**RAI 03.07.01-28, Revision 1**

**QUESTION:**

**Follow-up Question to RAI 03.07.01-20 (STP-NRC-100036)**

In the response to Item 2a) of the RAI 03.07.01-20, the applicant has calculated the site-specific vertical and horizontal soil spring values for the STP soil conditions for the Control Building (CB) using drained Poisson's ratios of 0.15 to 0.30. The weighted soil spring values obtained for the STP best estimate, upper range, and lower range soil cases are shown in Table 03.07.01-20c, where they are compared against those estimated using the soil input from DCD, Section 3H.2.4.2.1. For the best estimate and upper range soil cases, the calculated site-specific soil spring values for the CB are the same or higher than those of the DCD; for the lower range soil case, the calculated spring constants are lower than those of the DCD.

To evaluate the impact of the lower spring constants calculated for the CB on the mat design, the applicant has performed a sensitivity analysis comparing the stresses in the CB base mat obtained using the site-specific lower range spring values versus those obtained using the DCD-derived soil spring constants. This analysis was performed for the total dead load of the structure with seismic moment applied about the x-axis (along East-West). Based on the results of this analysis, the applicant has stated that there is no significant difference in the mat stresses calculated using site specific and DCD spring values.

In evaluating the mat stress analysis results, it is noted that for the seismic load combination, the seismic moment has been applied about the x-axis (along East-West) in which the mat is expected to behave in a more rigid manner (with the results presented in Figures 03.07.01-20b through 03.07.01-20i). However, it is not clear whether the stress analysis of the CB mat foundation included the vertical seismic loads. Furthermore, the mat is expected to behave in a more flexible manner about the y-axis (North-South direction) as compared to the x-axis (East-West direction) (as the mat thickness/length ratio is larger in the y-direction as compared to the x-direction, and the two shear walls in the y-direction have no stiffening effect on the mat flexural behavior about the y-axis). As such, the applicant is requested to evaluate the mat stresses due to seismic moment acting about the y-axis. The applicant is also requested to clarify whether the vertical seismic loads were included in the sensitivity analysis, and if not what is the justification for not including the vertical seismic loads in the mat stress analyses. The staff needs this information to conclude that CB foundation mat on STP site will be bounded by the standard plant CB design.

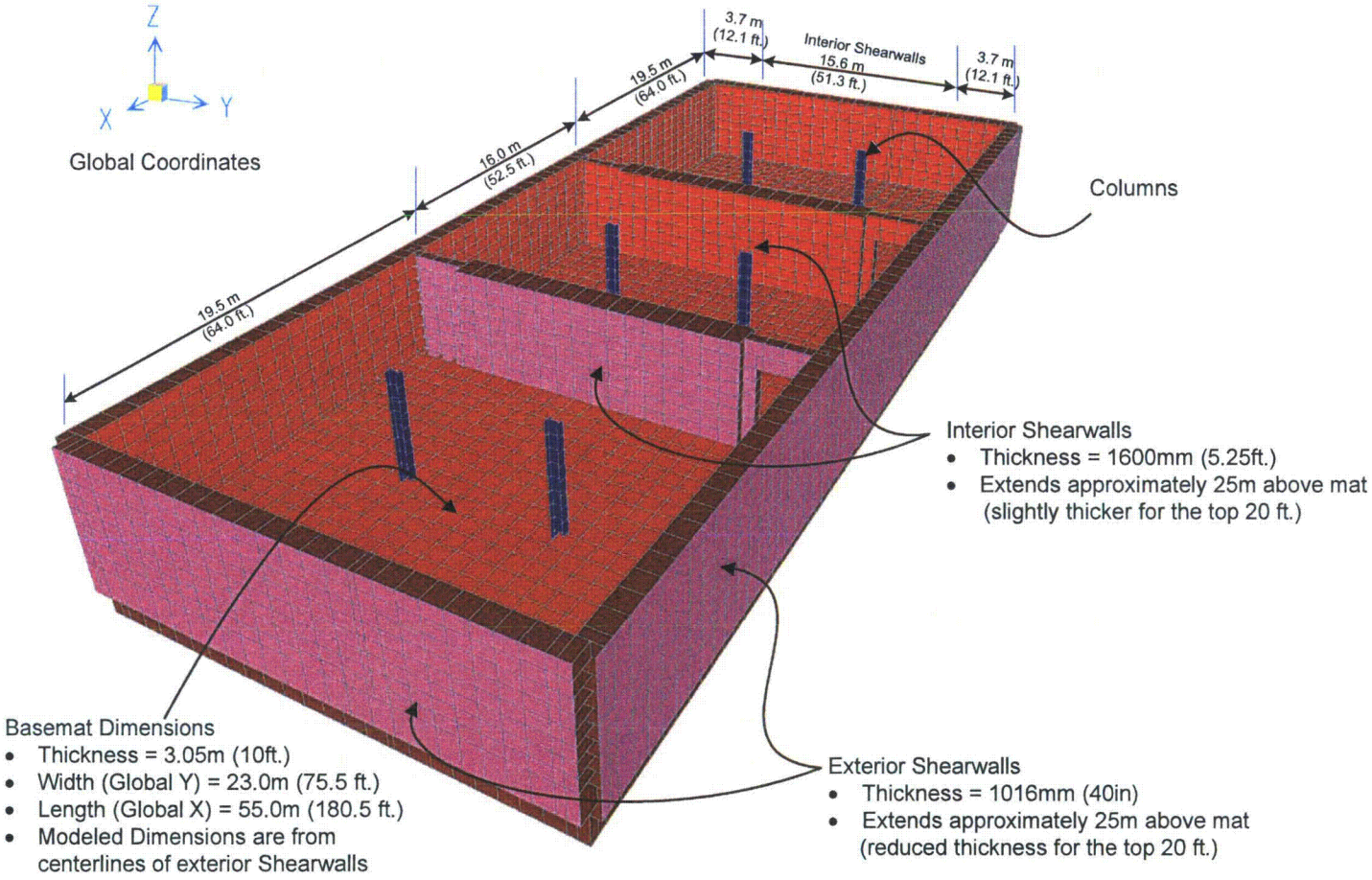
**REVISED RESPONSE:**

The original response to this RAI was submitted with STPNOC letter U7-C-STP-NRC-100208, dated September 15, 2010. This revision is being provided to include acceptability of potentially lower Control Building soil spring constants in COLA, based on discussions with the NRC on February 2nd and 3rd, 2011. The revisions are indicated by revision bars in the margin.

In the sensitivity/parametric study presented in response to RAI 03.07.01-20 vertical excitation was not considered because it would not have any impact on the conclusion of the parametric study. In order to demonstrate that neither inclusion of vertical excitation nor consideration of moment about the Y-axis will have any impact on the conclusion of the parametric study presented in response to RAI 03.07.01-20, the parametric study was repeated as follows.

Figure 03.07.01-28.1 shows the layout of the mat and the shear walls of a structure with a very similar arrangement to that of the Control Building as described in the DCD. The model used for this parametric study is a three dimensional finite element model. This model was analyzed eight times for the total dead load of the structure, vertical excitation (up or down) along with significant seismic moment about either the X-axis (along East-West) or the Y-axis (along North-South), once with DCD best estimate spring constants and the second time with lower bound site-specific spring constants. Figures 03-07-01-28.2 through 03-07-01-28.33 present contour plots of the resulting out-of-plane moments and shears. Comparison of the resulting out-of-plane moments and shears from these figures show that there is no significant change in mat design forces.

COLA Part 2, Tier 2 Sections 3H.1 and 3H.2 will be revised as shown in Enclosure 1.




**3-D View of Parametric Study Model**

- Cross Section up to 1st Level above Mat for clarity.
  - Non Shearwalls not shown.

