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Case Study
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Design of a 10T Flake Pile Roller Stand

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Abstract

This article provides a summary of the design and operating parameters for a 10T Flake Pile Roller Stand. The 10T Flake Pile Roller Stand is designed to reduce the force required to install conveyor belt that has been pre-spliced and assembled into a flake pile. The performance requirements of the 10T Flake Pile Roller Stand were initially determined through Excel spreadsheet calculations. Finite element analysis was used to determine the structural stresses induced by the belt tension during operation within the pulley shell, the pulley shaft and the stand. The maximum belt tension was 10 tonnes. Australian Standard AS3990 Mechanical Equipment–Steelwork has been utilized for determining the suitability of the design. The design meets the requirements of the standard for the proposed belt tension.

Keywords: Conveyor; Belt; Installation; Flake pile

Introduction

This case study provides a summary of the design and operating parameters for the 10T Flake Pile Roller Stand.

The 10T Flake Pile Roller Stand is designed to reduce the pulling force required to pull the belt off the flaked pile. By putting a roller stand midway along the flake pile, the flake pile is essentially reduced in length by two. Further, the roller stand lifts the belt off the pile and effectively again reduces the flake pile by a further factor of two.

These concepts are presented in the figures below. The belt will be begin to be pulled horizontally along the flaking pile when the friction force of the length of belt still contacting the flake pile is equal to the pull force lifting the belt off the flake pile. Due to the diameter of the pulley, the belt is elevated more while going over the top of the pulley (case 1) than when the belt is elevated from the bottom of the pulley (case 2) (Figure 1).

Note that in the above figure, 'b' is the length of belt lifted up off the flake pile (statically) (i.e. before any belt is sliding over the flake pile) while 'a' is the length of the flake pile between the 10T Flake Pile Roller Stand and the end of the flake pile. The belt labeled as 'to conveyor' is the belt leaving the flake pile to be installed on the conveyor (Figure 2).

Note that in the above figure, 'd' is the length of belt lifted up off the flake pile (statically) (i.e. before any belt is sliding over the flake pile) while 'c' is the length of the flake pile between the 10T Flake Pile Roller Stand and the end of the flake pile [1-3].

Figure 1: Conceptual overview of 10T Flaking Pile Breaking Roller Stand – case 1.

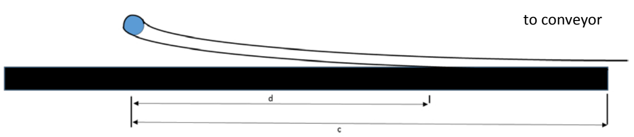

Figure 2: Conceptual overview of 10T Flaking Pile Breaking Roller Stand – case 2.

As a consequence, the roller can be positioned approximately 1/3 of the way from the far end of the flaked conveyor belt pile. The longer length of flake pile is positioned close to the conveyor. The exact roller position (height and longitudinal position) is determined for each job depending on the length and height of the flake pile.

The optimal position of the roller also changes as the flake pile reduces in height. Hence the position that can be chosen is midway between the optimal for the tallest and shortest flake pile. Another option would be to have a number of positions for the 10T Flake Pile Roller Stand which would be utilized as the flake pile reduces in height. The strategy regarding positioning of the 10T Flake Pile Roller Stand would depend on the pull forces involved and the belt puller and winders available for the particular job [4,5].

Finally, the belt leaving the flake pile (labeled as 'to conveyor' in figures above) can also be lifted above the flake pile by stands, as shown in the figure below. These stands do not have the belt wrapping around their pulleys but rather only function to lift the belt off the flake pile (Figure 3).

The following design assumptions have been made. The 10T Flake Pile Roller Stand will be used with belt of equal or less than 50 mm in thickness. 10T Flake Pile Roller Stand will be used for belt widths between 1000–2000 mm. Maximum belt tension is not to exceed 10T. It is assumed that the belt has been oriented such that the centre-line of the belt is collinear with the centre-line of the 10T Flake Pile Roller Stand. As a result, no lateral loading along the length of the 10T Flake Pile Roller Stand is assumed.

Calculations of Overall Performance Requirements

An example calculation will be described. As outlined above, each

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installation will have differences in regard to pull force, belt weight, flake pile length and equipment availability.

