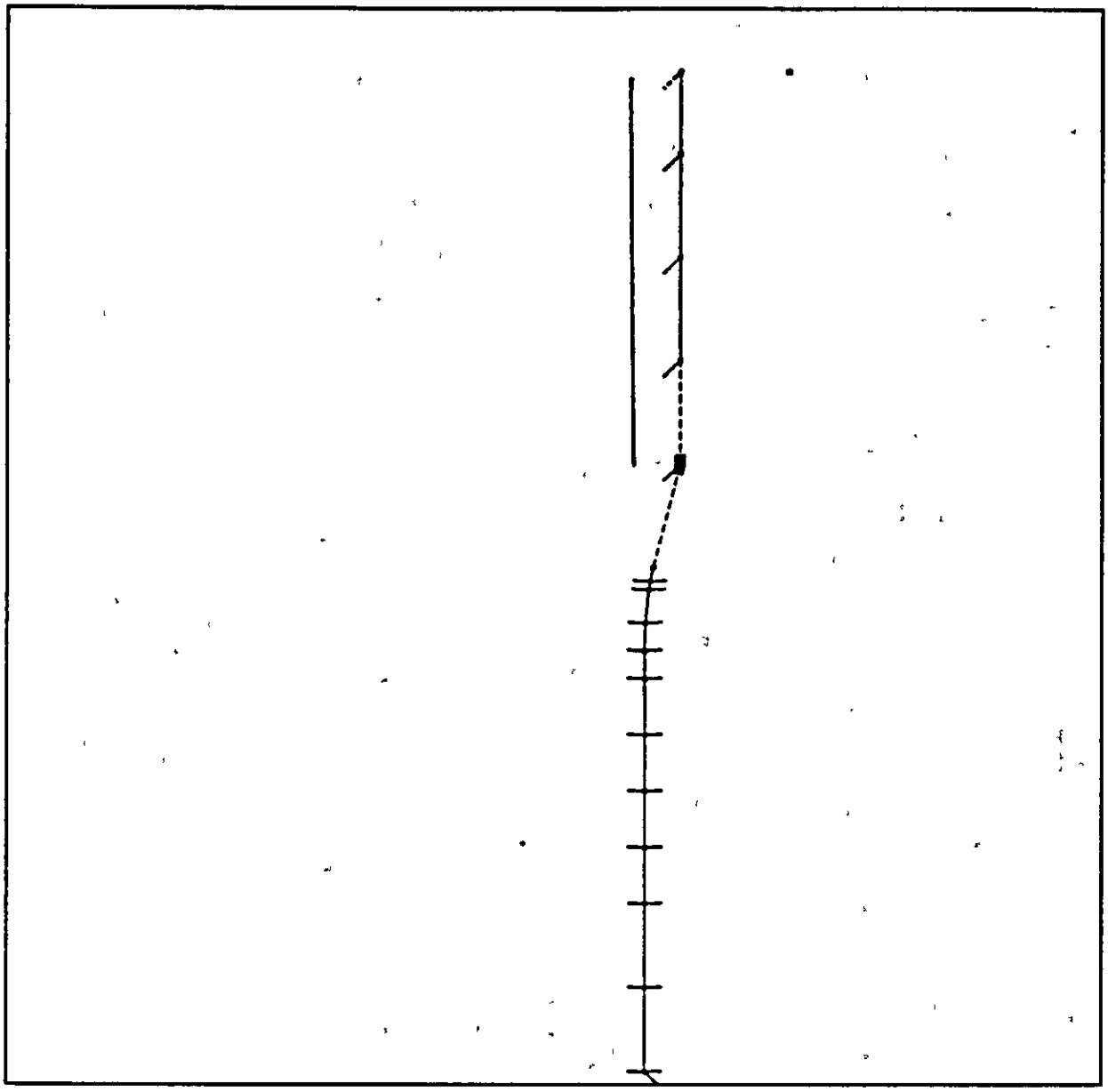
CAP z↑ →x Single Conductor Model

Project: ST151K Model: dir_2 Version: 7 Mon Nov 14 12:42:00 1994 *



CAP z x

Project: ST151K Model: Conductor Version: 1 Mon Nov 14 14:06:20 1994 *

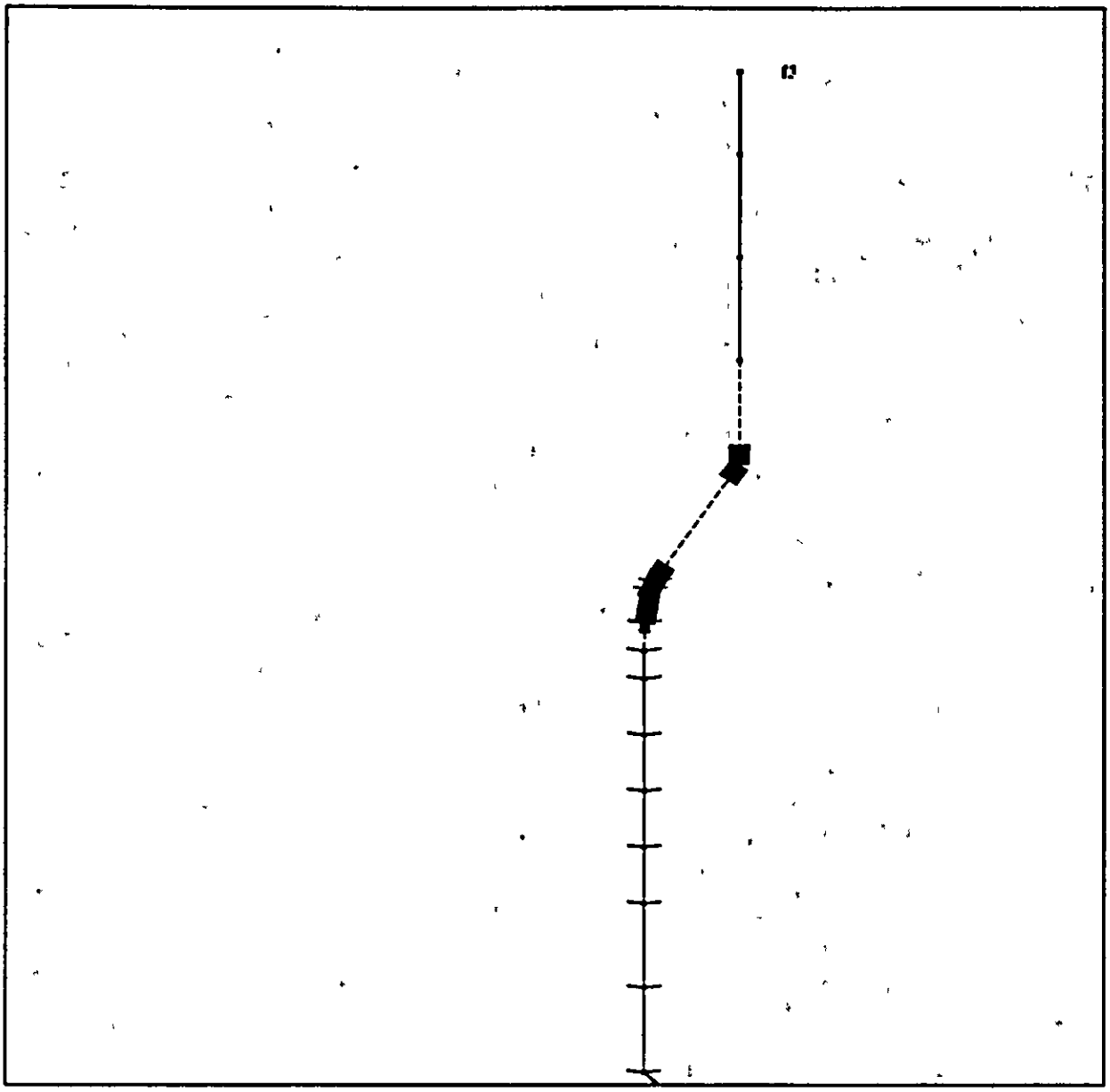


Uniform Displacement: step 6

Inelastic Events Legend

———	Elastic	.....	Strut Buckling
- - - - -	Strut Residual	- - - - -	Strut Reloading
.....	Plastic Strut/NLTruss	———	Beam Clmn Initial Yield
———	Beam Clmn Fully Plastic	.....	Fracture

Project: ST151K Model: Conductor Version: 1 Mon Nov 14 14:27:35 1994 *

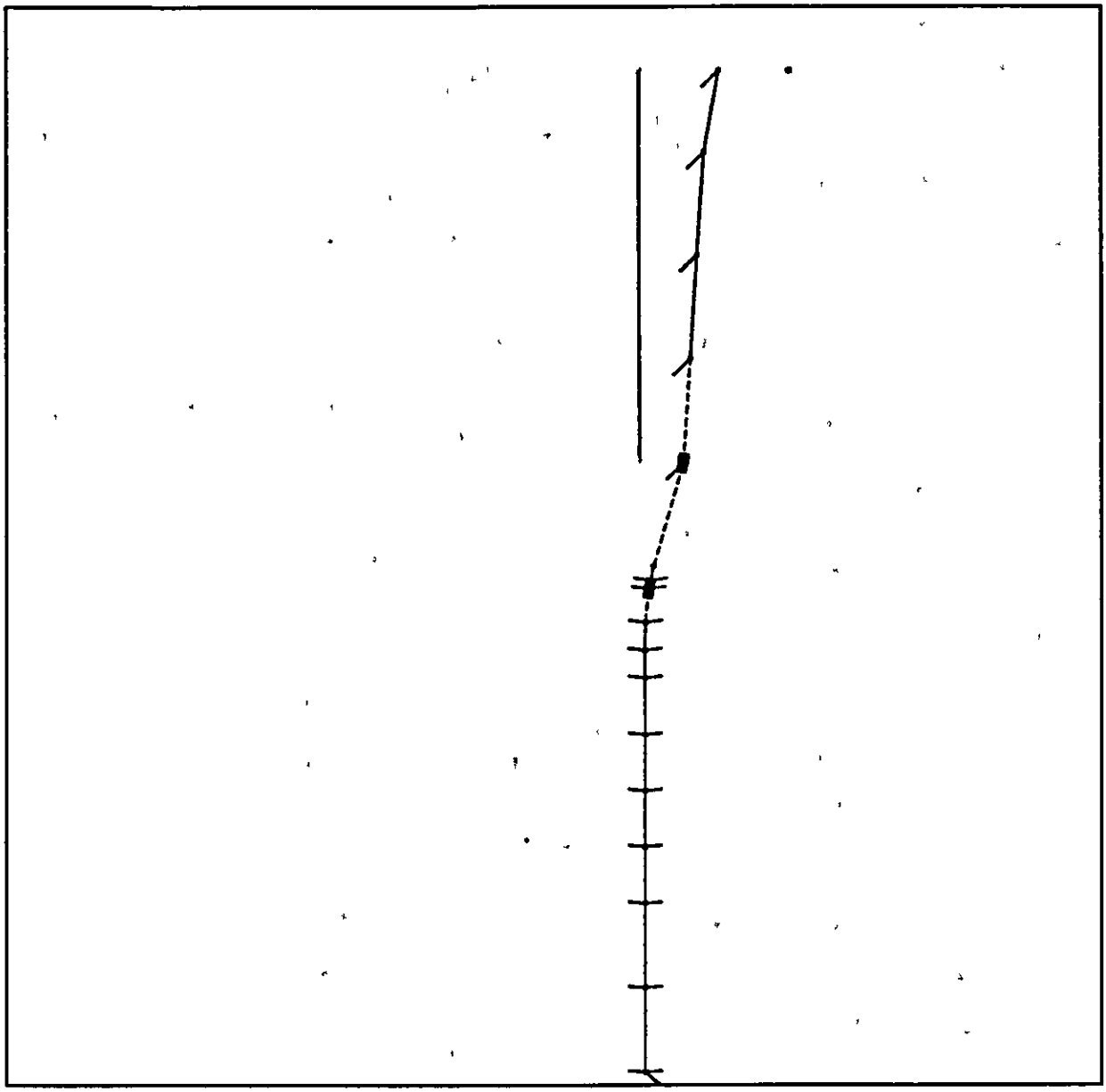


CAP z↑ →x Uniform Displacement: step 33

Inelastic Events Legend

———	Elastic	.....	Strut Buckling
- - - - -	Strut Residual	- - - - -	Strut Reloading
.....	Plastic Strut/NLTruss	- - - - -	Beam Clmn Initial Yield
———	Beam Clmn Fully Plastic	.....	Fracture

Project: ST151K Model: Conductor Version: 2 Mon Nov 14 14:20:25 1994 *

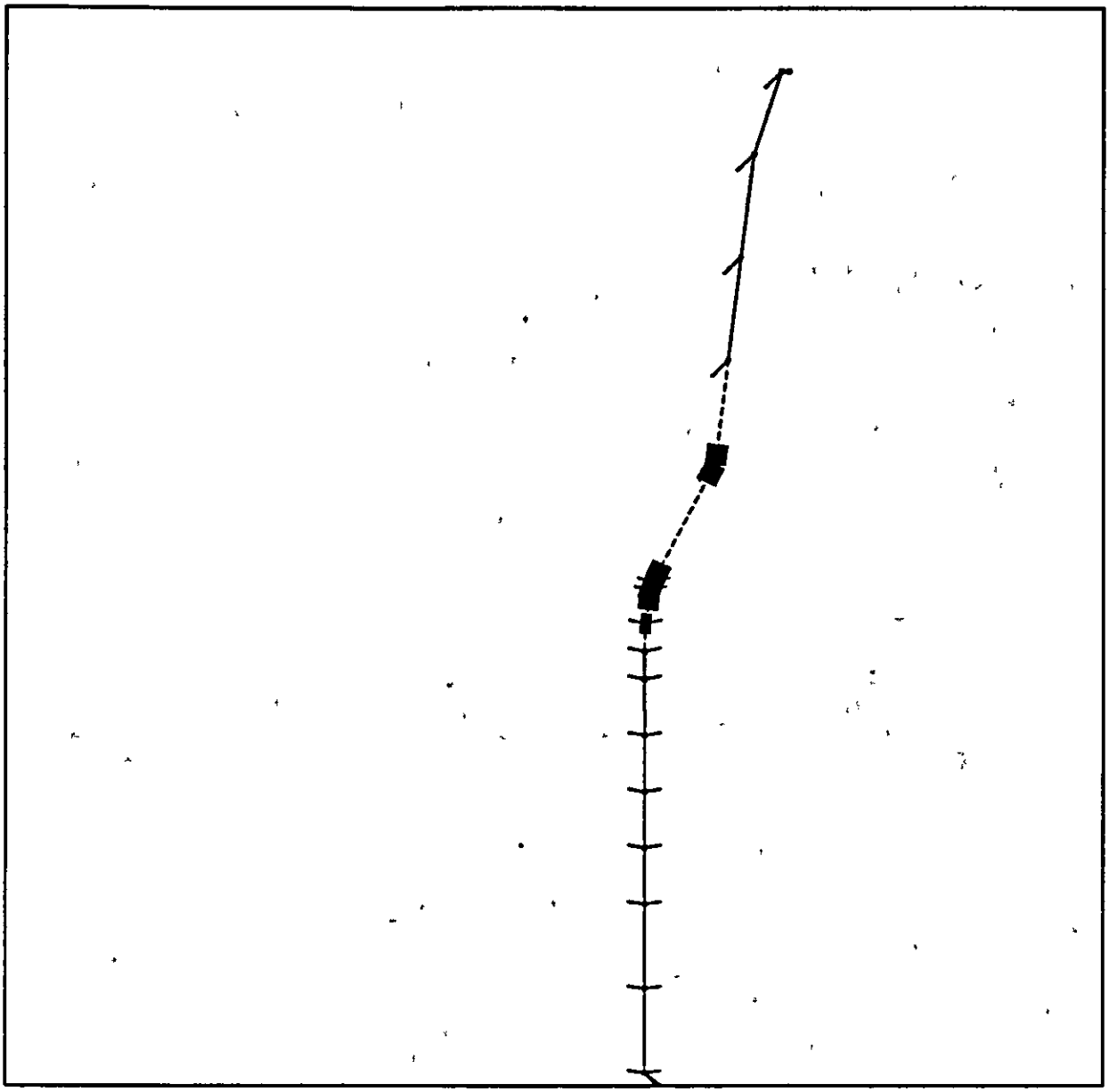


CAP z x Variable Displacement: step 9

Inelastic Events Legend

_____	Elastic	.....	Strut Buckling
- - - - -	Strut Residual	- - - - -	Strut Reloading
.....	Plastic Strut/NLTruss	- - - - -	Beam Clmn Initial Yield
_____	Beam Clmn Fully Plastic	.....	Fracture

