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International Workshop "Role of research infrastructures in seismic rehabilitation"

Seismic Response of the School Buildings in Van to the Earthquake October 23, 2011

(Observations and evaluations)

Zekai Celep
Yavuz Durgun

Istanbul Technical University, Faculty of Civil Engineering

SEISMIC RESPONSE OF THE SCHOOL BUILDINGS IN VAN TO THE EARTHQUAKE OCTOBER 23, 2011

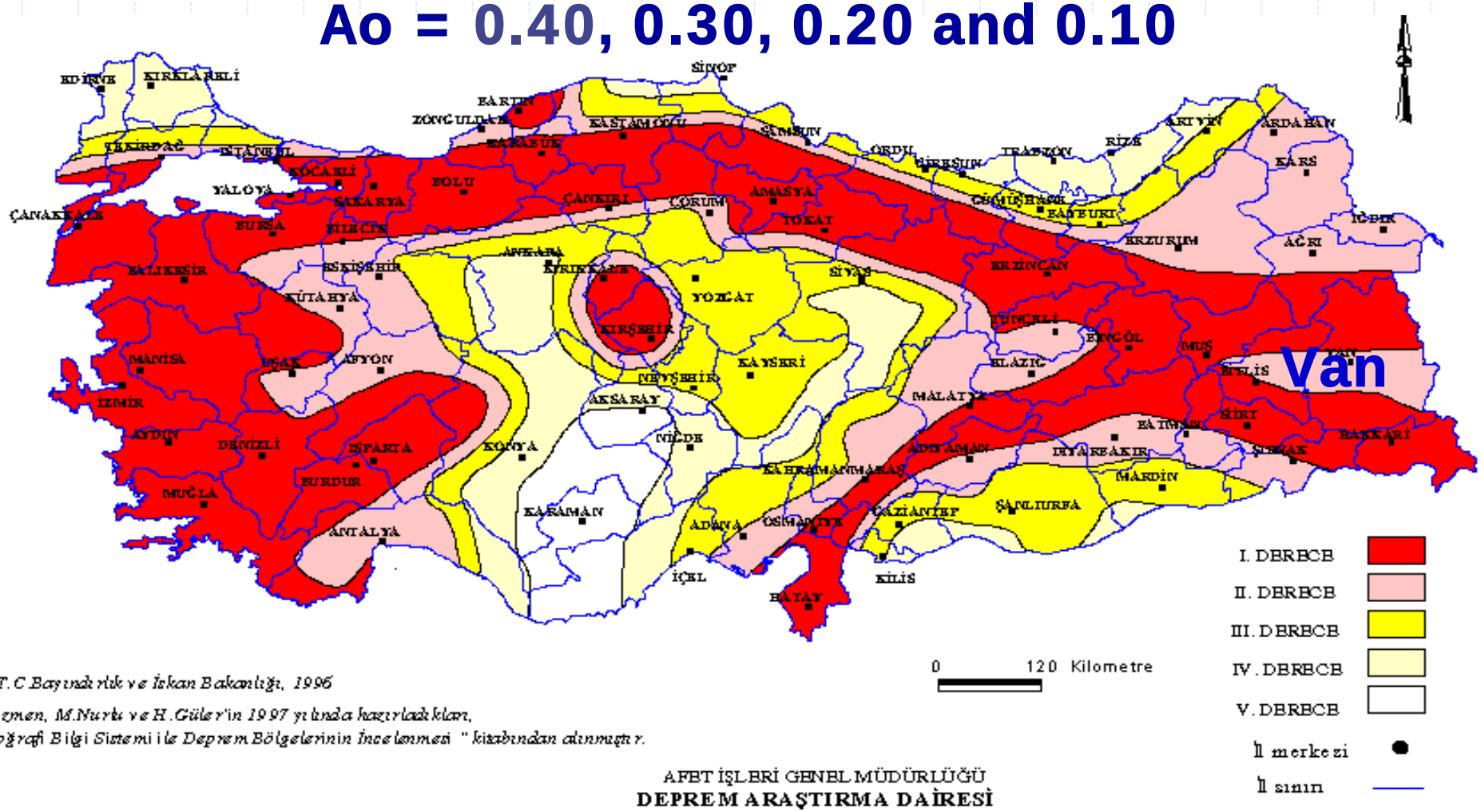
(Observations and evaluations)

1. Recent earthquakes in Van
   - Tabanlı (Van) 23.10.2011
   - Edremit (Van) 09.11.2011
2. School buildings in the Turkish Seismic Code
3. Typical school buildings in Turkey
4. Seismic damages in the school buildings in Van
5. Evaluation criteria of the building for further use
6. Conclusions

1. Recent earthquakes in Van

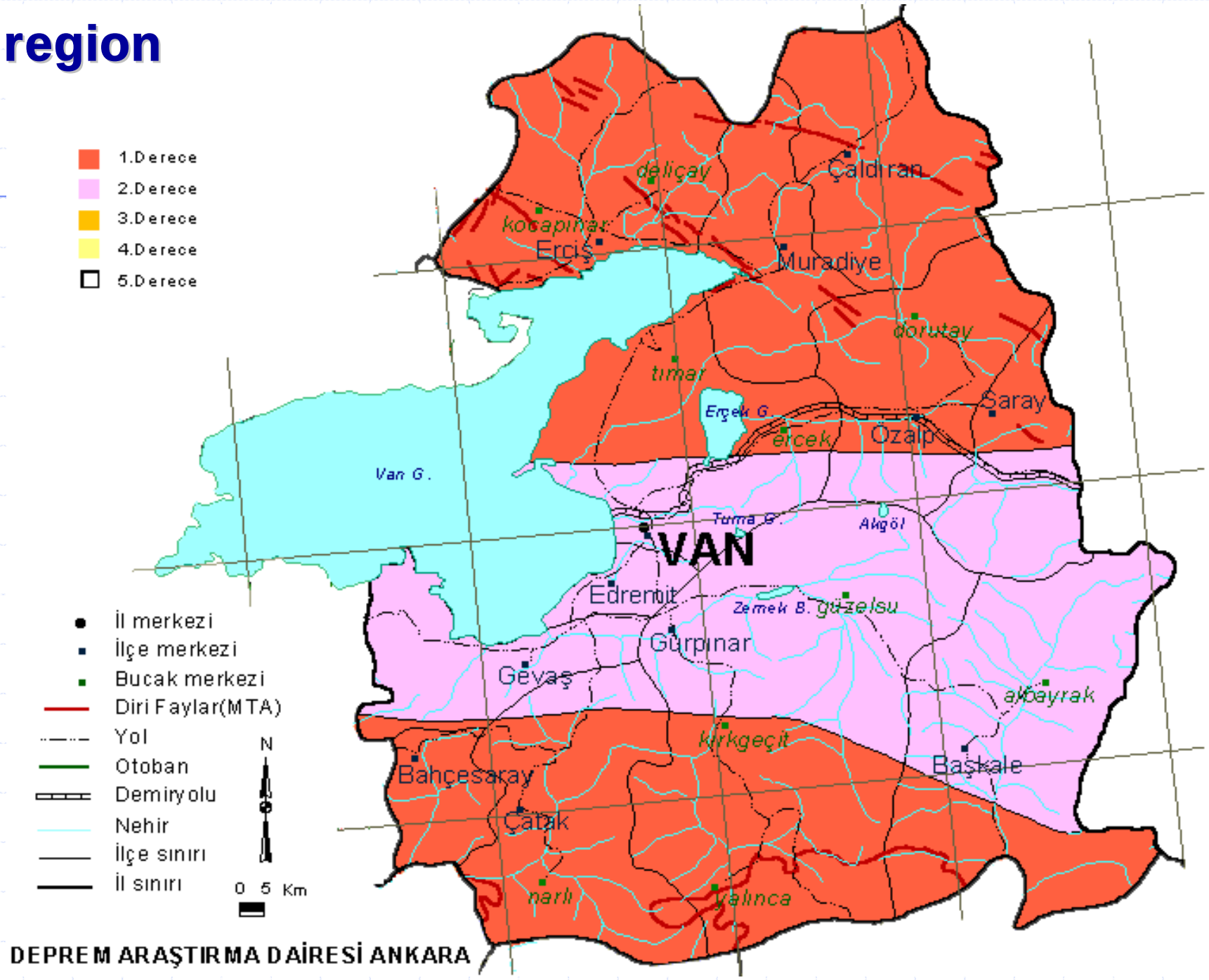
- Four seismic regions are defined in Turkey
- Effective ground acceleration coefficent

