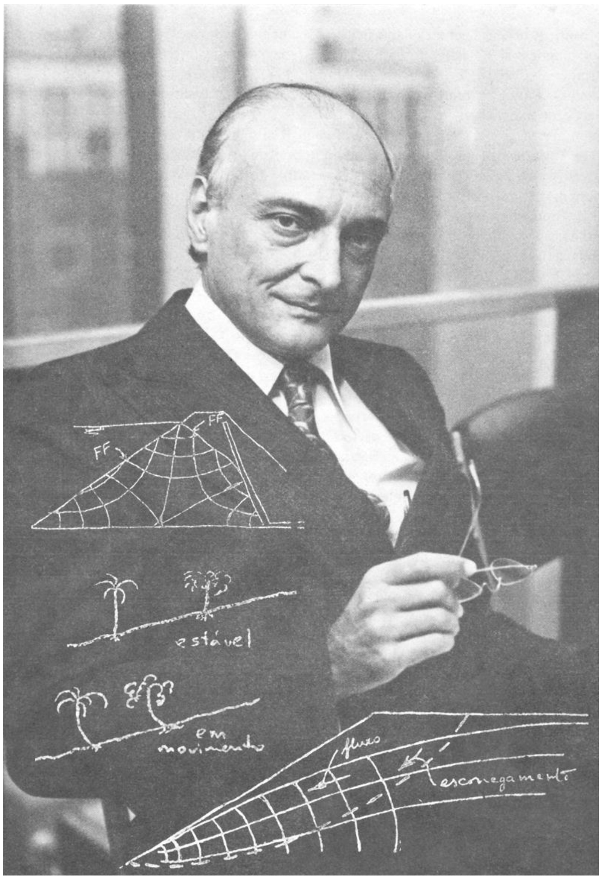
BEHAVIOR OF SUBSOIL MASSES AND OF CONSTRUCTED SOIL-ROCKY MATERIALS:

SLOPES, FILLS, EMBANKMENT DAMS, BREAK-WATER; ORIGIN, DISCUSSIONS, DEVELOPMENTS



Professor Victor F. B. de Mello

INTRODUCTION

Starting in 2000, Prof. Victor de Mello started to conceive the book in which he planned to summarize his thinking process, his experience and his approach to geotechnical engineering.

Unable to include all the topics he wanted in a single book, he accepted to have 3 books, focused in the soil mechanics of tropical soils, in fills and earth works, and on foundations and underground structures. He decided to update his personal library only until the end 2001, considering important to mention in the introduction of the books that he pretended to have incorporated the bibliography only till this date.

In a conflict with his own way of seeing the task of writing a technical book, in which it would be on technical papers and journals that an author publishes his research, and in books a summary and the conclusions of all this research, without starting new research, he drove himself in an almost frenzy task of research, interaction with colleagues, and study of each and all the topics and themes he chose.

At this time he practically put aside his consulting activity in order to have more time for research and writing the books.

Unfortunately this rich and intense process was interrupted, initially by cardiologic problems that resulted in surgery in 2005, and, towards the end of that year in the early signs of a process that, when diagnosed, was identified as amyotrophic lateral sclerosis (ALS, also called Lou Gehrig's disease).

Loss of motricity due to the development of the disease limited his writing conditions, and later to dictate. His work was interrupted by destiny.

The enormous responsibility to promote the legacy of a personality of the dimension of Prof. de Mello's lead me to discuss it with the family and with some of his close friends, and to choose to release this writings to the point Victor has developed them, without trying to advance the numerous incomplete chapters of the 2nd book, his initial focus.

I have heard from one of Victor's close friends that "some of the most beautiful symphonies are unfinished".

Unfortunately there was no time for Victor to dedicate any time for the 1st or the 3rd book. Specifically with relation to the material herewith made available, it is presented as Victor has left it, or how we could compile it following his directions, the comments he had made, the bibliography he thought would be related to that chapter. It is the main part of the Introductory Comments that Victor had written for the 2nd book, as originally conceived, which focus heavily in Victor´s approach to geotechnical engineering, strongly linked to statistics.

It is important to mention that lively interfaces and debates were happening between Victor and Profs. John Burland, Michele Jamiolkowski, Harry Poulos, Willian vam Impe, David Potts, Gholamreza Mesri, Georg Sadowski, with Drs. David Carrier and Paolo Mazzoni, to whom I would like to thank the support in pushing forward the task of promoting this work, developed to the stage it was taken by Victor.

It is also important to thank the group that Victor had in his office, totally dedicated to the research of the topics he was pursuing, in the persons of Engs. Raquel Quintanilha, Erica Sasaki, Ewerton Meirelles and Antonio Carlos Sobral. After the diagnosis of his disease and the manifestation of the initial symptoms Professors and Colleagues at Poli-USP Cláudio Wolle, Jaime Marziona and Waldemar Hachich gave valuable support, and thanking them is also important. Finally it cannot not be mentioned the enormous and continuous support given to Victor by his wife Maria Aparecida Fernandez de Mello and by his daughter, my sister, Lucia Beatriz de Mello Alessio.

Finally, it is of extreme relevance to mention that Construtora Andrade Gutierrez and Construtora Norberto Odebrecht, as well as ABEF – Associação Brasileira dos Executores de Fundações gave important financial support so that Prof. De Mello could dedicate all his attention to the task, which unfortunately was not concluded.

Luiz Guilherme de Mello

TOME II - BEHAVIOR OF SUBSOIL MASSES AND OF CONSTRUCTED SOIL-ROCKY MATERIALS: SLOPES, FILLS, EMBANKMENT DAMS, BREAK-WATER; ORIGIN, DISCUSSIONS, DEVELOPMENTS

1. SPECIFIC PREFACE

As has been systematically expatiated in the APPENDIX to all three VOLUMES, our intent is to review the progressive steps achieved by a deterministic conventional soil mechanics, while relying almost entirely on single pseudo-dominant parameters and the rough correlations or prudent prescriptions based thereon. The tone (leit-motif?) of our postulations subdivides into the two inexorable directions: firstly, the yearning to vectorize towards the future, wherein a thorough diffusion of relentless use of simple Statistics-Probabilities, expressed in terms of Hazards and Risks, should henceforth help optimize every decision, of professional solutions and of advancing theses; secondly, in every subject presumed to merit this inescapable trend for the future, the historic theories and practices, posited and taught with admirable engineering intuitions and intents, impose a grateful and respectful review regarding the context within which they were generated, in order to acquire the right to revise appropriately.

The author submits that the book has been written under responsibility to cover essentially all published material up to 31/December/2001. It is believed that such declarations should preface every technical book out of respect for (1) the desired widening and multiplying circle of desired prospective readers and (2) the modern rates of developments of data, especially on so richly complex a substratum technology-art, supporting all civil engineering efforts on behalf of humanity's quality of life in areas yet uncovered. Moreover, a thorough Revision should be envisioned at intervals of not more than every 5 years or so. The revised parts should be made salient, with due explanation.

The gist of the diagnoses and intents lies in the inevitable start of the new technology by investigating basic principles in the laboratory, as supported by highly idealized simple cases, as viewed from the then dominant theoretical principles transferred from "uniformly manufactured or constructed" materials, Concrete and Steel Associated with Structural Engineering, and Rigid-Plastic mathematically-fitted behaviors derived from Metals of the comparatively more matured Industrial Revolution. Obviously, moreover, the intuitively perceived single dominant parameters of characterization and behavior could only begin being used as they were historically presumed liberated from all subsidiary parameters inherent in a "natural Science". Looking towards the impositive future one concludes that the performance at amply satisfactory Hazards of the order of few per thousand despite employing parameters of individual Confidence Intervals never tighter than 20%/80% non-defaulting/non-exceedance could only be attributed to a transfer of the problem/solution into a different Statistical universe, of excessive prudence/cost. Society has become familiarized with Hazard evaluations in the above stated orders of few per thousand, and has doubtless progressed towards discarding illusions of a ZERO HAZARD. Meanwhile all factors associated with humanity's future inexorably imply that even a fixed level of Hazard leads to progressively increasing levels of Risks: and in the final analysis what one wants, and therefore needs, is the reasonably low levels of Risks.

The Appendix has posited that even if Confidence Intervals on each single parameter cannot reasonably expect to be lowered below the 20%/80% margin, the open gate and intrinsically interminable road lies in discovering and bringing into play successively more and more intervening parameters, justifiedly set aside during the erstwhile intuitive choice, by authoritative mentors, of the yet prevalent single dominant parameter. It was shown that by the multiplicative rule of probabilities a sequence of four to six jointly intervening parameters, of progressively greater specificity complementing the erstwhile dominant parameter intuited, helps well to achieve the diminutive risks while building on the past. The task therefore comprises pursuing investigations on all soils (each and all automatically meriting in some ways the characterizations as Problematic Soils) but in so doing, refraining from merely recording the unusual data (as compared with the conventional dicta) as CASE HISTORIES or EUREKA PROCLAMATIONS, and, instead, exercising the right and obligation of setting forth the complementary parameters (e.g. time, grain shapes, temperature, porosimetry, electrolyte contents of porewater, etc. etc.)[1] that cannot be dispelled.

Moreover one can hardly have failed to notice that almost none of the publications have ever mentioned the last two conjugate legs of engineering's tripod, technical, economic and logistical: furthermore, that the attentions tend to focus on the fewer successful major solutions of outstanding cases, rather than the countless moderate-range problems that call for modest stepwise improvements, cumulatively of greatest significance to Society.

Civil Engineering is supported on clearly separated (conservatively predicted) Actions, and corresponding evaluated Reactions: Civil-Geotechnical Engineering must be all the more so. In

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[1] One is aware that the etiquette on writing texts advises against using "etc" following a given parameter; because if one knows of a complement forthcoming one should not disrespect the reader by failing to designate it. The fact, however, is that in principle there will forever be complements to the body of knowns already posited and checked: but, in practice neither can the sequence of postulants and priorities be foreseen, nor can one predict when one has reached the practical "cut-off point of consequence" when another sector of the global composition of tasks takes over as the nevralgic ignorance. Thereupon the use

both, a fundamental principle is that behaviors and their acceptance are dependent on, and effectively reflected as per deformations (volumetric included[2]) and displacements: meanwhile, stresses and strains, inherited from Structural Engineering free from volumetric deformations of note, now call for serene but firm revisions. Meanwhile some very fundamental differences between structural materials and soils are that in the latter it is volumetric changes that dictate, and irreversibility is the most frequent rule. Every rationale points to the requirement that one must work under recognition of Actions as imposed changes of conditions, sequentially, for which at each stage one must posit the starting state of conditioning parameters, before applying arbitrarily the presumed prudently but reasonably maximized alteration. Right from the start "time" entered as significant, and it is far from novel to assert that very many other factors (conceptually everything, chemical, electrical, thermal, etc.., unless proved otherwise) are included, in principle, as potential Actions changing conditions. If and while many cases arise wherein the engineering problem has to be resolved without the required knowledge for logical performance prediction, one must honestly face no more than the most routine of logical engineering practices to postulate three or more hypothetical values, to foster judgment on the relevance and respective possible range and rate of change. To forego such quest (nowadays so very easily computerized), or to abandon a specific parameter automatically when taken as insufficiently known, inexorably signifies adopting it as DETERMINISTICALLY ZERO, an impossibility.

The predicaments of conventional soil mechanics in present-day conditions are exposed in such situations as: (1) side-by-side persistence of a welter and chaos of different "schools" of thought and practice; (2) the wide ranges of results ensuing in most Prediction vs. Performance Challenges (except when the overdesign domination leads to performance tending to near-zero deformations, when all predictors tend to the terribly uneconomical asymptotic answer); (3) impossibility of expressing benefit/cost ratios to the Client Owners, and Society as ultimate payee, in terms of Probability Risks; (4) worst of all, leaving the specialized Profession lost, disregarded in the frustrating and over trodden desert of Precedents without any magnetic North of prestigious purpose and action.

Finally the author must emphasize his experienced feel towards rejecting the vastly dominant methods of presentation of comparative test results in the format of different curves directly plotted in the same (or adjacent) graphs. It is believed, as a start, that practicing professionals prefer

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of the frequent (really omnipresent) "etc" should be understood and pardoned as part of a fundamental exercise of imprinting an innovative purposeful attitude.

[2] The volumetric deformations dictate possible generation of excess pore pressures in conditions of fast loading/deformation accompanied by contractile behaviour.

reasoning on, and remembering, in terms of proportions, e.g. x% higher or y% lower than a given reference, and so forth. Moreover, the bases for referencing must be chosen as the tests that have been, and will, for decades and a large majority of the laboratories, continue to be, the most common ones.

2. INTRODUCTORY COMMENTS

The present Volume concentrates on the behaviors of soil masses. As these have progressively increased in dimensions and loadings, some of primordial simplifications have become less acceptable or untenable. Despite Terzaghi's keen interest in, and cognizance of, geology and its specialized branches (such as geomorphology, sedimentology, structural geology and tectonics, glaciations, etc..) as definitely involved in **establishing the in situ starting stress, deformations, and ulterior deformability properties,** one can surmise that the overriding historic hubris concerned the consolidation theory of delayed settlements of horizontal beds of saturated clays under vertical loads. The principal civil works at the time comprised the application of significant vertical loads on to an adequately simplified condition of attributed geostatic vertical stresses[3]. One must note that the bifurcation of nevralgic problems to be solved therein was blatant: in cases of rapid loading to excessive levels there were the spectacular failures (bearing capacity problems to be solved), but the more surprising cases were of foundation loadings that gave satisfactory early performances of modest and acceptable settlements but gradually accumulated settlements of great unanticipated and unexplained magnitudes. One interprets that this was the principal fact that clinched the conjugate milestone theories, **the principle of effective stresses,** and the rheology and mathematics of **the theory of consolidation of clays.** One should recognize that, in essence, Terzaghi did not divert from recognizing **volume changes as the controlling feature:** essentially validated by annulment the problem's quest regarding lateral stresses by reasoning towards lateral deformations (not stresses) maintained as zero, in the oedometer-test developed to simulate a soil element in the stratum[4]. One must note with respect the fact that although donned with due recognition of the then advanced prevalence of the Hooke-Poisson concepts of Structural Engineering, yet the overwhelming adherence to **elastic theory for deformabilities** was postponed for about four decades, until the oncome of the irresistible wave of computers and

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[3] While vertical stresses were logically estimable and posited, one reflects that alterations on deformations and deformability behaviors were only perceived and studied much later.
[4] In Vols I and III one shall inquire into the revisions and advances in this idealization of the soil stratum as an integration of such oedometer elements of zero lateral strain.

respective software[5]. Meanwhile regarding the more disastrous **failures of bearing capacity,** one can interpret as quite justified the support sought and received from **rigid-plastic theorization transplanted from metals[6].** Concurrently problems of failures and of deformabilities remained irreconcilably divorced.

One's purpose herein is to reiterate the fundamental point of soil behaviors as associated with volumetric deformations. Moreover the reality that one must always "know" the initial condition in order to apply thereon the presumed Actions for concluding as to the Reactions. While hampered by the lack of the pseudo-knowledge (always insufficient) one cannot simply discard its need, tantamount to positing it as irrelevant. One posits firstly the obligation to hypothesize possible or probable basic principles. Thereupon and secondly one is obliged to investigate on that mental model a reasonable set of parametric variations in order to check the possible relevance that the sequence of different results might have: in other words in the light of the really great advances separately contributed, one must stitch them together into greater global compatibility[7]. Besides the directly purported global rational updating, one seeks to introduce the complementary intervening parameters for improved lowered-risk computations on practical professional problems.

Four basic principles that one proposed [Ref. de Mello Hong-Kong 1982,. etc] for compatibilizing civil-geotechnical engineering within its geomorphological indelible genetics[8] are summarizable as follows, in utmost simplicity:

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[5] Needless to emphasize, this new approach vigorously prevalent automatically failed to arouse any quest regarding lateral stresses, even bi-dimensional.
[6] One will comment in the respective chapters of Volume III on bearing capacities of pad foundations, both shallow and deep, the short-lived success permitted to the geometric solutions derived from the rigid-plastic theories while reasonably accepting single constant φ values attending to the vertical forces only. On the other hand, with general soils tending towards the three different nominal φs (drained, consolidated-undrained, and undrained-undrained, blatantly revealed by saturated clayey materials) the dominant quandaries as yet unresolved, that hitherto dismiss the practical applicability of these noble efforts on helpful background solutions. One must note that for bigger pads of important projects the stringent demands regarding settlements, total and differential, have shifted all of academia's attentions away from ultimate rigid-plastic failures onto unacceptable deformations. The orphaned silent majority of modest to small pad foundations have been left with prudent PRESCRIPTIONS based on the most conservative undrained-undrained strengths ...

[7] Merely as an important example one should mention the discovered and recognized dominance of the bulk and shear moduli (G,K), and of shear strengths of soils as better definable as related to the octahedral stresses than in terms of the principal stresses in the single plane of the conventional Mohr circle [Refs..., pgs...).
[8] One cannot refrain from calling attention to the almost inexistent geotechnical publications that begin by pin-pointing even in an extremely simplified panorama merely of "rational physical geology", the premises of the starting conditions of important works within which the anthropic activity is intended to survive its paltry 50 to 200 years of satisfactory operational life. For most current conditions the mention of chemical effects had been systematically set aside because on particulate sediments and most weathered horizons an

(1) the regolith's horizons and strata develop(ed) under the general laws of Natural Selection, wherein Nature has no prestige to preserve;

(2) the general pervading tendency is towards slow weathering and other degenerative imperceptible dynamics (notwithstanding occasional punctuation, in geography and time, of abrupt or different activity, as complex differentiations ever present) establishing apparent equilibrium (not without secondary deformations of creep, etc...) close to Factors of Safety Fs nearing about 1.1 to 1.4, admissible and judiciously attributable;

(3) under specific significant increased "stresses" of low recurrences (progressively heightened, as degenerations advance) the ΔF intervenes episodically in sufficient magnitude to force a physical failure, one of the distantly repetitive ones that reworks the topography into its subjection to the ultimate trends of peneplanizations.

(4) In the above reference (by inertial habit) to "stresses" one must implicitly encompass all "actions of predictable consequence". The intent herein is to emphasize the indispensable requirement regarding assessing starting conditions, and their probable trend of change irrespective of the project's manner of interference. As regards trends of change one must concentrate on recognizing those that should tend towards perceptible degeneration, and enhance those that may be made to improve infallibly, however little. As regards loadings one must judiciously distinguish between "soft loads" (that persist unchanged irrespective of deformation)[9] and "hard loads" (that redistribute because of internal strains). And so on.

The foolhardy mention of the geologic background is risked being inserted under a double-edged purpose: first and inherently to revive the most obvious genetic control (within which one promptly defers to judicious posits of the respective professionals); second, in order to admonish those selfsame respected cooperating specialized professionals to **concentrate on the actions and reactions** that might specifically intervene within the engineering problems and solutions. Close and purposeful interaction is indispensable, failing which most of the geologic reports establish no bridge with the civil-geotechnical cases on hand.

increment of our time scale is insignificant in the weathering rates of millions of years: however, there are increasing trends of dominant interferences (chemical, and other in special cases) as is herein exemplified by instances involving foundations of soluble evaporites, etc...

2.1 Sample cases which appeared to offer suggestions for incorporating complementary historic parameters of noticeable influence.

Without any presumptions whatever regarding generalizations without confirmatory investigations, one submits herewith a few really important civil-geotechnical cases wherein one was forced to postulate physical (pseudo-geologic) dominant conditions in order to solve problems on the spot with reasonable confidence of indispensable success. In all cases there was either no geologic report, or none such that even remotely hinted at a rational working hypothesis for the problem. Furthermore, regrettably the straight jacketing by self-satisfied conventional soil mechanics stymied any yearning towards the natural follow-up exploratory research.

(A) Sao Paulo (SP) highly preconsolidated clays. Surprising “shotcrete-like” massive consistency and posited distinction from slickensided equivalently preconsolidated London Clay (LC).

By prevalent gross primordial characterizations (grainsizes and Atterberg Limits) both clays are very similar. (fill in data, refs). There have been no complementary parameters offered, such as percentages of laminar clay-minerals and their colloid-chemical performances, including very long-term alterations. In SP a pair of under-river very wide vehicular tunnels with minimal cover were to be dug with foreseen excavation facilitated by prospective slickensides, to be supported by NATM and eventual bolts: the case essentially coincided in timing with the Heathrow Airport NATM tunnel failure despite its incomparably extensive monitoring. Both clays had been submerged throughout their history. The SP clay presented itself similar to a massive shotcrete, requiring very slow hard excavation by heaviest jack-hammers and even some explosive. There was no specific monitoring, leakage, measurable convergences, or primary NATM support. Revised planning was immediate. It is well established that the SP clays were preconsolidated by overburden, eroded through about 40 million years[10]. It was promptly postulated that the very slow pressure relief of deeply underlying moderate eroded earth slopes, as compared to the rapid similar relief by the melting of the glacier (LC, relatively shallow, possibly near subvertical scarps) could justify the differentiated stress-strain performances and consequences.

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[9] The best example, of incalculable responsibility, is the water pressure exerted on the upstream face of a gravity dam.
[10] Assuming 200m eroded the average rate of overburden removal would have been 2 x 10^5mm/4 x 10^7 yes., i.e. less than 0.01 mm per year.

Should rates and estimated conditions of stress relief of high loading-overconsolidation of clays be systematically incorporated into future characterizations of clay strata?

(B) Caisson foundations on SP tertiary slightly-clayey coarse sands, very loose as per SPT and CPT indices (1954-59).

About 6 – 8 high rise buildings (of 15 to 20 stories) were put up in very rapid succession in an important avenue in the center of SP. Because of a planned subway line, foundations had to be carried deep down into a layer of loose tertiary sands underlying a top clay stratum of preconsolidation around 7 kg/cm^2 on which a few analogous buildings had previously used very satisfactory shallow footings with allowable pressures of the same order. The tertiary sands were of highly crushable grains both because of great angularity and the 40 million years of weathering suffered by the feldspars and even siliceous grains. It has been postulated that the very loose unsorted very angular quality would suggest a grabben-type deposition[11]: the near-zero silt and 15 to 20% clay in the grainsize composition suggest a double-sedimentation condition with the sand-grains establishing the structure, and the clay having infiltrated and deposited from slower velocity waters of clayey suspensions.

In accordance with the then employed formulae (Ref) the designer had relied on increased base bearing capacities with depth. Settlements were millimetric until the buildings were topped and expensive finishes were being applied. At the start while the rate of settlements increased, deep concern centered on possible bearing capacity failure since the pressure-settlement curves matched closely the failure curves of load tests. Underpinning with different deeper pilings was rushed. Inevitably quite a proportion of the columns had their underpinnings delayed, and therefrom an interesting indication was extracted. The pressure-settlement and time-settlement curves plotted in the oedometer semi-log manners clearly showed that the loose crushable sands reflected roughly (obviously lower because of increased shear moduli deformations) the overlying clay's overconsolidation, moving into an apparent "virgin compression" stretch of modest magnitude, whereupon thereafter the incremental "secondary" settlement was negligible. Some of the expensive planned underpinning could be abandoned.

[11] The significant differentiation of Natural Selection between such sandy sediments and those of typical sea-shore beach sands are expatiated as to the geotechnical significance in the next example (C).

Posited reasonable conclusions were that: 1) loose crushable sands do register precompression due to loading in the way of a **range of significant incompressibility** (Ref. Bangkok): therefore one should interpret in the overlying interspersed clayey strata what caused the preconsolidation pressure[12] of reasonably routine laboratory determination, and may assign the respective benefited underformability of the precompression range to the interspersed sandy strata. (2) the brutal resistance SPT index, and even the CPT index (in some cases partly a lame underformability index) are clearly unsatisfactory for reflecting the sensitive benefit of acquired static underformability ensuing from the marked hysteresis on stress relief.

Should not static precompression of crushable sands be incorporated as complementary parameters in subsoil profilings ?

(C) Differentiated behavioral qualities of sand alluvia as regards deformabilities and consequences to differential settlements of footing foundations. (Confirm Terzaghi-Peck-Mesri).

Most geotechnical practicing professionals are still dominated by the very well-meaning PRESCRIPTIONS (Terzaghi Peck ref and separate pages) regarding generalized dicta for the design of footing foundations. They used SPT indices (posited at the time as deterministic trustworthy STANDARD Penetration Test values) and the intuitions that footing foundations of U.S. (Chicago?) high rise buildings depended on limiting the individual footings' total settlements, and principally on limiting the differential settlements between them (Pg.), while positing that maximum differential settlements were essentially equivalent (Pg) to the maximum footing's settlement. Practically everywhere in the major cities of the world the details of those historic PRESCRIPTIONS have been long since set aside through logically adjusted revisions: but to most practicing initiates as well as academia deprived of either convincing rationales on the subject or logic behind either the older or the bolder practices, the unnecessary haunt still persists. The many wrong points regarding SPT indices as brutal resistance-indices (and not deformability and/or principally undeformability-indices in precompressed ranges) and regarding estimations of bearing capacities and/or effectively conditioning settlements of columns' pads, are expatiated in Vols. I and III respectively. The purpose herein is to discuss some of the indispensable complementary performance characterization parameters for the broad noun "sands" as constituents of soil masses. It is

[12] Obviously barring suctions or shrinkages, not transmissible to sandy strata.

not merely grainsizes and SPT-indices, but some crucial differentiations of formative Natural Selection processes that absolutely require confirmatory research and incorporation, for geotechnique's renewals towards progressively decreasing hazards in design decisions. Only three widely different conditions are posited herein. Observant beach-watching geotechnicians should notice and note differences of fluvial sand-bar beaches and their sea/ocean shoreline counterparts, and not merely the "stable beach-slope inclinations" of varying grainsizes, but also at least two other important parameters, (1) the dense homogeneities of seashore highly reworked depositions (grains inevitably rounded and uniform) in comparison with the highly variable grainsize distribution and typical looseness of the upper steeper "steps" generated during unusual floods or stormy-wave reworkings, and also (2) the accompanying importance of crushable-angularity grains. The reasoning from Natural Selection seem clearly indicative, if one associates grain roundness with distances of transport from point of erosive liberation (in 10x times the grain diameter, flow-energy, and edge-breakage), and the deposit's loose non uniformity with the deposition in turbulence and upward flow, as well as with the lack of "reworkings" up to an equilibrium between destabilizing forces (analogous to shallow "rapid drawdown") and arrival at the dense stable slope as each wave recedes. At a seashore beach no grain needs to reach the size-density quality any more stable than minimum necessary to resist the downward erosion, while on the contrary all surficial volumes insufficiently stable under receding waves m to n are automatically removed and redeposited until stability certification under waves p to q. The regularity of reworkings by the thousands of typical lesser waves are contrasted by the turbulences and singularities of biggest storm waves. Similarly in fluvial sand-bars each passing flood removes and redeposits without reworkings. Finally one would presume (subject to valuable confirmation by geologists truly effective for geotechnique) that sands deposited very close to grabben sources should result angular-crushable to different degrees, and also deposited in densities if significantly variable combinations of grainsize-density, since the Natural Selection by flow-transport has not acted. And possibly[13] in a similar manner the variabilities of loose sand deposits generated from eskers might well have contributed as background information regarding the extremely conservative prescription on maximum differential settlements between footings of a given building.

[13] The author candidly confesses to no published knowledge on such types of sands, if usefully characterizable, as well as no respective personal experience at all. The irresistible intent is to demonstrate how much justified and profitable revision should ensue from reassessments of respected "judgment" by a systematic opening of new avenues through complementary generalizable parameters.

In recognition of some of the admirable work being published on “calcareous sands” (Refs) one queries to what extent the designation as “calcareous” interferes usefully or detrimentally, in possible comparisons with physical **indices to be developed reflecting the bulk moduli in compression, shear, and (revealingly) decompression**, as correlatable also for other minerals (such as feldspars, etc) equivalently coarse, loose, angular, crushable. The source characterization as a preliminary index must be investigated for potential first-degree usefulness, because sediments have already been sorted out under a succession of natural selections, and it would seem negligent to omit the last steps of differentiated depositions. However, the truly generalizable parameters must be developed and queried with respect to Confidence Intervals, in simple and due relations to the physically conditioning behavioral parameters of priorized uses in geotechnical engineering, independently of mineralogical peculiarities etc. [N.B. Check german references Schultze-Stuttgart, Muhs, etc]

(D) A very important very high embankment dam meticulously designed and constructed, founded on about 100m thickness of piedmontic sand-gravels with recognized “openwork gravels” and even boulders; foundation conditions concernedly investigated, and, as per precedents, a 14H long upstream impervious blanket adopted. A remarkably rapid first filling developed immense problems from sinkholes “punched through” the thick well-compacted blanket of select materials. The possibility of continuities of the open-work gravels was investigated (and discarded !) on the basis of a geometric grid of meticulous borings US→DS and parallel to the axis. The piedmontic material from flash snow-melt floods included some big boulders, 3 to 4m in diameter, obviously requiring transport velocities of the order of 15m/sec, and inevitable cross valley meanders to absorb the energy. Thus the US-DS geometric shortest path meant nothing, neither were simple geometric reasoning much altered by the roughly 50% longer sinusoidal paths. Regarding head-losses the 50% increase of flow paths, assuming meandering continuity, was still meaningless in comparison with permeability coefficients easily exceeding ratios of 106 times or more.

On judicious analysis (a posteriori) one could see that lenses of fine sands lay deposited beside the big boulders, i.e. behind them, protected by them as “breakwaters” permitting the deposition in the calm backwater: and the boulders inexorably created pore sizes and volumes immeasurably bigger than the adjacent sand lenses. Three factors could be reasoned to have come into play in a physically deterministic manner[14], upon the diagnosis that the deposited boulders acted as face-protections from high velocities, permitting the depositions of fines in the adjacent calm backwater (1) under vertical overburden loading the highly differentiated compressibilities automatically fostered the maximized absorption of the vertical stress by the boulders, essentially annulling vertical stresses on the adjacent fines[15]: thereby their shearing resistance to displacements should have greatly suffered. (2) Meanwhile in a directly opposite direction, in any flow path encompassing both the highly pervious gravels and stretches across the fines, it should be in the fines that without fail most of the loss of head and viscous displacement gradients should act, dominantly towards the adjacent more pervious open porosities. The conjunction of these two opposing tendencies should maximize "internal piping" and creation of cavities (3) Finally, the rate of filling of the reservoir (under seasonal floods) happened to have been very fast, probably generating total hydraulic head downward punching pressures before the establishing of the underlying uplift pressure under the blanket, as conventionally considered in theories on behaviors of blankets under steady flow conditions (Refs ASCE Trans, Bennet, Bibliogr, Cedergreen...). To one's knowledge there has not been either a prior or an ulterior study of transient **subsoil rates of establishment of** the statistically comfortable differential between downward and upward hydrostatic forces resisting punching[16]. The creation of multitudinous punched sinkholes ("instantaneous") would seem physically logical.

It is repeatedly emphasized in the profession that physical failures are most informative regarding failure scenarios. Knowledge has advanced so much that blatant failures have become rare except where gross ignorance intervene. However even where a near-dramatic failure has been averted (as happened, because of the very rapid emptying of the reservoir from another sector) the cases require even more careful evaluation and digestion because they tend to encompass exceptional conditions compared to the theoretical idealizations, and more important benefits ensue from the establishment of complementary logical principles.

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[14] Even setting aside the more commonly blamed suspect of probabilistic erraticities.

[15] The classical demonstration (e.g. Ref. Taylor, pg, Fig) of γz is established as prevailing when there are no shear stress redistributions on the sides of the parallelogram. Such important basic assumptions became accepted in so commonplace a manner that they are seldom mentioned or remembered, as prevailing only on a global average value, but with important local variations. It is of interest to note that those were the days when Finite Element Analyses were being intensely divulged to explain the dangerous "silo effects" of less compressible filter-transitions of earth-core dams on to the intermediate clayey cores. (Bibliog): and yet the analogous reasoning was not (and has never yet been, to one's knowledge) transferred into practical situations of subsoil conditions.

[16] A special caveat has to be emphasized with regard to volumes of air-pores possibly (and very frequently) left in the top horizon underlying the blanket, a feature that further delays the full development of the subsoil's permanent flownet uplifts. Fairly easy computations but left in academic and professional oblivion.

Among these one should herein summarize the importance of: (1) geologic and not geometrical orientations in subsoil investigations (a very serious omission in decades of geotechnique); (2) carefully evaluating the adjoining occurrences of maximal and minimal performance materials and conditions; (3) not obviating transient conditions, upon recognizing that primordial solutions generally and understandably concentrated on the simpler "permanent" conditions.

Should one not incorporate, with respect to extreme value probabilistic performances (e.g. internal piping and sinkholes) the probabilistic (or even deterministic) possible occurrence of adjoining maximum differentiations? In considering differential settlements does one not assume the maximum and minimum settlements as attributable to adjacent columns?

(E) Residual and saprolitic soil horizon profiling.

It should be literally prohibited that any reference be made to saprolites and residuals without specific reference to the respective rock parentage. Incomprehensibly and regrettably no amount of admonition has yet succeeded in this inexorable and logical sine qua non requirement. The author concentrates on the horizons derived from granitic-gneisses and from the immense basalt flows prevalent in Brasil. The extraction of basic reasoning, clearly differentiated from those of sediments, is merely exemplified from personal experience on successful practical problems, without the privilege of special confirmatory research that should have been enticed[17].

One has consistently recognized that in the said residual and saprolite horizons there are systematic occurrences of volumes of much greater "rigidities" alternating with other very soft (wet) volumes (e.g. at near Liquid Limit conditions) or even moderate-size cavities, irreproachably stable. During the inspections (about 3 decades ago) of some 20m deep test pits in the abutments for an earth dam, the author had the privilege of descending side-by-side with a very Senior international consultant, and the occasion arose for some postulations and

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[17] It must be recalled that below the saprolite horizon, yet a soil but conditioned by relict features of the parent rock, there are most often one or two horizons better treated under the principles of Rock Mechanics wherein the behaviors are dominated by discontinuities (cracks etc.., weathered or not) because the intermediate indurated blocks retain volumetric or elastic moduli very significantly better than any of the densest soils (continua of particular materials). These horizons are not considered herein. Moreover, as regards the soil horizons themselves, one refrains from broaching herein (cf. Vol I,...) the amply heralded (and quite as amply neglected) fact that grainsize and Atterberg Limit test characterizations are irrational and misleading, because everything connected with residuals and saprolites is dependent on

discussions of major importance, partly reflecting years of practical experience so favorable that, as is want to happen with a great silent majority of projects, case after case went by without any raw monitored data or backup research. The crux of the matter is that the Senior mentor concentrated all his concerned attentions on the soft volumes, predicting both construction period foundation sliding failures, or subsequent intolerable settlements: meanwhile the author's confident remonstration was that not a single highway or railroad approach fill to bridges (frequently up to 15 – 20 m) had ever failed or suffered significant post-inauguration settlements. Typical fill slopes are 1V: 1.5H[18] and often the final advances used common end-dumped rockfill slopes of 1V: 1.3H: in comparison the dam's slopes were to be 1:? (Refs).