Project: ST151K Model: Conductor Version: 2 Mon Nov 14 14:21:45 1994 *

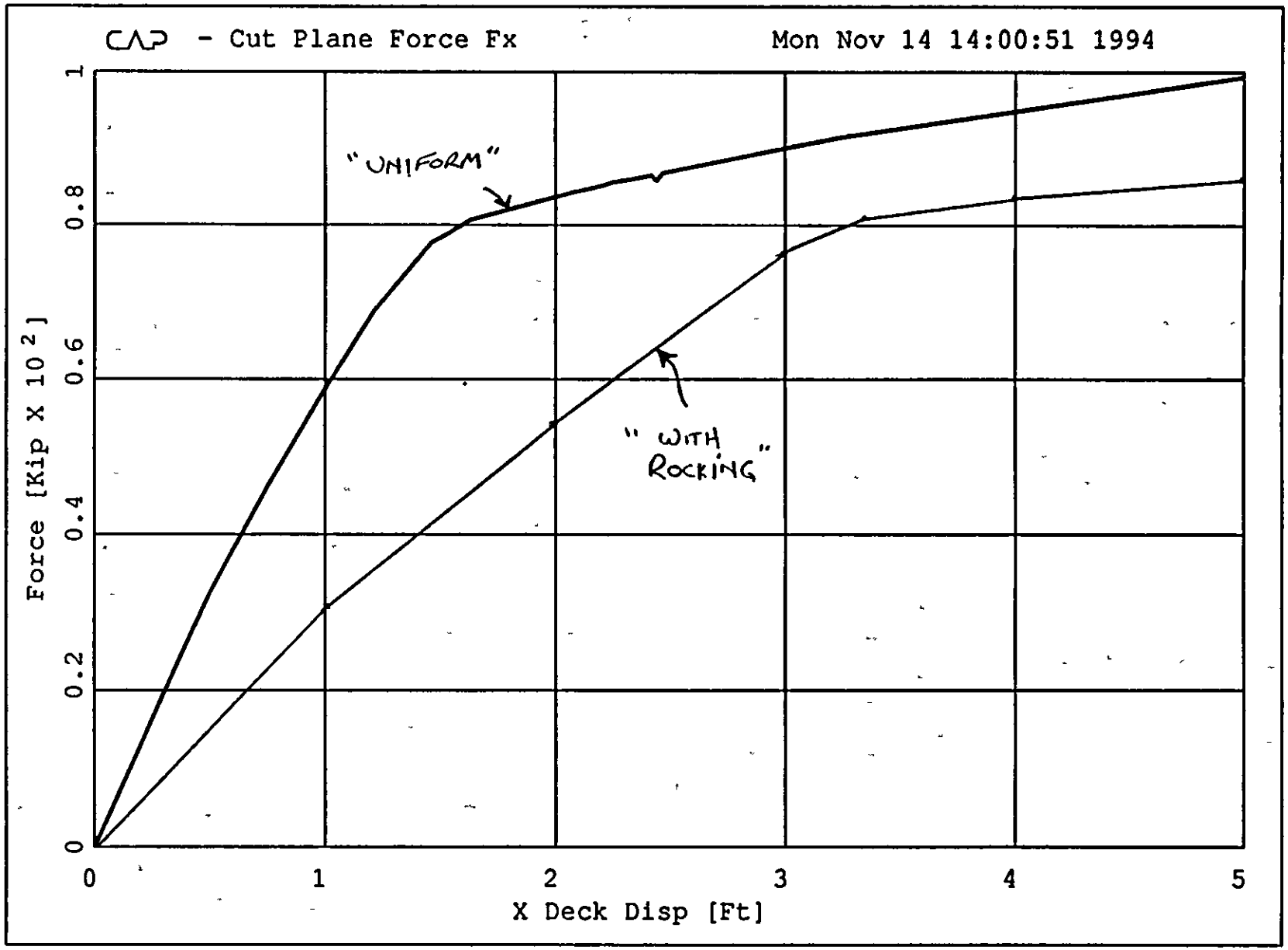


CAP Z↑ →X Variable Displacement: step 35

Inelastic Events Legend

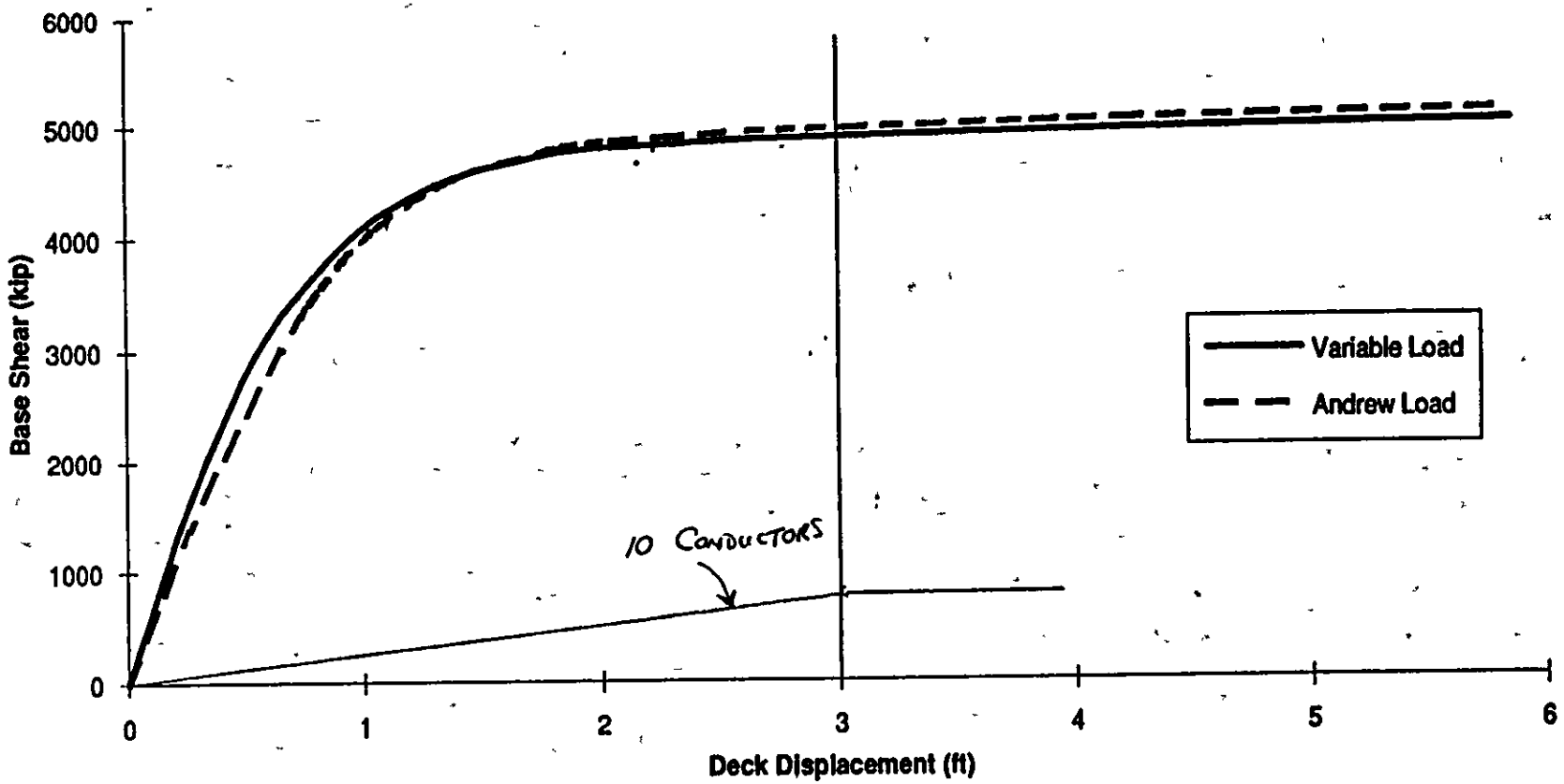
———	Elastic	.....	Strut Buckling
- - - - -	Strut Residual	- - - - - -	Strut Reloading
.....	Plastic Strut/NLTruss	- - - - -	Beam Clmn Initial Yield
———	Beam Clmn Fully Plastic	.....	Fracture

Project: ST151K Model: Conductor Version: 1



Uniform Node Displacement

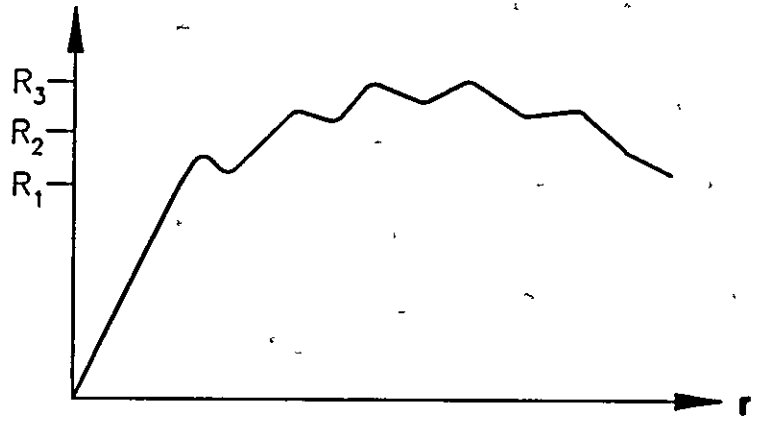
Comparison of Pushover Curves for ST 151K
Variable Load Pattern and Monotonic Load Pattern (Andrew)
Soil Improved 100%

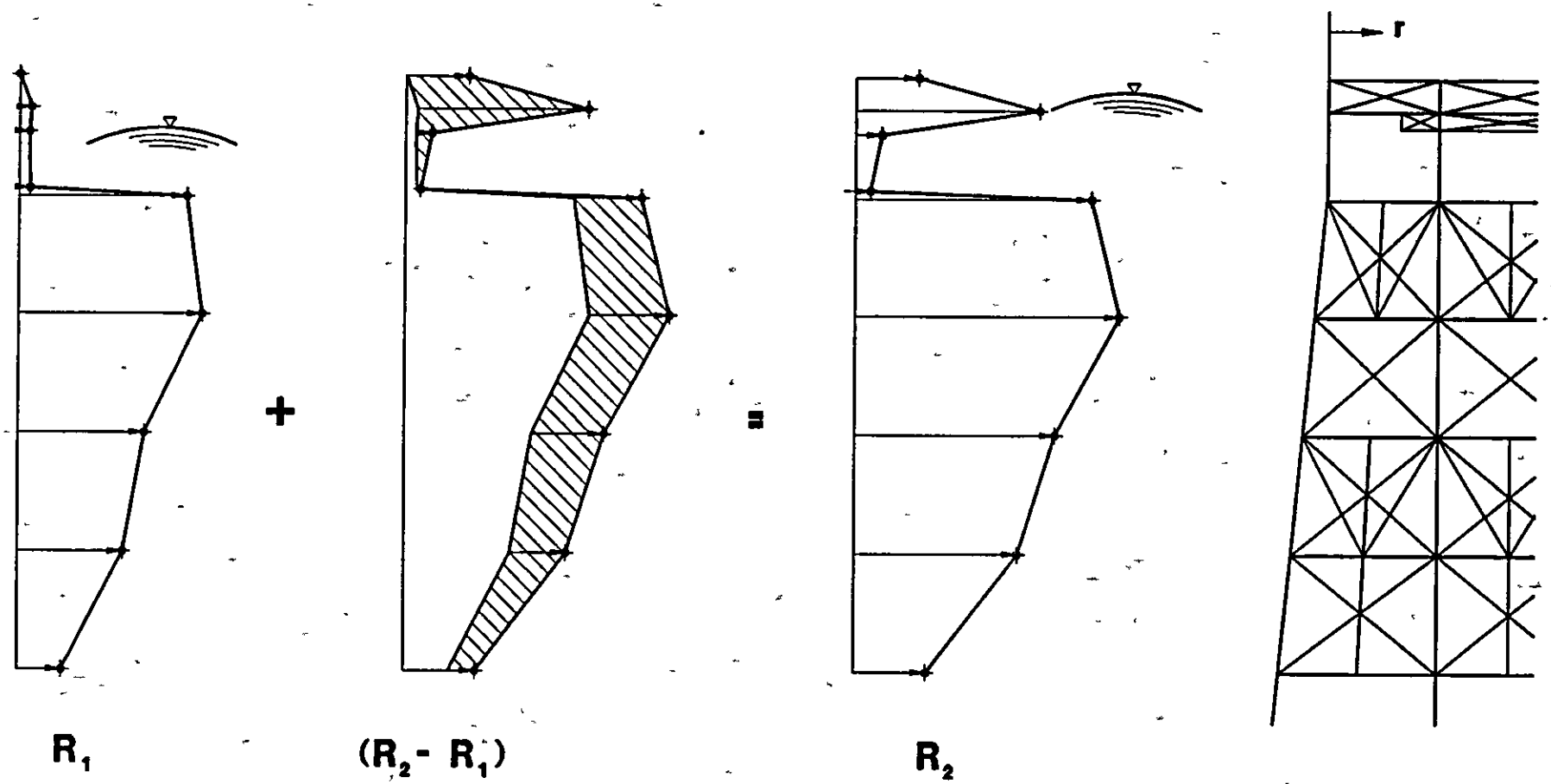


ANDREW PHASE II

WAVE FORCE PROFILE

- **DECK WAVE FORCE:**
  - **PHASE I USED SECTION 17 (1.056*H, Cd)**
  - **PHASE II USE REVISED SECTION 17 (1.000*H, Cd)**
- **PHASE I USED SINGLE FORCE PROFILE FOR PUSHOVER**
  - **USED WAVE HEIGHT CLOSE TO ULTIMATE CAPACITY**
- **PHASE II WILL STUDY THE USE OF VARIABLE PROFILE**
  - **IF FORCE LEVEL INCREASES (OR DECREASES) BY A FACTOR EQUIVALENT TO A 2 FOOT CHANGE IN WAVE HEIGHT, THE INCREMENTAL FORCE PATTERN IS CHANGED ACCORDINGLY (CAP FEATURE)**
  - **INITIAL EXAMPLE**





R_1 $(R_2 - R_1)$ R_2

INCREMENTAL WAVE HEIGHT PUSHOVER

ANDREW PHASE II

WAVE FORCE PROFILE

CAP AUTOMATIC APPLICATION FEATURE

STAT

$f*R_1$ $0 < f < 1$

STAT

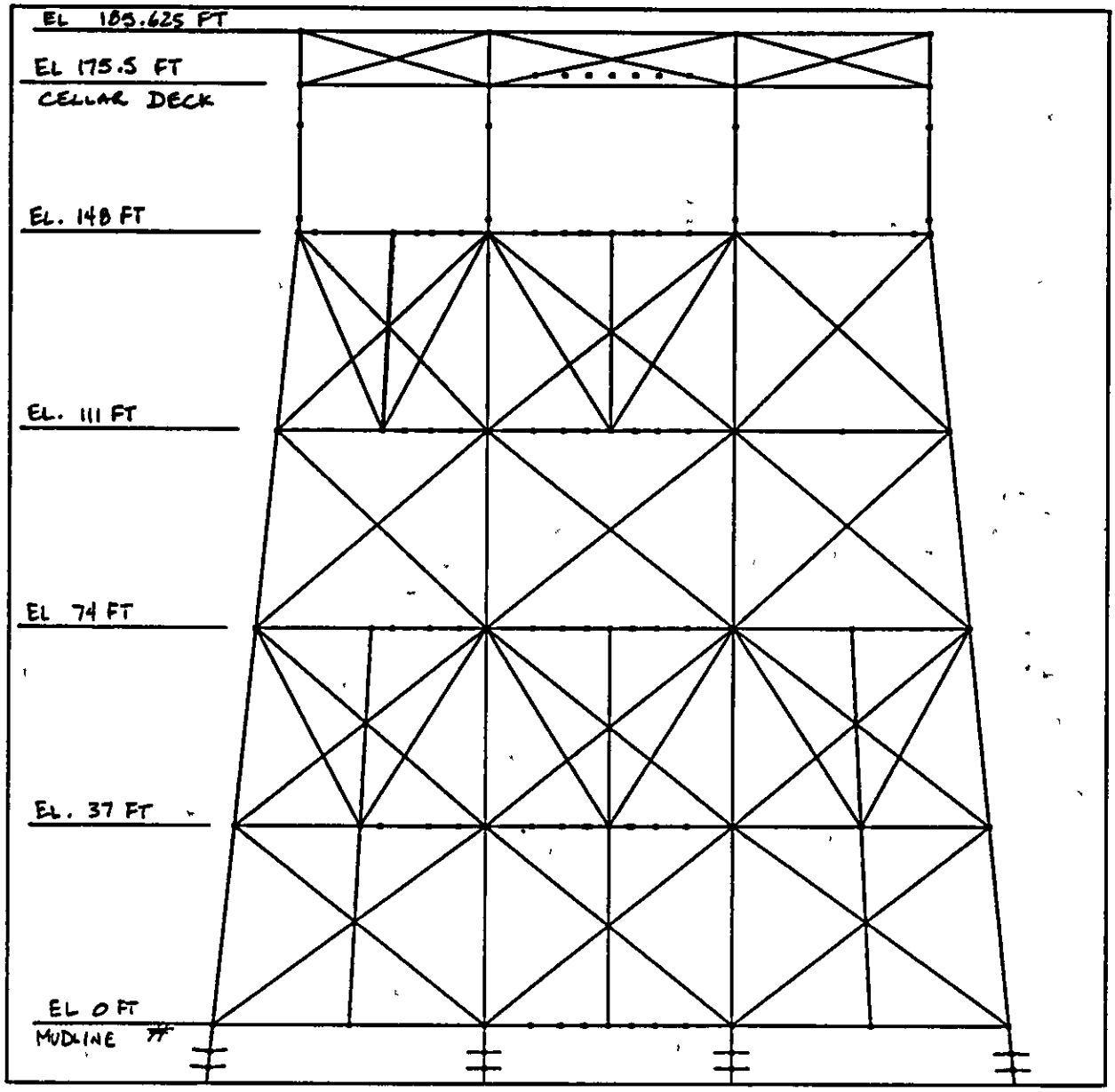
$f*(R_2-R_1)$ $f < 1$

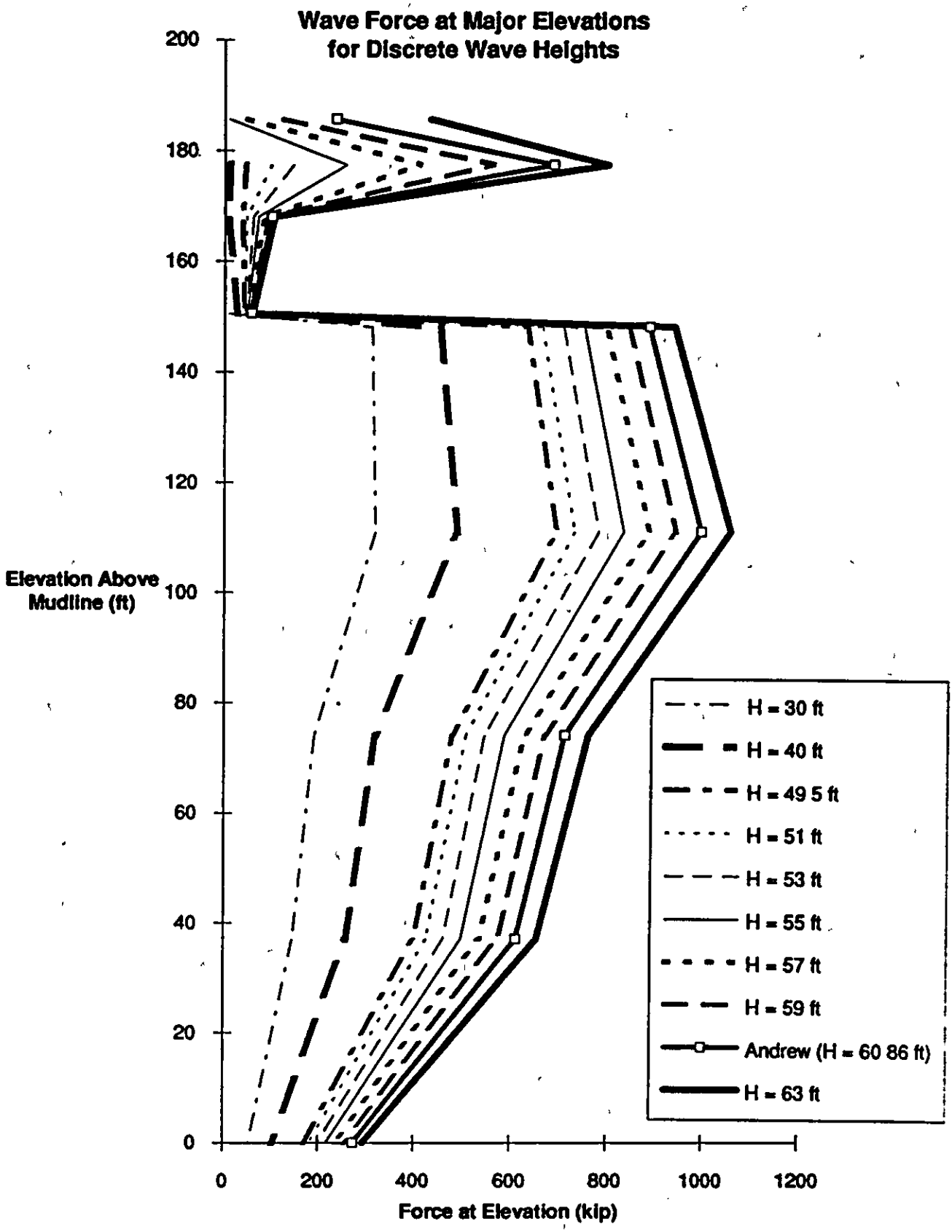
STAT

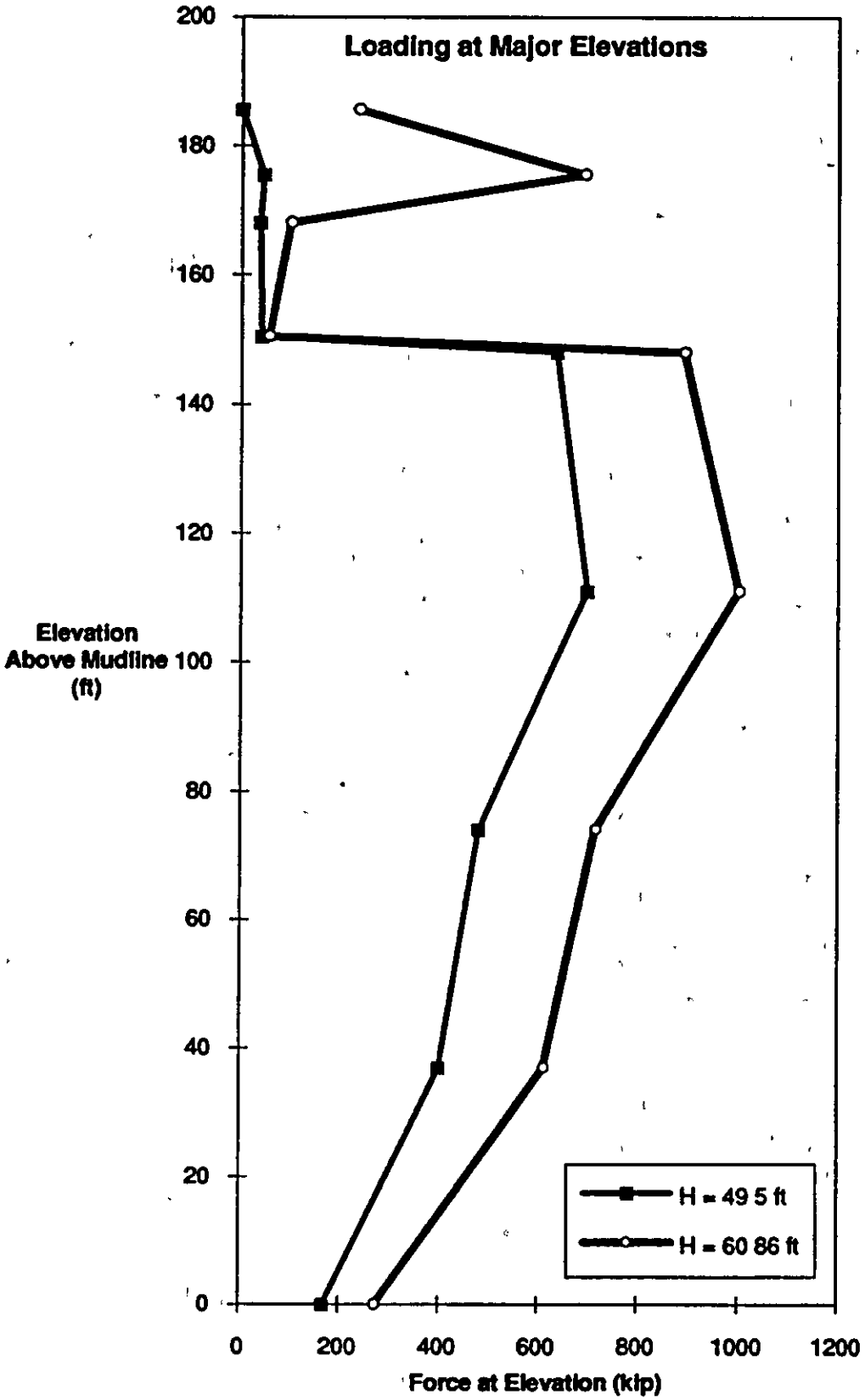
$f*(R_3-R_2)$ $f < 1$

...

