UNIVERSITY AT BUFFALO
State University of New York
SCHOOL OF ENGINEERING
AND APPLIED SCIENCES

Department of Civil, Structural, and Environmental Engineering

212 Ketter Hall, North Campus, Buffalo, NY 14260-4300 *Fax: (716) 645-3733* *Tel: (716) 645 2114, x 2419*
http://www.civil.buffalo.edu/ ***Andrei M. Reinhorn**, P.E., Ph.D.* *e-mail: reinhorn@buffalo.edu*
Professor of Structural Engineering

http://nees.buffalo.edu/

Multi Axis Load Cell

Design and Construction

***Andrei M. Reinhorn** P.E. Ph.D.*
Professor of Structural Engineering
University at Buffalo
reinhorn@buffalo.edu

***Joseph Bracci** P.E. Ph.D.*
Professor of Structural Engineering
Texas A & M University

Scot Weinreber
Senior Instrumentation Specialist
University at Buffalo

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Technical Report NCEER-92-0027, National Center for Earthquake Engineering Research,
BRACCI, J.M., REINHORN, A.M., MANDER, J.B.,
SUNY/Buffalo, 1992

GEOMETRIC LAYOUT, STRAIN GAGING, AND CALIBRATION CHARTS OF LOAD CELLS

Special force transducers (load cells) are used to measure the internal force response of the model as specified in section 3. The geometric layout of the a typical load cell is shown in Fig. B-1a. They are fabricated from a thick wall cylindrical steel tube. The turned down wall thickness, height, and radius of the tube are determined based on the expected maximum stresses in the load cells during testing and on the matching the flexural stiffness with that of the column to minimize disturbance in that member. The attachment plates, shown in Fig. B-1b, ensure a uniform stress distribution over the entire load cell and provide anchorage into the columns. Based on the yield strength of the steel tube, the axial, shear, and moment capacity ratings for the load cells are ±40 kips, ±5 kips, and ±40 kip-in, respectively, to ensure linearity and repeatability.

The strain gages used in the load cells are types EA-06-125UR-120 (rosettes) and EA-06-125UW-120 (single gages) from Measurement Group, Inc. The gages have a maximum strain range of ±0.00375 in. and an overall length and width of 0.30 in. and 0.56 in., respectively. The maximum strain range of the gage is well beyond the elastic range of the cylindrical steel tube, which the load cells are designed. Fig. B-2a shows the strain gage location (A-D) and orientation (1-5) on the steel tube wall. Note that gages 1, 2, and 3 are from a rosette. M-Bond 200 adhesive is used for attaching the gages.

Axial, shear, and moment stresses are measured from Wheatstone bridge circuits wired according to Fig. B-2b. The axial circuits use gages #2 and #6, where gage #6 is a compensating ("dummy") gage used for variations in temperature in the circuit. The shear circuits use gages #1 and #3, which are orientated 45° from the horizontal, and the moment circuits use gages #4 and #5, which are orientated in the vertical direction.

Based on the load capacity ratings of the load cells, calibration factors for the axial, shear, and moment circuits are determined as 4 kips/volt, 0.5 kips/volt, and 4 kip-in./volt, respectively. For calibration, the load cells are bolted together in groups of two and loaded according to Fig. B-3. The pivoting head in Fig. B-3a for axial load calibration helps distribute the axial compressive load evenly across the load cells. The shear setup results in a constant shear force and a linearly varying moment across the load cells. The moments recorded are correlated with a known moment arm to the strain gages for the moment circuits. The moment setup is a two point loading which creates a constant bending moment with no shear force.

The circuits are connected to 2310 Vishay Signal Conditioning Amplifiers from the Measurement Group, Inc. which filters frequencies above 25 Hz. and varies the amplification (gain) of the incoming signal from the wheatstone bridge circuit. Calibration charts are developed, typically shown for a particular load cell in Fig. B-4, based on several series of loading and unloading for each setup and adjustments in amplification from the conditioners to acquire the appropriate calibration factors. Note, that a loop in the unloading states of testing develops in the moment calibrations. However the initial loading is perfectly linear and returns to zero when the load is fully removed, which implies that the load cell behaves elastically. Therefore the loops were created by some errors in the setup, possibly due to some concentrated yielding or friction which develops in the components of the setup.

It is suggested to move the gages 5 and 4 to the mid-line of the load cell and place the rosette off-center. In case of addition of torque circuit add a second rosette on each face symmetric to the mid-line to the first rosette and wire the shear circuits to add up all signals from all faces

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Professor of Structural Engineering
e-mail: reinhorn@buffalo.edu

08-Dec-00

FIVE AXES LOAD CELL USING TUBE STRUCTURE

Designed by Prof. Andrei M. Reinhorn, Assisted by Prof. Joe Bracci (Texas A&M University)

