# PREPAREDNESS TO EARTHQUAKE AFTER THE CATASTROPHE OF AUGUST 17TH


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**President**

*JSCE Turkey Section*

# STRATEGIC PLAN by AFAD-
# DISASTER AND EMERGENCY MANAGEMENT PRESIDENCY

One should consider preventive and protective measures before disaster hits. It is futile to lament after the disaster hits.

***Gazi Mustafa Kemal ATATÜRK***
***Founder of Turkish Republic***

- Turkey is located on a high-risk geography that is heavily affected from disasters due to its geological structure, topography and climatic characteristics.

# STRATEGIC PLAN by AFAD (DISASTER AND EMERGENCY MANAGEMENT PRESIDENCY)

- The fundamental philosophy of the National Earthquake Strategy and Action Plan-2023 (NESAP-2023) has been summarized as achievement of new earthquake-resilient, safe, well prepared and sustainable settlements.

- The document aims to reduce the earthquake risk and enable a society that is prepared against this form of hazard through examining the institutional framework for this objective and establish the priorities of the R&D programs on the subject.

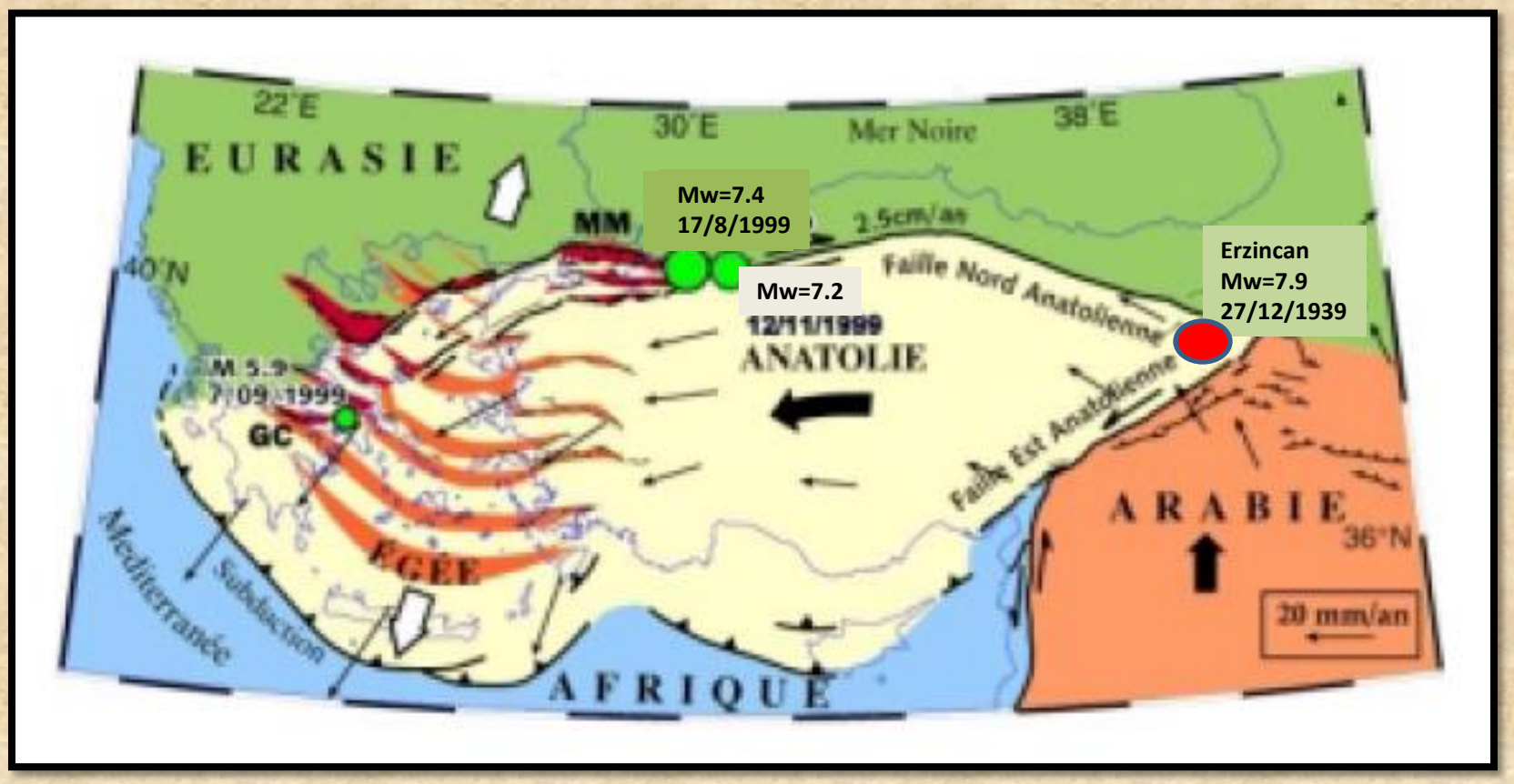
- Because of these reason that the physical, economic, social, environmental and political harms and losses that may be engendered by earthquakes are prevented or their effects reduced.

- We have to make our strategic policies and be prepared for the unexpected based on the foresight that the global climate change and instability may cause disasters and emergencies at unexpected dimensions.

# MAIN TOPICS

- Turkey's Seismicity and Studies
- August 17th Earthquake Effects-Damages
- New Settlements, New Constructions
- Retrofitting Damaged and/or Undamaged Buildings
- Retrofitting Viaducts, Suspension Bridges
- The Roles of IISEE, Contributions of Japanese Professors and Promotion of Earthquake Engineering in Turkey
- Challenging Projects-Suspension Bridges ,The Marmaray

# KOCAELİ (August 17th ) - DÜZCE (November 12th) 1999 EARTHQUAKES in TURKEY




**Tectonic Structure of Turkey and Neighboring Area**

# ERZİNCAN EARTHQUAKE ($M_s$=7.9)
# December 27, 1939

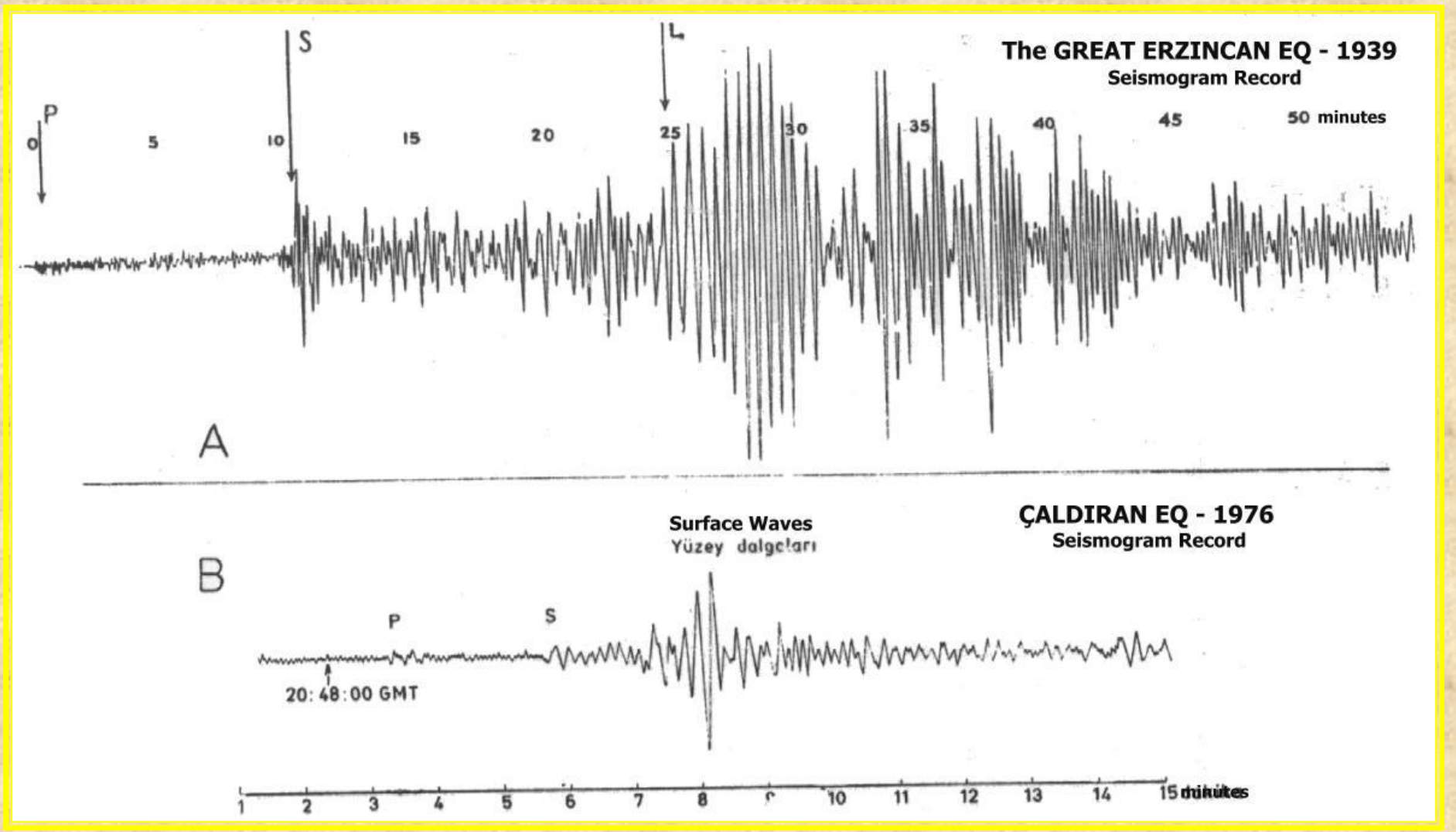

SKETCH MAP SHOWING THE APPROXIMATE EPICENTRE AND ISOSEISMAL LINES (MODIFIED MERCALLI SCALE OF 1931) OF THE ERZINJAN EARTHQUAKE OF DECEMBER 27, 1939.

*, EPICENTRE ; —10—, ISOSEISMAL LINE.

(NATURE- No. 3662 Jan. 6,1940 p.13)y E.TILLOTSON

- Between 1900 and 1999, 149 damaging earthquakes occurred in our country and 578544 (~ Half Million) buildings were destroyed or severely damaged.
- In these earthquakes, resulting in a total loss of 97203 (~ 100 Thousand) lives.

Epicenter & Isoseismal Lines
(Modified Mercalli Scale of 1931)
Fault Length: L=350km
h=20km




December 27, 1939 Great Erzincan Earthquake – Record: Harvard University, USA

November 24, 1976 Çaldıran Earthquake – Record: İstanbul Technical University, TR

# Some Earthquakes Occured on Alpin–Himalayan Belt in Turkey

| Earthquake | Year | Magnitud | Intensity | HumanLost |
|---|---|---|---|---|
| Düzce | 1999 | $M_s$=7.2 | MKS=X | 850 |
| Kocaeli(Marmara) | 1999 | $M_s$=7.4 | MKS=X | 17479 |
| Erzincan | 1992 | $M_s$=6.8(*$SI._2$) | MKS=VIII | 1086 |
| Ceyhan | 1998 | $M_s$=5.9 | MKS=VIII | 145 |
| Dinar | 1995 | $M_s$=5.9 | MKS=VIII | 94 |
| Adapazarı | 1967 | $M_s$=7.5 | MKS=IX | 89 |
| Bolu-Abant | 1957 | $M_s$=7.1 | MKS=IX | 25 |
| Yenice -Gönen | 1953 | $M_s$=7.5 | MKS=IX | 265 |
| Bolu-Gerede | 1944 | $M_s$=7.4 | MKS=IX | 3959 |
| Adapazarı-Hendek | 1943 | $M_s$=6.1 | MKS=IX | 336 |
| Büyük Erzincan | 1939 | $M_s$=7.9 | MKS=X~X1 | 32962 |

# Total or Partial Collapses Should be Prevented



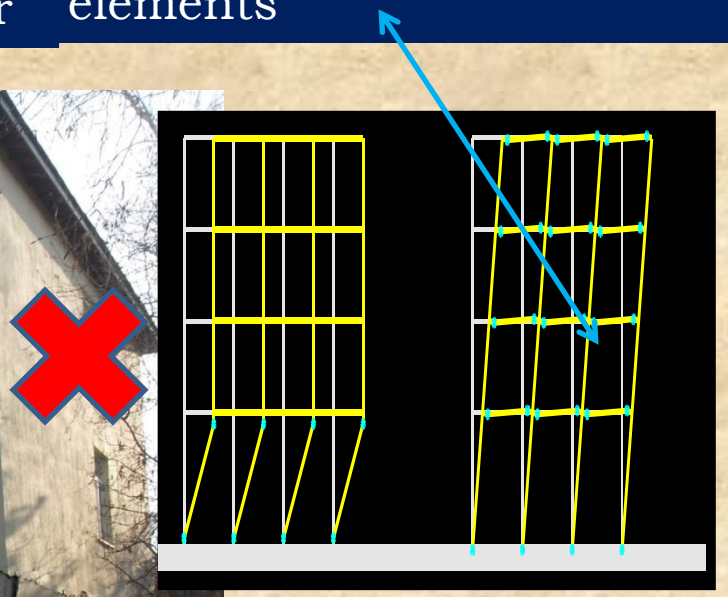
Turkish NGO's have emerged in both earthquakes in the Marmara region and made a significant contribution. They worked in coordination with international organizations.

