Appendix J: Data Correction for Ambient Thermal Response

J.1 Overview of Instrumentation

As part of the post-test analysis effort, ANATECH was also tasked with reviewing and standardizing the measurements taken during the Limit State Test (LST). There are a variety of factors that can influence gage read-outs so the goal of this standardization effort was to identify these factors and, to the extent that their influence is significant, adjust the raw data to produce a uniform data set.

Detailed presentation and discussion of the PCCV instrumentation is beyond the scope of this Appendix. The instrumentation measurements that were addressed in the "data correction" effort, and the effects and phenomena that were addressed, are listed in Table J.1.

Table J.1

Measurement	Name Abbreviation	Effects Considered for Correction
Displacement	DISP	Temp., Rigid Body Motion
Strains in Special Gaged Rebars	GBST	Temp., Strain Localization
Strains in Liner	LINST	Temp.
Pressure	PRES	--
Strains in Rebar	REBST	Temp., Strain Localization
Tendon Strains	TENDON	Temp.
Temperatures	TEMP	--

The data acquisition system was installed and activated more than seven months prior to the LST. Gage measurements taken at various time intervals throughout this seven moths have provided a vast database of the model's response to changes in temperature. Since the goal of the "data correction" effort is to create a standardized set of data that is free of temperature effects, two sets of this history data were extracted from the data base to calibrate a correction formula for each individual gage. These two datasets are the following: 1) March X - March Y, Before Prestressing (BPS) and 2) August 7-9, Post System Functionality Test, PSFT. The datasets are also designated as "dynamic" data (DYN) and "data of record" (DOR). The dynamic data represents nearly continuous scanning of data, at every frequent intervals, regardless of whether strain and displacement readings have stabilized, and the DOR are scanned only at pressure holds (during the LST) after gage readings have reached a stability criteria. The filenames for the data, therefore, are as listed in Table J.2 below.

Table J-2. Gage Data Filename Matrix

Data Type	DYN_BPS	DYN_PSFT	DYN_LST	DOR_LST
DISP_CVTD	X	X	X	X
GBST_CVTD	X	X	X	X
LINST_CVTD	X	X	X	X
PRES_CVTD			X	X
REBST_CVTD	X	X	X	X
TEDON_CVTD	X	X	X	X
TEMP_CVTD	X	X	X	X

The "DYN_BPS" and DYN_PSFT" data are used to develop the correction algorithms and the "DYN_LST" and "DOR_LST" are the data that are corrected. ANATECH was also tasked with correcting SOL_CVTD_LST_PLST, the standard output location data file.

J.2 Temperature Effects on Measurements

Change in temperature has a direct influence on the strains and displacements of a free-standing structure. Further, temperature changes have secondary effects on the voltage readouts of strain gages. Both of these effects have been considered and quantified in the data correction effort, the former being calibrated by direct observation of the model response during the two calibration periods and the latter being provided by the gage manufacturer. To correct for either phenomena, first requires that the temperature be known at every gage, or in effect, at all possible locations within the PCCV. This information has been obtained by developing a temperature mapping algorithm based on interpolation between the matrix of temperature gages. Development of this algorithm is described below.

J.2.1 Temperature Measurements

The matrix of temperature measuring gages in the PCCV is shown in Figure J-1. Temperature Gages exist on the inside surface of the liner and at certain locations embedded in the concrete wall. Since the matrix of gages has gaps (no gage) at certain elevations and certain azimuths, the interpolation mapping was done in three steps as follows:

1. Extrapolation of Temperature Readings For Liner Inside Surface

   (TI-C-##-##) and the Liner Outside Surface (TW-R-##-##) at Azimuth

   Locations (0° 90°, 135°, 240°, 324°).

2. Compute the thermal gradients at the inside of liner wall.

3. Produce a temperature reading at all strain gage locations using the extrapolated temperature readings and thermal gradients.

