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ABSTRACT

DETERMINATION OF EFFECTS OF STRESS ON POLYMERIC ANKLE-FOOT ORTHOSES DUE TO WEIGHT CHANGE: EXPERIMENTAL STRESS ANALYSIS

by
Lin Yu Wang

Ankle-Foot Orthoses (AFOs) are devices that assist patients who sustained an abnormal motion at the ankle joint of the foot due to traumatic injury and stroke, etc. The objective of this project is to determine the stress patterns in AFOs under different loading conditions such as weights and genders. Thus, the location of failure can be predicted, and a redesign process can be developed. Furthermore, those experimental results will be used to verify the results obtained from the previous Finite Element Analysis (FEA) [10, 11]. Results from the experiment showed a significant stress change due to load change. This stress change mainly occurred at the lateral side of the neck and upper neck regions of AFOs (Fig. 2.7). Particularly, at the lateral side, there is a significant tensile stress change due to load change. At the medial side of the AFO and at the neck or lower neck regions, results show a significant compressive stress change due to load change. Moreover, during backward walking, the change of the magnitude of the compressive stress is inversely proportional to the loads (e.g. the body weight). At the center of the heel region of the AFO, no significant change is indicated for all motions and loads simulated. This is because of its unique arc structure which has the superior function of dispersing concentrated forces. The experimental result also shows no significant stress change with a change of genders. These results are confirmed with FEA results [10, 11].

DETERMINATION OF EFFECTS OF STRESS ON POLYMERIC ANKLE-FOOT ORTHOSES DUE TO WEIGHT CHANGE: EXPERIMENTAL STRESS ANALYSIS

by
Lin Yu Wang

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DETERMINATION OF EFFECTS OF STRESS ON POLYMERIC ANKLE-FOOT ORTHOSES DUE TO WEIGHT CHANGE: EXPERIMENTAL STRESS ANALYSIS

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Dedicated to my family

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CHAPTER 1

INTRODUCTION

1.1 General Background

The human foot has evolved to carry substantial loads. It has three main functions: support, propulsion and shock absorption[1]. Failures of these functions are mainly caused by abnormal motion at the ankle-foot complex due to traumatic injury, stroke, cerebral palsy, spina bifida and spinal cord injury, etc. Ankle-Foot Orthoses (AFOs) are the devices that are prescribed to assist people during recovery of these lost functions especially due to the stroke, and to protect the ankle-foot from future injury when patients are in motion.

1.1.1 Functions of Ankle-Foot Complex

The motions of the foot are mainly governed by two joints, the ankle joint and the subtalar joint. The axis of the ankle joint measures 80° on the average from a vertical reference with the angle of movement ranging from 68° to 88°, and it measures 84° from a longitudinal axis of the foot with the angle of movement ranging from 68° to 99° (Fig.1.1). The axis of the subtalar joint is at an angle of 42° to the ground and 16° to the sagittal results plane (Fig.1.2). Apart from these two joints, there are midtarsal joints and metatarsals joints. Usually, the ankle joint and the subtalar joint dominate most activities of the lower limbs of the adaptable human being.

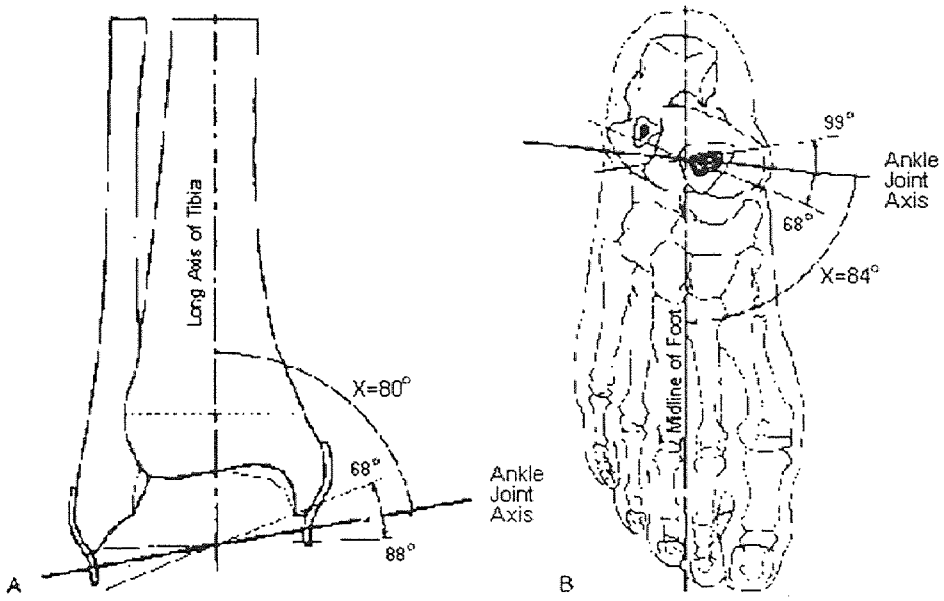


Fig.1.1 Orientation of the ankle joint axis. Mean values measure. (A) 80° from a vertica reference. (B) 84° from the longitudinal reference of the foot.

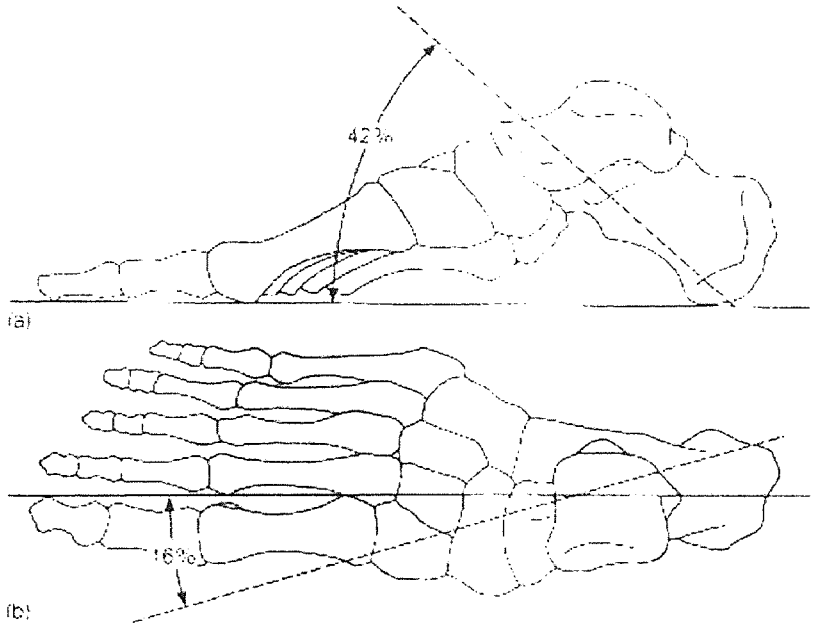


Fig. 1.2 The of the subtalar joint

1.1.2 About Ankle-Foot Orthosis (AFO)

An Ankle-Foot Orthosis (AFO) is a medical mechanical device to support and align the ankle and foot, to suppress spastic and overpowering ankle and foot muscles, to assist weak and paralyzed muscles of the ankle and foot, to prevent or correct ankle and foot deformities, and to improve the function of the ankle and foot[2]. An AFO is also known as below-knee orthosis, short leg brace, drop-foot brace and Klenzak ankle brace. However, the AFOs described here and tested in the experiment were the Molded Ankle-Foot Polymeric (e. g. Polypropylene) Orthoses (Fig. 1.3). These AFOs are commonly used to reduce the malfunction at the ankle-foot complex.

1.1.3 Possible Materials Used in the Fabrication of Ankle-Foot Orthosis

- *Stainless steel* is used in making uprights, ankle stirrups, foot plates, strap buckles, ankle joints, etc. It is very strong, durable, and adaptable, but it is heavy and lacks cosmetic appeal.
- *Aluminum* is significantly weaker than stainless steel, but is lighter, easier to fabricate, and more cosmetically acceptable. It is used in calf bands, and in uprights for much patients with lighter body weights.
- *Leather* is used in calf cuffs, and medial and lateral T-straps of ankle.
- *Thermoplastics and thermosetting plastics* are commonly used in fabricating molded Ankle-Foot Orthoses. In addition, polyvinyl chloride is often used both to coat orthoses to reduce the wear and tear on clothes caused by the bare metal surfaces and in the fabrication of the calf cuffs.

- *Plastics* are synthetics material capable of being softened, molded, laminated, extruded, hardened, or modified into almost any desired shape, color, texture, and consistency. **Polypropylene** is one kind of plastic material used to fabricate an AFO, and it was the material tested in this experimental study. Polypropylene is produced by polymerization of the monomer propylene. It is very light, chemically inert, tough, and odorless with good mechanical properties, and has a high impact strength. However, it is sensitive to extreme cold, ultraviolet, strong oxidizing agents, and nicks and notches. Polypropylene has superb flexing properties. Polypropylene hinges can withstand several million flexes before showing signs of failure. At normal temperature, polypropylene exists above its glass-transition temperature, so it is softer, more flexible, and less brittle than the acrylic. The high weight-strength ratio, high fatigue resistance, light weight, and excellent molding characteristics of polypropylene make it the most popular thermoplastic for all kinds of custom-made and extremity orthoses.

The characteristics of metal and plastic Ankle-Foot Orthosis described above are compared in Table 1.1.

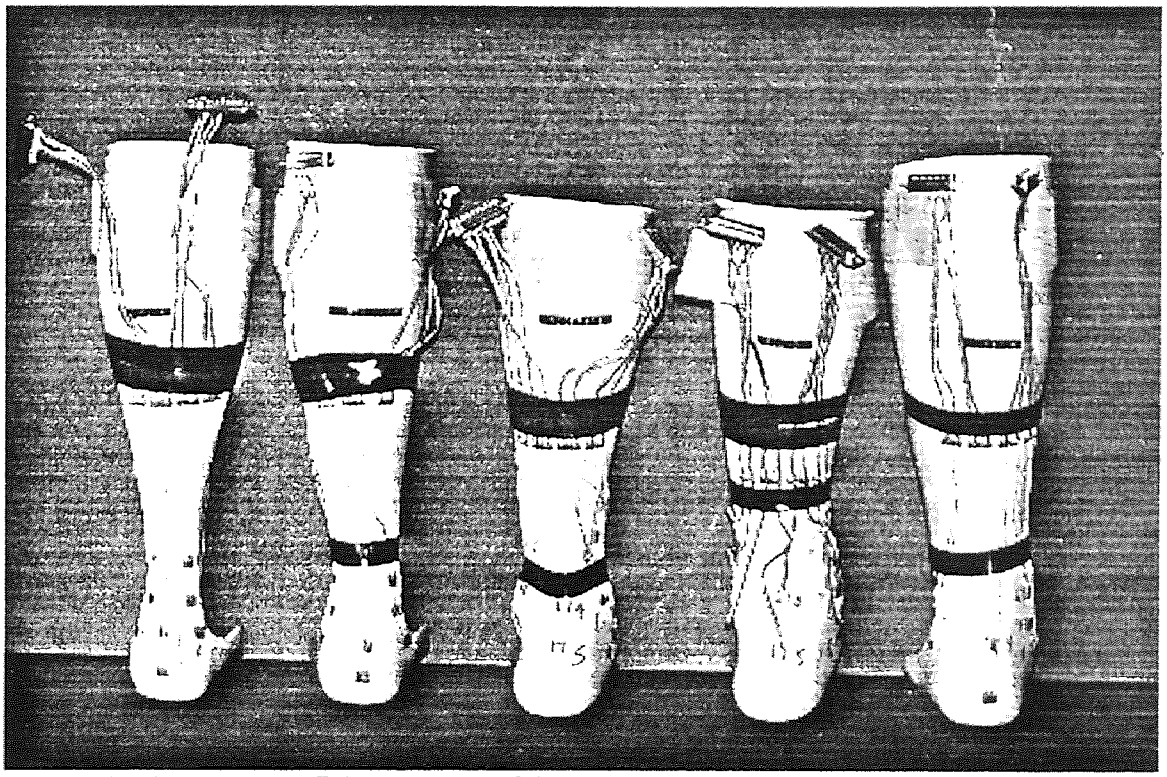
Table 1.1 Comparison of Metal and Plastic Ankle-Foot Orthosis:

Material of AFO	Metal	Plastic
Weight	heavy	Relatively light
Cost	Similar	Similar
Cosmetic appearance	Poor	Good
Patient's acceptance	Fair	Good
Proper and comfortable fit	Good	Excellent
Chances of produce damage clothes	Potentially present	Usually absent
Choice of footwear for MAFO needs counter force at foot instep	Limited	Unlimited
Plantar flexion and dorsiflexion of the ankle	Can be free	Fairly limited unless ankle joint are built in
Chances of causing contact allergies	Usually absent	Can be present
Proper fit on a swollen lower leg	Quite possible	Almost impossible
Mediolateral ankle stability	Good	Variable, depending on types
Durability	Very good	Variable, depending on types

1.1.4 Classification of Ankle-Foot Orthoses

There are many kinds of AFOs made from plastics such as Solid Ankled Polymeric AFO, Seattle AFO, Rancho Los Amigo AFO, Teufel AFO and Engen AFO. Five different Molded Ankle-Foot Polymeric Orthoses were tested in this experiment, namely the Flex,

Standard, Moderate, Solid, and Varus AFO. All five tested AFOs were made by Kessler Institute for Rehabilitation in Livingston, New Jersey. They are shown in Fig. 1.3.



(A) (B) (C) (D) (E)

Fig. 1.3 Five individual AFOs used in experiment: (A) Flex (B) Standard (C) Moderate (D) Solid (E) Varus

1. Flex AFO: The most flexible AFO that can be used for minor injured patient.
2. Standard AFO: It is suitable for most patients.
3. Moderate AFO: It is rigider than the Standard AFO due to the wider neck. It permits less dorsi-plantar flexion
4. Solid AFO: It has a wider neck than the Moderate AFO, and prohibit dorsi-planter flexion.

5. Varus AFO: It has a wider neck than the Solid AFO. Notably neck region is the widest one among the five AFOs. It has an additional extension support pad at the upper-neck lateral side that composes the three vectors structure. This structure restricts dorsi-plantar flexion, adduction/abduction, especially inversion/eversion. It is used for seriously injured patient.

1.2 Literature Review

In 1995, Terry J. Supan and Christopher F. Hovorka[3] studied the thermoplastic Ankle-Foot Orthoses adjustments/replacements in young cerebral palsy and spina bifida patients. They reviewed clinical records of 198 cerebral palsy and spina bifida patients with ages less then 21 years old. Six types of thermoplastic AFOs were used for these patients. They found that neuromusculoskeletal functional status appears to determine the AFO design and its replacement. The procedure of heat flaring was used to modify the existing orthosis design in their study. However, this study concerned how often the AFO needs to be replaced and adjusted within a group of patients. It didn't study the mechanism or factors that affect the replacement of the AFO quantitatively.

Sumiko Yamamoto, et al., and his group[4, 5] studied the measurement of the flexibility of AFOs fitted to the limb (flexibility in terms of the relationship between the forces acting on an AFO and its deformation). Four types of AFOs were measured in the experiment. They are Posterior Spring, Anterior Spring, Side Stay and Spiral. The authors measured the resistive movement of the ankle joint under conditions with and without the AFO by using a muscle training machine. The difference between these two results

represented the resistive movement of the AFO. The patient was instructed to completely relax his limb muscles, and the state of relaxation was confirmed by monitoring surface EMG signals of dorsi-plantarflexors. This is a solid experiment that provided a reference for the flexibility of the AFO under different motions, especially in dorsi-plantarflexors. Further more, they developed a quantification for the effect of dorsi-plantarflexibility of AFOs on Hemiplegic Gait. Although there were some shortages involved in the experiment, such as it took too long and too much labor to complete the measurement, the study still provided valuable information to improve the design and modification of the AFO.

Thermoplastic Klenzak AFO was introduced by Eugene Banziger[6] in 1992. The plastic Klenzak AFO has a similar function as traditional metal Klenzak which offer the biomechanical advantages of good ankle control. In addition, it has advantage of light weight and a modern appearance. However, compared with the Molded Ankle-Foot Polymeric Orthoses, the Thermoplastic Klenzak AFO is more complicated to manufacture and has a higher cost.

Louis J. Haberman developed another type of AFO, the Trera-Step AFO[7] . It has the characteristics of a total-contact fit, appropriate contours, proper positioning and specific pressures as compared with the conventional AFOs. However, it does not permit planter flexion and does not require extreme dorsi-flexion to perform its tasks which is good for the patients who have a severe drop foot but also limits patients who may need dorsi-flex exercises during recovery.

J. Martin Carlson, Fran Hollerbach and Bruce Day[8] designed a Calf Weightbearing AFO which is often prescribed for unweighting the lower tibia. The Calf Weightbearing AFO is more effective than the conventional Patella Tendon Weightbearing AFO. It is made of four parts: a foot plate, a polypropylene shell, a leather calf corset and two steel side bars that anchor the Polypropylene shell to the foot plate. This complex composition and high cost of material fabrication increase the cost of the AFO. In addition, high-tech equipment is required in the manufacture of the AFO in order to get a perfect match between the contours and alignment of the corset and the foot.

J. Martin Carlson, et al., also developed a double short flexure type ankle joint that achieved a hinge action in 1990[9] . The flexures can be located for full congruency at anatomic and orthotic joint axes. It enhanced the motion control of the conventional Polypropylene AFO. It allows dorsiflexion more easily than plantarflexion and short flexures tend to be more stable than long flexures. However, this type of AFO cannot be modified in the flexures region.

T. Chu, et al., analyzed stress distribution in a Polypropylene Solid Ankle AFO using 3-D Finite Element Analysis (FEA) in 1995[10, 11]. Although the authors did not conduct any dynamic analysis, they provided general information on stress distribution in the AFO. This information can be used by orthotists to effectively improve the design and modification of the AFO. The results can also be used for the prediction of AFO failure.

T. Chu, et al., developed an experimental method to study stress affects on the AFO due to static and dynamic loading conditions. In addition, during the experimental study a new bonding technique between strain gage and polypropylene was

established[12]. An UV light was used to treat the bonding surface before bonding. After treatment with the UV light, crazy glue is applied to the bonding surface which prepares it for bonding with the strain gage. Some preliminary results were obtained. Thus, the current project is the extension or follow up study of the described experimental investigation.

Ron Sutton studied the Thermoplastic Elastomer (TPE) as the material used for AFO in 1993[13]. TPE belongs to the category of plastics referred to as ethylene propylene thermoplastic vulcanites. The TPE has the superior characteristics of semi-rigidity, flexibility, durability and fatigue compared with the Polypropylene or Copolymer. However, there is no comparison between the physical description of the TPE and Polypropylene materials.

1.3 Objective

The purpose of this project is to analyze the stress changes in different regions of AFOs when persons are in motion. That is to determine the relationship between the stress change and load change. This experimental investigation is the continuation of a comprehensive study of AFO reliability, safety, and cost effectiveness[10, 11, 14]. Results obtained from the experiment can be used as valuable information for improving the design of AFOs. The contents of the experiment are:

1. Select a type of strain gage that is suitable for measuring strain changes due to activities involved in the rehabilitation recovery process.

2. Select the bonding locations for strain gages on the AFOs. According to the previous FEA studies[10, 11], stresses occurred around the neck and side arc regions of the AFO, (eight locations had been selected).
3. Apply the previously developed bonding method[12].
4. Create a data acquisition system to measure and display the stress change under different motions with different loads in real-time. The system developed will display the stress changes at different locations within an AFO simultaneously.
5. Collect the data of stress change under different loads with different motions, analyze the data, and provide the references for optimizing the design of AFOs.

1.4 Significance

Currently, AFOs are designed to be more and more sophisticated. Not only many kinds of material can be used in AFOs, but also many types of AFO were developed. This project is focused on the experimental stress analysis on Molded Ankle-Foot Polymeric Orthoses with four different samples. Result will provide valuable information for improving the design of AFOs.

Usually, an AFO will cost a patient about $800. Under normal conditions, if an AFO doesn't encounter a larger impact, if a patient doesn't suffer additional stroke, and if the body weight and the size of the patient's foot/leg do not change, then an AFO can last about 6-7 years. However, if the patient's body weight increases over 20 lb., for example, and the patient becomes active, then he/she will need a replacement of the AFO. In general, a weight gain lead to leg/foot size change, and weight gain is common for stroke

patients during the rehabilitation recovery process. In order to be cost effective and less time consuming during manufacture, a process of modification of the AFO to fit the increased size of the patient need to be determined. Therefore, questions such as how and where the AFO should be modified so that the AFO could be modified effectively and fitted to the patient's foot more comfortably needs to be analyzed. The current proposal experimental study will provide results which will be valuable in helping AFO design optimization and modification. Results will also provide information which can be used to predict the fatigue rate of the AFO. Furthermore, this experimental study will be used as a validation for the previous Finite Element Analysis[10, 11].

CHAPTER 2

THE THEORY AND METHOD OF THE EXPERIMENT

2.1 Strain and Stress

Strain is a measurement of the physical deformity of a substance produced by a load acting on it. Longitudinal strain is commonly expressed by the ratio of the change in a line to its original length. Its units are either inch/inch or cm/cm. Normally, there are three types of strain, they are shown in Fig. 2.1:

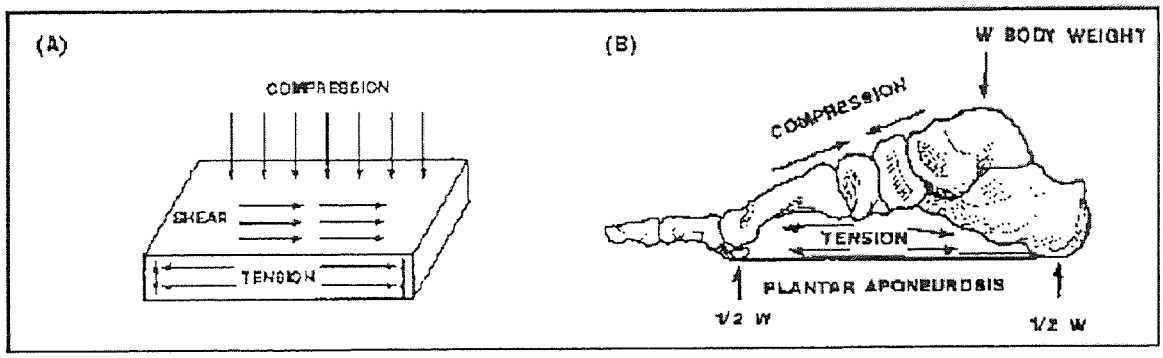


Fig. 2.1 Compression, tension, and shear strain (W= Body Weight).

1. Tensile strain: A physical elongation due to load.
2. Compressive strain: A physical shortening due to load.
3. Shear strain: Physical deformity produced by two parallel but opposite forces.

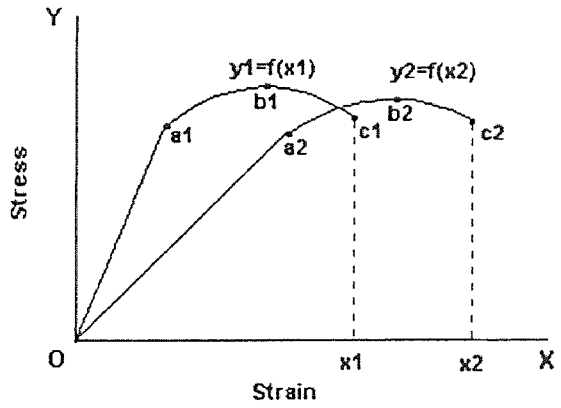


Fig. 2.2 The relationship between strain and stress. (a_1, a_2: elastic points. b_1, b_2: plastic points. c_1, c_2: failure points.)

Fig 2.2 shows the relationship between strain and stress. Every substance has its unique stress-strain curve when one plots the strain on the horizontal axis against the stress on the vertical axis. The first part of the curve (o to a) is a straight line along which the stress is always proportional to the strain. This is commonly known as the "Hookian range" or the elastic range. From a to b, the line starts to curve, the stress is no longer proportional to the strain, and the Hookian property no longer exists. However, if the stress is discontinued at point b, the material can still resume its original dimensions and shape but need a longer period of time. The point b represents its limit of elasticity (yield point) and has a zero slope. From b to c, the slope of the curve becomes negative, and the material starts to show permanent deformity that terminates at point c when the material finally breaks.

2.2 Strain Gages

Strain gages are often used to analyze stress when an object has been subjected to load. They are transducers and will convert a change in dimension (elongation or compression) into ohmic resistance. Then the ohmic resistance will be accurately measured by a Wheatstone bridge circuit. The Wheatstone bridge circuit provide a graphic solution which will determine the exact magnitude of mechanical strain. The selection of strain gage is mainly due to the considerations of these aspects:

- *Gage length:* Gage length is often a very important factor in determining gage performance. Strain measurements are usually made at the most critical points, or the most highly stressed points of the object. Usually, the highly stressed points are associated with the stress concentrations, where the strain gradient is quite steep and the area of maximum strain is restricted to a very small region. The strain gage tends to integrate or average the strain over the area covered by the grid. Fig. 2.3 illustrates a representative strain distribution in the vicinity of a stress concentration, and demonstrates the error in strain indicated by a gage which is too long with respect to the zone of peck strain. As a rule of thumb, the gage length should be no greater than 0.1 times the radius.
- *Gage Resistance:* Strain gages with resistance of 120 and 350 ohms are commonly used in experimental stress analysis testing. For the majority of applications, 120-ohm gages are usually suitable; 350-ohm gages would be preferred to reduce heat generation.

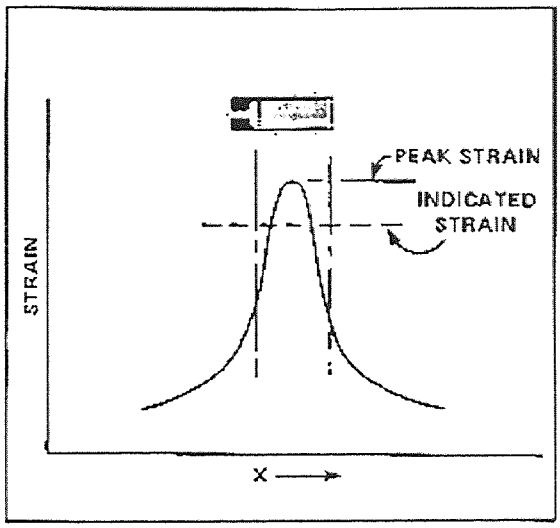


Fig. 2.3 Strain distribution in the vicinity of a stress concentration.

- *Gage Pattern:* The gage pattern refers cumulatively to the shape of the grid, the number and orientation of the grid in a multiple-grid gage, and the solder tab configuration. In experimental stress analysis, a single-grid gage would normally be used only when the stress state at the point of measurement is known to be uniaxial and the directions of the principal axes are known with reasonable accuracy (± 5°). For a biaxial stress state, a common case necessitating strain measurement, a two section rosette is required in order to determine the principal stress. It has two measuring grid perpendicular to each other (Fig.2.4). With the structure of biaxial rosette pattern, the stress can be measured in two perpendicular directions in a very small area.

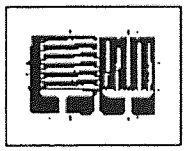


Fig. 2.4 Biaxial Rosette Strain Gage

Considering the aspects above, the type of strain gage used in this experiment is the biaxial rosette pattern strain gage manufactured by Measurements Groups Inc. The parts number is EA-XX-120, with the resistance of 120 ohm. For each section, the grid length is 0.125 inch, and 0.150 inch in with. It has the characteristics of tough, flexible and polyimide backing. It is primarily intended for general-purpose static and dynamic stress analysis.

