Hazard, Vulnerability and Risk Assessment of Himachal Pradesh

OBJECTIVE

- Estimate the damage of different typologies
  - Develop fragility curves for different typologies
  - Quantify the RVS scores of building with the associated damage states

CASE STUDY

- RVS is performed for 9100 buildings in 10 districts of Himachal Pradesh
  - No. of brick masonry buildings: 4363
  - No. of reinforced concrete buildings: 1!
  - No. of hybrid buildings: 1318
  - No. of stone masonry buildings: 1341
  - No. of rammed earth buildings: 518

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)}{2\sigma^2}}$$

$$PS = (BS) \pm \sum [(VSM) \times (VS)]$$

- Out of 45 buildings are screened based on RVS score for phase II survey, 15 buildings are selected on the basis of RVS score (low, medium and high), number of storey, geometry and building construction practices for detailed analysis
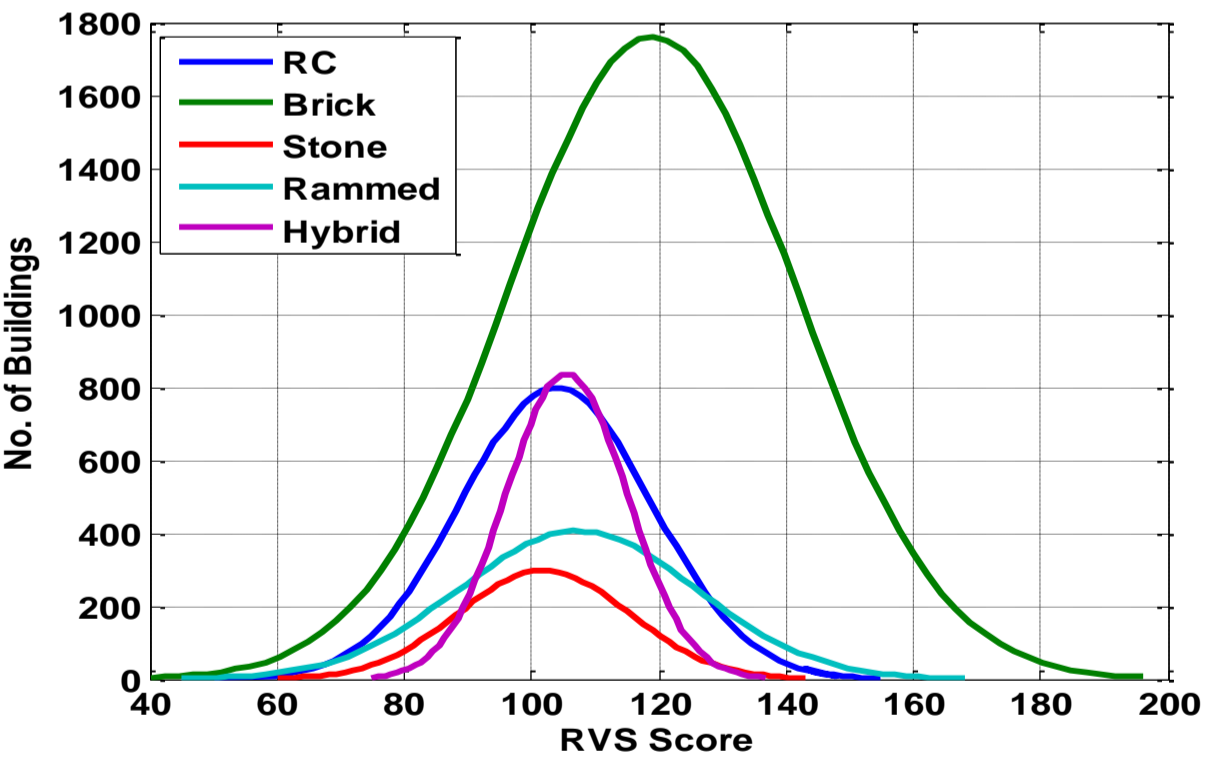