Procedure Followed:

1. Read in the Temperature Data for the DOR and the Temperature for the Dynamic Record.

2. Data is read into an array

   a. Gage = G (1D array)

   b. Azimuth = AZ (1D array)

   c. Elevation = EL (1D array)

   d. Radial Distance = RA (1D array)

   e. Temperature Readings = TEMP (2D array)

3. Output a new array

   a. Gage = GB (1D array)

   b. Azimuth = AZN (1D array)

   c. Elevation = ELN (1D array)

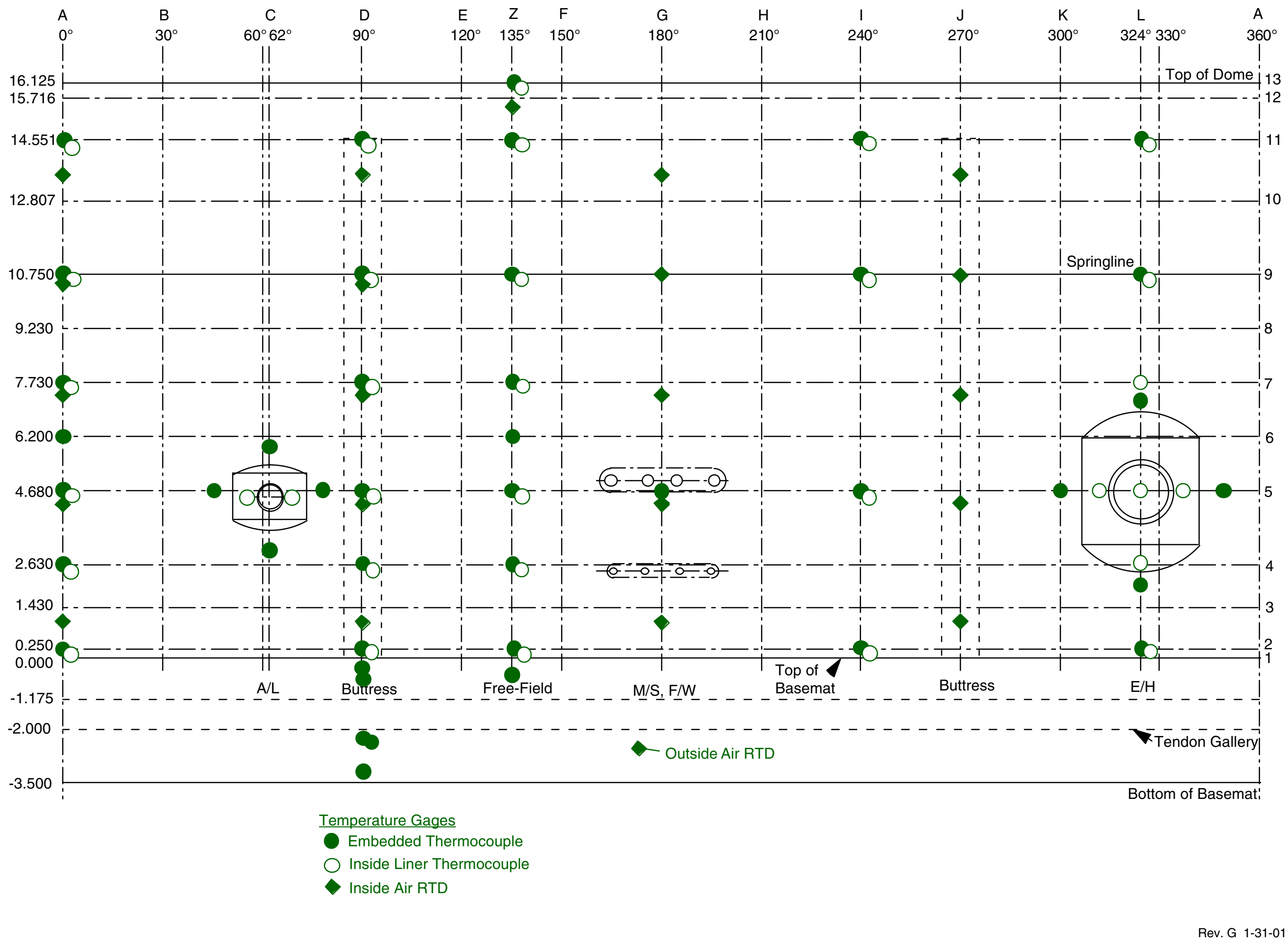

Figure J.1 Temperature Instrumentation Locations

d. Radial Distance = RAN (1D array)

e. Temperature Readings = R(i , j) (2D array)

