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1.Introduction

Italian historical cities are a unique treasury. When a historical city is hit by an earthquake, damage can be huge: specific activities must be set up to protect historical areas.

Historical cities in Italy are everywhere; the problem is not specific, but general. Correct approaches must be applied all over the Country by many prepared practitioners.

Many historical buildings possess an intrinsic resilience to earthquakes, due to the way they were built. However, several factors might increase the seismic threat, linked to subsequent human activities: e.g. lack of maintenance and repair, modifications after the construction, adjacent buildings.

Often buildings are modified, and thus may lose the ability to resist earthquake actions. Sometimes these modifications are applied as the result of general simplistic rules directly enforced by Laws, or suggested by common practices allowed by Laws.

Some of the potential threats paradoxically related to the official Laws, and Guides, with particular reference to the Laws currently in force in Italy (i.e. Norme Tecniche per le Costruzioni, briefly NTC [1], and MIBACT guide lines [9]), are illustrated.

2.Probability: is it *proba*?

"Probability": from the latin (*probus*, *good*, *honest*, *fit for some use* …). To think that our opinions are *probae*, it is not a prove of their effectiveness.

Several conceptions of *probability* have been proposed, and there is still much debate.

At least two conceptions are worth to be mentioned:

A) *Objective probability*, also called "frequentist". Here the probability **P** is a mathematical limit of a ratio *m/n* and it is necessary that a large number *n* of identical experiments are carried on, counting the "favourable" results *m*, and dividing by the number of experiments itself, so: $\mathbf{P}=m/n$ ($n \rightarrow$inf.).

B) *Subjective probability*: in this conception, due to Bruno de Finetti, probability is the degree of belief that someone has, referring to a given fact. Opinion might change due to new evidences, and also probabilities may (for this reason and due to the application of Bayes' theorem, the approach is also called Bayesian).

Bruno de Finetti, a leading mathematicians and thinker lived in XXth century, strongly criticized the frequentist approach:

> "Saying that the probability of number 37 at the play of lottery is 1/90 would therefore mean that that called f_n the frequency of 37s up to year n, when n increase indefinitely $f_n \rightarrow 1/90$. This assertion [...] is meaningless, as it will never be possible to verify it. But let's admit, nevertheless, to know it is true (e.g. by means of an infallible clairvoyant); from this, no practical conclusion can be drawn, that is no statement which can be checked in a finite time span. Considering 100,000 extractions it would then always be possible, from a logical viewpoint, that 37 never exits, or one time, two times, three, ...100,000" [2].

The criticism is of course even stronger if earthquakes are considered: no sufficient data is available, different phenomena (small and large events) are counted as being exchangeable.

3. The appearance of the *probability* in the Laws referring to seismic hazard assessment.

Probability applied to seismic hazard has directly appeared in the Italian Laws [1] in 2008. However, it has not been explained which kind of probability is used, so the term is questionable. A strict analysis of what was done shows that both approaches, (no-data) frequentist, and subjective expert-guesses, have been used, mixing them up. Also this, led expert statisticians at Berkeley University to write:

> "Making sense of earthquake forecasts is surprisingly difficult. In part, this is because the forecasts are based on a complicated mixture of geological maps, rules of thumb, expert opinions, physical models, stochastic models, numerical simulation, as well as geodetic, seismic and paleoseismic data. Even the concept of probability is hard to define in this context". […] "Probabilities are a distraction […] . [Residents] should largely ignore the USGS probability forecast".[3]

If we are not even surely able to define what kind of "probability" the laws are imposing, how can we rely on it to protect our historical cities? To underline this I proposed to call the "probability" in the Law, "bureaucrability", i.e. the degree of belief of the State ([4]).

4. Questionable assumptions (*inventions of the truth*)

There are several questionable assumptions in NTC 2008 and related official documents (e.g. MIBACT guide lines [9]). Their outcome is that un-experts are pushed to believe that the burocrabilities & related seismic accelerations in the Laws will be the worst seismic intensities of the next earthquakes, site by site, with good probability. Which, being false, is very dangerous.

The picture above, taken from the frontispiece of [4], well explains the difference between true facts, experimentally verified, and the *adhoccheries* (the term is de Finetti's, and comes from latin *ad hoc*, that is, specifically built to fit the need).

In [4] the PSHA has been considered from an engineering point of view, and strongly criticized, even if it is often claimed that PSHA is requested by engineering community. But truth is that engineers are basically forced to adopt it by the Law.

Next table has two columns.

