

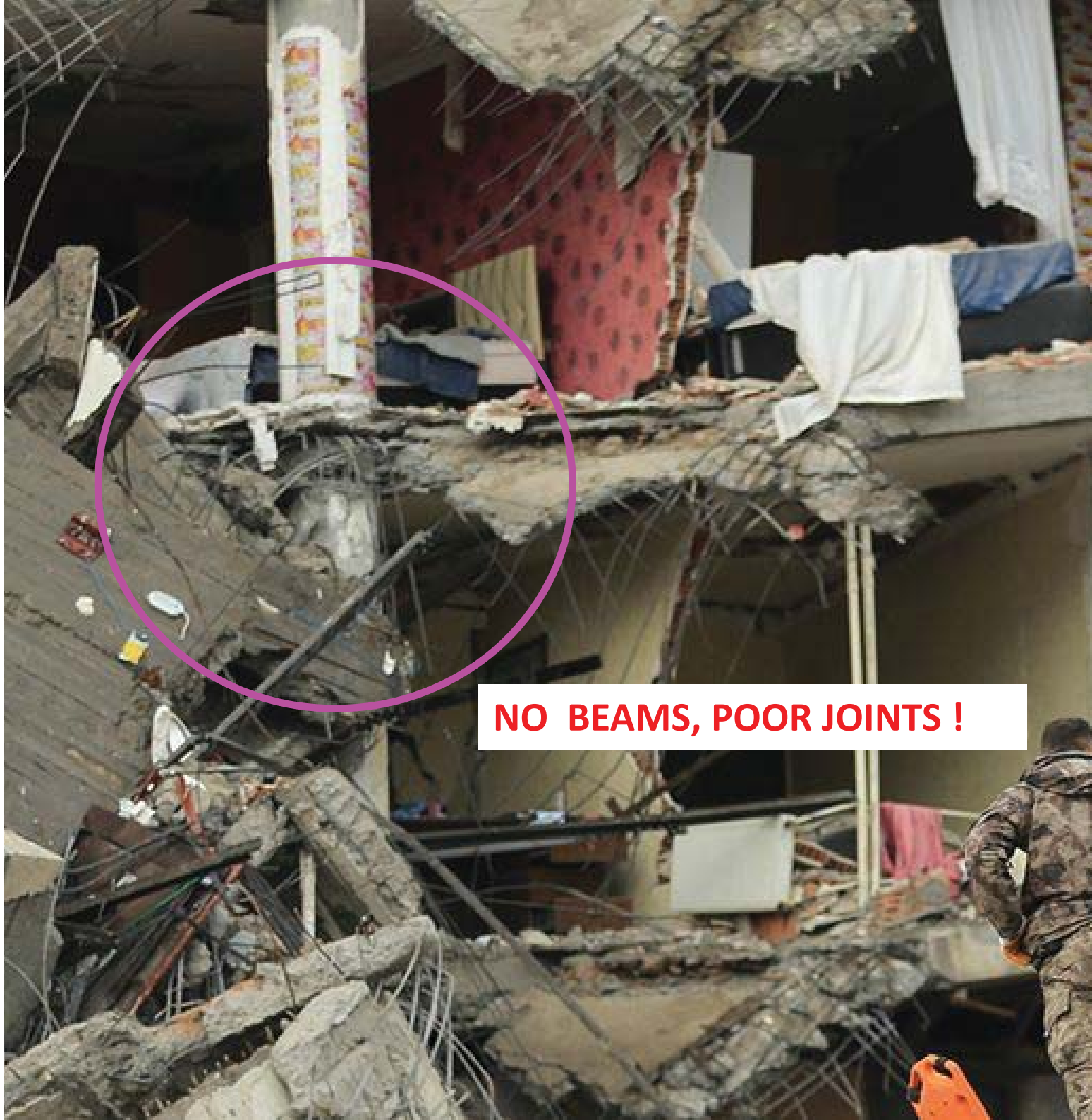


Rescue efforts in Diyarbakir, Turkey (**Aydin Arik/Anadolu Agency/Getty Images**)

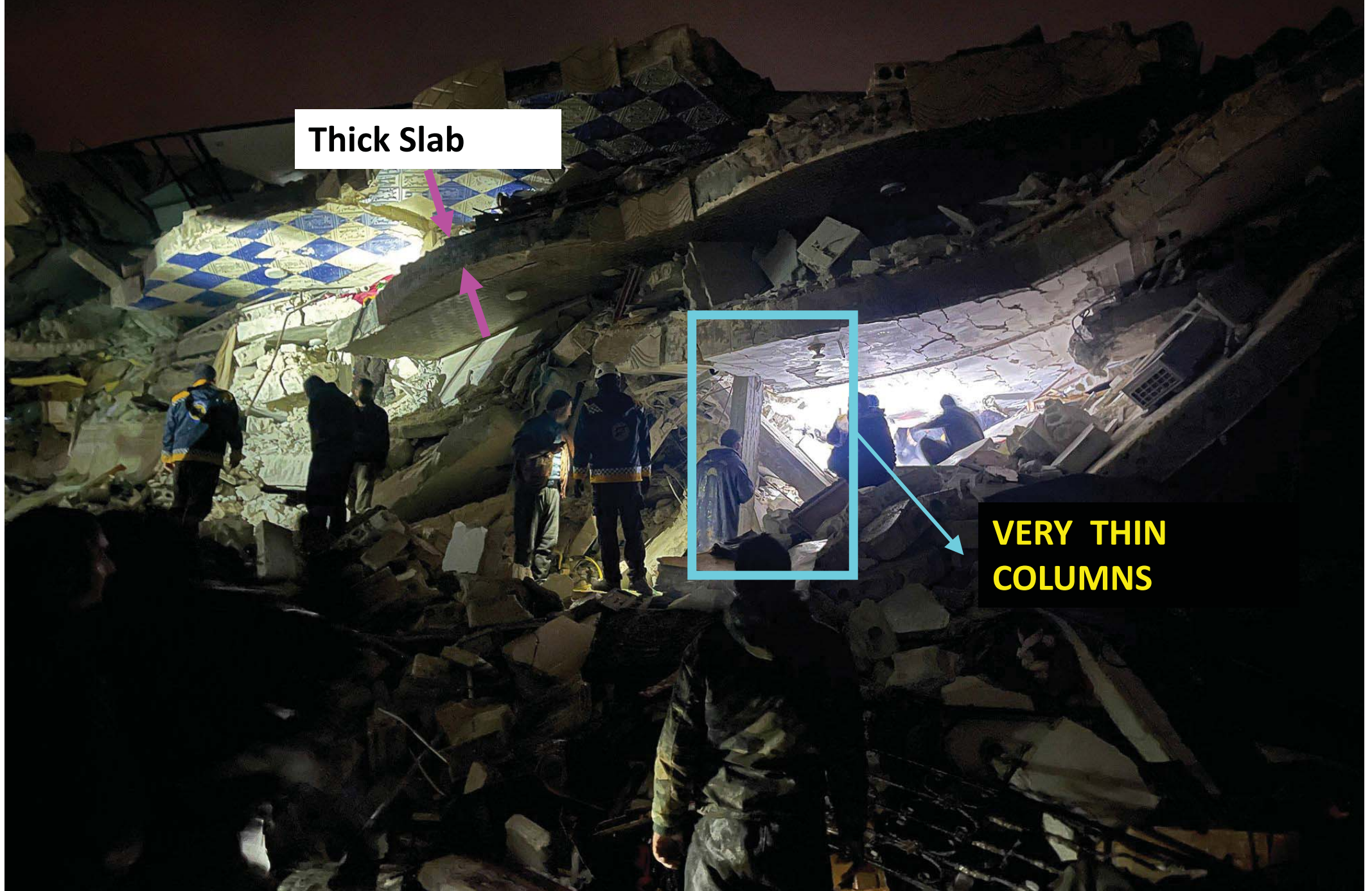
**See next slide for details** 55



**NO BEAMS, POOR JOINTS !**



**NO BEAMS, POOR JOINTS !**



Rubbles of a collapsed building in Idlib, Syria, on February 6. (Aaref Watad/AFP/Getty Images)



Thick SLABS

NO BEAMS, POOR JOINTS !

