# The tensile strength of deep concave tablets

The ability to convert the load at which a tablet fails in tension under diametrical compression, into a tensile strength, has been reported for tablets produced using flat-faced punches (Fell & Newton, 1968). This characteristic has been used for predicting tablet strength of mixed component systems (Fell & Newton, 1970) and for characterizing tablets of different dimensions (Newton, Rowley & others, 1971). However, many pharmaceutical tablets are not prepared with flat-faced punches and therefore application of the tensile strength values appears somewhat limited. To extend the applicability of this concept to tablets of other shapes, we have studied the case of tablets prepared with deep concave circular punches. The tablets were prepared from de-ionized Trudex (anhydrous dextrose obtained from starch, kindly supplied by Rank Hovis Ltd.), blended with 1% by weight of magnesium stearate. The tablet machine was instrumented as described by Newton & others (1971), the tablets being prepared at the rate of 60/min using 12·7 mm diameter deep concave punches.

The tablets were subjected to the diametrical compression test on an Instron physical testing instrument (Fell & Newton, 1968). The tablets failed along the diameter connecting the loading points, in the manner of a tensile failure of flat-faced tablets, without the need for packing between the tablets and platens. This apparently indicates that tablets prepared from deep concave punches will fail in tension. The relation between the breaking load P, and the mean compaction pressure Pm for 0·8 and 1·0 g tablets are shown in Fig 1A. Since there does not appear to be a stress analysis for specimens of this shape, an empirical solution to the problem was sought. The application of the standard formula

$$\sigma_x = \frac{2P}{\pi Dt}$$

where $\sigma_x$ is the tensile stress, D is the tablet diameter and t the tablet thickness, did not provide a common regression line for the two weights of tablets. Similarly, replacing $\pi Dt$ by the total cross sectional area of the failure plane or the total surface area of the tablet gave different regression lines for each tablet weight.

When tablets were prepared with flat-faced punches, a linear relation was obtained between breaking load P and mean compaction pressure Pm (Fig. 1B). From these results regression lines for the tensile strength $\sigma_x$/mean compaction pressure Pm were obtained. Analysis of the results by the method of Newton & others (1971) proved that these regression lines did not differ significantly at the 5% level and the common relation can be written as

$$\sigma_x = 0{\cdot}0296\ Pm - 0{\cdot}818 \quad .. \quad .. \quad .. \quad .. \quad (1)$$

Thus failure to obtain a common regression for the tablets prepared with deep concave punches is not a property of the material.

The existence of a common regression line for tablets prepared with flat-faced punches and the linear relation between breaking load and mean compaction pressure for tablets prepared using deep concave punches, enables an apparent tensile strength ($\sigma_{xa}$) for the deep concave tablets to be calculated. Thus from the equations

$$\sigma_x = m_1\ Pm + b \quad .. \quad .. \quad .. \quad .. \quad (2)$$

$$P = m_2\ Pm + c \quad .. \quad .. \quad .. \quad .. \quad (3)$$

where $m_1$ and b are the slope and intercept respectively, of the common regression line for tensile strength/mean compaction pressure; and $m_2$ and c are the slope and intercept respectively, of the regression line for the breaking load/mean compaction

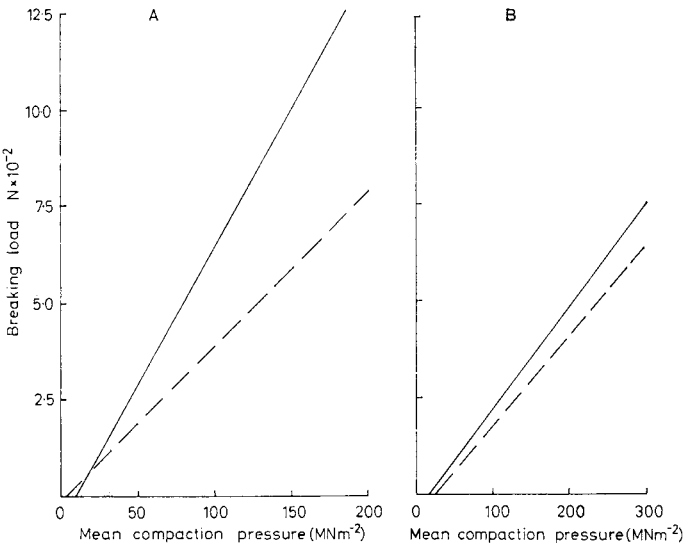


FIG. 1. Regression lines for the relation between the breaking load P, of A, deep concave tablets and B, flat tablets and the mean compaction pressure Pm. The equations of the lines are: A. 0·8 g tablets $P = 1{\cdot}99 \times 10^{-6}\,Pm - 8{\cdot}72$ (— —); 1·0 g tablets $P = 3{\cdot}57 \times 10^{-6}\,Pm - 65{\cdot}9$ (———). B. 0·8 g tablets $P = 2{\cdot}33 \times 10^{-6}\,Pm - 57{\cdot}17$ (— —); 1·0 g tablets $P = 2{\cdot}66 \times 10^{-6}\,Pm - 48{\cdot}34$ (———).

pressure with deep-concave punches, the apparent tensile strength $\sigma_{xa}$ at any mean compaction pressure can be calculated from the expression

$$\sigma_{xa} = \frac{m_1 (P\text{-}c) + bm_2}{m_2} \quad .. \quad .. \quad .. \quad .. \quad (4)$$

This assumes that a deep concave tablet has the same tensile strength as a flat tablet prepared at the same pressure, and that a linear relation exists between tensile strength of these tablets and applied pressure. For the 0·8 g tablets this gives a conversion factor of $\frac{0{\cdot}0296P + 0{\cdot}258}{1{\cdot}99 \times 10^{-6}}$ whilst for the 1·0 g tablets the factor is $\frac{0{\cdot}0296P + 1{\cdot}951.}{3{\cdot}57 \times 10^{-6}}$

Thus when tensile failure of tablets can be obtained by diametrical compression, an apparent tensile strength can be calculated by the above method, provided that a common regression line can be obtained for flat-faced tablets and a linear relation exists between breaking load and mean compaction pressure for shaped tablets.

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January 13, 1972

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