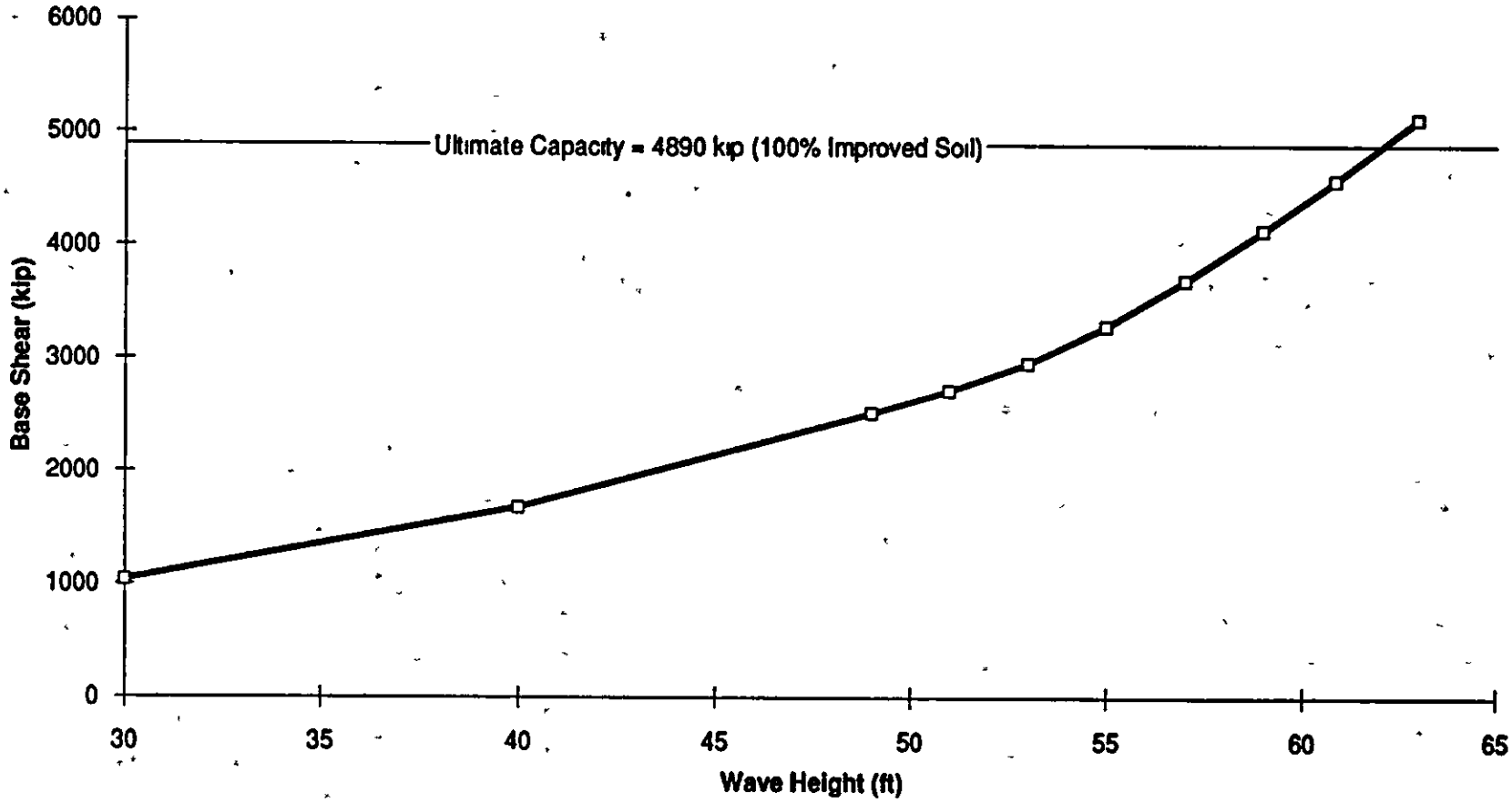
Project: ST151K Model: Wave_Loading Version: 1 Tue Nov 8 16:41:07 1994 *



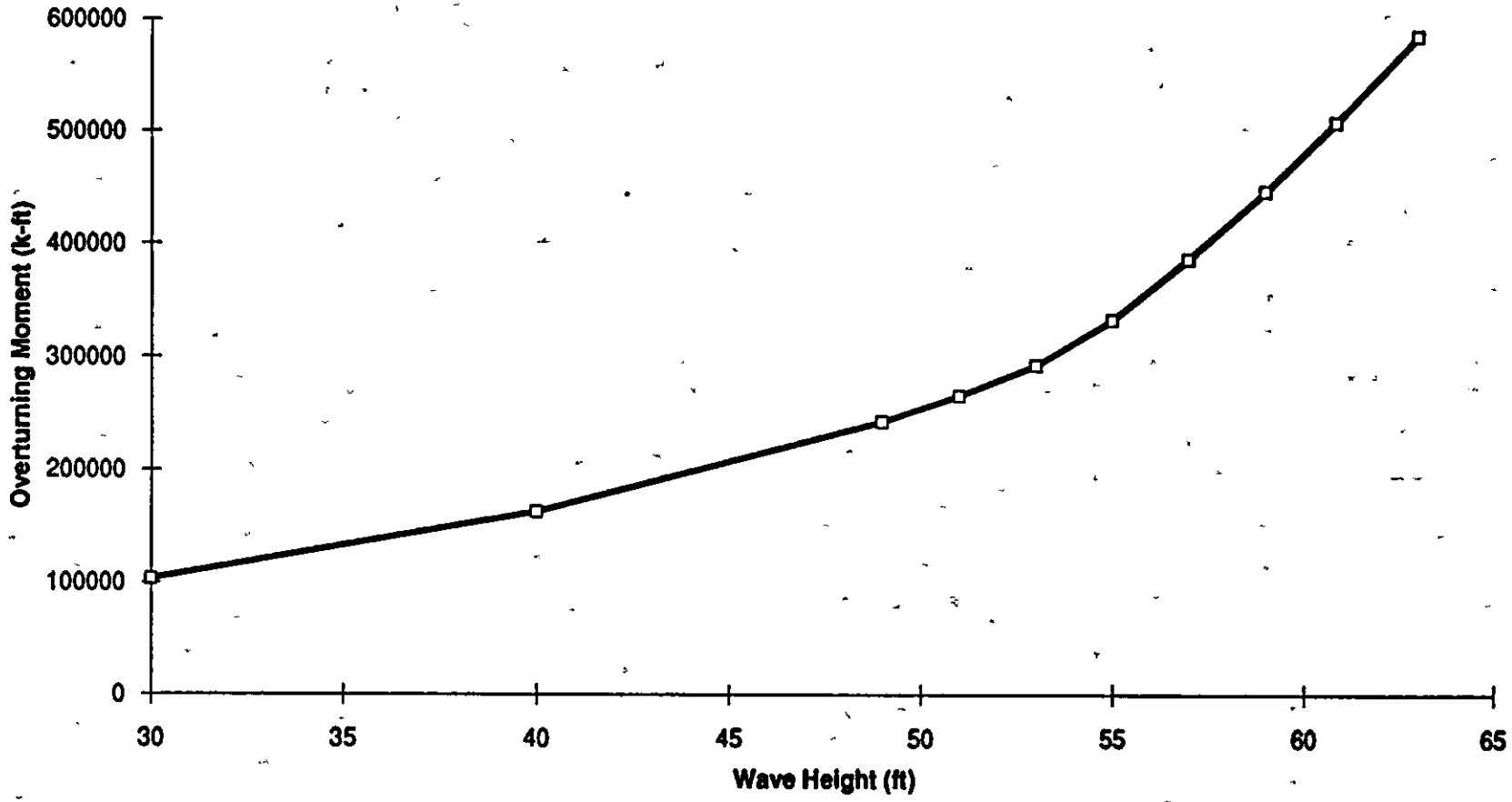

Wave Force at Major Elevations
for Discrete Wave Heights
Elevation Above Mudline (ft)
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Force at Elevation (kip)
H = 30 ft
H = 40 ft
H = 49 5 ft
H = 51 ft
H = 53 ft
H = 55 ft
H = 57 ft
H = 59 ft
Andrew (H = 60 86 ft)
H = 63 ft


Loading at Major Elevations
Elevation Above Mudline (ft)
200
180
160
140
120
100
80
60
40
20
0
0
200
400
600
800
1000
1200
Force at Elevation (kip)
H = 49 5 ft
H = 60 86 ft

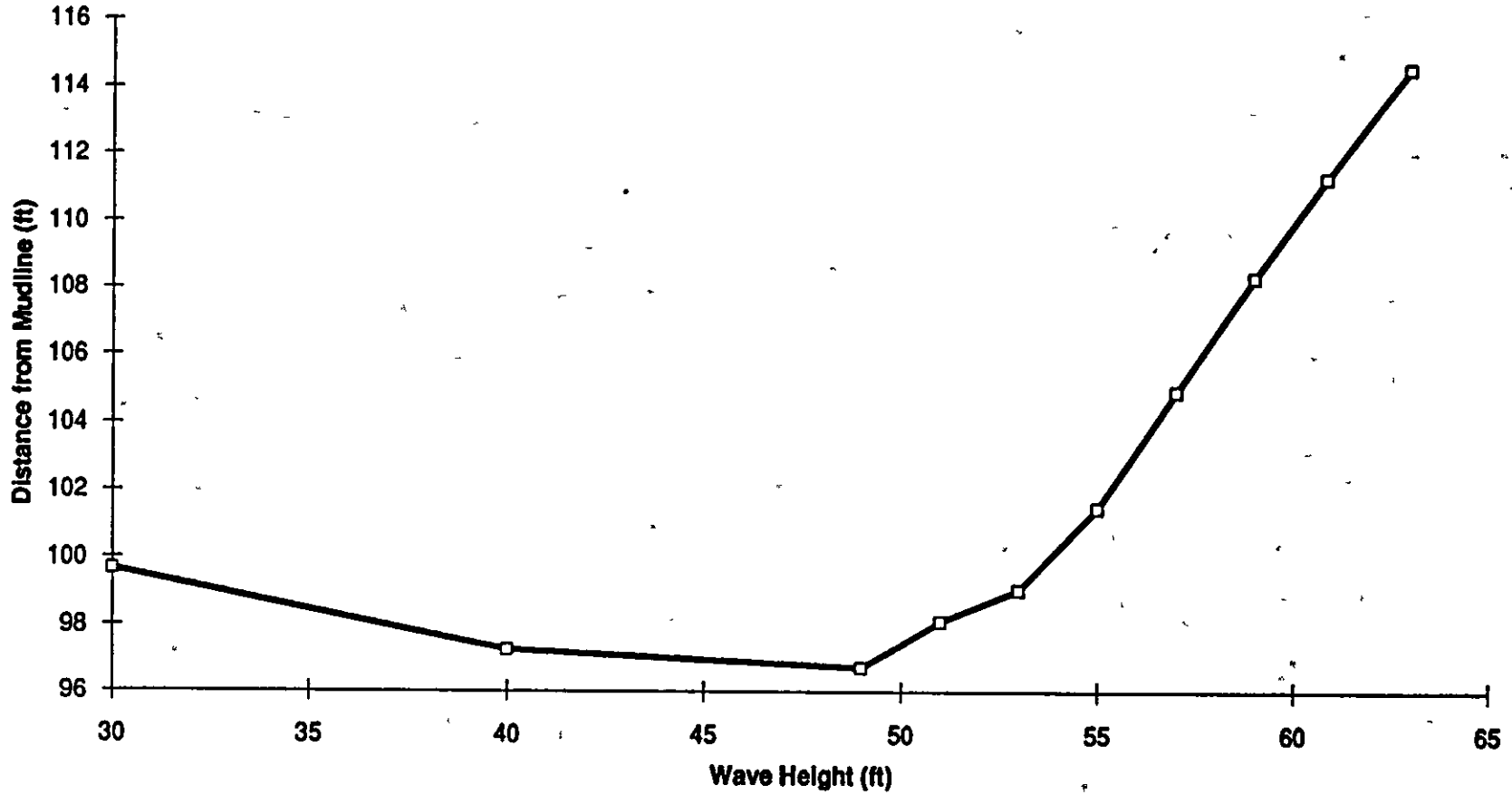
Base Shear vs Wave Height
ST151K



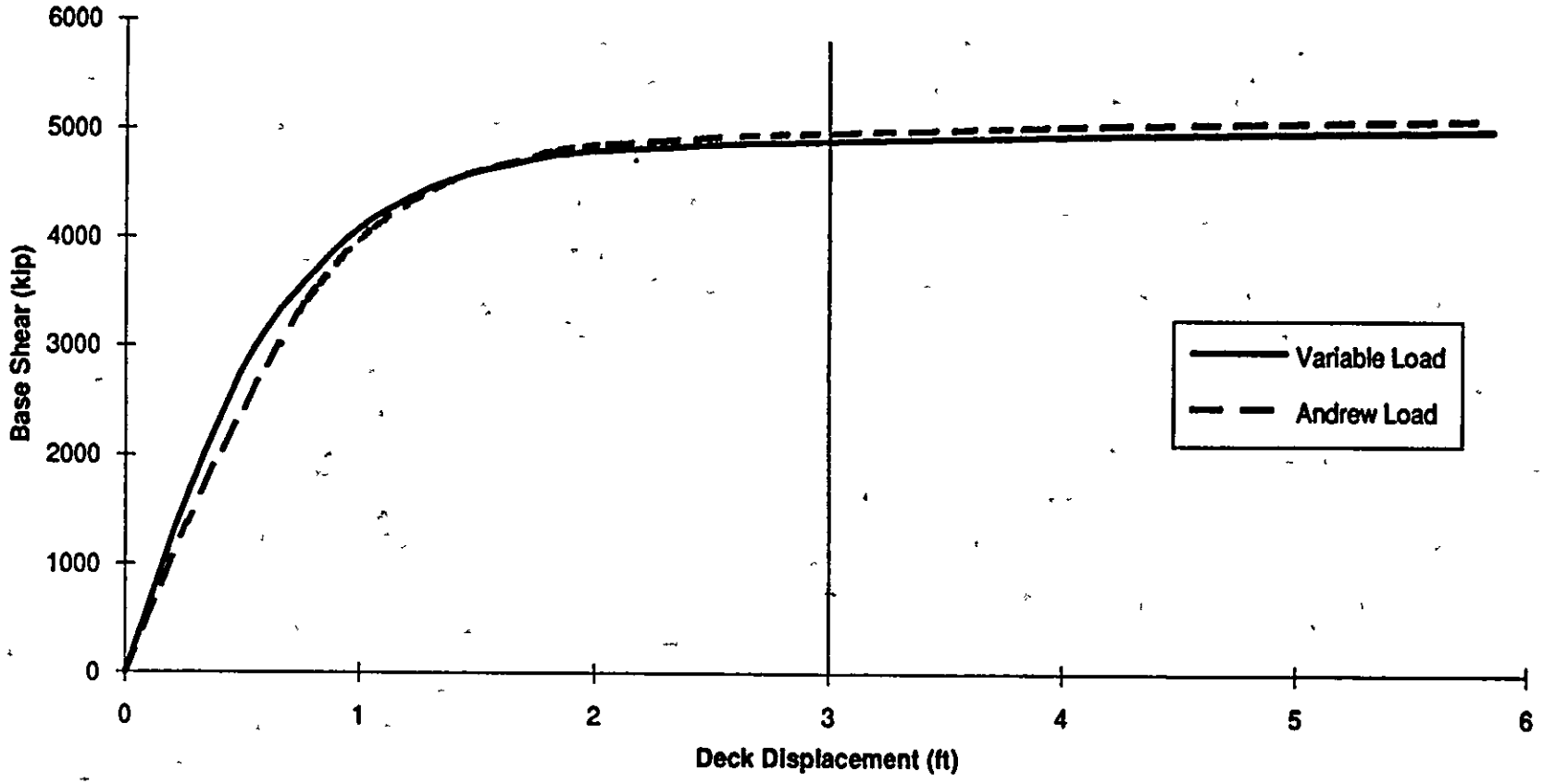
Wave Height vs. Overturning Moment
ST151K



Wave Height vs Center of Action
ST151K



Comparison of Pushover Curves for ST 151K
Variable Load Pattern and Monotonic Load Pattern (Andrew)
Soil Improved 100%

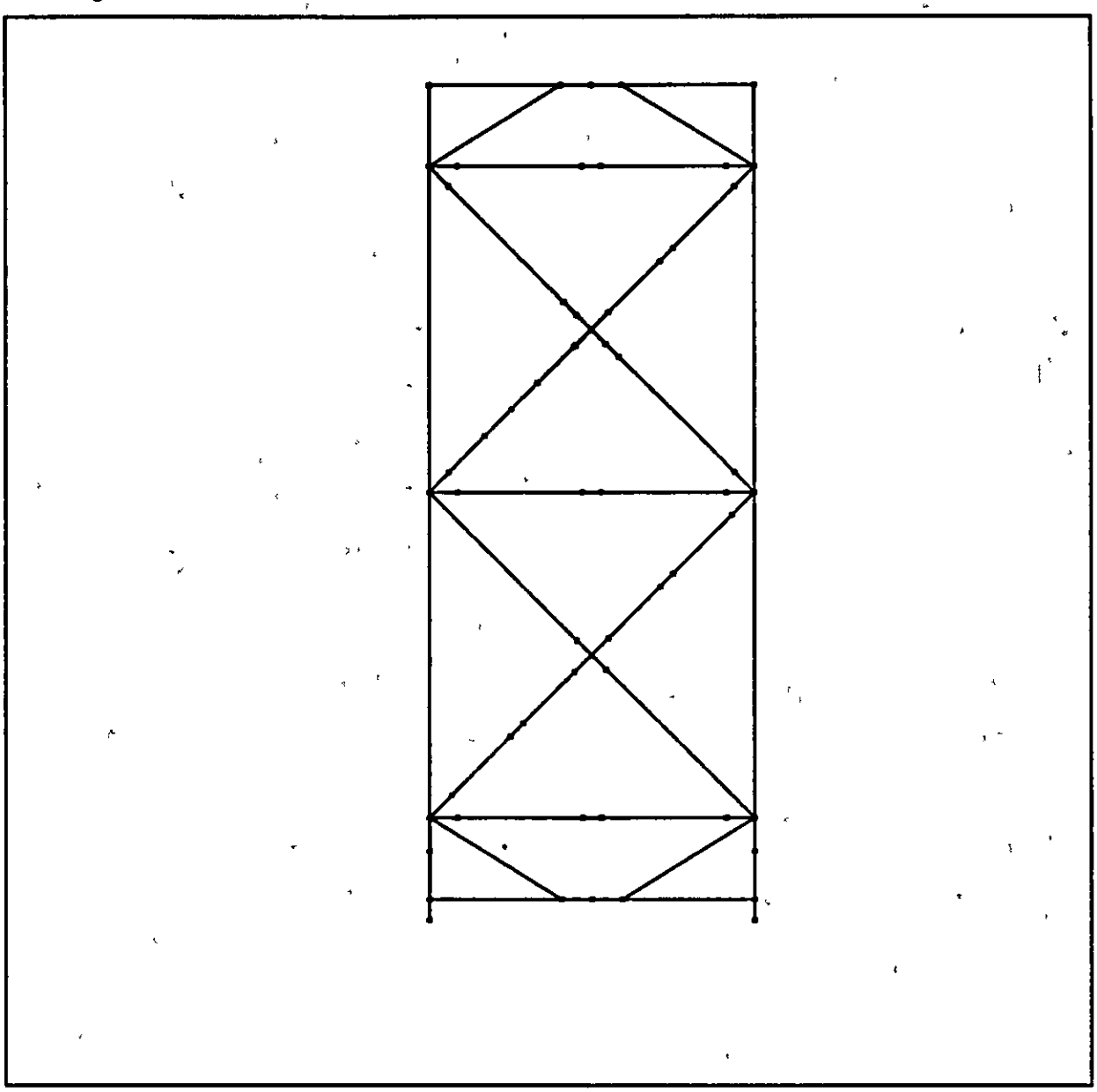


ANDREW PHASE II

BRACE MODELING

- MARSHALL STRUTS USED FOR PHASE I
- PHASE II WILL ASSESS DIFFERENCE IN USING BUCKLING BEAMS AND MARSHALL STRUTS
- COMPARE FOR 2D FRAME
- COMPARE FOR PLATFORM 177 WHERE LOWER BAY EXHIBITS LARGE BRACE MOMENTS

