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Live Load Stresses in Steel Curved Girder Bridges

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Their initial curvature make steel-cured girder bridges more susceptible to lateral-torsional bucking during construction. Critical in assessing the strength and fatigue life of the bridge components, predicting stresses in the main girders and the crossframes proves more complex than in straight bridges.

In this project, researchers investigated the correlation between measured and computed results in a two-span, four-girder, continuous composite steel curved girder bridge with skew supports. A previous phase involved computing the stresses through a linear elastic grillage finite element computer project and comparing the results with a typical third-party curved girder analysis program.

The project's second phase further investigated the correlation between measured and computed stresses by running two additional live load tests on the bridge. This report summarizes research to investigate the behavior of the curved girder bridge system through all phases of construction, as well as to a series of live load field tests. In addition, researchers investigated the effects of change in temperature on the bridge behavior and tracked any changes in behavior of the bridge system over time and under service load conditions.

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LIVE LOAD STRESSES IN STEEL CURVED GIRDER BRIDGES

Final Report for Mn/DOT Project 74708

Presented to the Minnesota Department of Transportation

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EXECUTIVE SUMMARY

Because steel curved girder bridges are potentially susceptible to lateral-torsional buckling during construction due to the initial curvature of the bridge, prediction of stresses in the main girders and the crossframes is more complex than in straight bridges and is critical for assessing the strength and fatigue life of the bridge components. This research has investigated the correlation between measured and computed results in a two span, four-girder, continuous composite steel curved girder bridge having skew supports. This is the second phase of research on this bridge, the first phase culminating in 1996. In the previous research, the stresses computed by a linear elastic grillage finite element computer program, written at the University of Minnesota for this project, were first compared with a typical third-party curved girder analysis program. The two programs yielded similar results. The grillage analysis results also compared favorably to more detailed finite element results conducted at the University of Toronto (Simpson, 2000). Measured results during all phases of construction of the bridge and due to live loading on the bridge were then compared to computed results from the University of Minnesota program. Correlation was often good between the measured and computed results (Galambos et al., 1996). However, it was noted that computed results from the grillage finite element analysis were less accurate in the girder flange tips and sometimes unconservative in the crossframe members when compared to the field measurements.

The second phase of the project further investigated the correlation between measured and computed stresses through running two additional live load tests on the bridge. The role of temperature effects on the member stresses was also investigated. In addition, field tests were done to determine if service loading on the bridge may change the overall behavior of the system over time, for example due to loss of composite action in the negative moment region, which did not have shear stud connectors in this bridge. The primary goals of this research are thus to:

- Investigate the behavior of the curved girder bridge system through all phases of construction as well as to a series of live load field tests.
- Investigate the effects of change in temperature on the bridge behavior.

- Determine if the bridge system has undergone a change in behavior over time under service load conditions.

Correlation criteria were established for all comparisons to quantify the correlation between measured and computed results based on percent errors. Correlation was then classified as strong, moderate, or weak per strain gage.

Two live load tests were performed on the bridge as part of this research, one in 1997 and one in 2000, included loading with up to nine 50 kip trucks. The field tests provided good insight into the general behavior of this bridge system, both under isolated loading conditions and over the three years separating the two tests. With respect to total stress, correlation for the gages was generally strong in the midspan region of the bridge for both sets of live load tests, moderate to strong in the gages located near the middle pier of the bridge, and weak to moderate in the crossframes. When the correlations were moderate in the midspan and middle pier gage lines, it was usually due to very low stress magnitudes, resulting in the potential for higher percent errors between measured and computed data. In addition, stresses were usually overpredicted in the midspan and middle pier regions, but sometimes remained underpredicted in the crossframes.

A parametric study was conducted to investigate whether composite action likely exists in the negative moment region at service loads, even though the bridge has no shear connectors in that region. Analyses with and without composite action in the negative moment region were thus conducted for all live load cases as well as for construction stages after hardening of the concrete deck. In addition, two values of the modular ratio of the steel and concrete materials, $N=E_s/E_c$, were investigated for the analysis, including N=8, representing nominal concrete strength, and N=6, representing the actual strength of the deck concrete. The different modular ratios did not make a substantial difference, although errors tended to be lower with N=6. However, accounting for composite action in the negative moment region substantially improved the correlation between measured and computed results over the middle pier. Friction and adhesion are not considered reliable mechanisms of composite force transfer in a negative moment region absent of shear connectors, as in this bridge. However, as composite action clearly affected the bridge behavior over the middle pier, some accounting of composite action in the negative moment region during the analysis of curved girder bridges may help to insure more accurate assessment of stresses, particularly live load stresses used to assess fatigue-prone details.

While the correlation was generally good overall, it was determined that the specific measured results that had weaker correlation for total stress (dead plus live load) usually also had the high percent errors at the end of the construction (dead load) phase. It was thus believed that the largest contributing factor to the majority of the weaker correlations was the alignment of the steel superstructure, and subsequent distortion of the steel members both due to construction and during subsequent live loading. Uneven load distribution, distortion of the girders due to formwork, and the possibility that the crossframes were modeled as too stiff also complicated the analysis and may have led to the instances of weaker correlation, particularly in the crossframe members.

Temperature effects were seen to be less influential in inducing errors in correlation between measured and computed results than the initial errors introduced in the construction stages. For example, the change in stress induced by normal daily variations in temperature were seen to be less than one-third of the difference between the computed stress and the measured stress in the crossframes. While thermal effects were not negligible, they were thus not thought to be the major contributing factor to the discrepancies observed between measured and computed stresses.

The effects of time and service loads on the behavior of the bridge system seemed to be negligible, as may be expected. It did not appear that there was any significant change in composite action in the midspan or middle pier regions of the bridge, nor did the measured total stresses appear to have changed beyond reasonable amounts due to indeterminate behavior and imperfectly reproduced live load tests.

CHAPTER 1
INTRODUCTION

During construction, thin-walled curved I-shape members of a curved steel girder bridge system are potentially subject to instability problems that are not present once the bridge is completely erected and the concrete deck is hardened. In order to design the bridge efficiently for both strength and fatigue, it is necessary to have an accurate assessment of the stresses, particularly in the steel girders and crossframes, during construction and due to live loading on the bridge.

In 1994, the Minnesota Department of Transportation (Mn/DOT) funded a research project at the University of Minnesota on the behavior of curved steel I-girder bridge systems with composite decks. The project involved instrumentation and monitoring the strains and stresses in the steel superstructure of a two-span, four-girder, continuous composite steel curved I-girder bridge having skew supports (Mn/DOT Bridge No. 27998) during its entire construction process. The field measurements were then compared with results obtained and from an analysis program (termed the "UMN program") developed at the University of Minnesota specifically for the project. The UMN program was initially compared with the third-party finite element program used by Mn/DOT to analyze curved steel I-girder bridges, to insure that the two programs produced similar results. The field measurements were then compared to the UMN program.

The UMN program uses the Grillage Method of finite element analysis, based on a planar grid model that is permitted to deflect in the third dimension, to analyze this structure. One assumption associated with this method is that a two-dimensional model can reasonably approximate a three-dimensional system. The curved girder element developed for the UMN program accounts for the warping effects of the open sections and for the composite behavior of the bridge. The UMN program has the capability of modeling the detailed loading and construction sequences of the bridge. The basic assumptions of the Grillage Method used in the

UMN program and the third party analysis program are reported in Galambos et al. (1996) and Huang (1996).

Zureick et al. (1993) provide an excellent synopsis of past research on curved steel I-girder bridges leading to current American Association of State Highway and Transportation Officials (AASHTO)design provisions, including extensive work done in the 1960's, 1970's, and 1980's. Recent additional research on the subject of curved steel girder bridge systems has been conducted in several general areas: planning for further research (Grubb et al., 1993; Duwadi et al., 1994; Hall, 1996), modeling strength and serviceability limit states of curved girders (Huang et al., 1995; Davidson et al., 1996; Yoo et al., 1996; Zureick and Naqib, 1997; Lee and Yoo, 1999; Simpson, 2000; Thevendran et al., 2000; Zureick et al., 2000), modeling crossframe spacing and strength (Schelling et al., 1989; Davidson et al., 1996; South and Hahim, 2000), and developing and drafting new design specifications (Yoo et al., 1995; Hall, 1997). Much of this recent research was conducted as part of an ongoing Federal Highway Administration (FHWA) project on assessing the behavior of steel curved girder bridge systems. The research herein presents some of the first comprehensive correlations between computed results and measurements taken in the field for a curved steel I-girder bridge system.

This research was conducted in two phases. The bridge opened to traffic in September 1995, and the first phase of the project included all correlation during construction and investigation of the behavior of the bridge under controlled live load. The initial truck live loading study, conducted on October 7, 1995, involved placing two dump trucks filled with sand, weighing approximately 50 kips each, in various positions on the bridge. However, these two trucks induced only about 1 to 2 ksi in the girders and crossframes at the points of measurement. Because of this low level of stress, it was not possible to make a definitive correlation between the analysis and the field measurements for the live loading (Galambos et al., 1996). Thus, in the second phase of the research in 1997 and 2000, two additional tests were initiated using increased live loading with up to nine 50 kip trucks so that more substantial and reliable strain readings could be attained. This report outlines the results this project, which includes correlating computational results with the measured results from construction dead load as well as from both sets of increased live loading applied to the bridge and the effects of temperature on the behavior of the bridge system.

Figures A.1 through A.3 show the plan and section views for Mn/DOT Bridge No. 27998, as well as the girder and deck dimensions, and a typical set of crossframes. Figures A.4 and A.5 show views of the north and south abutment end diaphragms. Sixty *Geokon VK-4100* vibrating wire strain gages were attached to the steel superstructure of the bridge. The primary advantage of this type of gage is that it holds its zero value for a period of years. In addition, the rate of thermal expansion and contraction of the gage is approximately that of the steel to which it is attached. Consequently, changes in strain due to change in temperature are a result of indeterminate action of the bridge. Figures A.6 and A.7 show the positions and nomenclature of these gages, as well as the locations of the deflection measurements that were taken at points during the project. Figure A.9 shows the modeling of the grid system used in the UMN program. Twenty-four gages were placed along a section at the midspan of Span 1 (the south span) to determine the stresses occurring in the positive moment region of the span. These gages were labeled Gage Line A and were numbered 1A, 2A, … 24A starting with the outside facia girder and progressing to the inside facia girder. All gages were oriented along the longitudinal axis of the girder. Six gages were attached to each of the four girders to determine the stresses in the top and bottom flange regions. Four of the gages, one for each flange tip, were attached approximately 1.25 inches from the flange edge. The other two gages were attached approximately 1.5 inches away from the flange on the web, one near the top flange and the other near the bottom flange. Twenty-four gages were also placed in the negative moment region, the section over the middle pier. These gages were labeled Gage Line B and were numbered 1B through 24B in the same manner as Gage Line A. The final twelve gages were placed across a set of three crossframes located near Gage Line A. The crossframes are made up of a WT section bottom chord, a double angle top chord, and double angle X-brace diagonals. The crossframe members are welded to gusset plates, which are bolted to the transverse stiffeners in the I-girders. A gage was attached to each section, oriented along the longitudinal axis of the member, to determine the axial stress present in each of the members. These gages were labeled Gage Line

C and were numbered 1C through 12C. The gage numbering started with the top horizontal member connected to the outside facia girder and the next inside girder and proceeded down and towards the inside facia girder. Galambos et al. (1996) provides additional information regarding the data acquisition system and the gage attachment procedure.

Zero readings for the curved girders were taken after the strain gages were attached at the fabrication shop. After the girders were delivered to the job site, another set of readings was taken. The largest percent error between the two reads was 5.32% (Galambos et al., 1996), and the readings taken at the fabrication shop were used as the zero readings for all the dead load measurements made on this project. Table 1.1 lists the strain readings taken at both sites.

Readings were taken during all phases of construction of the bridge. Eight dead load measurements were identified as the key points during construction of the bridge system and used in phase two for quantitative correlation per gage. These eight dead load stages are:

- Stage 1 - Step 1-1, Span 1 (south span) girders in place
- Stage 2 - Step 1-2, During the erection of the second girder from the outer facia girder in Span 2 (north span)
- Stage 3 - Step 1-3, All girders in place and the crossframe bolts tightened
- Stage 4 - Step 2-2, Formwork in place
- Stage 5 - Step 2-3a, Deck reinforcement in place
- Stage 6 - Step 3-3a, Concrete deck pour completed (concrete wet)
- Stage 7 - Step 4-1, Parapet completed (with $N = 6$ or $N = 8$)
- Stage 8 - Step 4-2, Two inch concrete overlay poured (with $N = 6$ or $N = 8$)

After the deck was hardened and the bridge was opened for service in 1995, a live load test with two 50 kip trucks was performed. The two trucks did not induce high strains in the members and the conclusion at that time was that higher load tests were appropriate to induce larger strains.

On August 7, 1997, as part of phase two of this report, the first of two truck live loadings with increased load was applied to Mn/DOT Bridge No. 27998. As many as nine dump trucks weighing approximately 50 kips each were used (see Figures B.1 to B.9 for the dimensions and weights of each truck in 1997). A similar loading was performed on June 26, 2000, to investigate the consistency of the results (see Figures B.21 to B.29 for the dimensions and weights of each truck in 2000), and whether the stiffness of the bridge is changing appreciably over time due, for example, to a gradual partial loss of composite action from repeated service-level live loading. Eleven different truck configurations were used (Figures B.10 to B.20 show the truck locations for each case in 1997; B.30 to B.40 show the truck locations for each case in 2000). The first six cases for each year (Figures B.10 to B.15 and B.30 to B.35) consisted of placing nine trucks in three rows of three at progressive locations along the length of the bridge. Case 7 involved eight trucks, four on each span (Figure B.16 and B.36). The trucks were placed in two rows of two, approximately centered along the length of each span each year. The final four truck cases, Cases 8 through 11, used only three trucks (Figures B.17 to B.20 and B.37 to B.40). The trucks were placed in one row of three transversely across the bridge in four different locations. In the summer of 2000, the cases and loadings were duplicated with as much accuracy as was possible based on truck locations on the bridge and gross weights and dimensions of the vehicles. Both the analyses and data collected from 1997 and 2000 are compared in this report. For each of the live loading cases, the change in strain in each gage was determined, measured relative to the strains due only to dead load (self weight) on the bridge, taken at the beginning of each of the field tests. These strains were converted to stresses assuming linear elastic response (Galambos et al., 1996) and added to the dead load stresses, which were determined after the construction was completed in 1995. The stresses due only to the dead load (self weight) only were recorded in Galambos et al. (1996) and are shown in Figure 1.1.

In addition to these two field studies, a reevaluation of the correlation between the measured and computed results was undertaken for the entire construction history of the bridge. Specifically, a series of analyses was conducted in which fully composite action was assumed in both the negative and positive moment regions of the bridge, versus assuming composite action only in the positive moment region and assuming bare steel behavior in the negative moment region (termed "partially non-composite analysis" in this work). Even though this bridge has no shear connectors over the interior support, at these relatively low levels of live load, friction and adhesion may induce composite action in the negative moment region. For composite analysis, the stiffness of the reinforcing bar was included for the elements in the negative moment region. It will be seen that whether or not one includes composite action substantially changes the analysis results over the center pier in this bridge, especially near the top (tension) flange. In addition, for all analyses conducted after the concrete slab hardened, two different values of the modular ratio, $N = E_s/E_c$, were used: 6 and 8. While $N = 8$ is customarily used for analysis of composite steel bridge systems, cylinder strengths for the concrete slab ranged from 5.6 to 6.2 ksi (Galambos et al.,1996). For a concrete strength of 6.2 ksi and for a steel modulus of 29,000 ksi, the approximate modular ratio, N equals 6.46. In addition, the strength (and thus the stiffness) of the deck concrete has almost certainly increased in the years since the deck was poured. Thus, $N = 6$ was felt to be an appropriate lower bound value of N to investigate, and these are the results used for primary correlation with the measured data (Boyer and Hajjar, 1997).

Percent errors between all measured and computed results were calculated for every reading for the full construction history of the bridge. These results are presented in this report. Quantitative criteria were then established which identify whether the correlation of each of the sixty gages was strong, moderate, or weak throughout the construction history of the bridge. In order to best compare the two live load tests done in phase two of the project, the same correlation criteria were applied to the data collected in 2000 as was applied to the data collected in 1997.

As will be discussed throughout this report, in 1997 it was noted that correlation was stronger between the measured data and analyses assuming fully composite action along the length of the bridge with $N = 6$ rather than between analyses using $N = 8$ or assuming partially non-composite action. In 2000, it was also noted that the correlations for 47 of the 48 active and reliable gages remained the same as the correlations found in 1997. Analysis using $N = 8$ or assuming partially non-composite action was thus not performed for the truck loadings from 2000.

Chapter 2 contains a discussion of temperature effects and their contributions to the complexity of the analysis of curved steel girder bridge systems. Chapter 3 discusses the effectiveness of the grillage method of analysis by correlating measured results from both the 1997 truck loadings and the 2000 truck loadings with computed results based on the 1997 truck loadings. Chapter 4 investigates whether the linear behavior of the system with respect to two, three, and nine truck loadings was approximately linear. Chapter 5 provides a discussion of the results of this study. Chapter 6 presents final conclusions on this research.

Appendix A shows the views of the bridge, crossframes, gage locations, and displacement reading locations. Appendix B shows truck dimensions and case-by-case truck locations for both the 1997 live load test and the 2000 live load test. Appendix C discusses the composite analysis based on 1997 truck loadings versus the same analysis performed on the 2000 truck loadings, both with $N = 6$. This establishes that all comparisons of both 1997 and 2000 measured data may be made to analysis using 1997 truck load with little loss of insight into the behavior. Appendix D shows plots of measured versus computed stress for $N = 6$ for all dead load cases. Appendix E contains a comparison between change in stress from the analysis for $N = 6$ due to 1997 truck loading, 1997 data collected due to live loading, and 2000 data collected due to live loading. Appendix F displays plots of total stress and change in stress from analysis due to 1997 truck loading versus data collected in 1997 and 2000 for $N = 6$. Appendix F also contains plots displaying $N = 6$ composite analysis due to 2000 live loading versus the measured data from 1997 and 2000. Appendix G contains plots investigating the linearity of the measured and computed results from 1997 for $N = 6$. Appendix H provides a case-by-case discussion of change in stress observed in the gages, a gage-by-gage assessment of the correlation of total stress, and a discussion of the damaged or erratic gages.

Table 1.1 Zero Readings Taken at the Fabrication Shop and Job Sites

Gage #	Initial Strain Reading Taken at Fabrication Shop on 07/13/1995 (microstrain)	Strain Readings Taken at Construction Site (microstrain)	Zero Strain Difference (microstrain)	Percent Difference Fabrication Shop	Percent Difference Construction Site
1A	2173.6	2231.1	57.5	2.65%	2.58%
2A	1991.5	2010.0	18.5	0.93%	0.92%
3A	1957.5	1946.2	11.3	0.58%	0.58%
4A	1991.6	2027.9	36.3	1.82%	1.79%
5A	2379.4	2389.7	10.3	0.43%	0.43%
6A	1938.7	1921.1	17.6	0.91%	0.92%
7A	2193.5	2255.7	62.2	2.84%	2.76%
8A	2488.3	2537.9	49.6	1.99%	1.95%
9A	1722.8	1757.7	34.9	2.03%	1.99%
10A	2172.2	2223.3	51.1	2.35%	2.30%
11A	2431.2	2485.9	54.7	2.25%	2.20%
12A	2281.2	2298.3	17.1	0.75%	0.74%
13A	2355.8	2352.3	3.5	0.15%	0.15%
14A	2200.6	2213.7	13.1	0.60%	0.59%
15A	2239.9	2230.0	9.9	0.44%	0.44%
16A	1657.5	1648.0	9.5	0.57%	0.58%
17A	2192.5	2222.0	29.5	1.35%	1.33%
18A	1832.1	1850.8	18.7	1.02%	1.01%
19A	2426.5	2430.2	3.7	0.15%	0.15%
20A	2105.4	2155.2	49.8	2.37%	2.31%
21A	2163.0	2130.0	33.0	1.53%	1.55%
22A	1567.5	1545.7	21.8	1.39%	1.41%
23A	2476.4	2485.9	9.5	0.38%	0.38%
24A	1802.8	1796.3	6.5	0.36%	0.36%
1B	1288.5	1280.0	8.5	0.66%	0.66%
2B	1895.1	1960.5	65.4	3.45%	3.34%
3B	2144.8	2169.0	24.2	1.13%	1.12%
4B	1691.7	1781.7	90.0	5.32%	5.05%
5B	1670.3	1681.9	11.6	0.69%	0.69%
6B	2592.3	2663.4	71.1	2.74%	2.67%
7B	1440.3	1459.2	18.9	1.31%	1.30%
8B	2179.9	2194.0	14.1	0.65%	0.64%
9B	2376.0	2413.2	37.2	1.57%	1.54%
10B	2188.4	2208.6	20.2	0.92%	0.91%
11B	1910.6	1928.3	17.7	0.93%	0.92%
12B	1785.3	1861.8	76.5	4.28%	4.11%
13B	2191.4	2209.8	18.4	0.84%	0.83%
14B	2327.7	2345.7	18.0	0.77%	0.77%
15B	2605.2	2647.3	42.1	1.62%	1.59%
16B	2224.9	2257.6	32.7	1.47%	1.45%
17B	1601.8	1524.9	76.9	4.80%	5.04%
18B	2589.6	2647.5	57.9	2.24%	2.19%
19B	1658.0	1668.0	10.0	0.60%	0.60%
20B	2059.6	2075.8	16.2	0.79%	0.78%
21B	2192.3	2217.3	25.0	1.14%	1.13%
22B	2599.0	2641.5	42.5	1.64%	1.61%
23B	1643.3	1659.8	16.5	1.00%	0.99%
24B	2262.9	2326.1	63.2	2.79%	2.72%

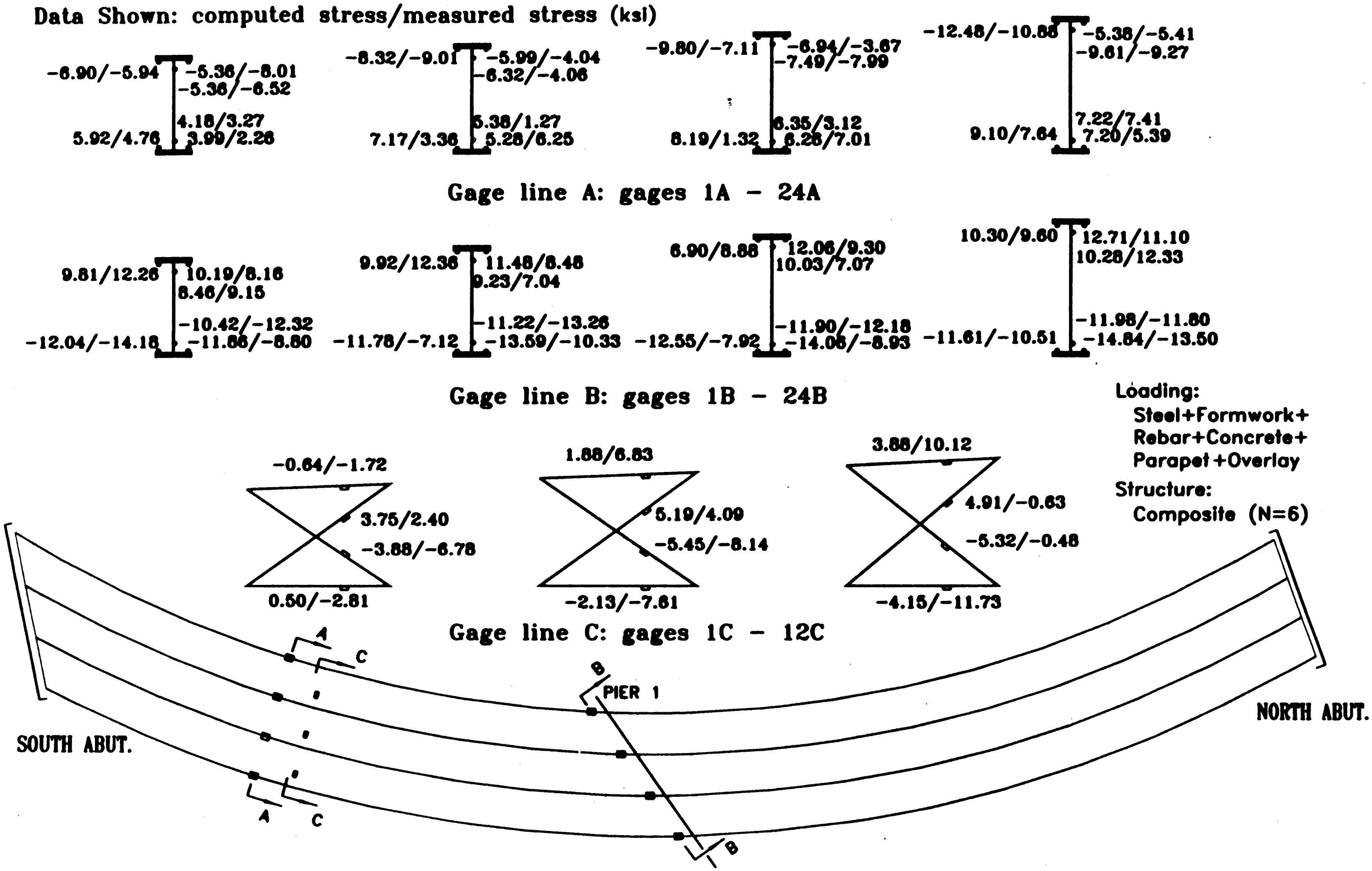


Figure 1.1: Stress Comparison at Three Gage Lines for Step 4-2 (N=6)

CHAPTER 2
TEMPERATURE EFFECTS

The initial phase of this research documented that the UMN program predicts the behavior of the curved girder bridge reasonably well with some exceptions, especially noticeable in the crossframes (Galambos et al., 1996). These differences are believed to originate primarily from the alignment of the steel superstructure and the subsequent distortion of the steel members. While these are certainly contributing factors, temperature effects may result in changes in strain in any indeterminate bridge structure. The effects of temperature on the behavior of this bridge are discussed in this chapter.

2.1 TEMPERATURE EFFECTS

In order to investigate the overall behavior of this curved girder bridge due to temperature, a series of field measurements were collected with the bridge open to traffic, but with little traffic on the bridge during the readings (Carlsson and Hajjar, 2000). The initial readings were measured approximately one year after the bridge was opened for traffic, with seven series of readings occurring over the subsequent four-year period, including three readings taken over the course of a cold day. Table 2.1 identifies the dates and the corresponding average temperatures on which field measurements were collected, ordered from hottest to coldest.

According to the manufacturer, the *Geokon VK-4100* vibrating wire strain gages have a coefficient of thermal expansion similar to the steel in the bridge of $6.3\text{x}10^{-6}/°\text{F}$ ($11.3\text{x}10^{-6}/°\text{C}$). Therefore any measured change in strain in the bridge due to indeterminate response to temperature may be accurately recorded. This fact was verified by attaching a strain gage to an unloaded steel specimen of similar material to the bridge, and subjecting it to temperature changes. Small differences were noticed (approximately 10 microstrain over a temperature shift from 32°F to 73°F (0°C to 23°C)). However, this was determined to have negligible influence on the field measurements and therefore was neglected (Carlsson and Hajjar, 2000).

The thermal coefficient of expansion of the concrete is approximately $5.5x10^{-6}$/°F ($10x10^{-6}$/°C), which results in a somewhat more rapid expansion of the steel structure as the temperature rises than in the surrounding concrete. Thus, any change in temperature will yield thermal stresses in the bridge due to the restraint of the concrete, the bridge boundary conditions, and the overall indeterminate action of the bridge.

The results from the temperature readings are shown in Figures 2.1 through 2.11. The change in strain is measured relative to the strain in each gage at 68°F (using the 8/7/97 readings), since this temperature is the approximate average temperature at which the bridge was built (particularly when the deck was poured), and is used to estimate the state at which the bridge was least affected by temperature. As noted in Appendix H, between 1997 and 2000, readings of gages 12A, 16A, possibly 18A, 1B, 12B, and 24B became inconsistent with the readings taken in 1997. Data from the readings of these gages are included in the figures, but are ignored in all conclusions in this report regarding the behavior of the bridge.

In Rudie (1997), it was shown that temperature influences the overall behavior of the bridge. As indicated in these plots, the gages in general show consistent trends of accumulating either tensile or compressive strain with a decrease in temperature due primarily to indeterminate action in the bridge. The magnitude of the change is typically on the order of 50 to 200 microstrain. However, while several of the gages do show a clear trend, others show results that indicate a negligible change in strain, or that exhibit more complex behavior by going first into tension and then into compression, or vice versa. In addition, it is difficult to characterize a clear trend of the bridge system as a whole. Figure 2.12 identifies for the gages along gage lines A and C the trends in this behavior, i.e., whether the gage generally picked up tension (T) or compression (C) as the temperature decreased. The general pattern of change in strain may indicate relative movement or rotation of the girders. For example, as indicated in Figures 2.9 to 2.11, the bottom crossframe members induced in general larger compressive strain than the top members, which indicates possible relative rotation of the girders. The middle crossframe illustrates a good example of this. The inner crossframe has similar results, however, gage 12C did not register between 10°F and 68°F and has therefore been extrapolated based on the general trend of the other two crossframes. The results in the outer crossframe are more erratic (Figure 2.9), which complicates the analysis. Nevertheless, the fact that all of the members in this crossframe induce compressive strain indicates potential relative lateral motion of Girders 1 and 2. However, a consistent pattern of behavior, incorporating clear evidence of torsion or bending in the girders, warping restraint in the flange tips, etc., cannot be synthesized from these results.

Table 2.2 illustrates the maximum estimated stress due to change in temperature in each gage. The accumulating strain build-up in the bridge due to the large temperature shift results in a maximum compressive stress of approximately 9 ksi in the bottom flange in Girder 3 at Gage Line A as well in the bottom member in the middle crossframe at Gage Line C (i.e., gage 8C). Even though these stress magnitudes may seem high, it is important to recognize that this is over relatively large temperature shifts [e.g., 75°F (40°C)]. For more reasonable day-to-day temperature shifts, these thermal stresses are much less. The concrete deck was poured between 4:45 am to 8:15 am at approximately 68°F (20°C). The largest measured temperature change during the following days was less than 18°F (10°C). Thus, the largest maximum thermal stress during pouring of the concrete (which is the largest contributor to the dead load stresses) may have only reached approximately 2 to 3 ksi in magnitude in the girders and crossframes. These thermal stresses may have potentially been locked into the structure as the concrete hardened and restrained the bridge. Thus, the temperature does influence the overall behavior of the bridge. However, temperature variations most likely do not yield thermal stresses large enough to be the primary contributing factor to the high measured stresses in the girders and the crossframes that are discussed in the following chapters.

Some factors that may have contributed to the erratic behavior in the temperature readings other than the indeterminate action on the bridge could have been the curing and creep of the concrete. Since the temperature readings were ordered from hottest to coldest and not chronologically, these contributing factors are diminished, although not eliminated.

These results indicate that some of the stresses reported throughout this project due to change in load may incorporate some small effects from indeterminate behavior due to change in temperature as well. A more in-depth discussion of the behavior of the bridge system as a whole is discussed in the next chapters.

Table 2.1: Dates and the Corresponding Average Temperatures on which Field Measurements were Collected, Ordered from Hottest to Coldest

Date	Average Temperature (Degrees Fahrenheit)
6/4/99	71.8
8/7/97	68
5/16/97	52.3
11/4/96	44.6
1/13/98	5.18
1/13/98	-2.02
1/13/98	-6.88

Table 2.2: Thermal Stresses

Gage Number	Max Difference (strain)	Stress (ksi)		Over 75 F(40 C)	Over 18 F (10 C)
1A	276.2	8.0			
2A	237.5	6.9			
3A	51.8	1.5	Max =	8.0 ksi	2.0 ksi
4A	139.8	4.1	Min =	1.5 ksi	0.4 ksi
5A	71.0	2.1			
6A	94.2	2.7			
7A	50.8	1.5			
8A	125.0	3.6		-	
9A	49.1	1.4	Max =	5.1 ksi	1.3 ksi
10A	-207.1	-6.0	Min =	-6.0 ksi	-1.5 ksi
11A	175.1	5.1			
12A	--	--			
13A	10.2	0.3			
14A	88.9	2.6			
15A	84.1	2.4	Max =	2.7 ksi	0.7 ksi
16A	--	--	Min =	0.3 ksi	0.1 ksi
17A	92.1	2.7			
18A	--	--			
19A	89.3	2.6			
20A	15.8	0.5			
21A	34.4	1.0	Max =	7.8 ksi	2.0 ksi
22A	269.8	7.8	Min =	0.5 ksi	0.1 ksi
23A	32.1	0.9			
24A	38.9	1.1			
1B	--	--			
2B	122.2	3.5			
3B	211.5	6.1	Max =	6.1 ksi	1.5 ksi
4B	119.1	3.5	Min =	0.5 ksi	0.1 ksi
5B	16.0	0.5			
6B	69.3	2.0			
7B	89.9	2.6			
8B	60.6	1.8			
9B	31.3	0.9	Max =	3.1 ksi	0.8 ksi
10B	107.2	3.1	Min =	0.9 ksi	0.2 ksi
11B	77.8	2.3			
12B	--	--			
13B	-21.4	-0.6			
14B	39.0	1.1			
15B	9.3	0.3	Max =	2.4 ksi	0.6 ksi
16B	25.9	0.8	Min =	-0.6 ksi	-0.2 ksi
17B	-5.3	-0.2			
18B	81.2	2.4			
19B	65.8	1.9			
20B	61.6	1.8			
21B	37.3	1.1	Max =	3.0 ksi	0.8 ksi
22B	78.5	2.3	Min =	1.1 ksi	0.3 ksi
23B	103.7	3.0			
24B	--	--			
1C	45.1	1.3			
2C	151.2	4.4	Max =	5.2 ksi	1.3 ksi
3C	178.6	5.2	Min =	1.3 ksi	0.3 ksi
4C	160.0	4.6			
5C	-7.3	-0.2			
6C	96.3	2.8	Max =	9.4 ksi	2.4 ksi
7C	164.7	4.8	Min =	-0.2 ksi	-0.1 ksi
8C	324.6	9.4			
9C	102.9	3.0			
10C	102.0	3.0	Max =	5.8 ksi	1.5 ksi
11C	200.9	5.8	Min =	3.0 ksi	0.7 ksi
12C	197.2	5.7			

Max= 9.4 ksi
Min = -6.0 ksi

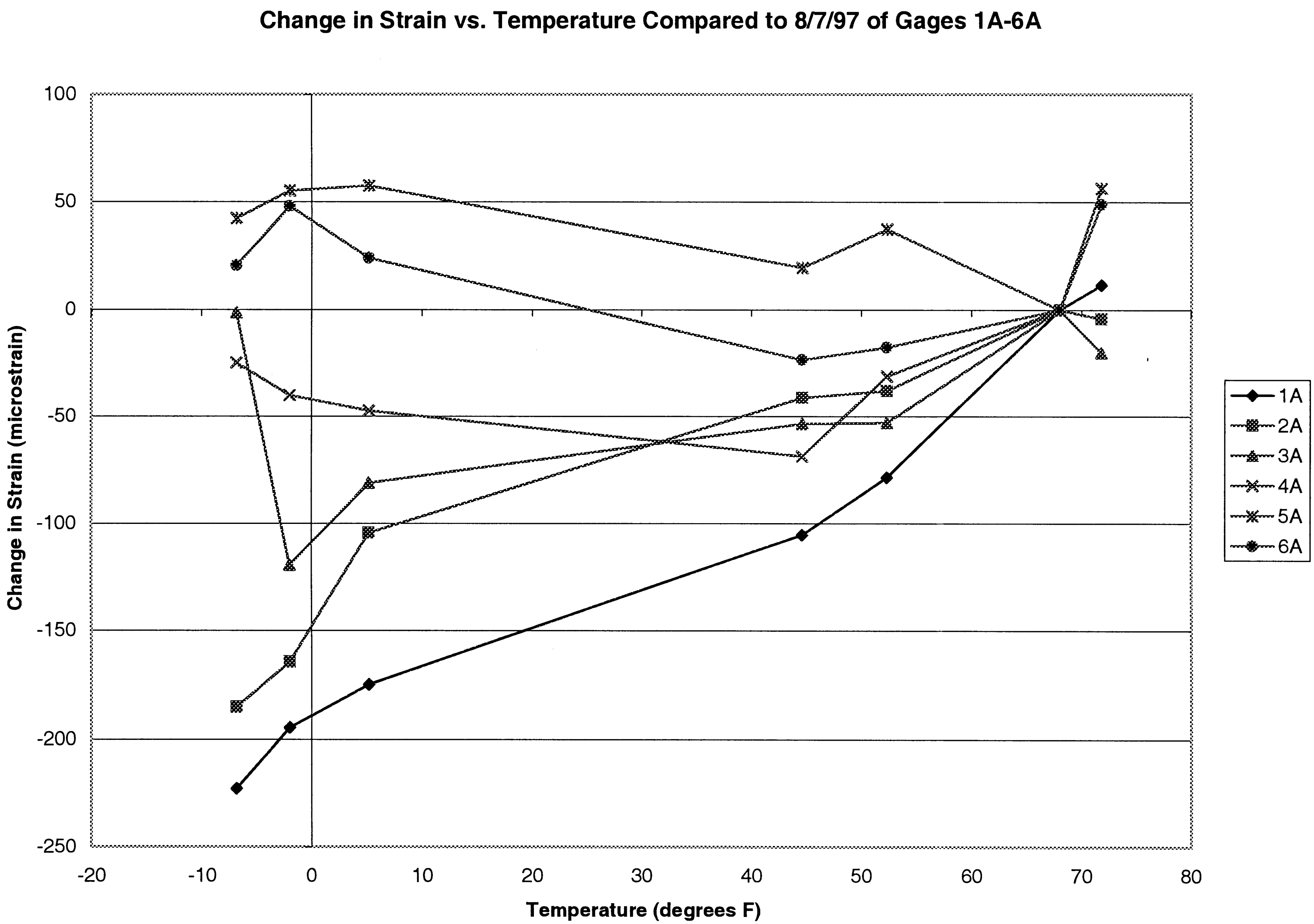


Figure 2.1: Change in Strain vs. Temperature of Gages 1A-6A

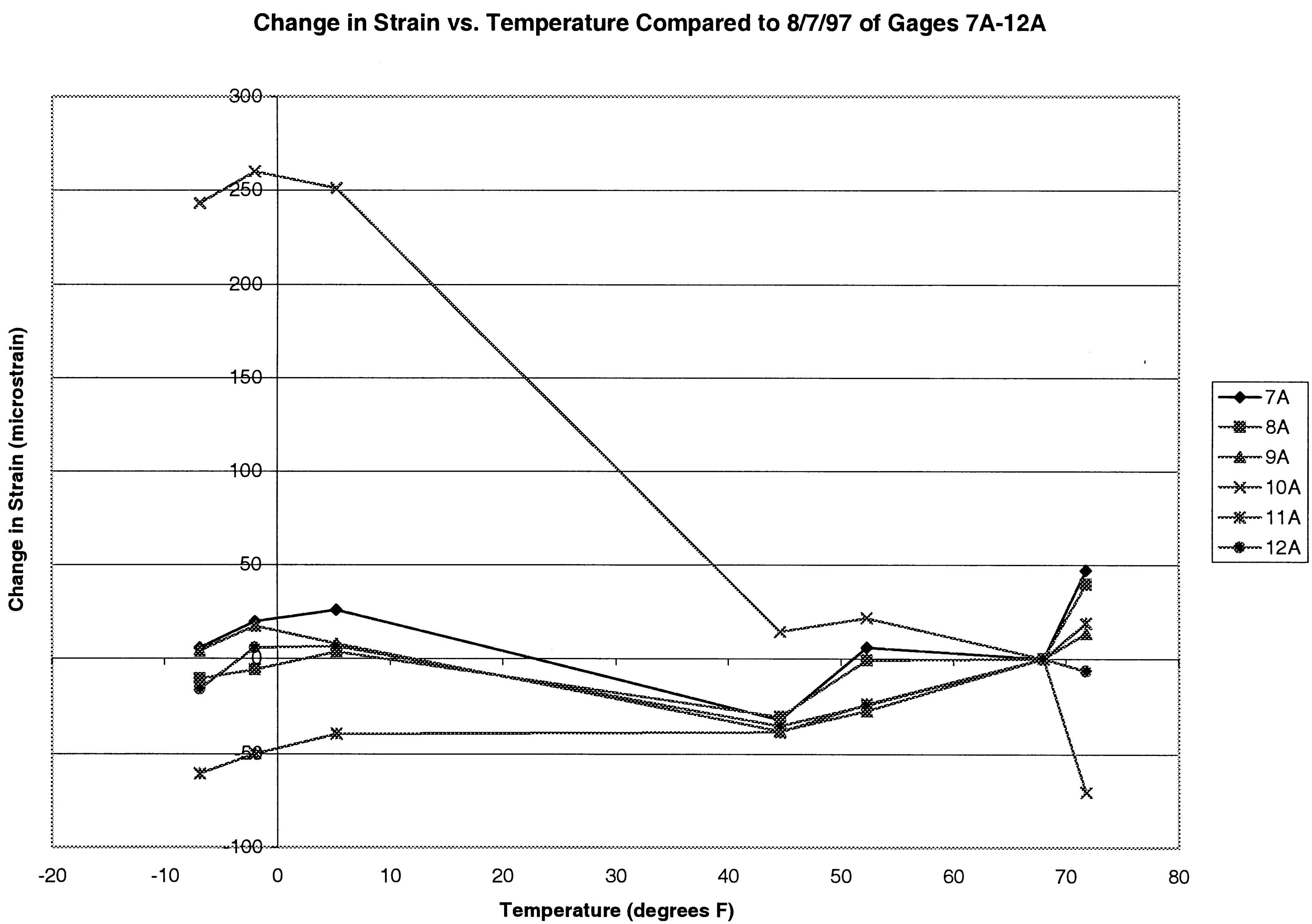


Figure 2.2: Change in Strain vs. Temperature of Gages 7A-12A

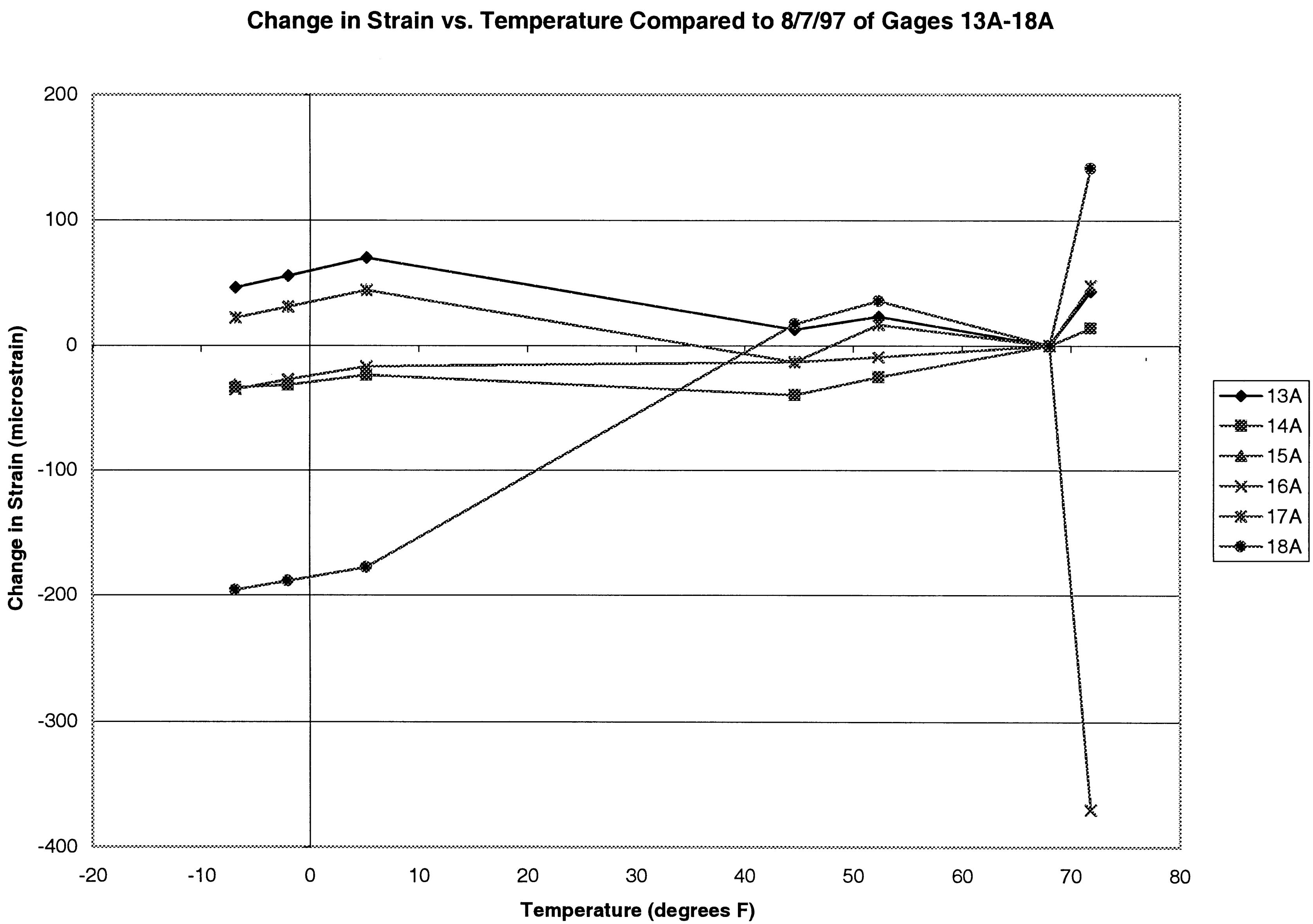


Figure 2.3: Change in Strain vs. Temperature of Gages 13A-18A

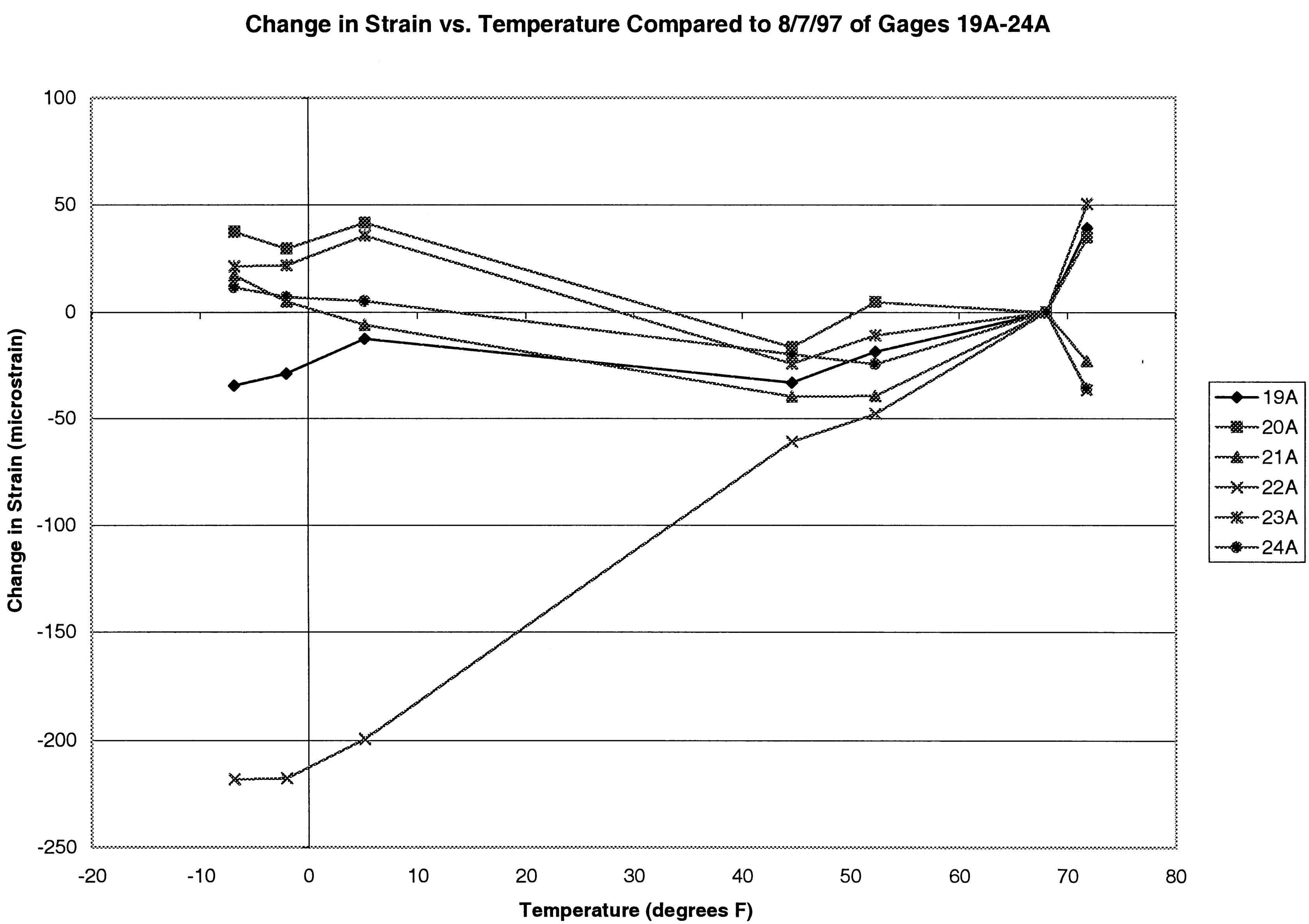


Figure 2.4: Change in Strain vs. Temperature of Gages 19A-24A

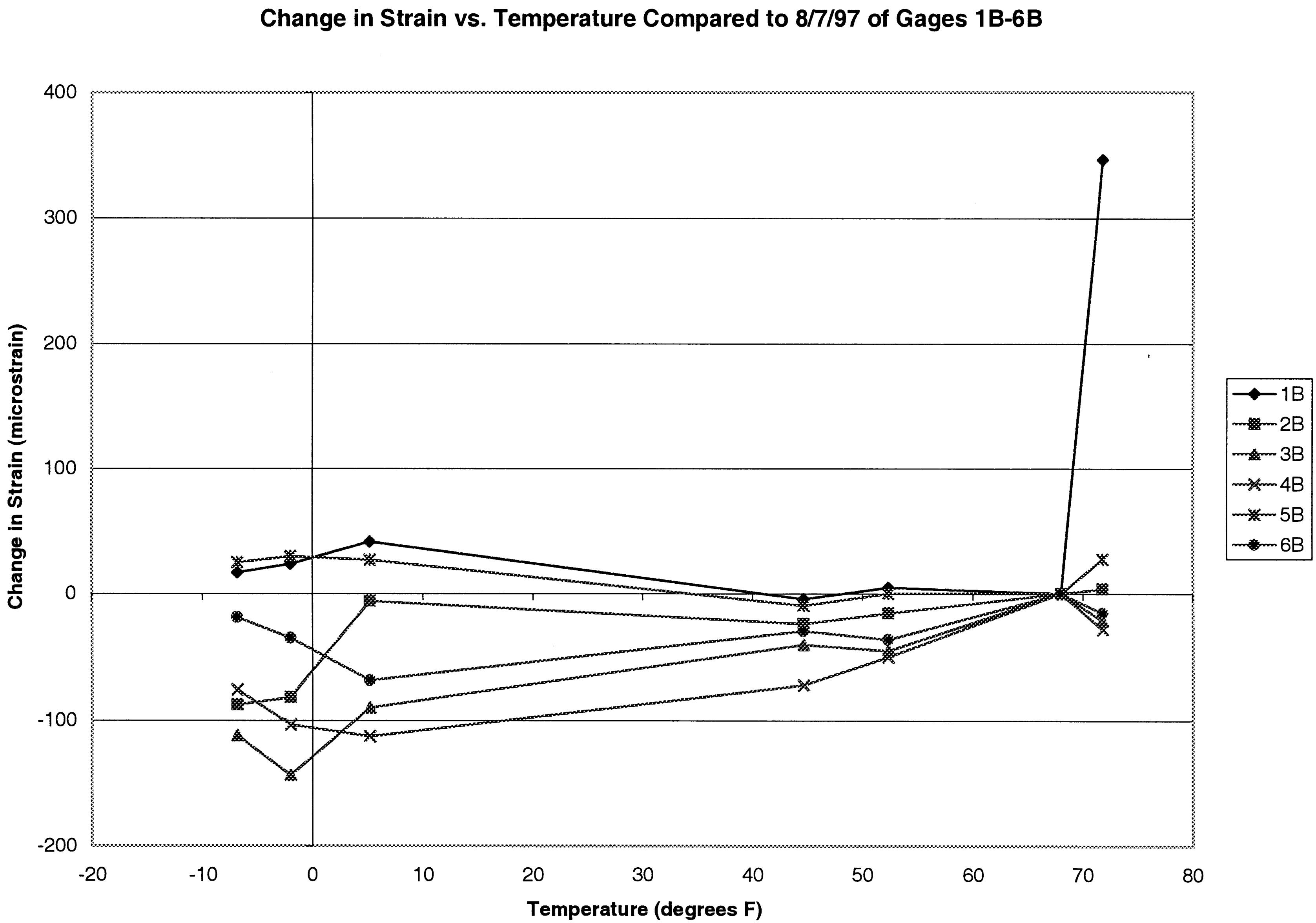


Figure 2.5: Change in Strain vs. Temperature of Gages 1B-6B

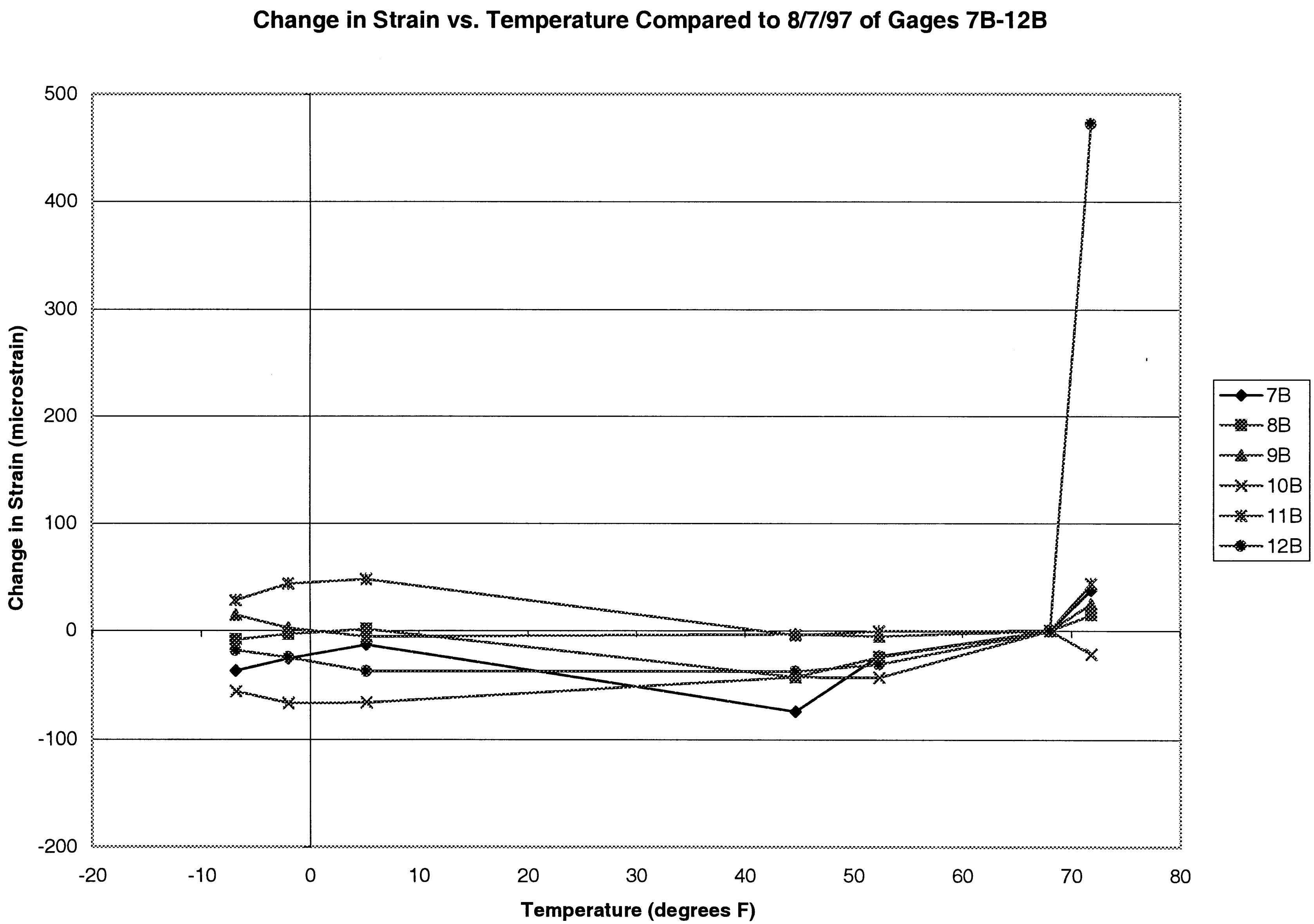


Figure 2.6: Change in Strain vs. Temperature of Gages 7B-12B

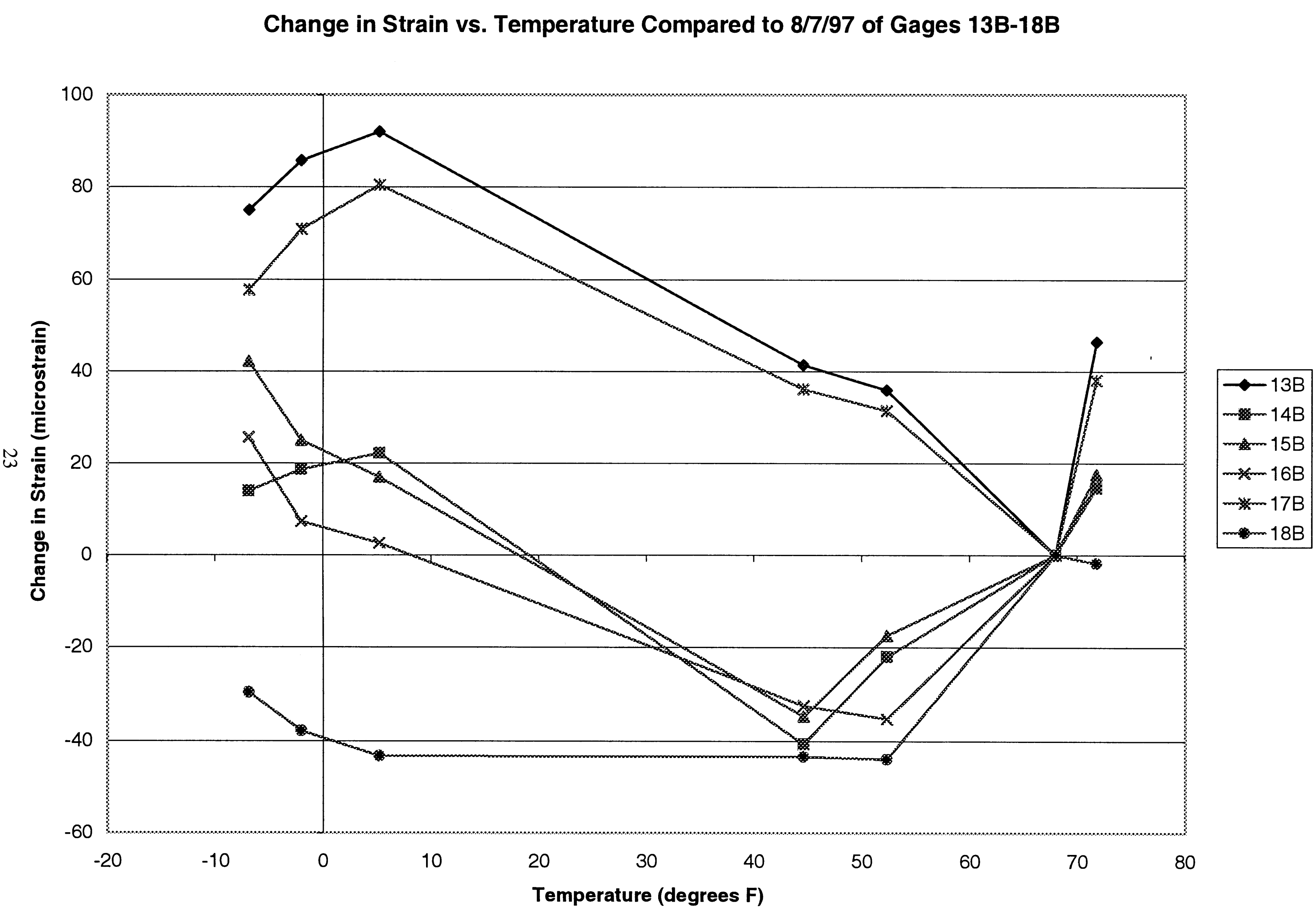


Figure 2.7: Change in Strain vs. Temperature of Gages 13B-18B

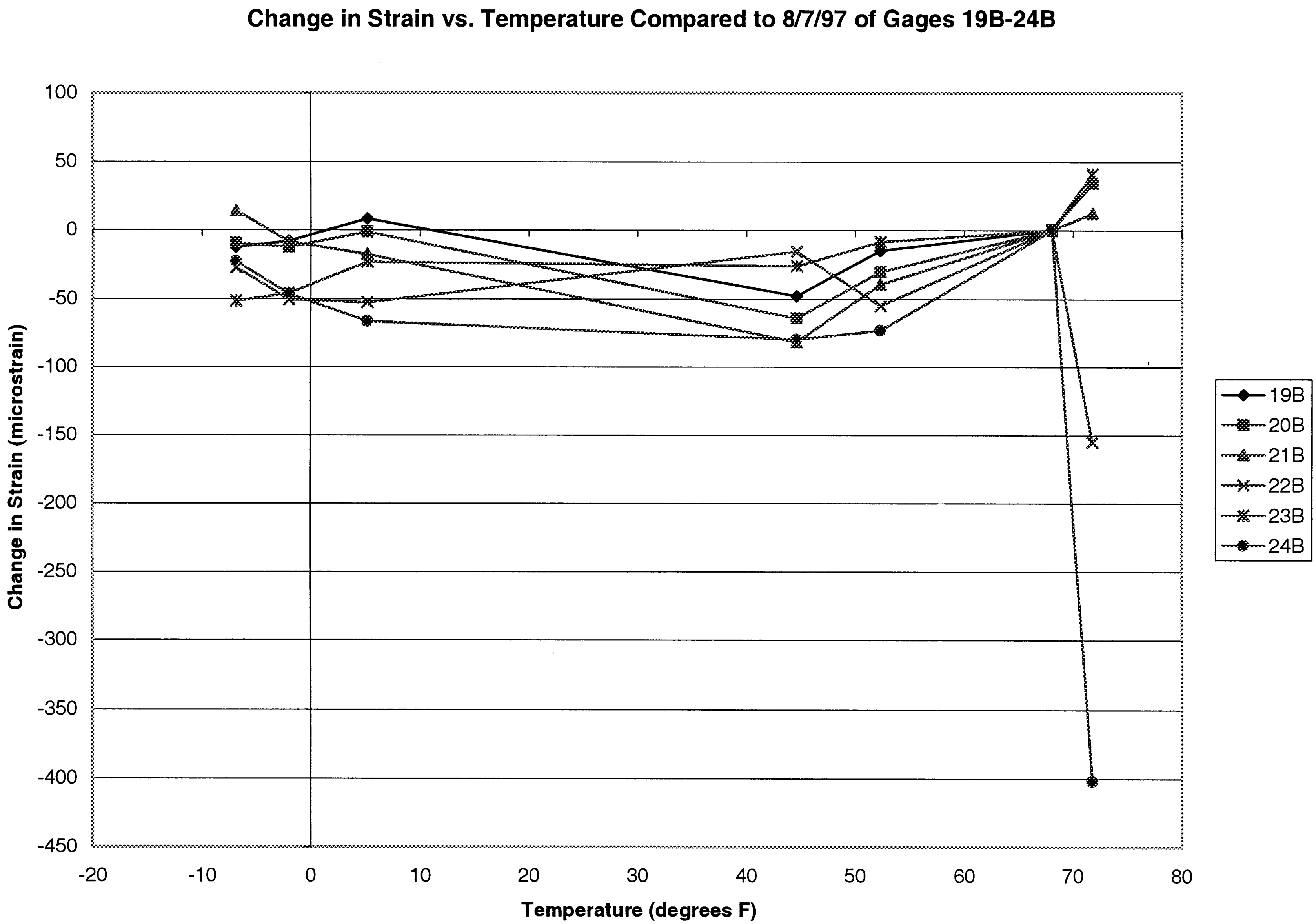


Figure 2.8: Change in Strain vs. Temperature of Gages 19B-24B

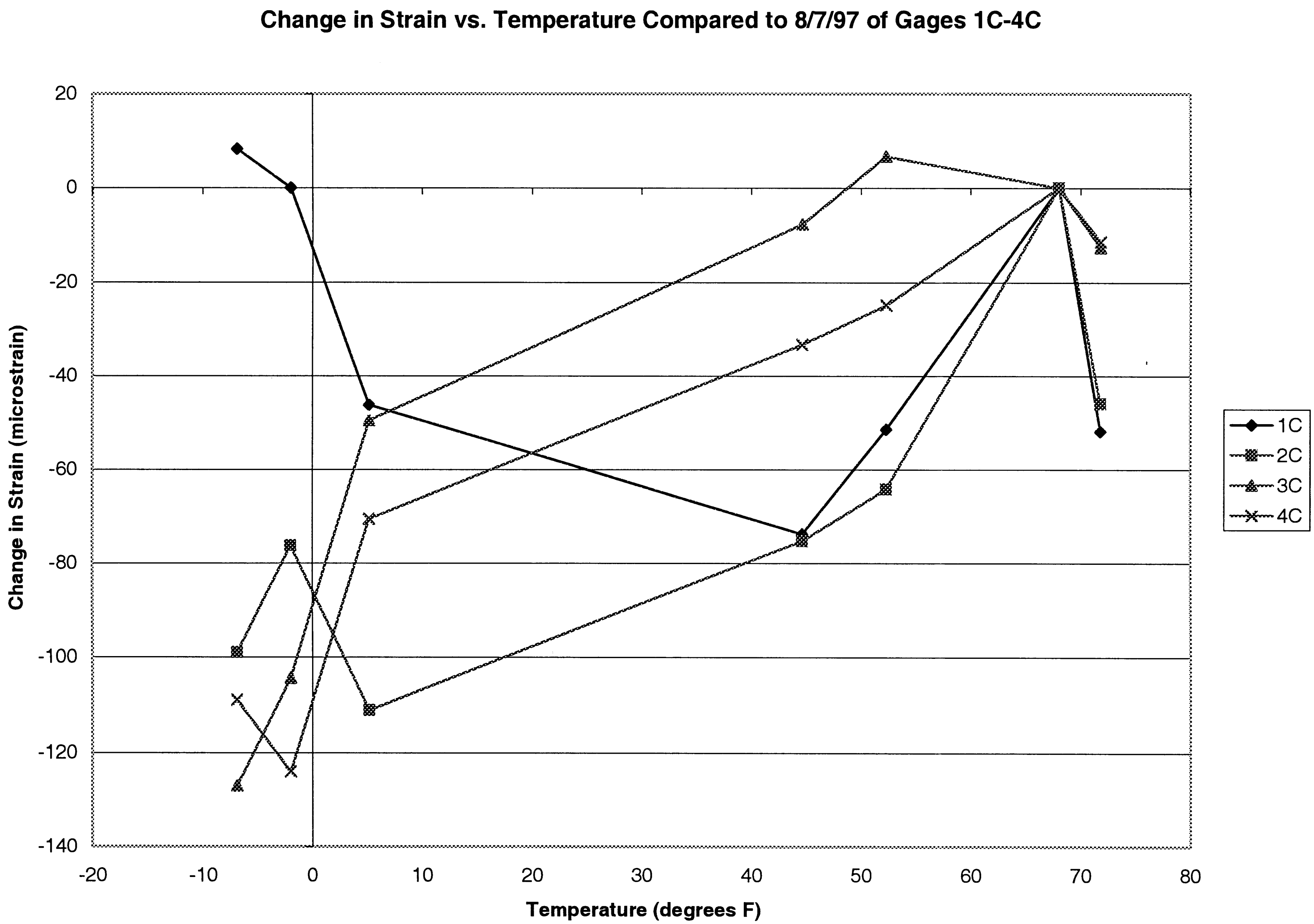


Figure 2.9: Change in Strain vs. Temperature of Gages 1C-4C

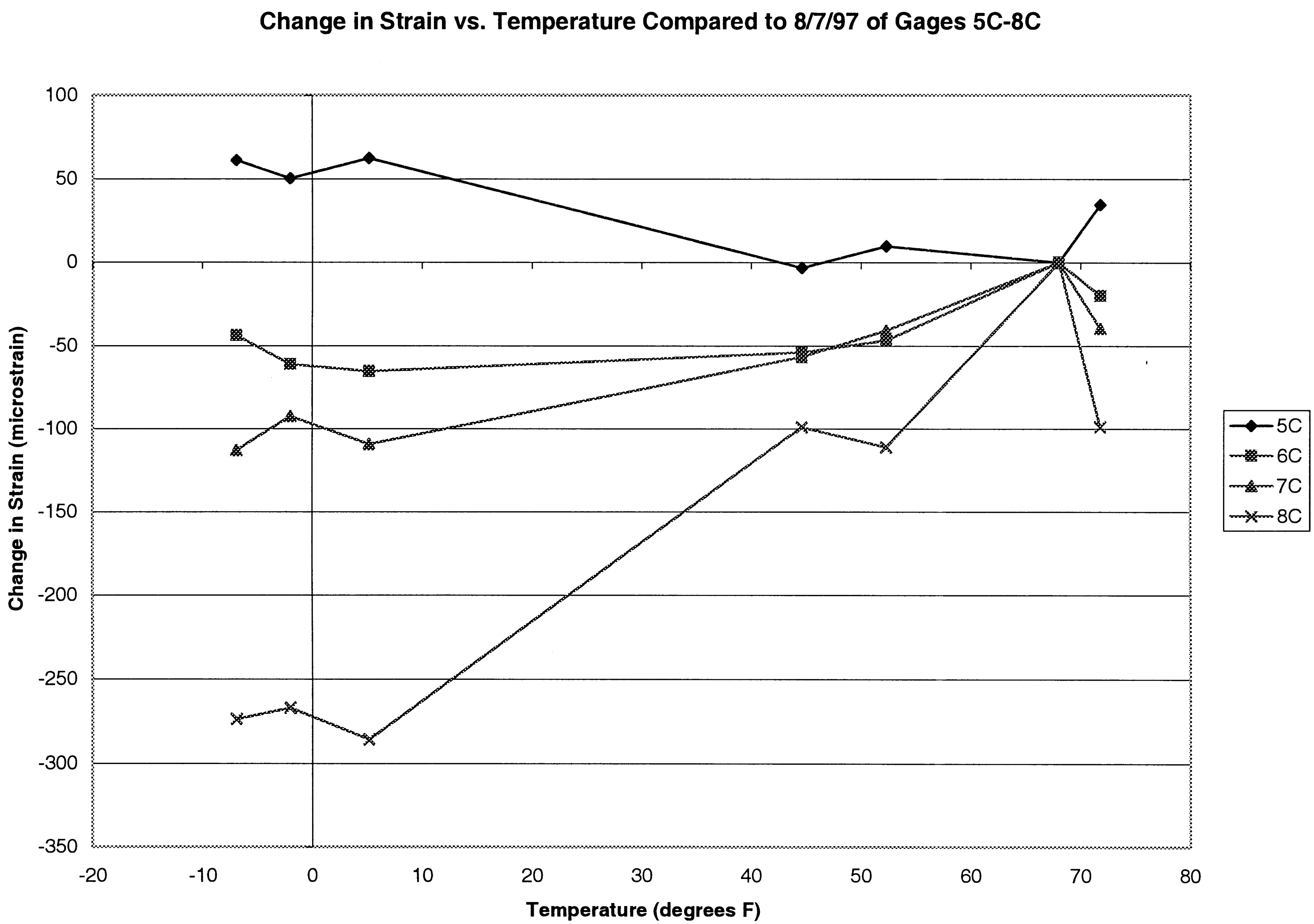


Figure 2.10: Change in Strain vs. Temperature of Gages 5C-8C

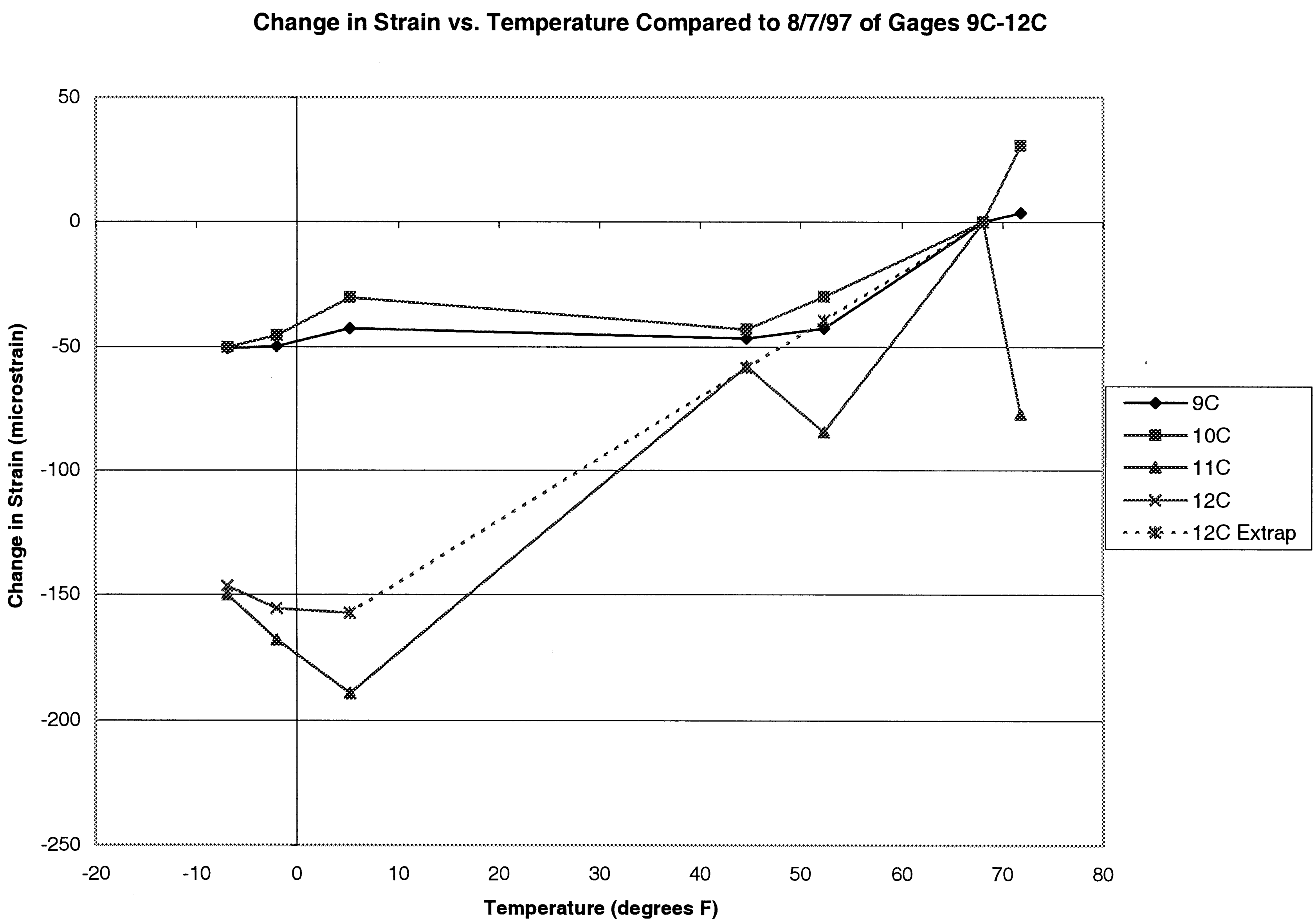


Figure 2.11: Change in Strain vs. Temperature of Gages 9C-12C

Note: T and C denote tensile and compressive stress, respectively

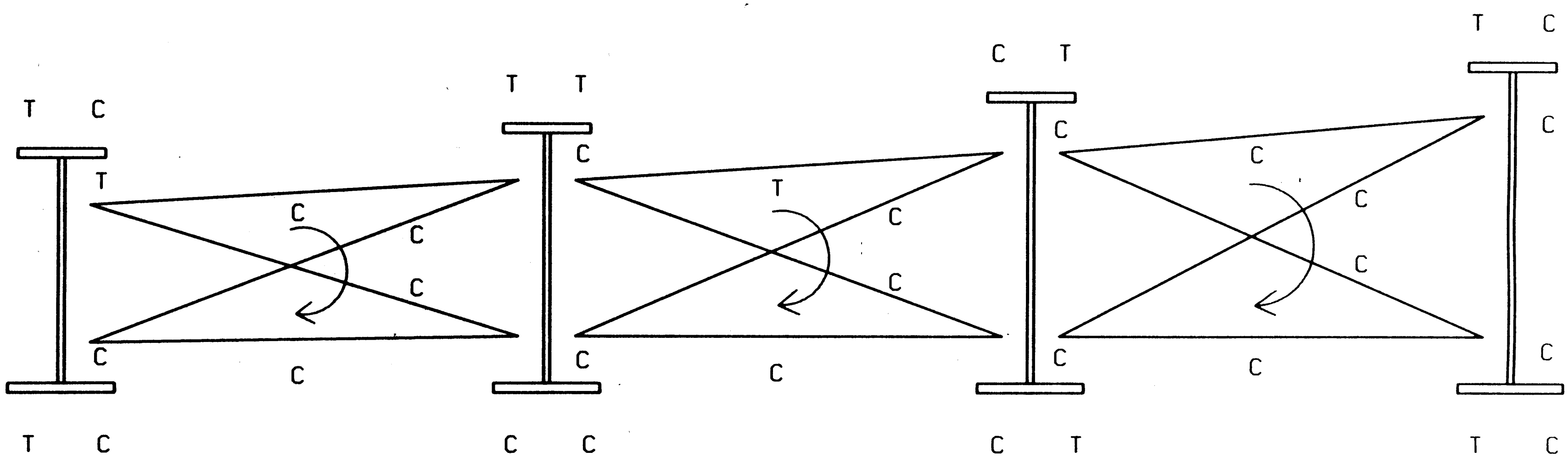


Figure 2.12: General Bridge Behavior with Decrease in Temperature

CHAPTER 3

CORRELATION OF MEASURED AND COMPUTED RESULTS

This chapter reports the correlation of measured and computed results, both during construction and due to live loading on the bridge. Correlation due to dead load is discussed first, followed by correlation due to live load.

In addition to the analyses of the curved girder bridge with the UM program, a three-dimensional finite element model (termed the "FE program" herein) of this bridge was developed and analyzed at the University of Toronto (Simpson, 2000). Four-node shell elements were utilized to model the girders, whereas the crossframe members were modeled using three-dimensional truss elements. The predicted stresses of the FE model during two construction stages are included here for comparison. Figures 3.1 through 3.6 shows a comparison between stresses for self weight of the bare steel structure (no formwork or deck) and at the completion of the placement of the wet concrete obtained from the field measurements, FE program, and the UMN program. The predicted behavior of the bridge during each individual construction stage, as well as under live loading, compared very well between the two models, which further confirms the validity of the UM program for this curved girder bridge.

3.1 CORRELATION OF MEASURED AND COMPUTED STRESSES DUE TO DEAD LOAD

To understand and accurately analyze the behavior predicted by each gage, an evaluation of the measured stresses for the entire construction history of the bridge was made based on analyses using composite action (after hardening of the deck) throughout the entire bridge, and also on analyses assuming only the bare steel bridge system acts over the center support (with composite action occurring everywhere else). Graphs of how each gage compared to the different analyses during construction can be seen in Figures D.1 to D.11 (for $N = 6$). In the figures, the measured results are shown with dashed lines, and the analysis results are shown with solid lines (throughout this report the legend "-c" refers to results assuming fully composite action over the center pier; the legend "-nc" refers to results assuming that only the bare steel structure acts over the center pier, with composite action retained in the positive moment region). The stages of construction that are plotted on the horizontal axis were itemized as stages 1 through 8 in Chapter 1.

It may be seen in the gage-by-gage evaluation in Appendix H that how each gage compared with the dead load analysis often greatly affects how the gage compared with the total stresses including live load. This effect carried through to the comparison of the 2000 measured live load data with 1997 and 2000 analysis. Even though predicting the behavior of the bare steel bridge does not involve inaccuracies based upon modeling of the composite behavior, larger percent errors often occurred in these earlier stages of construction. The stresses were generally low due to self-weight, and fit-up stresses or local anomalies in loading often dominated the behavior of certain gages. Any differences between measured and computed results for the bridge self weight sometimes then carried over to the comparisons of total stress in the gages once live loading was applied. This trend is common among many of the gages, and it warrants careful consideration of the correlation to dead load stresses during construction, versus due to live load stresses on the composite bridge. General conclusions about the correlation of the measured and computed results for dead load will be made in Chapter 5.

3.2 CORRELATION OF MEASURED AND COMPUTED STRESSES DUE TO LIVE LOAD

As part of phase two of this research two sets of live load readings were taken three years apart, in 1997 and 2000, in part to permit evaluation of whether changes were occurring in the bridge over time that affect live load response.

Over the course of this study, nine gages of the original sixty either stopped providing data, or began giving readings that are of questionable reliability. These gages are summarized in the next section.

3.2.1 GAGE BY GAGE DISCUSSION OF GAGES SHOWING ERRATIC BEHAVIOR

Gage 11B was damaged while being lifted during construction. Gage 1A was damaged when cantilever supports for the formwork was placed. Both were replaced during construction [see Galambos et al. (1996) for details of this replacement].

Three gages: 4A, 15A and 12C no longer provide data. Gage 12C was a dead gage during the 1997 live load tests, but 4A and 15A failed at some point between 1997 and 2000.

Six gages: 12A, 16A, 18A, 1B, 12B, and 24B began giving erratic readings at various times between 1997 and 2000. There is no consistent trend in the changes in readings of these gages. Three gages are in the positive moment region, and three in the negative moment region. Four of the gages were in tension in 1997, and two of those showed a significant increase in tension over the course of three years, while two showed a significant increase in compression. Of the two gages that were in compression in 1997, one picked up tension and the other compression.

All of the gages that began giving erratic readings between 1997 and 2000 are located near the flange tips, but all are on different girders (except for gages 16A and 18A). The only top flange gage is 1B, which is located in the negative moment region. Over the course of three years, multiple readings were taken with self weight on the bridge (see Chapter 2). The stress generally accumulated over the three years, but was not linear with time or temperature. The total stress accumulation did not occur between any two of the measurement dates, but rather was measured between multiple dates over the course of the study. There are no definable trends established by this data, except that all the gages are located near flange tips. Appendix H describes the specific shifts in strain seen for each of these six gages.

One possible explanation is that individual tack welds on each gage have failed over the course of time, and each gage had in effect re-zeroed itself after each weld failure. This hypothesis is supported by the fact that truck live loading in 2000 induced similar changes in the stresses as the 1997 live load test for the gages in question. However, it was not possible to verify this hypothesis definitively. Whether the readings taken in 1997 and 2000 agree or are similar does not alter the fact that any data collected from these gages is suspect, and this should be accounted for in the conclusions drawn from the data from these six gages.

3.2.2 CORRELATION OF 1997 AND 2000 LIVE LOAD MESUREMENTS TO COMPUTED RESULTS

Figures E.1 to E.30 compare the measured change in stress due to truck loading in both 1997 and 2000 to analysis results using the truck loading from 1997. In general, the measured change in stress magnitudes from 1997 and 2000 were qualitatively similar and agreed in sign. Individual cases vary with respect to their degree of similarity, but on the whole, the tendency was toward similarity rather than disparity between the two live load tests. Because the 2000 truck weights and locations could not be exactly reproduced from 1997, some discrepancy is understandable. Even though the total truck weight used in 2000 was heavier than that used in 1997, not all stresses measured in 2000 were larger in magnitude than those measured in 1997 were. A detailed assessment of each case is given in Appendix H.

Figures F.1 to F.88 (plotted for $N = 6$) include the graphs for the total stress and the change in stress (from the unloaded bridge) for each gage as either nine trucks or three trucks moved across the length of the bridge for both the 1997 and 2000 truck loadings compared to 1997 analysis results, including both composite and partially non-composite analysis. Figures F.89 to F.132 compare the same measured results to the 2000 analysis results assuming composite action and $N = 6$ throughout the length of the bridge. Appendix C discusses the appropriateness of comparing the 2000 measured data to analysis assuming loading based on the 1997 trucks.

In Appendix F are eight sets of the plots, as follows:

- Nine trucks, composite and partially non-composite analysis with $N = 6$, total stress versus 1997 analysis (Figures F.1 to F.22)
- Nine trucks, composite and partially non-composite analysis with $N = 6$, change in stress versus 1997 analysis (Figures F.23 to F.44)
- Three trucks, composite and partially non-composite analysis with $N = 6$, total stress versus 1997 analysis (Figures F.45 to F.66)
- Three trucks, composite and partially non-composite analysis with $N = 6$, change in stress versus 1997 analysis (Figures F.67 to F.88)
- Nine trucks, composite analysis with $N = 6$, total stress versus 2000 analysis (Figures F.89 to F.99)
- Nine trucks, composite analysis with $N = 6$, change in stress versus 2000 analysis (Figures F.100 to F.110)
- Three trucks, composite analysis with $N = 6$, total stress versus 2000 analysis (Figures F.111 to F.121)
- Three trucks, composite analysis with $N = 6$, change in stress versus 2000 analysis (Figures F.122 to F.132)

Zero readings were taken at the beginning and the end of the nights of the tests in both 1997 and 2000 while there were no trucks loading the bridge. For the readings taken in each year the differences were less than 2 percent. As a result the first reading was used as the zero reading for the night.

To obtain the total stress, the stress obtained from each truck loading case was added to the stress obtained from Step 4-2 (see Section 3.1). Assuming that temperature changes over the course of the test date are low, by using the stress obtained in Step 4-2 and adding the change in stress measured during the live load cases, thermal effects are minimized when comparing data collected at different dates. General conclusions about the correlation of the measured and computed results for live loading are made in Chapters 4 and 5.

Deflections were recorded in 1997 during the six nine truck cases using a surveying level at the locations shown in Figure A.9. Table 3.1 shows the measured deflections versus deflections calculated by linear analysis. Calculated deflections generally underpredicted the magnitudes of displacements, but most calculated displacements were on the same order of magnitude as measured displacements. All deflections recorded were within the design limitations for the bridge.

Table 3.1: Comparison of Measured and Computed Deflections for the 1997 Nine Truck Loading (Fully Composite Analysis, N = 6)

Deflections (inches) on Span 1 (South) for Nine trucks, N = 6, Fully Composite Analysis, N = 6, Measured/Computed						
Loading	**Case 1**	**Case2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
MNDoT Beam 1/ UMN Girder 4	-0.876/-0.600	-0.720/-0.410	-0.348/-.0122	0.012/0.069	0.168/0.136	0.156/0.121
MNDoT Beam 2/ UMN Girder 3	-0.948/-0.697	-0.948/-0.529	-0.468/-0.191	0.012/0.082	0.176/0.208	0.348/0.201
MNDoT Beam 3/ UMN Girder 2	-1.134/-0.962	-1.146/-0.826	-0.630/-0.349	0.030/0.123	0.486/0.383	0.522/0.388
MNDoT Beam 4/ UMN Girder 1	-1.320/-1.030	-1.308/-0.925	-0.732/-0.425	-0.024/0.128	0.528/0.462	0.612/0.480
Deflections (inches) on Span 2 (North) for Nine trucks, N = 6, Fully Composite Analysis, N = 6, Measured/Computed						
MNDoT Beam 1/ UMN Girder 4	0.372/0.250	0.348/0.239	0.324/-0.050	-0.312/0.579	-0.840/-1.110	-1.152/-1.220
MNDoT Beam 2/ UMN Girder 3	0.492/0.382	0.456/0.384	0.300/-0.058	-0.300/-0.563	-0.972/-1.180	-1.140/-1.310
MNDoT Beam 3/ UMN Girder 2	0.708/0.508	0.552/0.524	0.468/0.163	-0.012/-0.542	-1.020/-1.230	-1.176/-1.400
MNDoT Beam 4/ UMN Girder 1	0.714/0.632	0.618/0.659	0.366/0.262	-0.270/-0.529	-1.074/-1.290	-1.314/-1.490

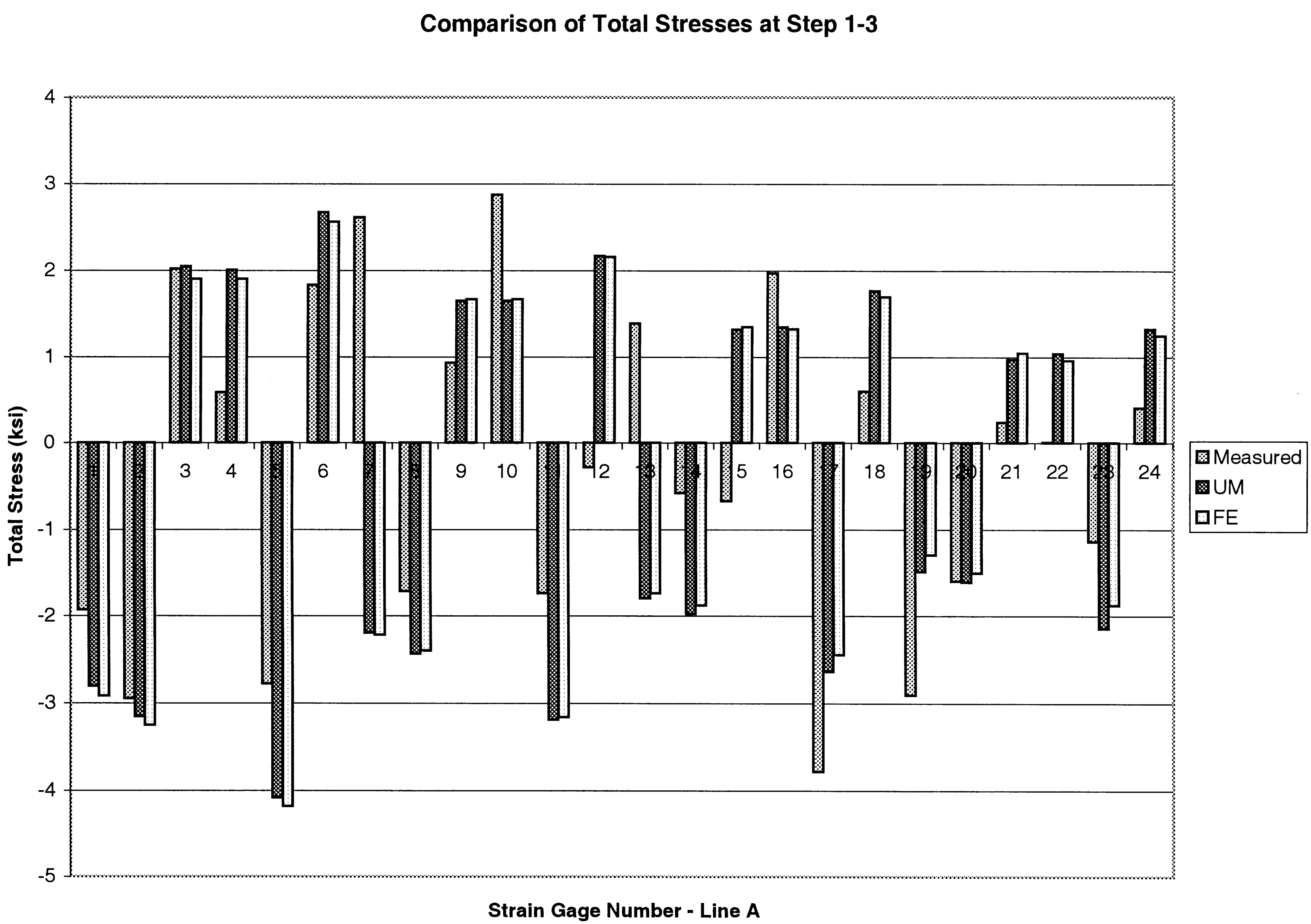


Figure 3.1: Comparison of Total Stresses at Step 1-3 [after (Simpson, 2000)]

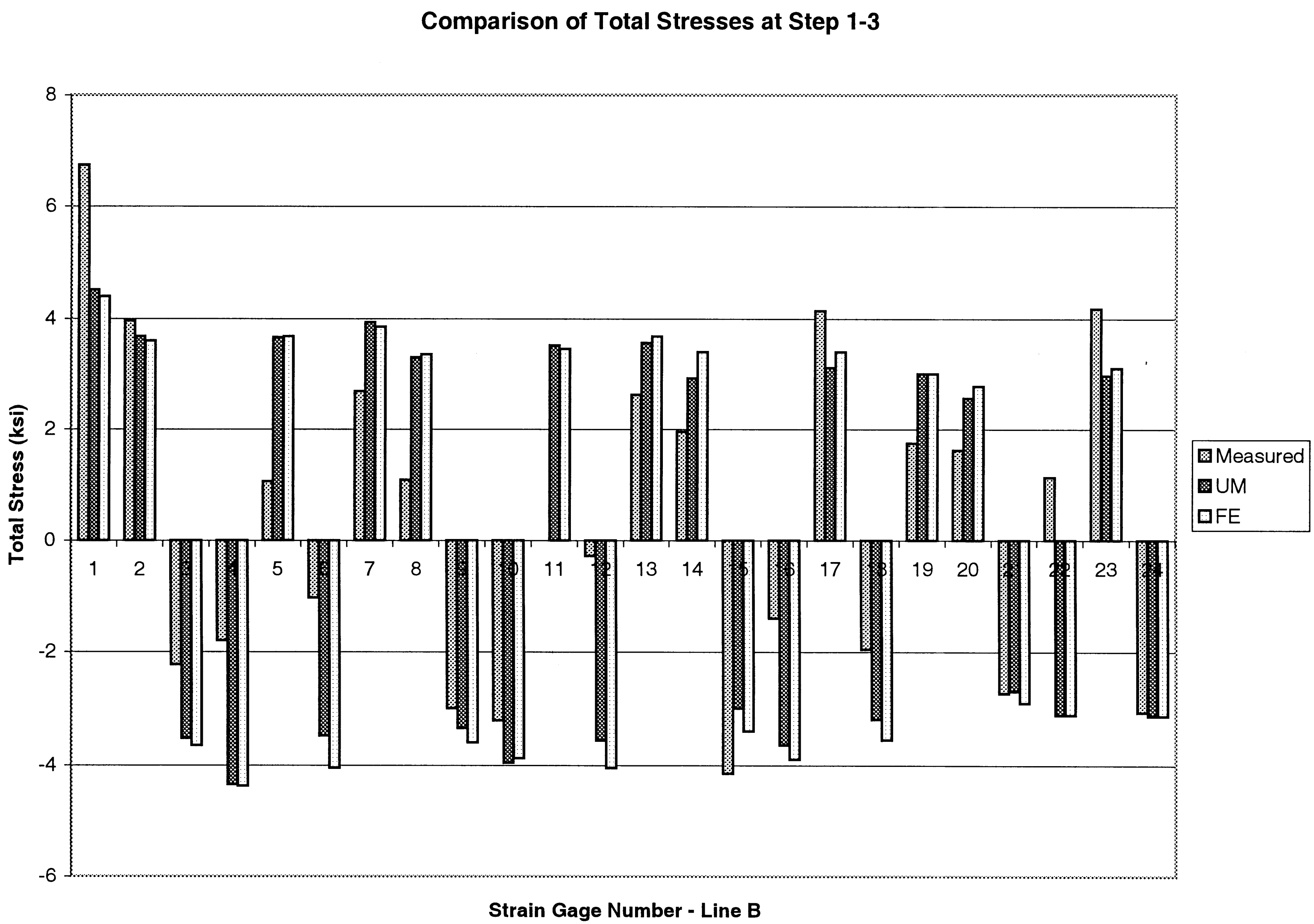


Figure 3.2: Comparison of Total Stresses at Step 1-3 [after (Simpson, 2000)]

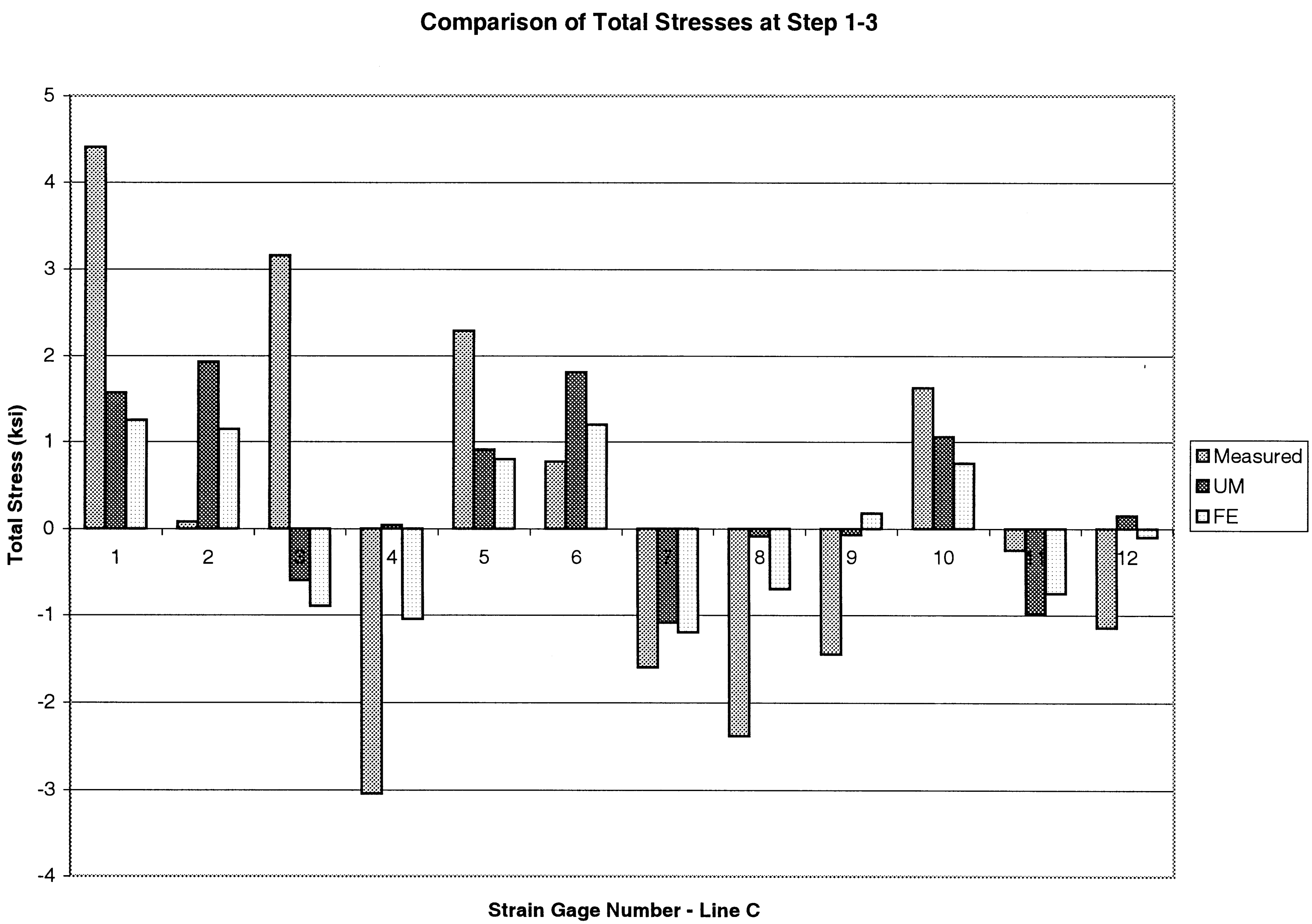


Figure 3.3: Comparison of Total Stresses at Step 1-3 [after (Simpson, 2000)]

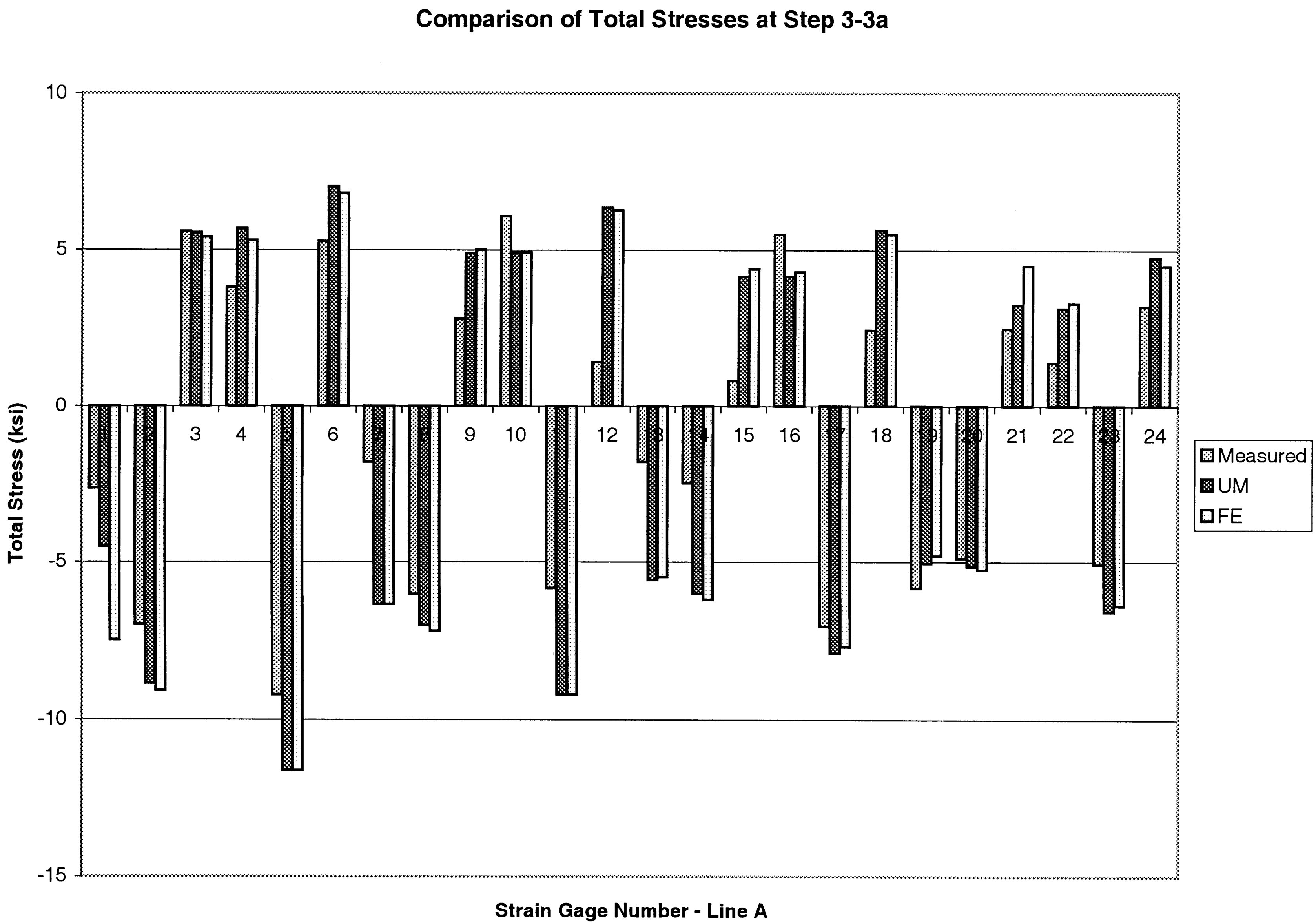


Figure 3.4: Comparison of Total Stresses at Step 3-3a [after (Simpson, 2000)]

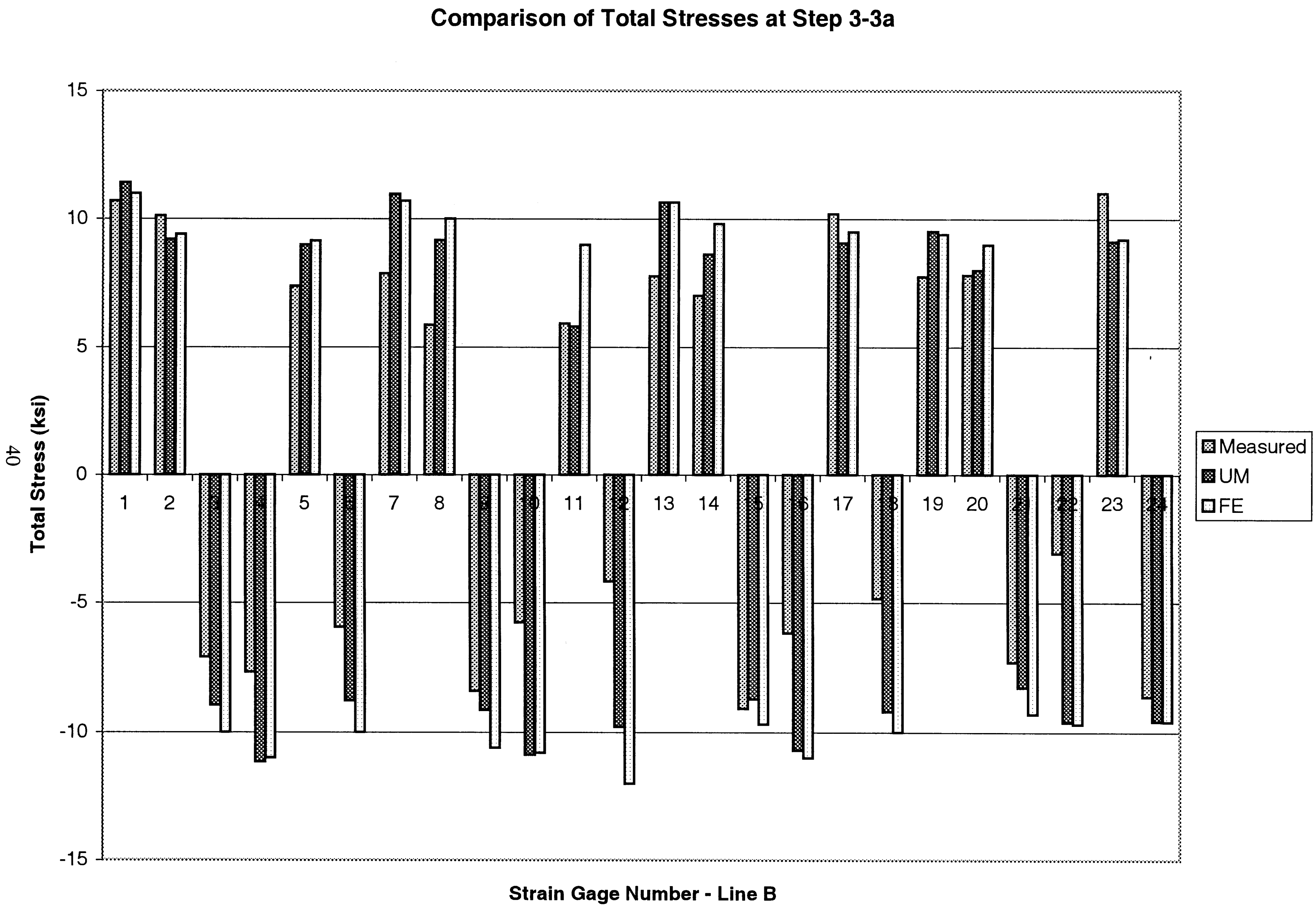


Figure 3.5: Comparison of Total Stresses at Step 3-3a [after (Simpson, 2000)]

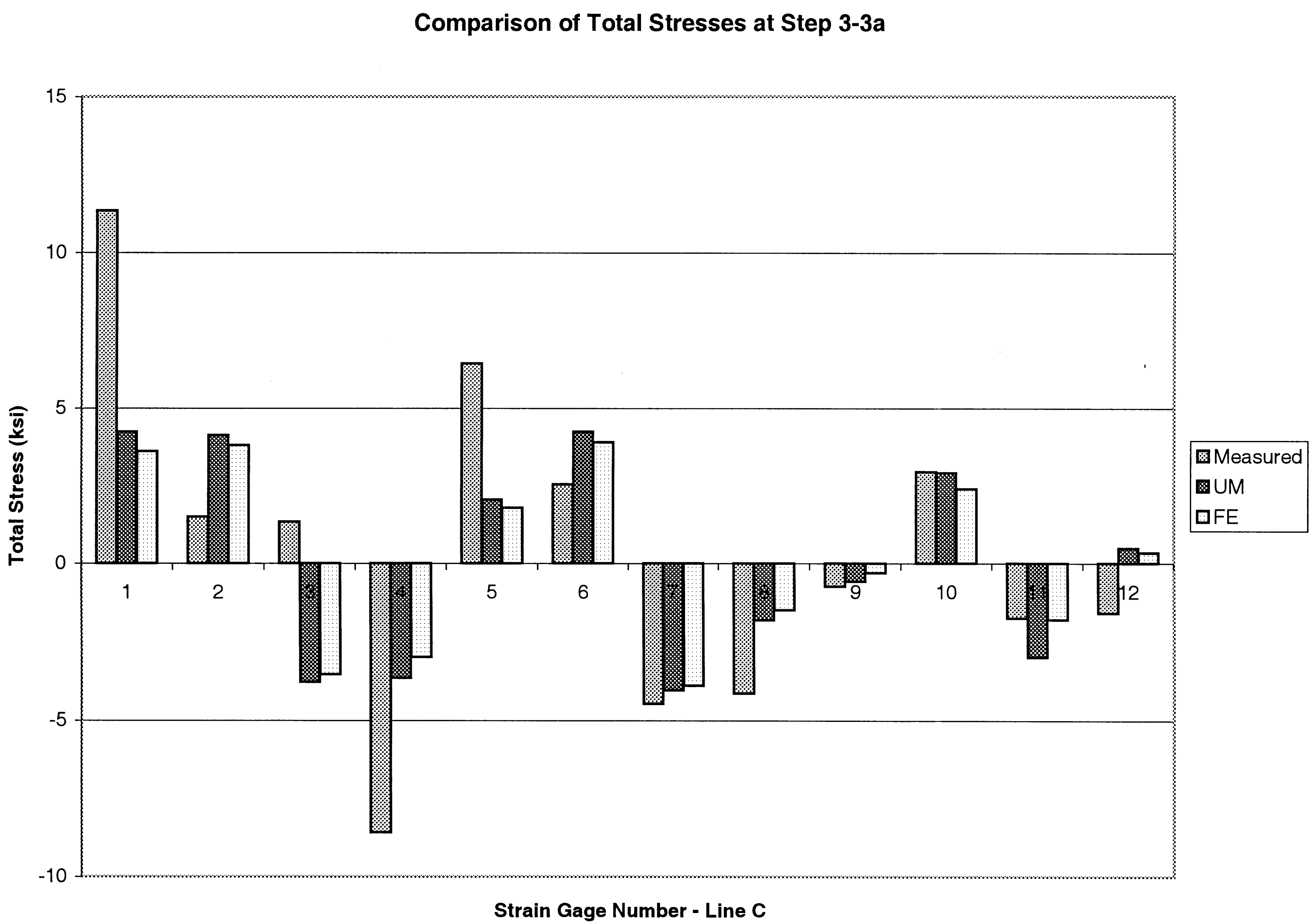


Figure 3.6: Comparison of Total Stresses at Step 3-3a [after (Simpson, 2000)]

CHAPTER 4

INVESTIGATION OF LINEAR BEHAVIOR OF BRIDGE SYSTEM

To provide an initial evaluation of the correlation between measured and computed results, a series of plots were created which show the stresses in the gages when two, three, and nine trucks were placed approximately symmetrically (i.e., centered) about either Crossframe 5 or Crossframe 7 (Figures G.1 to G.22 for N = 6 and composite analysis). A more complete set of results, including results from partially non-composite analyses, may be found in Boyer and Hajjar (1997). Each of these plots (termed "linear plots") shows the change in stress (from an unloaded bridge) for both the analysis and measured results as the number of trucks is increased. The cases used were 1995 Case 2 [two trucks, outlined in Galambos et al. (1996)], 1997 Case 8 (three trucks, Figure B.17), and 1997 Case 1 (nine trucks, Figure B.10) for Crossframe 5, and 1995 Case 3 (Galambos et al., 1996), 1997 Case 9 (Figure B.18), and 1997 Case 2 (Figure B.11) for Crossframe 7.

There is very little difference in the trends between the different sets of results (i.e., composite versus partially non-composite N = 6, and Crossframe 5 versus Crossframe 7) for the stresses in the midspan region (including for the crossframes). However, all plots of Gage Line B clearly portray the improvement in correlation of the analyses in which fully composite action was assumed over the negative moment region, versus assuming partially non-composite analyses (this will be explored further in Chapter 5).

All of the analyses produce approximately linear increases in the gages, which reestablishes credibility in the UMN analysis program. The measured stresses are not always linear, however.

Gages 4A, 16A, 20A, 21A, 1B, 2B, 3B, 4B, 5B, 6B, 10B, 11B, 12B, 13B, 15B, 16B, 17B, 18B, 21B, 22B, 23B, 24B, and 10C exhibit nearly linear behavior. Gages 3A, 6A, 9A, 15A, 18A, 22A, 24A, 7B, 8B, 14B, 19B, 20B, 2C, 3C, 4C, 5C, 6C, 7C, 8C, and 11C, have either a positive or a negative nonlinear change in stress between the two truck and three truck loadings. However, the magnitude of this nonlinear change is generally not large. The remainder of the gages exhibit neither linear behavior, nor a major jump in stress, but rather they exhibit what may be characterized as a continuously nonlinear response to the increase in truck loading. However, the deviation from linear behavior is in all cases generally moderate rather than extreme. Given that the different cases of truck loadings are distributed differently across the deck surface, these deviations from linearity appear to be reasonable. These results indicate that the bridge is behaving in a generally predictable fashion, but certainly that some effects of indeterminacy and local loading conditions in the structure are exhibited in the results. The results of this analysis are similar for the 2000 data. The linearity of the system did not change appreciably between 1997 and 2000.

CHAPTER 5

DISCUSSION OF MEASURED VERSUS COMPUTED RESULTS

The percent error in the correlations between the 1997 measured and computed results using the 1997 analysis are tabulated in Table 5.1 for the primary stages of dead loading and for all cases of loading during the 1997 live load tests. Table 5.2 contains the same information for the measured data collected in 2000 versus the analysis based on the 1997 truck loadings. Table 5.3 lists the percent errors between the measured data collected in 2000 and the analysis based on the truck loadings from 2000. In the tables, the percent error is computed as {[measured stress - computed stress] / [measured stress]} -- typically, if the analysis underpredicts the stress magnitude, the result may be considered unconservative; the corresponding percent error is shown as positive. In Table 5.4, each gage is assigned an overall rating regarding the correlation of 1997 data to 1997 analysis for total stress. In Table 5.5, each gage is rated regarding the correlation of 2000 data to 1997 analysis for total stress. Table 5.6 has the ratings for 2000 data versus 2000 analysis for total stress. Finally, in Table 5.7, each gage is rated regarding the correlation of 1997 change in stress analysis compared to 2000 measured change in stress. Because the ratings of the gages did not change between Tables 5.4 and 5.5, 1997 analysis results were used for all the data analysis in this report unless otherwise specified.

Tables 5.4, 5.5, and 5.6 show four percent errors for each gage, including Step 3-3a (the bare steel structure, including wet weight of the concrete deck), Step 4-2 (the self weight of the completed composite bridge), the average percent error for the nine truck cases (Cases 1-6), and the average percent error for the three truck cases (Cases 8-11). The averages were taken holding the sign on the percent errors, so that positive and negative errors offset each other. The percent errors for the nine and three truck cases are for the stresses due to the total load, not just the change in stresses from the trucks. Case 7 was not included because the percent error from the eight truck loading (four trucks on each span) related closely with the three truck loadings (see Table 5.1). Similar behavior was noted in 2000. Also, Tables 5.4, 5.5, and 5.6 were constructed based upon percent errors computed by comparing field results to analyses in which N was taken as 6, and fully composite action was assumed across the entire length of the bridge. Table 5.1 and plots of the data (Boyer and Hajjar, 1997) consistently show a small improvement in correlation when one uses $N = 6$ as compared to $N = 8$. For simplicity, the 1995 truck loading, the results with partially non-composite action, and the results with $N = 8$ were not included in the determination of strong, moderate, or weak correlation.

Tables 5.4, 5.5, and 5.6 also display how often the analysis is conservative for each gage, whether the stress magnitude for the gage is ever above 5 ksi, and if the measured stresses in the gage increase linearly with an increase in the number of trucks (as discussed in Chapter 4). Finally, the overall assessment of the correlation is included for each gage. The overall correlation rating was determined as follows:

- Strong = All of the percent errors for the four cases shown must be below 30%
- Moderate = All gages that do not fit within the criteria for a strong or weak correlation
- Weak = The measured stresses must be above 5 ksi, and 3 to 4 of the percent errors must be greater than 30% for the four cases shown

These criteria help eliminate percent error skews from early dead load stages or skews due to the overall stress in the gage being very low (i.e., below 5 ksi), which in turn can cause huge percent errors which are not necessarily representative of the overall correlation of the gage. This is discussed further in the conclusions below. It was determined that the criteria established for the comparison of the 1997 analysis versus the 1997 data was sufficient to compare the 1997 analysis to the 2000 data (as discussed further in Appendix C).

Note that the change in stress due to any temperature variation between the date on which the readings for Step 4-2 were taken (in 1995), versus the date on which the readings for the truck live loading in 1997 and 2000 were taken, were not considered. One could have added the change in stress due to live loading to the stresses due to self-weight of the bridge as measured on August 7, 1997. However, as seen in Chapter 2, the change in stress due to temperature is generally seen to be less than 2 ksi in most gages, and also the analyses do not account for change in temperature. In addition, since Step 4-2 represents a major step in the construction of the bridge, it was felt to be the appropriate basis for calculating the total stress due to self-weight plus truck loading.

A summary of the correlation of the gages with respect to total stress follows:

- The percent errors for both the 1997 and 2000 data generally reduce greatly as the magnitude of the strain in the gage increases. Thus, the percent errors due to initial dead loading are often excessive, although the overall correlation of the gage is acceptable once loading is applied. Consequently, to assess the correlation of the total stress due to self weight plus truck loading, this correlation may best be compared to the correlation for the gage due to self weight alone (Steps 3-3a and 4-2). Generally, if the gage correlated well at the end of the dead load analysis, the total stresses also correlate well. In contrast, if the correlation of the total stresses is moderate to weak, it is often largely because initial fit-up stresses immediately established a difference in stress between measured and computed results that is on the order of several ksi. These cases are marked with Comments 1 and 2 in Footnote f in Tables 5.4, 5.5, and 5.6. In addition, some gages see less than 5 ksi for their entire loading history. For these gages, a small difference in stress (which may be caused by local irregularities in the loading, small fit-up stresses, etc.) cause a large percent error. These cases are highlighted in the tables both in Column 7 ("Measured Stress Magnitude") and in the correlation classification.
- As a whole, the 24 gages attached to the girders near midspan correlate very well with the composite analyses based on 1997 truck loading as well as with the analyses based on the

2000 loading. All of the gages received ratings of strong or moderate, except gage 11A, which was the only gage with a weak correlation for both 1997 and 2000. However, the weak correlation of this gage, as seen for example in Figures D.2, F.3 and F.25, is not excessive, and it is largely due to errors introduced in the middle stages of dead loading. In addition, the gages that received a moderate rating that had stress magnitudes greater than 5 ksi were all very close to fitting into the strong gage criteria. They generally missed being rated strong because one of the dead load errors was greater than 30%. Of the gages that had stresses greater than 5 ksi, the gages attached to the web tended to correlate better, probably due to being less influenced by warping behavior.

- The 24 gages attached to the girders near the middle pier did not have as strong a correlation with the analysis as did the midspan gages. There were nine gages in this region of the bridge that received weak ratings, compared to only one in the midspan. However, thirteen gages had strong correlation in 1997 and 2000, and all weak correlations were readily explainable: the differences in the magnitudes of the measured and computed stresses largely occurred in the early or middle stages of dead loading, due perhaps to fit-up stresses. This is readily evident if one compares the plots in Appendix D (due just to dead load) with those in Appendix F (total stress and change in stress). Also, the analysis results are generally conservative. All of these nine gages except one (gage 22B) were on girders two and three, the center two girders. The two outer girders generally correlated well. In addition, of the gages that had stresses greater than 5 ksi, the gages attached to the web tended to correlate better, probably due to being less influenced by warping behavior. Gage 19B is the only gage which changed its rating from 1997 to 2000. The rating changed from strong to moderate. It should be noted that the gage was close to the 30% cutoff for strong correlation in 1997, and the fact that it is the only gage to have changed ratings indicates the bridge system has not changed its behavior significantly over time.

- The crossframes generally were much less predictable, with half of the gages having weak correlation, and the other half having moderate correlation. In addition, the moderate correlation was always due to the stresses in the crossframes being very small. Also, the analysis results are often not conservatively predicated. Table 5.4, 5.5, and 5.6 show that the behavior of the gages generally follows that of the calculated results. However, the measured stresses in the crossframes were not readily predictable, and further research would be required to determine how best to increase the accuracy of the analysis predictions.

- As seen in the figures of Appendix F, the gages near the interior pier showed a marked change in correlation depending on whether the behavior in this region of the bridge was assumed to be fully composite, or whether only the bare steel bridge was modeled in the negative moment region. The differences based upon the modeling of composite action are most noticeable in the gages that are nearest to the concrete deck (i.e., the top flange) in the negative moment region (i.e., gages 1B, 2B, 5B, 7B, 8B, 11B, 13B, 14B, 17B, 19B, 20B, 23B), as may be expected. The correlation of each group of three gages near the bottom flange of each girder over the interior pier changed little on the whole. The correlation of the gages in the positive moment region (both on the girders and the cross frames) changed little as well. The improvement in correlation when assuming fully composite action is generally both consistent and dramatic. Similar behavior was noted for data collected in 2000 with respect to analysis using 1997 truck data.

In Table 5.7, each gage is assigned an overall rating regarding the correlation of the 2000 measured change in stress to the analysis based on 1997 truck loadings. In the table, the percent error is computed as it was for the total stress correlations. If the analysis is unconservative, the percent error is positive.

Table 5.7 shows ten different percent errors for each gage, cases 1-6 (the nine truck cases) and cases 8-11 (the three truck cases). Case 7 was not included because the stresses induced were similar in magnitude to the three truck cases, and in an effort to compliment the correlations set forth in the total stress rating table as closely as possible.

Table 5.7 also displays how often the correlation is conservative for each gage, how often the stress magnitude is above 0.5 ksi, and the final correlation for each gage. The rating for each gage for change in stress was determined as follows:

- Strong = Eight to ten of the ten percent errors must be below 100%
- Moderate = All gages that do not fit within the criteria for a strong or weak criteria
- Weak = Seven to ten of the gages have change in stress magnitudes above 0.5 ksi, and three to ten of the ten percent errors must be greater than 100%

These criteria helped eliminate skews due to very low stress magnitudes. The limiting factor of 0.5 ksi was chosen because it was approximately a factor of ten greater than the tolerance of the *Geokon VK-4100 Vibrating Wire Strain Gages*. Change in stress due to temperature was neglected for the change in stress correlations because the analysis does not take temperature into account. In addition to the change in stress plots of Appendix F, Appendix E contains bar charts that show gage by gage comparisons of the 1997 analysis versus the 1997 and 2000 change in stress measured data for each case represented in Table 5.7.

A summary of the correlation of the gages with respect to change in stress follows:

- The percent errors are generally larger when the stress magnitudes are small, so the percent errors for the three truck cases tend to be larger than those for the nine truck cases.
- In general, the 24 gages attached at midspan and the 24 gages attached at the middle pier had similar change in stress correlations. In all but one gage (gage 16B) of the 25 gages that received a "moderate" correlation, the number of cases above 0.5 ksi measured change in stress was six or fewer. The one gage that had high measured stress only had six cases where the error was less than 100%. Generally, the gages that were rated "moderate" had low measured stresses along with high percent errors.
- The crossframes were the least predictable with respect to change in stress, as they were with the total stress correlations. The only strong rating was in a top chord member, and almost 40% of the ratings in the crossframes were weak, compared to 10.5% along the midspan, and 14.3% along the middle pier.

Overall, the correlation between measured and computed stresses was satisfactory in the girders, whereas the result in the crossframes were more erratic. One theory for this phenomenon is that the bridge is modeled too stiff, thus yielding lower stresses in the crossframe members. To confirm this theory, a parametric study was conducted in which the area of the crossframe members was varied to explore trends in the bridge behavior (Carlsson and Hajjar, 2000). In general, decreasing the area of the crossframes reduced the stiffness of the bridge, resulting in more rotation of the girders, which consequently increased the stresses in the crossframes without causing any significant changes in the correlation of the girders. Alternately, increasing the area of the crossframes increased the stiffness of the bridge, resulting in less rotation of the girders, which decreased the stresses in the crossframes without causing any significant changes in the correlation of the girders.

Table 5.8 compares the measured total stress from Step 3-3a (stage 6) with the analysis based on 1997 truck loading, and with the same analysis but with the crossframe cross sectional areas reduced by 65%. In Table 5.8, TL, TC, and TR refer to the top left, top center, and top right when looking north along the bridge (B similarly refers to the bottom flange gages). All stresses are in ksi. For the case when all crossframe member areas were reduced by 65%, the top and bottom crossframe members were predicted well, although the diagonal members exhibited more stress than desired. As seen in Table 5.9, reducing only the bottom crossframe member by the same amount (65%) also increased the stresses in all of the members. However, the increase was larger in the bottom member than at the top, and vice versa for decreasing only the top member (Table 5.10). The diagonal members correlated better for these two cases than the first case (i.e., reduction of all of the crossframe members) since the stresses did not increase as much. In all of these cases it was found that changing the stiffness of the crossframe members did not results in any significant differential stress in the girders. However, it has not yet been determined definitively what might be causing the increase in the stiffness of the model. One possibility may be the assumption of modeling the crossframes as X-brace diagonals with pinned-end connections. Bending in the crossframes may also cause some of this stress differential as well. However, no conclusive reason has been isolated.

Chapter 2 indicated that temperature changes may induce changes in stresses over large temperature shifts, thus potentially explaining some of the high measured stresses. However, during a normal day-to-day temperature shift, the thermal stress changes are much less. From the data reported in Chapter 2, the maximum expected built-in thermal stress in the girders is approximated 2 ksi, and in the crossframes 1.5 to 2.5 ksi in magnitude depending on the crossframe. The maximum measured stress in the crossframes at the end of stage 3-3a was approximately 11.33 ksi, with a deviation between the measured and computed stress of 7.09 ksi. Consequently, built-in thermal stresses in the bridge are important, but most likely not the sole contributing factor to the poor correlation in the crossframes.

While these results largely reaffirm the conclusions regarding correlation made in Galambos et al. (1996), the plotted results and correlation rating add clarity to the comparison. Also, the new analyses conducted with (versus without) composite action in the negative moment region shed light on how best to analyze steel girder bridges, pending further research. Finally, the fact that the ratings of the gages remained basically unchanged from tests and analyses performed in 1997 to tests and analyses performed in 2000 gives a good indication that the behavior of the system has not significantly changed over time.

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	1A	**2A**	**3A**	**4A**	**5A**	**6A**	**1A**	**2A**	**3A**	**4A**	**5A**	**6A**
Step 1-1	210%	-27%	49%	-12%	-128%	56%	210%	-27%	49%	-12%	-128%	56%
Step 1-2	4%	28%	-189%	975%	4680%	-55%	4%	28%	-189%	975%	4680%	-55%
Step 1-3	-46%	-7%	-1%	-241%	-47%	-46%	-46%	-7%	-1%	-241%	-47%	-46%
Step 2-2	213%	-2%	-27%	-391%	-65%	-83%	213%	-2%	-27%	-391%	-65%	-83%
Step 2-3a	60%	-10%	-39%	-354%	-62%	-92%	60%	-10%	-39%	-354%	-62%	-92%
Step 3-3a	-71%	-27%	0%	-49%	-26%	-33%	-71%	-27%	0%	-49%	-26%	-33%
Step 4-1 w/N=6	-91%	-22%	1%	-38%	-28%	-29%	-93%	-23%	0%	-41%	-29%	-31%
Step 4-2 w/N=6	1%	-4%	3%	-34%	-15%	-19%	-1%	-5%	0%	-37%	-15%	-22%
minimum error	**-91%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**	**-93%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**
maximum error	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**
average error	**35%**	**-9%**	**-25%**	**-18%**	**539%**	**-38%**	**35%**	**-9%**	**-26%**	**-19%**	**539%**	**-38%**
std. dev. error	**119%**	**18%**	**71%**	**429%**	**1674%**	**46%**	**119%**	**18%**	**71%**	**429%**	**1674%**	**46%**
Case 1	-248%	-386%	-2%	-29%	-222%	-2%	-249%	-388%	-2%	-30%	-222%	-3%
Case 2	-199%	-324%	13%	-12%	-186%	11%	-194%	-320%	14%	-12%	-183%	12%
Case 3	-90%	-154%	50%	20%	-86%	45%	-88%	-150%	51%	20%	-83%	46%
Case 4	350%	950%	149%	192%	767%	139%	250%	600%	131%	161%	500%	124%
Case 5	-408%	-409%	-215%	-360%	-267%	1221%	-262%	-264%	-128%	-236%	-161%	907%
Case 6	-450%	-409%	-125%	-297%	-230%	8000%	-275%	-245%	-57%	-179%	-125%	5550%
minimum error	**-450%**	**-409%**	**-215%**	**-360%**	**-267%**	**-2%**	**-275%**	**-388%**	**-128%**	**-236%**	**-222%**	**-3%**
maximum error	**350%**	**950%**	**149%**	**192%**	**767%**	**8000%**	**250%**	**600%**	**131%**	**161%**	**500%**	**5550%**
average error	**-174%**	**-122%**	**-22%**	**-81%**	**-37%**	**1569%**	**-136%**	**-128%**	**1%**	**-46%**	**-46%**	**1106%**
std. dev. error	**289%**	**534%**	**130%**	**208%**	**399%**	**3186%**	**201%**	**365%**	**89%**	**143%**	**272%**	**2205%**
Case 7	-57%	-121%	-15%	-12%	-85%	12%	-74%	-146%	-28%	-25%	-107%	2%
Case 8	-55%	-132%	-1%	-14%	-95%	9%	-56%	-134%	-2%	-16%	-97%	9%
Case 9	-9%	-70%	25%	12%	-56%	35%	-7%	-68%	26%	13%	-54%	36%
Case 10	269%	675%	-750%	688%	-440%	207%	219%	500%	-517%	525%	-280%	177%
Case 11	218%	375%	-1125%	540%	2700%	195%	177%	288%	-725%	410%	1800%	163%
minimum error	**-55%**	**-132%**	**-1125%**	**-14%**	**-440%**	**9%**	**-56%**	**-134%**	**-725%**	**-16%**	**-280%**	**9%**
maximum error	**269%**	**675%**	**25%**	**688%**	**2700%**	**207%**	**219%**	**500%**	**26%**	**525%**	**1800%**	**177%**
average error	**106%**	**212%**	**-463%**	**306%**	**527%**	**112%**	**83%**	**146%**	**-305%**	**233%**	**342%**	**96%**
std. dev. error	**161%**	**382%**	**569%**	**360%**	**1459%**	**104%**	**135%**	**300%**	**375%**	**275%**	**977%**	**86%**
Total Stress Case 1	-28%	-21%	1%	-32%	-28%	-12%	-30%	-22%	-1%	-34%	-29%	-14%
Total Stress Case 2	-22%	-17%	7%	-26%	-25%	-6%	-23%	-18%	5%	-27%	-26%	-8%
Total Stress Case 3	-6%	-8%	16%	-21%	-17%	0%	-7%	-8%	15%	-23%	-18%	-1%
Total Stress Case 4	6%	-2%	16%	-19%	-13%	2%	3%	-3%	13%	-24%	-14%	-2%
Total Stress Case 5	11%	1%	15%	-18%	-10%	3%	5%	-1%	7%	-27%	-13%	-5%
Total Stress Case 6	11%	1%	13%	-19%	-11%	2%	5%	-2%	5%	-28%	-13%	-7%
minimum error	**-28%**	**-21%**	**1%**	**-32%**	**-28%**	**-12%**	**-30%**	**-22%**	**-1%**	**-34%**	**-29%**	**-14%**
maximum error	**11%**	**1%**	**16%**	**-18%**	**-10%**	**3%**	**5%**	**-1%**	**15%**	**-23%**	**-13%**	**-1%**
average error	**-5%**	**-7%**	**11%**	**-22%**	**-17%**	**-2%**	**-8%**	**-9%**	**7%**	**-27%**	**-19%**	**-6%**
std. dev. error	**17%**	**10%**	**6%**	**6%**	**8%**	**6%**	**15%**	**9%**	**6%**	**4%**	**7%**	**5%**
Total Stress Case 7	-6%	-8%	-1%	-29%	-18%	-11%	-9%	-10%	-5%	-34%	-20%	-16%
Total Stress Case 8	-6%	-9%	2%	-29%	-19%	-11%	-8%	-10%	0%	-31%	-20%	-13%
Total Stress Case 9	0%	-6%	7%	-24%	-16%	-5%	-2%	-7%	5%	-26%	-17%	-7%
Total Stress Case 10	8%	-1%	9%	-23%	-13%	-3%	5%	-2%	4%	-28%	-14%	-8%
Total Stress Case 11	9%	0%	9%	-23%	-12%	-2%	6%	-2%	4%	-28%	-14%	-7%
minimum error	**-6%**	**-9%**	**2%**	**-29%**	**-19%**	**-11%**	**-8%**	**-10%**	**0%**	**-31%**	**-20%**	**-13%**
maximum error	**9%**	**0%**	**9%**	**-23%**	**-12%**	**-2%**	**6%**	**-2%**	**5%**	**-26%**	**-14%**	**-7%**
average error	**3%**	**-4%**	**7%**	**-25%**	**-15%**	**-5%**	**0%**	**-5%**	**3%**	**-28%**	**-16%**	**-9%**
std. dev. error	**7%**	**4%**	**3%**	**3%**	**3%**	**4%**	**7%**	**4%**	**3%**	**2%**	**3%**	**3%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	7A	8A	9A	10A	11A	12A	7A	8A	9A	10A	11A	12A
Step 1-1	105%	156%	85%	92%	50%	174%	105%	156%	85%	92%	50%	174%
Step 1-2	118%	-1750%	-88%	76%	13%	137%	118%	-1750%	-88%	76%	13%	137%
Step 1-3	184%	-42%	-77%	43%	-83%	875%	184%	-42%	-77%	43%	-83%	875%
Step 2-2	413%	-30%	-202%	34%	-32%	285%	413%	-30%	-202%	34%	-32%	285%
Step 2-3a	646%	-36%	-184%	26%	-44%	336%	646%	-36%	-184%	26%	-44%	336%
Step 3-3a	-255%	-17%	-73%	19%	-58%	-346%	-255%	-17%	-73%	19%	-58%	-346%
Step 4-1	-188%	-3%	-99%	18%	-63%	-461%	-190%	-3%	-102%	17%	-63%	-469%
Step 4-2	-89%	6%	-104%	11%	-38%	-520%	-91%	6%	-109%	8%	-39%	-536%
minimum error	**-255%**	**-1750%**	**-202%**	**11%**	**-83%**	**-520%**	**-255%**	**-1750%**	**-202%**	**8%**	**-83%**	**-536%**
maximum error	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**
average error	**117%**	**-214%**	**-93%**	**40%**	**-32%**	**60%**	**116%**	**-214%**	**-94%**	**39%**	**-32%**	**57%**
std. dev. error	**304%**	**624%**	**87%**	**30%**	**43%**	**476%**	**304%**	**624%**	**87%**	**30%**	**43%**	**480%**
Case 1	-119%	-188%	-40%	-95%	-224%	-44%	-123%	-194%	-45%	-103%	-231%	-48%
Case 2	-75%	-136%	-31%	-88%	-182%	-27%	-78%	-140%	-34%	-96%	-186%	-29%
Case 3	12%	-30%	-17%	-98%	-76%	14%	8%	-33%	-24%	-114%	-84%	10%
Case 4	182%	1200%	-67%	-23%	800%	254%	153%	800%	-10%	15%	550%	204%
Case 5	-1133%	-71%	-52%	-50%	-270%	-318%	-800%	-24%	-17%	-19%	-170%	-214%
Case 6	-620%	-56%	-47%	-38%	-289%	-253%	-400%	-6%	-8%	-4%	-178%	-156%
minimum error	**-1133%**	**-188%**	**-67%**	**-98%**	**-289%**	**-318%**	**-800%**	**-194%**	**-45%**	**-114%**	**-231%**	**-214%**
maximum error	**182%**	**1200%**	**-17%**	**-23%**	**800%**	**254%**	**153%**	**800%**	**-8%**	**15%**	**550%**	**204%**
average error	**-292%**	**120%**	**-42%**	**-65%**	**-40%**	**-62%**	**-207%**	**67%**	**-23%**	**-53%**	**-50%**	**-39%**
std. dev. error	**492%**	**532%**	**17%**	**32%**	**419%**	**204%**	**343%**	**367%**	**14%**	**57%**	**298%**	**146%**
Case 7	-32%	-97%	-45%	-136%	-100%	-32%	-45%	-116%	-59%	-159%	-118%	-45%
Case 8	-26%	-71%	-45%	-137%	-83%	-33%	-29%	-73%	-50%	-146%	-88%	-37%
Case 9	21%	-13%	-38%	-186%	-29%	-1%	20%	-16%	-43%	-200%	-29%	-4%
Case 10	225%	-500%	20%	30%	600%	-4600%	192%	-300%	39%	46%	467%	-3400%
Case 11	188%	-1000%	11%	31%	333%	1567%	156%	-600%	35%	48%	250%	1133%
minimum error	**-26%**	**-1000%**	**-45%**	**-186%**	**-83%**	**-4600%**	**-29%**	**-600%**	**-50%**	**-200%**	**-88%**	**-3400%**
maximum error	**225%**	**-13%**	**20%**	**31%**	**600%**	**1567%**	**192%**	**-16%**	**39%**	**48%**	**467%**	**1133%**
average error	**102%**	**-396%**	**-13%**	**-65%**	**205%**	**-767%**	**85%**	**-247%**	**-4%**	**-63%**	**150%**	**-577%**
std. dev. error	**123%**	**458%**	**33%**	**113%**	**322%**	**2662%**	**106%**	**265%**	**48%**	**129%**	**257%**	**1959%**
Total Stress Case 1	-94%	-5%	-72%	-13%	-51%	-168%	-96%	-6%	-77%	-17%	-52%	-175%
Total Stress Case 2	-87%	-2%	-70%	-9%	-47%	-163%	-88%	-2%	-75%	-12%	-48%	-169%
Total Stress Case 3	-77%	5%	-83%	3%	-39%	-225%	-79%	4%	-89%	0%	-40%	-234%
Total Stress Case 4	-77%	8%	-106%	12%	-35%	-385%	-80%	7%	-116%	8%	-37%	-407%
Total Stress Case 5	-80%	8%	-116%	16%	-35%	-575%	-85%	6%	-131%	11%	-37%	-623%
Total Stress Case 6	-82%	8%	-117%	15%	-35%	-606%	-86%	6%	-133%	9%	-37%	-658%
minimum error	**-94%**	**-5%**	**-117%**	**-13%**	**-51%**	**-606%**	**-96%**	**-6%**	**-133%**	**-17%**	**-52%**	**-658%**
maximum error	**-77%**	**8%**	**-70%**	**16%**	**-35%**	**-163%**	**-79%**	**7%**	**-75%**	**11%**	**-37%**	**-169%**
average error	**-83%**	**4%**	**-94%**	**4%**	**-40%**	**-354%**	**-86%**	**2%**	**-103%**	**0%**	**-42%**	**-378%**
std. dev. error	**7%**	**6%**	**22%**	**12%**	**7%**	**201%**	**6%**	**5%**	**27%**	**12%**	**7%**	**221%**
Total Stress Case 7	-81%	2%	-86%	-4%	-41%	-235%	-84%	1%	-94%	-8%	-43%	-249%
Total Stress Case 8	-79%	3%	-84%	-5%	-41%	-224%	-81%	2%	-90%	-8%	-42%	-232%
Total Stress Case 9	-74%	6%	-90%	1%	-37%	-255%	-76%	5%	-95%	-1%	-38%	-264%
Total Stress Case 10	-79%	8%	-125%	9%	-35%	-489%	-82%	6%	-135%	6%	-37%	-515%
Total Stress Case 11	-78%	8%	-119%	9%	-35%	-474%	-80%	6%	-128%	6%	-36%	-499%
minimum error	**-79%**	**3%**	**-125%**	**-5%**	**-41%**	**-489%**	**-82%**	**2%**	**-135%**	**-8%**	**-42%**	**-515%**
maximum error	**-74%**	**8%**	**-84%**	**9%**	**-35%**	**-224%**	**-76%**	**6%**	**-90%**	**6%**	**-36%**	**-232%**
average error	**-78%**	**6%**	**-105%**	**4%**	**-37%**	**-360%**	**-80%**	**5%**	**-112%**	**1%**	**-38%**	**-377%**
std. dev. error	**2%**	**2%**	**20%**	**7%**	**3%**	**141%**	**3%**	**2%**	**23%**	**7%**	**3%**	**150%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	13A	**14A**	**15A**	**16A**	**17A**	**18A**	**13A**	**14A**	**15A**	**16A**	**17A**	**18A**
Step 1-1	86%	0%	280%	122%	113%	123%	86%	0%	280%	122%	113%	123%
Step 1-2	95%	475%	90%	137%	108%	47%	95%	475%	90%	137%	108%	47%
Step 1-3	229%	-241%	297%	31%	30%	-195%	229%	-241%	297%	31%	30%	-195%
Step 2-2	240%	-126%	249%	32%	24%	-491%	240%	-126%	249%	32%	24%	-491%
Step 2-3a	310%	-122%	296%	26%	14%	-503%	310%	-122%	296%	26%	14%	-503%
Step 3-3a	-211%	-143%	-414%	24%	-12%	-130%	-211%	-143%	-414%	24%	-12%	-130%
Step 4-1	-91%	-101%	-316%	18%	-2%	-93%	-92%	-102%	-323%	17%	-2%	-96%
Step 4-2	-48%	-56%	-324%	16%	8%	-113%	-50%	-57%	-335%	13%	7%	-118%
minimum error	**-211%**	**-241%**	**-414%**	**16%**	**-12%**	**-503%**	**-211%**	**-241%**	**-414%**	**13%**	**-12%**	**-503%**
maximum error	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**
average error	**76%**	**-39%**	**20%**	**51%**	**35%**	**-170%**	**76%**	**-40%**	**17%**	**50%**	**35%**	**-171%**
std. dev. error	**182%**	**219%**	**315%**	**49%**	**48%**	**226%**	**182%**	**219%**	**318%**	**49%**	**48%**	**226%**
Case 1	-200%	-308%	-71%	7%	-171%	-96%	-223%	-342%	-83%	0%	-192%	-107%
Case 2	-151%	-221%	-48%	24%	-121%	-76%	-171%	-246%	-59%	16%	-140%	-86%
Case 3	-18%	-27%	-9%	54%	4%	-36%	-41%	-60%	-29%	43%	-19%	-56%
Case 4	650%	300%	-11%	-33%	210%	-23%	450%	250%	22%	0%	180%	16%
Case 5	-100%	-650%	-6%	27%	767%	-9%	-70%	-600%	9%	31%	700%	13%
Case 6	-100%	-550%	6%	37%	550%	3%	-67%	-500%	19%	38%	500%	24%
minimum error	**-200%**	**-650%**	**-71%**	**-33%**	**-171%**	**-96%**	**-223%**	**-600%**	**-83%**	**0%**	**-192%**	**-107%**
maximum error	**650%**	**300%**	**6%**	**54%**	**767%**	**3%**	**450%**	**250%**	**22%**	**43%**	**700%**	**24%**
average error	**13%**	**-243%**	**-23%**	**19%**	**206%**	**-39%**	**-20%**	**-250%**	**-20%**	**21%**	**172%**	**-32%**
std. dev. error	**318%**	**348%**	**30%**	**30%**	**380%**	**39%**	**241%**	**310%**	**44%**	**19%**	**361%**	**58%**
Case 7	-136%	-113%	-78%	12%	-72%	-108%	-157%	-135%	-94%	4%	-87%	-126%
Case 8	-113%	-89%	-95%	6%	-64%	-121%	-125%	-100%	-106%	-1%	-74%	-131%
Case 9	-12%	13%	-48%	43%	20%	-92%	-24%	0%	-65%	34%	9%	-108%
Case 10	900%	175%	48%	44%	162%	43%	800%	163%	55%	47%	154%	55%
Case 11	300%	150%	51%	52%	140%	45%	300%	140%	59%	52%	140%	57%
minimum error	**-113%**	**-89%**	**-95%**	**6%**	**-64%**	**-121%**	**-125%**	**-100%**	**-106%**	**-1%**	**-74%**	**-131%**
maximum error	**900%**	**175%**	**51%**	**52%**	**162%**	**45%**	**800%**	**163%**	**59%**	**52%**	**154%**	**57%**
average error	**269%**	**62%**	**-11%**	**36%**	**64%**	**-31%**	**238%**	**51%**	**-14%**	**33%**	**57%**	**-32%**
std. dev. error	**456%**	**123%**	**73%**	**21%**	**106%**	**88%**	**416%**	**123%**	**84%**	**24%**	**109%**	**101%**
Total Stress Case 1	-63%	-70%	-163%	12%	-2%	-106%	-67%	-73%	-174%	8%	-3%	-114%
Total Stress Case 2	-58%	-65%	-154%	19%	1%	-99%	-61%	-67%	-166%	14%	0%	-106%
Total Stress Case 3	-47%	-55%	-214%	23%	8%	-100%	-49%	-57%	-229%	19%	6%	-108%
Total Stress Case 4	-45%	-52%	-408%	17%	10%	-123%	-47%	-54%	-432%	14%	9%	-132%
Total Stress Case 5	-47%	-53%	-551%	14%	10%	-140%	-49%	-54%	-582%	11%	9%	-152%
Total Stress Case 6	-47%	-53%	-552%	13%	10%	-142%	-49%	-54%	-581%	10%	9%	-154%
minimum error	**-63%**	**-70%**	**-552%**	**12%**	**-2%**	**-142%**	**-67%**	**-73%**	**-582%**	**8%**	**-3%**	**-154%**
maximum error	**-45%**	**-52%**	**-154%**	**23%**	**10%**	**-99%**	**-47%**	**-54%**	**-166%**	**19%**	**9%**	**-106%**
average error	**-51%**	**-58%**	**-340%**	**16%**	**6%**	**-118%**	**-54%**	**-60%**	**-361%**	**13%**	**5%**	**-127%**
std. dev. error	**8%**	**8%**	**188%**	**4%**	**5%**	**20%**	**8%**	**8%**	**197%**	**4%**	**5%**	**22%**
Total Stress Case 7	-54%	-59%	-210%	15%	4%	-112%	-57%	-61%	-224%	11%	3%	-120%
Total Stress Case 8	-53%	-58%	-222%	13%	4%	-115%	-55%	-59%	-233%	10%	3%	-122%
Total Stress Case 9	-46%	-52%	-241%	20%	8%	-111%	-48%	-53%	-255%	17%	7%	-117%
Total Stress Case 10	-46%	-51%	-507%	14%	10%	-141%	-48%	-52%	-528%	11%	9%	-149%
Total Stress Case 11	-46%	-51%	-478%	14%	10%	-137%	-47%	-52%	-498%	11%	9%	-145%
minimum error	**-53%**	**-58%**	**-507%**	**13%**	**4%**	**-141%**	**-55%**	**-59%**	**-528%**	**10%**	**3%**	**-149%**
maximum error	**-46%**	**-51%**	**-222%**	**20%**	**10%**	**-111%**	**-47%**	**-52%**	**-233%**	**17%**	**9%**	**-117%**
average error	**-48%**	**-53%**	**-362%**	**15%**	**8%**	**-126%**	**-50%**	**-54%**	**-378%**	**12%**	**7%**	**-133%**
std. dev. error	**4%**	**3%**	**151%**	**3%**	**3%**	**15%**	**4%**	**3%**	**156%**	**3%**	**3%**	**16%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 6											
	Composite Analysis						Part. Non-Composite Analysis					
	19A	**20A**	**21A**	**22A**	**23A**	**24A**	**19A**	**20A**	**21A**	**22A**	**23A**	**24A**
Step 1-1	135%	-254%	183%	118%	457%	-700%	135%	-254%	183%	118%	457%	-700%
Step 1-2	119%	352%	58%	27%	421%	50%	119%	352%	58%	27%	421%	50%
Step 1-3	49%	-1%	-304%	-10300%	-89%	-224%	49%	-1%	-304%	-10300%	-89%	-224%
Step 2-2	66%	12%	-1414%	591%	15%	-99%	66%	12%	-1414%	591%	15%	-99%
Step 2-3a	55%	6%	-1109%	695%	8%	-144%	55%	6%	-1109%	695%	8%	-144%
Step 3-3a	13%	-5%	-31%	-126%	-30%	-48%	13%	-5%	-31%	-126%	-30%	-48%
Step 4-1	20%	20%	-54%	-38%	-48%	-63%	20%	19%	-56%	-41%	-49%	-65%
Step 4-2	33%	18%	-28%	-77%	-16%	-24%	33%	17%	-31%	-82%	-17%	-27%
minimum error	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**
maximum error	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**
average error	**61%**	**19%**	**-337%**	**-1139%**	**90%**	**-157%**	**61%**	**18%**	**-338%**	**-1140%**	**90%**	**-157%**
std. dev. error	**44%**	**163%**	**592%**	**3715%**	**218%**	**234%**	**44%**	**163%**	**592%**	**3714%**	**218%**	**234%**
Case 1	1400%	621%	2%	-94%	-320%	-10%	1500%	664%	-7%	-116%	-360%	-18%
Case 2	978%	493%	18%	-73%	-276%	7%	1056%	536%	9%	-100%	-324%	0%
Case 3		213%	61%	-35%	-550%	60%		275%	44%	-115%	-900%	47%
Case 4	214%	-100%	-79%	14%	500%	294%	186%	-33%	-29%	36%	400%	231%
Case 5	189%	700%	37%	46%	214%	-106%	178%	700%	37%	29%	229%	-75%
Case 6	140%	200%	63%	74%	156%	-67%	150%	233%	54%	45%	167%	-50%
minimum error	**140%**	**-100%**	**-79%**	**-94%**	**-550%**	**-106%**	**150%**	**-33%**	**-29%**	**-116%**	**-900%**	**-75%**
maximum error	**1400%**	**700%**	**63%**	**74%**	**500%**	**294%**	**1500%**	**700%**	**54%**	**45%**	**400%**	**231%**
average error	**584%**	**354%**	**17%**	**-11%**	**-46%**	**30%**	**614%**	**396%**	**18%**	**-37%**	**-131%**	**22%**
std. dev. error	**572%**	**303%**	**53%**	**67%**	**397%**	**142%**	**626%**	**286%**	**32%**	**81%**	**486%**	**111%**
Case 7	-1350%	-1950%	-10%	-152%	-146%	-11%	-1475%	-2100%	-18%	-170%	-163%	-19%
Case 8	-1000%	-3800%	1%	-144%	-133%	-2%	-1080%	-4000%	-6%	-166%	-150%	-8%
Case 9	-89%	-300%	39%	-360%	-21%	45%	-122%	-367%	26%	-490%	-50%	37%
Case 10	121%	140%	70%	86%	127%	320%	121%	140%	70%	80%	127%	300%
Case 11	107%	120%	88%	97%	108%	160%	107%	120%	79%	84%	115%	160%
minimum error	**-1000%**	**-3800%**	**1%**	**-360%**	**-133%**	**-2%**	**-1080%**	**-4000%**	**-6%**	**-490%**	**-150%**	**-8%**
maximum error	**121%**	**140%**	**88%**	**97%**	**127%**	**320%**	**121%**	**140%**	**79%**	**84%**	**127%**	**300%**
average error	**-215%**	**-960%**	**50%**	**-80%**	**20%**	**131%**	**-243%**	**-1027%**	**42%**	**-123%**	**11%**	**122%**
std. dev. error	**532%**	**1904%**	**38%**	**217%**	**122%**	**143%**	**569%**	**1996%**	**40%**	**271%**	**134%**	**138%**
Total Stress Case 1	19%	5%	-13%	-84%	-28%	-18%	18%	3%	-19%	-96%	-31%	-23%
Total Stress Case 2	22%	7%	-6%	-75%	-25%	-11%	21%	6%	-12%	-88%	-27%	-16%
Total Stress Case 3	31%	15%	-7%	-72%	-18%	-6%	30%	14%	-13%	-85%	-20%	-11%
Total Stress Case 4	35%	18%	-26%	-89%	-14%	-14%	34%	18%	-31%	-98%	-15%	-19%
Total Stress Case 5	35%	19%	-36%	-99%	-13%	-22%	34%	19%	-40%	-102%	-14%	-25%
Total Stress Case 6	34%	19%	-39%	-101%	-14%	-23%	34%	18%	-41%	-102%	-14%	-27%
minimum error	**19%**	**5%**	**-39%**	**-101%**	**-28%**	**-23%**	**18%**	**3%**	**-41%**	**-102%**	**-31%**	**-27%**
maximum error	**35%**	**19%**	**-6%**	**-72%**	**-13%**	**-6%**	**34%**	**19%**	**-12%**	**-85%**	**-14%**	**-11%**
average error	**29%**	**14%**	**-21%**	**-87%**	**-19%**	**-16%**	**29%**	**13%**	**-26%**	**-95%**	**-20%**	**-20%**
std. dev. error	**7%**	**6%**	**15%**	**12%**	**6%**	**7%**	**7%**	**7%**	**13%**	**7%**	**7%**	**6%**
Total Stress Case 7	26%	12%	-22%	-94%	-21%	-20%	25%	11%	-27%	-102%	-22%	-25%
Total Stress Case 8	27%	12%	-18%	-91%	-21%	-18%	26%	11%	-23%	-100%	-22%	-21%
Total Stress Case 9	32%	16%	-14%	-89%	-16%	-10%	31%	16%	-20%	-99%	-18%	-14%
Total Stress Case 10	35%	19%	-37%	-116%	-14%	-21%	34%	18%	-40%	-121%	-14%	-24%
Total Stress Case 11	34%	19%	-37%	-112%	-14%	-21%	34%	18%	-40%	-115%	-14%	-23%
minimum error	**27%**	**12%**	**-37%**	**-116%**	**-21%**	**-21%**	**26%**	**11%**	**-40%**	**-121%**	**-22%**	**-24%**
maximum error	**35%**	**19%**	**-14%**	**-89%**	**-14%**	**-10%**	**34%**	**18%**	**-20%**	**-99%**	**-14%**	**-14%**
average error	**32%**	**16%**	**-26%**	**-102%**	**-16%**	**-17%**	**31%**	**16%**	**-31%**	**-109%**	**-17%**	**-21%**
std. dev. error	**4%**	**3%**	**12%**	**14%**	**3%**	**5%**	**4%**	**3%**	**11%**	**11%**	**4%**	**4%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	1B	**2B**	**3B**	**4B**	**5B**	**6B**	**1B**	**2B**	**3B**	**4B**	**5B**	**6B**
Step 1-1	60%	51%	518%	131%	-94%	140%	60%	51%	518%	131%	-94%	140%
Step 1-2	29%	-6%	-76%	4%	6229%	880%	29%	-6%	-76%	4%	6229%	880%
Step 1-3	33%	7%	-59%	-142%	-245%	-238%	33%	7%	-59%	-142%	-245%	-238%
Step 2-2	20%	6%	-30%	-86%	-103%	-128%	20%	6%	-30%	-86%	-103%	-128%
Step 2-3a	12%	0%	-41%	-98%	-121%	-130%	12%	0%	-41%	-98%	-121%	-130%
Step 3-3a	-7%	9%	-26%	-45%	-22%	-48%	-7%	9%	-26%	-45%	-22%	-48%
Step 4-1	-9%	11%	-8%	-19%	-7%	-35%	-21%	1%	-7%	-18%	-18%	-36%
Step 4-2	-15%	17%	-2%	-10%	-7%	-10%	-35%	2%	-1%	-8%	-24%	-12%
minimum error	**-15%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**	**-35%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**
maximum error	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**
average error	**15%**	**12%**	**35%**	**-33%**	**704%**	**54%**	**11%**	**9%**	**35%**	**-33%**	**700%**	**54%**
std. dev. error	**25%**	**17%**	**197%**	**83%**	**2234%**	**351%**	**31%**	**18%**	**197%**	**83%**	**2235%**	**351%**
Case 1	-144%	-39%	-87%	2%	-7%	-120%	178%	-269%	-79%	-167%	-496%	98%
Case 2	-177%	-32%	-77%	12%	6%	-113%	248%	-258%	-74%	-163%	-471%	112%
Case 3	-344%	-56%	-115%	-48%	-19%	-113%	-350%	-347%	-122%	-177%	-430%	25%
Case 4	-323%	-120%	-181%	-196%	-102%	-70%	-1582%	-551%	-190%	-113%	-191%	-190%
Case 5	-205%	-161%	-222%	-295%	-202%	-64%	-1414%	-648%	-219%	-70%	-38%	-295%
Case 6	-114%	-123%	-176%	-221%	-150%	-48%	-926%	-525%	-167%	-37%	-30%	-237%
minimum error	**-344%**	**-161%**	**-222%**	**-295%**	**-202%**	**-120%**	**-1582%**	**-648%**	**-219%**	**-177%**	**-496%**	**-295%**
maximum error	**-114%**	**-32%**	**-77%**	**12%**	**6%**	**-48%**	**248%**	**-258%**	**-74%**	**-37%**	**-30%**	**112%**
average error	**-218%**	**-88%**	**-143%**	**-124%**	**-79%**	**-88%**	**-641%**	**-433%**	**-142%**	**-121%**	**-276%**	**-81%**
std. dev. error	**95%**	**53%**	**58%**	**130%**	**86%**	**31%**	**789%**	**163%**	**60%**	**58%**	**217%**	**180%**
Case 7	-73%	-51%	-113%	-96%	-51%	-66%	-403%	-311%	-104%	-73%	-220%	-90%
Case 8	-483%	-108%	-38%	21%	-50%	-111%	233%	-438%	-31%	-107%	-725%	94%
Case 9	-533%	-100%	-37%	24%	-27%	-98%	367%	-427%	-32%	-111%	-638%	102%
Case 10	-418%	-345%	-143%	-204%	-336%	-45%	-2464%	-1182%	-141%	-32%	-114%	-245%
Case 11	-216%	-240%	-116%	-153%	-225%	-31%	-1379%	-847%	-106%	-7%	-75%	-187%
minimum error	**-533%**	**-345%**	**-143%**	**-204%**	**-336%**	**-111%**	**-2464%**	**-1182%**	**-141%**	**-111%**	**-725%**	**-245%**
maximum error	**-216%**	**-100%**	**-37%**	**24%**	**-27%**	**-31%**	**367%**	**-427%**	**-31%**	**-7%**	**-75%**	**102%**
average error	**-413%**	**-198%**	**-84%**	**-78%**	**-159%**	**-71%**	**-811%**	**-723%**	**-78%**	**-64%**	**-388%**	**-59%**
std. dev. error	**139%**	**117%**	**54%**	**118%**	**147%**	**39%**	**1358%**	**363%**	**55%**	**53%**	**341%**	**183%**
Total Stress Case 1	-19%	15%	-8%	-9%	-7%	-21%	-28%	-9%	-6%	-23%	-57%	-1%
Total Stress Case 2	-19%	15%	-7%	-8%	-6%	-21%	-27%	-8%	-6%	-24%	-58%	0%
Total Stress Case 3	-19%	15%	-8%	-13%	-8%	-18%	-40%	-8%	-8%	-20%	-46%	-10%
Total Stress Case 4	-20%	13%	-13%	-23%	-12%	-16%	-65%	-14%	-12%	-16%	-32%	-27%
Total Stress Case 5	-22%	10%	-19%	-34%	-17%	-16%	-88%	-21%	-18%	-13%	-25%	-44%
Total Stress Case 6	-20%	10%	-19%	-33%	-16%	-16%	-87%	-22%	-17%	-11%	-25%	-43%
minimum error	**-22%**	**10%**	**-19%**	**-34%**	**-17%**	**-21%**	**-88%**	**-22%**	**-18%**	**-24%**	**-58%**	**-44%**
maximum error	**-19%**	**15%**	**-7%**	**-8%**	**-6%**	**-16%**	**-27%**	**-8%**	**-6%**	**-11%**	**-25%**	**0%**
average error	**-20%**	**13%**	**-12%**	**-20%**	**-11%**	**-18%**	**-56%**	**-14%**	**-11%**	**-18%**	**-40%**	**-21%**
std. dev. error	**1%**	**2%**	**6%**	**12%**	**5%**	**3%**	**28%**	**6%**	**5%**	**5%**	**15%**	**20%**
Total Stress Case 7	-18%	13%	-12%	-20%	-11%	-17%	-56%	-14%	-10%	-15%	-39%	-22%
Total Stress Case 8	-17%	15%	-3%	-8%	-8%	-15%	-34%	-3%	-2%	-13%	-38%	-8%
Total Stress Case 9	-17%	15%	-3%	-8%	-8%	-15%	-33%	-4%	-2%	-14%	-40%	-7%
Total Stress Case 10	-18%	13%	-8%	-19%	-12%	-12%	-59%	-9%	-7%	-9%	-25%	-26%
Total Stress Case 11	-18%	14%	-8%	-19%	-12%	-12%	-58%	-9%	-6%	-8%	-25%	-24%
minimum error	**-18%**	**13%**	**-8%**	**-19%**	**-12%**	**-15%**	**-59%**	**-9%**	**-7%**	**-14%**	**-40%**	**-26%**
maximum error	**-17%**	**15%**	**-3%**	**-8%**	**-8%**	**-12%**	**-33%**	**-3%**	**-2%**	**-8%**	**-25%**	**-7%**
average error	**-18%**	**14%**	**-6%**	**-14%**	**-10%**	**-13%**	**-46%**	**-6%**	**-4%**	**-11%**	**-32%**	**-16%**
std. dev. error	**1%**	**1%**	**3%**	**6%**	**2%**	**2%**	**14%**	**3%**	**3%**	**3%**	**8%**	**10%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	7B	**8B**	**9B**	**10B**	**11B**	**12B**	**7B**	**8B**	**9B**	**10B**	**11B**	**12B**
Step 1-1	-6%	-925%	-273%	12%		136%	-6%	-925%	-273%	12%		136%
Step 1-2	-592%	-2536%	-24%	-78%		743%	-592%	-2536%	-24%	-78%		743%
Step 1-3	-46%	-203%	-12%	-23%		-1171%	-46%	-203%	-12%	-23%		-1171%
Step 2-2	0%	1%	1%	0%	100%	-399%	0%	1%	1%	0%	100%	-399%
Step 2-3a	-70%	-253%	-7%	-27%	-13%	-291%	-70%	-253%	-7%	-27%	-13%	-291%
Step 3-3a	-40%	-56%	-9%	-88%	2%	-134%	-40%	-56%	-9%	-88%	2%	-134%
Step 4-1	-34%	-52%	9%	-83%	18%	-101%	-45%	-67%	11%	-81%	5%	-100%
Step 4-2	-30%	-42%	2%	-57%	22%	-58%	-48%	-65%	5%	-54%	3%	-58%
minimum error	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**
maximum error	**0%**	**1%**	**9%**	**12%**	**100%**	**743%**	**0%**	**1%**	**11%**	**12%**	**100%**	**743%**
average error	**-102%**	**-508%**	**-39%**	**-43%**	**26%**	**-159%**	**-106%**	**-513%**	**-39%**	**-42%**	**19%**	**-159%**
std. dev. error	**199%**	**873%**	**95%**	**39%**	**44%**	**537%**	**198%**	**870%**	**95%**	**38%**	**46%**	**537%**
Case 1	-293%	-124%	-74%	1%	-15%	-210%	476%	-518%	-49%	-246%	-617%	64%
Case 2	-270%	-93%	-51%	18%	2%	-200%	557%	-444%	-33%	-229%	-557%	77%
Case 3	-389%	-133%	-53%	-52%	-12%	-162%	-168%	-603%	-43%	-199%	-452%	3%
Case 4	-291%	-156%	-59%	-201%	-26%	-34%	-1614%	-693%	-53%	-72%	-51%	-163%
Case 5	-257%	-193%	-82%	-337%	-54%	34%	-2329%	-811%	-73%	23%	248%	-308%
Case 6	-159%	-129%	-63%	-293%	-32%	49%	-1719%	-586%	-49%	57%	262%	-263%
minimum error	**-389%**	**-193%**	**-82%**	**-337%**	**-54%**	**-210%**	**-2329%**	**-811%**	**-73%**	**-246%**	**-617%**	**-308%**
maximum error	**-159%**	**-93%**	**-51%**	**18%**	**2%**	**49%**	**557%**	**-444%**	**-33%**	**57%**	**262%**	**77%**
average error	**-277%**	**-138%**	**-64%**	**-144%**	**-23%**	**-87%**	**-800%**	**-609%**	**-50%**	**-111%**	**-195%**	**-98%**
std. dev. error	**74%**	**34%**	**12%**	**154%**	**19%**	**118%**	**1242%**	**129%**	**13%**	**132%**	**400%**	**169%**
Case 7	-237%	-135%	-44%	-111%	-13%	-63%	-817%	-568%	-27%	-70%	-165%	-71%
Case 8	2350%	-1600%	-13%	20%	-33%	-155%	-1900%	-4450%	5%	-164%	-713%	70%
Case 9		-640%	-11%	29%	-16%	-152%		-1980%	2%	-166%	-655%	73%
Case 10	-1900%	-1000%	-20%	-229%	-57%	52%	-13850%	-3333%	-13%	52%	271%	-223%
Case 11	-1133%	-933%	-8%	-203%	-41%	61%	-8567%	-2933%	2%	76%	290%	-195%
minimum error	**-1900%**	**-1600%**	**-20%**	**-229%**	**-57%**	**-155%**	**-13850%**	**-4450%**	**-13%**	**-166%**	**-713%**	**-223%**
maximum error	**2350%**	**-640%**	**-8%**	**29%**	**-16%**	**61%**	**-1900%**	**-1980%**	**5%**	**76%**	**290%**	**73%**
average error	**-228%**	**-1043%**	**-13%**	**-96%**	**-37%**	**-49%**	**-8106%**	**-3174%**	**-1%**	**-51%**	**-202%**	**-69%**
std. dev. error	**2265%**	**403%**	**5%**	**139%**	**17%**	**121%**	**5988%**	**1023%**	**8%**	**133%**	**558%**	**162%**
Total Stress Case 1	-38%	-46%	-6%	-50%	19%	-82%	-32%	-88%	-2%	-79%	-54%	-39%
Total Stress Case 2	-37%	-45%	-4%	-47%	20%	-81%	-29%	-87%	0%	-79%	-54%	-36%
Total Stress Case 3	-37%	-46%	-4%	-57%	20%	-72%	-50%	-87%	-1%	-71%	-33%	-50%
Total Stress Case 4	-36%	-46%	-4%	-73%	19%	-55%	-84%	-88%	-1%	-56%	-1%	-71%
Total Stress Case 5	-36%	-48%	-7%	-89%	17%	-46%	-115%	-93%	-4%	-45%	21%	-90%
Total Stress Case 6	-35%	-46%	-5%	-87%	18%	-43%	-112%	-89%	-2%	-40%	25%	-87%
minimum error	**-38%**	**-48%**	**-7%**	**-89%**	**17%**	**-82%**	**-115%**	**-93%**	**-4%**	**-79%**	**-54%**	**-90%**
maximum error	**-35%**	**-45%**	**-4%**	**-47%**	**20%**	**-43%**	**-29%**	**-87%**	**0%**	**-40%**	**25%**	**-36%**
average error	**-36%**	**-46%**	**-5%**	**-67%**	**19%**	**-63%**	**-70%**	**-89%**	**-2%**	**-62%**	**-16%**	**-62%**
std. dev. error	**1%**	**1%**	**1%**	**19%**	**1%**	**17%**	**39%**	**2%**	**1%**	**17%**	**36%**	**24%**
Total Stress Case 7	-36%	-46%	-4%	-65%	19%	-59%	-72%	-88%	1%	-56%	-12%	-60%
Total Stress Case 8	-35%	-46%	1%	-52%	20%	-66%	-44%	-77%	5%	-62%	-20%	-48%
Total Stress Case 9	-35%	-46%	1%	-50%	21%	-67%	-42%	-78%	4%	-63%	-24%	-46%
Total Stress Case 10	-34%	-46%	1%	-69%	20%	-50%	-78%	-79%	3%	-47%	11%	-70%
Total Stress Case 11	-33%	-46%	2%	-67%	20%	-50%	-75%	-77%	4%	-45%	12%	-68%
minimum error	**-35%**	**-46%**	**1%**	**-69%**	**20%**	**-67%**	**-78%**	**-79%**	**3%**	**-63%**	**-24%**	**-70%**
maximum error	**-33%**	**-46%**	**2%**	**-50%**	**21%**	**-50%**	**-42%**	**-77%**	**5%**	**-45%**	**12%**	**-46%**
average error	**-34%**	**-46%**	**1%**	**-59%**	**20%**	**-58%**	**-60%**	**-78%**	**4%**	**-54%**	**-5%**	**-58%**
std. dev. error	**1%**	**0%**	**0%**	**10%**	**0%**	**10%**	**19%**	**1%**	**1%**	**9%**	**20%**	**13%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	13B	14B	15B	16B	17B	18B	13B	14B	15B	16B	17B	18B
Step 1-1	-3%	-112%	-98%	454%	-277%	1286%	-3%	-112%	-98%	454%	-277%	1286%
Step 1-2	2592%	-858%	-117%	910%	-2771%	-196%	2592%	-858%	-117%	910%	-2771%	-196%
Step 1-3	-36%	-50%	28%	-160%	25%	-64%	-36%	-50%	28%	-160%	25%	-64%
Step 2-2	-60%	-77%	30%	-116%		-46%	-60%	-77%	30%	-116%		-46%
Step 2-3a	-59%	-68%	24%	-106%		-52%	-59%	-68%	24%	-106%		-52%
Step 3-3a	-37%	-23%	4%	-73%	11%	-89%	-37%	-23%	4%	-73%	11%	-89%
Step 4-1	-28%	-22%	22%	-36%	24%	-87%	-37%	-33%	24%	-34%	17%	-84%
Step 4-2	-35%	-31%	15%	-32%	20%	-65%	-54%	-53%	18%	-29%	7%	-62%
minimum error	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**
maximum error	**2592%**	**-22%**	**30%**	**910%**	**25%**	**1286%**	**2592%**	**-23%**	**30%**	**910%**	**25%**	**1286%**
average error	**292%**	**-155%**	**-11%**	**105%**	**-495%**	**86%**	**288%**	**-159%**	**-11%**	**106%**	**-498%**	**87%**
std. dev. error	**930%**	**286%**	**60%**	**379%**	**1122%**	**487%**	**931%**	**284%**	**60%**	**378%**	**1120%**	**487%**
Case 1	-19%	-92%	-58%	-1%	-13%	-269%	177%	-554%	-32%	-151%	-628%	23%
Case 2	-3%	-69%	-42%	18%	3%	-238%	224%	-485%	-21%	-148%	-593%	52%
Case 3	-9%	-103%	-44%	-26%	-1%	-185%	-11%	-634%	-30%	-109%	-419%	-31%
Case 4	8%	-86%	-43%	-103%	3%	-67%	-358%	-576%	-28%	-12%	-12%	-188%
Case 5	9%	-78%	-63%	-161%	-1%	-12%	-558%	-527%	-42%	45%	218%	-356%
Case 6	25%	-49%	-46%	-145%	15%	20%	-469%	-395%	-21%	72%	252%	-330%
minimum error	**-19%**	**-103%**	**-63%**	**-161%**	**-13%**	**-269%**	**-558%**	**-634%**	**-42%**	**-151%**	**-628%**	**-356%**
maximum error	**25%**	**-49%**	**-42%**	**18%**	**15%**	**20%**	**224%**	**-395%**	**-21%**	**72%**	**252%**	**52%**
average error	**2%**	**-80%**	**-49%**	**-70%**	**1%**	**-125%**	**-166%**	**-528%**	**-29%**	**-50%**	**-197%**	**-138%**
std. dev. error	**16%**	**19%**	**9%**	**77%**	**9%**	**122%**	**339%**	**82%**	**8%**	**99%**	**400%**	**179%**
Case 7	17%	-75%	-40%	-61%	8%	-117%	-143%	-478%	-15%	-31%	-139%	-99%
Case 8	0%	-600%	-33%	-1%	-3%	-187%	162%	-2200%	-8%	-141%	-550%	42%
Case 9	7%	-329%	-26%	15%	0%	-175%	178%	-1429%	-9%	-139%	-598%	46%
Case 10	21%	-333%	-29%	-134%	8%	22%	-491%	-1383%	-10%	60%	231%	-247%
Case 11	35%	-200%	-15%	-127%	26%	49%	-409%	-886%	5%	83%	256%	-224%
minimum error	**0%**	**-600%**	**-33%**	**-134%**	**-3%**	**-187%**	**-491%**	**-2200%**	**-10%**	**-141%**	**-598%**	**-247%**
maximum error	**35%**	**-200%**	**-15%**	**15%**	**26%**	**49%**	**178%**	**-886%**	**5%**	**83%**	**256%**	**46%**
average error	**16%**	**-365%**	**-26%**	**-62%**	**8%**	**-73%**	**-140%**	**-1474%**	**-5%**	**-34%**	**-165%**	**-96%**
std. dev. error	**16%**	**168%**	**8%**	**79%**	**13%**	**126%**	**359%**	**543%**	**7%**	**122%**	**472%**	**162%**
Total Stress Case 1	-34%	-34%	6%	-27%	18%	-96%	-33%	-78%	12%	-47%	-34%	-49%
Total Stress Case 2	-32%	-33%	8%	-24%	19%	-92%	-27%	-75%	13%	-47%	-34%	-44%
Total Stress Case 3	-33%	-34%	9%	-31%	18%	-81%	-50%	-76%	13%	-40%	-18%	-57%
Total Stress Case 4	-32%	-33%	9%	-41%	19%	-66%	-80%	-73%	13%	-26%	6%	-76%
Total Stress Case 5	-31%	-33%	7%	-51%	18%	-59%	-106%	-76%	12%	-18%	21%	-96%
Total Stress Case 6	-29%	-32%	9%	-48%	19%	-56%	-99%	-71%	14%	-14%	24%	-92%
minimum error	**-34%**	**-34%**	**6%**	**-51%**	**18%**	**-96%**	**-106%**	**-78%**	**12%**	**-47%**	**-34%**	**-96%**
maximum error	**-29%**	**-32%**	**9%**	**-24%**	**19%**	**-56%**	**-27%**	**-71%**	**14%**	**-14%**	**24%**	**-44%**
average error	**-32%**	**-33%**	**8%**	**-37%**	**19%**	**-75%**	**-66%**	**-75%**	**13%**	**-32%**	**-6%**	**-69%**
std. dev. error	**2%**	**1%**	**1%**	**11%**	**1%**	**17%**	**34%**	**3%**	**1%**	**15%**	**27%**	**22%**
Total Stress Case 7	-30%	-33%	9%	-36%	19%	-73%	-64%	-73%	14%	-29%	-3%	-67%
Total Stress Case 8	-34%	-34%	12%	-30%	19%	-75%	-44%	-65%	17%	-36%	-9%	-53%
Total Stress Case 9	-33%	-34%	12%	-28%	19%	-76%	-42%	-66%	16%	-37%	-12%	-52%
Total Stress Case 10	-33%	-34%	13%	-39%	19%	-60%	-75%	-64%	17%	-22%	14%	-73%
Total Stress Case 11	-32%	-33%	14%	-38%	20%	-59%	-71%	-61%	18%	-21%	14%	-71%
minimum error	**-34%**	**-34%**	**12%**	**-39%**	**19%**	**-76%**	**-75%**	**-66%**	**16%**	**-37%**	**-12%**	**-73%**
maximum error	**-32%**	**-33%**	**14%**	**-28%**	**20%**	**-59%**	**-42%**	**-61%**	**18%**	**-21%**	**14%**	**-52%**
average error	**-33%**	**-34%**	**13%**	**-34%**	**19%**	**-67%**	**-58%**	**-64%**	**17%**	**-29%**	**2%**	**-62%**
std. dev. error	**1%**	**1%**	**1%**	**6%**	**0%**	**9%**	**17%**	**2%**	**1%**	**9%**	**14%**	**12%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	19B	20B	21B	22B	23B	24B	19B	20B	21B	22B	23B	24B
Step 1-1	37%	-96%	-137%	254%	-23%	171%	37%	-96%	-137%	254%	-23%	171%
Step 1-2	-1850%	691%	18%	468%	11%	-149%	-1850%	691%	18%	468%	11%	-149%
Step 1-3	-71%	-58%	1%	375%	29%	-2%	-71%	-58%	1%	375%	29%	-2%
Step 2-2	-46%	-66%	18%	756%	55%	11%	-46%	-66%	18%	756%	55%	11%
Step 2-3a	-52%	-64%	13%	2258%	48%	3%	-52%	-64%	13%	2258%	48%	3%
Step 3-3a	-23%	-2%	-13%	-212%	17%	-11%	-23%	-2%	-13%	-212%	17%	-11%
Step 4-1	-15%	11%	28%	-34%	29%	21%	-24%	3%	29%	-31%	23%	22%
Step 4-2	-25%	8%	15%	-35%	20%	15%	-42%	-7%	18%	-30%	9%	16%
minimum error	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**
maximum error	**37%**	**691%**	**28%**	**2258%**	**55%**	**171%**	**37%**	**691%**	**29%**	**2258%**	**55%**	**171%**
average error	**-256%**	**53%**	**-7%**	**479%**	**23%**	**7%**	**-259%**	**50%**	**-7%**	**480%**	**21%**	**8%**
std. dev. error	**645%**	**261%**	**54%**	**784%**	**24%**	**86%**	**644%**	**262%**	**54%**	**784%**	**24%**	**86%**
Case 1	-152%	-132%	-99%	-27%	-45%	-97%	-588%	-864%	-79%	-25%	-458%	-84%
Case 2	-97%	-72%	-79%	10%	-15%	-89%	-442%	-655%	-69%	-5%	-382%	-80%
Case 3	-80%	-33%	-76%	-27%	11%	-65%	-480%	-488%	-69%	-30%	-235%	-67%
Case 4	-52%	-26%	-69%	-88%	15%	-9%	-414%	-369%	-40%	-49%	-120%	-9%
Case 5	-65%	-53%	-75%	-120%	-6%	15%	-446%	-413%	-32%	-66%	-122%	22%
Case 6	-52%	-56%	-57%	-108%	-6%	33%	-369%	-388%	-11%	-51%	-101%	47%
minimum error	**-152%**	**-132%**	**-99%**	**-120%**	**-45%**	**-97%**	**-588%**	**-864%**	**-79%**	**-66%**	**-458%**	**-84%**
maximum error	**-52%**	**-26%**	**-57%**	**10%**	**15%**	**33%**	**-369%**	**-369%**	**-11%**	**-5%**	**-101%**	**47%**
average error	**-83%**	**-62%**	**-76%**	**-60%**	**-8%**	**-35%**	**-457%**	**-529%**	**-50%**	**-37%**	**-236%**	**-29%**
std. dev. error	**38%**	**38%**	**14%**	**53%**	**21%**	**56%**	**74%**	**194%**	**27%**	**22%**	**152%**	**56%**
Case 7	-116%	-112%	-73%	-73%	-27%	-30%	-519%	-662%	-36%	-36%	-263%	-14%
Case 8	-1500%	675%	-65%	2%	-113%	-68%	-4200%	2350%	-42%	12%	-681%	-54%
Case 9	-675%	1200%	-49%	31%	-83%	-64%	-2200%	5150%	-49%	9%	-689%	-63%
Case 10	-338%	-2300%	-45%	-84%	-57%	29%	-1300%	-7600%	-7%	-37%	-219%	39%
Case 11	-480%	767%	-29%	-74%	-87%	47%	-1640%	2067%	12%	-25%	-233%	60%
minimum error	**-1500%**	**-2300%**	**-65%**	**-84%**	**-113%**	**-68%**	**-4200%**	**-7600%**	**-49%**	**-37%**	**-689%**	**-63%**
maximum error	**-338%**	**1200%**	**-29%**	**31%**	**-57%**	**47%**	**-1300%**	**5150%**	**12%**	**12%**	**-219%**	**60%**
average error	**-748%**	**85%**	**-47%**	**-31%**	**-85%**	**-14%**	**-2335%**	**492%**	**-21%**	**-10%**	**-456%**	**-4%**
std. dev. error	**520%**	**1607%**	**14%**	**57%**	**23%**	**61%**	**1298%**	**5571%**	**29%**	**24%**	**265%**	**63%**
Total Stress Case 1	-30%	4%	4%	-34%	17%	0%	-63%	-30%	8%	-29%	-13%	2%
Total Stress Case 2	-28%	5%	6%	-29%	18%	2%	-59%	-27%	10%	-27%	-11%	3%
Total Stress Case 3	-27%	6%	8%	-34%	19%	6%	-60%	-24%	11%	-30%	-5%	7%
Total Stress Case 4	-26%	6%	8%	-42%	20%	13%	-60%	-20%	13%	-32%	1%	13%
Total Stress Case 5	-27%	5%	5%	-50%	18%	15%	-67%	-24%	13%	-36%	1%	16%
Total Stress Case 6	-26%	5%	7%	-48%	19%	17%	-62%	-20%	15%	-33%	3%	19%
minimum error	**-30%**	**4%**	**4%**	**-50%**	**17%**	**0%**	**-67%**	**-30%**	**8%**	**-36%**	**-13%**	**2%**
maximum error	**-26%**	**6%**	**8%**	**-29%**	**20%**	**17%**	**-59%**	**-20%**	**15%**	**-27%**	**3%**	**19%**
average error	**-27%**	**5%**	**6%**	**-40%**	**19%**	**9%**	**-62%**	**-24%**	**12%**	**-31%**	**-4%**	**10%**
std. dev. error	**1%**	**1%**	**2%**	**8%**	**1%**	**7%**	**3%**	**4%**	**2%**	**3%**	**7%**	**7%**
Total Stress Case 7	-29%	4%	6%	-41%	18%	9%	-63%	-25%	12%	-31%	-5%	12%
Total Stress Case 8	-28%	5%	11%	-32%	18%	10%	-52%	-17%	15%	-27%	0%	11%
Total Stress Case 9	-28%	5%	12%	-30%	18%	10%	-52%	-18%	15%	-27%	-1%	10%
Total Stress Case 10	-28%	5%	12%	-39%	19%	16%	-54%	-15%	17%	-30%	5%	17%
Total Stress Case 11	-28%	5%	13%	-38%	19%	17%	-52%	-14%	18%	-29%	6%	18%
minimum error	**-28%**	**5%**	**11%**	**-39%**	**18%**	**10%**	**-54%**	**-18%**	**15%**	**-30%**	**-1%**	**10%**
maximum error	**-28%**	**5%**	**13%**	**-30%**	**19%**	**17%**	**-52%**	**-14%**	**18%**	**-27%**	**6%**	**18%**
average error	**-28%**	**5%**	**12%**	**-35%**	**19%**	**13%**	**-53%**	**-16%**	**16%**	**-28%**	**2%**	**14%**
std. dev. error	**0%**	**0%**	**1%**	**5%**	**0%**	**4%**	**1%**	**2%**	**1%**	**2%**	**4%**	**4%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis				Part. Non-Composite Analysis			
	1C	**2C**	**3C**	**4C**	**1C**	**2C**	**3C**	**4C**
Step 1-1	104%	643%	136%	116%	104%	643%	136%	116%
Step 1-2	94%	372%	132%	114%	94%	372%	132%	114%
Step 1-3	64%	-2313%	119%	101%	64%	-2313%	119%	101%
Step 2-2	69%		121%	102%	69%		121%	102%
Step 2-3a	62%	6100%	161%	54%	62%	6100%	161%	54%
Step 3-3a	63%	-175%	380%	57%	63%	-175%	380%	57%
Step 4-1	60%	1190%	274%	57%	60%	1188%	277%	56%
Step 4-2	62%	879%	-1008%	65%	62%	881%	-1035%	64%
minimum error	**60%**	**-2313%**	**-1008%**	**54%**	**60%**	**-2313%**	**-1035%**	**54%**
maximum error	**104%**	**6100%**	**380%**	**116%**	**104%**	**6100%**	**380%**	**116%**
average error	**72%**	**957%**	**39%**	**83%**	**72%**	**957%**	**36%**	**83%**
std. dev. error	**17%**	**2547%**	**433%**	**27%**	**17%**	**2547%**	**443%**	**27%**
Case 1	183%	-92%	14%	66%	160%	-92%	15%	61%
Case 2	218%	-93%	20%	74%	188%	-92%	23%	70%
Case 3	353%	-104%	51%	88%	297%	-100%	54%	84%
Case 4	159%	42%	121%	120%	118%	54%	113%	115%
Case 5	372%	67%	229%	56%	295%	103%	188%	59%
Case 6	398%	86%	236%	72%	312%	126%	188%	75%
minimum error	**159%**	**-104%**	**14%**	**56%**	**118%**	**-100%**	**15%**	**59%**
maximum error	**398%**	**86%**	**236%**	**120%**	**312%**	**126%**	**188%**	**115%**
average error	**280%**	**-16%**	**112%**	**79%**	**228%**	**0%**	**97%**	**77%**
std. dev. error	**105%**	**89%**	**101%**	**22%**	**83%**	**106%**	**78%**	**21%**
Case 7	89%	-43%	50%	32%	93%	-52%	45%	20%
Case 8	186%	-205%	37%	66%	166%	-205%	38%	62%
Case 9	343%	-279%	55%	77%	287%	-279%	57%	73%
Case 10	239%	90%	135%	-267%	200%	105%	124%	-233%
Case 11	256%	97%	133%	-200%	209%	114%	121%	-167%
minimum error	**186%**	**-279%**	**37%**	**-267%**	**166%**	**-279%**	**38%**	**-233%**
maximum error	**343%**	**97%**	**135%**	**77%**	**287%**	**114%**	**124%**	**73%**
average error	**256%**	**-74%**	**90%**	**-81%**	**216%**	**-66%**	**85%**	**-66%**
std. dev. error	**65%**	**196%**	**51%**	**178%**	**51%**	**205%**	**44%**	**157%**
Total Stress Case 1	76%	-991%	-68%	65%	74%	-994%	-68%	63%
Total Stress Case 2	78%	-1588%	-65%	67%	75%	-1588%	-65%	65%
Total Stress Case 3	72%	1485%	-80%	69%	70%	1485%	-80%	68%
Total Stress Case 4	60%	648%	-116%	68%	61%	653%	-128%	67%
Total Stress Case 5	49%	584%	-170%	65%	53%	598%	-206%	64%
Total Stress Case 6	47%	596%	-176%	64%	51%	611%	-217%	63%
minimum error	**47%**	**-1588%**	**-176%**	**64%**	**51%**	**-1588%**	**-217%**	**63%**
maximum error	**78%**	**1485%**	**-65%**	**69%**	**75%**	**1485%**	**-65%**	**68%**
average error	**64%**	**122%**	**-112%**	**66%**	**64%**	**127%**	**-127%**	**65%**
std. dev. error	**13%**	**1161%**	**50%**	**2%**	**10%**	**1164%**	**69%**	**2%**
Total Stress Case 7	64%	-1658%	-67%	62%	64%	-1683%	-75%	61%
Total Stress Case 8	68%	3389%	-81%	65%	67%	3395%	-84%	63%
Total Stress Case 9	70%	1210%	-77%	66%	68%	1212%	-78%	65%
Total Stress Case 10	56%	577%	-142%	65%	57%	584%	-157%	64%
Total Stress Case 11	55%	595%	-134%	65%	57%	602%	-150%	64%
minimum error	**55%**	**577%**	**-142%**	**65%**	**57%**	**584%**	**-157%**	**63%**
maximum error	**70%**	**3389%**	**-77%**	**66%**	**68%**	**3395%**	**-78%**	**65%**
average error	**62%**	**1443%**	**-109%**	**65%**	**63%**	**1448%**	**-117%**	**64%**
std. dev. error	**8%**	**1331%**	**34%**	**1%**	**6%**	**1330%**	**42%**	**1%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis				Part. Non-Composite Analysis			
	5C	**6C**	**7C**	**8C**	**5C**	**6C**	**7C**	**8C**
Step 1-1	71%	186%	-1588%	100%	71%	186%	-1588%	100%
Step 1-2	25%	-14500%	457%	97%	25%	-14500%	457%	97%
Step 1-3	60%	-135%	32%	96%	60%	-135%	32%	96%
Step 2-2	71%	-173%	39%	97%	71%	-173%	39%	97%
Step 2-3a	65%	-182%	14%	70%	65%	-182%	14%	70%
Step 3-3a	68%	-67%	9%	56%	68%	-67%	9%	56%
Step 4-1	67%	-59%	17%	59%	67%	-61%	15%	58%
Step 4-2	72%	-27%	33%	72%	72%	-30%	30%	70%
minimum error	**25%**	**-14500%**	**-1588%**	**56%**	**25%**	**-14500%**	**-1588%**	**56%**
maximum error	**72%**	**186%**	**457%**	**100%**	**72%**	**186%**	**457%**	**100%**
average error	**63%**	**-1870%**	**-123%**	**81%**	**62%**	**-1870%**	**-124%**	**81%**
std. dev. error	**16%**	**5105%**	**611%**	**18%**	**16%**	**5104%**	**611%**	**19%**
Case 1	157%	-119%	-33%	8%	128%	-128%	-35%	-19%
Case 2	175%	-111%	-16%	38%	142%	-118%	-17%	16%
Case 3	232%	-127%	21%	63%	183%	-146%	20%	46%
Case 4	167%	-14%	196%	176%	100%	29%	160%	165%
Case 5	411%	-59%	-620%	-9%	289%	-11%	-440%	-18%
Case 6	445%	-52%	-472%	15%	310%	0%	-316%	8%
minimum error	**157%**	**-127%**	**-620%**	**-9%**	**100%**	**-146%**	**-440%**	**-19%**
maximum error	**445%**	**-14%**	**196%**	**176%**	**310%**	**29%**	**160%**	**165%**
average error	**264%**	**-80%**	**-154%**	**49%**	**192%**	**-62%**	**-105%**	**33%**
std. dev. error	**130%**	**45%**	**318%**	**67%**	**88%**	**77%**	**226%**	**69%**
Case 7	84%	-53%	-20%	176%	84%	-69%	-38%	207%
Case 8	159%	-196%	-9%	50%	131%	-209%	-12%	36%
Case 9	239%	-207%	21%	64%	189%	-214%	21%	50%
Case 10	273%	48%	300%	227%	207%	64%	252%	245%
Case 11	307%	51%	267%	218%	221%	68%	221%	227%
minimum error	**159%**	**-207%**	**-9%**	**50%**	**131%**	**-214%**	**-12%**	**36%**
maximum error	**307%**	**51%**	**300%**	**227%**	**221%**	**68%**	**252%**	**245%**
average error	**245%**	**-76%**	**145%**	**140%**	**187%**	**-73%**	**121%**	**140%**
std. dev. error	**64%**	**145%**	**161%**	**96%**	**40%**	**160%**	**135%**	**112%**
Total Stress Case 1	83%	-52%	14%	66%	79%	-57%	11%	61%
Total Stress Case 2	85%	-47%	18%	68%	81%	-52%	16%	64%
Total Stress Case 3	81%	-35%	31%	71%	79%	-40%	28%	68%
Total Stress Case 4	72%	-28%	42%	74%	72%	-34%	38%	72%
Total Stress Case 5	63%	-24%	49%	76%	66%	-32%	42%	74%
Total Stress Case 6	61%	-25%	49%	75%	65%	-33%	41%	74%
minimum error	**61%**	**-52%**	**14%**	**66%**	**65%**	**-57%**	**11%**	**61%**
maximum error	**85%**	**-24%**	**49%**	**76%**	**81%**	**-32%**	**42%**	**74%**
average error	**74%**	**-35%**	**34%**	**72%**	**74%**	**-41%**	**29%**	**69%**
std. dev. error	**11%**	**12%**	**16%**	**4%**	**7%**	**11%**	**13%**	**5%**
Total Stress Case 7	73%	-32%	25%	68%	73%	-38%	20%	65%
Total Stress Case 8	77%	-47%	25%	70%	75%	-52%	22%	68%
Total Stress Case 9	79%	-39%	31%	71%	77%	-42%	29%	68%
Total Stress Case 10	68%	-35%	42%	74%	69%	-41%	38%	73%
Total Stress Case 11	68%	-35%	42%	74%	69%	-40%	38%	73%
minimum error	**68%**	**-47%**	**25%**	**70%**	**69%**	**-52%**	**22%**	**68%**
maximum error	**79%**	**-35%**	**42%**	**74%**	**77%**	**-40%**	**38%**	**73%**
average error	**73%**	**-39%**	**35%**	**72%**	**73%**	**-44%**	**32%**	**70%**
std. dev. error	**6%**	**6%**	**9%**	**2%**	**4%**	**5%**	**8%**	**3%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 6