**Figure 03.07.01-28.1**

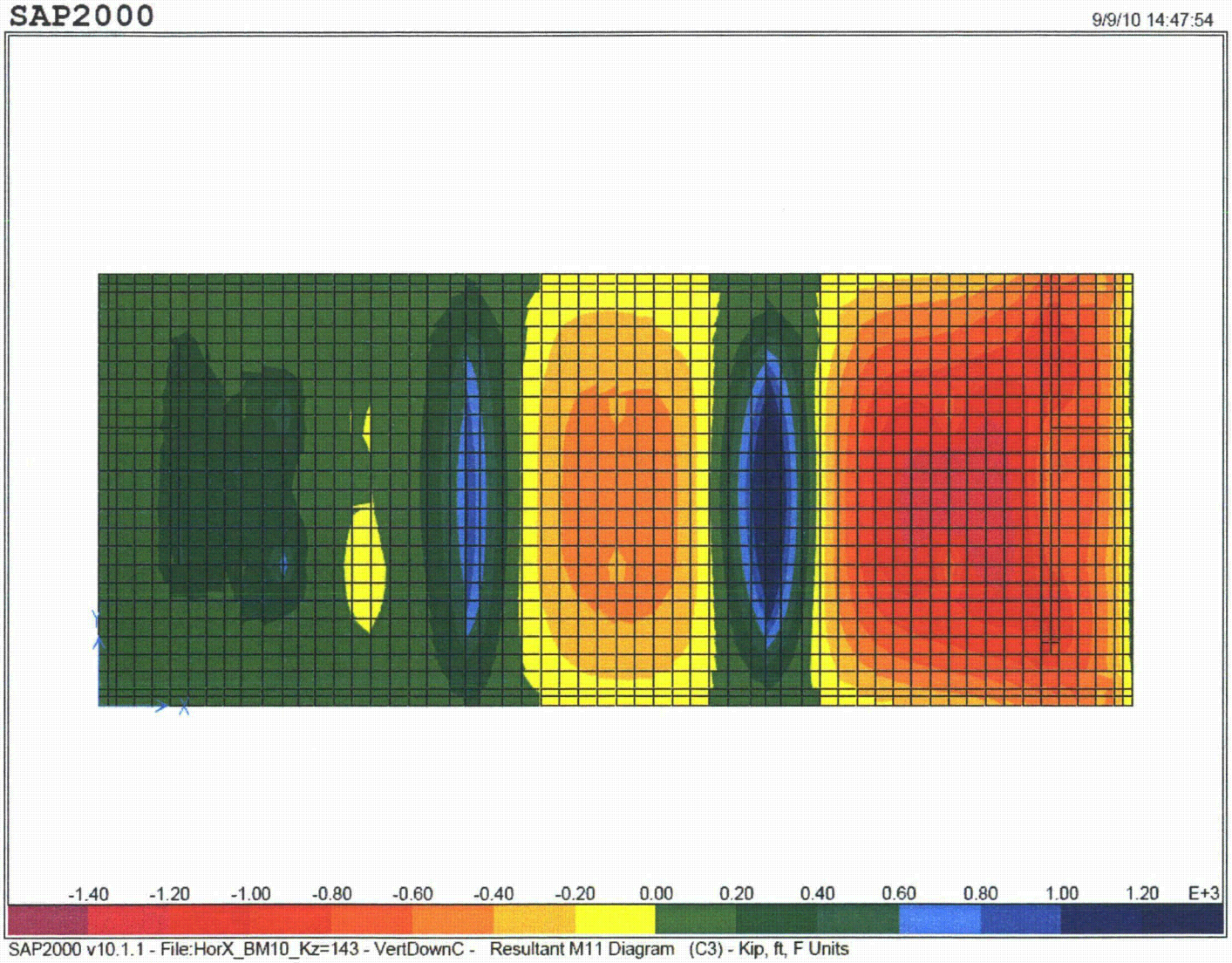



**Figure 03.07.01-28.2: Resultant Out-of-Plane Moment M11 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

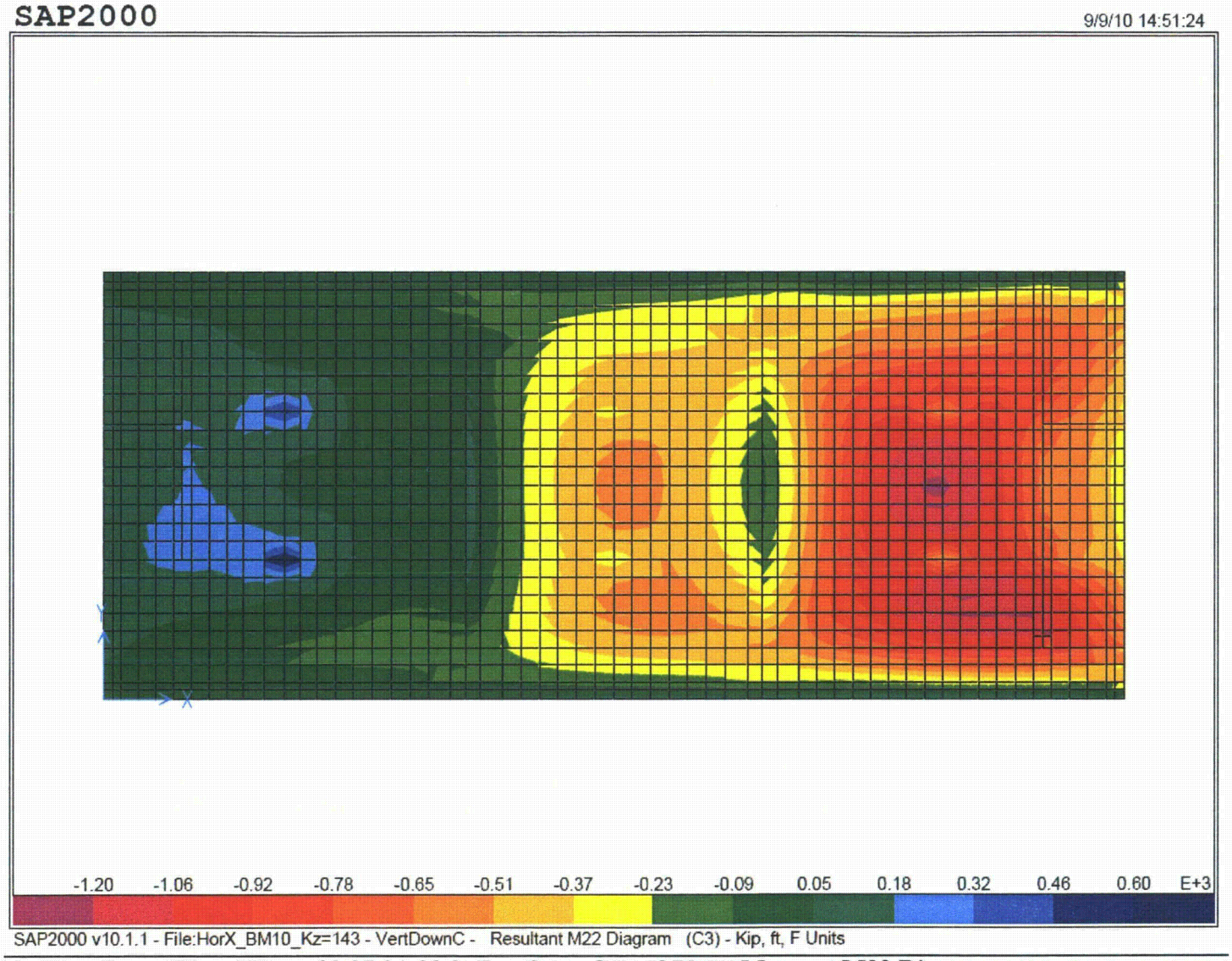



**Figure 03.07.01-28.3: Resultant Out-of-Plane Moment M22 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

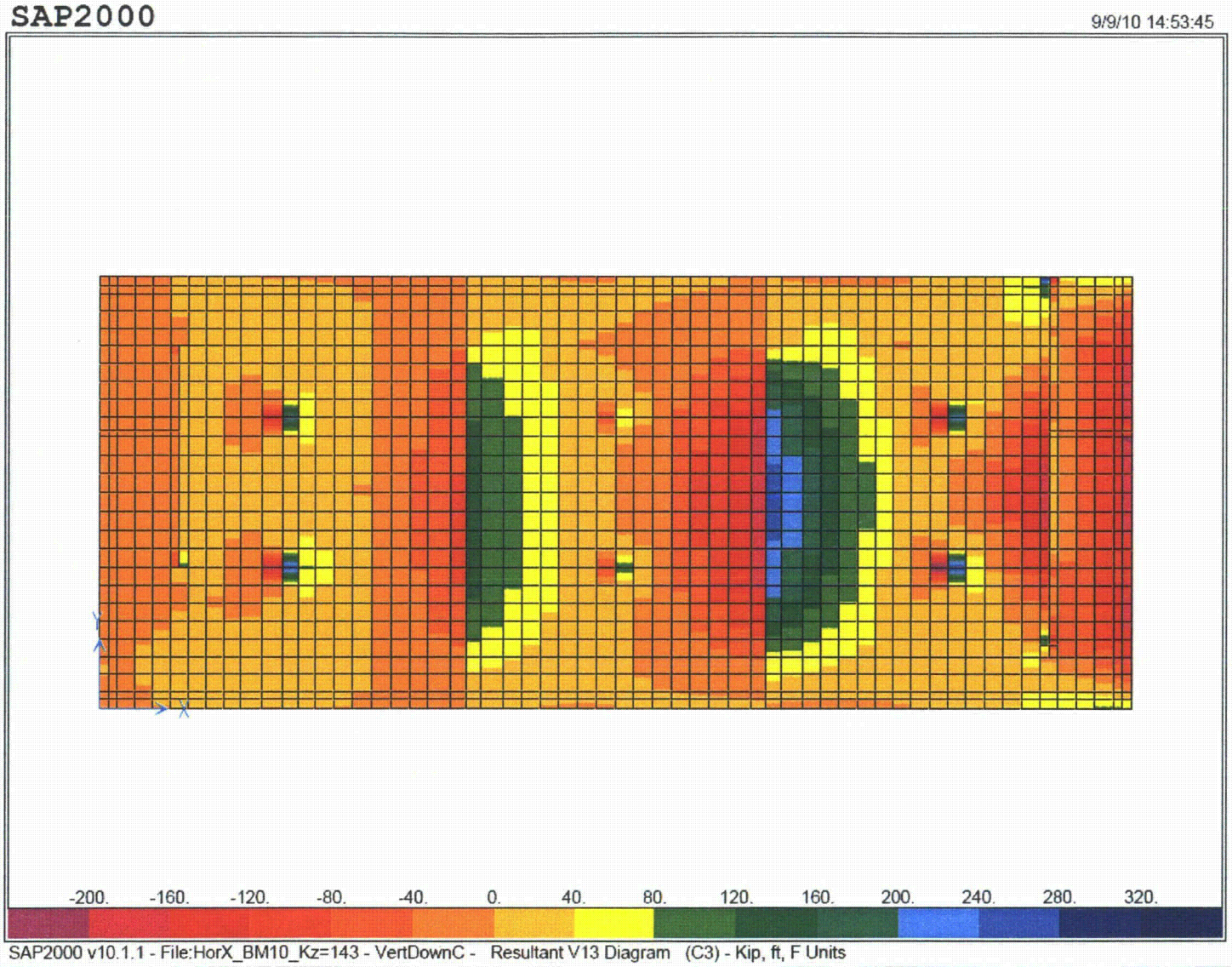



**Figure 03.07.01-28.4: Resultant Out-of-Plane Shear V13 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

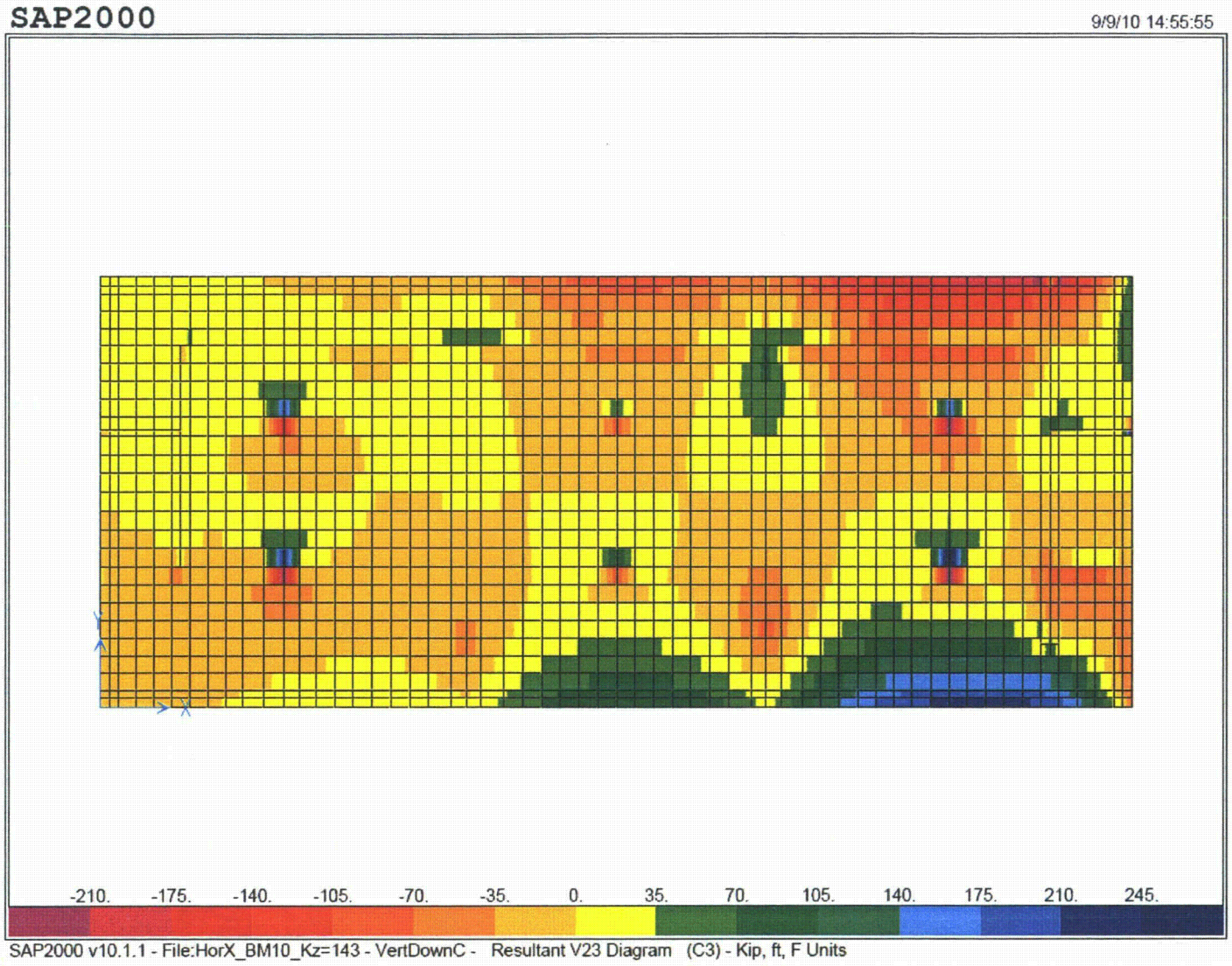



**Figure 03.07.01-28.5: Resultant Out-of-Plane Shear V23 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

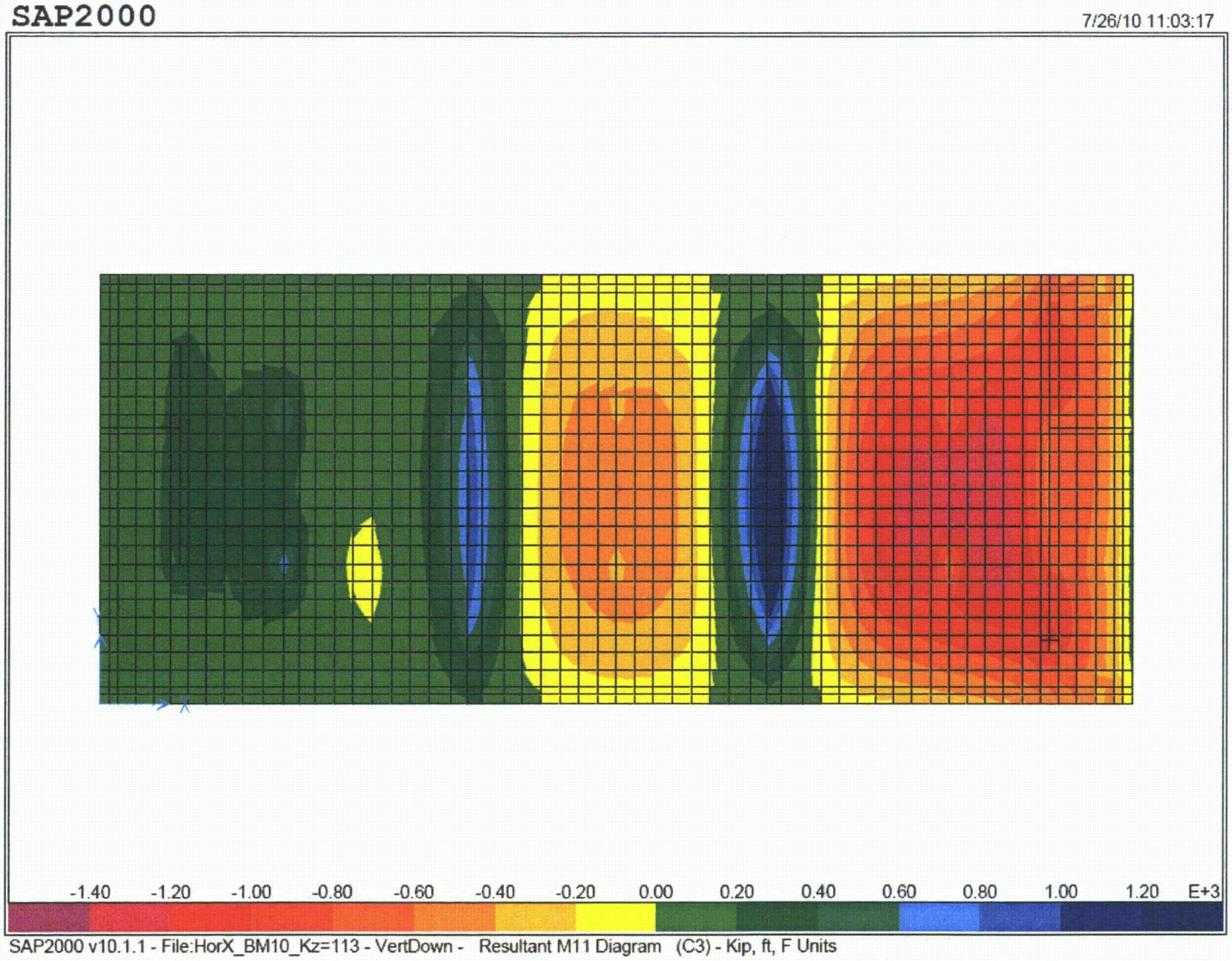



