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Kicking Horse Gondola Hanger Load Analysis

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Submitted to: Technical Safety BC
Prepared by McElhanney Ltd.

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1. Introduction

On March 10th 2025 a gondola on Kicking Horse's Golden Eagle Express suffered a catastrophic failure of the hanger arm connecting the cabin to the grip assembly as it was leaving the lower station.

Figure 1 - Gondola cabin that fell from Kicking Horse's Golden Eagle Express lift.

Technical Safety BC's (TSBC's) Incident Investigations group is leading the investigation of the incident to provide industry lessons learned. The investigation began with the Acuren Group completing a failure analysis of the hanger and inspection of additional hangers. McElhanney has been retained to provide ropeway-specific knowledge related to the expected loading of the carrier, including:

- The types and number of loading cycles experienced by the carrier.
- Estimation of stresses created by the different loading scenarios at the failure location.

The Golden Eagle Express is an 8-person gondola designed by Leitner Poma of America (LPOA). It was installed in 2000, operates over 3.4km with 23 towers and is top drive and bottom tensioned. The lift has a capacity of 1200 people per hour with 55 carriers. The hanger failed about three quarters of the way down its length, at the top of the 60-degree bend. Examination of the hanger's failure surfaces indicates that it suffered from periods of fatigue cracking, interspersed with periods of rapid (i.e. brittle) fracture.

Figure 2 - Upper portion of the broken hanger

Figure 3 - Failure surface of the broken hanger, with fatigue markings visible at the '1 o'clock' position

2. Sources

McElhanney received documents and photos about the incident from Technical Safety BC (TSBC). These included photos of the failed parts, from soon after the incident through to later off-site examination, drawings of the parts and assemblies, and the Acuren Group Inc report. The report included micrographs of the failure surfaces and results from material tests from the failed hanger and other similar hangers. The documents used in our analysis are listed in Table 1. Basic parameters about the lift, such as its length and operation speed, were obtained from liftblog.com.

Document
Acuren Group Inc., “Kicking Horse Mountain Ski Resort Golden Eagle Express Leitner-Poma of America Gondola - Hanger Arm Failure”, Draft C, 2025
LPOA, March 12, 2002 - Service bulletin – Omega Lift Lateral Rail Entrances
LPOA, February 2, 2007 - Service bulletin – Terminal Entrance Lateral Rails
LPOA, Drawing US3015.173 “Entry Guide Assembly”, 2003
LPOA, Drawing US3038.926 “Mech Adjustment Omega-6P8P/Drv-35T”, revision A, 1999
LPOA, Drawing US3039.082 “Gondola Cabin - 8P/CWA Omega 3LWI”, revision A, 2000
LPOA, Drawing US3039.675 “Lateral Rail Entry Angle Assembly”, rev A, 2006
LPOA, Drawing US4076601 “Detachable Hanger”, revision A, 1999

Table 1 - Documents provided by TSBC and used for this report

3. Operating Loads

Two different types of loading on the carriers were examined, static and dynamic loading. The static loads were reviewed for different load cases from an empty cabin to a fully loaded cabin with passengers. The dynamic loading consists of the different accelerations of the carrier that are experienced during operation while passing towers and entering the terminals.

The following figure shows the terminology that will be used in this report and the approximate location where the hanger broke apart. The grip connects the carrier to the steel rope and attaches and detaches at the top and bottom terminals. The hanger connects the grip to the cabin to allow clearances to line equipment. The cabin is connected to the hanger frame via 4 bolts and dampeners.

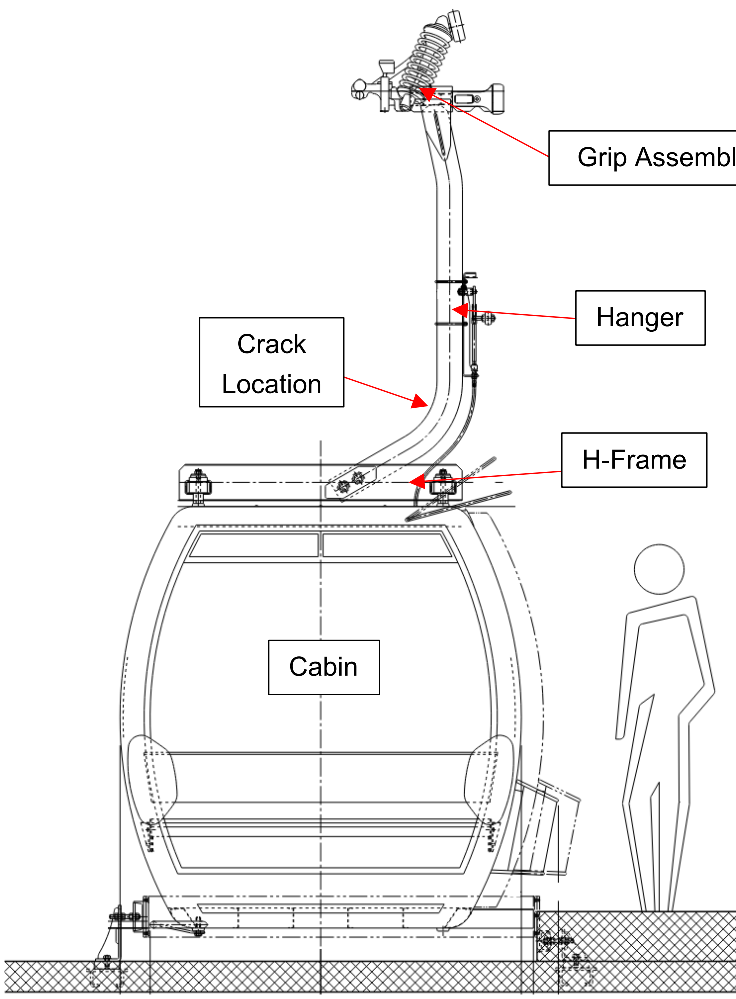


Figure 4 - Carrier Terminology

3.1. STATIC LOADING

Static loading at the crack location arises from the pull of gravity on the items hanging below it. This includes the 'dead load' (weight of the hardware) and 'live load' (total weight of the passengers). The dead load is the total weight of the parts below the crack location. The masses used in this analysis were derived from the cabin assembly drawing (US3039.082) and are listed in Table 2.

