# On the Seismic Response of School Buildings in Van: A Closer Look to the Collapsed Gedikbulak School

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## Outline

- The studies conducted for UNESCO/IPRED Mission aim to help better understanding the current state of the school buildings in case of seismic actions
- A case study has been chosen from Van, Turkey, where 2 of the 3 case study schools had been visited by an international UNESCO/IPRED Mission as well as the joint Sakarya Univ. and Bitlis Eren Univ. teams

## Remember the Past

- In 2003, Bingol Earthquake in Eastern Turkey, caused the collapse of the dormitory of the Celtiksuyu Primary School causing loss of 86 children's life


## Gedikbulak Primary School

- The primary school of Gedikbulak, built in 80's, collapsed during the October 2011 Tabanlı Earthquake of Mw=7.2
- There was a student meeting which ended some minutes before the shaking, thus luckily there were no fatalities
- The building has totally collapsed

## Gedikbulak Primary School *(contd.)*

Before

After

## Gedikbulak Primary School *(contd.)*

- Before our visit to the area, we did a preliminary search on the damage list of schools and the relevant blue prints
- We found the blue prints of the collapsed Gedikbulak Primary School
- Furthermore, we discovered that the plan of the collapsed Gedikbulak had been «improved» and applied to other schools in the region

## Kurubas & Y. Selim Primary Schools

- Two primary schools in the city center, with similar architectural plan to Gedikbulak, had been visited by our team
- Kurubas (above), sitting on rock, had no damage, while Y. Selim (below), on soil close to the lake, had some minor damages
- Both schools were built after in the period of 2000-2001

## Typical School Projects

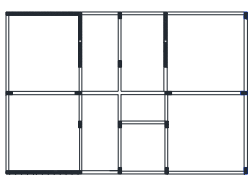
- During our investigations, we found out that several schools have been built in the area by using the same blue prints
- Thus, investigating a group of school buildings to find out the deficincies that caused Gedikbulak to collapse, would be rather easier

# Aim of the Study

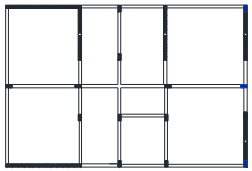
- The aim of our study on the visited school buildings is to answer three essential questions:

1. *If Gedikbulak was constructed perfectly by following the rules of 1975 Earthquake Code, could collapse be avoided?*
2. *If we assessed the existing situation of Gedikbulak per the Assessment part of the Turkish Earthquake Code, what we would find out?*
3. *What could be the causes behind the collapse?*

# RC Bearing Systems



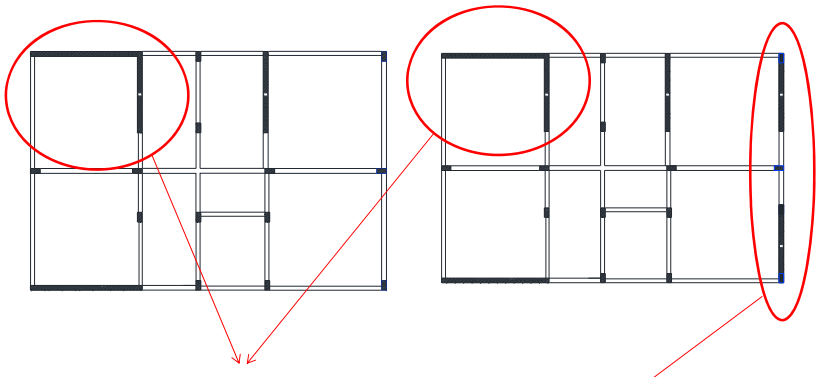
Gedikbulak Primary School

Kurubas & Y. Selim Primary Schools

- The design of Gedikbulak was done by 1975 Turkish Earthquake Code (above-left)
- In 1998, the design was improved and modified to comply with the 1998 Code (above-right)