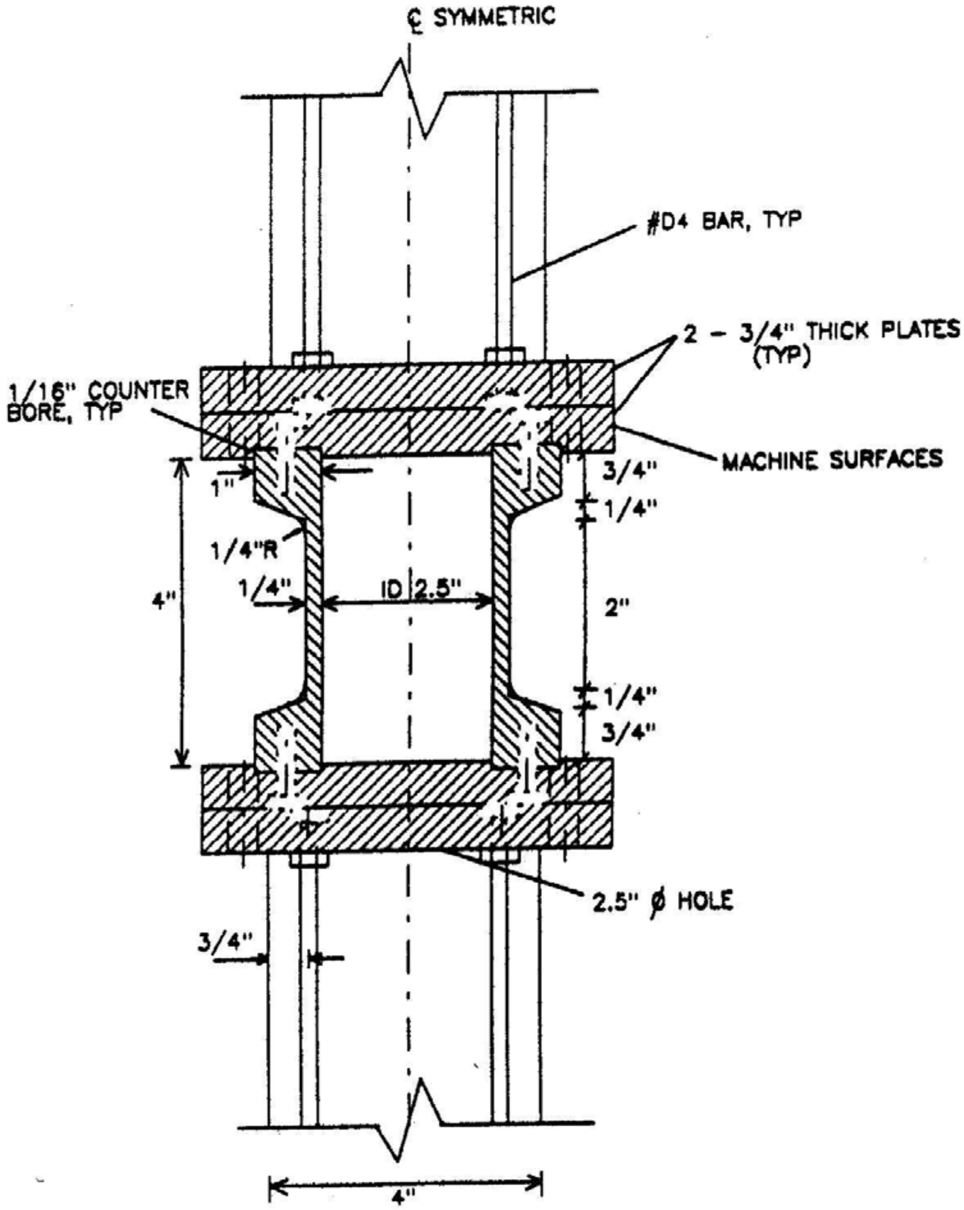
Capacity							
Axial Load Capacity	N	40.00	Kips	18.2 m-tons			
Moment Capacity	M	40.00	Kips-in	0.5 m-tons-m			
Shear Capacity	S	5.00	Kips	2.3 m-tons			
Design Data							
Outside Diameter	Do	4.50	in				
Outside Diameter Gap	Dg	3.00	in				
Inside diameter	d	2.50	in	| This dimension should be |			
Height of gap	hg	2.00	in	<-| equal or bigger than d !!|			
Height of pipe section	H	4.00	in				
Cross section area	A	2.16	in^2	11.0 in^2			
Moment of inertia	I	2.06	in^4	18.2 in^4			
Modulus of section	W	1.37	in^3	12.1 in^3			
Performance							
Axial Strain	en	638.6	μSt	4	16.6 mV	602	
Moment strain	em	1005.0	μSt	4	20.1 mV	497	
Shear strain	es	103.8	μSt	2	2.1 mV	4818	
Excitation Voltage	Vo	10.0	V	Gages	Output	Amplification	
Total Strains							
Modulus of elasticity	E	29000.0	ksi				μSt
Steel yield stress	fy	50.0	ksi				
Allowable yield strain	ey	1724.1	μSt				
Total principal strain	et	1650.2	μSt				
Natural Freq.							
Horizontal Stiffness	Kh	4.28E+03	kips/in				
Vertical Stiffness	Kv	1.57E+04	kips/in				
Horizontal Frequency	fx	92	Hz				
Vertical Frequency	fy	62	Hz				
Bolts							
Number of bolts	nnb	8		High Strength (Tens=180 ksi)			
Bolt diameter	db	0.375	in	(Shear=162 ksi)			
Bolt circle diameter	Db	3.50	in				
Distance between bolts	s	1.00	db				
Bolts tension Capacity	Nb	159.0	Kips				
Bolts shear capacity	Sb	143.1	Kips				

Colored data can be adjusted

NOTE: OUTPUT=10V*GF=2*uSt*#GAGES/4 = 10*2*463*2.6(MU=0.3)/4

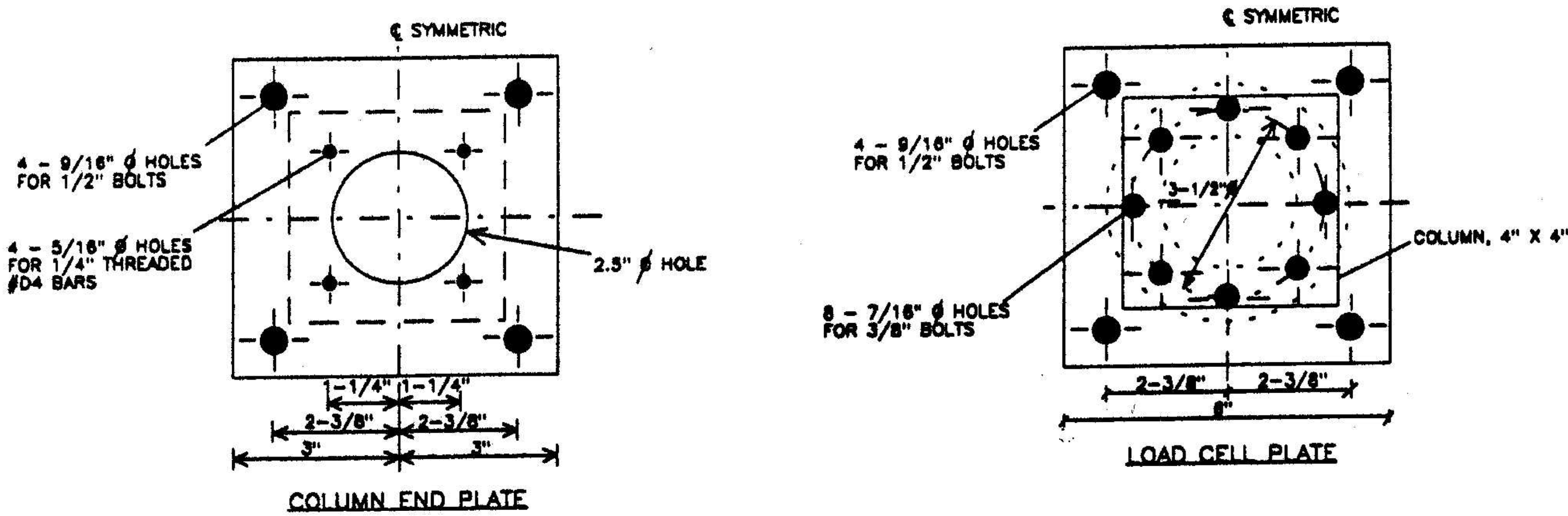
NOTE: OUTPUT=10V*GF=2*uSt*#GAGES/4 = 10*2*728*4/4

