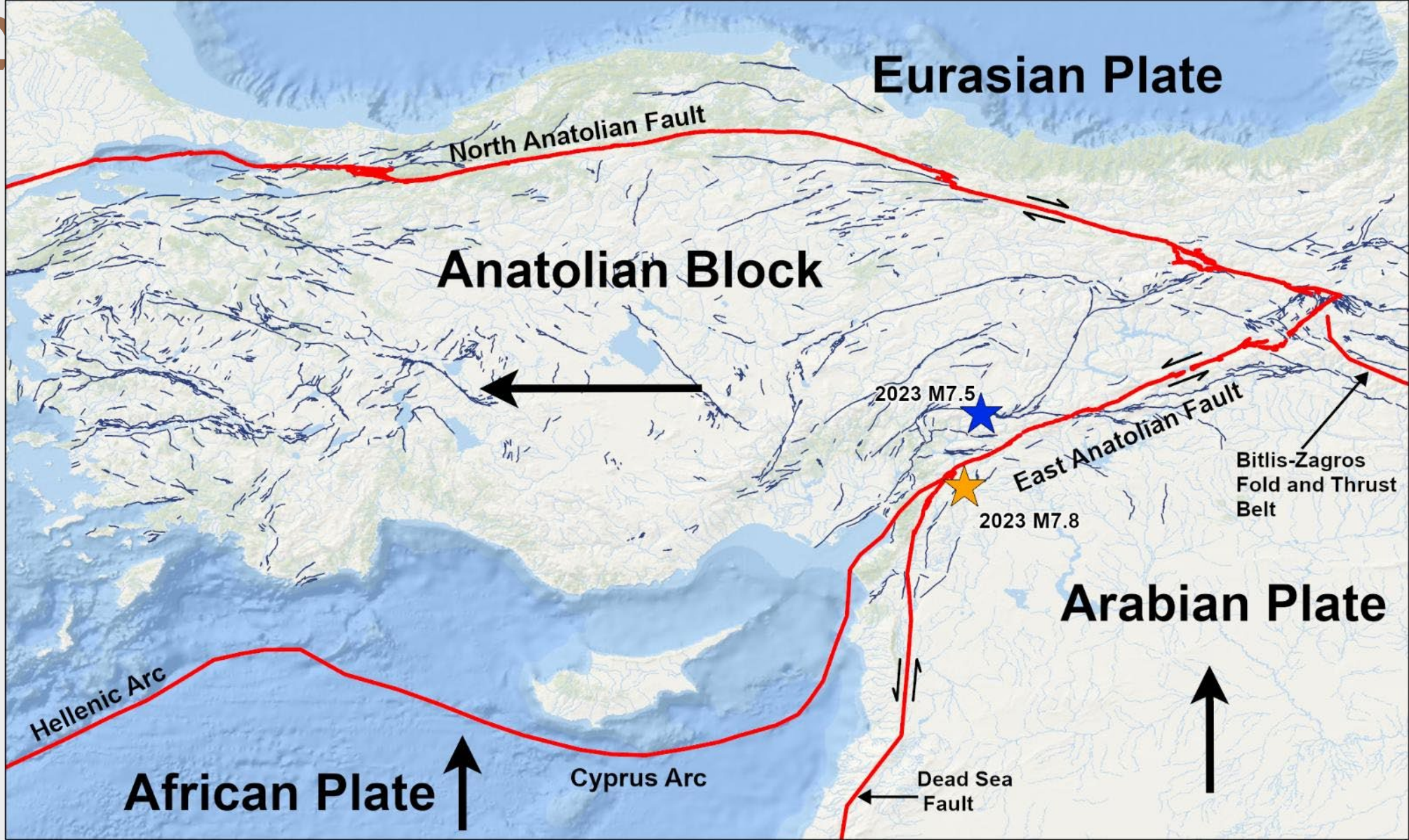
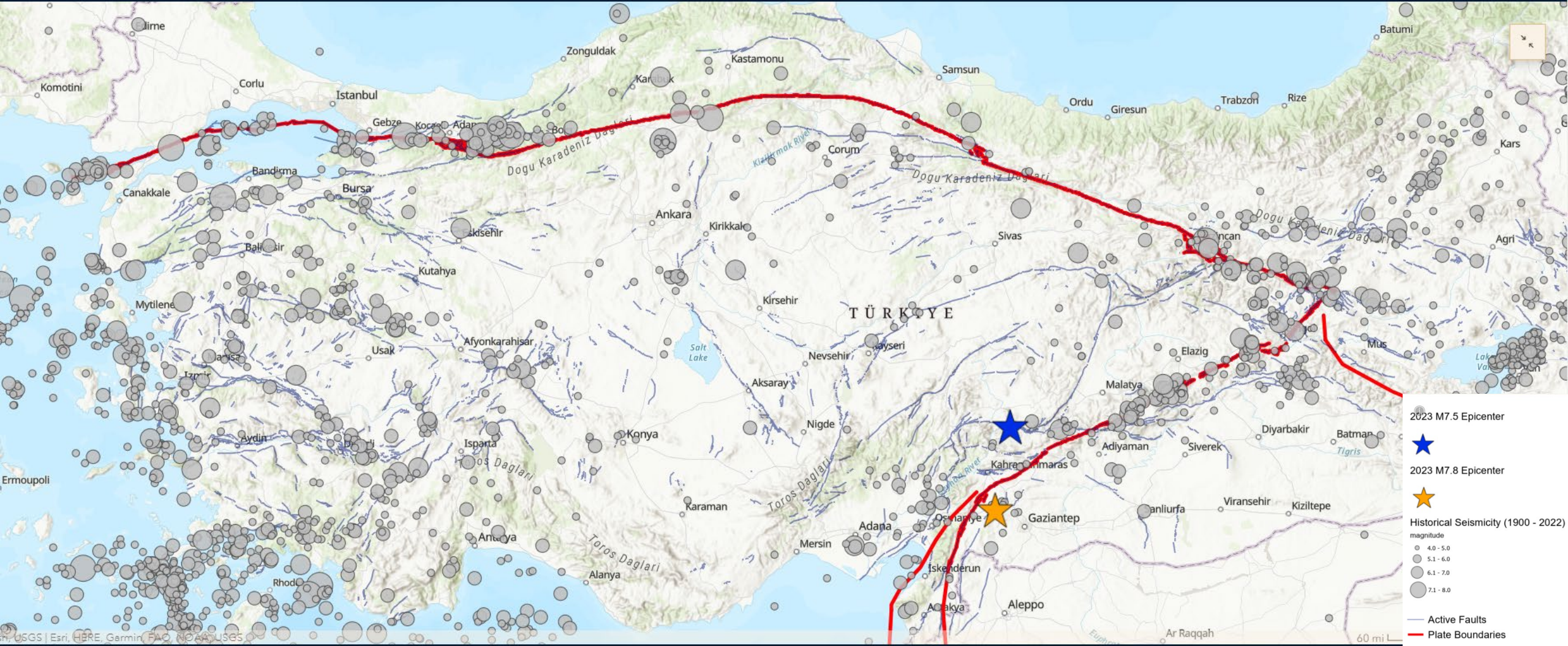


