

Appendix B: PCCV Model Material Properties

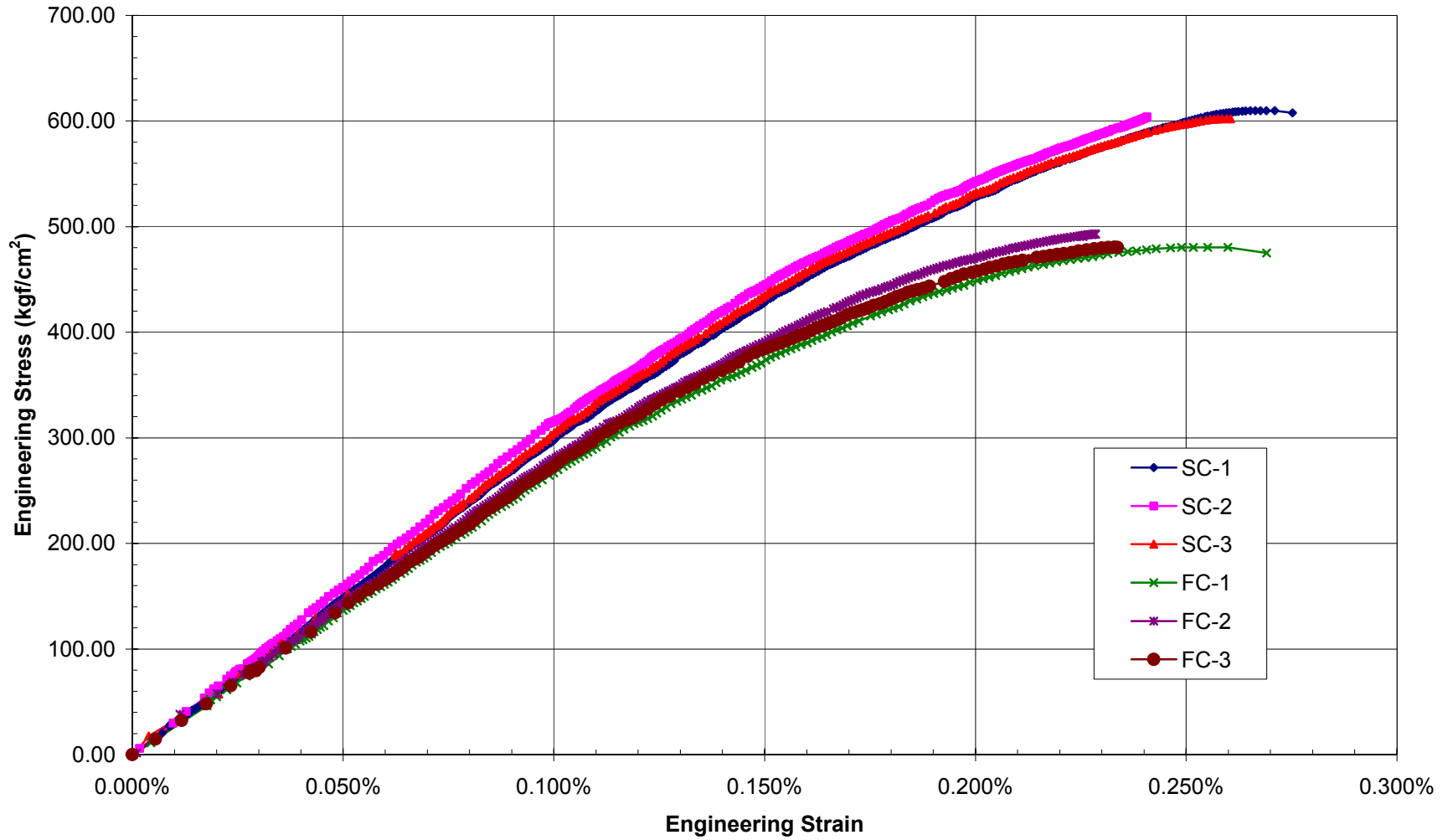
Section i. Trial Mix Concrete

Trial Concrete Mixture Test (METRIC)														
Procedures & Specifications														
JPN-14-T-1-6, Trial Concrete Mixture, Procedure, Rev. 1; 5/14/96														
Data & Test Reports														
(A) JPN-22-T-1, Ancillary Test Report, October 3, 1997														
(B) JPN-22-T-1(Rev.1), Ancillary Test Report, March 9, 1998														
(C) MH-K10-39, Concrete Creep Coeff. & Drying Shrinkage Test Report														
Test Items														
Fresh Concrete														
			<u>300 kgf/cm²</u>		<u>450 kgf/cm²</u>									
Slump w/o superplasticizers (cm)	ASTM C143-90a	(A)	16.8		10.8									
		(B)	9.2		8.9									
Slump w/ superplasticizers (cm)		(A)	19.4		20.7									
		(B)	16.2		18.7									
Air Content (%)	ASTM C231-91b	(A)	4.50		4.85									
		(B)	5.50		5.00									
Quantity of Chloride (%)	ASTM C1152-90	(A)	0.001		0.002									
		(B)	0.003		0.002									
Hardened Concrete														
			<u>300 kgf/cm²</u>		<u>450 kgf/cm²</u>		<u>300 kgf/cm²</u>		<u>450 kgf/cm²</u>		<u>300 kgf/cm²</u>		<u>450 kgf/cm²</u>	
Specimens	ASTM C31-91		SC	FC	SC	FC	SC	FC	SC	FC	SC	FC	SC	FC
			<u>1 week</u>				<u>4 weeks</u>				<u>13 weeks</u>			
Compressive Strength (kgf/cm ²)	ASTM C39-86 or -94(?)	(A)	343	300	399	418	411	341	507	492	524.00	425.00	614.00	498.00
		(B)	-	-	-	-	484	426	545	544	601.00	480.00	657.00	630.00
Split Tensile Strength (kgf/cm ²)	ASTM C496-90	(A)									40.10	34.40	42.90	35.20
		(B)									40.60	40.60	45.50	39.20
Flexural Strength (kgf/cm ²)	ASTM C-78-84	(A)									54.80	40.80	56.90	56.20
		(B)									57.40	60.20	58.80	44.80
Young's Modulus (kgf/cm ² x 10 ⁵)	ASTM C469-87	(A)									2.96	2.85	3.26	2.75
		(B)									3.04	2.73	3.02	2.97
Poisson's Ratio	ASTM C469-87	(A)									0.20	0.18	0.20	0.18
		(B)									0.22	0.23	0.23	0.23
Unit Weight (ton/m ³)	<u>weight of cylinders</u>	(A)									2.25	2.21	2.26	2.19
	<u>nominal volume</u>	(B)									2.25	2.23	2.24	2.23
Stress-Strain Relation	TTP-08, Rev. 1, 9/19/97	(A)*												
	using strain gages	(B)									X(B)	X(B)	X(B)	X(B)
Creep Coefficient	ASTM C512-87		(loaded at 175.8 kgf/cm ²)										X(C)	
Drying Shrinkage	ASTM C512-87		(w/o loading)										X(C)	
*For test A, stress-strain results were obtained up to about 40% of the maximum stress														

Trial Concrete Mixture Test (ENGLISH)														
Procedures & Specifications														
JPN-14-T-1-6, Trial Concrete Mixture, Procedure, Rev. 1; 5/14/96														
Data & Test Reports														
(A) JPN-22-T-1, Ancillary Test Report, October 3, 1997														
(B) JPN-22-T-1(Rev.1), Ancillary Test Report, March 9, 1998														
(C) MH-K10-39, Concrete Creep Coeff. & Drying Shrinkage Test Report														
Test Items														
Fresh Concrete														
			<u>4300 psi</u>		<u>6400 psi</u>									
Slump w/o superplasticizers (in)	ASTM C143-90a	(A)	6.6		4.3									
		(B)	3.6		3.5									
Slump w/ superplasticizers (cm)		(A)	7.6		8.1									
		(B)	6.4		7.4									
Air Content (%)	ASTM C231-91b	(A)	4.50		4.85									
		(B)	5.50		5.00									
Quantity of Chloride (%)	ASTM C1152-90	(A)	0.001		0.002									
		(B)	0.003		0.002									
Hardened Concrete														
			<u>4300 psi</u>		<u>6400 psi</u>		<u>4300 psi</u>		<u>6400 psi</u>		<u>4300 psi</u>		<u>6400 psi</u>	
Specimens	ASTM C31-91		SC	FC	SC	FC	SC	FC	SC	FC	SC	FC	SC	FC
			<u>1 week</u>				<u>4 weeks</u>				<u>13 weeks</u>			
Compressive Strength (psi)	ASTM C39-86 or -94(?)	(A)	4877	4266	5674	5944	5844	4849	7210	6996	7451	6044	8731	7082
		(B)	-	-	-	-	6882	6058	7750	7736	8546	6826	9343	8959
Split Tensile Strength (psi)	ASTM C496-90	(A)									570	489	610	501
		(B)									577	577	647	557
Flexural Strength (psi)	ASTM C-78-84	(A)									779	580	809	799
		(B)									816	856	836	637
Young's Modulus (psi x 10 ⁵)	ASTM C469-87	(A)									4.2	4.1	4.6	3.9
		(B)									4.3	3.9	4.3	4.2
Poisson's Ratio	ASTM C469-87	(A)									0.20	0.18	0.20	0.18
		(B)									0.22	0.23	0.23	0.23
Unit Weight (pcf)	<u>weight of cylinders</u> nominal volume	(A)									140	138	141	137
		(B)									140	139	140	139
Stress-Strain Relation	TTP-08, Rev. 1, 9/19/97 using strain gages	(A)*												
		(B)									X(B)	X(B)	X(B)	X(B)
Creep Coefficient	ASTM C512-87	(loaded at 2500 psi)											X(C)	
Drying Shrinkage	ASTM C512-87	(w/o loading)											X(C)	
*For test A, stress-strain results were obtained up to about 40% of the maximum stress														

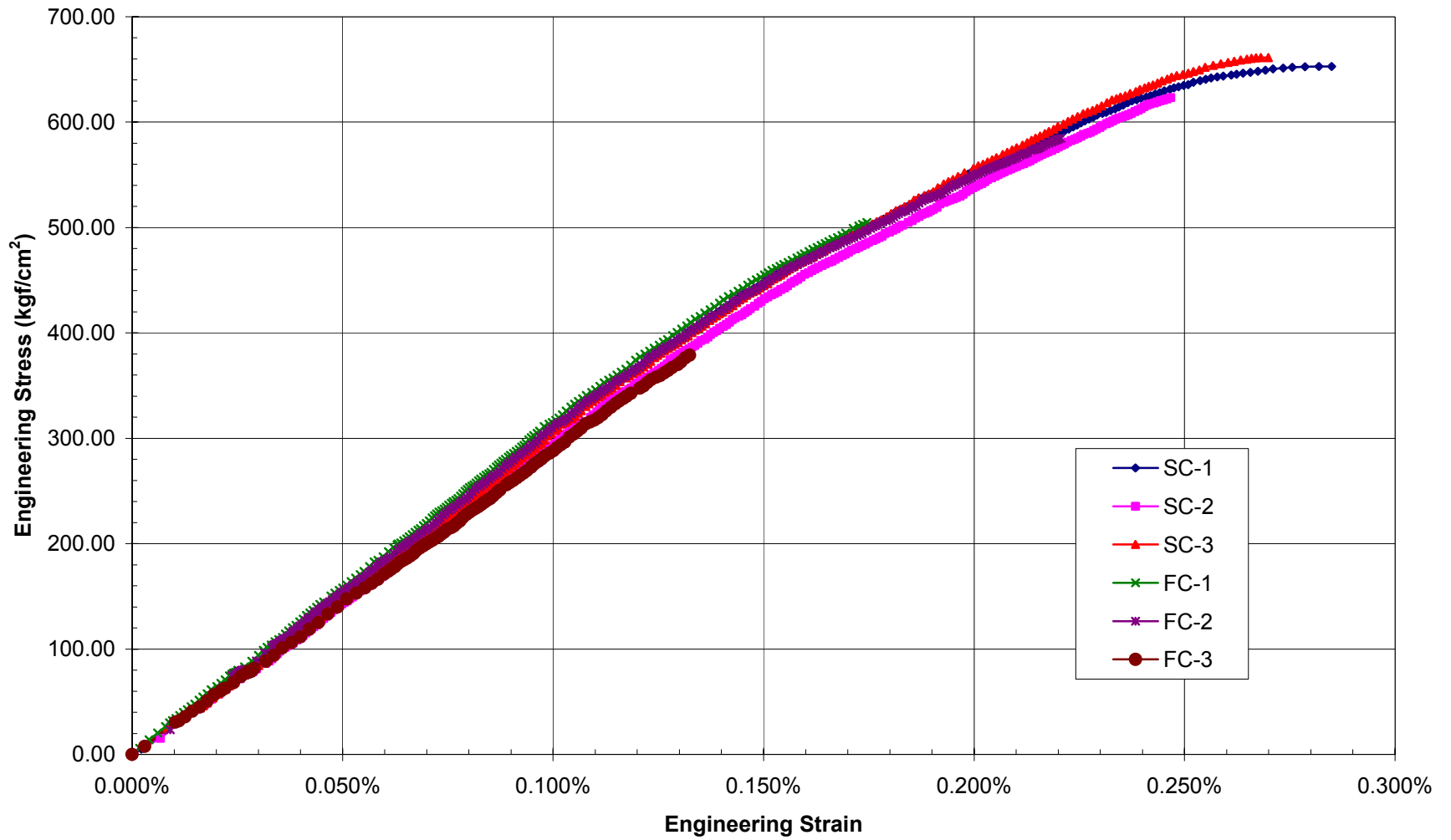
Trial Concrete Mix Stress-Strain @ 13 weeks (300 kg_f/cm²) - Series B

B-7



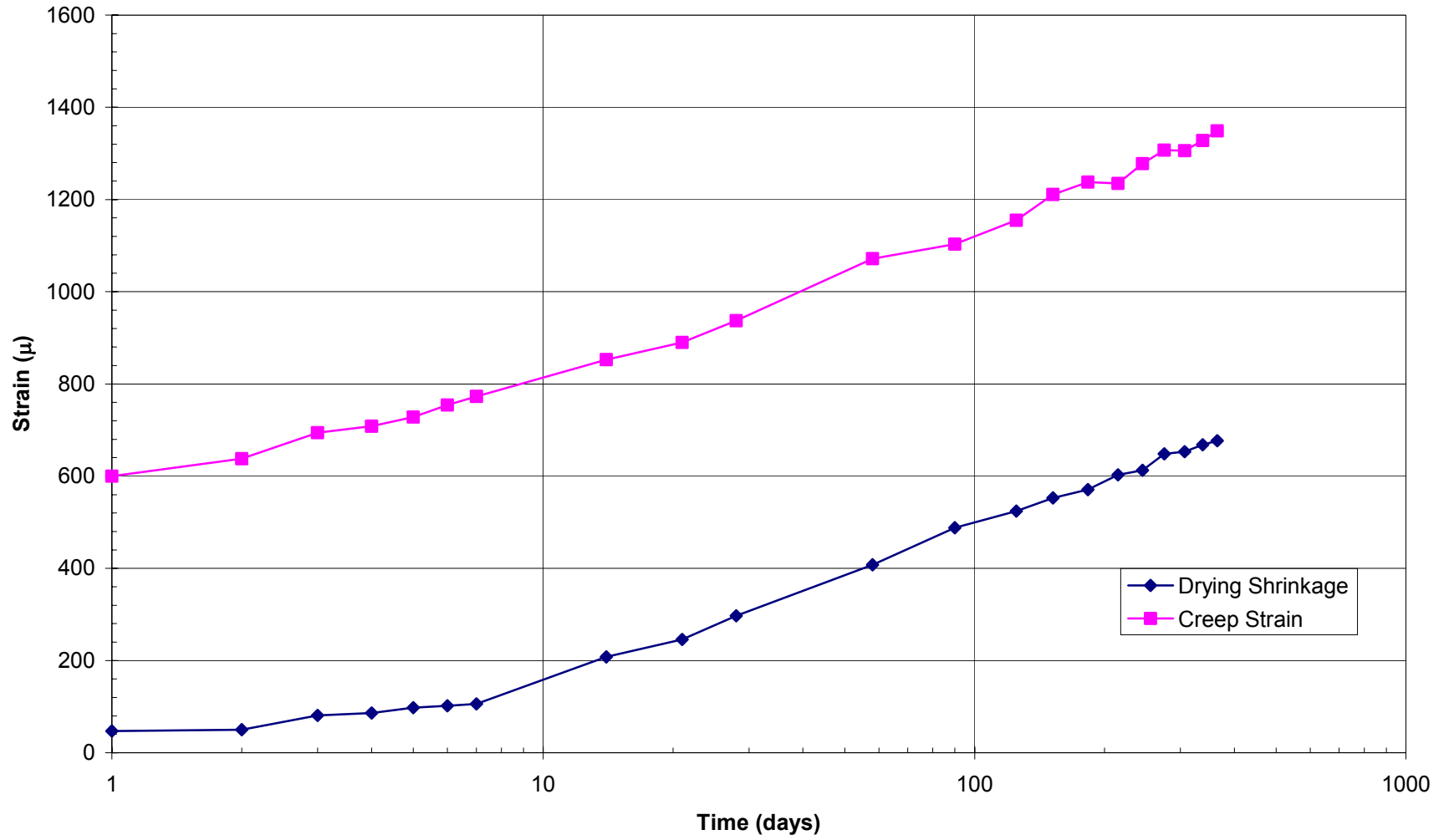
Trial Concrete Mix Stress-Strain @ 13 weeks (450 kgf/cm²) - Series B

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Concrete Creep and Shrinkage Strain

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Section ii. Model Concrete

PCCV Model Concrete Tests (METRIC)																
Procedures & Specifications																
Spec.-T-03-1(E) Specification for Concrete Work; Rev.2																
JPN-14-T-1-8; Concrete Material Test Procedure; Rev. 1; 6/14/96																
Submittal : T-03-1 (E) 2.17.0; Revised 10/30/97																
Data & Test Reports																
(A)* AGRA Reports of Compression Test Results, *NUPEC to issue Test Report																
(B) JPN-22-T-1 (Rev.1), Ancillary Test Report, 9 March 1998																
(C) "Strength and Creep Testing of Concrete in PCCV", ATR/UNM, 31 Jan. 2000																
(D) MH-K11-37: PCCV Stress-Strain Tests, CTL, 15 Feb 2000																
(E) "Mechanical Property Evaluation of Concrete Used in the NUPEC/NRC PCCV: Prestress and Limit State Test Results", Lenke & Gerstle, ATR Institute/UNM, 30 June 2001.																
(F)Draft "Standard Test Method for Determination of Direct Tension Properties of Hardened Concrete using the Stiff Tensile Test (STT) Apparatus", Feb. 2000																
	Specification	Lift:	F1	F2	F3a	F3b	F4	C1	C2	C3	C4	D1	D2	D3	F5	F6
Design Data Tests			300	300	300	450	450	450	450	450	450	450	450	450	300	450
@ Prestressing																
Date (M/D/Y)			01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00		
Compressive Strength (kgf/cm ²)	ASTM C39-96	FC	532	553	421	606	672	621	581	516						
		FC*									630	727	517	581		
			X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)		
Date (M/D/Y)			03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00		
Compressive Strength (kgf/cm ²)	ASTM C39-86	FC	600	558	551	553	629	553	534	528						
		FC*									730	665	624	700		
			X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)		
Young's Modulus (kgf/cm ² x 10 ⁵)	ASTM C39-96		2.66	2.92	2.27	2.87	3.03	2.77	2.86	2.53	2.98	3.12	2.43	2.41		
Young's Modulus (GPa)			26.1	28.6	22.3	28.1	29.7	27.2	28.0	24.8	29.2	30.6	23.8	23.6		
Poisson's Ratio			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
Unit Weight			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
@ Limit State Test			X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)
Unit Weight (kgf/m ³)			2167.5	2194.7	2170.7	2185.1	2181.9	2111.4	2095.4	2175.5	2186.7	2214.0	2181.9	2231.6	2210.8	2199.5
Date (M/D/Y)								08/24/00	08/24/00	08/24/00		08/24/00	08/24/00	08/24/00		09/28/00
Mean Comp. Strength (kgf/cm ²)	ASTM C39-86	FC						499	481	598						
		FC*										626	578	649		581
Date (M/D/Y)			10/05/00	10/07/00	10/09/00	10/12/00	10/12/00	10/09/00	10/09/00	10/10/00	10/10/00	10/11/00	10/11/00	10/11/00	10/11/00	10/11/00
Mean Comp. Strength (kgf/cm ²)	ASTM C469-87	FC	574	575	538	659	662	573	572	610						
		FC*									665	734	676	760	592	665
Young's Modulus (kgf/cm ² x 10 ⁵)	ASTM C469-87		2.86	2.97	2.62	2.89	2.78	2.51	2.55	2.60	2.83	2.94	2.78	2.96	2.64	2.59
Young's Modulus (GPa)			28.0	29.2	25.7	28.3	27.2	24.6	25.0	25.5	27.8	28.8	27.2	29.0	25.9	25.4
Poisson's Ratio	ASTM C469-87		0.22	0.22	0.20	0.22	0.22	0.21	0.22	0.22	0.22	0.22	0.21	0.22	0.21	0.22
Stress-Strain																
Date (M/D/Y)			08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	09/27/00	08/23/00	08/24/00	08/24/00	09/28/00	09/27/00
Split Tensile Strength (kgf/cm2)	ASTM C496-90		35	34	35	33	41	34	31	37	40	38	35	37	35	40
Date (M/D/Y)						10/12/00		10/18/00	10/20/00	10/23/00	10/23/00	10/25/00				
Direct Tension (kgf/cm2)	Draft ASTM Standard (F)					29		21	17	22	24	22				
Date (M/D/Y)						08/22/00		08/21/00	08/21/00	08/21/00	08/21/00	08/22/00	08/22/00	08/22/00		09/28/00
Modulus of Rupture (kgf/cm2)	ASTM C-78-84					41		37	41	38	43	44	44	45		41