Source: The New York Times



**NO CONTINUITY OF  
REINFORCEMENT,  
NO ANCHORING OF  
BARS**

Residents retrieve an injured girl from the rubble of a collapsed building following an earthquake in the town of Jandaris.  
AFP via Getty Images



(Photo by Mohammed AL-RIFAI / AFP)

**without any beams, with small size columns (inappropriate even for 1-story buildings in a region of moderate seismicity). It is a miracle that it did not fully collapsed.**



**NO BEAMS,  
VERY THIN COLUMNS**

**See next slide for comparison with a well-designed 2-story building  
in the island of Cephalonia, Greece (Design effective  $A = 0.36$  g)**

## **VISUAL COMPARISON with an UNDER-CONSTRUCTION 2-STORY BUILDING in CEPHALONIA, after two Earthquakes in 2014**



**Large shear walls, strong beams, brick masonry well-confined (with RC ties around openings and at mid-height).**

*(See Garini et al, 2017)*



See next slide for details

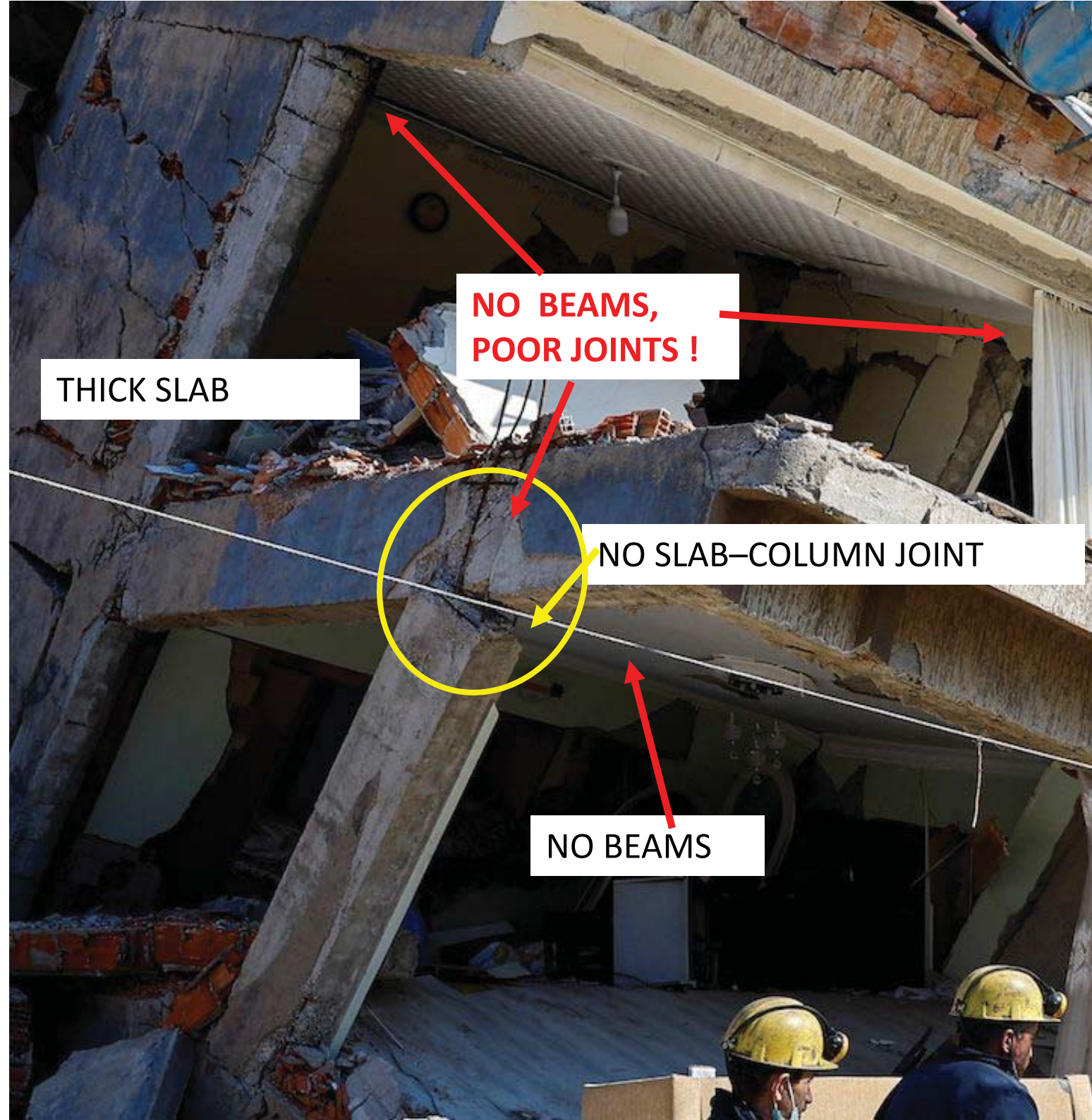
A woman sits on the rubble of a destroyed building in Nurdagi town on the outskirts of Osmaniye city southern Turkey, Tuesday, Feb. 7, 2023. **(AP Photo/Khalil Hamra)**



**VERY FEW REBARS OF VERY SMALL DIAMETER**



Photo: SUHAIB SALEM  
Credit: REUTERS



NO BEAMS,  
POOR JOINTS !

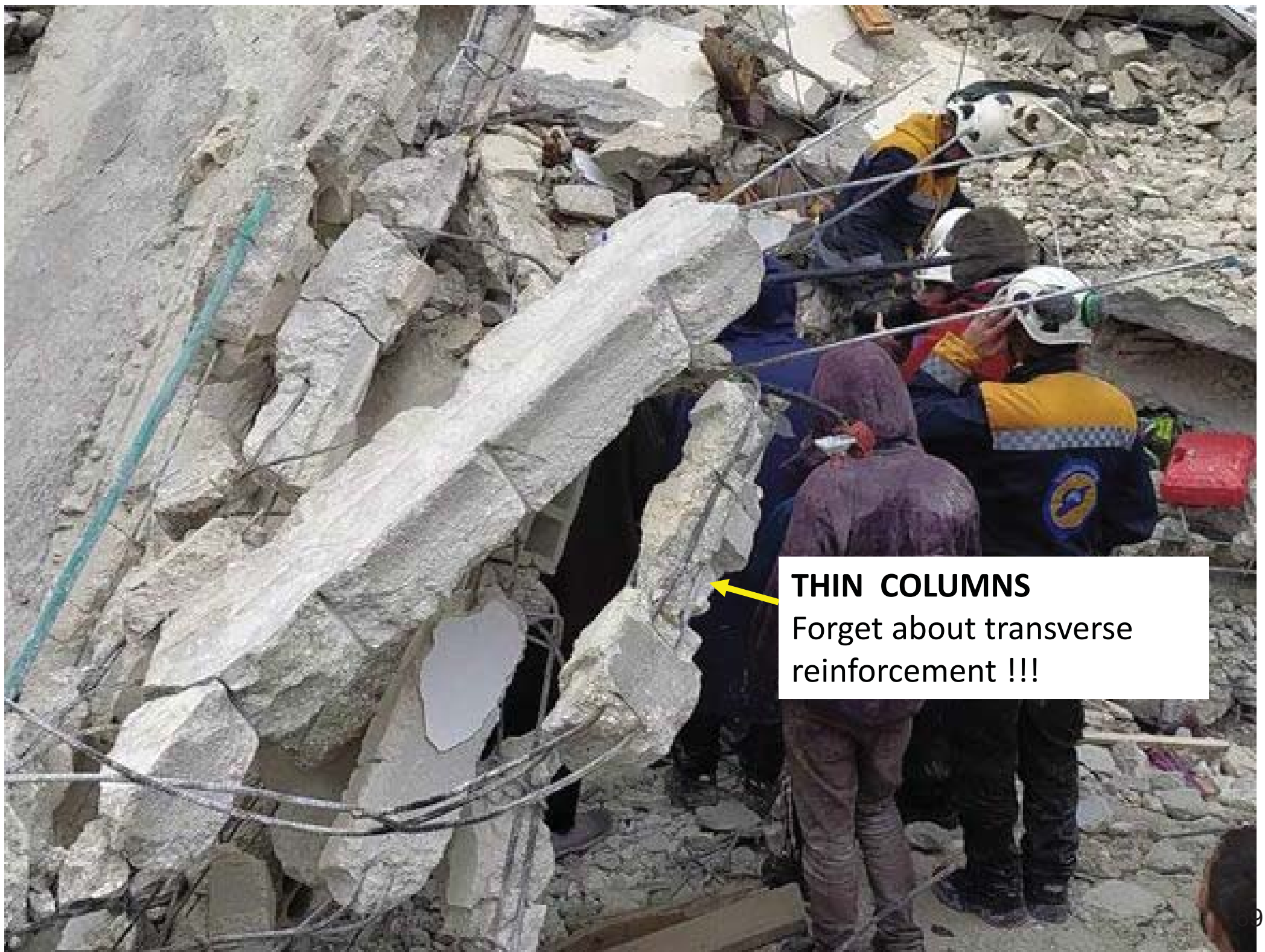
THICK SLAB

NO SLAB-COLUMN JOINT

NO BEAMS



<https://www.worldvision.org.uk/about/blogs/whats-happening-in-turkey-and-syria/>



