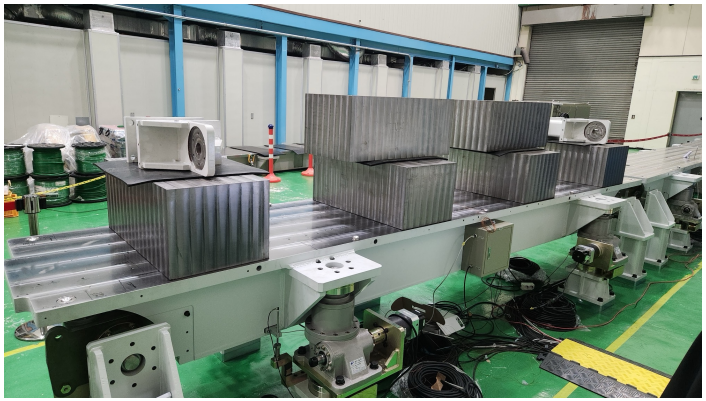
Research progress for ICABU 2026

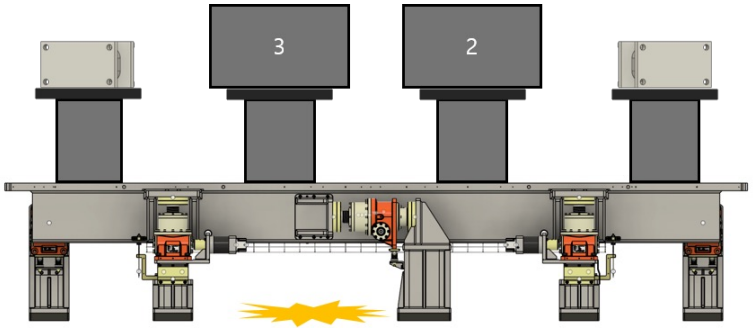
20252014 윤주환

Abstract

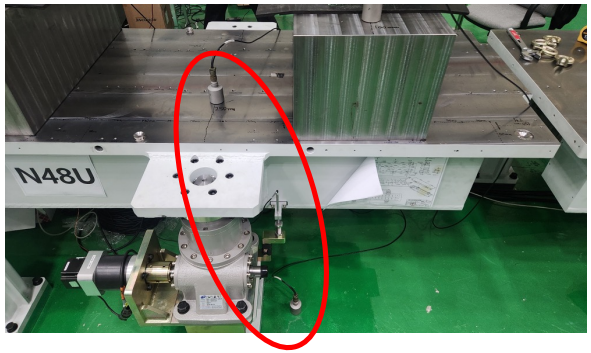
- To inspect dynamic behavior under the magnet loading (dummy).
- Vibration amplification at several points on the girder.
- Change in natural frequency compared to unloaded girder.
- Basis for subsequent assessments of mechanical stability and magnet vibration.