PCCV Model Concrete Tests (ENGLISH)

Procedures & Specifications

Spec.-T-03-1(E) Specification for Concrete Work; Rev.2
 JPN-14-T-1-8; Concrete Material Test Procedure; Rev. 1; 6/14/96
 Submittal : T-03-1 (E) 2.17.0; Revised 10/30/97

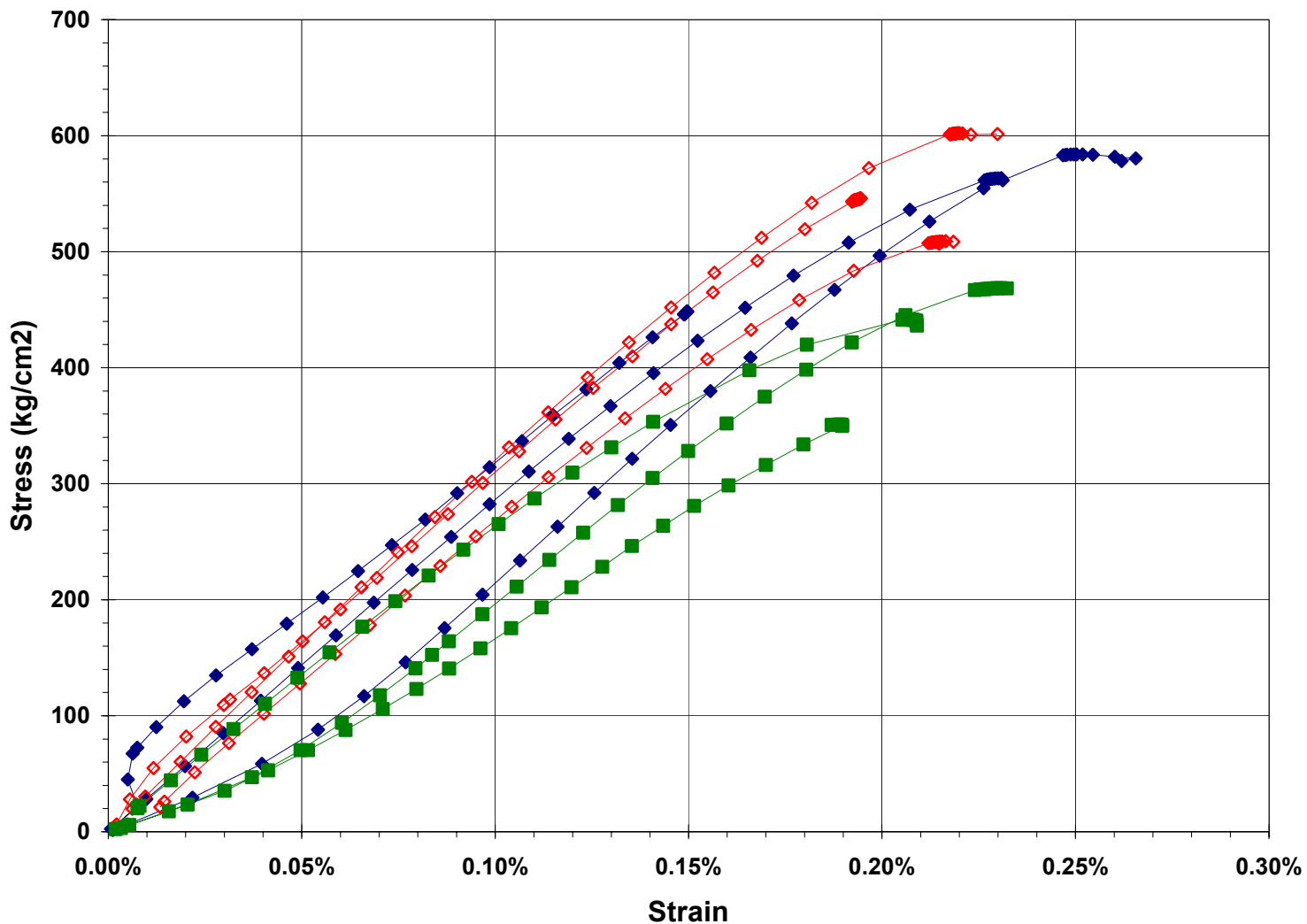
Data & Test Reports

(A)* AGRA Reports of Compression Test Results, *NUPEC to issue Test Report
 (B) JPN-22-T-1 (Rev.1), Ancillary Test Report, 9 March 1998
 (C) "Strength and Creep Testing of Concrete in PCCV", ATR/UNM, 31 Jan. 2000
 (D) MH-K11-37: PCCV Stress-Strain Tests, CTL, 15 Feb 2000
 (E) "Mechanical Property Evaluation of Concrete Used in the NUPEC/NRC PCCV: Prestress and Limit State Test Results", Lenke & Gerstle, ATR Institute/UNM, 30 June 2001.
 (F)Draft "Standard Test Method for Determination of Direct Tension Properties of Hardened Concrete using the Stiff Tensile Test (STT) Apparatus", Feb. 2000

	Specification	Lift:	F1	F2	F3a	F3b	F4	C1	C2	C3	C4	D1	D2	D3	F5	F6
			4300	4300	4300	6400	6400	6400	6400	6400	6400	6400	6400	6400	4300	6400
Design Data Tests																
@ Prestressing																
Date (M/D/Y)			01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	01/31/00	
Compressive Strength (psi)	ASTM C39-96	FC	7566	7857	5980	8617	9549	8825	8263	7339						
		FC*									630	727	517	581		
			X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)		
Date (M/D/Y)			03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	03/08/00	
Compressive Strength (psi)	ASTM C39-86	FC	8525	7940	7840	7870	8950	7860	7590	7510						
		FC*									10380	9455	8875	9950		
Young's Modulus (psi x 10 ⁵)	ASTM C39-96		X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)	X(D)		
Poisson's Ratio			3.78	4.15	3.23	4.08	4.31	3.94	4.06	3.60	4.24	4.43	3.45	3.42		
Unit Weight			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
@ Limit State Test			X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)	X(E)
Unit Weight (pcf)			135.3	137.0	135.5	136.4	136.2	131.8	130.8	135.8	136.5	138.2	136.2	139.3	138.0	137.3
Date (M/D/Y)								08/24/00	08/24/00	08/24/00		08/24/00	08/24/00	08/24/00		09/28/00
Mean Comp. Strength (psi)	ASTM C39-86	FC						7097	6840	8507						
		FC*									8895	8217	9230		8260	
Date (M/D/Y)			10/05/00	10/07/00	10/09/00	10/12/00	10/12/00	10/09/00	10/09/00	10/10/00	10/10/00	10/11/00	10/11/00	10/11/00	10/11/00	10/11/00
Mean Comp. Strength (psi)	ASTM C469-87	FC	8160	8183	7650	9367	9420	8148	8137	8680						
		FC*									9461	10433	9613	10805	8420	9453
Young's Modulus (psi x 10 ⁵)	ASTM C469-87		4.06	4.23	3.72	4.11	3.95	3.57	3.63	3.70	4.03	4.18	3.95	4.21	3.76	3.68
Poisson's Ratio	ASTM C469-87		0.22	0.22	0.20	0.22	0.22	0.21	0.22	0.22	0.22	0.22	0.21	0.22	0.21	0.22
Stress-Strain																
Date (M/D/Y)			08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	08/23/00	09/27/00	08/23/00	08/24/00	08/24/00	09/28/00	09/27/00
Split Tensile Strength (psi)	ASTM C496-90		498	485	500	468	585	483	435	527	568	537	492	525	503	565
Date (M/D/Y)						10/12/00		10/18/00	10/20/00	10/23/00	10/23/00	10/25/00				
Direct Tension (kgf/cm2)	Draft ASTM Standard (F)					409		303	235	318	337	316				
Date (M/D/Y)						08/22/00		08/21/00	08/21/00	08/21/00	08/21/00	08/22/00	08/22/00	08/22/00		09/28/00
Modulus of Rupture (kgf/cm2)	ASTM C-78-84					590		532	587	543	613	628	628	638		590

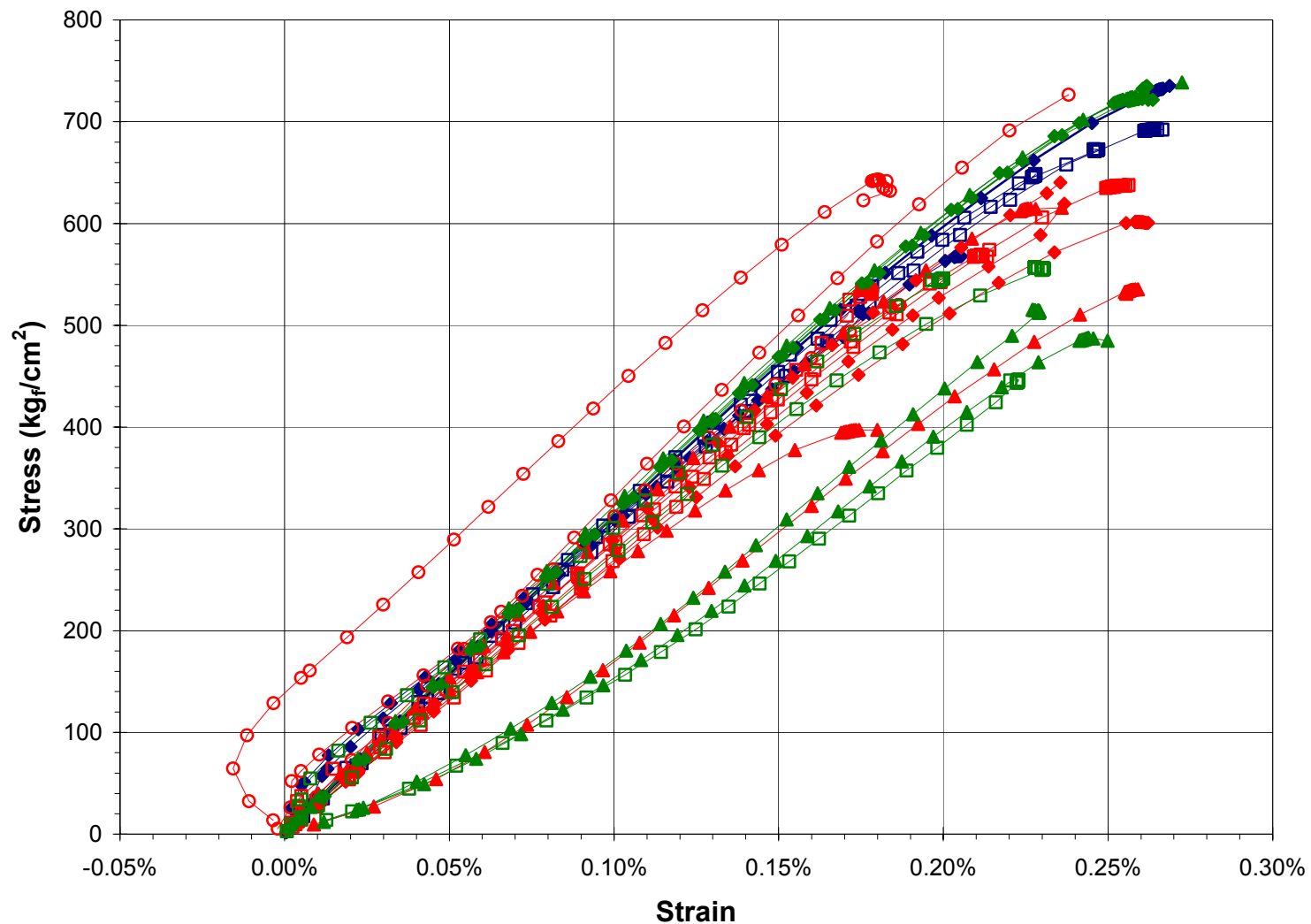
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PCCV Model Concrete Stress-Strain @ Prestressing



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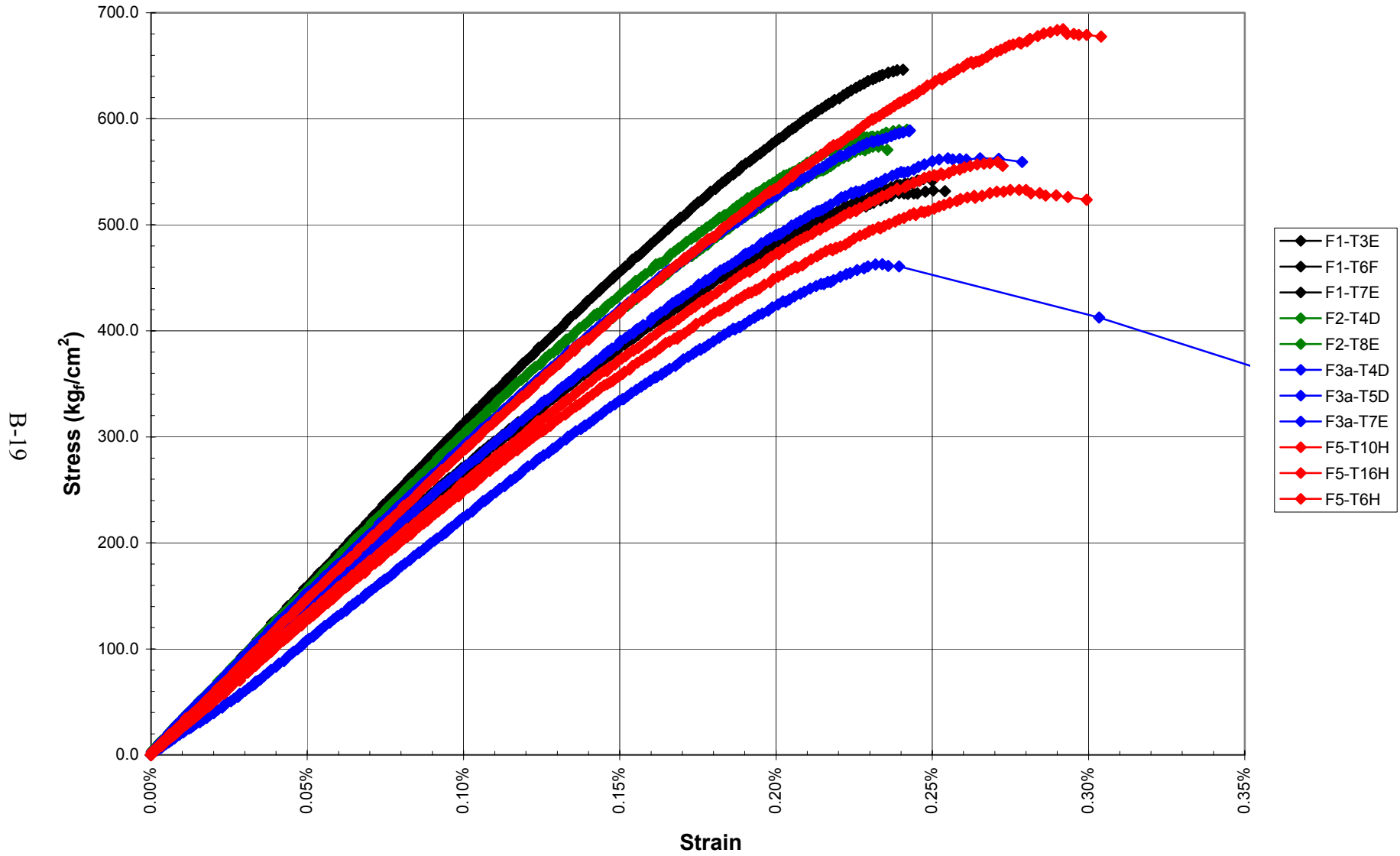
PCCV Model Concrete Stress-Strain @ Prestressing



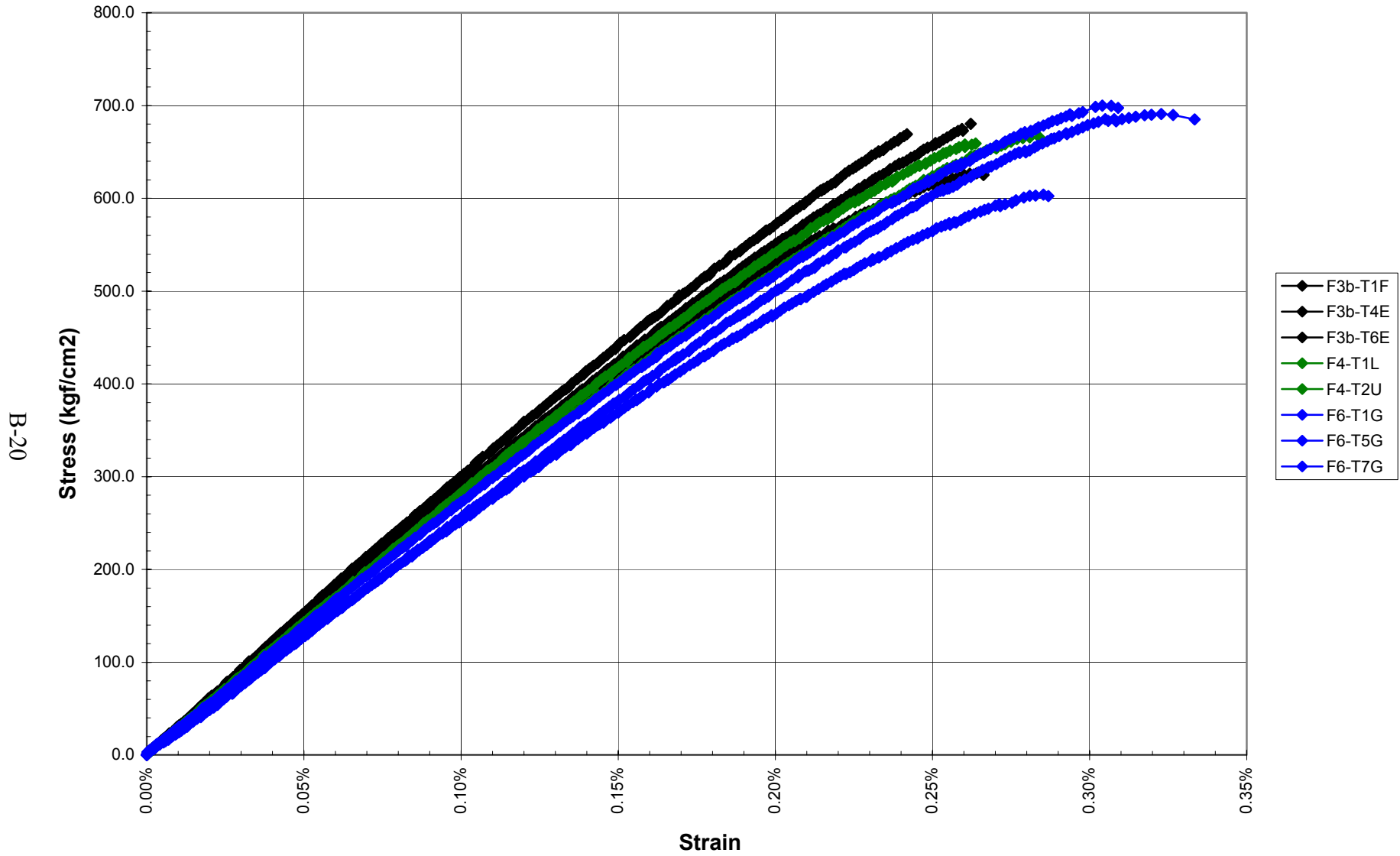
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- F3BT3
- F3BT7
- F4T1
- F4T2
- F4T2B
- C1T2
- C1T5
- C1T6
- C2T1
- C2T3
- C2T4
- C3T1
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- C3T5
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- C4T3
- D1T2
- D1T3
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- D2T4
- D3T1
- D3T2
- D3T2B

