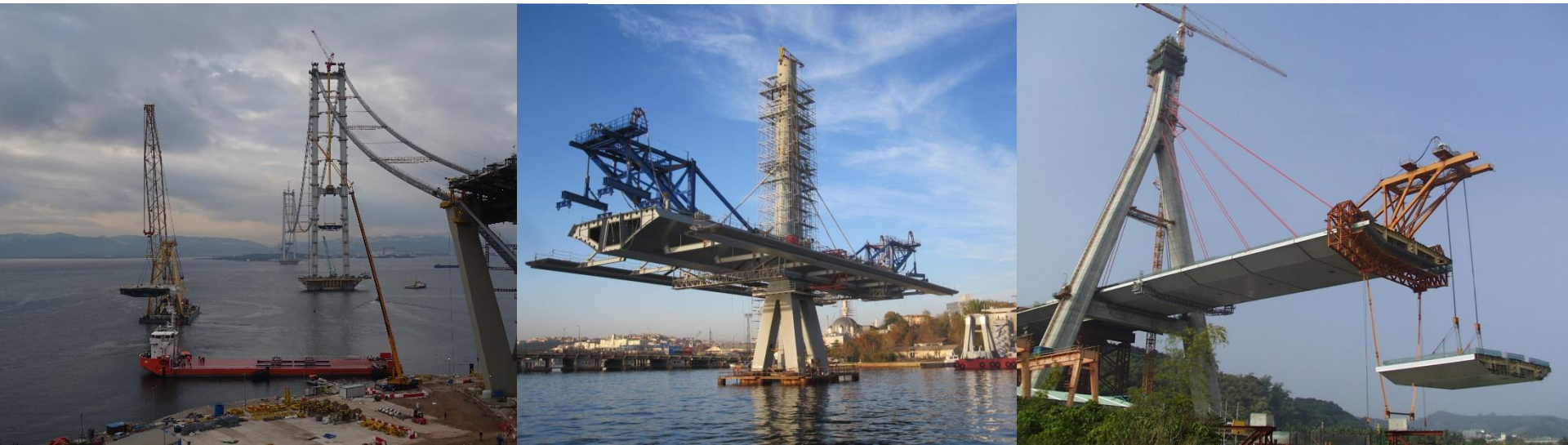

EVACES 2023 Milano

Helmut WENZEL // August 2023

Testing real Structures What Bridge Performance tells us

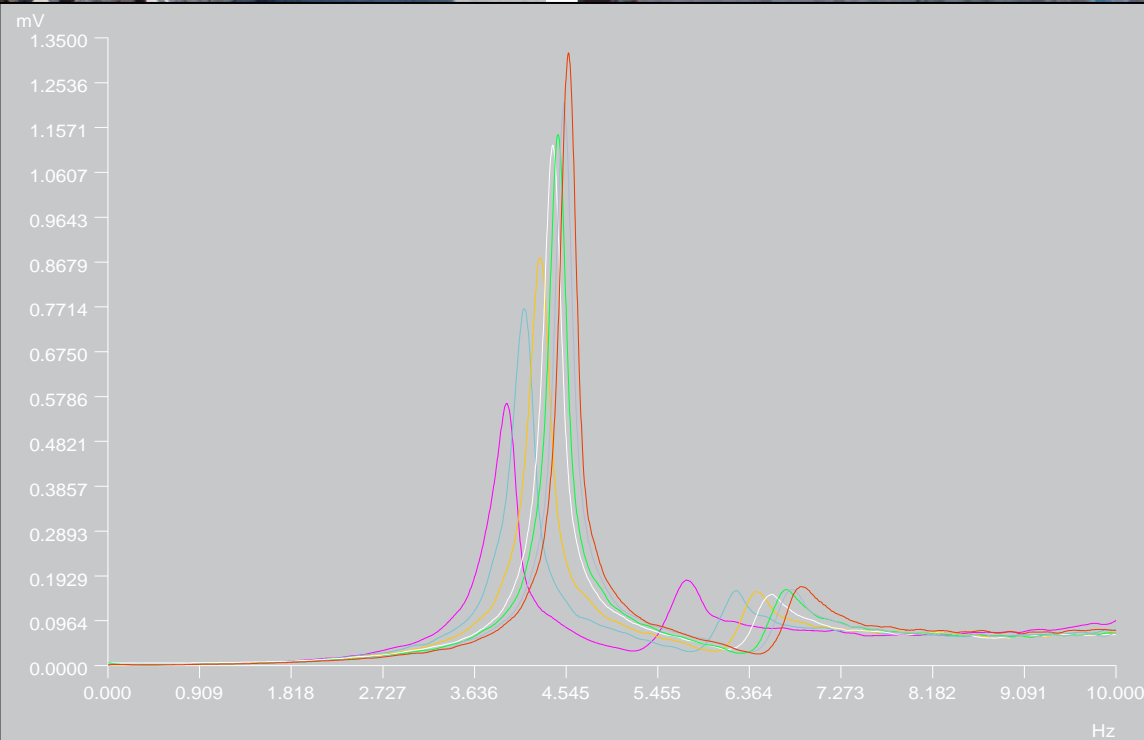




Example: Testing HARIS 1998



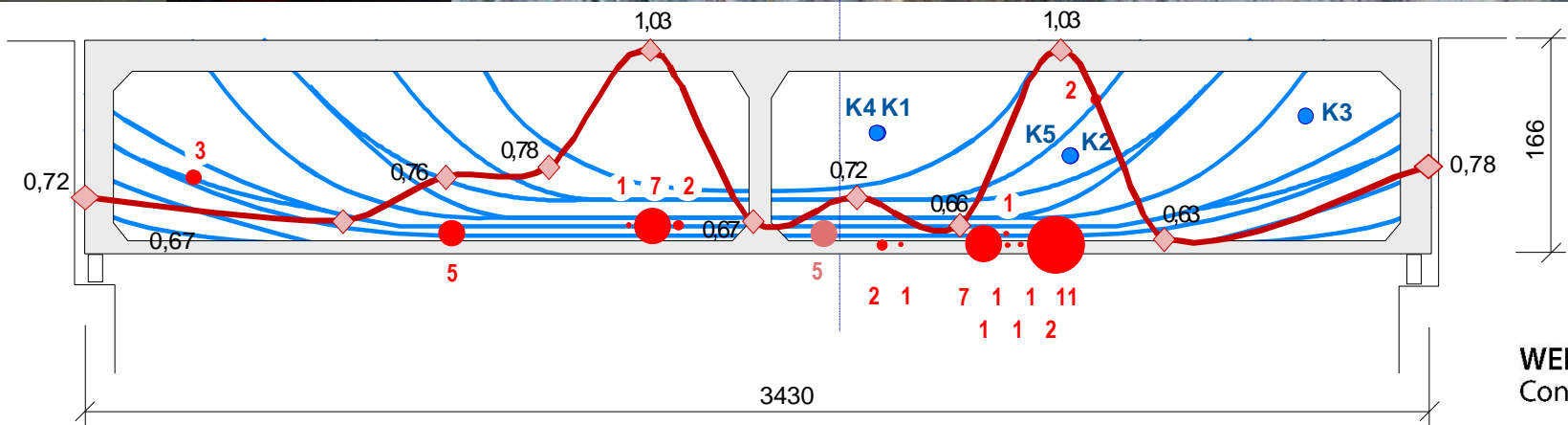
Example: Prestress Loss SAMCO 2003



03.04.03 08:56:01



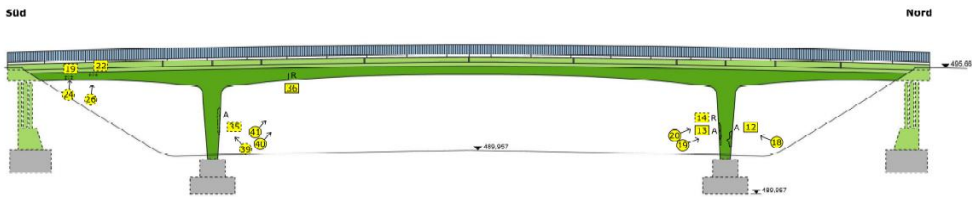
Example: Testing Regau 2002



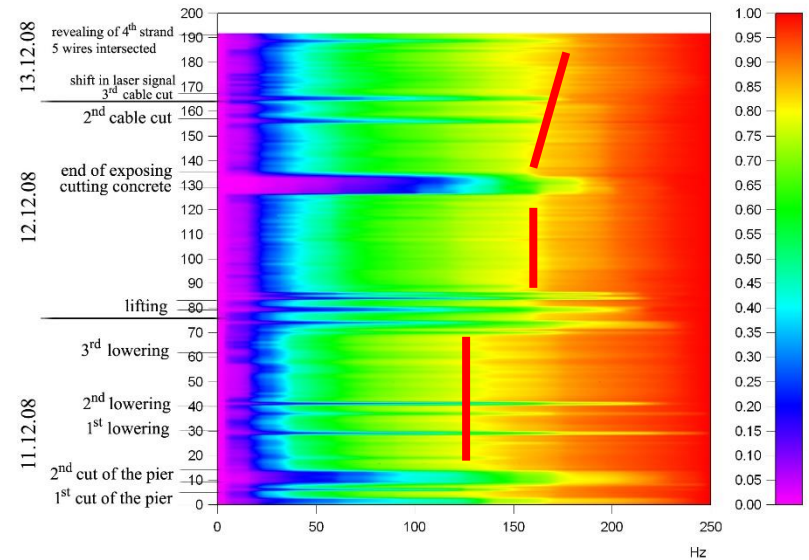
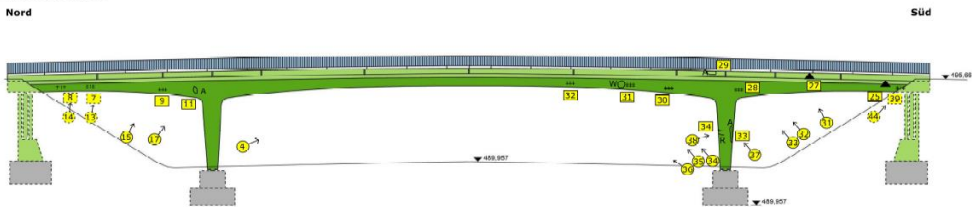
Example: Testing S101 2008