Component	Mass (kg)
Grip Assembly	92
Hanger	92
H-Frame	52
Cabin	368
Total	604
Hanger (below crack)	25
Total dead load below crack	445

Table 2 - Mass of main elements of an 8-person gondola

The nominal live load mass for each passenger was taken as 77kg (170lb) (per CSA Z98-14 cl. 4.4.2). We also considered the case of a gondola full of adult male skiers with equipment to account for a potential increased loading. Using the 95 percentile mass of a male 23-34 of 101.2 kg (223 lb) and adding 12kg for gear and clothing gives 113.2 kg per skier, for a total live load of 905.6kg. This is referred to as the '8 max' case below. Table 3 lists the total mass of the gondola with different passenger loads.

Loading	Total Gondola Mass Below Crack (kg)
Empty	445
4 Passengers (77kg each)	753
8 Passengers (77kg each)	1060
8 Passengers (113kg each)	1350

Table 3 – Total gondola mass with passengers

The center of mass of these loadings is assumed to be centered on the cabin with the hanger being offset resulting in a bending moment in the hanger pipe. These are equal to the force multiplied by the 'offset distance', i.e. the horizontal distance between the hanger and the center of mass of the elements below the crack. This offset distance, at the location of the crack, is 0.64m. The bending moments induced by this offset are listed, along with the forces that cause them, in Table 4.

Number of Passengers	Static Force, kN	Bending Moment, kN-m
0	4.4	2.8
4	7.4	4.8
8	10.4	6.7
8 max	13.2	8.5

Table 4 - Static loads on the hanger by passenger loading

3.2. DYNAMIC LOADING

During operation of the lift, the carriers experience two main dynamic loading conditions,

- Vertical accelerations from passing towers,
- Lateral swinging accelerations that can occur when a gondola enters a terminal while swinging due to wind or tilting sideways due to loading arrangement in the cabin.
- Torsional accelerations due to wind or eccentric cabin loading during rope speed changes.

3.2.1. Tower Accelerations

As a gondola passes over a tower, vertical accelerations are imposed, with larger accelerations at the hold down sheave assemblies due to impact of the grip passing under the sheaves. Accelerometer testing was conducted for the gondola on an empty carrier over a full lap of the lift circuit show in Figure 5 and Figure 6. Tower 1 is the only tower on this line with a hold down sheave assembly, and it had the greatest accelerations, with a maximum of 2.8g and minimum of -0.8g. The g-forces from passing over the rest of the support towers ranged from maximums of 1.3g to 1.8g, to minimums of 0g to 0.5g. A representative range of 1.5g to 0.25g was used for these towers in the calculations of this report.

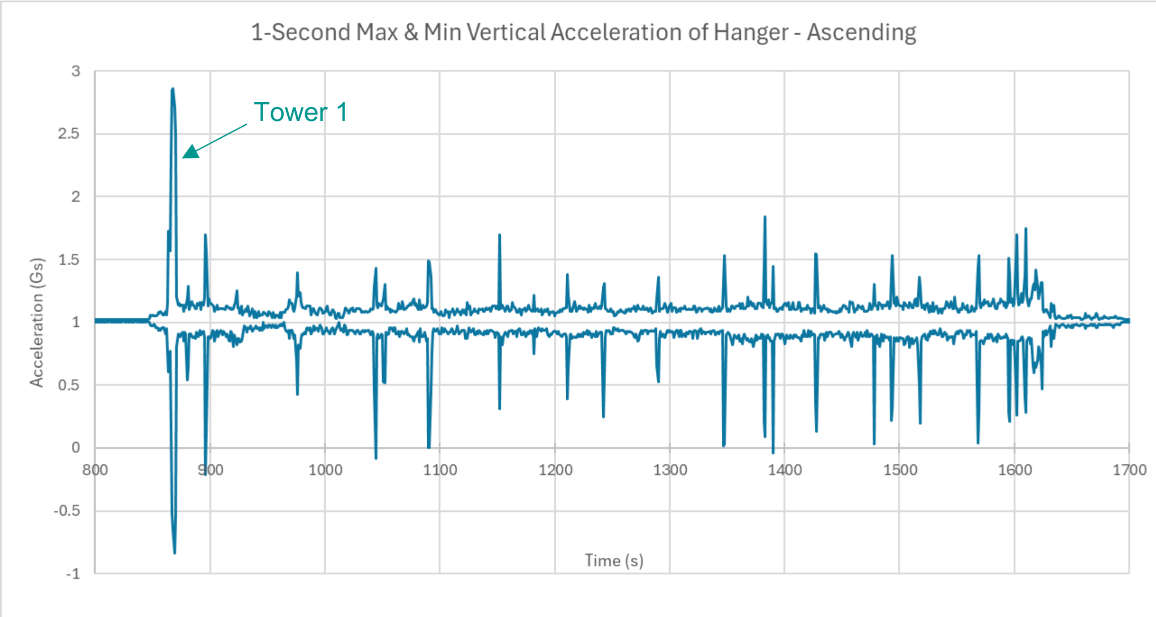


*Figure 5 – Max and min acceleration per second while **ascending** located at the top of the cabin*

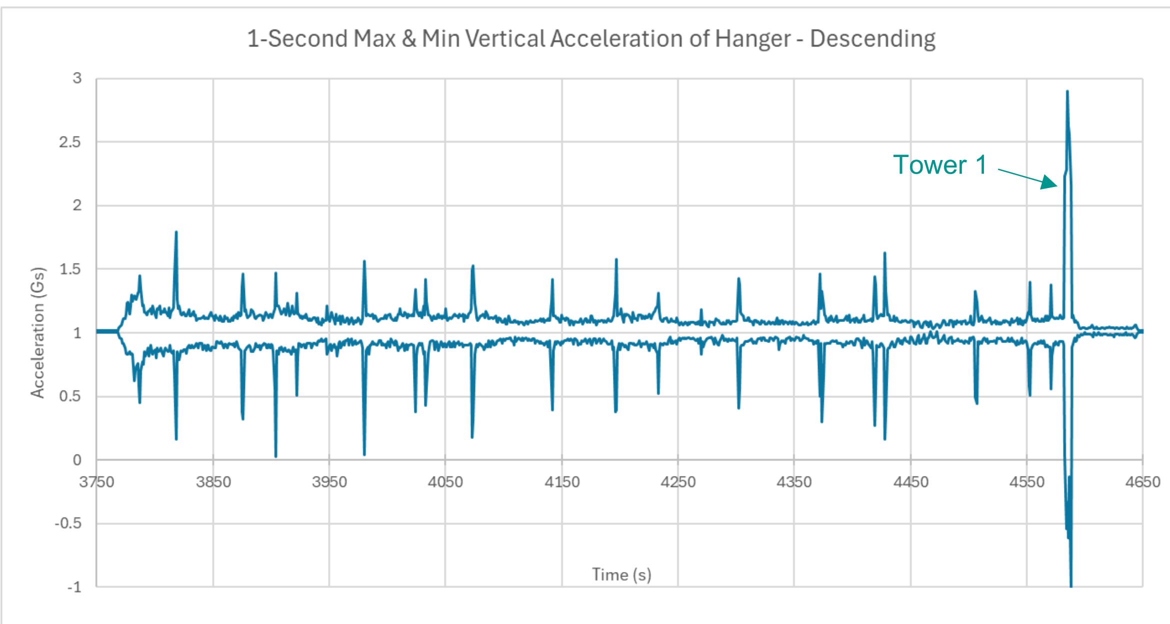


*Figure 6 - Max and min acceleration per second while **descending** located at the top of the cabin*