B-18

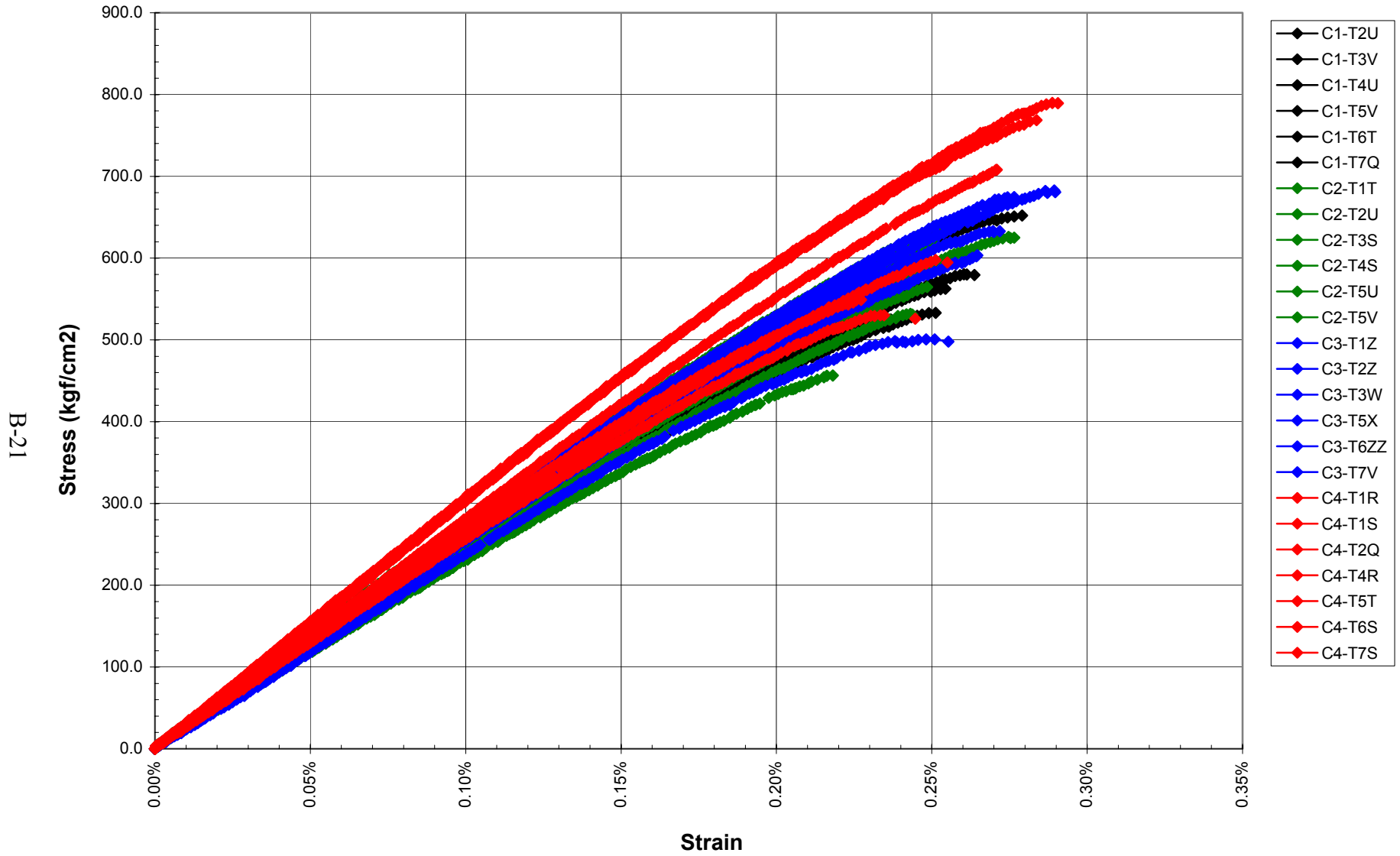
PCCV Concrete Properties @ Limit State Test



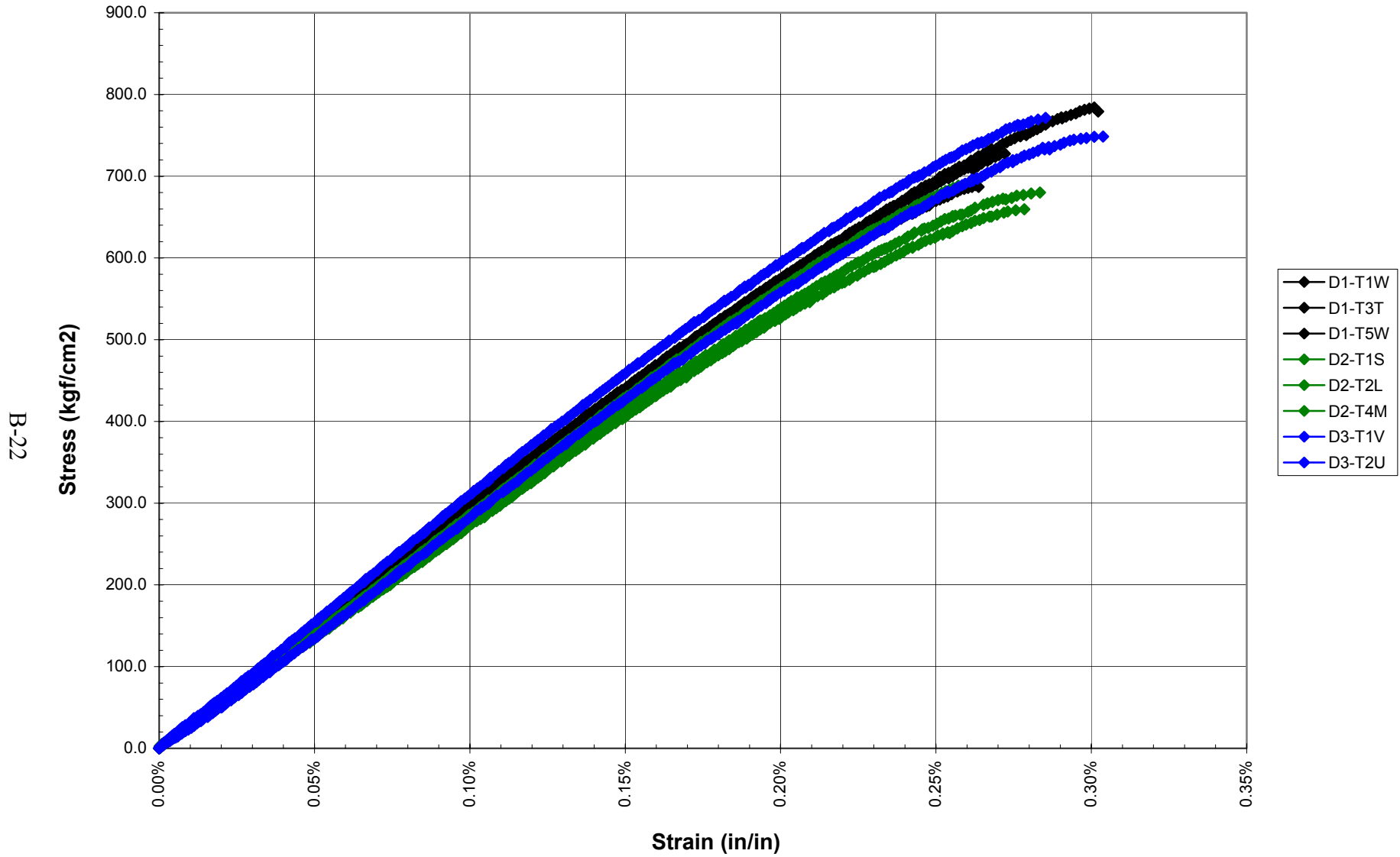
PCCV Concrete Properties @ Limit State Test



PCCV Concrete Properties @ Limit State Test

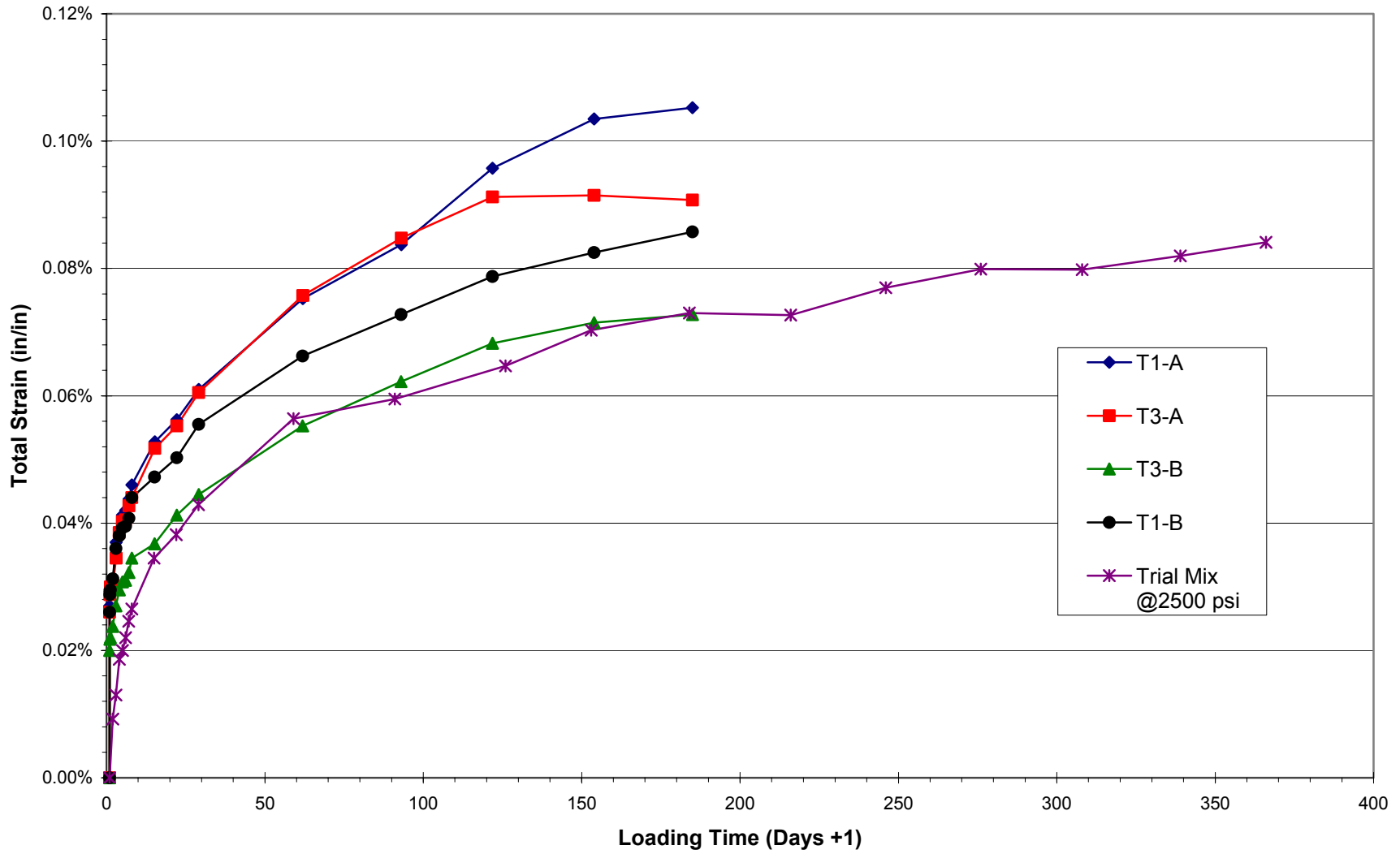


PCCV Concrete Properties @ Limit State Test



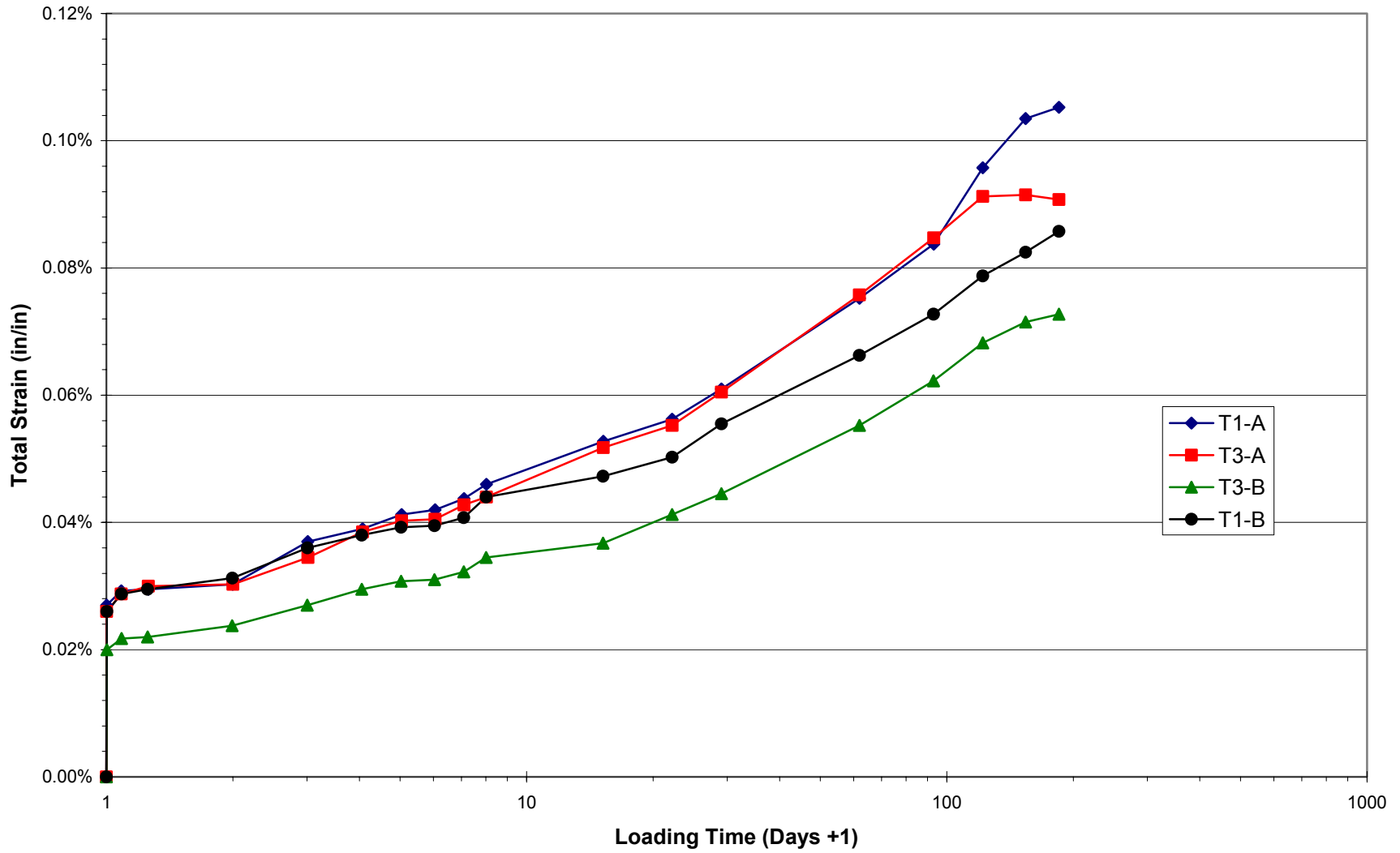
PCCV Model Concrete Creep
Lift C2 (loaded to ~850 psi @ 104 days)

B-23



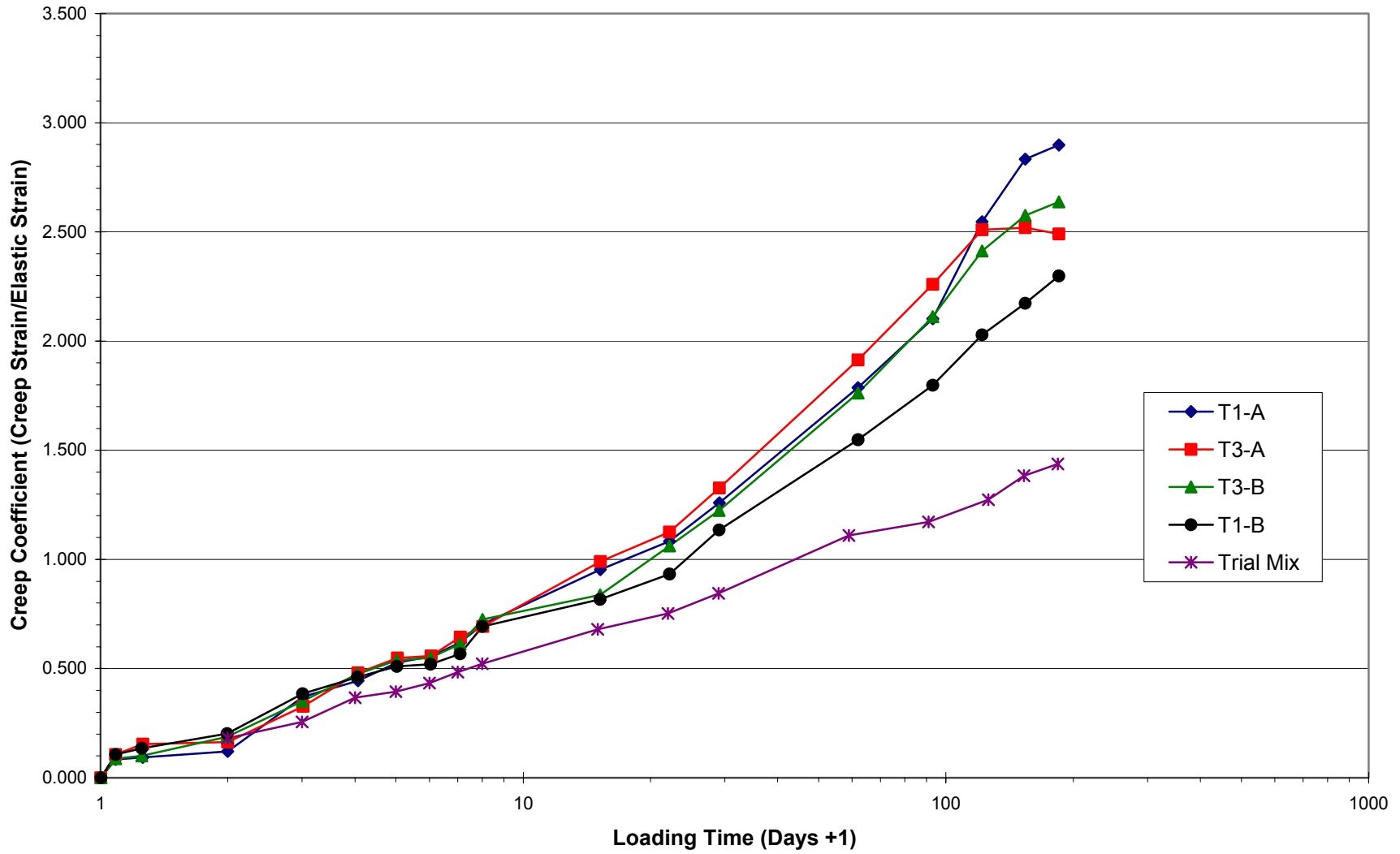
PCCV Model Concrete Creep
Lift C2 (loaded to ~850 psi @ 104 days)