	Composite Analysis				Part. Non-Composite Analysis			
	9C	10C	11C	12C	9C	10C	11C	12C
Step 1-1	49%	77%	162%	109%	49%	77%	162%	109%
Step 1-2	184%	-35%	-133%	82%	184%	-35%	-133%	82%
Step 1-3	95%	35%	-296%	113%	95%	35%	-296%	113%
Step 2-2	97%	23%	-88%		97%	23%	-88%	
Step 2-3a	90%	8%	-70%		90%	8%	-70%	
Step 3-3a	22%	1%	-71%	131%	22%	1%	-71%	131%
Step 4-1	11%	5%	32%		12%	1%	29%	
Step 4-2	63%	-56%	43%	118%	64%	-67%	39%	116%
minimum error	**11%**	**-56%**	**-296%**	**82%**	**12%**	**-67%**	**-296%**	**82%**
maximum error	**184%**	**77%**	**162%**	**131%**	**184%**	**77%**	**162%**	**131%**
average error	**76%**	**7%**	**-53%**	**111%**	**77%**	**5%**	**-54%**	**110%**
std. dev. error	**54%**	**41%**	**136%**	**18%**	**54%**	**43%**	**135%**	**18%**
Case 1	140%	-106%	-80%		100%	-147%	-111%	
Case 2	164%	-79%	-43%		115%	-121%	-70%	
Case 3	259%	-13%	16%		182%	-74%	-12%	
Case 4	107%	-68%	629%		87%	-32%	500%	
Case 5	197%	-13%	-79%	0%	148%	-34%	-89%	-117%
Case 6	206%	7%	-56%	36%	156%	-19%	-64%	-18%
minimum error	**107%**	**-106%**	**-80%**	**0%**	**87%**	**-147%**	**-111%**	**-117%**
maximum error	**259%**	**7%**	**629%**	**36%**	**182%**	**-19%**	**500%**	**-18%**
average error	**179%**	**-45%**	**65%**	**18%**	**131%**	**-71%**	**26%**	**-67%**
std. dev. error	**54%**	**45%**	**279%**	**26%**	**37%**	**53%**	**235%**	**70%**
Case 7	257%	-769%	893%	28%	271%	-900%	1050%	36%
Case 8	188%	-153%	-29%		88%	-193%	-47%	
Case 9	733%	-60%	19%		400%	-110%	1%	
Case 10	139%	44%	-850%		121%	30%	-925%	
Case 11	147%	53%	-3400%		125%	38%	-3600%	
minimum error	**139%**	**-153%**	**-3400%**		**88%**	**-193%**	**-3600%**	
maximum error	**733%**	**53%**	**19%**		**400%**	**38%**	**1%**	
average error	**302%**	**-29%**	**-1065%**		**183%**	**-59%**	**-1143%**	
std. dev. error	**288%**	**97%**	**1607%**		**145%**	**112%**	**1692%**	
Total Stress Case 1	31%	-75%	19%		49%	-97%	10%	
Total Stress Case 2	25%	-65%	25%		45%	-87%	16%	
Total Stress Case 3	41%	-48%	39%		51%	-68%	32%	
Total Stress Case 4	66%	-55%	49%		66%	-70%	44%	
Total Stress Case 5	83%	-70%	53%	120%	77%	-77%	50%	121%
Total Stress Case 6	86%	-76%	52%	121%	79%	-81%	49%	121%
minimum error	**25%**	**-76%**	**19%**	**120%**	**45%**	**-97%**	**10%**	**121%**
maximum error	**86%**	**-48%**	**53%**	**121%**	**79%**	**-68%**	**50%**	**121%**
average error	**56%**	**-65%**	**40%**	**121%**	**61%**	**-80%**	**33%**	**121%**
std. dev. error	**27%**	**11%**	**14%**	**1%**	**15%**	**11%**	**17%**	**0%**
Total Stress Case 7	70%	-101%	25%	127%	72%	-119%	18%	124%
Total Stress Case 8	57%	-76%	33%		63%	-92%	27%	
Total Stress Case 9	51%	-57%	39%		58%	-74%	33%	
Total Stress Case 10	75%	-78%	48%		73%	-88%	45%	
Total Stress Case 11	76%	-78%	48%		74%	-88%	44%	
minimum error	**51%**	**-78%**	**33%**		**58%**	**-92%**	**27%**	
maximum error	**76%**	**-57%**	**48%**		**74%**	**-74%**	**45%**	
average error	**65%**	**-72%**	**42%**		**67%**	**-85%**	**37%**	
std. dev. error	**13%**	**10%**	**7%**		**8%**	**8%**	**9%**	

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis						Part. Non-Composite Analysis					
	1A	**2A**	**3A**	**4A**	**5A**	**6A**	**1A**	**2A**	**3A**	**4A**	**5A**	**6A**
Step 1-1	210%	-27%	49%	-12%	-128%	56%	210%	-27%	49%	-12%	-128%	56%
Step 1-2	4%	28%	-189%	975%	4680%	-55%	4%	28%	-189%	975%	4680%	-55%
Step 1-3	-46%	-7%	-1%	-241%	-47%	-46%	-46%	-7%	-1%	-241%	-47%	-46%
Step 2-2	213%	-2%	-27%	-391%	-65%	-83%	213%	-2%	-27%	-391%	-65%	-83%
Step 2-3a	60%	-10%	-39%	-354%	-62%	-92%	60%	-10%	-39%	-354%	-62%	-92%
Step 3-3a	-71%	-27%	0%	-49%	-26%	-33%	-71%	-27%	0%	-49%	-26%	-33%
Step 4-1	-95%	-24%	2%	-38%	-29%	-29%	-97%	-24%	0%	-40%	-30%	-31%
Step 4-2	-3%	-6%	3%	-34%	-16%	-19%	-5%	-7%	1%	-36%	-17%	-22%
minimum error	**-95%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**	**-97%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**
maximum error	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**
average error	**34%**	**-9%**	**-25%**	**-18%**	**538%**	**-38%**	**34%**	**-9%**	**-26%**	**-19%**	**538%**	**-38%**
std. dev. error	**120%**	**18%**	**71%**	**429%**	**1674%**	**46%**	**120%**	**18%**	**71%**	**429%**	**1674%**	**46%**
Case 1	-324%	-505%	-1%	-29%	-290%	-2%	-325%	-507%	-2%	-30%	-292%	-2%
Case 2	-262%	-429%	14%	-13%	-249%	11%	-259%	-424%	14%	-13%	-244%	12%
Case 3	-129%	-215%	51%	20%	-126%	45%	-127%	-212%	51%	20%	-121%	46%
Case 4	400%	1150%	149%	192%	900%	139%	300%	800%	133%	163%	633%	126%
Case 5	-508%	-518%	-213%	-356%	-339%	1221%	-362%	-364%	-138%	-256%	-233%	943%
Case 6	-558%	-518%	-123%	-293%	-295%	8000%	-375%	-355%	-64%	-197%	-185%	5800%
minimum error	**-558%**	**-518%**	**-213%**	**-356%**	**-339%**	**-2%**	**-375%**	**-507%**	**-138%**	**-256%**	**-292%**	**-2%**
maximum error	**400%**	**1150%**	**149%**	**192%**	**900%**	**8000%**	**300%**	**800%**	**133%**	**163%**	**633%**	**5800%**
average error	**-230%**	**-173%**	**-21%**	**-80%**	**-66%**	**1569%**	**-191%**	**-177%**	**-1%**	**-52%**	**-74%**	**1154%**
std. dev. error	**347%**	**658%**	**129%**	**206%**	**479%**	**3186%**	**257%**	**488%**	**93%**	**152%**	**351%**	**2305%**
Case 7	-92%	-177%	-15%	-13%	-127%	12%	-111%	-205%	-26%	-24%	-149%	4%
Case 8	-88%	-191%	-1%	-14%	-137%	9%	-90%	-193%	-2%	-16%	-140%	9%
Case 9	-32%	-111%	26%	12%	-88%	35%	-31%	-108%	26%	12%	-85%	36%
Case 10	300%	800%	-750%	688%	-540%	207%	250%	625%	-550%	550%	-380%	180%
Case 11	241%	438%	-1125%	540%	3200%	194%	200%	338%	-775%	430%	2300%	168%
minimum error	**-88%**	**-191%**	**-1125%**	**-14%**	**-540%**	**9%**	**-90%**	**-193%**	**-775%**	**-16%**	**-380%**	**9%**
maximum error	**300%**	**800%**	**26%**	**688%**	**3200%**	**207%**	**250%**	**625%**	**26%**	**550%**	**2300%**	**180%**
average error	**105%**	**234%**	**-463%**	**306%**	**609%**	**111%**	**82%**	**165%**	**-325%**	**244%**	**424%**	**98%**
std. dev. error	**189%**	**449%**	**575%**	**343%**	**1591%**	**101%**	**164%**	**370%**	**401%**	**275%**	**1147%**	**86%**
Total Stress Case 1	-40%	-28%	1%	-32%	-35%	-12%	-42%	-29%	0%	-34%	-36%	-14%
Total Stress Case 2	-32%	-24%	7%	-26%	-31%	-6%	-34%	-24%	6%	-27%	-32%	-8%
Total Stress Case 3	-12%	-11%	16%	-21%	-21%	0%	-14%	-12%	15%	-23%	-22%	-1%
Total Stress Case 4	3%	-3%	17%	-19%	-14%	2%	-1%	-5%	13%	-23%	-16%	-2%
Total Stress Case 5	9%	1%	15%	-18%	-11%	3%	4%	-3%	8%	-25%	-14%	-5%
Total Stress Case 6	9%	1%	13%	-19%	-11%	2%	3%	-3%	6%	-27%	-15%	-7%
minimum error	**-40%**	**-28%**	**1%**	**-32%**	**-35%**	**-12%**	**-42%**	**-29%**	**0%**	**-34%**	**-36%**	**-14%**
maximum error	**9%**	**1%**	**17%**	**-18%**	**-11%**	**3%**	**4%**	**-3%**	**15%**	**-23%**	**-14%**	**-1%**
average error	**-11%**	**-11%**	**12%**	**-22%**	**-20%**	**-2%**	**-14%**	**-13%**	**8%**	**-26%**	**-23%**	**-6%**
std. dev. error	**22%**	**12%**	**6%**	**5%**	**10%**	**6%**	**20%**	**12%**	**6%**	**4%**	**9%**	**4%**
Total Stress Case 7	-13%	-13%	-1%	-29%	-22%	-11%	-16%	-15%	-4%	-33%	-24%	-15%
Total Stress Case 8	-14%	-14%	2%	-29%	-23%	-11%	-16%	-15%	0%	-31%	-25%	-13%
Total Stress Case 9	-6%	-10%	7%	-24%	-19%	-5%	-8%	-11%	6%	-26%	-21%	-7%
Total Stress Case 10	6%	-2%	9%	-23%	-14%	-3%	2%	-4%	5%	-27%	-16%	-7%
Total Stress Case 11	6%	-2%	9%	-23%	-13%	-2%	3%	-4%	5%	-28%	-16%	-7%
minimum error	**-14%**	**-14%**	**2%**	**-29%**	**-23%**	**-11%**	**-16%**	**-15%**	**0%**	**-31%**	**-25%**	**-13%**
maximum error	**6%**	**-2%**	**9%**	**-23%**	**-13%**	**-2%**	**3%**	**-4%**	**6%**	**-26%**	**-16%**	**-7%**
average error	**-2%**	**-7%**	**7%**	**-25%**	**-17%**	**-5%**	**-5%**	**-8%**	**4%**	**-28%**	**-20%**	**-9%**
std. dev. error	**10%**	**6%**	**3%**	**3%**	**5%**	**4%**	**9%**	**6%**	**3%**	**2%**	**4%**	**3%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 8											
	Composite Analysis						Part. Non-Composite Analysis					
	7A	8A	9A	10A	11A	12A	7A	8A	9A	10A	11A	12A
Step 1-1	105%	156%	85%	92%	50%	174%	105%	156%	85%	92%	50%	174%
Step 1-2	118%	-1750%	-88%	76%	13%	137%	118%	-1750%	-88%	76%	13%	137%
Step 1-3	184%	-42%	-77%	43%	-83%	875%	184%	-42%	-77%	43%	-83%	875%
Step 2-2	413%	-30%	-202%	34%	-32%	285%	413%	-30%	-202%	34%	-32%	285%
Step 2-3a	646%	-36%	-184%	26%	-44%	336%	646%	-36%	-184%	26%	-44%	336%
Step 3-3a	-255%	-17%	-73%	19%	-58%	-346%	-255%	-17%	-73%	19%	-58%	-346%
Step 4-1	-192%	-4%	-99%	18%	-64%	-461%	-194%	-4%	-102%	17%	-65%	-468%
Step 4-2	-93%	4%	-104%	11%	-40%	-521%	-95%	4%	-108%	9%	-41%	-535%
minimum error	**-255%**	**-1750%**	**-202%**	**11%**	**-83%**	**-521%**	**-255%**	**-1750%**	**-202%**	**9%**	**-83%**	**-535%**
maximum error	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**
average error	**116%**	**-215%**	**-93%**	**40%**	**-32%**	**60%**	**115%**	**-215%**	**-94%**	**39%**	**-33%**	**57%**
std. dev. error	**305%**	**624%**	**87%**	**30%**	**44%**	**476%**	**305%**	**624%**	**87%**	**30%**	**44%**	**479%**
Case 1	-176%	-279%	-40%	-96%	-307%	-45%	-181%	-285%	-44%	-103%	-319%	-48%
Case 2	-123%	-211%	-30%	-89%	-256%	-27%	-125%	-215%	-34%	-96%	-260%	-29%
Case 3	-12%	-70%	-16%	-96%	-124%	14%	-16%	-74%	-23%	-114%	-132%	10%
Case 4	206%	1600%	-67%	-23%	1000%	254%	171%	1100%	-19%	8%	700%	207%
Case 5	-1467%	-124%	-52%	-48%	-370%	-318%	-1067%	-71%	-20%	-22%	-260%	-225%
Case 6	-800%	-106%	-45%	-36%	-400%	-256%	-560%	-50%	-12%	-9%	-267%	-166%
minimum error	**-1467%**	**-279%**	**-67%**	**-96%**	**-400%**	**-318%**	**-1067%**	**-285%**	**-44%**	**-114%**	**-319%**	**-225%**
maximum error	**206%**	**1600%**	**-16%**	**-23%**	**1000%**	**254%**	**171%**	**1100%**	**-12%**	**8%**	**700%**	**207%**
average error	**-395%**	**135%**	**-42%**	**-65%**	**-76%**	**-63%**	**-296%**	**68%**	**-25%**	**-56%**	**-90%**	**-42%**
std. dev. error	**623%**	**722%**	**17%**	**33%**	**536%**	**205%**	**448%**	**514%**	**12%**	**54%**	**392%**	**151%**
Case 7	-67%	-159%	-45%	-137%	-153%	-32%	-82%	-181%	-57%	-158%	-173%	-44%
Case 8	-60%	-124%	-45%	-138%	-133%	-34%	-63%	-129%	-49%	-146%	-138%	-37%
Case 9	0%	-48%	-38%	-186%	-60%	-1%	-2%	-52%	-43%	-200%	-63%	-4%
Case 10	258%	-650%	22%	30%	733%	-4600%	217%	-500%	37%	43%	567%	-3600%
Case 11	206%	-1300%	11%	31%	383%	1567%	175%	-900%	32%	45%	300%	1167%
minimum error	**-60%**	**-1300%**	**-45%**	**-186%**	**-133%**	**-4600%**	**-63%**	**-900%**	**-49%**	**-200%**	**-138%**	**-3600%**
maximum error	**258%**	**-48%**	**22%**	**31%**	**733%**	**1567%**	**217%**	**-52%**	**37%**	**45%**	**567%**	**1167%**
average error	**101%**	**-531%**	**-12%**	**-66%**	**231%**	**-767%**	**82%**	**-395%**	**-6%**	**-64%**	**167%**	**-619%**
std. dev. error	**152%**	**608%**	**33%**	**112%**	**387%**	**2873%**	**134%**	**406%**	**45%**	**126%**	**315%**	**2231%**
Total Stress Case 1	-108%	-12%	-72%	-13%	-59%	-168%	-109%	-13%	-76%	-16%	-62%	-175%
Total Stress Case 2	-99%	-8%	-70%	-9%	-54%	-163%	-99%	-9%	-74%	-11%	-56%	-169%
Total Stress Case 3	-84%	2%	-83%	4%	-43%	-225%	-84%	1%	-89%	1%	-45%	-235%
Total Stress Case 4	-80%	6%	-106%	12%	-37%	-386%	-82%	5%	-115%	9%	-40%	-408%
Total Stress Case 5	-82%	7%	-116%	16%	-35%	-576%	-86%	5%	-129%	12%	-39%	-622%
Total Stress Case 6	-84%	7%	-117%	15%	-35%	-606%	-87%	5%	-131%	11%	-39%	-657%
minimum error	**-108%**	**-12%**	**-117%**	**-13%**	**-59%**	**-606%**	**-109%**	**-13%**	**-131%**	**-16%**	**-62%**	**-657%**
maximum error	**-80%**	**7%**	**-70%**	**16%**	**-35%**	**-163%**	**-82%**	**5%**	**-74%**	**12%**	**-39%**	**-169%**
average error	**-89%**	**1%**	**-94%**	**4%**	**-44%**	**-354%**	**-91%**	**-1%**	**-102%**	**1%**	**-47%**	**-378%**
std. dev. error	**11%**	**8%**	**22%**	**12%**	**10%**	**201%**	**11%**	**8%**	**26%**	**12%**	**10%**	**221%**
Total Stress Case 7	-90%	-2%	-86%	-4%	-46%	-235%	-93%	-3%	-93%	-8%	-48%	-248%
Total Stress Case 8	-88%	-2%	-84%	-5%	-46%	-225%	-89%	-3%	-89%	-8%	-48%	-233%
Total Stress Case 9	-81%	2%	-90%	1%	-41%	-255%	-82%	2%	-95%	-1%	-43%	-265%
Total Stress Case 10	-82%	6%	-125%	9%	-37%	-490%	-84%	5%	-133%	7%	-39%	-515%
Total Stress Case 11	-81%	6%	-119%	9%	-37%	-475%	-83%	5%	-127%	7%	-39%	-500%
minimum error	**-88%**	**-2%**	**-125%**	**-5%**	**-46%**	**-490%**	**-89%**	**-3%**	**-133%**	**-8%**	**-48%**	**-515%**
maximum error	**-81%**	**6%**	**-84%**	**9%**	**-37%**	**-225%**	**-82%**	**5%**	**-89%**	**7%**	**-39%**	**-233%**
average error	**-83%**	**3%**	**-105%**	**4%**	**-40%**	**-361%**	**-84%**	**2%**	**-111%**	**1%**	**-42%**	**-378%**
std. dev. error	**3%**	**4%**	**20%**	**7%**	**4%**	**141%**	**3%**	**4%**	**22%**	**7%**	**4%**	**150%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 8											
	Composite Analysis						Part. Non-Composite Analysis					
	13A	14A	15A	16A	17A	18A	13A	14A	15A	16A	17A	18A
Step 1-1	86%	0%	280%	122%	113%	123%	86%	0%	280%	122%	113%	123%
Step 1-2	95%	475%	90%	137%	108%	47%	95%	475%	90%	137%	108%	47%
Step 1-3	229%	-241%	297%	31%	30%	-195%	229%	-241%	297%	31%	30%	-195%
Step 2-2	240%	-126%	249%	32%	24%	-491%	240%	-126%	249%	32%	24%	-491%
Step 2-3a	310%	-122%	296%	26%	14%	-503%	310%	-122%	296%	26%	14%	-503%
Step 3-3a	-211%	-143%	-414%	24%	-12%	-130%	-211%	-143%	-414%	24%	-12%	-130%
Step 4-1	-93%	-103%	-316%	18%	-3%	-94%	-94%	-104%	-322%	17%	-3%	-96%
Step 4-2	-51%	-59%	-324%	16%	6%	-114%	-53%	-60%	-334%	13%	5%	-118%
minimum error	**-211%**	**-241%**	**-414%**	**16%**	**-12%**	**-503%**	**-211%**	**-241%**	**-414%**	**13%**	**-12%**	**-503%**
maximum error	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**
average error	**76%**	**-40%**	**20%**	**51%**	**35%**	**-170%**	**75%**	**-40%**	**18%**	**50%**	**35%**	**-170%**
std. dev. error	**183%**	**219%**	**316%**	**49%**	**49%**	**226%**	**183%**	**219%**	**318%**	**49%**	**49%**	**226%**
Case 1	-291%	-463%	-71%	7%	-251%	-98%	-316%	-500%	-81%	0%	-278%	-107%
Case 2	-229%	-342%	-48%	24%	-187%	-78%	-251%	-375%	-58%	17%	-211%	-86%
Case 3	-55%	-80%	-9%	55%	-26%	-37%	-82%	-113%	-26%	44%	-52%	-54%
Case 4	800%	375%	-11%	-38%	240%	-23%	600%	300%	19%	-5%	200%	10%
Case 5	-160%	-950%	-6%	28%	967%	-9%	-130%	-850%	8%	30%	933%	10%
Case 6	-156%	-800%	6%	37%	675%	1%	-122%	-750%	19%	37%	650%	21%
minimum error	**-291%**	**-950%**	**-71%**	**-38%**	**-251%**	**-98%**	**-316%**	**-850%**	**-81%**	**-5%**	**-278%**	**-107%**
maximum error	**800%**	**375%**	**6%**	**55%**	**967%**	**1%**	**600%**	**300%**	**19%**	**44%**	**933%**	**21%**
average error	**-15%**	**-377%**	**-23%**	**19%**	**236%**	**-41%**	**-50%**	**-381%**	**-20%**	**20%**	**207%**	**-34%**
std. dev. error	**407%**	**484%**	**30%**	**32%**	**492%**	**40%**	**331%**	**426%**	**42%**	**20%**	**490%**	**55%**
Case 7	-207%	-196%	-79%	11%	-123%	-110%	-232%	-217%	-92%	4%	-138%	-126%
Case 8	-178%	-159%	-96%	5%	-112%	-124%	-194%	-174%	-105%	-1%	-126%	-132%
Case 9	-44%	-21%	-48%	43%	-3%	-94%	-60%	-33%	-61%	35%	-17%	-106%
Case 10	1100%	200%	48%	47%	177%	43%	1000%	188%	55%	47%	177%	55%
Case 11	367%	170%	51%	52%	153%	45%	367%	160%	59%	52%	153%	57%
minimum error	**-178%**	**-159%**	**-96%**	**5%**	**-112%**	**-124%**	**-194%**	**-174%**	**-105%**	**-1%**	**-126%**	**-132%**
maximum error	**1100%**	**200%**	**51%**	**52%**	**177%**	**45%**	**1000%**	**188%**	**59%**	**52%**	**177%**	**57%**
average error	**311%**	**47%**	**-11%**	**37%**	**54%**	**-32%**	**278%**	**35%**	**-13%**	**33%**	**47%**	**-31%**
std. dev. error	**544%**	**173%**	**74%**	**23%**	**139%**	**87%**	**511%**	**175%**	**83%**	**26%**	**147%**	**99%**
Total Stress Case 1	-75%	-81%	-163%	12%	-7%	-107%	-79%	-86%	-174%	8%	-10%	-115%
Total Stress Case 2	-68%	-74%	-155%	18%	-3%	-100%	-71%	-79%	-166%	15%	-6%	-107%
Total Stress Case 3	-52%	-59%	-214%	23%	5%	-101%	-54%	-63%	-229%	19%	3%	-109%
Total Stress Case 4	-47%	-54%	-409%	17%	9%	-123%	-50%	-58%	-433%	14%	6%	-134%
Total Stress Case 5	-49%	-54%	-553%	14%	9%	-141%	-51%	-57%	-584%	11%	7%	-154%
Total Stress Case 6	-49%	-55%	-553%	13%	9%	-143%	-51%	-58%	-584%	11%	7%	-156%
minimum error	**-75%**	**-81%**	**-553%**	**12%**	**-7%**	**-143%**	**-79%**	**-86%**	**-584%**	**8%**	**-10%**	**-156%**
maximum error	**-47%**	**-54%**	**-155%**	**23%**	**9%**	**-100%**	**-50%**	**-57%**	**-166%**	**19%**	**7%**	**-107%**
average error	**-57%**	**-63%**	**-341%**	**16%**	**4%**	**-119%**	**-59%**	**-67%**	**-361%**	**13%**	**1%**	**-129%**
std. dev. error	**12%**	**12%**	**188%**	**4%**	**7%**	**19%**	**12%**	**12%**	**198%**	**4%**	**8%**	**22%**
Total Stress Case 7	-62%	-66%	-211%	14%	1%	-113%	-65%	-68%	-222%	11%	-1%	-120%
Total Stress Case 8	-61%	-65%	-223%	13%	1%	-116%	-63%	-68%	-234%	10%	-2%	-123%
Total Stress Case 9	-51%	-57%	-242%	20%	6%	-111%	-53%	-60%	-255%	17%	3%	-119%
Total Stress Case 10	-49%	-54%	-508%	14%	9%	-142%	-50%	-56%	-531%	12%	7%	-152%
Total Stress Case 11	-48%	-53%	-479%	14%	9%	-138%	-50%	-56%	-500%	11%	7%	-147%
minimum error	**-61%**	**-65%**	**-508%**	**13%**	**1%**	**-142%**	**-63%**	**-68%**	**-531%**	**10%**	**-2%**	**-152%**
maximum error	**-48%**	**-53%**	**-223%**	**20%**	**9%**	**-111%**	**-50%**	**-56%**	**-234%**	**17%**	**7%**	**-119%**
average error	**-52%**	**-57%**	**-363%**	**15%**	**6%**	**-127%**	**-54%**	**-60%**	**-380%**	**13%**	**4%**	**-135%**
std. dev. error	**6%**	**5%**	**151%**	**3%**	**4%**	**15%**	**6%**	**6%**	**157%**	**3%**	**4%**	**17%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis						Part. Non-Composite Analysis					
	19A	**20A**	**21A**	**22A**	**23A**	**24A**	**19A**	**20A**	**21A**	**22A**	**23A**	**24A**
Step 1-1	135%	-254%	183%	118%	457%	-700%	135%	-254%	183%	118%	457%	-700%
Step 1-2	119%	352%	58%	27%	421%	50%	119%	352%	58%	27%	421%	50%
Step 1-3	49%	-1%	-304%	-10300%	-89%	-224%	49%	-1%	-304%	-10300%	-89%	-224%
Step 2-2	66%	12%	-1414%	591%	15%	-99%	66%	12%	-1414%	591%	15%	-99%
Step 2-3a	55%	6%	-1109%	695%	8%	-144%	55%	6%	-1109%	695%	8%	-144%
Step 3-3a	13%	-5%	-31%	-126%	-30%	-48%	13%	-5%	-31%	-126%	-30%	-48%
Step 4-1	19%	19%	-54%	-38%	-49%	-63%	19%	19%	-56%	-40%	-50%	-65%
Step 4-2	32%	16%	-28%	-77%	-18%	-25%	31%	16%	-31%	-81%	-19%	-27%
minimum error	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**
maximum error	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**
average error	**61%**	**18%**	**-337%**	**-1139%**	**89%**	**-157%**	**61%**	**18%**	**-338%**	**-1140%**	**89%**	**-157%**
std. dev. error	**45%**	**163%**	**592%**	**3715%**	**218%**	**234%**	**45%**	**163%**	**592%**	**3714%**	**219%**	**234%**
Case 1	1825%	843%	2%	-95%	-456%	-11%	1938%	900%	-7%	-116%	-504%	-18%
Case 2	1256%	664%	18%	-74%	-400%	6%	1367%	721%	10%	-99%	-457%	-1%
Case 3		275%	61%	-35%	-800%	60%		338%	46%	-112%	-1200%	49%
Case 4	257%	-167%	-79%	14%	650%	300%	214%	-100%	-29%	32%	500%	238%
Case 5	222%	1000%	37%	46%	271%	-113%	211%	1000%	37%	29%	271%	-75%
Case 6	170%	267%	66%	77%	178%	-67%	170%	300%	54%	45%	200%	-42%
minimum error	**170%**	**-167%**	**-79%**	**-95%**	**-800%**	**-113%**	**170%**	**-100%**	**-29%**	**-116%**	**-1200%**	**-75%**
maximum error	**1825%**	**1000%**	**66%**	**77%**	**650%**	**300%**	**1938%**	**1000%**	**54%**	**45%**	**500%**	**238%**
average error	**746%**	**480%**	**17%**	**-11%**	**-93%**	**29%**	**780%**	**526%**	**19%**	**-37%**	**-198%**	**25%**
std. dev. error	**753%**	**434%**	**53%**	**68%**	**545%**	**145%**	**822%**	**420%**	**32%**	**79%**	**637%**	**112%**
Case 7	-1825%	-2800%	-11%	-154%	-221%	-12%	-1950%	-3000%	-17%	-172%	-242%	-19%
Case 8	-1360%	-5400%	1%	-145%	-204%	-4%	-1440%	-5800%	-6%	-166%	-229%	-9%
Case 9	-156%	-467%	39%	-360%	-64%	45%	-189%	-567%	27%	-480%	-93%	38%
Case 10	129%	160%	70%	86%	136%	340%	129%	160%	70%	80%	136%	300%
Case 11	114%	120%	88%	97%	115%	160%	114%	140%	79%	84%	123%	150%
minimum error	**-1360%**	**-5400%**	**1%**	**-360%**	**-204%**	**-4%**	**-1440%**	**-5800%**	**-6%**	**-480%**	**-229%**	**-9%**
maximum error	**129%**	**160%**	**88%**	**97%**	**136%**	**340%**	**129%**	**160%**	**79%**	**84%**	**136%**	**300%**
average error	**-318%**	**-1397%**	**49%**	**-80%**	**-4%**	**135%**	**-347%**	**-1517%**	**43%**	**-120%**	**-16%**	**120%**
std. dev. error	**769%**	**2934%**	**40%**	**226%**	**166%**	**146%**	**809%**	**3142%**	**41%**	**281%**	**181%**	**132%**
Total Stress Case 1	14%	-2%	-13%	-84%	-36%	-19%	11%	-5%	-20%	-97%	-40%	-24%
Total Stress Case 2	18%	2%	-6%	-76%	-31%	-12%	15%	-1%	-13%	-89%	-35%	-17%
Total Stress Case 3	30%	13%	-7%	-72%	-20%	-6%	28%	11%	-14%	-87%	-24%	-12%
Total Stress Case 4	34%	17%	-26%	-89%	-16%	-14%	32%	15%	-33%	-100%	-19%	-20%
Total Stress Case 5	34%	18%	-36%	-99%	-14%	-22%	33%	16%	-42%	-104%	-17%	-27%
Total Stress Case 6	34%	18%	-39%	-101%	-15%	-24%	32%	16%	-43%	-104%	-17%	-28%
minimum error	**14%**	**-2%**	**-39%**	**-101%**	**-36%**	**-24%**	**11%**	**-5%**	**-43%**	**-104%**	**-40%**	**-28%**
maximum error	**34%**	**18%**	**-6%**	**-72%**	**-14%**	**-6%**	**33%**	**16%**	**-13%**	**-87%**	**-17%**	**-12%**
average error	**27%**	**11%**	**-21%**	**-87%**	**-22%**	**-16%**	**25%**	**9%**	**-27%**	**-97%**	**-26%**	**-22%**
std. dev. error	**9%**	**9%**	**15%**	**12%**	**9%**	**7%**	**9%**	**9%**	**14%**	**8%**	**10%**	**6%**
Total Stress Case 7	23%	8%	-22%	-94%	-26%	-21%	21%	7%	-26%	-102%	-27%	-25%
Total Stress Case 8	23%	8%	-18%	-92%	-25%	-18%	21%	6%	-24%	-102%	-29%	-23%
Total Stress Case 9	30%	14%	-14%	-89%	-19%	-11%	28%	12%	-21%	-100%	-22%	-15%
Total Stress Case 10	34%	18%	-37%	-116%	-15%	-21%	32%	16%	-42%	-123%	-18%	-25%
Total Stress Case 11	33%	17%	-37%	-112%	-15%	-21%	32%	16%	-42%	-118%	-17%	-25%
minimum error	**23%**	**8%**	**-37%**	**-116%**	**-25%**	**-21%**	**21%**	**6%**	**-42%**	**-123%**	**-29%**	**-25%**
maximum error	**34%**	**18%**	**-14%**	**-89%**	**-15%**	**-11%**	**32%**	**16%**	**-21%**	**-100%**	**-17%**	**-15%**
average error	**30%**	**14%**	**-27%**	**-102%**	**-19%**	**-18%**	**28%**	**12%**	**-32%**	**-111%**	**-21%**	**-22%**
std. dev. error	**5%**	**4%**	**12%**	**14%**	**5%**	**5%**	**5%**	**5%**	**11%**	**11%**	**5%**	**5%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis						Part. Non-Composite Analysis					
	1B	**2B**	**3B**	**4B**	**5B**	**6B**	**1B**	**2B**	**3B**	**4B**	**5B**	**6B**
Step 1-1	60%	51%	518%	131%	-94%	140%	60%	51%	518%	131%	-94%	140%
Step 1-2	29%	-6%	-76%	4%	6229%	880%	29%	-6%	-76%	4%	6229%	880%
Step 1-3	33%	7%	-59%	-142%	-245%	-238%	33%	7%	-59%	-142%	-245%	-238%
Step 2-2	20%	6%	-30%	-86%	-103%	-128%	20%	6%	-30%	-86%	-103%	-128%
Step 2-3a	12%	0%	-41%	-98%	-121%	-130%	12%	0%	-41%	-98%	-121%	-130%
Step 3-3a	-7%	9%	-26%	-45%	-22%	-48%	-7%	9%	-26%	-45%	-22%	-48%
Step 4-1	-11%	10%	-8%	-20%	-9%	-35%	-22%	1%	-8%	-18%	-18%	-37%
Step 4-2	-17%	15%	-2%	-10%	-10%	-11%	-36%	1%	-1%	-9%	-25%	-13%
minimum error	**-17%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**	**-36%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**
maximum error	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**
average error	**15%**	**11%**	**35%**	**-33%**	**703%**	**54%**	**11%**	**9%**	**35%**	**-33%**	**700%**	**53%**
std. dev. error	**26%**	**17%**	**197%**	**83%**	**2234%**	**351%**	**31%**	**18%**	**197%**	**83%**	**2235%**	**352%**
Case 1	-197%	-73%	-84%	10%	-28%	-127%	147%	-280%	-79%	-161%	-494%	89%
Case 2	-239%	-66%	-75%	19%	-14%	-121%	213%	-268%	-74%	-157%	-468%	103%
Case 3	-444%	-94%	-115%	-44%	-44%	-118%	-388%	-356%	-122%	-174%	-430%	20%
Case 4	-414%	-177%	-185%	-206%	-147%	-69%	-1136%	-560%	-192%	-120%	-198%	-188%
Case 5	-268%	-225%	-228%	-312%	-269%	-60%	-1416%	-657%	-225%	-85%	-54%	-291%
Case 6	-161%	-177%	-180%	-234%	-206%	-45%	-932%	-535%	-173%	-49%	-44%	-234%
minimum error	**-17%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**	**-36%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**
maximum error	**-161%**	**-66%**	**-75%**	**19%**	**-14%**	**-45%**	**213%**	**-268%**	**-74%**	**-49%**	**-44%**	**103%**
average error	**-287%**	**-136%**	**-145%**	**-128%**	**-118%**	**-90%**	**-585%**	**-443%**	**-144%**	**-124%**	**-281%**	**-83%**
std. dev. error	**116%**	**66%**	**62%**	**140%**	**106%**	**36%**	**682%**	**163%**	**62%**	**49%**	**208%**	**175%**
Case 7	-111%	-87%	-114%	-99%	-84%	-67%	-414%	-319%	-108%	-77%	-225%	-92%
Case 8	-600%	-162%	-37%	26%	-85%	-115%	167%	-462%	-31%	-103%	-725%	87%
Case 9	-683%	-147%	-36%	30%	-54%	-105%	283%	-447%	-32%	-106%	-638%	93%
Case 10	-527%	-455%	-147%	-217%	-436%	-41%	-2473%	-1191%	-147%	-43%	-143%	-241%
Case 11	-284%	-327%	-119%	-164%	-295%	-27%	-1389%	-867%	-112%	-17%	-95%	-186%
minimum error	**-683%**	**-455%**	**-147%**	**-217%**	**-436%**	**-115%**	**-2473%**	**-1191%**	**-147%**	**-106%**	**-725%**	**-241%**
maximum error	**-284%**	**-147%**	**-36%**	**30%**	**-54%**	**-27%**	**283%**	**-447%**	**-31%**	**-17%**	**-95%**	**93%**
average error	**-524%**	**-272%**	**-84%**	**-81%**	**-217%**	**-72%**	**-853%**	**-741%**	**-80%**	**-67%**	**-400%**	**-62%**
std. dev. error	**172%**	**146%**	**57%**	**128%**	**181%**	**45%**	**1322%**	**357%**	**58%**	**44%**	**327%**	**177%**
Total Stress Case 1	-23%	11%	-8%	-8%	-11%	-22%	-30%	-10%	-7%	-23%	-58%	-3%
Total Stress Case 2	-23%	11%	-7%	-7%	-11%	-22%	-29%	-10%	-7%	-24%	-58%	-1%
Total Stress Case 3	-23%	11%	-8%	-13%	-12%	-19%	-41%	-9%	-8%	-21%	-46%	-10%
Total Stress Case 4	-25%	9%	-13%	-24%	-17%	-16%	-58%	-15%	-13%	-17%	-33%	-28%
Total Stress Case 5	-27%	6%	-20%	-36%	-23%	-16%	-89%	-22%	-19%	-15%	-26%	-44%
Total Stress Case 6	-26%	6%	-20%	-35%	-22%	-15%	-89%	-23%	-18%	-13%	-26%	-43%
minimum error	**-27%**	**6%**	**-20%**	**-36%**	**-23%**	**-22%**	**-89%**	**-23%**	**-19%**	**-24%**	**-58%**	**-44%**
maximum error	**-23%**	**11%**	**-7%**	**-7%**	**-11%**	**-15%**	**-29%**	**-9%**	**-7%**	**-13%**	**-26%**	**-1%**
average error	**-24%**	**9%**	**-13%**	**-21%**	**-16%**	**-18%**	**-56%**	**-15%**	**-12%**	**-19%**	**-41%**	**-21%**
std. dev. error	**2%**	**3%**	**6%**	**13%**	**6%**	**3%**	**27%**	**6%**	**6%**	**4%**	**15%**	**19%**
Total Stress Case 7	-22%	10%	-12%	-20%	-16%	-17%	-57%	-14%	-11%	-16%	-39%	-22%
Total Stress Case 8	-20%	13%	-3%	-9%	-12%	-15%	-35%	-4%	-2%	-13%	-39%	-9%
Total Stress Case 9	-21%	13%	-3%	-8%	-11%	-15%	-34%	-4%	-3%	-14%	-41%	-7%
Total Stress Case 10	-22%	10%	-8%	-20%	-16%	-12%	-60%	-10%	-8%	-10%	-27%	-26%
Total Stress Case 11	-22%	10%	-8%	-20%	-16%	-12%	-59%	-9%	-7%	-9%	-26%	-25%
minimum error	**-22%**	**10%**	**-8%**	**-20%**	**-16%**	**-15%**	**-60%**	**-10%**	**-8%**	**-14%**	**-41%**	**-26%**
maximum error	**-20%**	**13%**	**-3%**	**-8%**	**-11%**	**-12%**	**-34%**	**-4%**	**-2%**	**-9%**	**-26%**	**-7%**
average error	**-21%**	**12%**	**-6%**	**-14%**	**-14%**	**-14%**	**-47%**	**-7%**	**-5%**	**-12%**	**-33%**	**-17%**
std. dev. error	**1%**	**1%**	**3%**	**7%**	**3%**	**2%**	**14%**	**3%**	**3%**	**2%**	**8%**	**10%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis						Part. Non-Composite Analysis					
	7B	8B	9B	10B	11B	12B	7B	8B	9B	10B	11B	12B
Step 1-1	-6%	-925%	-273%	12%		136%	-6%	-925%	-273%	12%		136%
Step 1-2	-592%	-2536%	-24%	-78%		743%	-592%	-2536%	-24%	-78%		743%
Step 1-3	-46%	-203%	-12%	-23%		-1171%	-46%	-203%	-12%	-23%		-1171%
Step 2-2	0%	1%	1%	0%	100%	-399%	0%	1%	1%	0%	100%	-399%
Step 2-3a	-70%	-253%	-7%	-27%	-13%	-291%	-70%	-253%	-7%	-27%	-13%	-291%
Step 3-3a	-40%	-56%	-9%	-88%	2%	-134%	-40%	-56%	-9%	-88%	2%	-134%
Step 4-1	-35%	-54%	9%	-84%	16%	-101%	-45%	-67%	10%	-81%	5%	-101%
Step 4-2	-32%	-45%	2%	-58%	19%	-59%	-49%	-66%	4%	-55%	2%	-59%
minimum error	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**
maximum error	**0%**	**1%**	**9%**	**12%**	**100%**	**743%**	**0%**	**1%**	**10%**	**12%**	**100%**	**743%**
average error	**-103%**	**-509%**	**-39%**	**-43%**	**25%**	**-160%**	**-106%**	**-513%**	**-39%**	**-43%**	**19%**	**-159%**
std. dev. error	**199%**	**872%**	**95%**	**39%**	**44%**	**537%**	**198%**	**870%**	**95%**	**39%**	**46%**	**537%**
Case 1	-383%	-184%	-75%	10%	-40%	-223%	397%	-537%	-54%	-232%	-611%	39%
Case 2	-360%	-147%	-52%	26%	-20%	-213%	477%	-460%	-37%	-214%	-550%	52%
Case 3	-505%	-200%	-55%	-50%	-38%	-172%	-237%	-620%	-46%	-193%	-448%	-13%
Case 4	-382%	-226%	-61%	-212%	-56%	-31%	-1627%	-707%	-56%	-87%	-60%	-156%
Case 5	-339%	-279%	-84%	-357%	-92%	46%	-2311%	-829%	-76%	-9%	227%	-285%
Case 6	-219%	-191%	-64%	-313%	-64%	60%	-1711%	-603%	-53%	28%	243%	-244%
minimum error	**-505%**	**-279%**	**-84%**	**-357%**	**-92%**	**-223%**	**-2311%**	**-829%**	**-76%**	**-232%**	**-611%**	**-285%**
maximum error	**-219%**	**-147%**	**-52%**	**26%**	**-20%**	**60%**	**477%**	**-460%**	**-37%**	**28%**	**243%**	**52%**
average error	**-365%**	**-204%**	**-65%**	**-149%**	**-52%**	**-89%**	**-835%**	**-626%**	**-54%**	**-118%**	**-200%**	**-101%**
std. dev. error	**92%**	**45%**	**12%**	**167%**	**25%**	**130%**	**1197%**	**129%**	**13%**	**111%**	**388%**	**147%**
Case 7	-313%	-200%	-46%	-115%	-40%	-64%	-847%	-585%	-30%	-77%	-172%	-75%
Case 8	2850%	-2000%	-13%	28%	-63%	-167%	-1450%	-4600%	2%	-154%	-707%	49%
Case 9		-840%	-12%	35%	-42%	-163%		-2040%	-1%	-155%	-647%	53%
Case 10	-2400%	-1333%	-22%	-245%	-96%	61%	-13750%	-3400%	-16%	26%	250%	-205%
Case 11	-1400%	-1200%	-10%	-217%	-76%	70%	-8533%	-3000%	-1%	52%	269%	-180%
minimum error	**-2400%**	**-2000%**	**-22%**	**-245%**	**-96%**	**-167%**	**-13750%**	**-4600%**	**-16%**	**-155%**	**-707%**	**-205%**
maximum error	**2850%**	**-840%**	**-10%**	**35%**	**-42%**	**70%**	**-1450%**	**-2040%**	**2%**	**52%**	**269%**	**53%**
average error	**-317%**	**-1343%**	**-14%**	**-100%**	**-69%**	**-50%**	**-7911%**	**-3260%**	**-4%**	**-58%**	**-209%**	**-71%**
std. dev. error	**2788%**	**485%**	**5%**	**152%**	**23%**	**133%**	**6174%**	**1060%**	**8%**	**112%**	**541%**	**141%**
Total Stress Case 1	-43%	-52%	-7%	-49%	14%	-84%	-36%	-90%	-3%	-79%	-54%	-43%
Total Stress Case 2	-43%	-51%	-5%	-46%	15%	-84%	-33%	-89%	-1%	-78%	-54%	-41%
Total Stress Case 3	-42%	-52%	-4%	-57%	15%	-73%	-53%	-89%	-2%	-71%	-34%	-53%
Total Stress Case 4	-41%	-52%	-4%	-75%	14%	-55%	-86%	-90%	-2%	-59%	-2%	-71%
Total Stress Case 5	-41%	-54%	-7%	-92%	11%	-45%	-115%	-95%	-5%	-50%	19%	-88%
Total Stress Case 6	-40%	-52%	-6%	-90%	12%	-42%	-113%	-91%	-3%	-45%	22%	-86%
minimum error	**-43%**	**-54%**	**-7%**	**-92%**	**11%**	**-84%**	**-115%**	**-95%**	**-5%**	**-79%**	**-54%**	**-88%**
maximum error	**-40%**	**-51%**	**-4%**	**-46%**	**15%**	**-42%**	**-33%**	**-89%**	**-1%**	**-45%**	**22%**	**-41%**
average error	**-42%**	**-52%**	**-5%**	**-68%**	**14%**	**-64%**	**-73%**	**-91%**	**-3%**	**-63%**	**-17%**	**-64%**
std. dev. error	**1%**	**1%**	**1%**	**20%**	**2%**	**19%**	**37%**	**2%**	**1%**	**15%**	**35%**	**21%**
Total Stress Case 7	-41%	-52%	-4%	-66%	14%	-60%	-74%	-90%	0%	-58%	-13%	-61%
Total Stress Case 8	-39%	-51%	1%	-52%	17%	-67%	-46%	-79%	4%	-62%	-21%	-50%
Total Stress Case 9	-39%	-51%	1%	-50%	17%	-68%	-45%	-80%	3%	-63%	-24%	-49%
Total Stress Case 10	-38%	-51%	0%	-70%	16%	-50%	-79%	-80%	2%	-50%	10%	-69%
Total Stress Case 11	-37%	-50%	1%	-69%	16%	-49%	-77%	-78%	3%	-48%	11%	-68%
minimum error	**-39%**	**-51%**	**0%**	**-70%**	**16%**	**-68%**	**-79%**	**-80%**	**2%**	**-63%**	**-24%**	**-69%**
maximum error	**-37%**	**-50%**	**1%**	**-50%**	**17%**	**-49%**	**-45%**	**-78%**	**4%**	**-48%**	**11%**	**-49%**
average error	**-38%**	**-51%**	**1%**	**-60%**	**17%**	**-59%**	**-62%**	**-79%**	**3%**	**-56%**	**-6%**	**-59%**
std. dev. error	**1%**	**0%**	**0%**	**11%**	**0%**	**11%**	**19%**	**1%**	**1%**	**8%**	**19%**	**11%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 8											
	Composite Analysis						Part. Non-Composite Analysis					
	13B	14B	15B	16B	17B	18B	13B	14B	15B	16B	17B	18B
Step 1-1	-3%	-112%	-98%	454%	-277%	1286%	-3%	-112%	-98%	454%	-277%	1286%
Step 1-2	2592%	-858%	-117%	910%	-2771%	-196%	2592%	-858%	-117%	910%	-2771%	-196%
Step 1-3	-36%	-50%	28%	-160%	25%	-64%	-36%	-50%	28%	-160%	25%	-64%
Step 2-2	-60%	-77%	30%	-116%		-46%	-60%	-77%	30%	-116%		-46%
Step 2-3a	-59%	-68%	24%	-106%		-52%	-59%	-68%	24%	-106%		-52%
Step 3-3a	-37%	-23%	4%	-73%	11%	-89%	-37%	-23%	4%	-73%	11%	-89%
Step 4-1	-29%	-24%	22%	-36%	23%	-87%	-38%	-34%	24%	-34%	17%	-85%
Step 4-2	-38%	-34%	15%	-32%	18%	-66%	-55%	-53%	18%	-29%	7%	-63%
minimum error	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**
maximum error	**2592%**	**-23%**	**30%**	**910%**	**25%**	**1286%**	**2592%**	**-23%**	**30%**	**910%**	**25%**	**1286%**
average error	**291%**	**-156%**	**-11%**	**105%**	**-495%**	**86%**	**288%**	**-159%**	**-11%**	**106%**	**-498%**	**86%**
std. dev. error	**930%**	**286%**	**60%**	**379%**	**1121%**	**487%**	**931%**	**284%**	**60%**	**379%**	**1120%**	**487%**
Case 1	-50%	-157%	-60%	3%	-41%	-283%	142%	-573%	-37%	-141%	-613%	-10%
Case 2	-31%	-126%	-44%	22%	-22%	-252%	188%	-500%	-26%	-136%	-576%	18%
Case 3	-38%	-169%	-46%	-26%	-27%	-194%	-35%	-652%	-33%	-104%	-410%	-51%
Case 4	-18%	-152%	-45%	-110%	-25%	-63%	-362%	-590%	-32%	-22%	-24%	-182%
Case 5	-14%	-141%	-64%	-172%	-29%	0%	-549%	-546%	-45%	24%	192%	-330%
Case 6	6%	-100%	-47%	-156%	-8%	33%	-462%	-415%	-25%	51%	227%	-303%
minimum error	**-50%**	**-169%**	**-64%**	**-172%**	**-41%**	**-283%**	**-549%**	**-652%**	**-45%**	**-141%**	**-613%**	**-330%**
maximum error	**6%**	**-100%**	**-44%**	**22%**	**-8%**	**33%**	**188%**	**-415%**	**-25%**	**51%**	**227%**	**18%**
average error	**-24%**	**-141%**	**-51%**	**-73%**	**-25%**	**-126%**	**-180%**	**-546%**	**-33%**	**-55%**	**-201%**	**-143%**
std. dev. error	**20%**	**25%**	**9%**	**84%**	**11%**	**134%**	**319%**	**81%**	**8%**	**83%**	**380%**	**151%**
Case 7	-4%	-133%	-42%	-65%	-16%	-119%	-154%	-497%	-19%	-36%	-145%	-106%
Case 8	-26%	-825%	-34%	3%	-31%	-197%	133%	-2275%	-13%	-131%	-539%	16%
Case 9	-20%	-471%	-27%	18%	-28%	-186%	149%	-1457%	-13%	-128%	-580%	21%
Case 10	0%	-483%	-30%	-144%	-18%	33%	-481%	1633%	-14%	41%	205%	-227%
Case 11	19%	-300%	-16%	-137%	3%	60%	-405%	-929%	3%	63%	236%	-204%
minimum error	**-26%**	**-825%**	**-34%**	**-144%**	**-31%**	**-197%**	**-481%**	**-2275%**	**-14%**	**-131%**	**-580%**	**-227%**
maximum error	**19%**	**-300%**	**-16%**	**18%**	**3%**	**60%**	**149%**	**1633%**	**3%**	**63%**	**236%**	**21%**
average error	**-7%**	**-520%**	**-27%**	**-65%**	**-18%**	**-73%**	**-151%**	**-757%**	**-9%**	**-39%**	**-169%**	**-99%**
std. dev. error	**20%**	**220%**	**8%**	**87%**	**15%**	**138%**	**339%**	**1687%**	**8%**	**105%**	**451%**	**135%**
Total Stress Case 1	-39%	-40%	6%	-27%	14%	-98%	-37%	-78%	11%	-46%	-32%	-53%
Total Stress Case 2	-37%	-39%	8%	-24%	15%	-95%	-32%	-76%	13%	-45%	-32%	-49%
Total Stress Case 3	-38%	-39%	8%	-31%	15%	-83%	-53%	-76%	13%	-39%	-17%	-60%
Total Stress Case 4	-36%	-39%	9%	-42%	15%	-65%	-81%	-74%	13%	-28%	6%	-75%
Total Stress Case 5	-36%	-39%	7%	-53%	15%	-58%	-106%	-77%	11%	-21%	20%	-92%
Total Stress Case 6	-33%	-38%	9%	-50%	16%	-55%	-99%	-71%	14%	-17%	23%	-89%
minimum error	**-39%**	**-40%**	**6%**	**-53%**	**14%**	**-98%**	**-106%**	**-78%**	**11%**	**-46%**	**-32%**	**-92%**
maximum error	**-33%**	**-38%**	**9%**	**-24%**	**16%**	**-55%**	**-32%**	**-71%**	**14%**	**-17%**	**23%**	**-49%**
average error	**-37%**	**-39%**	**8%**	**-38%**	**15%**	**-76%**	**-68%**	**-75%**	**12%**	**-33%**	**-6%**	**-70%**
std. dev. error	**2%**	**1%**	**1%**	**12%**	**1%**	**19%**	**32%**	**2%**	**1%**	**12%**	**25%**	**18%**
Total Stress Case 7	-34%	-39%	8%	-37%	16%	-73%	-66%	-75%	13%	-30%	-4%	-69%
Total Stress Case 8	-37%	-39%	12%	-30%	17%	-76%	-46%	-65%	16%	-36%	-8%	-55%
Total Stress Case 9	-37%	-38%	12%	-28%	17%	-77%	-44%	-66%	16%	-37%	-11%	-54%
Total Stress Case 10	-36%	-38%	13%	-40%	17%	-59%	-75%	-38%	16%	-24%	14%	-72%
Total Stress Case 11	-35%	-37%	14%	-39%	17%	-58%	-72%	-61%	17%	-23%	15%	-70%
minimum error	**-37%**	**-39%**	**12%**	**-40%**	**17%**	**-77%**	**-75%**	**-66%**	**16%**	**-37%**	**-11%**	**-72%**
maximum error	**-35%**	**-37%**	**14%**	**-28%**	**17%**	**-58%**	**-44%**	**-38%**	**17%**	**-23%**	**15%**	**-54%**
average error	**-36%**	**-38%**	**13%**	**-34%**	**17%**	**-68%**	**-59%**	**-57%**	**17%**	**-30%**	**2%**	**-62%**
std. dev. error	**1%**	**1%**	**1%**	**6%**	**0%**	**10%**	**16%**	**13%**	**1%**	**7%**	**14%**	**10%**

Table 5.1: Percent Error tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 8											
	Composite Analysis						Part. Non-Composite Analysis					
	19B	**20B**	**21B**	**22B**	**23B**	**24B**	**19B**	**20B**	**21B**	**22B**	**23B**	**24B**
Step 1-1	37%	-96%	-137%	254%	-23%	171%	37%	-96%	-137%	254%	-23%	171%
Step 1-2	-1850%	691%	18%	468%	11%	-149%	-1850%	691%	18%	468%	11%	-149%
Step 1-3	-71%	-58%	1%	375%	29%	-2%	-71%	-58%	1%	375%	29%	-2%
Step 2-2	-46%	-66%	18%	756%	55%	11%	-46%	-66%	18%	756%	55%	11%
Step 2-3a	-52%	-64%	13%	2258%	48%	3%	-52%	-64%	13%	2258%	48%	3%
Step 3-3a	-23%	-2%	-13%	-212%	17%	-11%	-23%	-2%	-13%	-212%	17%	-11%
Step 4-1	-17%	10%	27%	-34%	28%	21%	-24%	3%	29%	-31%	23%	21%
Step 4-2	-27%	6%	15%	-35%	18%	15%	-43%	-7%	18%	-31%	8%	15%
minimum error	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**
maximum error	**37%**	**691%**	**27%**	**2258%**	**55%**	**171%**	**37%**	**691%**	**29%**	**2258%**	**55%**	**171%**
average error	**-256%**	**53%**	**-7%**	**479%**	**23%**	**7%**	**-259%**	**50%**	**-7%**	**480%**	**21%**	**7%**
std. dev. error	**645%**	**261%**	**54%**	**784%**	**24%**	**86%**	**644%**	**262%**	**54%**	**784%**	**24%**	**86%**
Case 1	-221%	-216%	-101%	-25%	-85%	-103%	-594%	-880%	-83%	-26%	-470%	-90%
Case 2	-153%	-134%	-81%	12%	-48%	-95%	-442%	-659%	-72%	-3%	-389%	-85%
Case 3	-129%	-82%	-77%	-27%	-12%	-69%	-486%	-494%	-71%	-31%	-239%	-71%
Case 4	-95%	-74%	-70%	-93%	-9%	-9%	-436%	-386%	-45%	-56%	-129%	-12%
Case 5	-113%	-110%	-76%	-127%	-37%	17%	-478%	-443%	-39%	-76%	-137%	19%
Case 6	-94%	-118%	-59%	-115%	-38%	36%	-402%	-424%	-18%	-62%	-117%	44%
minimum error	**-221%**	**-216%**	**-101%**	**-127%**	**-85%**	**-103%**	**-594%**	**-880%**	**-83%**	**-76%**	**-470%**	**-90%**
maximum error	**-94%**	**-74%**	**-59%**	**12%**	**-9%**	**36%**	**-402%**	**-386%**	**-18%**	**-3%**	**-117%**	**44%**
average error	**-134%**	**-122%**	**-77%**	**-63%**	**-38%**	**-37%**	**-473%**	**-547%**	**-55%**	**-42%**	**-247%**	**-33%**
std. dev. error	**48%**	**51%**	**14%**	**57%**	**28%**	**60%**	**67%**	**189%**	**25%**	**27%**	**150%**	**58%**
Case 7	-178%	-192%	-75%	-76%	-63%	-31%	-546%	-696%	-43%	-43%	-278%	-19%
Case 8	-1950%	875%	-68%	3%	-169%	-74%	-4250%	2400%	-46%	11%	-700%	-60%
Case 9	-900%	1600%	-51%	33%	-133%	-70%	-2175%	5150%	-50%	12%	-700%	-66%
Case 10	-463%	-3200%	-45%	-90%	-105%	31%	-1388%	-8100%	-12%	-46%	-243%	37%
Case 11	-640%	1000%	-29%	-80%	-140%	49%	-1780%	2233%	6%	-34%	-260%	58%
minimum error	**-1950%**	**-3200%**	**-68%**	**-90%**	**-169%**	**-74%**	**-4250%**	**-8100%**	**-50%**	**-46%**	**-700%**	**-66%**
maximum error	**-463%**	**1600%**	**-29%**	**33%**	**-105%**	**49%**	**-1388%**	**5150%**	**6%**	**12%**	**-243%**	**58%**
average error	**-988%**	**69%**	**-48%**	**-34%**	**-137%**	**-16%**	**-2398%**	**421%**	**-26%**	**-14%**	**-476%**	**-8%**
std. dev. error	**666%**	**2202%**	**16%**	**61%**	**26%**	**65%**	**1276%**	**5836%**	**27%**	**30%**	**259%**	**65%**
Total Stress Case 1	-35%	0%	4%	-34%	14%	-1%	-64%	-30%	8%	-30%	-13%	2%
Total Stress Case 2	-33%	1%	6%	-29%	15%	0%	-59%	-27%	10%	-27%	-11%	3%
Total Stress Case 3	-31%	3%	7%	-34%	17%	5%	-61%	-24%	11%	-30%	-5%	6%
Total Stress Case 4	-31%	3%	8%	-43%	17%	12%	-62%	-21%	13%	-34%	1%	13%
Total Stress Case 5	-33%	1%	5%	-52%	15%	15%	-69%	-25%	12%	-39%	0%	16%
Total Stress Case 6	-31%	1%	7%	-49%	15%	17%	-64%	-22%	14%	-36%	2%	19%
minimum error	**-35%**	**0%**	**4%**	**-52%**	**14%**	**-1%**	**-69%**	**-30%**	**8%**	**-39%**	**-13%**	**2%**
maximum error	**-31%**	**3%**	**8%**	**-29%**	**17%**	**17%**	**-59%**	**-21%**	**14%**	**-27%**	**2%**	**19%**
average error	**-32%**	**1%**	**6%**	**-40%**	**15%**	**8%**	**-63%**	**-25%**	**11%**	**-32%**	**-4%**	**10%**
std. dev. error	**1%**	**1%**	**2%**	**9%**	**1%**	**8%**	**4%**	**3%**	**2%**	**4%**	**7%**	**7%**
Total Stress Case 7	-34%	0%	6%	-42%	14%	9%	-65%	-26%	11%	-33%	-6%	11%
Total Stress Case 8	-32%	2%	11%	-33%	16%	9%	-53%	-17%	15%	-27%	0%	11%
Total Stress Case 9	-31%	2%	12%	-30%	16%	9%	-53%	-18%	15%	-27%	-1%	10%
Total Stress Case 10	-31%	2%	12%	-40%	16%	16%	-55%	-16%	16%	-32%	5%	17%
Total Stress Case 11	-31%	2%	13%	-39%	17%	17%	-53%	-14%	18%	-31%	6%	18%
minimum error	**-32%**	**2%**	**11%**	**-40%**	**16%**	**9%**	**-55%**	**-18%**	**15%**	**-32%**	**-1%**	**10%**
maximum error	**-31%**	**2%**	**13%**	**-30%**	**17%**	**17%**	**-53%**	**-14%**	**18%**	**-27%**	**6%**	**18%**
average error	**-31%**	**2%**	**12%**	**-36%**	**16%**	**13%**	**-53%**	**-16%**	**16%**	**-29%**	**2%**	**14%**
std. dev. error	**0%**	**0%**	**1%**	**5%**	**0%**	**4%**	**1%**	**2%**	**1%**	**2%**	**3%**	**4%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis				Part. Non-Composite Analysis			
	1C	**2C**	**3C**	**4C**	**1C**	**2C**	**3C**	**4C**
Step 1-1	104%	643%	136%	116%	104%	643%	136%	116%
Step 1-2	94%	372%	132%	114%	94%	372%	132%	114%
Step 1-3	64%	-2313%	119%	101%	64%	-2313%	119%	101%
Step 2-2	69%		121%	102%	69%		121%	102%
Step 2-3a	62%	6100%	161%	54%	62%	6100%	161%	54%
Step 3-3a	63%	-175%	380%	57%	63%	-175%	380%	57%
Step 4-1	60%	1195%	275%	57%	60%	1195%	277%	56%
Step 4-2	62%	884%	-1013%	65%	62%	887%	-1038%	64%
minimum error	**60%**	**-2313%**	**-1013%**	**54%**	**60%**	**-2313%**	**-1038%**	**54%**
maximum error	**104%**	**6100%**	**380%**	**116%**	**104%**	**6100%**	**380%**	**116%**
average error	**72%**	**958%**	**39%**	**83%**	**72%**	**958%**	**36%**	**83%**
std. dev. error	**17%**	**2547%**	**435%**	**27%**	**17%**	**2547%**	**444%**	**27%**
Case 1	182%	-99%	12%	67%	158%	-102%	14%	63%
Case 2	220%	-102%	19%	76%	190%	-103%	22%	71%
Case 3	366%	-113%	51%	89%	308%	-117%	53%	86%
Case 4	159%	38%	121%	120%	124%	50%	114%	115%
Case 5	385%	61%	232%	63%	310%	92%	195%	63%
Case 6	412%	80%	239%	79%	332%	114%	197%	79%
minimum error	**159%**	**-113%**	**12%**	**63%**	**124%**	**-117%**	**14%**	**63%**
maximum error	**412%**	**80%**	**239%**	**120%**	**332%**	**114%**	**197%**	**115%**
average error	**287%**	**-23%**	**112%**	**82%**	**237%**	**-11%**	**99%**	**79%**
std. dev. error	**113%**	**91%**	**103%**	**20%**	**90%**	**107%**	**83%**	**19%**
Case 7	84%	-48%	49%	32%	85%	-56%	45%	23%
Case 8	184%	-218%	36%	67%	164%	-218%	37%	63%
Case 9	350%	-300%	54%	79%	297%	-300%	56%	75%
Case 10	245%	87%	137%	-200%	209%	100%	126%	-200%
Case 11	266%	97%	134%	-133%	222%	108%	123%	-133%
minimum error	**184%**	**-300%**	**36%**	**-200%**	**164%**	**-300%**	**37%**	**-200%**
maximum error	**350%**	**97%**	**137%**	**79%**	**297%**	**108%**	**126%**	**75%**
average error	**261%**	**-83%**	**90%**	**-47%**	**223%**	**-77%**	**85%**	**-49%**
std. dev. error	**69%**	**206%**	**53%**	**141%**	**55%**	**212%**	**46%**	**139%**
Total Stress Case 1	76%	-1010%	-69%	65%	73%	-1018%	-70%	64%
Total Stress Case 2	78%	-1617%	-67%	68%	75%	-1624%	-66%	66%
Total Stress Case 3	73%	1497%	-81%	70%	71%	1505%	-82%	68%
Total Stress Case 4	60%	651%	-117%	68%	61%	656%	-127%	67%
Total Stress Case 5	49%	585%	-169%	65%	52%	598%	-202%	64%
Total Stress Case 6	47%	597%	-175%	64%	50%	611%	-212%	63%
minimum error	**47%**	**-1617%**	**-175%**	**64%**	**50%**	**-1624%**	**-212%**	**63%**
maximum error	**78%**	**1497%**	**-67%**	**70%**	**75%**	**1505%**	**-66%**	**68%**
average error	**64%**	**117%**	**-113%**	**67%**	**64%**	**121%**	**-127%**	**65%**
std. dev. error	**14%**	**1176%**	**49%**	**2%**	**11%**	**1184%**	**66%**	**2%**
Total Stress Case 7	63%	-1681%	-68%	62%	63%	-1706%	-75%	61%
Total Stress Case 8	68%	3437%	-83%	65%	67%	3447%	-85%	64%
Total Stress Case 9	70%	1222%	-78%	67%	69%	1227%	-79%	65%
Total Stress Case 10	55%	579%	-142%	65%	57%	586%	-156%	65%
Total Stress Case 11	55%	598%	-135%	65%	57%	604%	-149%	64%
minimum error	**55%**	**579%**	**-142%**	**65%**	**57%**	**586%**	**-156%**	**64%**
maximum error	**70%**	**3437%**	**-78%**	**67%**	**69%**	**3447%**	**-79%**	**65%**
average error	**62%**	**1459%**	**-109%**	**66%**	**62%**	**1466%**	**-117%**	**65%**
std. dev. error	**8%**	**1352%**	**34%**	**1%**	**6%**	**1354%**	**41%**	**1%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

	Percent Error with N = 8							
	Composite Analysis				Part. Non-Composite Analysis			
	5C	6C	7C	8C	5C	6C	7C	8C
Step 1-1	71%	186%	-1588%	100%	71%	186%	-1588%	100%
Step 1-2	25%	-14500%	457%	97%	25%	-14500%	457%	97%
Step 1-3	60%	-135%	32%	96%	60%	-135%	32%	96%
Step 2-2	71%	-173%	39%	97%	71%	-173%	39%	97%
Step 2-3a	65%	-182%	14%	70%	65%	-182%	14%	70%
Step 3-3a	68%	-67%	9%	56%	68%	-67%	9%	56%
Step 4-1	67%	-60%	16%	60%	67%	-62%	15%	58%
Step 4-2	72%	-28%	33%	72%	72%	-31%	30%	71%
minimum error	**25%**	**-14500%**	**-1588%**	**56%**	**25%**	**-14500%**	**-1588%**	**56%**
maximum error	**72%**	**186%**	**457%**	**100%**	**72%**	**186%**	**457%**	**100%**
average error	**63%**	**-1870%**	**-123%**	**81%**	**62%**	**-1870%**	**-124%**	**81%**
std. dev. error	**16%**	**5105%**	**611%**	**18%**	**16%**	**5104%**	**611%**	**19%**
Case 1	157%	-128%	-35%	14%	127%	-137%	-37%	-12%
Case 2	177%	-120%	-19%	44%	142%	-127%	-19%	22%
Case 3	237%	-138%	19%	68%	188%	-157%	18%	51%
Case 4	167%	-21%	198%	176%	100%	21%	166%	165%
Case 5	426%	-68%	-635%	3%	305%	-22%	-470%	-12%
Case 6	465%	-61%	-484%	25%	330%	-12%	-340%	13%
minimum error	**157%**	**-138%**	**-635%**	**3%**	**100%**	**-157%**	**-470%**	**-12%**
maximum error	**465%**	**-21%**	**198%**	**176%**	**330%**	**21%**	**166%**	**165%**
average error	**271%**	**-89%**	**-159%**	**55%**	**199%**	**-72%**	**-114%**	**38%**
std. dev. error	**138%**	**46%**	**324%**	**64%**	**97%**	**76%**	**240%**	**66%**
Case 7	80%	-58%	-23%	172%	79%	-74%	-39%	200%
Case 8	159%	-209%	-12%	55%	128%	-221%	-14%	41%
Case 9	246%	-221%	19%	66%	193%	-231%	20%	53%
Case 10	280%	43%	307%	218%	213%	60%	259%	236%
Case 11	314%	49%	270%	200%	236%	65%	227%	218%
minimum error	**159%**	**-221%**	**-12%**	**55%**	**128%**	**-231%**	**-14%**	**41%**
maximum error	**314%**	**49%**	**307%**	**218%**	**236%**	**65%**	**259%**	**236%**
average error	**250%**	**-85%**	**146%**	**135%**	**193%**	**-82%**	**123%**	**137%**
std. dev. error	**67%**	**151%**	**166%**	**86%**	**46%**	**167%**	**140%**	**104%**
Total Stress Case 1	83%	-55%	12%	66%	79%	-60%	10%	62%
Total Stress Case 2	85%	-50%	17%	69%	81%	-54%	16%	65%
Total Stress Case 3	82%	-37%	30%	72%	79%	-41%	28%	69%
Total Stress Case 4	72%	-28%	42%	75%	72%	-35%	38%	73%
Total Stress Case 5	62%	-24%	49%	75%	66%	-32%	43%	75%
Total Stress Case 6	61%	-25%	49%	75%	64%	-32%	42%	74%
minimum error	**61%**	**-55%**	**12%**	**66%**	**64%**	**-60%**	**10%**	**62%**
maximum error	**85%**	**-24%**	**49%**	**75%**	**81%**	**-32%**	**43%**	**75%**
average error	**74%**	**-37%**	**33%**	**72%**	**73%**	**-42%**	**29%**	**70%**
std. dev. error	**11%**	**13%**	**16%**	**4%**	**7%**	**12%**	**14%**	**5%**
Total Stress Case 7	73%	-34%	24%	68%	73%	-40%	20%	66%
Total Stress Case 8	77%	-50%	24%	71%	75%	-54%	22%	68%
Total Stress Case 9	79%	-41%	30%	72%	77%	-44%	28%	69%
Total Stress Case 10	68%	-36%	42%	74%	69%	-41%	38%	73%
Total Stress Case 11	67%	-35%	42%	74%	69%	-40%	38%	73%
minimum error	**67%**	**-50%**	**24%**	**71%**	**69%**	**-54%**	**22%**	**68%**
maximum error	**79%**	**-35%**	**42%**	**74%**	**77%**	**-40%**	**38%**	**73%**
average error	**73%**	**-40%**	**34%**	**73%**	**72%**	**-45%**	**31%**	**71%**
std. dev. error	**6%**	**7%**	**9%**	**2%**	**4%**	**6%**	**8%**	**2%**

Table 5.1: Percent Error Tables for 1997 Analysis vs 1997 Measured Stress

Percent Error with N = 8

	Composite Analysis				Part. Non-Composite Analysis			
	9C	**10C**	**11C**	**12C**	**9C**	**10C**	**11C**	**12C**
Step 1-1	49%	77%	162%	109%	49%	77%	162%	109%
Step 1-2	184%	-35%	-133%	82%	184%	-35%	-133%	82%
Step 1-3	95%	35%	-296%	113%	95%	35%	-296%	113%
Step 2-2	97%	23%	-88%		97%	23%	-88%	
Step 2-3a	90%	8%	-70%		90%	8%	-70%	
Step 3-3a	22%	1%	-71%	131%	22%	1%	-71%	131%
Step 4-1	10%	5%	32%		11%	1%	29%	
Step 4-2	62%	-58%	42%	118%	63%	-67%	39%	117%
minimum error	**10%**	**-58%**	**-296%**	**82%**	**11%**	**-67%**	**-296%**	**82%**
maximum error	**184%**	**77%**	**162%**	**131%**	**184%**	**77%**	**162%**	**131%**
average error	**76%**	**7%**	**-53%**	**111%**	**76%**	**5%**	**-54%**	**111%**
std. dev. error	**55%**	**41%**	**136%**	**18%**	**54%**	**44%**	**135%**	**18%**
Case 1	152%	-114%	-87%		108%	-153%	-116%	
Case 2	177%	-86%	-48%		128%	-126%	-74%	
Case 3	288%	-18%	13%		200%	-75%	-13%	
Case 4	107%	-73%	643%		87%	-41%	543%	
Case 5	210%	-16%	-85%	67%	161%	-39%	-96%	-67%
Case 6	221%	4%	-61%	73%	168%	-23%	-71%	0%
minimum error	**107%**	**-114%**	**-87%**	**67%**	**87%**	**-153%**	**-116%**	**-67%**
maximum error	**288%**	**4%**	**643%**	**73%**	**200%**	**-23%**	**543%**	**0%**
average error	**192%**	**-51%**	**62%**	**70%**	**142%**	**-76%**	**29%**	**-33%**
std. dev. error	**62%**	**47%**	**287%**	**4%**	**42%**	**53%**	**254%**	**47%**
Case 7	257%	-800%	929%	24%	271%	-919%	1064%	32%
Case 8	213%	-163%	-35%		113%	-202%	-51%	
Case 9	833%	-66%	16%		467%	-114%	-1%	
Case 10	145%	42%	-900%		124%	28%	-950%	
Case 11	153%	50%	-3500%		131%	35%	-3800%	
minimum error	**145%**	**-163%**	**-3500%**		**113%**	**-202%**	**-3800%**	
maximum error	**833%**	**50%**	**16%**		**467%**	**35%**	**-1%**	
average error	**336%**	**-34%**	**-1105%**		**209%**	**-63%**	**-1200%**	
std. dev. error	**333%**	**101%**	**1651%**		**172%**	**115%**	**1787%**	
Total Stress Case 1	25%	-79%	17%		45%	-99%	9%	
Total Stress Case 2	18%	-68%	23%		39%	-89%	15%	
Total Stress Case 3	37%	-50%	38%		48%	-69%	32%	
Total Stress Case 4	65%	-56%	48%		65%	-70%	44%	
Total Stress Case 5	84%	-70%	53%	119%	78%	-76%	50%	121%
Total Stress Case 6	88%	-77%	52%	120%	81%	-81%	49%	122%
minimum error	**18%**	**-79%**	**17%**	**119%**	**39%**	**-99%**	**9%**	**121%**
maximum error	**88%**	**-50%**	**53%**	**120%**	**81%**	**-69%**	**50%**	**122%**
average error	**53%**	**-66%**	**39%**	**120%**	**59%**	**-80%**	**33%**	**121%**
std. dev. error	**30%**	**11%**	**15%**	**1%**	**18%**	**12%**	**18%**	**1%**
Total Stress Case 7	69%	-104%	23%	127%	72%	-120%	17%	125%
Total Stress Case 8	54%	-79%	31%		61%	-94%	26%	
Total Stress Case 9	48%	-59%	38%		56%	-75%	33%	
Total Stress Case 10	75%	-79%	48%		73%	-88%	45%	
Total Stress Case 11	76%	-79%	47%		74%	-88%	44%	
minimum error	**48%**	**-79%**	**31%**		**56%**	**-94%**	**26%**	
maximum error	**76%**	**-59%**	**48%**		**74%**	**-75%**	**45%**	
average error	**63%**	**-74%**	**41%**		**66%**	**-86%**	**37%**	
std. dev. error	**14%**	**10%**	**8%**		**9%**	**8%**	**9%**	

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	1A	**2A**	**3A**	**4A**	**5A**	**6A**	**1A**	**2A**	**3A**	**4A**	**5A**	**6A**
Step 1-1	210%	-27%	49%	-12%	-128%	56%	210%	-27%	49%	-12%	-128%	56%
Step 1-2	4%	28%	-189%	975%	4680%	-55%	4%	28%	-189%	975%	4680%	-55%
Step 1-3	-46%	-7%	-1%	-241%	-47%	-46%	-46%	-7%	-1%	-241%	-47%	-46%
Step 2-2	213%	-2%	-27%	-391%	-65%	-83%	213%	-2%	-27%	-391%	-65%	-83%
Step 2-3a	60%	-10%	-39%	-354%	-62%	-92%	60%	-10%	-39%	-354%	-62%	-92%
Step 3-3a	-71%	-27%	0%	-49%	-26%	-33%	-71%	-27%	0%	-49%	-26%	-33%
Step 4-1 w/N=6	-91%	-22%	1%	-38%	-28%	-29%	-93%	-23%	0%	-41%	-29%	-31%
Step 4-2 w/N=6	1%	-4%	3%	-34%	-15%	-19%	-1%	-5%	0%	-37%	-15%	-22%
minimum error	**-91%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**	**-93%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**
maximum error	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**
average error	**35%**	**-9%**	**-25%**	**-18%**	**539%**	**-38%**	**35%**	**-9%**	**-26%**	**-19%**	**539%**	**-38%**
std. dev. error	**119%**	**18%**	**71%**	**429%**	**1674%**	**46%**	**119%**	**18%**	**71%**	**429%**	**1674%**	**46%**
Case 1	-265%	-465%	2%		-263%	-12%	-266%	-468%	1%		-263%	-13%
Case 2	-183%	-370%	15%		-216%	0%	-179%	-364%	16%		-213%	1%
Case 3	-43%	-136%	51%		-85%	26%	-42%	-133%	52%		-82%	28%
Case 4	163%	240%	150%		365%	7146%	138%	182%	132%		259%	4448%
Case 5	376%	1809%	-149%		-342%	-14%	297%	1321%	-80%		-215%	18%
Case 6	377%	1277%	-92%		-379%	0%	289%	899%	-34%		-227%	31%
minimum error	**-265%**	**-465%**	**-149%**		**-379%**	**-14%**	**-266%**	**-468%**	**-80%**		**-263%**	**-13%**
maximum error	**377%**	**1809%**	**150%**		**365%**	**7146%**	**297%**	**1321%**	**132%**		**259%**	**4448%**
average error	**71%**	**393%**	**-4%**		**-153%**	**1191%**	**39%**	**240%**	**14%**		**-123%**	**752%**
std. dev. error	**278%**	**939%**	**106%**		**274%**	**2918%**	**239%**	**723%**	**73%**		**197%**	**1811%**
Case 7	-10%	-78%	-4%		-54%	-33%	-22%	-98%	-16%		-73%	-48%
Case 8	-18%	-100%	-4%		-84%	-33%	-19%	-102%	-4%		-85%	-33%
Case 9	22%	-34%	27%		-32%	3%	23%	-32%	28%		-31%	4%
Case 10	145%	196%	1474%		344%	-5%	131%	167%	1097%		272%	25%
Case 11	138%	187%	1842%		317%	4%	125%	159%	1273%		242%	37%
minimum error	**-18%**	**-100%**	**-4%**		**-84%**	**-33%**	**-19%**	**-102%**	**-4%**		**-85%**	**-33%**
maximum error	**145%**	**196%**	**1842%**		**344%**	**4%**	**131%**	**167%**	**1273%**		**272%**	**37%**
average error	**72%**	**62%**	**835%**		**136%**	**-8%**	**65%**	**48%**	**598%**		**99%**	**8%**
std. dev. error	**82%**	**152%**	**962%**		**226%**	**17%**	**75%**	**136%**	**681%**		**183%**	**31%**
Total Stress Case 1	-29%	-21%	2%		-29%	-16%	-31%	-22%	1%		-30%	-18%
Total Stress Case 2	-21%	-18%	7%		-26%	-12%	-22%	-18%	6%		-27%	-13%
Total Stress Case 3	-3%	-8%	17%		-17%	-8%	-5%	-8%	15%		-18%	-10%
Total Stress Case 4	10%	-1%	16%		-12%	-13%	7%	-2%	12%		-14%	-18%
Total Stress Case 5	16%	3%	14%		-10%	-20%	11%	0%	6%		-13%	-31%
Total Stress Case 6	16%	3%	12%		-10%	-24%	11%	0%	3%		-13%	-36%
minimum error	**-29%**	**-21%**	**2%**		**-29%**	**-24%**	**-31%**	**-22%**	**1%**		**-30%**	**-36%**
maximum error	**16%**	**3%**	**17%**		**-10%**	**-8%**	**11%**	**0%**	**15%**		**-13%**	**-10%**
average error	**-2%**	**-7%**	**11%**		**-18%**	**-16%**	**-5%**	**-8%**	**7%**		**-19%**	**-21%**
std. dev. error	**20%**	**11%**	**6%**		**8%**	**6%**	**18%**	**10%**	**5%**		**8%**	**10%**
Total Stress Case 7	-1%	-7%	1%		-17%	-22%	-4%	-9%	-3%		-19%	-27%
Total Stress Case 8	-2%	-9%	1%		-19%	-22%	-4%	-10%	-1%		-19%	-25%
Total Stress Case 9	4%	-5%	8%		-16%	-15%	2%	-6%	6%		-16%	-17%
Total Stress Case 10	15%	1%	10%		-11%	-20%	12%	0%	6%		-13%	-26%
Total Stress Case 11	16%	1%	10%		-11%	-21%	13%	0%	5%		-13%	-27%
minimum error	**-2%**	**-9%**	**1%**		**-19%**	**-22%**	**-4%**	**-10%**	**-1%**		**-19%**	**-27%**
maximum error	**16%**	**1%**	**10%**		**-11%**	**-15%**	**13%**	**0%**	**6%**		**-13%**	**-17%**
average error	**8%**	**-3%**	**7%**		**-14%**	**-20%**	**6%**	**-4%**	**4%**		**-15%**	**-24%**
std. dev. error	**9%**	**5%**	**4%**		**4%**	**3%**	**8%**	**5%**	**3%**		**3%**	**5%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6												
	Composite Analysis						Part. Non-Composite Analysis					
	7A	**8A**	**9A**	**10A**	**11A**	**12A**	**7A**	**8A**	**9A**	**10A**	**11A**	**12A**
Step 1-1	105%	156%	85%	92%	50%	174%	105%	156%	85%	92%	50%	174%
Step 1-2	118%	-1750%	-88%	76%	13%	137%	118%	-1750%	-88%	76%	13%	137%
Step 1-3	184%	-42%	-77%	43%	-83%	875%	184%	-42%	-77%	43%	-83%	875%
Step 2-2	413%	-30%	-202%	34%	-32%	285%	413%	-30%	-202%	34%	-32%	285%
Step 2-3a	646%	-36%	-184%	26%	-44%	336%	646%	-36%	-184%	26%	-44%	336%
Step 3-3a	-255%	-17%	-73%	19%	-58%	-346%	-255%	-17%	-73%	19%	-58%	-346%
Step 4-1	-188%	-3%	-99%	18%	-63%	-461%	-190%	-3%	-102%	17%	-63%	-469%
Step 4-2	-89%	6%	-104%	11%	-38%	-520%	-91%	6%	-109%	8%	-39%	-536%
minimum error	**-255%**	**-1750%**	**-202%**	**11%**	**-83%**	**-520%**	**-255%**	**-1750%**	**-202%**	**8%**	**-83%**	**-536%**
maximum error	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**
average error	**117%**	**-214%**	**-93%**	**40%**	**-32%**	**60%**	**116%**	**-214%**	**-94%**	**39%**	**-32%**	**57%**
std. dev. error	**304%**	**624%**	**87%**	**30%**	**43%**	**476%**	**304%**	**624%**	**87%**	**30%**	**43%**	**480%**
Case 1	-161%	-254%	-45%	-13%	-218%	6%	-165%	-261%	-50%	-18%	-226%	4%
Case 2	-106%	-196%	-36%	0%	-171%	17%	-109%	-202%	-40%	-4%	-175%	16%
Case 3	-4%	-48%	-26%	22%	-48%	40%	-9%	-53%	-34%	16%	-55%	38%
Case 4	373%	271%	-10%	-207%	276%	-14728%	275%	209%	28%	-111%	213%	-9900%
Case 5	-216%	-663%	-34%	-32%	-1287%	-13%	-130%	-453%	-3%	-4%	-912%	15%
Case 6	-233%	-7327%	-12%	-9%	-7443%	2%	-131%	-4940%	17%	18%	-5288%	29%
minimum error	**-233%**	**-7327%**	**-45%**	**-207%**	**-7443%**	**-14728%**	**-165%**	**-4940%**	**-50%**	**-111%**	**-5288%**	**-9900%**
maximum error	**373%**	**271%**	**-10%**	**22%**	**276%**	**40%**	**275%**	**209%**	**28%**	**18%**	**213%**	**38%**
average error	**-58%**	**-1370%**	**-27%**	**-40%**	**-1482%**	**-2446%**	**-45%**	**-950%**	**-14%**	**-17%**	**-1074%**	**-1633%**
std. dev. error	**227%**	**2934%**	**14%**	**84%**	**2968%**	**6017%**	**166%**	**1967%**	**32%**	**48%**	**2098%**	**4050%**
Case 7	-35%	-49%	-52%	-19%	-46%	7%	-49%	-63%	-68%	-31%	-59%	-2%
Case 8	-33%	-39%	-67%	-18%	-52%	8%	-36%	-41%	-73%	-23%	-55%	5%
Case 9	25%	16%	-62%	5%	8%	32%	23%	13%	-68%	0%	8%	30%
Case 10	233%	163%	35%	-6%	178%	-65%	198%	142%	51%	18%	157%	-23%
Case 11	219%	160%	38%	2%	168%	-45%	177%	138%	55%	25%	144%	-2%
minimum error	**-33%**	**-39%**	**-67%**	**-18%**	**-52%**	**-65%**	**-36%**	**-41%**	**-73%**	**-23%**	**-55%**	**-23%**
maximum error	**233%**	**163%**	**38%**	**5%**	**178%**	**32%**	**198%**	**142%**	**55%**	**25%**	**157%**	**30%**
average error	**111%**	**75%**	**-14%**	**-4%**	**75%**	**-18%**	**90%**	**63%**	**-9%**	**5%**	**63%**	**3%**
std. dev. error	**135%**	**103%**	**59%**	**10%**	**115%**	**45%**	**115%**	**92%**	**71%**	**21%**	**104%**	**22%**
Total Stress Case 1	-100%	-6%	-75%	3%	-51%	-92%	-102%	-7%	-80%	0%	-52%	-97%
Total Stress Case 2	-92%	-3%	-73%	7%	-47%	-90%	-94%	-4%	-78%	5%	-48%	-94%
Total Stress Case 3	-80%	5%	-86%	12%	-38%	-162%	-82%	4%	-93%	10%	-39%	-170%
Total Stress Case 4	-83%	8%	-114%	14%	-34%	-489%	-86%	7%	-124%	10%	-36%	-516%
Total Stress Case 5	-85%	9%	-123%	15%	-33%	-2389%	-89%	8%	-139%	10%	-35%	-2566%
Total Stress Case 6	-85%	10%	-134%	13%	-33%	-4035%	-90%	8%	-151%	7%	-35%	-4340%
minimum error	**-100%**	**-6%**	**-134%**	**3%**	**-51%**	**-4035%**	**-102%**	**-7%**	**-151%**	**0%**	**-52%**	**-4340%**
maximum error	**-80%**	**10%**	**-73%**	**15%**	**-33%**	**-90%**	**-82%**	**8%**	**-78%**	**10%**	**-35%**	**-94%**
average error	**-87%**	**4%**	**-101%**	**11%**	**-39%**	**-1209%**	**-90%**	**3%**	**-111%**	**7%**	**-41%**	**-1297%**
std. dev. error	**7%**	**7%**	**26%**	**5%**	**8%**	**1643%**	**7%**	**6%**	**31%**	**4%**	**7%**	**1768%**
Total Stress Case 7	-82%	3%	-88%	5%	-38%	-169%	-85%	2%	-97%	1%	-40%	-180%
Total Stress Case 8	-81%	4%	-93%	5%	-39%	-154%	-82%	3%	-98%	2%	-40%	-161%
Total Stress Case 9	-73%	7%	-96%	10%	-35%	-185%	-75%	6%	-102%	7%	-36%	-192%
Total Stress Case 10	-80%	10%	-134%	11%	-32%	-646%	-82%	9%	-145%	8%	-34%	-677%
Total Stress Case 11	-80%	10%	-133%	11%	-32%	-663%	-82%	9%	-143%	8%	-34%	-696%
minimum error	**-81%**	**4%**	**-134%**	**5%**	**-39%**	**-663%**	**-82%**	**3%**	**-145%**	**2%**	**-40%**	**-696%**
maximum error	**-73%**	**10%**	**-93%**	**11%**	**-32%**	**-154%**	**-75%**	**9%**	**-98%**	**8%**	**-34%**	**-161%**
average error	**-78%**	**7%**	**-114%**	**9%**	**-35%**	**-412%**	**-81%**	**7%**	**-122%**	**6%**	**-36%**	**-432%**
std. dev. error	**3%**	**3%**	**23%**	**3%**	**3%**	**280%**	**4%**	**3%**	**25%**	**3%**	**3%**	**295%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

	Percent Error with N = 6											
	Composite Analysis						Part. Non-Composite Analysis					
	13A	**14A**	**15A**	**16A**	**17A**	**18A**	**13A**	**14A**	**15A**	**16A**	**17A**	**18A**
Step 1-1	86%	0%	280%	122%	113%	123%	86%	0%	280%	122%	113%	123%
Step 1-2	95%	475%	90%	137%	108%	47%	95%	475%	90%	137%	108%	47%
Step 1-3	229%	-241%	297%	31%	30%	-195%	229%	-241%	297%	31%	30%	-195%
Step 2-2	240%	-126%	249%	32%	24%	-491%	240%	-126%	249%	32%	24%	-491%
Step 2-3a	310%	-122%	296%	26%	14%	-503%	310%	-122%	296%	26%	14%	-503%
Step 3-3a	-211%	-143%	-414%	24%	-12%	-130%	-211%	-143%	-414%	24%	-12%	-130%
Step 4-1	-91%	-101%	-316%	18%	-2%	-93%	-92%	-102%	-323%	17%	-2%	-96%
Step 4-2	-48%	-56%	-324%	16%	8%	-113%	-50%	-57%	-335%	13%	7%	-118%
minimum error	**-211%**	**-241%**	**-414%**	**16%**	**-12%**	**-503%**	**-211%**	**-241%**	**-414%**	**13%**	**-12%**	**-503%**
maximum error	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**
average error	**76%**	**-39%**	**20%**	**51%**	**35%**	**-170%**	**76%**	**-40%**	**17%**	**50%**	**35%**	**-171%**
std. dev. error	**182%**	**219%**	**315%**	**49%**	**48%**	**226%**	**182%**	**219%**	**318%**	**49%**	**48%**	**226%**
Case 1	-186%	-263%		13%	-161%	-21%	-207%	-292%		6%	-180%	-27%
Case 2	-131%	-180%		26%	-107%	-4%	-149%	-202%		19%	-125%	-10%
Case 3	3%	7%		55%	21%	34%	-16%	-17%		44%	3%	25%
Case 4	245%	184%		-12%	172%	-78%	192%	163%		16%	153%	-21%
Case 5	-1337%	459%		35%	320%	6%	-1121%	435%		39%	298%	25%
Case 6	654%	255%		47%	254%	21%	562%	243%		48%	237%	38%
minimum error	**-1337%**	**-263%**		**-12%**	**-161%**	**-78%**	**-1121%**	**-292%**		**6%**	**-180%**	**-27%**
maximum error	**654%**	**459%**		**55%**	**320%**	**34%**	**562%**	**435%**		**48%**	**298%**	**38%**
average error	**-125%**	**77%**		**27%**	**83%**	**-7%**	**-123%**	**55%**		**29%**	**64%**	**5%**
std. dev. error	**668%**	**274%**		**25%**	**196%**	**40%**	**563%**	**277%**		**17%**	**196%**	**28%**
Case 7	-94%	-49%		8%	-47%	-24%	-111%	-64%		0%	-60%	-35%
Case 8	-45%	-23%		5%	-23%	-29%	-53%	-30%		-1%	-31%	-35%
Case 9	33%	47%		42%	43%	12%	26%	39%		33%	35%	6%
Case 10	143%	124%		52%	129%	27%	138%	120%		55%	125%	42%
Case 11	132%	120%		60%	121%	38%	132%	116%		60%	121%	51%
minimum error	**-45%**	**-23%**		**5%**	**-23%**	**-29%**	**-53%**	**-30%**		**-1%**	**-31%**	**-35%**
maximum error	**143%**	**124%**		**60%**	**129%**	**38%**	**138%**	**120%**		**60%**	**125%**	**51%**
average error	**66%**	**67%**		**40%**	**67%**	**12%**	**61%**	**61%**		**37%**	**63%**	**16%**
std. dev. error	**89%**	**70%**		**24%**	**72%**	**29%**	**92%**	**71%**		**28%**	**75%**	**39%**
Total Stress Case 1	-62%	-69%		14%	-1%	-63%	-66%	-71%		10%	-3%	-69%
Total Stress Case 2	-56%	-64%		20%	2%	-57%	-60%	-66%		15%	0%	-62%
Total Stress Case 3	-45%	-53%		23%	8%	-69%	-48%	-55%		19%	7%	-75%
Total Stress Case 4	-43%	-50%		17%	10%	-116%	-45%	-52%		13%	9%	-125%
Total Stress Case 5	-44%	-50%		13%	11%	-150%	-46%	-52%		10%	10%	-162%
Total Stress Case 6	-43%	-49%		11%	11%	-157%	-45%	-51%		8%	10%	-169%
minimum error	**-62%**	**-69%**		**11%**	**-1%**	**-157%**	**-66%**	**-71%**		**8%**	**-3%**	**-169%**
maximum error	**-43%**	**-49%**		**23%**	**11%**	**-57%**	**-45%**	**-51%**		**19%**	**10%**	**-62%**
average error	**-49%**	**-56%**		**16%**	**7%**	**-102%**	**-52%**	**-58%**		**13%**	**6%**	**-110%**
std. dev. error	**8%**	**8%**		**4%**	**5%**	**45%**	**9%**	**9%**		**4%**	**6%**	**48%**
Total Stress Case 7	-52%	-55%		14%	5%	-81%	-55%	-57%		10%	4%	-88%
Total Stress Case 8	-48%	-53%		13%	6%	-82%	-50%	-54%		10%	5%	-88%
Total Stress Case 9	-41%	-47%		20%	9%	-81%	-43%	-48%		17%	8%	-87%
Total Stress Case 10	-40%	-45%		13%	11%	-132%	-42%	-46%		10%	10%	-140%
Total Stress Case 11	-40%	-45%		13%	11%	-133%	-42%	-47%		10%	11%	-141%
minimum error	**-48%**	**-53%**		**13%**	**6%**	**-133%**	**-50%**	**-54%**		**10%**	**5%**	**-141%**
maximum error	**-40%**	**-45%**		**20%**	**11%**	**-81%**	**-42%**	**-46%**		**17%**	**11%**	**-87%**
average error	**-42%**	**-47%**		**15%**	**9%**	**-107%**	**-44%**	**-49%**		**12%**	**9%**	**-114%**
std. dev. error	**4%**	**4%**		**4%**	**3%**	**29%**	**4%**	**4%**		**3%**	**3%**	**31%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	19A	**20A**	**21A**	**22A**	**23A**	**24A**	**19A**	**20A**	**21A**	**22A**	**23A**	**24A**
Step 1-1	135%	-254%	183%	118%	457%	-700%	135%	-254%	183%	118%	457%	-700%
Step 1-2	119%	352%	58%	27%	421%	50%	119%	352%	58%	27%	421%	50%
Step 1-3	49%	-1%	-304%	-10300%	-89%	-224%	49%	-1%	-304%	-10300%	-89%	-224%
Step 2-2	66%	12%	-1414%	591%	15%	-99%	66%	12%	-1414%	591%	15%	-99%
Step 2-3a	55%	6%	-1109%	695%	8%	-144%	55%	6%	-1109%	695%	8%	-144%
Step 3-3a	13%	-5%	-31%	-126%	-30%	-48%	13%	-5%	-31%	-126%	-30%	-48%
Step 4-1	20%	20%	-54%	-38%	-48%	-63%	20%	19%	-56%	-41%	-49%	-65%
Step 4-2	33%	18%	-28%	-77%	-16%	-24%	33%	17%	-31%	-82%	-17%	-27%
minimum error	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**
maximum error	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**
average error	**61%**	**19%**	**-337%**	**-1139%**	**90%**	**-157%**	**61%**	**18%**	**-338%**	**-1140%**	**90%**	**-157%**
std. dev. error	**44%**	**163%**	**592%**	**3715%**	**218%**	**234%**	**44%**	**163%**	**592%**	**3714%**	**218%**	**234%**
Case 1	1399%	722%	10%	-92%	-349%	0%	1499%	773%	2%	-114%	-391%	-7%
Case 2	1813%	730%	21%	-89%	-291%	12%	1965%	799%	12%	-118%	-341%	5%
Case 3		-464%	65%	-127%	-16%	63%		-778%	49%	-264%	-78%	50%
Case 4	164%	218%	-827%	46%	219%	362%	148%	179%	-567%	60%	189%	277%
Case 5	148%	167%	16%	69%	175%	-58%	142%	167%	16%	59%	184%	-34%
Case 6	120%	122%	48%	86%	133%	-26%	125%	130%	36%	71%	140%	-13%
minimum error	**120%**	**-464%**	**-827%**	**-127%**	**-349%**	**-58%**	**125%**	**-778%**	**-567%**	**-264%**	**-391%**	**-34%**
maximum error	**1813%**	**730%**	**65%**	**86%**	**219%**	**362%**	**1965%**	**799%**	**49%**	**71%**	**189%**	**277%**
average error	**729%**	**249%**	**-111%**	**-18%**	**-22%**	**59%**	**776%**	**212%**	**-76%**	**-51%**	**-50%**	**46%**
std. dev. error	**814%**	**444%**	**351%**	**95%**	**245%**	**154%**	**888%**	**574%**	**242%**	**136%**	**265%**	**117%**
Case 7	-284%	-109%	-5%	-293%	-79%	-11%	-317%	-125%	-13%	-321%	-91%	-19%
Case 8	-255%	-138%	8%	-400%	-69%	0%	-281%	-151%	2%	-445%	-81%	-6%
Case 9	15%	39%	52%	327%	37%	48%	0%	29%	41%	391%	22%	41%
Case 10	111%	109%	23%	92%	113%	313%	111%	109%	23%	89%	113%	294%
Case 11	104%	104%	61%	99%	104%	167%	104%	104%	35%	92%	109%	167%
minimum error	**-255%**	**-138%**	**8%**	**-400%**	**-69%**	**0%**	**-281%**	**-151%**	**2%**	**-445%**	**-81%**	**-6%**
maximum error	**111%**	**109%**	**61%**	**327%**	**113%**	**313%**	**111%**	**109%**	**41%**	**391%**	**113%**	**294%**
average error	**-6%**	**29%**	**36%**	**30%**	**47%**	**132%**	**-17%**	**23%**	**25%**	**32%**	**41%**	**124%**
std. dev. error	**171%**	**116%**	**25%**	**306%**	**84%**	**140%**	**183%**	**121%**	**17%**	**348%**	**91%**	**135%**
Total Stress Case 1	19%	5%	-8%	-83%	-29%	-13%	18%	4%	-14%	-95%	-31%	-18%
Total Stress Case 2	23%	8%	-5%	-81%	-25%	-9%	22%	7%	-11%	-94%	-27%	-14%
Total Stress Case 3	32%	17%	-4%	-80%	-16%	-4%	31%	16%	-11%	-93%	-18%	-9%
Total Stress Case 4	35%	19%	-21%	-107%	-14%	-15%	34%	19%	-27%	-117%	-15%	-20%
Total Stress Case 5	35%	20%	-32%	-131%	-13%	-23%	35%	20%	-36%	-135%	-13%	-27%
Total Stress Case 6	35%	20%	-34%	-134%	-12%	-24%	35%	20%	-37%	-136%	-13%	-28%
minimum error	**19%**	**5%**	**-34%**	**-134%**	**-29%**	**-24%**	**18%**	**4%**	**-37%**	**-136%**	**-31%**	**-28%**
maximum error	**35%**	**20%**	**-4%**	**-80%**	**-12%**	**-4%**	**35%**	**20%**	**-11%**	**-93%**	**-13%**	**-9%**
average error	**30%**	**15%**	**-17%**	**-103%**	**-18%**	**-15%**	**29%**	**14%**	**-22%**	**-112%**	**-20%**	**-19%**
std. dev. error	**7%**	**7%**	**14%**	**25%**	**7%**	**8%**	**8%**	**7%**	**12%**	**20%**	**8%**	**7%**
Total Stress Case 7	27%	14%	-20%	-111%	-19%	-21%	26%	13%	-25%	-120%	-21%	-25%
Total Stress Case 8	28%	14%	-15%	-116%	-19%	-17%	27%	13%	-19%	-126%	-20%	-20%
Total Stress Case 9	33%	18%	-9%	-116%	-14%	-9%	32%	18%	-14%	-128%	-15%	-13%
Total Stress Case 10	36%	21%	-29%	-168%	-11%	-21%	35%	20%	-33%	-174%	-12%	-24%
Total Stress Case 11	35%	21%	-30%	-163%	-12%	-21%	35%	20%	-33%	-167%	-12%	-24%
minimum error	**28%**	**14%**	**-30%**	**-168%**	**-19%**	**-21%**	**27%**	**13%**	**-33%**	**-174%**	**-20%**	**-24%**
maximum error	**36%**	**21%**	**-9%**	**-116%**	**-11%**	**-9%**	**35%**	**20%**	**-14%**	**-126%**	**-12%**	**-13%**
average error	**33%**	**18%**	**-21%**	**-141%**	**-14%**	**-17%**	**32%**	**18%**	**-25%**	**-149%**	**-15%**	**-20%**
std. dev. error	**4%**	**3%**	**11%**	**29%**	**3%**	**6%**	**4%**	**3%**	**10%**	**25%**	**4%**	**5%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

	Percent Error with N = 6											
	Composite Analysis						Part. Non-Composite Analysis					
	1B	**2B**	**3B**	**4B**	**5B**	**6B**	**1B**	**2B**	**3B**	**4B**	**5B**	**6B**
Step 1-1	60%	51%	518%	131%	-94%	140%	60%	51%	518%	131%	-94%	140%
Step 1-2	29%	-6%	-76%	4%	6229%	880%	29%	-6%	-76%	4%	6229%	880%
Step 1-3	33%	7%	-59%	-142%	-245%	-238%	33%	7%	-59%	-142%	-245%	-238%
Step 2-2	20%	6%	-30%	-86%	-103%	-128%	20%	6%	-30%	-86%	-103%	-128%
Step 2-3a	12%	0%	-41%	-98%	-121%	-130%	12%	0%	-41%	-98%	-121%	-130%
Step 3-3a	-7%	9%	-26%	-45%	-22%	-48%	-7%	9%	-26%	-45%	-22%	-48%
Step 4-1	-9%	11%	-8%	-19%	-7%	-35%	-21%	1%	-7%	-18%	-18%	-36%
Step 4-2	-15%	17%	-2%	-10%	-7%	-10%	-35%	2%	-1%	-8%	-24%	-12%
minimum error	**-15%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**	**-35%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**
maximum error	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**
average error	**15%**	**12%**	**35%**	**-33%**	**704%**	**54%**	**11%**	**9%**	**35%**	**-33%**	**700%**	**54%**
std. dev. error	**25%**	**17%**	**197%**	**83%**	**2234%**	**351%**	**31%**	**18%**	**197%**	**83%**	**2235%**	**351%**
Case 1	-36%	-74%	-101%	3%	-43%	-82%	143%	-362%	-92%	-164%	-694%	99%
Case 2	-35%	-63%	-83%	14%	-18%	-71%	172%	-343%	-80%	-156%	-622%	110%
Case 3	-32%	-108%	-114%	-40%	-78%	-65%	-33%	-497%	-121%	-162%	-696%	42%
Case 4	-84%	-200%	-179%	-176%	-223%	-38%	-631%	-787%	-188%	-99%	-365%	-134%
Case 5	-125%	-233%	-230%	-268%	-383%	-37%	-1019%	-852%	-227%	-58%	-120%	-231%
Case 6	-126%	-199%	-184%	-206%	-270%	-22%	-981%	-739%	-174%	-31%	-92%	-178%
minimum error	**-126%**	**-233%**	**-230%**	**-268%**	**-383%**	**-82%**	**-1019%**	**-852%**	**-227%**	**-164%**	**-696%**	**-231%**
maximum error	**-32%**	**-63%**	**-83%**	**14%**	**-18%**	**-22%**	**172%**	**-343%**	**-80%**	**-31%**	**-92%**	**110%**
average error	**-73%**	**-146%**	**-149%**	**-112%**	**-169%**	**-53%**	**-391%**	**-597%**	**-147%**	**-112%**	**-432%**	**-49%**
std. dev. error	**45%**	**73%**	**57%**	**120%**	**145%**	**23%**	**553%**	**224%**	**58%**	**58%**	**280%**	**150%**
Case 7	-63%	-116%	-115%	-86%	-137%	-36%	-373%	-490%	-106%	-64%	-401%	-55%
Case 8	-454%	-478%	-71%	3%	-2011%	-152%	227%	-1399%	-61%	-154%	-11512%	92%
Case 9	-269%	-439%	-53%	18%	-522%	-103%	255%	-1319%	-48%	-129%	-3518%	102%
Case 10	985%	8993%	-163%	-221%	1415%	-46%	4480%	25690%	-161%	-39%	747%	-246%
Case 11	-1834%	-1607%	-121%	-154%	-20276%	-21%	-8956%	-4654%	-111%	-7%	-10872%	-166%
minimum error	**-1834%**	**-1607%**	**-163%**	**-221%**	**-20276%**	**-152%**	**-8956%**	**-4654%**	**-161%**	**-154%**	**-11512%**	**-246%**
maximum error	**985%**	**8993%**	**-53%**	**18%**	**1415%**	**-21%**	**4480%**	**25690%**	**-48%**	**-7%**	**747%**	**102%**
average error	**-393%**	**1617%**	**-102%**	**-89%**	**-5349%**	**-81%**	**-998%**	**4579%**	**-95%**	**-82%**	**-6289%**	**-54%**
std. dev. error	**1154%**	**4947%**	**50%**	**118%**	**10050%**	**59%**	**5669%**	**14159%**	**52%**	**70%**	**5929%**	**178%**
Total Stress Case 1	-16%	14%	-9%	-9%	-9%	-19%	-25%	-10%	-7%	-23%	-60%	1%
Total Stress Case 2	-16%	14%	-8%	-7%	-8%	-18%	-24%	-9%	-7%	-24%	-60%	3%
Total Stress Case 3	-15%	14%	-8%	-12%	-10%	-16%	-35%	-9%	-7%	-20%	-48%	-7%
Total Stress Case 4	-18%	12%	-13%	-23%	-14%	-13%	-61%	-14%	-12%	-15%	-34%	-25%
Total Stress Case 5	-20%	10%	-19%	-33%	-19%	-14%	-85%	-22%	-18%	-13%	-27%	-41%
Total Stress Case 6	-21%	9%	-20%	-33%	-19%	-12%	-88%	-23%	-18%	-11%	-27%	-39%
minimum error	**-21%**	**9%**	**-20%**	**-33%**	**-19%**	**-19%**	**-88%**	**-23%**	**-18%**	**-24%**	**-60%**	**-41%**
maximum error	**-15%**	**14%**	**-8%**	**-7%**	**-8%**	**-12%**	**-24%**	**-9%**	**-7%**	**-11%**	**-27%**	**3%**
average error	**-17%**	**12%**	**-13%**	**-20%**	**-13%**	**-15%**	**-53%**	**-15%**	**-12%**	**-18%**	**-43%**	**-18%**
std. dev. error	**2%**	**2%**	**6%**	**12%**	**5%**	**3%**	**29%**	**6%**	**5%**	**6%**	**15%**	**19%**
Total Stress Case 7	-17%	12%	-12%	-19%	-14%	-14%	-55%	-15%	-11%	-15%	-42%	-18%
Total Stress Case 8	-17%	15%	-4%	-9%	-10%	-16%	-34%	-4%	-3%	-14%	-41%	-9%
Total Stress Case 9	-17%	15%	-4%	-8%	-10%	-15%	-32%	-4%	-3%	-15%	-43%	-7%
Total Stress Case 10	-20%	13%	-9%	-20%	-14%	-12%	-61%	-10%	-7%	-10%	-28%	-26%
Total Stress Case 11	-20%	13%	-8%	-19%	-14%	-11%	-60%	-10%	-6%	-8%	-28%	-24%
minimum error	**-20%**	**13%**	**-9%**	**-20%**	**-14%**	**-16%**	**-61%**	**-10%**	**-7%**	**-15%**	**-43%**	**-26%**
maximum error	**-17%**	**15%**	**-4%**	**-8%**	**-10%**	**-11%**	**-32%**	**-4%**	**-3%**	**-8%**	**-28%**	**-7%**
average error	**-18%**	**14%**	**-6%**	**-14%**	**-12%**	**-14%**	**-47%**	**-7%**	**-5%**	**-12%**	**-35%**	**-16%**
std. dev. error	**2%**	**1%**	**3%**	**6%**	**2%**	**2%**	**16%**	**3%**	**3%**	**3%**	**8%**	**10%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis						**Part. Non-Composite Analysis**					
	7B	**8B**	**9B**	**10B**	**11B**	**12B**	**7B**	**8B**	**9B**	**10B**	**11B**	**12B**
Step 1-1	-6%	-925%	-273%	12%		136%	-6%	-925%	-273%	12%		136%
Step 1-2	-592%	-2536%	-24%	-78%		743%	-592%	-2536%	-24%	-78%		743%
Step 1-3	-46%	-203%	-12%	-23%		-1171%	-46%	-203%	-12%	-23%		-1171%
Step 2-2	0%	1%	1%	0%	100%	-399%	0%	1%	1%	0%	100%	-399%
Step 2-3a	-70%	-253%	-7%	-27%	-13%	-291%	-70%	-253%	-7%	-27%	-13%	-291%
Step 3-3a	-40%	-56%	-9%	-88%	2%	-134%	-40%	-56%	-9%	-88%	2%	-134%
Step 4-1	-34%	-52%	9%	-83%	18%	-101%	-45%	-67%	11%	-81%	5%	-100%
Step 4-2	-30%	-42%	2%	-57%	22%	-58%	-48%	-65%	5%	-54%	3%	-58%
minimum error	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**
maximum error	**0%**	**1%**	**9%**	**12%**	**100%**	**743%**	**0%**	**1%**	**11%**	**12%**	**100%**	**743%**
average error	**-102%**	**-508%**	**-39%**	**-43%**	**26%**	**-159%**	**-106%**	**-513%**	**-39%**	**-42%**	**19%**	**-159%**
std. dev. error	**199%**	**873%**	**95%**	**39%**	**44%**	**537%**	**198%**	**870%**	**95%**	**38%**	**46%**	**537%**
Case 1	-373%	-163%	-89%	47%	-38%	-130%	552%	-626%	-63%	-85%	-763%	74%
Case 2	-339%	-117%	-73%	56%	-16%	-115%	642%	-511%	-52%	-76%	-680%	84%
Case 3	-462%	-156%	-80%	20%	-32%	-82%	-208%	-671%	-68%	-58%	-551%	32%
Case 4	-376%	-169%	-80%	-54%	-48%	6%	-1987%	-735%	-73%	12%	-79%	-85%
Case 5	-412%	-201%	-103%	-127%	-82%	53%	-3384%	-836%	-92%	60%	276%	-194%
Case 6	-278%	-167%	-77%	-107%	-66%	64%	-2552%	-701%	-63%	77%	304%	-160%
minimum error	**-462%**	**-201%**	**-103%**	**-127%**	**-82%**	**-130%**	**-3384%**	**-836%**	**-92%**	**-85%**	**-763%**	**-194%**
maximum error	**-278%**	**-117%**	**-73%**	**56%**	**-16%**	**64%**	**642%**	**-511%**	**-52%**	**77%**	**304%**	**84%**
average error	**-373%**	**-162%**	**-84%**	**-28%**	**-47%**	**-34%**	**-1156%**	**-680%**	**-68%**	**-12%**	**-249%**	**-42%**
std. dev. error	**63%**	**27%**	**11%**	**80%**	**24%**	**86%**	**1712%**	**109%**	**13%**	**71%**	**480%**	**121%**
Case 7	-583%	-272%	-55%	-17%	-63%	-21%	-1759%	-956%	-37%	5%	-282%	-27%
Case 8	334%	378%	-38%	47%	-366%	-127%	-108%	844%	-16%	-75%	-2742%	73%
Case 9		520%	-29%	55%	-184%	-110%		1280%	-14%	-68%	-1753%	78%
Case 10	421%	453%	-33%	-98%	-571%	61%	2337%	1203%	-26%	71%	832%	-160%
Case 11	402%	433%	-19%	-86%	-636%	68%	2225%	1078%	-8%	85%	1088%	-140%
minimum error	**334%**	**378%**	**-38%**	**-98%**	**-636%**	**-127%**	**-108%**	**844%**	**-26%**	**-75%**	**-2742%**	**-160%**
maximum error	**421%**	**520%**	**-19%**	**55%**	**-184%**	**68%**	**2337%**	**1280%**	**-8%**	**85%**	**1088%**	**78%**
average error	**386%**	**446%**	**-30%**	**-21%**	**-439%**	**-27%**	**1485%**	**1101%**	**-16%**	**3%**	**-644%**	**-37%**
std. dev. error	**46%**	**59%**	**8%**	**83%**	**206%**	**106%**	**1380%**	**191%**	**8%**	**87%**	**1899%**	**130%**
Total Stress Case 1	-38%	-47%	-7%	-34%	18%	-73%	-33%	-89%	-3%	-61%	-56%	-32%
Total Stress Case 2	-38%	-46%	-6%	-30%	19%	-70%	-30%	-88%	-2%	-59%	-57%	-28%
Total Stress Case 3	-37%	-46%	-5%	-42%	19%	-63%	-51%	-88%	-2%	-55%	-35%	-42%
Total Stress Case 4	-36%	-46%	-5%	-57%	18%	-48%	-85%	-88%	-3%	-41%	-2%	-62%
Total Stress Case 5	-38%	-48%	-8%	-71%	16%	-39%	-117%	-94%	-5%	-31%	20%	-81%
Total Stress Case 6	-36%	-47%	-6%	-68%	16%	-35%	-115%	-91%	-3%	-26%	23%	-77%
minimum error	**-38%**	**-48%**	**-8%**	**-71%**	**16%**	**-73%**	**-117%**	**-94%**	**-5%**	**-61%**	**-57%**	**-81%**
maximum error	**-36%**	**-46%**	**-5%**	**-30%**	**19%**	**-35%**	**-30%**	**-88%**	**-2%**	**-26%**	**23%**	**-28%**
average error	**-37%**	**-47%**	**-6%**	**-50%**	**18%**	**-55%**	**-72%**	**-90%**	**-3%**	**-46%**	**-18%**	**-54%**
std. dev. error	**1%**	**1%**	**1%**	**17%**	**1%**	**16%**	**39%**	**2%**	**1%**	**15%**	**36%**	**23%**
Total Stress Case 7	-38%	-49%	-5%	-48%	17%	-51%	-75%	-91%	0%	-40%	-16%	-51%
Total Stress Case 8	-37%	-49%	0%	-47%	19%	-65%	-47%	-81%	3%	-56%	-23%	-46%
Total Stress Case 9	-37%	-49%	0%	-43%	19%	-64%	-45%	-82%	3%	-56%	-27%	-43%
Total Stress Case 10	-36%	-48%	0%	-62%	18%	-48%	-80%	-82%	3%	-41%	9%	-67%
Total Stress Case 11	-35%	-48%	1%	-60%	18%	-47%	-78%	-80%	4%	-40%	10%	-65%
minimum error	**-37%**	**-49%**	**0%**	**-62%**	**18%**	**-65%**	**-80%**	**-82%**	**3%**	**-56%**	**-27%**	**-67%**
maximum error	**-35%**	**-48%**	**1%**	**-43%**	**19%**	**-47%**	**-45%**	**-80%**	**4%**	**-40%**	**10%**	**-43%**
average error	**-36%**	**-49%**	**0%**	**-53%**	**18%**	**-56%**	**-63%**	**-81%**	**3%**	**-48%**	**-8%**	**-55%**
std. dev. error	**1%**	**0%**	**0%**	**9%**	**0%**	**10%**	**19%**	**1%**	**0%**	**9%**	**20%**	**12%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	13B	14B	15B	16B	17B	18B	13B	14B	15B	16B	17B	18B
Step 1-1	-3%	-112%	-98%	454%	-277%	1286%	-3%	-112%	-98%	454%	-277%	1286%
Step 1-2	2592%	-858%	-117%	910%	-2771%	-196%	2592%	-858%	-117%	910%	-2771%	-196%
Step 1-3	-36%	-50%	28%	-160%	25%	-64%	-36%	-50%	28%	-160%	25%	-64%
Step 2-2	-60%	-77%	30%	-116%		-46%	-60%	-77%	30%	-116%		-46%
Step 2-3a	-59%	-68%	24%	-106%		-52%	-59%	-68%	24%	-106%		-52%
Step 3-3a	-37%	-23%	4%	-73%	11%	-89%	-37%	-23%	4%	-73%	11%	-89%
Step 4-1	-28%	-22%	22%	-36%	24%	-87%	-37%	-33%	24%	-34%	17%	-84%
Step 4-2	-35%	-31%	15%	-32%	20%	-65%	-54%	-53%	18%	-29%	7%	-62%
minimum error	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**
maximum error	**2592%**	**-22%**	**30%**	**910%**	**25%**	**1286%**	**2592%**	**-23%**	**30%**	**910%**	**25%**	**1286%**
average error	**292%**	**-155%**	**-11%**	**105%**	**-495%**	**86%**	**288%**	**-159%**	**-11%**	**106%**	**-498%**	**87%**
std. dev. error	**930%**	**286%**	**60%**	**379%**	**1122%**	**487%**	**931%**	**284%**	**60%**	**378%**	**1120%**	**487%**
Case 1	-82%	-160%	-57%	11%	-33%	-214%	218%	-788%	-31%	-122%	-760%	35%
Case 2	-62%	-128%	-41%	27%	-18%	-185%	293%	-687%	-20%	-120%	-745%	59%
Case 3	-85%	-174%	-44%	-14%	-21%	-143%	-88%	-890%	-29%	-89%	-522%	-12%
Case 4	-68%	-155%	-40%	-78%	-18%	-41%	-736%	-827%	-25%	2%	-35%	-144%
Case 5	-43%	-124%	-57%	-126%	-25%	9%	-935%	-688%	-37%	53%	246%	-273%
Case 6	-30%	-129%	-39%	-112%	-13%	36%	-890%	-661%	-15%	76%	301%	-245%
minimum error	**-85%**	**-174%**	**-57%**	**-126%**	**-33%**	**-214%**	**-935%**	**-890%**	**-37%**	**-122%**	**-760%**	**-273%**
maximum error	**-30%**	**-124%**	**-39%**	**27%**	**-13%**	**36%**	**293%**	**-661%**	**-15%**	**76%**	**301%**	**59%**
average error	**-62%**	**-145%**	**-46%**	**-49%**	**-21%**	**-90%**	**-356%**	**-757%**	**-26%**	**-33%**	**-252%**	**-97%**
std. dev. error	**22%**	**21%**	**8%**	**65%**	**7%**	**105%**	**563%**	**92%**	**8%**	**88%**	**485%**	**144%**
Case 7	-64%	-235%	-33%	-41%	-20%	-75%	-384%	-1005%	-9%	-15%	-210%	-61%
Case 8	-797%	322%	-52%	-20%	-356%	-165%	652%	831%	-23%	-186%	-2782%	46%
Case 9	-355%	438%	-31%	10%	-232%	-138%	480%	1306%	-13%	-152%	-2218%	53%
Case 10	-637%	345%	-24%	-136%	-189%	38%	-5409%	939%	-6%	60%	510%	-176%
Case 11	-648%	289%	-9%	-129%	-138%	60%	-5754%	720%	10%	83%	601%	-156%
minimum error	**-797%**	**289%**	**-52%**	**-136%**	**-356%**	**-165%**	**-5754%**	**720%**	**-23%**	**-186%**	**-2782%**	**-176%**
maximum error	**-355%**	**438%**	**-9%**	**10%**	**-138%**	**60%**	**652%**	**1306%**	**10%**	**83%**	**601%**	**53%**
average error	**-609%**	**349%**	**-29%**	**-69%**	**-229%**	**-51%**	**-2508%**	**949%**	**-8%**	**-49%**	**-972%**	**-58%**
std. dev. error	**184%**	**64%**	**18%**	**75%**	**93%**	**116%**	**3552%**	**254%**	**14%**	**140%**	**1779%**	**125%**
Total Stress Case 1	-38%	-36%	6%	-24%	17%	-91%	-37%	-80%	12%	-44%	-35%	-45%
Total Stress Case 2	-37%	-35%	8%	-21%	18%	-87%	-32%	-78%	13%	-44%	-36%	-40%
Total Stress Case 3	-38%	-35%	9%	-29%	18%	-77%	-55%	-77%	13%	-38%	-20%	-54%
Total Stress Case 4	-37%	-35%	10%	-38%	18%	-62%	-87%	-75%	14%	-24%	5%	-73%
Total Stress Case 5	-36%	-35%	7%	-47%	17%	-55%	-113%	-78%	12%	-15%	20%	-91%
Total Stress Case 6	-35%	-34%	9%	-45%	18%	-52%	-108%	-74%	14%	-11%	23%	-87%
minimum error	**-38%**	**-36%**	**6%**	**-47%**	**17%**	**-91%**	**-113%**	**-80%**	**12%**	**-44%**	**-36%**	**-91%**
maximum error	**-35%**	**-34%**	**10%**	**-21%**	**18%**	**-52%**	**-32%**	**-74%**	**14%**	**-11%**	**23%**	**-40%**
average error	**-37%**	**-35%**	**8%**	**-34%**	**18%**	**-71%**	**-72%**	**-77%**	**13%**	**-29%**	**-7%**	**-65%**
std. dev. error	**1%**	**1%**	**1%**	**11%**	**0%**	**17%**	**36%**	**2%**	**1%**	**15%**	**27%**	**22%**
Total Stress Case 7	-37%	-36%	9%	-33%	18%	-67%	-73%	-77%	15%	-26%	-5%	-61%
Total Stress Case 8	-39%	-38%	12%	-31%	17%	-74%	-50%	-69%	16%	-38%	-11%	-52%
Total Stress Case 9	-39%	-37%	12%	-28%	17%	-73%	-48%	-70%	16%	-38%	-15%	-50%
Total Stress Case 10	-39%	-37%	13%	-39%	18%	-57%	-83%	-68%	17%	-22%	12%	-71%
Total Stress Case 11	-38%	-36%	14%	-38%	18%	-56%	-79%	-65%	18%	-21%	13%	-69%
minimum error	**-39%**	**-38%**	**12%**	**-39%**	**17%**	**-74%**	**-83%**	**-70%**	**16%**	**-38%**	**-15%**	**-71%**
maximum error	**-38%**	**-36%**	**14%**	**-28%**	**18%**	**-56%**	**-48%**	**-65%**	**18%**	**-21%**	**13%**	**-50%**
average error	**-39%**	**-37%**	**13%**	**-34%**	**18%**	**-65%**	**-65%**	**-68%**	**17%**	**-30%**	**0%**	**-60%**
std. dev. error	**0%**	**1%**	**1%**	**5%**	**0%**	**10%**	**18%**	**2%**	**1%**	**9%**	**15%**	**11%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis						Part. Non-Composite Analysis					
	19B	20B	21B	22B	23B	24B	19B	20B	21B	22B	23B	24B
Step 1-1	37%	-96%	-137%	254%	-23%	171%	37%	-96%	-137%	254%	-23%	171%
Step 1-2	-1850%	691%	18%	468%	11%	-149%	-1850%	691%	18%	468%	11%	-149%
Step 1-3	-71%	-58%	1%	375%	29%	-2%	-71%	-58%	1%	375%	29%	-2%
Step 2-2	-46%	-66%	18%	756%	55%	11%	-46%	-66%	18%	756%	55%	11%
Step 2-3a	-52%	-64%	13%	2258%	48%	3%	-52%	-64%	13%	2258%	48%	3%
Step 3-3a	-23%	-2%	-13%	-212%	17%	-11%	-23%	-2%	-13%	-212%	17%	-11%
Step 4-1	-15%	11%	28%	-34%	29%	21%	-24%	3%	29%	-31%	23%	22%
Step 4-2	-25%	8%	15%	-35%	20%	15%	-42%	-7%	18%	-30%	9%	16%
minimum error	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**
maximum error	**37%**	**691%**	**28%**	**2258%**	**55%**	**171%**	**37%**	**691%**	**29%**	**2258%**	**55%**	**171%**
average error	**-256%**	**53%**	**-7%**	**479%**	**23%**	**7%**	**-259%**	**50%**	**-7%**	**480%**	**21%**	**8%**
std. dev. error	**645%**	**261%**	**54%**	**784%**	**24%**	**86%**	**644%**	**262%**	**54%**	**784%**	**24%**	**86%**
Case 1	-242%	-184%	-80%	21%	-12%	-64%	-834%	-1080%	-61%	22%	-329%	-53%
Case 2	-199%	-96%	-63%	42%	18%	-58%	-721%	-760%	-54%	33%	-240%	-50%
Case 3	-166%	-77%	-70%	12%	17%	-45%	-756%	-680%	-63%	10%	-211%	-47%
Case 4	-133%	-54%	-61%	-30%	21%	3%	-687%	-474%	-33%	-3%	-103%	3%
Case 5	-192%	-98%	-65%	-54%	7%	24%	-869%	-567%	-24%	-16%	-94%	30%
Case 6	-282%	-141%	-46%	-44%	12%	41%	-1080%	-655%	-3%	-4%	-67%	53%
minimum error	**-282%**	**-184%**	**-80%**	**-54%**	**-12%**	**-64%**	**-1080%**	**-1080%**	**-63%**	**-16%**	**-329%**	**-53%**
maximum error	**-133%**	**-54%**	**-46%**	**42%**	**21%**	**41%**	**-687%**	**-474%**	**-3%**	**33%**	**-67%**	**53%**
average error	**-202%**	**-108%**	**-64%**	**-9%**	**11%**	**-16%**	**-825%**	**-703%**	**-40%**	**7%**	**-174%**	**-11%**
std. dev. error	**53%**	**47%**	**11%**	**39%**	**12%**	**45%**	**143%**	**210%**	**24%**	**18%**	**103%**	**46%**
Case 7	-514%	-568%	-57%	-22%	-25%	-18%	-1659%	-2304%	-24%	5%	-257%	-4%
Case 8	391%	230%	-123%	10%	-12927%	-74%	882%	610%	-92%	20%	-47793%	-60%
Case 9	394%	244%	-83%	33%	-250%	-73%	972%	760%	-83%	12%	-1407%	-71%
Case 10	418%	259%	-67%	-73%	-984%	25%	1119%	609%	-23%	-29%	-2100%	36%
Case 11	293%	215%	-44%	-62%	-666%	44%	680%	440%	2%	-16%	-1268%	58%
minimum error	**293%**	**215%**	**-123%**	**-73%**	**-12927%**	**-74%**	**680%**	**440%**	**-92%**	**-29%**	**-47793%**	**-71%**
maximum error	**418%**	**259%**	**-44%**	**33%**	**-250%**	**44%**	**1119%**	**760%**	**2%**	**20%**	**-1268%**	**58%**
average error	**374%**	**237%**	**-79%**	**-23%**	**-3707%**	**-20%**	**913%**	**604%**	**-49%**	**-3%**	**-13142%**	**-9%**
std. dev. error	**55%**	**19%**	**33%**	**53%**	**6154%**	**63%**	**183%**	**131%**	**46%**	**23%**	**23103%**	**66%**
Total Stress Case 1	-31%	3%	5%	-24%	18%	3%	-65%	-30%	9%	-20%	-11%	5%
Total Stress Case 2	-30%	5%	7%	-21%	20%	4%	-61%	-27%	11%	-19%	-9%	6%
Total Stress Case 3	-29%	5%	8%	-27%	20%	8%	-62%	-25%	11%	-23%	-5%	8%
Total Stress Case 4	-28%	6%	8%	-34%	20%	14%	-63%	-21%	14%	-25%	2%	14%
Total Stress Case 5	-31%	4%	6%	-39%	19%	16%	-72%	-25%	13%	-26%	1%	18%
Total Stress Case 6	-31%	4%	8%	-37%	19%	19%	-68%	-22%	16%	-24%	4%	21%
minimum error	**-31%**	**3%**	**5%**	**-39%**	**18%**	**3%**	**-72%**	**-30%**	**9%**	**-26%**	**-11%**	**5%**
maximum error	**-28%**	**6%**	**8%**	**-21%**	**20%**	**19%**	**-61%**	**-21%**	**16%**	**-19%**	**4%**	**21%**
average error	**-30%**	**5%**	**7%**	**-30%**	**19%**	**10%**	**-65%**	**-25%**	**12%**	**-23%**	**-3%**	**12%**
std. dev. error	**1%**	**1%**	**1%**	**7%**	**1%**	**7%**	**4%**	**3%**	**2%**	**3%**	**6%**	**7%**
Total Stress Case 7	-33%	2%	7%	-32%	18%	10%	-67%	-27%	13%	-22%	-5%	13%
Total Stress Case 8	-31%	3%	10%	-31%	17%	9%	-55%	-19%	14%	-26%	-1%	11%
Total Stress Case 9	-30%	4%	11%	-30%	18%	9%	-55%	-20%	14%	-27%	-2%	10%
Total Stress Case 10	-31%	3%	11%	-39%	17%	16%	-58%	-17%	16%	-30%	4%	17%
Total Stress Case 11	-31%	4%	13%	-37%	18%	17%	-55%	-15%	17%	-28%	5%	18%
minimum error	**-31%**	**3%**	**10%**	**-39%**	**17%**	**9%**	**-58%**	**-20%**	**14%**	**-30%**	**-2%**	**10%**
maximum error	**-30%**	**4%**	**13%**	**-30%**	**18%**	**17%**	**-55%**	**-15%**	**17%**	**-26%**	**5%**	**18%**
average error	**-31%**	**3%**	**11%**	**-34%**	**18%**	**13%**	**-56%**	**-18%**	**15%**	**-28%**	**1%**	**14%**
std. dev. error	**0%**	**0%**	**1%**	**4%**	**0%**	**4%**	**1%**	**2%**	**2%**	**2%**	**4%**	**4%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6	Composite Analysis				Part. Non-Composite Analysis			
	1C	**2C**	**3C**	**4C**	**1C**	**2C**	**3C**	**4C**
Step 1-1	104%	643%	136%	116%	104%	643%	136%	116%
Step 1-2	94%	372%	132%	114%	94%	372%	132%	114%
Step 1-3	64%	-2313%	119%	101%	64%	-2313%	119%	101%
Step 2-2	69%		121%	102%	69%		121%	102%
Step 2-3a	62%	6100%	161%	54%	62%	6100%	161%	54%
Step 3-3a	63%	-175%	380%	57%	63%	-175%	380%	57%
Step 4-1	60%	1190%	274%	57%	60%	1188%	277%	56%
Step 4-2	62%	879%	-1008%	65%	62%	881%	-1035%	64%
minimum error	**60%**	**-2313%**	**-1008%**	**54%**	**60%**	**-2313%**	**-1035%**	**54%**
maximum error	**104%**	**6100%**	**380%**	**116%**	**104%**	**6100%**	**380%**	**116%**
average error	**72%**	**957%**	**39%**	**83%**	**72%**	**957%**	**36%**	**83%**
std. dev. error	**17%**	**2547%**	**433%**	**27%**	**17%**	**2547%**	**443%**	**27%**
Case 1	178%	-88%	-27%	69%	156%	-89%	-24%	64%
Case 2	206%	-84%	-19%	76%	179%	-83%	-15%	72%
Case 3	295%	-64%	1%	89%	252%	-61%	7%	85%
Case 4	153%	52%	-512%	118%	116%	62%	-287%	114%
Case 5	355%	69%	-54%	59%	282%	103%	-5%	62%
Case 6	363%	87%	-48%	74%	288%	124%	5%	78%
minimum error	**153%**	**-88%**	**-512%**	**59%**	**116%**	**-89%**	**-287%**	**62%**
maximum error	**363%**	**87%**	**1%**	**118%**	**288%**	**124%**	**7%**	**114%**
average error	**258%**	**-5%**	**-110%**	**81%**	**212%**	**9%**	**-53%**	**79%**
std. dev. error	**92%**	**82%**	**198%**	**21%**	**72%**	**98%**	**115%**	**19%**
Case 7	90%	-26%	16%	38%	93%	-33%	7%	27%
Case 8	201%	-282%	-20%	67%	178%	-282%	-19%	63%
Case 9	339%	-253%	11%	79%	283%	-253%	15%	75%
Case 10	212%	91%	-133%	203%	180%	104%	-58%	194%
Case 11	223%	98%	-170%	199%	186%	112%	-72%	188%
minimum error	**201%**	**-282%**	**-170%**	**67%**	**178%**	**-282%**	**-72%**	**63%**
maximum error	**339%**	**98%**	**11%**	**203%**	**283%**	**112%**	**15%**	**194%**
average error	**244%**	**-87%**	**-78%**	**137%**	**207%**	**-80%**	**-33%**	**130%**
std. dev. error	**64%**	**209%**	**87%**	**74%**	**51%**	**217%**	**39%**	**71%**
Total Stress Case 1	76%	-956%	-138%	66%	74%	-959%	-139%	64%
Total Stress Case 2	78%	-1390%	-138%	68%	75%	-1390%	-137%	66%
Total Stress Case 3	72%	1730%	-225%	70%	71%	1730%	-227%	68%
Total Stress Case 4	60%	618%	-1082%	68%	61%	623%	-1147%	67%
Total Stress Case 5	49%	569%	1203%	65%	52%	582%	1351%	64%
Total Stress Case 6	47%	583%	1070%	64%	51%	598%	1216%	62%
minimum error	**47%**	**-1390%**	**-1082%**	**64%**	**51%**	**-1390%**	**-1147%**	**62%**
maximum error	**78%**	**1730%**	**1203%**	**70%**	**75%**	**1730%**	**1351%**	**68%**
average error	**64%**	**192%**	**115%**	**67%**	**64%**	**197%**	**153%**	**65%**
std. dev. error	**14%**	**1154%**	**869%**	**2%**	**11%**	**1157%**	**956%**	**2%**
Total Stress Case 7	64%	-1168%	-161%	63%	64%	-1186%	-173%	61%
Total Stress Case 8	68%	2339%	-215%	65%	67%	2343%	-219%	64%
Total Stress Case 9	70%	1233%	-210%	67%	68%	1235%	-213%	65%
Total Stress Case 10	55%	551%	-1800%	66%	57%	558%	-1919%	65%
Total Stress Case 11	55%	567%	-1568%	66%	57%	574%	-1679%	65%
minimum error	**55%**	**551%**	**-1800%**	**65%**	**57%**	**558%**	**-1919%**	**64%**
maximum error	**70%**	**2339%**	**-210%**	**67%**	**68%**	**2343%**	**-213%**	**65%**
average error	**62%**	**1173%**	**-948%**	**66%**	**62%**	**1178%**	**-1008%**	**65%**
std. dev. error	**8%**	**840%**	**855%**	**1%**	**6%**	**839%**	**919%**	**1%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

	Percent Error with N = 6							
	Composite Analysis				Part. Non-Composite Analysis			
	5C	6C	7C	8C	5C	6C	7C	8C
Step 1-1	71%	186%	-1588%	100%	71%	186%	-1588%	100%
Step 1-2	25%	-14500%	457%	97%	25%	-14500%	457%	97%
Step 1-3	60%	-135%	32%	96%	60%	-135%	32%	96%
Step 2-2	71%	-173%	39%	97%	71%	-173%	39%	97%
Step 2-3a	65%	-182%	14%	70%	65%	-182%	14%	70%
Step 3-3a	68%	-67%	9%	56%	68%	-67%	9%	56%
Step 4-1	67%	-59%	17%	59%	67%	-61%	15%	58%
Step 4-2	72%	-27%	33%	72%	72%	-30%	30%	70%
minimum error	**25%**	**-14500%**	**-1588%**	**56%**	**25%**	**-14500%**	**-1588%**	**56%**
maximum error	**72%**	**186%**	**457%**	**100%**	**72%**	**186%**	**457%**	**100%**
average error	**63%**	**-1870%**	**-123%**	**81%**	**62%**	**-1870%**	**-124%**	**81%**
std. dev. error	**16%**	**5105%**	**611%**	**18%**	**16%**	**5104%**	**611%**	**19%**
Case 1	154%	-101%	-39%	12%	126%	-110%	-42%	-13%
Case 2	172%	-94%	-25%	40%	140%	-101%	-26%	18%
Case 3	230%	-98%	5%	61%	182%	-115%	4%	41%
Case 4	136%	13%	967%	202%	100%	45%	642%	186%
Case 5	319%	-23%	-105%	-2%	234%	15%	-54%	-10%
Case 6	313%	-12%	-87%	27%	229%	26%	-36%	20%
minimum error	**136%**	**-101%**	**-105%**	**-2%**	**100%**	**-115%**	**-54%**	**-13%**
maximum error	**319%**	**13%**	**967%**	**202%**	**234%**	**45%**	**642%**	**186%**
average error	**221%**	**-53%**	**119%**	**57%**	**169%**	**-40%**	**81%**	**40%**
std. dev. error	**80%**	**51%**	**417%**	**74%**	**56%**	**76%**	**275%**	**74%**
Case 7	82%	-39%	-69%	152%	82%	-54%	-93%	173%
Case 8	185%	-228%	-25%	56%	144%	-242%	-28%	43%
Case 9	378%	-228%	6%	64%	278%	-235%	7%	51%
Case 10	174%	59%	-529%	210%	145%	72%	-377%	226%
Case 11	183%	63%	-530%	245%	149%	76%	-358%	256%
minimum error	**174%**	**-228%**	**-530%**	**56%**	**144%**	**-242%**	**-377%**	**43%**
maximum error	**378%**	**63%**	**6%**	**245%**	**278%**	**76%**	**7%**	**256%**
average error	**230%**	**-83%**	**-269%**	**144%**	**179%**	**-82%**	**-189%**	**144%**
std. dev. error	**99%**	**167%**	**301%**	**98%**	**66%**	**180%**	**207%**	**113%**
Total Stress Case 1	83%	-48%	12%	66%	79%	-53%	10%	62%
Total Stress Case 2	85%	-44%	17%	68%	81%	-49%	15%	64%
Total Stress Case 3	82%	-34%	28%	71%	79%	-38%	26%	68%
Total Stress Case 4	71%	-31%	39%	74%	72%	-37%	34%	72%
Total Stress Case 5	62%	-27%	46%	76%	66%	-36%	38%	74%
Total Stress Case 6	60%	-29%	45%	75%	64%	-37%	37%	74%
minimum error	**60%**	**-48%**	**12%**	**66%**	**64%**	**-53%**	**10%**	**62%**
maximum error	**85%**	**-27%**	**46%**	**76%**	**81%**	**-36%**	**38%**	**74%**
average error	**74%**	**-36%**	**31%**	**72%**	**74%**	**-42%**	**27%**	**69%**
std. dev. error	**11%**	**9%**	**15%**	**4%**	**7%**	**7%**	**12%**	**5%**
Total Stress Case 7	73%	-30%	22%	67%	73%	-35%	17%	64%
Total Stress Case 8	77%	-49%	23%	71%	75%	-53%	20%	68%
Total Stress Case 9	79%	-39%	29%	71%	76%	-43%	26%	68%
Total Stress Case 10	67%	-40%	39%	74%	68%	-45%	35%	73%
Total Stress Case 11	67%	-39%	39%	74%	68%	-45%	35%	73%
minimum error	**67%**	**-49%**	**23%**	**71%**	**68%**	**-53%**	**20%**	**68%**
maximum error	**79%**	**-39%**	**39%**	**74%**	**76%**	**-43%**	**35%**	**73%**
average error	**72%**	**-42%**	**33%**	**73%**	**72%**	**-47%**	**29%**	**71%**
std. dev. error	**6%**	**5%**	**8%**	**2%**	**4%**	**5%**	**7%**	**3%**

Table 5.2: Percent Error Tables for 1997 Analysis versus 2000 Measured Stress

Percent Error with N = 6

	Composite Analysis				Part. Non-Composite Analysis			
	9C	**10C**	**11C**	**12C**	**9C**	**10C**	**11C**	**12C**
Step 1-1	49%	77%	162%	109%	49%	77%	162%	109%
Step 1-2	184%	-35%	-133%	82%	184%	-35%	-133%	82%
Step 1-3	95%	35%	-296%	113%	95%	35%	-296%	113%
Step 2-2	97%	23%	-88%		97%	23%	-88%	
Step 2-3a	90%	8%	-70%		90%	8%	-70%	
Step 3-3a	22%	1%	-71%	131%	22%	1%	-71%	131%
Step 4-1	11%	5%	32%		12%	1%	29%	
Step 4-2	63%	-56%	43%	118%	64%	-67%	39%	116%
minimum error	**11%**	**-56%**	**-296%**	**82%**	**12%**	**-67%**	**-296%**	**82%**
maximum error	**184%**	**77%**	**162%**	**131%**	**184%**	**77%**	**162%**	**131%**
average error	**76%**	**7%**	**-53%**	**111%**	**77%**	**5%**	**-54%**	**110%**
std. dev. error	**54%**	**41%**	**136%**	**18%**	**54%**	**43%**	**135%**	**18%**
Case 1	144%	-106%	-75%		100%	-147%	-105%	
Case 2	175%	-90%	-49%		118%	-135%	-77%	
Case 3	370%	-38%	7%		240%	-112%	-24%	
Case 4	104%	-9%	3800%		92%	15%	2900%	
Case 5	170%	13%	-64%		135%	-4%	-72%	
Case 6	177%	28%	-44%		140%	8%	-52%	
minimum error	**104%**	**-106%**	**-75%**		**92%**	**-147%**	**-105%**	
maximum error	**370%**	**28%**	**3800%**		**240%**	**15%**	**2900%**	
average error	**190%**	**-34%**	**596%**		**137%**	**-63%**	**428%**	
std. dev. error	**92%**	**55%**	**1570%**		**54%**	**76%**	**1211%**	
Case 7	136%	1133%	376%		139%	1289%	431%	
Case 8	-40%	-204%	-20%		120%	-252%	-38%	
Case 9	-73%	-122%	19%		18%	-192%	2%	
Case 10	127%	57%	1050%		115%	46%	1125%	
Case 11	131%	65%	1850%		117%	55%	1950%	
minimum error	**-73%**	**-204%**	**-20%**		**18%**	**-252%**	**-38%**	
maximum error	**131%**	**65%**	**1850%**		**120%**	**55%**	**1950%**	
average error	**36%**	**-51%**	**725%**		**92%**	**-86%**	**760%**	
std. dev. error	**108%**	**134%**	**899%**		**50%**	**159%**	**959%**	
Total Stress Case 1	34%	-75%	20%		51%	-97%	11%	
Total Stress Case 2	29%	-68%	24%		48%	-91%	16%	
Total Stress Case 3	44%	-53%	38%		53%	-74%	31%	
Total Stress Case 4	68%	-64%	48%		67%	-80%	43%	
Total Stress Case 5	84%	-86%	53%		78%	-93%	49%	
Total Stress Case 6	87%	-94%	52%		80%	-100%	48%	
minimum error	**29%**	**-94%**	**20%**		**48%**	**-100%**	**11%**	**0%**
maximum error	**87%**	**-53%**	**53%**		**80%**	**-74%**	**49%**	**0%**
average error	**58%**	**-73%**	**39%**		**63%**	**-89%**	**33%**	
std. dev. error	**26%**	**15%**	**14%**		**14%**	**10%**	**17%**	
Total Stress Case 7	74%	-127%	22%		75%	-147%	14%	
Total Stress Case 8	60%	-82%	33%		66%	-99%	27%	
Total Stress Case 9	55%	-65%	39%		61%	-83%	33%	
Total Stress Case 10	77%	-91%	49%		75%	-101%	45%	
Total Stress Case 11	78%	-92%	48%		75%	-103%	45%	
minimum error	**55%**	**-92%**	**33%**		**61%**	**-103%**	**27%**	
maximum error	**78%**	**-65%**	**49%**		**75%**	**-83%**	**45%**	
average error	**67%**	**-82%**	**42%**		**69%**	**-96%**	**38%**	
std. dev. error	**12%**	**13%**	**7%**		**7%**	**9%**	**9%**	

Table 5.3: Percent Error Tables for 2000 Analysis versus 2000 Measured Stress

Percent Error with N = 6

2000 Composite Analysis

	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12A
Step 1-1	210%	-27%	49%	-12%	-128%	56%	105%	156%	85%	92%	50%	174%
Step 1-2	4%	28%	-189%	975%	4680%	-55%	118%	-1750%	-88%	76%	13%	137%
Step 1-3	-46%	-7%	-1%	-241%	-47%	-46%	184%	-42%	-77%	43%	-83%	875%
Step 2-2	213%	-2%	-27%	-391%	-65%	-83%	413%	-30%	-202%	34%	-32%	285%
Step 2-3a	60%	-10%	-39%	-354%	-62%	-92%	646%	-36%	-184%	26%	-44%	336%
Step 3-3a	-71%	-27%	0%	-49%	-26%	-33%	-255%	-17%	-73%	19%	-58%	-346%
Step 4-1 w/N=6	-91%	-22%	1%	-38%	-28%	-29%	-188%	-3%	-99%	18%	-63%	-461%
Step 4-2 w/N=6	1%	-4%	3%	-34%	-15%	-19%	-89%	6%	-104%	11%	-38%	-520%
minimum error	**-91%**	**-27%**	**-189%**	**-391%**	**-128%**	**-92%**	**-255%**	**-1750%**	**-202%**	**11%**	**-83%**	**-520%**
maximum error	**213%**	**28%**	**49%**	**975%**	**4680%**	**56%**	**646%**	**156%**	**85%**	**92%**	**50%**	**875%**
average error	**35%**	**-9%**	**-25%**	**-18%**	**539%**	**-38%**	**117%**	**-214%**	**-93%**	**40%**	**-32%**	**60%**
std. dev. error	**119%**	**18%**	**71%**	**429%**	**1674%**	**46%**	**304%**	**624%**	**87%**	**30%**	**43%**	**476%**
Case 1	-268%	-470%	1%		-266%	-13%	-168%	-267%	-50%	-18%	-229%	3%
Case 2	-187%	-378%	14%		-220%	-1%	-114%	-207%	-40%	-3%	-179%	15%
Case 3	-43%	-136%	52%		-85%	27%	-7%	-48%	-27%	21%	-52%	40%
Case 4	169%	248%	155%		392%	7746%	412%	286%	-23%	-246%	301%	-16452%
Case 5	380%	1839%	-155%		-349%	-16%	-233%	-716%	-40%	-38%	-1362%	-18%
Case 6	381%	1277%	-95%		-386%	-1%	-242%	-7592%	-15%	-11%	-7874%	-1%
minimum error	**-268%**	**-470%**	**-155%**		**-386%**	**-16%**	**-242%**	**-7592%**	**-50%**	**-246%**	**-7874%**	**-16452%**
maximum error	**381%**	**1839%**	**155%**		**392%**	**7746%**	**412%**	**286%**	**-15%**	**21%**	**301%**	**40%**
average error	**72%**	**397%**	**-5%**		**-152%**	**1290%**	**-59%**	**-1424%**	**-32%**	**-49%**	**-1566%**	**-2735%**
std. dev. error	**281%**	**950%**	**109%**		**287%**	**3163%**	**246%**	**3039%**	**13%**	**98%**	**3141%**	**6720%**
Case 7	-17%	-88%	-10%		-63%	-41%	-40%	-54%	-56%	-22%	-50%	4%
Case 8	-15%	-96%	-1%		-79%	-29%	-38%	-43%	-73%	-24%	-57%	5%
Case 9	22%	-34%	27%		-31%	3%	23%	13%	-65%	3%	8%	31%
Case 10	145%	196%	1501%		344%	-8%	233%	163%	33%	-12%	178%	-72%
Case 11	138%	187%	1877%		317%	3%	219%	160%	36%	-2%	168%	-48%
minimum error	**-15%**	**-96%**	**-1%**		**-79%**	**-29%**	**-38%**	**-43%**	**-73%**	**-24%**	**-57%**	**-72%**
maximum error	**145%**	**196%**	**1877%**		**344%**	**3%**	**233%**	**163%**	**36%**	**3%**	**178%**	**31%**
average error	**72%**	**63%**	**851%**		**138%**	**-8%**	**109%**	**73%**	**-17%**	**-9%**	**74%**	**-21%**
std. dev. error	**81%**	**150%**	**980%**		**224%**	**15%**	**137%**	**105%**	**60%**	**12%**	**117%**	**47%**
Total Stress Case 1	-29%	-22%	2%		-30%	-17%	-101%	-6%	-78%	1%	-52%	-94%
Total Stress Case 2	-22%	-18%	7%		-26%	-12%	-93%	-3%	-75%	6%	-47%	-92%
Total Stress Case 3	-3%	-8%	17%		-17%	-8%	-81%	5%	-87%	12%	-38%	-162%
Total Stress Case 4	10%	0%	17%		-12%	-12%	-82%	8%	-113%	15%	-34%	-485%
Total Stress Case 5	17%	3%	14%		-10%	-20%	-84%	10%	-121%	15%	-33%	-2371%
Total Stress Case 6	17%	3%	12%		-10%	-24%	-84%	10%	-133%	13%	-33%	-4018%
minimum error	**-29%**	**-22%**	**2%**		**-30%**	**-24%**	**-101%**	**-6%**	**-133%**	**1%**	**-52%**	**-4018%**
maximum error	**17%**	**3%**	**17%**		**-10%**	**-8%**	**-81%**	**10%**	**-75%**	**15%**	**-33%**	**-92%**
average error	**-2%**	**-7%**	**11%**		**-18%**	**-15%**	**-88%**	**4%**	**-101%**	**11%**	**-40%**	**-1204%**
std. dev. error	**20%**	**11%**	**6%**		**9%**	**6%**	**8%**	**7%**	**25%**	**6%**	**8%**	**1634%**
Total Stress Case 7	-2%	-8%	0%		-17%	-23%	-82%	3%	-90%	5%	-39%	-171%
Total Stress Case 8	-2%	-8%	2%		-18%	-21%	-81%	3%	-95%	4%	-39%	-156%
Total Stress Case 9	4%	-5%	8%		-15%	-15%	-74%	7%	-97%	10%	-35%	-186%
Total Stress Case 10	15%	1%	10%		-11%	-20%	-80%	10%	-134%	12%	-32%	-644%
Total Stress Case 11	16%	1%	10%		-11%	-21%	-80%	10%	-132%	11%	-32%	-662%
minimum error	**-2%**	**-8%**	**2%**		**-18%**	**-21%**	**-81%**	**3%**	**-134%**	**4%**	**-39%**	**-662%**
maximum error	**16%**	**1%**	**10%**		**-11%**	**-15%**	**-74%**	**10%**	**-95%**	**12%**	**-32%**	**-156%**
average error	**8%**	**-3%**	**7%**		**-14%**	**-19%**	**-79%**	**7%**	**-114%**	**9%**	**-35%**	**-412%**
std. dev. error	**9%**	**5%**	**4%**		**4%**	**3%**	**3%**	**3%**	**22%**	**4%**	**3%**	**279%**