2.3 Surface Preparation on an AFO for Bonding Strain Gage

The surface is abraded to remove any loosely bonded adherents (scale, rust, coating, oxides, etc.), and to develop a surface texture suitable for bonding. For a rough or coarse surface, it is necessary to start with silicon-carbide paper (SCP) of the appropriate grit. In the present experiment, a 320-grit silicon-carbide paper was used. Wipe the surface dry with the 320-grit SCP until a bright surface is produced. A sufficiently large area should be cleaned to ensure that contaminants will not be dragged back into the gagging area.

The desired location for the strain gage to be mounted on the test surface should be marked with a pair of crossed and perpendicular reference lines. The layout lines should be burnished, rather than scored. A medium-hard drafting pencil is needed. After the layout lines are marked, place the marked area under a UV light as close as possible for about 30 minutes[5]. Without this surface treatment, bonding between the plastic material and the strain gages will not be possible. As the final step for surface preparation, Acetone, the surface conditioner, should be applied repeatedly, and the

surface scrubbed with cotton-tipped applicators until a clean tip is no longer disordered by scrubbing.

2.4 Strain Gage Installations with Super Glue

For instant bonding , super glue has been proved to be the best choice. First, remove the strain gage from its acetate envelope by grasping the edge with a tweezers. Place it on a chemically clean glass plate with the bonding side of the gage down. Anchor one end of a 4 to 6 inch in length of cellophane tape to the glass plate behind the gage. Wipe the tape firmly down over the gage. Pick the gage up by carefully lifting the tape at a shallow angle (30 to 45 degree), until the tape comes free of the glass plate with the gage attached to the tape.

Apply a drop of super glue gently onto the surface of the AFO treated by UV light within the marked area. Attach one end of the tape to the specimen (AFO) at a shallow angle. Track the loose end of the tape under the press of the thumb to the surface so that the gage lies flat with the bonding side exposed without air bulbs under it. Hold the tape slightly and begin from the tab end of the gage, slowly and firmly make a single wiping stroke over the gage/tape assembly with a clean gauze sponge. Apply firm thumb pressure to the gage area. This pressure should be held for at least a minute. Wait several minutes, then remove the tape by pulling it back directly over itself, peeling it slowly and steadily off the surface. Terminals strips are bonded to the surface in the same way.

2.5 Surface Terminal and Lead Wires Soldering

Of those steps necessary for a successful strain gage installation, soldering lead-wires to strain gages usually requires the most practice to become proficiently skilled. Of the faults in gage soldering, lifted or dislodged solder tabs are perhaps the most common. This unexpected event is always frustrating because, when it occurs, the affected gage must be removed and replaced. Therefore, it is very important to select the soldering temperature properly to reduce the chances of this kind of situation. Most of strain gages are limited to use at soldering heat temperatures of +500°F (260°C) or lower. The temperature of the soldering iron tip typically must be in the range of +600°F (+315°C) to +700°F (+370°C). Even with this controlled heat, the contact time between the strain gage and the soldering iron tip should not be over 2-2.5 seconds.

After finishing the strain gages installation on the specific surface area of an orthosis, the wires can be led from the terminal to two 25-pins D-type male connectors. Each connector lead to 16 wires which services eight channels or four strain gages. It is convenient to attach and detach the orthoses from the input of the Wheatstone bridge circuit by using this kind of connector.

2.6 The Experimental Testing System

The entire experimental testing system developed for the present project is shown in Fig. 2.5. In order to determine the stress change in the AFO during motion and load change, strain gages are bonded at different location of the AFO. In steady state, the strain gage shows a certain value of resistance, e.g.120-Ohm. The resistance changes when the AFO

is deformed, and the change of the resistance is proportional to the magnitude of the deformation of the AFO within the elastic range of the strain gage. For a given object made of a certain kind of material, the change of the deformation, or the change of the strain is proportional to the magnitude of the stress forced on that object (Fig. 2.2). By use of the experimental testing system shown in Fig. 2.5, the change of the resistance of strain gage can be measured, displayed and recorded. By applying the strain-stress relationship, the stress changes on the AFO can be calculated.

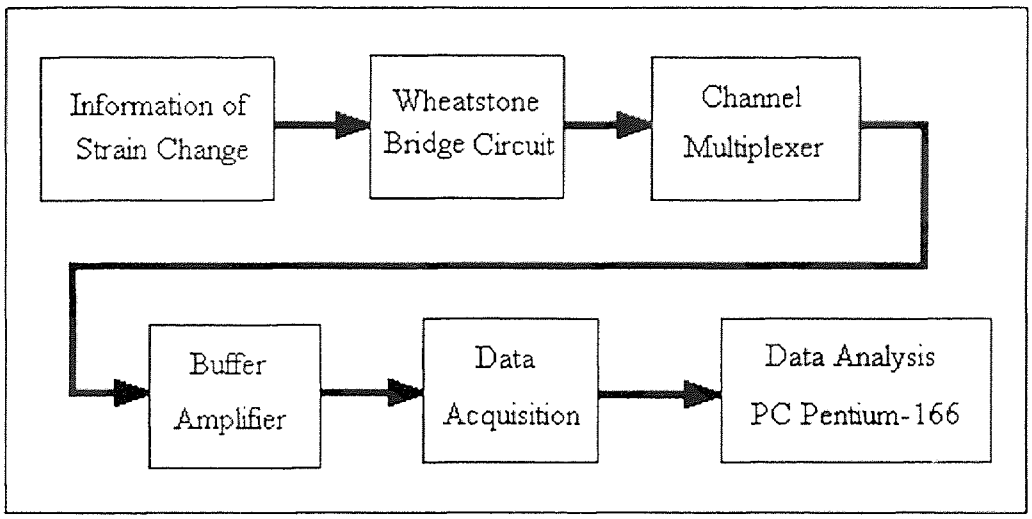


Fig. 2.5 Flow chart of the experimental testing system.

As mentioned in chapter 1, an ankle-foot complex is mainly governed by the ankle joint and subtalar joint during gait. Fig. 2.6 shows some motions referring to these joints. These are the fundamental motions of other activities. For example, the motion of forward walk is involved with dorsi-plantar flexion. Five motions were chosen as test conditions in this experiment. These motions are the most typical activities in people's daily life, they are:

1. Standing up and sitting down.
2. Slow forward walk.
3. Fast forward walk.
4. Backward walk.
5. Lifting a 25 lb. object.

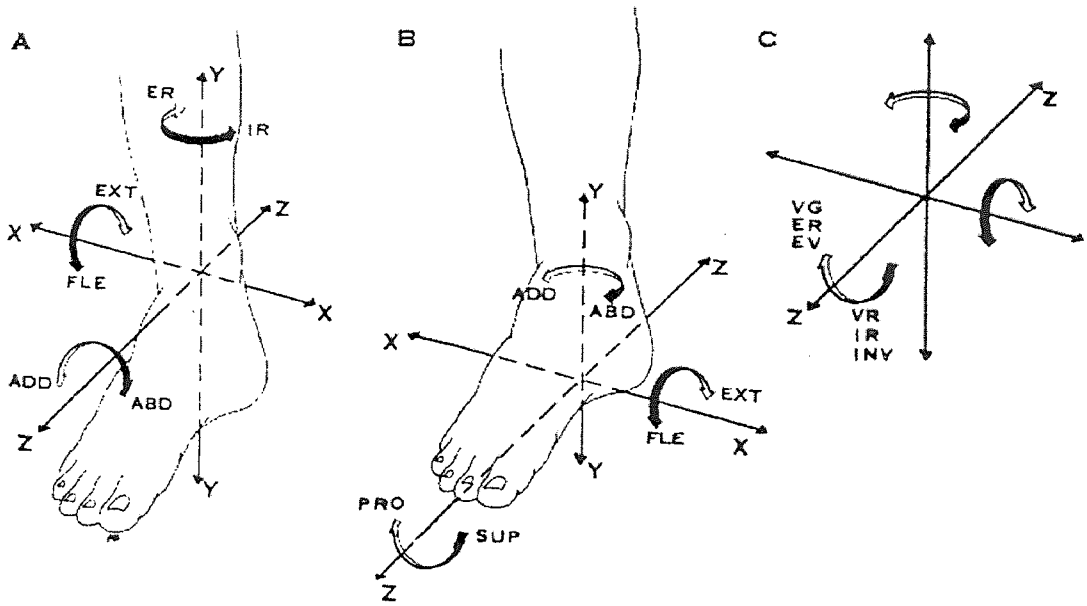


Fig. 2.6 (A) Axis of motion of the ankle and leg. YY axis is for ER, IR is for leg-talus. XX axis is for FLE, EXT is for the talus. ZZ axis is for ABD and ADD is for the talus. **(B) Axis of motion of the footplate.** YY axis is for ADD, ABD. XX axis is for FLE, EXT. ZZ axis is for SUP, PRO. **(C) Different terminology used for the motion around the longitudinal axis ZZ, VG, ER, EV and VR, IR, INV.** (ER, external rotation; IR, internal rotation; FLE, flexion; EXT, extension; ABD, abduction; ADD, adduction; VG, valgus; VR, varus; EV, eversion; INV, inversion.)

According to the FEA study earlier, the stress concentration is located at the neck region of the orthoses[3]. Therefore, this experimental study is focused on this region where significant stress concentrations occurred. There is a total of eight strain gages mounted on this region. Specifically, three were mounted on the lateral side, three were

mounted on the medial side, and two were mounted on the middle of the orthosis (Fig. 2.7). In addition, these strain gages were mounted almost symmetrically.

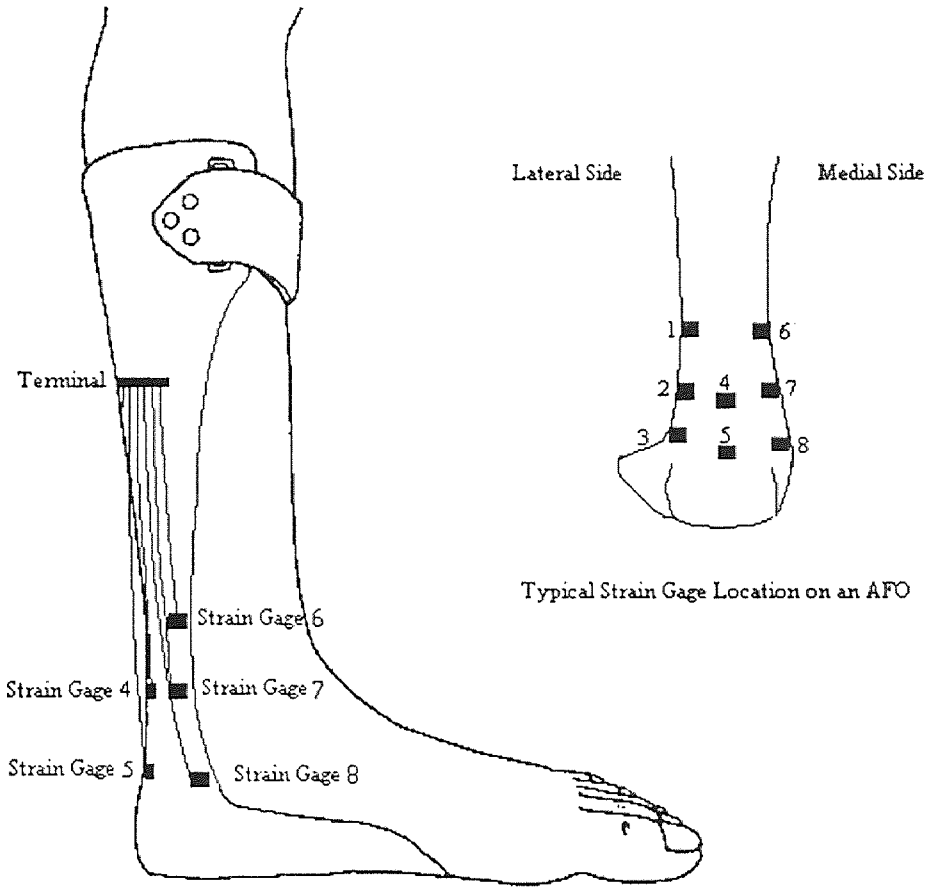


Fig. 2.7 A schematic presented an Ankle-Foot Orthosis with strain gages. (View from the sagittal plane)

CHAPTER 3

HARDWARE AND SOFTWARE APPLICATION

The experiment is a combination of hardware and software application. It consists of high performance data acquisition system, analysis packages and graphing features in realtime.

3.1 Hardware Application

The hardware system is composed of Wheatstone bridge circuit[15] build in breadboard, EXP-16 amplifier board, DAS 800 data acquisition board, and PC-166 system (Fig. 3.1).

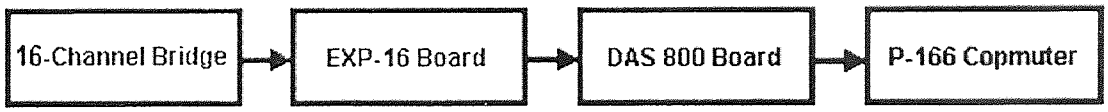


Fig. 3.1 Block diagram of the hardware system

3.1.1 Wheatstone Bridge Circuit

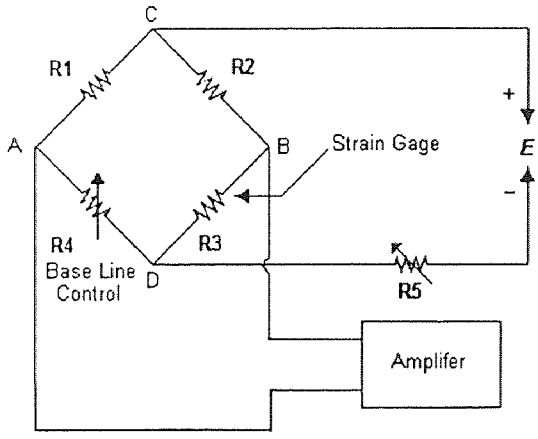


Fig. 3.2 Wheatstone bridge circuit

The Wheatstone bridge circuit is applied in the hardware system (Fig. 3.2). B and D are the input points of the circuit which were connected to the strain gage (R_3). A and B are the output points of the circuits which were connected to the amplifier circuit. R_3 is a strain gage with value of 120Ω, R_4 is a variable resistor with value of 120Ω. $R_1 = R_2 = 50\Omega$. ***E*** is an external power supply with 5 volts. At the begin, R_4 is adjusted to the same resistance of strain gage which is about 120Ω ($R_4 = R_3$), the voltage output $U_A - U_B$:

$$U_A = \frac{R_4}{R_1 + R_4} * U_{CD} \qquad \text{(Eq. 3.1)}$$

$$U_B = \frac{R_3}{R_2 + R_3} * U_{CD} \qquad \text{(Eq. 3.2)}$$

(U_{CD} is the voltage difference of $U_C - U_D$). Since $R_1 = R_2 = 50\Omega$, $U_A = U_B$, output is zero.

When the value of the resistance of the strain gage has been changed due to the physical deformity on the strain gage, R_3 is changed from its original value, then $U_A \neq U_B$, and there is a voltage output:

$$U_{AB} = U_A - U_B = \frac{R_4}{R_1 + R_4} * U_{CD} - \frac{R_3}{R_2 + R_3} * U_{CD}\,, \qquad \text{(Eq. 3.3)}$$

Usually, the value of the strain gage R_3 is changed a very small value of resistance ΔR compared with its steady value 120Ω, $R_2 + R_3 \approx R_1 + R_4 = 170\Omega$, $R_4 - R_3 = \Delta R$, $U_{AB} = \frac{\Delta R * U_{CD}}{170}$. In this case, the output voltage has a liner relationship with the change of the resistance of the strain gage.

The function of the variable resistor R_5 is to protect the current from over loading. Since the variable resistor R_4 is made of a tiny coil, it is easy to be burned by a large current. Certain value of R_5 can get partial voltage from the power supply, it reduces the

voltage of U_{CD}, that is, it reduces the voltage on the variable resistor R_4 which the power supply is distributed on. But R_5 can not be too large to reduce the accuracy of the output signal, this is because the larger the R_5, the less the voltage of U_{CD}, according to Eq. 3.3, the output U_{AB} will be decreased. It will cause an inaccuracy output signal if the R_5 is large enough.

Every strain gage has two grids that are perpendicular to each other. The vertical grid measures material deformation in the longitudinal direction, whereas the horizontal grid measures material deformation in the horizontal direction. Each grid connected to the input of a Wheatstone circuit individually, so there are total of 16 channel outputs from 8 strain gages.

Usually, the output of every channel is not adjusted to zero or the same value because channels need to be displayed simultaneously on the screen separately, so the baseline of each channel is adjusted separately from each other. The interval of each baseline is unfixed, it is adjusted according to the amplitude of adjacent channel so that the signals would not overlap each other.

3.1.2 EXP-16 Board

The EXP-16 is an expansion interface board equipped with half-inch standoffs. It can multiplex 16 analog input signals into a single signal for amplification and input to one single-ended input channel of a data acquisition system. Fig. 3.3 show the block diagram.

There is a gain control switch, an 83 -position DIP switch on the board. It offers for gains of 0.5, 1, 2, 10, 50, 100, 200, and 1000. Since the signal to be amplified from

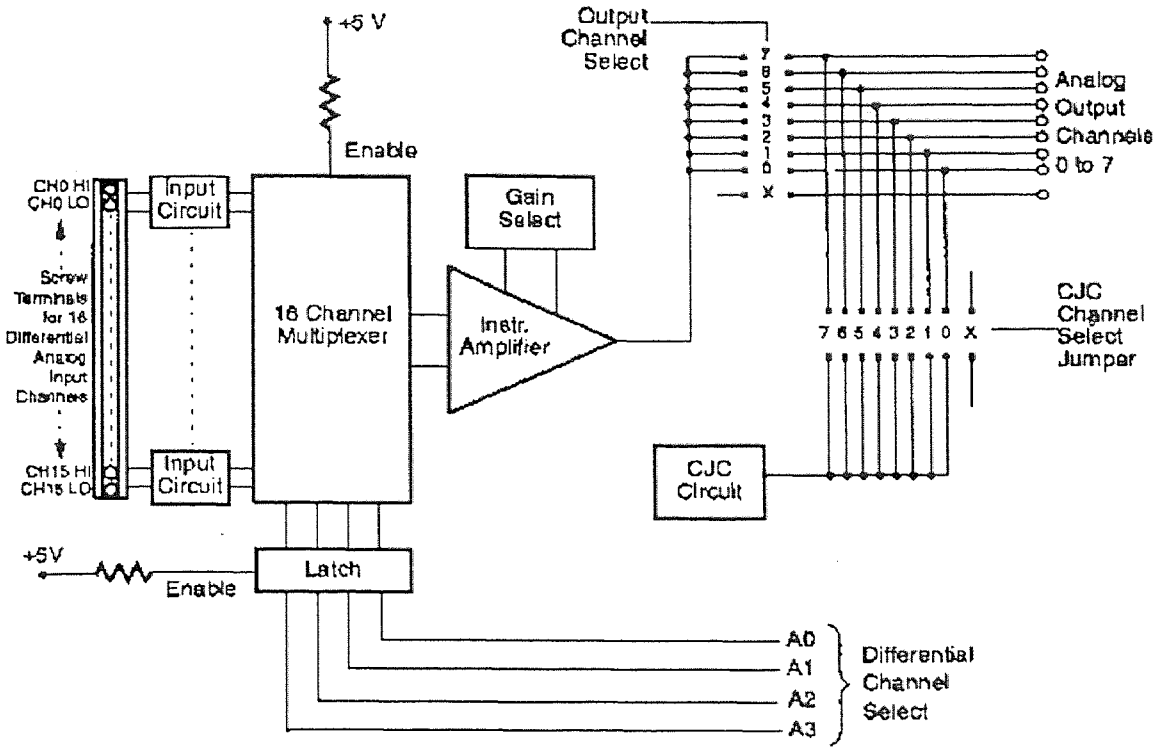


Fig. 3.3 Block diagram of an EXP-16

bridge circuit is very low (less than 0.5mV), the gain switch is set to 1000 in this experiment. The two 37 pin connectors J1 and J2 (marked on the board) are used to connect to other boards. Use either connector for connection to a DAS board and the other for connection to an STA-XX or an additional EXP-16 .

3.1.3 DAS-800 Board

The DAS-800 Series is a family of analog input and digital input and output (I/O) boards for an IBM® PC/XT™, AT® or compatible computer. The DAS-800 Series includes the DAS-800, DAS-801, and DAS-802 boards. DAS-800 is adopted in this experiment. It

was installed in one of the slots of the motherboard in the Pentium-PC. There is a 37 pin D type connector on the board. This connector is connected to one of the connector (J1 or J2) on EXP-16 board. The base address is set to 300H, the interrupt level is set to 5 on the DAS-800 board since it is not used by other hardware devices.

3.2 Software Application

By using VTX™ software (product of Keithely Metrabyte, version 1.1) with Visual Basic (version 3.0), the data collected from the data acquisition board is displayed, analyzed and graphed.

3.2.1 Hardware Configuration

From the windows 95 task bar, click Start. Slide the cursor over Programs, then slide to Keithely VTX, and click the VTX Configuration. When the VTX configuration utility window opens, choose the Add New button to register a board for utilizing with the VTX software. The Add New Board Dialog box appears, with a list of the board families whose VTX-compatibles software is currently installed, select DAS-800 Series and choose the OK button, then save the configuration and exit the board configuration utility.

3.2.2 Reserving Memory

After installing VTX software, the Keithley Memory Manager (KMM) is automatically installed so that the VTX application can use the KMM instead of the appropriate

Windows memory manager. By default, the KMM reserves 128K bytes of memory for VTX data acquisition applications.

3.2.3 Creating VTX Application

Design the user interface:

1. Double-click the Microsoft Visual Basic icon on the Keithely VTX window to start Visual Basic. A new form appears. If Visual Basic is already running with another project displayed, select New Project from menu to display a new form.
2. Move the cursor over the lower right corner of the form until the arrow changes to a double arrow, then press and hold down the left mouse button, move the mouse until an appropriate size of a form is appeared on the monitor.
3. Double-click the VTX DAS control icon in the Visual Basic Toolbox to place the control in the middle of the Visual Basic form, move the DAS control off to the left side of the form, leave the right side space for the VTX Text control.
4. double-click the VTX Text control icon to place the control on the form. Drag the Text control to the right side of the DAS control.
5. Double-click the Visual Basic command button icon three times to place the three buttons for the application on the form. Drag the buttons in the appropriate position show in figure 3.4.

   Save the work and you are now ready to set the properties.

Set the properties:

1. Set the form properties: Click the form to select it and then press **F4** to display its Properties window (Fig. 3.5). From the Properties window, double-click the Caption property. When the default text is highlighted, enter the following text:

   Display Analog Signal

   Set the appropriate dimension such as Width, Height and BackColor, etc. Finally, locate and double-click the Name property. When the default text is highlighted, enter text: frmMain

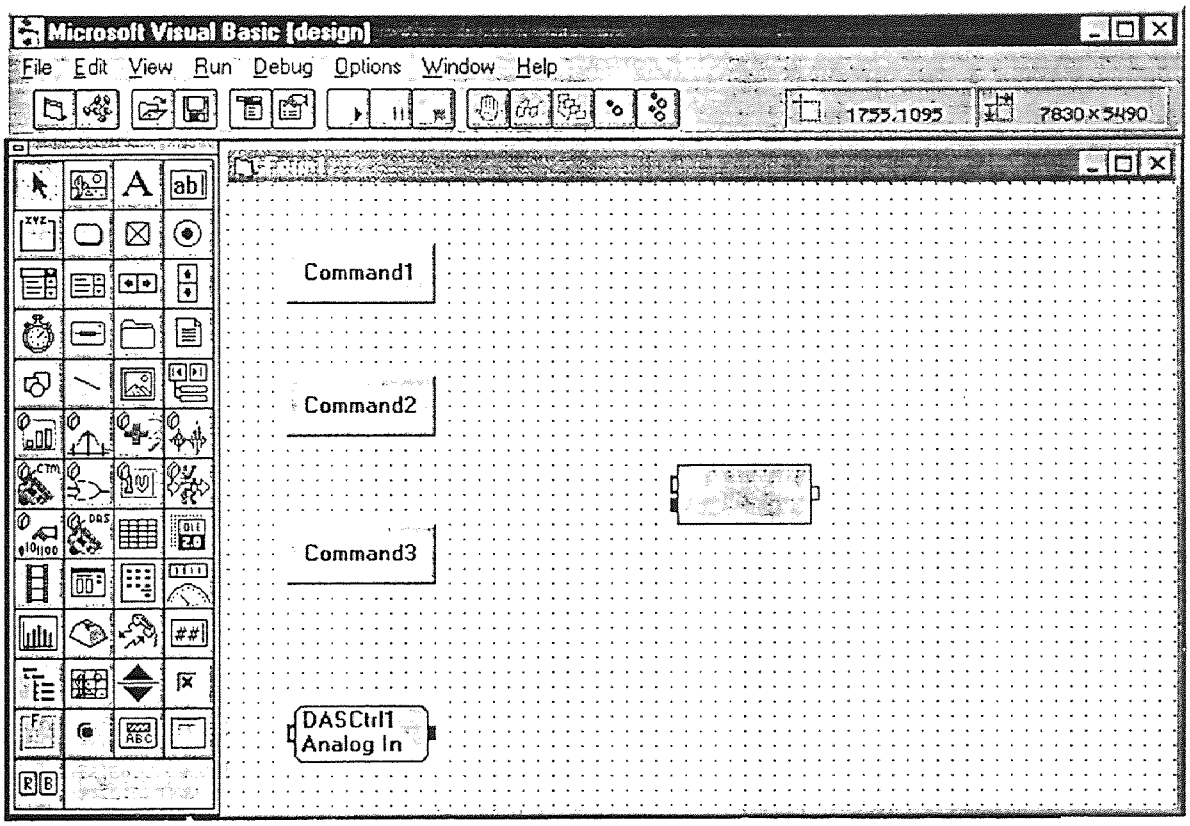


Fig. 3.4 The user interface in design-time view

2. Set the DAS control properties: The DAS control properties can specify parameters for a data acquisition operation. Click the DAS control once to select it and then click the properties window to view the properties and their default settings for the DAS control. The major items to be set are :

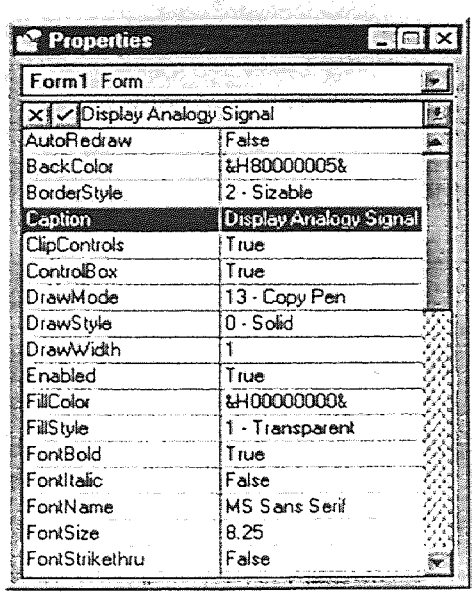


Fig. 3.5 The window of properties.

- Device to use for the operation (ProcessSrc property): DAS800 Board1.
- The operation to perform (Process property): Analog In.
- When the control can start the process (ArmState property): 0 - Wait For Control Connection.
- The mode in which the operation runs (OpMode property): Interrupt.