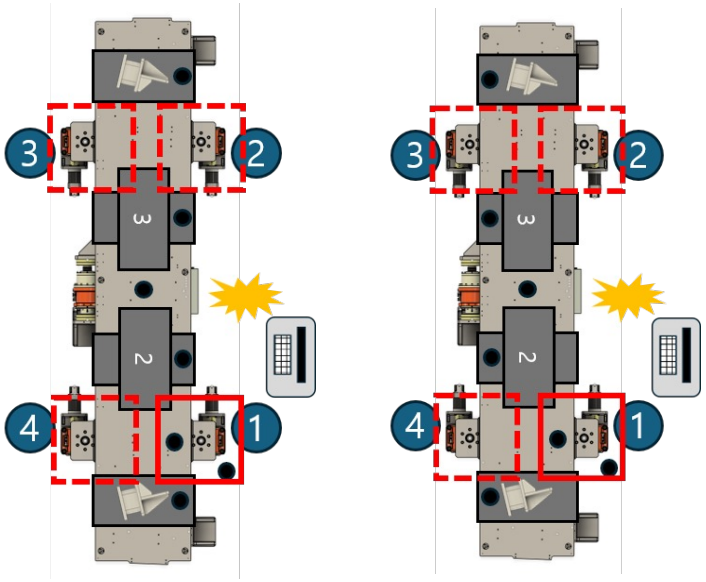


Transmissibility: how much ground vibration is amplified





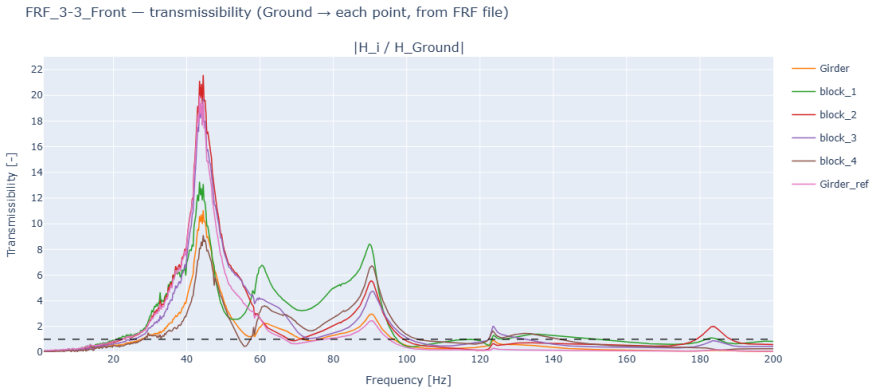


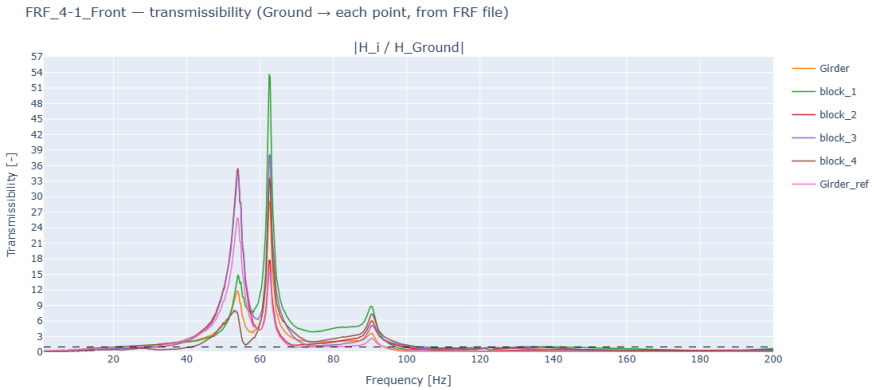


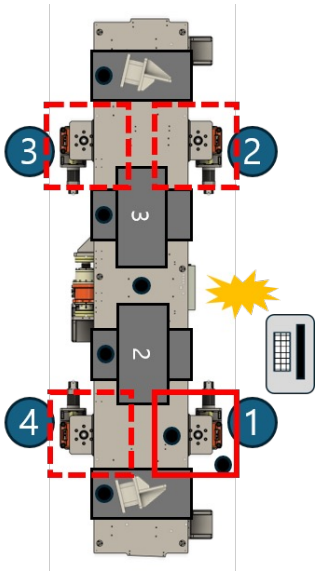
Vibration trasmissibility

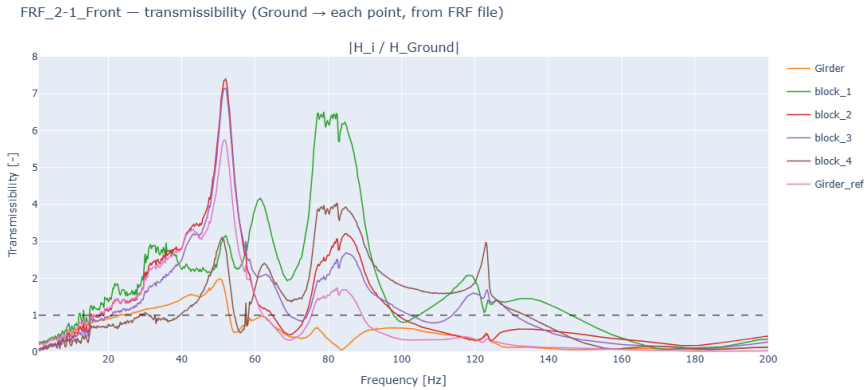
- Ratio of the vibration transmitted on the girder(output) to the vibration through the ground (input).
- Impact hammter's vibration is delivered to each point of interest.
- Calculate FRF using the acceleration (output) at each point relative to the hammer strike (input) [$(m/s^2)/N$].
- Calculate transmissibility (A_o/A_g) by dividing the object vibration FRF (A_o/F) by the ground vibration FRF (A_g/F) [Dimensionless].
- Girder is loaded by about 5 tons of block throughout the measurement.
- Accelerometers are mounted on each blocks and girder plates.

