CHAPTER 17
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TRANSITIONAL WALKER

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Client Coordinator: Scott Sall, Children's Hospital of Alabama
Supervising Professor: Alan W. Eberhardt, Department of Biomedical Engineering
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INTRODUCTION

A physical therapist who specializes in motor coordination and balance of children with cerebral palsy found that many of the children he works with have a difficult time improving their gait with a traditional walker, and even more difficulty transitioning from a walker to hand canes. Common four-wheel pull-behind walkers are designed to hold the upper body rigid, placing all of the weight in the arms and dragging the feet along. After using the walkers for a prolonged length of time, many children develop a rigid upper body and are unable to adjust to the upper body movement required to walk with hand canes. The aim of the present project was to develop a transitional walker that would allow arm movement (flexion and extension) as in contrary walking (where the arm that swings forward is on the opposite side of the foot moving back). This new walker is designed to help children develop the upper body movement necessary to walk with a cane, while still providing the stability of a four-leg walker.

The design was subject to the following criteria:

- Adjustable in height for children ranging from 14-30 inches,
- Able to withstand a 70 pound child (at maximum),
- Enabling arm movement, so that the arms can move forward (extension) five inches and backward (flexion) five inches,
- Having stability and easy maneuverability, and
- Appealing to children and free of sharp edges or exposed bolts that might affect the child's safety.

SUMMARY OF IMPACT

The walker is currently being used at a children's hospital. If the design is successful, it will provide a child-friendly device with which children may transition from a traditional walker to hand canes, thereby allowing a greater degree of independence.

TECHNICAL DESCRIPTION

The design involved a modification to the Gator® brand walker. The Gator® was chosen because the two back wheels had small metal brakes that could be locked to prevent the walker from rolling backward with the child in it and the two front wheels had a pin lock that could lock into place so that they only roll straight. The Gator® frame was stainless steel, painted with a colorful veneer, and weighed only 13.5 pounds. The walker had a weight capacity of 70 pounds. The Gator was 18 inches wide and could adjust to heights between 13.5 and 26 inches.

To connect the forward and backward handle movement, plastic cording was looped through the back tube of the Gator walker and attached at the same point on both handles. The arm bars and handles were made from pediatric hand canes. This way, when one arm was pulled forward, the other arm would be automatically pulled back. Rubber stoppers were attached at the end of the back arm bar and the rubber cord was fed through holes in the center of the stoppers. These stoppers cushioned forceful arm movement and kept the child from overextending the arms. The arm handles were attached to the base of the walker with pin joints. Flanges were fabricated from A36 steel metal, which was wrapped around the frame and welded at the desired location. A steel cylinder with concave sides was machined and welded to the frame inside the two wings of the flanged steel. A 3/8th inch bronze bearing was fit inside and machine bolts (Grade A A307 steel) served as the axle for the arm canes. The final design is illustrated in Figure 17.1.

The total cost was $501.

Figure 17.1. Transitional Walker.

BATHCHAIR TRANSFER SYSTEM FOR ADULT WITH CEREBRAL PALSY

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Client Coordinator: Dr. Bharat Soni, Chair, Department of Mechanical Engineering
Supervising Professors: BJ Stephens, PhD, Department of Mechanical Engineering,
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INTRODUCTION

A mobile shower chair/bath lift was requested for a client who has severe cerebral palsy (CP). The lift was to be used by a caregiver to assist in moving and bathing an adult client. The caregiver had been lifting and lowering the individual in and out of the bathtub, which placed strain on her back. The purpose of this shower chair/bath lift was to move the client from the bed to the bathroom, lower him into the bathtub, and then to raise him to the edge of the bathtub and transport him back.

The design constraints were to:

- Lift and lower the adult weighing 100 to 120 pounds, 5.5 feet in height, with a depth of 13 inches;
- Be made of materials and systems compatible with a bathing environment, with materials and systems that will not corrode, degrade, malfunction, or exhibit any other changes in water; and.
- Be safe for the adult or the caregiver.

There was to be no risk of drowning as a result of using the device. The client remains in the device until intentionally removed by the caregiver. There are no sharp or rough surfaces, corners, or edges on the device that might cut or otherwise harm the skin of the client or caregiver. Clearances are such that none of the adult's body could be caught between the bathtub and the device during normal operation.

SUMMARY OF IMPACT

Many caregivers of individuals with cerebral palsy or other motor control problems have back pain as a result of regularly lifting a heavy person from a bed and into and out of a bathtub. The device has helped the caregiver in moving and bathing the adult, relieving the strain on the caregiver's back.