Ao = 0.40, 0.30, 0.20 and 0.10



Map for seismic regions

Van region


1.Derece
2.Derece
3.Derece
4.Derece
5.Derece
İl merkezi
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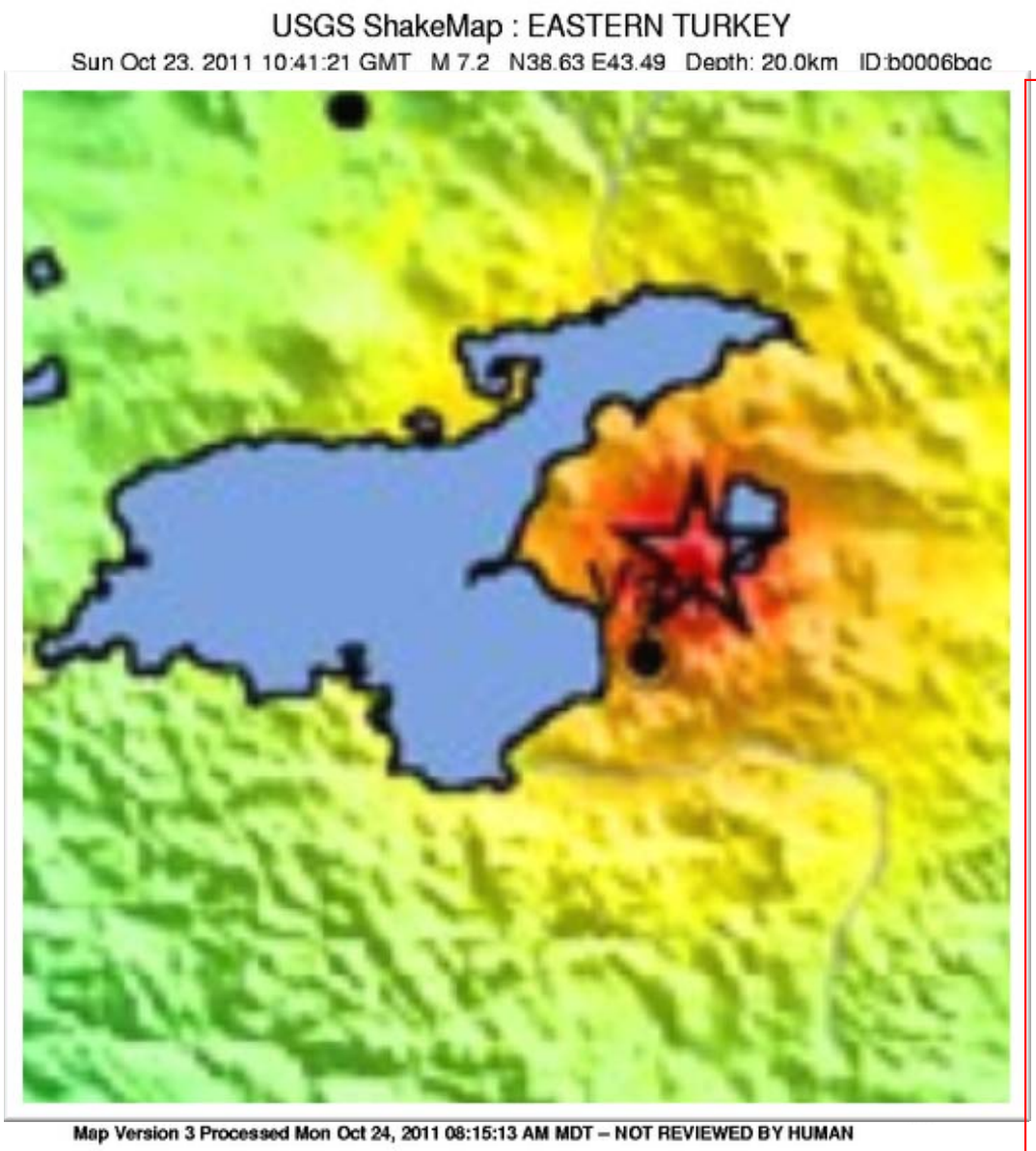
Bucak merkezi
Diri Faylar(MTA)
Yol
Otoban
Demiryolu
Nehir
İlçe sınırı
İl sınırı
N
0 5 Km
VAN
Van G.
Erçek G.
Turna G.
Akgöl
Zemek B.
Çaldıran
Muradiye
Saray
Özalp
Erciş
Edremit
Gürpınar
Gevaş
Bahçesaray
Çatak
Başkale
deliçay
kocapınar
dörütay
tırnar
ercek
güzelsu
akbayrak
kırkgeçit
narlı
yalınca
DEPREM ARAŞTIRMA DAİRESİ ANKARA

Recent earthquakes in Van



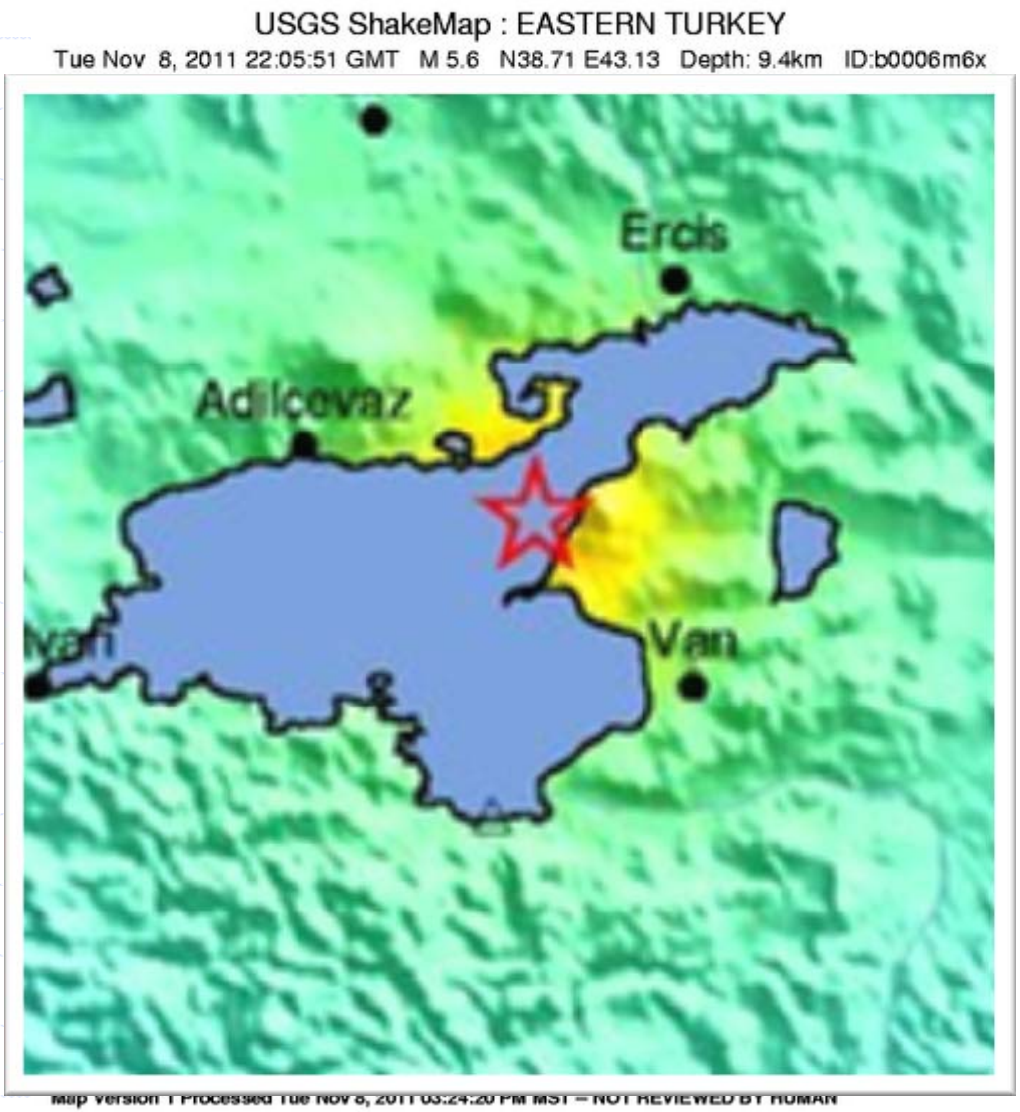
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Tabanlı (Van) 23.10.2011
Mw: 7.2

