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The zest of holistic civil-geotechnical engineering job decisions

Victor de Mello

University students face inexorably biased messages in their search for their professional calling. The truth is that one must choose one's love and love one's choice: one cannot love a misrepresented life partner.

The biases are inescapable: increased recourse to expensive construction equipment and to sophisticated calculations on idealised theories, and publication only of special successes or failures.

Yet civil engineering is mostly concerned with jobs that have no thesis to propound and no advancements to document: just the art of diagnosing, deciding despite doubts and determining a course of action on the basis of valid principles digested and gut instinct. And it is the rewarding feeling of an aim fulfilled.

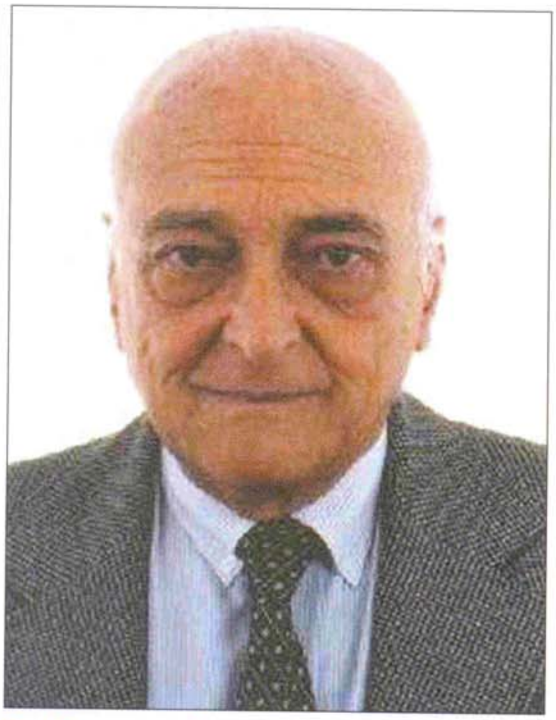
Today's overriding priority of pecuniary benefit/cost ratios has lessened the profession's sense of purpose, and macroproduction has lessened its sense of identity.

In the brave new world immediately after the Second World War, there was an emphatic distinction between the exponentially successful military engineering, aimed at destruction, and its civil counterpart, dedicated to construction. Their similarity lay in the urgency of the need for decisions and action. Brazil, for instance, was forced to grow from 42M to 160M inhabitants.

Writing about it now reminds me of the challenging pace I faced there as an immigrant from Goa in 1949. The rate of changes imposed by modernity means the brave new world imprint never ceases for dedicated professionals.

Why does one accept tasks of such momentous responsibility? Passion, principally. We are humans, citizens of nation, region and world; and for happy and rewarding creativity, passion is the driving force. Love your profession, love it knowing what its vector really is – the moulding of nature (rediscovered as environment) for optimised benefits to mankind.

We belong to nature, not nature to us. We do not inherit it from our grandparents, we borrow it from our children. We embrace professions to be better citizens and humans, not the opposite. We accept a specialisation to become better professionals. Like all others, we make mistakes, but the intentions which matter should lead us to correct them and avoid situations that are irreversible or too repetitive.



For happy and rewarding creativity, passion is the driving force. Love your profession, love it knowing what its vector really is – the moulding of nature for optimised benefits to mankind.

Above all, through steadfast principles and rapidly adjusting practices, dignify your professional activity and stand proud of it, considering (and exposing to public assessment) the alternate solutions in the prevailing context.

In advanced societies there is an automatic subdivision of tasks among several specialisations. There has to be a score, and conductor, for a symphonic orchestration, and every player must be fully conscious of their own performance and its limits. In developing countries the conductor (and, very often, soloist) tends to be the civil-geotechnical engineer. Civil because of the holistic responsibility, from investor and project to end-use, society and nature; and geotechnical because of the dominant complexities that support everything that comes on top.

In the holistic task we gratefully receive the contribution of critics because the ever-different prototype nature and our clients are the severest critics.

Most major projects in advanced countries rely on considerable volumes of tests, criteria, and analyses, but there are emergency situations in which distilled professional experience has to go back to the simplest principles of physical geomechanics, logic and uncommon "common sense".

The examples I give below, not without a shudder at the apparent egocentricity, are merely aimed at emphasising aptitudes plus passion, for generating an exhilarating vicious circle as work becomes a delight, success probable; and aptitudes whetted make success addictive.

This is tempered by the knowledge that in this profession the fleeting elation of achievement is accompanied with a humble perception of what was learnt, was wrong but spared by luck, could be corrected or improved, and how in redoing a similar case it will never be fully repeated.

Multiple first

One is carefully taught not to mix different foundation types in the same structure, but in this case I reinterpreted the dictum as "one must not use differently behaving foundations". This daring relied (as it often does) on intuition, such as basing everything on SPT subsoil profiles – no special testing and monitoring was available locally.