2. Set the Graphic control properties: The Graphic control display the analog signal in graphics format. Click the Graphic control once to select it and then click the Properties windows to view the default property settings for the Graphic control. The major items to be set are:

- The Process property setting to : Strip Chart
- The ProcessSrc property setting to : KM_Graph
- The Graphic control must wait until it receives the data from the DAS control before it can run the Strip Chart process. Therefore, set the default of ArmState property to: 0 - Wait For control connection.

3. Set the command button properties: a command button lets an application start, interrupt, or end a process. The button actually appears to be pushed in when clicked at run time. The steps of set the properties of command buttons are:

   - Click the first command button (command 1) once to select it and then click the Properties windows to view the properties for a Visual Basic command button.
   - From the Properties window, double-click the caption Properties.
   - When the default text is highlighted, enter the following text: Start
   - Double-click the Name property.
   - When the default text appears in the Settings box, highlight the text and enter cmdStart
   - Repeat the above steps on Command 2 (Stop) button and commend 3 (Exit) button, enter "stop" for Stop button and "Exit" for Exit button instead of "Start" in commend 1 button; enter "cmdStop" for Stop button and "cmdExit" for Exit button instead of "cmdstart" in command 1 button.
   - From the File menu, select Save Project.

Now, all the properties required for the form and the controls have been set. Next, connect the VTX control to enable them to pass the analog data.

Connect the VTX controls:

The form now shows the command buttons with their new captions.

Here, we will enable the DAS control to pass the analog data to the Graphic control for display by drawing a line, or connection, from the DAS control to the Graphic control. The control sending the data and/or program control is the *source* control; the

control receiving data and/or program control is the *destination* control. So the DAS control is the source control and Graphic control is the destination control. Draw the connection by performing these steps:

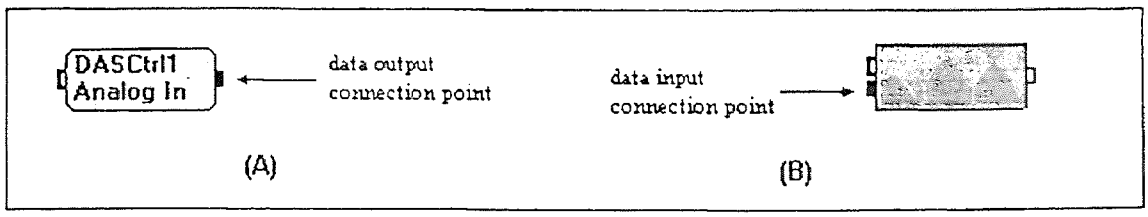


Fig. 3.6 (A)Data output connection point. (B) Data input connection point.

- Position the cursor over the right side of the DAS control which is the *data output connection point* (fig.3.6 (A)).
- When the cursor changes to an arrow with a soldering iron, press and hold down the left mouse button. When the arrow disappears, drag the soldering iron to the left side of the Graphic control which is the *data input connection point* (Fig. 3.6(B)).
- When the arrow reappears with the soldering iron, release the left mouse button. The connection has been done (Fig. 3.7).
- From the File menu, select Save Project. Next, write the code.

Write the code:

1. Write the code for the Start button: The Start button lets the users of this application decide when to run the Analog In process of the DAS control. To write the code for this button, follow these steps:

- Double-click the commend button captioned Start to display the code window for its Click event procedure.
- Click the blank line between Sub and End Sub.
- Enter the following code between the Sub and End Sub statements:

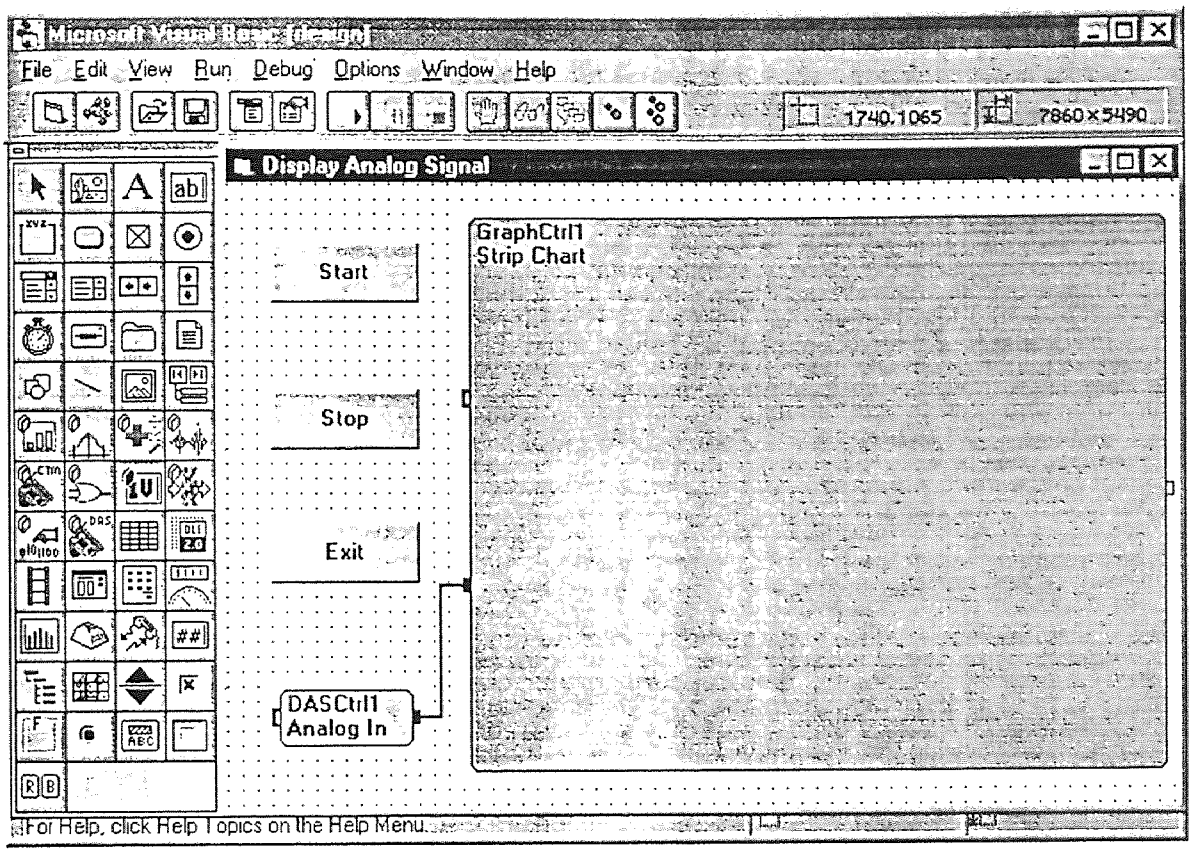


Fig. 3.7 Connect graphic to VTX control

```
x = frmMain.TextCtrl1.ClearInputs    'clear data from Text control
frmMain.TextCtrl1.ArmState = 0       'Wait for control connection
frmMain.DASCtrl1.ArmState = 1        'Ignore control connection
frmMain.cmdStart.Enabled = False     'Prevent additional mouse clicks
```

```
frmMain.cmdExit.Enabled = True      'Enable Exit button
frmMain.cmdStop.Enabled = True      'Enable Stop button
frmMain.cmdStop.SetFocus            'Make the Stop button the default
```

- From the File menu in Visual Basic, select Save Project.

2. Write the code for the Stop button: The Stop button lets users of this application prevent the DAS and Text control processes from starting again until the Start button is clicked. To add the code for the Stop button, follow these steps:
   - From the code window in Visual Basic, click the down arrow next to the Object field. Click cmdStop to display the click event procedure for the Stop command button.
   - Click the blank line between Sub and End sub.
   - Enter the following code between the Sub and End Sub statements:

```
frmMain.TextCtrl1.ArmState = 2      'Put Text control on hold
frmMain.DASCtrl1.ArmState = 2       'Put DAS control on hold
frmMain.cmdStop.Enabled = False     'Disable the Stop button
frmMain.cmdStart.Enabled = True     'Enable the Start button
frmMain.cmdStart.SetFocus           'Make the Start button the default
```

   - From the File menu in Visual Basic, select Save Project.

3. Write code for the Exit button: the Exit button lets users of this application exit the program with all processes stopped. To add the code for the Exit button, follow these steps:
   - From the Visual Basic code window, click the down arrow next to the Object field to display the list of objects on the form.

- Click cmdExit to select the button and display its Click event procedure.
- In the code window, click the line between the Sub and End Sub Statements and enter the following statement:

  ```
  End    'Stop all processes and exit the program
  ```

- From the File menu in Visual Basic, select Save Project.
- Double-click the icon in the top left corner of the code window to close it.

That's all the code required for this application and it can be run.

Run the application:

1. Make sure the orthosis is connected. Bridge circuit and amplifier circuit are connected well. Select Start from the run menu. There are eight base lines should be appear in the run-time view of the Graph control. Usually, adjustment is needed for every bridge circuit to set the eight base lines display in the proper position on the screen.
2. Start to perform each mode of action on the orthosis, each of the eight lines will show its curve according to the changes of strain vi time on each strain gage (Fig. 3.8).
3. To re-activate the Start button, click the Stop button.
4. Repeat steps 2 and 3 to see the different graphics performed by different mode on orthosis.
5. To exit the program, click the Exit button.

So far, the application with Visual Basic and VTX software for acquisition and graphing data from each orthosis has been built. For statistical purposes, restoring the data and analysis data quantitatively is necessary.

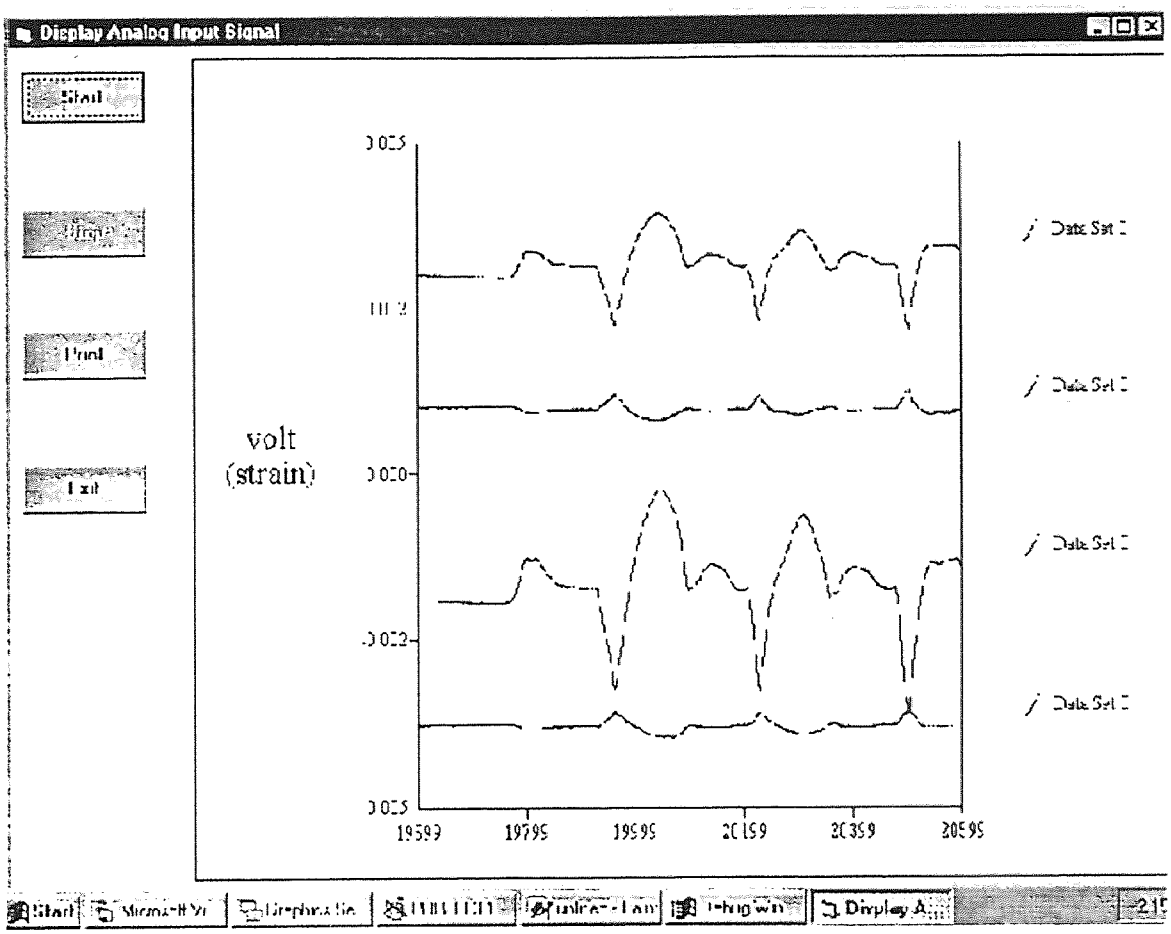


Fig. 3.8 The user interface in run-time view

CHAPTER 4

RESULTS

4.1 Motions and AFOs Used in the Stress Analysis

This experiment was focused on the stress analysis in AFOs using four different samples which include body weight and genders. There were four Molded Ankle Polymeric AFOs (Flex, Moderate, Standard, and Varus) and one Solid Ankle Polymeric AFO tested in the experiment. Five motions were selected as testing pattern for samples. These motions are common daily activities for people in general and specially for patients in the recovery process. They are:

1. Standing Up and Sitting Down: Standing up and sitting down is the earliest and basic motion for a patient begin to use after stroke. So, this is one of the most important motions which need to be tested.
2. Slow Forward Walk: Slow forward walk usually is for a patient who is in an earlier stage of the recover process and needs a strong AFO support.

   Note: Slow forward walk in the current experiment is conducted at 2.5 seconds per cycle. Fig. 4.1 is a typical graph of stress change in neck region (G2, Fig. 4.7) of a normal person. The stance phase of the gait begins at point A and ends at point E. Point A starts the "Heel Strike". The Compressive stress at G2 is increased rapidly to point B. From point B to point C is the "heel strike to foot flat transition period". The compress stress is decreased from point B to zero. Point C which is the point where foot flat is completed. From point C to point D, the "Heel Rise" period, the tensile

stress is increased. Point D is the push off point. The tensile stress of G2 is decreased till the toe off point E is reached at the end of the stance phase. From point E to F, the foot is changed from plantarflexion to dorsiflexion. It is also the beginning and the end of the swing phase. During the middle of the swing phase, the foot gradually dorsiflexes, thus clearing the toes off from the ground. The curve EF shows a decrease in compressive stress, an increase in tensile stress, then a decrease in tensile stress followed by an increase in compressive stress. The swing phase end at point F. Normally, in the cycle of A to F, stance phase last about 60% of the cycle while swing phase last 40%.

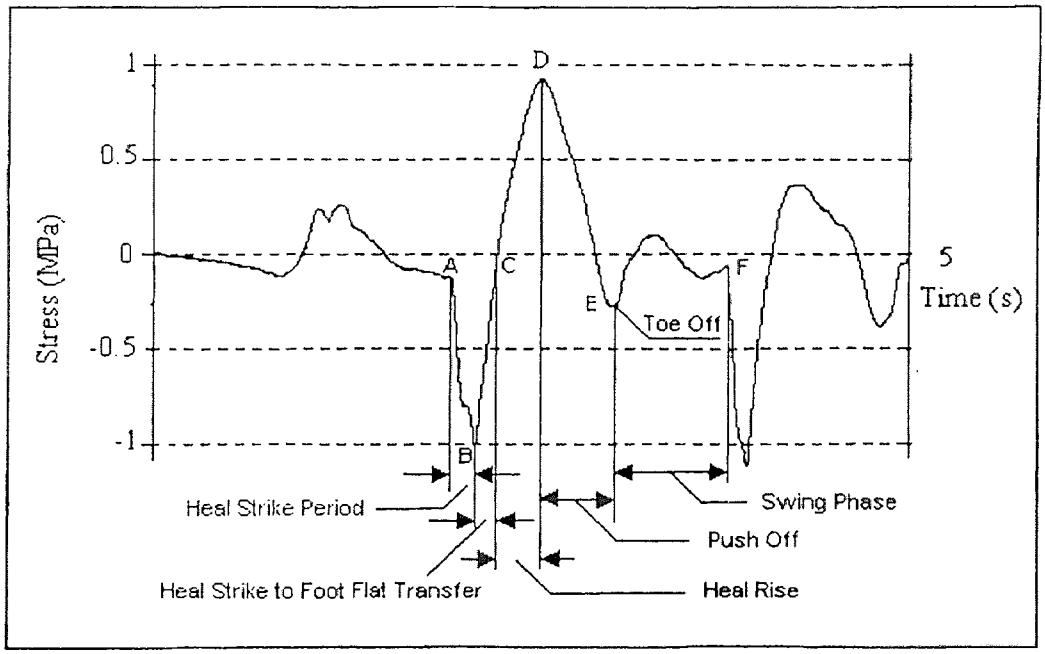


Figure 4.1 A typical graph of stress change in the neck region (G2) of an AFO for a normal person during the motion of slow forward walk.

3. Fast Forward Walk: Fast forward walk usually occurs for a patient who is in the later stage of the rehabilitation recovering process with an increase in exercises activities.

4. Backward Walk: Backward walk is not as common as forward walk. However, it occurs before sitting down, while vacuuming the carpet, or cleaning the floor with a mop. It is usually associated with a slow forward walk while a patient is doing exercise for rehabilitation.

Note: Fig. 4.2 is a typical graph for peak stress change in the neck region (G2) of a normal person in the motion of backward walk. It starts from point A, the toe strikes the ground. The tensile stress increased toward point B which is the beginning of pull down motion. The tensile stress is then decreased till point C, where the foot become completely flat. From point C to point D, it is the toe off of the foot period. The compressive stress is increased from zero to the maximum at point D, the end of the stance phase. The cycle of the gait is completed by a swing phase, D to E.

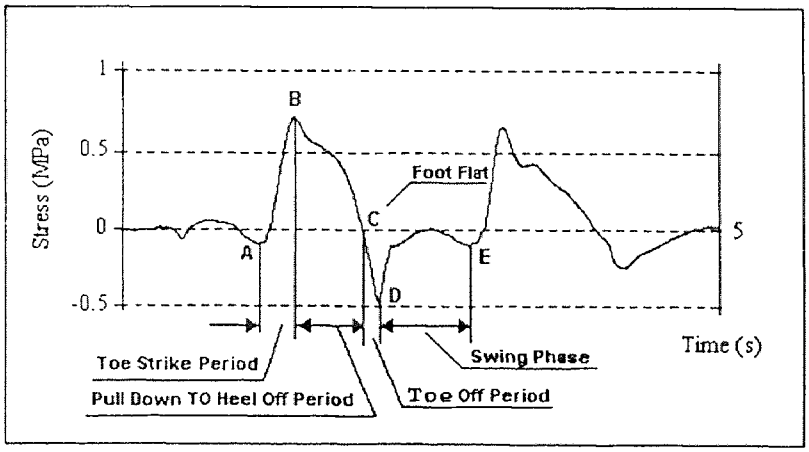


Figure. 4.2 A typical graph of stress change in the neck region (G2) of AFO for a normal person during the motion of backward walk.

5. Lifting a 25 lb. object: Lifting an object is a common activity in daily life, especially for exercises. A patient who is in the recovering process needs to do this kind of exercises to strengthen his/her up extremities in order to use other assistant device such as an arm cane.

Note: Among the five AFOs, Standard and Moderate AFO were tested with four samples and four motions. Flex, Solid and Varus AFOs were tested with three samples and five motions.

In order to get accurate data, each test was performed with three trials. The maximum value was selected among the three trials. The maximum peak stress of each strain gage was calculated by using of Hookian's law, and it was input into spread sheet (Appendix). The MS-Excel was applied (Table B1 to Table B25). Special terminology were used in the following stress analysis:

- *Significant Stress Changes:* The standard deviation of peak stress change of the three/four samples is over 0.08 MPa.
- *Minor Stress Changes:* The standard deviation of peak stress change of the three/four samples is between 0.03 ~ 0.08 MPa.
- *No Significant Stress Change:* The standard deviation of peak stress change of the three/four samples is less than 0.03 MPa.
- *Vertical Direction:* The vertical grid of a strain gage measures the deformation of an AFO in the longitudinal direction.
- *Horizontal Direction:* The horizontal grid of a strain gage measures the deformation of an AFO in the horizontal direction.

4.2 Determination of Stress Change in AFOs with Four Samples

Three male samples (weights of 125 lb., 162 lb., and 192 lb.) were tested on each of the five AFOs with each of the five motions stated above. However, one female sample (weight of 100 lb.) was tested only on two AFOs among the five, namely the Moderate and Standard AFOs. In addition, only four motions (1, 2, 3, and 4) out of the five, except the motion of "lifting a 25 lb. object" were tested with the female sample.

4.2.1 Stress Change in the Moderate AFO of Four Samples During the Motion of "Standing Up and Sitting Down"

- *Sample 1*: During the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis), the maximum tensile peak stress (0.85 MPa) in the vertical direction in the Moderate AFO occurred at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.55 MPa) in the horizontal direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO (Table 4.1, Fig 4.3). The maximum compressive peak stress (-0.35 MPa) in the vertical direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO. The maximum compressive peak stress (-0.28 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and it is located at the medial side of the upper neck region (G6) of the AFO (Table 4.2, Fig. 4.3).

- *Sample 2*: Within the entire motion, the maximum tensile peak stress (0.84 MPa) in the vertical direction occurred during the period of halfway the standing up/sitting down (the knee is about 45° to horizontal axis) and it is located at the lateral side of the upper neck region (G1) of the Moderate AFO. The maximum tensile peak stress (0.55 MPa) in the horizontal direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO (Table 4.1, Fig. 4.3). However, the maximum compressive peak stress (-0.35 MPa) in the vertical direction occurred at the moment of fully standing up and it is located at the lateral side of lower neck region (G3) of the AFO. The maximum compressive peak stress (-0.23 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and it is located at the medial side of the upper neck region (G6) of the AFO (Table 4.2. Fig. 4.3).
- *Sample 3*: Although the location where the stress was concentrated was the same, the magnitude of the peak stresses was different. The maximum tensile peak stress (0.63 MPa) in the Moderate AFO in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and it is located at the lateral side of the upper neck region (G1) of the AFO. In the horizontal direction, the maximum tensile peak stress (0.45 MPa) occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO (Table 4.1, Fig. 4.3). The maximum compressive peak stress (-0.45 MPa) in the vertical direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO. The maximum compressive peak

stress (-0.35 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis), the location of this stress is located at the medial side of the upper neck region (G6) of the AFO (Table 4.2, Fig. 4.3).

- *Sample 4*: Similar to sample 3, during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis), the maximum tensile peak stress (0.44 MPa) in the vertical direction in the Moderate AFO occurred at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.27 MPa) in the horizontal direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO (Table 4.1, Fig. 4.3). The maximum compressive peak stress (-0.25 MPa) in the vertical direction occurred at the moment of fully standing up and it is located at the middle of the upper heel region (G4) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down and it is located at the medial side of the upper neck region (G6) of the AFO (Table 4.2, Fig. 4.3).

Table 4.1 Magnitude and location of the maximum tensile stress occurred in the Moderate AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.85	HW of SU/SD	G4	0.55	Fully SU
2 (162)	G1	0.84	HW of SU/SD	G4	0.55	Fully SU
3 (190)	G1	0.63	HW of SU/SD	G4	0.45	Fully SU
4 (100)	G1	0.44	HW of SU/SD	G4	0.27	Fully SU

Note: HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7) .

Table 4.2 Magnitude and location of the maximum compressive stress occurred in the Moderate AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G4	-0.35	Fully SU	G6	-0.28	HW of SU/SD
2 (162)	G3	-0.35	Fully SU	G6	-0.23	HW of SU/SD
3 (190)	G4	-0.45	Fully SU	G6	-0.35	HW of SU/SD
4 (100)	G4	-0.25	Fully SU	G6	-0.20	HW of SU/SD

Note: HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis)
Fully SU = Fully Standing Up.
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

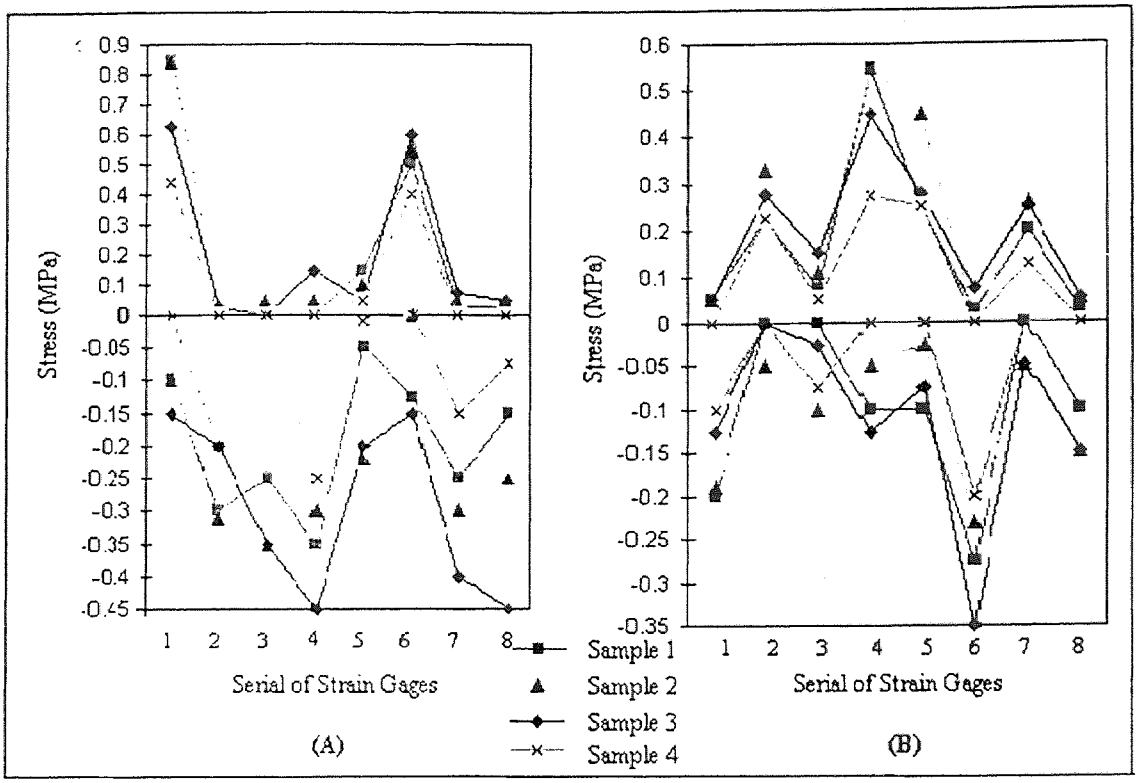


Figure 4.3 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Moderate AFO in the motion of standing up/sitting down. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.2 Stress Change in the Moderate AFO of Four Samples During the Motion of "Slow Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.55 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred also during the period of push off and is located at the middle of the upper heel region (G5) of the AFO (Table 4.3, Fig. 4.4). The maximum compressive peak stress (-0.48 MPa) in the vertical direction occurred during the

period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.33 MPa) in the horizontal direction also occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.4, Fig. 4.4).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.50 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.39 MPa) in the horizontal direction occurred also during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.3, Fig. 4.4). The maximum compressive peak stress (-0.80 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.40 MPa) in the horizontal direction also occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.4. Fig. 4.4).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.85 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.85 MPa) in the horizontal direction also occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.3, Fig. 4.4). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.35 MPa) in the horizontal

direction also occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.4, Fig. 4.4).