B-24



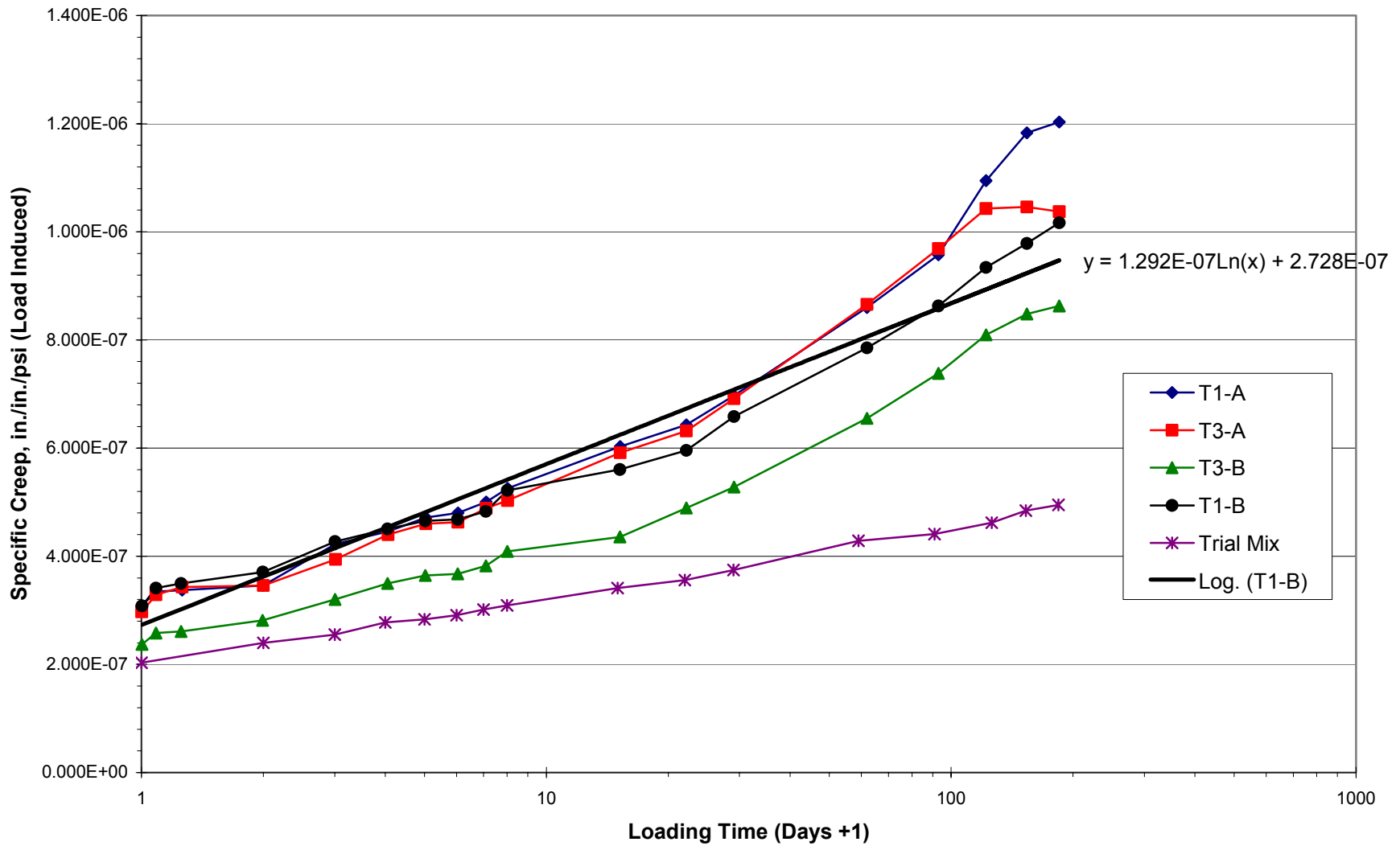
PCCV Model Concrete Creep
Lift C2 (loaded to ~850 psi @ 104 days)

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PCCV Model Concrete Creep
Lift C2 (loaded to ~850 psi @ 104 days)

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Section iii. Liner

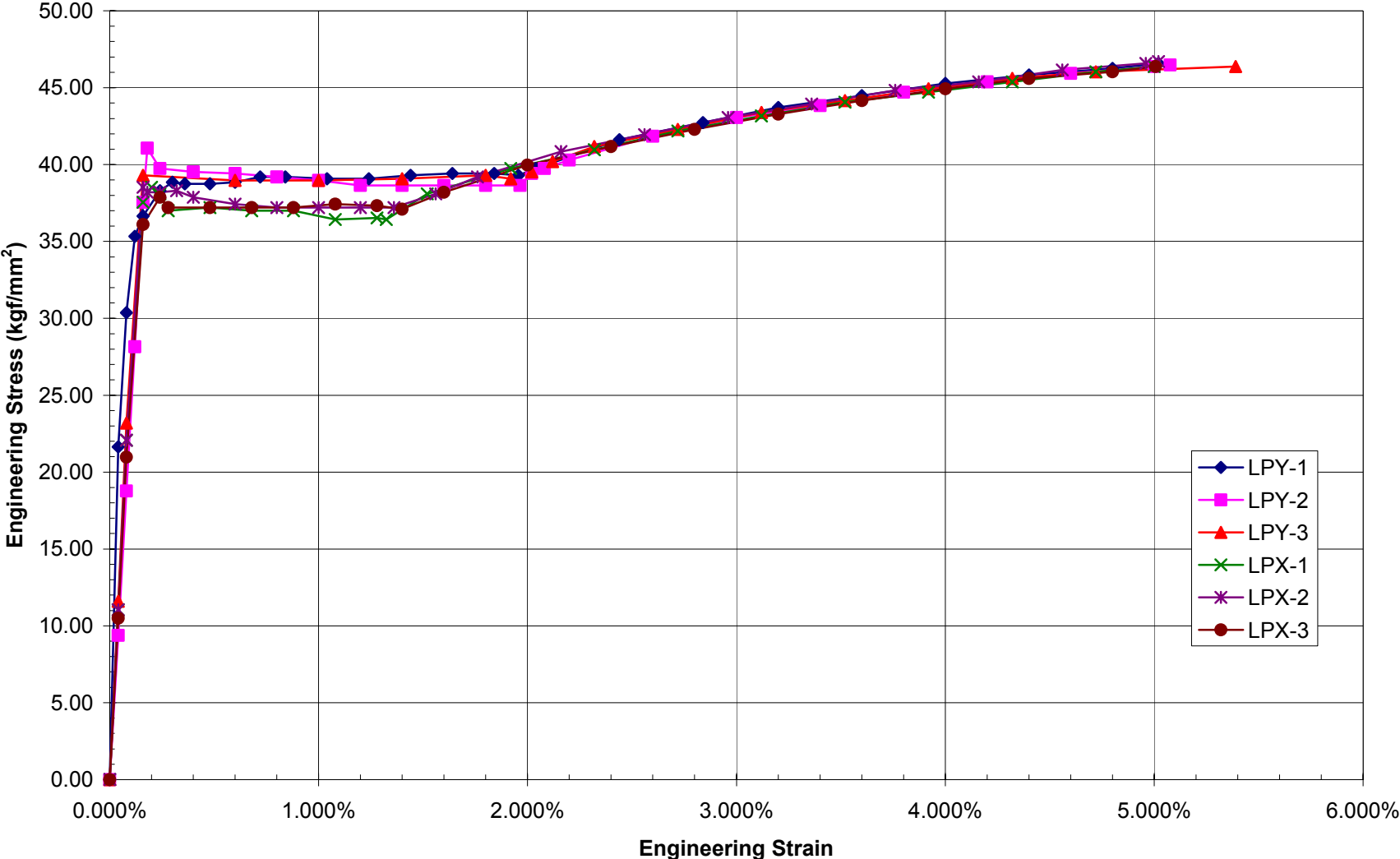
PCCV Liner Material Tests (METRIC)						
Procedures & Specifications						
PCCV Liner Construction Procedure, MH-K9-25A, Rev. 1, Apr. 25, 1997						
Dimension Tolerance for PCCV Liner Installation, MH-K9-26A, Rev. 2, 5/29/97						
Liner Dimension Measurement Procedure, MH-K9-31, Rev. 1						
Procedure for Nondestructive Examinations (RT and PT) and Leak Testing, UGS-L9-970200A, Rev. 2, Apr. 16, 1997						
Repairing Procedure for 5-9 Liner Panel, MH-K9-36, Rev. 0						
Liner Welding Re-Confirmation Test, MH-K9-37, Rev. 1						
Alteration of RT Acceptance Criteria; MH-K9-39						
JIS-Carbon Steel Plates for Pressure Vessels for Intermediate and Moderate Temperature Service, JIS G 3118, 1987						
JIS-Rolled Steels for General Structure, JIS G 3101, 1995						
Data & Test Reports						
(A) Results of Liner Material (SGV410) Test; MH-K9-45, February 1998						
(B) Welded Joint Tensile Test Results; MH-K9-43;9/12						
(C) JPN-16-M-1; Ancillary Test/Liner Material Test, September 1995						
(D) Liner Anchor Test Report; JPN-15-M-2, March 1995						
(E) Results of Liner Welding Re-Confirmation Test, MH-K9-38						
(F) The Repair of 5-9 Liner Panel, MH-K9-41						
(G) Liner Dimensional Inspection Record, MH-K9-46						
	Mat'l Spec.	Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
Liner Plate	SGV410	kgf/mm ²	kgf/mm ²		kgf/mm ²	
Nominal (JIS G 3118-1987)	min.	22.9	41.8	21.0%		
	max.		50.0			
Test (JIS Z 2241)		X(A)	X(A)	X(A)	X(A)	X(A)
(T*W*G=25.1*1.84*50mm)						
Meridional	LPY-1	38.9	50.5	33.8%	2.21E+04	
	LPY-2	41.1	50.8	33.0%	2.23E+04	
	LPY-3	39.3	50.7	33.6%	2.29E+04	
	Average	39.8	50.7	33.5%	2.24E+04	
Hoop	LPX-1	38.5	50.9	33.0%	2.17E+04	
	LPX-2	38.5	51.0	33.0%	2.32E+04	
	LPX-3	37.8	50.7	33.0%	2.19E+04	
	Average	38.3	50.9	33.0%	2.23E+04	

PCCV Liner Material Tests (METRIC)							
Procedures & Specifications							
PCCV Liner Construction Procedure, MH-K9-25A, Rev. 1, Apr. 25, 1997							
Dimension Tolerance for PCCV Liner Installation, MH-K9-26A, Rev. 2, 5/29/97							
Liner Dimension Measurement Procedure, MH-K9-31, Rev. 1							
Procedure for Nondestructive Examinations (RT and PT) and Leak Testing, UGS-L9-970200A, Rev. 2, Apr. 16, 1997							
Repairing Procedure for 5-9 Liner Panel, MH-K9-36, Rev. 0							
Liner Welding Re-Confirmation Test, MH-K9-37, Rev. 1							
Alteration of RT Acceptance Criteria; MH-K9-39							
JIS-Carbon Steel Plates for Pressure Vessels for Intermediate and Moderate Temperature Service, JIS G 3118, 1987							
JIS-Rolled Steels for General Structure, JIS G 3101, 1995							
Data & Test Reports							
(A)Results of Liner Material (SGV410) Test; MH-K9-45, February 1998							
(B)Welded Joint Tensile Test Results; MH-K9-43;9/12							
(C)JPN-16-M-1; Ancillary Test/Liner Material Test, September 1995							
(D)Liner Anchor Test Report; JPN-15-M-2, March 1995							
(E)Results of Liner Welding Re-Confirmation Test, MH-K9-38							
(F)The Repair of 5-9 Liner Panel, MH-K9-41							
(G)Liner Dimensional Inspection Record, MH-K9-46							
			Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
			kgf/mm ²	kgf/mm ²		kgf/mm ²	
Welded (SMAW) Liner Plate							
(JIS Z 3121, Test Piece 1A)			X(B)	X(B)	X(B)		X(B)
	As-welded (avg.)		39.4	51.7	19.1%		
	Repaired (avg.)		37.9	51.4	18.4%		
	w/o Back-up bar (avg.)		39.2	51.7	17.9%		
	w/ Back-up bar (avg.)		38.1	51.4	19.7%		
	Mat'l Spec.		Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
Liner Anchor	SS400		kgf/mm ²	kgf/mm ²		kgf/mm ²	
Nominal							
	JIS G 3101-1995	min.	25.0	40.8	21.0%		
		max.		52.0			
Test			X(C)	X(C)	X(C)	X(C)	
		vertical	29.5	46.5	33.0%	2.12E+04	
		horizontal	31.5	45.3	38.0%	2.20E+04	
			fc'	Max. Load	Max. Disp.	Initial Stiffness	Force-Deflection
			kgf/cm ²	kgf	mm	kgf/mm	
Liner Anchor Force-Deflection			X(D)	X(D)	X(D)	X(D)	X(D)
	Tension, prestressed		410	4,433	0.100	127,333	
	Tension, non-prestressed		410	3,20	0.129	52,667	
	Shear, prestressed		410	14,700	2.865	59,267	
	Shear, non-prestressed		410	11,100	1.155	39,667	

PCCV Liner Material Tests (ENGLISH)						
Procedures & Specifications						
PCCV Liner Construction Procedure, MH-K9-25A, Rev. 1, Apr. 25, 1997						
Dimension Tolerance for PCCV Liner Installation, MH-K9-26A, Rev. 2, 5/29/97						
Liner Dimension Measurement Procedure, MH-K9-31, Rev. 1						
Procedure for Nondestructive Examinations (RT and PT) and Leak Testing, UGS-L9-970200A, Rev. 2, Apr. 16, 1997						
Repairing Procedure for 5-9 Liner Panel, MH-K9-36, Rev. 0						
Liner Welding Re-Confirmation Test, MH-K9-37, Rev. 1						
Alteration of RT Acceptance Criteria; MH-K9-39						
JIS-Carbon Steel Plates for Pressure Vessels for Intermediate and Moderate Temperature Service, JIS G 3118, 1987						
JIS-Rolled Steels for General Structure, JIS G 3101, 1995						
Data & Test Reports						
(A)Results of Liner Material (SGV410) Test; MH-K9-45, February 1998						
(B)Welded Joint Tensile Test Results; MH-K9-43;9/12						
(C)JPN-16-M-1; Ancillary Test/Liner Material Test, September 1995						
(D)Liner Anchor Test Report; JPN-15-M-2, March 1995						
(E)Results of Liner Welding Re-Confirmation Test, MH-K9-38						
(F)The Repair of 5-9 Liner Panel, MH-K9-41						
(G)Liner Dimensional Inspection Record, MH-K9-46						
	Mat'l Spec.	Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
Liner Plate	SGV410	psi	psi		psi	
Nominal (JIS G 3118-1987)	min.	32,626	59,451	21.0%		
	max.		71,052			
Test (JIS Z 2241)		X(A)	X(A)	X(A)	X(A)	X(A)
(T*W*G=25.1*1.84*50mm)						
	Meridonal	LPY-1	55,316	71,811	33.8%	3.143E+07
		LPY-2	58,444	72,238	33.0%	3.171E+07
		LPY-3	55,885	72,095	33.6%	3.256E+07
		Average	56,548	72,048	33.5%	3.190E+07
	Hoop	LPX-1	54,747	72,380	33.0%	3.086E+07
		LPX-2	54,747	72,522	33.0%	3.299E+07
		LPX-3	53,752	72,095	33.0%	3.114E+07
		Average	54,415	72,332	33.0%	3.166E+07

PCCV Liner Material Tests (ENGLISH)						
Procedures & Specifications						
PCCV Liner Construction Procedure, MH-K9-25A, Rev. 1, Apr. 25, 1997						
Dimension Tolerance for PCCV Liner Installation, MH-K9-26A, Rev. 2, 5/29/97						
Liner Dimension Measurement Procedure, MH-K9-31, Rev. 1						
Procedure for Nondestructive Examinations (RT and PT) and Leak Testing, UGS-L9-970200A, Rev. 2, Apr. 16, 1997						
Repairing Procedure for 5-9 Liner Panel, MH-K9-36, Rev. 0						
Liner Welding Re-Confirmation Test, MH-K9-37, Rev. 1						
Alteration of RT Acceptance Criteria; MH-K9-39						
JIS-Carbon Steel Plates for Pressure Vessels for Intermediate and Moderate Temperature Service, JIS G 3118, 1987						
JIS-Rolled Steels for General Structure, JIS G 3101, 1995						
Data & Test Reports						
(A)Results of Liner Material (SGV410) Test; MH-K9-45, February 1998						
(B)Welded Joint Tensile Test Results; MH-K9-43;9/12						
(C)JPN-16-M-1; Ancillary Test/Liner Material Test, September 1995						
(D)Liner Anchor Test Report; JPN-15-M-2, March 1995						
(E)Results of Liner Welding Re-Confirmation Test, MH-K9-38						
(F)The Repair of 5-9 Liner Panel, MH-K9-41						
(G)Liner Dimensional Inspection Record, MH-K9-46						
		Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
		psi	psi		psi	
Welded (SMAW) Liner Plate						
(JIS Z 3121, Test Piece 1A)						
	As-welded (avg.)	55,971	73,517	19.1%		
	Repaired (avg.)	53,941	73,082	18.4%		
	w/o Back-up bar (avg.)	55,681	73,517	17.9%		
	w/ Back-up bar (avg.)	54,231	73,082	19.7%		
	Mat'l Spec.	Yield Stress	Ultimate Stress	Elongation	Elastic Modulus	Stress-Strain
Liner Anchor						
SS400						
		psi	psi		psi	
Nominal	JIS G 3101-1995	min.	35,526	58,001	21.0%	
		max.	-	73,952		
Test		X(C)	X(C)	X(C)	X(C)	
	vertical	41,906	66,122	33.0%	3.016E+07	
	horizontal	44,806	64,382	38.0%	3.132E+07	
		fc'	Max. Load	Max. Disp.	Initial Stiffness	Force-Deflection
		psi	lbs	in.	lb/in.	
Liner Anchor Force-Deflection		X(D)	X(D)	X(D)	X(D)	X(D)
	Tension, prestressed	5835	9,774	0.004	7,130,375	
	Tension, non-prestressed	5835	7,070	0.005	2,949,213	
	Shear, prestressed	5835	32,408	0.113	3,318,797	
	Shear, non-prestressed	5835	24,471	0.045	2,221,242	

Liner Stress-Strain



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Section iv. Rebar and Couplers

PCCV Rebar/Coupler Material Tests (METRIC)												
Procedures & Specifications												
JPN-14-T-1-3; Rebar Material Test Procedure; 6/14/96												
JPN-14-T-1-4; Rebar Connection Test Procedure; 6/14/96												
Spec.-T-04-2(E) Rev. 2; Specification for Reinforcement Material												
Spec.-T-04-3(E) Rev. 2; Specification for Mechanical Joint												
Data & Test Reports												
(A) JPN-21-T-5, Ancillary Test Report, Rebar Joint Test, May 20, 1997												
(B) TAP 9702; Material Property data for a mechanical model used in pre/post analyses, 4/21/97												
(C) JPN-21-T-4, Ancillary Test Report, Rebar Material Test, May 20, 1997												
(D) MH-K10-37, Tensile Test Result for #3 Position Threaded Coupler												
(E) MH-K10-38, Tensile Test Result for #6 Position Threaded Coupler												
(F) SNL Rebar Calibration Tests, February, 1999												
Component												
Design Data Tests												
Mat'l Spec.												
Reinforcing Steel		Diameter	Area	Yield Stress	Ultimate Stress	Gage Length	Elongation ¹	Elastic Modulus	Stress-Strain ²			
		(mm)	(mm ²)	(kN)	(MPa)	(kN)	(MPa)	Initial	Final	(%)	(N/mm ²)	
Nominal (JIS G 3112)	SD345											
	min.			345.0		490.0				18.0%		
	max.			390.0								
Test (JIS Z 2241)		X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93)	D6	1	6.35	31.67	12.1	382.1	15.5	489.4	47.7	62.5	31.0%	1.68E+05
	(G=8D, Grip=10D)	2	6.35	31.67	11.5	363.1	15.5	489.4	47.7	62.0	30.0%	1.71E+05
		3	6.35	31.67	11.5	363.1	15.5	489.4	47.8	62.2	30.1%	1.67E+05
	mean		6.35	31.67	11.7	369.4	15.5	489.4	47.7	62.2	30.4%	1.69E+05
	D10	1	9.53	71.33	26.3	368.7	39.2	549.6	79.7	97.5	22.3%	1.82E+05
	(G=8D, Grip=10D)	2	9.53	71.33	26.6	372.9	39.9	559.4	80.0	98.6	23.3%	1.85E+05
		3	9.53	71.33	26.5	371.5	39.2	549.6	80.0	100.7	25.9%	1.80E+05
	mean		9.53	71.33	26.5	371.0	39.4	552.8	79.9	98.9	23.8%	1.82E+05
¹ Elongation @ ultimate load based on gage length of broken bars.												
² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.												
JIS Z 2441 references use of extensometer for strain measurement.												