Objekt S101
Ansicht Ost
sud

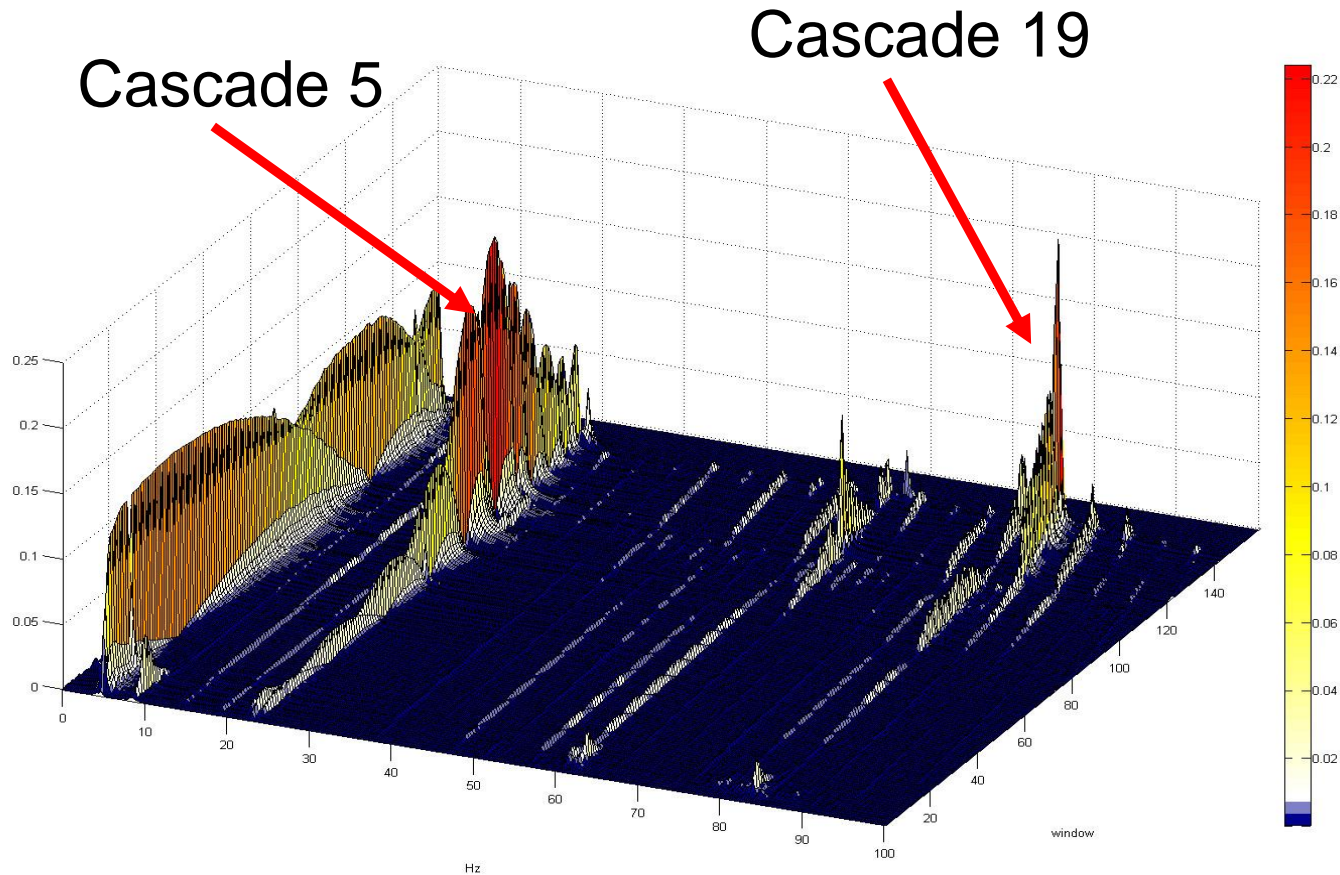


Ansicht West
Nord



Energy Leakage with progressive Damage

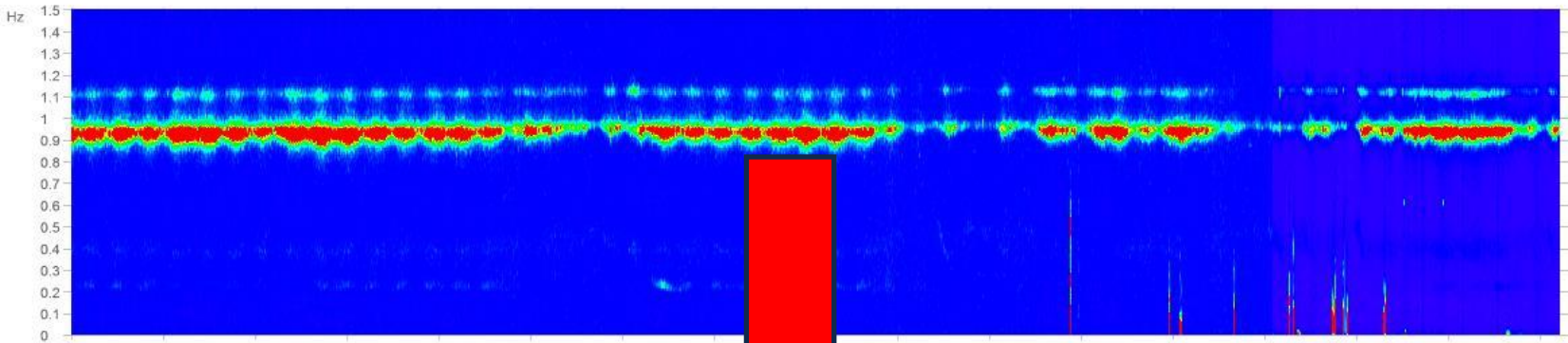
Response of the **Damaged** Structure



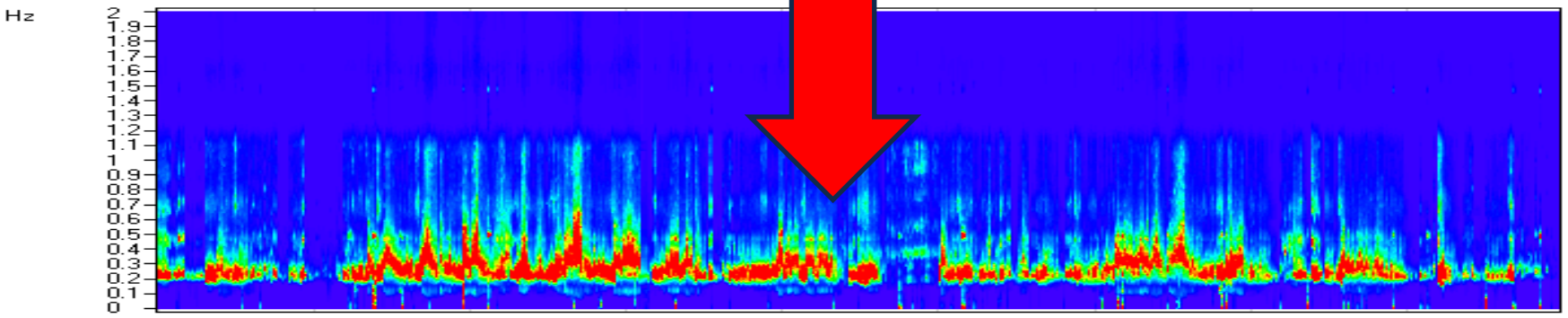
Performance after Degradation of Structure

Relevant frequencies shifted from 0,92Hz to 0,23Hz

Position Aux Power Deck, Axis C4: Frequency North-South 0 to 1,5 Hz



Position E4: Trendcard x-Direction:

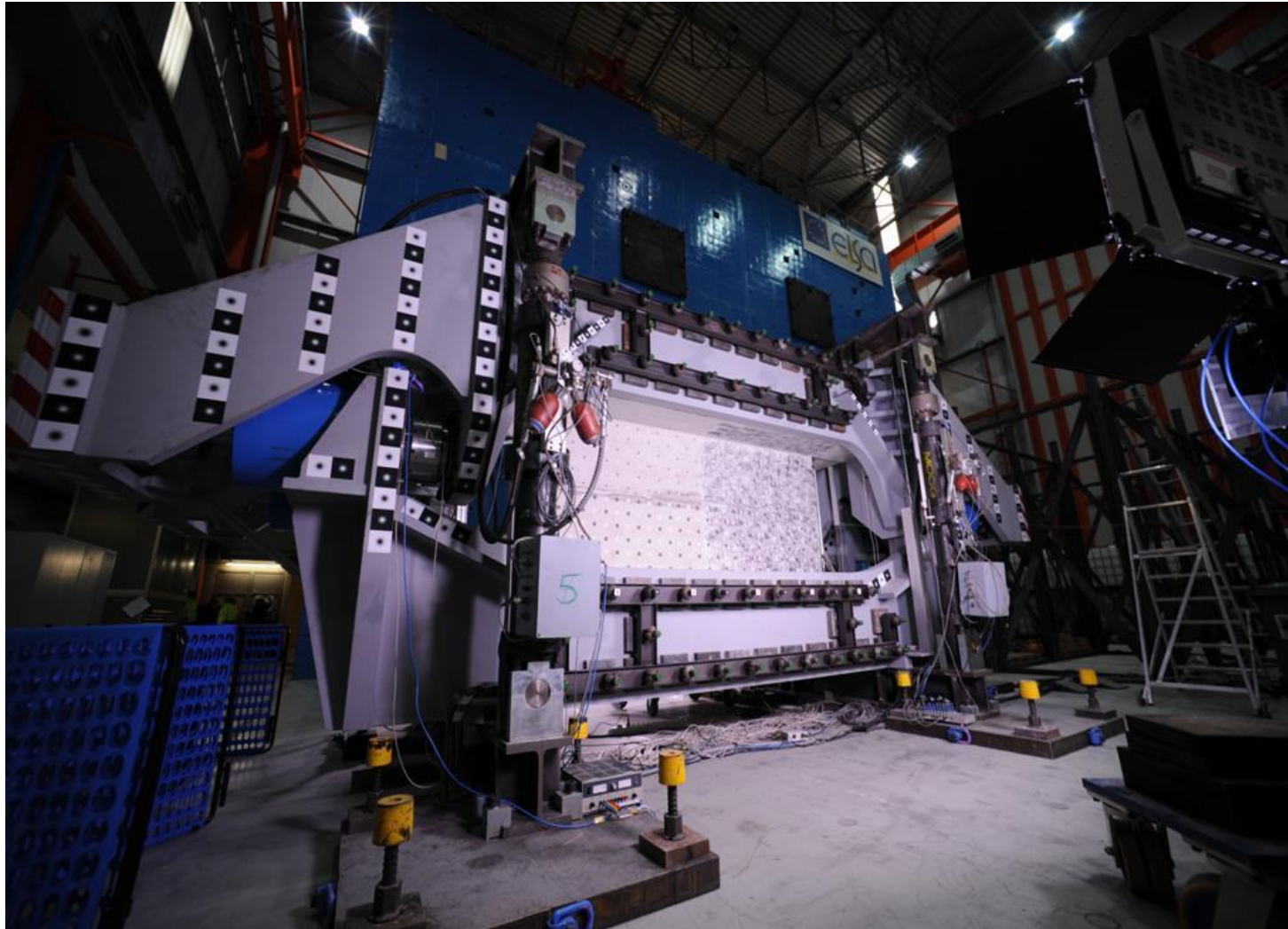




Sultanganj Bridge Collapse of Cantilevers 2022-04

TESSH at JRC

Shear testing of a thick reinforced concrete wall



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



Sultanganj Bridge Collapse 2023-06-04



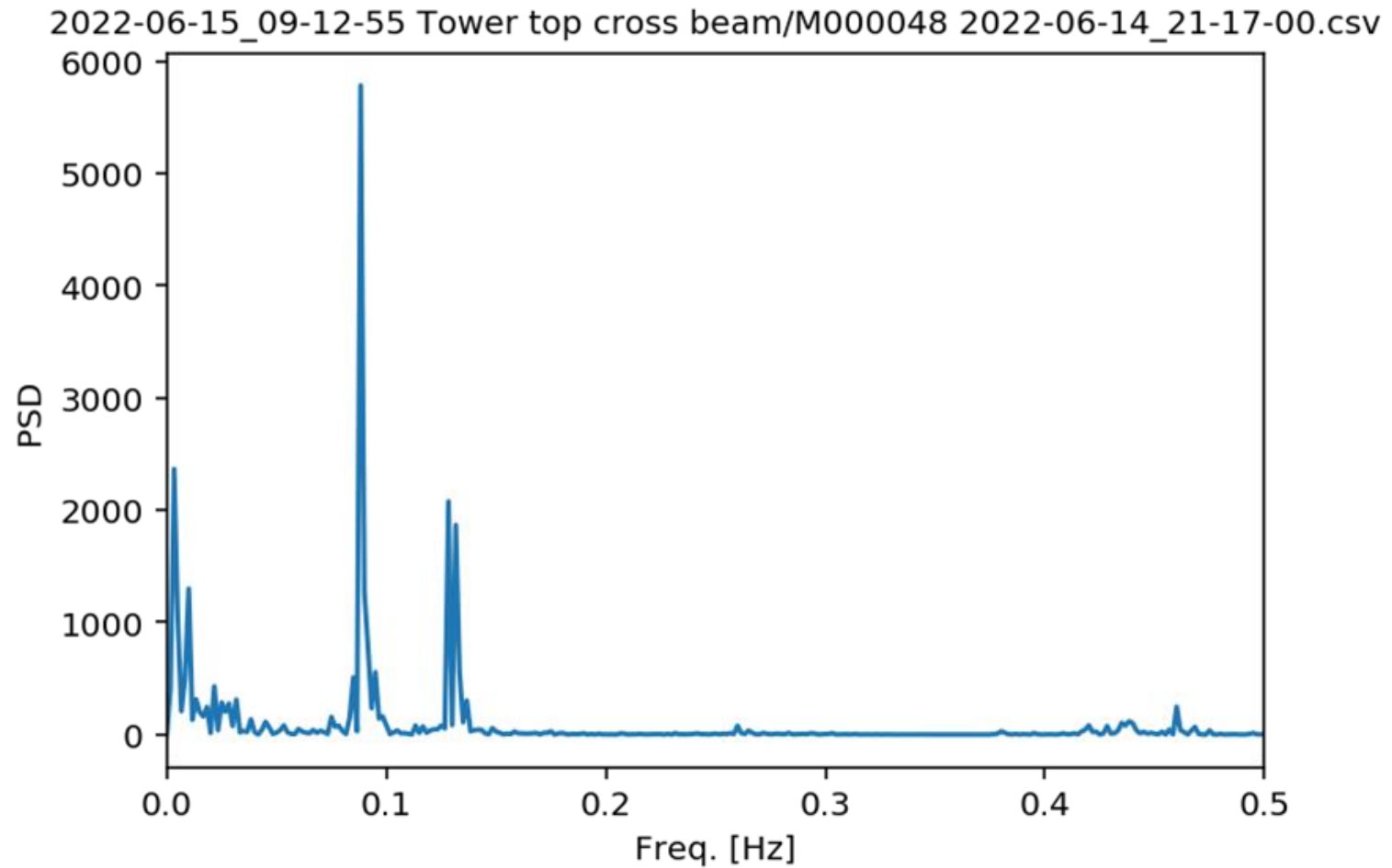


Osmangazi Bridge (1550m) 2012-24 Asset Management, Monitoring



Osmangazi Bridge (1550m) Wind Event 2021

First vertical mode at 0,09Hz





TC20-MRW THERMAL 14.06.2022 15:09:20



04.11



STOP BY

08/06/22	15:30:41.292	1	P50-L101	Güney pompa istasyonı derinliği ayarlı durdu
		2		

