Rapid Seismic Assessment Procedures for Turkish Building Stock

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Introduction

- Project initiated by Disaster and Emergency Management Presidency (AFAD)
- To develop standard rapid assessment procedures and the forms for RC and masonry buildings in Turkey

Content

- Proposed procedure for RC Buildings
  - Summary of existing procedures
  - Procedure
  - Data collection form
  - Verification of the procedure
- Proposed procedure for Masonry buildings
  - Summary of existing procedures
  - Procedure
  - Data Collection form
  - Verification
- Final Remarks

Rapid Screening Procedures

Objective: Ranking buildings according to their safety (risk)

- Building is inspected from the street:
  - Number of stories
  - Plan and vertical irregularities
  - Location
  - Age
  - Material and workmanship quality
  - Structural system

Rapid Screening Procedures-RC Buildings

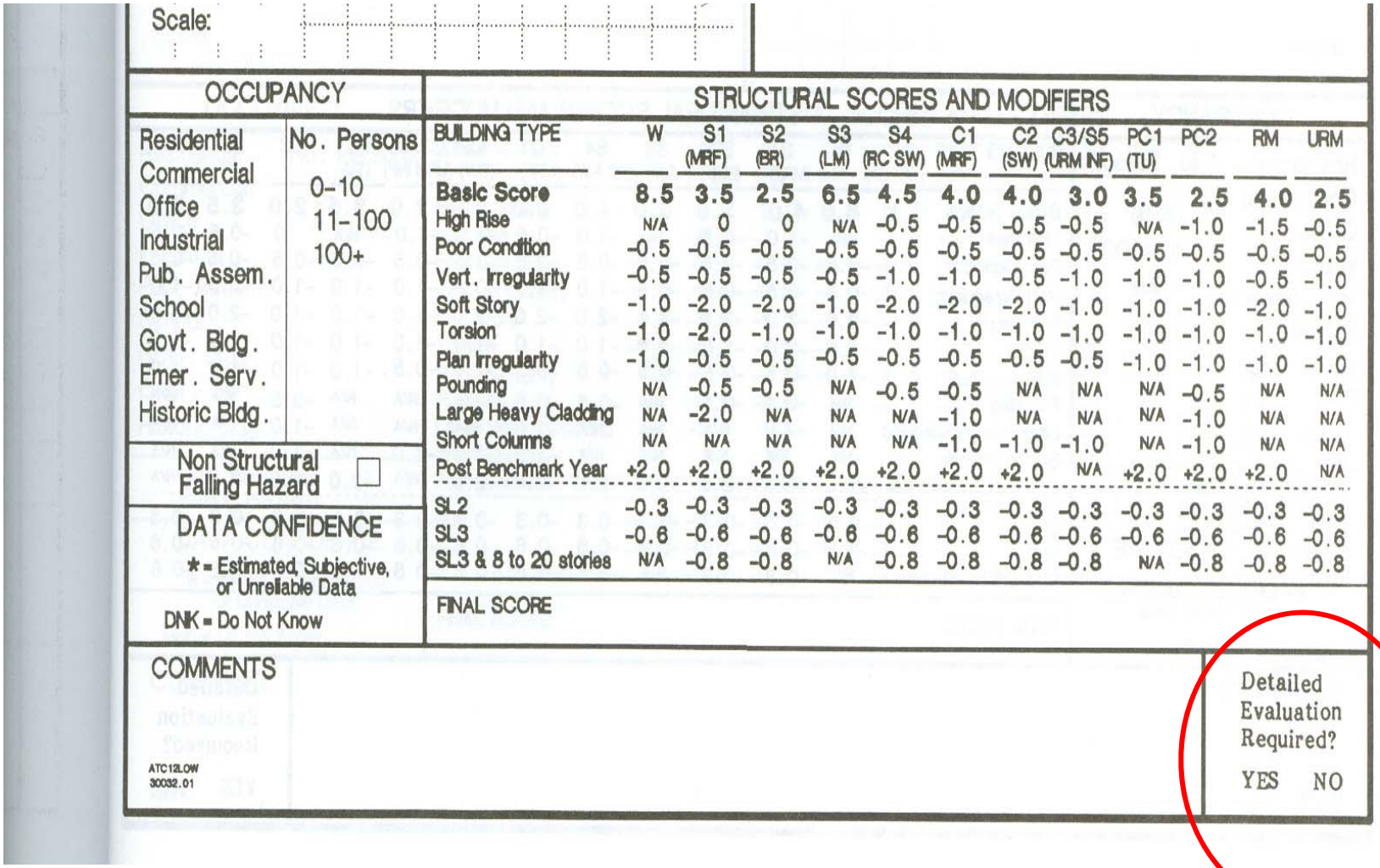
- FEMA 154/ATC21
- Japonesse Seismic Index Method
- METU procedure
- DURTES method
- P25 procedure
- A procedure by Greek researchers

FEMA 154/ATC-21 Procedure

Parameters

- From street survey:
  - Apparent quality
  - Vertical irregularity
  - Soft story
  - Post benchmark year/age
  - Torsion
  - Structural system
  - Short column
  - Pounding

FEMA154/ATC21 procedure



Scale:

OCCUPANCY

Residential	No. Persons
Commercial	0–10
Office	11–100
Industrial	100+
Pub. Assem.	
School	
Govt. Bldg.	
Emer. Serv.	
Historic Bldg.	

Non Structural Falling Hazard ☐

DATA CONFIDENCE

* = Estimated, Subjective, or Unreliable Data

DNK = Do Not Know

STRUCTURAL SCORES AND MODIFIERS

BUILDING TYPE	W	S1 (MRF)	S2 (BR)	S3 (LM)	S4 (RC SW)	C1 (MRF)	C2 (SW)	C3/S5 (URM INF)	PC1 (TU)	PC2	RM	URM
Basic Score	**8.5**	**3.5**	**2.5**	**6.5**	**4.5**	**4.0**	**4.0**	**3.0**	**3.5**	**2.5**	**4.0**	**2.5**
High Rise	N/A	0	0	N/A	-0.5	-0.5	-0.5	-0.5	N/A	-1.0	-1.5	-0.5
Poor Condition	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
Vert. Irregularity	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-0.5	-1.0	-1.0	-1.0	-0.5	-1.0
Soft Story	-1.0	-2.0	-2.0	-1.0	-2.0	-2.0	-2.0	-1.0	-1.0	-1.0	-2.0	-1.0
Torsion	-1.0	-2.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
Plan Irregularity	-1.0	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-1.0	-1.0	-1.0	-1.0
Pounding	N/A	-0.5	-0.5	N/A	-0.5	-0.5	N/A	N/A	N/A	-0.5	N/A	N/A
Large Heavy Cladding	N/A	-2.0	N/A	N/A	N/A	-1.0	N/A	N/A	N/A	-1.0	N/A	N/A
Short Columns	N/A	N/A	N/A	N/A	N/A	-1.0	-1.0	-1.0	N/A	-1.0	N/A	N/A
Post Benchmark Year	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	+2.0	N/A	+2.0	+2.0	+2.0	N/A
SL2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3
SL3	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
SL3 & 8 to 20 stories	N/A	-0.8	-0.8	N/A	-0.8	-0.8	-0.8	-0.8	N/A	-0.8	-0.8	-0.8

FINAL SCORE

COMMENTS

ATC12LOW
30032.01

Detailed Evaluation Required?