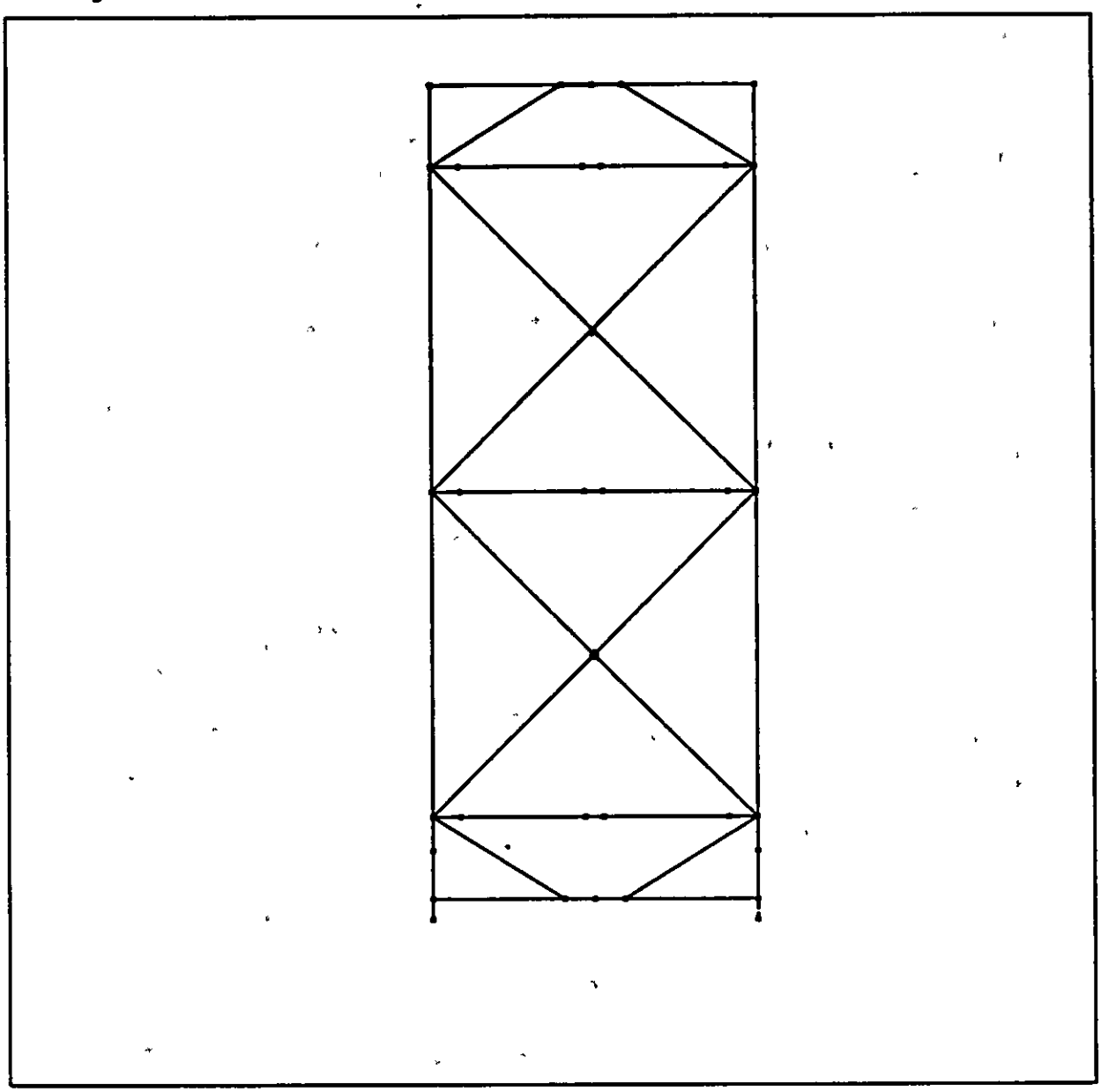
Project: andrew Model: beamframe Version: 1 Mon Nov 14 14:54:47 1994 *



CAP Y

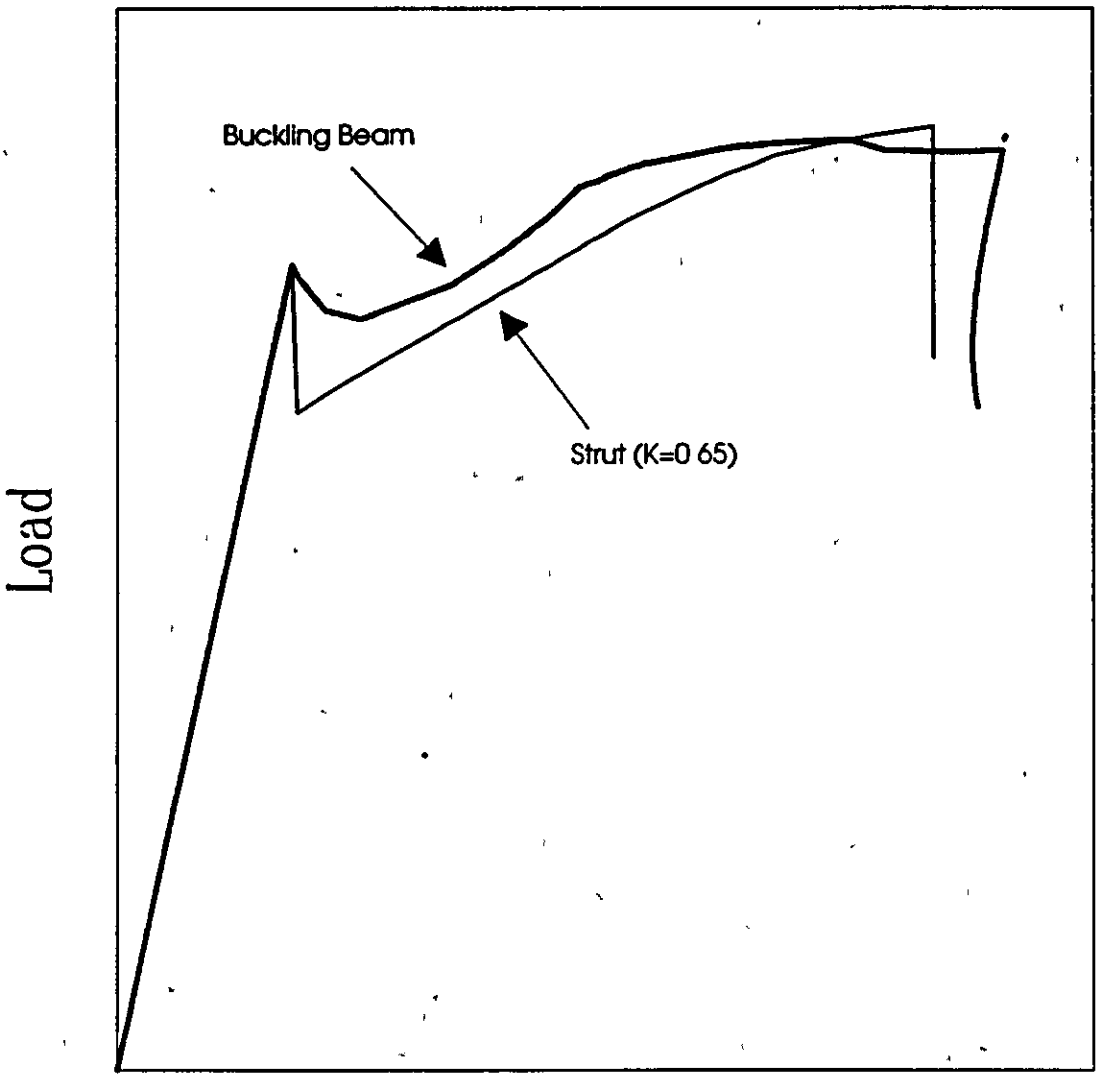
Frame Test: buckling beam-column model

Project: andrew Model: strutframe Version: 1 Mon Nov 14 14:57:54 1994 *



CAP Y

Frame Test: strut model


Buckling Beam
Strut (K=0 65)
Load
Lateral Displacement

ANDREW PHASE II

FOUNDATIONS

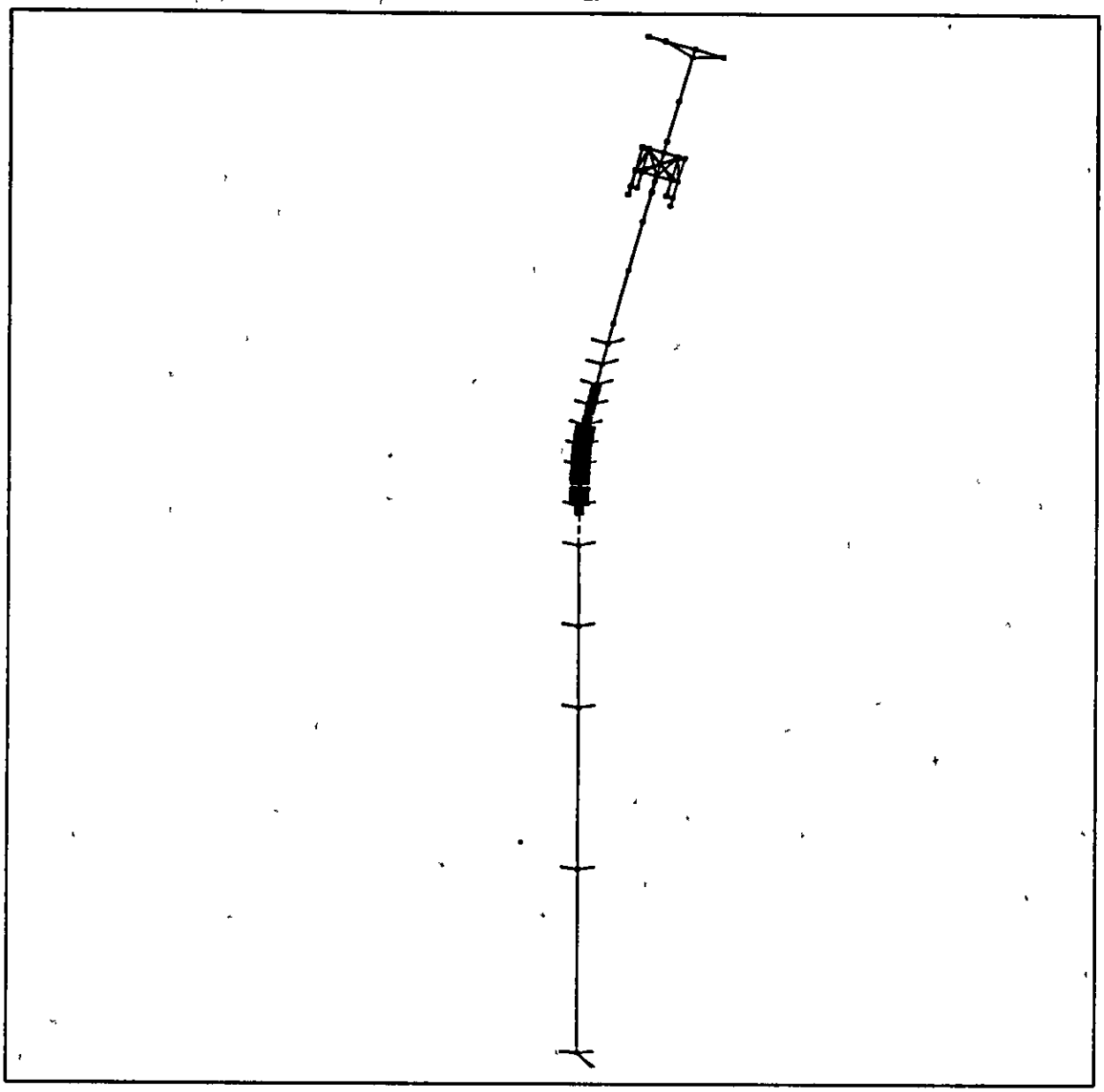
- **EXPLICIT NONLINEAR API FOUNDATION USED IN PHASE I**

- **FOUNDATIONS JIP SELECTED MINI-VANE DATA FOR STRENGTH PROFILE**

- **COMMENTS ON BENCHMARK COMPARISONS**

  - **SIGNIFICANT VARIABILITY DUE TO FOUNDATION MODELING METHODS**

Project: apipile Model: South_Pelto_10 Version: Wed May 18 07:21:06 1994 *

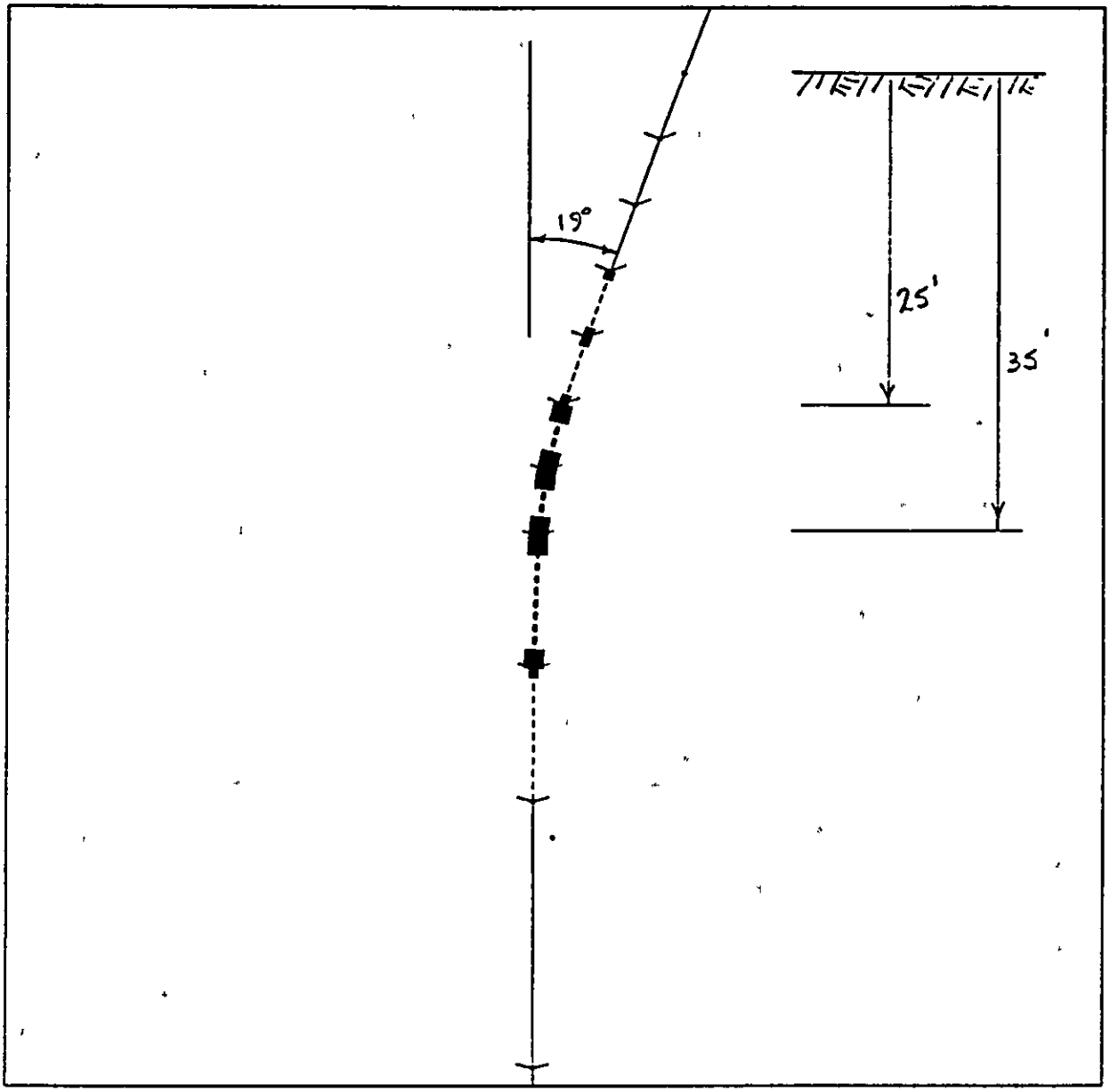


CAP z x SP10 Caisson:fy=42s soil=api(lf=0.97,step=114)

Inelastic Events Legend

————	Elastic	.....	Strut Buckling
---------	Strut Residual	-.-.-.-.-	Strut Reloading
.....	Plastic Strut/NLTruss	---------	Beam Clmn Initial Yield
---------	Beam Clmn Fully Plastic	.....	Fracture

Project: apipile Model: South_Pelto_10 Version: Wed May 18 07:22:35 1994 *



CAP z↑ →x SP10 Caisson:fy=42s soil=api(lf=1.00,step=137)

Inelastic Events Legend

———	Elastic	. . . . .	Strut Buckling
- - - - -	Strut Residual	- - - - -	Strut Reloading
.....	Plastic Strut/NLTruss	- - - - -	Beam Clmn Initial Yield
- - - - -	Beam Clmn Fully Plastic	.....	Fracture

ANDREW PHASE II

JOINT MODELING

- API RIGID-PLASTIC USED IN PHASE I
- ELASTIC-BRITTLE USED IN PHASE IB
- MSL WILL PROVIDE NONLINEAR FORCE-DEFORMATION AND MOMENT-DEFORMATION RELATIONS FOR PHASE II
- MODELING OPTIONS FOR PHASE II
  - UNCOUPLED, ONE DIMENSIONAL MEMBER END JOINT MODELING

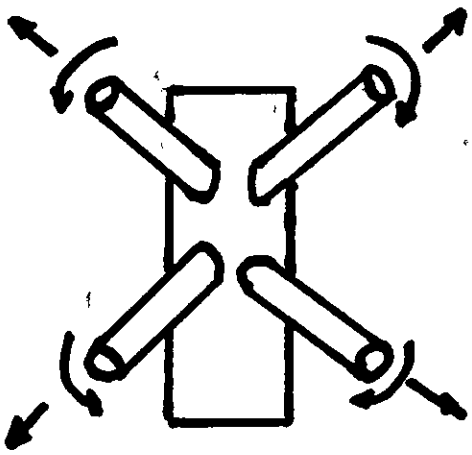
ANDREW PHASE II

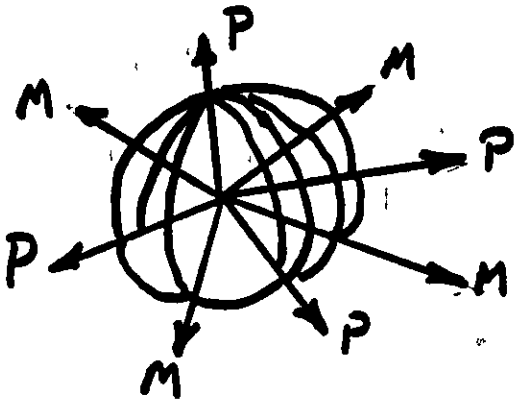
JOINT MODELING OPTIONS DISCUSSION

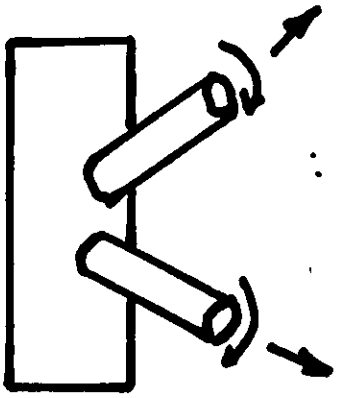
- **3D COUPLED INTERACTION SURFACE**
  - **IDEAL**
  - **DATA NOT AVAILABLE TO CALIBRATE**
- **2D COUPLED INTERACTION SURFACE**
  - **SIGNIFICANT MODELING IMPROVEMENT**
  - **DATA AVAILABLE**
  - **IMPLEMENTATION PRACTICAL BUT NEEDS DEVELOPMENT AND CALIBRATION**
- **2D UNCOUPLED INTERACTION SURFACE**
  - **SIGNIFICANT MODELING IMPROVEMENT**
  - **DATA AVAILABLE**
  - **IMPLEMENTATION PRACTICAL AND AVAILABLE**

