

Microtremor Survey ကို အသုံးပြု၍ မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများကို လေ့လာခြင်း

Site Amplification Characteristics Along Sagaing Fault

By Microtremor Survey

ဒေါက်တာအောင်အောင်စိုး



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တွဲဖက်များ - Dr. Yoshimitsu YAMADA | Mr. Tatsuru AOYAMA နှင့် ဦးမင်းသိမ်းကျော်။

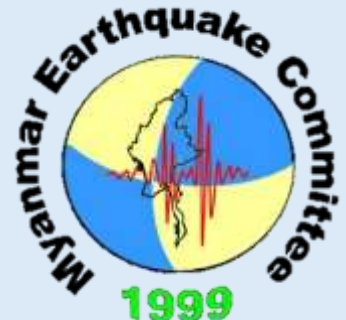
တွဲဖက်ရေးသားသူ -

ဒေါ်ရီရီငြိမ်း

Vice President (MEC)

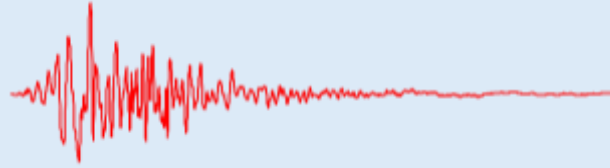
Research in collaboration with

Myanmar
Earthquake
Committee



နိဒါန်း

EARTHQUAKE

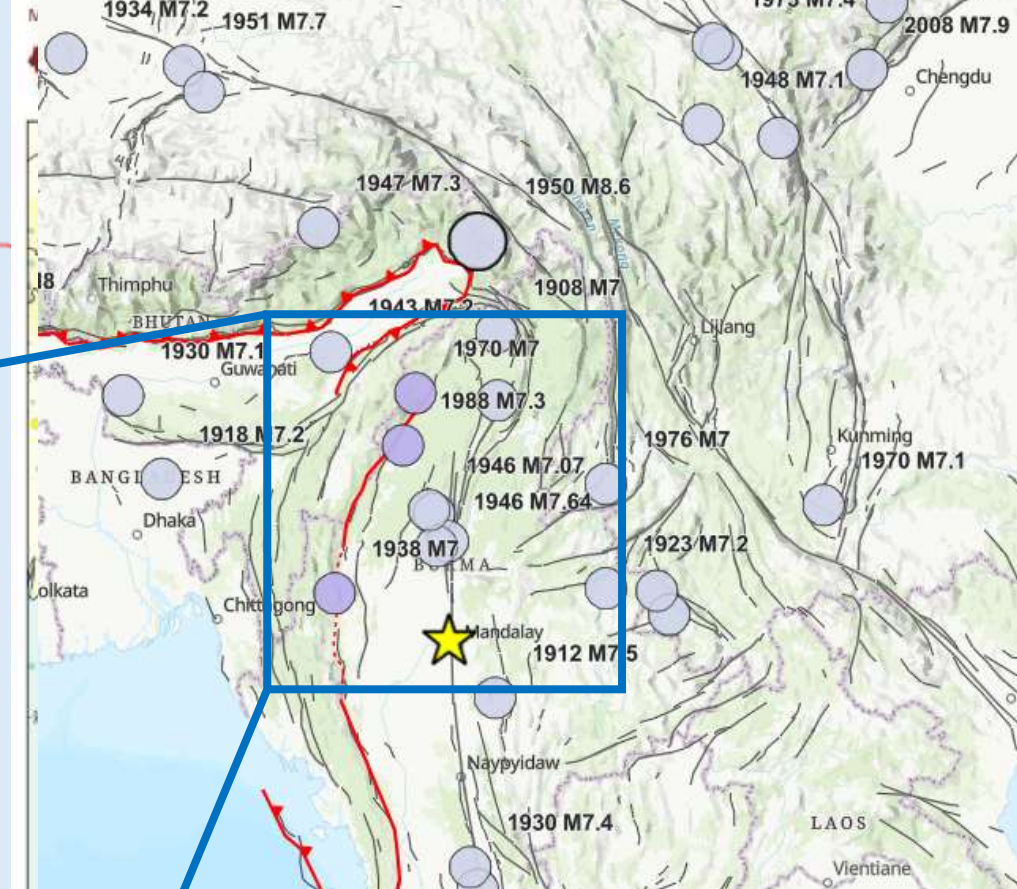
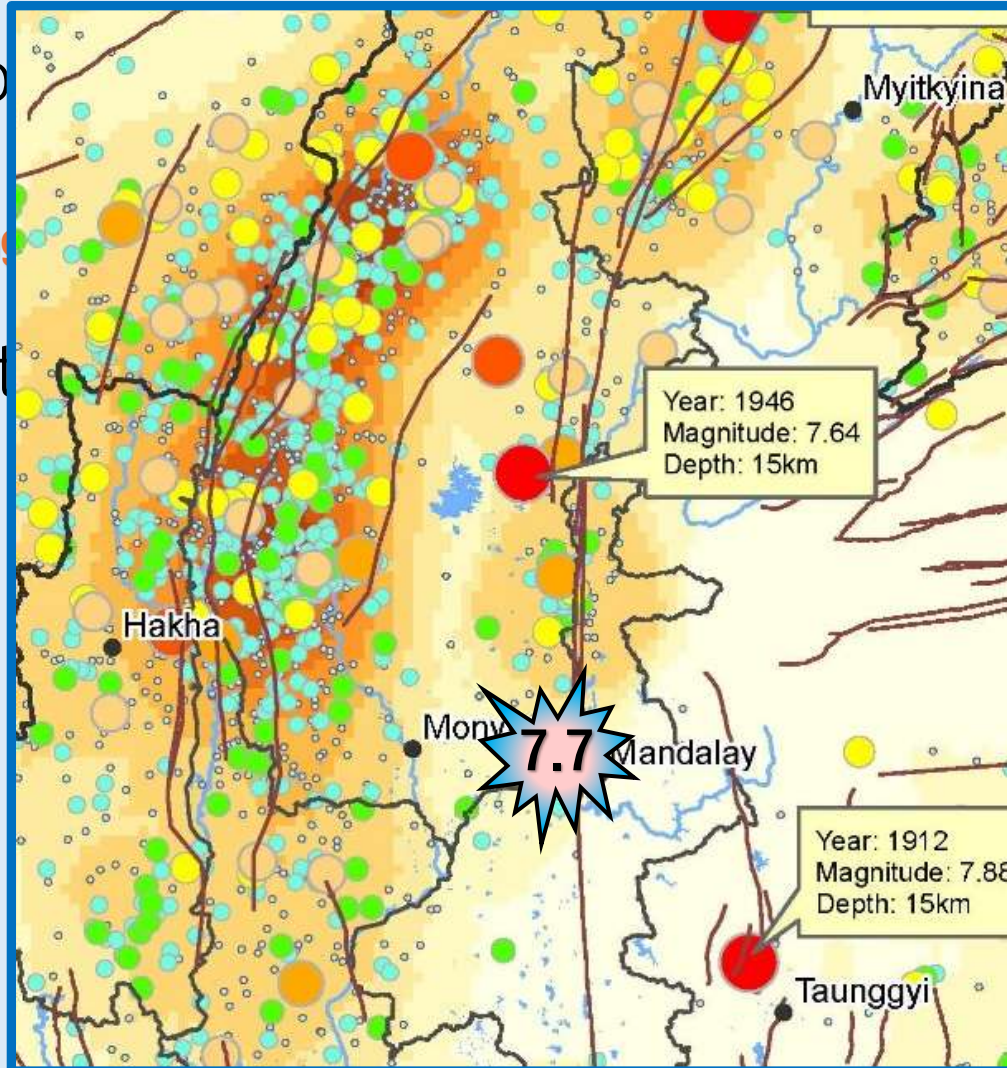