YES NO

METU procedure (Sucuoğlu *et al*. 2007)

1-7 story RC

- Number of stories
- Soft story
- Heavy overhangs
- Pounding
- Short column
- Apparent quality

METU procedure (Sucuoğlu *et al*. 2007)

- Local soil conditions and seismicity

  Zone I : PGV>60 cm/s

  Zone II : 40<PGV<60 cm/s

  Zone III : PGV<40 cm/s

Japanese Seismic Index Method

- Relies on field survey and simple engineering computations
- Adopted for Turkey by İTÜ
- Three-level procedure
- Member capacities are computed from areas and material properties

Japanese Seismic Index Method

- Building performance is represented by Structure Seismic Index, I_S

$$I_s = E_o * S_D * T$$

- Seismic Index Demand, I_{SO} is expected to be less than the seismic index

$$I_{so} = E_o * Z * G * C$$

DURTES Method

The information including;

- Properties of structure
- Local soil conditions
- Seismic sources
- Existing damage

is used to determine performance

DURTES Method

- Structural Safety Factor, GS

$$GS = \frac{(V_x - V_y)_{min}}{V_{dep}}$$

- Relative Condition Score, GDP

  GDP= GS*Structure score

  Structure score (<100) is obtained from the information compiled through the form

DURTES: Risk assessment

Structural Safety Score(GS)	Relative Condition Score Range(GDP)	Risk level
≥ 1	-	Minimum risk
< 1	75	Low risk
< 1	50 - 74.999	Moderate risk
< 1	25 - 49.999	High risk
< 1	0 - 24.999	Very high risk

P25 procedure (Bal *et al*. 2007)

- Identify buildings having risk of collapse
- Use of drawings or information from field surveys
- Basic structural score is calculated
  - Member size and properties
  - Irregularities
  - Material properties
  - Soil properties
- Seven failure scores are calculated and combined for final score to determine collapse risk

Procedure of Greek researchers (Sextos *et al*. 2008)

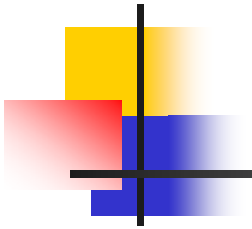
Similar to FEMA 154

- Irregularity
- Pounding
- Short Column
- Prior damage
- Seismic zone and soil class
- Structural system

Proposed Procedure: RC Buildings-Parameters

- Structural system: RC frame, RC frame with walls, RC walls
- Number of free stories: Number of stories free to vibrate (exluding basements).
- Existing condition and apparent quality: Visual assessment

  Good, Poor, Moderate



Parameters

- Soft story/weak story: Height difference, apparent difference in rigidity
- Vertical irregularity: Discontinuous frames, vertical members
- Heavy overhangs
- Plan irregularity/torsion: Irregular floor plan and unsymmetric member layout

Parameters

- Short column
- Adjacency/pounding: Floor levels, building location within a block
- Topographic effect: Buildings on a slope/hill
- Seismic zone and soil class: Consistent with the current seismic code

Data collection form

Front

BETONARME BİNA HIZLI DEĞERLENDİRME VERİ DERLEME FORMU

TARİH :

FORM 1 BİNA KİMLİK BİLGİLERİ **Sıra No:.....**

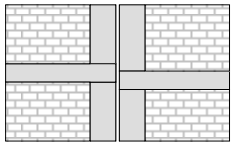
BÖLGE NO					
MAHALLE					
CADDE / SOKAK					
KAPI NO / BİNA ADI					
PAFTA / ADA / PARSEL					
KENT BİLGİ SİST.NO					
BİNANIN TAHMİNİ YAŞI					
COĞRAFİ KOORDİNATLAR (GPS) (E/ N)					
FORM 2 BİNA TEKNİK BİLGİLERİ					
YAPISAL SİSTEM TÜRÜ	☐ BA ÇERÇEVE			☐BA ÇERÇEVE VE PERDE	
KAT ADEDİ (BODRUM HARİÇ)	.....ZEMİN	.....ASMA	.....NORMAL	.....ÇEKME	.....TOPLAM
GÖMÜLÜ BODRUM	☐ VAR(.....)	☐ YOK	☐ KISMİ		
SERBEST KAT ADEDİ	....ADET				
KOROZYON DURUMU	☐ YOK	☐ AZ	☐ ORTA	☐ ÇOK	
TAŞIYICI ELEMANLARIN HASAR DURUMU	☐ ÇOK KÖTÜ	☐ KÖTÜ	☐ ORTA	☐ İYİ	☐ ÇOK İYİ
YAKLAŞIK CEPHE GENİŞLİĞİ	.....m				
YAKLAŞIK BİNA DERİNLİĞİ	.....m				
YAPI NİZAMI	☐ AYRIK	☐ BİTİŞİK	☐ KÖŞEDE BİTİŞİK		
BİTİŞİK BİNALARLA DÖŞEME SEVİYELERİ	☐ AYNI	☐ FARKLI			
İLAVE KAT DURUMU	☐ VAR (.....)	☐ YOK	☐ BELİRLENEMEDİ		
AĞIR ÇIKMALAR	☐ VAR	☐ YOK			
ZAYIF / YUMUŞAK KAT	☐ VAR	☐ YOK			
KISA KOLONLAR	☐ VAR	☐ YOK			
KONSOLA OTURAN KOLON	☐ VAR	☐ YOK			
DÜŞEYDE DÜZENSİZLİK	☐ VAR	☐ YOK			
PLANDA DÜZENSİZLİK	☐ VAR	☐ YOK			
ARSADA İSTİNAT DUVARI	☐ VAR(.....)	☐ YOK			
BİNA GÖRSEL KALİTESİ	☐ İYİ	☐ ORTA	☐ KÖTÜ		
TABİİ ZEMİN EĞİMİ	☐ DÜZ	☐ AZ EĞİMLİ	☐ ÇOK EĞİMLİ		
TARİHİ BİNAYA BİTİŞİK Mİ?	☐ EVET	☐ HAYIR			
ZEMİN KAT FONKSİYONU	☐ KONUT	☐ TİCARET	☐ SANAYİ	☐ KAMU	☐ METRUK
ZEMİN SINIFI	☐ Z1	☐ Z2	☐ Z3	☐ Z4	
NORMAL KATLAR FONKSİYONU	☐ KONUT	☐ TİCARET	☐ SANAYİ	☐ KAMU	☐ METRUK
YANGIN MERDİVENİ	☐ VAR	☐ YOK			
FOTOĞRAF	☐ VAR	☐ YOK			

İNCELEME EKİBİ **KONTROL EKİBİ** **İDARE KONTROL TEŞKİLATI**

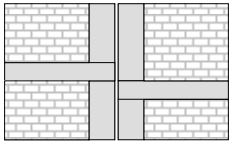
....

....