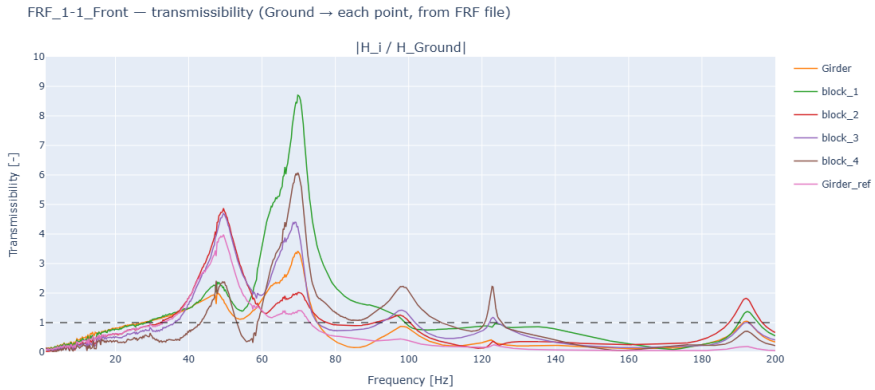
Result of transmissibility



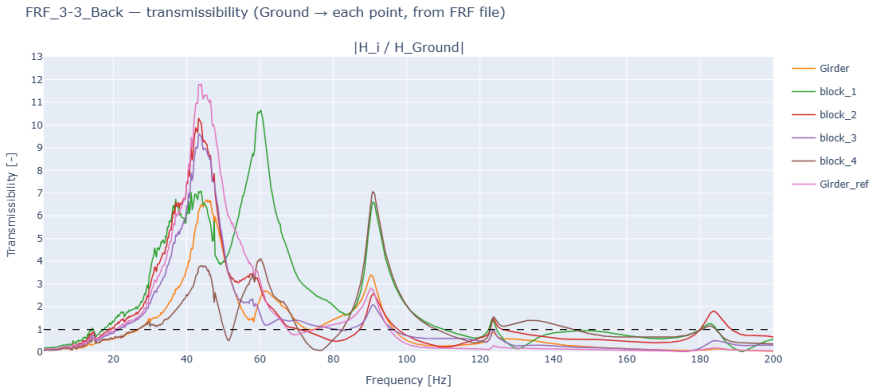


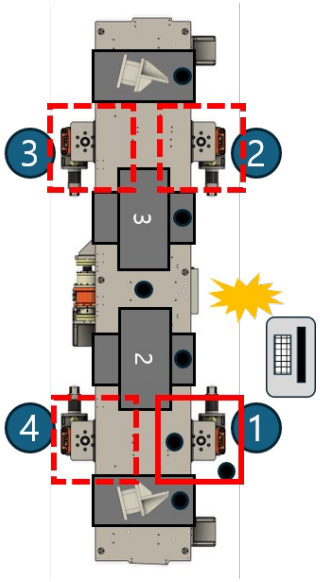


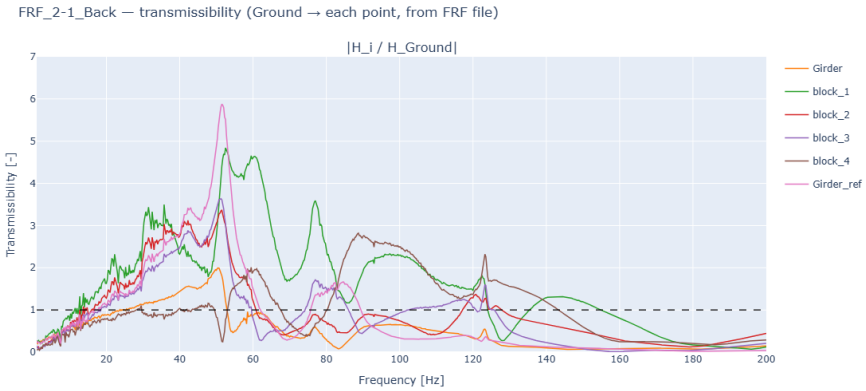


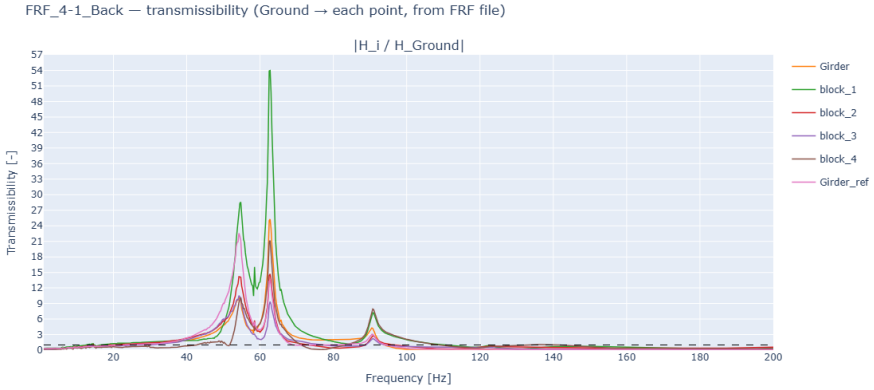


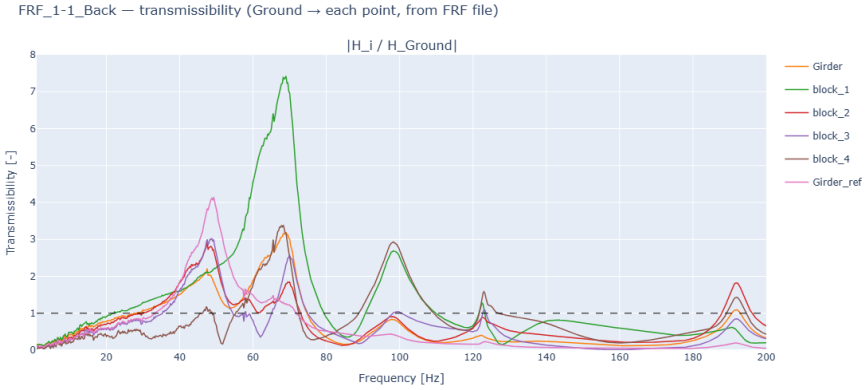
Result of transmissibility







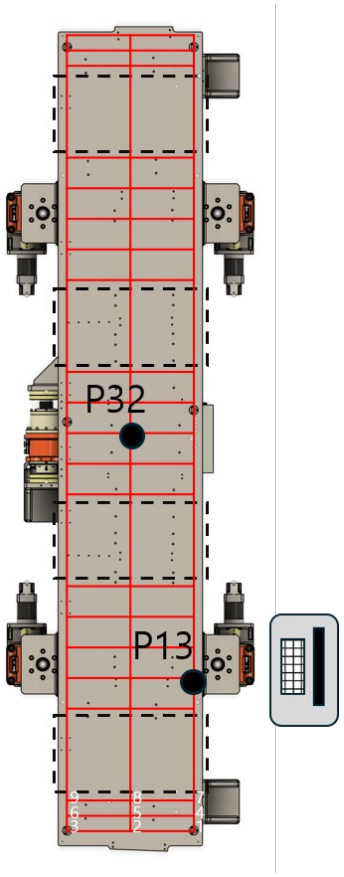




Assessment of vibration amplification

- Major amplification is observed at 50 Hz for all supports.
- For all configurations at 50 Hz, transmissibility of the girder's top plate is higher at the center than in the vicinity of supporters.
- For supporter #3, the transmission rate is generally high—reaching 10 or more—while for supporter #4, it surges as high as 50.
- For all supporter measurements, transmissibility for blocks 2 and 3 is higher when the block sensor is in the left-side configuration than when it is in the right-side configuration.