02,7 % P50-L102

03,3 % P50-L101

0,6 % P50-L101

Kuzey

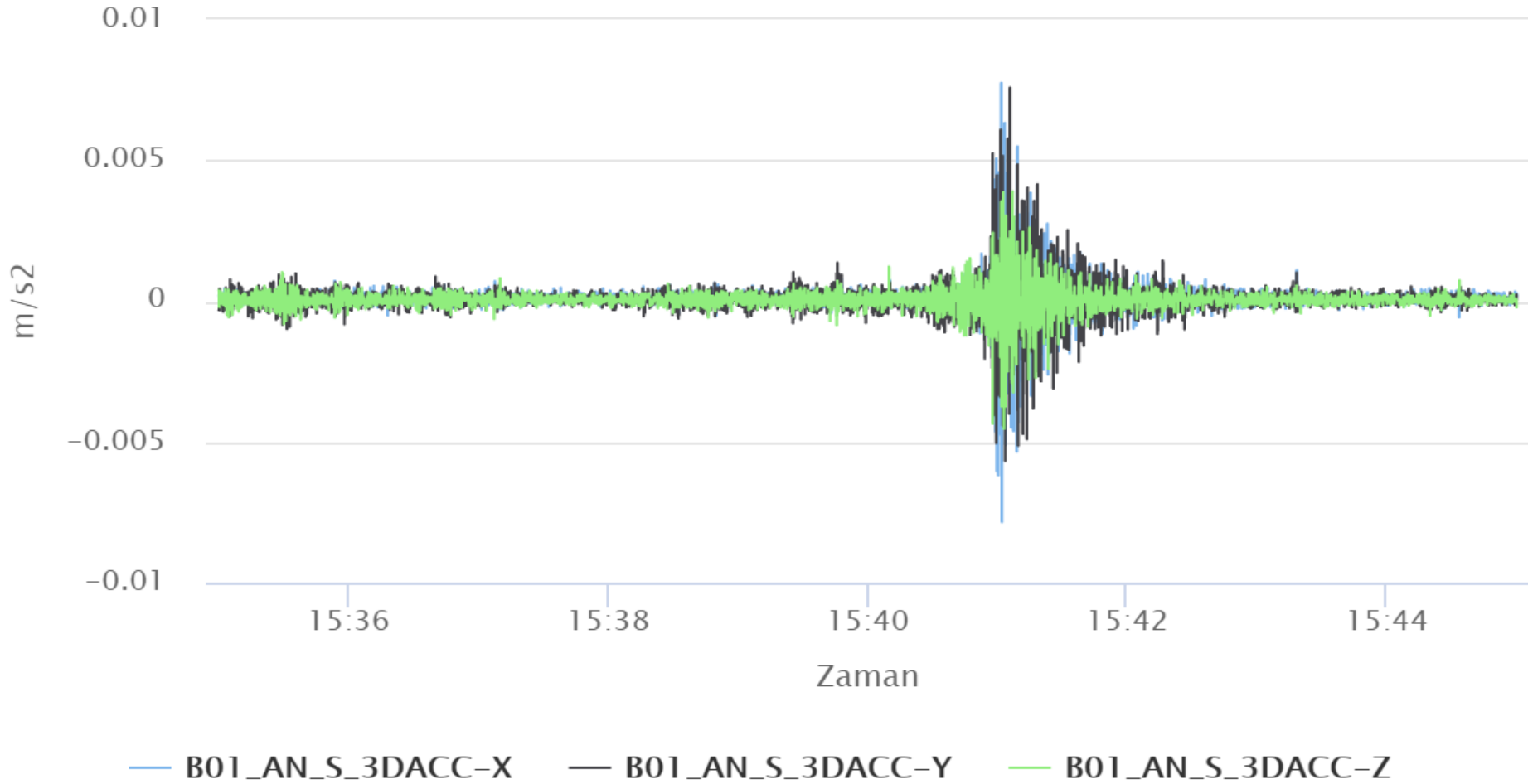
Güney

Güney Yükselmesi



Ham Veri Görselleştirme

17/11/2021 15:35:00 – 17/11/2021 15:45:00

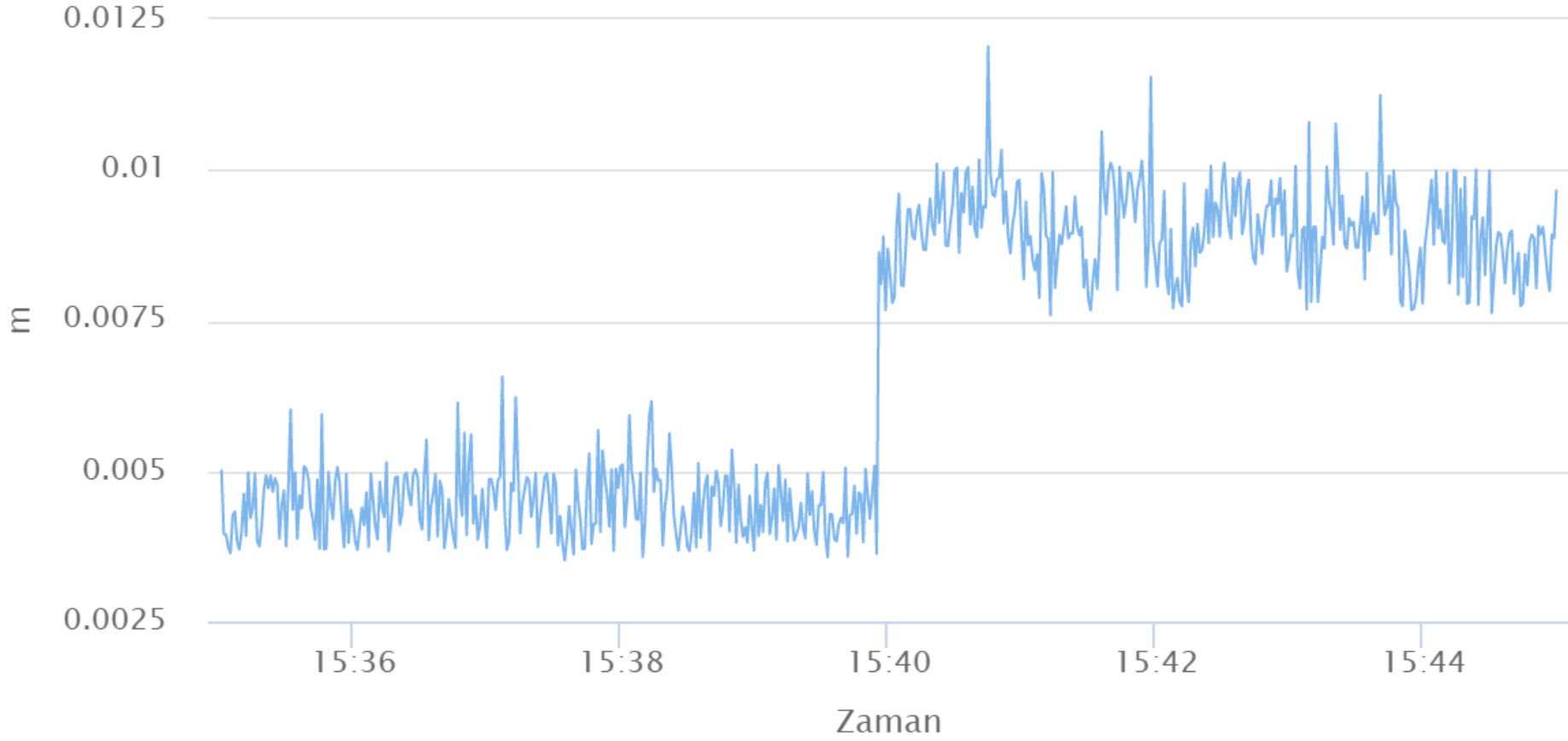


Osmangazi Bridge (1550m)

Seismic Event 2021

Ham Veri Görselleştirme

17/11/2021 15:35:00 – 17/11/2021 15:45:00



— V01_PR_00W_SDS-X

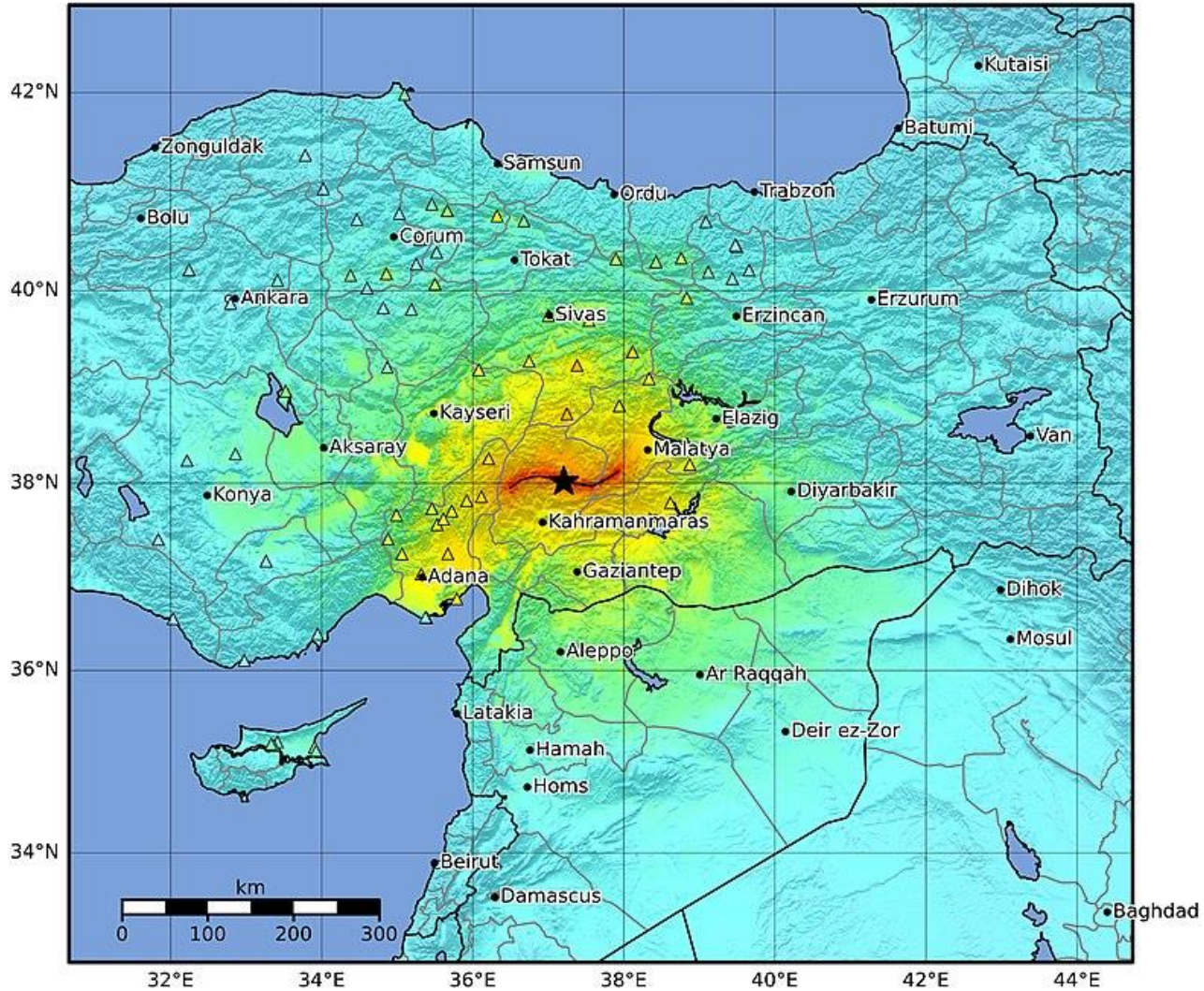
Osmangazi Bridge (1550m)

Permanent Displacement after EQ



Kormurhan Bridge (380m) 2021-24 Asset Management, Monitoring

Macroseismic Intensity Map USGS
 ShakeMap: 5 km SSE of Ekinözü, Kahramanmaraş, TR
 Feb 06, 2023 10:24:50 UTC M7.5 N38.02 E37.21 Depth: 15.0km ID:us6000jlqa



SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	None	None	None	Very light	Light	Moderate	Moderate/heavy	Heavy	Very heavy
PGA(%g)	<0.0464	0.297	2.76	6.2	11.5	21.5	40.1	74.7	>139
PGV(cm/s)	<0.0215	0.135	1.41	4.65	9.64	20	41.4	85.8	>178
INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based on Worden et al. (2012)

Version 9: Processed 2023-03-08T17:21:31Z

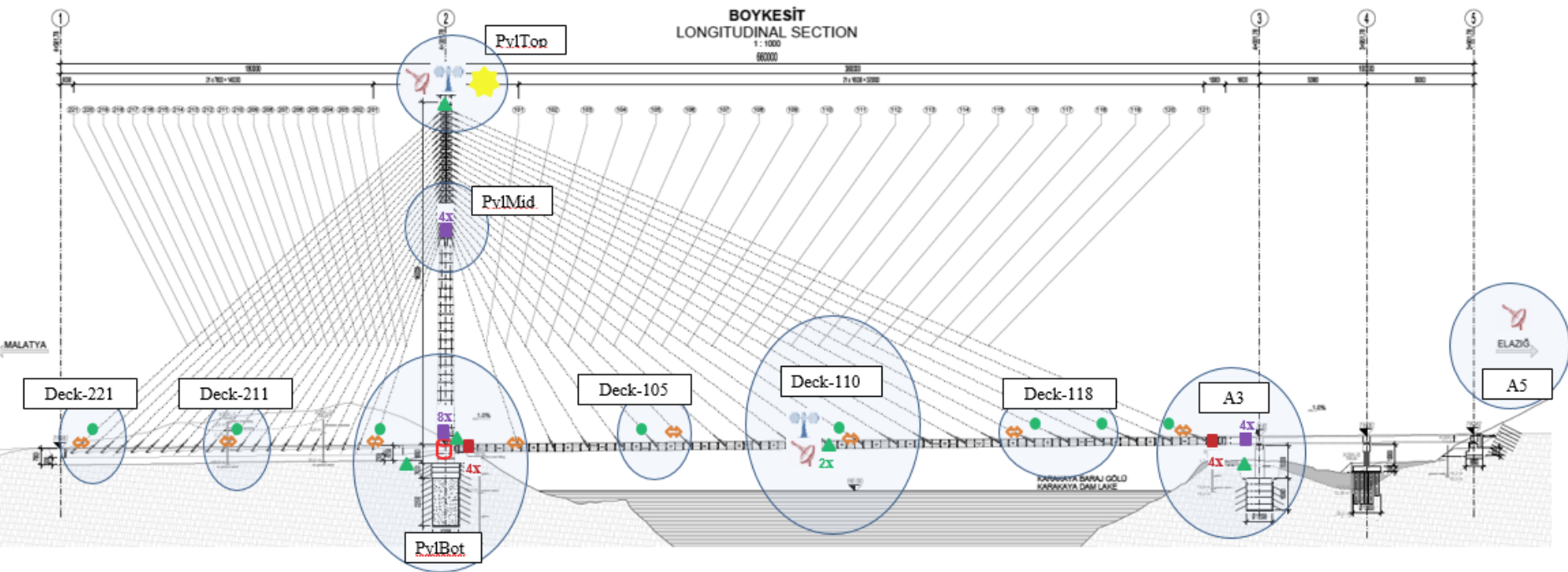
△ Seismic Instrument ○ Reported Intensity