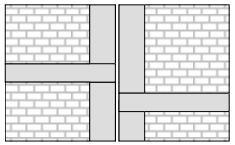
Back



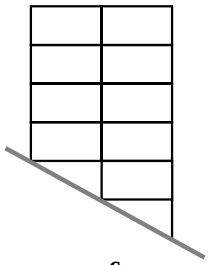
1) AYNI



2) AYNI
(LİMİT DURUM)



3) FARKLI



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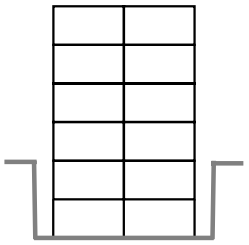

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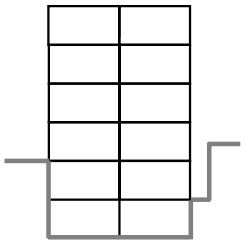

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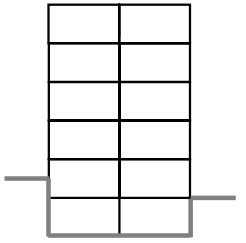
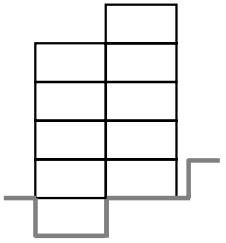


$n_s = 5$



$n_s = 5$

Part 1: Building ID

FORM 1 BUILDING ID **Sıra No:…….**

REGION NO			
MAHALLE			
STREET			
APT NAME AND NUMBER			
PAFTA / ADA / PARSEL			
KENT BİLGİ SİST.NO			
BUILDING AGE			
COORDINATES (GPS) (E/ N)			

Part 2: Building Structural Data

FORM 2 BUILDING DATA					
STRUCTURAL SYSTEM	☐ RC FRAME	☐ RC WALL	☐ RC FRAME AND WALL		
NUMBER OF STORIES (BODRUM HARİÇ)	…..GROUND	….MEZZ	…..NORMAL	...PENTHOUS	…….TOTAL
EMBEDDED BASEMENT	☐ YES(……..)	☐ NO	☐ PARTIAL		
NUMBER OF FREE STORIES	…. …….				
CORROSION LEVEL	☐ NO	☐ LIGHT	☐ MODERATE	☐ HEAVY	
MEMBER STRUCTURAL DAMAGE	☐ LIGHT		☐ MODERATE	☐ HEAVY	
PLAN WIDTH	……m				
PLAN LENGTH	……m				
ADJACENCY	☐ SEPARATED	☐ ADJACENT	☐ ADJACENT CORNER		
FLOOR LEVEL	☐ SAME	☐ DIFFERENT			
ADDITIONAL STORY	☐ YES (……..)	☐ NO	☐ UNKNOWN		
HEAVY OVERHANGS	☐ YES	☐ NO			
WEAK / SOFT STORY	☐ YES	☐ NO			
SHORT COLUMN	☐ YES	☐ NO			
VERTICAL IRREGULARITY	☐ YES	☐ NO			
PLAN IRREGULARITY	☐ YES	☐ NO			
SOIL CLASS	☐ Z1	☐ Z2	☐ Z3	☐ Z4	

Performance assessment procedure

- For each building a performance score is calculated
- Buildings are ranked according to their performance score
- Lower score indicates higher risk

Performance score

$$PS = TP + \sum O_i * Op_i + OP$$

PS: Performance score

TP: Base score

O_i: Penalty score multiplier

O_{pi}: Penalty score for vulnerability parameter

OP: Positive score

Penalty score multipliers

O_i can take values of 0, 1 or 2

VULNERABILITY PARAMETER	EXISTS	DOES NOT EXIST
Soft Story	0	1
Heavy Overhangs	0	1
Short Column	0	1
Plan irregularity	0	1
Vertical irregularity	0	1
Topographic Effects	0	1

VULNERABILITY PARAMETER	GOOD	MODERATE	POOR
Apparent Quality	0	1	2

Base scores and positive scores

Number of stories	Base score (TP)				Positive scores		
	Seismic zone				Structural System		
	I	II	III	IV	BAÇ	BAÇP	BAP
1,2	90	120	160	195	0	100	200
3	80	100	140	170	0	85	170
4	70	90	130	160	0	75	150
5	60	80	110	135	0	65	130
6,7	50	65	90	110	0	55	110

Penalty scores

Number of stories	Penalty scores										
	Soft story	Apparent quality	Heavy overhang	Adjacency/Floor level				Vertical irregularity	Plan irregularity /Torsion	Short column	Hill/ slope effect
				Same	Aynı	Farklı	Farklı				
				Middle	Edge	Middle	Edge				
1,2	-10	-10	-10	0	-10	-5	-15	-5	-5	-5	-3
3	-20	-10	-20	0	-10	-5	-15	-10	-10	-5	-3
4	-30	-15	-30	0	-10	-5	-15	-15	-10	-5	-3
5	-30	-25	-30	0	-10	-5	-15	-15	-10	-5	-3
6,7	-30	-30	-30	0	-10	-5	-15	-15	-10	-5	-3

Classification of seismic zones

Proposed seismic zones (PGV, cm/s)	Code earthquake zones	Code soil class
I (60-80)	1	Z3/Z4
II (30-60)	1	Z1/Z2
	2	Z3/Z4
III (15-30)	2	Z1/Z2
	3	Z3/Z4
IV (0-15)	3	Z1/Z2
	4	all

Verification/Calibration

- Application to damage database
  - Düzce damage database
- Comparison with detailed procedures
  - Database of assessed existing buildings

Application to Düzce database

- Damage assessment was carried out for 454 RC buildings after 1999 earthquakes

Number of stories	Observed damage				
	No	Light	Moderate	Heavy/Collapse	Total
3	18	62	29	15	124
4	17	43	60	27	147
5 and 6	18	30	60	75	183
Total	53	135	149	117	454

Assigning Observed Performance Scores

Observed Damage	Observed Performance Score (GPS)
No	100
Light	80
Moderate	50
Heavy/collapse	0

Observed (GPS) and Calculated Performance Scores (HPS)

- Buildings in the database are classified as
  - Low risk if no or light damage
  - High risk if moderate or heavy damage
- A threshold performance score (SD) is determined to classify buildings according to their risk
  - If HPS < SD High risk
  - If HPS > SD Low risk

Rate of correctness

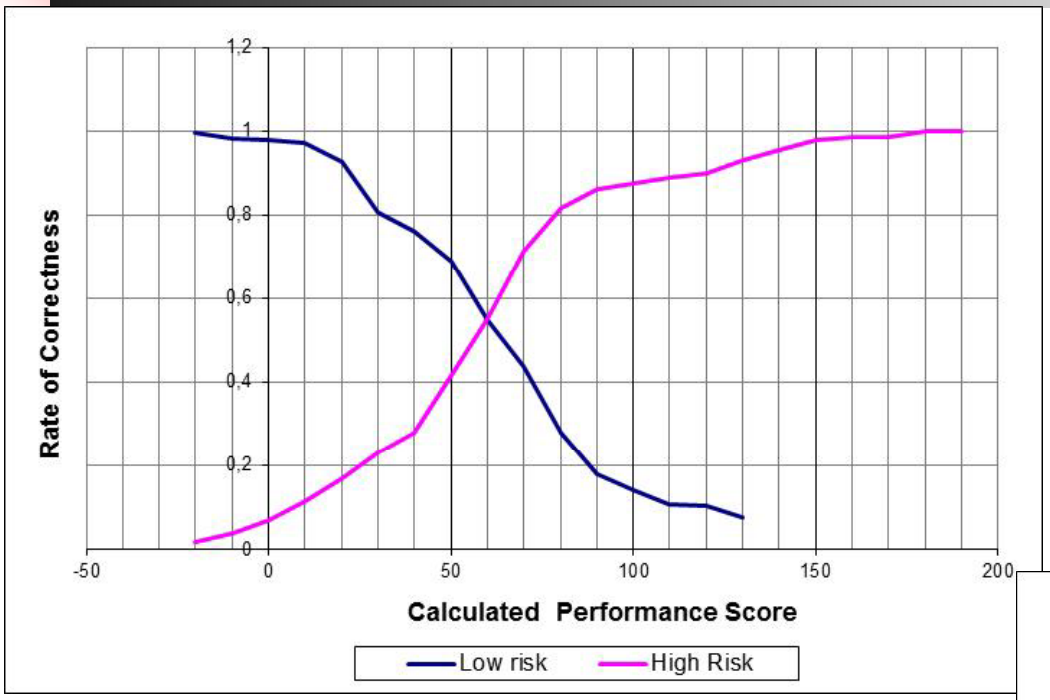
Classification basis	Risk Level	Risk Level
Observed GPS	Low risk/high risk	Low risk/high risk
Calculated HPS	Low risk/high risk	High risk/Low risk
Correctness	**Correct**	**Wrong**