- Dangerous
- No !!!!!**
early warning

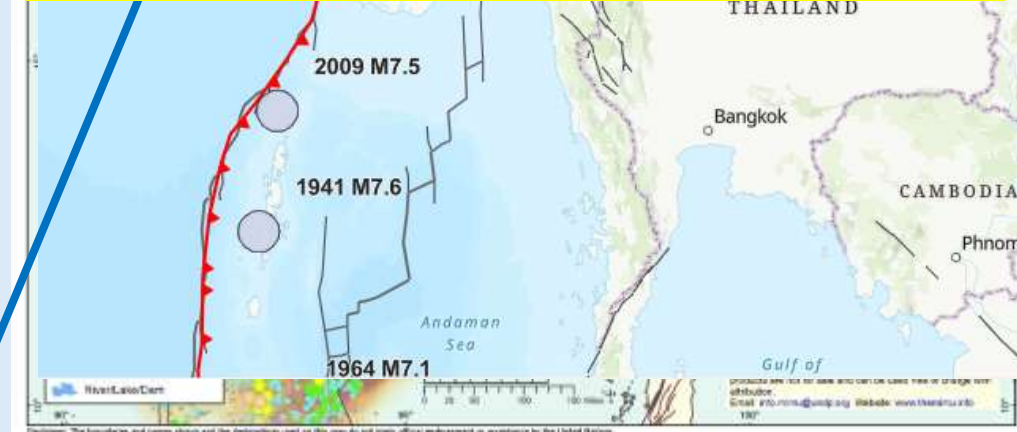
- Destructive

- UNPREDICTABLE

- Unknown




Historical > M7.0 in the region

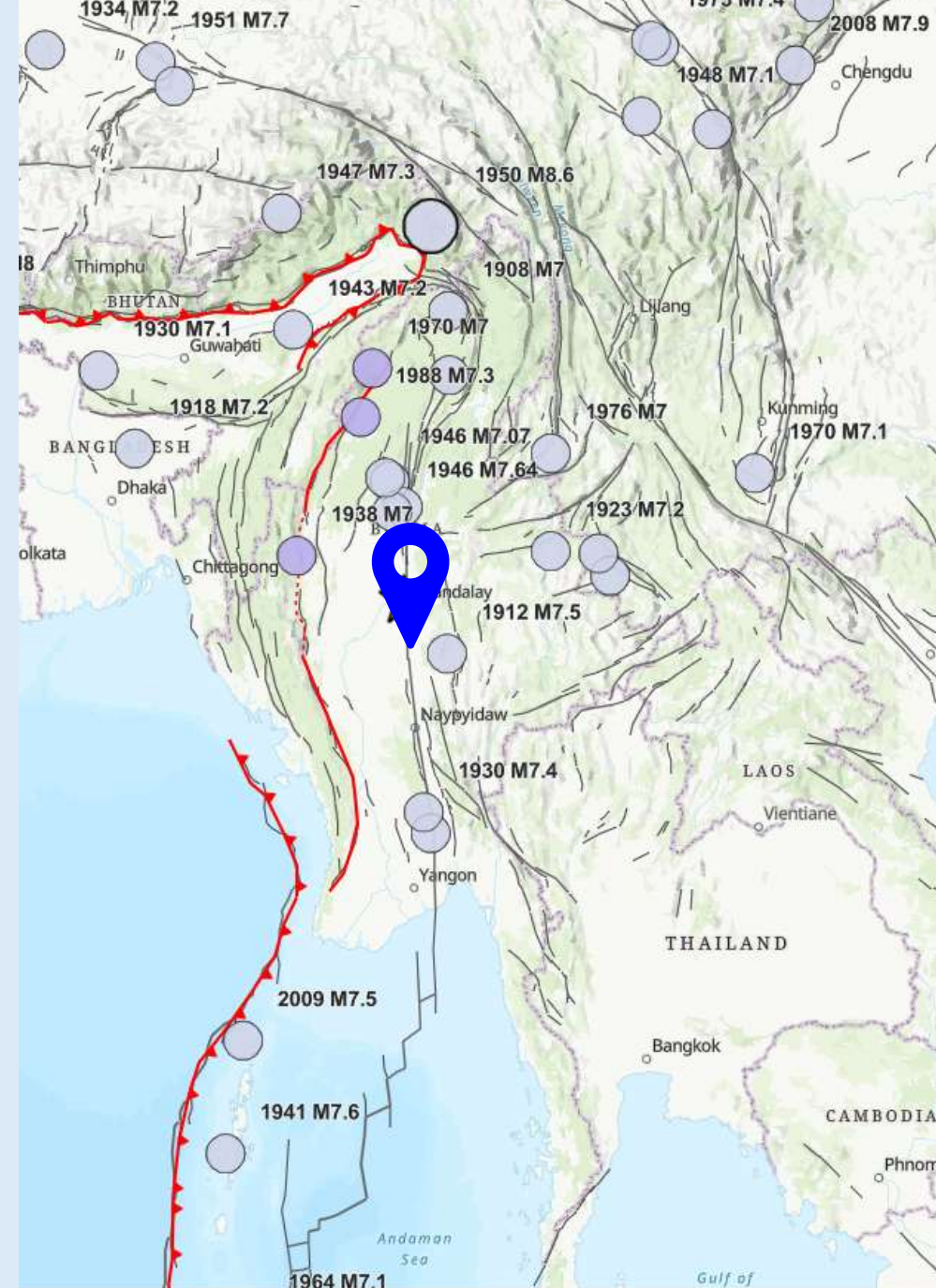


မှတ်တမ်း ဗီဒီယို

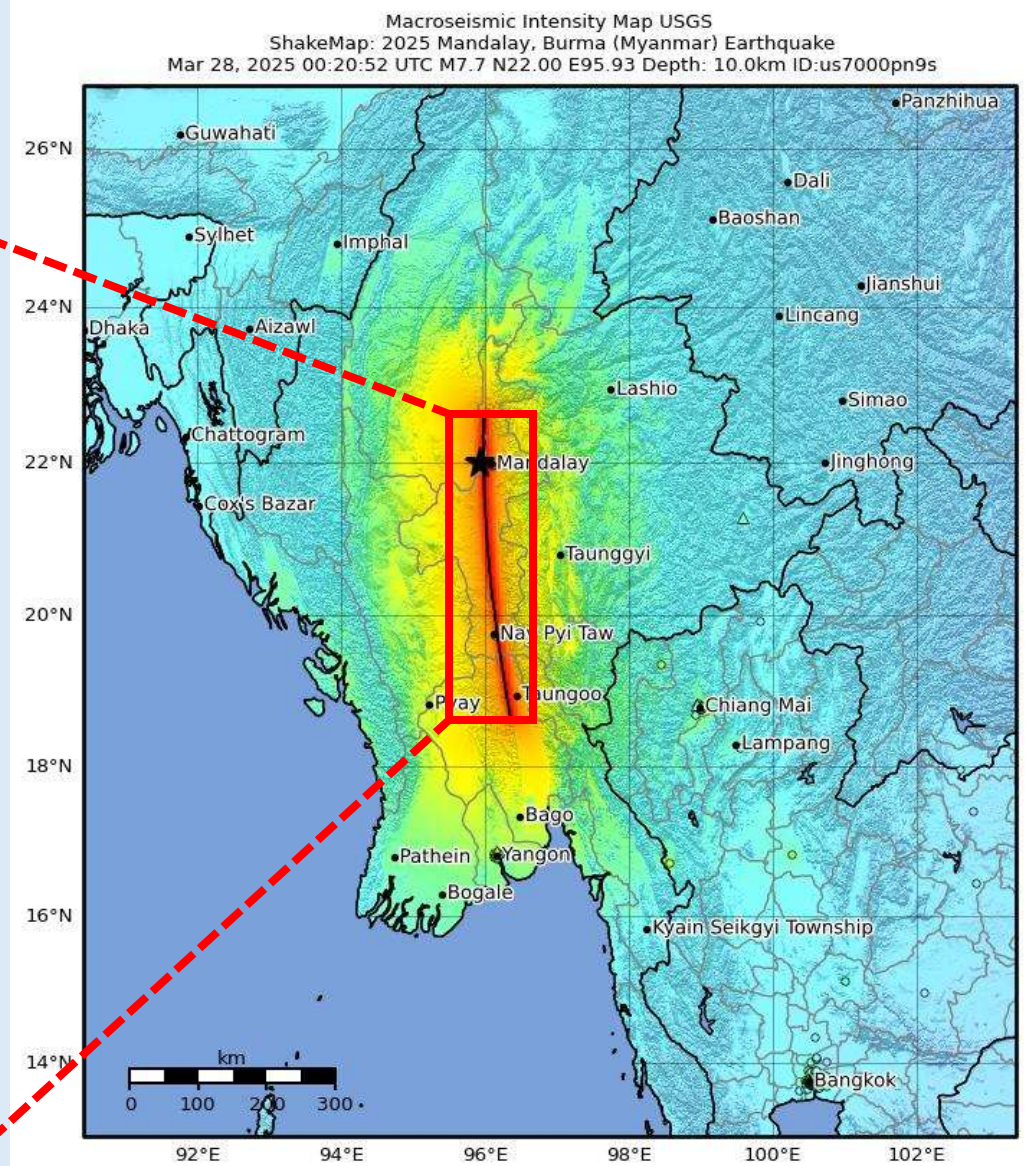
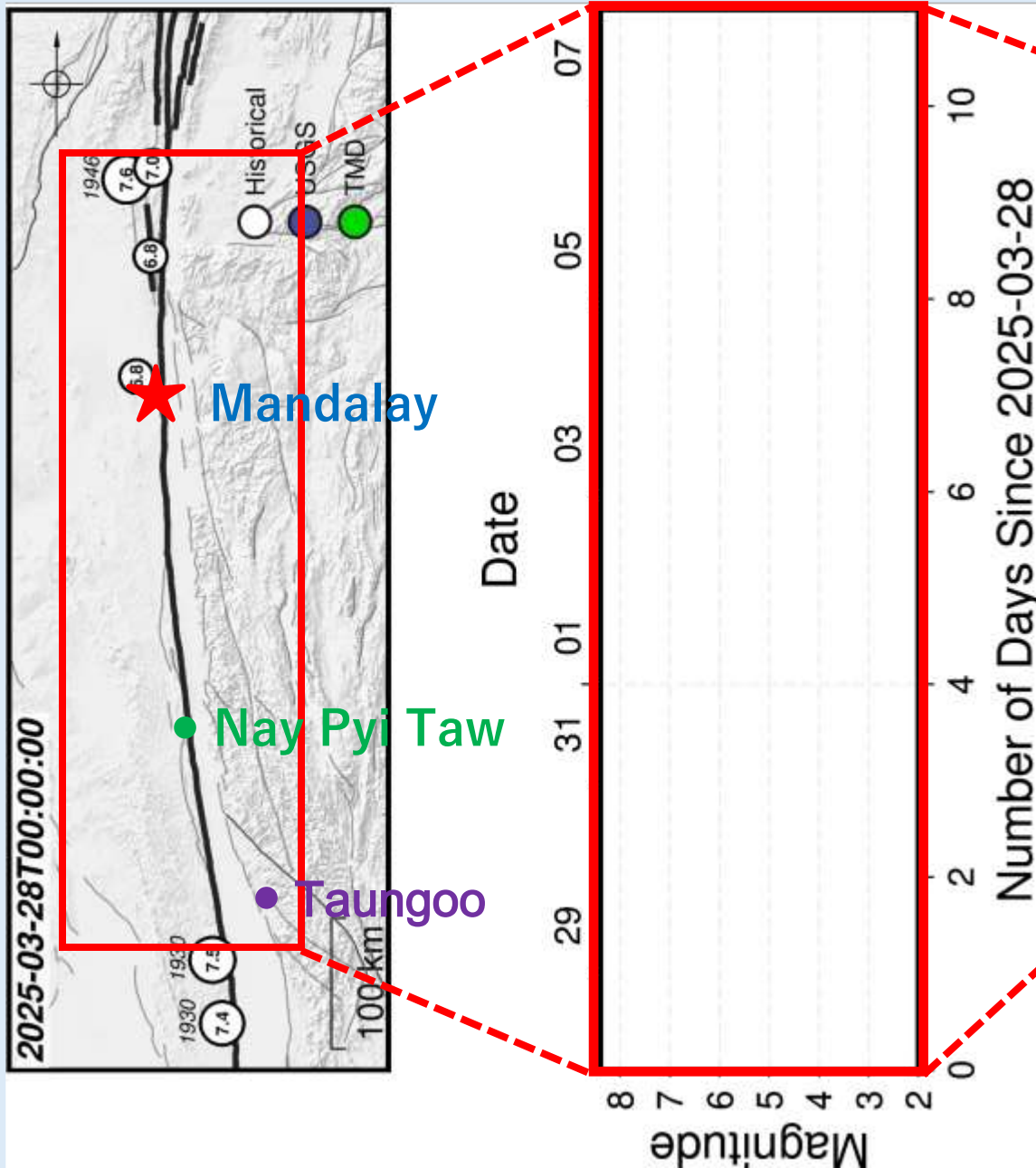
Thapyay Wa 30 MW Solar Firm

Thazi Tsp., Meiktila, Mandalay Region, X2G7+V3, Tha Phay Wa, Myanmar (Burma)

 **Htin Aung**
May 11 · 🌐
the Super Shear Mandalay Earthquake!!
Valuable Recorded "Super Shear Mandalay Earthquake_28th March 2025" in Thapyay Wa Solar Firm from our losses! (Appx.12' land slide) **≈ 4 m Slip**
(Credit to: GP Energy Myanmar for their valuable recorded)



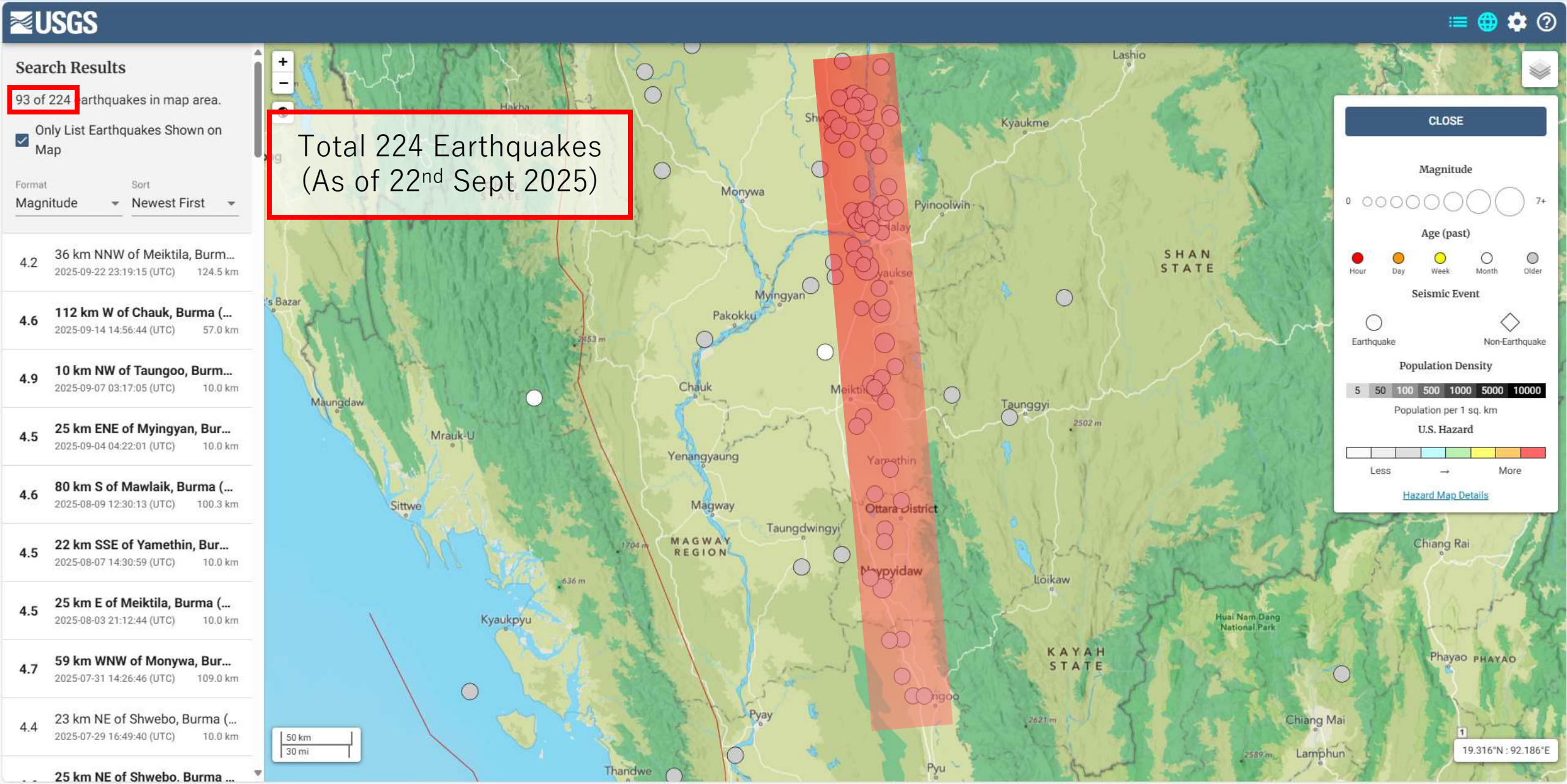
နောက်ဆက်တွဲလျှင်ငယ်များ: After Shocks



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 13: Processed 2025-03-31T04:01:33Z

နောက်ဆက်တွဲလျှင်ငယ်များ: After Shocks



မှတ်တမ်းဓာတ်ပုံများ

Fault, found in Phayargyi, Bago Region



Liquefaction near 145 Milestone



Liquefaction near Sagaing-Mandalay Road



Land Slide @ Tatkon Road, NPT



Fault & House Damage in Innwa



Bridge collapse



Road collapse Sagaing-Mdy Road

မှတ်တမ်းဓာတ်ပုံများ



မန္တလေးနန်းတော်
အနောက်မြောက်ထောင့်



နေပြည်တော်



ဝမ်းတွင်းချည်မျှင်စက်ရုံ



Lack of fuel @ 355 Milestone



Collapse of Sagaing Bridge (Old)



မယ်နုအုတ်ခဲ



တစ်



ကြီးကျောင်း

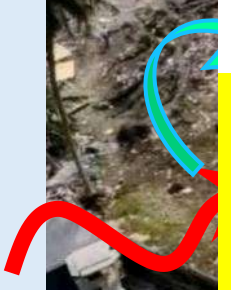
အဆောက်အဦပျက်ဆီးမှု မှတ်တမ်းဓာတ်ပုံများ



During same Earthquake,
Some buildings collapsed, while others couldn't.

WHY? ⇒ Structural quality, foundation, &
Site Response [Site Effect]!