★ Epicenter □ Rupture



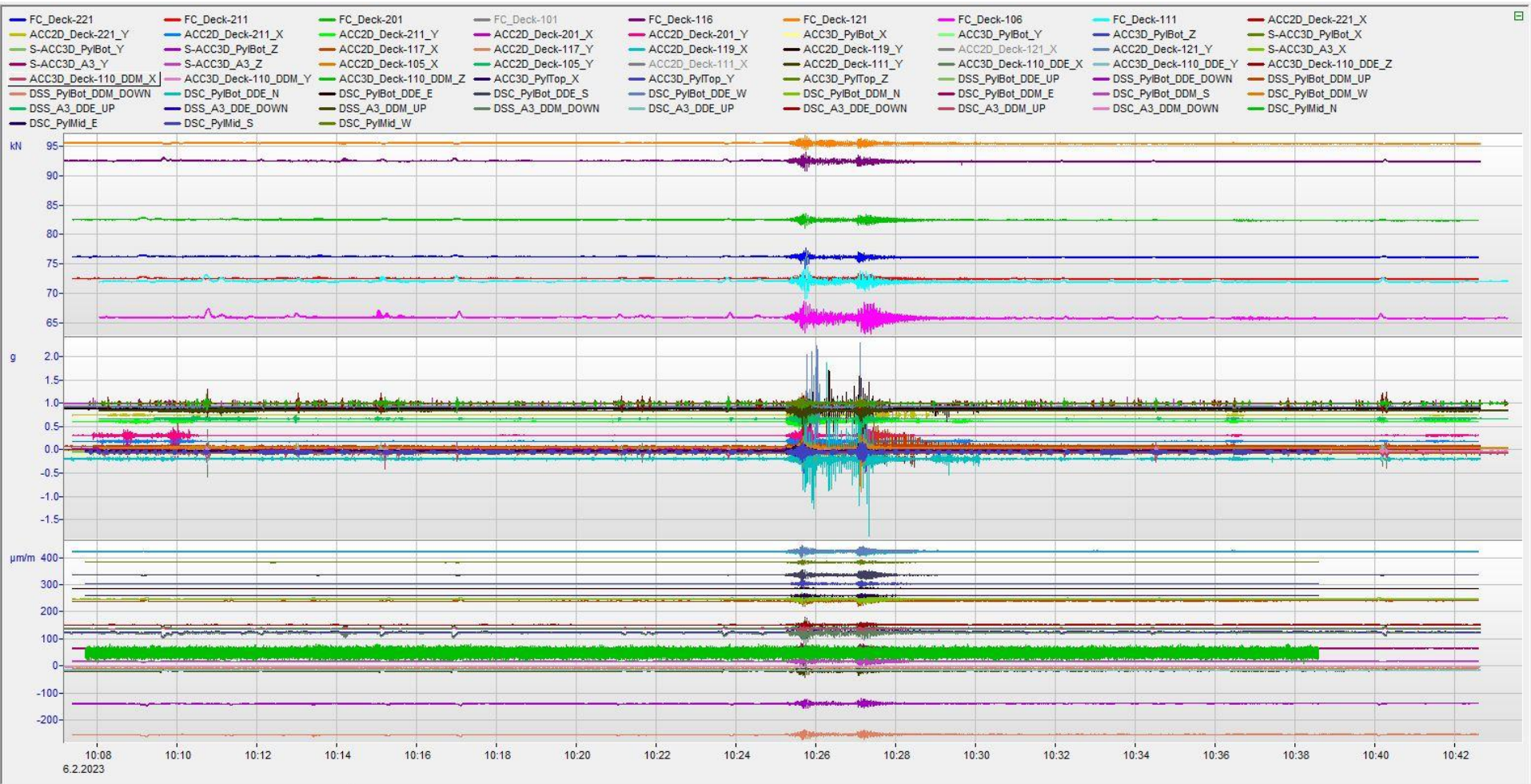
#علاء عليوي

الأربعاء، ٨ فبراير ٢٠٢٣ ١٥:٣٩

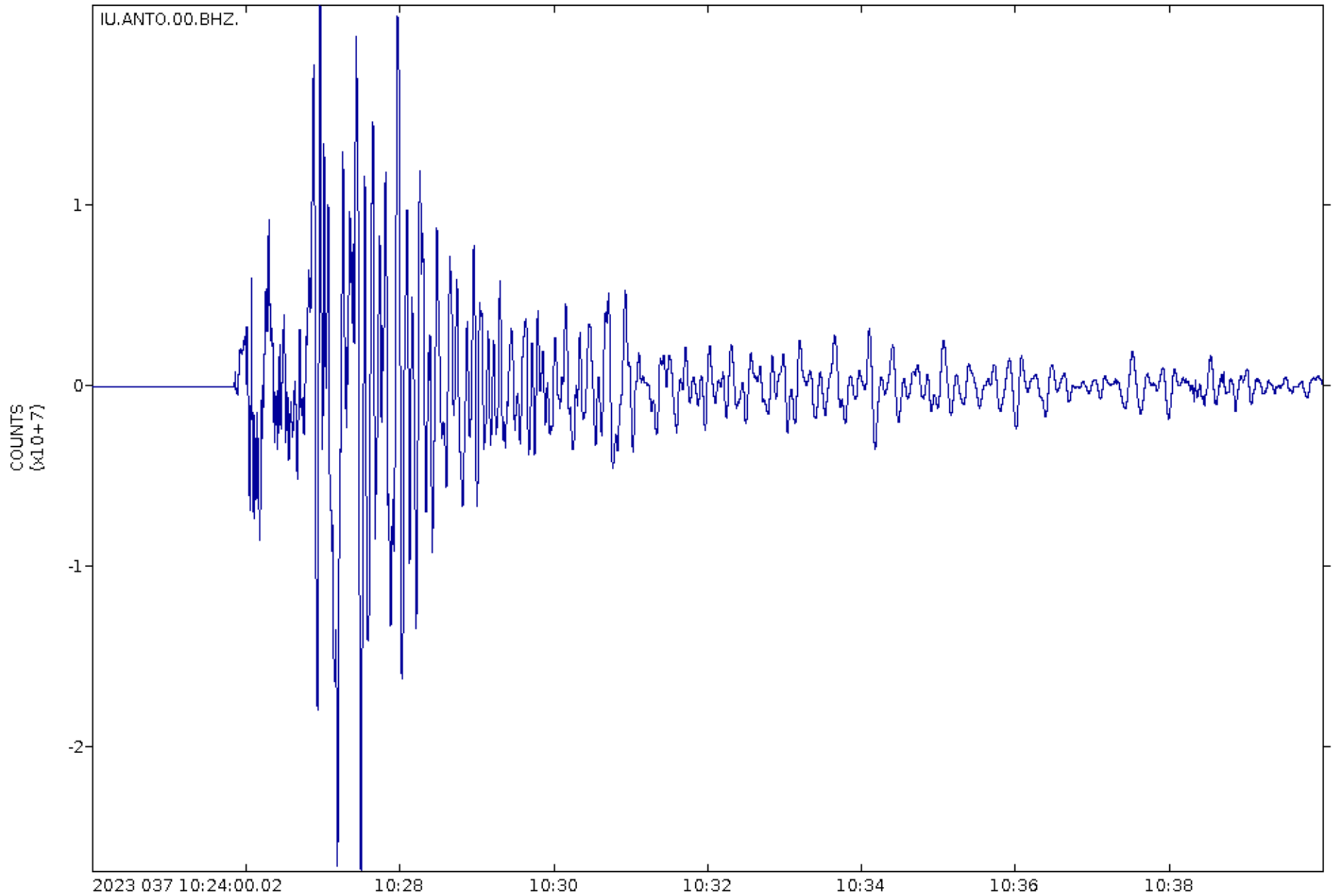


-  **Monitoring Master Station**
-  **GPS Sensor**
-  **Weather station (wind speed, wind direction, humidity, air temperature, barometric pressure)**
-  **3d-accelerometer**
-  **2d-accelerometer for stay cable**
-  **Cable force sensor**
-  **Strain gauge for concrete**
-  **Strain gauge for steel**
-  **Pyranometer (Luminosity)**

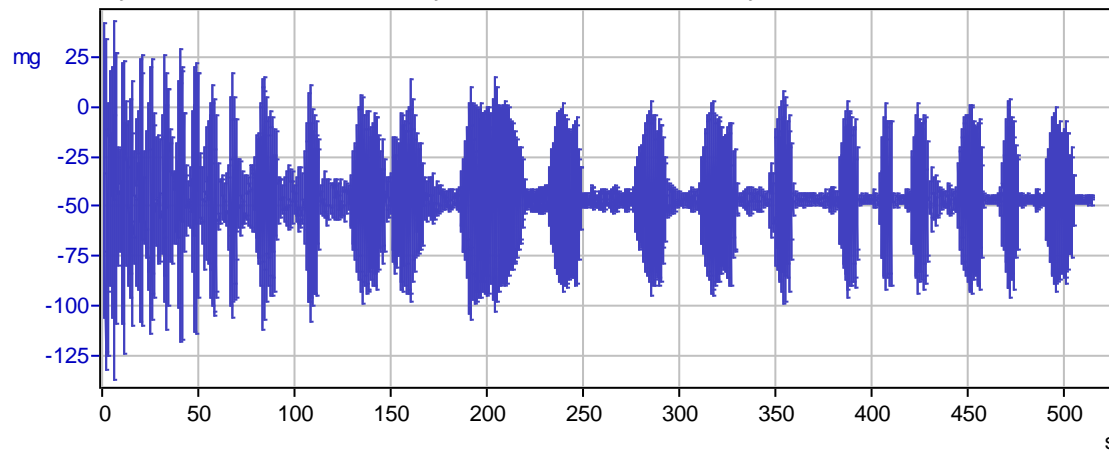
Kormurhan Bridge (380m) 2021-24 Asset Management, Monitoring



Kormurhan Bridge (380m) 2021-24 Asset Management, Monitoring

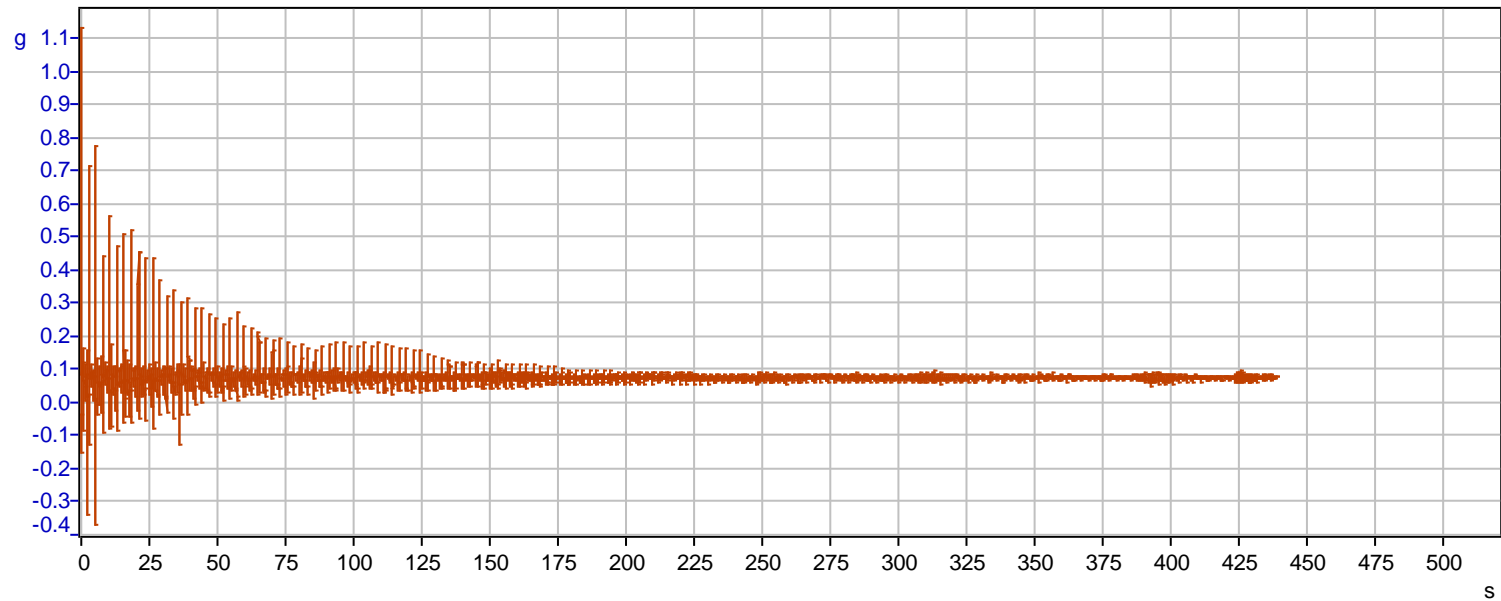


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| FC_Deck-221 | FC_Deck-211 | FC_Deck-201 |
| FC_Deck-101 | FC_Deck-116 | FC_Deck-121 |
| FC_Deck-106 | FC_Deck-111 | ACC2D_Deck-221_X |
| ACC2D_Deck-221_Y | ACC2D_Deck-211_X | ACC2D_Deck-211_Y |
| ACC2D_Deck-201_X | ACC2D_Deck-201_Y | ACC3D_PylBot_X |
| ACC3D_PylBot_Y | ACC3D_PylBot_Z | S-ACC3D_PylBot_X |
| S-ACC3D_PylBot_Y | S-ACC3D_PylBot_Z | ACC2D_Deck-117_X |
| ACC2D_Deck-117_Y | ACC2D_Deck-119_X | ACC2D_Deck-119_Y |
| ACC2D_Deck-121_X | ACC2D_Deck-121_Y | S-ACC3D_A3_X |
| S-ACC3D_A3_Y | S-ACC3D_A3_Z | ACC2D_Deck-105_X |
| ACC2D_Deck-105_Y | ACC2D_Deck-111_X | ACC2D_Deck-111_Y |
| ACC3D_Deck-110_DDE_X | ACC3D_Deck-110_DDE_Y | ACC3D_Deck-110_DDE_Z |
| ACC3D_Deck-110_DDM_X | ACC3D_Deck-110_DDM_Y | ACC3D_Deck-110_DDM_Z |
| ACC3D_PylTop_X | ACC3D_PylTop_Y | ACC3D_PylTop_Z |
| DSS_PylBot_DDE_UP | DSS_PylBot_DDE_DOWN | DSS_PylBot_DDM_UP |
| DSS_PylBot_DDM_DOWN | DSC_PylBot_DDE_N | DSC_PylBot_DDE_E |
| DSC_PylBot_DDE_S | DSC_PylBot_DDE_W | DSC_PylBot_DDM_N |
| DSC_PylBot_DDM_E | DSC_PylBot_DDM_S | DSC_PylBot_DDM_W |
| DSS_A3_DDE_UP | DSS_A3_DDE_DOWN | DSS_A3_DDM_UP |
| DSS_A3_DDM_DOWN | DSC_A3_DDE_UP | DSC_A3_DDE_DOWN |
| DSC_A3_DDM_UP | DSC_A3_DDM_DOWN | DSC_PylMid_N |
| DSC_PylMid_E | DSC_PylMid_S | DSC_PylMid_W |