TECHNICAL DESCRIPTION

A large shower chair was purchased from Flaghouse (Hasbrook Hts., NJ). The chair was made of PVC tubing with a blue mesh set on a PVC frame. This chair was mounted onto a rolling cart made of extruded aluminum provided by Parker Hannifin Corp. There were no welds on the cart; aluminum corner brackets with stainless steel bolts were used for the connections to provide stability and strength.

A pneumatic lift was designed to lift a maximum load of 200 pounds. The lift was made of a rectangular frame, two cross bars, and a pneumatic cylinder, which was mounted onto the bottom of the frame and connected to a center bar. The system is shown in Figure 17.2.

The total cost was $858.

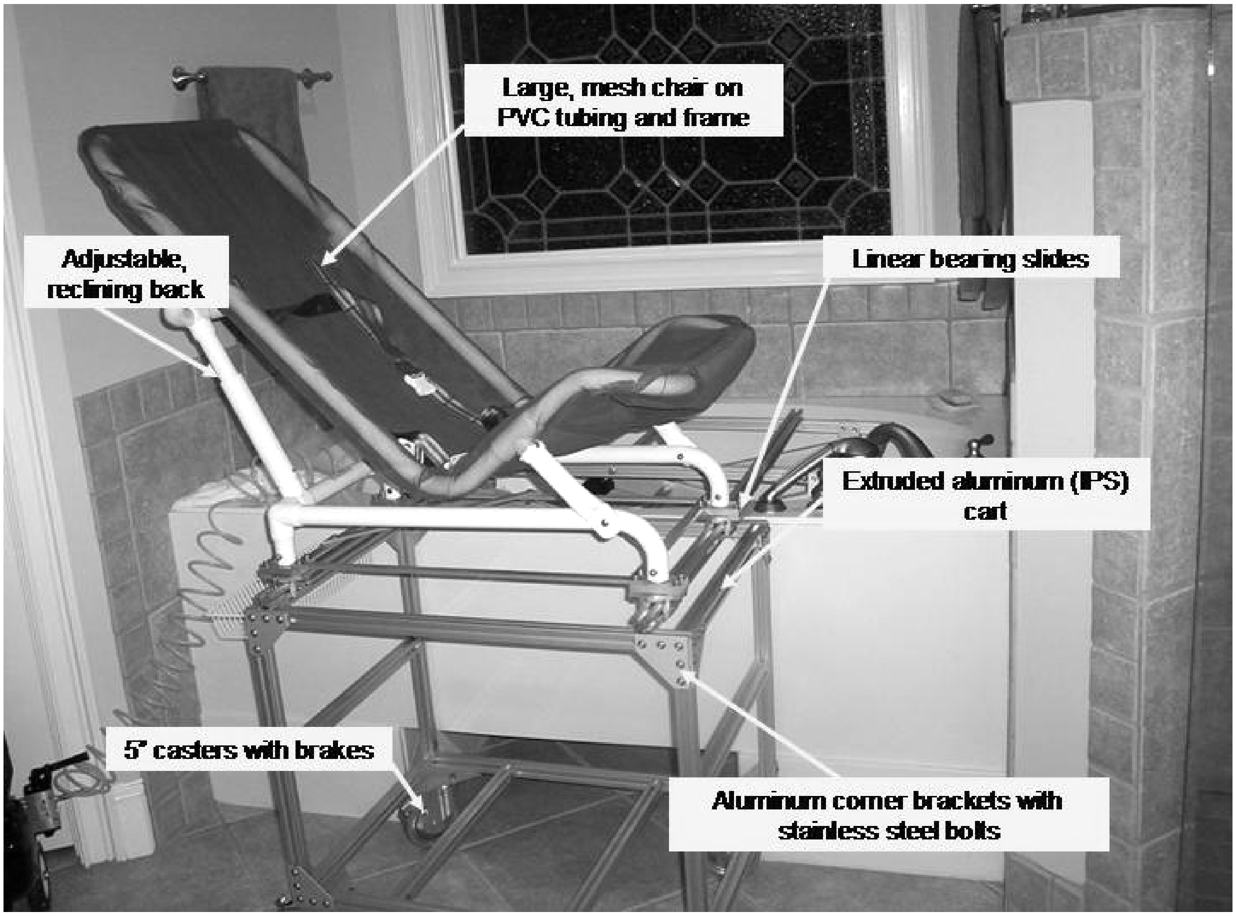

Figure 17.2. Bath Chair Transfer System.