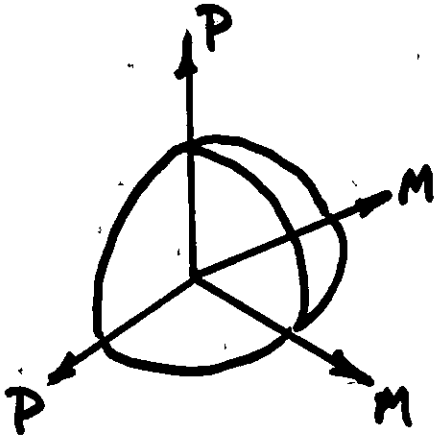
ANDREW PHASE II

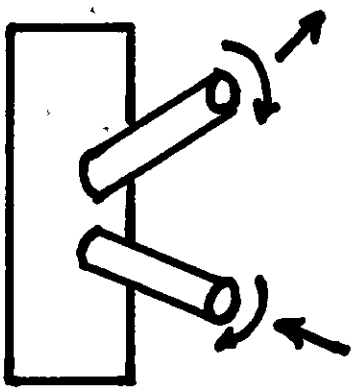
JOINT MODELING OPTIONS ILLUSTRATIONS

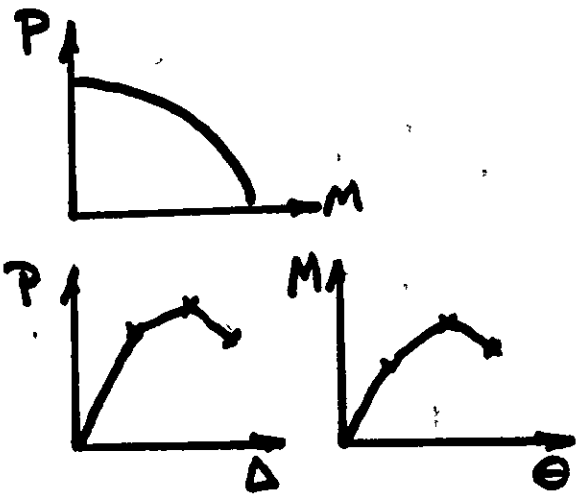






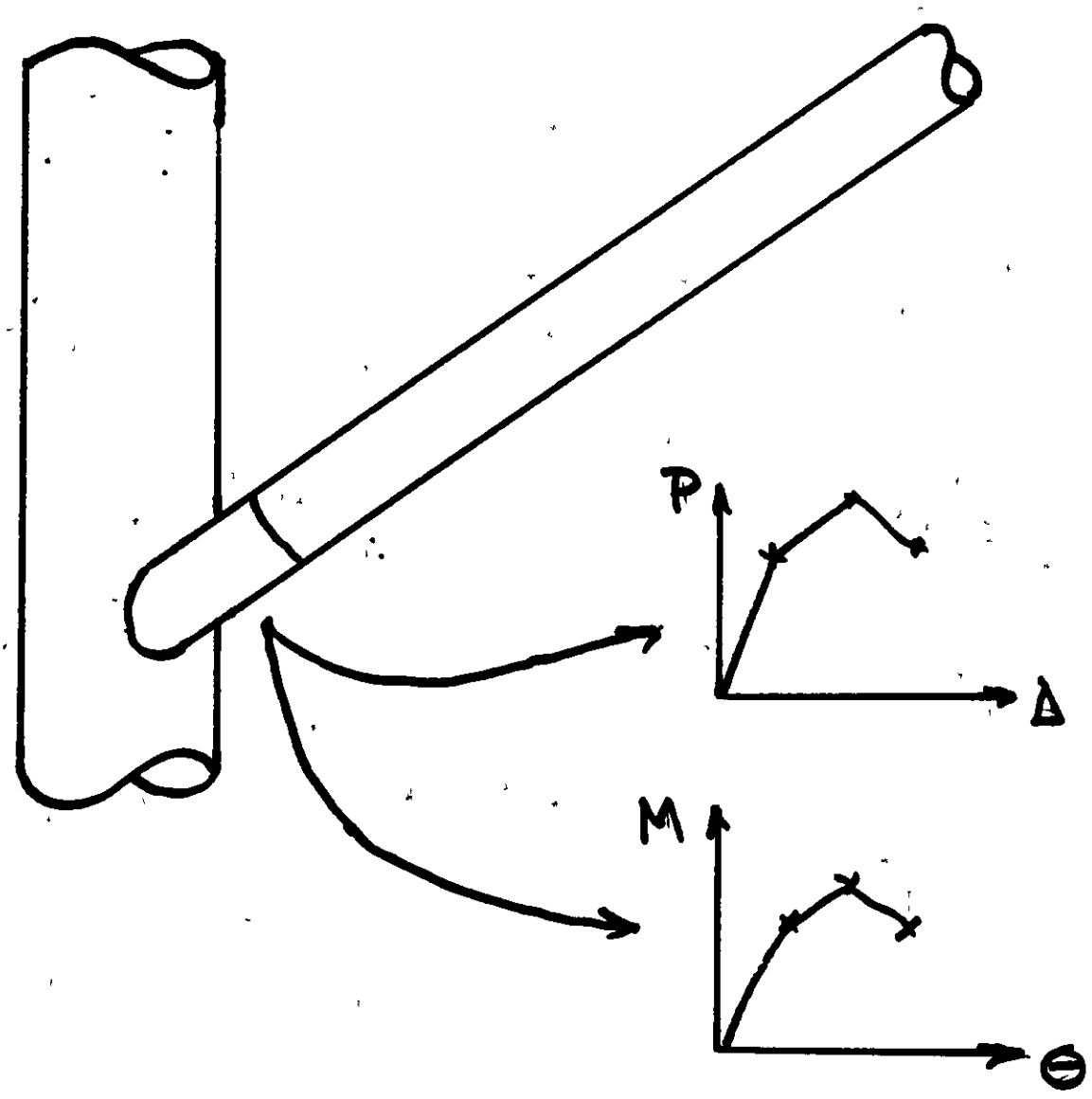






ANDREW PHASE II

JOINT MODELING PHASE II METHOD



ANDREW PHASE II

ANDREW STORM CONDITIONS UPDATED

- **PHASE I USED OCEANWEATHER HINDCAST (Nov. 1992)**

- **PHASE II WILL USE THE REVISED HINDCAST (Nov. 1994)**

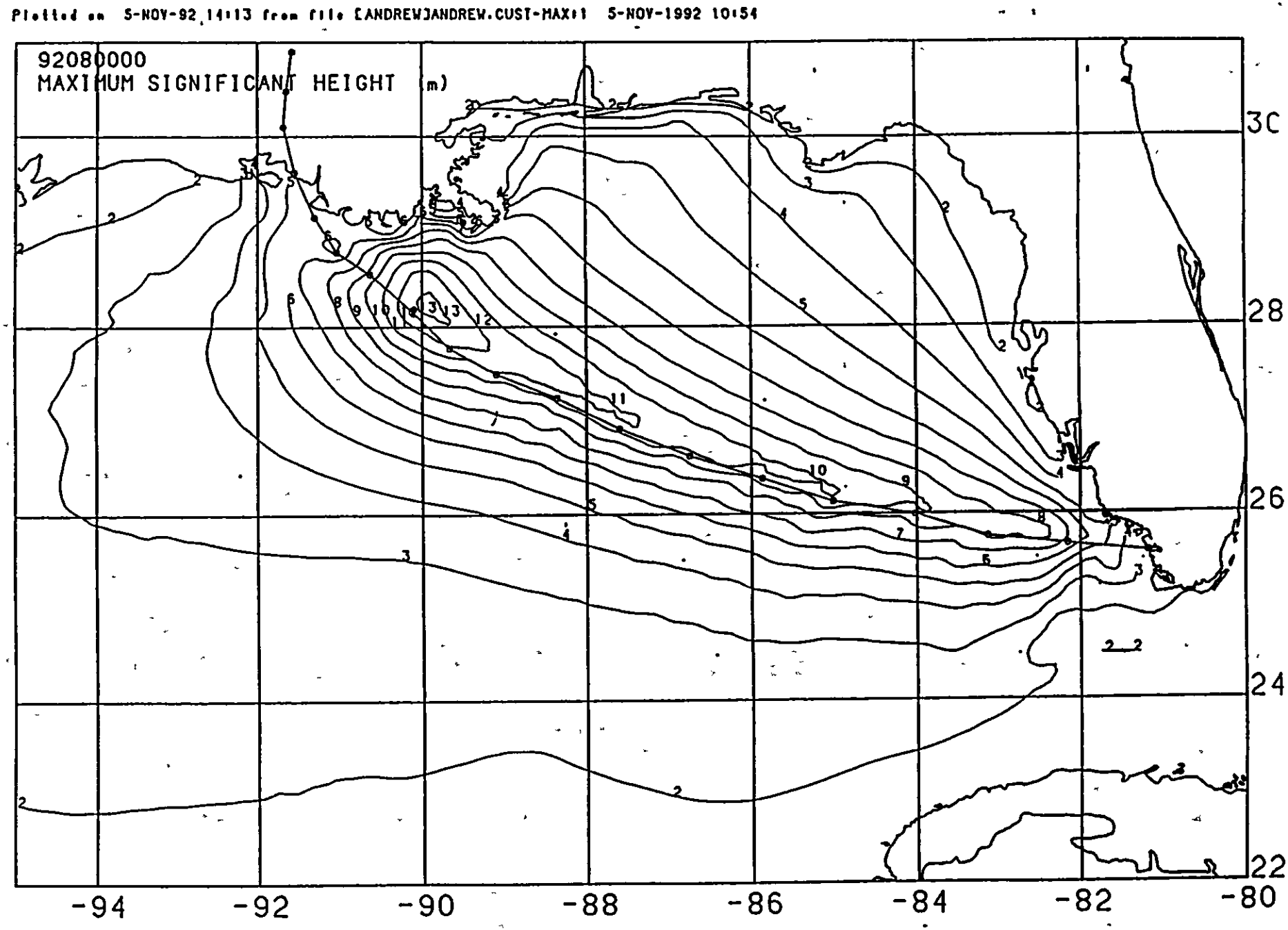
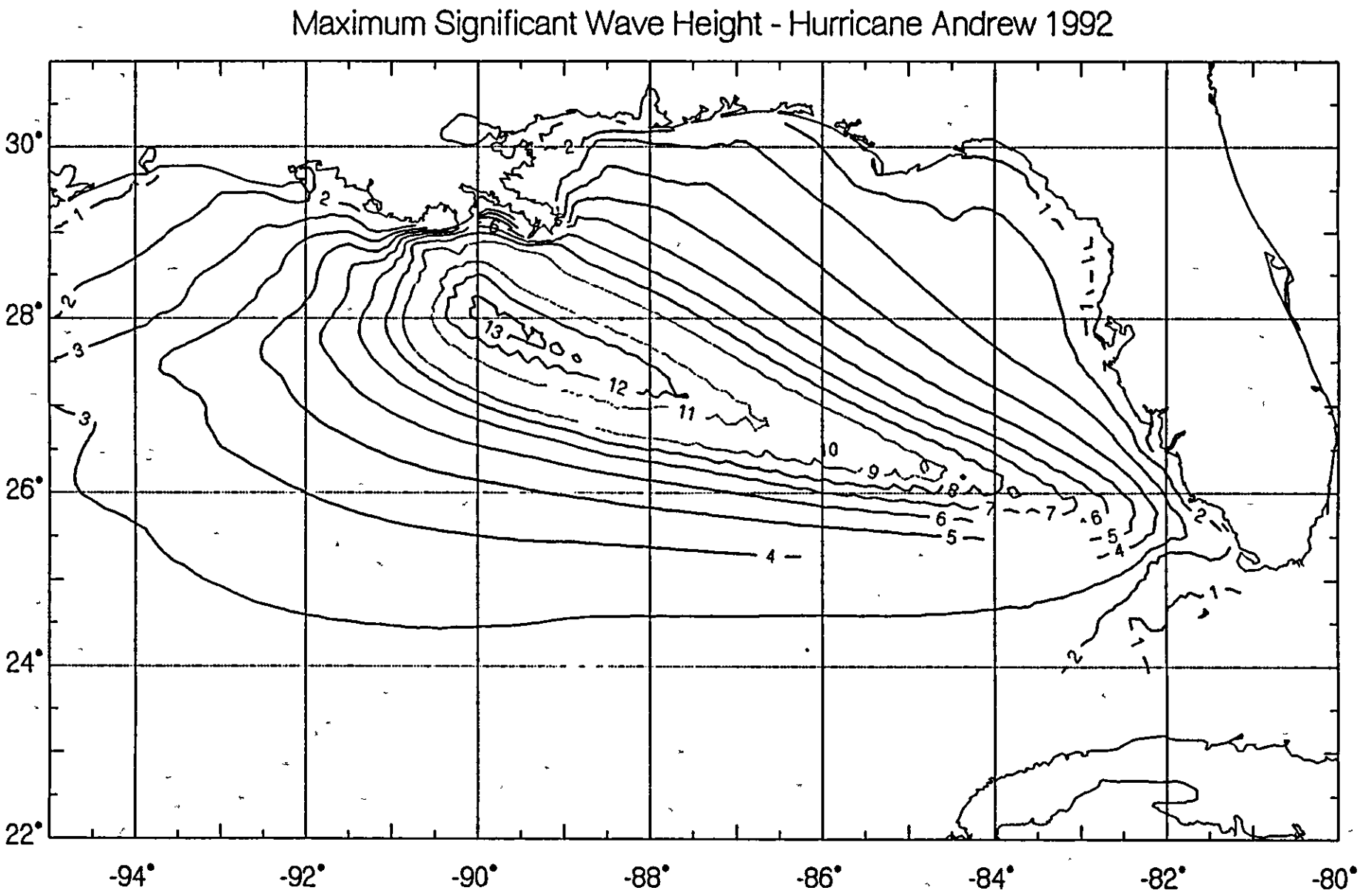


Figure 7. Contours of maximum hindcast significant wave height.

NOVEMBER, 1994 MMS STUDY



Platform Selection

- Basis/Criteria for Selection
- Review of Phase I Platforms
- Alternative Platforms
- PMB Recommendations
- Participants Comments

Basis/Criteria for Selection

- **Benefit for Calibration**
  - Classification (Unexpected/Expected)
  - Failure Mode (Structures/Foundations)
  - Damaged Structures/Known response
  - Better Representation of Full Population
- **Availability of Data**
  - Existing Models
  - Inspection Data
  - Damage Data

PREDICTED BEHAVIOR

OBSERVED BEHAVIOR	SURVIVED	DAMAGED	FAILED
SURVIVED	ST134W WD90A MC311 MC397		ST151K ST130Q
DAMAGED		ST 52 SS 139 ST177B ST161A	
FAILED			ST151H ST130A ST 72

OVERVIEW OF PLATFORMS SURVIVED/DAMAGED/FAILED

Operator	Platforms Survived	Platforms Damaged & Failed
Andrew Observations:		
JIP Participants		
Amoco	30	1
Chevron	143	12
Exxon	72	-
Mobil	22	1
Phillips	7	-
Shell	39	-
Unocal	25	1
Total Participants Platforms	338	15
Other Operators	310	13
Total Platforms	648	28
Phase I Sample:		
Platforms Considered	6	7
%ge of Total Platforms	1%	25%

Platforms Evaluated in Phase I

Platform Name	Water Depth ft.	Year of Installation	Number of legs	Analysis Model	Availability of Detailed Inspection Information	Availability of Soil Report	Platform Classification Based on Phase I Calibration
Survival Platform Cases:							
ST151K	137	1963	8	CAP	Yes	Yes	Unexpected Survival
ST130Q	170	1964	4	CAP	Yes	ST134 data	Unexpected Survival
ST134W	137	1981	4	CAP	Yes	Yes	Expected Survival
WD90A	184	1964	8	CAP	-	Yes	Expected Survival
MC311	343	1978	8	KARMA	-	Yes	Sure Survival
MC397	468	1991	4	KARMA	-	Yes	Sure Survival
Damage Platform Cases:							
T23ST52	63	1969	4	CAP	Yes	Yes	Expected Survival/Likely to Damage
T25SS139	62	1969	4	CAP	Yes	Yes	Unexpected Survival/Likely to Damage
ST161A	118	1964	8	USFOS	Yes	Yes	Expected Survival/Likely to Damage
Failure Platform Cases:							
ST177B	142	1965	8	CAP	Yes	at about 1 mile	Expected failure
ST151H	137	1964	8	CAP	Collapsed	Yes	Expected Failure
ST130A	140	1958	8	CAP	Yes	ST134 data	Likely Failure
T21ST72	61	1969	4	CAP	Collapsed	No	Likely Failure

Platforms Identified for Evaluating Their Likelihood of Falling Under Unexpected Survival Category

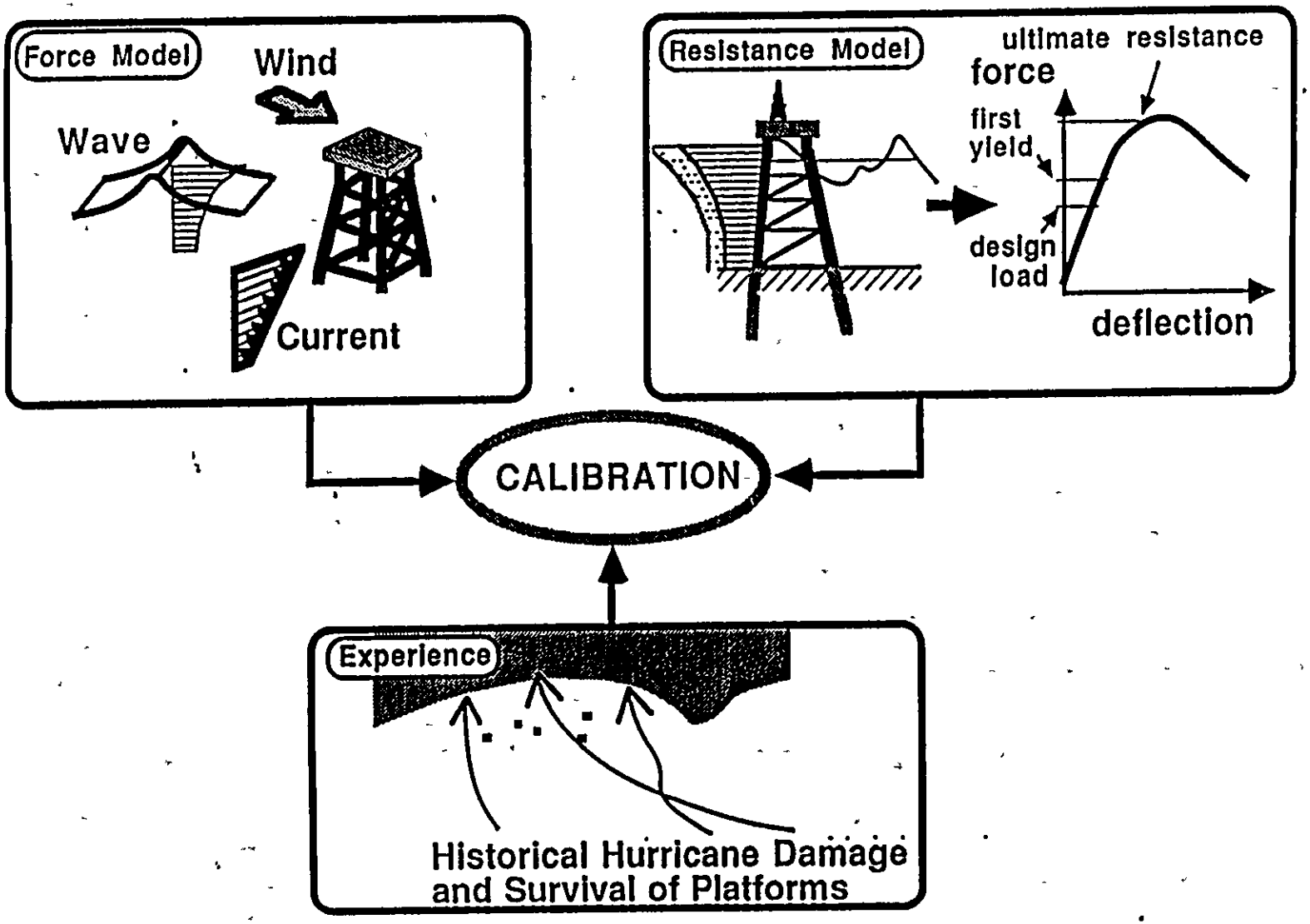
OPERATOR	AREA BLOCK	STRUCTURE NAME	YEAR INSTALLED	WATER DEPTH	DISTANCE FROM SHORE (MILES)	Hs (M)
AMOCO	EI 0193	A	59	87	44	6
	ST 0161	B	69	120	32	10
	WD 0075	D	64	172	20	8
CHEVRON	ST 0130	C	61	180	28	11
	ST 0130	D	62	160	28	11
	ST 0134	F	62	137	29	11
	ST 0151	G	61	137	32	11
	ST 0151	I	63	128	32	11
	ST 0151	J	62	140	32	11
	ST 0151	K	64	137	32	11
	ST 0151	PROD-1	62	137	32	11
	ST 0151	PROD-2	62	137	32	11
	ST 0176	A	63	140	35	11
	WD 0117	C	65	214	34	10
EXXON	ST 0055	E	58	67	14	8
	ST 0165	A	69	93	34	9
	WD 0073	A	64	168	22	8
	WD 0073	A-Tower	62	168	22	8
	WD 0073	C	64	172	22	8
	WD 0093	E	65	160	27	9
	WD 0099	A	63	194	31	9
MOBIL	EI128	A	50's	50	?	?
	SS 0087	B	50	31	8	6
MURPHY	SS114	H	?	50	?	?
PHILLIPS	SS 0149	A	56	55	33	7
SAMEDAN	ST172	A	64	107	?	?
SHELL	WD 0103	A	65	223	27	9
	WD 0103	B	65	228	27	9
	WD 0104	C	65	228	27	9
	WD 0104	D	67	260	27	9
UNOCAL	SS 0208	E	63	103	34	8
	SS 0208	F	64	97	34	8
	SS 0208	PURE	64	97	34	8
	SS 0209	A	72	95	34	8
	SS 0209	B	61	100	34	8
	SS 0209	D	63	95	34	8
	SS 0209	G	67	100	34	8
	SS 0253	A	62	165	54	8
	SS 0253	C	69	175	54	8