February 2023 Earthquakes in Türkiye and Syria: Observations from the Field and the Structural Engineering Office

Ayşe Hortaçsu
Applied Technology Council





2023 M7.5 Epicenter

★ 2023 M7.8 Epicenter

★ Historical Seismicity (1900 - 2022)
magnitude

- 4.0 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0
- 7.1 - 8.0

— Active Faults

— Plate Boundaries

60 mi

Historical seismicity <M5.5 since 1900

Losses

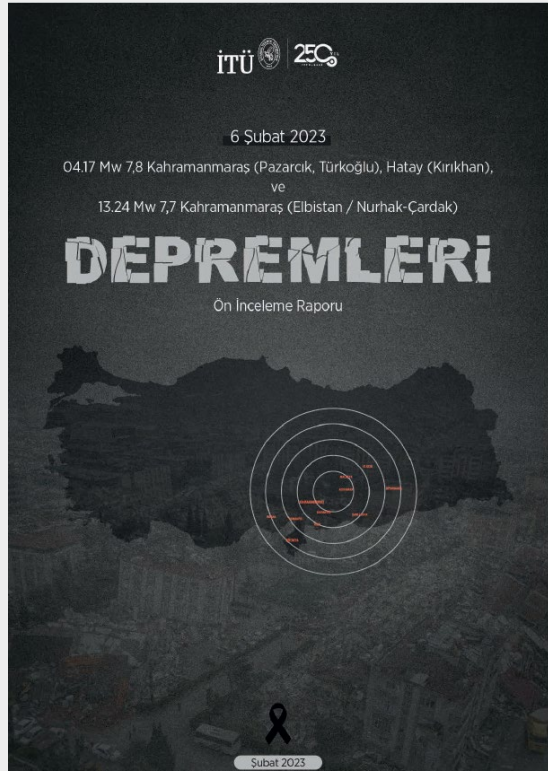
- >48,000 casualties
- \$100B damage - 9% of the GDP
- 1.7M buildings inspected in region
 - (65% of all buildings)
- 15% heavy damage /collapse/demolition (230k)

Tablo 11: Depremden Etkilenen İllerde Toplam Bina Sayısı

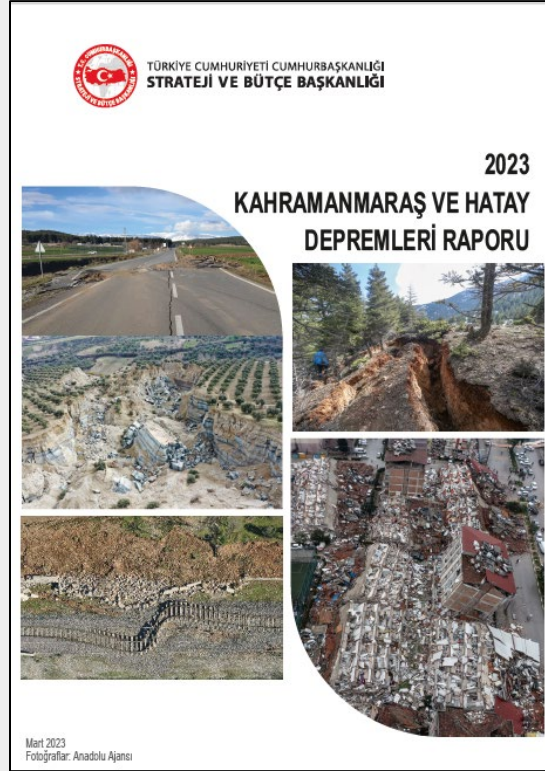
İl	Mesken	İşyeri	Kamu	Diğer	Genel Toplam
Adana	404.502	29.920	8.916	7.779	451.117
Adıyaman	107.242	5.765	4.370	3.119	120.496
Diyarbakır	199.138	11.412	11.964	3.165	225.679
Elazığ	106.569	7.221	2.872	7.051	123.713
Gaziantep	269.212	22.829	5.480	8.162	305.683
Hatay	357.467	33.511	10.382	5.489	406.849
Kahramanmaraş	219.351	12.358	6.879	4.565	243.153
Kilis	33.399	1.526	1.651	736	37.312
Malatya	159.896	8.370	6.670	4.051	178.987
Osmaniye	128.163	9.428	3.105	2.384	143.080
Şanlıurfa	347.902	18.847	11.790	4.089	382.628
Bölge Toplamı	2.332.841	161.187	74.079	50.590	2.618.697