FLOOR MATERIALS TO PREVENT HIP FRACTURES

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INTRODUCTION

Fall-related hip fractures are a major source of injury in elderly persons. The current design was intended to develop flooring materials that remain stiff under normal walking conditions (low strain rates) and soften to provide cushion during a fall (high strain rates). The use of shear-thinning fluids in sandwich composites offers a promising method for such floor systems. Shear-thinning fluid is a strain rate sensitive material, which caters to a flooring system that will absorb impact. Based on understanding this fact, the present design study was performed to investigate new materials' abilities to minimize the peak force seen during impact and to maximize the amount of energy attenuated. The target force values utilized were based on research conducted by Hayes and coworkers who showed hip fractures occurred within 0.78 – 4.00 kN range at energies of 5-50J.

SUMMARY OF IMPACT

An adult day care center was the main client for this design. Three falls had occurred in the facility in the previous year. The facility to be floored was an eight by eight foot restroom in a high traffic area. The goal was a flooring system to help minimize or prevent injury (i.e. hip fracture) in elderly people.

TECHNICAL DESCRIPTION

The floor would consist of a shear-thinning fluid component encased in a silicone rubber liner. The silicone rubber selected for this project was uncured Smooth-SilTM 930, (Smooth-On Inc). The ratio for mixing rubber and catalyst was 10:1. The rubber cured in 16-24 hours. The shear-thinning components tested were Laponite® RD (Rockwell Additives) and Carbopol® (Noveon). Laponite® RD is a synthetic silicate clay that mimics the naturally occurring smectite mineral called hectorite. The open network structure of Laponite® RD allows the chains to align under high shear rates, which causes a thinning response in the material. Carbopol® acts in a similar manner. Previous analyses of the rheology of these products with water alone, suggested that Laponite® has a greater capacity to shear thin. By mixing both the silicone rubber and the shear-thinning component, a composite material could be developed, exhibiting the strength and resiliency (of the rubber) and shear-thinning ability (Laponite® RD or Carbopol®). In essence, the flooring system was designed to be a shear-thinning rubber.

The silicone rubber/powder mix was poured into seven centimeter aluminum containers. The samples were degassed in a vacuum chamber for five minutes and allowed to cure for 16 to 24 hours. The samples were then post-cured in a recirculating air furnace for two hours at 80º C then one hour at 100º C. All samples were made at a thickness of 1.27 centimeters (0.5 inches).

Testing was performed according to ASTM F 1931-98, using a drop tower (Dynatup Instron Model 830-1). The initial setup incorporated the use of a striker head affixed to a load cell to determine energy, force, and velocity values during an impact. A high speed motion detector, operating at 300 Hertz, was also used to record rebound information during the testing. Both the load cell and motion detection data were recorded electronically and converted to spreadsheet form for further review. Testing for comparative values of impact force and time to peak load was performed using a 3.5 kilogram mass dropped from a height of five centimeters. A rectangular (seven by ten centimeter) striking surface was attached to the load cell. Each sample was impacted three times with a minimum of one minute between each successive strike.

The TUP software generated several key values for the samples tested. Among these values were peak force (kN) and energy produced at peak force (J).

Peak force values from the six trials performed on each sample were plotted as function of the amount of shear-thinning agent present. Figure 17.3 shows the peak force values of all the silicone rubber/shear thinning agent samples tested. The 12.5 weight percent silicone rubber/Laponite® RD samples showed the lowest force out of all the samples tested (see Figure 17.3).

The results achieved during this project indicate the mechanical properties of the silicon rubber/ Laponite® system are a potentially viable solution for this type of a flooring system. Further testing and characterization of the compound is needed to fully quantify the role Laponite® contributes to energy absorption. Advantages of the silicone rubber/ Laponite® compound over the close cell foam include sanitation and ease of fabrication.

The primary disadvantage is cost. The projected production cost is in excess of 16 times the cost of commercially available closed cell rubber foam mats.

Projected costs of the flooring system (eight by eight foot room) are given below.