Table 5.3: Percent Error Tables for 2000 Analysis versus 2000 Measured Stress

Percent Error with N = 6

2000 Composite Analysis

	13A	14A	15A	16A	17A	18A	19A	20A	21A	22A	23A	24A
Step 1-1	86%	0%	280%	122%	113%	123%	135%	-254%	183%	118%	457%	-700%
Step 1-2	95%	475%	90%	137%	108%	47%	119%	352%	58%	27%	421%	50%
Step 1-3	229%	-241%	297%	31%	30%	-195%	49%	-1%	-304%	-10300%	-89%	-224%
Step 2-2	240%	-126%	249%	32%	24%	-491%	66%	12%	-1414%	591%	15%	-99%
Step 2-3a	310%	-122%	296%	26%	14%	-503%	55%	6%	-1109%	695%	8%	-144%
Step 3-3a	-211%	-143%	-414%	24%	-12%	-130%	13%	-5%	-31%	-126%	-30%	-48%
Step 4-1	-91%	-101%	-316%	18%	-2%	-93%	20%	20%	-54%	-38%	-48%	-63%
Step 4-2	-48%	-56%	-324%	16%	8%	-113%	33%	18%	-28%	-77%	-16%	-24%
minimum error	**-211%**	**-241%**	**-414%**	**16%**	**-12%**	**-503%**	**13%**	**-254%**	**-1414%**	**-10300%**	**-89%**	**-700%**
maximum error	**310%**	**475%**	**297%**	**137%**	**113%**	**123%**	**135%**	**352%**	**183%**	**695%**	**457%**	**50%**
average error	**76%**	**-39%**	**20%**	**51%**	**35%**	**-170%**	**61%**	**19%**	**-337%**	**-1139%**	**90%**	**-157%**
std. dev. error	**182%**	**219%**	**315%**	**49%**	**48%**	**226%**	**44%**	**163%**	**592%**	**3715%**	**218%**	**234%**
Case 1	-205%	-285%		7%	-177%	-28%	1524%	781%	1%	-111%	-391%	-9%
Case 2	-142%	-191%		22%	-117%	-9%	1943%	776%	15%	-105%	-321%	5%
Case 3	-1%	2%		53%	18%	32%		-590%	59%	-166%	-33%	58%
Case 4	258%	195%		-28%	179%	-96%	181%	238%	-938%	40%	249%	396%
Case 5	-1480%	483%		27%	342%	-2%	166%	178%	-8%	58%	203%	-101%
Case 6	685%	267%		41%	263%	15%	130%	130%	32%	78%	140%	-64%
minimum error	**-1480%**	**-285%**		**-28%**	**-177%**	**-96%**	**130%**	**-590%**	**-938%**	**-166%**	**-391%**	**-101%**
maximum error	**685%**	**483%**		**53%**	**342%**	**32%**	**1943%**	**781%**	**59%**	**78%**	**249%**	**396%**
average error	**-148%**	**79%**		**20%**	**85%**	**-15%**	**789%**	**252%**	**-140%**	**-34%**	**-26%**	**48%**
std. dev. error	**729%**	**291%**		**29%**	**210%**	**45%**	**875%**	**507%**	**392%**	**105%**	**274%**	**179%**
Case 7	-96%	-49%		8%	-47%	-25%	-277%	-104%	-3%	-281%	-73%	-9%
Case 8	-59%	-35%		-6%	-34%	-41%	-320%	-175%	-8%	-493%	-96%	-16%
Case 9	29%	44%		37%	39%	7%	5%	29%	44%	366%	29%	41%
Case 10	143%	124%		47%	129%	22%	111%	109%	4%	90%	118%	371%
Case 11	138%	120%		57%	124%	35%	104%	104%	48%	97%	109%	178%
minimum error	**-59%**	**-35%**		**-6%**	**-34%**	**-41%**	**-320%**	**-175%**	**-8%**	**-493%**	**-96%**	**-16%**
maximum error	**143%**	**124%**		**57%**	**129%**	**35%**	**111%**	**109%**	**48%**	**366%**	**118%**	**371%**
average error	**63%**	**63%**		**34%**	**65%**	**6%**	**-25%**	**17%**	**22%**	**15%**	**40%**	**143%**
std. dev. error	**97%**	**75%**		**28%**	**78%**	**33%**	**202%**	**133%**	**28%**	**362%**	**99%**	**172%**
Total Stress Case 1	-64%	-70%		12%	-2%	-67%	18%	4%	-13%	-91%	-30%	-17%
Total Stress Case 2	-58%	-64%		18%	1%	-59%	22%	8%	-8%	-86%	-26%	-12%
Total Stress Case 3	-45%	-53%		23%	8%	-70%	31%	16%	-5%	-82%	-16%	-5%
Total Stress Case 4	-43%	-50%		17%	10%	-115%	35%	19%	-20%	-105%	-13%	-14%
Total Stress Case 5	-43%	-50%		14%	11%	-148%	36%	20%	-30%	-127%	-12%	-21%
Total Stress Case 6	-42%	-49%		12%	11%	-155%	35%	20%	-33%	-131%	-12%	-23%
minimum error	**-64%**	**-70%**		**12%**	**-2%**	**-155%**	**18%**	**4%**	**-33%**	**-131%**	**-30%**	**-23%**
maximum error	**-42%**	**-49%**		**23%**	**11%**	**-59%**	**36%**	**20%**	**-5%**	**-82%**	**-12%**	**-5%**
average error	**-49%**	**-56%**		**16%**	**7%**	**-102%**	**30%**	**15%**	**-18%**	**-104%**	**-18%**	**-15%**
std. dev. error	**9%**	**9%**		**4%**	**6%**	**43%**	**8%**	**7%**	**11%**	**21%**	**8%**	**6%**
Total Stress Case 7	-58%	-58%		-21%	3%	-223%	27%	14%	-19%	-109%	-19%	-20%
Total Stress Case 8	-49%	-54%		11%	5%	-87%	26%	13%	-21%	-127%	-20%	-22%
Total Stress Case 9	-41%	-47%		19%	9%	-82%	32%	18%	-11%	-120%	-14%	-11%
Total Stress Case 10	-40%	-45%		13%	11%	-132%	36%	21%	-29%	-166%	-11%	-20%
Total Stress Case 11	-40%	-45%		13%	11%	-133%	35%	21%	-30%	-162%	-12%	-21%
minimum error	**-49%**	**-54%**		**11%**	**5%**	**-133%**	**26%**	**13%**	**-30%**	**-166%**	**-20%**	**-22%**
maximum error	**-40%**	**-45%**		**19%**	**11%**	**-82%**	**36%**	**21%**	**-11%**	**-120%**	**-11%**	**-11%**
average error	**-43%**	**-48%**		**14%**	**9%**	**-108%**	**32%**	**18%**	**-22%**	**-144%**	**-14%**	**-18%**
std. dev. error	**5%**	**4%**		**4%**	**3%**	**28%**	**4%**	**4%**	**9%**	**24%**	**4%**	**5%**

Table 5.3: Percent Error Tables for 2000 Analysis versus 2000 Measured Stress

Percent Error with N = 6
2000 Composite Analysis

	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	11B	12B
Step 1-1	60%	51%	518%	131%	-94%	140%	-6%	-925%	-273%	12%		136%
Step 1-2	29%	-6%	-76%	4%	6229%	880%	-592%	-2536%	-24%	-78%		743%
Step 1-3	33%	7%	-59%	-142%	-245%	-238%	-46%	-203%	-12%	-23%		-1171%
Step 2-2	20%	6%	-30%	-86%	-103%	-128%	0%	1%	1%	0%	100%	-399%
Step 2-3a	12%	0%	-41%	-98%	-121%	-130%	-70%	-253%	-7%	-27%	-13%	-291%
Step 3-3a	-7%	9%	-26%	-45%	-22%	-48%	-40%	-56%	-9%	-88%	2%	-134%
Step 4-1	-9%	11%	-8%	-19%	-7%	-35%	-34%	-52%	9%	-83%	18%	-101%
Step 4-2	-15%	17%	-2%	-10%	-7%	-10%	-30%	-42%	2%	-57%	22%	-58%
minimum error	**-15%**	**-6%**	**-76%**	**-142%**	**-245%**	**-238%**	**-592%**	**-2536%**	**-273%**	**-88%**	**-13%**	**-1171%**
maximum error	**60%**	**51%**	**518%**	**131%**	**6229%**	**880%**	**0%**	**1%**	**9%**	**12%**	**100%**	**743%**
average error	**15%**	**12%**	**35%**	**-33%**	**704%**	**54%**	**-102%**	**-508%**	**-39%**	**-43%**	**26%**	**-159%**
std. dev. error	**25%**	**17%**	**197%**	**83%**	**2234%**	**351%**	**199%**	**873%**	**95%**	**39%**	**44%**	**537%**
Case 1	-39%	-79%	-105%	2%	-44%	-87%	-385%	-172%	-95%	46%	-42%	-137%
Case 2	-35%	-63%	-82%	15%	-18%	-71%	-343%	-119%	-74%	55%	-19%	-117%
Case 3	-33%	-111%	-120%	-45%	-84%	-67%	-474%	-163%	-85%	16%	-36%	-84%
Case 4	-82%	-200%	-177%	-178%	-219%	-32%	-398%	-177%	-87%	-62%	-55%	4%
Case 5	-117%	-218%	-216%	-262%	-363%	-25%	-438%	-216%	-112%	-136%	-91%	49%
Case 6	-120%	-190%	-175%	-202%	-260%	-15%	-290%	-174%	-83%	-113%	-71%	61%
minimum error	**-120%**	**-218%**	**-216%**	**-262%**	**-363%**	**-87%**	**-474%**	**-216%**	**-112%**	**-136%**	**-91%**	**-137%**
maximum error	**-33%**	**-63%**	**-82%**	**15%**	**-18%**	**-15%**	**-290%**	**-119%**	**-74%**	**55%**	**-19%**	**61%**
average error	**-71%**	**-143%**	**-146%**	**-112%**	**-165%**	**-49%**	**-388%**	**-170%**	**-89%**	**-32%**	**-52%**	**-37%**
std. dev. error	**41%**	**67%**	**51%**	**117%**	**137%**	**29%**	**66%**	**31%**	**13%**	**83%**	**26%**	**86%**
Case 7	-70%	-123%	-123%	-92%	-146%	-42%	-603%	-282%	-61%	-20%	-68%	-27%
Case 8	-438%	-457%	-66%	8%	-2011%	-147%	329%	370%	-37%	48%	-366%	-126%
Case 9	-269%	-421%	-50%	20%	-503%	-100%		520%	-29%	55%	-184%	-110%
Case 10	954%	8630%	-155%	-217%	1393%	-35%	437%	475%	-38%	-106%	-602%	58%
Case 11	-1834%	-1607%	-121%	-156%	-20276%	-19%	411%	433%	-22%	-91%	-654%	67%
minimum error	**-1834%**	**-1607%**	**-155%**	**-217%**	**-20276%**	**-147%**	**329%**	**370%**	**-38%**	**-106%**	**-654%**	**-126%**
maximum error	**954%**	**8630%**	**-50%**	**20%**	**1393%**	**-19%**	**437%**	**520%**	**-22%**	**55%**	**-184%**	**67%**
average error	**-397%**	**1536%**	**-98%**	**-86%**	**-5349%**	**-75%**	**392%**	**449%**	**-32%**	**-24%**	**-452%**	**-28%**
std. dev. error	**1141%**	**4761%**	**49%**	**119%**	**10048%**	**59%**	**56%**	**64%**	**7%**	**87%**	**218%**	**104%**
Total Stress Case 1	-16%	14%	-9%	-9%	-9%	-19%	-39%	-48%	-8%	-34%	17%	-74%
Total Stress Case 2	-16%	14%	-8%	-7%	-8%	-18%	-38%	-46%	-6%	-31%	19%	-71%
Total Stress Case 3	-15%	14%	-8%	-13%	-10%	-16%	-37%	-46%	-6%	-43%	18%	-63%
Total Stress Case 4	-17%	12%	-13%	-23%	-14%	-13%	-37%	-47%	-6%	-58%	17%	-48%
Total Stress Case 5	-20%	10%	-18%	-33%	-18%	-12%	-38%	-48%	-9%	-73%	15%	-40%
Total Stress Case 6	-20%	10%	-19%	-32%	-18%	-11%	-37%	-47%	-7%	-69%	16%	-36%
minimum error	**-20%**	**10%**	**-19%**	**-33%**	**-18%**	**-19%**	**-39%**	**-48%**	**-9%**	**-73%**	**15%**	**-74%**
maximum error	**-15%**	**14%**	**-8%**	**-7%**	**-8%**	**-11%**	**-37%**	**-46%**	**-6%**	**-31%**	**19%**	**-36%**
average error	**-17%**	**12%**	**-12%**	**-19%**	**-13%**	**-15%**	**-38%**	**-47%**	**-7%**	**-51%**	**17%**	**-55%**
std. dev. error	**2%**	**2%**	**5%**	**12%**	**4%**	**3%**	**1%**	**1%**	**1%**	**18%**	**1%**	**16%**
Total Stress Case 7	-18%	12%	-13%	-20%	-14%	-15%	-39%	-49%	-5%	-49%	16%	-52%
Total Stress Case 8	-17%	15%	-4%	-9%	-10%	-15%	-37%	-49%	0%	-46%	19%	-64%
Total Stress Case 9	-17%	15%	-4%	-8%	-10%	-15%	-37%	-49%	0%	-43%	19%	-64%
Total Stress Case 10	-20%	13%	-8%	-19%	-14%	-12%	-36%	-49%	0%	-62%	18%	-48%
Total Stress Case 11	-20%	13%	-8%	-19%	-14%	-11%	-36%	-48%	1%	-61%	18%	-47%
minimum error	**-20%**	**13%**	**-8%**	**-19%**	**-14%**	**-15%**	**-37%**	**-49%**	**0%**	**-62%**	**18%**	**-64%**
maximum error	**-17%**	**15%**	**-4%**	**-8%**	**-10%**	**-11%**	**-36%**	**-48%**	**1%**	**-43%**	**19%**	**-47%**
average error	**-18%**	**14%**	**-6%**	**-14%**	**-12%**	**-13%**	**-37%**	**-49%**	**0%**	**-53%**	**18%**	**-56%**
std. dev. error	**2%**	**1%**	**3%**	**6%**	**2%**	**2%**	**1%**	**0%**	**0%**	**10%**	**0%**	**10%**

Table 5.3: Percent Error Tables for 2000 Analysis versus 2000 Measured Stress

Percent Error with N = 6

2000 Composite Analysis

	13B	14B	15B	16B	17B	18B	19B	20B	21B	22B	23B	24B
Step 1-1	-3%	-112%	-98%	454%	-277%	1286%	37%	-96%	-137%	254%	-23%	171%
Step 1-2	2592%	-858%	-117%	910%	-2771%	-196%	-1850%	691%	18%	468%	11%	-149%
Step 1-3	-36%	-50%	28%	-160%	25%	-64%	-71%	-58%	1%	375%	29%	-2%
Step 2-2	-60%	-77%	30%	-116%		-46%	-46%	-66%	18%	756%	55%	11%
Step 2-3a	-59%	-68%	24%	-106%		-52%	-52%	-64%	13%	2258%	48%	3%
Step 3-3a	-37%	-23%	4%	-73%	11%	-89%	-23%	-2%	-13%	-212%	17%	-11%
Step 4-1	-28%	-22%	22%	-36%	24%	-87%	-15%	11%	28%	-34%	29%	21%
Step 4-2	-35%	-31%	15%	-32%	20%	-65%	-25%	8%	15%	-35%	20%	15%
minimum error	**-60%**	**-858%**	**-117%**	**-160%**	**-2771%**	**-196%**	**-1850%**	**-96%**	**-137%**	**-212%**	**-23%**	**-149%**
maximum error	**2592%**	**-22%**	**30%**	**910%**	**25%**	**1286%**	**37%**	**691%**	**28%**	**2258%**	**55%**	**171%**
average error	**292%**	**-155%**	**-11%**	**105%**	**-495%**	**86%**	**-256%**	**53%**	**-7%**	**479%**	**23%**	**7%**
std. dev. error	**930%**	**286%**	**60%**	**379%**	**1122%**	**487%**	**645%**	**261%**	**54%**	**784%**	**24%**	**86%**
Case 1	-89%	-171%	-64%	7%	-39%	-226%	-266%	-204%	-93%	12%	-19%	-73%
Case 2	-67%	-135%	-44%	25%	-20%	-190%	-220%	-108%	-74%	33%	13%	-64%
Case 3	-92%	-183%	-49%	-21%	-26%	-149%	-182%	-89%	-81%	1%	12%	-51%
Case 4	-80%	-174%	-51%	-91%	-27%	-49%	-152%	-68%	-75%	-41%	15%	-5%
Case 5	-57%	-148%	-72%	-144%	-38%	-10%	-222%	-118%	-81%	-65%	-1%	12%
Case 6	-40%	-144%	-50%	-123%	-20%	24%	-306%	-159%	-56%	-51%	5%	33%
minimum error	**-92%**	**-183%**	**-72%**	**-144%**	**-39%**	**-226%**	**-306%**	**-204%**	**-93%**	**-65%**	**-19%**	**-73%**
maximum error	**-40%**	**-135%**	**-44%**	**25%**	**-20%**	**24%**	**-152%**	**-68%**	**-56%**	**33%**	**15%**	**33%**
average error	**-71%**	**-159%**	**-55%**	**-58%**	**-28%**	**-100%**	**-225%**	**-124%**	**-77%**	**-18%**	**4%**	**-25%**
std. dev. error	**20%**	**20%**	**11%**	**71%**	**8%**	**102%**	**56%**	**50%**	**12%**	**39%**	**13%**	**44%**
Case 7	-68%	-240%	-36%	-43%	-22%	-80%	-522%	-568%	-57%	-20%	-25%	-19%
Case 8	-820%	330%	-57%	-28%	-380%	-171%	437%	247%	-156%	-17%	-14843%	-89%
Case 9	-377%	449%	-35%	6%	-249%	-143%	432%	257%	-103%	15%	-282%	-84%
Case 10	-702%	364%	-35%	-151%	-213%	27%	437%	265%	-79%	-83%	-1082%	14%
Case 11	-675%	298%	-16%	-139%	-155%	54%	300%	221%	-50%	-69%	-694%	39%
minimum error	**-820%**	**298%**	**-57%**	**-151%**	**-380%**	**-171%**	**300%**	**221%**	**-156%**	**-83%**	**-14843%**	**-89%**
maximum error	**-377%**	**449%**	**-16%**	**6%**	**-155%**	**54%**	**437%**	**265%**	**-50%**	**15%**	**-282%**	**39%**
average error	**-644%**	**360%**	**-36%**	**-78%**	**-249%**	**-58%**	**401%**	**247%**	**-97%**	**-39%**	**-4225%**	**-30%**
std. dev. error	**188%**	**65%**	**17%**	**79%**	**96%**	**115%**	**67%**	**19%**	**45%**	**45%**	**7086%**	**66%**
Total Stress Case 1	-39%	-36%	6%	-25%	17%	-93%	-32%	3%	3%	-26%	18%	1%
Total Stress Case 2	-37%	-35%	8%	-22%	17%	-88%	-30%	4%	6%	-23%	19%	3%
Total Stress Case 3	-38%	-36%	8%	-30%	17%	-78%	-29%	5%	7%	-29%	20%	7%
Total Stress Case 4	-38%	-35%	8%	-40%	17%	-63%	-29%	5%	7%	-36%	20%	13%
Total Stress Case 5	-37%	-36%	5%	-50%	17%	-58%	-32%	3%	4%	-42%	18%	15%
Total Stress Case 6	-36%	-35%	8%	-47%	18%	-53%	-32%	4%	7%	-39%	19%	18%
minimum error	**-39%**	**-36%**	**5%**	**-50%**	**17%**	**-93%**	**-32%**	**3%**	**3%**	**-42%**	**18%**	**1%**
maximum error	**-36%**	**-35%**	**8%**	**-22%**	**18%**	**-53%**	**-29%**	**5%**	**7%**	**-23%**	**20%**	**18%**
average error	**-37%**	**-36%**	**7%**	**-36%**	**17%**	**-72%**	**-31%**	**4%**	**6%**	**-32%**	**19%**	**9%**
std. dev. error	**1%**	**0%**	**1%**	**12%**	**1%**	**16%**	**1%**	**1%**	**2%**	**8%**	**1%**	**7%**
Total Stress Case 7	-37%	-37%	9%	-34%	17%	-68%	-33%	2%	7%	-32%	18%	10%
Total Stress Case 8	-39%	-38%	11%	-31%	17%	-75%	-31%	3%	9%	-33%	17%	8%
Total Stress Case 9	-39%	-37%	12%	-29%	17%	-74%	-31%	3%	10%	-31%	18%	8%
Total Stress Case 10	-39%	-37%	12%	-40%	17%	-58%	-31%	3%	11%	-40%	17%	15%
Total Stress Case 11	-38%	-36%	14%	-38%	18%	-57%	-31%	3%	12%	-38%	18%	16%
minimum error	**-39%**	**-38%**	**11%**	**-40%**	**17%**	**-75%**	**-31%**	**3%**	**9%**	**-40%**	**17%**	**8%**
maximum error	**-38%**	**-36%**	**14%**	**-29%**	**18%**	**-57%**	**-31%**	**3%**	**12%**	**-31%**	**18%**	**16%**
average error	**-39%**	**-37%**	**12%**	**-35%**	**17%**	**-66%**	**-31%**	**3%**	**11%**	**-36%**	**17%**	**12%**
std. dev. error	**1%**	**1%**	**1%**	**5%**	**0%**	**10%**	**0%**	**0%**	**1%**	**4%**	**0%**	**4%**

Table 5.3: Percent Error Tables for 2000 Analysis versus 2000 Measured Stress

Percent Error with N = 6

2000 Composite Analysis

	1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C
Step 1-1	104%	643%	136%	116%	71%	186%	-1588%	100%	49%	77%	162%	109%
Step 1-2	94%	372%	132%	114%	25%	-14500%	457%	97%	184%	-35%	-133%	82%
Step 1-3	64%	-2313%	119%	101%	60%	-135%	32%	96%	95%	35%	-296%	113%
Step 2-2	69%		121%	102%	71%	-173%	39%	97%	97%	23%	-88%	
Step 2-3a	62%	6100%	161%	54%	65%	-182%	14%	70%	90%	8%	-70%	
Step 3-3a	63%	-175%	380%	57%	68%	-67%	9%	56%	22%	1%	-71%	131%
Step 4-1	60%	1190%	274%	57%	67%	-59%	17%	59%	11%	5%	32%	
Step 4-2	62%	879%	-1008%	65%	72%	-27%	33%	72%	63%	-56%	43%	118%
minimum error	**60%**	**-2313%**	**-1008%**	**54%**	**25%**	**-14500%**	**-1588%**	**56%**	**11%**	**-56%**	**-296%**	**82%**
maximum error	**104%**	**6100%**	**380%**	**116%**	**72%**	**186%**	**457%**	**100%**	**184%**	**77%**	**162%**	**131%**
average error	**72%**	**957%**	**39%**	**83%**	**63%**	**-1870%**	**-123%**	**81%**	**76%**	**7%**	**-53%**	**111%**
std. dev. error	**17%**	**2547%**	**433%**	**27%**	**16%**	**5105%**	**611%**	**18%**	**54%**	**41%**	**136%**	**18%**
Case 1	169%	-103%	-30%	68%	146%	-115%	-43%	18%	133%	-118%	-79%	
Case 2	197%	-99%	-22%	75%	165%	-107%	-27%	43%	163%	-100%	-51%	
Case 3	278%	-81%	1%	88%	216%	-110%	6%	62%	350%	-44%	8%	
Case 4	153%	45%	-561%	121%	136%	2%	1057%	218%	100%	-21%	4200%	
Case 5	338%	57%	-56%	53%	304%	-35%	-110%	-5%	163%	3%	-71%	
Case 6	352%	79%	-49%	72%	303%	-21%	-90%	24%	172%	22%	-47%	
minimum error	**153%**	**-103%**	**-561%**	**53%**	**136%**	**-115%**	**-110%**	**-5%**	**100%**	**-118%**	**-79%**	
maximum error	**352%**	**79%**	**1%**	**121%**	**304%**	**2%**	**1057%**	**218%**	**350%**	**22%**	**4200%**	
average error	**248%**	**-17%**	**-119%**	**80%**	**212%**	**-64%**	**132%**	**60%**	**180%**	**-43%**	**660%**	
std. dev. error	**87%**	**86%**	**217%**	**23%**	**76%**	**52%**	**455%**	**80%**	**87%**	**56%**	**1734%**	
Case 7	100%	-23%	13%	35%	91%	-38%	-76%	162%	126%	1140%	391%	
Case 8	157%	-345%	-23%	67%	137%	-270%	-27%	66%	120%	-234%	-21%	
Case 9	309%	-300%	10%	79%	342%	-257%	6%	65%	-45%	-136%	20%	
Case 10	207%	89%	-137%	222%	168%	53%	-551%	218%	125%	54%	1100%	
Case 11	223%	98%	-176%	199%	180%	61%	-542%	256%	131%	64%	1900%	
minimum error	**157%**	**-345%**	**-176%**	**67%**	**137%**	**-270%**	**-551%**	**65%**	**-45%**	**-234%**	**-21%**	
maximum error	**309%**	**98%**	**10%**	**222%**	**342%**	**61%**	**6%**	**256%**	**131%**	**64%**	**1900%**	
average error	**224%**	**-115%**	**-81%**	**142%**	**207%**	**-103%**	**-278%**	**151%**	**83%**	**-63%**	**750%**	
std. dev. error	**63%**	**241%**	**89%**	**80%**	**92%**	**185%**	**310%**	**100%**	**86%**	**146%**	**926%**	
Total Stress Case 1	75%	-984%	-141%	66%	82%	-52%	11%	66%	38%	-79%	19%	
Total Stress Case 2	77%	-1427%	-140%	68%	84%	-48%	16%	68%	33%	-72%	24%	
Total Stress Case 3	72%	1745%	-225%	70%	81%	-35%	28%	71%	45%	-54%	38%	
Total Stress Case 4	60%	616%	-1075%	68%	71%	-30%	40%	74%	67%	-62%	49%	
Total Stress Case 5	50%	564%	1197%	65%	63%	-26%	47%	76%	83%	-82%	53%	
Total Stress Case 6	48%	580%	1068%	64%	61%	-28%	46%	75%	86%	-91%	52%	
minimum error	**48%**	**-1427%**	**-1075%**	**64%**	**61%**	**-52%**	**11%**	**66%**	**33%**	**-91%**	**19%**	
maximum error	**77%**	**1745%**	**1197%**	**70%**	**84%**	**-26%**	**47%**	**76%**	**86%**	**-54%**	**53%**	
average error	**64%**	**182%**	**114%**	**67%**	**74%**	**-36%**	**31%**	**72%**	**59%**	**-73%**	**39%**	
std. dev. error	**13%**	**1173%**	**865%**	**2%**	**10%**	**11%**	**15%**	**4%**	**23%**	**13%**	**15%**	
Total Stress Case 7	65%	-1162%	-163%	62%	74%	-29%	21%	67%	72%	-127%	21%	
Total Stress Case 8	66%	2418%	-217%	65%	75%	-54%	23%	72%	64%	-87%	33%	
Total Stress Case 9	69%	1248%	-211%	67%	78%	-41%	28%	71%	56%	-67%	39%	
Total Stress Case 10	55%	550%	-1796%	66%	67%	-39%	40%	74%	76%	-90%	49%	
Total Stress Case 11	55%	567%	-1565%	66%	67%	-39%	39%	74%	78%	-92%	48%	
minimum error	**55%**	**550%**	**-1796%**	**65%**	**67%**	**-54%**	**23%**	**71%**	**56%**	**-92%**	**33%**	
maximum error	**69%**	**2418%**	**-211%**	**67%**	**78%**	**-39%**	**40%**	**74%**	**78%**	**-67%**	**49%**	
average error	**61%**	**1196%**	**-947%**	**66%**	**72%**	**-43%**	**33%**	**73%**	**69%**	**-84%**	**42%**	
std. dev. error	**7%**	**877%**	**852%**	**1%**	**6%**	**7%**	**8%**	**2%**	**10%**	**12%**	**8%**	

Table 5.4: Correlation of 1997 Computed and 1997 Measured Results: Gage Correlation Rating, Fully Composite Analysis with $N = 6$

Gage	% Error[a]				Conservative[b]	Measured Stress Magnitude[c]	Linearity[d]	Correlation[e]	Comments[f]
	Step 3-3a	Step 4-2	Average 9 Trucks, '97	Average 3 Trucks, '97					
1A	-71%	1%	-5%	3%	63%	> 5 ksi (-2.64)	NU	Moderate	4
2A	-27%	-4%	-7%	-4%	84%	> 5 ksi	NU	Strong	
3A	0%	3%	11%	7%	32%	> 5 ksi	NN+	Strong	
4A	-49%	-34%	-22%	-25%	100%	> 5 ksi (3.81)	L	Moderate	
5A	-26%	-15%	-17%	-15%	100%	> 5 ksi	NU	Strong	
6A	-33%	-19%	-2%	-5%	79%	> 5 ksi	NN+	Moderate	
7A	255%	-89%	-83%	-78%	74%	**< 5 ksi**	NU	Moderate	
8A	-17%	6%	4%	6%	42%	> 5 ksi	NU	Strong	
9A	-73%	-104%	-94%	-105%	95%	**< 5 ksi (6.23, 5.79)**	NU	Moderate	
10A	19%	11%	4%	4%	21%	> 5 ksi	NN-	Strong	
11A	-58%	-38%	-40%	-37%	89%	> 5 ksi	NU	Weak	2
12A	-346%	-520%	-354%	-360%	79%	**< 5 ksi (5.09)**	NU	Moderate	
13A	-211%	-48%	-51%	-48%	74%	**< 5 ksi**	NU	Moderate	
14A	-143%	-56%	-58%	-53%	100%	**< 5 ksi**	NU	Moderate	
15A	-414%	-324%	-340%	-362%	79%	**< 5 ksi**	NN-	Moderate	
16A	24%	16%	16%	15%	0%	> 5 ksi	L	Strong	
17A	-12%	8%	6%	8%	16%	> 5 ksi	NU	Strong	
18A	-130%	-113%	-118%	-126%	89%	**< 5 ksi (5.81, 5.51)**	NN-	Moderate	
19A	13%	33%	29%	32%	0%	> 5 ksi	NU	Moderate	
20A	-5%	18%	14%	16%	11%	> 5 ksi (4.88)	L	Strong	
21A	-31%	-28%	-21%	-26%	89%	**< 5 ksi (6.46, 6.18)**	L	Moderate	
22A	-126%	-77%	-87%	-102%	79%	**< 5 ksi**	NN-	Moderate	
23A	-30%	-16%	-19%	-16%	79%	> 5 ksi	NU	Strong	
24A	-48%	-24%	-16%	-17%	95%	**< 5 ksi**	NN+	Moderate	
1B	-7%	-15%	-20%	-18%	74%	> 5 ksi	L	Strong	
2B	9%	17%	13%	14%	11%	> 5 ksi	L	Strong	
3B	-26%	-2%	-12%	-6%	100%	> 5 ksi	L	Strong	
4B	-45%	-10%	-20%	-14%	89%	> 5 ksi	L	Moderate	
5B	-22%	-7%	-11%	-10%	100%	> 5 ksi	L	Strong	
6B	-48%	-10%	-18%	-13%	95%	> 5 ksi	L	Moderate	
7B	-40%	-30%	-36%	-34%	100%	> 5 ksi	NN-	Weak	1
8B	-56%	-42%	-46%	-46%	100%	> 5 ksi	NN-	Weak	1
9B	-9%	2%	-5%	1%	68%	> 5 ksi	NU	Strong	
10B	-88%	-57%	-67%	-59%	95%	> 5 ksi	L	Weak	2
11B	2%	22%	19%	20%	6%	> 5 ksi	L	Strong	3
12B	-134%	-58%	-63%	-58%	95%	> 5 ksi (-4.18)	L	Weak	2
13B	-37%	-35%	-32%	-33%	100%	> 5 ksi	L	Weak	1
14B	-23%	-31%	-33%	-34%	100%	> 5 ksi	NN-	Weak	1
15B	4%	15%	8%	13%	11%	> 5 ksi	L	Strong	
16B	-73%	-32%	-37%	-34%	95%	> 5 ksi	L	Weak	2
17B	11%	20%	19%	19%	12%	> 5 ksi	L	Strong	
18B	-89%	-65%	-75%	-67%	100%	> 5 ksi (-4.86)	L	Weak	2
19B	-23%	-25%	-27%	-28%	95%	> 5 ksi	NN-	Strong	
20B	-2%	8%	5%	5%	26%	> 5 ksi	NN-	Strong	
21B	-13%	15%	6%	12%	16%	> 5 ksi	L	Strong	
22B	-212%	-35%	-40%	-35%	84%	> 5 ksi (-3.08)	L	Weak	2
23B	17%	20%	19%	19%	5%	> 5 ksi	L	Strong	
24B	-11%	15%	9%	13%	21%	> 5 ksi	L	Strong	
1C	63%	62%	64%	62%	0%	> 5 ksi	NU	Weak	
2C	-175%	879%	122%	1443%	68%	**< 5 ksi**	NN-	Moderate	
3C	380%	-1008%	-112%	-109%	63%	**< 5 ksi (-6.02, -5.76)**	NN-	Moderate	
4C	57%	65%	66%	65%	0%	> 5 ksi	NN-	Weak	
5C	68%	72%	74%	73%	0%	> 5 ksi	NN-	Weak	
6C	-67%	-27%	-35%	-39%	95%	**< 5 ksi (5.61, 5.41, 5.15)**	NN-	Moderate	
7C	9%	33%	34%	35%	5%	> 5 ksi (-4.47)	NN-	Weak	
8C	56%	72%	72%	72%	0%	> 5 ksi (-4.14)	NN-	Weak	2
9C	22%	63%	56%	65%	0%	**< 5 ksi**	NU	Moderate	
10C	1%	-56%	-65%	-72%	74%	**< 5 ksi**	L	Moderate	
11C	-71%	43%	40%	42%	26%	> 5 ksi (-1.75)	NN-	Weak	
12C	131%	118%	121%		0%	**< 5 ksi**		Moderate	5

[a] A negative percent error signifies that the analysis is conservative in relation to the measured stress.

[b] The percentage that the gage is conservative for the dead loads and the total stress cases (19 total).
100% means the gage is conservative for all 19 readings, 0% means the gage is not conservative for any of the readings.

[c] The category, above or below 5 ksi (absolute value), for the magnitude of the measured stresses for Step 3-3a, Step 4-2, and the Total Stress Cases. There are 13 cases for this rating, and 9 of the 13 must fall into the category listed.
The numbers in ( )'s are the stresses that do not fall in the previously listed category.

[d] L = Linear, NU = Nonlinear but uniform, NN+ = Nonlinear and not uniform due to a positive jump,
and NN- = Nonlinear and not uniform due to a negative jump.

[e] Strong = All of the four % errors in this table are < 30%,
Moderate = Gages that do not fit the criteria for being strong or weak, and
Weak = Measured Stress category is > 5 ksi and 3 to 4 of the percent errors are > 30%.

[f] Comments:

1 The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is strong thereafter. Strong correlation refers to the change in stress percent errors for the truck loading being less than 30%, or the measured changes in stress from the trucks being negligible.

2 The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is moderate thereafter due to the analysis at the bottom flanges predicting slightly more direct stress due to warping than the field results. Moderate correlation signifies that the changes in the measured stresses were greater than 30% and the measured stresses were not negligible.

3 Gage was damaged during the erection of the steelwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.

4 The gage was damaged during the placement of the formwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.

5 The gage gives sporadic readings.

Table 5.5: Correlation of 1997 Computed and 2000 Measured Results: Gage Correlation Rating, Fully Composite Analysis with $N = 6$

Gage	% Error[a] Step 3-3a	% Error[a] Step 4-2	% Error[a] Average 9 Trucks, 2K	% Error[a] Average 3 Trucks, 2K	Conservative[b]	Measured Stress Magnitude[c]	Linearity[d]	Correlation[e]	Comments[f]
1A	-71%	1%	-2%	8%	42%	> 5 ksi (-2.64)	NU	Moderate	4
2A	-27%	-4%	-7%	-3%	74%	> 5 ksi	NU	Strong	
3A	0%	3%	11%	7%	21%	> 5 ksi	NN+	Strong	
4A	-49%	-34%				> 5 ksi (3.81)	L		5
5A	-26%	-15%	-18%	-14%	95%	> 5 ksi	NU	Strong	
6A	-33%	-19%	-16%	-20%	95%	> 5 ksi (-4.72, -4.72)	NN+	Moderate	
7A	255%	-89%	-87%	-78%	74%	**< 5 ksi**	NU	Moderate	
8A	-17%	6%	4%	7%	42%	> 5 ksi	NU	Strong	
9A	-73%	-104%	-101%	-114%	95%	**< 5 ksi (6.11, 5.68)**	NU	Moderate	
10A	19%	11%	11%	9%	0%	> 5 ksi	NN-	Strong	
11A	-58%	-38%	-39%	-35%	89%	> 5 ksi	NU	Weak	2
12A	-346%	-520%	-1209%	-412%	68%	**< 5 ksi (7.11, 6.63)**	NU	Moderate	5
13A	-211%	-48%	-49%	-42%	74%	**< 5 ksi**	NU	Moderate	
14A	-143%	-56%	-56%	-47%	89%	**< 5 ksi**	NU	Moderate	
15A	-414%	-324%				**< 5 ksi**	NN-		5
16A	24%	16%	16%	15%	0%	> 5 ksi	L	Strong	5
17A	-12%	8%	7%	9%	16%	> 5 ksi	NU	Strong	
18A	-130%	-113%	-102%	-107%	89%	**< 5 ksi (5.31, 5.30, 6.99, 7.35)**	NN-	Moderate	5
19A	13%	33%	30%	33%	0%	> 5 ksi	NU	Moderate	
20A	-5%	18%	15%	18%	16%	> 5 ksi (4.88)	L	Strong	
21A	-31%	-28%	-17%	-21%	89%	**< 5 ksi (6.76, 6.27, 5.10)**	L	Moderate	
22A	-126%	-77%	-103%	-141%	79%	**< 5 ksi**	NN-	Moderate	
23A	-30%	-16%	-18%	-14%	79%	> 5 ksi	NU	Strong	
24A	-48%	-24%	-15%	-17%	95%	**< 5 ksi (for 7 of 13 cases)**	NN+	Moderate	
1B	-7%	-15%	-17%	-18%	74%	> 5 ksi	L	Strong	5
2B	9%	17%	12%	14%	5%	> 5 ksi	L	Strong	
3B	-26%	-2%	-13%	-6%	95%	> 5 ksi	L	Strong	
4B	-45%	-10%	-20%	-14%	89%	> 5 ksi	L	Moderate	
5B	-22%	-7%	-13%	-12%	95%	> 5 ksi	L	Strong	
6B	-48%	-10%	-15%	-14%	89%	> 5 ksi	L	Moderate	
7B	-40%	-30%	-37%	-36%	95%	> 5 ksi	NN-	Weak	1
8B	-56%	-42%	-47%	-49%	95%	> 5 ksi	NN-	Weak	1
9B	-9%	2%	-6%	0%	68%	> 5 ksi	NU	Strong	
10B	-88%	-57%	-50%	-53%	89%	> 5 ksi	L	Weak	2
11B	2%	22%	18%	18%	5%	> 5 ksi	L	Strong	3
12B	-134%	-58%	-55%	-56%	89%	> 5 ksi (-4.18)	L	Weak	2, 5
13B	-37%	-35%	-37%	-39%	95%	> 5 ksi	L	Weak	1
14B	-23%	-31%	-35%	-37%	100%	> 5 ksi	NN-	Weak	1
15B	4%	15%	8%	13%	11%	> 5 ksi	L	Strong	
16B	-73%	-32%	-34%	-34%	89%	> 5 ksi	L	Weak	2
17B	11%	20%	18%	18%	11%	> 5 ksi	L	Strong	
18B	-89%	-65%	-71%	-65%	95%	> 5 ksi (-4.86)	L	Weak	2
19B	-23%	-25%	-30%	-31%	95%	> 5 ksi	NN-	Moderate	
20B	-2%	8%	5%	3%	26%	> 5 ksi	NN-	Strong	
21B	-13%	15%	7%	11%	11%	> 5 ksi	L	Strong	
22B	-212%	-35%	-30%	-34%	74%	> 5 ksi (-3.08)	L	Weak	2
23B	17%	20%	19%	18%	5%	> 5 ksi	L	Strong	
24B	-11%	15%	10%	13%	33%	> 5 ksi	L	Strong	5
1C	63%	62%	64%	62%	0%	> 5 ksi	NU	Weak	
2C	-175%	879%	192%	1173%	21%	**< 5 ksi**	NN-	Moderate	
3C	380%	-1008%	115%	-948%	53%	**< 5 ksi**	NN-	Moderate	
4C	57%	65%	67%	66%	0%	> 5 ksi	NN-	Weak	
5C	68%	72%	74%	72%	0%	> 5 ksi	NN-	Weak	
6C	-67%	-27%	-36%	-42%	95%	**< 5 ksi (5.74, 5.52, 5.25)**	NN-	Moderate	
7C	9%	33%	31%	33%	5%	> 5 ksi (-4.47)	NN-	Weak	
8C	56%	72%	72%	73%	0%	> 5 ksi (-4.14)	NN-	Weak	2
9C	22%	63%	8%	67%	0%	**< 5 ksi**	NU	Moderate	
10C	1%	-56%	-73%	-82%	68%	**< 5 ksi**	L	Moderate	
11C	-71%	43%	39%	42%	26%	> 5 ksi (-1.75)	NN-	Weak	
12C	131%	118%				**< 5 ksi**			5

[a] A negative percent error signifies that the analysis is conservative in relation to the measured stress.

[b] The percentage that the gage is conservative for the dead loads and the total stress cases (19 total).
100% means the gage is conservative for all 19 readings, 0% means the gage is not conservative for any of the readings.

[c] The category, above or below 5 ksi (absolute value), for the magnitude of the measured stresses for Step 3-3a, Step 4-2, and the Total Stress Cases. There are 13 cases for this rating, and 9 of the 13 must fall into the category listed.
The numbers in ( )'s are the stresses that do not fall in the previously listed category.

[d] L = Linear, NU = Nonlinear but uniform, NN+ = Nonlinear and not uniform due to a positive jump, and NN- = Nonlinear and not uniform due to a negative jump.

[e] Strong = All of the four % errors in this table are < 30%,
Moderate = Gages that do not fit the criteria for being strong or weak, and
Weak = Measured Stress category is > 5 ksi and 3 to 4 of the percent errors are > 30%.

[f] Comments:

1. The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is strong thereafter. Strong correlation refers to the change in stress percent errors for the truck loading being less than 30%, or the measured changes in stress from the trucks being negligible.
2. The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is moderate thereafter due to the analysis at the bottom flanges predicting slightly more direct stress due to warping than the field results. Moderate correlation signifies that the changes in the measured stresses were greater than 30% and the measured stresses were not negligible.
3. Gage was damaged during the erection of the steelwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
4. The gage was damaged during the placement of the formwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
5. The gage gives sporadic readings.

Table 5.6: Correlation of 2000 Computed and 2000 Measured Results: Gage Correlation Rating, Fully Composite Action, $N = 6$

Gage	% Error[a]				Conservative[b]	Measured Stress Magnitude[c]	Linearity[d]	Correlation[e]	Comments[f]
	Step 3-3a	Step 4-2	Average 9 Trucks, 2K	Average 3 Trucks, 2K					
1A	-71%	1%	-2%	8%	42%	> 5 ksi (-2.64)	NU	Moderate	4
2A	-27%	-4%	-7%	-3%	74%	> 5 ksi	NU	Strong	
3A	0%	3%	11%	7%	21%	> 5 ksi	NN+	Strong	
4A	-49%	-34%				> 5 ksi (3.81)	L		5
5A	-26%	-15%	-18%	-14%	95%	> 5 ksi	NU	Strong	
6A	-33%	-19%	-15%	-19%	95%	> 5 ksi (-4.72, -4.72)	NN+	Moderate	
7A	255%	-89%	-88%	-79%	74%	< 5 ksi	NU	Moderate	
8A	-17%	6%	4%	7%	42%	> 5 ksi	NU	Strong	
9A	-73%	-104%	-101%	-114%	95%	< 5 ksi (6.11, 5.68)	NU	Moderate	
10A	19%	11%	11%	9%	0%	> 5 ksi	NN-	Strong	
11A	-58%	-38%	-40%	-35%	89%	> 5 ksi	NU	Weak	1
12A	-346%	-520%	-1204%	-412%	68%	< 5 ksi (7.11, 6.63)	NU	Moderate	5
13A	-211%	-48%	-49%	-43%	74%	< 5 ksi	NU	Moderate	
14A	-143%	-56%	-56%	-48%	89%	< 5 ksi	NU	Moderate	
15A	-414%	-324%				< 5 ksi	NN-		5
16A	24%	16%	16%	14%	0%	> 5 ksi	L	Strong	5
17A	-12%	8%	7%	9%	16%	> 5 ksi	NU	Strong	
18A	-130%	-113%	-102%	-108%	89%	< 5 ksi (5.31, 5.30, 6.99, 7.35)	NN-	Moderate	
19A	13%	33%	30%	32%	0%	> 5 ksi	NU	Moderate	
20A	-5%	18%	15%	18%	16%	> 5 ksi (4.88)	L	Strong	
21A	-31%	-28%	-18%	-22%	89%	< 5 ksi (6.76, 6.27, 5.10)	L	Moderate	
22A	-126%	-77%	-104%	-114%	79%	< 5 ksi	NN-	Moderate	
23A	-30%	-16%	-18%	-14%	79%	> 5 ksi	NU	Strong	
24A	-48%	-24%	-15%	-18%	95%	< 5 ksi (for 7 of 13 cases)	NN+	Moderate	
1B	-7%	-15%	-17%	-18%	74%	> 5 ksi	L	Strong	5
2B	9%	17%	12%	14%	5%	> 5 ksi	L	Strong	
3B	-26%	-2%	-12%	-6%	95%	> 5 ksi	L	Strong	
4B	-45%	-10%	-19%	-14%	89%	> 5 ksi	L	Moderate	
5B	-22%	-7%	-13%	-12%	95%	> 5 ksi	L	Strong	
6B	-48%	-10%	-15%	-13%	89%	> 5 ksi	L	Moderate	
7B	-40%	-30%	-38%	-37%	95%	> 5 ksi	NN-	Weak	1
8B	-56%	-42%	-47%	-49%	95%	> 5 ksi	NN-	Weak	1
9B	-9%	2%	-7%	0%	68%	> 5 ksi	NU	Strong	
10B	-88%	-57%	-51%	-53%	89%	> 5 ksi	L	Weak	2
11B	2%	22%	17%	18%	5%	> 5 ksi	L	Strong	3
12B	-134%	-58%	-55%	-56%	89%	> 5 ksi (-4.18)	L	Weak	2, 5
13B	-37%	-35%	-37%	-39%	95%	> 5 ksi	L	Weak	1
14B	-23%	-31%	-36%	-37%	100%	> 5 ksi	NN-	Weak	1
15B	4%	15%	7%	12%	11%	> 5 ksi	L	Strong	
16B	-73%	-32%	-36%	-35%	89%	> 5 ksi	L	Weak	2
17B	11%	20%	17%	17%	11%	> 5 ksi	L	Strong	2
18B	-89%	-65%	-72%	-66%	95%	> 5 ksi (-4.86)	L	Weak	3
19B	-23%	-25%	-31%	-31%	95%	> 5 ksi	NN-	Moderate	
20B	-2%	8%	4%	3%	26%	> 5 ksi	NN-	Strong	
21B	-13%	15%	6%	11%	11%	> 5 ksi	L	Strong	
22B	-212%	-35%	-32%	-36%	74%	> 5 ksi (-3.08)	L	Weak	3
23B	17%	20%	19%	17%	5%	> 5 ksi	L	Strong	
24B	-11%	15%	9%	12%	33%	> 5 ksi	L	Strong	
1C	63%	62%	64%	61%	0%	> 5 ksi	NU	Weak	
2C	-175%	879%	182%	1196%	21%	< 5 ksi	NN-	Moderate	
3C	380%	-1008%	114%	-947%	53%	< 5 ksi	NN-	Moderate	
4C	57%	65%	67%	66%	0%	> 5 ksi	NN-	Weak	
5C	68%	72%	74%	72%	0%	> 5 ksi	NN-	Weak	
6C	-67%	-27%	-36%	-43%	95%	< 5 ksi (5.74, 5.52, 5.25)	NN-	Moderate	
7C	9%	33%	31%	33%	5%	> 5 ksi (-4.47)	NN-	Weak	
8C	56%	72%	72%	73%	0%	> 5 ksi (-4.14)	NN-	Weak	2
9C	22%	63%	59%	69%	0%	< 5 ksi	NU	Moderate	
10C	1%	-56%	-73%	-84%	68%	< 5 ksi	L	Moderate	
11C	-71%	43%	39%	42%	26%	> 5 ksi (-1.75)	NN-	Weak	
12C	131%	118%				< 5 ksi			5

[a] A negative percent error signifies that the analysis is conservative in relation to the measured stress.

[b] The percentage that the gage is conservative for the dead loads and the total stress cases (19 total). 100% means the gage is conservative for all 19 readings, 0% means the gage is not conservative for any of the readings.

[c] The category, above or below 5 ksi (absolute value), for the magnitude of the measured stresses for Step 3-3a, Step 4-2, and the Total Stress Cases. There are 13 cases for this rating, and 9 of the 13 must fall into the category listed. The numbers in ( )'s are the stresses that do not fall in the previously listed category.

[d] L = Linear, NU = Nonlinear but uniform, NN+ = Nonlinear and not uniform due to a positive jump, and NN- = Nonlinear and not uniform due to a negative jump.

[e] Strong = All of the four % errors in this table are < 30%,
Moderate = Gages that do not fit the criteria for being strong or weak, and
Weak = Measured Stress category is > 5 ksi and 3 to 4 of the percent errors are > 30%.

[f] Comments:

1. The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is strong thereafter. Strong correlation refers to the change in stress percent errors for the truck loading being less than 30%, or the measured changes in stress from the trucks being negligible.
2. The dead load up to Step 3-3a introduced possible built-in stresses; correlation due to change in stress is moderate thereafter due to the analysis at the bottom flanges predicting slightly more direct stress due to warping than the field results. Moderate correlation signifies that the changes in the measured stresses were greater than 30% and the measured stresses were not negligible.
3. Gage was damaged during the erection of the steelwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
4. The gage was damaged during the placement of the formwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
5. The gage gives sporadic readings.

Table 5.7: Correlation of 1997 Computed and 2000 Measured Change in Stress Results: Gage Correlation Rating, Fully Composite Action, $N = 6$

Gage	% Error[a]										Conservative[b]	Measured Stress Magnitude[c]	Correlation[d]	Comments[e]
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 8	Case 9	case 10	Case 11		# cases > 0.5 ksi		
1A	-265%	-183%	-43%	160%	376%	377%	-18%	22%	145%	136%	40%	7	WEAK	1
2A	-465%	-370%	-136%	240%	1809%	1277%	-100%	-34%	196%	187%	50%	1	MODERATE	
3A	2%	15%	51%	150%	-149%	-92%	-4%	27%	1474%	1842%	30%	8	WEAK	
4A														3
5A	-263%	-216%	-85%	365%	-342%	-379%	-84%	-32%	344%	317%	70%	4	MODERATE	
6A	-12%	0%	26%	7146%	-14%	0%	-33%	3%	-5%	4%	40%	9	STRONG	
7A	-161%	-106%	-4%	373%	-216%	-233%	-33%	25%	233%	219%	60%	4	MODERATE	
8A	-254%	-196%	-48%	271%	-663%	-7327%	-39%	16%	163%	160%	60%	0	MODERATE	
9A	-45%	-36%	-26%	-10%	-34%	-12%	-67%	-62%	35%	38%	80%	9	STRONG	
10A	-13%	0%	22%	-207%	-32%	-9%	-18%	5%	-6%	2%	60%	7	STRONG	
11A	-218%	-171%	-48%	276%	-1287%	-7443%	-52%	8%	178%	168%	60%	3	MODERATE	
12A	6%	17%	40%	-14728%	-13%	2%	8%	32%	-65%	-45%	40%	7	STRONG	3
13A	-186%	-131%	3%	245%	-1337%	654%	-45%	33%	143%	132%	40%	0	MODERATE	
14A	-263%	-180%	7%	184%	459%	255%	-23%	47%	124%	120%	30%	0	MODERATE	
15A														3
16A	13%	26%	55%	-12%	35%	47%	5%	42%	52%	60%	10%	7	STRONG	3
17A	-161%	-107%	21%	172%	320%	254%	-23%	43%	129%	121%	30%	2	MODERATE	
18A	-21%	-4%	34%	-78%	6%	21%	-29%	12%	27%	38%	40%	7	STRONG	3
19A	1399%	1813%	333%	164%	148%	120%	-255%	15%	111%	104%	10%	0	MODERATE	
20A	722%	730%	-464%	218%	167%	122%	-138%	39%	109%	104%	20%	0	MODERATE	
21A	10%	21%	65%	-827%	16%	48%	8%	52%	23%	61%	10%	5	STRONG	
22A	-92%	-89%	-127%	46%	69%	86%	-400%	327%	92%	99%	40%	6	MODERATE	
23A	-349%	-291%	-16%	219%	175%	133%	-69%	37%	113%	104%	40%	0	MODERATE	
24A	0%	12%	63%	362%	-58%	-26%	0%	48%	313%	167%	20%	5	MODERATE	
1B	-36%	-35%	-32%	-84%	-125%	-126%	-454%	-269%	985%	-1834%	90%	6	MODERATE	3
2B	-74%	-63%	-108%	-200%	-233%	-199%	-478%	-439%	8993%	-1607%	90%	0	MODERATE	
3B	-101%	-83%	-114%	-179%	-230%	-184%	-71%	-50%	-180%	-121%	100%	9	WEAK	
4B	3%	14%	-40%	-178%	-288%	-206%	0%	18%	-221%	-154%	60%	10	WEAK	
5B	-43%	-18%	-78%	-223%	-383%	-270%	-2011%	-522%	1415%	-20276%	90%	2	MODERATE	
6B	-82%	-71%	-65%	-38%	-37%	-22%	-152%	-103%	-46%	-21%	100%	9	STRONG	
7B	-373%	-339%	-462%	-376%	-412%	-278%	334%	403%	421%	402%	60%	0	MODERATE	
8B	-163%	-117%	-156%	-169%	-201%	-167%	378%	520%	453%	433%	60%	0	MODERATE	
9B	-89%	-73%	-80%	-80%	-103%	-77%	-38%	-29%	-33%	-19%	100%	10	STRONG	
10B	47%	56%	20%	-54%	-127%	-107%	47%	55%	-98%	-86%	50%	10	STRONG	
11B	-38%	-16%	-32%	-48%	-82%	-66%	-366%	-184%	-571%	-636%	100%	6	MODERATE	2
12B	-130%	-115%	-82%	8%	53%	64%	-127%	-110%	61%	68%	50%	10	WEAK	3
13B	-82%	-62%	-85%	-68%	-43%	-30%	-797%	-355%	-637%	-648%	100%	4	MODERATE	
14B	-160%	-128%	-174%	-155%	-124%	-129%	322%	438%	345%	289%	60%	0	MODERATE	
15B	-57%	-41%	-44%	-40%	-57%	-39%	-52%	-31%	-24%	-9%	100%	10	STRONG	
16B	11%	27%	-14%	-78%	-126%	-112%	-20%	10%	-136%	-129%	70%	10	MODERATE	
17B	-33%	-18%	-21%	-18%	-25%	-13%	-356%	-232%	-189%	-138%	100%	6	MODERATE	
18B	214%	-185%	-143%	-41%	9%	36%	-165%	-136%	36%	80%	60%	10	WEAK	
19B	-242%	-199%	-166%	-133%	-192%	-282%	391%	394%	418%	293%	60%	0	MODERATE	
20B	-184%	-96%	-77%	-54%	-98%	-141%	230%	244%	259%	215%	60%	0	MODERATE	
21B	-80%	-63%	-70%	-61%	-65%	-46%	-123%	-83%	-67%	-44%	100%	9	STRONG	
22B	21%	42%	12%	-30%	-54%	-44%	10%	33%	-73%	-62%	50%	10	STRONG	
23B	-12%	18%	17%	21%	7%	12%	-12927%	-250%	-984%	-666%	50%	6	MODERATE	
24B	-64%	-58%	-45%	3%	24%	41%	-74%	-73%	25%	44%	50%	10	STRONG	3
1C	178%	206%	295%	153%	355%	363%	201%	339%	212%	223%	0%	2	MODERATE	
2C	-88%	-84%	-64%	52%	69%	87%	-282%	-253%	91%	98%	50%	2	STRONG	
3C	-27%	-19%	1%	-512%	-54%	-48%	-20%	11%	-133%	-170%	60%	7	WEAK	
4C	69%	76%	89%	119%	69%	74%	87%	79%	203%	199%	0%	8	WEAK	
5C	154%	172%	230%	136%	319%	313%	185%	378%	174%	183%	0%	2	MODERATE	
6C	-101%	-94%	-98%	13%	-23%	-12%	-228%	-228%	59%	63%	70%	4	MODERATE	
7C	-39%	-25%	5%	967%	-105%	-87%	-25%	8%	-529%	-530%	70%	7	WEAK	
8C	12%	40%	61%	202%	-2%	27%	56%	64%	210%	245%	10%	5	MODERATE	
9C	144%	175%	370%	104%	170%	177%	-40%	-73%	127%	131%	20%	0	MODERATE	
10C	-106%	-90%	-38%	-9%	13%	28%	-204%	-122%	57%	65%	60%	6	MODERATE	
11C	-75%	-49%	7%	3900%	-84%	-44%	-20%	19%	1060%	1850%	50%	7	WEAK	
12C														3

[a] A negative percent error signifies that the analysis is consevrative in relation to the measured stress.

[b] The percentage that the gage is conservative for the change in stress cases (10 total).
100% means the gage is conservative for all 10 readings, 0% means the gage is not conservative for any of the readings.

[c] The number of cases above 0.5 ksi (absolute value), for the magnitude of the change in the measured stress.
There are 10 cases for this rating.

[d] Strong = Eight to ten percent errors in this table are < 100%,
Moderate = Gages that do not fit the criteria for being strong or weak, and
Weak = Seven to ten gages have change in stress > 0.5 ksi and three to ten of the percent errors are greater than 100%.

[e] Comments:
1 Gage was damaged during the erection of the steelwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
2 The gage was damaged during the placement of the formwork. It was replaced after Step 1-3, with all of the steel for the girders and crossframes in place.
3 The gage gives sporadic or erratic readings.

Table 5.8: Comparison of Stresses from Analysis with Reduction of All of the Crossframe Members by 65%

1A-6A	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-11.73	-8.73	-7.32	6.89	5.46	5.61
Original Computed Stress	-11.60	-8.87	-7.74	7.02	5.55	5.67
Measured Stress	-9.23	-7.00	-5.68	5.27	5.57	3.81

7A-12A	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-9.01	-6.76	-5.98	6.09	4.68	4.73
Original Computed Stress	-9.21	-7.02	-6.35	6.34	4.88	4.92
Measured Stress	-5.83	-6.02	-1.79	1.42	2.82	6.07

13A-18A	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-7.86	-5.95	-5.48	5.62	4.16	4.15
Original Computed Stress	-7.90	-6.01	-5.57	5.62	4.16	4.16
Measured Stress	-7.06	-2.47	-1.79	2.44	0.81	5.50

19A-24A	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-6.30	-4.93	-4.88	4.66	3.11	2.86
Original Computed Stress	-6.59	-5.14	-5.05	4.75	3.26	3.14
Measured Stress	-5.07	-4.88	-5.83	3.20	2.49	1.39

1C-4C	1	2	3	4
Computed from Reduced Section	11.91	13.41	-12.17	-9.92
Original Computed Stress	4.24	4.13	-3.78	-3.66
Measured Stress	11.33	1.50	1.35	-8.56

5C-8C	5	6	7	8
Computed from Reduced Section	5.72	13.12	-12.36	-4.73
Original Computed Stress	2.06	4.23	-4.05	-1.82
Measured Stress	6.44	2.54	-4.47	-4.14

9C-12C	9	10	11	12
Computed from Reduced Section	-1.36	8.26	-8.33	1.32
Original Computed Stress	-0.57	2.91	-2.99	0.49
Measured Stress	-0.73	2.95	-1.75	-1.59

Table 5.9: Comparison of Stresses from Analysis with Reduction of the Bottom Crossframe Members by 65%

	1A-6A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-113.65	-8.83	-7.59	6.91	5.5	5.68
Original Computed Stress	-11.6	-8.87	-7.74	7.02	5.55	5.67
Measured Stress	-9.23	-7	-5.68	5.27	5.57	3.91

	7A-12A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-9.13	-6.92	-6.2	6.19	4.8	4.9
Original Computed Stress	-9.21	-7.02	-6.35	6.34	4.88	4.92
Measured Stress	-5.83	-6.02	-1.79	1.42	2.82	6.07

	13A-18A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-7.87	-5.97	-5.52	5.59	4.16	4.18
Original Computed Stress	-7.9	-6.01	-5.57	5.62	4.16	4.16
Measured Stress	-7.06	-2.47	-1.79	2.44	0.81	5.5

	19A-24A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-6.44	-5.08	-5.06	4.79	3.23	3.01
Original Computed Stress	-6.59	-5.14	-5.05	4.75	3.26	3.14
Measured Stress	-5.07	-4.88	-5.83	3.2	2.49	1.39

	1C-4C			
	1	2	3	4
Computed from Reduced Section	5.29	3.4	-5.54	-7.63
Original Computed Stress	4.24	4.13	-3.78	-3.66
Measured Stress	11.33	1.5	1.35	-8.56

	5C-8C			
	5	6	7	8
Computed from Reduced Section	2.57	4.08	-5.07	-3.62
Original Computed Stress	2.06	4.23	-4.05	-1.82
Measured Stress	6.44	2.54	-4.47	-4.14

	9C-12C			
	9	10	11	12
Computed from Reduced Section	-0.71	3.12	-2.78	1.09
Original Computed Stress	-0.57	2.91	-2.99	0.49
Measured Stress	-0.73	2.95	-1.75	-1.59

Table 5.10: Comparison of Stresses from Analysis with Reduction of the Top Crossframe Members by 65%

	1A-6A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-11.59	-8.81	-7.62	7.01	5.52	5.63
Original Computed Stress	-11.6	-8.87	-7.74	7.02	5.55	5.67
Measured Stress	-9.23	-7	-5.68	5.27	5.57	3.81

	7A-12A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-9.09	-6.93	-6.26	6.26	4.8	4.84
Original Computed Stress	-9.21	-7.02	-6.35	6.34	4.88	4.92
Measured Stress	-5.83	-6.02	-1.79	1.42	2.82	6.07

	13A-18A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-7.87	-5.99	-5.57	5.61	4.16	4.15
Original Computed Stress	-7.9	-6.01	-5.57	5.62	4.16	4.16
Measured Stress	-7.06	-2.47	-1.79	2.44	0.81	5.5

	19A-24A					
	TL	TC	TR	BL	BC	BR
Computed from Reduced Section	-6.54	-5.1	-5.02	4.7	3.22	3.1
Original Computed Stress	-6.59	-5.14	-5.05	4.75	3.26	3.14
Measured Stress	-5.07	-4.88	-5.83	3.2	2.49	1.39

	1C-4C			
	1	2	3	4
Computed from Reduced Section	8.52	6.15	-2.93	-4.56
Original Computed Stress	4.24	4.13	-3.78	-3.66
Measured Stress	11.33	1.5	1.35	-8.56

	5C-8C			
	5	6	7	8
Computed from Reduced Section	3.95	5.36	-3.84	-2.19
Original Computed Stress	2.06	4.23	-4.05	-1.82
Measured Stress	6.44	2.54	-4.47	-4.14

	9C-12C			
	9	10	11	12
Computed from Reduced Section	-1.14	2.68	-3.15	0.65
Original Computed Stress	-0.57	2.91	-2.99	0.49
Measured Stress	-0.73	2.95	-1.75	-1.59

CHAPTER 6
CONCLUSIONS

This research has documented the correlation between measured and computed stresses in a two-span, four-girder, continuous steel curved girder bridge with a composite concrete deck and skew supports. Computed stresses using a linear elastic program developed for this project, which in turn was shown to correlate well with a common third-party curved girder analysis program used by the Minnesota Department of Transportation, were compared to measured stresses taken throughout construction and during live loading with up to nine 50 kip trucks. Chapter 5 presented a detailed summary and interpretation of the results from this study. The following are the primary conclusions from this research:

- The bridge was shored during construction, and the design of its components was controlled by stiffness, not strength. As a consequence, the stresses remained well below yield, and the deflections remained safely within the specified deflection limits. The magnitudes of stresses and deflections were sufficiently low that a revision of the deflection criteria used for stiffness design of curved girder bridges may be warranted, particularly when assessing existing curved girder bridges that were designed by stiffness and are being reevaluated to establish permitting restrictions. As this conclusion is based only upon investigation of a single bridge, for future research, correlation of the deflections and stresses in other stiffness-controlled curved girder bridges would provide added support to this recommendation.
- The strength of the deck concrete in this bridge, evaluated by testing concrete cylinders cast during the pouring of the concrete deck, was higher than the nominal strength of the deck mix, as is common in practice. As a consequence of this, the majority of analyses used in this research to compare to measured results were conducted using a modular ratio of $N = 6$ (defined as the ratio of the steel modulus of elasticity to the concrete modulus of elasticity) rather than the more common value used in practice of $N = 8$. This lower modular ratio was seen to give more accurate results for most gage locations, although the difference in results

between analyses using the two modular ratios was generally small. It is recommended that a more thorough statistical assessment be done of the ratio of actual to nominal strength of the concrete in typical deck mixes, and that a revised estimate of N be considered for future analyses. This may be particularly appropriate for evaluating existing bridges relative to assessing new permitting restrictions. It should be noted that the deterioration of the concrete deck could also be considered in any decision regarding the appropriate value of the modular ratio to be used for analysis.

- The correlation between measured and computed stresses was strong for major axis bending of the girders. This was documented primarily by comparison of the results of the gages at the top and bottom of the webs of the girders. More substantial differences were seen in the girder flange tip locations, indicating influence from lateral bending and restraint of warping at the girder cross sections. The weaker correlation in the flange tips was influenced by the complexity of accurately predicting the effects from fit-up stresses, local eccentricities, and the detailed influence of the cross frame stiffnesses, on the lateral bending and torsion of the girders. Nevertheless, when assuming fully composite action along the length of the bridge, and using $N = 6$, the correlation in the girders in general was moderate to strong, and the computed stresses were generally conservative, both in the positive and negative moment regions. However, the correlation between measured and computed stresses was moderate to weak in the cross frames in the positive moment region of the south span. While this lack of correlation in the cross frames occurred due both to dead load stress and change in stress from the live load, the results indicate that the primary breakdown in correlation in the cross frames was generally established during the construction stages from built-in stresses due to fit-up and local eccentricities. Built-in stresses as high as 6 ksi were seen in some cross frame members during construction stages when only small stresses were being predicted in the analysis. The effects of these built-in stresses dissipated as more load was put onto the bridge, thus improving the correlation. However, the correlation in the cross frames remained moderate at best. More importantly, the stresses in the cross frames were often underpredicted in the analysis, both due to dead load alone, and due to combined dead and live load. As this bridge was controlled by stiffness, none of the cross frame members instrumented in this study approached their failure loads. However, based on these results, this same degree of confidence in the safety of the cross frame members cannot be made for a curved girder bridge whose cross frame members are controlled by strength. It is recommended that further research be conducted into the accuracy of modeling lateral bending and restraint of warping stresses in curved bridge girders, and also of modeling the behavior of cross frame members. For example, establishing practical modeling guidelines within the context of linear elastic analysis to bracket the possible stress magnitudes in cross frame members, particularly during construction phases, will help insure they are designed safely both for ultimate strength and fatigue.

- This bridge did not have shear connectors in the negative moment region. In this absence of shear connectors, it would be common when conducting analyses of this type of bridge to ignore the effect of composite action in the negative moment region (specifically the influence of the deck reinforcing bars on bridge stiffness, as the concrete is assumed to be cracked in this region). However, the comparison of measured and computed results clearly showed better correlation for the gages on or near the top tension flange in the negative moment region if composite action was assumed throughout the bridge (the gages elsewhere in the bridge were essentially unaffected by the variation in this modeling assumption). Both dead load correlation (after hardening of the concrete deck) and live load correlation improved. This indicates that the bridge appeared to exhibit composite action in the negative moment region of the bridge even when loaded with nine 50 kip trucks in the positive moment region of either span. Specifically, the gages near the top flange showed considerably larger strains in the analysis than in the field if no composite action was assumed in the analysis, as compared to the strains seen when composite action in the negative moment region was included in the analysis (i.e., the effect on the bridge stiffness of the deck reinforcing bars). While this particular bridge indicated that neglecting composite action was generally conservative, this conclusion cannot be made categorically for all bridges, as the difference in behavior involves a shift in the neutral axis in the girders. As the analysis neglecting composite action was shown to be conservative for this bridge, this outcome primarily has implications for assessment of the stress range for fatigue detailing in the negative moment region. However, this study may be considered to be too limited to make broad conclusions regarding whether composite action should be modeled in the negative moment region of a girder even if no shear connectors are used in that portion of the bridge. It is thus recommended that this modeling issue be explored in future research. Alternately, if shear connectors are used in the negative moment region, it would be advisable to consider the slab to be acting compositely (albeit cracked, leaving only the effect of the reinforcing bars) in the negative moment region. The resulting stress predictions will likely be much more accurate in that region.

- The effects of temperature variations up to approximately eighty degrees were investigated on this bridge. Measurements were taken periodically at different times during the year, over a period of several years, with only light traffic loading on the bridge. Change in stress due to indeterminate action in the bridge was observed for this wide temperature variation, with stresses in several gages in the girders and cross frames shifting by as much as 9 ksi, although a majority of gages had accumulations in stress of less than 3 ksi over the eighty degree temperature variation. Generally, each gage showed a specific trend of accumulating either tension or compression during a monotonic temperature shift, although several gages showed more erratic response in this regard. For this reason, it was difficult to discern a clear pattern of movement or behavior in the bridge due to temperature shifts. In addition, the range of temperatures during the construction stages of this bridge were much smaller than eighty degrees, indicating that the influence of temperature on the measured accumulation of stress in this bridge during construction was minimal, as compared to built-in stresses due to fit-up. New zeros were taken at the beginning of each live load test, and the temperature change during the course of the live load measurements was minimal, so change in temperature also did not significantly influence the change in stress measurements due to live load. In summary, change in temperature does impact the stress state of the bridge and should continued to be considered in the design of indeterminate bridge structures. However, change in temperature did not significantly influence the value of strains measured in this specific project as compared to the effects of loading and fit-up, since the range of temperatures at which measurements were taken was relatively small, and the readings of the gages with minimal traffic on the bridge remained approximately constant over time if taken at similar temperatures.

- The behavior of this bridge was measured over a five year period on this project, including testing with nine fifty kip trucks at a three year interval. Little change in behavior was seen, as may be expected. Future research could include reloading of the bridge at multi-year intervals to track its behavior over time. Sixty vibrating wire gages were installed on this bridge in the fabrication shop. After five years, nine of the sixty gages, or 15%, had failed. The remaining gages retained their zero value well. While it is anticipated that this rate of failure may accelerate, the vibrating wire gages provided a good method of taking long-term measurements of this bridge.

The behavior of curved steel girder bridge systems remains a topic of research nationwide. This project provides added confidence in the correlation between measured and computed stresses for linear elastic behavior of curved steel girder bridge systems, but also highlights several areas where future research is warranted.

REFERENCES

Boyer, T. A. and Hajjar, J.F. (1997). "Live Load Stresses in Steel Curved Girder Bridges," Mn/DOT Project 74708 Task 1 Report, Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota.

Carlsson, M. and Hajjar, J. F. (2000). "Stresses in Steel Curved Girder Bridges," Structural Engineering Report No. ST-00-1, Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota.

Davidson, J., Keller, M., and Yoo, C. (1996). "Cross Frame Spacing and Parametric Effects in Horrizontally Curved I-Girder Bridges," *Journal of Structural Engineering*, ASCE, Vol. 122, No. 9, pp. 1089-1096.

Duwadi, S., Yadlosky, J., and Yoo, C. (1994). "Horizontally Curved Steel Bridge Research – Update," Proceedings of the ASCE Structures Congress XII, Baker, N. C. and Goodno, B. J. (eds.), Atlanta, Georgia, April 24-28, 1994, ASCE, New York, New York, pp. 1071-1076.

Galambos, T. V., Hajjar, J. F., Leon, R. Huang, W.-H., Pulver, B., and Rudie, B. (1996). "Stresses in Steel Curved Bridges," Report No. MN/RC-96/28, Minnesota Department of Transportation, Saint Paul, Minnesota, 345 pp.

Grubb, M., Yadlosky, J., and Hermann, A. (1993). "Behavior of Horizontally Curved Steel Highway Bridges," Proceedings of the ASCE Structures Congress XI, Ang, A. H.-S. and Villaverde, R. (eds.), Irvine, California, April 19-23, 1993, ASCE, New York, New York, pp. 858-863.

Hall, D. (1996). "Curved Girders are Special," *Engineering Structures*, Vol. 18, No. 10, pp. 769-777.

Hall, D. (1997). "Proposed Curved Girder Provisions for AASHTO," Proceedings of the ASCE Structures Congress XV, Kemper, L., Jr. and Brown, C. B. (eds.), Portland, Oregon, April 13-16, 1997, ASCE, New York, New York, pp. 151-154.

Huang, D. Z., Wang, T. L., and Shahawy, M. (1995). "Dynamic Behavior of Horizontally Curved I-Girder Bridges," *Computers and Structures*, Vol. 57, No. 4, pp. 703-714.

Huang, W.-H. (1996). "Curved I-Girder Systems," Ph.D. Dissertation, Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota.

Lee, S. C. and Yoo, C. H. (1999). "Strength of Curved I-Girder Web Panels under Pure Shear," *Journal of Dtructural Engineering*, ASCE, Vol. 125, No. 8, pp. 847-853.

Pi, Y. L., Branford, M. A., and Trahair, N. S. (2000). "Inelastic Analysis and Behavior of Steel I-Beams Curved in Plan," *Journal of Structural Engineering*, ASCE, Vol. 126, No. 7, pp.772-779.

Rudie, B. (1997). "A Study of the Deflections of a Curved Steel Girder Bridge," M. S. Thesis, Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota.

Schelliing, D., Namini, A., and Fu, C. (1989). "Construction Effects on Bracing on Curved I-Girders," *Journal of Structural Engineering*, ASCE, Vol. 119, No. 9, pp. 2145-2165.

Simpson, M. (2000). "Analytical Investigation of Curved Steel Girder Behaviour," Ph.D. Dissertation, Department of Civil Engineering, University of Toronto, Canada.

South, J. and Hahim, C. (2000). "Methods to Reduce Built-in Residual Stress in Steel Bridge Diaphragms (Phase 1)," Report No. FWHA/IL/PRR-109, Illinois Department of Transportation, Springfield, Illinois.

Thevendran, V., Shanmugam, N. E., Chen, S., and Liew, J. Y. R. (2000). "Experimental Study on Steel-Concrete Composite Beams Curved in Plan," *Engineering Structures*, Vol. 22, No. 8, pp. 877-889.

Yoo, C. H., Hall, D., and Sabol, S. A. (1995). "Improved Design Specifications for Horizontally Curved Steel Girder Highway Bridges," *Restructuring Americal and Beyond*, Proceedings of the ASCE Structures Congress XIII, Sanayei, M. (ed.), Boston, Massachusetts, April 12-15, 1995, ASCE, New York, New York, pp. 1699-1702.

Yoo, C. H., Kang, Y. J., and Davidson, J. S. (1996). "Buckling Analysis of Curved Beams by Finite-Element Discretization," *Journal of Engineering Mechanics*, ASCE, Vol. 122, No. 8, pp. 762-770.

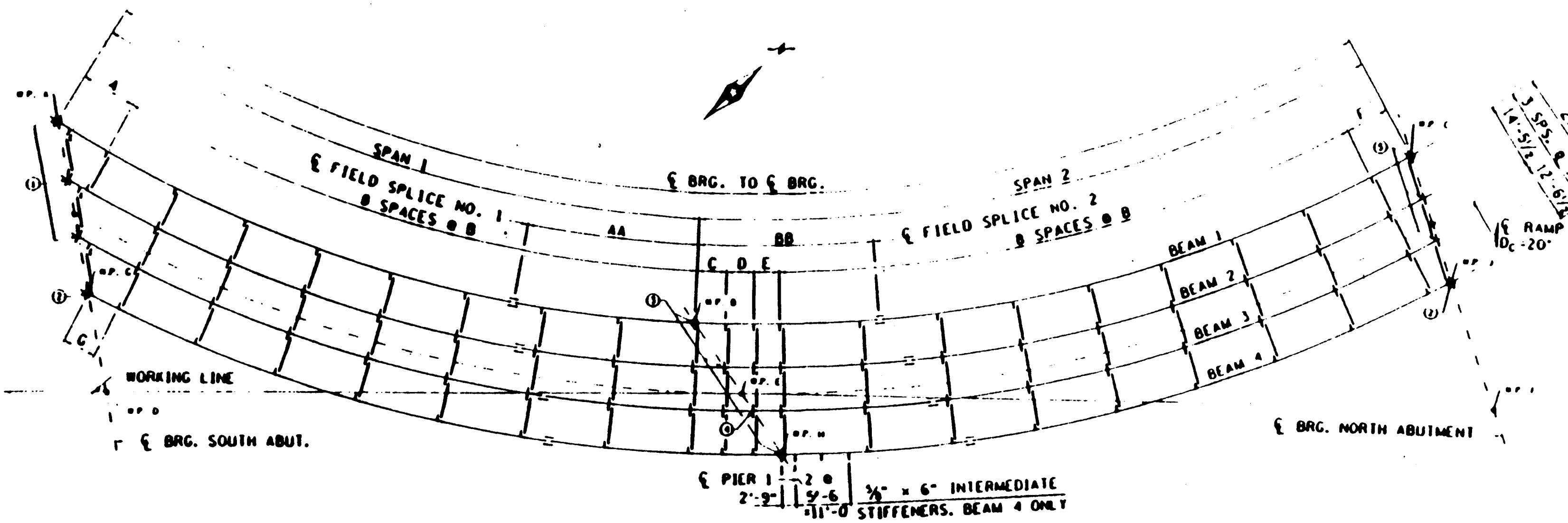
Zureick, A., Naqib, R., and Yadlosky, J. M. (1993). "Curved Steel Bridge Research Project, Interim Report I, Synthesis," Report No. FWHA/RD/93-129, Federal Highway Administration, McLean, Virginia.

Zureick, A. and Naqib, R. (1997). "Horizontally Curved Steel I-Girders State-of-the-Art Analysis Methods," *Journal of Bridge Engineering*, ASCE, Vol. 4, No. 1, pp. 38-47.

Zureick, A., Linzell, D., Leon, R., and Burrell, J. (2000). "Curved Steel I-Girder Bridges: Experimental and Analytical Studies," *Engineering Structures*, Vol. 22, No. 2, pp. 180-190.

APPENDIX A

BRIDGE DIMENSIONS, GAGE LOCATIONS, AND DISPLACEMENT MEASUREMENT LOCATIONS



DIAPHRAGM SPACING							
	A	B	C	D	E	F	G
℄ BEAM 1	11'-11"	16'-0"	6'-5 3/8"	5'-11 5/8"	5'-6 3/8"	9'-5 1/4"	---
℄ BEAM 2	4'-1 5/8"	16'-6 3/8"	6'-8 1/8"	6'-2"	5'-8 1/2"	8'-0"	---
℄ BEAM 3	---	17'-0 3/4"	6'-10 3/4"	6'-4 3/8"	5'-10 3/4"	6'-6 3/4"	13'-7 1/4"
℄ BEAM 4	---	17'-7"	7'-1 1/4"	6'-6 3/4"	6'-0 3/8"	5'-1 3/8"	6'-8 1/2"

FIELD SPLICE LOCATIONS		
	AA	BB
℄ BEAM 1	38'-0"	38'-0"
℄ BEAM 2	43'-0"	38'-0"
℄ BEAM 3	44'-0"	37'-0"
℄ BEAM 4	49'-0"	39'-0"

SPAN LENGTHS			
	RADIUS	SPAN 1	SPAN 2
℄ BEAM 1	272'-0 1/4"	139'-10 3/8"	155'-4 3/4"
℄ BEAM 2	281'-0 1/4"	143'-0 3/8"	152'-1 3/8"
℄ BEAM 3	290'-0 1/4"	146'-3 3/8"	148'-11 1/8"
℄ BEAM 4	299'-0 1/4"	149'-6 1/8"	145'-10 1/8"

(1) VULCANIZED EXPANSION CURVED PLATE BEARING ASSEMBLY, TYPE 1

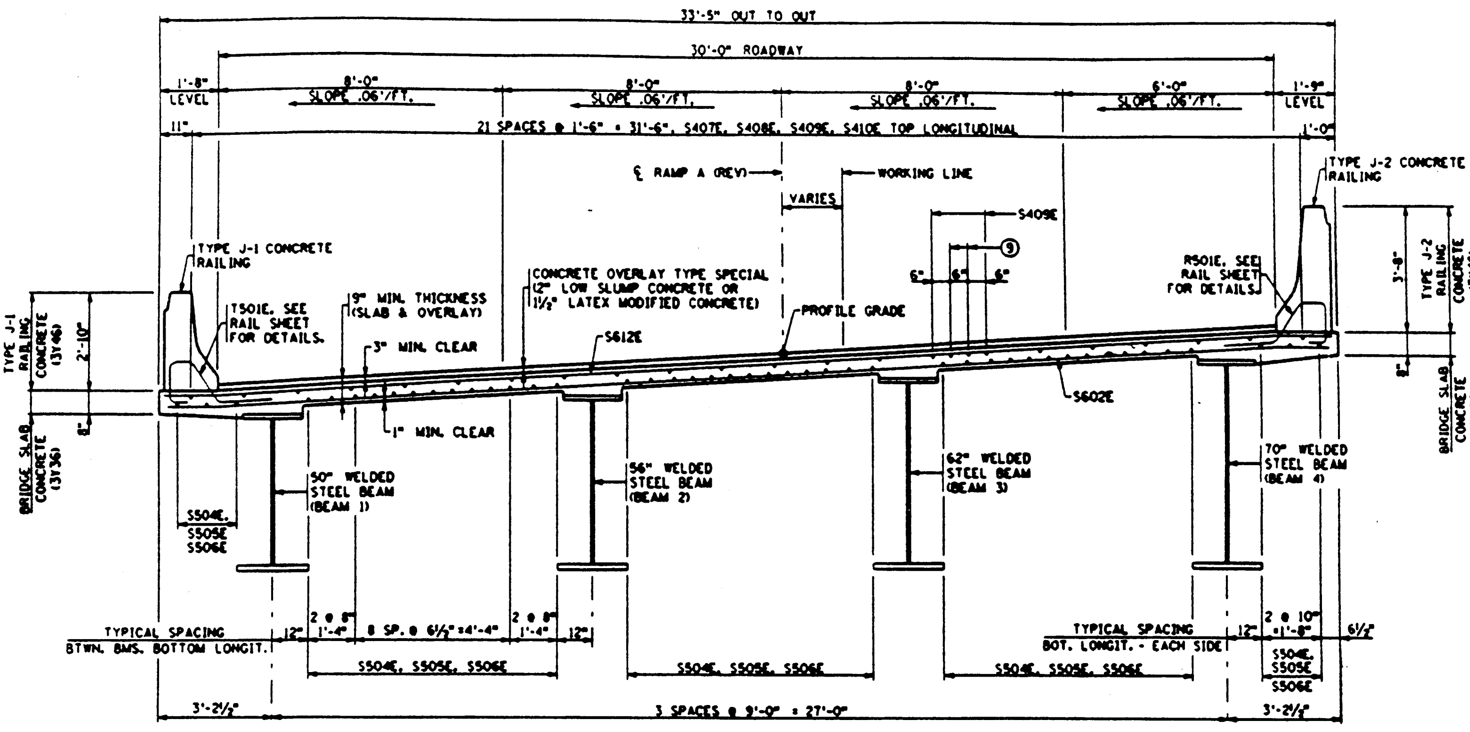
(2) VULCANIZED EXPANSION CURVED PLATE BEARING ASSEMBLY, TYPE 2

(3) FIXED CURVED PLATE BEARING ASSEMBLY, TYPE 1

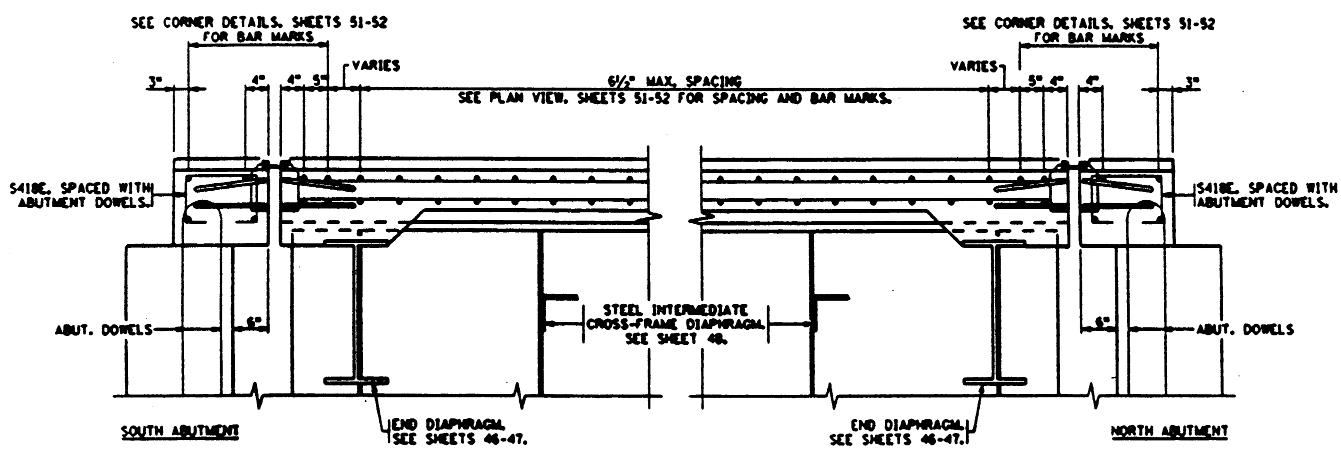
(4) FIXED CURVED PLATE BEARING ASSEMBLY, TYPE 2

(5) VULCANIZED EXPANSION CURVED PLATE BEARING ASSEMBLY, TYPE 3.

Figure A. 1 Framing Plan

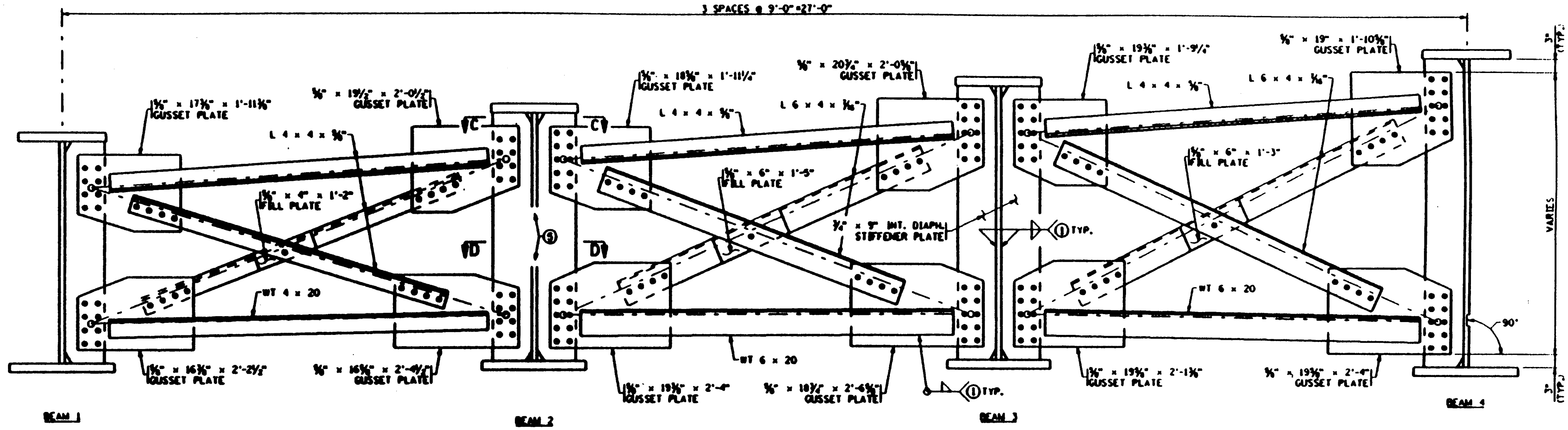


TRANSVERSE SECTION

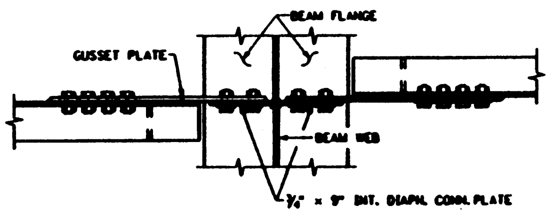


PART LONGITUDINAL SECTION

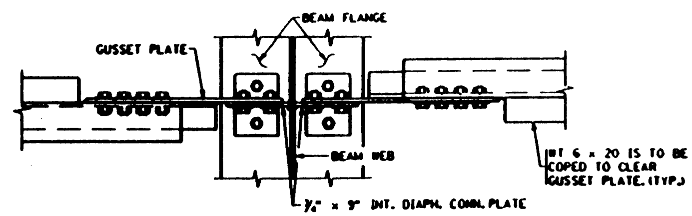
Figure A.2: Superstructure profiles.



ELEVATION - INTERMEDIATE CROSS FRAME DIAPHRAGM



SECTION C-C



SECTION D-D

NOTES:

ALL STEEL SHALL CONFORM TO SPEC. 3309.

① SEE SPEC. 2471.3J4b) FOR MINIMUM SIZE OF FILLET WELD. WELD SIZE NEED NOT EXCEED 3/8" FOR INTERMEDIATE DIAPHRAGM STIFFENERS.

② BOLT HOLES IN GUSSET PLATE MAY BE FIELD DRILLED.

Figure A.3: Elevation of intermediate cross frame diaphragms

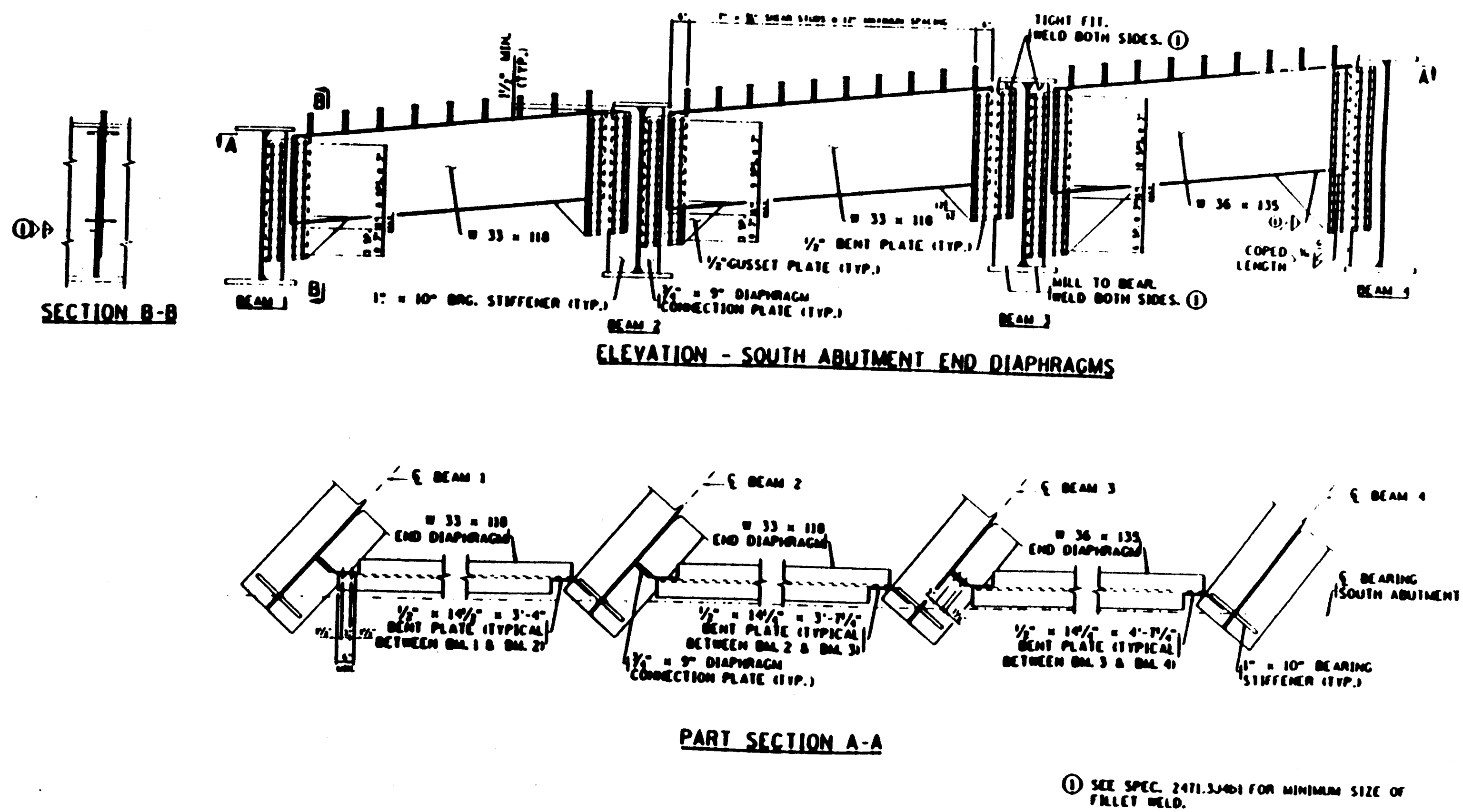
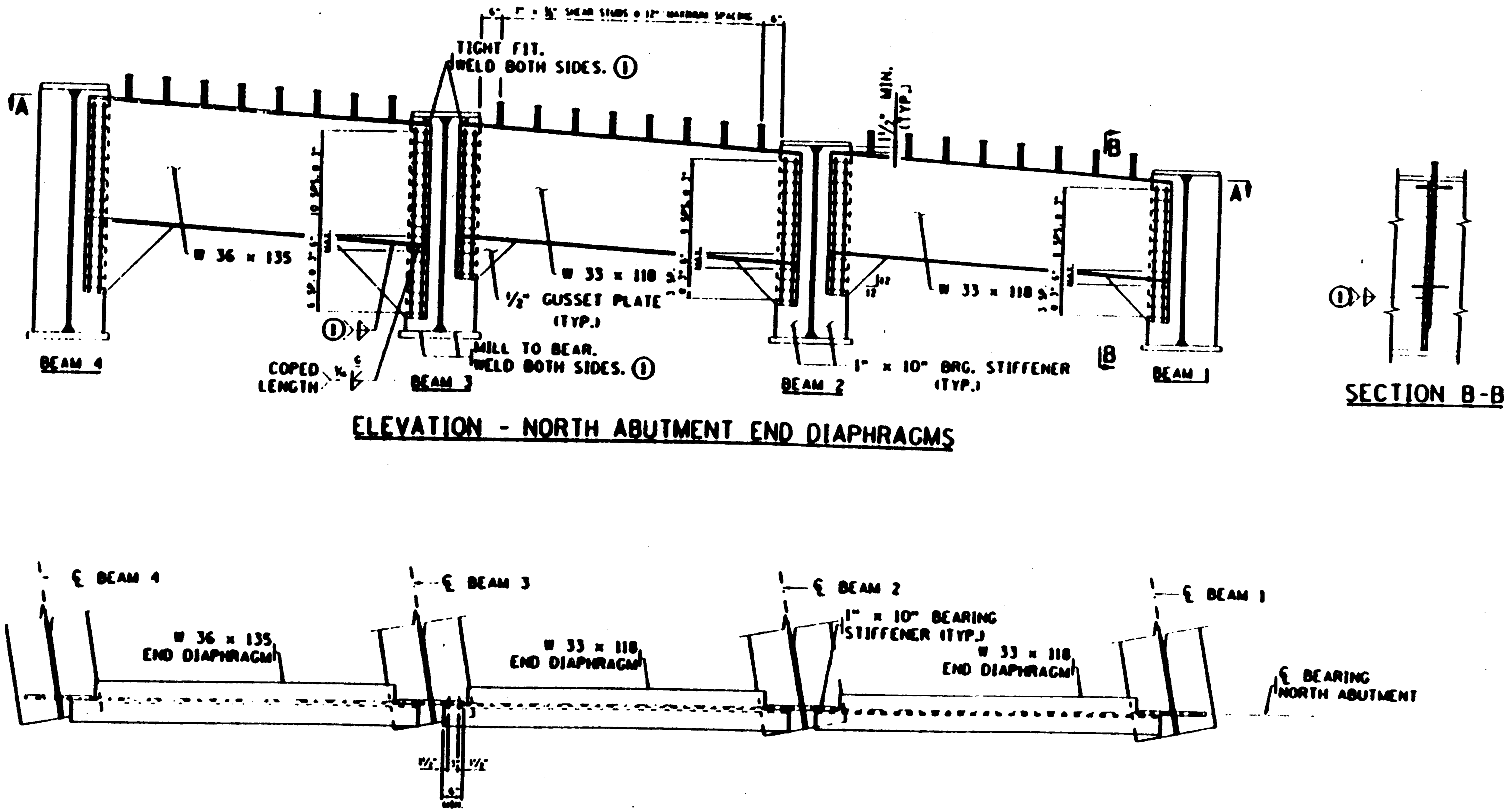


Figure A. 4: South Abutment End Diaphragms



① SEE SPEC. 2471.3J4b1 FOR MINIMUM SIZE OF FILLET WELD.

Figure A.5: North Abutment End Diaphragms

Notes:

Line A– located at midspan between crossframes 4 and 5, 24 gages in total.
Line B– located 3 feet (approx.) from PIER 1 in south span, 24 gages in total.
Line C– located on three crossframes at frame line 5, 12 gages in total.

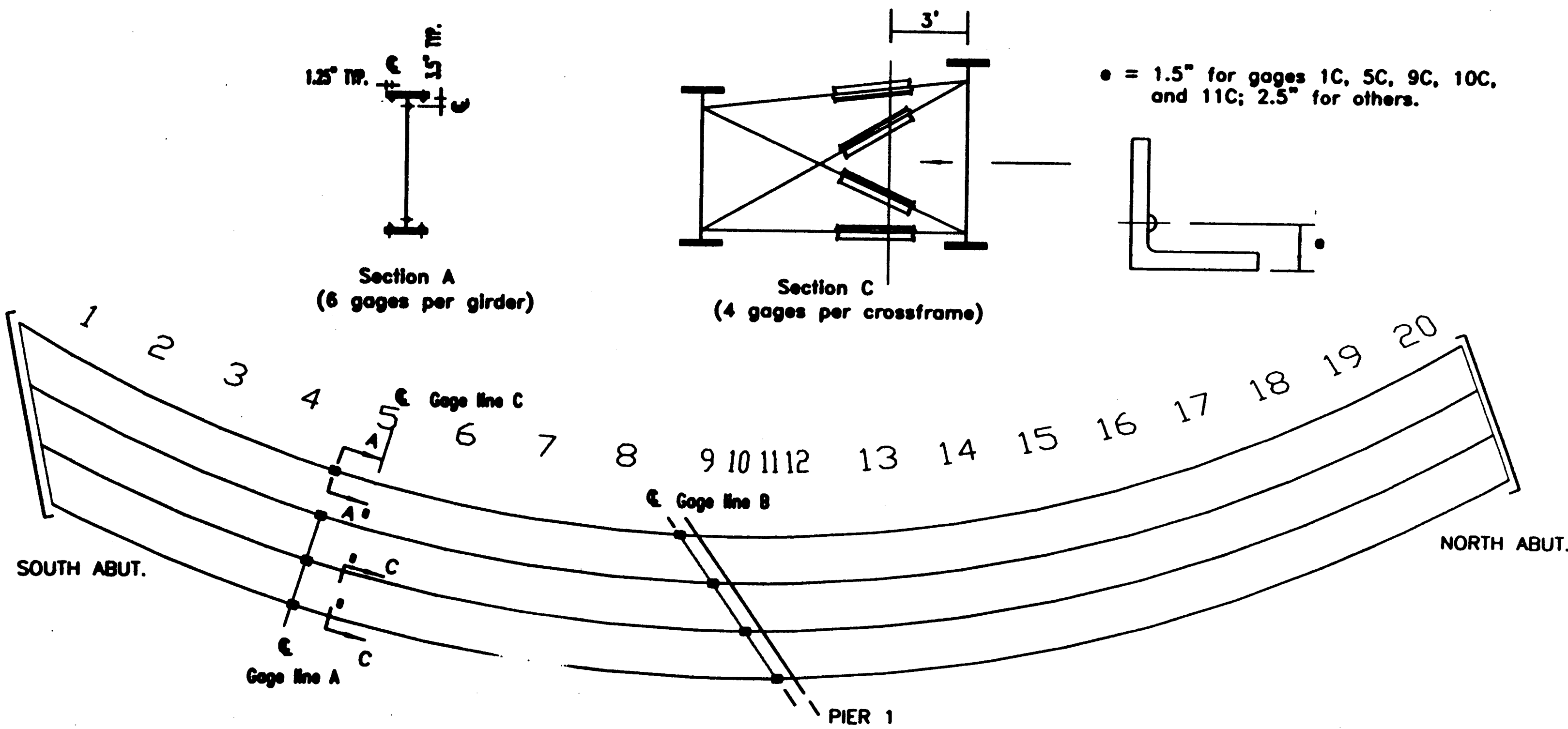


Figure A.6: Instrumentation of Strain Gages

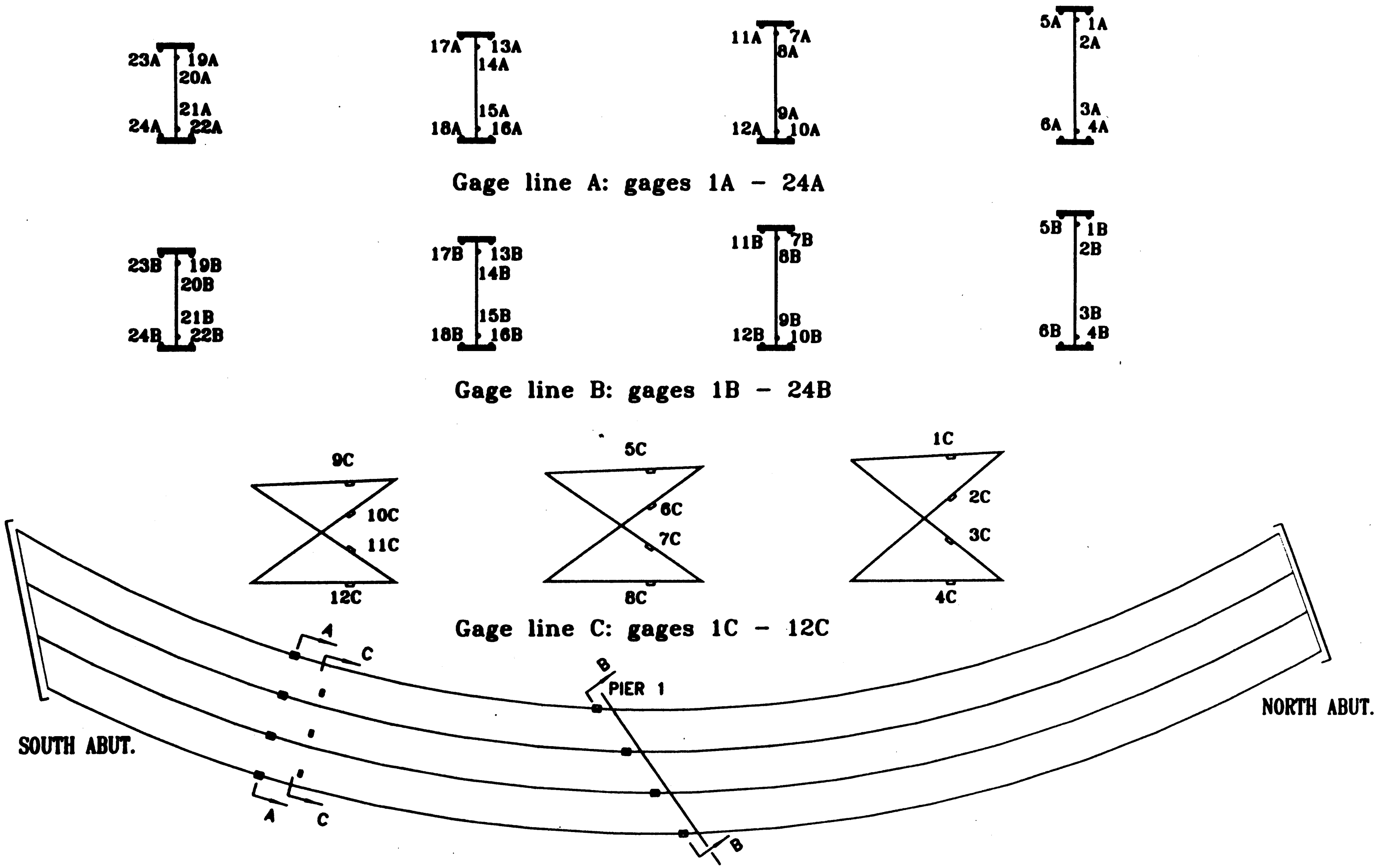
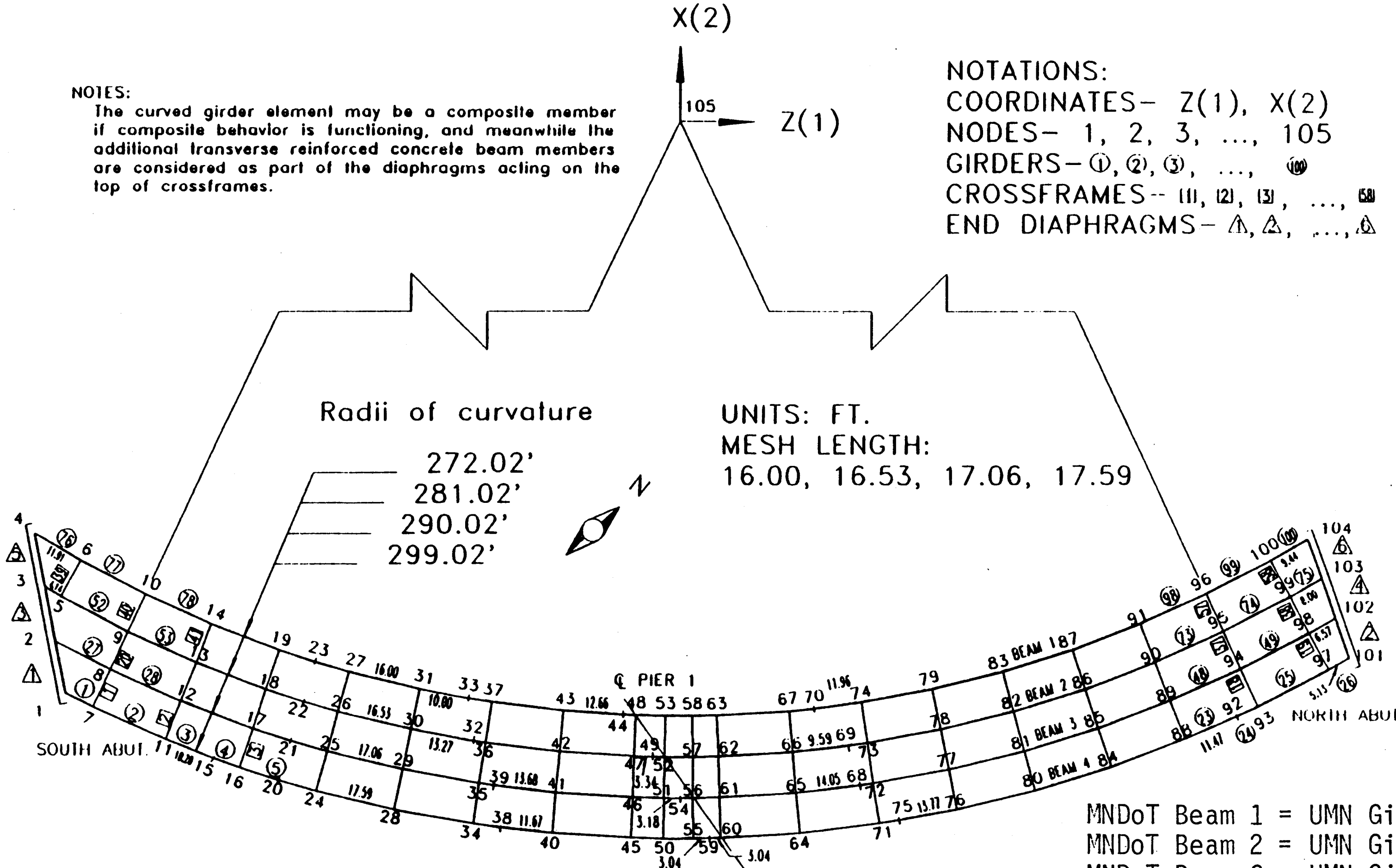


Figure A.7: Designation of Strain Gages



MNDoT Beam 1 = UMN Girder 4
MNDoT Beam 2 = UMN Girder 3
MNDoT Beam 3 = UMN Girder 2
MNDoT Beam 4 = UMN Girder 1

Fig. A.8: Modeling of the grid system

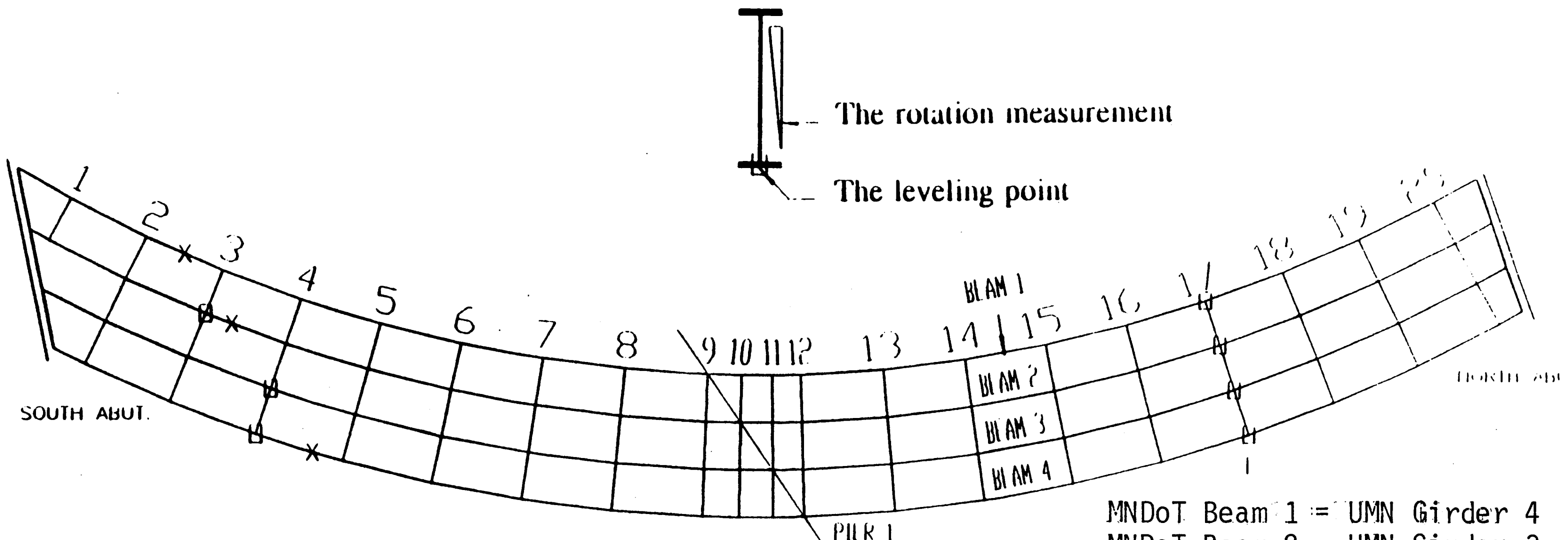
Notes:

1. The surveying points are underneath the centerline of the girder's web
2. Traffic condition on TH94 affects the surveying points of the south span

X- The proposed surveying points

O- The actual surveying points

T- The tiltmeter measuring point



MNDoT Beam 1 = UMN Girder 4
MNDoT Beam 2 = UMN Girder 3
MNDoT Beam 3 = UMN Girder 2
MNDoT Beam 4 = UMN Girder 1

Fig. A.9: Locations of deflection and rotation measuring

APPENDIX B

TRUCK WEIGHTS, DIMENSIONS, AND PLACEMENTS

Truck # 82508 – 1997

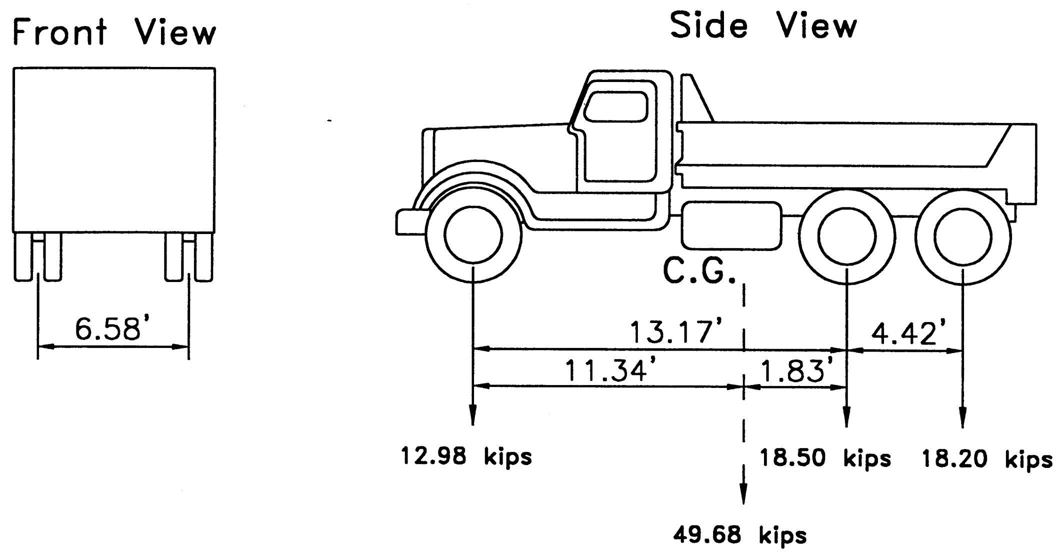


Figure B.1: MN/DOT truck 82508, unit weight = 49.68 kips

Truck # 85258 – 1997

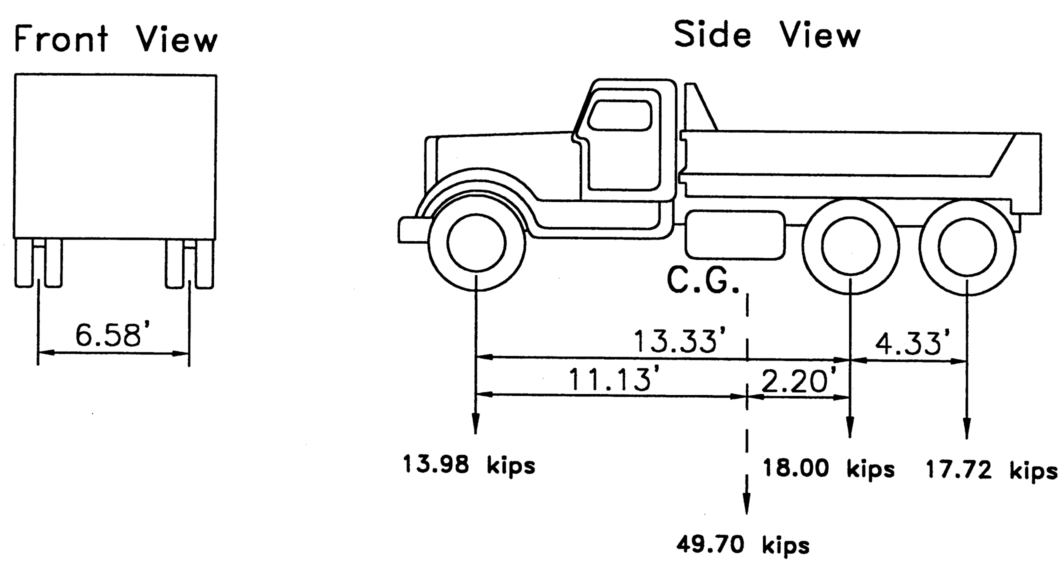


Figure B.2: MN/DOT truck 85258, unit weight = 49.70 kips

Truck # 85262 – 1997

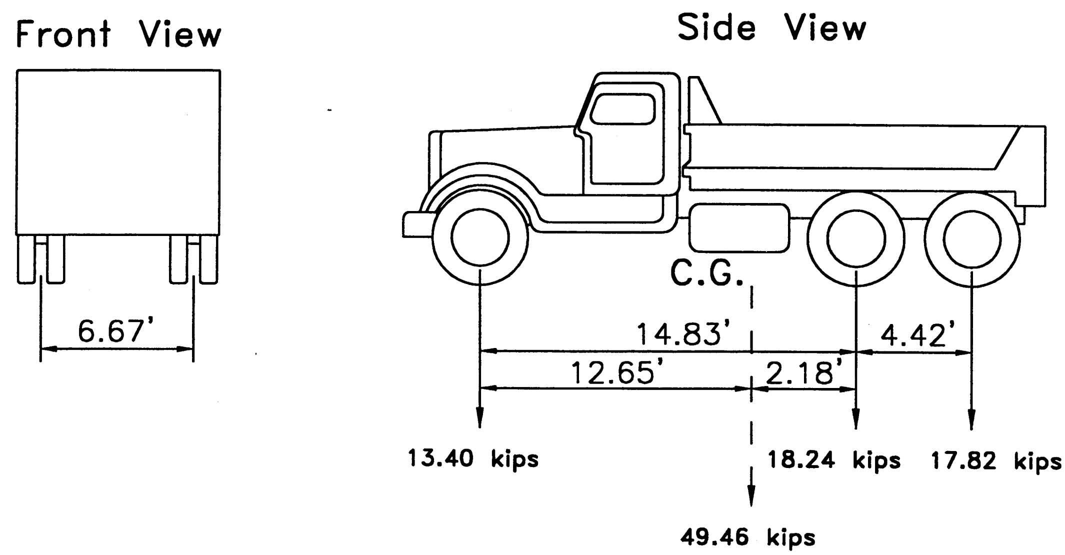


Figure B.3: MN/DOT truck 85262, unit weight = 49.46 kips

Truck # 91048 – 1997

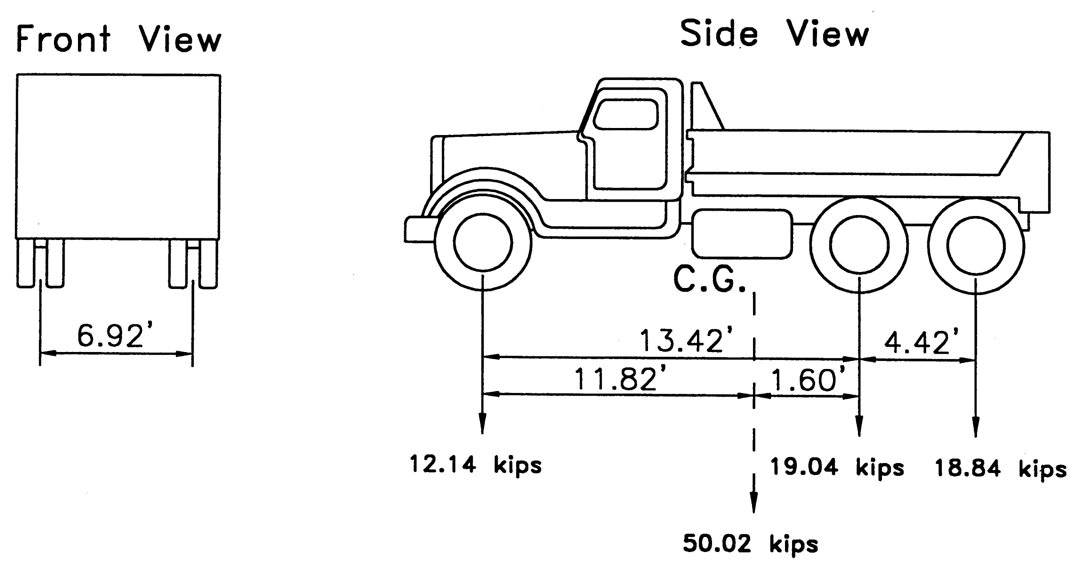


Figure B.4: MN/DOT truck 91048, unit weight = 50.02 kips

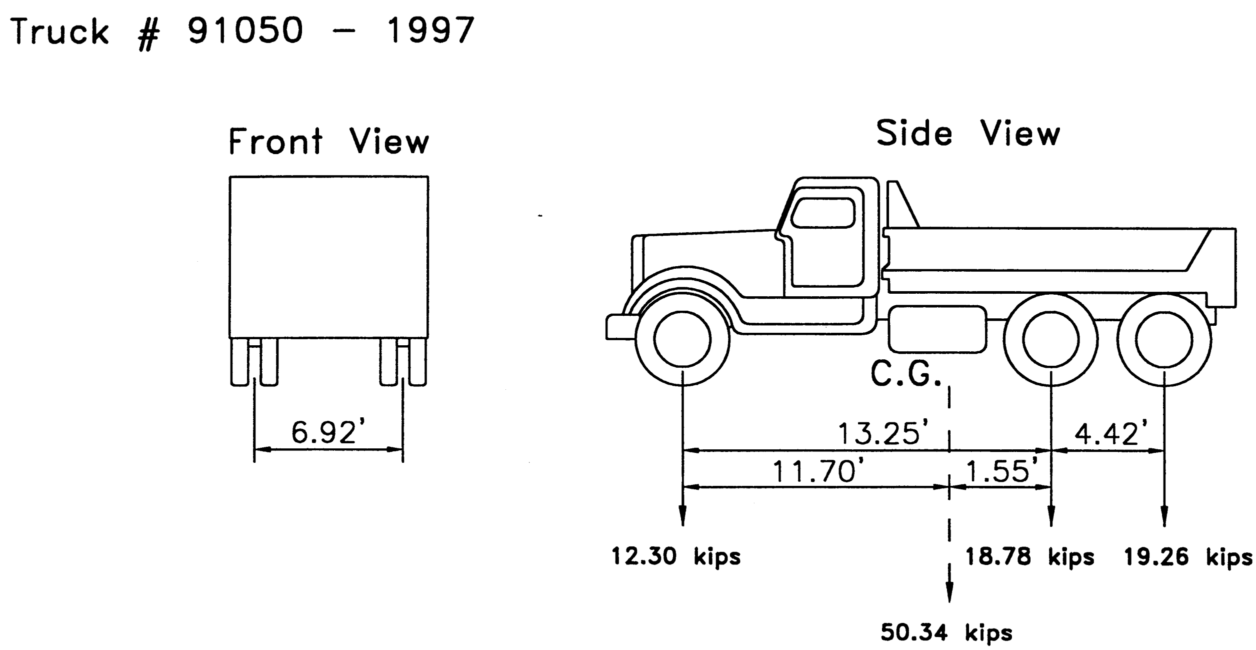


Figure B.5: MN/DOT truck 91050, unit weight = 50.34 kips

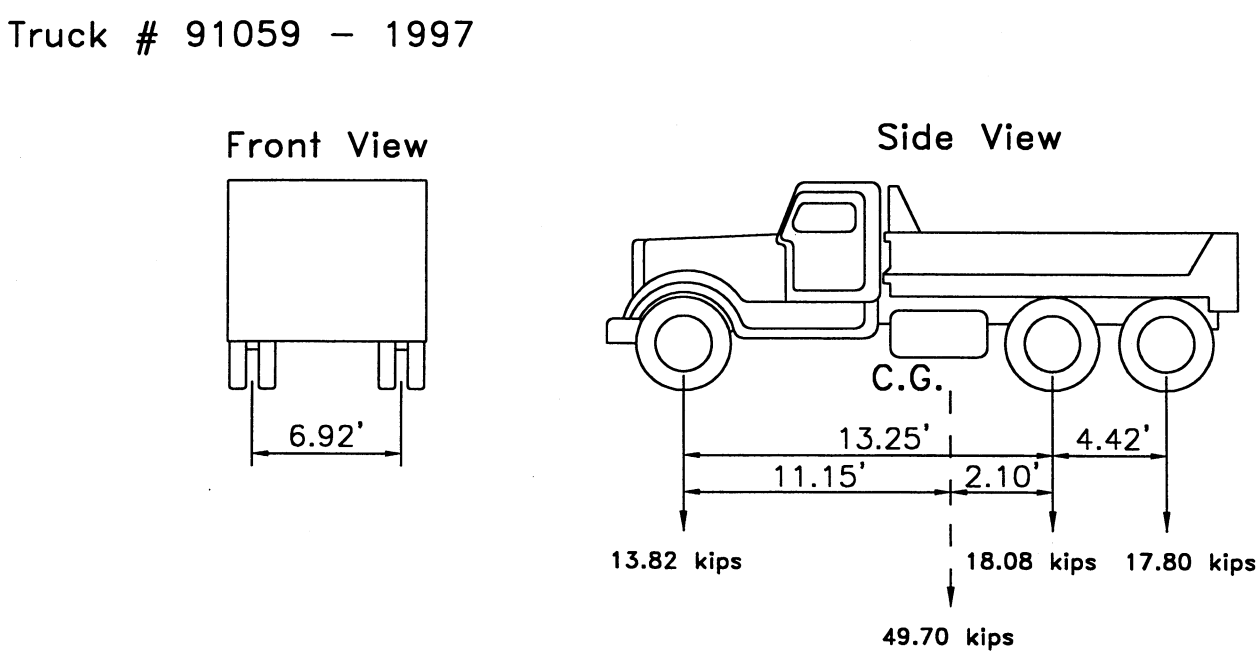


Figure B.6: MN/DOT truck 91059, unit weight = 49.70 kips

Truck # 92089 – 1997

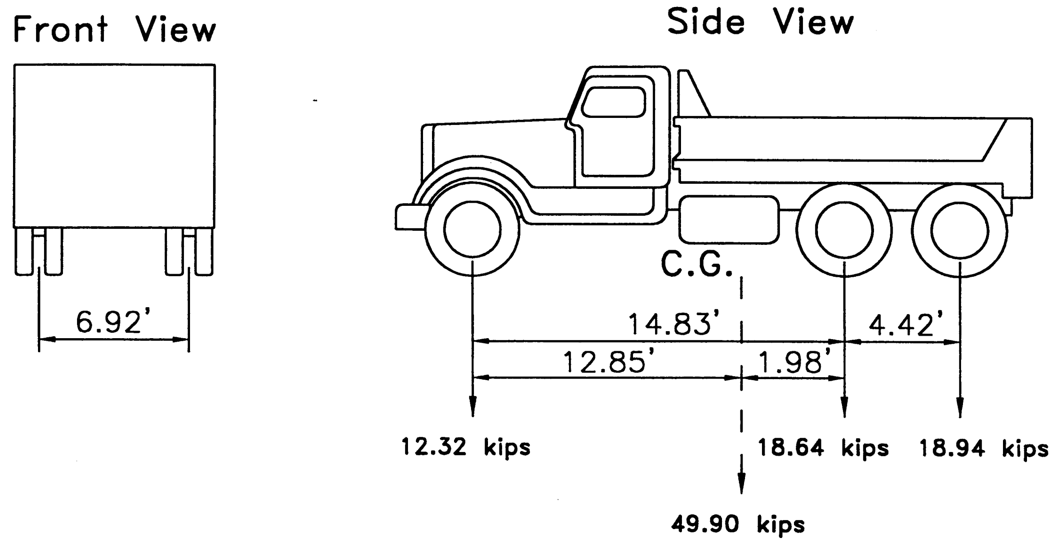


Figure B.7: MN/DOT truck 92089, unit weight = 49.90 kips

Truck # 92090 – 1997

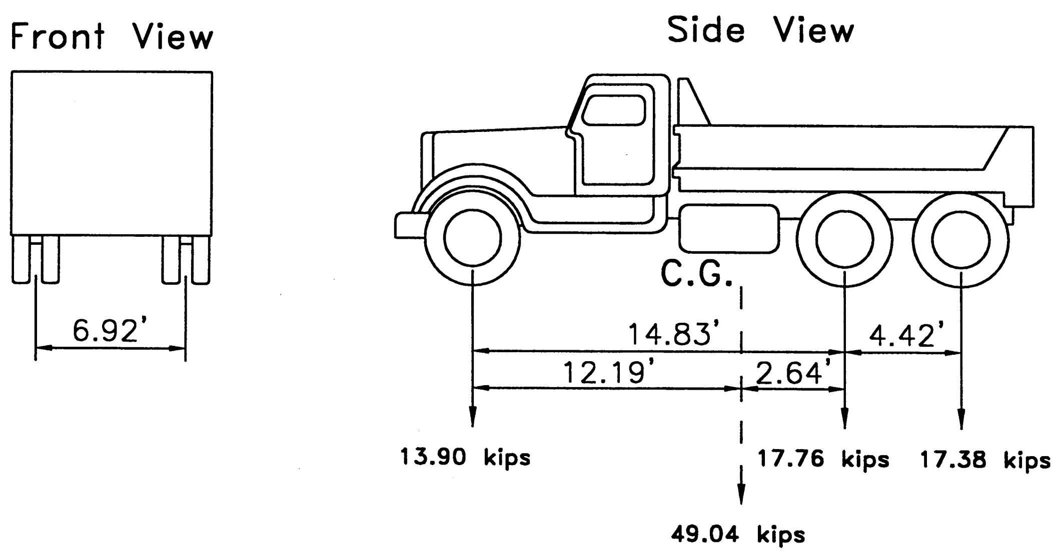


Figure B.8: MN/DOT truck 92090, unit weight = 49.04 kips

Truck # 93211 – 1997

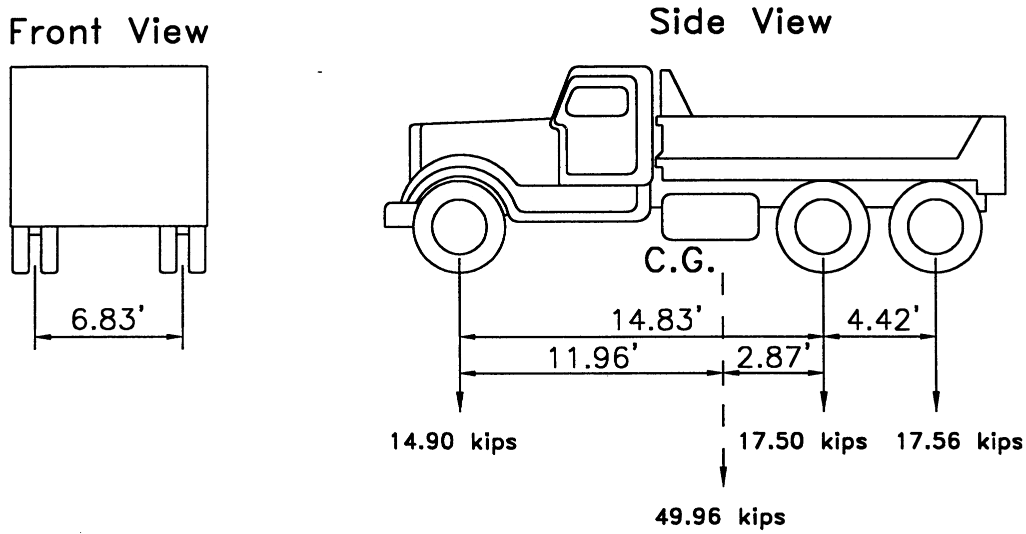
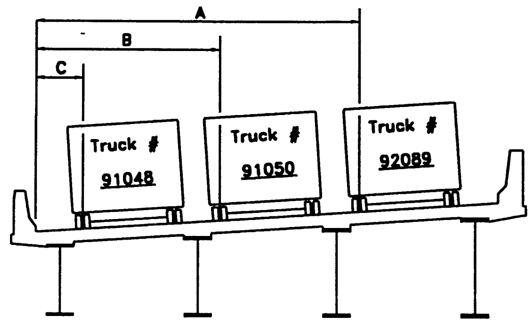


Figure B.9: MN/DOT truck 93211, unit weight = 49.96 kips

Case 1 Field Test – 1997

Truck Positions and Truck Numbers

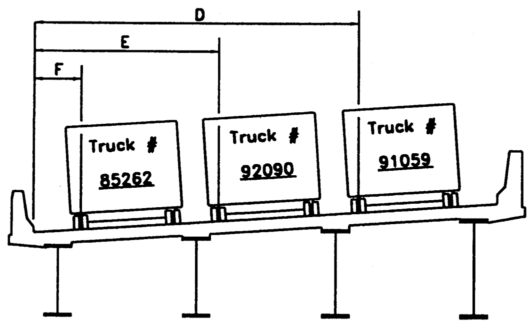


Trucks on Crossframe 7

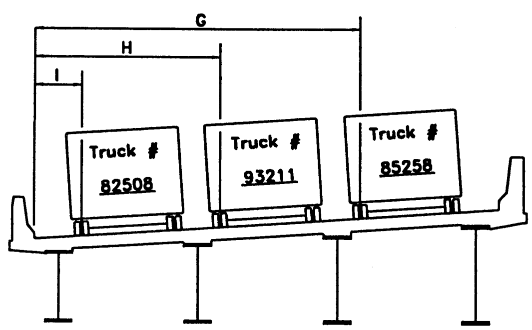
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

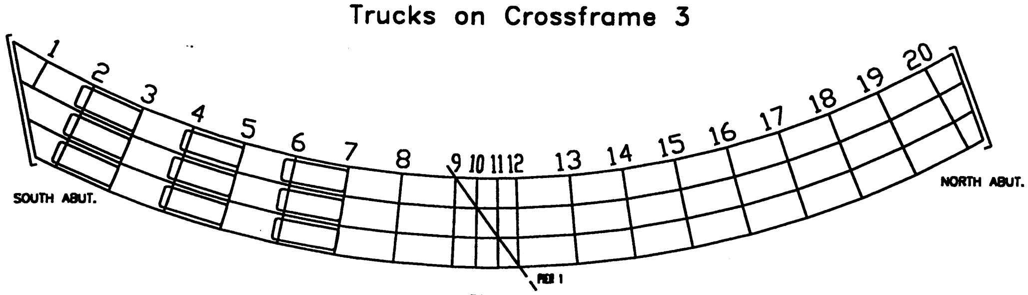
A	21.92'
B	12.17'
C	2.17'
D	21.58'
E	11.92'
F	2.25'
G	21.42'
H	11.17'
I	1.33'



Trucks on Crossframe 5



Trucks on Crossframe 3



Case 1 Field Test – 1997

Figure B.10: Truck Positions for Case 1

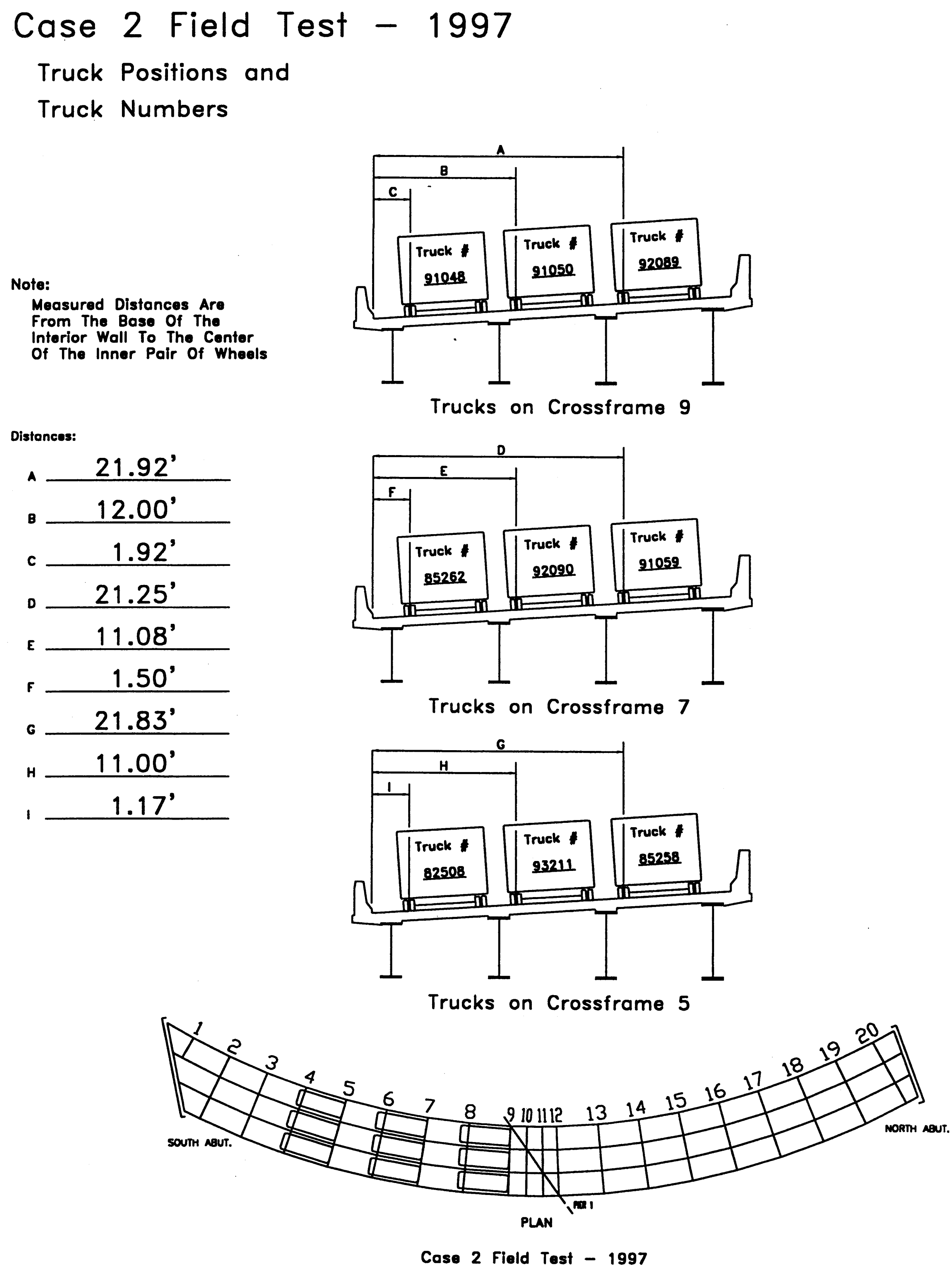


Figure B.11: Truck Positions for Case 2

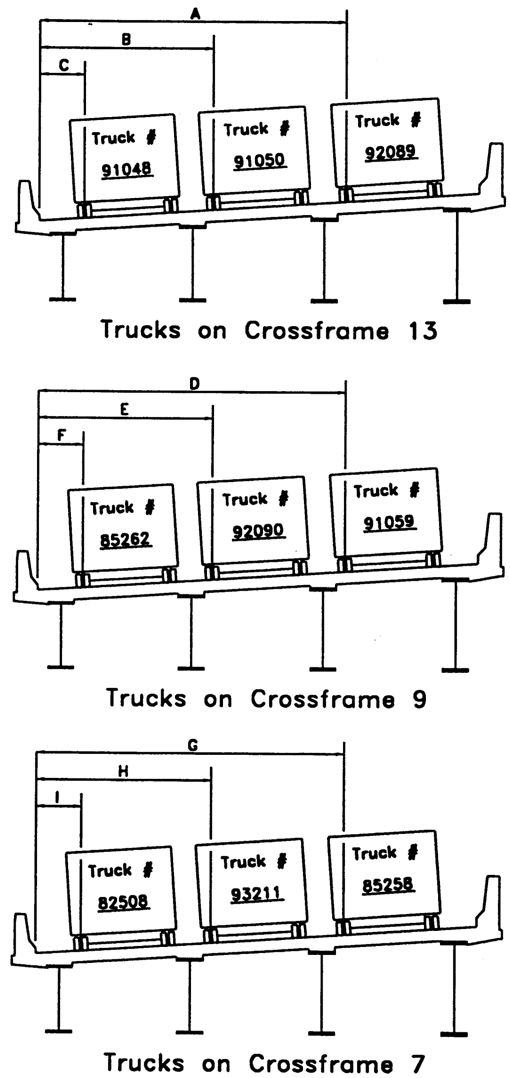
Case 3 Field Test – 1997

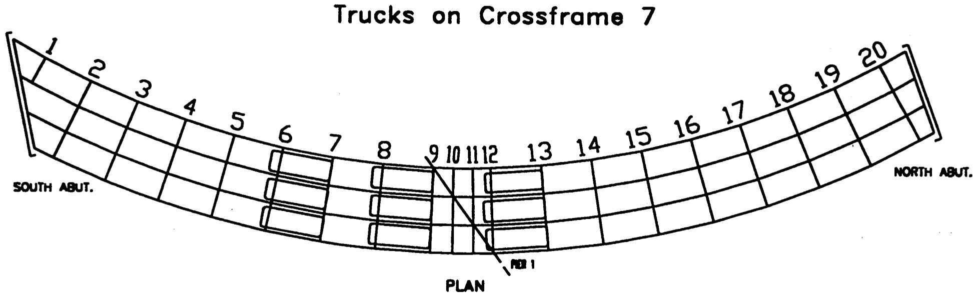
Truck Positions and Truck Numbers

Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

A	21.58'
B	10.92'
C	1.58'
D	21.58'
E	11.50'
F	1.58'
G	21.92'
H	11.00'
I	1.00'



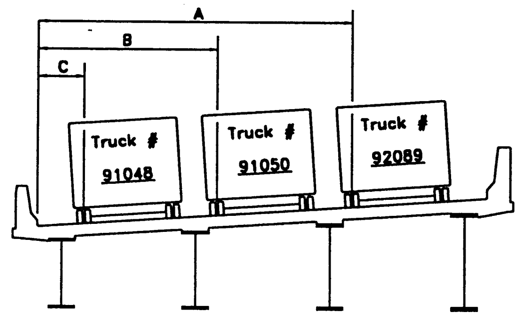


Case 3 Field Test – 1997

Figure B.12: Truck Positions for Case 3

Case 4 Field Test – 1997

Truck Positions and Truck Numbers

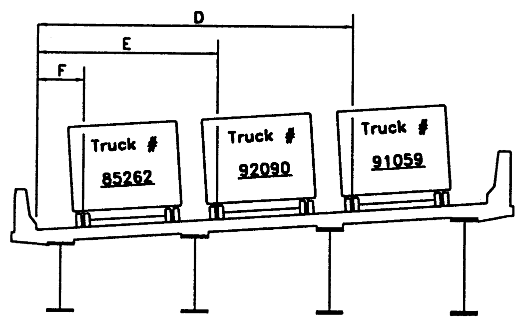


Trucks on Crossframe 15

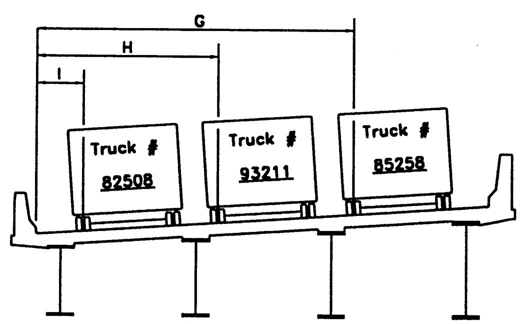
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

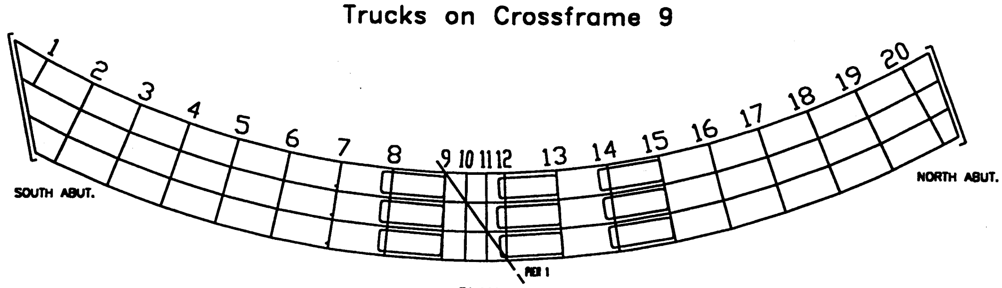
A 22.00'
B 12.17'
C 1.83'
D 22.00'
E 11.25'
F 1.42'
G 22.83'
H 11.42'
I 1.00'



Trucks on Crossframe 13



Trucks on Crossframe 9



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Case 4 Field Test – 1997

Figure B.13: Truck Positions for Case 4

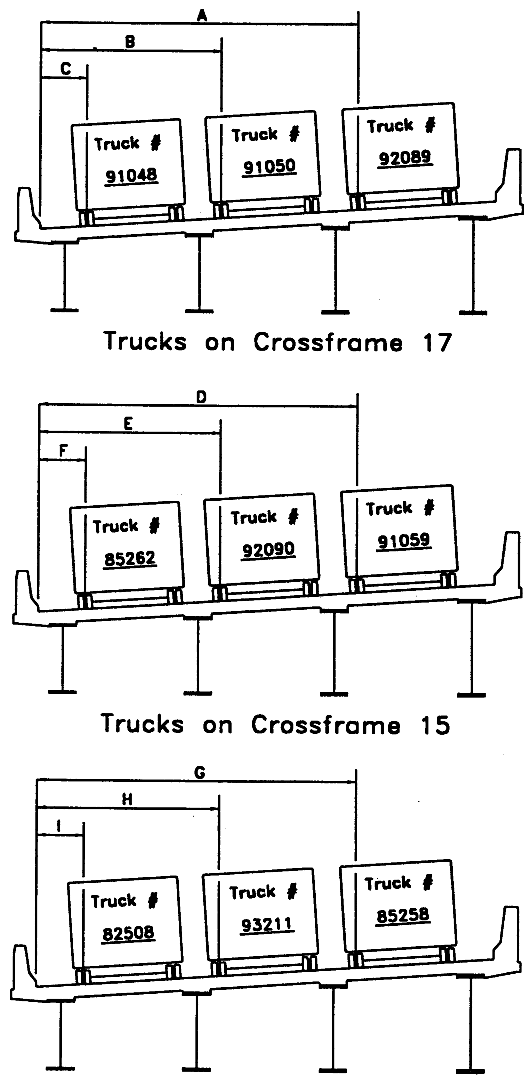
Case 5 Field Test – 1997

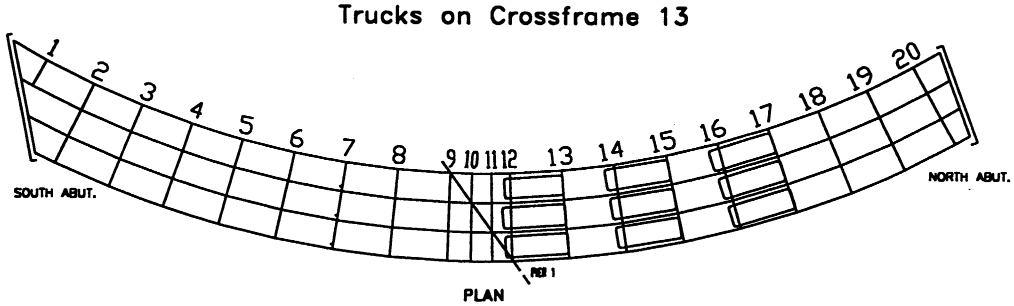
Truck Positions and Truck Numbers

Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

A	21.50'
B	12.00'
C	1.83'
D	21.92'
E	11.75'
F	1.67'
G	22.17'
H	11.58'
I	1.42'





Case 5 Field Test – 1997

Figure B.14: Truck Positions for Case 5

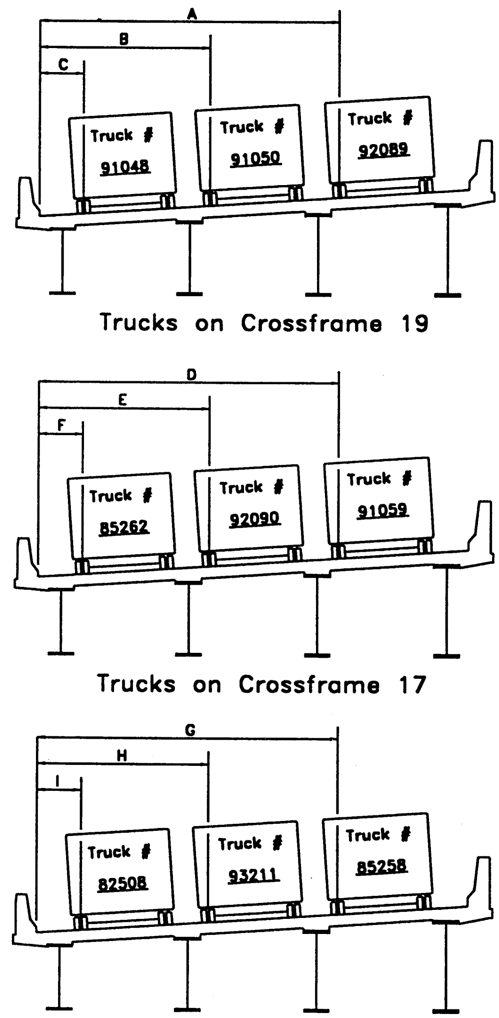
Case 6 Field Test – 1997

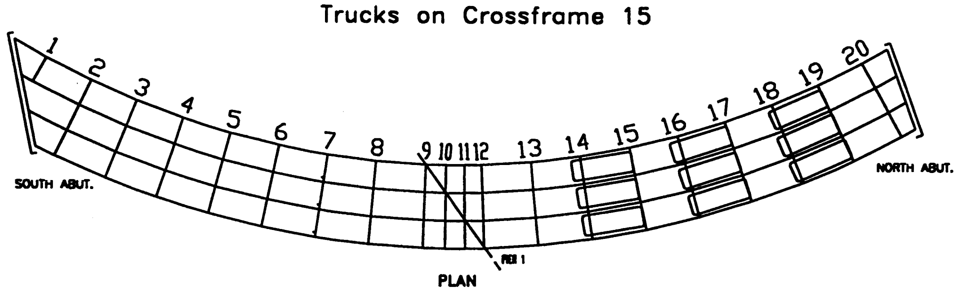
Truck Positions and Truck Numbers

Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

A	22.00'
B	12.33'
C	1.67'
D	22.00'
E	11.83'
F	1.67'
G	21.75'
H	11.17'
I	1.08'





Case 6 Field Test – 1997

Figure B.15: Truck Positions for Case 6

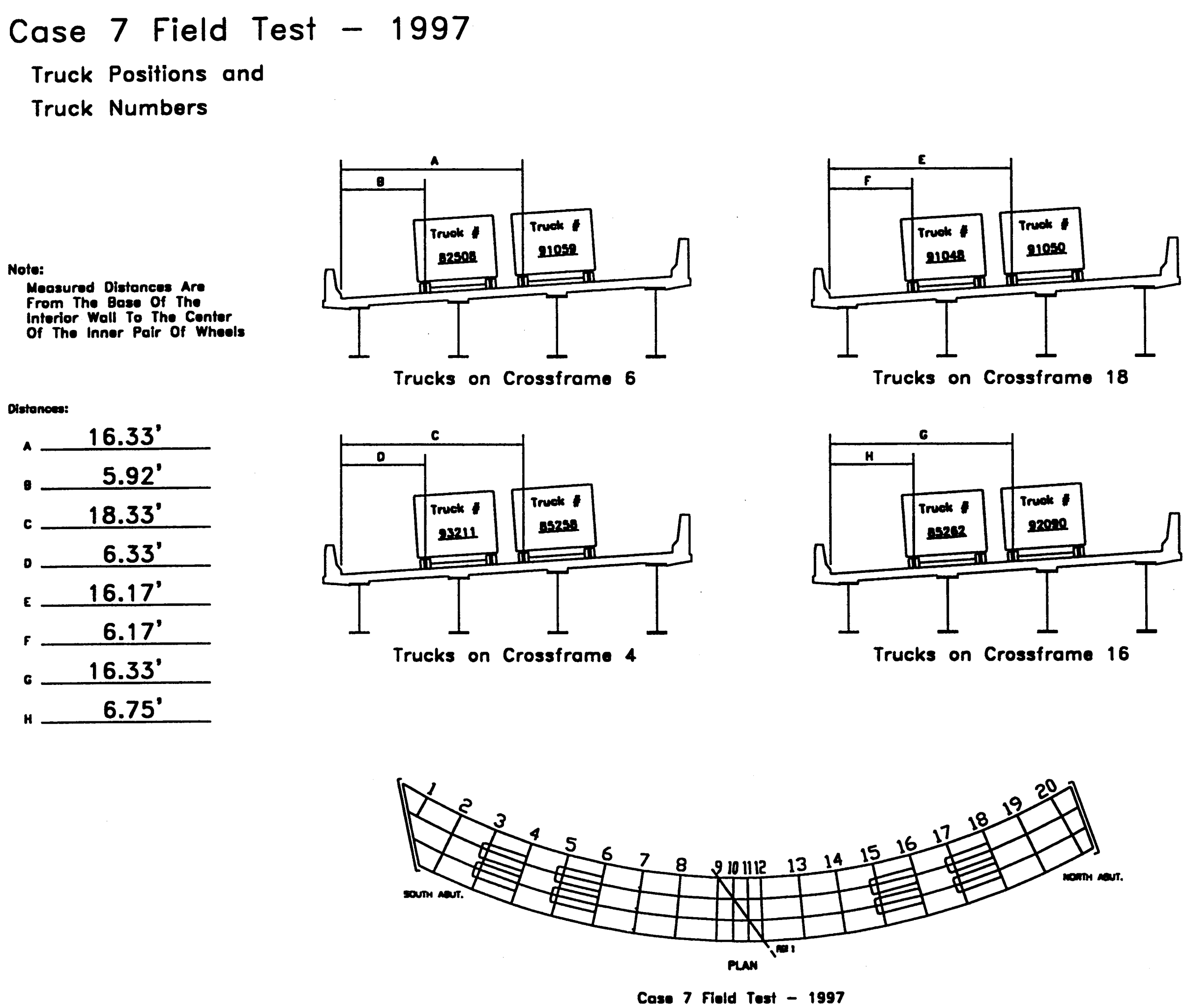


Figure B.16: Truck Positions for Case 7

Case 8 Field Test – 1997

Truck Positions and Truck Numbers

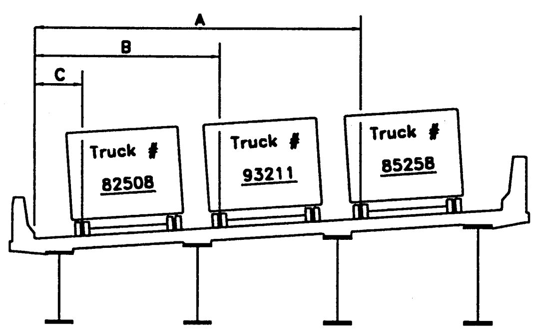
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

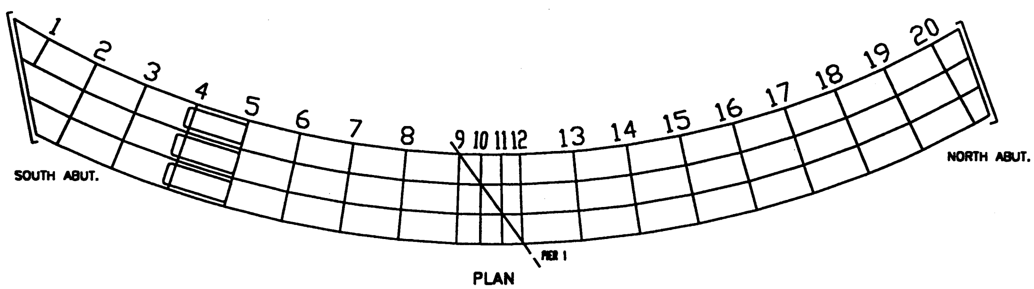
A 22.25'

B 12.00'

C 1.75'



Trucks on Crossframe 5



Case 8 Field Test – 1997

Figure B.17: Truck Positions for Case 8

Case 9 Field Test – 1997

Truck Positions and Truck Numbers

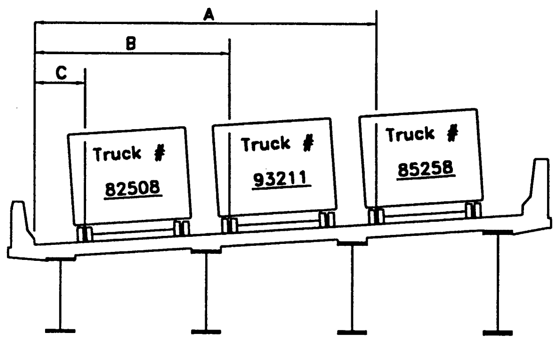
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

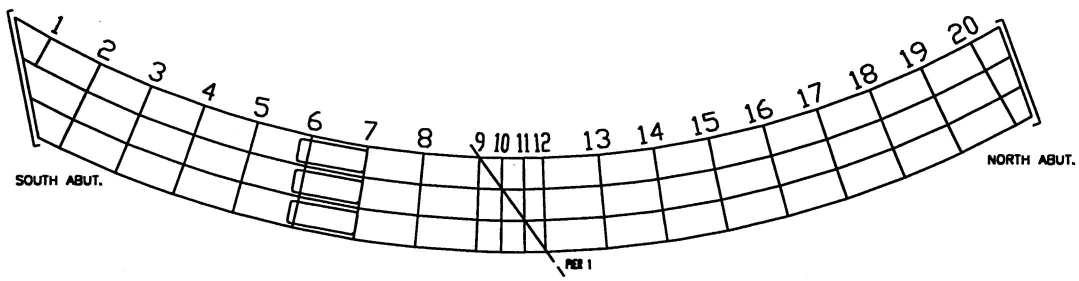
A 22.58'

B 11.92'

C 1.17'



Trucks on Crossframe 7



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Case 9 Field Test – 1997

Figure B.18: Truck Positions for Case 9

Case 10 Field Test – 1997

Truck Positions and
Truck Numbers

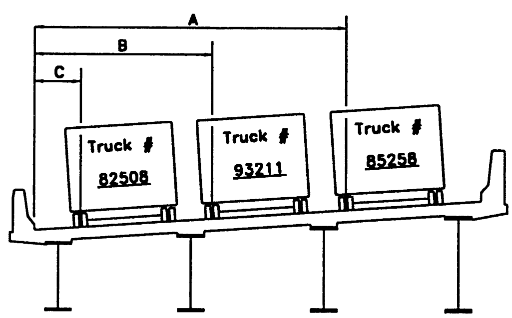
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

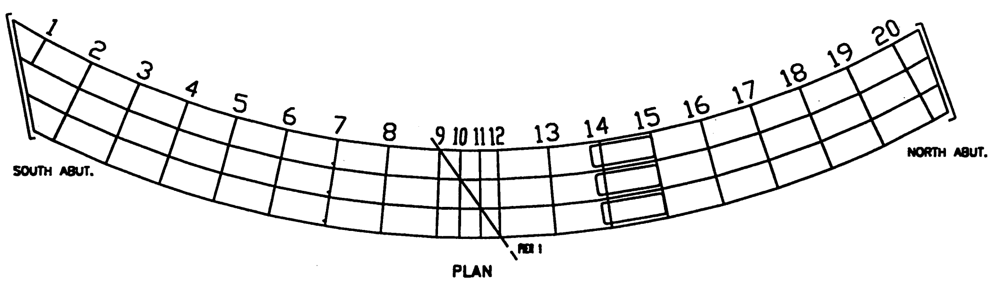
A 22.00'

B 12.00'

C 1.75'



Trucks on Crossframe 15



Case 10 Field Test – 1997

Figure B.19: Truck Positions for Case 10

Case 11 Field Test – 1997

Truck Positions and Truck Numbers

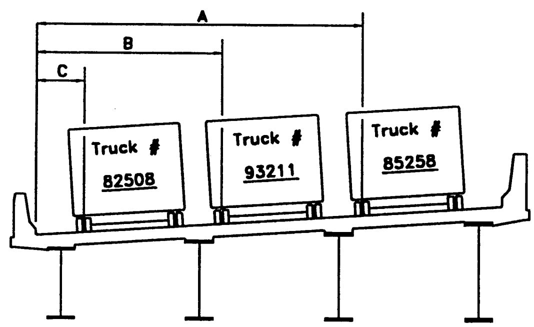
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

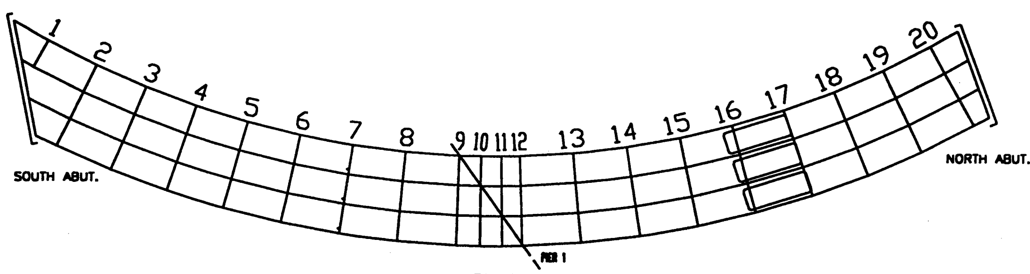
A 22.17'

B 11.42'

C 1.58'



Trucks on Crossframe 17



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Case 11 Field Test – 1997

Figure B.20: Truck Positions for Case 11

Truck # 97803 – 2000

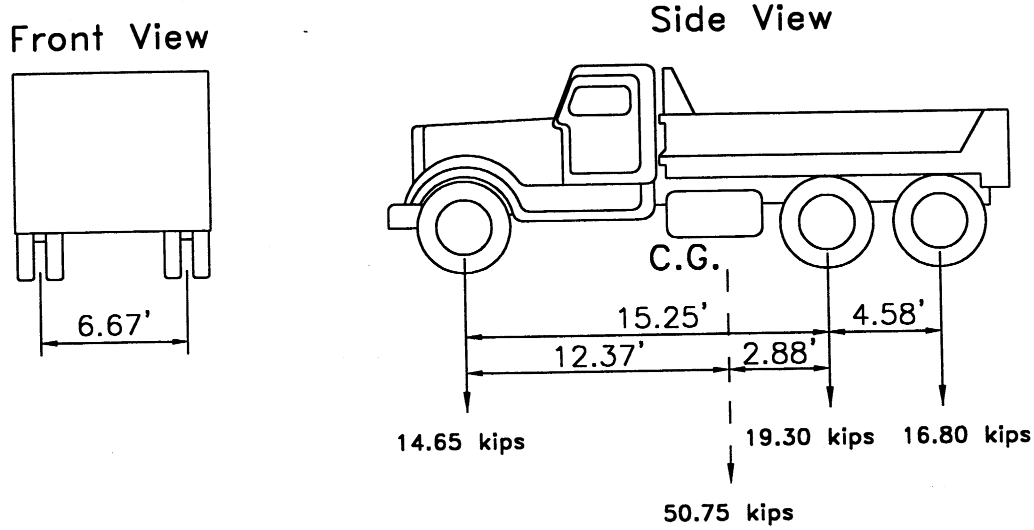


Figure B.21: MN/DOT truck 97803, unit weight = 50.75 kips

Truck # 97462 – 2000

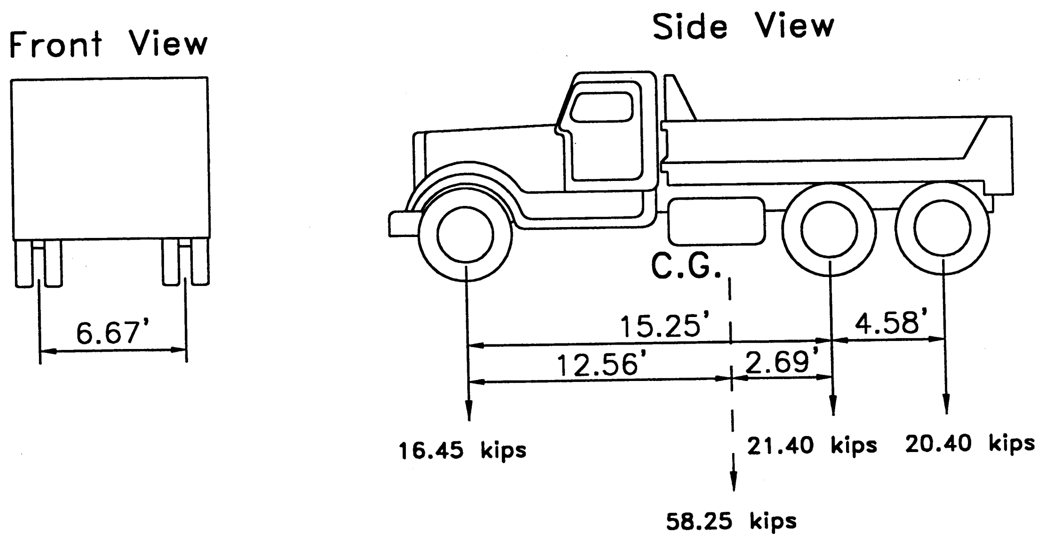


Figure B.22: MN/DOT truck 97462 unit weight = 58.25 kips

Truck # 97438 – 2000

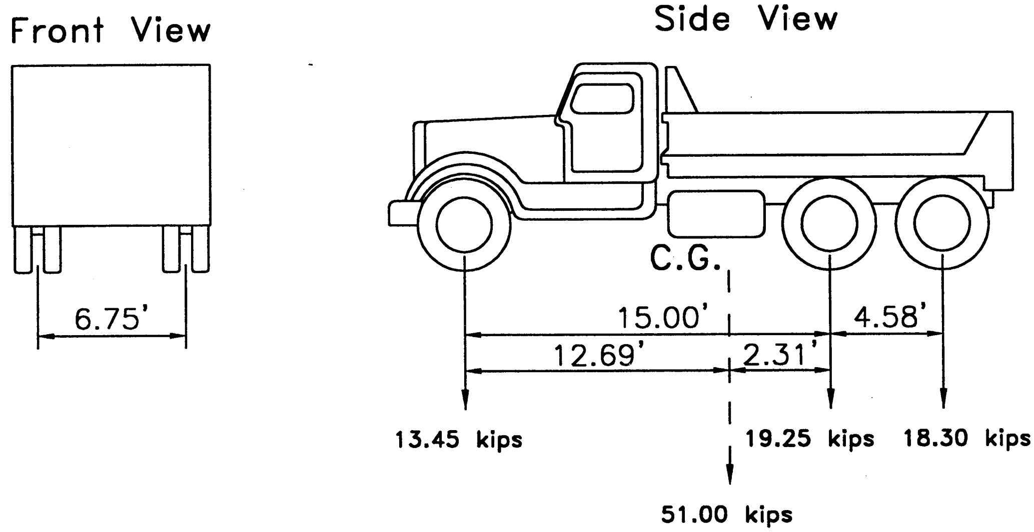


Figure B.23: MN/DOT truck 97438, unit weight = 51.00 kips

Truck # 97433 – 2000

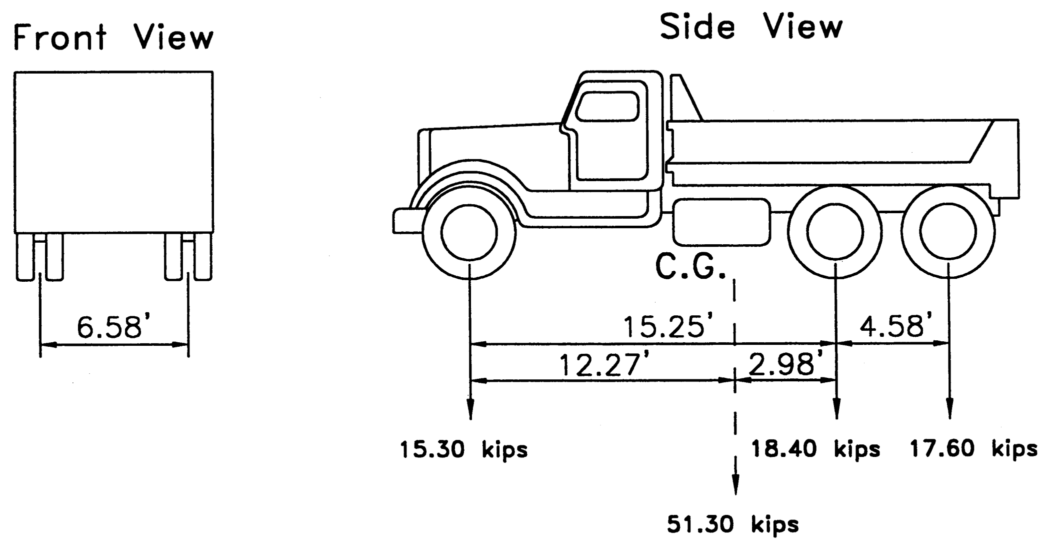


Figure B.24: MN/DOT truck 97433, unit weight = 51.30 kips

Truck # 97436 – 2000

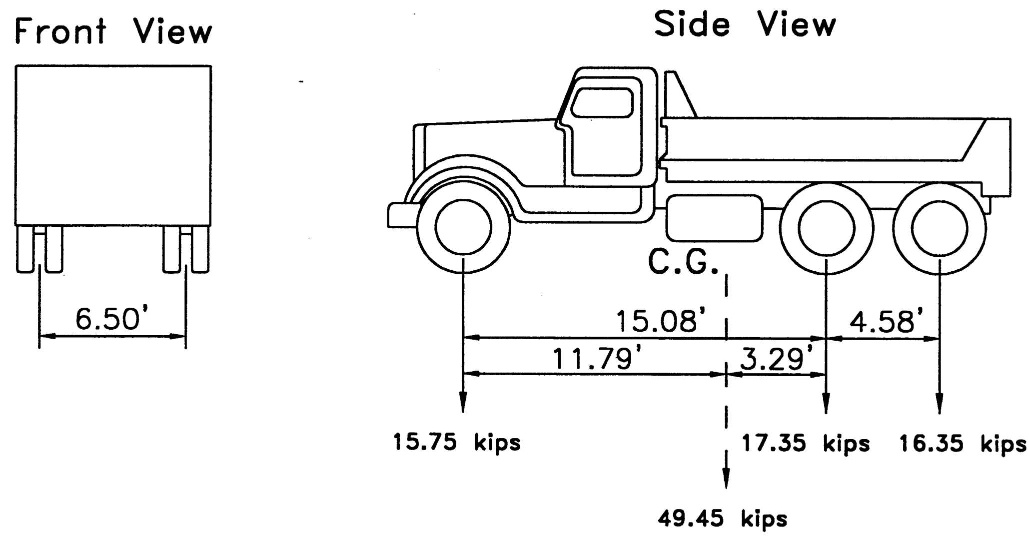


Figure B.25: MN/DOT truck 97436, unit weight = 49.45 kips

Truck # 97802 – 2000

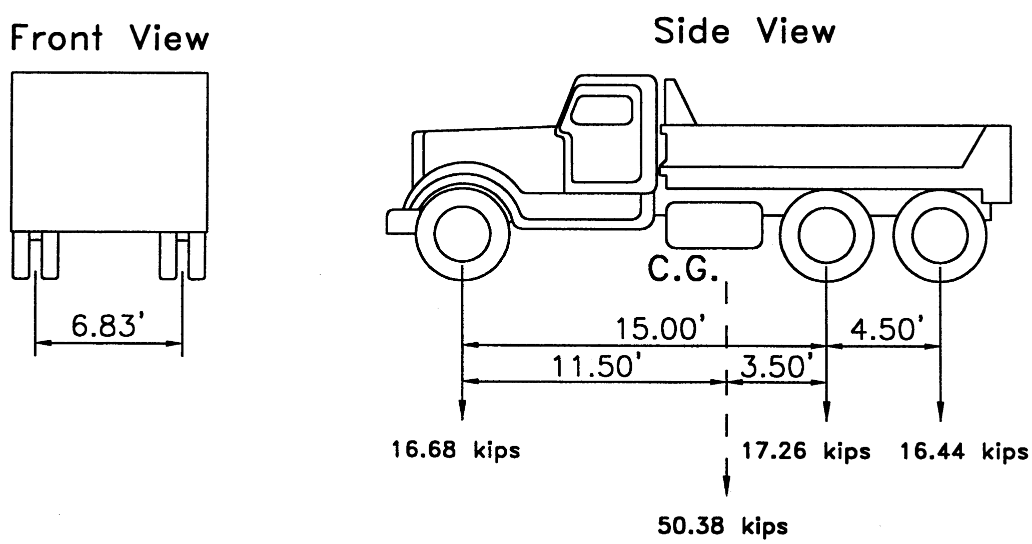


Figure B.26: MN/DOT truck 97802, unit weight = 50.38 kips

Truck # 98409 – 2000

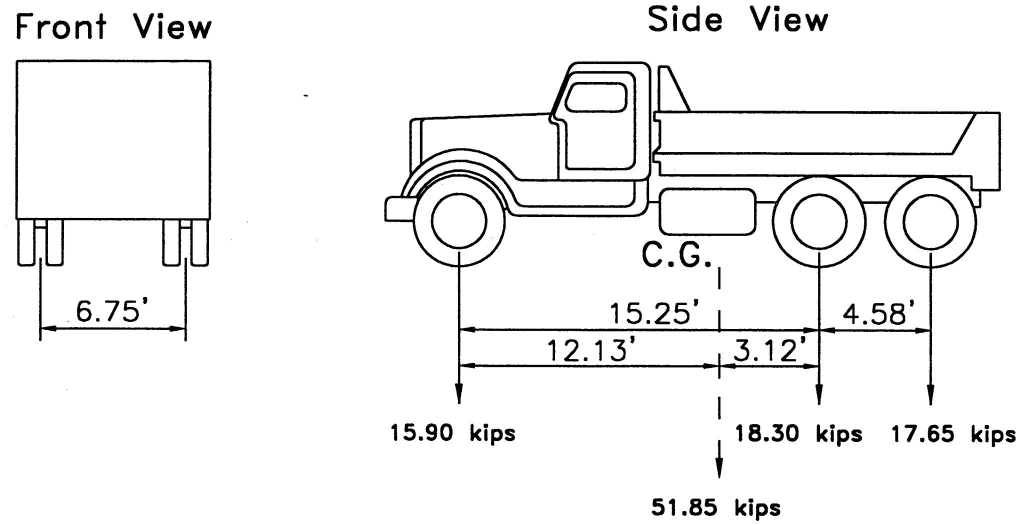


Figure B.27: MN/DOT truck 98409, unit weight = 51.85 kips

Truck # 99047 – 2000

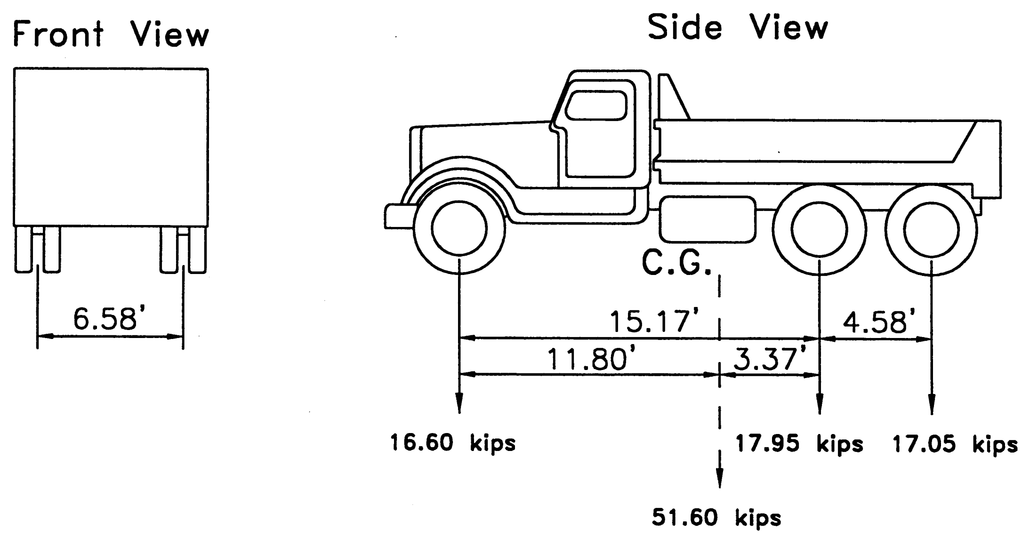


Figure B.28: MN/DOT truck 99047, unit weight = 51.60 kips

Truck # 97801 – 2000

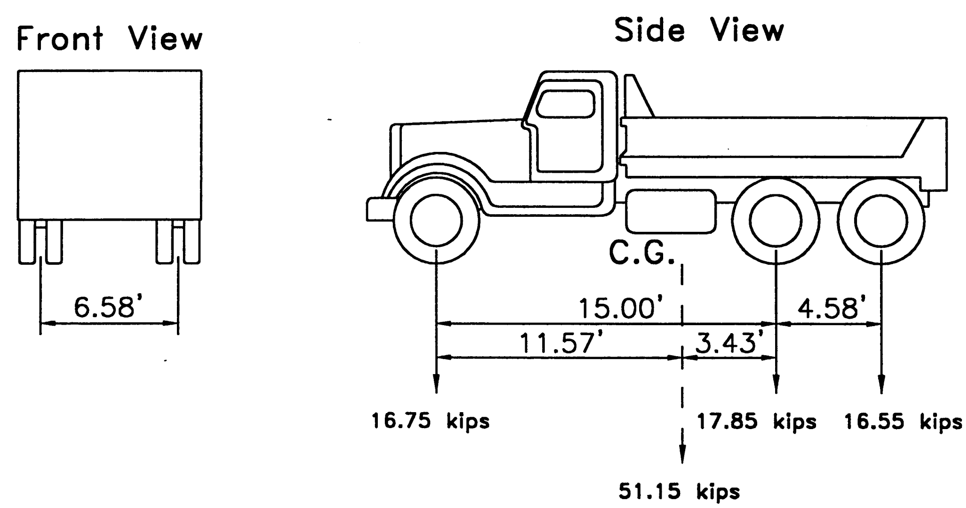


Figure B.29: MN/DOT truck 97801, unit weight = 51.15 kips

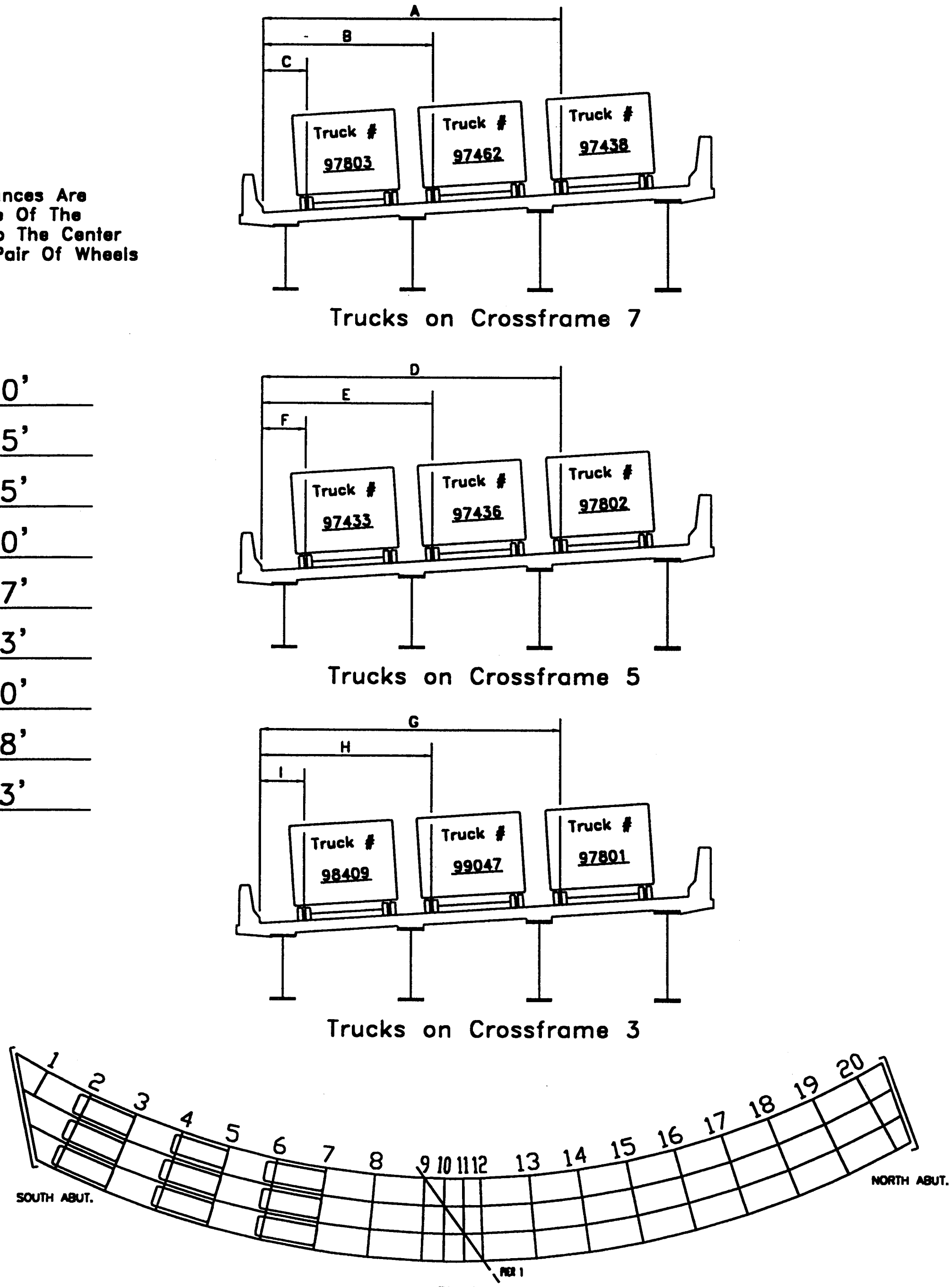
Case 1 Field Test – 2000

Truck Positions and Truck Numbers

Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

A	22.00'
B	12.75'
C	2.25'
D	21.00'
E	11.17'
F	1.33'
G	21.50'
H	11.58'
I	1.83'