Kaynak: İçişleri Bakanlığı, MAKS





Istanbul Technical University



Türkiye Ministry of Strategy



NSF-funded StEER and EERI

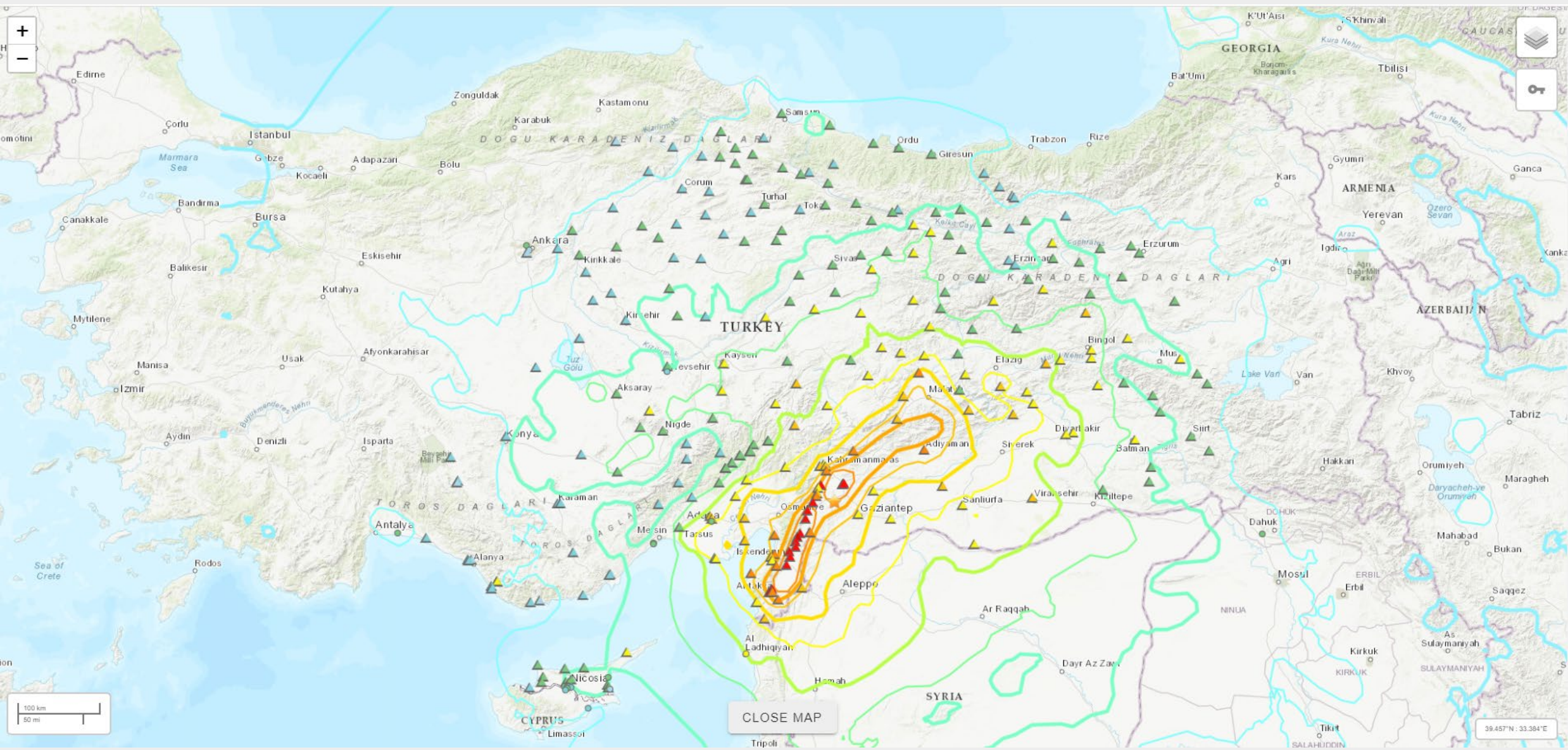


NSF-funded GEER and EERI



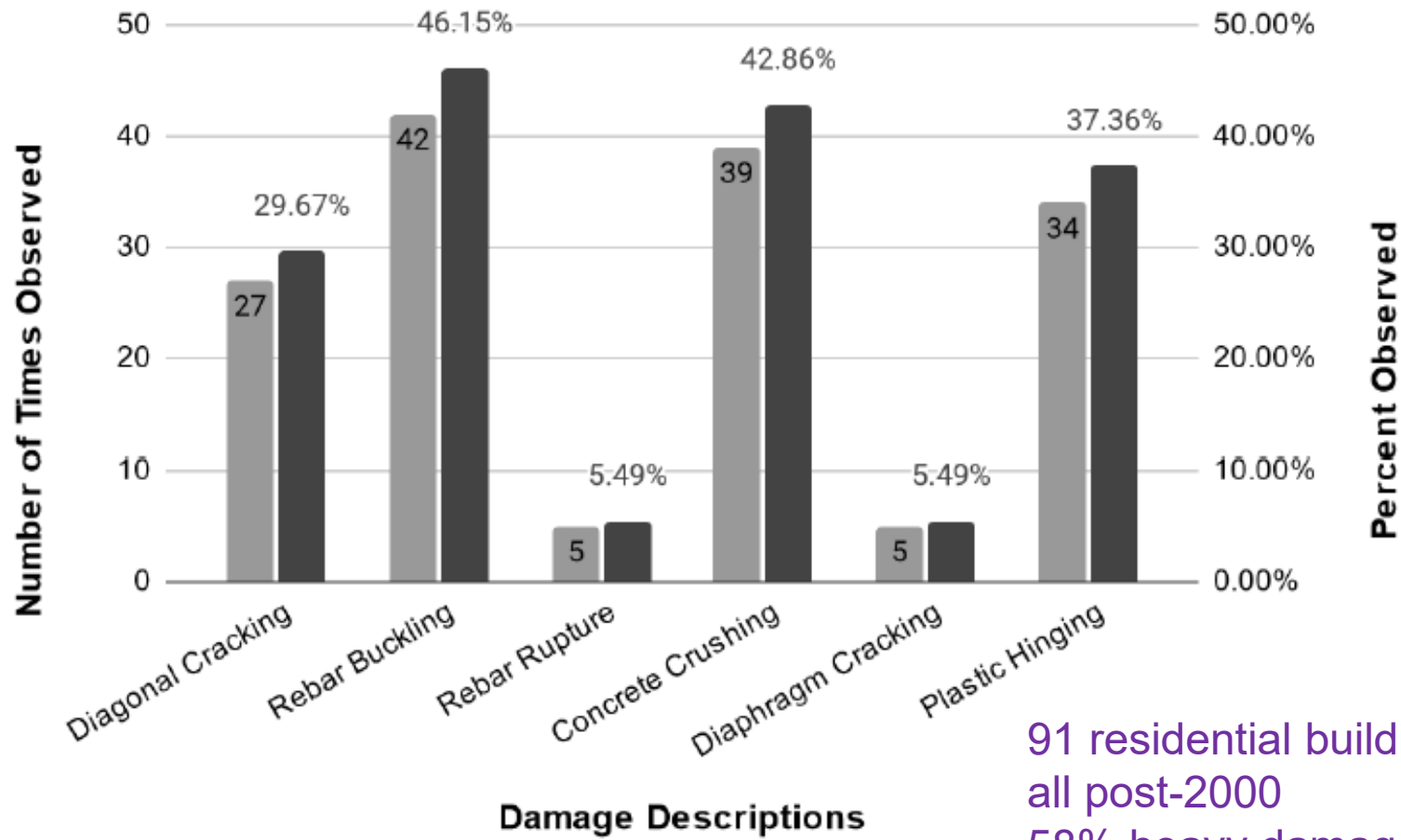
Conference Special Sessions and Journals:

- 2023 EERI Annual Meeting
- 18th World Conference on Earthquake Engineering (June 2024)
- Earthquake Spectra Special Issue



Typical construction
Typical damage





91 residential buildings
all post-2000
58% heavy damage

Figure 5.10. Types of damage observed in the residential buildings visited by the EERI Buildings team.



