Microtremor Survey ကို အသုံးပြု၍ မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများကို လေ့လာခြင်း

Site Amplification Characteristics Along Sagaing Fault By Microtremor Survey

ဒေါက်တာအောင်အောင်စိုး

Dy. Head (Geo-Department)
FUKKEN Co., Ltd. (Yangon)
aungsoe@fukkenmyanmar.com
www.fukkenmyanmar.com

တွဲဖက်ရေးသားသူ -

ဒေါ် ရီရီငြိမ်း

Vice President (MEC)

Research in collaboration with

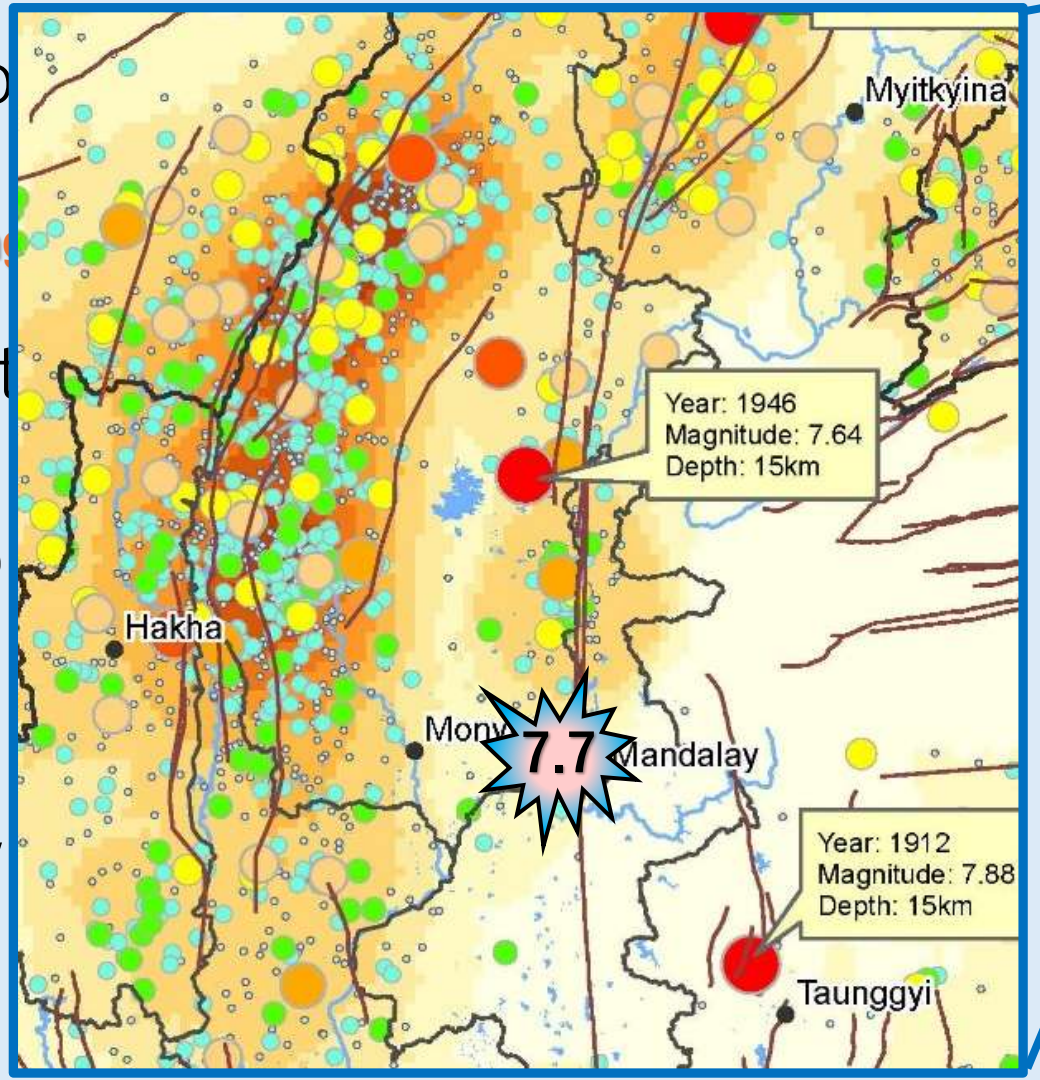
Myanmar
Earthquake
Committee

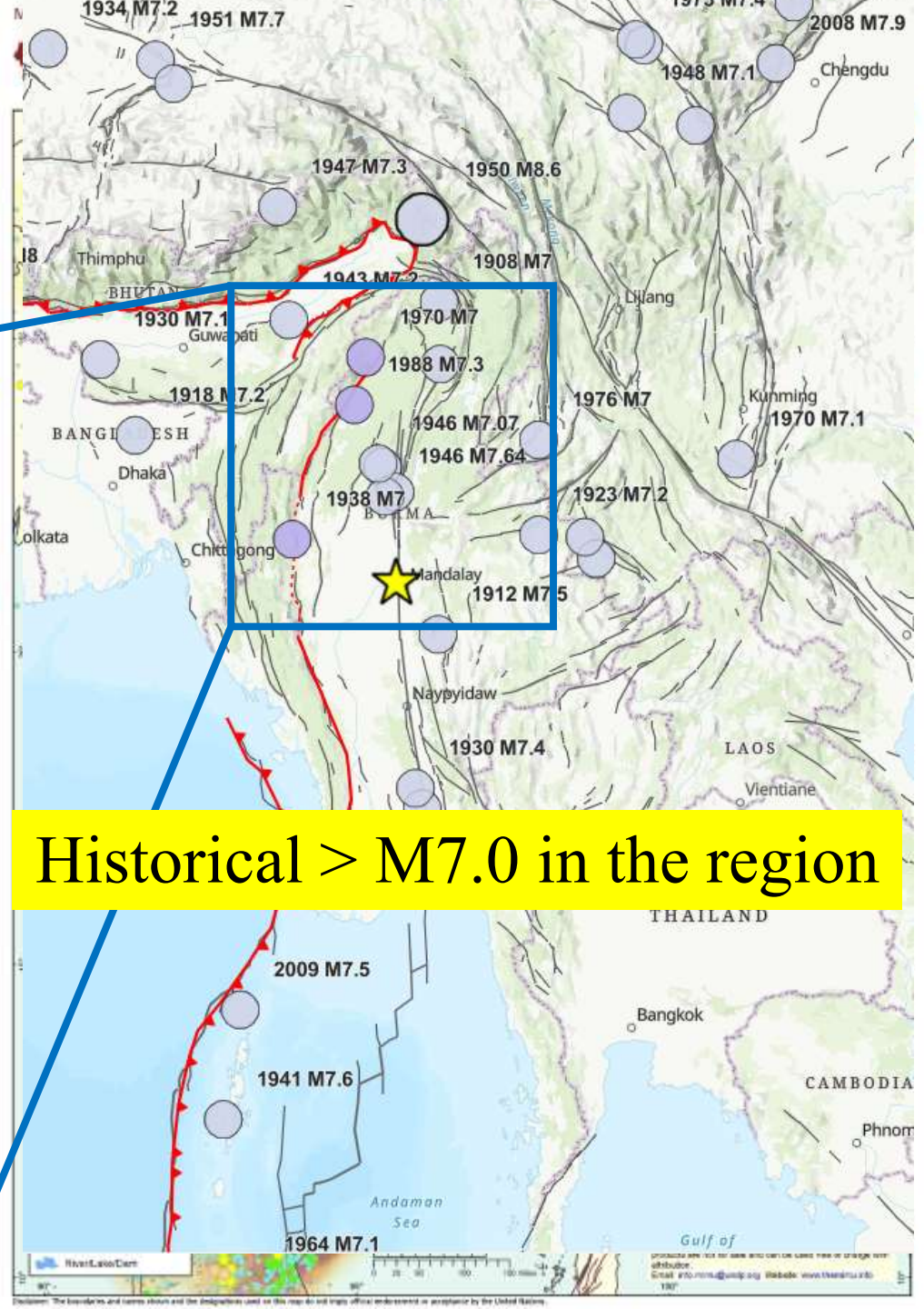
တွဲဖက်များ - Dr. Yoshimutsu YAMADA ၊ Mr. Tatsuru AOYAMA နှင့် ဦးမင်းသိမ်းကျော်။