Design Spread Sheet fpr the Multiaxial Load cells. – Available form Prof. A.M.Reinhorn



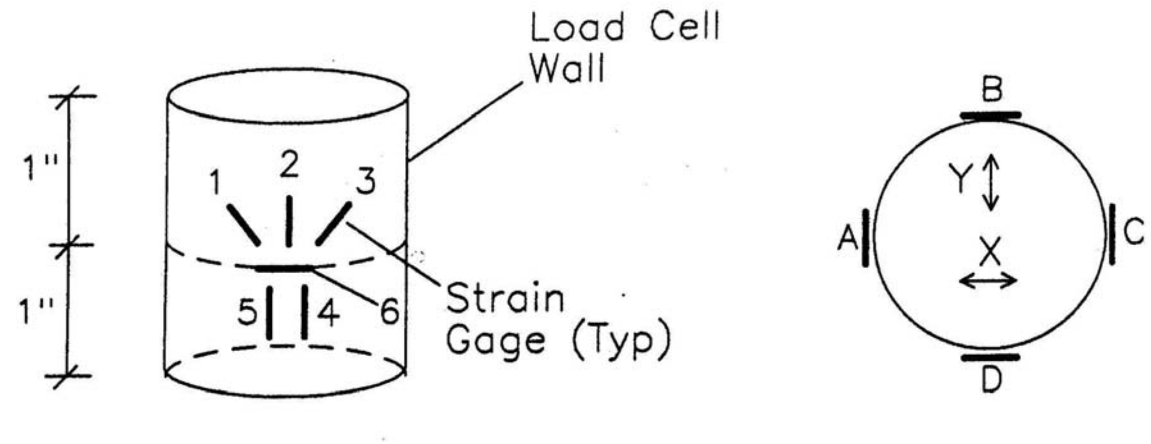
℄ SYMMETRIC
#D4 BAR, TYP
2 - 3/4" THICK PLATES (TYP)
1/16" COUNTER BORE, TYP
MACHINE SURFACES
1"
3/4"
1/4"
1/4"R
1/4"
ID 2.5"
4"
2"
1/4"
3/4"
2.5" ø HOLE
3/4"
4"