- ## Rate of correctness

Ratio of correctly classified buildings (N_{CC}) in a given risk level (Ri) to total number of buildings (N_T) in the given risk level

$$RC = \frac{(N_{CC})_{Ri}}{(N_T)_{Ri}}$$

Performance scores



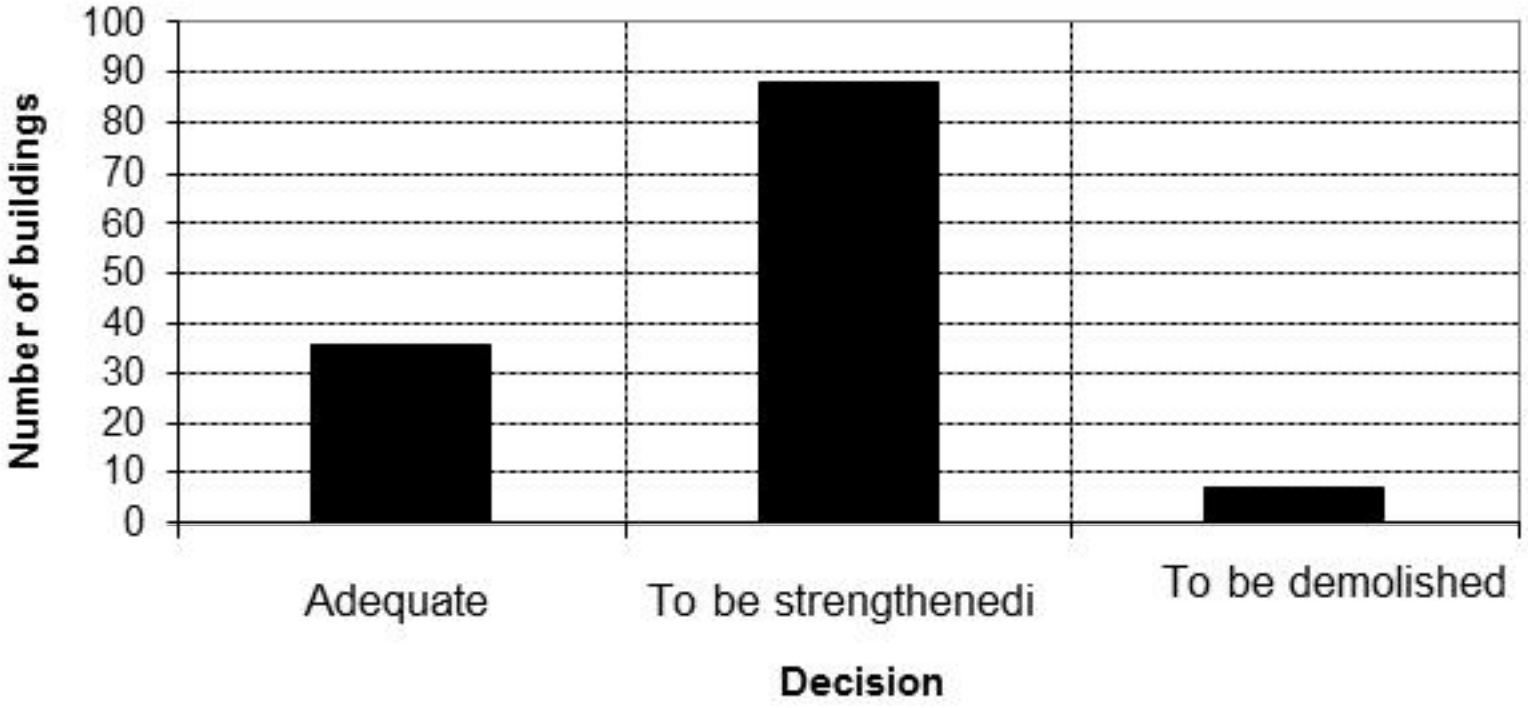
Correct Classification rates

- For SD=52
  - RC=0.60 for both high and low risk
- For SD=65
  - RC= 0.80 for high risk
  - RC= 0.40 for low risk

To classify high risk buildings more accurately a larger SD,
To classify low risk buildings more correctly a smaller SD must be selected

Application to Existing building database

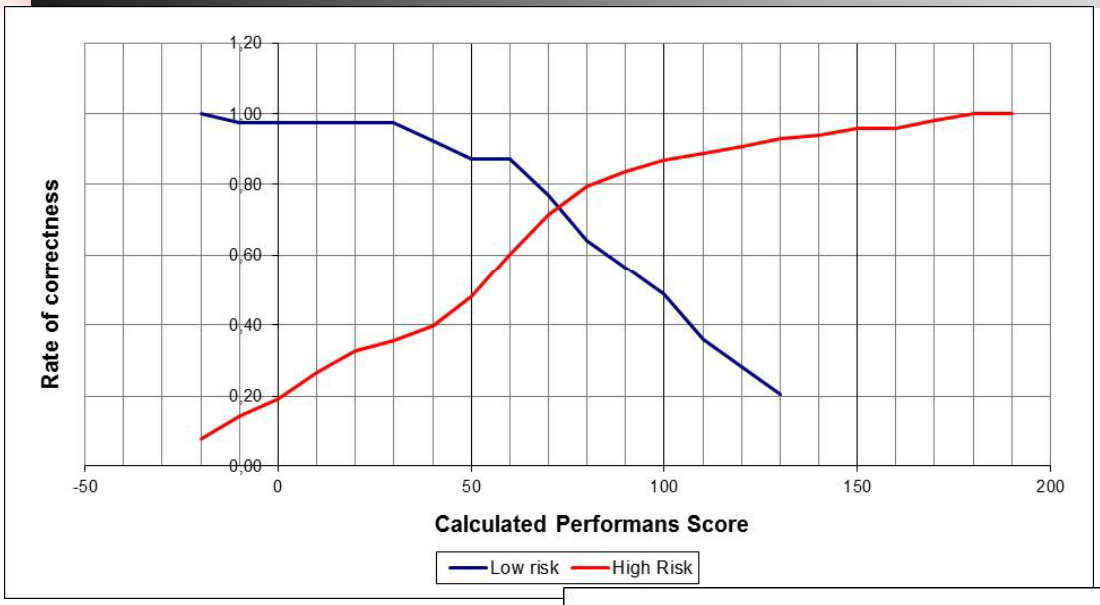
- Detailed assessment of 131 RC buildings according to 1997 Turkish seismic code