နိဒါန်း

EARTHQUAKE

- Dangero
  No !!!!!
  early warnin
- Destruct
- **UNPRED**
- Unknow





Historical > M7.0 in the region

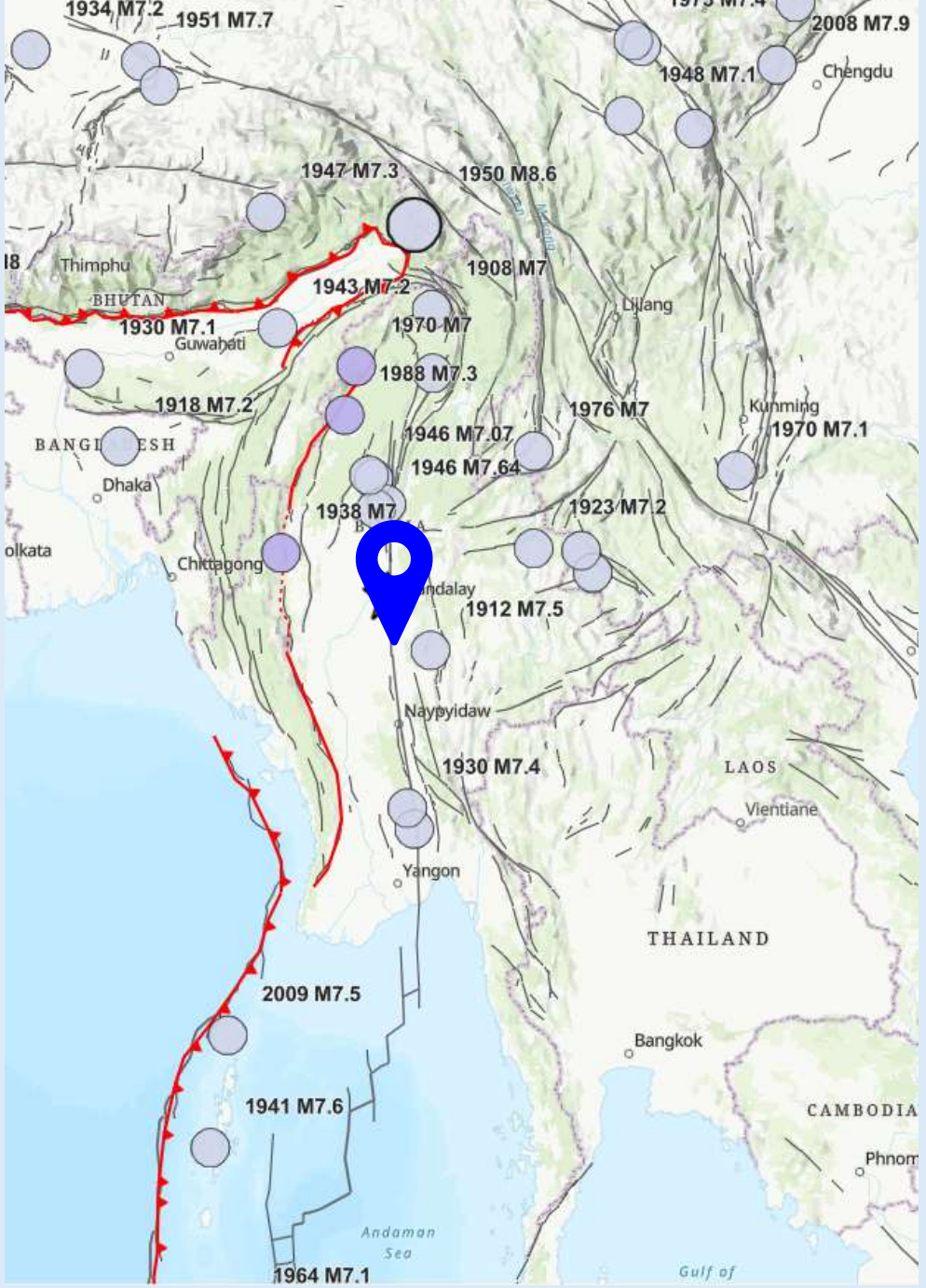
မှတ်တမ်း ဗီဒီယို

Thapyay Wa 30 MW Solar Firm

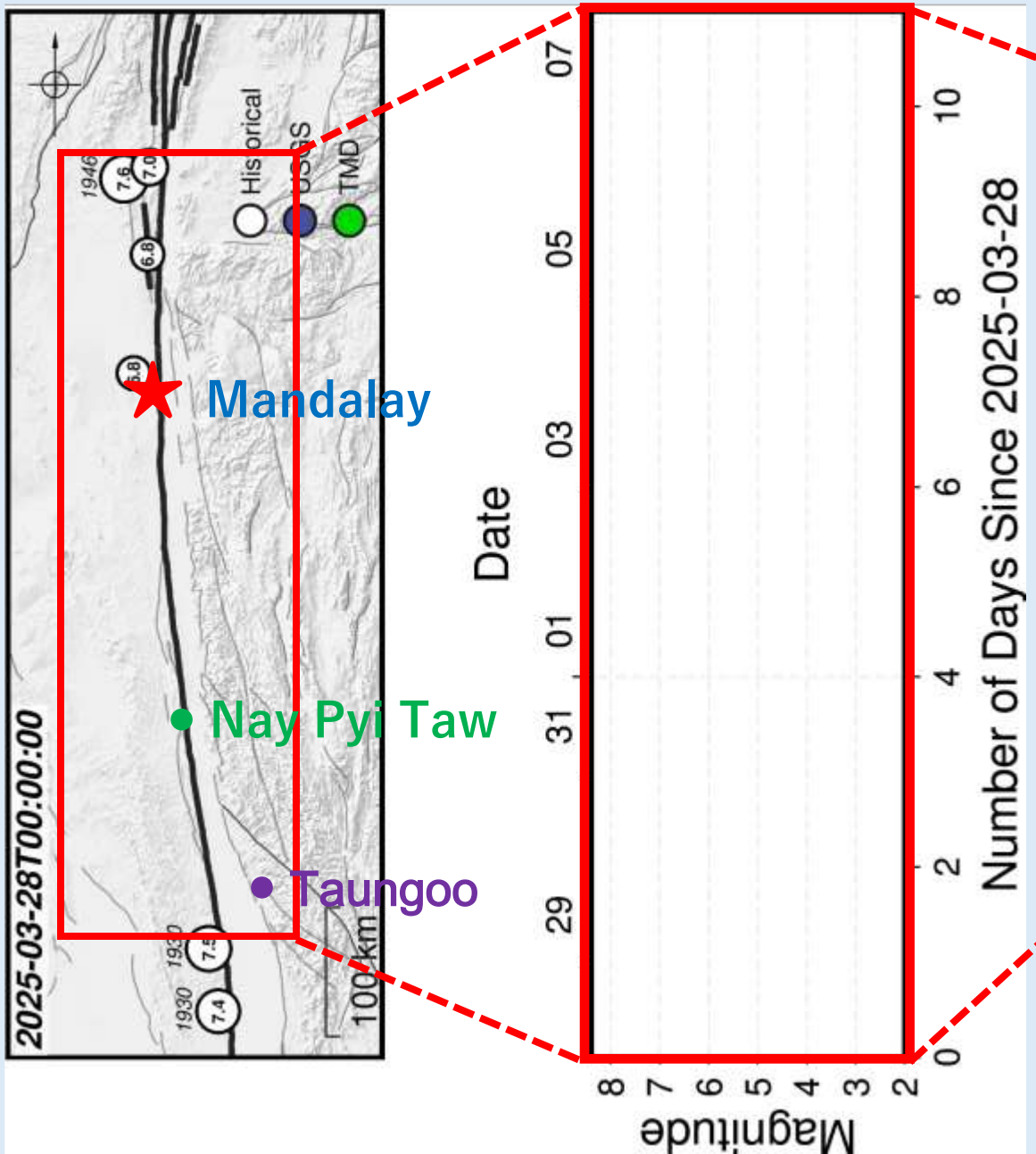
Thazi Tsp., Meiktila, Mandalay Region, X2G7+V3, Tha Phay Wa, Myanmar (Burma)

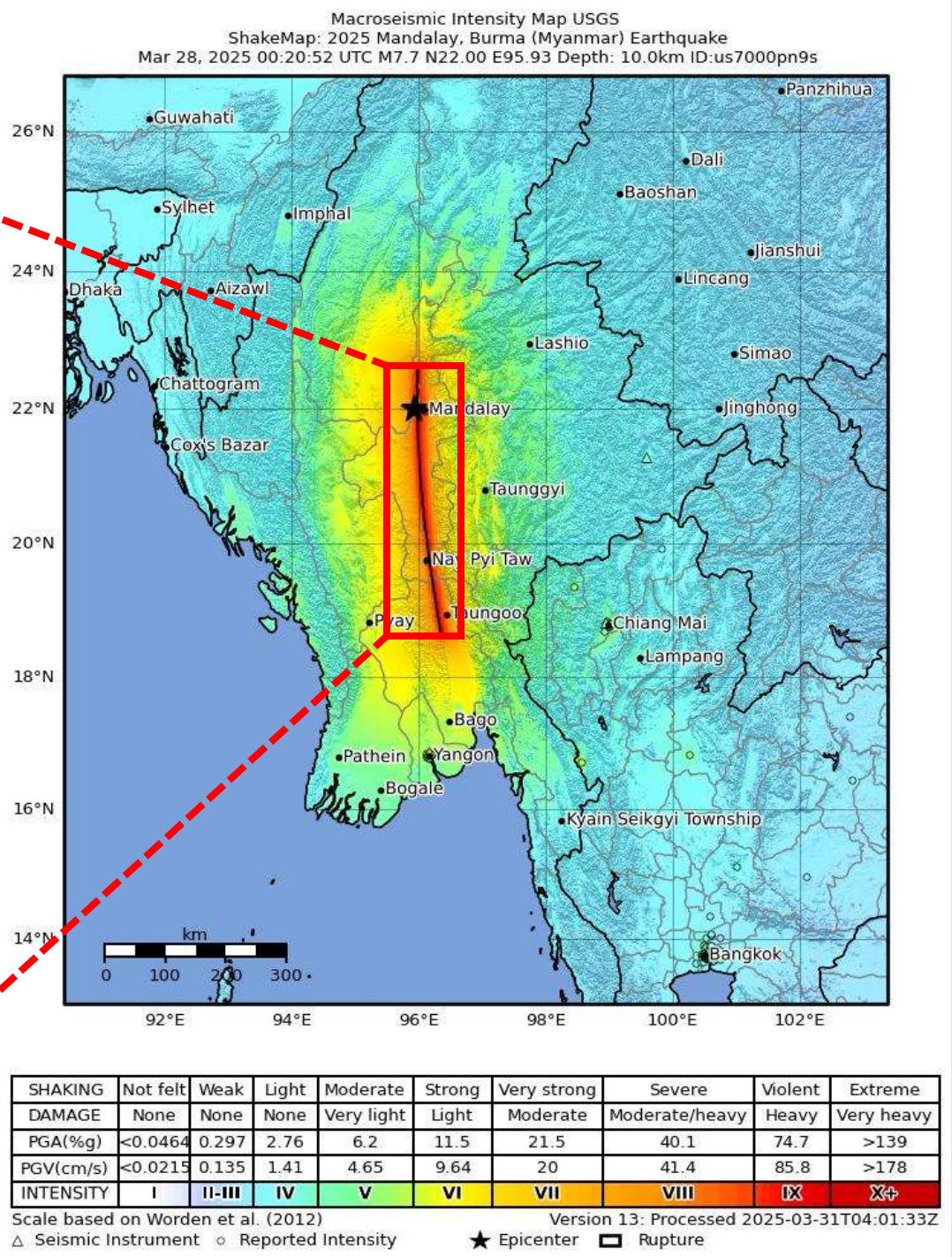
Htin Aung
May 11 ·

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)

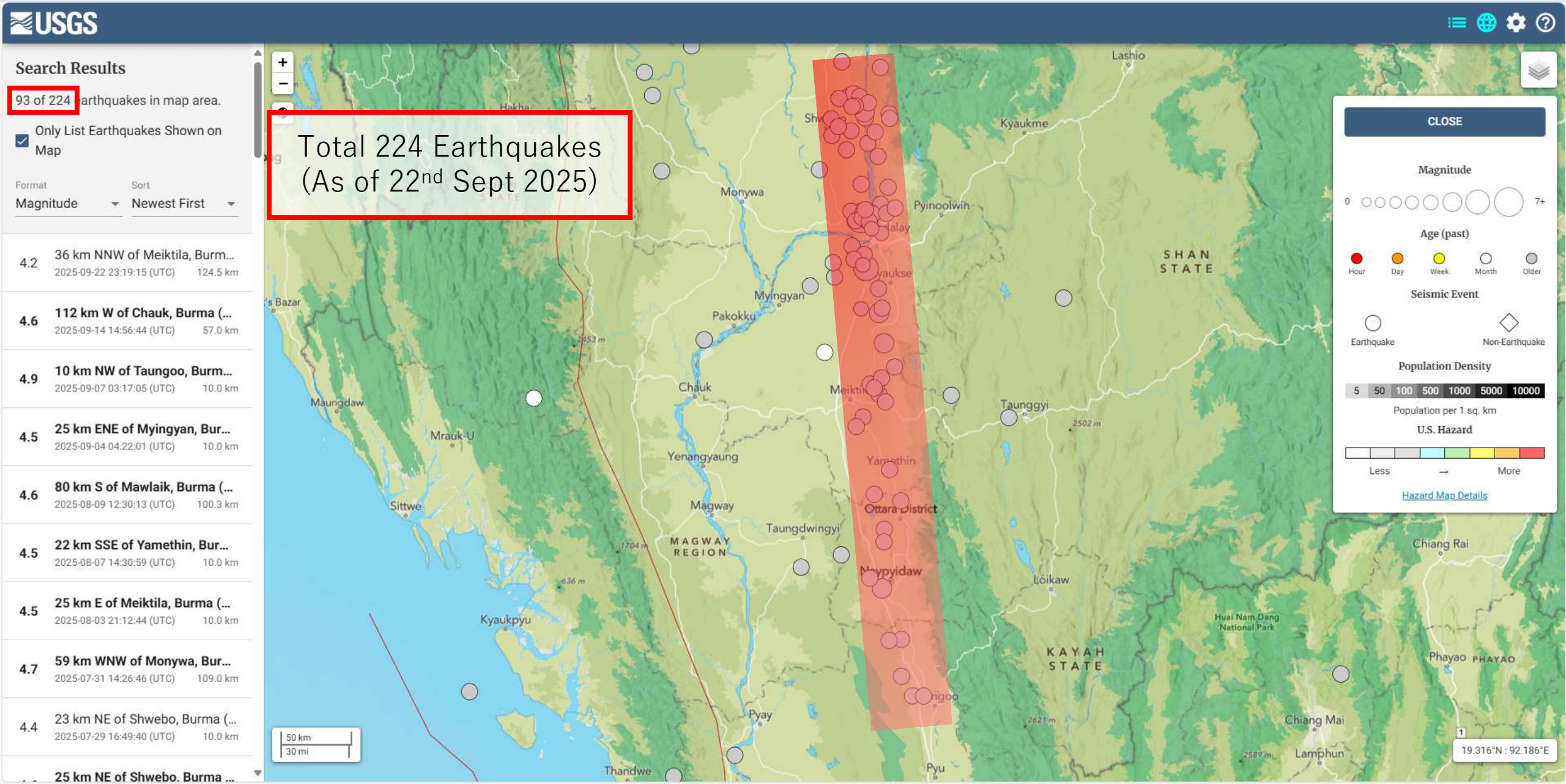


နောက်ဆက်တွဲလျင်ငယ်များ After Shocks





နောက်ဆက်တွဲလျင်ငယ်များ 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

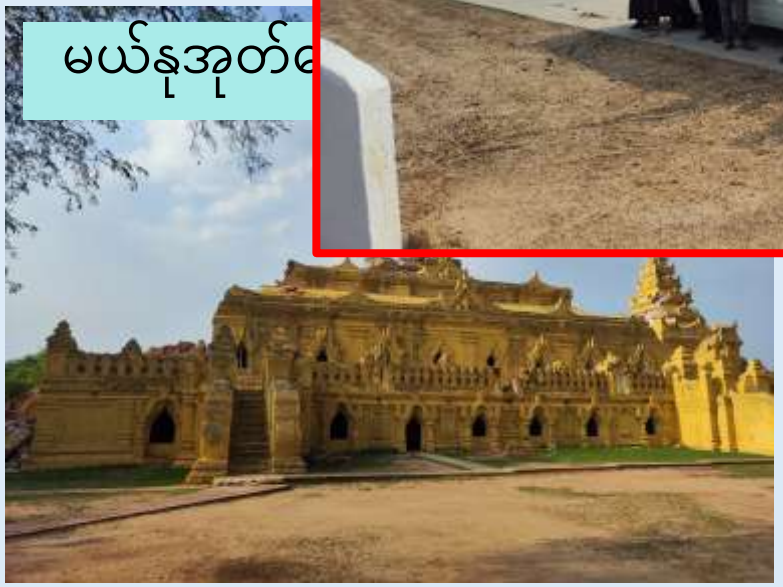

မန္တလေးနှန်းတော်
အနောက်မြောက်ထောင့်


နေပြည်တော်


ဝမ်းတွင်းချည်မျှင်စက်ရုံ


Lack of fuel @ 355 Milestone


Collapse of Sagaing Bridge (Old)


မယ်နုအုတ်


ကြီးကျောင်း

အဆောက်အဦပျက်ဆီးမှု မှတ်တမ်းဓာတ်ပုံများ

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

WHY? ⇨ Structural quality, foundation, &

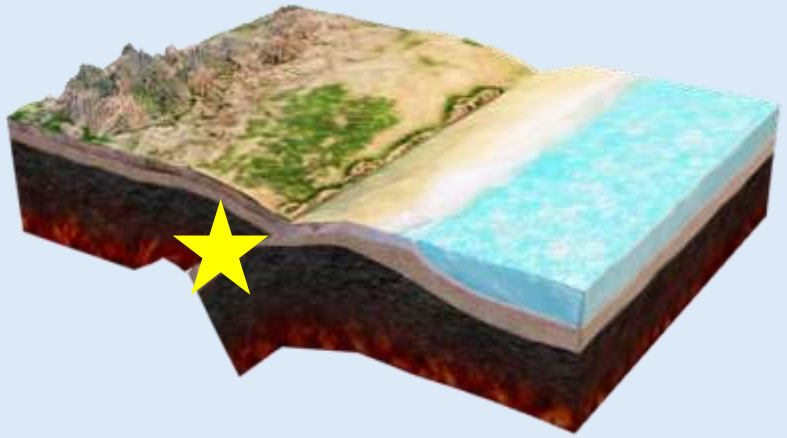
Site Response [Site Effect]!

မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ

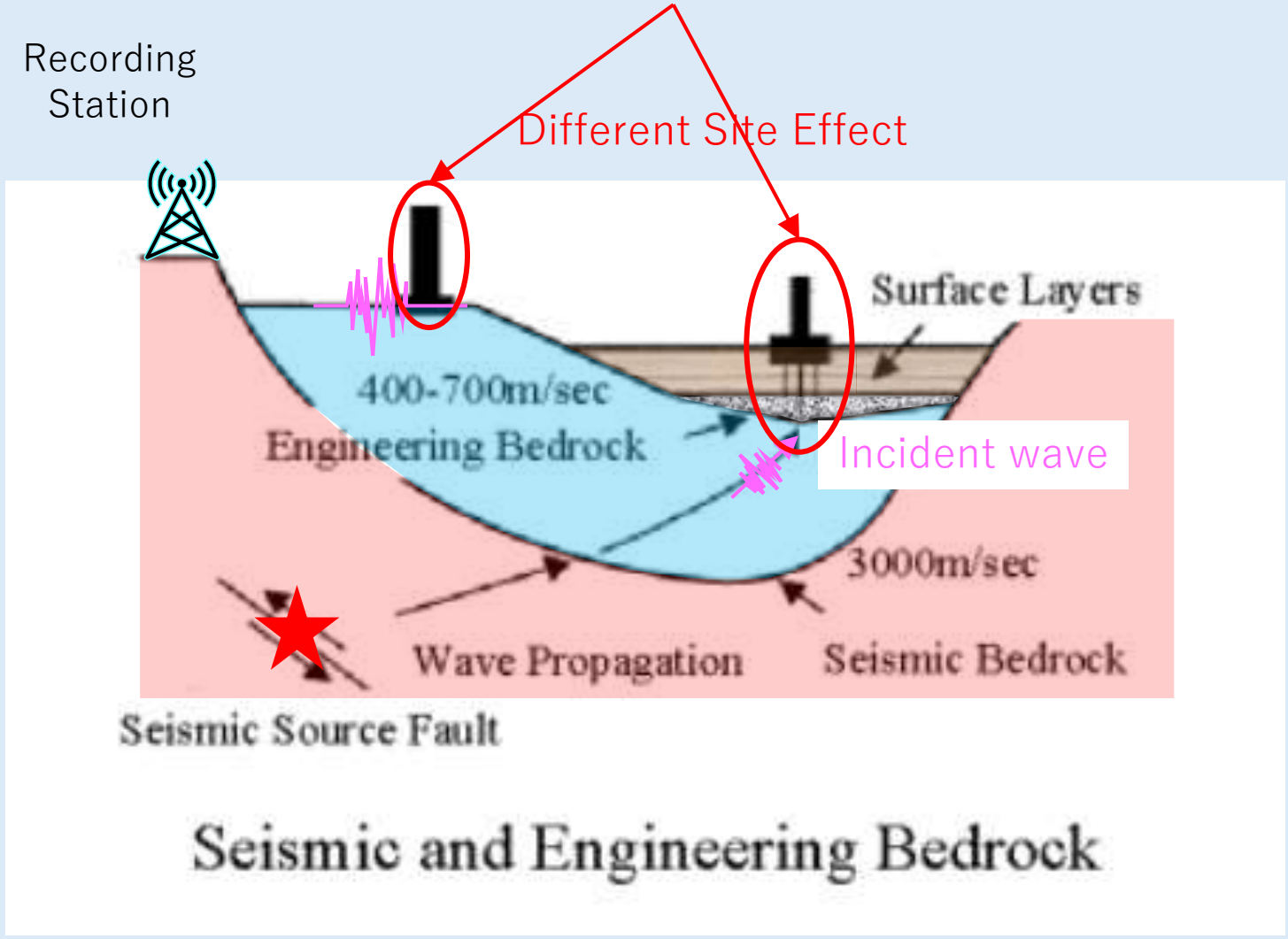
မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု

Importance of Site Effect

Structures will differently response depending on where they are standing.