Normal distribution of the sample data according to typology of buildings
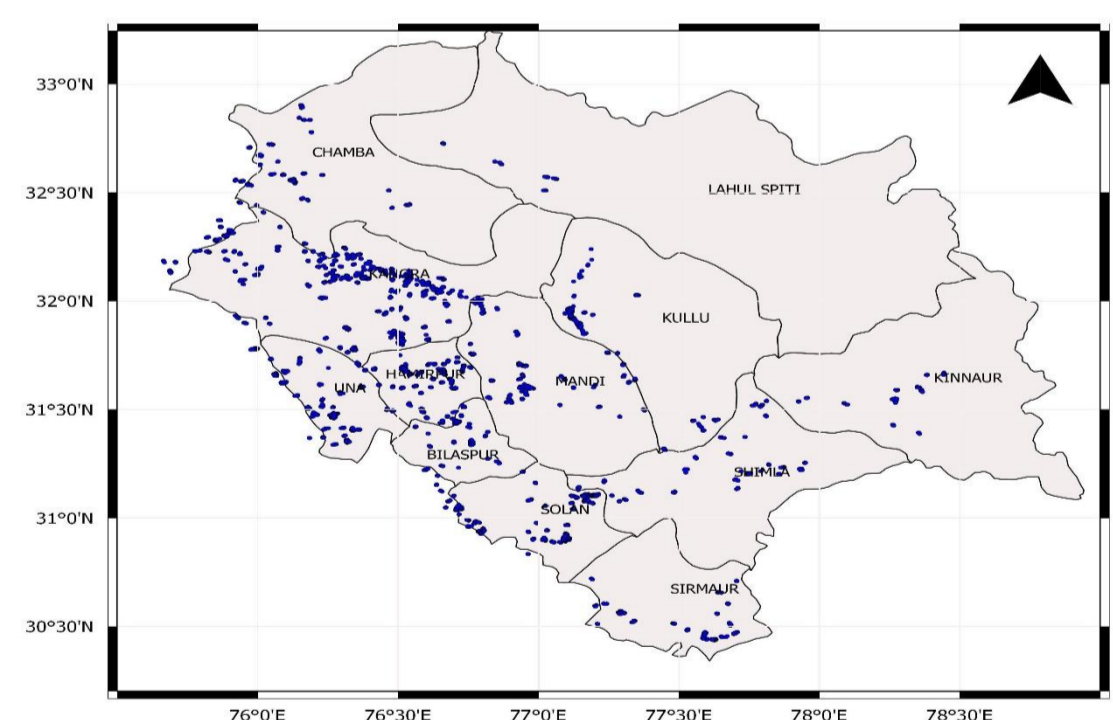
Location of buildings surveyed in Himachal Pradesh