Assigning Performance Scores

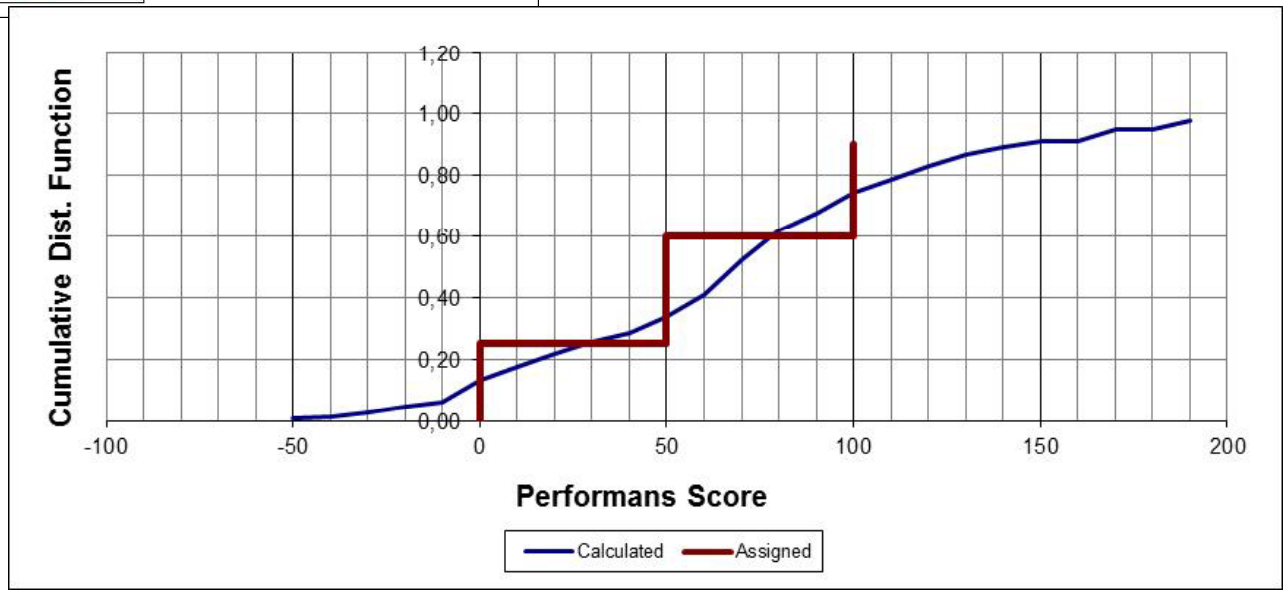
Assessment result	Performance score
Adequate	100
To be strengthened	50
To be demeolished	0

Performance scores



For SD=70

- RC=0.75 for both high and low risk



Rapid Screening Procedures-Masonry Buildings

- FEMA 154/ATC21
- AFAD procedure
- METU procedure
- A procedure by Canadian researchers
- A procedure by Indian researchers

FEMA 154/ATC-21 Procedure

Structural parameters	Seismic hazard level		
	Low	Moderate	High
Basic score	4.6	3.4	1.8
Mid-rise	-0.6	-0.4	-
High-rise	-	-	-
Vertical irregularity	-1.5	-1.5	-1.0
Plan irregularity	-0.8	-0.5	-0.5
Pre-code construction	-	-0.4	-0.2
After-code construction	+0.4	-	-
Site class C	-0.4	-0.4	-0.4
Site class D	-0.8	-0.8	-0.6
Site class E	-1.4	-1.6	-0.8

AFAD Procedure (Kocaman *et al.*, 2009)

- Developed for the rapid assessment of seismic safety of masonry buildings in Denizli (Turkey)
- An evaluation form for masonry buildings
- Score assignment by basic structural parameters

  Number of stories

  Existing condition and apparent quality

  Plan geometry

  Ratio of openings in structural walls

  Arrangement of opening in structural walls

  Previous damage

METU procedure (Sucuoğlu *et al*. 2007)

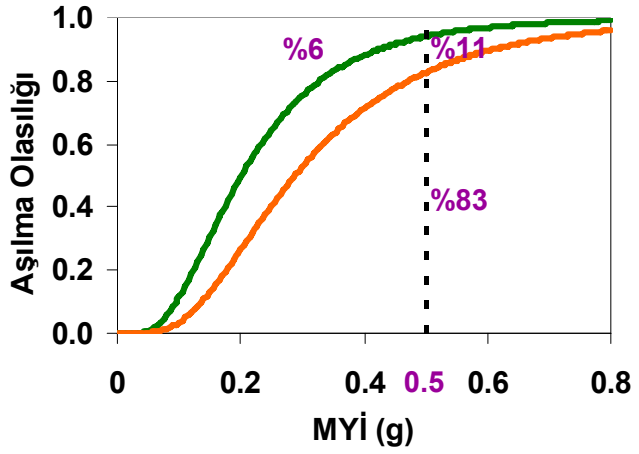
Street survey conducted by using an evaluation form

<u>Major structural parameters</u>

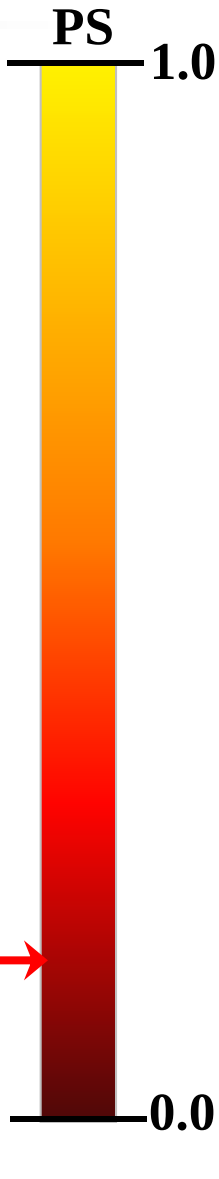
- Number of stories
- Material properties
- Workmanship
- Vertical and plan irregularity
- Amount of structrual walls
- Arrangement of openings in walls

METU procedure (Sucuoğlu *et al.* 2007)

- In order to rank masonry buildings according to their seismic performance, fragility curves are employed.
- Fragility curve sets were generated for 120 different sub-classes.
- Performance score (PS) is calculated for each building by using the corresponding fragility information.



PS=(1)*(0.06)+(0.5)*(0.11)+(0)*(0.83)=0.12



Procedures by other researchers

Arya (2007)

- Developed for the seismic assessment of existing buildings in India.
- Similar to FEMA 154, but new parameters were added to the procedure for masonry buildings

Karbasi and Nollet (2008)

- Developed for the seismic assessment of existing buildings in Quebec, Canada.
- Similar to FEMA 154, but scores were calibrated

Proposed Procedure: Masonry Buildings Structural parameters

- Number of stories
- Location of building
- Plan geometry
- Type of masonry unit
- Vertical arrangement of openings in walls
- Previous damage (if any)

Proposed Procedure: Masonry Buildings Structural parameters (continued)

- Typical story height
- Wall thickness
- Unsupported wall length (> 5 m ?)
- Wall length between two openings (< 1 m ?)
- Wall length between opening and corner (< 1.5 m ?)