## THIN COLUMNS

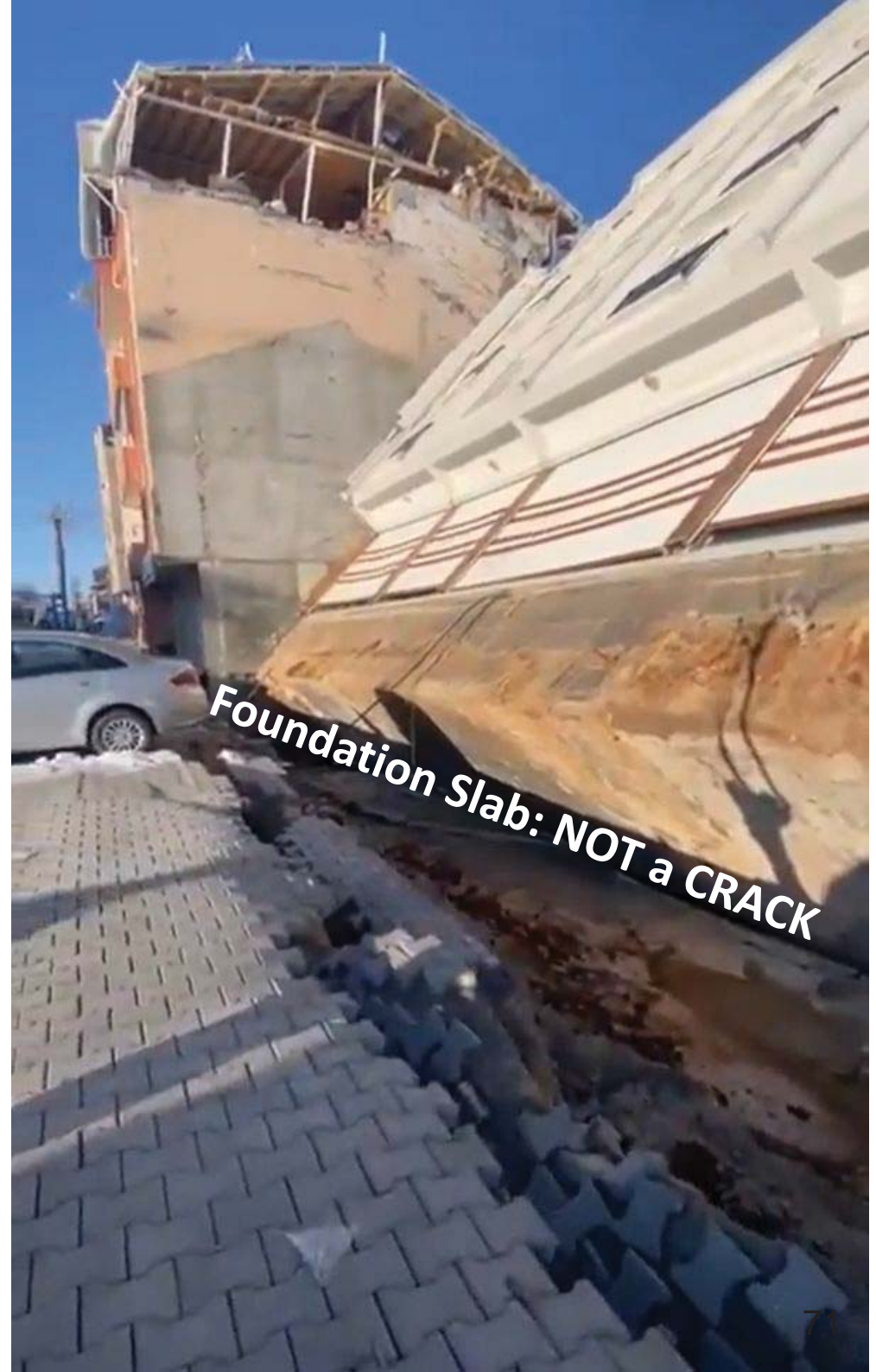
Forget about transverse reinforcement !!!

## **Finally, a purely GEOTECHNICAL Failure :**

**Overturning of a building apparently due to bearing-capacity failure on soft soil (perhaps with a high water table) under strong seismic moment. No evident damage in the structure. The glass windows remain unscathed ! Similarly intact appears to be the foundation slab.**

**This is reminiscent of ADAPAZARI in the 1999 Kocaeli (Izmit) Earthquake !!!**

Structure seems intact.  
Glass windows: unbroken



Foundation Slab: NOT a CRACK

# Some critical reasons for the collapse of a huge number of buildings

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**EXTREMELY STRONG GROUND SHAKING, PERHAPS LOCALLY SOIL-AMPLIFIED (see Part B)**

**DEFFECTIVE STRUCTURAL SYSTEMS WITH SEVERAL FATAL TECHNICAL FAULTS, as follows:**

- 1. Very thin columns, but rather thick slabs**
- 2. Very inadequate steel reinforcement (in size and number of longitudinal bars)**
- 3. Transverse reinforcing bars of inadequate density and improperly tied)**
- 4. NO beams !! Slabs directly on columns, without continuity of Rebars, and no proper connection**
- 5. Nowhere to be seen Shear Walls, even in > 10 story buildings**

## Our SOURCES

- 1) <https://en.armradio.am>
- 2) [www.worldvision.org.uk](http://www.worldvision.org.uk)
- 3) **Associated Press**: Ghaith Alsayed via AP, Ahmet Akpolat/DIA, Khalil Hamra
- 4) **Reuters**: Umit Bektas, Mahmoud Hassano, Suhaib Salem, WHITE HELMETS
- 5) **Getty Images**: Mohammed Al-Rifai/AFP, Anas Alkharboutli, Aydin Arik/Anadolu Agency, Aaref Watad/AFP, AFP via Getty Images,
- 6) <https://kazibaonline.com>
- 7) The New York Times: <https://www.nytimes.com/>
- 8) <https://en.as.com>
- 9) **Shutterstock**: Ymphotos/Shutterstock
- 10) <https://www.rescue.org>
- 11) USGS website: [www.usgs.gov](http://www.usgs.gov)
- 12) **Twitter**: @PAOK\_FC, The\_Georgios
- 13) Garini E., Gazetas G., and Anastasopoulos I. (2017) "**Evidence of Significant Forward Rupture Directivity Aggravated by Soil Response in an  $M_w$ 6 Earthquake, and the Effect on Monuments "**, *Earthquake Engineering & Structural Dynamics*, 46: 2103–2120.