(a) Elevation

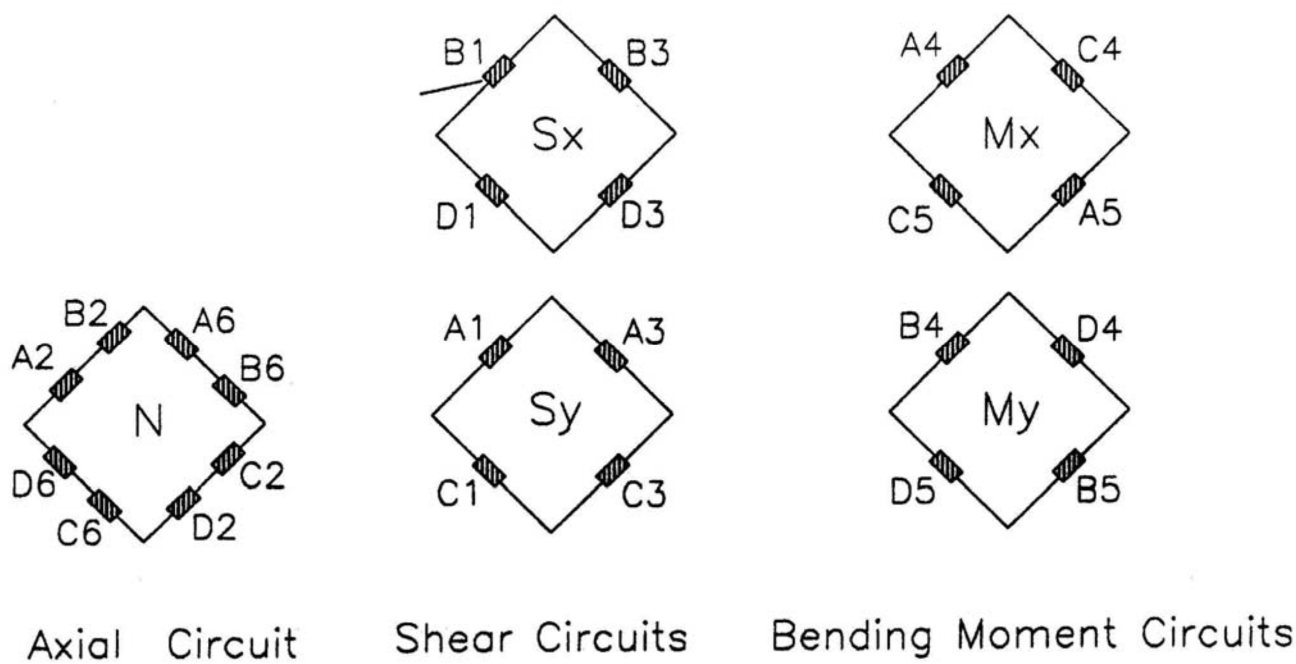


(b) Attachment Plates

FIG. B-1 Load Cell Geometric Layout



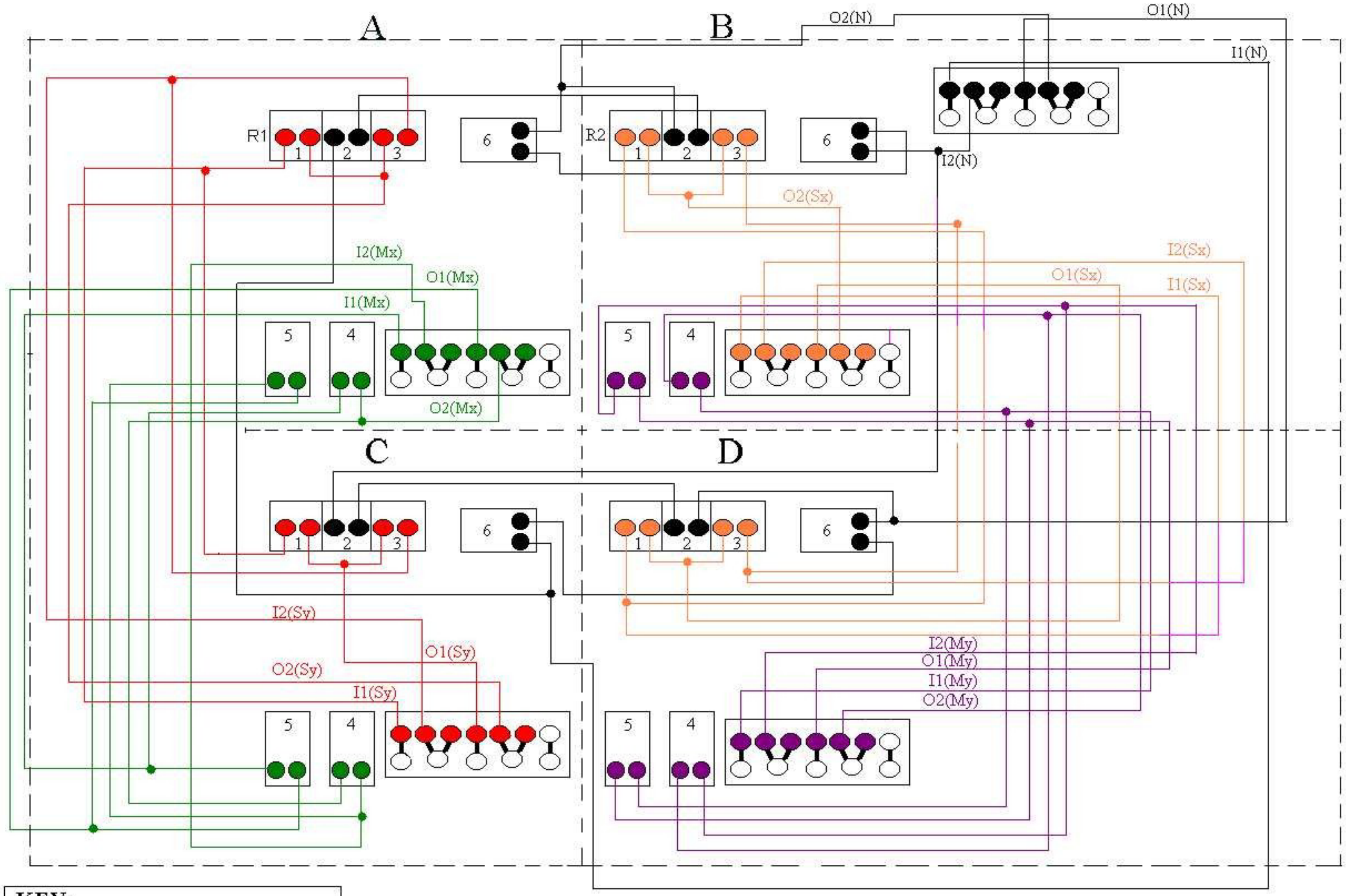
(a) Strain Gage Postioning on Load Cell



(b) Wheatstone Bridge Circuits

