



Bulletin
98-6

February 10, 1998

MFG: GRAVITY WORKS X
NAME: SKY SCRAPER
TYPE: NON-KIDDIE

Dear Mr. Rinehart,

This is a follow-up letter in reference to our conversation regarding the reuse of ASTM A-325 bolts and nuts and to the crack that was discovered and repaired on the mobile Skyscraper.

The structural steel code allows for the reuse of non-galvanized A-325 bolts and nuts if approved by the engineer responsible (AISC, Ninth Edition, page 5-276(e)). We contacted the American Institute of Steel Construction (AISC) to get clarification of under what circumstance should the bolts and nuts be replaced. They said that as long as the nut can be hand threaded onto the bolt the nuts and bolts can be reused. If the nut cannot be run by hand along the entire threaded portion of the bolt then the nut and bolt must be replaced. Galvanized A-325 nuts and bolts and high strength A-490 nuts and bolts may not be reused.

Because the structural code allows for the reuse of certain bolts and most normal structures do not replace fasteners on a regular basis the annual replacement of fasteners on amusement rides is arbitrary. Because it seems to have become standard in our industry to replace fasteners annually we have instituted a fastener replacement program according to the following schedule:

Chair to Sweep Attachment Bolts	Annually
Inner to Outer Mast Attachment Bolts	Every two years
Sweep Interface Attachment Bolts	Annually
Sweep to Hub Attachment Bolts	Annually
Mast Top Plate Attachment Bolts	Annually
Mast Bottom Plate Attachment Bolts	Annually
All Threaded Fasteners	Every four years

No other fasteners need to be replaced unless they are damaged or extremely rusted. All of the fasteners that need to be replaced annually need not be replaced until after the Florida State Fair ends but before the Skyscraper is erected and assembled again.

Any cracks in the mast plates can be rewelded. Any crack should be ground out or air-arc gouged out before being rewelded subject to accessibility. There are certain welds along the welded mast plates where it would be difficult if not impossible to grind out without damaging the base metal in the tube steel.

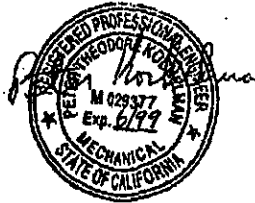
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Please contact us should you find any cracks where it would be impossible to grind out the crack so we can determine the best solution for repair.

I hope this answers your questions. Please feel free to contact me should you have any further questions.

Sincerely,
Peter Kockelman
Peter Kockelman



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4

Incident #3

Daytona Beach, Florida
120-foot Permanent Ejection Seat
July 2000
Improperly Swaged Hoist Cable

Description of Incident:

Hoist cables were replaced on a permanent Ejection Seat in Daytona Beach, Florida. After the chair was launched and had a few rebounds the hoist cable slipped through the swage. The cable became detached from the swivel causing the chair to swing into one of the towers.

Two female teenage riders were in the chair at the time of the accident. They were suspended sideways in the chair for about 90 minutes until the fire department was able to bring them down. Both girls suffered minor injuries.

Analysis:

The manufacturer of the cable assembly was contacted and upon examination of the cable took full responsibility for an improperly swaged sleeve on the cable. Initial reports seem to show that the dead end of the cable was never fully inserted into the sleeve before it was compressed around the cable.

Corrective Action:

Because of this accident and other close calls with the hoist cables in the past, Gravity Works is now requiring all ride operators to purchase their hoist cables from Gravity Works. We have developed a program with a manufacturer for insuring that hoist cables for the Ejection Seat are properly made, documented, serialized, and proof loaded prior to installation on any Ejection Seat.

This quality program will insure that the cables are all made from one controlled source from only domestic wire rope. In addition, each cable will be dynamically tested after the end is swaged. This load is 200% of the safe working load. The safe working load is 1.4 tons.

In addition, the hoist cables must be replaced annually or sooner if the cable exhibits any of the wear conditions delineated in the Operation and Maintenance Manual.

Ride owners have 30 days from this directive to replace the hoist cables with cables provided by Gravity Works.

Peter Horkelmann

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3

down. The sudden reversing of the winch while the chair was still rebounding caused the Nord winch drum to flip a wrap of cable off of the drum.

The cable became entangled and subsequent lowering caused the cable to hoist in rather than to pay out cable. The hoist cable was then lowered on one side and raised on the other. This caused the cable to kink severely as the winch stalled and applied full stall torque. This stall torque was equal to 150% of maximum torque. This condition could cause the cable to see over 4000 pounds.