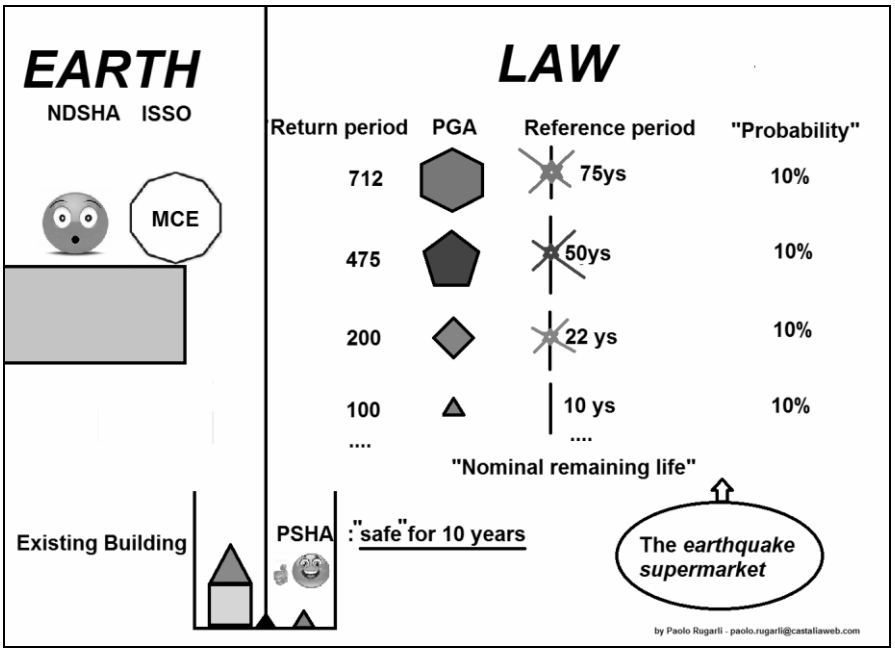
- On the left quotations from [1], and [9].
- On the right the author's comment to these.

All the quotations are, for some reason, intrinsically dangerous. Due to space limitation many more have not been added.

"Seismic hazard is defined in terms of maximum horizontal acceleration ***expected***…[…] referring to preset *probabilities* of exceeding, P_{VR}". [1a §3.2, emph. mine]	The word "expected" is misleading. The wishes of the standard must not be confused with a forecast, which is now impossible. Which "probability" does the Law refer to?
"in annex to the present standard […] are printed the values […] ***necessary*** for the determination of the seismic actions" [1a §3.2, emphasis mine]	This means it seems not possible to use different values, and this is clearly dangerous as use of better of different studies is thus apparently forbidden.
"The possibilities offered by the ***definition*** of the seismic hazard, recently produced and web-diffused by Istituto Nazionale di Geofisica e Vulcanologia, **are used in the best way**". [1b, §C3.2, emphasis mine]	All this text tend to transfer the idea that PSHA maps issued by INGV are "definitions" (from latin *finis*: boundary), of the seismic intensities related to each site. But this is not true. They are guesses.

"Seismic action is now evaluated free field on bedrock, not referring to a seismic zone embedding more municipalities […], as in the past, ***but site by site and construction by construction.*** *"* [1b §C3.2, emph. mine]	Here, the *illusion of validity* ([5]) is so strong that the Law dares to state that hazard is "evaluated" at the bedrock "construction by construction". This is a baseless statement (mirrored by "interpolation over the grid", 100 meters precision needed).
"The [earthquake response spectrum] values […] are listed in annex B. Their average in term of ***return period*** T_R is in figure C3.2.1 a,b,c. Besides for each T_R the 95% ***confidence intervals*** evaluated using a log-normal distribution are provided to give a ***measure*** of their regional variation."[1b §C3.2, emph mine] The values in annex B are median values. However, contradictorily the Law states: "***For small variation coefficients***, or for values ***not directly referring*** to resistances ***or actions***, 50% probability, median values can be used" [1a 2.3, emph. mine]. No safety factor γ_A is applied to PSHA PGAs.	"Return period" does not, as such, exist ([8]): earthquake does not "return" as a comet. Or it would be predictable. This is misleading. We cannot say when a new strong earthquake will hit: it can even be tomorrow. "Confidence intervals" use the 16 different experts-guessed maps, and apply a log-normal distribution using standard deviation between maps. 95% is then median +/- "1.645" standard deviation. What is measured, however, is only the scatter between the maps, *not the confidence with which these maps can "measure" true earthquakes*. The word "confidence" is thus misleading. Practitioners will believe 16 maps envelope what is "expected", which is not.
"The reference period of a building […] is very important as, assuming that the recurrence law of the seismic action is a ***Poisson process***, it is used to evaluate, at fixed probability of exceedance **P**, related to the limit state considered, the ***return period*** of the seismic action to be considered." [1b §C.2.4.3, emphasis mine]	Strong earthquakes are not stationary Poisson processes. Poisson had been checked ([6]) limited to low magnitude earthquakes (M≤5.3), considering very large areas, so that the sources size might be considered very small compared to the area considered. This is not true for strong earthquakes when considering small regions ([7]). In Poisson process the probability does not change at each experiment (has no memory), as in dice. But earthquakes are related to faults deformation, which is slow, but continuous even if not regular. Annual probability cannot be constant.
"If the protection against serviceability limit states is of primary importance, the [probability] values of P_{VR} in the table must be reduced as a function of the wished degree of protection" [1a §3.2.1] "The protection levels that possibly must be increased are **only** those referring to serviceability limit states, while the protection levels against ultimate limit states **can** remain basically **unchanged** as considered **already sufficient** by the Law" [1b §C.3.2.1., emphasis mine]	If on one hand the Law allows using different protection levels (it does), on the other hand it does this only within the rigid (and baseless) frame of "probabilities", and explicitly discouraging the use of values higher than those of the Law for the most threatening limit states. As higher protection levels are unilaterally declared "much more expensive" (see below) and more difficult for design, the real outcome of these provisions is to make it more difficult to design in a safer way.
"...The [alternative] design strategy just hypothesized, though, leads to a building **much more expensive and <u>therefore is lecit to use it only when serviceability limit states are really of primary importance</u>**" [1b C.3.2.1.underlined in original, bold and color mine]	It is not true that higher protection against seismic hazard leads to buildings "much more expensive". The Law *de facto* discourages the use of better anti seismic design. These *a priori*, drive inexperts to the only possible conclusion: using directly the mapped values with no modifications.