FIG. B-2 Strain Gage Positioning and Wiring

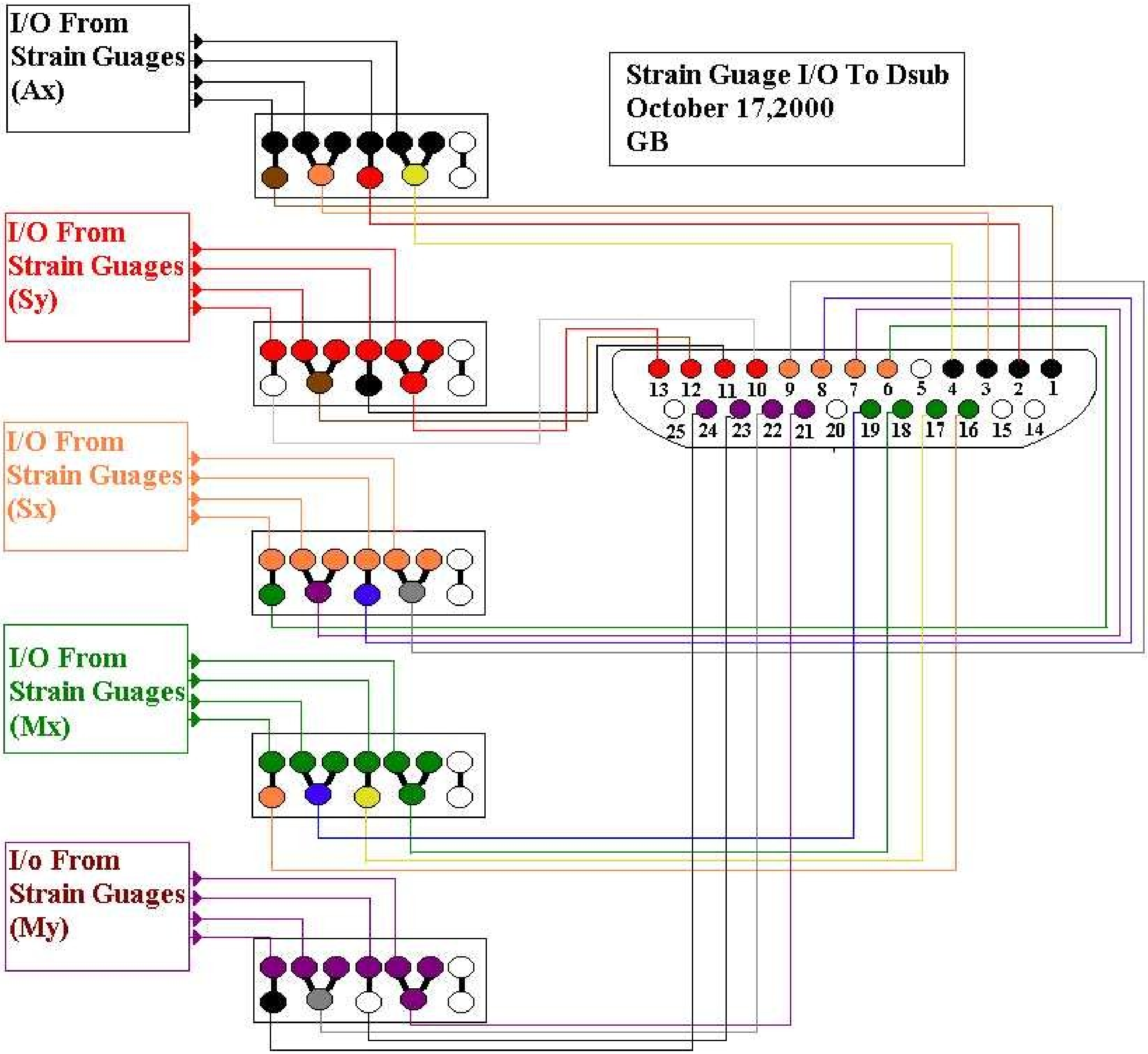
Main Circuits of Load cells

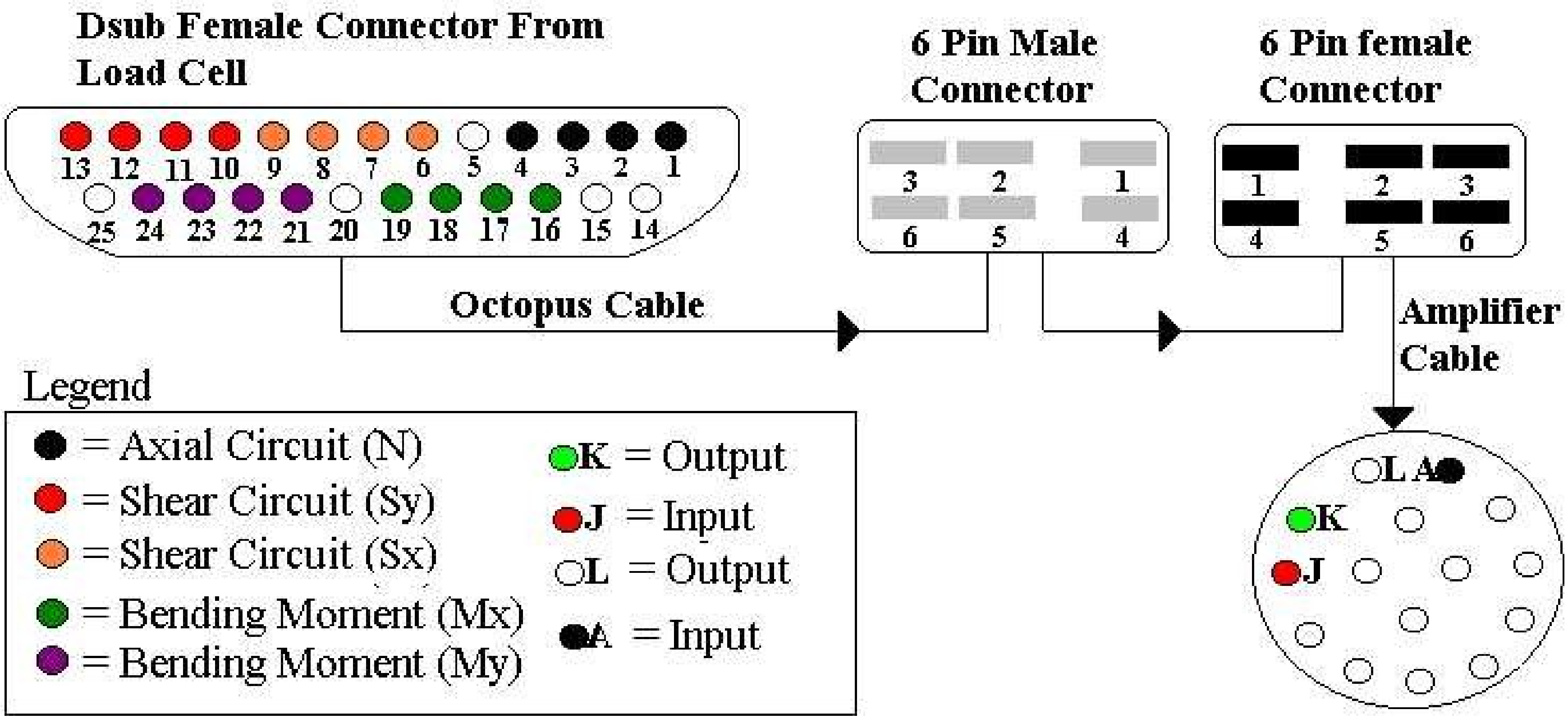


KEY:
Axial Circuit = Black
Shear Circuits (Sy)= Red
(Sx)= Orange
Bending Moments (Mx)= Green
(My)= Purple