Case 1 Field Test – 2000

Figure B.30: Truck Positions for Case 1

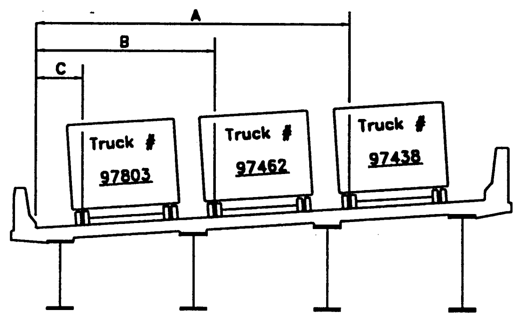
Case 2 Field Test – 2000

Truck Positions and Truck Numbers

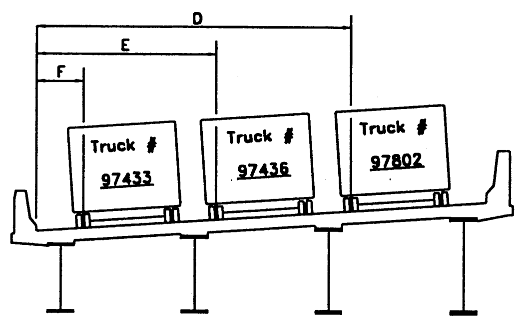
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

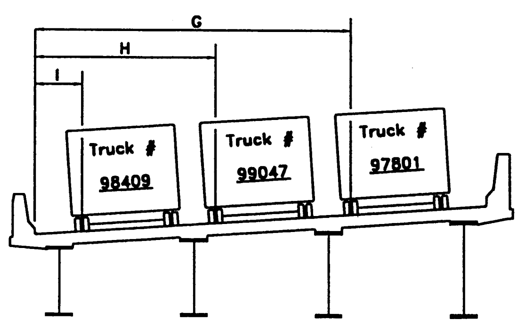
A	21.50'
B	11.42'
C	1.58'
D	20.75'
E	10.83'
F	1.33'
G	21.33'
H	11.08'
I	1.67'



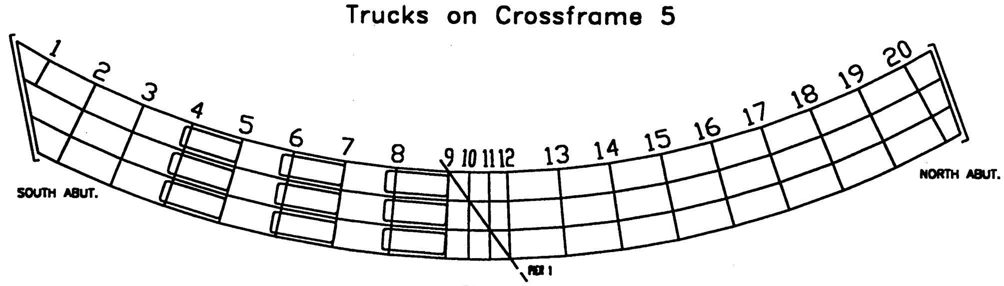
Trucks on Crossframe 9



Trucks on Crossframe 7



Trucks on Crossframe 5



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Case 2 Field Test – 2000

Figure B.31: Truck Positions for Case 2

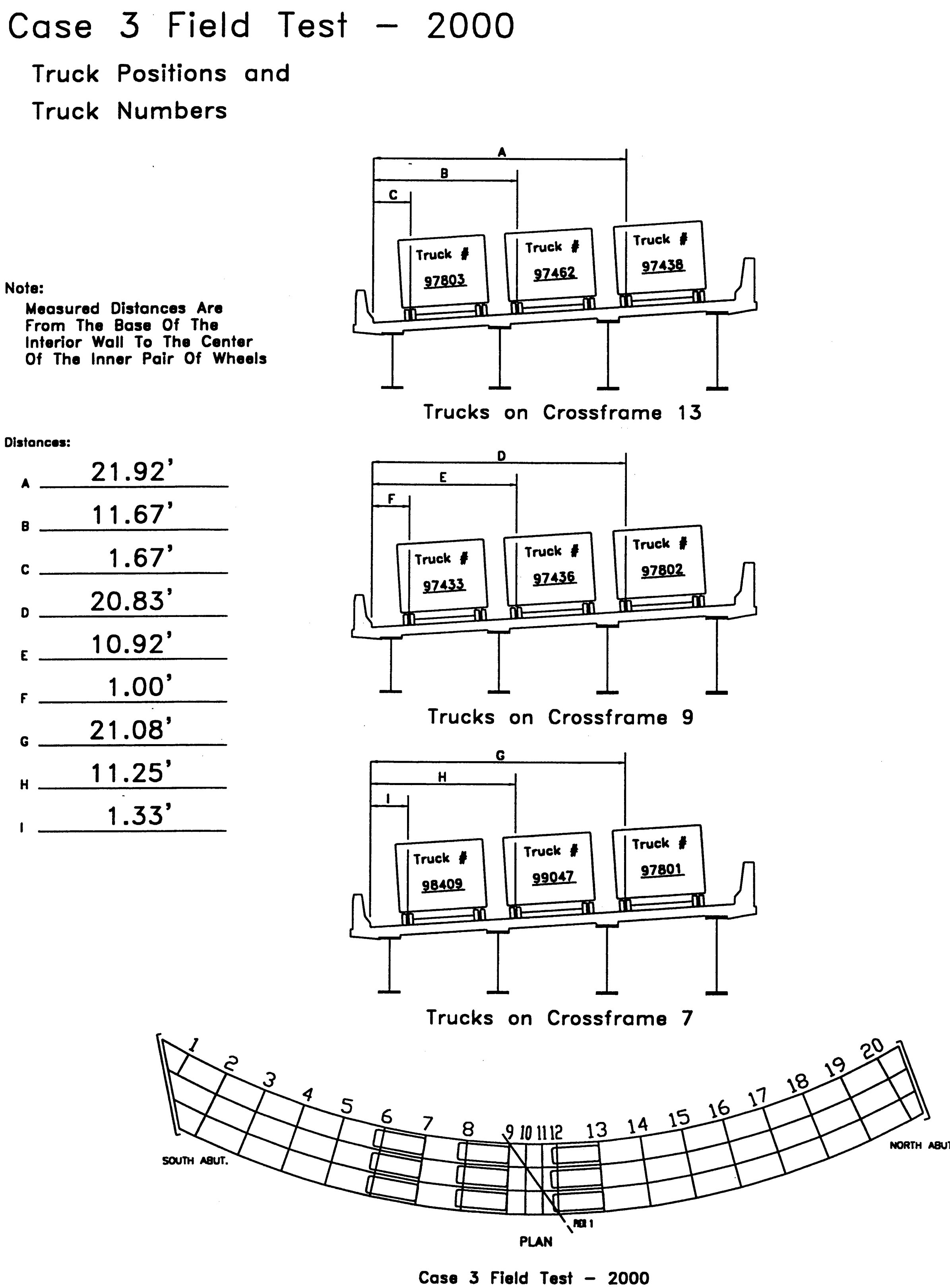


Figure B.32: Truck Positions for Case 3

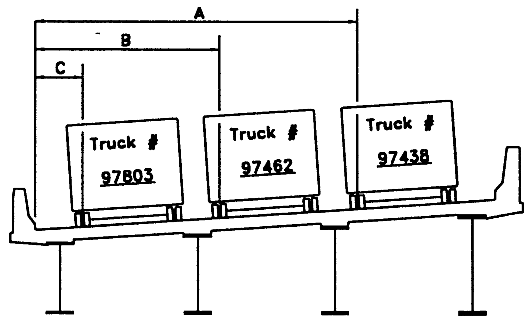
Case 4 Field Test – 2000

Truck Positions and Truck Numbers

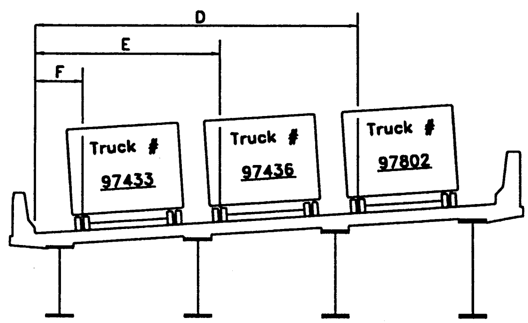
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

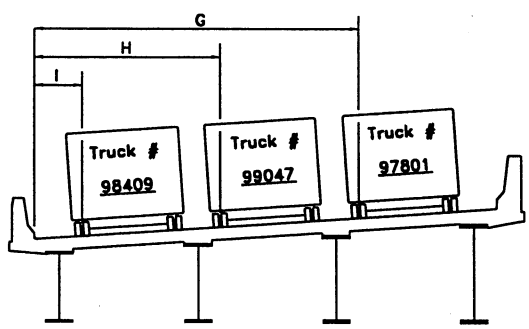
A	22.00'
B	11.58'
C	1.50'
D	21.08'
E	10.92'
F	1.25'
G	21.58'
H	11.33'
I	1.42'



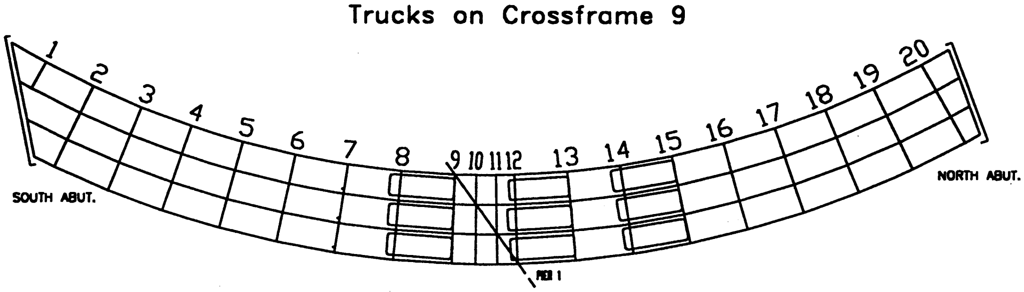
Trucks on Crossframe 15



Trucks on Crossframe 13



Trucks on Crossframe 9



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Case 4 Field Test – 2000

Figure B.33: Truck Positions for Case 4

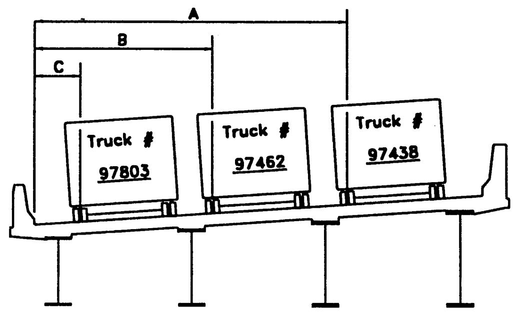
Case 5 Field Test – 2000

Truck Positions and Truck Numbers

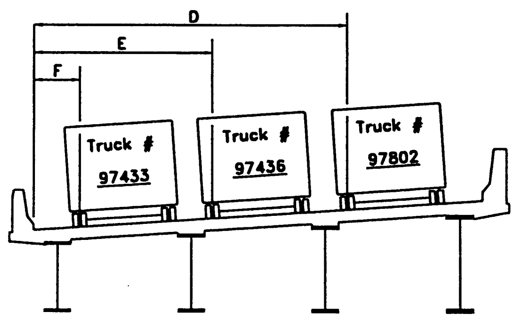
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

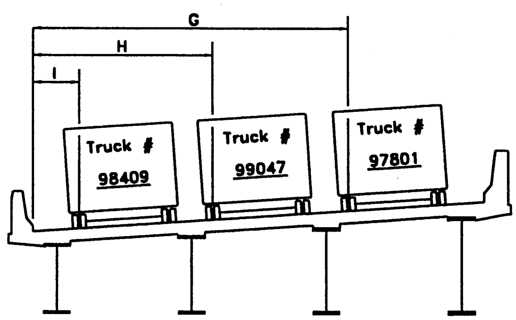
A	21.92'
B	11.33'
C	1.33'
D	20.75'
E	10.92'
F	1.08'
G	21.58'
H	11.42'
I	1.25'



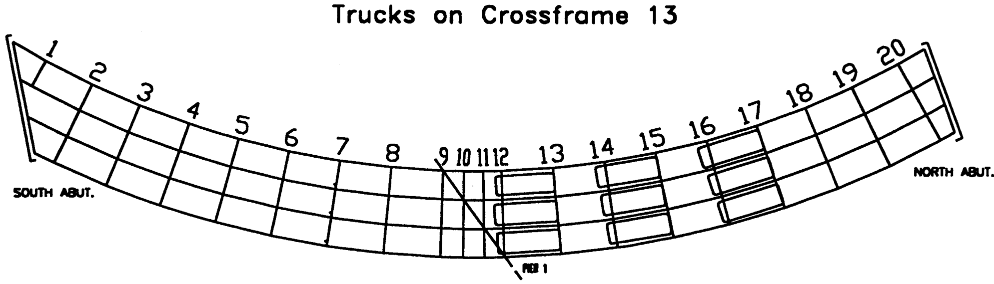
Trucks on Crossframe 17



Trucks on Crossframe 15



Trucks on Crossframe 13



Case 5 Field Test – 2000

Figure B.34: Truck Positions for Case 5

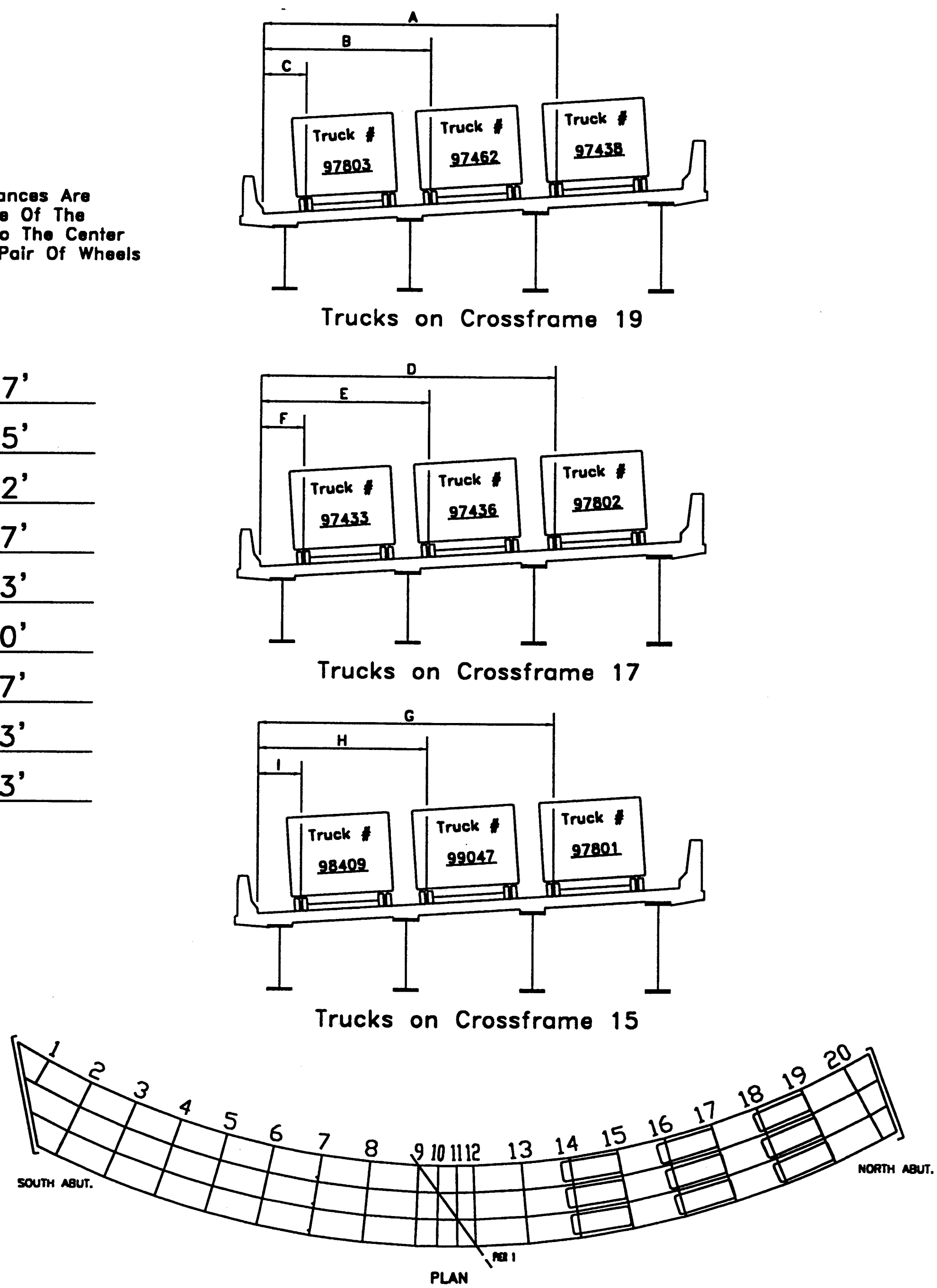
Case 6 Field Test – 2000

Truck Positions and
Truck Numbers

Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

A	21.67'
B	11.25'
C	1.42'
D	21.17'
E	10.83'
F	1.00'
G	21.67'
H	11.33'
I	1.33'



Case 6 Field Test – 2000

Figure B.35: Truck Positions for Case 6

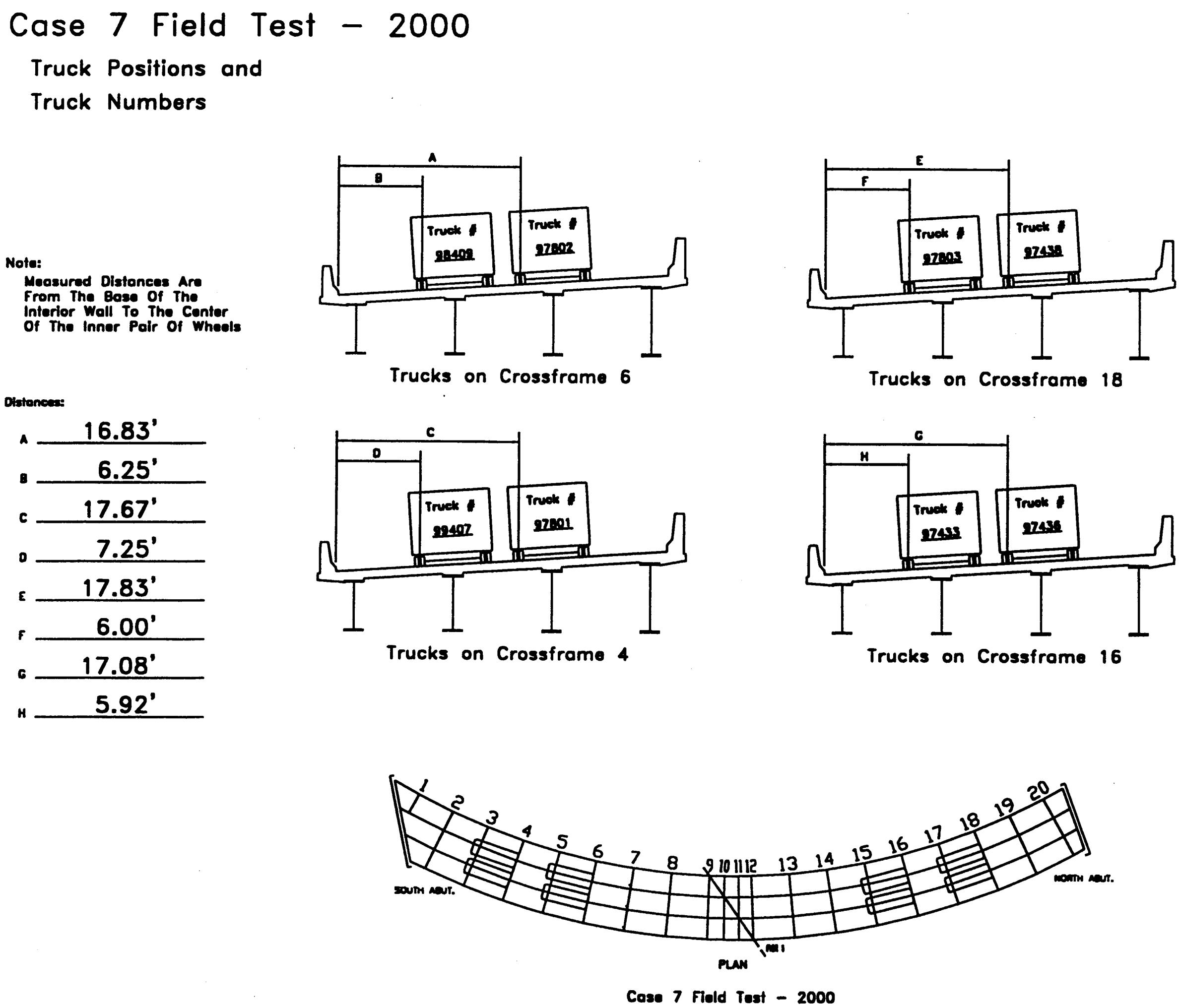


Figure B.36: Truck Positions for Case 7

Case 8 Field Test – 2000

Truck Positions and Truck Numbers

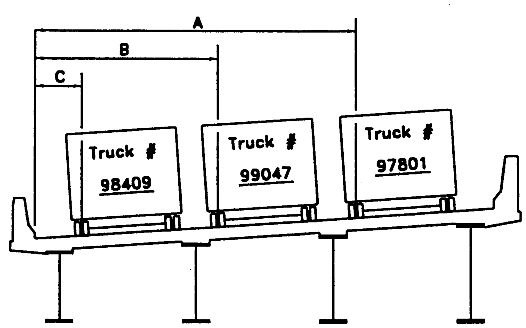
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

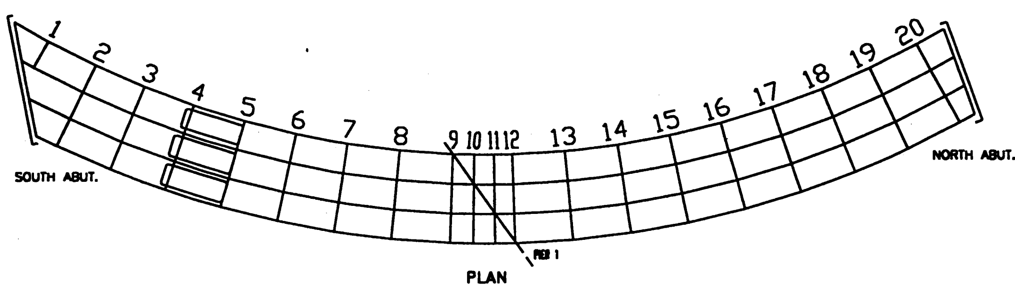
A 21.42'

B 11.42'

C 1.17'



Trucks on Crossframe 5



Case 8 Field Test – 2000

Figure B.37: Truck Positions for Case 8

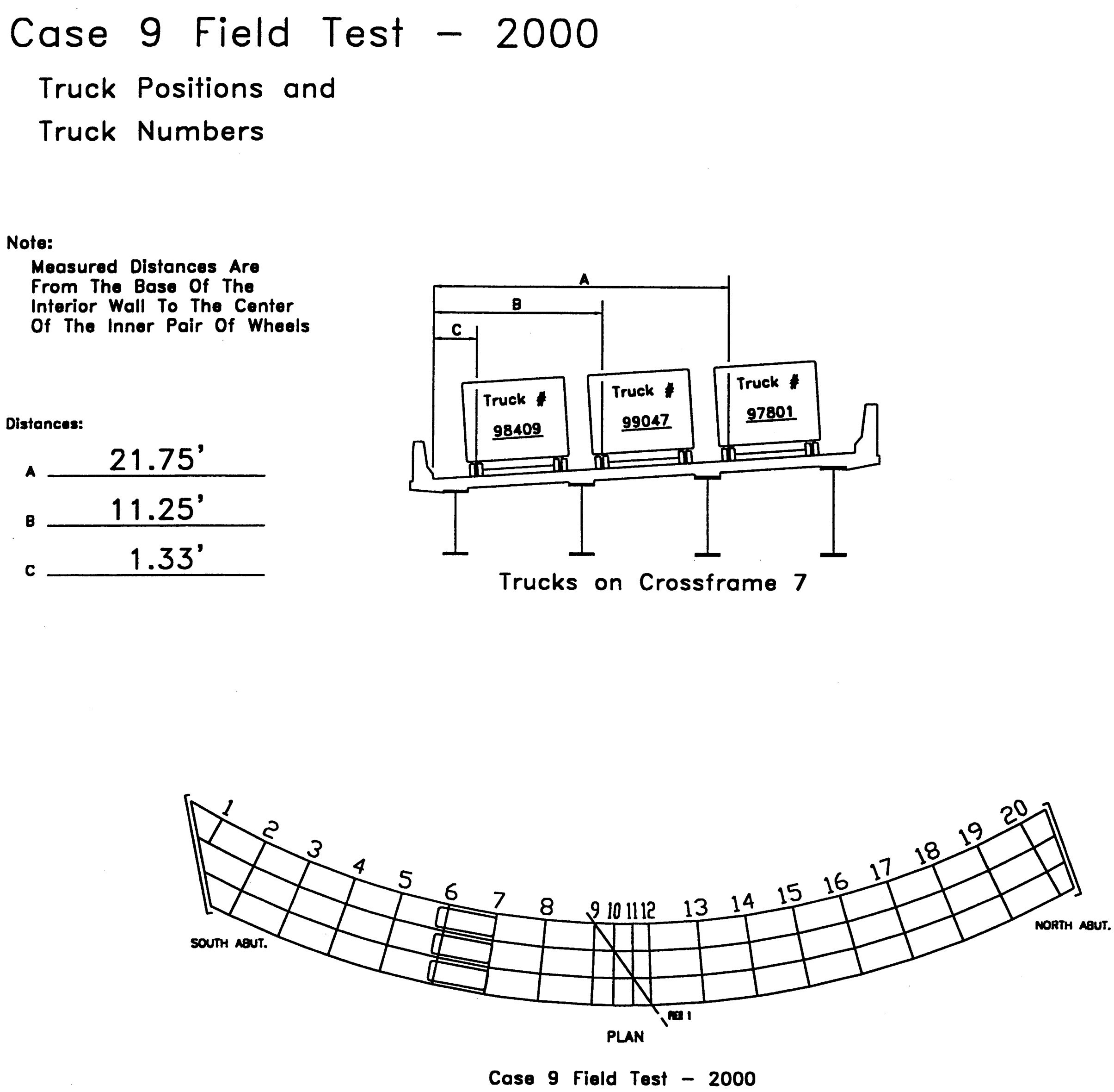


Figure B.38: Truck Positions for Case 9

Case 10 Field Test – 2000

Truck Positions and

Truck Numbers

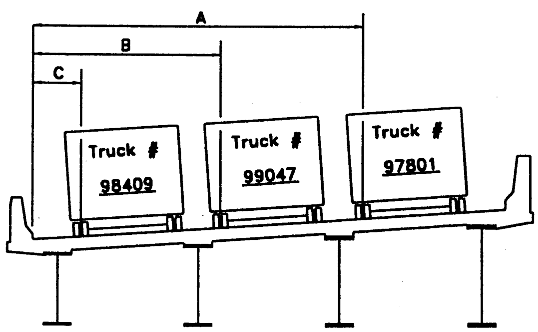
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

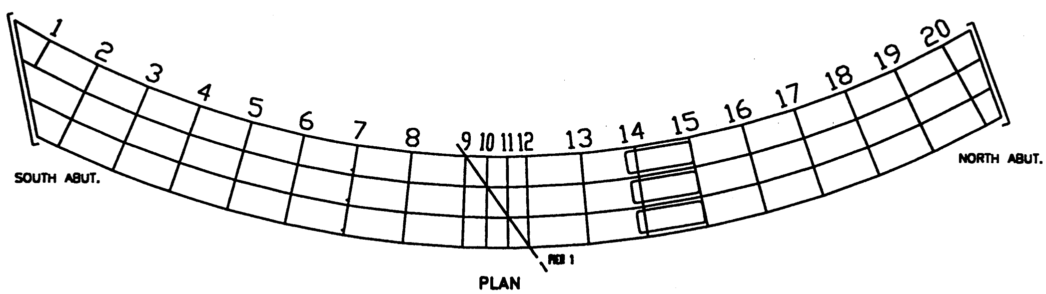
A 21.50'

B 11.42'

C 1.50'



Trucks on Crossframe 15



Case 10 Field Test – 2000

Figure B.39: Truck Positions for Case 10

Case 11 Field Test – 2000

Truck Positions and
Truck Numbers

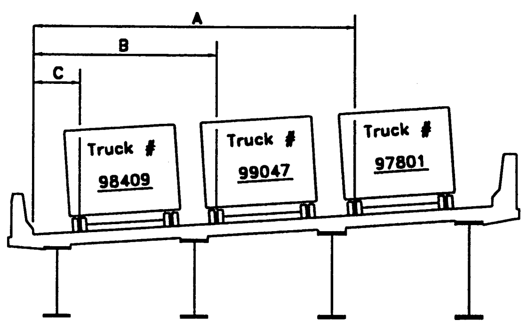
Note:
Measured Distances Are From The Base Of The Interior Wall To The Center Of The Inner Pair Of Wheels

Distances:

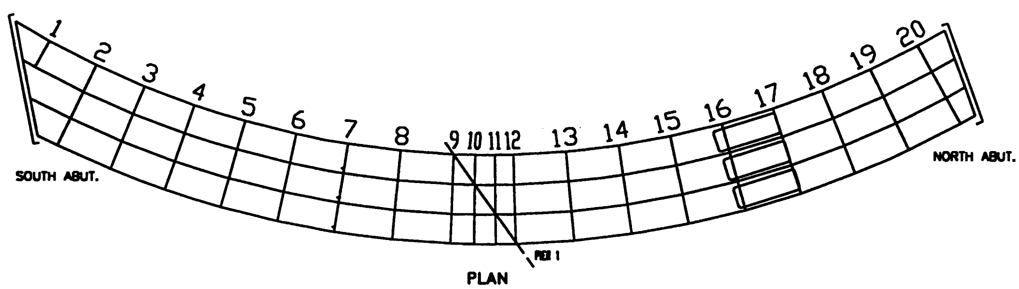
A 21.58'

B 11.50'

C 1.42'



Trucks on Crossframe 17



Case 11 Field Test – 2000

Figure B.40: Truck Positions for Case 11

APPENDIX C

BAR CHARTS FOR 1997 CHANGE IN STRESS ANALYSIS VS. 2000 CHANGE IN STRESS ANALYSIS

The UMN program derives its total stress from the combination of dead load stresses and stresses calculated from live load cases. The dead load stresses are the same for the analyses based on 1997 and 2000 truck loading, so any difference in the total stress is a result of only the change in stress due to the truck loading. Figures C.1 to C.10 graph the change in stress magnitudes for each gage for truck live load cases 1 to 6 and 8 to 11 in the 1997 and 2000 field tests.

Using the 1997 analysis as a baseline, percent differences were calculated between 1997 analysis and the 2000 analysis for the nine truck cases and the three truck cases. The formula to calculate these percent errors was: [(2000 stress) – (1997 stress)]/(2000 stress). Negative percent differences indicate that a 2000 analysis result is larger than a 1997 analysis result.

The maximum and minimum percent differences between the 1997 change in stress analysis and the 2000 change in stress analysis are 114.3% in gage 9C, Case 8, and –300% in gage 12C, Case 9, respectively (Table C.1). Both errors occur in crossframes in the three truck live load cases. For gage 9C, in Case 8, the 1997 calculated change in stress was –0.07 ksi, and 2000 calculated change in stress was 0.01 ksi. For gage 12C, Case 9, the 1997 change in stress was 0.10 ksi, while the 2000 analysis predicted 0.04 ksi. Because the calculated stresses are generally very low, the percent errors appear high for the change in stress. In the cases and gages where the percent errors were in double or triple digits, stresses from the analysis were below 5 ksi, and generally were less than 2 ksi. In contrast, for gages having a change in stress exceeding 5 ksi, the difference between the 1997 and the 2000 analysis was never more than 10%.

Because the higher percent errors occur in cases and gages where calculated stresses are low and the final correlations discussed in Chapter 5 do not change when using 2000 analysis or 1997 analysis. Throughout this work, the 1997 analysis was thus used as the computational baseline for data collected in both 1997 and 2000.

Table C.1: Percent Differences Between Change in Stress from 1997 and 2000 Analyses

	% difference cases 1-6					Max	Min
1A	2A	3A	4A	5A	6A		
-0.81%	-0.96%	-0.84%	-1.14%	-0.81%	-0.68%	-0.68%	-1.14%
-1.46%	-1.72%	-1.52%	-1.66%	-1.46%	-1.22%	-1.22%	-1.72%
0.00%	0.00%	0.67%	0.73%	0.00%	0.54%	0.73%	0.00%
-10.00%	-5.88%	-10.53%	-11.43%	-10.00%	-8.51%	-5.88%	-11.43%
-1.52%	-1.79%	-2.38%	-1.74%	-1.52%	-1.91%	-1.52%	-2.38%
-1.52%	0.00%	-1.59%	-0.87%	-1.52%	-1.27%	0.00%	-1.59%
7A	8A	9A	10A	11A	12A		
-2.86%	-3.62%	-3.45%	-3.75%	-3.43%	-3.13%	-2.86%	-3.75%
-3.57%	-3.60%	-2.87%	-3.14%	-2.84%	-2.73%	-2.73%	-3.60%
-2.27%	0.00%	-0.91%	-1.01%	-2.27%	-0.71%	0.00%	-2.27%
-14.29%	-9.09%	-11.43%	-12.50%	-14.29%	-11.63%	-9.09%	-14.29%
-5.41%	-6.90%	-4.40%	-4.94%	-5.41%	-4.27%	-4.27%	-6.90%
-2.78%	-3.57%	-2.27%	-2.60%	-5.71%	-2.65%	-2.27%	-5.71%
13A	14A	15A	16A	17A	18A		
-6.82%	-6.12%	-6.25%	-6.76%	-6.02%	-6.03%	-6.02%	-6.82%
-4.85%	-3.90%	-5.02%	-5.49%	-4.81%	-4.76%	-3.90%	-5.49%
-3.85%	-5.26%	-4.05%	-4.55%	-3.85%	-4.21%	-3.85%	-5.26%
-9.09%	-12.50%	-13.33%	-14.29%	-9.09%	-10.53%	-9.09%	-14.29%
-10.00%	-6.67%	-10.71%	-12.24%	-10.00%	-8.11%	-6.67%	-12.24%
-5.56%	-7.69%	-8.16%	-9.76%	-5.56%	-7.69%	-5.56%	-9.76%
19A	20A	21A	22A	23A	24A		
-9.62%	-9.59%	-9.90%	-10.17%	-9.52%	-9.39%	-9.39%	-10.17%
-7.59%	-7.27%	-7.56%	-8.18%	-7.59%	-7.24%	-7.24%	-8.18%
-15.38%	-22.22%	-15.00%	-17.14%	-15.38%	-13.21%	-13.21%	-22.22%
-25.00%	-16.67%	-12.00%	-12.50%	-25.00%	-12.90%	-12.00%	-25.00%
-37.50%	-16.67%	-29.17%	-36.84%	-37.50%	-27.27%	-16.67%	-37.50%
-50.00%	-33.33%	-30.77%	-62.50%	-20.00%	-30.00%	-20.00%	-62.50%
1B	2B	3B	4B	5B	6B		
-2.27%	-2.94%	-2.19%	-1.41%	-1.30%	-2.79%	-1.30%	-2.94%
0.00%	0.00%	0.56%	0.74%	0.00%	0.00%	0.74%	0.00%
-1.41%	-1.79%	-2.58%	-3.82%	-3.13%	-1.13%	-1.13%	-3.82%
1.08%	0.00%	0.90%	-0.96%	1.05%	4.19%	4.19%	-0.96%
3.73%	4.35%	4.22%	1.81%	4.14%	9.30%	9.30%	1.81%
2.70%	3.15%	3.00%	1.29%	2.50%	6.10%	6.10%	1.29%
7B	8B	9B	10B	11B	12B		
-2.63%	-3.53%	-2.95%	-2.22%	-2.94%	-3.10%	-2.22%	-3.53%
-0.90%	-1.20%	-0.75%	-1.63%	-2.02%	-0.88%	-0.75%	-2.02%
-2.15%	-2.86%	-2.64%	-5.43%	-3.49%	-0.65%	-0.65%	-5.43%
-4.65%	-2.90%	-3.59%	-4.79%	-4.55%	-1.34%	-1.34%	-4.79%
-5.00%	-4.88%	-4.48%	-3.98%	-4.59%	-7.69%	-3.98%	-7.69%
-3.13%	-2.50%	-3.08%	-2.63%	-2.80%	-5.88%	-2.50%	-5.88%
13B	14B	15B	16B	17B	18B		
-4.00%	-4.23%	-4.39%	-4.79%	-4.17%	-3.71%	-3.71%	-4.79%
-3.26%	-3.03%	-2.20%	-3.90%	-2.27%	-1.82%	-1.82%	-3.90%
-3.70%	-3.39%	-3.77%	-5.74%	-3.80%	-2.25%	-2.25%	-5.74%
-6.85%	-7.41%	-7.34%	-7.21%	-8.11%	-5.73%	-5.73%	-8.11%
-10.23%	-10.61%	-9.81%	-7.63%	-9.78%	-20.00%	-7.63%	-20.00%
-7.79%	-6.90%	-7.33%	-5.32%	-6.17%	-17.81%	-5.32%	-17.81%
19B	20B	21B	22B	23B	24B		
-7.23%	-6.90%	-7.27%	-11.52%	-6.90%	-5.69%	-5.69%	-11.52%
-7.04%	-6.00%	-6.41%	-15.32%	-6.67%	-3.98%	-3.98%	-15.32%
-6.35%	-6.82%	-6.44%	-12.00%	-6.06%	-4.10%	-4.10%	-12.00%
-7.81%	-9.09%	-8.59%	-8.08%	-7.81%	-9.14%	-7.81%	-9.14%
-10.11%	-9.84%	-9.52%	-6.99%	-9.20%	-15.79%	-6.99%	-15.79%
-6.33%	-7.55%	-7.11%	-4.55%	-8.00%	-13.85%	-4.55%	-13.85%
1C	2C	3C	4C				
10.53%	-7.97%	-2.72%	-2.14%			10.53%	-7.97%
8.03%	-8.46%	-2.38%	-2.75%			8.03%	-8.46%
8.33%	-10.20%	0.61%	-5.56%			8.33%	-10.20%
0.00%	-14.29%	-7.89%	-12.50%			0.00%	-14.29%
6.60%	-41.67%	-1.54%	-13.33%			6.60%	-41.67%
4.10%	-60.00%	-0.76%	-8.00%			4.10%	-60.00%
5C	6C	7C	8C				
14.29%	-6.91%	-2.41%	6.33%			14.29%	-6.91%
9.86%	-6.47%	-2.00%	4.76%			9.86%	-6.47%
11.11%	-5.95%	0.63%	3.45%			11.11%	-5.95%
0.00%	-12.50%	-10.42%	-15.38%			0.00%	-15.38%
6.78%	-10.17%	-2.78%	-2.78%			6.78%	-10.17%
4.35%	-8.00%	-1.40%	-2.94%			4.35%	-8.00%
9C	10C	11C	12C				
25.00%	-5.82%	-2.08%	-35.00%			25.00%	-35.00%
16.67%	-5.26%	-1.57%	-26.32%			16.67%	-26.32%
7.41%	-4.35%	1.09%	-200.00%			7.41%	-200.00%
100.00%	-10.81%	-10.81%	0.00%			100.00%	-10.81%
10.00%	-11.11%	-4.21%	16.67%			16.67%	-11.11%
5.56%	-9.43%	-2.17%	0.00%			5.56%	-9.43%
Max and Min % Difference:						100.00%	-200.00%

Table C.1: Percent Differences Between Change in Stress from 1997 and 2000 Analyses

	% difference cases 8-11					Max	Min
1A	**2A**	**3A**	**4A**	**5A**	**6A**		
2.48%	1.96%	2.16%	1.42%	2.48%	2.78%	2.78%	1.42%
0.00%	0.00%	0.00%	0.00%	1.33%	0.56%	1.33%	0.00%
0.00%	0.00%	-1.96%	-2.13%	0.00%	-3.13%	0.00%	-3.13%
0.00%	0.00%	-2.04%	-2.27%	0.00%	-1.61%	0.00%	-2.27%
7A	**8A**	**9A**	**10A**	**11A**	**12A**		
-3.41%	-2.86%	-3.65%	-5.03%	-3.41%	-2.91%	-2.86%	-5.03%
-2.27%	-2.86%	-1.82%	-2.00%	0.00%	-1.44%	0.00%	-2.86%
0.00%	0.00%	-2.70%	-6.25%	0.00%	-4.26%	0.00%	-6.25%
0.00%	0.00%	-3.03%	-3.45%	0.00%	-2.27%	0.00%	-3.45%
13A	**14A**	**15A**	**16A**	**17A**	**18A**		
-10.29%	-9.80%	-10.05%	-11.54%	-8.70%	-9.13%	-8.70%	-11.54%
-7.14%	-4.76%	-6.25%	-8.33%	-7.14%	-5.88%	-4.76%	-8.33%
0.00%	0.00%	-9.09%	-10.53%	0.00%	-6.90%	0.00%	-10.53%
-16.67%	0.00%	-5.56%	-6.67%	-16.67%	-4.17%	0.00%	-16.67%
19A	**20A**	**21A**	**22A**	**23A**	**24A**		
-18.18%	-15.38%	-17.26%	-18.59%	-16.07%	-16.36%	-15.38%	-18.59%
-11.76%	-16.67%	-16.00%	-17.39%	-11.76%	-15.38%	-11.76%	-17.39%
0.00%	0.00%	-25.00%	-33.33%	-33.33%	-27.27%	0.00%	-33.33%
0.00%	0.00%	-33.33%	-100.00%	-100.00%	-16.67%	0.00%	-100.00%
1B	**2B**	**3B**	**4B**	**5B**	**6B**		
2.86%	3.70%	2.78%	5.26%	0.00%	2.02%	5.26%	0.00%
0.00%	3.33%	2.47%	3.17%	3.03%	1.80%	3.33%	0.00%
3.51%	4.08%	2.84%	1.43%	1.64%	7.53%	7.53%	1.43%
0.00%	0.00%	0.00%	-0.92%	0.00%	1.96%	1.96%	-0.92%
7B	**8B**	**9B**	**10B**	**11B**	**12B**		
2.22%	2.94%	0.93%	1.82%	0.00%	0.57%	2.94%	0.00%
0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
-5.00%	-6.06%	-3.70%	-3.92%	-4.55%	-6.67%	-3.70%	-6.67%
-2.70%	0.00%	-3.03%	-2.62%	-2.44%	-4.00%	0.00%	-4.00%
13B	**14B**	**15B**	**16B**	**17B**	**18B**		
-2.56%	-3.57%	-3.45%	-6.67%	-5.41%	-2.25%	-2.25%	-6.67%
-4.76%	-3.33%	-3.20%	-5.41%	-5.00%	-2.02%	-2.02%	-5.41%
-8.82%	-7.69%	-8.74%	-6.42%	-8.33%	-18.42%	-6.42%	-18.42%
-3.57%	-4.76%	-5.95%	-4.35%	-6.90%	-13.04%	-3.57%	-13.04%
19B	**20B**	**21B**	**22B**	**23B**	**24B**		
-15.63%	-13.04%	-14.95%	-30.77%	-14.71%	-8.82%	-8.82%	-30.77%
-12.90%	-9.09%	-10.89%	-28.26%	-9.09%	-6.25%	-6.25%	-28.26%
-5.71%	-4.17%	-7.55%	-5.92%	-9.09%	-14.29%	-4.17%	-14.29%
-3.45%	-5.00%	-4.55%	-4.05%	-3.57%	-9.09%	-3.45%	-9.09%
1C	**2C**	**3C**	**4C**				
43.75%	-16.42%	-2.13%	0.00%			43.75%	-16.42%
12.33%	-13.21%	-0.65%	-2.38%			12.33%	-13.21%
4.35%	-25.00%	-1.89%	-18.18%			4.35%	-25.00%
0.00%	0.00%	-1.92%	0.00%			0.00%	-1.92%
5C	**6C**	**7C**	**8C**				
56.52%	-12.65%	-1.38%	24.24%			56.52%	-12.65%
12.82%	-8.99%	-0.65%	3.23%			12.82%	-8.99%
7.69%	-13.64%	-3.45%	-7.14%			7.69%	-13.64%
3.45%	-5.56%	-1.82%	-7.69%			3.45%	-7.69%
9C	**10C**	**11C**	**12C**				
114.29%	-9.87%	-0.69%	-61.54%			114.29%	-61.54%
15.79%	-6.25%	1.04%	-300.00%			15.79%	-300.00%
7.69%	-8.33%	-5.26%	33.33%			33.33%	-8.33%
0.00%	-5.26%	-2.86%	0.00%			0.00%	-5.26%
Max and Min % Difference:						**114.29%**	**-300.00%**

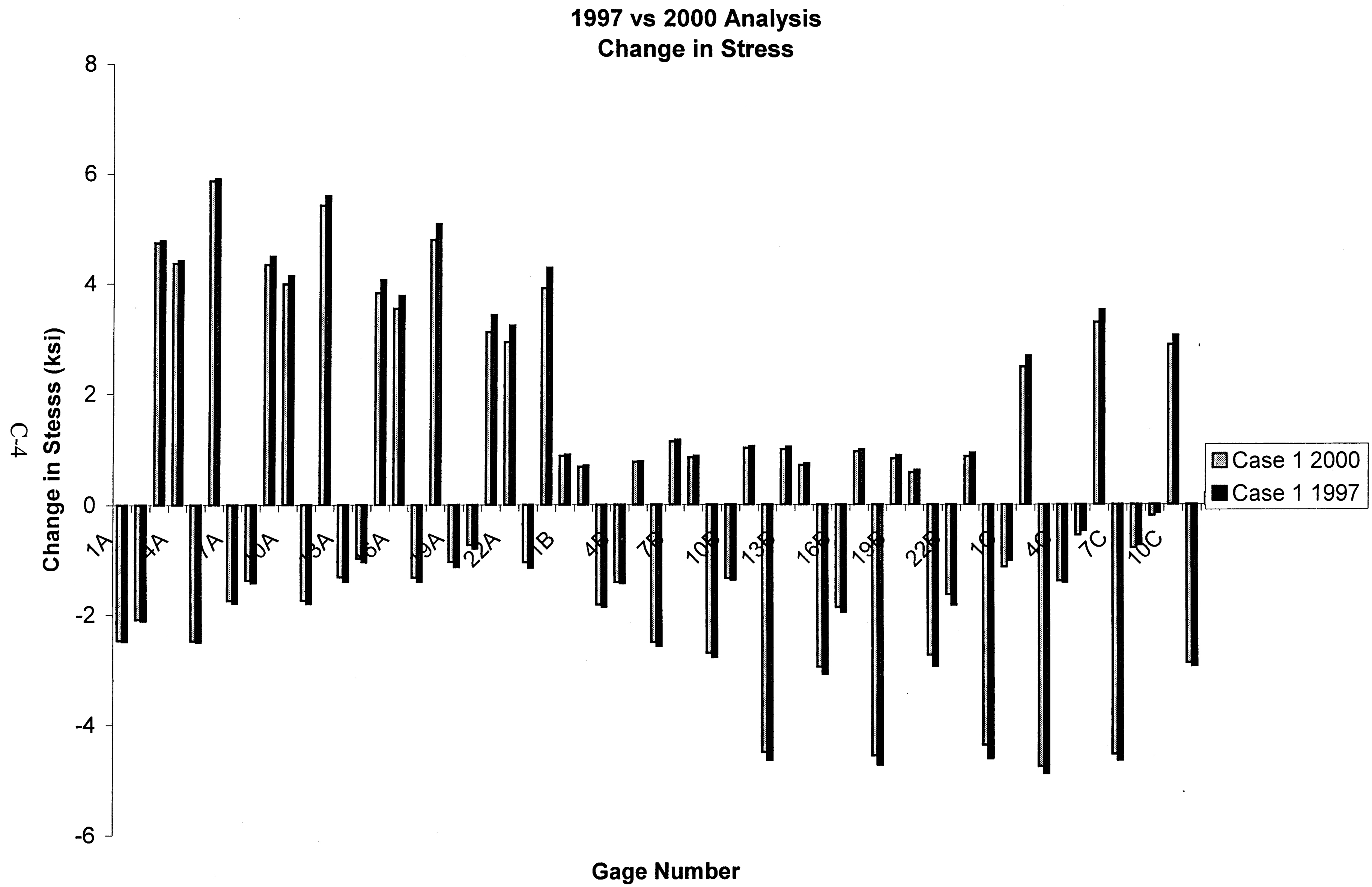


Figure C.1: Change in Stress Comparison of 1997 and 2000 Analyses

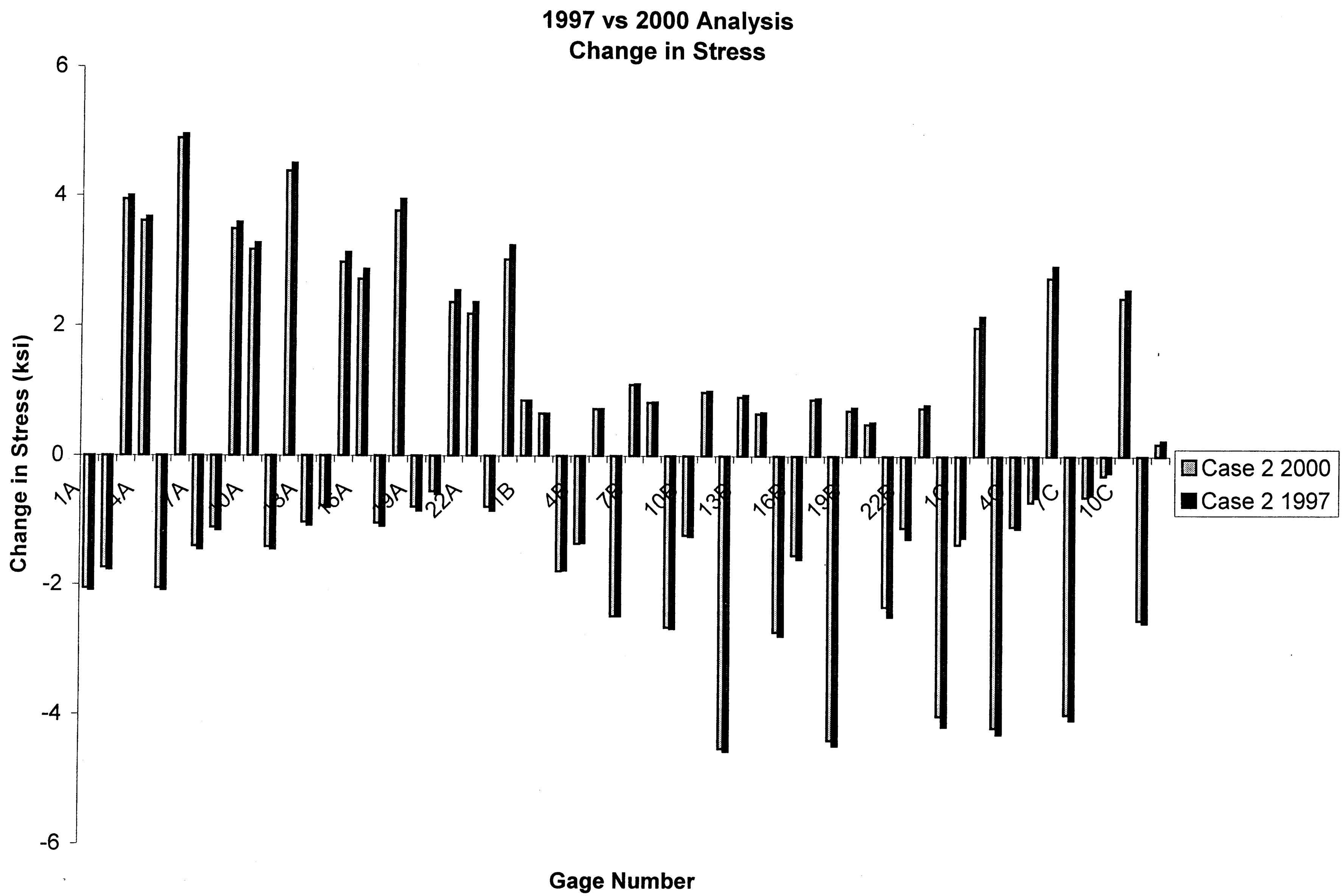


Figure C.2: Change in Stress Comparison of 1997 and 2000 Analyses

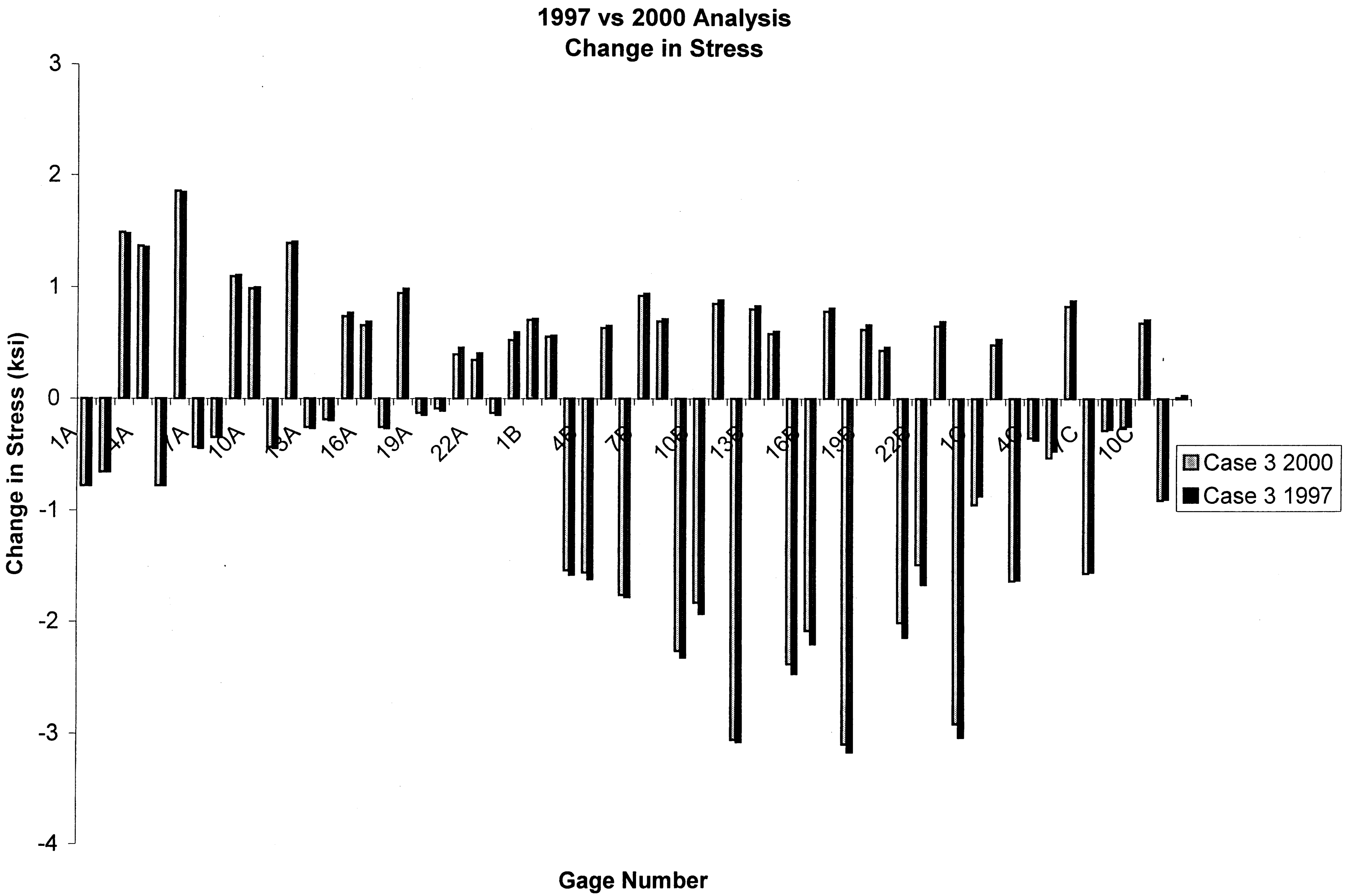


Figure C.3: Change in Stress Comparison of 1997 and 2000 Analyses

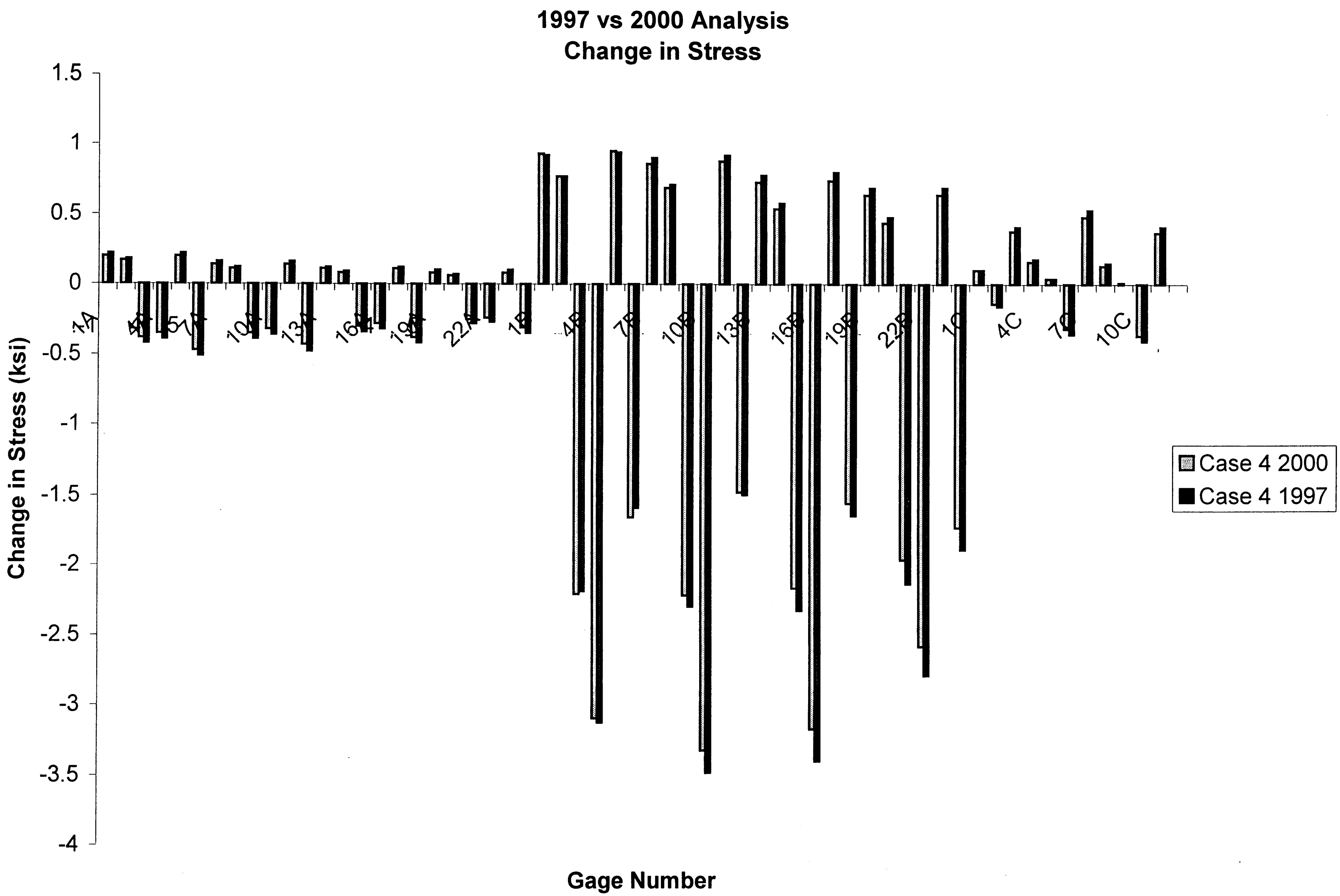


Figure C.4: Change in Stress Comparison of 1997 and 2000 Analyses

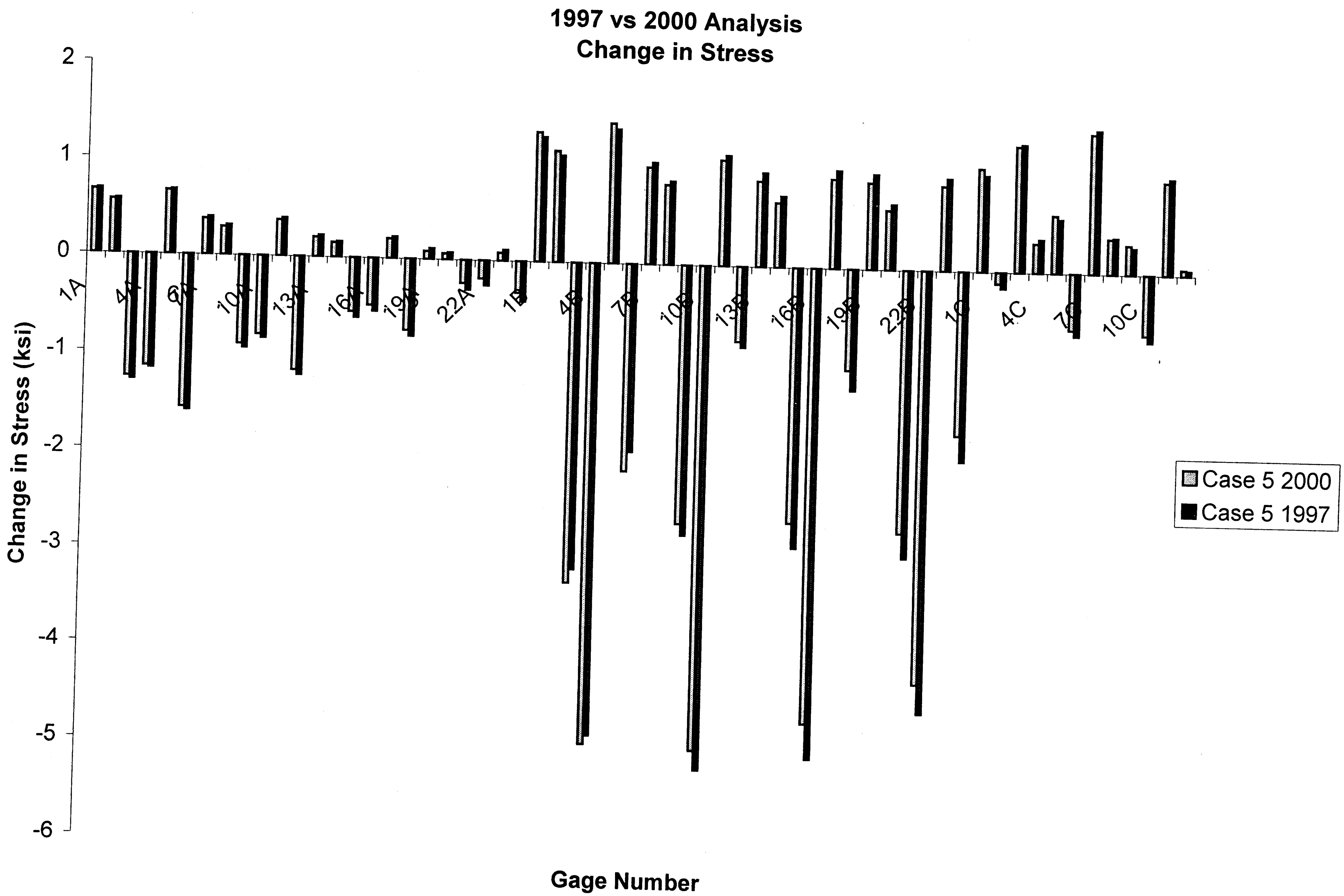


Figure C.5: Change in Stress Comparison of 1997 and 2000 Analyses

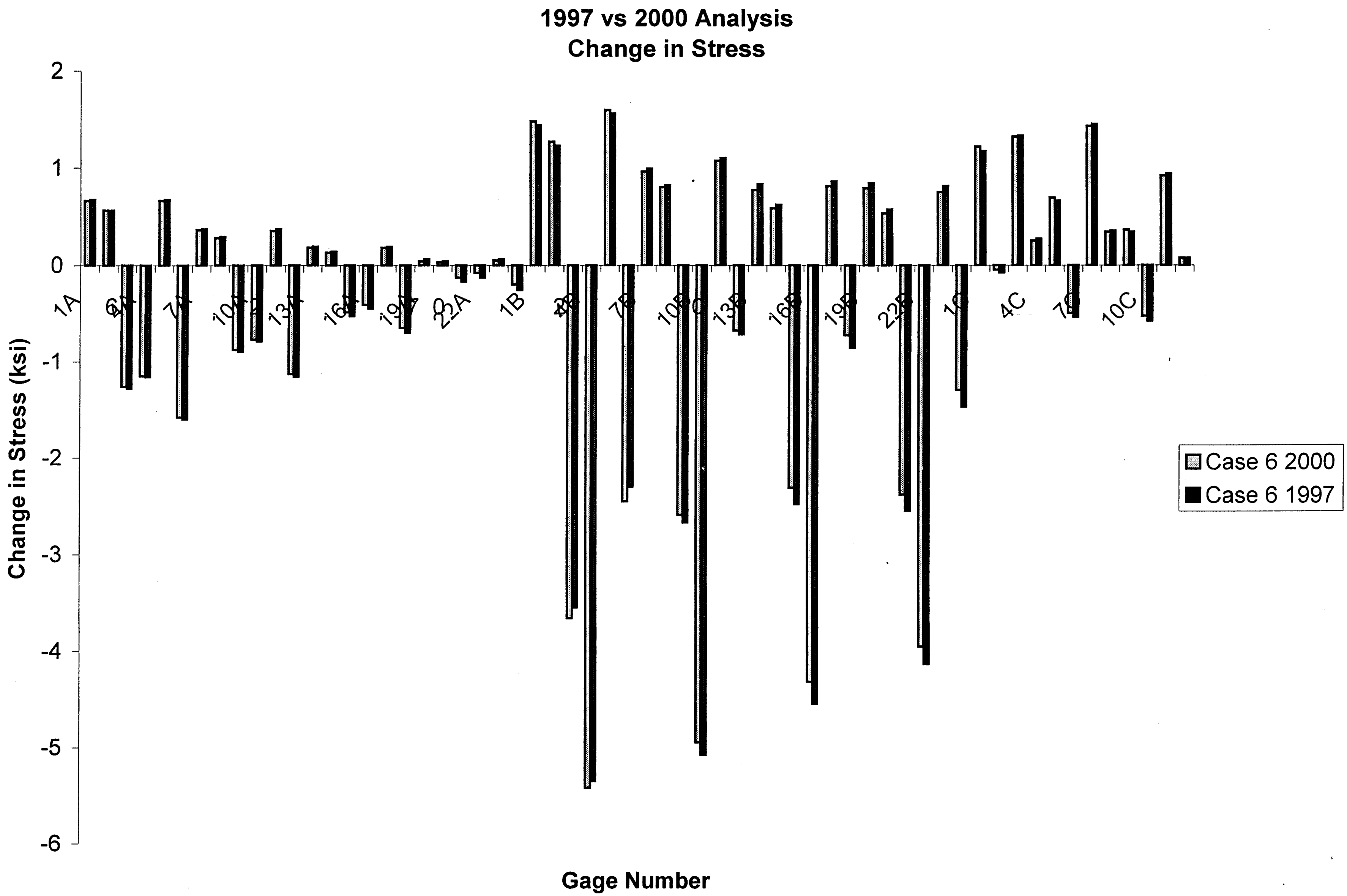


Figure C.6: Change in Stress Comparison of 1997 and 2000 Analyses

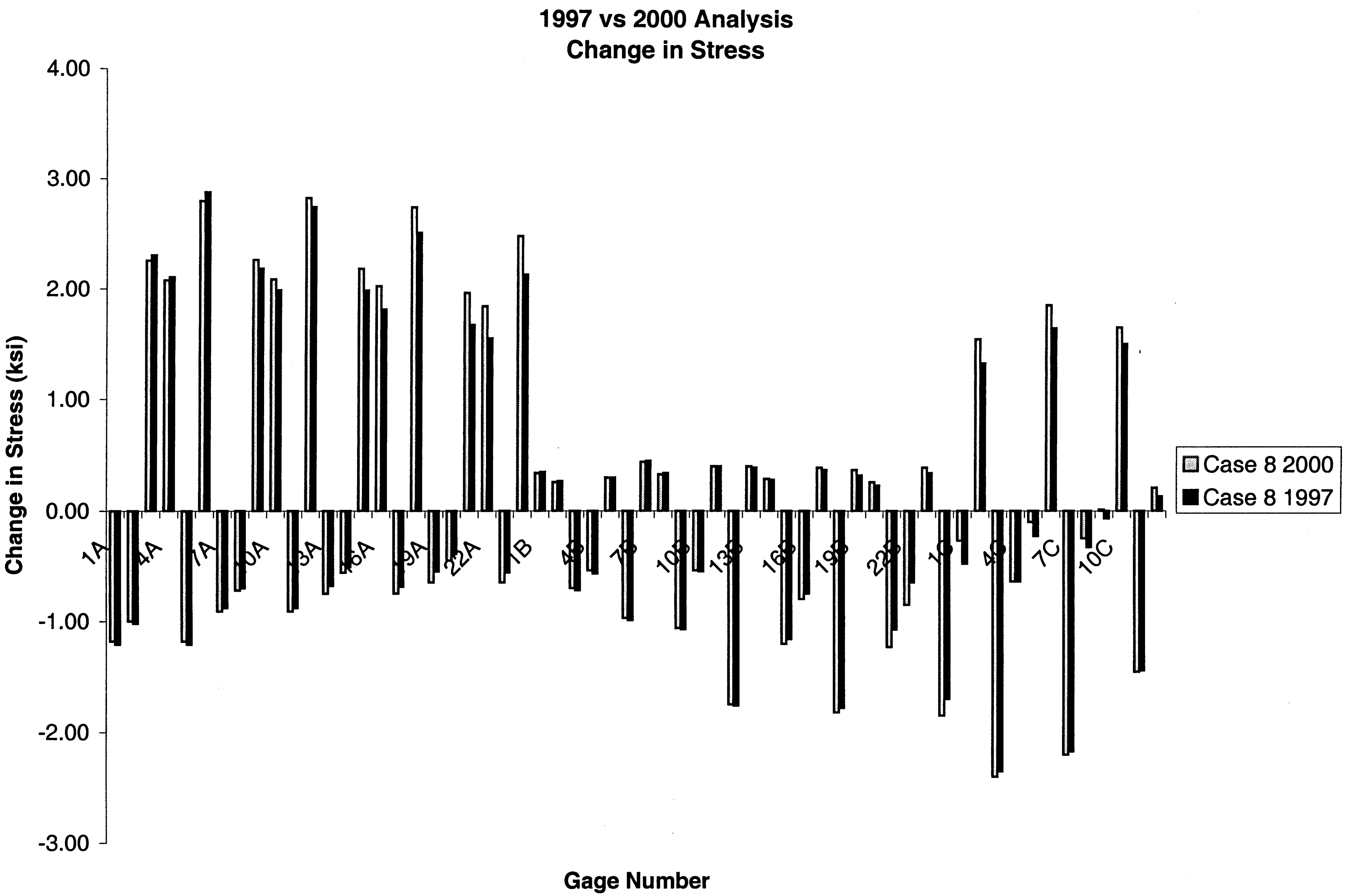


Figure C.7: Change in Stress Comparison of 1997 and 2000 Analyses

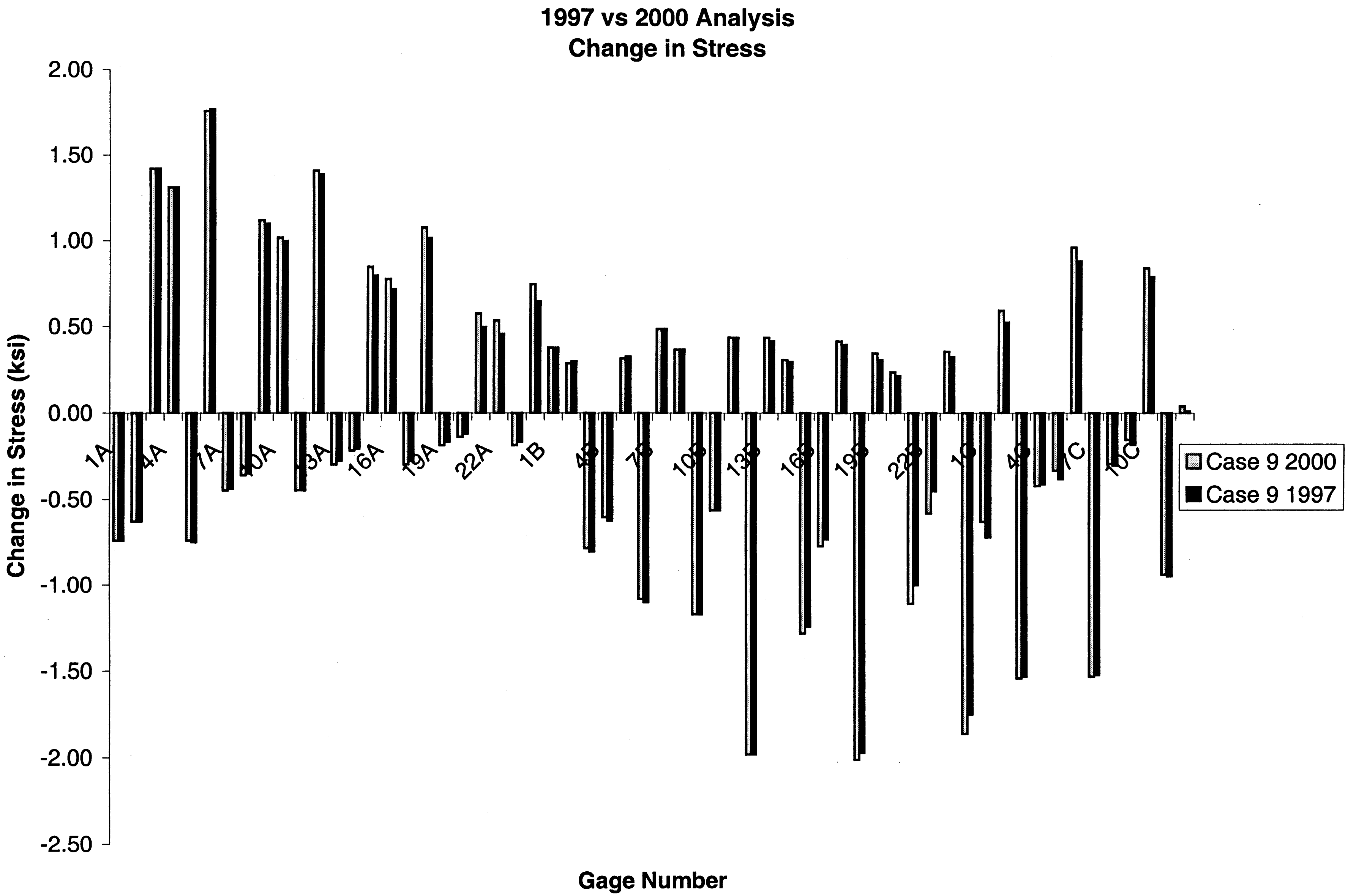


Figure C.8: Change in Stress Comparison of 1997 and 2000 Analyses

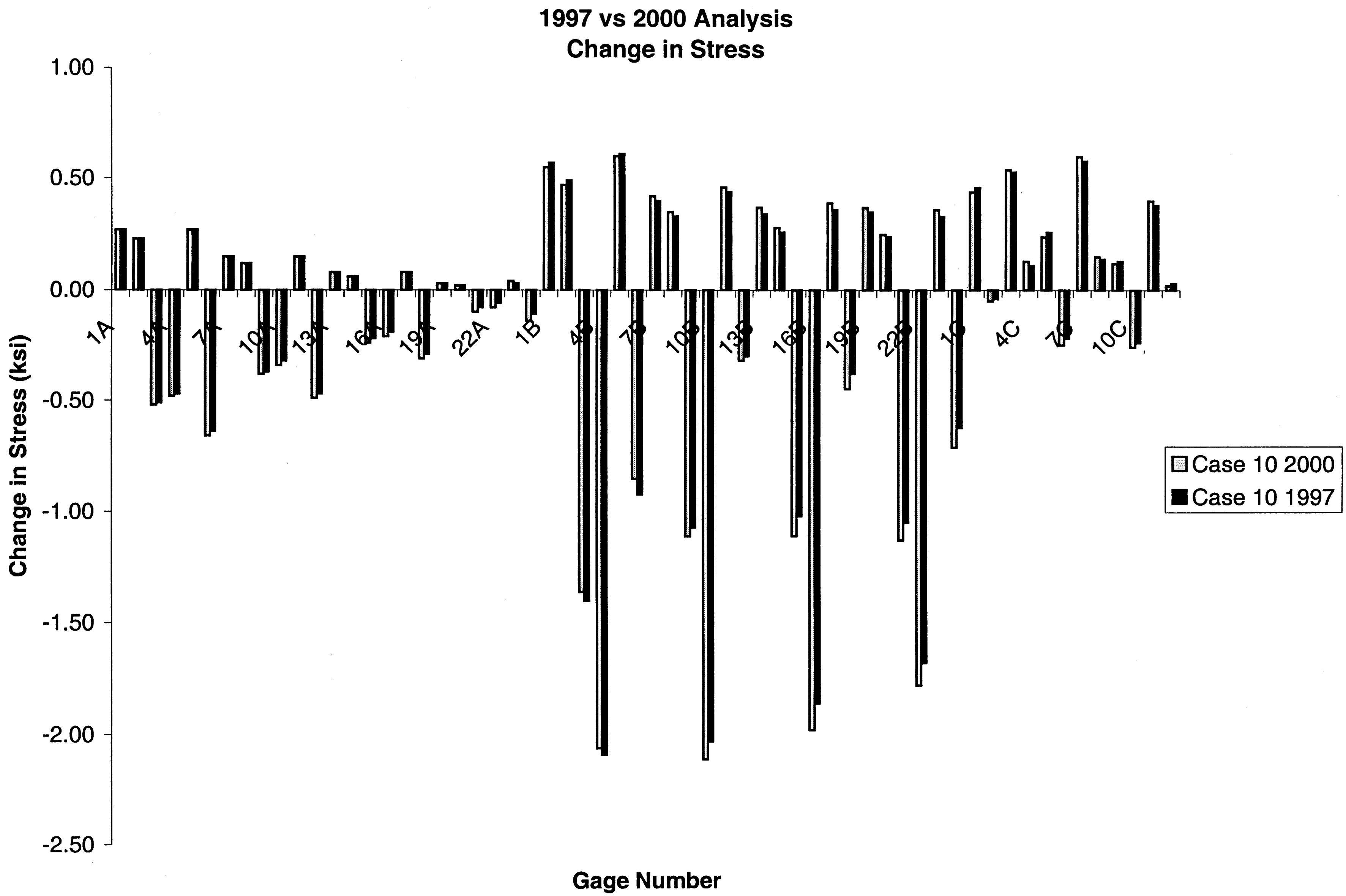


Figure C.9: Change in Stress Comparison of 1997 and 2000 Analyses

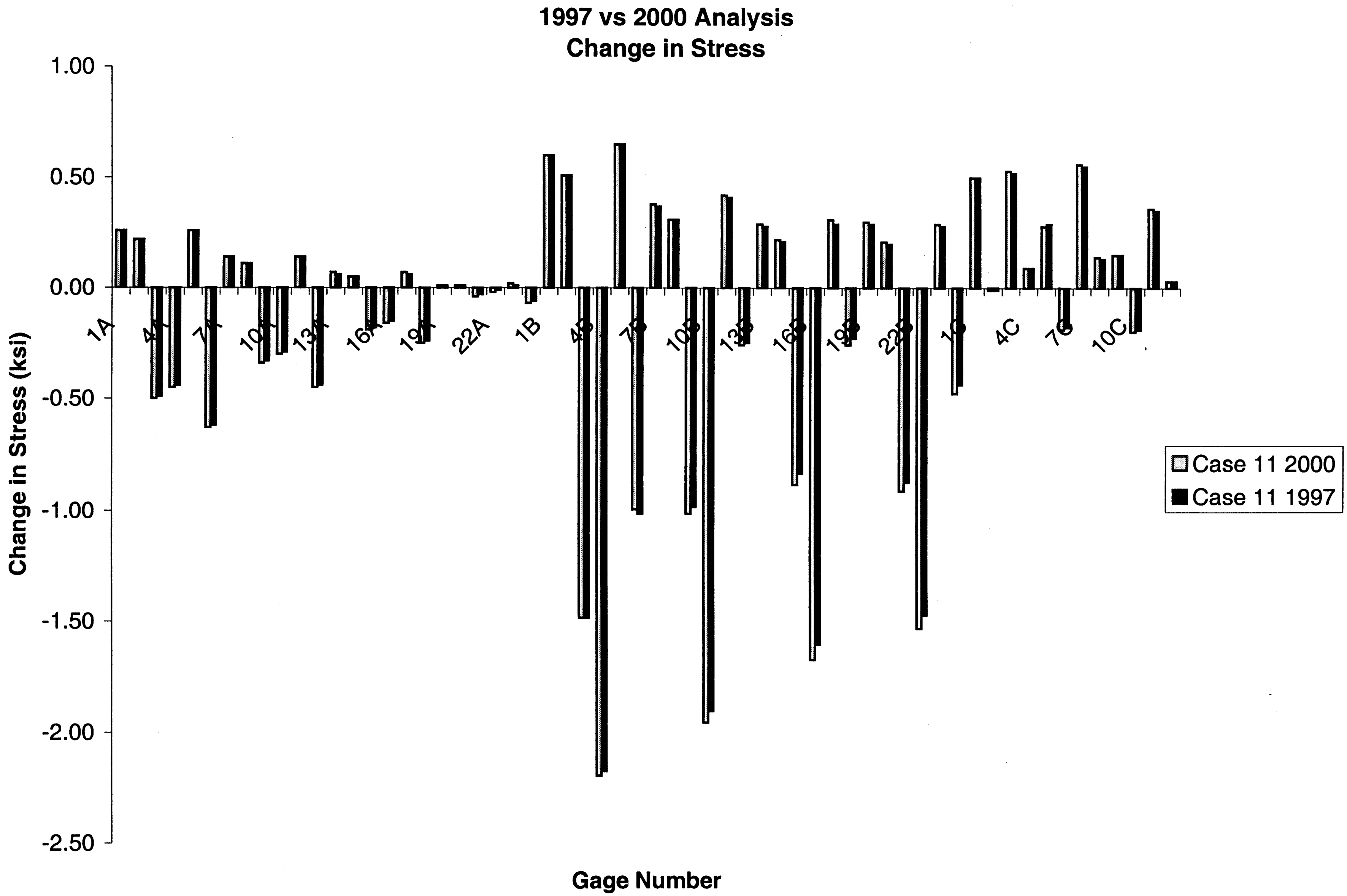


Figure C.10: Change in Stress Comparison of 1997 and 2000 Analyses

APPENDIX D

PLOTS OF MEASURED VS. COMPUTED STRESS FOR DEAD LOAD, $N = 6$

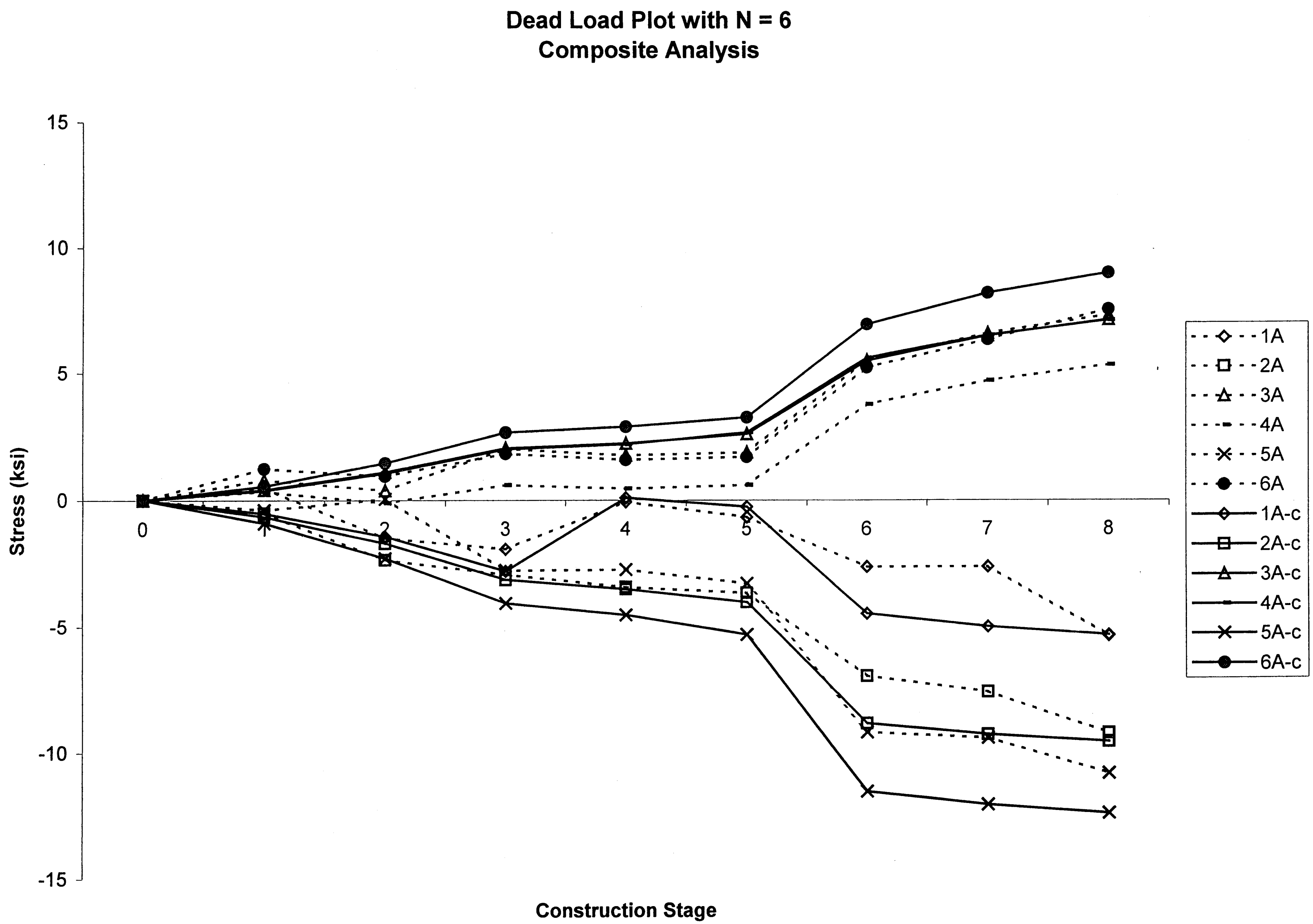


Figure D.1: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 1A-6A)

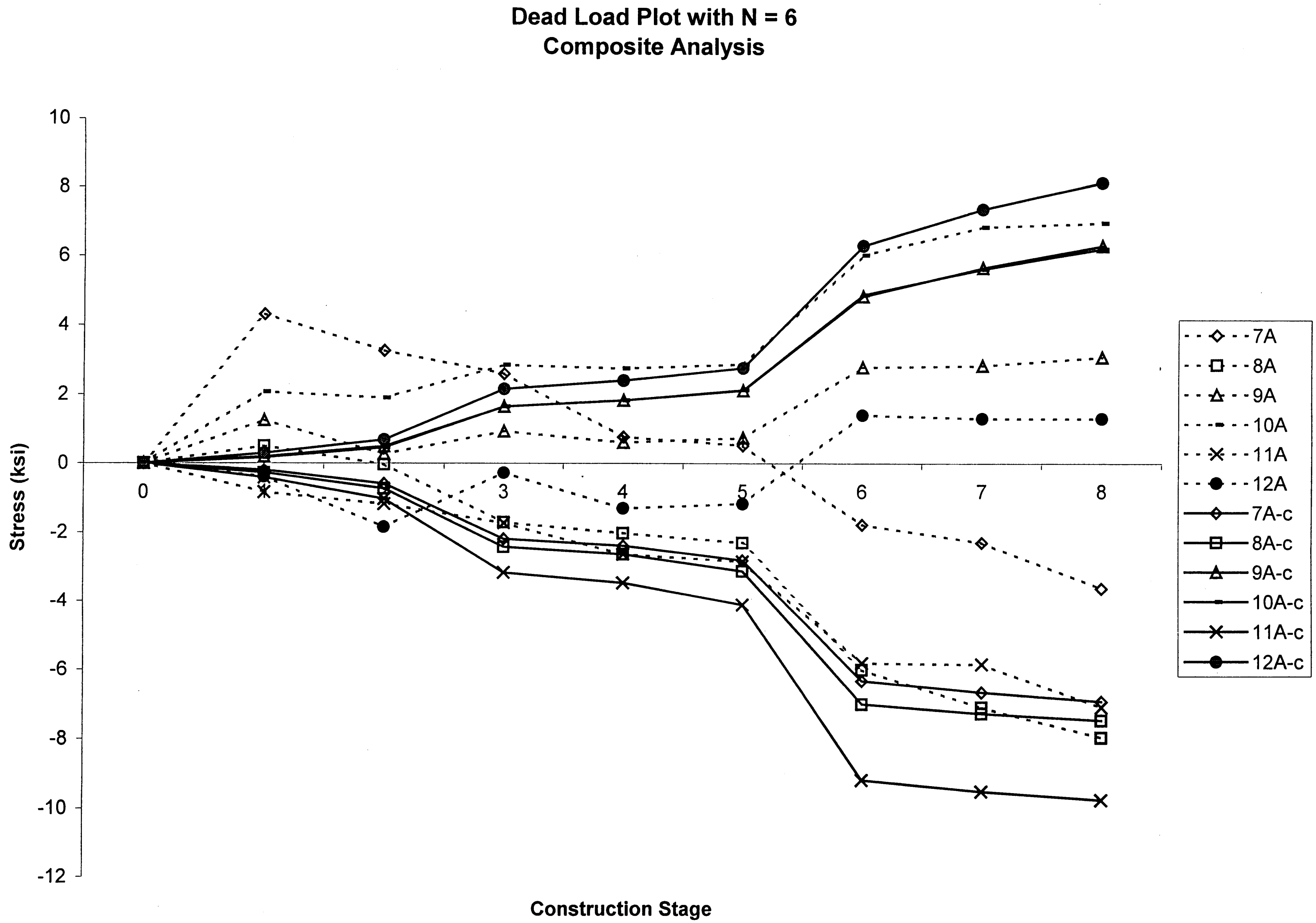


Figure D.2: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 7A-12A)

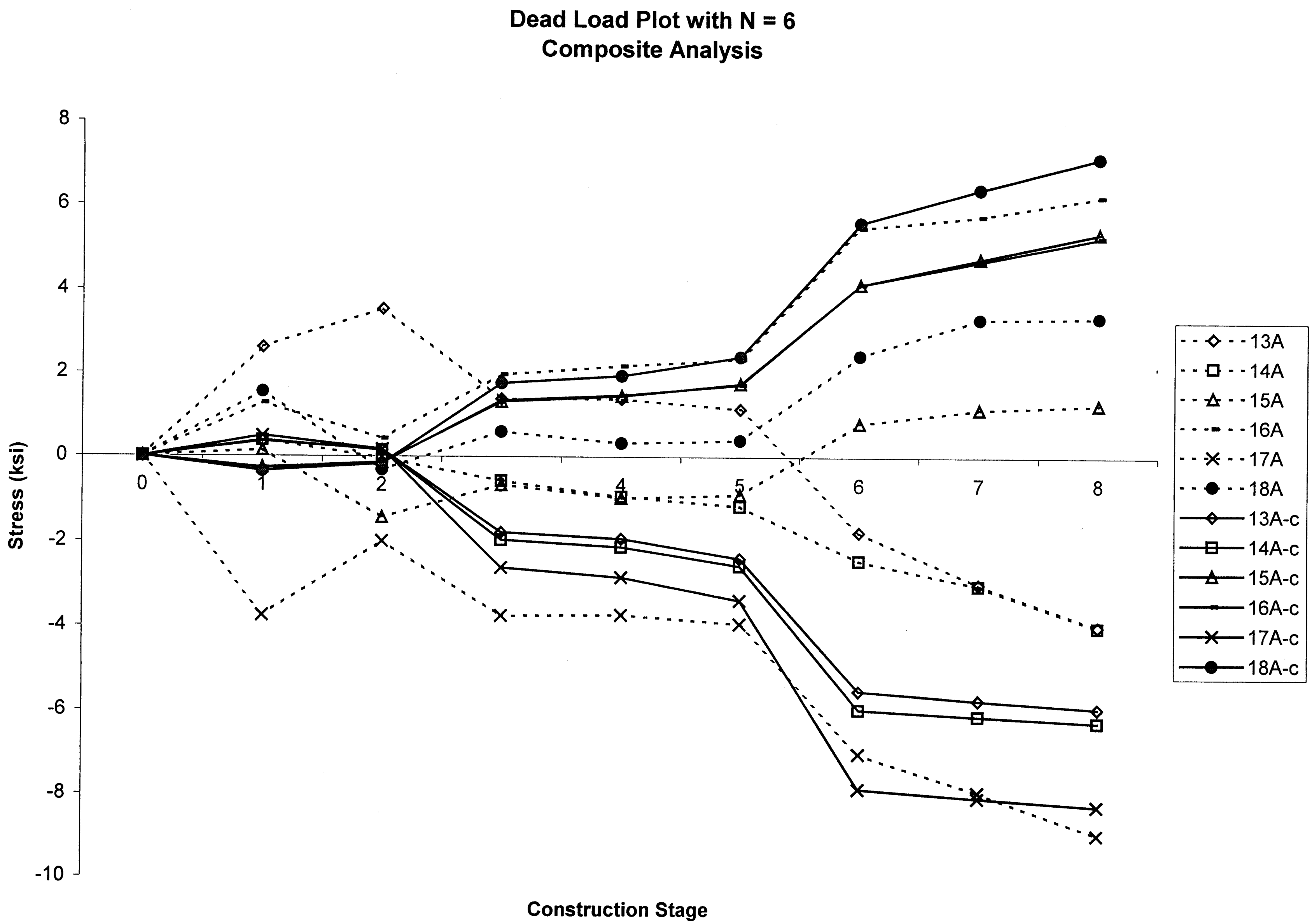


Figure D.3: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 13A-18A)

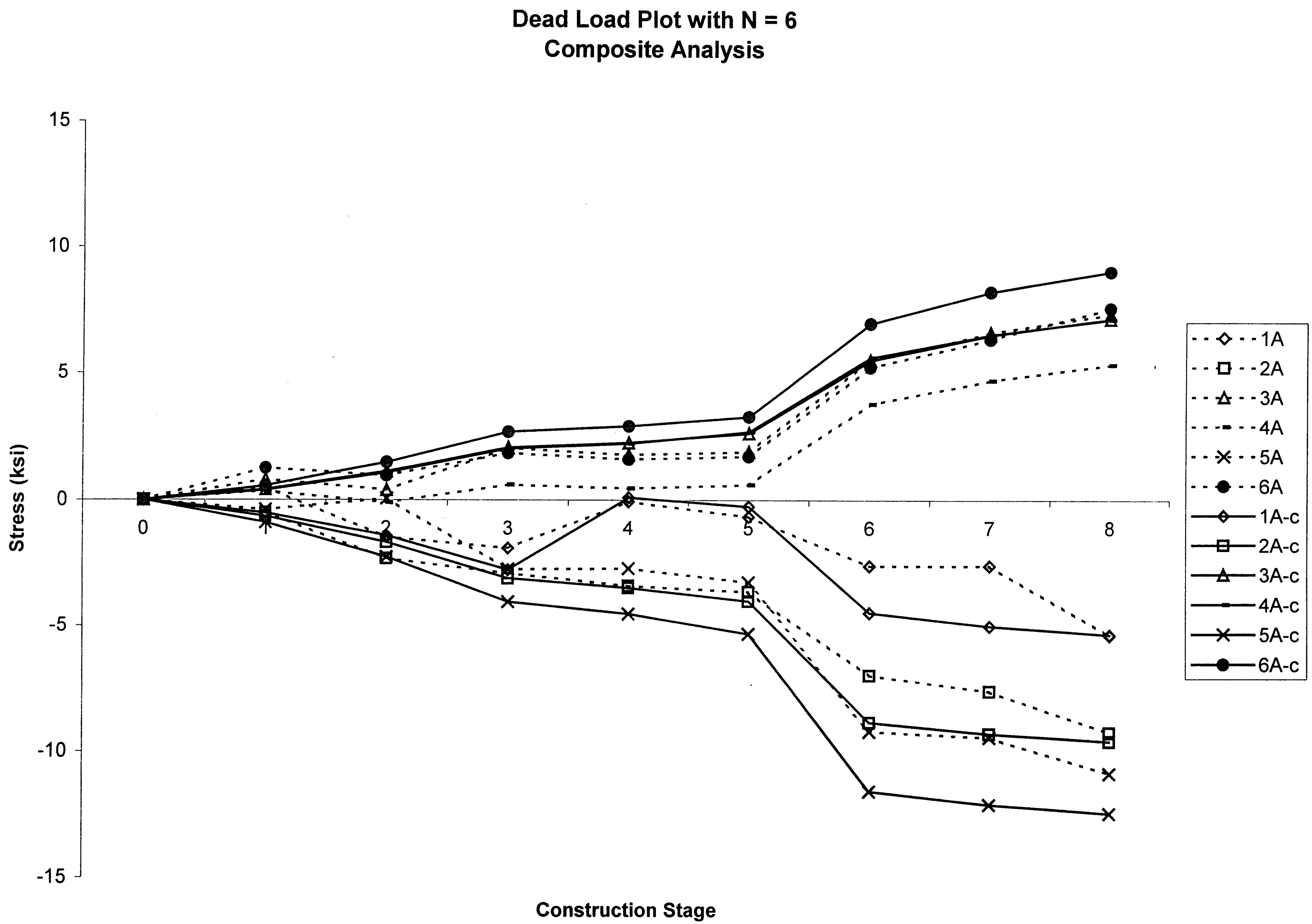


Figure D.4 Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 19A-24A)

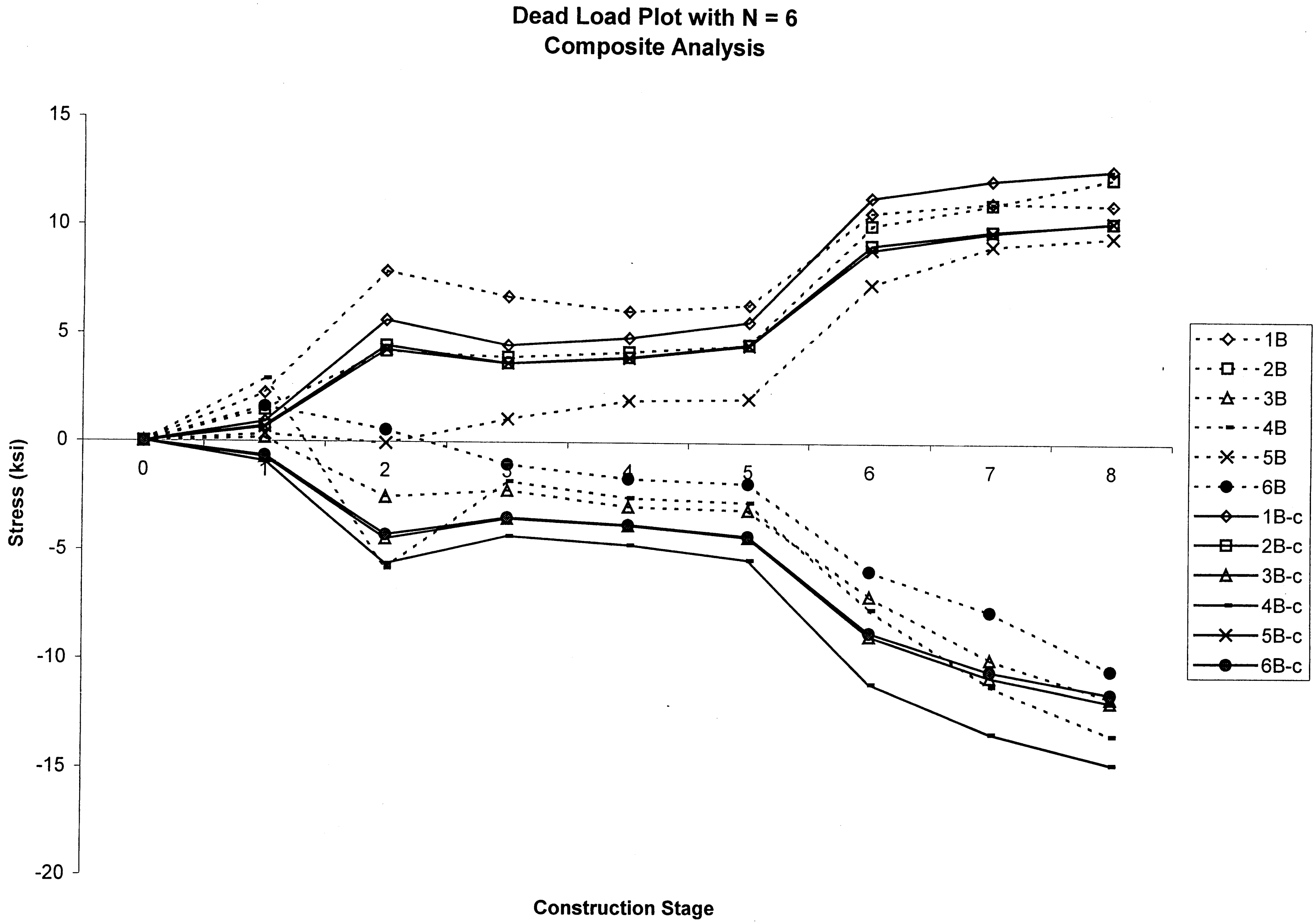


Figure D.5: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 1B-6B)

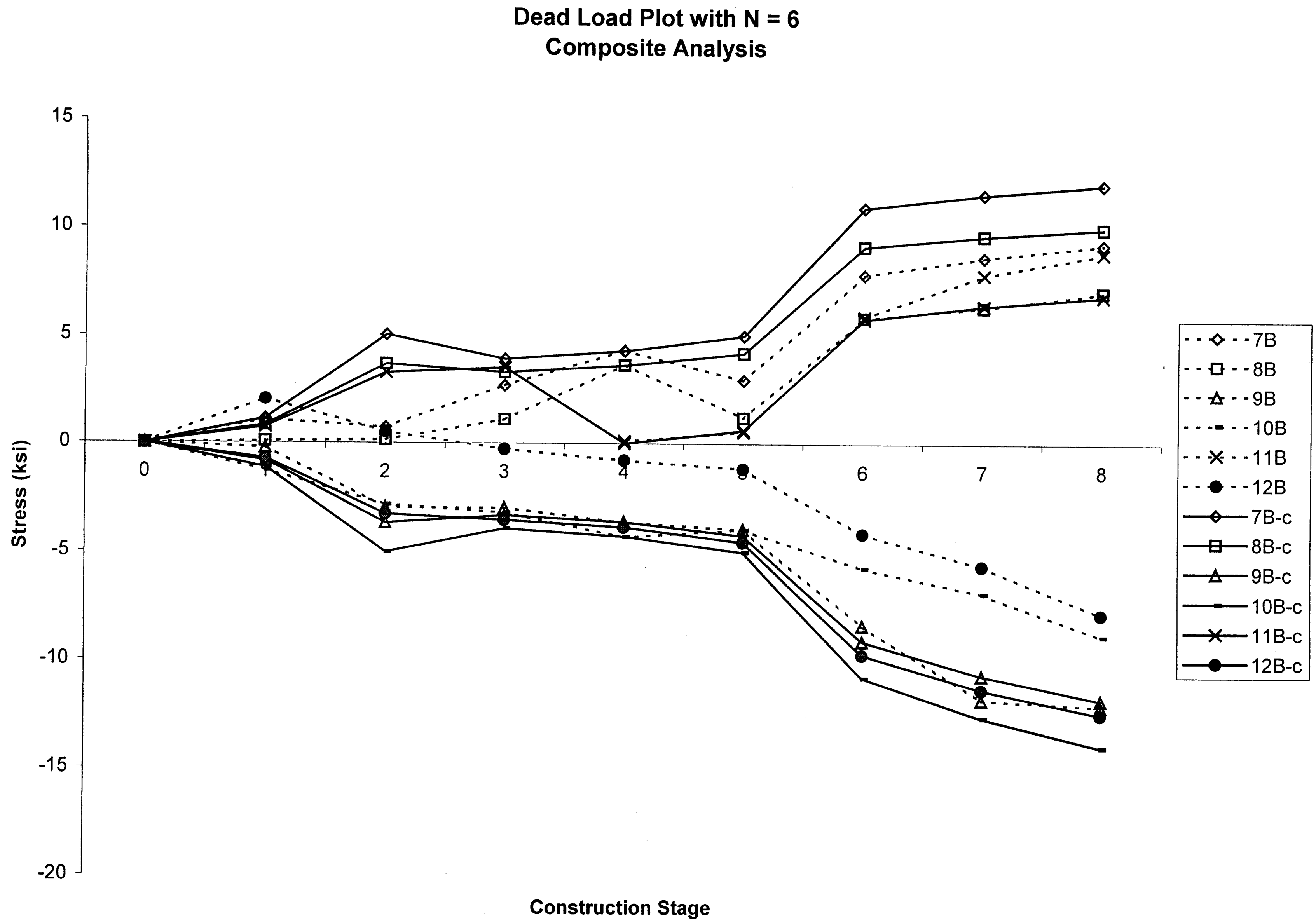


Figure D.6: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 7B-12B)

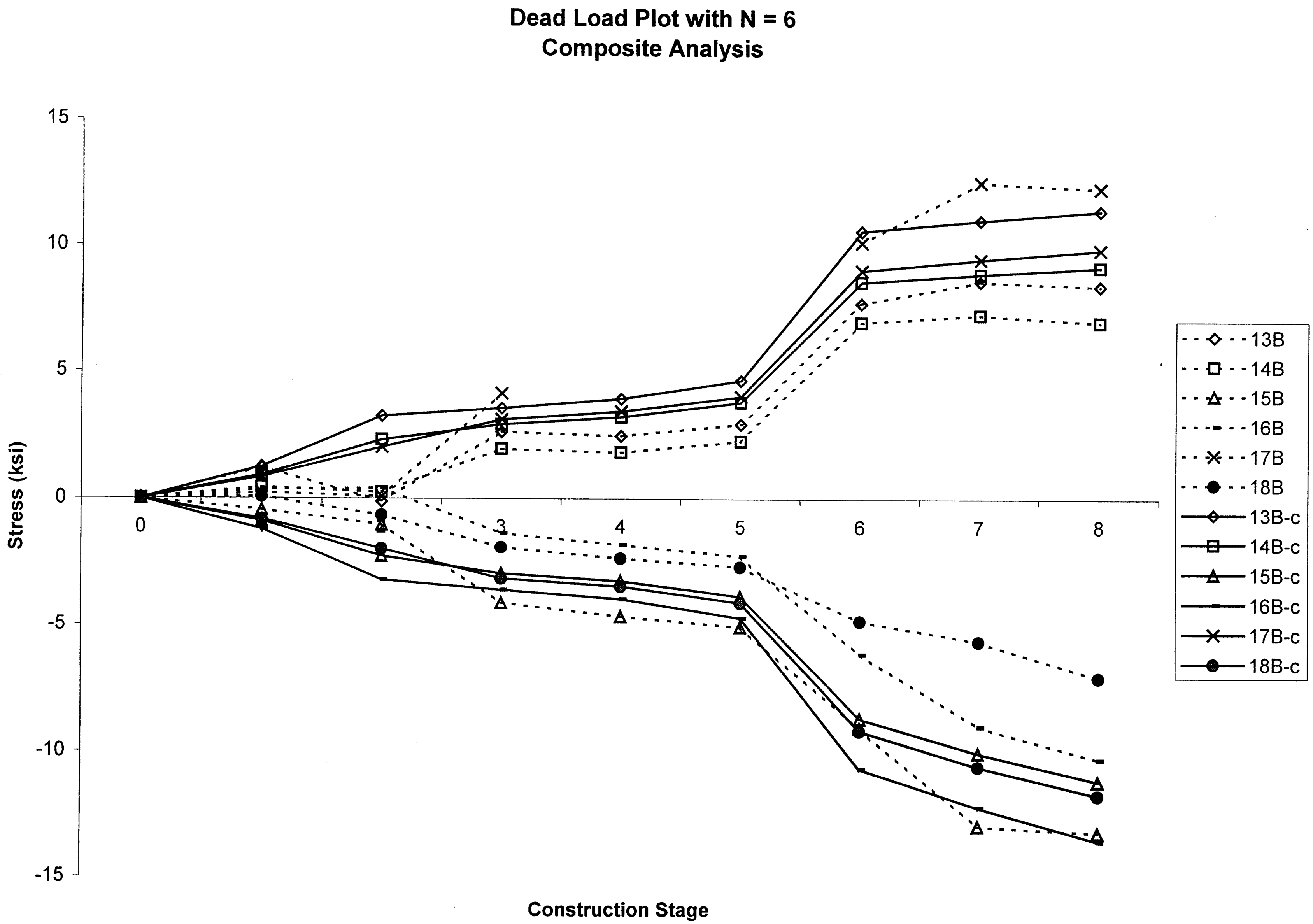


Figure D.7: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 13B-18B)

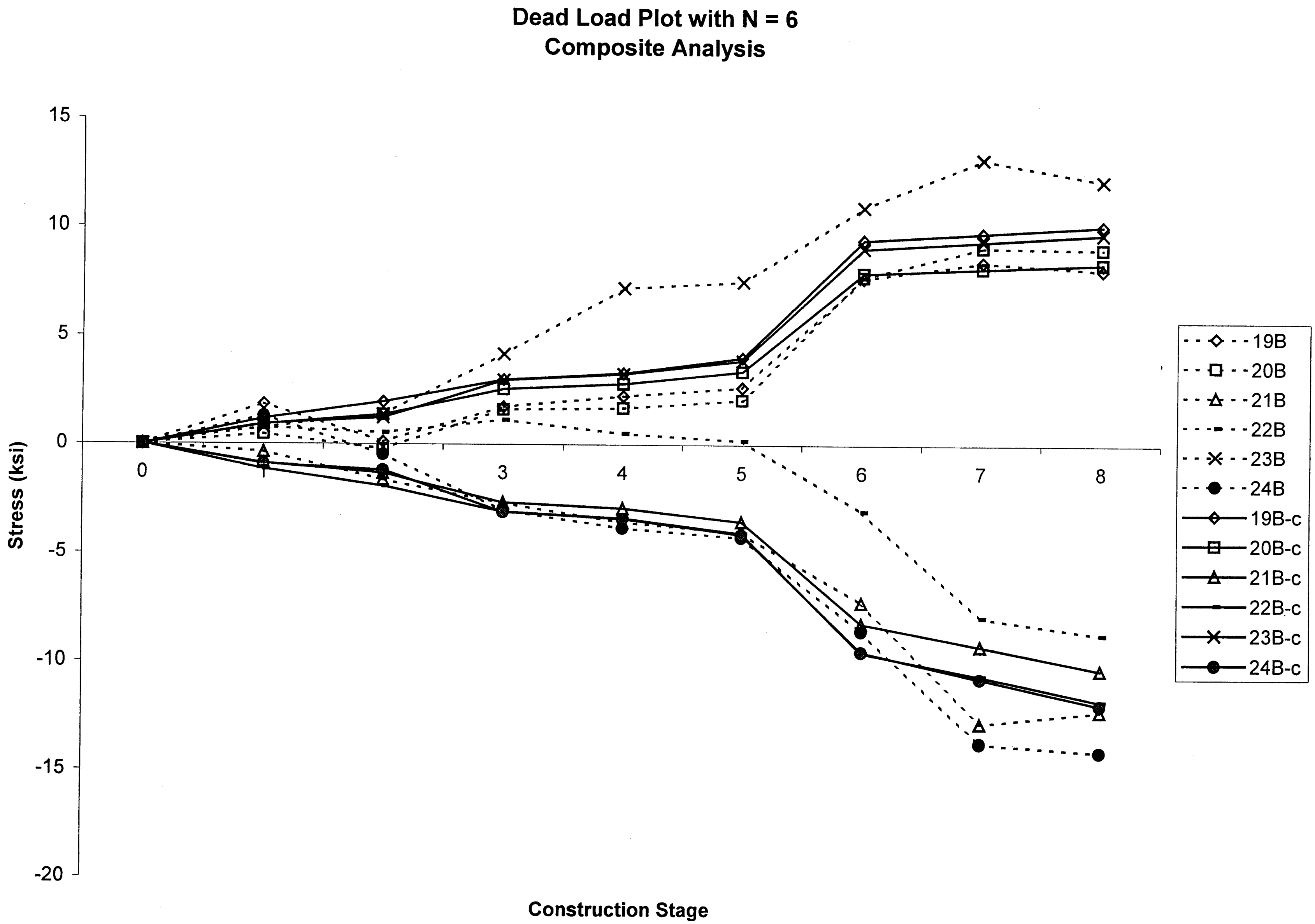


Figure D.8: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 19B-24B)

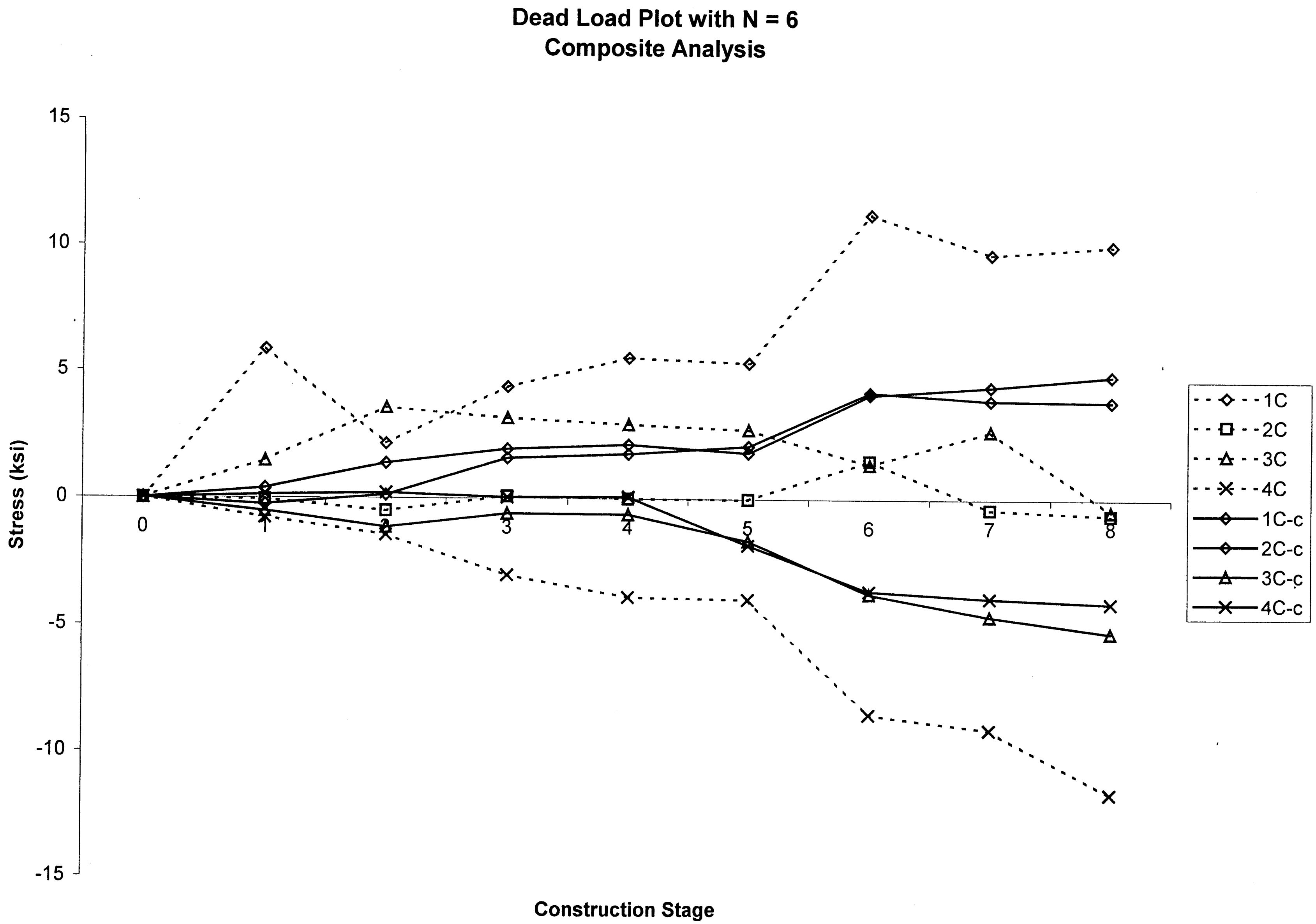


Figure D.9: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 1C-4C)

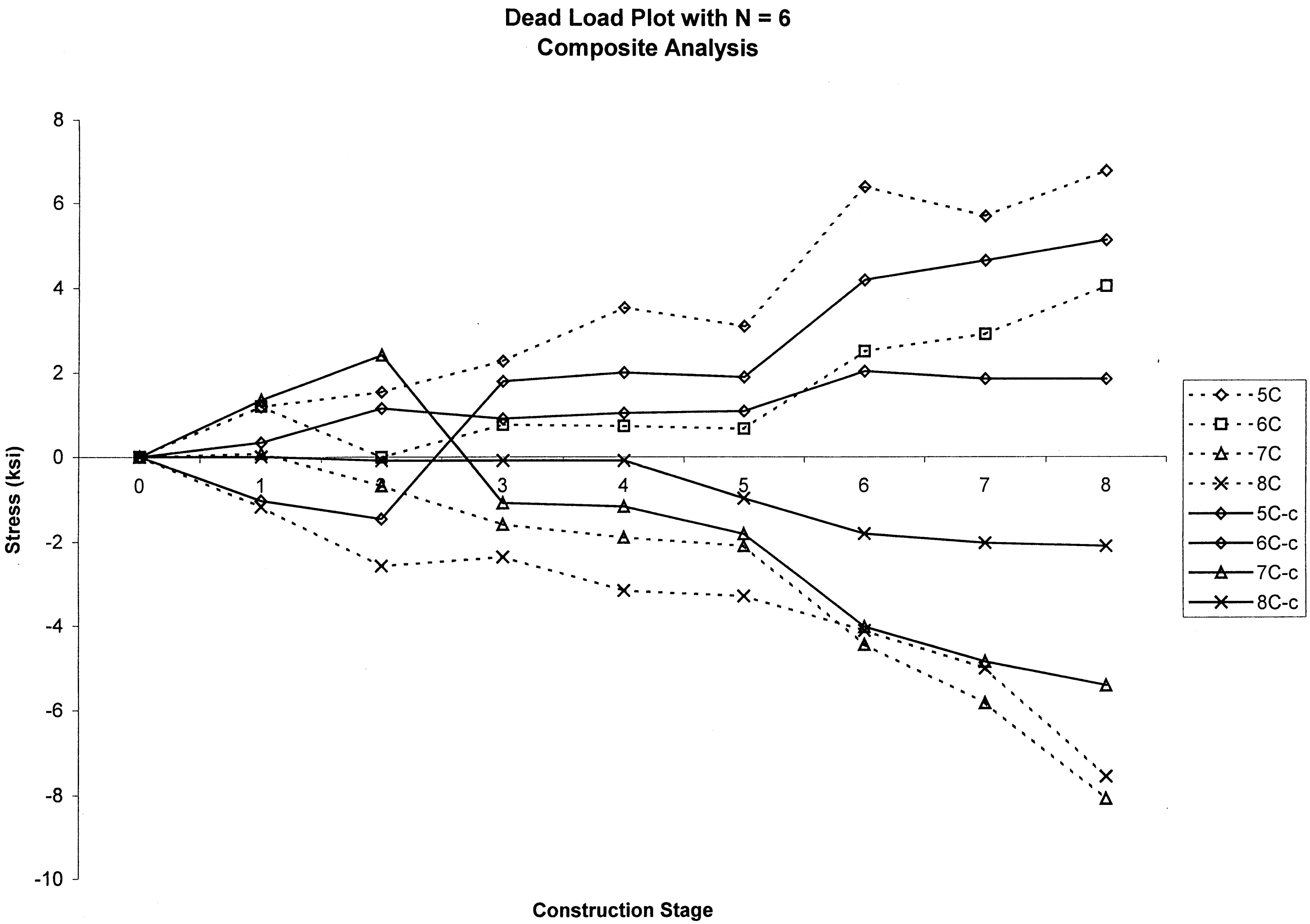


Figure D.10: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 5C-8C)

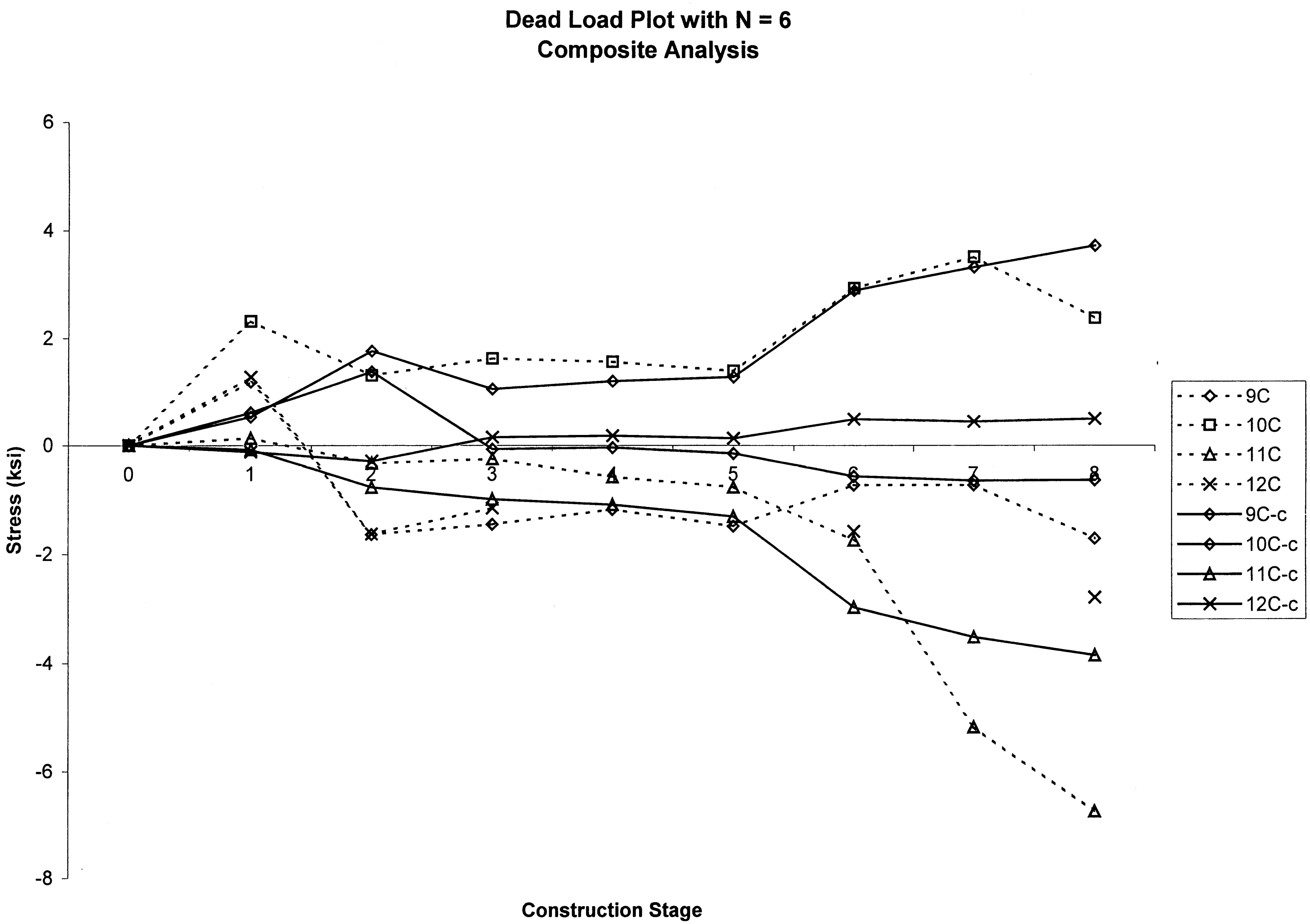


Figure D.11: Dead Load Stress During Construction, Composite Analysis, N = 6 (Gages 9C-12C)

APPENDIX E

BAR CHARTS OF 1997 ANALYSIS VS. 1997 AND 2000 MEASURED STRESSES

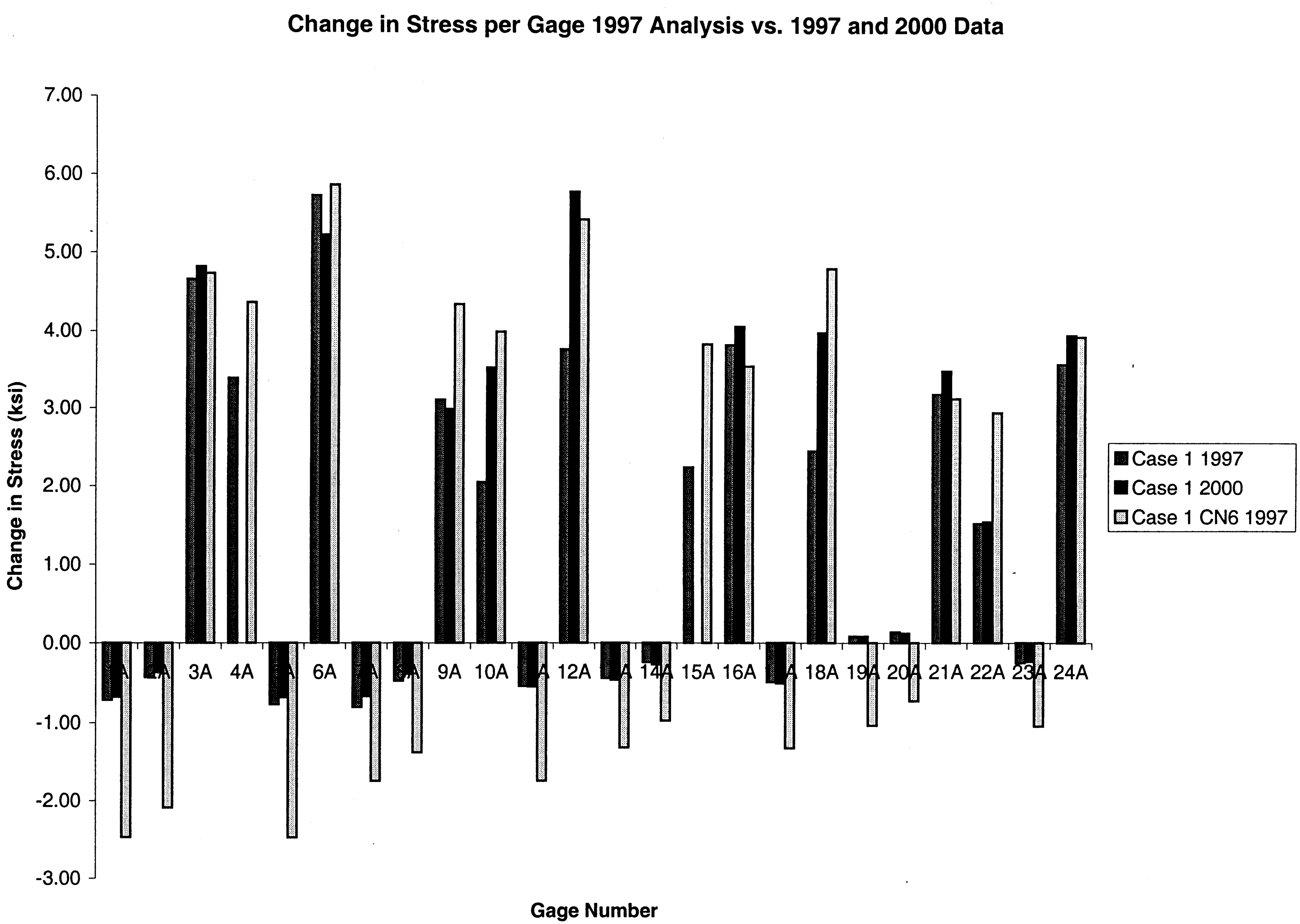


Figure E.1: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 1, Gage Line A)

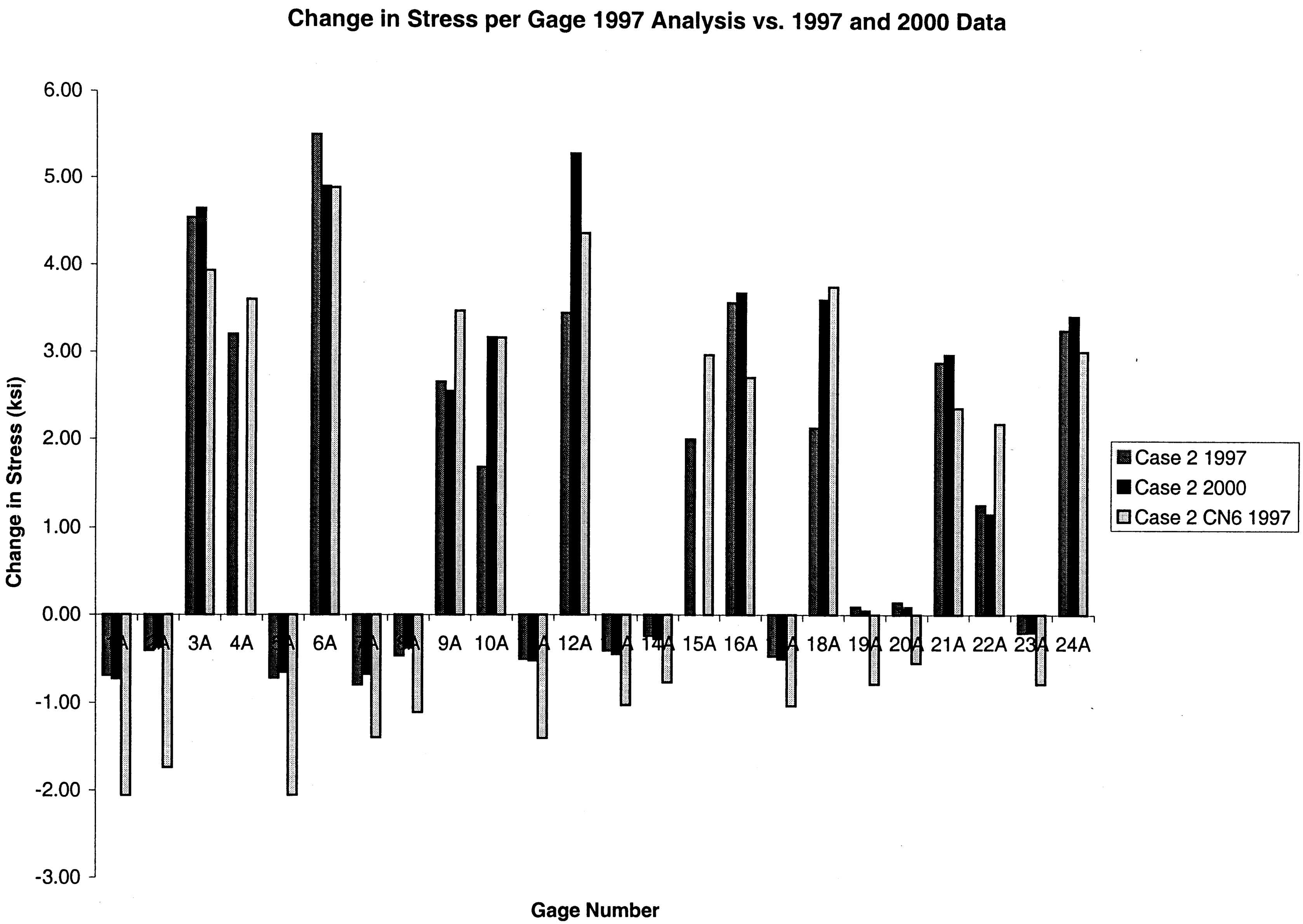


Figure E.2: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 2, Gage Line A)

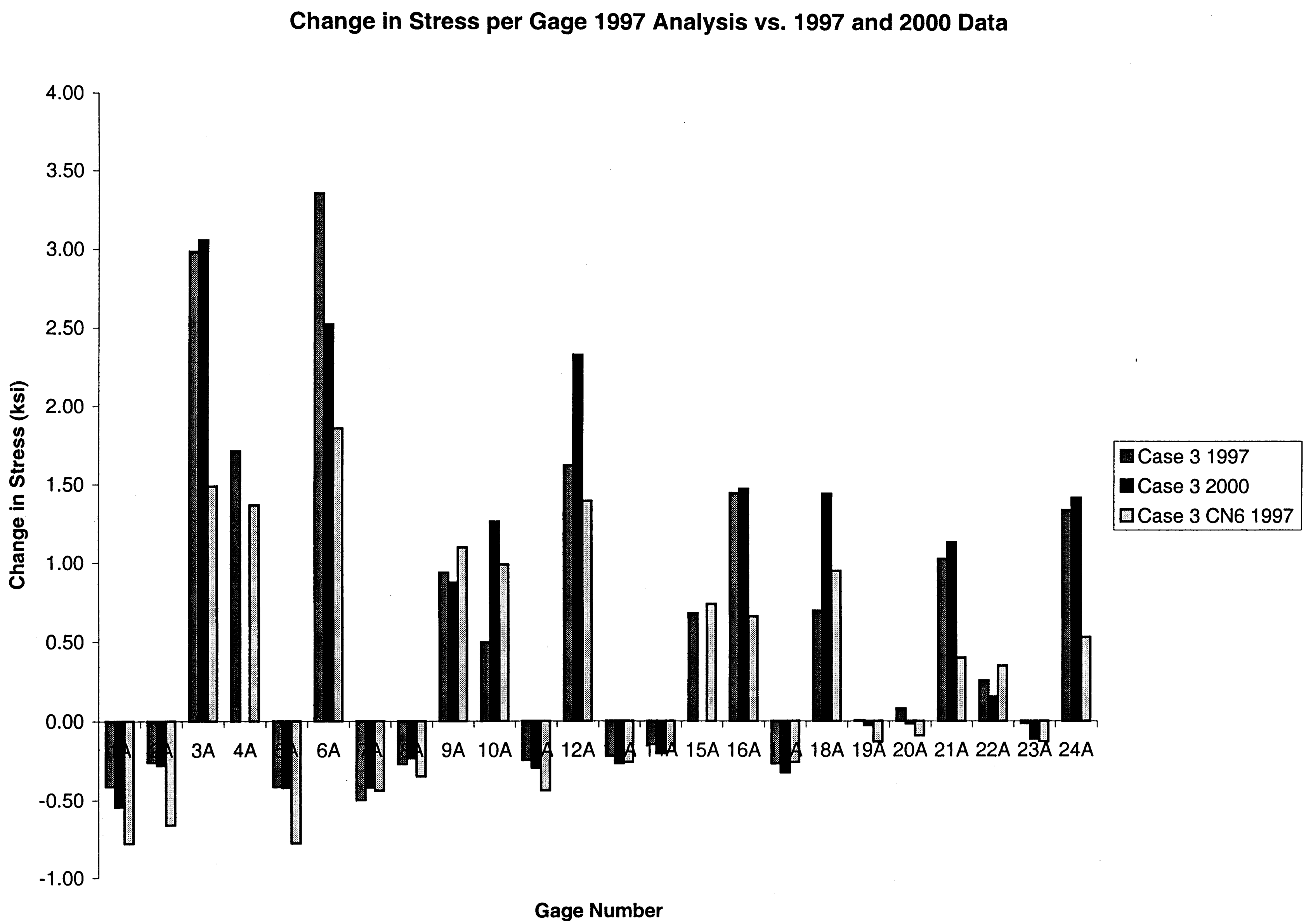


Figure E.3: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 3, Gage Line A)

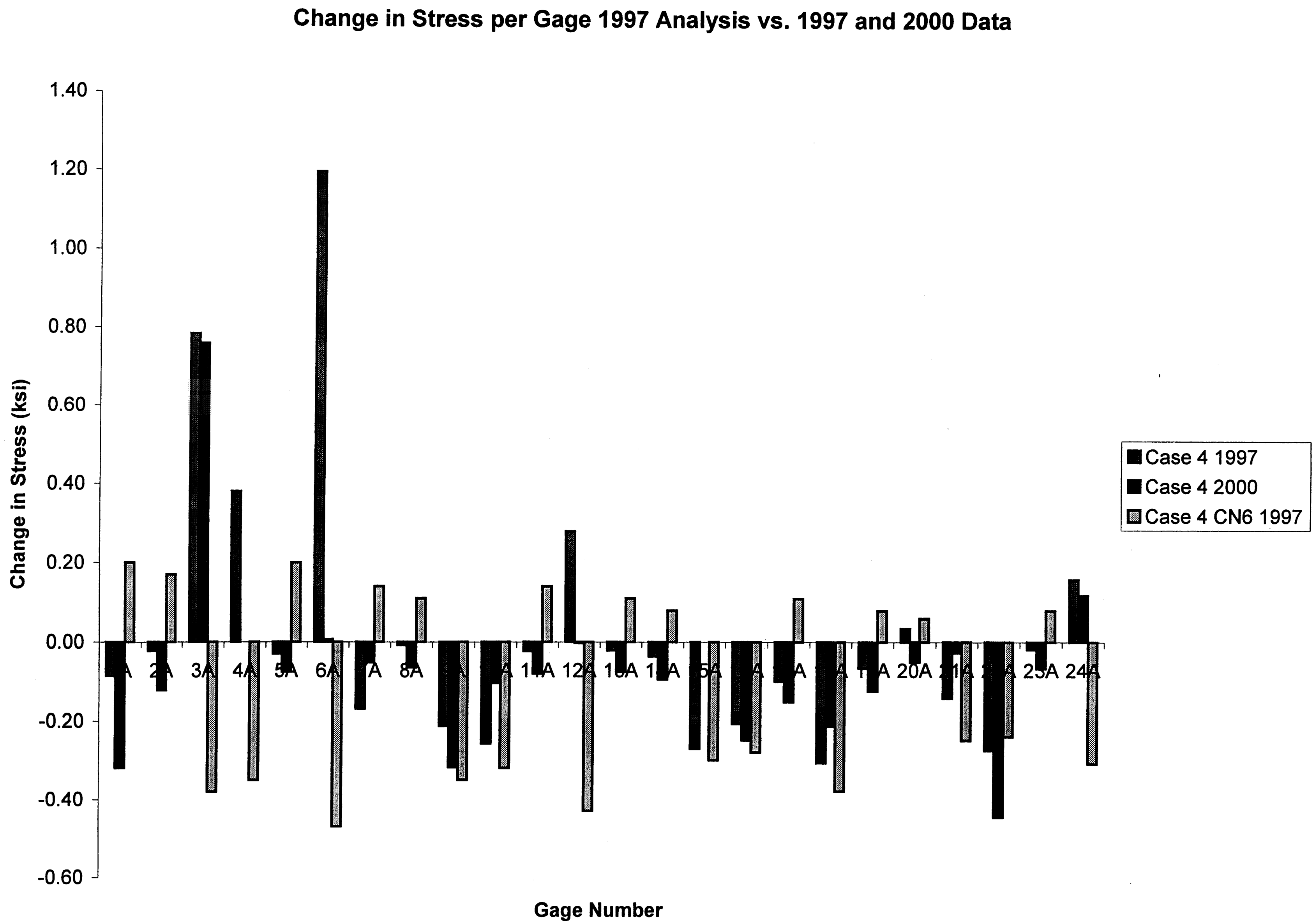


Figure E.4: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 4, Gage Line A)

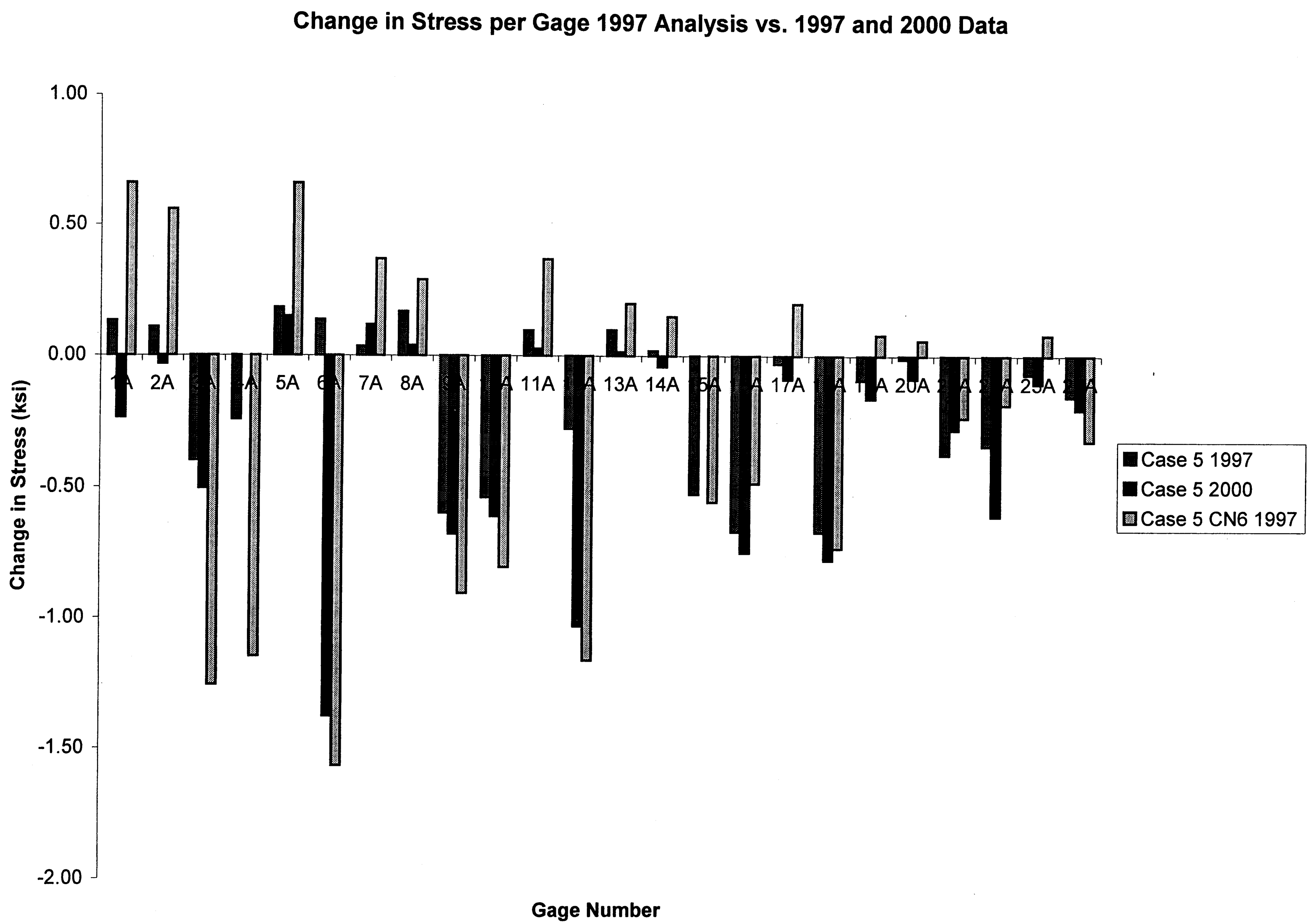


Figure E.5: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 5, Gage Line A)

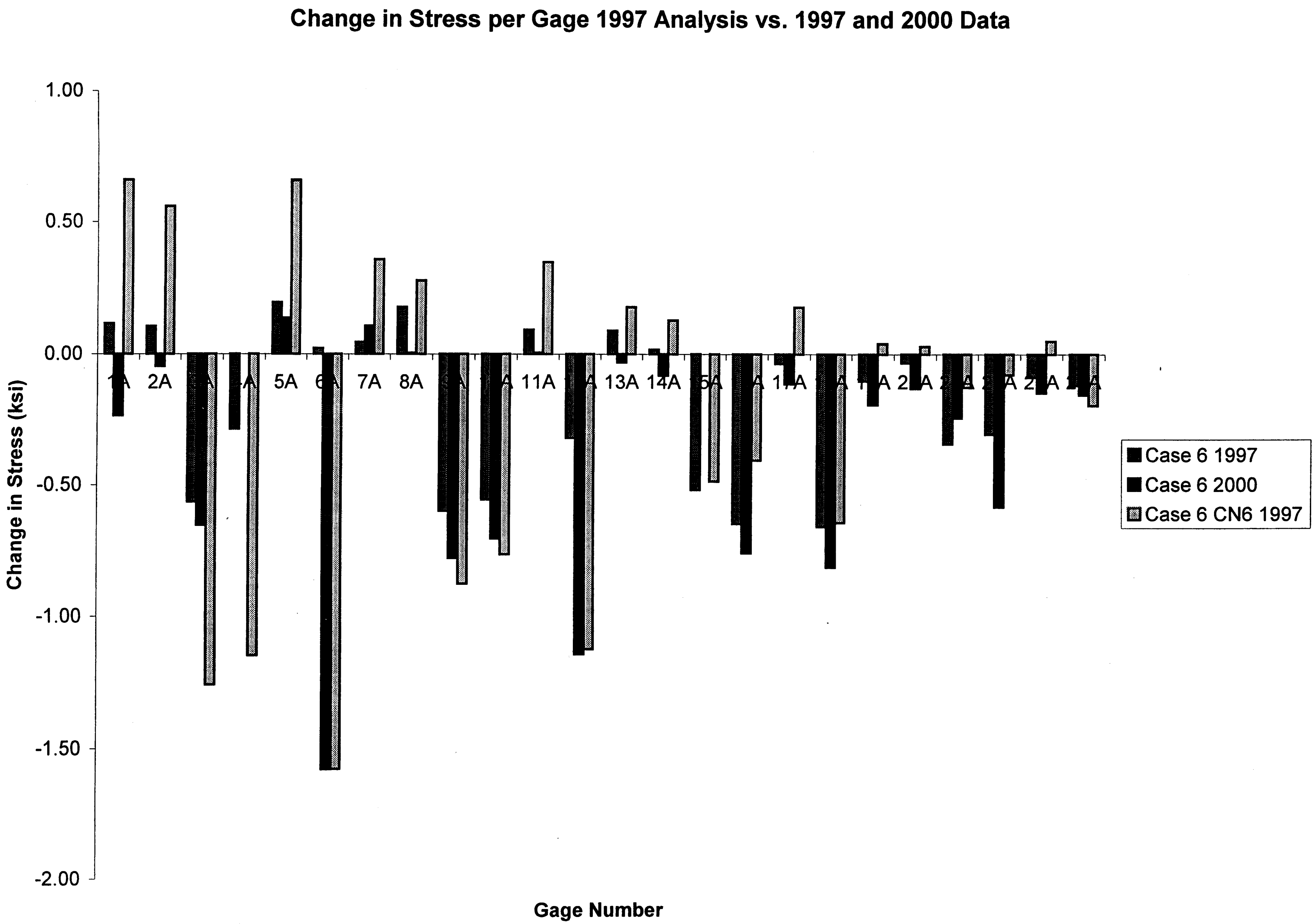


Figure E.6: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 6, Gage Line A)

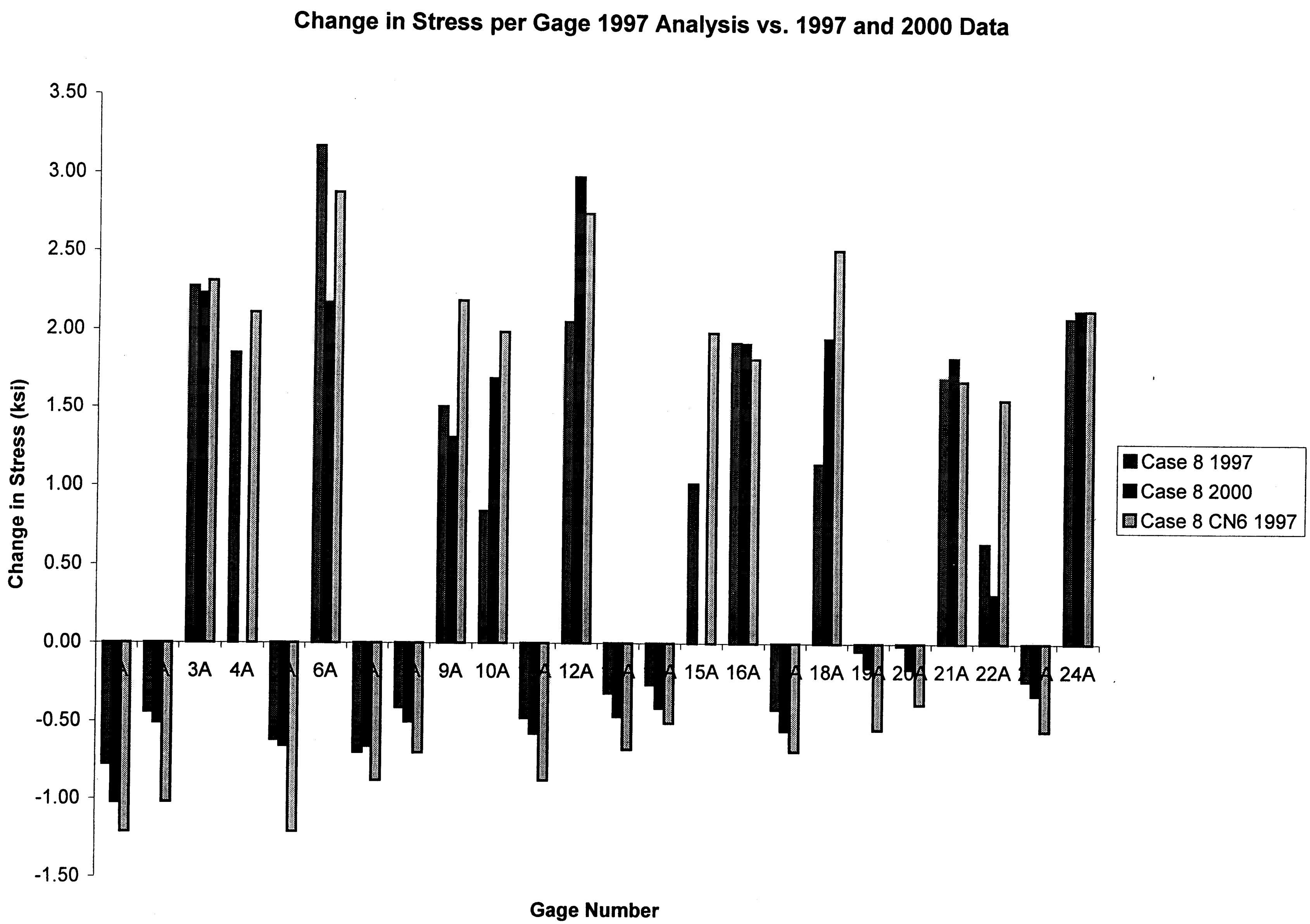


Figure E.7: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 8, Gage Line A)

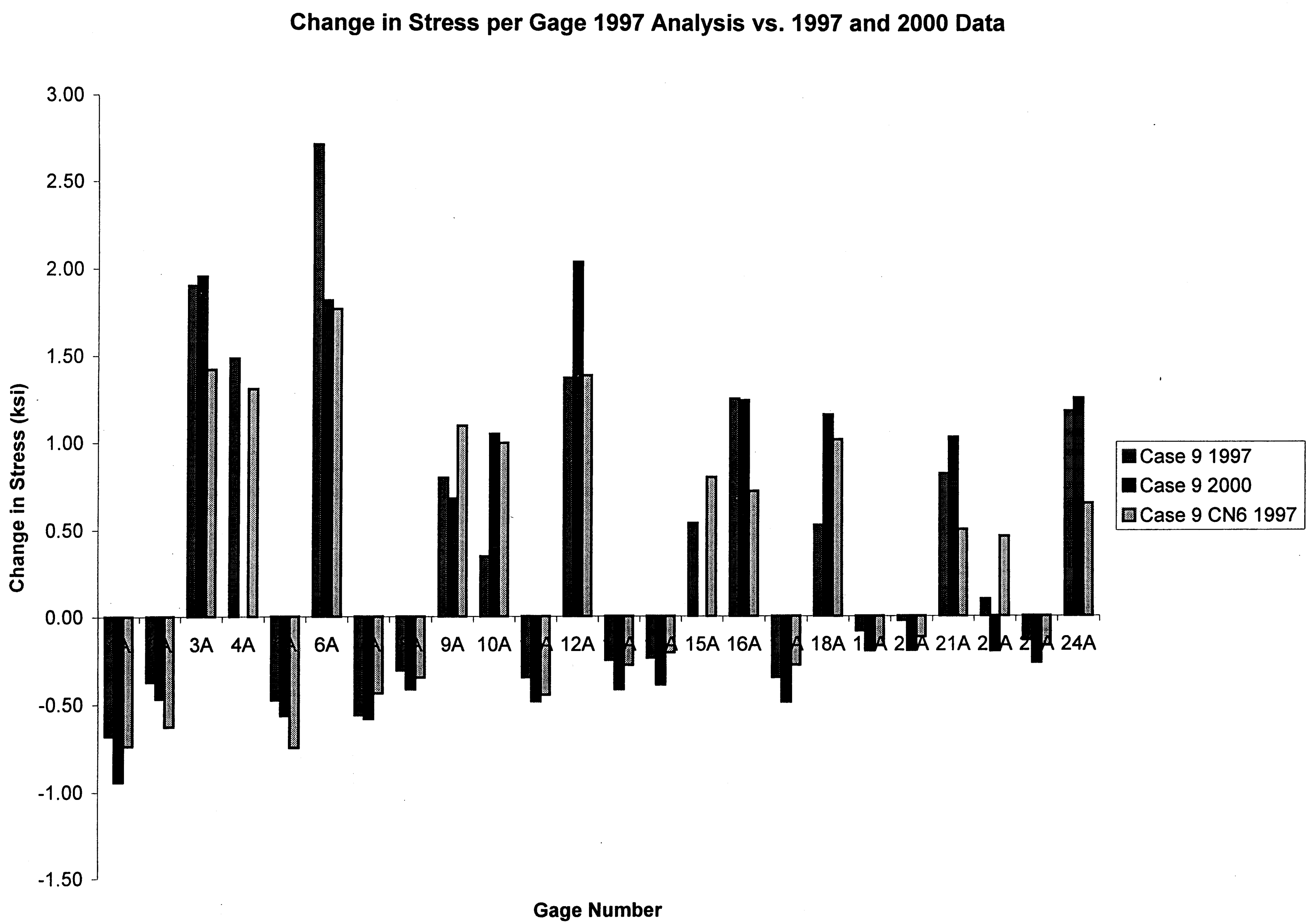


Figure E.8: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 9, Gage Line A)

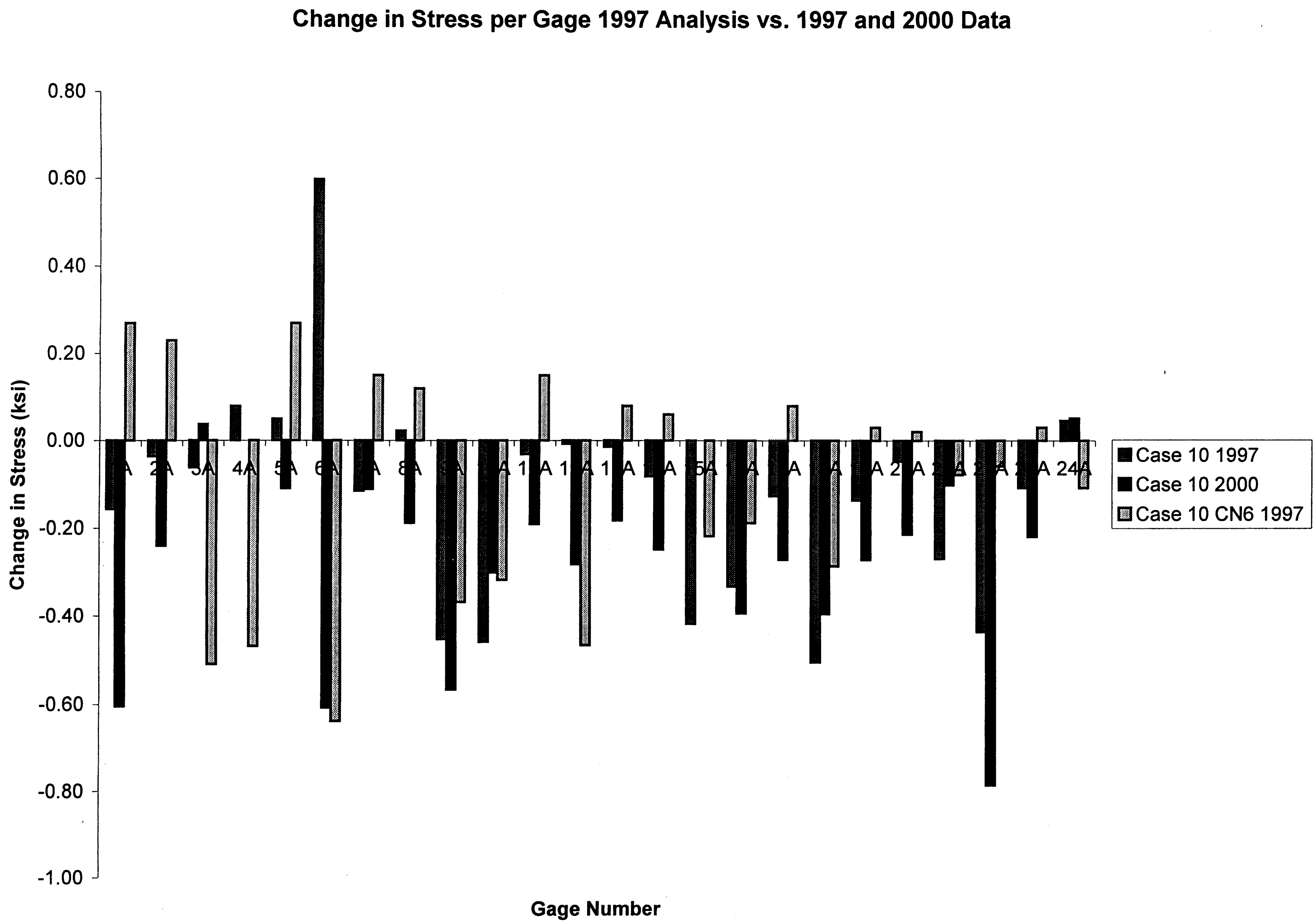


Figure E.9: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 10, Gage Line A)

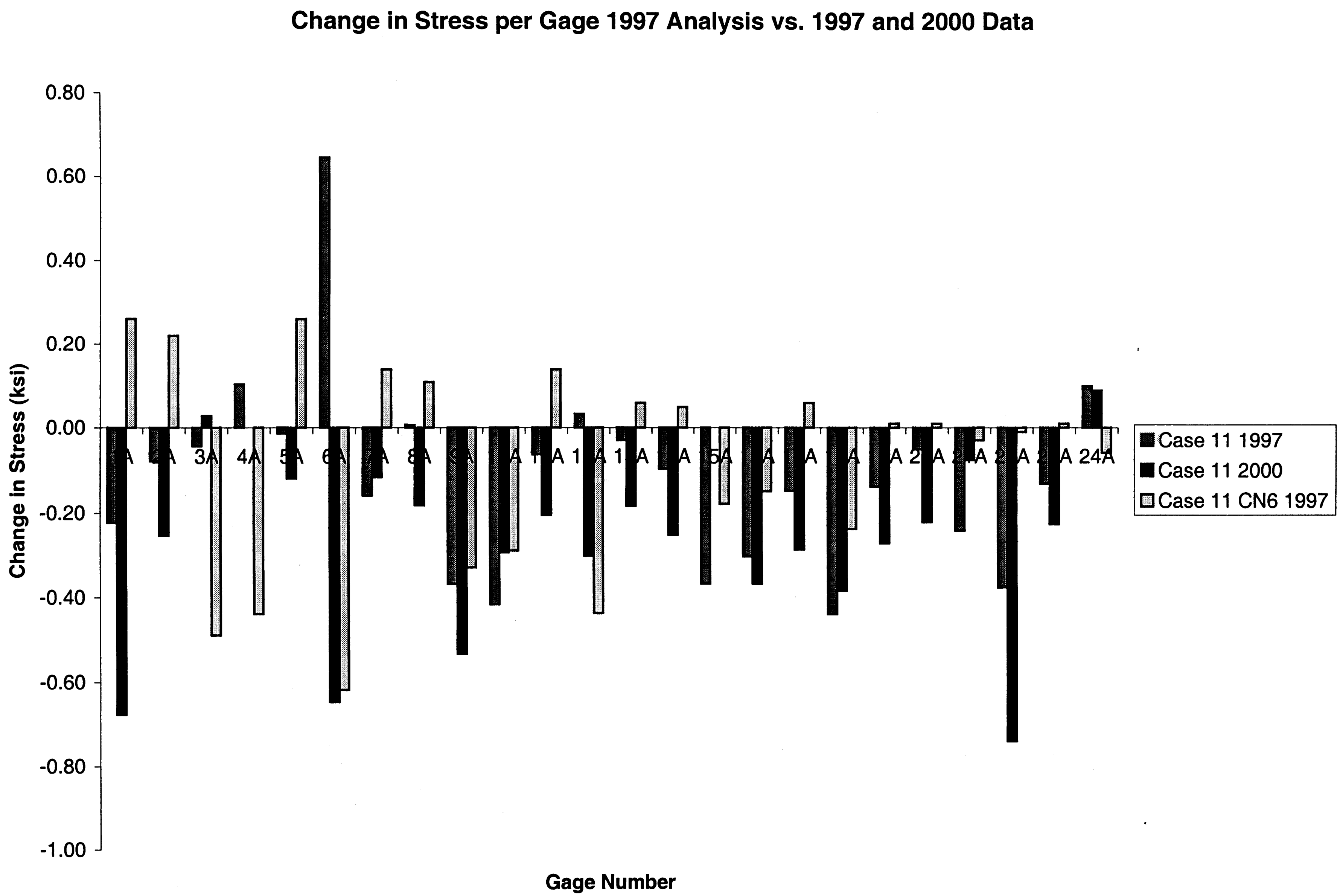


Figure E.10: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 11, Gage Line A)

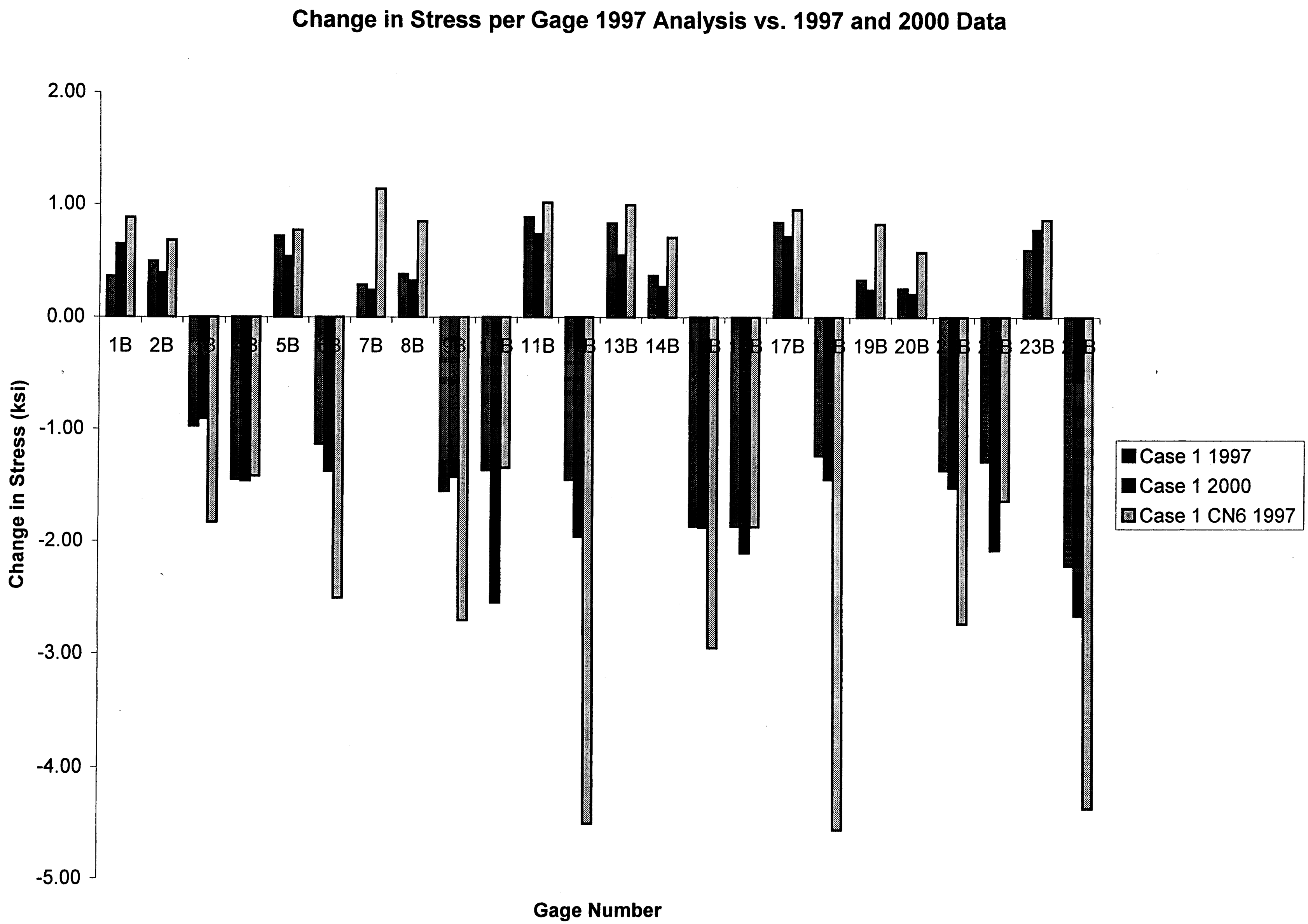


Figure E.11: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 1, Gage Line B)