From historical data, fully loaded carriers are known to experience lower peak g-forces due to the dampening effect of the increased load. These reductions in acceleration are estimated in

	Vertical Acceleration (Gs)			Hanger Force (kN)		
Load Case	**0 pass**	**8 pass**	**8 max**	**0 pass**	**8 pass**	**8 max**
Static	1	1	1	4.4	10.4	13.2
Support Towers - Min	0.25	0.4	0.5	1.1	4.2	6.6
Support Towers - Max	1.5	1.4	1.33	6.5	14.6	17.6
Compression Tower - Min	-0.8	-0.4	0	-3.5	-4.2	0
Compression Tower - Max	2.8	2.4	2.0	12.2	25	26.5

Table 5.

	Vertical Acceleration (Gs)			Hanger Force (kN)		
Load Case	**0 pass**	**8 pass**	**8 max**	**0 pass**	**8 pass**	**8 max**
Static	1	1	1	4.4	10.4	13.2
Support Towers - Min	0.25	0.4	0.5	1.1	4.2	6.6
Support Towers - Max	1.5	1.4	1.33	6.5	14.6	17.6
Compression Tower - Min	-0.8	-0.4	0	-3.5	-4.2	0
Compression Tower - Max	2.8	2.4	2.0	12.2	25	26.5

Table 5 - Approximate vertical accelerations and forces on the gondola hanger when passing a tower

3.2.2. Terminal Entry

The top and bottom terminals capture each carrier, detach it from the rope and then slow it down to the terminal speed. Figure 7 below shows the general arrangement of the grip when its in the terminal.

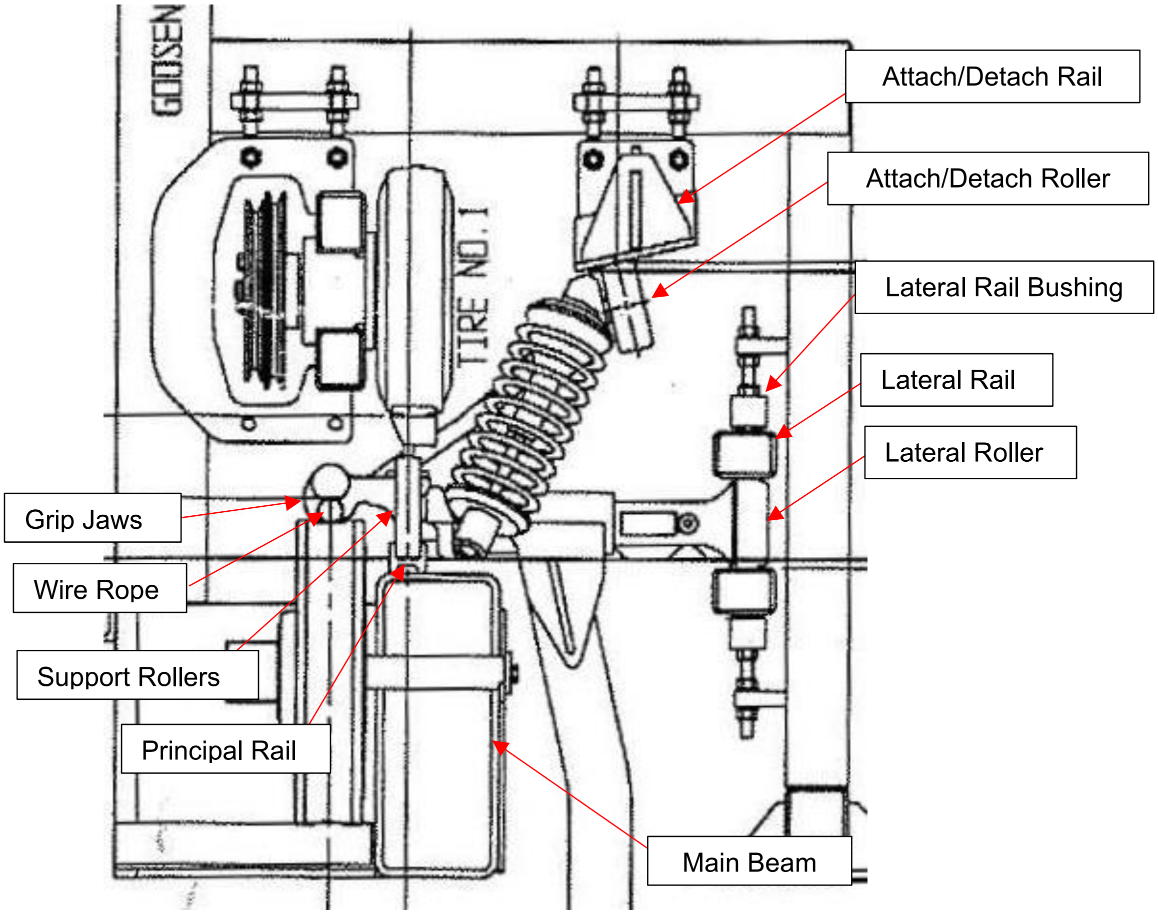


Figure 7 - Grip terminal terminology

Prior to entering the station, the carrier can have a few different positions,

- Vertical with a balanced load and no wind.
- Hanging at an angle due to an unbalanced load.
- Cross wind loading causing constant angle deflection or oscillation from gusting winds.

To ensure that all potential positions of the carrier are captured by the terminal, flared rails known as the “Trumpet”, are installed as shown in Figure 8.