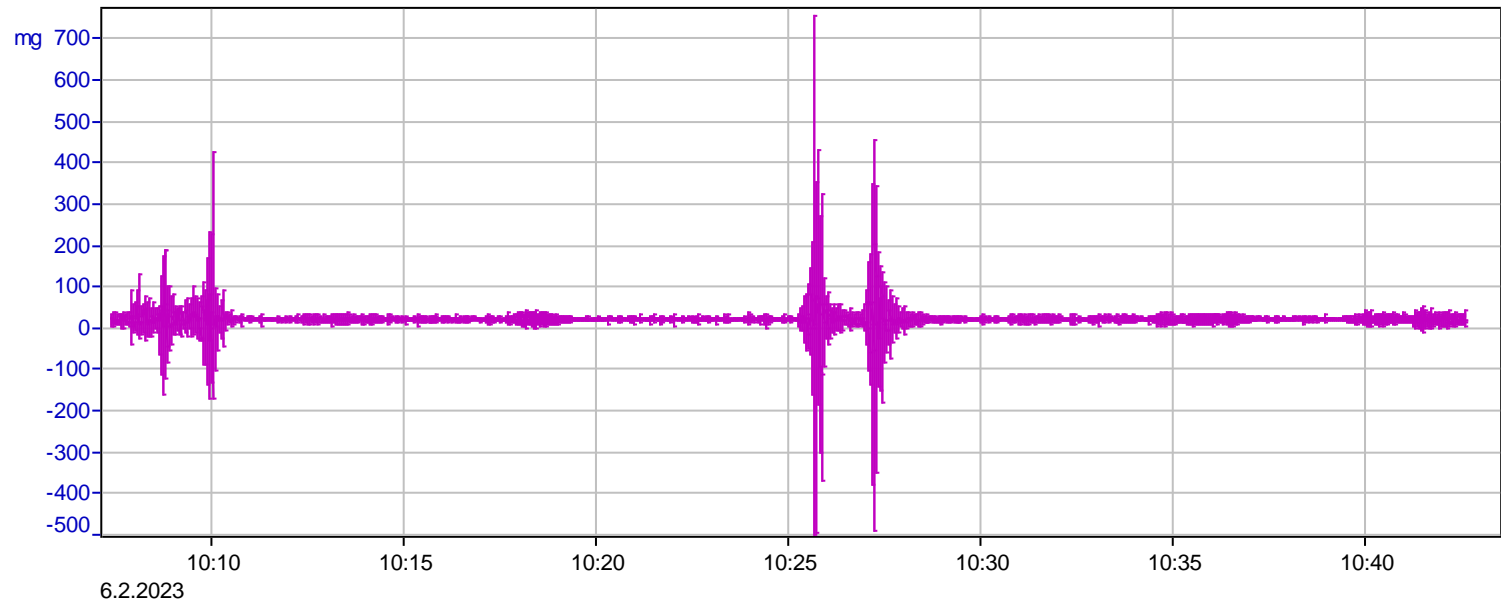


Kormurhan Bridge (380m) 2021-24 Asset Management, Monitoring

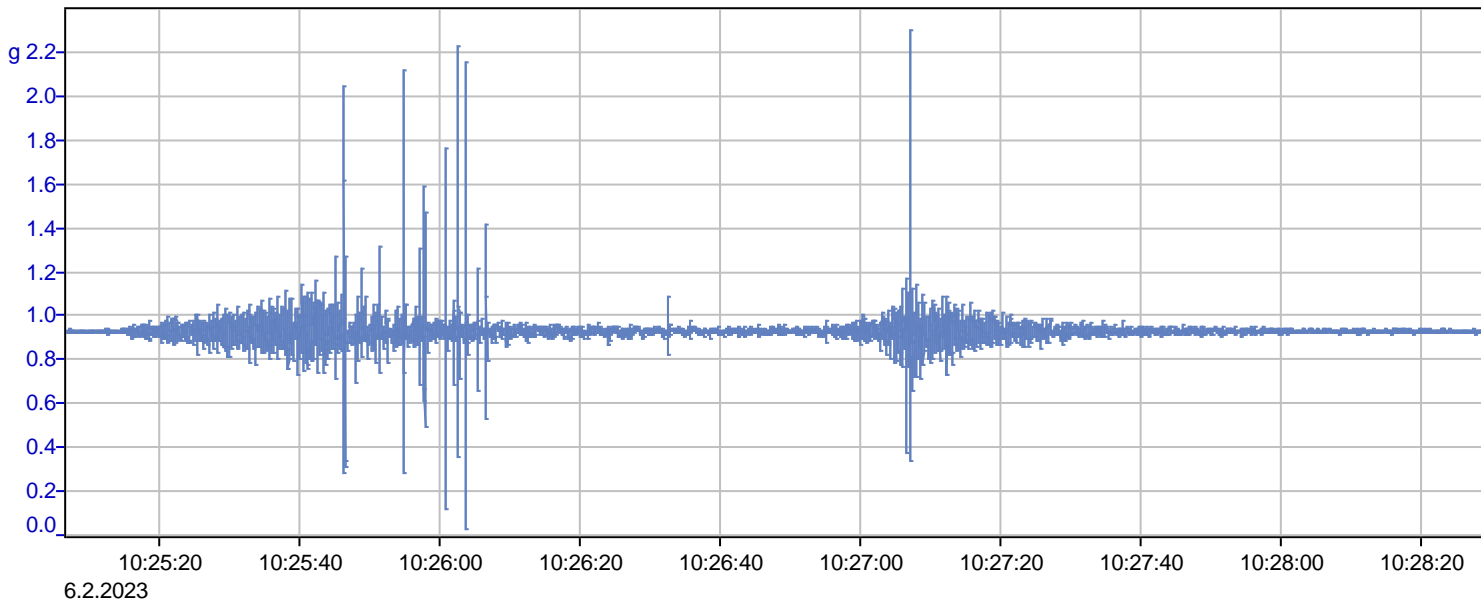
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| FC_Deck-116 | FC_Deck-121 | FC_Deck-106 | FC_Deck-111 |
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| ACC2D_Deck-201_X | ACC2D_Deck-201_Y | ACC3D_PylBot_X | ACC3D_PylBot_Y |
| ACC3D_PylBot_Z | S-ACC3D_PylBot_X | S-ACC3D_PylBot_Y | S-ACC3D_PylBot_Z |
| ACC2D_Deck-117_X | ACC2D_Deck-117_Y | ACC2D_Deck-119_X | ACC2D_Deck-119_Y |
| ACC2D_Deck-121_X | ACC2D_Deck-121_Y | S-ACC3D_A3_X | S-ACC3D_A3_Y |
| S-ACC3D_A3_Z | ACC2D_Deck-105_X | ACC2D_Deck-105_Y | ACC2D_Deck-111_X |
| ACC2D_Deck-111_Y | ACC3D_Deck-110_DDE_X | ACC3D_Deck-110_DDE_Y | ACC3D_Deck-110_DDE_Z |
| ACC3D_Deck-110_DDM_X | ACC3D_Deck-110_DDM_Y | ACC3D_Deck-110_DDM_Z | ACC3D_PylTop_X |
| ACC3D_PylTop_Y | ACC3D_PylTop_Z | DSS_PylBot_DDE_UP | DSS_PylBot_DDE_DOWN |
| DSS_PylBot_DDM_UP | DSS_PylBot_DDM_DOWN | DSC_PylBot_DDE_N | DSC_PylBot_DDE_E |
| DSC_PylBot_DDE_S | DSC_PylBot_DDE_W | DSC_PylBot_DDM_N | DSC_PylBot_DDM_E |
| DSC_PylBot_DDM_S | DSC_PylBot_DDM_W | DSS_A3_DDE_UP | DSS_A3_DDE_DOWN |
| DSS_A3_DDM_UP | DSS_A3_DDM_DOWN | DSC_A3_DDE_UP | DSC_A3_DDE_DOWN |
| DSC_A3_DDM_UP | DSC_A3_DDM_DOWN | DSC_PylMid_N | DSC_PylMid_E |
| DSC_PylMid_S | DSC_PylMid_W | | |



- | | | | |
|-------------------------|----------------------|----------------------|----------------------|
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| FC_Deck-116 | FC_Deck-121 | FC_Deck-106 | FC_Deck-111 |
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| ACC2D_Deck-201_X | ACC2D_Deck-201_Y | ACC3D_PylBot_X | ACC3D_PylBot_Y |
| ACC3D_PylBot_Z | S-ACC3D_PylBot_X | S-ACC3D_PylBot_Y | S-ACC3D_PylBot_Z |
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| S-ACC3D_A3_Z | ACC2D_Deck-105_X | ACC2D_Deck-105_Y | ACC2D_Deck-111_X |
| ACC2D_Deck-111_Y | ACC3D_Deck-110_DDE_X | ACC3D_Deck-110_DDE_Y | ACC3D_Deck-110_DDE_Z |
| ACC3D_Deck-110_DDM_X | ACC3D_Deck-110_DDM_Y | ACC3D_Deck-110_DDM_Z | ACC3D_PylTop_X |
| ACC3D_PylTop_Y | ACC3D_PylTop_Z | DSS_PylBot_DDE_UP | DSS_PylBot_DDE_DOWN |
| DSS_PylBot_DDM_UP | DSS_PylBot_DDM_DOWN | DSC_PylBot_DDE_N | DSC_PylBot_DDE_E |
| DSC_PylBot_DDE_S | DSC_PylBot_DDE_W | DSC_PylBot_DDM_N | DSC_PylBot_DDM_E |
| DSC_PylBot_DDM_S | DSC_PylBot_DDM_W | DSS_A3_DDE_UP | DSS_A3_DDE_DOWN |
| DSS_A3_DDM_UP | DSS_A3_DDM_DOWN | DSC_A3_DDE_UP | DSC_A3_DDE_DOWN |
| DSC_A3_DDM_UP | DSC_A3_DDM_DOWN | DSC_PylMid_N | DSC_PylMid_E |
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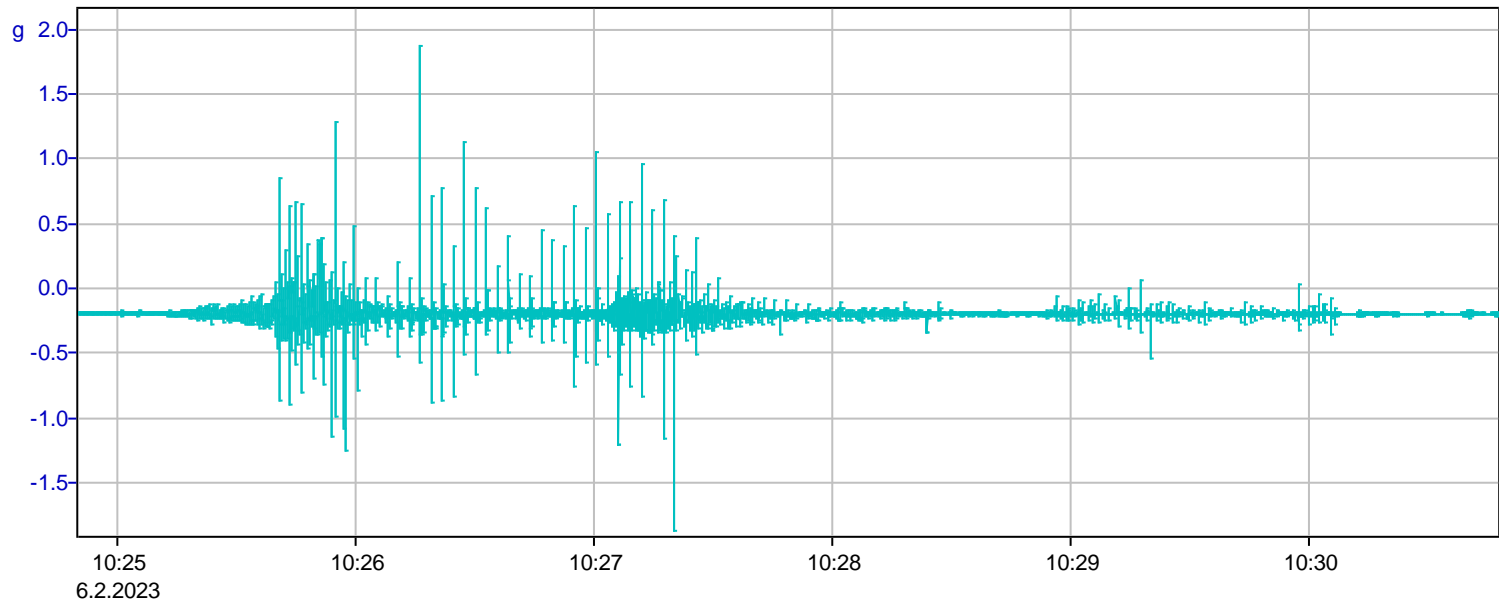


- FC_Deck-221
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- ACC3D_PylBot_Z
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- ACC2D_Deck-121_X
- S-ACC3D_A3_Z
- ACC2D_Deck-111_Y
- ACC3D_Deck-110_DDM_X
- ACC3D_PylTop_Y
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- DSC_PylBot_DDE_S
- DSC_PylBot_DDM_S
- DSS_A3_DDM_UP
- DSC_A3_DDM_UP
- DSC_PylMid_S
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- FC_Deck-121
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- ACC2D_Deck-201_Y
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- ACC2D_Deck-117_Y
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- DSC_PylBot_DDE_W
- DSC_PylBot_DDM_W
- DSS_A3_DDM_DOWN
- DSC_A3_DDM_DOWN
- DSC_PylMid_W
- FC_Deck-201
- FC_Deck-106
- ACC2D_Deck-211_X
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- ACC2D_Deck-105_Y
- ACC3D_Deck-110_DDE_Y
- ACC3D_Deck-110_DDM_Z
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- DSC_PylBot_DDE_N
- DSC_PylBot_DDM_N
- DSS_A3_DDE_UP
- DSC_A3_DDE_UP
- DSC_PylMid_N
- FC_Deck-101
- FC_Deck-111
- ACC2D_Deck-211_Y
- ACC3D_PylBot_Y
- S-ACC3D_PylBot_Z
- ACC2D_Deck-119_Y
- S-ACC3D_A3_Y
- ACC2D_Deck-111_X
- ACC3D_Deck-110_DDE_Z
- ACC3D_PylTop_X
- DSS_PylBot_DDE_DOWN
- DSC_PylBot_DDE_E
- DSC_PylBot_DDM_E
- DSS_A3_DDE_DOWN
- DSC_A3_DDE_DOWN
- DSC_PylMid_E