Load Cell Wiring Diagram
October 2, 2000 G.B

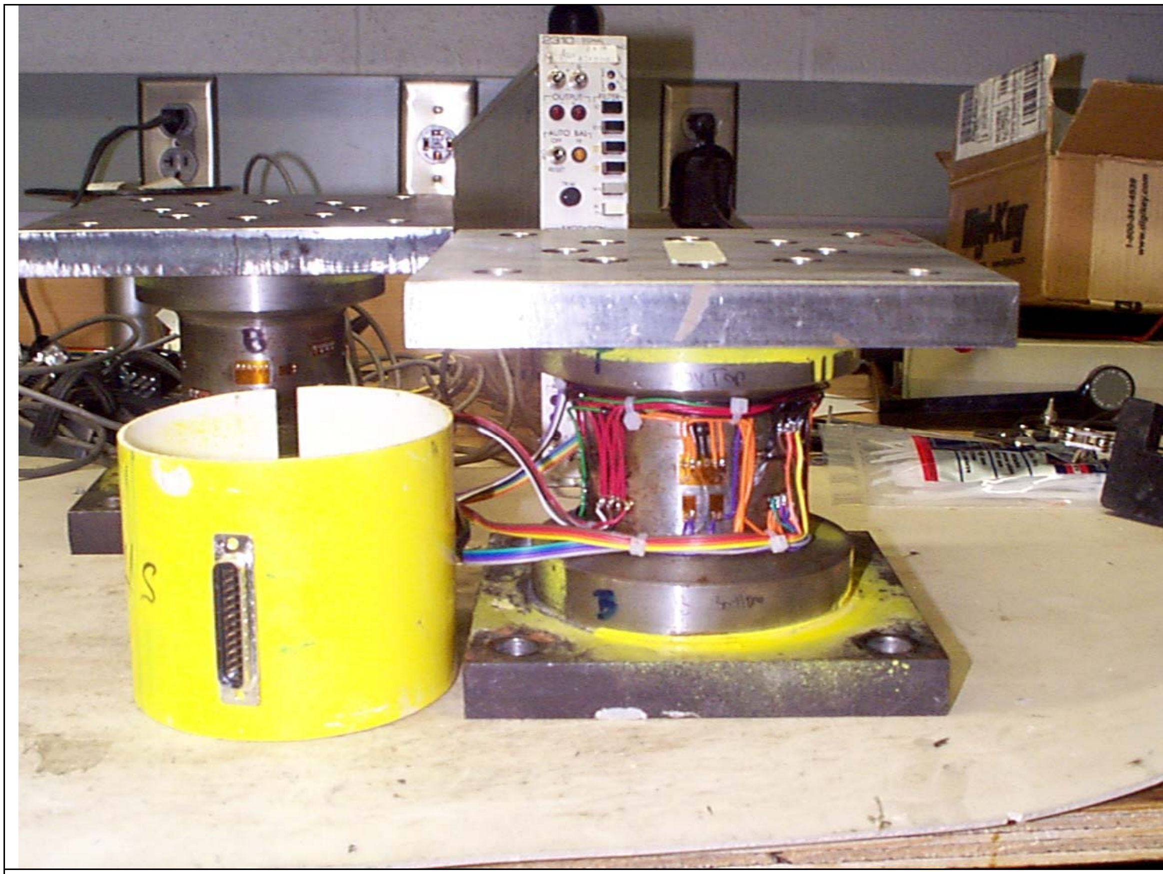
Cable form circuits to main connectors





Cable Layout Diagram

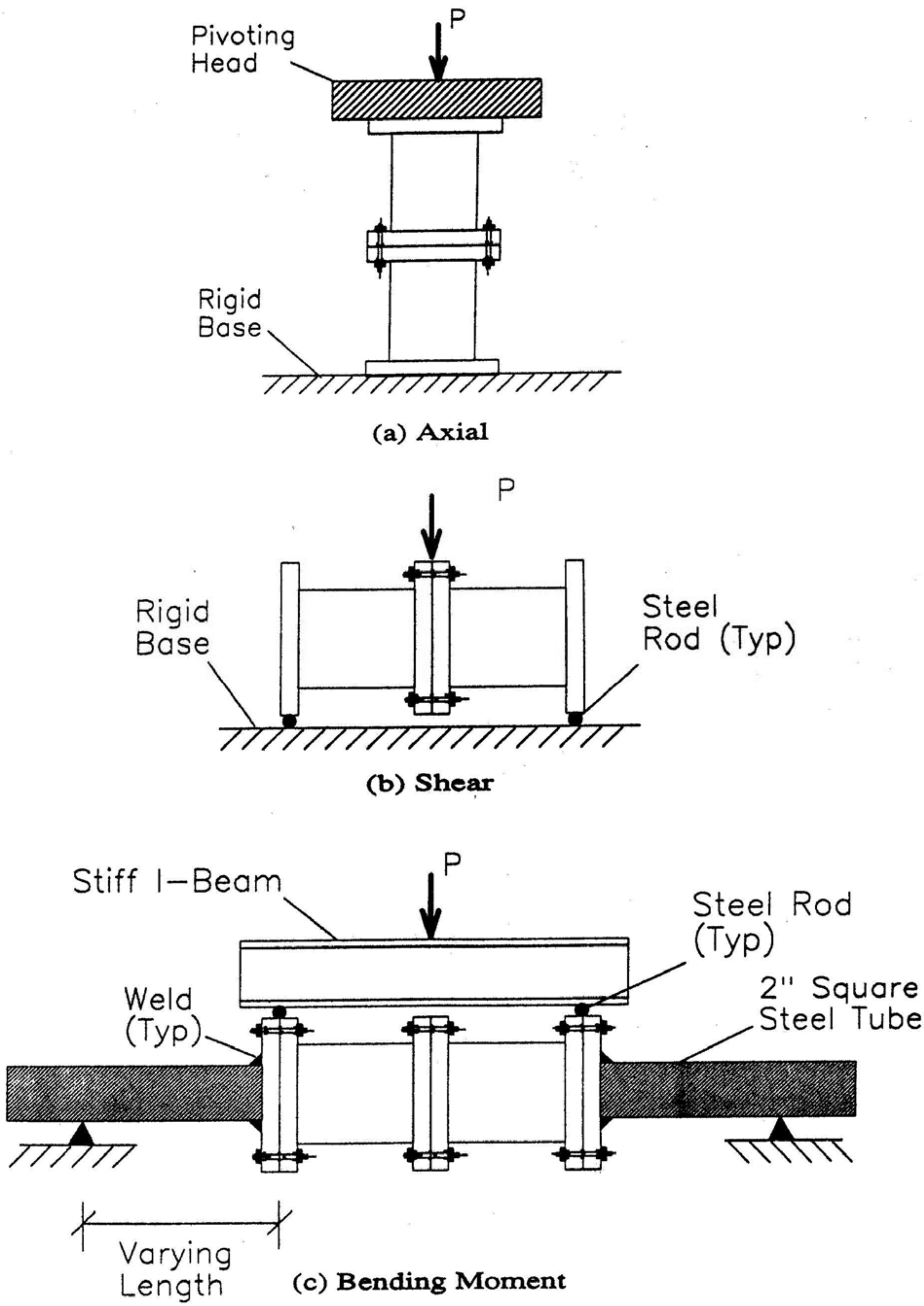
September 21,2000 GB



View of circuits of load cells

View of gauges and terminals

	Octopus Cable	Octopus Cable	Octopus Cable	Amplifier Cable	Amplifier Cable	Amplifier Cable	Amplifier Cable	
	DSUB (FEMALE FROM LOAD CELL)	Male Connector From Dsub Female (6 Pin)	Male Connector From Dsub Female (6 Pin)	Female Connector From Male (6Pin)	Female Connector From Male (6Pin)	MM Connector From Female (6Pin)	MM Connector From Female (6Pin)	Input/Output
	Pin Number	**Color**	**Pin Number**	**Color**	**Pin Number**	**Color**	**Pin Letter**	**I/O**
N Circuit = P1-P4	1	Black	5	Black	5	Black	A	Input
	2	White	1	White	1	White	L	Output
	3	Red	2	Red	2	Red	J	Input
	4	Green	4	Green	4	Green	K	Output
	5							
Sx Circuit= P6-P9	6	Black	2	Black	2	Black	J	Input
	7	White	1	White	1	White	L	Output
	8	Red	5	Red	5	Red	A	Input
	9	Green	4	Green	4	Green	K	Output
Sy Circuit= P10-P13	10	Black	2	Black	2	Black	J	Input
	11	White	1	White	1	White	L	Output
	12	Red	5	Red	5	Red	A	Input
	13	Green	4	Green	4	Green	K	Output
	14							
	15							
Mx Circuit= P16-P19	16	Black	5	Black	5	Black	A	Input
	17	White	1	White	1	White	L	Output
	18	Red	2	Red	2	Red	J	Input
	19	Green	4	Green	4	Green	K	Output
	20							
My Circuit= P21-P24	21	Black	5	Black	5	Black	A	Input
	22	White	1	White	1	White	L	Output
	23	Red	2	Red	2	Red	J	Input
	24	Green	4	Green	4	Green	K	Output
	25							
	CABLE LAYOUT			September 21,2000				