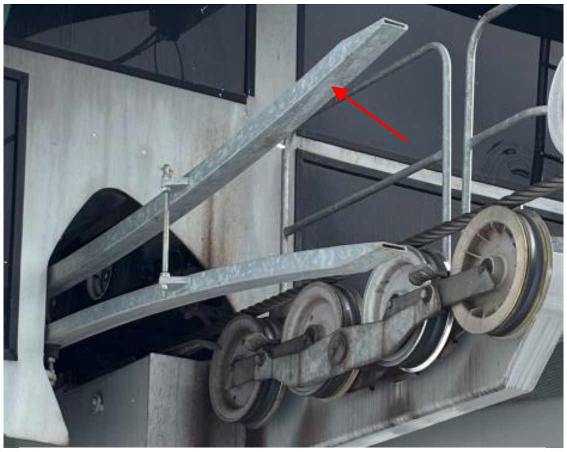


Figure 8 - Lateral rail ‘trumpet’

When a carrier is swinging or angled to the side as it enters a terminal, the lateral roller contacts the trumpet and creates a lever action on the hanger which acts to quickly bring the gondola back vertical. A typical layout of this is shown in Figure 9.

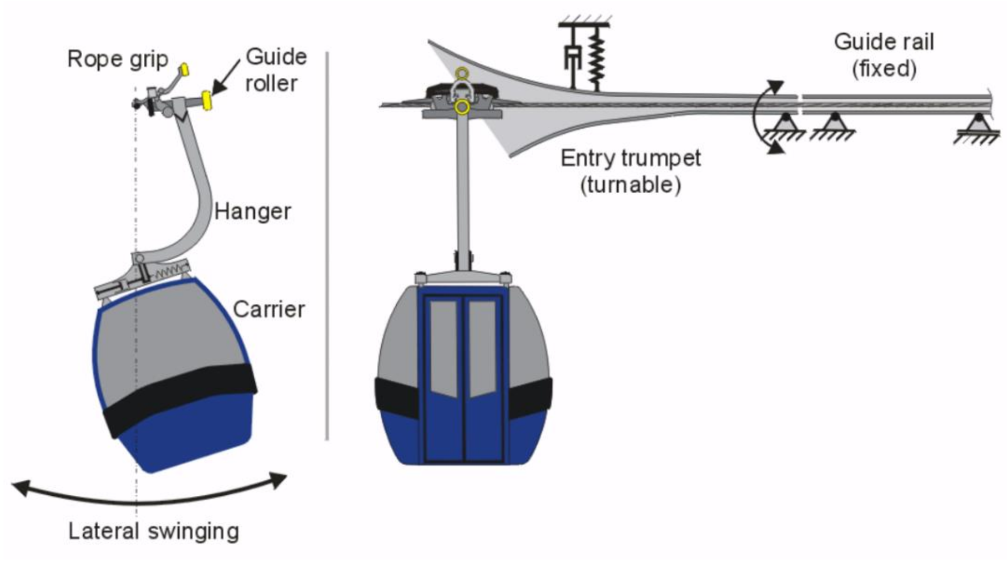


Figure 9 - Left: Lateral swinging of gondola on the rope; Right: Gondola entering the hinged, shock-absorbing ‘trumpet’ rail. (Löhr M (2002)).

The forces involved with this realignment can be large and are affected by several factors of the system such as,

Flexibility and Geometry of the Trumpet

The steeper the angle of the trumpet the larger the load that is transferred to the carrier. In addition, once impact of the carrier has occurred the trumpet acts like a spring. The studies reviewed showed that after an impact the rebound forces due to this spring action could exceed the force of the initial contact with the trumpet rail. Thus, a flexible structure that has good dampening properties results in the lowest forces to the carrier.

Based on the documentation provided by LPOA, the installed trumpet assembly should have two spring dampers and two rubber bumpers at gooseneck #1, and two rubber dampers at gooseneck #2. Inspection of the lift in the fall of the 2025 and review of previous photos showed that some of these were missing. It is unclear how long these were missing for.

The missing rubber dampeners would cause the trumpet to be more flexible and cause a couple of issues. The increased flexibility could cause lateral deflection that would result in the carrier missing the trumpet however this is less likely with the additional items added. Additionally, there is potential that the increased flexibility causes a larger rebound acceleration from the spring effect structure.

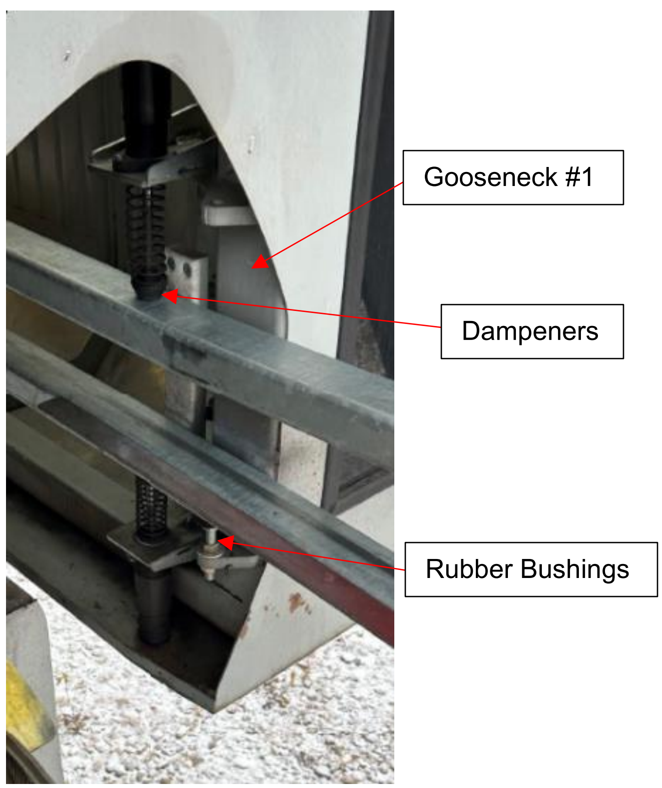


Figure 10 - Missing Upper Bumper Return Entry

Flexibility of the Carrier System

In the same way that the flexibility of the trumpet helps dampen the system, the carrier structure can also help dampen the terminal entry forces. There are three different parts that can affect the forces in the system:

- Flexibility of the hanger affects how much force is transferred between the grip and carrier. A certain stiffness is required for structural strength; this can cause the same spring effect as seen in the trumpet and potentially increase the accelerations in the hangers.
- Flexible rubber bumpers between the cabin and hanger partially decouple the cabin from the hanger. This would result in reduced acceleration forces being applied to the hanger compared to rigidly coupled connection and is what the current cabin uses.
- The most effective method is use of an articulated hanger with a pivot between the cabin and the hanger. This helps dissipate much of the rotational inertia of the cabin and passenger mass by decoupling the mass from the rotational motion which reduces the stress on the hanger. The current cabin does not use this system.