The inputs are the flake pile height, roller diameter, frame height, a, b, and d.The calculated results are the top of the roller, the force to lift the belt to the top of the roller, the friction force remaining when the belt is going over the top of the roller, the height at the bottom of the roller, c, the force to lift the belt to the bottom of the roller and the friction force remaining when the belt is going over from the bottom of the roller.

A different frame height affects the result. The frame must be as low as possible and yet still provide clearance for the belt to be pulled under the roller. By positioning the 10T Flake Pile Roller Stand along the length of the pile, the force to pull from either end of the flake pile can be balanced.

In any case, it has been decided that the Flake Pile Roller Stand will be engineered to withstand a 10T belt pulling force. The height of the stand has been decided to be 2m to the top of the frame with the pulley centre located at that height.

Figure 3: Typical belt installation at site showing use of Flake Pile Roller Stand (i), belt lifting stands along the length of the flake pile (ii) and Turning Frames (iii).

Finite Element Analysis

FEA of pulley shell

Autodesk Inventor Professional 2014 was used for FEA analysis. The pulley shell is designed to be fabricated from OneSteel American Standard Steel Pipe ASME B36.10 DN 800 (OD 813 mm) and wall thickness 9.53 mm with length of 2550 mm. The yield strength of this pipe is 360 MPa. The end discs are fabricated from 10mm thick plate and are designed to be welded to the shaft and the shell. The belt width can vary between 1000 and 2000 mm.

The fixed areas of the model are shown highlighted in white. The belt force is shown by the yellow arrows (Figures 4-6).

For the 1000 mm wide belt case, the reaction force at the fixed areas is -100kN in the x direction and 59.34N in the Z direction. Therefore there is very little bulging of the end discs with this loading. For the 2000 mm wide belt case, the reaction force at the fixed areas is -100kN at each point. That is, the belt tension is resisted by the fixed areas with very little bending of the pulley. The reaction forces will be entered into the shaft analysis.

In any case, these results are less than the maximum allowable of 237.6 MPa as per AS3990 for the selected construction material.

FEA of pulley shaft

The shaft is designed to be fabricated from K1045 steel which has a yield strength of 600 MPa2. The Autodesk Inventor 2014 Shaft Component Generator was used for this analysis. In order to provide space for the shell and the bearing blocks, an overall length of 3295 mm was provided. The length of bar for the bearings was 180 mm on each end. The diameter of these lengths was 90 mm. The diameter of the

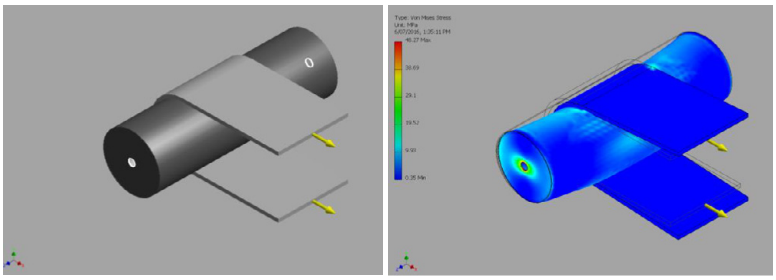

Figure 4: Fixed areas and forces in 10T Flake Pile Roller Stand pulley model (L) Maximum stress in 10T Flake Pile Roller Stand pulley from 1000 mm wide belt (R).

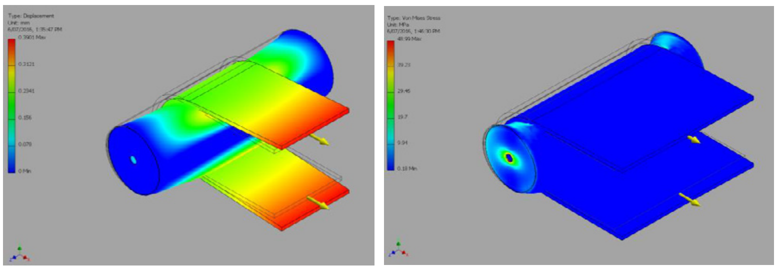

Figure 5: Maximum displacement in 10T Flake Pile Roller Stand pulley from 1000 mm wide belt (L) Maximum stress in 10T Flake Pile Roller Stand pulley from 2000 mm wide belt (R).

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remaining length was 100 mm (Figure 7).