Reinforcing Steel			Diameter	Area	Yield Stress		Ultimate Stress		Gage Length		Elongation ¹	Elastic Modulus	Stress-Strain ²
			(mm)	(mm ²)	(kN)	(MPa)	(kN)	(MPa)	Initial	Final	(%)	(N/mm ²)	
Nominal (JIS G 3112)	SD390												
	min.				390.0		539.0				16.0%		
	max.				490.0								
Test (JIS Z 2241)			X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93)	D10	1	9.53	71.33	33.2	465.4	46.7	654.7	80.2	94.1	17.3%	1.83E+05	
	(G=8D, Grip=10D)	2	9.53	71.33	34.4	482.3	47.0	658.9	79.5	97.7	22.9%	1.85E+05	
		3	9.53	71.33	33.6	471.1	46.0	644.9	79.7	96.6	21.2%	1.82E+05	
		mean	9.53	71.33	33.7	472.9	46.6	652.8	79.8	96.1	20.5%	1.83E+05	
	D13	1	12.7	126.7	53.4	421.5	77.2	609.3	104.0	129.4	24.4%	1.83E+05	
	(G=8D, Grip=10D)	2	12.7	126.7	55.8	440.4	77.5	611.7	103.9	128.4	23.6%	1.83E+05	
		3	12.7	126.7	55.1	434.9	77.4	610.9	104.0	129.6	24.6%	1.84E+05	
		mean	12.7	126.7	54.8	432.3	77.4	610.6	104.0	129.1	24.2%	1.83E+05	
	D16	1	15.9	198.6	90.9	457.7	122.5	616.8	128.0	146.6	19.4%	1.82E+05	
	(G=8D, Grip=10D)	2	15.9	198.6	91.3	459.7	123.0	619.3	128.2	147.4	24.1%	1.84E+05	
		3	15.9	198.6	90.4	455.2	121.8	613.3	127.9	146.5	22.7%	1.84E+05	
		mean	15.9	198.6	90.9	457.5	122.4	616.5	128.0	146.8	22.1%	1.83E+05	
	D16	1	12.5	122.7	66.0	537.9	87.8	715.6	49.7	63.5	27.8%	2.09E+05	
	(dumbbell)	2	12.5	122.7	63.8	520.0	88.2	718.8	50.0	63.0	26.0%	2.09E+05	
	(D x G = 12.5 x 50)	3	12.5	122.7	63.4	516.7	87.8	715.6	50.0	63.7	27.4%	2.09E+05	
		mean	12.5	122.7	64.4	524.9	87.9	716.7	49.9	63.4	27.1%	2.09E+05	
	D19	1	19.1	286.5	135.2	471.9	188.2	656.9	152.2	181.5	19.3%	1.83E+05	
	(G=8D, Grip=10D)	2	19.1	286.5	135.6	473.3	188.8	659.0	152.2	183.9	20.8%	1.83E+05	
		3	19.1	286.5	135.8	474.0	188.8	659.0	151.9	187.2	23.2%	1.86E+05	
		mean	19.1	286.5	135.5	473.1	188.6	658.3	152.1	184.2	21.1%	1.84E+05	
	D22	1	22.2	387.1	176.6	456.2	263.7	681.2	176.0	200.3	16.8%	1.90E+05	
	(G=8D, Grip=10D)	2	22.2	387.1	177.9	459.6	263.9	681.7	176.0	202.3	20.0%	1.91E+05	
		3	22.2	387.1	178.5	461.1	263.0	679.4	176.1	202.1	19.1%	1.92E+05	
		mean	22.2	387.1	177.7	459.0	263.5	680.8	176.0	201.6	18.7%	1.91E+05	
	D22	1	14	153.9	73.0	474.5	113.7	739.0	50.8	63.7	25.4%	2.10E+05	
	(dumbbell)	2	14	153.9	73.4	476.8	112.0	728.0	50.6	63.8	26.1%	2.08E+05	
	(D x G = 14 x 50)	3	14	153.9	70.8	460.2	115.0	747.0	51.3	64.8	26.3%	2.08E+05	
		mean	14	153.9	72.4	470.5	113.6	738.0	50.9	64.1	25.9%	2.09E+05	
		¹ Elongation @ ultimate load based on gage length of broken bars.											
		² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.											
		JIS Z 2441 references use of extensometer for strain measurement.											

Reinforcing Steel			Diameter	Area	Yield Stress		Ultimate Stress		Gage Length		Elongation ¹	Elastic Modulus	Stress-Strain ²
			(mm)	(mm ²)	(kN)	(MPa)	(kN)	(MPa)	Initial	Final	(%)	(N/mm ²)	
Nominal (JIS G 3112)	SD490												
	min.				490.0		618.0				12.0%		
	max.				620.0								
Test (JIS Z 2241)			X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93)	D10	1	9.53	71.33	35.1	492.1	47.6	667.3	79.7	97.9	22.8%	1.86E+05	
	(G=8D, Grip=10D)	2	9.53	71.33	35.0	490.7	47.2	661.7	79.8	95.5	19.7%	1.87E+05	
		3	9.53	71.33	35.0	490.7	47.7	668.7	80.0	97.4	21.8%	1.87E+05	
		mean	9.53	71.33	35.0	491.1	47.5	665.9	79.8	96.9	21.4%	1.87E+05	
	D13	1	12.7	126.7	69.2	546.2	94.8	748.2	104.0	122.7	18.0%	1.83E+05	
	(G=8D, Grip=10D)	2	12.7	126.7	69.2	546.2	95.1	750.6	103.9	121.5	16.9%	1.85E+05	
		3	12.7	126.7	70.0	552.5	95.7	755.3	104.0	119.0	14.4%	1.85E+05	
		mean	12.7	126.7	69.5	548.3	95.2	751.4	104.0	121.1	16.4%	1.84E+05	
	D16	1	15.9	198.6	96.2	544.9	134.3	676.2	128.2	143.3	17.0%	1.84E+05	
	(G=8D, Grip=10D)	2	15.9	198.6	102.3	544.9	138.9	699.4	128.0	143.1	15.2%	1.86E+05	
		3	15.9	198.6	99.3	551.2	136.9	689.3	128.0	144.6	19.0%	1.84E+05	
		mean	15.9	198.6	99.3	547.0	136.7	688.3	128.1	143.7	17.1%	1.85E+05	
	D16	1	12.5	122.7	69.2	544.9	97.3	793.0	49.6	62.1	25.2%	2.12E+05	
	(dumbbell)	2	12.5	122.7	67.4	544.9	96.8	788.9	50.2	62.1	23.7%	2.10E+05	
	(D x G = 12.5 x 50)	3	12.5	122.7	68.3	551.2	95.7	780.0	49.9	62.2	24.6%	2.09E+05	
		mean	12.5	122.7	68.3	547.0	96.6	787.3	49.9	62.1	24.5%	2.10E+05	
	D19	1	19.1	286.5	146.4	511.0	203.4	709.9	151.7	178.6	17.7%	1.85E+05	
	(G=8D, Grip=10D)	2	19.1	286.5	147.2	513.8	202.8	707.9	151.9	177.5	16.9%	1.87E+05	
		3	19.1	286.5	146.6	511.7	203.8	711.3	151.8	180.2	18.7%	1.86E+05	
		mean	19.1	286.5	146.7	512.2	203.3	709.7	151.8	178.8	17.8%	1.86E+05	
		¹ Elongation @ ultimate load based on gage length of broken bars.											
		² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.											
		JIS Z 2441 references use of extensometer for strain measurement.											

Rebar/Couplers	Slip*		Yield Stress		Fracture		Gage Length		Elongation	Elastic Modulus	Stress-Strain
	(mm)		(kN)	(MPa)	Loc.	(MPa)	Initial	Final	(%)	(N/mm ²)	Stress-Stroke
SD390	min.	max.									
min.		0.30			Rebar				2.0%		
									>10e _y		
Test (ASTM E8M-92)	X(B)	X(B)				X(B)	X(B)		X(B)		X(B)
Threaded Couplers											
D10	0.01	0.02				736			8.05%		
D13	0.11	0.17				762			7.93%		
D16	0.09	0.14				696			9.69%		
D19	0.14	0.16				735			8.76%		
D10-D13	0.01	0.02				759			6.59%		
D10-D16	0.01	0.02				807			5.73%		
D13-D16	0.02	0.04				762			7.20%		
D13-D19	0.02	0.04				775			6.29%		
D16-D19	0.05	0.11				711			6.83%		
Position Threaded Couplers											
D10	0.04	0.07				737			7.87%		
D13	0.03	0.11				753			7.18%		
D16	0.16	0.18				702			8.69%		
D19	0.13	0.23				732			7.71%		
D22	0.16	0.19				760			8.77%		
D10-D13	0.02	0.07				726			5.99%		
D13-D16	0.07	0.07				754			6.68%		
D13-D19	0.03	0.05				745			5.89%		
D16-D19	0.14	0.27				706			6.28%		
SD490	min.	max.									
min.		0.30			Rebar				2.0%		
									>10e _y		
Threaded Couplers											
D13	0.11	0.16				789			9.75%		
D16	0.08	0.14				792			9.59%		
D19	0.03	0.09				796			6.69%		
D16-D19	0.16	0.22				762			9.52%		
Position Threaded Couplers											
D13	0.07	0.12				795			8.45%		
D16	0.15	0.21				797			9.76%		
D19	0.05	0.16				799			7.11%		
D16-D19	0.05	0.27				764			9.11%		
	*Slip = difference between final and initial strain @ 20.7 N/mm ² after loading to 207N/mm ²										

PCCV Rebar/Coupler Material Tests (ENGLISH)													
Procedures & Specifications													
JPN-14-T-1-3; Rebar Material Test Procedure; 6/14/96													
JPN-14-T-1-4; Rebar Connection Test Procedure; 6/14/96													
Spec.-T-04-2(E) Rev. 2; Specification for Reinforcement Material													
Spec.-T-04-3(E) Rev. 2; Specification for Mechanical Joint													
Data & Test Reports													
(A) JPN-21-T-5, Ancillary Test Report, Rebar Joint Test, May 20, 1997													
(B) TAP 9702; Material Property data for a mechanical model used in pre/post analyses, 4/21/97													
(C) JPN-21-T-4, Ancillary Test Report, Rebar Material Test, May 20, 1997													
(D) MH-K10-37, Tensile Test Result for #3 Position Threaded Coupler													
(E) MH-K10-38, Tensile Test Result for #6 Position Threaded Coupler													
(F) SNL Rebar Calibration Tests, February, 1999													
Component													
Design Data Tests													
Mat'l Spec.													
Reinforcing Steel			Diameter	Area	Yield Stress		Ultimate Stress		Gage Length		Elongation ¹	Elastic Modulus	Stress-Strain ²
			(in.)	(in ²)	(kips)	(ksi)	(kips)	(ksi)	Initial	Final	(%)	(psi)	
Nominal (JIS G 3112) SD345													
min.					50.03		71.05				18.0%		
max.					56.55								
Test (JIS Z 2241)			X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93) D6		0.250	0.049	2.72	55.40	3.48	70.96	1.878	2.461	31.0%	2.44E+07	1.68E+05	
(G=8D, Grip=10D)		2	0.250	0.049	2.59	52.65	3.48	70.96	1.878	2.441	30.0%	2.48E+07	
		3	0.250	0.049	2.59	52.65	3.48	70.96	1.882	2.449	30.1%	2.42E+07	
mean			0.250	0.049	2.63	53.56	3.48	70.96	1.878	2.449	30.4%	2.45E+07	
D10		1	0.375	0.111	5.91	53.46	8.81	79.69	3.138	3.839	22.3%	2.64E+07	
(G=8D, Grip=10D)		2	0.375	0.111	5.98	54.07	8.97	81.11	3.150	3.882	23.3%	2.68E+07	
		3	0.375	0.111	5.96	53.87	8.81	79.69	3.150	3.965	25.9%	2.61E+07	
mean			0.375	0.111	5.95	53.80	8.86	80.16	3.146	3.894	23.8%	2.64E+07	
¹ Elongation @ ultimate load based on gage length of broken bars.													
² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.													
JIS Z 2441 references use of extensometer for strain measurement.													

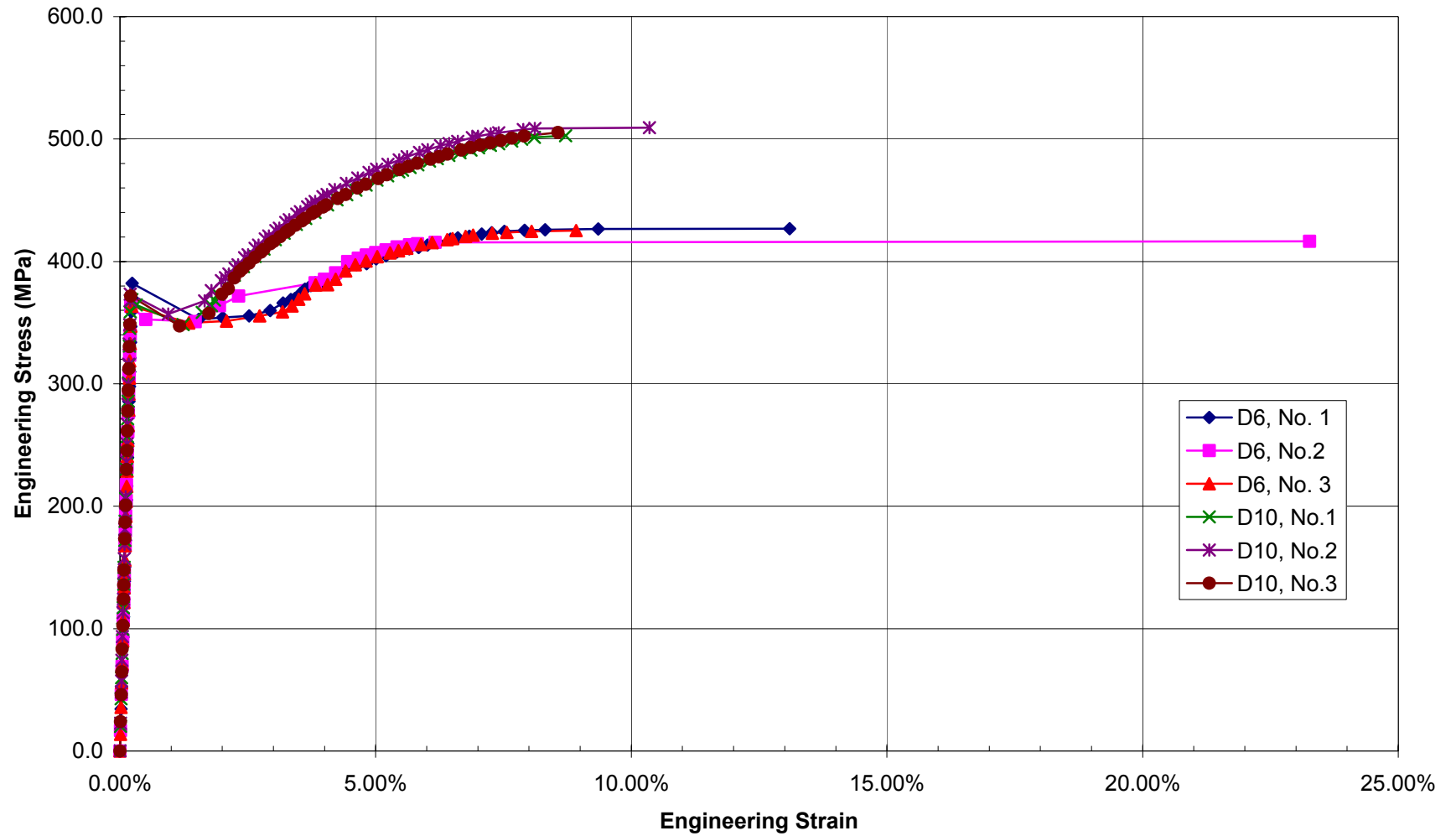
Reinforcing Steel		Diameter	Area	Yield Stress		Ultimate Stress		Gage Length		Elongation ¹	Elastic Modulus	Stress-Strain ²
		(in.)	(in ²)	(kips)	(ksi)	(kips)	(ksi)	Initial	Final	(%)	(psi)	
Nominal (JIS G 3112)	SD390											
	min.				56.55		78.16			16.0%		
	max.			71.05								
Test (JIS Z 2241)		X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93)	D10	0.375	0.111	7.46	67.48	10.50	94.93	3.157	3.705	17.3%	2.65E+07	1.83E+05
	(G=8D, Grip=10D)	2	0.375	0.111	7.73	69.93	10.57	95.54	3.130	3.846	22.9%	2.68E+07
		3	0.375	0.111	7.55	68.31	10.34	93.51	3.138	3.803	21.2%	2.64E+07
		mean	0.375	0.111	7.58	68.57	10.47	94.66	3.142	3.783	20.5%	2.65E+07
	D13 (#4)	1	0.500	0.196	12.00	61.12	17.35	88.35	4.094	5.094	24.4%	2.65E+07
	(G=8D, Grip=10D)	2	0.500	0.196	12.54	63.86	17.42	88.70	4.091	5.055	23.6%	2.65E+07
		3	0.500	0.196	12.39	63.06	17.40	88.58	4.094	5.102	24.6%	2.67E+07
		mean	0.500	0.196	12.31	62.68	17.39	88.54	4.094	5.083	24.2%	2.65E+07
	D16 (#5)	1	0.626	0.308	20.43	66.37	27.54	89.44	5.039	5.772	19.4%	2.64E+07
	(G=8D, Grip=10D)	2	0.626	0.308	20.52	66.66	27.65	89.80	5.047	5.803	24.1%	2.67E+07
		3	0.626	0.308	20.32	66.00	27.38	88.93	5.035	5.768	22.7%	2.67E+07
		mean	0.626	0.308	20.43	66.34	27.52	89.39	5.039	5.780	22.1%	2.65E+07
	D16 (#5)	1	0.492	0.190	14.84	78.00	19.74	103.76	1.957	2.500	27.8%	3.03E+07
	(dumbbell)	2	0.492	0.190	14.34	75.40	19.83	104.23	1.969	2.480	26.0%	3.03E+07
	(D x G = 0.5 x 2.0)	3	0.492	0.190	14.25	74.92	19.74	103.76	1.969	2.508	27.4%	3.03E+07
		mean	0.492	0.190	14.48	76.11	19.77	103.92	1.965	2.496	27.1%	3.03E+07
	D19 (#6)	1	0.752	0.444	30.39	68.43	42.31	95.25	5.992	7.146	19.3%	2.65E+07
	(G=8D, Grip=10D)	2	0.752	0.444	30.48	68.63	42.44	95.56	5.992	7.240	20.8%	2.65E+07
		3	0.752	0.444	30.53	68.73	42.44	95.56	5.980	7.370	23.2%	2.70E+07
		mean	0.752	0.444	30.46	68.60	42.40	95.45	5.988	7.252	21.1%	2.67E+07
	D22 (#7)	1	0.874	0.600	39.70	66.15	59.28	98.77	6.929	7.886	16.8%	2.76E+07
	(G=8D, Grip=10D)	2	0.874	0.600	39.99	66.64	59.32	98.85	6.929	7.965	20.0%	2.77E+07
		3	0.874	0.600	40.13	66.86	59.12	98.51	6.933	7.957	19.1%	2.78E+07
		mean	0.874	0.600	39.95	66.56	59.23	98.72	6.929	7.937	18.7%	2.77E+07
	D22 (#7)	1	0.551	0.239	16.41	68.80	25.56	107.16	2.000	2.508	25.4%	3.05E+07
	(dumbbell)	2	0.551	0.239	16.50	69.14	25.18	105.56	1.992	2.512	26.1%	3.02E+07
	(D x G = 0.5 x 2.0)	3	0.551	0.239	15.92	66.73	25.85	108.32	2.020	2.551	26.3%	3.02E+07
		mean	0.551	0.239	16.28	68.22	25.54	107.01	2.004	2.524	25.9%	3.03E+07
		¹ Elongation @ ultimate load based on gage length of broken bars.										
		² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.										
		JIS Z 2441 references use of extensometer for strain measurement.										