**Figure 03.07.01-28.6: Resultant Out-of-Plane Moment M11 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

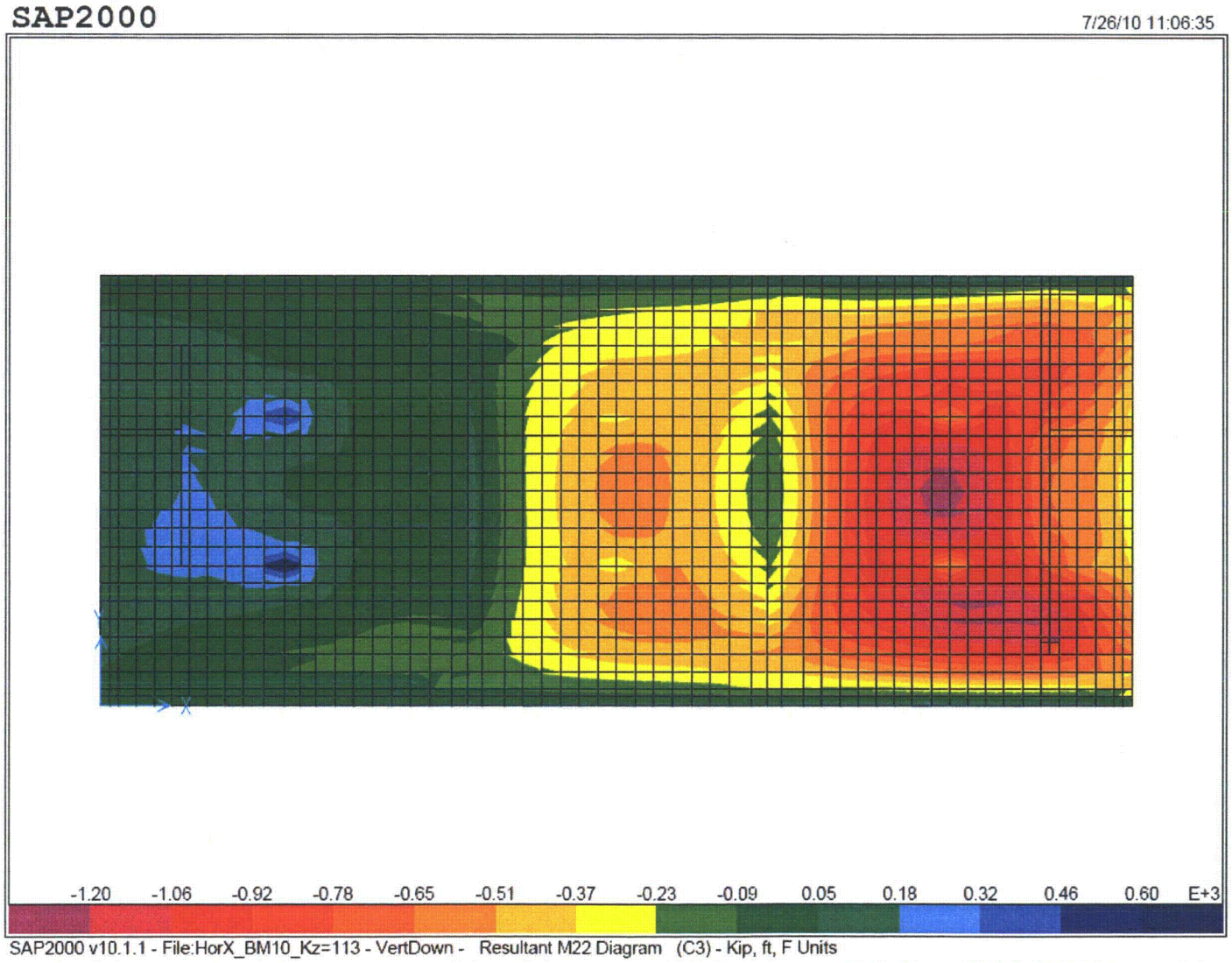



**Figure 03.07.01-28.7: Resultant Out-of-Plane Moment M22 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

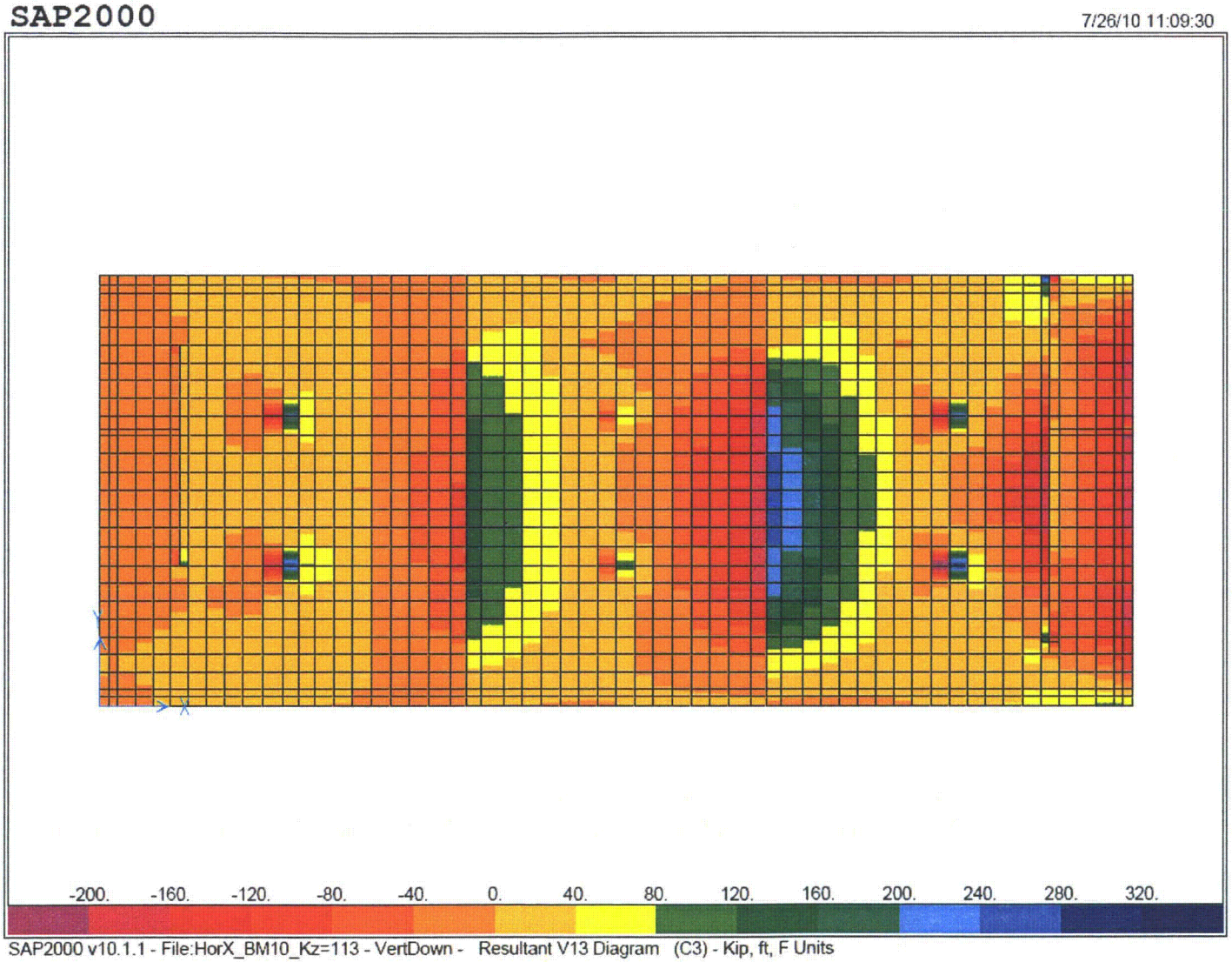



**Figure 03.07.01-28.8: Resultant Out-of-Plane Shear V13 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

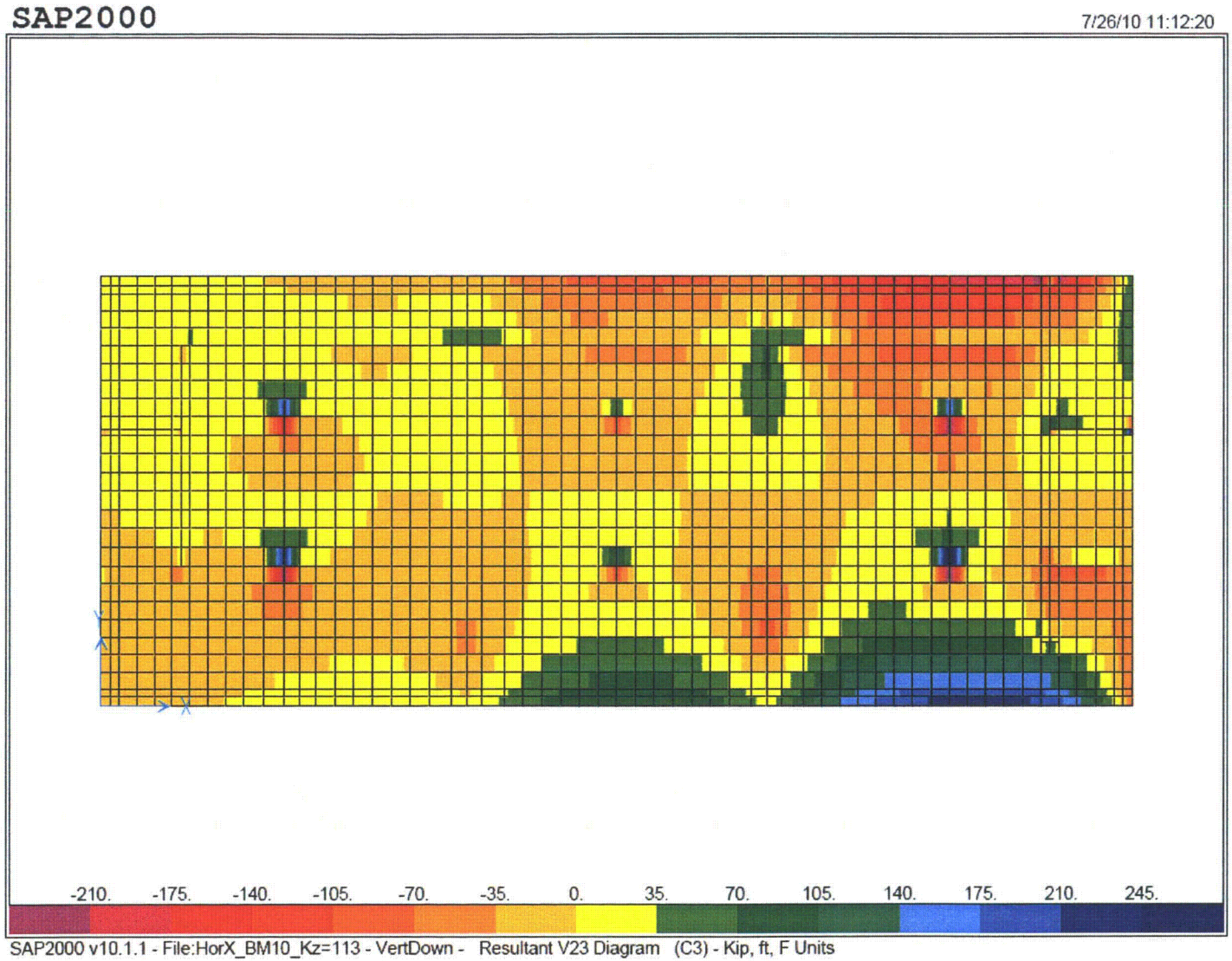



**Figure 03.07.01-28.9: Resultant Out-of-Plane Shear V23 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_y$**

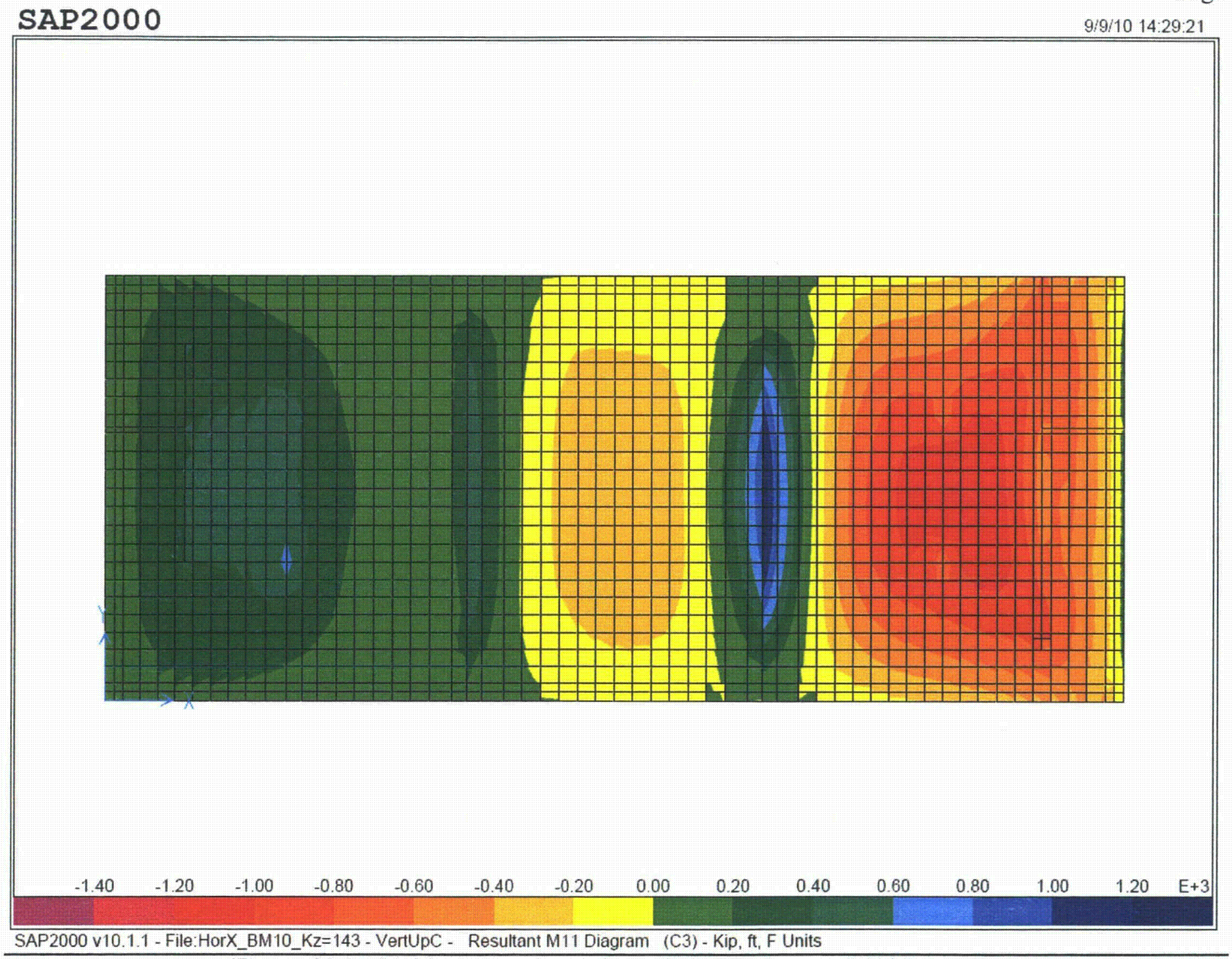



**Figure 03.07.01-28.10: Resultant Out-of-Plane Moment M11 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

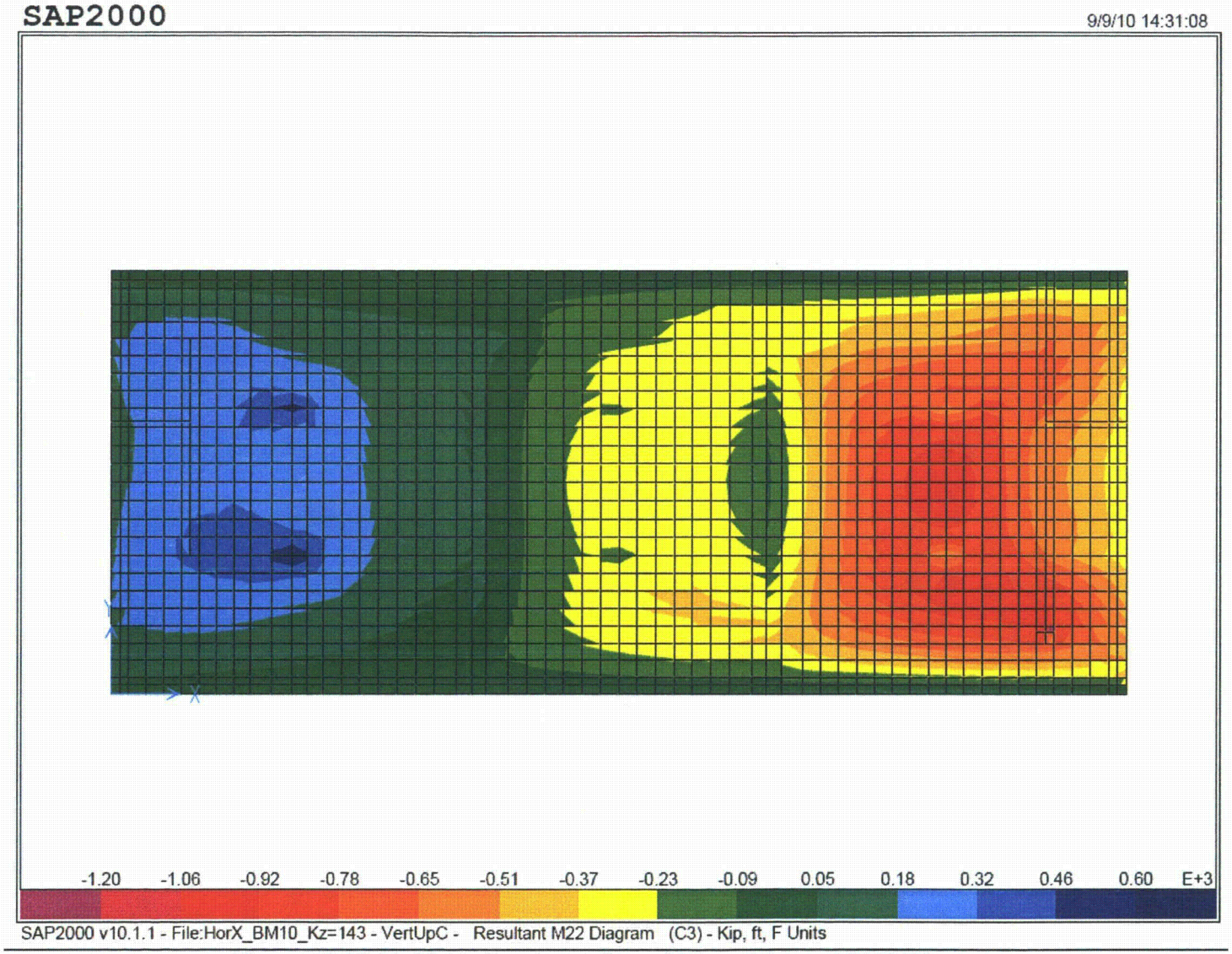