August 17th, 1999 Kocaeli Earthquake, Adapazarı Prefecture

# DUCTILE BEHAVIOUR & ABSORPTION OF ENERGY DURING THE EARTHQUAKE WITH BEAM-MECHANISM IN THE STRUCTURE

DSİ Van Regional Directorate Building: Column-Mechanism in the Ground Floor

"ductile behavior" with their elements



*Mechanism in columns* *Mechanism in beams*

Van Earthquake 2017 $M_w$=7.2

# Causes Increasing the Risk of Damage in Earthquakes

- **The absence of a strict inspection system at the time of their construction**
- Local ground conditions are not realistically taken into account during the design phase
- **Low concrete strength of the structure;**
- The confinement reinforcement at the beam and column ends is not sufficient;
- **Beam-column combination without stirrup;**
- The stirrup hooks are bent at an angle of 90°
- If there are bearing system irregularities in plan and vertical direction;

# Bearing system irregularities in plan and vertical direction

**Almost No Damage In Front of Building**


Shear Wall

**Heavy Damage Behind the Building**

# Contrary to Regulations or Code

**Especially for Masonary Structures Irregular & Big Openings**

*Adana 1998*

- The second point is prevention of further damage and injury from buildings that collapse in the aftershocks of a major quake.
- A system of rapid inspections by qualified inspectors to determine whether damaged buildings are safe to move back into is needed.

# Design of Buildings as Earthquake Resistant Structures

## Main Philosophy

- According to the survey results in the case of a 7-magnitude earthquake in Turkey and Japan, the structural damage to our country 30 times, the loss of life was found to be 15 times, more than that in Japan.

- Economic statistics for the last sixty years show that direct and indirect economic losses engendered by natural disasters account for 3 percent of the country's GDP. The forecasts tell us that in a major earthquake in a major city this ratio may well be double.

- We need to take lessons from recent earthquakes in order to reduce loss of life and destruction. We have to understand and apply the science and the content of the earthquake regulations based on these experiences as well.

# Measures to Prevent Secondary Disasters After the Quake

**One of the important points to prevent secondary disasters is fire fighting.**

- In the Kobe disaster, water mains were broken and fire hydrants damaged.
- Without water, it took two full days for the fires to be completely extinguished.
- Consequently, the development of an earthquake-resistant water supply infrastructure is urgently needed.

Kobe, 17 Ocak 1995, 5:46

# INDUSTRIAL FIRES

## (*1999 Kocaeli Earthquake,* Turkey)

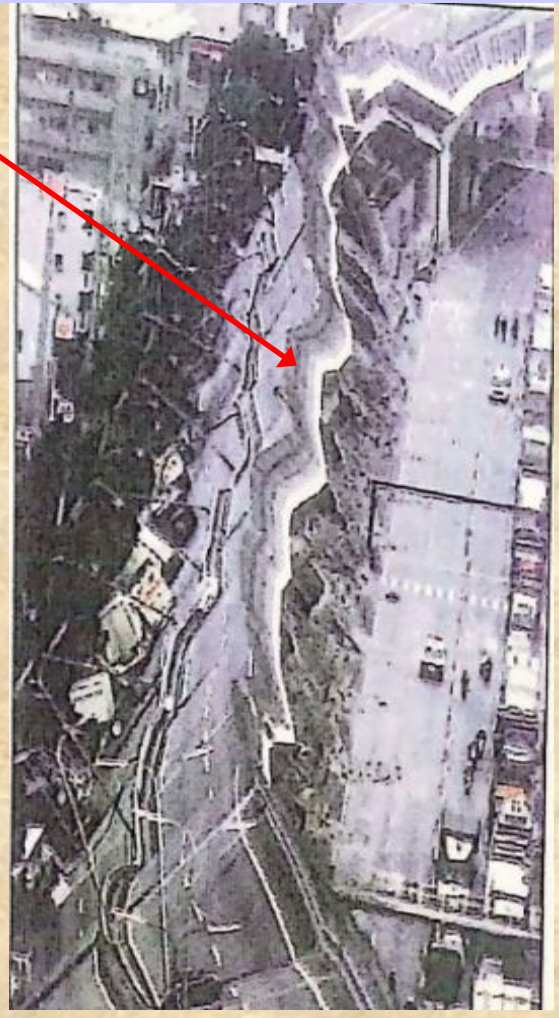
TÜPRAŞ Refinery Fire

- First, a 90 m high and 10 m diameter reinforced concrete chimney in the crude oil unit fell into the middle of the units, causing a fire.
- The second one, unlike the crude oil unit, was caused by sparks in Nafta tanks.
- These fires could only be controlled within three days.

# Great Hanshin Earthquake Effect in Kobe Viaducts, 1995

Even though Japan has the strictest Seismic Design Codes in the World, Great Hanshin Earthquake caused greater damage than had been anticipated.

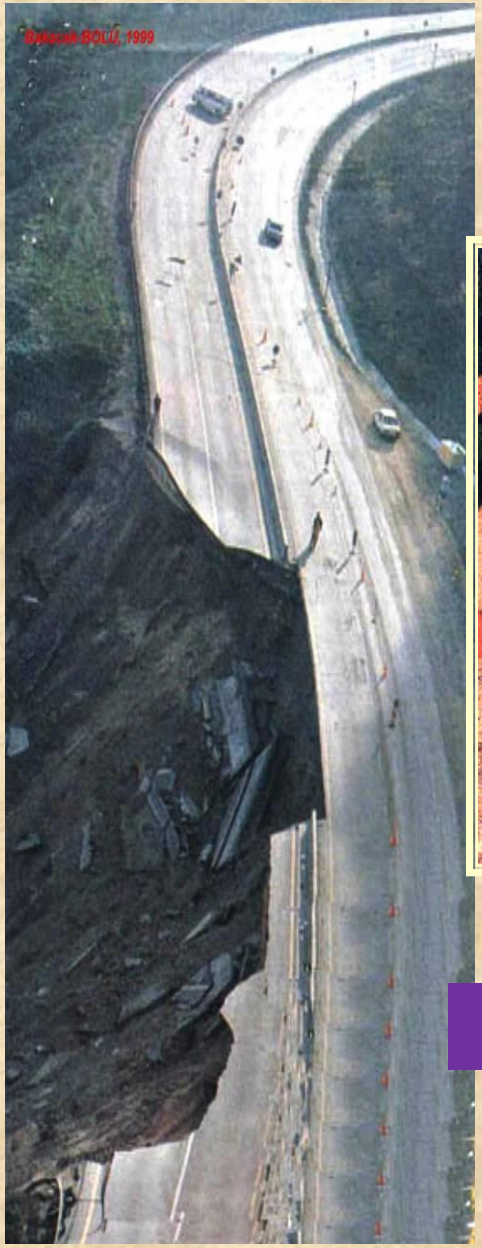
Overturned Viaduct in Kobe with the 630m Length