MAY 6, 2023

FEBRUARY 6, 2023 TÜRKIYE EARTHQUAKES:
REPORT ON GEOSCIENCE AND
ENGINEERING IMPACTS

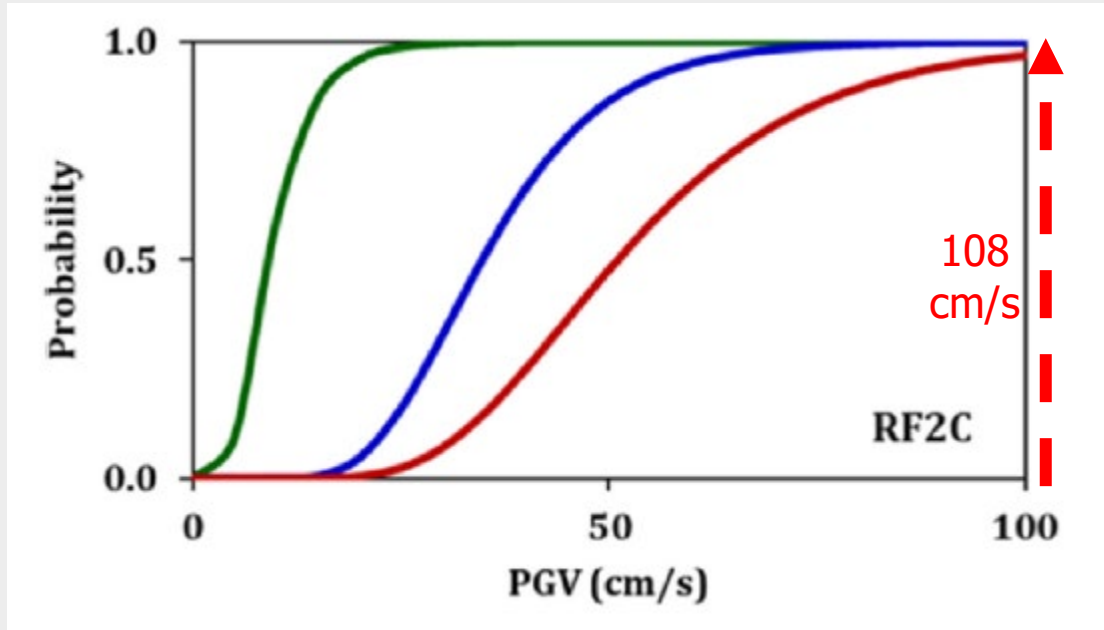


<https://learningfromearthquakes.org/2023-02-06-nurdagi-turkey/>

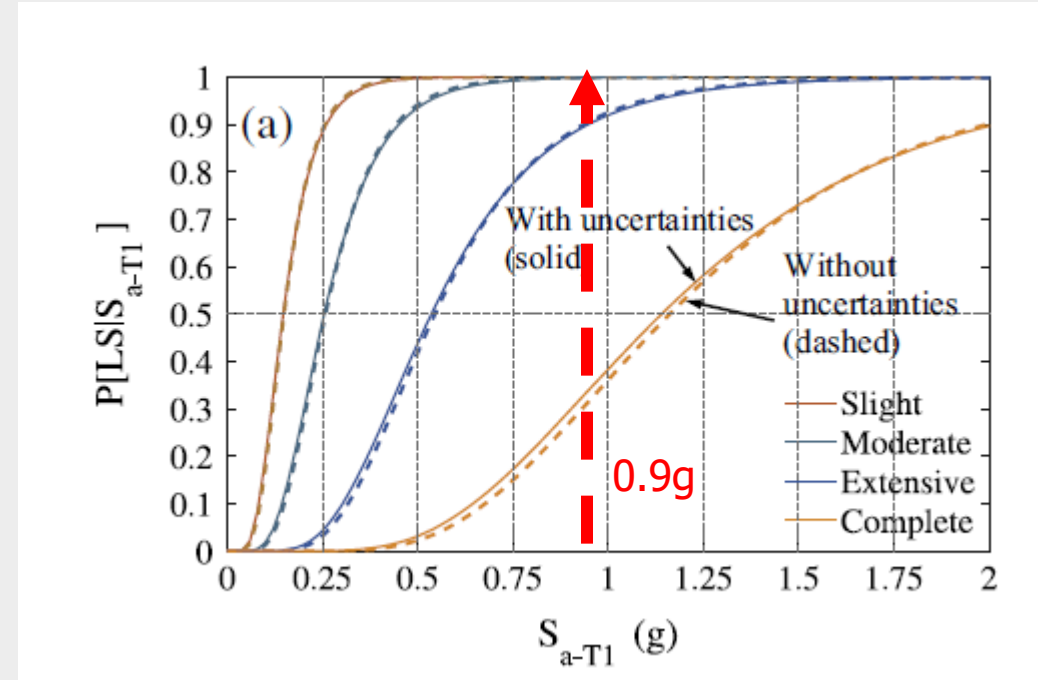


Implications for the US (Preliminary)

slide from Gunay and Mossalam



4-8 story reinforced concrete (RC) frames with no code compliance (Kelam et al., 2022)



Non-code compliant nonductile RC frame in California (Jeon et al., 2015)

Kelam, A.A., Karimzadeh, S., Yousefibavil, K., Akgün, H., Askan, A., Erberik, M.A., Koçkar, M.K., Pekcan, O. & Ciftci, H., 2022. An evaluation of seismic hazard and potential damage in Gaziantep, Turkey using site specific models for sources, velocity structure and building stock. *Soil Dynamics & Earthquake Engineering*, 154, p.107129.

Jeon, J.S., Lowes, L.N., DesRoches, R. & Brilakis, I., 2015. Fragility curves for non-ductile reinforced concrete frames that exhibit different component response mechanisms. *Engineering Structures*, 85, pp.127-143.



Kahramanmaraş (by A. İrfanoğlu)



Kahramanmaraş (by A. İrfanoğlu)

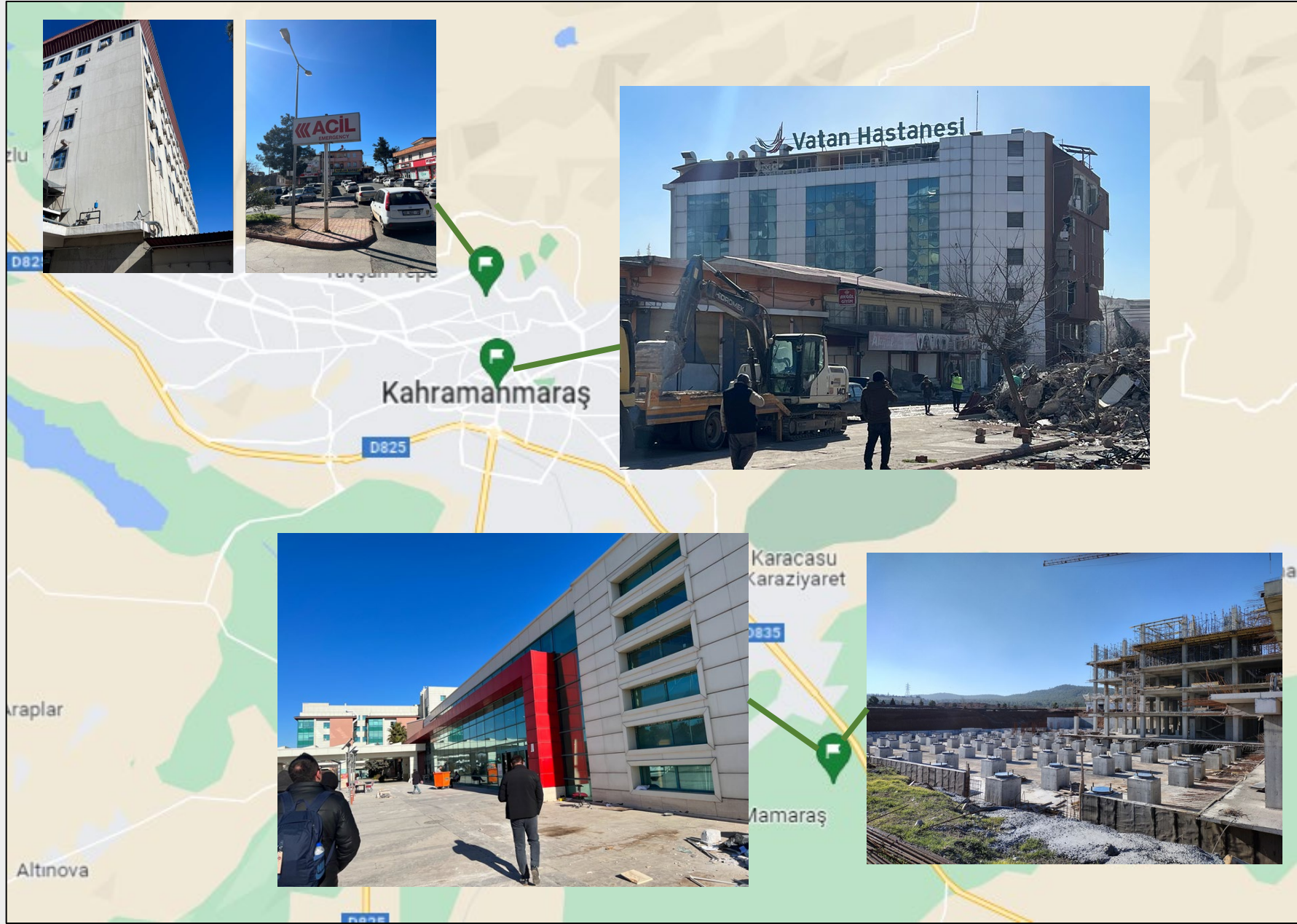


Kahramanmaraş from Google Street View (by A. İrfanoğlu)



