Some past decision theory models for euro construction model codes and for road drainage in Spain, and modest hints with multi-criteria methods for agro and environmental assurance

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Introduction Decision theory models used as aid, for the theory, combined with other forms of state of art, for construction systems, road drainage, and others, that can include agro and environmental planning and assurance.

1 In the European system for construction

Let us call it ESC, it was developed by steps after 1945 from national systems, contains Eurocodes and norms, enormous living praxis, adapted for nations as from 1985. There is an USA complete system, and some others partially (Japan, Brazil for concrete, Rusia, ...), others tend to adopt them.

For Spain early action of Pr. E. Torroja, in CEB (Comité Européen du Béton, also in FIP (for prestressed), now both in fib, etc .... , they included in "Probabilistic theories for structures" a frame for risk, now maybe "Safety and Performance Concepts" as in fib. com2, used for loads, resistances, safety factors models. Resistances augmented, got controled with quality formats, safety factors were reduced. Earlier CEB for concrete and CECM (=ECSC) for steel, to group them JCSS (with J.Ferry Borges from Lisbon) for all, also CIB, other for quality control, also with ISO.

From AIPC symposiums ICOSSAR (Throndheim 1981, ..., in sept 2009, in Osaka, J.) now association IASSAR, centered in Columbia U. NY, USA, for stochastic methods and techniques in structural engineering. Such risks exist from nature and humans, the goal is to have failures only very exceptionnally and from unexpected effects, controlling the cost of being safe.

2 A model for superposition of independent loads.

Since Nov. 1967, J Antón Madrid participated in CECM, for steel construction, with J. Batanero et al. They had to reduce safety factors when different independant loadings supperposed (Service, Wind, Snow), maximums ulikely coincide.

A load S taken with a <u>characteristic value</u> (cv) S_{cN} or S, often <u>nominal</u> , legal limit, from codes or contract, "that has 5% probability of been exceeded in N as "50 years", as a "life of structure"; N needed "to compare permanent and service loads".

S majorated for checking as $\gamma_S \cdot \mathbf{S}$ by load safety factor, such as γ_S = 1.5 for variable loads, 1.3 for permanent loads. A variable $S_{c,N}$ grows with period N. Extreme value Gumbel type I:

-in N years, $p_N(X)$ = $Prob_N(S > X) = 1 - exp(-N·exp(-(X-M)·L))$, is $M+(0.577+Log_e N)/L$, σ is 1.28/L. In 1 year mode = M.

- X grows with N, "speed" in % from $(\mu_1/\sigma) = 1.28/(M·L+0.577)$.

-Return period $T_X = Esp_X(N) = exp((X-M)·L) =[-log_e(1-p_1(X))]^{-1}$,

-if $T_X > 5$ then $Prob_1 (S > X) \# 1/T_X$.

If $k·s^{\wedge} =exp((X-M)·L)$, Gumbel type II, $p_N(X) = 1-exp(-N·k^{-1}·s^{-\wedge})$,

return period $T_s = Esp_s(N) = k·s^{\wedge}$.