Kormurhan Bridge (380m) 2021-24 Asset Management, Monitoring

- | | | | |
|----------------------|----------------------|-------------------------|----------------------|
| FC_Deck-221 | FC_Deck-211 | FC_Deck-201 | FC_Deck-101 |
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| ACC2D_Deck-201_X | ACC2D_Deck-201_Y | ACC3D_PylBot_X | ACC3D_PylBot_Y |
| ACC3D_PylBot_Z | S-ACC3D_PylBot_X | S-ACC3D_PylBot_Y | S-ACC3D_PylBot_Z |
| ACC2D_Deck-117_X | ACC2D_Deck-117_Y | ACC2D_Deck-119_X | ACC2D_Deck-119_Y |
| ACC2D_Deck-121_X | ACC2D_Deck-121_Y | S-ACC3D_A3_X | S-ACC3D_A3_Y |
| S-ACC3D_A3_Z | ACC2D_Deck-105_X | ACC2D_Deck-105_Y | ACC2D_Deck-111_X |
| ACC2D_Deck-111_Y | ACC3D_Deck-110_DDE_X | ACC3D_Deck-110_DDE_Y | ACC3D_Deck-110_DDE_Z |
| ACC3D_Deck-110_DDM_X | ACC3D_Deck-110_DDM_Y | ACC3D_Deck-110_DDM_Z | ACC3D_PylTop_X |
| ACC3D_PylTop_Y | ACC3D_PylTop_Z | DSS_PylBot_DDE_UP | DSS_PylBot_DDE_DOWN |
| DSS_PylBot_DDM_UP | DSS_PylBot_DDM_DOWN | DSC_PylBot_DDE_N | DSC_PylBot_DDE_E |
| DSC_PylBot_DDE_S | DSC_PylBot_DDE_W | DSC_PylBot_DDM_N | DSC_PylBot_DDM_E |
| DSC_PylBot_DDM_S | DSC_PylBot_DDM_W | DSS_A3_DDE_UP | DSS_A3_DDE_DOWN |
| DSS_A3_DDM_UP | DSS_A3_DDM_DOWN | DSC_A3_DDE_UP | DSC_A3_DDE_DOWN |
| DSC_A3_DDM_UP | DSC_A3_DDM_DOWN | DSC_PylMid_N | DSC_PylMid_E |
| DSC_PylMid_S | DSC_PylMid_W | | |

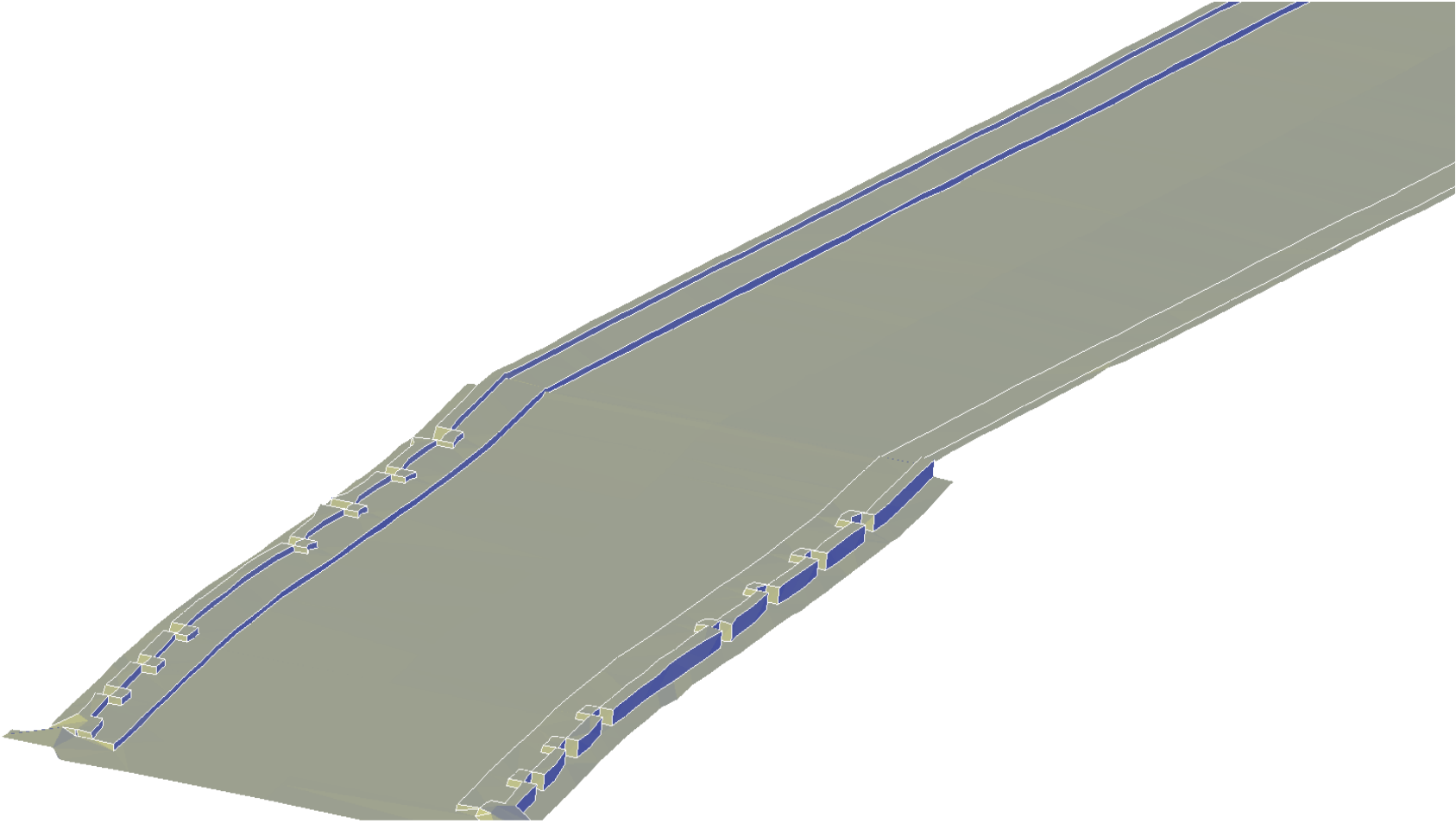




COCORILLOS
NO SEAN
CROCODILES
NO SEAN
COCORILLOS



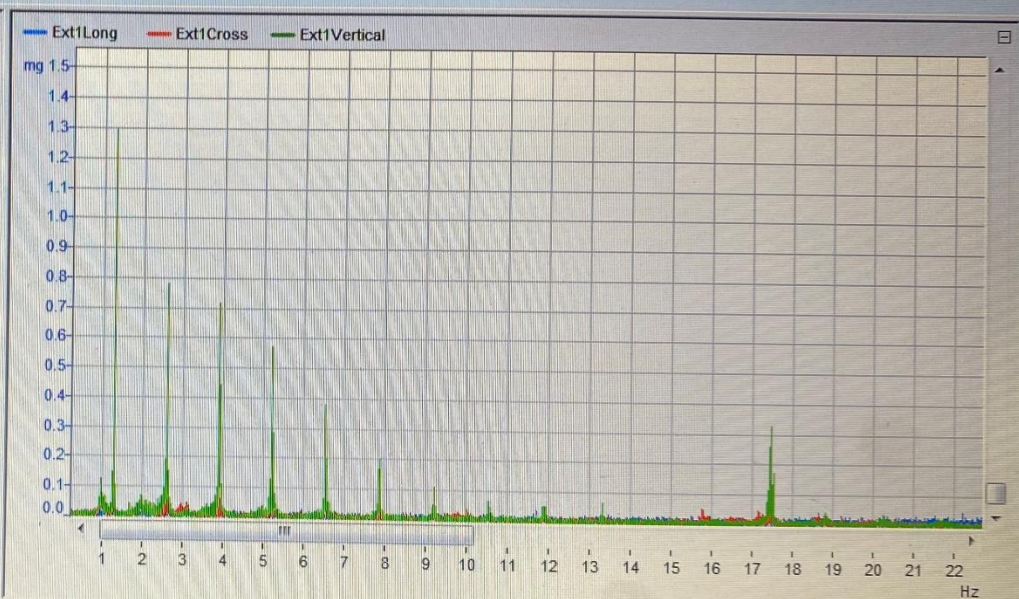
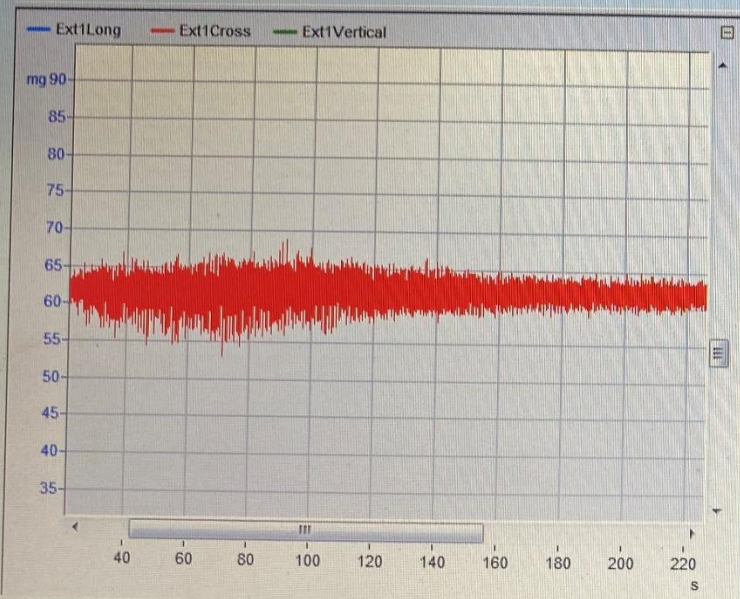
Scan of actual Bridge Surface











Navigation controls including zoom in (+), zoom out (-), home, play/pause, stop, and close (X) buttons.

Windows taskbar icons including Firefox, File Explorer, Photos, Eye, Scissors, and other applications.