Focal depth: 10~20km
Distance of the epicenter to Van: 32km

Acceleration record in Muradiye (43km to Van) :
0.18g
Acceleration estimated in Van:
0.10g

Recent earthquakes in Van



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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Edremit (Van) 09.11.2011

Mw = 5.6

Focal depth : 5km

Distance of the epicenter to Van: 20km

Acceleration record in Van: 0.25g

2. School buildings in the Turkish Seismic Code

Effective seismic acceleration coefficients

Ao = 0.40, 0.30, 0.20, 0.10

- **New residential buildings:**
  - **Design Earthquake**
  - **Building importance factor: I = 1.00**
  - **Life Safety is targeted**

- **New school buildings to be designed:**
  - **Design Earthquake**
  - **Building importance factor: I = 1.40**
  - **Life Safety is targeted**

- **Existing school buildings to be checked seismically:**

  Design Earthquake (Ao)

  Immediate Occupancy performance level is targeted

  Maximum Considered Earthquake (1.5Ao)

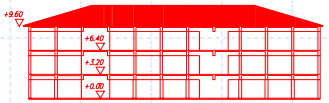
  Life Safety performance level is targeted

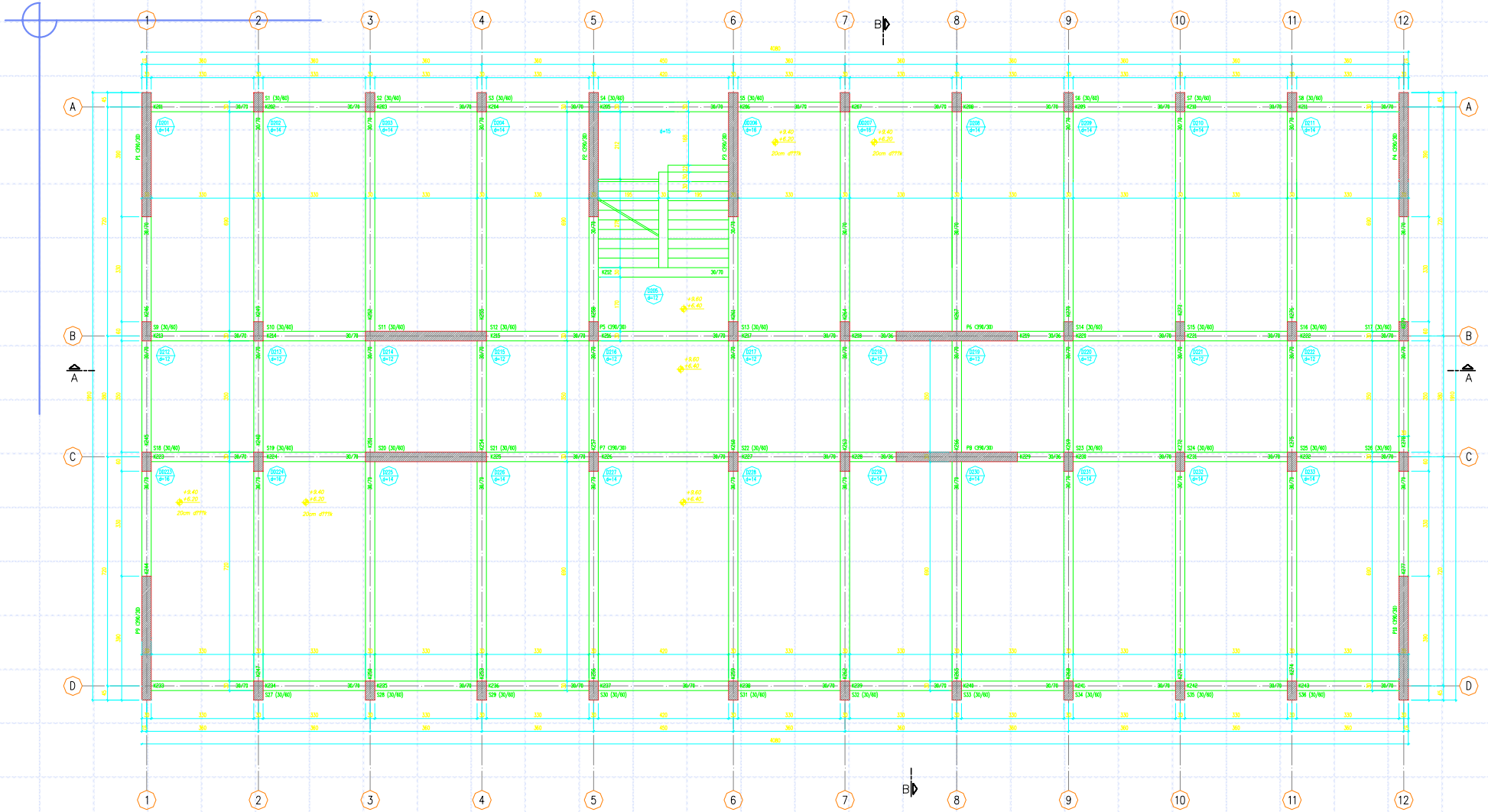
Generally it is difficult to satisfy. These conditions are more severe than those applied to new school buildings to be design.

3. Typical school buildings in Turkey

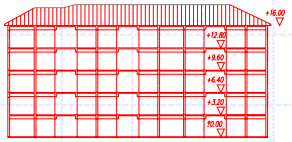
- There various typical projects prepared by the Ministry of Educations. There are reinforced concrete buildings having frame system consisting of beam columns and shear walls.
- School buildings have various number of stories, such as 3, 4 and 5.
- Some examples are given to represent school typical buildings and their strengthening intervention.

