Report to

FEDERAL AVIATION ADMINISTRATION
WILLIAM J. HUGHES TECHNICAL CENTER

REPORT OF STRAIN GAGE VERIFICATION TESTS FOR THE NATIONAL AIRPORT PAVEMENT TEST FACILITY, ATLANTIC CITY INTERNATIONAL AIRPORT, NEW JERSEY

Submitted by

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March 2002

STRAIN GAGE VERIFICATION TESTS

OBJECTIVE: To provide confirmation of strain data obtained using CTL fabricated embedded concrete strain gages.

METHOD: Prepare two concrete specimens with CTL embedded concrete strain gages as shown in Figure 1. Instrument the specimens with other types of similar instruments to obtain strain data for comparison.

Concrete Cylinder - One specimen was a 6” x 12” cylinder tested in compression to provide compressive strains. This specimen had the embedded gage placed in the center of the specimen and secured using tie-wire during concrete placement. For immediate comparison, the embedded strain gage bar was also instrumented with two quarter-bridge resistance strain gages. These two gages were placed on each side of the bar adjacent to the full-bridge strain gage. The external surface of the cylinder was instrumented with three 120-ohm electrical resistance strain gages with a gage length of 4.7 inches. These gages were spaced equal distant around the circumference of the cylinder and oriented in the longitudinal direction to measure axial compression. In addition, a compressometer was placed on the cylinder during testing to also measure concrete compressive strain during loading. This test setup is shown in Figure 2.

Concrete Beam - The other specimen was a 6” x 6” x 22” concrete beam tested in flexure under third point loading to provide tensile stains. The top two load points were spaced at 6 inches over the center of the specimen. The bottom two reaction points were spaced at 18 inches. The specimen had the embedded gage placed in the longitudinal center and center width of the beam. The gage was supported at a center height of 1-1/8” from the bottom. The external surface of the beam was instrumented with three 120-ohm electrical resistance strain gages with a gage length of 4.7 inches. Two of these gages were placed on the sides of the beam, at the longitudinal center, at a height of 1” from the bottom. The third gage was placed on the underside of the beam at the longitudinal center and center width of the beam. This test setup is shown in Figure 3.

Data Collection - Data from the strain gages were collected using a Hewlett Packard 3497A data acquisition system (DAS) and laptop computer as controller. The quarter-bridge electrical resistance strain gages had bridge completion on the plug-in cards of the HP DAS. The embedded strain gages are full-bridge sensors and were wired into standard voltage input plug-in cards of the HP DAS. Data was collected automatically at pre-defined time increments of approximately every 2 seconds.

Data from the compressometer were collected using a Mitutoya data logger and digital dial gage. Data were collected at even loading point increments by manually pressing the data logger record key.

RESULTS: Excitation voltage for all strain gages was 5.0 volts. The calibration factors were **–754.8 ue/mv/v** and **–767.3 ue/mv/v** for the embedded cylinder and beam strain gages, respectively. The data were reduced using the equation:

Micro-strain = Change in Voltage * Calibration Factor / Excitation Voltage

The plotted data from the cylinder compression test is shown in Figure 4. The plotted data from the beam flexural test is shown in Figures 5 and 6.

Data plotted in Figure 4 from the cylinder test show the compressive strains from the external resistance strain gages and the compressometer match the measured strain from the embedded concrete gage. The plotted data also shows excellent correlation between the embedded full-bridge strain gage and the quarter-bridge strain gages placed on that bar.

Data presented in Figure 5 from the beam test show the tensile stains from the external resistance strain gages and internal concrete strain gage. This plot shows a loose connection in the solder tab of the left side electrical resistance strain gage. To better compare these test results, a linear regression was performed on the data as presented in Figure 6.

Data presented in Figure 6 show excellent correlation between the two side gages. The comparison of the side gages with the embedded gage shows slightly lower measured tensile strains in the embedded strain gage. Part of this is due to the height difference between the centerline of the side gages (1”) and the embedded gage (1-1/8”). If the embedded gage was moved (not parallel to beam sides) during concrete placement this would also contribute to slightly lower measured strains in the embedded gage. The comparison of the bottom gage with the embedded gage shows higher measured tensile strains in the bottom gage, which would be expected.