Monitoring of GODAVARI Bridge, Rajahmundry





SPAN
2

इब्ल्यूए जी ९ एच

31736

गोला

5/18



Problem : Dina hangers got damaged



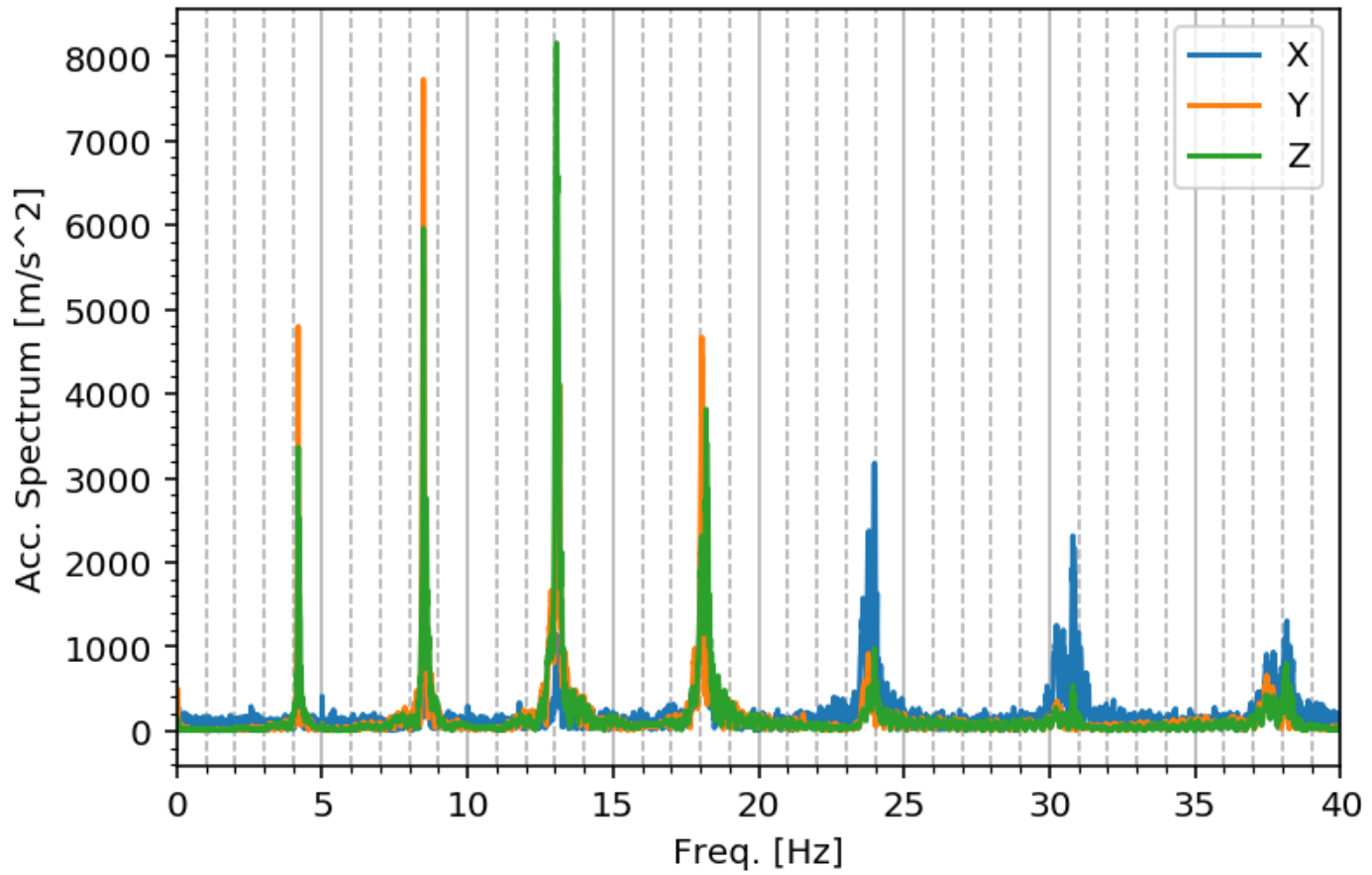


Rajahmundry

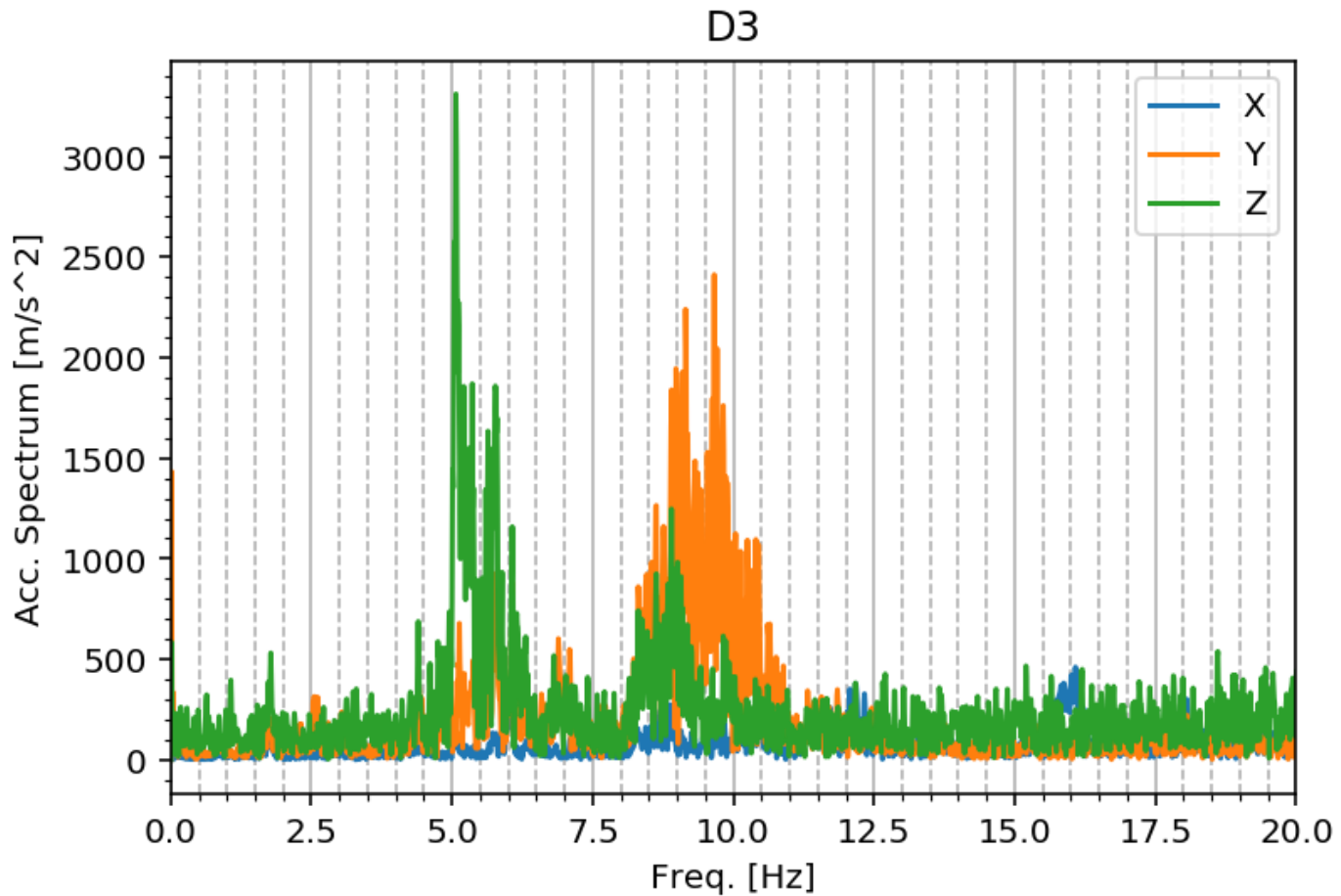


Rajahmundry Railway Bridge (100m) 2023, Condition Monitoring

A5



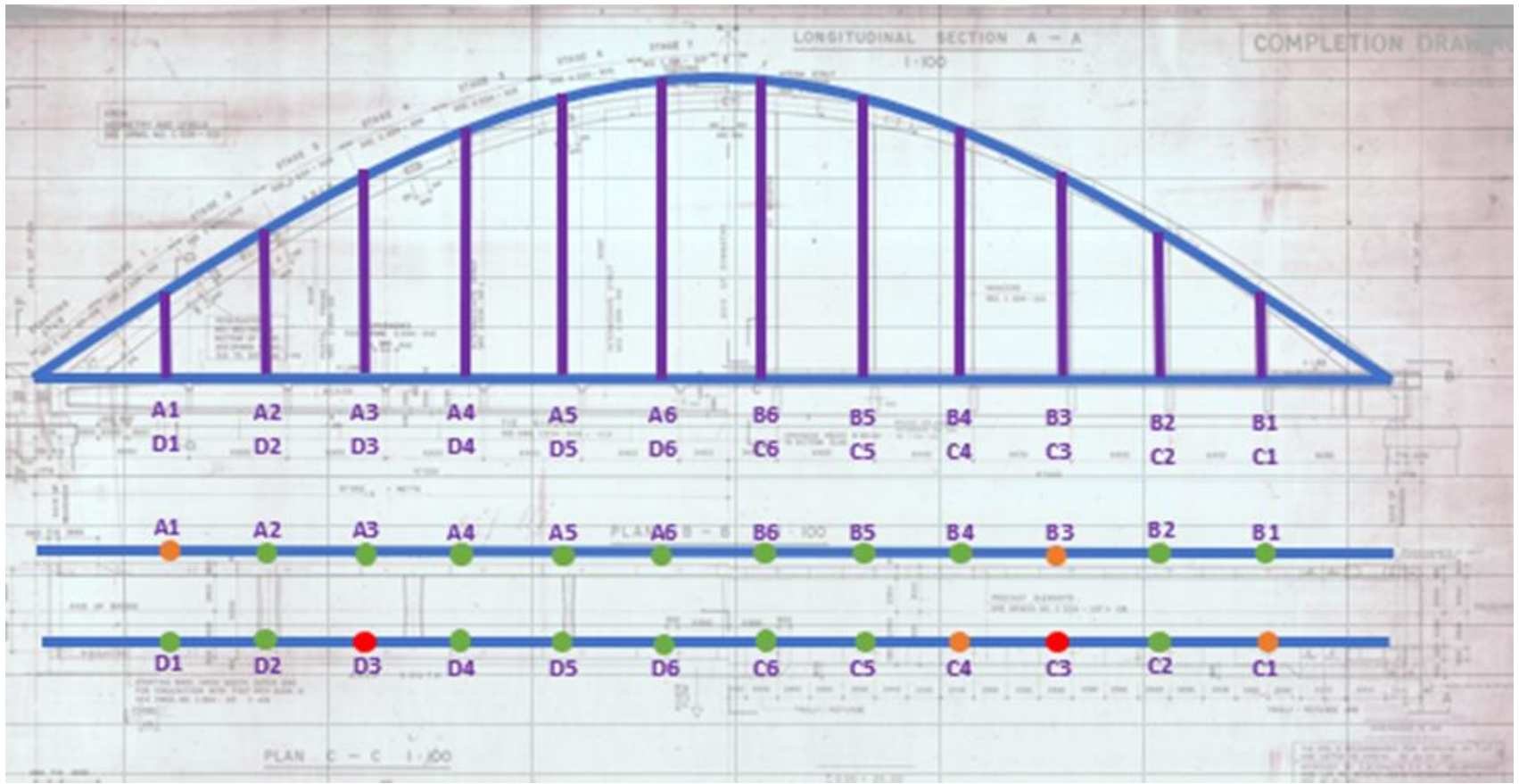
Rajahmundry Railway Bridge (100m) 2023, Condition Monitoring



Rajahmundry Railway Bridge (100m) 2023, Condition Monitoring

Cable			Condition				
Cable	Length [m]	Freq [hz]	Freq	Damp	Energy	Harmonics	Total
A1	7,89	14,00	3,0	4,0	2,0	5,0	3,50
A2	12,08	8,00	2,0	3,0	2,0	3,0	2,50
A3	15,43	6,00	1,0	2,0	2,0	1,0	1,50
A4	17,95	5,00	1,0	1,0	1,0	1,0	1,00
A5	19,63	4,10	1,0	1,0	1,0	1,0	1,00
A6	20,47	4,20	1,0	3,0	1,0	1,0	1,50
B6	20,47	4,20	1,0	1,0	1,0	1,0	1,00
B5	19,63	4,10	1,0	1,0	1,0	1,0	1,00
B4	17,95	4,90	1,0	1,0	1,0	1,0	1,00
B3	15,43	5,60	1,0	3,0	3,0	2,0	2,25
B2	12,08	7,60	1,0	1,0	1,0	1,0	1,00
B1	7,89	12,00	2,0	2,0	2,0	5,0	2,75
C1	7,89	17,60	4,0	4,0	3,0	5,0	4,00
C2	12,08	6,80	1,0	2,0	1,0	1,0	1,25
C3	15,43	5,00	2,0	4,0	4,0	4,0	3,50
C4	17,95	5,00	2,0	5,0	4,0	3,0	3,50
C5	19,63	3,90	1,0	1,0	1,0	1,0	1,00
C6	20,47	3,90	1,0	1,0	3,0	2,0	1,75
D6	20,47	4,20	1,0	1,0	1,0	1,0	1,00
D5	19,63	4,30	1,0	3,0	2,0	1,0	1,75
D4	17,95	5,20	1,0	1,0	1,0	1,0	1,00
D3	15,43	2,50	4,0	5,0	5,0	5,0	4,75
D2	12,08	8,40	1,0	1,0	1,0	1,0	1,00
D1	7,89	13,00	1,0	2,0	1,0	1,0	1,25