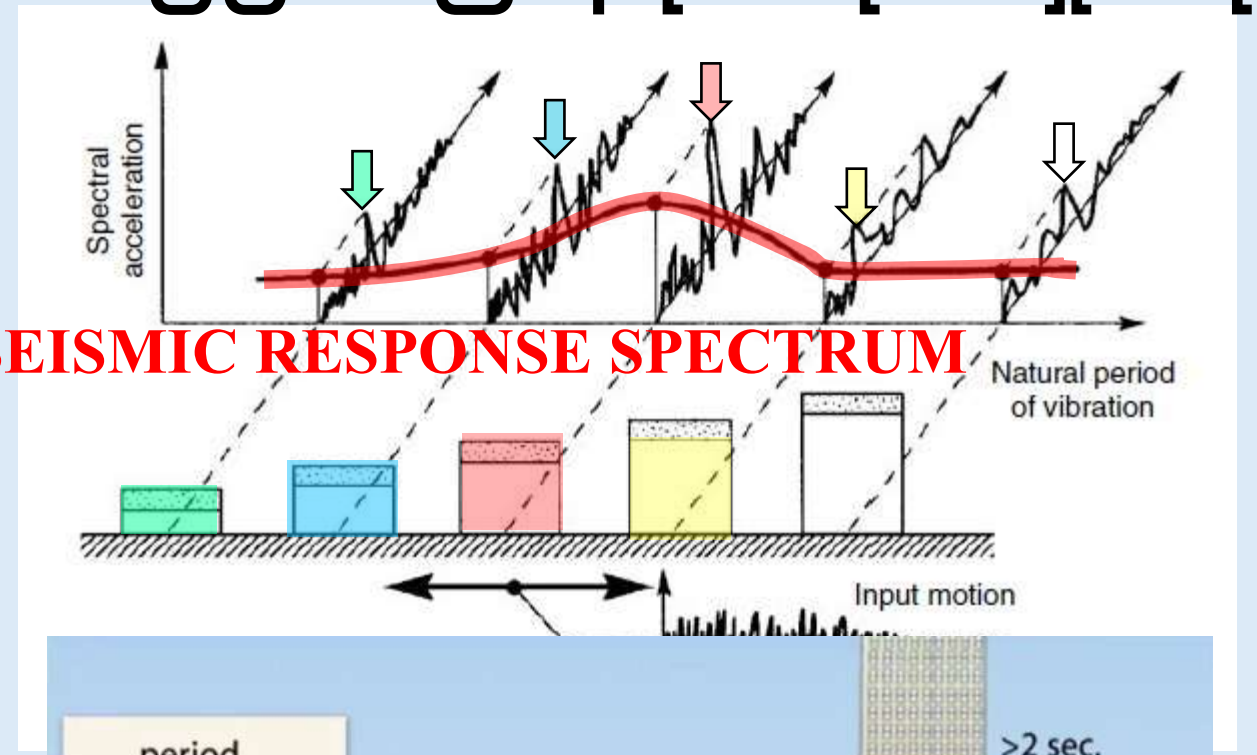


Occurred due to the movement of tectonic plates

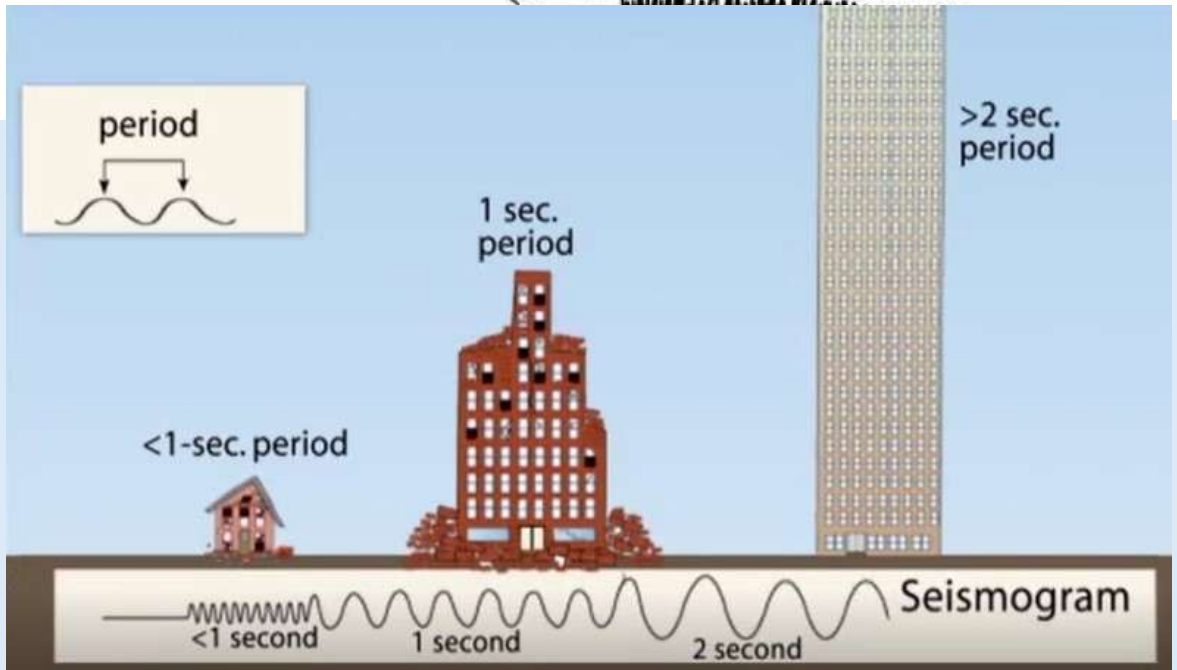


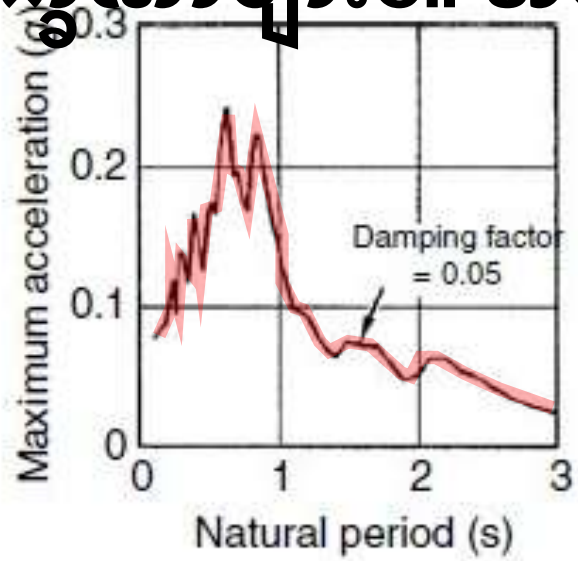
Seismic and Engineering Bedrock

မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု

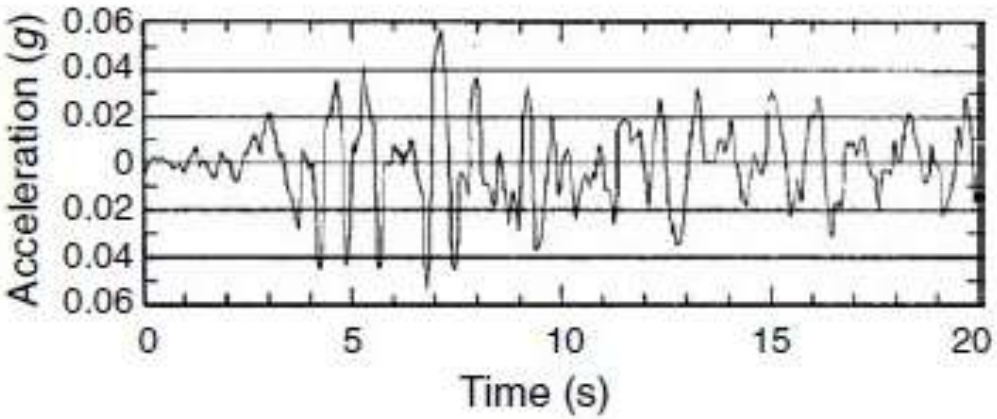


SEISMIC RESPONSE SPECTRUM



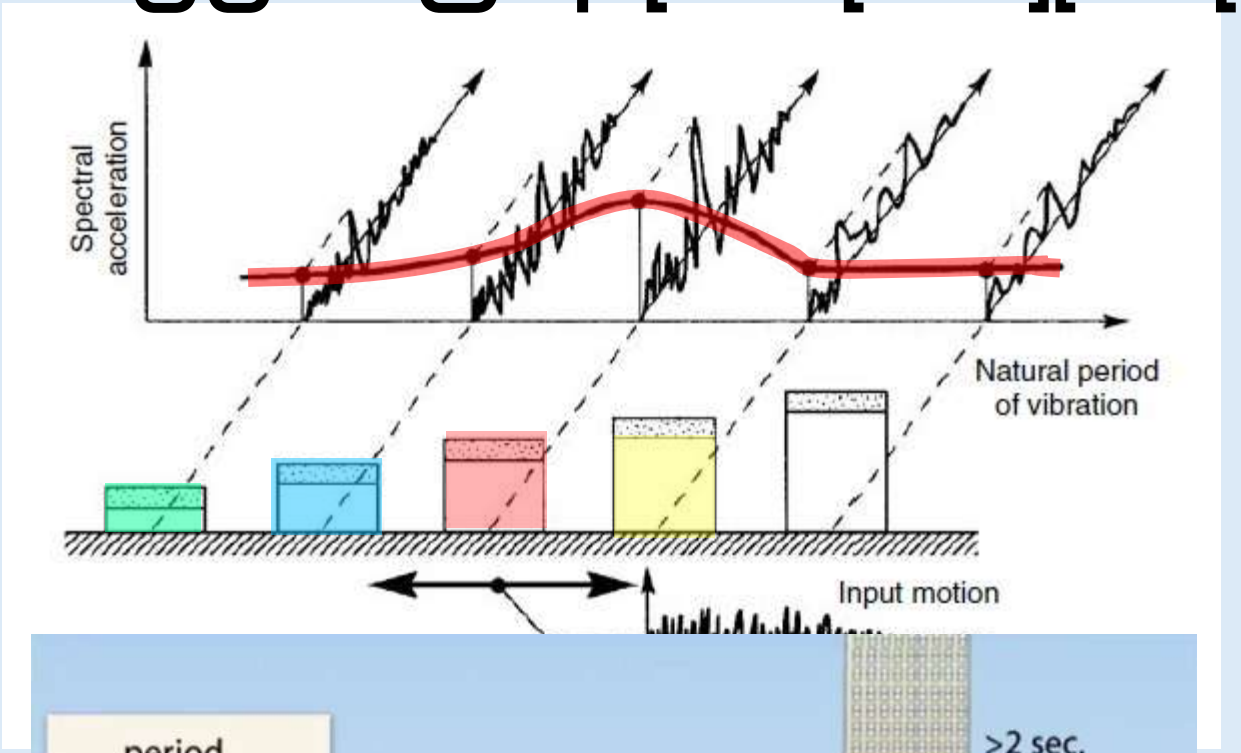


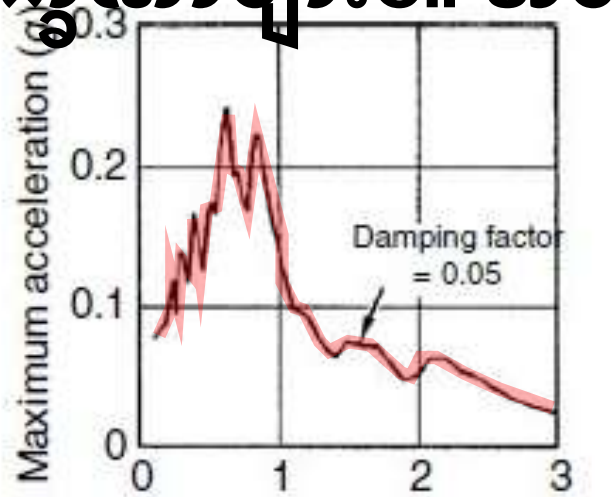
Acceleration Response Spectrum
Pasadena Ground motion



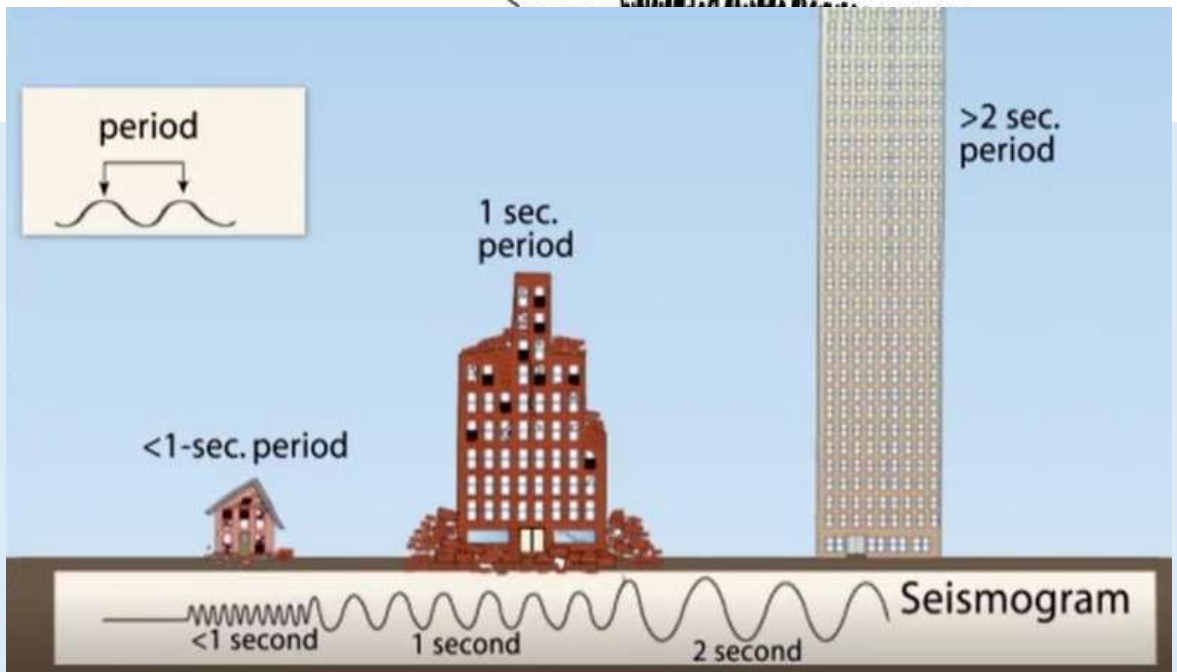
Accelerogram—Pasadena, Kern County, California earthquake, July 21,1952

မြေပြင်တည်နေရာအလိုက် လှိုင်းတိုးချဲ့မှု လက္ခဏာများ၏ အရေးပါမှု





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



ရည်ရွယ်ချက်

စစ်ကိုင်းပြတ်ရွေ့ကြောတစ်လျှောက် 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။

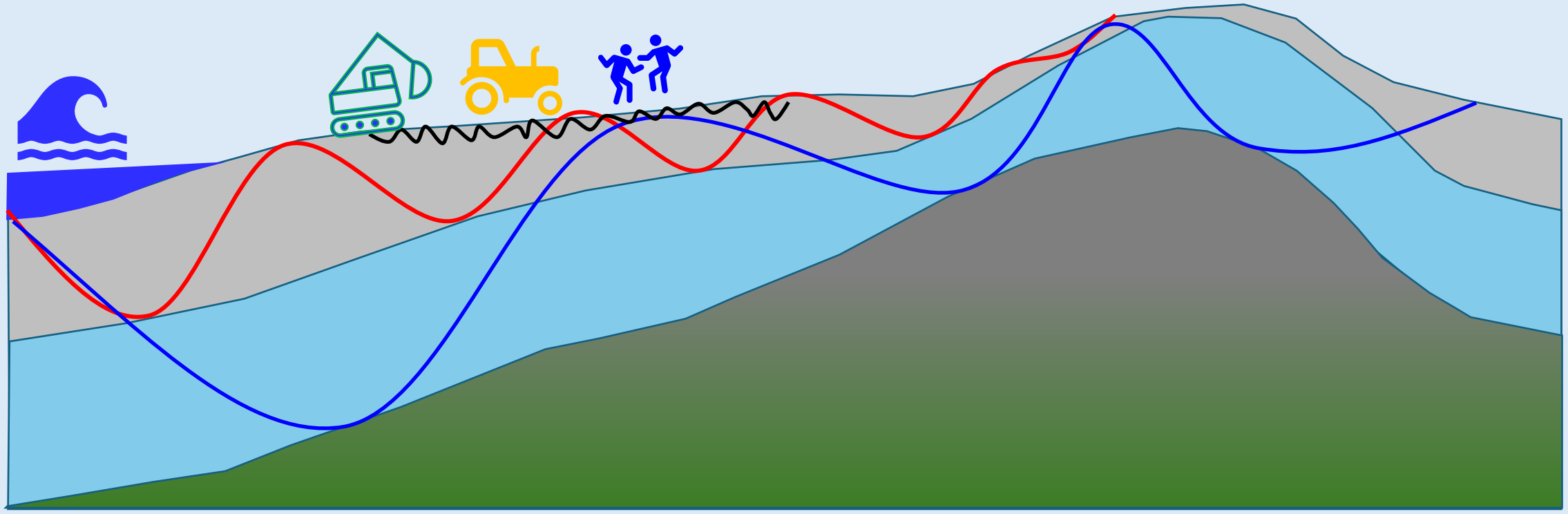
- Evaluate potential amplification factor using HVSR method

Microtremor Survey Method

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

လူသားများ ခံစားရှိမရနိုင်သော လှိုင်းရှည်များနှင့် လှိုင်းတိုများကို အာရုံခံ ဖမ်းယူခြင်း