- *Sample 4*: Within the same motion and same Moderate AFO, the maximum tensile peak stress (0.40 MPa), for this sample, in the vertical direction also occurred during the period push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.27 MPa) in the horizontal direction located at the middle of the upper heel region (G4) of the AFO and with the same period of time as the previous one (Table 4.3, Fig. 4.4). The maximum compressive peak stress (-0.38 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.18 MPa) in the horizontal direction occurred at the heel strike at the same period and is located at the middle of the upper heel region (G4) of the AFO (Table 4.4, Fig. 4.4).

Table 4.3 Magnitude and location of the maximum tensile stress occurred in the Moderate AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.55	Push Off	G5	0.40	Push Off
2 (162)	G1	0.50	Push Off	G4	0.39	Push Off
3 (190)	G1	0.85	Push Off	G4	0.85	Push Off
4 (100)	G1	0.40	Push Off	G4	0.32	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G5=Gage 5, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.4 Magnitude and location of the maximum compressive stress occurred in the Moderate AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	-0.48	Heel Strike	G4	-0.33	Heel Strike
2 (162)	G6	-0.80	Heel Strike	G4	-0.40	Heel Strike
3 (190)	G6	-0.60	Heel Strike	G4	-0.35	Heel Strike
4 (100)	G6	-0.38	Heel Strike	G4	-0.18	Heel Strike

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

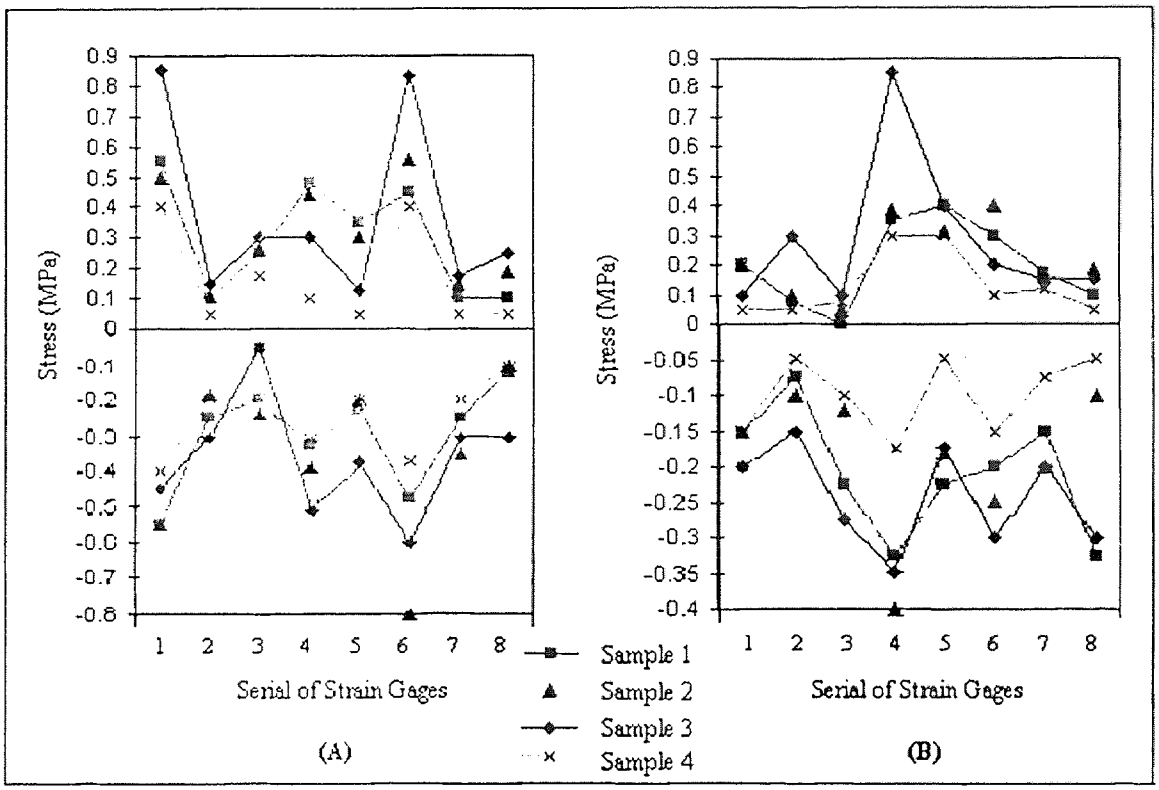


Figure 4.4 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Moderate AFO in the motion of slow forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.3 Stress Change in the Moderate AFO of Four Samples During the Motion of "Fast Forward Walk"

- *Sample 1*: With this motion, the maximum tensile peak stress (0.60 MPa) in the Moderate AFO in the vertical direction occurred during the period of push off and is located at the medial side of the upper neck (G6) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and located at the middle of the upper heel region (G4) of the AFO (Table 4.5, Fig.4.5). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.4 MPa) in the horizontal direction occurred during the same period of heel strike and is also located at the middle of the upper heel region (G4) of the AFO (Table 4.6, Fig. 4.5).
- *Sample 2*: Similar with sample 1, the maximum tensile peak stress (0.69 MPa) in the Moderate AFO, in the vertical direction, occurred during the period of push off and is located at the medial side of the upper neck region (G6). The maximum tensile peak stress (0.5 MPa) in the horizontal direction occurred during the same period and is located at the middle of the upper heel region (G4) (Table 4.5, Fig. 4.5). The maximum compressive peak stress (-0.6 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.31 MPa) in the horizontal direction occurred during the same period located at the middle of the upper heel region (G4) of the AFO (Table 4.6, Fig. 4.5).

- *Sample 3*: Same as sample 1 and 2, the maximum tensile peak stress (0.85 MPa) in the vertical direction in the Moderate AFO occurred during the period of push off and is located at the medial side of the upper neck (G6). The maximum tensile peak stress (0.73 MPa) in the horizontal direction occurred at the middle of the upper heel region (G4) of the AFO (Table 4.5, Fig. 4.5). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the middle of upper heel region (G4) of the AFO. The maximum compressive peak stress (-0.58 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.6, Fig. 4.5).
- *Sample 4*: For the same motion, however, the maximum tensile peak stress (0.65 MPa) in the vertical direction is occurred at the lateral side of the upper neck region (G1) of the Moderate AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.5, Fig. 4.5). On the other hand, the maximum compressive peak stress (-0.53 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.33 MPa) in the horizontal direction is located at the middle of the upper heel region (G4) of the AFO (Table 4.6, Fig. 4.5).

Table 4.5 Magnitude and location of the maximum tensile stress occurred in the Moderate AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.60	Push Off	G4	0.40	Push Off
2 (162)	G6	0.69	Push Off	G4	0.50	Push Off
3 (190)	G6	0.85	Push Off	G4	0.73	Push Off
4 (100)	G1	0.65	Push Off	G4	0.45	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

Table 4.6 Magnitude and location of the maximum compressive stress occurred in the Moderate AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125 lb.)	G6	-0.60	Heel Strike	G4	-0.40	Heel Strike
2 (162 lb.)	G6	-0.60	Heel Strike	G4	-0.31	Heel Strike
3 (190 lb.)	G4	-0.60	Heel Strike	G3	-0.58	Heel Strike
4 (100 lb.)	G6	-0.53	Heel Strike	G4	-0.33	Heel Strike

Note: G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

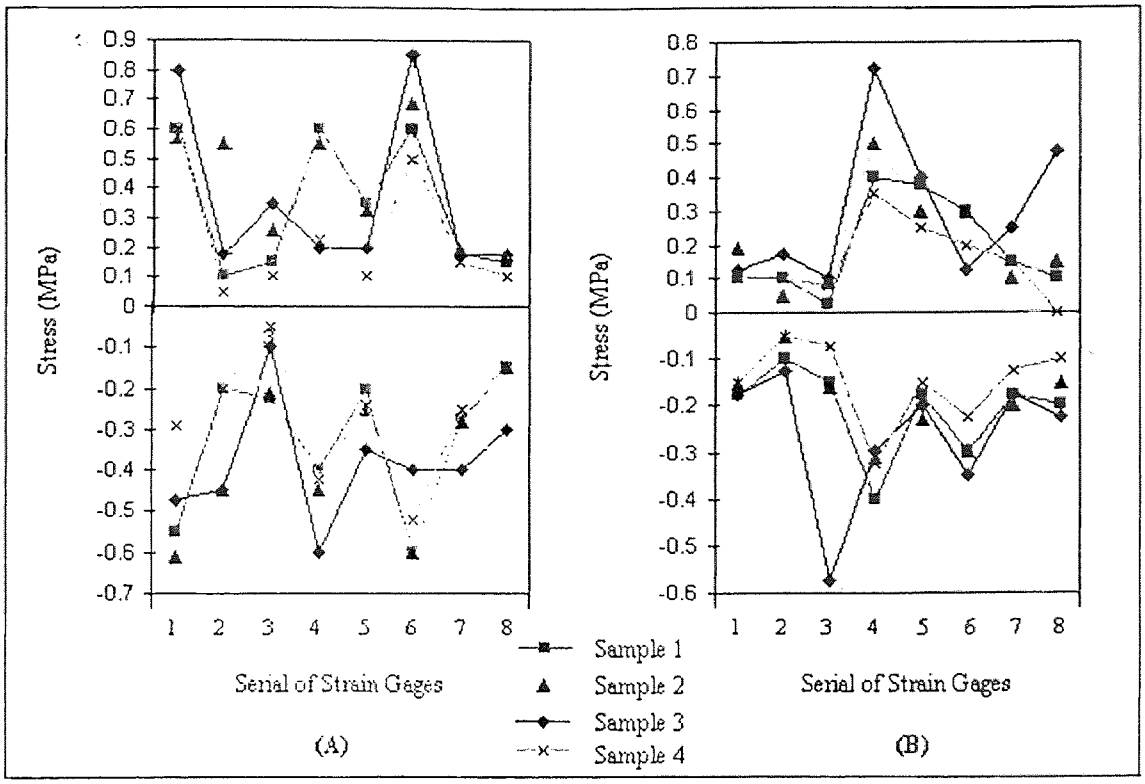


Figure. 4.5 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Moderate AFO in the motion of fast forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.4 Stress Change in the Moderate AFO of Four Samples During the Motion of "Backward Walk"

- *Sample 1*: Within this motion and with the Moderate AFO, the maximum tensile peak stress (0.60 MPa) in the vertical direction is located at the lateral side of the upper neck (G1) of the AFO and is occurred during the period of toe strike. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of toe off is located at the middle of the upper heel region (G4) (Table 4.7, Fig. 4.6). The maximum compressive peak stress (-0.63 MPa) in the vertical direction is located at

the medial side of upper neck region (G6) and is occurred during the period of toe off. The maximum compressive peak stress (-0.48 MPa) in the horizontal direction, on the other hand, occurred during the period of toe strike. It is located at the medial side of the lower neck region (G8) of the AFO (Table 4.8, Fig.4.6).

- *Sample 2*:similar with sample 1, the maximum tensile peak stress (0.60 MPa) in the vertical direction with same AFO occurred at the lateral side of the upper neck region (G1) during the period of toe strike. The maximum tensile peak stress (0.50 MPa) in the horizontal direction is located at the middle of the upper heel region (G4) of the AFO (Table 4.7, Fig. 4.6), but it occurred during the period of toe off. The maximum compressive peak stress (-0.80 MPa) in the vertical direction is located at the medial side of upper neck region (G6). On the other hand, the maximum compressive peak stress (-0.41 MPa) in the horizontal direction is occurred during the period of toe strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.8, Fig. 4.6).
- *Sample 3*: The maximum tensile peak stress (0.75 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction, on the other hand, occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.7, Fig. 4.6). The maximum compressive peak stress (-0.95 MPa) in the vertical direction also occurred during the period of toe off. It is located at the medial side of upper neck region (G6) of the AFO. However, the maximum compressive peak stress (-0.43 MPa)

in the horizontal direction occurred during the period of toe strike, and is located at the middle of the upper heel region (G4) (Table 4.8, Fig. 4.6).

- *Sample 4*: Although the test conditions for this sample are the same as above, the maximum tensile peak stress (0.65 MPa) in the vertical direction is located at the lateral side of the upper neck region (G1) of the AFO, and is occurred during the period toe strike. On the other hand, the maximum tensile peak stress (0.65 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.7, Fig. 4.6). The maximum compressive peak stress (-0.60 MPa) in the vertical direction is also occurred during the period of heel off but is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.40 MPa) in the horizontal direction is located at the medial side of the upper neck region (G6), but is occurred during the period of toe strike (Table 4.8, Fig. 4.6).

Table 4.7 Magnitude and location of the maximum tensile stress occurred in the Moderate AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.75	Toe Strike	G4	0.70	Toe Off
2 (162)	G1	0.60	Toe Strike	G4	0.50	Toe Off
3 (190)	G1	0.75	Toe Strike	G4	0.40	Toe Off
4 (100)	G1	0.65	Toe Strike	G4	0.60	Toe Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.8 Magnitude and location of the maximum compressive stress occurred in the Moderate AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	-0.63	Toe Off	G8	-0.48	Toe Strike
2 (162)	G6	-0.80	Toe Off	G4	-0.41	Toe Strike
3 (190)	G6	-0.95	Toe Off	G4	-0.43	Toe Strike
4 (100)	G7	-0.60	Toe Off	G6	-0.40	Toe Strike

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

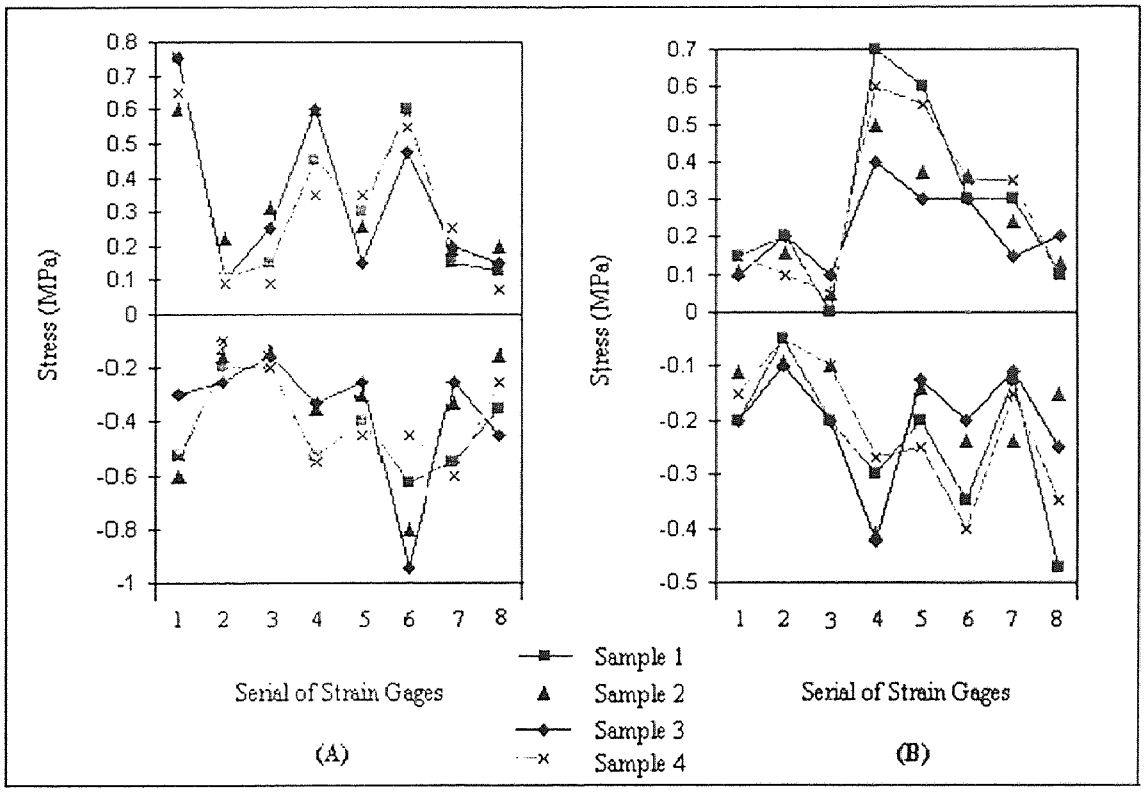


Figure. 4.6 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Moderate AFO in the motion of backward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.5 Stress Change in the Standard AFO of Four Samples During the Motion of "Standing Up and Sitting Down"

- *Sample 1*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.63 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.9, Fig. 4.7). The maximum compressive peak stress (-0.50 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.10, Fig. 4.7).
- *Sample 2*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.50 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.65 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.9, Fig.4.7). The maximum compressive peak stress (-0.80 MPa) in the vertical direction occurred at the moment of fully standing up down and is located at the lateral

side of lower neck region (G3) of the AFO. The maximum compressive peak stress (-0.10 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.10, Fig. 4.7).

- *Sample 3*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.90 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.60 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.9, Fig. 4.7). The maximum compressive peak stress (-0.30 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of the neck region (G2) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.10, Fig. 4.7).
- *Sample 4*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.96 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.60 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO (Table

4.9, Fig. 4.7). The maximum compressive peak stress (-0.40 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G6) of the AFO (Table 4.10, Fig. 4.7).

Table 4.9 Magnitude and location of the maximum tensile stress occurred in the Standard AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.63	HW of SU/SD	G3	0.45	Fully SU
2 (162)	G1	0.50	HW of SU/SD	G3	0.65	Fully SU
3 (190)	G2	0.90	HW of SU/SD	G3	0.60	Fully SU
4 (100)	G1	0.96	HW of SU/SD	G3	0.60	Fully SU

Note: HW of SU/SD = Halfway of Standing Up and Sitting Down (the knee is about 45° to horizontal axis)
Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

Table 4.10 Magnitude and location of the maximum compressive stress occurred in the Standard AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G3	-0.50	Fully SU	G1	-0.15	HW of SU/SD
2 (162)	G3	-0.80	Fully SU	G1	-0.10	HW of SU/SD
3 (190)	G2	-0.30	Fully SU	G1	-0.15	HW of SU/SD
4 (100)	G3	-0.40	Fully SU	G1	-0.20	HW of SU/SD

Note: HW of SU/SD = Halfway of Standing Up and Sitting Down (the knee is about 45° to horizontal axis). Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

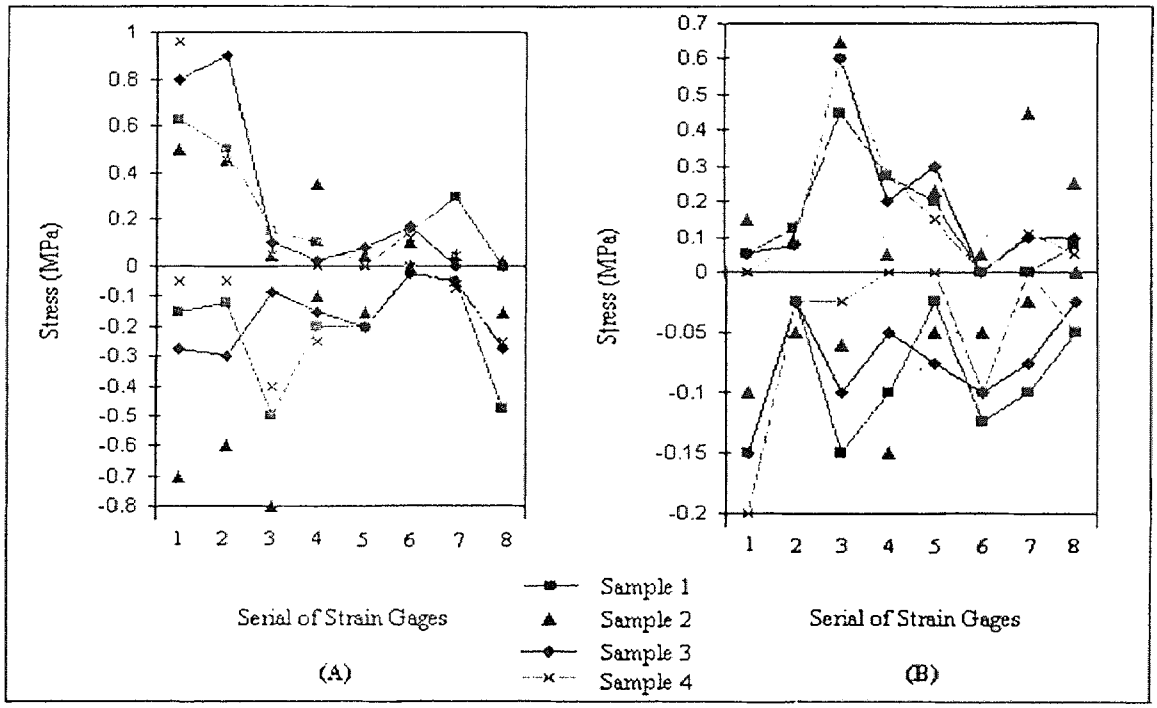


Figure. 4.7 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Standard AFO in motion of standing up/sitting down. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.6 Stress Change in the Standard AFO of Four Samples During the Motion of "Slow Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.35 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of lower neck region (G3) of the AFO (Table 4.11, Fig. 4.8). The maximum compressive peak stress (-0.73 MPa) in the vertical direction occurred during the period of heel strike and it located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the medial side of the lower neck region (G3) of the AFO (Table 4.12, Fig. 4.8).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.83 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.39 MPa) in the horizontal direction occurred during the period of push off and is located at the medial side of the lower neck region (G3) of the AFO (Table 4.11, Fig. 4.8). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.35 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.12, Fig. 4.8).

- *Sample 3*: Within the entire motion for Standard AFO, the maximum tensile peak stress (1.56 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.75 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.11, Fig. 4.8). The maximum compressive peak stress (-0.63 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.12, Fig. 4.8).
- *Sample 4*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.65 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower heel region (G3) of the AFO (Table 4.11, Fig. 4.8). The maximum compressive peak stress (-0.43 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.12, Fig. 4.8).

Table 4.11 Magnitude and location of the maximum tensile stress occurred in the Standard AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.35	Push Off	G3	0.25	Push Off
2 (162)	G2	0.83	Push Off	G3	0.39	Push Off
3 (190)	G2	1.56	Push Off	G3	0.75	Push Off
4 (100)	G2	0.65	Push Off	G3	0.25	Push Off

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

Table 4.12 Magnitude and location of the maximum compressive stress occurred in the Standard AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.73	Heel Strike	G3	-0.30	Heel Strike
2 (162)	G1	-0.60	Heel Strike	G4	-0.35	Heel Strike
3 (190)	G2	-0.63	Heel Strike	G3	-0.30	Heel Strike
4 (100)	G2	-0.48	Heel Strike	G3	-0.30	Heel Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

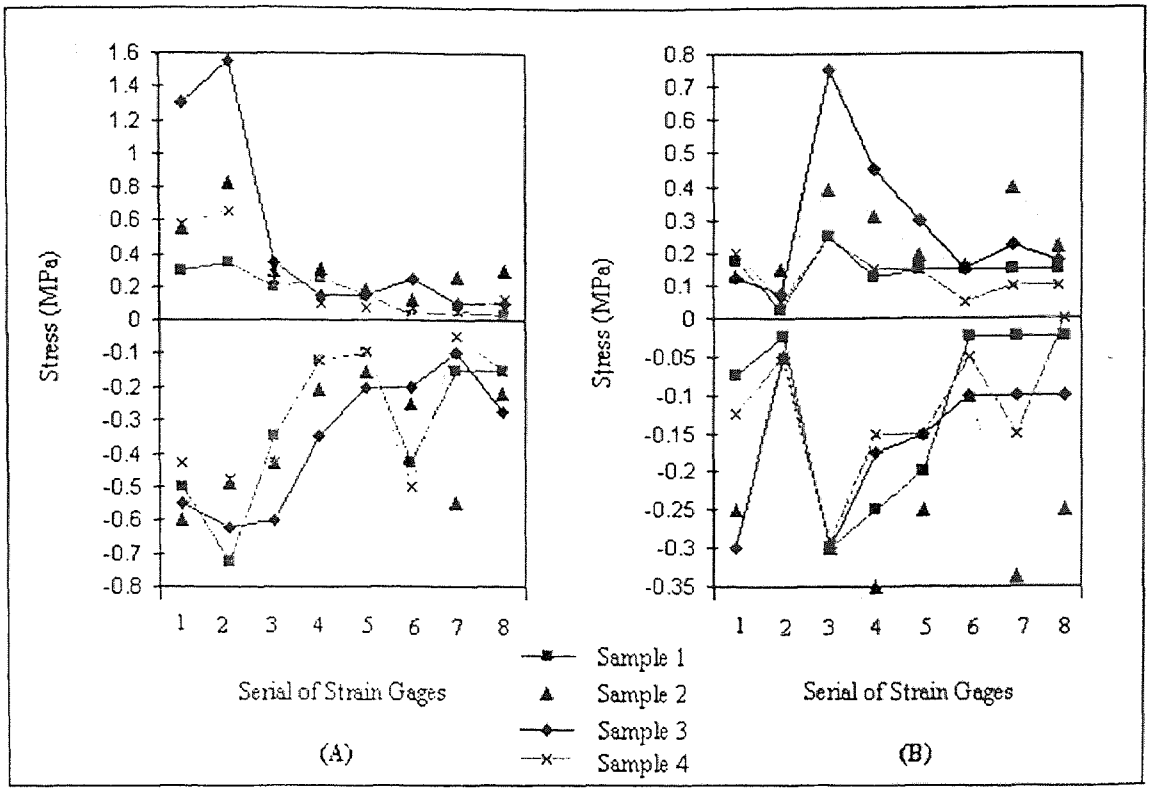


Figure. 4.8 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Standard AFO in the motion of slow forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.7 Stress Change in the Standard AFO of Four Samples During the Motion of "Fast Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.55 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.43 MPa) in the horizontal direction occurred during the period of push off and is located at the medial side of the lower neck region (G3) of the AFO (Table 4.13, Fig. 4.9). The maximum compressive peak stress (-0.75 MPa) in the vertical direction occurred during the

period of heel strike and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.14, Fig. 4.9).

- *Sample 2*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.7 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.46 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.13, Fig. 4.9). The maximum compressive peak stress (-0.75 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.35 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of AFO (Table 4.14, Fig. 4.9).
- *Sample 3*: Within the entire motion for Standard AFO, the maximum tensile peak stress (1.40 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.60 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.13, Fig. 4.9). The maximum compressive peak stress (-1.18 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of lower neck region (G3) of the AFO. The maximum compressive peak stress (-

0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of AFO (Table 4.14, Fig. 4.9).

- *Sample 4*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.90 MPa) in the vertical direction occurred during the period push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.13, Fig. 4.9). The maximum compressive peak stress (-0.64 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of lower neck region (G3) of the AFO. The maximum compressive peak stress (-0.23 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.14, Fig. 4.9).