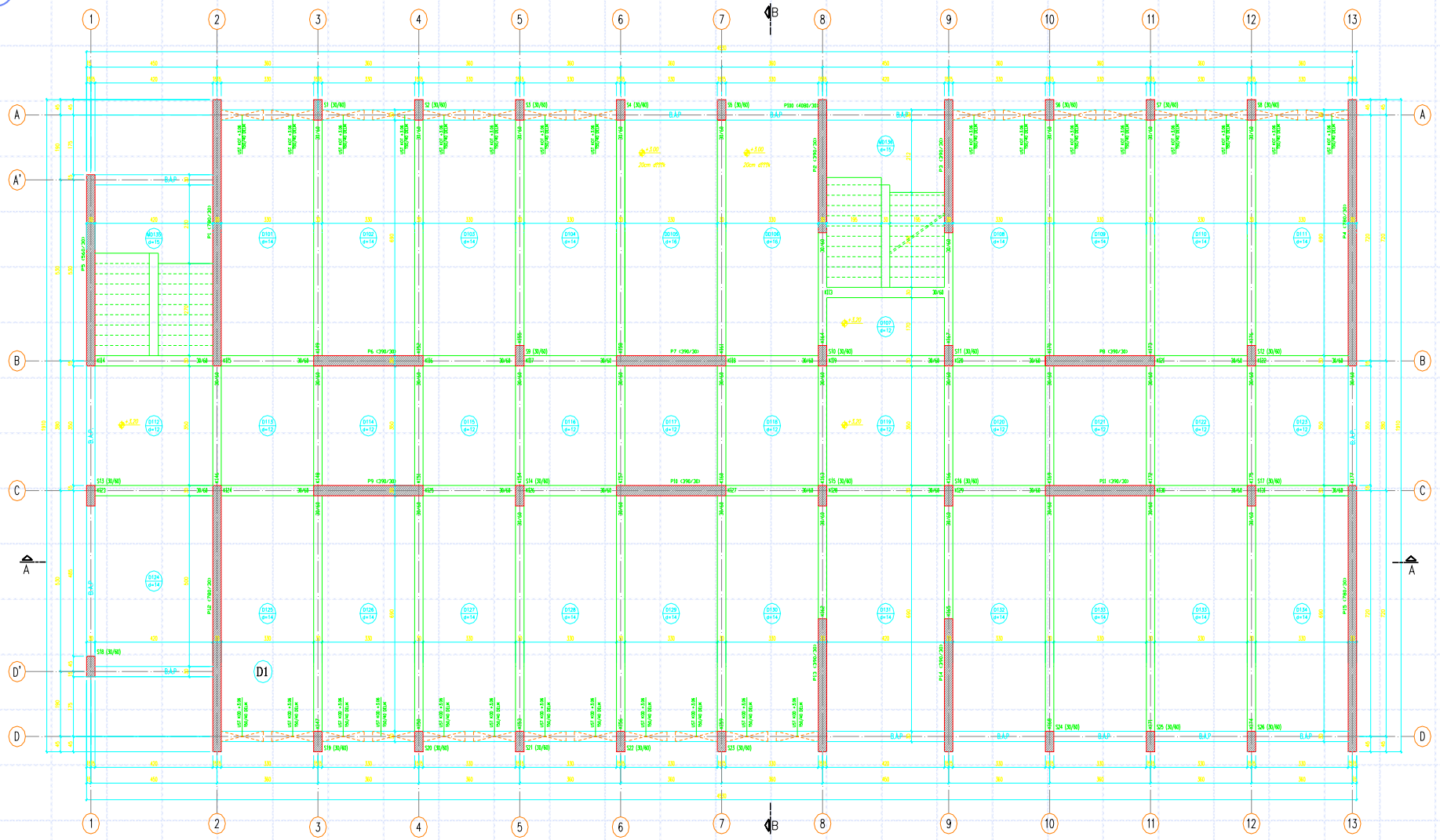
School building type 1: Existing structure



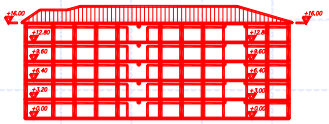


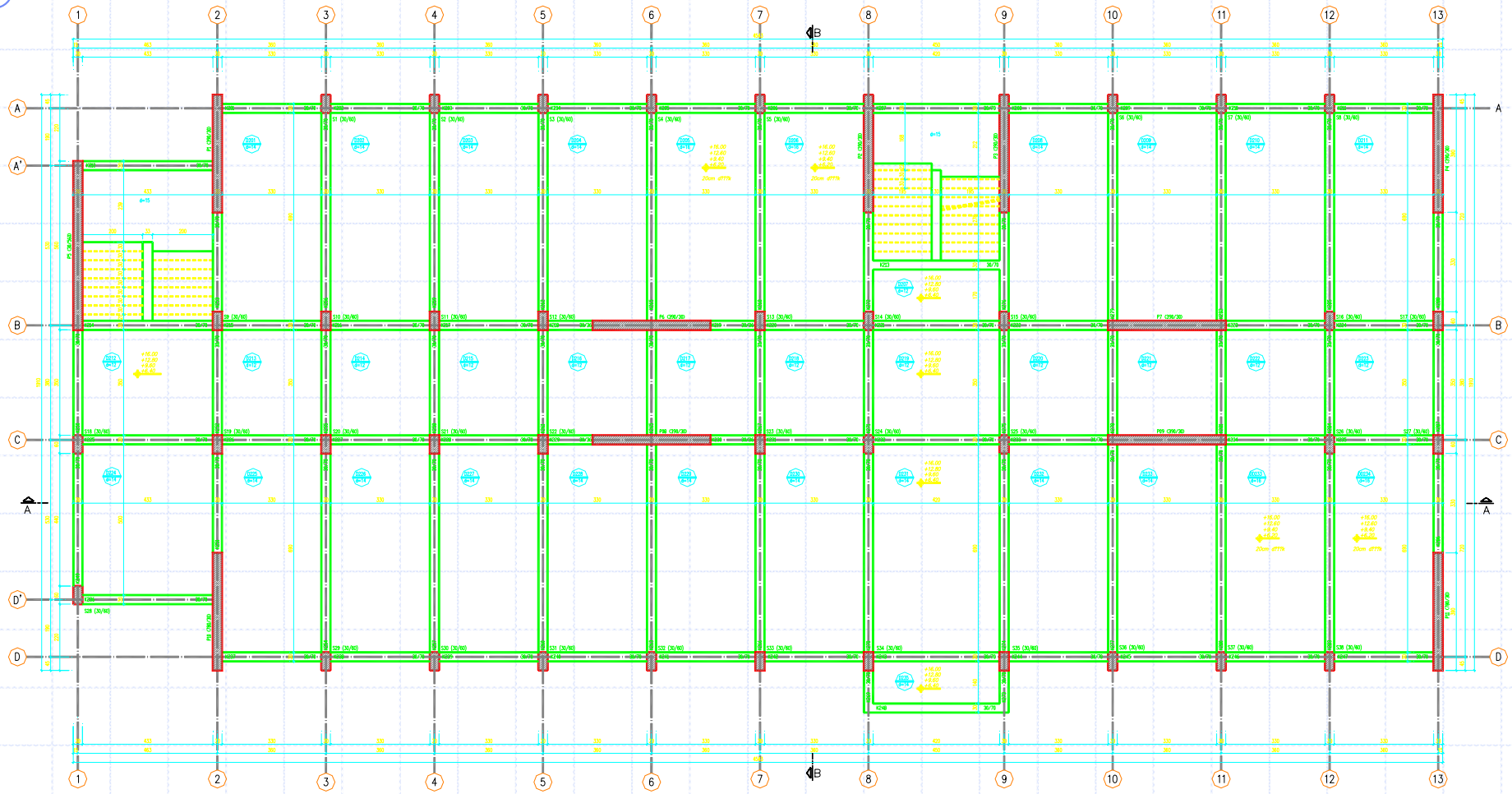
School building type 2: Existing structure





School building type 3: Existing structure





4. Seismic damages in the school buildings in Van

- Following the destructive Van Earthquake of 23 October 2011 epicentered in Tabanlı (Van), the teams from Istanbul Technical University, Middle East Technical University and Sakarya University investigated school buildings in Van to determine the extent of the seismic damages upon the request of the governorship of Van.
- The authors were two members of the team of formed by Earthquake Engineering and Emergency Management Institute and Faculty of Civil Engineering, Istanbul Technical University and took part in this investigation extensively.

