ΑΝΑΚΟΙΝΩΣΕΙΣ ΜΗ ΜΕΛΩΝ

ΜΕΤΕΩΡΟΛΟΓΙΑ.—**Estimation of the concentration time for the computation of storm drains by the rational method,** *by G. P. Karakassonis*. Ἀνεκοινώθη ὑπὸ κ. Δ. Λαμπαδαρίου.

The time-intensity rainfall curve is used for the design of storm drains. This curve has usually the form

$$i=\frac{a}{b+t} \tag{1}$$

where a, and b are arithmetical standards resulting from the plotting of the time-intensinty rainfall-curve of the area under consideration and from the frequency adopted (ance each year, once each 5 years, etc.), i represents the intensity of the rainfall for the stated time t.

The determination of the disharge of the drains / / / / / / / / / / / through the rational method is now simple and based on the formula:

$$q=i\cdot\varphi\cdot A=\frac{a}{b+t}\cdot\varphi\cdot A \tag{2}$$

where φ is the runoff coefficient and A the area tributary to the sewer at the point of the estimation of the discharge.

The arithmetical standards a and b, and the runoff coefficicient φ are sizes fixed by the designing engineer by means of more or less elaborate work and are not discussed in this paper.

The time t, entering in the above formulae and usually called *time oj concentration* needs a closer consideration. This time t is universally adopted to be made up of two components: the *inlet time* t_i i. e. the estimated time required for (the) rainwater to flow over the tributary area from its most remote point to the first inlet, and the *flow time* t_f required for (the) water to flow from the first inlet of the system to the drain the discharge of which is to be estimated. The computation of the size of the drains is then simple by the usual trial method.

The inlet time t_i, which theoretically is the time of concentration in the inlet is usually arbitrarily adopted. According Metcalf and Eddy[1] it includes various retarding influences. The same authors in an example of

[1] *American Sewerage Practice.* New-York 1928. Volume I, p. 320.

design adopt $t_i = 20'$[1], while in their textbook[2] they suggest $t_i = 15'\text{-}20'$. Imhoff[3] adopts the same rate $t_i = 15'\text{-}20'$ for the inlet time. Metcalf and Eddy[4] give further the inlet time used for the design of storm drains in various american cities as follows:

TABLE I.— *Inlet time used in various cities.*

Baltimore Md.	4-10'	Manhattan	N. Y.	4'	Portland Ore.	5'
Boston Mass	5'	Brooklyn	N. Y.	5'-10'	Rochester N. Y.	5'-10'
Philadelphia Pa	3'	Queens	N. Y.	5'	(usually)	7'
Chicago Ill.	15'	Bronx	N. Y.	10'	San-Francisco Calif.	3'-5'
Cleveland Oh.	7-8'	Richmond	N. Y.	5'-7'	Washington D. C.	5'-12'

This table shows that the inlet time used on various designs has a smaller value than the one suggested in textbooks and is practically still too small. If we consider as inlet time the time necessary for rainwater to flow with constant velocity on the roof and street gutters we will find that for a length of 100-125 meters of city blocks this time will amount $= 5'$ to $6'$ approximately; to this time various retarding influences must by added.

Of these retarding influences the time required for the water to go through the inlet structure was considered the most important. But under a modern drain system the inlet structures can be so designed that this retarding factor may be reduced to a minimum.

Much more important as a retarding influence must be regarded the *accumulation* of water on the wetted surfaces and their depressions. A part of the rain water will be absorbed, in the very beginning of precipitation from roof-tiles, walls of buildings, leaves of trees, sidewalk and street pavements etc., while another part of rhe rain will fill all the depression of said surfaces. Besides, for the formation of any runoff, the rainwater must acquire a certain water-depth on the watershed (flow depth) before any flow may start. The thickness of the sheet of water so created depends on the slope of the surfaces.

The above stated rainfall absorption and rainfall *accumulation*, which

[1] l. c. pp. 326, 327.

[2] Design of sewers and sewage disposal. New-York 1930.

[3] K. IMHOFF, Taschenbuch der Stadtentwässerung. München 1941.