Insensible long-period waves & short-waves

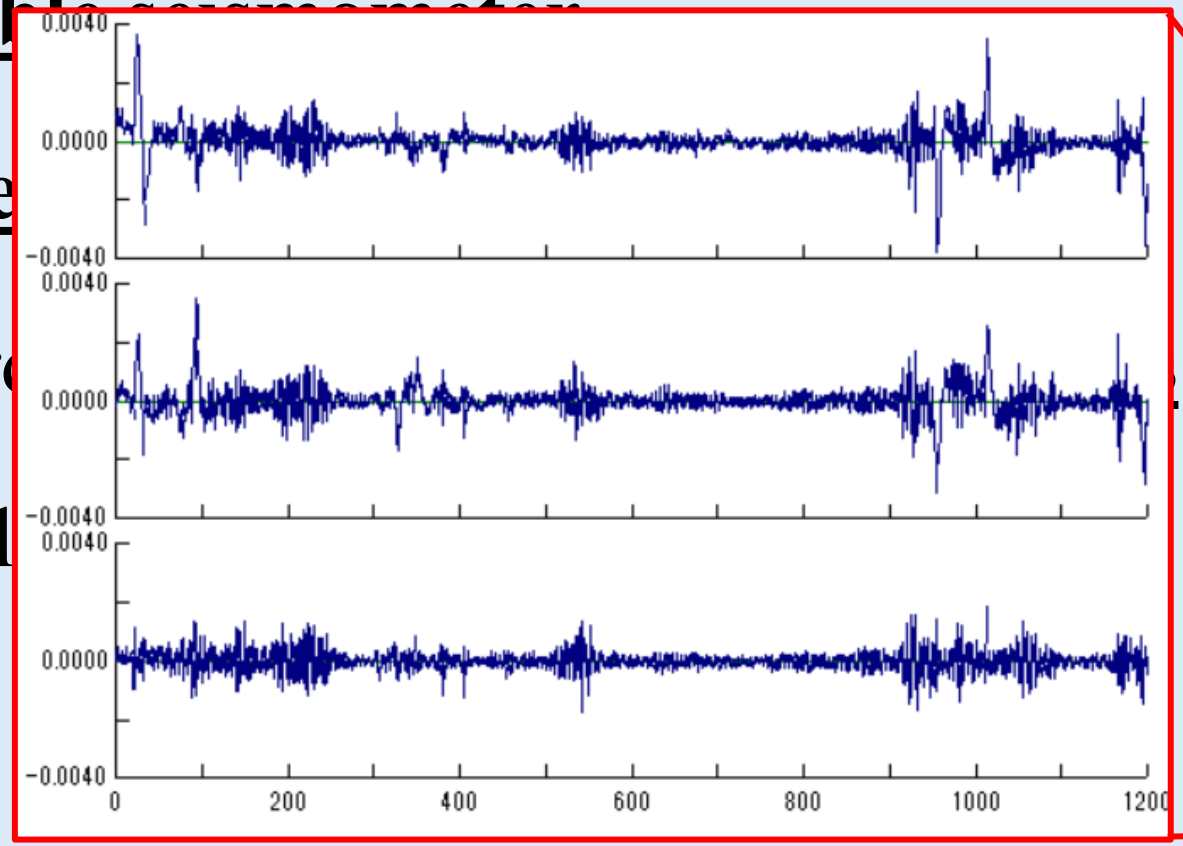


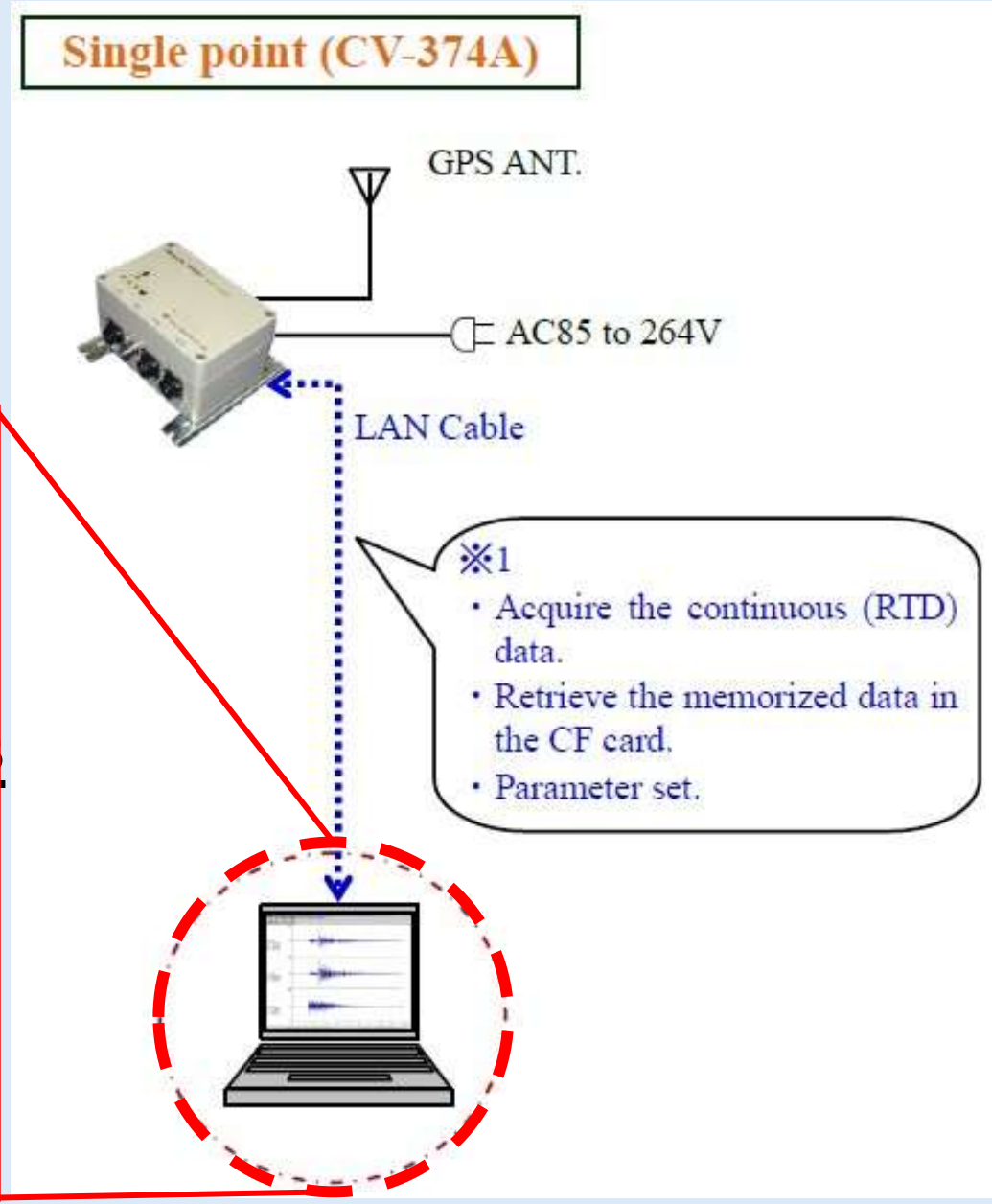
Microtremor Survey Instrument

- 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 seismometer**
- **Single**
- Record
- Sampl

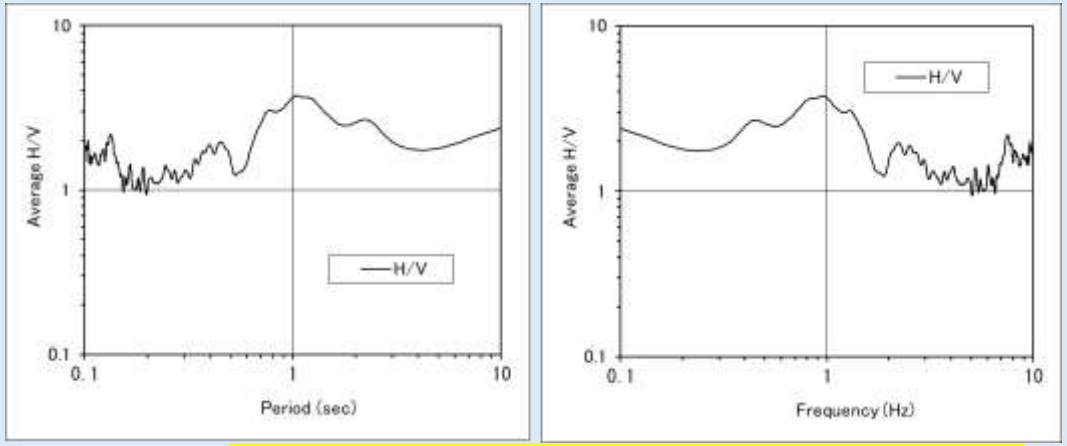




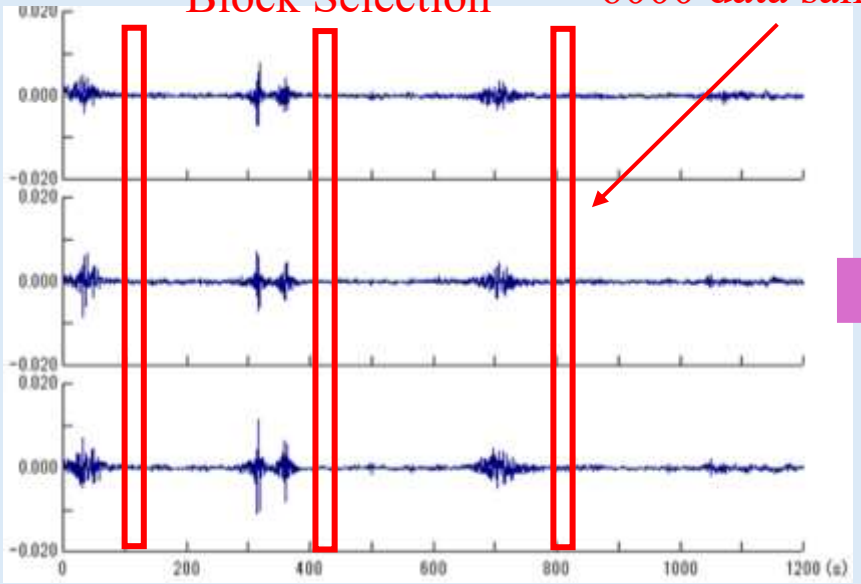
Data Processing and Analysis

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

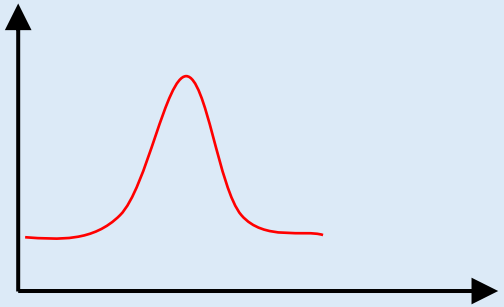
Horizontal to vertical spectrum ratio HVSR



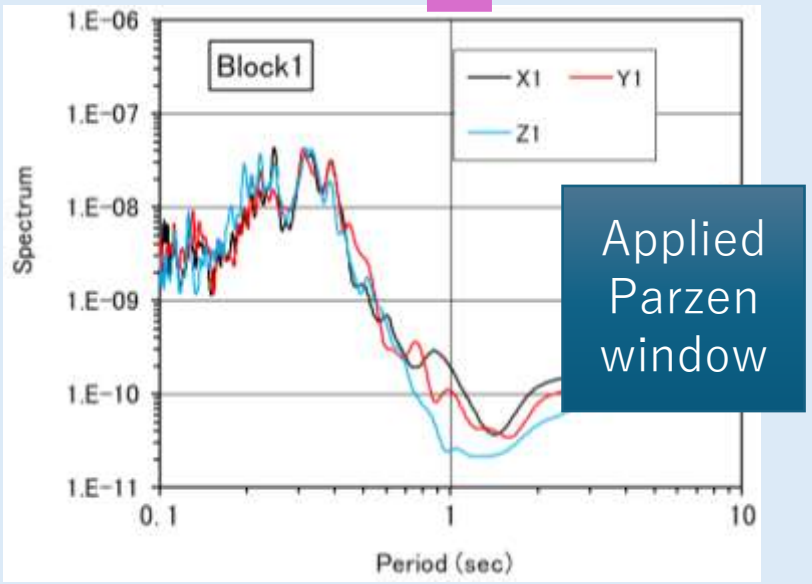
$$\frac{H}{V}(f) = \frac{\sqrt{P_{EW}(f)+P_{NS}(f)}}{\sqrt{P_{UD}(f)}}$$



Recorded data



Fourier Transform



Power Spectrum

Microtremor Survey ဆောင်ရွက်ခဲ့သော နေရာများ

Myanmar Earthquake Committee 1999

Myanmar
Earthquake
Committee

19 ~ 23
April, 2025

Innwa

Nay Pyi Taw

Pharyargyi, Bago

SG-1
SG-5
Fault near Innwa
Fault near Tada-U
Wundwin Fault
Sin The Dam
A-Lyin-Lo Village NPT
Chitthu St., NPT
NPT Airport
Phayargyi, Bago