Lateral swing angle of the carrier

The angle that the carrier enters the terminal can be affected by unbalanced loads or wind. Unbalanced loads tend to produce constant tilting angles, up to around 6-8 degrees. Wind tends to create swinging oscillations of the carrier. The phase of the oscillation as it enters the terminal can greatly affect the loading.

Unbalanced loading occurs more frequently, as it only depends on passengers' preferences. Swinging due to wind will be less frequent because the lift is supposed to be slowed or shut down when the wind begins to cause excessive swinging.

Stress calculations for the carrier during terminal entries require a complex dynamic model that accounts for all the items listed above. Due to the complexity of the calculations, direct measurement is the simplest and most accurate method to determine actual loading. Direct force calculations were not completed and potential loading from research papers only is discussed.

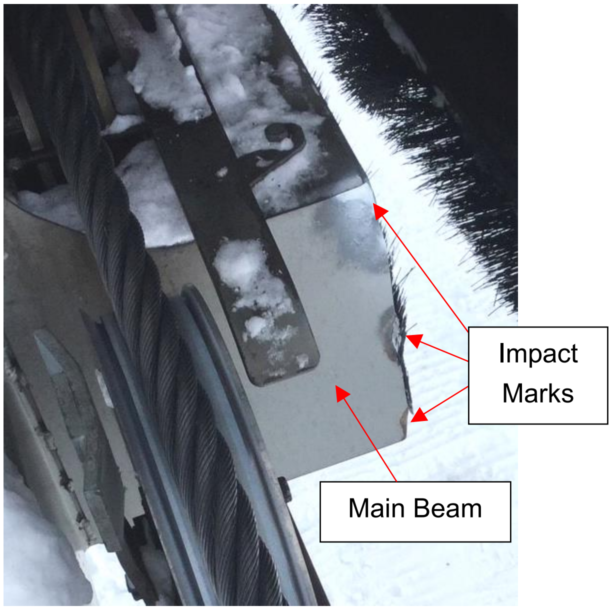
3.2.3. Terminal Impacts

Shortly after installation of the gondola an issue with the terminal entry system was found. During certain conditions the lateral roller could miss the trumpet all together. This would result in the upper part of the hanger impacting the main beam. An impact of this nature would cause a large force that is difficult to estimate. Evidence of such impacts were still visible in the fall of 2025 in the form of marks on the edge of the main beams of the terminals, bending of the first tire beam supports and on the upper hanger's gussets, as shown in Figure 11.

The marks on the main beam of the upper terminal are more pronounced than on the lower terminal. There are a few reasons that could explain this:

- Higher winds at the top terminal, which would result in larger swing amplitudes.

- Unbalanced loads, due to uneven passenger loading, are experienced more often on the uphill line.
- The nearest support tower to the bottom terminal is very close so limited lateral rope deflection is possible as the gondola enters the lower terminal. At the upper terminal, however, the nearest tower is much further away, so more rope deflection is possible.



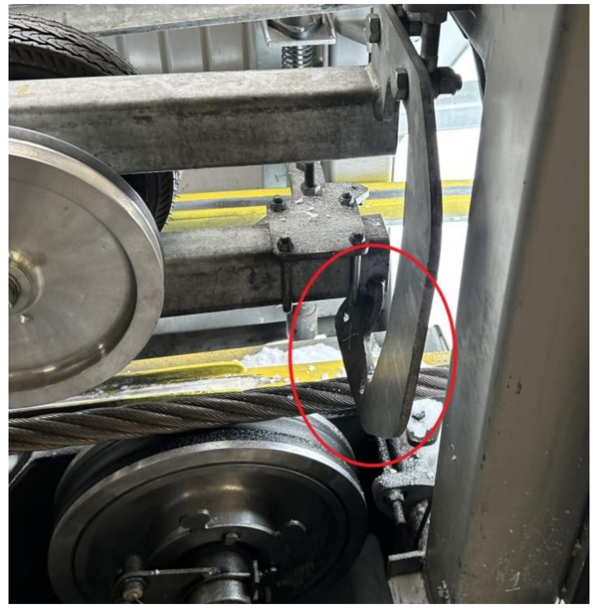


Figure 11 - Left: Impact marks on the main beam of the upper terminal (arrival side)
Right: Bending of the first tire beam support

As a result of this issue the follow sequence of events appears to have transpired,

- March 12, 2002 – The first bulletin of lateral rail misses due to unbalanced loads was issued.
  - Drawing US3039.251 was issued to check the distance from rope to the inside edge or lateral rail.
  - Updated zone 1 switch and rope position drawings soon followed.
  - The bulletin provided no guidance on inspection criteria to carrier or terminals if an impact occurs.
- March 13/14, 2002 – Three new drawings were issued (US3039.250/252 and 253). These show the new zone proximity and rope position switches.
- April 1, 2003 – A new entry guide assembly drawing was created, as shown in Figure 12. This shows an additional bracket that mounts to main beam and directs any carriers into the station to avoid major contact.

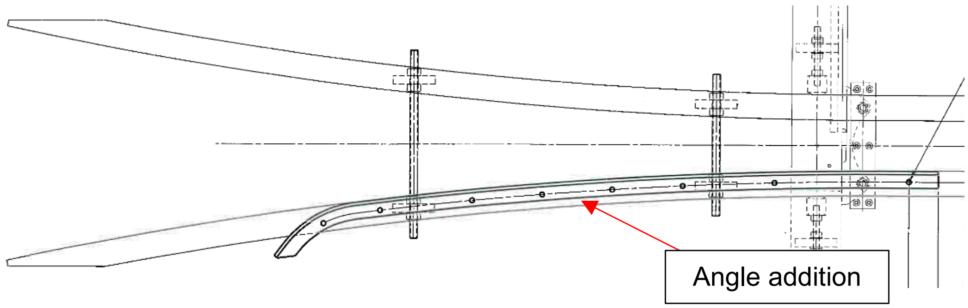


Figure 12 - Angle bracket added to trumpet rail

- February 2, 2007 – A second bulletin was issued for the addition of an angle-steel piece to widen the lateral rail as shown in Figure 13. The bulletin also reiterated the lateral alignment of the lateral rail indicated on the older bulletin.