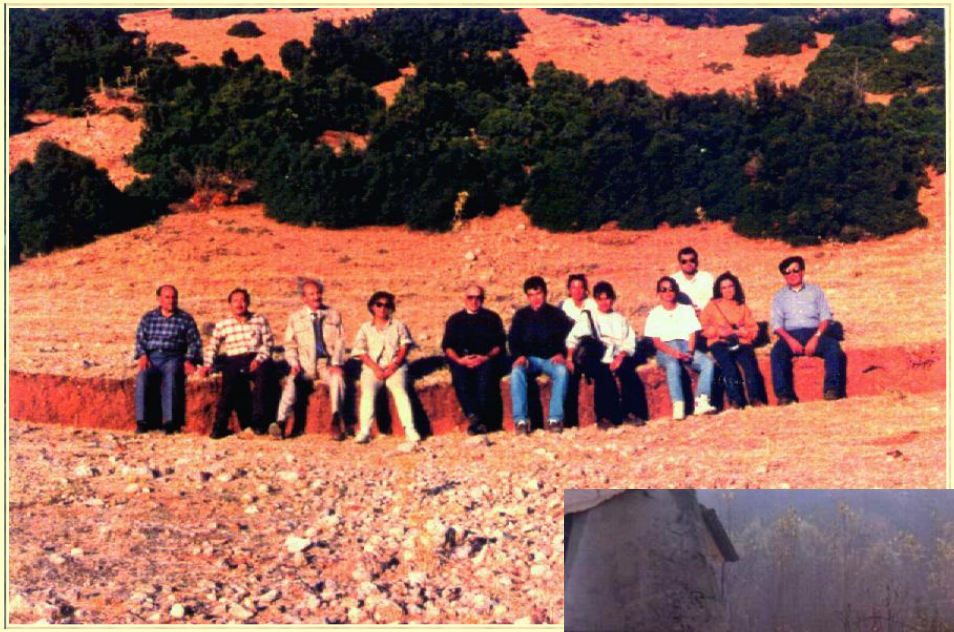
# Bridge & Railway Damages

**Collapses of TEM Highway, Arifiye Grade Separation in Kocaeli Earthquake**

# Previous Earthquakes & Structural Damages

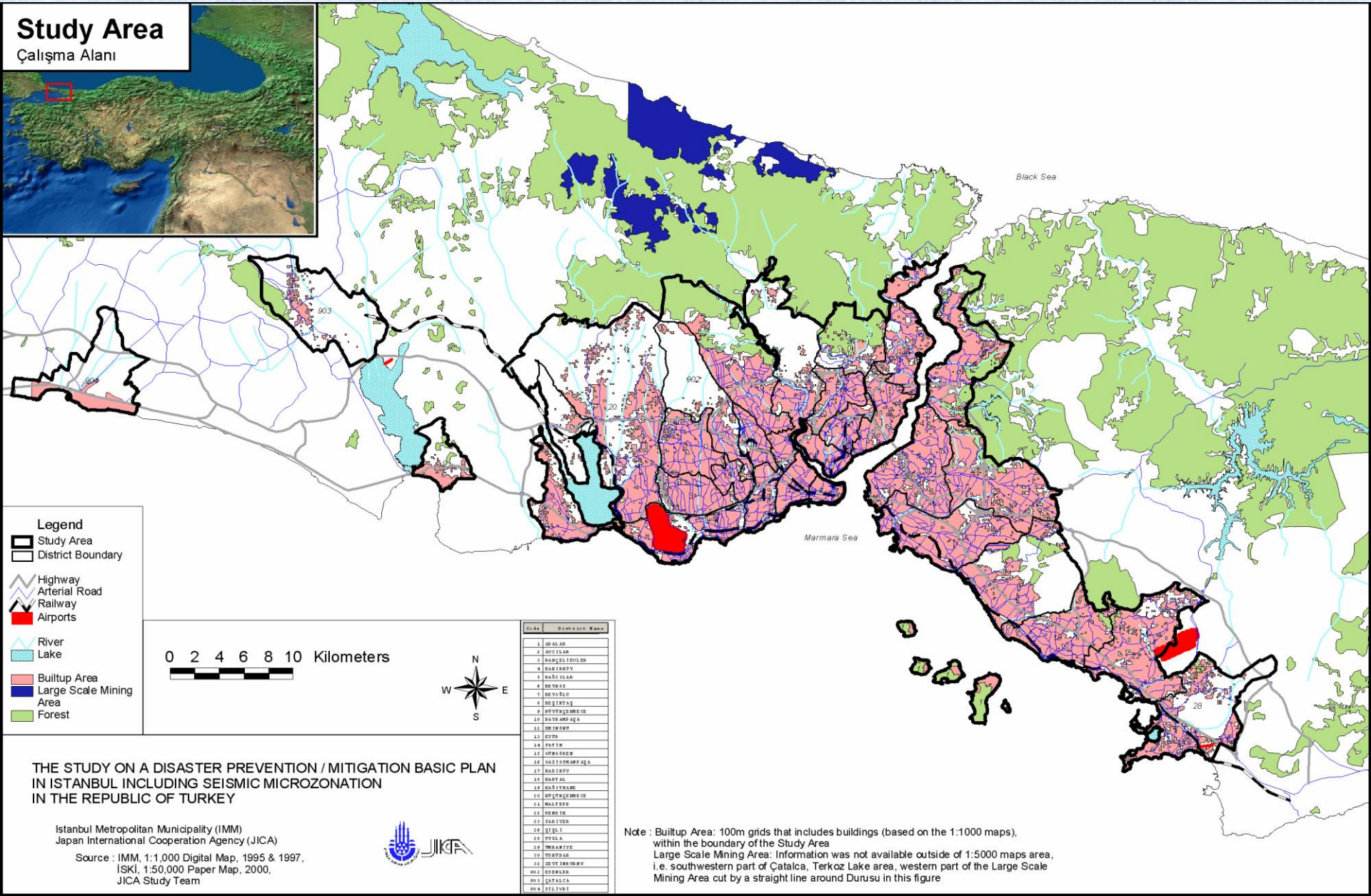


**Extreme amount of ground displacements**

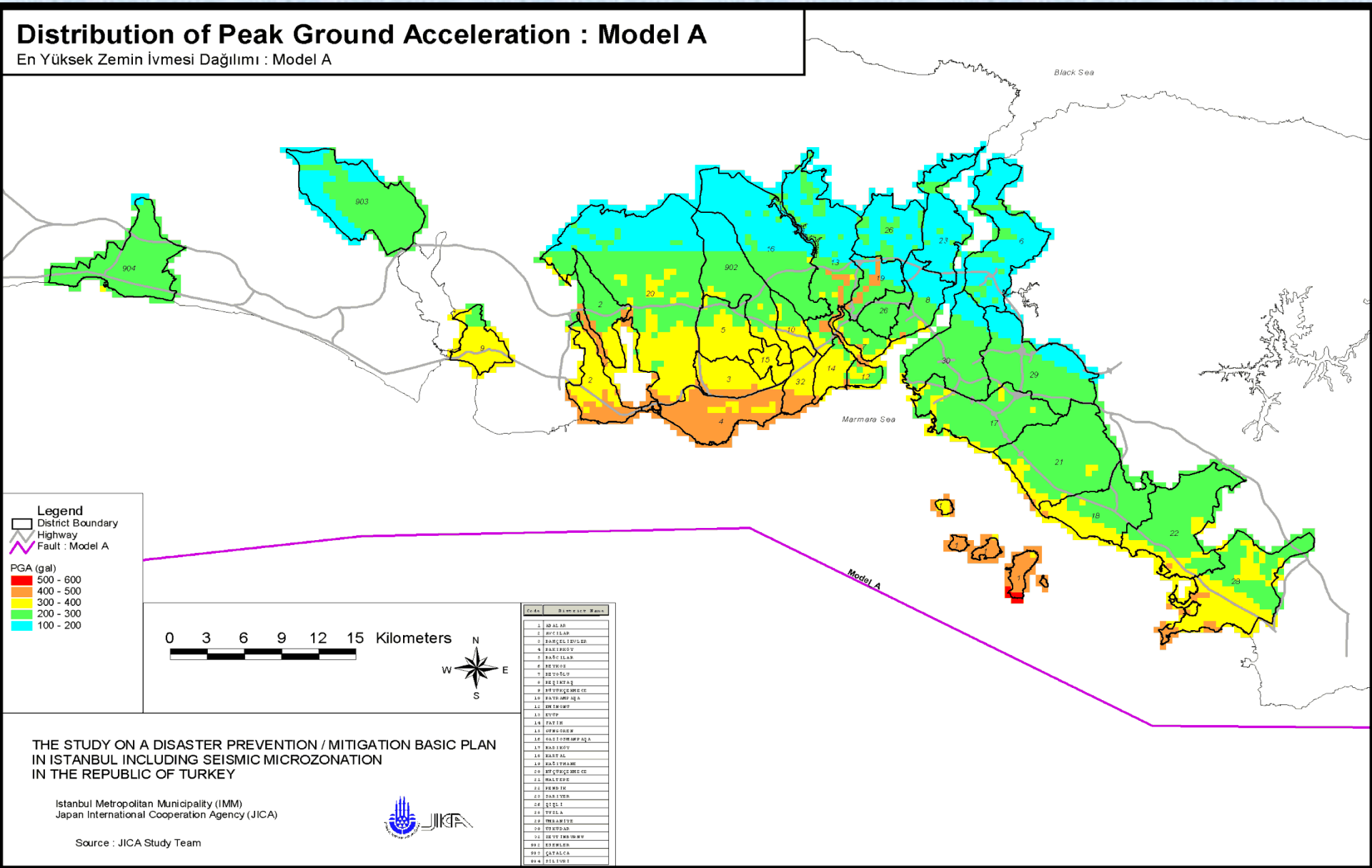


**Fault Movements**

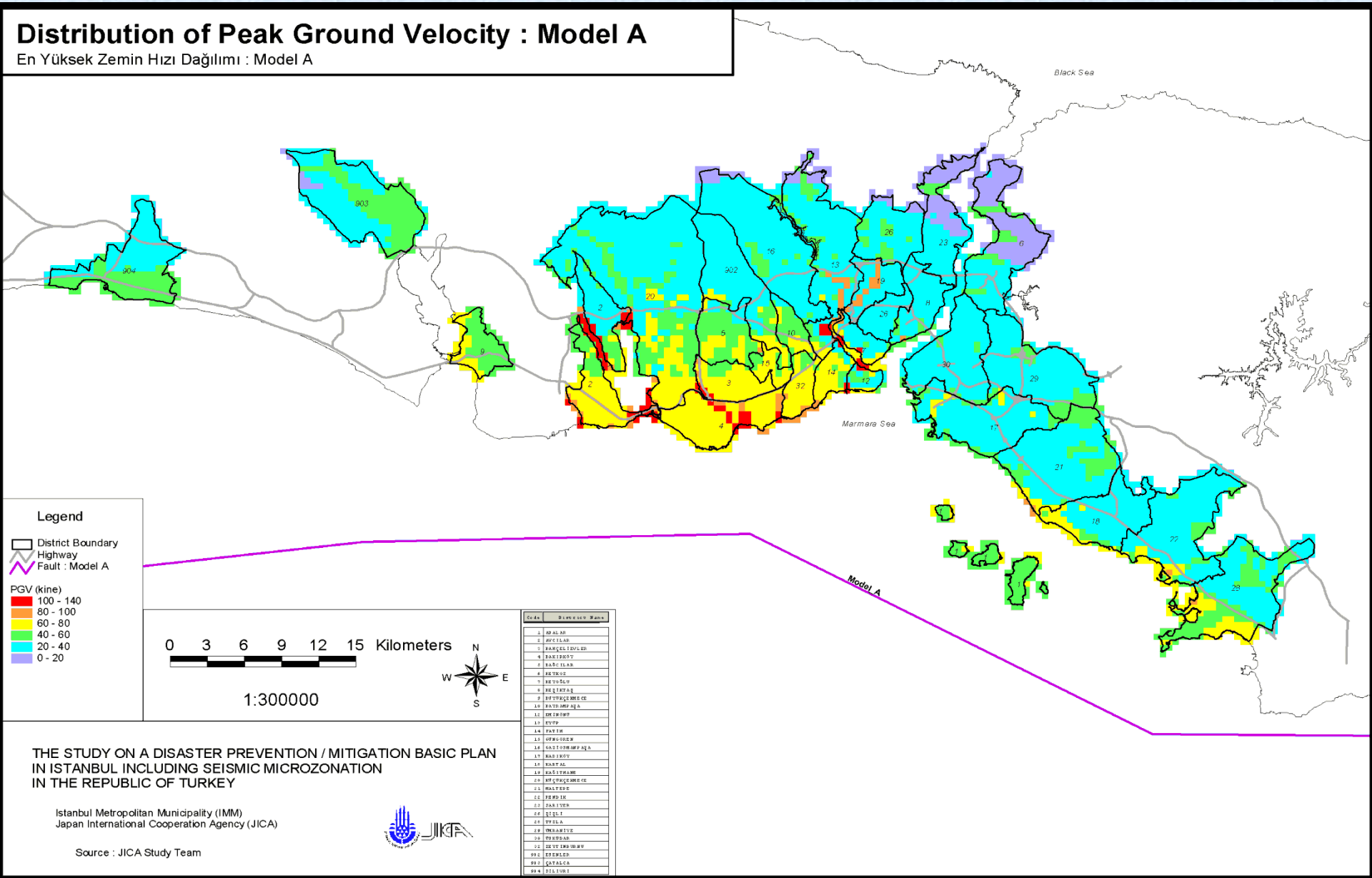
# SEISMIC MACROZONATION STUDIES BY JICA & ISTANBUL MUNICIPALTY ADMINISTRATION FOR EXPECTED EARTHQUAKE



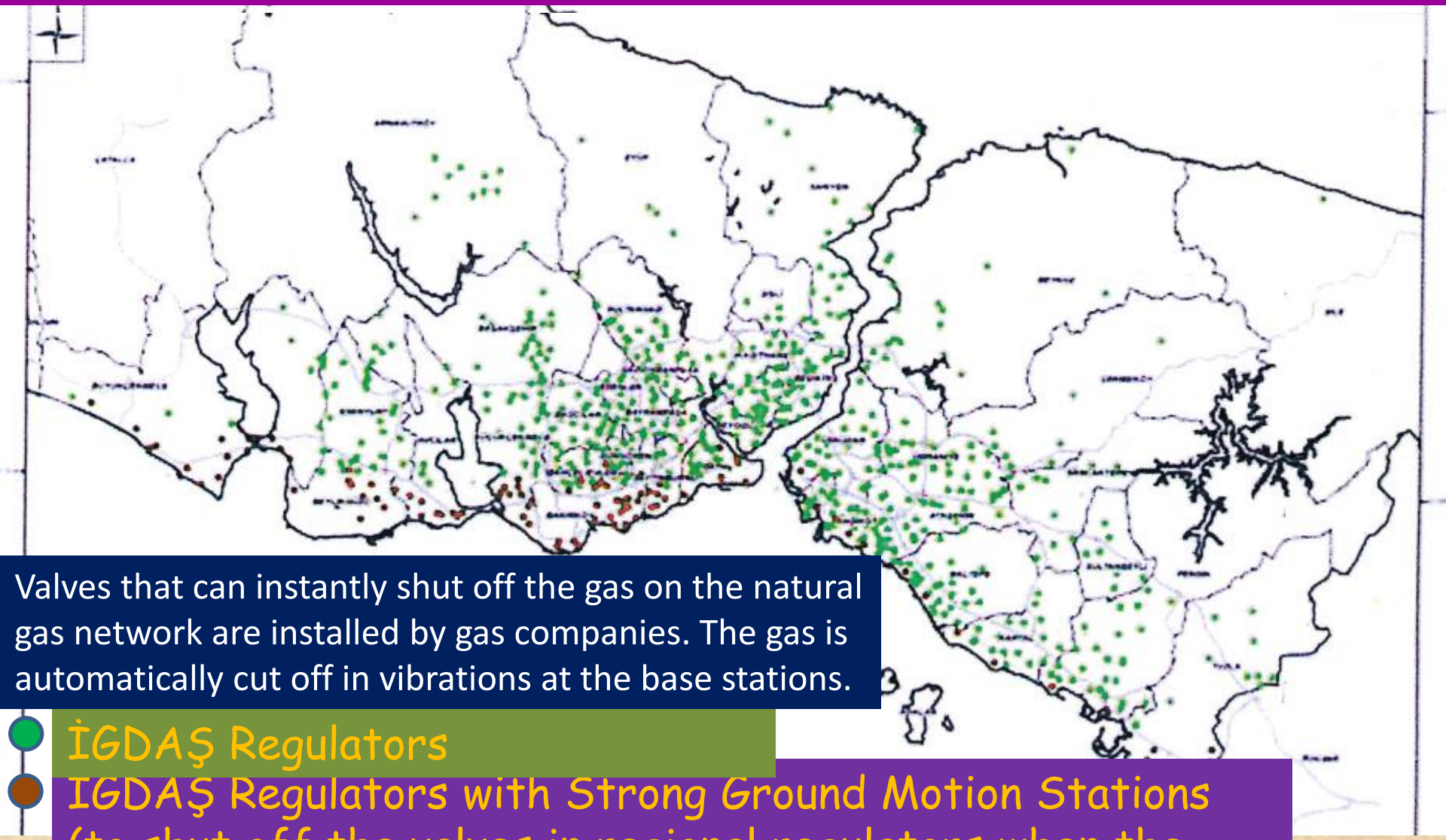
# PREPAREDNESS for an EXPECTED EARTHQUAKE in ISTANBUL