Reinforcing Steel		Diameter	Area	Yield Stress		Ultimate Stress		Gage Length		Elongation ¹	Elastic Modulus	Stress-Strain ²
		(in.)	(in ²)	(kips)	(ksi)	(kips)	(ksi)	Initial	Final	(%)	(psi)	
Nominal (JIS G 3112)	SD490											
	min.				71.05		89.61			12.0%		
	max.				89.90							
Test (JIS Z 2241)		X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)	X(B)
(ASTM E8M-93)	D10	0.375	0.111	7.89	71.35	10.70	96.76	3.138	3.854	22.8%	2.70E+07	1.86E+05
	(G=8D, Grip=10D)	2	0.375	0.111	7.87	71.15	10.61	95.95	3.142	3.760	19.7%	2.71E+07
		3	0.375	0.111	7.87	71.15	10.72	96.96	3.150	3.835	21.8%	2.71E+07
	mean	0.375	0.111	7.87	71.21	10.68	96.56	3.142	3.815	21.4%	2.71E+07	
	D13	1	0.500	0.196	15.56	79.20	21.31	108.49	4.094	4.831	18.0%	2.65E+07
	(G=8D, Grip=10D)	2	0.500	0.196	15.56	79.20	21.38	108.84	4.091	4.783	16.9%	2.68E+07
		3	0.500	0.196	15.74	80.11	21.51	109.52	4.094	4.685	14.4%	2.68E+07
	mean	0.500	0.196	15.62	79.50	21.40	108.95	4.094	4.768	16.4%	2.67E+07	
	D16	1	0.626	0.308	21.63	79.01	30.19	98.05	5.047	5.642	17.0%	2.67E+07
	(G=8D, Grip=10D)	2	0.626	0.308	23.00	79.01	31.22	101.41	5.039	5.634	15.2%	2.70E+07
		3	0.626	0.308	22.32	79.92	30.78	99.95	5.039	5.693	19.0%	2.67E+07
	mean	0.626	0.308	22.32	79.32	30.73	99.80	5.043	5.657	17.1%	2.68E+07	
	D16	1	0.492	0.190	15.56	79.01	21.87	114.99	1.953	2.445	25.2%	3.07E+07
	(dumbbell)	2	0.492	0.190	15.15	79.01	21.76	114.39	1.976	2.445	23.7%	3.05E+07
	(D x G = 12.5 x 50)	3	0.492	0.190	15.35	79.92	21.51	113.10	1.965	2.449	24.6%	3.03E+07
	mean	0.492	0.190	15.35	79.32	21.72	114.16	1.965	2.445	24.5%	3.05E+07	
	D19	1	0.752	0.444	32.91	74.10	45.72	102.94	5.972	7.031	17.7%	2.68E+07
	(G=8D, Grip=10D)	2	0.752	0.444	33.09	74.50	45.59	102.65	5.980	6.988	16.9%	2.71E+07
		3	0.752	0.444	32.96	74.20	45.81	103.14	5.976	7.094	18.7%	2.70E+07
	mean	0.752	0.444	32.98	74.27	45.70	102.91	5.976	7.039	17.8%	2.70E+07	
¹ Elongation @ ultimate load based on gage length of broken bars.												
² Stress-Strain relationship measured by 2 dia. opposed strain gages located @ center of gage length.												
JIS Z 2441 references use of extensometer for strain measurement.												

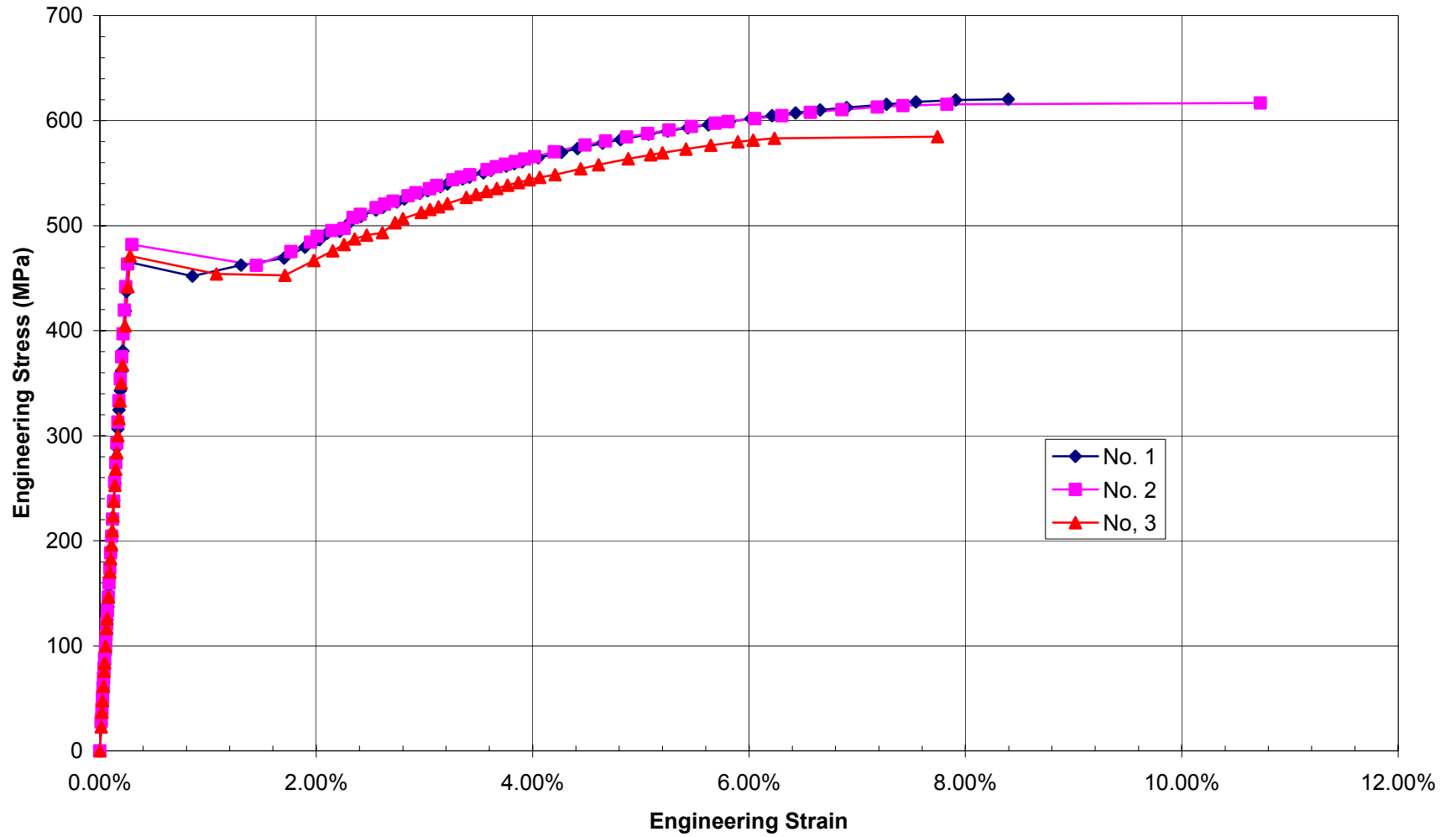
Rebar/Couplers	Slip*		Yield Stress		Fracture		Gage Length		Elongation	Elastic Modulus	Stress-Strain
	(IN)		(kips)	(ksi)	Loc.	(ksi)	Initial	Final	(%)	(psi)	Stress-Stroke
SD390	min.	max.									
min.		0.30			Rebar				2.0%		
									>10e _y		
Test (ASTM E8M-92)	X(B)	X(B)				X(B)	X(B)		X(B)		X(B)
Threaded Couplers											
D10	0.00039	0.00079				106.72			8.05%		
D13	0.00433	0.00669				110.49			7.93%		
D16	0.00354	0.00551				100.92			9.69%		
D19	0.00551	0.00630				106.58			8.76%		
D10-D13	0.00039	0.00079				110.06			6.59%		
D10-D16	0.00039	0.00079				117.02			5.73%		
D13-D16	0.00079	0.00157				110.49			7.20%		
D13-D19	0.00079	0.00157				112.38			6.29%		
D16-D19	0.00197	0.00433				103.10			6.83%		
Position Threaded Couplers											
D10	0.00157	0.00276				106.87			7.87%		
D13	0.00118	0.00433				109.19			7.18%		
D16	0.00630	0.00709				101.79			8.69%		
D19	0.00512	0.00906				106.14			7.71%		
D22	0.00630	0.00748				110.20			8.77%		
D10-D13	0.00079	0.00276				105.27			5.99%		
D13-D16	0.00276	0.00276				109.33			6.68%		
D13-D19	0.00118	0.00197				108.03			5.89%		
D16-D19	0.00551	0.01063				102.37			6.28%		
SD490	min.	max.									
min.		0.30			Rebar				2.0%		
									>10e _y		
Threaded Couplers											
D13	0.00433	0.00630				114.41			9.75%		
D16	0.00315	0.00551				114.84			9.59%		
D19	0.00118	0.00354				115.42			6.69%		
D16-D19	0.00630	0.00866				110.49			9.52%		
Position Threaded Couplers											
D13	0.00276	0.00472				115.28			8.45%		
D16	0.00591	0.00827				115.57			9.76%		
D19	0.00197	0.00630				115.86			7.11%		
D16-D19	0.00197	0.01063				110.78			9.11%		
	*Slip = difference between final and initial strain @ 20.7 N/mm ² after loading to 207N/mm ²										

SD345, D6 (#2) & D10 (#3) Stress-Strain

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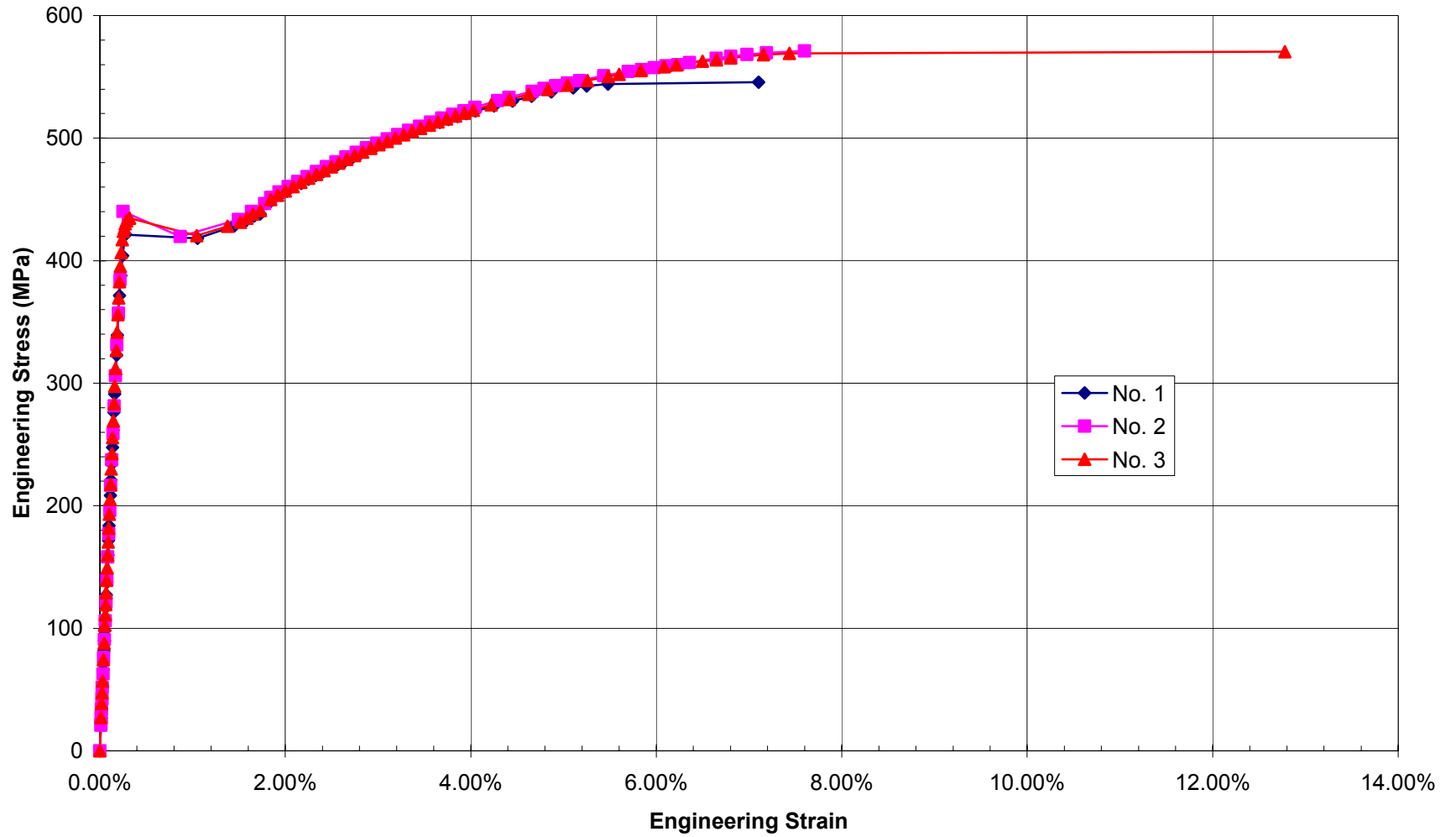