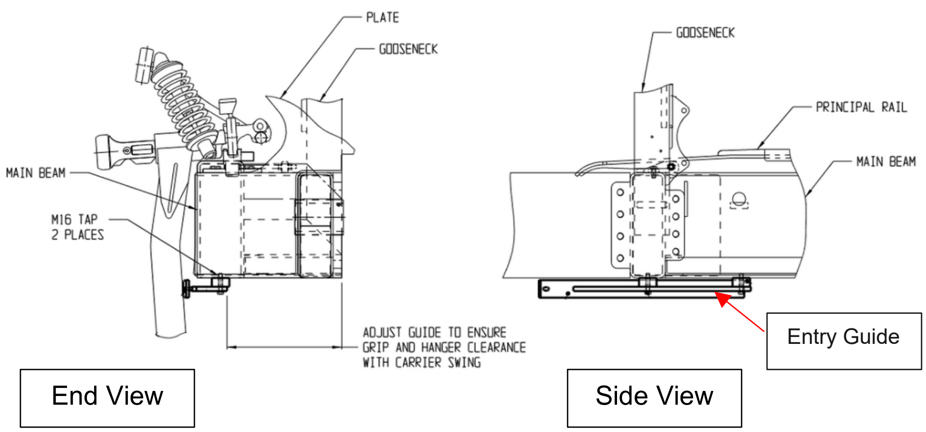


Figure 13 – Main Beam deflector

The combination of ensuring correct setup, widening of the lateral rail and addition of the main beam deflector (entry guide) should ensure that no future major impacts are experienced.

As discussed in this section, the setup of the entry system is very important to the reliability of the lift. The relative location of the rope, principal rail, lateral rail and attach/detach roller all affect how the forces are transferred. These relative positions are specified in the drawings provided from LPOA however the lateral dimension of the principal rail on the main beam along with the lateral dimension of the trumpet are not specified.

The measurement of the principal rail on the main beam from the rope is not specified. This location was observed be in a different location on the main beam for all the entrance and exits of the terminals. LPOA may not intend for this spacing to be adjustable but the different locations of the principal rail suggests that it is. The clearance between the hanger and the main beam is very tight and based on the evidence of impacts this dimension should be clarified.

The trumpet does not have much for lateral adjustment however there is not specification on the dimension to the lateral beam. This could cause issues with missing the trumpet and should be confirmed max and min dimensions.

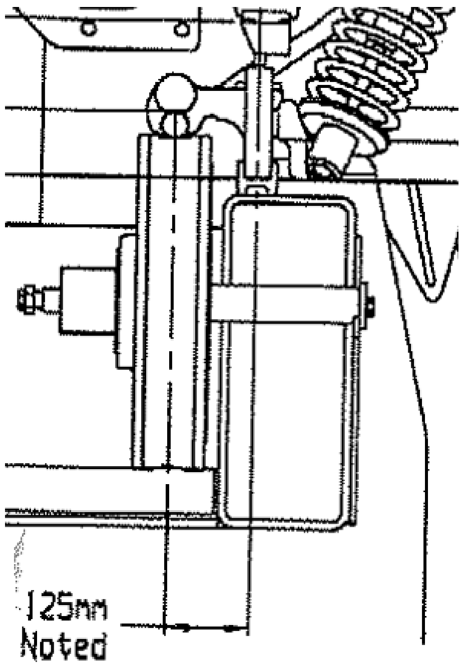


Figure 14 - Principal Rail Adjustment

3.3. LOADING SUMMARY

The following table summarizes the maximum loads cases for this analysis,

Load Type	Number of Passengers	Force (kN)		Moment (kNm)	
		Min	Max	Min	Max
Static	0	4.4		2.8	
	8	10.4		6.7	
	8 max	13.2		8.5	
Towers 2 to 23	0	1.1	6.5	0.7	4.2
	8	4.2	14.6	2.7	9.4
	8 max	6.6	17.6	4.3	11.3
Tower 1	0	-3.5	12.2	-2.2	7.9
	8	-4.2	25	-2.7	16.1
	8 max	0	26.5	0	17.0

Table 6 - Loading Summary. Forces for Static and Passing Towers cases are the vertical force of the gondola's grip on the rope. Forces for Terminal Entry are vertical forces on the lateral roller.

4. Loading Cycles

The number of loading cycles was calculated to indicate which cases could have fatigue implications.

4.1. TOWER PASSES AND TERMINAL ENTRIES

The number of each type of loading depends on the frequency of gondola laps and the frequency of occurrence on each lap. The following are some metrics for the gondola,

- Lap time of the gondola at nominal speed is about 22 minutes for a round trip, i.e. 2.73 laps per hour.
- The number of terminal entries per hour is twice the number of laps per hour, so 5.45 cycles per hour.
- Number of tower passes per hour was calculated by multiplying the laps per hour by the number of tower passes per lap. The lift has 23 towers, so there are about 2.73 x 23 x 2 = 125 tower passes per hour.
  However, Tower 1 produces substantially different accelerations on the carrier, so it is worth calculating towers passes excluding Tower 1. This is 2.73 x 22 x 2 = 120 tower passes per hour.

The lift has been in service for 25 years and as of fall 2025 has operated for 61,423 hours. This has resulted in,

- Up to 335,000 terminal entries and passes of Tower 1 over the life of the lift, or 13,400 per year
- Nearly 7.4 million passes of the other towers over the life of the lift, or about 300,000 passes per year of Towers 2 to 23

These counts assume that the lift is operating at full speed whenever it is on; as such they can be taken as conservative overestimates.

4.2. DISTRIBUTION OF TERMINAL ENTRY EVENTS

As seen in the previous section, the loads during terminal entry vary widely according to how heavily loaded the carrier is and, especially, how energetically it is swinging.

The frequency of different amplitudes of swinging, we use the estimates from Zbil (1999), which are summarized in Table 7 below.

Maximum Swing Angle	Frequency Empty Carriers	Frequency Full Carriers
0° to 3°	80%	95%
3° to 6°	12%	4.5%
6° to 9°	7%	0.3%
Over 9°	1%	0.2%

Table 7 - Estimated frequency for different swing amplitude ranges for empty and full load cases of a 6-person gondola, from Zbil (1999)

4.3. CYCLES BY LOAD CASE

Using these frequency estimates, the number of cycles for each load case were estimated and are listed in Table 8.