CONCLUSIONS

NON-LINEAR STATIC ANALYSIS

- The target displacement for pushover analysis is based on either of the two criteria
  - 50% of the maximum strength
  - Drift limit exceed the value prescribed in code
- The stiffness of the building is reduced when the yield starts or the first spring fails. The spring fails when the principle stress exceeds the limiting value.
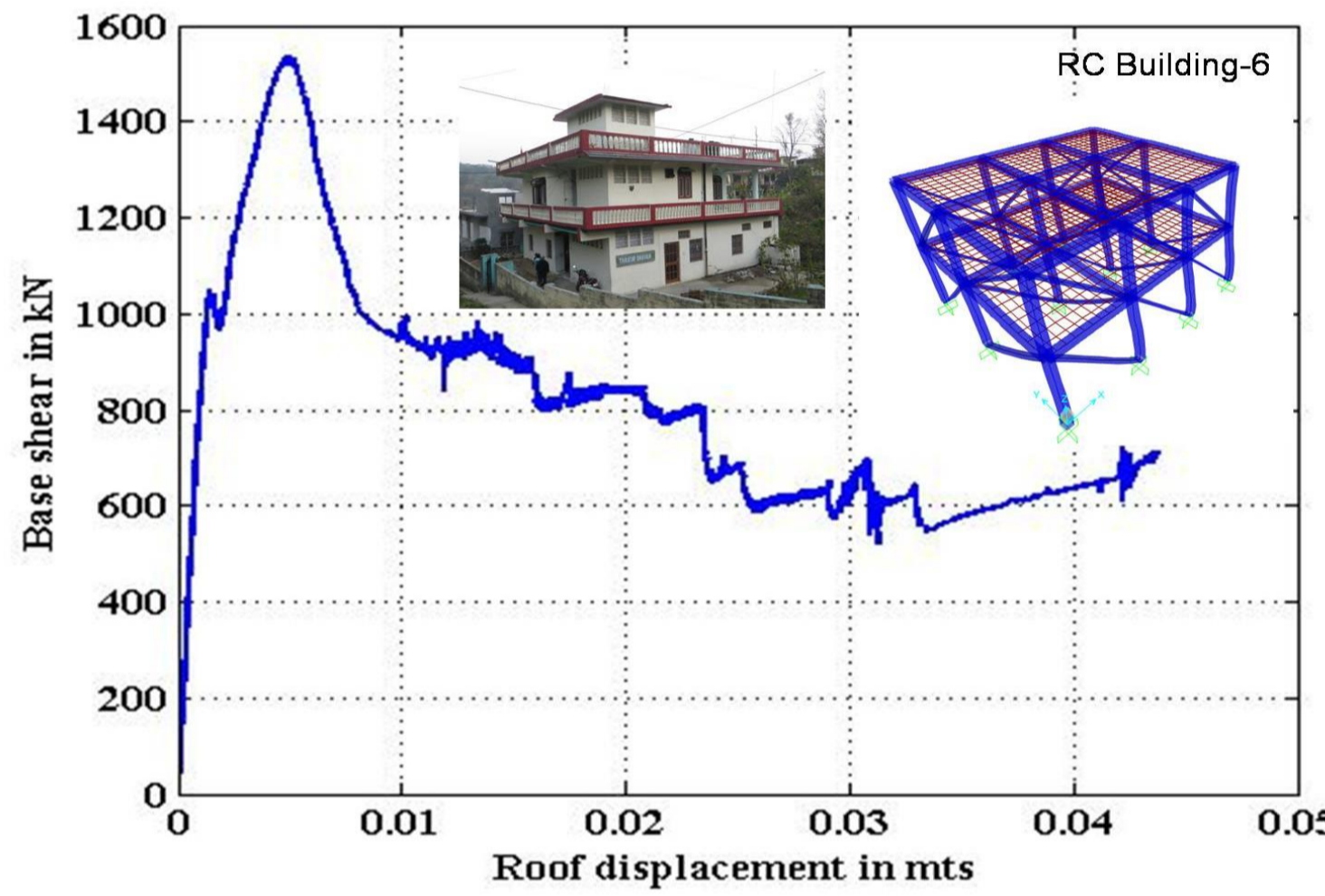