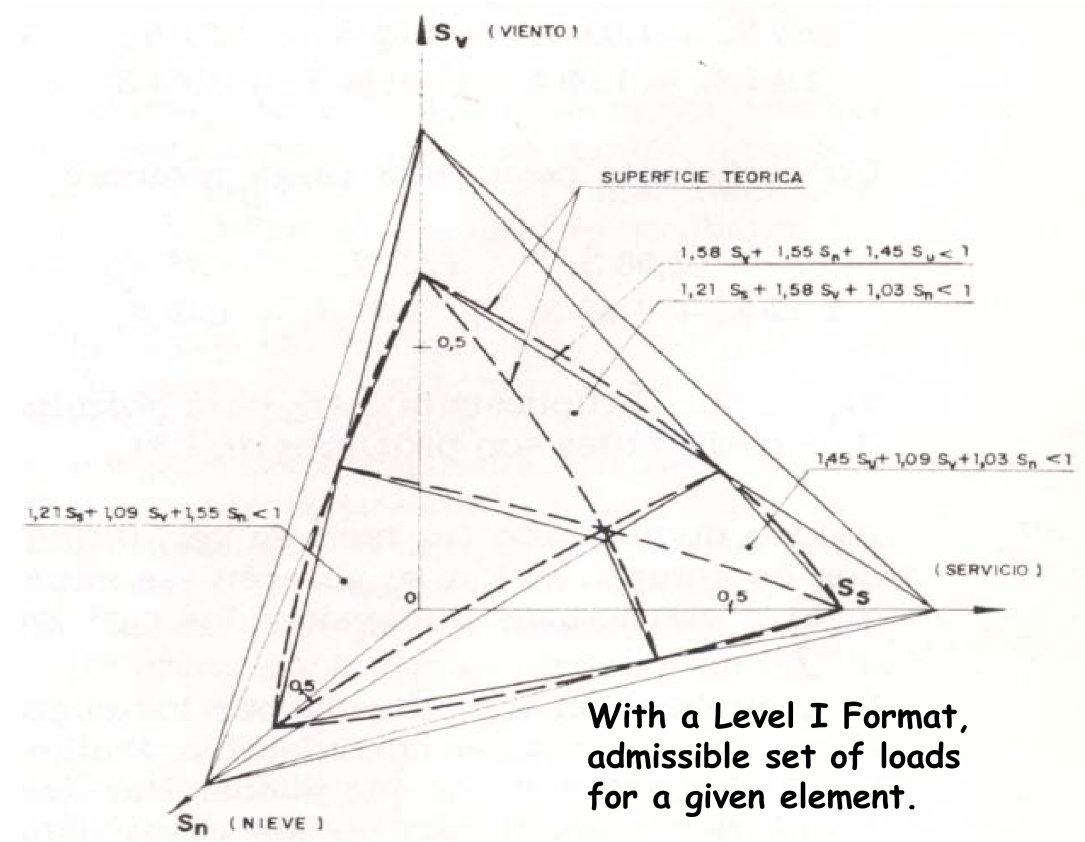
Generalized extreme value law:

$$F(x;\mu,\sigma,\xi) = \exp\left\{-\left[1+\xi\left(\frac{x-\mu}{\sigma}\right)\right]^{-1/\xi}\right\}$$

3 Optimizing to indicate safety factors.

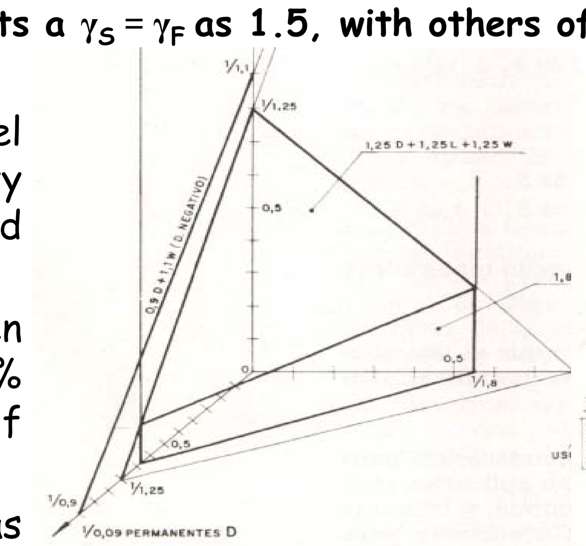
For a main resisting element, distribution of loads, of resistances and of model uncertainties indicates a probability of failure in 50 years, or life of the structure.