4. Output the Thermal Gradients of Inside Liner Location

a. Formula used:

1 $T_{grad} = (T_{conc} - T_{liner}) / \Delta r$

where Δr = Rconc – Rliner

5. Data array of strain gage locations read into new program with corresponding temperature readings on the inner liner and middle thickness of wall. The Subprogram Inter produces a temperature corresponding to a given elevation, azimuth, and radial distance.

6. Output strain gage readings and temperature readings.

J.2.2 Temperature Interpolation

The FORTRAN program algorithms for this procedure and three illustrative examples are outlined below. These examples show the temperature interpolation at three specific points within the PCCV cylinder. It should be noted that no basemat temperature extrapolation was attempted due to the lack of detailed temperature information within the basemat. Basemat gages were all assumed to be the same as the temperature at the base of the wall.

Temperature Interpolation of the Absent Strain Gages

The following example shows how temperature is extrapolated to a "missing" location.

Gages on Line 0 Degree
Gage 1 - TW-R-A2-01
Gage 2 – TW-R-A3-01
Gage 3 – TW-R-A4-01

Given: Gage 1 – Given by TEMP_CVTD_DOR_LST
Gage 3 – Given by TEMP_CVTD_DOR_LST

Required: Extrapolation of Gage 2

$$X(1) = 1. - \frac{elev.\ (TW-R-A3-01) - elev.\ (TW-R-A2-01)}{elev.\ (TW-R-A4-01) - elev.\ (TW-R-A2-01)} = 1 - \left(\frac{1430-254}{2642-254}\right) = 0.50754$$

$$X(2) = 1. + \frac{(elev.(TW-R-A3-01) - elev.(TW-R-A4-01))}{elev.(TW-R-A4-01) - elev.(TW-R-A2-01)} = 1 + \left(\frac{1430-2642}{2642-254}\right) - = 0.4924$$

Temperature TW-R-A3-01 = Temperature (TW-R-A2-01)*X(1) + Temperature (TW-R-A4-01)*X(2)

Temperature TW-R-A3-01 = (13.864)*0.50754+16.294901*(0.4924) = 15.0601 @ Time = 03/03/00 11:47

Temperature placed into Data Array at Time "L"

Temperature Interpolation at a Specific Location

Given: Temperature reading on line (2,3,4,5,6,7,8,9,10,11,12,13) and on azimuth (0°, 90°, 135°, 240°, 324°)

Examples: Extrapolation of Temperatures for Following Locations

1. Location1: Elevation =1425 Azimuth 35 degree, Radius 5699.7mm
2. Location2: Elevation =9130 Azimuth 210 degree, Radius 5359.4mm
3. Location3: Elevation =12900 Azimuth 310degree, Radius 5780.95mm

Information entered for subroutine temperature extrapolation

1. Azimuth Data: data az / 0.0, 90.0, 135.0, 240.0, 324.0, 360.0 /

2. Elevation Data: data elev / 254.0, 1430.0, 2642.0, 4674.0,
6200.0, 7722.0, 9230.0,10744.0,12807.0,
14554.0,15716.0,16125.0 /

3. Radial Data: data ra / 5359.4, 5537.2, 5638.8 /
where, data ra / inner liner radius, middle wall radius (except on line D), middle wall radius on line D /

Example 1.