# RC Bearing Systems - Notes



Note the asyymetry in opposite directions

Additional RC walls in the 1998 version

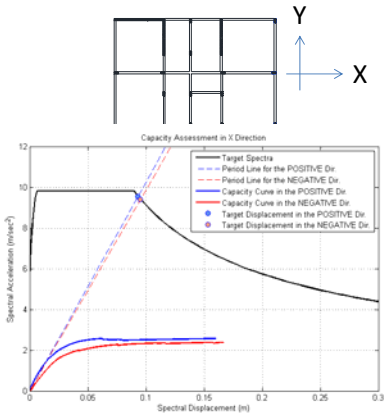
Colum dimensions were also increased

# Analyses

- Conventional pushover analyses have been conducted on the case study buildings
- Initially, material qualities indicated in the project have been used to create the ideal case so that the design mistakes, if any, can be captured
- C16 concrete and S220 steel have been used, no confinement has been taken into account
- OpenSees ans SeismoStruct softwares are used for modelling

# Target Displacement per TEC 2007

- Target displacements have also been calculated per Turkish Earthquake Code'07



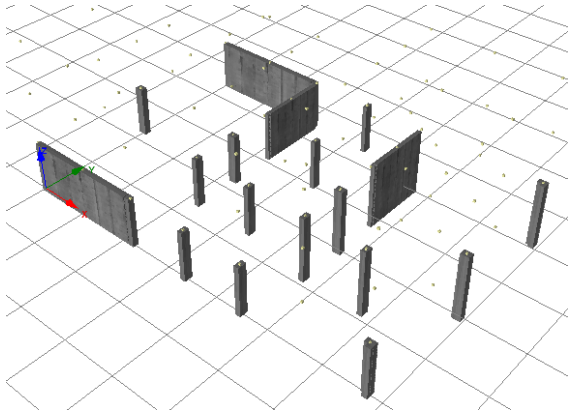

# Preliminary Results

- The bearing system of the Gedikbulak Primary School is quite strong with very long RC walls, thus the reasons behind the collapse need to be investigated with care
- In structures where T or C-shape RC walls are dominating the response, the capacity curves in opposite directions may be asyymetric, something that is not much examined in the existing assessment codes

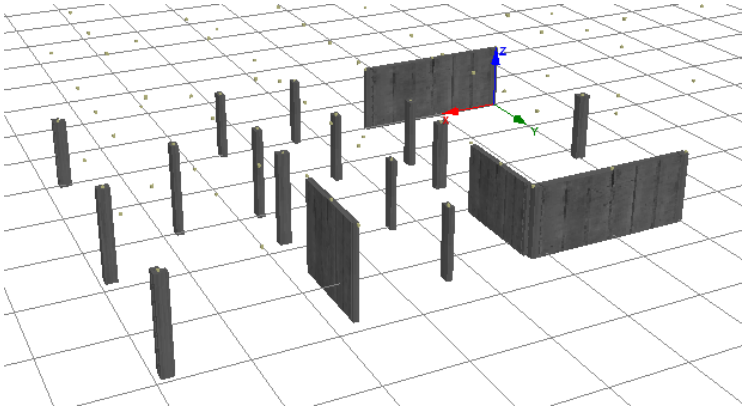
# Ongoing Research as IPRED Mission

- Assessment of 3 school buildings in Van, per Turkish Earthquake Code of 2007
- Assessment of the vulnerability of the school buildings built according to the 1975 Code
- Validity of the assessment section of the current Turkish Code
- Paranetric study to see the relvance of the workmanship and bad material quality with the collapse mechanism
- Assessment of the design of these particular school buildings

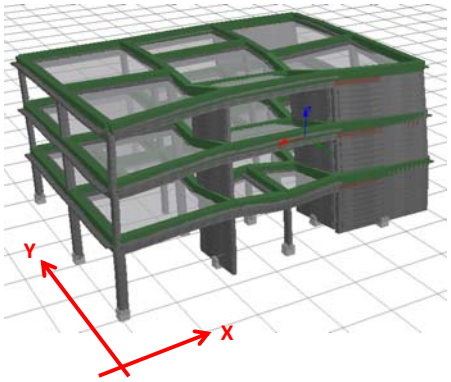
# A Closer Look to Gedikbulak



# A Closer Look to Gedikbulak



# Model and the 1st Mode Shape




T1=0.23sec (69% contr. in Y)
T2=0.16sec (60% contr. in Rz)
T3=0.15sec (55% contr. in X)

