# FEA Analysis Summary

# SFGD BOX

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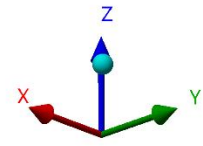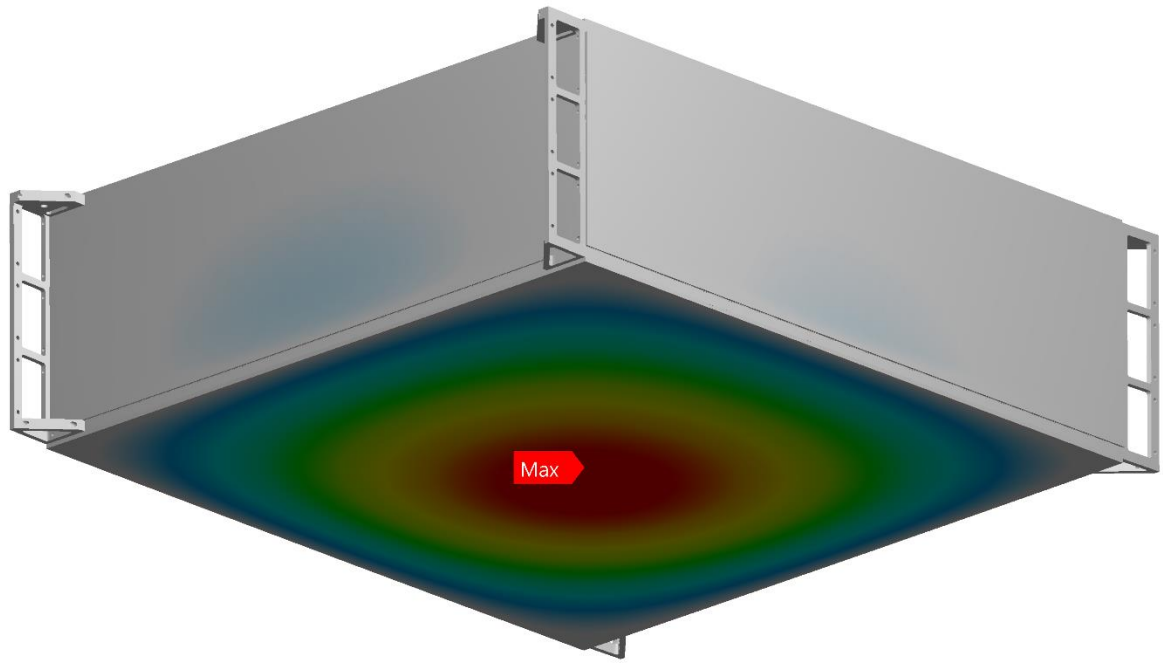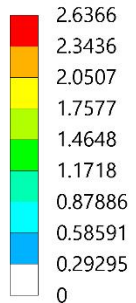Swiss Federal Institute of Technology Zurich

- FEA studies Static and Dynamic

- All Materials were tuned including effect of the holes (implementing various tests that has been done)

- Simplyfication at the model were done trying to be conservative

- <u>First Analysis:</u> Static Structural **1.** Self Weight  **2.**0.65g in each direction:
  **1.** Cubes simulated as a Force
  **2.** it's pratically considering as100% the Mass partecipation of the cubes with a 0.65g acceleration in each direction
  → Deformations always under 5mm
  → Stresses always below the limit (SF included)

- <u>Second Analysis</u>: Tentative to implement the cubes as a solid and perform a dynamic random vibration test using the PSD spectrum given by KEK.
  → Acelleration response always below the 0.65g calculated in the static structural analysis

# STATIC STRUCTURAL ANALYSIS

- The fact that the maximum allowed deformation of the Box was set as 5mm, has brought a very stiff design. Here below images of deformation at different scenarios



Self Weight Only

C: Static with G and Nominal Cubes Weight
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
Custom
Max: 2.6369
Min: 0

| | |
|---|---|
| 2.6366 | |
| 2.3436 | |
| 2.0507 | |
| 1.7577 | |
| 1.4648 | |
| 1.1718 | |
| 0.87886 | |
| 0.58591 | |
| 0.29295 | |
| 0 | |