Platforms Recommended for Phase II

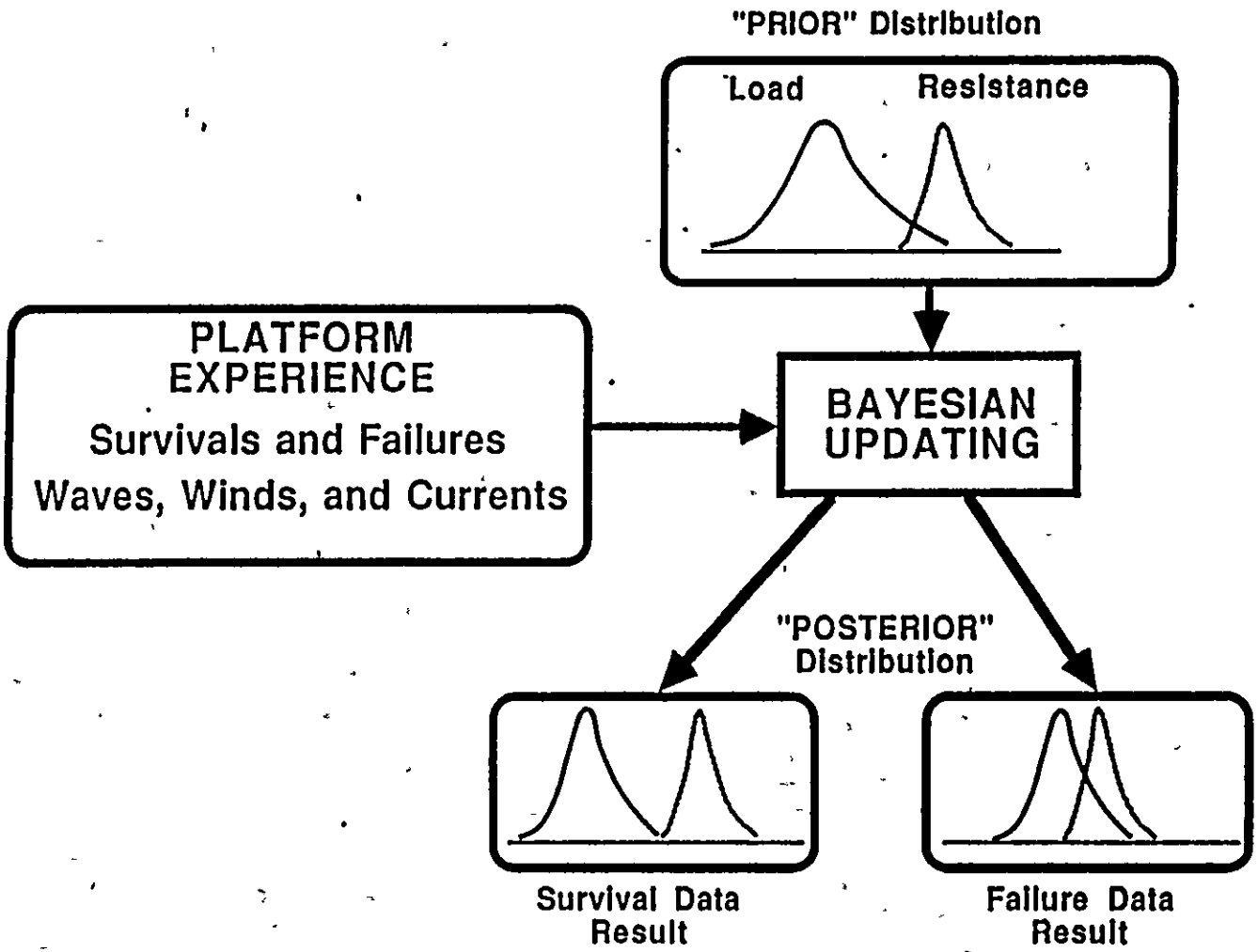
Platform Name	Water Depth ft.	Year of Installation	Number of legs	Analysis Model	Availability of Detailed Inspection Information	Availability of Soil Report	Platform Classification Based on Phase I Calibration (where applicable)	Ranking According to Importance to Calibration	Platforms Recommended for Phase II
Survival Platform Cases:									
ST151K	137	1963	8	CAP	Yes	Yes	Unexpected Survival	I	Yes
ST130Q	170	1964	4	CAP	Yes	ST134 data	Unexpected Survival	I	Yes
ST134W	137	1981	4	CAP	Yes	Yes	Expected Survival	II	Yes
WD90A	184	1964	8	CAP	-	Yes	Expected Survival	II	-
MC311	343	1978	8	KARMA	-	Yes	Sure Survival	-	-
MC397	468	1991	4	KARMA	-	Yes	Sure Survival	-	-
Damage Platform Cases:									
T23ST52	63	1969	4	CAP	Yes	Yes	Expected Survival/Likely to Damage	II	Yes
T25SS139	62	1969	4	CAP	Yes	Yes	Unexpected Survival/Likely to Damage	I	Yes
ST177B	142	1965	8	CAP	Yes	at about 1 mile	Expected to Damage	I	Yes
ST161A	118	1964	8	USFOS	Yes	Yes	Expected Survival/Likely to Damage	II	-
Failure Platform Cases:									
ST151H	137	1964	8	CAP	Collapsed	Yes	Expected Failure	II	Yes
ST130A	140	1958	8	CAP	Yes	ST134 data	Likely Failure	I	Yes
T21ST72	61	1969	4	CAP	Collapsed	No	Likely Failure	I	Yes
Other Cases:									
SS209A	95	1967	16	CAP		Yes	Marginal Survival	II	?
SS114 H							??		?
EI 128 A			48				Unexpected Survival ??	II	?
SS 274 (AIM IV)				CAP					?

CALIBRATION

- PHASE I APPROACH
- CALIBRATION ISSUES
- PHASE II WORK SCOPE
- SOFTWARE AVAILABILITY
- EFFECT OF ADDITIONAL PLATFORMS
- WEIGHTING APPROACH
- EXAMPLE APPLICATION



Components Required for Calibration (Petrauskas, 1992)

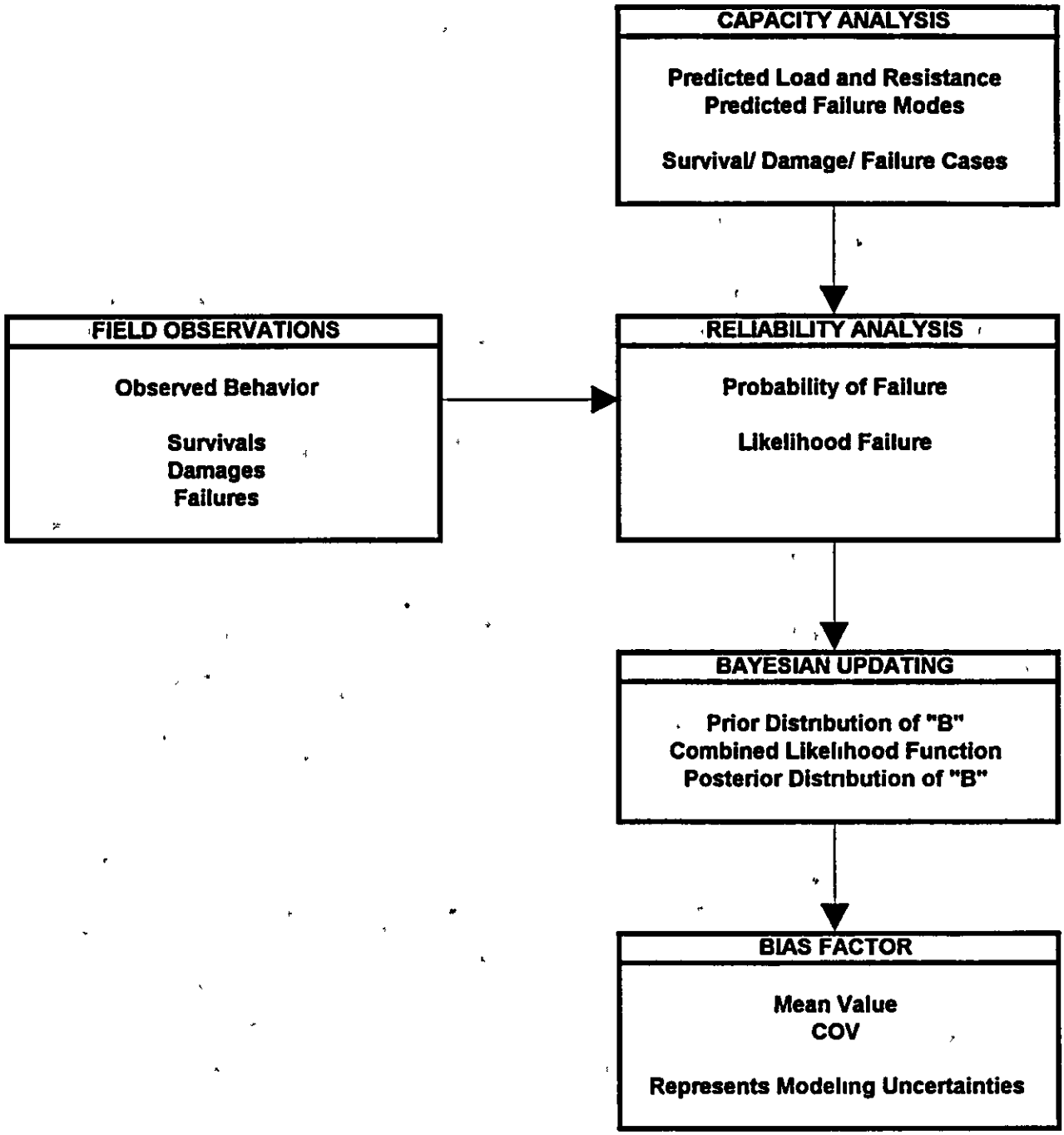


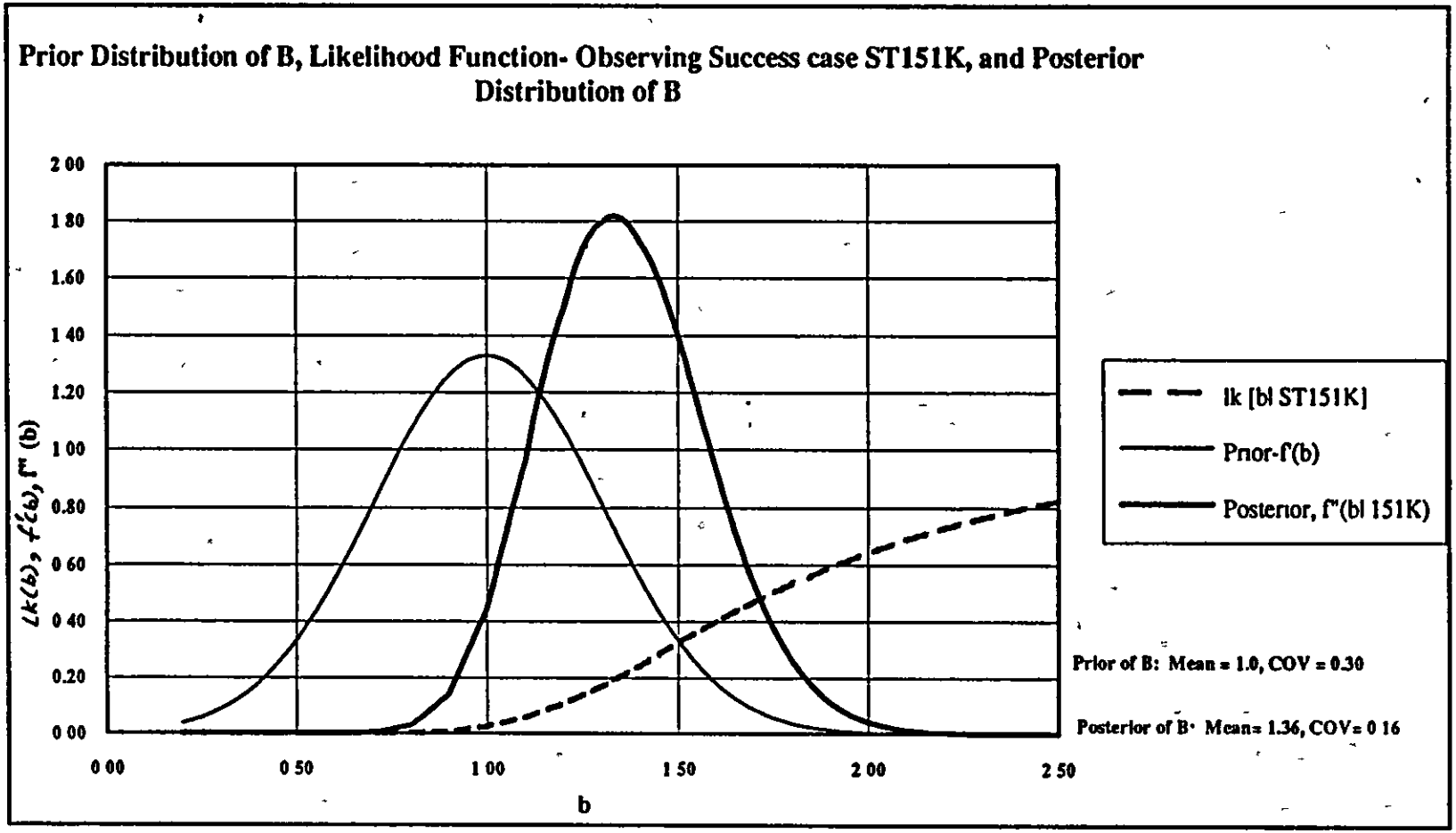
Bayesian Updaing - General Description (Petrauskas, 1992)

WHERE TO INTRODUCE BIAS FACTOR (B) ??

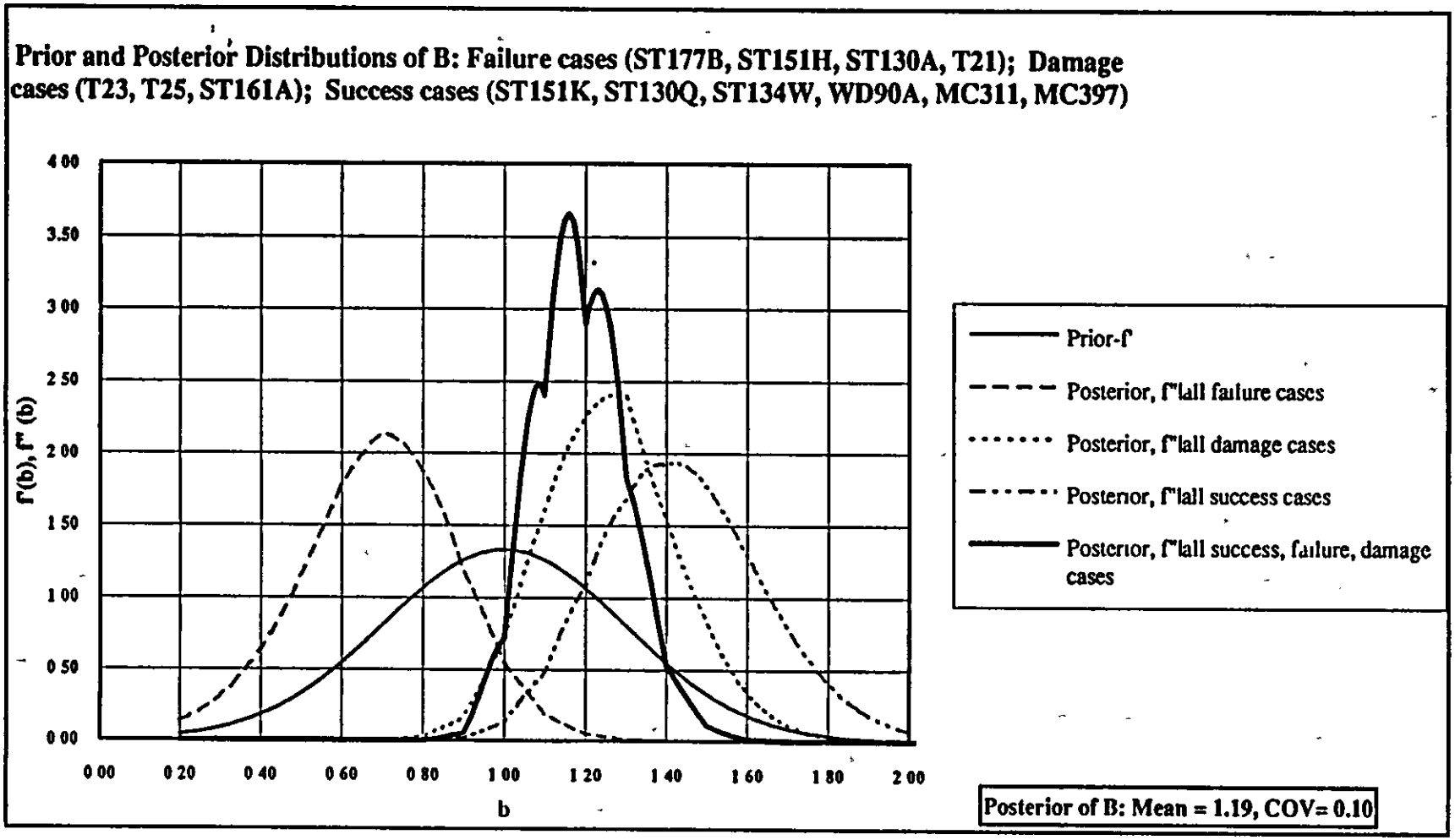
On Resistance:	$(R)_{TRUE}$	= B	$(R)_{PREDICTED}$
On Loads:	$(S)_{TRUE}$	= B	$(S)_{PREDICTED}$
On Safety Margin:	$(R/S)_{TRUE}$	= B	$(R/S)_{PREDICTED}$

CALIBRATION METHODOLOGY





Likelihood Function and Posterior Distribution - Example Platform ST151K



Posterior Distribution of Bias Factor (B) - Different Categories and All Cases Combined

PHASE I - KEY CONCLUSIONS

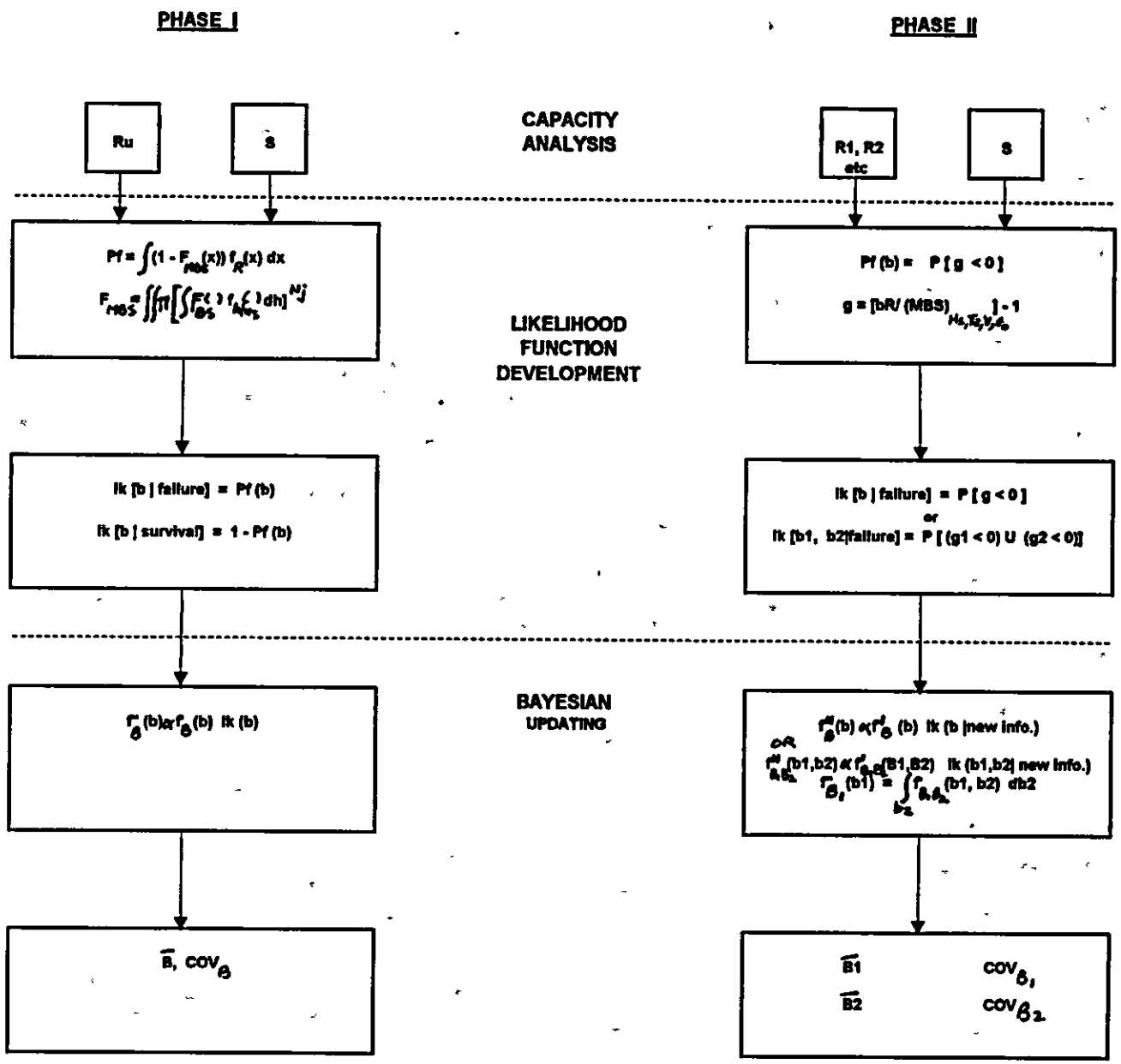
- GLOBAL CORRECTION FACTOR
- 15 TO 20 % CONSERVATISM (MEAN)
- UNEXPECTED SURVIVALS HAVE GREATEST IMPACT
- DAMAGED CASES MORE INFORMATIVE