**Figure 03.07.01-28.11: Resultant Out-of-Plane Moment M22 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

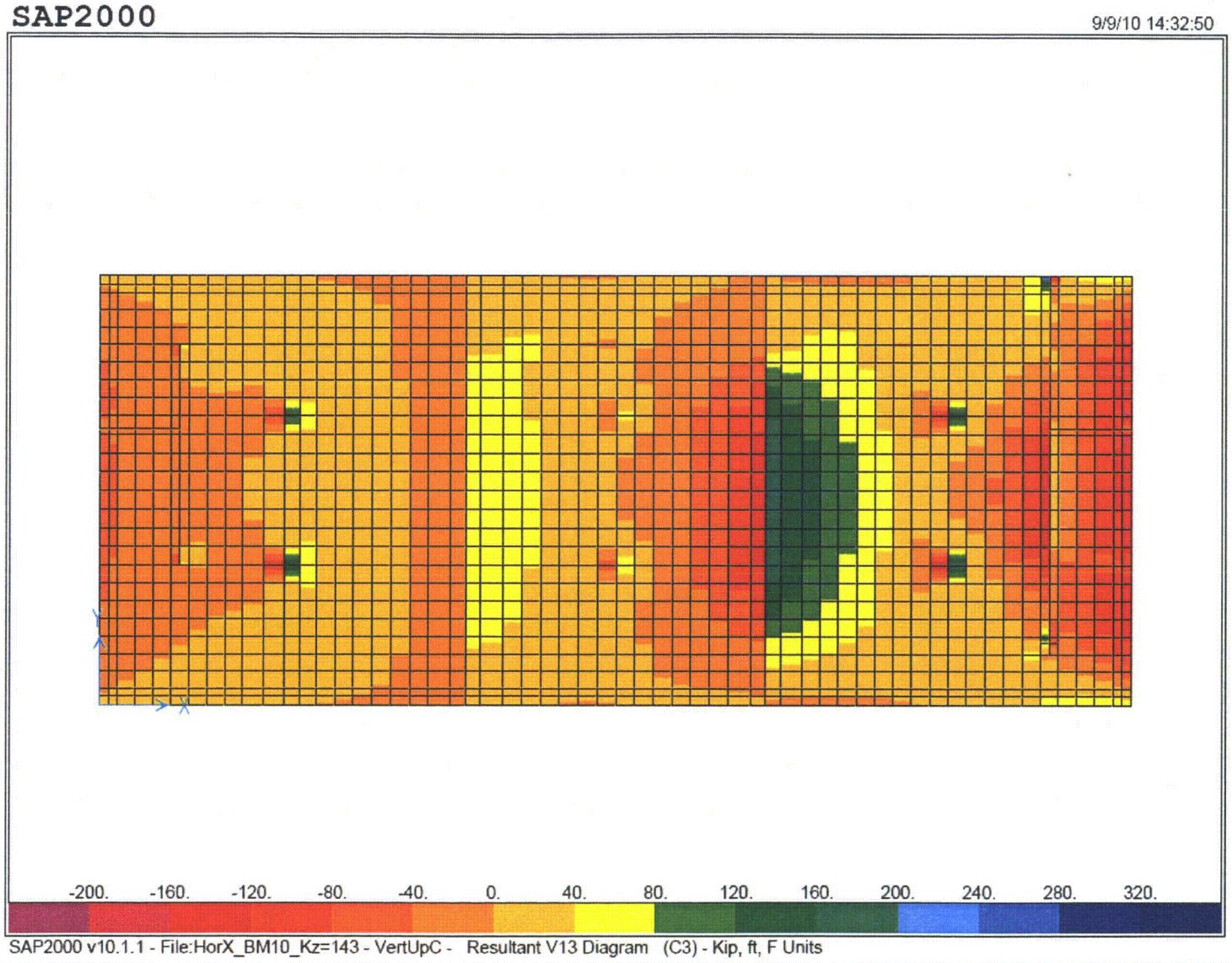



**Figure 03.07.01-28.12: Resultant Out-of-Plane Shear V13 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

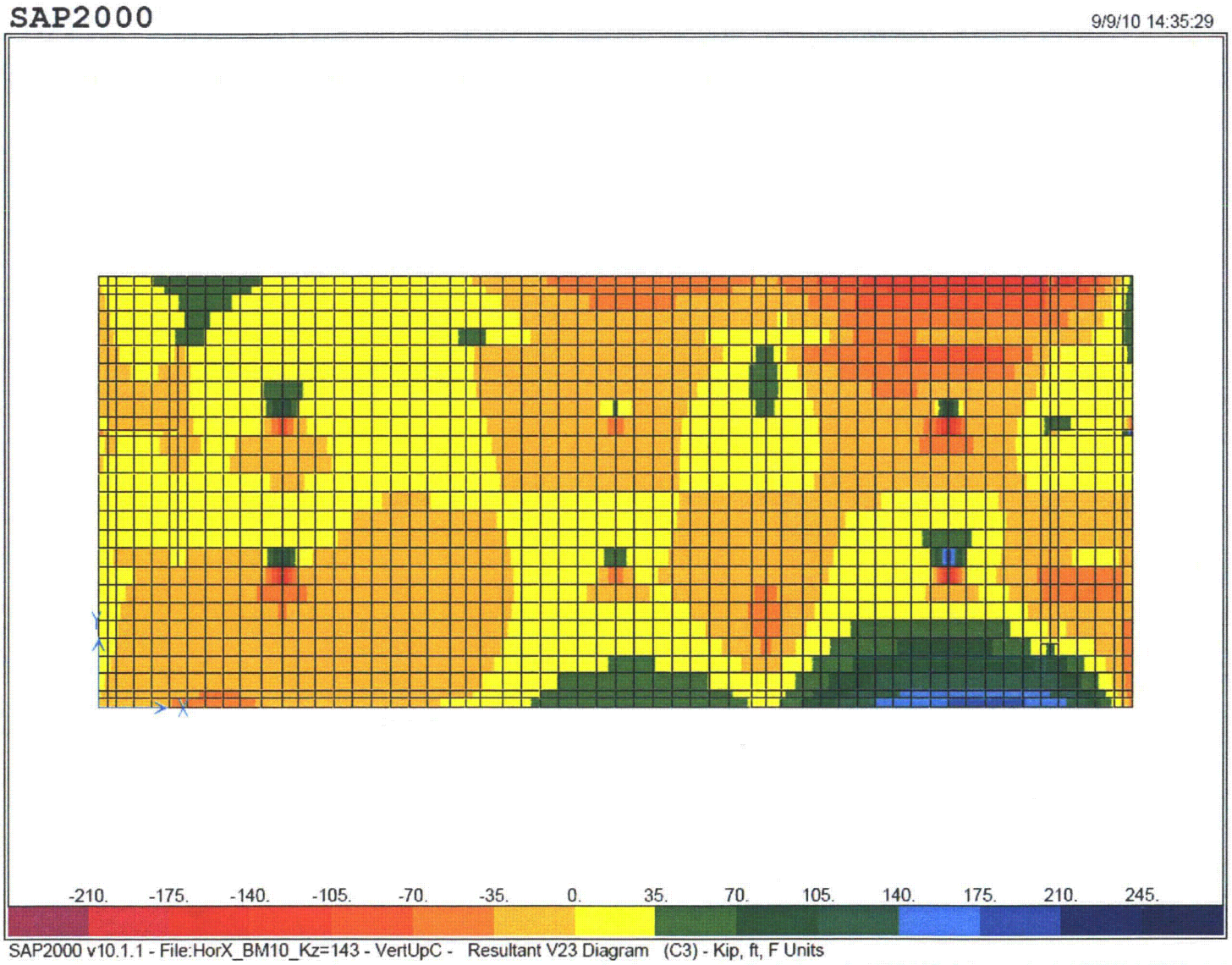



**Figure 03.07.01-28.13: Resultant Out-of-Plane Shear V23 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

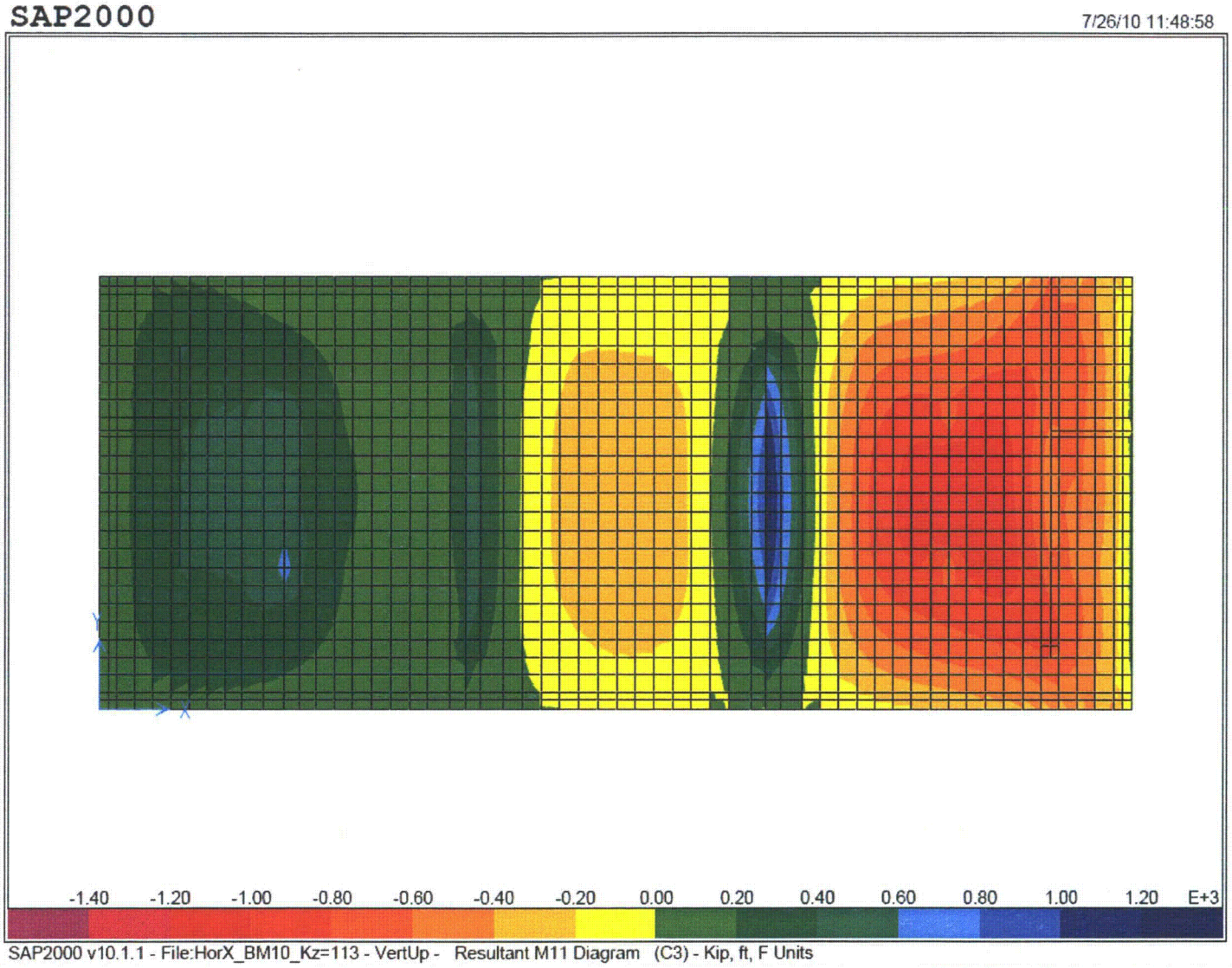



**Figure 03.07.01-28.14: Resultant Out-of-Plane Moment M11 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

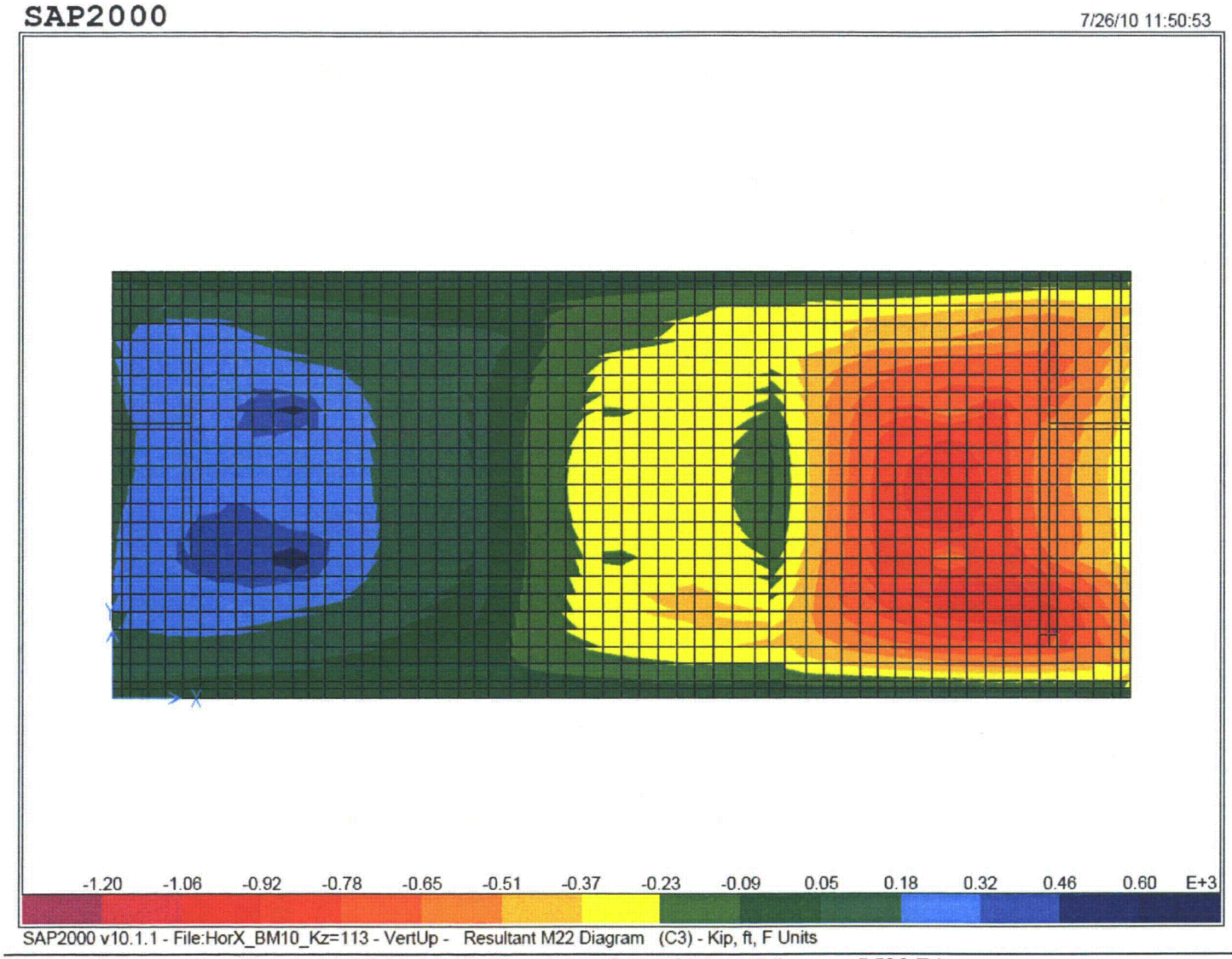



**Figure 03.07.01-28.15: Resultant Out-of-Plane Moment M22 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

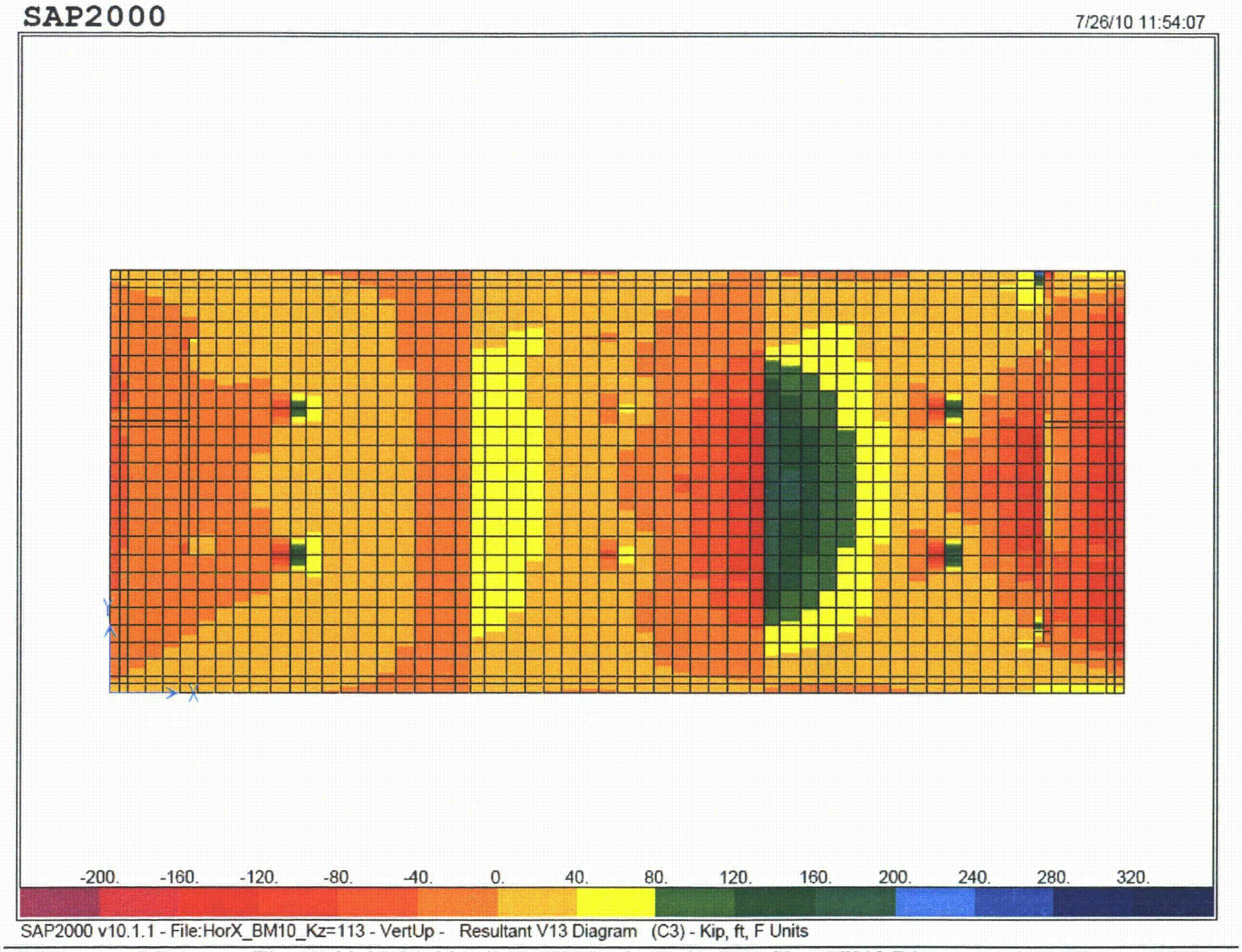