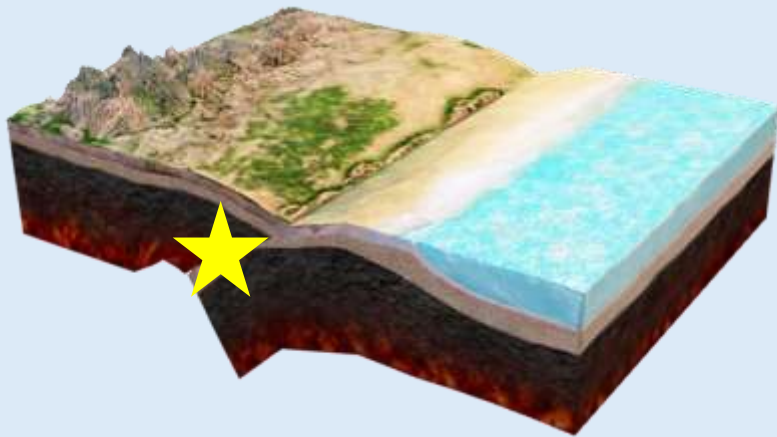
မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ



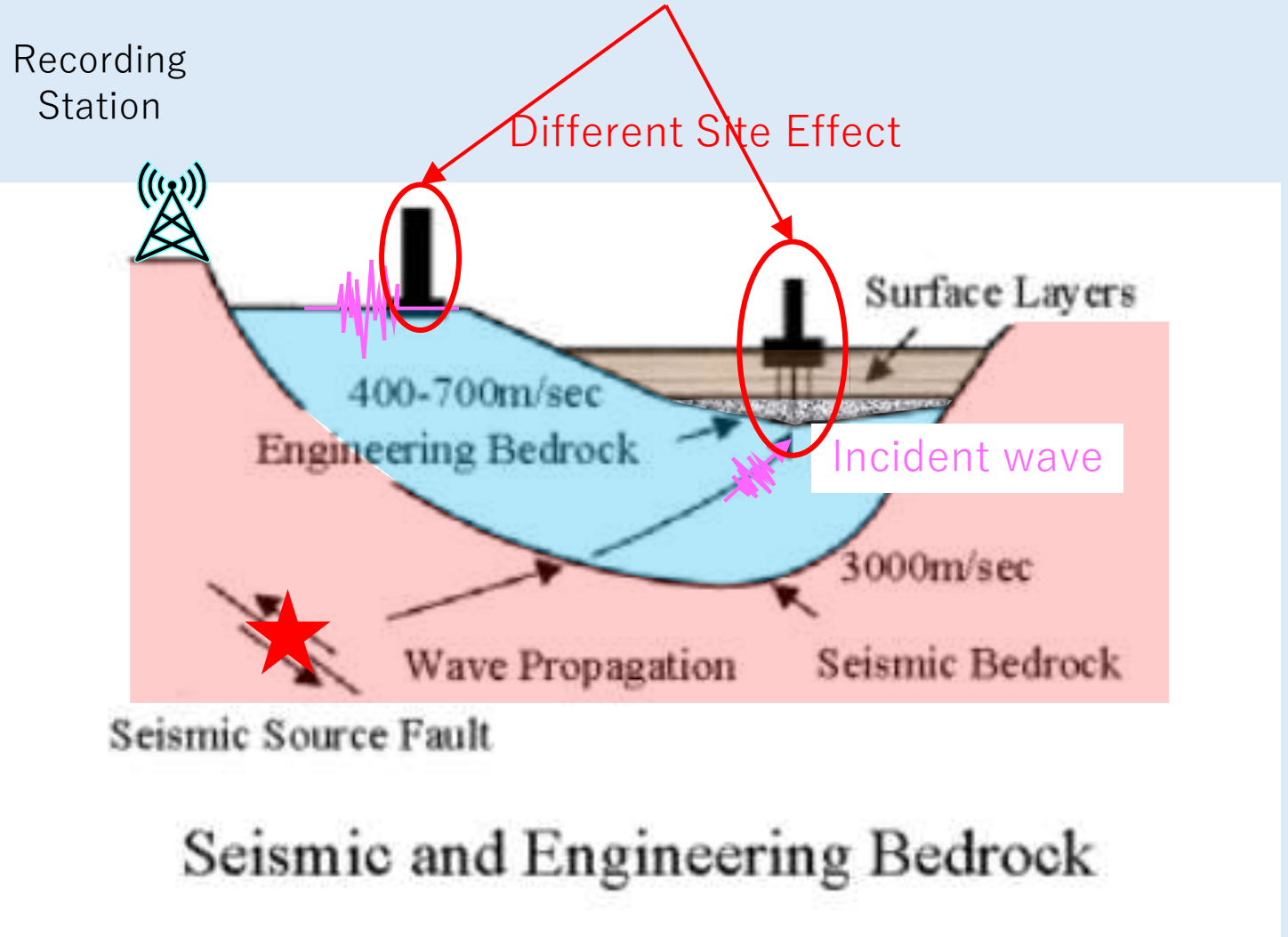
မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု

Importance of Site Effect

Structures will **differently response** depending on where they are standing.



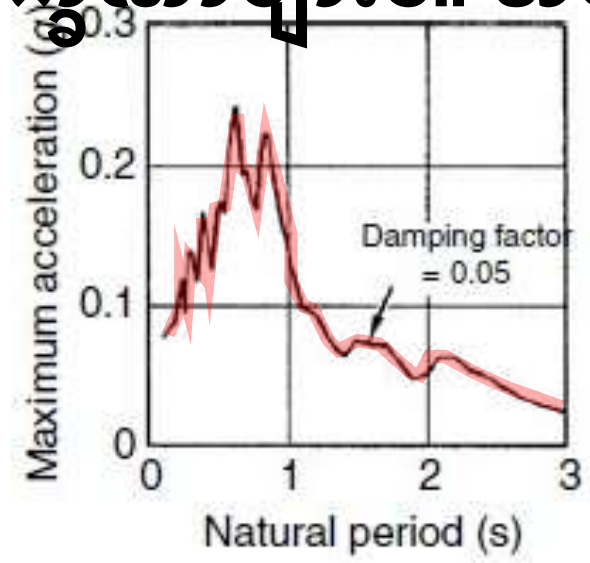
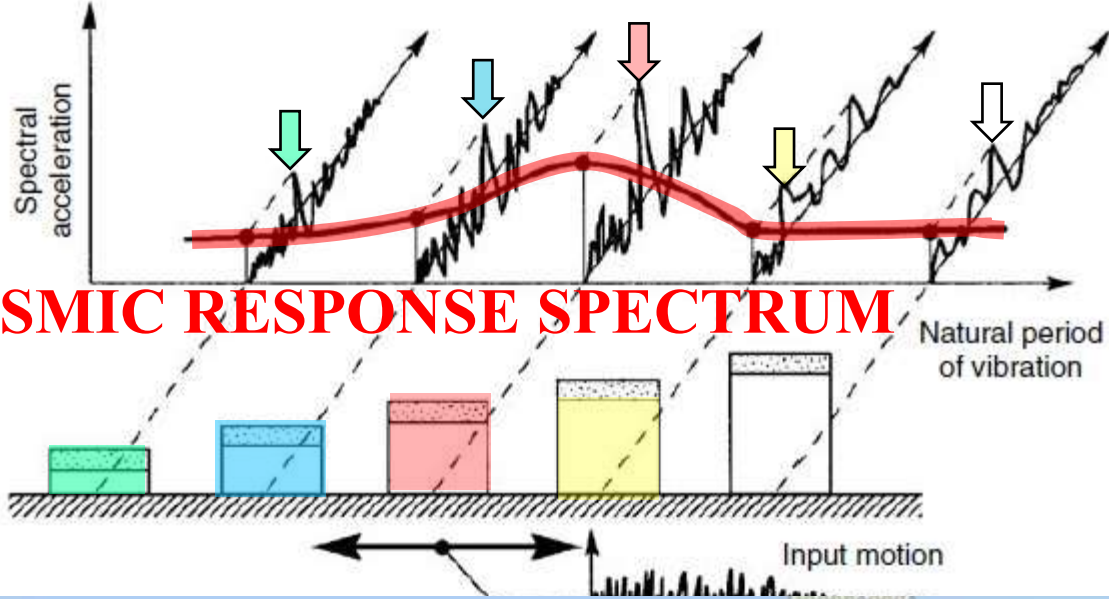
Occurred due to the movement of tectonic plates



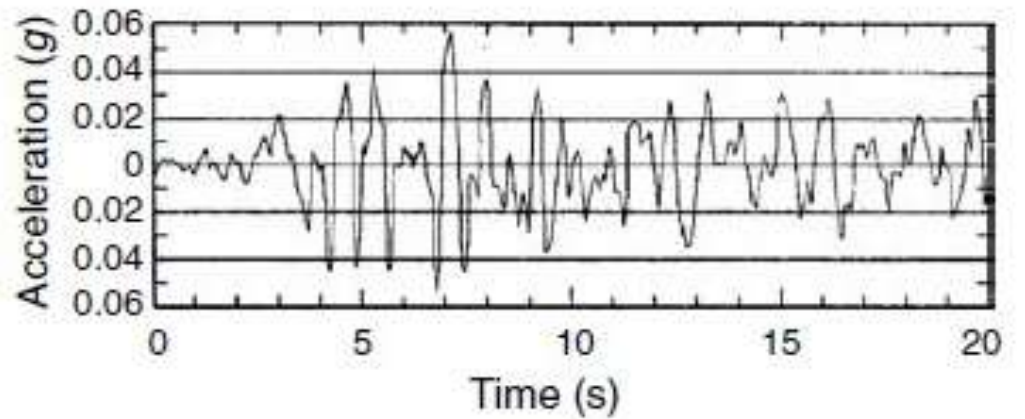
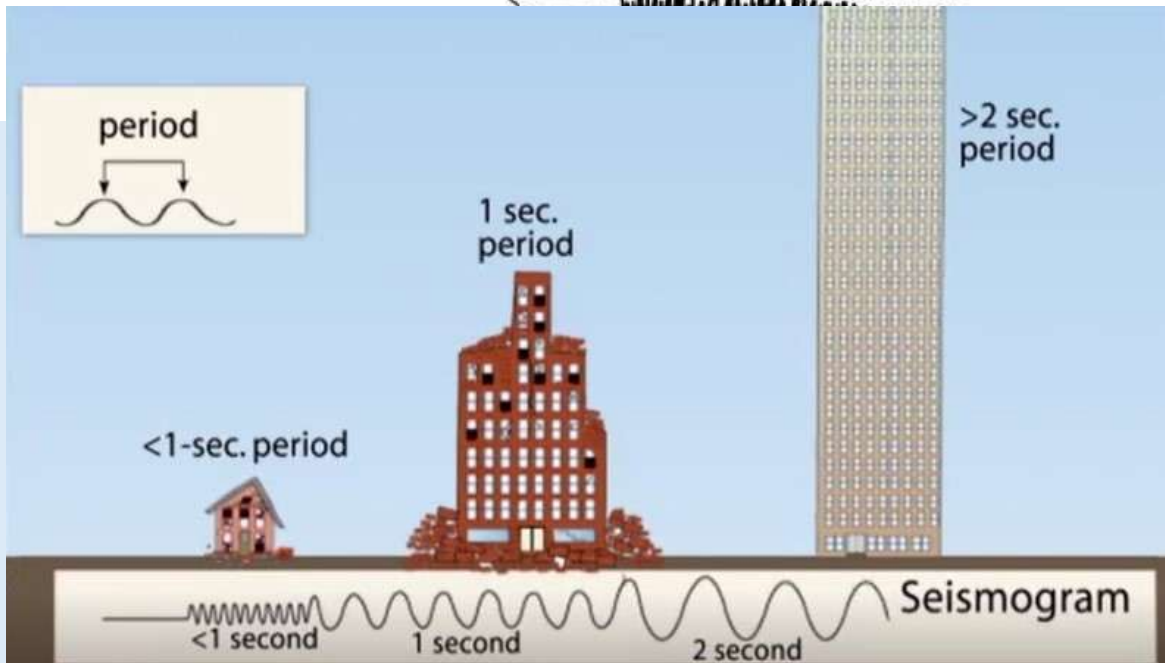
Seismic and Engineering Bedrock

မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုင်းချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု

SEISMIC RESPONSE SPECTRUM

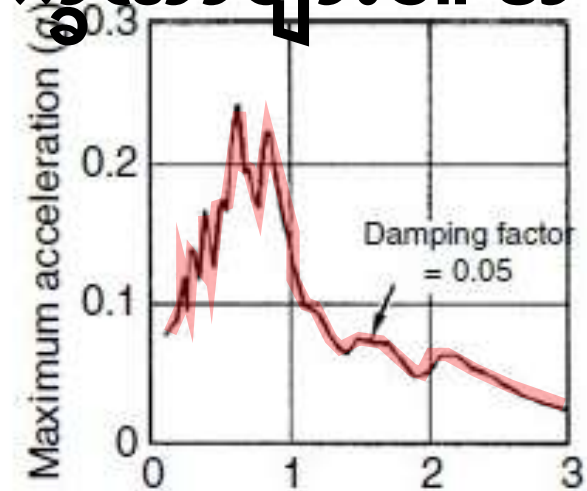
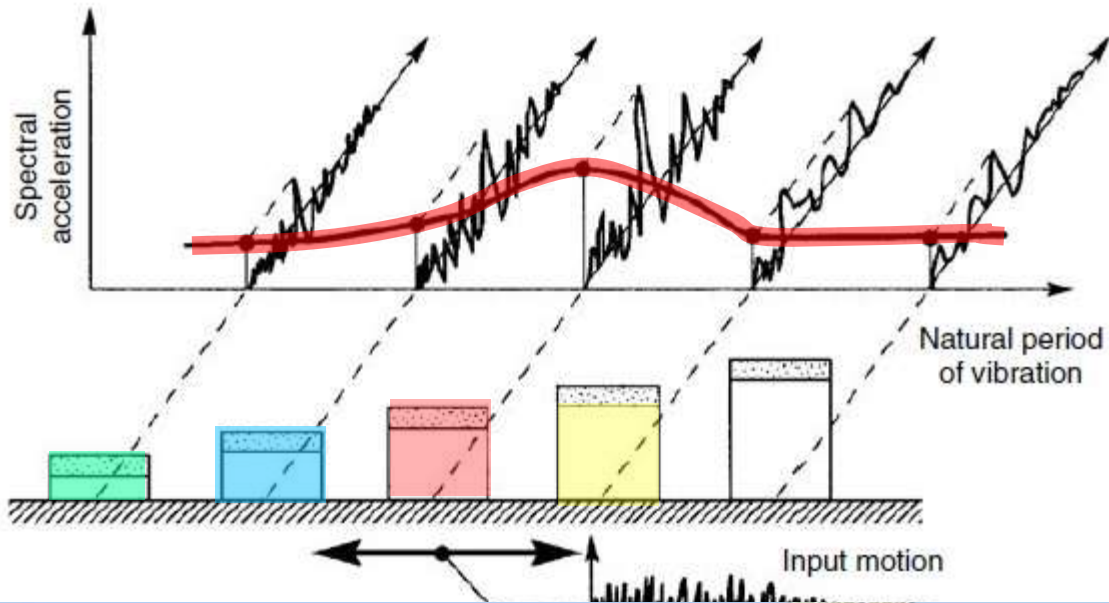