Base shear vs. roof displacement of RC frame
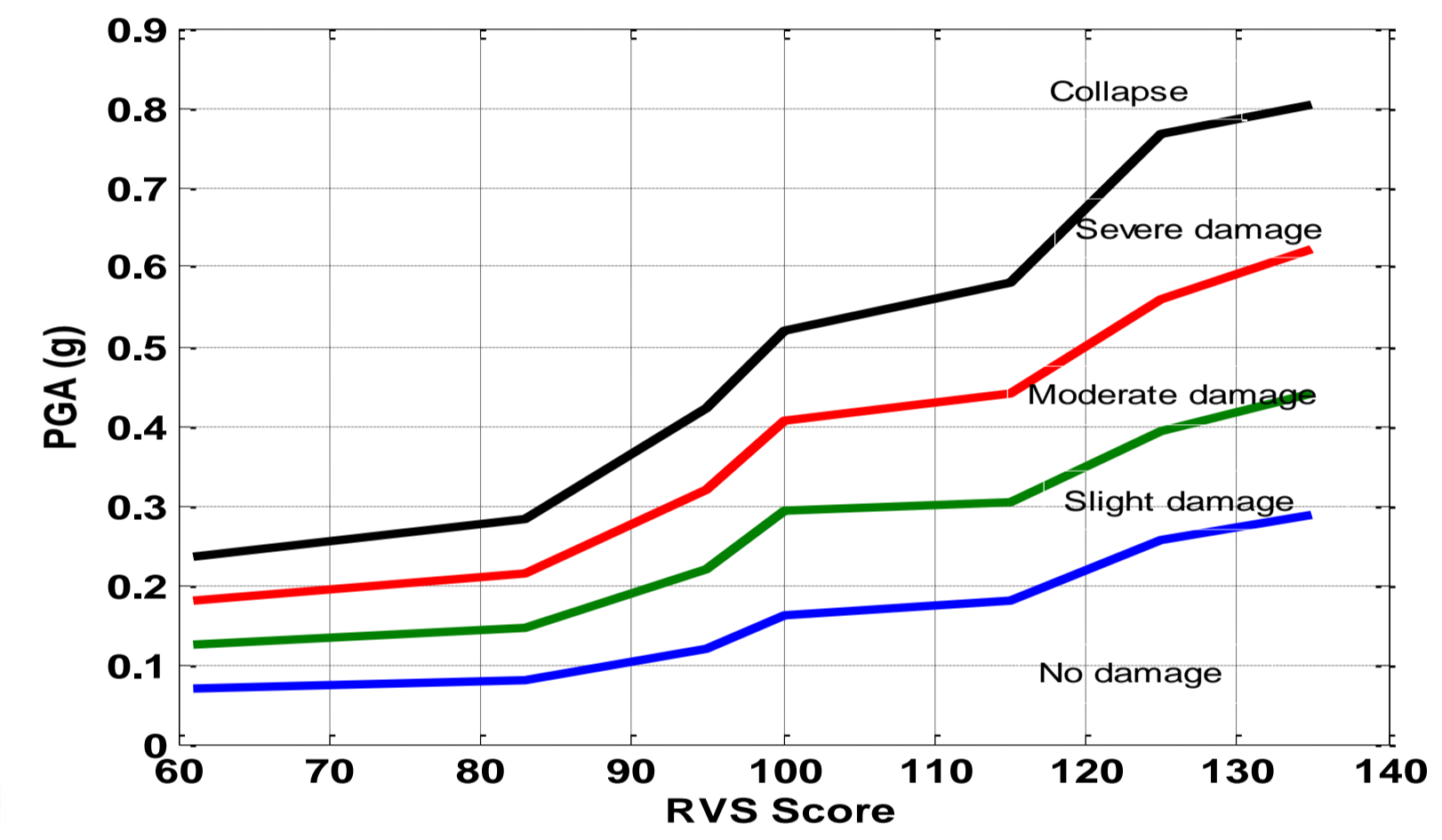
Generalized state of damage for RC and Brick masonry buildings w.r.t. RVS scores