Sagaing

Mandalay

Wundwin

Legend
Feature 1
Investigated Area

Microtremor

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

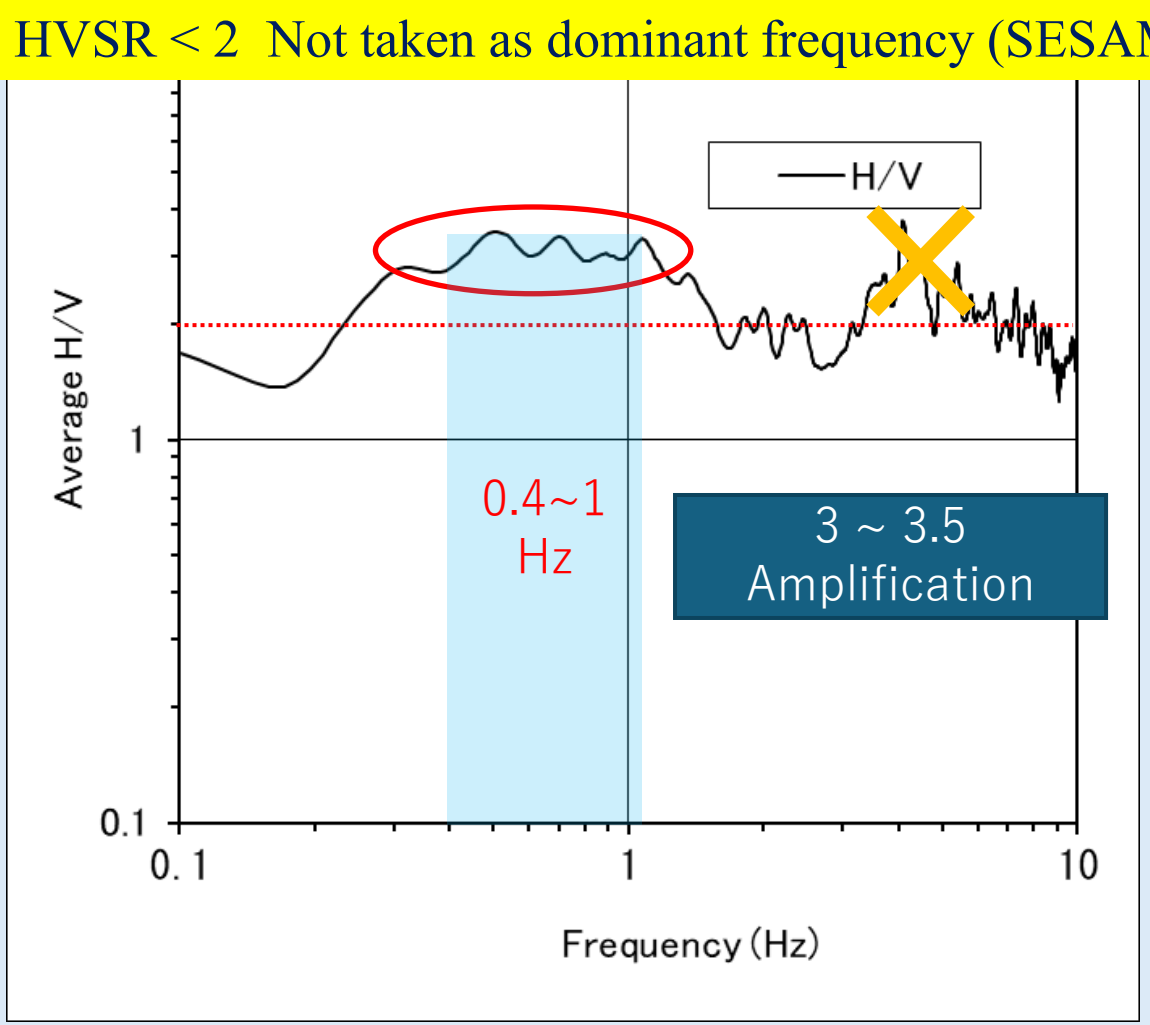
N

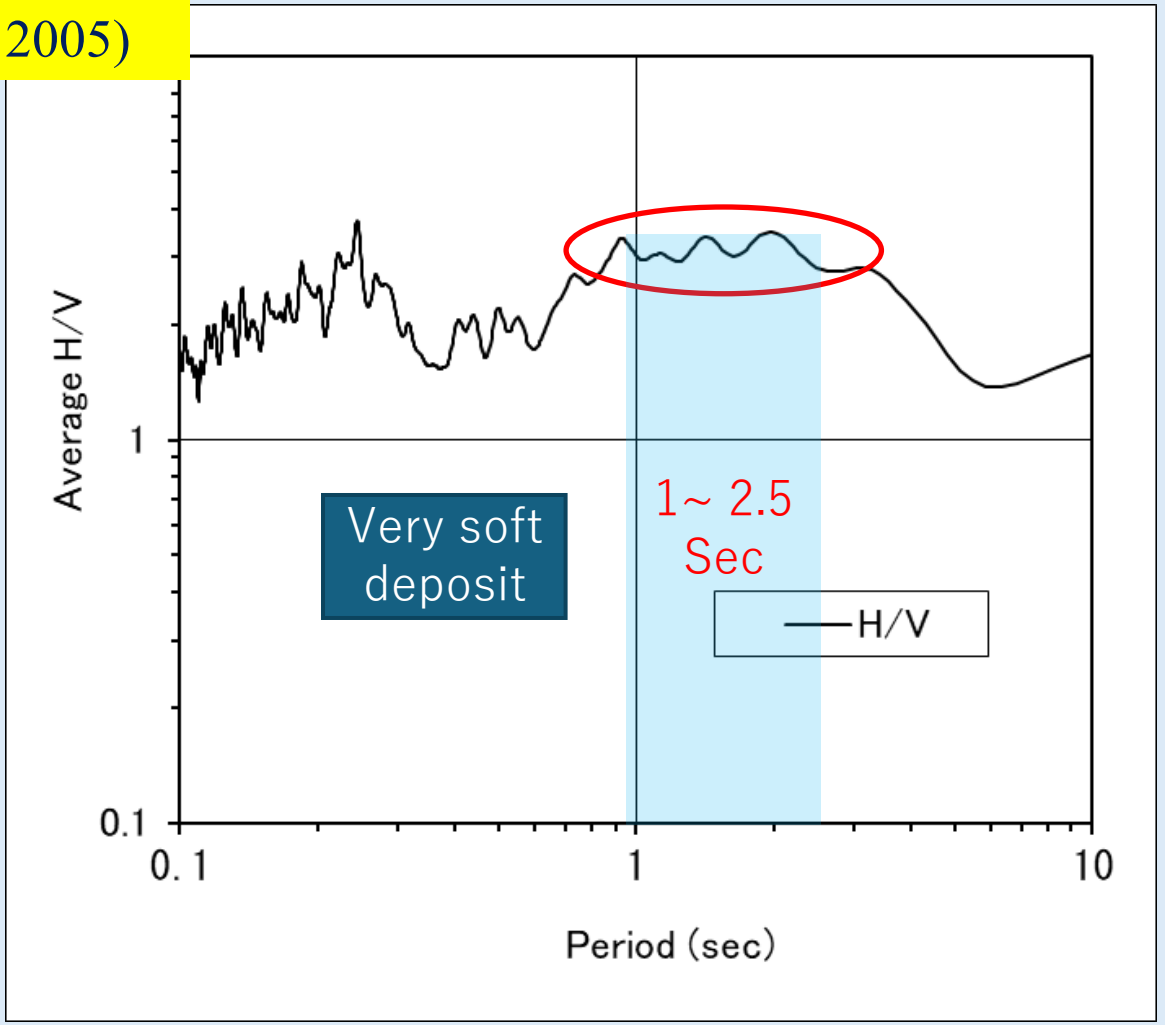
400 km

ပဲခူးတိုင်းဒေသကြီး

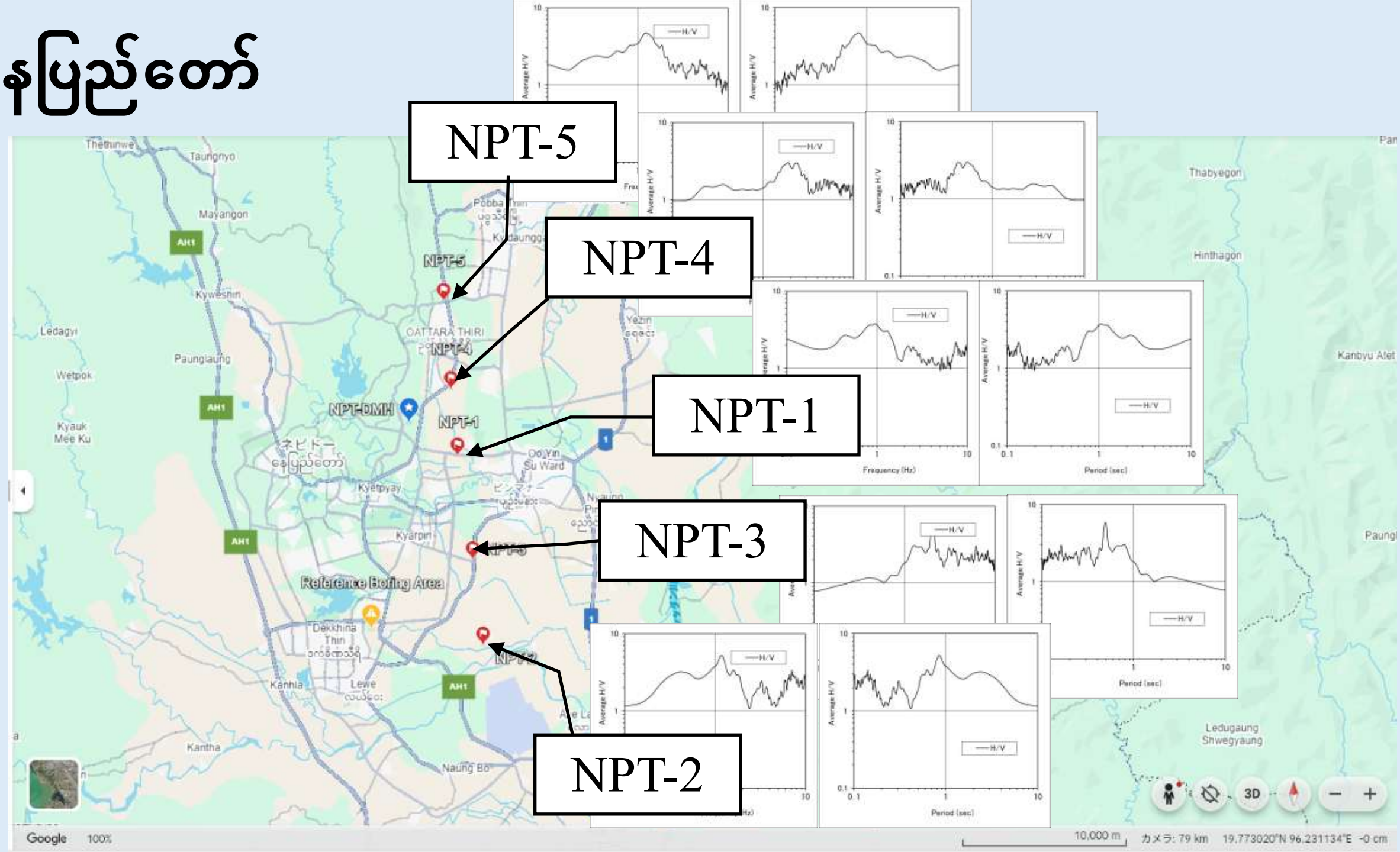
SESAME: **S**ite **E**ffect**S** assessment using **AM**bient **E**xcitations

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





နေပြည်တော်


NPT-5
NPT-4
NPT-1
NPT-3
NPT-2
NPT-5
NPT-4
NPT-DMH
NPT-1
Reference Boring Area
Thethunwe
Taungnyo
Mayangon
Kyweshin
Ledagyi
Paunglaung
Wetpok
Kyauk Mee Ku
Kyetpyay
Kyarpin
Dekkhina Thin
Kanhla
Lewe
Kantha
Naung Bo
Thabyegon
Hinthagon
Kanbyu Atet
Ledugaung
Shwegyaung
AH1
Google
100%
10,000 m
3D

နေပြည်တော်

Location – All

NPT-5

NPT-4

Shallow Deposit

NPT-3

NPT-2

f_0 = 1.2Hz | T_0 = 0.6 ~ 0.8 Second | A_0 = 5.0

f_0 = 1.6 ~ | 3 ~ 3.5

f_0 = 0.9 ~ | 3 ~ 4.0

f_0 = ~ | = ~ 6.0

f_0 = ~ | 4 ~ 6.0

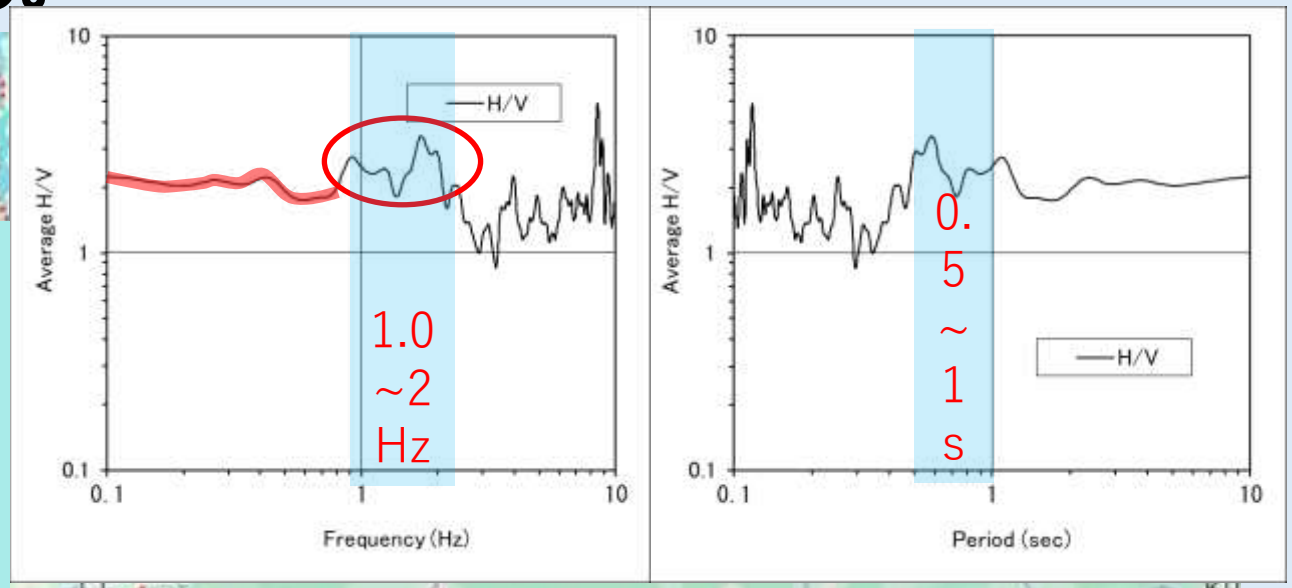
Larger Amplification in South of City.

မန္တလေးတိုင်းဒေသကြီး ဝမ်းတွင်း

Amplification > 2.0 for very low

Frequency Region.

Old buildings were highly affected!!!