Acceleration Response Spectrum Pasadena Ground motion

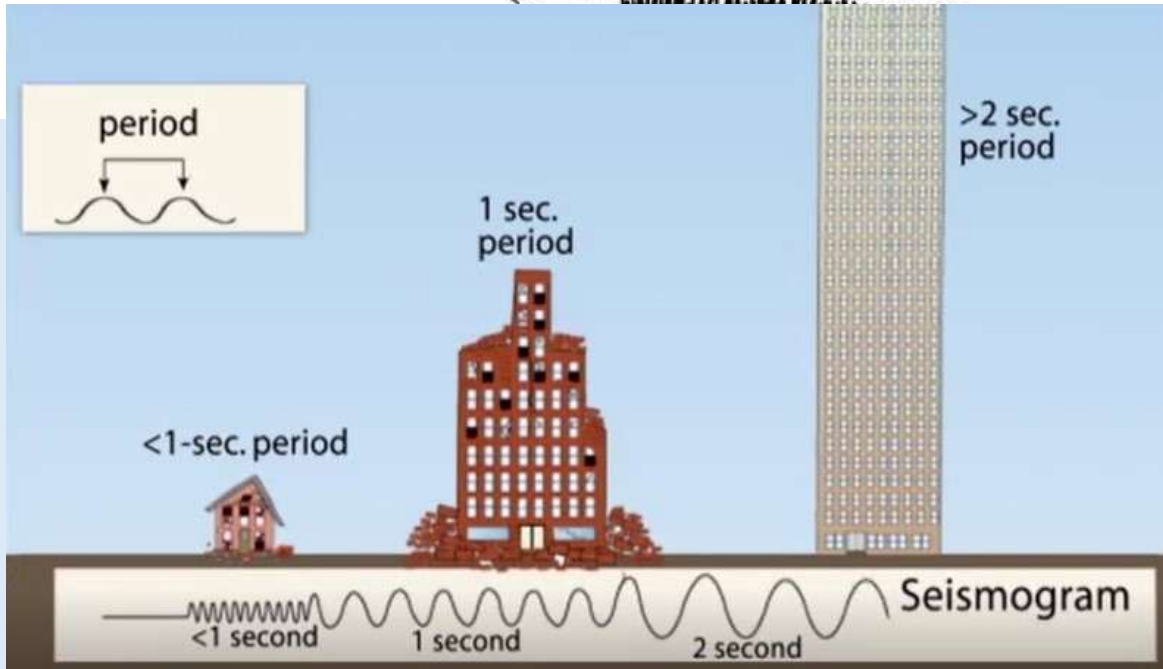


Accelerogram—Pasadena, Kern County, California earthquake, July 21, 1952

မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု



Seismic Waves amplify with local soil deposit. ⇒ **SITE AMPLIFICATION!**



ရည်ရွယ်ချက်

စစ်ကိုင်းပြတ်ရွှေ့ကြောတစ်လျှောက် မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများကို လေ့လာရန်

- Investigate site amplification characteristics along Sagaing Fault

လုပ်ငန်းစဉ်များ

Scope of works:

ပဲခူးတိုင်း ဒေသကြီးမှ စစ်ကိုင်းတိုင်းဒေသကြီး အထိ Microtremor Survey ဆောင်ရွက်ခြင်း၊

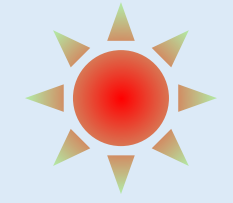
- Conduct microtremor survey Bago Region to Sagaing Region

နေရာအလိုက် လွှမ်းမိုးသောကြိမ်နှုန်း (dominant frequency) နှင့် သဘာဝမြေသားလှိုင်းလွှဲချိန် (Natural Ground Period) တို့ကိုခန့်မှန်းခြင်း၊

- Estimate dominant frequency and natural ground period

HVSR နည်းကို အသုံးပြု၍ လှိုင်းတိုးချဲ့မှု အလားအလာကို အကဲဖြတ်ခြင်း။

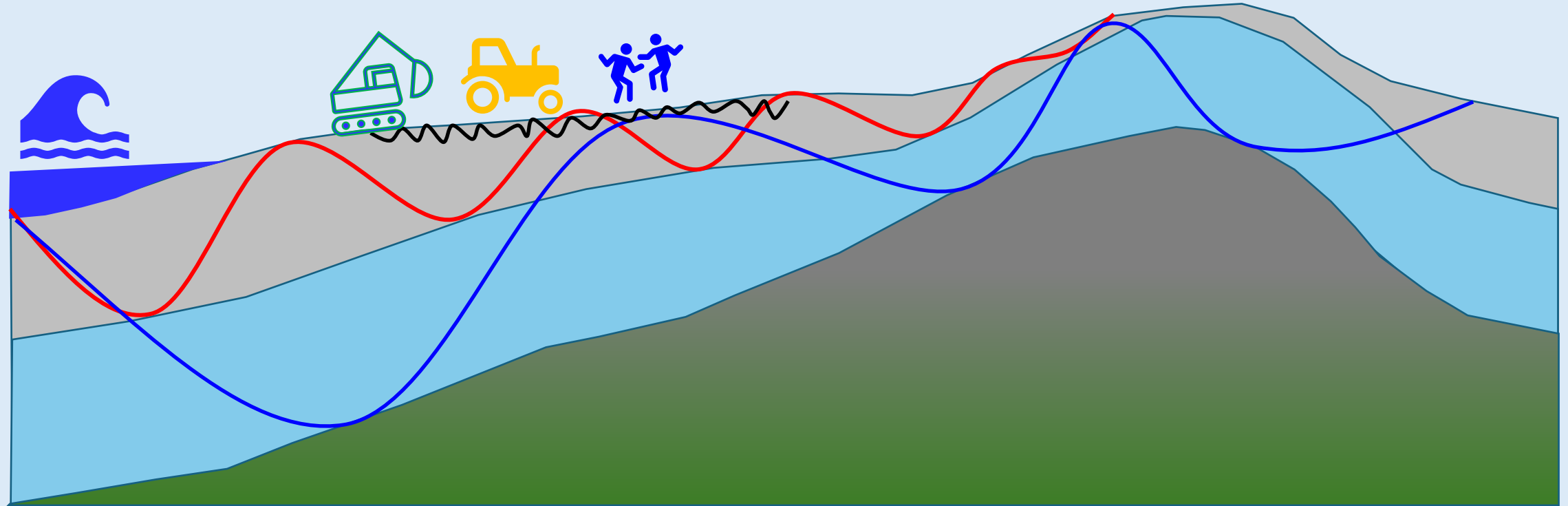
- Evaluate potential amplification factor using HVSR method



Microtremor Survey Method

Microtremors = **Surface wave** + **Body Wave**

လူသားများ ခံစား၍မရနိုင်သော လှိုင်းရှည်များနှင့် လှိုင်းတိုများကို အာရုံခံ ဖမ်းယူခြင်း
Insensible long-period waves & short-waves



Microtremor Survey Instrument



- Three-component servo accelerometer
- Name: Network Sensor
- Model: CV-374 (AV3) – Tokyo Sokushin
- 24-bit A/D converter
- High resolution for microtremor measurement

Microtremor Survey Method

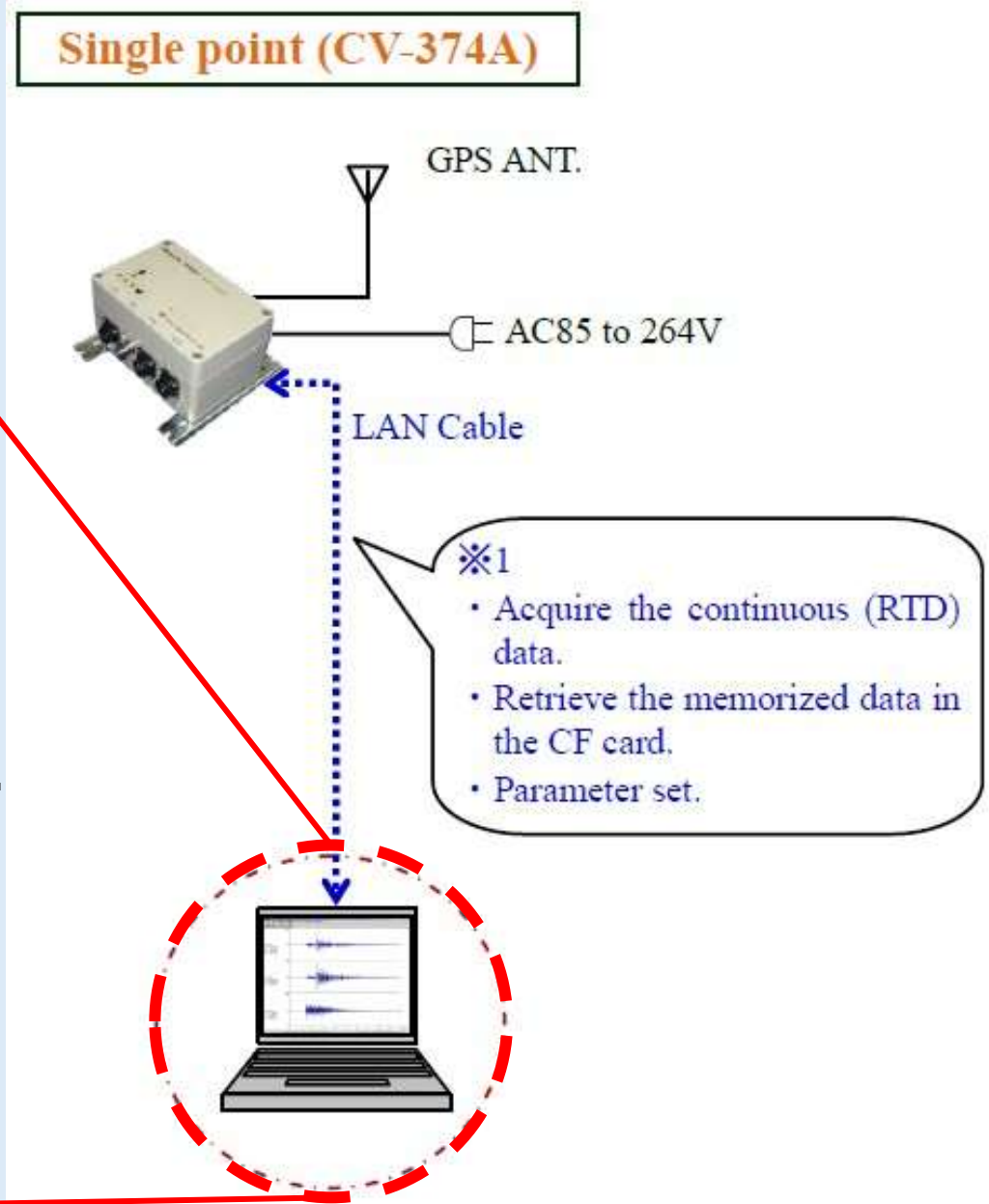
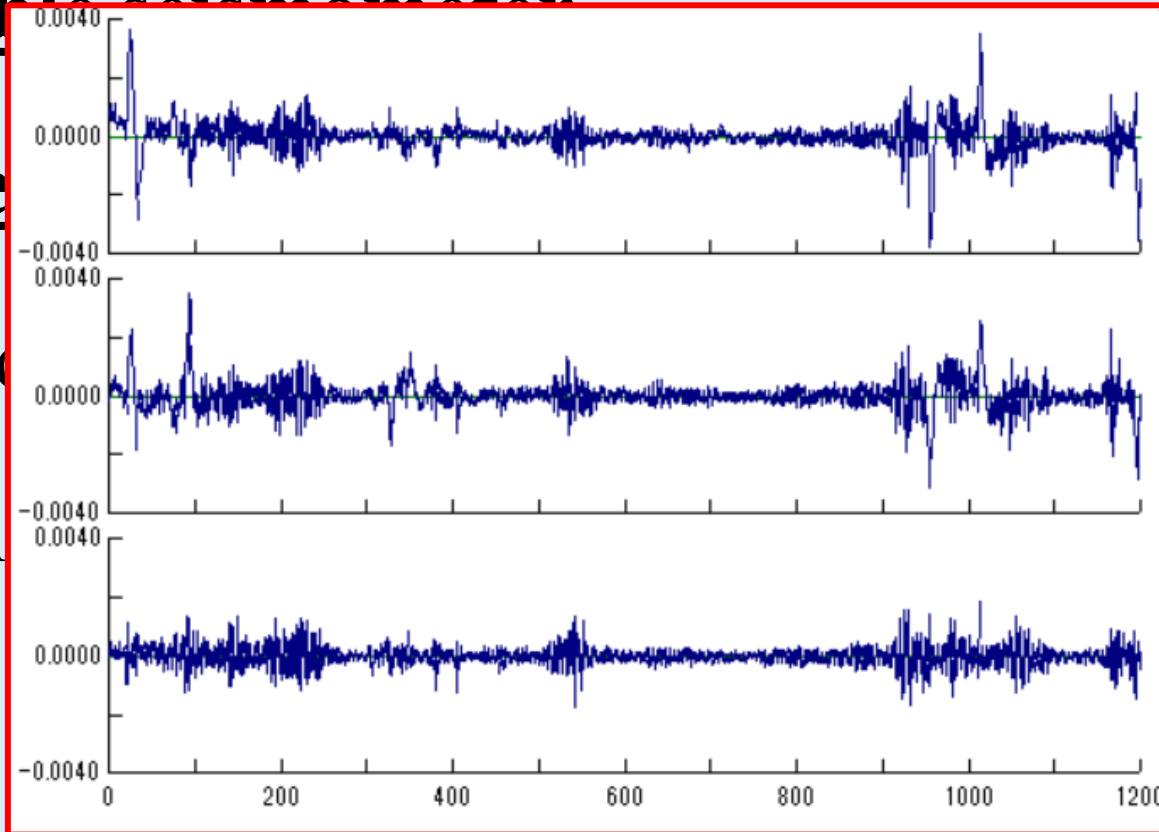
- Ambient vibration measurements using

