Physical and Mechanical Characterization of Soya, Colza and Rye Seeds

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Abstract:
This paper presents a characterization of the following dry granular materials: soya, colza and rye seeds. The physical properties of the grains and the materials are useful for characterizing the materials' behaviour during flow, while the external conditions (consolidation) determine storage and handling conditions. The physical properties of the grains (specific densities) and of the materials as a whole (compacity or porosity, and critical angles) were measured. The flow functions were determined by modified shear box testing. Then the internal friction angles and the flowability index for each granular material were obtained. Indeed, the behaviour of a flowing granular material results from these two groups of factors and is characterized by the flowability, which is the ratio of highest consolidation stress and unconfined yield strength. In practice, the flowability index is used to classify materials, so that the larger the flowability index, the smaller the bulk solids strength will be in relation to the consolidation stress, and therefore the higher the flowability of the bulk solid.

Zusammenfassung:
Das Fließverhalten von drei verschiedenen trockenen Schüttgütern, Soja-, Raps- und Roggensamen wird in dieser Veröffentlichung vorgestellt. Die physikalischen Eigenschaften der Körner sind wichtig, um das Materialverhalten in Strömung zu charakterisieren, während externe Parameter (Verfestigung) die Lager- und Transporteigenschaften bestimmen. Die Eigenschaften der Körner (spezifische Dichte) und des Materials als Ganzes (Kompaktheit oder Porosität, kritischer Winkel) sowie die Fließeigenschaften wurden mittels einer modifizieren Scherzelle bestimmt und daraus der Reibungswinkel und der Strömungsindex für jedes Material berechnet. Das Fliessverhalten der Schüttgüter wird durch diese beiden Parameter ausgedrückt, wobei der Strömungsindex das Verhältnis der höchsten Verdichtungskraft und der Fließgrenze ist. Als Klassifizierungsmethode drückt ein großer Strömungsindex kleine Festkörperkräfte im Verhältnis zu großen Verdichtungskräften und somit eine höhere Fließfähigkeit des Schüttgutes aus.

Résumé:
Le présent article traite de la caractérisation des matériaux granulaires secs suivants : soja, colza et seigle. L'étude des propriétés physiques des grains et des matériaux est nécessaire pour caractériser le comportement des matières en écoulement, alors que les conditions extérieures (consolidation) déterminent les conditions de stockage et de manutention. Les propriétés physiques des grains (densités spécifiques) et des matériaux formés par ces grains (compacité ou porosité et angles critiques) ont été mesurées. Les fonctions d'écoulement ont été déterminées à l'aide d'une boîte de cisaillement modifiée. L'angle de frottement interne et l'indice de coulabilité de chacun de ces matériaux granulaires ont ensuite été obtenus. En effet, le comportement d'un matériau granulaire en écoulement dépend de ces deux groupes de facteurs et est caractérisé par la coulabilité, qui est le rapport de la contrainte de cohésion sur la contrainte majeure de consolidation. En pratique, l'indice de coulabilité est utilisé pour classer les matériaux, de telle sorte que plus cet indice est élevé, moins la cohésion des matériaux dépend de la contrainte de consolidation, et plus le matériau est cohésif.

Key words: colza seeds, rye seeds, soya seeds, dry grains, silos, flowability, granular material, modified shear box testing

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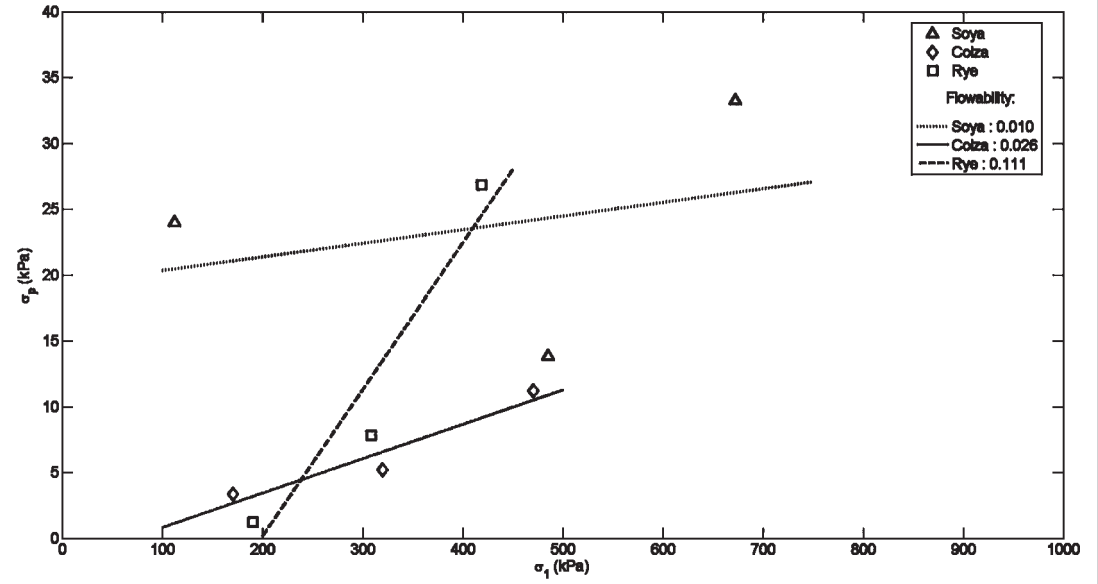

Figure 5:
Flow functions of the granular materials studied.

Table 2 shows the values obtained in this work for the different characteristics of each granular material studied.

5 CONCLUSION

The prediction of the behavior of a granular solid is useful to the engineer. This paper concerns the flowability properties of dry granular materials. The specific bulk characteristics and properties, called flow properties of soya, colza and rye seeds that affect flow were considered. Numerous physical properties are defined in the literature, and only the most relevant were characterized, namely shape, size, critical angles and particle densities. These flow properties refer to the behavior of the bulk material and arise from the collective forces acting on individual particles. The grain sizes were determined using appropriate sieves. The respective average diameters were fairly large, the matters were dry and the absence of very fine particles and humidity were noted, so the Van der Waals, electrostatic and surface tension forces were ignored in this study.

Observation of SEM images shows that the soya and colza seeds have a smooth regular surface with an oval shape while the rye seeds have a rough irregular surface with an elongated shape. Thus, the effect of shape and surface on the flowability is more favourable for the soya and colza seeds than for the rye seeds. The different critical angles were measured and found to be less than 36° and thus it can be assumed that all three matters tested are free-flowing. In addition, their respective porosities (about 40 %) are those which characterize free-flowing materials. Conversely, the densities of dry granular solids cannot be directly used to characterize their flowability. Nevertheless, measure of bulk density gives an estimate of how much volume the matter will occupy in the silo, the weight being the main cause of consolidation and failure, necessary for its flow. Bulk and apparent densities of the different matters were then measured using accurate equipment.

The mechanical characterization of the grains was then carried out, using a modified shear box testing with a procedure similar to Jenike's test. The effective internal friction angle of each tested granular material was derived from the corresponding *EYL*. For a given material, a flow function which is the aptitude of the material to undergo consolidation under stress is then derived from different EYL obtained with various consolidations. The flow function obtained with this test is an intrinsic flow characteristic of the granular material studied and is used for the silo design. A material which undergoes a higher consolidation (steeper flow function) will tend to form steadier arches and will require a higher hopper slope and a larger outlet diameter. The following classification of the tested materials according to their respective flowability index, i.e. from the highest flowable material to the lowest was then obtained: soya > colza > rye. The flow function obtained with this test is an intrinsic flow characteristic of the studied granular material and is used for the silo design.

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