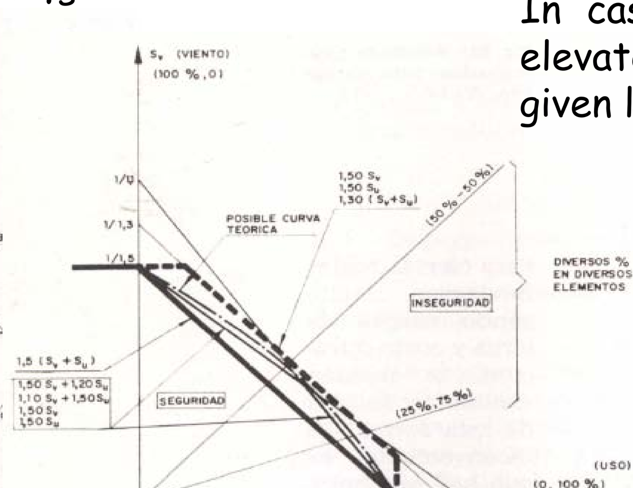
Safety levels prescribed with coeficients for loads γ_S or for resistances γ_M. The cost of structure grows with $C = \gamma_S \cdot \gamma_M$ and the probability of failure P_F increases, an optimum C minimises sum Σ of expected cost of failure in life of structure plus cost of independant element.



Format as adopted for Model Codes (CIB et al., Granada 1976), like suggested by J.Antón in Roma feb 1969 with CECM and others (CEB, FIP, when ISO setting format with γ_M and γ_S).

Different Formats for superposition of loads (from 1970), of different nature. Figures represent sets of the of loads, in different proportions, resisted by an element with resistance 1. Such formats were called "level I type format, are in codes. From JCSS Lisbon Feb 1974 unification for concrete, steel, on load side, getting set of Model Codes, from them Eurocodes. Each variable load gets a $\gamma_S = \gamma_F$ as 1.5, with others of γ_S as 1.3 .