**Figure 03.07.01-28.16: Resultant Out-of-Plane Shear V13 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

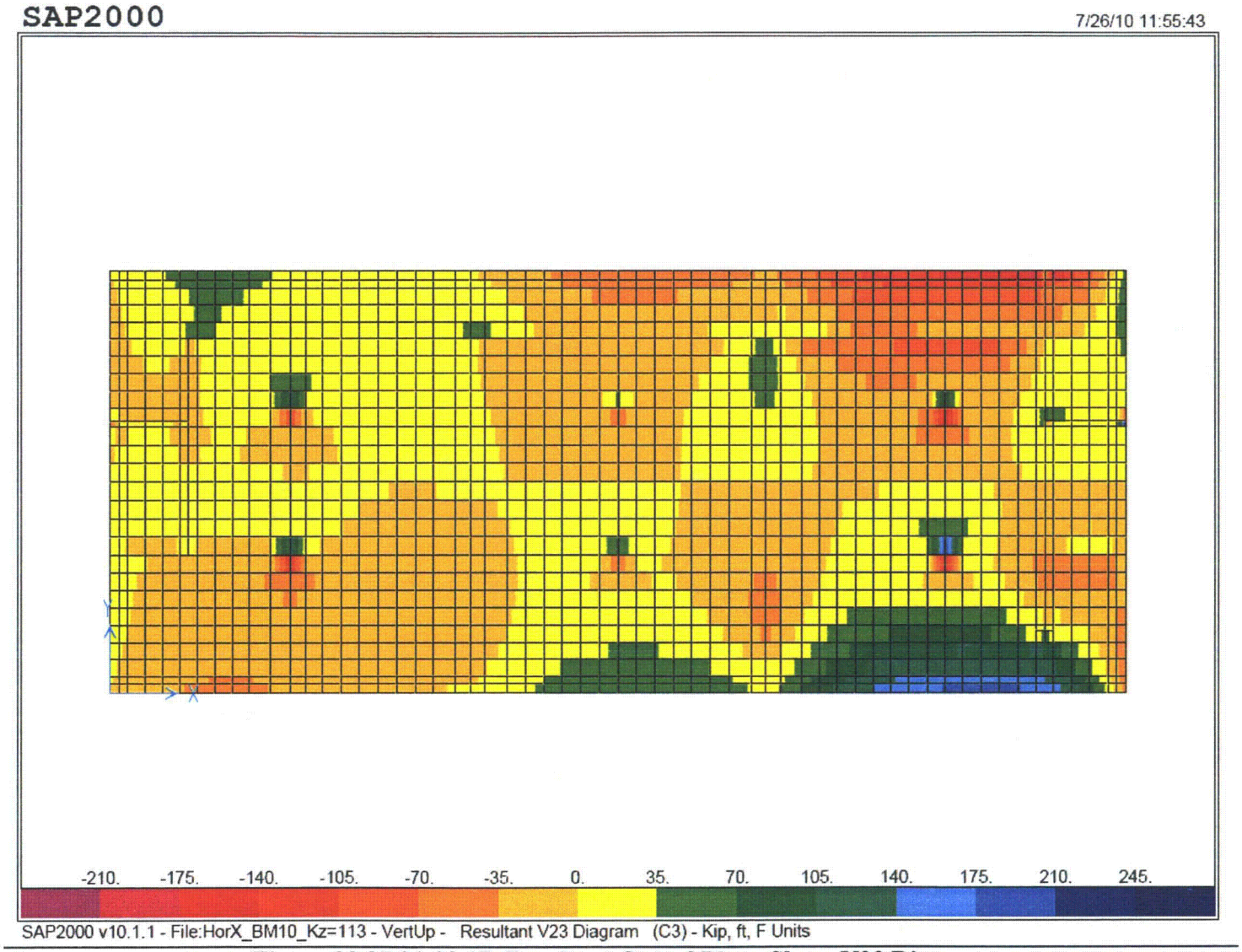



**Figure 03.07.01-28.17: Resultant Out-of-Plane Shear V23 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_y$**

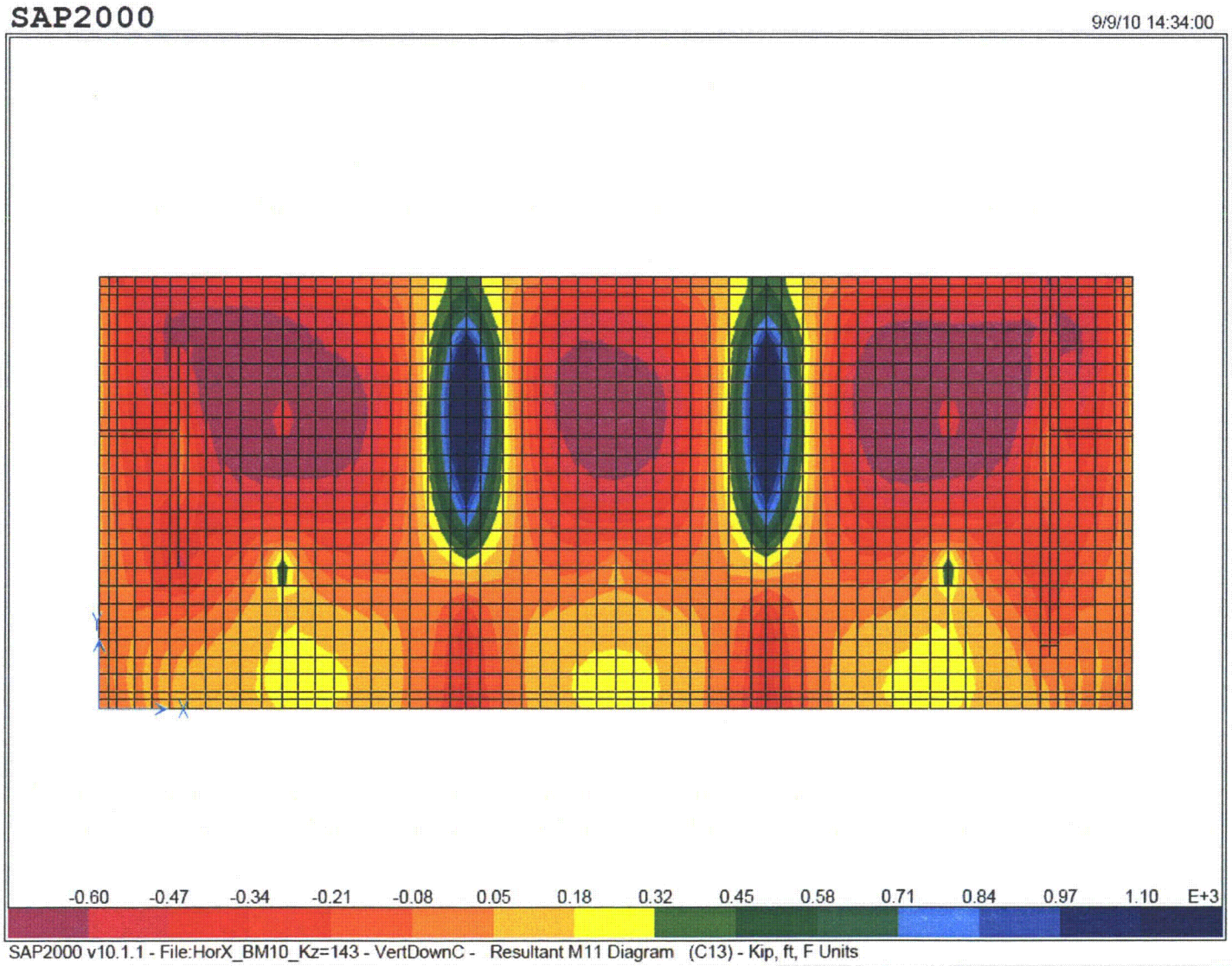



**Figure 03.07.01-28.18: Resultant Out-of-Plane Moment M11 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

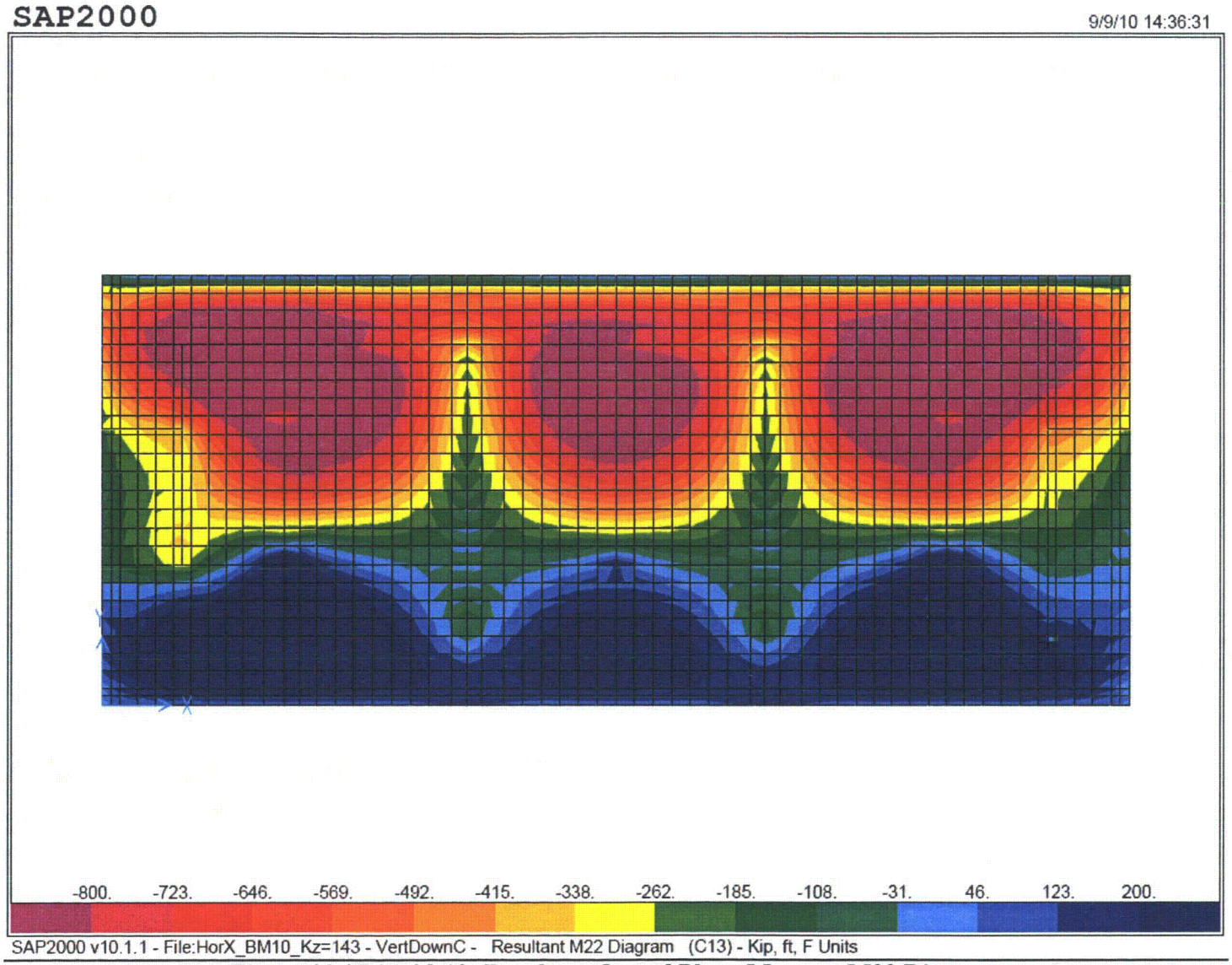



**Figure 03.07.01-28.19: Resultant Out-of-Plane Moment M22 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

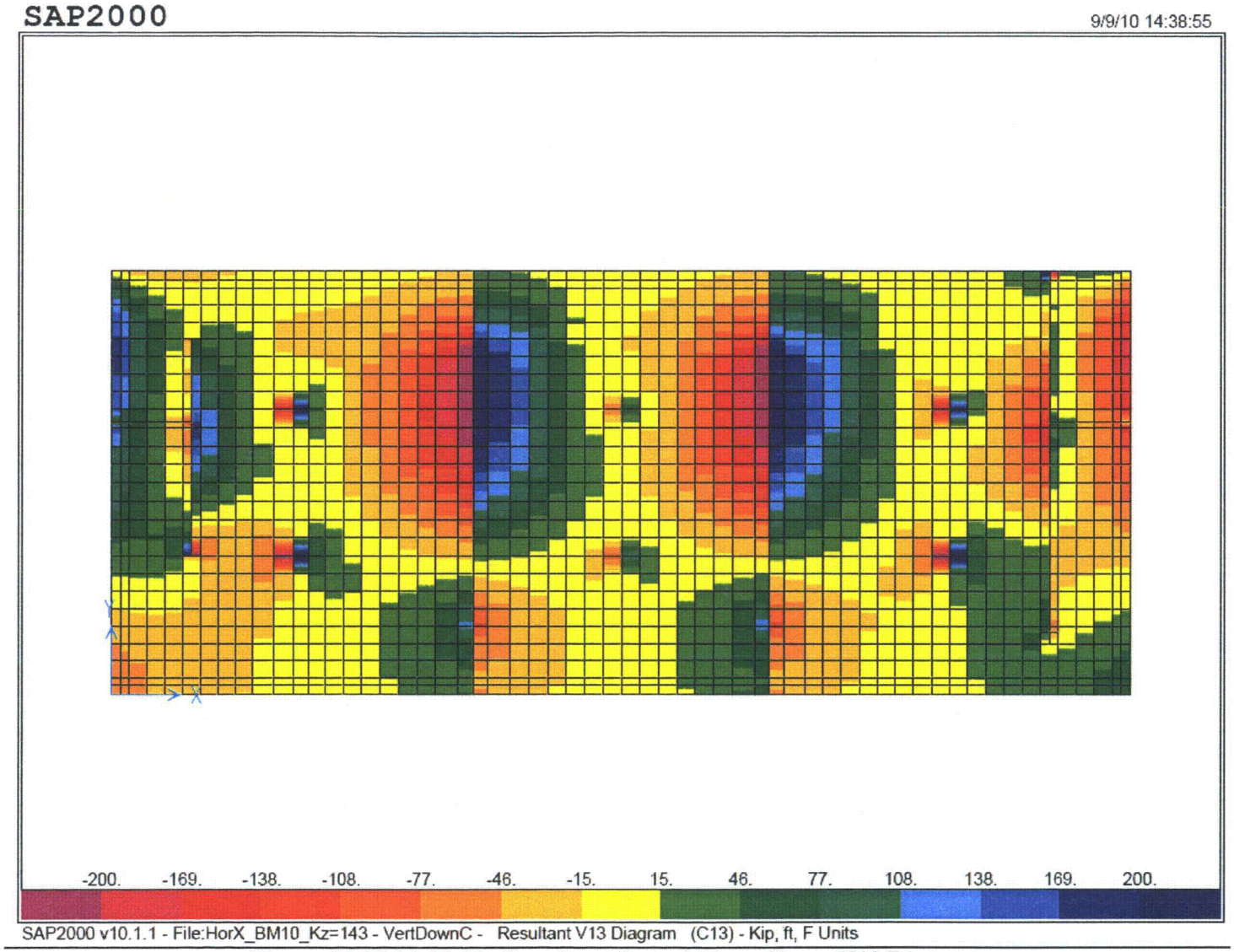



**Figure 03.07.01-28.20: Resultant Out-of-Plane Shear V13 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

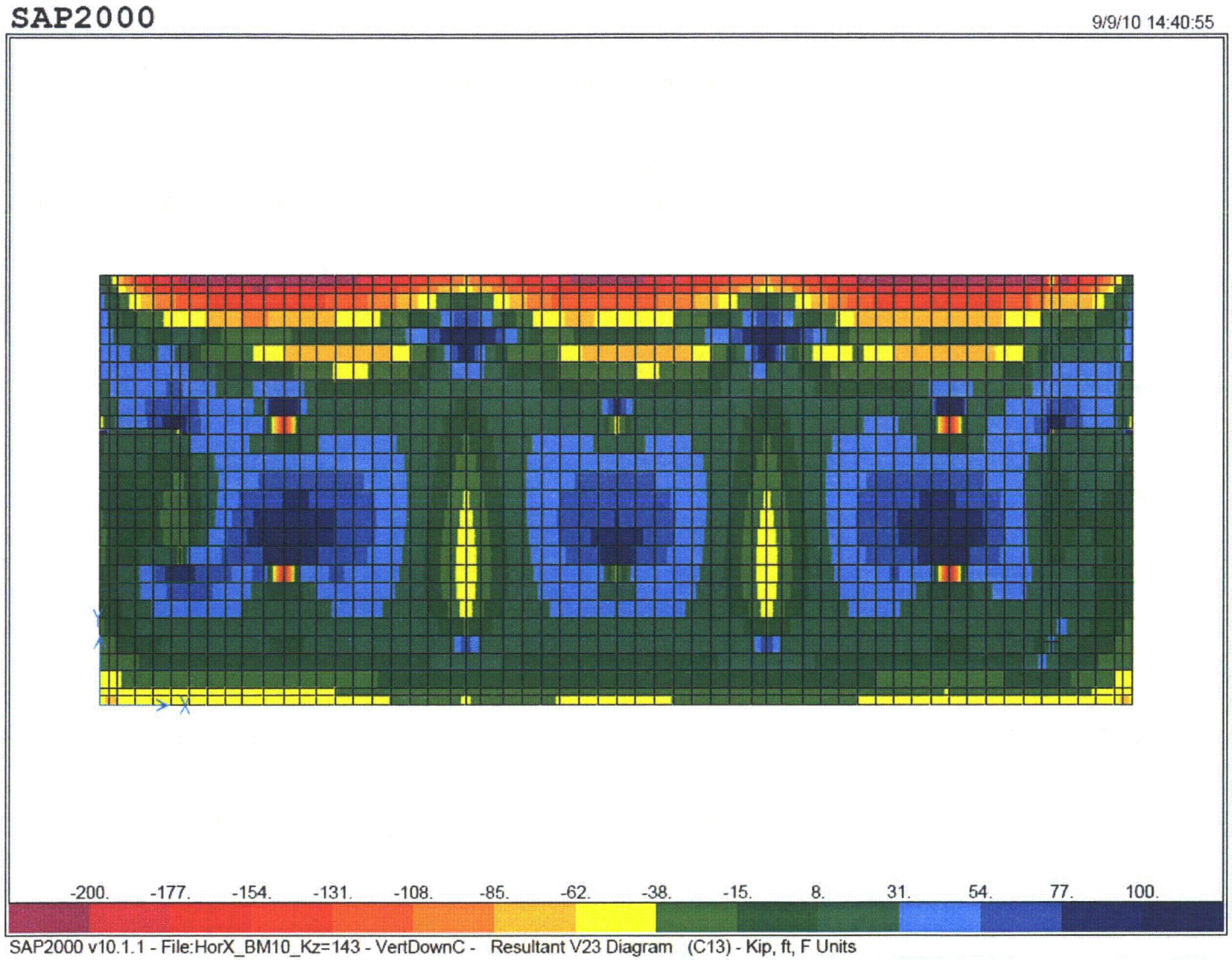