Kahramanmaraş (by A. İrfanoğlu)

The story of 4 hospitals



City Hospital



- Back-up systems operational
- Continued operations after 1st shock
- Paused operations for one day
- Serving 300 patients



Private Hospital





New Hospital (under construction)

- 361 base isolators
- 9-story wing to be added
- 18cm movement



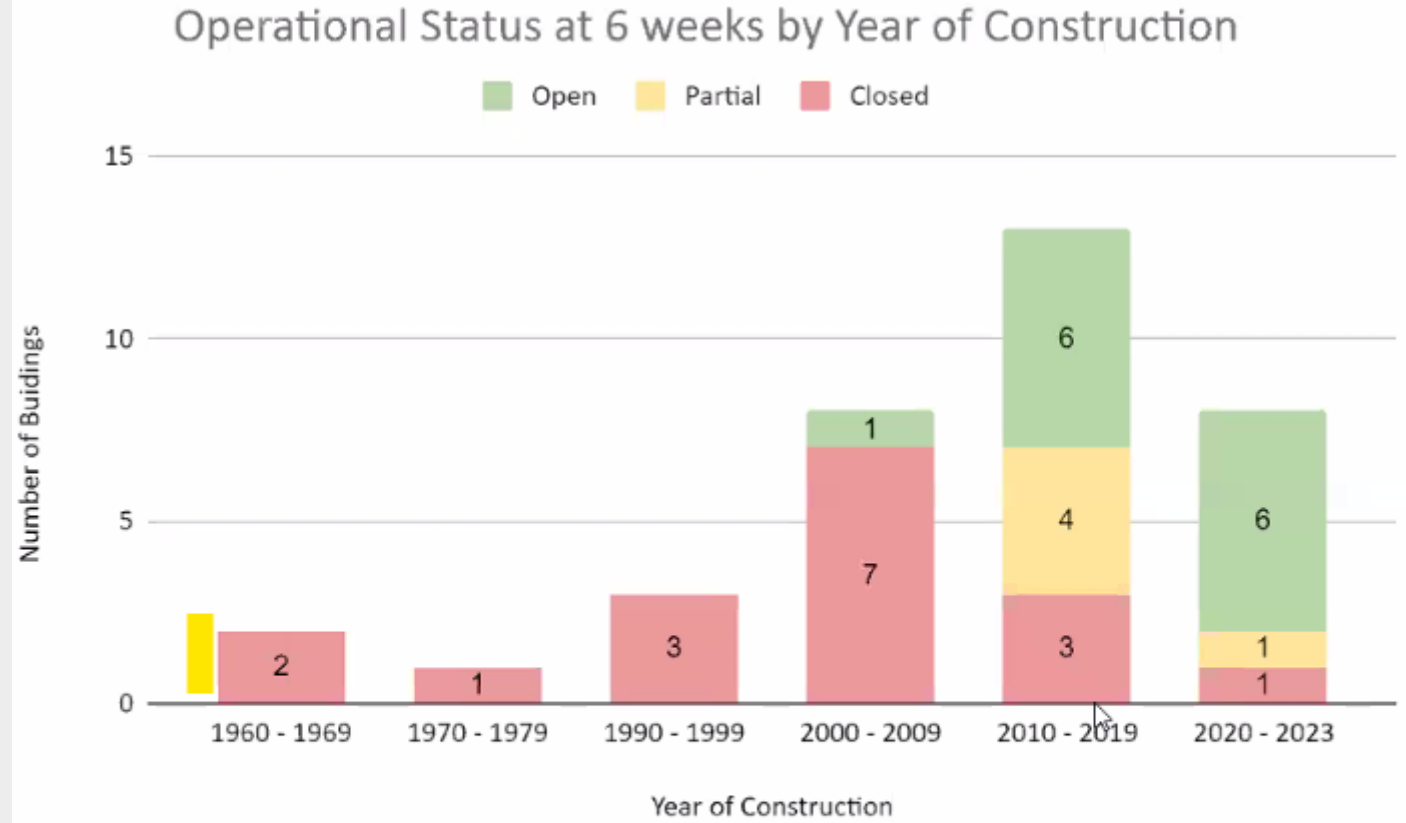
City Hospital







from EERI-GEER report



- There are more hospitals built recently.
- Newer hospitals had better functional recovery.
- Fixed base construction: 1962 to 2023
- Seismically isolated construction: 2017 to 2023

Lifelines Performance

“Hatay had its bones broken in pieces”
– Anton Andonov (EEFIT Team)



Fire Station in Antakya



turkiyeitfaiyeteskilati • Follow

Original audio



Hayat kurtarmak için çıktıkları yollarda onlarla beraber olan itfaiye araçları bu seferde kahramanlarımızı korudu. Hatay'ın Antakya ilçesinde itfaiye ekiplerinin kaldığı bina çöktü. O sırada kaçmaya çalışan görevdeki itfaiyecileri ölümden bindikleri araçlar kurtardı. Binanın tamamen çökmesini, itfaiye araçları engellerken, enkazdan çıkan itfaiyeciler koşa koşa yardıma gitti. Bazı itfaiye erlerinin ise yakınlarını enkazda bıraktıkları, hiç düşünmeden can kurtarmak için göreve koştuğu öğrenildi. Yakınlarını kaybeden itfaiye erlerinin, cenazelere bile katılamadıkları 10 gündür görevde oldukları ifade edildi.

Böyle güzel bir meslek (sayılmıyor) işte



36,965 likes

FEBRUARY 15

Log in to like or comment.