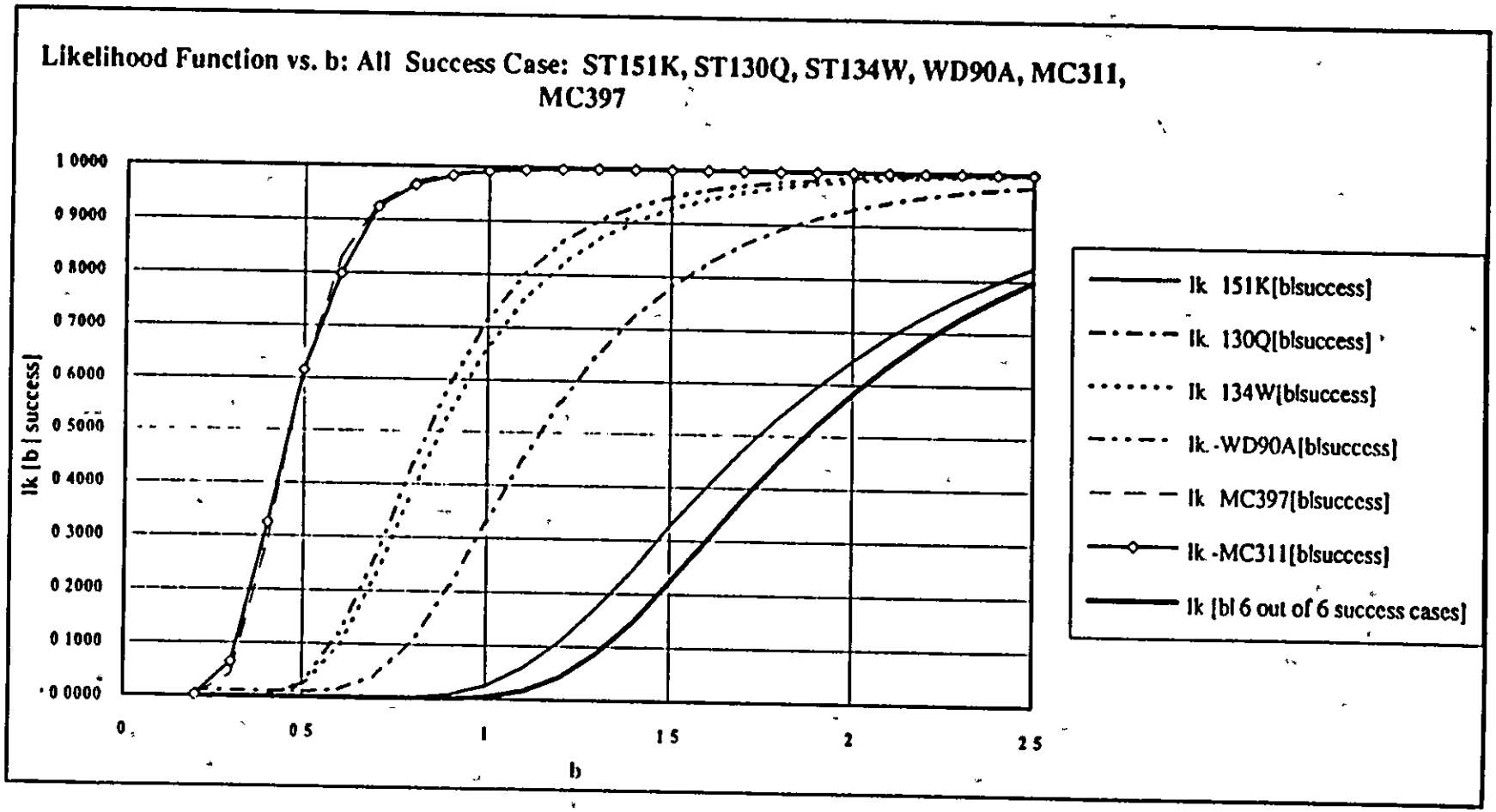
CALIBRATION ISSUES - PHASE II

- EFFECT OF IMPROVED CAPACITY ANALYSIS RECIPE
- APPLICABILITY TO MULTIPLE FAILURE MODES
- NO FOUNDATION DAMAGE CASE INCLUDED
- IMPROVED REPRESENTATION OF FULL ANDREW DISTRIBUTION
- NUMBER OF PLATFORMS CONSIDERED

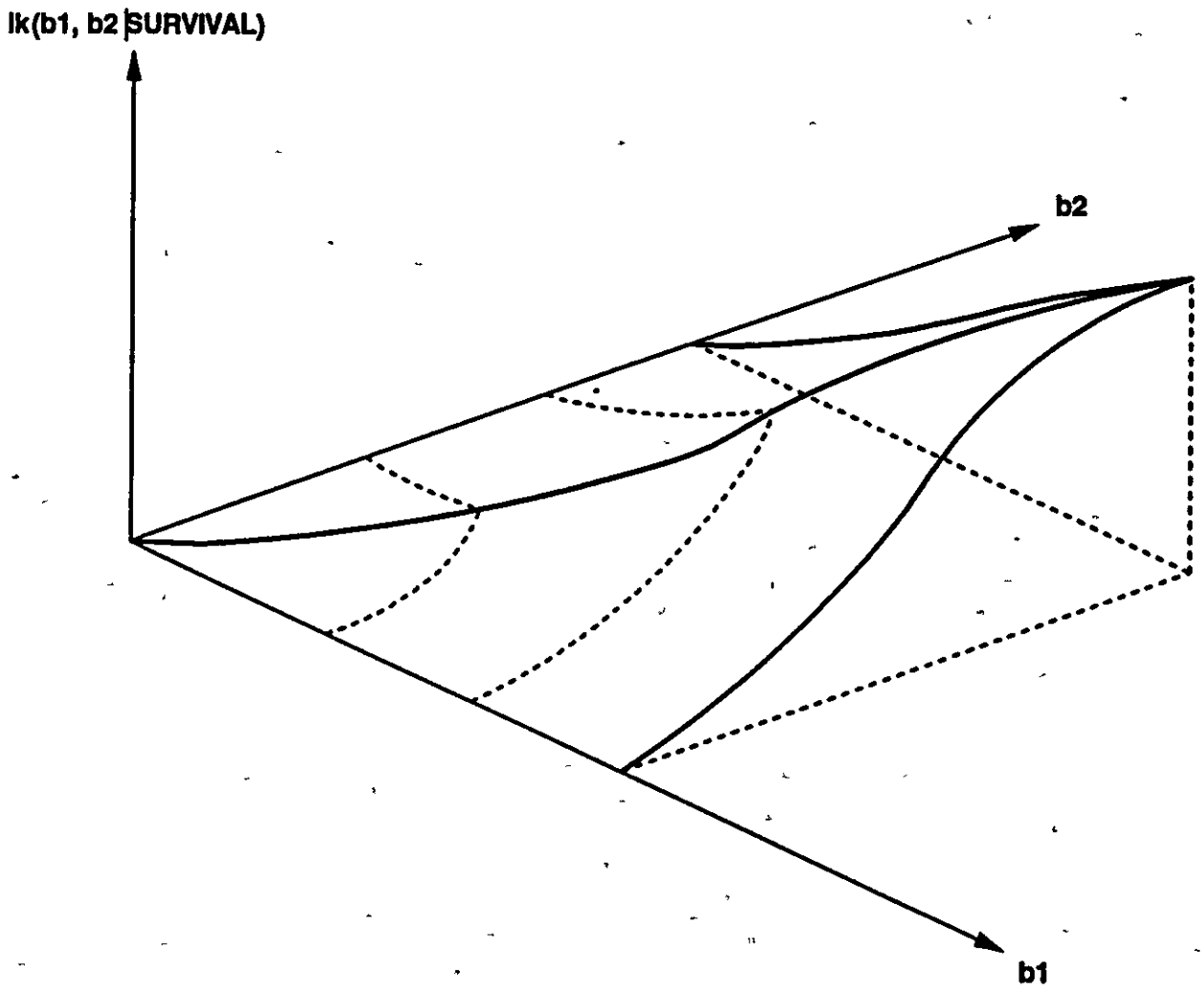
PHASE II WORK SCOPE (CALIBRATION)

- **ESTABLISH MULTIPLE BIAS FACTORS**
  - — Use Nine Base Case Platforms
  - — Capacity Analysis for Revised recipe
  - — Foundation Bias Factor from Foundation JIP
- **DEVELOP WEIGHTING APPROACH**
- **UPDATE MULTIPLE BIAS FACTORS**
  - — Effect of Platforms Not in the Nine Base Cases
- **EXAMPLE APPLICATION OF BIAS FACTORS**


PHASE I
PHASE II
CAPACITY ANALYSIS
Ru
S
R1, R2 etc
S
LIKELIHOOD FUNCTION DEVELOPMENT
Pf = ∫(1 - F_MBS(x)) f_R(x) dx
Pf (b) = P [g < 0]
g = [bR/ (MBS)] - 1
lk [b | failure] = Pf (b)
lk [b | survival] = 1 - Pf (b)
lk [b | failure] = P [g < 0]
or
lk [b1, b2|failure] = P [(g1 < 0) U (g2 < 0)]
BAYESIAN UPDATING
f''_B(b) ∝ f'_B(b) lk (b)
f''_B(b) ∝ f'_B(b) lk (b |new info.)
OR
f''_B1B2(b1,b2) ∝ f'_B1B2(B1,B2) lk (b1,b2| new info.)
f''_B1(b1) = ∫ f''_B1B2(b1, b2) db2
B̄, COV_B
B̄1
B̄2
COV_B1
COV_B2



Likelihood Functions - Success Cases — Phase I



LIKELIHOOD FUNCTION - SURVIVAL CASE

PHASE II

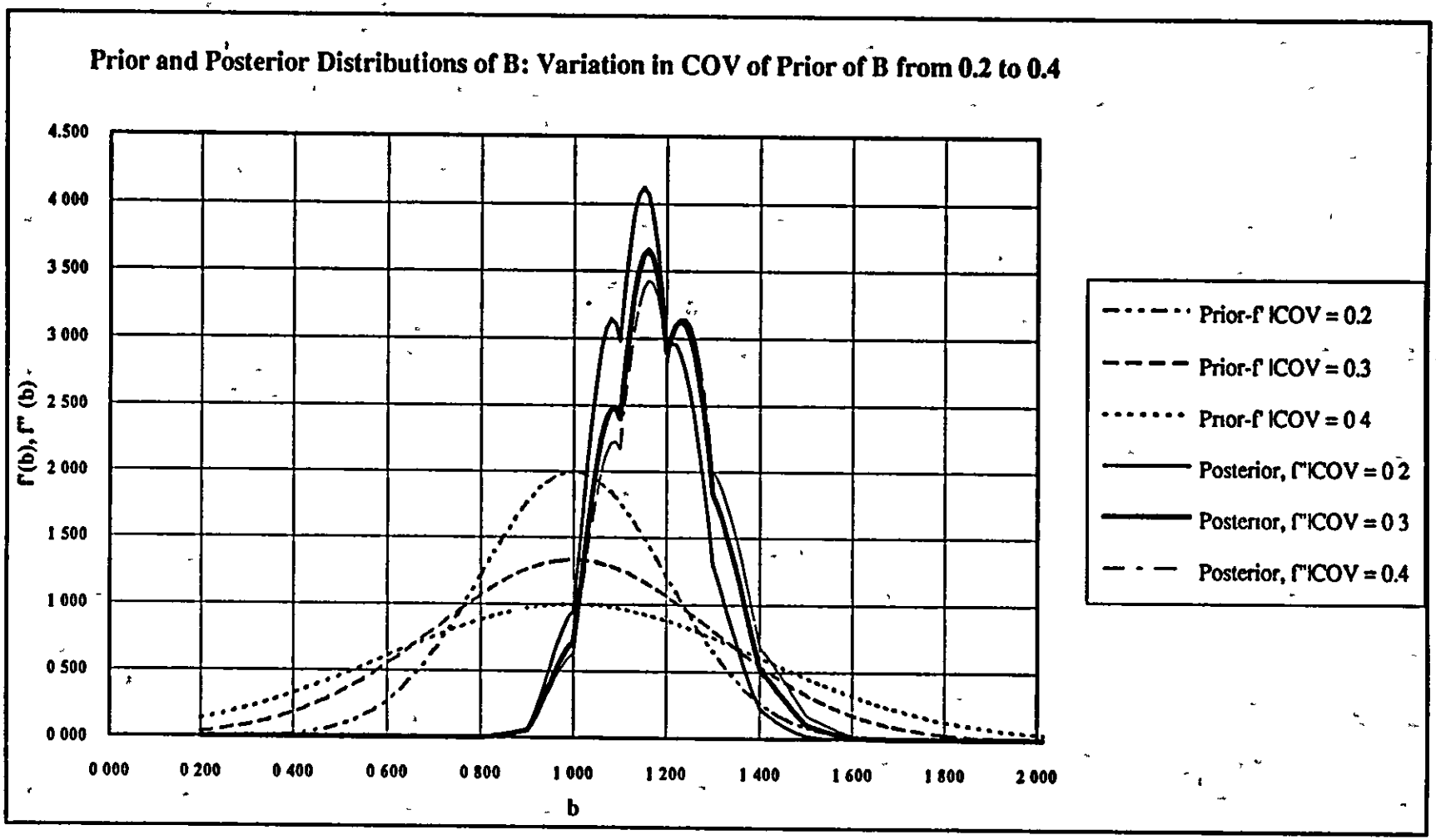
SOFTWARE

- PF PROGRAM
- CALREL
- PF + CALREL
- RELACS

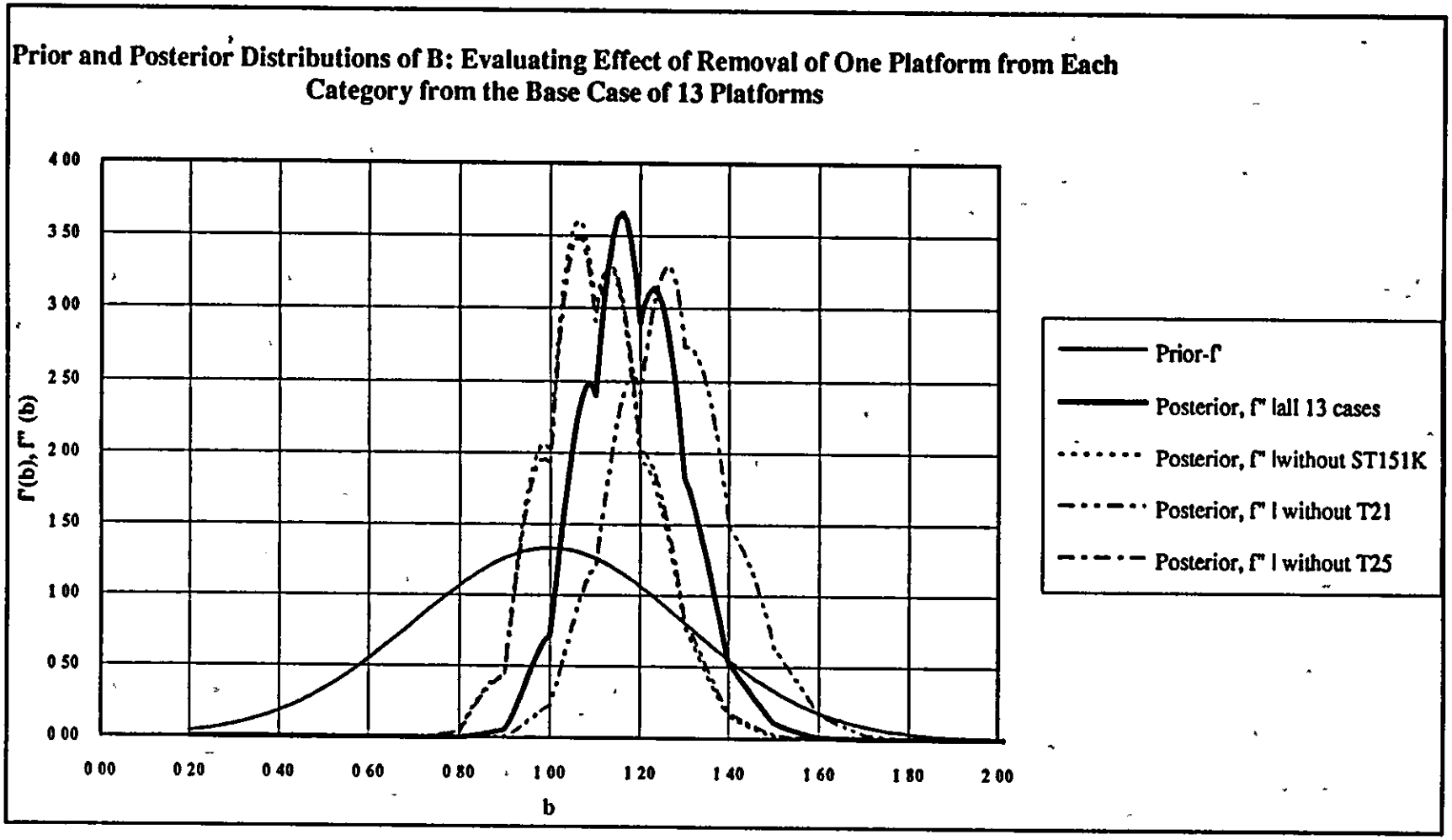
SENSITIVITY STUDIES:

POSTERIOR DISTRIBUTION OF 'B'

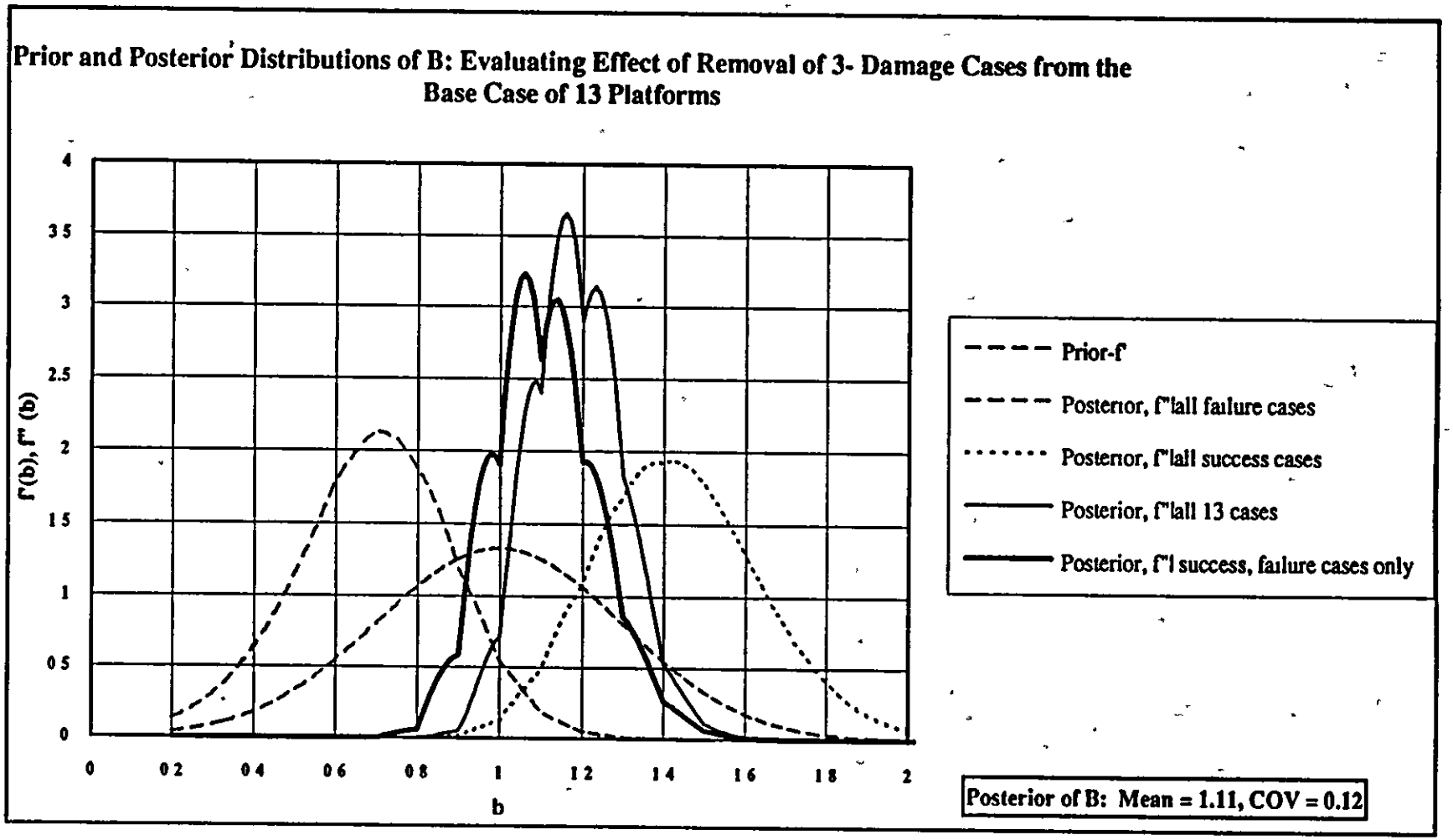
- EFFECT OF CHANGE IN DISTRIBUTION OF PRIOR OF "B"
- EFFECT OF REMOVAL OF ONE PLATFORM FROM EACH CATEGORY
- EFFECT OF REMOVAL OF THREE DAMAGE CASES
- EFFECT OF ADDITIONAL 13 SIMILAR PLATFORMS