Percentage of Damage to buildings in seismic zone IV

Building Type	No damage	Slight Damage	Moderate Damage	Severe Damage	Collapse
Reinforced Concrete	1.7	72.9	17.2	8.0	0.16
Brick Masonry	0	79	11.2	8.8	1
Stone Masonry	25	7.7	15.6	0	51.7
Rammed Earth	0	0	0	100	0
Hybrid	100	0	0	0	0
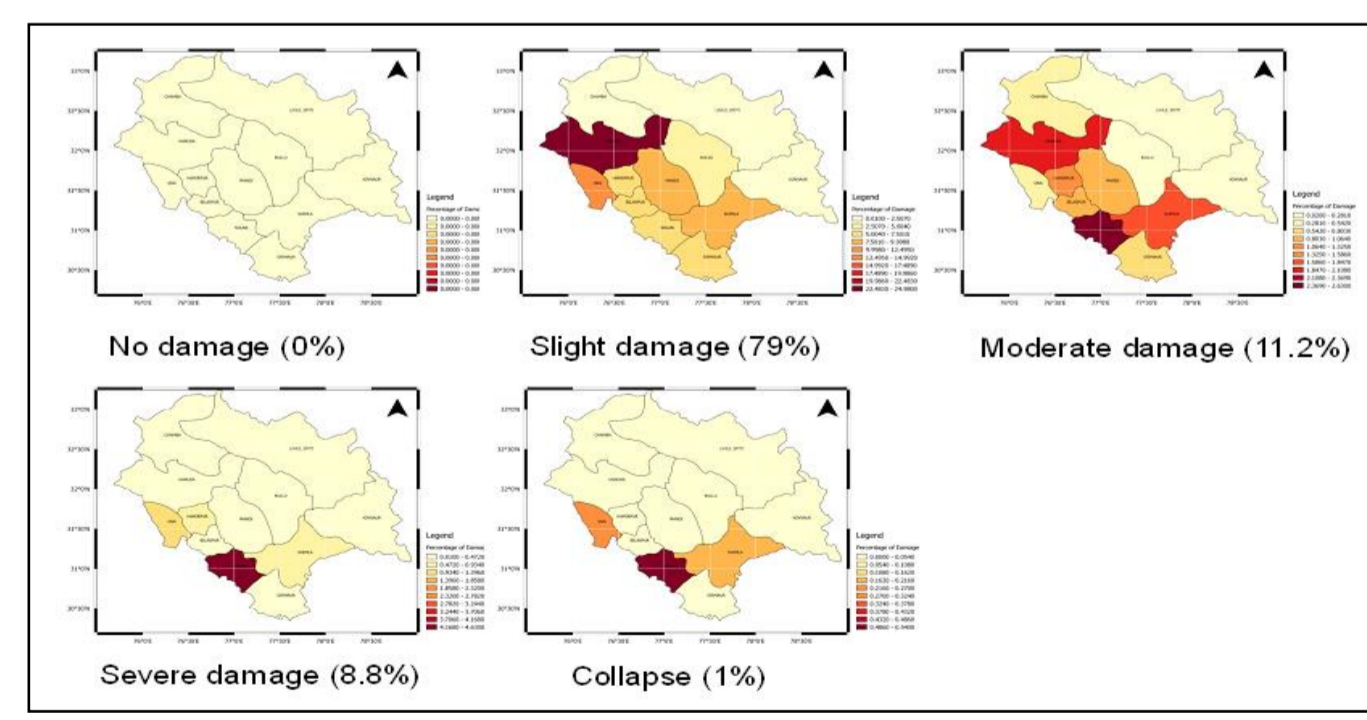
No damage (0%) | Slight damage (79%) | Moderate damage (11.2%)
Severe damage (8.8%) | Collapse (1%)
State of damage of RC buildings in HP

1. Damage is quantified at every displacement level and normalized to 1. It means when D=0 then building will not experience any damage and if D=1 means it is complete collapse. The damage states of the building are defined as no damage (D<0.2), slight damage (D<0.4), Moderate damage (D<0.6), severe damage (D<0.8) and complete collapse (D>0.8).
2. These damage values are correlated with RVS scores. More number of brick masonry buildings is susceptible to slight damage to moderate damage. Few brick masonry buildings are susceptible to collapse during earthquakes

Rajaram Chenna, Ajay Kumar, Pradeep Kumar Ramancharla   Earthquake Engineering Research Centre