The principal posits that ensued, calling for confirmatory research of predictable crucial significance, were as forthwith summarized:

(1) Regarding vertical stresses and resistance (failure or deformability) to vertical loadings. Classically considered sediments indeed develop under γz stresses, **on average,** and gradually increase their resistance and "at rest static equilibrium" starting from zero resistance fluid deposition. If there is (conceptually inexorable) any lack of **perfect homogeneity, it is the least resistant soil elements that tend to control the mass,** because no soil element needs to improve any more than the minimum necessary to support its stress condition. Quite to the contrary is the trajectory of soil elements of a saprolite, that start from a condition of a much greater strength than necessary for γz, and gradually loose it as they suffer differentiated weathering mostly from penetrating meteorological factors. So it is the more "rigid" elements that carry the global overburden weight[19], and where there are soft pockets and even cavities it is **because they have been made inactive,** they have been permitted to develop with

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microstructure, and both the characterization tests of sediments are based on the rationale of destructuring the soil element down to its unitary particle.

[18] Even on top residual "red porous clay horizons" of SPT-indices as low as 2-4. It must be reasonably understood that low SPT values, quite a brutal crude resistance index test, most often fail to reflect such advantages as those of precompressions and/or microcementations: and air macropores avoid destabilizations under highly contractile bulk and shear moduli.

[19] It is well recognized that within every volume of soil of greater porosity and permeability, the substitution of independent volumes (up to about 30%, Ref) of cobbles, of much higher density and incompressibility automatically increases (algebraically) the global bulk and shear moduli. The present postulations concern a somewhat different and complementary performance, wherein weathering (most frequently descending by rainfall infiltration, and its subvertical seepage effective stresses) attack certain preferential paths (often sinuous) while leaving a network structure of more resistant material responding for the stress redistribution to preserve deformations essentially equivalent under the countless successive stressing episodes.

impunity without damage to the "equilibrium" that continues to evolve by redistributions of the stresses. It is important to reiterate, however, that **Nature's ultimate principle of performance for the weathered regolith is that of seeking the equivalence of deformations, not stresses.**[20] [21]

(2) Regarding other fundamental performance parameters, such as permeabilities and chemical and physical degradations of all sorts, one must unfailingly distinguish between the parameters of the masses between relict discontinuities, and the inexorably very different parameters and dominant actions along them. In short, in principle **saprolites should always be characterized by two sets of parameters, those of the mass, and those of the discontinuities** [Ref...]. Regrettably one does not seem to be able to record a single publication that demonstrated having recognized this principle, posited as unquestionably rational.

(3) Residual soils and saprolites as borrow materials for homogeneous earth dams or for impervious cores. The imported reputation that preceded one's first dams [Ref...] had been very bad [Ref...] attributing to them the generation of very high construction pore pressures and a rooted suspicion against the so-called MH group of Casagrande's classification. In fact, Terzaghi's innovative design of the two milestone so-called "Brazilian homogeneous" dams, roughly 40m high, had employed the so-called vertical ("chimney" or better-defined) curtain intercepting filter just downstream of the axis, not for flownet control, but hopefully (not unquestionably) as an antidote against these predicted high pore pressures. It was, however,

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[20] For fair comparisons one must herein assume that the precisions, accuracies and confidence intervals (cf. APPENDIX) of the fundamental parameter tests, for both the conventional sediments and the saprolites are essentially equivalent: it is emphasized, however, that this has never been researched or proven, and would rationally seem to muster important reasons for not being so, to the detriment of the saprolites.

[21] Regarding destabilization analyses most mentors have posited as an obvious conservative practice the generalized adoption of conscientiously sought minimized (undefin(ed)(able)) strength values in sediments. A more careful analysis will, however, correct the comfortable impression and decry the comparative conditions regarding saprolites. Firstly we must, however, assume the test parameters in consideration to be "perfectly" correct in expressing the in situ mobilizable strengths: or, at least, for the purposes of the very disparaging comparisons detrimental to saprolites, we must assume the same degree and direction of error in both cases. It has been tersely declared that in sediments no soil element need be any more resistant than the minimum necessary to support its maximum natural stressing. **The inescapable corollary is that it is the minimum strengths that prevail and tend to control the global stability**. Quite to the contrary, **in saprolites it is the stronger elements that dominate**, permitting the softening of certain volumes without default to the global. Thereupon the use of the minimal values is irrational and erroneous: at best one might employ for conservatism some reduction factor applied to the averages of higher rigidities/strengths. As noted in Ref.... pg...., all settlement computations based on average parameters led to predictions about 4 to 7 times higher than observed. It should be indispensable and highly profitable to query such first-order practical observations and postulations by adequate follow-up research.

demonstrated without ado or delay that the excessively high pore pressure-ratios, ($u/\gamma z$), under starting fill overburdens arose from a petty installation error[22] wherein the double-tube water connections of the USBR pervious cell were deaired by circulating water with 100 psi at one end and zero at the other, causing the pumping of much water at 50 psi into the surrounding fill at the mid-point of the just-installed cell [Ref........]. At any rate, under the serious premonitions for a series of subsequent dams, to greater heights, it was systematically required that the borrow pit's suitability be confirmed by checking the in-situ water content w% and percent saturation Sr% compared to the Hilf-Proctor values at the optimum. Residuals, and principally saprolites with their greatly varied mineralogical and granulometric compositions gained a progressive notable preference[23]. The clinching proof of the pudding arose by coincidence in a dam of very modest height (25m ±) in which really high construction period pore pressures were generated. The above mentioned precautionary specifications regarding borrow pit checks had been meticulously followed as usual, and all construction procedures were routine. The red "porous" unsaturated silty clay had all characterization indices exactly alike those of many residuals used previously. Some differentiating indications may be recalled as having been the distinctly perceptible difference in the existence of macropores (both continuous and in occluded volumes[24]) in the residuals, and none such in the borrow pit presently employed. A geologist identified the latter as derived from a sediment, and it was conjectured that its porosimetry would tend to be of relatively homogeneous micropores. In sediments several steps of natural selection lead to strata of relative homogeneity: meanwhile in residuals once a preferential path for eroding and/or lixiviating flows (or, for instance, a root-hole that rotted) has been established there is no reason for the same natural factors to choose a change of course, and therefore macropores are frequent.

Regrettably the author has not had any access to porosimetry testing which would have been of great interest in the comparative case [Ref...]. However passing reference is herein made to the importance of diameters of air bubbles (Chpt. ... Fig ...). And one boldly submits [Ref...] to an urgent important highway fill of saprolite that had to be pushed into and across a reservoir

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[22] Among several others only very slowly extirpated progressively, and not yet thoroughly satisfying.

[23] Many other factors connected with the construction plant and soil's detailed handling gradually revealed themselves in successive major projects as significantly intervening. Only one, less apparent but specifically connected with Natural Selections is herein summarized.

[24] The details of porosimetries, and differentiations between continuous vs. occluded macropores, as well as the different intrusion (e.g. mercury) techniques for the respective investigations, are expatiated to the extent possible in Vol. I, Chpt... . Despite complexities it is logically sufficient in the present context to posit physically that the same global porosimetry achieved by multitudinous micropores results in higher compression pore pressures when subjected to external compressions, than when achieved by a much more heterogeneous porosimetry, including a moderate number of macropores.

up to water depths of 20m (?), for which one resorted to a thorough disking and aeration of a saprolite, then forming an adequately compacted "slug" thereof containing pressurized macro air bubbles, and pushing it down the end slope. Speed was emphasized as indispensable since the principle involved was to have the pressurized air bubbles temporarily resist the entrance of the wetting and softening surrounding water. The fill crossing was achieved without noticeable spreading into "slurry slopes": it settled considerably from rapid air compressions, but proved to be a relatively successful expedient [Ref...].

(F) Highly cracked hard rock formations incorrectly characterized. And caveats to starry-eyed preservationists of pseudo-static environmental dynamics in its enormously greater complexibilities than geomechanical.

Two cases are submitted from which interesting lessons were extracted. The author confesses to the greatest respect for what he does not know, even more than for what he knows he cannot possibly ever get to know: thereupon he cannot but comment on factors that are glibly never reevaluated, as they systematically should. The examples concern the great unknowns of lateral stresses.

The first case involved a very highly cracked sound siliceous rock, easily reduced into aggregate sizes, upon light detonation and excavation. For some important dam foundation investigations very careful revised-updated Lugeon-type tests were run, which resulted in high water-loss coefficients automatically indicating groutability and precedents of required grouting [Ref...]. Strangely one noticed that there was no decrease in the water-loss indices with depth, neither were there (on posterior examination) any yellowish signs of seepages along preferential paths of the rock cracks. The grouting budget was predicted to be extremely high since merely for the perforation the consumption of diamond bits averaged 1 to 3 per meter. As is usual by critical-path considerations, the works began with 25m (?) deep excavations for the powerhouse, in a pit of about 100 x 60 m x m (?) adjacent to the diverted river's total heads of the order of 35m (?). One noticed that total seepage into this "rectangular well" was absolutely negligible[25].

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[25] The author has since (over 4 decades and countless dam sites) insisted in every case that the pumped flows (corrected for rains) from such pits be roughly measured, being much more valuable than scores or hundreds of borings and "point tests". Incredibly one must note that such comparative data have apparently never been gathered, probably because they are not blessed or mentioned in any respected texts.

At any rate, curiosity was aroused, and a new series of bore-hole water-loss tests was carried out using the abutments to provide the constant hydraulic head, for accompanying the water loss during very delayed infiltration up to rate constancy. The impressions earlier gathered had been that the cracks were under high compressions: therefore the new tests were by the descending technique (against the untouched bottom), and the upper seal was lengthened considerably (i.e. to a couple of meters, still minute compared to the embankment's base). It was suspected that with the cracks slightly opened by mechanical drilling torsions plus stress release, the water loss could have been adulterated by bypassing the conventional short seals. Indeed, to summarize the net result it turned out that all the long-term constant head tests reached, after some hours to a couple of days, a dead stoppage of inflow, obviating the presumed need of grouting. The poignant lesson was that rock quality classifications (RQDs and subsidiaries) and test characterizations turn out most unfavourably erroneous if the geologist does not observe and declare a strongly compressive state of stress compressing the cracks (Bibliog)

True to the intent of pinpointing some significant complementary parameters to be incorporated for the retrieval of geotechnique towards acceptable hazard levels, it behoves one to signal that test techniques and interpretations have persistently predicated idealized academic details, for groutability and grouting needs and effects, oblivious of important exceptions.

The second case involves an unsuspected vicious circle ensuing from simplistic determinations (doubtless well-intended) towards environmental preservation as static: they encompass some unpardonable lack of humility towards Nature's reality of very complex eco-dynamics[26]. At the head (the nevralgic contributing area) of high steep cuts in some very important superhighways the environmental authority has been prohibiting touching the trees in their natural condition, and even penetrating the forest for monitoring inspection. The geology involved weathered rocks of metamorphic beds compressed into a steep inclination into the slope (thus explaining the steep mountain range).

[26] Amazingly one fails to digest the newspapers' general knowledge of hundreds of slides periodically occurring deep inside the forest, far from any anthropic action under any incidence of intense rains. Note that these cannot infiltrate beyond a modest limit, because of the steepness of the ground and no logical increases of surficial permeabilities.

"Toppling failures" are much mentioned and uncontested, but seem academically restricted to the Alps and textbooks: the reality is that weathering accompanied by stress releases and creep, such as induce and accompany dense tropical forestation are preliminary phases, and taller trees with deepening roots become the most active agent toward slope destabilizations far from any anthropic activity. Ironically one concludes being thus sucked (doubtless by the good intentions, but abetted by absolute practical ignorance and uncontesting irrationality) and with unpardonable lack of humility towards Nature's reality of very complex dynamics, into a vicious cycle of maximizing the local destabilizations destroying the very trees that were meant to be optimally defended. Across millenia mankind has made use of the force of tumescence of dry wood when wetted, and of growing roots of trees, to open erstwhile closed cracks: the solid rock blocks on either side of a crack are not "attacked" by the roots' natural selection. In complement about four decades have firmly established Skempton's clear **concept of cleft water pressures** [refs], hydrostatic, filling the V-shaped cracks, independent of flownets and head losses. The speed of progressive iterative increase of the hydrostatic force (SO EASILY DRAINABLE, GOOD LORD!), and depth of the V-crack if maintained filled to the top, can readily be seen to justify the typically sudden localized slope destabilizations. When steep cuts have been used and proven stable, it is along the flatter platform behind the crest that preventive attention (and sealing maintenance) must be applied against the inexorable long-term destabilizing openings of cracks. Hydrostatic pressures do not change with width of crack (once opened until eliminating net average compressive stress[27]), on the contrary, with narrower cracks it is easier for the oncoming surficial runoff to maintain them filled to the top, even as they progressively deepen.

The present example is introduced in further connection with "lateral" stresses, an almost forgotten parameter. Just for an introduction into typical conditions of variabilities of vertical and lateral in-situ stresses, or rather their consequent differentiated deformabilities, a couple of sample cases are illustrated in Figs ... herein, and further expatiated in Chapter... However the case submitted serves even better for summarizing the faltering steps along which the very prevalent problems of slope destabilizations by groundwater historically "evolved" while insufficiently related to changing actions and reactions.

[27] One notes that the diligent but foolhardy measuring of in-situ stresses in rocks must perforce refer to cracks, but the erraticities are inevitably tremendous (as well as hysteretic) regarding localized ("point-test") determinations and effective average values of mini-contacts between very highly incompressible masses on either side.

Firstly there is the idealized condition of the infinite slope, with groundwater flownet also parallel to the slope (e.g. Taylor..., pg...and others, Bibliog..). There is no postulation regarding inflow or outflow conditions, even while destabilizing stresses encompass a parallel rise of the phreatic.

Then there was the “advance of wetting front” postulation introduced in Hong Kong, typically plagued with slope destabilizations by rainfalls. Then, under a sprout (still attributable to Hong Kong’s and Brazil’s analogous problems) towards primordial advances on suctions and the losses of strength by loss of suction, there was the postulation of slope destabilizations under this single highly idealized agent (de Mello PanAm Conf. Bs. As. 1975 etc). Besides very many factors of oversimplifications, obviating multiple factors of evapotranspirations and highest infiltrations and suctions incompatibly dependent on most materials etc.., the principal practical objections (Refs) were immediately put forward because suctions should be the first to be annulled by essentially 100% infiltration coefficients of many successive days of drizzly weather. These never, never, produced landslides.

Then came the obvious (to the point of ridicule) pseudo-correlations of Landslides with heavy rainfall episodes (Refs). The condition of heavy rainfall could not help being a necessary participant: **necessary but not sufficient**, as a causative factor, because one has to consider as really participating only the part of the incident rainfall[28] that infiltrates, excluding the obvious runoff coefficients: moreover, as the prior drizzly infiltrations saturate the upper horizons (whose suction is lost) the runoff coefficients increase and mass “flownet” infiltrations decrease.

Thereupon appeared the blatant corrective consideration of the influences as composed of two parts, the “antecedent rainfall over several days” complemented by the high intensity final triggering rain [Ref...]. The factors regarding the reactions (or resulting performances) began to match considerably better. But among many queries associated with hydro-meteorology and infiltration rates and evapotranspirations, the blatant query remained inasfar as (a) obviously more than a couple or few localized factors have to be involved (b) no explanation was sought in the direction of **significantly increasing inflows in the upper reaches, raising the destabilizing pressures** (both cleft-water, and flownet seepage gradients) **in the**

[28] There are many additional caveats regarding rainy episodes being crudely extracted from daily data and isohyatels, whereas slides and respective infiltration intensities should be local and short duration data.

upper part while reducing resistances in the lower stretch. The most probable increased capacities of upper inflows, while developing more slowly the downstream outflow capacities would clearly seem to be blamable on cracks in the upper platform.

The global subject, of immeasurable importance to real geotechnical problems and hazards and risks (increasing exponentially in urban areas) remains dismally deprived of rational complementations.

(G) An interesting serious example wherein the sound solid “resistant, incompressible” body of “rock” in the foundations of a big dam embodied the problem. In most cases of so-called “rocks”, it is the cracks (compressive, sheared, or tensile, and weathered, slickensided, or clean, etc...) that encompass the problem. Not rarely, however, it is the sound body of rock that constitutes the problem, because of its derivation from evaporites and being highly soluble. The author finds it necessary to remind geotechnicians of such cases in as far as he intervened to some extent in redirecting very extensive repair works that had been on-going for a couple of years in a very deep foundation of an extremely soluble rock body.

No “sound body of rock mass” is devoid of some cracks; and these obviously played an important part in making the sound soluble rock accessible to flows and dissolution. The immediate repair consideration was to use grouting, and cement slurry grouting. A careful visual-tactile examination of the material surviving in the existing cracks led directly to the conclusion that the intensive grouting works could not help being a failure. The crack’s pores were smaller as the two faces of adjoining sound rock were approached. This observation must need to be coupled with the practical cognizance [Ref... Bibl...] that no grouting method achieves 100% imperviousness over adequate lengths of flowpaths. Once again, a question of natural selection, the grouts following their preferential paths, and leaving some untreated. “Reduction ratios” may be 8, 10 or 20 times, but never 100 or more. The only possible solution would be to introduce a diaphragm wall (Hydrofraise etc...). Even if it continued to have occasional defects, the hazards would be reduced to coincidences of a defect in the diaphragm superposing a defect (original crack) in the rock.

Closing comment. The present chapter has attempted to arouse interests towards really reevaluating the orphaned condition of present conventional single-parameter primordial soil mechanics. A really affectionate interest in the marvels of the complexities through which we must nurture our qualms, queries, postulations, posits and solutions will always reveal with delight how the incorporation of additional parameters, rationally embodied, will achieve great reductions in hazards and risks even if each parameter continues deprived of narrow confidence intervals. In Nature's Natural Selection creation and birth are made difficult and strenuous, whilst discarding and "death" are the incomparably more frequent reality, easy and cheap. As Bertrand Russell said, "What men most want is not knowledge but certainty". And to that purpose one has mustered the three musketeers to defend the "institutions'" pillars – Precedents, Standards, and Codes ... all three irreparably questionable in as far as always prescribed from a much more ignorant set of past premises.

2.2 Milestones in the Geotechnical trek since the historic beginnings in 1936/1948.

1. Soil Science; atomic structure, bonding, crystal structures, surfaces (cf. Mitchell, Chapter 2) Bonding, Crystal Structure, Surface Characteristics. Interatomic Bonding. DIFFICULT TO ASSOCIATE with geotechnical engineering properties, as formulated erstwhile and constituting an ineffaceable dominant volume of conditioning experience. DEAD END.

2. Clay Mineralogy etc (1950 →): Persists, but regrettably bifurcated: nobody mustered the courage to incorporate into the erstwhile parameter (CLAY FRACTION) with successive variations of % of given clay minerals (type, cation, etc) into the fixed quantity of CLAY FRACTION, in order to achieve MULTIPLICATIVE S-P.., and thus remains sterile ADDITIVE S-P (Lambe, Boulder 1960?) Demonstrated valid and usable by some cases and soil conditions back-analyzed "pathologically". Calls for systematic research well-programmed to establish trends, and thereupon proliferating the systematic use in predesign investigation and parameter decisions.

3. First attempts at S-P (simple Gaussian), (1956→) for Rejection Criteria of Constructed Embankments, etc… and Definition of the "Field" of sampling data for S-P.: expanded with great fervour etc.., but also bifurcated, with multiple great promises.

Presently promising a very important come-back because of Hazards and Risks etc… Because of rapid complicating sophistications, no penetration into Professional Practice of Civil-Geotechnique (3A). It is ever more self-evident that it is far preferable to use the simplest (e.g. Gaussian) S.P. to (1) destroy the Determinism (2) Emphasize S.P. in view of complexity / erraticity (3) multitude of cases (4) communicability (5) Maximum & Minimum. International advances of S.P. for global Civil Engineering were noteworthy in the 1960 (P.Lumb) to 1980 period, marked by the I^st International Congress on Applied Statistics and Probability, Hong Kong, ICASP 197, Ed. Peter Lumb (followed by the 2nd, Aachen 1975, 3rd, Sydney 1979, etc..). Having been modestly initiated in Geotechnique, S.P. with simple Gaussian, in São Paulo 1953-‘9, it is considered an indispensable tool within the complexities / erraticities of soils. However, we advocate strong preference for simplest/inviting procedures applied to the multitude of anonymous constructions of Professional Practice, to focusing on the rare to few more sophisticated academic cases. Fallacies of Extreme-Value applications and existence of singular conditions of Determinism are exposed: however the prevalence is of dispersions at the extremities of the PDF, within the upper and lower ± 25%, for judicious decisions incorporating Maximizations of Active Agents and Minimizations of the Reacting Factors. Modern trend enforcing a RELIABILITY Index calls for important reflection.

4. The Great Theoretical-Academic Battle of Boulder Colorado, ASCE 1960, with unchallengeable theoretical foreboded victory; but because of (RIGID ELASTIC)-PLASTIC DETERMINISMS (including $F \cong 1.00$ etc) misleading as regards Professional Practice. Field u measurements, POINT, impossible to “average” under some space variability pattern etc… Stability analyses.

5. Then came Rock Mechanics for foundations of European high double-curvature arch dams. Recognition of discontinuities and their PERSISTENCES: “bridges” separating rigid-brittle cracks at ends, REMAIN(ED) FORGOTTEN. Moduli of Elasticity, cores examined principally, very modest field tests, $E >$ a minimum requirement $\approx 50000\ kg/cm^2$ of little interest: disturbances comparatively more conditioning, for “installations of field testing”, because of high unknown internal stresses and brittleness.

Great damage to Subsoil **Geologic-Geomechanics FOR Civil Engineering,** bereaving especially the saprolites and highly weathered transitional horizons to sounder rock. Tropical laterites similarly orphaned. ENGINEERING GEOLOGY intervened as a MISNOMER, and too little Geology, too many interventions mixing with geotechnique.

Highly significant cleft water pressures in cracks, and changes of permeability in **tension vs. compression:** Malpasset catastrophic failure (Mayer, A. “La mechanique des Roches”, Montreal, 1965, ICSMFE, III, 104-112).

Vajont catastrophe and its misled association with φ’res! (Repeated in GUAVIO, Colombia 1983). Obvious **engineering ALERT** as to unpredictability of the phase when both the τ drops due to

Break of Structure, especially in the higher St_{CD} cases and due to the increased Δu corresponding to a change from St_{CD} to St_{CU} condition: the duality not postulated, and historic St_u mostly omitted in characterization.

6. STANDARDS and CODES promulgated since start of post-war period. Compulsory.

Further damage $\approx$ 1985 incorporated and spread (from industries) of ISOs, which merely confirm REPETIVITIES, for practices inevitably somewhat insufficient if stationary, and sometimes even erroneous.

Whilst Geotechnique - Civil Eng'g. suffered from the undiagnosed Factor of Ignorance (F_{IG}) within the F, and professional practice exponentially spread was never concerned with the two complementary legs of the tripod Technical (Safety) – Financial/Economic – Logistics of the works, the Standards and Codes were produced as understandable struts affecting not merely the younger professionals but also academic substrata. Standards/Codes should have been recognized as aimed at (1) establishing common bases for REFERENCE (transient) and COMMUNICATION, but also (2) stimulating (and not thwarting) progressive updatings. Each document should have postulated which priority complements were hypothesized for continuing optimizing adjustment. In the face of endless conditionings of dispersions and erraticities of COMPLEXITIES (that were suppressed by the mechanical-mathematical DETERMINISMS) at each postulated updating change desired the prior EXPERIENCE (in different MUSEUM-SOILS) and the minimal statistical sampling should have been analyzed via accessible simple S.P. NEVER were such logical tenets (cf. MEDICINE) respected.

They turned into no more no less than a protecting shield perpetuating MEDIOCRITY in the face of which novelties stood-out statistically only through CATASTROPHIC PHYSICAL RUINS. In gist, each alteration demanded being minimally cross-examined (10-12 tests of "sample universe" covering the statistical field) for simplest S.P., but querying principally if they belonged to the ADDITIVE (independent) or MULTIPLICATIVE (progressively specifying) PROBABILITY rules: and this towards each of the three supports of THEORY and ENGINEERING ACTION.

Each "advance" should recognize the great delay in dissemination, aggravated by very different levels of developments. Conclusions should summarize average (MEDIAN), MAXIMUM and MINIMUM results, normalized into maximum and minimum PROBABLE spreads (CIs). Excluding rare cases of truly cumulative behaviors the use of averages has been a persistent mediocre fancy. The progressive specificity should attempt priorization of logically presumed more conditioning factors.

For example in practice, presently least known parameters are (1) real stress conditions in situ; (2) how to express varying conditions normalized into reasonably grouped proportions of the most current conventional idealized cases, past, and of revised ultimate goal; (3) in more rigid-brittle materials, the persistences of discontinuities, and dimensions and parameters of “bridges” between them; (4) how to incorporate into soil masses, of varying states and changes of Acting and Reacting Factors, the adequate engineering decision aids.

7. A theory originated and intensely furthered in the most authoritative Academic Centers of the UK stands out for note: Critical State Soil Mechanics; CSSM, its stress-strain paths and Yield points. Historically it is unquestionable that a theoretical kernel had to start with idealized soils and effective stress behaviours: moreover, that it accentuated attributed dichotomic expectations, granular and “plastic”, i.e. dense incompressible GRANTA-gravel and the clay of compressible drained stress-strain failure idealized “plasticity” from steel, the CAM-clay. Thereupon, avoiding any complications, with idealized straight-line diagrams a series of parameters were established, easily recognizable as independent, therefore ADDITIVE. However, in using the least active kaolinite, and remoulded reconsolidated specimens, avoiding the intrinsic complications of rapid failures and Sensitivities S_t that represented principal concerns of undisturbed active clays, the mathematical perfectioning of the double-phased “true elasticity” and “perfect plasticity” for the parameters impeded any retroacting S.P. connection with the professional past, and impaired embracing the wider statistical universe of force-displacement failure problems.

Finally, in the present daring expression of personal qualm on CSSM in its earlier prevalent formulations (very recently approached with promising modified-models) one is reminded that twin failings towards practice’s decisions occurred in not questioning (1) S.P. variabilities and (2) their automatic sprouts of maximizing and minimizing parameters affecting Active and Reactive agents respectively.

8. During the entire summarized trek, the erstwhile earnestly stimulated reporting on CASE HISTORIES proliferated, progressively exposing cases less encompassed within the idealized theorizations (1) never giving enough details for adjusting theorizations (2) never comparing alternate theorizations and solutions (3) extolling solutions applied to a category denominated

"PROBLEMATIC SOILS", steadily increasing (4) advocating "Judgment", "Experience" and the "Observational Method".

Regarding the Observational Method one must emphasize that regrettably the markets and highly varied legislations on design and construction contracting have literally killed that possibility except in conditions bordering on very serious difficulties and pre-failures, and to the progressively fewer recognized very senior "experts". It has become an illusion contractually and logistically. Regarding judgment and experience one must recognize even more regrettably that since both derive from inevitably restricted avenues of repeating analogous cases, the humans involved are not immune to pollutions by professional and personal biases. One cannot fail to note important cases that did suffer from such unsuspected and unquestioned imperceptibly growing biases.

9. Problems of disturbances to the in-situ qualities of soil elements (clays of high S_t and looser sands, both extremes, "granular" and "cohesive") in sampling, recovering, and handling, were progressively more recognized, all the more since they dominated the greatest professional problems. Every step starting from perforation access to the element, to the dimensions and shaping of the specimen, interfered. Thereupon, shunning sampling, attentions turned to in situ testing: the unknown, poorly investigated unknown but inevitable could not be avoided. Every variation and precaution introduced incorporated some counterpart, such as, for instance, decreasing the dimension of the delicate inserted instrument, simultaneously decreasing its potential for provoking the deforming action: moreover, physically the sizes coupled with increased natural subsoil erraticities and additionally behaviour dominated by the immediate vicinity. Additionally the concept fell into the vicious circle of extracting the parameters by use of the very equations from the idealized theories available (e.g. expansion of cavity). Finally, practical reasons reduced the opportunities to repeat 10 to 15 times the "reasonably equivalent" test position, necessary for minimal S.P. of CIs and ACs.

A more thorough investigation for each invented in-situ test would have used the reasonings analogous to the (1) Schmertmann 1955 research on specimen dimensions and trimming in consecutive oedometer tests, (2) the multiple-stage concept.

The net result, in short, abutted in another series of data pertaining to ADDITIVE Ps. and further impaired by the default (partially fulfilled by the recovery of "representative sample" for visual-tactile assessments) of not coupling the tests with representative sampling.

9.1. Regarding the SPT, on which attention turned rather mistakenly only to the problems of transmitted energy, the regret is that nobody pursued the rational line of adjusting internal reamed diameters for matching the retrieved 30 cm of sampling to the 30 cm of the penetration index.

9.2. One in-situ test to be commended regarding successive MULTIPLICATIVE Ps (but hitherto never used as such) is the CPT → CPTU → SEISMIC CTP/CPTU, etc…

9.3. Two much used in-situ tests that could be coupled towards furnishing MULTIPLICATIVE Ps. could be the push-in PMT with differently oriented PMTs and additionally incorporating the U-transducers and the SEISMIC generator.

10. The attraction to CONSTITUTIVE EQUATIONS for stress-strain simulation (of strain control tests) was understandably generated by the special cases of the Hyperbolae of Konder et al., extendable to the 10 to 20% denominated "ultimate". However apparently the attractive illusion persisted in search for equations capable of establishing the complete curves, retaining the post-failure interests up to the "ultimate strengths, asymptotic" and in the past decade extending prefailure deformations down to microseismic ranges of about 10^{-4}%. The intents should have been abandoned in the light of many reasonings above noted, such as interferences of S_t, the professional reality generally being FORCE-DISPLACEMENT (accommodated into stress-strain because of effective stresses etc…), and the fact that in each single professional problem no more than a part of "stress-stain behaviour of stress-control tests is involved (e.g. 1 to 4% or so) the principal problem being to estimate or pin-point the in-situ stress-strain condition of the element starts being altered by the imposed project.

Apparently the root intention of CSSM has been indeed towards such establishment of such entire stress-strain-strength curves, wherein the theoretically perfectioned idealized mathematical models prevailed, to the point of establishing additionally conservative YIELD values.

Once again, the practical professional needs and goals were set aside in favour of deterministic mathematical dictates. In truth, if one bowed to the realities of statistical erraticities definitions of the paths could more profitably be researched, determined, and established within 5-10% confidence intervals amply sufficient, by regressions, by stretches, separate and successive. And once again such a policy would point towards the easy repetitions of 10 to 15 analogous tests for the S.P. and design decisions.

11. Predictions vs. Performance challenges, always in extensive and expensive conditions have systematically proved that the profession is unable to predict within the ± 50% margins implicit in most design PRESCRIPTIONS and CODES. Results varying between $^1/_3$ and 3 and up to $^1/_5$ to 5 have been frequent except when a given procedures, even rather primordial, has been adjusted "mentally" for specific subsoils encompassed by the given engineer's "experience".

The mental model of such experiments should be abandoned in favour of reconsidering the case of the CSSM (that invites many points of criticism because of emphasized dichotomic premises when in truth the dominant reality is of soils constituted of continua of grainsizes gravelly-sandy-silty-clayey and the differentiated salient behaviours attributed to "sands" and "clays". A similar dichotomy is associated to its YIELD SURFACES (theoretically engendered between perfect ELASTIC-RECOVERABLE strains and interminable horizontal PLASTICITY failure in the corrected (p', q) curves. Should it not be sufficient to focus on the Roscoe-Rowe principle of Contractive vs. Dilative Energies, as erstwhile put forth by Taylor, with the Complemented precisions of measurements associated with the "failure zones" statistically broader than the singled "failure plane"? Incidentally, since all Civil Engineering aims at shrinking the onset of effective failure should one not be concentrated on PREFAILURE BEHAVIOURS, FOR ALERTNESS, but focused on the prospective failure zone and neither of the specimen as a whole nor of the plane singled out? All the more so since the "PEAKS" have been "pin-pointed" by means of STRAIN-CONTROL testing which is, in the vast majority of problems incompatible with realism in practical professional problems? The G/G_0 curves of nano-measurements point to such exposed continuities although in the microscopic scales of soil science it has been observed that the relative movements of particles in shear generate micro-acoustical vibrations of moving-stopping. The limited number of stress (FORCE)-strain (DISPLACEMENT) tests conducted under progressively increased forces ("stress-control") reveal the grossly-differentiated behaviours that occur within a very small range of Δstress steps.

To what extent do such nano-physical scientific realisms lead geotechnicians away from engineering merely because of the lack of (1) Engineering Perspective of other indeterminations that take over (2) the departure from S.P. bands of CIs?

12. Progressively more stringent requirements of special projects elaborated deterministically in the richer-developed centers, and the shockingly shown cases of catastrophic physical failures (errors) have engendered (1) increased conservatisms condoned by the oblivion of benefit/cost and logistical partners in engineering (2) restriction of deformations (total and differential) to SERVICEABILITY LIMITS assuming expensive “finishes” when to almost all cases, and living reality it is an inescapable reality that minor illnesses are part of life (3) the statistical discovery that humans have about 70% greater preference for avoiding losses than for seeking gains.

13. Finally one reflects that one reached this presently dominant situation as a net consequence of the erstwhile ANALYTIC-DETERMINISTIC THEORIZATIONS and the trend of the erstwhile prophetic mentors having responded to calls of importance by short interventions and concise reports, despising tests and calculations (though insistently taught by themselves when teaching) and imperceptibly developing personal biases of thinking and opinions transformed into dogmas. And Academia exponentially diffused (with few remarkable “Schools of pursued thinking and research through one or two decades” (such as the IMPCOL group as led by Skempton Seed, Boulder Conf., Lambe) having based their production and publication as a patchwork of directioned spot-tasks, which when “concluded in response to the specific demand” without attempted integrated readjustment of collateral consideration. The net present result is o of chaos of a multitude of “Solitary Schools internally-solitary” pursuing side-by-side their tasks more towards broaching and solving imagined goals in lieu of contributing to advances professional useful and fertile.

14. One notices the dominant, almost exclusive, conduct of “research efforts” as “directed INVESTIGATIONS of “discovering another” (intuitively predictable) parameter e.g. “pluviated sand”, cf. p. 409, STP 977, 1988, ASTM, which INFLUENCES RESULTS, eventually distantly related to dune sands of deserts (?) but even these limited to few tests to demonstrate that the INFLUENCE EXISTS (“Eureka”). The basic reasoning (cf. VFBM Mexico 1969) should arise under the abstract principle that everything has innumerable conditioning factors and our tasks in the trek are, step by step, to (1) Research to find which appear to be priority and the degree of importance academically compared as ratios (2) sufficient quantification to check in PROFESSIONAL CASES what COMPARATIVE INFLUENCE should be accredited to prior conventional tests and procedures, in S.P. comparisons (within the statistical sample of the UNIVERSE) (3) pursue on down to subsequent lesser priority subdivision (MULTIPLICATIVE PROBABILITIES) under the reasoning of PARTIAL DIFFERENTIALS.

2.3 Prediction vs Performance Challenges PPCs. The historic milestone PPC, and analysis of some erstwhile lessons, hitherto tentatively.

About 35 years have elapsed since the milestone set by T.W. Lambe (Ref.) and M.I.T's geotechnical staff by the first Prediction and Performance Contest PPC that exposed a surprisingly frustrating result. For the fill on soft saturated Boston Blue Clay the predictions of the 10 select scholars with sophisticated analyses resulted worse than the average calculated from the mistakenly presumed "experienced" guesses expressed by the 26 participants as the Session's audience after the exposition of the data. Fig. 1 summarizes the principal items [A2], [A3], [A4], wherein some points of interest should be noted, considering the distant days reflected in one of the most advanced centers of worldwide geotechnique. Firstly regarding the shear strength attributed to the subsoil profile: the incredible **scatter of test results stands patent, leading to the use of a "boundary curve" without attempt at judicious corrections** for sample or test qualities. This practice understandably abounds as a first-step solution in the profession when judiciously quantifiable conditions are minimal. Secondly it is noted that three of the scholarly predictors gave deterministic point answers without a range, whereas all the audience's professionals gave answers ranging widely from maxima to minima. For both groups the global average (if such a project were ever to be privileged by 10 scholarly studies or 26 consultants' guesses) ended up incorporating a 15% prudence bias considering the 16.5 ft. fill height predicted in comparison with the 19 ft. reached on failure (although failure developed to the side opposite to the one foreseen, a crucial deterministic warning).