Max

0.00    500.00    1000.00 (mm)
250.00    750.00

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# Results

## STATIC STRUCTURAL ANALYSIS

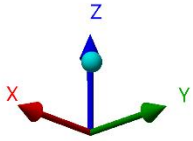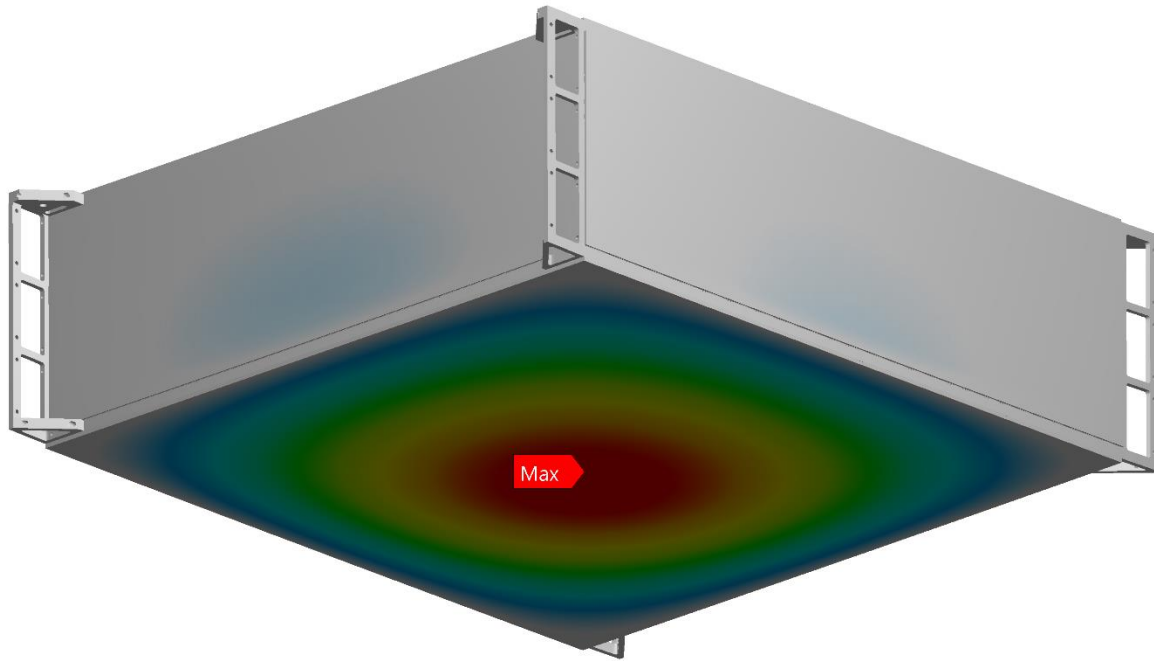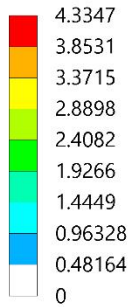| Scenario 1 | Material | Yield Stress [MPa] | Von Mises [MPa] | SF | SFM | $MoS = \dfrac{\sigma_m}{\sigma \cdot SF \cdot SFM} - 1 \geq 0$ |
|---|---|---|---|---|---|---|
| Earth gravity | AISI 316L | 290 | 118.28 | 1.1 | 1.1 | 1.026 |
| +0.65g in −Z | ALU 6061-T651 | 276 | 36.351 | 1.1 | 1.1 | 5.275 |
| direction | FR4/G10 | 300 | 5.5928 | 1.1 | 2.0 | 23.382 |
| | PMMA/Acrylic | 62 | 3.4881 | 1.1 | 2.0 | 7.075 |
| | Divinycell H250 | 9.2 | 3.0395 | 1.1 | 2.0 | 0.3758 |
| | | | | | | Inverse Reserve Factor <1 |
| | Carbon Fiber | | | | | 0.1144 |

**Self Weight + 0.65g Z-direction**

**D: Static Earthquake Load Bottom Panel**
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
Max: 4.3347
Min: 0



Legend:
4.3347
3.8531
3.3715
2.8898
2.4082
1.9266
1.4449
0.96328
0.48164
0

Max

0.00   500.00   1000.00 (mm)
250.00   750.00

ANSYS
2019 R3
ACADEMIC

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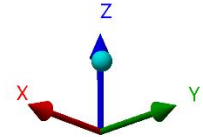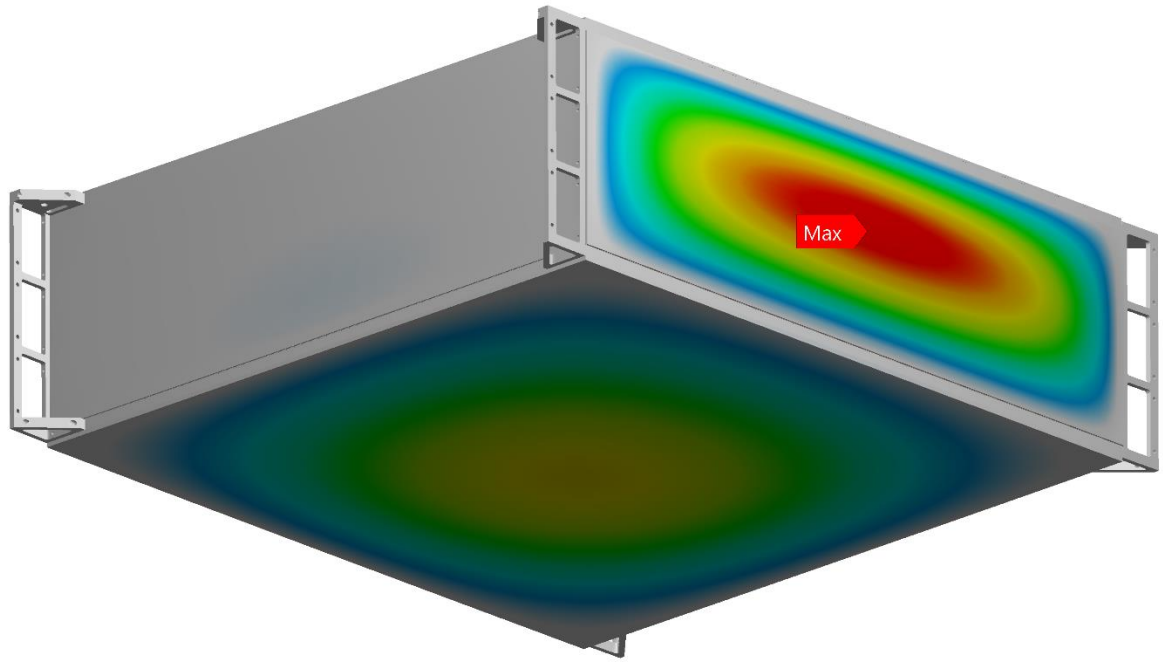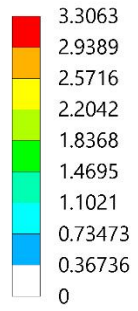Swiss Federal Institute of Technology Zurich