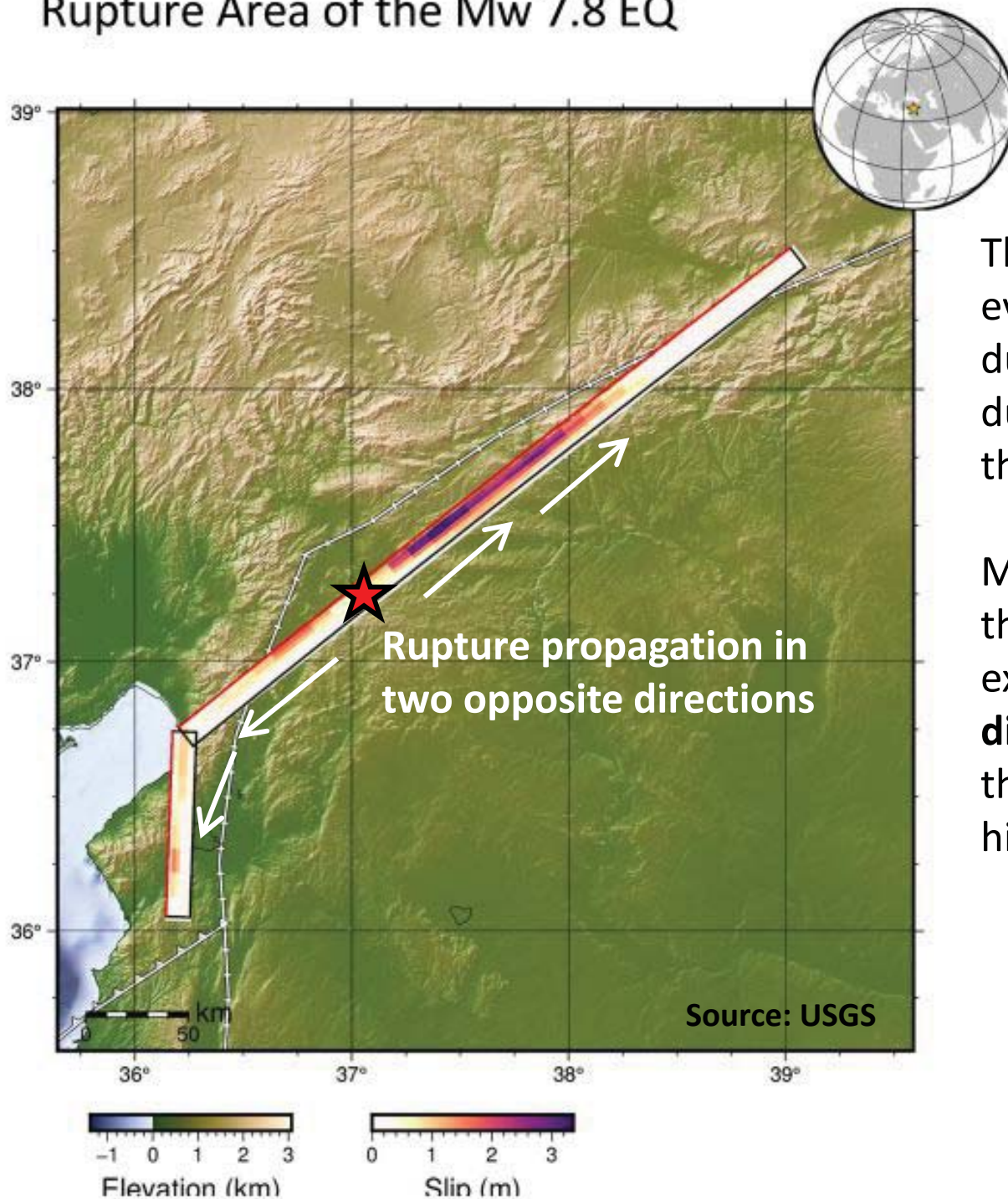
## PART C

### **Recorded Accelerograms and their Response Spectra**

Disclaimer: The data utilised are taken from the AFAD website, as they are published on 10 February 2023. Mistakes on baseline corrections or other issues are noticed by the Authors but are not solved here.

*We are thankful to our Turkish colleagues for the immediate and open publishing of the huge number of accelerograms.*

## Rupture Area of the Mw 7.8 EQ



The recorded motions of this M7.8 event are of relatively limited duration (for such a huge magnitude) due to the **bilateral propagation** of the fault rupture.

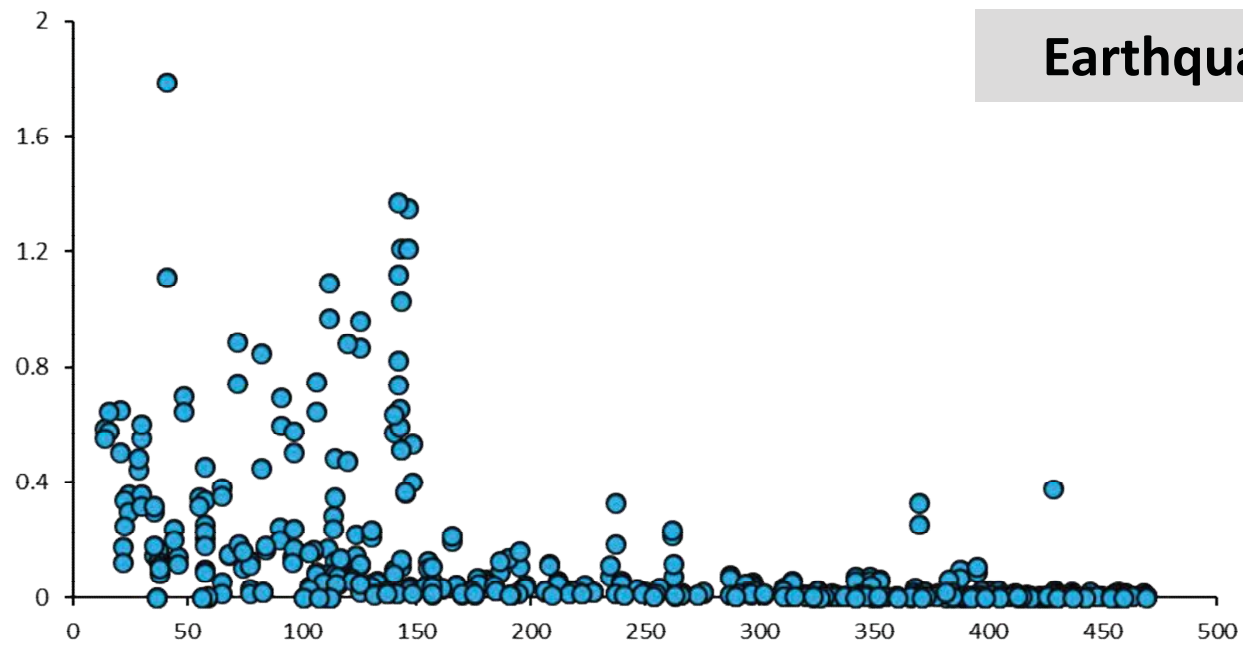
Moreover, in the **southern part** (in the region of Antakya) the records exhibit strong **forward-rupture directivity effects** as you can see in the acceleration and velocity time histories.

## Records from the M<sub>w</sub>7.8 event with **PGA > 0.5 g**

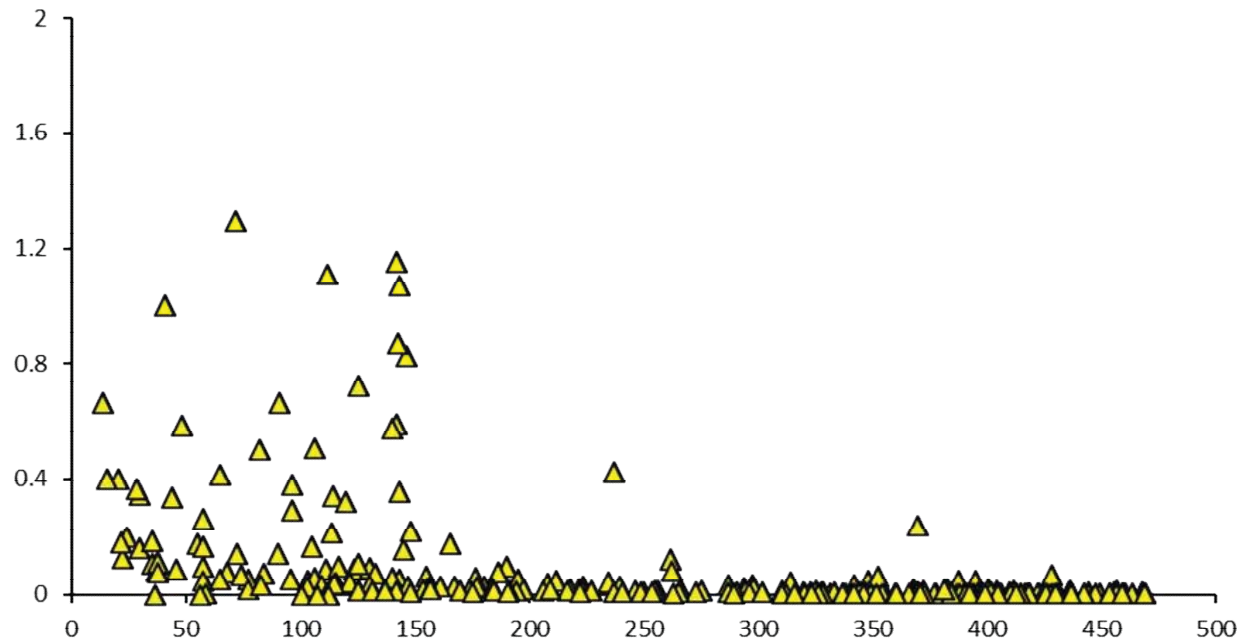
Code	R <sub>epi</sub> [km]	PGA <sub>NS</sub> [g]	PGA <sub>EW</sub> [g]	PGA <sub>UD</sub> [g]
2708	41	1.788	1.110	1.003
3129	146	1.353	1.210	0.826
3126	144	1.211	1.030	1.071
3117	112	0.969	1.093	1.111
3141	125	0.961	0.869	0.723
3138	72	0.889	0.747	1.296
3125	142	0.823	1.122	1.152
3135	142	0.741	1.372	0.589
2718	48	0.702	0.645	0.586
3123	143	0.656	0.594	0.868
4616	21	0.653	0.503	0.397
3142	106	0.647	0.750	0.506
NAR	15	0.647	0.579	0.399
3145	91	0.600	0.696	0.663
4615	14	0.588	0.556	0.665
3139	96	0.577	0.505	0.379
3124	140	0.573	0.638	0.578
2712	30	0.555	0.603	0.346
3136	148	0.534	0.402	0.220
3132	143	0.515	0.515	0.354
201	120	0.474	0.880	0.319
3137	82	0.453	0.848	0.502

## Earthquake $M_w 7.8$

$PGA_{HORIZONTAL} : g$



$PGA_{VERTICAL} : g$



Epicentral Distance : km

# Earthquake $M_w 7.8$

Station 2708:

at **Gaziantep** city, İslahiye District

Station at **Free field**,  $V_{s30} = 523$  m/s (EC8 Type B)