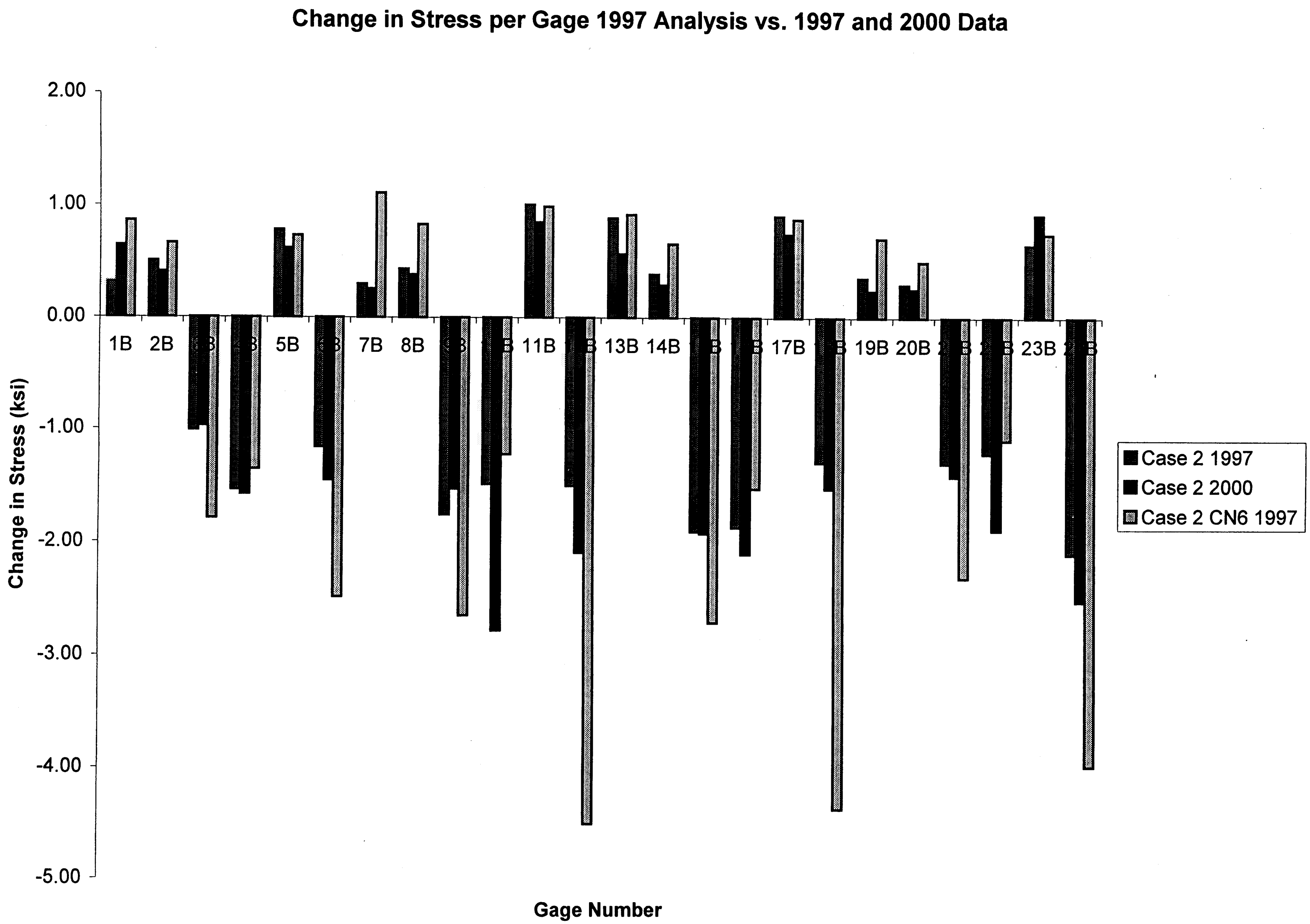


Figure E.12: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 2, Gage Line B)

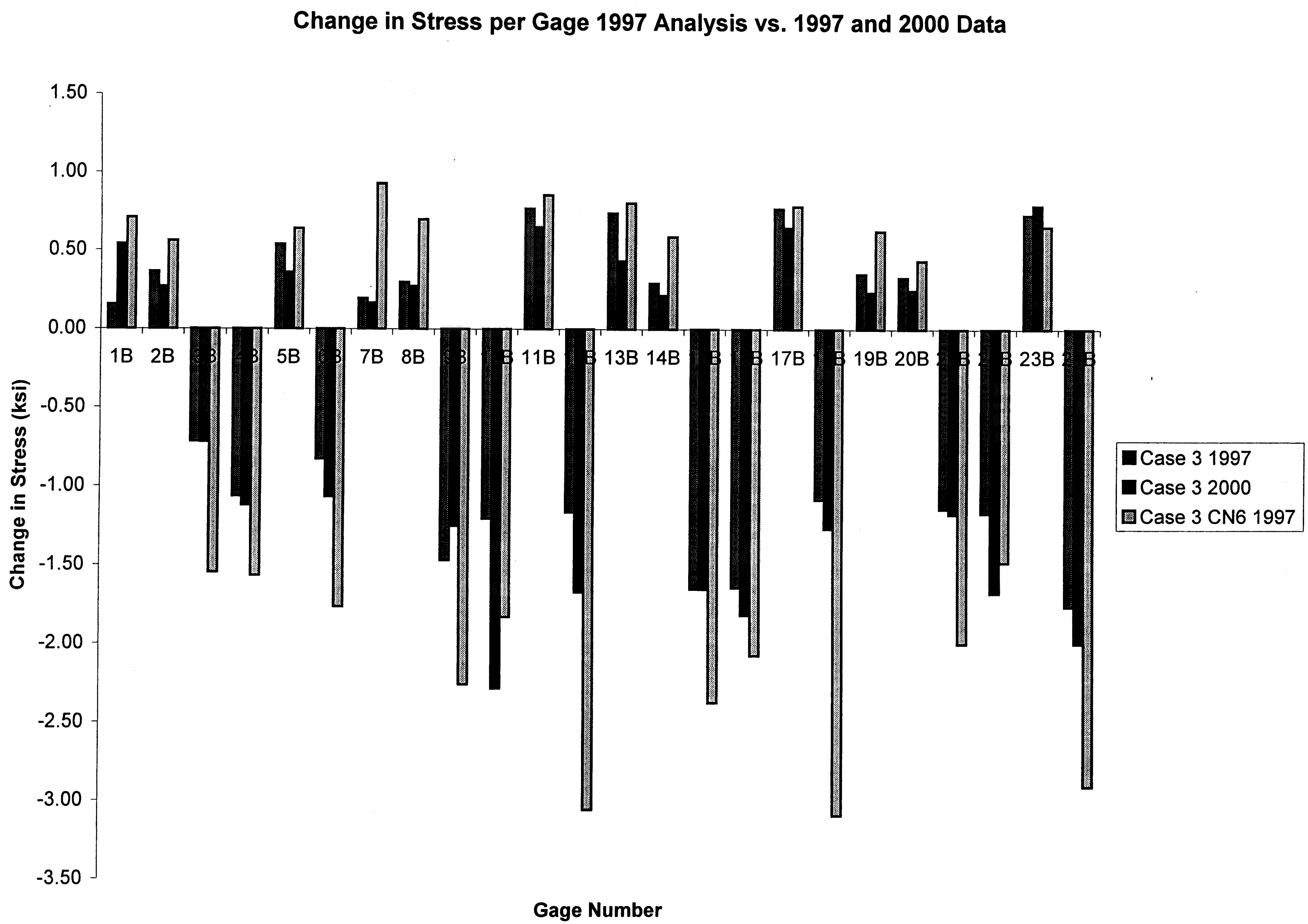


Figure E.13: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 3, Gage Line B)

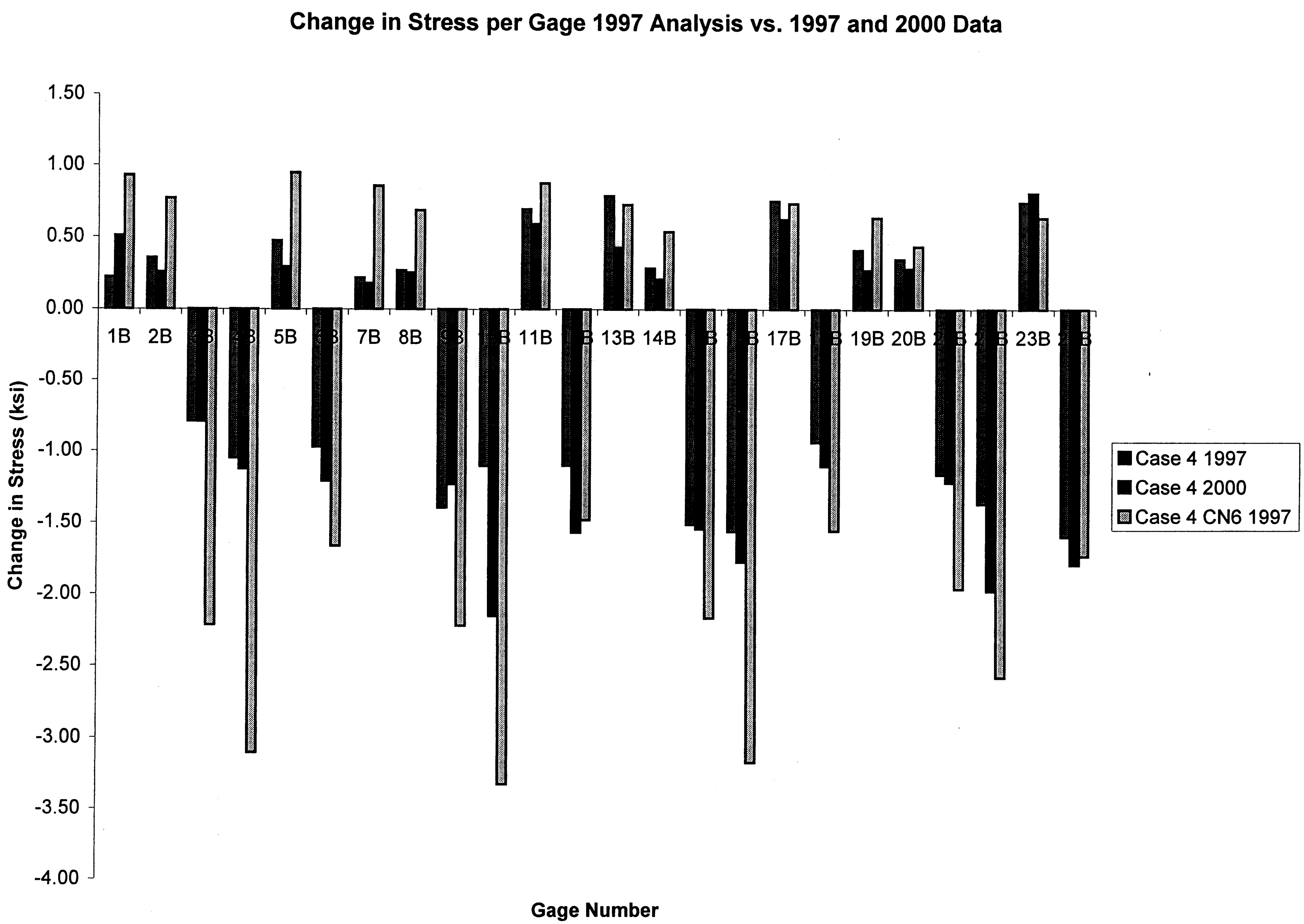


Figure E.14: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 4, Gage Line B)

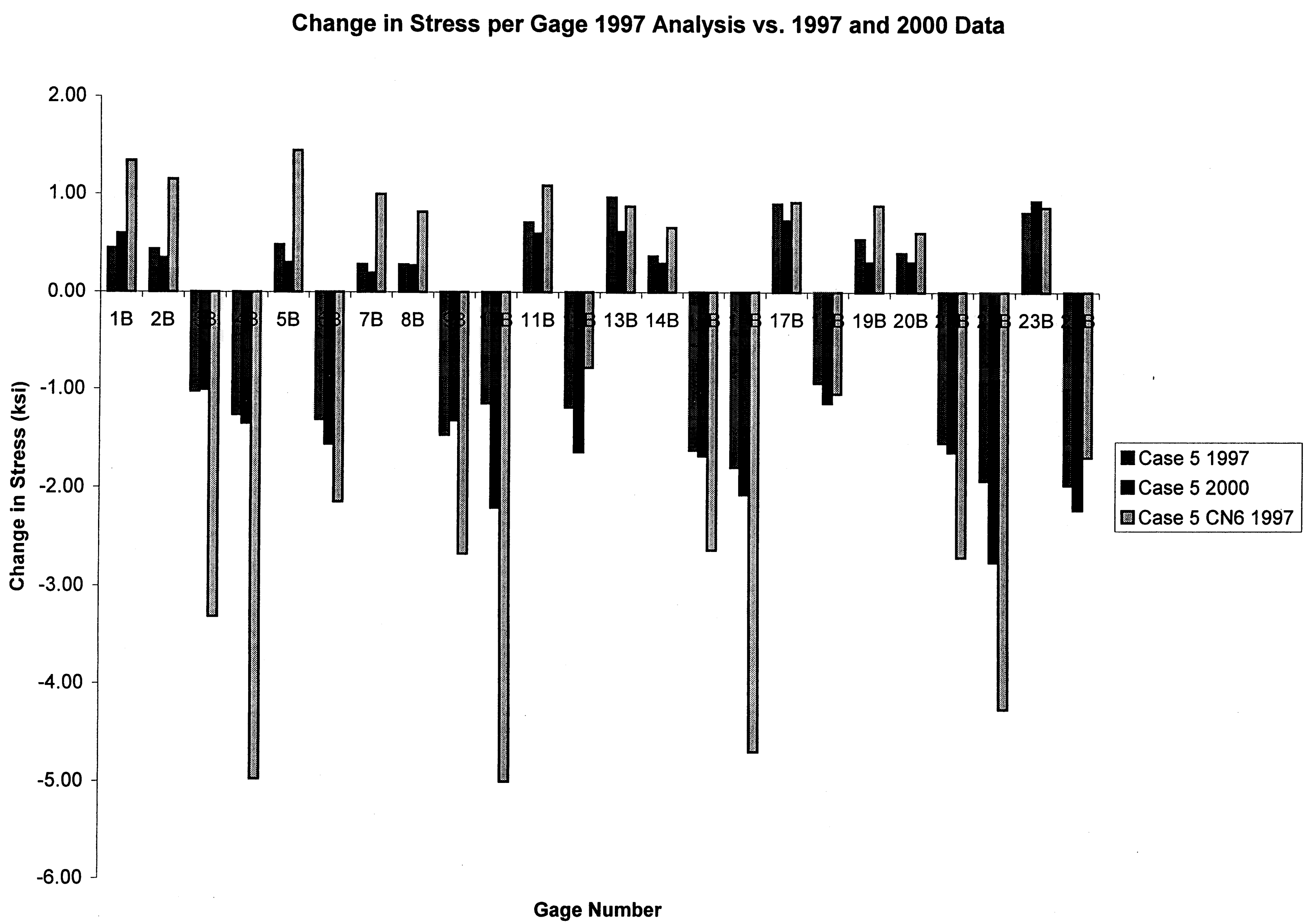


Figure E.15: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 5, Gage Line B)

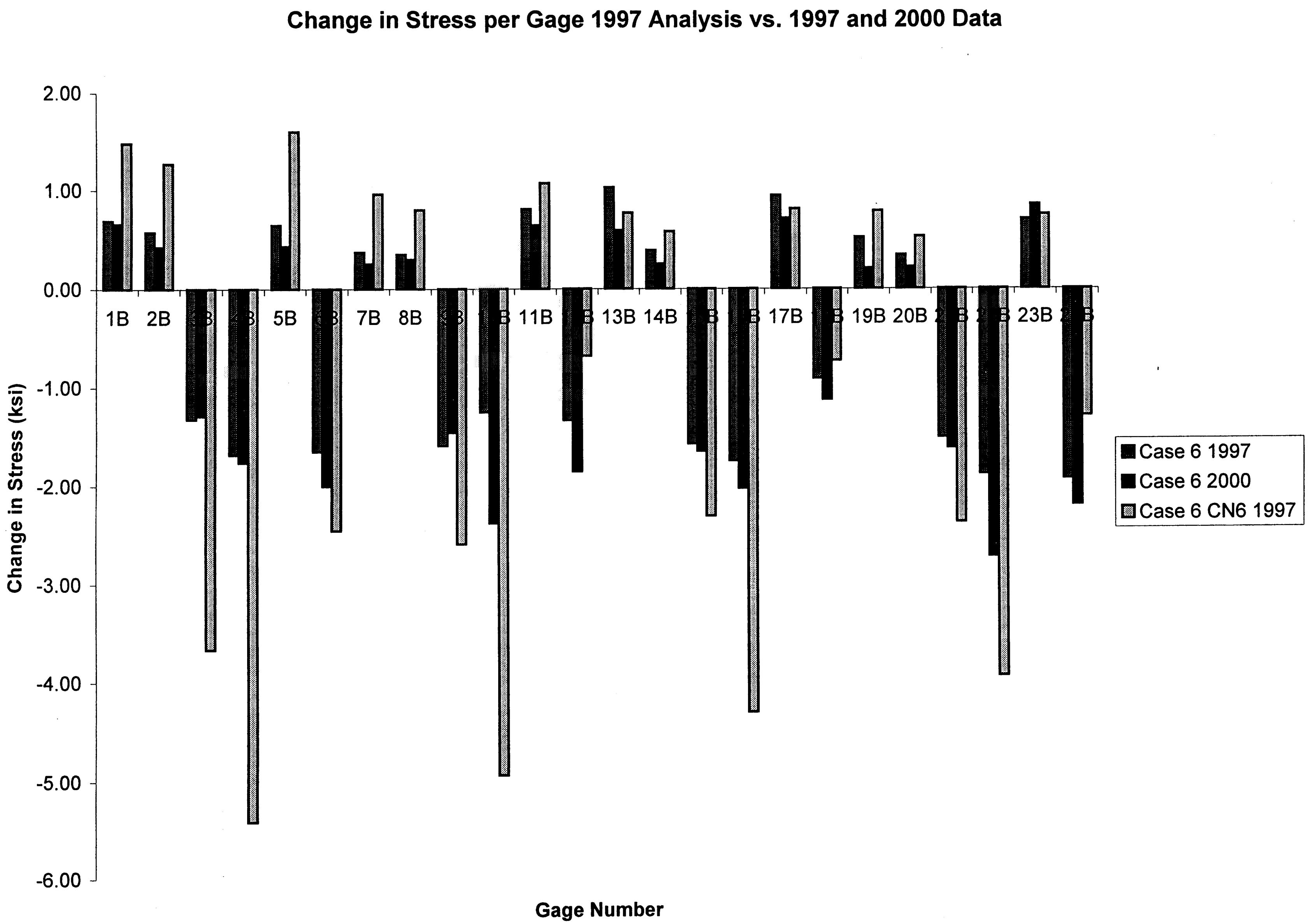


Figure E.16: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 6, Gage Line B)

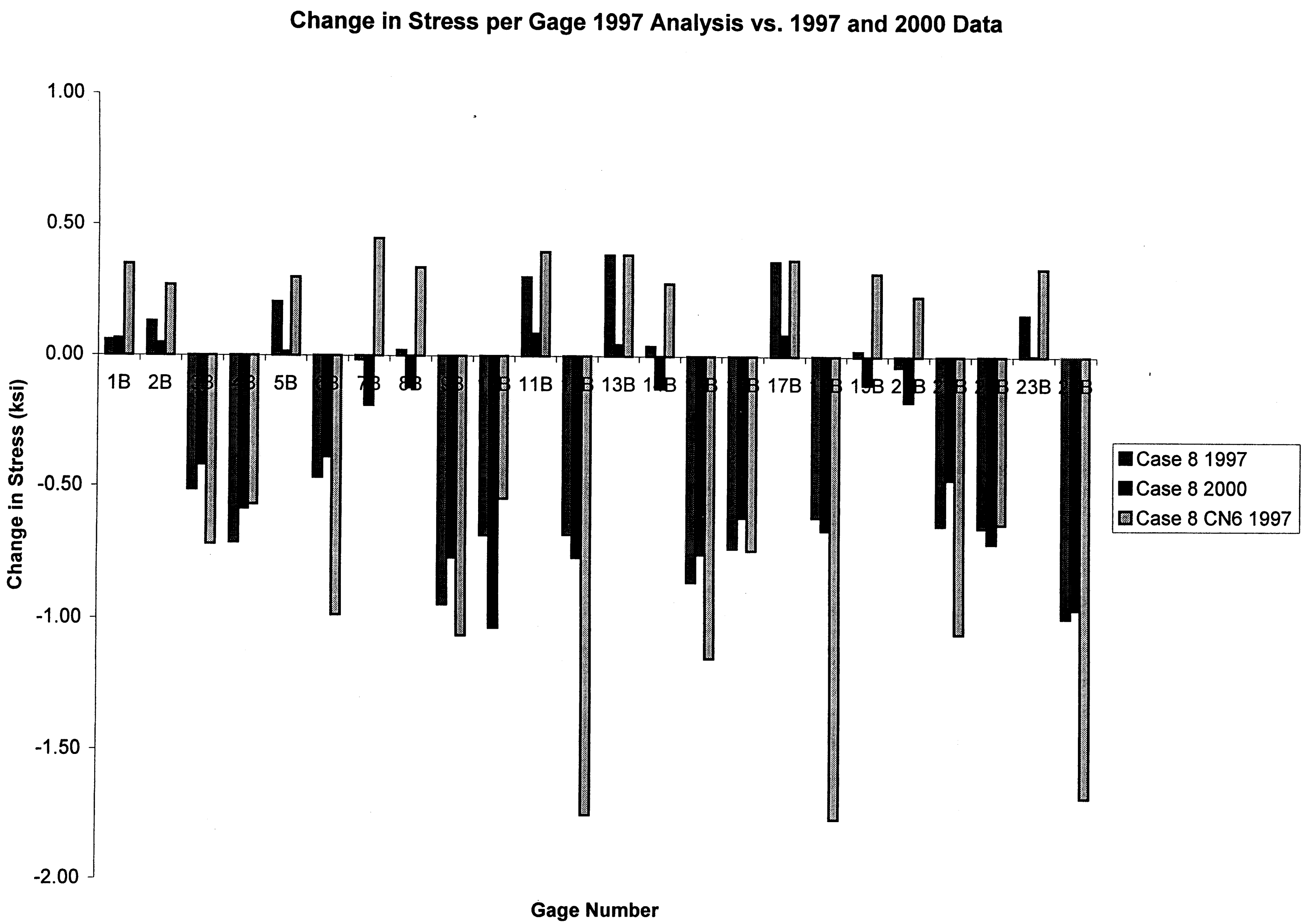


Figure E.17: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 8, Gage Line B)

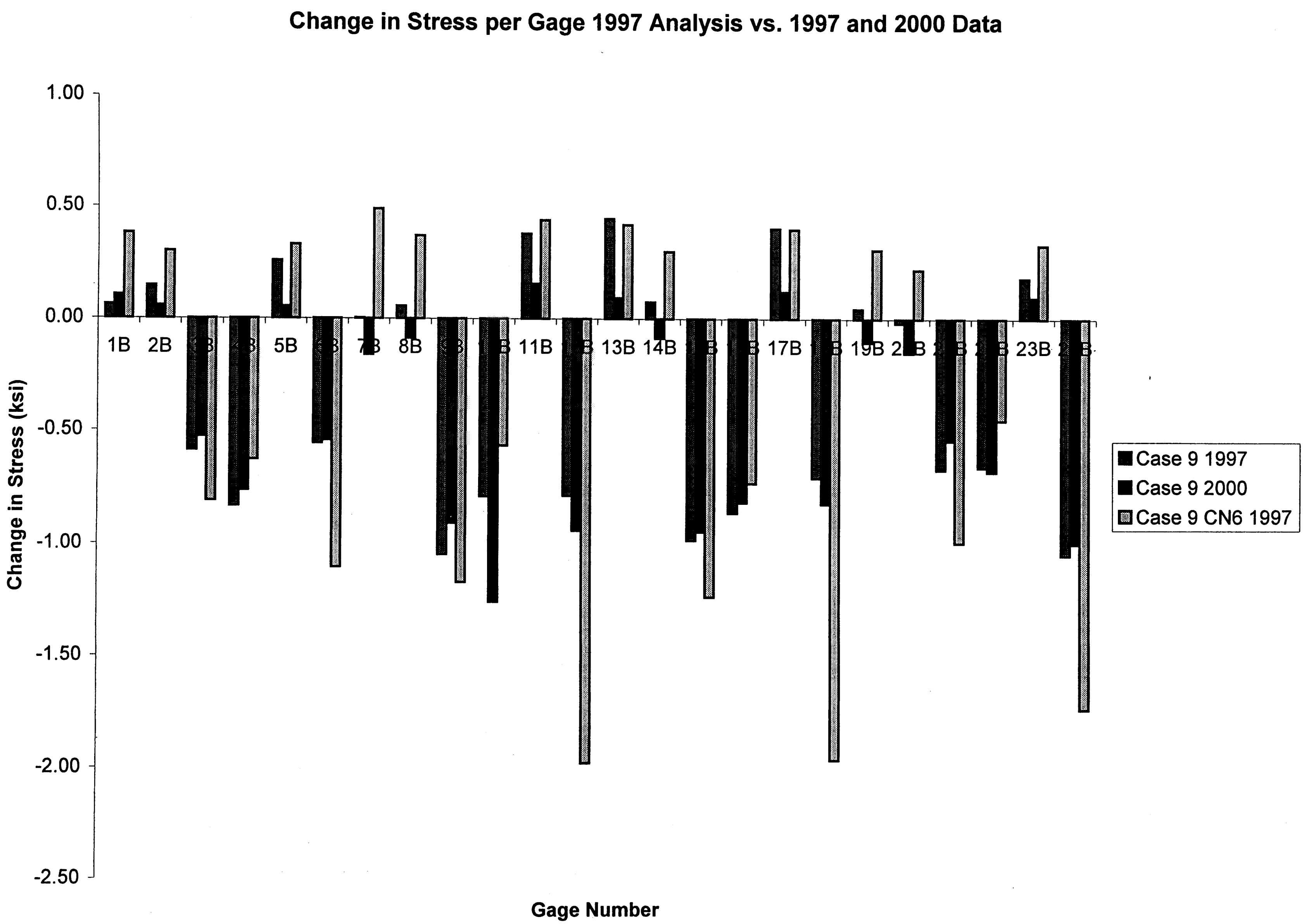


Figure E.18: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 9, Gage Line B)

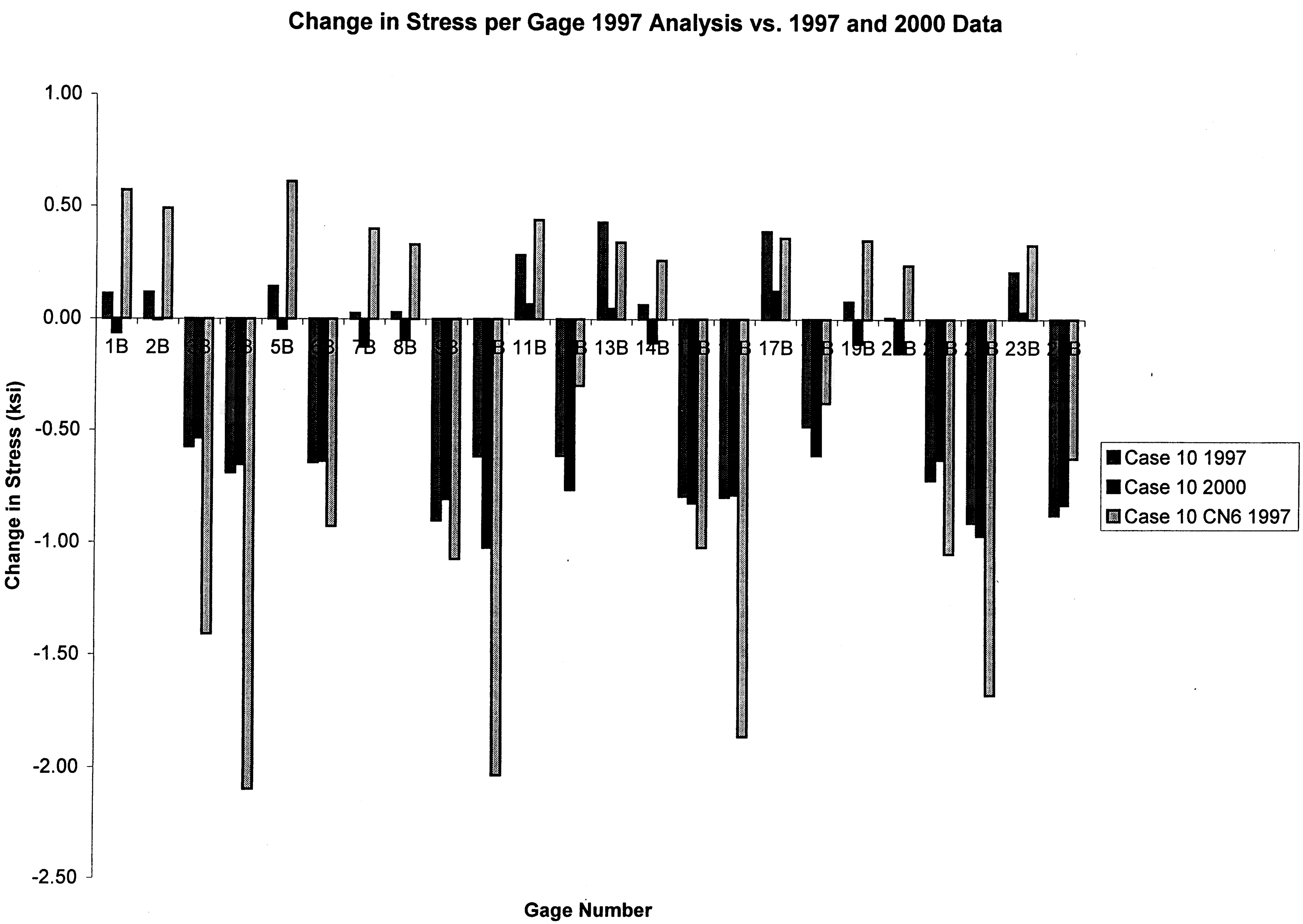


Figure E.19: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 10, Gage Line B)

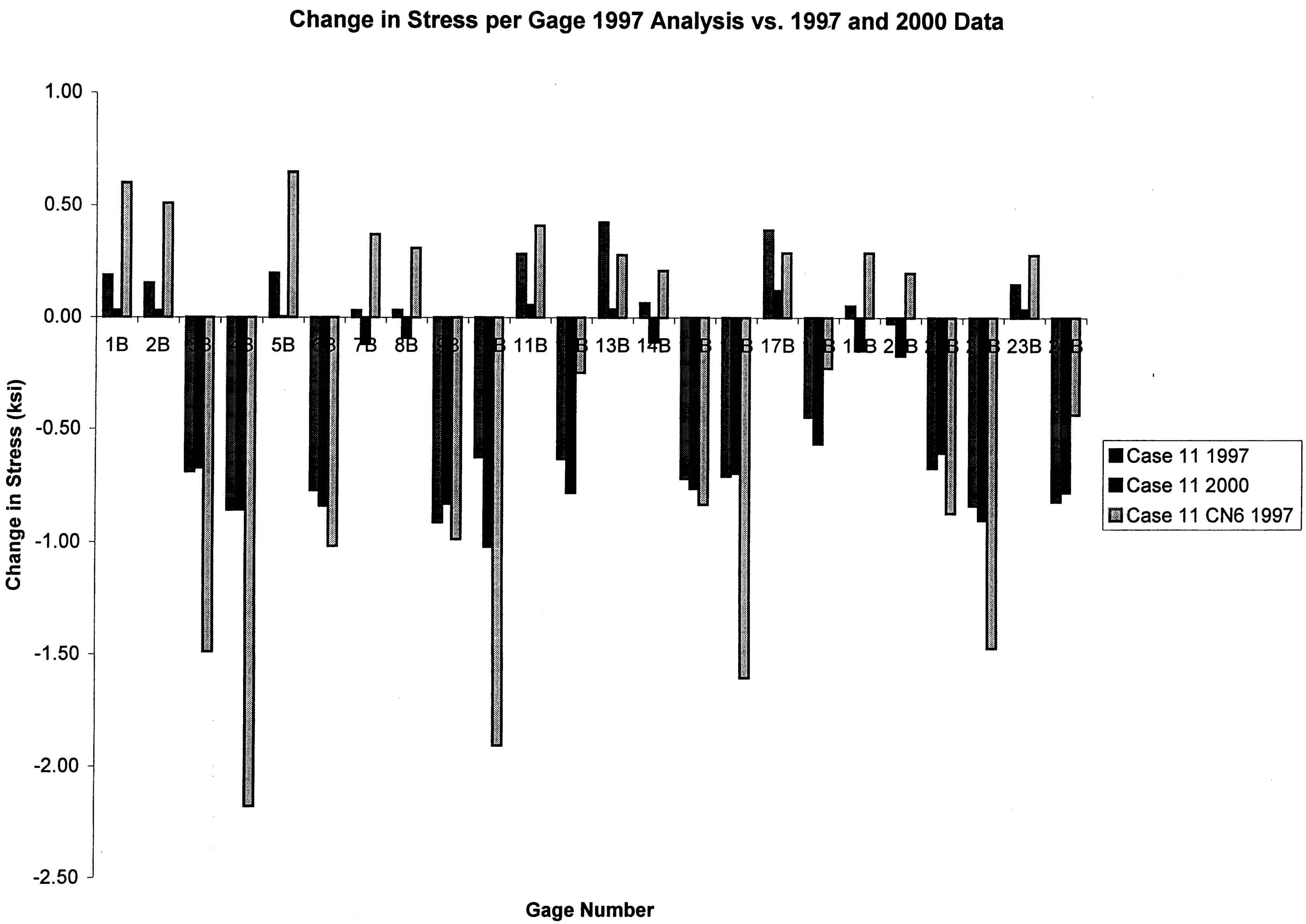


Figure E.20: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 11, Gage Line B)

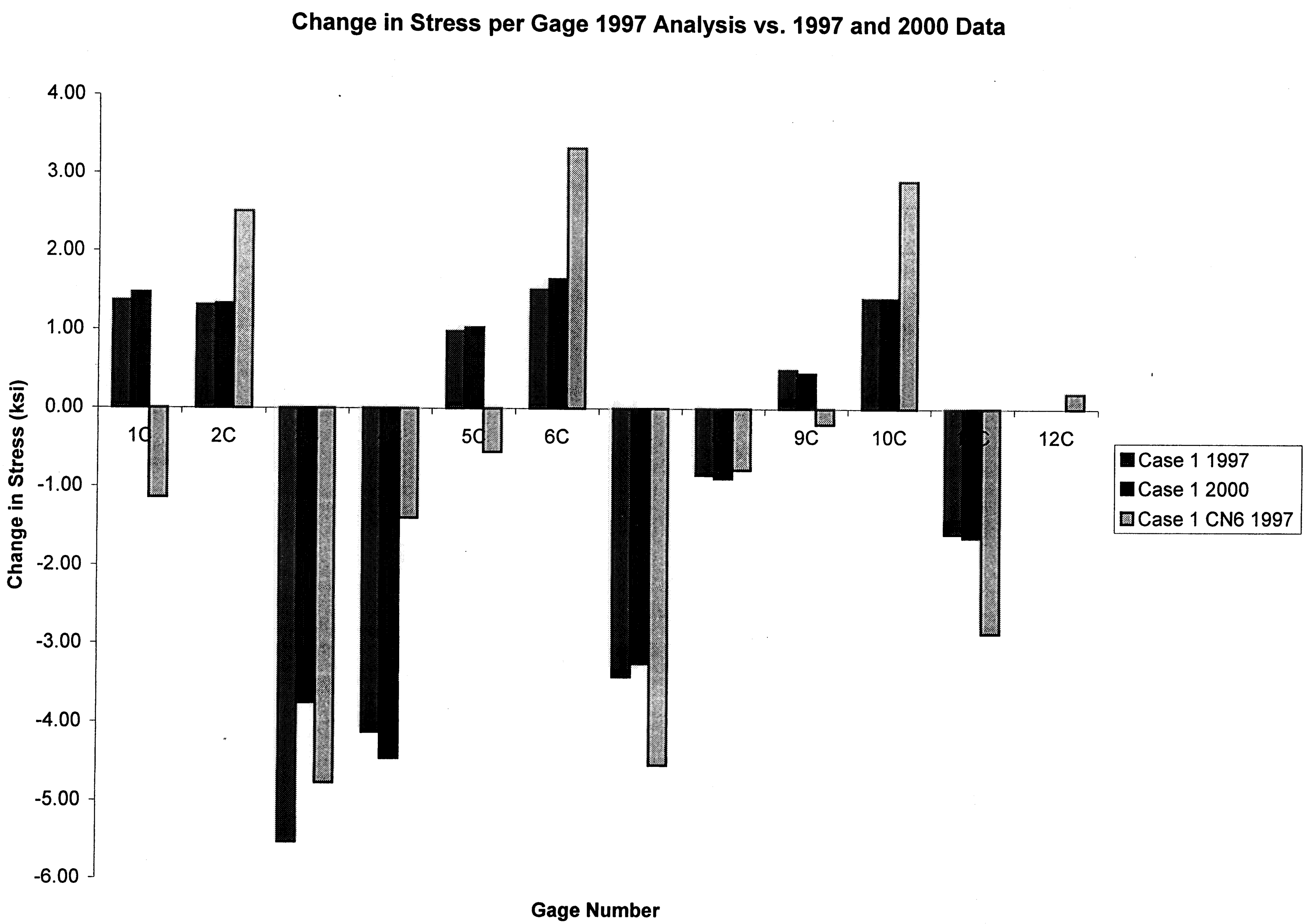


Figure E.21: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 1, Gage Line C)

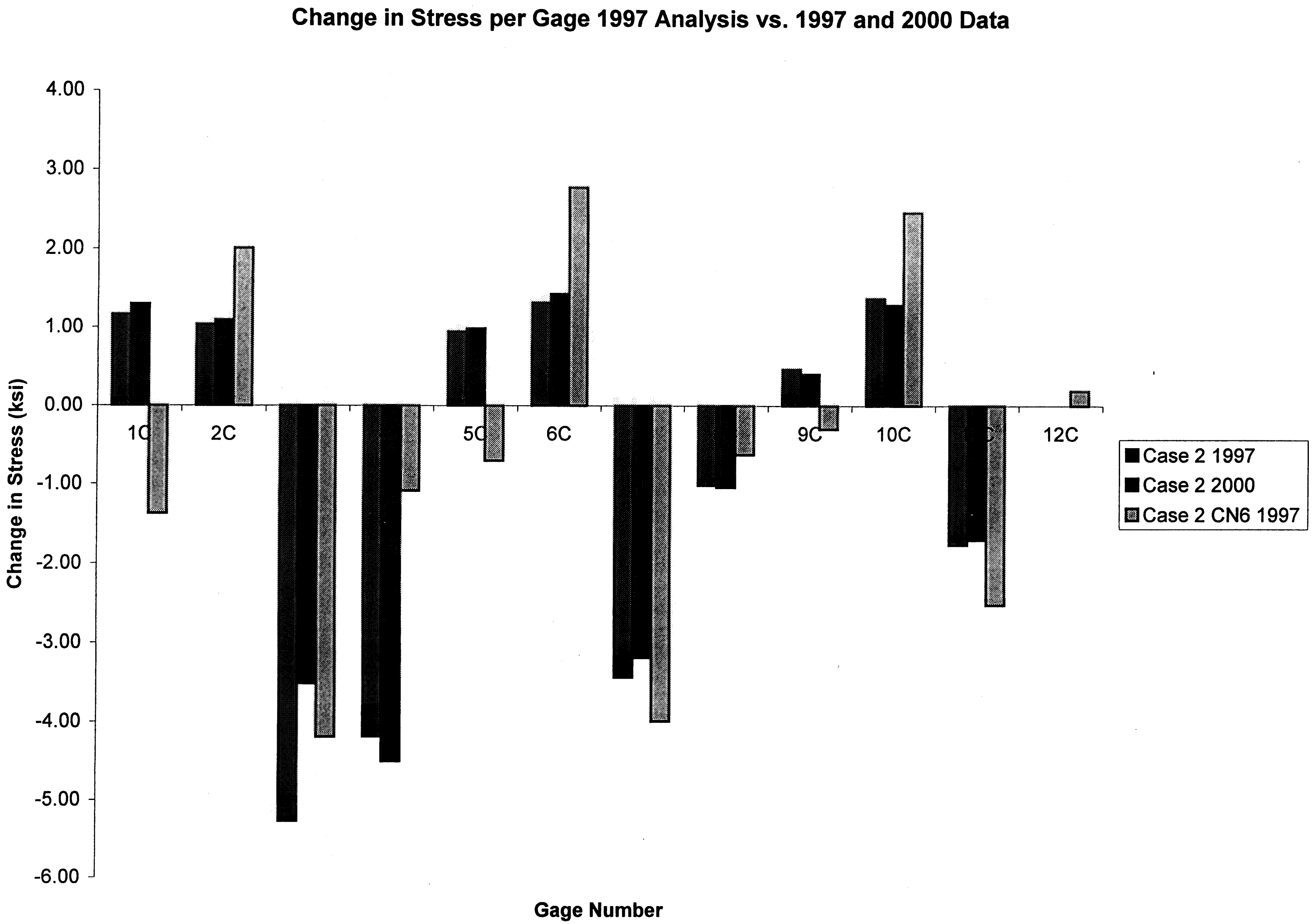


Figure E.22: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 2, Gage Line C)

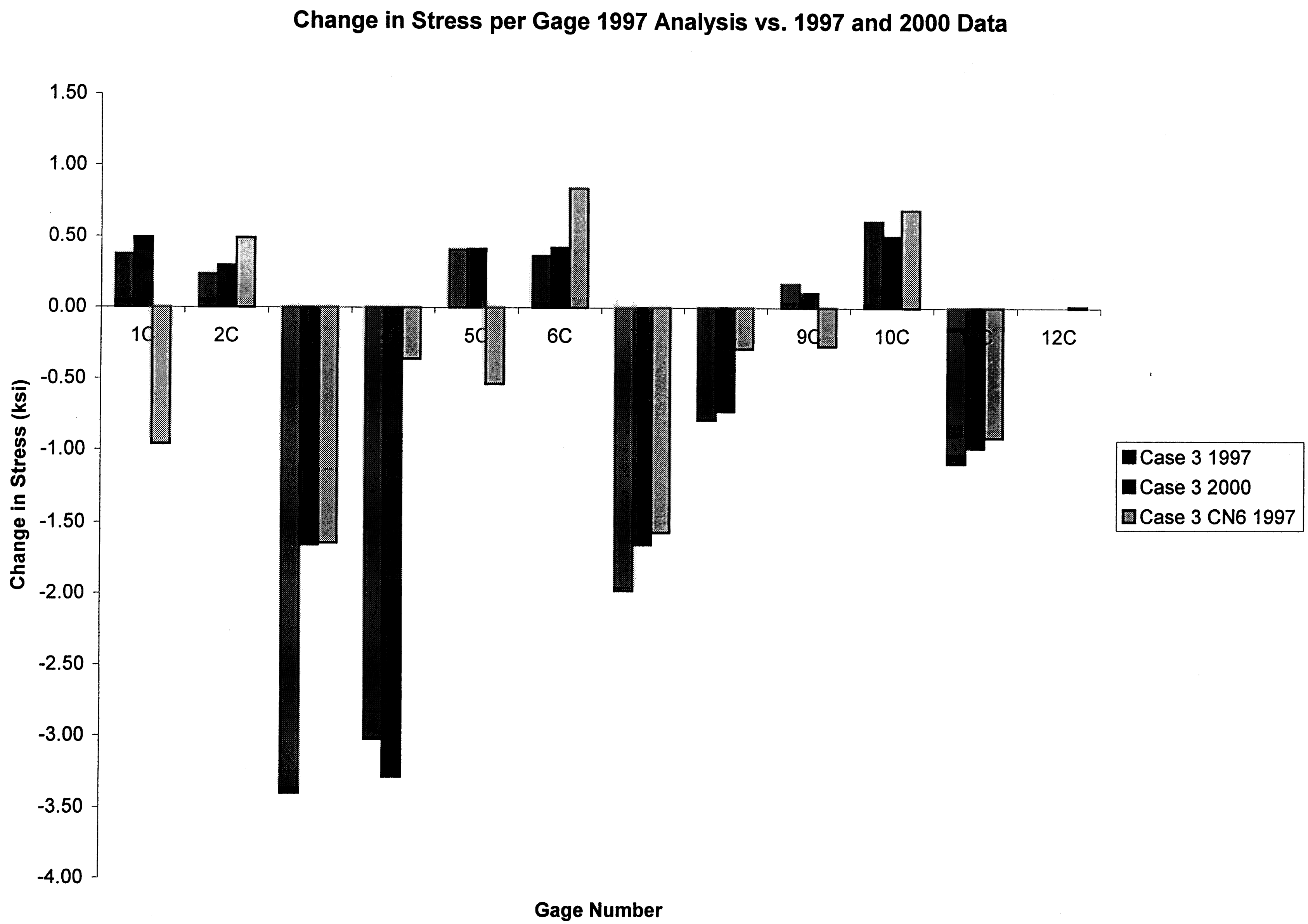


Figure E.23: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 3, Gage Line C)

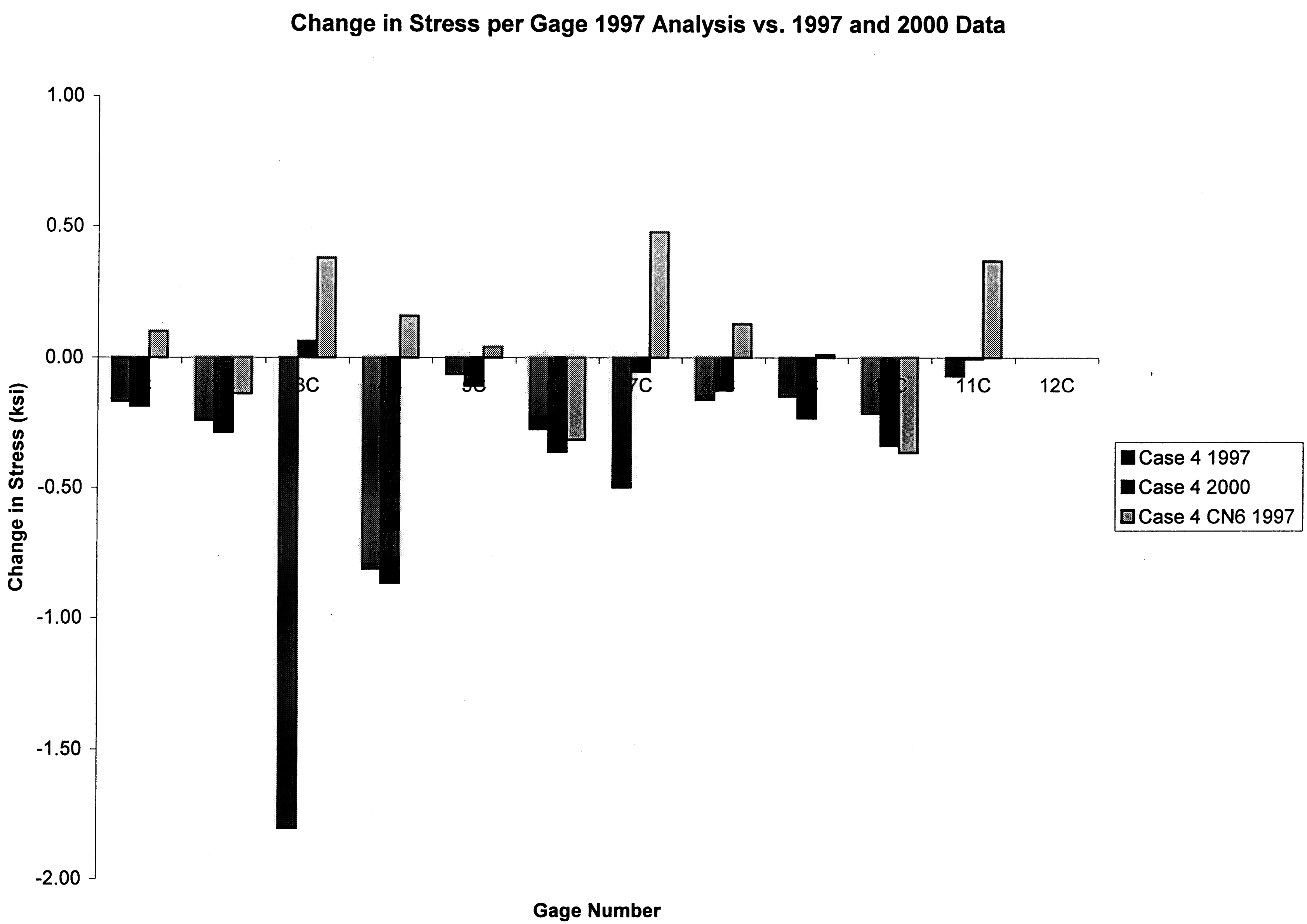


Figure E.24: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 4, Gage Line C)

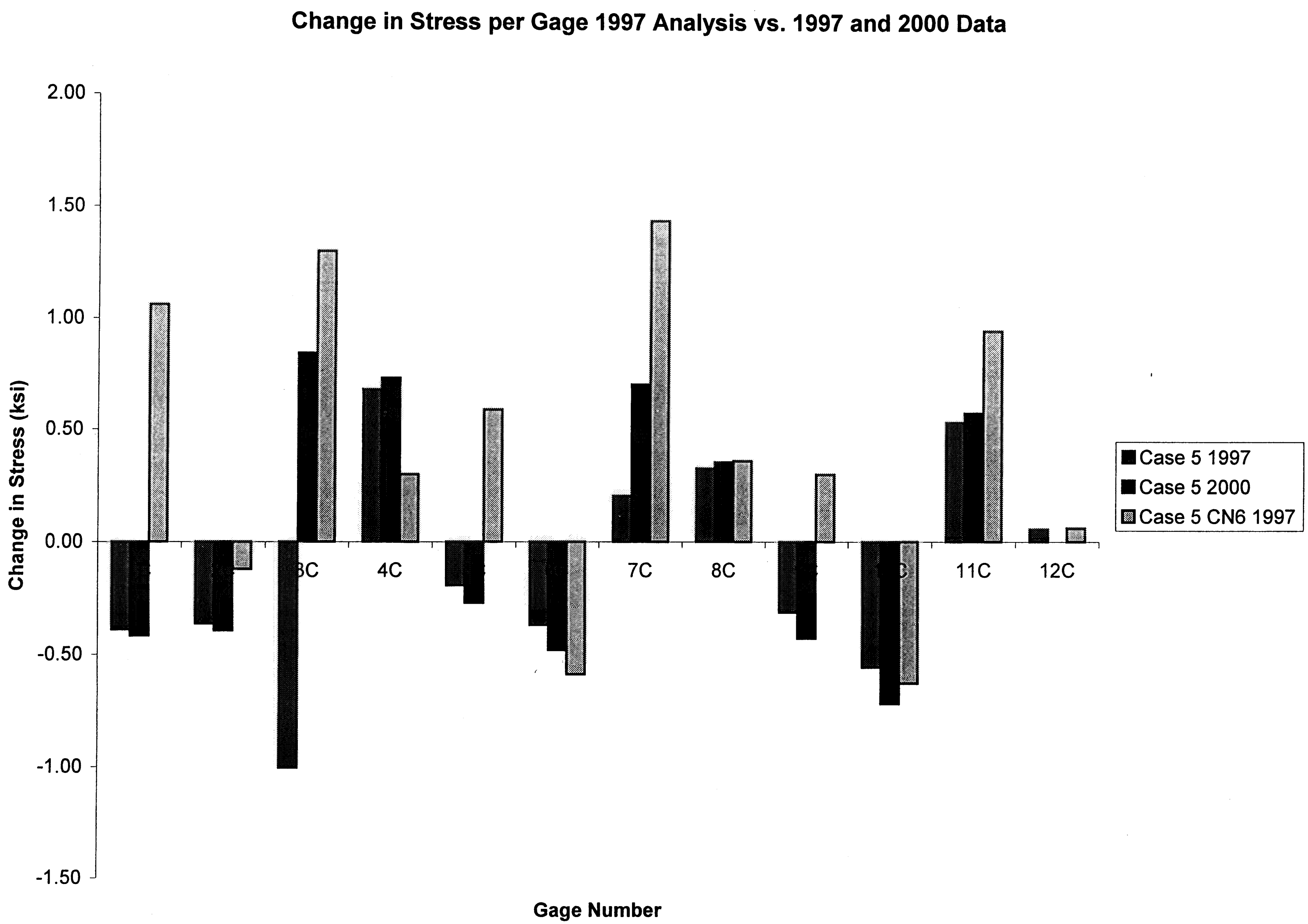


Figure E.25: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 5, Gage Line C)

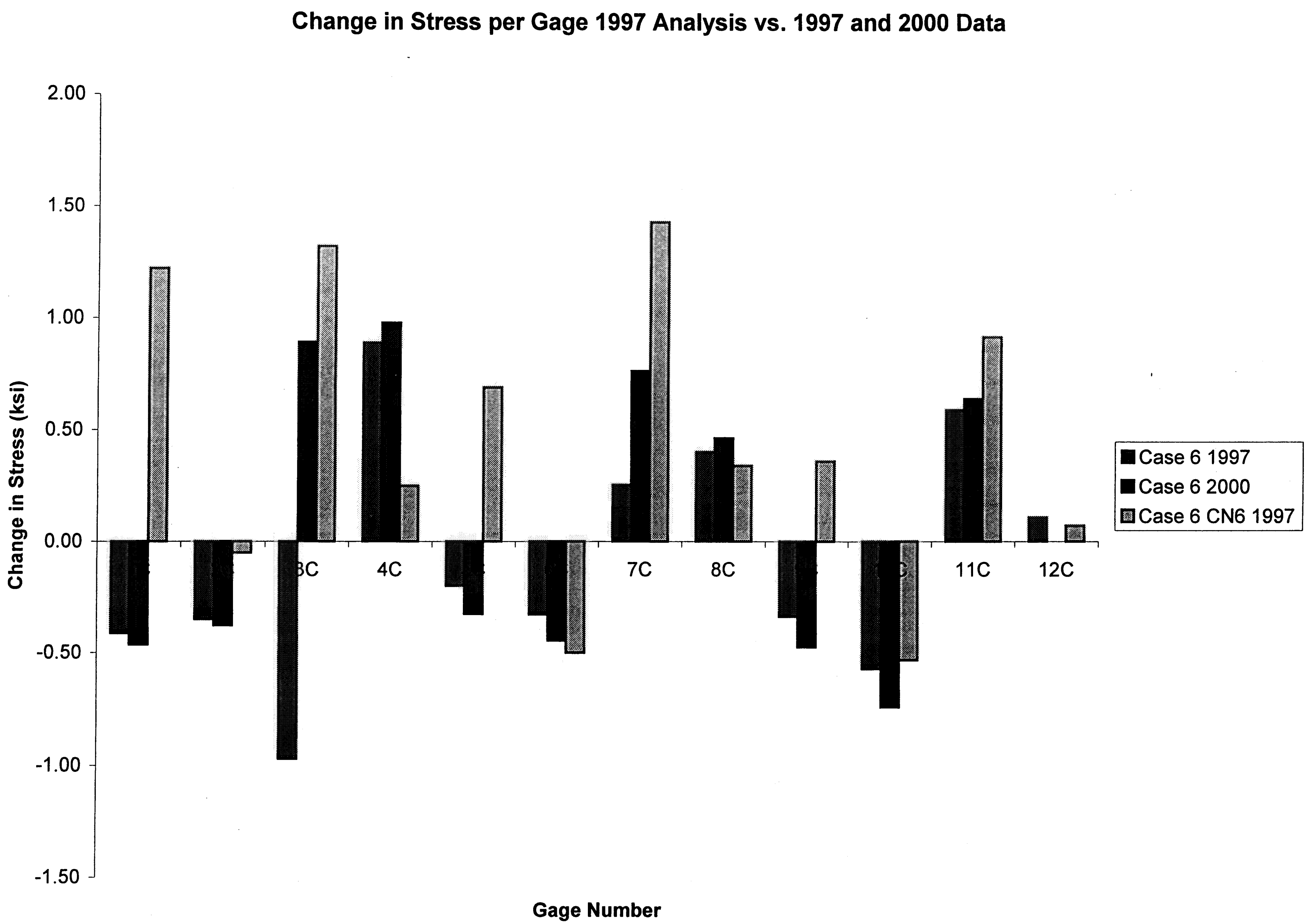


Figure E.26: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 6, Gage Line C)

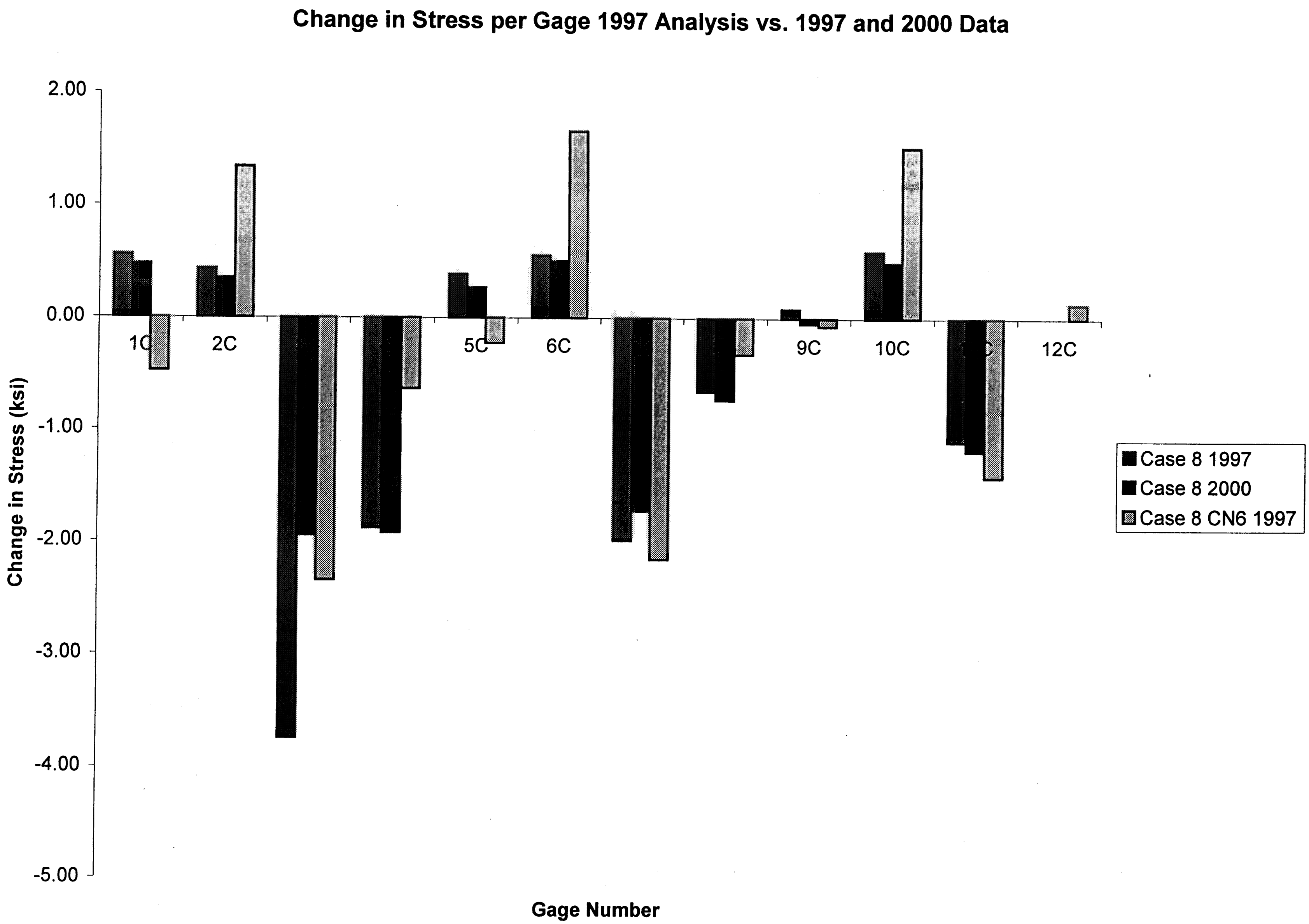


Figure E.27: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 8, Gage Line C)

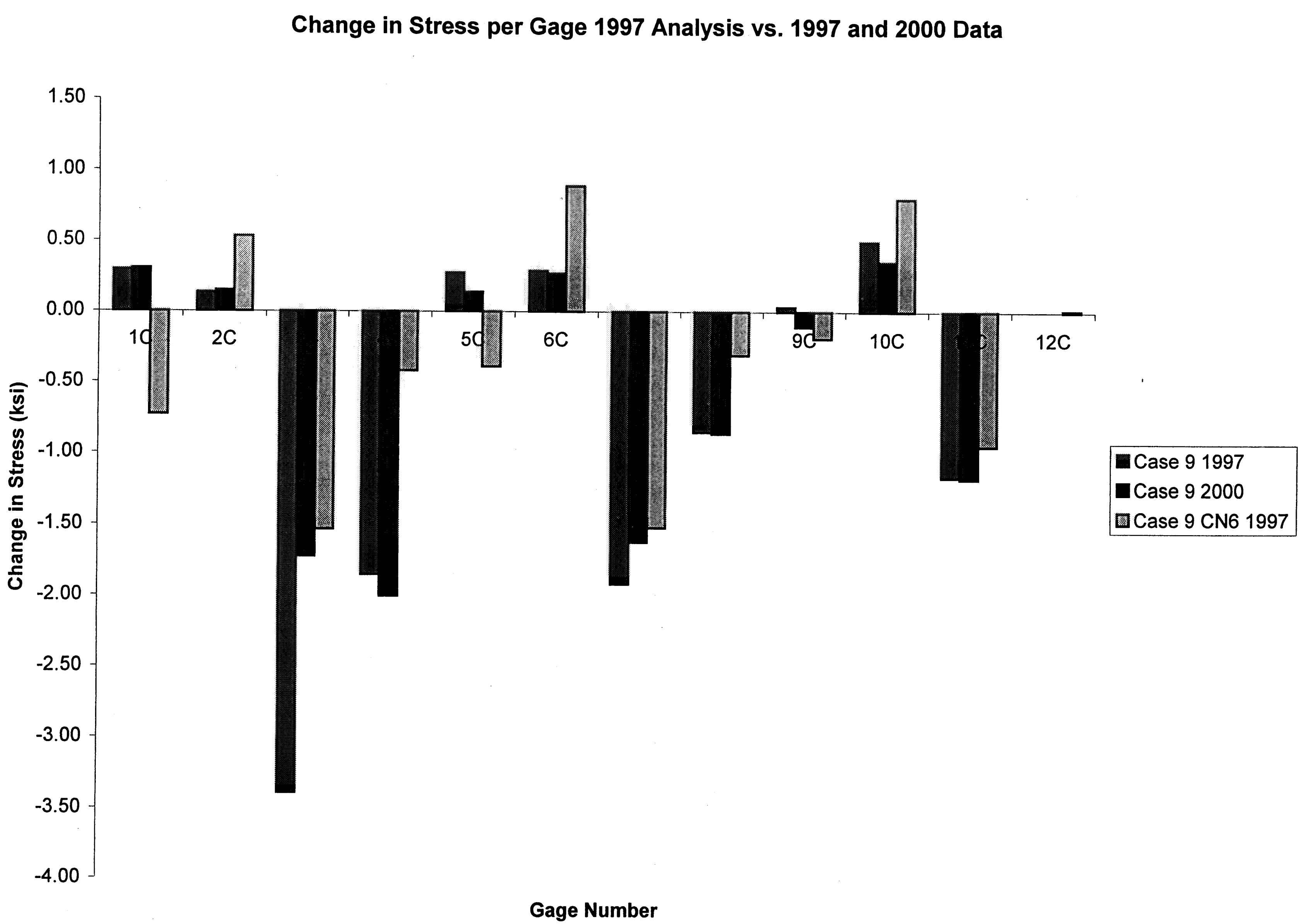


Figure E.28: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 9, Gage Line C)

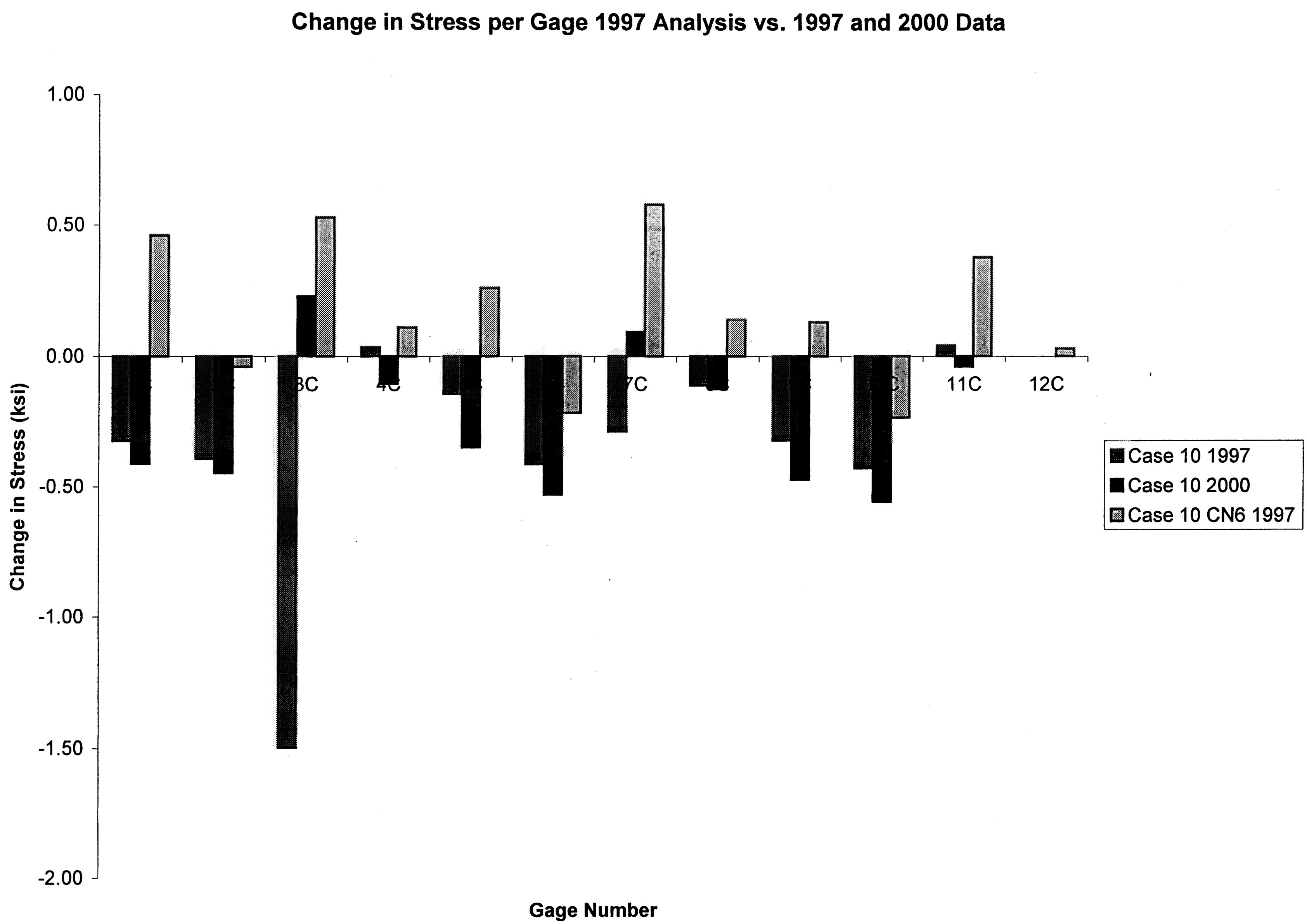


Figure E.29: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 10, Gage Line C)

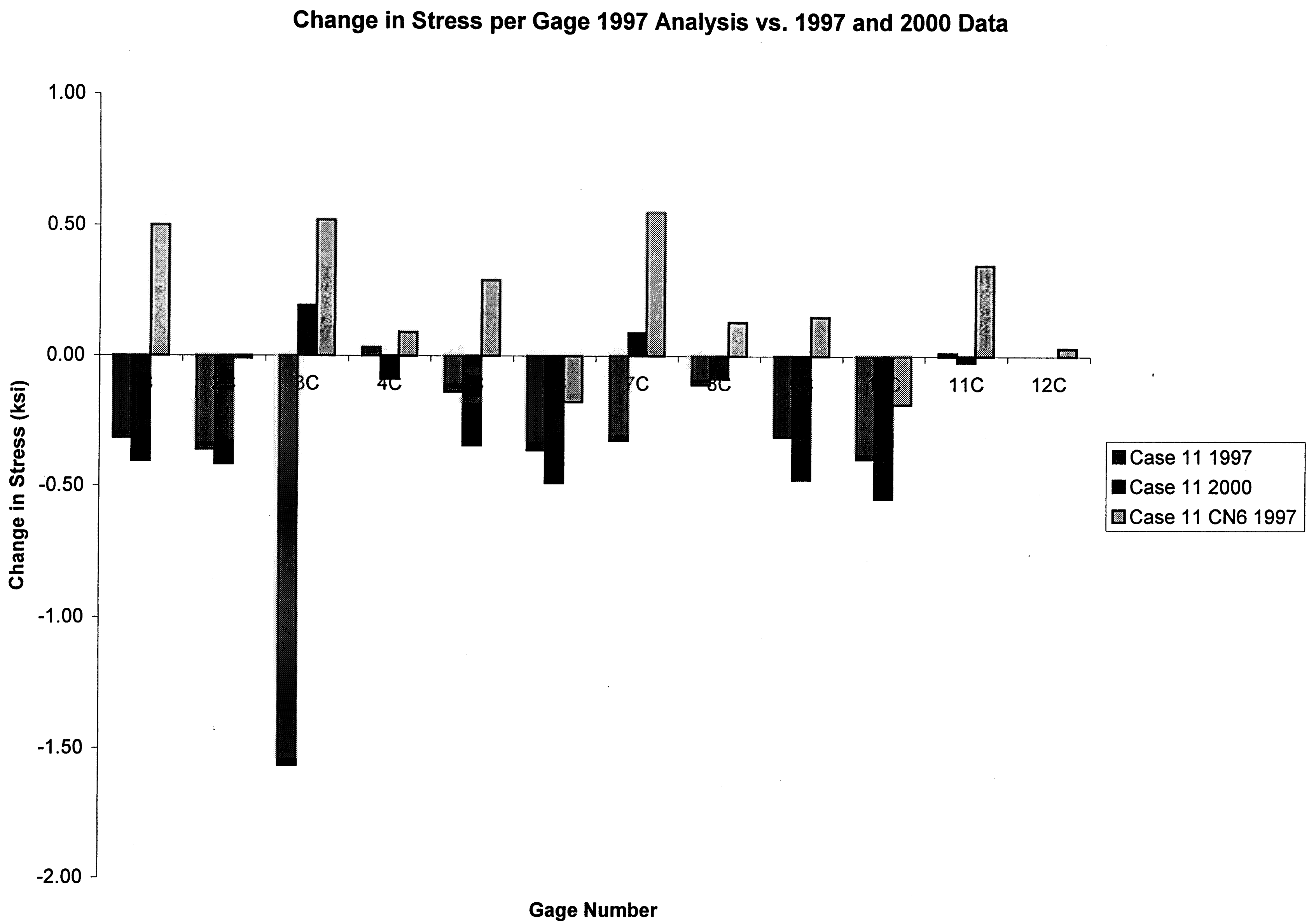


Figure E.30: Change in Stress Comparison of 1997 Analysis vs. 1997 and 2000 Measured Stress (Case 11, Gage Line C)

APPENDIX F

PLOTS OF MEASURED VS. COMPUTED STRESS FOR LIVE LOAD (TOTAL STESS AND CHANGE IN STRESS, FOR NINE TRUCKS AND THREE TRUCKS, 1997 AND 2000 ANALYSIS, *N* = 6)

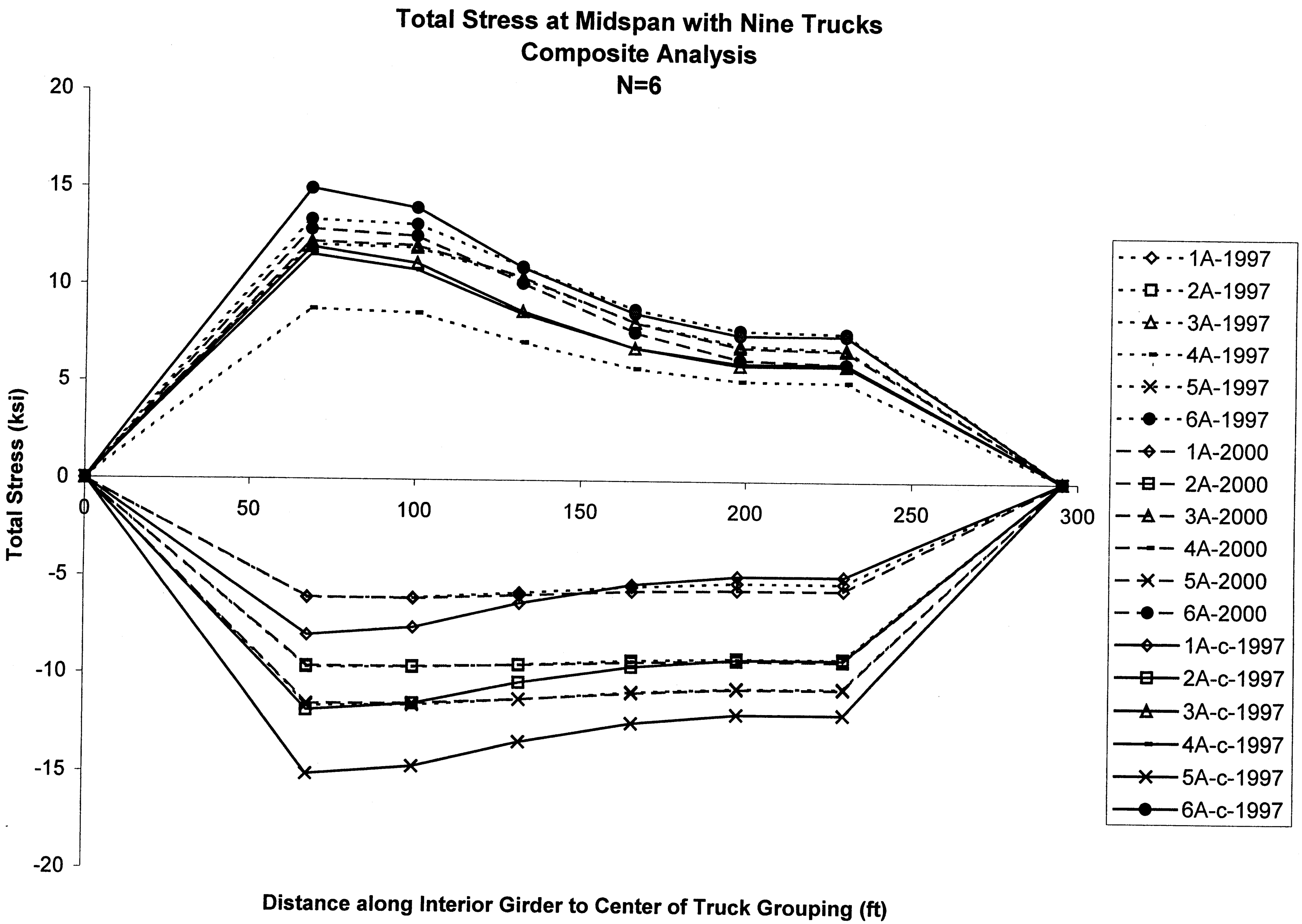


Figure F.1: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1A-6A)

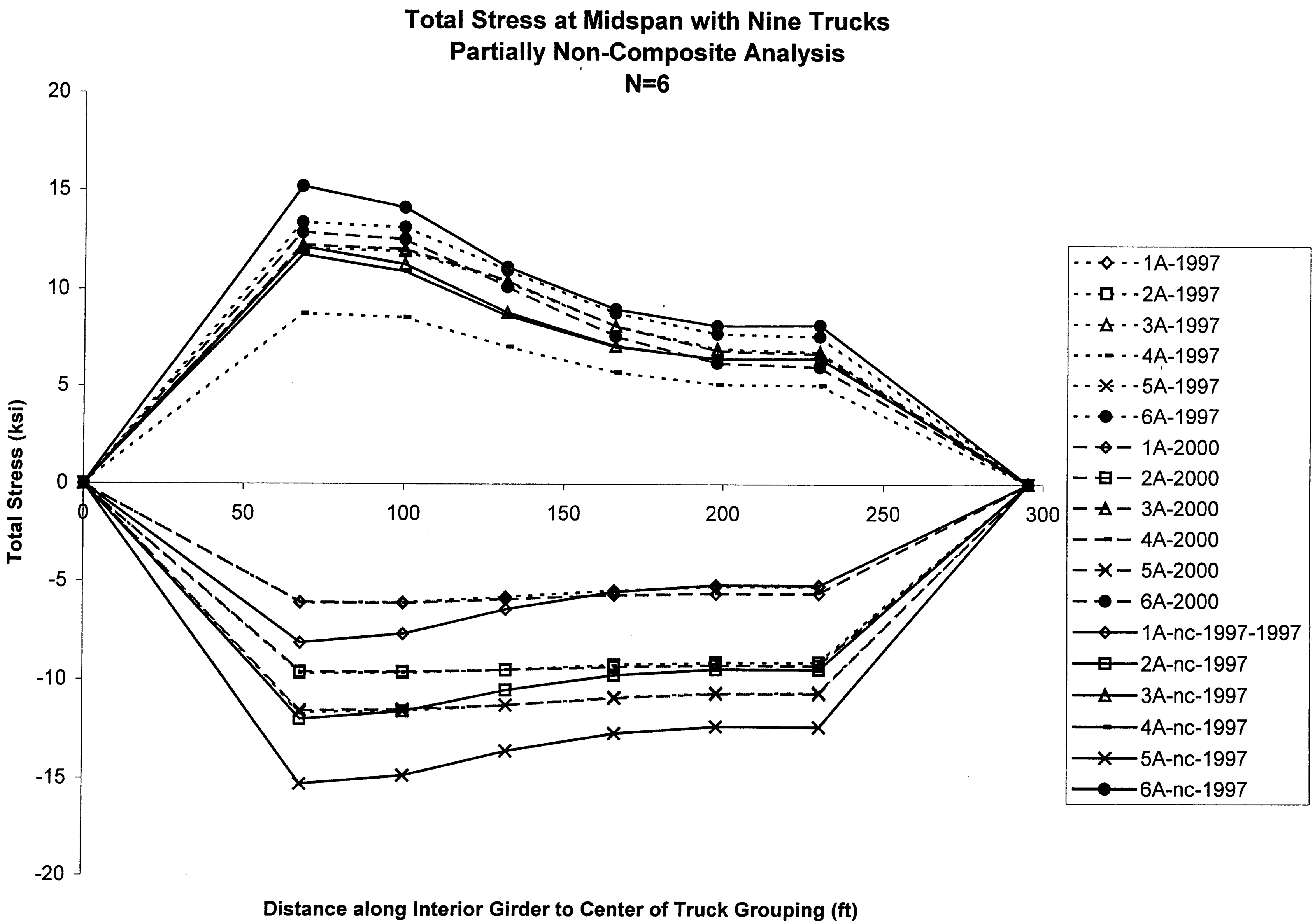


Figure F.2: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1A-6A)

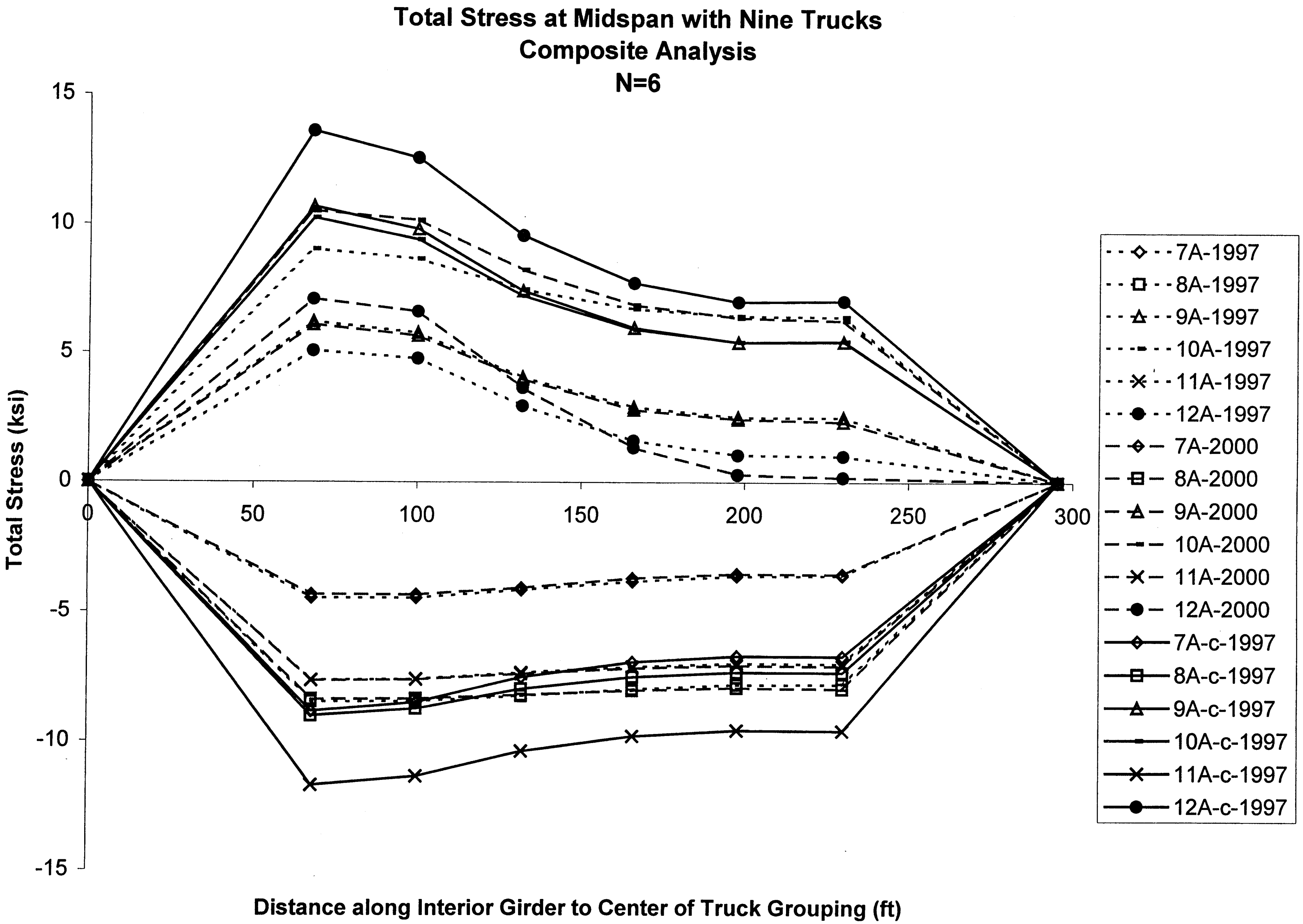


Figure F.3: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 7A-12A)

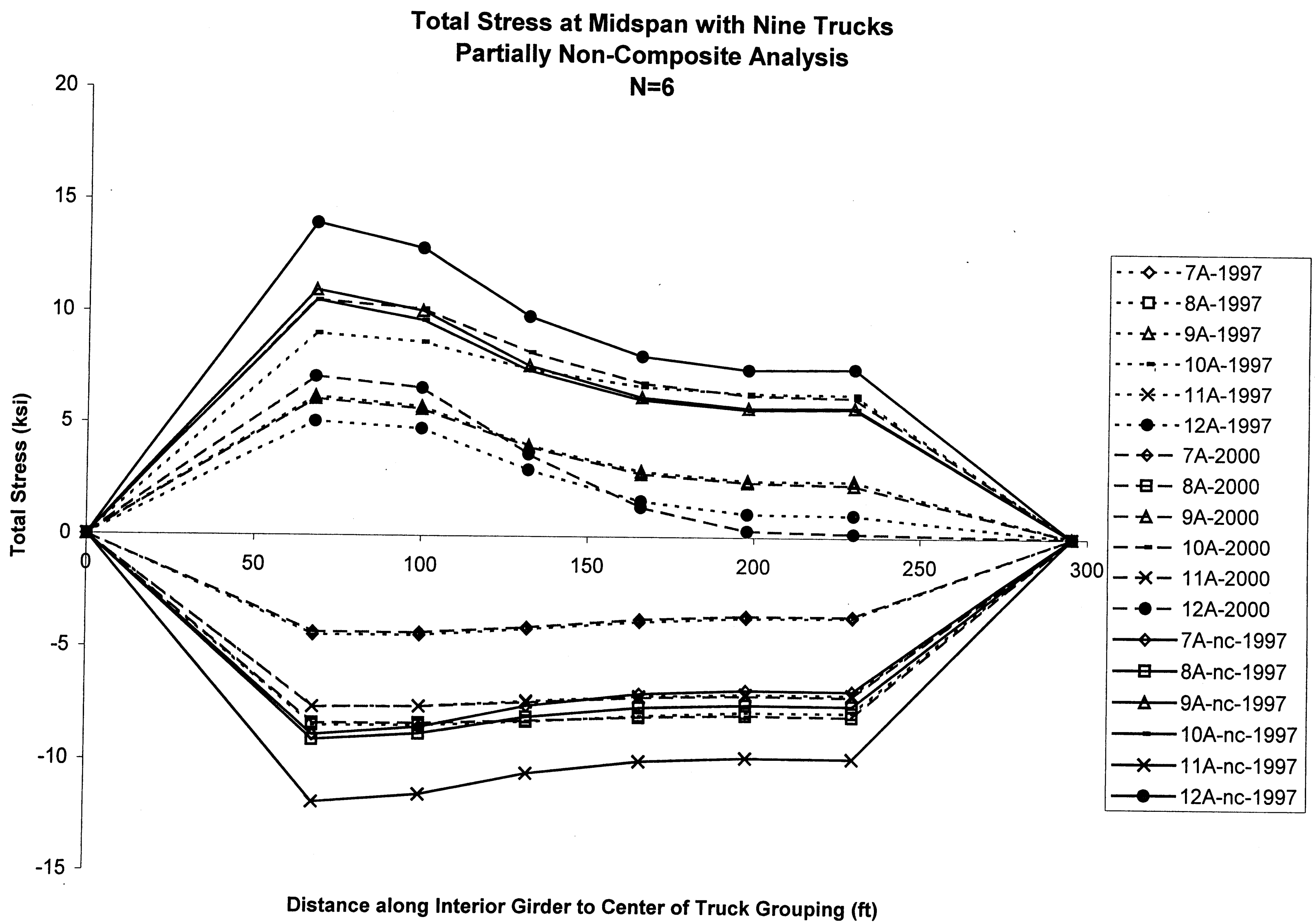


Figure F.4: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7A-12A)

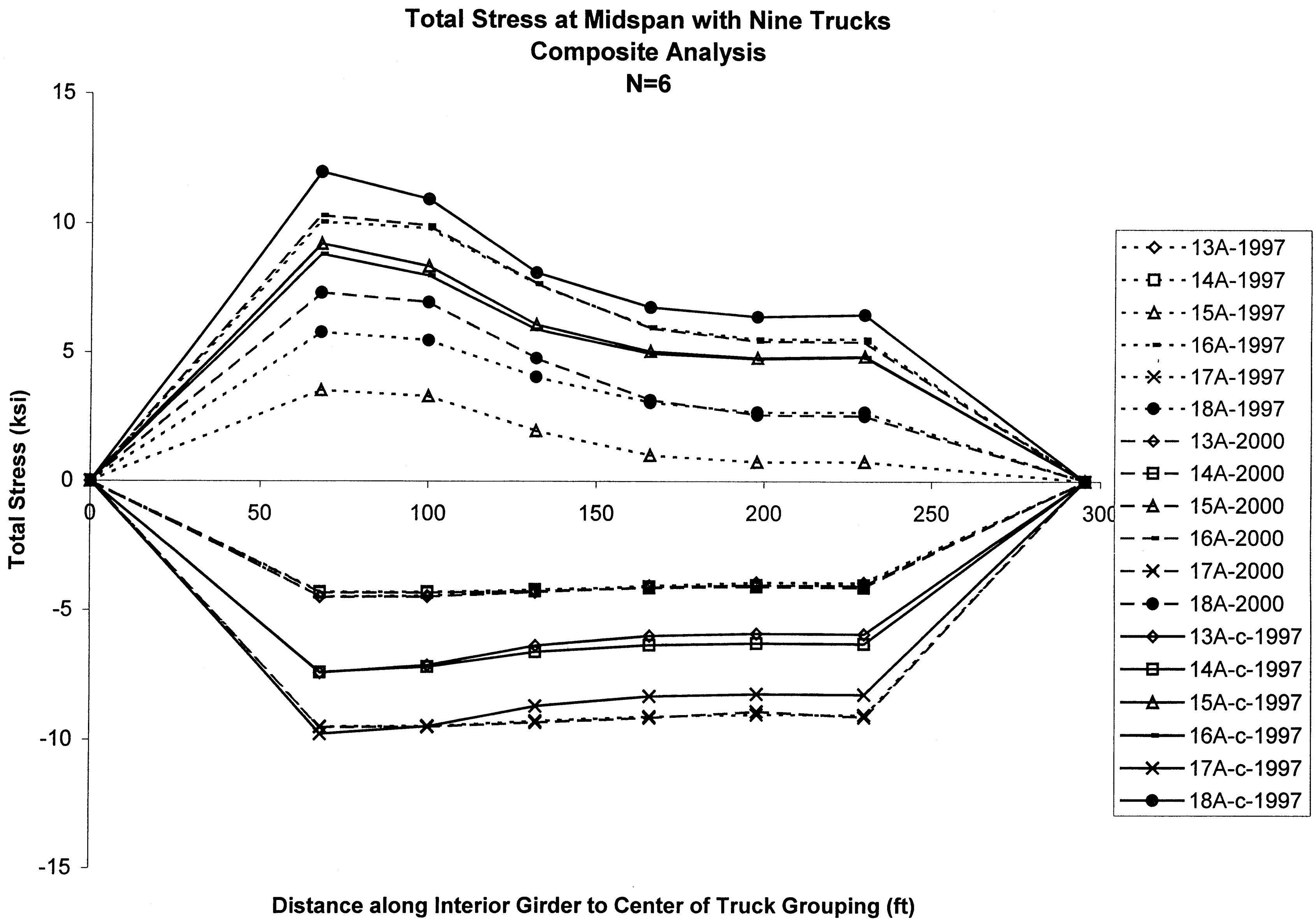


Figure F.5: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 13A-18A)

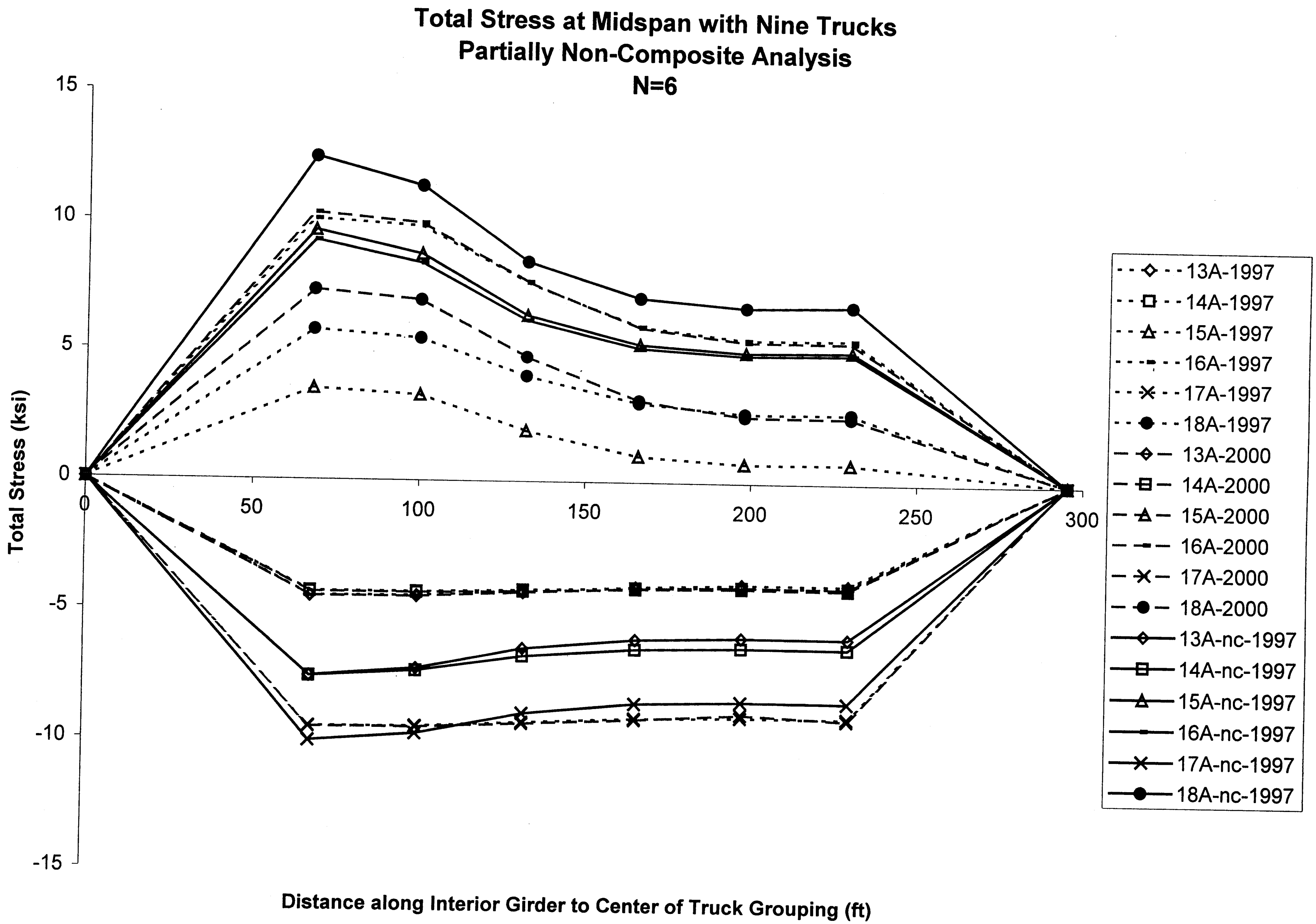


Figure F.6: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13A-18A)

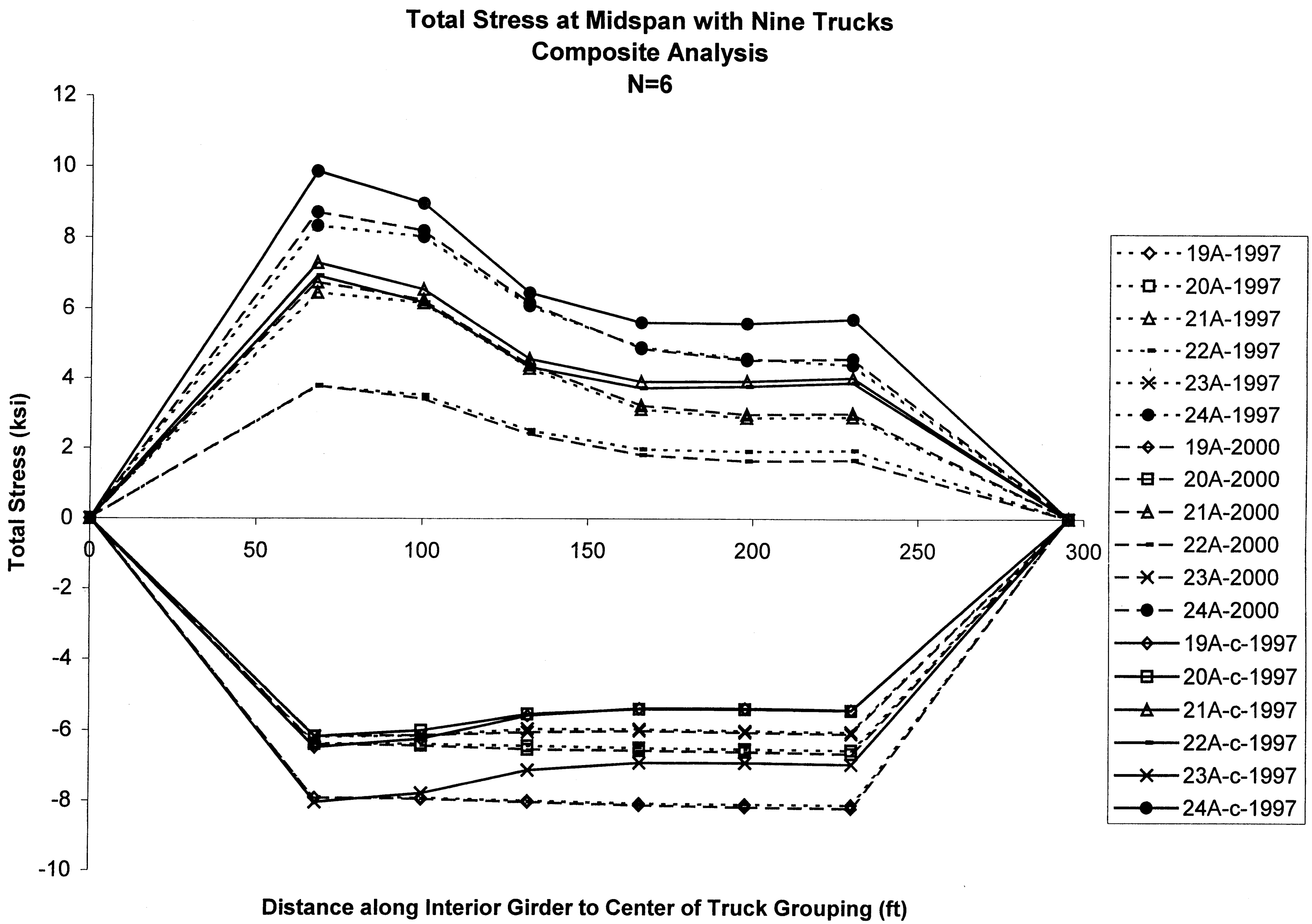


Figure F.7: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 19A-24A)

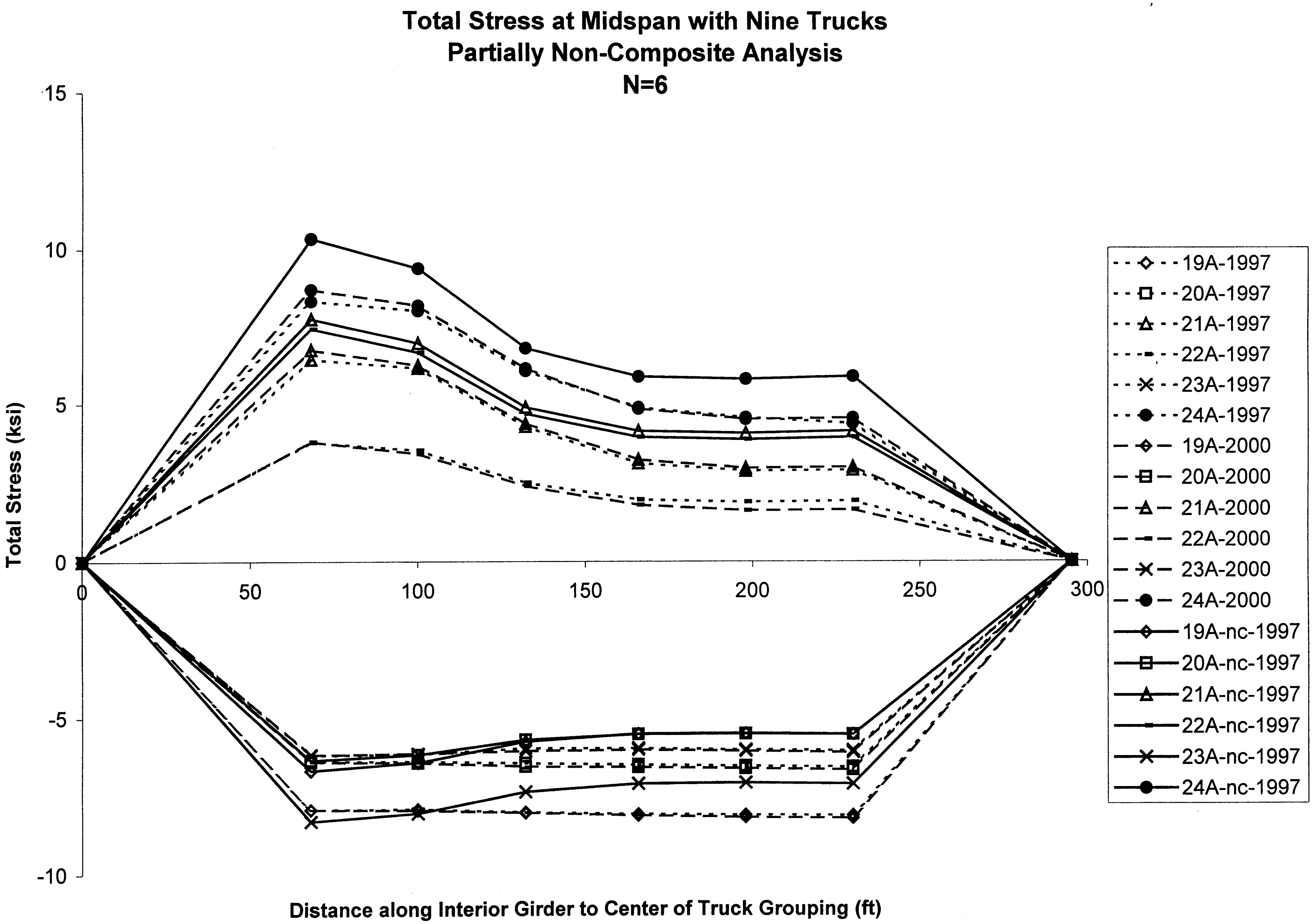


Figure F.8: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19A-24A)

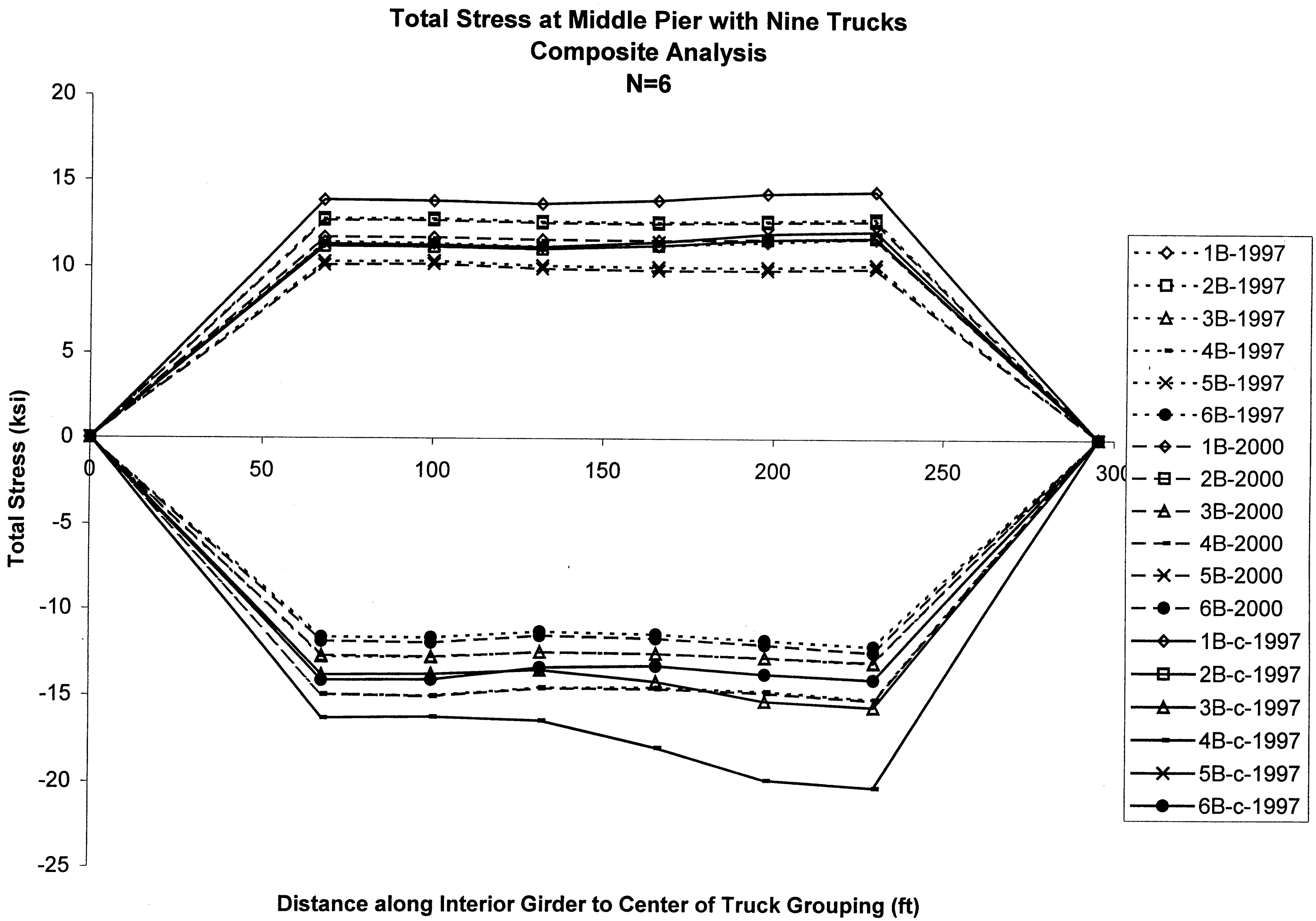


Figure F.9: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1B-6B)

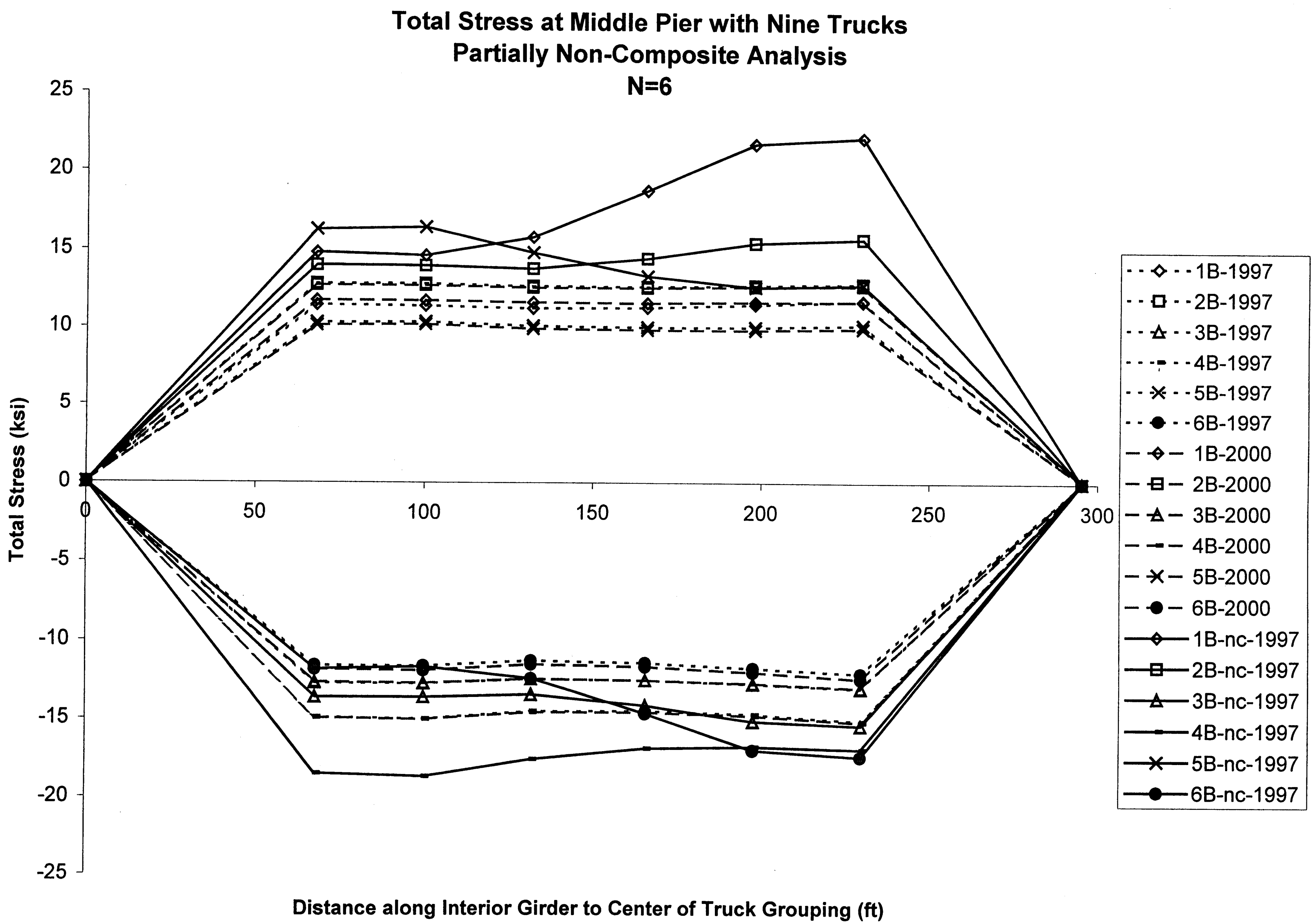


Figure F.10: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1B-6B)

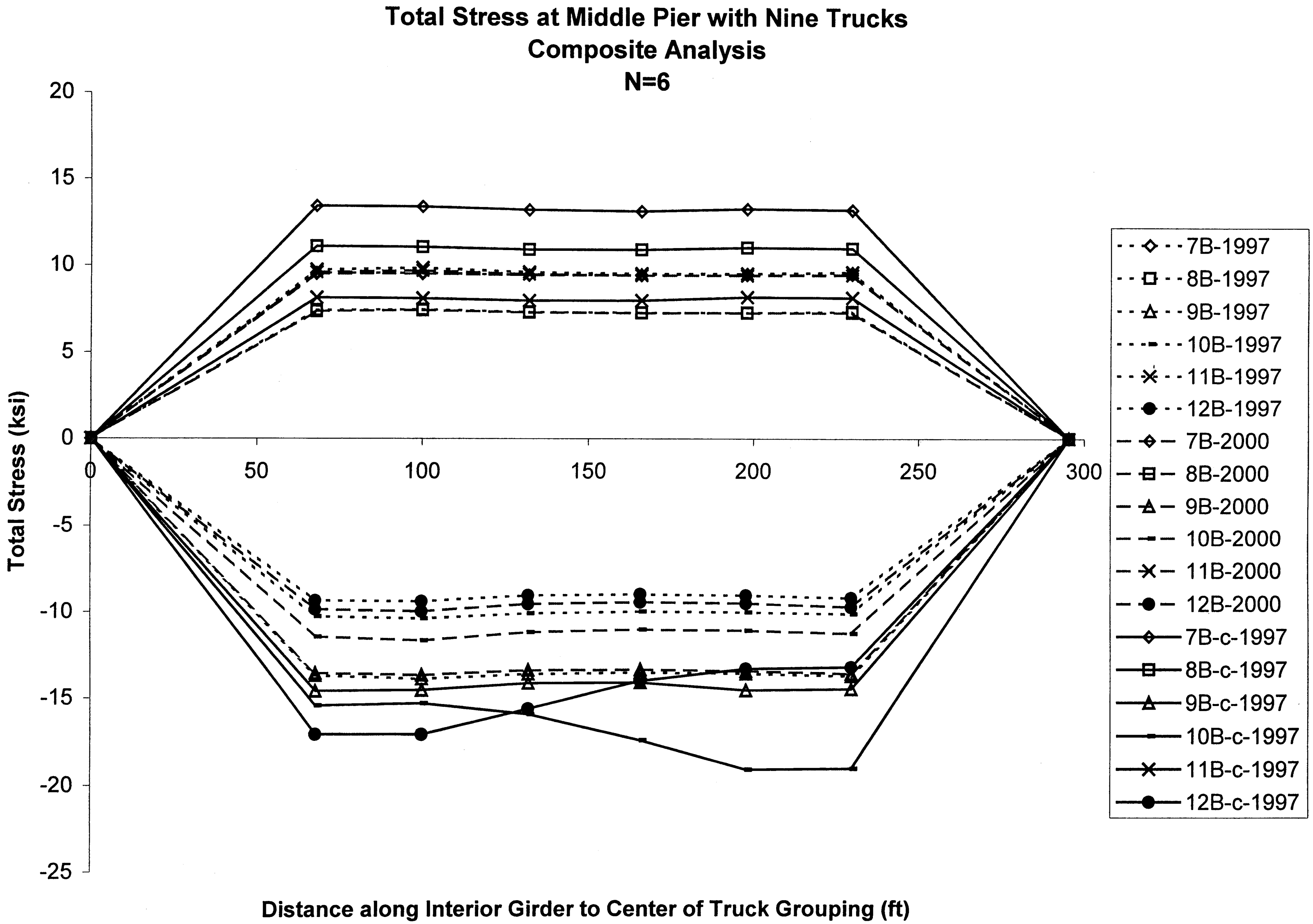


Figure F.11: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 7B-12B)

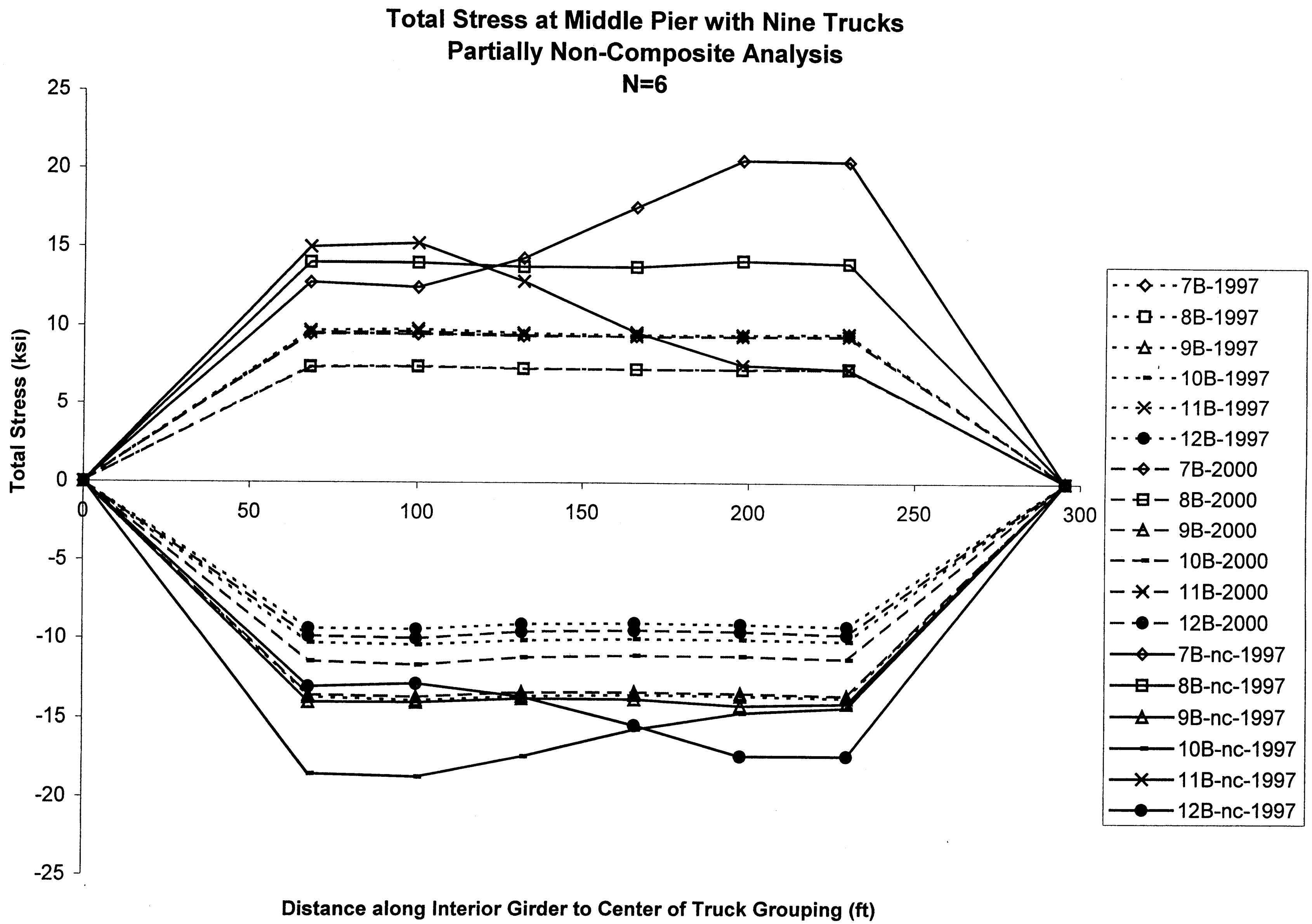


Figure F.12: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7B-12B)

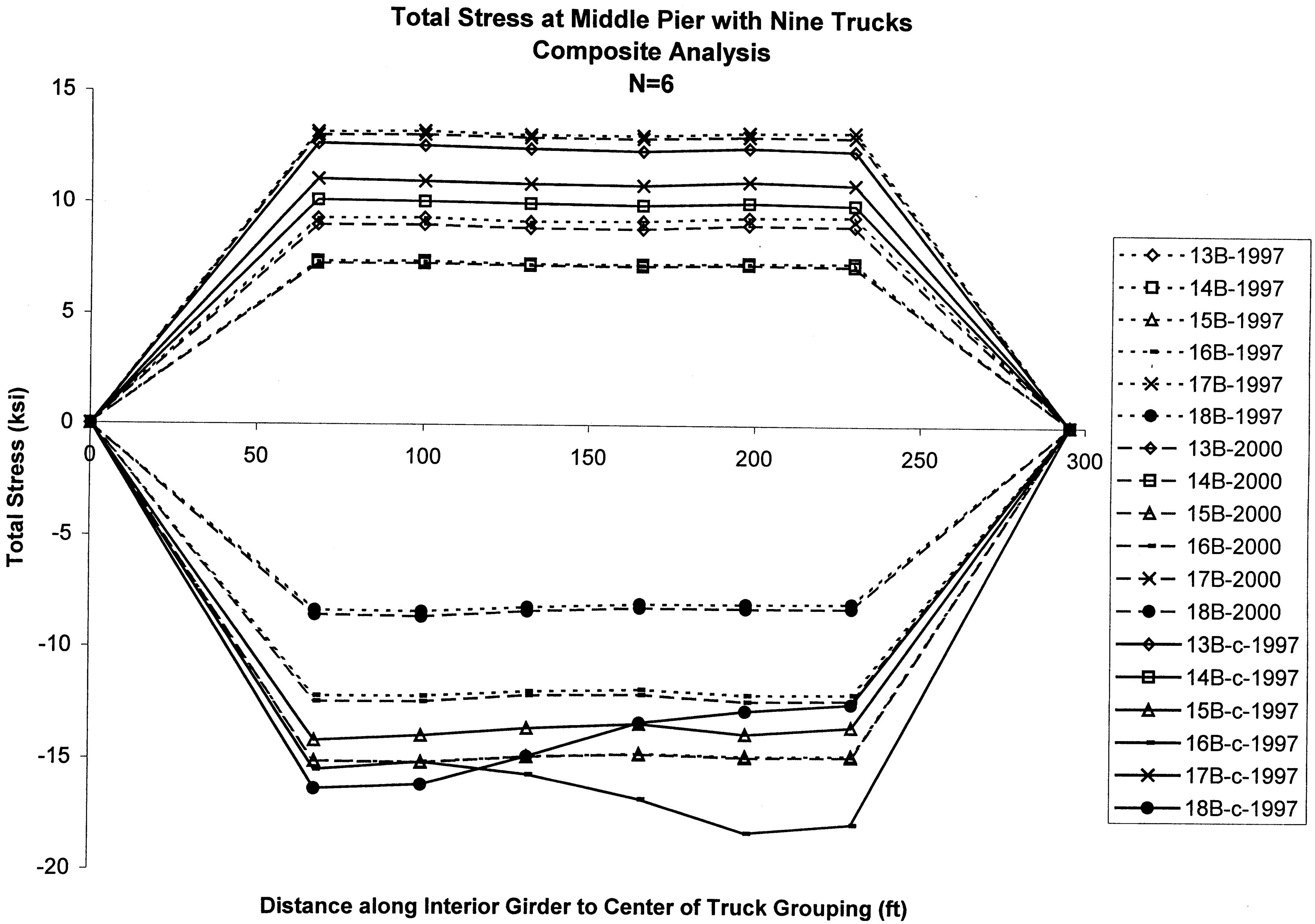


Figure F.13: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 13B-18B)

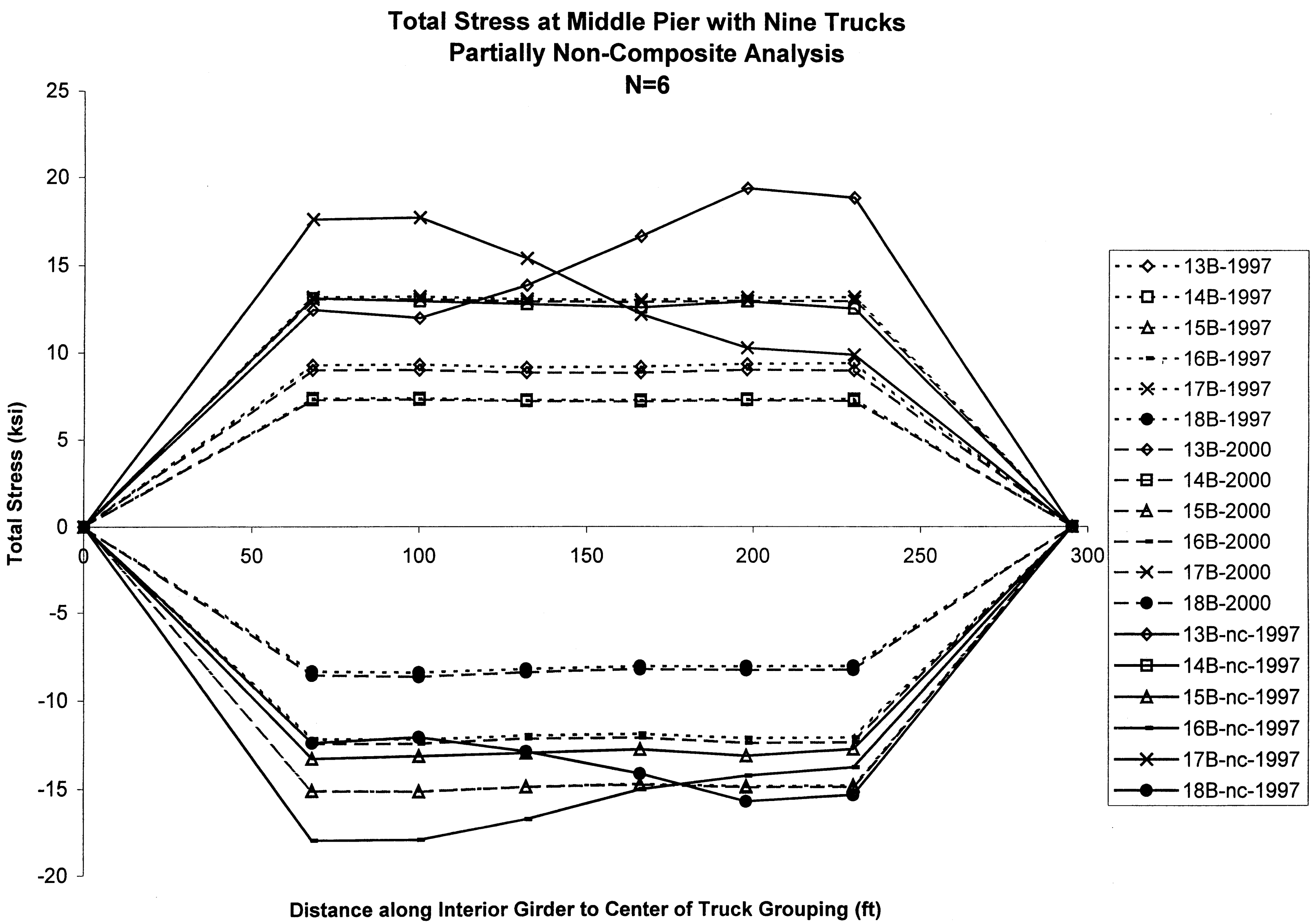


Figure F.14: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13B-18B)

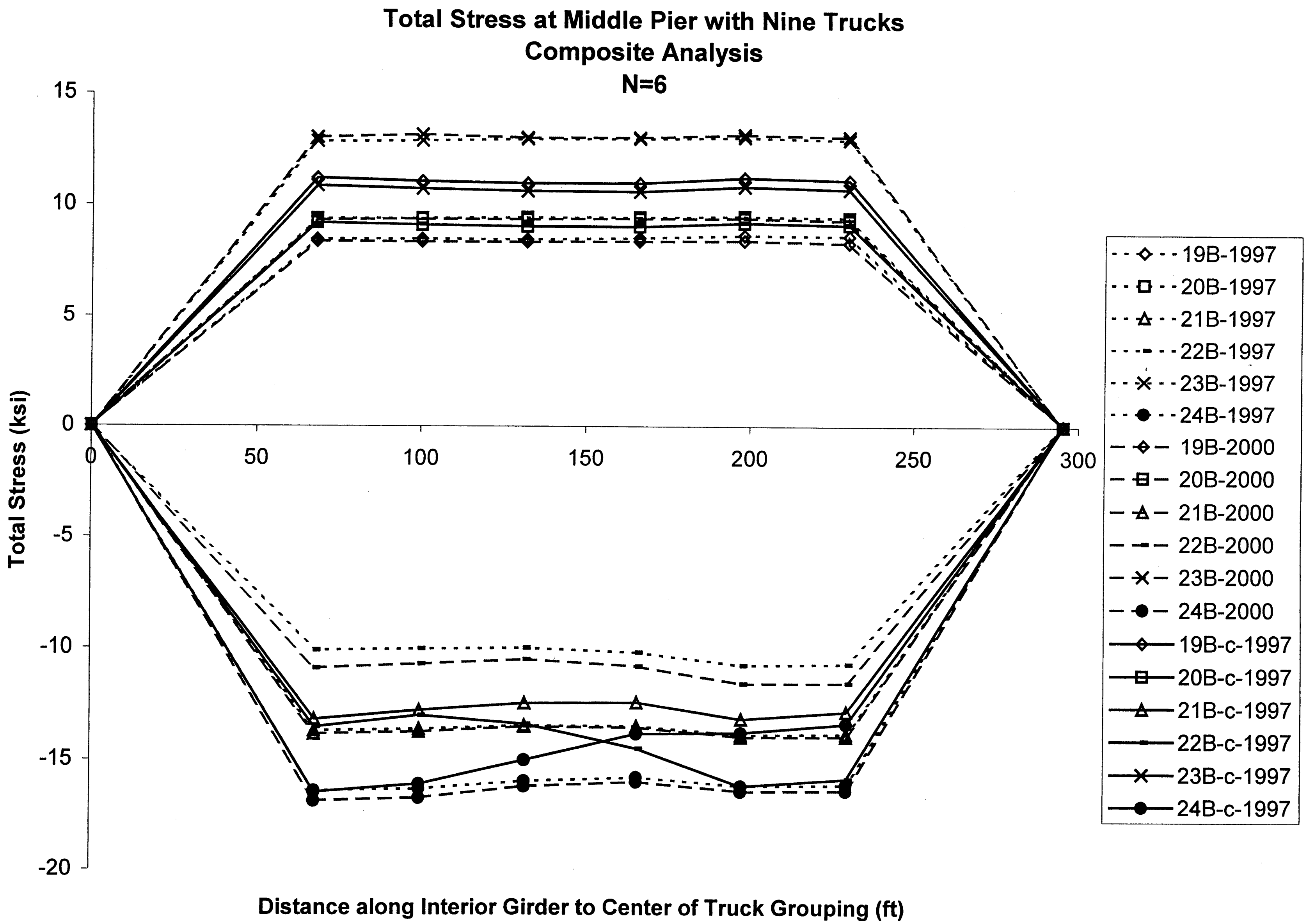


Figure F.15: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 19B-24B)

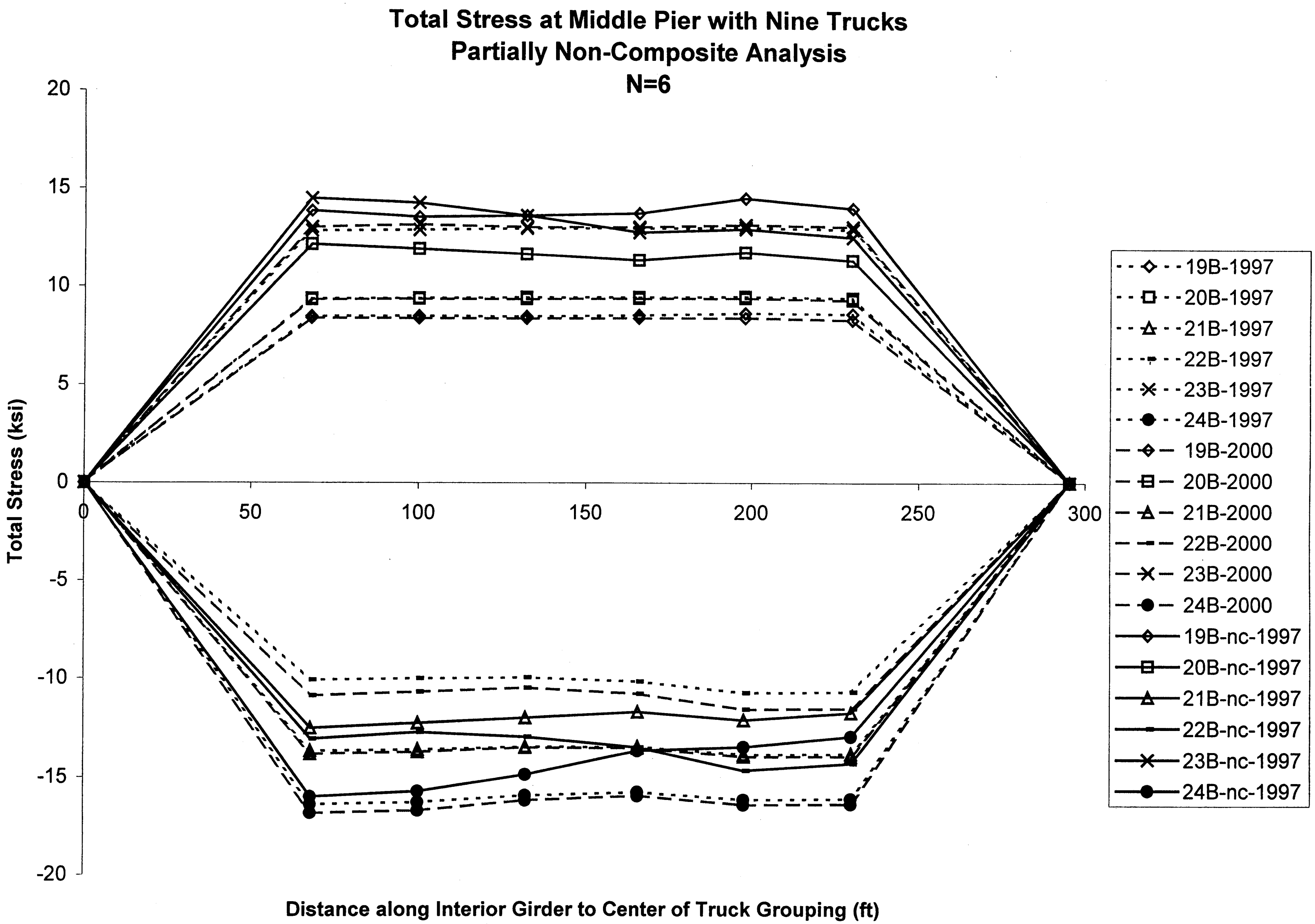


Figure F.16: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19B-24B)

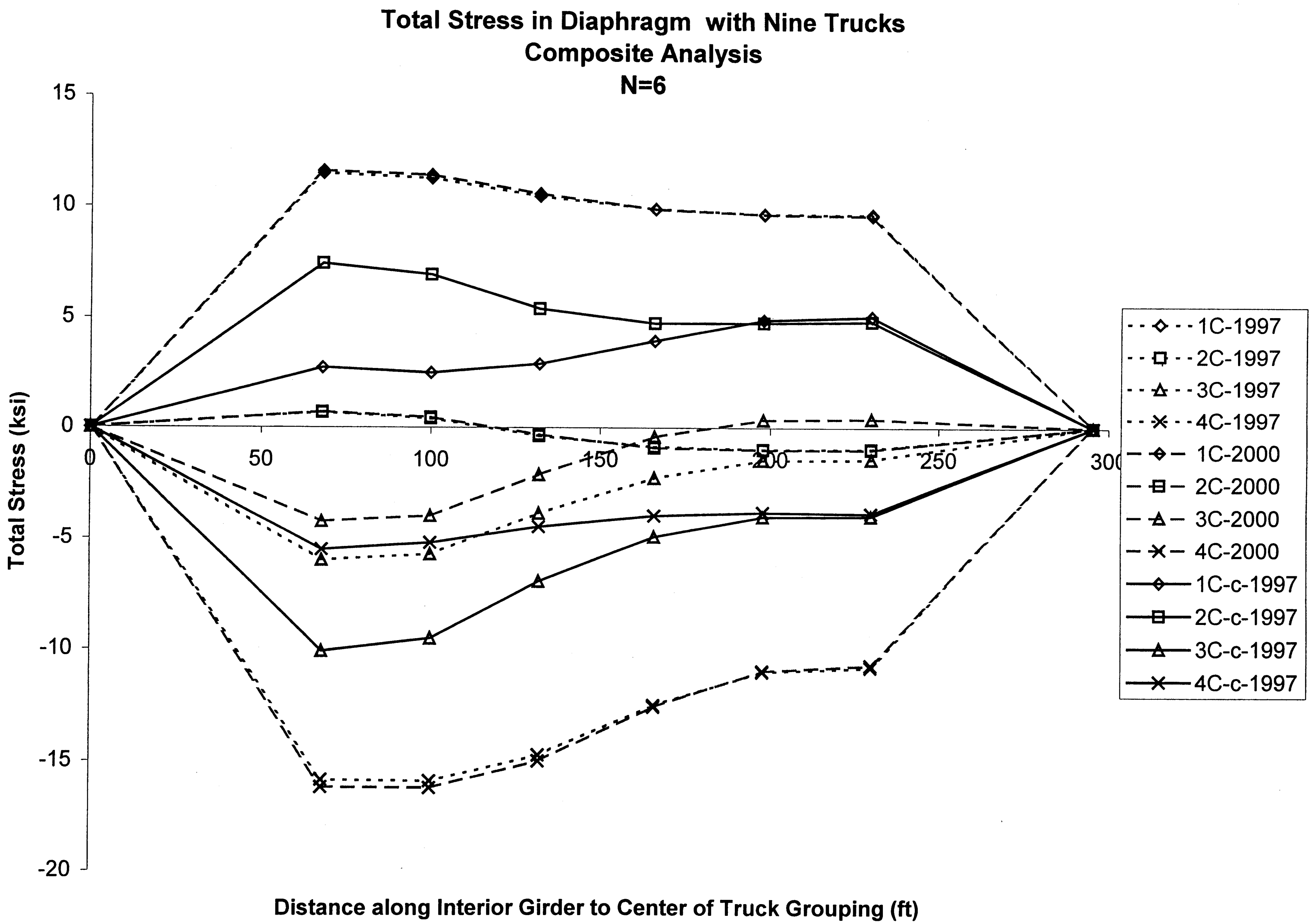


Figure F.17: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1C-4C)

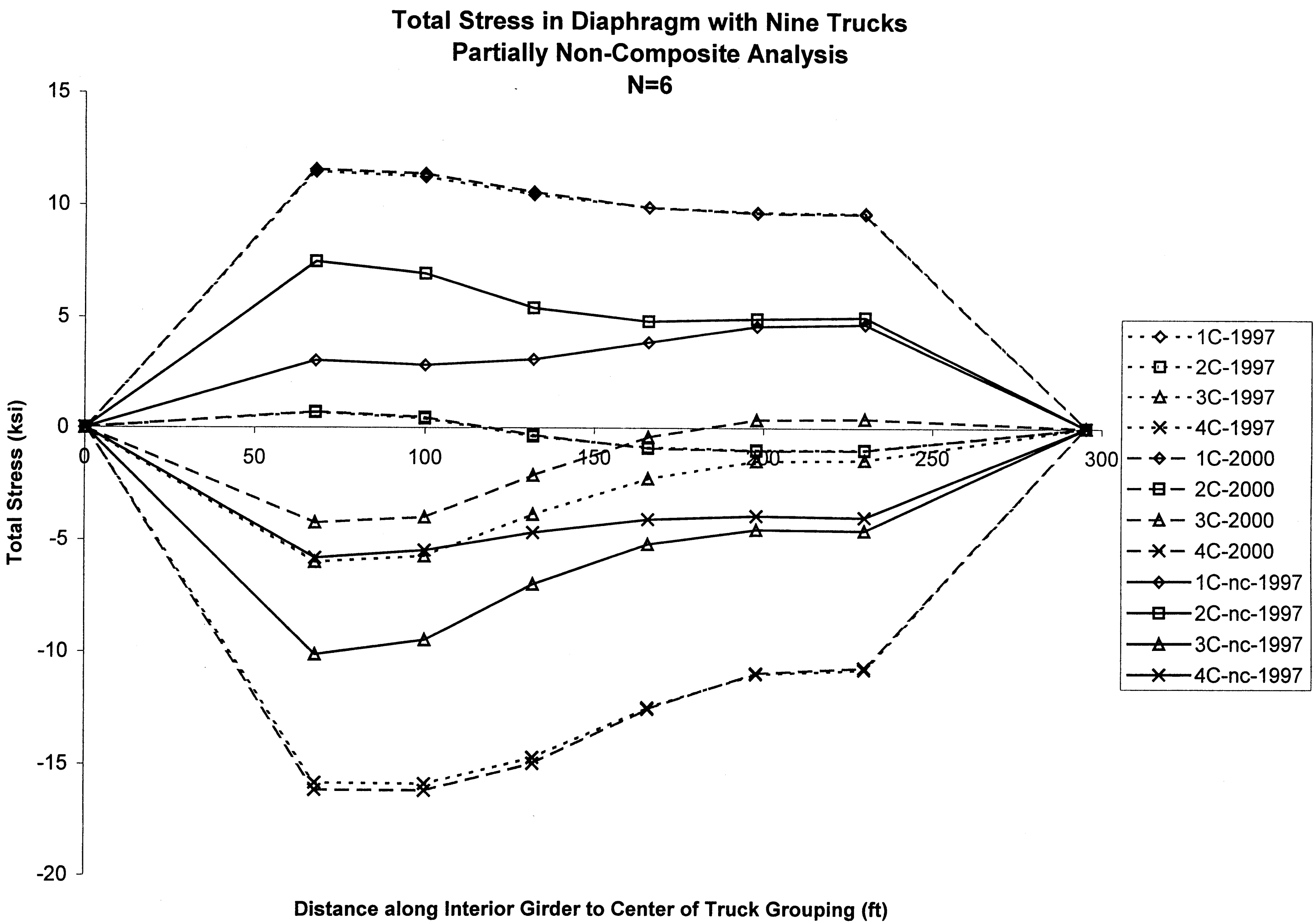


Figure F.18: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1C-4C)

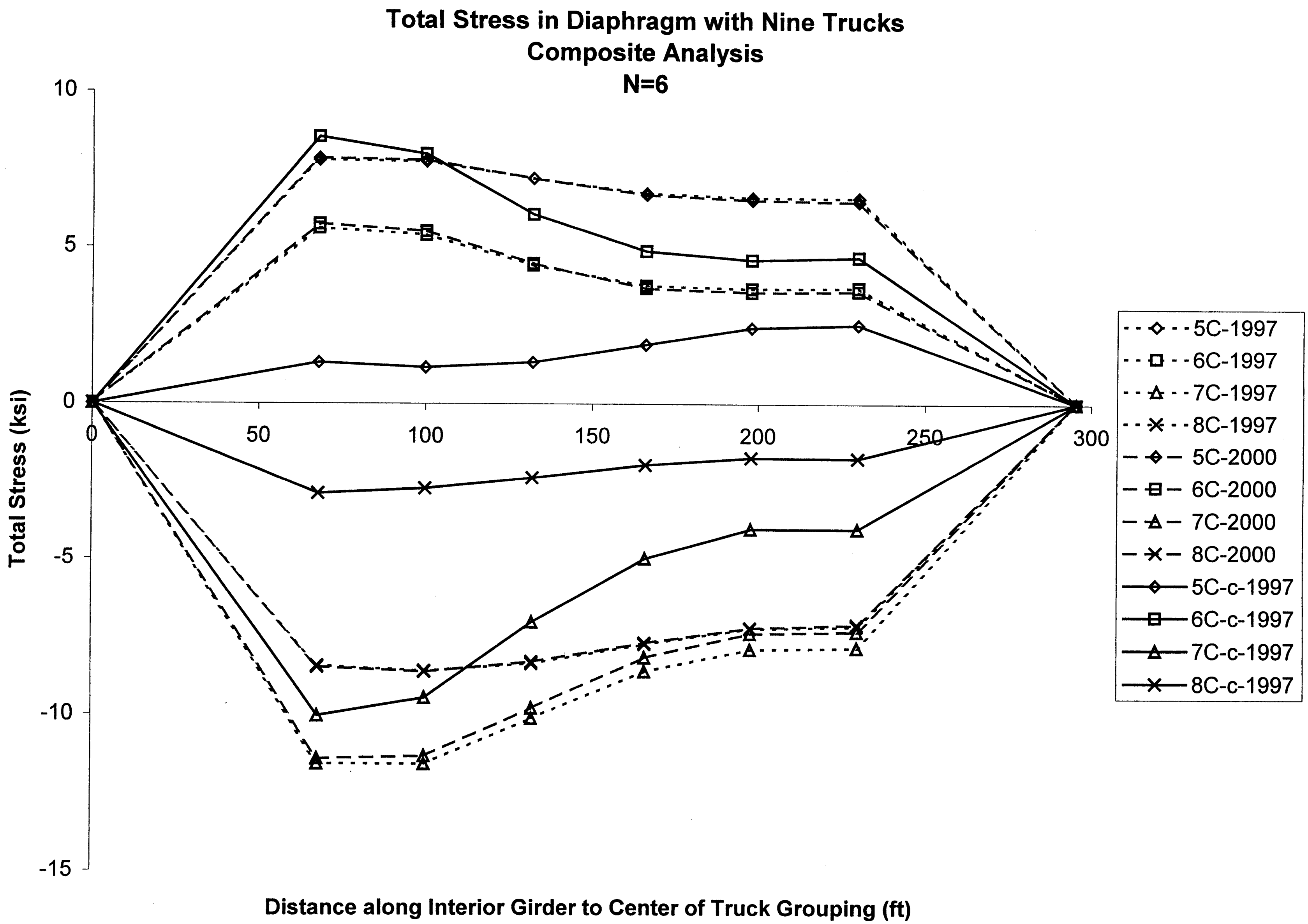


Figure F.19: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 5C-8C)

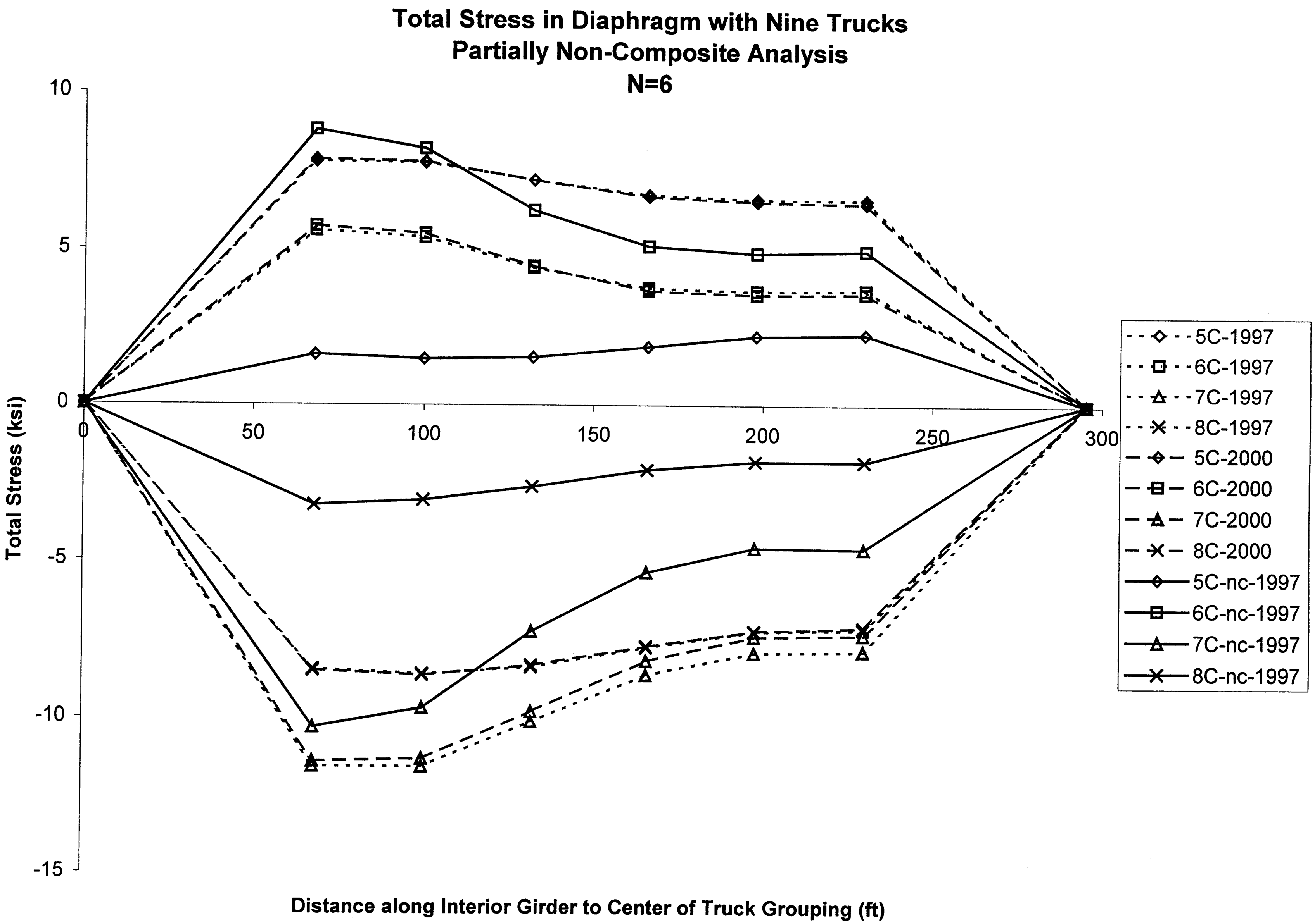


Figure F.20: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 5C-8C)

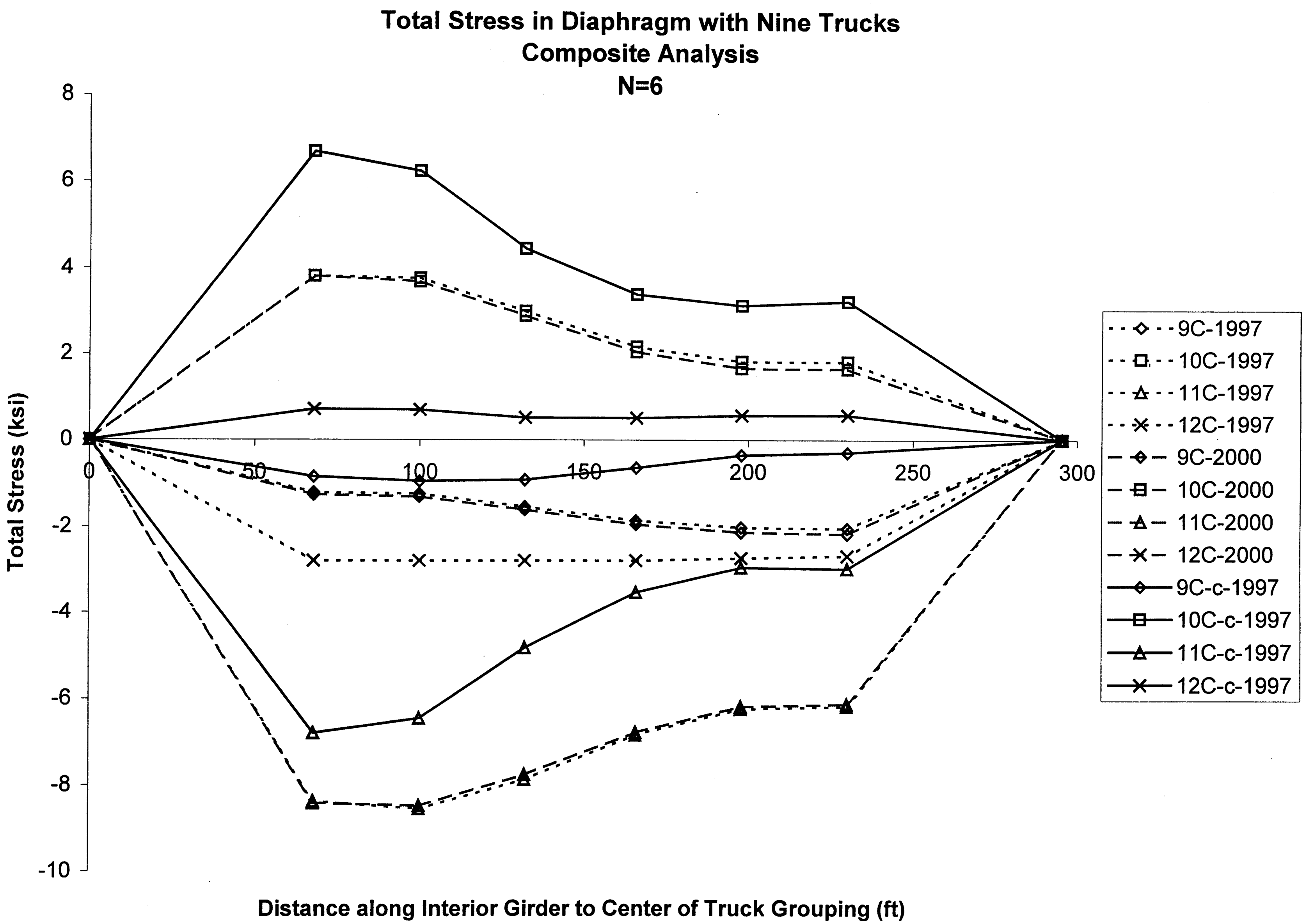


Figure F.21: Plot of Total Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 9C-12C)

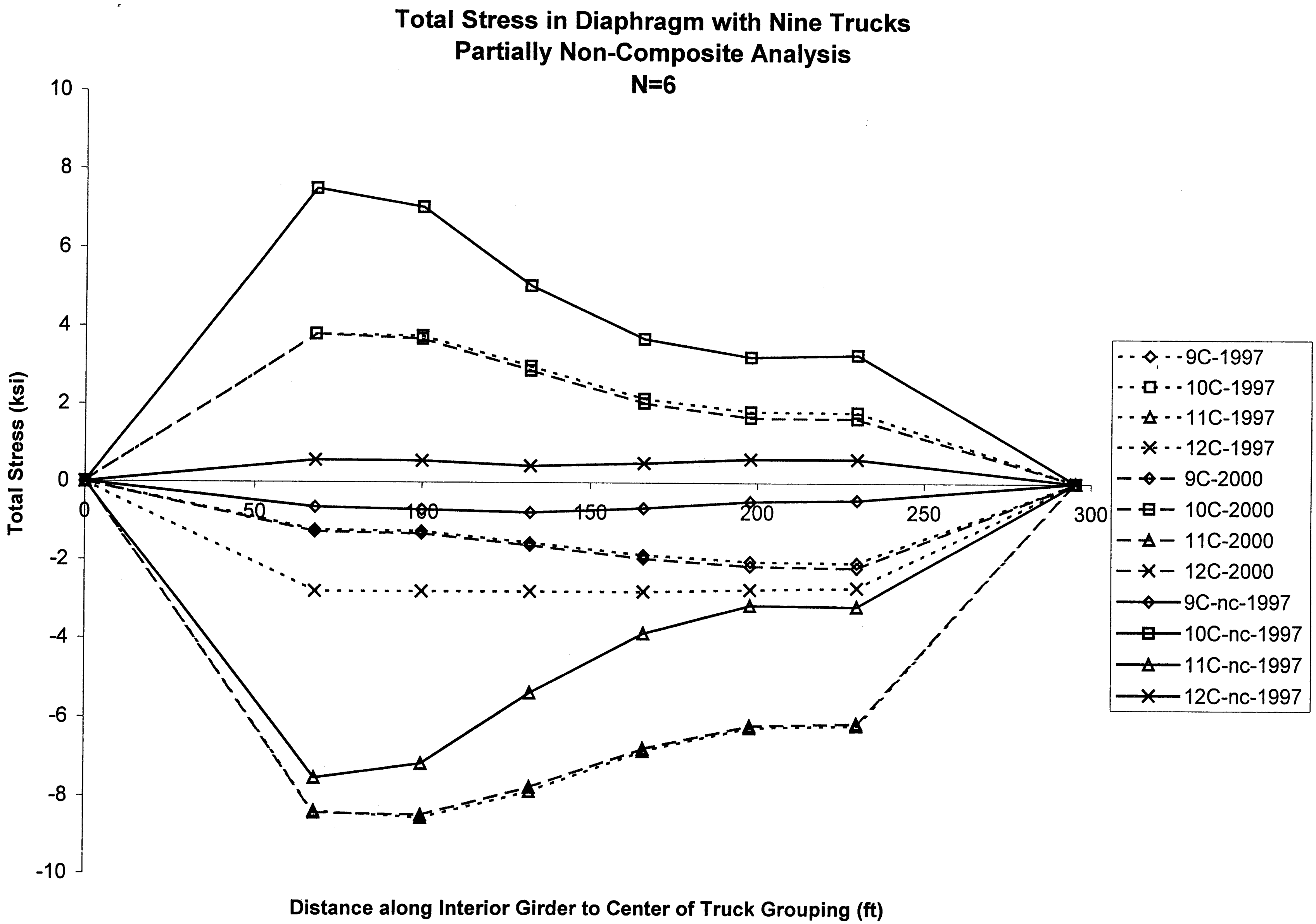


Figure F.22: Plot of Total Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 9C-12C)

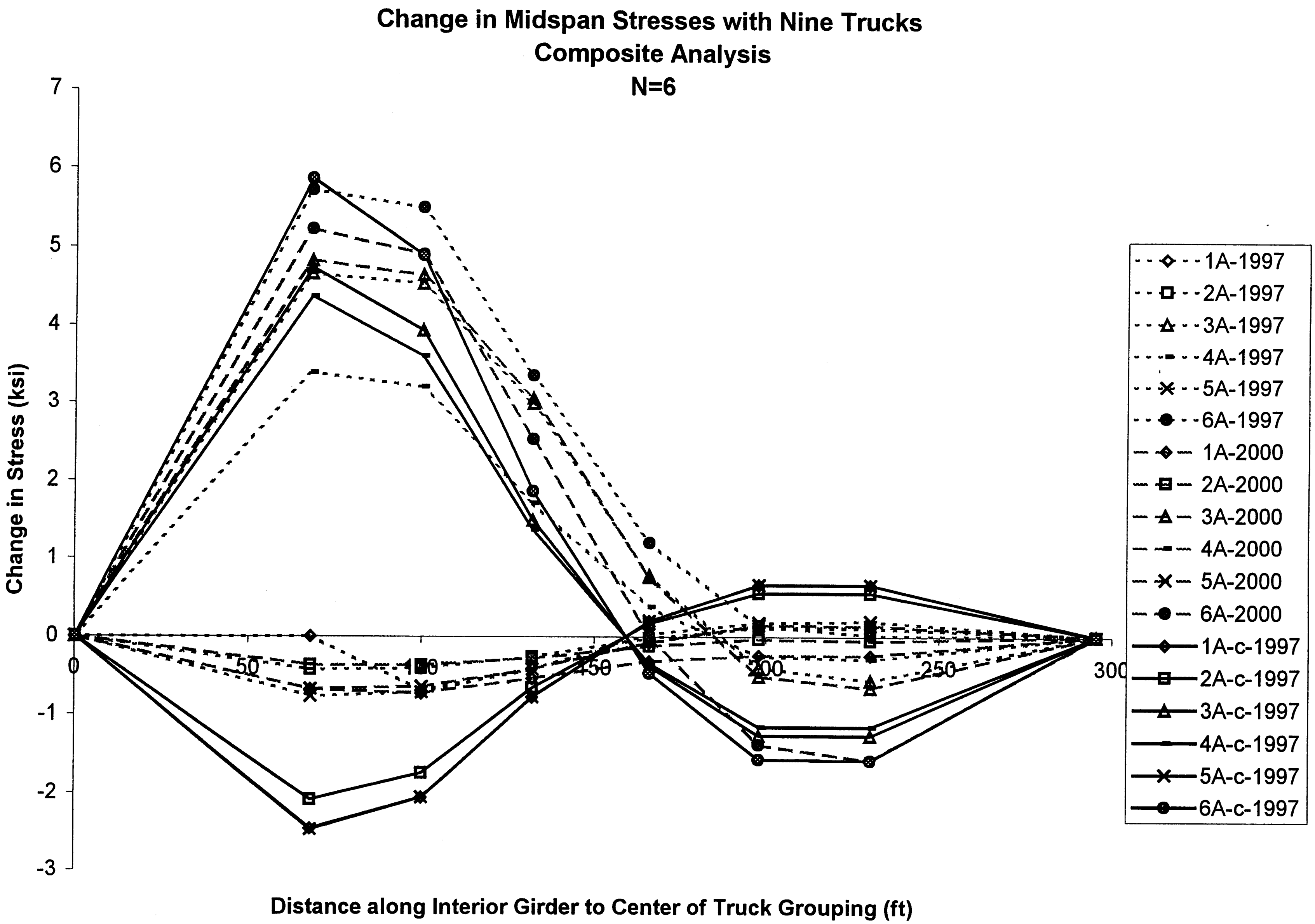


Figure F.23: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1A-6A)

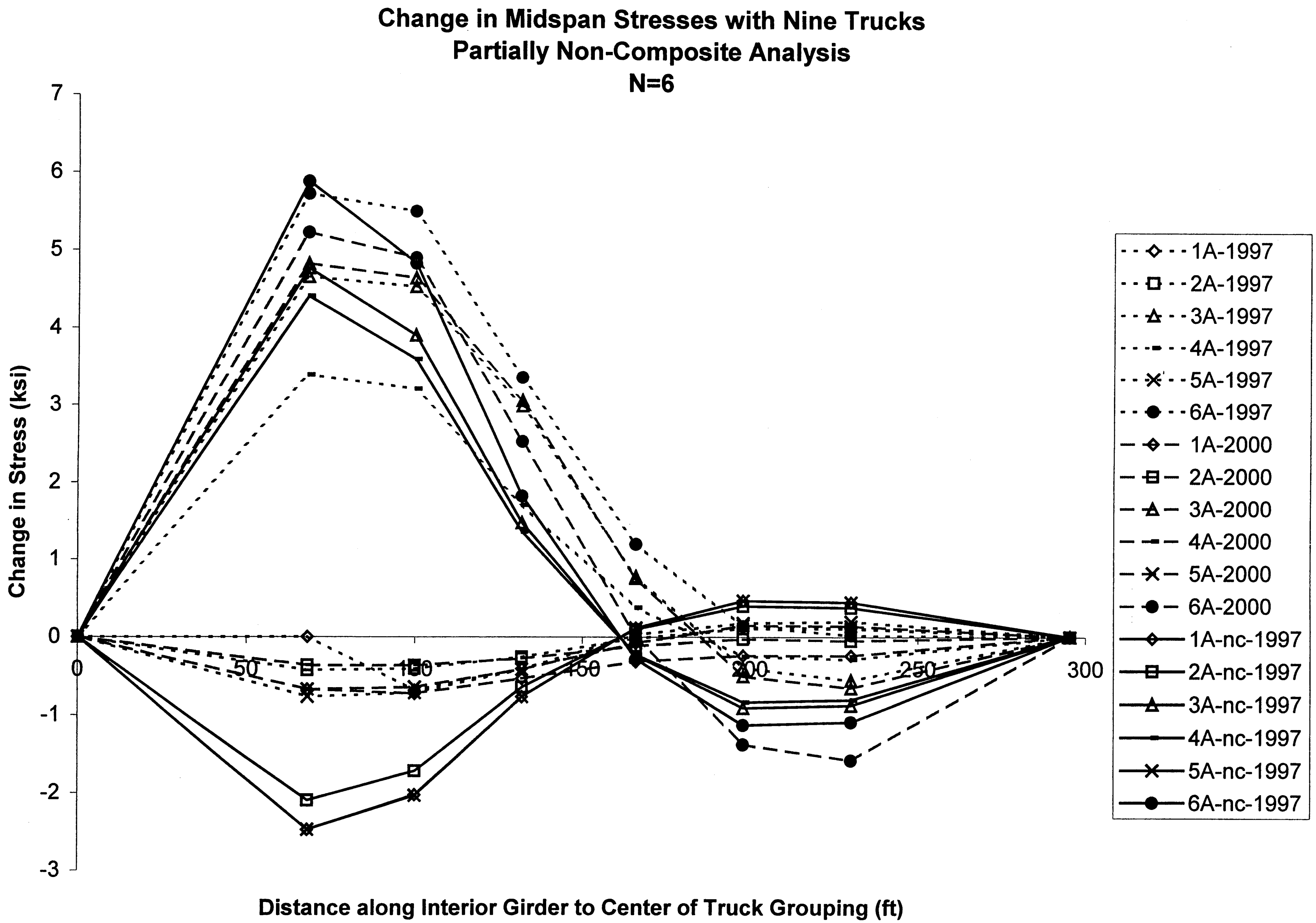


Figure F.24: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1A-6A)

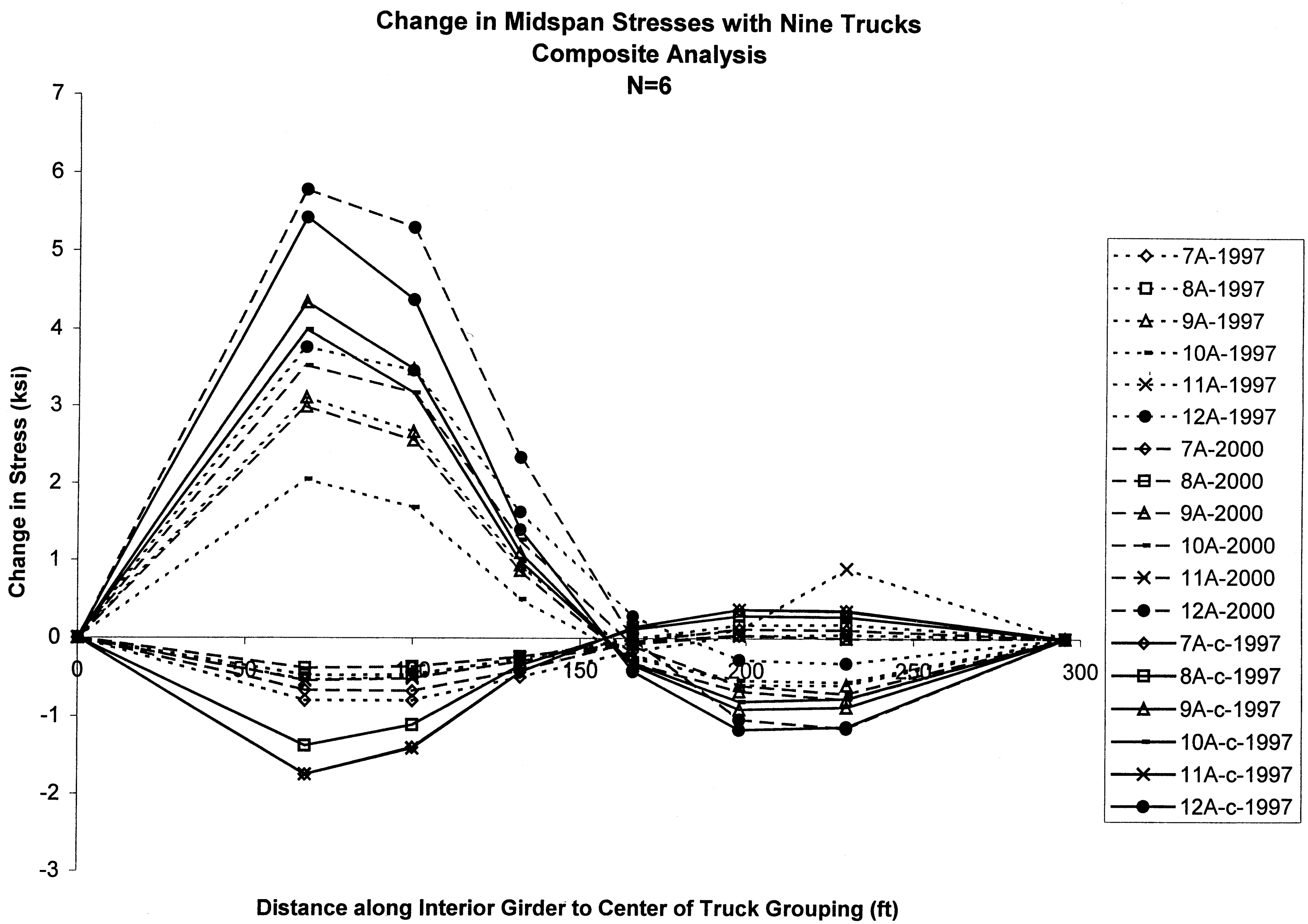


Figure F.25: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 7A-12A)

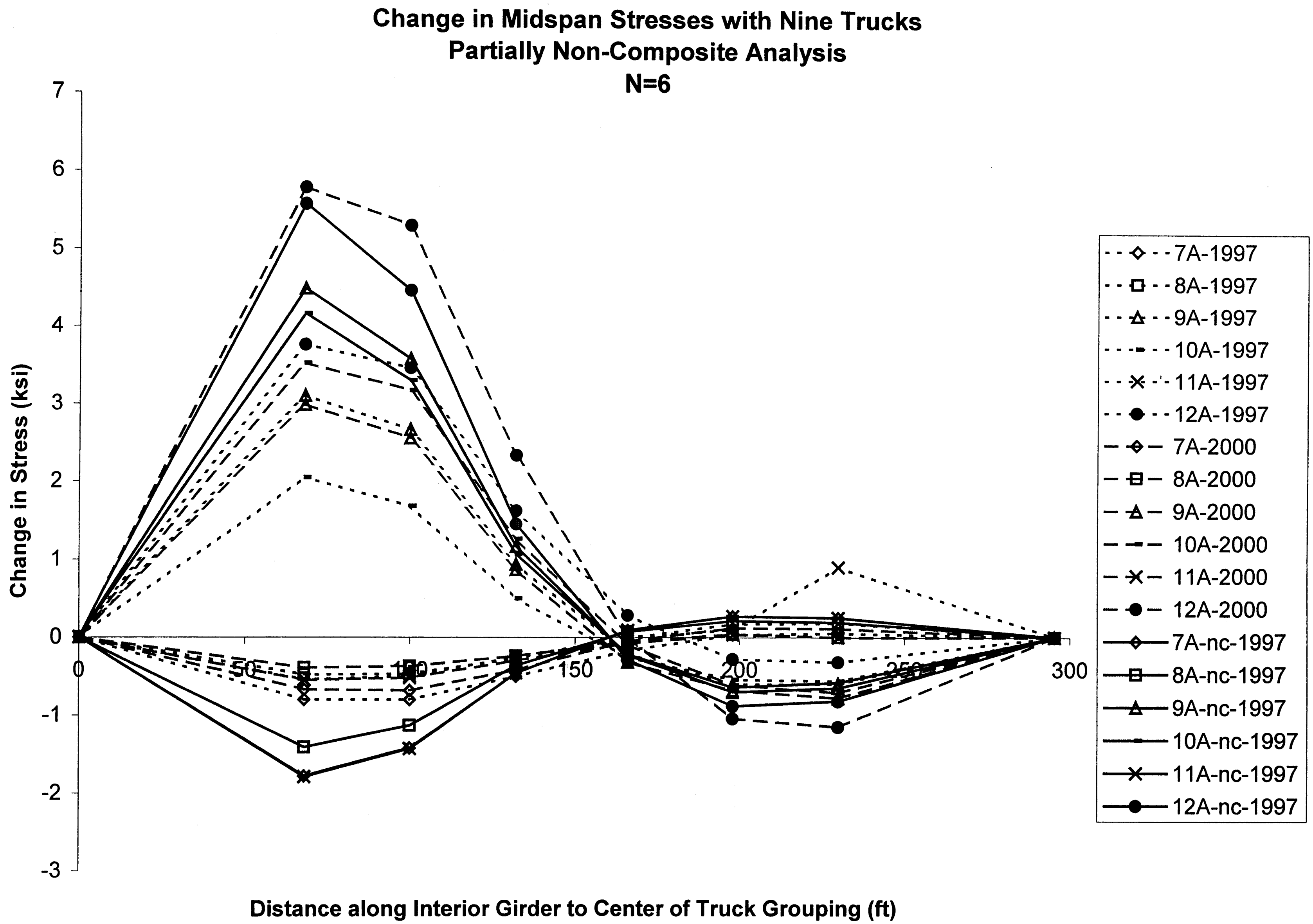


Figure F.26: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7A-12A)

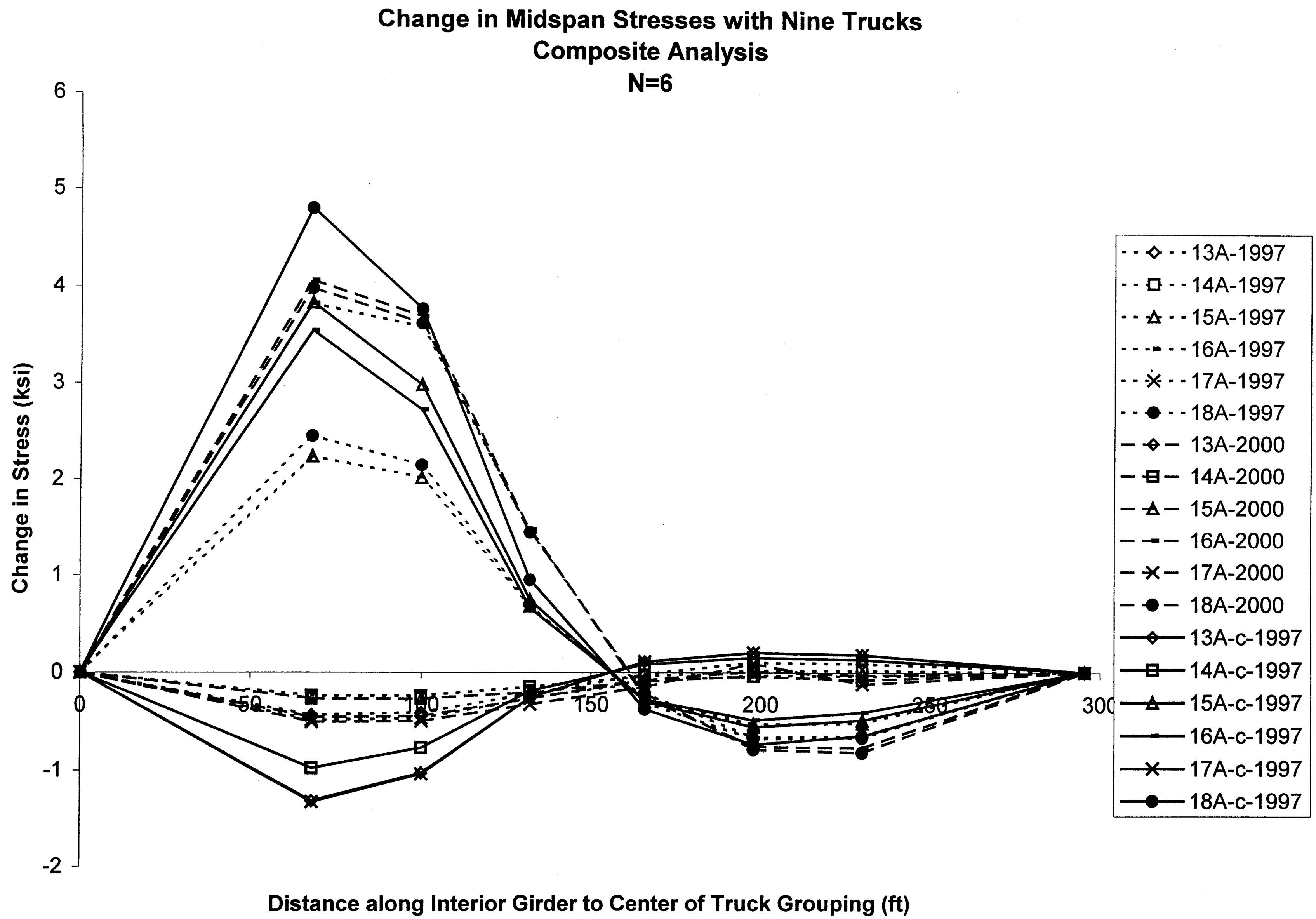


Figure F.27: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 13A-18A)