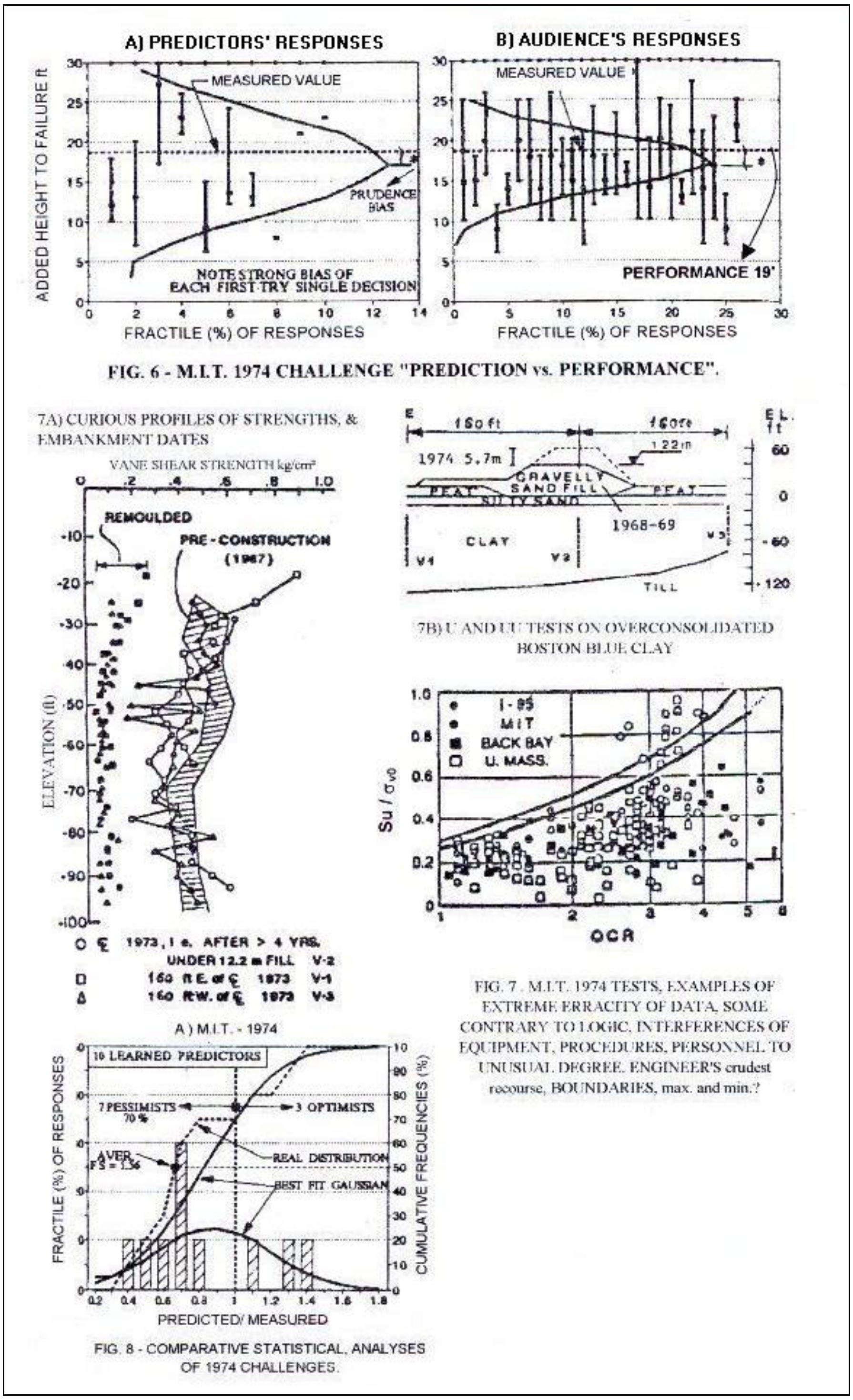

Fig. 1 – Summarized published data, first Prediction and Performance Contest PPC – MIT 1974

In some publications including the Author’s own [4a] extracting from others, the gross conclusion was transmitted somewhat in favour of the “judgment” of practicing professionals: however, this book is dedicated to indicating how to grow, through acquiring and querying the desired judgment. Anyhow, on closer analysis it is noticed that a great number of replies crossed both the real and the average result, in going from maximum to minimum predictions. The illusory comforting tolerance towards the off-the-cuff hunches disappears quickly upon analyzing separately the presumed separate averaging of the maxima and the minima. In neither case do the optimizable regressions yield any result minimally mentionable ($r^2 \approx 0.003$)[29]. Interestingly the presumable averages both yielded a confidence band of ± 30% around the global average. With regard to the real performance the excess safety was about 15%, and the band between 13% on the optimist side and 50% on the pessimist-expensive side. Altogether, finally a comment is merited, to be reiterated in most similar cases: it regards the incorporation of a confusing mixture of academic quests towards forefront developmental research goals, and the profession's experience at prior and prevalent dominant worrying design needs. One cannot move to Probabilities Ps without Statistics Ss, and one cannot have Ss on a single or few novel cases. Successive analogous PPCs ever-growing in numbers[30], extents and costs, and conducted by several of the most advanced centers of geotechnique, have imitated these efforts, well-intentioned and most richly documented[31], putting to the test the expected improvement of the profession's capacitation. With regard to such cases, as many as one has been able to collect and analyze, a few brief syntheses are presented herein, and more detailed in the corresponding chapters. There has been a widened distancing between the academic eagerness and recommendations, and the experienced professional practice from which the "qualitative-statistical" intuitions sprout. The basic frustration has been systematically repeated, on the demonstrated incapacity to reach convincingly

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[29] r^2, the sample variance, the square of the STANDARD DEVIATION SD, is the routinely used measure of the dispersion (calculated by the sum of the squares of distances from the sample mean) and rendered independent of the number n of data dividing the said sum by n. Found in every engineer's textbook and software on S it indicates the quality of the Probability Density Function PDF, approaching 1 as the limit of absolute uniformity. There are sound reasons (of pure statistics) favouring division by (n-1) [5, Pg. 11] but common division by n is retained herein since no statistical analysis in geotechnique becomes meaningful, to less than 25% error, without at least 15 to 20 data. For simple and multiple SRs respectively the symbols separately used are r^2 and R^2 respectively. A directly related coefficient of generalized interest, the COEFFICIENT OF VARIATION CV, dimensionless, results from dividing the SD by the sample mean. An effort is made herein to categorically reject referring merely to r^2 or R^2, without consequent estimations of CIs because five decades of experience prove that to the majority of professionals they do not convey any direct feel regarding percent dispersions and consequent hazard HZ probabilities P, a designer's absolute need. The needed specific proviso on the nominal CIs has already been mentioned as foreseen.

[30] One will systematically note also the most laudable increase in the past decade of recourse to firm special test sites in advanced countries. They serve the purpose not only to evaluate dispersions of state-of-practice (embodying knowledge, experience, standards and codes) but also ipso facto furnish the bases for influencing (subjectively and/or formally) the immediately forthcoming design prescriptions and teachings. These initiatives must concentrate on trifurcated aims, to: (a) compare past, to present, to advancing techniques for retrieving the enormous data-bank; (b) incorporate complementary characterizing parameters for the intermediate "general-quality" soils alongside with the idealized ones, and; (c) develop more pertinent parameters specific to the various "problematic soils". Under recognition of the dominant differentiations of soils by regional factors of "physical geography" emphasis falls on greater development of such test sites in regions of developing countries.

[31] In fact one criticism applicable to the PPCs is that they have automatically been very much more documented with tests than almost all projects of professional practice.

comforting predictions, even with the test documentation, both in situ and laboratory, many times more ample, dense and special than that which accompanies the majority of current jobs. Often it extends even to important projects built with meticulous quality control and monitoring.

In the Prefaces of each of the three Volumes (I. Soil Behaviour Fundamentals; II. Soil Masses, Slopes, Embankments and Dams; III. Foundations and Underground Structures) one seeks to sort out from the respective examples the essence of the significant revisions of concepts and methods that seem indicated, for wider generalized use, starting from the discarding of the theoretical-mathematical determinism of presumed grave and fearful events, setting bridles to the theoretical-mathematical determinisms, in order to achieve socially acceptable optimized probabilistic HZs and RKs, both against "fearful events" of nominal failures, and against costly overconservatism. It is imperative to favor of the sequential statistical analysis of the multi-documented prefailure behaviors that keep developing in monitorable conditions (cf. Item 2.14). It seems important, however, to emphasize herein, in this general APPENDIX that accompanies the three volumes, and that enjoins professionals to the use of SP absolutely without exception, some strongly insinuating comments, in justification:

(1) The past merits understanding and imposes respect, particularly in order to consolidate the right and obligation to reshape it progressively updated. From the **infinite possibilities** that collapse into **thousands of probabilities**, which in turn collapse into a single **deterministic yes/no concrete reality**, one must cull the experience extractable from those **facts**: these must be diagnosed regarding how they fulfilled the desires as associated with the theories and prescriptions of that period, having worthily served within their contexts. In constructive criticism one posits that they do not fail to exact collaterally the recognitions of, distortions, both important conceptual, and systematic moreover from the pseudo-statistical erraticities that never resulted convincing, they impose questioning the arbitrary inherited FACTORS OF SAFETY F in widespread use with reference to physical failures; collaterally as well, regarding the fixing of SERVICEABILITY LIMITS SLs (for what purpose and for whom?) of acceptance and tolerability. Such "limits" are insufficiently repeatable for trustworthy quantifications, except in very limited groups of closely similar cases.

(2) It behoves one to summarize a constructive criticism, however well-intentioned, on the past, with due recognition of its limitation to present knowledge and its forced transience. One must conclude that the first steps were brilliant, amply justified and understandable. Their present inadequacy derives from the illuministic-deterministic origins including the assumed generalized applicability in going from the particular (inexorably investigated in idealized condition) to the

general cases, complex, of denominated “problematic soils”. And the fault, strongly fostered by misunderstandings on STANDARDS, CODES[32] and PRECEDENTS, falls on the successors, who have not re-examined the original theorems and their inherent implications.

(2.1) Primordial attentions were concentrated on the rigid-plastic rapid physical failure at constant volume as a yes/no deterministic event occurring on the global project “geometrically ready”, and with all soil elements reacting with the same strain, under an action either undefined or imaginary.

(2.2) Failure was historically defined as coinciding with a Factor of Safety F ≡ 1.00, with no heed given to a deterministic fallacy the differentiated variabilities of the dominant agents of ACTION A and REACTION RE.

(2.3) A first liberating step from this straight-jacketing arises from the conceptual recognition that accepting the uncertainties, deficiencies and errors as analogous in two sequential undesirable behaviors, the net error is considerably decreased by extracting quantification of differences, cause-effect, from an initial to a subsequent condition. Thereupon the arguments are strong towards stepwise SRs to be progressively improved for posterior extrapolations.

(2.4) Thereby the evolving serviceable states invite interest, since there are many of them offered for opportunities of SP analyses. Therefrom what are the new probabilistic HZs to take into account to orient the DESIGN[33] should be extracted.

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[32] All such PRESCRIPTIONS (which constitute the second step of ignorant solution after the yes-no boundaries) have to exist “duly dated regarding promulgation and proposed revision or riddance” but they inevitably reflect only the acceptable questionable knowledge gathered up to then. Therefore ipso facto they neither are, nor can be binding, but serve only two basic functions of great importance:
(3.1) furnish a reference basis for communication and data-banking in a common language, for use as a basis for comparison, if and when the professional exercises the right and obligation of differing from the usual-general;
(3.2) introduce consciousness of the increment of responsibility (HAZARD HZ and RISK RK) upon employing (in his specific case) the different condition of his choice or subjection. The only intrinsic STANDARD in concept and reality is that nothing is ever truly equivalent, everything differs and changes with place and time, and the only binding principle is to do the best that may be wrought under technical-economic-logistic requirements, as compared with the STATE-OF-THE-ART associated with those prescriptive documents. One must reflect with consciousness on the consequences invited by the adopted alterations, and must justify them. Generalized acceptance regarding terminology sets the difference between HZ (probability of occurrence of the undesired behavior) and RK (the probabilistic cost of the consequences of the HZ that materializes). The inexorable increase of the RK in any area progressively developed constitutes an ample caveat against acceptance of maintaining a constant specified HZ, as lies implicit in any and every STANDARD, CODE or PRECEDENT.

[33] In ultimate judgment to be oriented in function of RK and not of HZ (hitherto the only one brought into consideration).

(2.5) Notwithstanding having accepted the principle of SP analyses as established, in diverse pre-distress stress-strain conditions, the primordial constraint[34] remained (and still persists) in all publications and software, of trying to research in order to feel semi-quantitatively **some main complete stress-strain trajectories of the idealized behavior, of idealized soil, by means of some single equation (CONSTITUTIVE EQUATIONS CON EQs) from beginning to end of the behavior history**. Possibly the induced habit derived from the most common elasto-plastic relationship, really exhibited by very many soils of simple unpretentious behaviors. One will briefly refer to this additional distancing of any possible realism of the geotechnique of multiple complexities and important stress-strain-time influences as compared with the primordial idealized tests. Unnecessarily, and with serious detriment to the profession, the preference for the following principles was left by the wayside: (a) the quest for successive best possible SP regressions stepwise along the trajectory; (b) the use of such regressions and their CIs by step-integrations of incremental actions and consequences, capable of better respecting the reality of the influence of the soil element's history on the behavior.

(2.6) Civil Engineering is eminently an executive profession calling for challenging or reformist adjustment of Nature, in accordance with diagnoses and data always insufficient, capped by decisions and determinations despite doubts. In the face of the recognized queries regarding the complex realities of the Project and the heavy responsibilities towards Society, one of the preachings of geotechnique's respected mentors (all along five decades) has been the insistence to employ the OBSERVATIONAL METHOD OM, of revisions on the on-going construction[35]. However, the first reflection of querying that strikes surprisingly is that the emphasis given to the analyses of failures led dichotomically to utter oblivion that there was no systematic collateral development of the indispensable procedures for analyzing (statistically) the evolutions (by steps, suggestive of extrapolations by prudent increments) during the phase of abundance of pre-failure data. What prevailed was the fear and shame of failure (blatant, and specifically so if dominantly during construction activities, end-of-construction or start of operation) in comparison with the

[34] Of the psychologically ever-present complex of the mediaeval "philosopher's stone capable of turning everything into gold".

[35] In fact it is qualitatively intrinsic to our Bayesian cultural evolution, but herein it is focused on quantitatively monitored observation for cause-effect adjustments in adequate scale and effective timing, for extrapolation to the final goals and smooth incorporation of foreseen allaying measures. Many obstacles, principally contractual and the frequently indirect and retarded cause-effect behaviors, make this undisputable concept relatively impractical.

chronic corrosive damage to Society, unperceived by the lay public, due to excessive safety and cost, with effects amplified at compound interest, resulting in destruction of quality of life[36].

One seeks to revert the goal towards the improvement, inescapable and endless, modest but ever inviting to evolutions, by way of employing formulations favouring effective observation, even if initially only in levels of PRECISION PRE ("scientific") accompanied by modest ACCURACY ACC minimally necessary to expose well the phenomenology and predictability.[8][37]

(2.7) Finally one returns to the subject of STANDARDS, CODES and PRECEDENTS, with a purposely daring and striking declaration that until now, as a result of their inherited and intuitive arbitrary origins, and the presumption that they be relatively immutable, the submission to them as requirements is absolutely wrong, and has been a great hindrance to the profession [9]. In all problems the intervening parameters are countless, but one's limitations (transitory) force one to select a specific parameter (or 2 to 3 at most, presently) as dominantly conditioning. Moreover, everything changes with time, and everything interacts. Thus, each STANDARD must be related to a specific period and historic context, clearly dated as regards origin and obsolescence, and programmed for obligatory periodic revision[38]. The only tenable and binding STANDARD to the professional is that of the **principle of doing in each case the best possible.** Under such a requirement the existing STANDARD has to be interpreted as a REFERENCE STANDARD for various reasons of utmost importance: for (1) uniformity of communication comparatively, with the past (PRECEDENT) and with the UPDATED STATE-OF-ART; (2) obliging one to check to what extent one is introducing an alteration possibly greater than would be suggested in respect of prudence; (3) forcing one to query really with regard to the provable support, with which the alteration is introduced within the range of HZ/RK desirable and acceptable, in the face of the triple-legged support of engineering, failure (or behavior physically unacceptable), incremental cost, and damaged logistics.

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[36] One should revert to the statement by Freudenthal, A.M. (1947, 1956) "The fact that design procedures [6], [7], generally result in structures of excessive safety rather than in unsafe structures is an indication of the caution exercised", and also, specifically, to emphasize the need of judicious distinction between real results and those deduced, such as, for example, the fact that in Structures the Weights (Loads) are relatively close to being realities, and so also the displacements, but the strains and stresses, which dominate calculations, are deduced values tied to the respective theoretical assumptions.

[37] Important publications have used ACC [10] in place of PRE [11]. One repeats the importance of promoting uniformity of nomenclature as was done with HZ and RK.

[38] Obviously with preference for the active participation of "new" contributors, including for each item under consideration, its most competent critics.

Within this professional purpose many are the presently reigning aberrations, which will be systematically exposed in each chapter. Herein suffice it to emphasize some root incoherences. For example, the enormous difference in the establishment of SP of knowledge/behavior upon comparing a subsoil profile, characterized by some 7.5cm borings at 20-30 m distances, versus a slope of a compacted fill for a dam, technically supervised layer by layer and quality - controlled by tests at every 200 to 300 m^3 [39]. And, among the subsoil conditions, the enormous conceptual and practical differences between a sedimentary profile of fine grainsizes serenely deposited, in comparison with torrentially deposited piedmontic strata, or with saprolitic horizons of igneous rocks[40], intercepted by geologic features, and generated by factors of natural selection that maximize the survivals, side by side, of markedly different conditions.

(2.8) In closing these fundamental directives that orient the present effort of constructive criticism, it becomes important to emphasize the choice between SP sophistications and Theoretical Mathematical behavior formulations, in comparison with resorting to the minimum acceptable and inviting of the SP routines of possible and acceptable use, absolutely generalized, for everything and everybody. In one's professional field always inescapably erratic and approximate, one chooses to give strong preference to the great mass of lower level of refinement in comparison with the spear point advancing SP which directly shoos away the prospective contributors of such a treasure of current realistic data from project files. One has to implement roughly quantifiable methods of profiting from “the vast silent majority of cases that did not generate theories or merit publication” [12].

The second road has been chosen, to which one invites everybody to adhere enthusiastically, in function of everything that derived from the publishing vanguard of the profession since 1946, end of the catastrophic success of MILITARY ENGINEERING, and the exhilarating opening to the construction of the “Brave New World” of CIVIL ENGINEERING. The files of the offices of Design and Construction Companies are incalculably replete with available data: the publishing tendencies favouring “Eureka” and “major Case History” papers from the vanguards of each subspecialization that composes the multidisciplinary engineering of professional reality[41] **suppressed** those files into shy **discarding or oblivion**, inasmuch as felt devoid of a blaring thesis to postulate. This aim is pursued herein as an offer, with

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[39] And furthermore subject to critical loadings quite well defined, with exception of the seismic ones.

[40] Each and every subsoil profile of residual and saprolitic soil must without exception be required to specify from what bedrock it derives, complete with its oriented discontinuities (an obligation forgotten in a high percentage of cases).

[41] If necessary made anonymous and unrecognizable by changing inconsequential data.

emphasis on separating the grain from the chaff from the first plantations, and towards putting the patchwork together alongside with investigating the end-product of each important topic with reference to the SP of greater benefit / cost value.

2.4 The Profession's Recourse to Linearized Relations in Advancing Beyond Crude "Boundaries" and Prescriptions, and Prior to SRs. Exemplifying Extending to SRs and CIs, and lessons.

To a young graduating engineer around April 1946 a lecture by the famous Hardy Cross could not fail to leave an unforgettable imprint. He affirmed that the Civil Engineer looked assiduously everywhere for linearized relations. He first tried the arithmetic graph: if not visually satisfied, he moved to semilog graphs that accommodated many more cases; finally, if yet unsuccessful, he moved to the log-log. Everything ended-up accommodated into the visually satisfying straightness[42]. Fig. 2.4.1 presents a set of 30 hypothetical pairs of (X,Y) data within the ranges of $20<X<40$ and $22<Y<34$ for which the arithmetic-linear regression reflected the crude "reasonableness index r^2" of the order of 0.73, an often accepted value. Simultaneously one derived the two semi-log regressions, and the log-log one also, all of them matching the data-bank with equivalent adequacy although failing to result strictly linear. Within the range thus represented by the universe's sample one finds that the maximum disagreements between the four equations fell within ± 2 %. Such a fact may well have constituted the support, throughout 80 years, for the practice above mentioned, alongside with the comfort with "hand-drawn" linearizations: the fact is that there is never any ground for qualms in ± 5 to 10% exceedance or defaulting dispersions in geotechnical engineering.

[42] Those were, moreover, the days when one systematically bought printed graphical sheets with scales destined to linearize various other less usual equations. Further down it will behove us to refer to some fundamental idealizations, theories, and laboratory practices, unsuspected as to their trustworthiness, which have such "genetic-impurity" while they are advanced to high levels of sophistications in analyses and Designs.

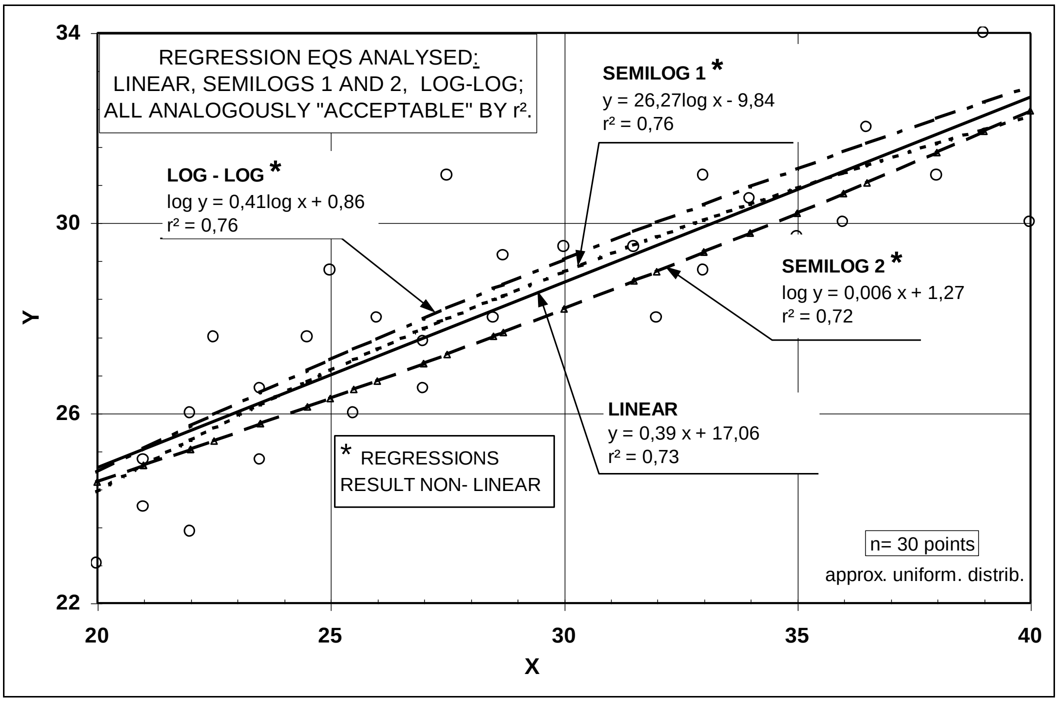


Fig. 2.4.1 – Adopted data-bank for comparisons of classical regression equations, acceptably equivalent, in lieu of visual linearizations practiced in 1950s – 1960.

As a sequel, however, one has to take into consideration the CIs (generally signifying the width of the band) of the data around the equation adopted for definition of its mean. One must remember that **there is nothing more deterministic than an equation**, and without CIs the entire goal of resorting to SPs gets nipped in the bud. There are numerous distribution functions and goodness-of-fit tests offered for use[43] but Fig. 2.4.2 is prepared employing only (however crudely at times) a single hypothesis and procedure. One must always recall the comparative degrees of presumed precisions of other parameters and factors that enter into the final global result which is relating effects (REs) to postulated causes (As). Both because of professional realism and because of the core intent of the book, to draw everybody without exception to systematic use of, and expression in, terms of SPs, one shall limit oneself to the use of CIs assuming the Normal (Gaussian) distribution that would, at any and every position of the bar diagram of frequency distributions, presumably prevail if one had ample quantities of Y-data at the respective X-position.

[43] Reminding ever insistently that our engineering reasonings are based on maxima or minima, and exceedance/defaulting percent probabilities thereof. The goodness-of-fit tests of more detailed SP are found in most textbooks specific to the area, but are set aside herein to preserve the inducement to simplicity of reasonable acceptability.(cf. Item 13)

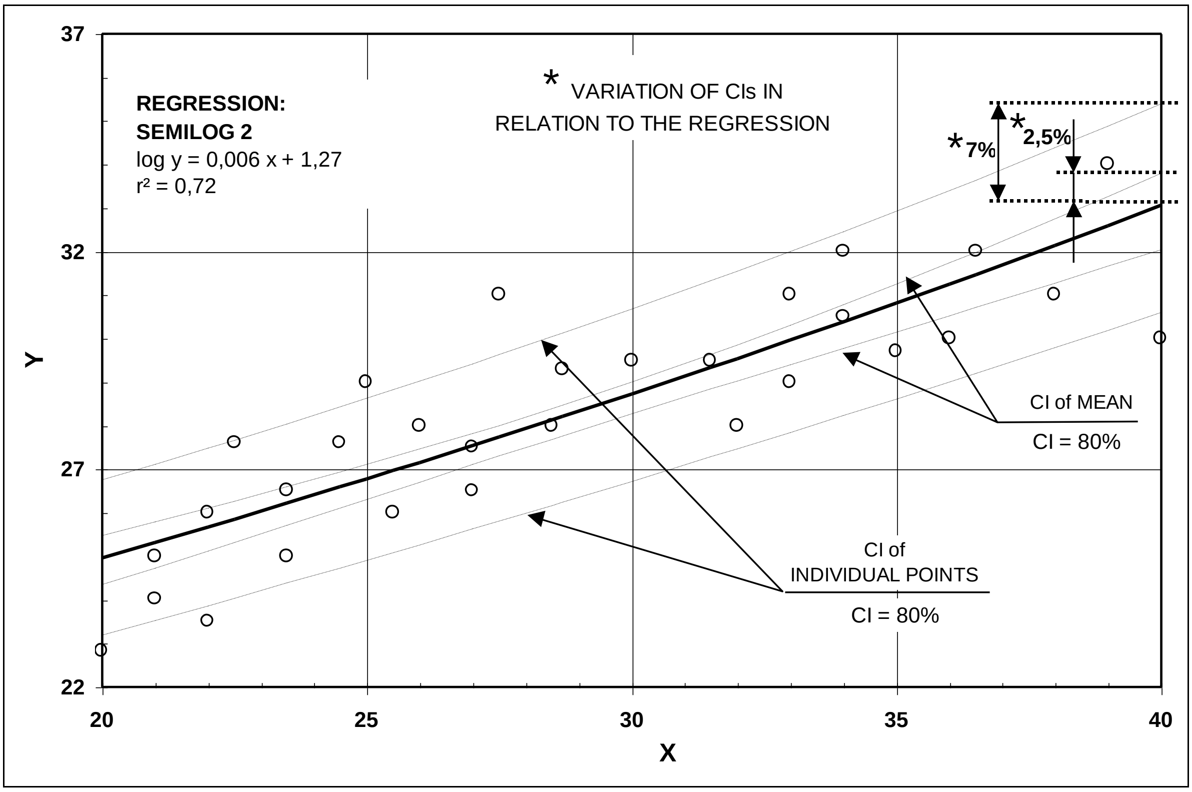


Fig. 2.4.2 – Exemplifying CIs of same 30 points of Fig. 2.4.1.

The points exemplified are three. For clarity one employs only one of the equations, semilog2. Firstly that the CIs should be estimated both on "averages" and on "individual points" (spurious values reasonably discarded). The second obviously gives a wider band for any % CI; the use of the one or the other is not arbitrary, but follows a definite reasoning. As expatiated further it is important to recognize that depending on the type of behavior at stake either one or the other of the CIs will be involved. Whenever a behavior arises from cumulative participations, the average prevails. For instance, the consolidation settlement of a clay layer results from the integration of the compressions of all underlying soil elements. Setting aside mutual different installation effects, as might be pertinent, a group of 3 to 6 piles supporting a column[44] merits tending towards CIs of averages in comparison with columns supported on single piles (CIs of individual points). A preferential sliding plane, or the supporting contribution of a set of bolts instead of pretensioned anchors, would also call for CIs of individual points. Although this is an easily perceptible point, it serves to illustrate that use of SP requires experienced discrimination pertaining to the specific professional specialization and problem, a point very frequently missed.

[44] Referring merely to one much respected and quoted book [5] one can summarize: (a) discarding a preference for the Kolmogorov - Smirnov (p. 468) test etc.; (b) The first list of tests (pp. 459-466, cf. Item 13).

The other aspect worth emphasizing is that one prefers to aim at realism, using CIs for no more than 10 to 15% probabilities (on averages) of being outside the band, i.e. CIs of 80% and 70%. Influences from other fields, with much smaller dispersions and greater numbers of tests have introduced a prevalence of mention of only 5% probabilities of the average (multitudinous tests, fabricated materials) lying beyond the band of CI 90%. Even in a well-controlled compacted fill it would be unrealistic to consider more than 80% CI (of averages), while in connection with subsoil profiles even the use of 60% CI (of points) would most often be starry-eyed. These inescapable realities have very important implications for achieving the desired very low HZ ranges of failure, as is expatiated in item 2.9.

Finally pursuing the rudimentary recommendations one step further, and continuing with the same case, in Fig. 2.4.3 one exemplifies the importance of really programming an investigation for realistic and trustworthy SR optimizations by concentrating the investigations with greater percentages of points towards the limits of the desired field of SR. Opening a crucial parenthesis one reports here to a drawing, Fig. 2.4.4 herein, presented as a result of a very thorough bibliographic research for a State-of-the-Art elaborated in 1968-‘9 [12]. The question concerned the then available (published) confirmations for the conventional footing bearing capacity formulae for routine ranges of interest of (c,φ) soils. The query was oriented by an authority in SP programming for industrial productions, who did not refrain from expressing his shock at the dismal lack of programmed range of data, even when simplifying intervening parameters to the utmost. Much has been added since, as expatiated in Vol. III.

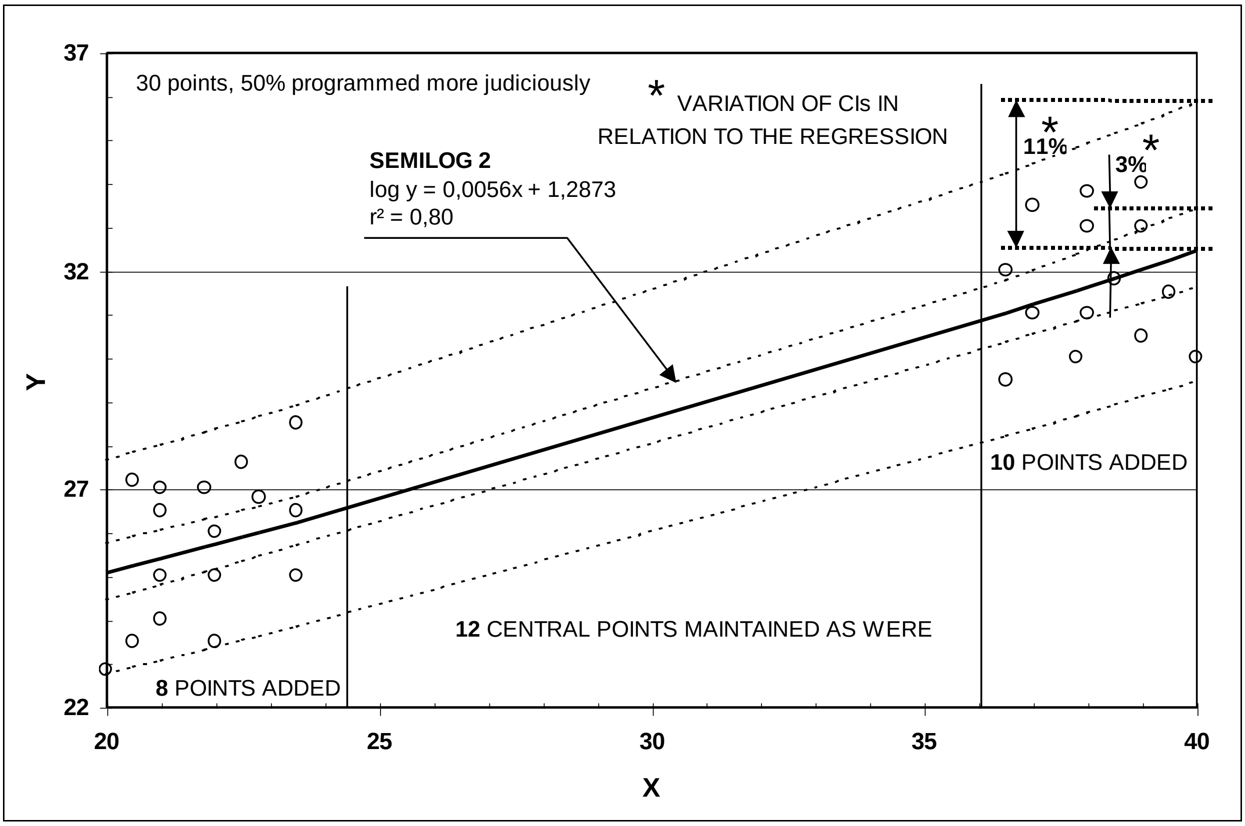


Fig. 2.4.3 – Programming tests for optimizing universe definition. Similar scatter at borders would tighten CIs. Widening CIs, as chosen, insinuate changing parameter dominance towards border.

Naturally almost all early correlations extracted data from non-programmed data-points, and could not resist the desire-induced need of extending as far as possible a presumed correlation. For Fig. 2.4.3 the 30 points of Fig. 2.4.2 have been redistributed, concentrating more points towards the extremes. The pitfalls of extrapolations are mentioned further on. For updating presently much-used correlations one should not merely (1) respect the limits of the data-bank and (2) generalize use of SRs and CIs, but also (3) complement with programmed investigations to optimize the definitions of the borders of the field, including acceptance of their indication of changing trends.