In conclusion, the embedded strain gages using the calibration factors established by CTL during fabrication and used in this test program provided accurate, reliable strain measurements as compared with other methods.

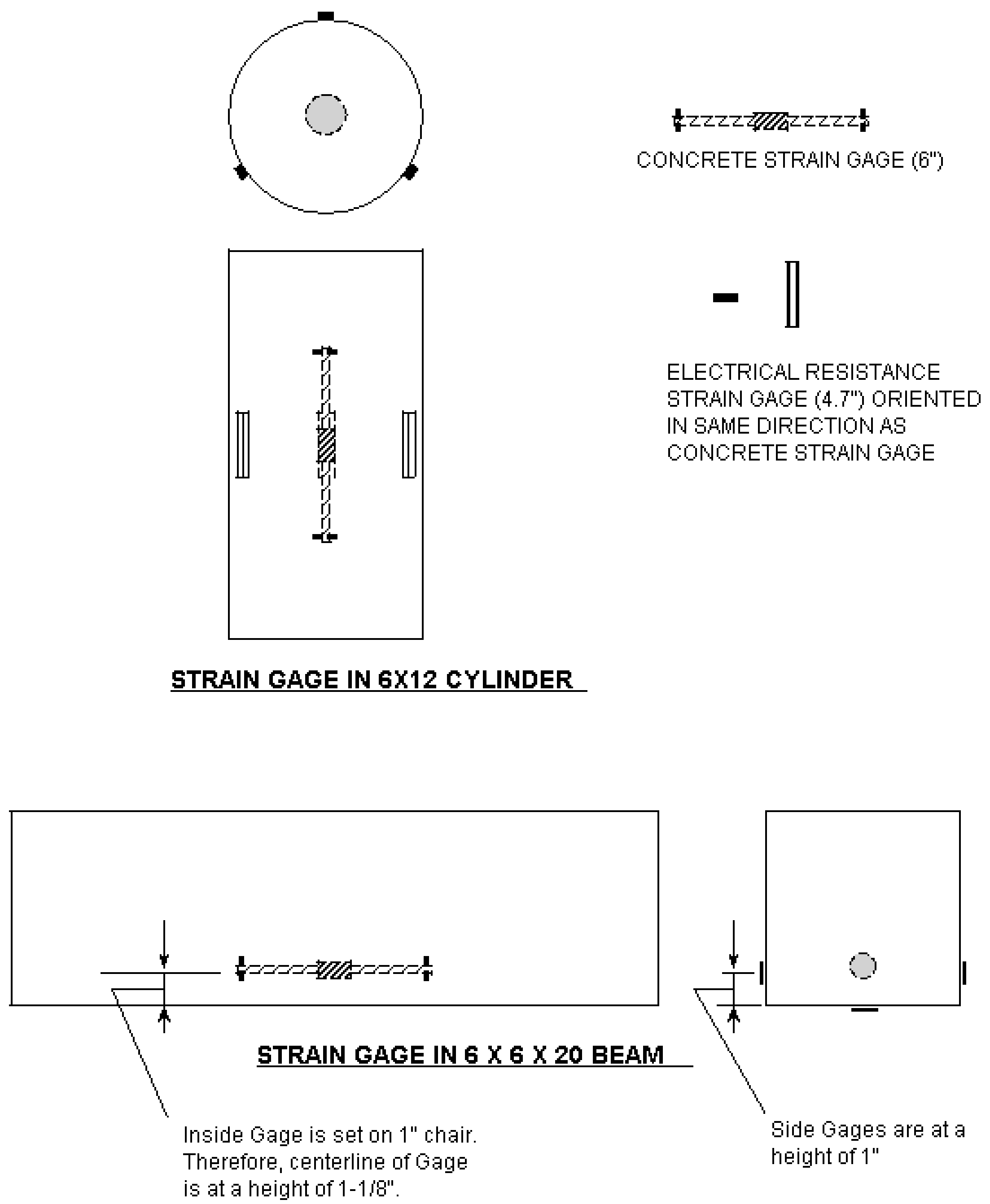

Figure 1 – Test Samples

Figure 2 – Compression Test of Cylinder