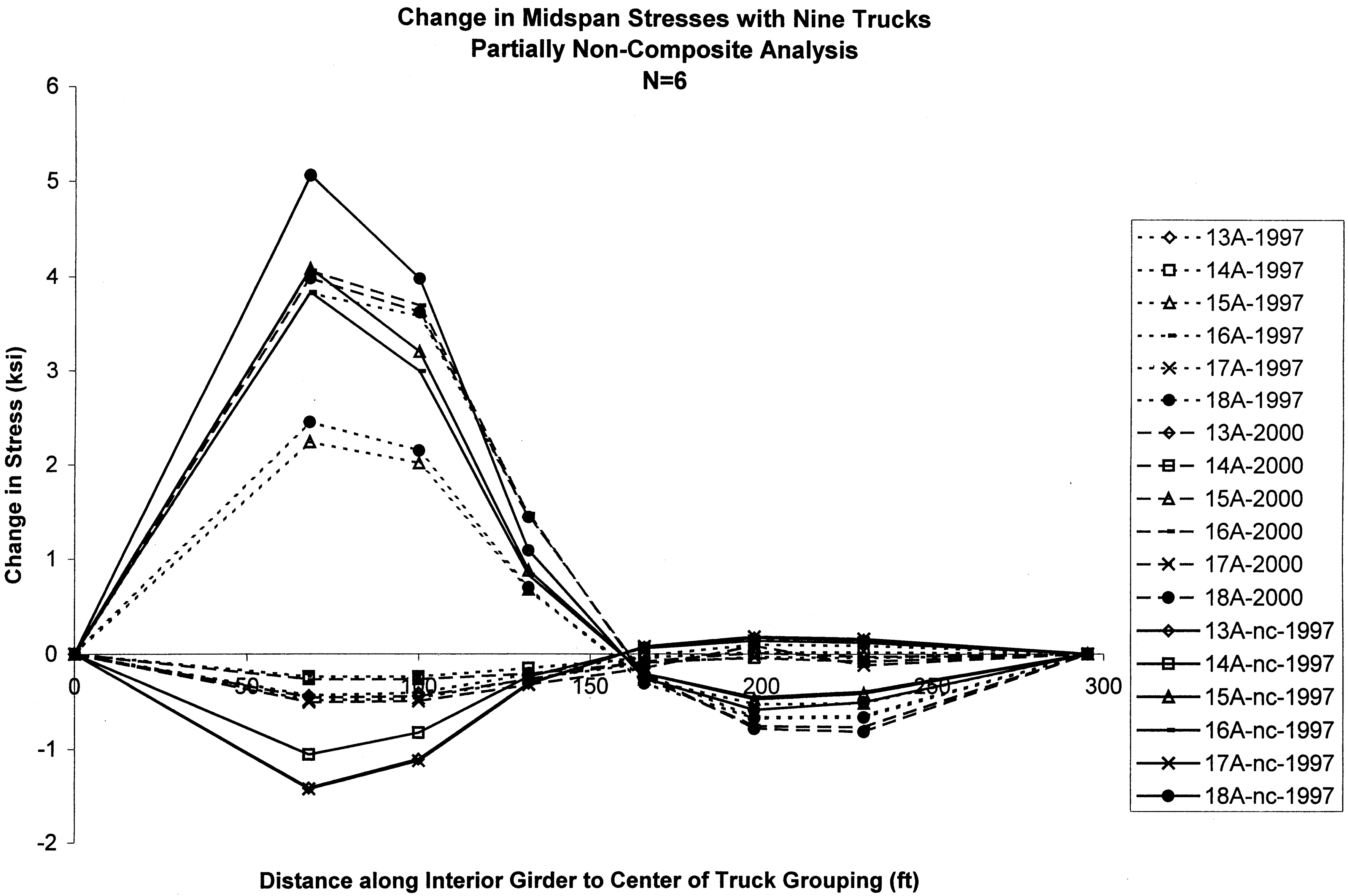


Figure F.28: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13A-18A)

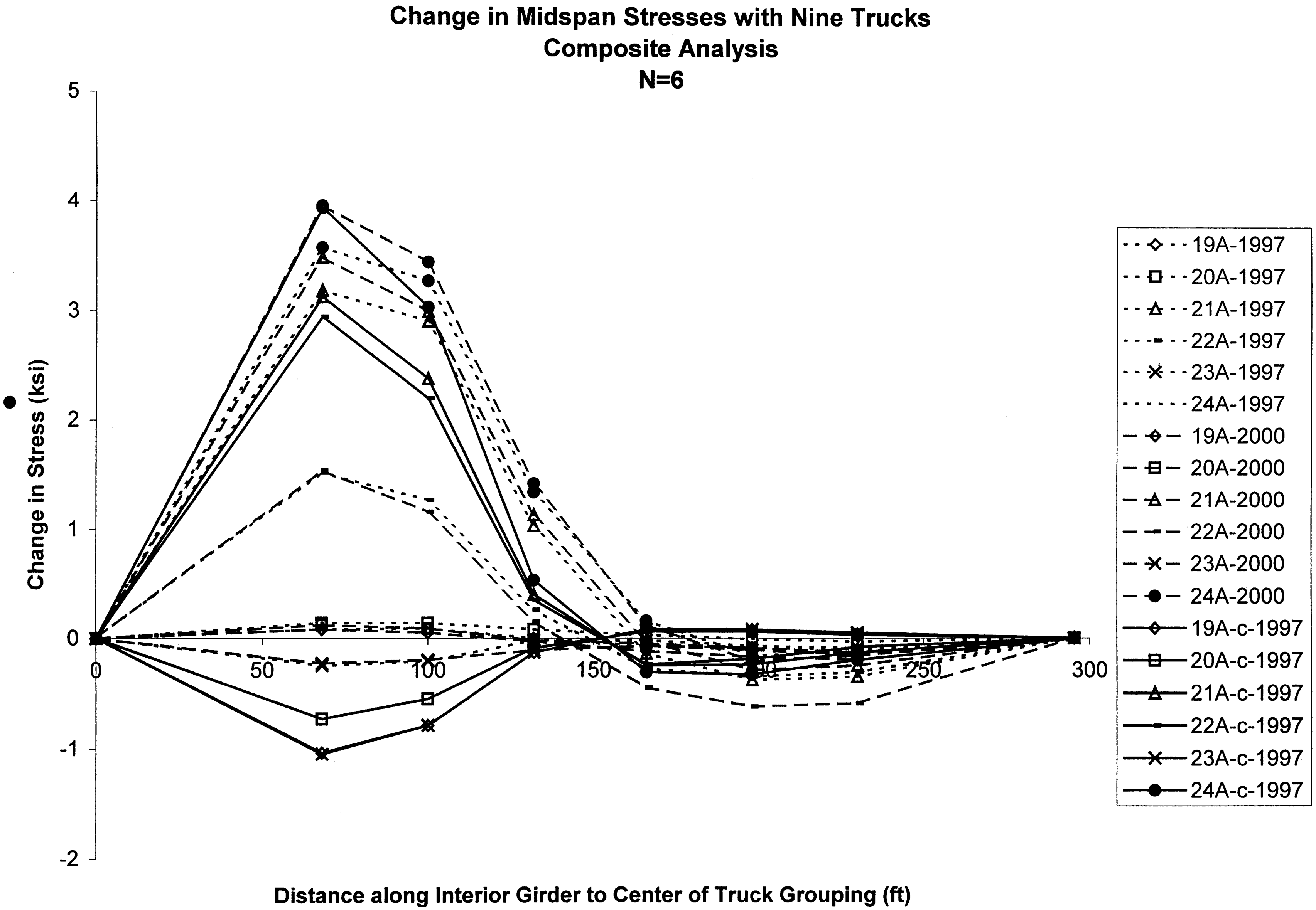


Figure F.29: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 19A-24A)

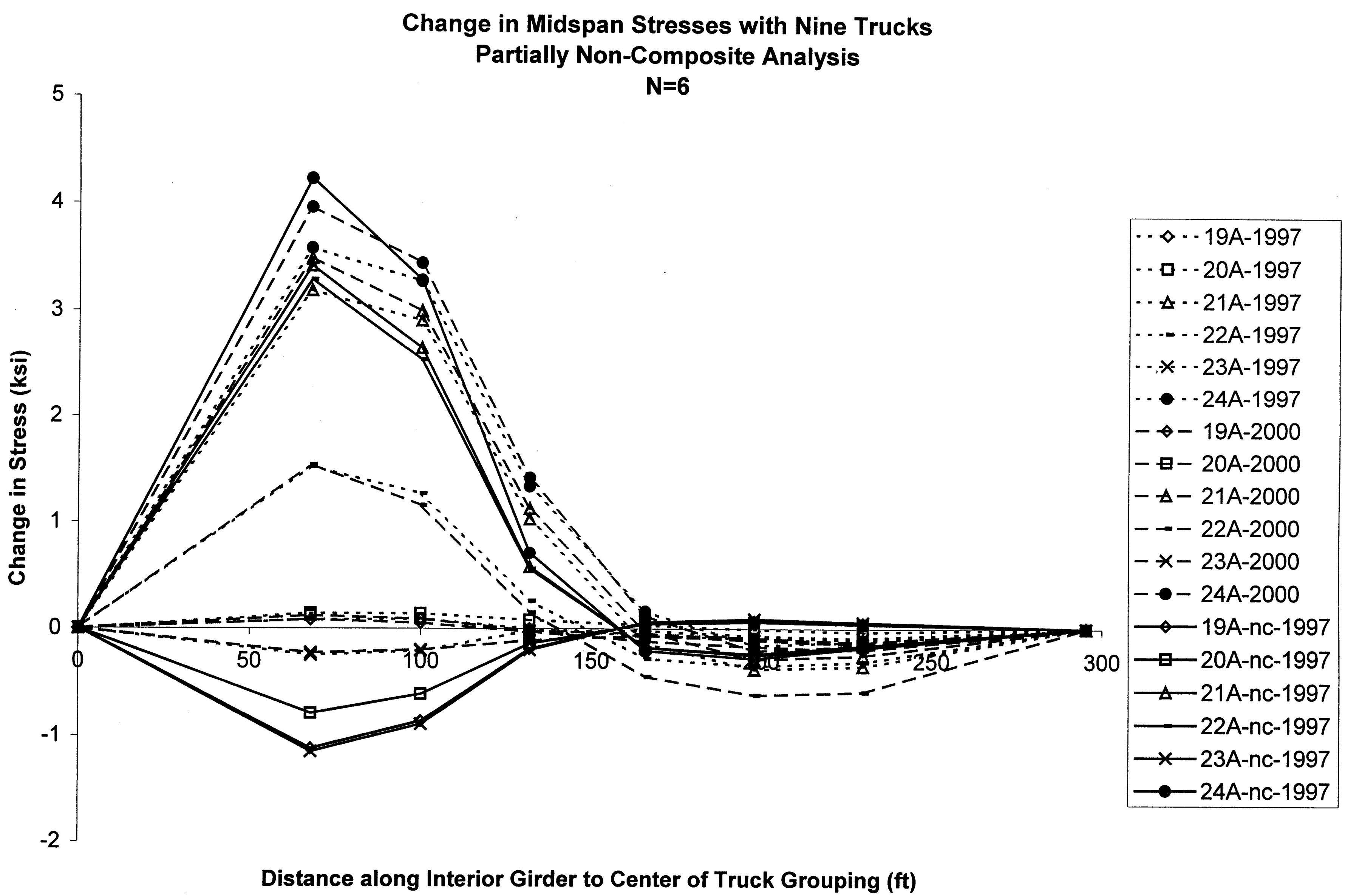


Figure F.30: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19A-24A)

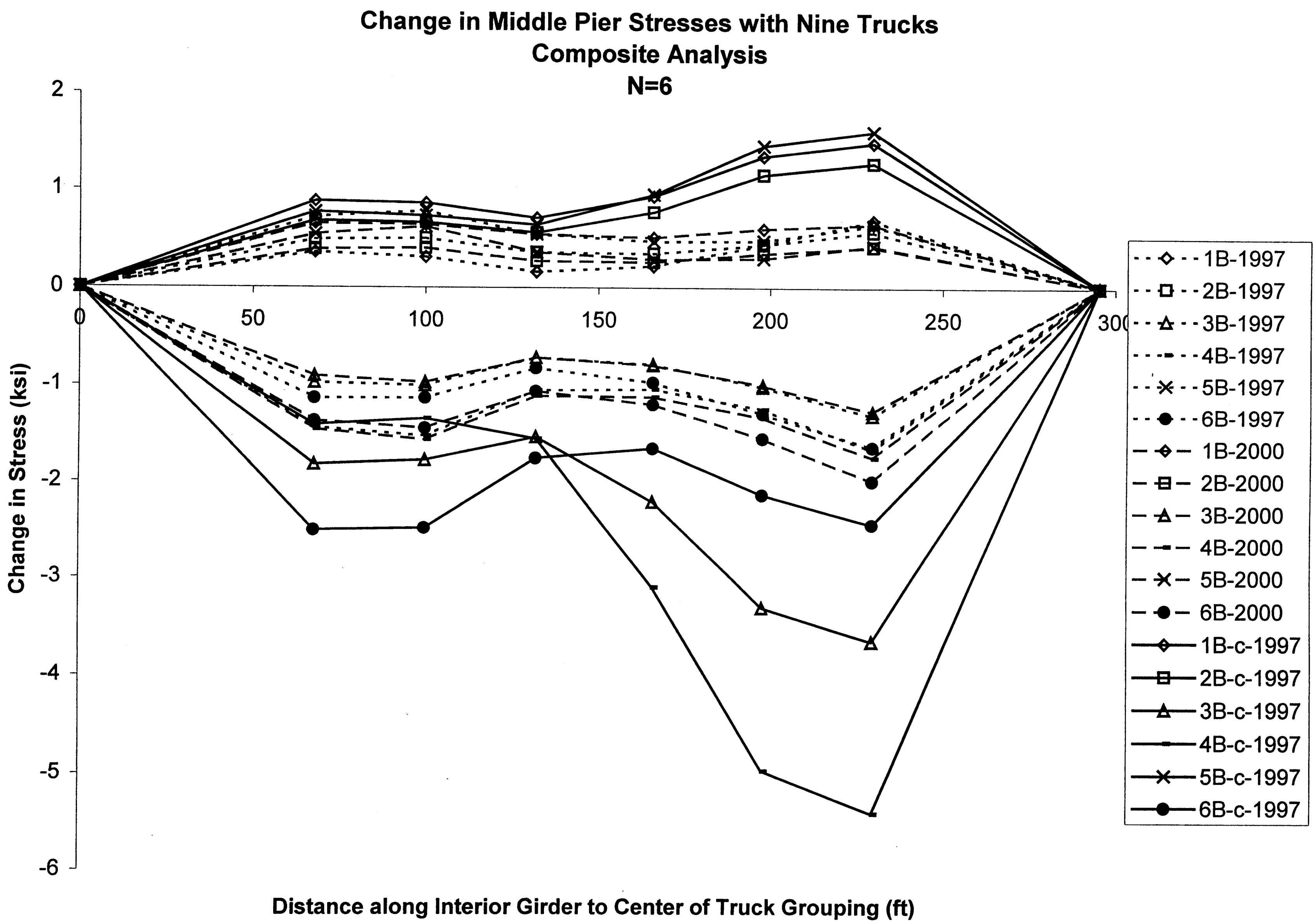


Figure F.31: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1B-6B)

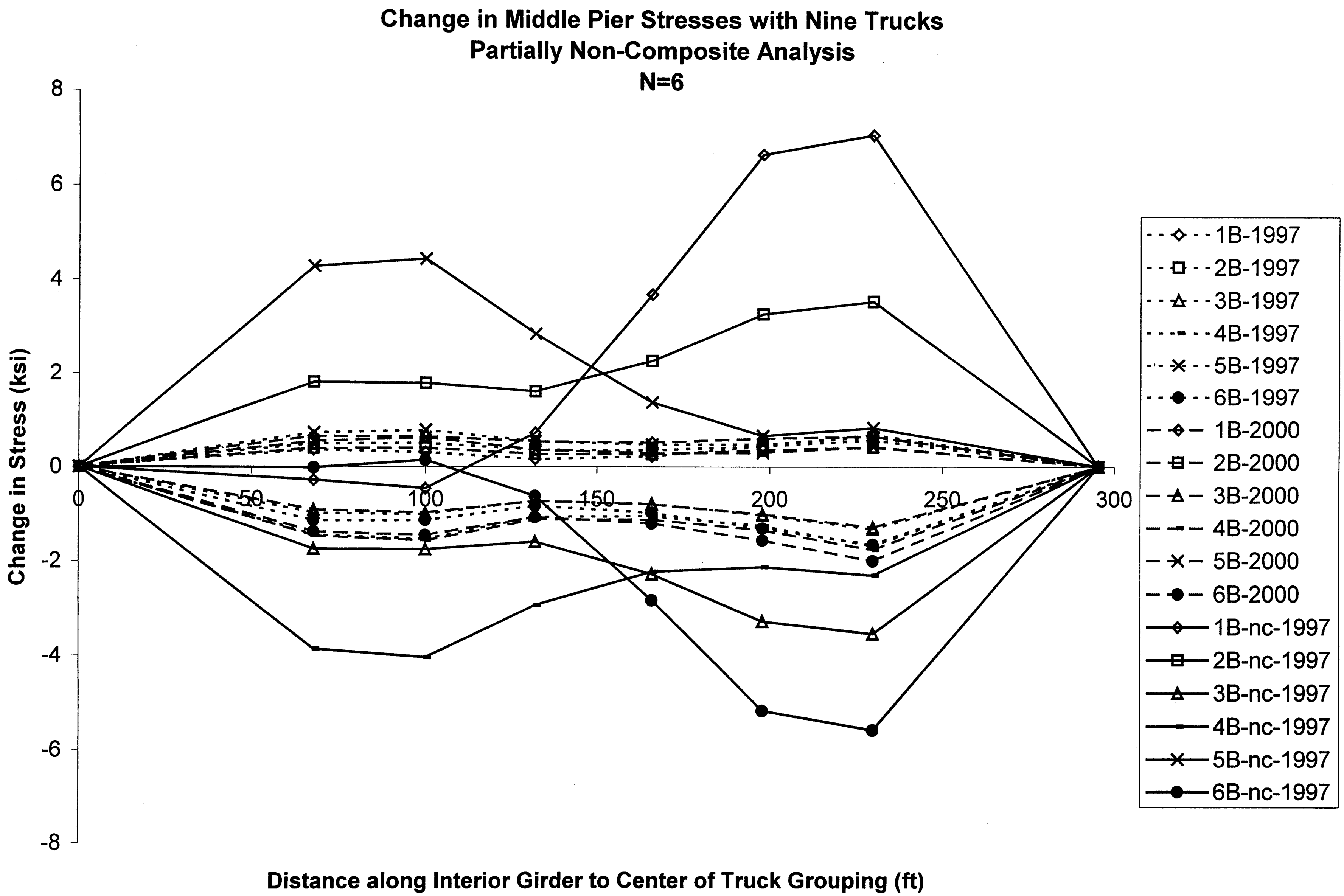


Figure F.32: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1B-6B)

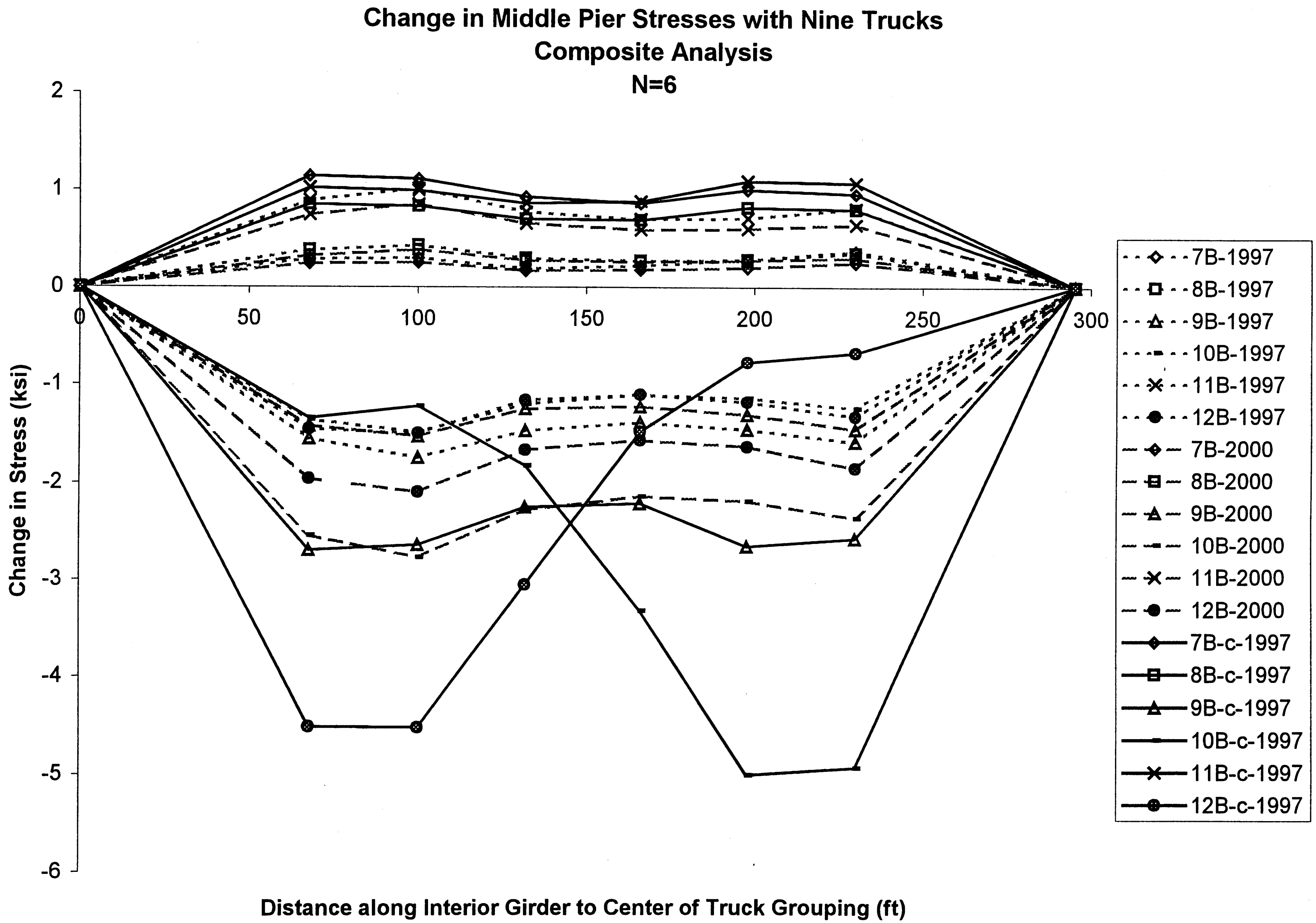


Figure F.33: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 7B-12B)

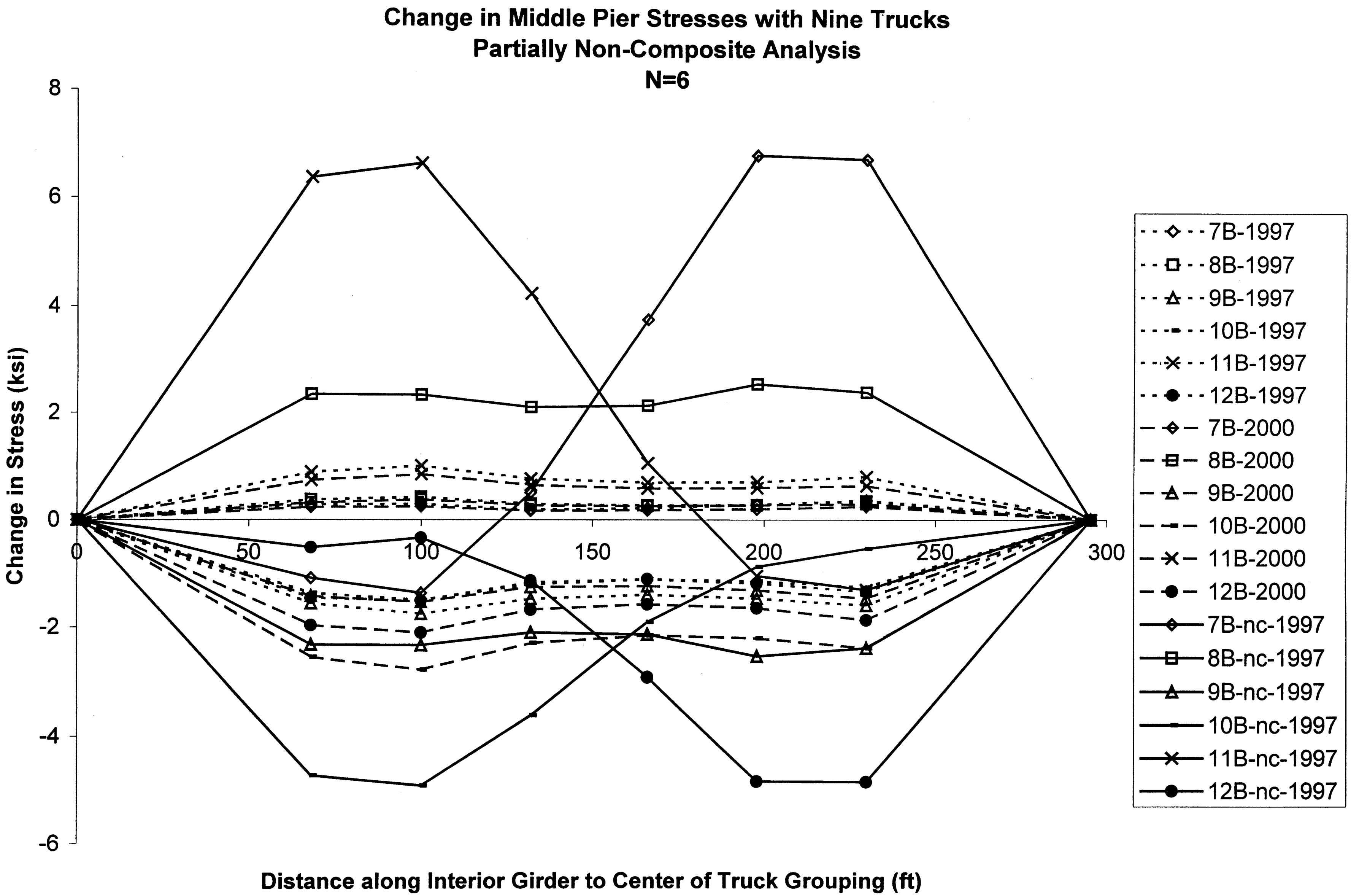


Figure F.34: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7B-12B)

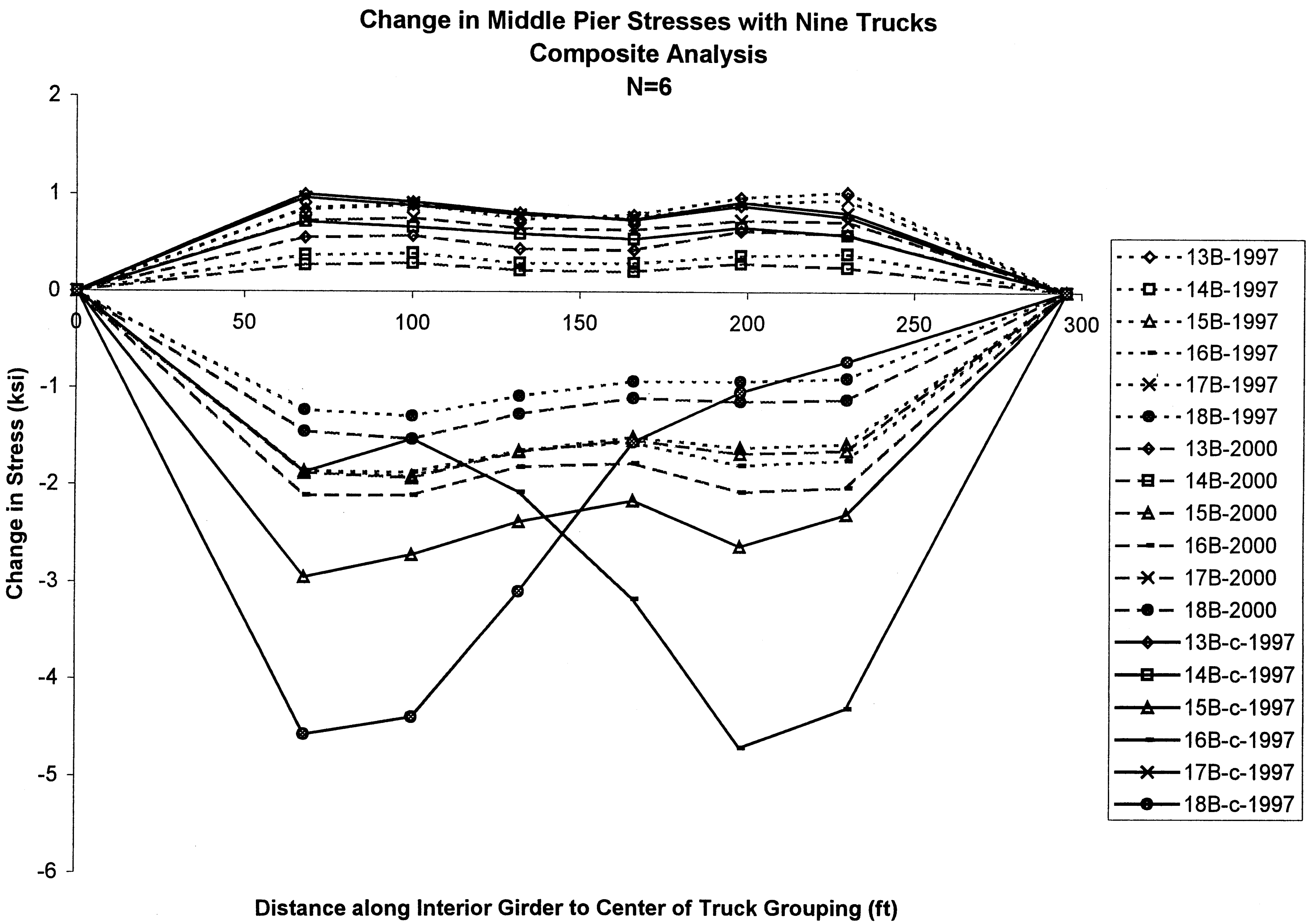


Figure F.35: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 13B-18B)

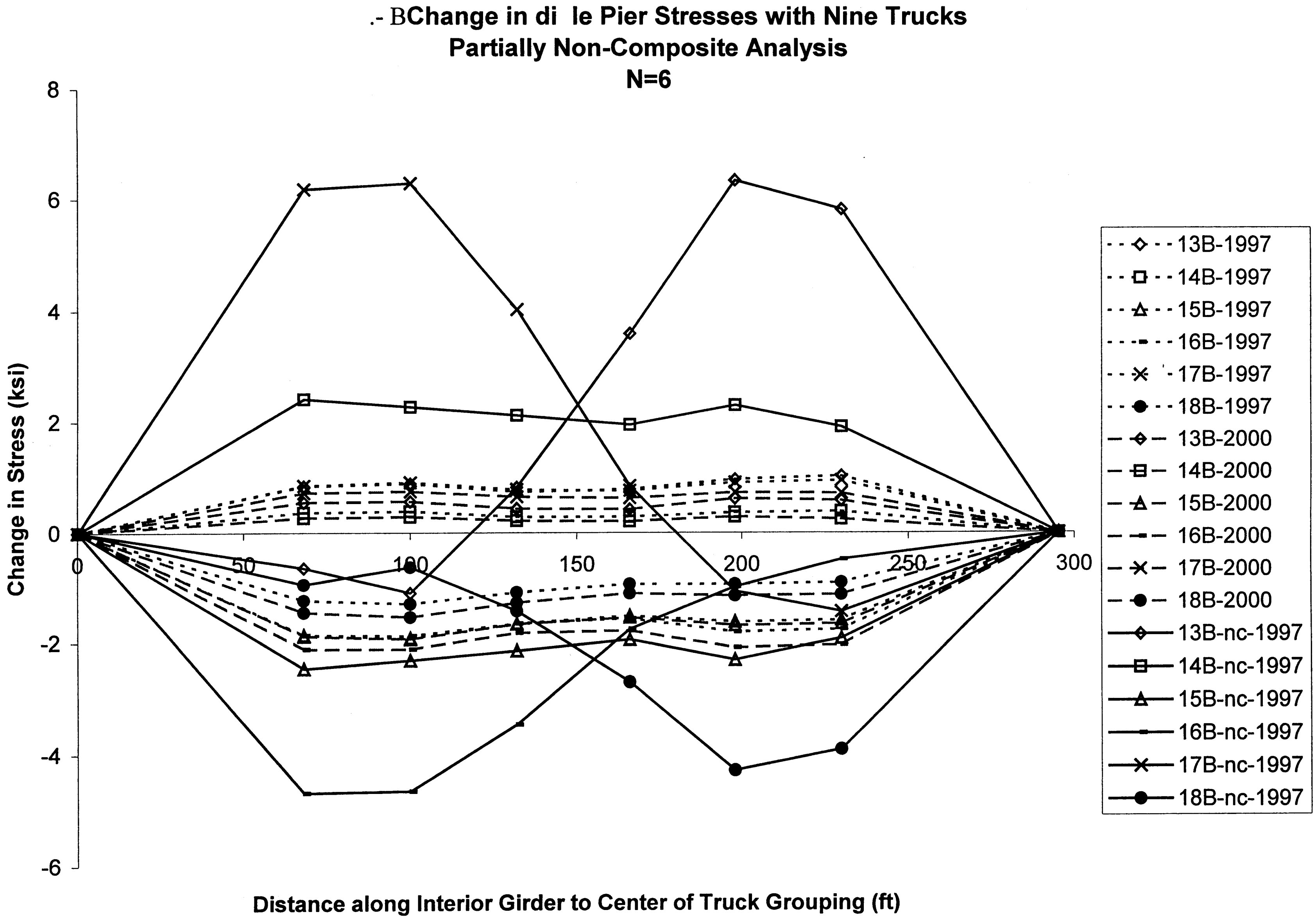


Figure F.36: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13B-18B)

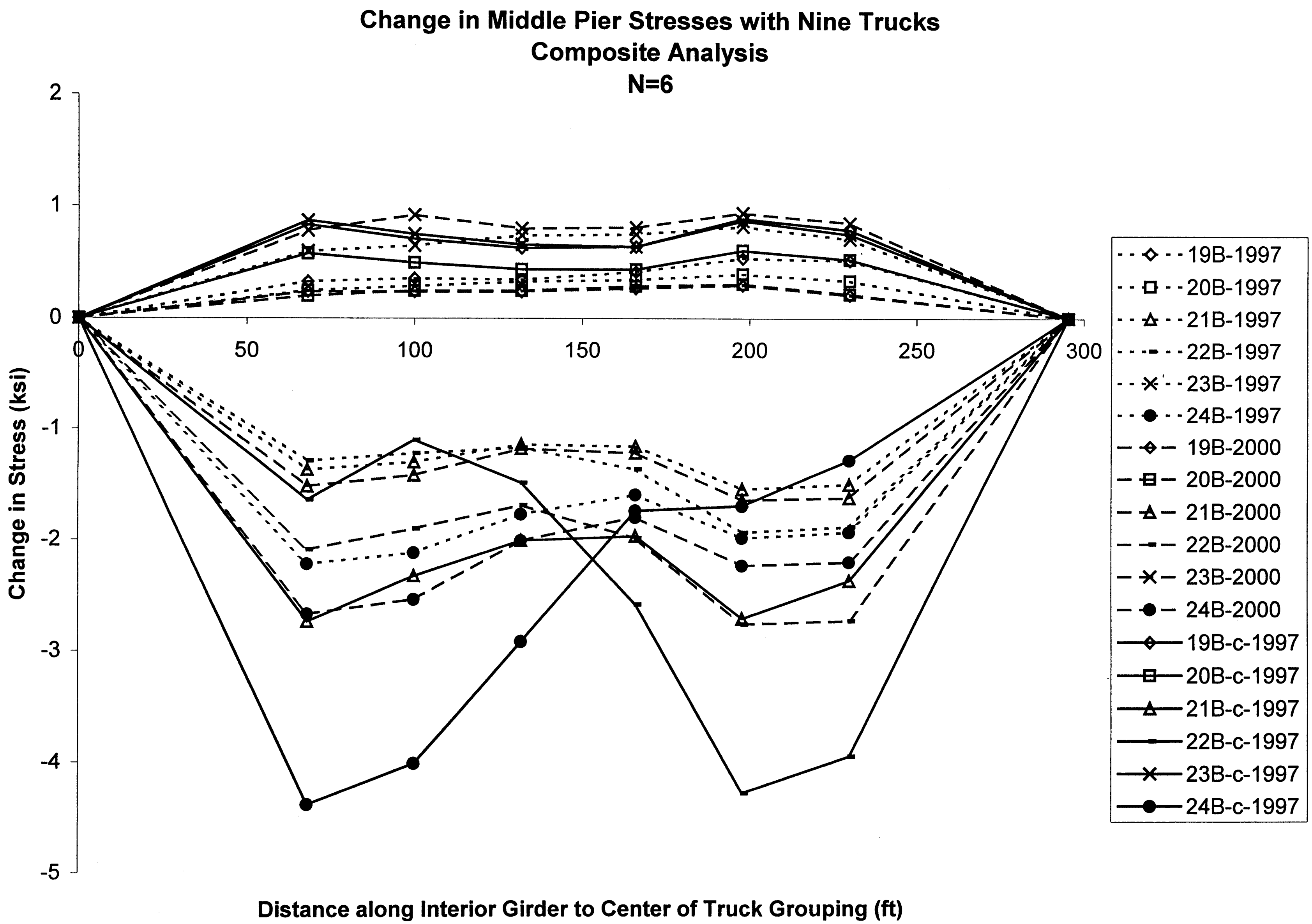


Figure F.37: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 19B-24B)

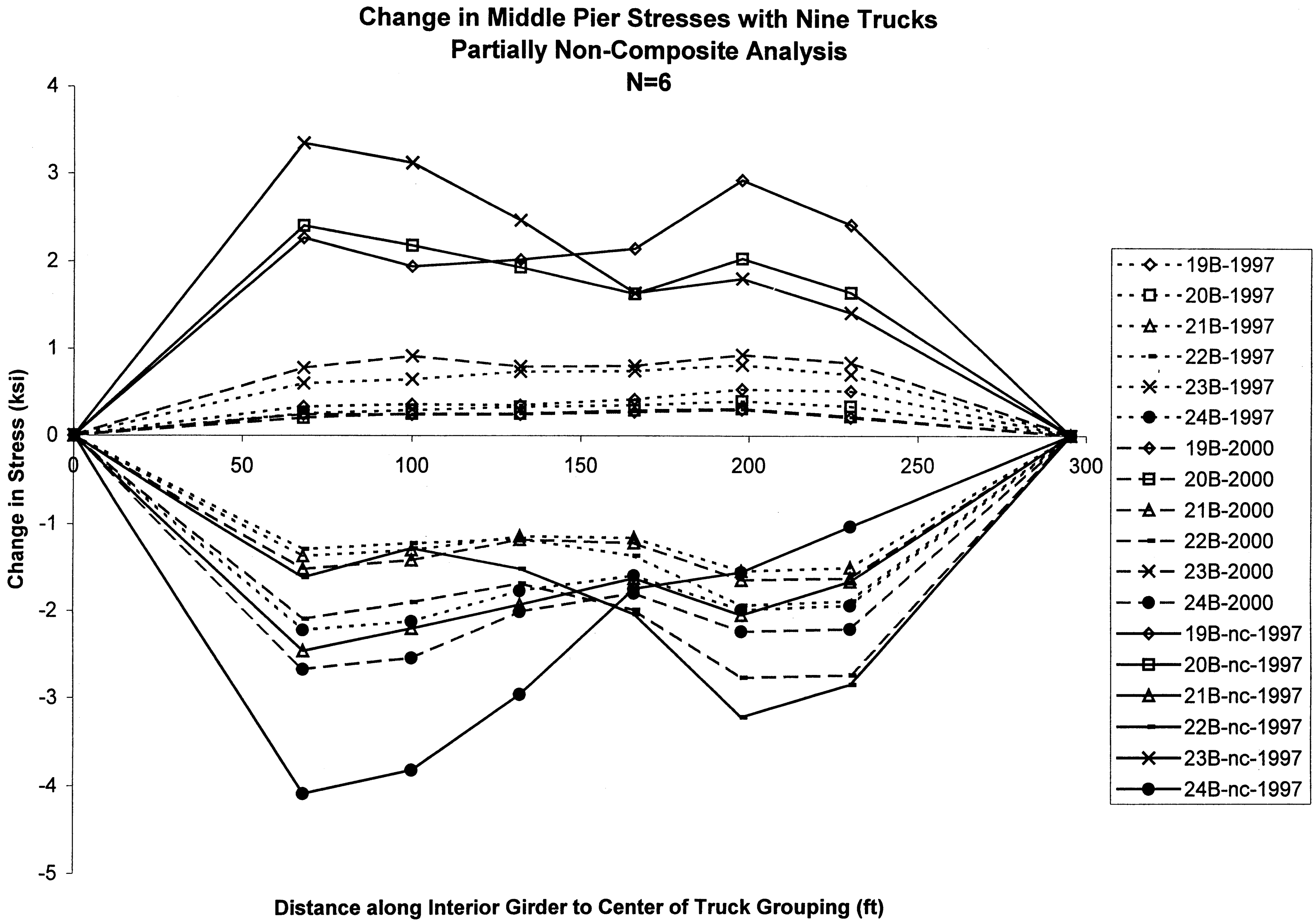


Figure F.38: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19B-24B)

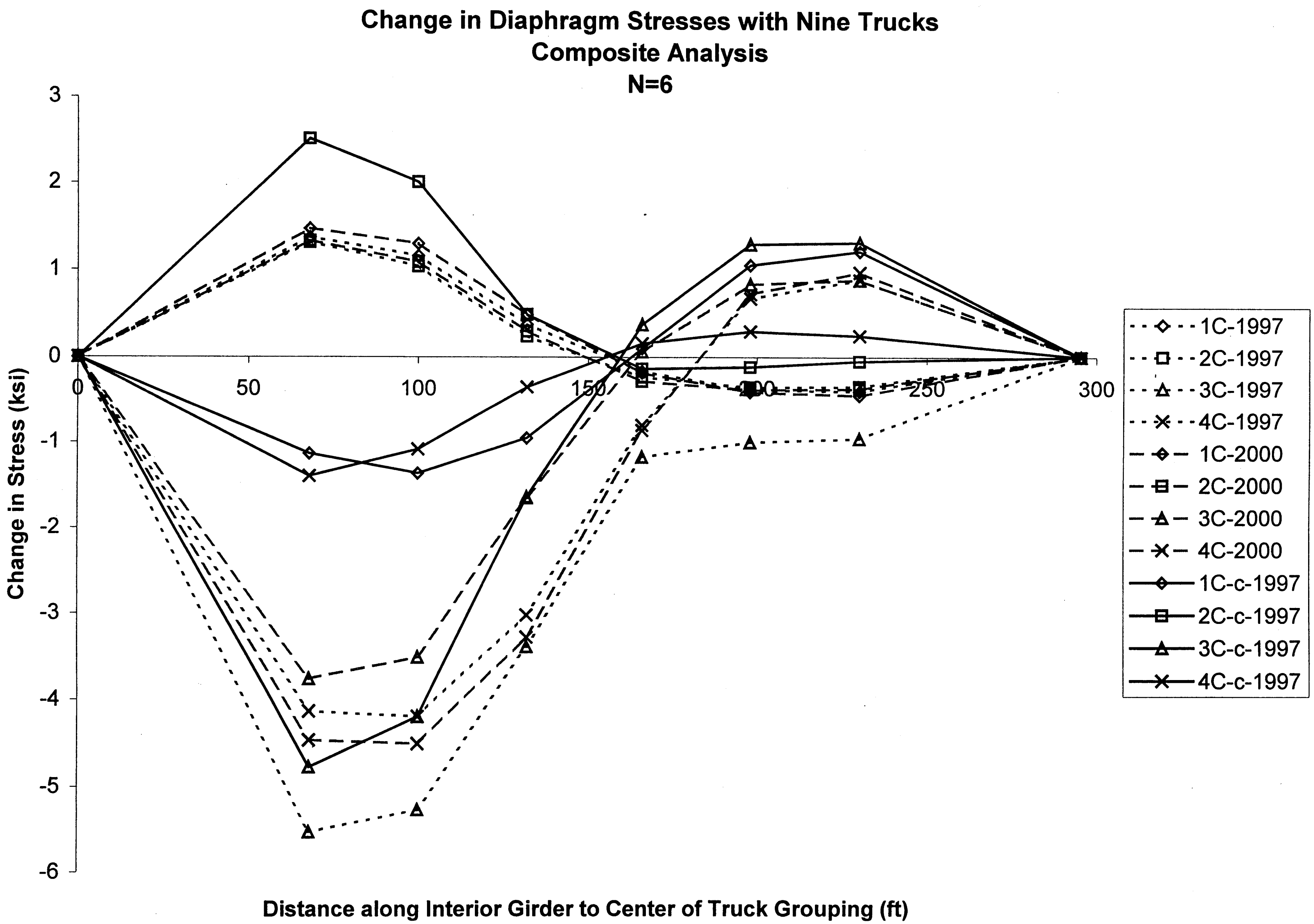


Figure F.39: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 1C-4C)

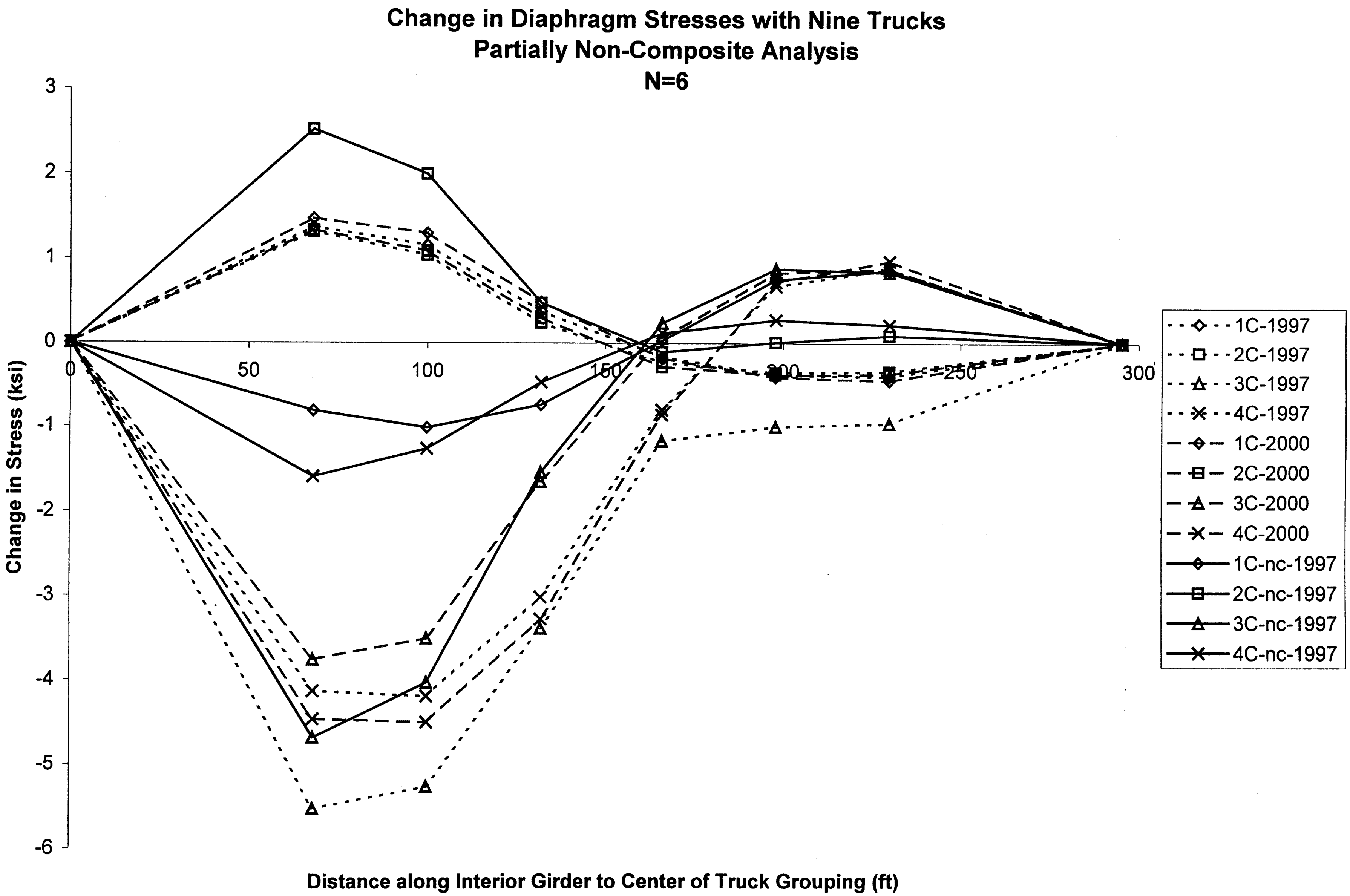


Figure F.40: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1C-4C)

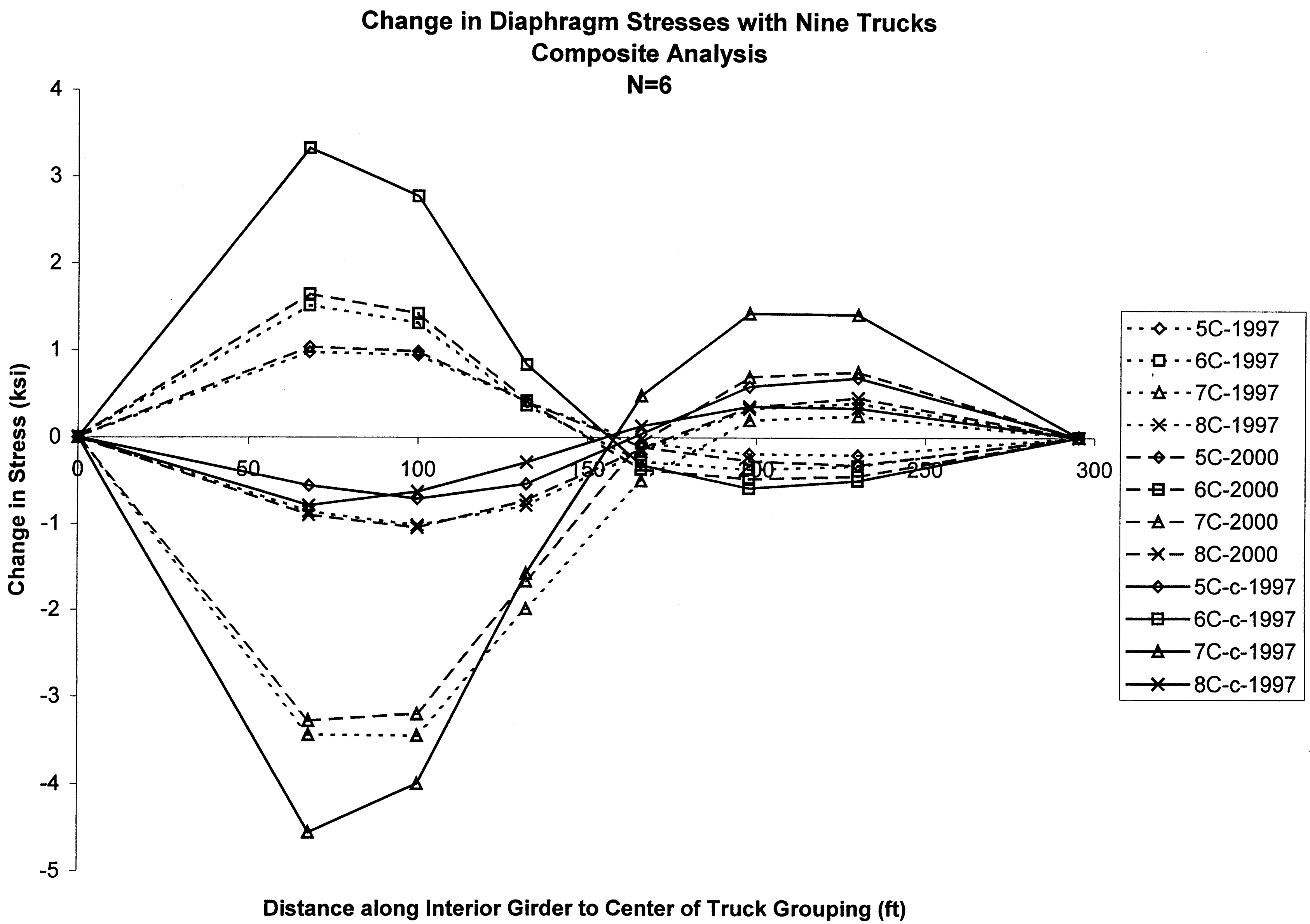


Figure F.41: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 5C-8C)

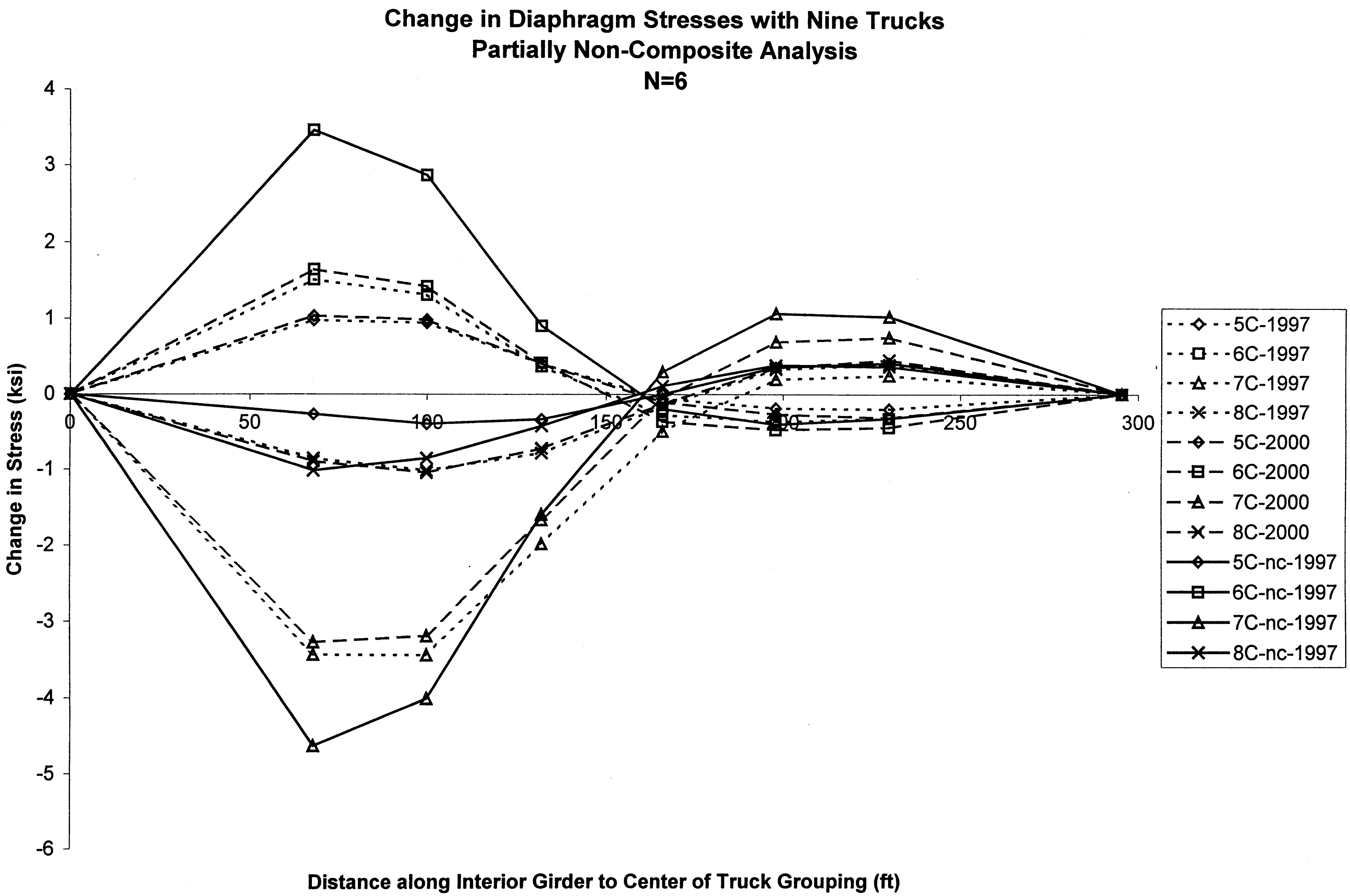


Figure F.42: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 5C-8C)

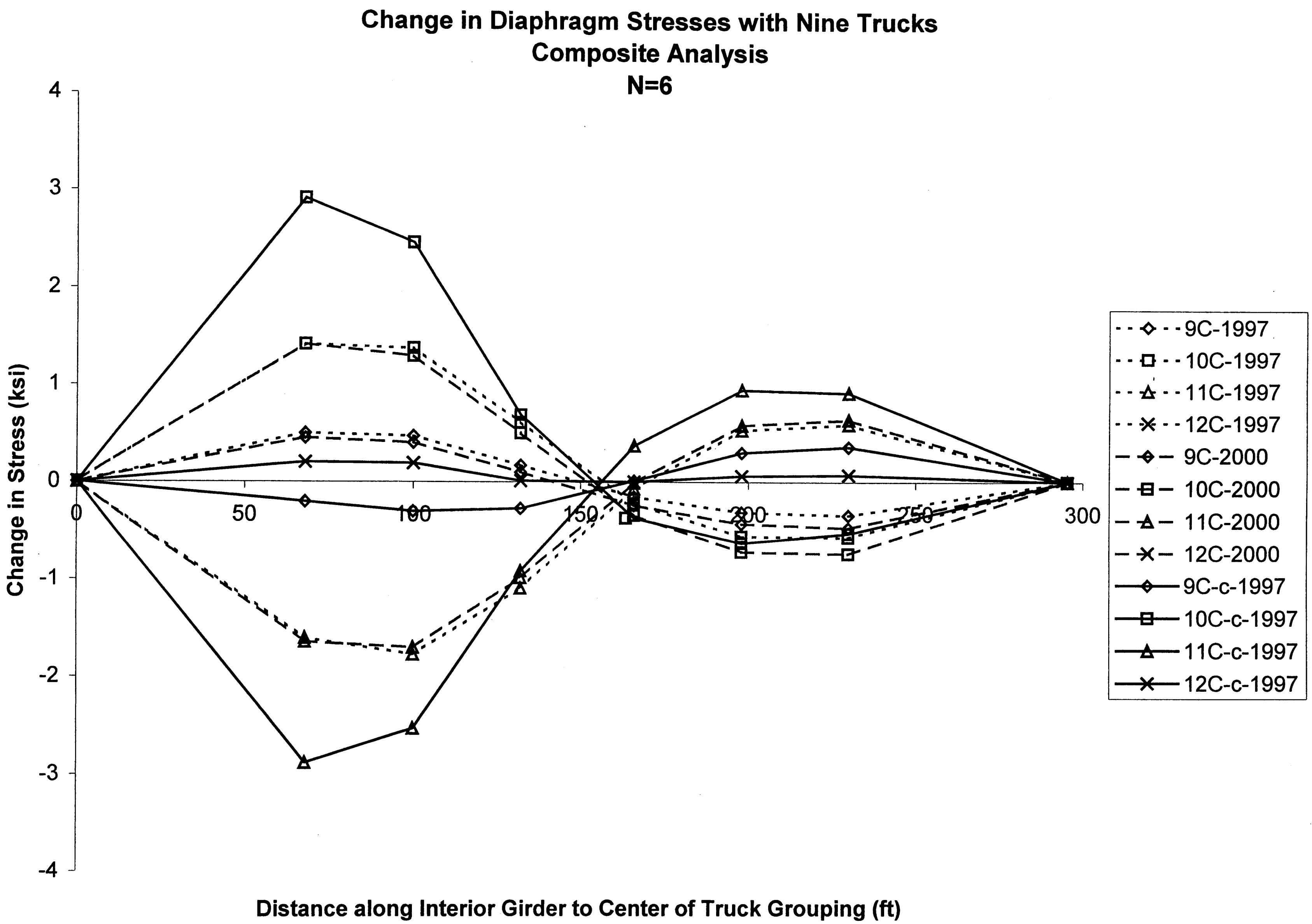


Figure F.43: Plot of Change in Stress with Nine Trucks 1997, Composite Analysis, N = 6 (Gages 9C-12C)

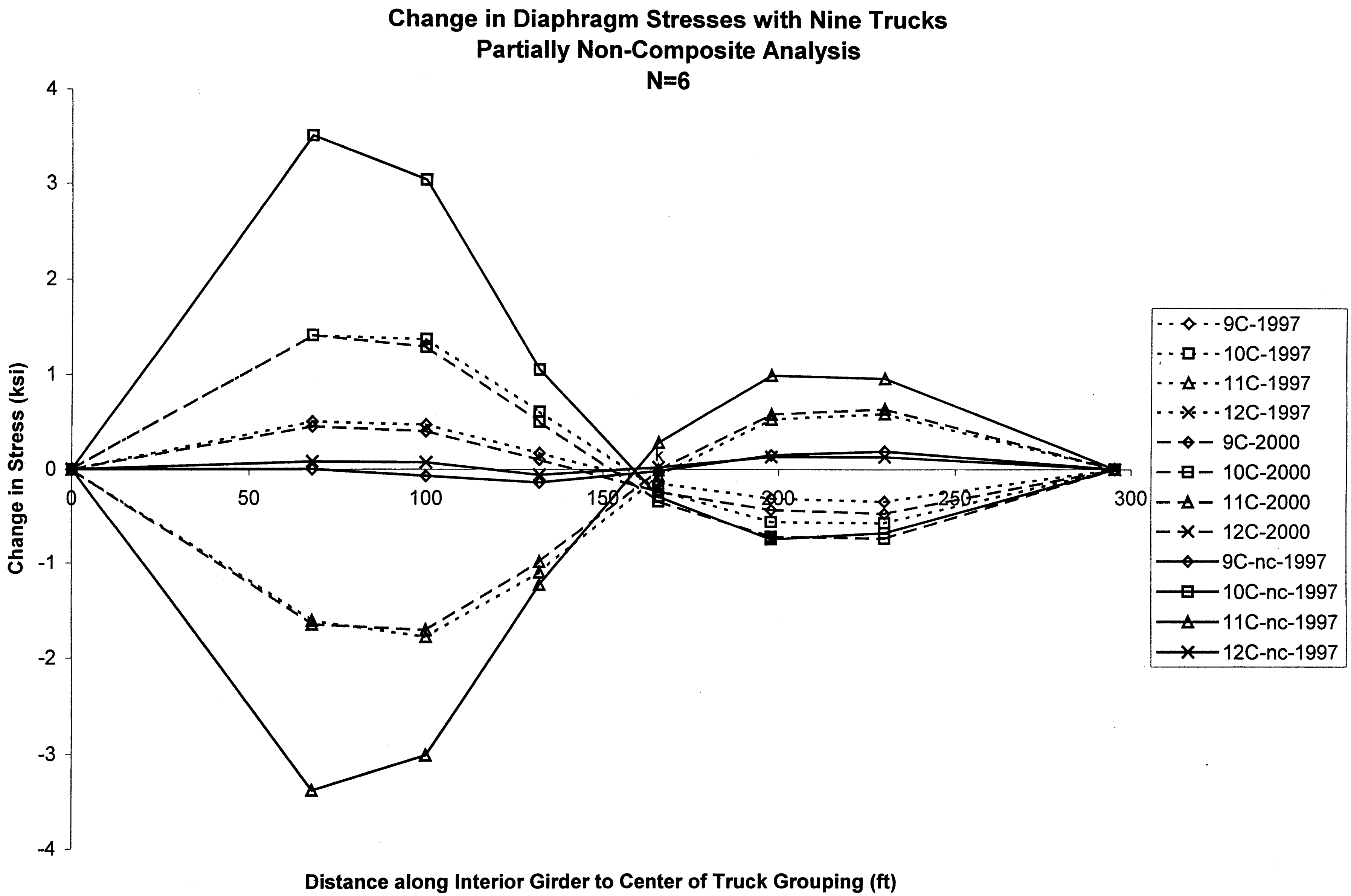


Figure F.44: Plot of Change in Stress with Nine Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 9C-12C)

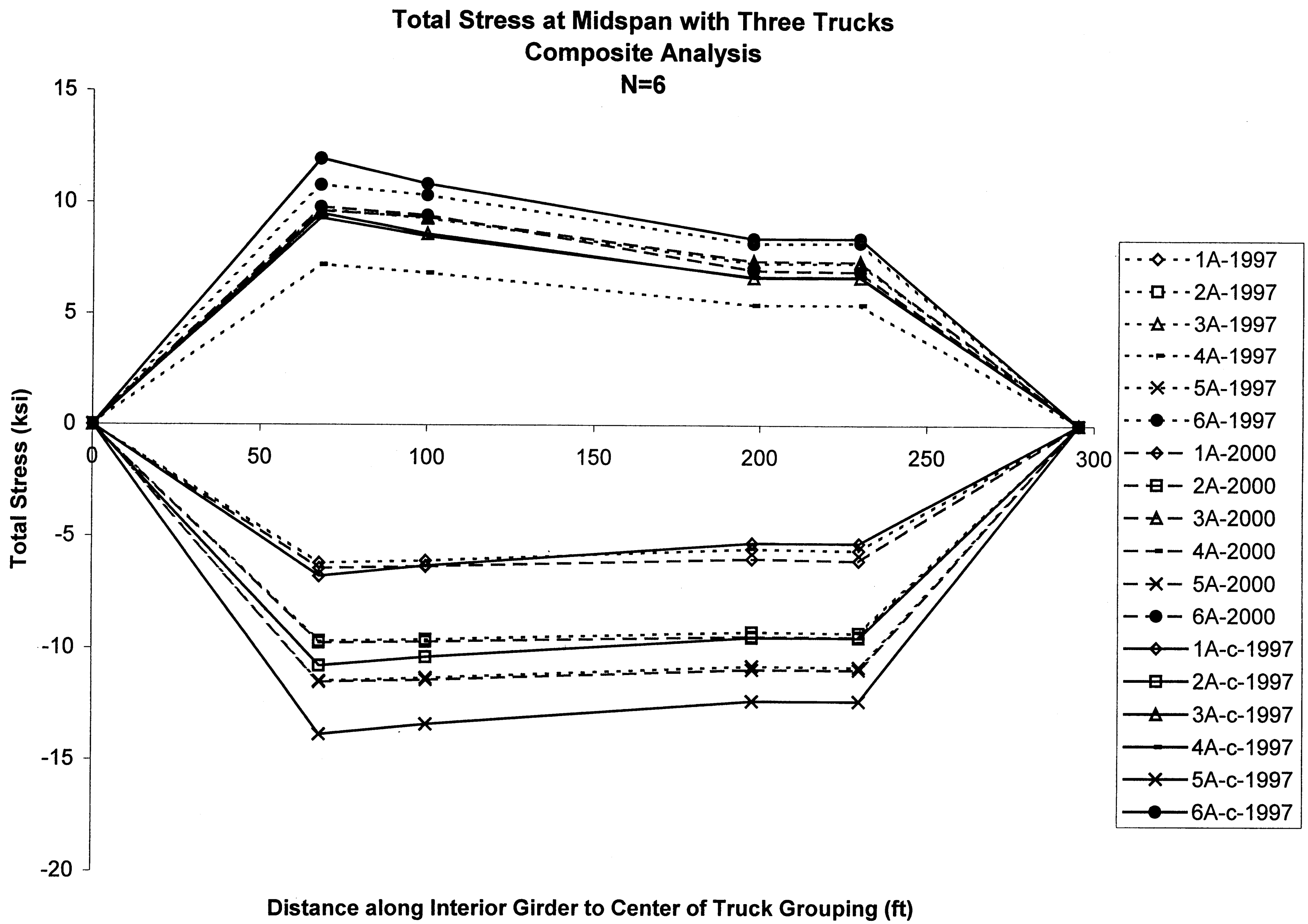


Figure F.45: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1A-6A)

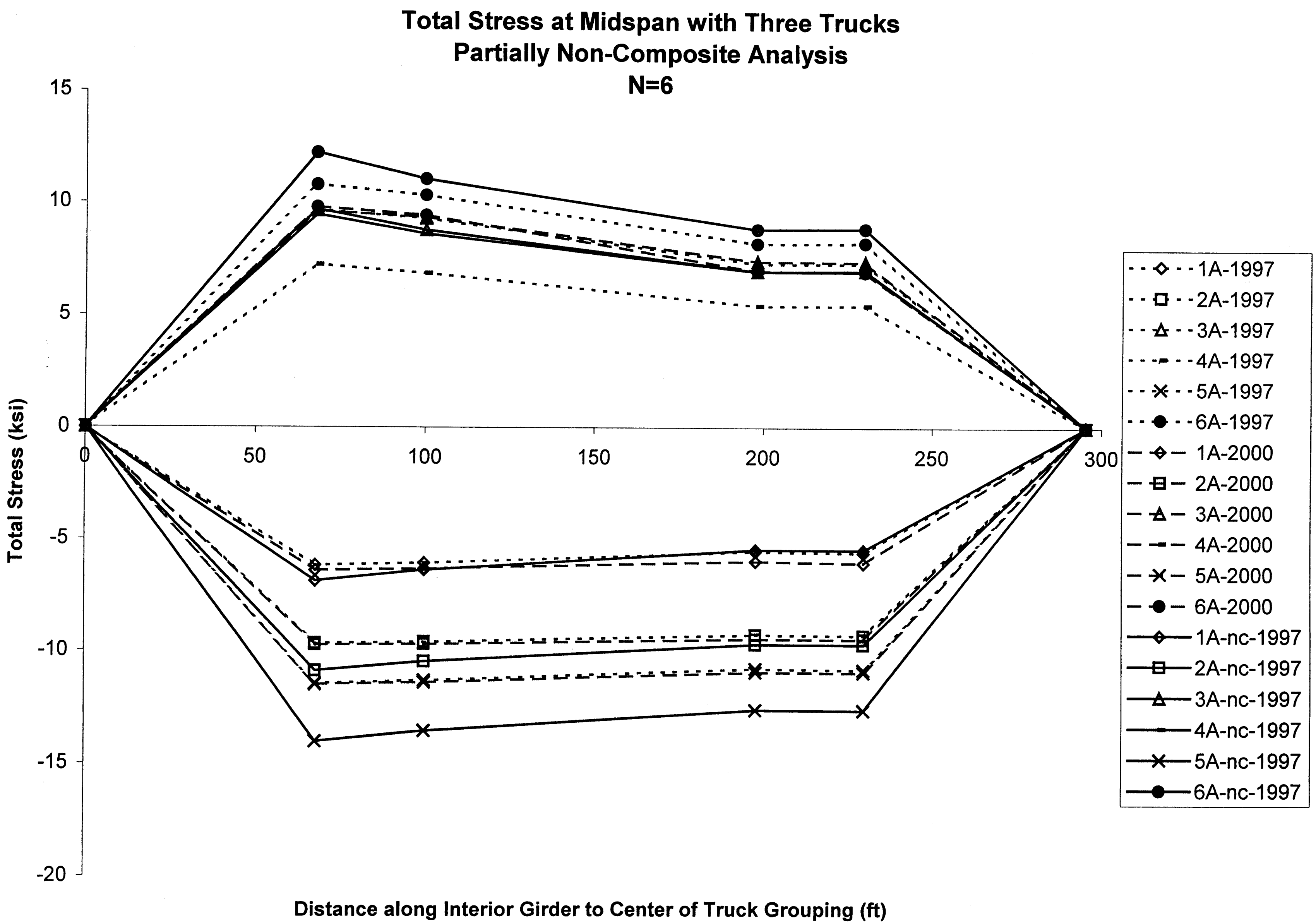


Figure F46.: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1A-6A)

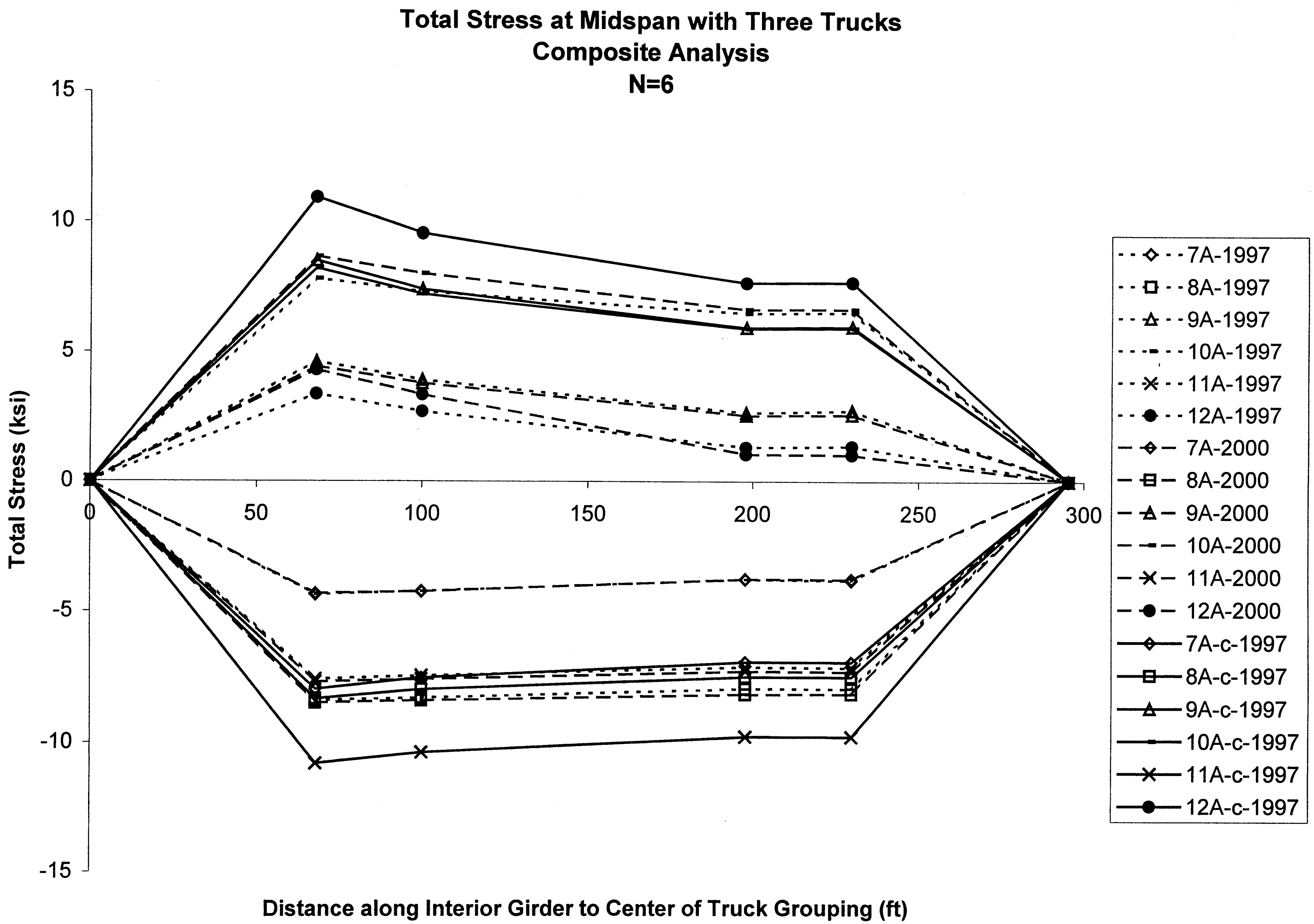


Figure F.47: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 7A-12A)

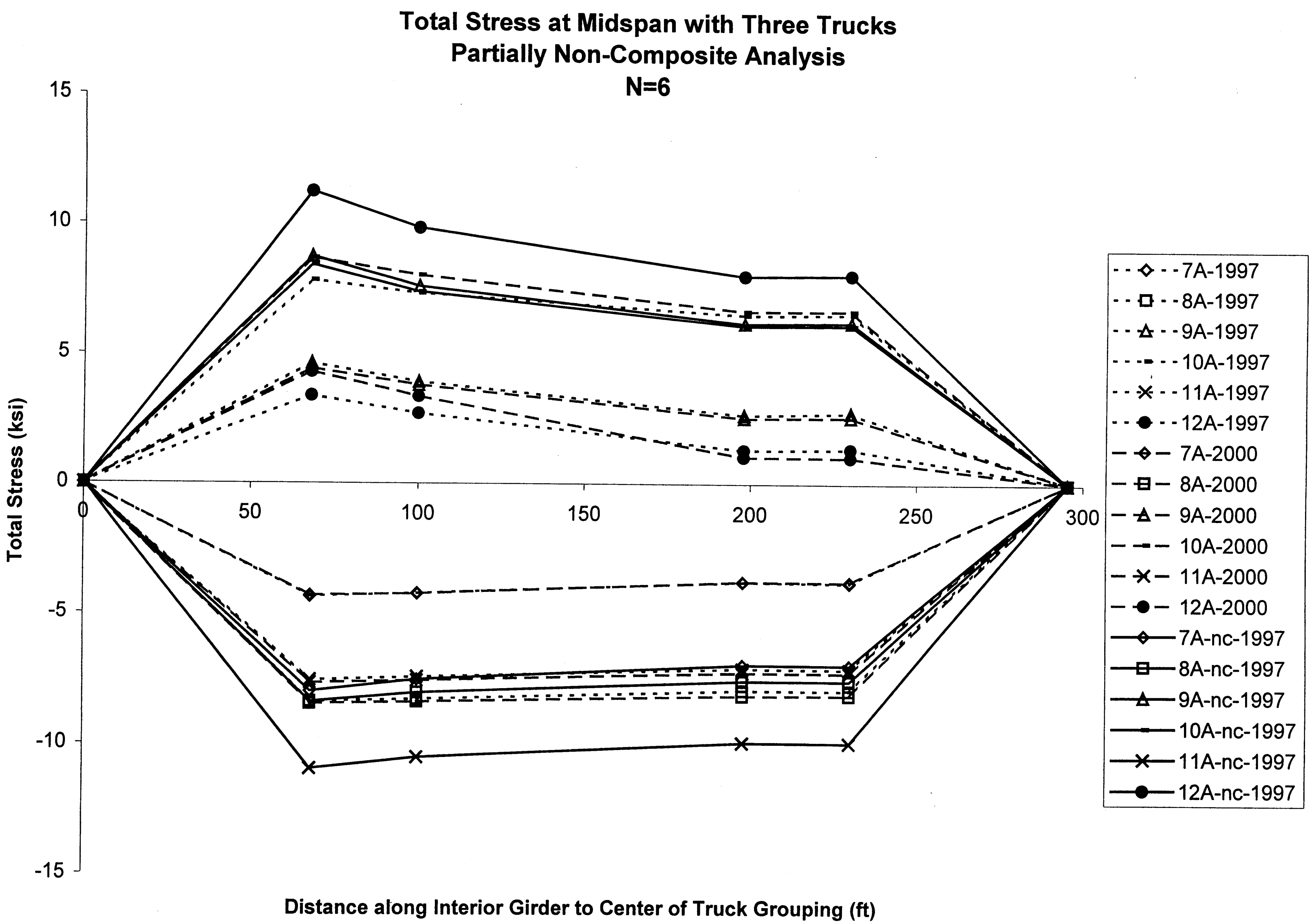


Figure F48.: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7A-12A)

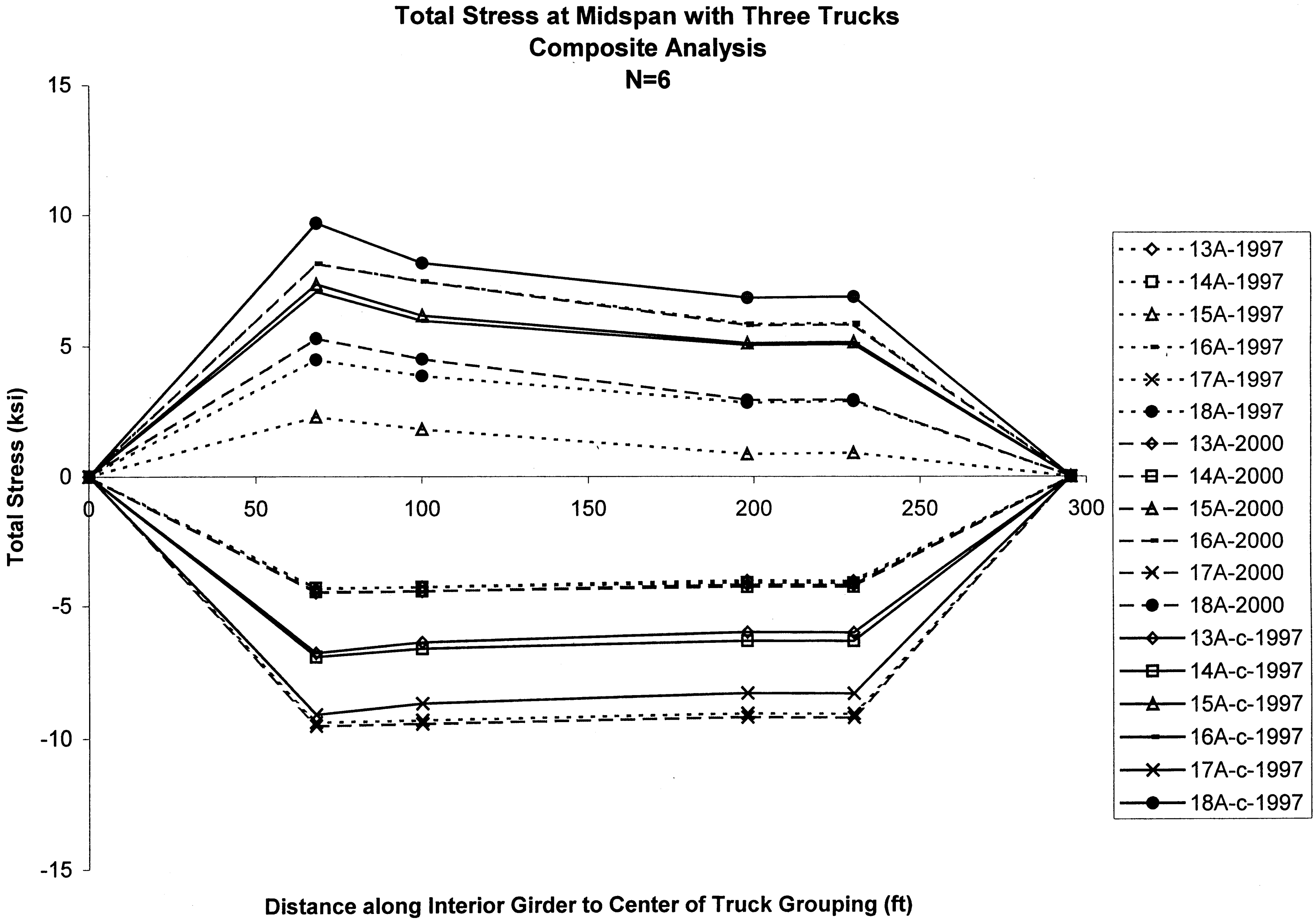


Figure F.49: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 13A-18A)

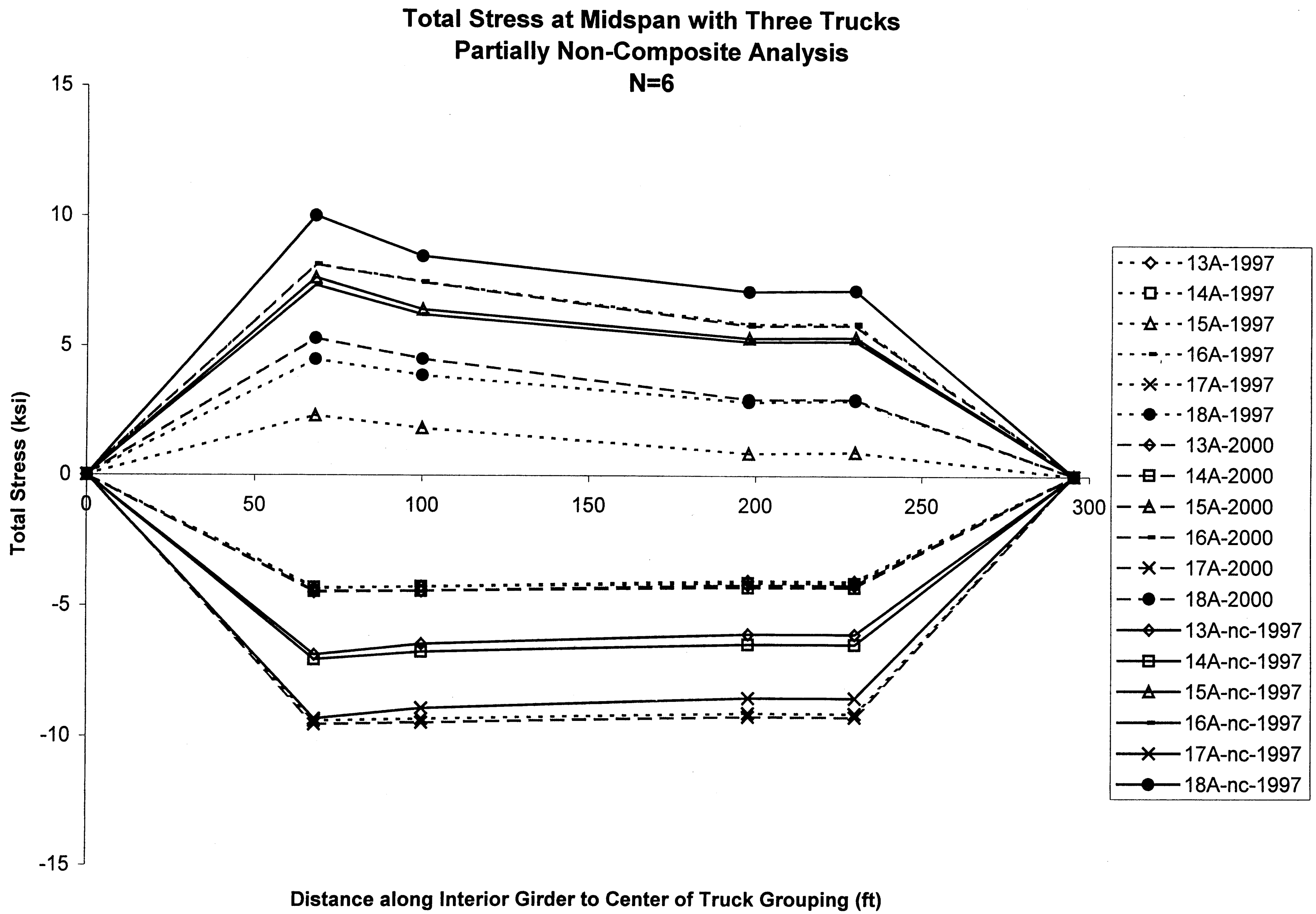


Figure F.50: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13A-18A)

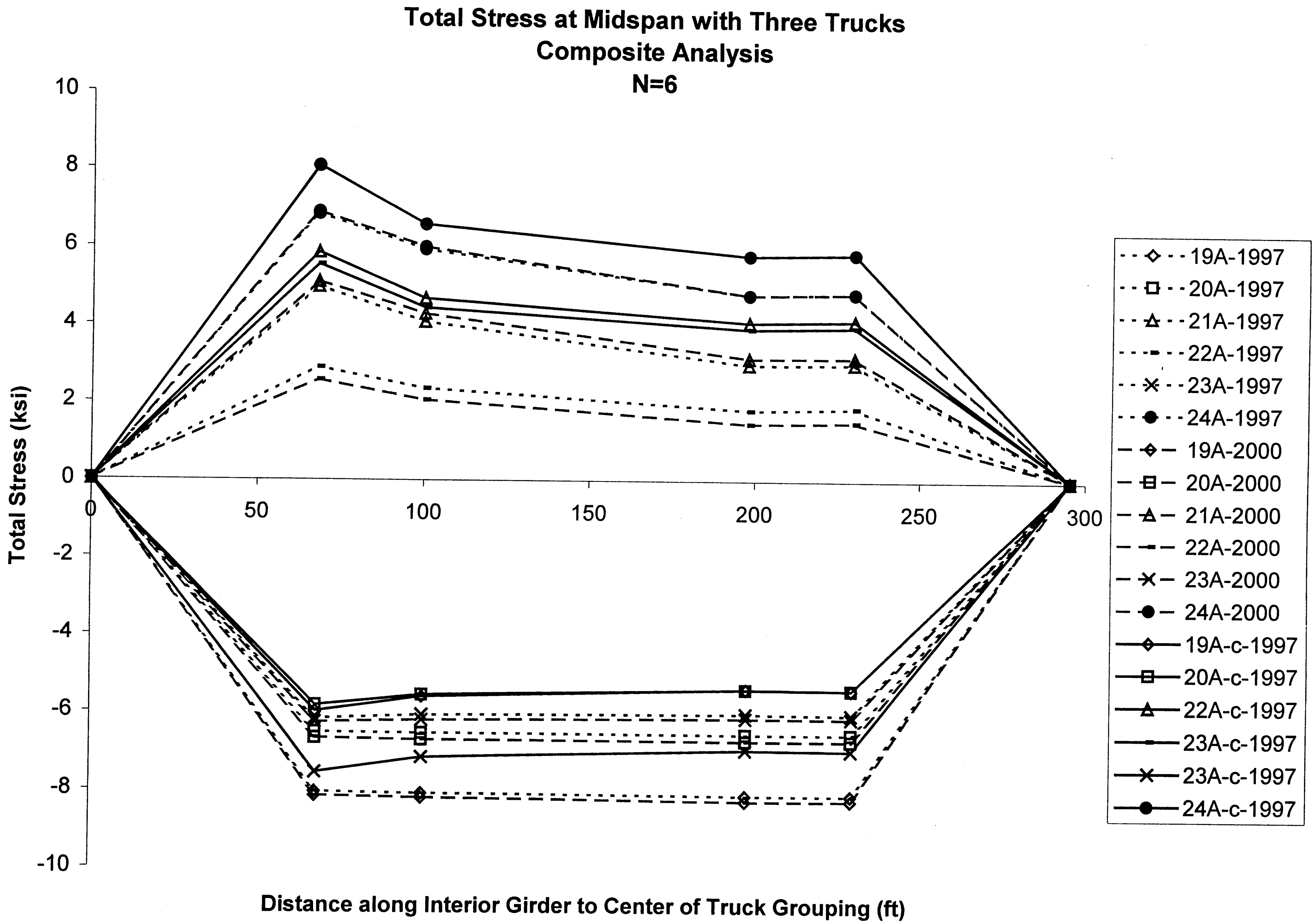


Figure F.51: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 19A-24A)

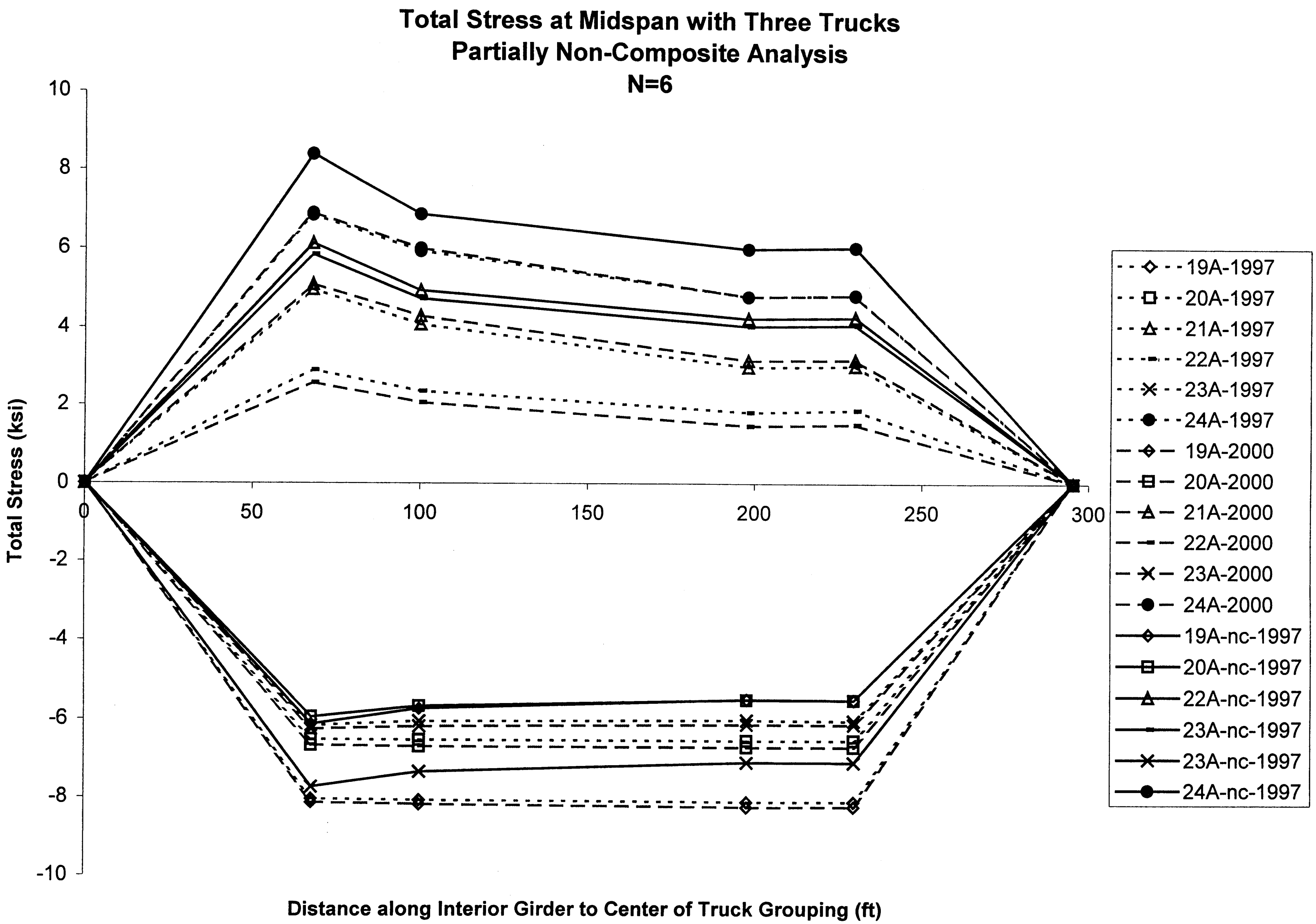


Figure F.52: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19A-24A)

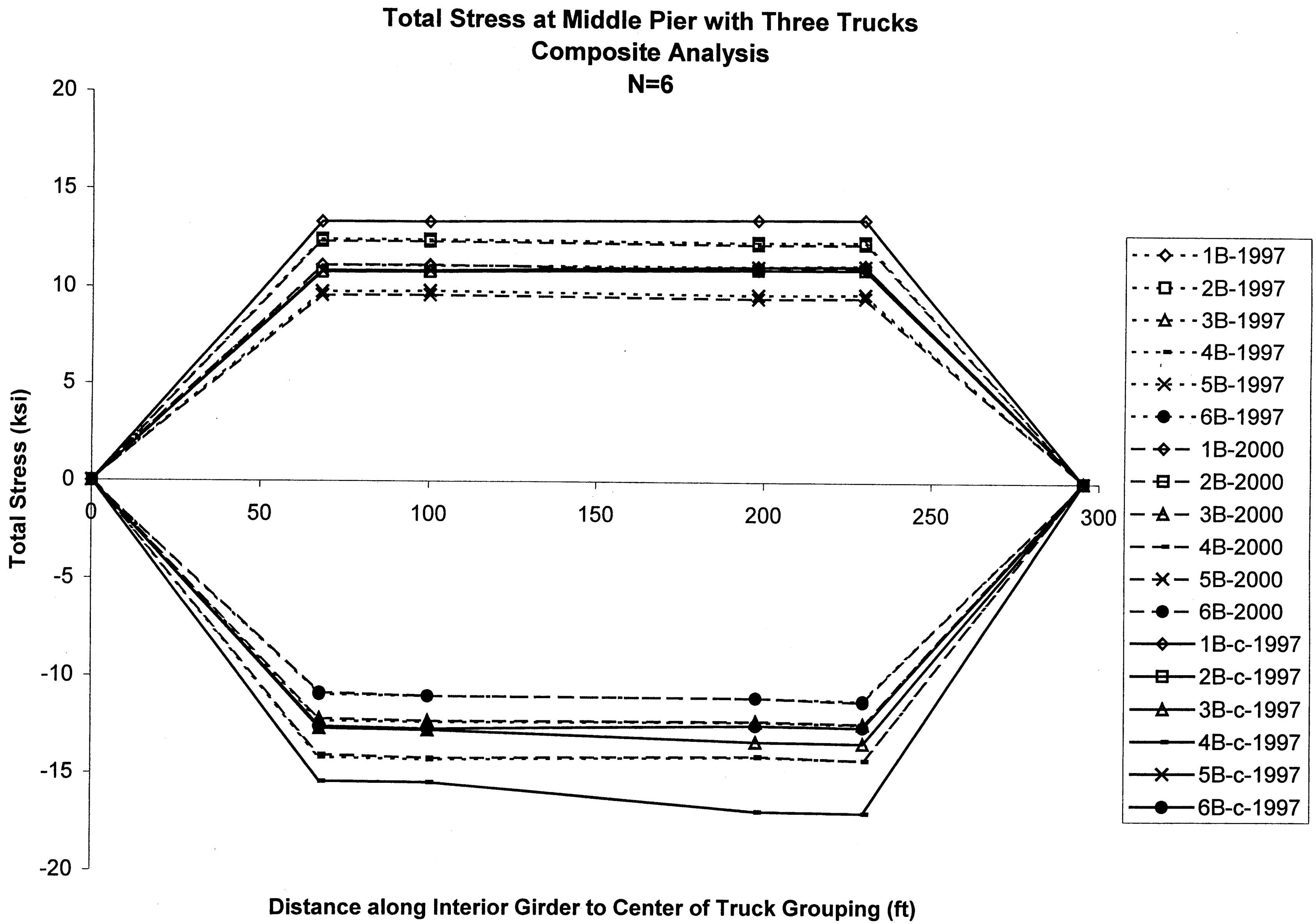


Figure F.53: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1B-6B)

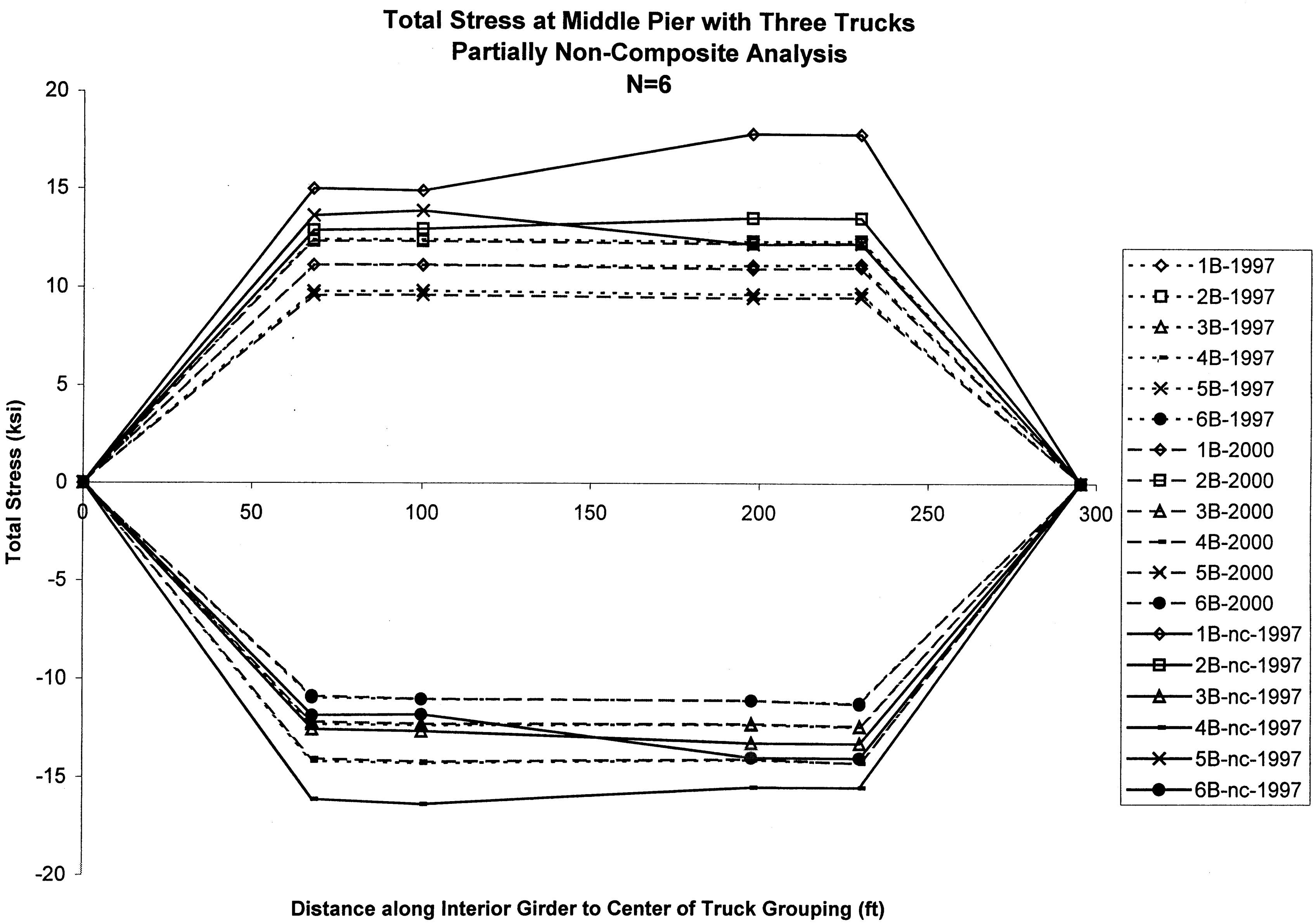


Figure F.54: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1B-6B)

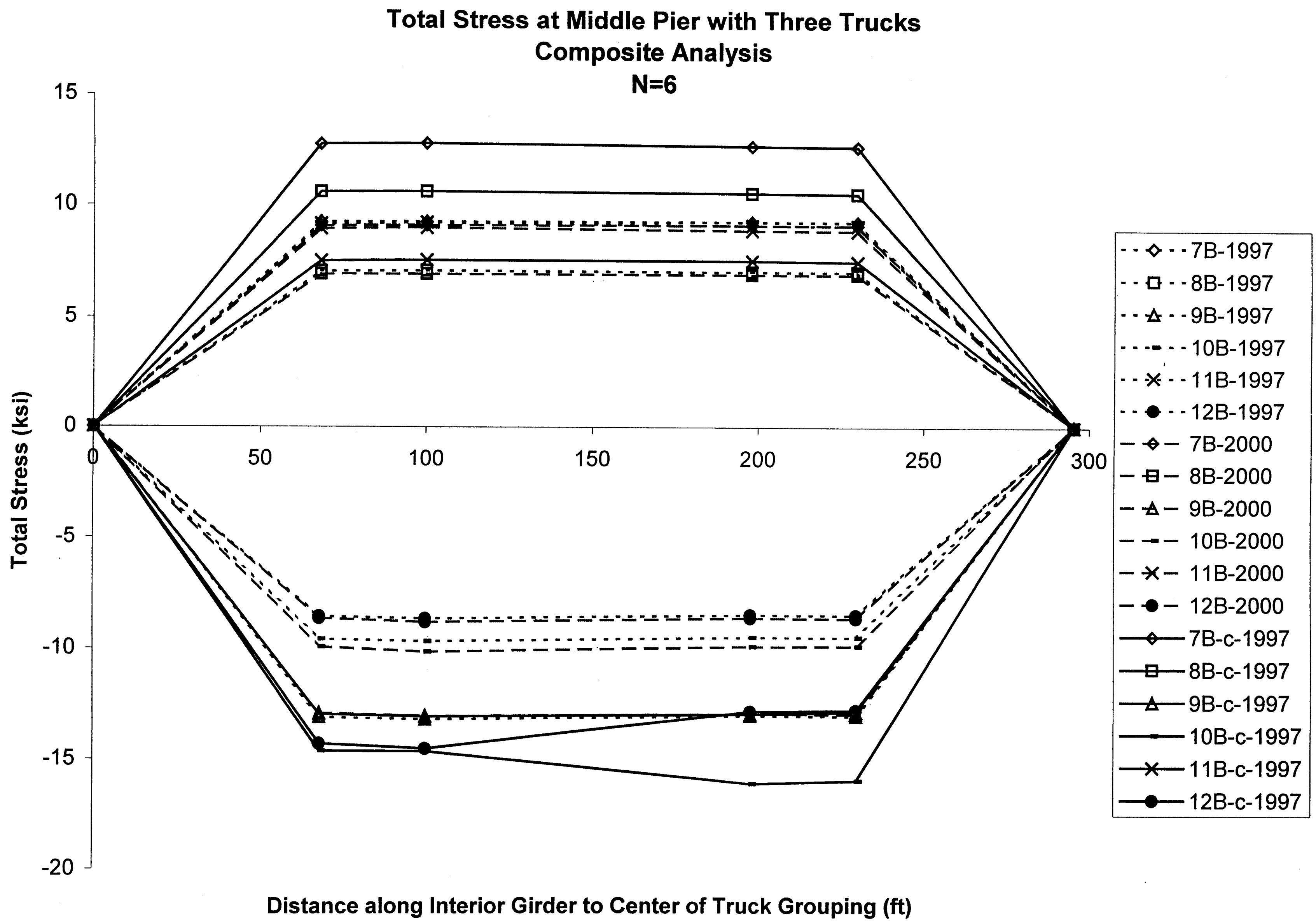


Figure F.55: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 7B-12B)

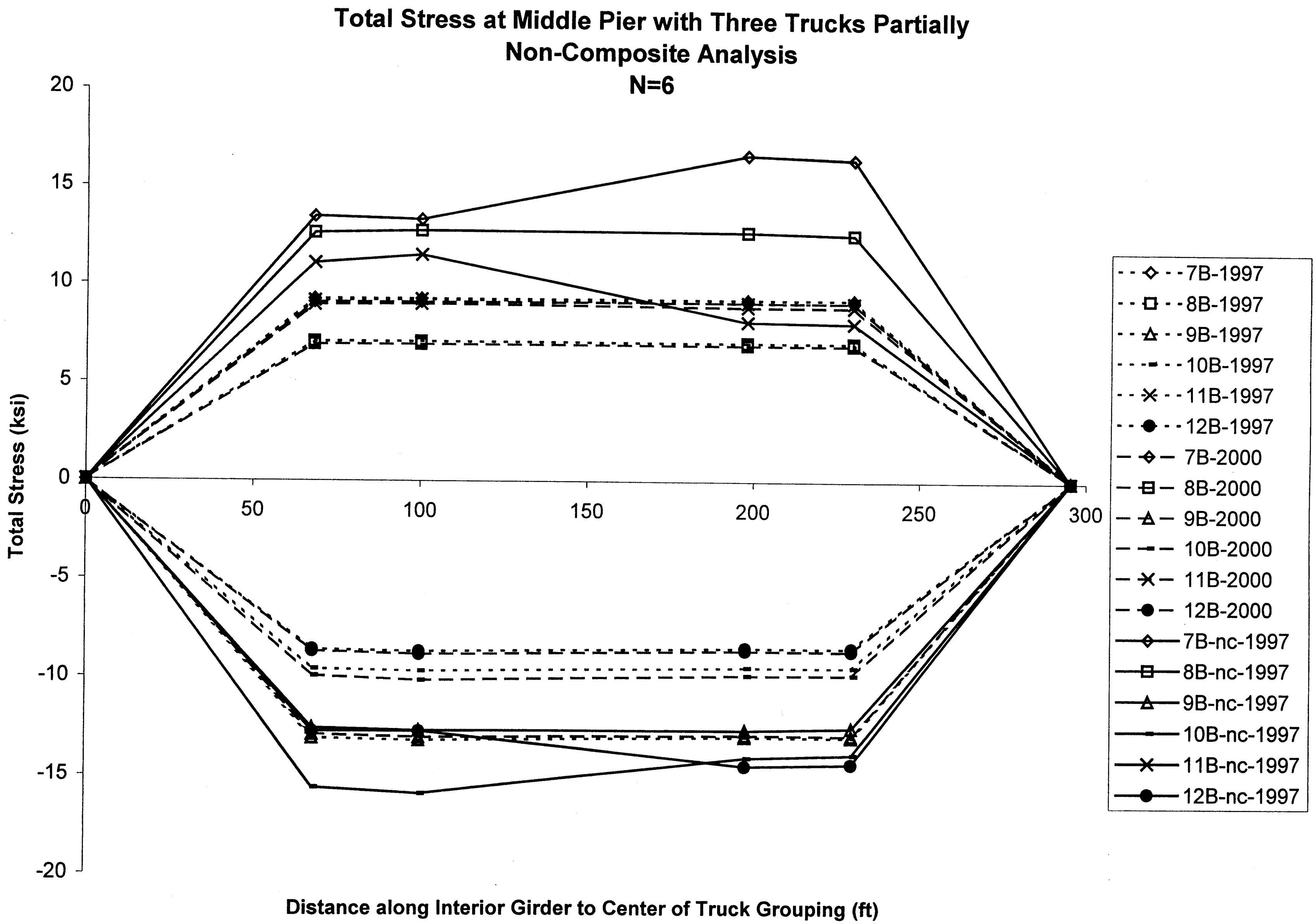


Figure F.56: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7B-12B)

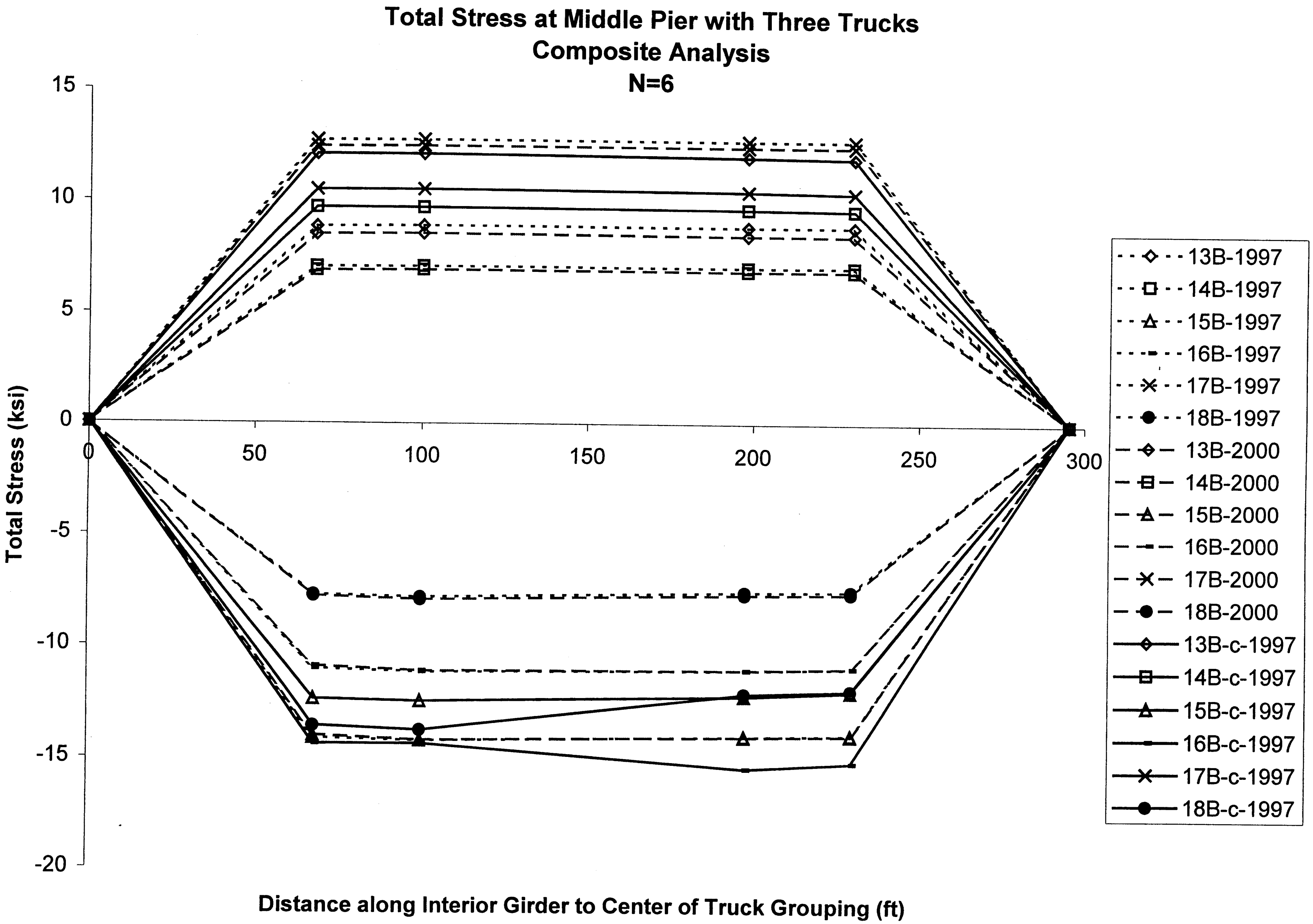


Figure F.57: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 13B-18B)

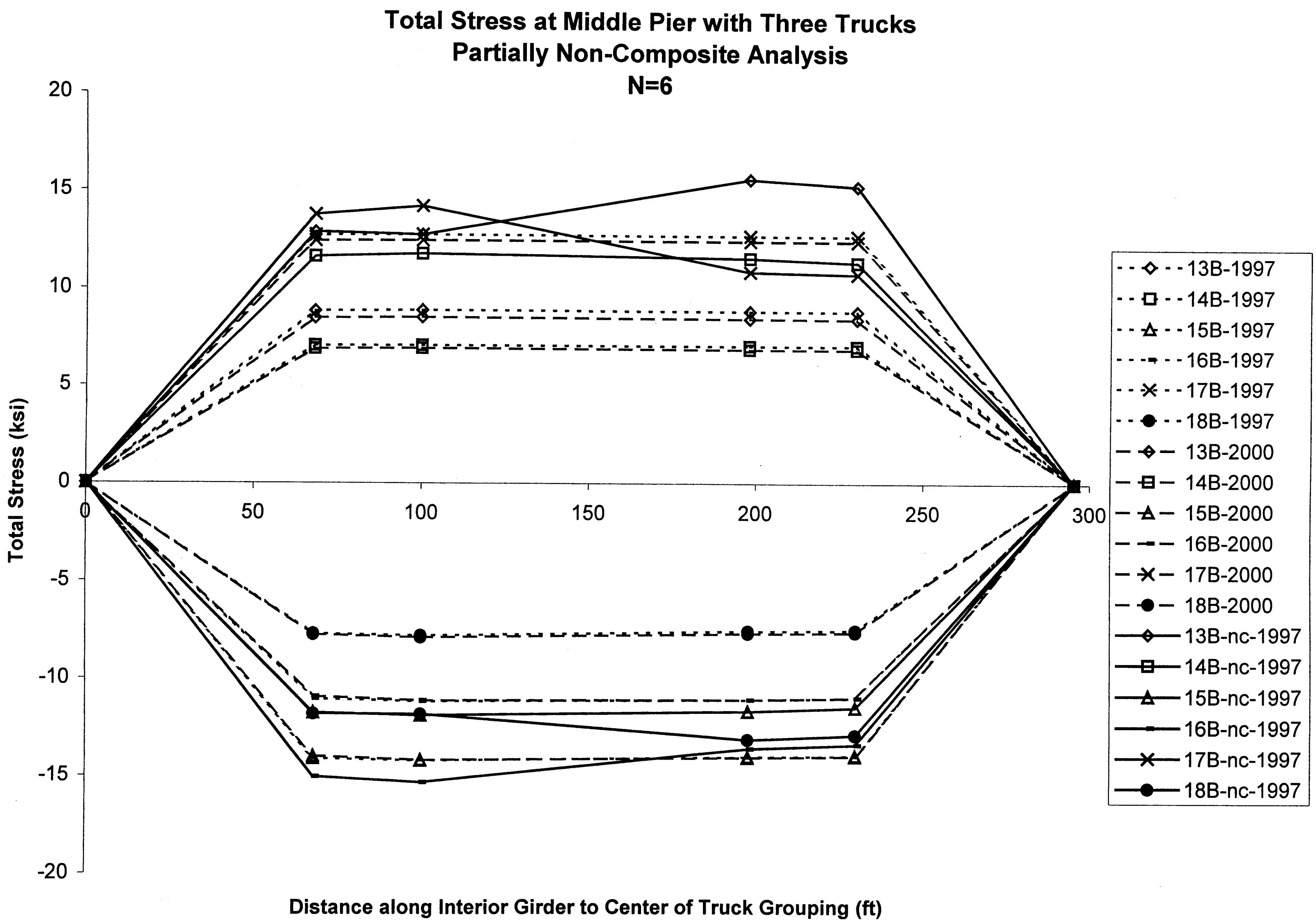


Figure F.58: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13B-18B)

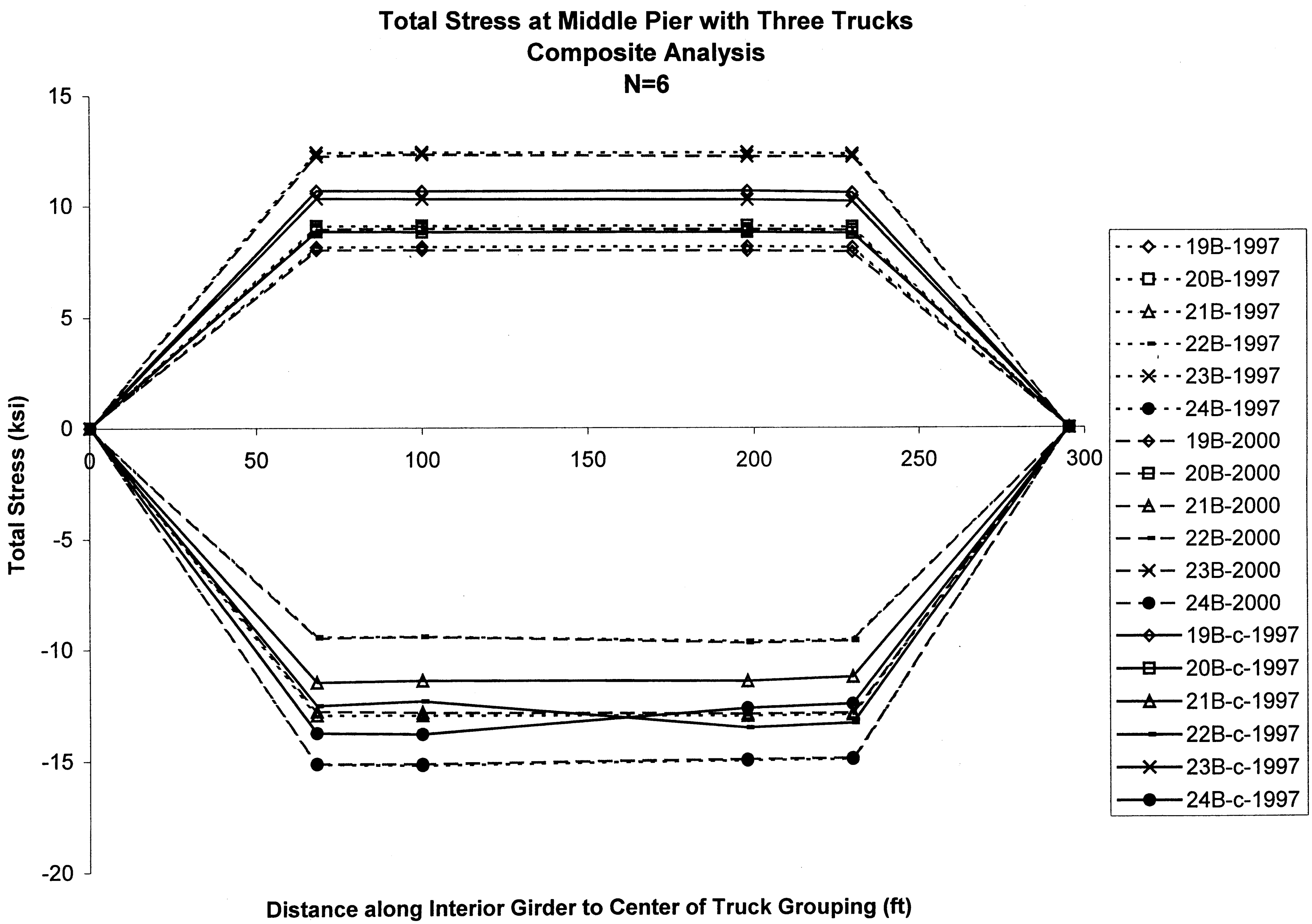


Figure F.59: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 19B-24B)

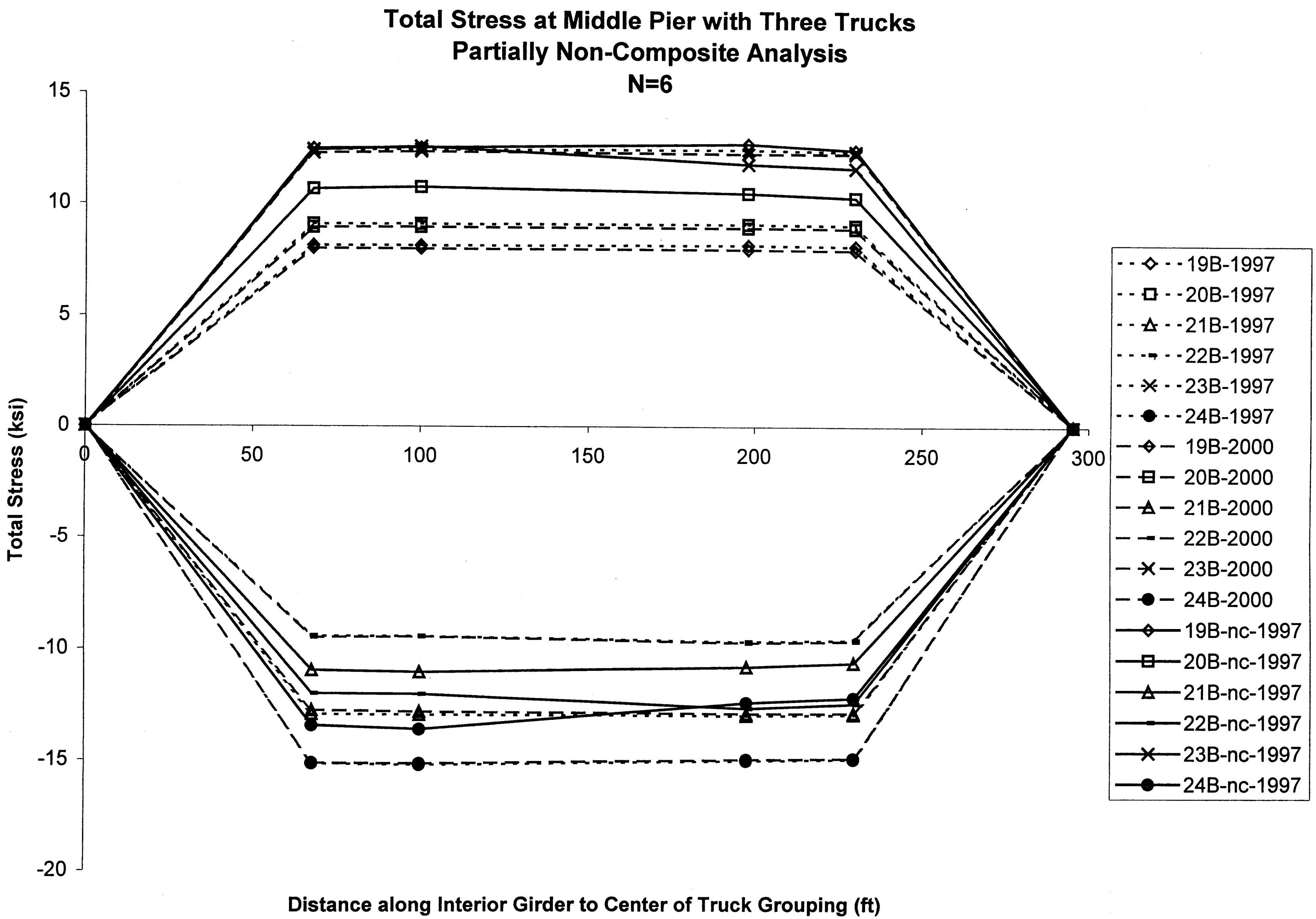


Figure F.60: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19B-24B)

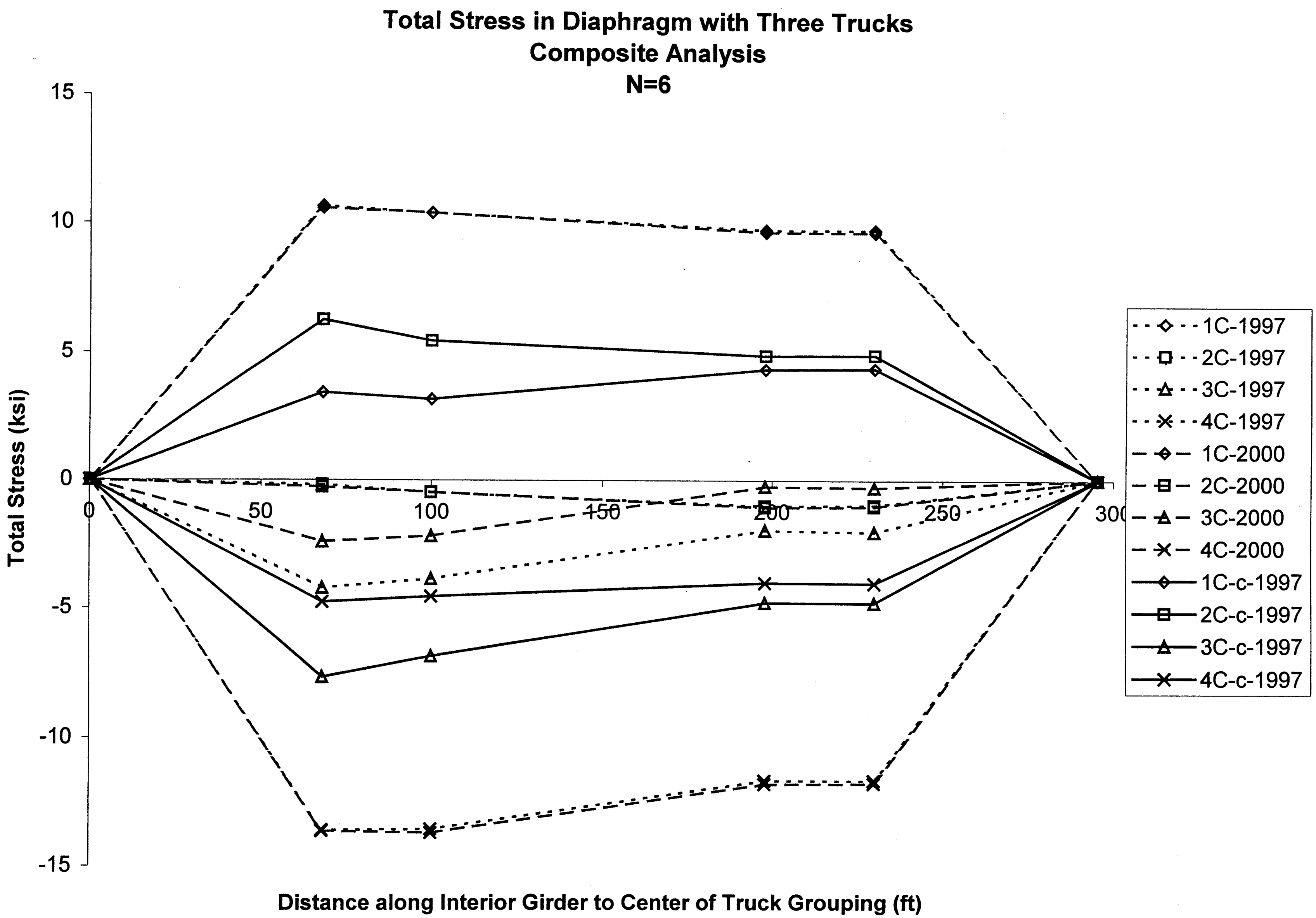


Figure F.61: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1C-4C)

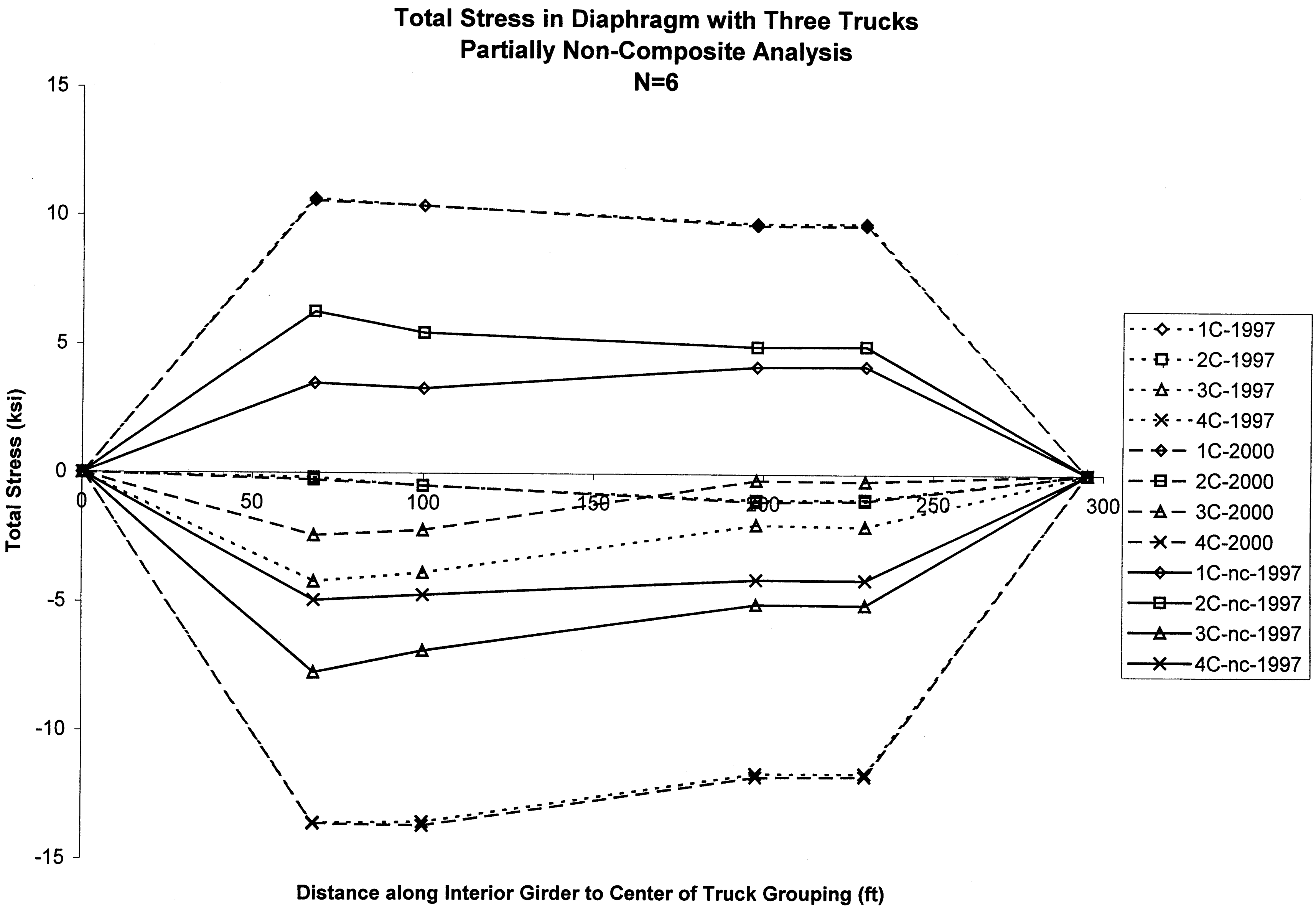


Figure F.62: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1C-4C)

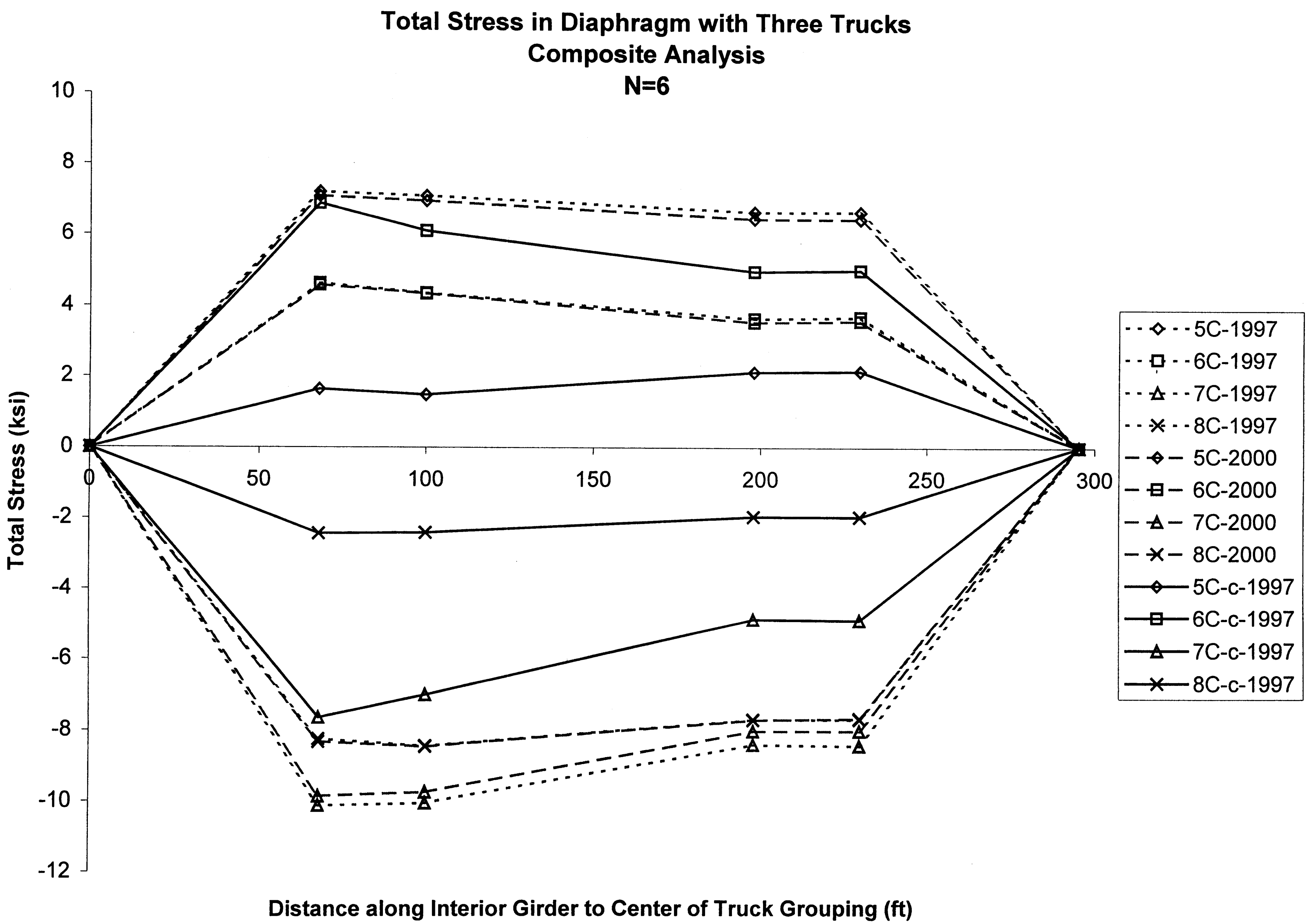


Figure F.63: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 5C-8C)

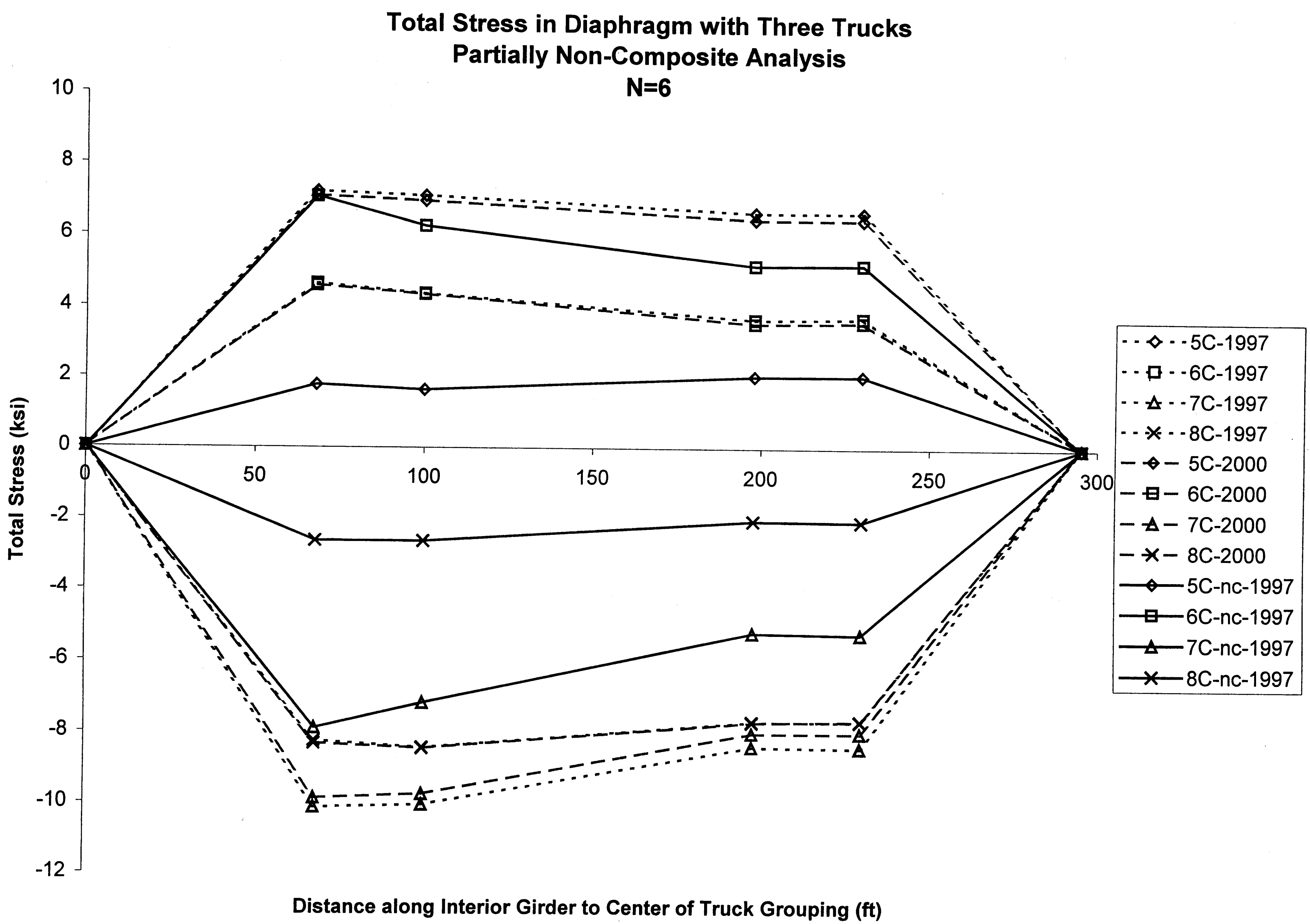


Figure F.64: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 5C-8C)

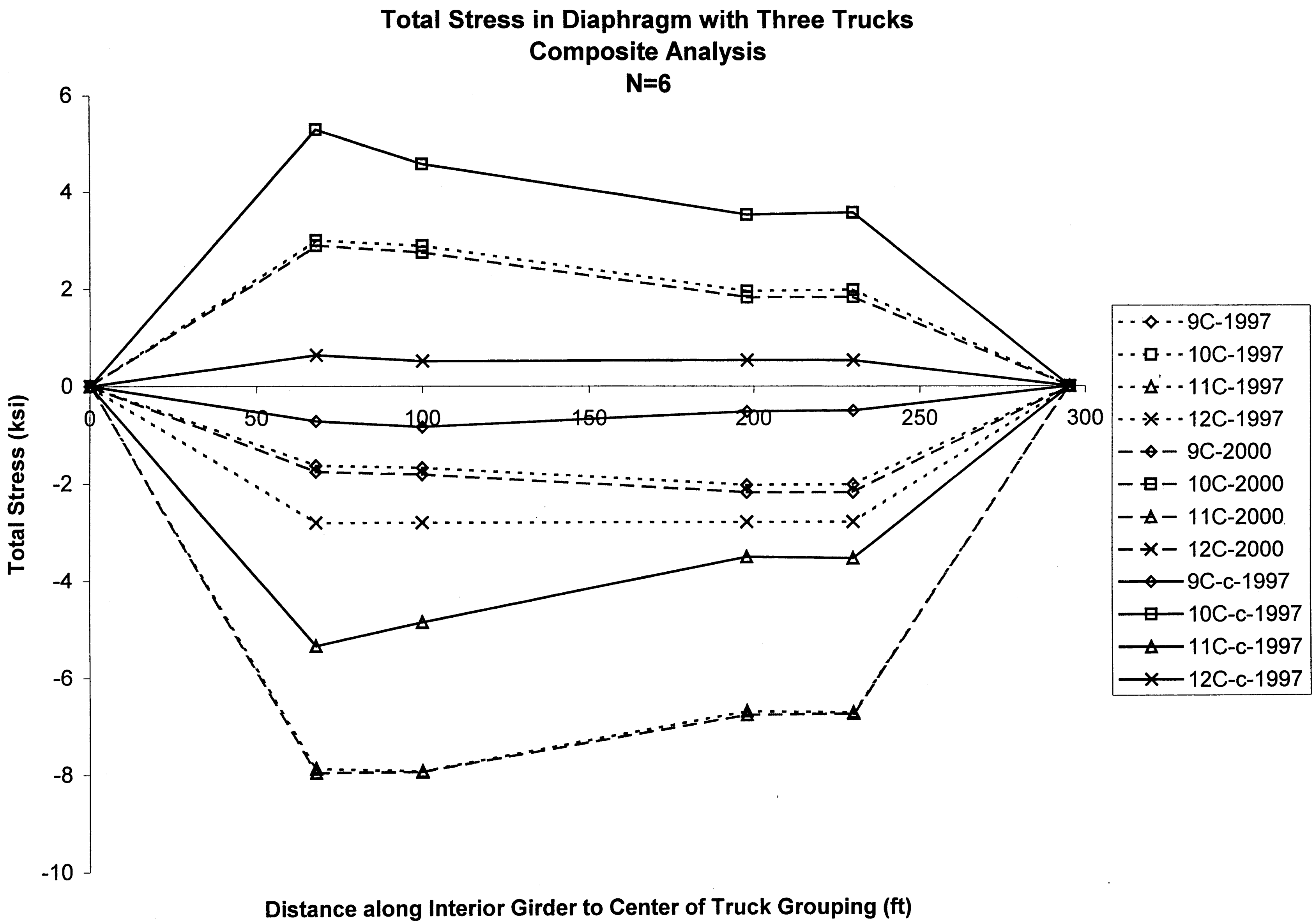


Figure F.65: Plot of Total Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 9C-12C)

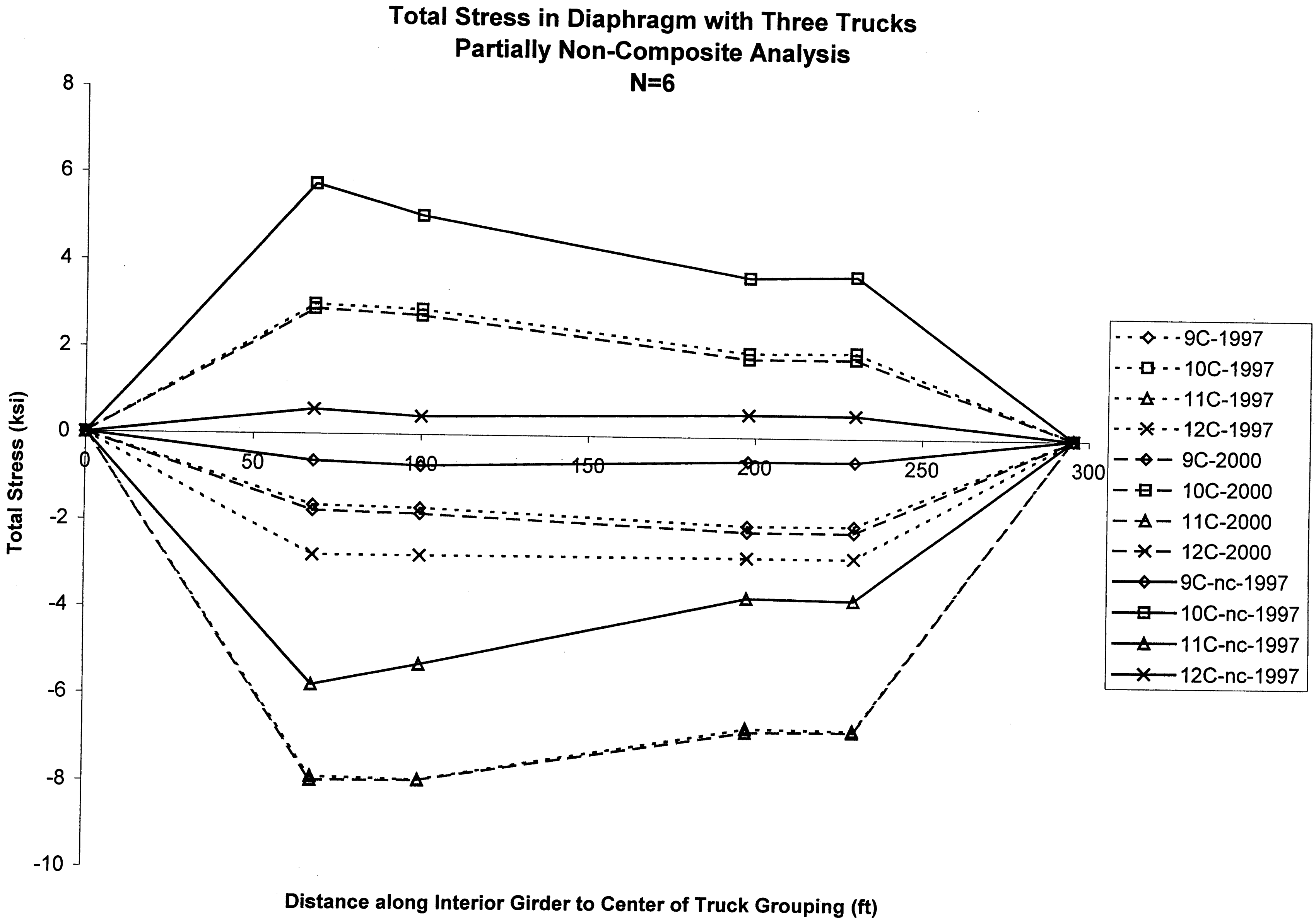


Figure F.66: Plot of Total Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 9C-12C)

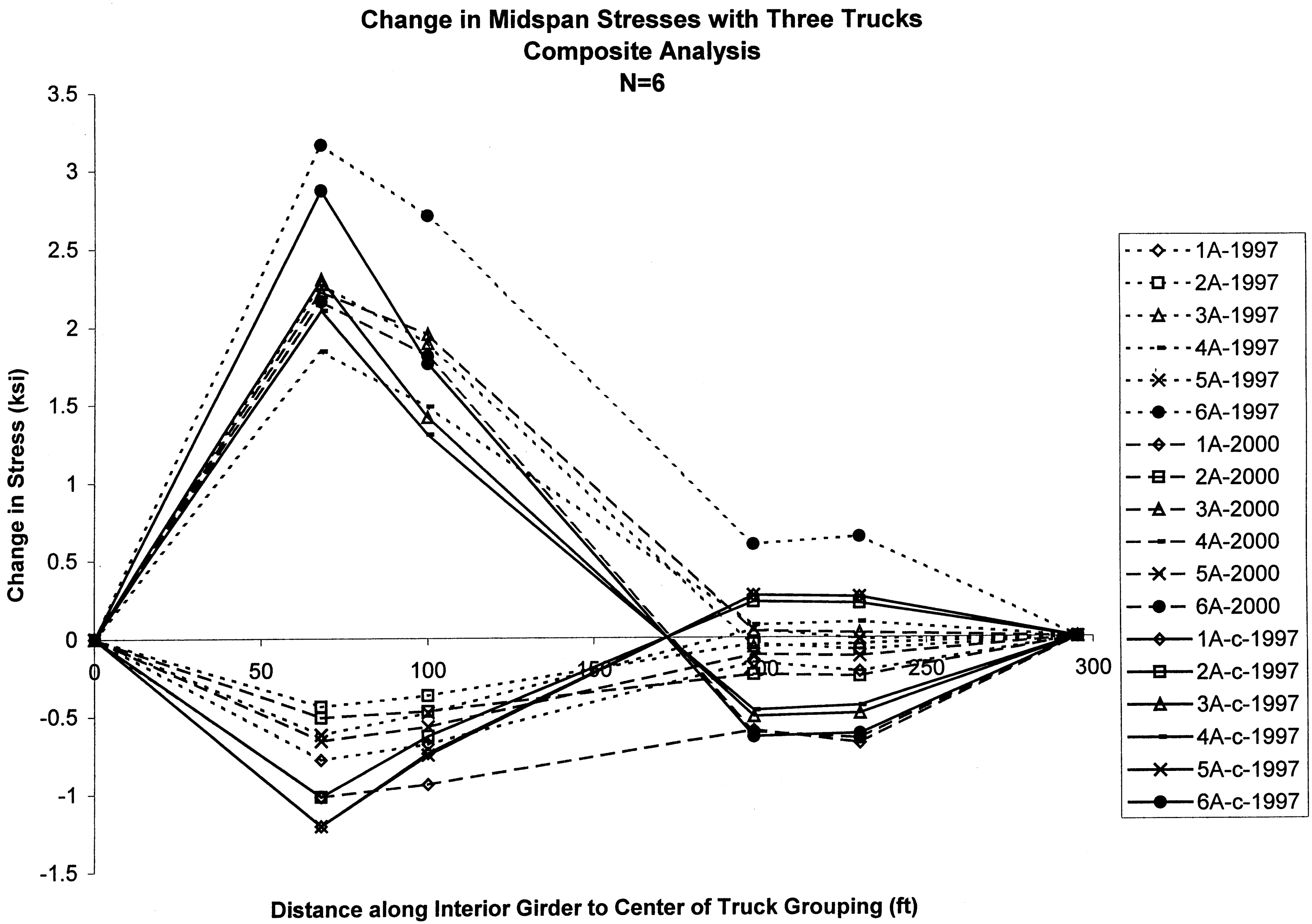


Figure F.67: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1A-6A)

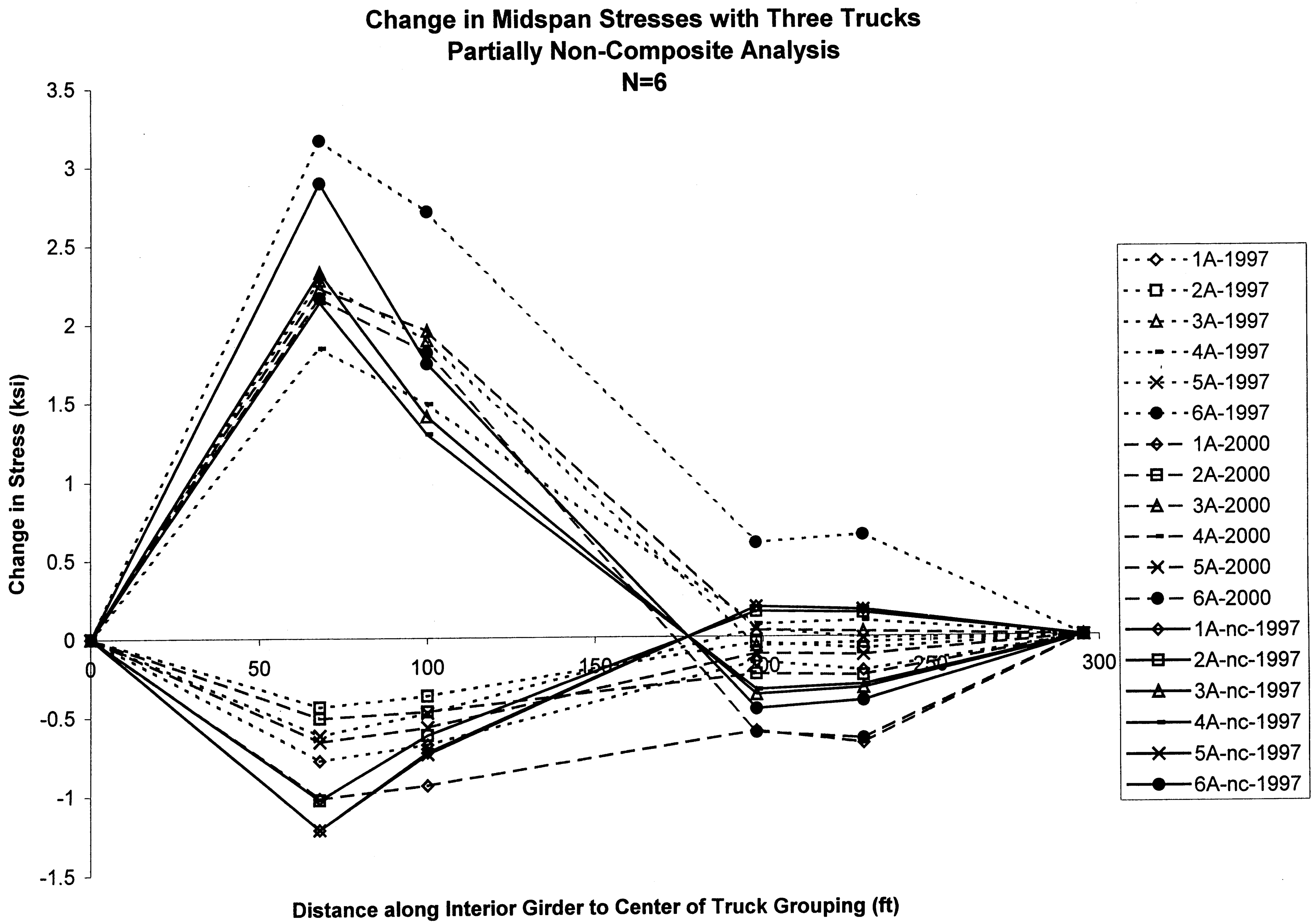


Figure F.68: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1A-6A)

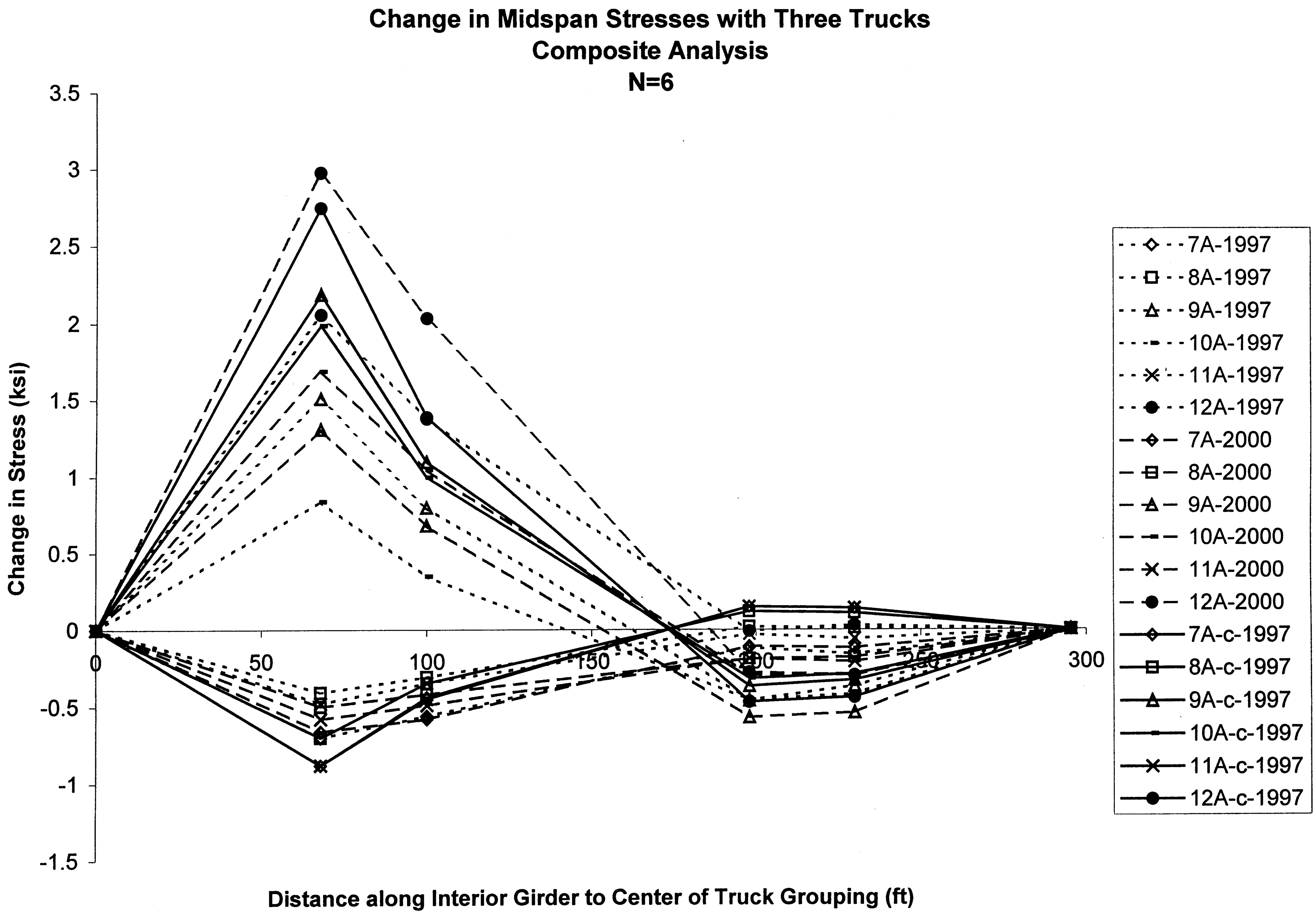


Figure F.69: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 7A-12A)

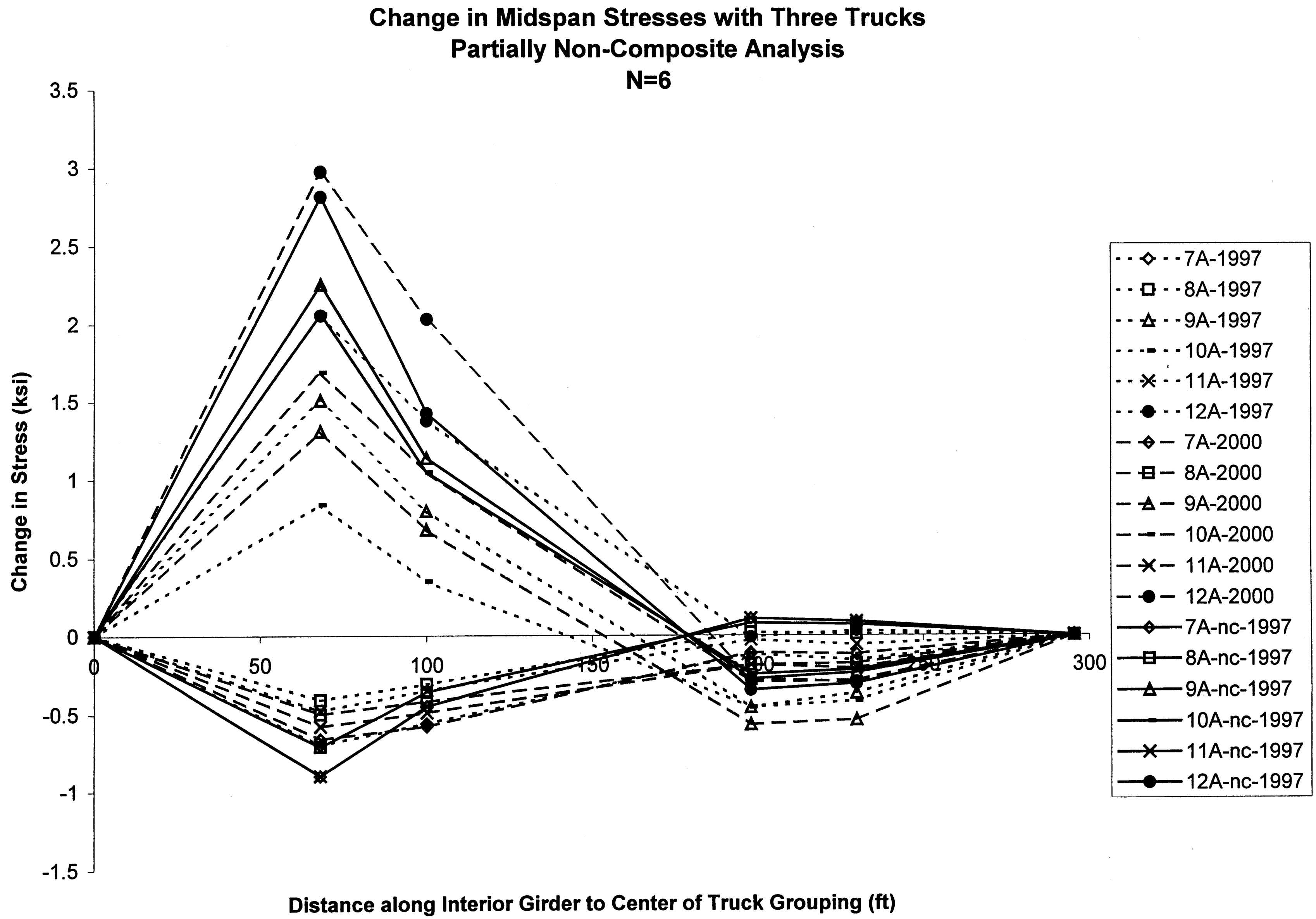


Figure F.70: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7A-12A)

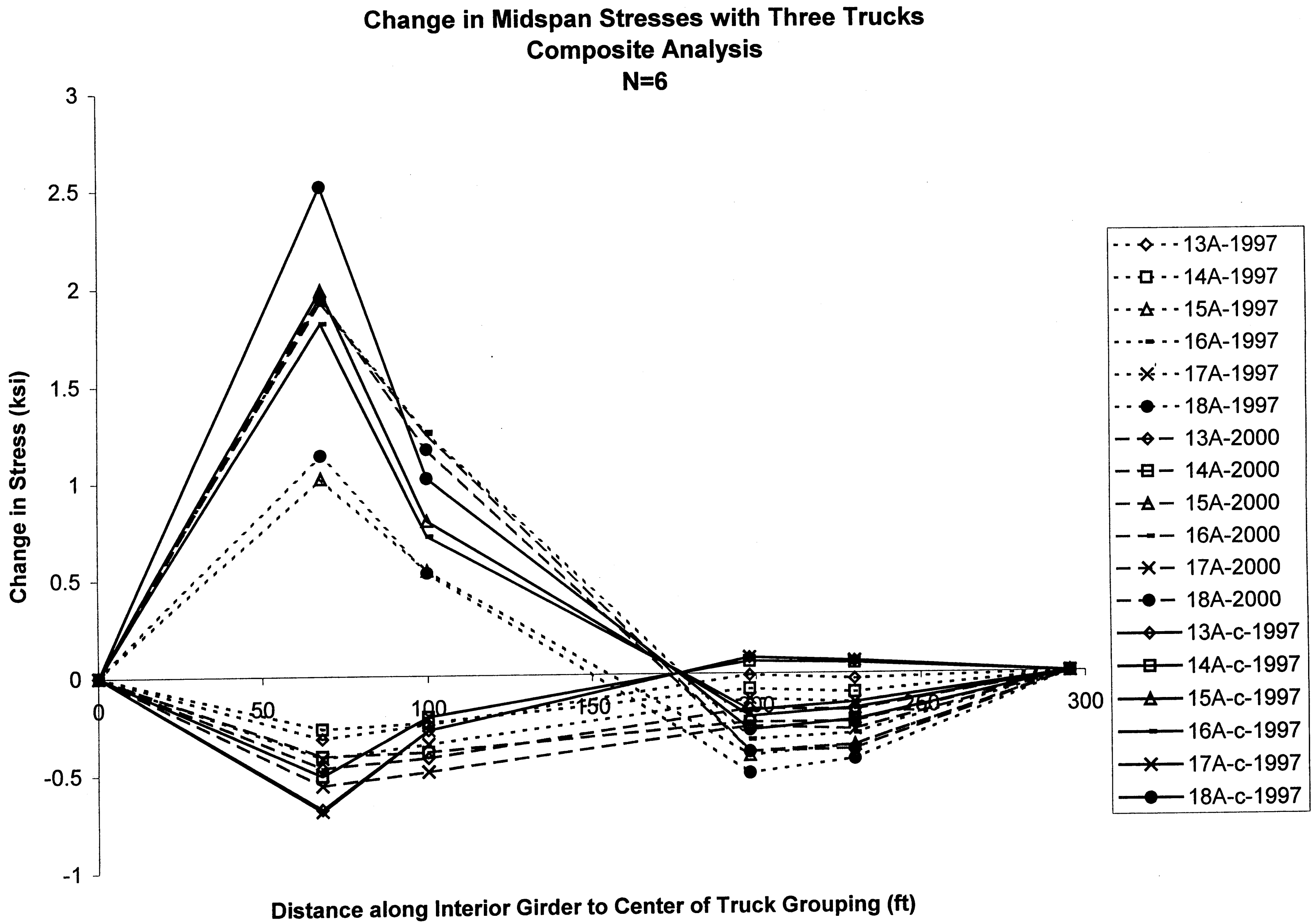


Figure F.71: Plot of Change inStress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 13A-18A)

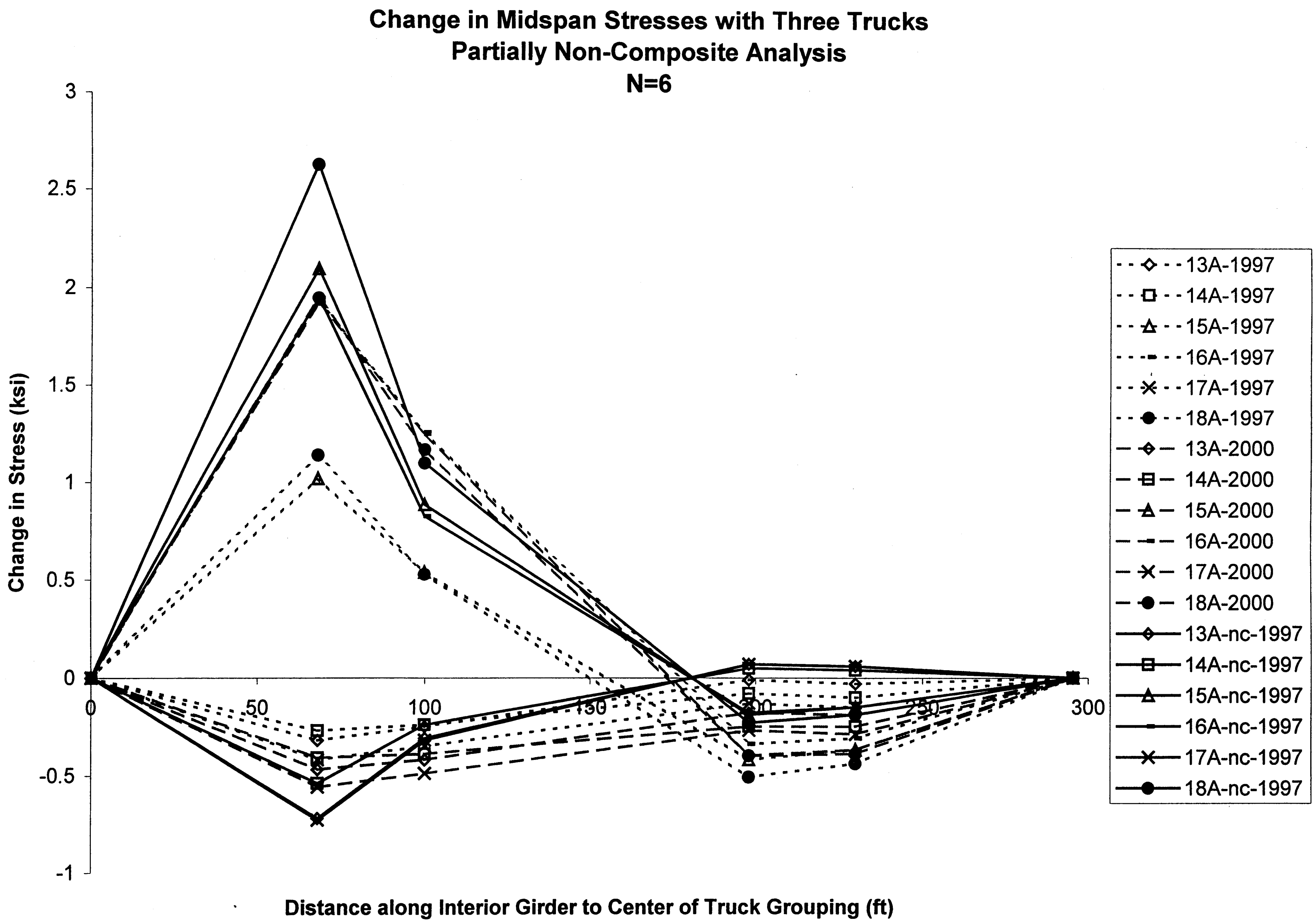


Figure F.72: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13A-18A)

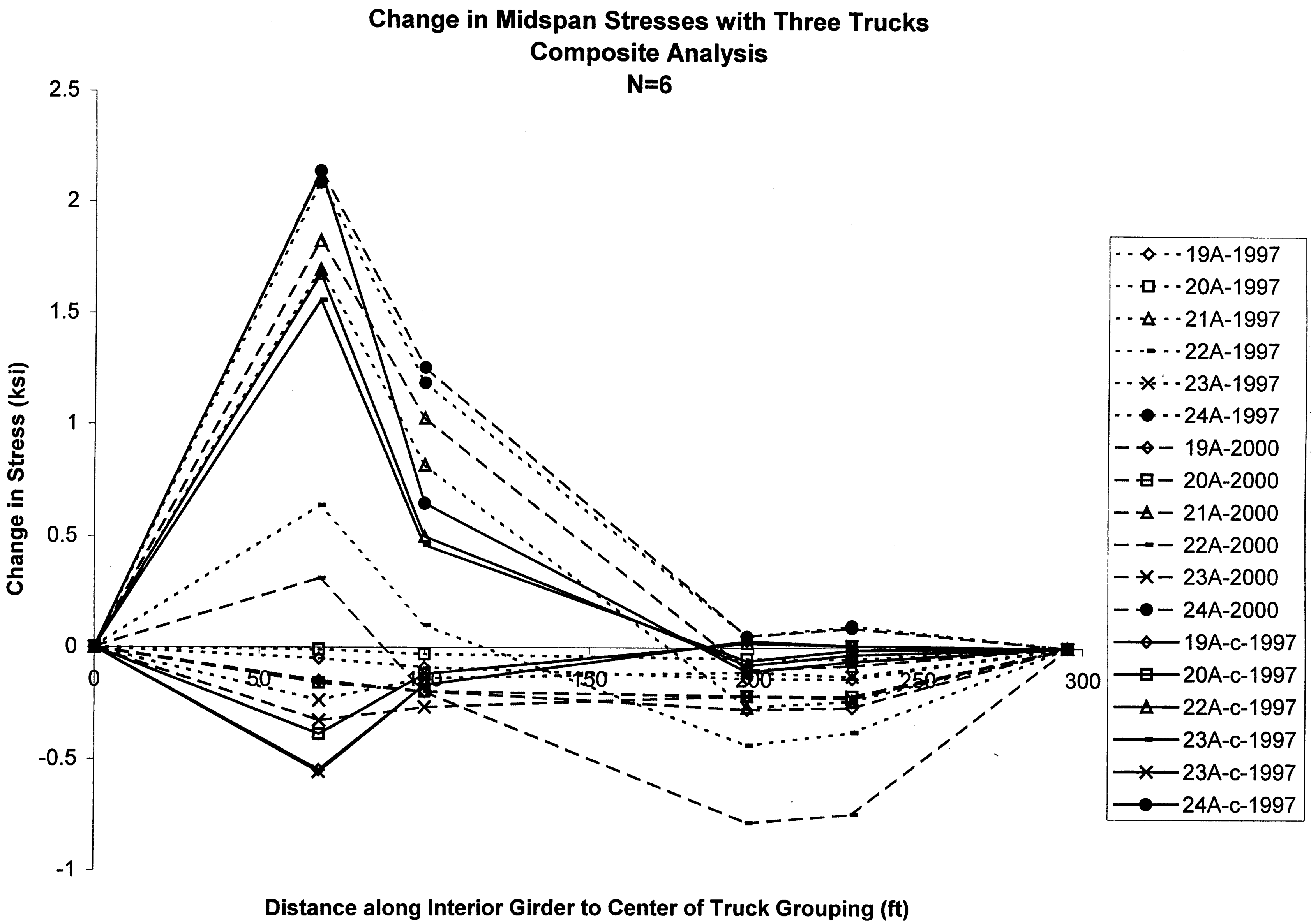


Figure F.73: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 19A-24A)

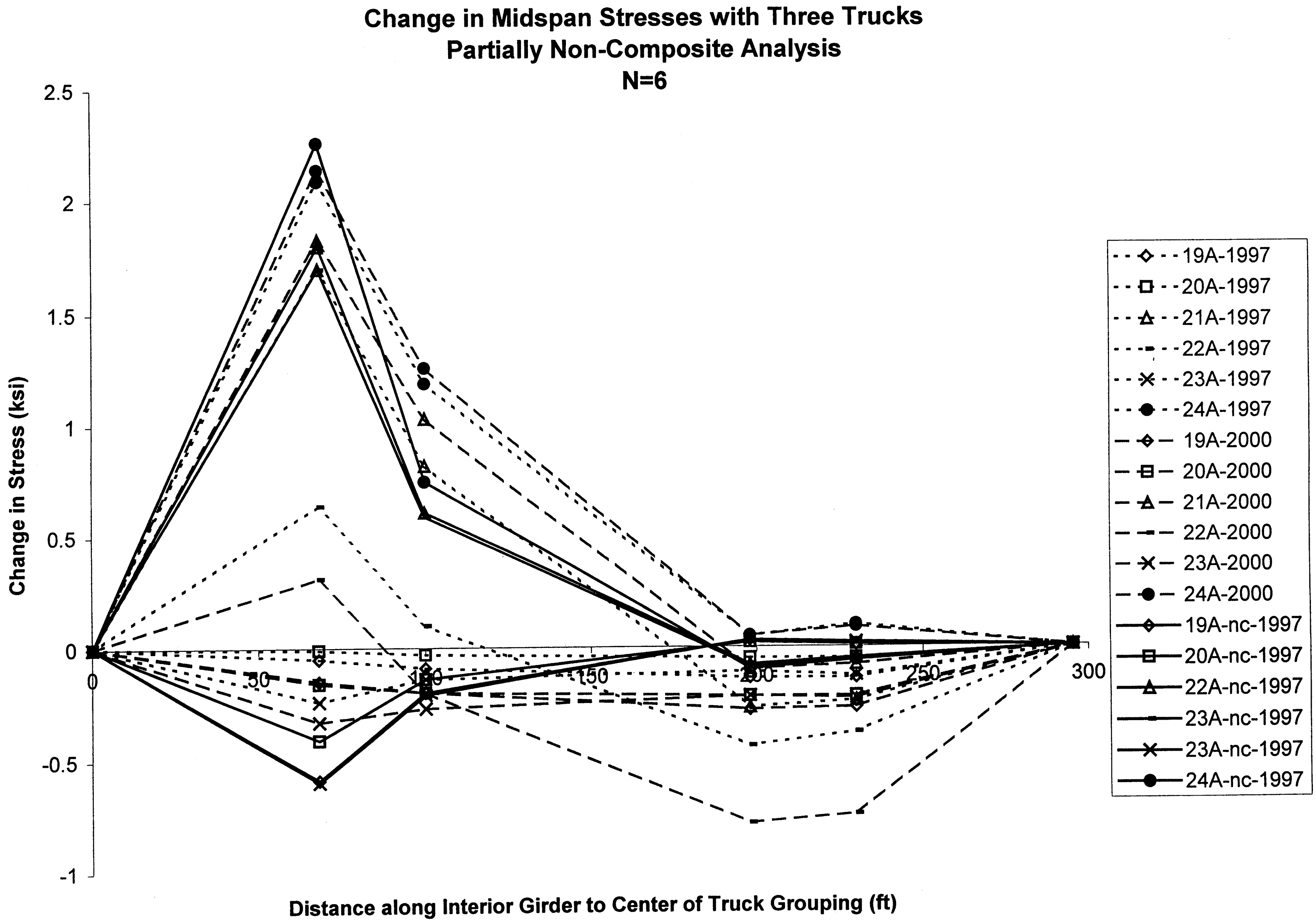


Figure F.74: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19A-24A)