The forces determined from the shell analysis above were then inputted into the Shaft Component Generator analysis as per below (Figure 8).

The maximum bending stress is 128 MPa. The maximum shear force is 15.8 MPa. The maximum deflection is 9.06 mm. As per AS3990, the maximum permissible bending stress is 0.75 of the yield stress or 450 MPa, the maximum permissible shear stress is 0.45 of the yield stress of 270 MPa and the maximum deflection is the span/360 or 9.15 mm. The 10T Flake Pile Roller Stand pulley shaft therefore passes AS3990.

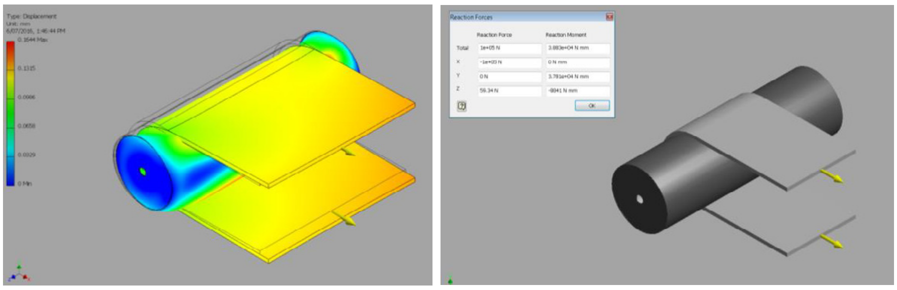

Figure 6: Maximum displacement in 10T Flake Pile Roller Stand pulley from 2000 mm wide belt (L) Reaction forces in fixed area which is welded to shaft (R).

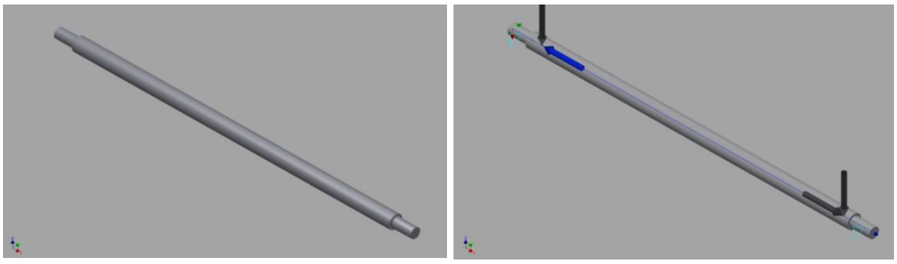

Figure 7: Pulley shaft model (L) Pulley shaft showing forces (R).

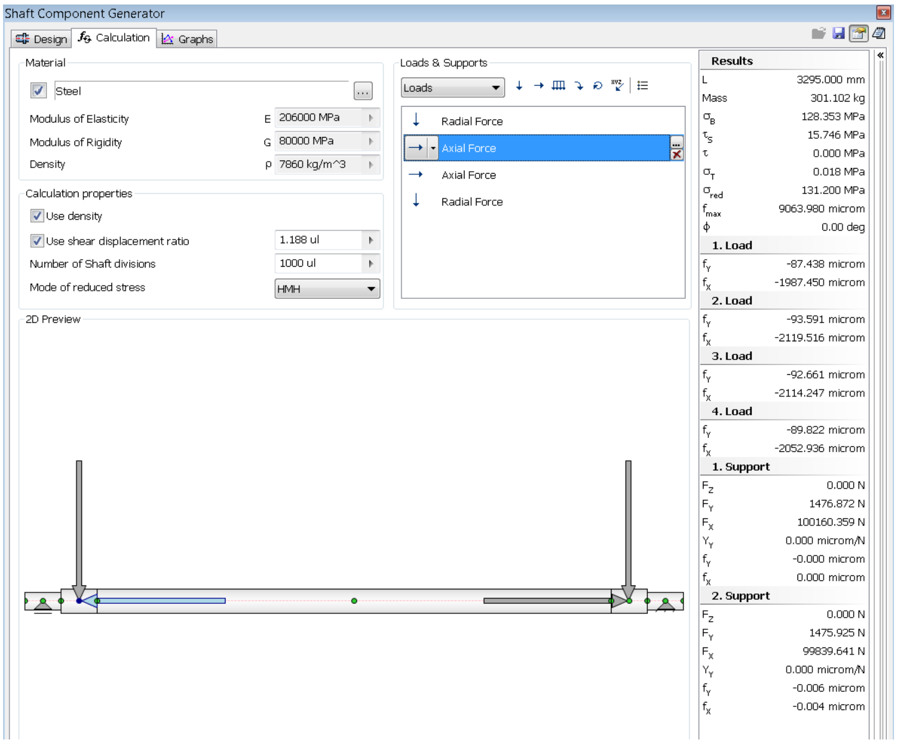

Figure 8: Pulley shaft results.

