Spirit of Wamego Accessible Train Car

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Final Project Design Report

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Abstract

The Spirit of Wamego is a small children's train located in the Wamego City Park in Wamego, Kansas. The scope of this project was to design and build a train car that is compatible with the existing train that will allow a child confined to a wheelchair and a parent or guardian, to ride the train. The final design consists of a removable ramp placed on the loading platform, and a drop down door located on the left side of the train car that will act as an additional platform to assist in loading positioning the child. The primary consideration in the design is safety; both in loading the child and while the train is in use. Tipping of the car is the main safety concern. While loading, the car could tip over on the child or guardian, and while running, tipping of the train car could cause derailment. To solve these issues, a low center of gravity of the train car will be paramount. The likelihood of tipping while loading is also decreased by using a removable ramp and a fold down platform because the removable ramp supports the platform and limits the motion of the tipping. Ease of use of the train car is also of concern, as the operators of the train are typically elderly persons. The ease of use also directly affects the time and effort spent loading the child. The goal is for the loading of the train car to take three minutes or less. The design weight limit for the car is a maximum load of 500 lbs.

Problem Statement

In Wamego, KS a children's train car runs two hours a day during the season of operation, April 15-0ctober 15. The train carries about ten thousand children a year. Typically, the train goes around the track one time in about seven minutes. In order to increase its accessibility to the rest of the community, a handicap accessible train car will be fully designed and built for use with the existing train. The accessible car will be coupled to the rear of the train at all times. As well as holding a wheelchair, the train car will also be used by other passengers when a wheelchair bound child is not using the train car. Also, an adult, parent or guardian, will be able to ride with the wheelchair bound child in the train car. The target time for loading of the child on to the train will be three minutes. The design weight including the adult, child, and wheelchair was 500 lbs.

Introduction

The city of Wamego, KS is home to a little over 4,000 residents covering a total area of 2.25 square miles. It is widely known for holding the tourist attraction Wizard of Oz Museum based off the renowned book and film. Due to the significance of the tourist attraction, the city holds many festivals and fairs which bring visitors from many places. These festivals and fairs also allow tourists to experience the historical significance of the city, as it holds a replica model of an Union Pacific train. This children's train was first built in 1947, operating in the Wamego, KS City Park. In 2009, a full replacement of the train was completed which retired the original model in the newly built train depot (Fig. 1). The children's train car runs free of charge two hours a day on Thursday, Saturday, and Sunday from April 15th to October 15th. During the full renovation of the train, the Three Rivers Inc. Center for Independent Living as well as many community members suggested making a car fully accessible to children with disabilities.

Figure 1. Spirit of Wamego Children's Train

The Three Rivers Inc. Center for Independent Living first began as a volunteer organization in 1986 serving Central Northeast Kansas as a nonprofit. Today, the organization has grown promoting self-reliance of individuals with disabilities through education, advocacy, training and support. Due to the renowned attractions of the city of Wamego, KS Three Rivers Inc. along with the community members felt a need to provide an accessible children's train car which all children can participate in and enjoy. However, the volunteer builders of the fully renovated train car felt this task was more than they wanted to take on and therefore Three Rivers Inc. submitted a grant proposal to the KU BREAK Program in hope of acquiring the necessary funds and design engineers. The requirements of this project include a single accessible train car which could be added to the train currently used. The car must also fit in the train depot after being added. The train car must also look similar or fit in with the rest of the cars and provide extra seating when the car is not being used for wheelchair accessibility. The most important requirement is that the car be safe for children with disabilities. The specific timeline of project deliverables can be seen in Appendix B. The final design will be completed before the summer; prime time for usage of the train.

ADA Specifications

Due to the design requirements of the Americans with Disabilities Act, the accessible train car must meet several product specifications. Ramps 30 inches or longer shall support a load of 600 pounds, placed at the centroid of the ramp distributed over an area of 26 inches by 26 inches, with a design factor of at least 3 based on the yield strength of the material. If the height of the vehicle floor from which the ramp is deployed is 6 inches or less, but greater than 3 inches, above a 6-inch curb, a maximum slope of 1 ":6" is permitted. Each side of the ramp shall have barriers at least 2 inches high to prevent mobility aid wheels from slipping off. The ramp surface shall be continuous and slip resistant; shall not have protrusions from the surface greater than ~ inch high; shall have a clear width of 30 inches; and shall accommodate both four-wheel and three-wheel mobility aids. When in use for boarding or alighting, the ramp shall be firmly attached to the vehicle so that it is not subject to displacement when loading or unloading a heavy power mobility aid and no gap between vehicle and ramp exceeds 5/ 8 inch. The securement system shall secure common wheelchairs and mobility aids and shall either be automatic or easily attached by a person familiar with the system and mobility aid and having average dexterity. These product specifications along with the requirements from the Wamego community are necessary for successful completion of the project.