Figure 3 – Flexural Test of Beam

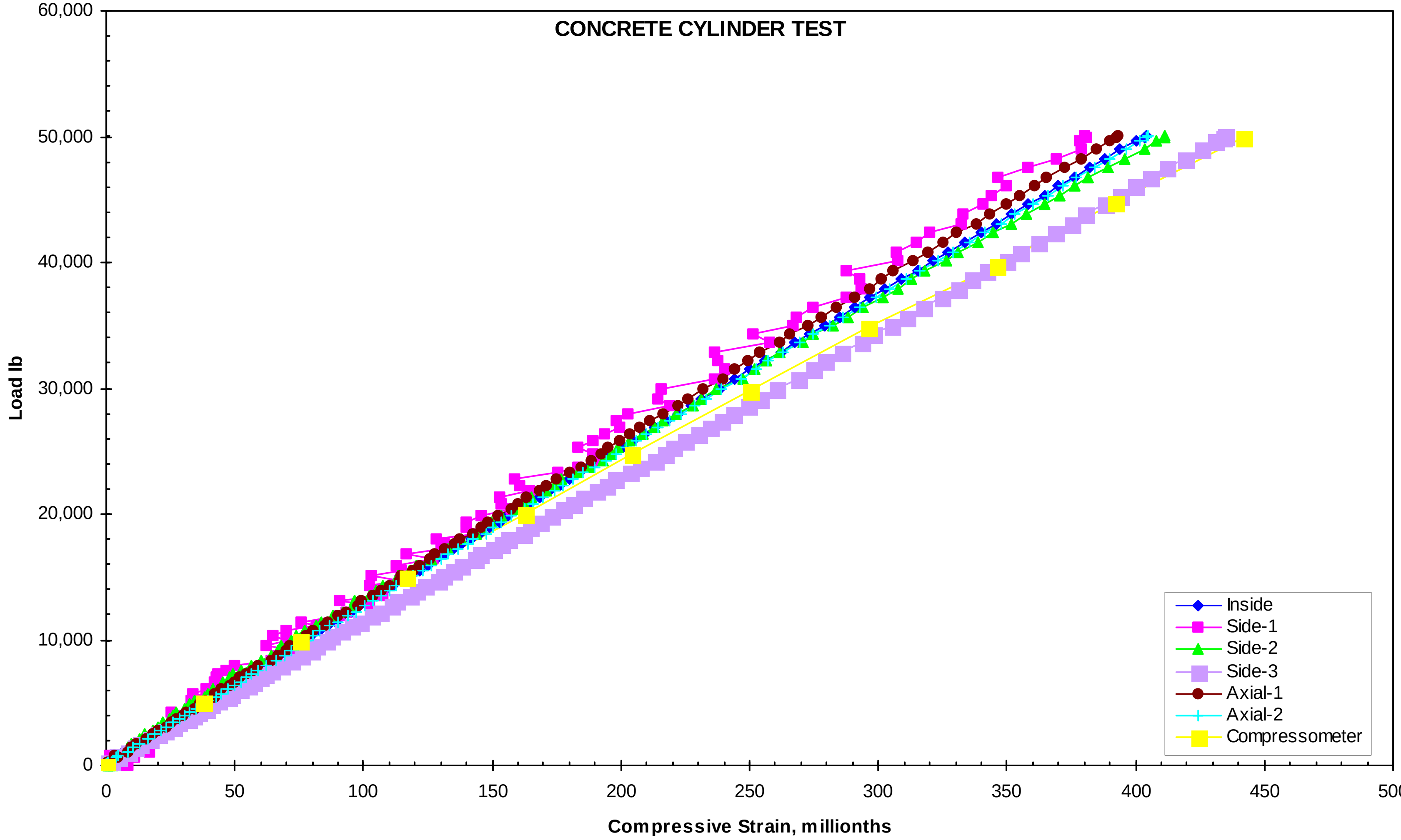

Figure 4 – Comparison of Compressive Strain Data

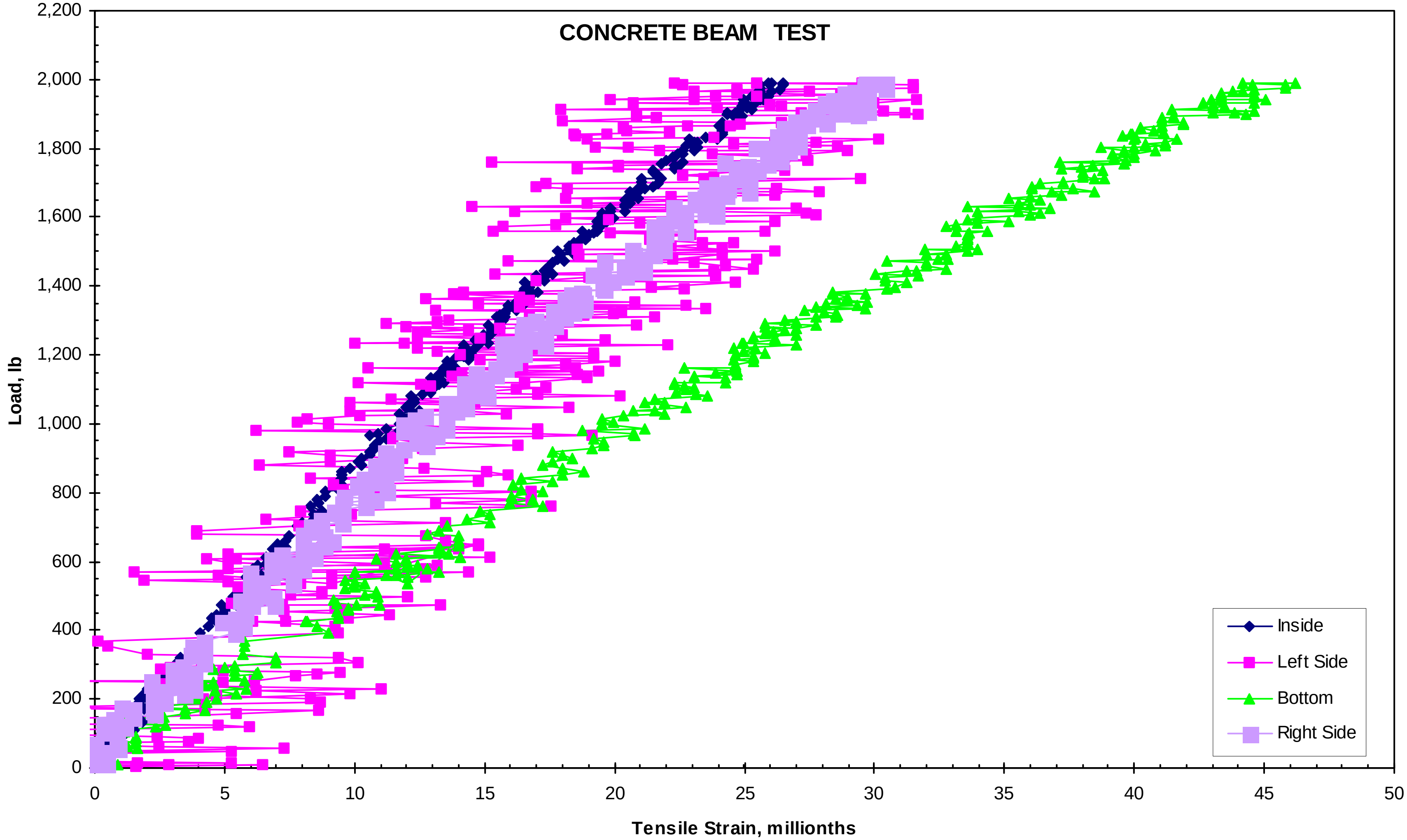