"Life guard limit state SLV: **10% exceeding probability during V_R** (50 years for normal buildings)" [1a table 3.2.1, emphasis mine].	A simple new building has a 10% *probability* not to protect the life of people inside it, during 50 years. A value too *probable* but required, to avoid unrealistic results. Existing historical buildings? E.g. using 1% in 100 years would require "return period" of 9950 years. 1% in 200 years a "return period" of 19900 years. And PGA unrealistic (see bel. [9 §2.4]).
[existing buildings] "The evaluation of the safety **is a quantitative** process" [1B c.8.3., emphasis mine]. Can we *compute* anything? Is it wise?	Not anything can always be computed or evaluated numerically with 3 figures, especially when dealing with historical buildings. Qualitative judgment should also be considered, on the basis of experience, but is instead implicitly forbidden, so pushing to use "formulae" where they cannot be used.
[existing buildings] "The **recheck is not compulsory** for the situation determined by a variation of the loads that happens due to a revision of the Law, referring to the part defining the amount of the loads or the zoning that maps the environmental loads (**earthquake**, wind, snow)". [1b C.8.3., emphasis mine]	Seismic maps may thus continuously change with no effect of the major part of the buildings. Besides, this means that clearly unsafe buildings are "forgiven" and can stay with no modifications at all: e.g. all the buildings in seismic areas with no lateral resistance at all, by design. A *political* choice, this, to be compared to the excess of impossible "precision" systematically required by the Law.
[existing buildings] "It will be the owners or the managers of single constructions […] to define the best action, setting one or more load levels **related to the nominal remaining life**…"[1b C.8.3.]	"Nominal remaining life" is a dangerous, misleading nomenclature, which pushes to believe that this index is related to the number of years "remaining" before the earthquake hits. It is pretty much like assuming that only after *m* throws of a *m*-die a number will come out.
"It is premised that the maximum ground accelerations a_g values are given by INGV **with a precision of the order of +/- 0.01g**" [1b CA]	How can this hold true if the most part of strong motions data is *not* machine recorded, and stems from macro seismic intensities (rough) estimates, *I*, using integer values (6, 7, 8)? Why the Law has hundreds pages of 3 to 4 figures values, if they are not reliable?