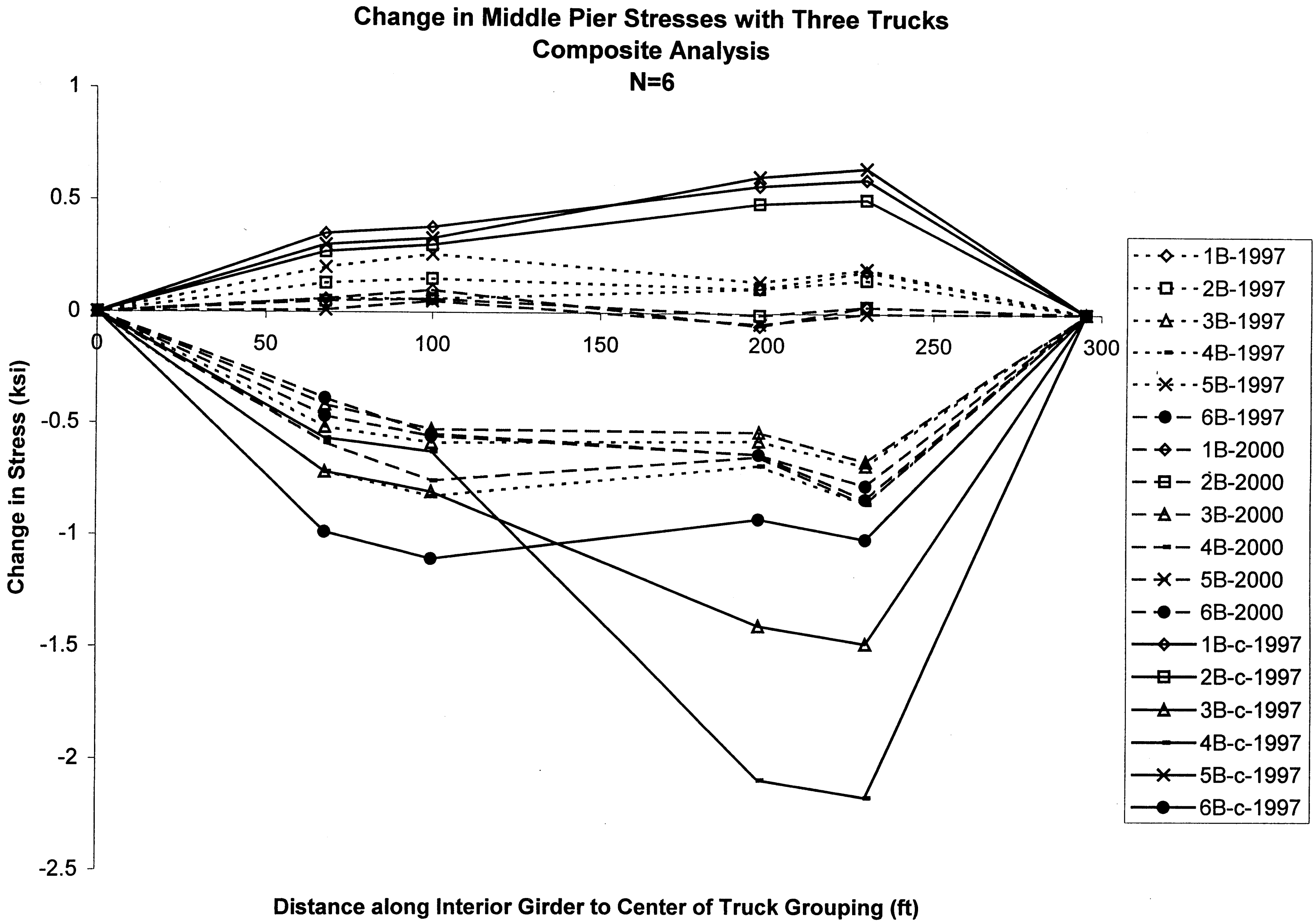


Figure F.75: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1B-6B)

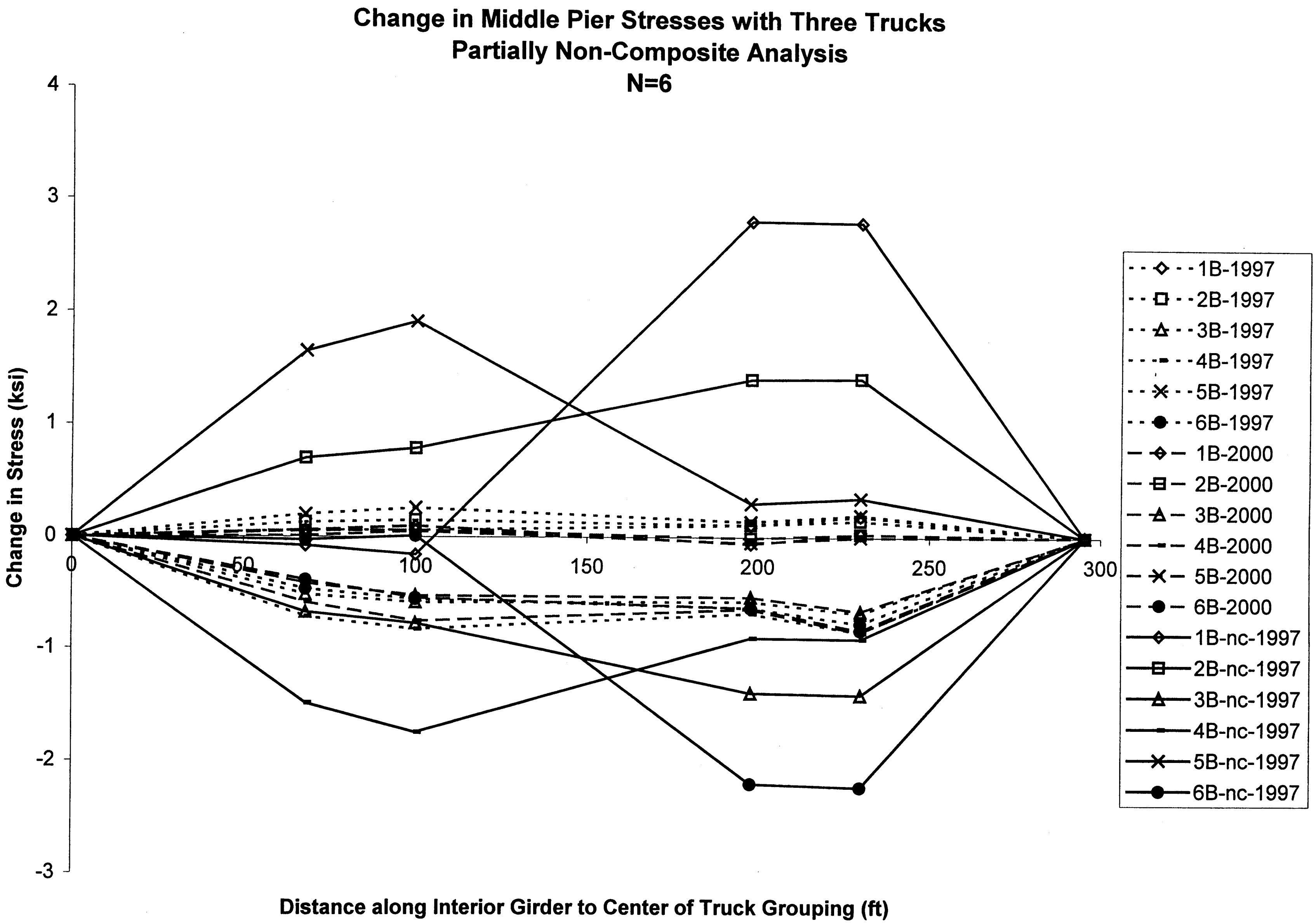


Figure F.76: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1B-6B)

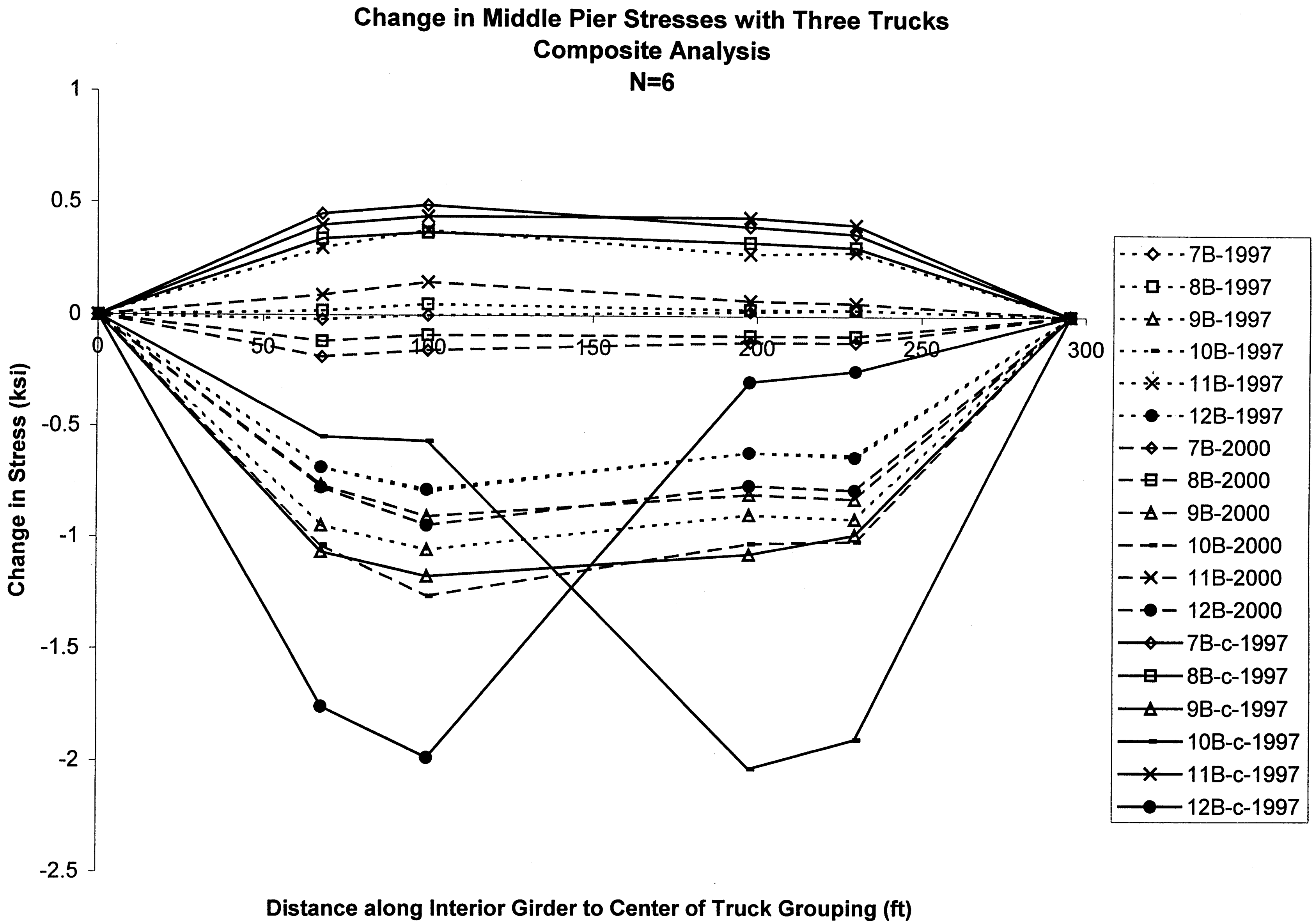


Figure F.77: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 7B-12B)

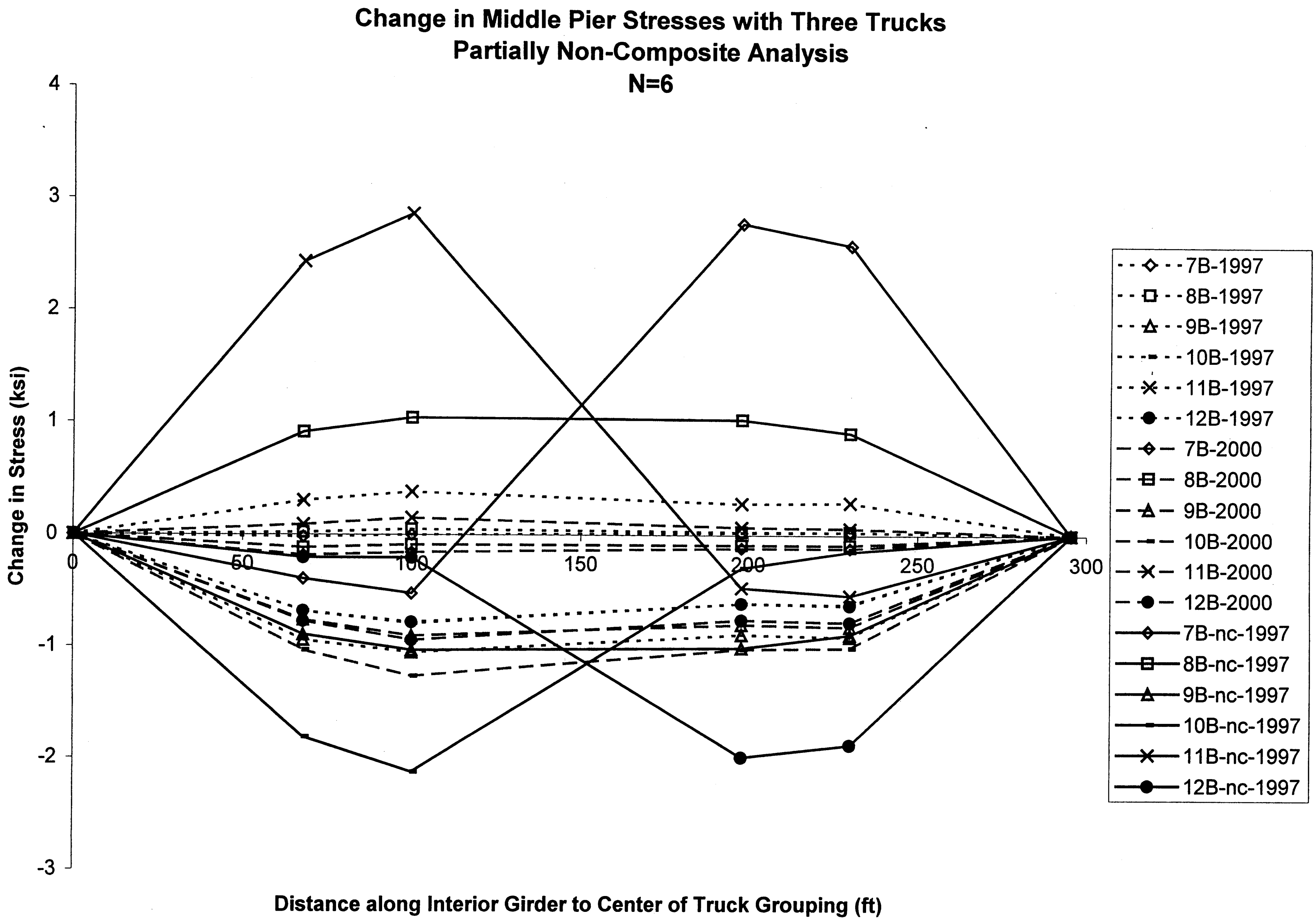


Figure F.78: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 7B-12B)

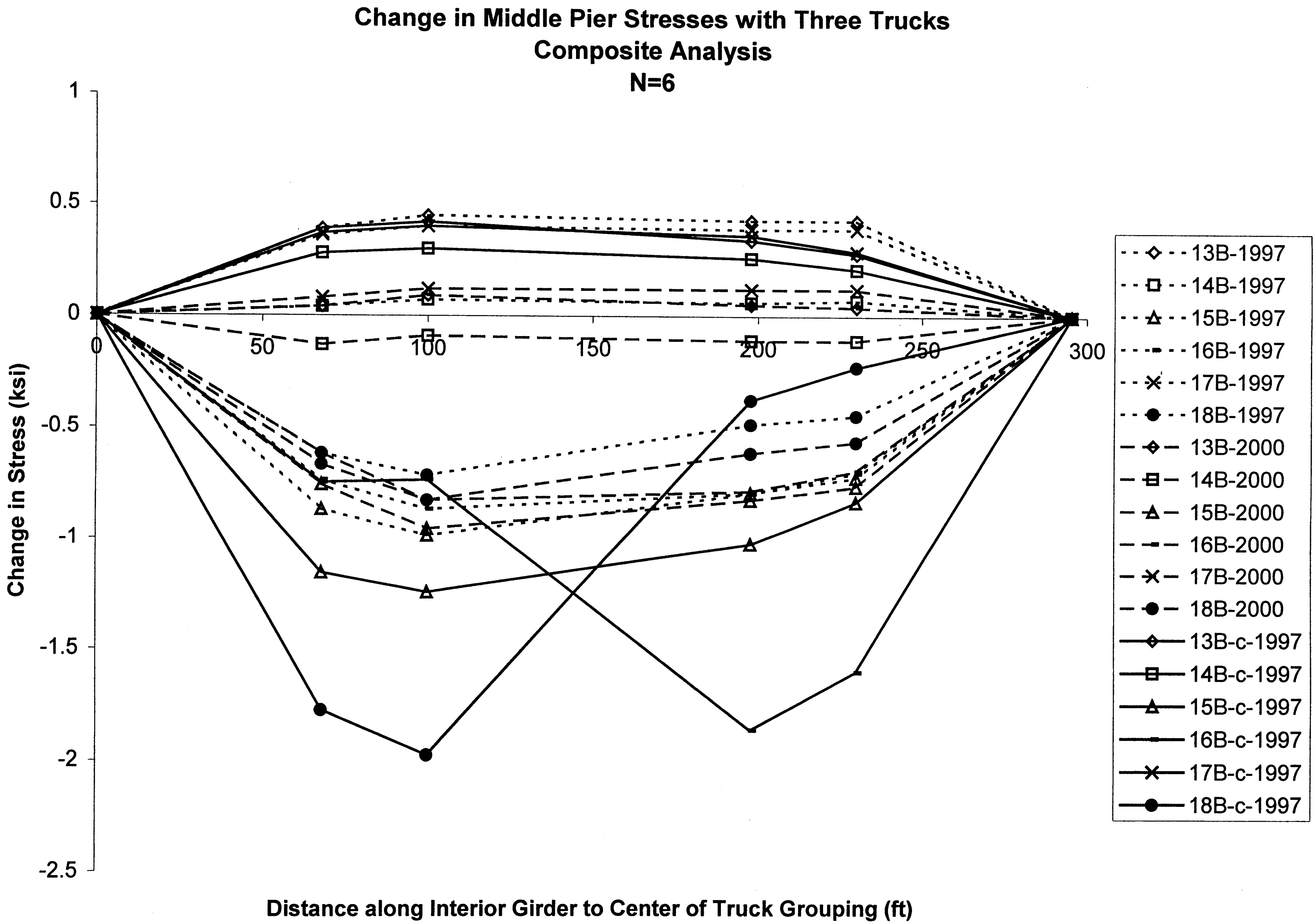


Figure F.79: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 13B-18B)

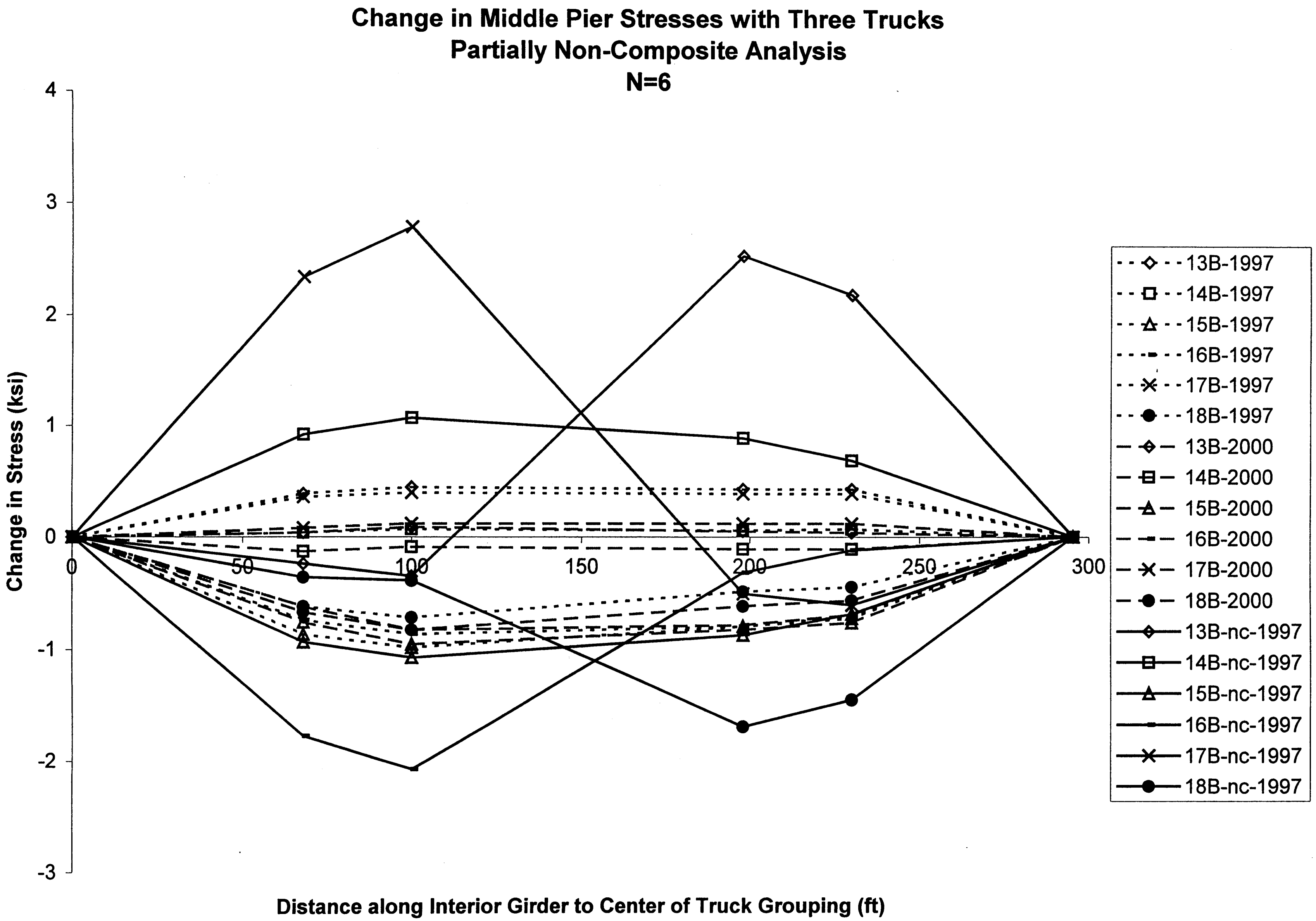


Figure F.80: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 13B-18B)

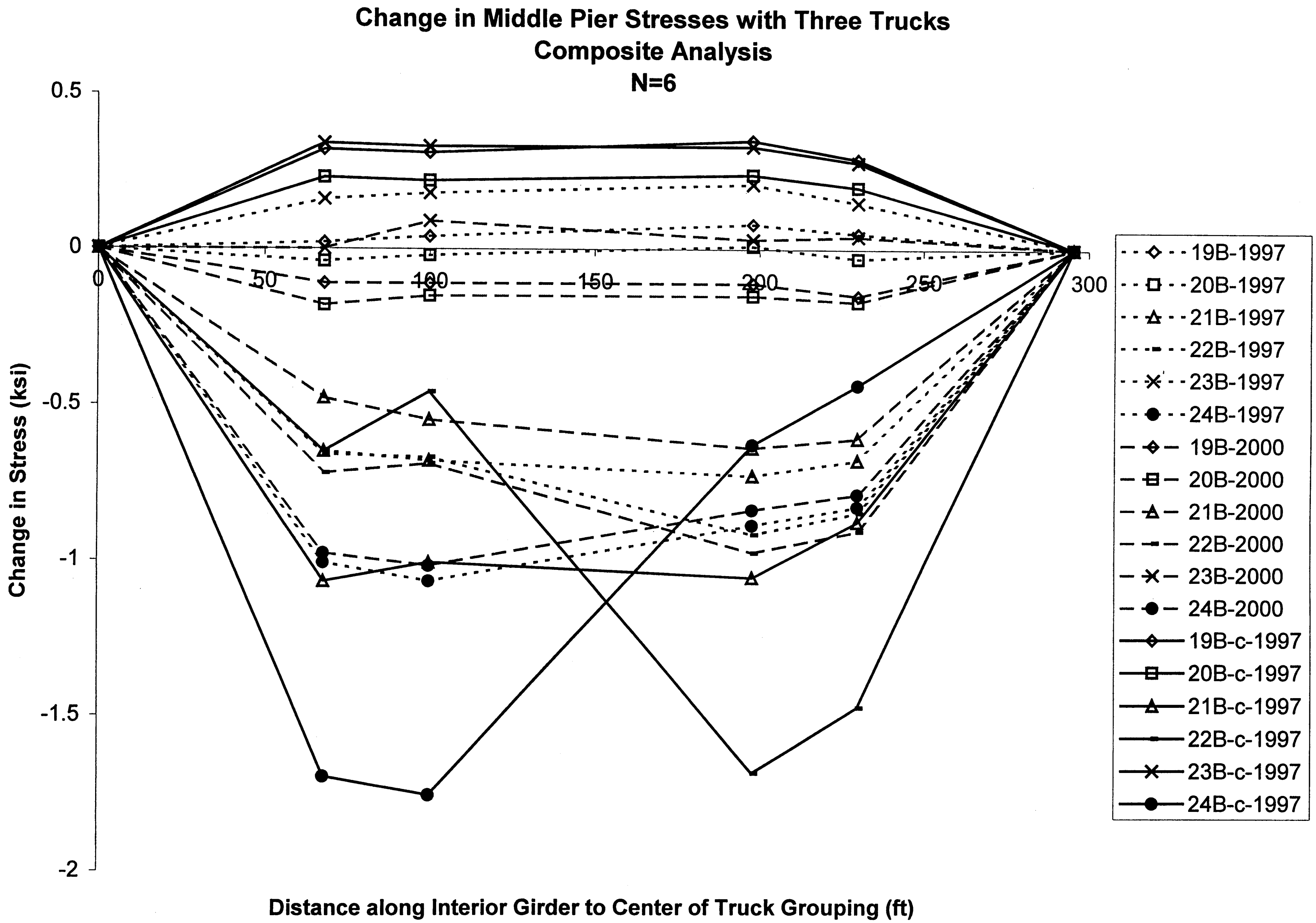


Figure F.81: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 19B-24B)

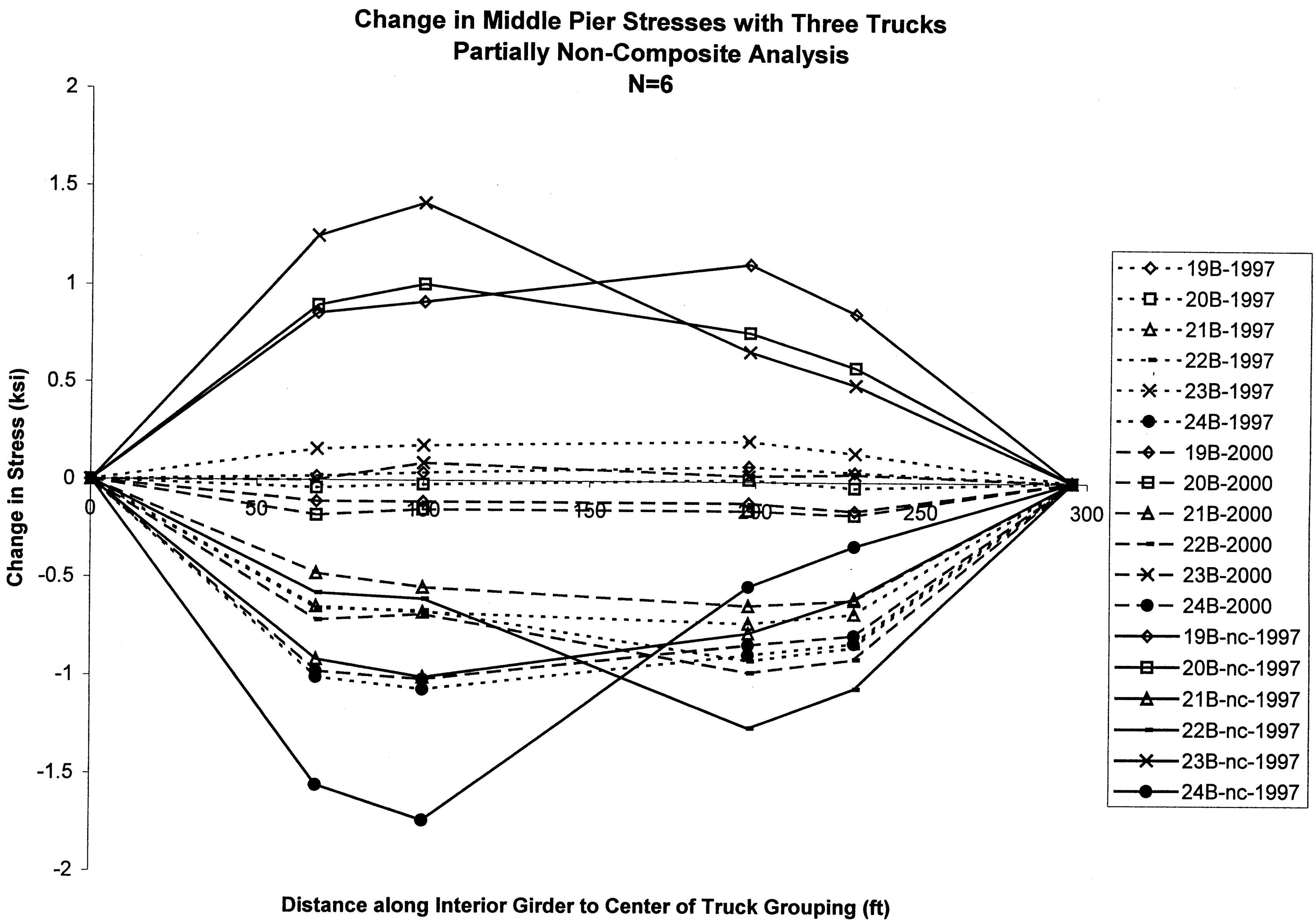


Figure F.82: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 19B-24B)

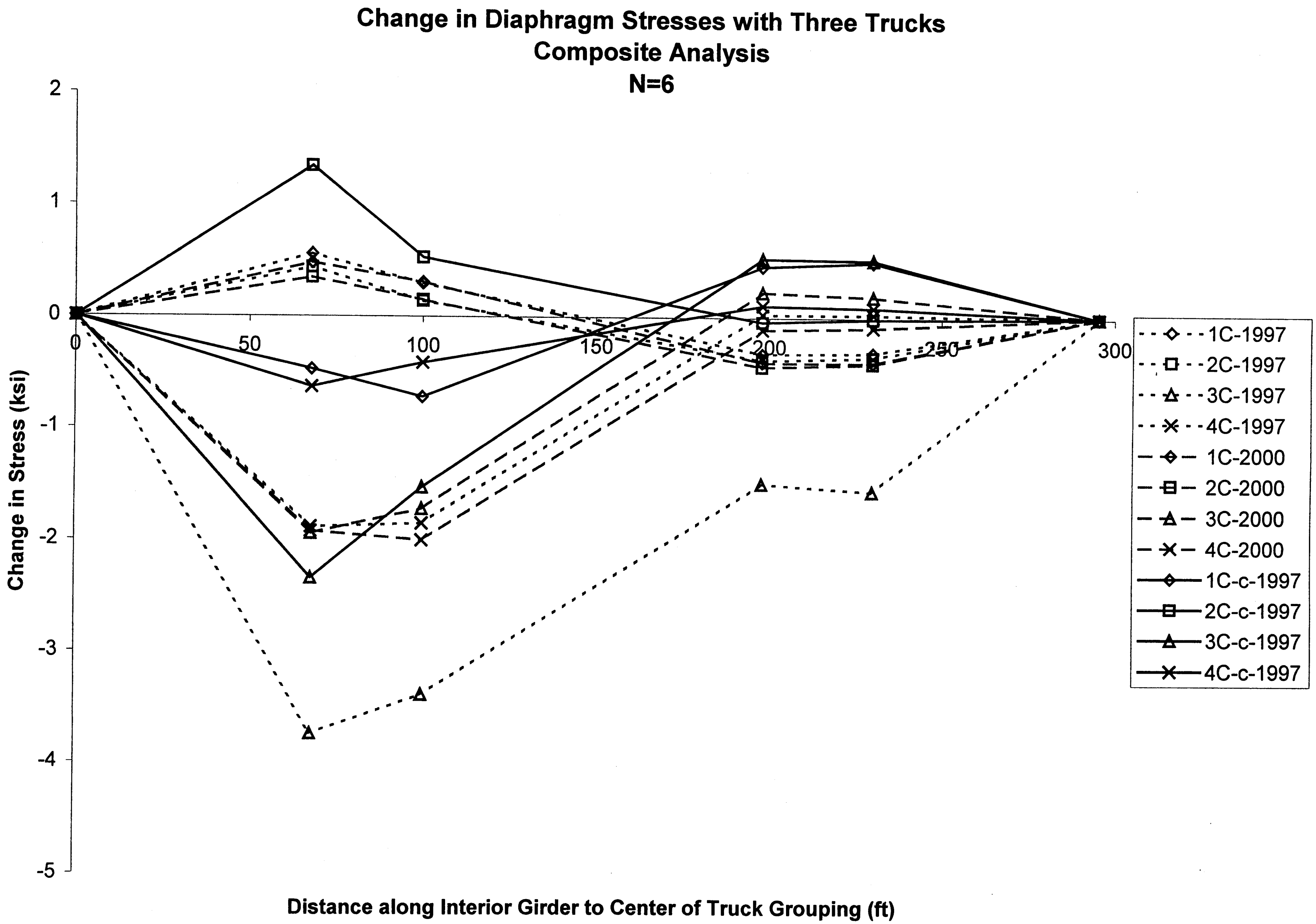


Figure F.83: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 1C-4C)

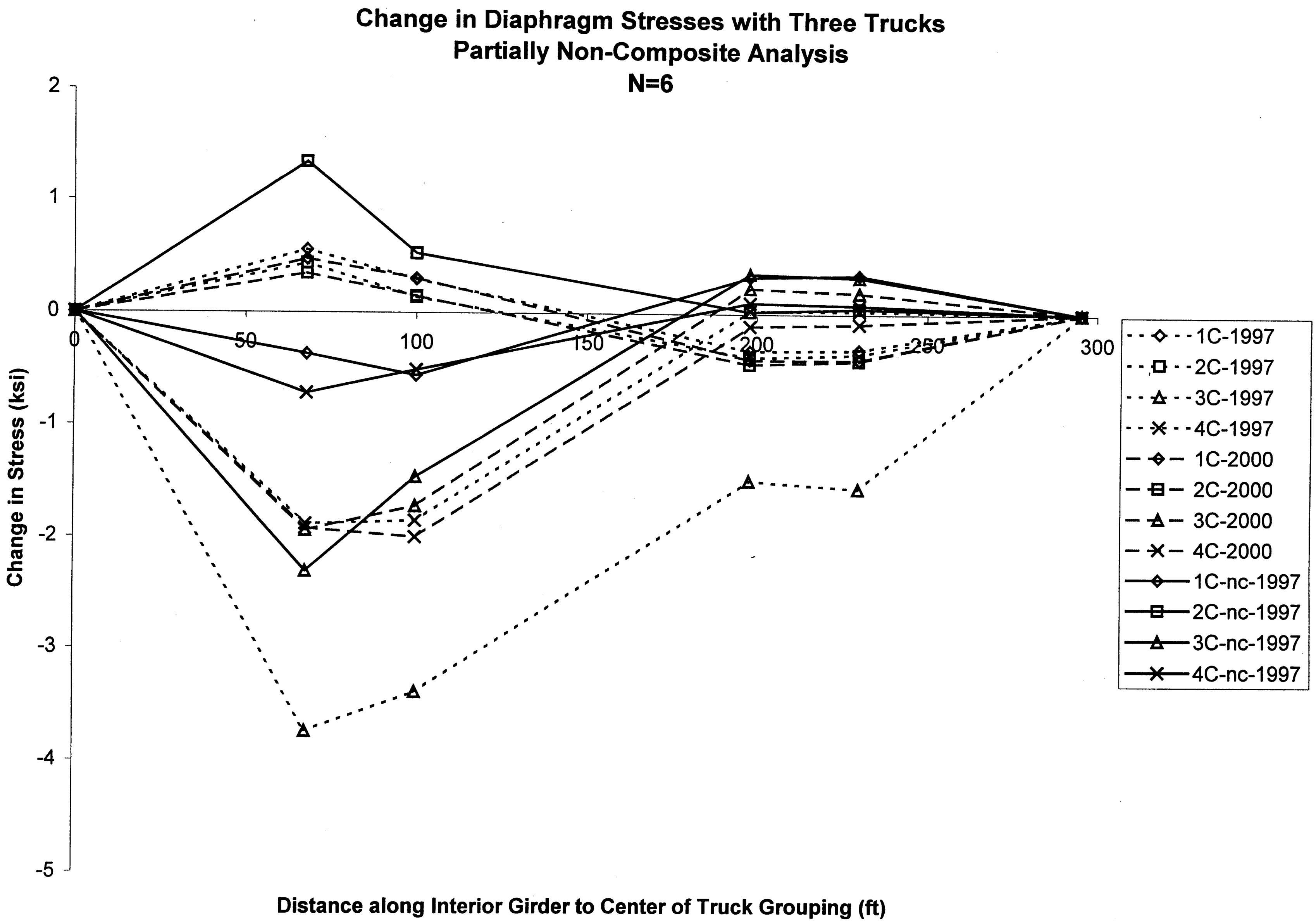


Figure F.84: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 1C-4C)

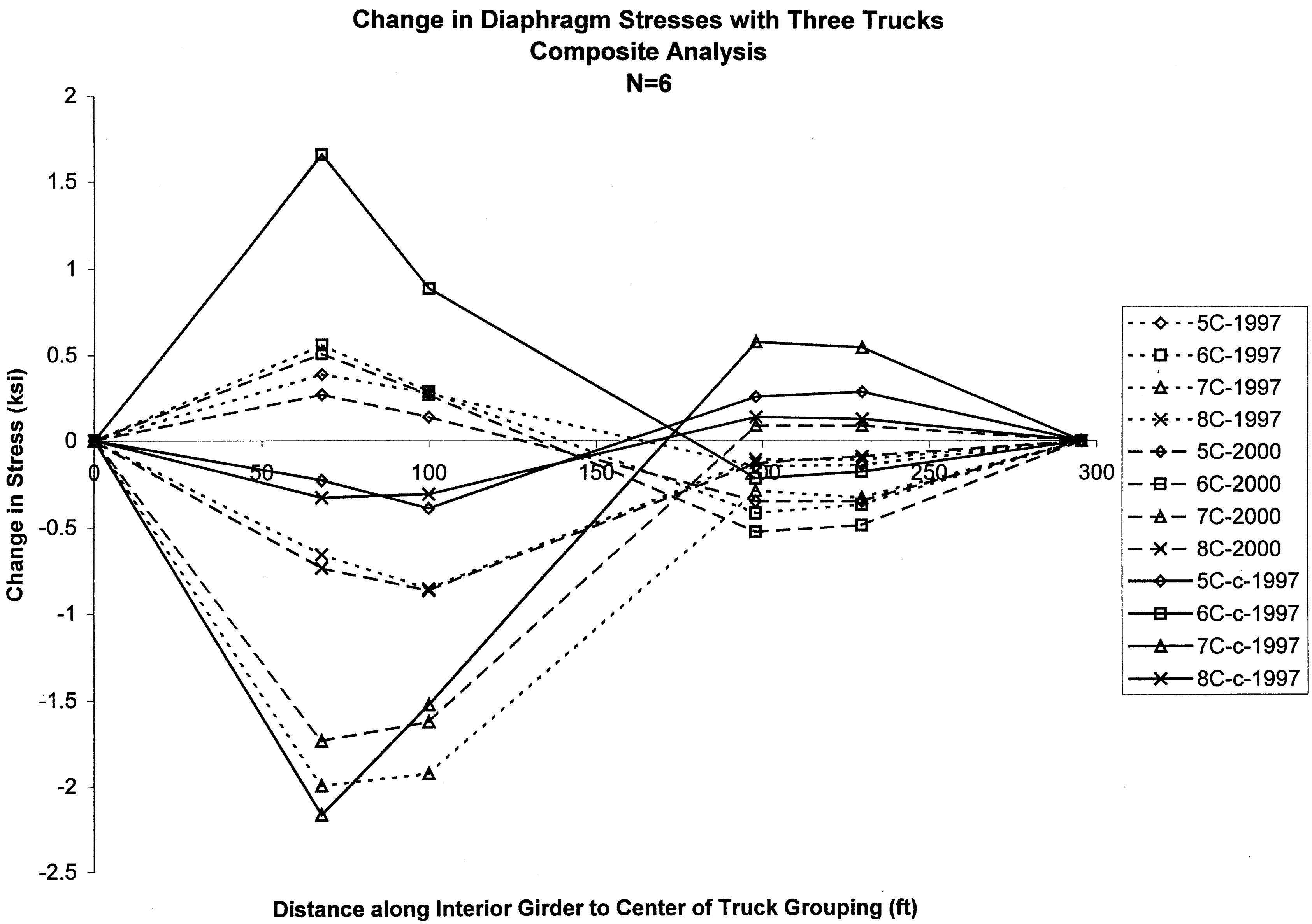


Figure F.85: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 5C-8C)

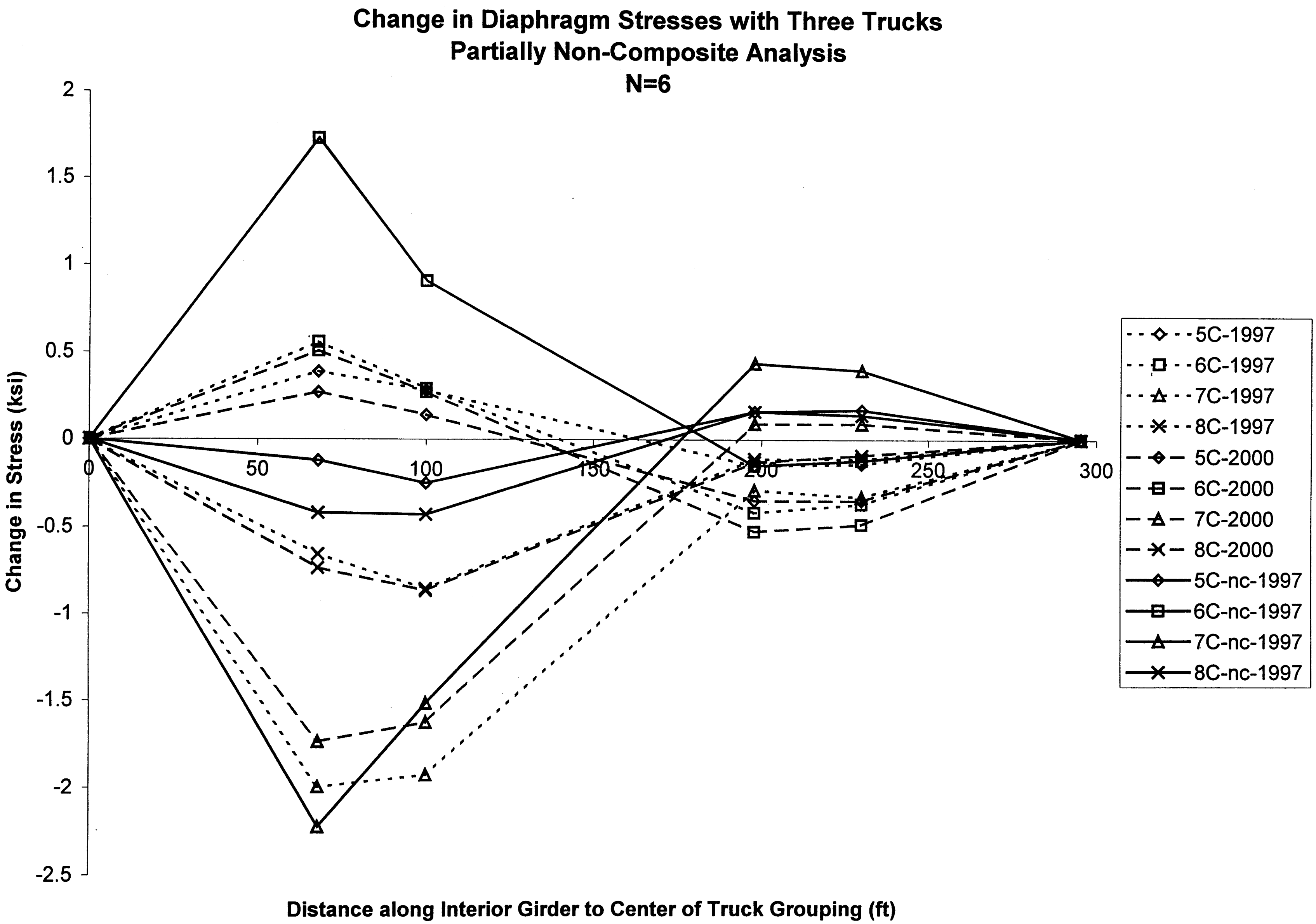


Figure F.86: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 5C-8C)

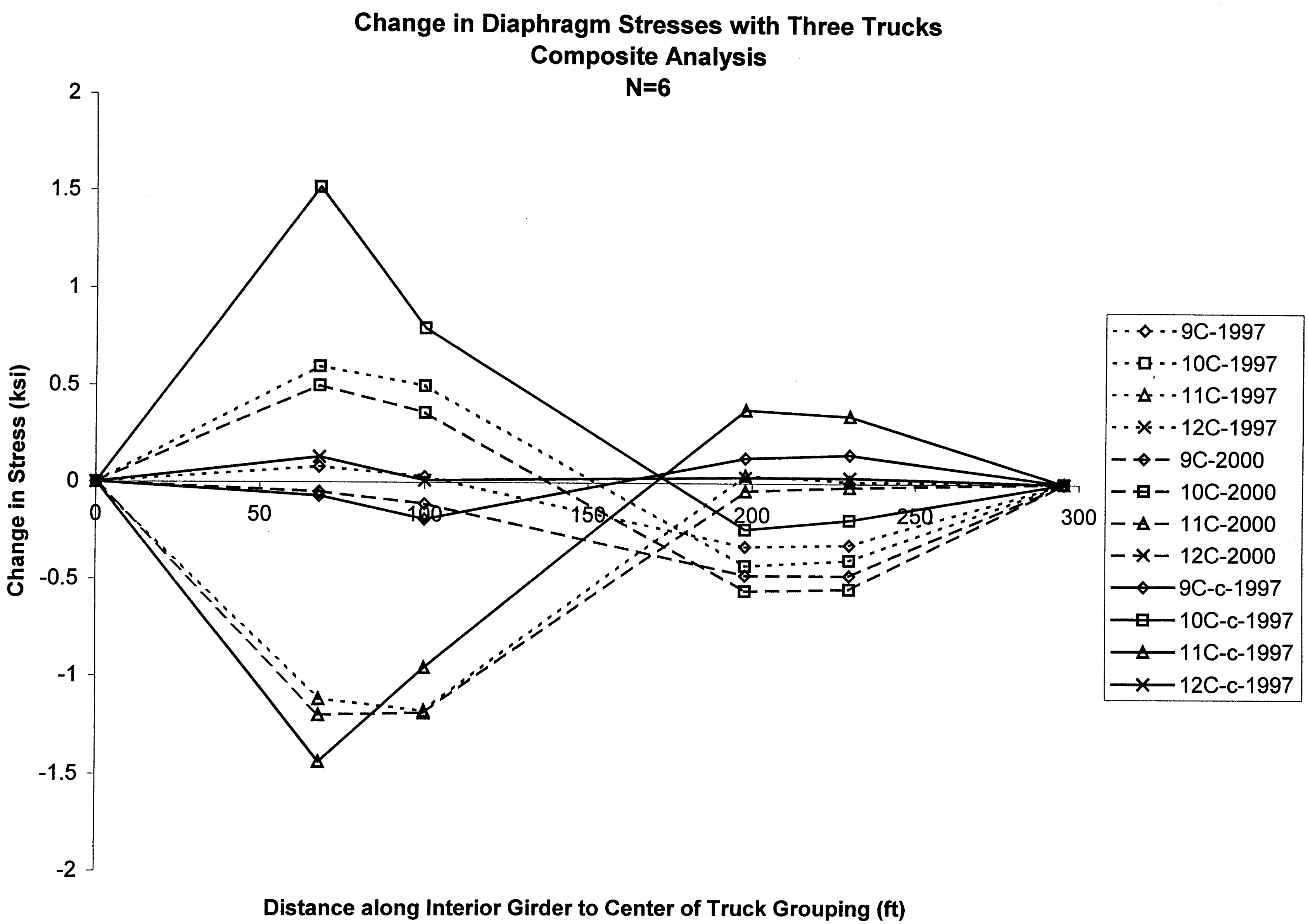


Figure F.87: Plot of Change in Stress with Three Trucks 1997, Composite Analysis, N = 6 (Gages 9C-12C)

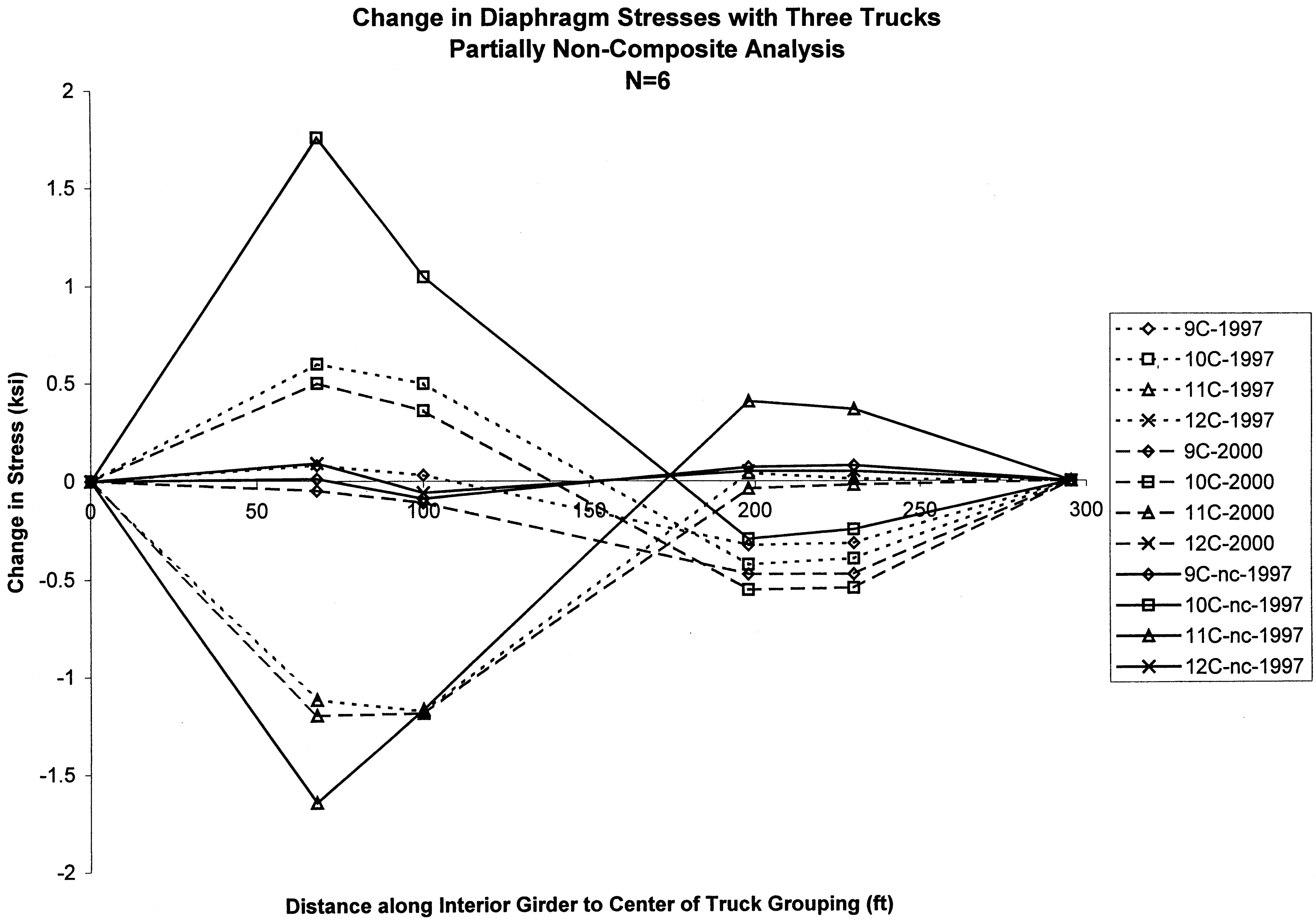


Figure F.88: Plot of Change in Stress with Three Trucks 1997, Partially Non-Composite Analysis, N = 6 (Gages 9C-12C)

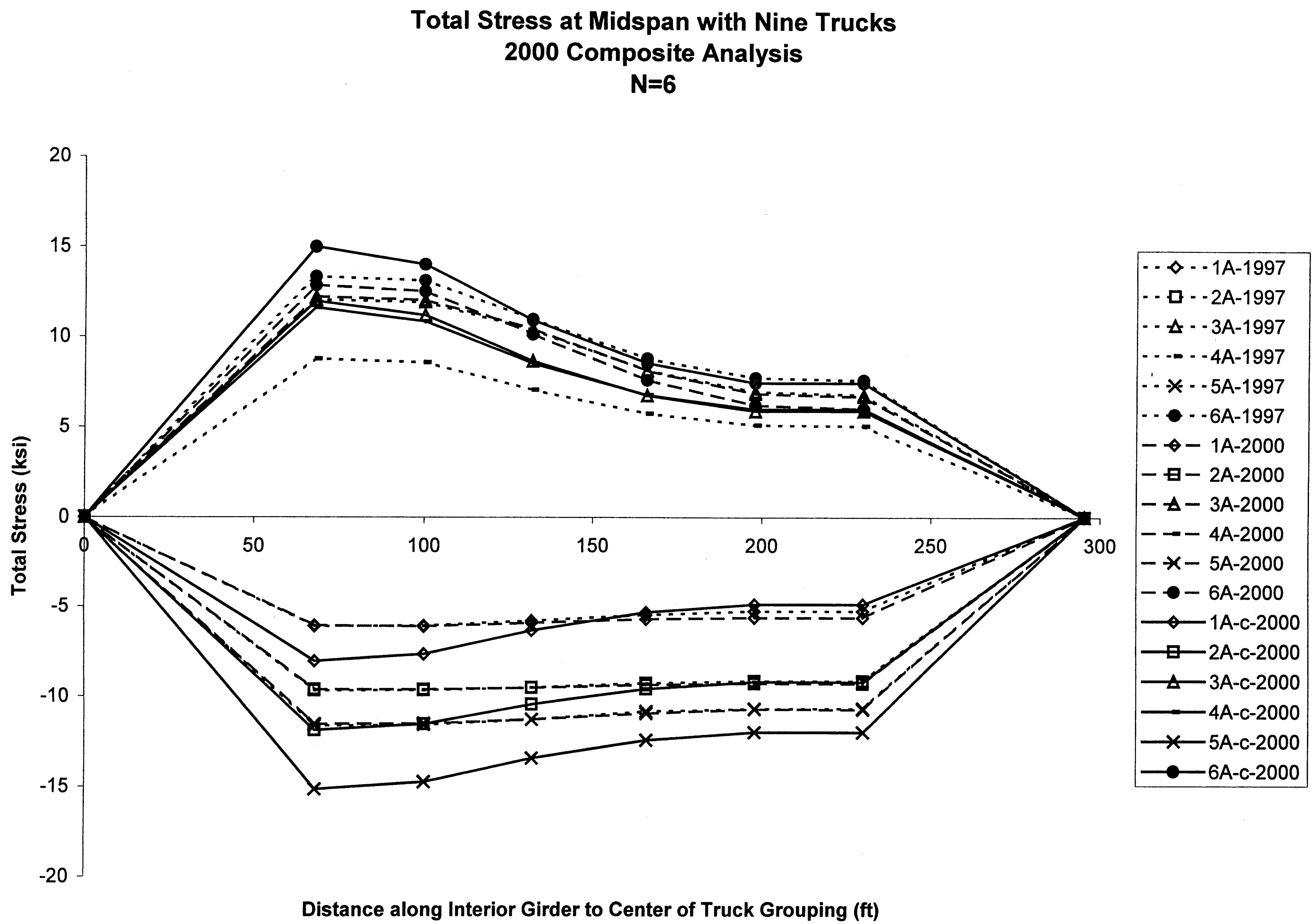


Figure F.89: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1A-6A)

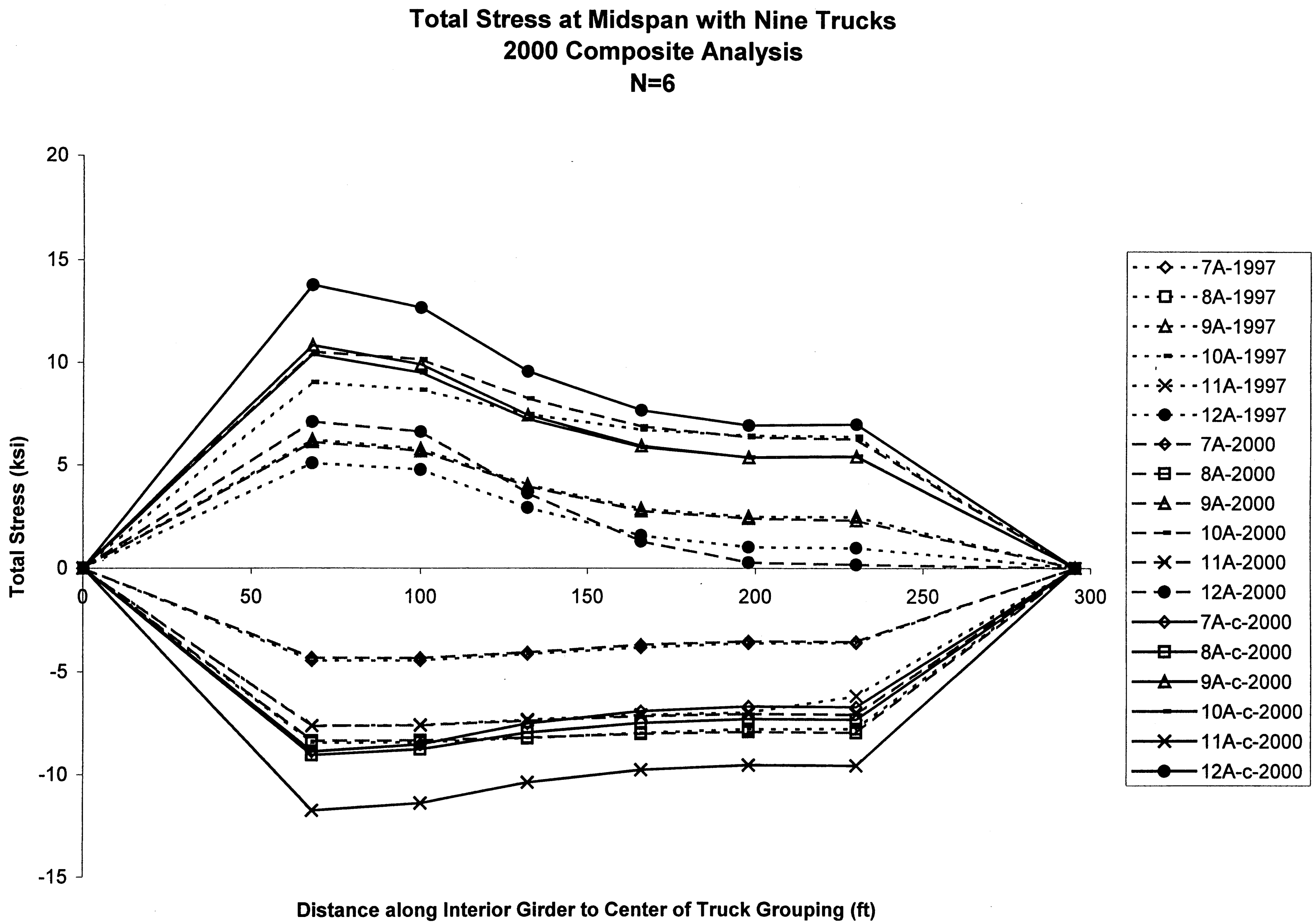


Figure F.90: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 7A-12A)

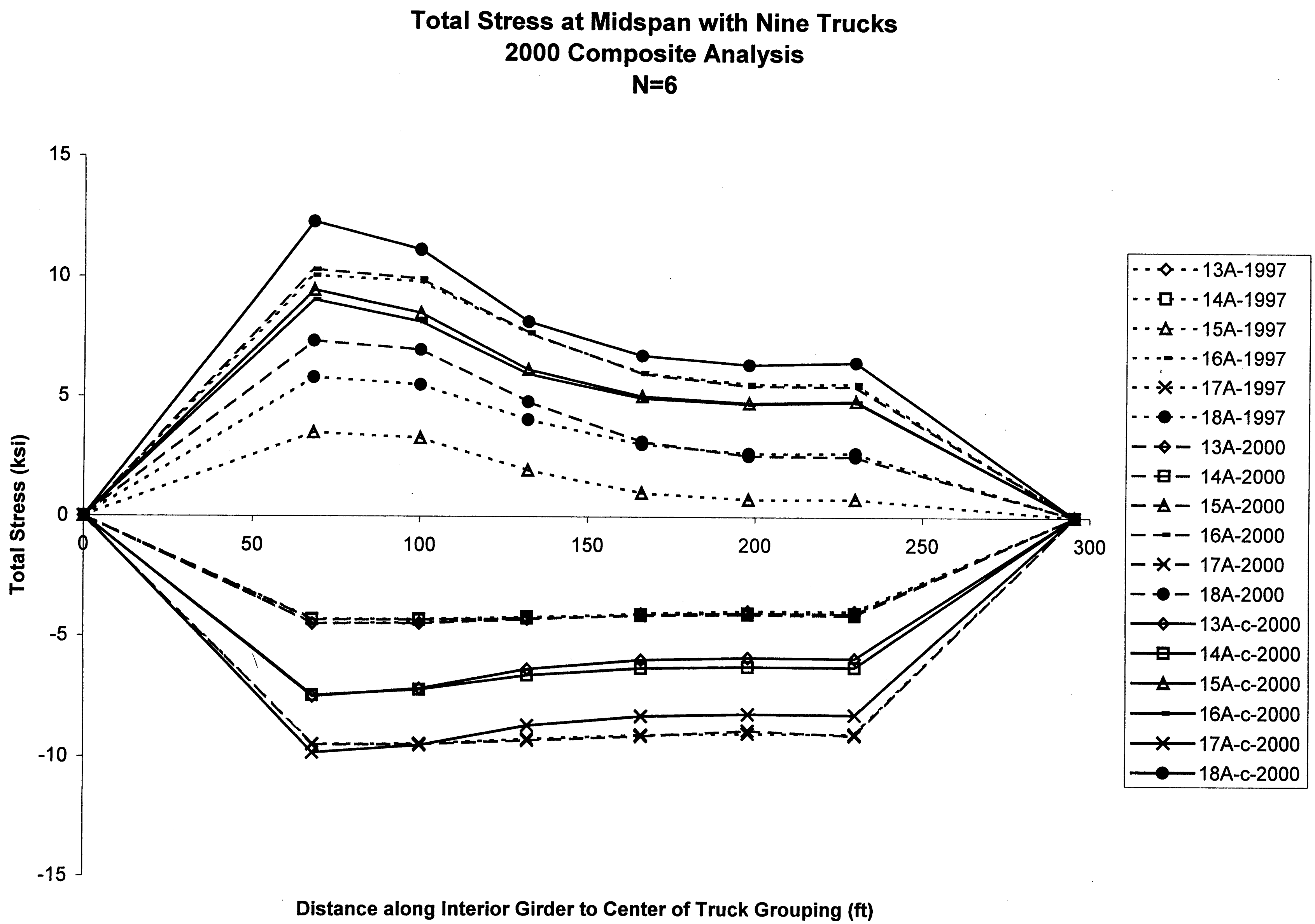


Figure F.91: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 13A-18A)

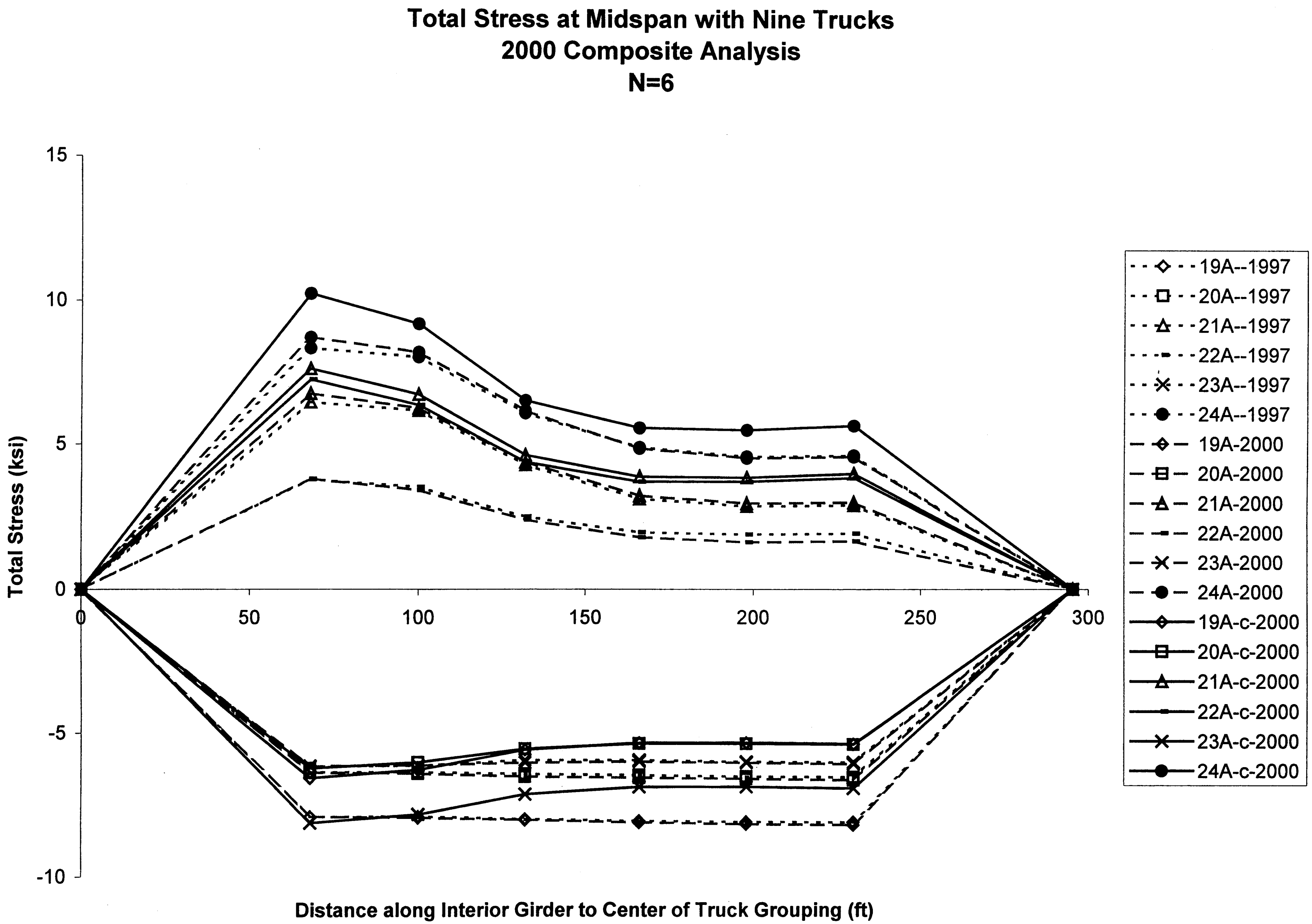


Figure F.92: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 19A-24A)

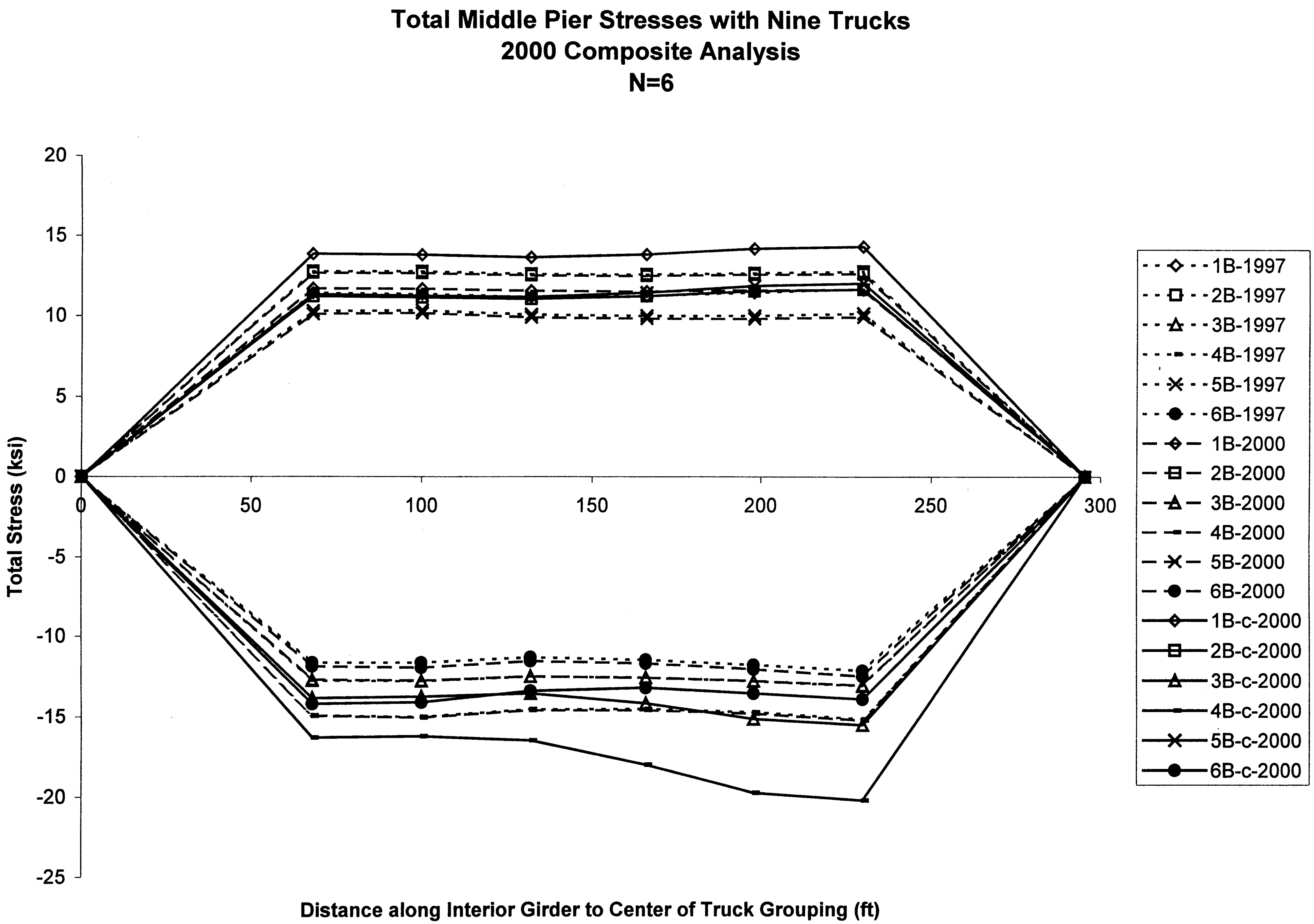


Figure F.93: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1B-6B)

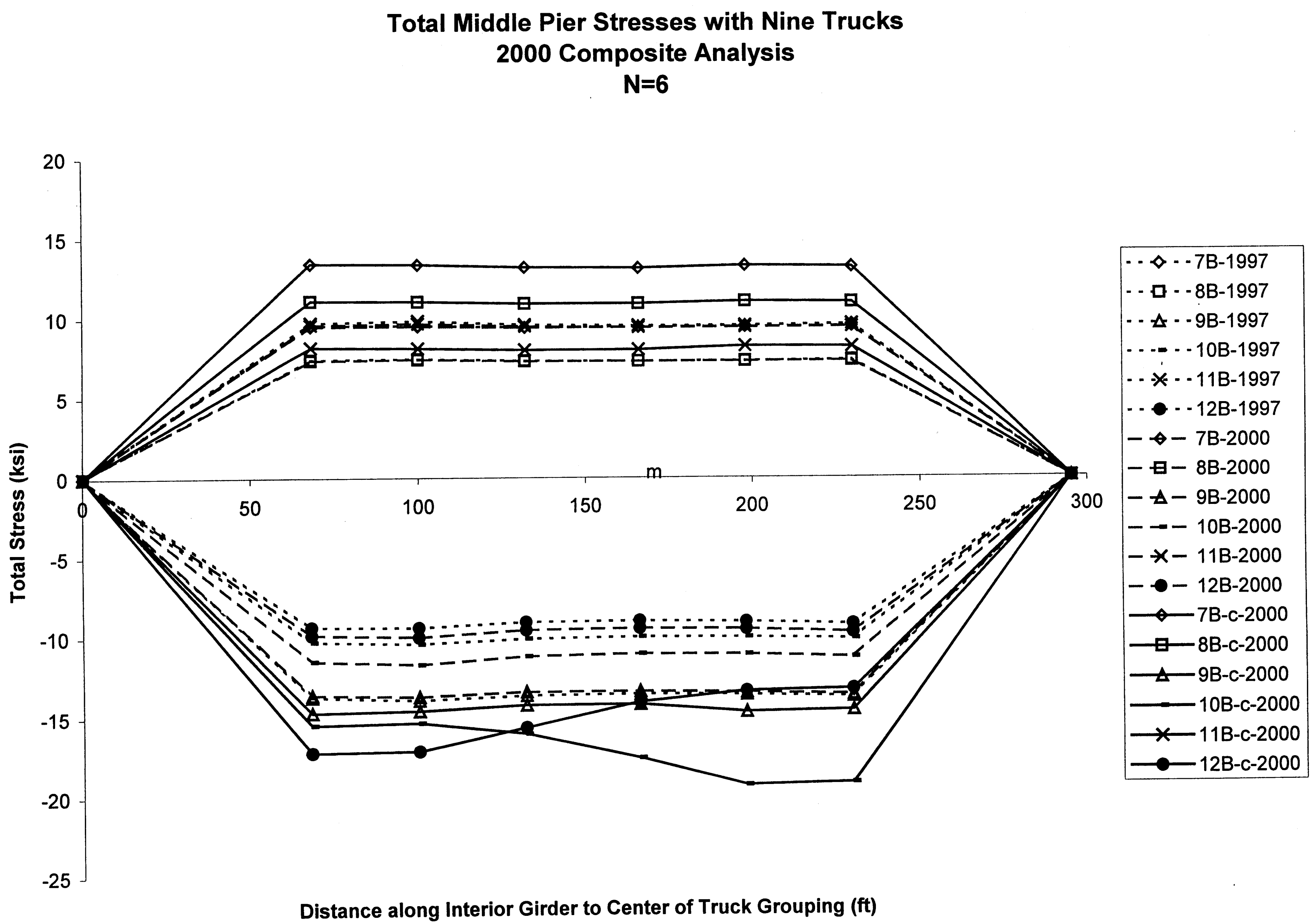


Figure F.94: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 7B-12B)

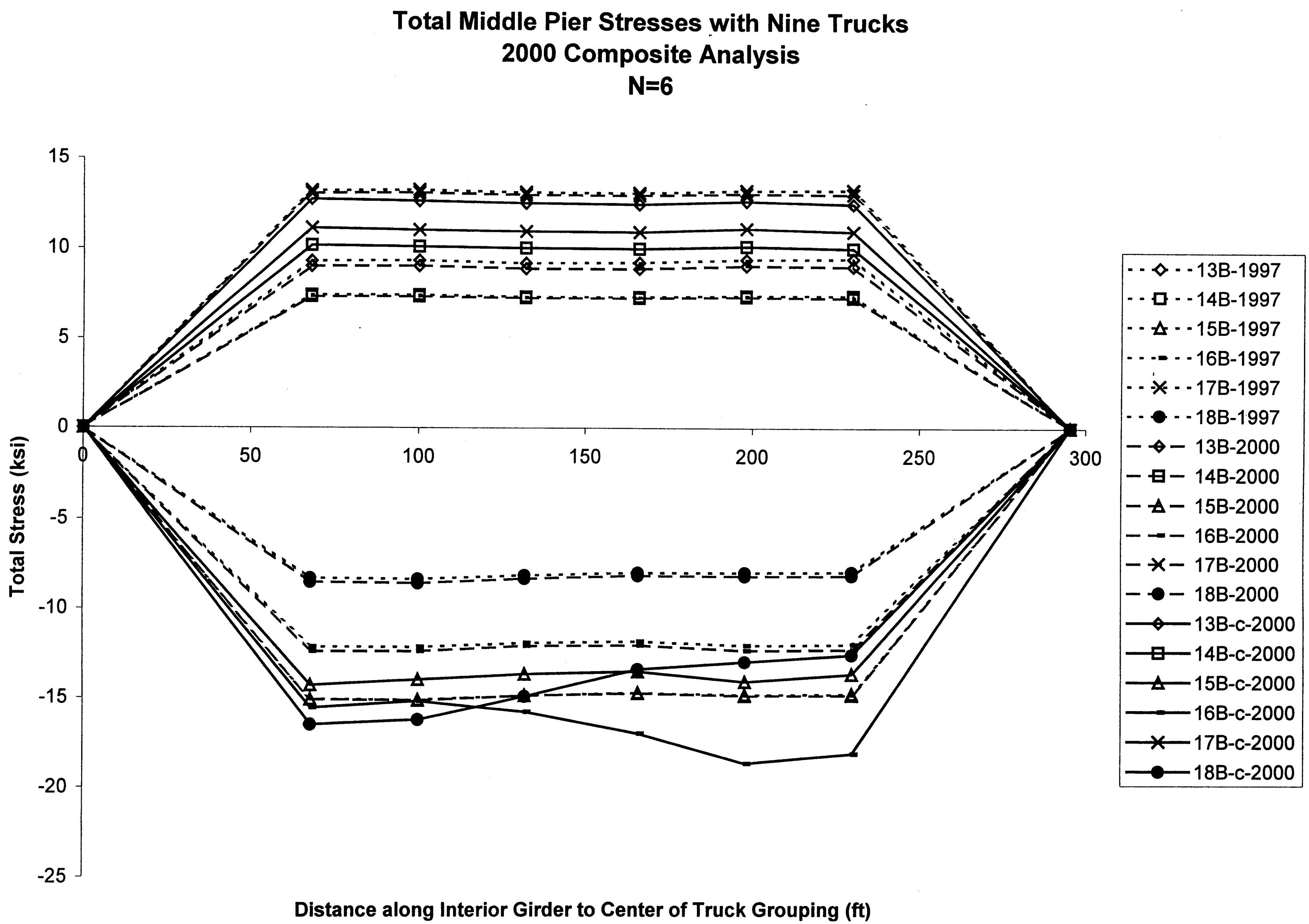


Figure F.95: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 13B-18B)

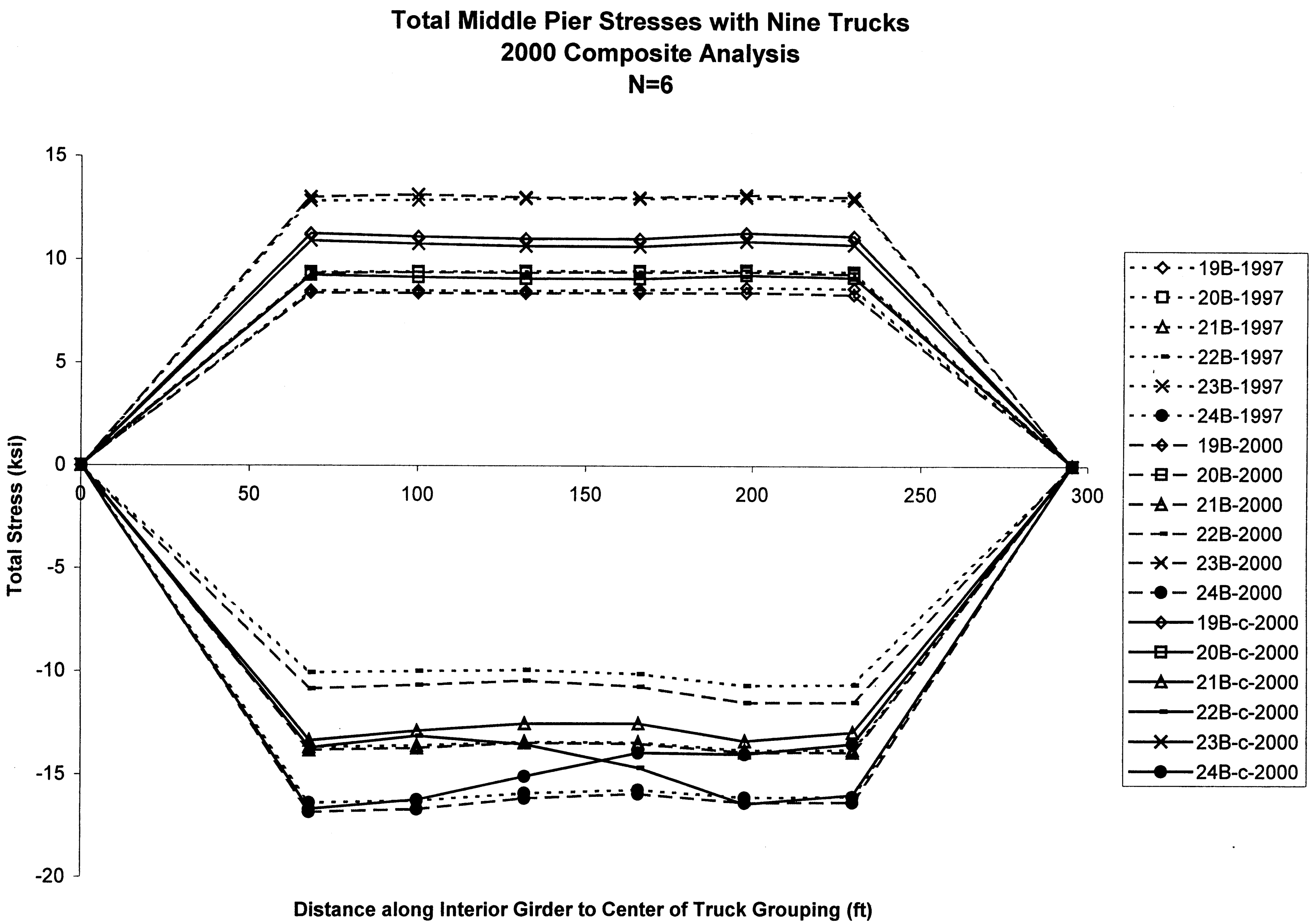


Figure F.96: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 19B-24B)

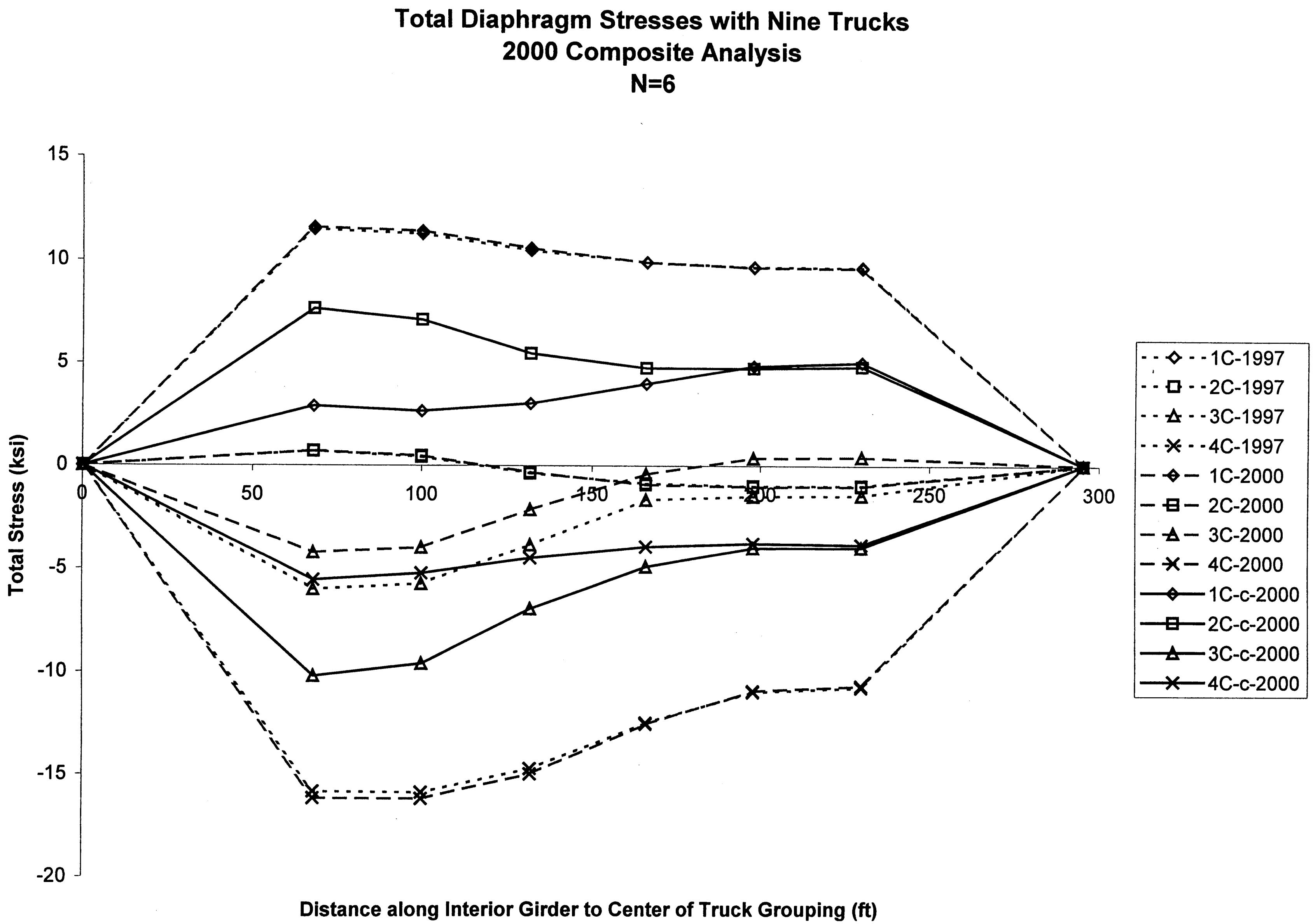


Figure F.97: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1C-4C)

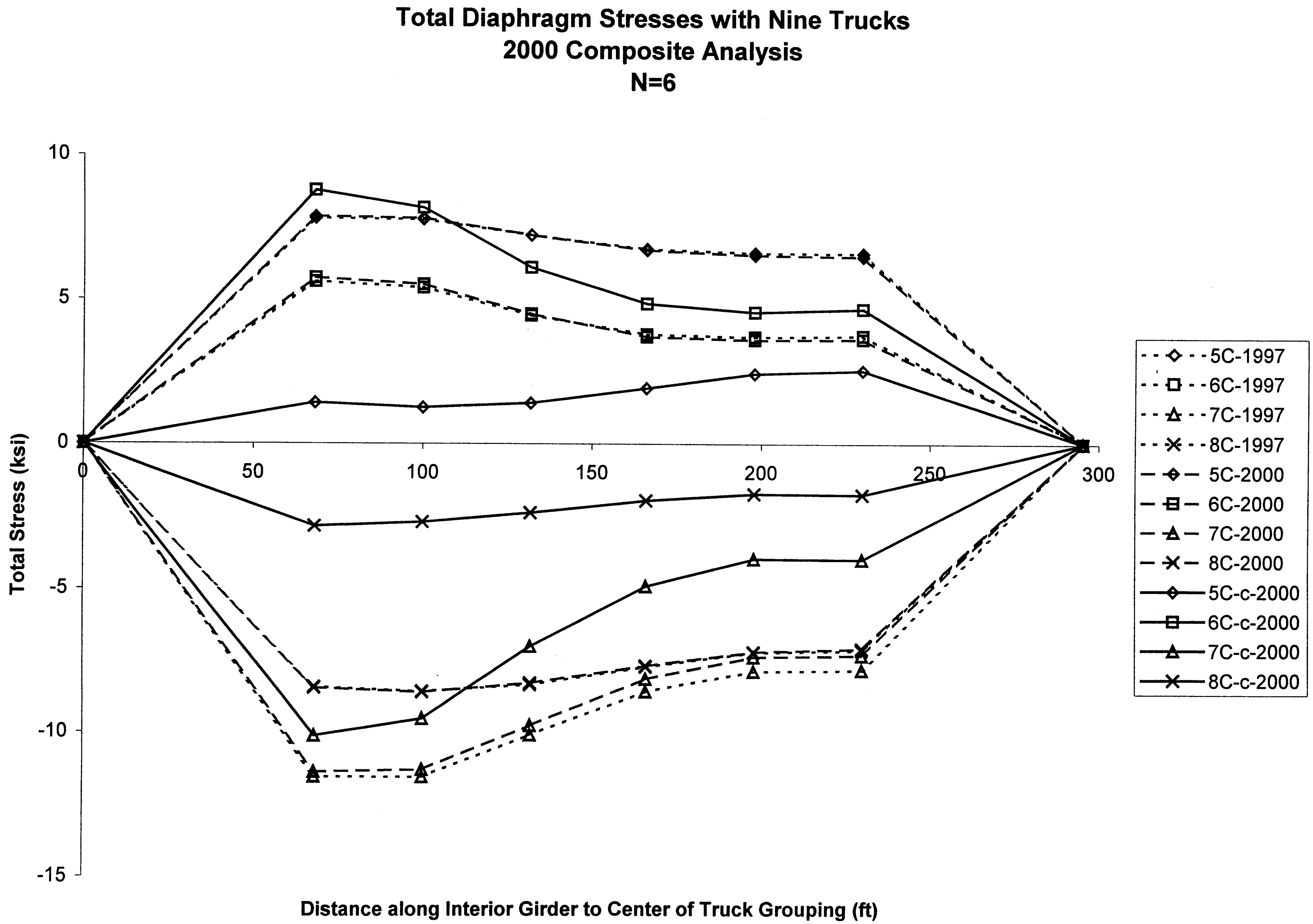


Figure F.98: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 5C-8C)

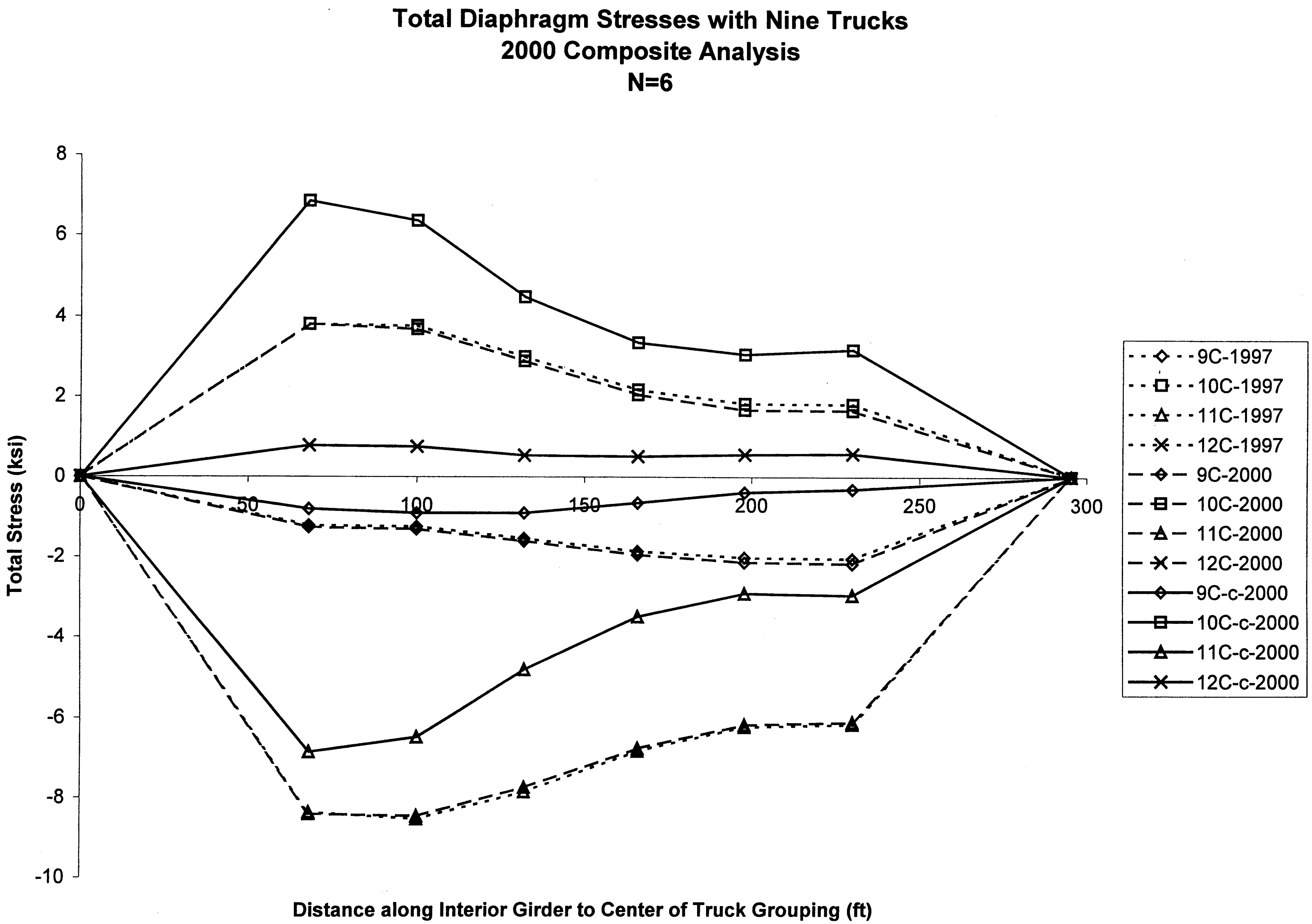


Figure F.99: Plot of Total Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 9C-12C)

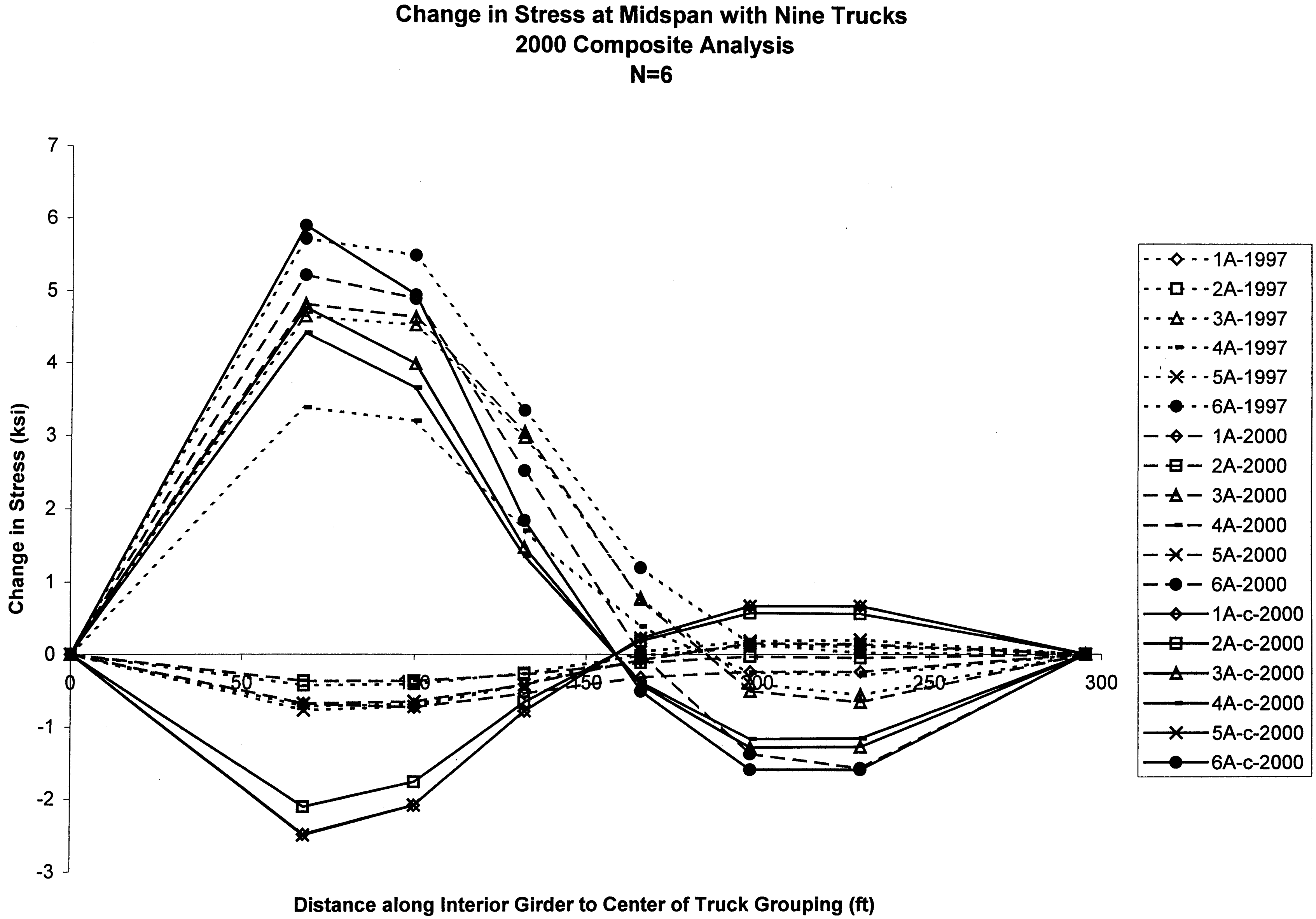


Figure F.100: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1A-6A)

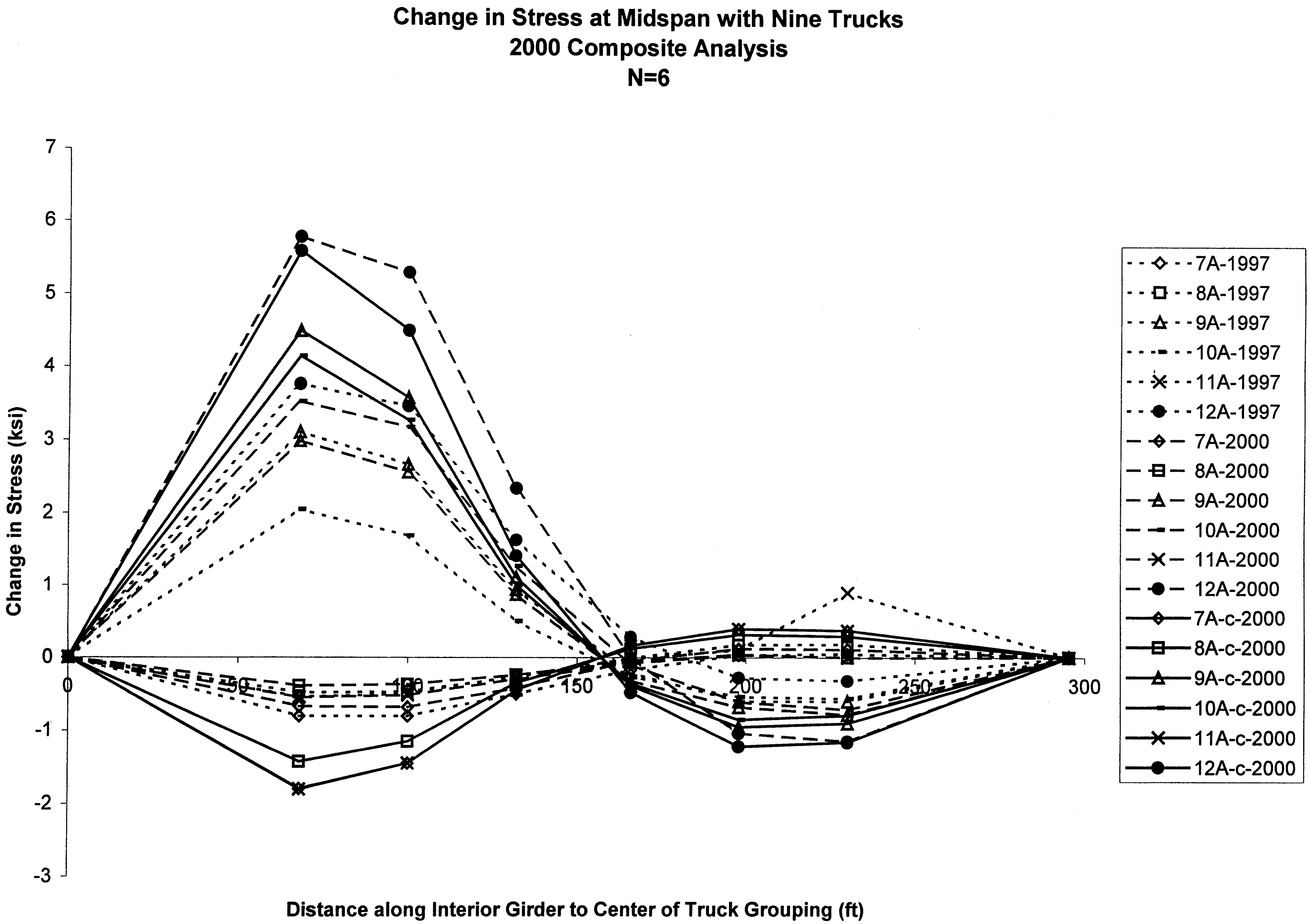


Figure F.101: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 7A-12A)

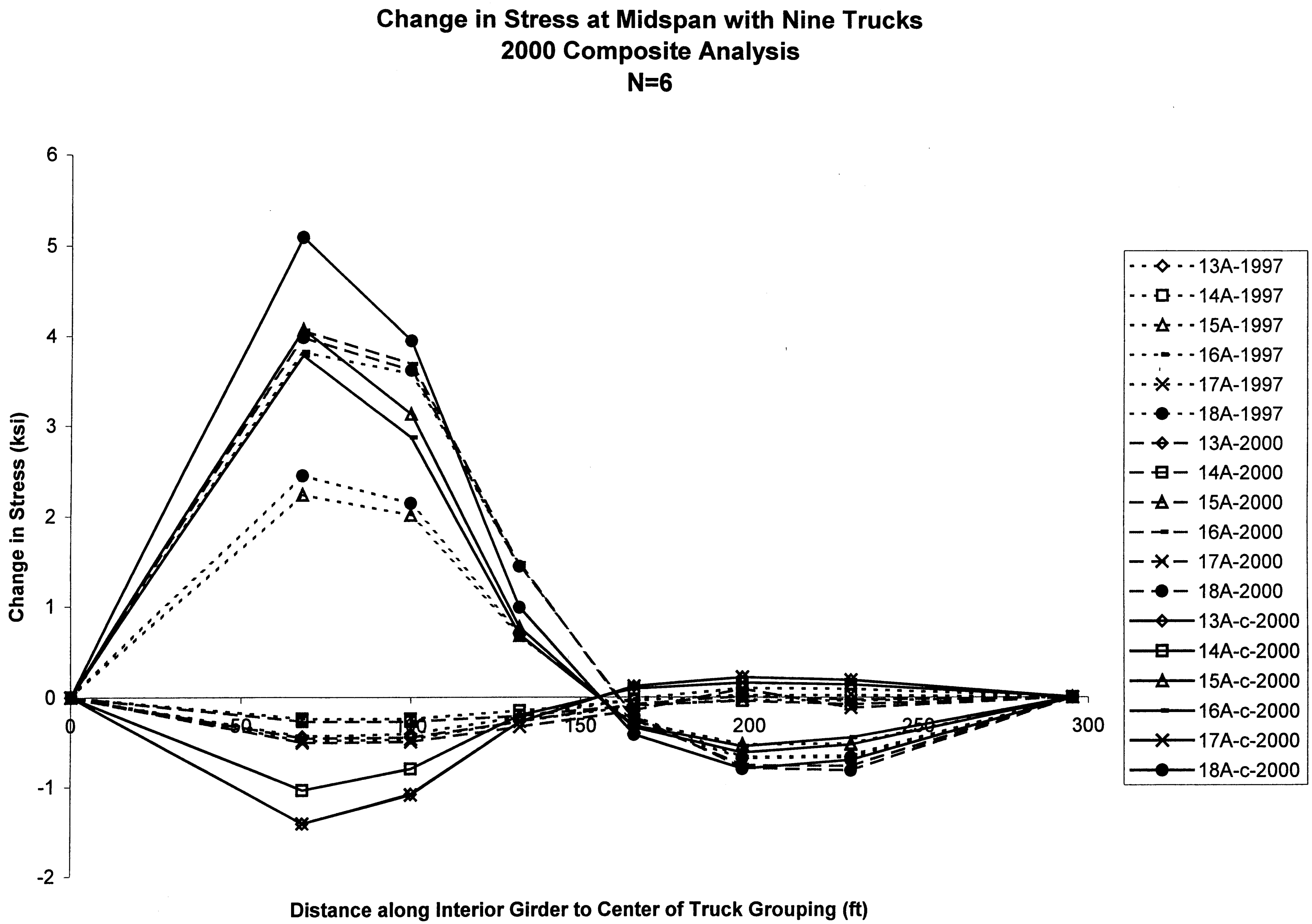


Figure F.102: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 13A-18A)

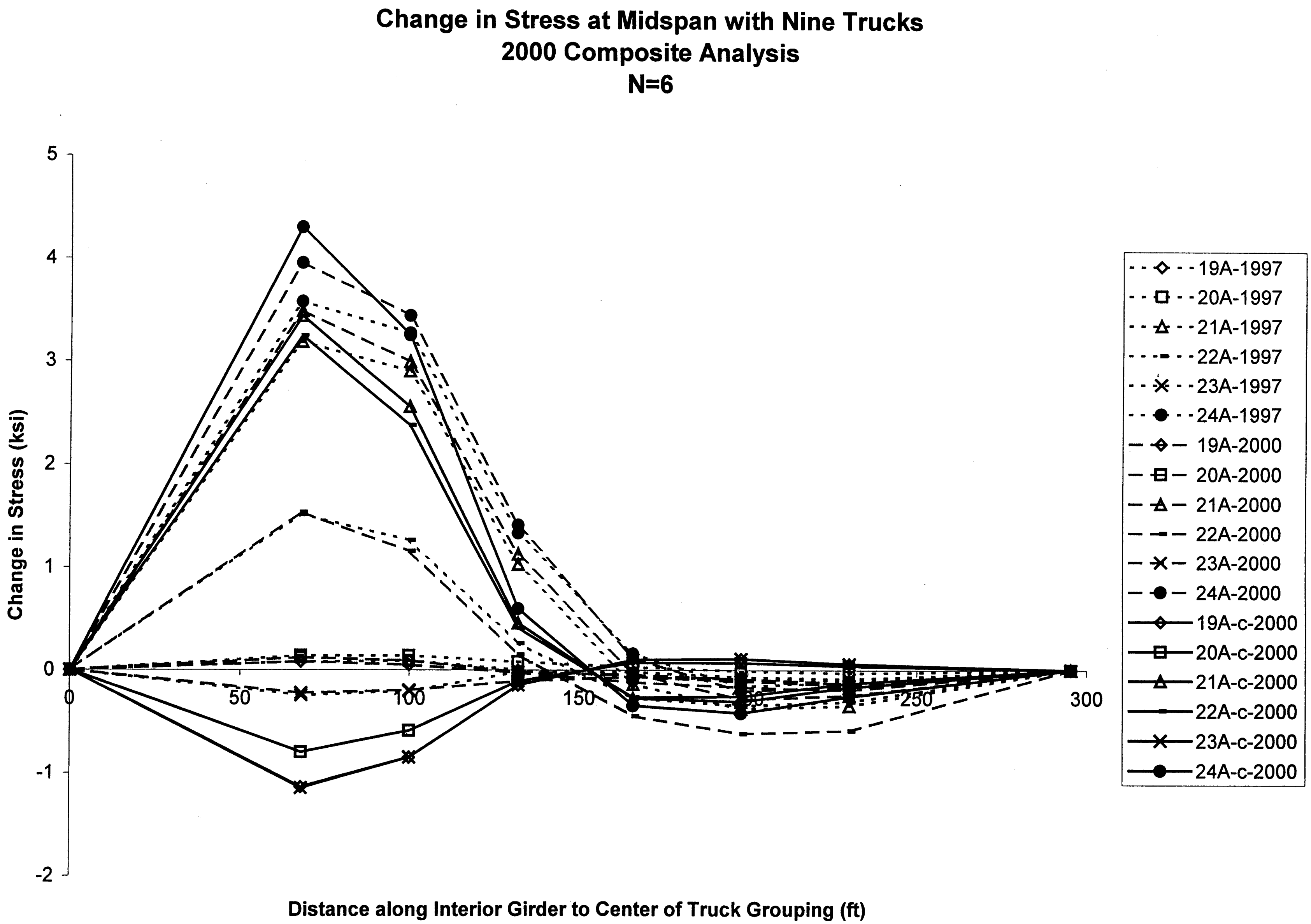


Figure F.103: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 19A-24A)

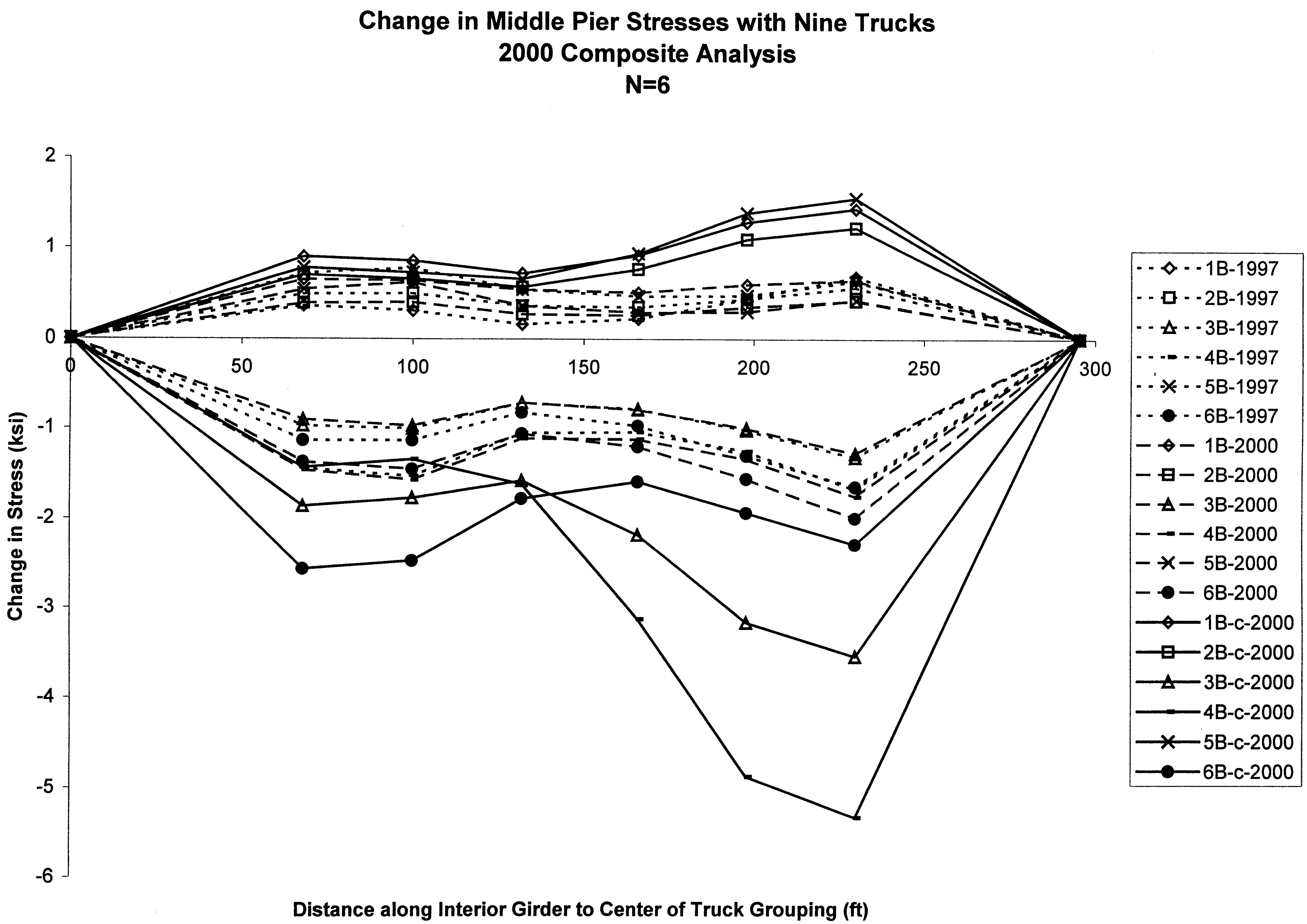


Figure F.104: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1B-6B)

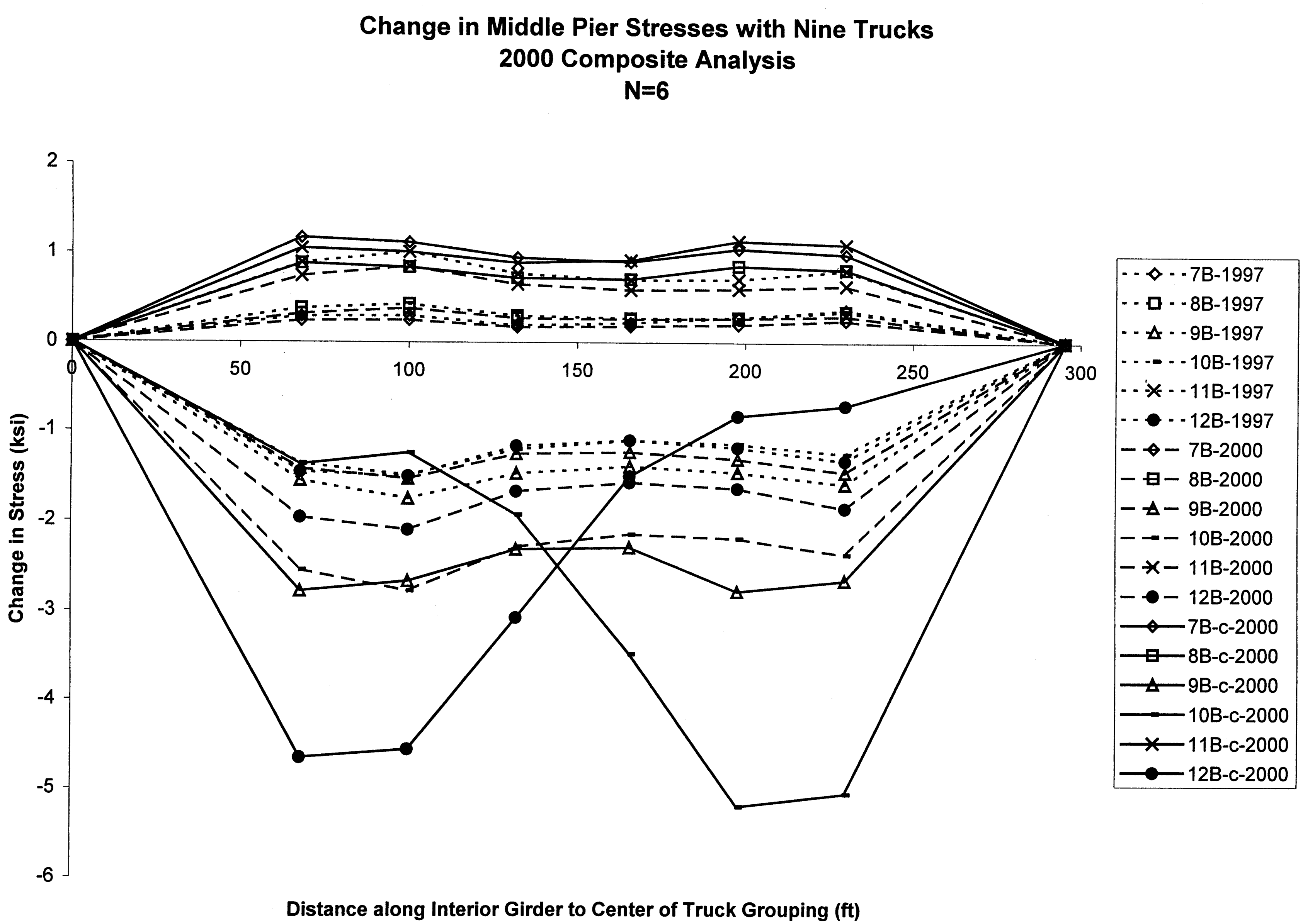


Figure F.105: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 7B-12B)

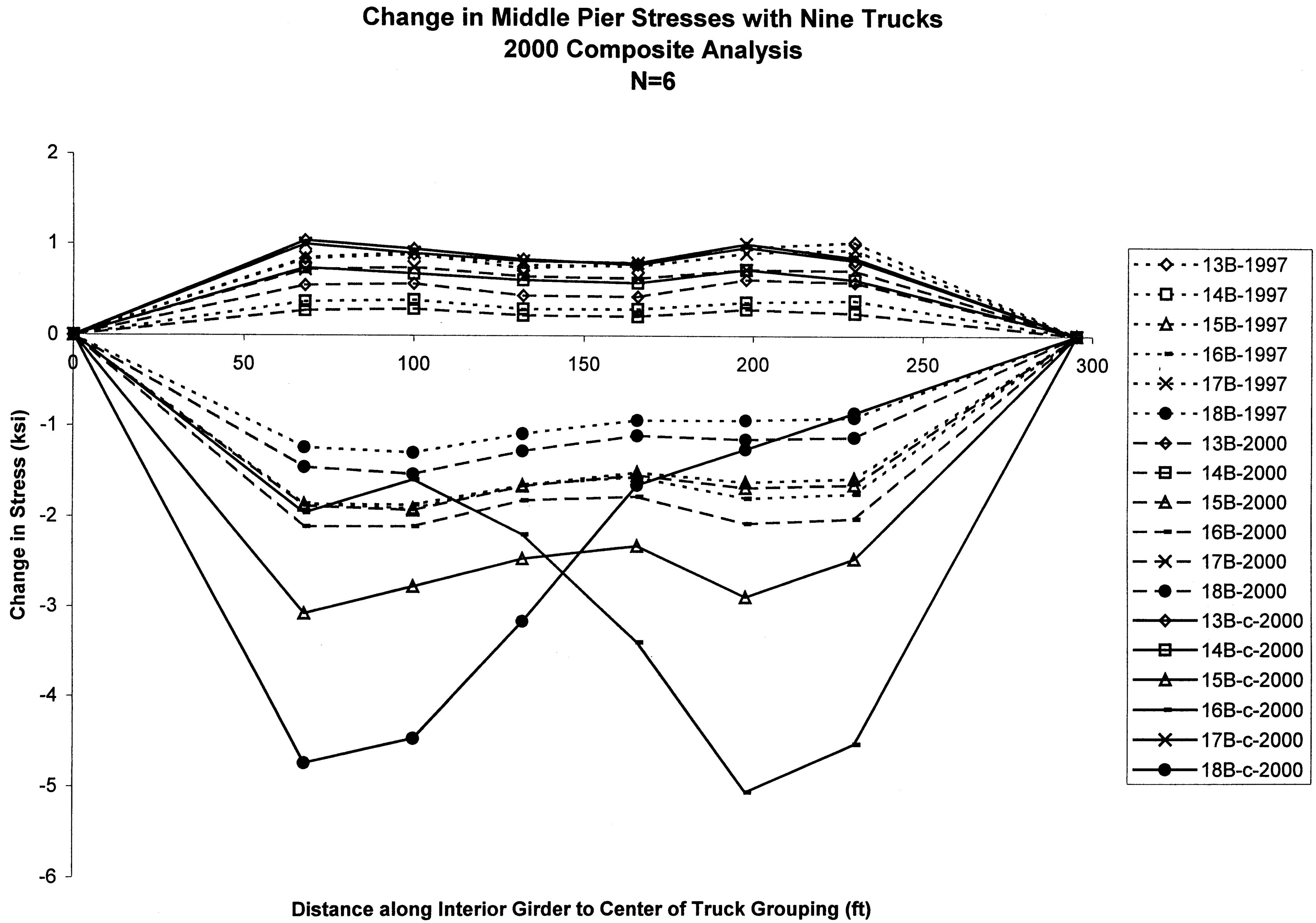


Figure F.106: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 13B-18B)

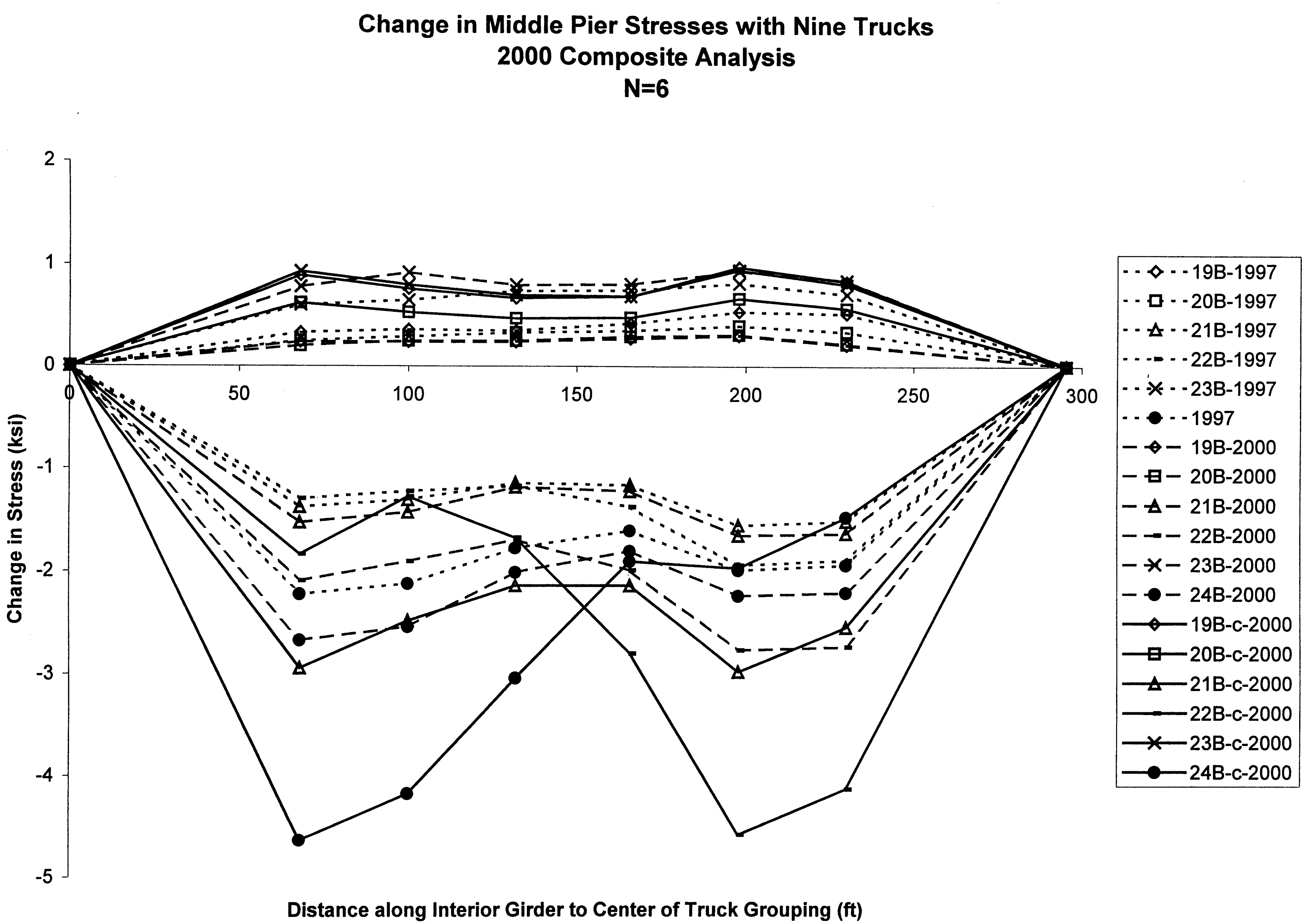


Figure F.107: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 19B-24B)

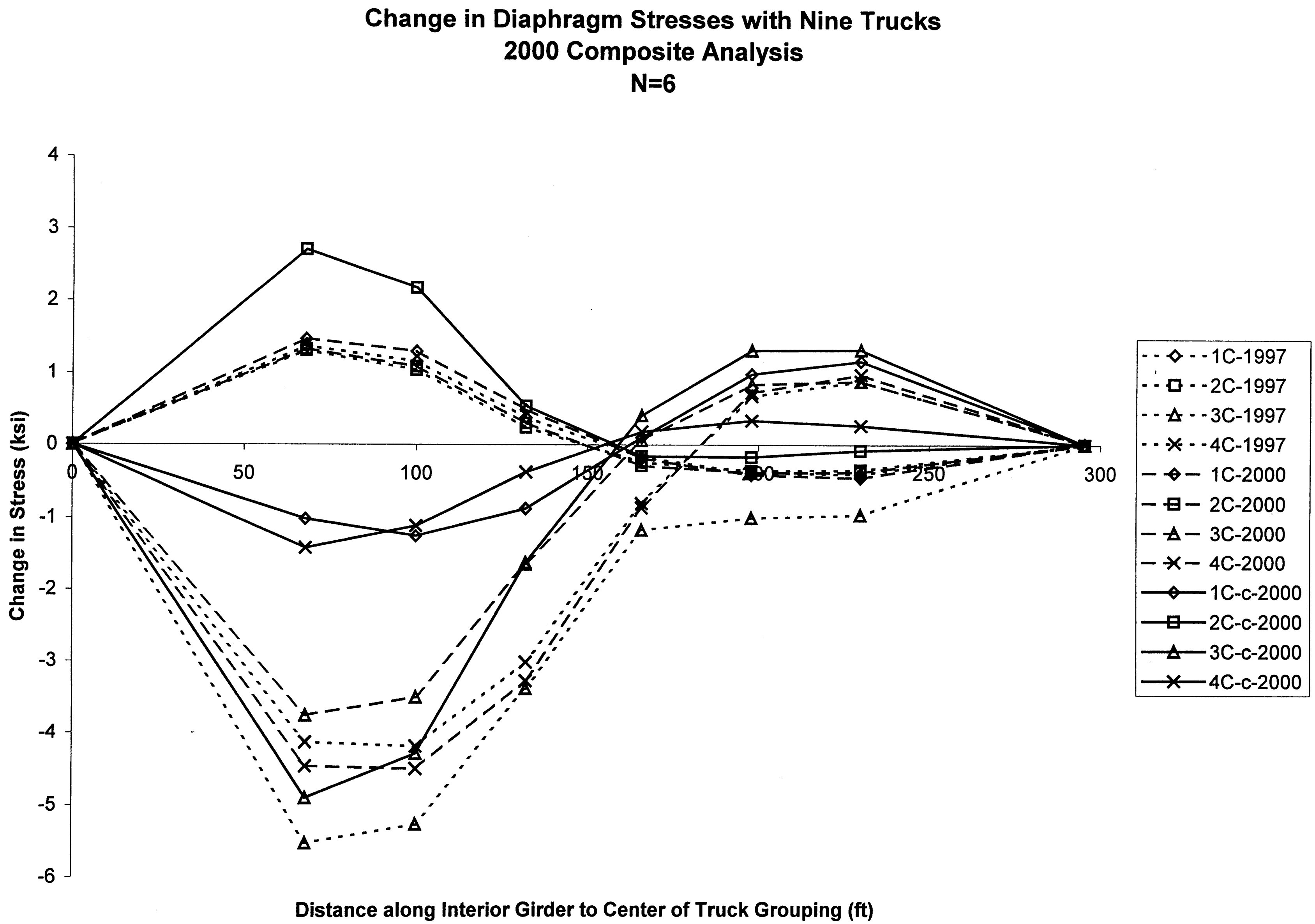


Figure F.108: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 1C-4C)

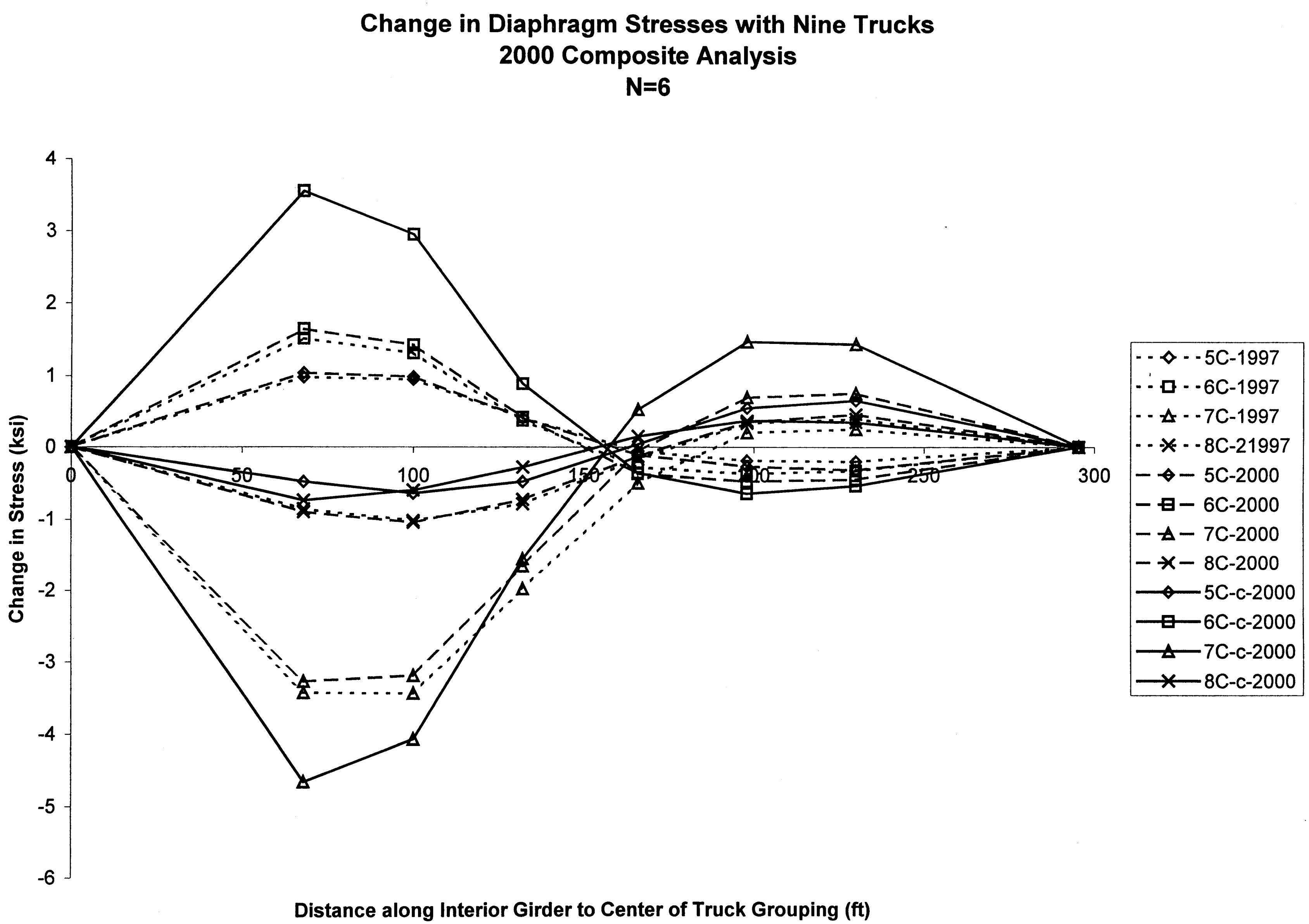


Figure F.109: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 5C-8C)

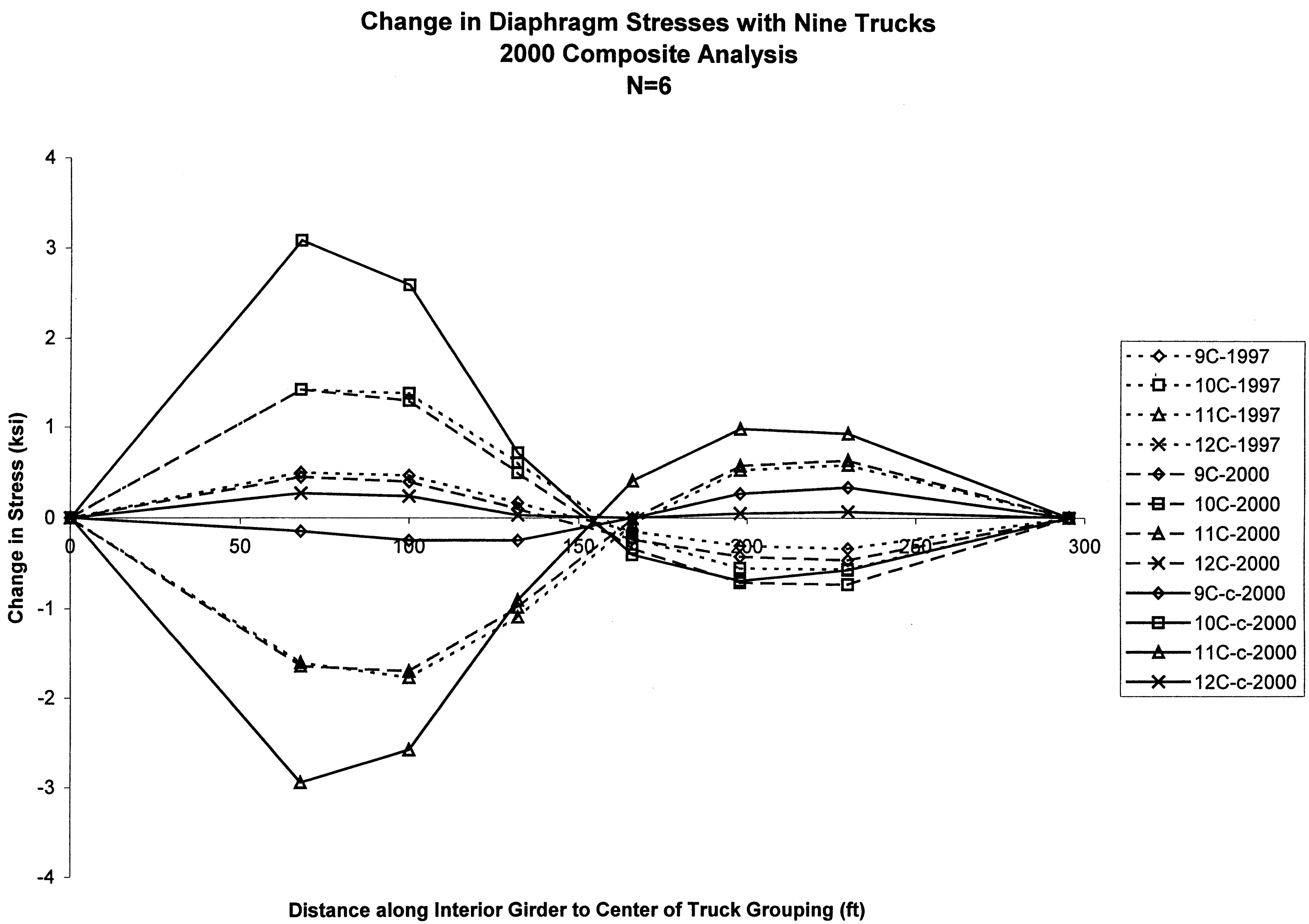


Figure F.110: Plot of Change in Stress with Nine Trucks 2000, Composite Analysis, N = 6 (Gages 9C-12C)

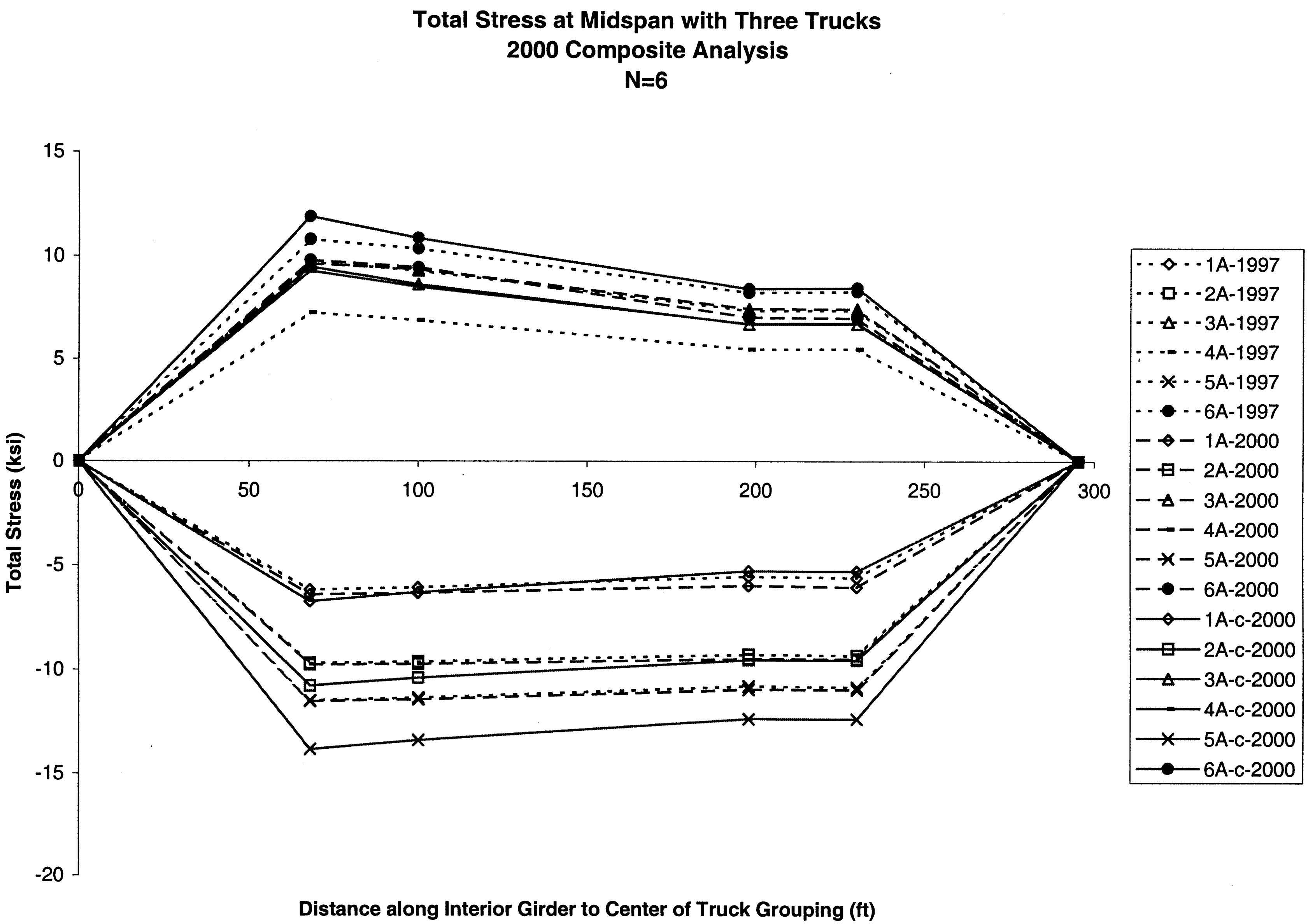


Figure F.111: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1A-6A)

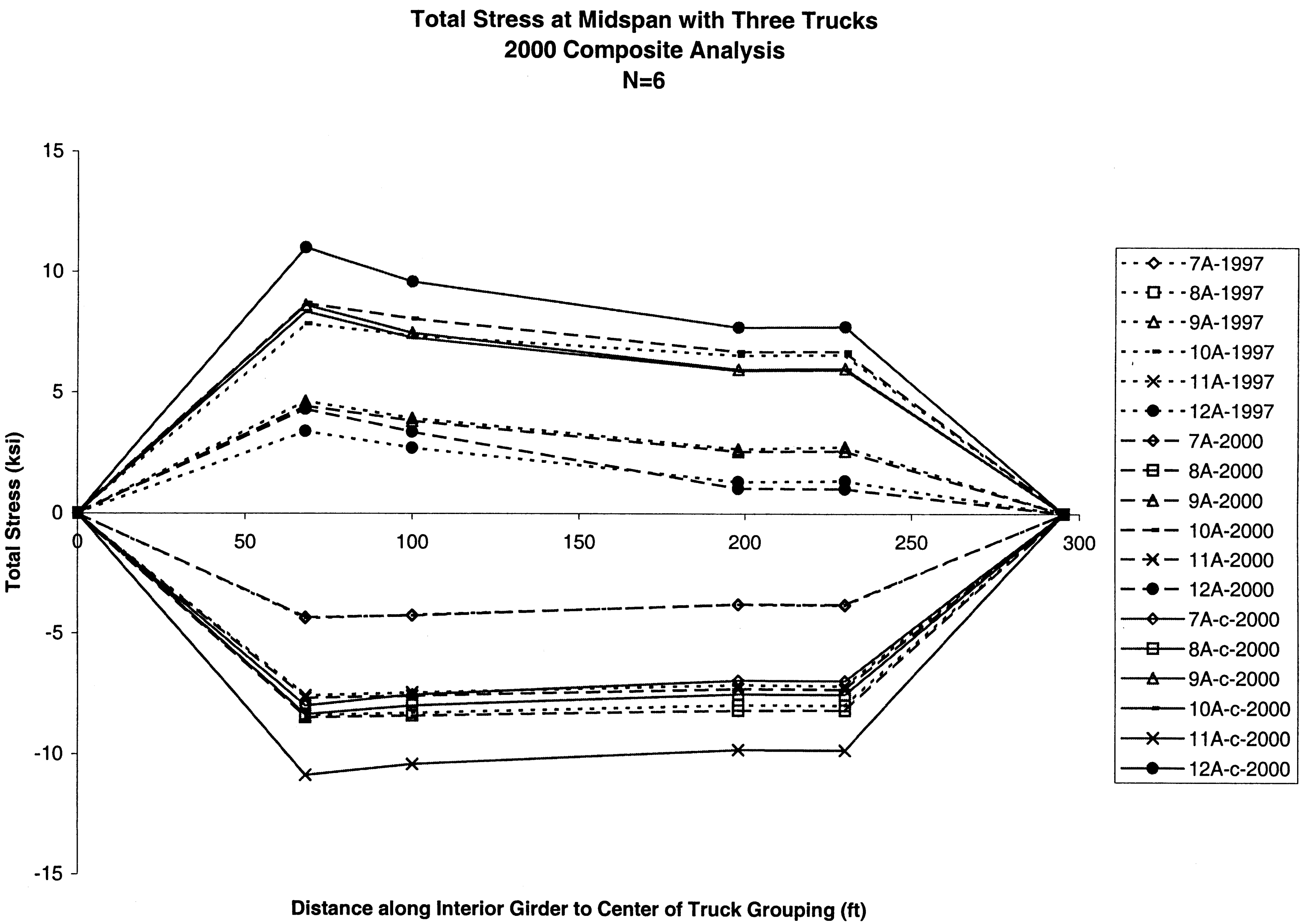


Figure F.112: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 7A-12A)

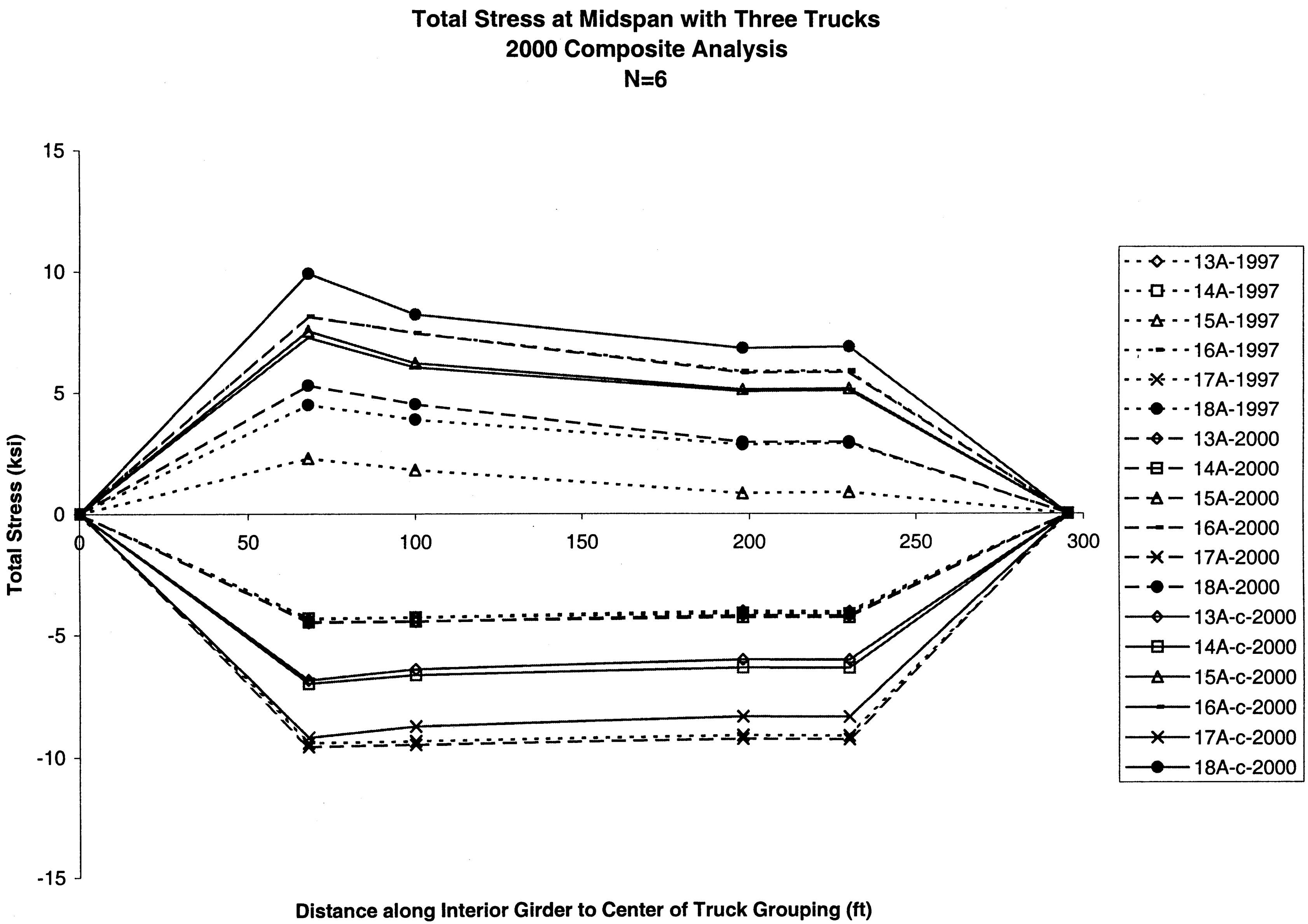


Figure F.113: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 13A-18A)

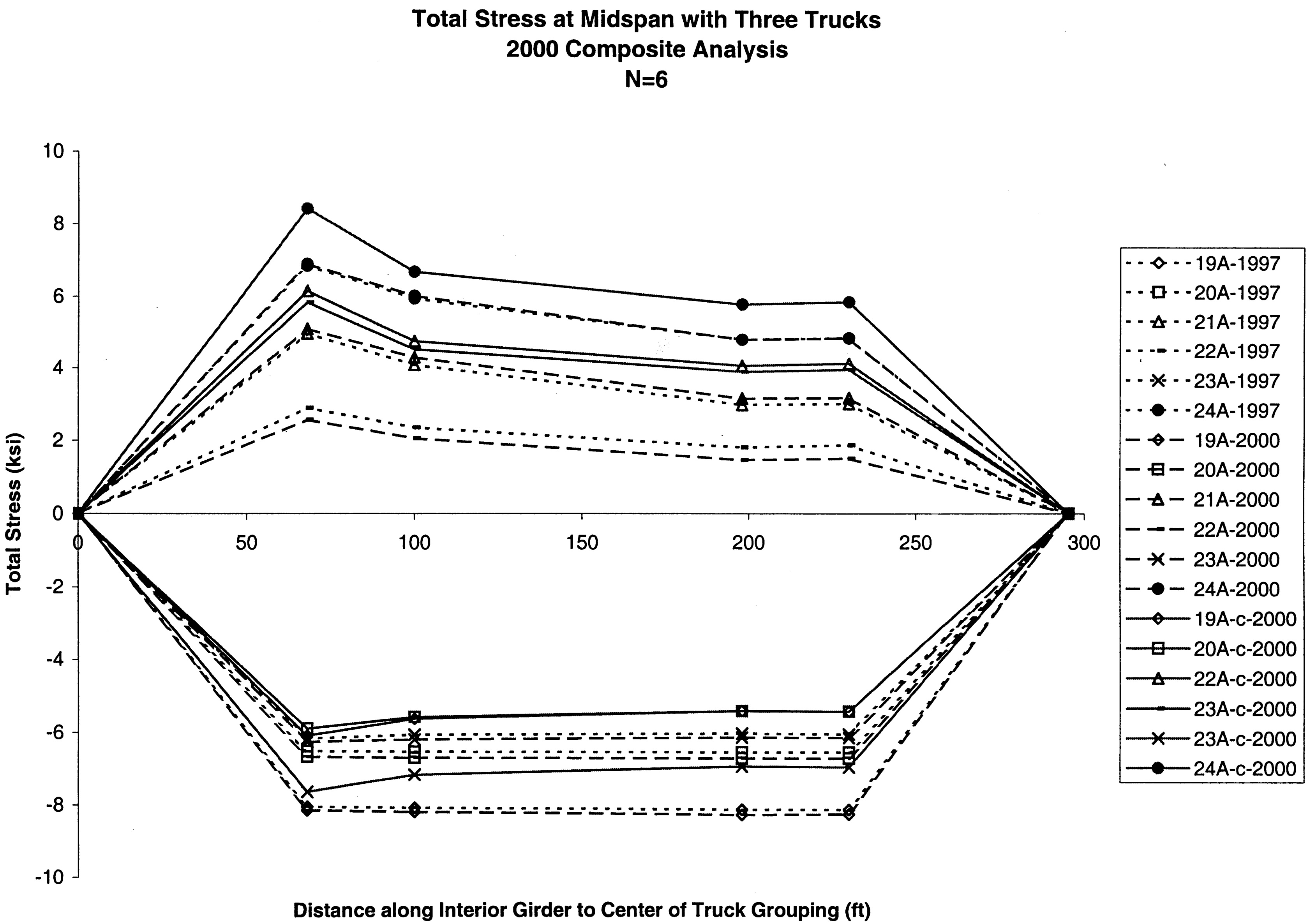


Figure F.114: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 19A-24A)

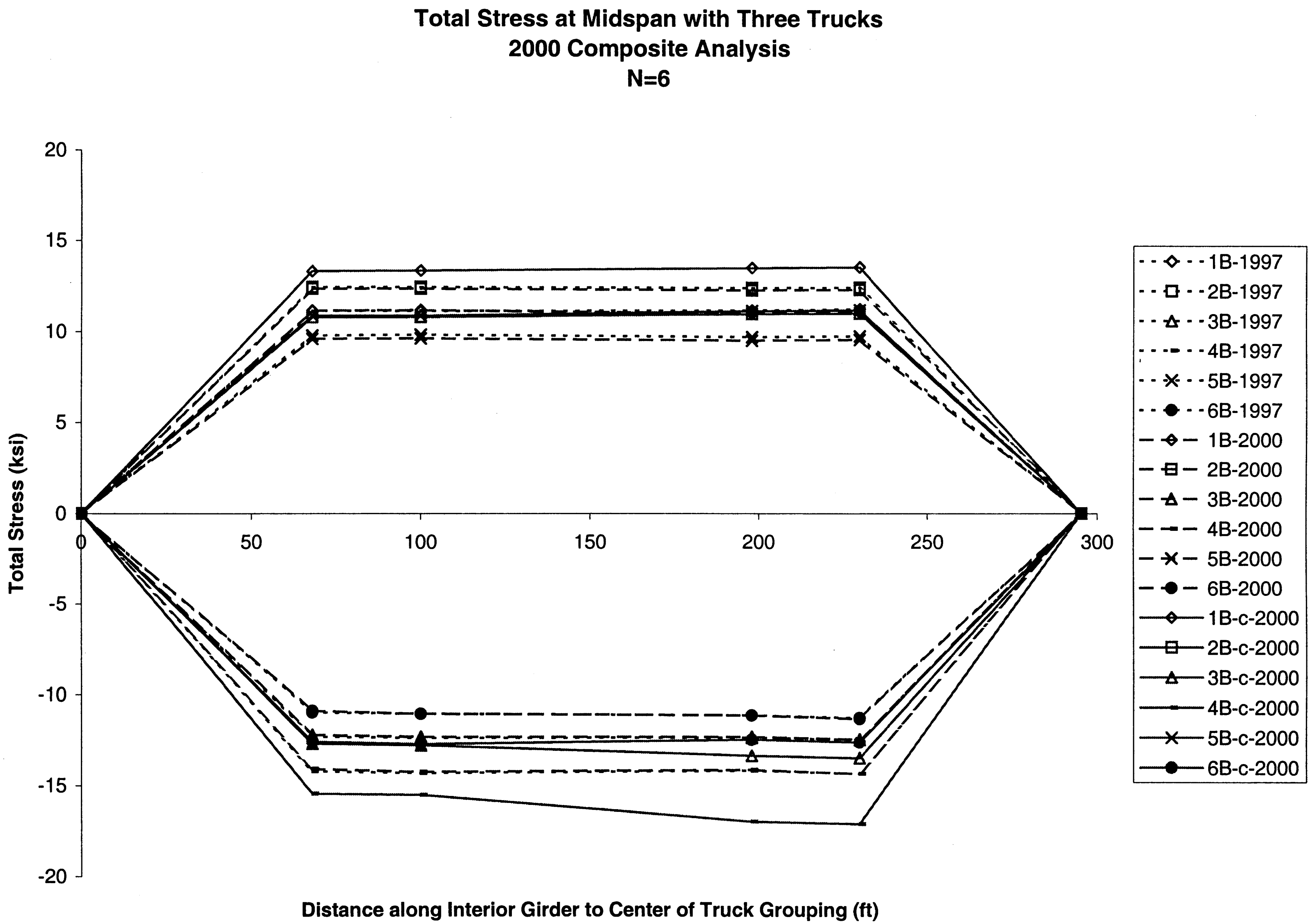


Figure F.115: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1B-6B)

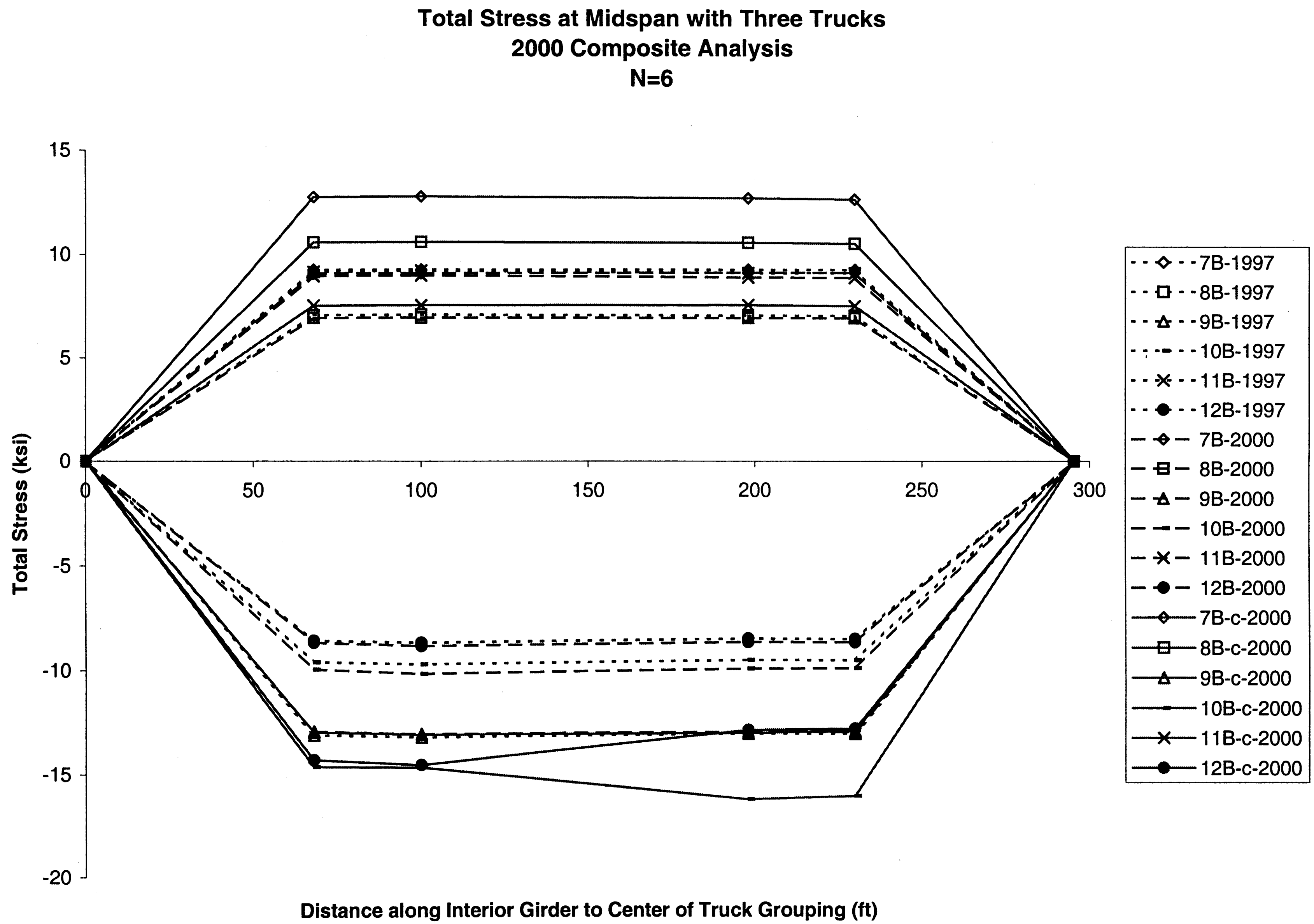


Figure F.116: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 7B-12B)

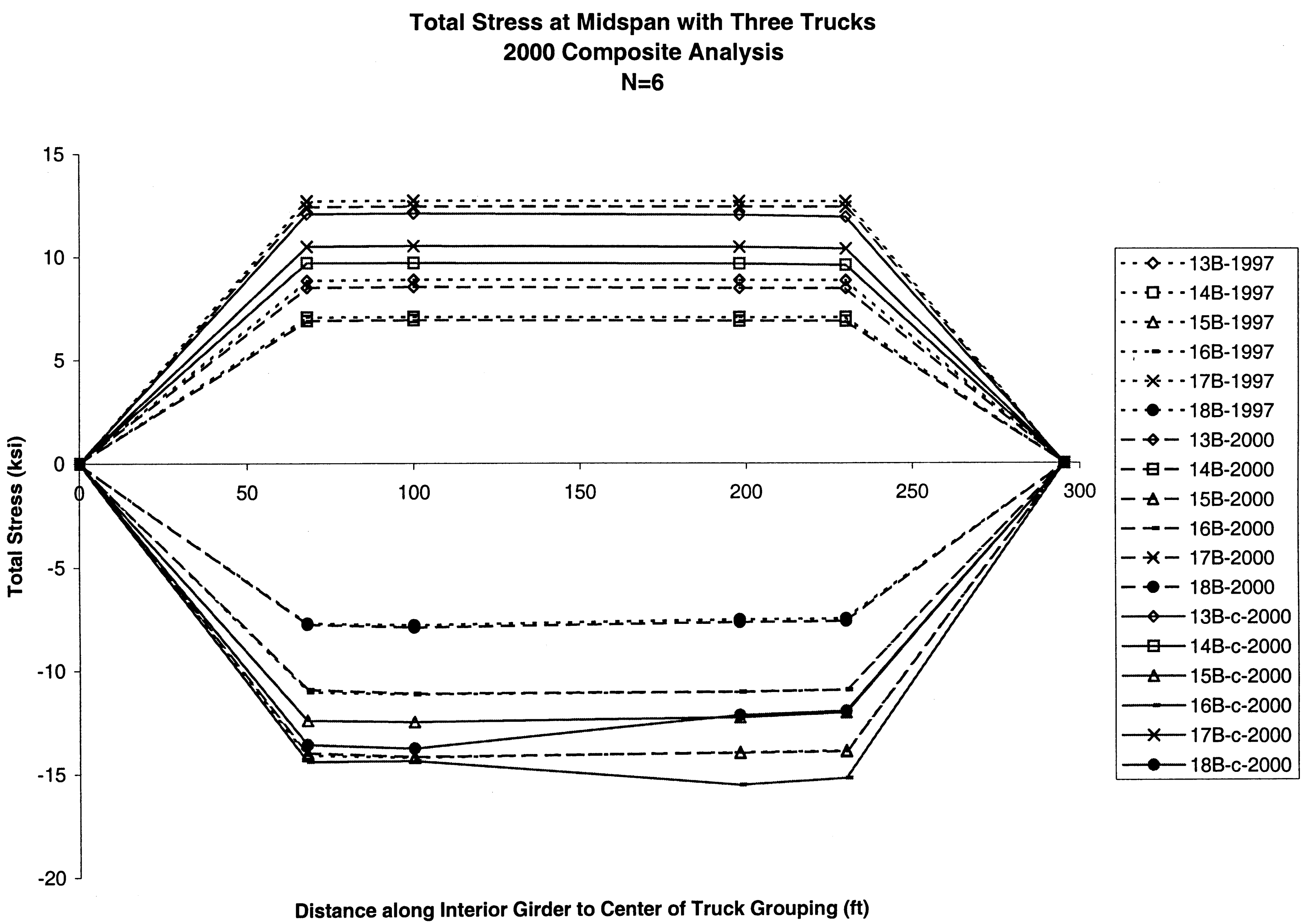


Figure F.117: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 13B-18B)

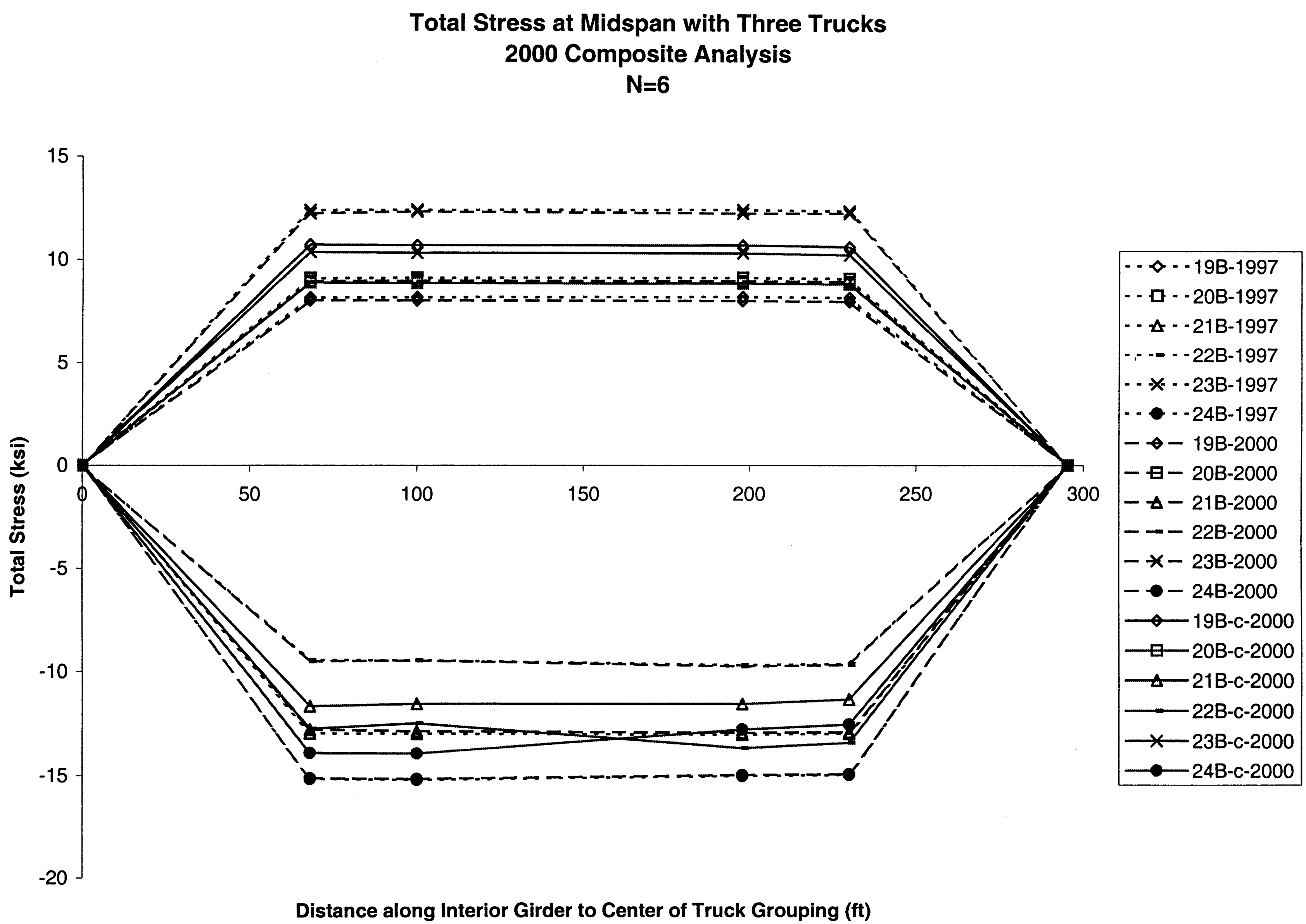


Figure F.118: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 19B-24B)

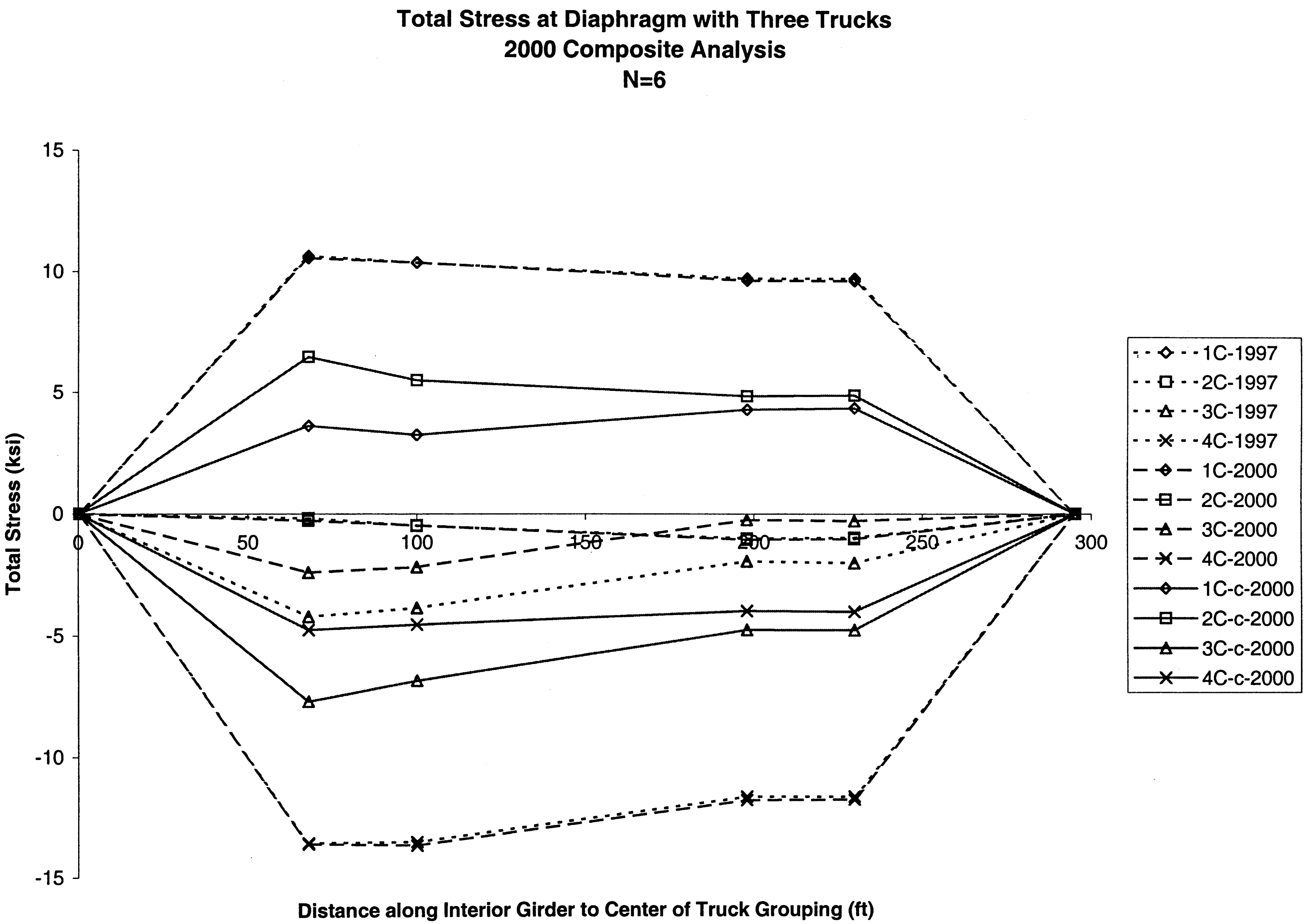


Figure F.119: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1C-4C)

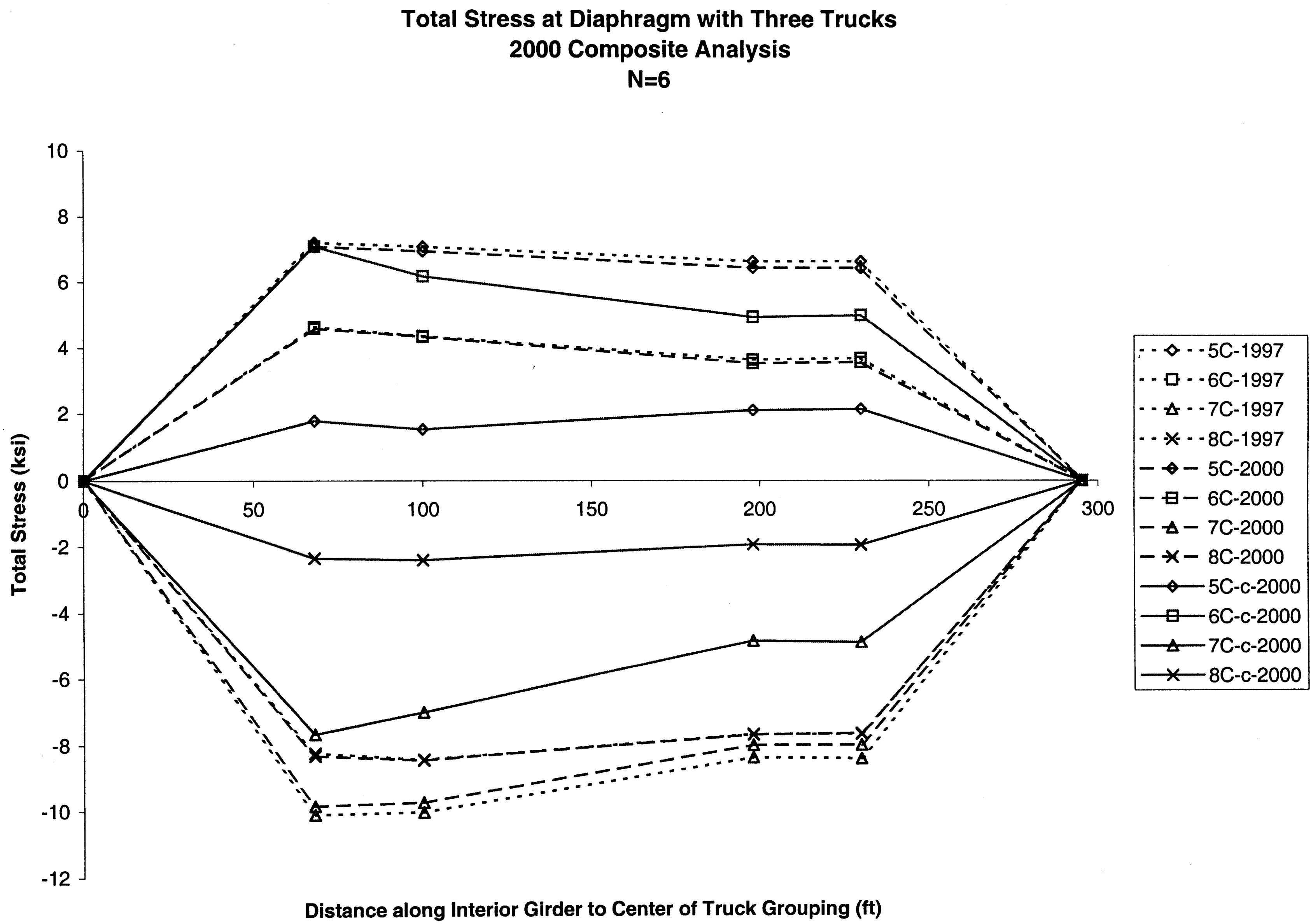


Figure F.120: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 5C-8C)