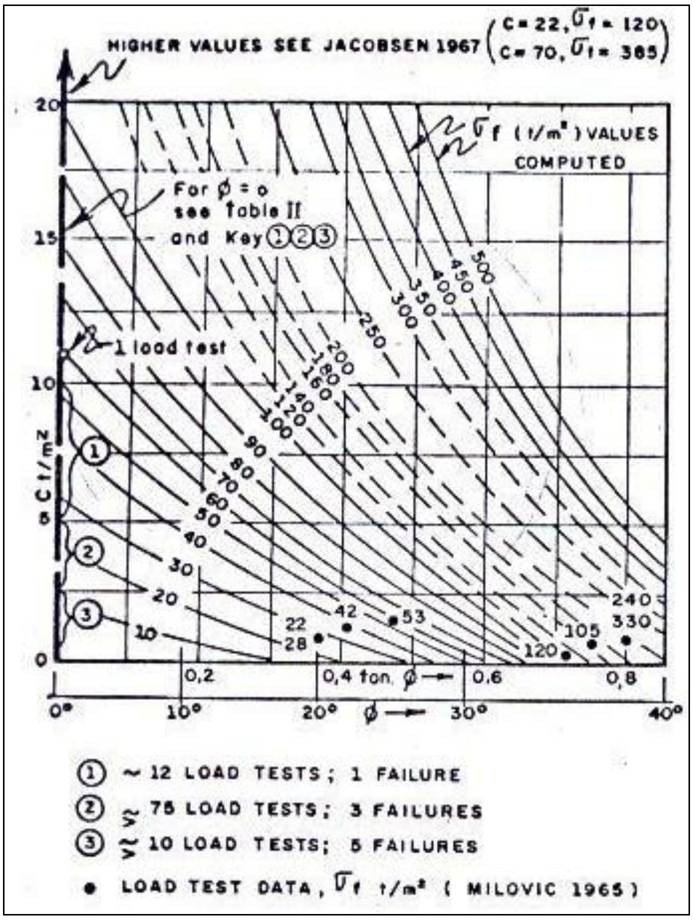
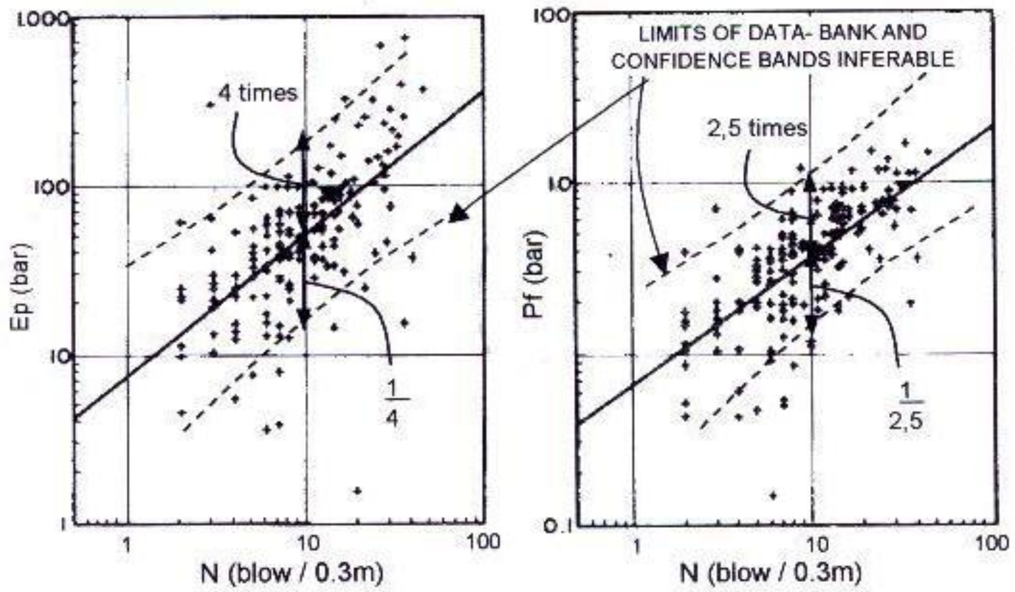


Fig. 2.4.4 – Field of interest in bearing capacities and available confirmatory evidence.

Taken from [13]

The improvement or not of the CIs by such a programming leads to an additional conclusion of practical importance. To begin with, it is rational and obvious that if realistically similar scatter is maintained at the extremes, the greater number of points at the ends should confirm the validity of the data-bank's dominant parameter influences by narrowing the CI band widths that otherwise go broader. The opposite condition, not so clearly recognized and mentioned, was therefore consciously used for preparing Fig. 2.4.3. Greater scatter at ends, reverting the natural trend of tighter CIs, becomes a clear indication that the dominant parameters of the SR are beginning to change, an important warning to the profession of multi-variant intervening parameters. Amidst very many parameters vying for dominance, the practical limitation to only one or two erstwhile intuited parameters (maintained unchanged throughout all applications and ranges thereof) imposes alert attention to such changes.



N values-pressuremeter parameter relationships (diluvial clayey soils) [14]

Fig. 2.4.5 – Example of indiscriminate use of log-log linearization for erratic pseudo-correlations of too many data, and broad bands visually set, with no use professionally responsible.

Finally under these rudimentary considerations one submits Fig. 2.4.5 as a mere example of very frequent practices to be guarded against. They are associated with the already mentioned ability of log-log graphication to fit intuitive pseudo-correlations with easy linearizations. The two graphs arise from a facility at gathering too much indiscriminate data. Points already made will not be repeated. Note, however, that the undefined CIs would encompass values up to ranges of 2.5 to 4 times (or the inverse) the presumed average. No design engineer could comfortably refer to, or use, any such information in view of the typical nominal values generally assigned to Fs. However, even further, one must also recommend that prior attention be given to the presumed physics of the problem taken to correlations. In one of the graphs (right-hand) there is some relationship between two index tests on shear strength: but in the other (left-hand) there is the questionable attempt to relate quantifiedly a parameter of deformation to that of strength, a point already ironically posited (e.g. 13, pg. 2, 3).

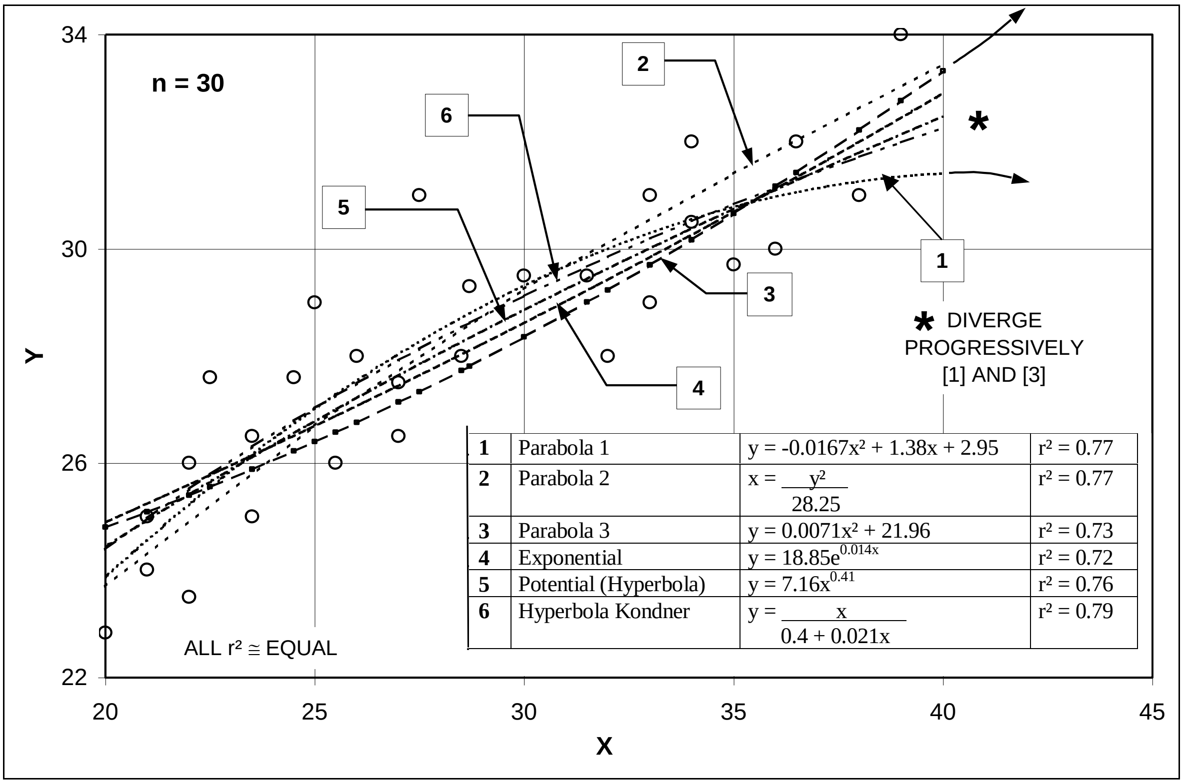
2.5 Prudence Regarding Extrapolations.

Needless to say a young technology facing multitudes of problems of great responsibility (towards all superstructures) had to progress step-by-step creating index tests for characterizations and offering prescriptions and provisional correlations for estimations of the necessary fundamental behavioral parameters for designs. The problem, understandable, was that those correlations started with limited data and were not accompanied by CIs and clear delimitations of data-banks' ranges. Therefore it will be important to go back in as far as possible to the conventionally accepted equations to apply to them the procedural admonitions above advanced. The message must be transmitted and embraced burgently: one regrets mentioning as a single mere example among multitudes, a very scholarly and important paper on correlations regarding behaviors of compacted clayey soils [15] wherein the 26 samples constituting the data-bank included about 60% of $20 < W_L < 40\%$, and 30% of $55 < W_L < 90\%$, and 10% of $160 < W_L < 170\%$.

Attention is further drawn forthwith (cf. Item 2.14 of this APPENDIX) to the despicable lack of minimal conscious use of SP rationales in pre-failure analyses, wherein lie the attractions to multitudinous data of importance for progressive performance regressions. It results from the primordial fearful concern only with physical failures, the ultimate condition.

At any rate one has to reflect on the professional adage that recommends not exceeding established satisfactory precedents by more than about 10 to 15% at each project growth, retained for a while for collecting a minimum of adequate S ratification.

In order to exemplify the ingrained wisdom of such experience the same data of Fig. 2.4.1 are used in Fig. 2.5.1 to deduce six regressions of equations among the most currently occurring in geotechnique, all of them achieving roughly similar r^2 values, of the order of 0.75, commonly thought acceptable. One repeats the experience that the dispersion between the different equations is not significant within the bounds of the data: however, assuming a personal preference for parabolae, one notes that in extrapolating beyond X=40 the equations begin to diverge progressively growing either upward or downward, and by sheer coincidence the maximum divergence occurs between two parabolae, $N^{rs.}$ 1 and 3.



1	Parabola 1	$y = -0.0167x^2 + 1.38x + 2.95$	$r^2 = 0.77$
2	Parabola 2	$x = \frac{y^2}{28.25}$	$r^2 = 0.77$
3	Parabola 3	$y = 0.0071x^2 + 21.96$	$r^2 = 0.73$
4	Exponential	$y = 18.85e^{0.014x}$	$r^2 = 0.72$
5	Potential (Hyperbola)	$y = 7.16x^{0.41}$	$r^2 = 0.76$
6	Hyperbola Kondner	$y = \frac{x}{0.4 + 0.021x}$	$r^2 = 0.79$

Fig. 2.5.1 – Some current regression equations differing only ± 2% within data-bank: warning against extrapolating.

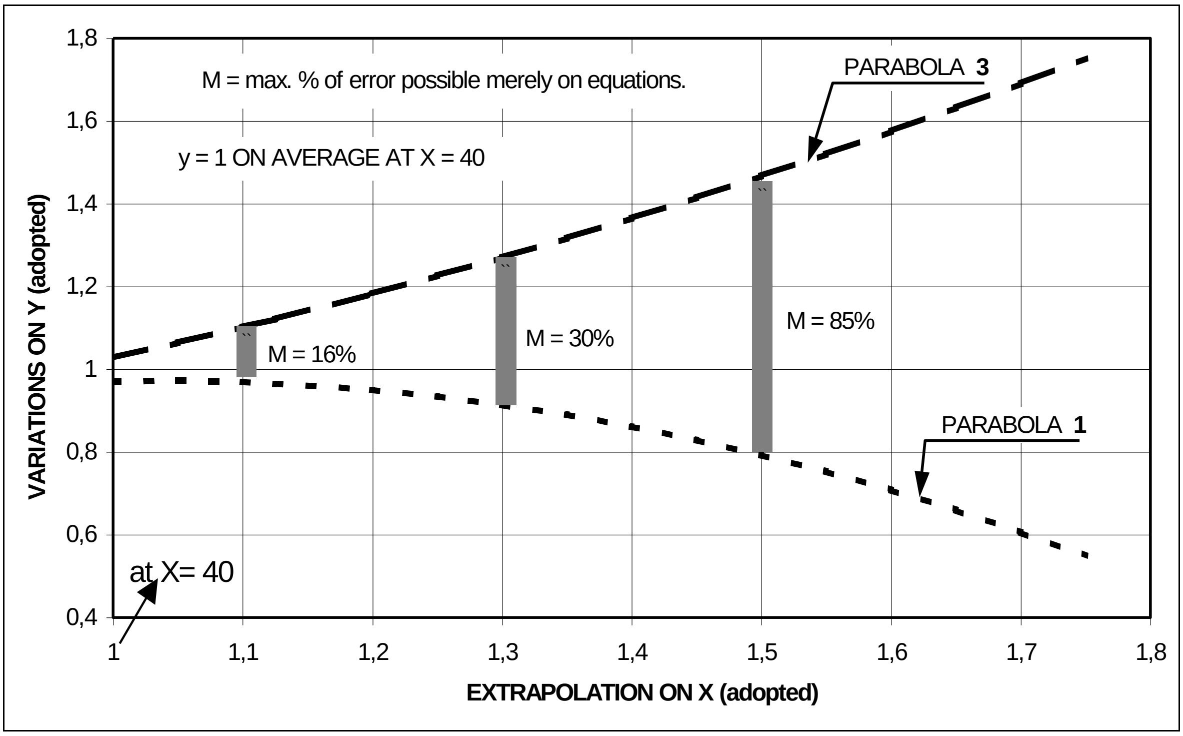


Fig. 2.5.2 – Errors possible on extending beyond data,

under exercised preference for parabola.

The demonstrations are thereupon extended. In Fig. 2.5.2 one signals the maximum % error of divergence, merely on the equations themselves, as they would result upon extrapolating the X value by 10%, 30% and 50% respectively, reaching digressions of 16%, 30% and 85% respectively.

Finally one should not fail to include the CIs on the equations, since engineering decisions are based on judicious maxima and minima. For ease of presentation and understanding one limits the analysis to CIs with reference to the 50% extrapolation, X=60. The results and ratified admonition speak for themselves, as shown on Fig. 2.5.3.

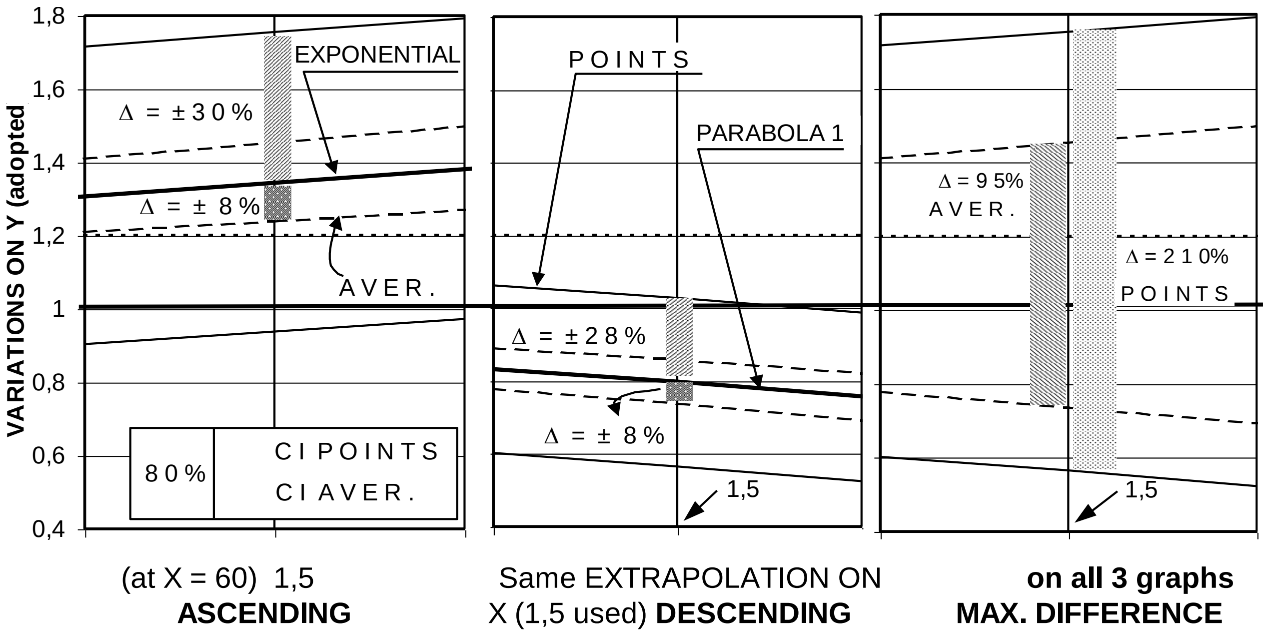


Fig. 2.5.3 – Added max. dispersions due to CIs (only 80% used) at 50% extrapolation on data-bank bound. Distancing trends as per Eq. 4, Fig. 5.1, ascent and Eq. 1, descent, both of frequent use.

Two basic rudimentary points of S and meaningful communicability of results to professionals and society merit being summarized. The **multiplying rule of probabilities** is the one most current. But one should mention the less commonly recognized **additive rule of probabilities** in simplified terms, because of the philosophical reflection that **everything interacts to some extent, nothing**

is absolutely independent. One can and has to adjust to prioritizations and one's prototype's realistic magnitudes. And special tests of theoretical S to prove or disprove auto-correlations etc... can be set aside. It is acceptably reasoned that there are many dominant scenarios essentially independent of each other, whereupon the probabilities are additive. For instance, if earth dams have shown applicable statistical probabilities for failures of 30% by overtopping, 20% by piping, and 10% by slope destabilizations, the global failure probability would be the sum 60%.

It will be noted in Fig. 2.5.3 that the CIs used are limited to 80%, which should be recognized as a realistic limiting precision for most single parameters of geotechnique. In anticipation of a later expatiation in the light of common society's requirements of much smaller percent probabilities of unsuccessful performance, such as 1:100 to 1:1000, one might forecast that the trend towards solving the problem should **look towards significant subdivisions of present conventional single complex parameters into many more integrating parameters, and thereupon to reach the low probabilities via the multiplicative rule**. Such a forecast points to the need of collective efforts along some progressive "schools of thinking and systematic research."

The second point is that for communication and leaving a mental imprint, percentage changes tend to be most useful. But for some design decisions which change by steps, it is quite as frequent that what matters is the difference in dimensional value. For instance, a 50% difference on a settlement of 2-4 cms may be quite irrelevant while a 20% difference on a settlement of 10 cm, or a 30% difference in a computed F (if realistic), may merit being alarming. It will be continuously important to choose judiciously between the one or the order depending on the relevance to the specific academic or professional problem.

2.6 Markedly Different Aims: "What is Predicted to Happen" vs. What is Aimed at "Not Being Allowed to Happen". [16]

Firstly it must be emphasized [17] that in real-life professional predictions, markedly as opposed to PPCs, one should aim at answering four questions: WHY, HOW, WHERE and WHEN would the undesirable behavior occur. A second fallacy of underlying misunderstanding that enters into the majority of the PPCs embodies forgetting that civil-geotechnical engineering is not based on "hitting on the fly", predicting exactly what shall happen, but rather to program probabilistically, by minimized causative agents As and maximized resisting REs, the controlling measures to implement the promotion of what is to be avoided happening (within minimized margins of error). However, for quite understandable historical reasons of SOIL MECHANICS, of deterministic calculation fed on clear cut idealizations, the pseudo-theories and PRESCRIPTIONS aim at calculating what shall happen. And therein lay (and mostly still lies) the most outstanding aberration of imagining a single deterministic "fly" in lieu of a histogram of intended equivalent flies: a histogram of predictions (virtual pseudo-designs) vs. a single deterministic coincidental result as hypothetical goal [18]. Assuming a perfectly uniform histogram, the performance result represents the median.

Moreover, undeniably the prediction of what should not be countenanced as having a higher-than-accepted HZ of happening will be progressively improved as one improves two components: (a) the PRE of defining the median's SR equation, and (b) the ACC tightening the respective CI. However, needless to stress that civil-geotechnical engineering is obliged to "experiment" with the prototype itself as sample, always somewhat singular, and of great responsibility: and that it is theoretically forbidden, by historical factors (tradition of Hamurabi code, etc…) both sociological and legal, to accept less than "absolute safety"[45], primarily abolishing physical ruin of patent or catastrophic collapse. And while failures have provided important qualitative scenarios for analyses and revisions, the fact is that the great accumulation of experience is on serviceability conditions. In this matter one must reflect that professional experience is gathered on global lumped-parameter performance appearances. The most common professional reality in the Offices is that the most experienced engineer (in a global problem) indicates a first set of parameters for use in the computer calculations along some idealization. Upon receiving the result brought by the junior colleague he doesn't hesitate to declare *"Oh! this cannot be it should not go beyond the band between x and y. Try changing the parameter M to 1.5 and/or 2 times"*. This surprises the diligent junior that judges it to be fudging. In truth, however, the fact is that one does not acquire experience in diverse parameters that enter into complex formulae, but yes in the global result that "bleeds, or steps on one's toe". Moreover, one does not acquire experience in numbers and graphs such as are presented almost exclusively: experience that leaves its imprint is of DIFFERENCES, relative to a nominal reference, either in percentages or in conditioning quantities [19].[46]

Having pinpointed the understandable impact of physical failure scenarios qualitatively, one cannot understate the ponderous trends towards collaterally generated effects rendering the great majority of routine projects progressively more expensive, representing a chronic failure,

[45] The closing sentence of Ref. 10 invites transcribing "geotechnical performance would be enhanced if geotechnical engineering shifted from the promise of certainty to the analysis of uncertainty".
[46] Thereupon the opposite tendency tends to grow, statistically prevailing, of the financial-economical ruin accompanying chronic prudence and over cost, itself also a failure in engineering, although not exposed to perception, except in the slow loss of competitiveness and quality of life of a society.

unperceiv(ed)(able) to the lay. Firstly since the definitions and quantifications of Failures are nowhere near easily analyzable, either as single cases or, much less, as statistical PDFs, the obligation of prudence leads to maximizing every component. Failures include also intolerable Serviceability Limits SLs, and are always unpredicted and backanalysed some time later under inescapable biases and limitations. Secondly it must be reminded [4b], [4d] that according to considerable testing of dominant human decision reactions there is a 70% greater tendency towards avoiding loss than to seeking gain: thereupon all concerns and doubts lead to progressively more conservative, expensive recommendations and practices.

The term PRE as expressing a ratio of 1.00 of predicted (or designed) values to the observed ones seems most appropriate. One could reason that if the desired prudence is already incorporated via Partial Fs of increased As and decreased REs (how evaluated?) the aim could be towards a minimal bias of PRE and a tight histogram of ACCs, but never ACC $\equiv$ 1.00. Correspondingly RELIABILITIES RELs would seem appropriate as qualitatively defined by the “percentage of cases for which the calculated (settlement) is greater than or equal to the measured” [11]: or, more generally, “the calculated behavior is worse than or equal to that fulfilled in the performance”. But, when moving to numerical values two points stand out as directly obvious[47]: the numbers on RELs should be moderately high (but not too high, to guard against unjustifiable overcosts) and, very fundamental, should not be permitted to have great erraticity, since what counts is the lower tail fractile, percentages of cases that could lead to unacceptable lack of prudence on RELs. The absence of the bases of SP reasoning permitted expressing, unqualifiedly and erroneously, for REL “a value approaching 100% represents the most desirable characteristics of reliability”[20].

When setting up, in the basic tests, the PPC results against their frustrating inferences, presumably as compared with sufficiently frequent repetitive professional realities, one will notice the bifurcation into two facets: on the one hand one will note the unfavorable tendency of investigating concomitantly some novel thesis of academic advance, as regards PRE, ACC, REL, etc, alongside with the TRUSTWORTHINESS of the experienced professional predictability of means and ends taken as already made available; this tendency goes grossly against the grain of scientific-technological investigation, which is to tackle a single parameter at each turn, all the

[47] Notwithstanding the advantage to SP analyses that settlements are dictated by CIs of means, there are serious further queries regarding the design PRESCRIPTIONS investigated such as, for instance, in the 76 cases of plate load tests[20]. Behaviors of buildings (our ultimate aims) are controlled by maximum settlements of bigger footings, but also by maximum distortions between maximized load-settlement cases and minimized cases of small loads-settlements, both under CIs of point values. The publication falls far short of opening any door to such indispensable queries and analyses.

others maintained constant. On the other side bearing in mind with repudiation the automatic and persistent tendency, hitherto absolutely unquestioned, to associate the extreme fractile results as indications for adoption of Fs, it is important that one correct this conceptual error. The doors opened were connected with FACTORS OF GUARANTEE FGs and FACTORS OF INSURANCE FIs [21] and consequent relations to Fs interpreted as attached to median probabilities since the PPC performance, inevitably affected by some PDF, has mostly been taken as deterministically established (single performance test). Besides the burdens of the very laborious and expensive PPC initiatives, the profession and Society tend to be burdened thereby and thereafter by more conservative and expensive projects.

To repeat the distancing of T. W. Lambe's Type A [REF] PPCs from experienced professional practice, the shocking factors are many:

(1) too much, and varied and novelty, data vs. too little and rough conventional data;

(2) meddling of futuristic academic pursuits with standard professional challenges;

(3) aim at PRE and ACC only, deterministic without CI, vs. professional reality of designing for maxima and minima, to optimize safety, cost, logistics;

(4) inevitable result of very scarce PDF density of results (analogous to virtual designs but not truly their equivalent) close to the proposed goal;

(5) failure to recognize the proposed goal itself as only "nominally definable";

(6) resulting misinterpretations and some misplaced frustrations despite mostly focusing on "idealized" soils;

(7) no quest of ACs tying past and present, and/or differentiated prescriptions and practices.

2.7 Continued Evaluation of Most PPCs as Regards Presumed or Possible Inferences Towards Design and Code Indications, and F Values.

Most of the PPCs have led to frustrating direct interpretations and consequent pessimisms. However they merit somewhat closer analyses from the professional point of view because of the praiseworthy enthusiasms and very significant expenses and investments dedicated, and the fact that a significant proportion of engineering works still depend on the subsoils and soil-based structures employed. The values inherited from primordial intuitions either regarding physical failure or SLs should therefore incorporate significant adjustments oriented from PPCs. On the contrary in many a field such as that of heavy foundations, wherein the principal conditioning factor is not Nature's softer and erratic conditions but the applied strongly dominant constructed element, the industrial advances of equipment, materials and savings have been so outstanding as to compensate the disparaging revelations, by an attitude of dispensing with closer concerns through increased robustness at modest incremental cost. The principal factors forcing concern are the disproportionately great number of poorly investigated and managed cases, and the fact that many a construction procedure goes through some inexorable transient "installation conditions" taxing the soil to near-failure states analogous to the so-called "stand-up time". In short, despite the vastly improved construction abilities at reduced costs, the need persists to progressively evaluate-improve-reevaluate the capacities of the profession to predict at optimized conditions and minimized costs.

In short, very many have been the successive PPCs on a vast range of different prototype-scale problems, during the past 30 years, following the ad vocation of Type A Predictions [REF]. Besides the general conclusions to be drawn on many a query regarding their purposes, conducts and published conclusions, as will be successively commented in the Prefaces to the pertinent chapters, the limited repetitive conditions that merit emphasis in this Appendix are that;

1) There is a significant growing awareness that they have to be judged on the basis of SPs regarding HZs and RKs.

2) The most typical results representing the various predictions tend to yield PDFs varying widely between values of about 1/3 and 3 times the subsequently determined PERFORMANCE PERF. However, there is a marked dominance (about 60 to 70%) of pessimists, a modest fractile (about 25%) of optimists some unacceptably high and a near void (about 12%) in the central range of results within ± 20% of the real one (cf. Fig. 2.6.1). The capacity of foolhardiness to err can be great, while there is somewhat of a natural limit to pessimisms before the project is abandoned or transferred to other designers. Some prudence bias on PRE seems habitual.

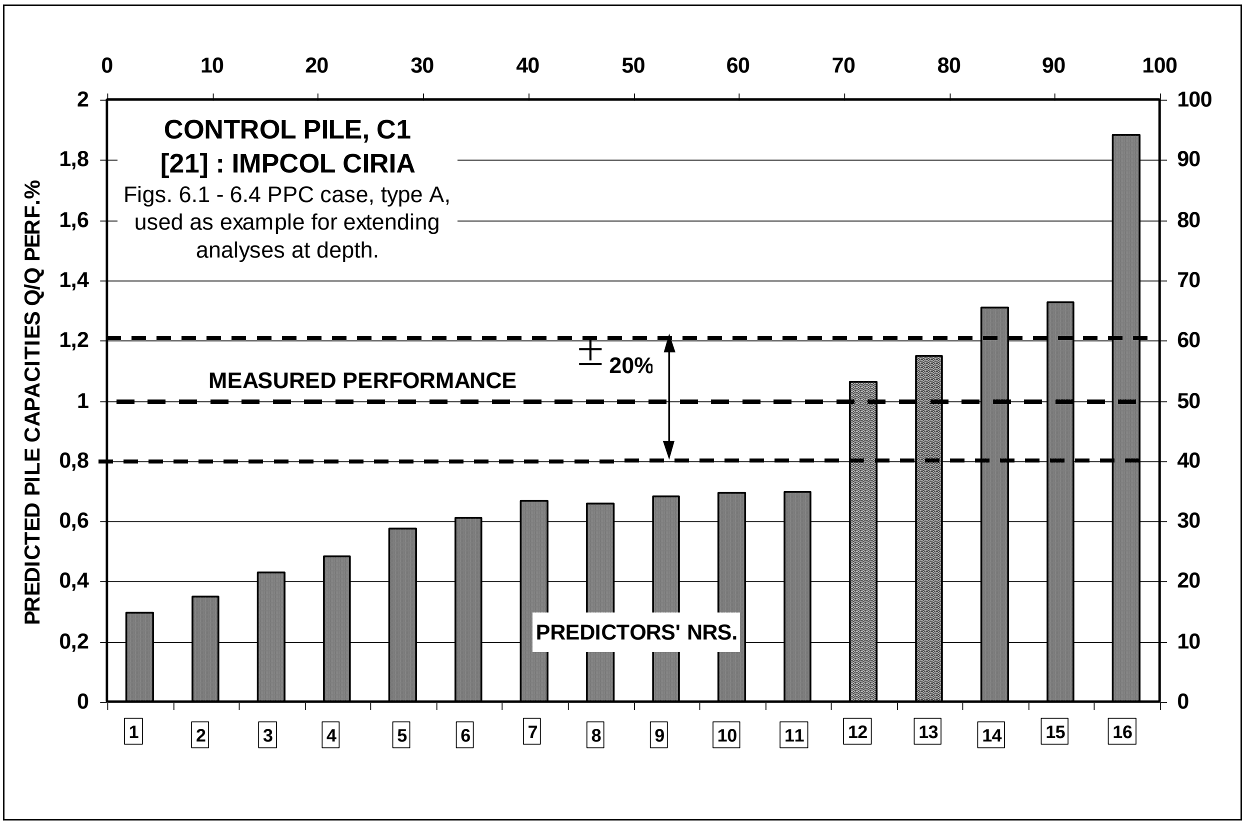


Fig. 2.6.1 – Histogram of PREDICTIONS (PREDs) submitted, on PPC.

3) Several serious pertinent criticisms have been leveled regarding most Type A PPCs, and even Type B ones (extrapolating during an on-going construction) unless specially programmed as expatiated further down. What has been missing to the profession almost systematically is that at each instance when some mentor freely proposed a new method there have been no comparative confirmations of (a) reproducibility (repeatability) of results (b) statistical improvements on the prior prescription (c) which are the critically dominant parameters to the prototypes as they vary in specific data or levels thereof. Upon detained consideration it is emphasized that the most significant and fertile PPCs should **result from well-anonymized repeated challenges of the Type C, autopsial ones, on real frequent-enough professional cases, sufficiently masked on secondary details to avoid any possible identification**. The repeatability as affected by subjective or new influences is important, and about 10 to 15 repetitions would yield minimal meaningful statistical analyses at zero incremental cost.

The above frustrating failures and privations have induced some of the very important Prestige Lecturers of late [REFs] to direct attention to Risk Management [REF], and to Errors as a principal factor, therein including the misplacements of theories and practices as well as individual human errors.[48]

2.7.1 Reanalysing a PPC as if Predictions ≡ Virtual Design Aims (Without Responsibility) and Performance ≡ Deterministic Correct Value.

The case of the very special IMPCOL-CIRIA PPC of 1999 is summarized in Figs. 6 for use[49] towards putting forth some additional basic arguments and recommendations, picked out from many a publication and pieced together to favour the desired rationalization and efficiency in extracting the simplest uses of SP towards renewed bases for integrated geotechnical methodologies.

In principle one always deals with two PDFs, one of actions As and the other of reactions REs, and in design intents one has to aim at a pair of fractile positions, one on each curve, such that RE = (F)A. Fig. 2.6.1 represents schematically the nominal bar-diagram PDF on the IMPCOL-CIRIA [REF] predictors' results, taken merely as representing hypothetically the RE curve. Since (when) there is a single PERF determined, by default presumed deterministically accurate, the statistical universe of PERF results is assumed perfectly uniform and the PRE + ACC A value would be the median. In practical reality for developing one's reasoning one should have a real, or nominal, A histogram of different median, standard deviation, and details representing the variable As. In the case of nominal PDFs the position and characteristics have to be judiciously inserted, as is exemplified in Figs. 2.7.1.1 through 2.7.1.3.

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[48] Attention is drawn to several important voicings [REF] that have appropriately emphasized the disparaging cost overruns. One of the increasingly prevalent management errors is minimizing investigation costs (really investments) as percentages of fixed tender costs. Consequently there has been a perceptible relation of job cost overruns as associated with tightening of investigations, proportionally paltry. However, in the cases of the PPCs the inverse seems to prevail, which rather indicates unfavourable consequences of increasingly varied procedures predicated, lacking controlled SP comparisons regarding applicabilities to prematurely generalized conditions. The caveat should therefore be amended to include the qualification of known, proven pertinent investigations as regards the insufficiency that leads to cost overruns. Further emphasis must be allocated to the fact that the author merely focuses on a one-sided negative view assuming hypothetical deterministic costs attributed to the Project. The great positive contributions of good investigation and design should generally be the global reduction of total costs, including the savings by bettered design and reduction of RK in operational life.

[49] With due excuses because of the very many other concomitant points at stake.

