SZÉKELY ENGINEERING
EXPLANATIONS & EXAMPLES

Dimensional Analysis and Engineering Formulae *or* How does the "A" in Civil Engineering's Q=CiA yield storm flow in cubic feet per second from rainfall in inches per hour and site area in acres?

Dimensional Analysis is the process by which, keeping our units straight, we can express numerical values in one set of units to an equivalent numerical value in another set of units, such as in the conversion of a velocity expressed in miles per hour to the same velocity expressed in feet per second, or, my favorite (most useful for turtle races), furlongs per fortnight.

A diversion which may explain my concern with formulae handed down from on high:

Back in late 1980 or early 1981 when I was permitted to sit for the Professional Engineering licensing examination on the basis of 12 years *acceptable to the Board* experience, I had been a senior electrical designer, dealing with the trig and complex numbers necessary to account for reactive power in AC power systems, and dealt with those exam questions related to fields other than electrical engineering via what I'd learned in my high school Physics, Chemistry, Advanced Algebra, and Introductory Calculus courses as well as correspondence courses which included statics, dynamics, and engineering economics as part of their non-accredited electrical engineering curriculum.

My very first engineering-related job (my file clerkship in Bechtel's NYC office ca. 1963-64 doesn't count, though I returned later as an electrical designer) with a consulting engineering firm was ca. 1965-66 with Jansen and Rogan in NYC where I was able to start as an electrical draftsman (the uppity 'draughtsman' spelling of my earliest newsletters does not apply here) because of having taken a mechanical drawing elective in high school, working my way into becoming a designer because of having at my previous job gone through AT&T's Long Lines Plant Craftsman basic electronics course.

This is all to preface the fact than when, upon becoming licensed in April of 1981, I hung out my shingle as a Professional Engineer, I had to rely moonlighters for HVAC, Plumbing, and Sprinkler design because all my experience had been in electrical engineering and design.

As those of you with whom I've spoken may recall me saying, I was dragged, kicking and screaming into doing my own HVAC, Plumbing, and Sprinkler design and engineering because the two things my moonlighters turned out to be best at were being late and being wrong.

Because of that I've had to teach myself things such as heat loss and gain calculations, affinity laws, sprinkler hydraulic calculations, etc., etc.

Ending the diversion and getting us back to the point in the headline of this piece, storm water system engineering, per the equation in the headline of this piece, where stormwater flow in ***cubic feet per second*** ('Q') is equal to the site area, ('A') in ***acres***, times the rainfall intensity, (i) in ***inches per hour***. (The 'C' in the equation a coefficient indicating how much of that rainfall actually runs off the area rather than being absorbed.).

I was more than a wee bit confused.

When one has to teach oneself, understanding is no longer merely useful, but, as I learned from sad experience in the design of a good-sized hydronic heating system some decades back, crucial.

To get cubic feet per second (cfs) of runoff, inches per hour of rainfall would have to be converted to feet per second (straightforward), and multiplying that result by the area of a site in square feet, would indeed yield a result in cubic feet per second. In forms of the equation where a site's area is given in square feet rather than acres it becomes understandable, where inches are subunits of feet, but acres?

Though what follows did not come to me easily, an acre ***is*** *43,560* square feet, and with a foot being 12 inches and there being 3600 seconds in an hour, *43,200* (12 x 3600) would thus be the dimensional conversion constant needed to convert from inches per hour per square foot of runoff to cubic feet per second per acre of runoff; not an exact conversion, but an approximation about 99.2% of the actual value, which is, as the saying goes, close enough for government work.

The New York City Department of Environmental Protection's 126-page Stormwater Manual, published this past February, does a much better job of explaining stormwater engineering calculations than does their 17-page 2012 Criteria for Detention Facility Design, (a much earlier 6-page version of which was my "textbook") in, among other things, specifying the calculations be done units of square feet for the site area, and explaining (sort of) how to get from the inches per hour units of rainfall to the cubic feet per second units of runoff.

The 2012 document referred to above, however, still led off with the flow equation in this piece's headline from the original 1973 paper, where the site area is expressed in acres, and considers something called 'allowable flow' to the sewer system – a locution appearing nowhere in the aforementioned Stormwater Manual (though it's defined in 2012's 15RCNY19.1, rules for sewer system connections), nor in the similar 496-page New York State manual, in keeping with their focus upon on-site stormwater retention.

To put a point on it, the new Stormwater Manual explicitly states that it supersedes (". . . replaces . . .") the earlier documents.

This is quite a change, where allowable flows from sites up to a bit less than a quarter of an acre (10,000 square feet or less), had been allowed a runoff from 1.75 cfs to 3.5 cfs, depending upon the capacity of the sewer system. Site release rates are now limited to no more 1 cfs ***per acre*** into a dedicated storm sewer (I know of none though I recently thought I'd found one), and a tenth of that into a combined storm/sanitary sewer, regardless of earlier purported sewer system capacity.

This is probably a good time to be in the drywell business.

Engineering Catalog Data, Submittals, and Commissioning

Back when I started in this business, I was amazed (not to say upset) by designers who specified equipment and systems which were then designed by manufacturer's reps during their visits to our offices rather than by the designers.

Not only that, these reps were then invited to review submittals and advise the designers the basis for which substitutions could be rejected so the order would be placed for the specified items, thus ensuring the rep's commission.

Granted, the designer's quid pro quo amounted to no more (that I knew of) than a free lunch every time the rep came around, and while I like a free lunch as much as the next guy, it put such a bad taste in my mouth that I have never called a rep into my office while I was designing. if catalog data was insufficient, I would phone the rep, who not infrequently passed me on to a factory engineer as my questions were, often as not, over his head.

Lately, I have had more and more situations where even online catalog data has not kept up with, or not clearly explained, a manufacturer's latest changes, with the result that I've had to deal with reps who in some cases appear to be almost as lost as I.

Even worse, I recently had an experience where I discovered Siemens USA seems to have no engineering reps – only distributors – some of whom are even more clueless than the average engineering rep I've run across. So, I called their national customer care phone number, where I got a recording telling me their mailbox was full.

Great.

Ultimately, I found a distributor who was able to answer my question – I think.

Since my 2005 newsletter on commissioning I have finally had a project where such is required for the HVAC system, with the project being small enough *(just* under 10,000 square feet) that I'm not required to be 'accredited' (quoted to me at $7,600.00!!!!! last September) as a Special Inspection Agency in order to perform said commissioning.

While commissioning involves a bit more than system balancing and a balancing report, as seen in the project's Commissioning Plan, accreditation apparently is either a much more time consuming process, or requires years and years of study for one to become qualified to perform such services – ***or*** maybe it's so costly because supply is so ***severely*** limited.