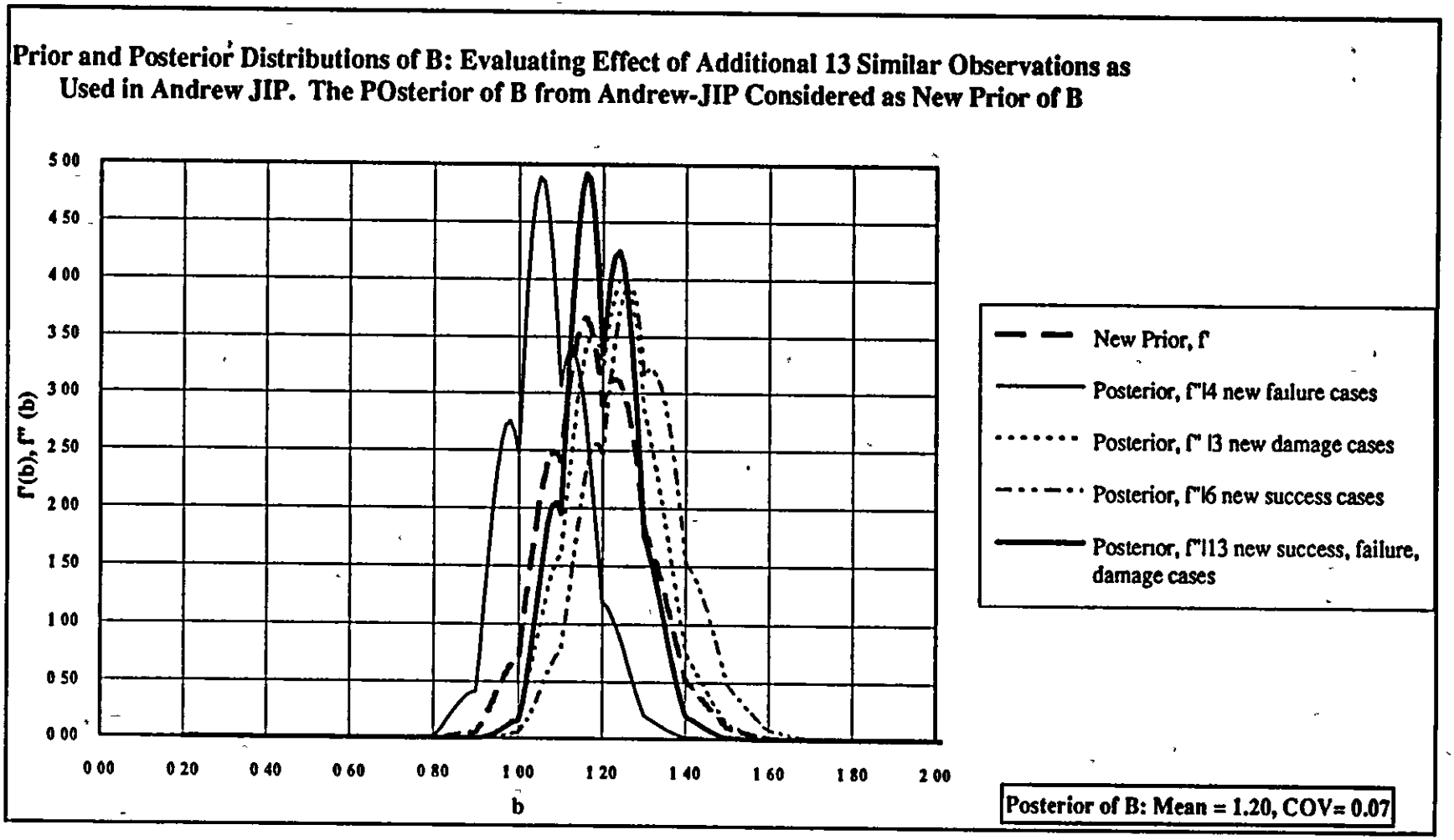
Posterior Distribution of Bias Factor (B) - Effect of Variation in COV of Prior of B



Posterior Distribution of Bias Factor (B) - Effect of Removal of 1-Platform from Any Category



Posterior Distribution of Bias Factor (B) - Effect of Removal of 3-Damage Cases



Posterior Distribution of Bias Factor (B) - Effect of Additional 13-Similar Observations

WEIGHTING APPROACH

- **ASSESSMENT OF PLATFORMS DATA**
  - — **Select Platforms Most Mappable to the Analyzed Platforms**
  - — **Unlikely Survival/Damage Cases Identification**
  - — **Based on Cut-Off Criteria: Age, Hs, etc.**
- **INFORMATION REQUIRED FOR COMPARISON**
- **CATEGORIZATION OF ADDITIONAL PLATFORMS**
- **UPDATING OF CALIBRATION RESULTS**

OVERVIEW OF PLATFORMS SURVIVED/DAMAGED

Operator	Platforms Survived (S)	Platforms Damaged (D)	Platforms Used in Phase I JIP
<u>JIP Participants</u>			
Amoco	30	1	1 (S) + 1 (D)
Chevron	143	12	3 (S) + 3(D)
Exxon	72	-	2 (S)
Mobil	22	1	-
Phillips	7	-	-
Shell	39	-	-
Unocal	25	1	-
Total Participants Platforms	338	15	10 (6 S + 4 D)
Other Operators	310	13	3 (D)
Total Platforms	648	28	13 (6 S + 7 D)

Summary of Andrew JIP - Phase I Platforms

Platform Name	Water Depth ft.	Year of Installation	Number of legs	Leg-Pile annulus grouted/ ungrouted	Brace type in Jacket frames	Cellar deck elevation ft.	Hindcast maximum wave height H ft.	Does Wave Inundate the Deck ?	Platform Classification Based on Phase I Calibration
Survival Platform Cases:									
ST151K	137	1963	8	grouted	diagonal/ K	36.5	60 854	Cellar deck	Unexpected Survival
ST130Q	170	1964	4	grouted	K	39	62.269	Cellar deck	Unexpected Survival
ST134W	137	1981	4	ungrouted	diagonal	43	60 854	-	Expected Survival
WD90A	184	1964	8	grouted	diagonal/ K	26.75*/ 34 83	50.531	Sub-cellar deck	Expected Survival
MC311	343	1978	8	ungrouted	diagonal/ X	57	62	-	Sure Survival
MC397	468	1991	4	ungrouted	X-braces	53.3*/ 65 0	65 911	-	Sure Survival
Damage Platform Cases:									
T23ST52	63	1969	4	grouted	K-braces	52.594	50.3	-	Exepcted Survival/Likely to Damage
T25SS139	62	1969	4	grouted	K-braces	50.594	50.63	-	Unexepcted Survival/Likely to Damage
ST161A	118	1964	8	grouted	diagonal/ K	34 75	58 495	Cellar deck	Exepcted Survival/Likely to Damage
Failure Platform Cases:									
ST177B	142	1965	8	grouted	diagonal/ K	39	60.167	Cellar deck	Expected failure
ST151H	137	1964	8	grouted	diagonal/ K	39.5	60.854	Cellar deck	Expected Failure
ST130A	140	1958	8	grouted	diagonal/ K	55	60 95	-	Likely Failure
T21ST72	61	1969	4	grouted	K-braces	54.594	49 74	-	Likely Failure

INFORMATION REQUIRED (PRELIMINARY) FOR COMPARISON

- WATER DEPTH
- YEAR OF INSTALLATION/DESIGN
- PLATFORM ORIENTATION
- PLATFORM LATITUDE AND LONGITUDE
- KEY SKETCHES OF PLATFORM STRUCTURAL FRAMING
  - Number of Legs/ Piles
  - Leg Batter
  - Number of Conductors
  - Deck Elevations (including sub-cellar deck, if any)
  - Jacket Framing Elevations
  - Brace type in Vertical Frames
  - Sizes of Primary Members (leg, pile, vertical frames braces, primary horizontals)
  - Joint Details (can, gap, etc.)
  - Leg/Pile Annulus Grouting Status
- POST ANDREW INSPECTION REPORT
  - Significant Wave Height, Hs (ft.)
- INFORMATION ON DAMAGES PRIOR TO ANDREW
- RESULTS FROM IN-HOUSE STUDIES, IF AVAILABLE
- ORIGINAL DESIGN CRITERIA INFORMATION, IF AVAILABLE
- SOIL SHEAR STRENGTH PROFILE, IF AVAILABLE

Platforms Identified for Evaluating Their Likelihood of Falling Under Unexpected Survival Category

OPERATOR	AREA BLOCK	STRUCTURE NAME	YEAR INSTALLED	WATER DEPTH	DISTANCE FROM SHORE (MILES)	Hs (M)
AMOCO	EI 0193	A	59	87	44	6
	ST 0161	B	69	120	32	10
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	ST 0130	D	62	160	28	11
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	ST 0151	G	61	137	32	11
	ST 0151	I	63	128	32	11
	ST 0151	J	62	140	32	11
	ST 0151	K	64	137	32	11
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	ST 0151	PROD-2	62	137	32	11
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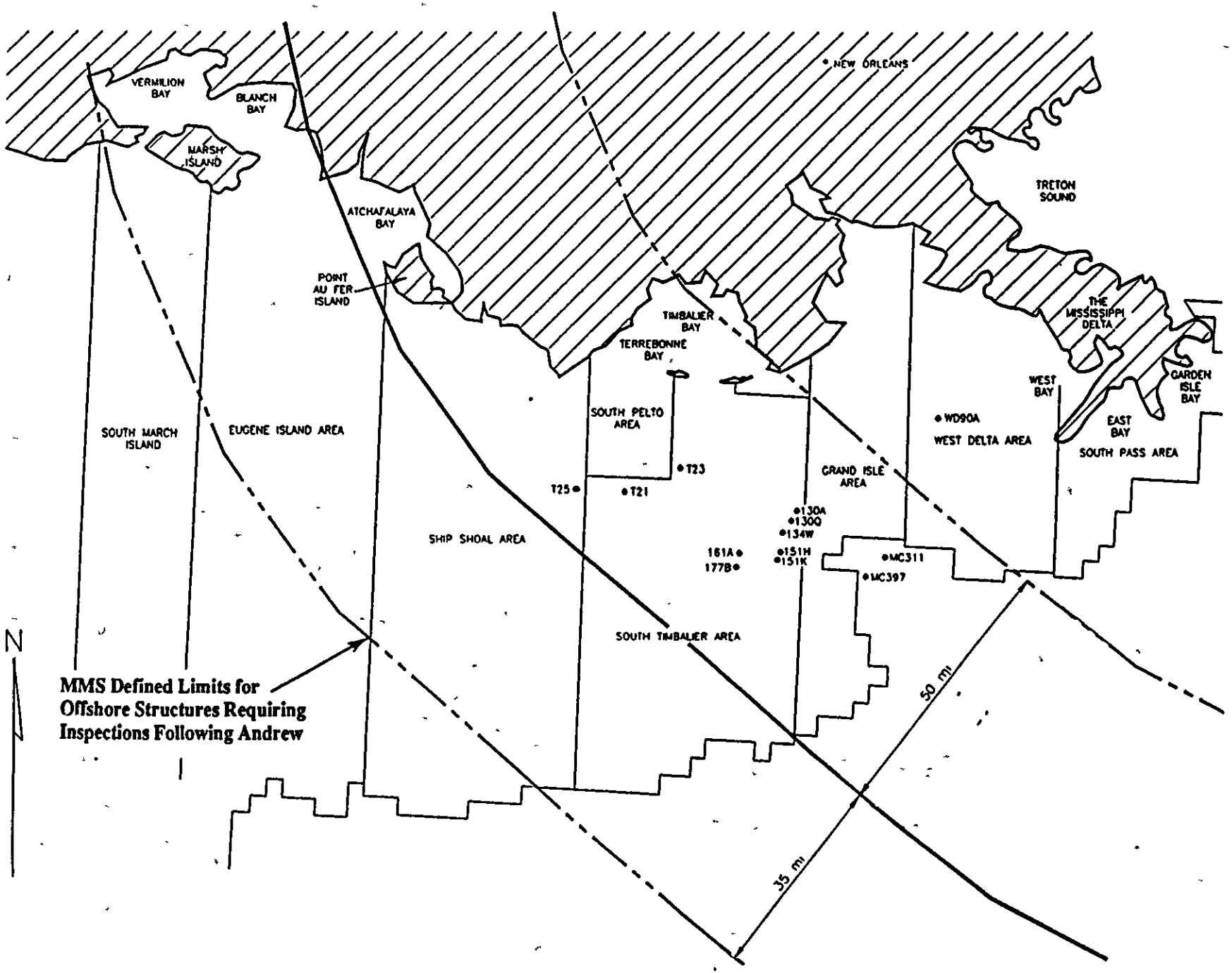
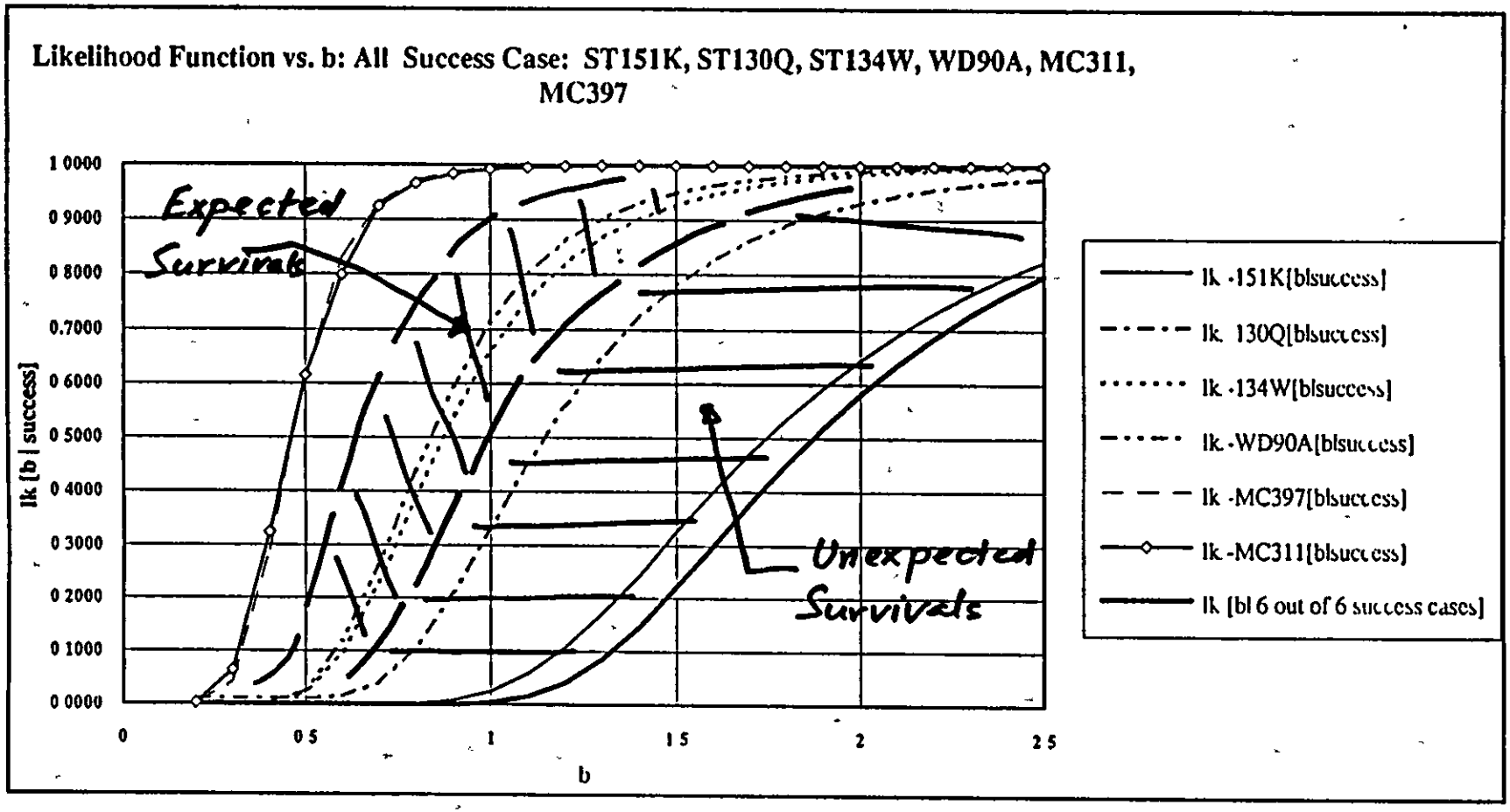
	WD 0093	E	65	160	27	9
	WD 0099	A	63	194	31	9
MOBIL	EI128	A	50's	50	?	?
	SS 0087	B	50	31	8	6
MURPHY	SS114	H	?	50	?	?
PHILLIPS	SS 0149	A	56	55	33	7
SAMEDAN	ST172	A	64	107	?	?
SHELL	WD 0103	A	65	223	27	9
	WD 0103	B	65	228	27	9
	WD 0104	C	65	228	27	9
	WD 0104	D	67	260	27	9
UNOCAL	SS 0208	E	63	103	34	8
	SS 0208	F	64	97	34	8
	SS 0208	PURE	64	97	34	8
	SS 0209	A	72	95	34	8
	SS 0209	B	61	100	34	8
	SS 0209	D	63	95	34	8
	SS 0209	G	67	100	34	8
	SS 0253	A	62	165	54	8
	SS 0253	C	69	175	54	8



Path of Hurricane Andrew with Platforms Used in Calibration



Likelihood Functions - Success Cases – Phase I

CATEGORIZATION OF ADDITIONAL PLATFORMS

- **CATEGORIES**
  - — **Unexpected Survivals**
  - — **Expected Survivals**
- **APPROACH**
  - — **Identify Corresponding Platform(s) Evaluated in the JIP**
  - — **Determine Max. Wave Height at Platform Location**
  - — **Evaluate Whether Wave Hit the Deck**
  - — **Evaluate Likelihood of R and S to Differ from the Base Cases**
  - — **Review Joint Information**
  - — **Assess Special Features**
- **IDENTIFY NUMBER OF PLATFORMS IN EACH CATEGORY**

UPDATING OF CALIBRATION RESULTS

- **INCLUDE EFFECT OF ADDITIONAL PLATFORMS ON "B"**
  - — Consider Increased Uncertainties in R and S
  - — Develop "New" Likelihood Functions for Different Categories
  - — Let "x" Number of Likely Unexpected Survival Cases and "y" Number of Likely Expected Survival Cases
  - — Determine Combined Likelihood Function, $lk'(b \mid \text{additional platforms})$
- **REVISED LIKELIHOOD FUNCTION:**
  - — $lk^*(b \mid \text{all cases}) = lk(b \mid 9 \text{ platforms}) \times lk'(b \mid x \text{ platforms}) \times lk'(b \mid y \text{ platforms})$
- **ESTABLISH REVISED BIAS FACTOR, B***

$$f^*_B(b) \quad \alpha \quad f^*_B(b) \quad lk^*(b \mid \text{all cases})$$

APPLICATIONS OF BIAS FACTORS

- APPLICABLE TO PARTICULAR LOAD AND RESISTANCE RECIPE
- USE BY THE API COMMITTEES AND MMS
  - Criteria Revisions
  - Recommended Design Guidelines Revisions
- REASSESSMENT STUDIES AND DECISION MAKING
- RISK ASSESSMENT STUDIES BY THE OPERATORS
  - Individual Platforms
  - Fleet of Platforms
  - IMR Program Implementation
- NOT TO BE USED IN DESIGN

EXAMPLE USE OF BIAS FACTORS

- **PHASE I EXAMPLE APPLICATION**

- **EVALUATION OF ANNUAL PROBABILITY OF FAILURE**
  - **Establish Annual Maximum Seastate Data**
  - **Determine Coefficients to Define Base Shear**
  - **Determine Ultimate Capacity of Platform**
  - **Determine Probability of Failure Versus "b"**

- **DETERMINE UPDATED PROBABILITY OF FAILURE**
  - $Pf = P[S > R]$
  - $Pf' = \int P[S > Rb \mid b] f_B'(b)\, db$
  - $Pf'' = \int P[S > Rb \mid b] f_B''(b)\, db$

- **TOTAL PROBABILITIES OF FAILURE:**
  - $\text{Total } Pf = 1 - \Pi[1 - Pf] = \Sigma Pf$
  - $\text{Total } Pf' = 1 - \Pi[1 - Pf'] = \Sigma Pf'$
  - $\text{Total } Pf'' = 1 - \Pi[1 - Pf''] = \Sigma Pf''$

EXAMPLE APPLICATION - PHASE I

PLATFORM ST 151 K

- GULF OF MEXICO
- WATER DEPTH = 137 FT
- ANNUAL MAXIMUM HS: MEDIAN 17.5 ft. COV 0.31
- ASSUMED STORM DURATION: 3 hours
- ASSUMED NUMBER OF WAVES: 800
- MEDIAN HS FOR STORM HOURS 1, 2, AND 3
- MEDIAN CURRENT VALUE
- DETERMINE ULTIMATE CAPACITY FOR THREE DIRECTIONS
- DETERMINE ANNUAL FAILURE PROBABILITIES

	Broadside	Diagonal	End-on
Pf	0.037	0.025	0.007
Pf'	0.071	0.044	0.018
Pf"	0.022	0.016	0.004

- DETERMINE TOTAL ANNUAL PROBABILITY OF FAILURE

Pf = 0.07

Pf' = 0.13

Pf" = 0.04

EXAMPLE USE OF BIAS FACTORS — PHASE II

- **DETERMINE PREDICTIVE PROBABILITY OF FAILURE**

Case - 1:

— $Pf = \int \int Pf\,[b_1, b_2]\, f''_{B1,B2}\,(b_1, b_2)\, db_1\, db_2$

$Pf\,[b_1, b_2] = P\,[(g_1 < 0)\,(g_2 < 0)]$

$g_1 = (b_1 * R_1 / S) - 1$

$g_2 = (b_2 * R_2 / S) - 1$

Case -2:

- $Pf = \int Pf\,[b_1]\, f''_{B1}\,(b_1)\, db_1$

$Pf\,[b_1] = P\,[g_1 < 0]$

$g_1 = (b_1 * R_1 / S) - 1$

BENEFITS OF ANDREW JIP - PHASE II

- IMPROVED LOAD AND RESISTANCE RECIPE
- IMPROVED CALIBRATION PROCEDURE
- MULTIPLE BIAS FACTORS
- PROCEDURE TO INCLUDE EFFECT OF OTHER PLATFORMS
- PROCEDURE TO USE MULTIPLE BIAS FACTORS