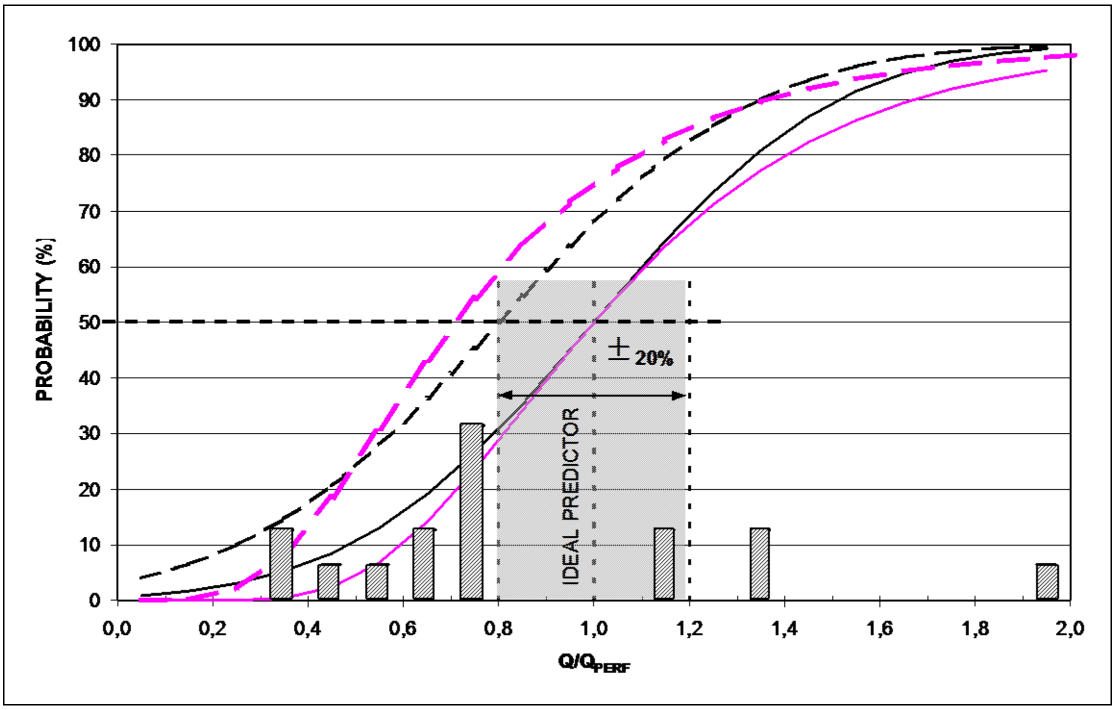

Fig. 2.7.1.1 – Most current PDFs applied to bar-diagram Ps of (PRED / PERF) Qs.

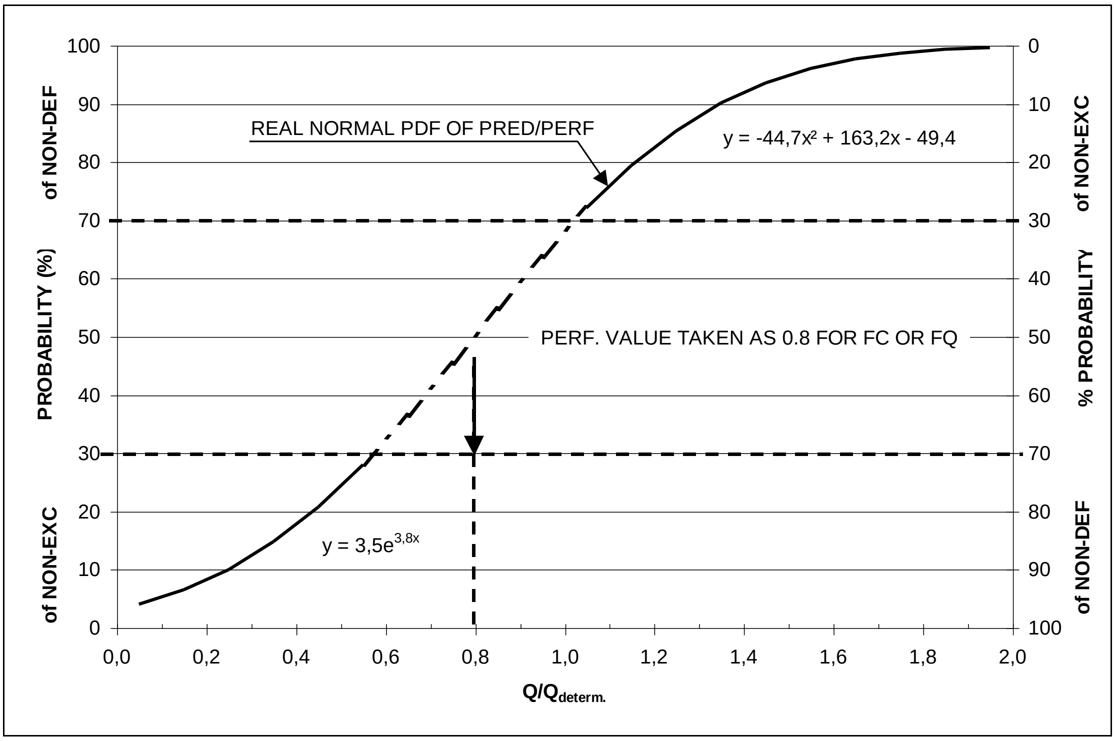

Fig. 2.7.1.2 – Regressions of upper and lower stretches of one PDF of Fig. 6.2.

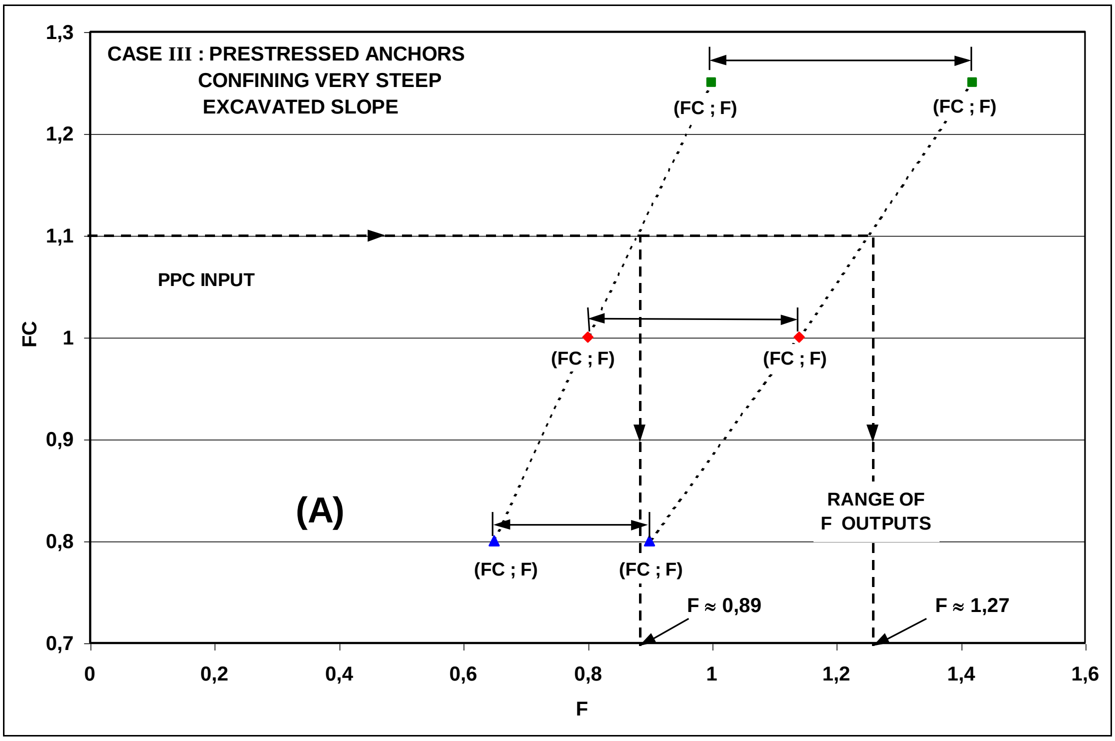

Fig. 2.7.1.3 (A) – Const. A assumed: PPC input to F (output range).

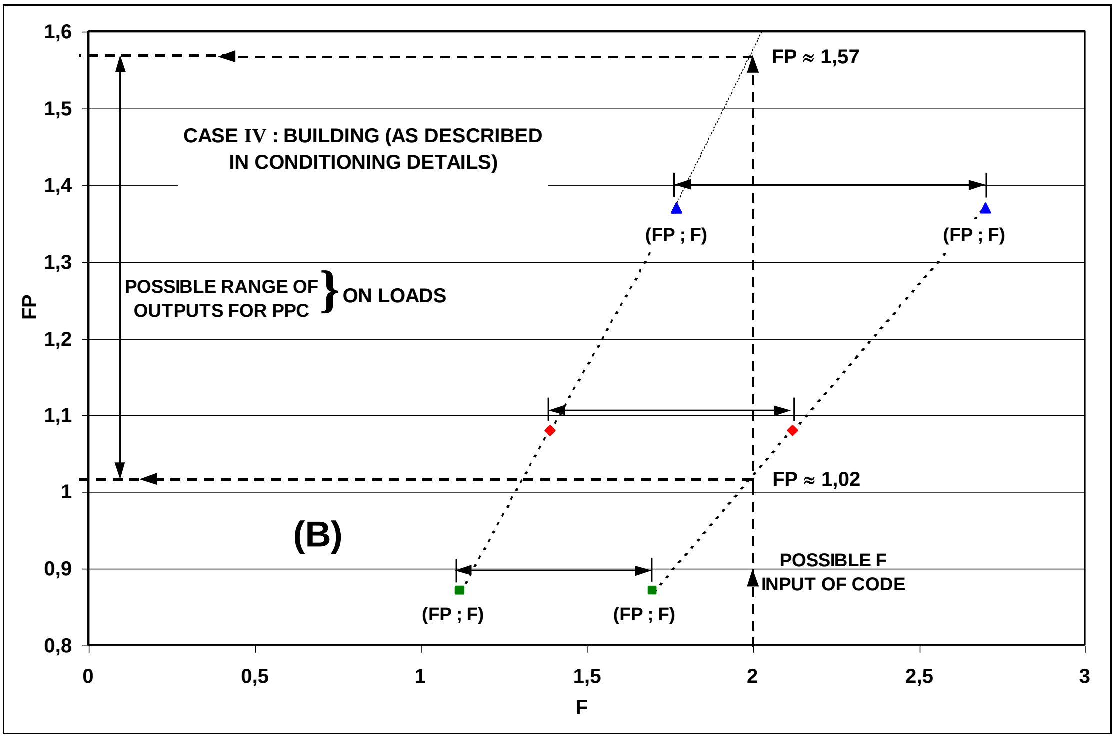

Fig. 2.7.1.3 (B) – Fixed CODE input F → wide FP range output.

From the results of the said PPC there have been published conclusions [REF] emphasizing the frustrating evidences that (a) the F values determined ranged disparagingly between about $^1/_2$ (the great number of pessimists) and 2 (the few super-optimists) (b) there was a near-vacuum of vindicating results within a range of about $\pm$20% around the established value. The entire subject merits earnest reconsiderations.

Firstly, in Fig. 2.7.1.1 one applies to a bar-diagram of grouped predictions the PDFs most frequently cited as being found applicable to geotechnical parameters, the Normal and Lognormal[50], the first reckoned as more applicable when factors are additive, and the second when multiplicative (Ref. Cornell). Their medians are found to lie at around 0.8 and 0.7 ratios of Qs (PRED / PERF). Next, as posited, for a single value of PERF determined, one transfers both the PDFs to the idealized position passing through the median, 50% P at ratio 1.0 of Qs. The transfer distance between the real and idealized PDFs serves principally to expose the hypothetical prudence bias of about 20 to 30%, for uniform PRE + ACC PERF at the determined value.

Next one moves to expatiating on the example by moving to Fig. 2.7.1.2, intended to concentrate on regressions for the top and bottom fractiles. For simplicity and clarity a single PDF of Fig. 2.7.1.1 is employed. One needs no explanation regarding the interchangeable NON-EXCEEDING NON-EXC vs. NON-DEFAULTING NON-DEF ordinates, depending on the problem and calculation judiciously faced, and its design criteria.

Firstly one must again emphasize, and definitely consider it established beyond doubt or discussion that in civil-geotechnical engineering one should not be interested in equations that purport to define adequately the entire range of the behaviors in question, such as the stress-strain equation (CON EQs[51]) or the global PDF. **Progressive phenomena keep varying continually with regard to priorities and proportional participations, and it is at the top and bottom "end fractiles" that the definitions of the curves become most variable and erratic**. The tops and bottoms are of priority interests because designs are based on maxima or minima, one needs high or low probabilities of values not being exceeded or not defaulting, depending on what cases and conditions are under consideration. It is at the bottoms or tops that conditions are least known (e.g. initial stresses, installation effects, etc, and at the other extreme, the rapid changes through increasing deformabilities towards plastifications and failures). Moreover it is at the extremes that

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[50] According to [REF] the Normal prevails when phenomena incorporate additive/subtractive participations, whereas the Lognormal fits better when participations are multiplicative.

[51] Note, in due place the dismal frustrations reflected in International Workshops on CON EQS, Mexico 1969 (III) and McGill-ASCE (IV).

there are the least number of data. Finally, one's principle is irrevocably affirmed that for many a cogent reason, including the long-yearned symbiosis between the OM procedures and progressive adjustments, there can only be reasonable support of SP in short extensions of optimized regressions of ample data, to be readjusted stepwise by Bayesian reasoning, and significantly revised computational procedures thereto, accompanying the progressive input data.

Regarding the greatly different rigidities (e.g. 5 to 10 times higher) at the small strain levels (of the order of 0.1%) that dictate the bottom fractiles of most modern projects of ponderous responsibility, it is important to reflect on the multitudes of tests of the past 15 years, stimulated by seismic liquefaction studies, run with sensitive sensors. These great differentiations were eloquently focused by the phrase "Small is beautiful" (Ref Burland) and are widely published, discrediting all conventional tests in an order of magnitude (without mention of installation and handling disturbances) (e.g. Ref.VM).

As mentioned, each type of problem will have to be judged with regard to the likely regressions or estimated curves to be attributed to As and REs, and for NON-EXC vs. NON-DEF. There are natural tendencies for greater numbers of pessimisms, but lying on a flatter curve, because there is a limit to pessimism before the project is turned over to a competitor. There is, however an astounding difficulty of limiting erroneous and spurious optimisms, including human errors (10).

Since the PPC's data are being used as herein derived, but for a purely nominal condition, based on the above multiple arguments one chooses to concentrate on appropriate regression equations in the 5 to 30% and 70 to 95% probability ranges, simplifiedly dualistic of As and REs.

In some past publications [REFs] one had postulated the interest in defining, besides the conventional F, two other factors, the FG, and FI on the basis of different positions of the possible histograms towards representing different degrees of assurances in construction conditions. For instance, driven piles could be considered pre-tested not to risk lower results than as established by a histogram corresponding conceptually to the automatic control of every single pile not to default on a satisfying driving "set" or better. Meanwhile the common unsophisticated bored piles, oriented only by nearby boring profiles, but subject to damaging installation effects, would forecast a significantly lower and wider histogram of possible allowable loads especially if principally dependent on base resistances. These clearly different histograms were defined as pertaining to the Factors (1) FG, and (2) FI. Correspondingly Design (or Code) requirements should recognize the reality of differentiated HZs since there would be a systematic displacement to the left (lower allowable loads) with FG $>$ F $>$ FI, the common F condition being implicitly associated with an intermediate conventional condition, neither of more guaranteed non-defaulting nor of greater innate risk of construction deteriorations.

The above suggestions have not yet merited implementation with the necessary quantified histograms of load tests: thereupon one herein sets them aside.

Two slightly different factors the FACTORS OF CONFIDENCE FCs and OF PRECAUTION FPs are presently posited on the basis of the more frequent comparisons of F values with reference to single or scant factual (e.g. load test) data.[52]

In point of fact however, in the PPC one does not really know the fractile position of the established performance result, whether it was a 30%, 50%, or 90% P of NON-EXC, or p%, q%, r% P of NON-DEF. All that one knows is that it is a fixed observed deterministic value, and one is obviously induced into taking it as pertaining to the median P.

The established definition of Factor of Safety F recognizes the probabilistic variabilities of both the numerator and denominator, $F = RE \pm \delta_R / A \pm \delta_A$. Note that it is subconsciously and simplistically **assumed there are no other more appropriate regression equations and/or further/graver dispersions in the direct linear ratio automatically adopted from stability analysis** theories and procedures. Thereupon one posits herein that in some cases of professional practice, and also in some PPCs, the fixed (known, established) numerator or denominator permit one to name the two other Factors of minimally more likely applicability, as the

$$FC = \frac{RE \pm \delta_{RE}}{A} \quad \text{and} \quad FP = \frac{RE}{A \pm \delta_A}$$ [53]

Some examples must be brought forward for clarity. Moreover, the question of high or low probabilities to be considered, of NON-EXC of As or NON-DEF of REs must also be expatiated via typical professional examples.

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[52] In reality the idealized simplest constant ratio should be rare in Nature. For instance, in geotechnique's slope stability theories the strength equation is divided by a constant mobilized F. In Rock Mechanics one realistically adopts a much higher $3 \le F_c \le 5$ for the cohesion intercept than for the $\tan\varphi$ contribution $1.2 \le F\varphi \le 1.4$, because of the very much smaller ACC of the cohesion parameter ((ref. Manuel Rocha), Real conditions would even abandon unnecessary linearity, reverting to regressions.

[53] By the multiplicative rule, the functions attributed to the denominators must be used in the respective inverse functions.

The final aim is to propose for design criteria the F values to be required, but duly recognizing the cases in which they may in reality justifiably "collapse" into FP or FC conditions on considering the dominant likely dispersions, with reference to a single expensive PERF test value. And therefore, in the inverse condition, if interpreted from PPCs as FC or FP values to orient readjusting F recommendations for future analogous cases, the relations between FC and FP as inputs, for Fs as outputs, must be deduced by SPs.

2.7.2 Idealized Professional Cases Analyzed Using Non-Exc / Non-Def Regressions from Fig. 2.6.1.

The following common professional cases are summarized for exemplified clarification.

(I) The case of a steel oil tank (e.g. 42 m. diameter, 10-12 m high) supported on saturated clay is conspicuously a case of fixed A, soft load[54] well defined, about 98% liquid pressure-loading applied rapidly in test filling. A low (say 5%) probability of NON-EXC of loading should be sufficient. But, considering the HZ and RK, in the Design criteria of codes a high P (e.g. 70-95%) of NON-DEF of RE (with variabilities calculated as to possible incremental consequence) should be recommended: there is a really great possible dispersion on RE because of the scale-effect, the questionable strength profiling, and the highly questionable stress-strain distribution along the LIMIT EQUILIBRIUM METHOD LEM destabilization calculation. Considering the apparently ample data-base (of Fig. 3 [REF], and increased since) of small to medium dimensions of load tests and test fills on s = (c, $\varphi = 0^0$) conditions, the principal variabilities affecting the RE should be on the field and laboratory test results, the debatable (but most often adopted without queries) applicable c value depending on sampling and testing adulterations, and the great and variable effects of scale. Geomorphological considerations would often suggest adoption of CIs on averages, but, as revealed by Scandinavian quick clays, geochemical effects may impose dramatic changes of SENSITIVITIES St [I] and recourse to CIs on points. At any rate, since the effects of damaging the in-situ c values prevail in essentially all tests, the adoption of low or averaged-median values of c should find little support.[55] Moreover, there are greatly varied schools of teaching, thought and practice regarding applicable c profiles, when advancing

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[54] a denomination put forth by Rock Mechanics for dams, being a load that does not depend on, or alter with deformations, even very large ones.

[55] The topic belongs in the appropriate chapter of Vol. I for due expatiation: regarding the crucial problems of sampling and testing qualities and stress-strain-strength dispersions. Moreover, it inevitably incorporates also

from the primordial BOUNDARY condition of Fig. 1 and subsequent PRESCRIPTIONS. At any rate, A is “known, defined”. In moving from the project feasibility stage to basic (bid) design, to final executive design, one may postulate progressively decreasing variations from 10 to 5 to 0% prudently higher on the fixed A value. These are not 10% and 5% variability ranges on Ps they are ever-present decisions from “experience”. In any case, the A will be taken as defined, and thereupon there is a perfect numerical coincidence between the failure PERF value of FC and the extractable F indication. The obligatory expectation of high indeterminancy of the RE probability of NON-DEF suggested the use of the regression on the 70%, 85% and 95% P fractile stretch. Thus, although FC = F, the difference of purposes (a) performance achieved in a PPC, FC, and (b) design F recommendations for future analogous projects, may be tabulated as follows:

FC	% Prob. 70%	85%	95%
1,97	$2 < F < 3$		
1,29		$1{,}3 < F < 4{,}3$	
1,0			$1{,}0 < F < 5{,}5$

These interpretable conclusions on F for future analogous designs might thus be concluded more appropriately to represent higher needed values and covering surprisingly wide ranges.

(II) For embankments on soft saturated clays, cases of shallow loose end-dumped advances of the fill still involve a soft load, but the dispersion on A may well reach ± 15%. REs also variable.

In the cases of higher embankments that after having spread a minimum thickness of loose pad for trafficability proceed the raising by compacted lifts, conditions change considerably. The loading ceases to be a soft load, some stress-strain redistributions and involvement of the compacted fill strength interfere, and evaluations of dispersions on A may well exceed 30 to 40%. Meanwhile the dominant high HZ probabilities continue to be on REs.

The very many cases of embankments on soft clays merit qualitative mention. They do not fit into either category, FC or FP, and almost never have been documented sufficiently for

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expatiations in specific chapters of Vols. II and III depending on judicious interpretations of the hypotheses implicit in the classical analyses, mostly adopting unrealistic single-value strains simultaneously mobilized.

improved SP conclusions on the varied range of F conditions. Countless test fills have been performed, but knowledge on HZs does not seem have advanced noticeably.

The dispersions affecting the REs are not too different, and might lend the impression of being dominant, leading closer to FC conditions: on the one hand the subsoil strength profiling would generally provide greater HZs (at surface and softer) but the reduced HZs associated with scale (mentioned for the tank) should compensate by the narrower width of advance of the end-dozed first fill for trafficability. However, after establishment of this base, usually highly draining by absorption, much depends on the subsequent raising by moderately compacted lifts with their stress-strain mobilizable strengths. Thus the loading As should also be subject to significant variability HZs, thereby leading the problem into the conventional F conditions within a very wide spectrum. One should not wonder, therefore, at the multitudes of localized failures that continue to abound despite the countless test embankments performed and analyzed. It might be one of the cases for which the modest benefit/cost ratio of additional prior test embankments (e.g. in access roads), always poorly documented in terms of SPs, should justify their being dispensed except in rather special cases and conditions.

(III) Idealized conditions of REs essentially definite and known, resulting in FP inputs.

For very steep slopes relying almost totally on tiebacks for the supporting REs, one begins by neglecting second-order variabilities of the soil's complementary RE on the prospective sliding surface, predictably involving a narrow wedge under these conditions. Moreover this idealization is not unreasonable because of marked predominance of the tieback RE employed for minimized deformation. Finally it is done herein for the sake of additionally clarifying by maximizing differentiations of conceptual conditions. Incidentally, it should be reminded that a significant differentiation would incur in a near-similar reinforcement, by departing from the really “fixed” dominant REs of pre-stressed anchors, periodically adjustable to compensate creep, and substituting it by mere “bolts” much more variable and not adjustable.

In short, having exemplified two extreme cases (tank and anchors) involving admissible knowledge of the As, together with maximized concerns on the CIs of the respective REs, for reaching inputs of FPs towards inferable ranges of Fs, the present case is structured to yield inputs of FCs for the range of outputs of the Fs. The results of the two cases, III and IV are summarized in Figs. 2.7.1.3 (A) and (B). For due comparisons the same regressions are used throughout.

In Figs. 2.7.1.3 (A) and (B) one indicates the dual possibility of entering with a PPC input and abutting in a range of F outputs, and vice versa, of the range of possible PPC outputs that can be produced by an F value prescribed by a misjudged design criterion input. The wide variations have been elaborated on purpose for emphasized exemplification throughout. The middle band in Fig. 2.7.1.2, involved in PRE + ACC as the goal and conceptually representing better the central PDF fractiles, was left blank from roughly 30 to 70% P (alterable judiciously). Recognized professional practice narrows this stretch. It is noticeable also that such a wide blank weakens an important part of the representative transition, important for the OM, revealingly from excessive pessimism (safety) towards transposing SLs. The profession's reality is that theories and prescriptions preferred mostly some prudence bias for PRE + ACC.

(IV) For cases of modest high rise buildings on areas of dimensions noticeably smaller than the height, the A-values of nominal starting loads of columns are greatly different: in Brazil's most frequent reinforced concrete buildings, of about 85% dead loads, the ratios of maximum to minimum totals reach about 8 to 10 whereupon the typical footing dimensions would reach proportions of $\sqrt{8 to 10}$, about 3 times, for scale effects. However due to building-rigidity redistributions the differences naturally decrease with differential deformations. Since the worst effects on performance derive from distortions of differential settlements, the Engineer's directive of prudent fear should be towards assuming a % increase on the high nominal loads or corresponding settlements, causative factors, and a % decrease for the lower predictable resulting settlement cases. However, the redistributions normally revert the trend, with some penalty of possible fissuring. Thus in principle, more than one condition of variabilities on As (up to four)should be evaluated, judiciously, (One sample case is expatiated in the present item 2.7.2).

Once again the clear distinction of purposes of PRE + ACC in PPCs and of design PRESCRIPTIONS can be exemplified. One must repeat that many factors intervene inevitably in changing the trends in different cases, and disregarding them can only signify employing exaggerated umbrella or belt-and-suspenders solutions. For instance: it is assumed that a constant design ("allowable") bearing pressure is used for all footings as has become routine; the available load test data-bank would not cover higher buildings requiring footings of much wider dimensions; cases of steel-structured buildings with significantly higher percentages of live/dead loads will require changes, as will also the susceptibilities of expensive finishes to the residual differential deformations that wring first damages on them; so will also buildings substituting brick wall panels that contribute considerably to rigidity, by glass or other flimsy facades; many a special building's architecture and structure change radically the range of column load values and differences initially posited; and so on, and so forth.

To get back to the case. Since the live loads are essentially irrelevant, as a first exercise one assumes that for each footing the RE (conditioned not to load, as stress, but to settlement's SLs) may be reasonably knowable and known, fixed, insofar as the footing dimensions and pressures lie within the known universe of load tests, scale-effects adopted as subject to routine evaluations. The net result for designs therefore comprises comparing the probabilities of big, average, and small footings neighbouring the other extreme, leading to maximized differential settlements. However, there results from the distortion redistributions (a) very little reduction in the highly loaded column and (b) great increases in the nearby lightly loaded columns.

The possible combinations are many, but true to the aim of simplified exemplification, and to the principles that one decides on maxima and minima, one abandons the average footings and assumes a reasonable vicinity of small and big footings to maximize estimated distortions.

Biding by engineering practice of never limiting an investigation to less than three points, the graphs of Figs. 2.7.1.3 (A) and (B) have been so prepared and give an impression of near linearity because of many factors maintained constant in the idealized exemplifying computations. The CASE III graph Fig. 2.7.1.3 (A) shows a possible PPC input leading to orientation for future designs: with the PERF result at FC = 1.1 it would lead to a recommendation of not less than F = 1.3. Meanwhile the CASE IV Fig. 2.7.1.3 (B) exemplifies an opposite condition, such as entering with calculations resulting from an F = 2 (established, for instance, by some CODE or generalized professional practice): the consequent possible range of outputs in a PPC could vary between $1.02 \leq FP \leq 1.7$.

Needless to say the input and output conditions are reversible in either graph, their separation having been adopted merely for avoiding confusions in graphs too densely filled.

2.7.3 Dire Consequences of Astounding Overdesign in Repetitive Professional Research/Design Cysts.

It is indispensable to illustrate emphatically that we always deal with a serious lack of real data, filled in by hypotheses mostly unmentioned and unsuspected. The example of item 2.7.1 lacked realism because of misdirected aim, itself posited as fixed deterministic, alongside with virtual “designs” (really PREDs), with no responsibility and engaging the highest updated levels of participants. Depending on lacking access to bibliography with earnestly exposing discussion, the biases, side-trackings and degenerations really cause unbelievable regional aberrations: they seem caused by the cauldron of lessons, however well-intended, specifically historic over lived on the one hand, and regional unprecisely characterized on the other, that descended into and crystallized in common teaching and professional practice. The present intent is to revert to real foundation design conditions, and to offer an example, possibly extreme, of the extent to which such marked branchings can have occurred therein, even while fostered by extended and intensive cooperation between local academia and practicing professionals. Chaos unrecognized pervades between continents, countries, nearby regions of same countries, and even distinct nuclei of academia and their credulous specialist professionals, and it constitutes a main cause of bifurcated amplified trends towards anticipated HZs and mostly over costs, calling for exposure. The case concerns a vast geologic region of residual very unsaturated upper horizons of fine uniform sands with only about 10 – 15% cementitious ferric clay. Various types of perforated piles and piers[56] have been used with ease through upper collapsible soils of linearly increasing SPT and CPT values, and entering a meter or two into a very dense base layer of $20 \leq SPT \leq 40$. Many hundreds of 12 to 25 floor rigid-block buildings of reinforced concrete structures with brick walls have been built to full technical satisfaction under easy foundation and superstructure routines. Because of encompassing about 80% of local practice through more than 15 years, the many simple practical options of pile and pier foundations enticed a call for foundation research and ratification, dictated by the premise of deterministic column loads, which thus became one (usual) critical void[57] in thorough RE = f(A) performance fulfillment. The uniformed quest thus aimed at possible suspects in Ps of variable foundation performances and consequent foundation-structure interaction load-settlement redistributions. The cases of at least three buildings, of 12, 13 and 14

[56] And even cast-in-place concrete elements in driven perforations produced by dry pounding weights displacing the porous soil outward.

[57] In analogy it might be recalled that for initial PRESCRIPTIONS (pre-1948, e.g. Terzaghi-Peck) column loadings of high-rise buildings were estimated, and since then with only a couple of recent very notable exceptions of real measurements, the revised prescriptions were based on loads calculated by structural engineers, almost generally dispensing redistributions because of distortions.

floors have been published in Proceedings of International Conferences [REFs]. In all three cases the varying PERF loads were taken as the dead loads corresponding to the numbers of floors, and using as proportions of dead to dead-plus-live nominal loads the routine proportion of the order of 83 to 87%, average 85%, given by the structural engineer; i.e. the As adopted without query or validation. The latest case attracted attention by the graph of PRED/PERF ratios of settlements shown in Fig. 2.7.3.1 (A) and (B) (rearranged compacting therein other Figs. of the publication).

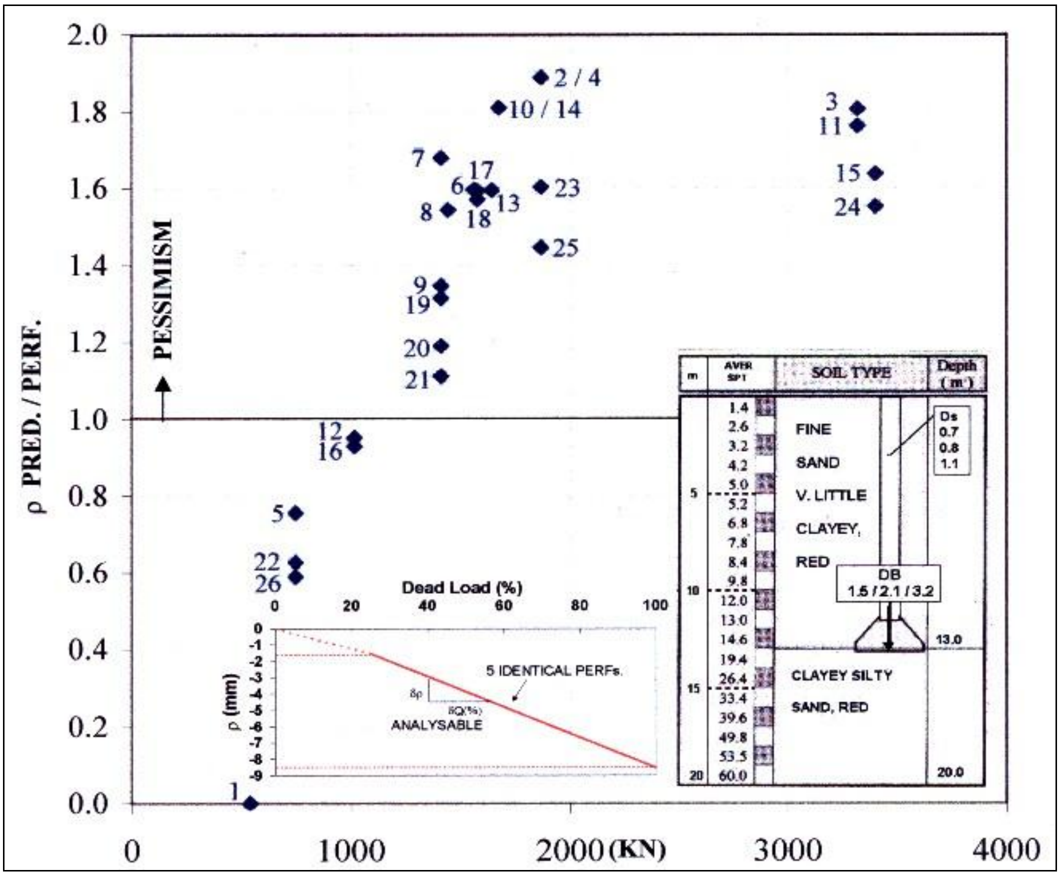


Fig. 2.7.3.1. (A) – Basic published data, design, PRED / PERFs calculated, and $\Delta\rho/\Delta Q$ monitored.

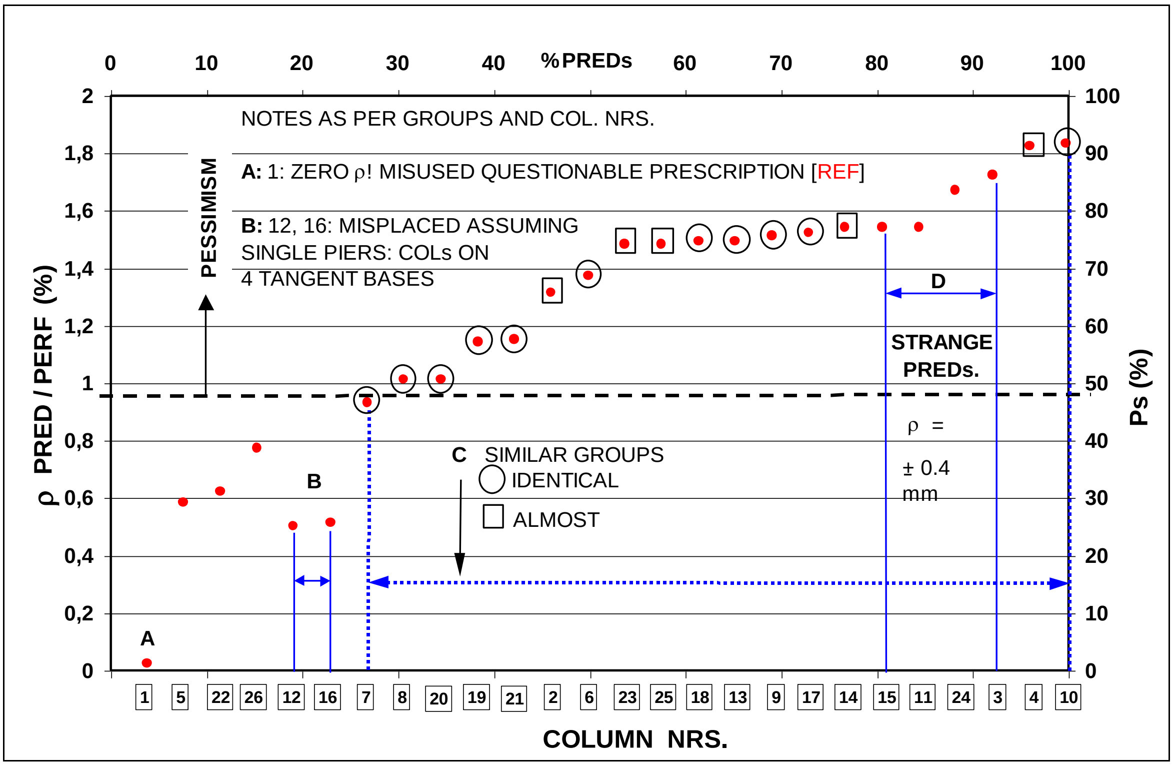


Fig. 2.7.3.2 (B) – Confirmation of overdesigns, comments, queries. Incredible conservatism.