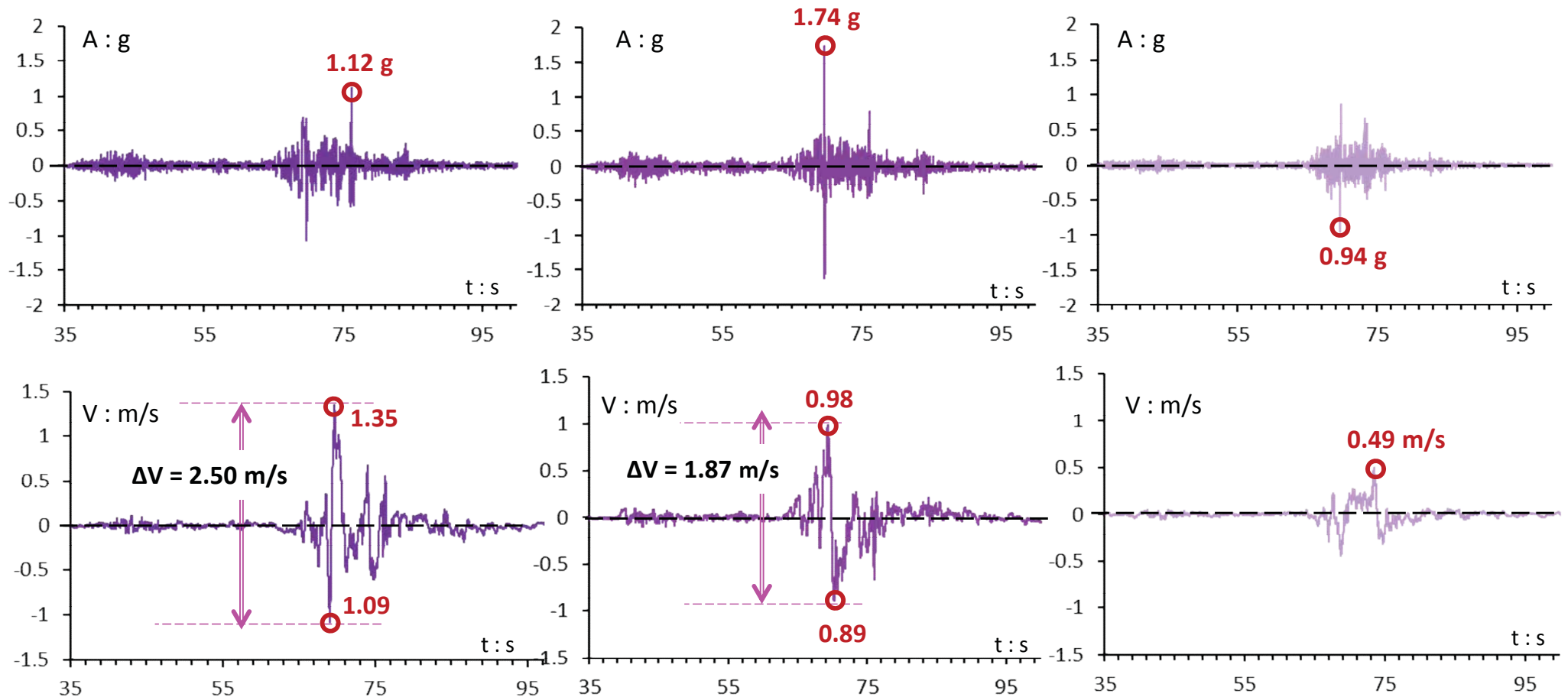
Exact Location: 36.648373 (Long.) 37.09933 (Lat.)



Horizontal EW  
component

Horizontal NS  
component

Vertical  
component

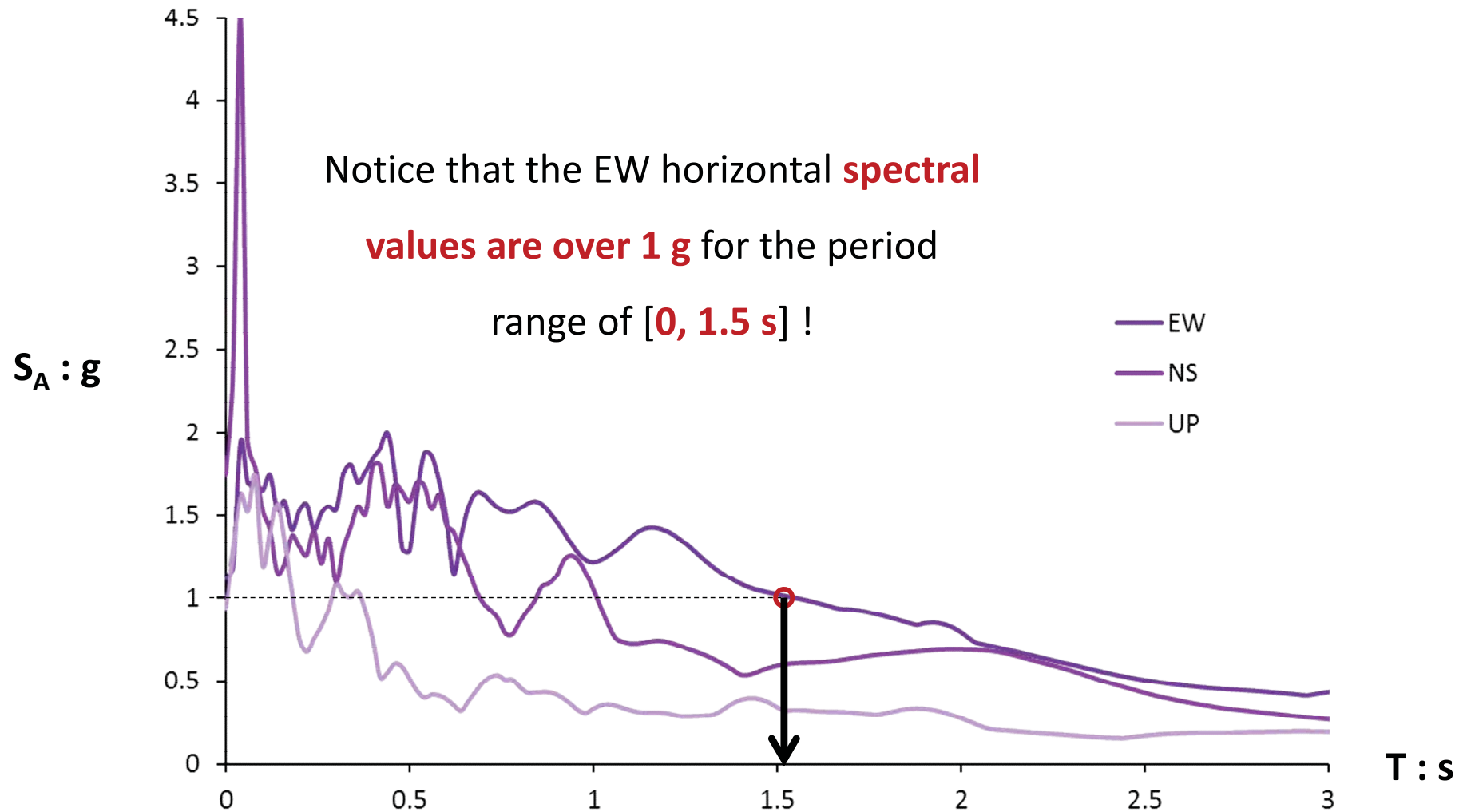


# Earthquake $M_w 7.8$

Station 2708: at **Gaziantep** city, İslahiye District

Station at **Free field**,  $V_{s30} = 523 \text{ m/s}$  (EC8 Type B)

Exact Location: 36.648373 (Long.) 37.09933 (Lat.)