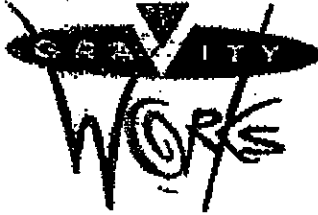
The breaking strength of 3/8" XIPS IWRC cable is a little over 15,000 pounds. The stalled winch could not generate enough force to break the cable unless the cable was seriously damaged already.

Corrective Action:

1. Do not begin lowering the chair until the chair is no longer bouncing up and down. All winching systems need some weight at the end of the cable in order for the cable to come off the winch drum correctly. Most hoists use a heavy ball at the end of the hoisting cable to keep some tension on the cable for proper operation of the winch. The weight of the bungee cords, swivels, and chair is more than adequate for the proper operation of the Nord winching system. However, if the chair is still rebounding then there is not enough weight on the hoisting cable for cable to peel off the winch properly.
2. Gravity Works is designing a roller system to keep the cable from flipping off the Nord winch drum should an operator begin to lower the chair before the bouncing has subsided. We should have a system out to all owners within the next 30 days. The only modification to your winches will be to drill two mounting holes in your winch frame. We will provide the mounting hardware with the roller system.
3. Grind the three Nord winch drum check plates to a full radius. The check plates are 3/8" thick mild steel plates. This rounding of the plates will prevent the cable from becoming severely kinked should a malfunction ever cause the cable to flip off the drum. Remove the cable completely from the winch drum before grinding the check plates.

Ride owners have 30 days from this directive to grind the check plates and to install the roller system.

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What we found was that the leg stresses are indeed low and at this point would indicate an almost infinite life. The fact that the tower failed after less than 20,000 launches would seem to indicate that there were defects in the towers after manufacturing. The insurance company is investigating the failure. Gravity Works will keep everyone informed as more information is learned.

Corrective Action:

All permanent rides are to have their leg to flange welds inspected annually by a certified NDT company. The process is to be magnetic particle. This is an easy and effective test for locating surface cracks. If any cracks are found, Gravity Works needs to be notified in order to specify the proper repair procedure.

In addition, any crack that would completely sever a solid 2-inch steel rod would have existed for some time before the final failure. Do not become complacent in your inspections of the tower sections. Every 2000 launches your towers must be inspected completely by your employees.

Incident #2

**Pigeon Forge, Tennessee
70-foot Permanent Ejection Seat
July 2000
Broken Hoist Cable**

Description of Incident:

A hoist cable was severed on a 70-foot permanent Ejection Seat in Pigeon Forge after the launch was over and the operator was lowering the chair back to the ground.

After the ride was completed the operator attempted to lower the chair but the chair would not lower beyond a certain point. The operator then tried to raise the chair. The chair rose slightly and then the cable broke causing the chair to swing into the tower.

The operator lowered the chair, brought the riders to the ground, and unloaded them. The riders suffered minor injuries and spent the rest of the following day riding the rides for free.

Analysis:

After talking with the operator and ride owner what became apparent was that the ride was lowered too soon after the chair was launched. The chair was still bouncing up and



July 26, 2000

Dear Ejection Seat Ride Owner,

There have been a few incidents and accidents this season that have produced some injuries and one broken ankle. Please take the time to read this carefully and to hold a safety meeting with all your employees so these incidents can be prevented.

Incident #1

**Lake of the Ozarks, Missouri
Permanent 120-foot Ejection Seat
Towers Fabricated by Cascade Manufacturing
July 2000
Tower Collapsed**

Description of Incident:

One of the permanent towers collapsed while the bungee cords were being tightened prior to launching the chair. The outside leg of the three-sided tower at about 40-feet up from the ground experienced a complete failure. The leg was made from solid round bar stock and failed right above the flange. Initial reports indicate that the leg severed right through the fillet weld.

The tower was pulled over into the other tower damaging both towers. Two riders were injured with a broken ankle the most serious injury.

Analysis:

Gravity Works immediately contacted all permanent ride owners and instructed them to have an NDT certified company come out and inspect the tower leg to flange welds on all tower sections.

At this point all rides have been inspected with only one crack found on a ride in Gulf Shores, Alabama. This tower was also found to have undercut in most of the tower leg to flange welds. As of today all deficient welds have been repaired and are just waiting to be reinspected. This tower was fabricated by ESCO of Burleson, Texas.

The tower that fell was designed by Chi Lee for a 70-mph wind zone. The wind loads governed the design of the tower. In order to verify that there are no strange dynamics after launching the chair that would cause higher cyclic loads than were anticipated, we hired an independent firm to test for the stress range the tower legs are subjected to.

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