“The main fire station in Antakya collapsed on top of three fire engines and one Search&Rescue vehicle. Fortunately all of it's 25 strong shift miraculously survived as the trucks below stopped the failing slab. The crew didn't have any time to recover from the shock as they needed to immediately start suppressing numerous earthquake induced fires in addition to Search&Rescue operations.” – Anton Andonov (EEFIT Team)

<https://www.instagram.com/reel/CorYeULqoQ/?igshid=OTRmMjhIYjM%3D>

Turkish Earthquake Code



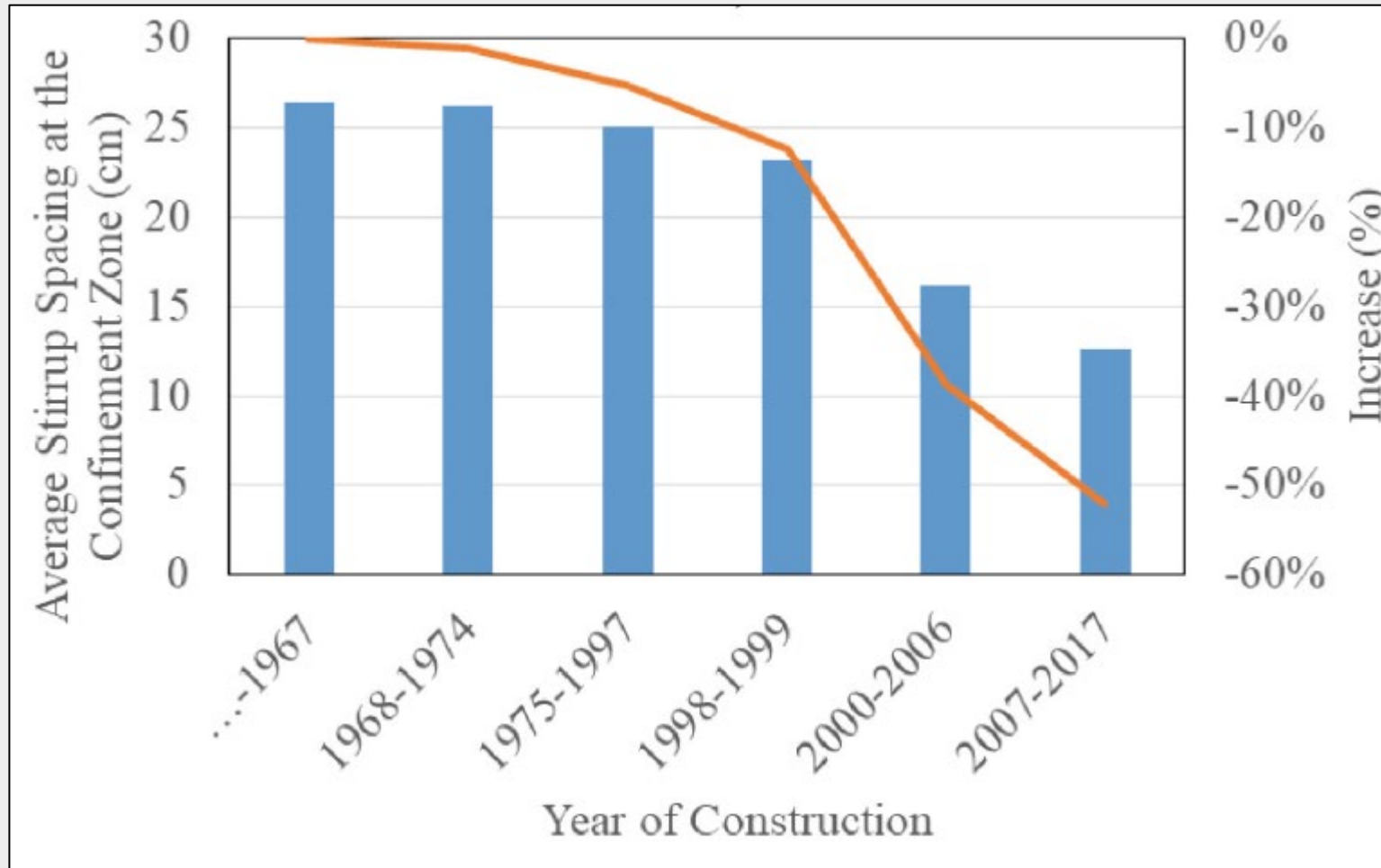


Table 2. Minimum requirements in various Turkish Seismic Design Codes.

	Seismic Design Code			
	1975	1998	2007	2018
Min. Longitudinal Reinforcement for Columns	1%	1%	1%	1%
Confinement Zone Max. Stirrup Spacing (cm)	10	10	10	10
135° Stirrup Hook Ends	Yes	Yes	Yes	Yes
Min. Compressive Strength of the Concrete (MPa)	18	20	20	25
Compulsory Deformed Longitudinal Reinforcement	No	No	Yes	Yes
Shear Wall End Zones: Reduced Confinement Spacing	No	Yes	Yes	Yes
Shear Wall End Zones: Increased Number of Longitudinal Bars	Yes	Yes	Yes	Yes
Max. N_d/A_{cfck} allowed	0.6*	0.5	0.5	0.4

*from TS500–1984 [19] - Requirements for design and construction of reinforced concrete structures ($N_d = 1.4N_g + 1.6N_q$, whereas for the other columns $N_d = N_g + N_q + N_e$)

Avg. Stirrup Spacing in Confinement Zone



Spectral Acceleration Capacity



Who designs?

- 127 Civil Engineering departments
- EVERY graduate gets a certificate to design upto 3 buildings a year
- No licensing
 - “yetkin muhendis”



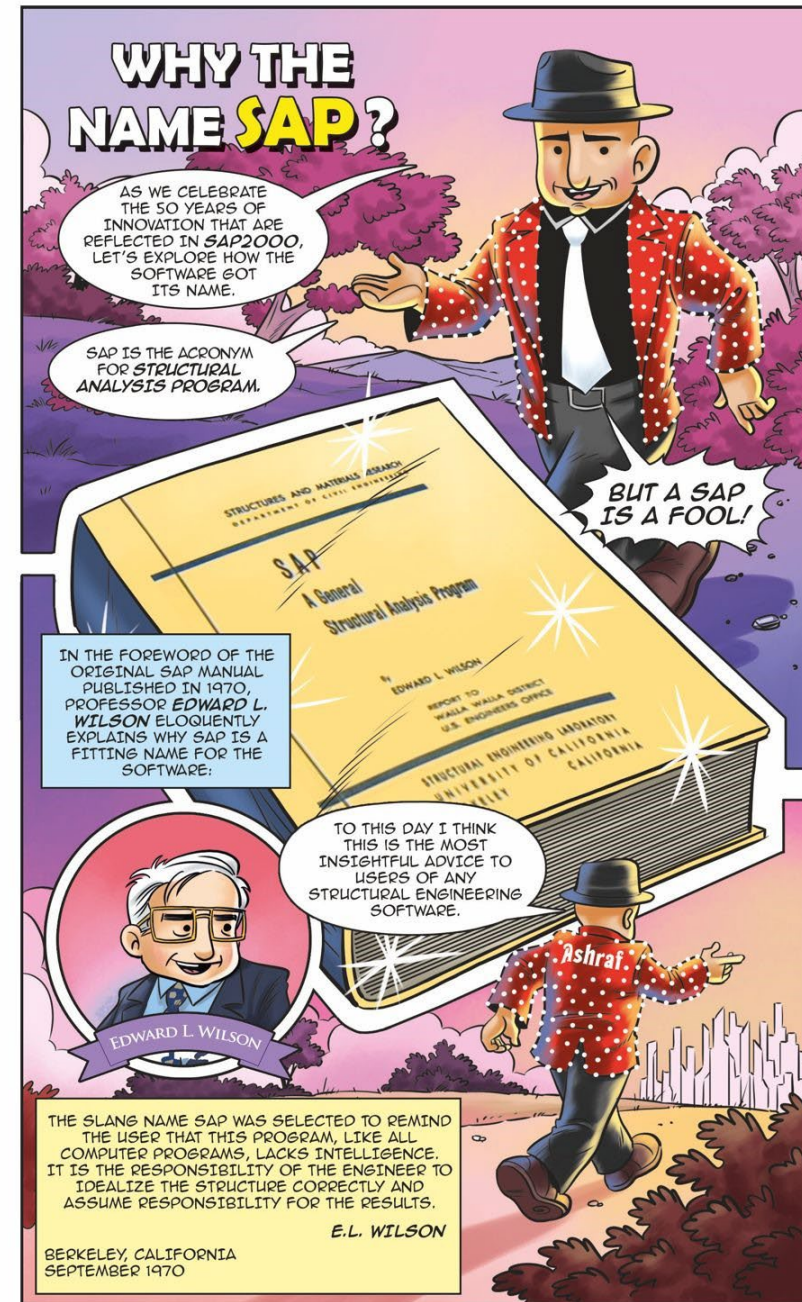
What tools do they have?