# Collapse of the School Building

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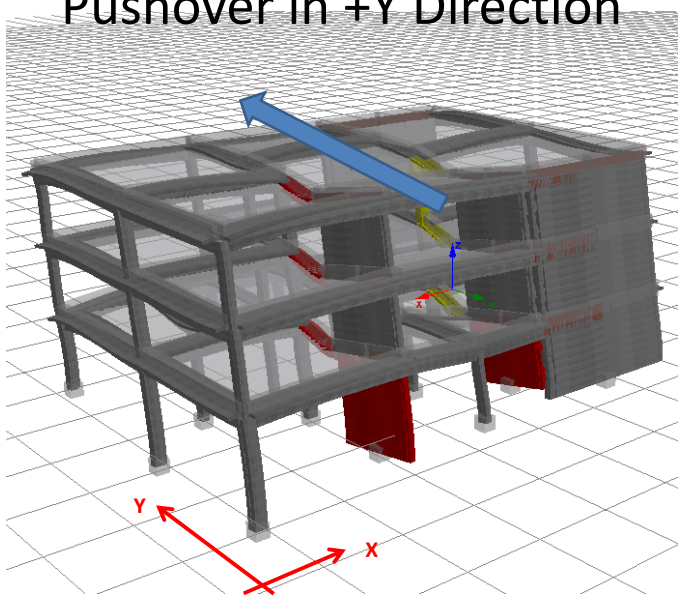
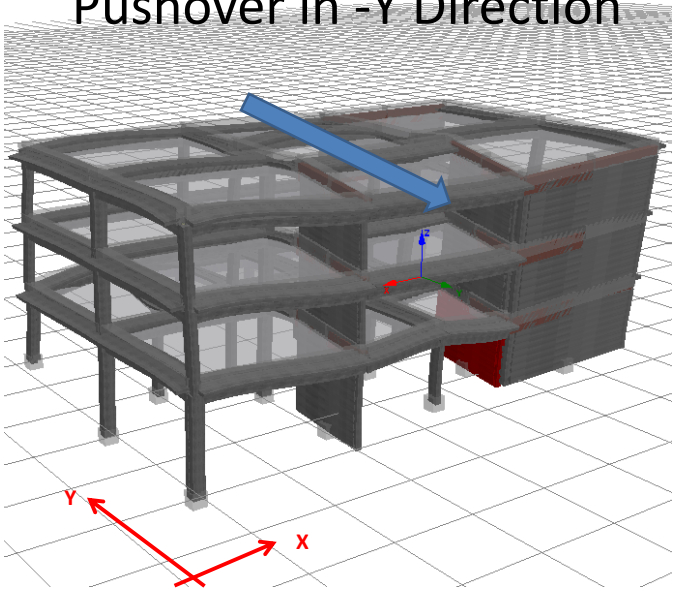
**Observations to mention are:**

- Half of the building has collapsed in pan-cake shape
- The RC walls, though quite large, they still failed at the ground floor
- The RC walls have moved from their axes

