A note on the wind loadings of conveyer belt housings

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Abstract
Selected results of a wind-tunnel study into the design wind loads for the housings of conveyer belt structures are presented. These results concentrate on the 'dog-house' type of housing and include the influence of selected factors on the magnitude of the measured drag coefficients.
The results of the tests show that the drag coefficients depend on the detailing of the cross-section of the housings. It also appears that the 'dog-house' is both uneconomical and in many cases underdesigned, and a substantial reduction of the wind loads (and therefore cost) can be achieved by introducing alternative shapes of housings.

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1. Introduction

The CSIR's Wind Engineering group at the Division of Building Technology (BOUTEK) is frequently approached by designers of conveyer-belt housings for the correct value of drag coefficients to be used in the design of these structures. No information in this regard is given in the South African structural design code or other leading international wind loading codes (Canadian, Australian, British and US).

Our discussions with several consultants involved in the structural design of housings for conveyer-belts revealed that a wide range of values (between 1,4 and 2,1) is used. Otherwise forces of individual components of the conveyer belts and their housing are integrated. From an engineering point of view, neither approach is satisfactory and the only viable way of determining the relevant values of drag coefficients for various shapes of conveyer-belt housings is to undertake wind-tunnel measurements.

The present note describes selected results of a broader wind-tunnel study into the design wind loads of conveyer belt housings which was undertaken at the CSIR. The results presented concentrate on the most commonly used type of housing - the 'dog house'.

2. Experimental set-up

The investigation was carried out in BOUTEK's Boundary Layer Wind Tunnel. A scale of 1:13 was used for the modelling. Provision was made to accommodate various modifications to the cross-sections of the models. Measurements of the overturning moment and force coefficients were made by an electronic force balance. Figure 1 shows the force balance with the central portion of one of the models (in this case of a gantry) mounted on top.

Drag force coefficients measured were expressed in terms of the force applied at mid-level of the canopy and the projected area of the structure.

3. Selected results

Results of the investigation into the effects of the radius of the canopy are presented in Figure 2 together with the definitions of the parameters of the cross-section. Three typical radii (R) are considered namely: 300 mm, 500 mm and 1100 mm in full-scale, which correspond to the h/R ratios of 1,09; 2,40 and 4,0 respectively. The remaining parameters (ie. h/h_1, h/d and ϕ) were kept constant at 1,29, 0,6 and 5° respectively.

The results show that the drag coefficient increases with an increase in the ratio of h/R, in other words a larger radius results in a lower drag coefficient. This figure also presents the respective drag coefficients measured for a wind direction of 180° (ie. from behind). It can be seen that the pattern is similar to that observed for 0° and that the induced wind loads are significantly lower (more than two times) than those induced for 0°.

It can also be seen in Figure 2 that, depending on the details of the cross-section of the conveyer-belt housing, drag coefficients of up to 2,5 are not unrealistic. (This magnitude of drag force can be attributed to the contributing lift force induced on the 'roof' of the canopy.) A concern can be raised in regard to the design safety margins if the results of these tests are considered in the light of the range of typical drag force coefficients used in design practice.

Next the influence of the extension of the canopy at the 'back' (ratio h/h_1) was investigated. Four values of the h/h_1 ratio were considered: 1,29; 2,33; 4,71 and 19. (The h/h_1 of 19 corresponds to the situation in which only a small gap between the wall sheeting and ground level is left open.) The remaining cross-sectional parameters (ie. the ratios h/R and h/d and ϕ) were kept constant at 4,0, 0,6 and 5° respectively.

The results of the measurements are presented in Figure 3. In the first instance the drag coefficients are plotted in terms of a drag force applied at mid-level of the canopy (ie. the median elevation between its top and bottom). It can be seen that this increases as h/h_1 increases, reaching a value of more than three for an h/h_1 of 19.

From a design point of view, this presentation of the experimental results may be misleading as the equivalent drag force is applied at a different elevation for each geometry tested (ie. the ratio h/h_1). For this reason results of these tests are also plotted in Figure 3 in terms of the force applied to the top of the canopy which in each case remains constant. It can be seen that the magnitude of all measured coefficients is more or less the same and less than 2, ie. the drag force is proportional to the increase in the area of the sheeting at the back.

Finally the results of the investigation into the effects of the slope of the canopy (ϕ) are presented in Figure 4. Three typical slopes of the canopy were initially investigated: 0°, 5° and 10°. The remaining parameters were kept constant at: h/d = 0,6; h/h_1 = 1,29 and h/R = 4.

The results showed that the drag coefficients remained fairly insensitive to the slope of the canopy. Another model (referred as to -10°) was, therefore, introduced in which the slope of the canopy was opposite to the slope in the previous models.

