ESTIMATING WASTE INDUCED BY EARTHQUAKES WITHIN DAMAGE SCENARIOS

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Waste management, an essential lifeline in post-earthquake urban resilience

Post-disaster waste is an important, often underestimated, aspect in territory resilience. Brown et al. (2011) observe the waste management after Christchurch earthquake in New Zealand. They underline that significant work needs to be done not only from a technical but also an organizational point of view. The objective of this work was to find and test tools to estimate waste tonnage caused by earthquakes

3 methods to estimate waste quantities after earthquakes

- **Hirayama** et al. (2010). The simplest method, in tons/household and damage state
- **MECADEPI & HAZUS**. Hybrid method developed in the framework of this project.
  - MECADEPI (Beraud et al. 2013): methodology built in France for post-floods wastes. Estimation of contents per household
  - HAZUS (FEMA). Method adapted to USA current building. % of waste coming from structural and non-structural elements.
- **L'Aquila observations** (ITC-CNVF 2010). Based on demolition ratios observed in some buildings after L'Aquila earthquake in Italy.

	Complete collapse	Moderate collapse
Case 1	60	30
Case 2	85	42.5
Case 3	113	56.5

Hirayama et al. (2010). This method is adapted to Japan current building stock, waste ratios are given in tons per household. 3 cases are given (1=min, 2=mean, 3=max). Complete collapse state has been attributed to D4 and D5 EMS98 DS. Moderate collapse is considered to include all D3 households and 50% of households in D2

Equipment (tons/household)	Mixed waste (in m³)	Furniture tons/household	Total tons/household
0.218	7.09 (density could be considered 0.3 t/m3)	1.025	3.343

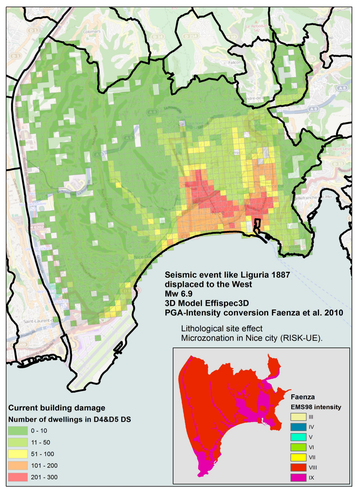
	HAZUS based % waste produced by building collapse											
	% waste (building structure)					% waste (non-structural elements and contents)					Inert waste t/m² of gross floor area	Metal & wood structure waste t/m² of gross floor area
EMS98 DS	D1	D2	D3	D4	D5	D1	D2	D3	D4	D5		
Masonry	5	5	35	100	100	2	2	12	45	100	0.9	0.008
RC	5	5	35	100	100	1	1	7	35	100	1.067	0.2

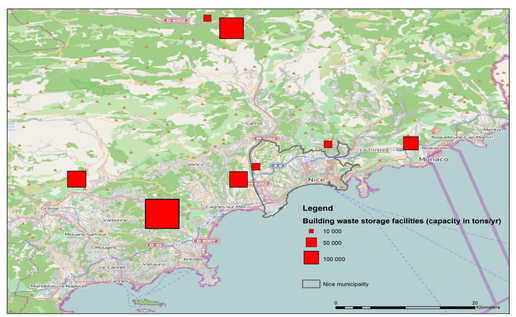
EMS98 DS	D0	D1	D2	D3	D4	D5
Waste volume/total building solid volume	1%	3%	12%	30%	60%	100%

L'Aquila observations (ITC-CNVF 2010). First of all they calculate total building volume (as a parallelepiped) and secondly the solid portion (25% for RC buildings, 35% for masonry). Then they link damage states and % of solid building volume becoming waste.

Seismic damage scenario

- In the present work we have used a seismic risk assessment of current buildings in the city of Nice (south of France), based on first works done in EU-funded project RISK-UE (2004)
- Damages are estimated in EMS98 damage degrees (D0 to D5), aggregated by urban units (Armagedom software, Sedan et al. (2013)). The objective was to produce a method with indicators adapted to EMS98 scale, which is commonly used in France
- Two damaging earthquakes in Nice have been simulated, 1) Vesubie scenario, with intensity VII in Nice city and 2) Liguria sea scenario, which is like 1887 historical event but displaced to the West, with intensity IX in the study area. Further details are given by Lemoine et al. (2014)

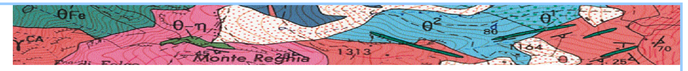




Building waste storage facilities in Nice area and their capacity in tons/year (from CCI 2013).

Waste facilities' capacities

- The waste estimation after earthquakes has to be compared with the territory's capacity of treatment, in order to measure the degree of abnormality. Which is the normal capacity of the territory (in tons per year)? Where are the inert waste facilities located? Earthquake waste is expressed as "n" normal years of waste tons.
- For example, the most impacting earthquake scenario, IX intensity, could produce the equivalent of 5 normal years of waste in Nice city alone.



Lorca earthquake in Spain. Daniel Monfort ©

MECADEPI & HAZUS.
MECADEPI project goal was to produce ratios for post-flood waste in France. In terms of waste types, floods and earthquakes do not have many common points; in earthquakes we find much more inert wastes. However, MECADEPI's building contents estimations are adapted to French context and transposable to the seismic case.
From HAZUS waste estimation module we consider the % to transform between damages states and building types (masonry and RC structures).
Mean inert waste in tons/gross floor area is taken from several back analyses of demolitions done by the French Environment agency.

Application in Nice city

- Waste quantity is estimated for the 2 seismic damage scenarios (Vesubie and Liguria sea)
- For the most damaging scenario, ~5 million tons in Nice city (only for current buildings)

	Hirayama			Hazus & MECADEPI			L'Aquila
	C1	C2	C3	Inert	Metal & wood	Mixed waste	
Liguria scenario	4.24	6	8	5	0.5	0.065	6.2
Vesubie scenario	0.6	0.8	1	.65	0.07	0.007	1

Conclusions

- Reproducible method as it can be derived from seismic damage scenarios
- Agreement of results of all 3 methods, in the same order of magnitude
- Further work: use these methods in order to evaluate different action strategies (prevention tasks) as it has been done by Zhi-Hua et al. (2013) in China

Project DSS EVAC (2012-2015), founded by French and German Research Agencies.