# STATIC STRUCTURAL ANALYSIS

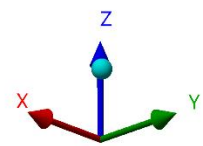Self Weight + 0.65g Y-direction

**E: Static Earthquake Load Y Direction**
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
Max: 3.3063
Min: 0

| |
| --- |
| 3.3063 |
| 2.9389 |
| 2.5716 |
| 2.2042 |
| 1.8368 |
| 1.4695 |
| 1.1021 |
| 0.73473 |
| 0.36736 |
| 0 |

Max

0.00      500.00      1000.00 (mm)
     250.00      750.00

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# STATIC STRUCTURAL ANALYSIS

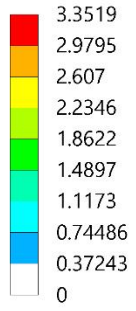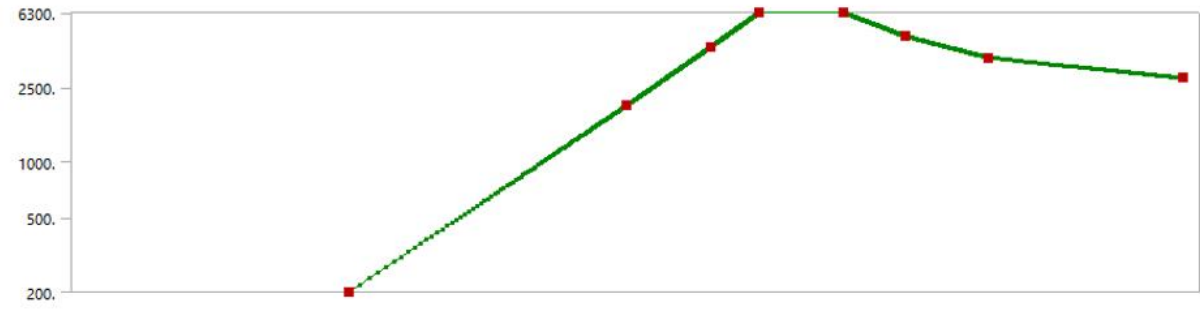Self Weight + 0.65g X-direction

**F: Static Earthquake Load X Direction**
Total Deformation
Type: Total Deformation
Unit: mm
Time: 1
Max: 3.3519
Min: 0

3.3519
2.9795
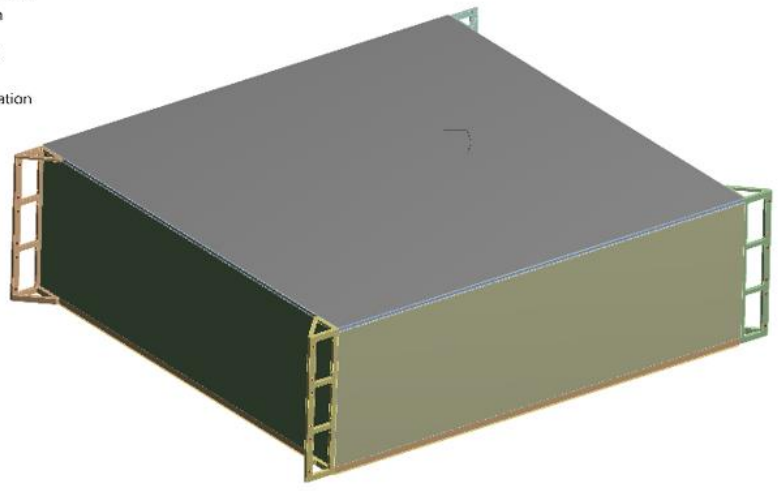2.607
2.2346
1.8622
1.4897
1.1173
0.74486
0.37243
0

Max

0.00        500.00        1000.00 (mm)