# PREPAREDNESS for an EXPECTED EARTHQUAKE in ISTANBUL



# Distribution of IGDAŞ Discrete Regulators in İstanbul

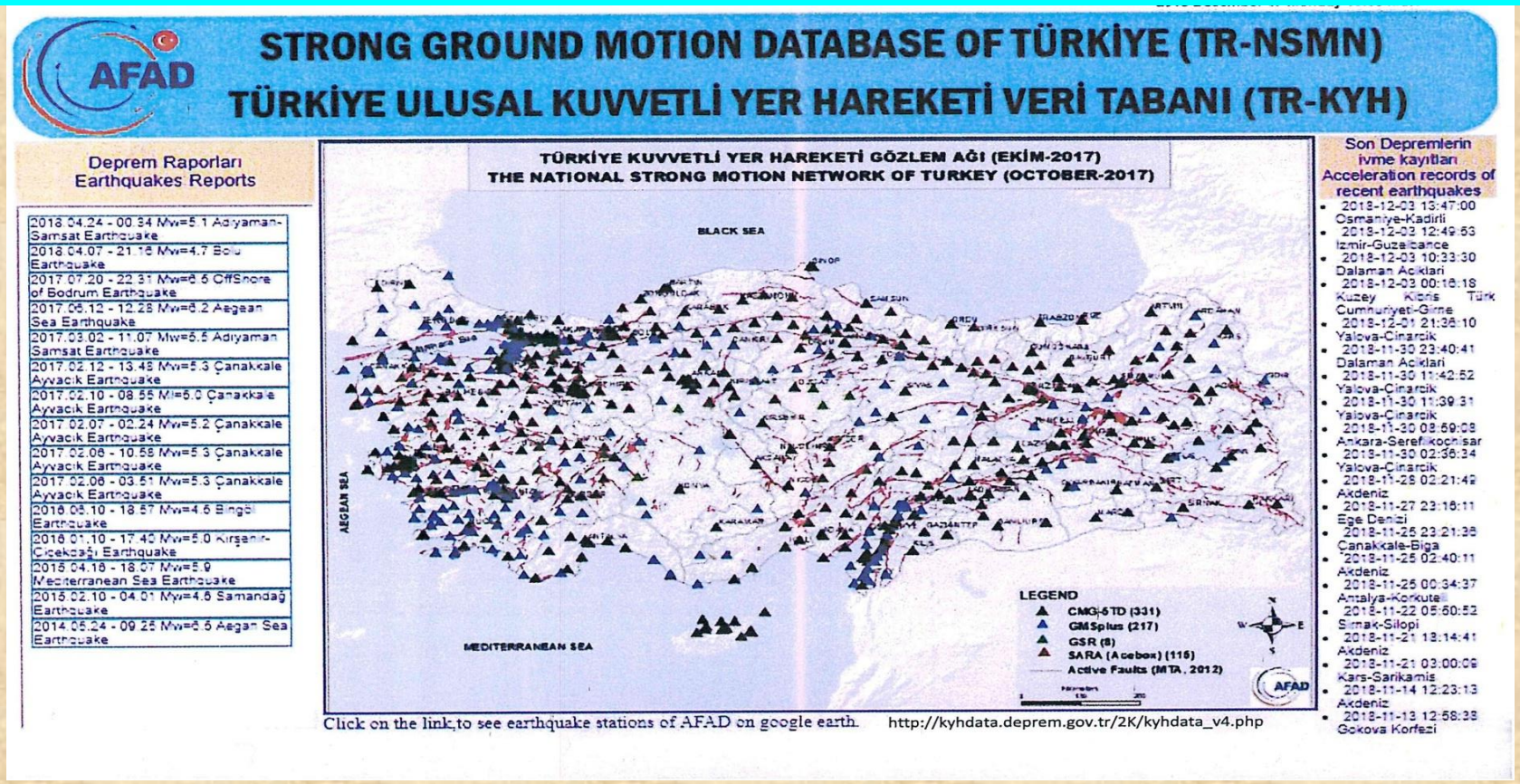


Valves that can instantly shut off the gas on the natural gas network are installed by gas companies. The gas is automatically cut off in vibrations at the base stations.

İGDAŞ Regulators

IGDAŞ Regulators with Strong Ground Motion Stations (to shut off the valves in regional regulators when the threshold ground motion parameters values exceeded)

# Great Hanshin Earthquake Effect in Kobe




The number of accelerometer stations operated by our Agency is 757, as of October 2019. Immediately after a damaging earthquake, the structural damage and loss of life that may occur in the earthquake zone is estimated before the information is received yet.

# NEW TURKISH BUILDING SEISMIC DESIGN CODE (2019)

https://tdth.afad.gov.tr/main.xhtml

Interactive Web Application


- It is planned to present "Earthquake Hazard Maps of Turkey", which are also developed consistent with "Turkish Building Earthquake Code".
- Earthquake hazard maps in terms of peak ground acceleration, peak ground velocity, 5%-damped pseudo-spectral accelerations at 0.2 sec and 1.0 sec periods for return periods of 43, 72, 475 and 2475 years (68%, 50%, 10%, 2% probability of exceedance in 50 years, respectively)

# NEW TURKISH BUILDING SEISMIC DESIGN CODE (2019)

## Turkish Building Earthquake Code-2019

### Scope

- Design of new buildings
- Assessment of existing buildings
- Strengthening of Existing buildings

# Legislative Preparedness for Future

- Construction Supervision- Professional qualification of the inspection engineer should be made.
- Refinement of Earthquake Resistant Design Procedure (Revised Code)
- Found of Compulsory Earthquake Insurance (DASK) is Established by Law- September 2000

The Main and Unique Objective of Scientists is to Reduce the Sorrow of Humanity - **Bertold Brecht**

# Training Programs for Engineers & Earthquake Drills for NGO

- Training Programs & Drills Incorporated with The Civil Defence & Fire Brigades Organized byThe Directorate of Emergency Rescue Services
- It Also Targets Training Volunteers & Certifies Their Accomplishments


- Training Programs for Damaged Structures Carried Out For Engineers Continuously by The Turkish Civil Engineering Chamber

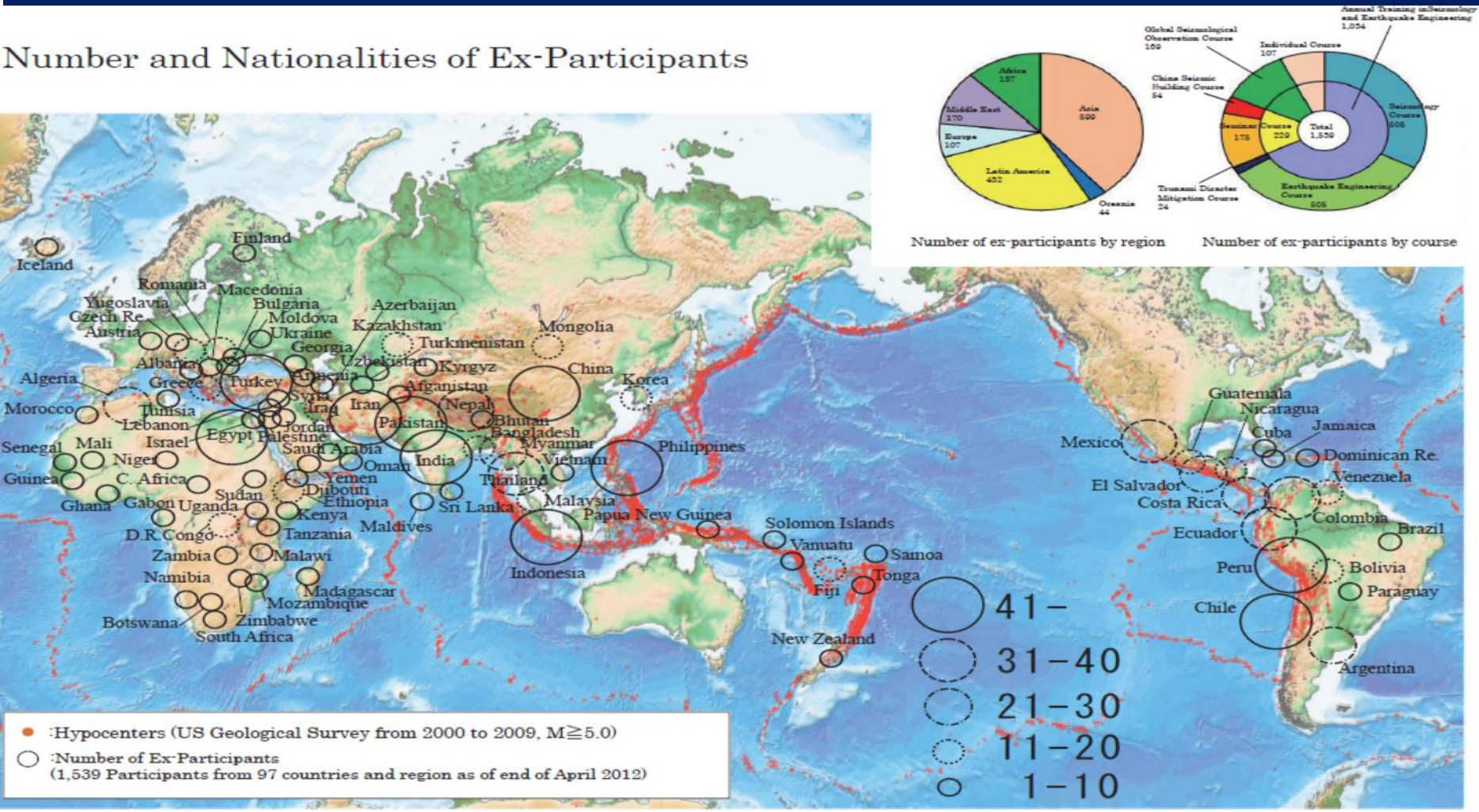
- Earthquake Drill Organized by Istanbul Metropolitan Municipality (IMM)
- Emergency Rescue Training for High School and University Students as well as Ordinary Citizens.

# RETROFITTING WORKS for SCHOOL BUILDINGS in ISTANBUL just After August 17th 1999

| | |
|---|---|
| Total Number of Schools | 2364 |
| Total Number of Blocks | 2672 |
| Planned for Retrofitting | 1783 Number of Blocks |
| Completed Projects | 478 Number of Blocks |
| Decided for Demolishing | 54 Number of Blocks |
| Completed Retrofitting | 72 Number of Blocks |
| Newly Constructed | 41 Number of Blocks |

# THE ROLE OF IISEE

•IISEE-Total:1960 to April 2012 : 1,539 (Turkey: Seismology : 31 -Erthquake Eng.: 23 )
+Countries : 97 (1970-2012 JICA) (Individual (S ): 4 ( E ): 9+Seminar+Global:14;Total: 81



# The Pioneers Japanese Academicians, on Visiting at İstanbul Technical University

Prof.Dr. Umemura with Dr. M. İpek who was his assistant and translator of his book, 1991)

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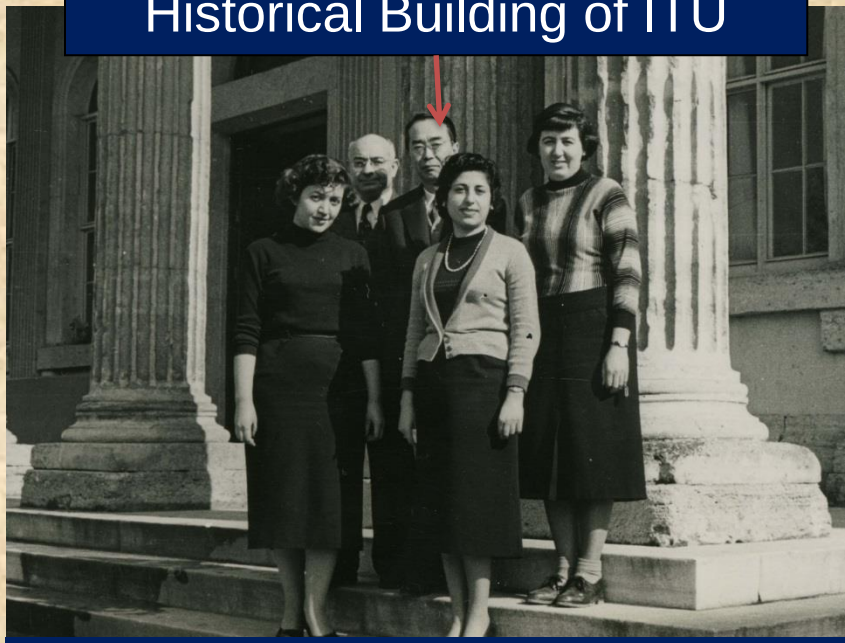
Engineering Seismology lecture notes are organized and the book was printed in Turkish in 1963

Prof. Dr. Takahiro Hagiwara In front of Taşkışla; Central Historical Building of ITU

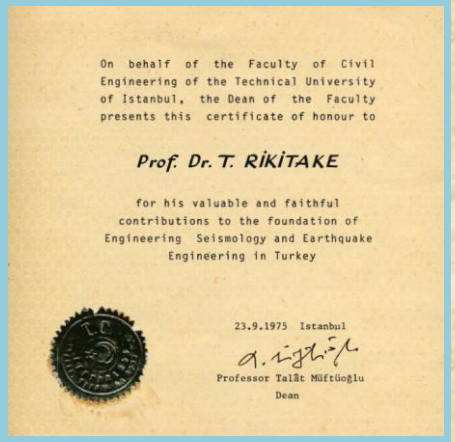


He gave the first 'Seismology' course in Istanbul Technical University between the years of 1953 – 1955 assisted by Dr. Silva Büyükaşıkoğlu

# The Pioneers Japanese Academicians, on Visiting at İstanbul Technical University

- **Prof. Dr. Shun'ichiro Omote** specialist (later he became first director of IISE in Tokyo) for Seismology **came to Turkey in the** 1957
- Prof. Dr. Tsuneji Rikitake has lived in Turkey, İstanbul for more than one year(1975) and has visited our country several times.

Prof. Dr. Omote with Prof. Dr. M. İpek (November 1991)



On behalf of the Faculty of Civil Engineering of the Technical University of Istanbul, the Dean of the Faculty presents this certificate of honour to

*Prof. Dr. T. RİKİTAKE*

for his valuable and faithful contributions to the foundation of Engineering Seismology and Earthquake Engineering in Turkey

23.9.1975 Istanbul

Professor Talât Müftüoğlu
Dean

# Prof. Dr. Keizaburo KUBO, Devoted His Life to the Earthquake Resistant Design of Lifeline Structures




Sep. 11, 1980; Moda Deniz Klübü

TRILATERAL CELEBRATION OF PROFESSOR H. UMEMURA'S CONTRIBUTIONS TO ENGINEERING IN JAPAN, TURKEY, AND THE UNITED STATES OF AMERICA

今回は大変ありがとう存じました、思いもかけない会合をもおおしていただいて、一生の思い出です。好い人、おいしい、よい酒、いつまでもトルコ、アメリカ、日本の親しみが続きますように。

梅村 魁

Muzaffer Şpek

Many more happy and productive years for H. Umemura —

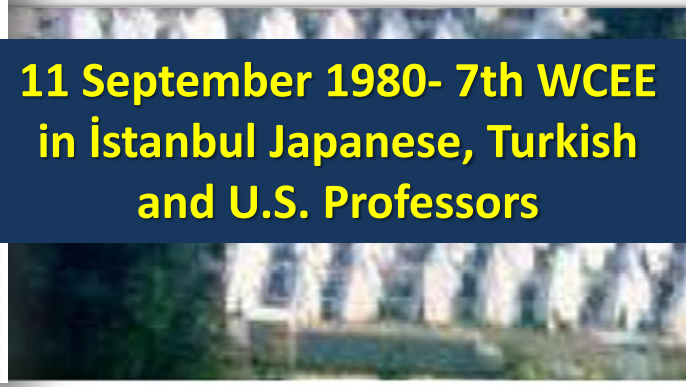
George Housner

With very best regards —
Donald & Phyllis Hudson

To one of the real pioneers of earthquake engineering! Best wishes
Henry & Anna Degenkolb

An honour to see the greats of the technical world
To a long life — Denby Morrison U of ILLINOIS.

