take care of the excessive toe pressure, but even that method, while adding greatly to the expense, often fails to prevent settlement and cracks. The only safe rule is to so design the wall that the resultant will pass through the centre of the base, or perhaps a little better, just back of the centre.

The misconception of the middle-third theory and its application has alone been responsible for most of the failures and partial failures of retaining walls and abutments.

Fig. 1 shows clearly a typical case of a wall having tipped forward on account of excess toe pressure, and consequent settlement.

The Earth Pressure Affecting the Foundation Reaction.

In the treatment of wall design we are at once confronted with the question, what is the amount and direction of the earth pressure against the wall, and how does it affect the direction of the resultant foundation reaction, and the determination of the point at which it cuts the base.

It has long been recognized that the data and formulae relating to earth pressure are not as complete and reliabe as we should have for correct designing, but for most condiwhich the two methods gave the same values. Namely, with vertical back of wall, and fill level back of wall.

To mention only one case of disagreement at this point; for the angle of repose or natural slope of 45° , surcharge of 45° , and with the back of wall batter away from the fill at an angle of $33^{\circ} 42'$ with the vertical, Rankine's formula gives the value of the Constant C as 144 lb., while Rebhann gives only 84 lt. Then again, neither theory gives self-consistent results throughout. Some of the points of divergence between the two theories, as well as the break-downs in the theories themselves, are clearly shown in the accompanying Figs. 2, 3, 4, 5 and 6.

Before discussing the figures it may be well to state the conventional abbreviations which are used. As Greek letters have been almost universally used in the treatment of earth pressure, a few of those in most common use have been retained, as follows:

 ϕ = the angle of repose or natural slope of the earth or fill, measured from the horizontal.

 ϕ' = the angle of friction between the earth and the back of the wall.

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FARTH PRESSURE CONSTANTS (C) AND ANGLE (S) OF RESULTANT WITH THE HORIZONTAL FOR DIFFERENT ANGLES OF REPOSE \$\$																					
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Table No. 1.-Constants C from Analytical Theory of Rankine. (C

nkine. (Courtesy of Engineering News).

tions they are unquestionably better than guessing or working in the dark. Many of the formulae and resulting computations are very long and complicated, and it is almost a hopeless task to work out results for use and comparison.

Preparation of Tables, From Old Theories.

In order to get data in shape for convenient use and comparison, based on such theories and formulae as were available, the author computed tables* of constants (C (socalled) for a large number of varying conditions governed by angles of repose or natural slope, back of wall batters, angles of surcharge, etc.

First, from the Analytical Theory of Rankine, of 1856. Second, from the Sliding Prism Theory of Vauban, ¹⁶7, Coulomb, etc., after the graphics of Rebhann, of 1871.

After the tables were completed it was found, on comparison, that there was only one set of assumptions in

*Tables published in Engineering News, Vol. 62, No. 22, Nov. 25, 1900, page 588.

- ϵ = the angle of surcharge of fill back of wall with the horizontal.
- a = the angle which the batter of the back of wall makes with the vertical; positive when the back batter slopes up away from the fill and negative when it slopes up toward the fill.
- δ = the angle which the direction of the resultant earth pressure makes with the horizontal.
- γ = the weight in pounds per cu. ft. of the earth fill or backing.
- h = the height in feet of fill or backing retained.
- P = the horizontal component of the earth pressure.
- We = the weight of earth carried on the wall foundation and is the vertical component of the earth pressure, being derived from the earth wedge over the back of wall batter.
- E = the total earth pressure acting against the back of the wall.
- C = the constant (so-called) of the tables, and has the