# Earthquake $M_w 7.8$

Station 2718: at **Gaziantep** city, İslahiye District

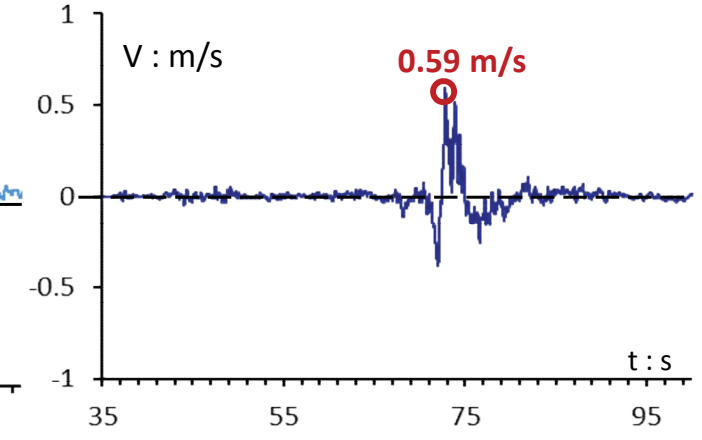
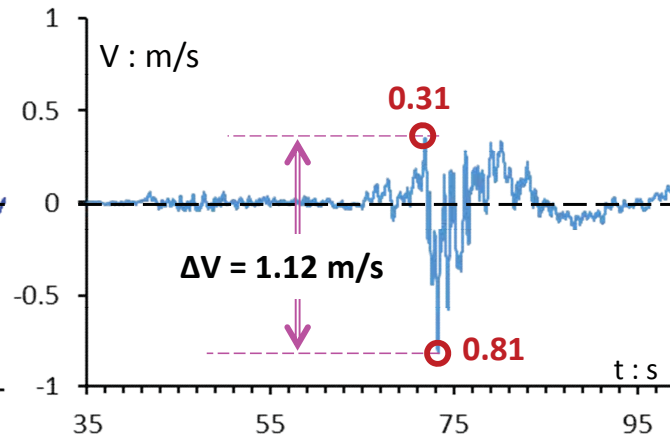
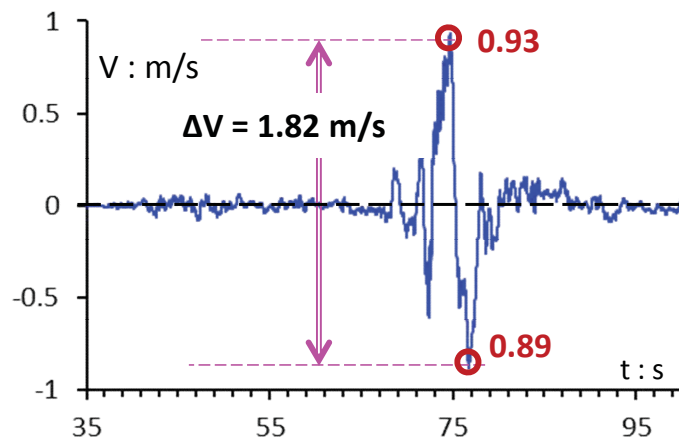
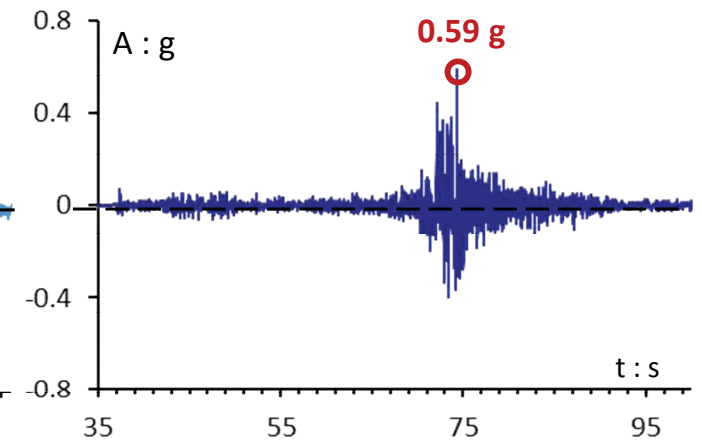
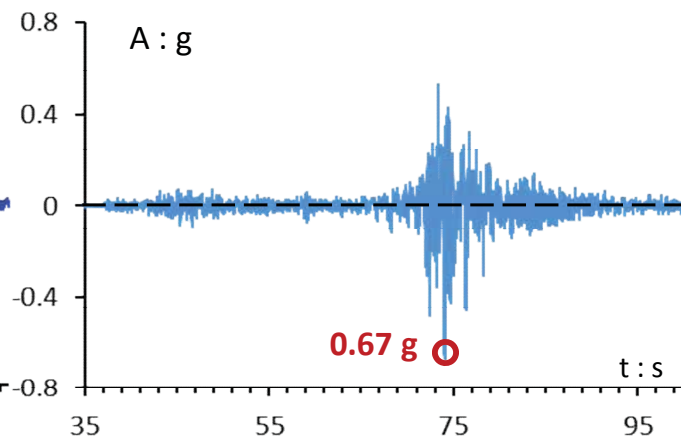
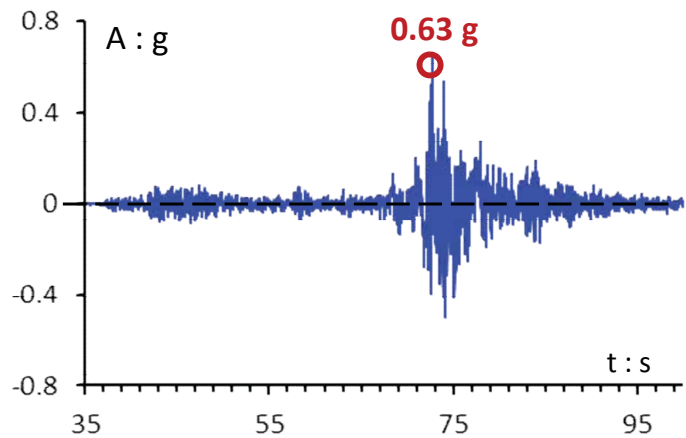
NO soil data available

Exact Location: 36.6266 (Long.) 37.00777 (Lat.)

Horizontal EW  
component

Horizontal NS  
component

Vertical  
component

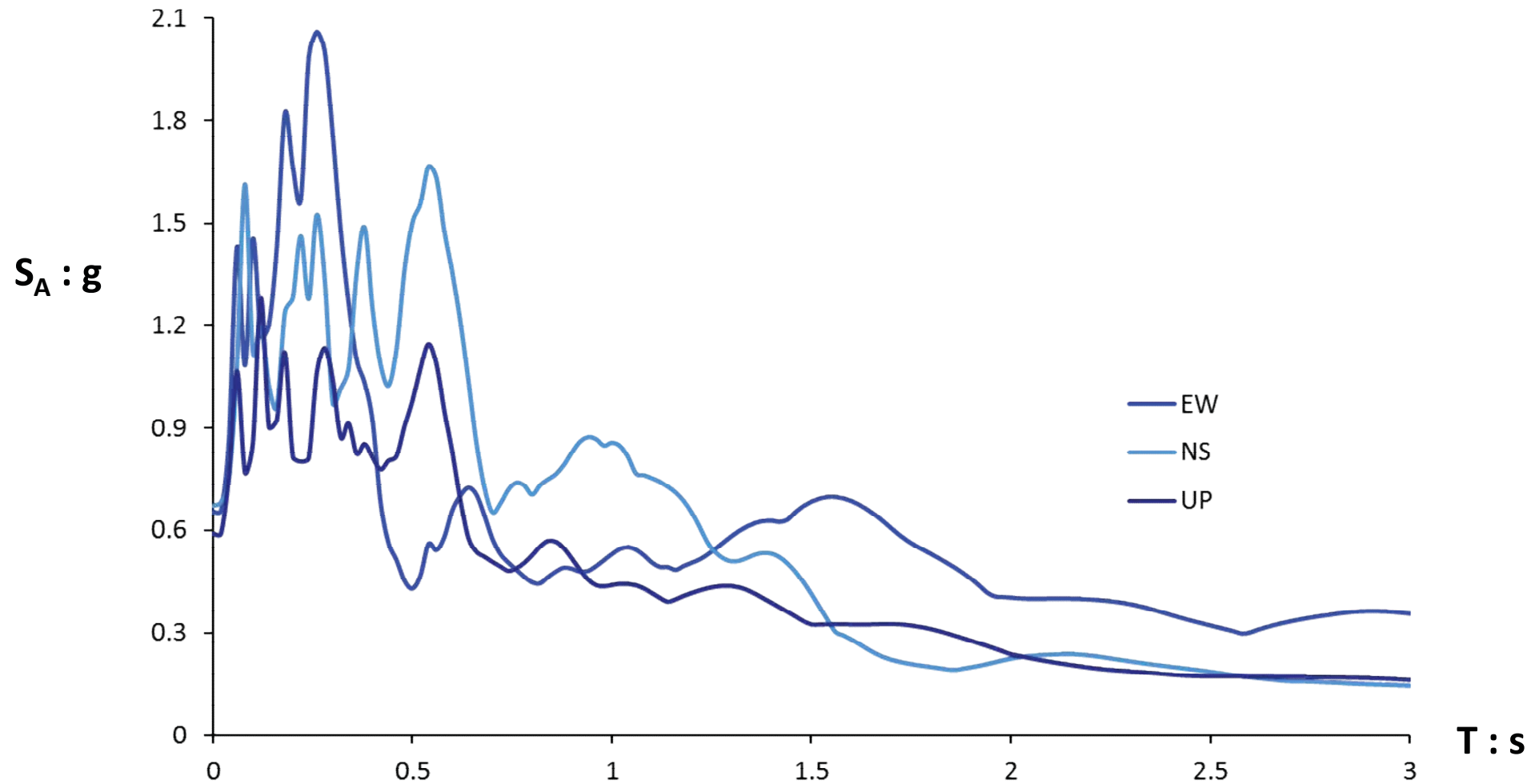


# Earthquake $M_w 7.8$

Station 2718: at **Gaziantep** city, İslahiye District

NO soil data available

Exact Location: 36.6266 (Long.) 37.00777 (Lat.)