Cursory examination of the references quoted confirm that complete conventional laboratory test investigations had been conducted employing a 20m deep self-stable pit with undisturbed block samples. One notes that no stress-strain curves are given[58]: more notably as a dearth for shaft lateral frictions, no direct shear tests were run, with their shear-displacement indications[59]. The building lot itself averaged results of 5 SPT borings, all similar.

Attention was attracted directly to the data of PDF of PRED/PERF ratios repeating essentially the conclusion of the inevitable trend exposed in Fig. 2.6.1, as summarized in Fig. 2.7.3.1 (B), with a high proportion of pessimistic ratios higher than 1, up to about 2. The presenting of this case thus appeared justified by fulfilling the first intent of confirming the widespread built-up trend towards overdesign[60], even incredible.

58 A regrettable generalized dearth in the past score of years.

59 In the light of the posited starting reactive participation of the shaft lateral friction, this factor became the second critical vacuum for the desired thorough analysis.

60 It must further be noted that in none of the publications that offered revisions on the limiting total and differential settlements did the data-base include any PRED/PERF considerations in terms of Ps, because they were all based on the effects, estimated or measured settlements. Meyerhof, 1965, [REF], quoted in the paper under scrutiny) in his timid proposal of increasing Terzaghi-Peck's recommended allowable pressures on shallow footings by 50% without undesirable effects, pioneeringly postulated anticipating (purely based on the

On second view of Fig. 2.7.3.1 (B) and correlated data analysis one perceived three points of curiosity:

(a) among the lowest loads, corner columns 1, 5, 22, 26 the first one is recorded as having predicted a zero settlement, while the other three were the only ones with optimistic ratios of 0.6 to 0.8. How could there be any prediction of zero settlement?

(b) a significant group of columns with same loads of about 1400kN and same pier designs gave pessimistic PRED/PERF ratios, but with a broad variation, almost between 1.0 and 1.8, almost the maximum range.

(c) thirdly, a group of four heavy columns of about double the load of the central group appeared significantly detached from the overall trend, a success possibly attachable to the bigger diameters of shaft and belled base of the piers.

These questions, crucial in principle, suggested investigating the possible causes in suspected differentiations within the calculations: and the approach seemed indicated of analyzing the linear stretch of the graphs of % Q vs. ρ mm, after firstly interpreting the frequently occurring "initial adulterations", such as recorded, of a flatter slope up to 1.5mm up to 30% total "real" load (calculated dead load). At measured settlements so minute, and checking against prior theses and publications of the regional group one recalled possible minute textbook details instilled in design practices:

1) the pre-monitoring starting net pressure increase, acting on base and shaft lateral stress due to the increased unit weight of soil to concrete of about 0.6 t/m^3;

2) designer's oblivion of the weight of the transition blocks pier-to-column;

3) some collapsivity due to excess water ceded by the concrete to the soil annulus;

4) the self-supporting soil-wall face starting with zero lateral pressure;

5) the opposing hypotheses on lateral friction development;

"experienced feel") ratios of 0.8 to 2.0 in the consequent PRED/PERF settlements. A surprising numerical coincidence with the great prevalence of pessimisms summarized herein.

5.1) historically inexorable adopted zero in the compressed-air caissons descending under self-weight of heavy reinforced-concrete rings;

5.2) the lateral friction being absorbed first, totally if the required shear displacement is forgotten or neglected, as occurs frequently. The concept of extracting lateral friction values from CONE PENETRATION TESTS CPTs misguided a school of thought in many points; among them the serious slip regarding the fact that there cannot be a stress without a deformation, whereupon an impossible zero displacement/stress behavior became attached to lateral friction.

All such hypotheses had to be abandoned, and really do not pertain to this APPENDIX on SP except in as far as to emphasize again that applications of SPs cannot be faced as numerical without good understanding of the dominant professional phenomena. On closer query it was confirmed that the shaft PERF PRED had been guided by a sequence of PRESCRIPTIONS from an important mentor (and subsequent school of investigations and publications, (Refs Kulhawy etc... Deep foundations 2002) that entered the analysis via a posited load/settlement “idealized” graph and corresponding idealized interpretations of linearized stretches. One must profit of the case to reiterate that diagnoses should start from judicious physically justifiable behavioral intuitions, and definitely not from the visual appearances of graphications, a periodic historic expedient that persists unnoticed. The facts are that numerically the designer’s calculations went to details such as assigning compressions to the concrete of the piers, in average, maximum and minimum values of 1.2; 1.6; 0.3 mm ! And hypothetical column load redistributions were postulated for minimal angular distortions of less than 1:1500 to 1:5000 ! Further, the net conclusions to the profession are of querying how there can arise cysts of misdirected concerns, instituting chaotically reshuffled dicta even when a nearby coastal city (Santos) on thick very compressible clay has been famous for intensely discussed shallow foundations with very many distortions higher than even 1:50. Finally, as regards SP reference is made to Fig. 2.7.3.1 (B) of the global PDFs of PRED/PERF ratios and monitored settlements (of but mms!) alongside with comments on noticed peculiarities on Fig. 2.7.3.1 (A). One witnesses a tragedy of excessive pessimisms by human errors of all kinds, even to this level of absolutely inconsequential mini-settlements. And the expense of monitoring column loads, decreasing the vacuum arisen from Structural Engineers’ design loads as unquestionably acting (for ultimate consequence RE = f (A) needs) must be faced on some typical buildings in sufficient numbers for Ss. Note that even if using many load tests for the PPC of Fig. 2.6.1, only a partial question will be answered by the incremental investment.

The striking significant observation that derives from Figs. 2.7.1.3 and 2.7.3.1 is that with regard both to bearing capacity loading ratios, and to settlement ratios, the PRED/PERF results tend to be noticeably conservative, as is justifiable in stages of scant documentation and ratified analyses, thereupon imposing prudence.

2.8 Statistics of Extremes. Achieving Zero HZ or Very Low Nominal HZs With Realistically Limited Set of Inexorably Low ACC Data.

Special attentions have been devoted, understandably, to conditions associated with natural disasters, also denominated “Acts of God”. The extreme rarity of the event becomes coupled with the catastrophic consequences thereof. Since the Engineer’s task has been irrevocably affirmed as aimed at quantifiedly assuring himself and Society of what is not permitted to happen to his Project, but data-banks on the really extreme events are also extremely scant, one faces a quandary. In mathematical terms it would correspond to the indeterminancy of multiplying an infinitesimal HZ by an infinite RK, $(^1/_\infty)\ (\infty)$, clearly indeterminate.

A number of very nobly-intended and undaunted mentors posited mathematical models that might be applicable: the frequently encountered reference suggests mention, as one example, of the equation derived by Weibull for his “weakest link theory for tensile failure”. But the serious problem persisted of the need to confirm minimally such mathematical postulations by real data and the hope is absolutely imaginary regarding natural disasters, even those of meteorological cycles. Industrial productions of small conveniently testable pieces opened an opportunity, and presented more surprises than confirmations [Ref]. Fig. 2.8.1 reproduces only some of the classical EXTREME VALUE PROBABILITY EQUATIONS, EVPEs, and therefrom one immediately sees that at really low recurrences (e.g. below 10^{-1} to 10^{-2}) the differences between computed probabilities become unprofitably great. One should note [cf. REF] that even in industrial cases that permitted running thousands of tests, the matching of the data to the imaginable equations becomes increasingly questionable at very low recurrences.

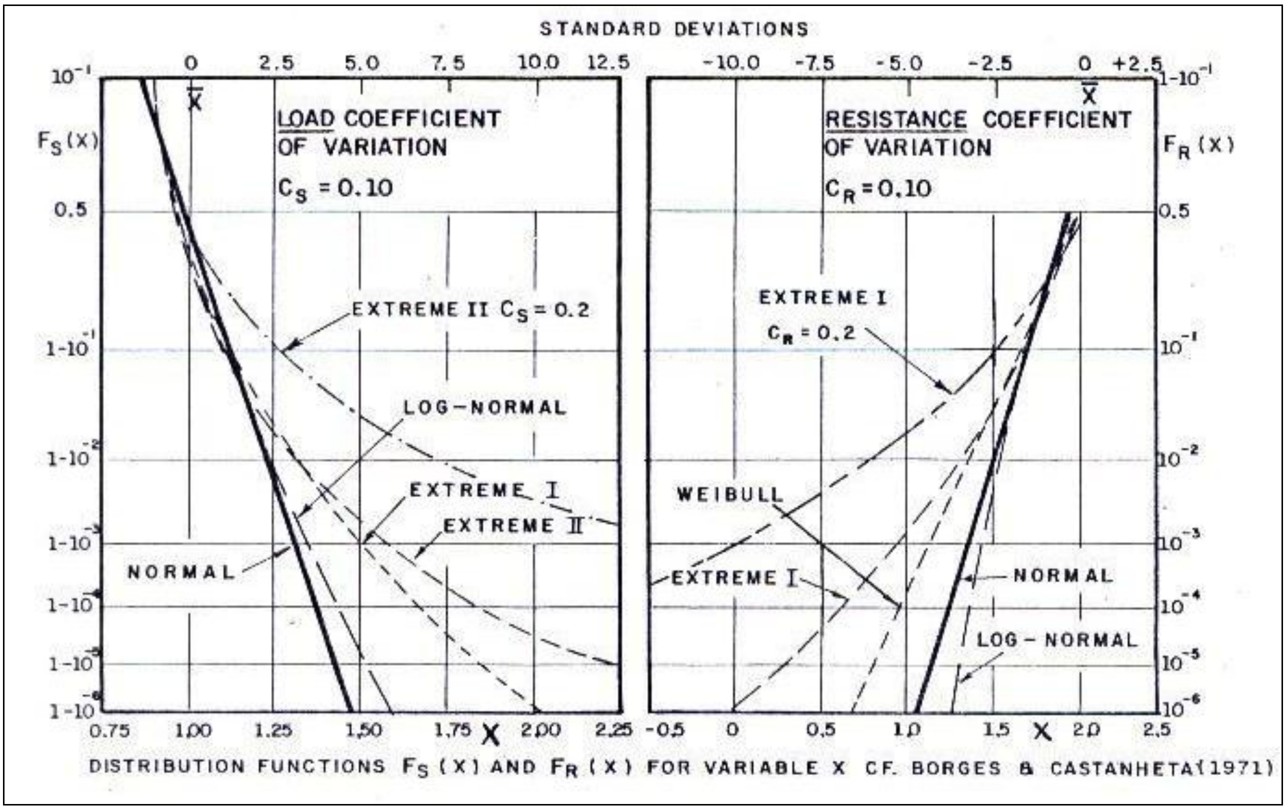


Fig. 2.8.1 – Indication on great variations of computed probabilities at low risks depending on type of extreme-value distribution assumed (Fig. 1, [32] VI).

As is well-known, in the face of prospective catastrophic flood events the hydrologist (although yearly favoured by cyclic events of the extreme population) has beaten a retreat, in considerable frustration at direct EVPE extrapolations, and reverted to a multiplicity of intervening meteorological and upper-ground parameters synthesized into computerizable “numbers”. Apart from being prudently sought as exaggerated prognostications, they prove to be mere comforting “numbers”, because of repeated catastrophic events he was unable to predict or fend against. Hydrometeorological conditions have recognizedly changed much with time and anthropic effects in most basins, and continue to suffer such changes, thus destroying the S-constancy basis; but, principally, the profession’s appreciation of random and non-random intervening factors has also continually changed. Thus a significant change of engineering attitude was introduced, which appears to be an unfortunate involution, contributing to increasing conservatism and costs: in the wise words of [REF] the engineers “have a PMP, probable maximum precipitation, a PMF, probable maximum flood, maximum credible events and the like. Upon investigation, however, we find that there are no probabilities in these events, only certainties"[61].

In short, in aiming at designing to protect from a 1:10000 recurrence probability one would be really invited to protect against a ONCE-NEVER flood or ONCE-NEVER earthquake. And the applicable CIs should be on "points", individual events, not on averages, let alone the absurdity of a stretchedly extrapolated deterministic equation.

Under such a predicament one has to resort to a "choice of change of statistical universe", which at the limit can reduce conditions to ZERO HZ, or at least can reduce very significantly the HZ and especially the RK. As expressed repeatedly since first posited [REF] "an engineering structure may often be engineered to exclude a phenomenon: arching a bridge is sufficient to exclude tensions: prestressing concrete is a search (less definitive) in the same direction: such "total" changes of conditions while achieving the same function (of form and averted de-formations) constitute what I refer to as a "choice of change of statistical universe." Can there be a zero HZ? Yes indeed, physically although not in the mathematical equations. It behoves one to posit one's conviction that there is, indeed, a ZERO HZ because it is the physical reality (of Nature) that prevails, and not its attributed mathematical deterministic idealization, all the less so the more one **departs to asymptotically infinitesimal unconfirmable probabilities**. It is a curious misconception by word-associations to think that Ps persist even when one has used, for extended extrapolations, **the equations, mathematically deterministic**, even if special (e.g. EVPEs). What is the statistical sample universe and PDF for the snouts of ant-eaters and elephants, both grouped together? Analogously, if high head overtopping failure of an embankment dam might be at stake, a change of physical universe might be studied by using a shallow fuse-plug spillway on a rocky abutment, and preferably discharging into a modest affluent basin nearby. The problem of piping erosion, extreme-value starting at a weakest point of flow exit and progressing with acceleration, is prevalent with seepages exiting with development of tensile stresses, and is ably controlled by use of an appropriate filter coupled with seepage stresses directed to apply compressive stresses at the interface.

[61] One might add facetiously that the adjectives were selected to cast a mist on the real lack since there are neither any probabilities attached to the reasonably repetitive hydrological events nor any credibilities attachable to the anti-recurrence (and not recurrence) trends of seismic energy liberations.

One main aim herein is to propose one, and possibly the only, optimized engineering manner of achieving the clearly unquestionable desire and need of very low Ps of seriously objectionable performances (cf. Item..9, last paragraph....).

The principle was thus emphasized that a responsible professional engineer facing a really serious quandary should abstain from further faith and pursuit of mathematical equations that only seek and reach increasingly high/safe unconfirmable numbers, and should employ the dominating Gordian knot solution of literally changing the physical universe as much as necessary. Examples were given. But at some extreme one has been asked "how can I change the physical universe for an existing concrete gravity dam if it has to face an unquantifiable seismic action?" Well, change to a compacted rockfill dam or embrace it with rockfill shoulders, not at all difficult to justify and quantifiably ratify, especially since the dams themselves seldom represent more than 30-50% of the project's global investment, and differences between different types, each well optimized, seldom exceed about 10% of the dam's component. The cost difference is paltry in comparison with the failure RK.

Other attenuating solutions often capable of turning the incalculable extreme flood event somewhat more calculably absorbable incorporate the principles of assisting in averaging behaviors, by making cumulative actions predominate over point reactions. Reservoir flood routing ability with increased freeboards and surcharge **as necessary alongside with operational rules**, to be assessed economically. Reservoir and spillway operational rules do become progressively more important with time for the most catastrophic natural hydrologic disasters: they justify the estimations of HZs in dam-years and suffer from greatly increased RKs for same HZs. In the cases of foundation piling the risks are greatly attenuated if cumulative reaction by side friction (the first to be mobilized) is made dominant in comparison with point-base resistance: and in the latter condition the risk is greatly reduced in driven piling that compacts, pre-tests and pre-stresses the base into comparative residual incompressibility (not stresses, that dissipate) in comparison with bored piles that stress-relieve the base with no control or improvement.

Inescapably, however, one will still be faced with many cases in which Society has become accustomed to thinking in terms of probabilistically occurring HZs, and levels of acceptances of HZs are part of the obligatory jargon employed and understood (to be respected), while simultaneously the imposition of very low acceptable HZs unquestionably prevails by comparison with many other happenings and pursuits of normal life. The distinction between voluntarily sought higher risks, such as in many daring sports, is clearly distinguished from conditions considered purely accidental, and even more strongly differentiated from those considered as suffered more recognizedly as a passive victim.

The blatant restrictions summarized by Fig. 2.8.1 concern a single totally dominant parameter when carried to extremely low Ps. There are some other important conceptual restrictions to be summarized regarding widely spread practices.

1. Adulterations arising from word-associations, and artifices of data-bank extension under earnest intentions and needs. Not infrequently there occur cases in which an identical term used in different contexts leads to erroneous presumed applicability of EVPEs. For instance, the P of farthest run out of a mass flow invites the use of EVPEs if it is expressed as the “extreme” run out. [24] The fitting of the data is mostly done visually on special graphication papers (e.g. Gumbell, Extreme I and II, Pearson, etc.) for maximizing data as the ranges of the complex-parameter queried are widened, with Ps nearing qualitative certainty that dominant As and REs have changed or been complemented. There are no quests on CIs and their changing trends. Curves, and the very frequent S-shaped plots end-up being linearized. One must repeat that SP is more than a desire and need, it is a must: but it must be physically assessed to incorporate the more significantly interfering parameters, and **the very low HZs sought should ultimately result from the multiplicative rule on Ps of the several reasonably interpretable parameters, progressively defined and quantified.**

	A		RE		Symbol
	Distribution	CV_A	Distribution	CV_{RE}	
1	Normal	0.10	Normal	0.10	______
2		0.30		0.10	___
3	Lognormal	0.10	Lognormal	0.10	
4		0.10		0.30	______
5		0.30		0.10	__
6		0.30		0.30	
7	Normal truncated	0.10	Lognormal	0.10	
8		0.10		0.30	______
9		0.30		0.10	__
10		0.30		0.30	
11	ExtremeType I	0.10	Lognormal	0.10	
12		0.10		0.30	______
13		0.30		0.10	__
14		0.30		0.30	

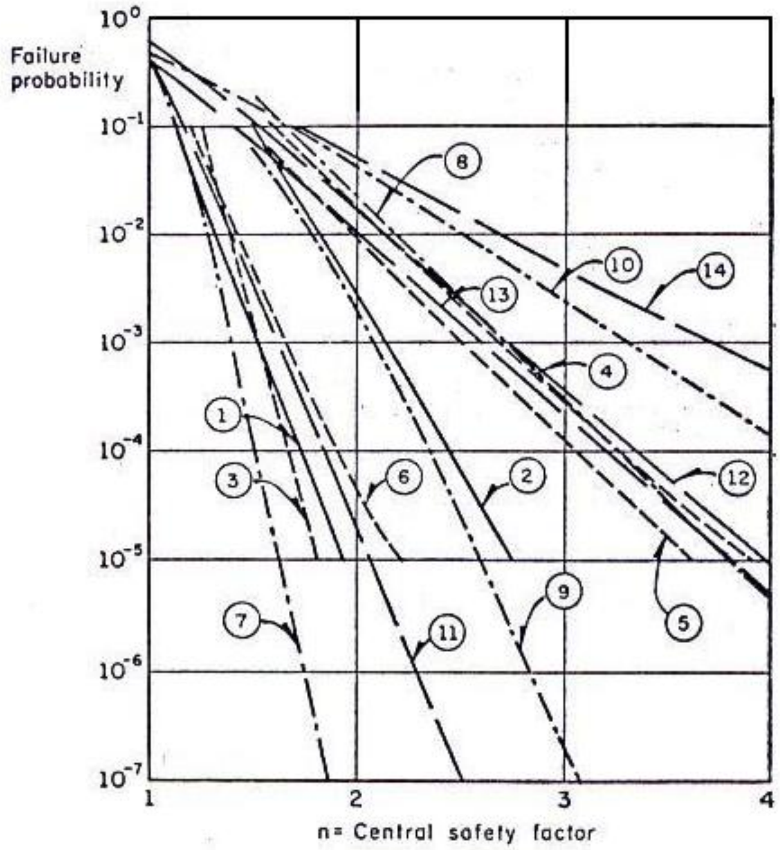


Fig. 2.8.2 – Failure Probabilities for several families of distributions. Difficulties of achieving 1:100 Ps even with simplest PDF combinations, of As & REs for usual CVs.

2. Complemented difficulty of reaching HZs even lower than but 10^{-2} when but 2 dominant parameters are involved. Fig. 2.8.2 [25] is reproduced to illustrate how widely the failure Ps can vary, even but at the levels of 10^{-1} to 10^{-2}, when resulting from different combinations of P equations for the As and REs. One must note that the first three combinations, and corresponding ten curves, employ merely the most accepted “common” PDFs, normal and lognormal, with their realistic CVs, even without CIs. The variability in F obviously increases greatly when an Extreme I EVPE is introduced, even if merely for the As, as represented by the tabulated cases 11 through 14.

3. Indispensable revisions of authoritatively cited HZs rendered meaningless by indiscriminate mixing of phenomena, historic periods, and stages of cognition.

Very summarily, the evaluator must begin by recognizing that there is a marked difference of HZs of old structures built prior to, and new ones subsequent to, progressively developed rational solutions to distinct systematically disclosed failure scenarios. Moreover one should repeat emphasis that challenging designs should aim [22] **at promoting performances naturally improving with “curing” time and age**: and in case of doubt, one should foresee what might be done within operational programming in order to attenuate or revert undesired trends. Developments of success establish milestones, separating S and P universes almost to a deterministic degree: widely known examples are the use of good filter designs in embankment dams, and the change, within the broad category of rockfill dams, by substituting the erstwhile dumped ones by the ones well compacted in quality-controlled lifts.

Within the broad indiscriminate HZs quoted frequently and authoritatively, analogies have been insinuated by such cases as passengers-miles of air travel, etc.., wherein conclusions would result entirely different if one separated the more critical episodes of take-off and landing (independent of interim mileage) from the high altitude flight mileage. Moreover one must separate clearly the cases wherein the structure is a victim of an absolutely distinct scenario of As from those in which there is disclosure of a lack of compatibility in the RE vs. A equilibrium: such is, for instance, the overtopping breach of an embankment dam by an unforeseeably high event.

In short one cannot perpetuate such published generalized HZs on embankment dams [26] in which **critical once-only** conventionally analyzed destabilizing conditions (e.g. the END-OF-CONSTRUCTION destabilization case of clayey earth dams compacted too wet) were lumped together with exceptional overtoppings and (appropriately for old-fashioned cases) the slowly developed downstream destabilizations because of improper control of seepage flownet and piping erosion.

Authoritative HZ quotations [27] have to be judiciously revised by subdividing the clearly distinct cases. And, as already mentioned, in fairly frequent cases one must further recognize that the routine dam-year assessments implicitly consider linearity regarding number of year: in principle linearity is the first crude hypothesis, rarely valid, since effects of successive similar phenomena either grow or hopefully attenuate with repetitions and age. For instance regarding concern on seismic HZs the critical condition should probabilistically be preceded by many lesser events with possible cumulative benefits regarding absorbed modest contractive cyclic mobilities.

One reiterates call the attention to the shocking dispersion of the tabulations and graphs of Fig. 2.8.2 for the simplest PDFs, shamefully repetitive to all, but felt needed as reminders of the orders of magnitudes pertinent to geotechnique.

This important reality, envisioned as a fundamental requirement for a renewed future of Geotechnique in Natural conditions (not cut-across by prepotent industrial means, an unquestionably efficacious technical solution increasingly promoted) is exemplified in Fig. 2.8.3.

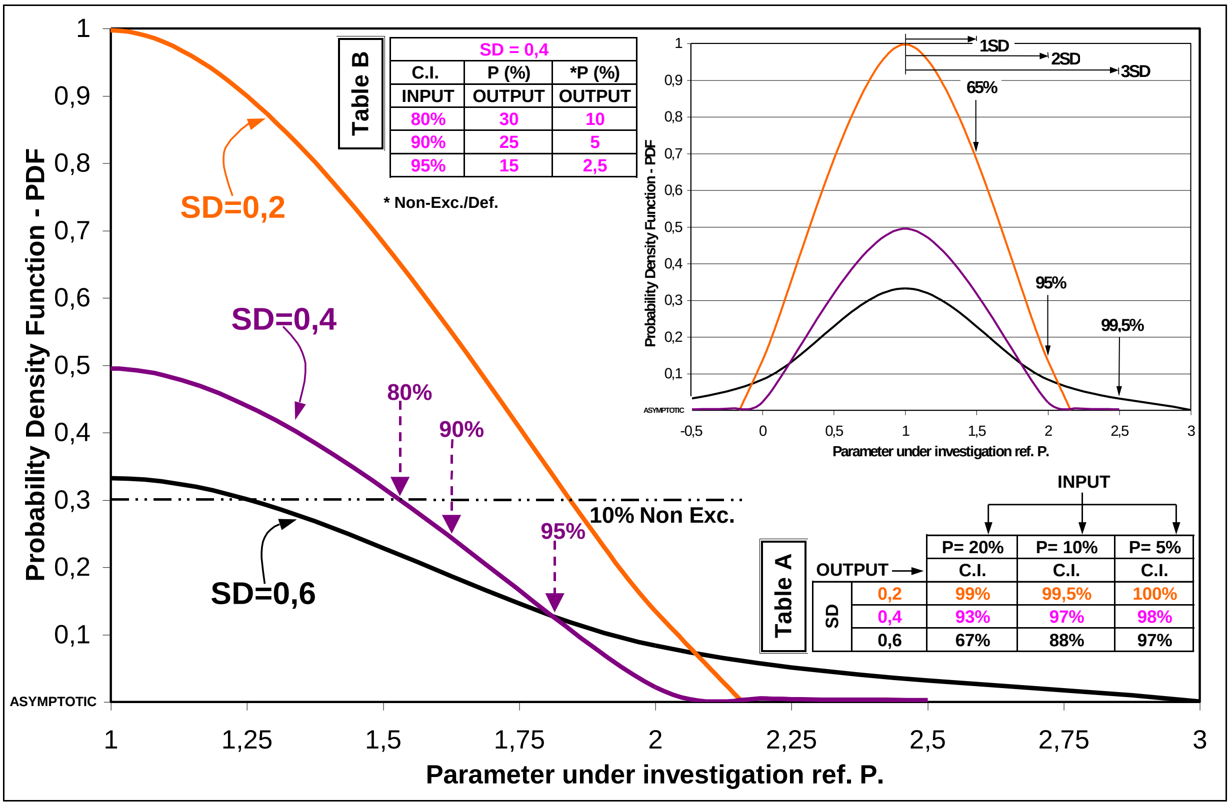


Fig. 2.8.3 - Simplest PDF cases and Tables to exemplify sequences
P→ CI →Non-EXC/DEF P.

The graphs are absolutely routine showing how broadly the bell-graphs widen as the SD increases, leading to rapidly decreasing Ps of satisfying a desired criterion. In table A one then shows for three sets of SDs and individual occurrence Ps the corresponding CIs. For instance the SD = 0.6 and 20% P of occurrence will correspond to a CI of 67%, itself ipso facto corresponding to a cumulative (area) Non-EXC./DEF. P of 33/2 = 16.5%. Thereafter, moving to table B, and limiting to the single case of SD = 0.4 one submits the respective correspondences between CI values frequently mentioned as criteria, and the respective individual P values of occurrence and corresponding Non-EXC/DEF P values for design decisions. One should note that 95% is an often quoted recommendation taken from structural fields for intuitions inapplicable in geotechnique. Attention is also drawn to the quoted THREE-SIGMA RULE [REF] (cf. Item 13) listed also in item 12, since it would correspond to a completely unrealistic CI of 99.4%, i.e. Non-EXC/Non-DEF Ps restricted to about 0.25%.

2.9 Additional Considerations Regarding Extreme Value HZs and Point Value CIs of HZs of Extreme RK Consequences.

For the important emphasis on continual updating, both of thinking, theories, procedures, and of data themselves, one begs leave to resort to one of the most authoritative textbooks on Hydroelectric Engineering[62] which for spillway-designs used visually fitted straight lines in log-log “recurrence probability graphs” and extrapolations for maximum probable future flood estimations. Extrapolations to nominal 1/1000 and 1/2000 year recurrences were dominant. It represented a declared and recognized marked advance over the then simpler, (often inescapable though obviously with dangerously poor documentation) indefensible practice of applying an imagined factor of multiplication (e.g. doubling) on the “maximum flood of record”. Such historic realities need mention not merely because of the immense number of dams-years that survived such criteria despite accelerated changes of land-occupation runoff coefficients and governing meteorological operational predictabilities, but also for the more important emphasis on continual updating both of theories, procedures and data, towards P estimations both of HZs and of RKs[63]. As will be further

[62] [23] First edited 1927, 2nd edition Dec. 1949 doubtless in direct use for 2 or 3 decades more.
[63] One respectfully restrains from mentioning second-order details of the historic practical handling of 41 years providing 179 data, separated into 44 groups (of which 8 without occurrences, leaving 36 values for plotting) and finally plotting 31 in the probability paper. The noteworthy advance embodied admitting a possible curvature of lesser significance in lieu of the visually fitted straight line, as well as mentioning an existing

posited in Item 10 regarding the Bayes' Theorem, **knowledge and experience inevitably start from zero and grow in an S curve, slow → accelerating → decelerating → asymptotic on each topic.**

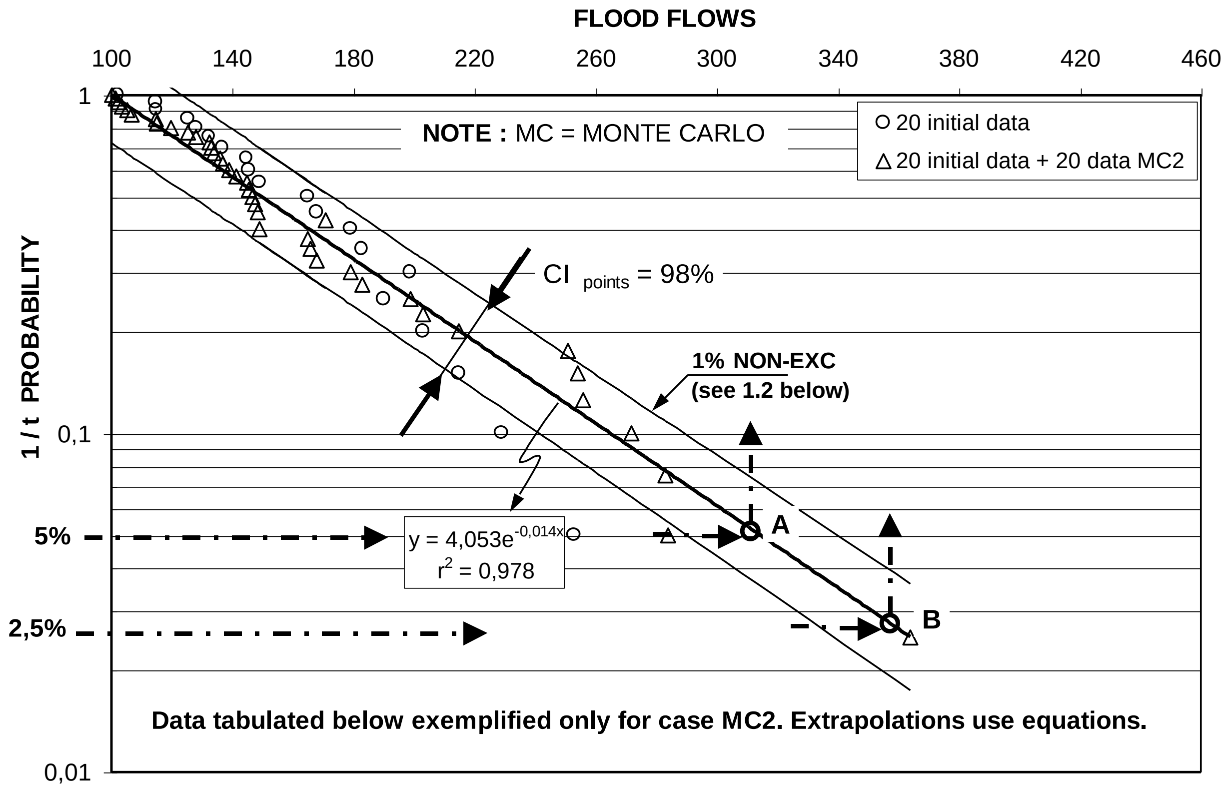
Resorting to the 179 sets of data found tabulated [23] one submits in Fig. 2.9.1 a further critical updating purely regarding caveats on applications of SPs analogously occurring in civil-geotechnical conditions[64]. Firstly, one always deals with limited data and limited complements of data, such as develop during construction and operational project life. Nevertheless at the other extreme one needs for the end product a very, very low exceedance probability of the single "point" catastrophic event. It is clearly irrational to extrapolate the median (even if improved into an optimized regression), all the way from about 20 to 40 events (5% to 2.5% median Ps) to the very distant Non-EXC Ps of 1/1000 to 1/10000. One thus returns to abutting into recommending use of CIs. Note that one simultaneously improves the knowledge on the conditioning A's natural phenomena's erraticities, introducing a second significant intervening parameter, which for small basins subject to more erratic point behaviors often emphasize need of added prudence.

In Fig. 2.9.1 one exemplifies the problem and indeterminacies by starting with 20 data and complementing with 20 additional. From the data-bank of 179 data (therefore retroanalysable) the first 20 were sorted out by MONTE CARLO, MC choice, and subsequent 6 alternates for the 20 complementary data were also sorted by MC from the remaining 159 data. Separate calculations were carried out for hypothetical 1/4000 Non-EXC Ps (a) extrapolating the median to hypothetical 2500 data; (b) for 1/40 Non-EXC Ps coupled with the respective 98% CI (corresponding to the 1% Ps of Non-EXC). For easier visual perception only one group of data-points and consequent pair of derived equations are plotted in the graph.

---

mathematical method for closer analysis (N.B. the opposite extreme, discussed in Figs. 7.1 and 7.2 herein). One's point in pursuing one step further is that even by using optimized regressions with CIs, problems of irrationality and high levels of discrepancies persist.

[64] One emphasizes that one consciously bypasses many an important updated consideration regarding meteorology, hydrology, reservoir operational management and design-flood probability estimations.



		1 - EQUATIONS		2 - $Q_{CALCULATED}$		3 - Proportions	
		1.1) Median	**1.2) Non-EXC**	**2.1) For 1.1 ***	**2.2) For 1.2 * ***	**3.1) 2.1 / 2.2**	**3.2) (B to G) / A * * ***
A	20 inicial data	$Y = 9,4500e^{-0,0191x}$	$Y = 15,259e^{-0,0189x}$	**552**	**339**	1,63	
B	20 inicial data + MC1	$Y = 5,5487e^{-0,0151x}$	$Y = 3,3267e^{-0,0151x}$	663	394	1,68	1,16
C	21 inicial data + MC2	$Y = 4,0534e^{-0,0141x}$	$Y = 2,963e^{-0,0141x}$	687	389	1,77	1,15
D	22 inicial data + MC3	$Y = 5,4714e^{-0,0169x}$	$Y = 4,0844e^{-0,0169x}$	591	340	1,74	1
E	23 inicial data + MC4	$Y = 6,9014e^{-0,0175x}$	$Y = 4,4276e^{-0,0175x}$	584	348,5	1,68	1,03
F	24 inicial data + MC5	$Y = 5,9261e^{-0,0167x}$	$Y = 4,1691e^{-0,0167x}$	582	348	1,67	1,03
G	25 inicial data + MC6	$Y = 7,9992e^{-0,0195x}$	$Y = 5,7885e^{-0,0195x}$	515	323	1,59	0,95

* $Q_{CALCULATED}$ for y = 1/4000 recurrence.