- Software packages for “statik proje”

THE SLANG NAME SAP WAS SELECTED TO REMIND THE USER THAT THIS PROGRAM, LIKE ALL COMPUTER PROGRAMS, LACKS INTELLIGENCE. IT IS THE RESPONSIBILITY OF THE ENGINEER TO IDEALIZE THE STRUCTURE CORRECTLY AND ASSUME RESPONSIBILITY FOR THE RESULTS.

E.L. WILSON

BERKELEY, CALIFORNIA
SEPTEMBER 1970



Turkey's chamber of civil engineers, for example, has argued for years that experienced engineers are stretched too thin to adequately supervise construction projects. The group has called for every project to get a dedicated engineer. That idea, which could have slowed down construction, went nowhere. The Erdogan government sued the group in 2015, blocking it from issuing its own, stricter certifications for engineers.

In Erdogan's Turkey, a Building System Fatally Weakened by Corruption

Turkish families got wealthy off a construction system rife with patronage. A Times investigation reveals just how fatally shaky that system was.

Who is responsible?



<https://www.nytimes.com/2023/05/04/world/europe/turkey-earthquake-corruption.html>

What's Next?

Impact on households in the region

Region	Population	Total Household	% Heavy Damage Collapse Demolish	% Any Damage
Kahramanmaraş	1.2M	480k	20%	60%
Hatay	1.7M	850k	25%	48%
EQ Region (11 cities)	14M	5.6M 14% of country	10%	34%

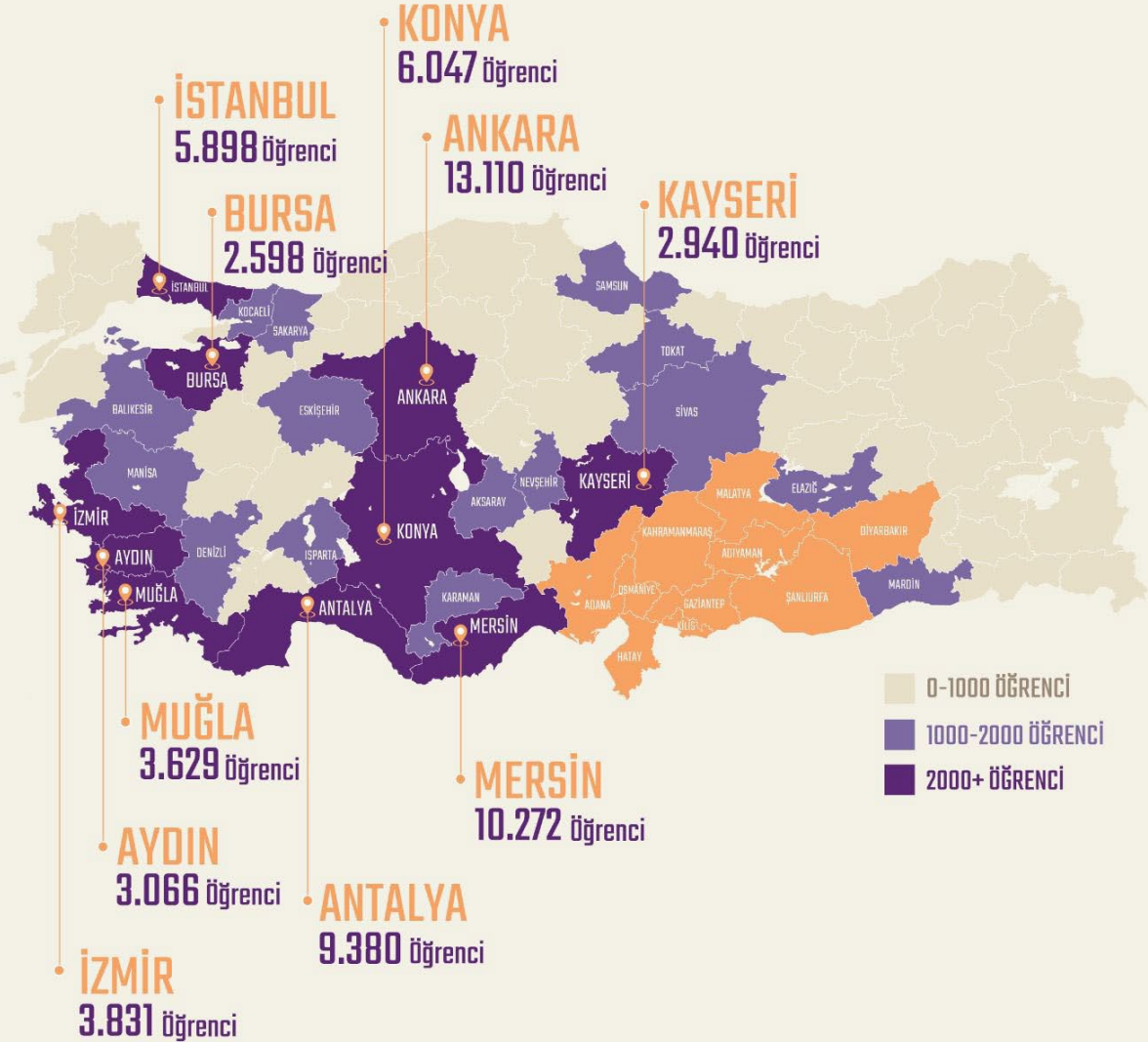
Housing for 2.7M people affected in the region

(Avg 3.5 persons per household)