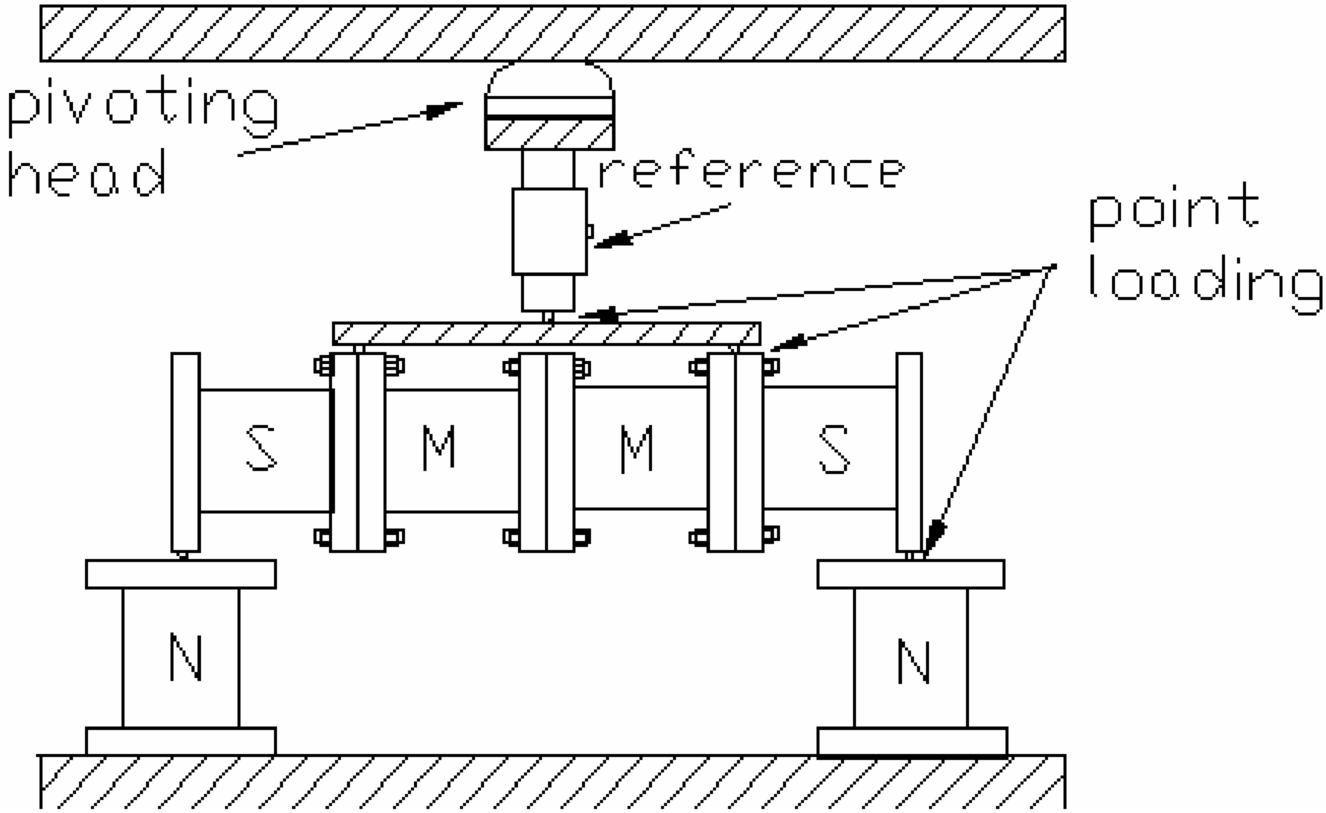


(a) Axial

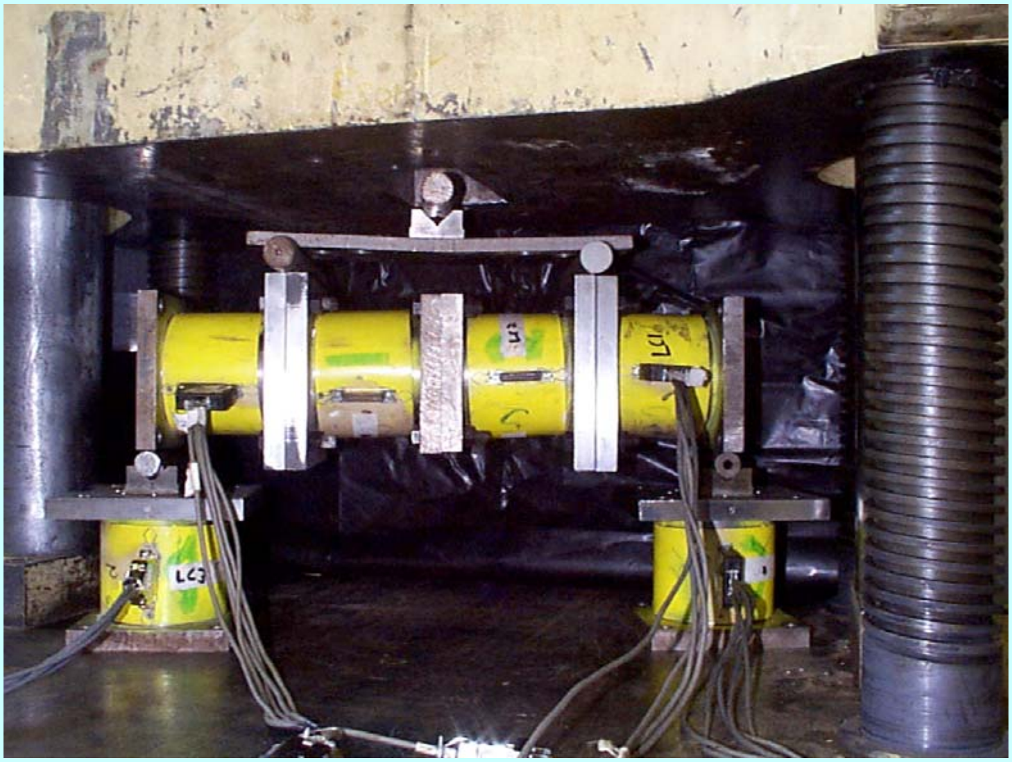
(b) Shear

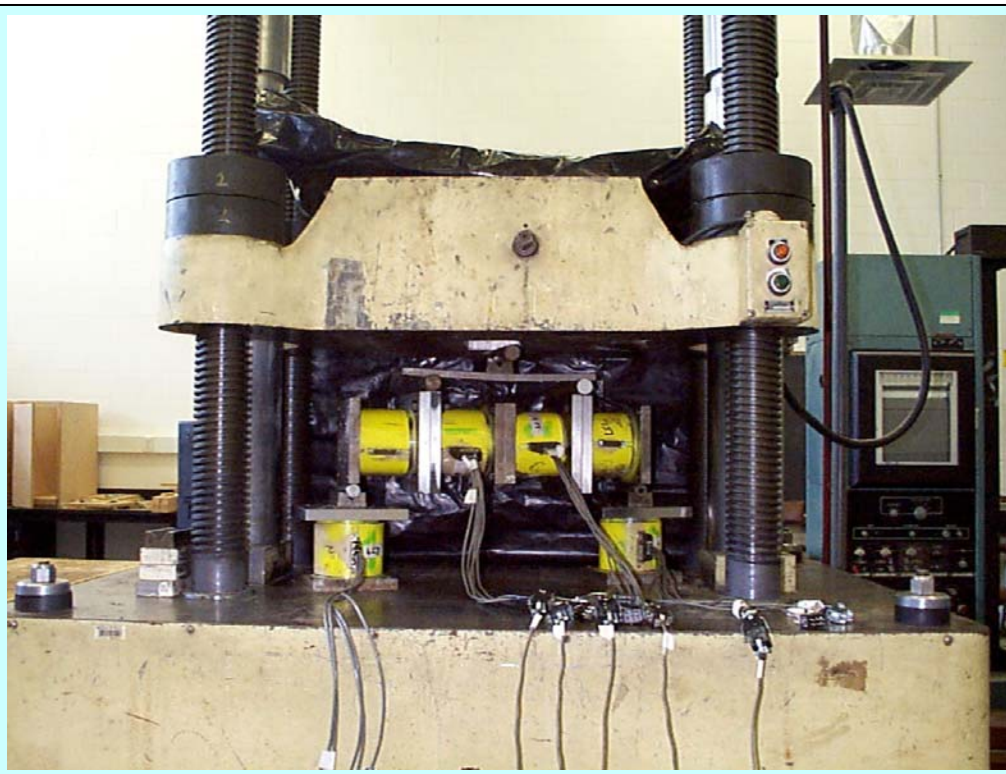
(c) Bending Moment

FIG. B-3 Load Cell Calibration Setup