Figure 5 - Comparison of Flexural (Tensile) Strain Data

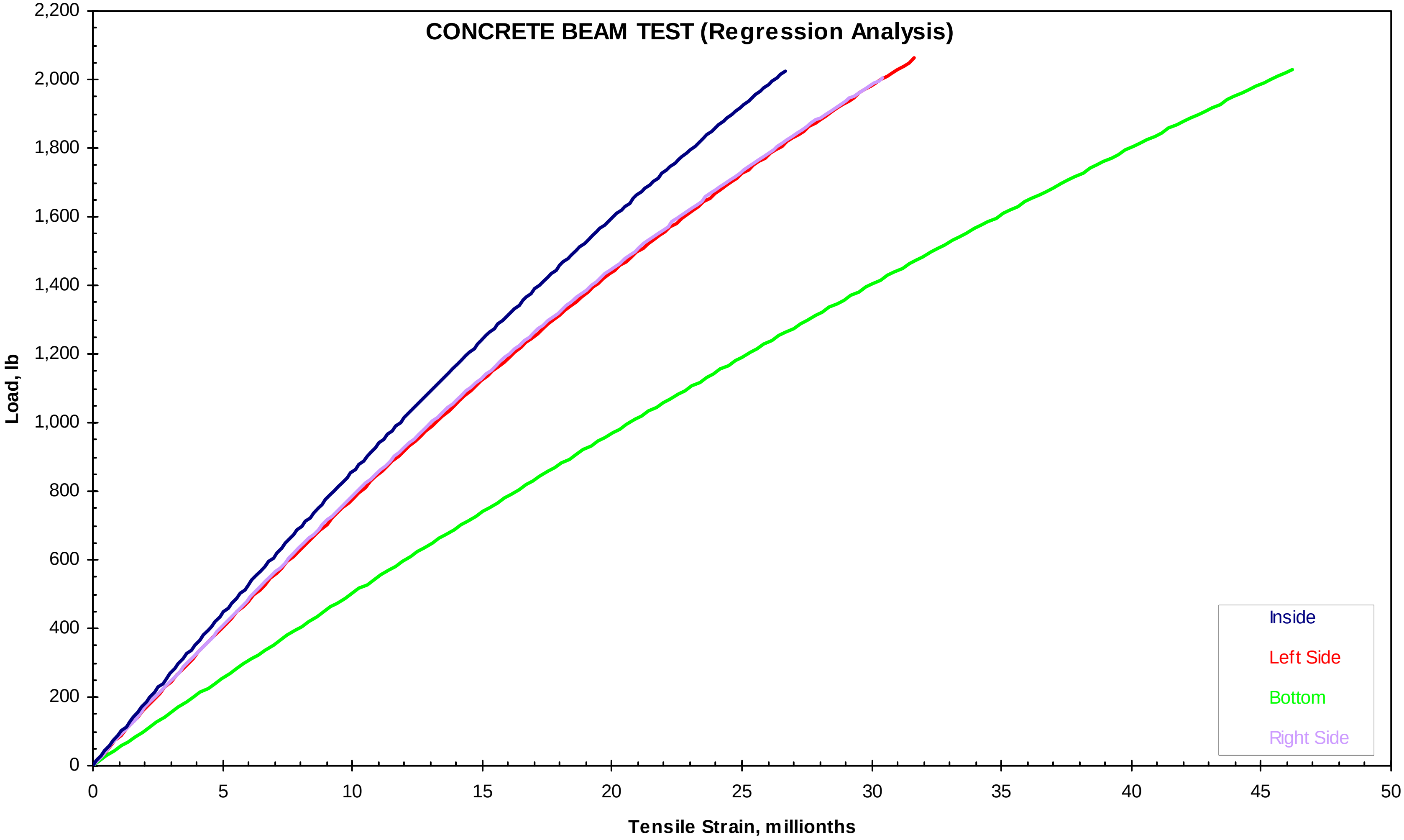

Figure 6 – Linear Regression of Strain Data from Beam Test