Table 4.13 Magnitude and location of the maximum tensile stress occurred in the Standard AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.55	Push Off	G3	0.43	Push Off
2 (162)	G1	0.70	Push Off	G3	0.46	Push Off
3 (190)	G1	1.40	Push Off	G3	0.60	Push Off
4 (100)	G2	0.90	Push Off	G3	0.40	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

Table 4.14 Magnitude and location of the maximum compressive stress occurred in the Standard AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.75	Heel Strike	G4	-0.30	Heel Strike
2 (162)	G1	-0.75	Heel Strike	G4	-0.35	Heel Strike
3 (190)	G3	-1.18	Heel Strike	G3	-0.30	Heel Strike
4 (100)	G3	-0.64	Heel Strike	G4	-0.23	Heel Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

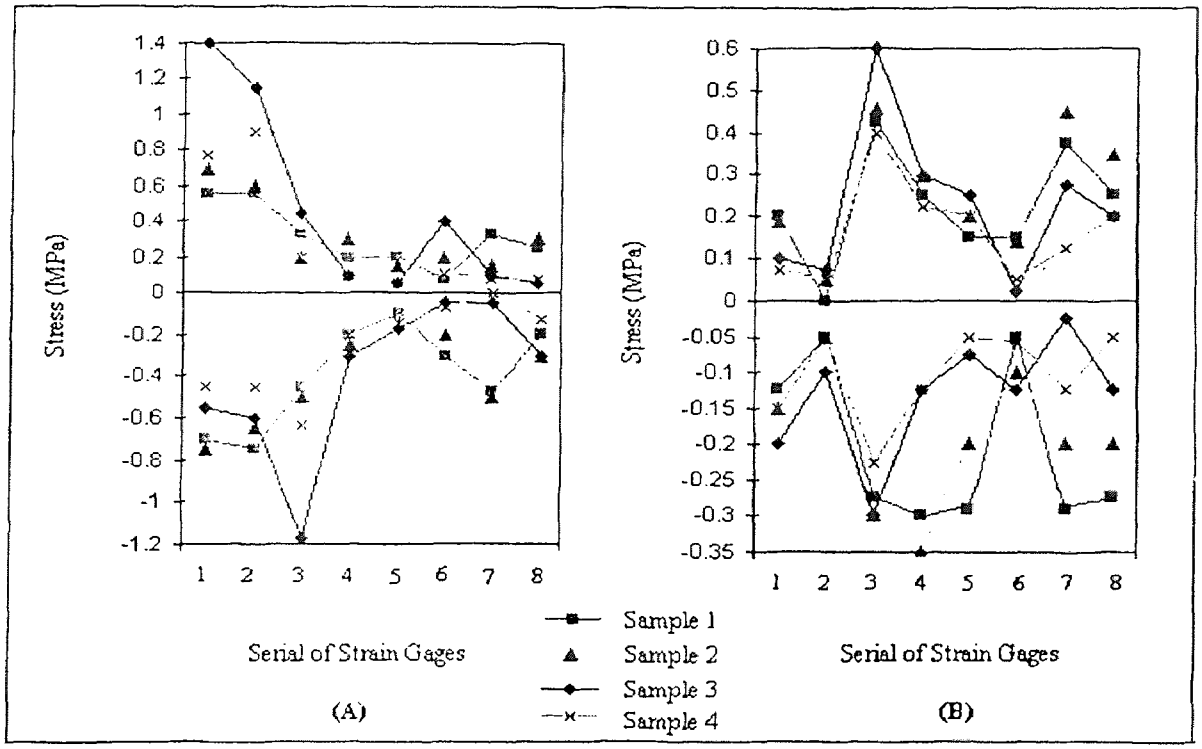


Figure. 4.9 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Standard AFO in the motion of fast forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.2.8 Stress Change in the Standard AFO of Four Samples During the Motion of "Backward Walk"

- *Sample 1*: The maximum tensile peak stress (0.83 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck (G2) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.15, Fig. 4.10). The maximum compressive peak stress (-0.50 MPa) in the vertical direction occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.16, Fig. 4.10).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (1.20 MPa) in the vertical direction occurred during the period of toe strike and it is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred during the period of toe off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.15, Fig. 4.10). The maximum compressive peak stress (-0.85 MPa) in the vertical direction occurred during the period of heel off and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.26 MPa) in the horizontal direction occurred during the period of toe strike and it is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.16, Fig. 4.10).

- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.40 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.20 MPa) in the horizontal direction occurred during the period of toe off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.15, Fig. 4.10). The maximum compressive peak stress (-0.75 MPa) in the vertical direction occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.28 MPa) in the horizontal direction occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.16, Fig. 4.10).
- *Sample 4*: Within the entire motion for Standard AFO, the maximum tensile peak stress (0.6 MPa) in the vertical direction occurred during the period toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.15, Fig. 4.10). The maximum compressive peak stress (-0.58 MPa) in the vertical direction occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.28 MPa) in the horizontal direction occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.16, Fig. 4.10).

Table 4.15 Magnitude and location of the maximum tensile stress occurred in the Standard AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.83	Toe Strike	G4	0.40	Toe Off
2 (162)	G1	1.20	Toe Strike	G3	0.35	Toe Off
3 (190)	G2	0.40	Toe Strike	G3	0.20	Toe Off
4 (100)	G2	0.60	Toe Strike	G4	0.45	Toe Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.16 Magnitude and location of the maximum compressive stress occurred in the Standard AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.50	Toe Off	G3	-0.25	Toe Strike
2 (162)	G1	-0.85	Toe Off	G3	-0.26	Toe Strike
3 (190)	G2	-0.75	Toe Off	G3	-0.28	Toe Strike
4 (100)	G2	-0.58	Toe Off	G3	-0.28	Toe Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

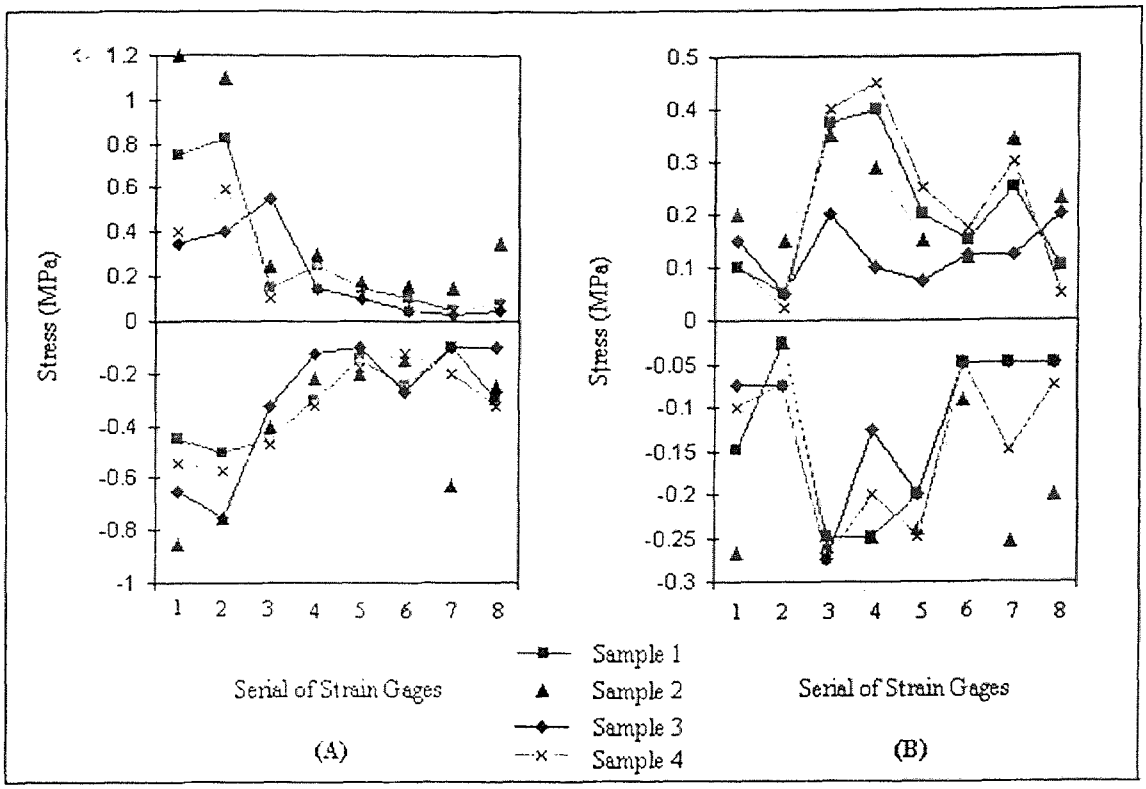


Figure. 4.10 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from four samples for Standard AFO in the motion of backward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3 Determination of Stress Change in AFOs with Three Samples

There were totally five AFOs tested for the entire experiment. However, under this section, only three samples were tested and only on the Flex, Solid and Varus AFO with each of the five motions namely the "Standing Up and Sitting Down", the "Slow Forward Walk", the "Fast Forward Walk", the "Backward Walk" and the "Lifting a 25 lb. Object". The three samples were sample 1 (male, 125 lb.), sample 2 (male, 162 lb.) and sample 3 (male, 192 lb.).

4.3.1 Stress Change in the Flex AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

- *Sample 1*: During the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis), the maximum tensile peak stress (0.40 MPa) in the vertical direction in the Flex AFO occurred at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.53 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.17, Fig. 4.11). The maximum compressive peak stress (-0.70 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of the neck region (G2) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the middle of the upper heel region (G5) of the AFO (Table 4.18, Fig. 4.11).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.64 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the lower neck region (G3) of the Flex AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.17, Fig. 4.11). However, the maximum compressive peak stress (-0.55 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of neck region (G2) of the

AFO. The maximum compressive peak stress (-0.57 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.18, Fig. 4.11).

- *Sample 3*: Although the location where the stress concentration were the same, the magnitude were different. The maximum tensile peak stress (1.25 MPa) in the Flex AFO in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.55 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.17, Fig. 4.11). The maximum compressive peak stress (-0.8 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the lateral side of the neck region (G2) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.18, Fig. 4.11).

Table 4.17 Magnitude and location of the maximum tensile stress occurred in the Flex AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.40	HW of SU/SD	G3	0.53	Fully SU
2 (162)	G3	0.64	HW of SU/SD	G4	0.25	Fully SU
3 (190)	G2	1.25	HW of SU/SD	G4	0.55	Fully SU

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.18 Magnitude and location of the maximum compressive stress occurred in the Flex AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.70	Fully SU	G5	-0.25	HW of SU/SD
2 (162)	G2	-0.55	Fully SU	G3	-0.57	HW of SU/SD
3 (190)	G2	-0.80	Fully SU	G3	-0.20	HW of SU/SD

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G5=Gage 5, located at the middle of upper heel region of the AFO (Figure 2.7).

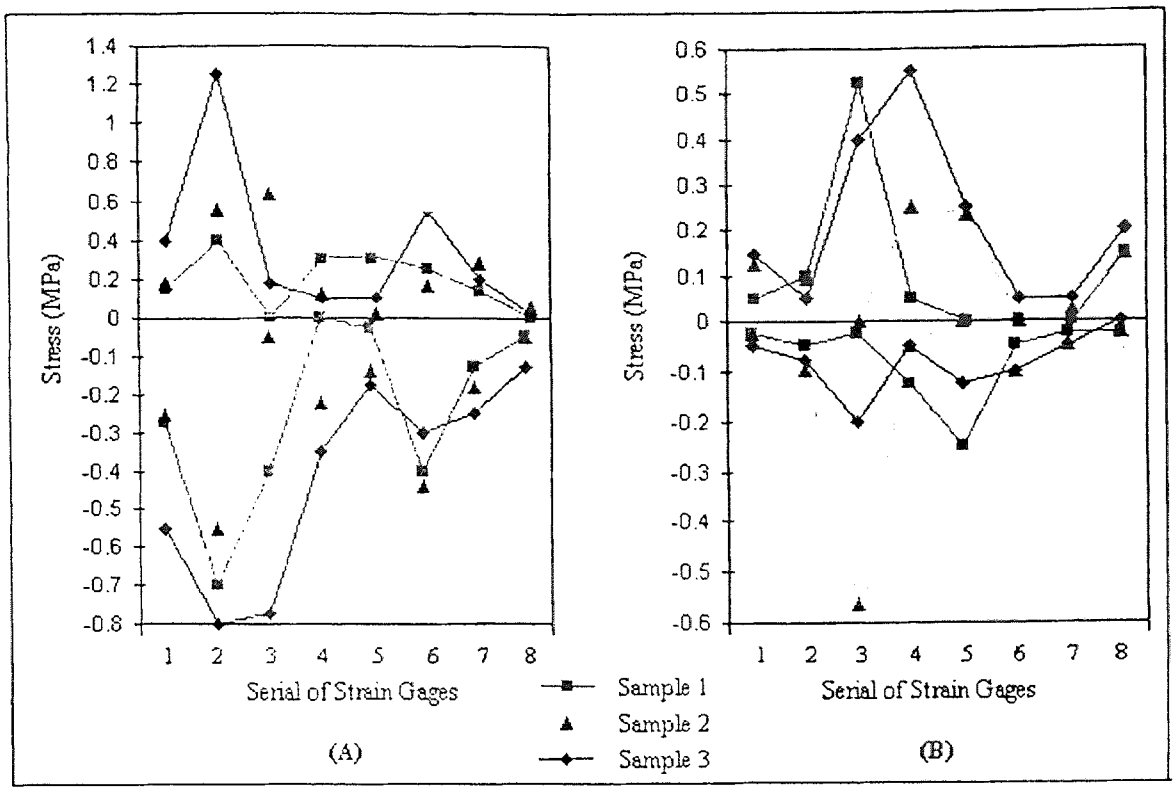


Figure. 4.11 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Flex AFO in the motion of standing up/sitting down. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation. Note: The tensile and compressive stress occurred at different period of gait.

4.3.2 Stress Change in the Flex AFO of Three Samples During the Motion of "Slow Forward Walk"

- *Sample 1*: Within this motion for Flex AFO, the maximum tensile peak stress (0.93 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.19, Fig. 4.12). The maximum compressive peak stress (-1.10 MPa) in the vertical direction

occurred during the period of heel strike and it located at the lateral side of neck region (G2) the AFO. The maximum compressive peak stress (-0.50 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.20, Fig. 4.12).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.90 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.19, Fig. 4.12). The maximum compressive peak stress (-0.90 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.38 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.20, Fig. 4.12).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (1.20 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.19, Fig. 4.12). The maximum compressive peak stress (-1.15 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.45 MPa) in the horizontal

direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.20, Fig. 4.12).

Table 4.19 Magnitude and location of the maximum tensile stress occurred in the Flex AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.93	Push Off	G3	0.35	Push Off
2 (162)	G2	0.90	Push Off	G4	0.25	Push Off
3 (190)	G2	1.20	Push Off	G4	0.45	Push Off

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.20 Magnitude and location of the maximum compressive stress occurred in the Flex AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-1.10	Heel Strike	G3	-0.50	Heel Strike
2 (162)	G2	-0.90	Heel Strike	G3	-0.38	Heel Strike
3 (190)	G2	-1.15.	Heel Strike	G3	-0.45	Heel Strike

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

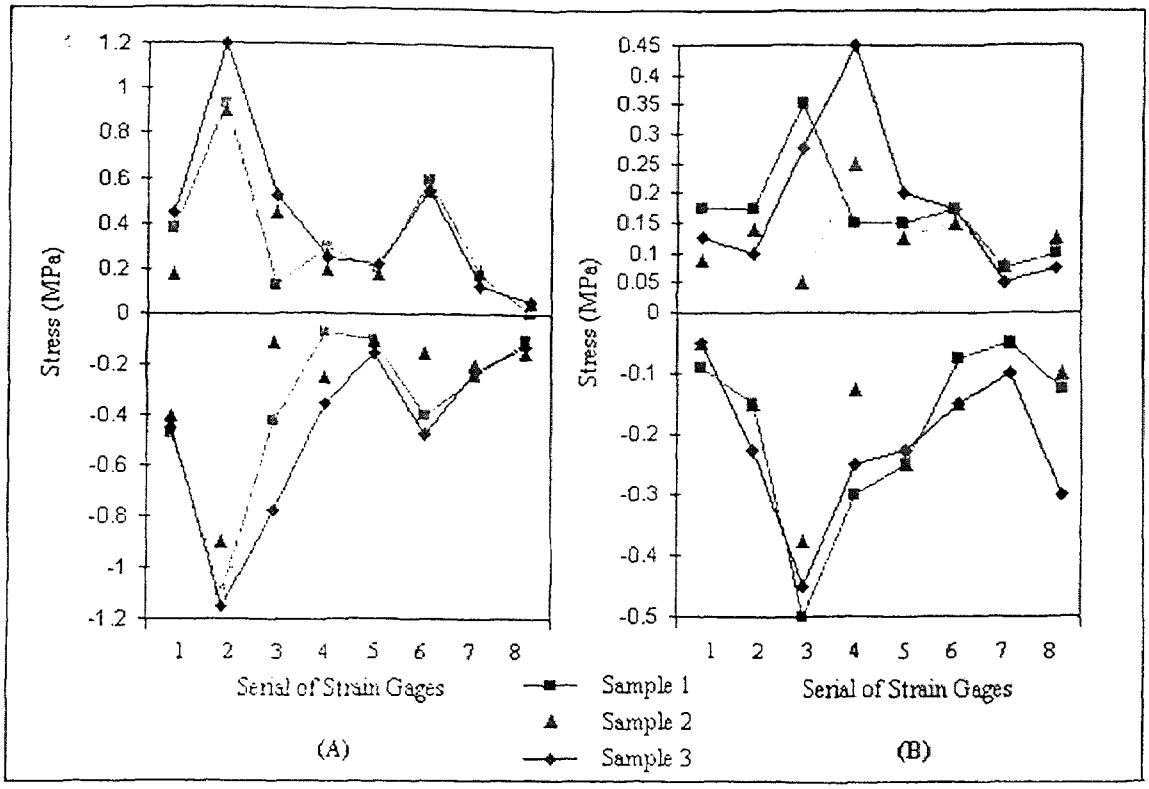


Figure. 4.12 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Flex AFO in the motion of slow forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.3 Stress Change in the Flex AFO of Three Samples During the Motion of "Fast Forward Walk"

- *Sample 1*: With this motion, the maximum tensile peak stress (0.78 MPa) in the vertical direction in the Flex AFO occurred during the period of push off and is located at the lateral side of the neck (G2) of the AFO. The maximum tensile peak stress (0.38 MPa) in the horizontal direction occurred during the period of push off and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.21, Fig. 4.13). The maximum compressive peak stress (-0.78 MPa) in the vertical direction occurred

during the period of heel strike and it located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.22, Fig. 4.13).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.85 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.21, Fig. 4.13). The maximum compressive peak stress (-0.70 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.45 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.22, Fig. 4.13).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.95 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred during the period of push off and it located at the middle of the upper heel region (G4) of the AFO (Table 4.21, Fig. 4.13). The maximum compressive peak stress (-1.35 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.50 MPa) in the horizontal

direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.22, Fig. 4.13).

Table 4.21 Magnitude and location of the maximum tensile stress occurred in the Flex AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.78	Push Off	G3	0.38	Push Off
2 (162)	G2	0.85	Push Off	G4	0.25	Push Off
3 (190)	G2	0.95	Push Off	G4	0.45	Push Off

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.22 Magnitude and location of the maximum compressive stress occurred in the Flex AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.78	Heel Strike	G3	-0.30	Heel Strike
2 (162)	G2	-0.70	Heel Strike	G3	-0.45	Heel Strike
3 (190)	G2	-1.35	Heel Strike	G3	-0.50	Heel Strike

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

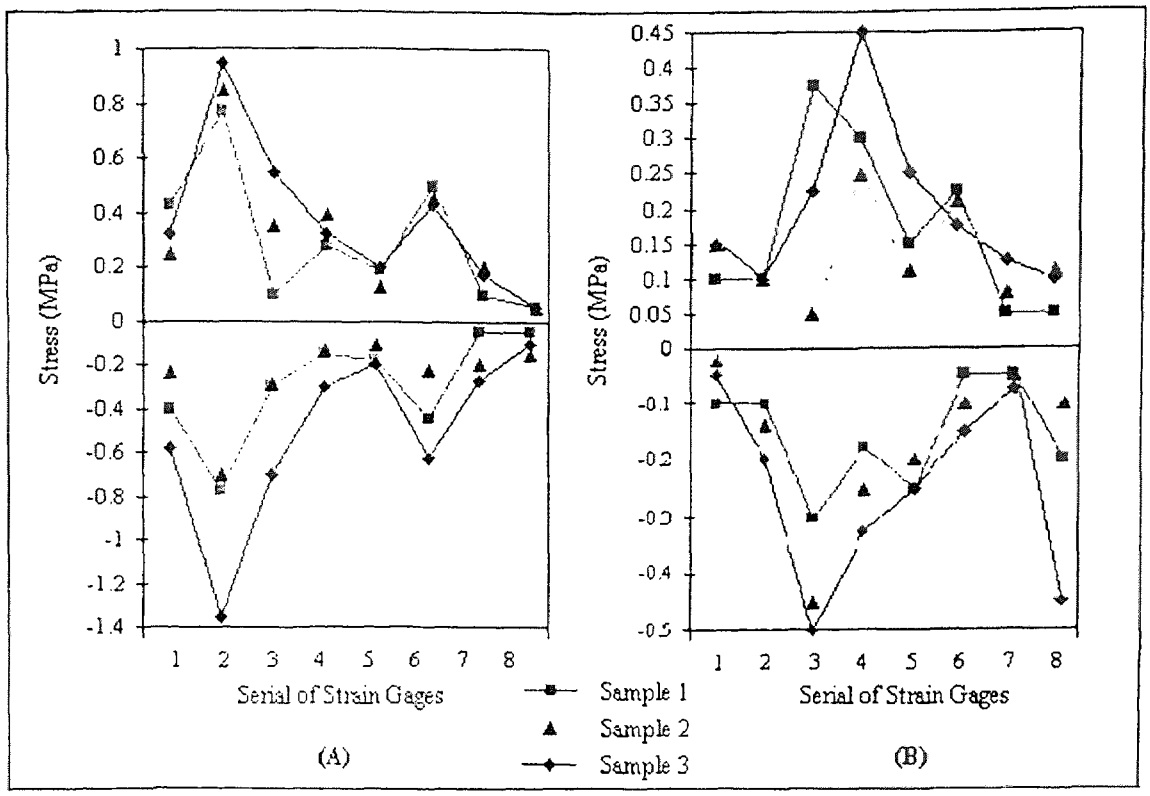


Figure. 4.13 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Flex AFO in the motion of fast forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.4 Stress Change in the Flex AFO of Three Samples During the Motion of "Backward Walk"

- *Sample 1*: Within this motion and with the Flex AFO, the maximum tensile peak stress (0.74 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.38 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.23, Fig. 4.14). The maximum compressive peak stress (-0.55 MPa) in the vertical direction

occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.45 MPa) in the horizontal direction occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.24, Fig. 4.14).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.90 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.30 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.23, Fig. 4.14). The maximum compressive peak stress (-0.70 MPa) in the vertical direction occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of toe strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.24, Fig. 4.14).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (1.00 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.23, Fig. 4.14). The maximum compressive peak stress (-0.80 MPa) in the vertical direction occurred during the period of toe off and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.45 MPa) in the horizontal direction

occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.24, Fig. 4.14).

Table 4.23 Magnitude and location of the maximum tensile stress occurred in the Flex AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.74	Toe Strike	G4	0.38	Toe Off
2 (162)	G2	0.90	Toe Strike	G4	0.30	Toe Off
3 (190)	G2	1.00	Toe Strike	G4	0.25	Toe Off

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.24 Magnitude and location of the maximum compressive stress occurred in the Flex AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.55	Toe Off	G3	-0.45	Toe Strike
2 (162)	G2	-0.70	Toe Off	G3	-0.30	Toe Strike
3 (190)	G2	-0.80	Toe Off	G3	-0.45	Toe Strike

Note: G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

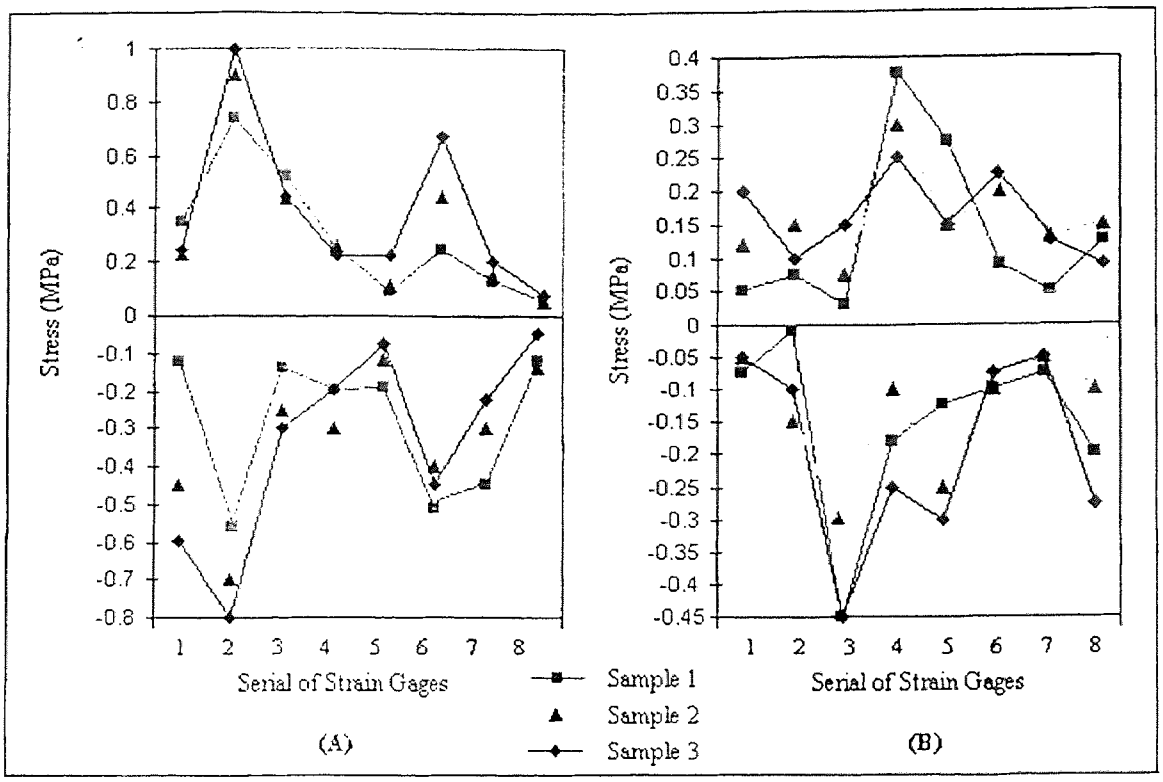


Figure. 4.14 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Flex AFO in the motion of backward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.5 Stress Change in the Flex AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

- *Sample 1*: The maximum tensile peak stress (0.25 MPa) in the vertical direction occurred during the period of touch the object and is located at the medial side of the neck region (G6) of the AFO. The maximum tensile peak stress (0.15 MPa) in the horizontal direction occurred during the period of touch the object and is located at the medial side of the lower neck region (G8) of the AFO (Table 4.25, Fig. 4.15). The maximum compressive peak stress (-0.80 MPa) in the vertical direction occurred

during the period of before standing straight and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the lateral side of the lower neck region (G3) (Table 4.26, Fig. 4.15).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.85 MPa) in the vertical direction occurred during the period of touch the object and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.15 MPa) in the horizontal direction occurred during the period of touch the object and is located at the medial side of the lower neck region (G8) of the AFO (Table 4.25, Fig. 4.15). The maximum compressive peak stress (-0.40 MPa) in the vertical direction occurred during the period of before standing straight and is located at the lateral side of neck region (G2) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the lateral side of the neck region (G2) of the AFO (Table 4.26, Fig. 4.15).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.60 MPa) in the vertical direction occurred during the period of touch the object and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred during the period of touch the object and is located at the middle of the upper heel region (G4) of the AFO (Table 4.25, Fig. 4.15). The maximum compressive peak stress (-0.30 MPa) in the vertical direction occurred during the period of before standing straight and is located at the lateral side

of neck region (G2) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the lateral side of the lower neck region (G3) (Table 4.26, Fig. 4.15).