Material Cost/Square Foot $38.73

Estimated Fabrication Cost/Square Foot $3.49

Estimated Installation Cost/Square Foot $2.00

Material Cost for 8′ X 8′ Floor $2,478.78

Installation Cost for 8′ X 8′ Floor $128.00

Total Cost for 8′ X 8′ Floor $3,180.97

Cost/Square Foot $44.22

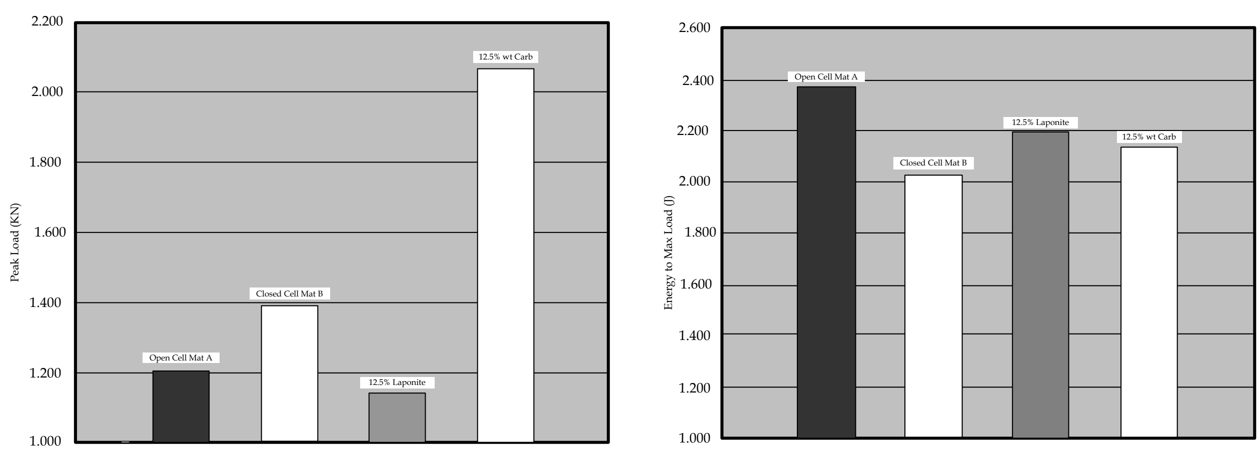

Figure 17.3. Laponite Containing Material Exhibited the Lowest Impact Force (left) and Second Highest Energy Dissipation (right).

JOYSTICK CONTROL TOY VEHICLE WITH REMOTE OVERRIDE

Designers: Eranga Devasurendra, Grant Harwell, Walter Reggel, Brian Rinne, Jide Emiola, Brad Hammond, Brent Hand, Juan La Rota, and Alva Kepple.
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INTRODUCTION

The client is a 22 month-old child diagnosed with cortical blindness and hypotonia. Cortical blindness is a term used to describe an apparent lack of visual functioning, in spite of anatomically and structurally intact eyes. The cause is assumed to be that the visual cortex of the brain is non-functional. The client is unable to crawl or walk due to hypotonia in her hips. Her mother also has a medical condition that limits the amount of time she is able to carry her child. The client's mother requested a toy vehicle with the ability to self operate using hand joystick controls instead of foot pedals. Furthermore, the parent wanted to be able to operate the vehicle using a remote control that overrides the joystick control.

SUMMARY OF IMPACT

The child is able to control the car on her own, which gives her greater mobility. Her mother can actively override the child using the remote, in cases where the child may be in danger or "stuck" somewhere. The mother stated, "Thank you … this will provide a means of self-mobility/transportation for her. I cannot express the level of excitement that you have infused in our home and support family."

TECHNICAL DESCRIPTION

Furnished equipment included a toddler vehicle, battery charger, and owners' manual. The first design aspect was steering, and it was proposed to use a RC servo motor and speed controller. The advantages included operating voltage 4.8 to 6Volts DC, it was readily available and inexpensive, and included a feedback system for positioning. It provided sufficient torque for steering a one-fourth scale car model (HS-805BB 343 oz-in) and could have additional gearing if necessary (4:1 or 5:1 gear box). RC servo motors have a standard interface that may be linked directly to a receiver for remote control. Disadvantages included the fact that the positional control signal was a pulsed signal, which required an additional interface between the potentiometer signal and the servo.

The second design component was the control system for remote control. This was accomplished by connecting the motor speed controller and the servo motor to a receiver and local control from the joystick pots through an interface board. Switch-over was accomplished by using a three-channel receiver, in which channel one linked to the servo, channel two to the speed controller, and channel three to a switch module or forward speed controller. The speed controller powered a relay with contacts connecting to the output of the local interface board. PWM signals the servo and speed controller when powered. When not powered, the relay contacts connect PWM signals from the receiver to the servo and speed controller. Local control was through an interface board that converts a potentiometer signal into the proper PWM signal. A combined switch and signal pot interfaced to a single board computer takes the pot signals and the receiver PWM signals and creates a PWM from the pots. It also does the switching based on the on/off module connected to the receiver. The finished product is shown in Figure 17.4.

The total cost was $1061.

Figure 17.4. Joystick Controlled Vehicle with Remote Override.