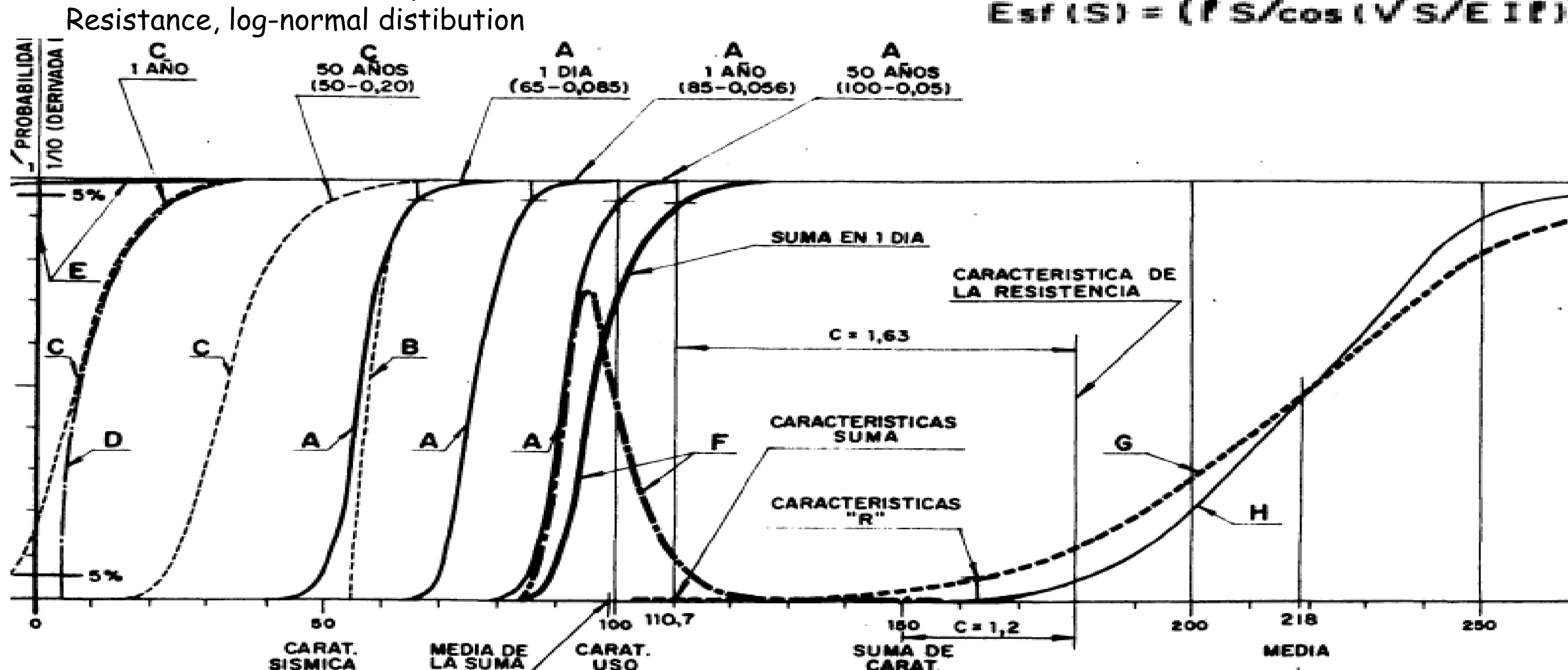




of Final state rules ACI 1963

With hypothesis on loads, resistances and model uncertainties (less measurable) an optimum value of C is indicated as result.

Loads growing with time, "Extreme value type I" with two loads, theory curve, codes Resistance, log-normal distibution



4 Superposition of independent variable loads.

For two loads, random distributions (extreme value I), the authors in models reduced them to their "in 1 year" distribution (exponential non negative), supperposed as sum of independant variables. They got distribution of sums of variable proportion, and from them they obtain the extreme value type I asymtote distribution for 50 years.

Curves represented sum of actions on an element, to have a probabilities of failure P_F, that were optimised to obtain global γ_F of partial γ_{F1} and γ_{F2} .

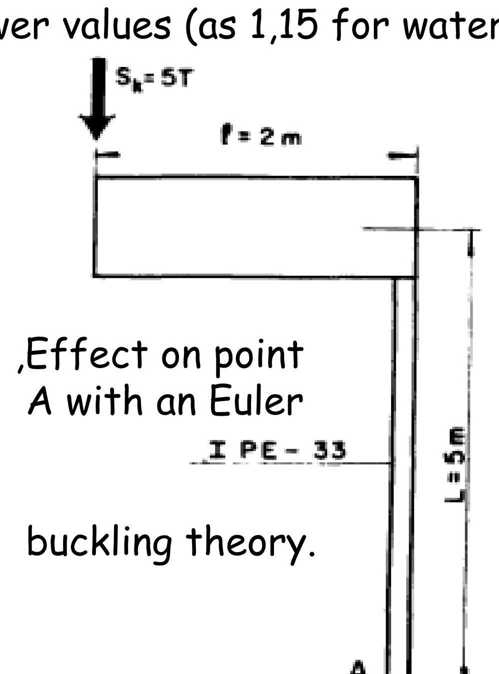
The obtained P_F are low, as $10^{-3.5}$ in 50 years. Hence such theory gives mostly indication of what is involved in a Level I code format, used mainly for construction considering also the safety coeficients in real state of art.

To consider more visibly probability other levels II to IV, were suggested and developed for more stochastic theories.

5 Other main effects to be considered

Effects of loads may be non lineal, and buckling is an evident real example (see fig.). Author´s completed optimisation model with Euler formula buckling formats, getting that safety with (variable load) . $\gamma_F = 1.5$, and $\gamma_C = 1.4$ for concrete and with $\gamma_F = 1.5$, and $\gamma_s = 1$ for steel, corresponded to the desired optimisation.

In cases of real limitation of loads, as in an elevated water reservoir, the γ_F could be given lower values (as 1,15 for water weight).



Effect on point A with an Euler buckling theory.

$E_r(6_k) = 6_k$

$E_{sf}(S) = (f\ S/\cos(\sqrt{S/EI}\,\ell))/W + S/A$

Permanent loads such as weight of building get if unfavorable some $\gamma_P = 1.5$, but some $\gamma_P = 1$ (as a resistance) if favorable for a section. That reduction is in excess in cases as for the construction of a prestressed bridge with successive dovels. An author indicated effect of correlation in permanent weights, favorable and unfavorable, in a Manuel de Sécurité of Commission 6 of CEB about in 1982. Opositedly J.Schneider focused on Hazard Scenario concept, as in norm SIA-160 used in Suisse, as natural hazards effects may be increased by human dispositions.