(a) Search on Azimuth Location
First Azimuth Location = 0° (a)
Second Azimuth Location = 90° (a+1)

(b) Search on Elevation Location
First Elevation Location = 250.0 (e)
Second Elevation Location = 1430.0 (e+1)

(c) Search for Radial location

1. Since the gage is located at 35 degrees
- If radius of wall temperature is located at 0° then Radius = 5537.2 mm
- If radius of wall temperature is located at 90° then Radius = 5638.8 mm
5638.8 mm - 5537.2 mm = 101.6 mm

Therefore, radius of the wall for the example 1 gage location:
Formula: (liner radius + (wall radius on Line D) - (wall radius on Line A)

$$\left(\frac{(Az.(2) - Az.(gage))}{Az.(2) - Az.(1)}\right)$$

Value for Wall Radius:

5537.2 mm (liner radius) + (5537.2 mm) $\left(\frac{(90-35)}{90-0}\right) = 5599.29 \ mm$

(d) Temperature is interpolated for Vertical Elevation

fact1=(elev(e+1)-EL1(i))/(elev(e+1)-elev(e)) = (1430.0-1425)/(1430.0 – 254.0) = 0.00425
fact2=(EL1(i)-elev(e))/(elev(e+1)-elev(e)) = (1425-254)/(1430-254) = 0.99575

1. LINER Temperature taken as % from 1st loc. + % from 2nd loc. data temperature at 1st elev., 1st az, 1st rad. loc. and 2nd elev.,1st az,1st rad. loc.

temp(1,ii)=fact1* temp. liner(254mm, 0°, 1-34) + fact2* temp. liner(1430mm, 0°, 1-34)
temp(1,2) = 0.00425*20.1455 + 0.99575 * 19.616 =19.6183

2. LINER Temperature taken as % from 1st loc. + % from 2nd loc.
   1st elev., 2nd az, 1st rad. loc.to 2nd elev.,2nd az,1st rad. loc.

temp(2,ii)=fact1* temp. liner(254mm, 90°, 1-34)+fact2* temp. liner(1430mm, 90°, 1-34)
temp(2,2) = 0.00425*20.2373 + 0.99575 * 19.783 =19.7849

3. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
   1st elev., 1st az, 2nd rad. loc.to 2nd elev.,1st az,2nd rad. loc.

temp(3,ii)=fact1* temp. wall(254mm, 0°, 1-34)+fact2* temp. wall(1430mm, 0°, 1-34)
temp(3,2) = 0.00425*19.2764 + 0.99575 * 18.519 =18.5222

4. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
   1st elev., 2nd az, 2nd rad. loc.to 2nd elev.,2nd az,2nd rad. loc.

temp(4,ii)=fact1* temp. wall(254mm, 90°, 1-34)+fact2* temp. wall(1430mm, 90°, 1-34)
temp(4,2) = 0.00425*19.9335 + 0.99575 * 19.436 =19.4381

2. Interpolation along the azimuth

fact1=(az(a+1)-AZ1(i))/(az(a+1)-az(a)) = (90-35)/(90-0) = 0.611
fact2=(AZ1(i)-az(a))/(az(a+1)-az(a)) = (35-0)/(90-0)=0.3889
tempa(1,ii)=fact1* temp(1,ii)+fact2* temp(2,ii)
tempa(1,2) = 0.611*19.6183+ 0.3889 * 19.7849 =19.6811

tempa(2,ii)=fact1*temp(3,ii)+ fact2*temp(4,ii)
tempa(2,2) = 0.611*18.5222 + 0.3889 * 19.4381 =18.8764

3. Finally the interpolation through the thickness

fact1=(rm-RA1(i))/(rm-ra(1)) = (5599.29 mm -5699.7 mm)/(5599.29 mm-5359.4) = -0.4186
fact2=(RA1(i)-ra(1))/(rm-ra(1)) = (5699.7mm-5359.4)/(5599.29 mm-5359.4) = 1.4186

tempr(i,ii)=fact1*tempa(1,ii)+fact2*tempa(2,ii)
tempr(1,2) = -0.4186*19.6811+1.4186*18.8764 = 18.5396

Example 1 for DOR_LST @ 9/26/00 10:03

Example Pt.	***Gage 1***	***Temp.***	***Gage 2***	***Temp.***	***Gage 3***	***Temp.***	***Gage 4***	***Temp.***
Liner	TI – C-A2-01	20.146	TI – C-A3-01	19.62	TI – C-D2-01	20.237	TI – C-D3-01	19.7838
Outside	TW – R-A2-01	19.276	TW – R-A3-01	18.52	TW – R-D2-01	19.9335	TW – R-D3-01	19.4368
Final								18.5396

Example 2.