portable equipment

- Single

- Record

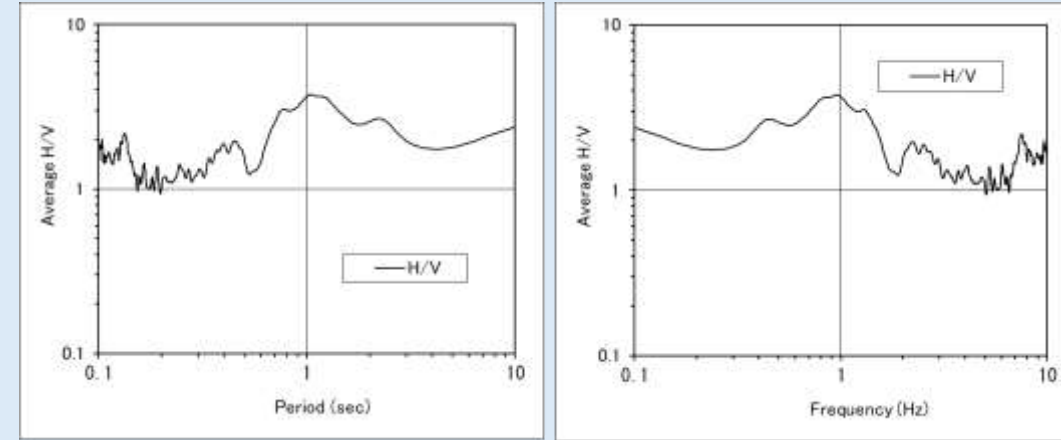
- Sample



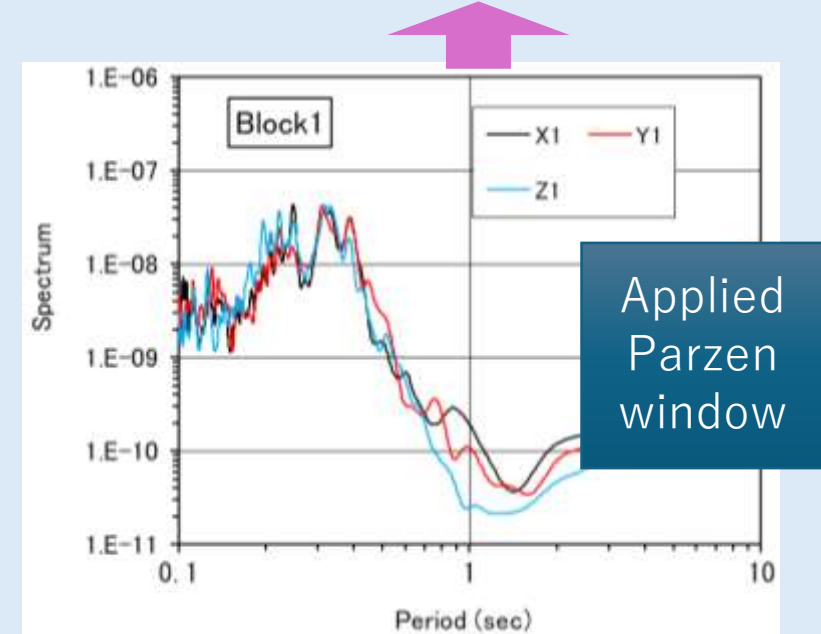
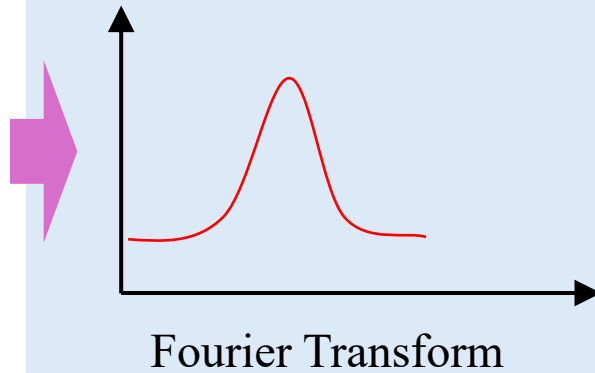
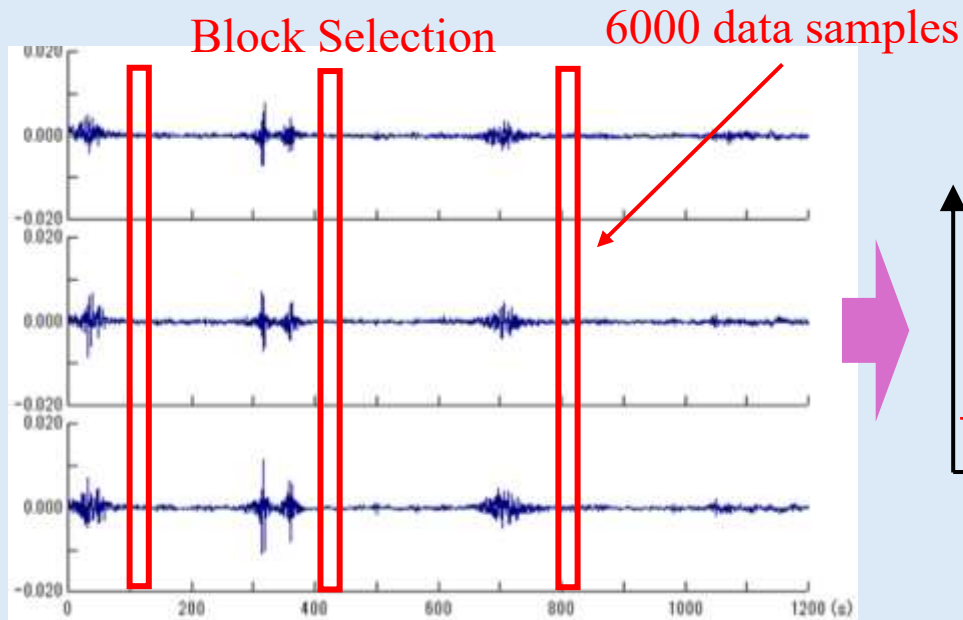
Data Processing and Analysis

- Record microtremor in EW, NS, and UD directions
- Select stable time windows
- Apply Fourier Transform
- Power Spectrum, smoothed by Parzen Window
- Averaging for HVSR

Horizontal to vertical spectrum ratio HVSR



$$\frac{H}{V}(f) = \frac{\sqrt{P_{EW}(f) + P_{NS}(f)}}{\sqrt{P_{UD}(f)}}$$



Recorded data

Power Spectrum

Microtremor Survey ဆောင်ရွက်ခဲ့သော နေရာများ



Myanmar Earthquake Committee

19 ~ 23 April, 2025

Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus



Innwa



Nay Pyi Taw



Pharyargyi, Bago



Sagaing



Mandalay



Wundwin



Legend

- Feature 1
- Investigated Area

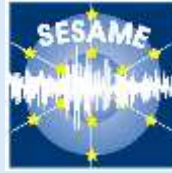


Microtremor



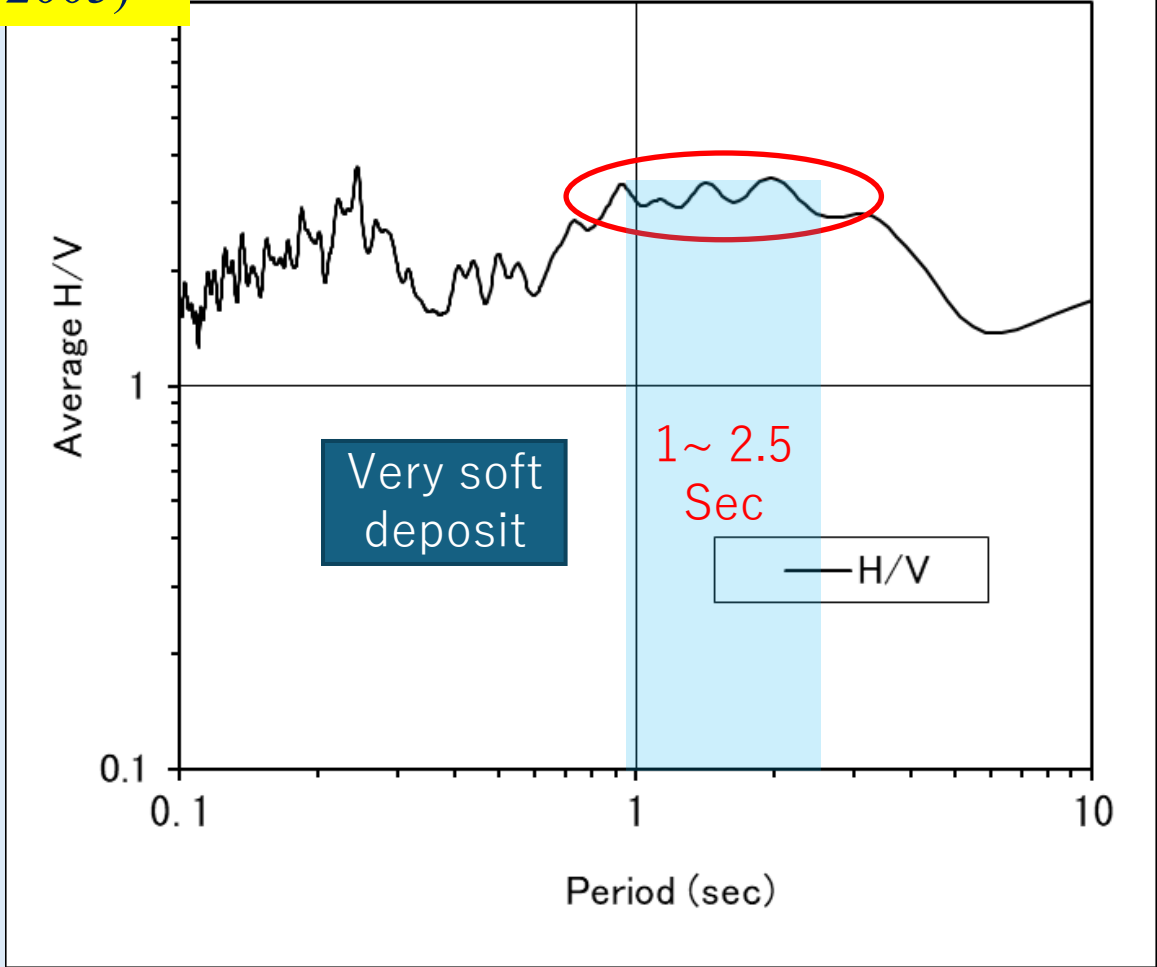
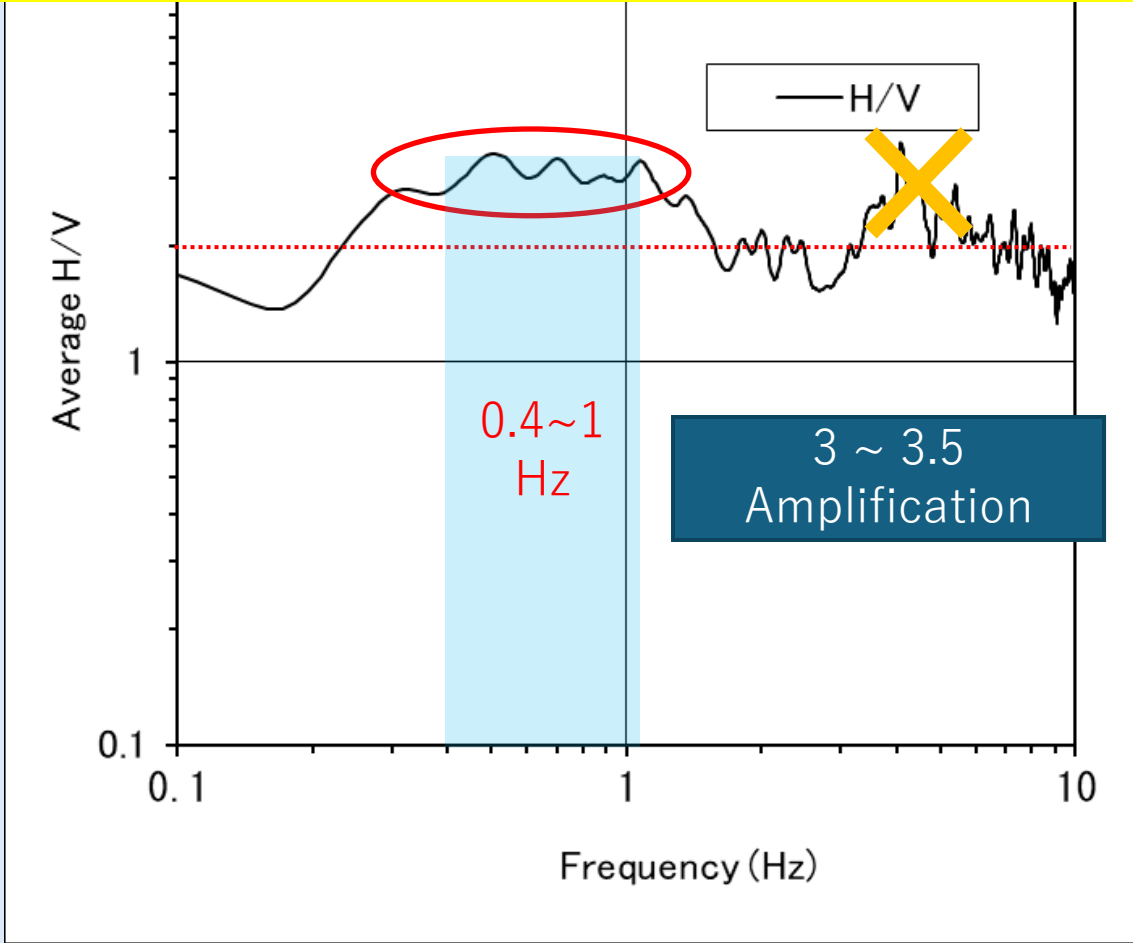
400 km