Proposed Procedure: Masonry Buildings Structural parameters (continued)

- Quality of workmanship
- Type of mortar
- Floor type
- Horizontal and/or vertical bond beams
- Condition of connections (wall-to-wall, floor-to-wall)
- Roof type and material

Data Collection Form

T.C. BAŞBAKANLIK AFET VE ACİL DURUM YÖNETİMİ BAŞKANLIĞI
DEPREM DAİRESİ BAŞKANLIĞI
MEVCUT YIĞMA BİNALARIN DEPREM GÜVENLİĞİNİN BELİRLENMESİ İÇİN FORM

BİNA KİMLİK BİLGİLERİ

BİNA KİMLİK NO	
İNCELEME TARİHİ	
BİNA ADRESİ	
KOORDİNATLAR (GPS) (E/N)	
BİNANIN YAŞI	
İNCELEME EKİBİ	

Binanın Fotoğrafı

YIĞMA BİNA TÜRÜ (Bakınız -1-)

☐ DONATISIZ YIĞMA ☐ KUŞATILMIŞ YIĞMA
☐ DONATILI YIĞMA ☐ KARMA (YIĞMA + B/A)

BİNA DIŞI GÖZLEMLER (Bakınız -2-)

SERBEST KAT ADEDİ	..... (ADET)	
CEPHEYE GÖRE KAT FARKLILIĞI ?	YOK ( ) VAR ( )	
BODRUM KAT	YOK ( ) VAR ( ) BELİRLENEMEDİ ( )	
PLAN GEOMETRİSİ	DÜZENLİ ( ) DÜZENSİZ ( )	
PLAN GENİŞLİĞİ (ÖN CEPHE) ..... Metre	ZEMİN KAT BOŞLUK MİKTARI (ÖN CEPHE) ..... Metre	
PLAN GENİŞLİĞİ (YAN CEPHE) ..... Metre	ZEMİN KAT BOŞLUK MİKTARI (YAN CEPHE) ..... Metre	
BİNA DÜŞEY BOŞLUK DÜZENİ	DÜZENLİ ( ) AZ DÜZENLİ ( ) DÜZENSİZ ( )	
YAPI NİZAMI	AYRIK ( ) BİTİŞİK ORTA ( ) BİTİŞİK KÖŞE ( )	
BİTİŞİK BİNA İLE YÜKSEKLİK FARKI	YOK ( ) VAR ( )	
BİTİŞİK BİNA İLE DÖŞEME SEVİYESİ	AYNI ( ) FARKLI ( )	
MEVCUT HASAR	YOK ( ) VAR ( )	
TARİHİ BİNAYA BİTİŞİK Mİ ?	EVET ( ) HAYIR ( )	

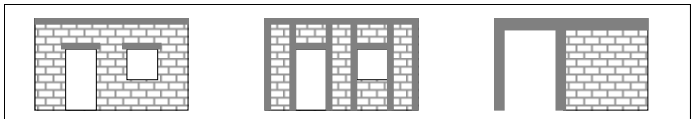
BİNA İÇİ GÖZLEMLER (Bakınız -3-)

TİPİK KAT YÜKSEKLİĞİ	..... metre
TİPİK DUVAR KALINLIĞI	..... metre
MESNETLENMEMİŞ DUVAR BOYU (L_m) > 5.0 m ?	EVET ( ) İSE ..... KERE HAYIR ( )
İKİ BOŞLUK ARASI DUVAR BOYU (L_b) < 1.0 m ?	EVET ( ) İSE ..... KERE HAYIR ( )
BOŞLUK VE KÖŞE ARASI DUVAR BOYU (L_k) < 1.5 m ?	EVET ( ) İSE ..... KERE HAYIR ( )

GENEL GÖZLEMLER (Bakınız -4-)

TAŞIYICI DUVAR TİPİ	DOLU TUĞLA ( )	DÜŞEY DELİKLİ TUĞLA ( )	DOLU BRİKET ( )
	DELİKLİ BRİKET ( )	GAZBETON ( )	KESME TAŞ ( )
	MOLOZ TAŞ ( )	KERPİÇ ( )	
HARÇ MALZEMESİ	ÇİMENTO ( )	KİREÇ ( )	ÇAMUR ( ) YOK ( )
YIĞMA DUVAR İŞÇİLİĞİ	İYİ ( )	ORTA ( )	KÖTÜ ( )
DÖŞEME TİPİ	BETONARME ( )	AHŞAP ( )	VOLTO ( )
YATAY HATIL ?	PENCERE ÜSTÜ ( )	DUVAR ÜSTÜ ( )	YOK ( )
DÜŞEY HATIL ?	VAR ( ) İSE ..... metre aralıklı	YOK ( )	
LENTO ?	VAR ( )	YOK ( )	
LENTO/HATIL MALZEMESİ	BETONARME ( )	AHŞAP ( )	
ÇATI TİPİ	DÜZ ( )	KALKAN DUVARSIZ ( )	EĞİK ( ) KALKAN DUVARLI ( )
ÇATI MALZEMESİ	KİREMİT ( )	BETON ( )	SAÇ ( ) TOPRAK ( )
DUVAR BAĞLANTILARI	İYİ ( )	KÖTÜ ( )	
YUMUŞAK/ZAYIF KAT	VAR ( )	YOK ( )	

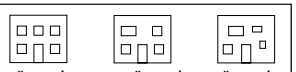
-1- YIĞMA BİNA TÜRÜ



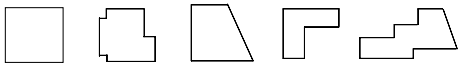
-2- BİNA DIŞI GÖZLEMLER

Cepheye göre kat farklılığı olması:

Boşluk Düzeni:

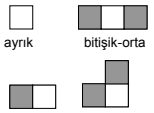


Plan Geometrisi:



***Yönetmelikte verilen A3 türü düzensizlik tanımının dışında kalan binalar için*

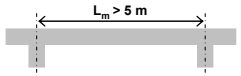
Yapı Nizamı:

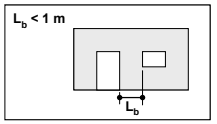


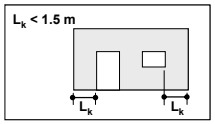
Mevcut Hasar:
YOK - Söz konusu yığma binada, geçmiş depremlerden, yapısal tadilatlardan, oturmalardan vb. kaynaklanan önemli bir hasar bulunmamaktadır.
VAR - Duvar ortasına yakın bölgelerde diyagonal çatlaklar, genellikle duvarın üst kısmına yakın dikey çatlaklar, duvar-duvar ve/veya duvar-döşeme bölgelerinde hasar veya çatlama, duvar derzlerini takip eden belirgin çatlaklar, genellikle oturmaya bağlı yatay yönde belirgin çatlaklar, duvarda gözle görülür düzlem dışı deformasyon.

-3- BİNA İÇİ GÖZLEMLER

Mesnetlenmemiş duvar boyu

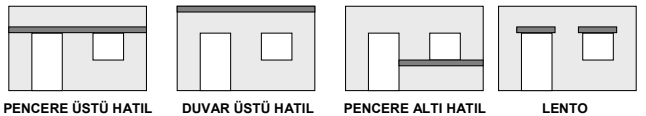






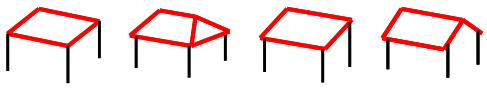
-4- GENEL GÖZLEMLER

Yatay hatıl / Lento



Çatı Tipi:

A) DÜZ
B) KALKAN DUVARSIZ
C) EĞİK
D) KALKAN DUVARLI



Performance assessment procedure

- Similar to the one used for RC buildings
- For each building a performance score is calculated
- Buildings are ranked according to their performance score
- Lower score indicates higher risk

Performance score

$$PS = TP + \sum O_i * Op_i + OP$$

PS: Performance score

TP: Base score

O_i: Vulnerability parameter

O_{pi}: Penalty score for vulnerability parameter

OP: Positive score (depending on masonry construction type: for confined masonry 30 pts, for reinforced masonry 60 pts)

Base score (TP) calculation

- Function of seismic zone and number of storeys
- Determined separately for adobe masonry buildings
- Lower values in the case of adobe masonry construction

Masonry (other than adobe)

No of stories	Zone I PGA ≥ 0.4g	Zone II 0.2g ≤ PGA < 0.4g	Zone III PGA < 0.2g
1	110	120	130
2	100	110	120
3	90	100	110
4	80	90	100
5	70	80	90