A narrow strategic lot in downtown São Paulo, involving a 16m difference of levels on a 45° slope, was the site for a hurried investment – a 16 storey car park built to take advantage of the city's fourth centenary celebrations in 1954. The narrow 12.4m wide entrance at the higher street and the earthpressure loadings suggested a steel structure, the first in the country.

Speedy construction required a simultaneous descent (top-down) of the seven basement floors while the upper nine floors also progressed. For temporary support special steel piles were driven, later becoming building columns.

During construction, support was provided by the net depth pile length below final excavation, but for permanent foundation the column piles were incorporated into reinforced concrete footings. The few very heavy columns needed for the big spans of the entire structure had to be installed into pneumatic caissons.

Finally, because of the eccentric peripheral loading in the narrow upper part of the lot, it was more economical to use an arched "raft" foundation (concave upward), minimising the concrete and reinforcement. In short, besides the innovations in materials and construction sequences, the building used every type of foundation: piles, footings, caissons and raft.

Monitoring has shown performance free of any cracking and displacements, either of the adjacent buildings or the new structure. A brief summary of the project was published in the London 1957 International Conference. An immediately adjacent 11 storey building was on footings.

Hydrologic-hydraulic tunnelling challenge

Geological investigations for a big earth dam had indicated a talus weathered insitu, and in 1956 tunnelling was much feared, especially in such subsoil. Shafts were an inviting option, as there was an underground powerhouse in rock.

Hydrology, hydropower discharges and maximum spillway floods proved to be of surprisingly manoeuvrable proportions. A single diversionary tunnel was driven, with a short elbow bypass at mid-length. With appropriate concrete plugging, the two permanent hydraulic circuits (operation and spillway) were integrated into this single tunnel. The upstream stretch of the tunnel connected to a shaft (in rock)

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down to the powerhouse. The downstream stretch was used for discharging the spillway flows descending from a morning-glory crowning another self-stabilising shaft through the residual soil. The geomechanical problems of tunnelling, underground structures, and embankment dam, meant that good interactions with meteorology, hydrology, and hydraulics could not be ignored.

Geotechnical behaviour in fast and steep raising of an embankment dam.

In 1959 construction of Brazil's new capital Brasilia was being pushed forward in 24-hour schedules and the paramount need was for the earth-rock dam for the lake.

There had been great difficulties and delays in starting the job, which was designed and supervised by a foreign company.

On May 1 there was a strike

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and the President of the Republic "drafted" us to take over, with local contractors to start construction on the spot: one for the compacted rockfill shoulders, another for the core and filters transitions.

The diversion gallery was accepted as completed. The quarries gave less than 30% rock, 70% was weathered sand and silts.

The core material was very clayey, and suspected of giving high construction period pore pressures, such that stable computed slopes were supposed to be flatter than 1 in 3. Two months of the dry season for core construction, from mid-March to mid-November, had been wasted. Core typical index parameters were WL = 70% and Proctor optima (1.38 t/m3, Wopt 43%).

Around the end of August the President's personal engineer-in-charge began to feel optimistic and asked us to close the diversion gates in commemoration of the President's birthday in mid-September The upstream rockfill had reached 15m height, the core about 8m, and the downstream shoulder about 3m.

Quick hydrologic-hydraulic calculations showed the plan's impossibility because of inevitable early overtopping, even with dry-period flows. The previous

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year a major dam, Oros, nearing the top, had suffered a catastrophic overtopping failure. It became imperative for the core to reach the elevation of the rock sill of the spillway.

Even at full speed, construction rates could not meet the requirement unless the slope was made much steeper, leaving the downstream half of the dam's section for later.

The unsaturated porous red clays of the borrow revealed unexpectedly favourable behaviour, quite contrary to that inferred from the index tests. Triaxial tests and recalculations were quickly finalised.

The downstream slope of the core was steepened to roughly 1 in 1.25, and the compacted fill raised roughly 35m in 42 days. A sudden flood in early November filled the reservoir to nearly 3m below the spillway excavated rock sill, and catastrophe was avoided.

The slope was executed with frequent berms, with wooden ditches to catch rain runoff, for fear of erosion. One learns from experience. The borrow excavation could not avoid some bigger clayey clods, which segregated towards the steep downstream slope.

There was no erosion, and practically no runoff: the short intense rains were fully absorbed by the clods. Incidentally, after the rainy season the downstream shoulder of the dam was completed with an inclined filter against the downstream temporary core slope, and with compacted clay on the 1 in 2 permanent slope destined for the rockfill. This produced a major saving because of the awful quarry production and very much cheaper compacted clay. The case was very briefly reported, among others, in a paper at the African Regional Conference, Durban 1975.

Conclusion

There must be zestful participation, involvement, commitment, and dedication. As civil-geotechnical engineers we must always be prepared for surprises, hopefully not for dismay. One basic aim in accepting a function is to do the best one can: the other, no less important, is to do everything possible to make oneself unnecessary.