[4] l. c.[1] p. 330.

build up the major part of water losses—taken into account through the runoff coefficient—cause the most serious retarding influence, and increases the value of the concentration time. The time corresponding to this water accumulation will be called further: *accumulation time.* The concentration time will then consist of the three components:

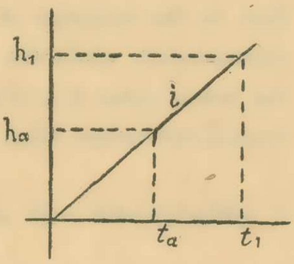
Accumulation time + inlet time + flow time = concentration time

or: $t_a + t_i + t_f = \Sigma t$

where $t_i + t_f = t$, the time used until now in the formula (1) which now will take the form:

(1′) $$i = \frac{a}{b + \Sigma t}$$

The computation of the accumulation time is possible now if the volume of water accumulated on the watershed, expressed more conveniently in millimeters of rainfall, may be defined. Let us suppose that a precipitation of a height h_1 m. m. falls during the time t_1, with an intensity $i = \frac{h_1}{t_1}$ (fig. 1).



If the accumulated height will be assumed to be h_a, the accumulation time will be:

(3) $$t_a = h_a \frac{t_1}{h_1} = \frac{h_a}{t_1} = h_a \left(\frac{b + \Sigma t}{a}\right)$$

Since $\Sigma t = t_1 + t_f + t_a$

(3′) we will have $t_a = h_a \frac{b + t_1 + t_f}{a - h_a}$

and substituting in the formula (1′) the estimated value as above for t we get:

(3″) $$\boxed{i = \frac{a - h_a}{b + t_1 + t_f} = \frac{a - h_a}{b + t}}$$

It results from this formula that the accumulation time does not appear in the determination of the rainfall intensity (3″) much more, the accumulation height h_a enters into the final time-intensity rainfall curve. Deducting now the height h_a (based on observation and local conditions) from the value of the standart a of the formula (3″), we may proceed with the calculation of the drain system by the hitherto usual rational method, where t will be the sum of inlet time and flow time as used till now. It is obvious that this suggested method is simple, it corresponds more accurately to existing conditions and gives more economical results.

Example: As an example we take the time-intensity rainfall curve in Athens area, which is found to be:

$$i = \frac{40}{20+t} \text{ in mm/minute.}$$

Assuming that $h_a = 6$ m/m and that usually the expected unfavourable duration time of rainfall, for the design of storm drains, is about 25′ we get:

$$t_a = 6\,\frac{40}{40} = 6'.$$

Adding to this value the above accepted minimum inlet time $t_i + t_a = -12'$, which should correspond to the values usually accepted for the inlet time (to in textbooks), and given in the table I. It follows therefrom that in the majority of cases of table I the inlet time has been selected rather small, while the values suggested in textbooks should be limited to the lower value ($t = 15'$); consequently the values between 15′-20′ should be considered rather high for greater cities. (Thickly built up).

Γ. ΑΡΒΑΝΙΤΑΚΗ.— *Τὸ σύγχρονον ρωσικὸν ἡμερολόγιον.*

Μ. ΚΑΛΟΜΟΙΡΗ. — *Παρουσίασις μουσικοῦ δράματός του «᾿Ανατολὴ» καὶ ἀνάλυσις μερικῶν τεχνικῶν καινοτομιῶν εἰς τὸ μουσικὸν δρᾶμα.*

ΜΑΘΗΜΑΤΙΚΗ ΑΝΑΛΥΣΙΣ.— **Generalization of some linear differential equations of Mathematical Physics,** *by* ***Spyridon B. Sarantopoulos****. ᾿Ανεκοινώθη ὑπὸ κ. Παν. Ζερβοῦ.

1.— It is known[1] that all the linear differential equations which occur in certain branches of Mathematical Physics are confluent forms of a differential equation of the second order which has every point except a_1, a_2, a_3, a_4 and ∞ as an ordinary point. These five points are regular points and the difference of the two exponents α_σ, β_σ at a_σ ($\sigma = 1, 2, 3, 4$) and of the two exponents at ∞ is $^1/_2$. Such confluent forms are the linear differential equations of Legendre, Bessel, Stokes, Weber, Hermite, Mathiew and Lamé.

In a work which I hope to be published in a short time, I make some generalization of certain of these equations. I present here only some rusalts of my research.

* ΣΠΥΡΙΔΩΝΟΣ Β. ΣΑΡΑΝΤΟΠΟΥΛΟΥ, Γενίκευσις γραμμικῶν τινων διαφορικῶν ἐξισώσεων τῆς Μαθηματικῆς Φυσικῆς.

[1] See E. T. WITTAKER, Modern Analysis, 1920, p. 203.