Accessible Train Car Design

The main goal of the accessible train car is for it to be as similar as possible to the current cars already on the train while providing a safe and accessible option to those with disabilities. To blend the new car to the rest of the train, the final design will be constructed primarily out of the same types of tubing, support, frame, and floor structure as the current cars (Fig. 2). Some of the major similarities, differences, strengths, and weaknesses of the accessible car design follow.

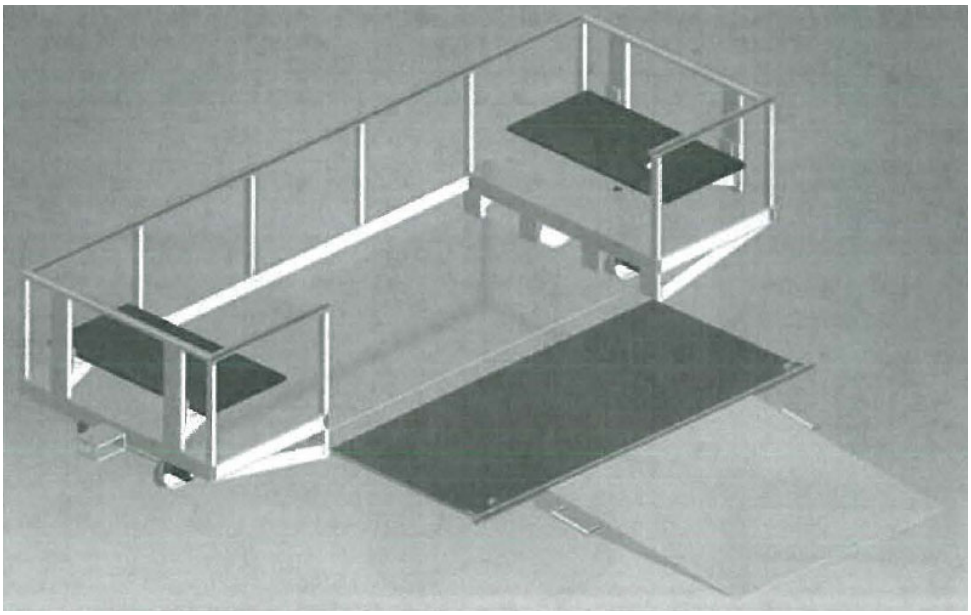

Figure 2: Rendering of the computer modeled train car after fabrication.

The exterior sheet metal is not shown to allow for a better view of the interior. The accessible car is just over 9 .5 feet long compared to 13 feet of the existing cars. The shortening was necessary because of the limited amount of space in the depot where the car is stored, which has about 10 feet of currently unused space from end to end when the train is fully pushed to the front of the garage and all the slack between the cars is removed. The overall length of the car was by far the most critical constraint of the design because over 5 feet of length is necessary as a minimum clearance for the wheelchair to be able to swing in without interference of the frame, and then also have enough room to accommodate a set of wheels and trucks on each the front and back, which are over a foot in length each before clearances are accounted for. Because of the length constraints, the trucks of the final design have shortened distances between the wheels, allowing for a larger dropped down portion than previous measurements allowed for. The shortened distance also allows for additional support for the dropped down area, in the form of more square tubing.

After doing some simple diagrams, as well as in person simulations using boxes and tape on the floor, it was determined 32" would be the minimum inside width of the car, which is 11" wider than the original cars. Normally, this would make the design slightly unstable, however, the drop in the center of the car significantly lowers the center of gravity, and made tipping less of a concern after doing simple tipping analysis. Next was the amount of room the conductor would need to load and unload a child's wheelchair. Since the conductor would roll the wheelchair in backwards, it would require there to be some room behind the drop down section for the conductor to stand while pulling the wheelchair against the back wall of the drop down portion. At the same time, a chair will be placed in the area the conductor would need to stand for loading. To alleviate the problem, the seat was made to enable it to fold up during loading. The seats will be placed in the front and back of the car to allow the parent an option to either sit in front of or behind their child.

The original floor design slopes toward holes in the center of the floor for cleaning. The new car will not have these, but will still have the holes in the center. This may make cleaning more difficult, however, the floor of the car must be flat to allow for maneuvering a wheelchair into and out of the car.