- **Although the maximum acceleration in the seismic event is found to be considerable lower than the maximum acceleration expected in the region, various levels of damages starting from fine cracks to the serious damages in the structural members are observed.**

- **Besides of the structural damages, often non-structural damages are found to be surprisingly high.**

➢ Typical school buildings in Van

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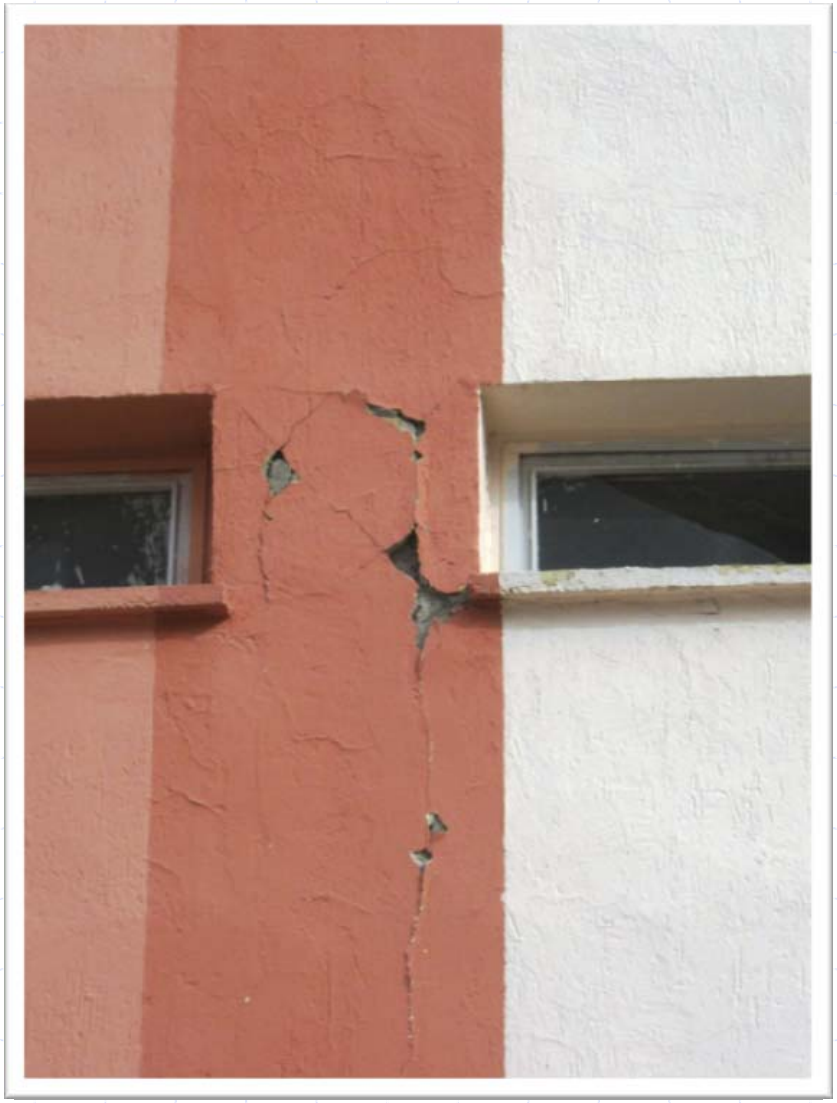
➢ Typical school buildings in Van