Table 4.25 Magnitude and location of the maximum tensile stress occurred in the Flex AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.25	Touch the Obj.	G8	0.15	Touch the Obj.
2 (162)	G2	0.85	Touch the Obj.	G3	0.13	Touch the Obj.
3 (190)	G2	0.60	Touch the Obj.	G4	0.35	Touch the Obj.

Note: Touch the Obj. = Touch the object.
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7)
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7)

Table 4.26 Magnitude and location of the maximum compressive stress occurred in the Flex AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	-0.80	BF Straight	G3	-0.20	BF Straight
2 (162)	G2	-0.40	BF Straight	G2	-0.15	BF Straight
3 (190)	G2	-0.30	BF Straight	G3	-0.20	BF Straight

Note: BF Straight = Before Standing Straight.
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).

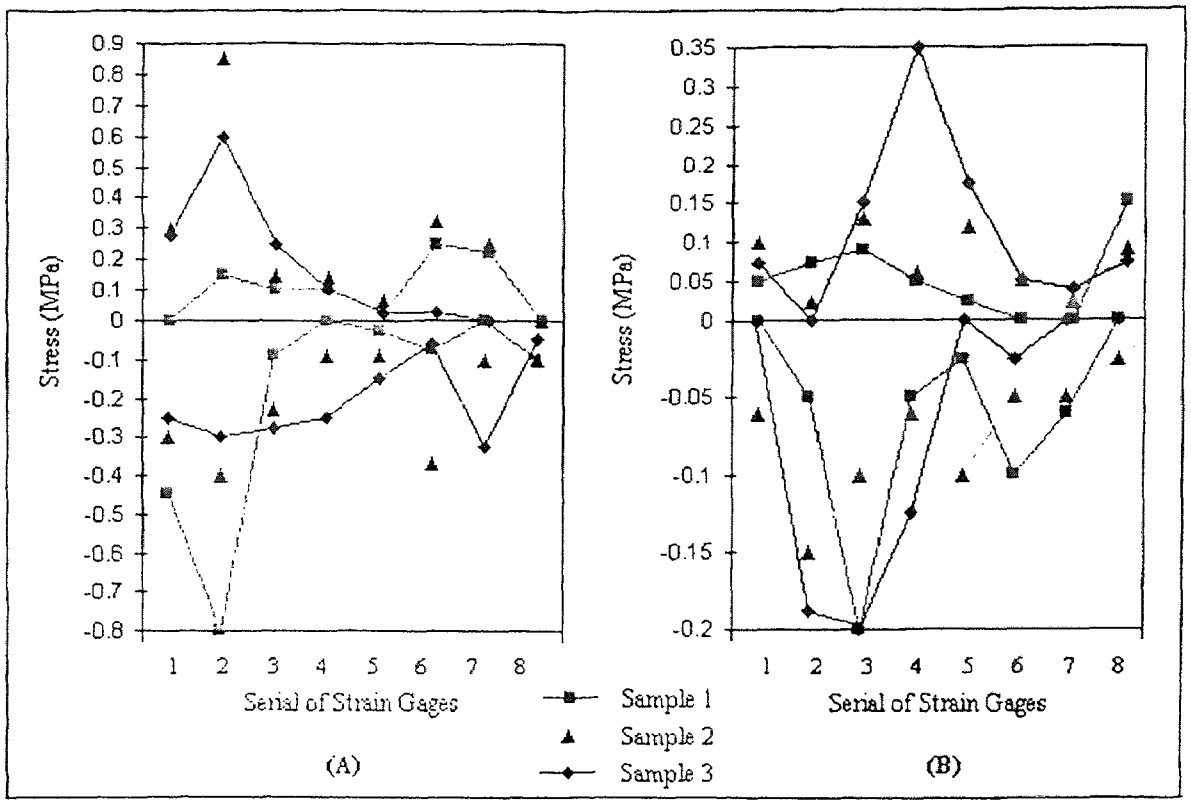


Figure. 4.15 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Flex AFO in the motion of lifting a 25 lb. object. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.6 Stress Change in the Solid AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

- *Sample 1*: With this motion and the Standard AFO, the maximum tensile peak stress (0.60 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.27, Fig. 4.16).

The maximum compressive peak stress (-0.53 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the medial side of the neck region (G7) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.28, Fig. 4.16).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.80 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.70 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.27, Fig. 4.16). The maximum compressive peak stress (-0.93 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the medial side of lower neck region (G7) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.28, Fig. 4.16).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (1.05 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.7 MPa) in the

horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.27, Fig.4.16). The maximum compressive peak stress (-0.95 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the medial side of the lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.18 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.28, Fig. 4.16).

Table 4.27 Magnitude and location of the maximum tensile stress occurred in the Solid AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.60	HW of SU/SD	G4	0.35	Fully SU
2 (162)	G6	0.80	HW of SU/SD	G4	0.70	Fully SU
3 (190)	G6	1.05	HW of SU/SD	G4	0.70	Fully SU

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

Table 4.28 Magnitude and location of the maximum compressive stress occurred in the Solid AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G7	-0.53	Fully SU	G1	-0.20	HW of SU/SD
2 (162)	G7	-0.93	Fully SU	G1	-0.15	HW of SU/SD
3 (190)	G8	-0.95	Fully SU	G1	-0.18	HW of SU/SD

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

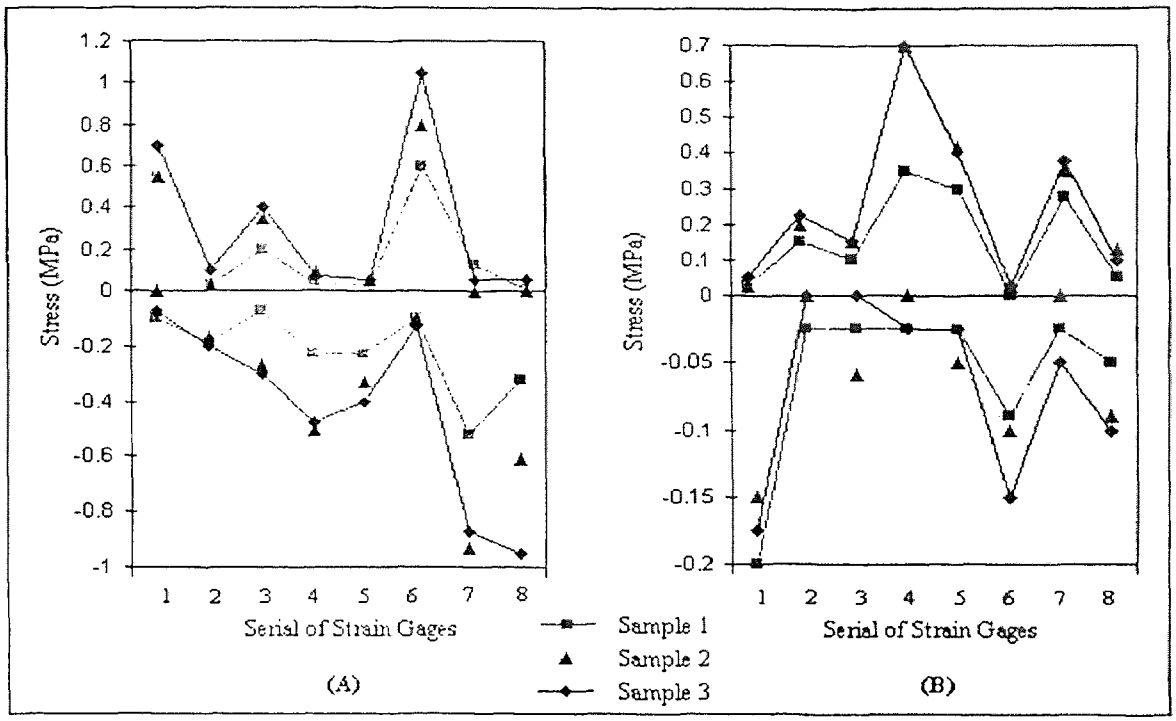


Figure. 4.16 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Solid AFO in the motion of standing up/sitting down. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation. Note: The tensile and compressive stress occurred at different period of gait.

4.3.7 Stress Change in the Solid AFO of Three Samples During the Motion of "Slow Forward Walk"

- *Sample 1*: With this motion and the Solid AFO, the maximum tensile peak stress (0.45 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G1) of the AFO. The maximum tensile peak stress (0.23 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of upper heel region (G4) of the AFO (Table 4.29, Fig. 4.17). The maximum compressive peak stress (-0.70 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.18 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.30, Fig. 4.17).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.43 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.21 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.29, Fig. 4.17). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.30, Fig. 4.17).

- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.85 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.4 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.29, Fig. 4.17). The maximum compressive peak stress (-0.95 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of the neck region (G7) of the AFO. The maximum compressive peak stress (-0.23 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.30, Fig. 4.17).

Table 4.29 Magnitude and location of the maximum tensile stress occurred in the Solid AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.45	Push Off	G4	0.23	Push Off
2 (162)	G1	0.43	Push Off	G4	0.21	Push Off
3 (190)	G1	0.85	Push Off	G4	0.40	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.30 Magnitude and location of the maximum compressive stress occurred in the Solid AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G7	-0.70	Heel Strike	G4	-0.18	Heel Strike
2 (162)	G7	-0.60	Heel Strike	G4	-0.25	Heel Strike
3 (190)	G7	-0.95	Heel Strike	G4	-0.23	Heel Strike

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).

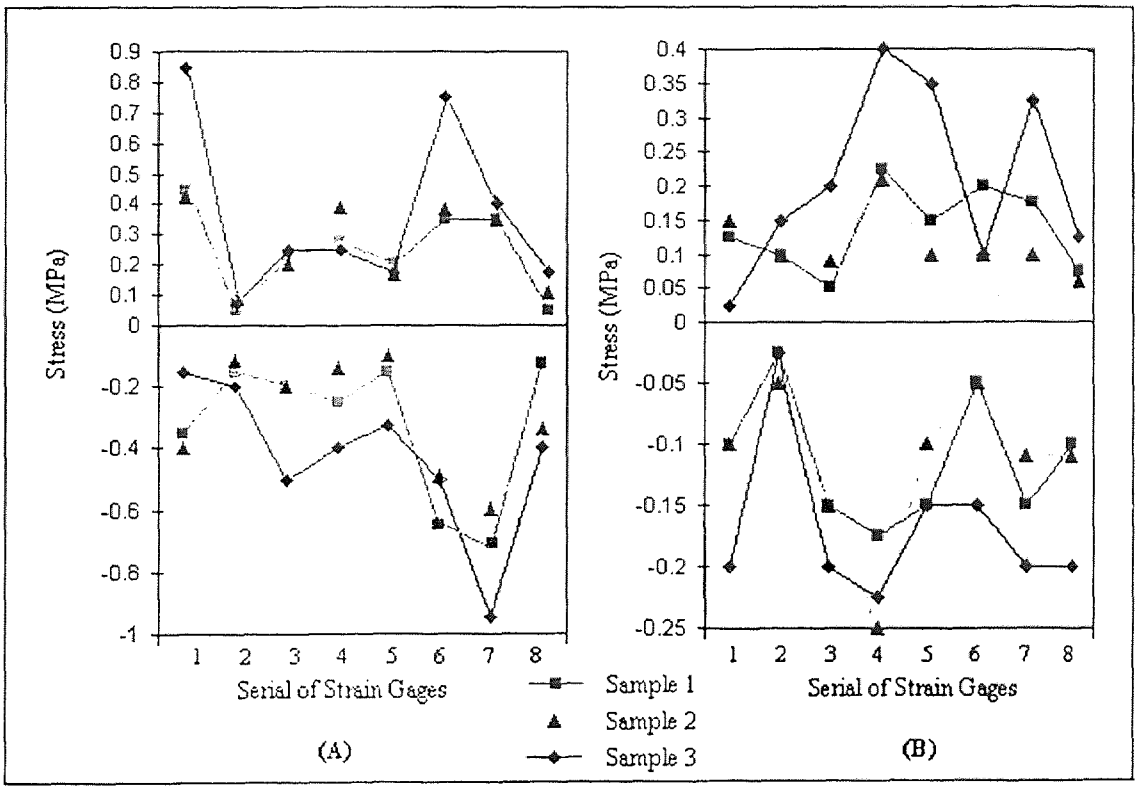


Figure. 4.17 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Solid AFO in the motion of slow forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.8 Stress Change in the Solid AFO of Three Samples During the Motion of "Fast Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.50 MPa) in the vertical direction occurred during the period of push off and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.33 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.31, Fig. 4.18). The maximum compressive peak stress (-0.58 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of upper neck region (G6) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.32, Fig. 4.18).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.55 MPa) in the vertical direction occurred during the period of push off and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.31, Fig. 4.18). The maximum compressive peak stress (-0.48 MPa) in the vertical direction occurred during the period of heel strike and it located at the medial side of the neck region (G7) of the AFO. The maximum compressive peak stress (-0.14 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.32, Fig. 4.18).

- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (1.20 MPa) in the vertical direction occurred during the period of push off and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.63 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.31, Fig. 4.18). The maximum compressive peak stress (-0.85 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.40 MPa) in the horizontal direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.32, Fig. 4.18).

Table 4.31 Magnitude and location of the maximum tensile stress occurred in the Solid AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.50	Push Off	G4	0.33	Push Off
2 (162)	G6	0.55	Push Off	G4	0.40	Push Off
3 (190)	G6	1.20	Push Off	G4	0.63	Push Off

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

Table 4.32 Magnitude and location of the maximum compressive stress occurred in the Solid AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	-0.58	Heel Strike	G4	-0.15	Heel Strike
2 (162)	G7	-0.48	Heel Strike	G3	-0.14	Heel Strike
3 (190)	G7	-0.85	Heel Strike	G3	-0.4	Heel Strike

Note: G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).

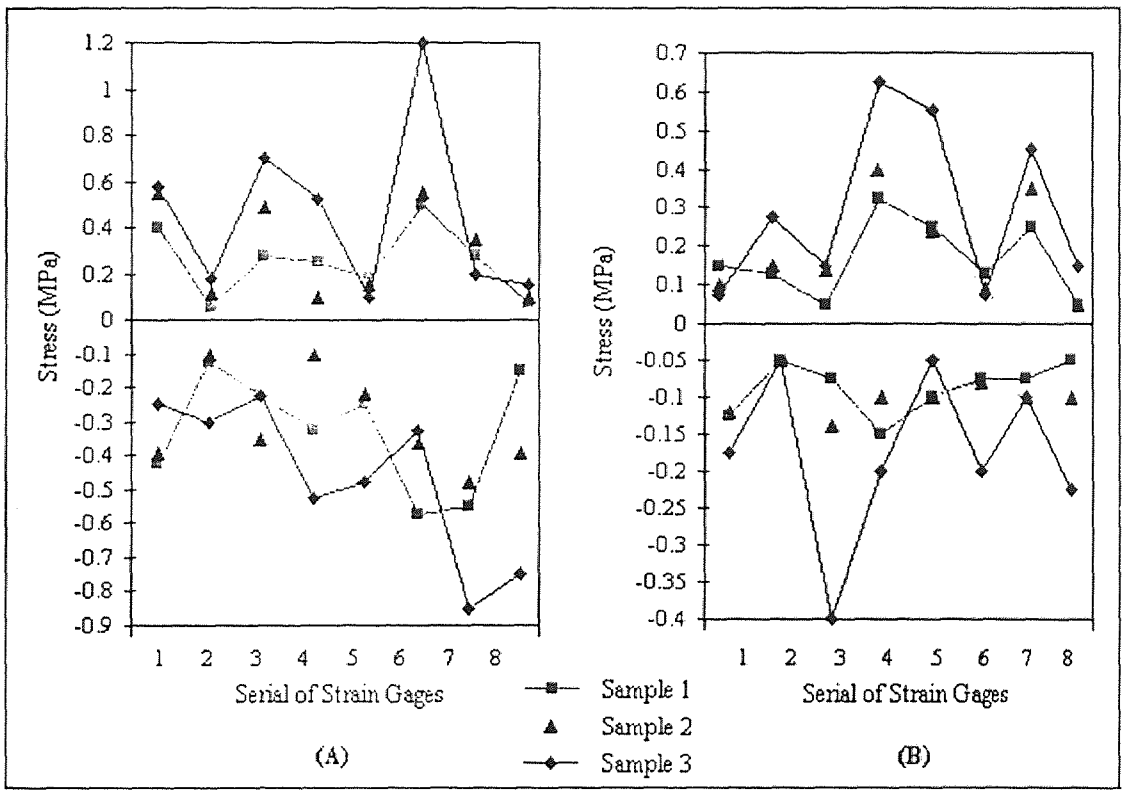


Figure. 4.18 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Solid AFO in the motion of fast forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.9 Stress Change in the Solid AFO of Three Samples During the Motion of "Backward Walk"

- *Sample 1*: The maximum tensile peak stress (0.90 MPa) in the vertical direction occurred during the period of toe strike and is located at the medial side of the upper neck (G6) of the AFO. The maximum tensile peak stress (0.56 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.33, Fig. 4.19). The maximum compressive peak stress (-0.74 MPa) in the vertical direction occurred during the period of toe off and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of toe strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.34, Fig. 4.19).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.45 MPa) in the vertical direction occurred during the period of toe strike and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.25 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.33, Fig. 4.19). The maximum compressive peak stress (-0.32 MPa) in the vertical direction occurred during the period of toe off and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.27 MPa) in the horizontal direction occurred during the period of toe strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.34, Fig. 4.19).

- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.86 MPa) in the vertical direction occurred during the period of toe strike and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.33, Fig. 4.19). The maximum compressive peak stress (-0.53 MPa) in the vertical direction occurred during the period of toe off and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of toe strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.34, Fig. 4.19).

Table 4.33 Magnitude and location of the maximum tensile stress occurred in the Solid AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.90	Toe Strike	G4	0.56	Toe Off
2 (162)	G6	0.45	Toe Strike	G4	0.25	Toe Off
3 (190)	G6	0.86	Toe Strike	G4	0.35	Toe Off

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).

Table 4.34 Magnitude and location of the maximum compressive stress occurred in the Solid AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G8	-0.74	Toe Off	G4	-0.25	Toe Strike
2 (162)	G7	-0.32	Toe Off	G4	-0.27	Toe Strike
3 (190)	G7	-0.53	Toe Off	G4	-0.30	Toe Strike

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

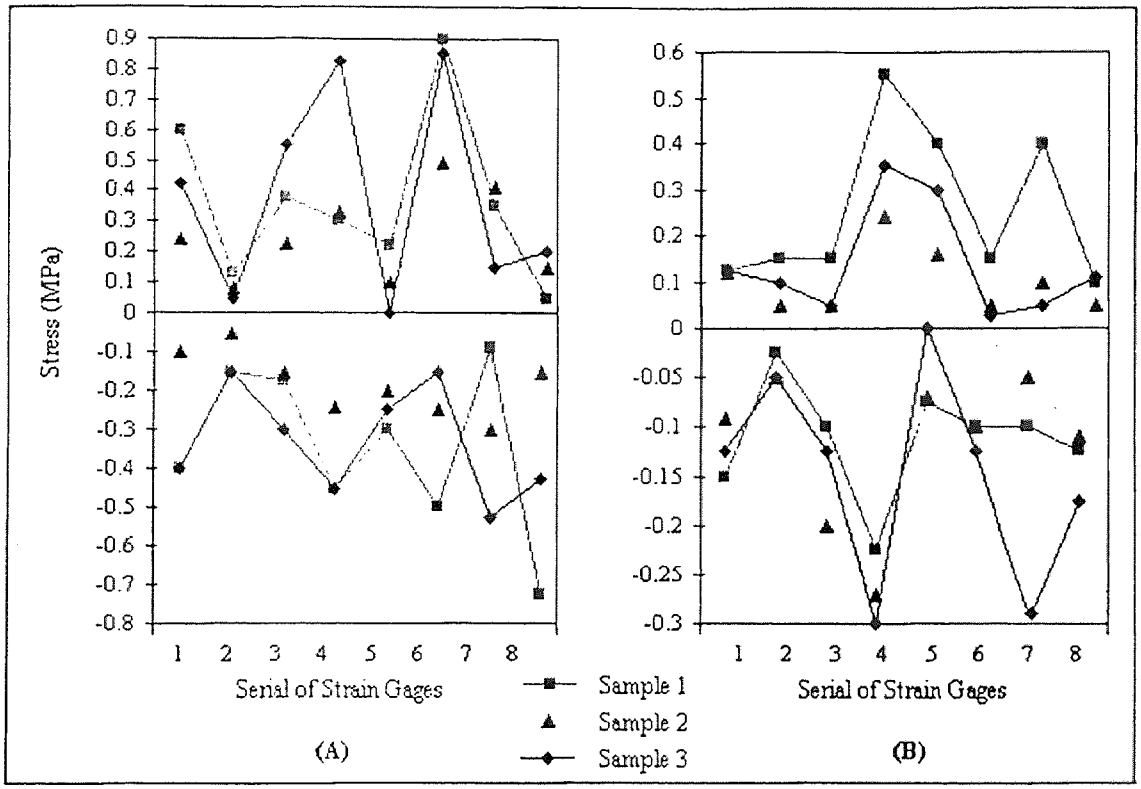


Figure. 4.19 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Solid AFO in the motion of backward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.10 Stress Change in the Solid AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

- *Sample 1*: The maximum tensile peak stress (0.15 MPa) in the vertical direction occurred during the period of touch the object and is located at the medial side of the neck region (G6) of the AFO. The maximum tensile peak stress (0.13 MPa) in the horizontal direction occurred during the period of touch the object and is located at the middle of the upper heel region (G4) of the AFO (Table 4.35, Fig. 4.20). The maximum compressive peak stress (-0.35 MPa) in the vertical direction occurred during the period of before standing straight and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.08 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the medial side of the lower neck region (G8) of the AFO (Table 4.36, Fig. 4.20).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.25 MPa) in the vertical direction occurred during the period of touch the object and is located at the medial side of the neck region (G7) of the AFO. The maximum tensile peak stress (0.36 MPa) in the horizontal direction occurred during the period of touch the object and is located at the middle of the upper heel region (G4) of the AFO (Table 4.35, Fig. 4.20). The maximum compressive peak stress (-0.31 MPa) in the vertical direction occurred during the period of before standing straight and is located at the middle of upper heel region (G4) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of before standing straight

and is located at the middle of the upper heel region (G4) of the AFO (Table 4.36, Fig. 4.20).

- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.78 MPa) in the vertical direction occurred during the period of touch the object and is located at the medial side of the upper neck region (G6) of the AFO. The maximum tensile peak stress (0.60 MPa) in the horizontal direction occurred during the period of touch the object and is located at the middle of the upper heel region (G4) of the AFO (Table 4.35, Fig. 4.20). The maximum compressive peak stress (-0.58 MPa) in the vertical direction occurred during the period of before standing straight and is located at the medial side of neck region (G7) of the AFO. The maximum compressive peak stress (-0.15 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.36, Fig. 4.20).

Table 4.35 Magnitude and location of the maximum tensile stress occurred in the Solid AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	ax Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G6	0.15	Touch the Obj.	G4	0.13	Touch the Obj
2 (162)	G7	0.25	Touch the Obj.	G4	0.36	Touch the Obj
3 (190)	G6	0.78	Touch the Obj.	G4	0.60	Touch the Obj

Note: G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).

Table 4.36 Magnitude and location of the maximum compressive stress occurred in the Solid AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G7	-0.35	BF Straight	G8	-0.08	BF Straight
2 (162)	G4	-0.31	BF Straight	G4	-0.15	BF Straight
3 (190)	G7	-0.58	BF Straight	G1	-0.15	BF Straight

Note: BF Straight = Before Standing Straight.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G7=Gage 7, located at the medial side of neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

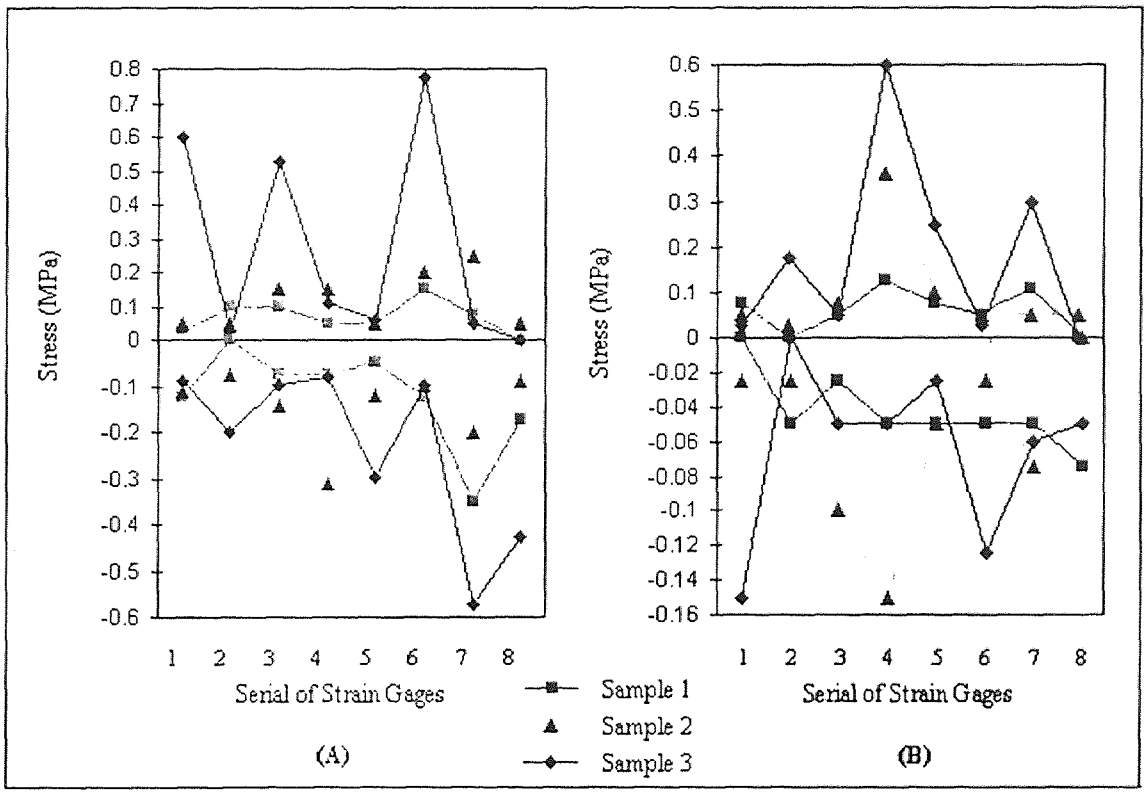


Figure. 4.20 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Solid AFO in the motion of lifting a 25 lb. object. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.11 Stress Change in the Varus AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

- *Sample 1*: During the period of halfway standing up/sitting down. (the knee is about 45° to horizontal axis), the maximum tensile peak stress (0.50 MPa) in the vertical direction in the Flex AFO occurred at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.37, Fig. 4.21). The maximum compressive peak stress (-0.43 MPa) in the vertical direction occurred at the moment of fully standing up and it located at the medial side of the lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down. (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.38, Fig. 4.21).
- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.70 MPa) in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis).and is located at the lateral side of the neck region (G2) of the Flex AFO. The maximum tensile peak stress (0.3 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G5) of the AFO (Table 4.37, Fig.4.21). However, the maximum compressive peak stress (-0.57 MPa) in the vertical direction occurred at the moment of fully standing up and is located at the medial side of lower neck region (G8) of the

AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.38, Fig. 4.21).