Adobe construction

No of stories	Zone I PGA ≥ 0.4g	Zone II 0.2g ≤ PGA < 0.4g	Zone III PGA < 0.2g
1	80	90	100
2	70	80	90
3	60	70	80
4	50	60	70
5	40	50	60

Negative parameters and scores

O_i can take values of 0, 1 or 2

Existing condition

Material: Good (0); Moderate (1); Poor(2)

Workmanship: Good (0); Moderate (1); Poor(2)

Previous damage: No (0); Yes (1)

Horizontal irregularities

Plan irregularity: No (0); Yes (1)

Too much opening?: No (0); In between (1); Yes (2)

Bond beam?: Available (0); N/A (1)

Penalty scores

Negative parameters

Existing condition

No of stories	Existing condition / apparent quality		
	Material (0/1/2)	Workmanship (0/1/2)	Damage (0/1)
1	-10	-5	-5
2	-10	-5	-5
3	-10	-5	-5
4	-10	-5	-5
5	-10	-5	-5

Horizontal irregularities

No of stories	Horizontal irregularities		
	Plan (0/1)	Opening (0/1/2)	Bond beam (0/1)
1	-5	-5	-5
2	-10	-5	-5
3	-10	-10	-5
4	-15	-10	-5
5	-20	-15	-5

Negative parameters and scores

O_i can take values of 0, 1 or 2

Vertical irregularities

Opening layout: Regular (0); F. Regular (1); Irregular (2)

High slope: No (0); Yes (1)

Soft/weak story: No (0); Yes (1)

Position

Adjacency: Separated (0); Adjacent (1)

Floor levels?: Same (0); Different (1)

Penalty scores

No of stories	Vertical irregularities		
	Openings in vertical (0/1/2)	High slope (0/1)	Soft/weak story (0/1)
1	0	-5	0
2	-5	-5	-5
3	-5	-5	-5
4	-10	-5	-10
5	-10	-5	-10

Vertical irregularities

Position of the building

No of stories	Location of the building /adjacency & floor levels				
	Separated	Adjacent (middle) / same level	Adjacent (corner) / same level	Adjacent (middle) / different level	Adjacent (corner) / different level
1	0	0	-5	-5	-10
2	0	0	-5	-5	-10
3	0	0	-5	-5	-10
4	0	0	-5	-5	-10
5	0	0	-5	-5	-10

Negative parameters and scores

- Roof type (earthen roof)

Extra penalty score (10 pts) is given for this special case since such types of roofs increase the death toll during an earthquake

- Out-of-plane vulnerability

Extra penalty score (10 pts) is given for out-of-plane vulnerability of structural walls if at least three of the five deficiencies given below exist in the building.

1-Poor connection, 2-Flexible floor diaphragm, 3-Poor mortar quality, 4-Existing OOP damage (like bulging), 5-Unsupported gable end walls.

Verification/Calibration

- Application to damage database
  - Dinar (Afyon) damage database
- Comparison with existing procedures
  - Zeytinburnu and Fatih (İstanbul) databases

Dinar (Afyon) Damage Database

- Damage assessment was carried out for 102 masonry buildings after the 1995 earthquake.
- The form developed by the Ministry of Public Works and Settlement was employed

Observed damage state	Score range
Undamaged	0
Minor	1-3
Moderate	4-6
Severe	7-9
Collapse	>9

Dinar (Afyon) Damage Database

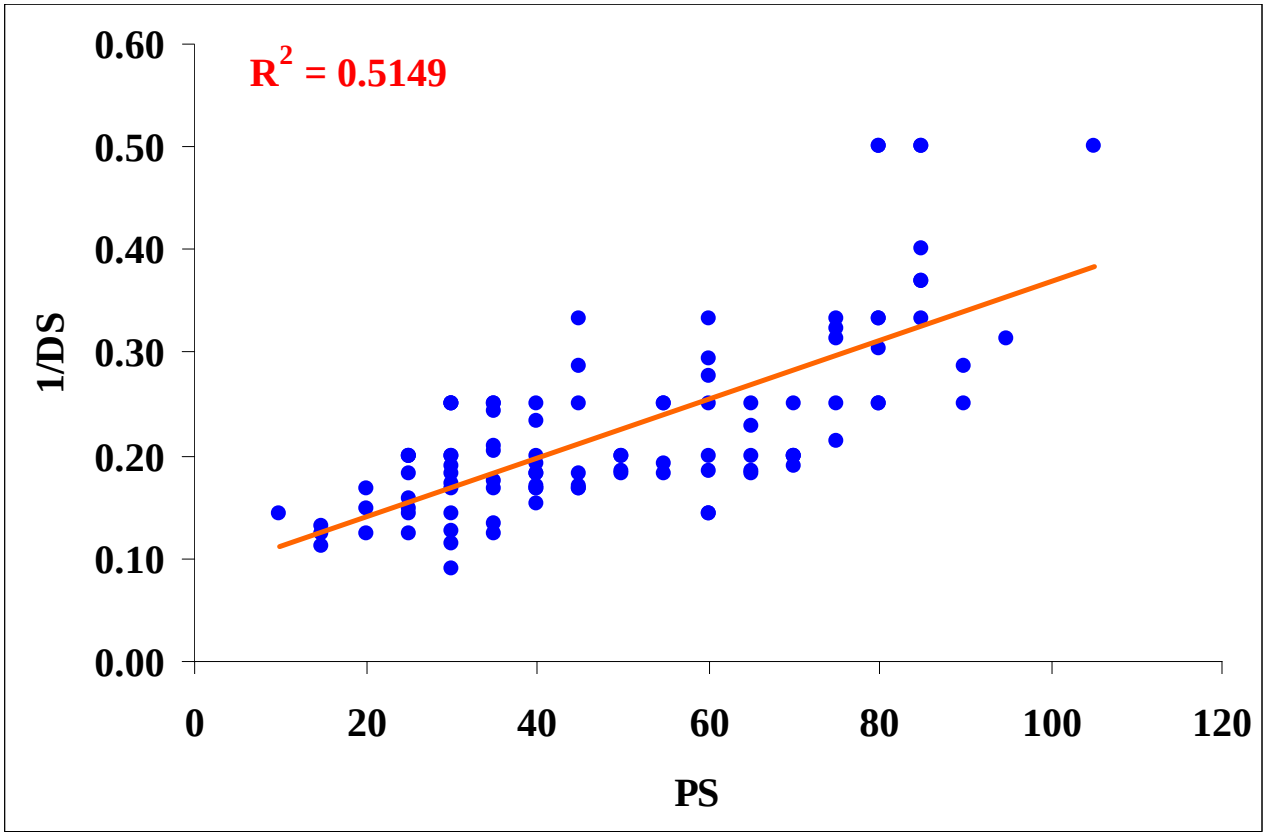
Building was observed to have severe damage.

Calculated PS = 10

Building was observed to have minor damage.

