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Structural Analysis of a Rail Mounted Travelling Tripper

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***Abstract*: Travelling trippers are rail-mounted equipment's used in bulk material handling plant to feed material into a bunker/silo or stockyard. Apart from direct feeding, they have bypass option as well. Steel rolled sections and plates are used for fabricating travelling tripper structure (also known as tripper car). Structural analysis is done for a typical travelling tripper suitable for 1000mm Belt width. Bending stresses, nodal displacements, reaction forces and utilization ratios are analysed. STAAD Pro is the design computer program used for the analysis.**

***Keywords*: Travelling tripper, Conveyor, STAAD, Raw material handling, CHP (Coal Handling Plant), Chutes, Pulleys, Idlers, Nodal displacements, Support reactions, Utility check.**

1. Introduction

In raw material handling plants with conveyor system, travelling trippers are extensively used. They are common in CHP (Coal Handling Plants) to feed the crushed coal to Mill bunkers. In steel plants, a common application is on the top of silos in Blast furnace and coke oven conveyor. Travelling tripper consists of fabricated frames or panels, discharge chute arrangement, flap gates, drive arrangement (either chain drive or a drive using motor-coupling-gear box or a geared motor), platforms, walkways, ladders, pulleys, idlers, wheels connected to wheel axles, Cable reeling drum (CRD) etc.

The travel of a tripper is due to the traction force generated by the drive which over comes the rolling resistance, bearing frictional force, track slope resistance etc. We can Ensure the stability of the machine by keeping the CG (Centre of Gravity) of entire assembly within the rail span. In few applications, additional counter weights are added in order to ensure that the tilting tendency is nullified.

Following are the critical parameters of the travelling tripper considered for analysis:

Belt width= 1000mm
Belt speed= 3.1m/s
Tripper inclination= 14 degrees
Material flow rate= 600 TPH (rated)/ 720 TPH (design)

2. Loading Conditions of a Travelling Tripper

The survival of travelling tripper depends on how the designer adjusts the maximum stresses in components to values less than the component's strength at critical locations. In order to perform the structural analysis of a travelling tripper, one should have a fair idea about the forces acting on the tripper car and combination of these forces which constitute various Loading conditions. Load calculation is a complex process requiring clear understanding of principles of operation of machine.

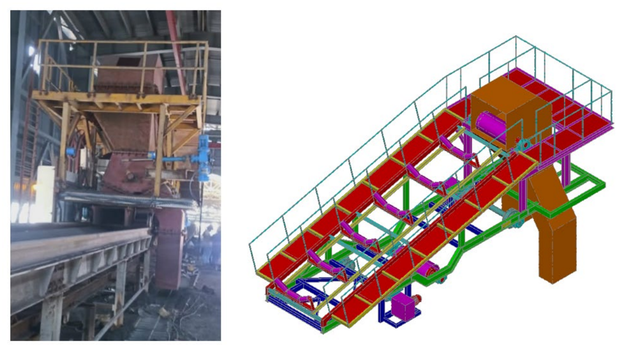

Fig. 1. Travelling tripper

Following are the loads acting on a travelling tripper:

a) *Dead load*: Dead load is the force generated by the self-weight of tripper car, weight of pulleys, idlers, dead weight of chutes, CRDs, Panels, drives etc. Walkway load of 65 kg/m² is considered over and above these forces as and where applicable. In STAAD, once the modelling of the tripper car is done by applying material density and defining relevant sections, the self-weight of the structure can be extracted from "Loads and definitions". Following table can be used for assuming the weights of few components. Weight of chutes are calculated based on the geometry (two way feeding or three way feeding). Chute loads are applied as UDL (Uniformly distributed load) as the chute shoe bracket is generally welded to the supporting member and hence line contact is always ensured.
b) *Live load*: 200kg/m² live load is applied on all the chequered plate platforms.
c) *Material load*: Material load is the load of material on the conveyor belt. If Q is the design TPH, V is the belt velocity, the weight of material in unit length Wm= Q / (3.6*V). The conveyor length on tripper is multiplied with Wm. The material load is applied through idler bracket fixing points as concentrated loads.