* * $Q_{CALCULATED}$ for y = 1/40 recurrence and 1% Non-EXC.

* * * Example: 394/339 = 1,16

Fig. 2.9.1 – Reassessments of an estimation of spillway design floods, (dominant) parameter, as restrained by scant data.

Important physical realities both regarding As' HZs and regarding consequences and RKs impose the use of CIs on points. And the important principle of not attempting big extrapolations on any mathematical formulation (deterministic and idealized) remains emphatic because the dominant physical intervening realities change. One reaches the conclusion, shown in the tabulation of Fig. 2.9.1, that errors in the ranges of 70% and 30% persist, with the distant probability extrapolation on the median leading to the bigger error (on the prudent side, possibly over prudent, penalizing economy and logistics).

The automatic conclusion is that even after excluding EVPEs and reverting to applying optimized regressions of routine SPs one cannot set aside judgment, considering perceptible variabilities from project to project, and condition to condition.[65] All the resulting numbers strike one as being quite different, but one has to revert to judging also the basic numbers defining the very data, through erraticities of flow measurements and calculations that generated them, especially in flood conditions. These are always much extrapolated, physically towards the wider temporary river channel, and numerically from amenable measured modest flooding to higher flooding levels and velocities.

In short, it is much more reasonable to join a moderate extrapolation in yearly recurrence with a prudent CI on point values. For instance a 1/10000 P recurrence flood extrapolated estimation is more reasonably conducted by multiplying the 1/100-year median flood extrapolation together with the 98% CI (on points), i.e. a 1% P of Non-EXC of the higher equation.

Historic conventional geotechnique invites as a major criticism the fact that it is continuing to retain single-parameter (pseudo)-correlations, even when fully recognizing that practically none are obtainable within variabilities of less than ± 20 to 30%. For the progress desired it is all-important to infer intuitively, introduce, investigate, and characterize quantifiedly more complementary parameters demonstrable as intervening perceptively in the RE = F (A) relationships. If one could find a correlated relationship using parameter I as incorporating also the parameters and Non-EXC or Non-DEF Ps as tabulated below the global Non-EXC/DEF P would drop astoundingly to (0.2)(0.25)(0.15)=7.5/1000.

[65] One must reemphasize attention to some noted publications that refer to dam-years of HZs. One sets aside the continuous variations of the A and RE physical universes, and concentrate only on the aberration of confusing repetitive and yearly-cyclic occurrences with some special single-occasion deterministic critical A (cf. Footnote 24).

Parameter	I	J	N
Non-exceedance %	20	25	15

For a very realistic and accessible example one may revert to the elasto-plastic stress-strain equations of [REF] well-behaved, very widely used, and well-recognized triaxial test PERFs of sands, and thereupon can promptly signal for joint incorporation the amply **documented intervening parameters (a) relative density RD**, with an indispensable improved redefinition, (b) OPTIMIZED effectively participating **GRAINSIZE DISTRIBUTION OGD parameters for well-packed particle contacts**, instead of the conventional D_{10} and CU=D_{60}/D_{10} (c**) ANGULAR of shape of GRAINS AG** (d**) MINERAL CRUSHABILITY OF GRAINS MCG**, and (e) **STRESS LEVELS STL**, giving, successively, 25%, 24%, 25%, 28% and 23% Ps, the global Non-EXC/Non-DEF P should result about 1:1000 (by multiplicative rule, (0.25)(0.24)(0.25)(0.28)(0.23)= 0.00097), a figure very commonly fixed in the minds of clients and society.(Cf. Fig. 2.10.1)

2.10 Posited Recommendation Towards Maximized Use of Simple Inviting Optimizing Regressions and Accompanying CIs Expressed In Terms of Probability HZs of Non-EXC/Non-DEF (Oriented by RKs as Final Destiny).

What the majority of professionals should aim at doing internally, with persistent automatism, has already been discussed at length. Adjustment Coefficients ACs tying present and future developments back to past experience should be rapidly achievable. Concomitantly the areas of principal misfits and voids in data will be exposed and their relevance should be inferable easily as a first step, by insertions of parametric variations in successive computer runs in conventional problems benefited by recognized software. The selective second step should follow by programmed laboratory and/or field testing, and the ultimate validating tests will follow by the postulated anonymized PPCs of Type C. [REF]. The fact is that one has to estimate and present one’s results in terms of Non-EXC/DEFs of HZs and RKs as Ps.

The ultimate validation for civil and civil-geotechnical engineering is emitted by civil society, the specific and global clients. Because of generalized use in all walks of life and insurances, everything needs to be presented in percent improvements (often a percent difference on the previous conditions) and probability HZs and RKs.

Activity	Probability *
Voluntary individual risks:	
Air travel (crew)	1:1000
Car Travel (1984 British Columbia)**	1:3500
Construction	1:6000
Air Travel (passenger)	1:9000
Involuntary individual risks:	
Fire	1:50 x 10^3
Drowning	1:100 x 10^3
Lightning	1:5000 x 10^3
Structural failure	1:10,000 x 10^3
* Relative to population involved in the activity ** For individual traveling 10,000 mi/yr	

Fig. 2.10.1 – Table 1. Annual probabilities of death of a selected individual from various activities (after R.T. Peck et al. (1987 [REF])

Fig. 2.10.1 reproduces a tabulation of HZs as repeatedly cited by principal mentors. It is well understood to comply with engineering criteria of attending to maxima and minima, and therefore reclines naturally into being associated with a qualitative concept of Reliabilities (RELs).

The tabulation of Fig. 2.10.2 (A) and consequent Fig. 2.10.2 (B) extend the fully endorsable concept of RELs into a RELIABILITY INDEX, REL IND presently much-posited by authoritative creators and mentors in theories of SPs [REFs] [BIBL]. One begs leave to disagree promptly and concernedly, initially for two cogent reasons of respect for society and professionals not specialized in novel efforts of SPs. In as far as concerns society, the new INDEX does not convey any understandable message on HZ probabilities of RKs, which is the fully absorbed day-to-day communicative reference. Secondly as regards the professional practitioner there is a starting conceptual rejection in circles of science and development: one never compresses a more detailed and meaningful level of information into tighter compartments that have to generate special group categories, and embrace in each narrow range of the grouped (index) a wide range of the more expressive and communicative index. REL IND 1 for instance is supposed to cover from 10^{-2} to $4x10^{-3}$ Ps: group 4 REL IND purports to cover from $4x10^{-3}$ to $1x10^{-4}$ Ps. What does one gain by such compressions of evaluations already made to a greater degree of definition, quite as telegraphic in communication, and fully understood both as regards the values and their differences?[66]

	Structure	Probability of failure	Reliability index, β
	Geotechnical works:	(*) Postulated and Posited	
1	offshore foundations	$1x10^{-2}$ - $4x10^{-3}$	2,3 - 2,7
2	earthworks	$4x10^{-3}$ - $1x10^{-3}$	2,7 - 3,1
3	retaining structures	$1x10^{-3}$ - $4x10^{-4}$	3,1 - 3,4
4	foundations	$4x10^{-4}$ - $1x10^{-4}$	3,4 - 3,7
5	Reinforced concrete structures	$5x10^{-4}$ - $1x10^{-5}$	3,3 - 4,3
6	Steel structures	Less than $1x10^{-4}$	higher than 3,7

Fig. 2.10.2 (A) - Table of Probability of failure and reliability index [REF]

[66] The comment reverts to an interesting example of misinterpretation and misuse that ensued from the Casagrande Plasticity Chart. The level of knowledge necessarily acquired as input by the pair of values W_L and W_P was of much greater precision than the group characterizations as CH or ML etc… And as regards telegraphic communication of **knowledge** there is absolutely no gain in abbreviating from (W_L, W_P) (60%, 40%) to CH. It was for the level of **field decisions** of military engineers in preparing base-courses for airfields that the grouped indices were erstwhile elaborated. Enthusiasm and adulation led to the confusion between levels of knowledge and of stepwise decisions for a purpose. For designs of foundations on clays, all CH materials cannot be globally discarded, and the difference is meaningfully enormous between a (60%, 40%) and a (110%, 70%) clay stratum.

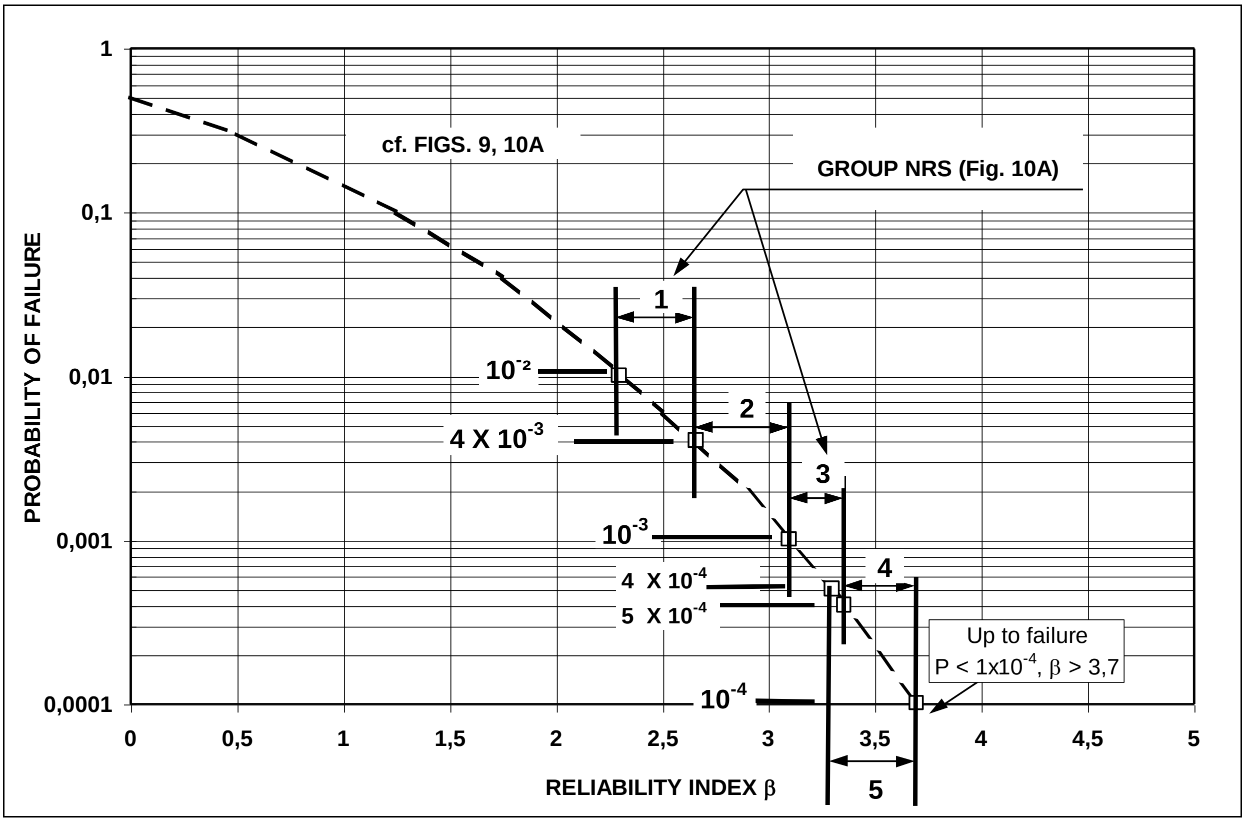


Fig. 2.10.2 (B) – Graphical representation of the Table from Fig. 10 A.

The obvious goal of Reliability REL in preference to Accuracy ACC is so ingrained in Civil-Geotechnical engineering that qualitative ad vocation of RELs has been systematically emphasized by most eminent mentors. It was inherited from the historic requirement of ZERO HZ, and might seem more comforting to parties eventually affected with some degree of incomprehensible dissociation from clear cut exposition of HZ Ps in 1:n. The dominant proposals towards the eagerly desired assurance of safety has concentrated into the very repeatedly posited REL IND [REFs]. One is thus led to dedicating Item 12 to complementary comments on the REL IND. Meanwhile it is also noted that several other refinements and posited specialized indices on SP have sprouted systematically. The ones encountered in a cursory review are listed, and, with due respect for their well-meaning mentors towards other purposes, all are emphatically set aside, as summarized in Item 13, on behalf of guarding from dissuading complications for first steps of updating professional geotechnique.

2.11 Interests, Uses and Necessary Adjustments Attached to Bayes' Theorem, or its Downright Substitution by Multiple MC Options.

Bayes' theorem for advancing from a prior probability SP "sample" to a posterior P thereof, by employing "experience" and/or complemented data, has been much cited. **The concept embodied in the theorem is unquestionably a controlling root principle attributable to humans[67] under the theory of natural selection**, interpretable as protective selection between unfavourable NON-EXC/DEF probabilities for significant activities. However, it is from the conditions and results of the quantifications ensuing from its probability equation that one is led to varied reflections on its questionable applicability for the profession.

In anticipated summary one concludes that the principal value of the Bayes' equation should arise from probabilistic formulations of the existing EXPERIENCE as a "prior state", and also for an estimate of the analogously defined incremented sample: and the nature of experience in the field of geotechnical engineering has already been briefly queried and qualified in item 9 above.

The innate desire is for predictive capabilities, the respective need being exponentially greater as the HZ, RK and cost of the data-acquisition become greater or proportionally more significant compared to the RK of unsatisfactory performance of the prototype. In truth one exposes the reality that the bifurcation of academic theorizations and PRESCRIPTIONS on the one hand, and the vast mental collection of undigested practical experience by the EXECUTORS, has cornered the profession into a yearning for horoscopic hints. Thus the more frequent use of Bayes' Theorem had been for retroanalysing pertinent data already paid for, in order to confirm how to limit the data-acquisition consciously for given NON-EXC/DEF CIs: but in routine practice this retroanalysing seems irrational for any distinct problem, being understandable only if done frequently enough on similar cases to establish generalized immutable experience for future uses.

As a start one should recognize that the equations for applying Bayes' Theorem presuppose that the prior and posterior probabilistic samples are aptly defined by their PDFs. The caveats regarding the tail fractiles were and are ever present as a primordial dissuasion. But there was in the 1960-'70s a hiatus, before the proficient computer proliferations, when there was no efficient alternate. Presently the use of computer generations of data by the Monte Carlo MC technique resulted in superseding the interest in Bayes. Nonetheless one notes a moderate survival of applications of Bayes in lieu of MC, under the premise that one can only use the

[67] reasonably presumed extendable to all living creatures, that are not passive but suffer and exercise interactive adjustments to the Ps of NON-EXC/NON-DEF events.

latter on retroanalysing data already acquired. The premise is misconceived. In the same manner as one would use predictable PDFs of prior and posterior probabilities, one can even better generate a sequence of hypothetical MC future cases, such as would presumably embody the respective Ps for application in the basic formula. The principal intent remains as checking when no further gains would be, or are, achievable by additional tests or data, a goal of more specific interest for expensive tests of greater responsibilities.

As transcribed from [REF], “Bayes” theorem can be generalized in application by **calling the unknown classification the state,** and by considering that **some generalized sample has been observed**. Symbolically the equation

$$P\,[B_j / A] = \frac{P\,[A / B_j]\,P\,[B_j]}{\sum_{i=1}^{n} P\,[A / B_i]\,P\,[B_i]}$$

becomes

$$P\,[\text{state} / \text{sample}] = \frac{P\,[sample / state]\,P\,[state]}{\sum_{allstates} P\,[sample / state]\,P\,[state]}$$

Under this premise the formula has been applied to the following cases for elucidations of concepts and comparisons with MCs regarding efficiencies for reaching the goals, alongside with postulations on the rationales derivable.

2.11.1 A Set of 50 Results of Liquid Limits ω_L of Exactly the Same Sample Tested UNDER Rigid Conventional Standards (U.S.A. – ASTM) by 50 Accredited Laboratories, Are Used to Exemplify.

The test is a cheap index test, and therefore the analyses may be (and were) conducted as retroanalyses of existing data[68]. But at any of the successive steps the Bayes’ prior STATE may be postulated as dictated by “experience” and the SAMPLE may be assumed as guessed, in aiming at prediction: the SAMPLE may also be used via a set of MC results assumed as “predicted from experience”. Parallel comments are to be brief because one’s end conclusions lead to discarding

Bayes unless and until extensive and intensive collaboration may be engendered from executors, and from their files of mentalized experience on repetitive procedures reaching asymptotes. As shown in [REF] the prior PDF is almost without exception taken as Normal; in the extreme case where the engineer does not rely on his judgment the SD becomes infinite; and unless he is extremely confident about the median, a large value of SD would be adopted. On the other hand, dealing with a good degree of Confidence (subjective) would mostly tend to some bias requiring caveats.

Since CIs are very seldom (if ever) mentioned regarding either the “means” or the “points” as physically significant, one might note that for each and all the applications of due worth routinely recommended, the starting data of the PDFs would be established already incorporating the interpreted desired significant parameter CI among the two.

Considering the reality of existing data, each incremental SAMPLE was sorted subjectively from the data outstanding: the sorted group could have constituted a set predicted by experience but not synthesized into a PDF median and SD as used in Bayes.

In this manner the Bayes equation was used directly for a succession of prior-to-posterior situations as shown in Fig. 2.11.1.1 In parallel the same data were similarly used from MC computer sortings, leading to direct calculations of the progressive PDF medians expressed as differences (positive and negative) with respect to the total average. Semilog scale is used for salience of differences. The basic line of reference separating the +ve and -ve (mirror image) differences was established as equivalent to the arithmetic average of all 50 standard immutable tests.

[68] In separate it should be commented that the said index test is not significant to precisions either of estimations or of consequent decisions. The exercise is presented merely for computational interest and direct conclusions on trends.

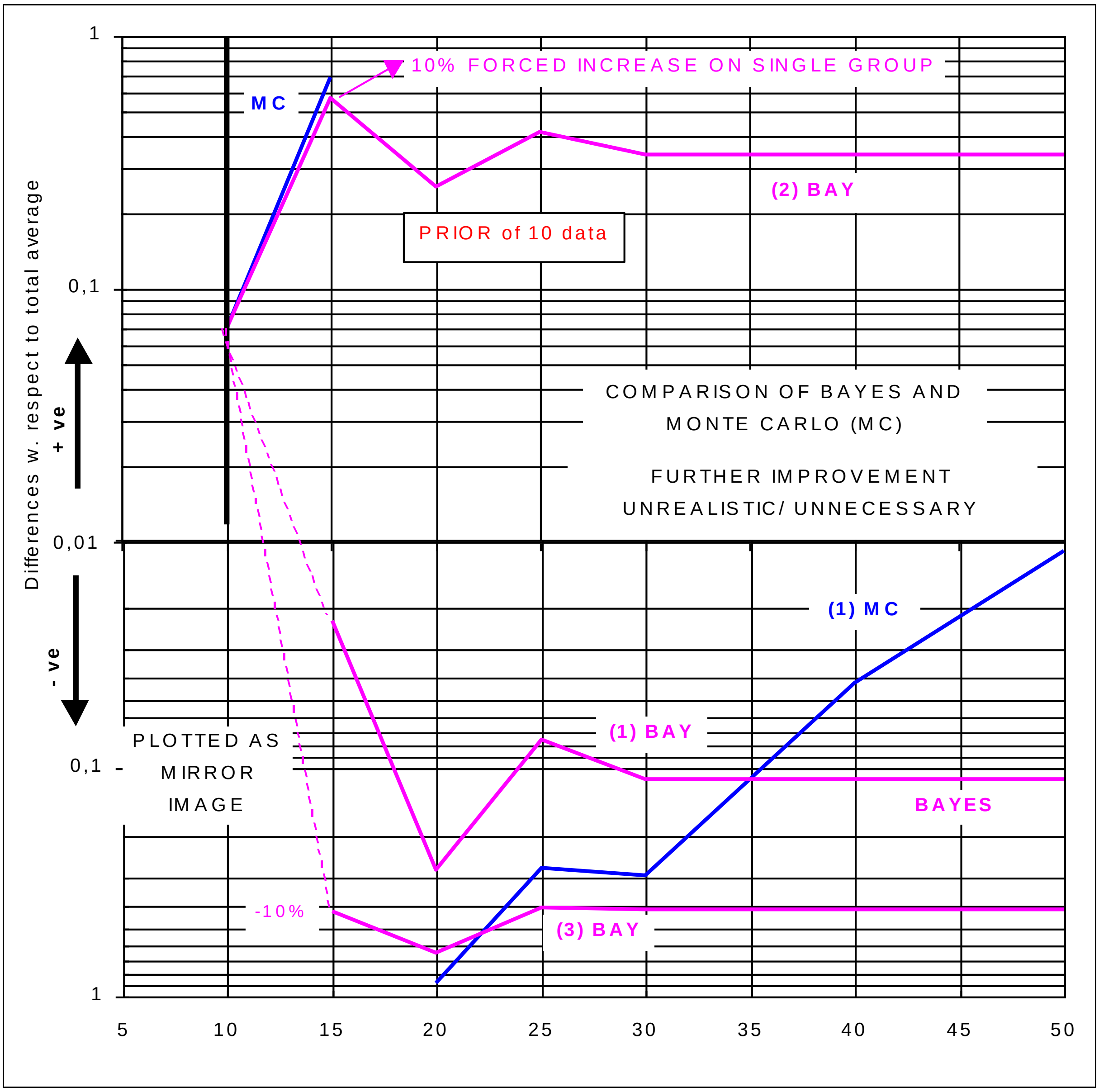


Fig. 2.11.1.1 – Comparing progressive Ps by Bayes` Theorem and MC sortings towards confirming sufficiency of numbers of absolutely standard tests (Liquid Limits) towards reaching asymptotic average.

Three fundamental conditions were analysed, which for convenient identification are numbered alongside of the respective graphs as cases (1) (BAY for BAYES, and MC), (2), and (3). For case (1) the start-off, representing the PRIOR-STATE data, was sorted by MC. By coincidence it fell in a moderately high +ve position. Thereafter successive additional groups of 5 data were sorted from the remaining data-bank. The distinction between the calculations for MC group and for Bayes' prior-plus-posterior groups was that in the MC graphs at each added group the entire earlier-plus-increment group was reanalysed as to Ps with no distinction between the successive sequences in which the data occurred, whereas in the Bayes' case the prior preserved its pre-eminence (as per formula) representing the posited experience.

By coincidences the 10-15 group moved up high and the 15-20 forced a significant drop. [N.B. As a side comment it is noted that in three of the graphs, both case (1) BAY and (3) BAY in the 10-15 stretch, and in case (1) MC the 15-20 stretch, the lines would cross a "zero difference line" that does not exist in the semilog: therefore these stretches are drawn as dashed lines]. The first immediately noticed results showed that the (1) MC graph zig-zagged greatly while the (1) BAY followed similar tendencies, but very much attenuated.

Thereafter the incremented groups of 5 data followed with a remarkable difference, that the MC rapidly approached the final value, whereas the Bayes persisted with significant dominance exerted at each step by the successive priors, increasingly inertial, to the extent that final near stabilization did not amend the significant bias, failing to approach the final mean value. The inferences neatly confirmed the conceptual dominant worth given to EXPERIENCE, calling for some very important conclusions, towards downright rejection of Bayes in very many cases and conditions, and important practical amending exhortations to the profession in practically every endeavour. The rational and well-intended dominance through experience given by Reverend Bayes to the prior, was unquestionable conceptually, but called for confirmation, in applications to a profession's specific stigmas.

The above unfavorable indications of Bayes' extremely inertial effect suggested running cases (2) and (3) to force achieving proof positive. The same computational procedures were maintained. However, in presumed respect for "subjective experience" it was assumed that a chief engineer might interfere after the first 15 results with a comment that according to his experience with that stratum the typical results should have been 10% higher (case2) or lower(case3). Thereby he would have instructed the laboratory technician to incorporate those changes at that single point in the sequence, and to follow on with his routine testing. The blatant consequence needs no additional comment. The Bayes' equation really gives an incredible inertial value to prior experience, essentially increasing exponentially the responsibility on the detailed applicability of the experiences minutiae, and representing a serious stumbling block to geotechnical engineering and adjustments to creativity.

The two conclusions that arise directly are that:

(1) the Bayes treatment is relatively slow at responding to additional data;

(2) (2) ipso facto the importance of the “prior” embodying EXPERIENCE is emphasized. And one must not forget the fact that in final analysis the experience that counts for the geotechnical profession is that of similar prototype works, as built. The concepts conveyed by the terms STATE and SAMPLE are expressive. Important caveats and requirements for the specific case of geotechnical engineering are to be summarized as a close of this Item.

2.11.2 Analyzing Progressively Predicted and Accumulated Data Influenced by a Learning Process Dominated by Serious Non-EXC/DEF REQUIREMENTS. Interference of Experience and Convinced Persistence.

For illustration one resorts to analysing a group of driven precast concrete piles accompanied by a good number of load tests, principally DYNAMIC LOAD TESTS DLTs and few confirming STATIC LOAD TESTS SLTs. They have already been treated in publications [REF] under a different context which is herein being partly revoked.

This second type of case is much more relevant to professional practice because the engineer involved is aimed at deciding and doing on the one hand, and because higher costs and responsibilities are involved at the other end. Moreover he mostly starts either by recognizing the near-zero experience of facing a new case, and perceived to seem different, or comes armed with some feeling of confidence in experience transplanted from other conditions not recognized to be different in relevant minutiae. However, it reaffirms the extreme importance of direct specific experience to be distilled into NON-DEF/EXC SP of prior – STATE: but it also simultaneously emphasizes how the prior-STATE PDF fractiles from the two determining extremes undergo progressive unavoidable adjustment by desire and decision during a typical reasonably controlled execution[69]. Finally it must be emphasized further that the mentioned S curve of development of experience pertains not merely to the ambit of international mentors, but also to regional and local scarcities, and, above all repeats itself in every single graduated engineer, who commonly accrues also the school’s biases and erraticities.

In gist one shall arrive at the practical conclusions towards foregoing or even discarding Bayes in favour of MCs, the importance of tapping interpretably and discriminatingly the data profusely

[69] One may be reminded that one of the most current and proficient methods of “deterministic dominant” intervention comprises conscious overdesign with bigger equipment and dimensions, at modest incremental cost beyond the fixed mobilization and installation. But the thousands of routine cases handled under such an orientation unnoticeably and chronically degenerate the profession and society’s quality of life.

available in Contractors' files[70], and the classical recommendations on the "pinching-in" procedures[71] for advancing in cognizance with responsibilities attached.

Within this category, however, one must carefully separate interpretable subgroups in order to minimize indiscriminate SP formulations, and MC or Bayesian successive adjustments that almost surely will never reach the very small NON-DEF HZs absolutely indispensable. No amount of proliferated testing (in real or mental tests) with single parameters of CIs of 70 or 80% (because of systematic and/or erratic errors) will ever yield approaching the 1:1000 ranges of HZs.

The case involves 30 DLTs (accompanied by 2 SLTs) obtained during prototype execution of foundations for scores of 5-storey buildings of a low-class housing development. The pertinent data of the DLTs are summarized in a frequency distribution diagram (in Fig. 2.11.2.1) representing the tops of the bar-diagrams of load ratios, bearing capacity to working load, coincidentally reaching the desired median of F=1.5. Within present interests the question of equivalence of SLTs' PERFs is not broached. The subsoil profile is schematically shown in the same figure. The singularities of the case involved the driving of long flimsy reinforced concrete piles that had to transpose the 4m of very soft clay recently loaded by a fill of city wastes including bouldery obstacles. The preboring can be promptly interpreted on the basis of driving conditions and obviating predicted negative skin frictions. The additional critical singularity concerned the point embedment and base capacity problem, because the relatively dense granitic saprolite also included moderately frequent core stones causing premature penetrability rejections and driving breakages. The foundation had to be of single piles per column, creating additional constraints on the execution, risking either insufficient capacity or possible driving breakages, mostly requiring substitution of the broken pile by two adjacent ones with the capping block. The prebored conditions greatly increased the HZs of driving breakages, by lack of lateral confinement. It was a very tight fixed-price bid price contract.

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[70] In professional practice each Company commonly concentrates on one repetitive technique chosen for investment and progressively adjusted in the mind's natural selection. Most PPCs on the contrary invite all parties to offer equivalent proficiency at a specific problem and procedure. Few have been the cases of greater fairness inviting free choices for similar performance and cost. In part this becomes an additional cause of the more disparaging results.

[71] In the "deterministic phase "of design computations, the minimal recommendation was to employ three comparative conditions, a maximum, minimum and an average one. It would reveal the sensitivity of the solution to the dominant parameter(s). With the exponential diffusion of computer use, such a practice should have become absolutely routine. One notes however, strangely that it has not been employed as expected; the fact seems to reflect the credence given disparagingly to numbers.

Altogether it embodied a recognizable very singular case on which experience from other normal friction-plus-base driven piling would prove very unrealistic or misleading.

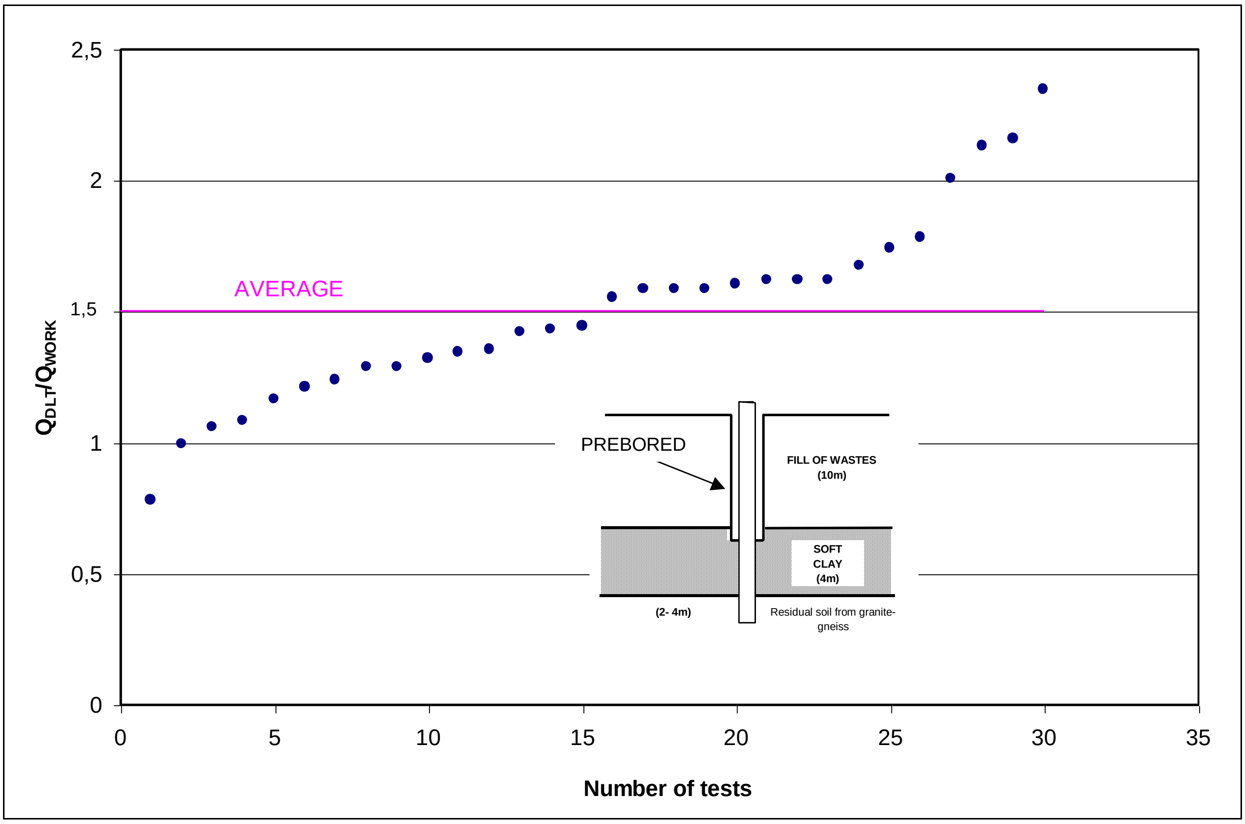


Fig. 2.11.2.1 – Basic data from driving 30 flimsy concrete piles.

In Fig. 2.11.2.2 one summarizes in a readjusted manner the analyses previously published, investigating with the entire PDF of ultimate capacity loads, the number of DLTs that should have proved sufficient. It had been concluded visually (a practice presently decried) that about 13 to 17 DLTs should have been sufficient, whether analyzed in the real chronological succession or by random incremented groups from the remaining data. Moreover the preference was confirmed for MC compared to Bayes regarding speed of reaching conclusions when liberated from the inertia of presumed experience, philosophically valued as a treasure in slow natural selection. Presently the analyses have been deepened and are presented in accordance with the updated posits of referring to ratios and incorporating SDs permitting estimates of CIs for HZs.

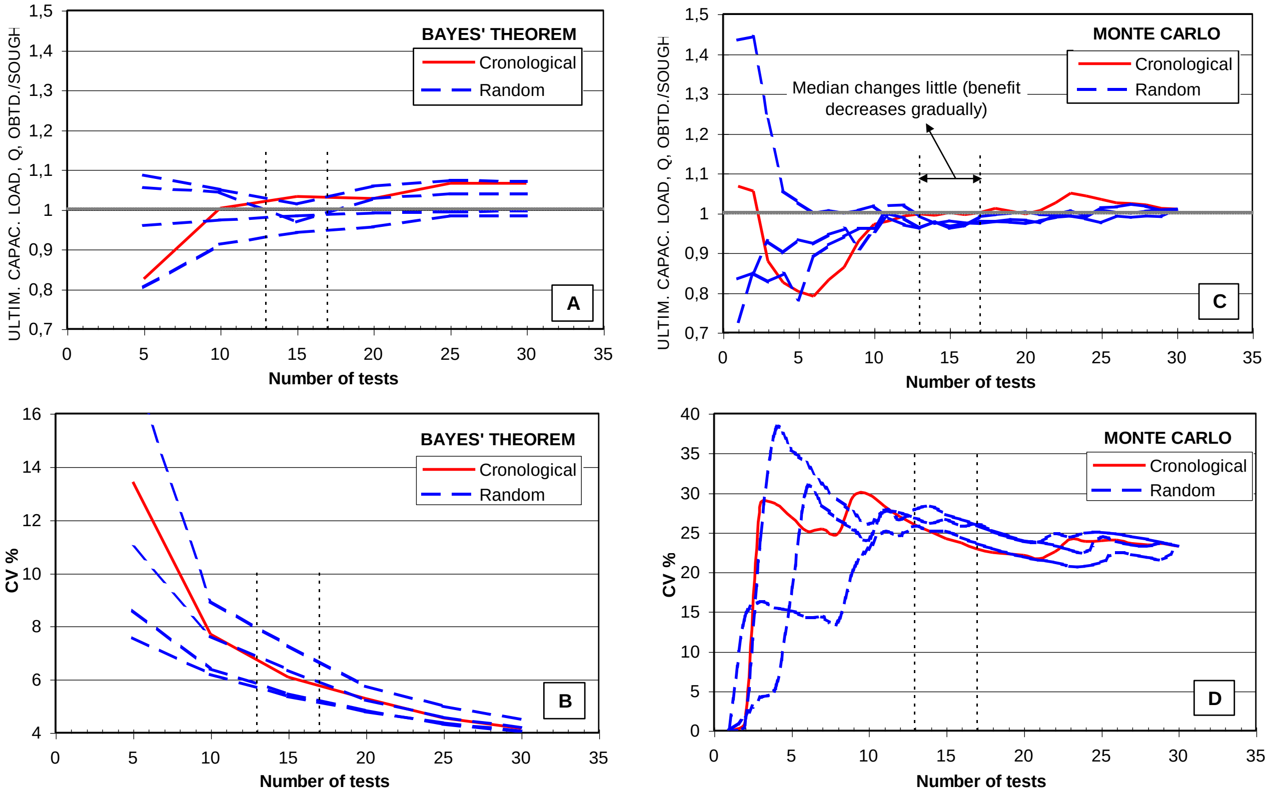


Fig. 2.11.2.2 – Comparative speeds and efficiencies of achieving decision levels sought: Bayes vs. MC

For the next step one repeats the conceptual procedures already followed and explained in detail in Figs (2.7.1.1 through). Fig. 2.11.2.3 presents the global PDF of the ratio of Qs, OBTAINED/SOUGHT for the design F. However as per convinced concept, the two fractiles of the global PDF, alternatively denominated as the optimists and pessimists, or better stated the NON-DEF and NON-EXC groups, have been separated. The concept fits perfectly the case on hand. One group, presumably with one universe of satisfactory pile driving experience is fearful of breakages and intent on achieving adequate DLT capacities with minimum driving energies: presumably the family of lower ratios of Q, denominated the pessimists (as already explained, reversible depending on which end of the problem is considered), would be generated by this approach. The opposite group with another self-satisfying conviction of no fear of breakages, but opposite fear of not achieving high enough DLT ratios of Q would have established the PDF of the "optimists". The one point in which the present case is conducted somewhat differently from that of Figs 2.7.1.1 – 2.7.1.2 is that the two partial fractiles, upper and lower, have been extended up to the median, because the goal should obviously be to optimize the PRE around the median, and to achieve simultaneously the minimum acceptable ACCs.