Calculated PS = 80

Dinar (Afyon) Damage Database



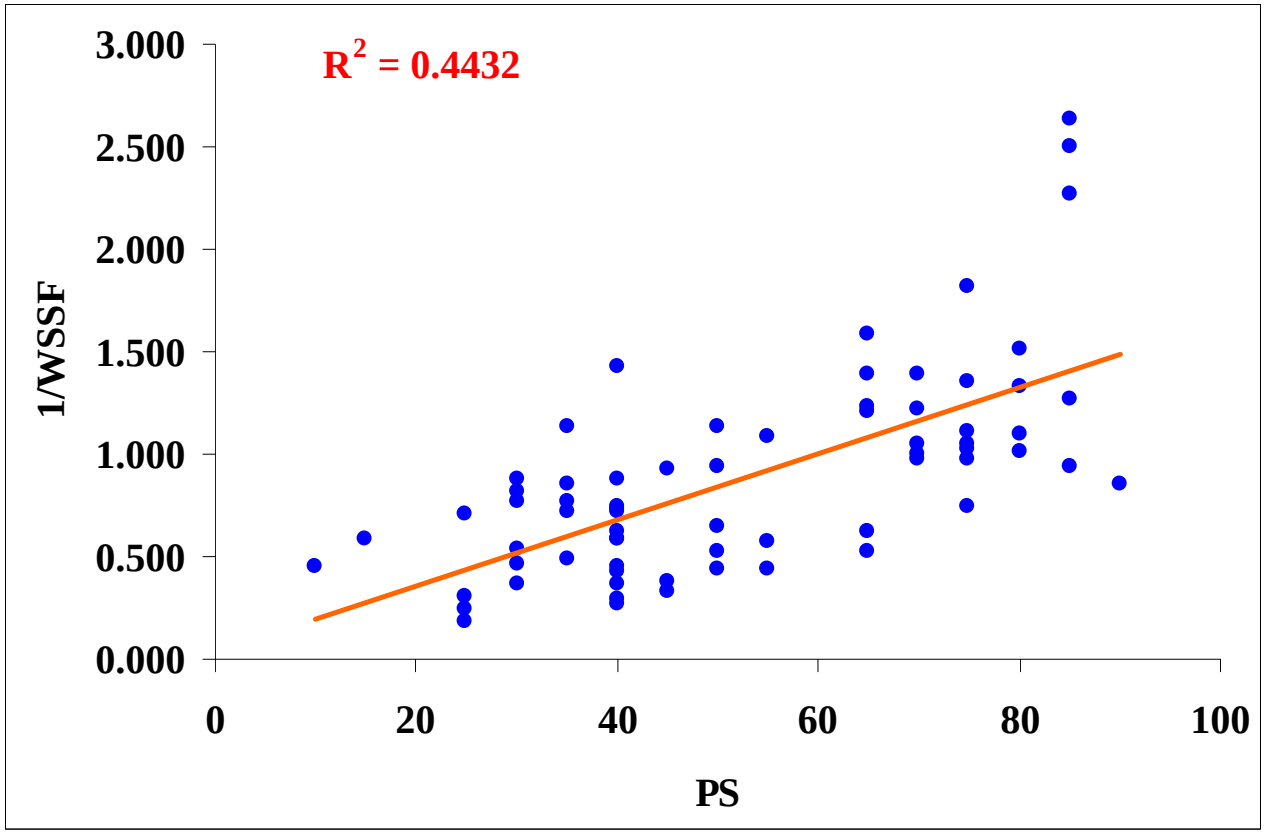
Zeytinburnu (Istanbul) database

- Composed of 69 existing masonry buildings
- Examined for seismic safety during Istanbul Earthquake Masterplan Project
- Weighted shear strength factor (WSSF) was calculated for each building as the seismic performance indicator

$$WSSF = \frac{\sum_i \left(\frac{\tau_i}{\tau_d} \times A_i \right)}{\sum_i A_i}$$

Range of values	Seismic risk level
WSSF<1	Low
1<WSSF<2	Medium
WSSF>2	High

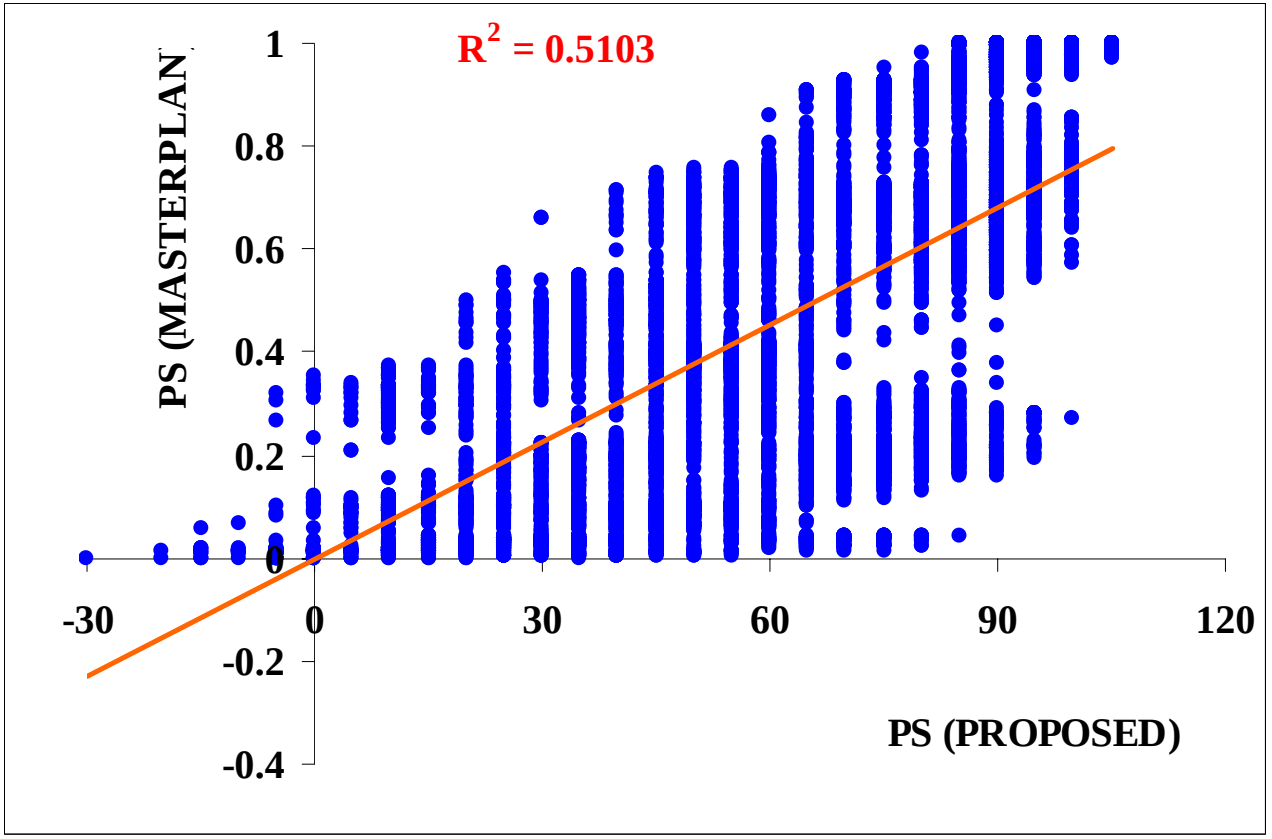
Zeytinburnu (Istanbul) database



Fatih (Istanbul) database

- Composed of 9,457 existing masonry buildings
- Examined for seismic safety during Istanbul Earthquake Masterplan Project
- Performance score (PS) was obtained from the damage state probabilities by using generated fragility functions.
- PS takes values in the range 0-1

Fatih (Istanbul) database



Concluding Remarks

- Objective of the proposed methods is to rank buildings according to their risk not assess individual building performans.
- Calibration and validation of the scores and the whole procedure will be continuously done as more data becomes available.
- These procedures are expected to be used by local authorities for not only ranking the risk but also providing data for building inventory.
- Training of engineers and local authorities is intended for correct understanding and implementation.