The final portion of the design is the removable ramp and drop down door. The loading side of the train will have a drop down door that will be piano-hinged along the bottom of the floor where it meets with the sidewall. There are vertical supports on each side of the door that are a part of the frame and act as a backstop for the drop down door when being folded back up, to ensure the wall is flush with the rest of the car, and that it is not folded too far. There will also be a "foam" weather-stripping material added to these supports to reduce the noise when being folded up, as well as reduce any rattling in the latches as the train runs. When folding down, the side door of the car will be met with a portable ramp that will already be in place. The two-piece ramp (ramp and fold down door used in conjunction) was chosen, because ADA regulations require the ramp to be nearly double the length of what our current height of our car sidewall. One of the problems with using a removable ramp is how the conductor would be able to achieve

proper placement on the loading platform. During construction, it was decided that the fold-down door would have pins on the top railing that would fit into slots that are created by the supports on the removable ramp. This not only helps with proper placement, but will not allow the ramp to be placed in an area most convenient to the conductor. The pins also prevent the ramp from moving relative to the train and vice-versa. The round tubing on the top of the fold down door will fit into a notch on the removable ramp. This enables the fold down door to meet the portable ramp at a slight incline, and reduces the risk of the car tipping because of weight added to the outside of the ramp. It also allows the grade of the overall ramp to be shallower. Since the portion of the drop down door that people walk on is the inside wall of the train car sidewall, it makes it possible to spray this with a non-stick compound without worrying about altering the outside paint of the car.

Another modification made was the two interior vertical side posts on the frame. This does not add any structural integrity and was done for cosmetic reasons during welding. The two posts provided the opportunity for rivets to be added for extra strength, but since riveting was already overdone to mimic the look of an actual train, this was not necessary.

For the trucks, the main modification made was the alignment and placement of the main support channel bar under the main frame. This was designed to be placed roughly half an inch back towards the end, but there was a miscommunication in the transfer in drawings which made for some on the spot decisions about the exact placement by the welder. This slight difference caused for a critical error between the turning radius of the wheels and drop down portion of the frame. When the wheels were at the maximum turning radius, the outmost part of the inside wheels rubbed on the drop down uprights by about an eighth of an inch. Because of this, the two most inside drop down upright supports were shaved down an eighth of an inch, which slightly lowered the structural integrity of this part. Even after this modification was made, analysis showed that the uprights themselves still held the load of 600 pounds with a factor of safety over 2.0.

The last modification made was the attachment methods for the hinges to the end steel uprights. Normally, these were planned to be bolted on, but because of the width of the hinges themselves, it was easier to weld them directly to the uprights. Also, it was discovered that it would look better cosmetically if the hinges were lowered roughly 2 inches, which would allow the seats to fold up without being seen from outside of the car.

System Operation and Assessment

The final train car (Fig. 3-4) was assessed for function and safety. After completing the fabrication of train car three test procedures were performed in order to ensure the safety of the design. The first test procedure that was performed was the Stability in Loading and Unloading Test. Five trials were conducted to test the stability of the drop down door and removable ramp. These trials consisted of team members standing on the drop down door and removable ramp and a test subject in an adult sized wheelchair being loaded and unloaded onto the train car. After performing all five trials, no tipping, deflection, or failure was observed, and therefore the train

car was determined stable for loading and unloading procedures. The second test procedure performed was Timing of Loading and Unloading Test. Four trials were conducted consisting of loading the wheelchair onto the train car from the time the train comes to a complete stop to strapping the wheelchair in and closing the fold down door. Unloading consisted of the time to unload the wheelchair off the train and closing the fold down door. Based on the first several trials loading and unloading took over three minutes due issues figuring out the loading position and strapping in the wheelchair. After several trials, it was determined that loading and unloading would take about 3 minutes assuming that the removable ramp was positioned correctly. It was also noted that marks on the concrete pavement would need to be made to cut down on loading and unloading time. The final test procedure that was performed was the Stability of Wheelchair Accessible Train Car in Motion. Three trials were conducted with the train car completing the entire track course. An adult sized wheelchair and test subject was strapped in the train car for all three trials. Based on the three trials around the track course no tipping or instability was detected by the observers or felt by the test subject.

Figure 3: A family is loaded into the wheelchair accessible car.

Figure 4: Another family ready to ride the Spirit of Wamego in the wheelchair accessible car.

Conclusions & Future Work

Once all three test procedures were performed it was determined that the wheelchair accessible train was safe for public use. In the future, more decals will be added to the train car in order to look similar to the other cars. A handicap accessible sign will be built near the loading pavement and a wheelchair accessible decal will be added to the exterior of the train. The removal of the handrail post on the loading pavement is being considered to allow for more room for wheelchairs to move and placement of the removable ramp. Another proposal that is being considered is moving the wheelchair restraints closer to the drop down floor to allow for easier access. All future actions will be executed by the City of Wamego and their local contractors. The wheelchair accessible train car is open for public use and was unveiled and dedicated to the city on June 4th, 2016 (Fig. 5-6). The train runs from 10 AM – Noon and 2-4 PM every Thursday and Saturday each summer and during special city festivals.

Figure 5: Spirit of Wamego (left) nose-to-nose with the Union Pacific street train at the Wheelchair Accessible Train Car dedication.

Figure 6: Balloon release at the Spirit of Wamego Wheelchair Accessible Train Car dedication.