250.00        750.00

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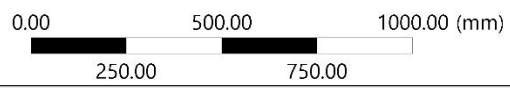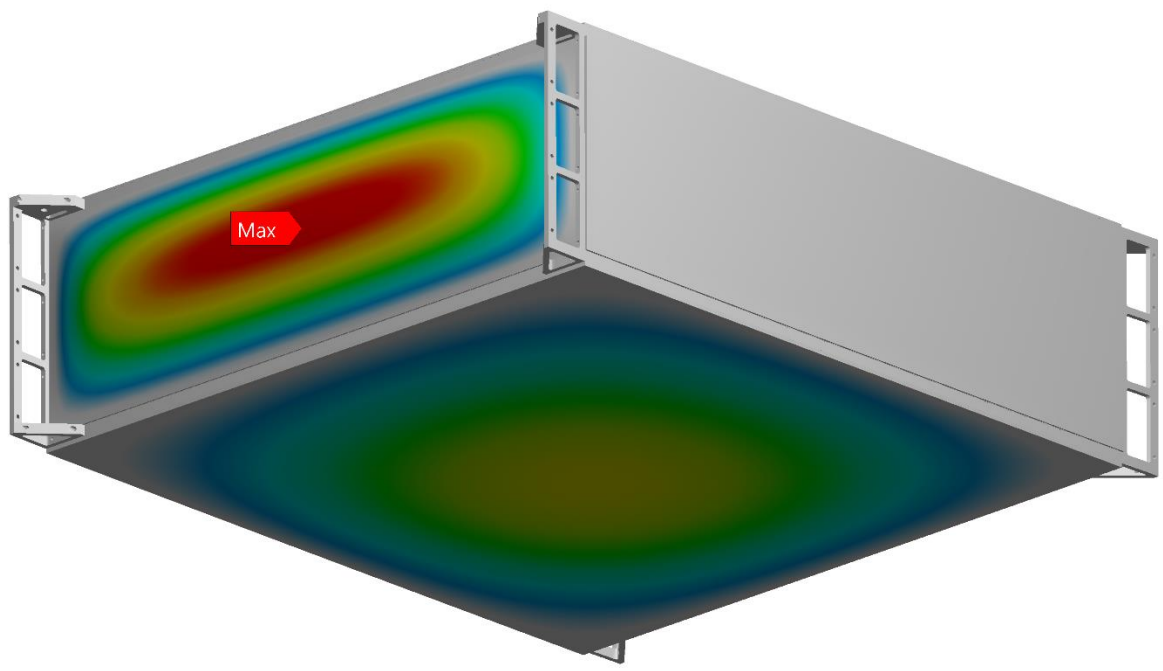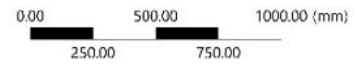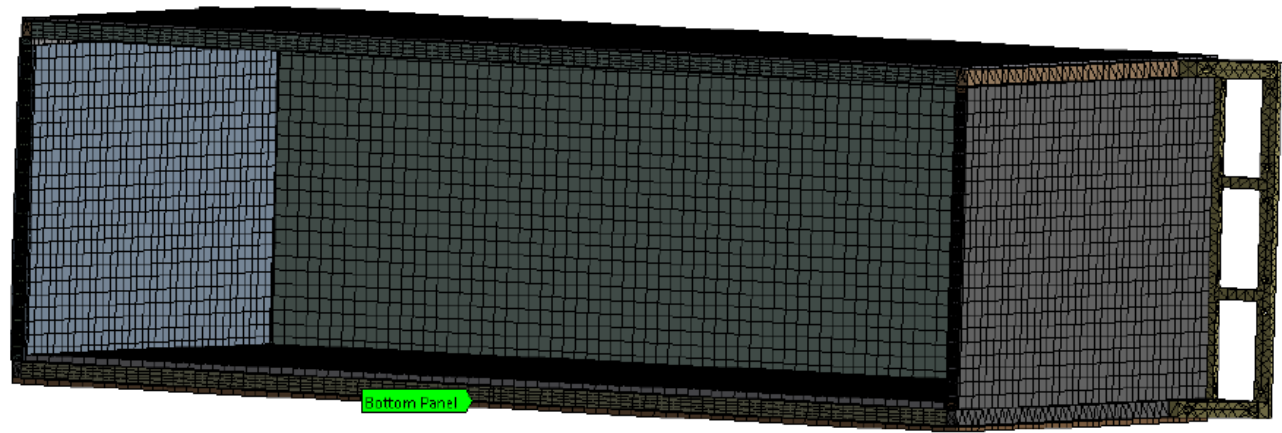
# DYNAMIC STRUCTURAL ANALYSIS

PSD Spectrum given by KEK



**E: Random Vibration**
PSD Acceleration
Time: 1. s
19.10.2020 11:23

■ PSD Acceleration

| | Frequency [Hz] | ☑ Acceleration [(mm/s²)²/Hz] |
|---|---|---|
| 1 | 0.1 | 200. |
| 2 | 1. | 2000. |
| 3 | 2. | 4100. |
| 4 | 3. | 6300. |
| 5 | 6. | 6300. |
| 6 | 10. | 4700. |
| 7 | 20. | 3600. |
| 8 | 100. | 2800. |
| * | | |