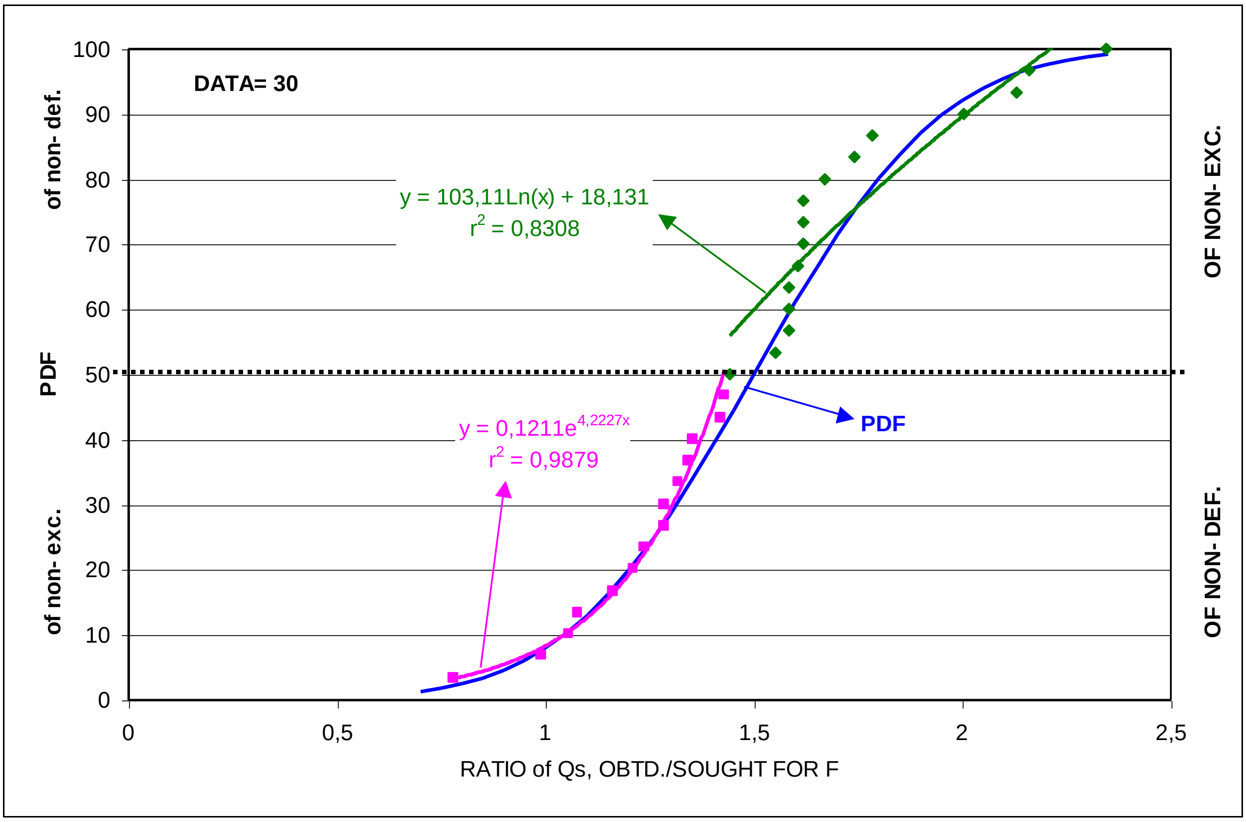


Fig. 2.11.2.3 – PDF of data, separated in non-exc and non-def.

The two distinct optimized regressions are shown in Fig. 12.3. Firstly the calculations were carried out with some conscious manipulations for reinforcing the important points regarding the indispensable need to view the quantifications by Bayes as mostly subject to qualms and rejection, (unless and until minute details of conditioning factors of the "experience prior-STATE" can be studied, analyzed, defined, and published a "check-lists" from Contractors and for Designers). It must be recalled that if load tests are required (by some CODES, most often not strictly observed) on 1% of the piles of a project, the Contractors' feel of experience is 100 times greater in number, although less precise, than what has hitherto been fed out to the profession in learned publications.

The reader is referred to Figs. 2.11.2.4 (A) and (B), described and discussed forthwith. Fig. 2.11.2.4 (A) analyses the progression from top down, while Fig. 2.11.2.4 (B) proceeds from the bottom up, in each case employing obviously its distinct regression equation. In each case for the purpose of exposing the degrees of influence of the possible conviction from prior experience, the first point was calculated and plotted using the hypothesis of a set of five similar values as pertained, in reality, to the single extreme PDF data points. The subsequent evolutions were computed comparatively for two distinct hypotheses, and by the two procedures under query, Bayes and MC.

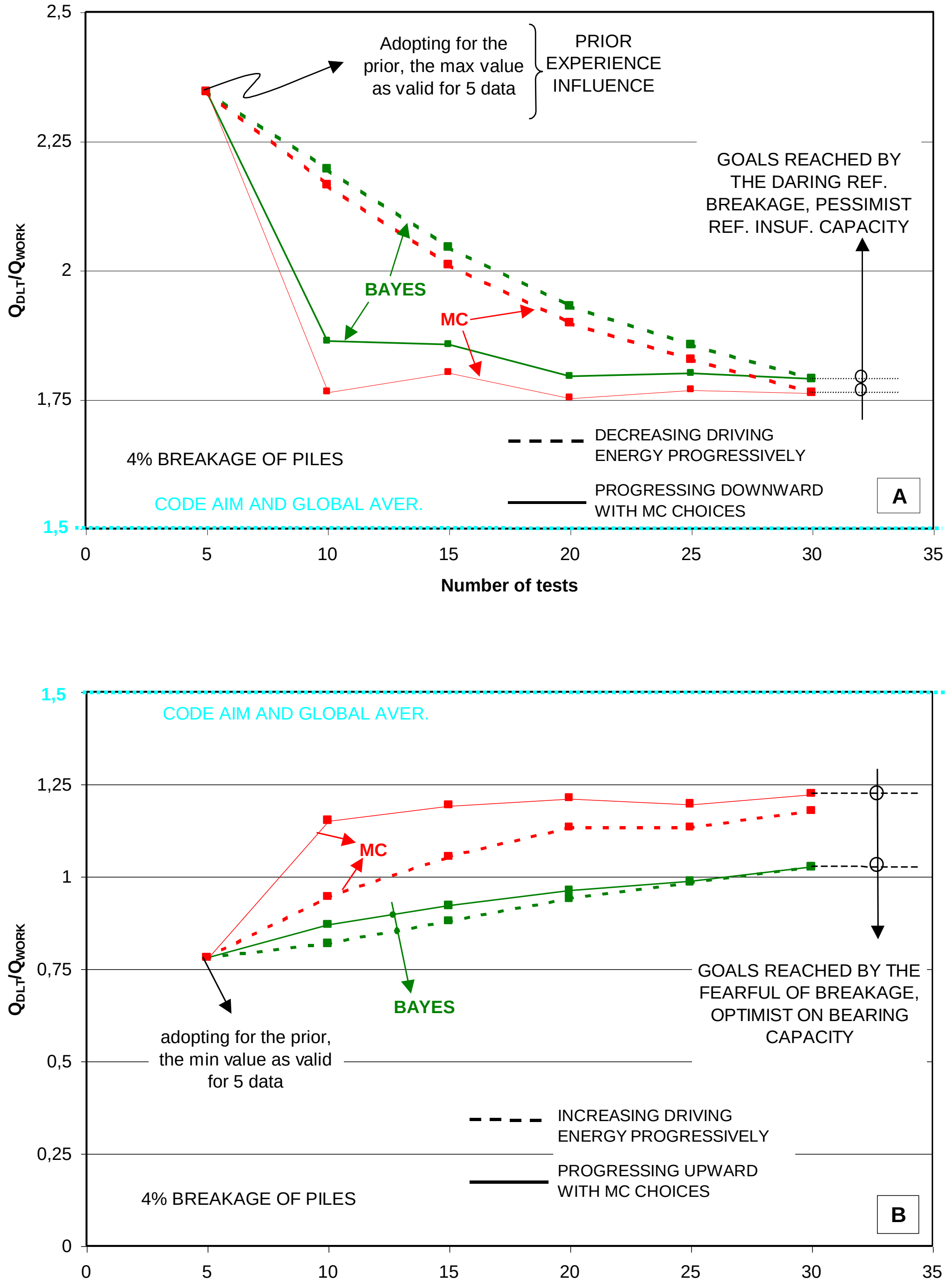


Fig. 2.11.2.4 – Comparative agilities of progressive adjustments, and results achieved for decisions. Influence of prior experience of suspect applicability.

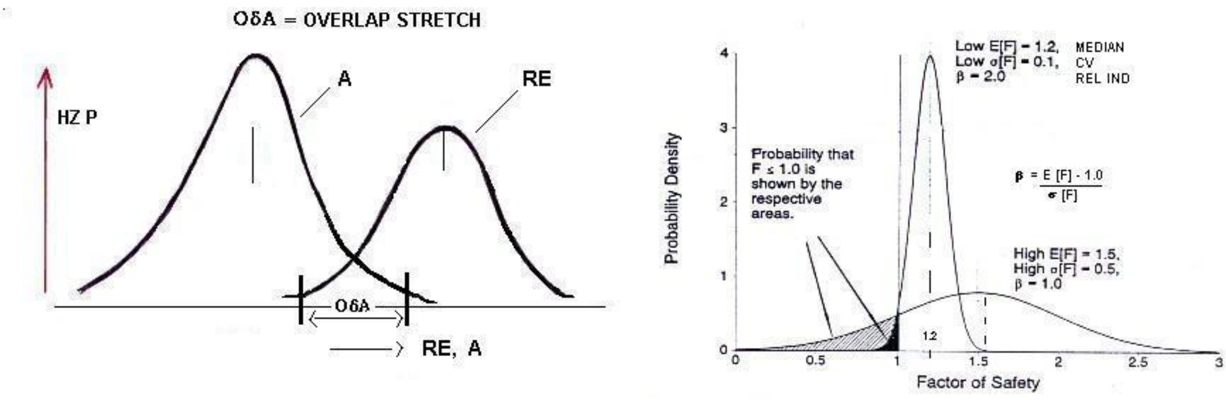
Moreover, the graphs have been developed for two distinctly different procedures, as derived from decision and eventual persistence or not in the erstwhile experienced conviction. In one case the successive groups of five incremental data were taken following downwards (or upwards) along the respective sets of data: it would represent a person who was so confident with his experience and predictability, and so afraid of reaching the unacceptable boundary, that he would proceed towards reaching the final goal of Non-EXC/Non-DEF on both counts, step by step. On the other hand the successive groups for the calculations were sorted out by MC.

The results are self-explanatory and patent. Firstly the same reasons abound towards rejecting Bayes in favour of MC, unless the presumed experience is thoroughly applicable to the level of sufficient perceived significant minutiae. This point reemphasizes the needs to tap the Ss from Contractors' files. Secondly the inertia inherent in Bayes' quantifications, as demonstrated, seems incompatible with geotechnique's constraints and present rates of changes of creative developments. Thirdly one notes the marked separation of the two goals, straddling the true calculated mean of about 1.5, as reached in accordance with the two opposite conditionings regarding decision: the operator concerned about bearing capacity and carefree about breakage would reach the final ratio of about 1.8, as compared with about 1.2 by the opposite viewer. But one must yet add the proviso from Fig. 2.11.2.4 (B) that the inertia imposed by Bayes' calculations has proved so dominant that at the end of driving the 30 piles with DLTs the asymptotic result is still being slowly approached.

In summarized conclusion one must note that in the great majority of real cases of engineering actions (somewhat differently from the robotized case of an imposed repetitivity as was the Liquid Limit case, Item 2.10.1) one cannot discard the significant interference of human conditionings of thoughts and actions: one cannot foresee relinquishing final results merely to the mathematics of numbers, which, in some levels of perception, would imply a digression from the very concepts of SPs towards decisions and actions.

2.12 Complementary Comments on the Reliability Index, REL IND Intellectually Inviting, and Most Cited and Posited in Quantified Developments.

Without any attempt or claim to more than moderate coverage, regarding either chronological primacy or depth of study of the subject and its inevitable advances, it seems sufficient to adopt [REF] as the important keynote lecture introducing the concept of REL from structural engineering into geotechnical engineering. In comparison with the more conventional concept of **safety as a purely linear ratio** of F = RE/A (also analyzed in that milestone paper) the salient feature of the REL IND would lie in the adoption of a **difference** between the two histograms, as schematically shown in Fig. 2.12.1 (M) (p. 365 Cornell). The REL IND in principle would thus be related to the area of superposition of the lower tail of the RE histogram with the upper tail of the A histogram as they shift towards each other. It is remarkable to not how far the REL IND concept has been promoted in comparison with CIs of HZs.



M, GENERAL **N, SLOPE OVER F ≡ 1.00 ≡ FAILURE**

Fig. 2.12.1 M, N – Schematic representations of REL.

As side issues one should record two principal facts entailed in most published applications to geotechnical stability computations:

(1) One, that most commonly the shifts have been applied to the median as an idealized simplification assuming that histograms would not change in shapes (medians and CVs) if/when the data-hypotheses-calculations would suggest possible shifts. In other words, as hitherto used it becomes a purely mathematical exercise. However, one posits that it should be just as feasible to apply the shifts to the fractiles corresponding to desired CIs of interest (as values of NON-EXC/DEF): and even between them, distinguishing, as the physical case might suggest, between CIs of means (ductile, averaging behaviours) or of points (preferential, brittle behaviours).

(2) Second, that the REL concept has been applied in a composite manner, including ratio and difference. A single composite histogram of F is mentally shifted against the reference axis of F = 1.0 to determine the residual area of HZ against the hypothesis that failure coincides exactly with FS ≡ 1.00. The starting qualm regarding the CIs on the "knowledge[72]" is complemented by a

[72] [REF] "A major application of probability has been in the determination of reliability of systems made up of components whose reliabilities are known. (The reliability of a component is the probability that it will function properly throughout the period of interest)". Almost deterministic?

repeatedly queried misconception inherited in conventional geotechnique. (cf. Fig. 2.12.1 (N)). One can hardly suppress querying the sore oversight, unsuspected and unperceived, represented by mixedly incorporating so blatantly deterministic a value as F = 1.00 at failure. The unquestionable earnest and studied intent, of achieving optimized evaluations of SP definitions of PERF, crash against this determinism and its value, obviously also a SP reality, and difficult to evaluate or ratify in field conditions, and predictably possessing a broad PDF essentially impossible to validate except by dogmatic definition.

Moreover it has already been repeatedly posited that failure (rigid-plastic) at F = 1.00, as a gross misconception, is increasingly so as the dimensions of projects have increased, even independently of assuming an ideally homogeneous and accurately known soil mass. One must duly respect the recognition, in geomechanics, of the importance of prior states towards cause-effect behaviours. Adding the significant variabilities and scarcity of data and knowledge, the only tenable stance is to calculate initial F_i, and causable ΔF, and thereafter asserting that FAILURE corresponds to final $F_f = F_i - \Delta F$ passing through 1.0. [REFs]

Finally, one must recall: (1) the early comments regarding apparent equivalences of several regressions and the caveats against extrapolations; (2) the erraticities and scarcity of data: (3) the great variabilities in Ps as one presumes to advance to the tails of histograms below about 10^{-2} Ps; (4) the critical comments of Item 6 regarding the type of INDEX and characterization GROUPS, and their lack of communicability and feel.

Thereupon it is posited to be quite beyond reason to lean towards REL IND on its own merits, absolutely inexpressive in comparison with the damage of shooing away almost the entire spectrum of professional geotechnicians from indispensable simple SP. One reverts to the hope and goal that additional geotechnical characterizations, parameters, calculations, etc..., do not delay in introducing a sufficient increment of defined and quantified intervening parameters (e.g. shapes and crushabilities of sand grains, besides grainsizes, and others such, already embodied in “mental perception” of experience) so as to reduce HZ Ps from around 5% to the desired and needed 1:1000 range.

Although the eminent KEYNOTE exhortation sprouted from the field of structures, built to specifications and very much better quality-controlled and documented, the key statements must be reproduced (taking the liberty to adjust, for subsoil conditions and parameters and calculations, from 10^{-3} to between 10^{-1} and 10^{-2} as optimally realistic): (say 10^{-2}). One transcribes (Ref. pg. 3) “are extremely sensitive to the distribution functions of RE and A ...” makes the precise determination of these distributions impossible” (pg. 5 However, for pf $<< 10^{-2}$, the designs again become extremely sensitive to the distributions of RE and A”, (pg. 11) “the theoretical risk models lack the necessary consistency when very small risks, $<< 10^{-2}$, are required for safety”.

2.13 Partial and Transient Listing of Well-Intended and Respected Advanced Postulations, for Discarding Summarily in Defense of Simplicity First

2.14 Closing Comments on Present Status and Minimal Proposals of Keynote Purpose.

As continuously posited in this general APPENDIX the fundamental needs for geotechnical engineering are to tie the wealthy backlog of civil construction of the past 55 years to a broader creative spectrum of indices and parameters to be analyzed by progressive pre-failure SP regressions with CIs, continuously adjustable in consonance with efficient applicability of the OM towards NON-EXC/DEF. compatibilizations of As and REs. To begin with, the following summarized data reflect the four dominant realities regarding:

a) the binding inheritance of determinisms on primordial indices and parameters employed with inescapable wide dispersions through single-parameter correlations and prescriptions;

b) extending such indices and pseudo-correlations, already seriously queried in the ideal soils (e.g. uniform sediments) from which and for which they were intuitively created, into grosser misuses in “problematic soils” in which reasoning and experience would reject them completely (such as dense saprolites) [BIBL];

c) lack of any routine use whatsoever of minimum profitably simple systematic analyses via SP in order to reflect the multitudes of repeatable pre-failure performances;

d) the abysmal distancing between academic and computational advances, exponential both in theorizations and in computer facilities, and the real sources of quantified data derivable from the files of EXECUTORS of the works, wherein EXPERIENCE is ipso facto moulded by need or desire;

e) the understandable rejection-syndrome generated towards global adherence to simple minimal SP by the periodic well-intended postulations of quite a separate and new refined specialization giving advanced indices of probabilistic characterizations to minute HZs (e.g. 1: n, 500 ≤ n ≤ 2000) though sprouting from the same conventional, crude, and erratic single geotechnical indices.

1. In the following tabulations of a survey one uses the abbreviations:

PESSP = poorly expressed simple SP

IAPSP = innovative advanced proposed SP

1.1 One could not look for a more propitious source than the two International Symposia on PRE--FAILURE DEFORMATION CHARACTERISTICS OF GEOMATERIALS (N.B. obviously the priority concern centered on Failure does not avoid going through undesired deformations), the 1994 Sapporo one, and the Torino 1999 one: the results of the eager cursory search revealed the conclusions given in the top part of Table 1.

1.2 Similar search conducted through the produce of four of the most prestigious international geotechnical journals Geotechnique, ASCE GT., Canadian Geotech. Jr., and Soils and Foundations, yields the results transcribed in the lower part of Table 1:

	Nr. Papers	Pages	PESSP	IAPSP
1.1. Sapporo, Japan 1994	147	1256	- - - - - - - - - - -	- - - - - - - - -
	146	1415	4 (pg. 33, 102, 420)	- - - - - - - - -
Torino, Italy 1994				
1.2. Géotechnique 2001	76	826	8 (pg. 472, 589, 624-6, 819-21)	3 (Aug., Aug., Nov.)
ASCE GT 2001	99	1084	18 (pg. 111, 401, 654, 865, 923)	4 (Aug., Aug., Aug., Dec.)
Canadian Geot. Jr. 2001	105	1367	42 (Feb., Aug., Oct., Dec.)	3 (Aug., Dec., Dec.)
Soils and Foundations 2001	56	747	1 (pg. 42)	- - - - - - - - - -

2. It is an excruciating personal task to walk on a very high tightrope between deep respect and affection for illustrious mentors to whom the profession and oneself owe so much, and positing the need to look up high, hopefully in earnest greater loyalty to an enhanced future.

Regarding a radically new proposal one must question oneself:

(1) does it answer important questions?

(2) are the assumptions testable and predictions verifiable, a posteriori but soon enough?

(3) is it consistent with first principles of logic and cause-effect mechanics and other less suspected interactions?

(4) is it practical, at least sufficiently to spread and prevail despite heavy inertias and rooted interests?

(5) does it open a door to the wealth of stored information to be profitably reanalized?

(6) will it survive the long period foreseeable of unperceived micro-benefits that will only slowly accumulate in quality of life for the immense silent majority, individually incapable of noticing or judging?

3. One cannot honestly be in favour of emphasizing the possibility of culmination of knowledge (abstract, and much less practically applicable) without recognizing and respecting divergences of views, the catalyst of progress. It behoves one to declare transparently not only the limitations of the scope of reference coverage and dates, but also one's subjective temporary offerable conclusions as but one earnest perception felt through laborious studies and intense experience. Many eminent papers from illustrious colleagues [REFs] have points both in common and in disagreement, and, in either case, because of well-documented as well as untenable reasons. One's purposeful well-intentioned message is offered, and is pursued throughout the chapters and topics through one's proposal's kern of accommodating both the accumulation of good average results and minimizing risks of highly damaging periodic episodes.

Principal attention must be given to the most recent pronouncements by the recognized illustrious vanguard of developers of the SP posits on the profession's behalf, as seen from the side of the indispensable specialization, evolving meritoriously from general principles. In particular one must respectfully refer to those who have progressed along the years in their refinements: and, if their visualized and intended applicability to the case of civil-geotechnical activity fails (in one's vision) to attend to its intrinsic problems, the fault is to a large extent of the two separate vanguard mentors, for having allowed the two specializations to progress in parallel, and progressively distancing. A few may be mentioned, and apologies advanced promptly to the others for the obvious lack or possibility of intent of adequate coverage.

Tang, W.H. et al, 1999 "Some uses and misuses of Reliability Methods in Geotechnical Engineering", in the Hong Kong Institution of Engineers Seminar on GEOTECHNICAL RISK MANAGEMENT, concur with one's posits in very many respects but do not seem to adjust their thinking to the great majority of one's works under serious constraints as essentially single cases, with minimal data, obliged to work with prototypes of great responsibility as if belonging to idealized homogenized cases.

Cheug, R.W.M. and Tang, W.H., 2000, "Bayesian Calibration of Slope Failure Probability" ASCE, GSP 101, Slope Stability 2000, 72-85 embody a significant advance with regard to (Refs do Christian) the adoption of the deterministic definition of failure at $F \equiv 1.00$, relying on PERF records of 80 cut slopes in a specific geologic formation, separating in a 13-year record the failed and non-failed cases. The design requirement of a new cut slope is to sustain a rainfall of a 10-year return period. The net result is an "expected probability of failure will be 0.18% per annum" which would seem reasonable (1.8 per 1000), but for an operational period of 30 years (minimum of interest to the population) would correspond to 5.4% total, hardly satisfying. The required simplifications are yet too many (VMello Ref. Hong Kong 1972) and the posited caveats against Bayes and REL IND are not dispelled, neither is the lack of the concept of ΔFS passing through the failed/non-failed definition, even if dissociated from $F \cong 1.00$.

Tang, W.H. and Cheung, R.W.M., 2002, "Bayesian Calibration of Failure Probability from Observed Performances" 10^{th} IFIP WG 7.5 "Working Conference on Reliability and Optimization of Structural Systems" again indicate close affinity with one's points and advance further the crusade in favor of two instruments, Reliability and Bayes' Theorem but digress perceptibly when encompassing soil cut slopes within the family of structures, adopt an eventual neat separation (questionable) of fail/not-fail, alongside with Bayes, without incorporating trends of continuous variations with ageing and successive effects of stressing episodes, among other important intervening factors.

APPENDIX

Reconstructing a practical comparative Geotechnique for the immediate future, using a minimal basis of STATISTICS-PROBABILITY (SP) broadly inviting for all facets of its professional challenges. These must be referred to probabilities of HAZARDS (HZ) and RISKS (RK) intelligible to the common sense of clients, society. Concomitantly seeking to rationalize the rapidly mounting chaos of the multiple "schools of academic-professional solutions" of conventional SOIL MECHANICS.

1. GIST OF THE MESSAGE.

1. There is unanimous recognition that performance predictability in geotechnical practice is very poor, involving multiple co-persisting distinct models, theories and calculations employing pseudo-correlations. These result in prescriptions and intuitive FACTORS OF SAFETY (F), mostly consecrated with no probabilistic bases.

2. Physically patent periodic unfavourable performances derive mostly from human errors. However, undesirable model errors of over-conservatism abound throughout, understandably from prudence imposed by primordial ignorances. The resulting overcosts, unperceivable to society, accumulate into greater loss than accidents. Occasionally the two losses even occur unexpectedly compounded in the same project.

3. Conventional geotechnique developed around single parameter correlations, with many parameters intuitively posited, others well studied, but for idealized test conditions and the premisse that real conditions should resemble those idealized, except for secondary details. It is indispensable to revise markedly.

4. In truth every single natural condition is different unless proved acceptably analogous to others already experienced. Hitherto prioritized parameters seldom achieve precisions and accuracies within ranges tighter than about 20-30%, i.e. CONFIDENCE INTERVALS (CIs), of non-exceedance or non-defaulting, less than the 15-10% separate cumulative frequencies each. The herein denominated CIs are only nominal in the light of the recognized theory of statistics, but are retained for pragmatic reasons as expatiated in topic 7.2.

5. Geotechnical works, forced to abandon classical requirements of presumed ZERO Hazard HZ, are required at least to respect extremely small hazards, e.g. 1:1000 etc... Simple optimized regression equations suggest the best solution, but with important caveats, for widespread use. This is an absolute need in the face of countless complexities and erraticities, and decision optimizations between fewer studies by special ists, and more numerous statistical samples of unselected approximate professional realities.

6. Unquestionably engineering is based on the RELIABILITY of design-construction. Such reliability ensues from the ACCURACIES (ACCs) and respective CIs expressed in terms of 1:x probabilities, reasonably understood by society, the ultimate client. The other components of a project choice, that are specifically the benefit/cost optimization and logistics, are not broached herein.

7. There is an immeasurably wide dispersion of conditions encompassed by Nature's complexities and erraticities. Thus for instance, an embankment dam's foundation investigations embody immensely different probabilities of errors as compared with the carefully controlled execution of its superstructure. It is therefore clearly quite untenable to use by routine a single presumed F value encompassing both components of the problem. The separate parameters have to be judiciously adjusted into compatibility.

8. Every case is different, mostly comprising some extrapolation. There is nothing more deterministic than an equation, even if it be derived by a good global SP regression, accompanied by its CIs either of averages or of individual points, as dictated by the “physics” of the problem. With each and every extrapolation complementary and changing prioritized parameters take over dominance on the problem.

9. In lieu of global regression equations of PROBABILITY DISTRIBUTION FUNCTIONS (PDFs) to represent the full range of performance, separate regressions are posited for the upper and lower fractiles, of NON-EXCEEDANCE (NON-EXC) and NON-DEFAULTING (NON-DEF) probabilities.

10. The choice between CIs of “points” or of “averages” is based on an assessment if the behavior is perceptibly conditioned by a singularity, or may be attributed to cumulative participation.

11. The desired low risks are only achievable by the multiplicative rule of Probabilities by incorporating, say, five intervening parameters of 25% dispersions. Based on countless piecemeal research papers without much exertion the additional parameters to incorporate, as perceptibly proven, can be found for trials.

12. Comparisons are made between the conceptually irrefutable philosophy, much adopted, of Bayesian prior-to-posterior probability advances, and the alternate method of advancing provided by MONTE CARLO (MC) sortings. The conclusions turn out very consistent and convincing. Where there is valid experience it weighs heavily against change, a situation favouring Bayes’ Theorem which advances slowly, practically fails to set a revised conclusion but embodies noticeably lesser variabilities; it reemphasizes the dearth of, and

thirst for, back-analysing the data-banks of project executors. But in most conditions of naturally seeking ingenious engineering, experience starts as zero; it thus imposes needs of test sites and an initial minimum of pilot executions and tests even for the earliest positing of Standards, Precedents, and Codes. MC sortings advance towards medians much more rapidly, though apparently without tightening the CIs.

13. Data and experience are not only erratic, and forever scarce, but principally involve questionable and unsuspected differences between theoretical and design models, and prototype realities. It behoves one to tap the wealth of ratios (of about several-hundred to one) of subjective experience on prototype field conditions stored in the files of executors. Progressively adjusted regressions on prefailure conditions are most inviting. Data of lesser accuracies ACCs can be evaluated statistically, to be coupled with parametric variations on insufficiently quantified parameters for assessing the degrees of relevance. The principal caveat is not to mix conditions physically interpretable as differentiated.

14. In many a situation the automatic mathematical integration from (dx, dy, dz, dt) conditions of soil elements at positions $(X, Y, Z, T)_m$ in the soil mass must be queried as leading adequately to the physical behavior for positions $(X, Y, Z, T)_n$ or for integrating $1\rightarrow n$ $\sum_{1\rightarrow n}(dx, dy, dz, dt)$. Pure mathematics of differential and integral calculus may often fail to encompass important differentiations of the prioritizing parameters, as additional parameters taken as unquestionably intervening, begin to be incorporated.

3. ABBREVIATIONS

Statistical-Probabilistic	SP
Statistics	S
Statistical Regressions	SR
Probabilistic Prediction	PP
Adjustment Coefficients	ACs
Prediction vs. Performance	PPCs
Standard Deviation	SD
Probability Density Function	PDF
Coefficient of Variation	CV
Confidence Intervals	CIs
Factor of Safety	F
Serviceability Limits	SLs
Hazard	HZ
Risk	RK
Action	A
Reaction	RE
Constitutive Equations	CON EQs
Observational Method	OM
Precision	PRE
Accuracy	ACC
Reliabilities	RELs
Factors of Guarantee	FGs
Factors of Insurance	FIs
Performance	PERF
Non-exceeding	NON-EXC
Non-Defaulting	NON-DEF
Factors of Confidence	FCs
Factors of Precaution	FPs
Limit Equilibrium Method	LEM
Sensitivities	St
Cone Penetration Tests	CPTs
Extreme Value Probability	EVPEs

Equations	
Monte Carlo	MC
Relative Density	RD
Optimized Grainsize Distribution	OGD
Angular Grains	AG
Mineral Crushability Grains	MCG
Stress Levels	STL
Reliability Index	REL IND
Bayes	BAY
Dynamic Load Tests	DLTs
Static Load Tests	SLTs

TOME I. SOIL BEHAVIOR FUNDAMENTALS OF EFFECTIVE SIGNIFICANCE FOR FEASIBLE ENGINEERING OPTIMIZATION

1. Preface

2. Introductory Comments

3. Elements of Rock Formations Consequent to Civil Engineering

Elements of Rock Mechanics, and Weathered and Laterized Materials.

4. Elementary Principles of Soil Formations, and Relevance

5. Physical Indices

6. Stresses in Soils in Horizontal Masses and Idealized Homogeneous Infinite Slope Conditions.

7. Soil Classifications; Inferences, Prior and Posterior

8. Elementary Terrain Evaluation, Geomorphology. Seisms, Volcanoes.

9.Subsoil Reconnaissance; Soil Sampling

10. Seepage, Flow, Capillarity, Suction; Problems, Solutions. Importance of Viscosity to Effective Stress. Piping, Filters, Clogging.

11. Deformability, Delayed Deformation, Consolidation

12. Strengths of Soils; Shear, Tensile. Liquefaction.

13.Stress-Strain-Time Transmissions in Soil Masses

14. Compaction, Chemical Treatments.

15. Principal Materials, Behaviors, Constitutive Equations. Correlations. Unsat, Residuals, Saprolites, Evaporites, Laterites.

16. Specific Investigations. In Situ Tests. Correlations

TOME III. FOUNDATIONS, CONTAINEMENTS, UNDERGROUND STRUCTURES,TUNNELS.

1. Preface

2. Introductory Comments. Limit State Design, Standards, Codes, ISO, etc

3. Shallow Foundations. Bearing Capacity. Load Tests. Direct Footing Settlements and Allowable Pressures. Size Effects. Composite Settlements Including Deeper Compressible Strata.

4. Loaded Deep Plates, Settlement and Failure. Lateral Resistance. Caissons. Negative Skin Friction.

5. Large Bored Piles, Composite Lateral and Point Bearing, Loads and Deformations. Varied Execution Methods and Comparative Effects, Concept and Practice. Correlations, with In Situ Tests, and Comparative.

6. Precast Piles. Drivability and Penetrability. Driving Controls and Design Inferences. Dynamic and Static Load Tests. Standards and Codes.

7. Special Pile Types. Driven Cast-In-Situ. Grouted and Grouting-Preloaded. Root Piles. Barretes: Diaphragm. Underpinning. Soil Reinforcement for Load-Bearing.

8. Settlement Calculations of Principal Foundations. Allowable Settlements for Structures, Depending on Foundation.

9. Deep Excavations, Flexible and Rigid Walls. Strutted Support. Anchors. Deformations. Base Failures. Uplift Control.

10. Lateral Loaded Piles, Deformations, Coefficients of Reaction, Sheetpiling.

11. Pressures on Rigid and Flexible Culverts, Excavated in Soft Ground, or under Cut-and-Cover Fill. Cellular Cofferdams. Elements of Silo Behaviors.

13. Tunneling in Soft Ground, Soils and Weathered Rocks. Conditionings by Adjacent Destabilizations. Consequent Deformations, Deformations Transmitted to Overlying Foundations, and to Surface.

14. Tunneling Procedures and Treatments. Drainage, Partialization of Excavation, Primary Lining. Floating Tunnels

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