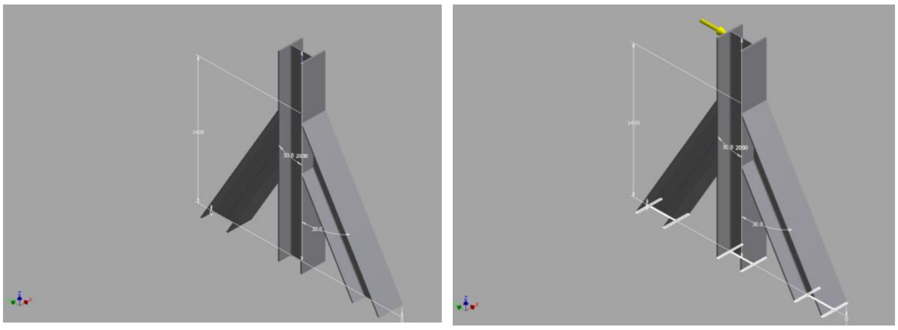

Figure 9: 10T Flake Pile Roller Stand frame (L) 10T Flake Pile Roller Stand frame showing force and fixed areas (R).

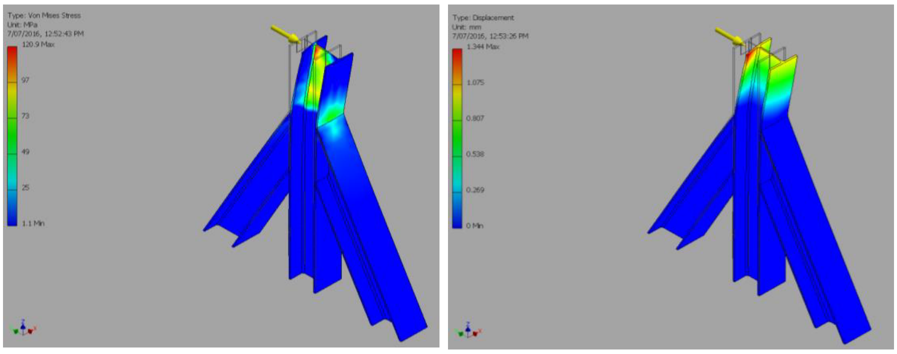

Figure 10: Maximum stress in 10T Flake Pile Roller Stand frame (L) Maximum displacement in 10T Flake Pile Roller Stand frame (R).

FEA of frame

The load of 10kN is shown applied at the top of the frame where the bearing and shaft centre shall be. The fixed points are at the bottom of the frame. The frame shall be mounted onto a steel plate which shall have the flaking pile laid on top of it. When the flake pile is short, counterweights shall be used to secure the steel plate on which the frame is mounted (Figure 9).

The maximum stress in the frame is shown below (Figure 10).

The maximum displacement is shown below. The maximum stress allowable for GR350 material is 360 MPa hence the maximum stress allowable by AS3990 is 0.66 Y or 237.6 MPa. The frame therefore satisfies AS3990.

Conclusion

This article provides a summary of the design and operating parameters for a 10T Flake Pile Roller Stand. The 10T Flake Pile Roller Stand is designed to reduce the force required to install conveyor belt that has been pre-spliced and assembled into a flake pile. The performance requirements of the 10T Flake Pile Roller Stand were initially determined through Excel spreadsheet calculations. Finite element analysis was used to determine the structural stresses induced by the belt tension during operation within the pulley shell, the pulley shaft and the stand. The maximum belt tension was 10 tonnes. Australian Standard AS3990 Mechanical Equipment–Steelwork has been utilized for determining the suitability of the design. The design meets the requirements of the standard for the proposed belt tension.

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