The e*arthquake supermarket*

"It is anyhow necessary to evaluate quantitatively the seismic action at Life Safety limit state and the expected one in the site with a preset probability of exceedance in a reference period defined on the basis of the construction features and its use (…): thanks to the ratio of the related return periods it will be defined in the following the seismic safety index, useful to highlight the critical situations and to set priorities for future actions." [9, §2.1. No more commas in original]	This procedure does not check against the MCE (maximum credible earthquake), which might hit the structure. As return period is a fake, the ratio of return periods is the ratio of two fakes. Moreover, PGA alone cannot embed all the safety issues related to a construction work. The word "seismic safety index" is thus seriously misleading to population and technicians. These computations are meaningless and useless. Priorities cannot be set according to these fakes.
"If the seismic action at Life Safety limit state is significantly lower than the **expected** one for the site, when is **assumed a reference period compatible with** the features and usage conditions of the construction work, this causes the need to execute a more refined evaluation and possibly to act within a time span shorter than the reference period. In fact, coherently with the probabilistic concept of safety, the structure might be considered safe against an earthquake with a return period shorter than that of the reference seismic action; **the nominal life, introduced in NTC, is therefore the parameter to be used to program the action of risk lowering**". [9, §2.1, emphasis as in original]	Let's explain it by dice (see picture above). Throw a die. If 3 comes out the weight of the die will load your structure. You wish to throw a die 50 times with ("only") a probability 0.1 that number 3 comes out. The die must have 475 faces. It's however a too big die for your structure. So, You will take a die with less faces, and throw it less times to have the same probability. For instance, a die with 200 faces can be thrown 21 times. With probability 0.1 that number 3 will come out. Alas, *nominal life,* in years, is the number of throws. If 200 faces are once more too many, the die is too heavy for your structure, at the earthquake supermarket you will always find a die with so few faces, thrown so few times, that probability fits. For instance, a die with 100 faces can be thrown 10 times. For ten throws, i.e. ten years you are "safe"... However the true die is not the one you choose, it's Earth. *Can this absurd criterion be applied to our safety and to the safety of historical heritage?*

"The nominal life **of a cultural good should be very** long, **wishing to assure the conservation for a long time also against seismic loads having a high return period**; **however, this would lead** to a seismic check too onerous and if the required actions **would result** too invasive toward the good, coherently with the possibility to limit to "improvement", the design will apply a nominal life shorter." [9 §2.4. Emphasis as in original.]	Translation. If what should be done require too serious actions, do not do them. Protect the good against its protection from earthquakes! Take at the earthquake supermarket an earthquake fit for your need and declare the structure safe for some time. However, you will be paid for your work. If the good will be lost, there was a probability for this to happen.
"Further and heavier actions shall in this way be posponed in time; **at the end of nominal life a new check will have to be done, and consequently new actions shall be necessary** (…)". [9 §2.4, emphasis as in original]	That's it. You've transferred the problem to next generation. Which is one of the goal of [9].
"**The seismic hazard to be used for next check will obviously have to keep into account the time elapsed, and if the seismic hazard map then available would still be not depending on the time elapsed since the last significant earthquake (poissonian model), when defining the reference period it will have to be considered also the time elapsed since the first check**". [9 §2.4, bold in original]	So, a memoryless model is modified to insert memory, which is contradictory. This is pretty much like "delaying numbers" at the lottery. If in the future we will have to keep into account the time span passed since the first retrofitting action, then why when considering the hazard at the first retrofitting no consideration must be done about the previous years, i.e. the history of the building? So all the method is flawed, contradictory and baseless.

5. Dangers related to these "inventions of the truth"

1. **Waste of public efforts** (time, money, work) in the wrong direction.
2. **Waste of private efforts** (time, money, work) related to the not useful procedures.
3. **No spread of knowledge** due to the needlessly complex procedures (often paradoxically software-driven by inexperts).
4. **Slowing down** of the development of alternative researches and methods.
5. **Discouraging** of the use of alternative hazard evaluation methods or the use of higher protection levels.
6. **Irresponsible spread of baseless safety feelings** related to the use of the hazard values of the Law (especially for existing buildings). **Irresponsible attribution of "safe" labels.**
7. **Stopping *sine die*** of the intervention to improve existing buildings and historical heritage.
8. **Confusion** between the every day probability and the bureaucrabilities of the Law, which are not comparable

6.Conclusions

The Law should be written in such a way to avoid the dangers related to a too strict adoption of methods which do not have an experimental feedback.

When there is a lack of knowledge this must be clearly identified and People must be warned against this. Reasonable envelopes must be used.

When no precision is possible, the math, if used, should be coherent and avoid to waste numbers.

Italian cultural heritage is at stake. Temporary, fallacious actions, are only useful to transfer the problem to next generation.

7. References

[1[a]] Norme Tecniche per le Costruzioni, D.M. 14-1-2008

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[5] Kahneman D., *Thinking Fast and Slow*, Penguin Books

[6] Gardner J. K., Knopoff L., *Is the Sequence of Earthquakes in Southern California, with Aftershocks Removed, Poissonian?*, Bull.Seis. Soc. Am.,1974,**64**,5

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[9] MIBACT 2011, Linee Guida per la Valutazione e la Riduzione del Rischio Sismico del Patrimonio Culturale con Riferimento alle Norme Tecniche per le Costruzioni di cui al D.M. 14-1-2008, Circolare 26/2010.

Quotations from [1] [2] and [5] have been translated from Italian by the author.