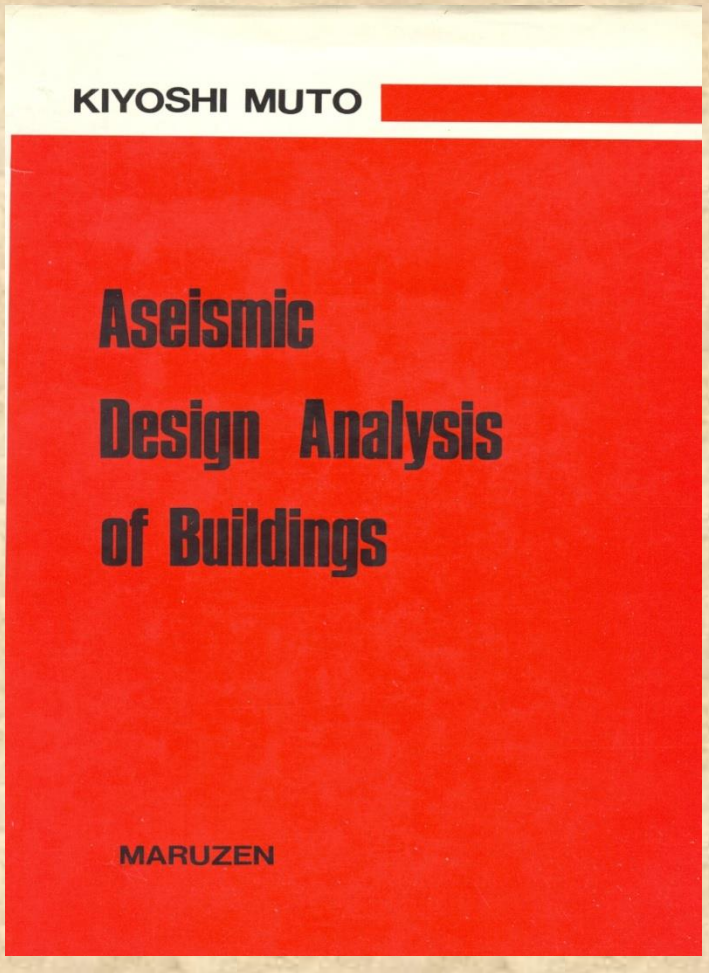
Best wishes to a long life in honour of your many accomplishments in earthquake engineering
Irving & Beverly Wyllie



**11 September 1980- 7th WCEE in İstanbul Japanese, Turkish and U.S. Professors**

# The Pioneers Japanese Academicians, on Visiting at İstanbul Technical University

Photo 4. Professors Yarar and Muto at Muto's office in Tokyo (July, 1977)




"D Method" was introduced to the world by an article presented to the 1956 Earthquake Engineering World Conference by Kiyoshi Muto, a professor at Tokyo University.

# Contributions of Japanese Professors Promotion of Earthquake Engineering in Turkey


At Erzurum Airport - April-1992 on the way of Erzincan

## Prof. Dr. Masanori HAMADA- JSCE 2006 President

## (Doctoral Student of Prof. KUBO)

- After 17th August Marmara Earthquake, Prof. Hamada Organized Japanese Academician Group for Earthquake Site Investigation as He Had Come to Turkey with Prof. Ömer Aydan after 1992 Erzincan Earthquake.
- He always supported to develop Turkish and Japan Civil Engineering relationship.
- After the 2011 Great East Japan Disaster (GEJE), he criticized the situation: “The Origin of the GEJE and tsunami disaster was the unrepairable failure of earthquake and tsunami prediction. The sours energy of the earthquake was 180 times larger than of the prediction one.”

# Establishment of ITU Structural and Earthquake Engineering Laboratory is Supported by Prof. Yarar &Prof.Kubo

JICA organizes courses to teach Earthquake Engineering and Disaster Management in ITU.

Pseudo dynamic experiments for model structurall elements is being carried out.

# 3rd Country Training Programs led by ITU were performed in the years of 2014; 2015 and 2016

- Lecturer were from the different establishments such as ITU, JICA, AFAD and TIKA.
- The program contents in these courses are mainly cover:
- Earthquake Engineering, Damages, Seismology, Risk Based Approach to Flood in Turkey, National Strong Motion Observation Systems of Turkey, Experimental Works on Earthquake Engineering, Remediation methods against liquefaction, Soil Dynamics

- Each of them usually has 13-15 participants from the Central Asia and neighboring countries Albania, Azerbaijan, Georgia, Kazakhstan, Moldova, Tajikistan, Turkmenistan, and Uzbekistan.

# ITU – JSCE THE JOINT SYMPOSIUMS

The 2nd JOINT SYMPOSIUM


The 3rd JOINT SYMPOSIUM


# Restructuring and Binding Up Wounds

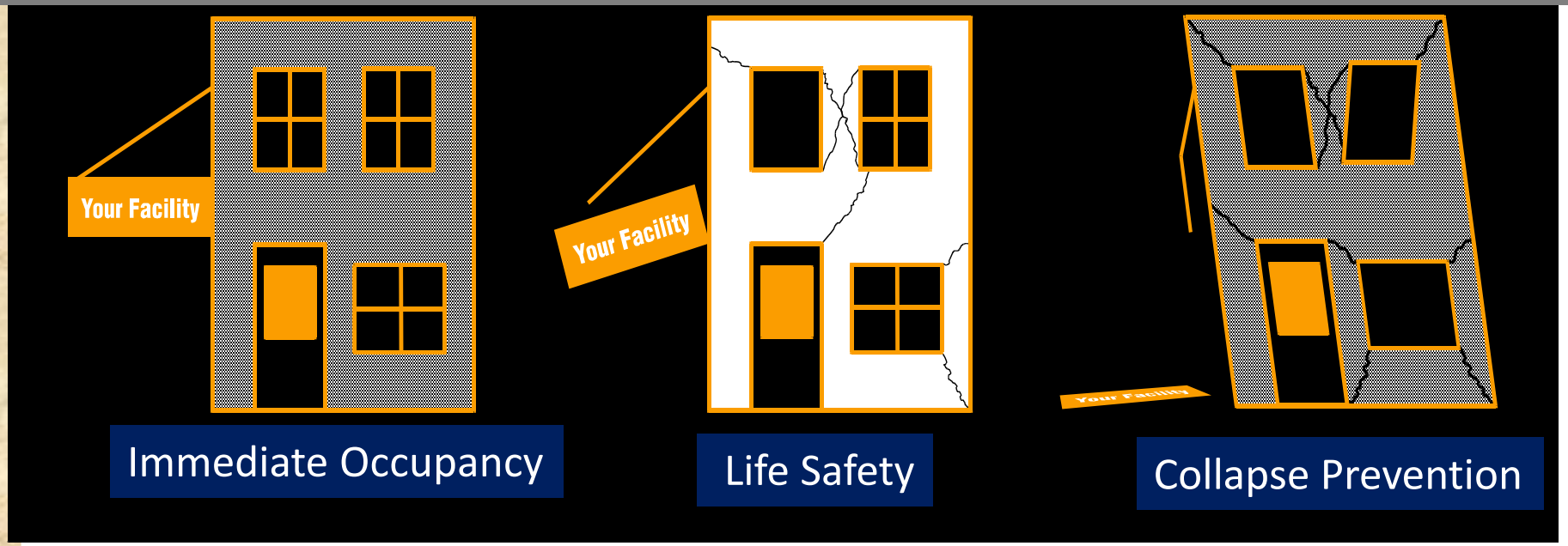
121 Temporary Emergency Shelters Established in Disaster Area in Two Months

12 Thousand Tents - (Field kitchens provided hot food to 200 thousand people)

# Engineering for Earthquakes

## Design Considerations

### Performance objectives



# Seismic Isolation Example -Turkey

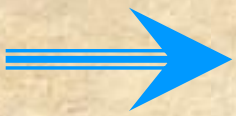

Faculty of Medicine Hospital -Kocaeli University

# The Main Plan after August 17 Kocaeli & November 12, 1999 Düzce Earthquakes

Assessment of Damage & Ownership of Build.

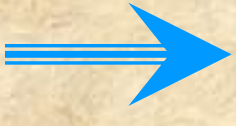
In a short time

Completing the Temporary Structure (26Thousand)



November 30th 1999

Completing Permanent Build.(23 Thousand)



December 2000

# New Settlement Near Hereke- KOCAELİ Province -Project with the World Bank Credit


Reconstructed Buildings in Hereke

# Restructuring & Settlement Areas in ADAPAZARI Province

- Stiff Soil Condition
- Large Area for New Settlement
- Infrastructure completed
- Social facilities completed

Residential Area - 20 km to ADAPAZARI (the city center)

# Social Facilities (Primary School) - New Settlement –Gölcük-Town

# New Settlement Area in Kocaeli Province

Reconstructed Buildings – Gölcük Town

# $S_{BG}$ Indexes-Classical Retrofitting

After the Miyagiken-Oki earthquake in 1978, a total of 362 buildings, 90 of which were apartment buildings, were subjected to earthquake resistance surveys in 1982 and SBG coefficients given by the Institute of Architecture of Japan (*AIJ*) were determined empirically.

Earthquake resistance indexes were calculated for the framed structures in 1983, by Mochizuki, T. and Goto, N. in the region on the North Anatolian Fault:

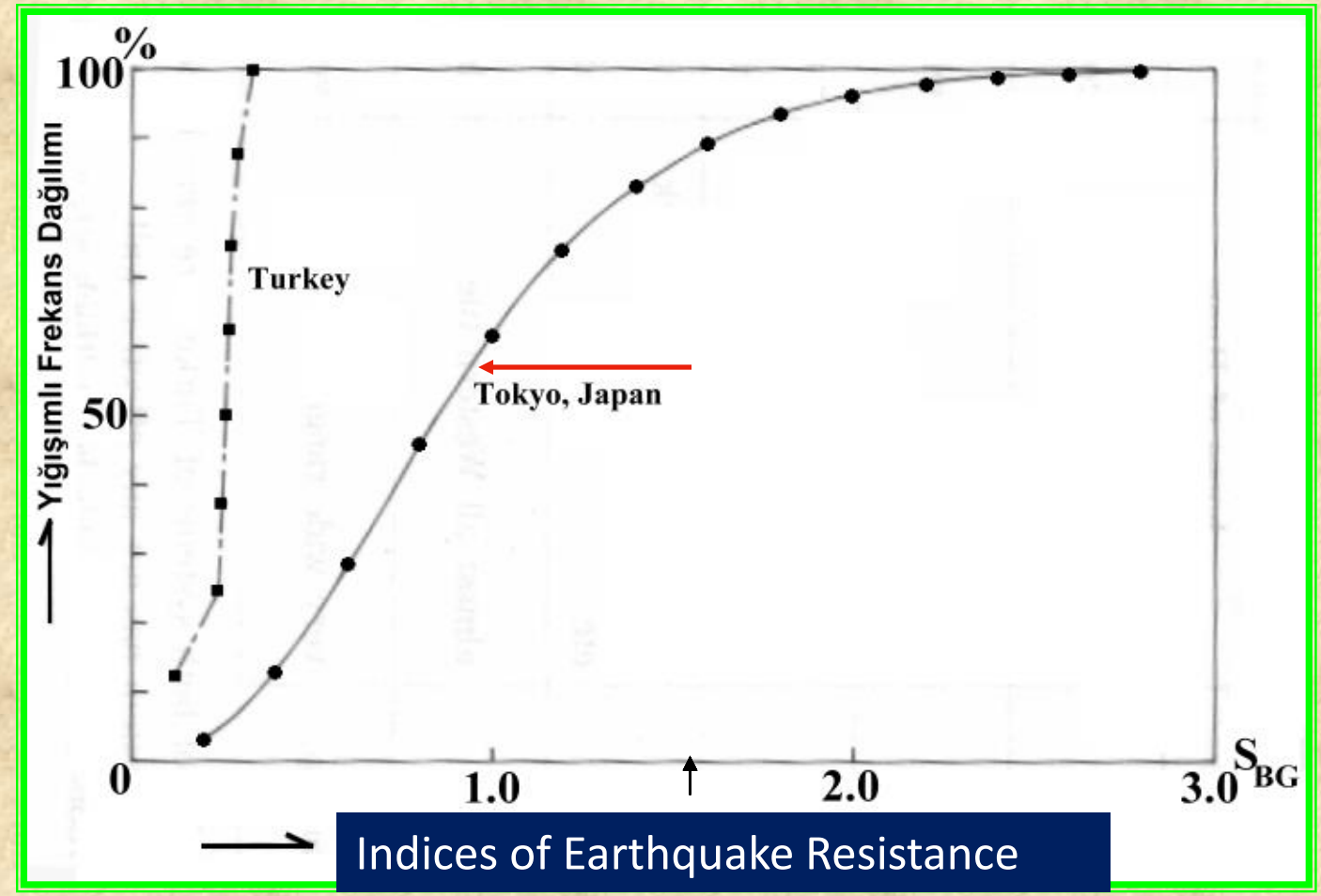
$\Rightarrow$ **$S_{BG}$ = 0.25~0.37**

Before retrofitting when the **$S_{BG}$** indices were examined considering the variability in the compressive strength of 11 buildings in Yalova prefecture obtained as follows:

$\Rightarrow$ **$S_{BG}$ = 0.07~0.22**

After the Kocaeli Earthquake 1999

# $S_{BG}$ Indıces(Mochuzuki,T.and Goto,N.1983




($0.6 \leq S_{BG} < 1.0$) Quite resistant to earthquakes

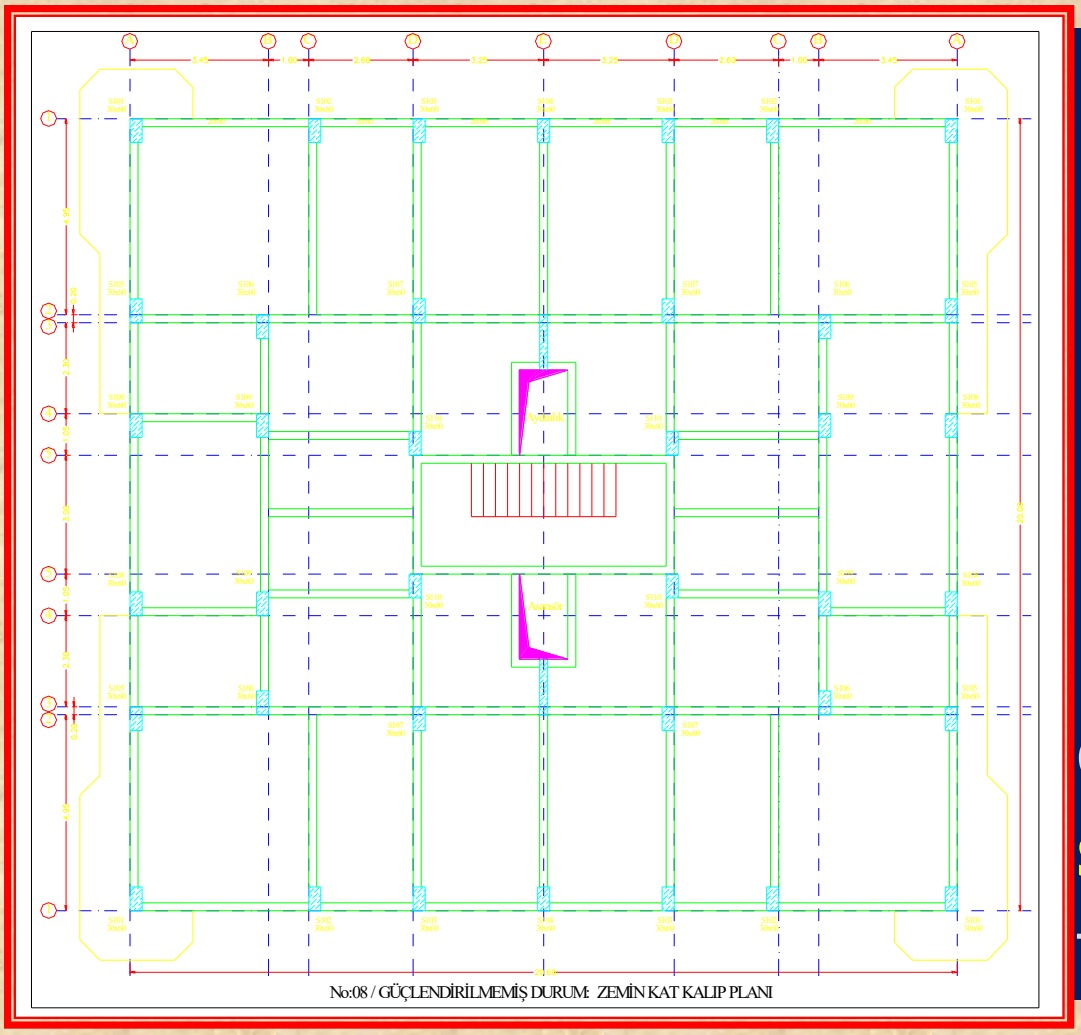
($0.4 \leq S_{BG} < 0.6$ Inadequate against earthquake

# Investigations of $S_{BG}$ Indexes-(in 2000-Yalova Prefecture)

| Building | | | Before Retrofitting | | | After Retrofitting | | |
|---|---|---|---|---|---|---|---|---|
| No | Floor | σ (MPa) | Concrete Class | $S_{BG}$ in X | $S_{BG}$ in Y | Concrete Class | $S_{BG}$ inX | $S_{BG}$ inY |
| B01 | 6 | 3.943 | C12 | 0.11 | 0.14 | C20 | 0.85 | 1.20 |
| B02 | 6 | 3.453 | C12 | 0.13 | 0.22 | C20 | 1.31 | 1.93 |
| B03 | 5 | 4.498 | C12 | 0.24 | 0.07 | C20 | 2.02 | 0.90 |
| B04 | 4 | 2.719 | C12 | 0.17 | 0.20 | C20 | 1.05 | 1.62 |
| B05 | 3 | 2.532 | C10 | 0.09 | 0.15 | C20 | 1.35 | 2.18 |
| B06 | 3 | 2.763 | C10 | 0.21 | 0.20 | C20 | 2.07 | 2.02 |
| B07 | 6 | 4.061 | C13 | 0.08 | 0.14 | C20 | 0.56 | 0.79 |
| **B08** | **6** | **4.120** | **C08** | **0.08** | **0.10** | **C30** | **1.24** | **1.12** |
| B09 | 5 | 4.012 | C18 | 0.16 | 0.18 | C25 | 1.27 | 1.06 |
| B10 | 4 | 3.984 | C10 | 0.13 | 0.13 | C20 | 1.22 | 1.21 |

# EXAMPLE- RC BUILDING -B08 in YALOVA PROVINCE

## *BEARING SYSTEM BEFORE RETROFITTING*




17.08.1999 KOCAELI EARTHQUAKE

B08 : 6 FLOORS

**MODERATE DAMAGE**

FRAMED STRUCTURE

Material Strength:

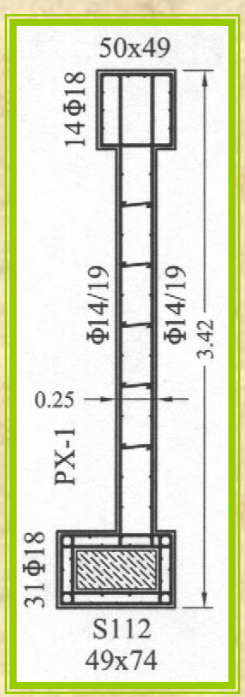
C8-S220) R=4.0

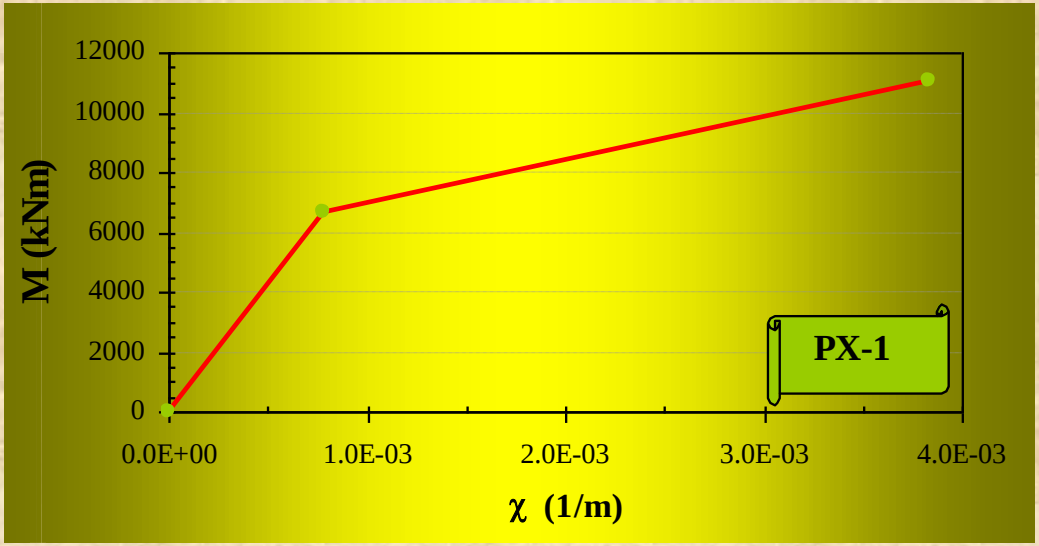
$S_{BG} \cong 0.08$(x-x doğrultusu),

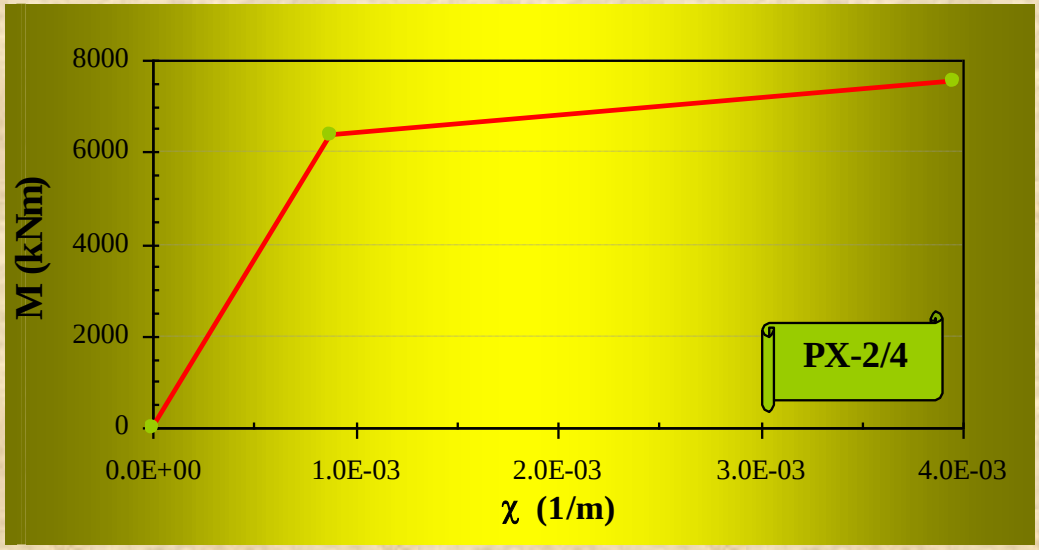
$T_{(x-x),1}=0.85$

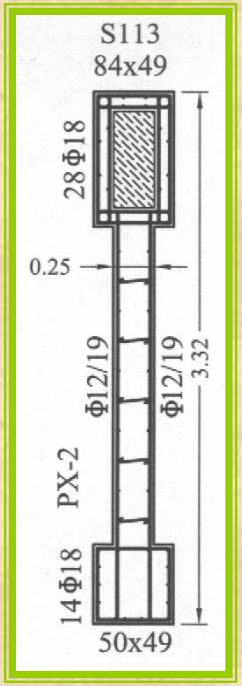
# EXAMPLE- R-C BUILDING -B08

## AFTER RETROFITTING



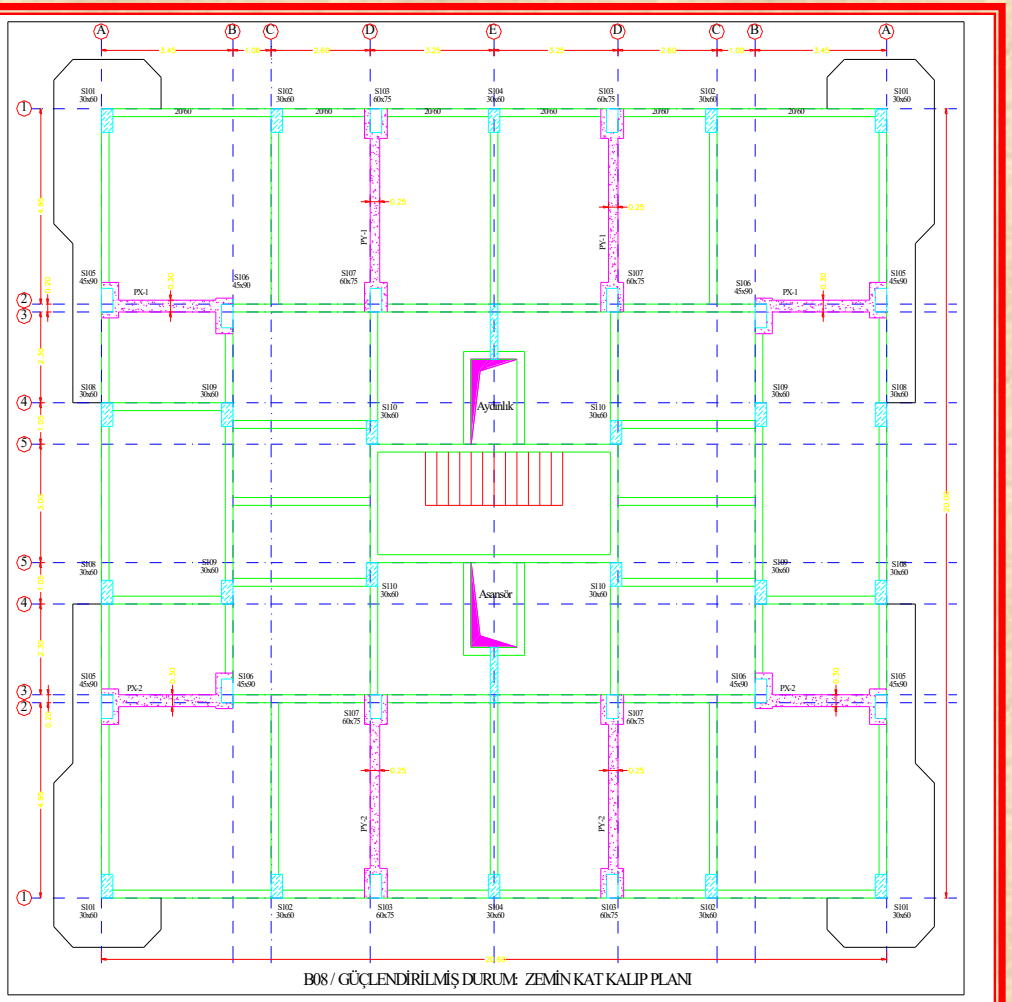



# INCREASING BEARING CAPACITY of RC BUILDING (B08)

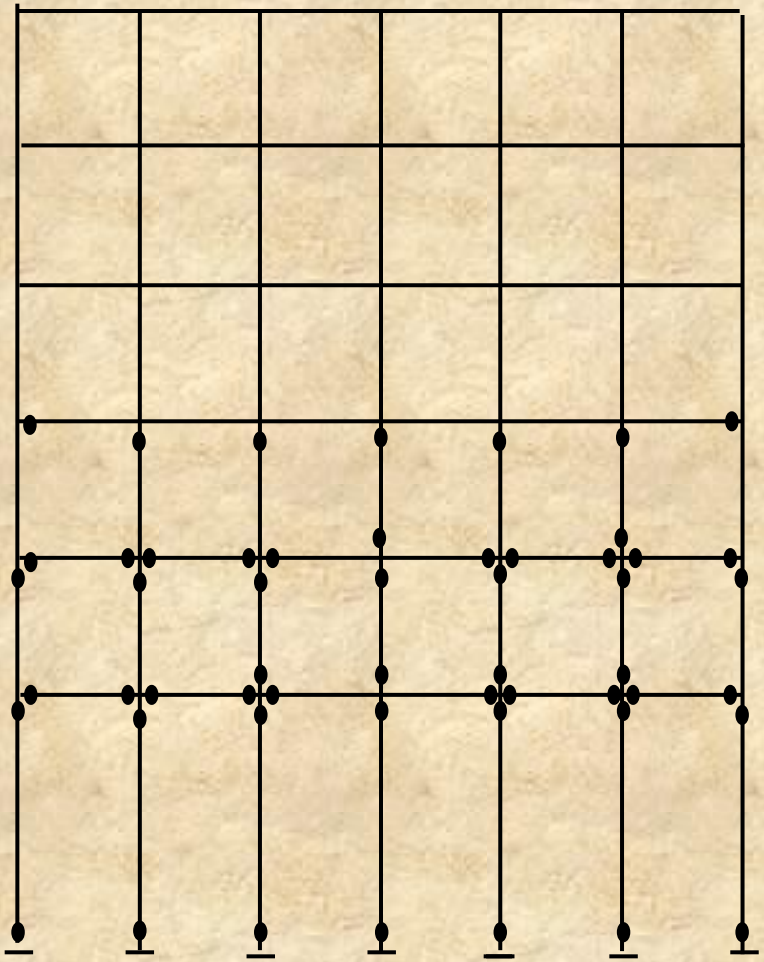
## (AFTER RETROFITTING)

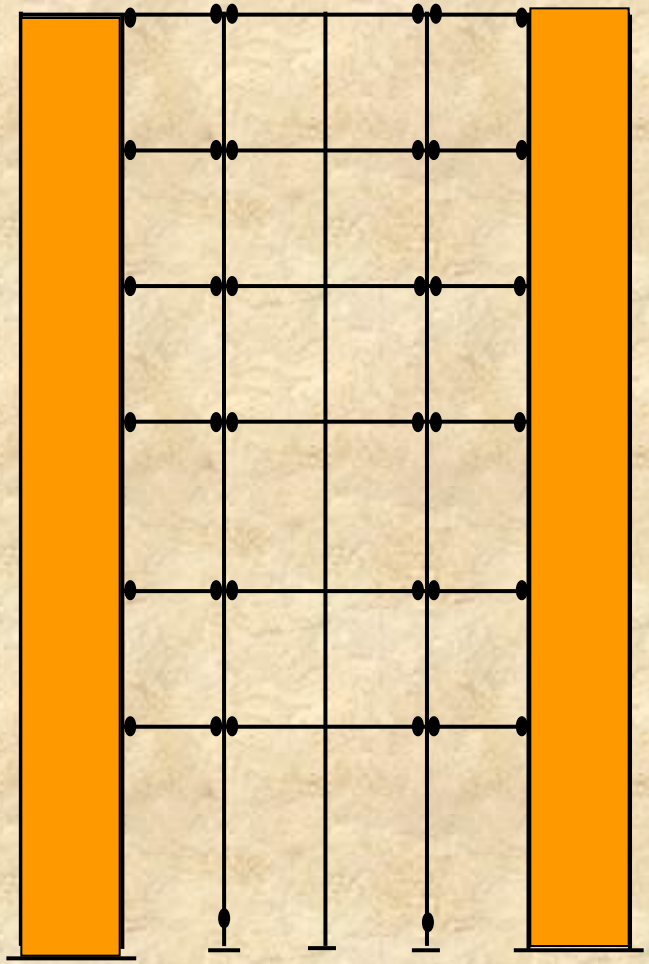
$S_{BG} \cong 1.24$ (x-x ), C30/ S420




- Totally 8 RC shear walls were added.
- Columns were placed at the both ends of the walls.
- New columns were added just below the stud beams corresponding to the ends of the added walls.
- Only for the ground floor, all old columns are jacketed due to the provision of load transfer to the foundation and corrosion effects.

# Plastic Hinges Distribution in 2-2 Axes





Before Retrofitting

After Retrofitting

**Nonlinear Time Domain Analysis Solutions for the Sample Building, under the Sakarya-EW 1999 Acceleration Record.**

# Measures Against Ground Shaking &Tsunami in Japan

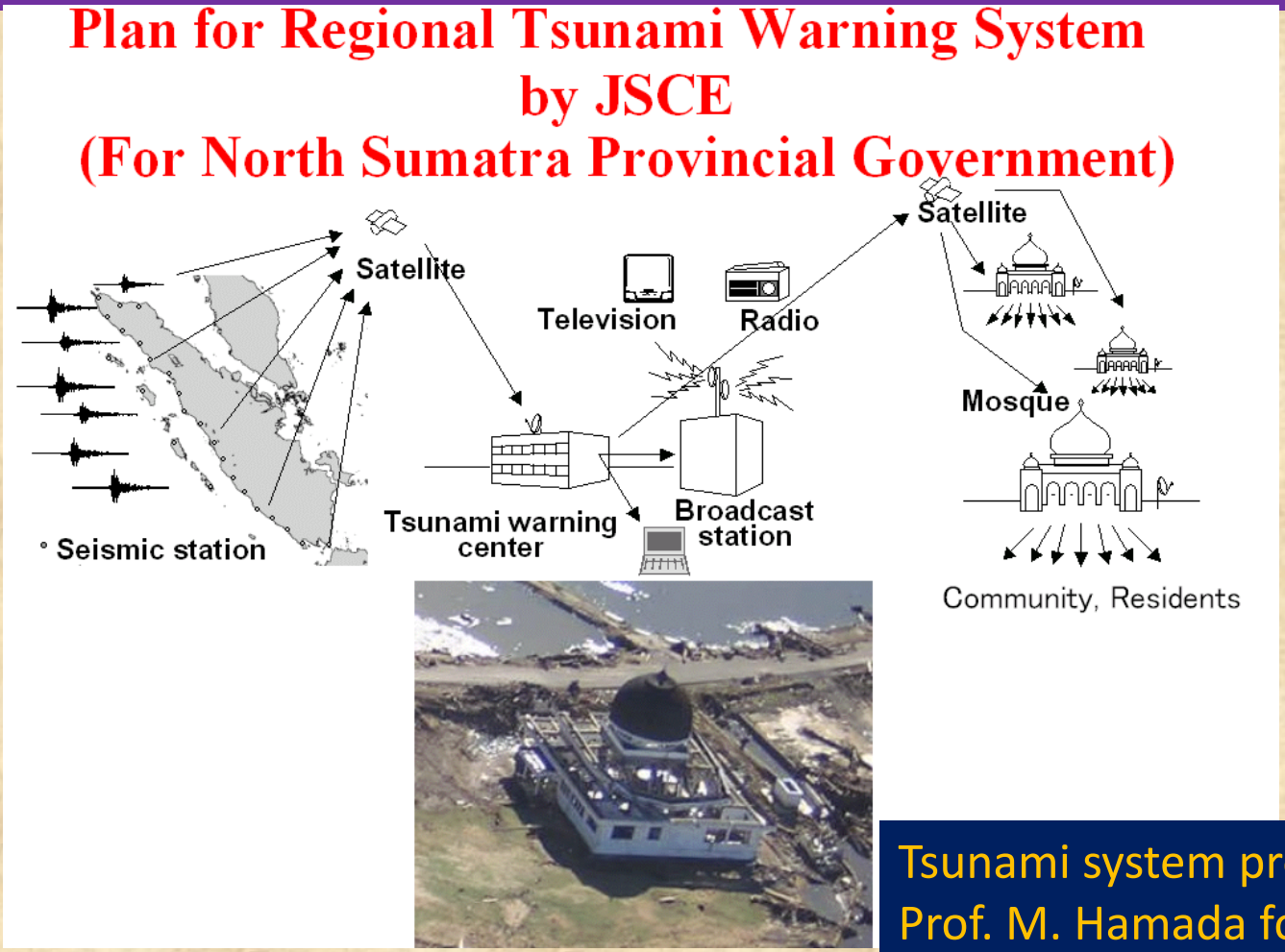
Tokai University Shimizu Campus

**The existing buildings must be retrofitted against strong ground shaking and they should be equipped with terraces and stairs for the vertical evacuation in tsunami-vulnerable areas**

*Prof.Ömer Aydan*

# Strengthening **Tokai University Shimizu Campus** -Steel Trusses

# Recommendations for measures against Tsunami




Tsunami system proposed by Prof. M. Hamada for Sumatra

Japanese Tsunami Warning System

Vertical Evacuation (Retrofitted RC Buildings with Terraces on top）

Education of people – KOGAMI

# World Ranking of Suspension Bridges to Their Interior Spans

| | Bridge Name | Country | Interior Span | Completion Year |
|---|---|---|---|---|
| 1 | Akashi Kaikyo | Japan | 1991 m | 1998 |
| 2 | Xihoumen | China | 1650 m | 2009 |
| 3 | Great Belt East | Denmark | 1624 m | 1998 |
| **4** | **Osman Gazi** | **Turkey** | **1550 m** | **2017** |
| 5 | Yi Sun-sin | Korea | 1545 m | 2012 |
| 6 | Runyang | China | 1490 m | 2005 |
| 7 | Nanjing Fourth Yangtze | China | 1418 m | 2012 |
| **8** | **Humber** | **England** | **1410 m** | **Ranked first between 1981 - 1998** |
| 9 | Jiangyin Yangtze | China | 1385 m | 1999 |
| 10 | Tsing Ma | Hong Kong | 1377 m | 1997 |
| 11 | Verrazano Narrows | USA | 1298 m | 1964 |
| 12 | Golden Gate | USA | 1280 m | 1937 |
| 13 | Yangluo | China | 1280 m | 2007 |
| 14 | Högakustenbron | Sweden | 1210 m | 1997 |
| 15 | Mackinak Straits | USA | 1158 m | 1957 |
| 16 | Aizhai | China | 1146 m | 2012 |
| 17 | Huangpu | China | 1108 m | 2008 |
| 18 | Minami Bisan- Seto | Japan | 1100 m | 1988 |
| **19** | **Fatih Sultan Mehmet** | **Turkey** | **1090 m** | **1988** |