ပဲခူးတိုင်းဒေသကြီး

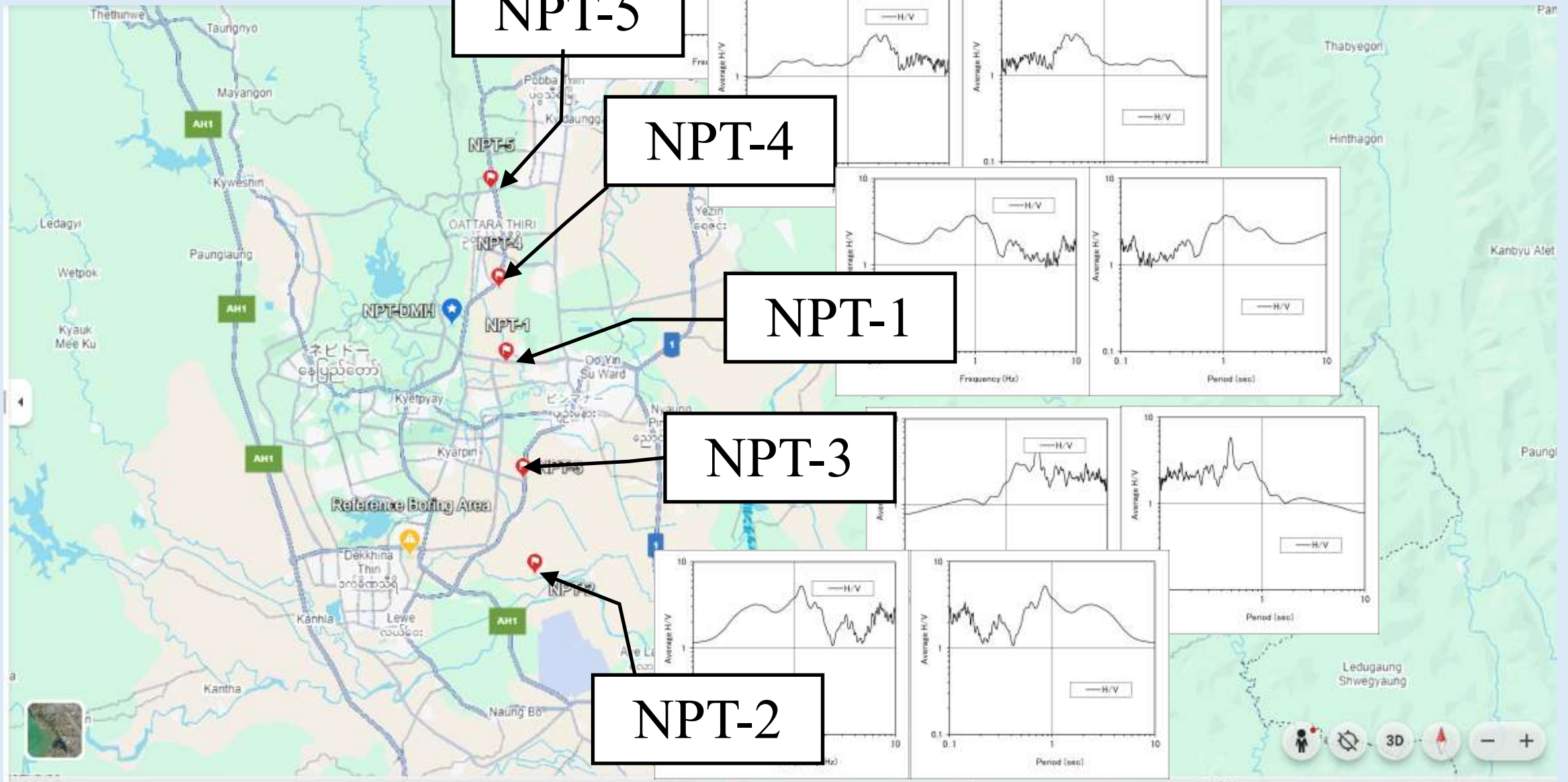


SESAME: Site EffectS assessment using AMBient Excitations

HVSR < 2 Not taken as dominant frequency (SESAME, 2005)

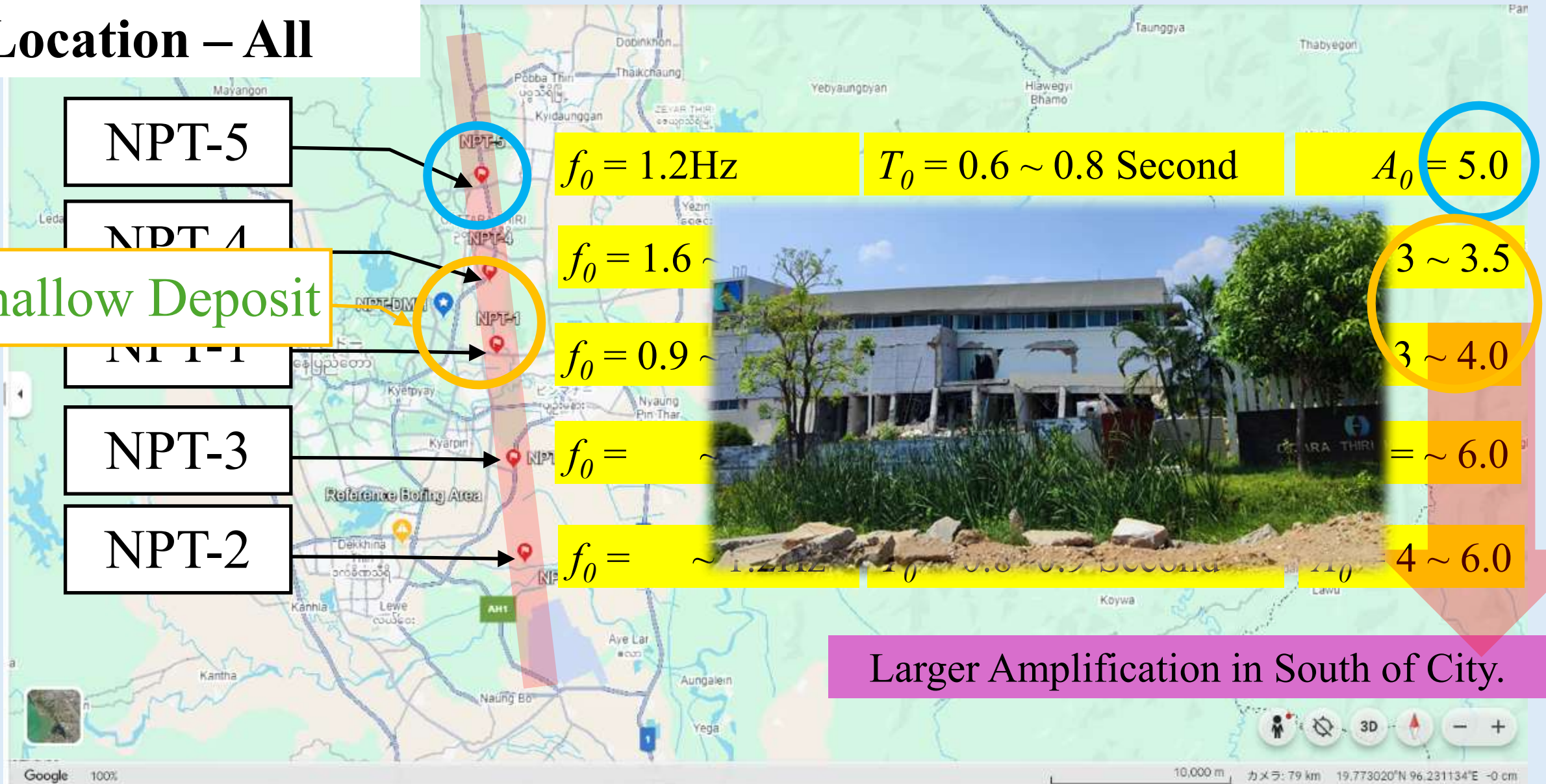


နေပြည်တော်

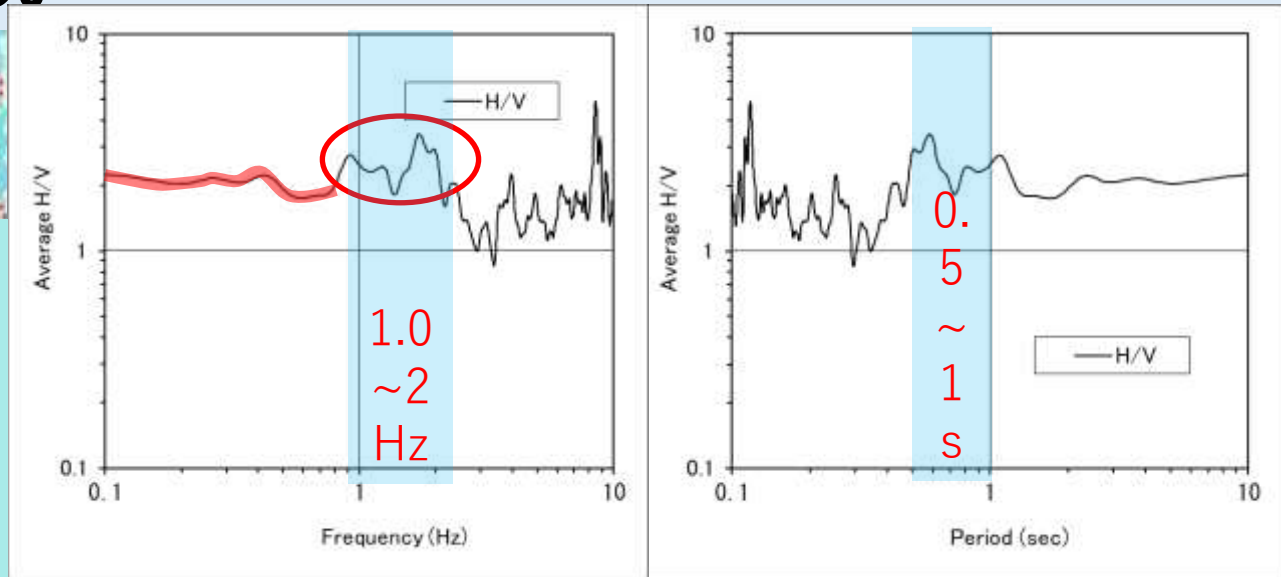


နေပြည်တော်

Location – All



မန္တလေးတိုင်းဒေသကြီး ဝမ်းတွင်း

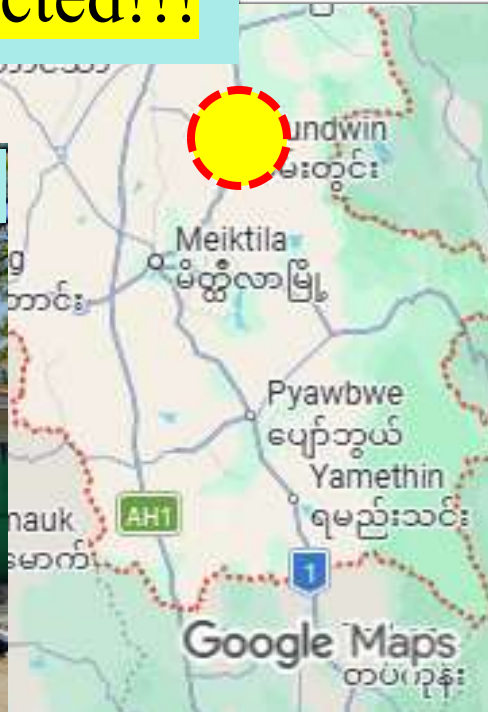


Amplification > 2.0 for very low Frequency Region.