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Table 1
Weights of components

S.No.	Belt Width in Mm	Pulley Value (in kg)	Idler Set (Consisting of 3 Rollers & Bracket) in Kg	Drive (in Kg)
1	800-1000	800	60	700
2	1200-1400	1250	78	
3	1600	1500	85	
4	1800	2300	95	
5	2000	2820	105	

Note: These values can vary based on specific client requirements if any

d) *Tractive force when Tripper is travelling towards head end of the conveyor:* The drive of travelling tripper is connected to a cantilever bracket. The torque generated by the drive is converted into a pair of equal and opposite forces separated by a distance equal to the spacing between support points

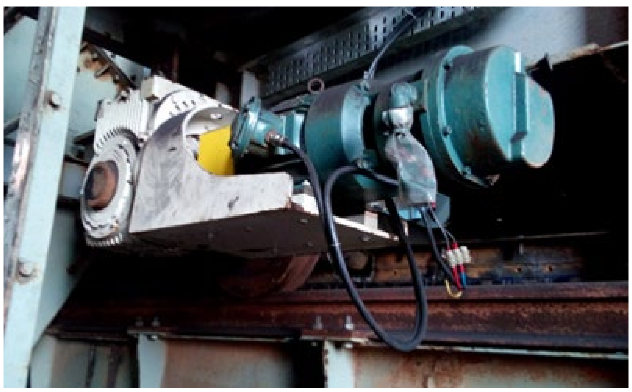

Fig. 2. Drive of a travelling tripper

e) Tractive force when Tripper is travelling towards tail end of the conveyor: In this case, the direction of forces are opposite to that in d).

f) *Belt tension*: Peripheral forces acting on the top discharge pulley and bottom bend pulley shall be calculated. Power calculation of conveyor are calculated based of CEMA or IS 11592.

g) *Buffer strike load on tail end*: During in-advertent situations when there is an over travel for travelling tripper, it can hit on the buffer which is fixed to prevent the fall. Total Strike load is equal to 2 times of drag force and hence on each buffer point on tripper strike load will be equal to drag force.

h) *Buffer strike load on head end*: In this case, the direction of forces are opposite to that in g).

i) *Chute clogged load*: Under plugged condition, the entire inner volume of chute can be filled with material. Chute clogged load is applied on individual supporting members as UDL

Following are the load combinations to be analysed:

- *Load combination-1*: Tripper over travel with empty chute towards tail end. Loads to be considered are a), b), c), e), f) and g).
- *Load combination-2*: Tripper over travel with empty chute towards head end. Loads to be considered are a), b), c), d), f) and h).
- *Load combination-3*: Tripper at rest with clogged chute. Loads to be considered are a), b), c), f) and i).
- *Load combination-4*: Tripper over travel without live load towards head end. Loads to be considered are a), c), d), f) and h).
- *Load combination-5*: Tripper over travel without live load towards head end. Loads to be considered are a), c), e), f) and g).

3. Staad Analysis & Interpretation of Results

To start the modelling of tripper, one should prepare the layout first. Layout (or General assembly drawing) is prepared by taking into account the required feed arrangement (two way or three way), rail gauge, belt width, flow rate (in TPH), maximum permissible inclination (generally restricted upto 14 degrees), number of wheels etc., maintenance platform and walkway sizes etc. Initial selection of members are done based on the previous project references and sizes are selected from section database.

Code selected for design check is IS-800 (General construction in steel structures). Pin joints are selected at the nodes at wheel support points.

Utility check is done in post processing and normalized ratio (actual/allowable) was found to be less than 1 in all the load cases. For two members (1 beneath the side walkway on panel structure and one beneath the chute support) were found to have ratio more than 0.8. These members were upgraded to have lesser utilization of limits Maximum beam stresses are checked for axial, bending, combined and shear stresses.

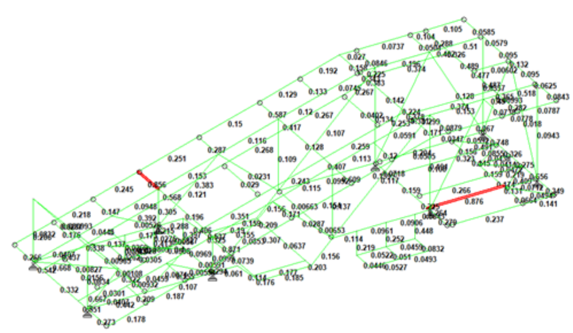

Fig. 3. Utility check

For design of floor beams, wheel load data is required. Here support reactions are the loads applied on the wheels. It is observed that the maximum vertical load is acting on the wheel near the discharge chute (3.824T).