Experimental modal analysis



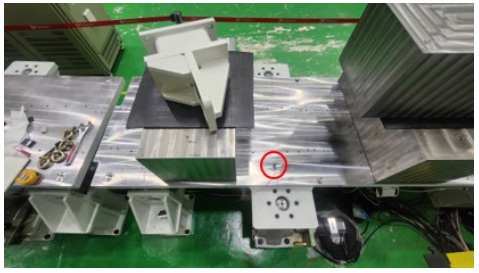
Criteria for Selecting Impact Points

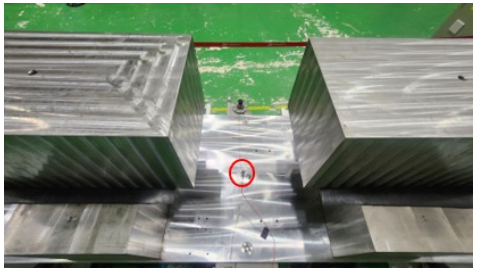
- Even if an impact point coincides with a node (a point of zero vibration), other impact points ensure that the vibration data remains complete.
- Impact points are marked and arranged at regular intervals.

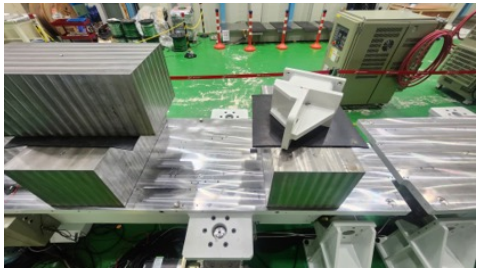
Placement of Accelerometers

- While increasing the number of impact points helps address ”stationary spots" (nodes) in the excitation locations, the placement of multiple accelerometers helps address "blind spots" in the measurement locations.
- Longitudinal direction: Captures vertical bending (relative to the centerline along the width, where P32 is positioned).
- Width direction: Captures vertical bending (relative to the centerline along the length).
- Diagonal direction: Captures torsional (twisting) motion.