(a) Search on Azimuth Location
First Azimuth Location = 135° (a)
Second Azimuth Location = 240° (a+1)

(b) Search on Elevation Location
First Elevation Location = 7722.0 (e)

Second Elevation Location = 9230 (e+1)

(c) Search for Radial location

Since the gage is located at 200 degrees Radius of wall = 5537.2 mm
- If radius of wall temperature is located at 135° then Radius = 5537.2 mm
- If radius of wall temperature is located at 240° then Radius = 5537.2 mm
5537.2 mm - 5537.2 mm = 0 mm

(d) Temperature is interpolated for Vertical Elevation

fact1=(elev(e+1)-EL1(i))/(elev(e+1)-elev(e)) = (9230.-9130)/(9230 – 7722.0) = 0.066313
fact2=(EL1(i)-elev(e))/(elev(e+1)-elev(e)) = (9130-7722.0)/(9230-7722.0) = 0.933687

1. LINER Temperature taken as % from 1st loc. + % from 2nd loc.
data temperature at 1st elev., 1st az, 1st rad. loc.and 2nd elev.,1st az,1st rad. loc.

temp(1,ii)=fact1* temp. liner(7722mm, 135°, 1-34) + fact2* temp. liner(9230mm, 135°, 1-34)
temp(1,2) = 0.066313*17.0938 + 0.933687 * 17.065506 =17.06738

2. LINER Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 2nd az, 1st rad. loc.to 2nd elev.,2nd az,1st rad. loc.

temp(2,ii)= fact1* temp. liner(7722mm, 240°, 1-34) + fact2* temp.liner(9230mm, 240°, 1-34)
temp(2,2) = 0.066313*16.8714 + 0.933687 * 16.794495 =16.799594

3. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 1st az, 2nd rad. loc.to 2nd elev.,1st az,2nd rad. loc.

temp(3,ii)=fact1* temp. wall(7722mm, 135°, 1-34) +fact2* temp. wall(9230mm, 135°, 1-34)
temp(3,2) = 0.066313*15.5703 + 0.933687 * 15.857828 =15.83876

4. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 2nd az, 2nd rad. loc.to 2nd elev.,2nd az,2nd rad. loc.

temp(4,ii)=fact1* temp. wall(7722mm, 240°, 1-34)+fact2* temp. wall(9230mm, 240°, 1-34)
temp(4,2) = 0.066313*16.368855+ 0.933687 * 14.087605 =14.2388

(e) Interpolation along the azimuth

fact1=(az(a+1)-AZ1(i))/(az(a+1)-az(a)) = (240-210)/(240-135) = 0.2857
fact2=(AZ1(i)-az(a))/(az(a+1)-az(a)) = (210-135)/ (240-135)=0.71429
tempa(1,ii)=fact1* temp.(1,ii)+fact2* temp.(2,ii)
tempa(1,2) = 0.2857*17.06738+ 0.71429 * 16.799594 =16.87593

tempa(2,ii)=fact1*temp(3,ii)+ fact2*temp(4,ii)
tempa(2,2) = 0.2857*15.83876+ 0.71429 * 14.2388 =14.69577

(f) Finally the interpolation through the thickness

fact1=(rm-RA1(i))/(rm-ra(1)) = (5537.2mm-5359.4mm)/(5537.2mm -5359.4mm) = 1.0
fact2=(RA1(i)-ra(1))/(rm-ra(1)) = (5359.4mm-5359.4)/(5537.2mm -5359.4mm) = 0.0

tempr(i,ii)=fact1*tempa(1,ii)+fact2*tempa(2,ii)
tempr(1,2) = 1.0*16.87593+1.0*14.2388 = 16.87593

Example 2 for DOR_LST @ 9/26/00 10:03

Example Pt.	*Gage 1*	*Temp.*	*Gage 2*	*Temp.*	*Gage 3*	*Temp.*	*Gage 4*	*Temp.*
Liner	TI – C-Z7-01	17.094	TI – C-Z8-01	17.06551	TI – C-I7-01	16.87147	TI – C-I8-01	16.7945
Outside	TW – R–Z7-01	15.570	TW – R-Z8-01	15.8578	TW – R–I7-01	16.36885	TW – R-I8-01	14.08761
Final								16.87593

Example 3.