# After Retrofitting

# BOSPHOROUS SUSPENSION BRIDGE-(1973) L=1.560KM

Oldest Suspension Bridge Closest to North Anatolian Fault

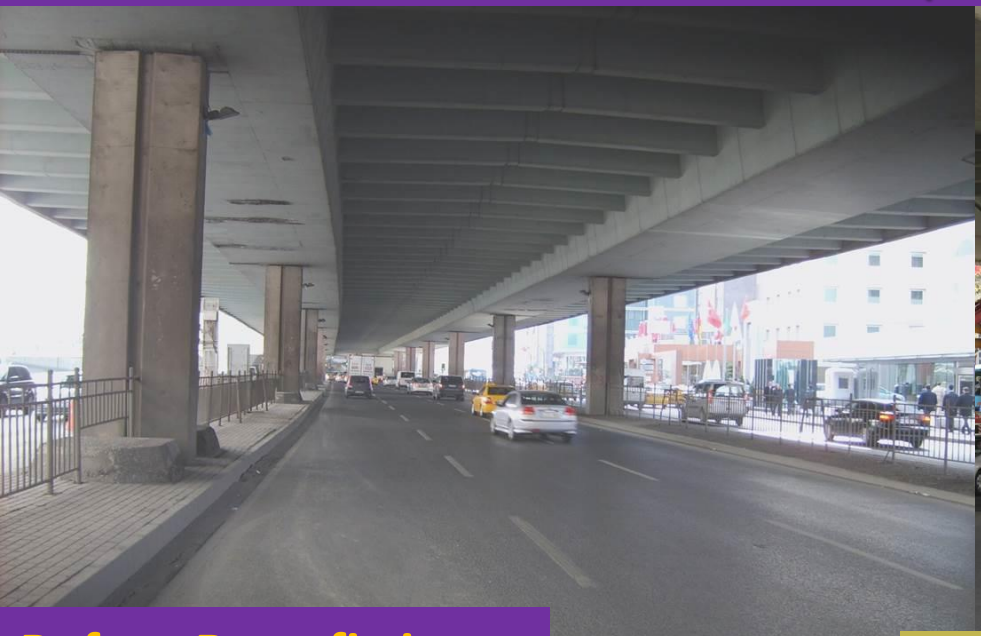
# Important Maintenance of the Bosphorus Suspension Bridge in the 40th Year

Replacement of Old Oblique Hanger Ropes with New Vertical Hangers

4 New Viscous Dampers

# Retrofitting Works

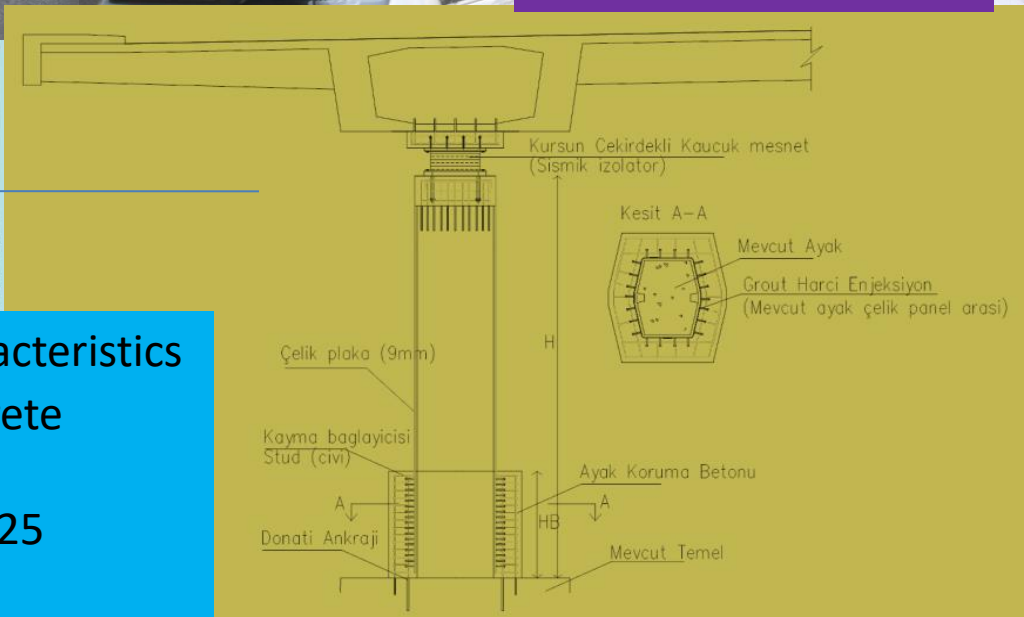
## MECİDİYEKÖY VIADUCT(IN ISTANBUL-1973) L=860M



Before Retrofitting

After Retrofitting

Material Characteristics
General Concrete
Quality: C30
Foundation: C25
Steel:S420

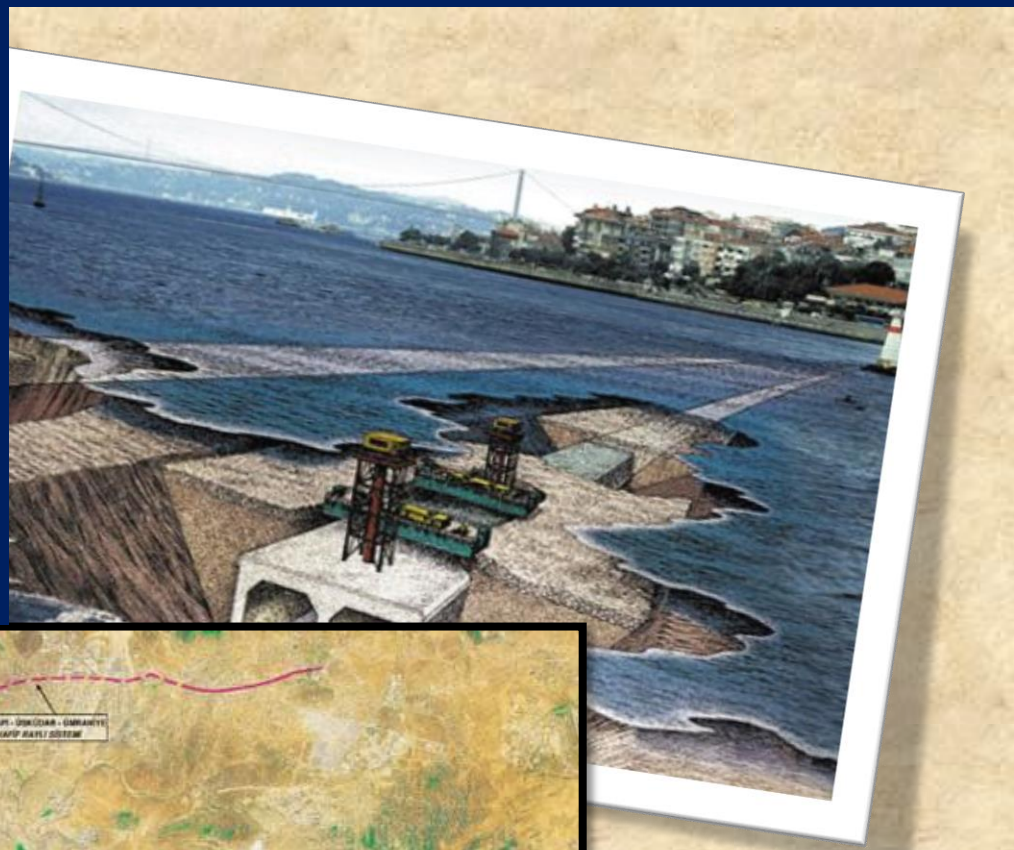


# ORTAKÖY – V408
## (RETROFITTING THE VIADUCT PIER)

# Immersed Tube Tunnel in Bosporus

## The minimum performance requirements

- Damage should be repaired easily and would not result in a loss of function or lives;
- The tunnel would remain watertight;
- The facility would remain operational following the earthquake



# The Marmaray Immersed Tube Tunnel (Opened in 29th of October 2013)


Historic projects joining the two Turkish sides.

75.000 passengers/hour on single direction

Transportation time between two sides of the Strait **now is 4 min.**

# THE CONTEMPORARY, SAFE AND MODERN RAILWAY SYSTEM THAT IS AIMED WITH THE MARMARAY PROJECT

- Following the earthquake require not more than a few days for inspection and adjustment of the rail alignment

- Repair work could be performed with minimum disruption to the operation of the facility

# (Osman GAZİ) İZMİT BAY SUSPENSION BRIDGE

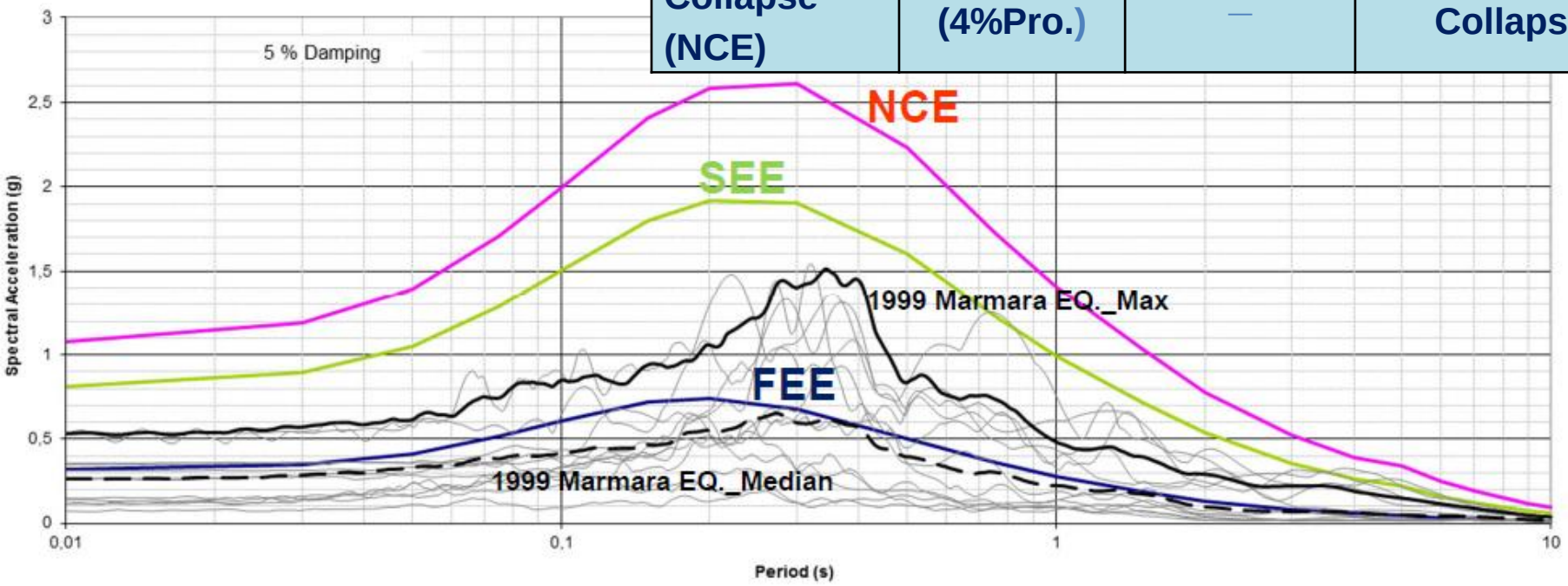
- The Izmit Bay Suspension Bridge is completed as world's fourth longest suspension bridge, by length of central span.
- The total length of the bridge is 3.3 kilometers, with a main span of 1580 meters.

Newest Suspension Bridge Closest to North Anatolian Fault

# Suspension Bridge Earthquake Acceleration Spectra Comparison with the 1999 Marmara Earthquake Data

**Economic Life-100 Year**

| Seismic Event | Return Period | Service P. Level | Damage Level |
|---|---|---|---|
| **Functional (FEE)** | **150 Year (50% Pro.)** | **Instant Access** | **No Damage** |
| **Safety (SEE)** | **1000 Year (10%Pro.)** | **Limited Access** | **Repairable Damage** |
| **Non-Collapse (NCE)** | **2475 Year (4%Pro.)** | — | **No Collapse** |



# A Brief History of Earthquake Codes Enforced in Turkey

***Some Remarks:***

- It is important to note that the Turkish Seismic Design Code has been upgraded in certain time intervals, between 1940 and 2018.

- Only a small portion of the existing buildings has been constructed in accordance with Seismic Design Code until the 1999 Kocaeli Earthquake which has been a milestone in terms of public awareness.

- 1999 Kocaeli Earthquake has deeply affected public and constructors in terms of potential threat to human lives and economy.

- The experienced disaster has been far more effective on the awareness of the public and the attitude of constructors than the revisions in the seismic design codes.

- Economic statistics for the last sixty years show that direct and indirect economic losses engendered by natural disasters account for 3 percent of the country's GDP. Forecasts exist that tell us that in a major earthquake in a major city this ratio may well be doubled.

# Last Remarks

- Some of the natural disasters, just like hurricanes and floods, can be watched and predicted.

- Unfortunately, no one can predict the magnitude of the earthquake on which day and at what time.

- What we need to do is to prepare and plan to minimize the effects of earthquakes.

- Our goal should be to achieve a reliable reconstruction of our country.

- Turkey or in any corner of the world, lost all lives, all the structures for migration, we have to ask this question:

  WHAT WAS WRONG?


Thank You for Your Attention

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