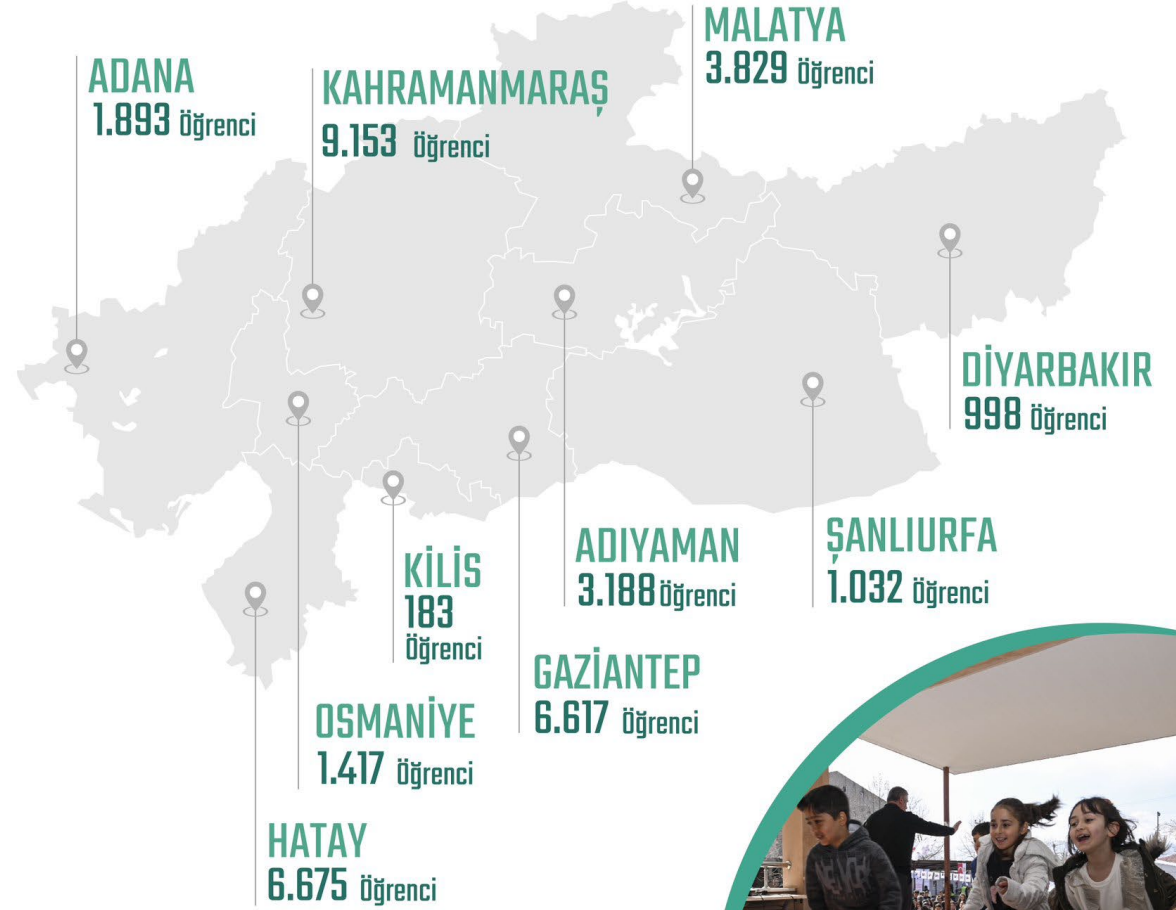
Estimated cost \$100B (9% of GDP)

21.02.2023 TARİHİ İTİBARIYLA

99.853 ÖĞRENCİMİZİN DİĞER İLLERE NAKİLLERİNİ GERÇEKLEŞTİRDİK

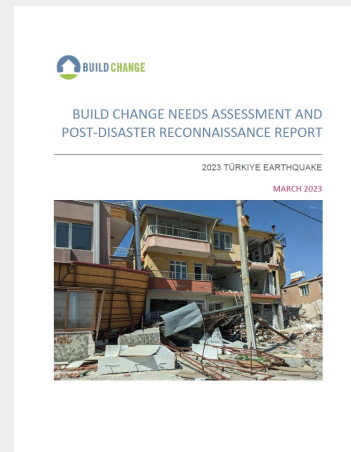


DEPREM SONRASINDA NAKİLLERİNİ FARKLI İLLERE ALDIRAN 34 BİN 985 ÖĞRENCİMİZ İLLERİNE GERİ DÖNDÜ



Insurance

- DASK initiated in 2000
- In 2019, 9.5M subscribers
 - 54% of the country
 - 66% in Marmara region
- DASK has a claims-paying capacity of approx. US \$5B



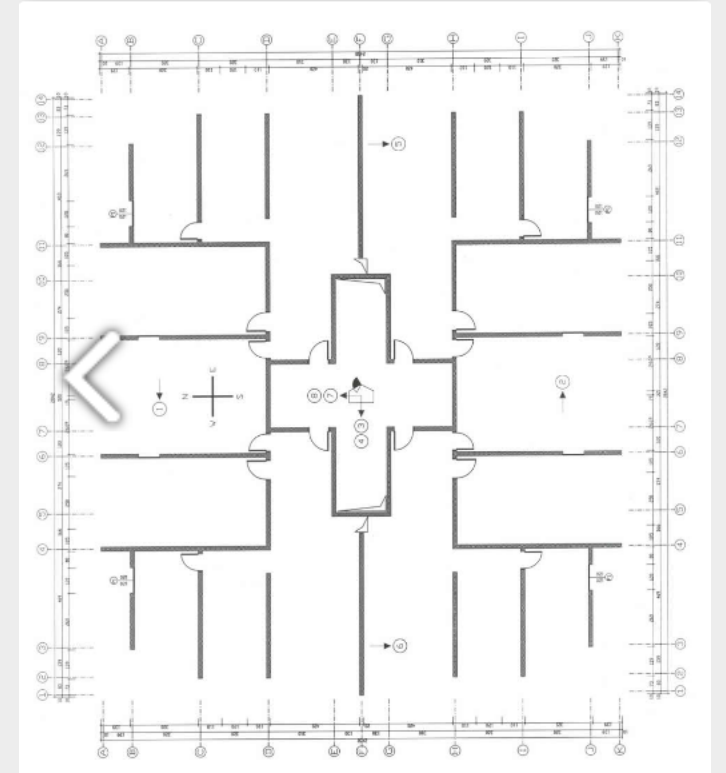
On 2023-08-23:
1USD = 28 TL

LEVEL OF DAMAGE	STATE SUBSIDIES	DASK	HOUSING INSURANCE	STATE CREDITS	BANK CREDITS
Not Damaged	NA	NA	NA	Retrofitting credits by AFAD*	State Banks provide retrofitting credits*
Slightly damaged	10,000 TL per household	Insurance refunds**	Some firms provide insurance refunds**	Retrofitting credits by AFAD*	State Banks provide retrofitting credits*
Moderately Damaged	Cash aids for rent, moving and basic needs****	Insurance refunds**	Insurance refunds**	Retrofitting credits by AFAD* Right owner process***	State Banks provide retrofitting and rebuilding credits
Highly Damaged	- Cash aids for rent, moving/ furniture and basic needs**** - Container house	Insurance refunds**	Insurance refunds**	Right owner process***	At least 70% of the building process must be finished to apply for mortgage loans
Needs Urgent Demolition or Demolished	- Cash aids for rent, furniture and basic needs**** - Container house	Insurance refunds**	Insurance refunds**	Right owner process***	At least 70% of the building process must be finished to apply for mortgage loans

*To obtain retrofitting credits, estate owners must obtain a "risky area certificate" from the Ministry.

Rebuilding / Retrofit

- Accelerated rebuilding
 - Tunnel form construction
- Istanbul has 250,000 high risk buildings!



<http://db.world-housing.net/building/101/>



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