- *Sample 3*: The maximum tensile peak stress (0.50 MPa) in the Varus AFO in the vertical direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and it located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.45 MPa) in the horizontal direction occurred at the moment of fully standing up and is located at the middle of the upper heel region (G4) of the AFO (Table 4.37, Fig. 4.21). The maximum compressive peak stress (-0.85 MPa) in the vertical direction occurred at the moment of fully standing and is located at the medial side of the lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.35 MPa) in the horizontal direction occurred during the period of halfway standing up/sitting down (the knee is about 45° to horizontal axis) and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.38, Fig. 4.21).

Table 4.37 Magnitude and location of the maximum tensile stress occurred in the Varus AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.50	HW of SU/SD	G4	0.45	Fully SU
2 (162)	G2	0.70	HW of SU/SD	G5	0.30	Fully SU
3 (190)	G1	0.60	HW of SU/SD	G4	0.55	Fully SU

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G5=Gage 5, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.38 Magnitude and location of the maximum compressive stress occurred in the Varus AFO during the motion of Standing Up/Sitting Down

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G8	-0.43	Fully SU	G1	-0.25	HW of SU/SD
2 (162)	G8	-0.57	Fully SU	G1	-0.25	HW of SU/SD
3 (190)	G8	-0.85	Fully SU	G1	-0.35	HW of SU/SD

Note:HW of SU/SD = Halfway Standing Up and Sitting Down (the knee is about 45° to horizontal axis).
Fully SU = Fully Standing Up.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

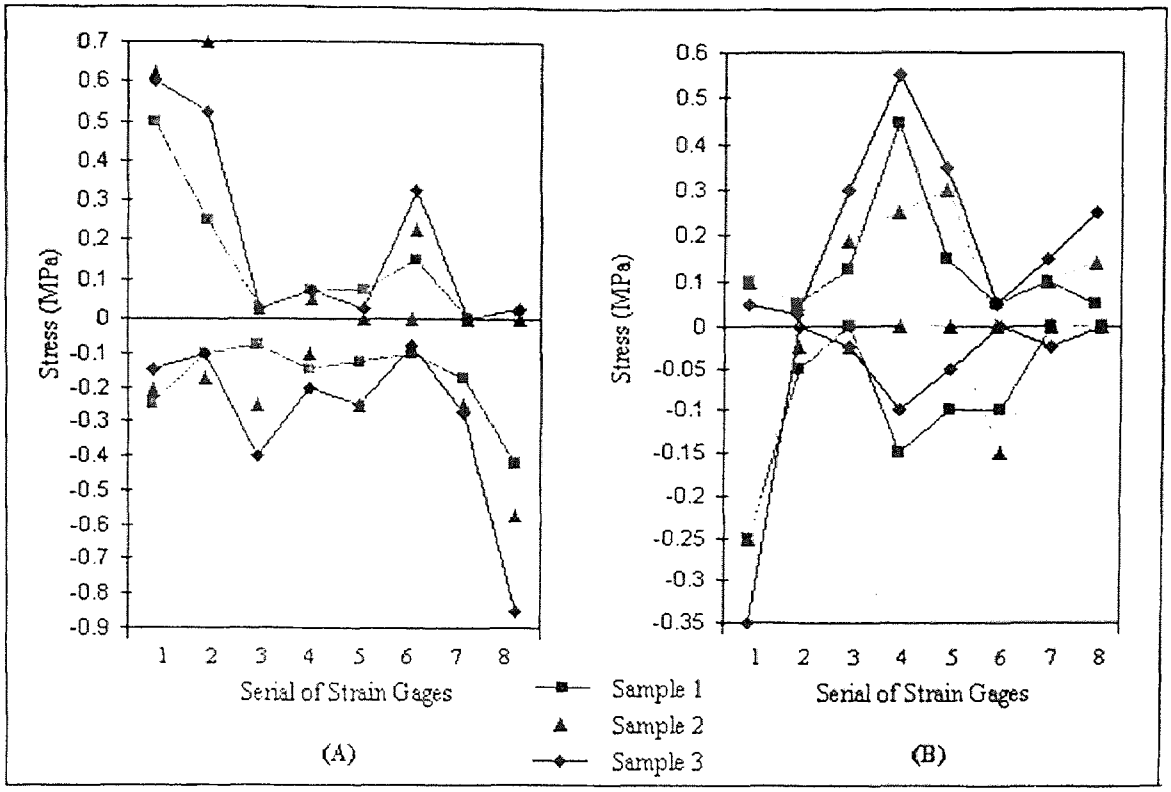


Figure. 4.21 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Varus AFO in the motion of standing up/sitting down. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.12 Stress Change in the Varus AFO of Three Samples During the Motion of "Slow Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.48 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.28 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.39, Fig. 4.22). The maximum compressive peak stress (-0.40 MPa) in the vertical direction occurred during the

period of heel strike and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.40, Fig. 4.22).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.35 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.28 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.39, Fig. 4.22). The maximum compressive peak stress (-0.50 MPa) in the vertical direction occurred during the period of heel strike and it located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G5) of the AFO (Table 4.40, Fig. 4.22).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.55 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.39, Fig. 4.22). The maximum compressive peak stress (-0.60 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.33 MPa) in the horizontal

direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.40, Fig. 4.22).

Table 4.39 Magnitude and location of the maximum tensile stress occurred in the Varus AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.48	Push Off	G4	0.28	Push Off
2 (162)	G1	0.35	Push Off	G4	0.20	Push Off
3 (190)	G1	0.55	Push Off	G4	0.40	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.40 Magnitude and location of the maximum compressive stress occurred in the Varus AFO during the motion of Slow Forward Walk

	Vertical Direction			Horizontal Direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	-0.40	Heel Strike	G4	-0.25	Heel Strike
2 (162)	G1	-0.50	Heel Strike	G5	-0.25	Heel Strike
3 (190)	G8	-0.60	Heel Strike	G4	-0.33	Heel Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G5=Gage 5, located at the middle of upper heel region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

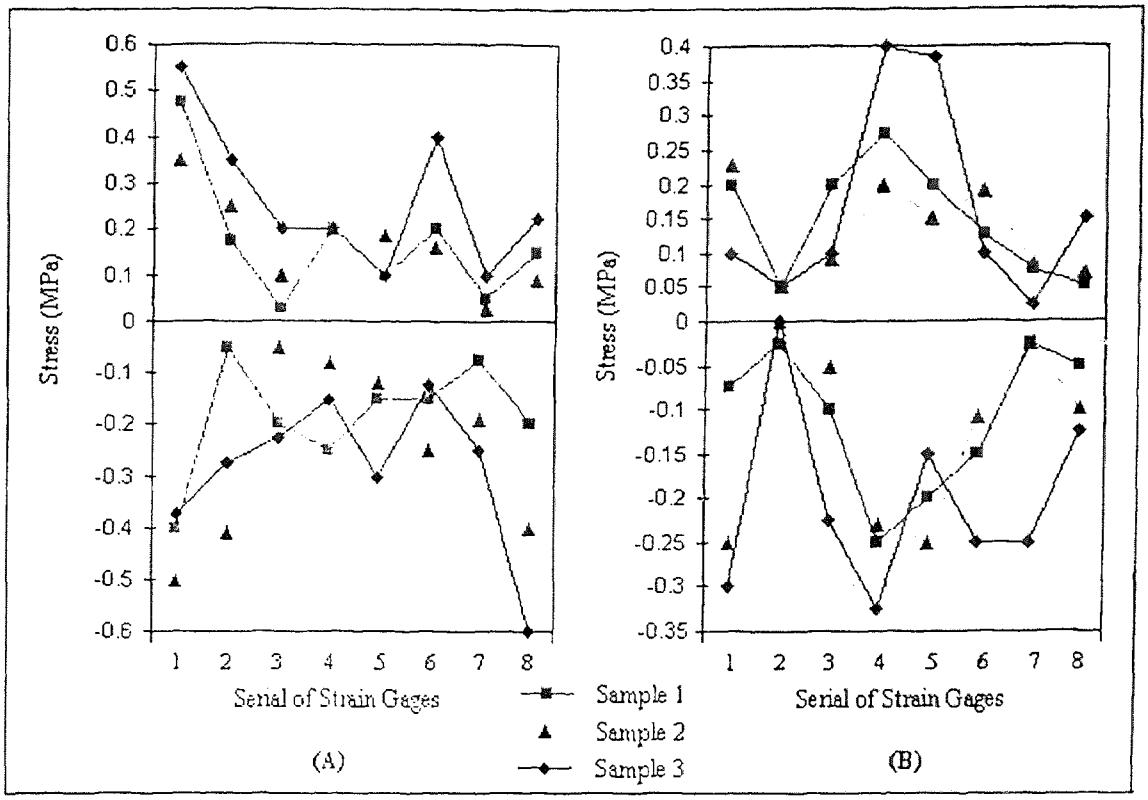


Figure. 4.22 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Varus AFO in the motion of slow forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.13 Stress Change in the Varus AFO of Three Samples During the Motion of "Fast Forward Walk"

- *Sample 1*: The maximum tensile peak stress (0.58 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.41, Fig. 4.23). The maximum compressive peak stress (-0.45 MPa) in the vertical direction occurred during the

period of heel strike and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.30 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.42, Fig. 4.23).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.34 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.41, Fig. 4.23). The maximum compressive peak stress (-0.50 MPa) in the vertical direction occurred during the period of heel strike and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of heel strike and is located at the middle of the upper heel region (G4) of the AFO (Table 4.42, Fig. 4.23).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.93 MPa) in the vertical direction occurred during the period of push off and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.40 MPa) in the horizontal direction occurred during the period of push off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.41, Fig. 4.23). The maximum compressive peak stress (-0.65 MPa) in the vertical direction occurred during the period of heel strike and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.23 MPa) in the horizontal

direction occurred during the period of heel strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.42, Fig. 4.23).

Table 4.41 Magnitude and location of the maximum tensile stress occurred in the Varus AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	0.58	Push Off	G4	0.40	Push Off
2 (162)	G1	0.34	Push Off	G4	0.30	Push Off
3 (190)	G2	0.93	Push Off	G4	0.40	Push Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.42 Magnitude and location of the maximum compressive stress occurred in the Varus AFO during the motion of Fast Forward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G1	-0.45	Heel Strike	G4	-0.30	Heel Strike
2 (162)	G1	-0.50	Heel Strike	G4	-0.20	Heel Strike
3 (190)	G8	-0.65	Heel Strike	G3	-0.23	Heel Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

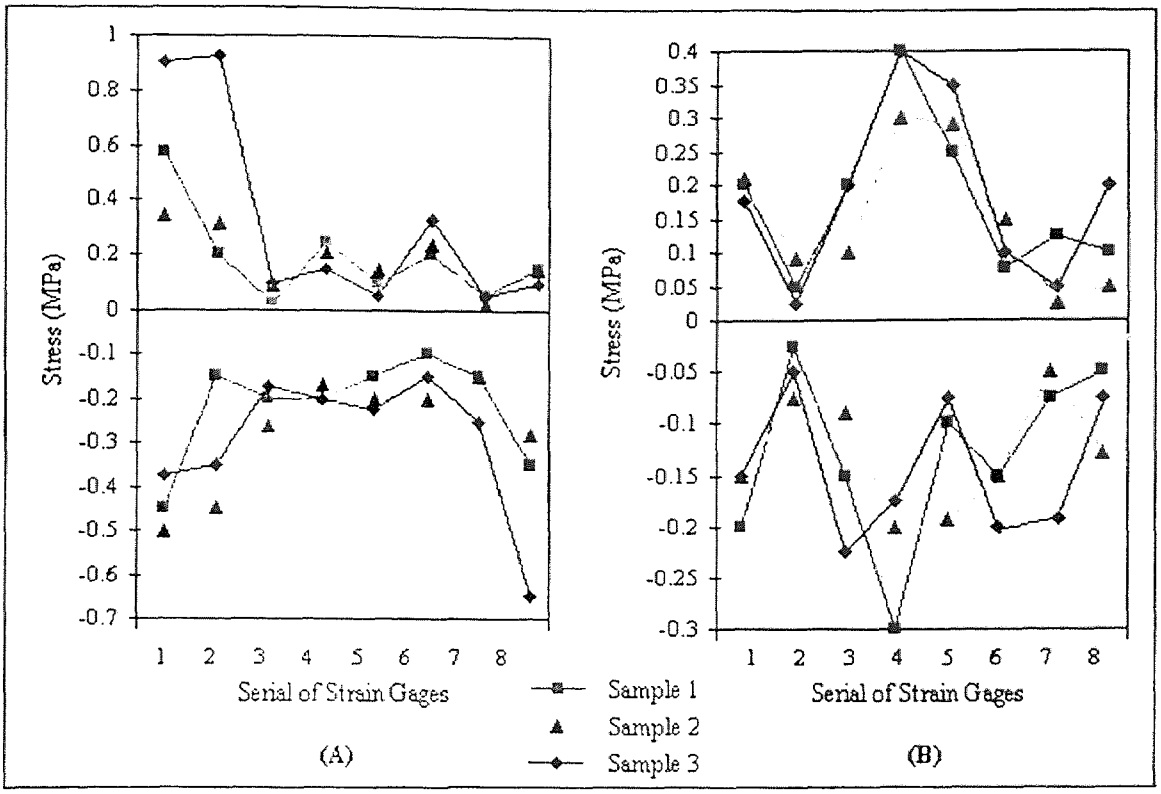


Figure. 4.23 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Varus AFO in the motion of fast forward walk. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.14 Stress Change in the Varus AFO of Three Samples During the Motion of "Backward Walk"

- *Sample 1*: The maximum tensile peak stress (0.35 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.38 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.43, Fig. 4.24). The maximum compressive peak stress (-0.95 MPa) in the vertical direction occurred during the

period of toe off and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.35 MPa) in the horizontal direction occurred during the period of toe strike and is located at the medial side of the lower neck region (G8) of the AFO (Table 4.44, Fig. 4.24).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.25 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.20 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.43, Fig. 4.24). The maximum compressive peak stress (-0.30 MPa) in the vertical direction occurred during the period of toe off and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal direction occurred during the period of toe strike and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.44, Fig. 4.24).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.45 MPa) in the vertical direction occurred during the period of toe strike and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.38 MPa) in the horizontal direction occurred during the period of toe off and is located at the middle of the upper heel region (G4) of the AFO (Table 4.43, Fig. 4.24). The maximum compressive peak stress (-0.50 MPa) in the vertical direction occurred during the period of toe off and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.25 MPa) in the horizontal

direction occurred during the period of toe strike and is located at the lateral side of the lower neck region (G3) of the AFO (Table 4.44, Fig. 4.24).

Table 4.43 Magnitude and location of the maximum tensile stress occurred in the Varus AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.35	Toe Strike	G4	0.38	Toe Off
2 (162)	G1	0.25	Toe Strike	G4	0.20	Toe Off
3 (190)	G2	0.45	Toe Strike	G4	0.38	Toe Off

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.44 Magnitude and location of the maximum compressive stress occurred in the Varus AFO during the motion of Backward Walk

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G8	-0.95	Toe Off	G8	-0.35	Toe Strike
2 (162)	G8	-0.30	Toe Off	G1	-0.25	Toe Strike
3 (190)	G8	-0.50	Toe Off	G3	-0.25	Toe Strike

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G3=Gage 3, located at the lateral side of lower neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

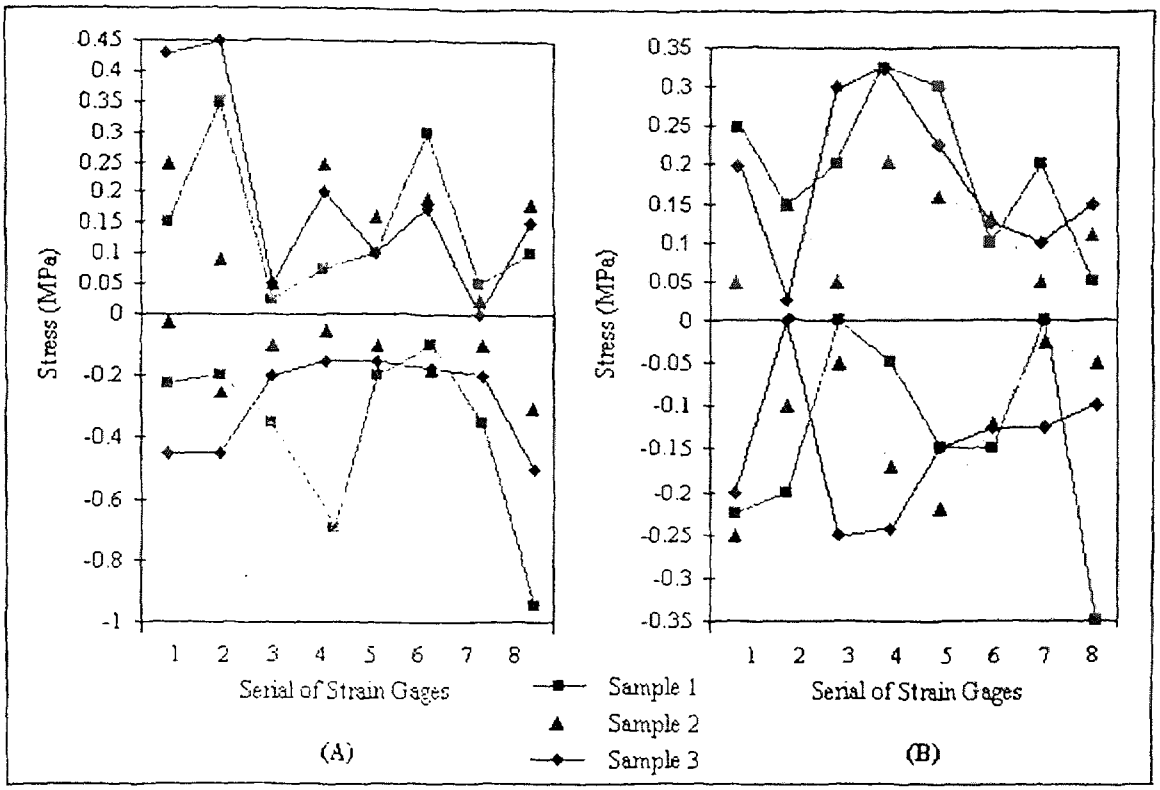


Figure. 4.24 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Varus AFO in the motion of backward. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation.
Note: The tensile and compressive stress occurred at different period of gait.

4.3.15 Stress Change in the Varus AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

- *Sample 1*: The maximum tensile peak stress (0.25 MPa) in the vertical direction occurred during the period of touch the object and is located at the lateral side of the neck region (G2) of the AFO. The maximum tensile peak stress (0.18 MPa) in the horizontal direction occurred during the period of touch the object and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.45, Fig. 4.25). The maximum compressive peak stress (-0.45 MPa) in the vertical direction occurred

during the period of before standing straight and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.14 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the medial side of the upper neck region (G6) of the AFO (Table 4.46, Fig. 4.25).

- *Sample 2*: Similar to sample 1, the maximum tensile peak stress (0.18 MPa) in the vertical direction occurred during the period of touch the object and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.10 MPa) in the horizontal direction occurred during the period of touch the object and is located at the lateral side of the upper neck region (G1) of the AFO (Table 4.45, Fig. 4.25). The maximum compressive peak stress (-0.25 MPa) in the vertical direction occurred during the period of before standing straight and is located at the lateral side of upper neck region (G1) of the AFO. The maximum compressive peak stress (-0.12 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the medial side of the upper neck region (G6) of the AFO (Table 4.46, Fig. 4.25).
- *Sample 3*: Similar to sample 1 and 2, the maximum tensile peak stress (0.40 MPa) in the vertical direction occurred during the period of touch the object and is located at the lateral side of the upper neck region (G1) of the AFO. The maximum tensile peak stress (0.35 MPa) in the horizontal direction occurred during the period of touch the object and is located at the middle of the upper heel region (G4) of the AFO (Table 4.45, Fig. 4.25). The maximum compressive peak stress (-0.53 MPa) in the vertical

direction occurred during the period of before standing straight and is located at the medial side of lower neck region (G8) of the AFO. The maximum compressive peak stress (-0.20 MPa) in the horizontal direction occurred during the period of before standing straight and is located at the medial side of the upper neck region (G6) of the AFO (Table 4.46, Fig. 4.25).

Table 4.45 Magnitude and location of the maximum tensile stress occurred in the Varus AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G2	0.25	Touch the Obj.	G1	0.18	Touch the Obj
2 (162)	G1	0.18	Touch the Obj.	G1	0.10	Touch the Obj
3 (190)	G1	0.40	Touch the Obj.	G4	0.35	Touch the Obj

Note: G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G2=Gage 2, located at the lateral side of neck region of the AFO (Figure 2.7).
G4=Gage 4, located at the middle of upper heel region of the AFO (Figure 2.7).

Table 4.46 Magnitude and location of the maximum compressive stress occurred in the Varus AFO during the motion of Lifting a 25 lb. Object

	Vertical Direction			Horizontal direction		
Samples (lb.)	Location	Max Value (MPa)	When	Location	Max Value (MPa)	When
1 (125)	G8	-0.45	BF Straight	G6	-0.14	BF Straight
2 (162)	G1	-0.25	BF Straight	G6	-0.12	BF Straight
3 (190)	G8	-0.53	BF Straight	G6	-0.20	BF Straight

Note: BF Straight = Before Standing Straight.
G1=Gage 1, located at the lateral side of upper neck region of the AFO (Figure 2.7).
G6=Gage 6, located at the medial side of upper neck region of the AFO (Figure 2.7).
G8=Gage 8, located at the medial side of lower neck region of the AFO (Figure 2.7).

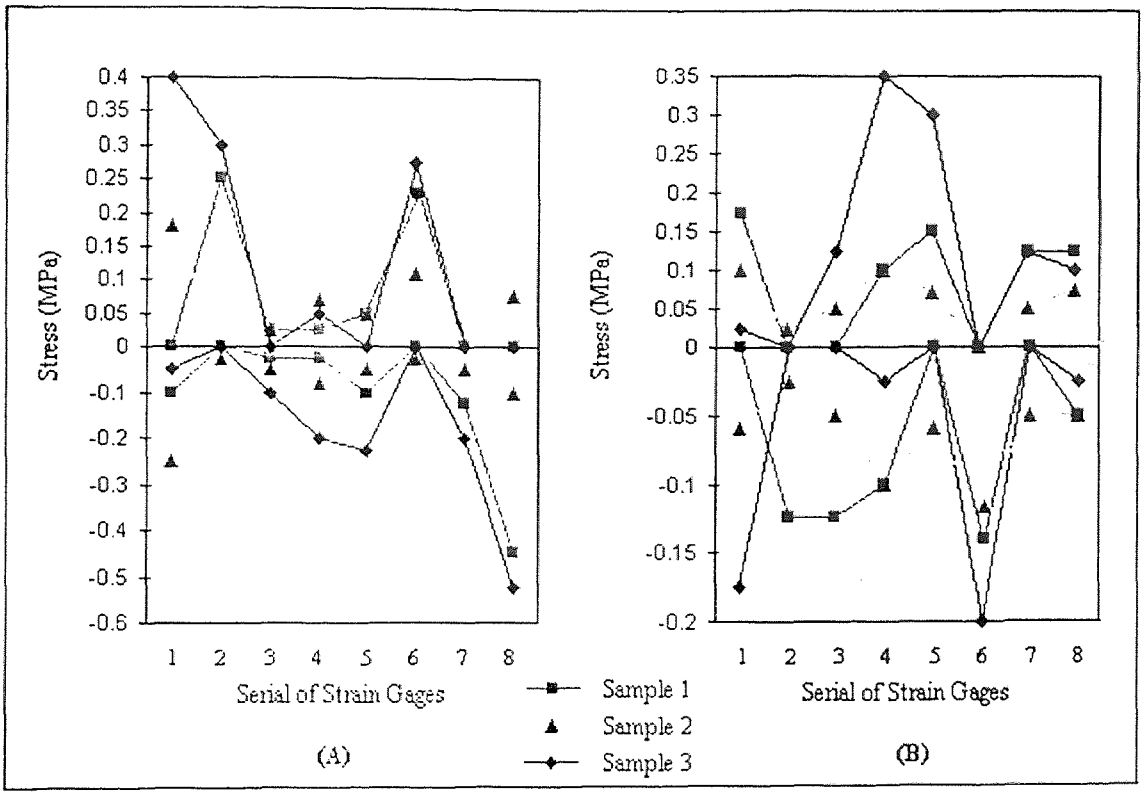


Figure. 4.25 The tensile peak stresses (positive value) and compressive peak stresses (negative value) obtained from each channel of strain gages from three samples for Varus AFO in the motion of lifting a 25 lb. object. (A) Stress due to longitudinal deformation. (B) Stress due to horizontal deformation. Note: The tensile and compressive stress occurred at different period of gait.

CHAPTER 5

DISCUSSION

Data from chapter 4 revealed that the stress changed significantly with different loads with different types of motions and different types of AFOs. These stress changes are located mainly in the region of neck and upper neck of the AFO. However, there is some stress change in the heel region. These stress changes are either in tension and/or compression and the direction measured where stress propagates are vertical and horizontal. In addition, results verified the FEA[10, 11] results and hypothesis stated earlier.

Five motions were selected as testing pattern for samples. These motions are common daily activities for people in general and specially for a patient who is in the recovery process. They are:

1. Standing Up and Sitting Down: Standing up and sitting down is the earliest and basic motion for a patient to begin to use their body after stroke. So, this is one of the most important motions which needs to be tested.
2. Slow Forward Walk: Slow forward walk usually is for a patient who is in an earlier stage of the recover process and needs a strong AFO support.
3. Fast Forward Walk: Fast forward walk usually occurs for a patient who is in the later stage of the rehabilitation recovering process with an increase in exercises activities.
4. Backward Walk: Backward walk is not as common as forward walk. However, it occurs before sitting down, while vacuuming the carpet, or cleaning the floor with a

mop. It is usually associate with slow forward walk while a patient is doing exercise for rehabilitation.

5. Lifting a 25 lb. object: Lifting an object is a common activity in daily life, especially for exercises. A patient who is in the recovering process needs to do these kinds of exercises to strengthen his/her upper extremities in order to use other assistant devices such as an arm cane.

5.1 Stress Change in AFOs with Four Samples

Four samples were tested on Moderate and Standard AFOs with each of the four motions: "Standing Up and Sitting Down", "Slow Forward Walk", "Fast Forward Walk" and "Backward Walk". The four samples were sample 1 (male, 125 lb.), sample 2 (male, 162 lb.), sample 3 (male, 192 lb.) and sample 4 (female, 100 lb.). All four samples have no abnormalities during gait.

5.1.1 Stress Change in the Moderate AFO of Four Samples During the Motion of "Standing Up and Sitting Down"

Generally, in the motion of standing up and sitting down, for Moderate AFO, the tensile and compressive stresses increased when the sample's body weight increased in both a horizontal and vertical direction (Fig. 4.3). However, the vertical direction, G1 of sample 3 shows significantly less tensile stress than sample 1 and 2 during the period of halfway of standing up/sitting down. This is because the knees of sample 3 move less far away toward lateral side than the rest of the samples during this period. The vertical direction, G3 of sample 1 and 4 show the opposite trend of compressive stress to samples 2 and 3.

The reason for this may be that there are not as much muscles in sample 1 and 4 as in sample 2 and 3 near G3, so there are less interactive forces between sample 1, 4 and the AFO than the interactive forces between sample 2, 3 and the AFO in the G3 region.