(a) Search on Azimuth Location
First Azimuth Location = 240° (a)
Second Azimuth Location = 324° (a+1)

(b) Search on Elevation Location
First Elevation Location = 12807.0 (e)
Second Elevation Location = 14554.0 (e+1)

(c) Search for Radial location

Since the gage is located at 310 degrees Radius of wall = 5537.2 mm
- If radius of wall temperature is located at 135° then Radius = 5537.2 mm
- If radius of wall temperature is located at 240° then Radius = 5537.2 mm
5537.2 mm - 5537.2 mm = 0 mm

(d) Temperature is interpolated for Vertical Elevation

fact1=(elev(e+1)-EL1(i))/(elev(e+1)-elev(e)) = (14554.-12900)/(14554 – 12807.0)
= 0.9468
fact2=(EL1(i)-elev(e))/(elev(e+1)-elev(e)) = (12900-12807.0)/(14554-12807.0) = 0.05323

1. LINER Temperature taken as % from 1st loc. + % from 2nd loc.
data temperature at 1st elev., 1st az, 1st rad. loc.and 2nd elev.,1st az,1st rad. loc.

temp(1,ii)=fact1* temp. liner(12807mm, 240°, 1-34) + fact2* temp. liner(14554, 240°, 1-34)
temp(1,2) = 0.9468*16.584515 + 0.05323* 15.8984 =16.5485

2. LINER Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 2nd az, 1st rad. loc.to 2nd elev.,2nd az,1st rad. loc.

temp(2,ii)= fact1* temp.liner(12807, 324°, 1-34) + fact2* temp.liner(14554, 324°, 1-34)
temp(2,2) = 0.9468 *17.45914 + 0.05323* 17.5098 =17.4624

3. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 1st az, 2nd rad. loc.to 2nd elev.,1st az,2nd rad. loc.

temp(3,ii)=fact1* temp. wall(12807, 240°, 1-34) +fact2* temp. wall(14554, 240°, 1-34)
temp(3,2) = 0.9468 *15.976255 + 0.05323* 15.619388 =15.9577

4. WALL Temperature taken as % from 1st loc. + % from 2nd loc.
1st elev., 2nd az, 2nd rad. loc.to 2nd elev.,2nd az,2nd rad. loc.

temp(4,ii)=fact1* temp. wall(12807, 324^0, 1-34)+fact2* temp. wall(14554, 324°, 1-34)
temp(4,2) = 0.9468 *18.13707+ 0.05323* 18.0732 =18.1342

(e) Interpolation along the azimuth

fact1=(az(a+1)-AZ1(i))/(az(a+1)-az(a)) = (324-310)/(324-240) = 0.1667
fact2=(AZ1(i)-az(a))/(az(a+1)-az(a)) = (310-240)/ (324-240)=0.8333
tempa(1,ii)=fact1* temp.(1,ii)+fact2* temp.(2,ii)
tempa(1,2) = 0.1667*16.5485+ 0.8333 * 17.4624=17.3101

tempa(2,ii)=fact1*temp(3,ii)+ fact2*temp(4,ii)
tempa(2,2) = 0.1667*15.9577+0.8333 * 18.1342 =17.7713

(f) Finally the interpolation through the thickness

fact1=(rm-RA1(i))/(rm-ra(1)) = (5537.2mm-5780.95mm)/(5537.2mm -5359.4mm) = -1.371
fact2=(RA1(i)-ra(1))/(rm-ra(1)) = (5780.95mm-5359.4)/(5537.2mm -5359.4mm) = 2.37

tempr(i,ii)=fact1*tempa(1,ii)+fact2*tempa(2,ii)
tempr(1,2) = -1.371*17.3101+2.371*17.7713 = 18.4195