Multi purpose Load calibration set-up for low size Load Cells – Space permitting.


LC3



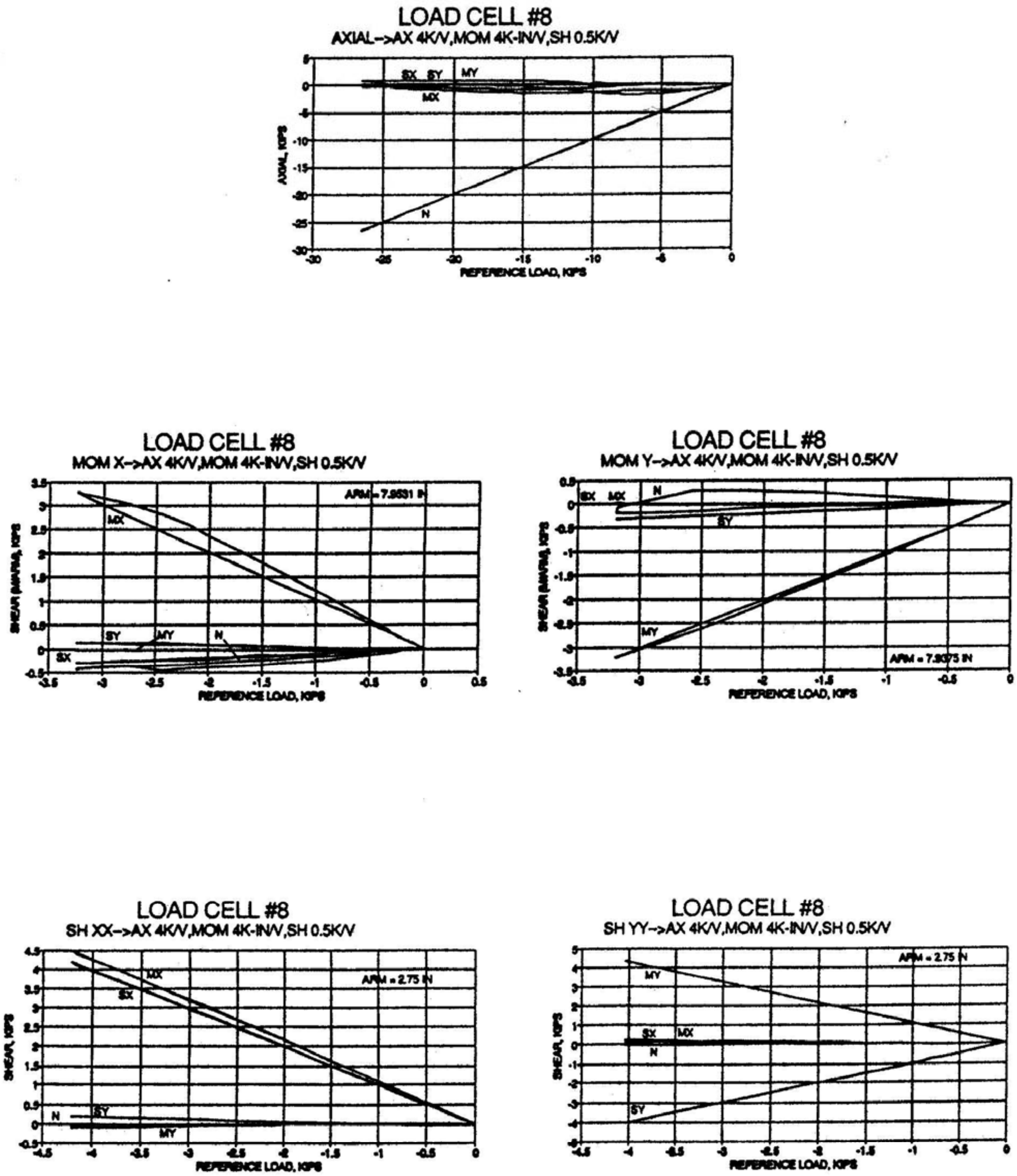


FIG. B-4 Calibration Curves for a Typical Load Cell