6 Resistant side, control of quality.

For steel or concrete characteristic values are defined, having 5% probability of being lower in concrete cases. Authors intervened in regulation, linked to control of quality theories: control problems occur if population is bimodal as mixed from two qualities. Moreover that enters in industrial production organisation, control of internal control, with maybe a residual control with on site probes.

7 Road drainage in Spain, norm, small basins

of Time of concentration Tc (h) lesser than 1 day, for flows with return period Rp from 5 to 100 years. Rate of discharge (m^3/s) Q = (C·I·A)/3, A area km^2, I mean rain (mm/h), I=f(Tc of basin, Rp), $C \in (0,1)$ run off coefficient.

Maps with 24h I_{24} expected rain for Rp ≤ 100 years from meteo rain records, extreme value Gumbel 1 was used first.

For Spain small basins, MOPU, J.Témez, from BPR of USA, L km length, J (tg α) slope, main creek.

$$\mathbf{Tc} = 0.3 \cdot \left(\mathbf{L}/\mathbf{J}^{1/4}\right)^{0.76}$$

In Spain weather more extreme in Barcelona at NE, less in Galicia at NO. At E occasional small drop high rains (as 400mm a day, river Turia set 5km South in Valencia 1957). To get I_D for D =Tc, d = 24h:

$$\mathbf{I_D}/\mathbf{I_d} = \left(\mathbf{I}_1/\mathbf{I_d}\right)^{\frac{28^{0.1}-\mathbf{D}^{0.1}}{0.4}}$$

where $\mathbf{I}_1/\mathbf{I_d}$ from map.

Also rules for C = f(P, P_0), P rain in mm, P_0 threshold for P, depend on surface and use, and on region, with a map.

Sources: -Instrucción drenaje carreteras, Min. de Fomento y documento CEDEX sobre Drenaje en pequeñas cuencas, Spain. //-Documents of BPR, Washington, USA.

8 Election of return periods Rp for drainage

Do not depend on region, depend on consequences of failure, tables of Rp for roads adopted by consensus, higher when greater damages or interruption of services. For roads with enough trafic, T=Rp from 10 to 100 years. Probabilistic model presented in (Simposium OECD, Recherche routière, Berne, 1976). To have a T, optimise mean anual cost failure + anualised cost of drainage work:

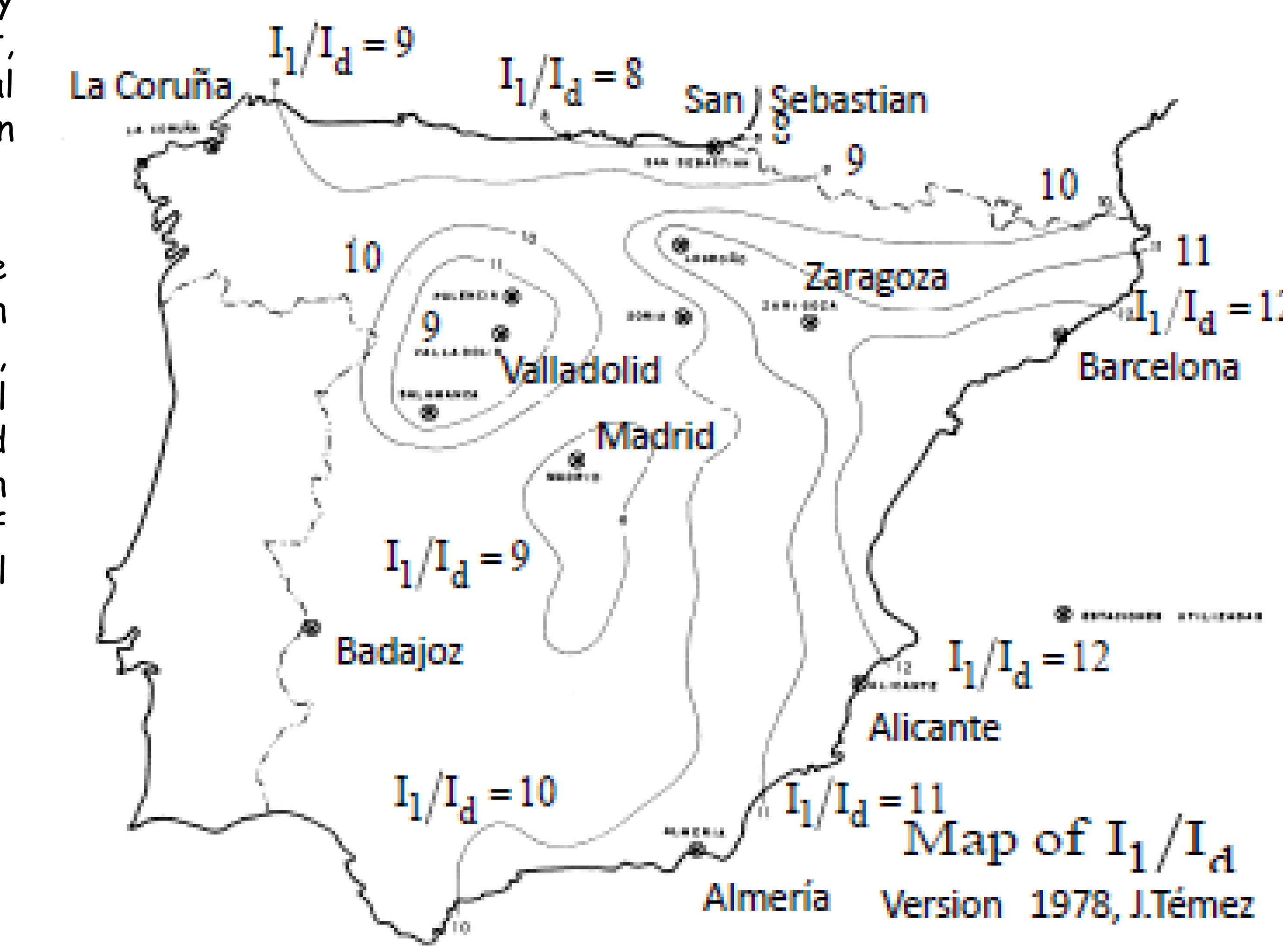
$$\mathrm{Min}_T\left[C_f/T + i \cdot (k \cdot Q_T^{\,b})\right]$$

As for extreme value laws $Prob_1$ failure # 1 / T, and as Construction cost Cc = $K·Q^b$ with **b** as 0.52 for drainage, i for anualisation of cost, taken as 0.23. Minimising:

-For Q=S with Gumbel type I :
$$T = C_f \cdot (L \cdot Q)/(i \cdot b \cdot Cc)$$
example from J.Témez, river in SE of Spain, L·Q # 5.

-For Q=S with Gumbel type II :
$$T = C_f \cdot \lambda/(i \cdot b \cdot Cc)$$
example from Ven Te Chow Mississipi in Keokul, λ # 5 From both examples, similar i and b,
$$T = 40 \cdot C_f / Cc$$

Revista de Obras Públicas, Sep1979, Madrid; Symposium spanish-intern. Málaga; r. Carreteras nov-dec1985, SEC.



9 Evaluating risk situations for agriculture.

Complicated system, natural risks from jail, irregular rains poorly predictable in Spain (11 year cycles different, drought in 2004, rain in 9-2010 and 10-2011 ?), market hardness, protection PAC in EC, poor state aid needed for extended comercial or natural events, conservation of natural sytems as with forests.

Agro-inssurance, private in Spain, for some evaluable cases as hail. More damage for farmer that for insurer as depending on D/S=Damages/Suportable amount, big for farmer and low for insurer as hail (or tornado) is rather local, not for extended actions (tsunami ... , general fires, hurricanes, big droughts), catastrophes needing public aid; they may be too extensive (climatic changes?) for it.

Models may use **utility functions** for damage to an agent,

$$U(D) = (1 - e^{-v \cdot D})/v$$

, such as $U_D'(0)$ = 1 and U(0)=0,

that may suffer a damage D < 0 and has a limit of risk as 1/v or k/v , v·D being low for insurer and big for farmer that has a much lower resistance k/v, so part of risk D is transferred at a price to insurer, both getting better U.

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Load formats in Model Codes, Euronorms for construction.

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