Old buildings were highly affected!!!



ဝမ်းတွင်းချည်မျှင်စက်ရုံ

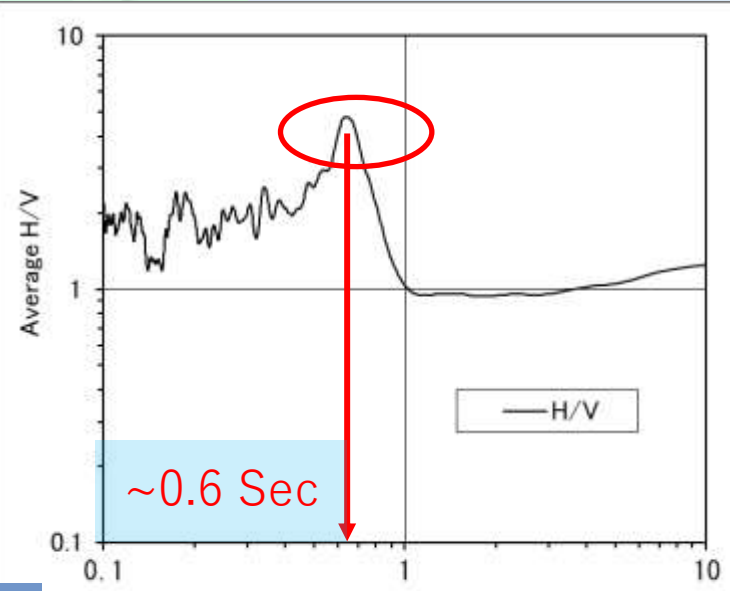
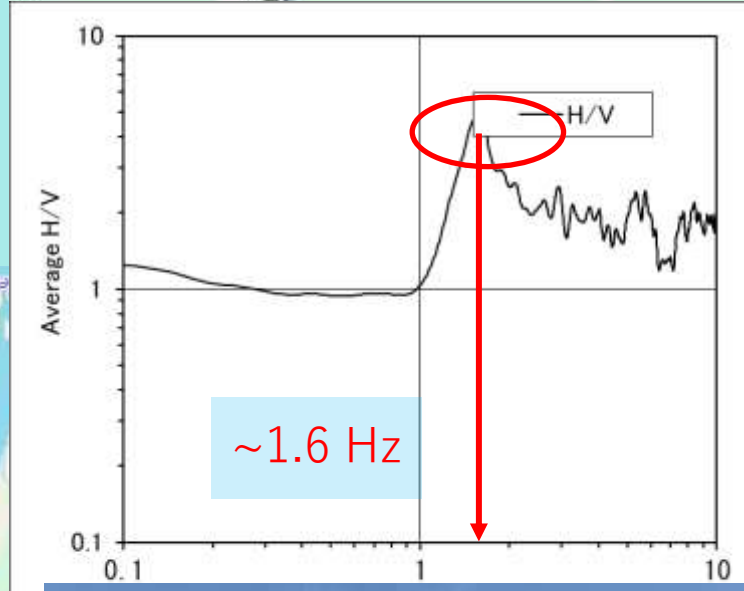


ဝမ်းတွင်းရှိဘုန်းတော်ကြီးကျောင်း

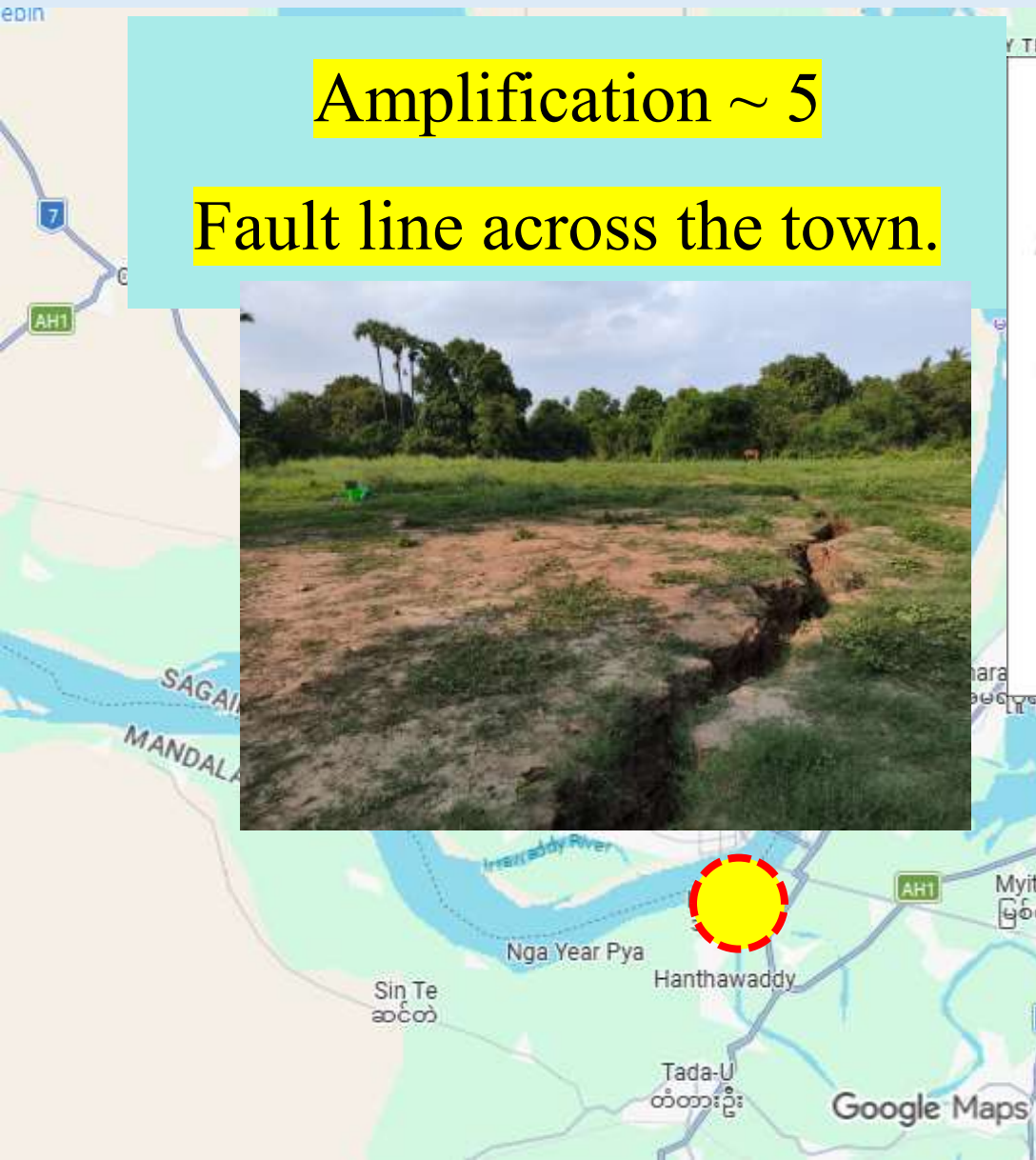
မန္တလေးတိုင်းဒေသကြီး အင်းဝ

Amplification ~ 5

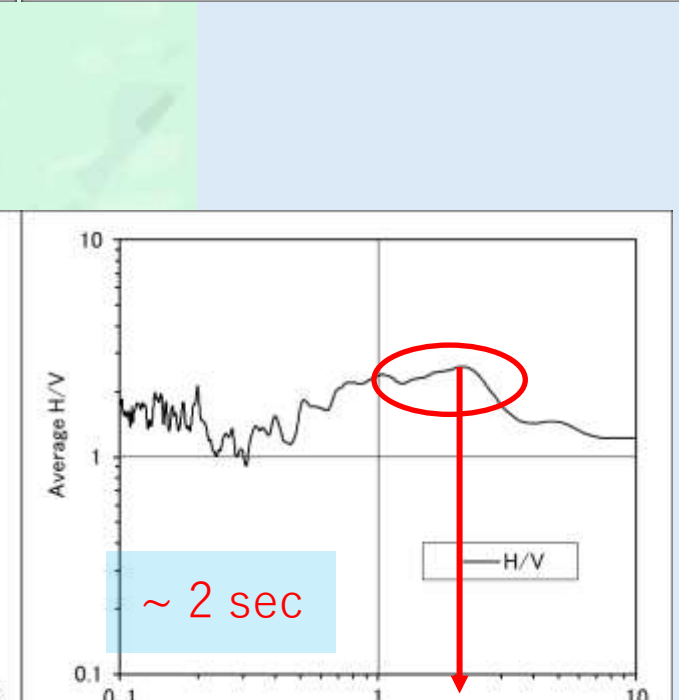
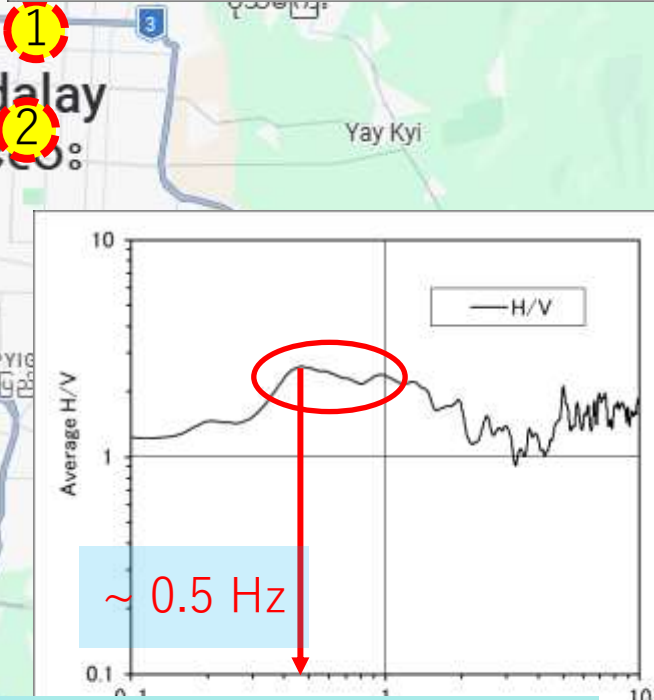
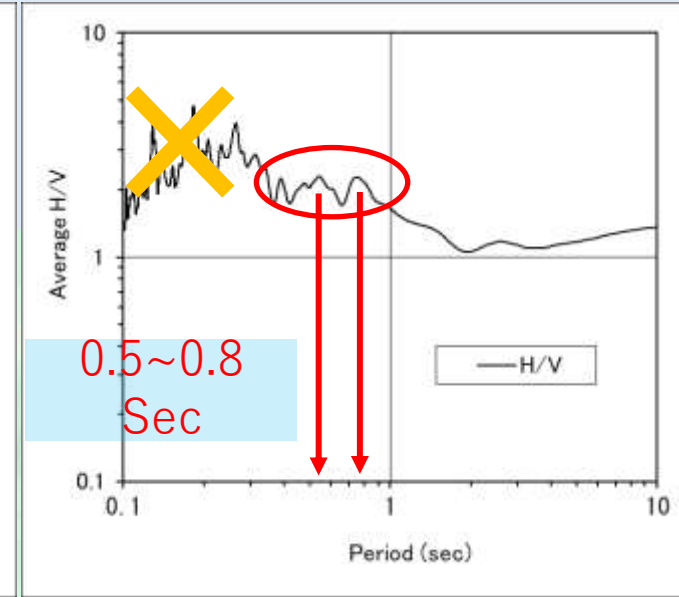
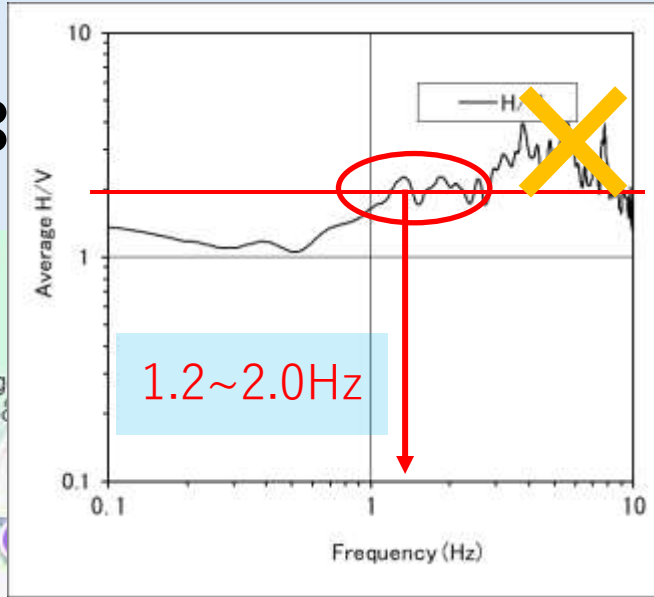
Fault line across the town.