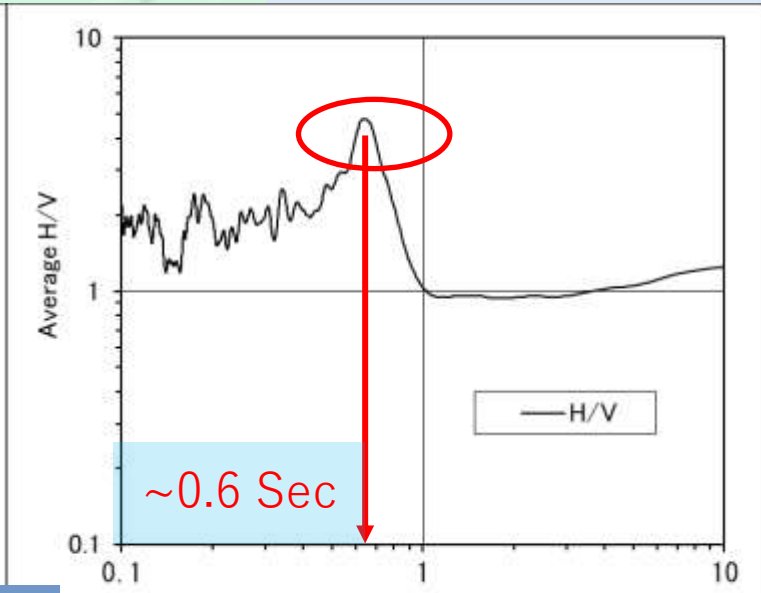
ဝမ်းတွင်းချည်မျှင်စက်ရုံ

ဝမ်းတွင်းရှိဘုန်းတော်ကြီးကျောင်း

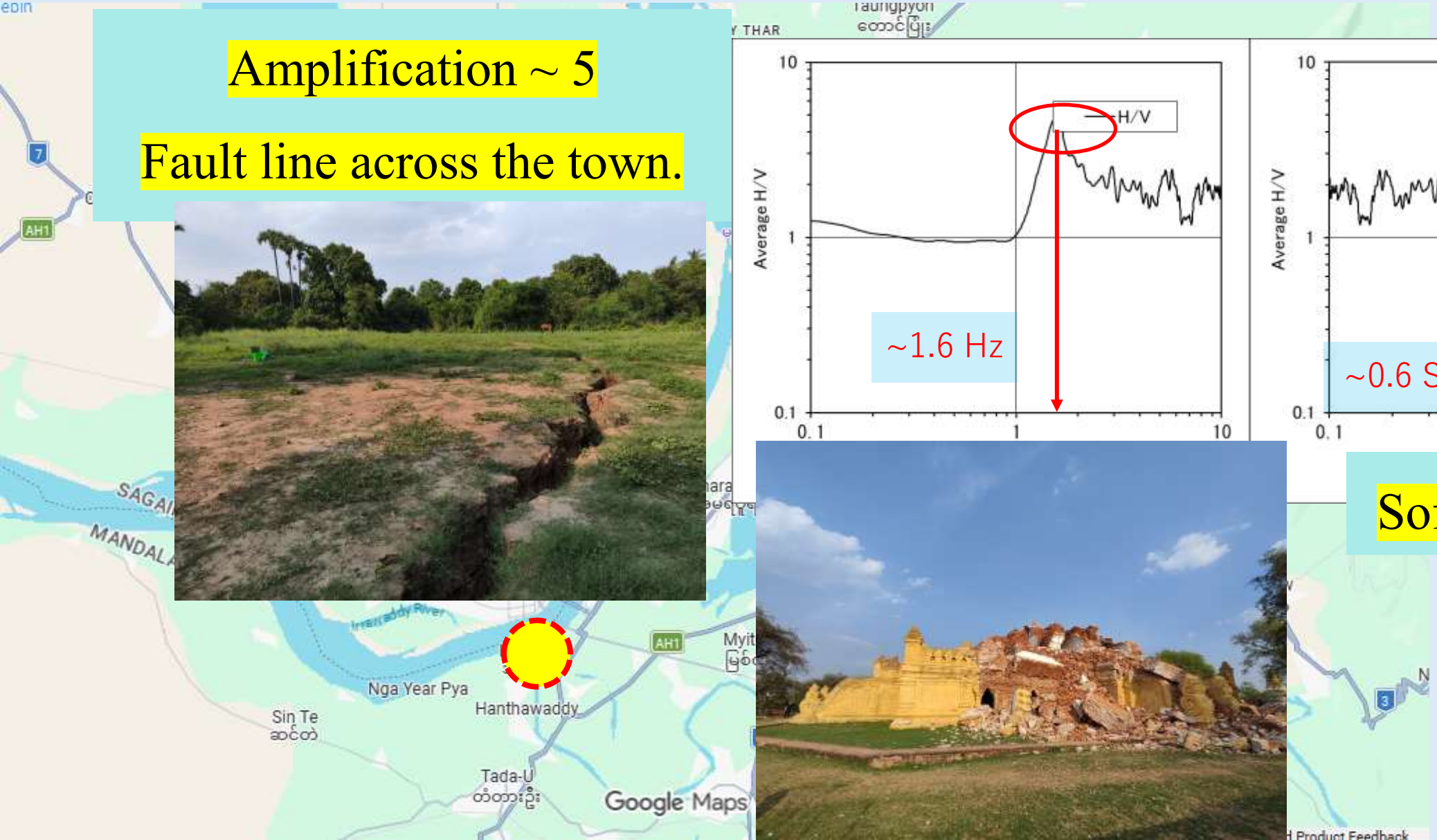
မန္တလေးတိုင်းဒေသကြီး အင်းဝ

Amplification ~ 5

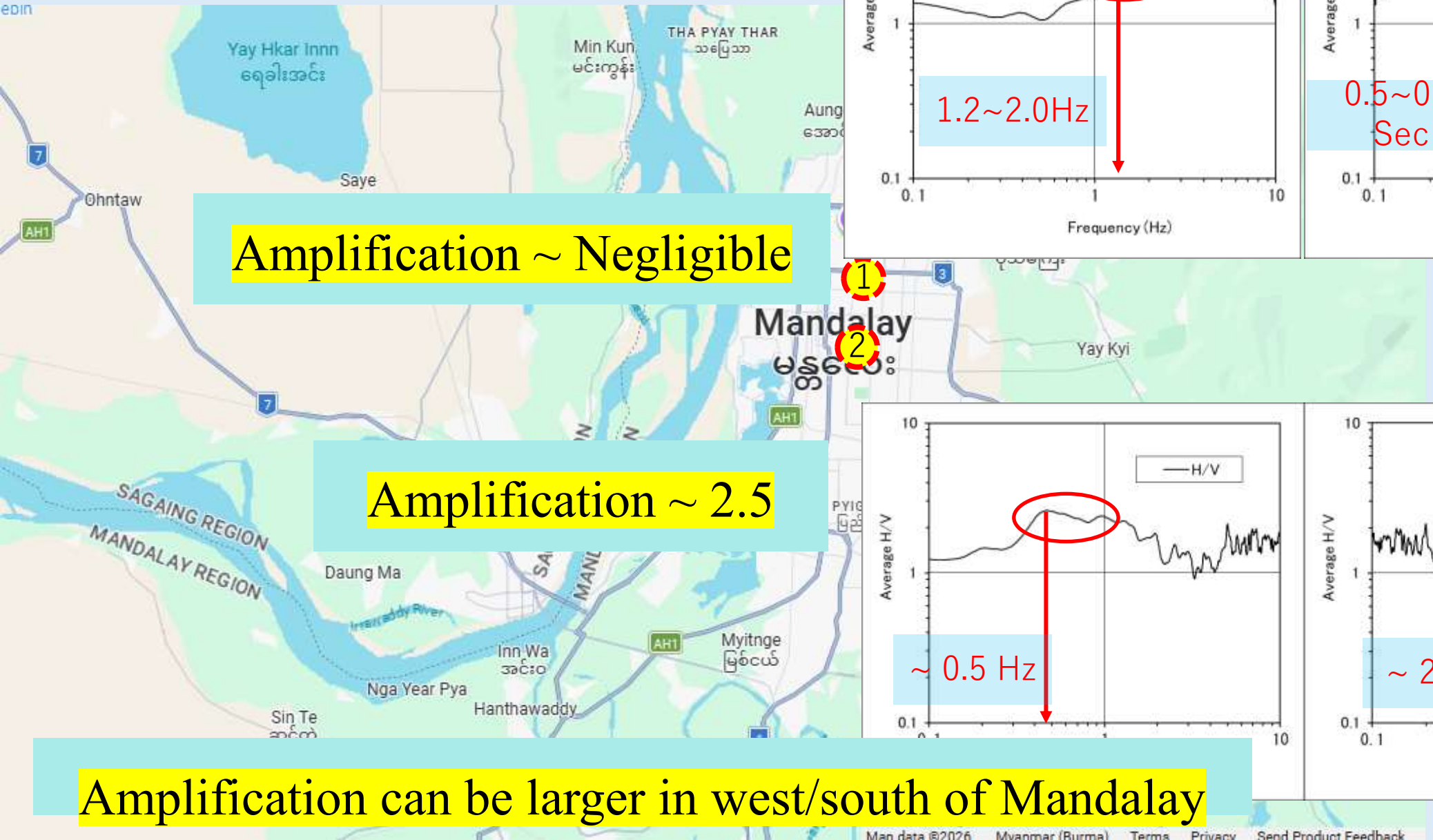
Fault line across the town.



