FLEXURE TESTING OF COMPACTED RECTANGULAR BEAMS

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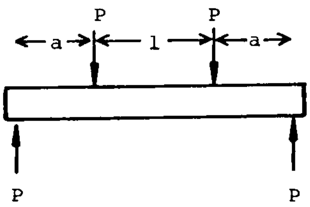
The bonding that occurs when a pressure is applied to a pharmaceutical powder is often assessed by determining the mechanical properties of the resultant specimens. The diametral compression test (Fell & Newton 1970) has found wide acceptability for this purpose, largely because of the ease with which cylindrical specimens are tested. However, this test method does have some limitations and disadvantages. Firstly, the specimens are subjected to a complex system of stresses, and secondly, it is very difficult to measure the strain corresponding to the tensile stress. Consequently, it is not easy to establish the stress-strain relationship and the Young's Modulus of the material.

The stress-strain behaviour of materials is often determined by a uniaxial tensile test, but this technique is unsuitable for brittle powder compacts. A more acceptable procedure is the flexure or bending test. Three-point flexure tests have been suggested previously for cylindrical tablets (David & Augsburger 1974). However, as for the three-point bending of rectangular beams, the induced tensile stress is non-uniform. In four-point bending (see diagram), the lower surface between the two inner contact points experiences a uniform tensile stress.



It can be shown that the tensile stress, σ, and the associated strain, ε, are given by

$$\sigma = \frac{6Pa}{bh^2} \quad \text{and} \quad \varepsilon = \frac{4\delta h}{l^2}$$

where δ is the vertical displacement of the mid-point of the beam, and h and b are the height and breadth of the beam respectively.

Rectangular beams have been prepared by compressing dry Avicel PH-101 powder at known forces on an Instron Testing Machine (Model 1195) using single-ended compaction in a punch and die system at a rate of 5 mm min^{-1}. Their dimensions were 100 mm by 10 mm by b mm where b depends upon the force applied and the weight of powder compressed. The table below shows mean values of data obtained after the beams were subjected to four-point bending using the Instron 1195 and a crosshead speed of 0.5 mm min^{-1}.

Compaction Pressure MNm^{-2}	Mean Fracture Stress MNm^{-2}	Mean Fracture Strain ($x10^{-3}$)	Young's Modulus ($x10^{3}$) MNm^{-2}	Number of specimens tested
25	3.88	8.23	0.84	4
30	5.16	6.94	1.10	5
35	5.86	6.61	1.16	2
40	8.32	7.45	1.44	7
50	12.77	8.00	1.91	4

The stress-strain relationships showed linearity only for low stresses, and the Young's Modulus values given were estimated from this linear region. The data demonstrates that the fracture stress and Young's Modulus are dependent on the compaction pressure used to prepare the beam. However, there is no obvious trend for fracture strain, although more data is needed to confirm this observation. It is clear that this approach can provide useful information about the mechanical properties of pharmaceutical compacts and in future studies other materials will be evaluated and comparisons made with the diametral compression test.

David, S.T. and Augsburger, L.L. (1974) J. Pharm. Sci. 63: 933-936
Fell, J.T., Newton, J.M. (1970) J. Pharm. Sci. 59: 688-691

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