**Figure 03.07.01-28.21: Resultant Out-of-Plane Shear V23 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

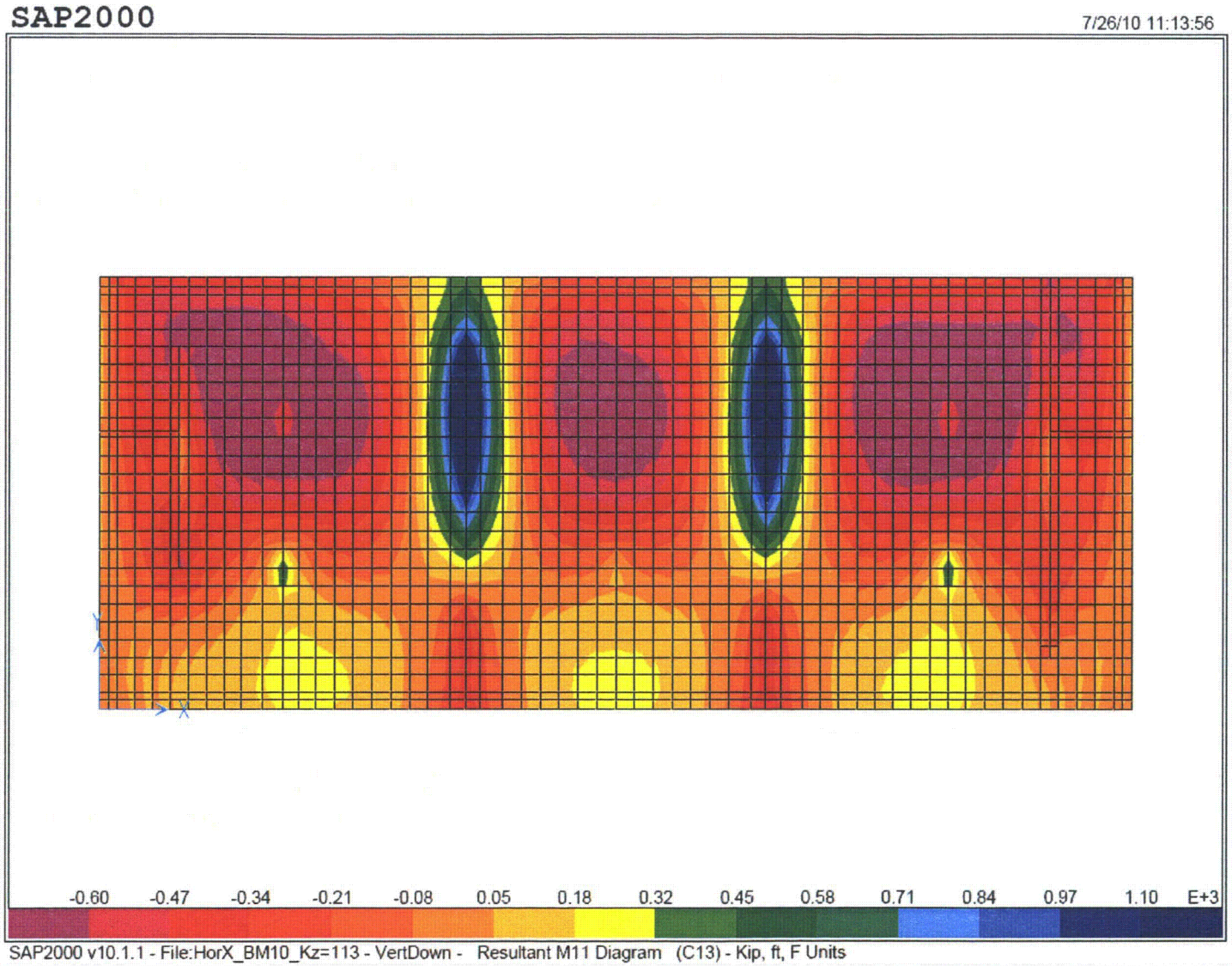



**Figure 03.07.01-28.22: Resultant Out-of-Plane Moment M11 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

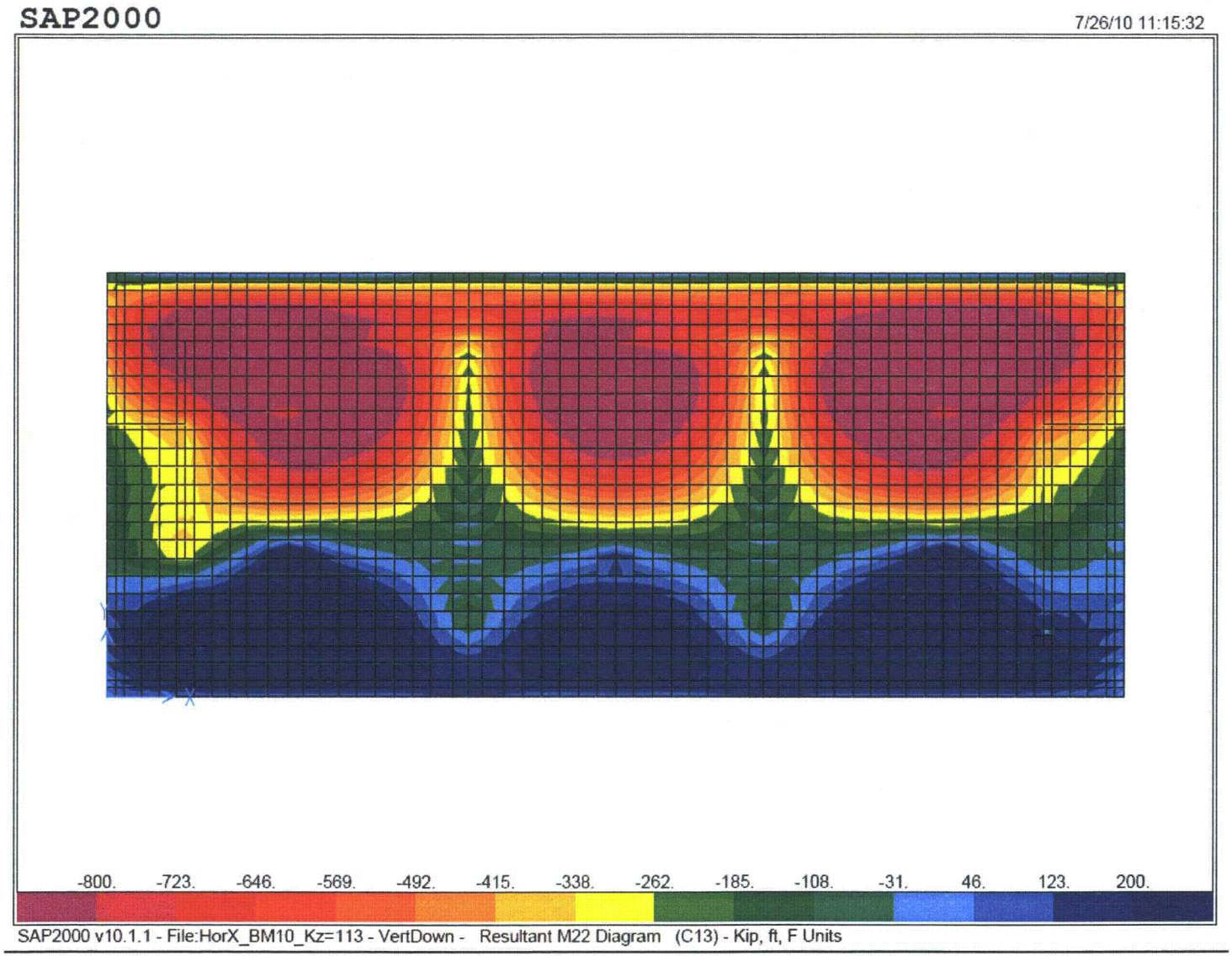



**Figure 03.07.01-28.23: Resultant Out-of-Plane Moment M22 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

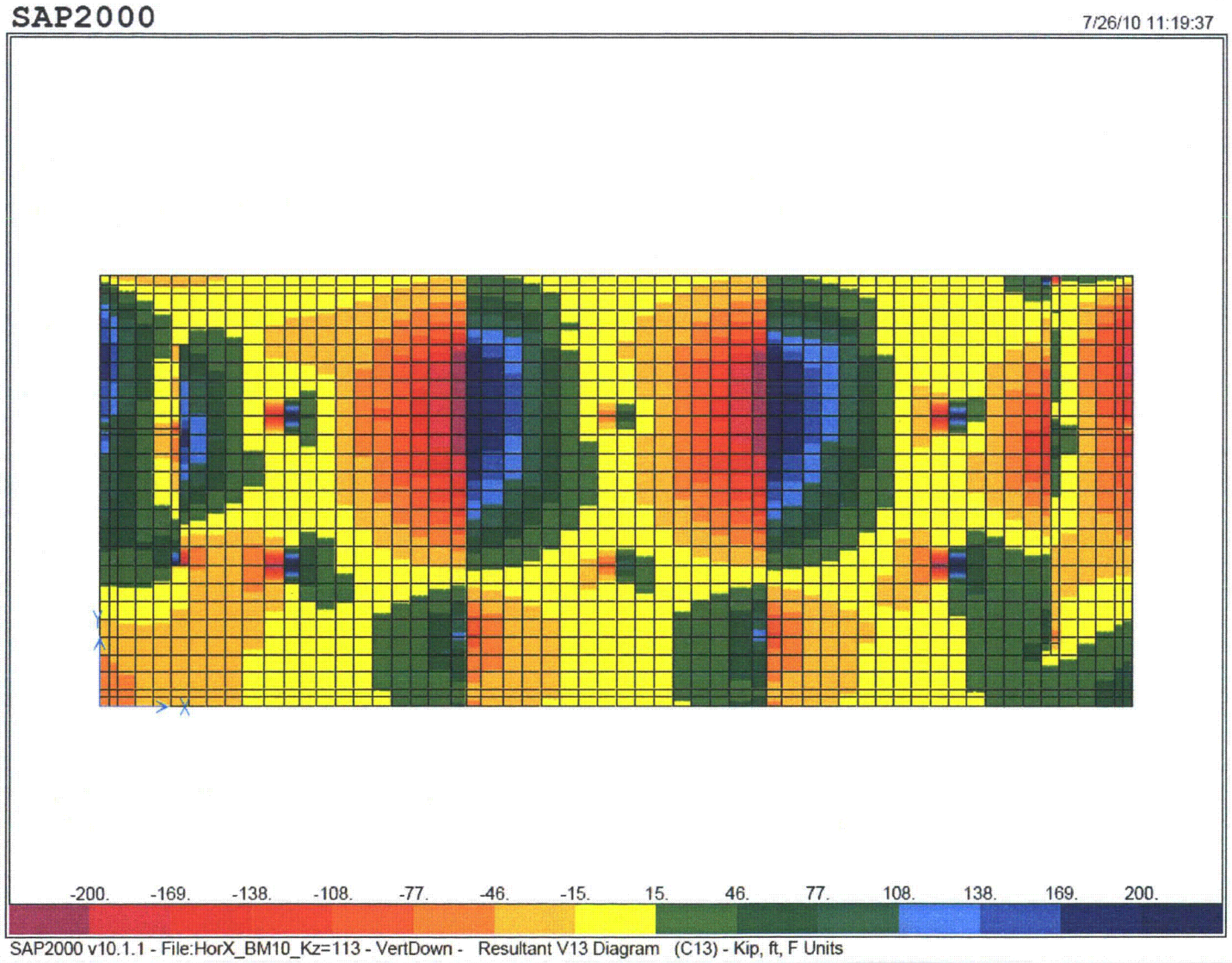



**Figure 03.07.01-28.24: Resultant Out-of-Plane Shear V13 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

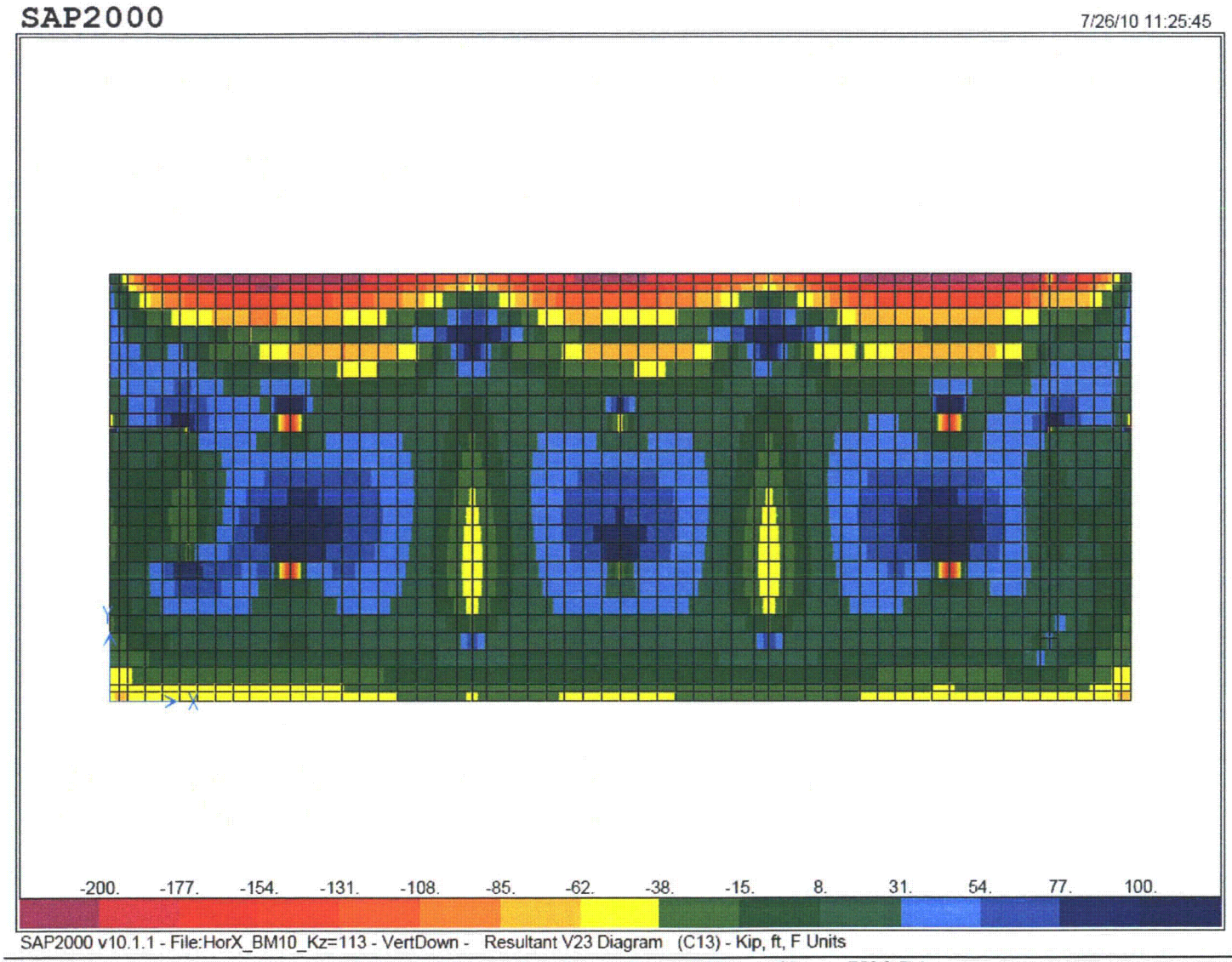



**Figure 03.07.01-28.25: Resultant Out-of-Plane Shear V23 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Down, and Moment $M_x$**