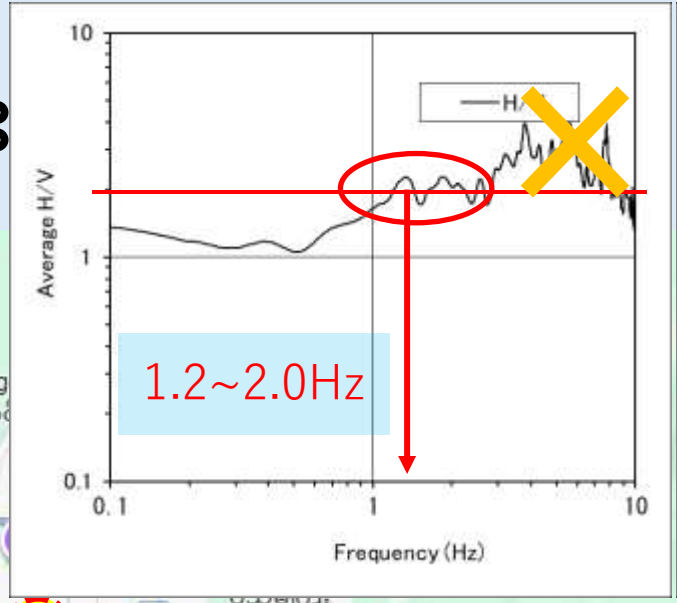
Soft soil deposit

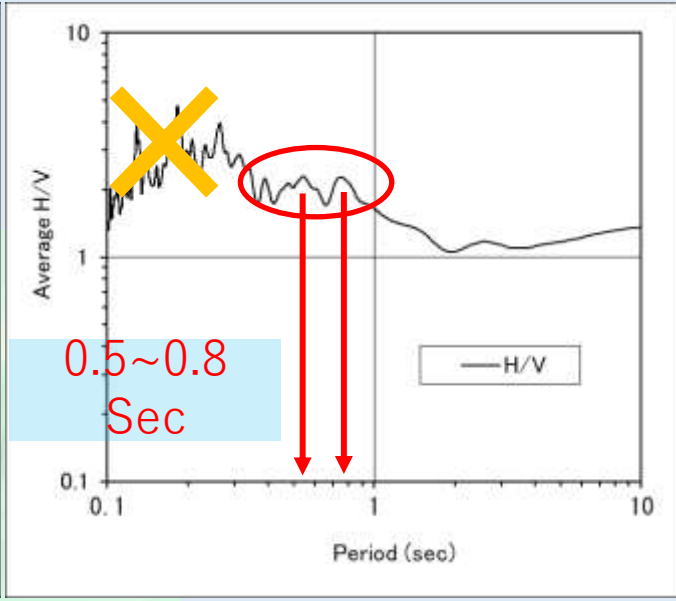


မန္တလေးတိုင်းဒေသကြီး မန္တလေး

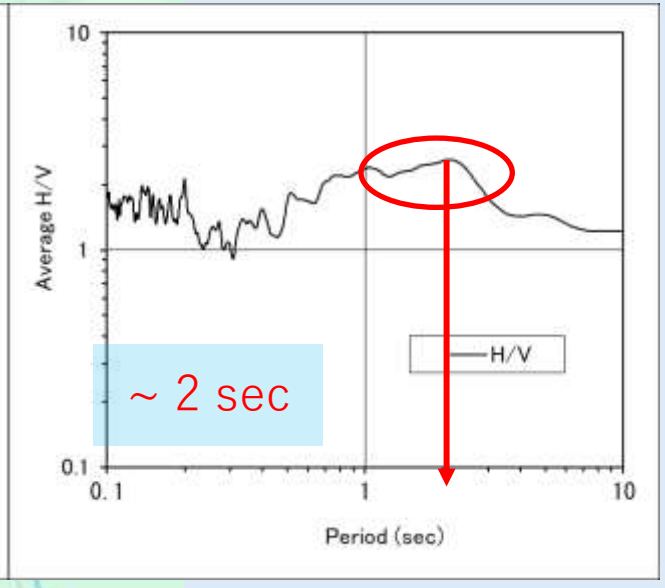


Amplification ~ Negligible





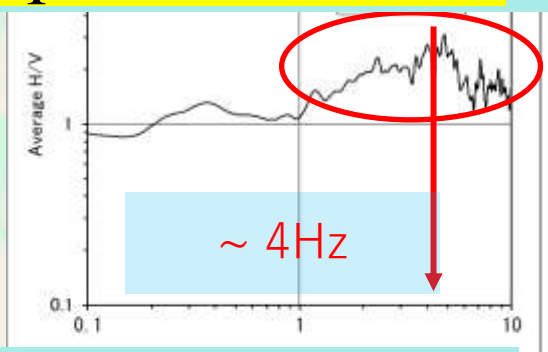
Amplification ~ 2.5

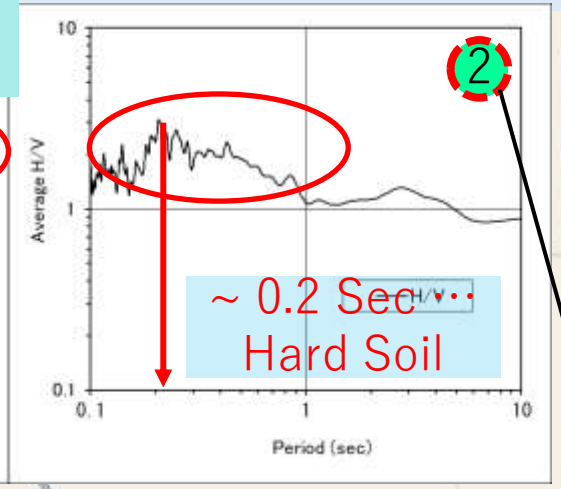


Amplification can be larger in west/south of Mandalay

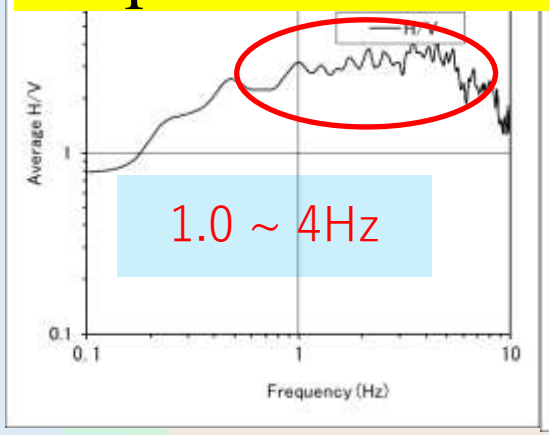
စစ်ကိုင်းတိုင်းဒေသကြီး

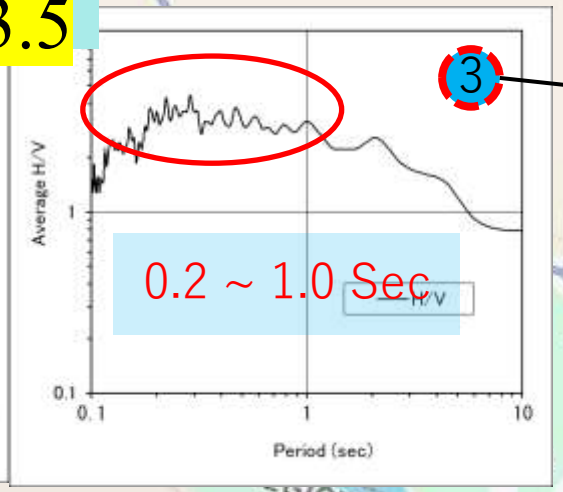
Amplification ~ 3.0

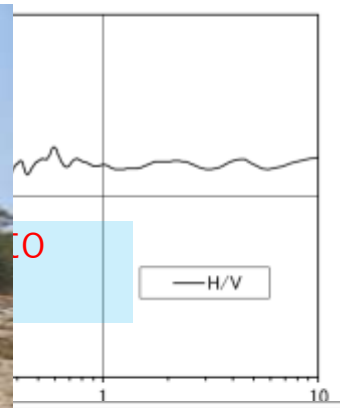


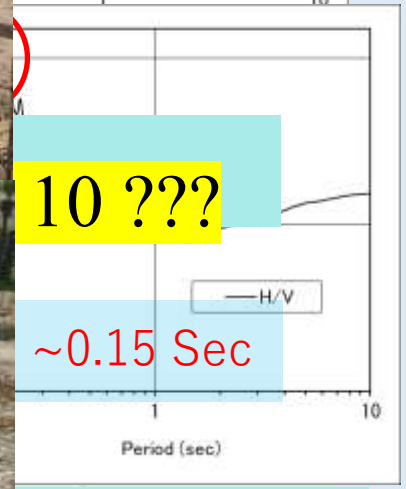


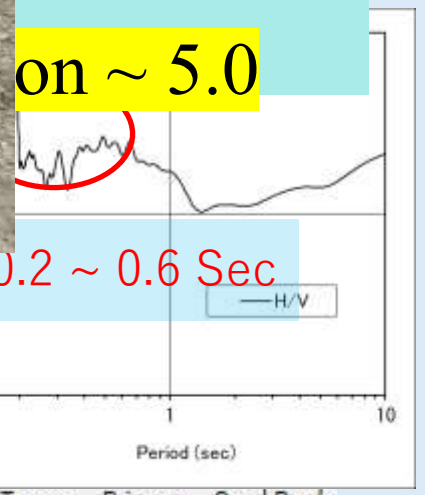
Amplification ~ 3.5

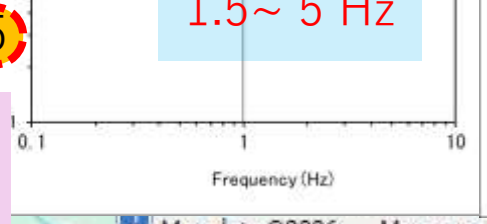












Sagaing
စစ်ကိုင်းမြို့

Inn Wa

Map data ©2026 Myanmar (Burma) Terms Privacy Send Produ

Potentially higher amplification in Southern Part

Key Findings

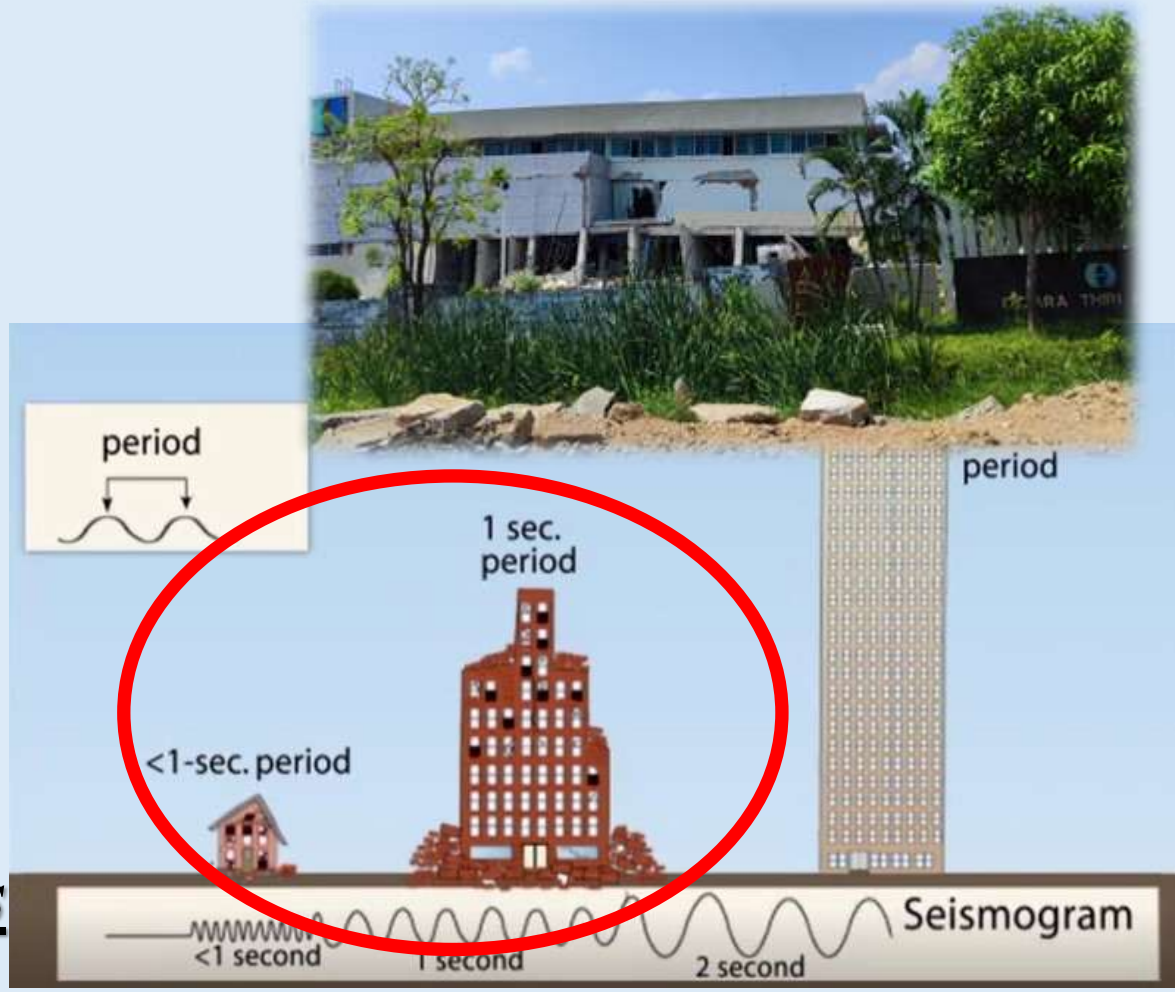
<u>Bago</u> (1 Point @ Phayargyi)

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

Key Findings

<u>Naypyitaw</u> (5 Points)

- Dominant frequency range: ***<u>0.9~2.3 Hz</u>***
- Natural ground period: ***<u>0.4 ~ 2.0 seconds</u>***
- Potential amplification: ***<u>3 ~ 6.0 times</u>***
- Potential amplification for Low to Medium Height Buildings.



Key Findings

<u>Mandalay - Wundwin</u> (1 Point)

- Dominant frequency range: ***<u>1 ~ 2 Hz</u>***
- Natural ground period: ***<u>0.5 ~ 1 seconds</u>***
- Potential amplification: ***<u>~ 2 + times</u>***
- **Insignificant** Potential amplification for Low to Medium Height Buildings.

Key Findings

<u>Mandalay - Innwa</u> (1 Point)

- Dominant frequency range: ***<u>~1.6 Hz</u>***
- Natural ground period: ***<u>~ 0.6 seconds</u>***
- Potential amplification: ***<u>~ 5 times</u>***
- High Potential amplification for Small Buildings.

Key Findings

<u>Mandalay – Mandalay City</u> (2 Points)

- Dominant frequency range: ***<u>0.5 ~ 2.0 Hz</u>***
- Natural ground period: ***<u>0.5 ~ 2.0 seconds</u>***
- Potential amplification: ***<u>~ 2.5 times</u>***
- High Potential amplification for Medium Height Buildings.

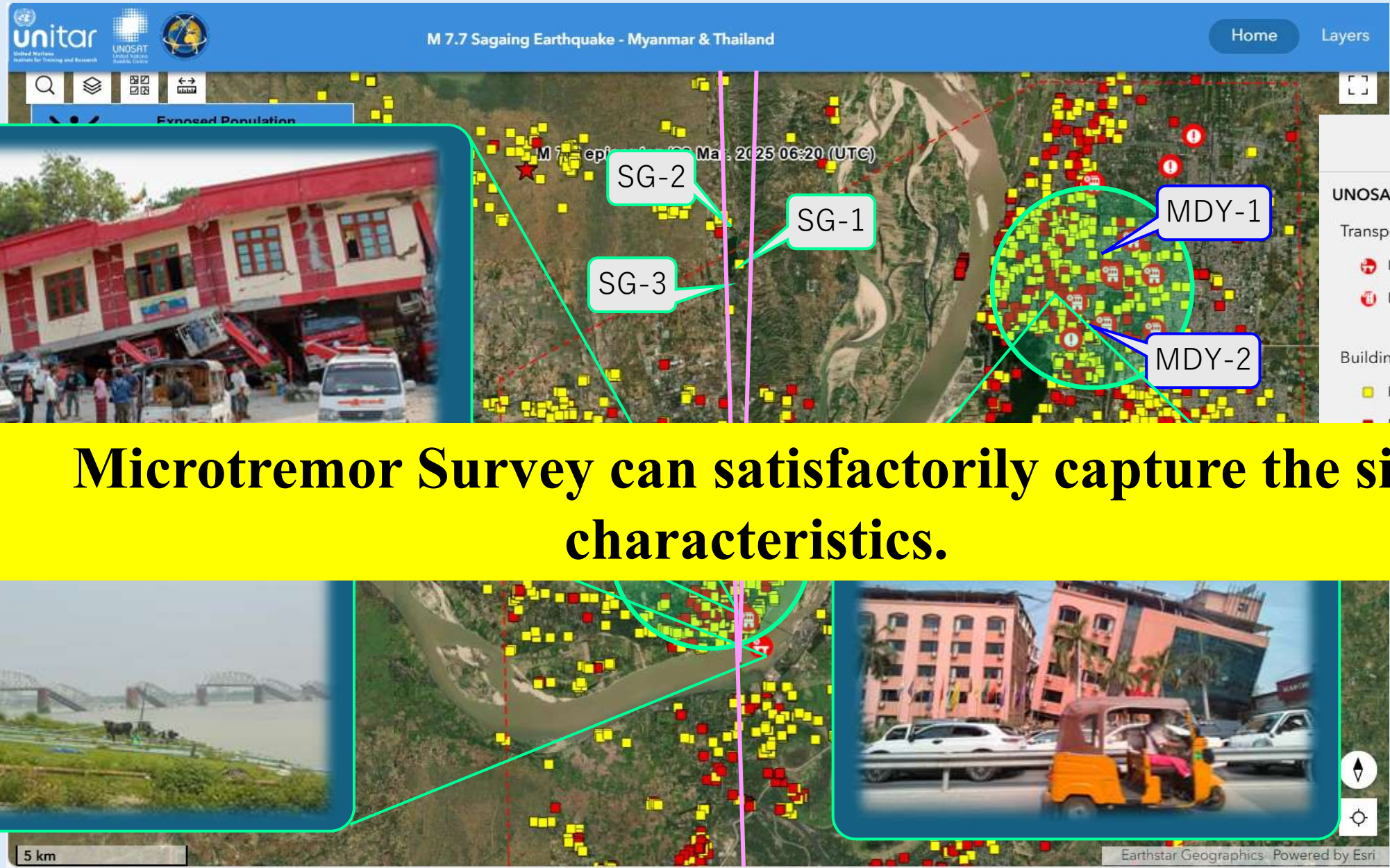
Key Findings

Sagaing (5 Points)

- Dominant f & 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 **The United Nations Satellite Centre (UNOSAT)**



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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