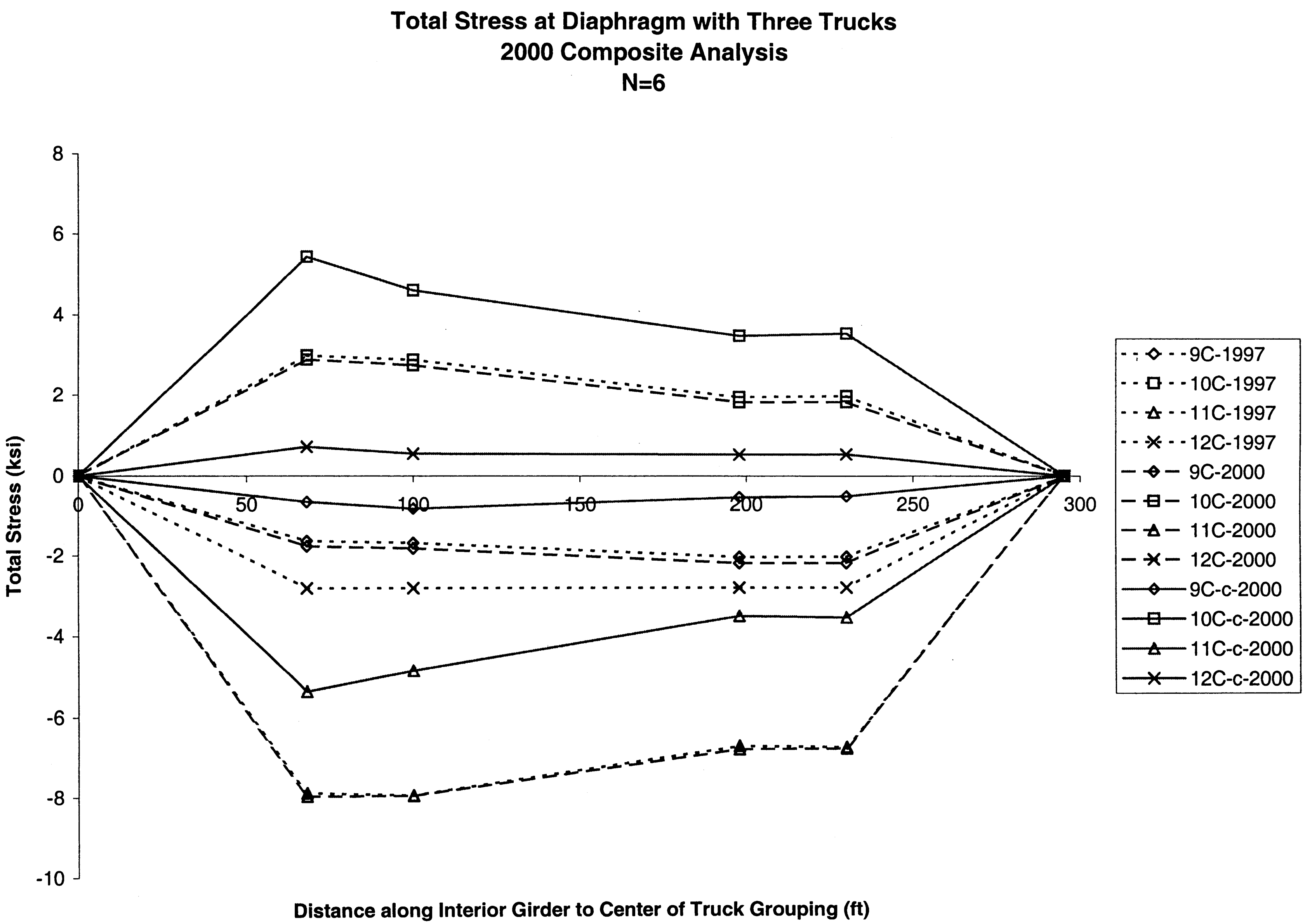


Figure F.121: Plot of Total Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 9C-12C)

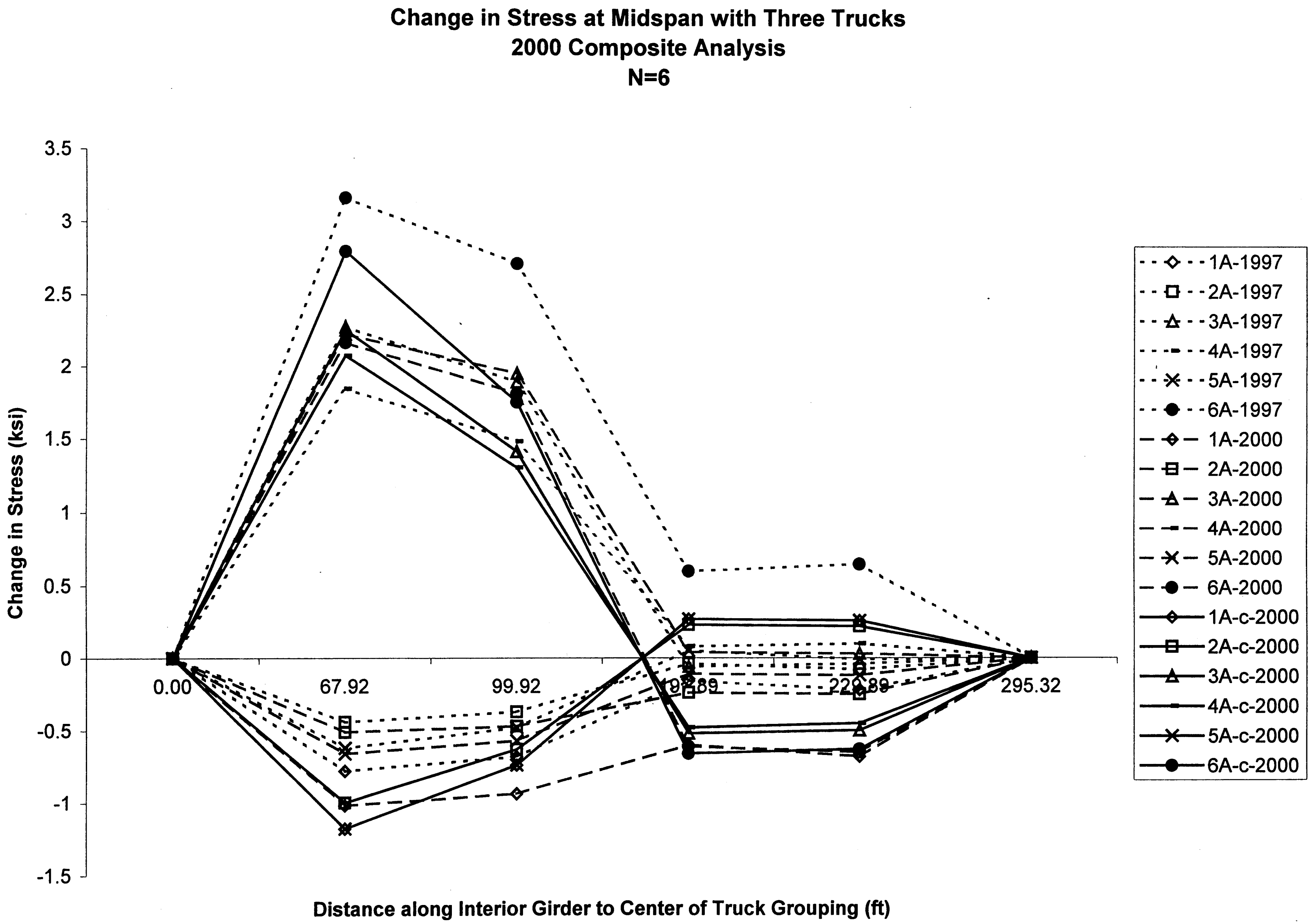


Figure F.122: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1A-6A)

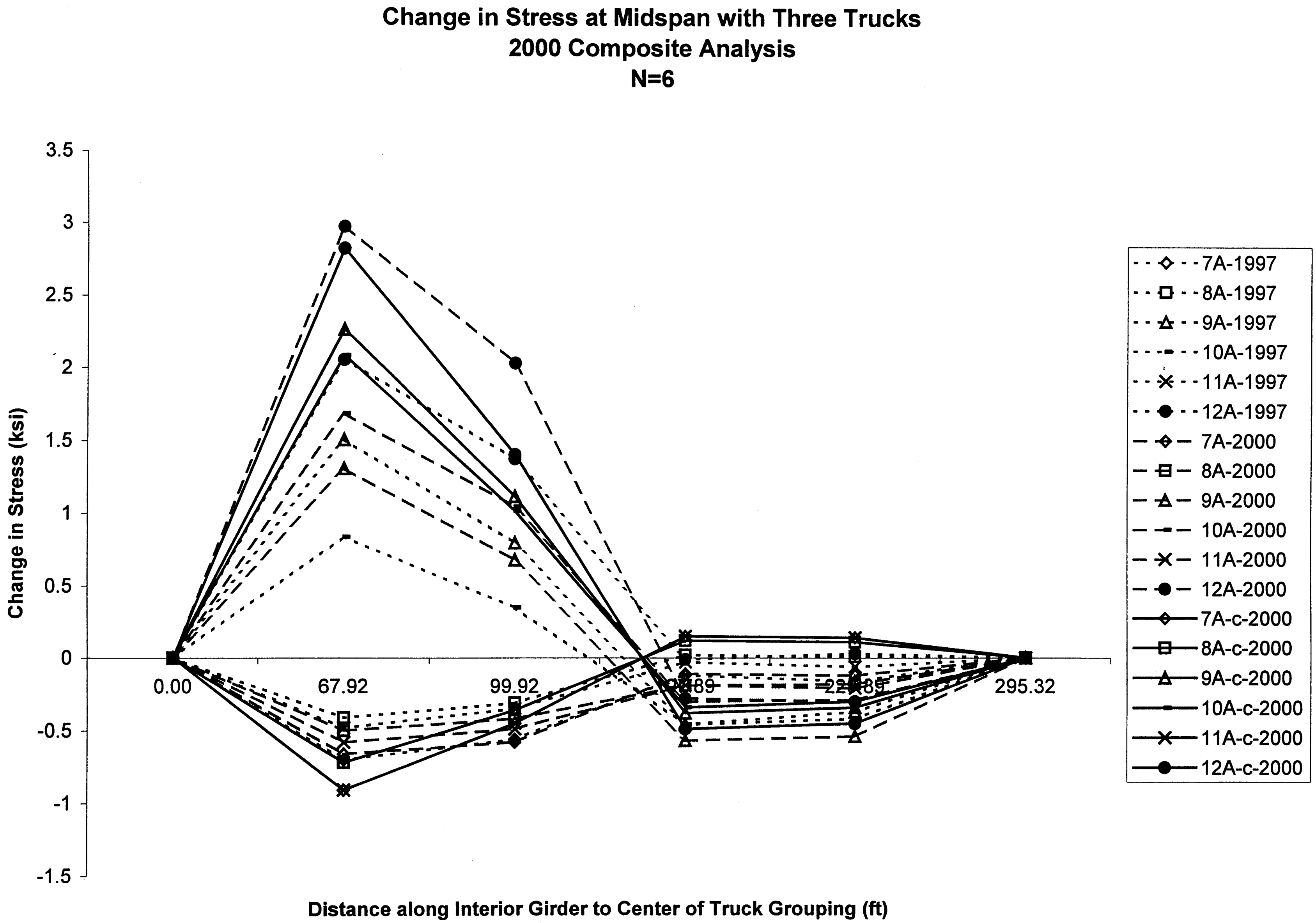


Figure F.123: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 7A-12A)

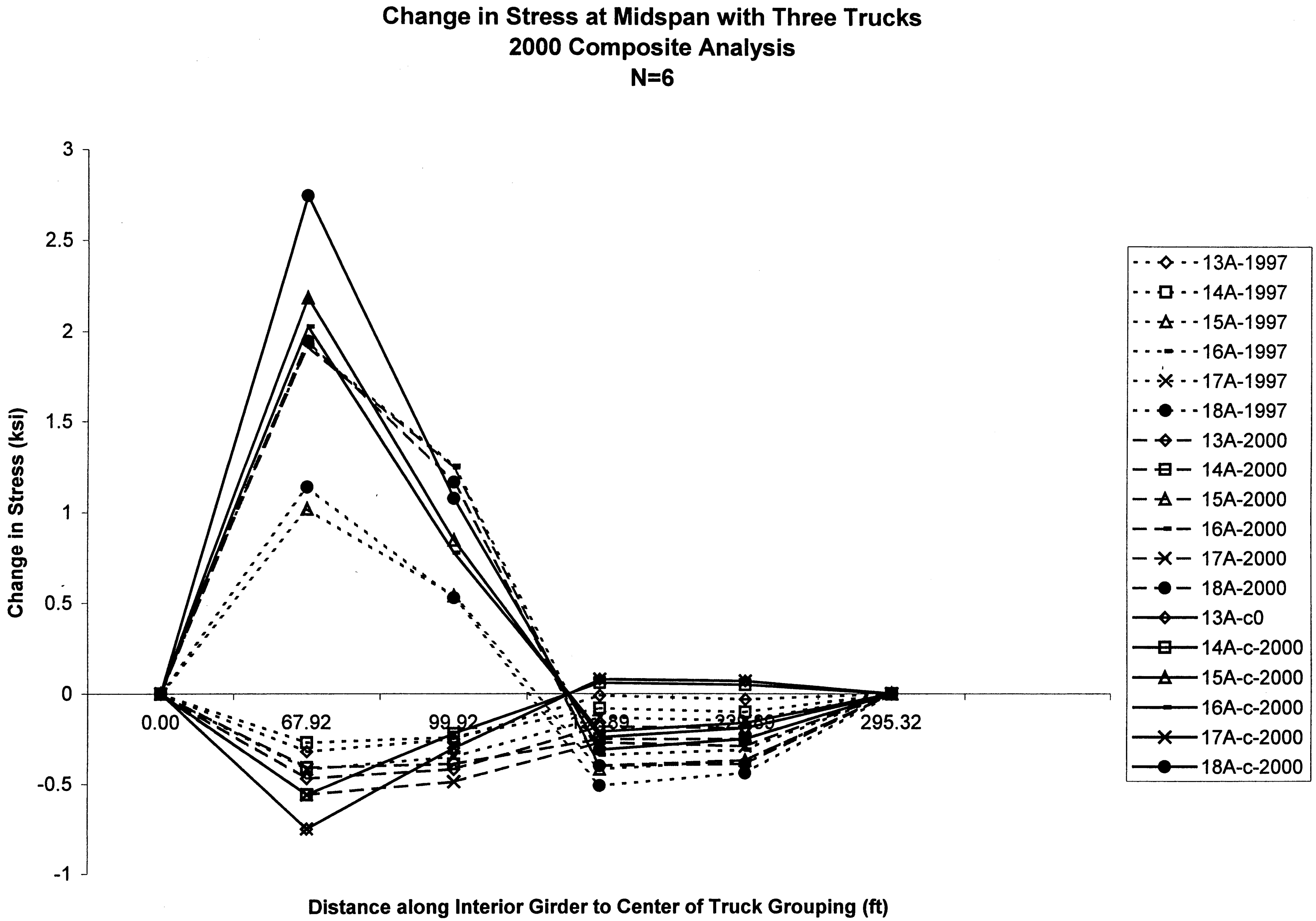


Figure F.124: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 13A-18A)

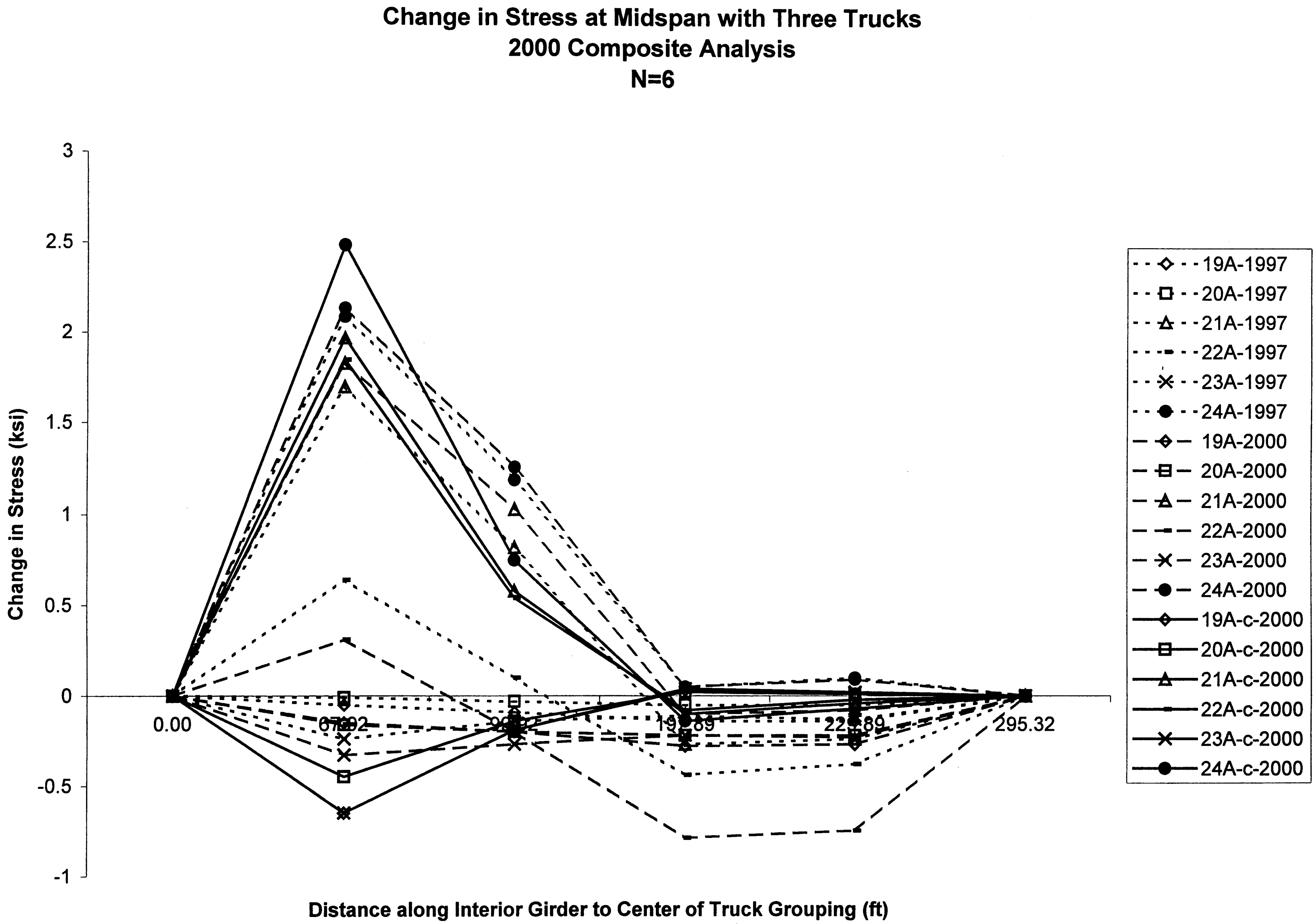


Figure F.125: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 19A-24A)

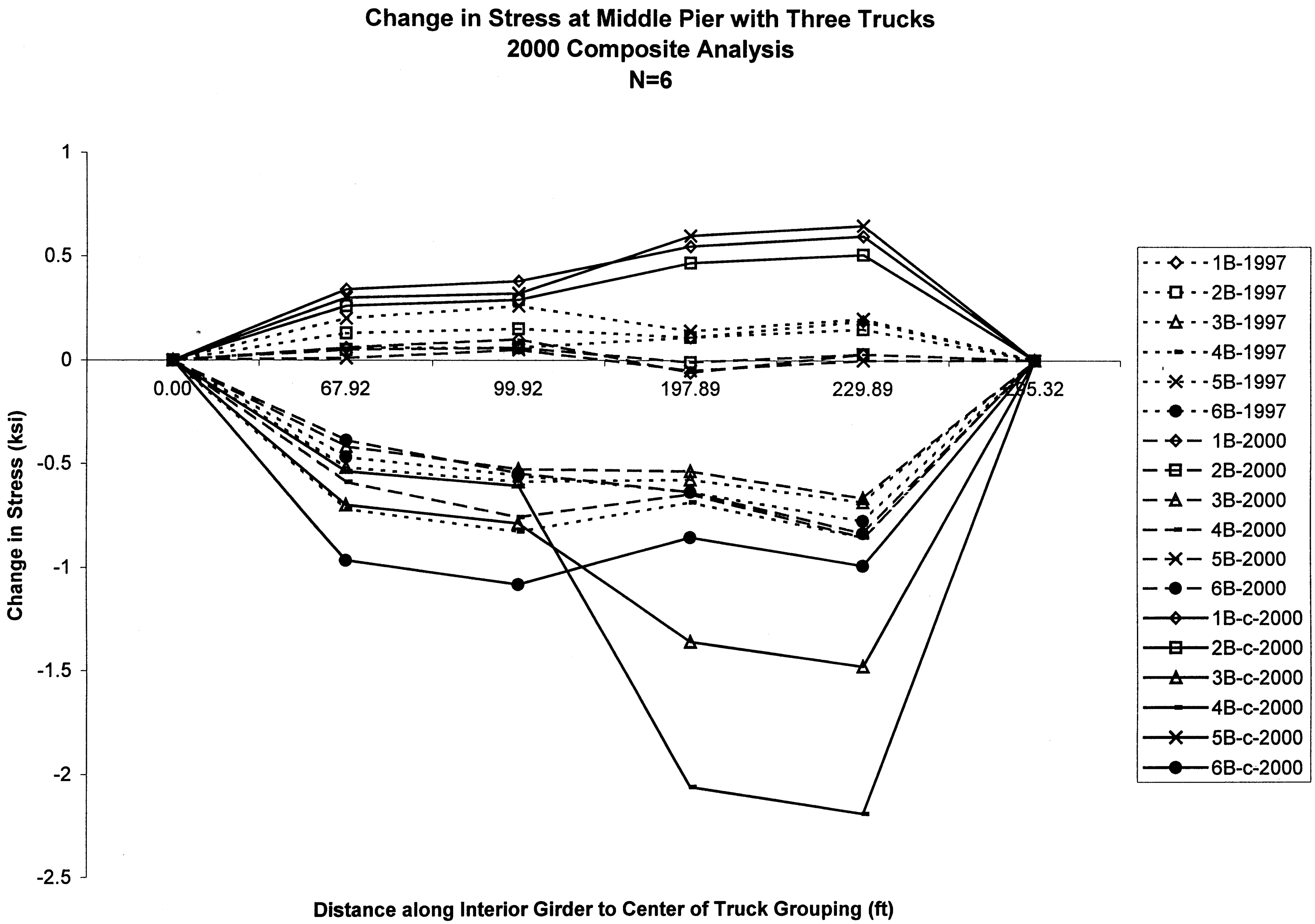


Figure F.126: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1B-6B)

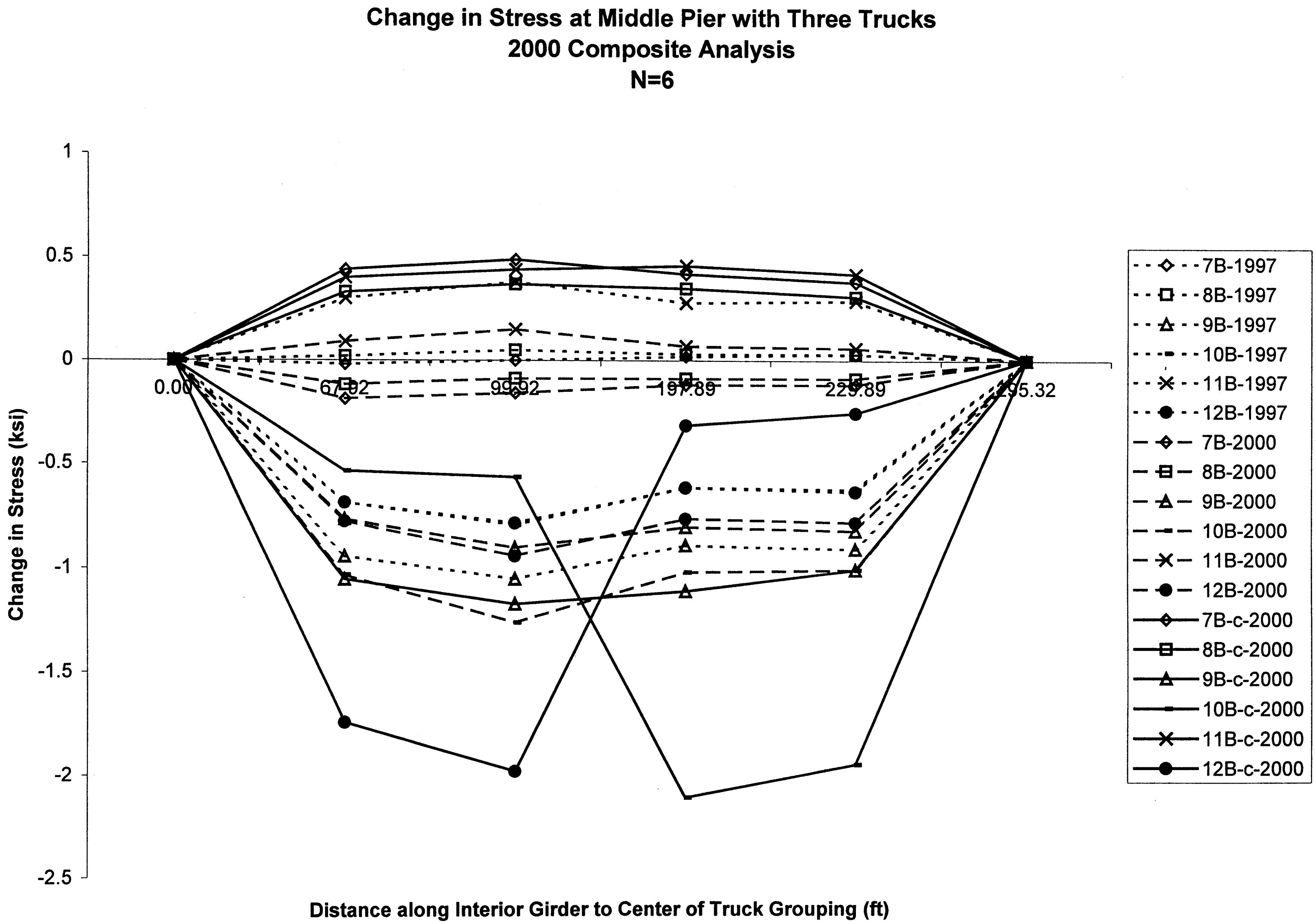


Figure F.127: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 7B-12B)

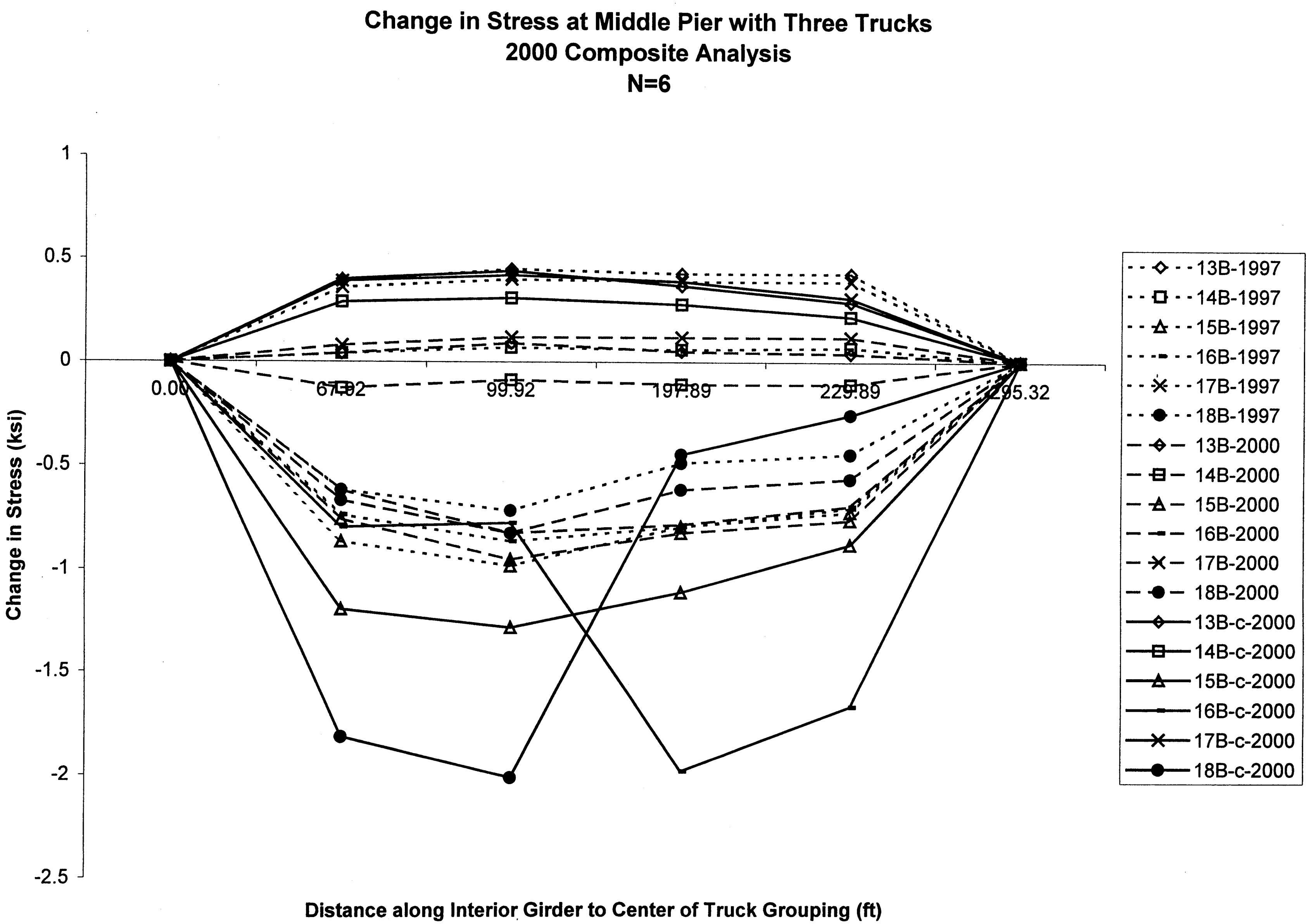


Figure F.128: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 13B-18B)

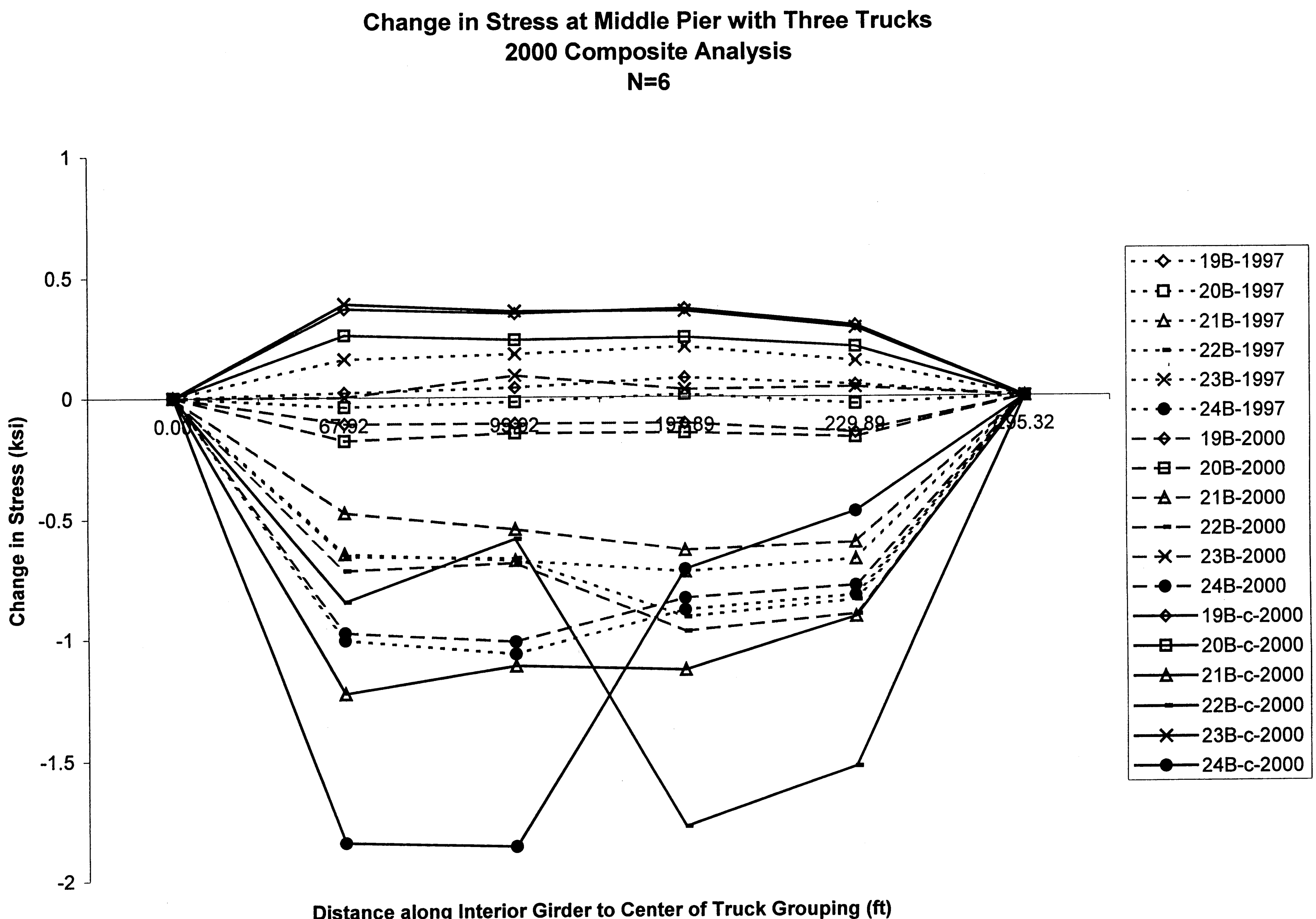


Figure F.129: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 19B-24B)

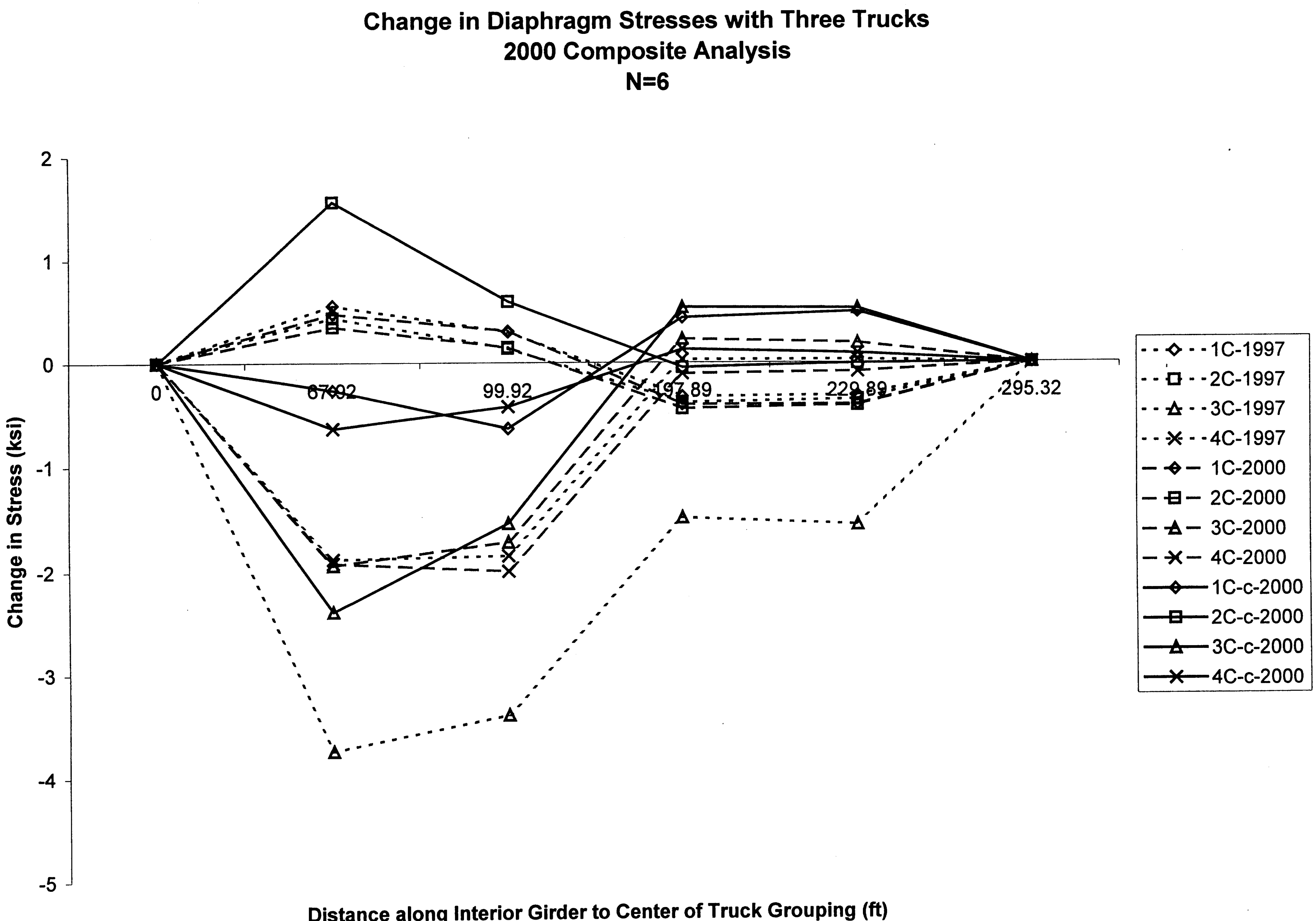


Figure F.130: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 1C-4C)

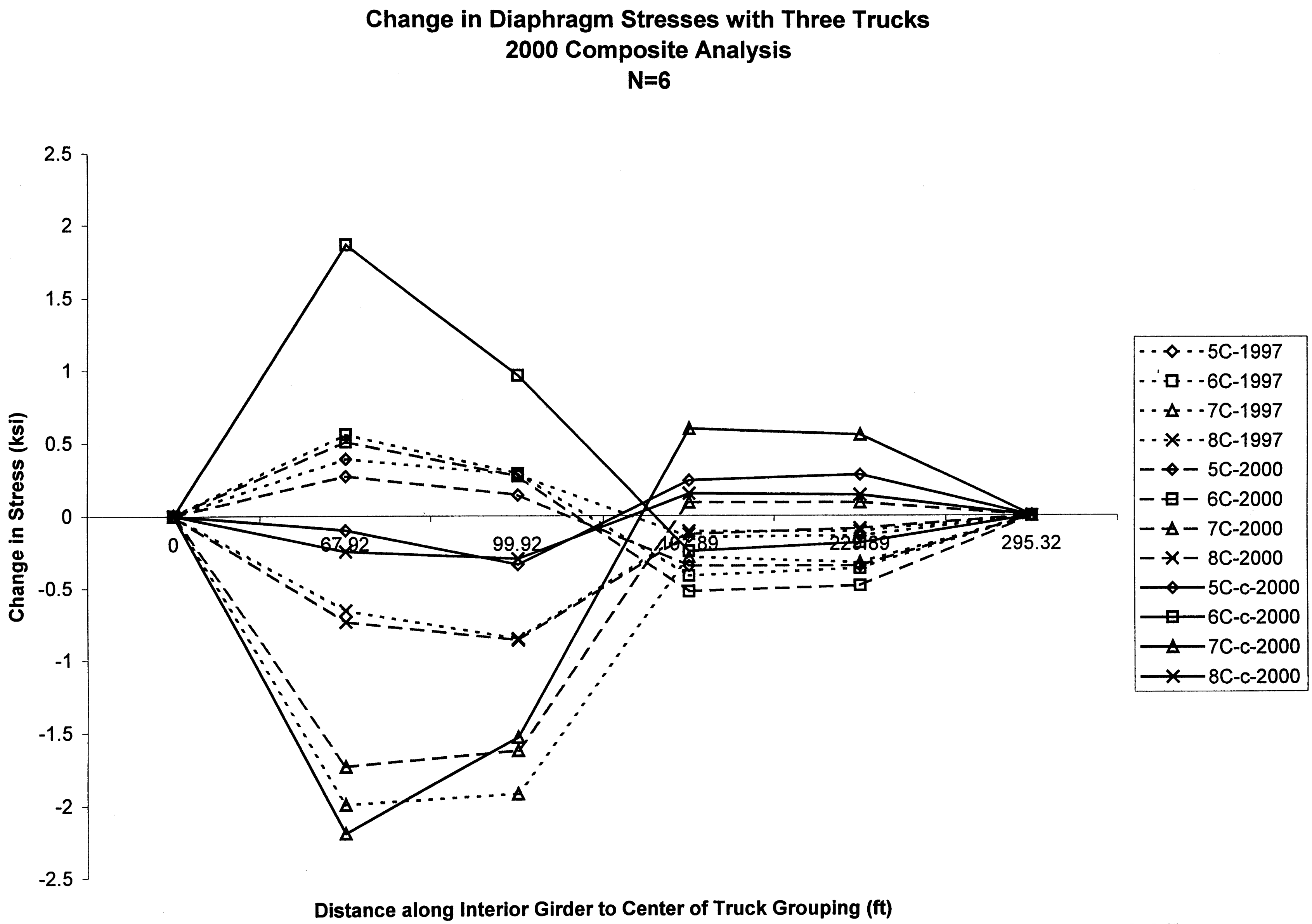


Figure F.131: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 5C-8C)

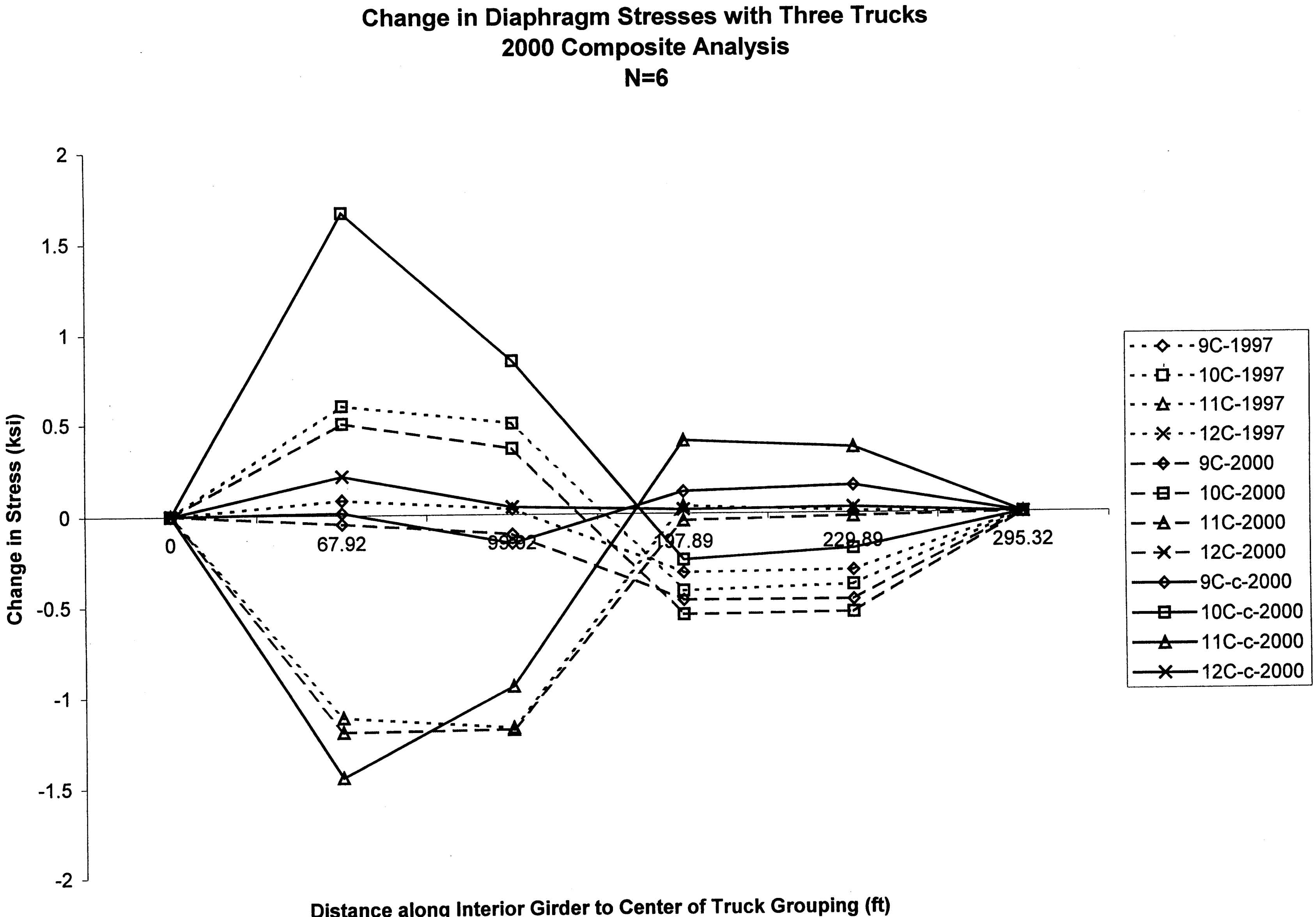


Figure F.132: Plot of Change in Stress with Three Trucks 2000, Composite Analysis, N = 6 (Gages 9C-12C)

APPENDIX G

PLOTS OF LINNEARITY OF STRESS FOR LOADS CENTERED ON CROSSFRAMES 5 AND 7, $N = 6$

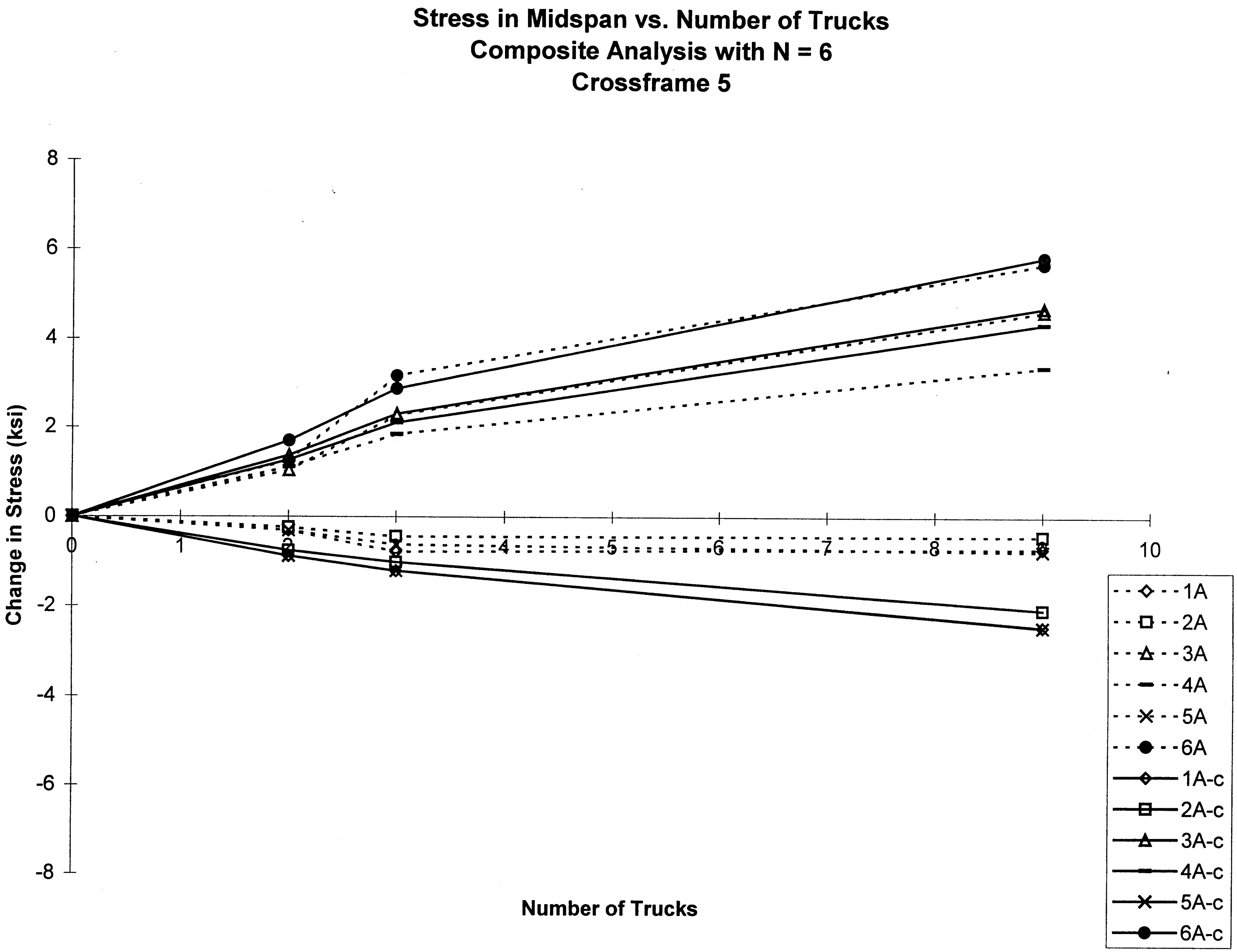


Figure G1: Stress Comparison in Gages 1A-6A for Composite Analysis (August 7, 1997)

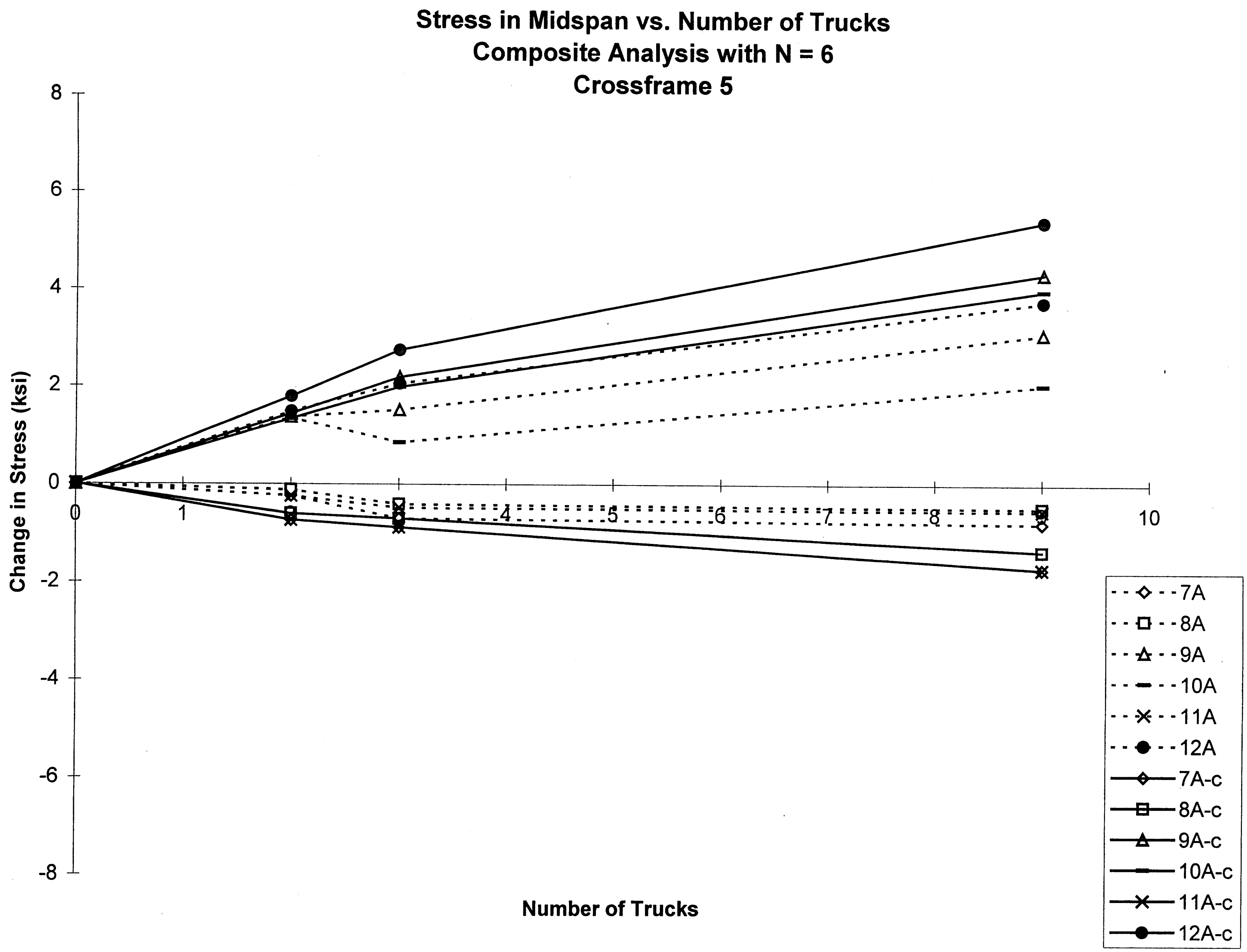


Figure G2: Stress Comparison in Gages 7A-12A for Composite Analysis (August 7, 1997)

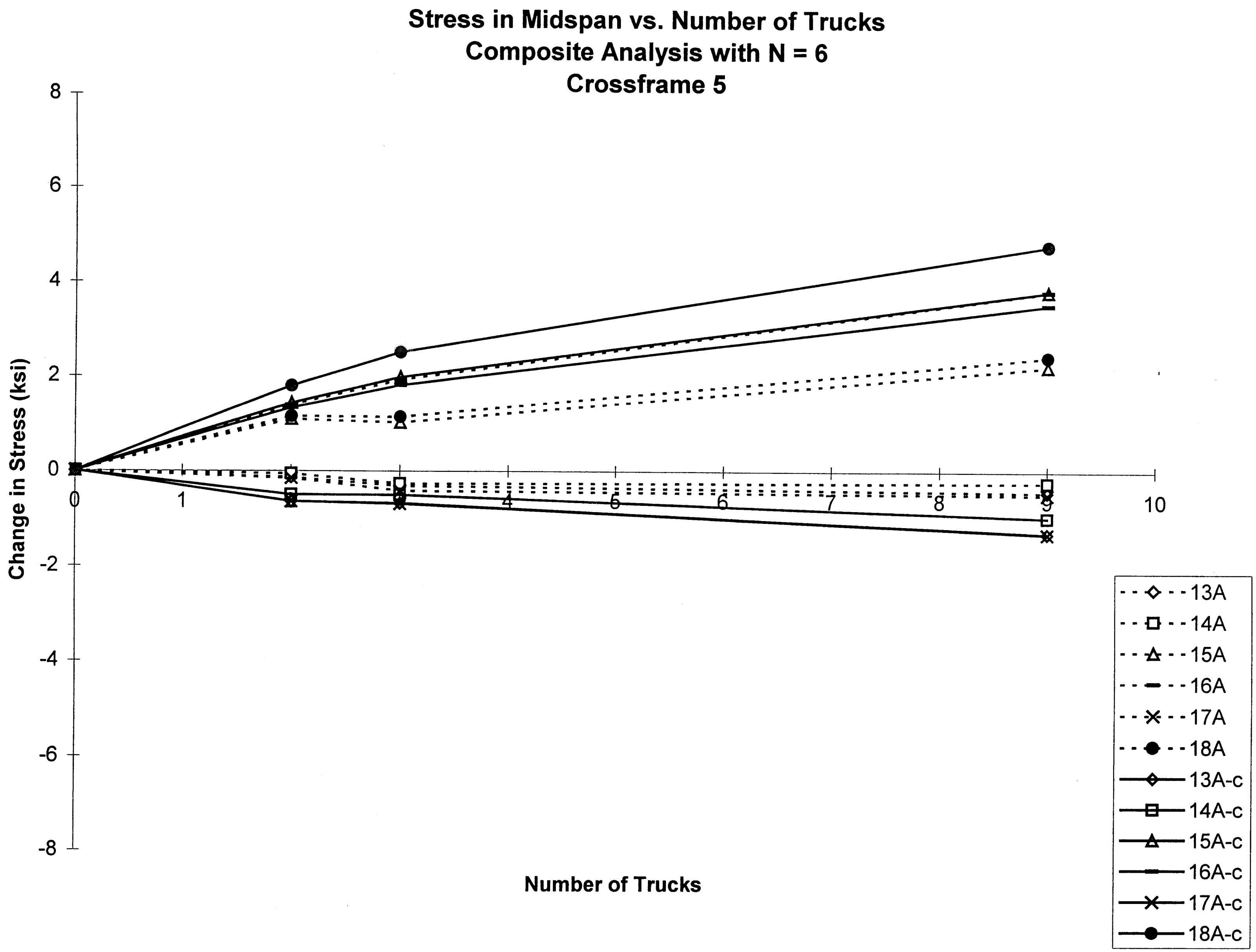


Figure G3: Stress Comparison in Gages 13A-18A for Composite Analysis (August 7, 1997)

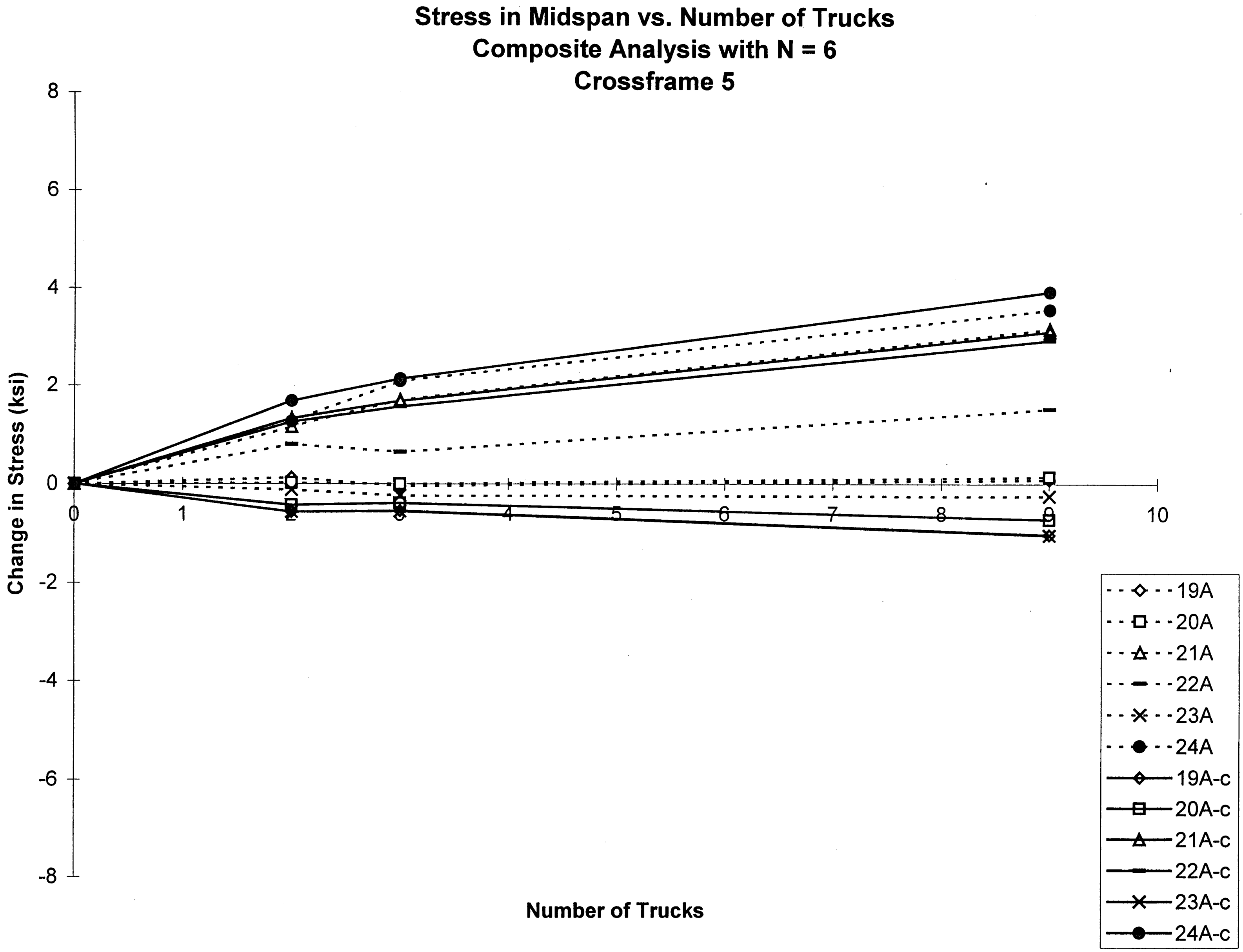


Figure G4: Stress Comparison in Gages 19A-24A for Composite Analysis (August 7, 1997)

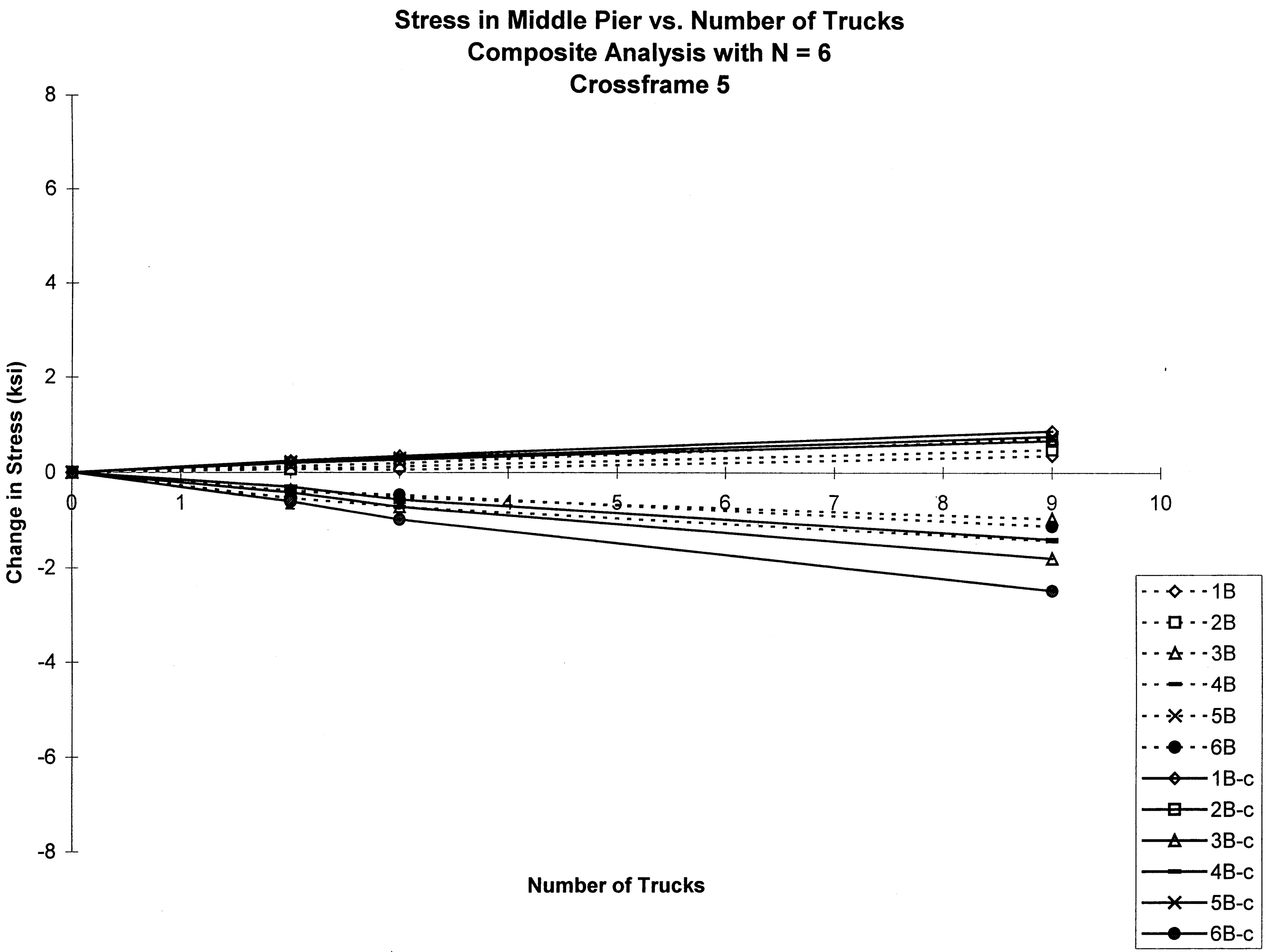


Figure G5: Stress Comparison in Gages 1B-6B for Composite Analysis (August 7, 1997)

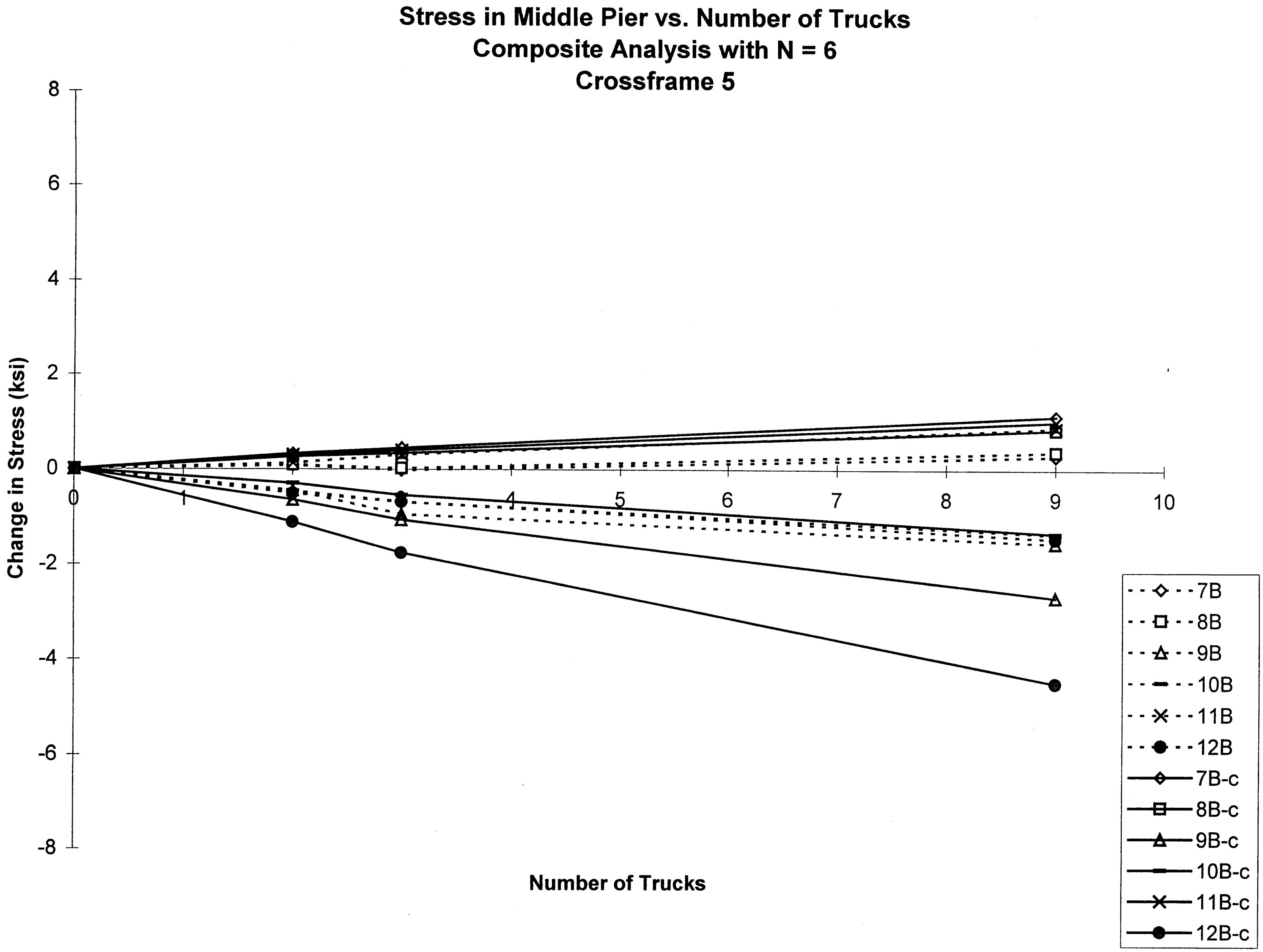


Figure G6: Stress Comparison in Gages 7B-12B for Composite Analysis (August 7, 1997)

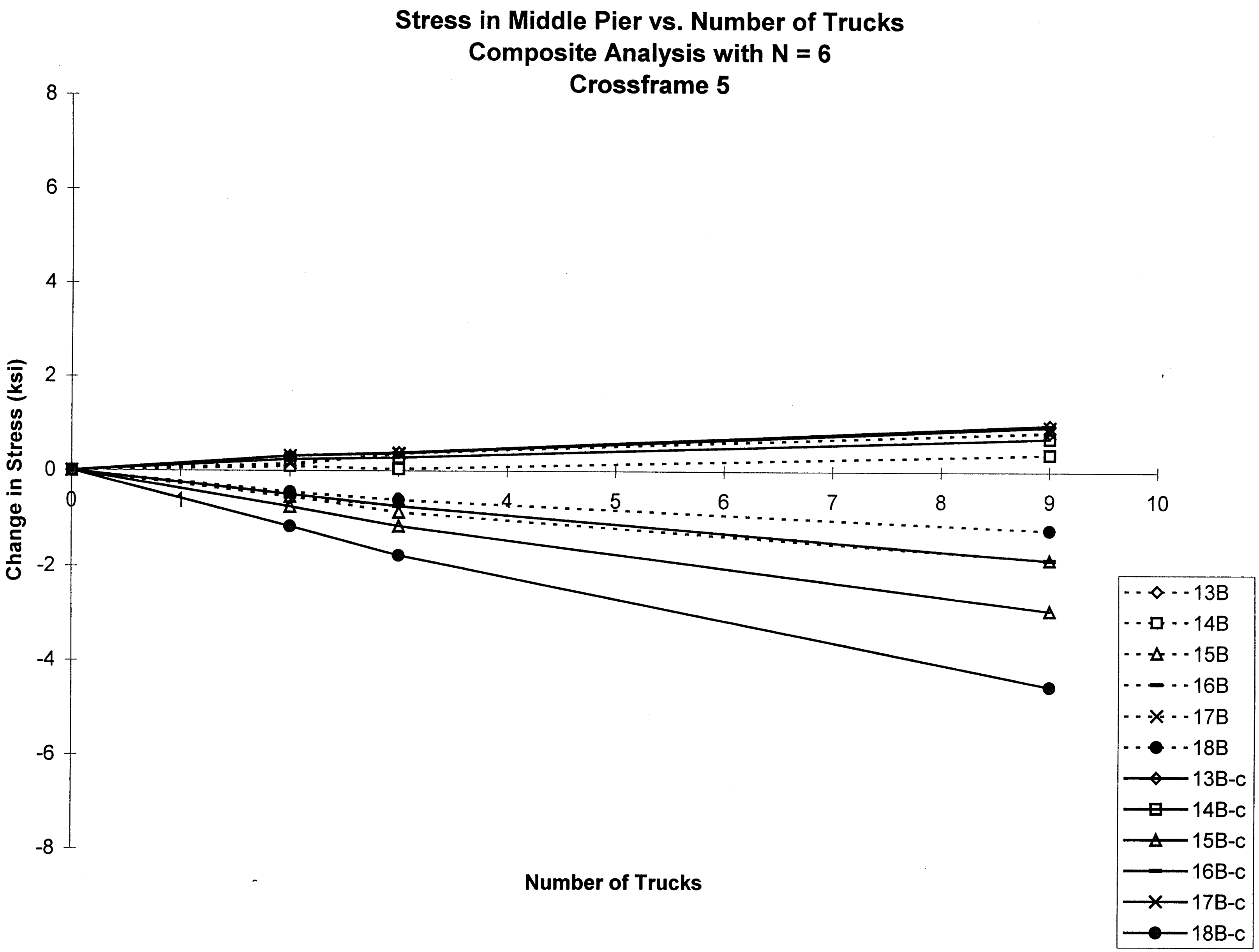


Figure G7: Stress Comparison in Gages 13B-18B for Composite Analysis (August 7, 1997)

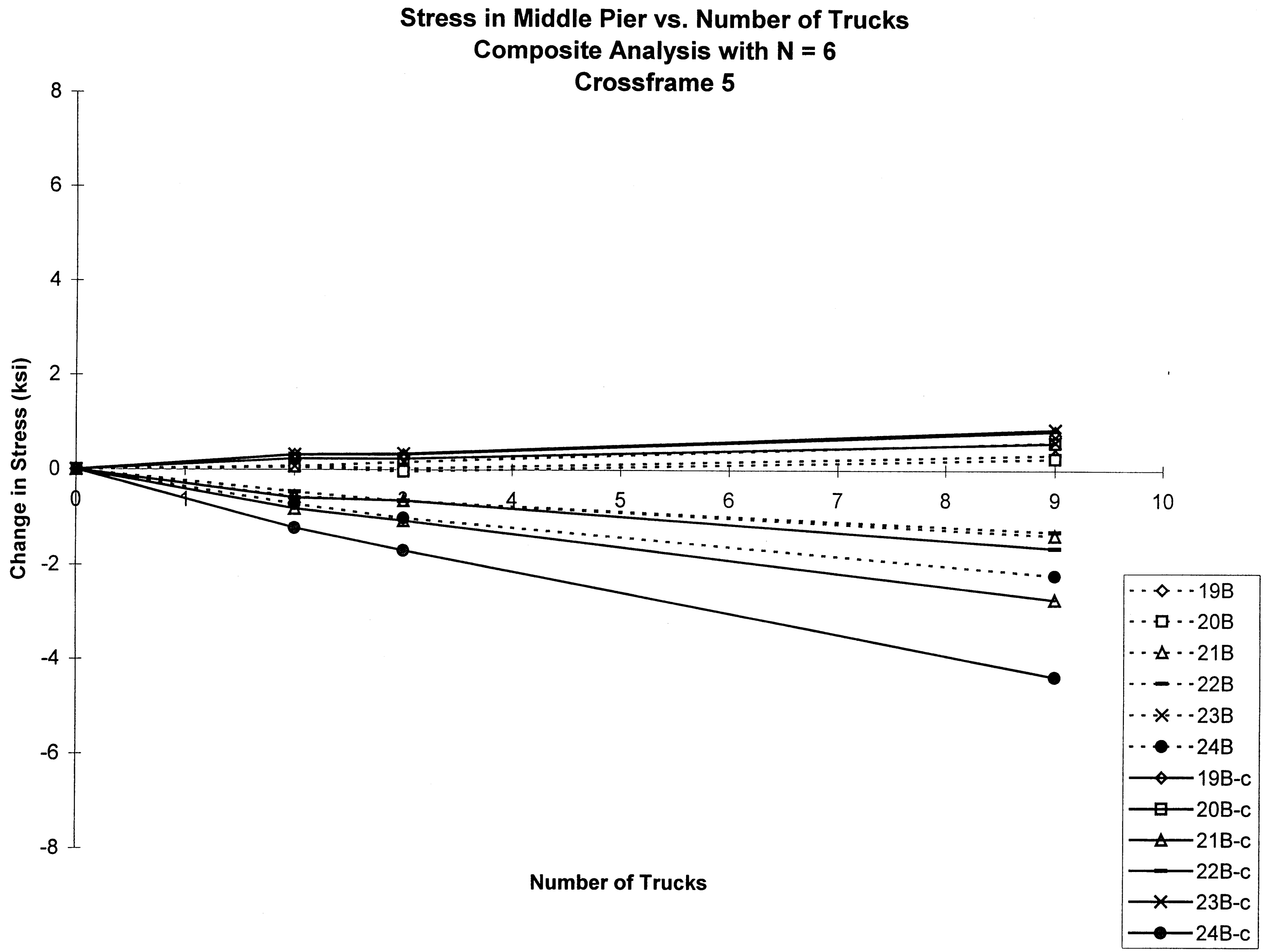


Figure G8: Stress Comparison in Gages 19B-24B for Composite Analysis (August 7, 1997)

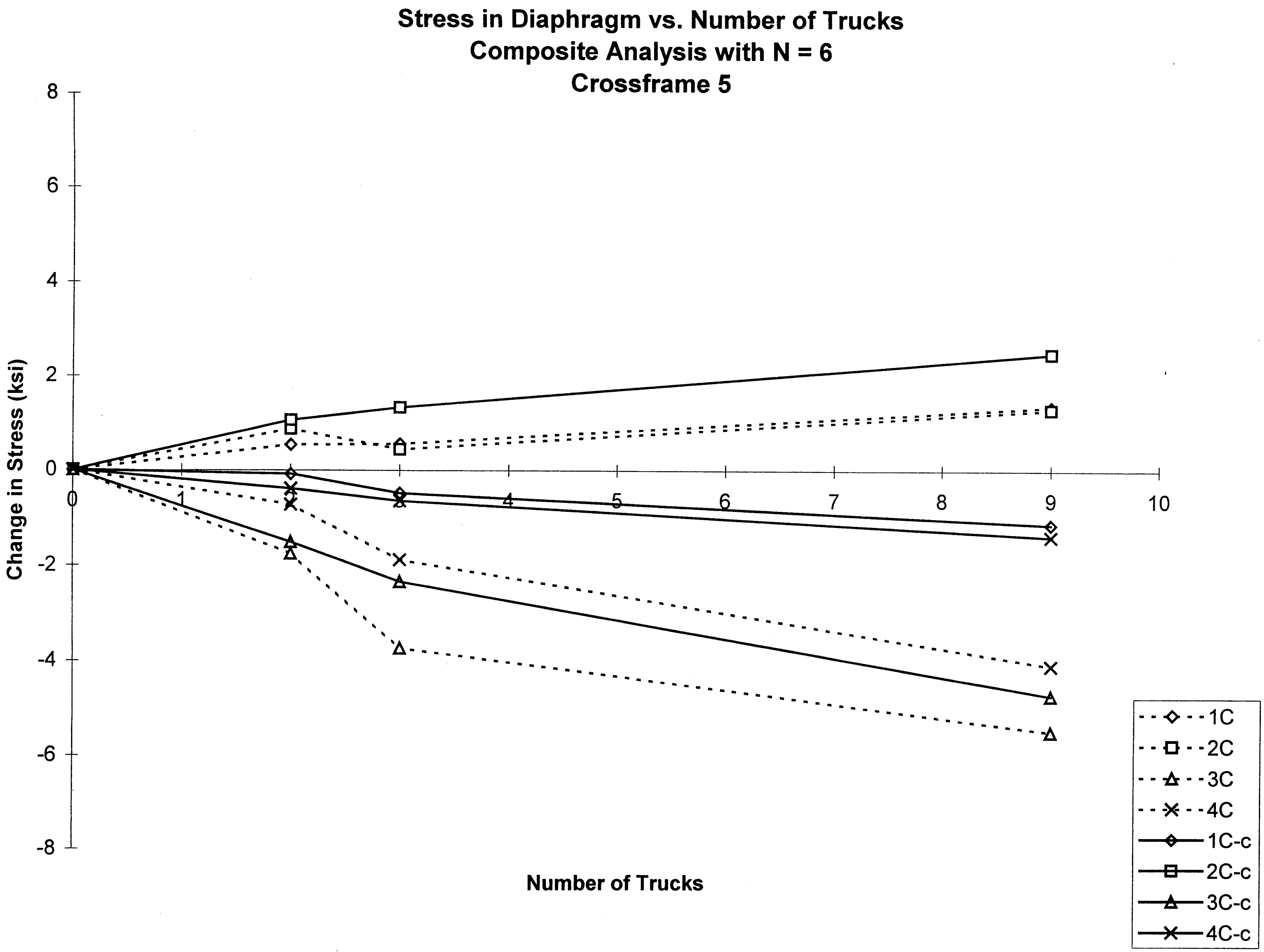


Figure G9: Stress Comparison in Gages 1C-4C for Composite Analysis (August 7, 1997)

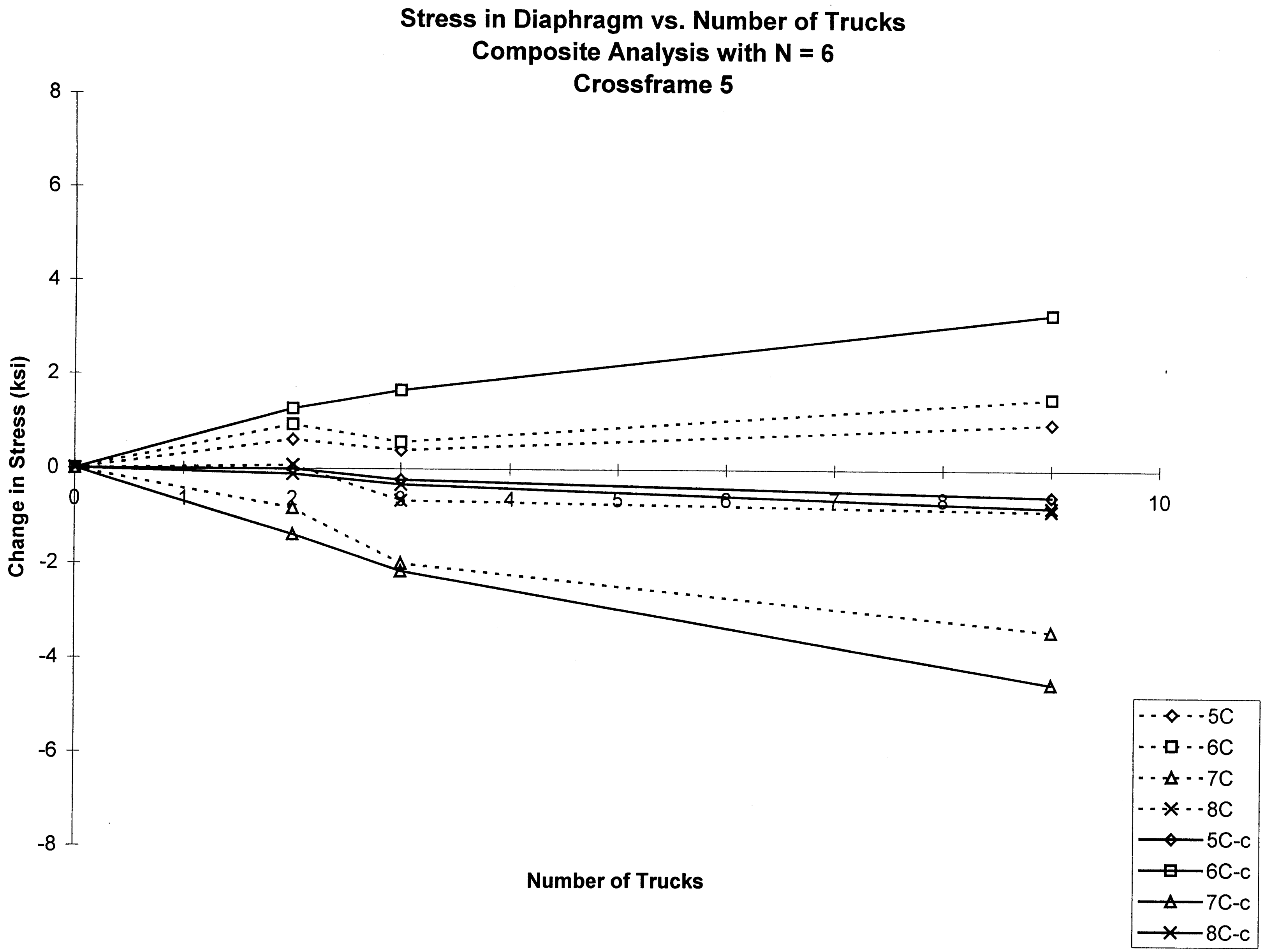


Figure G10: Stress Comparison in Gages 5C-8C for Composite Analysis (August 7, 1997)

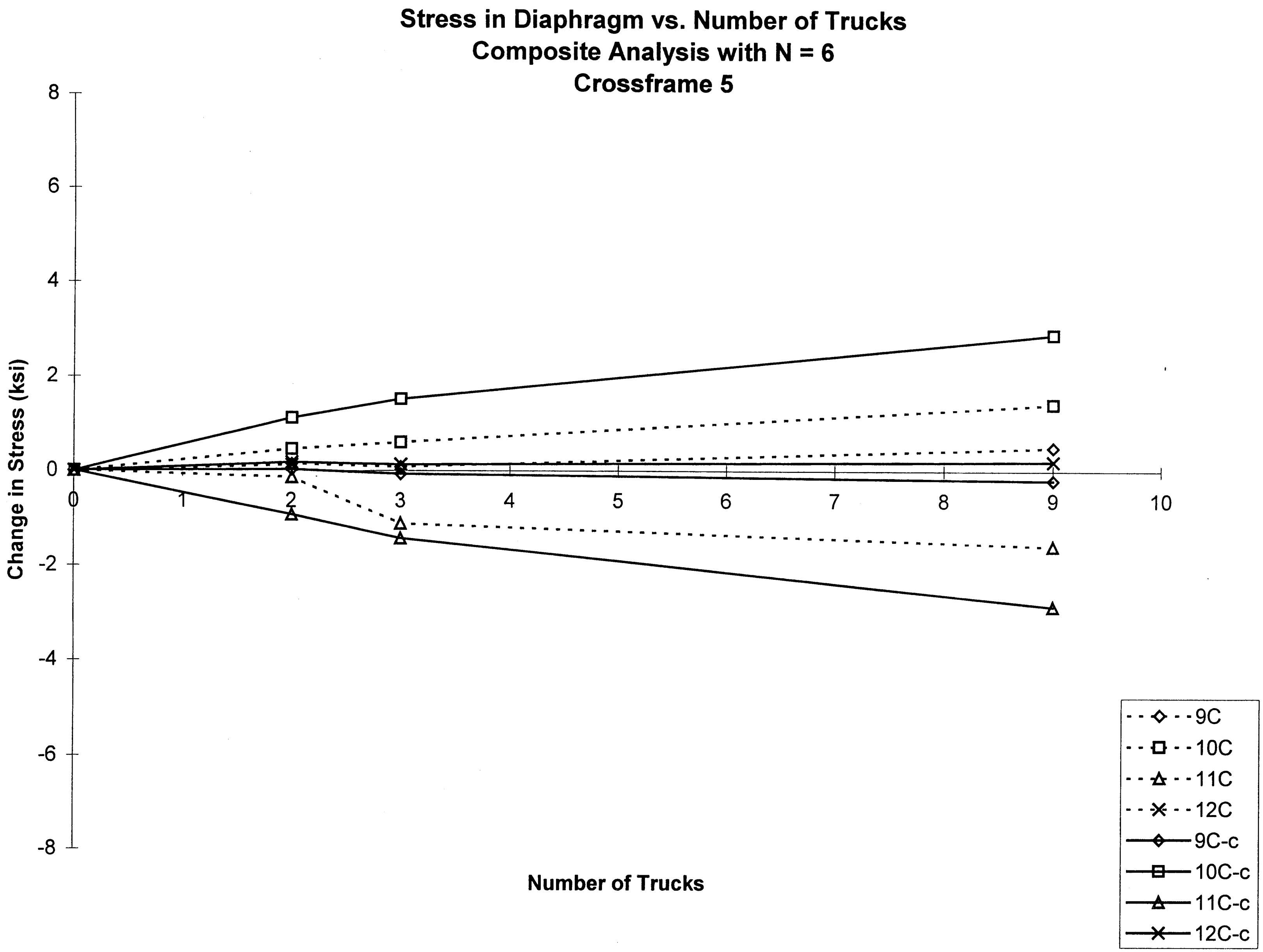


Figure G11: Stress Comparison in Gages 9C-12C for Composite Analysis (August 7, 1997)

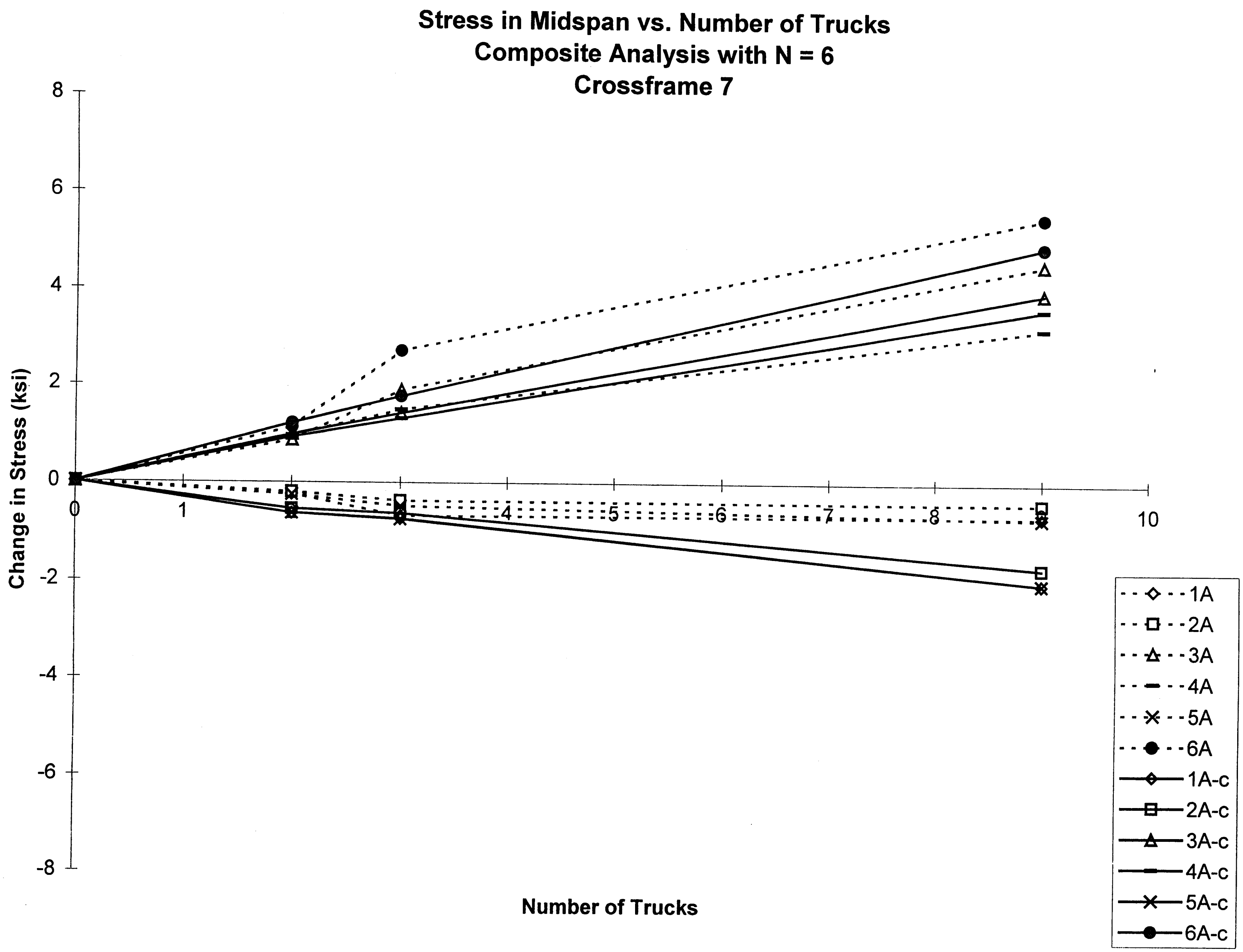


Figure G12: Stress Comparison in Gages 1A-6A for Composite Analysis (August 7, 1997)

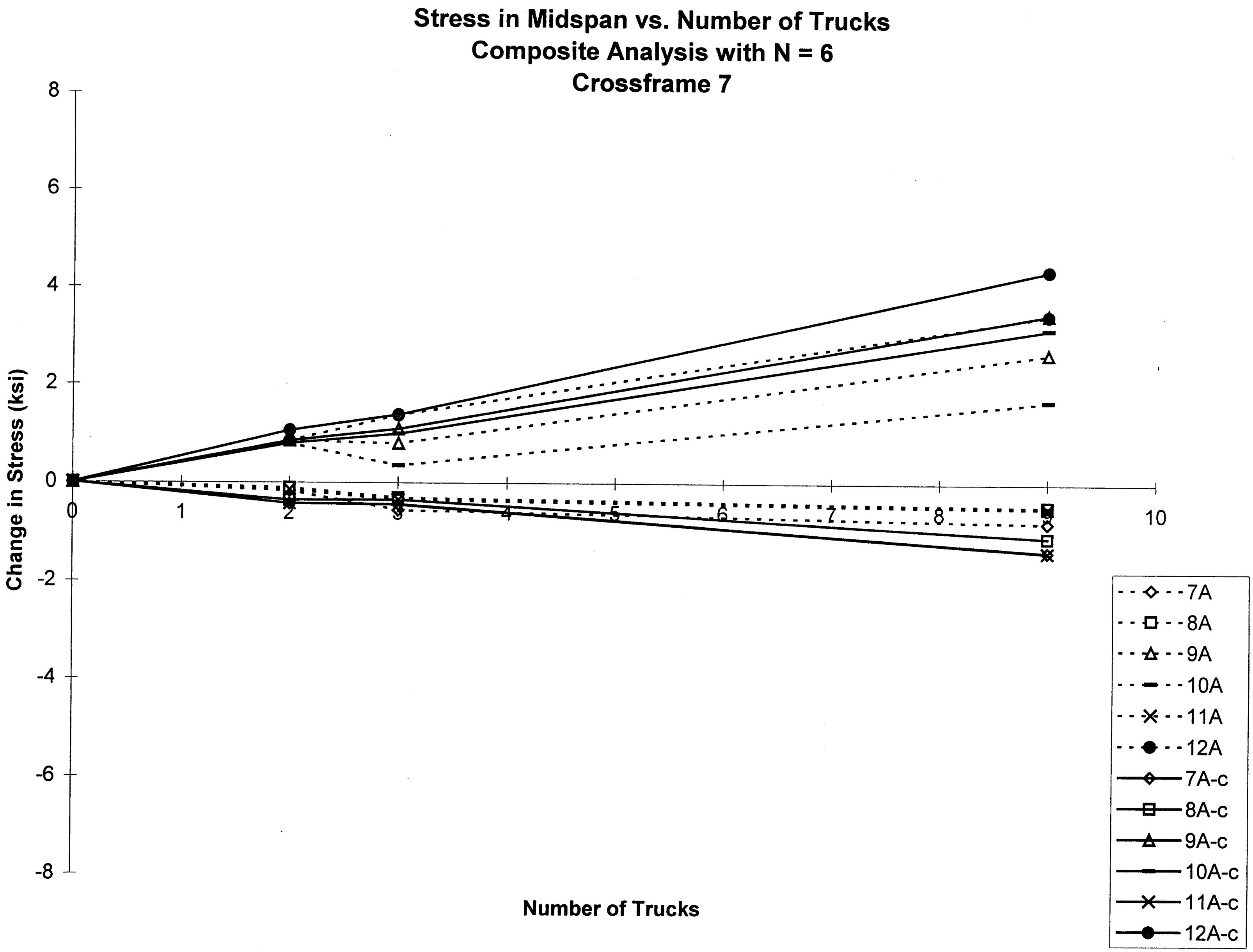


Figure G13: Stress Comparison in Gages 7A-12A for Composite Analysis (August 7, 1997)

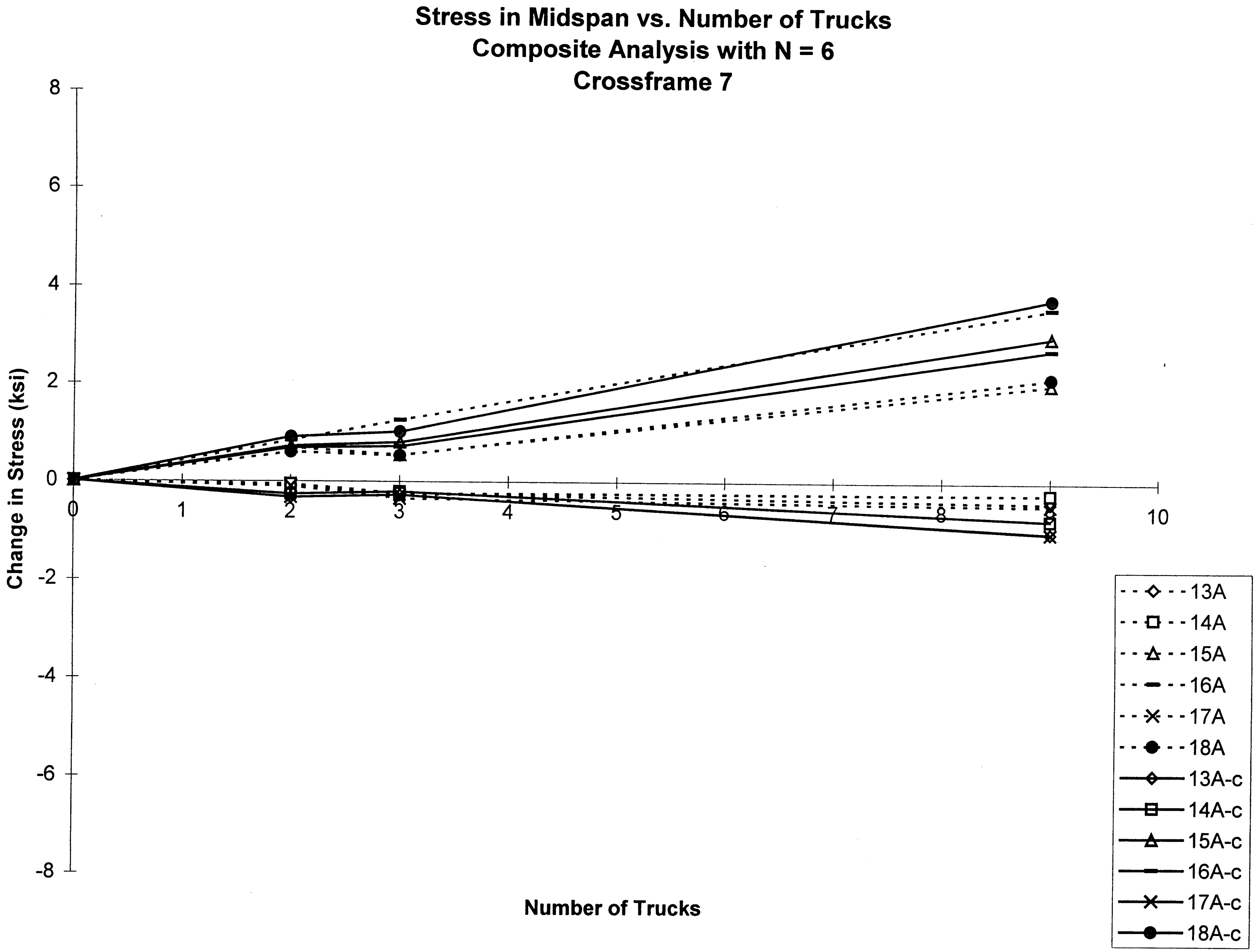


Figure G14: Stress Comparison in Gages 13A-18A for Composite Analysis (August 7, 1997)

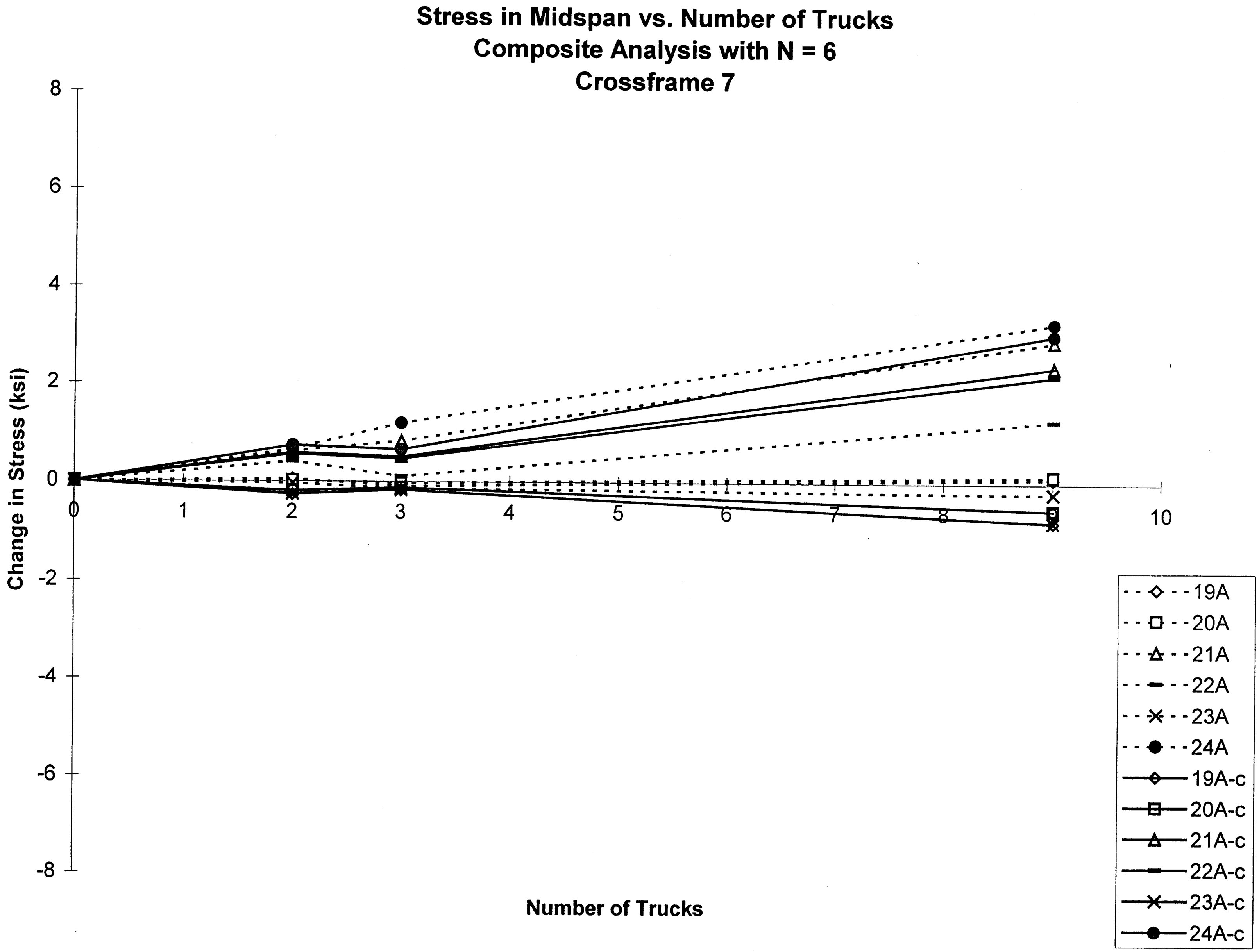


Figure G15: Stress Comparison in Gages 19A-24A for Composite Analysis (August 7, 1997)

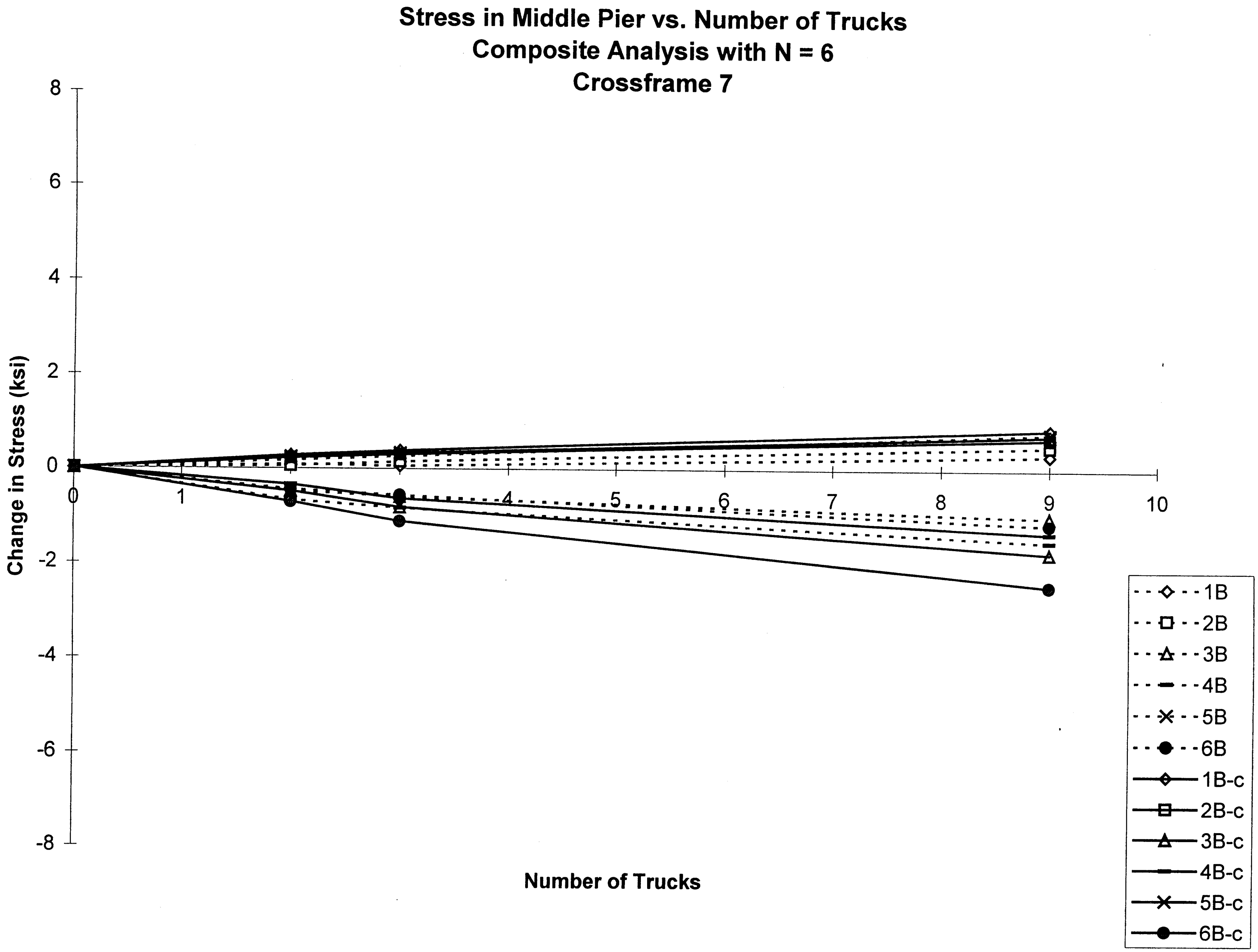


Figure G16: Stress Comparison in Gages 1B-6B for Composite Analysis (August 7, 1997)

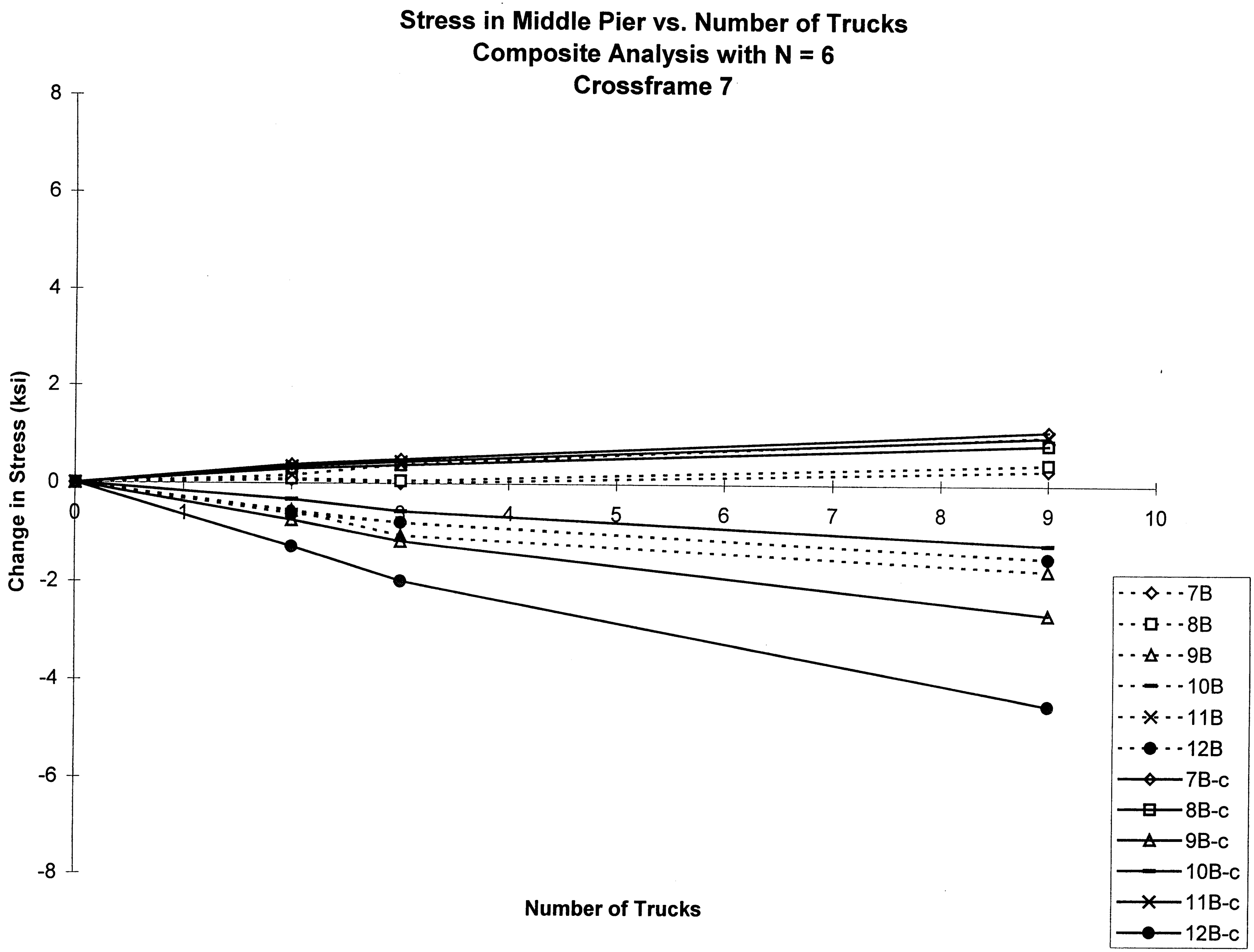


Figure G17: Stress Comparison in Gages 7A-12A for Composite Analysis (August 7, 1997)

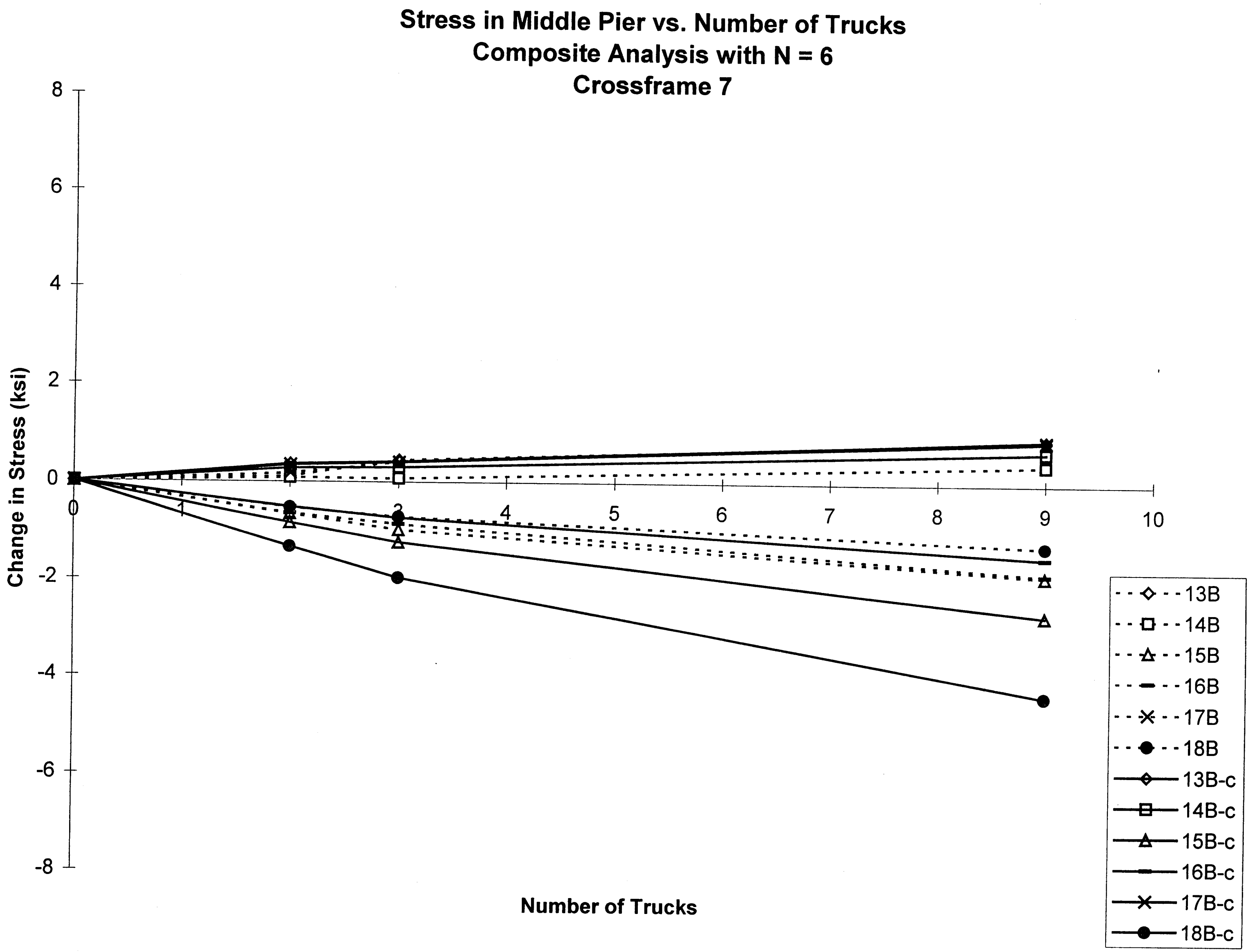


Figure G18: Stress Comparison in Gages 13B-18B for Composite Analysis (August 7, 1997)

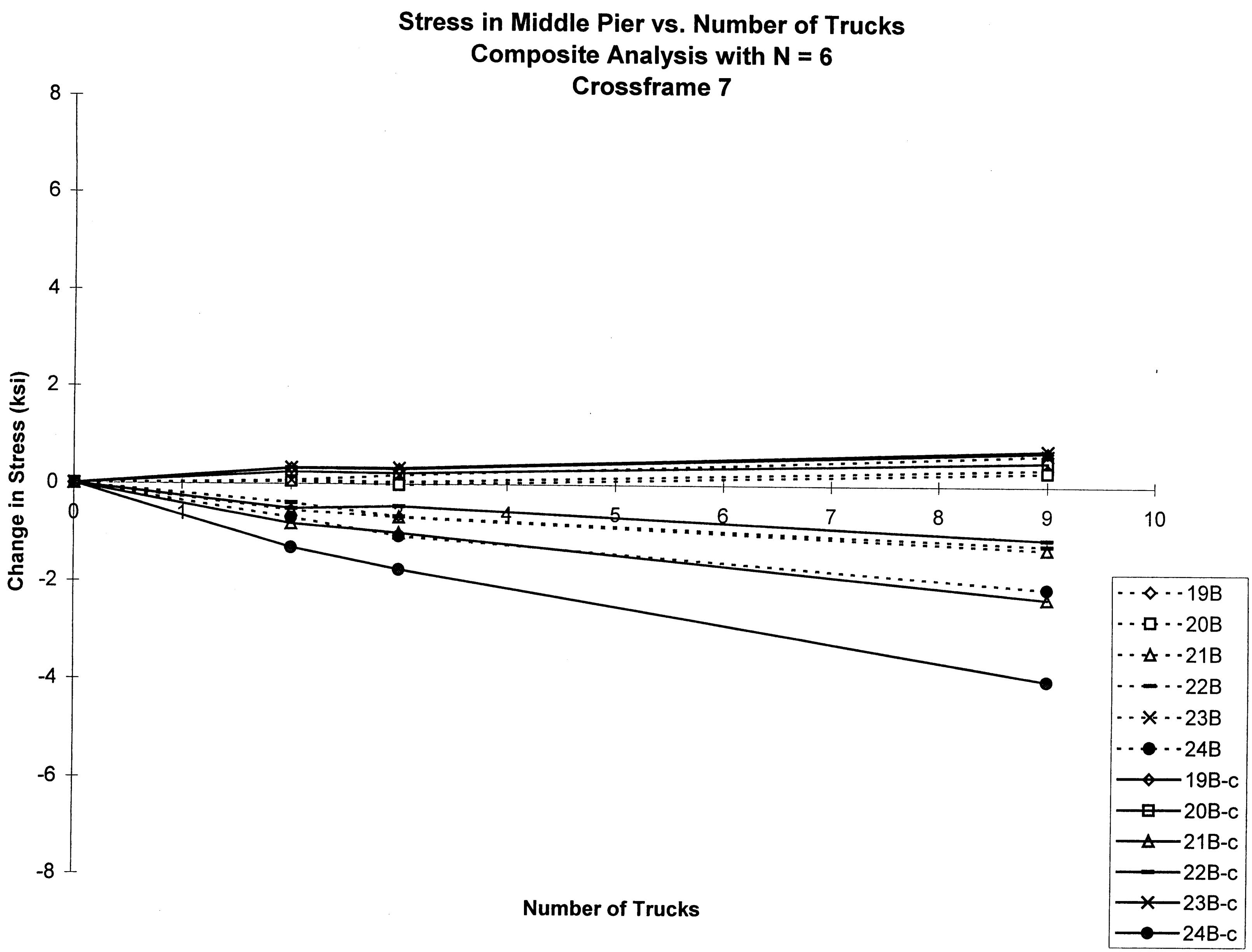


Figure G19: Stress Comparison in Gages 19B-24B for Composite Analysis (August 7, 1997)

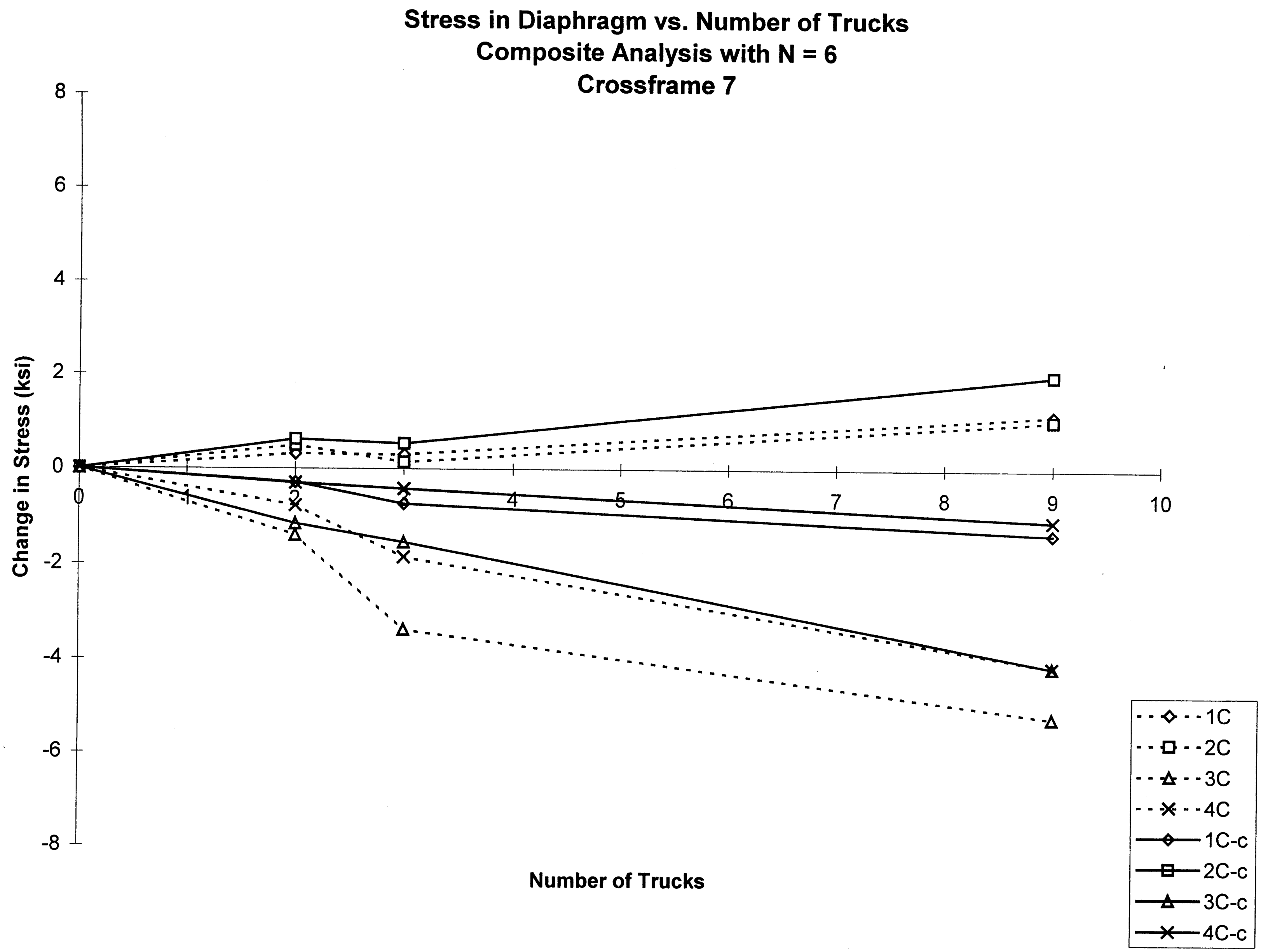


Figure G20: Stress Comparison in Gages 1C-4C for Composite Analysis (August 7, 1997)

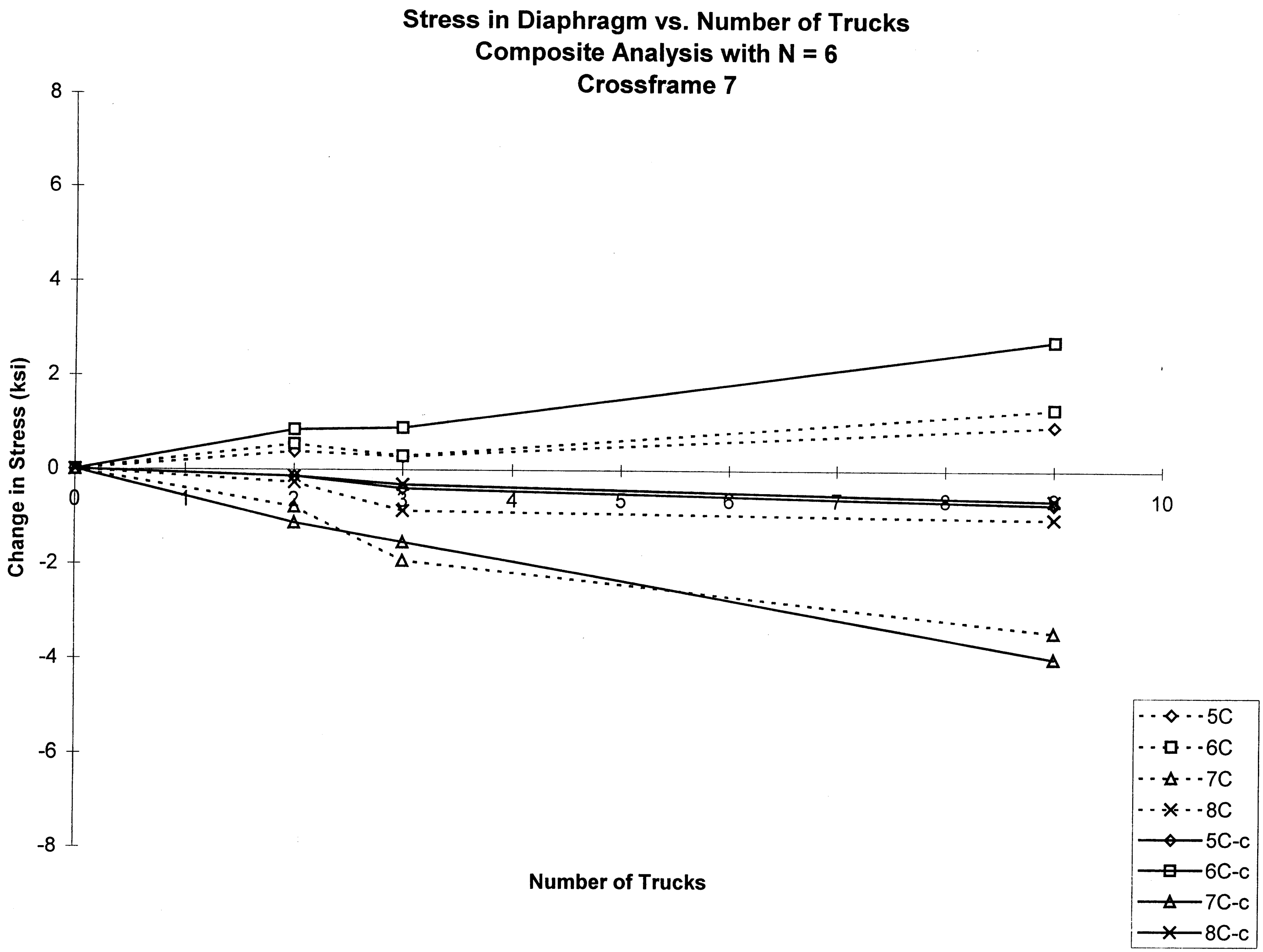


Figure G21: Stress Comparison in Gages 5C-8C for Composite Analysis (August 7, 1997)

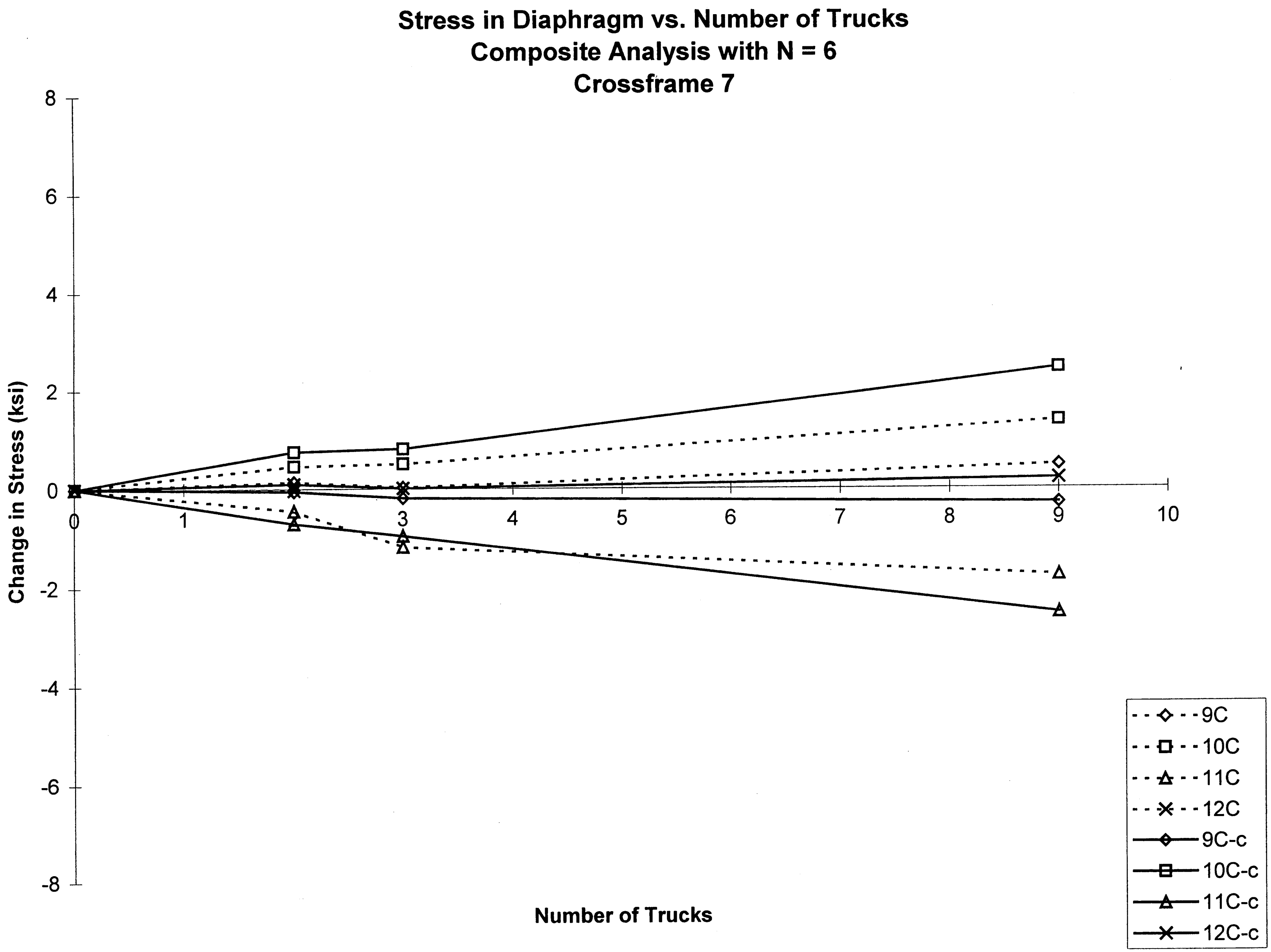


Figure G22: Stress Comparison in Gages 9C-12C for Composite Analysis (August 7, 1997)

APPENDIX H

EVALUATION OF THE CORRELATION OF EACH GAGE FOR CHANGE IN STRESS AND TOTAL STRESS

H.1 Evaluation of Change in Stress Due to 1997 and 2000 Truck Loadings: Case by Case Assessment

A case by case analysis was conducted in which the measured change in stress correlation to the change in stresses from the composite analyses with $N = 6$ was determined for the cases from the live loading with three and nine trucks in both 1997 and 2000. The composite analyses with $N = 6$ generally provided the best correlation, and conclusions from this correlation are discussed further in Chapters 3 through 5. For simplicity, the 1995 truck loading, the results with partially non-composite action, and the results with $N = 8$, and the results from the gages whose results have become suspect are not included in the evaluation in this section.

For measured change in stress, a discrepancy was noted between data taken in 1997 and that taken in 2000 for gages 6A and 3C. Beginning in Case 4, and continuing through Case 11, the 1997 measured data appears to be markedly different from 1997 analysis and data collected in 2000. Because the change in stress in these gages and in these cases is generally less than 2 ksi the discrepancies do not affect the final correlations of total stress.

Case 1

With the exception of gages 19A, 20A, 1C, 5C and 9C, all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 10A, 12A, 18A, 10B and 3C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other. Analysis based on the 1997 truck loadings was conservative for 38 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 14 of the 19 functioning gages had conservative analysis. In the middle pier, 17 of the 21 functioning gages had conservative analysis. On the diaphragms, 6 of the 11 functioning gages had conservative analysis.

Case 2

With the exception of gages 19A, 20A, 1C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 10A, 12A, 18A, 10B and 3C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other. Analysis based on the 1997 truck loadings was conservative for 34 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 12 of the 19 functioning gages had conservative analysis. In the middle pier, 16 of the 21 functioning gages had conservative analysis. On the diaphragms, 6 of the 11 functioning gages had conservative analysis.

Case 3

With the exception of gages 19A, 20 A, 1C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 19A and 20A. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 10B and 3C. Analysis based on the 1997 truck loadings was conservative for 32 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 11 of the 19 functioning gages had conservative analysis. In the middle pier, 18 of the 21 functioning gages had conservative analysis. On the diaphragms, 3 of the 11 functioning gages had conservative analysis.

Case 4

With the exception of gages 1A-8A, 11A-14A, 17A, 19A, 20A, 23A, 24A, 1C, 3C, 7C-9C and 11C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 20A and 3C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 6A, 10B and 3C. Analysis based on the 1997 truck loadings was conservative for 25 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 13 of the 19 functioning gages had conservative analysis. In the middle pier, 20 of the

21 functioning gages had conservative analysis. On the diaphragms, 2 of the 11 functioning gages had conservative analysis.

Case 5

Between Case 4 and Case 5 there was a distinct drop in the measured change in stress induced in the bridge. With the exception of gages 1A, 2A, 6A, 13A, 14A, 17A, 19A, 20A, 23A, 1C, 3C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 1A, 2A, 6A, 14A and 3C.All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 6A and 10B. Analysis based on the 1997 truck loadings was conservative for 34 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 10 of the 19 functioning gages had conservative analysis. In the middle pier, 19 of the 21 functioning gages had conservative analysis. On the diaphragms, 5 of the 11 functioning gages had conservative analysis.

Case 6

With the exception of gages 1A, 2A, 6A, 13A, 14A, 17A, 19A, 20A, 23A, 1C, 3C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 1A, 2A, 6A, 13A, 14A and 3C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 6A and 10B. Analysis based on the 1997 truck loadings was conservative for 31 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 8 of the 19 functioning gages had conservative analysis. In the middle pier, 19 of the 21 functioning gages had conservative analysis. On the diaphragms, 4 of the 11 functioning gages had conservative analysis.

Case 8

With the exception of gages 7B, 8B, 19B, 20B, 1C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 8B, 14B, 19B and 9C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gage 3C. Analysis based on the 1997 truck loadings was conservative for 37 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 17 of the 19 functioning gages had conservative analysis. In the middle pier, 13 of the 21 functioning gages had conservative analysis. On the diaphragms, 7 of the 11 functioning gages had conservative analysis.

Case 9

With the exception of gages 22A, 7B, 8B, 14B, 19B, 20B, 1C, 5C and 9C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 22A, 7B, 8B, 14B, 19B and 9C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gage 3C. Analysis based on the 1997 truck loadings was conservative for 19 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 3 of the 19 functioning gages had conservative analysis. In the middle pier, 12 of the 21 functioning gages had conservative analysis. On the diaphragms, 4 of the 11 functioning gages had conservative analysis.

Case 10

With the exception of gages 1A-8A, 11A, 13A, 14A, 17A, 19A, 20A, 23A, 24A, 1B, 5B, 7B, 8B, 9B, 15B, 20B, 21B, 1C, 3C, 4C, 5C, 7C, 8C, 9C and 11C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 3A, 5A, 6A, 8A, 1B, 5B, 7B, 8B, 14B, 19B, 20B, 3C, 4C, 7C and 11C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 6A and 3C. Analysis based on the 1997 truck loadings was conservative for 17 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 2 of the 19 functioning gages had conservative analysis. In the middle pier, 13 of the 21 functioning gages had conservative analysis. On the diaphragms, 2 of the 11 functioning gages had conservative analysis.

Case 11

With the exception of gages 1A-8A, 11A-14A, 17A, 19A, 20A, 23A, 24A, 7B, 8B, 14B, 19B, 20B, 1C, 3C, 4C, 5C, 7C, 8C, 9C and 11C all measured stresses due to the truck loads in 2000 were of the same sign as the 1997 analysis. In addition, all 1997 and 2000 measured data agreed in sign with the exception of gages 3A, 6A, 8A, 12A, 7B, 8B, 14B, 19B, 3C, 4C, 5C, 7C, 8C, 9C and 11C. All measured stress magnitudes for 1997 and 2000 were within 1 ksi of each other with the exception of gages 6A and 3C. Analysis based on the 1997 truck loadings was conservative for 17 of the 51 gages still functioning reliably for the 2000 live load test. In the midspan, 0 of the 19 functioning gages had conservative analysis. In the middle pier, 15 of the 21 functioning gages had conservative analysis. On the diaphragms, 2 of the 11 functioning gages had conservative analysis.

H.2 Evaluation of Total Stress Due to 1997 and 2000 Truck Loadings: Gage by Gage Assessment

A gage by gage analysis was conducted in which the measured stress correlation to the stresses from the composite analyses with $N = 6$ was determined for the gages from the beginning of construction to the live loading with three and nine trucks. The composite analyses with $N = 6$ generally provided the best correlation, and conclusions from this correlation are discussed further in Chapters 3 through 5. For simplicity, the 1995 truck loading, the results with partially non-composite action, and the results with $N = 8$ are not included in the evaluation in this section.

In the time between the tests performed in 1997 and the tests in 2000, six gages began giving readings that were inconsistent with data collected in 1997. Readings of gages 12A, 16A, possibly 18A, 1B, 12B and 24B taken to assess temperature effects on self weight stresses changed noticeably. These readings were taken over the course of three years. While these aberrant readings did not affect the final ratings of the gages in question (because the measured change in stress was summed with the same change in stress due to self weight for the 1997 and 2000 measured data) all data collected from the gages should be assessed with the knowledge that their reliability is compromised with respect to the scope of this report.

Gage 12A was a gage in tension in 1997. The dead load stress was approximately 1 ksi, the truck loads in 1997 induced a maximum of 4 ksi, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up 34 ksi in tension. The truck loads in 2000 induced a maximum stress of approximately 6 ksi.

Gage 16a was a gage in tension in 1997. The dead load stress was approximately 6 ksi, the truckloads in 1997 induced a maximum of 4 ksi, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up –11.5 ksi in compression. The truck loads in 2000 induced a maximum stress of approximately 4 ksi

Gage 18A was a gage in tension in 1997. The dead load stress was approximately 3 ksi, the truck loads in 1997 induced a maximum of 3 ksi, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up –13 ksi in compression. The truck loads in 2000 induced a maximum stress of approximately 4 ksi.

Gage 1B was a gage in tension in 1997. The dead load stress was approximately 11 ksi, the truck loads in 1997 induced a maximum of 1 ksi, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up 17 ksi in compression. The truck loads in 2000 induced a maximum stress of approximately 1 ksi.

Gage 12B was a gage in compression in 1997. The dead load stress was approximately -7 ksi, the truck loads in 1997 induced a maximum of -2 ksi in tension, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up 17 ksi in tension. The truck loads in 2000 induced a maximum stress of approximately -2 ksi.

Gage 24B was a gage in tension in 1997. The dead load stress was approximately -13 ksi, the truck loads in 1997 induced a maximum of –2.5 ksi in tension, and if the subsequent readings due to self weight are to be accepted as accurate this gage picked up -13 ksi in compression. The truck loads in 2000 induced a maximum stress of approximately –2.5 ksi

The following section is the Gage by Gage discussion of behavior for both Live Load tests conducted in 1997 and 2000. Wherever it was appropriate an indication of erratic gage behavior was indicated.

Gage 1A started with a high percent error for Step 1-1, due to its low measured stress of 0.48 ksi. However, its correlation improved as the measured stress increased; at Step 4-2, with the completed bridge subjected just to self weight, the error was only 1%. In 1997, the total stresses compared well for 1A with the exception of truck Cases 1 and 2, where the errors were -28% and -22% (Table 4). All other total stress errors were between -6% and 11%. The stresses were not linear for the trucks plots (Figure G.1) due to a decrease in the compressive stress between the three and nine truck cases. The analysis results for the gage were generally conservative, and the stresses at this location were over 5 ksi. The overall rating for 1A was moderate. A strong rating would have been given except for the poor correlation for Step 3-3a, the steel superstructure alone, where the percent error was -71%.

In 2000, total stress compared well with 1997 analysis. Cases 1 and 2 again had the largest percent errors with –29% and –21%, respectively. All other gages were within -3% to 16% (Table 5). The rating for gage 1A remained moderate.

Gage 2A compared very well throughout the loading history. The largest percent error from the dead load stages or from the total stress comparisons was only 28% (Table 4), with average errors for dead load, nine truck loading, and three truck loading in 1997 being -9%, -7%, and -4% respectively. The stress increase for the gage was not linear with the increase in number of trucks (Figure G.1); the compressive stress decreased between the three and nine truck loading. However, this nonlinearity was mild. The measured stresses were all over 5 ksi and the overall rating was strong.

In 2000, total stress compared similarly to 1997 analysis. Average errors for dead load, nine truck, and three truck cases were –9%, -7% and 3%, respectively (Table 5). The 2000 data compared favorably and yielded the same rating as the 1997 data.

Gage 3A correlated poorly for Step 1-2, when the measured stress was very low. Otherwise, the analysis predicted the stresses well. The total stress percent errors in 1997 were between 1 and 16% (Table 4), which were generally low, although it should be noted that the analysis often underestimated the stress in this gage. The gage also had a small jump in stress for the linear plots between the two and three truck loading (Figure G.1). However, overall, the stresses were above 5 ksi and the rating was strong.

In 2000, total stress percent errors ranged from 1% to 17% (Table 5). Again, analysis tended to underestimate stress in this gage. The rating of this gage remained strong due to high stresses and low percent errors.

Gage 4A had some high percent errors through the dead load cases, but this was mainly due to low measured stresses in the gage. This gage, which was on the outside tensile flange tip of the outside facia girder, was not quite as accurate as gages 1A through 3A, with average errors in 1997 of -18%, -22%, and -25% for the dead load, nine trucks, and three trucks, respectively. The analysis results for the gage were almost always conservative and the stresses increase linearly with the increase in truck loading (see Figure G.1). Overall the rating was moderate due to the percent errors for Step 3-3a being -49% and for Step 4-2 being -34%, which were both above 30%.

Gage 4A failed prior to the 2000 test date.

Gage 5A had some high errors during the dead loading. Some of these errors were high because of low measured stresses (e.g., Steps 1-1 and 1-2), but others, such as Steps 2-2 and 2-3a, were due to poor correlation (Table 4). However, the correlation improved starting with Step 3-3a, and from then on the percent errors were less than 30%. The average error in 1997 for the nine truck loading cases was -17% and the average for the three truck loading cases was -15%. The measured stresses were not linear when the number of trucks loaded on the bridge was increased. It behaved like gages 1A and 2A, the other two gages on the top flange, in that the compressive stress decreased mildly between the three and nine truck cases (Figure G.1). Nevertheless, overall the gage rating was strong.

In 2000, the average error for the nine truck loading cases was –18% and the average error for the three truck cases was –14%. The analysis for this gage was conservative with all percent errors falling between -10% and –29%. Cases 1 and 2 demonstrated the largest percent errors with –29% and –26%, respectively (Table 5). The rating remained strong between the 2000 data and 1997 analysis.

Gage 6A compared closely with the analysis for the total stress cases. There were some errors between -46% and -92% during the dead loading, but this dissipates to only -19% by Step 4-2 (Table 4). The total stress errors were low, ranging between -12% and 3% (Table 4). The measured stress had a positive jump between the two and three truck cases for the linear plots (Figure G.1), but the analysis results were conservative and the gage received a moderate rating. The rating would have been strong if it weren't for its error of -33% for Step 3-3a.

In 2000, the total stress percent errors ranged from –8% to –24% (Table 5). The analysis was conservative in all the live load cases. The rating was again moderate due to step 3-3a, with all stresses were above 5 ksi.

Gage 7A correlated poorly throughout all analysis stages due to its measured stresses being below 5 ksi (i.e., the stresses were fairly insignificant and may be heavily influenced by local conditions in the midspan region of that girder). The sign of the analysis result did not even share the same sign as the actual stress until Step 3-3a, and percent errors were between -74% and -94% for the total stresses (Table 4 and Figure H.3). The measured stresses were not linear for the truck loadings (Figure G.2); the gage behaved similarly to the corresponding gage, 1A, in girder 1. Its compressive stress decreased a small amount between the three and nine truck loading cases rather than increasing. The analysis results were conservative from Step 3-3a forward, and the overall rating was moderate.

In 2000, the percent errors were between –73% and -100% for all total stresses (Table 5). The analysis was again conservative for all live load cases, and rating was moderate due to low stress magnitudes.

Gage 8A showed strong similarities with the analyses. With the exception of Steps 1-1 and 1-2, when the measured stresses were low, the percent errors were reasonable. The gage had 6% error at the end of the dead loading, and total stress errors were excellent, ranging between -5% and 8% (Table 4). The gage was not linear for the linear plots since its compressive stress decreased slightly between the three and nine truck loading, similar to the other gages in the region of the top flanges at midspan (Figure G.2). The overall rating for 8A was strong.

In 2000, the total stress errors ranged from –3% to 10% (Table 5). The rating remained strong for the 2000 data versus the results from 1997 analysis.

Gage 9A was similar to gage 7A in its correlation to the analysis. The errors started high and remained high throughout all of the analysis. However, the gage had very little stress, generally less than 5 ksi, which resulted in these high errors. The error at the end of the dead load was -104% and the total stress errors remain in this same range, being -70% to -125% (Table 4). The linear plots showed a small nonlinearity between the two and three truck loadings (Figure G.2). The overall rating was moderate, however, due to its magnitude of stress being less than 5 ksi.

The major contributors to error were the large error in step 4-2 and low stress magnitudes. In 2000, the percent error range was –73% to -134% (Table 5). The rating remained moderate due to low stress magnitudes, with the exceptions of two of the nine truck loads with magnitudes of 6.11 ksi and 5.68 ksi.

Gage 10A began the dead load with percent errors of 92% and 76% for Steps 1-1 and 1-2 (Table 4). As the construction sequence proceeded, the gage continued to improve in its correlation to the analysis, and the total stress correlation was excellent. The range of percent errors for the total stresses was -13% to 9%. However, the analysis results were generally not conservative, especially for the dead load. The gage behavior was also nonlinear between the two and three truck loading for the linear plot (Figure G.2). It had a small negative jump in the tensile stress between these two loads. Nevertheless, the overall rating for the gage was strong.

In 2000, the total stress percent error range was 3% to 15% (Table 5). The 1997 analysis was never conservative for the 200 data, but because the percent error remained low, the rating of the gage remains strong.

Gage 11A was the first gage to receive a weak rating. The measured stresses were not low and the percent errors were above the 30% cutoff criteria (Table 4). However, the analysis results were nearly always conservative. The behavior was not linear for the linear plots since it decreased in compressive stress between the three and nine truck loading (Figure G.2). The range of errors for the total stress cases was -35% to -51%. However, as may be seen in Figure H.3, the general trends of the gage behavior were reasonable.

In 2000, the total stress cases had percent errors in the range of -32% to –51% (Table 5). The rating was weak for the 2000 data, and the case by case behavior of the gage was similar to the 1997 cases.

Gage 12A had large percent errors throughout all of the analysis stages (Table 4). This was the result of the measured stresses generally being less than 1.5 ksi for the load history, with only the total stress for Case 1 being above 5 ksi at 5.09 ksi. The percent errors were very high, but since the stresses were low, gage 12A was rated as moderate.

The percent errors in 2000 versus the 1997 analysis were very high, but with the exception of two cases the stresses were all below 5 ksi. The rating remained moderate for this gage. It should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 13A had poor correlation during the dead load cases up to Step 3-3a. Several of the measured stresses were not even the same sign as the analysis results. However, all of the analysis results after Step 2-3a were conservative, and the high percent errors were largely due to the measured stresses being low in the gage. The total stress errors range from –45% to –63%. The gage was not linear for the linear plots (Figure G.3) since there was a small decrease in the compressive stress between the three and nine truck cases. However, the gage was rated as moderate since the measured stresses were all less than 5 ksi.

In 2000, the total stress errors were between –43% and –62% (Table 5). All analysis results were conservative for the live load cases, and the rating was unchanged due to low total stresses in all live load cases.

Gage 14A had correlation that was very similar to gage 13A. The percent error at the end of the dead load was –56% (Table 4), and it remained high for the total stress cases, due largely to the low stresses in the gage. Gage 14A was again not linear in the linear plots since the compressive stress decreased slightly between the three and nine truck loading (Figure G.3). The overall rating for the gage was moderate since the measured stresses were all less than 5 ksi.

For the 2000 data, gage 14A behaved similarly to 13A. The percent errors ranged from –45% to –69% (Table 5). All analysis results were conservative compared to the 2000 data. The rating was still moderate due to the low total stresses in all live load cases.

Gage 15A was a gage that consistently had poor correlation between the analysis and measured stresses (Table 4). The stresses were not linear for the linear plots (Figure G.3). It was a top flange gage, and it decreased slightly in compressive stress between the three and nine truck cases, similar to the other top flange gages. The poor correlation was due largely to the measured stresses being low, and the analysis results were conservative for all of the total stress cases. The overall rating of 15A was moderate.

Gage 15A failed prior to the 2000 test date.

Gage 16A showed very good correlation. This gage exhibited linear behavior for the linear plots (Figure G.3) and had low percent errors of 12% to 23% for the total stress cases (Table 4). However, the analysis results for the dead loads and for the total stress cases were often not conservative with respect to the measured data. Nevertheless, the errors were small, and the gage was rated strong.

In 2000, the analysis was not conservative for any Case of live loading. The percent errors in live load cases ranged from 11% to 23% (Table 5). Because the percent errors were low the rating remained strong. It should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 17A also showed strong correlation. Its measured stresses were greater than 5 ksi and the total stress errors were all less than 10% (Table 4). It followed the pattern of the other top gages in that it was not linear for the linear plots due to the decrease in compressive stress (Figure G.3), and it generally did not have a conservative analysis compared to the measured results. The gage holds a strong rating, however, as a result of its measurable stress magnitudes and its low percent errors.

In 2000, the total stress percent errors ranged from –1% to 11% (Table 5) and analysis was generally not conservative compared to the 2000 data. The correlation was strong due to the relatively low errors and high total stresses.

Gage 18A had poor correlation for several load cases, but the measured stress in the gage was low. Step 4-2 exhibited a high error of -113%, and this error remained high for the total stresses (Table 4). The total stress errors were between -99% and -142%. The measured stress in 18A was also not linear with respect to an increase in truck loading because of a negative drop in the tensile stress between the two and three truck cases (Figure G.3). The analysis was conservative for all of the cases except the first two dead load steps. The final rating for this gage was moderate since its stress errors were high but its stress magnitudes low.

The measured total stresses in 2000 were inconsistent in magnitude. Approximately half were above 5 ksi and half were below. The percent errors in the total stress cases behaved similarly to the 1997 data; the errors were between –57% and –157% (Table 5). The correlation remained moderate, even though the measured stresses were somewhat larger than those recorded in 1997. It should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 19A had measured stresses in the gage that were significant, with percent errors all hovering around 30% (Table 4). It was similar to other top flange gages in the midspan region in that it decreased in compressive stress with the increase from three to nine trucks (Figure G.4). Also, the analysis results were never conservative throughout the dead loads and total stresses. The total stress errors range between 19% and 35%, with the averages for the three and nine truck cases being 29% and 32% respectively. The gage borders on the strong rating criteria, but ultimately fell into the moderate rating.

In 2000, the total stress errors ranged from 19% to 36%. The averages for nine and three truck cases were 30% and 33% respectively (Table 5). The correlation remains moderate with respect to 1997 analysis and gage behavior was qualitatively similar to the data collected in 1997.

Gage 20A was one of the top flange gages that did not follow the decreasing compressive stress trend in the linear plots; in exhibited linear behavior with increased truck loading (Figure G.4). The percent errors in this gage were all 20% or lower for all of the cases from Step 1-3 on, with the averages on the total stress three and nine truck cases being 14% and 16% respectively. The analysis results were not conservative for any of the total stress cases. The overall rating for 20A, however, was strong because of its consistently low errors.

The 1997 analysis was not conservative for the 2000 data, but the percent errors were relatively low. The percent errors ranged from 5% to 21% in all of the total stress cases (Table 5). Because the percent errors remained low, and stresses were all above 5 ksi, correlation was rated strong.

Gage 21A was rated moderate due to the -31% error on Step 3-3a and the low magnitude of the stresses (Figure H.7). The gage behavior was linear for the linear plots (Figure G.4) and the analysis results were conservative for all of the cases from Step 1-3 on (Table 4).

The 2000 data was qualitatively similar to the 1997 data and analysis. Three live load cases provided stresses above 5 ksi. The correlation remained moderate, and the 1997 analysis results were conservative for all the 2000 loading cases.

Gage 22A had poor correlation with the dead load cases, which remained throughout the live loading cases, due mainly to low stresses. The errors for the total stresses ranged between -72% and -116%, which followed the -77% for Step 4-2 of the dead load (Table 4). The analysis results were conservative for all of the total stress cases. The stress decreased slightly between the two and three truck loading in the linear plot (Figure G.4). However, even though the errors were high for 22A, it was rated moderate as a result of its low measured stresses.

In 2000, the percent errors for the total stress cases ranged between –80% and –168% for the nine and three truck cases (Table 5). All the 1997 analyses were conservative. Due to the low total stresses, the correlation remained moderate.

Gage 23A had low errors for all of the cases where the stress magnitude was significant. The total stress errors were all less than -28% and they were all conservative analysis results (Table 4). The gage behavior was mildly nonlinear in the linear plots (Figure G.4). The overall rating was strong.

In 2000, the total stress percent errors all remained below –29% in magnitude (Table 5). The rating was still strong with respect to the 1997 analysis, and the behavior of the bridge under the 2000 load cases was similar to the 1997 cases. All the analysis results were conservative for the 2000 data.

Gage 24A had some poor correlation in the dead load cases, but generally the analysis correlation for the gage was acceptable. The tensile stress jumped upward between the two and three truck loading in the linear plots (Figure G.4). The analysis results were conservative for all of the cases analyzed with the exception of Step 1-2. The total stress percent errors were all lower than -23% (Table 4), but the overall rating was moderate due to the error from Step 3-3a being -48%.

In 2000, the percent errors ranged from –4% to -24% in the total stress cases (Table 5). The behavior was similar to the data collected in 1997 and the correlation was again moderate with respect to 1997 analysis. The stress magnitudes were again split approximately evenly between above and below 5 ksi, but this did not affect the correlation.

Gage 1B was predicted well by the analysis. The largest error between the analysis and measured stress was in Step 1-1, when the error was 60%. The errors immediately decreased by Step 1-2 to only 29%, and they remained below this throughout the remainder of the analyses. The total stress errors were all less than -22%, with the averages of the three and nine cases respectively being -18% and -20% (Table 4). Gage 1B showed a linear increase in stress with the increase in truck loading (Figure G.5), and it was conservative for cases 3-3a on. The overall rating was strong.

In 2000, all the percent errors for the total stress cases were between –15% and –21% (Table 5). The 1997 analysis results were conservative with respect to the data collected in 2000. The correlation remained strong for this gage. It should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 2B also correlated well. The largest error between the analysis and measured stress was also in Step 1-1, at 51% (Table 4). The error then decreased for subsequent load cases. The total stress errors were all 15% or less, with the averages for the three and nine truck cases being 14% and 13% respectively. The stress increased linearly with the increase in truck loading (Figure G.5). The analysis results were almost never conservative. However, the overall rating was strong because of its low percent errors.

In 2000, all the percent errors were less than 15% for the nine and three truck cases. The average percent error for the nine truck cases was 12%, and for the three truck cases it was 14% (Table 5). 1997 analysis was not conservative for 2000 data, but the low percent errors resulted in strong correlation.

Gage 3B also showed good correlation. The errors were low (Table 4), the stresses increased linearly for the linear plots (Figure G.5), and the analysis results were always conservative. The total stress errors ranged between -3% and -19%, and the gage was rated as strong.

The 2000 data was qualitatively similar to the 1997 data, and the percent errors were in the range of –4% to –20% (Table 5). All analysis results were conservative for the 2000 data, and the correlation was unchanged with regard to 1997 analysis.

Gage 4B was rated as moderate due to the dead load Step 3-3a error exceeding 30% (Table 4). The stress increases were linear with the increase in truck loading (Figure G.5) and the analysis results were conservative for all cases except the first two dead loads. The total stress errors ranged between -8% and -34%, with the averages for the three and nine truck cases being -14% and -20% respectively. The overall rating was moderate, because of the error in Step 3-3a.

In 2000, the total stress errors ranged from –7% to –33%. The three and nine truck cases had –14% and –20% errors respectively with respect to 1997 analysis (Table 5). The correlation remained moderate for this gage due to the error in step 3-3a.

Gage 5B had high percent errors for the initial dead loading, but the error lowered to -7% by Step 4-2 (Table 4). The average total stress errors for the three and nine truck cases were -10% and -11%. The stresses increased linearly with the increase in truck loading (Figure G.5) and the analysis results were always conservative. The overall rating was strong.

The average total stress errors for the three and nine truck cases were -12% and -13% respectively, and errors ranging from –8% to –19% (Table 5). Qualitatively, the data was similar to that from 1997, and the correlation was again strong for this gage.

Gage 6B received a moderate rating because the error from Step 3-3a exceeded 30% (Table 4). All of the other errors were low, with the maximum error in the total stress cases being -21%. The stresses increased linearly with the increase in truck loading (Figure G.5), and the analysis was conservative for all of the cases except Step 1-1. The overall rating was moderate, just missing a strong rating because of the -48% error for Step 3-3a.

In 2000, the maximum percent error for this gage was –19% for the truck loading cases (Table 5). The analysis was again conservative with respect to the data collected in 2000, but the rating remained moderate due to higher errors in the construction sequence.

Gage 7B had percent errors of -40%, -30%, -36%, and -34% for Step 3-3a, Step 4-2, the nine truck average, and three truck average, respectively (Table 4). The errors all slightly exceeded the criteria of 30% for the ratings, and so the gage was rated as weak. The dead load may have induced some fit-up stresses for the gage up to Step 3-3a; the correlation between the analysis and the measured stresses was actually fairly strong thereafter. The gage behavior was not linear for the linear plots because of a small negative jump in the tensile stress between the two and three truck cases (Figure G.6). All of the analysis stresses were conservative for this gage.

In 2000, the rating of this gage remained weak as compared to 1997 analysis. The percent errors were similar to those from 1997 data, and the analysis results were conservative for all live load cases of this gage.

Gage 8B showed similar behavior to gage 7B. The errors were slightly larger for 8B, with the total stress errors ranging between -46% and -48% (Table 4). There were some high errors through the dead load cases because of low measured stresses. The dead load may have induced some fit-up stresses up to Step 3-3a, but the correlation between the analysis and measured data was strong thereafter, similar to gage 7B. The stresses did not increase linearly for the linear plots. There was a decrease in the tensile stress between the two and three truck loading cases, the same as for gage 7B (Figure G.6). The analysis results were again always conservative, but the final rating was weak because of the high percent errors.

The 1997 analysis compared to the 2000 data yielded total stress errors ranging from –46% to –49% in the live load cases (Table 5). The analysis was conservative for all the cases, but the correlation was weak due to high percent errors.

Gage 9B had behavior that was opposite that of gages 7B and 8B, and the percent errors were very low. The total stress average errors were 1% and -5% for the three and nine truck loading cases respectively, and the only error that was larger than -24% was from Step 1-1, when the measured stress was low (Table 4). The stresses showed mild nonlinearity for increased truck loading (Figure G.6). The overall rating was strong due to its extremely low percent errors.

In 2000, the percent errors were again low for the live load cases. The total stress cases yielded a percent error ranging from 1% to -8% (Table 5). This gage still qualified for a strong rating, but not all of the 1997 analysis was conservative with respect to the 2000 data.

Gage 10B had high percent errors and the gage correlation was rated as weak. The errors here were even larger than for gage 8B, with the total stress averages being -59% and -67% for the three and nine truck cases, respectively (Table 4). This gage did show a linear increase in stress with the increase in truck loading (Figure G.6), and the analysis results were conservative for all of the cases except Step 1-1. More importantly, dead loads may have induced fit-up stresses up to Step 3-3a, and there was moderate correlation between the analysis and the measured results thereafter due to the analysis predicting slightly more direct stress due to warping than the field results (moderate correlation here refers to the errors from the change in stress from the truck loading being greater than 30%, and the stresses being non-negligible).

In 2000, the gage rating remained weak compared to the 1997 analysis. The total stress percent errors range from –31% to –70% for the nine and three truck cases (Table 5). The 1997 analysis was conservative with respect to the 2000 data.

Gage 11B was one of the gages that was damaged and replaced during the construction of the bridge. It was damaged during the placing of the formwork, so data for the first three dead load cases were not available. It was replaced along with gage 1A prior to Step 2-1 (see MnDOT Report No. MN/RC-96/28). Gage 11B shows strong correlation with the analysis and was given a strong rating. The errors were all low, 20% or less for the total stress cases (Table 4), and there was a linear increase in stress with the increase in truck loading (Figure G.6). However, the analysis was not conservative for any of the total stress cases.

The percent errors remained below 20% for the 2000 measured data when compared to the 1997 analysis results (Table 5). The analysis was not conservative for any live load Case. The gages rating remained strong due to low errors and relatively high stresses.

Gage 12B was another weak gage in the negative moment region. There could have been some fit-up stresses during dead load up to Step 3-3a, but the correlation thereafter was still not acceptable. The total stress errors ranged between -43% and -82% (Table 4). The analysis results were conservative for all but Step 1-1 of the dead load, and the measured stress increases linearly with the increase in the truck loading (Figure G.6). The gage was determined to be weak in its correlation, however, because of its high errors throughout.

Based on data collected in 2000, the rating of this gage was still weak due to high percent errors. The analysis was still conservative for all live load cases, but it should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 13B also had a weak correlation. However, the errors in Table 1 were near 30%, with the total stress errors ranging between -29% and -34% (Table 4). The measured stress increased with the increase in truck load (Figure G.7), and the analysis results were always conservative. There were possible fit-up stresses due to the dead load up to Step 3-3a, which caused the errors to be high throughout the remainder of the analyses. The correlation was moderate thereafter. The overall rating was weak because the errors often slightly exceeded the 30% cutoff.

In 2000, this gage again received a weak correlation. The 2000 data was very similar to 1997 data.

Gage 14B was similar in behavior to gage 13B in that all of the errors were hovering near 30% (Table 4). Three of the four errors tabulated in Table 1 were between 31 and 34%, so the overall rating was weak. The analysis results were always conservative. The stresses showed mild nonlinear behavior with the increase in truck load (Figure G.7).

With regard to the 2000 data, the 1997 analysis was still conservative in all live load cases. The percent errors ranged from –34% to –38%, and the correlation was weak due to errors being higher than 30% and relatively high total stresses (Table 5).

Gage 15B correlated well with the analysis. All of the errors between the analysis and measured results were between 6% and 14% for the total stress cases (Table 4). The measured stress also increased linearly with the increase in truck load (Figure G.7), but the analysis results were not conservative for any of the total stress cases. The overall rating was strong due to all of the errors tabulated being less than 15%.

The percent errors for this gage ranged from 6% to 14%, but none of the 1997 analysis results were conservative with respect to the 2000 data (Table 5). The rating was again strong for this gage based on low percent errors and relatively high total stresses.

Gage 16B was a gage which had weak correlation, possibly due to having initial fit-up stresses arising from the dead load up to Step 3-3a. After this, the correlation was moderate (Table 4). The measured stresses were linear with respect to the increase in truck load (Figure G.7), and the analysis results were conservative for all of the cases except Step 1-1. The overall rating was weak because all of the four tabulated errors exceeded 30%.

In 2000, the percent errors for the nine and three truck loading cases fell between –21% and –47% with averages of –34% for all 10 cases (Table 5). Due to relatively high total stresses and high percent errors, the correlation remained weak.

Gage 17B had strong correlation, with the maximum tabulated error being 20% (Table 4). The total stress errors were all between 18% and 20%, and the measured stress increased linearly with the increase in truck loading (Figure G.7). The analysis results were not conservative for any of the total stress cases. However, the overall rating remained strong because of the consistently low error between the analysis and the measured stresses.

For the 2000 data, the total stress percent errors were either 17% or 18% with respect to the 1997 analysis (Table 5). None were conservative for the nine or three truck cases, but the rating of the gage was strong.

Gage 18B was another weak gage in the middle pier that possibly had fit-up stresses due to the dead load up to Step 3-3a. Beyond this, the correlation was moderate, with the final errors remaining above -60% (Table 4). The measured stresses were linear with respect to the increase in truck load (Figure G.7), and the analysis results were all conservative. The overall rating was weak as a result of the high errors.

The rating remained weak for the 2000 data for this gage. The percent errors for the nine and three truck cases ranged from –52% to –91%, all conservative results (Table 5). The rating of this gage was still weak due to high percent errors and relatively high stresses.

Gage 19B had percent errors remaining just less than 30% (Table 4). The range of the errors for the total stress cases was -26% to -30%. The analysis results were conservative for all of the cases except Step 1-1, but the increase in stress was not linear with respect to an increase in truck load; the stress decreased slightly between the two and three truck cases (Figure G.8). However, the overall rating was strong.

Gage 19B was the only gage to change its rating from 1997 data to 2000 data. The percent errors for 1997 data were close to the 30% cutoff, and the stresses were different enough to impact the percent errors and push them up to 30% d 31% for the nine and three truck cases, respectively (Table 5). The total stresses remained above 5 ksi.

Gage 20B also correlated well. All of the total stress errors were between 4% and 6% (Table 4). Gage 20B was similar to gage 19B for the linear plots, with a slight decrease in stress between the two and three truck cases (Figure G.8). This gage was not conservative for any of the total stress cases, but since the errors were so small, the rating was strong.

The total stress percent errors ranged from 3% to 6% in the live load cases for the 2000 data (Table 5). The analysis was not conservative for the 2000 data, but because the percent errors were small the rating remained strong.

Gage 21B also correlated well with the analysis. The total stress errors ranged between 4% and 13% (Table 4) and the stresses increased linearly with the increase in truck load (Figure G.8). The analysis results were not conservative for any of the total stress cases. The overall rating was strong due to the low errors.

This gage behaved similarly to 1997 data in the 2000 total stress cases. The percent errors were from 5% to 13% in the total stress cases (Table 5). The analysis wasn't conservative, but errors were low, so the rating remained strong.

Gage 22B was the final weak gage in the middle pier region. This gage probably had some initial fit-up stresses from the dead load up to Step 3-3a, and it correlated moderately well thereafter. The error at the end of the dead loading was -35%, and the total stress errors ranged between -29% and -50% (Table 4). The stresses increased linearly with the increase in truck load (Figure G.8), and the analysis results were conservative for all of the total stress cases. The overall rating remained weak because of the high percent errors throughout.

The 2000 data yielded a percent error range in the nine and three truck cases of –21% to –39% (Table 5). Gage 22B's behavior was similar to the 1997 data and the gage received a weak rating due to high percent errors.

Gage 23B had a strong correlation, with a maximum tabulated stress error of 20% (Table 1). Its behavior was linear with respect to an increase in truck load (Figure G.8). However, the analysis results were not conservative for any of the total stress cases.

In 2000, gage 23B showed strong correlation to the 1997 analysis results. None of the total stress cases were conservative with respect to the 2000 data, but all the percent errors were 20% or lower, so the rating was strong (Table 5).

Gage 24B was similar to gage 23B. Its correlation was strong, with a maximum tabulated stress error of 15% in Table 1. The stresses increased with the increase in truck load (Figure G.8), but the only total stress analysis that was conservative compared to the measured data was Case 1. The overall rating was strong due to the low errors.

The correlation was again strong, with percent errors similar to the 1997 measured data, but it should be noted that this gage had behaved erratically since the 1997 tests, and all conclusions about this gage with respect to change in behavior from 1997 to 2000 should be made with the knowledge of the erratic behavior.

Gage 1C had a weak correlation, with percent errors of approximately 60%. The analysis was never conservative and the increase in stress was not linear with the increase in truck load (Figure G.9). The range of errors for the total stress cases was 47% to 78%, which could be an effect of the high dead load error from Step 4-2 of 62% (Table 4).

The 2000 data was virtually identical to the 1997 data, ranging from 47% to 78% for the live load cases, and consequently the correlation was again weak (Table 5).

Gage 2C had a moderate correlation, receiving this rating because of its low stress magnitudes. The percent errors were high, but there was little stress induced in the gage from the bridge weight and truck loading. The measured stress was not linear with the increase in truck loading (Figure G.9), and the analysis results were conservative for approximately half of the total stress cases (Table 4).

The stress magnitudes were again low in the 2000 tests. The percent errors were similar to the 1997 data and a moderate rating applied again for 2000 data with respect to 1997 analysis.

Gage 3C also had a moderate correlation because of its low measured stresses. The errors for the total stress were not as high as for gage 2C because the stresses for 3C were on the order of 4 ksi (versus less than 1 ksi for gage 2C). The total stress errors were still quite high though, with the errors ranging between -65% and -176% (Table 4). The measured stress was not linear with the increase in truck loading (Figure G.9), and the analysis results were conservative for only a little over half of the cases.
The percent errors and stress magnitudes were on the same order for the 2000 data as the 1997 data. The analysis was again conservative in only about half the cases. The rating for this gage remained moderate due to low stress magnitudes.

Gage 4C had errors ranging between 64% and 69% for the total stress cases, and the errors at the end of the dead load were 57% and 65% respectively for Step 3-3a and Step 4-2 (Table 4). The analysis results were not conservative for any of the loading cases. The increase in stress was not linear with the increase in truck load (Figure G.9), and due to the errors exceeding 30%, the overall rating was weak.

In 2000, the analysis was not conservative for the live load cases. The total stress magnitudes were all above 5 ksi. The percent errors were again on the same order as the 1997 data, so the overall rating of this gage remained weak.

Gage 5C had results very similar to gage 4C. The errors ranged between 61% and 85% for the total stresses, and the errors for Steps 3-3a and 4-2 for the dead load were 68% and 72% respectively (Table 4). The behavior was not linear for the linear plots (Figure G.10), and the analysis results were never conservative for any of the analyses. The overall rating was weak due to the high errors.

The 2000 data was remarkably similar to the 1997 data, and the rating of the gage was weak due to high stress and high percent errors.

Gage 6C had moderate correlation. The stress magnitude in this gage was generally below 5 ksi, but the errors were only -24% to -52% for the total stress cases (Table 4). The increase in stress was not linear with the increase in truck load (Figure G.10), but the analysis results were conservative for all of the cases except dead load Step 1-1. The overall rating was moderate because three of the four tabulated errors exceeded 30% and the stress magnitudes were below 5 ksi.

Gage 6C had three live load cases that resulted in stresses over 5 ksi. However, because 9 of 13 of the reads were below 5 ksi, the rating was moderate even though the total stress percent errors were similar to the errors from the 1997 measured results.

Gage 7C had errors for Step 3-3a, Step 4-2, and the averages for the three and nine truck cases were 9%, 33%, 34%, and 35%, respectively (Table 4). The increase in stress with the increase in truck load showed mild nonlinearity (Figure G.10), and the analysis results were not conservative for any of the cases beyond Step 1-1. The overall rating was weak since three of the four errors just exceeded 30%.

The 2000 data was again remarkably similar to the 1997 measured data and yielded the same weak rating for this gage. The analysis was not conservative for the 2000 data.

Gage 8C was similar in its percent errors to gage 5C. It had total stress percent errors between 66% and 76% (Table 4), its behavior was not linear for the linear plots (Figure G.10), and the analysis results were not conservative for any of the analyses. The total stress errors remain in the same range as the errors from Step 3-3a, 56%, and Step 4-2, 72%. There may have been some fit-up stresses from the dead load up to Step 3-3a, which would account for the high errors from the dead load cases, but the correlation was only moderate thereafter. The overall rating was weak due to its high errors.

The stresses recorded in 2000 gave the same rating as the 1997 data. No significant change in percent errors was noted with respect to the 1997 analysis, and the total stresses were above 5 ksi in all cases.

Gage 9C had moderate correlation since its stress magnitudes were less than 5 ksi. The error was only 22% for Step 3-3a, but then increases to 63% for Step 4-2 and remained in this range for the total stress cases (Table 4). The stresses do not increase linearly with an increase in truck load (Figure G.11), and the analysis results were unconservative for the gage.

The total stresses in the nine and three truck cases were less than 5 ksi in 2000. The percent errors for the total stresses were on the same order as the 1997 data, so the rating of gage 9C remained moderate.

Gage 10C also had moderate correlation because its measured stress magnitudes were less than 5 ksi. The stresses do show a linear increase with the increase in truck load (Figure G.11), being the only gage in the crossframes that had this property. The analysis results were conservative for all of the total stress cases (Table 4), and the total stress errors were in the range of -48% to -78%. The overall rating was moderate.

In 2000, gage 10C received a moderate rating due primarily to its low total stresses. Total stress percent errors range from –53% to –94% (Table 5).

Gage 11C was the final weak gage in the crossframes. The total stress percent errors were 19% to 53%, with the error from dead load Step 4-2 at 43% (Table 4). The stress did not increase linearly with the increase in truck load (Figure G.11), and the analysis results were not conservative for any of the total stress cases.

Gage 11C's 1997 analysis was not conservative for any of the 2000 data, and the average of the percent errors was 39% for the nine truck cases and 42% for the three truck cases (Table 5). The rating was again weak for this gage.

Gage 12C was a gage that continually gives sporadic readings (Table 4). It was hard to determine any trends for this gage since the data was so limited, but the overall rating given as moderate since the available stresses were all less than 5 ksi.

Gage 12C failed prior to the 2000 test date.