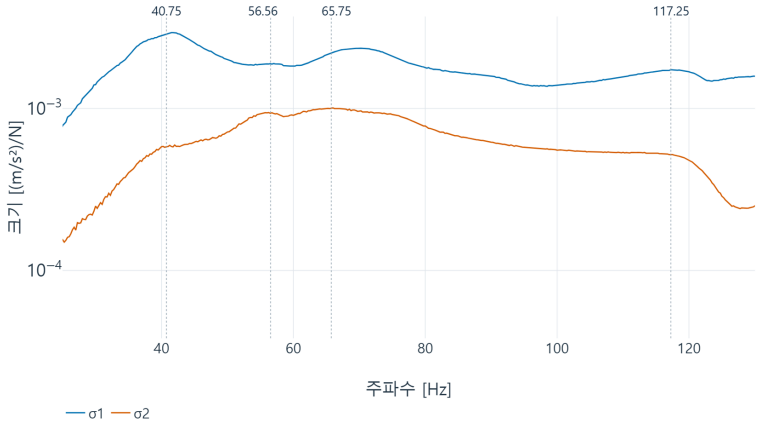






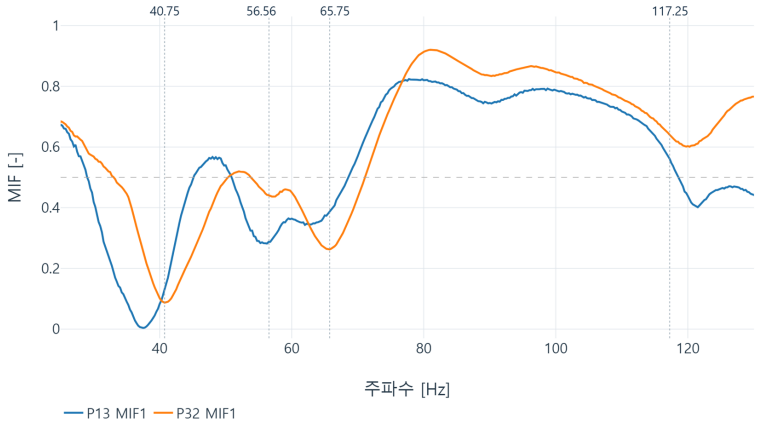
Natural frequencies

CMIF : 공진 후보 주파수 탐색



- $\mathbf{H}(f) = \begin{bmatrix} H_{13,1}(f) & H_{13,2}(f) & \dots & H_{13,63}(f) \\ H_{32,1}(f) & H_{32,2}(f) & \dots & H_{32,63}(f) \end{bmatrix}$
- $H_{2X63}(f) = U_{2X2} \cdot \Sigma_{2X63} \cdot V_{2X63}^{H}$ (SVD decomposition)
- Peaks of σ_1 and σ_2 are included as natural frequency.
- Magnitudes of the two strongest independent vibration patterns at each frequency.

MIF: 위상 직교성으로 공진 주파수 후보 평가

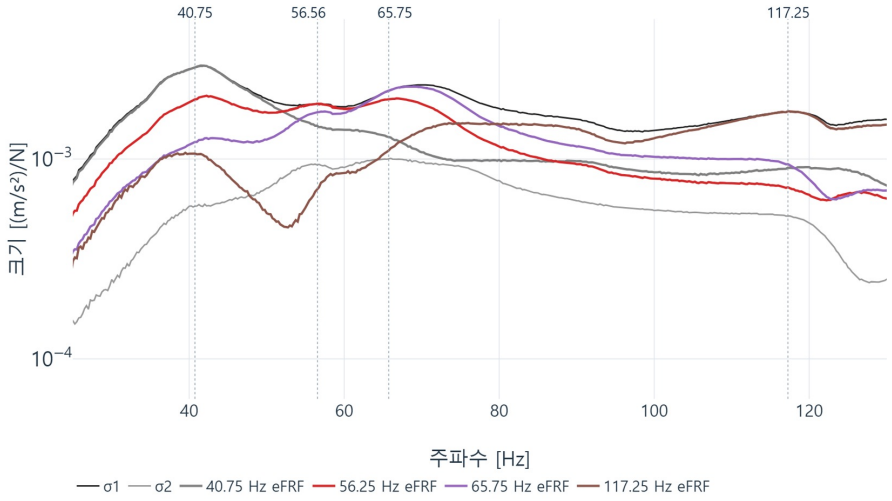


$$\mathrm{MIF}(f) = \frac{\sum_j [\mathrm{Re}H_j(f)]^2}{\sum_j |H_j(f)|^2} = \frac{\sum_j |H_j(f)|^2 \cos^2 \phi_j(f)}{\sum_j |H_j(f)|^2}$$

- Peaks of σ_1 and σ_2 are included as natural frequency.
- When the phase of the FRF is close to ±90°, MIF becomes small.

Damping ratio

- $h_r(f) = \mathbf{u}_r(f_r)^H \mathbf{H}(f) \mathbf{v}_r(f_r)$
- eFRF (enhanced FRF) is obtained by taking "singular vector" calculated at that peak frequency, using it as a weighting factor, and summing all the FRFs accordingly.
- Left and right singular vectors (mode shapes and modal participation factors) obtained at the CMIF peak points are used as weighting filters and multiplied by the original FRF matrix.
- Obtain FRF plots for each frequency by highlighting the singular vectors corresponding to the respective candidate frequencies.
- For all candidates, peak is first selected using SDOF approach; if other candidates are present within a range of ±5 Hz around a given candidate, MDOF approach is used instead.



기존 고유주파수 [Hz]	선정 고유주파수 [Hz]	감쇠비 [%]	적합 모델
66.25	40.75	11.13	MDOF
98.25	56.25	4.92	SDOF
115.25	65.75	10.63	SDOF
229.25	117.25	5.65	MDOF