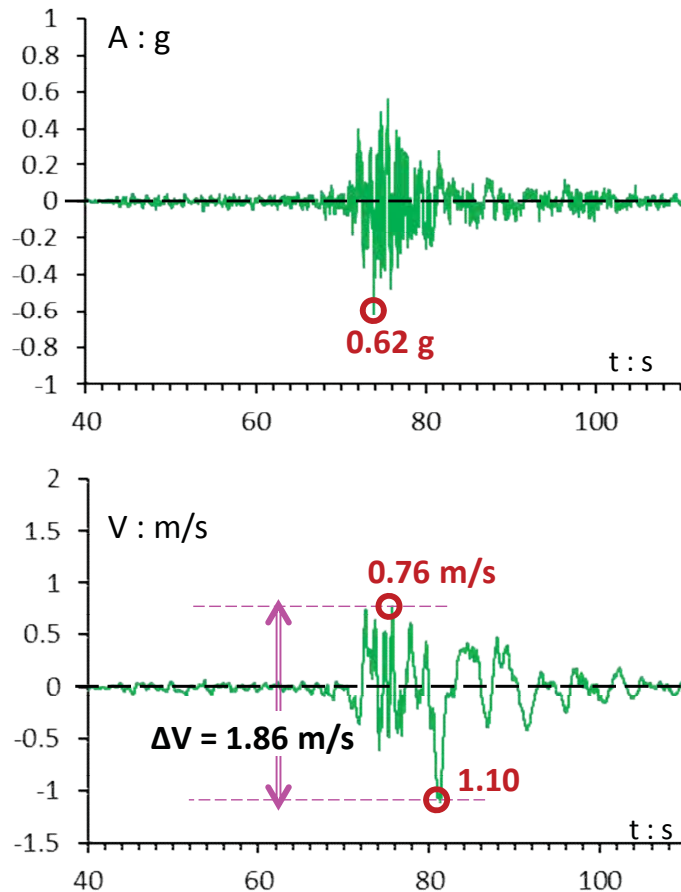
# Earthquake $M_w 7.8$

Station 3123: at **Hatay** city, Antakya District

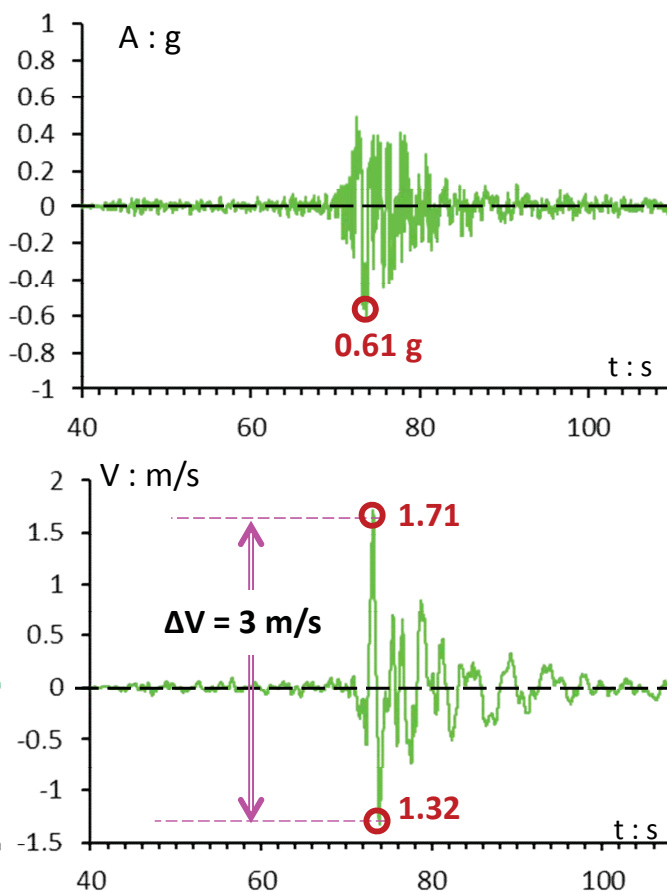
Station at **Free field**,  $V_{s30} = 470$  m/s (EC8 Type B)

Exact Location: 36.15973 (Long.) 36.21423 (Lat.)