Load Type	Load Case	Swing Angle Range	Est. Percentage of Cycles	Cycles Per Year (1000s)	Total Life Cycles (1000s)
Passing Towers	Empty	0°	65	150	3300
Passing Towers	Loaded	0°	35	150	3300
Terminal Entry	Empty	0° to 3°	40	5.4	134
Terminal Entry	Empty	3° to 6°	6	0.80	20
Terminal Entry	Empty	6° to 9°	3.5	0.47	12
Terminal Entry	Empty	Over 9°	0.5	0.07	1.7

Terminal Entry	Loaded	0° to 3°	47.5	6.4	159
Terminal Entry	Loaded	3° to 6°	2.2	0.29	7.4
Terminal Entry	Loaded	6° to 9°	0.2	0.03	0.67
Terminal Entry	Loaded	Over 9°	0.1	0.01	0.34

Table 8 - Estimated number of cycles for the load cases considered, rounded to 2 significant figures.

5. Stresses

There are three main stresses that are observed in the hanger tube,

1) Direct tensile stresses, due to the vertical load
2) Bending stresses in the hanger, due to the offset force path between the center of mass of the load and the hanger.
3) Potential residual stresses in the pipe due to bending. This was not included in our review.

5.1. STATIC STRESSES

The stresses created by the hanger loads depend on the geometry of the cross section of the hanger. Acuren scanned the failed hanger tube as part of their analysis. Although the nominal cross section of the tube is circular, the cross section at the location of the crack is actually an ellipse, due to flattening during the bending process. It was measured to be 5.15” by 4.72”, with the lateral dimension being narrower. The wall thickness was approximately ⅜ inch (9.5mm), from drawing #US4076.601 of the hanger. The equation for area of an ellipse ($A = \pi ab$, where width=2a and height=2b) gives a net cross-sectional area of 3475mm^2.

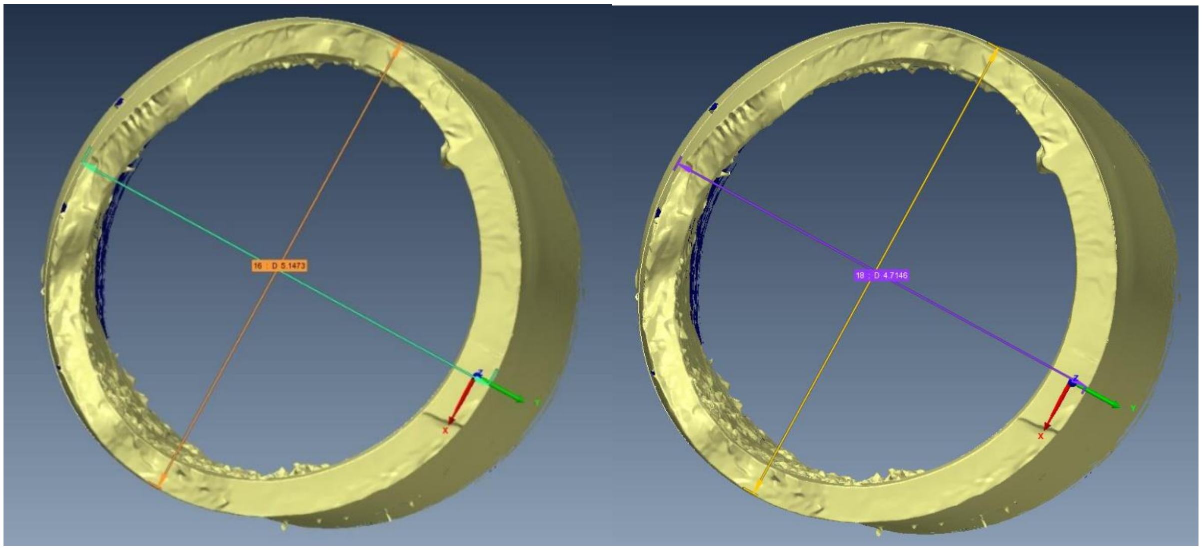


Figure 15 - Pipe ovality at the crack location.
(from Acuren Inc. report “Hanger Arm Failure”, 18 Sept. 2025, p.10)

The direct stress is calculated as the applied force divided by the cross sectional area of the hanger. A ‘stress concentration factor’ of 1.075 is also applied. This accounts for how stresses are concentrated on the inside of a curved member, as at the crack location. This factor was calculated using the equation for a curved bar (Equation 5.11) in the 1997 textbook by Walter Pilkey, "Stress Concentration Factors". Tensile stresses are developed on the inner side of the hanger by the induced bending moments (due to the offset between the hanger and line of action of the static force, per Table 4).

Table 9 lists the calculated static stresses at the crack location and shown in Figure 16 heat map,

Number of Passengers	Static Load (kN)	Direct Stress (MPa)	Bending Stress (MPa)	Total Static Stress (MPa)
0	4.4	1.3	36	38
4	7.4	2.3	61	64
8	10.4	3.2	87	90
8 max	13.2	4.1	110	114

Table 9 - Static stresses in the hanger at the location of the crack

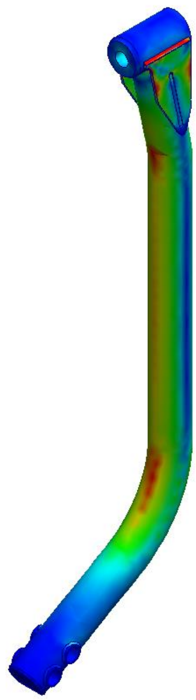


Figure 16 - Static Stress Analysis Heat Map

5.2. TOWER ACCELERATION STRESSES

The stresses produced by passing by the towers are calculated by scaling the static stresses on Table 9 by the accelerations in

	Vertical Acceleration (Gs)			Hanger Force (kN)		
Load Case	**0 pass**	**8 pass**	**8 max**	**0 pass**	**8 pass**	**8 max**
Static	1	1	1	4.4	10.4	13.2
Support Towers - Min	0.25	0.4	0.5	1.1	4.2	6.6
Support Towers - Max	1.5	1.4	1.33	6.5	14.6	17.6
Compression Tower - Min	-0.8	-0.4	0	-3.5	-4.2	0
Compression Tower - Max	2.8	2.4	2.0	12.2	25	26.5

Table 5. This gives the values shown in Table 10 below.

	Stress (MPa)								
	Direct	**Bending**	**Total**	**Direct**	**Bending**	**Total**	**Direct**	**Bending**	**Total**
Load Case	**Empty**			**8 Passenger**			**8 Max (100kg ea)**		
Static	1.3	36	38	3.2	87	90	4.1	110	114
Support Towers Min	0.3	9	9	1.3	35	36	2.0	55	57
Support Towers Max	2.0	54	56	4.5	121	126	5.4	147	152
Compression Towers Min	-1.1	-29	-30	-1.3	-35	-36	0	0	0
Compression Towers Max	3.8	102	105	7.7	208	215	8.2	221	229

Table 10 - Dynamic stresses on the inside of the hanger (at the initial crack location) due to passing support towers

5.3. TERMINAL ENTRY STRESSES

The lateral swinging torque produced by the lateral roller forces manifests as a bending moment in the hanger and increases with larger forces applied to the lateral rollers. As discussed in above sections this is a difficult calculation to complete thus general analysis of potential stresses is discussed.