Example 3 for DOR_LST @ 9/26/00 10:03

Example Pt.	***Gage 1***	***Temp.***	***Gage 2***	***Temp.***	***Gage 3***	***Temp.***	***Gage 4***	***Temp.***
Liner	TI – C-I10-01	16.584	TI – C-I11-01	15.8984	TI – C-L10-01	17.459	TI – C-L11-01	17.51
Outside	TW – R-I10-01	15.976	TW – R-I11-01	15.619	TW – R-L10 - 01	18.137	TW – R-L11-01	18.073
Final								18.4195

J.2.3 Direct Temperature Effects on Gages

The basic premise for the gate temperature corrections is to calculate, for each gage, a gage adjustment function that is a function only of the temperature at that gage. This premise accepts the simplification that the correction is only a function of the individual gage temperature, when in reality it may be a function of the complete temperature distribution caused structural interaction effects. Since these interactions are judged to be secondary effects compared to the direct thermal expansion occurring directly at each gage, these secondary effects are being ignored in the data correction. Further, since much of the temperature changes are caused by passage of the sum, it is likely that daytime temperature distributions will at least be similar to each other (i.e. the sun will never be shining on the north side of the model, regardless of the seasonal changes in solar apogy). It is also noted that by using the BPS and the PSFT datasets, temperature corrections at a range of different PCCV stress levels have been evaluated.

J.2.4 Secondary Temperature Effects on Strain Gages(Correction Terms)

These effects are provided directly from the gage manufacturer. The corrections are in the form of Lot Numbers, with corrections given in units of microstrain.

Lot Number R-A12BP25:

$\Sigma = 4.97 \times 10^{1} + 1.12 \times 10^{0}T - 2.81 \times 10^{-2}T^{2} + 6.18 \times 10^{-5}T^{3} - 3.11 \times 10^{-8}T^{4}$ (deg F)

$\Sigma = 5.87 \times 10^{1} - 8.93 \times 10^{-1}T - 7.24 \times 10^{-2} T^{2} + 3.37 \times 10^{-4} T^{3} - 3.26 \times 10^{-7} T^{4}$ (deg C)

Lot Numbers R-A19A595, R-A19AP58, R-A19AP61, R-A19AP75, R-A19AP81, R-A19AP82, R-A19AP83,

R-A19AP95, R-A19AP96, R-A19AP97:

$\Sigma = -3.81 \times 10^{1} + 2.74 \times 10^{0}T - 3.52 \times 10^{-2}T^{2} + 7.64 \times 10^{-5}T^{3} - 4.30 \times 10^{-8}T^{4}$ (deg F)

$\Sigma = 1.60 \times 10^{1} + 1.29 \times 10^{-0}T - 9.11 \times 10^{-2}T^{2} + 4.13 \times 10^{-4}T^{3} - 4.51 \times 10^{-7}T^{4}$ (deg C)

Lot Number R-A19BP02:

$\Sigma = -1.39 \times 10^{1} + 2.41 \times 10^{0}T - 3.51 \times 10^{-2}T^{2} + 7.74 \times 10^{-5}T^{3} - 4.62 \times 10^{-8}T^{4}$ (deg F)

$\Sigma = 2.99 \times 10^{1} + 7.17 \times 10^{-1}T - 9.06 \times 10^{-2}T^{2} + 4.17 \times 10^{-4}T^{3} - 4.85 \times 10^{-7}T^{4}$ (deg C)

Lot Numbers R-A42AP02, R-A42AP04, R-A42AP08:

$\Sigma = -1.50 \times 10^{2} + 4.44 \times 10^{0}T - 3.82 \times 10^{-2}T^{2} + 7.93 \times 10^{-5}T^{3} - 4.33 \times 10^{-8}T^{4}$ (deg F)

$\Sigma = -4.45 \times 10^{1} + 4.02 \times 10^{0}T - 1.00 \times 10^{-1}T^{2} + 4.30 \times 10^{-4}T^{3} - 4.54 \times 10^{-7}T^{4}$ (deg C)

J.3 Standardize Gage Measurements

The development of the algorithm for temperature correction proceeded as follows.

1. Compute a mean linearized temperature correction factor $\overline{A}_1$, and standard deviation, σ_{A1} for every gage from Data Set 1 (the BPS data).