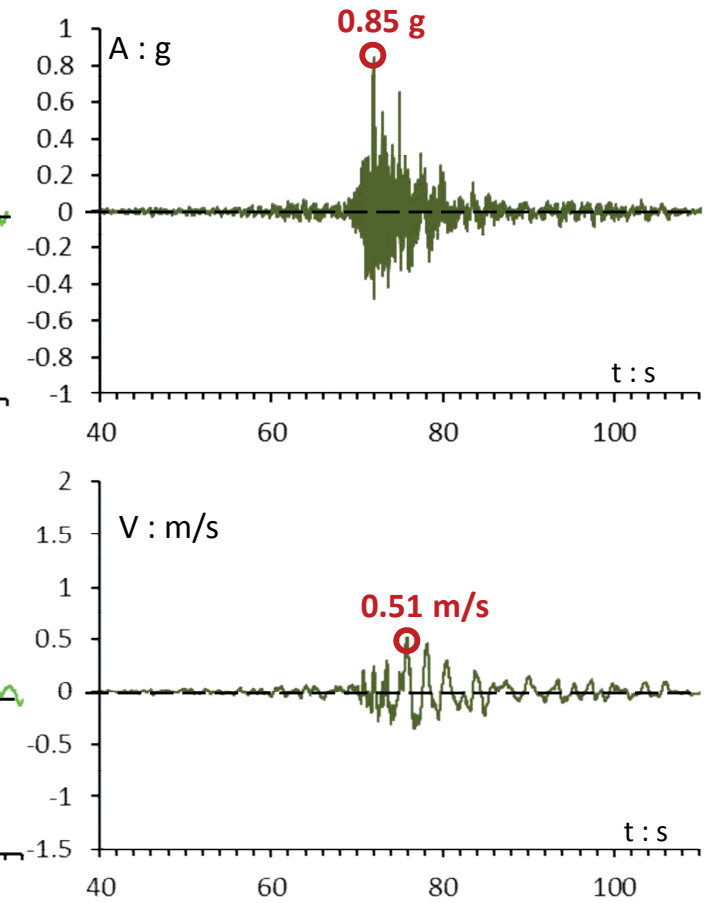
Horizontal EW  
component



Horizontal NS  
component



Vertical  
component

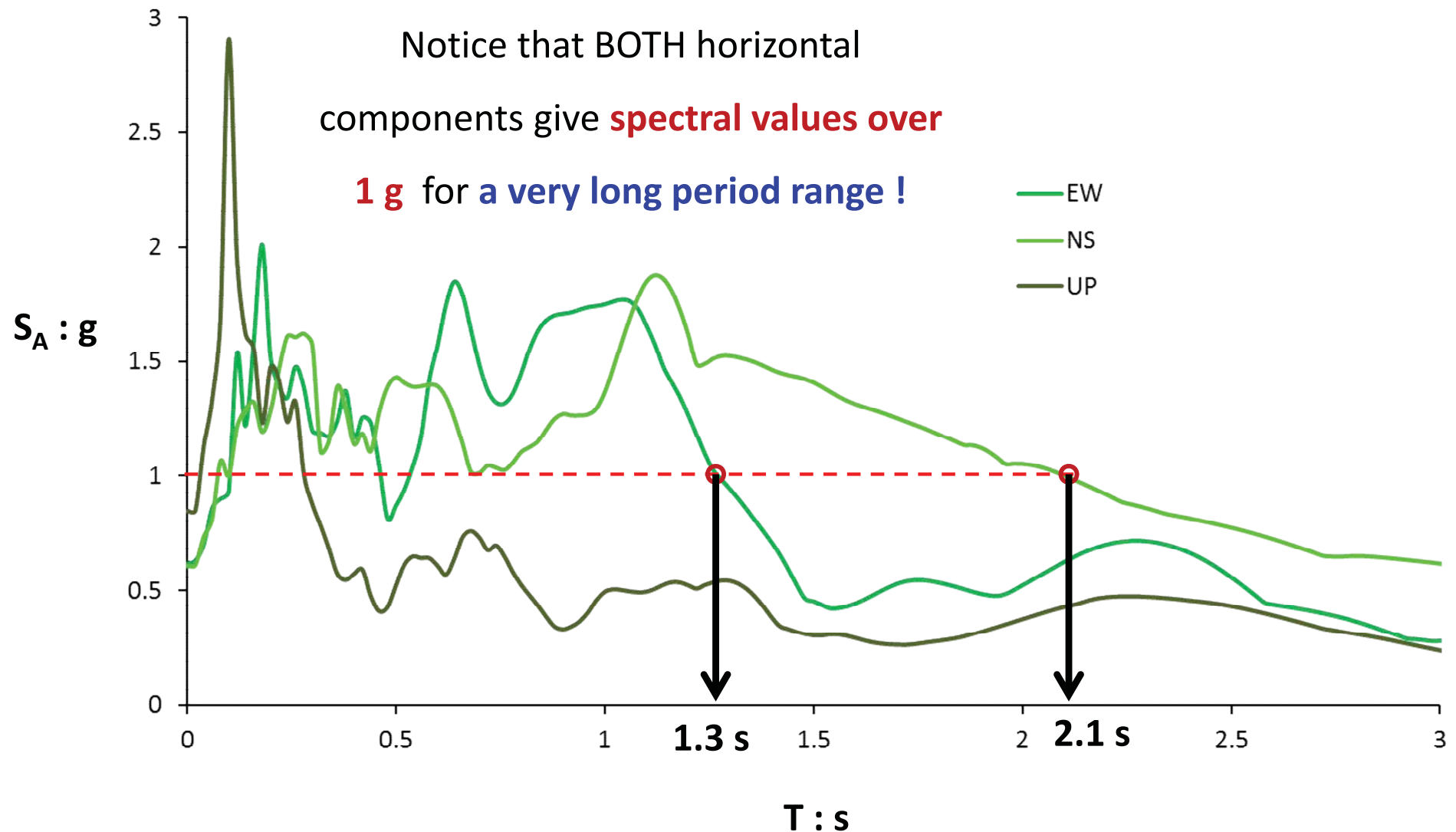


# Earthquake $M_w 7.8$

Station 3123: at **Hatay** city, Antakya District

Station at **Free field**,  $V_{s30} = 470 \text{ m/s}$  (EC8 Type B)

Exact Location: 36.15973 (Long.) 36.21423 (Lat.)



# Earthquake $M_w 7.8$

Station 3125:

at **Hatay** city, Antakya District

Station at **Free field**,  $V_{s30} = 448 \text{ m/s}$  (EC8 Type B)

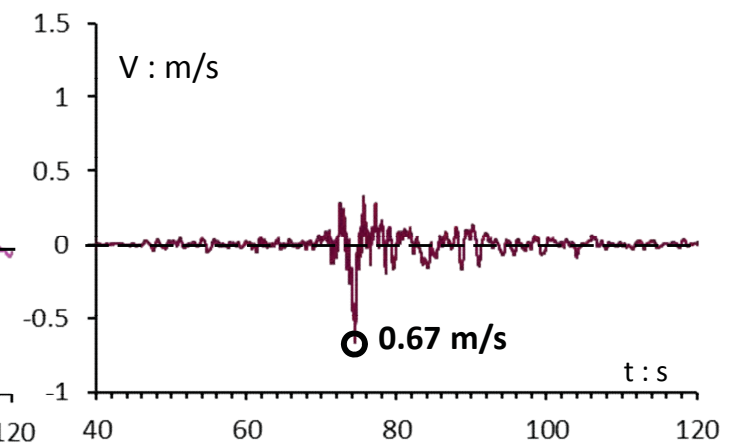
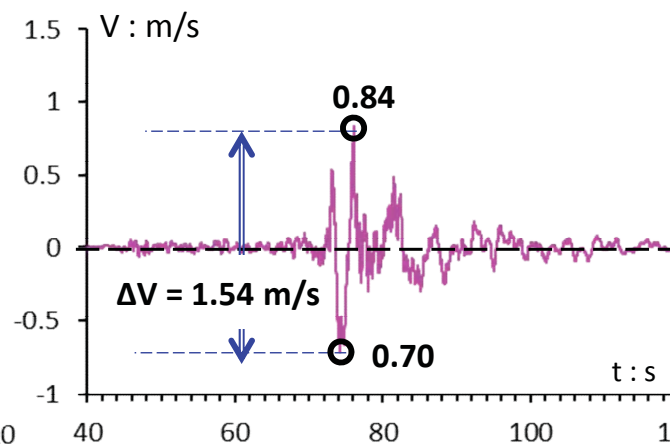
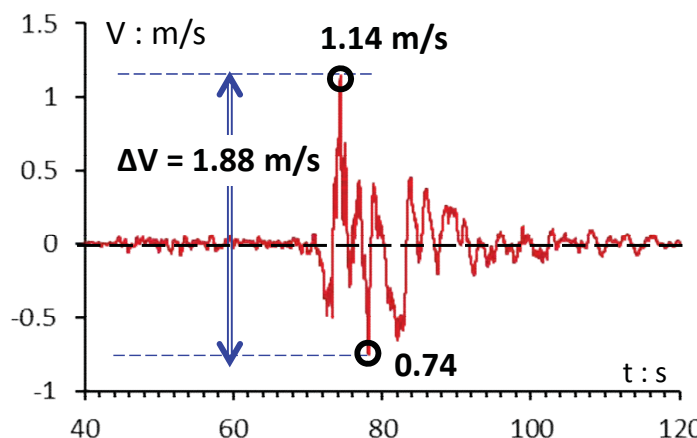
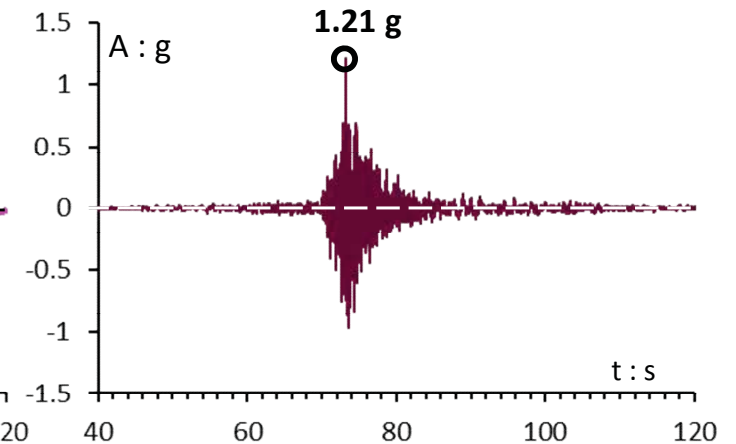
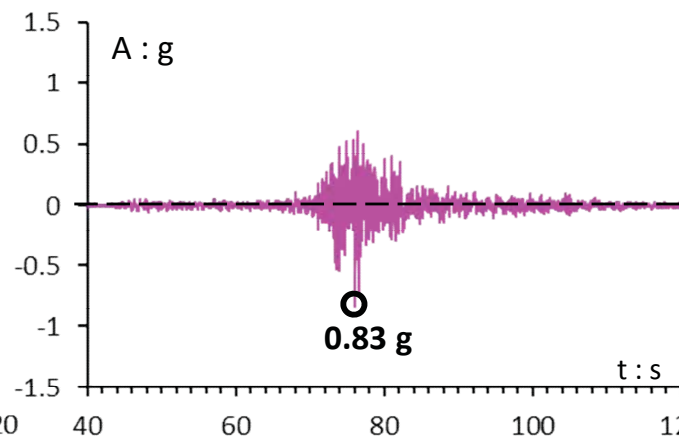
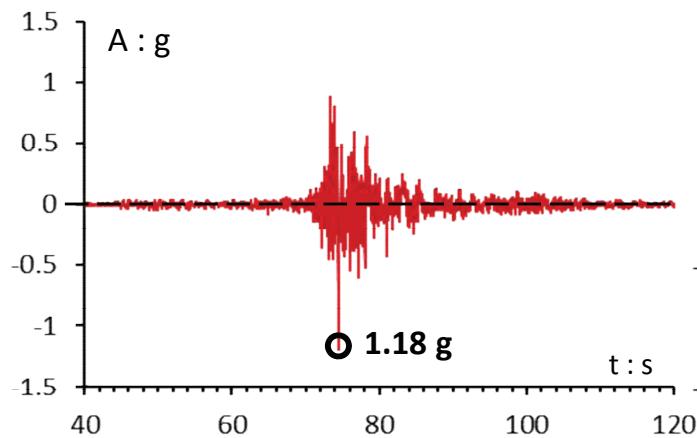
Exact Location: 36.13264 (Long.) 36.23808 (Lat.)



Horizontal EW  
component

Horizontal NS  
component

Vertical  
component



# Earthquake $M_w 7.8$

Station 3125: at **Hatay** city, Antakya District

Station at **Free field**,  $V_{s30} = 448 \text{ m/s}$  (EC8 Type B)

Exact Location: 36.13264 (Long.) 36.23808 (Lat.)