It can be seen that a substantial reduction in the drag coefficient (in this case from 2,5 to 1,9) was achieved by introducing a 'negative' slope to the canopy. It appears that the mining industry has never considered such a configuration for the 'dog house' type of housing, possibly because of overriding maintenance and operational considerations.

In view of the above finding a set of measurements was also undertaken to compare wind loads induced by a 'dog house' and an equivalent 'cylindrical' shape of housing (ie. shape with identical projected areas) for which a significantly lower drag coefficient was measured.

4. Conclusions

- The magnitude of drag forces induced by the housings of conveyer belts depend on their cross-sectional geometry and, therefore, the adoption of a common drag coefficient value (irrespective of the cross-sectional geometry used) is unwise.
- The most commonly used type of housing - the 'dog house' - appears to be underdesigned in many cases and uneconomic if compared with other generic shapes of housings.

5. Acknowledgements

Discussions were held and the working drawings of various conveyer-belt structures were obtained from several organisations including: Anglo-American, Genmin, Keeve Steyn Consultants, Krupp SA, Secunda Collieries and WLPU Consultants.

Figure 1. A wind-tunnel model on the force balance

Figure 2. Drag coefficient as a function of radius

Figure 3. Variation in the drag coefficient with h/h_1 ratio

Figure 4. Drag coefficient as a function of roof slope

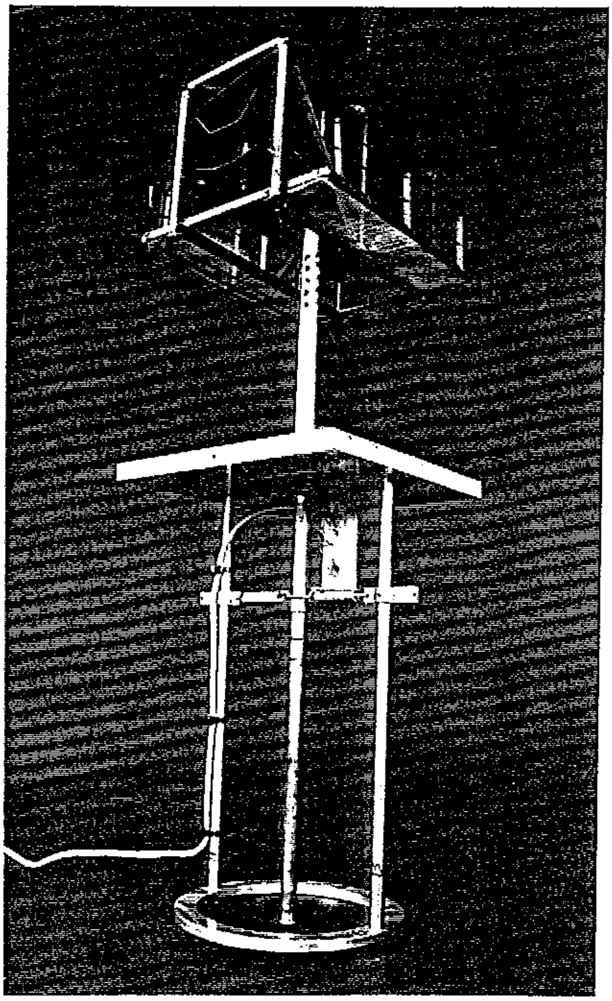

Figure 1

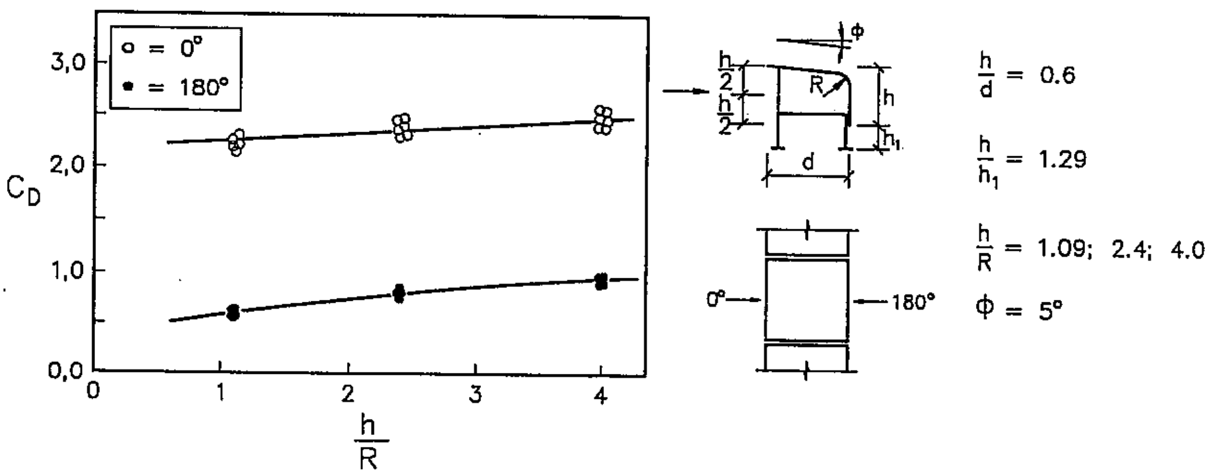

Figure 2

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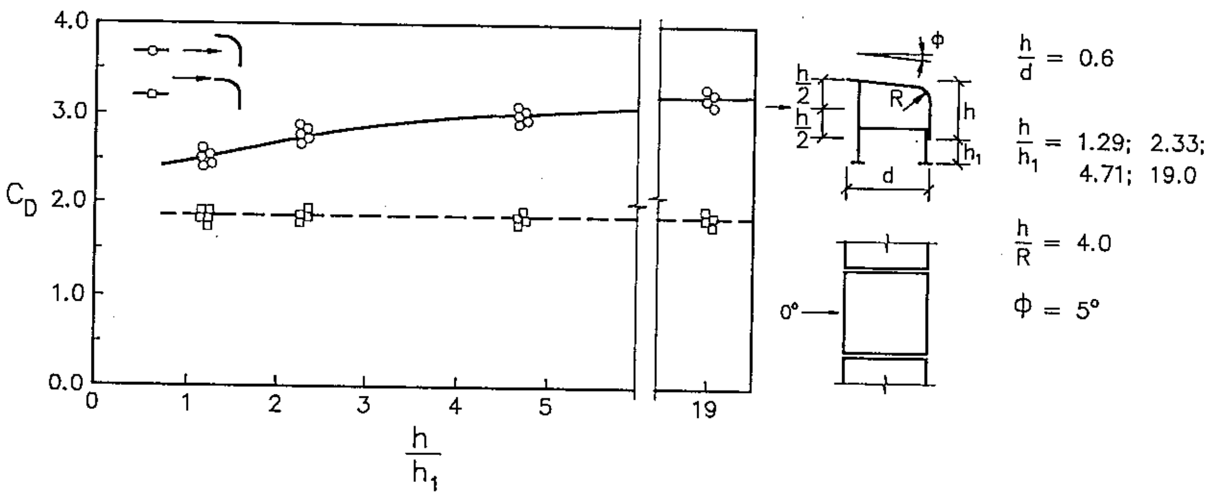

Figure 3

B586- SCALE 1=1

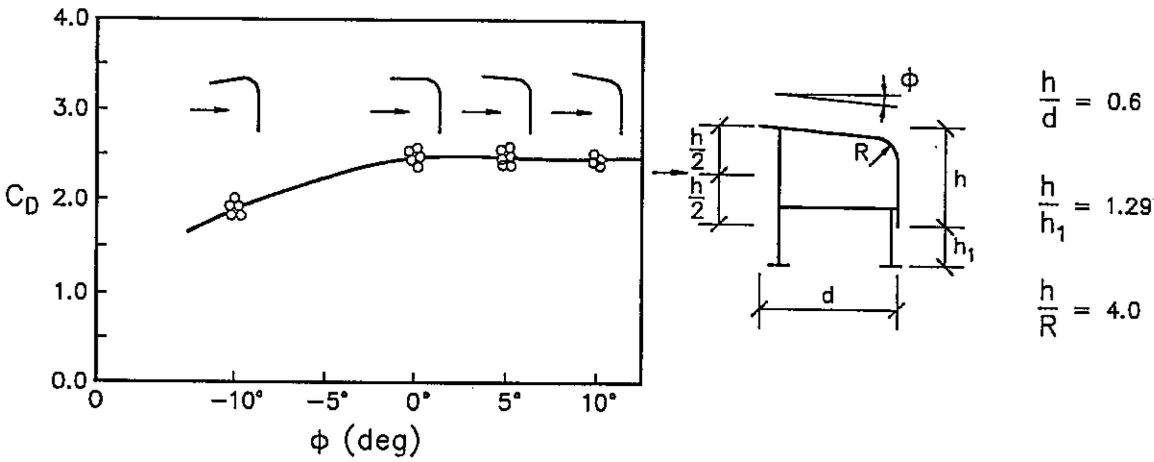

Figure 4

B586-3 SCALE 1=1