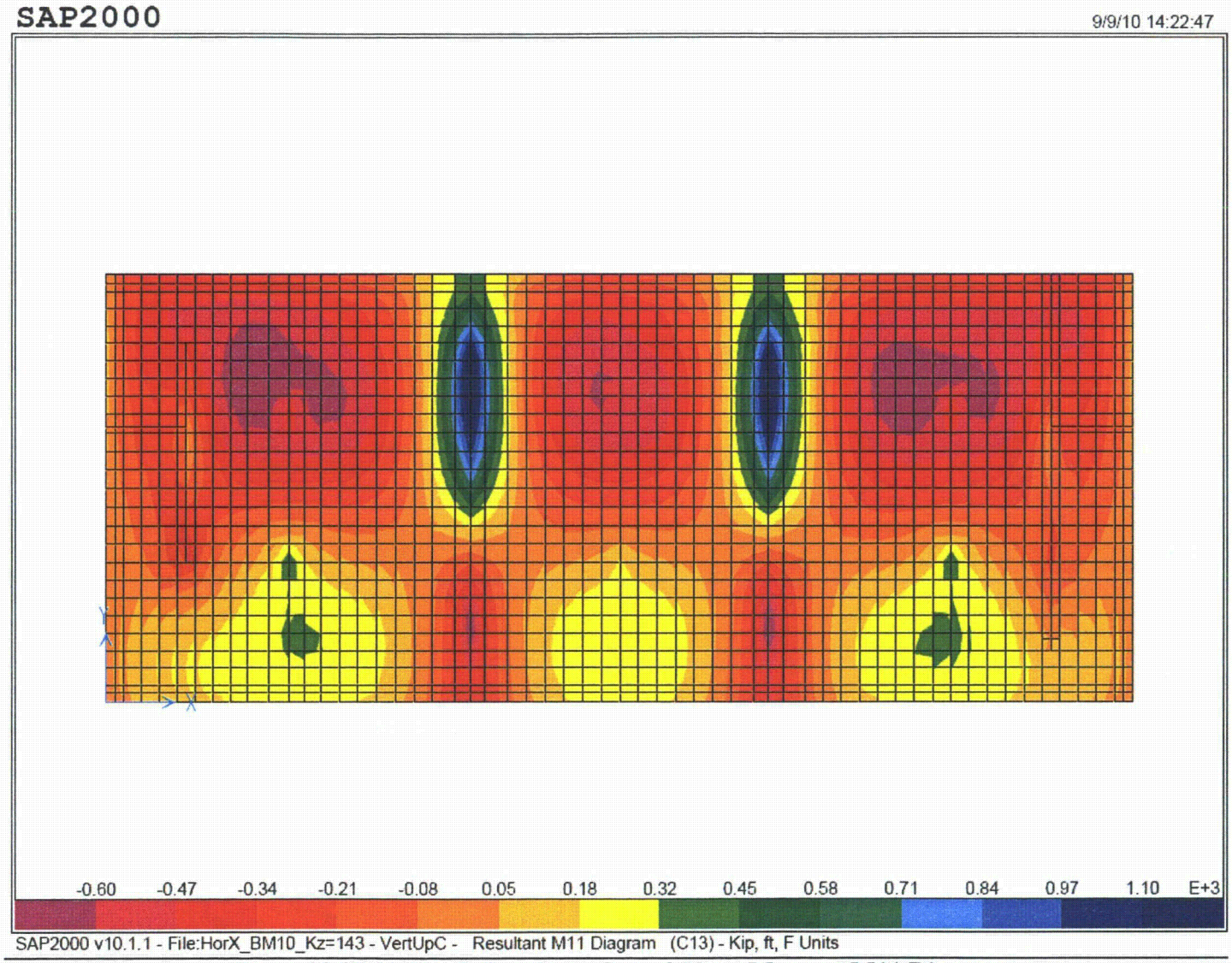



**Figure 03.07.01-28.26: Resultant Out-of-Plane Moment M11 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

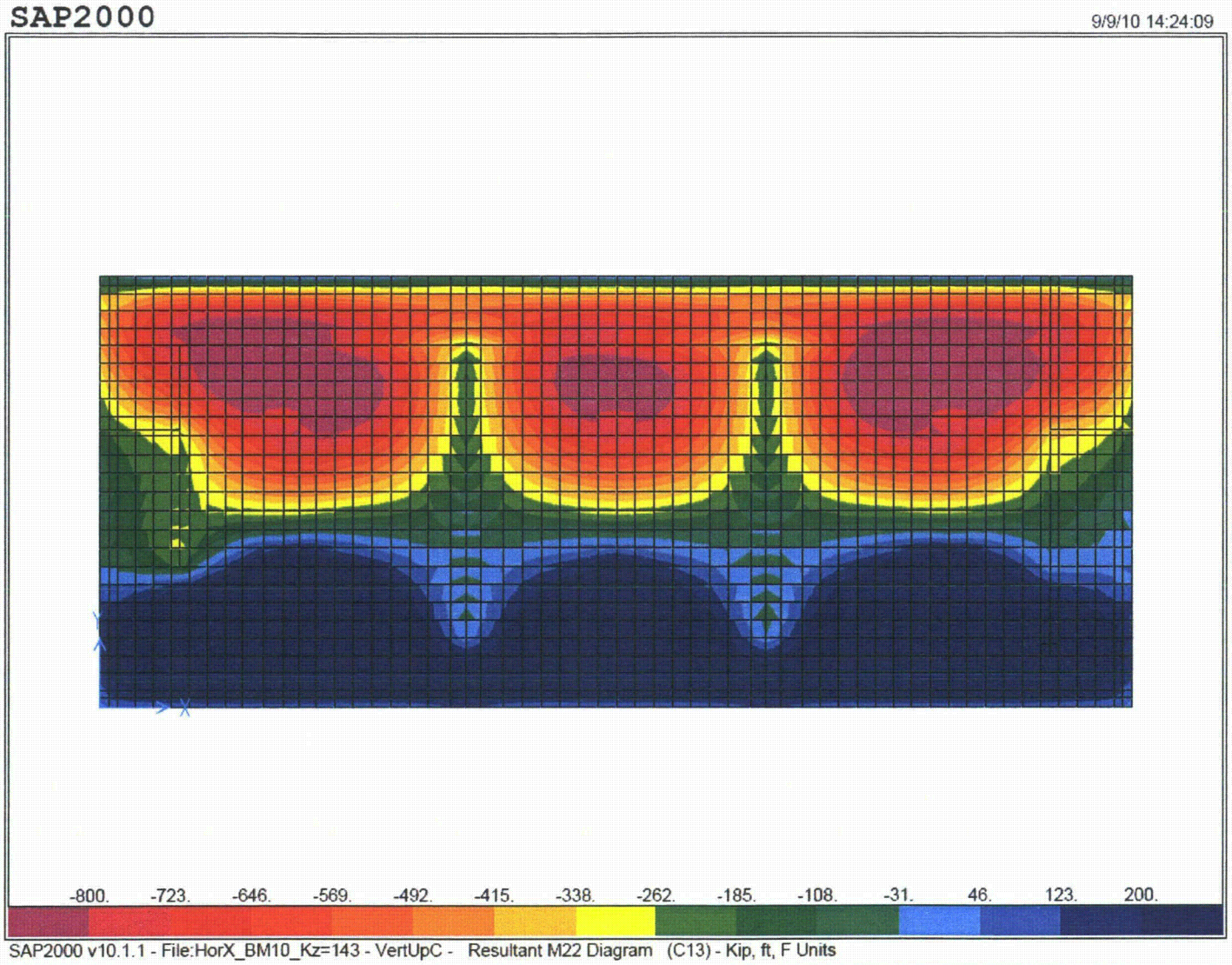



**Figure 03.07.01-28.27: Resultant Out-of-Plane Moment M22 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

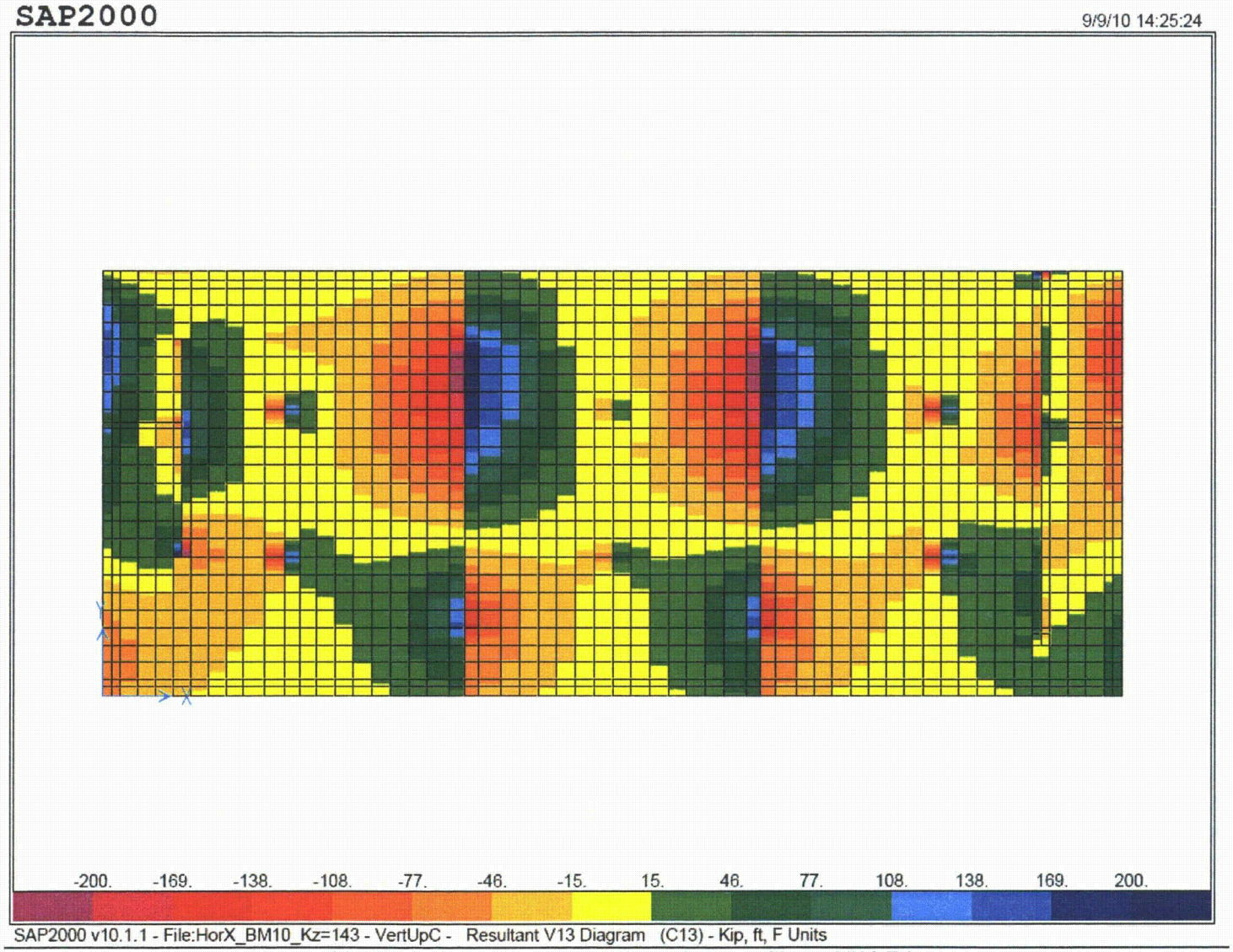



**Figure 03.07.01-28.28: Resultant Out-of-Plane Shear V13 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

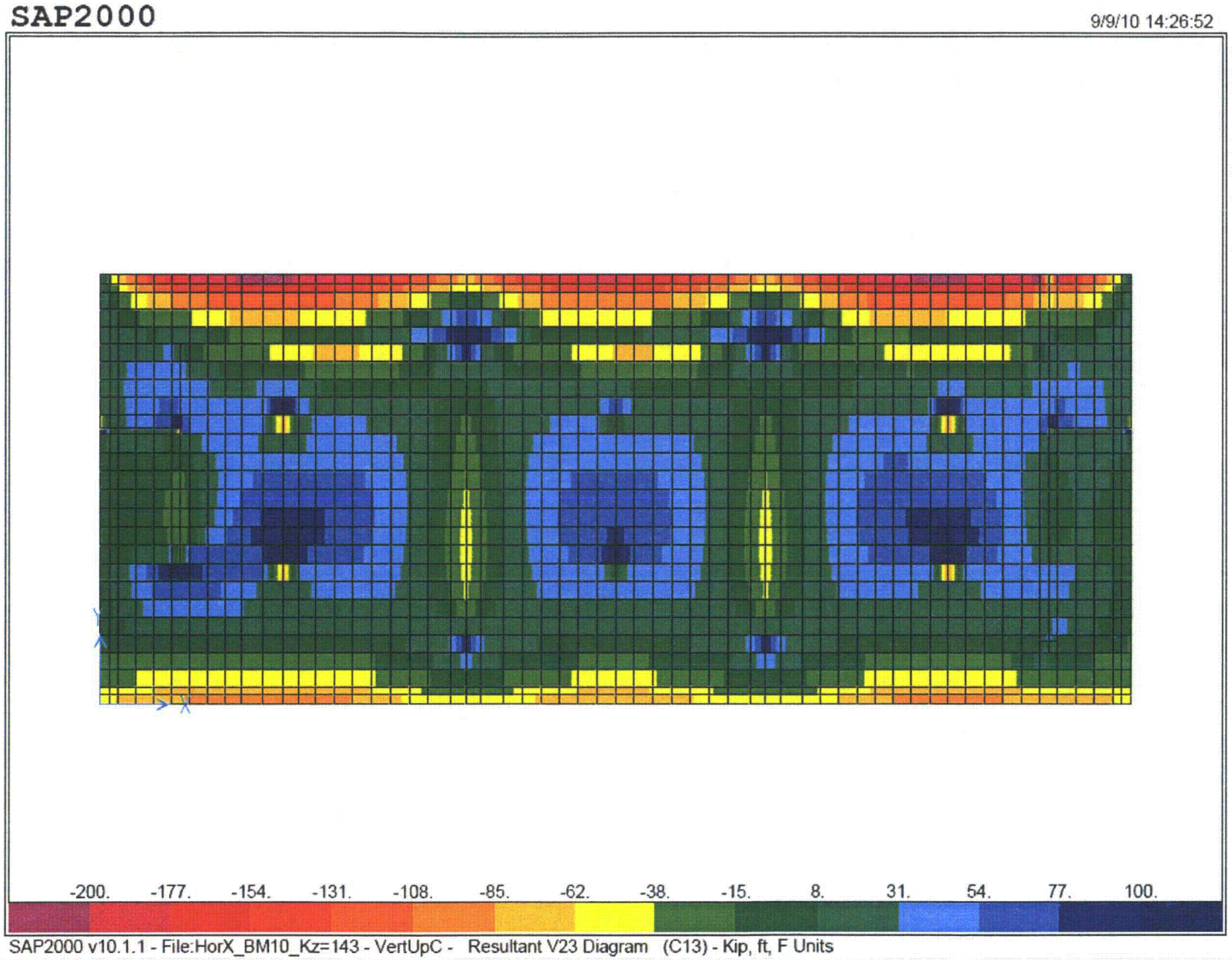



**Figure 03.07.01-28.29: Resultant Out-of-Plane Shear V23 Diagram (Using DCD Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

