THE UNIVERSITY OF NEWCASTLE AUSTRALIA

TUNRA BULK SOLIDS

Silo Quaking Analysis on Coal Bins

Project Scope:

Bulk Material: Coal

Equipment: Concrete Coal Silo

Problem: Severe silo quaking problems were experienced in an installation of three, 12,700 tonnes, reinforced concrete coal silos.

The silos dimensions are shown schematically in Figure1.

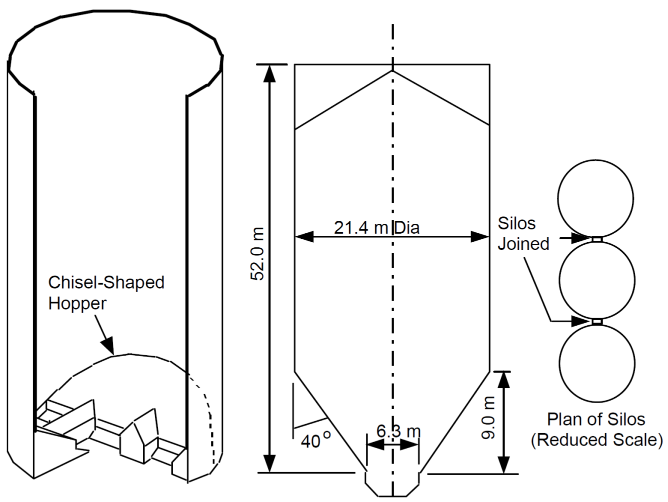

Figure 1: Tall Coal Silos

Adjacent silos are connected by concrete along the vertical lines of intersection. The silos have chisel-shaped, plane-flow hoppers lined with carbon steel plate, the half-angle *a* being 40°, this being the angle with respect to the vertical. The hopper splits into three outlets, the lower hoppers being lined with stainless steel.

The maximum discharge rate is 2700 tonnes/h through vibratory feeders.

The reported period of the shocks was 3 to 5 seconds, the shock loading being most severe when the silos were substantially full. After several years of use, severe damage started to occur, with sections of concrete being dislodged.

Computation of Shock Loads

The shock plane is assumed to be located at a height of 26 m above the base of the hopper. The head of coal above the shock plane is h = 22 m. The estimated amplitude of the dynamic pressure was calculated as $\Delta pw0 = 56 kPa$

The shock pressure amplitude results are illustrated in Figure 2; also shown are the static and flow pressures. In view of the curved transition of the chisel-shaped hopper with the cylinder, the pressure profiles vary around the periphery of the bin. Figure 2 applies to the side of the bin where the chisel-shaped hopper has its highest intersection point with the cylinder wall.

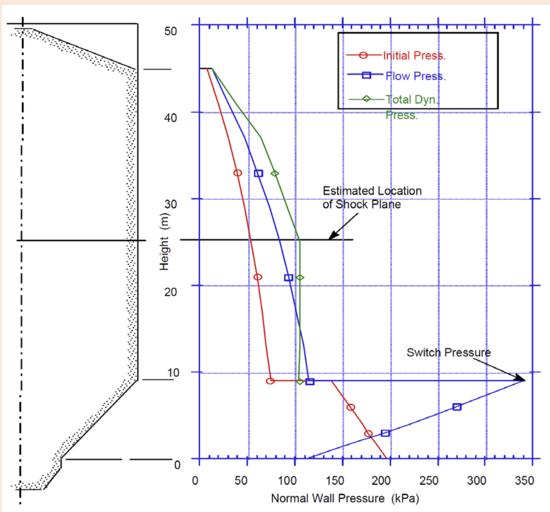

Figure 2: Pressure Distributions for Silo

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Estimation of Pulse Period

The following values were calculated for the pulse period:

For discharge rate Q = 2700 t/h T= 2.4 secs

For discharge rate Q = 1500 t/h T= 4.4 secs

These values, which are based on $\Delta ey = 5mm$ for the coal, are in general agreement with the approximate values of 3 to 5 seconds as reported for the actual silo.

Vibration of Structure

A critical factor in the operation of the silos is the influence of the dynamic characteristics of the overall structure. Noting that the silos were supported on columns on a base, which, in turn, was supported on piles, a simplified dynamic model of the silos is shown schematically in Figure 3. There will be vertical and lateral stiffness due to the columns and piles as well as vertical and lateral stiffness due to the concrete connecting adjacent silos. In view of the significant variation in the silo mass from the full to the empty condition, there is a significant variation in the natural frequencies.

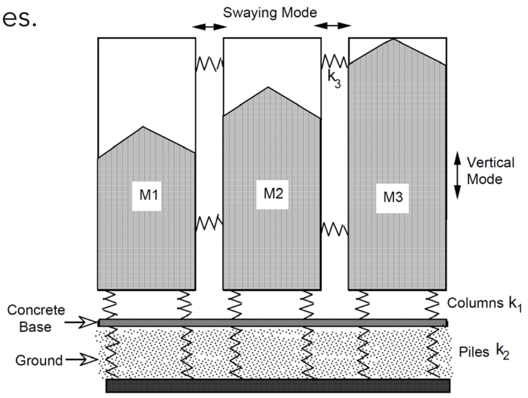

Figure 3: Simplified Dynamic Model of Silos

The natural frequency for the fundamental mode is given by

$$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

Noting the variation in mass, the natural frequency of each silo will change as follows:

$$\frac{f_n \text{ full}}{f_n \text{ empty}} = 0.56$$

The natural frequency of the full silo is only 0.56 of the empty silo. While the various stiffnesses of the structures are not known, it is possible that the load pulse frequency of 3 to 5 seconds could excite one of the silo modes.

As each silo fills and empties, there will be different mass contents and, hence, different frequencies for adjacent silos. As a result, there will be dynamic coupling between adjacent silos which could impose significant loads on the concrete connecting these silos. The modes of vibration, while complex, would involve a combination of vertical and sideways swaying motion, the latter induced by non-symmetrical loadings of coal in the silos as well as variations in ground stiffness in the zone of the supporting piles.

Why TUNRA Bulk Solids?

Experience and Expertise

We have provided expert solutions to industry for over 45 years and are the leading organisation for materials handling research and consulting in Australia and internationally

Research and Development

We have a proven track record in research and development through the close association with The University of Newcastle

Quality Service

We have highly qualified, well-trained and specialist staff that are committed to delivering excellence

First Class Facilities

Our laboratory is a state of the art facility located within the Newcastle Institute of Energy and Resources (NIER) at The University of Newcastle

Industry Standards

We are accredited to ISO 9001, ISO 45001 and ISO 14001

Independent

We are independent and not for profit

Advancing the Bulk Materials Handling Discipline Globally

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