Soft soil deposit



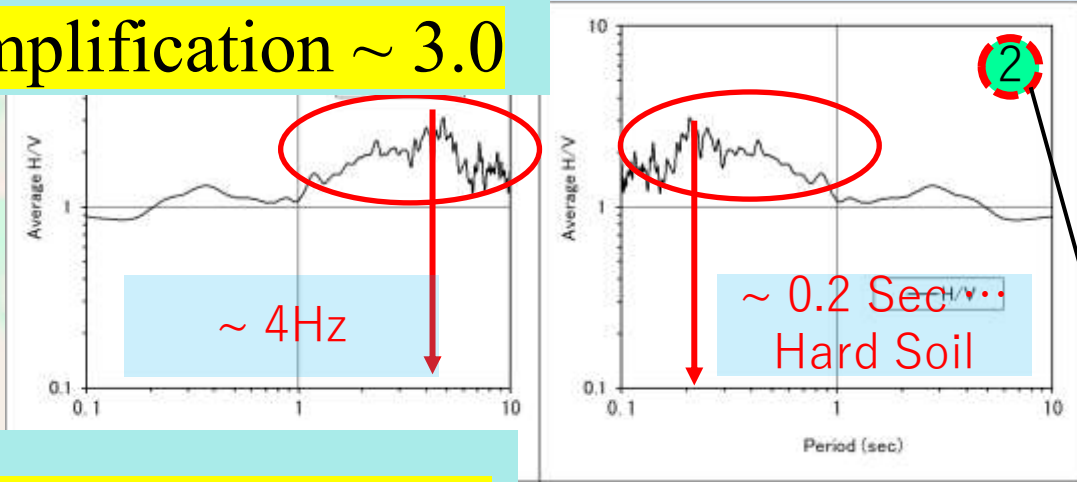
မန္တလေးတိုင်းဒေသကြီး မန္တလေး



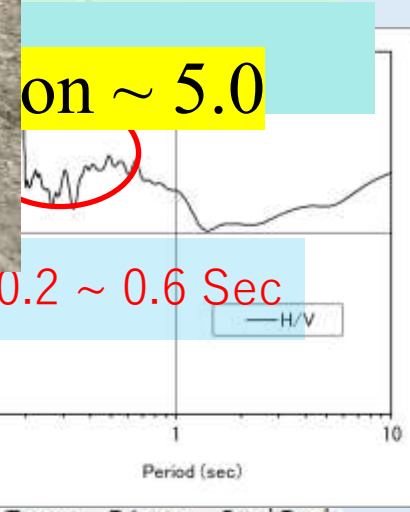
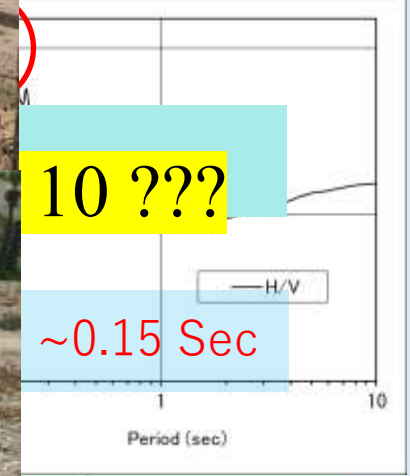
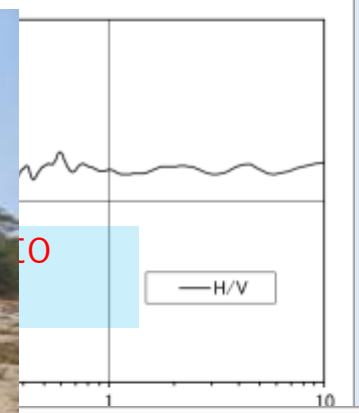
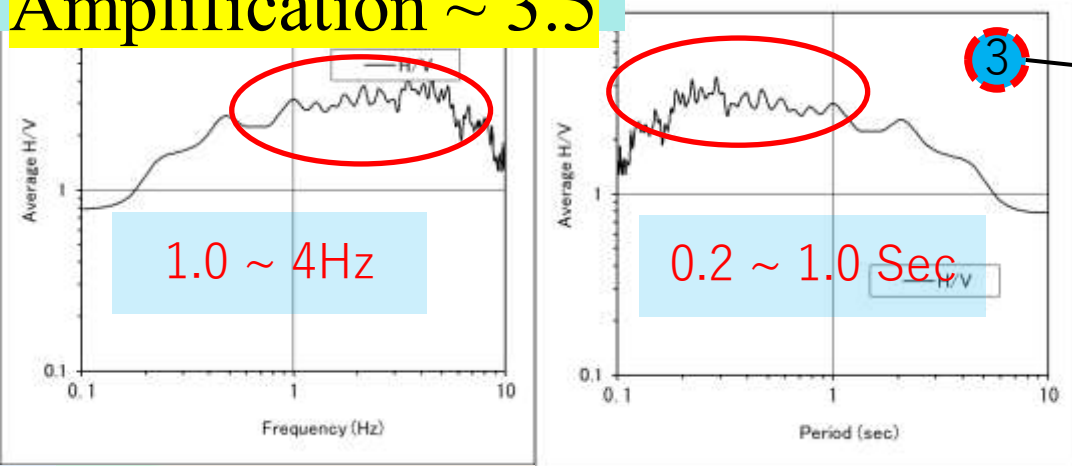
Amplification can be larger in west/south of Mandalay

စစ်ကိုင်းတိုင်းဒေသကြီး

Amplification ~ 3.0



Amplification ~ 3.5



Potentially higher amplification in Southern Part

Key Findings

Bago (1 Point @ Phayargyi)

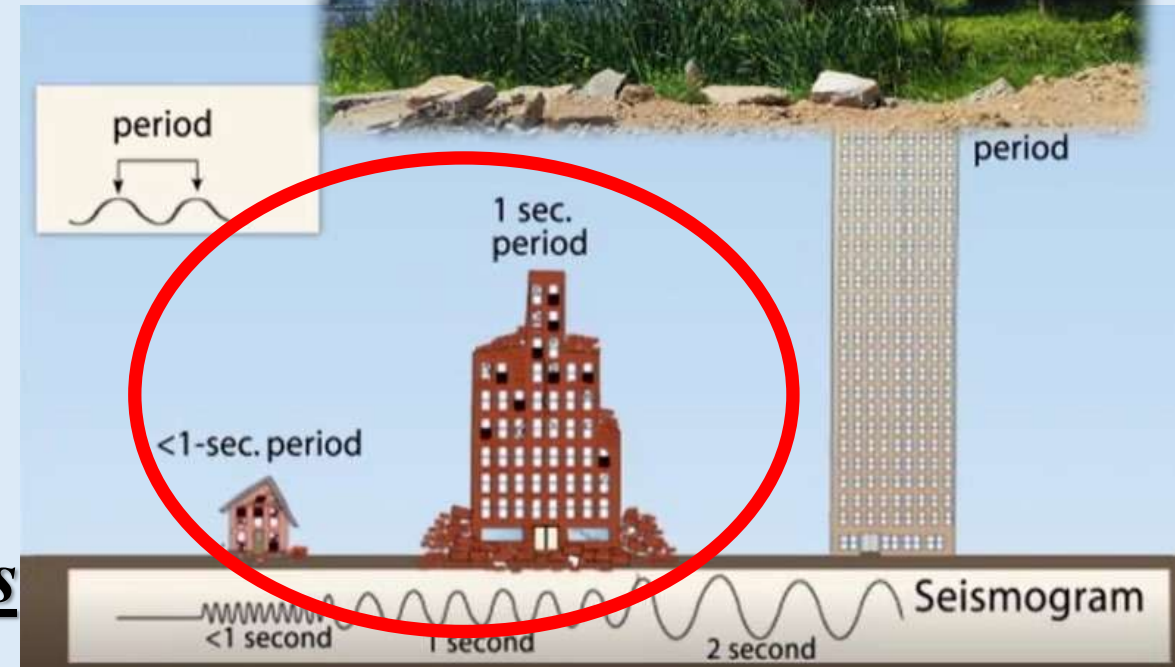
- Dominant frequency range: *0.4~1.0 Hz*
- Natural ground period: *1~2.5 seconds*
- Potential amplification: *3 ~ 3.5 times*
- Potential amplification for **Medium Height Buildings.**



Key Findings

Naypyitaw (5 Points)

- Dominant frequency range: $0.9 \sim 2.3 \text{ Hz}$
- Natural ground period: $0.4 \sim 2.0 \text{ seconds}$
- Potential amplification: $3 \sim 6.0 \text{ times}$
- Potential amplification for **Low to Medium Height Buildings.**



Key Findings

Mandalay - Wundwin (1 Point)

- Dominant frequency range: $1 \sim 2 \text{ Hz}$
- Natural ground period: $0.5 \sim 1 \text{ seconds}$
- Potential amplification: $\sim 2 + \text{times}$
- **Insignificant** Potential amplification for **Low to Medium Height Buildings.**



Key Findings

Mandalay - Innwa (1 Point)

- Dominant frequency range: $\sim 1.6 \text{ Hz}$
- Natural ground period: $\sim 0.6 \text{ seconds}$
- Potential amplification: $\sim 5 \text{ times}$
- High Potential amplification for **Small Buildings.**



Key Findings

Mandalay – Mandalay City (2 Points)

- Dominant frequency range: $0.5 \sim 2.0 \text{ Hz}$
- Natural ground period: $0.5 \sim 2.0 \text{ seconds}$
- Potential amplification: $\sim 2.5 \text{ times}$
- High Potential amplification for **Medium Height Buildings.**



Key Findings

Sagaing (5 Points)

- Dominant

& **1.5 ~ 6.5 Hz (South)**

- Natural gro

& **0.15 ~ 0.6 sec (South)**

- Potential a

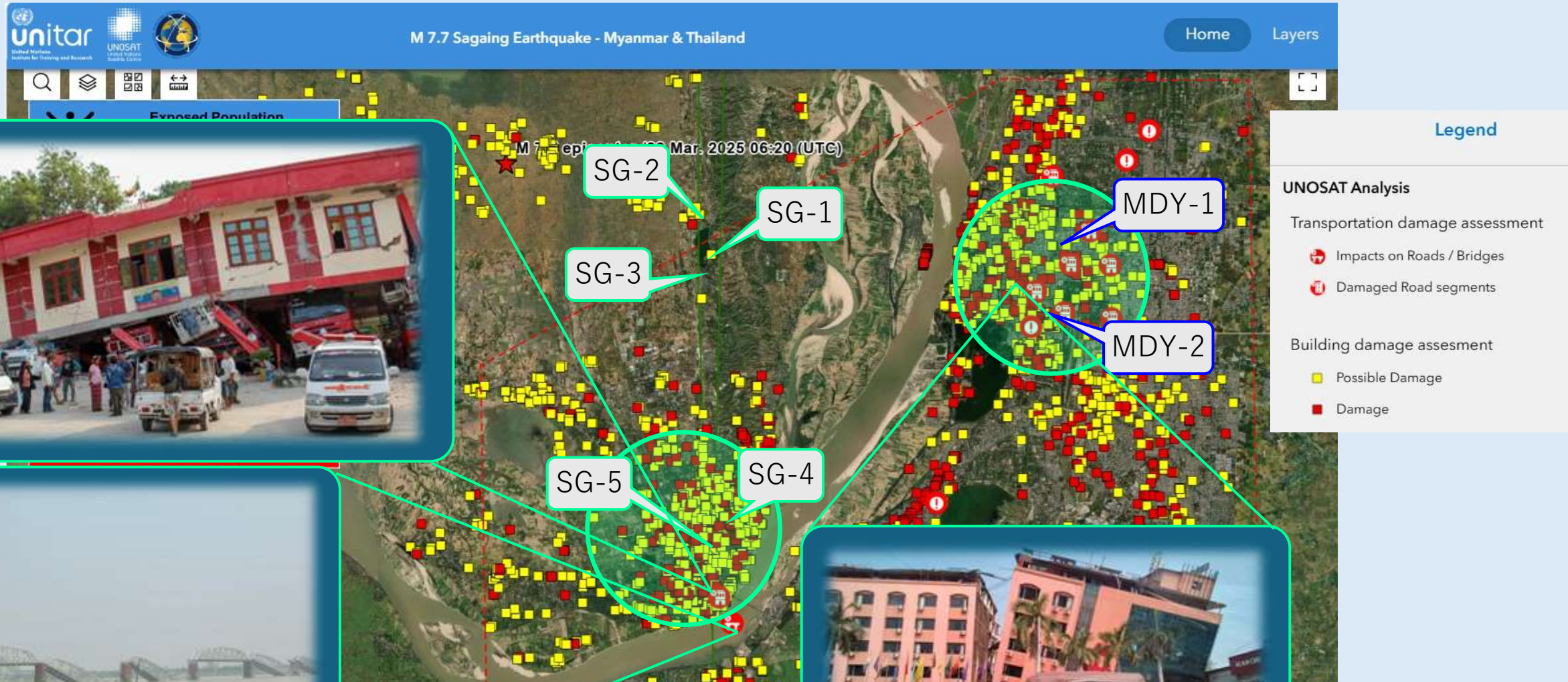
& **5 ~ 10 (South)**



- **High amplification in South** of Sagaing City (esp. **Low buildings**)

UNOSAT Analysis: Building Damage Assessment

Source: [M. 7.7 - Sagaing earthquake - Myanmar / Thailand](#)



Microtremor Survey can satisfactorily capture the site characteristics.

Limitations and Future Recommendations

Limitations

- Survey conducted during daytime with ambient noises
- Results represent **preliminary site amplification** (Not an exact factor)

Future Recommendations

- Microtremor Survey shall be conducted in night time.
- Future work should include borehole data and Vs profiles
- Verification with 1-D site response analysis (SHAKE) + MCE Waveforms.

Thank You for Your Kind Attention.

Site Amplification Characteristics Along Sagaing Fault

By Microtremor Survey

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Research in collaboration with

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