- With the knowledge of wheel load data, we can check if the adhesive force is higher than the forces resisting the motion minus the friction forces in bearings of wheels. Adhesion is the grip produced by friction

Table 2
Maximum beam stresses

	Axial MPa	Bend-Y MPa	Bend-Z MPa	Combined MPa	Shear-Y MPa	Shear-Z MPa
MAX (+)	45.675	92.181	92.181	122.088	17.246	15.739
MAX (-)	-10.443	-121.348	-115.584	-123.117	-16.68	-15.062

Table 3
Nodal displacements

	H	V	H	R	Rotational		
	X (in mm)	Y (in mm)	Z (in mm)	in mm	Rx (IN RAD)	Ry (in Rad)	Rz (in Rad)
Max positive nodal displacement	1.713	7.148	7.276	36.817	0.053	0.003	0.003
Max negative nodal displacement	-1.534	-26.409	-25.597	0	-0.014	-0.003	-0.007
Node with Max nodal displacement	76	133	133	133	13	2	3

between the steel wheels and steel rails. Adhesion is required to keep the wheels from slipping.

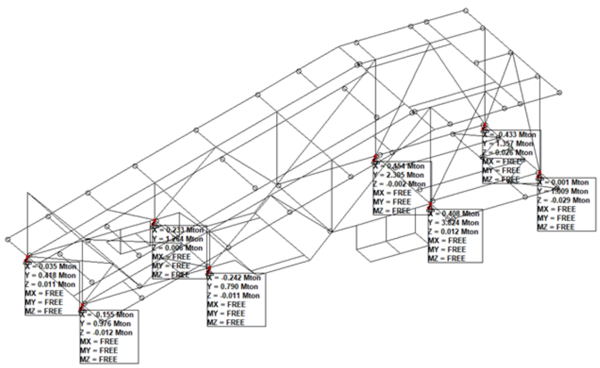

Fig. 4. Support reactions

Adhesion traction is the frictional force between rail and wheel.

$$\text{Ie } Q\text{-}A<Z$$

Q= Traction force= P*B*(μ*d + 2*K)/D, Where P is the total weight of tripper, B is the friction coefficient between rail flanges and wheel, μ is the coefficient of friction in the roller bearings, d is the shaft diameter at the bearing and D is the wheel diameter.

A= Friction forces in bearings of wheels= (Dead load * μ*d)/D

Z= Coefficient of adhesion of wheels with rails (=0.15)*Maximum wheel load.

Node displacements are global displacements for each node in X, Y and Z direction as per the global coordinate system. Node displacements are verified and following maximum values were observed:

The nodal displacements are maximum at the free end of drive supporting cantilever bracket. Local strengthening is done by considering additional rib plates between the flanges of the section.

As the travelling tripper considered is used on the bunker floor covered with cladding sheet no wind loads are considered. Seismic check and mode shape extraction are also not performed.

4. Conclusion

Structural stability and sturdiness of travelling tripper frame are checked with STAAD Pro. It is observed that heaviest sections are required for the vertical members which connect the bottom chord with the top chord and the simply supported beams on which the loads of top chute portion and pulley frames are applied. In the case considered we have used ISMB 200. Diagonal bracings are used in elevation for distribution of load from the top portion towards the bottom. Additional plan bracings can ensure further structural stability for higher capacity applications.

It is found that tripper over travel with empty chute is the most conservative case among all the combinations for the stress limit. However, chute support beams and connecting members are sized based upon the chute clogged condition and maximum wheel load is generated when the chute is plugged.

The material of construction of all structural members is Mild steel Fe E-250 BR (with yield strength around 250 MPa) is the designated steel considered. These steels are also used for locomotive carriages, car structures and screw stocks. The limiting values of elements in the steel shall be as the following [5].

Table 4
Ladle analysis (Max)

C	Mn	S	P	Si
0.22%	1.50%	0.007%	0.05%	0.04%

References

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