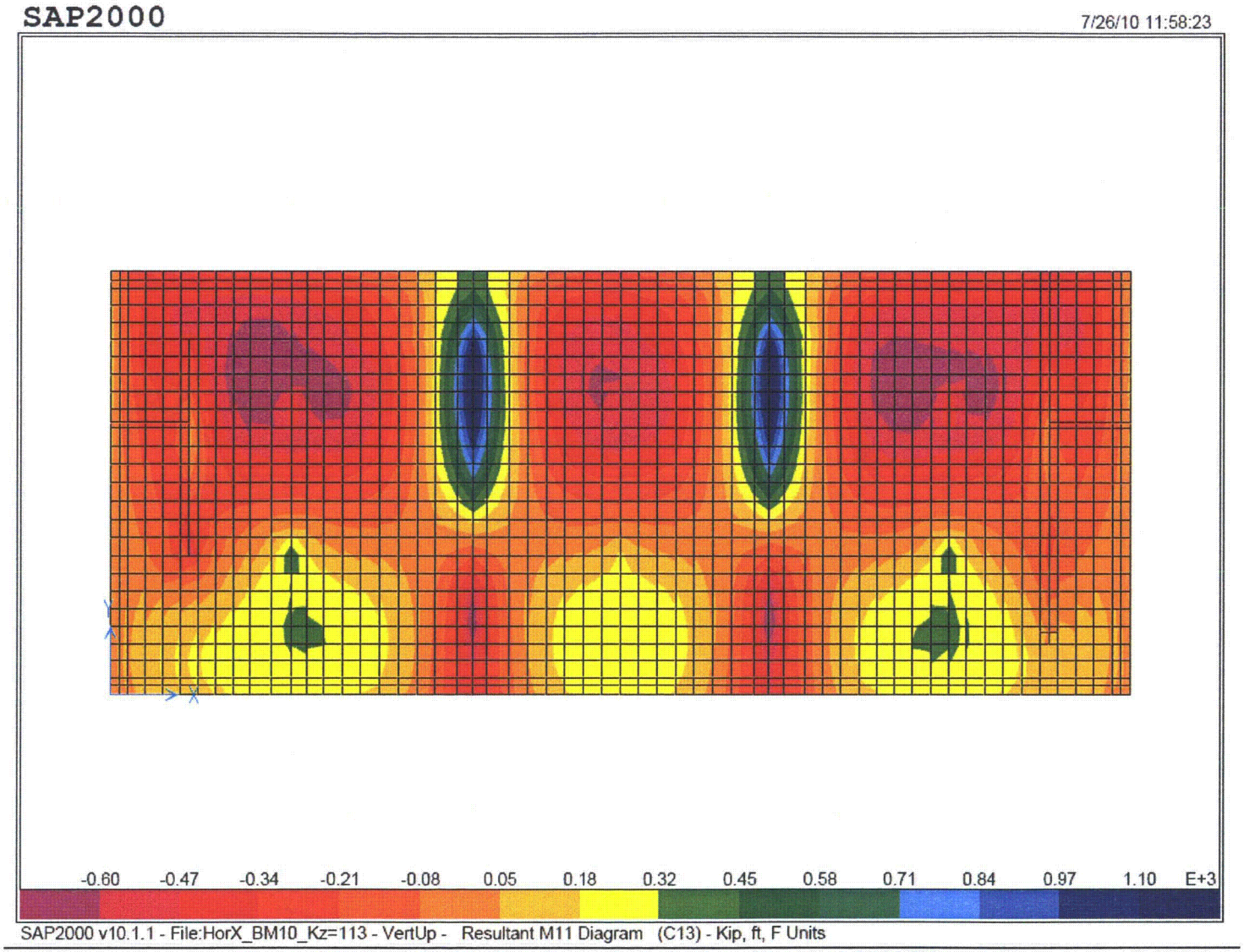



**Figure 03.07.01-28.30: Resultant Out-of-Plane Moment M11 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

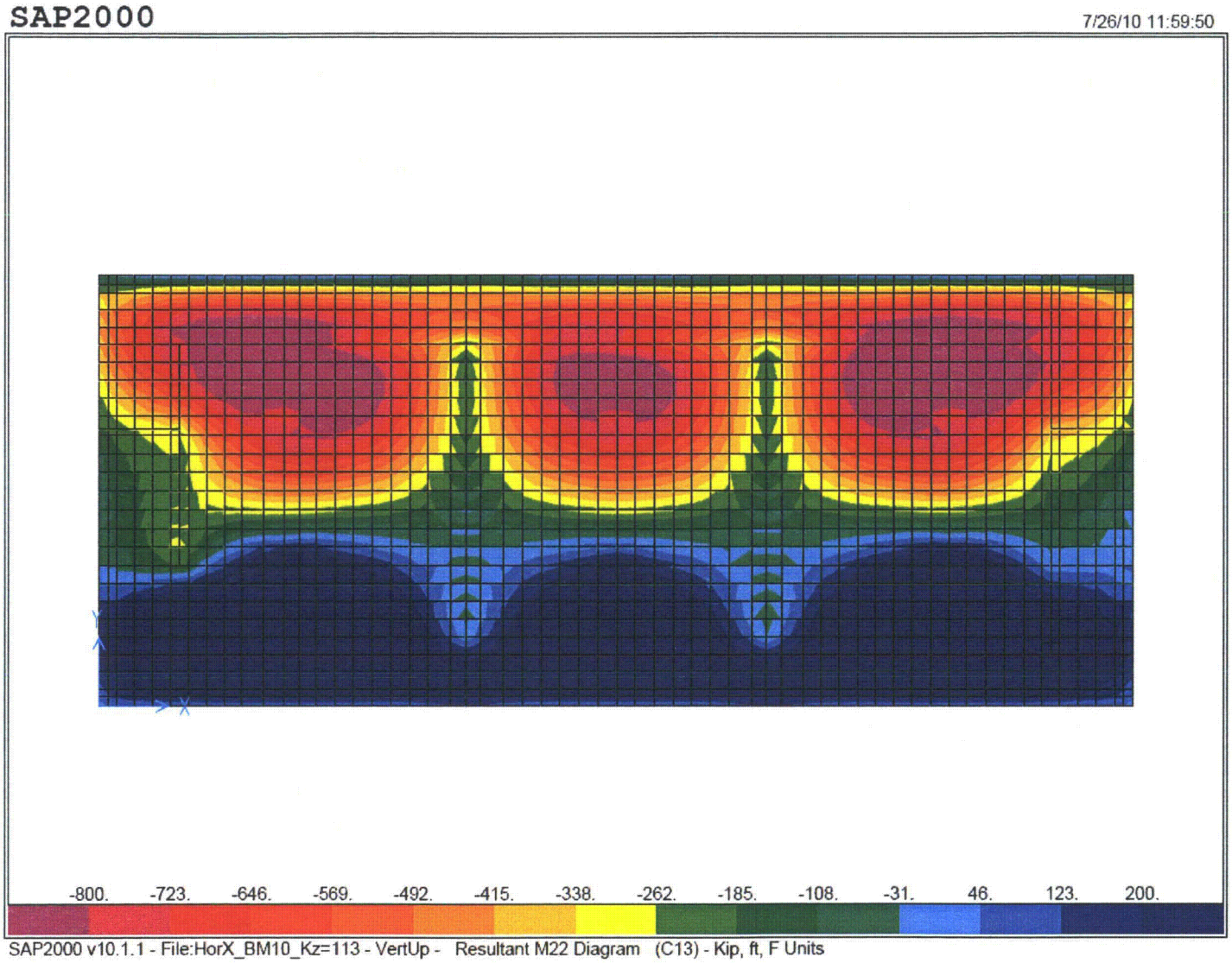



**Figure 03.07.01-28.31: Resultant Out-of-Plane Moment M22 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

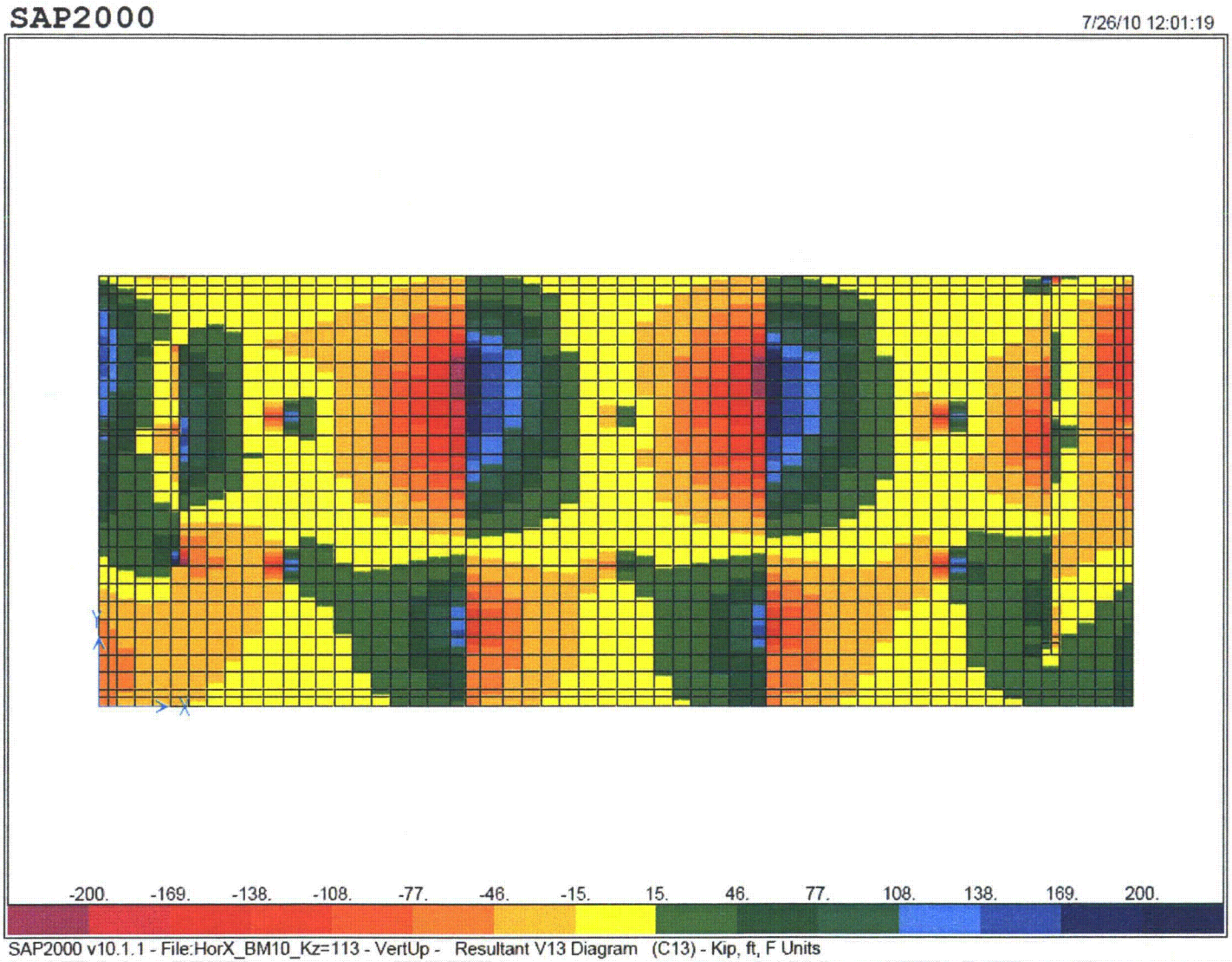



**Figure 03.07.01-28.32: Resultant Out-of-Plane Shear V13 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

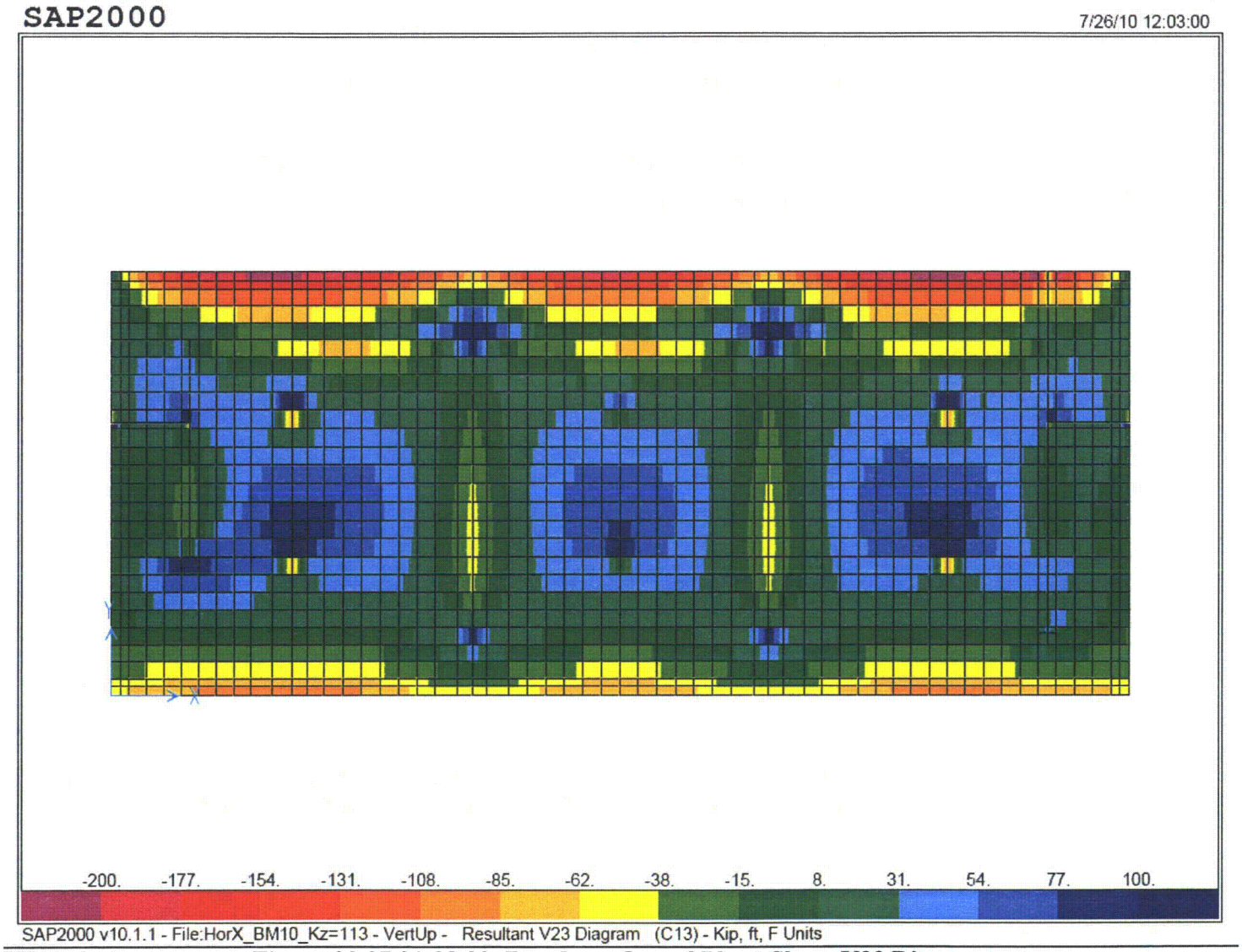



**Figure 03.07.01-28.33: Resultant Out-of-Plane Shear V23 Diagram (Using Lower Range Site-Specific Spring Constants) Dead Load, Vertical Excitation Up, and Moment $M_x$**

# Enclosure 1

## Revision to COLA Sections 3H.1 and 3H.2

### 3H.1.5.2 Foundation Soil Springs

STP DEP T1 5.0-1

*The foundation soil is represented by soil springs. The spring constants for rocking and translations are determined based on the following soil parameters:*

- *Shear wave velocity* ~~*305 m/s*~~(See FSAR Subsections 2.5S.4.4 and 2.5S.4.7)
- *Unit weight* ~~*1.92 t/m*$^3$~~ 121 pcf (1.94 t/m$^3$) to 140 pcf (2.24 t/m$^3$)
- *Shear modulus* ~~*1.8 x 10*$^4$ *t/m*$^3$~~ 3,011 ksf (1.47x10$^4$ t/m$^2$) to 9,324 ksf (9.55x10$^4$ t/m$^2$)
- *Poisson's Ratio* ~~*0.38*~~ 0.46 to 0.48

For the undrained condition (i.e. Poisson's Ratio 0.46 to 0.48), ~~T~~the calculated vertical spring constant under the mat foundation of the Reactor Building (RB) for STP site conditions ranges from 132 kips/ft$^3$ to 288 kips/ft$^3$ with 197 kips/ft$^3$ for best estimate case. The calculated horizontal spring constant for the STP site conditions ranges from 94 kips/ft$^3$ to 211 kips/ft$^3$ with minimum of 141 kips/ft$^3$ for best estimate case. The potential degree of variability is indicated by the spread of values from lower range to upper range. The soil properties used to compute these spring constants are strain-compatible and were developed from the site response analyses described in Section 2.5S.2.5. Soil depths for the vertical and horizontal mode spring calculations are 2500 ft and 1300 ft, respectively. Soil layers at depths greater than these depths were ignored due to their insignificant contribution to the spring values.

The above calculated STP site-specific soil spring constants are higher than the soil spring constants used for the ABWR DCD~~standard~~ design. For the drained condition with Poisson's Ratio of 0.15, the lower range site-specific spring constants are nearly the same as those for the standard design with a maximum difference of about 5%. Considering that the layer weighted Poisson's Ratio is between 0.15 for clay layers and 0.30 for sand layers, even for the drained condition the STP site-specific spring constants will be either the same or higher than the spring constants for the standard design. Higher soil spring constants at the STP site will result in mat design forces smaller than those used for the ABWR DCD~~standard~~ design. Therefore, the ~~standard~~ ABWR DCD mat design is adequate for the STP site.

### 3H.2.6 Site Specific Structural Evaluation

*The following site specific supplement addresses the structural evaluation of the site specific design parameters for STP 3 & 4.*

As documented in Subsection 3.3, the ABWR Standard Plant Control Building (CB), wind loads, and tornado loads bound these site specific parameters for STP 3 & 4.

Soil spring constants for the undrained condition (i.e. Poisson's Ratio 0.46 to 0.48) are higher than spring constants for drained condition (i.e. Poisson's ratio of 0.15 for clay layers and 0.30 for sand layers). The calculated vertical spring constant under the mat foundation of the Control Building (CB) for STP site conditions using drained Poisson's ratio of 0.15 ranges from 113 kips/ft$^3$ to 251 kips/ft$^3$ with 169 kips/ft$^3$ for best estimate case. The calculated horizontal spring constant for the STP site conditions using drained Poisson's ratio of 0.15 ranges from 101 kips/ft$^3$ to 241 kips/ft$^3$ with minimum of 152 kips/ft$^3$ for best estimate case. The potential degree of variability is indicated by the spread of values from lower range to upper range. The soil properties used to compute these spring constants are strain-compatible and were developed from the site response analyses described in Section 2.5S.2.5. Soil depths for the vertical and horizontal mode spring calculations are 1500 ft and 700 ft, respectively. Soil layers at depths greater than these depths were ignored due to their insignificant contribution to the spring values.

While the calculated best estimate and upper range STP site-specific soil spring constants are higher than the best estimate calculated DCD soil spring constants, the lower range STP site-specific vertical and horizontal soil spring constants are lower by about 20% and 30%, respectively.

Considering the size and geometry of the CB, arrangement of the exterior and interior shear walls, thickness of shear walls, and the basemat thickness, the CB basemat is quite rigid and not significantly sensitive to the soil spring constant values. To demonstrate this, a three dimensional parametric study was performed where the CB was subjected to its dead load along with significant seismic moments about the two horizontal axes and vertical excitation. The CB model was analyzed for two cases, once with best estimate calculated DCD soil spring constants and the second time with calculated lower range STP site-specific soil spring constants. Comparison of the resulting out-of-plane shears and moments from these two analyses show that there is no significant change in basemat design forces. Based on this parametric study and the fact that STP site-specific SSE is less than half the standard design SSE, the ABWR DCD mat design is adequate for the STP site.