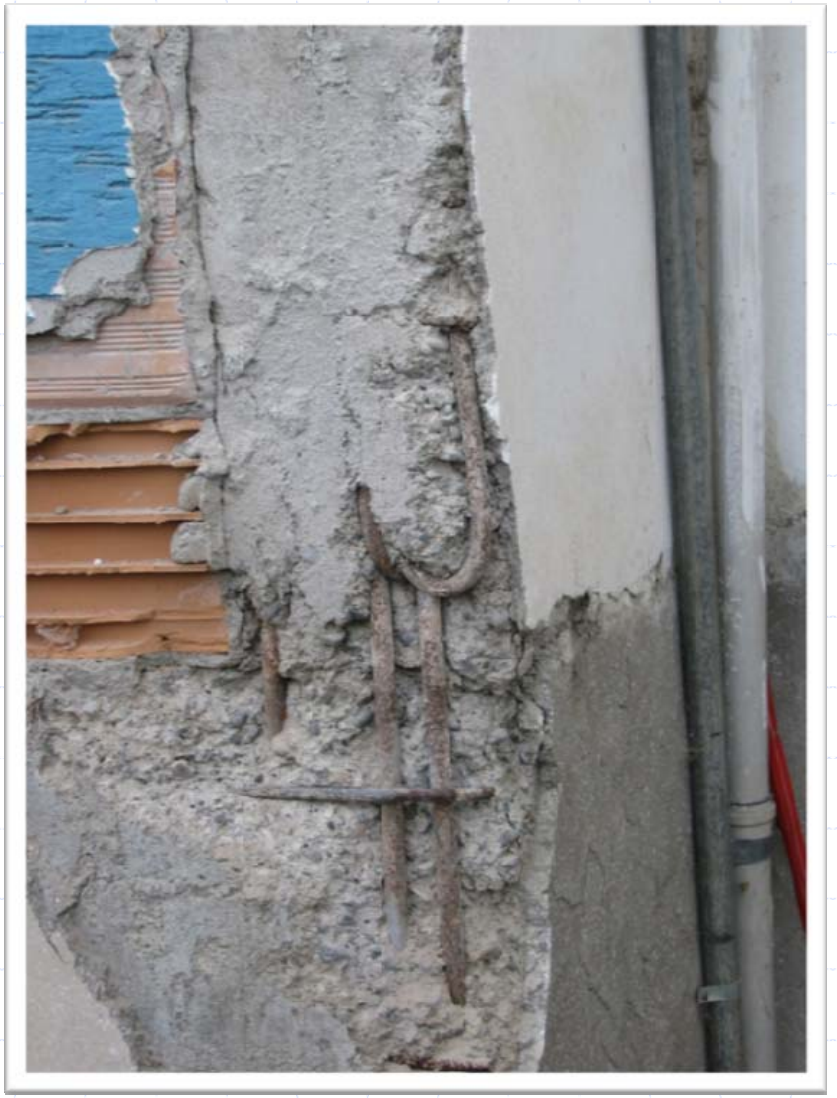
Damage in concrete cover

Cracks in Partition walls

Short column damages

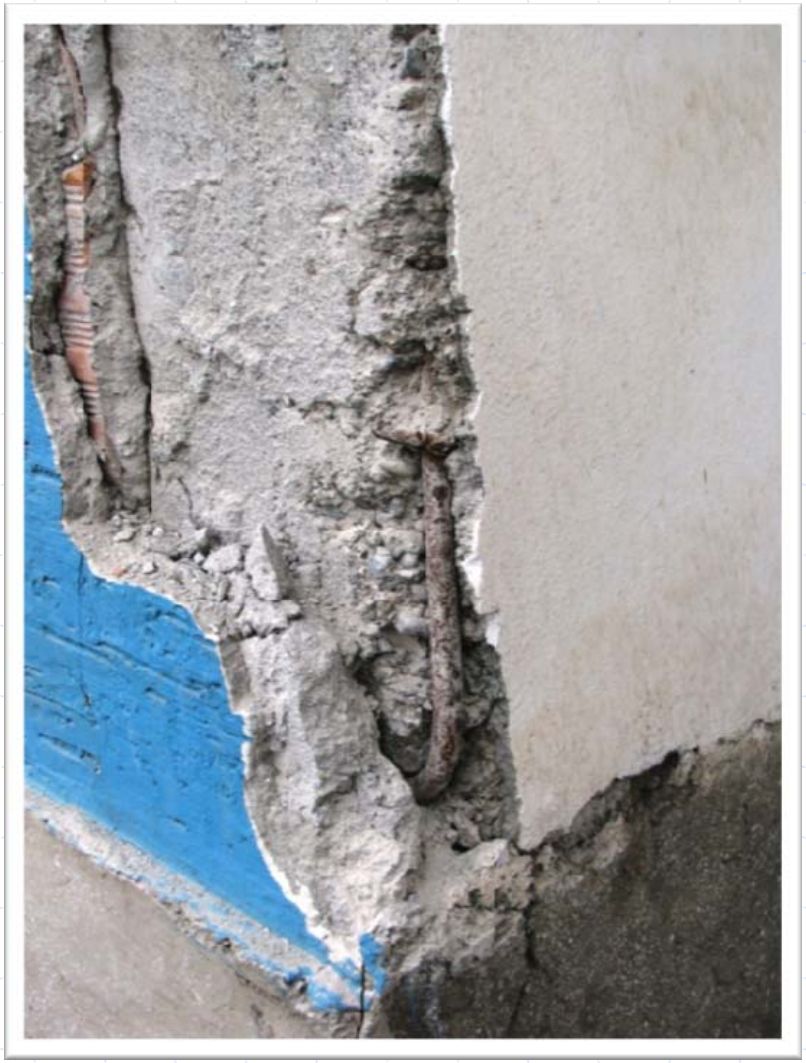


Inadequate splice



Inadequate concrete cover

No ties in beam-column joints



Segregation in concrete

Partition wall damage

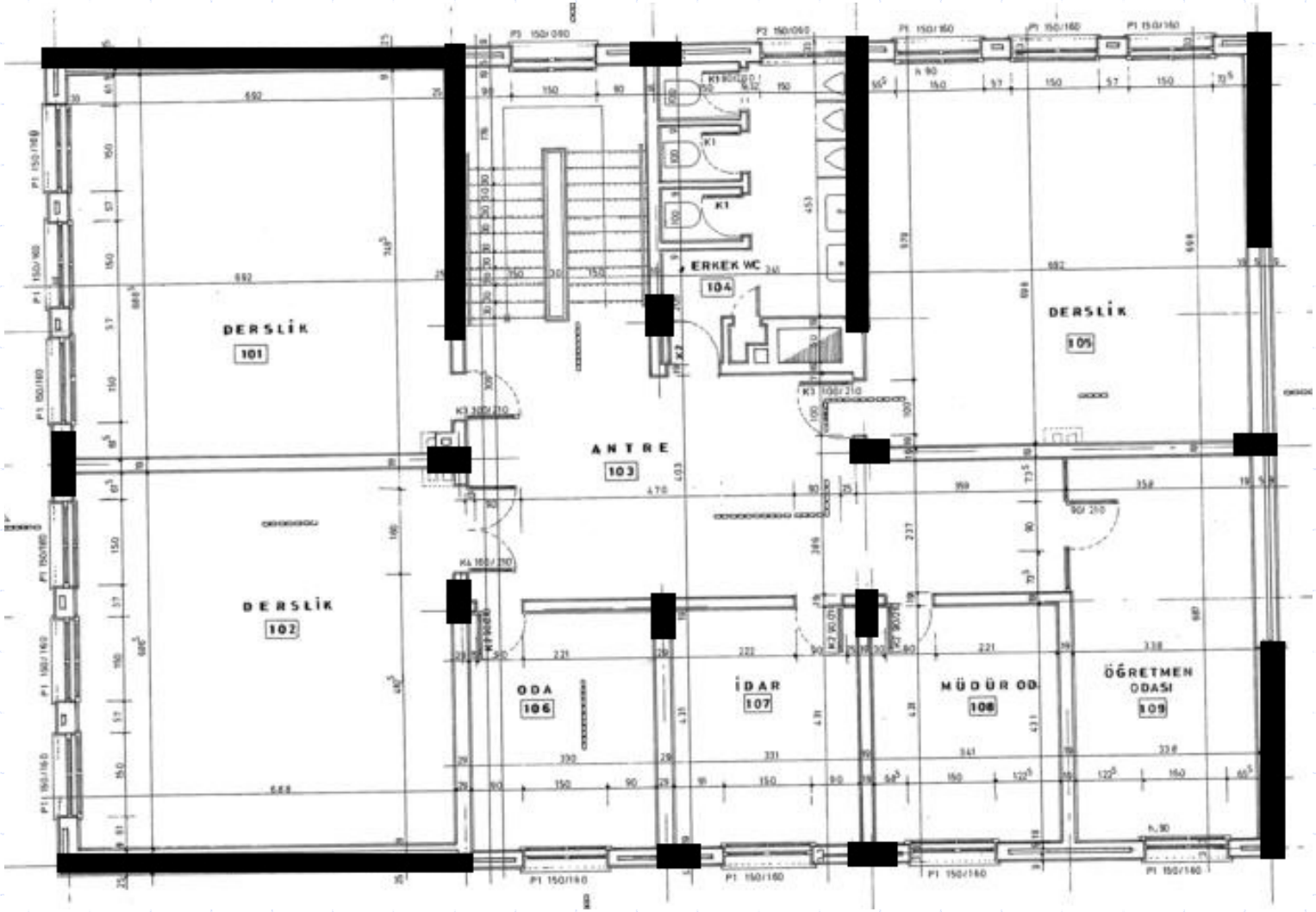
Cracks in beams

Total collapse
(Gedik Bulak School)

Total collapse
(Gedik Bulak School)

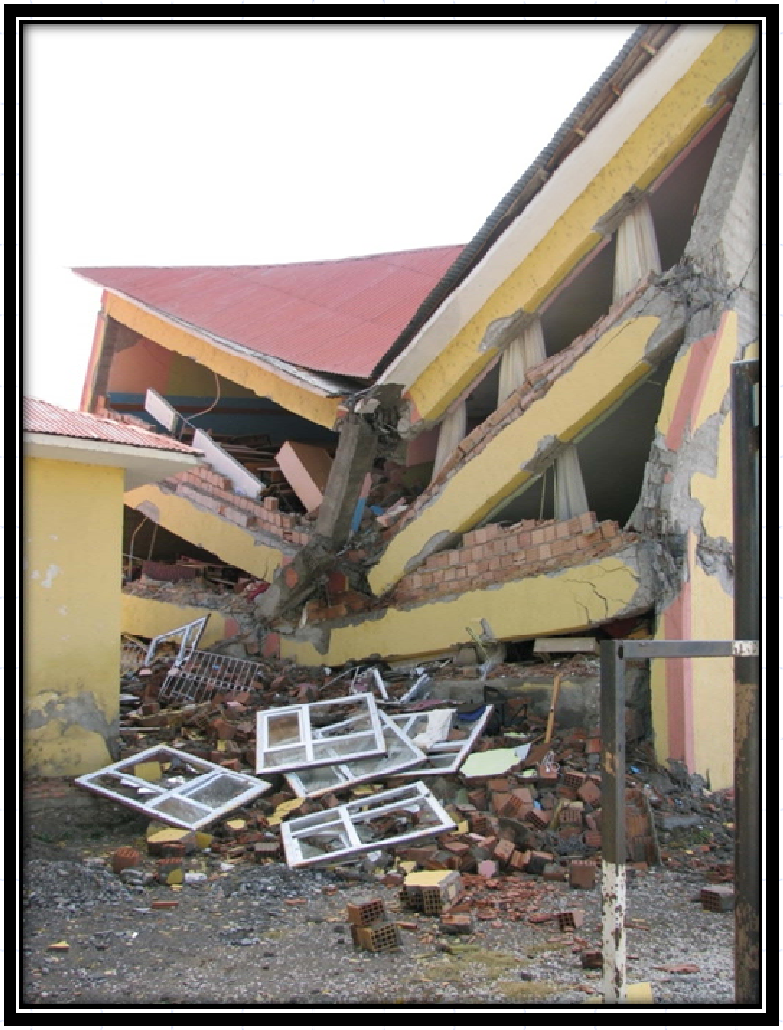
Total collapse
(Gedik Bulak School)

Gedik Bulak School

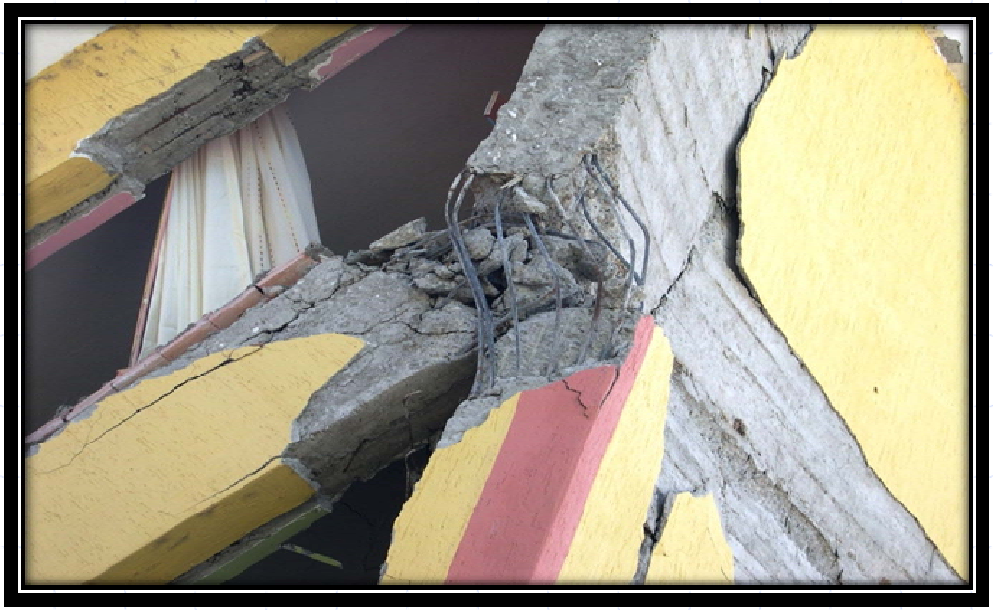


Inadequate hooks configuration (Gedik Bulak School)