SD390, D10 (#3) Stress-Strain



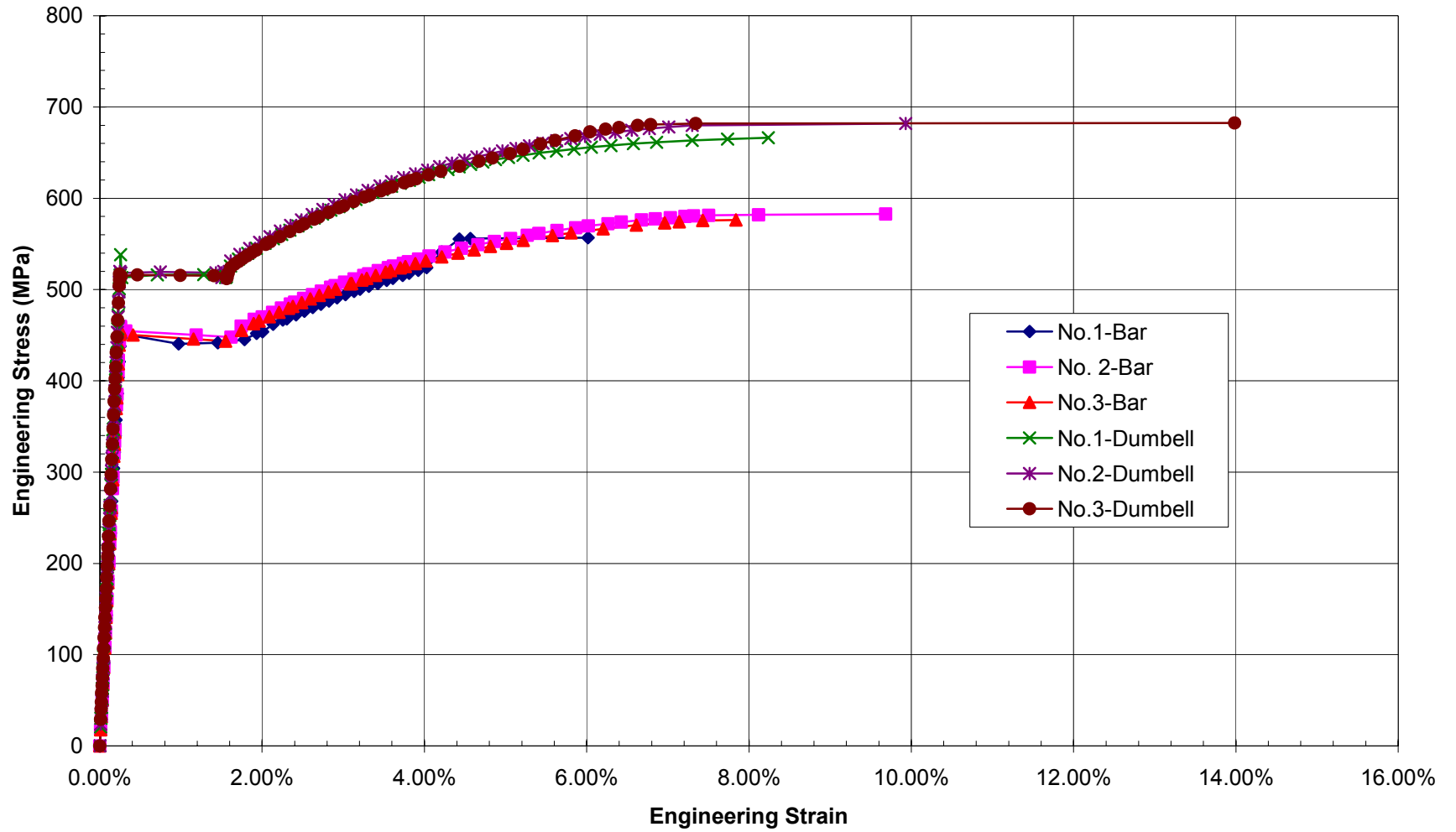
B-46

SD390, D13 (#4) Stress-Strain



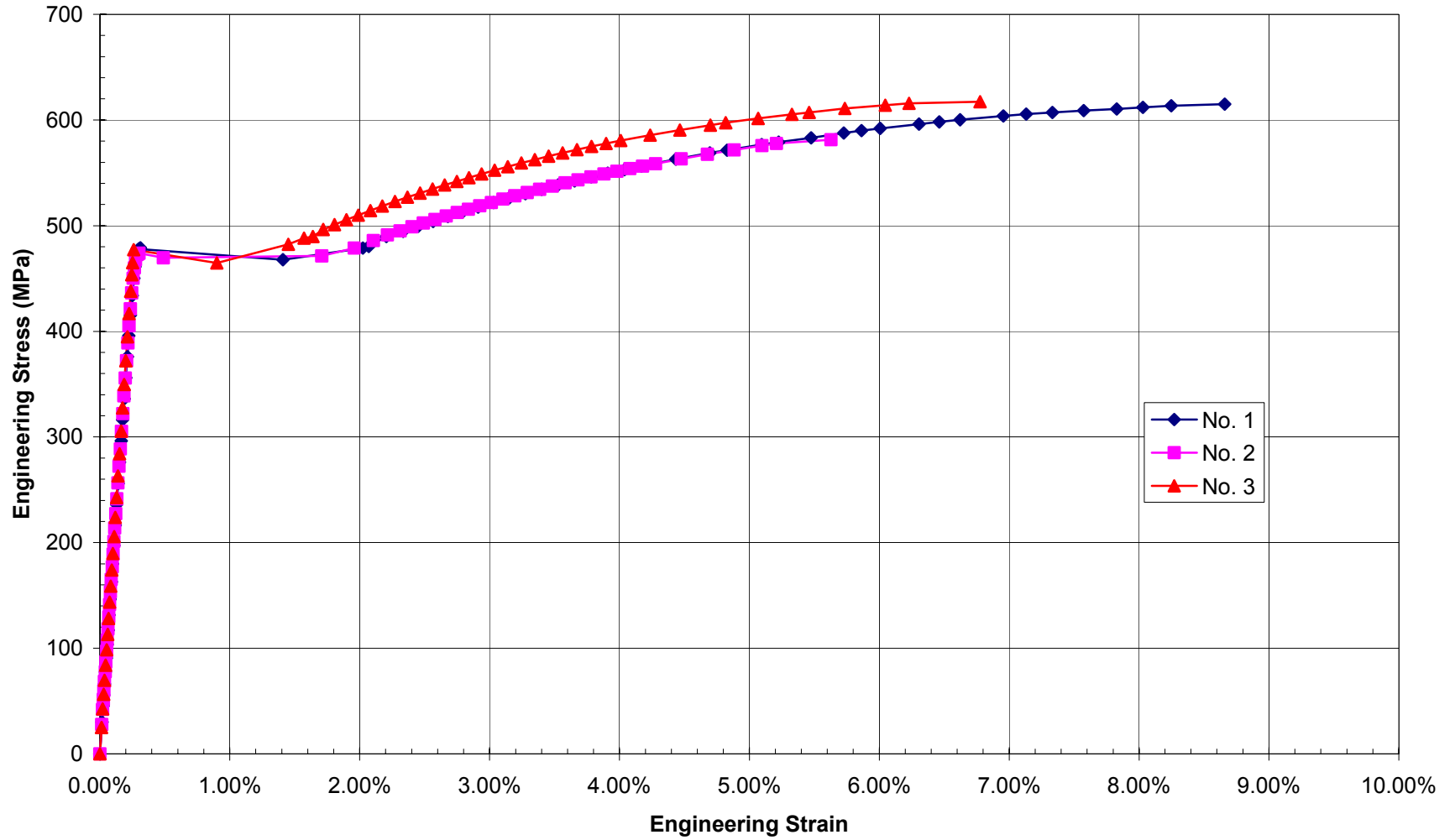
B-47

SD390, D16 (#5) Stress-Strain



B-48

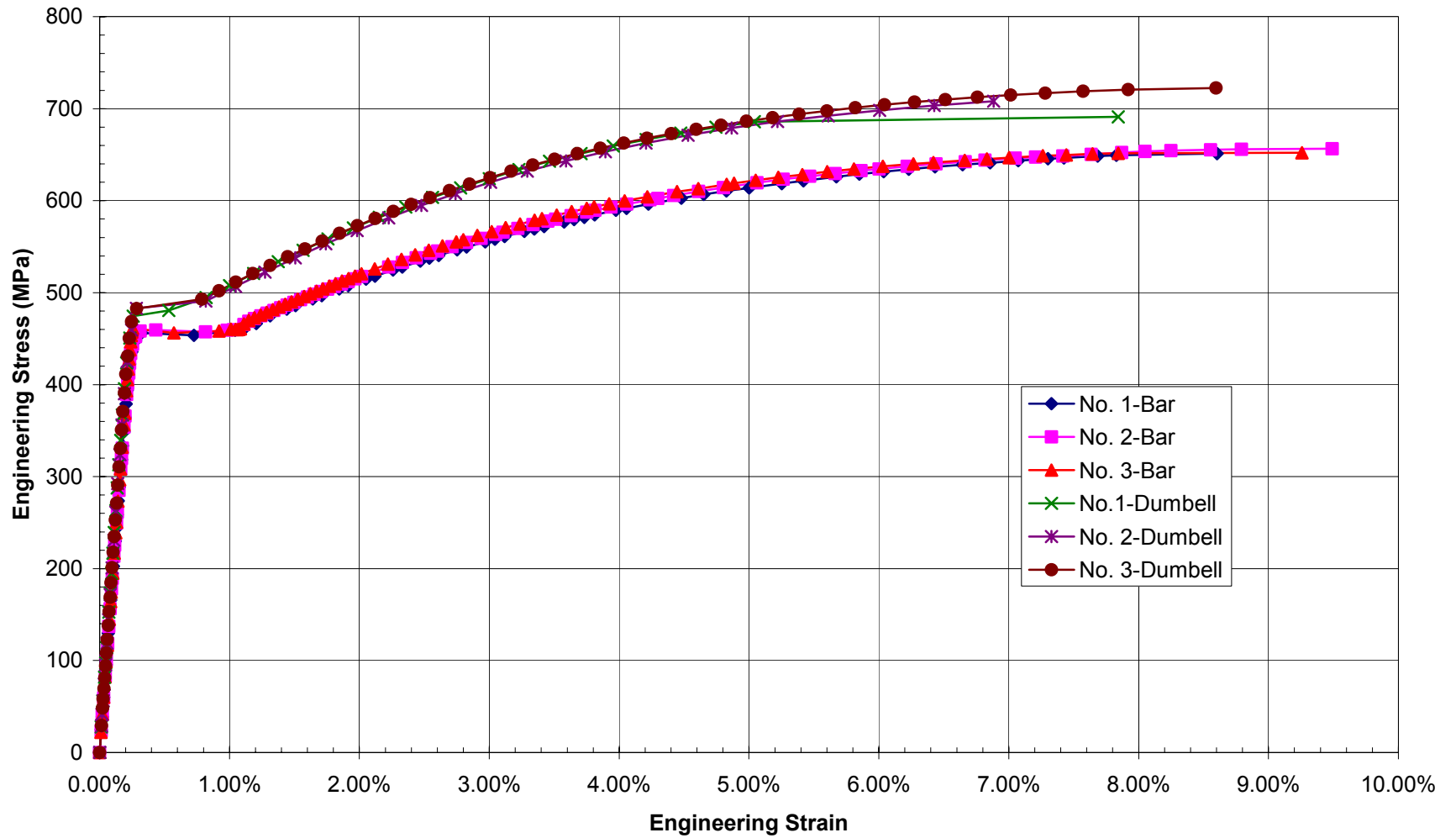
SD390, D19 (#6) Stress-Strain



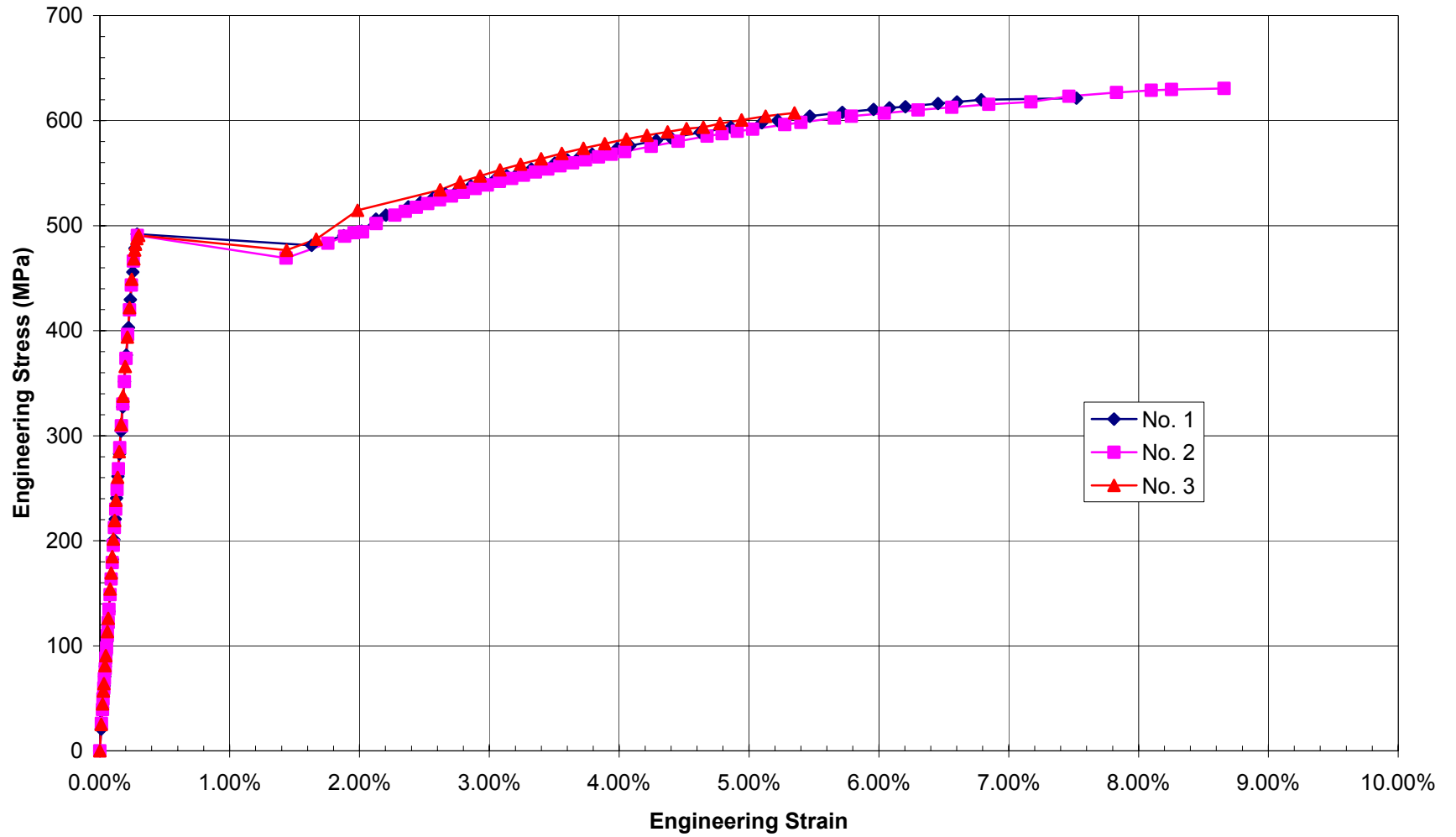
B-49

SD390, D22 (#7) Stress-Strain

B-50

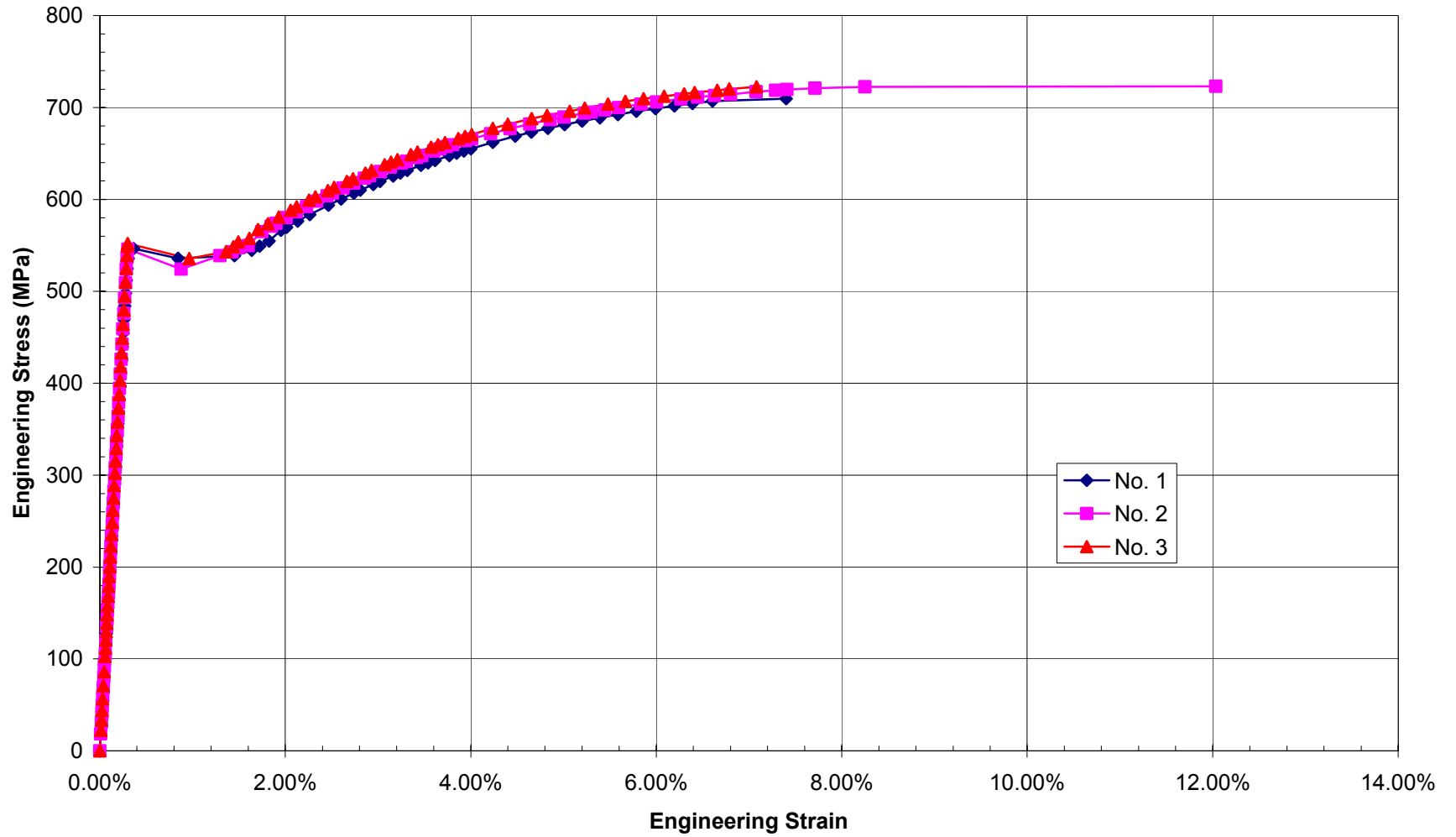


SD490, D10 (#3) Stress-Strain



B-51

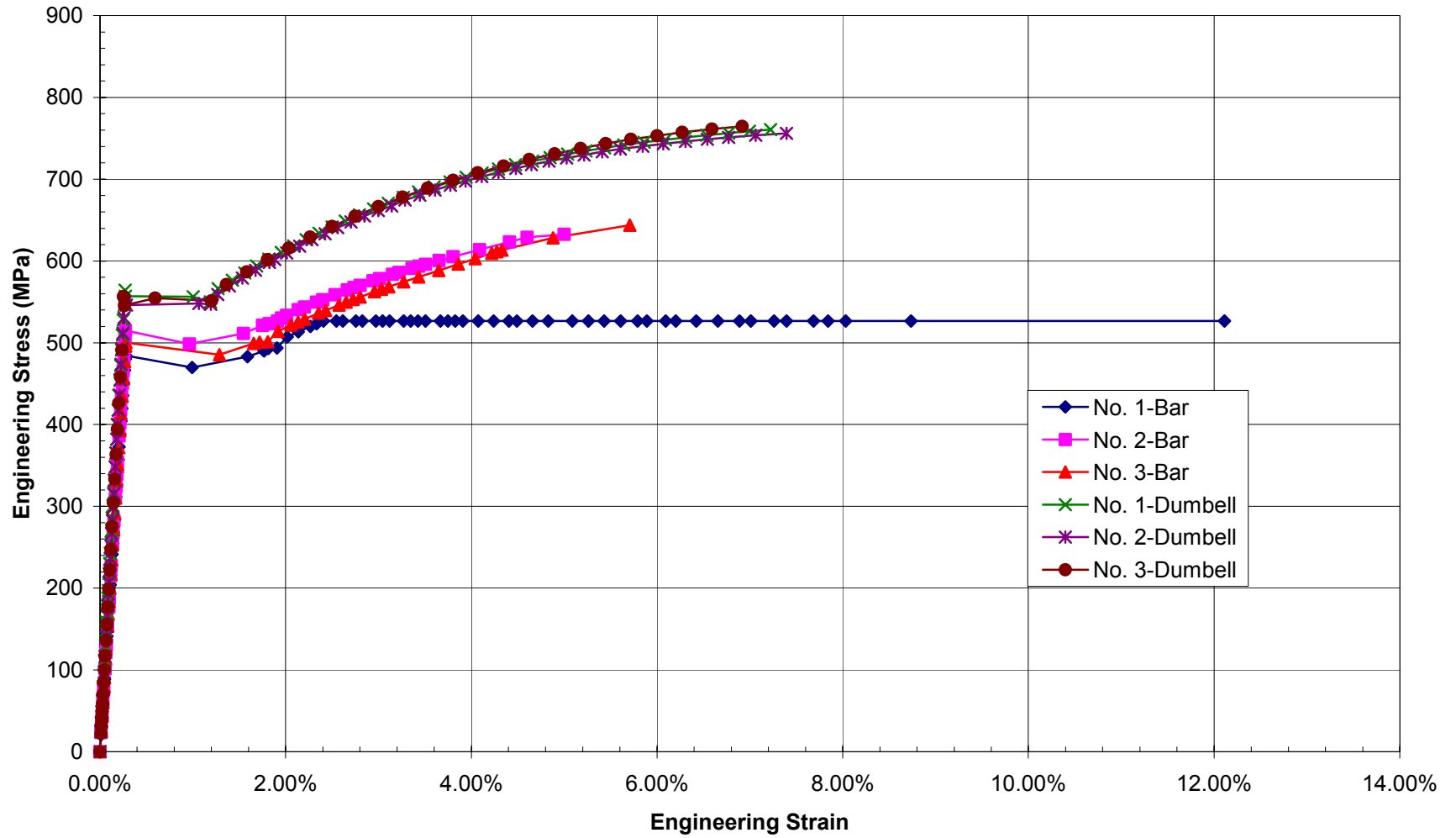
SD490, D13 (#4) Stress-Strain



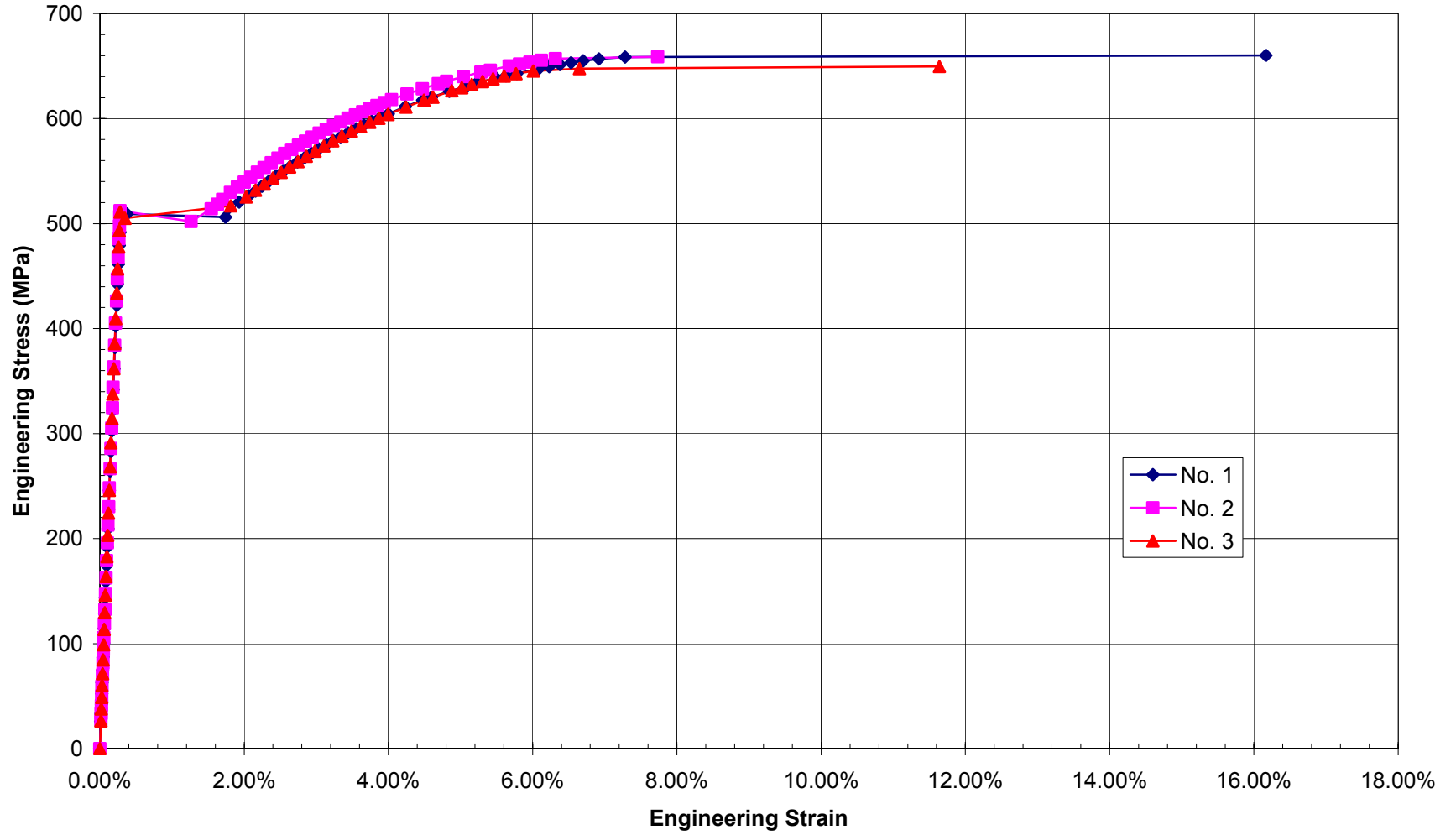
B-52

SD490, D16 (#5) Stress-Strain

B-53



SD490, D19 (#6) Stress-Strain



B-54

Section v. Tendons

PCCV Tendon Material Tests (METRIC)										
Procedures & Specifications						Data & Test Reports				
1. JPN-12-T-2: Outline of Ancillary Tests						(A) JPN-12-T-3: "The Result of Trial Manufacturing of Tendon System" Electronic Data on the Server				
2. JPN-14-T-1-5; Tendon Material Test Procedure; Rev.1; 9/30/96						(B) JPN-18-T-4; Tendon Friction Coefficient and Set Loss Verification Test; 5/14/96				
3. JPN-14-T-1-7; Prestressing Tendon Tensile Test Procedure; Rev.1; 9/30/96						(C) MH-K10-26 Tendon Material Test Report; June 1998				
4. Spec.-T-05-2(E), Rev.1; Specification for PC Materials						(D) MH-K10-40, Tendon System Test Report				
Component	Material Specifications									
			Diameter (mm)	Pitch	Dia. Diff. (mm)	Weight (kg)	Yield ¹ (kN)	Ultimate (kN)	Elongation ² (%)	Relaxation (% per 1000 hr)
Raw Material:	SWRS82B per JIS G3502	min.	13.5	12	0.08		190	210	4.50%	
Strand:	SWPR7BL per JIS G3536	nom.	13.7							
		max.	14.1	18						1.50%
Sample Tendon System Test (1, A)										Load-Elong. ³
										Stress-Strain
Tendon Strand Material Test (2, C)										
JIS G 3536 (G=600mm)		8022530	13.62	14.1	0.10	2565	197	213	8.4%	Elong. Only
		8022531	13.60	14.1	0.10	2561				
		8022532	13.60	14.1	0.09	2561	196	214	8.0%	Elong. Only
		8022533	13.61	14.0	0.11	2563	195	214	8.3%	Elong. & Strain
		8022534	13.60	14.1	0.10	2553				
		8022535	13.61	14.2	0.10	2565	197	214	8.3%	Elong. Only
		8022536	13.60	14.2	0.11	2561				
		8022537	13.60	14.0	0.10	2564	199	214	8.3%	Elong. & Strain
		8022538	13.60	14.1	0.10	2559	198	214	8.3%	Elong. Only
¹ Load at 0.2% permanent Elongation										
² [(Stroke @ breakage - Stroke @10%Min. Strength)/Initial Distance bet. Grips]+0.1%										
³ Elongation determined from stroke of testing machine(?); Strain from strain gages mounted on individual wires.										
Tendon Sytem Test (3, D)										
Anchorhead:	S55CN per JIS G4051		Diameter	Pitch	Dia. Diff.	Ultimate		Displacement		Elongation ¹
Bearing Plate	SS400 per JIS G3101		(mm)		(mm)	Jack	Load Cell	Load End	Fixed End	Elastic Modulus
Sheath:	SGCC per JIS G3302	min.	13.5	12	0.08	(kN)	(kN)	(mm)	(mm)	(%)
Wedge:	SCM415 per JIS G4105	nom.	13.7							(kN/mm ²)
Strand:	SWPR7BL per JIS G3536	max.	14.1	18						
Strand:	JIS G 3536 (G=600mm)		13.6	14.2	0.11		215			7.7%
Tendon:		min.				630	630			2.0%
										Load-Elong. ²
										Stress-Strain
		1				653	641	286.49	5.02	3.94%
		2				647	637	281.27	4.92	3.87%
		3				647	637	267.25	4.98	3.67%
		Avg.				649	638	278.34	4.97	3.83%
¹ Elongation = (Load End Displacement - Fixed End Displacement)/(7150mm)										
² Strain measured using three strain gages each on wires of three strands, not corrected for pitch of wire.										

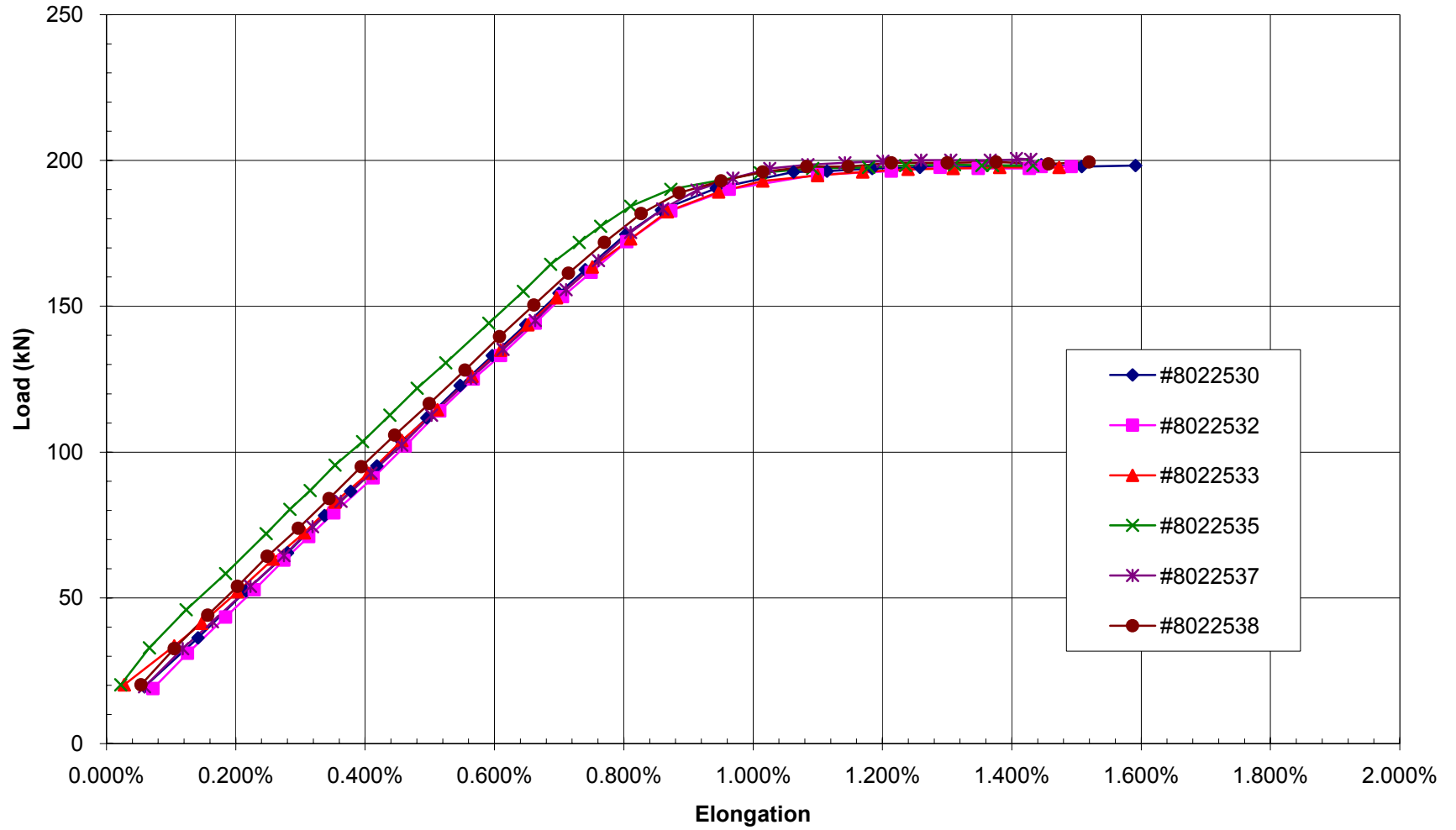
Tendon Friction and Set Loss Test (B)									
Average Friction Coefficient:		0.21							
Setting Loss		Anchor Force			Set				
	Tendon	Before	After	Loss	Strand 1	Strand 2	Strand 3	Avg.	
		(kN)	(kN)	(kN)	(mm)	(mm)	(mm)	(mm)	
	#1	481.4	383.2	98.2	4.7	5.1	4.1	4.6	
	#2	464.5	374.2	90.3	4.7	4.9	4.7	4.8	
	#3	473.8	385.9	87.9	4.8	4.4	4.9	4.7	
	Average:			92.1				4.7	
Tendon Strand Calibration Tests									
JIS G 3536 (G=600mm)		Diameter	Yield ¹	Ultimate	Elongation			Elastic Modulus ⁵	
		(mm)	(kN)	(kN)	Stroke ²	Tensmeg ³	WSG ⁴	(N/mm ²)	
					(%)	(%)	(%)		
Strand:	SWPR7BL per JIS G3536	min.	13.5	190	210	4.50%			
		nom.	13.7						
		max.	14.1						
		1		191.3	208.4	5.6%	4.2%	4.2%	203448
		2 ⁷		189.9	192.5	3.6%	1.5%	1.6%	193103
		3		191.7	209.7	6.1%	4.4%	4.5%	200000
		4		191.3	210.8	6.6%	4.5%	4.9%	197931
		5 ⁸	13.6						
		6 ⁸	13.6						
		7		191.3	210.7	6.5%	4.9%	5.0%	200000
		8		190.8	210.0	5.8%	4.5%	4.5%	195172
		9		191.3	210.5	6.4%	na	4.9%	195862
		10		191.3	209.1	5.7%	na	4.3%	201379
		Average	13.6	191.3	209.9	6.1%	4.5%	4.6%	199113
¹ Load at 0.2% permanent Elongation using Offset Method									
² $[(\text{Stroke @ breakage} - \text{Stroke @ 10\% Min. Strength}) / \text{Initial Distance bet. Grips}] + 0.1\%$									
³ Final Tensmeg reading									
⁴ Final average wire strain gage (WSG) reading									
⁵ Slope of Stress versus Extensometer Strain between 140 MPa and 1400 MPa									
⁶ Elongation & Strain determined from calibrated extensometer									
⁷ Strand #2 experienced some grip slippage causing premature failure (data not included in averages)									