0.00        500.00        1000.00 (mm)
    250.00        750.00

**Results**



## DYNAMIC STRUCTURAL ANALYSIS
### (no_cubes)

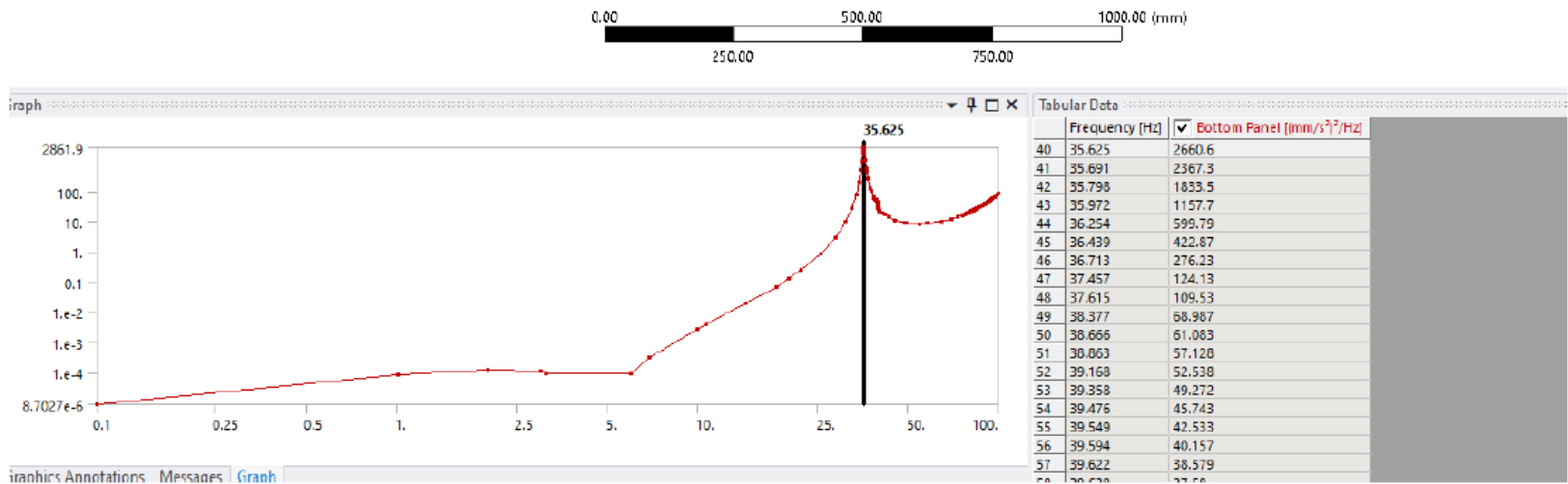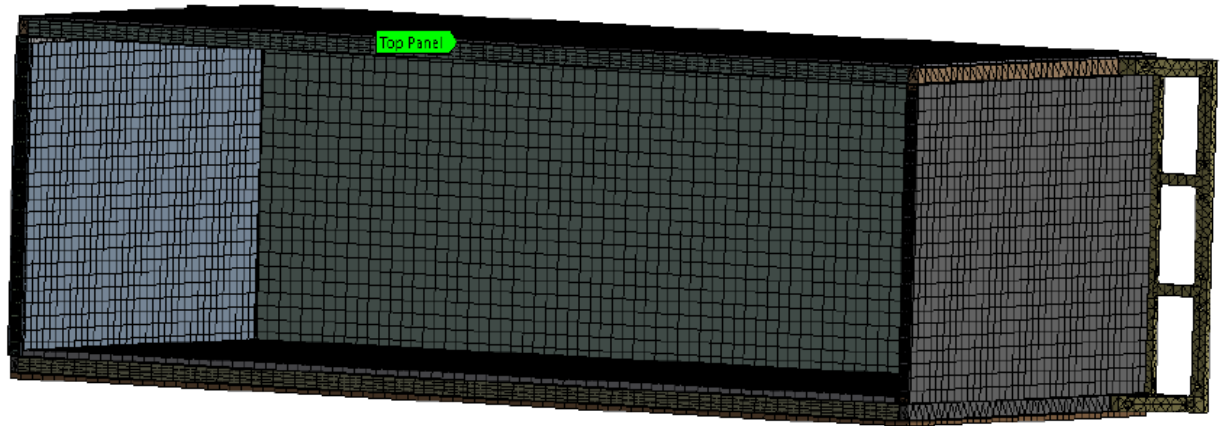PSD acceleration response (Z-axis) at center of Bottom Panel



Figure 3-13 Bottom Panel PSD response; cubes weight as a Force – PSD results of acceleration

A peak is found at 36.625 [Hz] with a PSD response of 2660.6 [(mm/s²)²/Hz]

Indicatively vibrational acceleration derived of the Top Panel → a= 0.308 m/s²

**DYNAMIC STRUCTURAL ANALYSIS**

(no_cubes)