# Pushover in +Y Direction



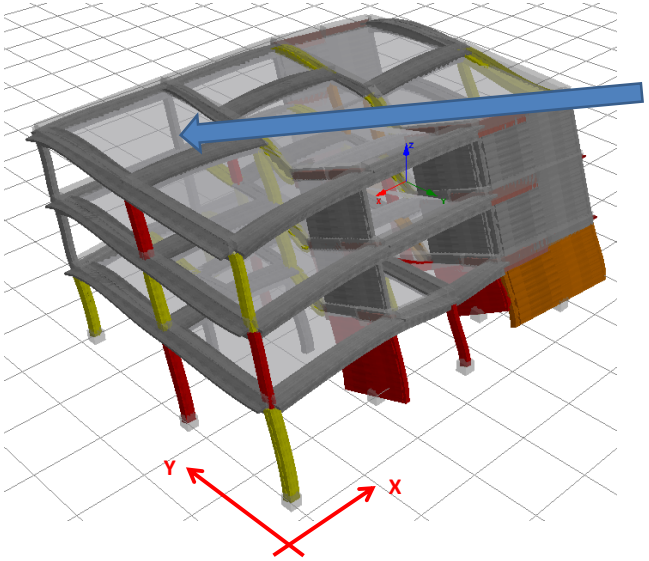

# Pushover in -Y Direction




# Collapse of the School Building

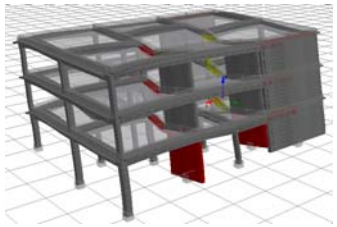
We cannot catch this with orthogonal loading

# Pushover in +X&Y Direction

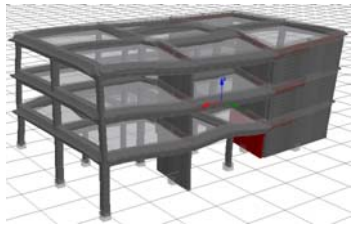


# Collapse of the School Building

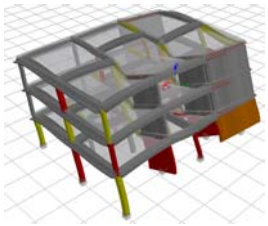
Push in +Y



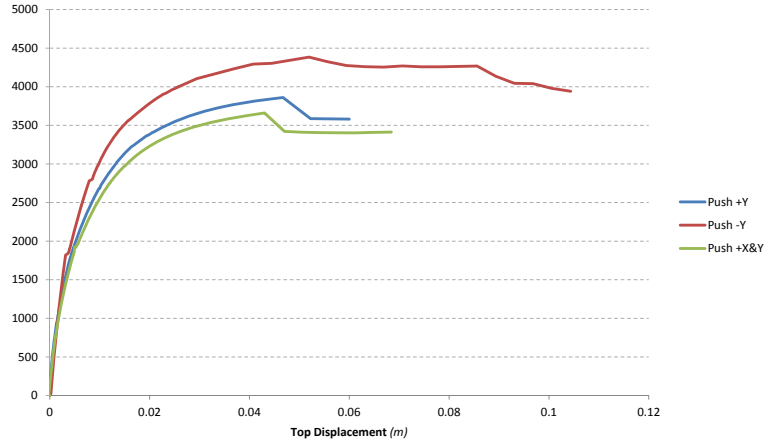
Push in -Y



Push in +X&Y



# Capacity Curves




# Some of the Things That Are «Missing»

- The interaction of the large shear walls with the relatively weak strip foundation and soil should be taken into account so that the large rotations & rocking of the walls and their foundations can be accurately modelled
- The beam-to-column connections lack the enough adherence length, thus the «perfect» models are not fair

# Conclusions (or Speculations?)

- The design, even if follows the 1975 Code perfectly, has bad arrangement of the bearing system
- The over-sized walls impose a behaviour that is dominated by some unusual phenomena, such as:
  - *early failure of beams*
  - *uplifting of slabs (slab OOP cracks in other schools)*
  - *failure of RC wall flanges*
  - *partial failure of the bearing system*

## Conclusions (or Speculations?) - *contd.*

- The response and the damage level detected varies on the loading direction *(it is obvious as much as it is not!)*
- The damage level varies significantly if bi-lateral loading is considered, a fact that is amplified with the selection of an unbalanced bearing system
- The typical designs are, most of the times, disasters more than the disaster itself