Typical calculation

e_{n_i} is a set of dynamic gage data for gage n and time/temperature i=1, 2, 3, ...

$e^{t}_{n_i} = e_{n_i} - \Sigma_{n_i}$ (where Σ is a polynomial correction from Section 3.2.4)

$$e^{'}_{n_i} = f_n\left(e^{t}_{n_i}\right)$$

Where f_n is a non-temperature correction function defined only for certain gages; in most cases $e^{'}_{n_i} = e^{t}_{n_i}$

$$\Delta e^{'}_{n_i} = e^{'}_{n_i} - e^{'}_{n_i}$$

$$\Delta^{T}_{n_i} = T_{n_i} - T_{n_1}$$

$$A_{i_n} = \frac{\Delta e^{'}_{n_i}}{\Delta T_{n_i}}$$

Calculate a weighted average A_n- weighted average because we want the data correction to be the most heavily influenced by strain-temperature observation data that causes the largest strains:

$$\bar{A}_n = \frac{\dfrac{1}{\bar{\Delta}e'_{n_i}} \sum_{i=1}^{I} \Delta e'_{n_i} \dfrac{\Delta e'_{n_i}}{\Delta T_{n_i}}}{I}$$

Where I = number of temperature points and $\bar{\Delta}e'_{n_i}$ is the average of $\Delta e'_{n_i}$

Check s_A (Criteria $s_{A_n} < 0.2\bar{A}_n$)

The assumed basic correction formula is therefore: $e^c_{n_i} = e_{n_i} - \Sigma_{n_i} - \bar{A}_n \Delta T_{n_i}$

This should produce a set of "corrected" gage readings that have less than 20% variation from the reading at time 1 over the entire time period.

2. Repeat same procedure for $\bar{A}_2$ and s_{A_2} for every gage from Data Set 2 (the PSFT data)

Let $a_n = \dfrac{\bar{A}_{n_1} + \bar{A}_{n_2}}{2}$ (or some other combination using other parameters or judgment)

3. Apply the correction to the DYN_LST and DOR_LST data.

The data for comparison to analysis that is free of temperature effects the (DYN_LST and DOR_LST), cannot be simply "zeroed" at the start, because the strains and displacements associated with the prestressing load and dead weight of the structure are important. To make the data free of temperature effects, the temperature corrections must be applied to a certain reference temperature. Since the LST started in the early morning prior to solar heating of the PCCV (and of course, prior to any heating or cooling caused by pumped in nitrogen), the LST DOR point 1 (zero pressure) is used as the reference temperature at each gage. (These temperatures can be different at each gage.) Using this reference temperature, the final correction formula becomes

$$e^c_{n_i} = f_n\left(e_{n_i} - \Sigma_{n_i}\right) - a_n\left(T_{n_i} - T_{n_i}\right) \qquad \text{(J-1)}$$

Note that the function f_n could cover other, non-temperature related correction terms and might only be defined for certain gages.

J.3.1 Correction Summaries by Gage Group

Displacements

For the displacement measurements, Equation J-1 is followed without further correction except for some of the vertical displacement measurements. For the vertical displacement, there may have also been some movement of a portion of the instrumentation frame that influenced the gage readings.

Rebar Strains

Equation J-1 is followed with no function f_n.

A typical bar area reduction as a result of the grinding is 1.019. Then it is assumed that for all strain ε, there is a unique stress, σ, according to the engineering stress-versus engineering strain data. Using the data for the SD390-D13 bars, averaged, the yield curve is approximately

ε	σ
.002	58 ksi
.009	60.9 ksi
.013	62.06 ksi
.015	63.075 ksi
.020	66.7 ksi

For $e_{n_i}^{t}, s_{n_i}^{t}$ is "looked-up" from the yield function

Then $s_{n_i}^{'} = s_{n_i}^{t}$ / (Area Ratio)

$e_{e_i}^{'}$ is then "looked-up" from the yield function.

Thus, function "f_n" for rebar strain is a two-step "look-up" function.

Liner Strains

Equation J-1 is followed with no function f_n.

Tendon Strains

Equation J-1 is followed with no function f_n.