PSD acceleration response (Z-axis) at center of Top Panel Panel



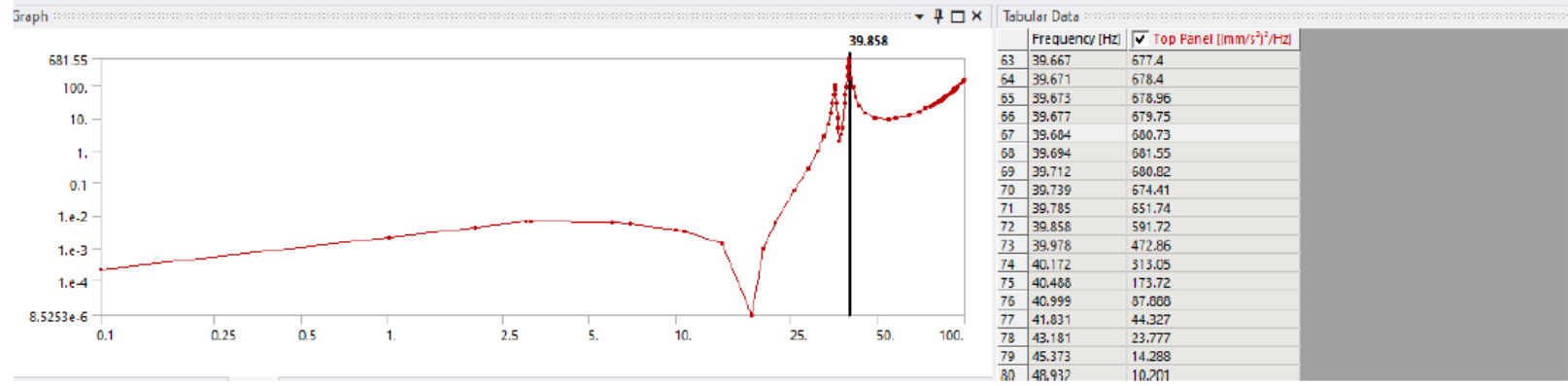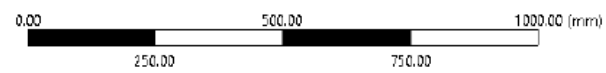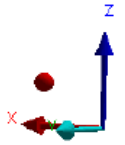| | Frequency [Hz] | ✓ Top Panel [(mm/s²)²/Hz] |
|---|---|---|
| 63 | 39.667 | 677.4 |
| 64 | 39.671 | 678.4 |
| 65 | 39.673 | 678.96 |
| 66 | 39.677 | 679.75 |
| 67 | 39.684 | 680.73 |
| 68 | 39.694 | 681.55 |
| 69 | 39.712 | 680.82 |
| 70 | 39.739 | 674.41 |
| 71 | 39.785 | 651.74 |
| 72 | 39.858 | 591.72 |
| 73 | 39.978 | 472.86 |
| 74 | 40.172 | 313.05 |
| 75 | 40.488 | 173.72 |
| 76 | 40.999 | 87.888 |
| 77 | 41.831 | 44.327 |
| 78 | 43.181 | 23.777 |
| 79 | 45.373 | 14.288 |
| 80 | 48.932 | 10.201 |

Figure 3-14 Top Panel PSD response; no cubes effect – PSD results of acceleration

A peak is found at 39.684 [Hz] with a PSD response of 680.73 [(mm/s²)²/Hz]

Indicatively vibrational acceleration derived of the Top Panel → a= 0.164 m/s²

## Results | <u>DYNAMIC STRUCTURAL ANALYSIS:</u> Cubes Implemented

Linear System with all contact bonded

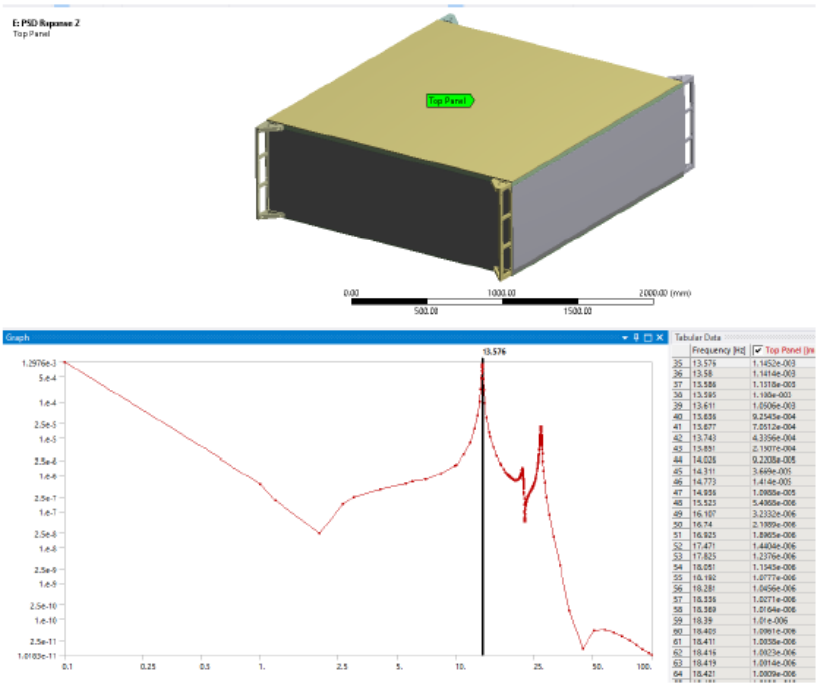PSD amplitude response (Z-axis) at Top and Bottom Panel



Figure 3-7 Scenario 1 – Vibration in Z direction – Results at the Top Panel

A peak is found at 13,576 [Hz] with a PSD of 1.1452e-3 [(mm²)/Hz]