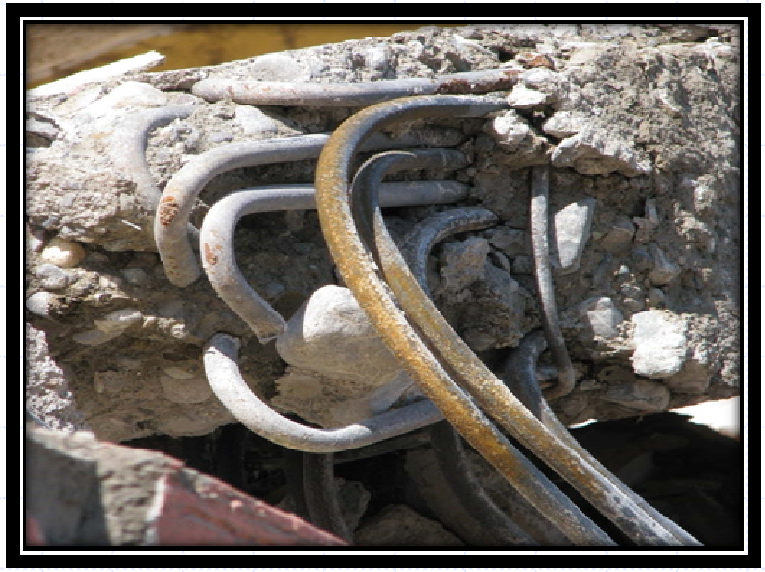
Inadequate ties in the beam-column joints and damages in the shear wall (Gedik Bulak School)



Inadequate ties in the beam-column joints (Gedik Bulak School)



(Gedikbulak school)

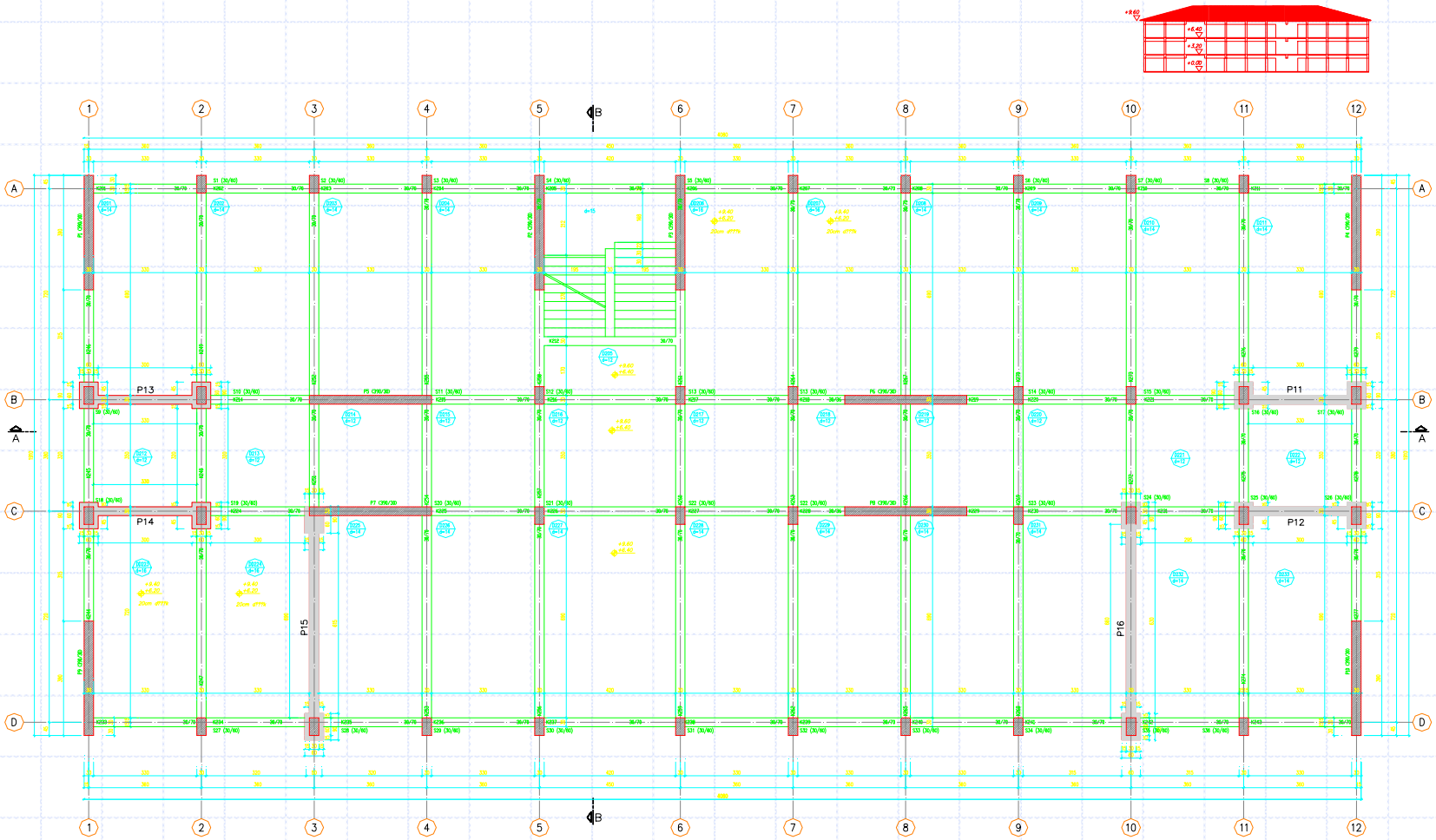


- Improper granulometry in concrete
- Low concrete strength,
- Low bond strength

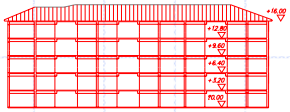
5. Possible strengthening recommendation:

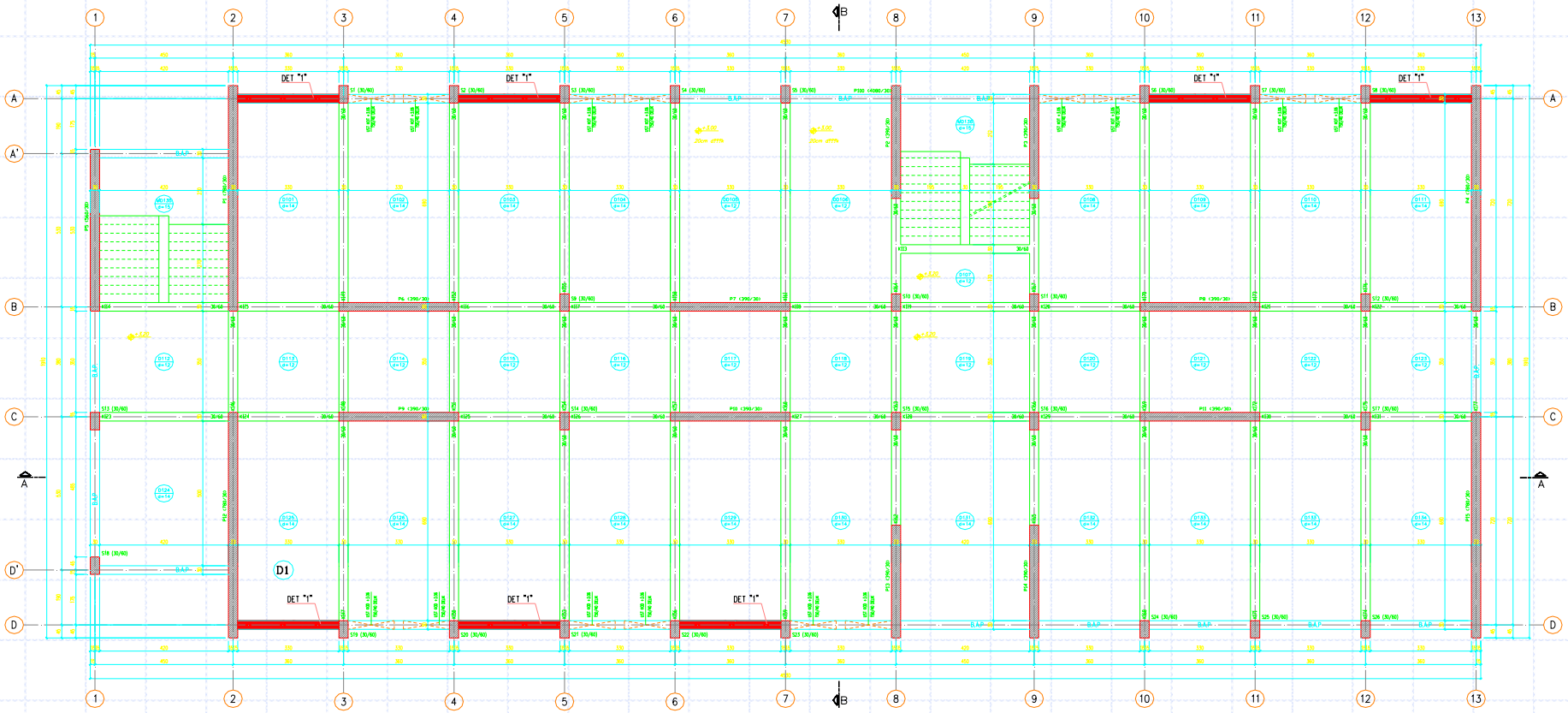
Shear wall addition

School building type 1 : Strengthened structure

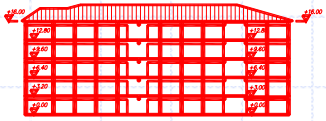


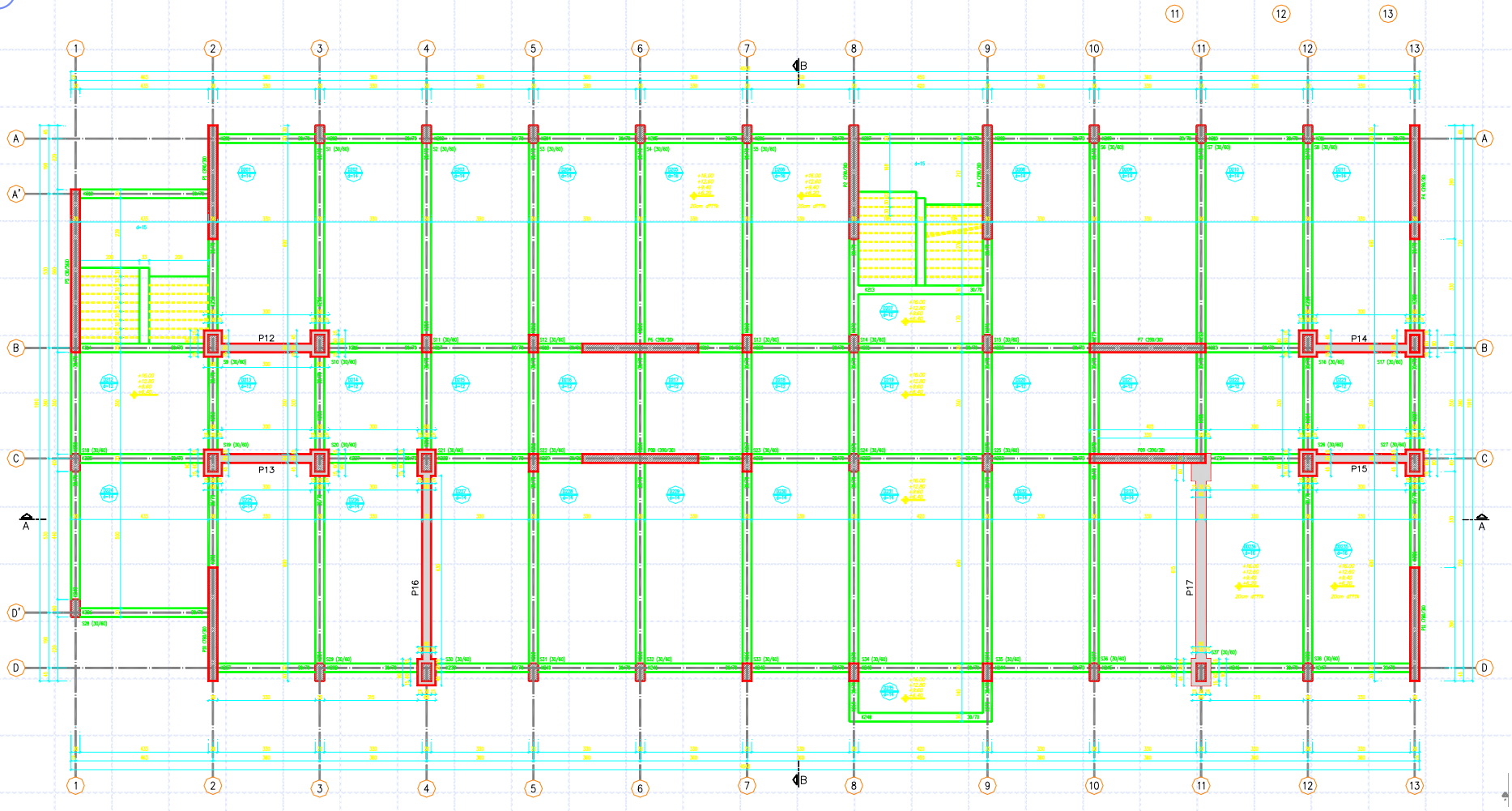
School building type 2 : Strengthened structure





School building type 3: Strengthened structure





Damages:

- Damages are due to deficiencies which have been seen in the previous events as well.
- Most of them due to simple engineering errors done in worksites. In other words buildings do not received adequate engineering attention.
- Low concrete quality, inadequate granulometry
- Low bond strength, inadequate workmanship,
- Inadequate lateral reinforcement detailing
- Inadequate lap splice length

6. Evaluation of seismic damage in the school buildings:

In Van area relatively large number school are constructed in last 10 years. The crucial question asked by the governorship of Van:

Can the school buildings be used for schooling?

The team of the universities have grouped the school buildings into three categories:

6.Evaluation of seismic damage in the school buildings:

The school buildings which do not have almost structural and non-structural cracks and damages. Most of them are new buildings and have received engineering attention in construction. They can be used for schooling.

The school buildings which have limited cracks in the structural elements. They can be used for schooling temporarily, however it should be investigated to decide whether any strengthening is required.

The school buildings which have serious cracks and damages in the structural elements. They can not be used for schooling, however it should be investigated thoroughly to decide whether any strengthening is required.

Evaluation of seismic damage in the school buildings

Evaluated by

Earthquake Engineering and Emergency Management Institute and Faculty of Civil Engineering, Istanbul Technical University

Damage level	No damage	Light damage	Medium damage	Serious Damage
Number of the school buildings	44	105	32	8

A proposal for the existing school buildings to be investigated for seismic safety:

Design earthquake (Ao)
Life safety performance level is checked

Maximum considered earthquake (1.5Ao)
Collapse prevention performance level is checked

A proposal for the existing school buildings which do not pass above check. They should be strengthened by considering:

Design earthquake (Ao)
Immediatle occupancy performance level is targeted

Maximum considered earthquake (1.5Ao)
Life safety performance level is checked

Seismic Response of the School Buildings in Van to the Earthquake October 23, 2011

Thank you for your attention