Rajahmundry Railway Bridge (100m) 2023, Condition Monitoring



Rajahmundry Railway Bridge (100m) 2023, Condition Monitoring

Recent example from Offshore Site



Recent example from Offshore Site

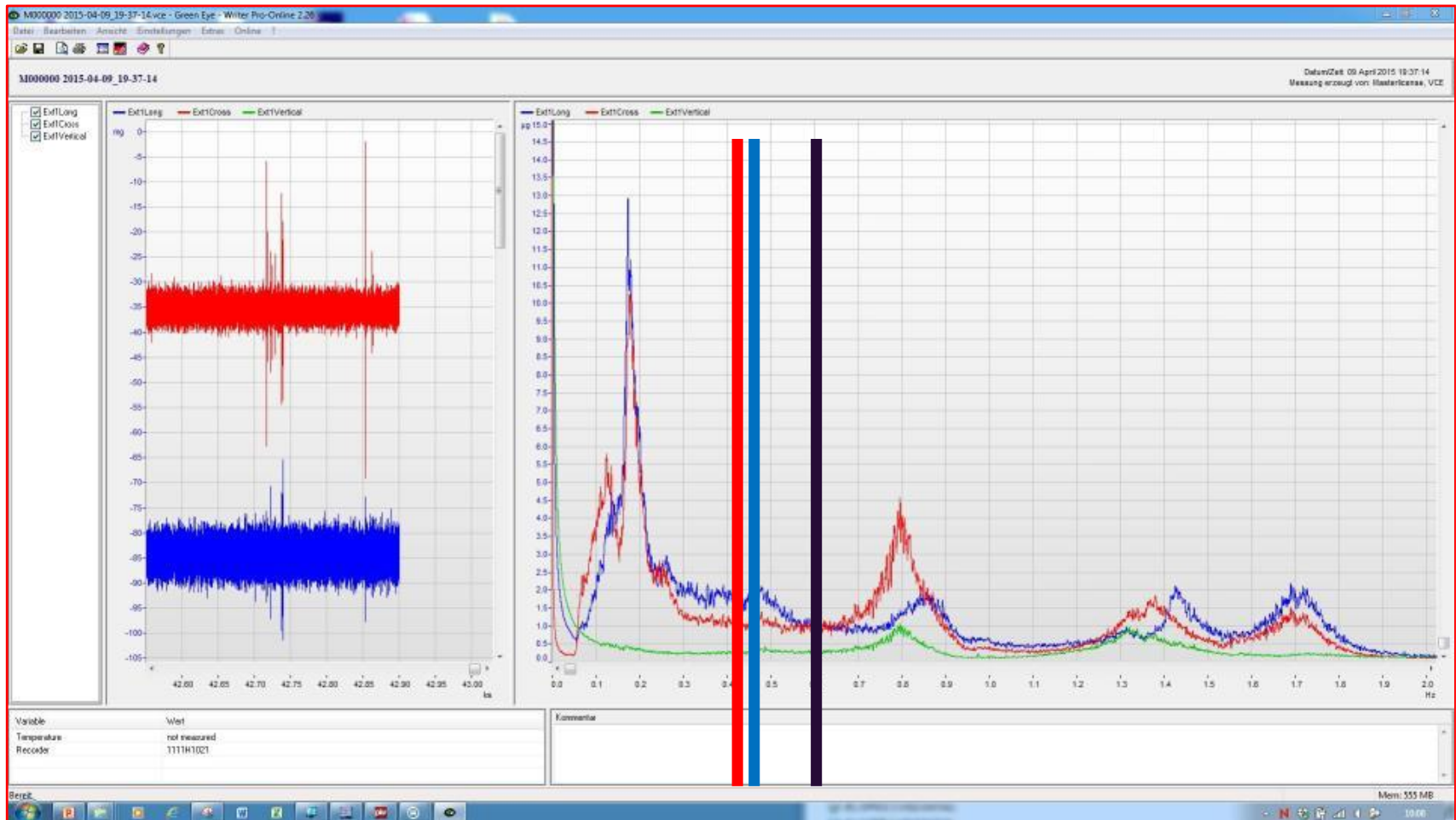


DolWin alpha

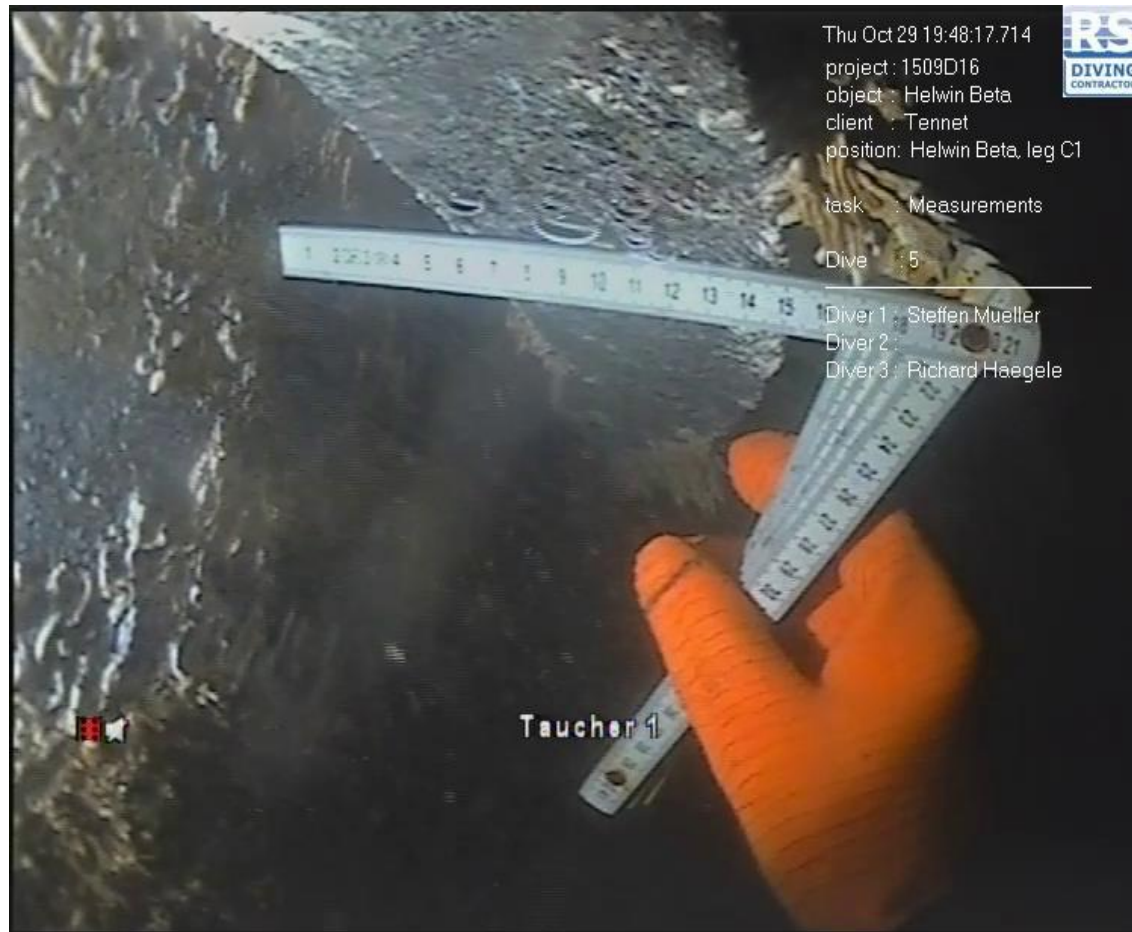


North Sea Application Fundamental Frequencies

Model vs Measurements



4. Ergebnisse - Sea Bed Survey



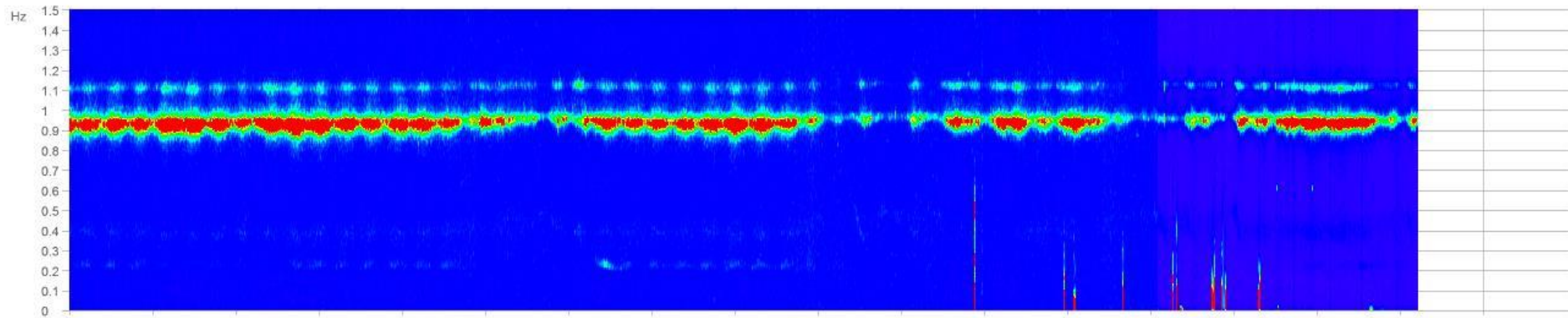


Performance Indicator: Dynamic Signature

Desired Performance

Position Aux Power Deck, Axis C4: Frequency North-South 0 to 1,5 Hz

g 0.0001 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.078054 - 2.660368



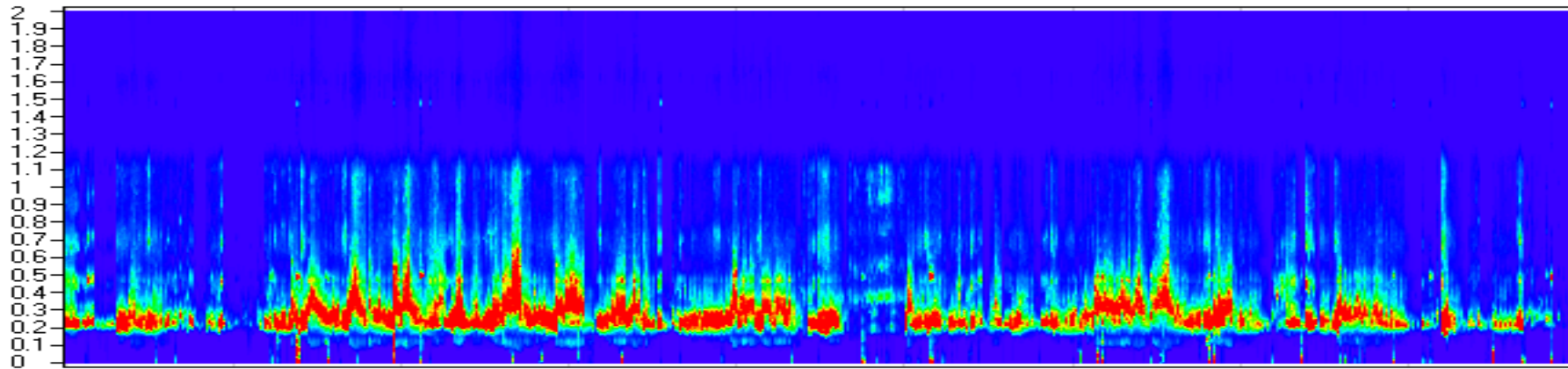
Monitoring Results (Trend Cards)

Monitored Performance

Position E4: Trendcard x-Direction:

g 0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5 5,5 6 6,5 7.029263 - 67.582311

Hz

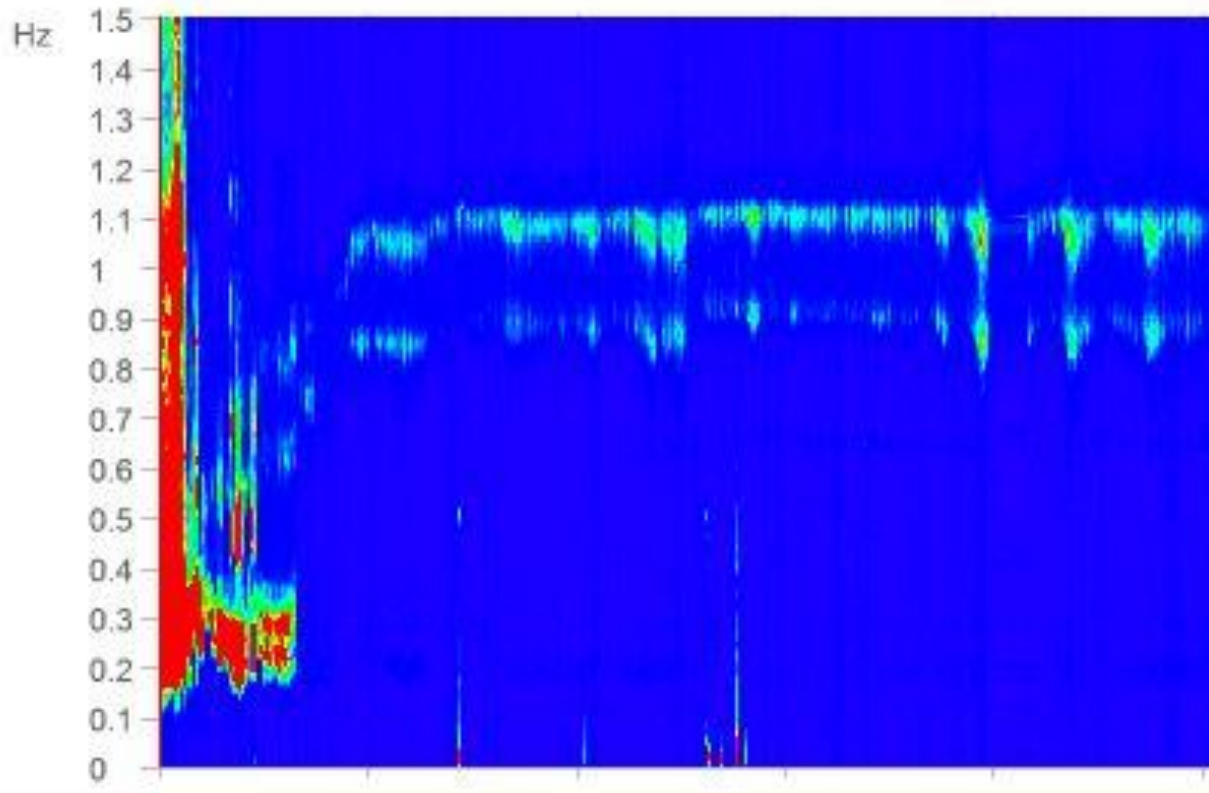




Performance Indicator: Dynamic Signature

Position Top Deck, Axis D1: Frequency East-West 0 to 1,5 Hz

Performance during Repair



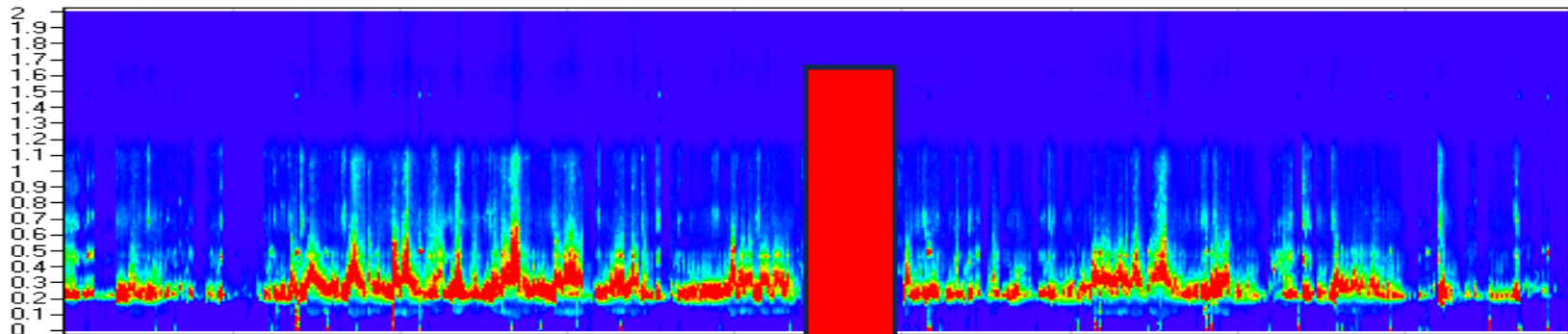
Performance after Mitigation

Relevant frequencies shifted from 0,23Hz to 0,92Hz

Position E4: Trendcard x-Direction:

g 0 0,5 1 1,5 2 2,5 3 3,5 4 4,5 5 5,5 6 6,5 7,029263 - 67,582311

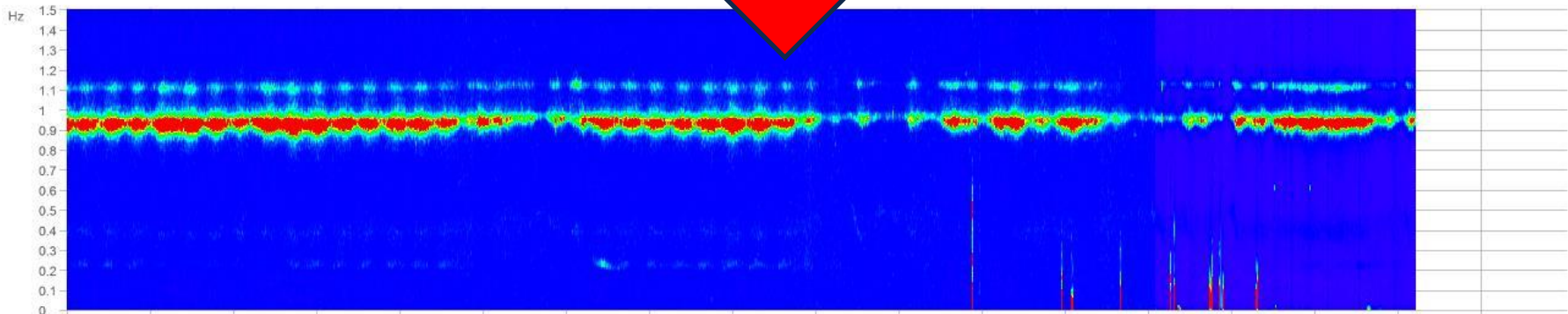
Hz



Position Aux Power Deck, Axis C4: Frequency North-South 0 to 1,5 Hz

g 0,0001 0,01 0,02 0,03 0,04 0,05 0,06 0,07 0,078054 - 2,660368

Hz



Summary

- AVM is mature
- Monitoring, System Identification and Risk Management have to be combined
- Interdisciplinary Engineering is required

Thank You

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