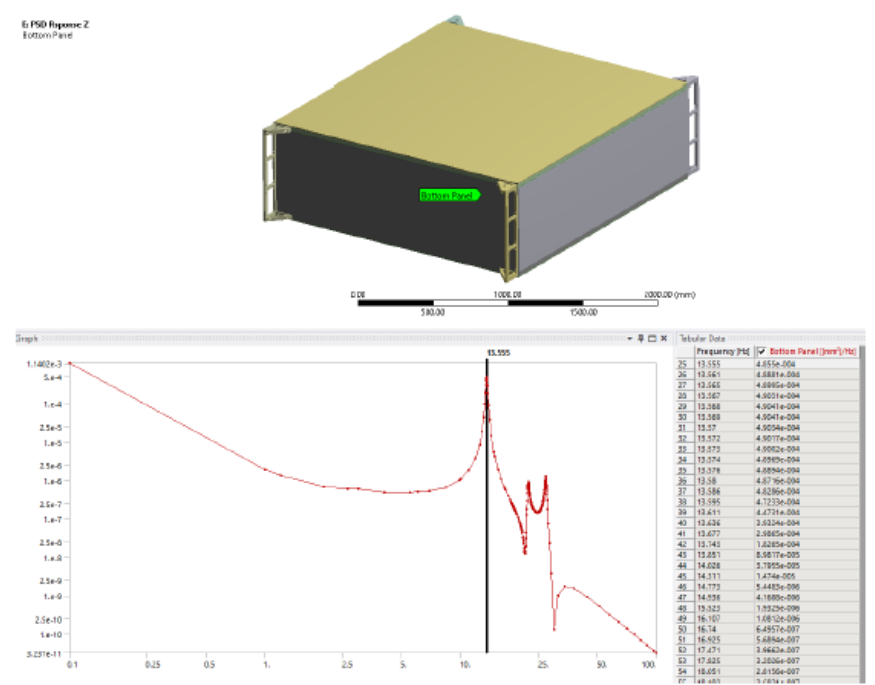Indicatively vibrational amplitude derived of the Top Panel → A= 0.140 mm

Figure 3-8 Scenario 1 – Vibration in Z direction – Results at the Bottom Panel

A peak is found at 13,555 [Hz] with a PSD of 4.855e-4 [(mm²)/Hz]

Indicatively vibrational amplitude derived of the Top Panel → A= 0.081 mm

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# Results   DYNAMIC STRUCTURAL ANALYSIS: Cubes Implemented

Linear System with all contact bonded
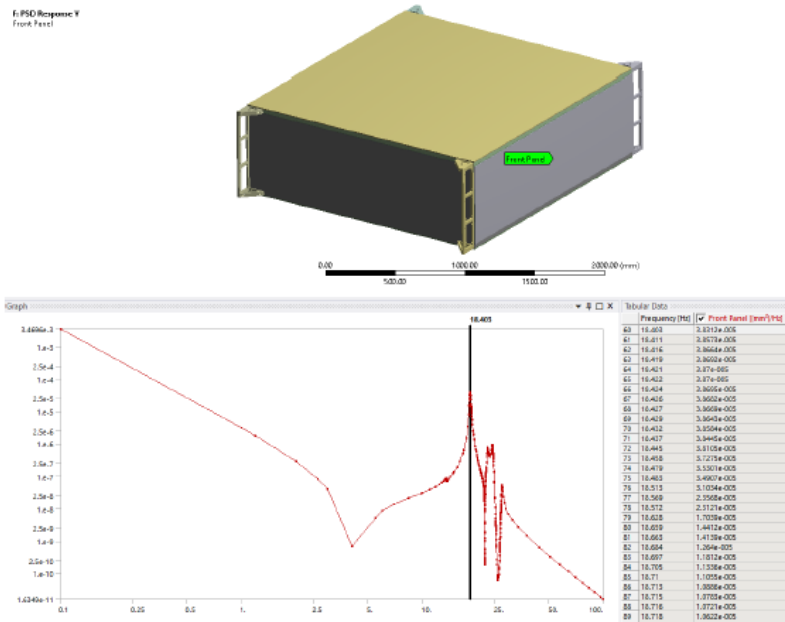
PSD amplitude response (Y-axis) at Top and Bottom Panel



Figure 3-9 Scenario 2 – Vibration in Y direction – Results at the Front Panel

A peak is found at 18.403 [Hz] with a PSD of $3.83122e^{-5}$ [(mm²)/Hz]