⁸ Strands #5 and #6 will be tested just prior to PCCV pressure testing									

PCCV Tendon Material Tests (ENGLISH)												
Procedures & Specifications						Data & Test Reports						
1. JPN-12-T-2: Outline of Ancillary Tests						(A) JPN-12-T-3: "The Result of Trial Manufacturing of Tendon System" Electronic Data on the Server						
2. JPN-14-T-1-5; Tendon Material Test Procedure; Rev.1; 9/30/96						(B) JPN-18-T-4; Tendon Friction Coefficient and Set Loss Verification Test; 5/14/96						
3. JPN-14-T-1-7; Prestressing Tendon Tensile Test Procedure; Rev.1; 9/30/96						(C) MH-K10-26 Tendon Material Test Report; June 1998						
4. Spec.-T-05-2(E), Rev.1; Specification for PC Materials						(D) MH-K10-40, Tendon System Test Report						
Component	Material Specifications		Diameter (in)	Pitch	Dia. Diff. (in)	Weight (lbs)	Yield ¹ (kips)	Ultimate (kips)	Elongation ² (%)	Relaxation (% per 1000 hr)		
Raw Material:	SWRS82B per JIS G3502	min.	0.531	12	0.003		42.7	47.2	4.50%			
Strand:	SWPR7BL per JIS G3536	nom.	0.539									
		max.	14.1	0.555	18					1.50%		
Sample Tendon System Test (1, A)										Load-Elong. ³		
										Stress-Strain		
Tendon Strand Material Test (2, C)												
JIS G 3536 (G=600mm)	8022530		0.536	14.1	0.004	5655	44.3	47.9	8.4%	Elong. Only		
	8022531		0.535	14.1	0.004	5646						
	8022532		0.535	14.1	0.004	5646	44.1	48.1	8.0%	Elong. Only		
	8022533		0.536	14.0	0.004	5650	43.8	48.1	8.3%	Elong. & Strain		
	8022534		0.535	14.1	0.004	5628						
	8022535		0.536	14.2	0.004	5655	44.3	48.1	8.3%	Elong. Only		
	8022536		0.535	14.2	0.004	5646						
	8022537		0.535	14.0	0.004	5653	44.7	48.1	8.3%	Elong. & Strain		
8022538		0.535	14.1	0.004	5642	44.5	48.1	8.3%	Elong. Only			
¹ Load at 0.2% permanent Elongation												
² {(Stroke @ breakage - Stroke @10%Min. Strength)/Initial Distance bet. Grips}+0.1%												
³ Elongation determined from stroke of testing machine(?); Strain from strain gages mounted on individual wires.												
Tendon Sytem Test (3, D)												
Anchorhead:	S55CN per JIS G4051		Diameter (in)	Pitch	Dia. Diff. (in)	Jack (kips)	Load Cell (kips)	Load End (in)	Fixed End (in)	Elongation ¹ (%)	Elastic Modulus (kN/mm ²)	
Bearing Plate	SS400 per JIS G3101											
Sheath:	SGCC per JIS G3302	min.	0.531	12	0.003		47.2			4.50%		
Wedge:	SCM415 per JIS G4105	nom.	0.539									
Strand:	SWPR7BL per JIS G3536	max.	0.555	18								
Strand:	JIS G 3536 (G=600mm)		0.535	14.2	0.004		48.3			7.7%	27695	
Tendon:		min.				141.6	141.6			2.0%		
											Load-Elong. ²	
											Stress-Strain	
		1					146.8	144.1	11.279	0.198	3.94%	Elong. & Strain
		2					145.4	143.2	11.074	0.194	3.87%	Elong. & Strain
		3					145.4	143.2	10.522	0.196	3.67%	Elong. & Strain
		Avg.					145.9	143.5	10.958	0.196	3.83%	
¹ Elongation = (Load End Displacement - Fixed End Displacement)/(7150mm)												
² Strain measured using three strain gages each on wires of three strands, not corrected for pitch of wire.												

Tendon Friction and Set Loss Test (B)									
Average Friction Coefficient:		0.21							
Setting Loss		Anchor Force			Set				
		Tendon	Before	After	Loss	Strand 1	Strand 2	Strand 3	Avg.
			(kips)	(kips)	(kips)	(in)	(in)	(in)	(in)
		#1	108.2	86.1	22.1	0.184	0.200	0.162	0.182
		#2	104.4	84.1	20.3	0.186	0.193	0.187	0.189
		#3	106.5	86.8	19.8	0.187	0.174	0.191	0.184
Average:				20.7				0.185	
Tendon Strand Calibration Tests									
JIS G 3536 (G=600mm)		Diameter	Yield ¹	Ultimate	Elongation			Elastic Modulus ⁵	
		(in)	(kips)	(kips)	Stroke ²	Tensmeg ³	WSG ⁴	(ksi)	
					(%)	(%)	(%)		
Strand:	SWPR7BL per JIS G3536	min.	0.531	42.7	47.2	4.50%			
		nom.	0.539						
		max.	0.555						
		1		43.0	46.85	5.6%	4.2%	4.2%	29500
		2 ⁷		42.7	43.27	3.6%	1.5%	1.6%	28000
		3		43.1	47.14	6.1%	4.4%	4.5%	29000
		4		43.0	47.38	6.6%	4.5%	4.9%	28700
		5 ⁸	0.535						
		6 ⁸	0.535						
		7		43.0	47.36	6.5%	4.9%	5.0%	29000
		8		42.9	47.21	5.8%	4.5%	4.5%	28300
		9		43.0	47.31	6.4%	na	4.9%	28400
		10		43.0	47.00	5.7%	na	4.3%	29200
		Average		0.535	43.0	47.18	6.1%	4.5%	4.6%
¹ Load at 0.2% permanent Elongation using Offset Method									
² $[(\text{Stroke @ breakage} - \text{Stroke @ 10\%Min. Strength}) / \text{Initial Distance bet. Grips}] + 0.1\%$									
³ Final Tensmeg reading									
⁴ Final average wire strain gage (WSG) reading									
⁵ Slope of Stress versus Extensometer Strain between 140 MPa and 1400 MPa									
⁶ Elongation & Strain determined from calibrated extensometer									
⁷ Strand #2 experienced some grip slippage causing premature failure (data not included in averages)									
⁸ Strands #5 and #6 will be tested just prior to PCCV pressure testing									

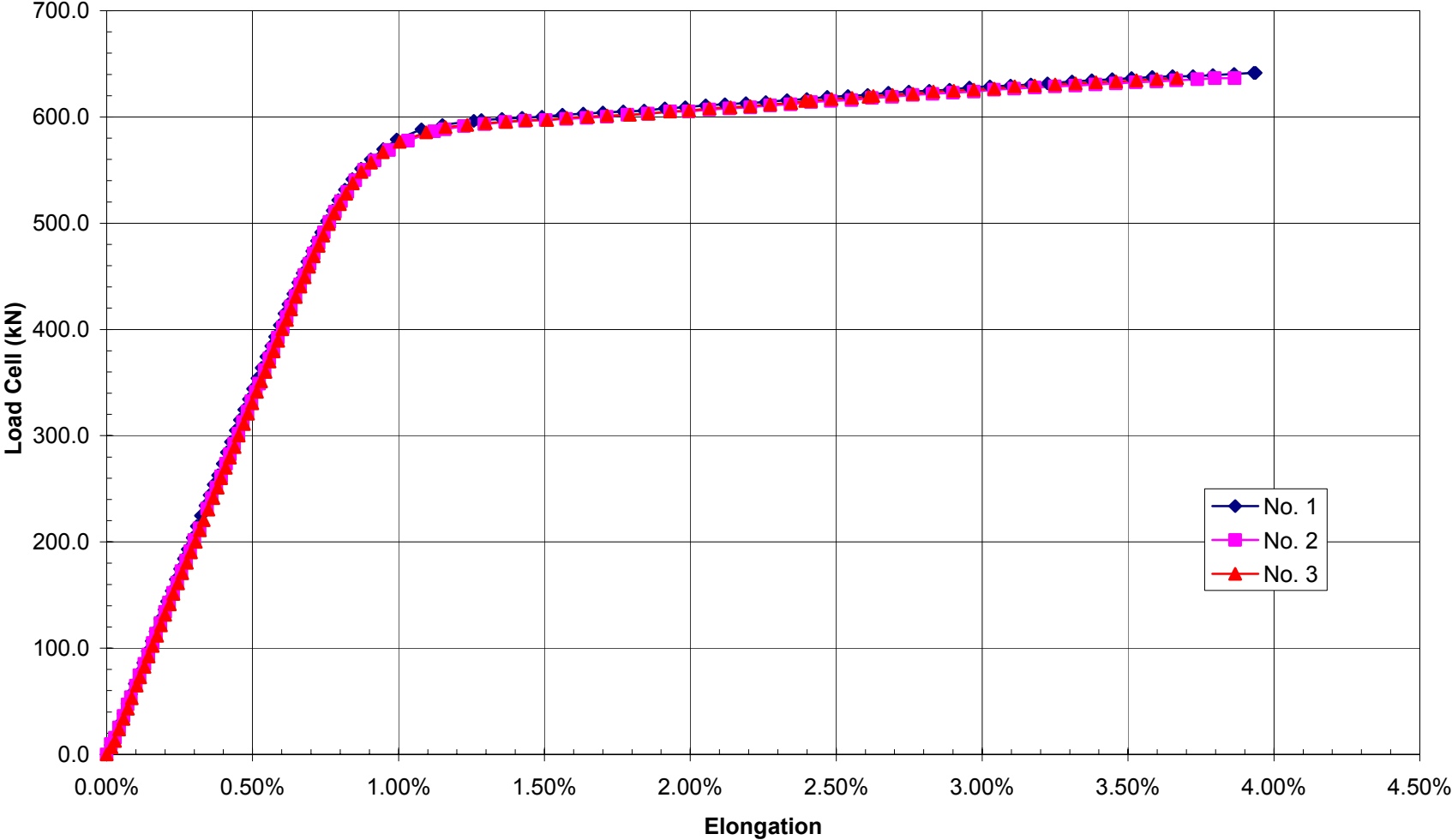
Tendon Strand (SWPR7BL), Load-Elongation

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Tendon System Load-Elongation

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Strand & Tendon Stress-Strain

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