Based on the findings in Degasperi (1999) the increased stresses above a static empty-cabin baseline were found.

- For chairlifts, dynamic stress increments at the hanger (suspension head) were:

  - Empty: 189% of static stress
  - Half-load unbalanced: 84%
  - Full load: 100%
- For 6-person articulated gondolas:
  - Empty: 108%
  - Half-load unbalanced: 31%
  - Full load: 63%

For extreme cases:

- With fixed lateral inclination (simulating wind), dynamic stress increments at the hanger reached up to 428% (chair) and 513% (gondola) of static stress.

These values if experience could have contributed to the initial brittle failures.

5.4. FATIGUE CRACKING

Fatigue cracking in steel is characterized by the presence of an 'infinite life' fatigue stress limit. This is the amplitude of alternating stress below which the steel can withstand effectively infinite number of cycles. For steel this value is typically about 5 million cycles. That is, if the alternating stress is low enough that a steel member can survive 5 million cycles then for most steels it should survive indefinitely. The Canadian Ropeway standard, CSA Z98-14 requires that carriers be designed to withstand 5 million loading cycles, and be tested to this number with alternating stresses that represent the dynamic stresses of operation.

The fatigue limit of most steels is approximately half of the steel's ultimate tensile strength. The hanger arms on the Golden Eagle Express were made from ASTM A500-B steel, which has a minimum ultimate tensile strength of 400MPa. Thus, even though the A500 standard does not specify fatigue properties for the steel, its fatigue limit is expected to be approximately 200MPa.

Another estimate of fatigue stress limit comes from Canadian Steel Design standard CSA S-16. The standard lists 'constant amplitude stress ranges' which correspond to fatigue life limits for different 'detail categories' (loading situations) (implicitly, the infinite life fatigue stress is similar for most mild steels). The

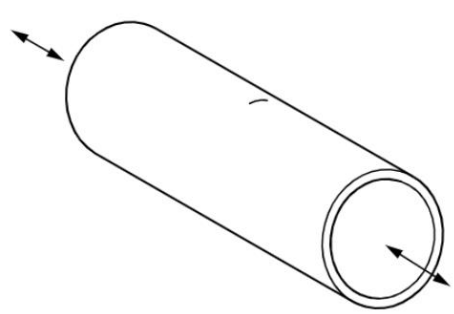


Figure 17 - Example 1c of detail category A of CSA S16:19's section 26.3 on fatigue design. This closely resembles the geometry of the hanger arm at the crack location

section of the pipe where cracking propagated is best described as detail category A Figure 17, which has a ‘constant amplitude stress range’ of 165 MPa. This means for max to min stress ranges of less than 165MPa the steel should theoretically have infinite fatigue life.

It should be noted, however, that these limits are based on testing of undamaged specimens. If a structural member has a sufficiently large pre-existing crack then even if the overall stress is below the fatigue limit, stress concentration at the crack tip can create a high enough stress field to advance fatigue cracking.

5.5. SUMMARY OF STRESSES

The following table summarizes the stresses calculated.

Load Type	Number of Passengers	Maximum Stress (MPa)	Minimum Stress (MPa)
Static	0	38	-
	8	90	-
	8 max	114	-
Passing Towers	0	56	9
	8	126	36
	8 max	160	46
Comp. Towers	0	105	-30
	8	215	-36
	8 max	229	0

Table 11 - Maximum tensile stresses for different loading situations

CSA S16 Design of steel structures provides allowable stress ranges for different types of connections. The hanger section would be a detail A category with an infinite life stress range of 165MPa and 290MPa at the 335,000 cycles experienced at tower 1 or terminals.

The maximum tensile stress range for the above loading conditions are below these limits. Also, the maximum static stress of 90MPa for a full load of nominal weight (77kg) passengers still gives a factor of safety greater than 3 relative to minimum yield strength of A500-B steel (315MPa), as required by CSA Z98:14.

6. Conclusions

In March 2025, a hanger supporting a gondola on Kicking Horse's Golden Eagle Express failed catastrophically. This report estimates the static and dynamic loads and stresses acting on this hanger for key load cases. The static load cases for full design load were found to be 90MPa which results in a safety factor that exceeds the safety factor of 3 required by CSA Z98.

The dynamic stresses at the crack location for a gondola with full design load were estimated to cycle from 36 to 126 MPa when passing over support towers. These stresses are below the yield strength of the steel, with a safety factor of 2.5, and are below the allowable fatigue stress limit of 165MPa. The dynamic stresses are also below the allowable fatigue stress limit for the increased loading at tower 1.

Although these nominal-case stresses are within limits, higher short-duration forces could have been caused by:

- Impact of the hanger on the terminal main beam.
- Entry of the gondola into a terminal while swinging at angles of 8 deg or more.

These peak loadings, though rare, could have been sufficient to initiate cracks in the hanger through local brittle fracture, especially if they occur during cold conditions. Once a crack is present in a highly stressed location, stress concentration at crack tip can allow fatigue cracks to advance even if the average peak tensile stress is below the fatigue limit.

Future instances of peak loading can be effectively mitigated through appropriate setup and operational procedures. The requirements for station configuration should be clearly defined by the LPOA to ensure the proper functioning of newly installed deflectors. Additionally, ensuring operational controls for personnel to regulate load distribution and to adjust or suspend activities during wind events will further reduce the likelihood of significant peak loading occurrences previously observed.

7. References

CSA Group, Z98:24: “Passenger ropeways and passenger conveyors”, 2024

Canadian Institute of Steel Construction (CISC), "Handbook of Steel Construction" (12th ed.), 2021

Degasperi F, “Measurement of dynamic stresses on carriers with detachable grip at station entrance: LA.T.I.F. experiences and future prospects”, 1999

Engineering Library, “Fatigue crack growth and life prediction”, retrieved 1 October 2025 (link)

Mark-Oliver Löhr, “Simulation of the station entry of detachable monocable gondolas” (PhD thesis), 2002

Pilkey W., “Peterson's stress concentration factors” (2nd ed.), 1997

Zbil H.U., “Dimensioning carrier-components of modern circulating monocable ropeways”, 1999

APPENDIX A

Statement of Limitation

Statement of Limitations

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