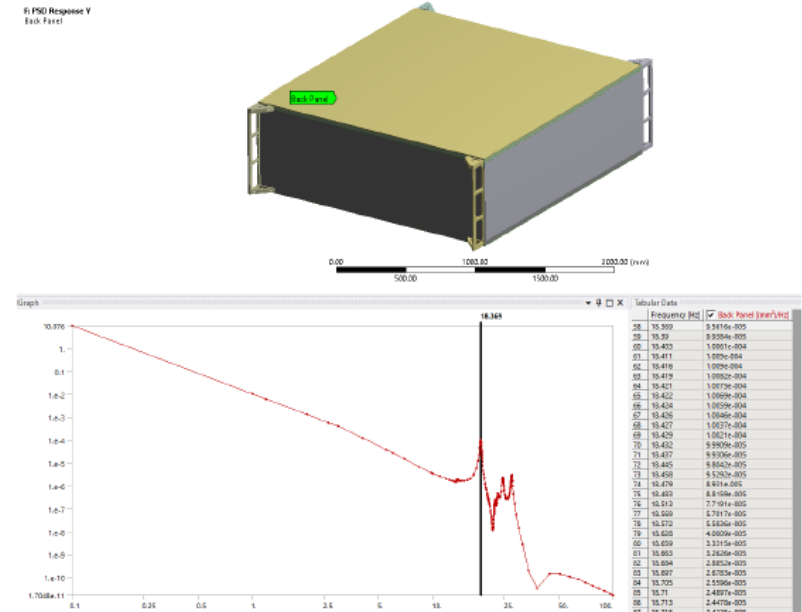Indicatively vibrational amplitude derived of the Top Panel → A= 0.026 mm



Figure 3-10 Scenario 2 – Vibration in Y direction – Results at the Back Panel

A peak is found at 13,369 [Hz] with a PSD of $9.5616e^{-5}$ [(mm²)/Hz]

Indicatively vibrational amplitude derived of the Top Panel → A= 0.042 mm

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Linear System with all contact bonded
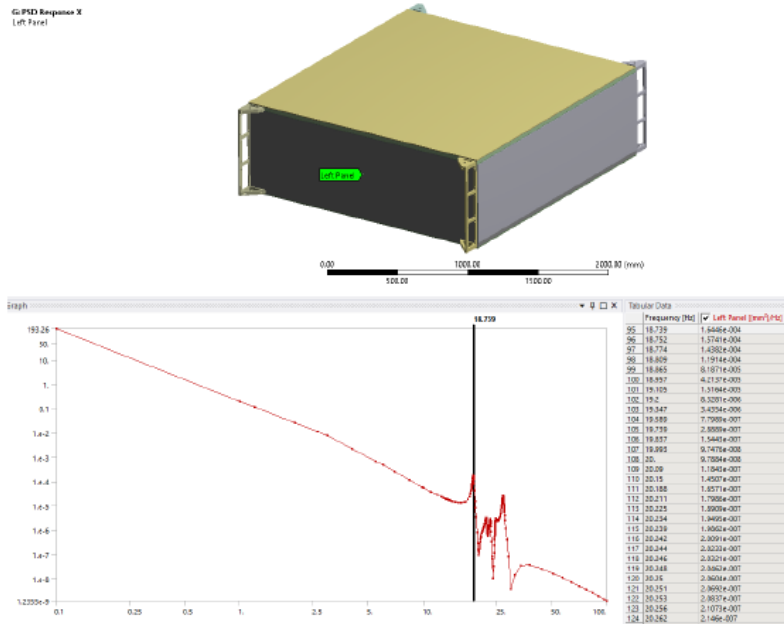
PSD amplitude response (X-axis) at Top and Bottom Panel



Figure 3-11 Scenario 3 – Vibration in Y direction – Results at the Left Panel

A peak is found at 18.739 [Hz] with a PSD of 1.6446e-4 [(mm²)/Hz]

Indicatively vibrational amplitude derived of the Top Panel → A= 0.056 mm
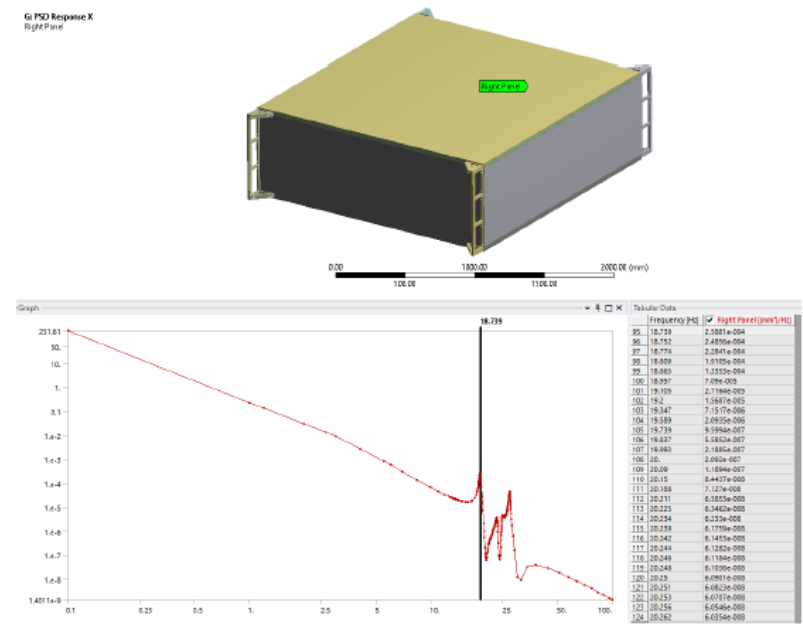
Figure 3-12 Scenario 3 – Vibration in Y direction – Results at the Right Panel

A peak is found at 18.739 [Hz] with a PSD of 2.5881e-4 [(mm²)/Hz]

Indicatively vibrational amplitude derived of the Top Panel → A= 0.070 mm