5.1.2 Stress Change in the Moderate AFO of Four Samples During the Motion of "Slow Forward Walk"

Fig. 4.4 shows the stresses change in the Moderate AFO during the motion of slow forward walk. In the vertical direction, G6 of sample 2 shows significantly larger compressive stress in the vertical direction than of the rest of the samples, especially than of sample 3 during heel strike. This is because sample 2 tends to shift the center of body weight toward the lateral side during that period. For the same reason, G4 of sample 2 shows similar phenomena in the horizontal direction. In the horizontal direction, G2 of sample 3 shows significantly larger tensile stress during the swing phase. This is due to the reason that sample 3 has a larger size foot and affects the AFO during that period. In the vertical direction, G8 of samples 2 and 4 show the decreased compressive stresses from G7 while samples 1 and 3 show the increased compressive stresses from G7 during the period of heel strike. This is because that during the period of heel strike, samples 2 and 4 complete this step more quickly than samples 1 and 3.

5.1.3 Stress Change in the Moderate AFO of Four Samples During the Motion of "Fast Forward Walk"

Fig. 4.5 shows the stresses change in the Moderate AFO during the motion of fast forward walk. In the vertical direction, G1 of sample 3 shows significantly less

compressive stress than samples 1, 2 and 4 in the identical location during the period of heel strike. This is because sample 3's foot tend to move more toward the medial side than the others during this period. On the other hand, in the horizontal direction, G8 of samples 2 and 3 shows the opposite trend of tensile stress to samples 1 and 4. This is because the same reason as in section 5.1.1 that the geometry of the feet of sample 1 and 4 near G8 are not as much muscle as that of samples 2 and 3, so there are less interactive forces between samples 1, 4 and the AFO than the interactive forces between samples 2, 3 and the AFO in the G3 region.

5.1.4 Stress Change in the Moderate AFO of Four Samples During the Motion of "Backward Walk"

Fig. 4.6 shows the stresses change in the Moderate AFO during the motion of backward walk. In the vertical direction, G1 of sample 3 shows significantly less compressive stress than of sample 1 and 2 in the identical location during the period of toe strike. This is due to the reason that sample 3 tends to shift the body weight to the lateral side in this motion instead of shifting the body weight to the medial side during the motion of forward walk. During the period of toe strike in the motion of backward walk, the body weight is concentrated on the fibular pad instead of the hallucal pad. This leads to the AFO been rotated a small angle in abduction, and shows more tensile stress and less compressive tress in the lateral side. The more the body weight acts on the AFO, the more this phenomenon is prominently exhibited. In the horizontal direction, G8 of sample 2 shows smaller compressive stresses than the rest of the sample. It indicates that sample 2 has a slow walking pace during the toe off phase.

5.1.5 Stress Change in the Standard AFO of Four Samples During the Motion of "Standing Up and Sitting Down"

Fig. 4.7 shows the stresses change in the Standard AFO during the motion of standing up and sitting down. In the vertical direction, G1, G2 and G3 of sample 2 show a significantly larger compressive stress than of sample 1, 3 and 4 in their identical locations during the period of fully standing up. This is because the knees of sample 2 move further away from the medial side than of sample 3. In the vertical direction, G1 of sample 4 shows the largest tensile stress of the four sample during the moment of fully standing up. This could be for the following reasons: (1). The speed of sample 4 was larger than the other's during the halfway of standing up/sitting down. That is, the momentum of sample 4 was larger at that time and influenced the magnitude of the stress. (2). The knees of sample 4 moved more toward the lateral side, so the area where G1 located got a larger force than that of the rest of the samples. (3). The hands of sample 4 were on her knees when sample 4 was performing the test, and enhanced the forces on the AFO. In the vertical direction, G2 of sample 3 shows a larger tensile stress than G1, while the rest of the samples show the opposite result. This is because sample 3 has an extremely large foot which affects the stress in that region of the AFO.

5.1.6 Stress Change in the Standard AFO of Four Samples During the Motion of "Slow Forward Walk"

Fig. 4.8 shows the stresses change in the Standard AFO during the motion of slow forward walk. In the vertical direction, G1 and G2 of sample 1 show significantly less tensile stress than the others, even than that of sample 4. On the other hand, G2 of sample

1 shows the largest compressive stress among the four samples. This result indicates that sample 1 tends to shift body weight more toward the medial side than others, especially samples 2 and 3. However, compared with the results of the same motion in Moderate AFO in Fig. 4.4, sample 1 does not show this phenomenon. So this is most probably due to the geometry of Standard AFO that lets sample 1 tend to shift forces toward the medial side. In the vertical direction, G7 of sample 2 shows the largest compressive stress from among the four samples. This is because of the replacement of the broken strain gage for the new strain gage and that these two strain gages are not bonded to exactly the same location of the AFO.

5.1.7 Stress Change in the Standard AFO of Four Samples During the Motion of "Fast Forward Walk"

The result of stresses change during the motion of fast forward walk with Standard AFO shows in the Fig. 4.9. Similar to the motion of slow forward walk (the speed was not fast enough to show a significant difference between these two motions) in the section above, sample 1 tends to shift the center of the body weight to the medial side. It confirmed that the geometry of Standard AFO let sample 1 tend to shift the center of body weight to the medial side. In addition, this result also confirmed that the heavier the weight (the loading), the larger the compressive stress in the AFO.

5.1.8 Stress Change in the Standard AFO of Four Samples During the Motion of "Backward Walk"

Fig. 4.10 shows the stresses change in the Standard AFO during the motion of backward walk. In the horizontal direction, the tensile stresses of G3, G4 and G5 are decreased when the sample's body weight increased. This is mainly because the size of the foot for each sample is increased. The more the size of the foot increased, the less bending of the AFO in those regions in the horizontal direction is permitted.

5.2 Determination of Stress Change in AFOs with Three Samples

Three normal subjects were tested with Flex, Solid and Varus AFOs and with five motions: "Standing Up and Sitting Down", "Slow Forward Walk", "Fast Forward Walk", "Backward Walk" and "lift a 25 lb. object". These three samples were exactly the same as sample 1 (male, 125 lb.), sample 2 (male, 162 lb.) and sample 3 (male, 192 lb.) among the four samples in the previous section. Four motions except the motion of "lift a 25 lb. object" stated above have been analyzed in the four sample group in the previous section.

5.2.1 Stress Change in the Flex AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

Fig. 4.11 shows the stresses change in the Flex AFO during the motion of standing up and sitting down. In the horizontal direction, G3 of sample 2 shows significantly larger compressive stress than sample 3 (even sample 2 has a lower weight) during the period of fully standing up. The reason for this is similar to the one in section 5.1.5 that the knees

of sample 2 move more farther away from the medial side than those of sample 3. This AFO is the most flexible one among the five AFOs. Results (tensile stress) in the vertical direction clearly indicated that the heavier the body weight, the larger stress affection on the AFO, especially for a very flexed AFO.

5.2.2 Stress Change in the Flex AFO of Three Samples During the Motion of "Slow Forward Walk"

Fig. 4.12 shows the stresses change in the Flex AFO during the motion of slow forward walk. In the horizontal direction, G1, G2 and G3 of sample 1 show significantly larger tensile stress than others. This is because the geometry of Flex AFO is fitter for sample 1 than for samples 2 and 3 on those locations, and this greatly increased the effects of stress on these locations for sample 1 than it did for sample 2 and 3.

5.2.3 Stress Change in the Flex AFO of Three Samples During the Motion of "Fast Forward Walk"

The results of stresses change during the motion of fast forward walk with Flex AFO is shown in Fig. 4.13. Similar to the results in the motion of slow forward walk in the last section. This is because the length of the cable and the walking speed were not long and high enough for the true condition to be simulated. However, G1 of sample 1 shows a larger tensile stress than those of sample 2 and 3 in the vertical direction, and G3 of sample 1 shows a significantly larger tensile stress than that of samples 2 and 3 in the horizontal direction. It verified that the geometry of Flex AFO is fitter for sample 1 than

for samples 2 and 3 on those locations, and the effects of stress on these locations for sample 1 are larger than for samples 2 and 3.

5.2.4 Stress Change in the Flex AFO of Three Samples During the Motion of "Backward Walk"

Fig. 4.14 shows the stresses change in the Flex AFO during the motion of backward forward walk. The results show a similar situation as slow forward walk and fast forward walk. Thus backward walk will not affect the stress pattern in the AFO significantly. In the horizontal direction, G4 and G5 of sample 1 show significantly larger tensile stresses than of others in the period of toe off. This is due to the reason that sample 1 has the thinner foot, thus, the AFO has more bending on G4 and G5 in the horizontal direction.

5.2.5 Stress Change in the Flex AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

Fig. 4.15 shows the stresses change in the Flex AFO during the motion of lifting a 25 lb. object. It is revealed from the experiment that the posture of this motion will significantly dominate the magnitude of the stress, especially in the lateral side and medial side of the AFO. The more the knees bend while people are picking up the object, the larger the stresses show on these two sides. The inclination of the body is another major factor that influences the tensile/compressive stress in the medial/lateral side of the AFO. The body weight influenced the magnitude of the stress mainly on the middle of the heel region of the AFO during this motion, especially in the horizontal direction. For example, G4 of sample 3 shows significantly large tensile stress in the horizontal direction. In addition,

the results showed that there were similar affects (stress change) on this AFO (Fig. 4.11, Fig. 4.15) between this motion and the motion of standing up/sitting down. However, the magnitudes of stress change were different and there were some delay phenomenon occurred (Fig. 4.11, Fig. 4.15).

5.2.6 Stress Change in the Solid AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

Fig. 4.16 shows the stresses change in the Solid AFO during the motion of standing up and sitting down. In the horizontal direction, G3 of sample 2 shows significantly larger compressive stress than sample 3 during the period of fully standing up. Again, the reason is similar to the one in section 5.1.5 that the knees of sample 2 move farther away from the medial side than those of sample 3, and G3 of sample 2 shows larger compressive stress than that of sample 3. In the vertical direction, G8 of sample 3 shows increased compressive stress from G7 other than the decreased one like in samples 1 and 2 in the period of halfway of standing up/sitting down. This is because the size of the foot of sample 3 is significantly larger near the G8 region affecting the large compressive stress.

5.2.7 Stress Change in the Solid AFO of Three Samples During the Motion of "Slow Forward Walk"

Fig. 4.17 shows the stresses change in the Solid AFO during the motion of slow forward walk. In the vertical direction, G1 of sample 3 shows a significant less compressive stress than of sample 1 and 2 during the period of push off. G1 of sample 3 also shows a significant larger tensile stress than of sample 1 and 2 in the same direction and same

period. It indicated that sample 3 tended to shift a greater center of body weight to the lateral side than others. Again, the results proved the earlier hypothesis. That is, the heavier the body weight, the larger the stresses in the AFO.

5.2.8 Stress Change in the Solid AFO of Three Samples During the Motion of "Fast Forward Walk"

The result of stresses change during the motion of fast forward walk with Solid AFO shows in Fig. 4.18. Again, results show the similar stresses pattern between these two motions (slow forward walk and fast forward walk, Fig. 4.17 and Fig.4.18). Specifically, in the vertical direction, similar to the motion of slow forward walk in the last section, G1 of sample 3 still shows significantly less compressive stress than of sample 1 and 2 during the period of push off. It verified that sample 3 tended to shift more forces toward lateral side than others.

5.2.9 Stress Change in the Solid AFO of Three Samples During the Motion of "Backward Walk"

The result of stresses change during the motion of backward walk with Solid AFO shows in Fig. 4.19. Results also show the similar stresses patterns among the three motions (slow forward walk, fast forward walk and backward walk). However, they are different in magnitude (Fig. 4.17, Fig. 4.18 and Fig. 4.19). In the horizontal direction, sample 1 shows almost the largest tensile stresses in all of the locations. This is because that sample 1 has the skinner foot and extremely loose to the Solid AFO compare with the other samples, so the AFO has more bending in the horizontal direction for sample 1 than for other samples during this motion.

5.2.10 Stress Change in the Solid AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

The result of stresses change during the motion of lifting a 25 lb. object with Solid AFO shows in Fig. 4.20. Sample 2 shows a different pattern. Specifically, in the vertical and horizontal direction, G4 of sample 2 shows a significant large compressive stress. This is because sample 2 bends more of his knee during the lifting. There are the similar stresses affection on the AFO between this motion and the motion of standing up/sitting down. That is, the more the knees bend while people is picking up the object, the larger the stresses show in the lateral and medial sides. The inclination of the body is the second fact that influence the tensile/compressive stress in the medial/lateral side of the AFO. It shows that the body weight influences the tensile stresses in the G4 in the horizontal direction significantly. This motion and the motion of standing up have a similar stress pattern but different magnitude on samples 1 and 3.

5.2.11 Stress Change in the Varus AFO of Three Samples During the Motion of "Standing Up and Sitting Down"

Fig. 4.21 shows the stresses change in the Varus AFO during the motion of standing up and sitting down. In the vertical direction, G1 of sample 3 continues to show a significant less compressive stress than of sample 1 and sample 2 during the period of halfway of standing up and sitting down. It shows that sample 3 tend to shift more center of mass to the lateral side than the others.

5.2.12 Stress Change in the Varus AFO of Three Samples During the Motion of "Slow Forward Walk"

Fig. 4.22 shows the stresses change in the Varus AFO during the motion of slow forward walk. In the vertical direction, G1 and G2 of sample 2 show significantly larger compressive stress than of sample 3 during heel strike. It is due to the reason that sample 2 shifts the center of mass farther to the medial side.

5.2.13 Stress Change in the Varus AFO of Three Samples During the Motion of "Fast Forward Walk"

Fig. 4.23 shows the stresses change in the Varus AFO during the motion of fast forward walk. Similar stress pattern with slow forward walk (Fig.4.22), in the vertical direction, G1, G2 and G3 of sample 2 show significantly larger compressive stress than of sample 3 during the period of heel strike. It is due to the same reason as in the section 5.2.12 that sample 2 shifts the center of mass to the medial side.

5.2.14 Stress Change in the Varus AFO of Three Samples During the Motion of "Backward Walk"

Fig. 4.24 shows the stresses change in the Varus AFO during the motion of backward walk. G8 of sample 1 shows significantly larger compressive stresses in both vertical and horizontal direction during the period of toe strike. This is due to the reason that the hallucal pad of sample 1 is extremely bend to more than that of the others, and the G8 in Varus AFO is located near the region of the hallucal pad of sample 1. Influenced by this extreme bending of the hallucal pad of sample 1, G6 in the vertical direction and G7 in the horizontal direction shows the largest tensile stresses among the three samples.

5.2.15 Stress Change in the Varus AFO of Three Samples During the Motion of "Lifting a 25 lb. Object"

Fig. 4.24 shows the stresses change in the Varus AFO during the motion of lifting a 25 lb. object. The phenomenon and the reason are similar to those in the section 5.2.5. In general, the stress change were not affected by the change of the body weight on the all five AFOs in the lateral/medial side rather than affected significantly by one's posture while he/she is bending his/her knees. The more bending of his/her knees, the larger the stresses show in the lateral and medial side.

Table 5.1 Mechanical and Physical Property of Polypropylene[16]

Young's Module (MPa)	Poissn's Ratio	Tensile Strengt (MPa)	Yield Strength (MPa)
1034	0.43	24.8160	18.6120

Although, the stresses determined from the experiment did not exceed the material limitation (Table 5.1). The fracture due to fatigue of these AFOs often occur with a low stress/high cyclic load. For the purpose of redesigning, the thickness and geometry of the AFOs can not simply been increased or decreased. Redesigning information needs to be calculated and analyzed before manufacturing.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Summary

The stress analysis on ankle-foot orthoses in this experiment used eight strain gages. Each strain gage has vertical and horizontal direction. They are bonded in the neck, upper neck and lower neck region of five types of AFOs, namely Flex, Moderate, Standard, Solid and Varus AFO. Experimental analysis provides result of stress distribution on these areas of AFOs. The stress change in these areas can be observed simultaneously in real-time. Overall, from the experimental analysis, we can come to the following conclusions:

Results from the experiment showed that significant stress changes were due to load change. This stress change mainly occurred at the neck and upper neck regions of AFOs, especially on the lateral side, and it shows wazzu a significant tensile stress change due to load change. On the medial side of the AFO, at the neck or lower neck regions, results show a significant compressive stress change due to load change. Moreover, during the motion of backward walk, the change of the magnitude of the compressive stress is inversely proportional to the loads (e.g. the body weight). At the upper heel region of the AFO, it shows no significant stress change. This is because of its unique arc structure which has a superior function of dispersing a concentrated forces. The experimental results show no significant stress change with a change of genders. These results are confirmed with FEA results [10, 11].

6.2 Specific Findings

Results from the experiment show a significant stress change due to load change, especially in the neck or upper neck region of AFOs. In general, for all the AFOs selected in this experiment, the stresses increased when the loads increased. However, the stress changes have their individual characteristics with different motions, the different motion in behavior of people, the differences of the foot geometry of people, etc. Specifically:

1. In the motion of standing up and sitting down: The stresses are influenced by the behavior of people. During the period of halfway standing up/sitting down, the stress, especially the tensile stress in the neck region, is increased if people have the behavior that moves their knees farther away from medial side. The stress will also increase if people have a higher speed of standing up. The momentum of people with higher speed is larger and is reflects in the larger stress.
2. In the motion of slow forward walk: The stresses are influenced by the motion behavior of people who tend to shift their center of the body weight to the lateral/medial side. Usually, the tensile stresses will increase in the lateral side with one's center of the body weight shifted to the lateral side, together with the decrease of the compressive stress.
3. In the motion of fast forward walk: Compared with the motion of slow forward walk, the magnitude of stresses are larger in the slow forward walk than in the fast forward walk. This is due to the reason that the magnitude of stresses are significantly influenced by the bending angle of the ankle joint and the bending angle of the hallucal pad (or the angle between the foot flat to the horizontal axis before push off). The

larger bending angle leads to the larger deformation or stress in AFOs. In this experimental test, those bending angles are larger in the motion of slow forward walk than that of in the motion of fast forward walk. This is because the space of the lab and the length of the cables are not big and long enough. Although the speed increased in the motion of fast forward walk, the stride length did not increase, so the bending angle of the ankle joint and hallucal pad did not increase and the stress did not increase. In another hand, according to $F=\frac{1}{2}MV^2$, the impact between AFO and ground will increase due to the walking speed increase. However, it did not play an important role since the speed is not fast enough.

4. In the motion of backward walk: There is a notable phenomenon that the tensile stresses decreased in the medial side with the sample's body weight increased during the period of toe off. This is due to the reason that in the period of toe off, the another foot is in swing phase. Thus, the body weight is concentrated on the heel region of the AFO, and leads to the AFO being rotated a small angle in abduction. So the body will incline to the lateral side to balance the body. The heavier the body weight, the more incline to the lateral side of the body and the less the tensile stress in the medial side.
5. In the motion of lifting a 25 lb. object: The more the knee bends during picking up objects, the larger the stresses show in the lateral/medial side. The body weight influences the magnitude of the stress mainly on the middle of the heel region of the AFO during this motion, especially in the horizontal direction. That is the heavier the body weight, the larger the stresses at these locations.

The geometry of the foot and the bending angle of the hallucal pad of samples will also alter the stress change for the specific AFO during the specific motion. Specifically:

1. For the Moderate AFO during the motion of standing up and sitting down, in the lateral side of lower neck region (G3), sample 1 and 4 show the opposite trend to sample 2 and 3. It indicates that during this motion, there are less interactive forces between sample 1, 4 and the AFO in the G3 region than that between sample 2,3 and the AFO in the same region. This is due to the reason that sample 1, 4 have less muscles in that region.
2. For the Flex AFO during the motion of slow forward walk, sample 1 shows the largest tensile stresses in the lateral side among the three samples. It shows that the geometry of the Flex AFO lead the sample 2 and 3 shift the center of the body weight to the medial side.
3. The range of bending angle in the hallucal pad (or the angle between the foot flat to the horizontal axis before push off) of people will alter the stress change during some motions, especially during the motion of forward walk and backward walk. Usually, the larger the bending angle the hallucal pad has, the larger the stresses show in the AFO. However, different type of AFOs will be affected differently by one's bending angle of the hallucal pad. This difference depends on the fitting condition between foot and AFOs.

6.3 Recommendation

Results from this experimental study reveal that different body weight significantly alters the stress change in the AFOs, especially in the neck or upper neck regions. However, people's motion behavior and the distinct geometry of the foot will also alter the magnitude of stress during specific motion and specific AFOs. This information is useful for the improvement of the manufacturing of AFOs.

For those people who tend to shift their body weight to the medial/lateral side, it is suggested to increase the thickness of the AFOs in the medial/lateral side by applying the thermal melting technology, or to make the center of the mass of the AFOs shift to the reverse side by modifying the geometry of the AFO. In this way, both the medial and lateral side of the AFOs have the equivalence of stresses and fatigues.

For people who have a superior bending angle in the hallucal pad, it is suggested to change the ingredients of the material of the AFO in order to increase the elasticity of the AFO.

The bonding technology of strain gages was successfully used in the experiment. However, failures of bonding between strain gages and AFOs still occurred in the experiment, especially for sample 3 whose body weight is over 190 lb. The proper selection of strain gages is needed before the experiment, especially to test those samples whose body weight is heavier than usual.

The superiority of low ratio of noise to signal of the system can detect the weak stress in the AFO in 10^{-2} MPa. However, after the strain gages broke, the new strain gages would not keep bonding at exactly (100%) of the original location of the AFO, and this

could have severely affected the test results of stress analysis under different loads due to this non-identical location of the two strain gages. In addition, the different postures of different people during the same motion will also significantly influence the test results, although this can be reduced by increasing the sample size.

Although the tested material is considered as polypropylene, the actual proportional of mixture ingredient of the material depends on the individual manufactures. Thus, the following parameters need to be investigated for design purpose:

1. The actual value of fatigue stress and yield stress for this material need to be determined.
2. Stress cycle for the recoverable fatigue life need to be determined.
3. Tensile modulus and bending modulus need to be determined. If these two parameters are not equal, the relationship of the stress and the strain will not be linear. This will present a complication in determination of stress from experiment in using strain gage technology. Possible method is to use computational analysis, for example, the Finite Element Analysis.

Further investigation of patient weight effects on other type of AFOs is needed. These quantitative data will be input to the Final Data Bank which can be used by the orthotists as reference for prescription. Effect of stress concentration due to material processing and surface finishing need to be investigated.

APPENDIX

TABLES OF MAXIMUM AND MINIMUM PEAK STRESS OF EACH CHANNEL OF EACH STRAIN GAGES OBTAINED FROM THE MEASUREMENT OF THREE/FOUR SAMPLES

Table 1 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Standing Up and Sitting Down				**Type of AFO:** Flex	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.15	0.175	0.4	0.2416667	0.137689264
MinG1Ver	-0.275	-0.255	-0.55	-0.36	0.164848415
MaxG1Hor	0.05	0.125	0.15	0.1083333	0.05204165
MinG1Hor	-0.025	-0.025	-0.05	-0.0333333	0.014433757
MaxG6Ver	0.25	0.17	0.55	0.3233333	0.200333056
MinG6Ver	-0.4	-0.44	-0.3	-0.38	0.072111026
MaxG6Hor	0	0	0.05	0.0166667	0.028867513
MinG6Hor	-0.05	-0.1	-0.1	-0.0833333	0.028867513
MaxG2Ver	0.4	0.55	1.25	0.7333333	0.453688586
MinG2Ver	-0.7	-0.55	-0.8	-0.6833333	0.125830574
MaxG2Hor	0.1	0.095	0.05	0.0816667	0.027537853
MinG2Hor	-0.05	-0.095	-0.075	-0.0733333	0.022546249
MaxG7Ver	0.14	0.285	0.2	0.2083333	0.07285831
MinG7Ver	-0.125	-0.18	-0.25	-0.185	0.06264982
MaxG7Hor	0	0.025	0.05	0.025	0.025
MinG7Hor	-0.025	-0.05	-0.05	-0.0416667	0.014433757
MaxG3Ver	0	0.64	0.175	0.2716667	0.330769305
MinG3Ver	-0.4	-0.05	-0.775	-0.4083333	0.362571832
MaxG3Hor	0.525	0	0.4	0.3083333	0.274241378
MinG3Hor	-0.025	-0.565	-0.2	-0.2633333	0.27551467
MaxG8Ver	0	0.05	0.025	0.025	0.025
MinG8Ver	-0.05	-0.05	-0.125	-0.075	0.04330127
MaxG8Hor	0.15	0.15	0.2	0.1666667	0.028867513
MinG8Hor	-0.025	-0.025	0	-0.0166667	0.014433757
MaxG5Ver	0.525	0.025	0.1	0.2166667	0.269644828
MinG5Ver	-0.025	-0.14	-0.175	-0.1133333	0.078475049
MaxG5Hor	0	0.235	0.25	0.1616667	0.140208179
MinG5Hor	-0.25	0	-0.125	-0.125	0.125
MaxG4Ver	0.3	0.125	0.1	0.175	0.108972474
MinG4Ver	0	-0.22	-0.35	-0.19	0.17691806
MaxG4Hor	0.05	0.25	0.55	0.2833333	0.251661148
MinG4Hor	-0.125	-0.05	-0.05	-0.075	0.04330127

Note: Average and Standard Deviation were obtained from sample size

Table 2 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Standing Up and Sitting Down				**Type of AFO:** Moderate		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.85	0.84	0.625	0.771666667	0.12711543	0.44
MinG1Ver	-0.1	-0.1	-0.15	-0.116666667	0.02886751	-0.05
MaxG1Hor	0.05	0.05	0.05	0.05	0	0
MinG1Hor	-0.2	-0.19	-0.125	-0.171666667	0.04072264	-0.1
MaxG6Ver	0.625	0.6	0.55	0.591666667	0.03818813	0.4
MinG6Ver	-0.125	0	-0.15	-0.091666667	0.08036376	0
MaxG6Hor	0.025	0	0.075	0.033333333	0.03818813	0
MinG6Hor	-0.275	-0.23	-0.35	-0.285	0.06062178	-0.2
MaxG2Ver	0	0	0.025	0.008333333	0.01443376	0
MinG2Ver	-0.3	-0.31	-0.2	-0.27	0.06082763	-0.2
MaxG2Hor	0.225	0.33	0.275	0.276666667	0.05251984	0.225
MinG2Hor	0	-0.05	0	-0.016666667	0.02886751	0
MaxG7Ver	0.025	0.05	0.075	0.05	0.025	0
MinG7Ver	-0.25	-0.3	-0.4	-0.316666667	0.07637626	-0.15
MaxG7Hor	0.2	0.26	0.25	0.236666667	0.0321455	0.125
MinG7Hor	0	-0.05	-0.05	-0.033333333	0.02886751	0
MaxG3Ver	0	0.05	0	0.016666667	0.02886751	0
MinG3Ver	-0.25	-0.35	-0.35	-0.316666667	0.05773503	0
MaxG3Hor	0.075	0.11	0.15	0.111666667	0.03752777	0.05
MinG3Hor	0	-0.1	-0.025	-0.041666667	0.05204165	-0.075
MaxG8Ver	0.025	0.05	0.05	0.041666667	0.01443376	0
MinG8Ver	-0.15	-0.25	-0.45	-0.283333333	0.15275252	-0.075
MaxG8Hor	0.025	0.05	0.05	0.041666667	0.01443376	0
MinG8Hor	-0.1	-0.15	-0.15	-0.133333333	0.02886751	0
MaxG5Ver	0.15	0.1	0.05	0.1	0.05	0.05
MinG5Ver	-0.05	-0.22	-0.2	-0.156666667	0.09291573	-0.01
MaxG5Hor	0.25	0.45	0.275	0.325	0.10897247	0.25
MinG5Hor	-0.1	-0.025	-0.075	-0.066666667	0.03818813	0
MaxG4Ver	0	0.05	0.15	0.066666667	0.07637626	0
MinG4Ver	-0.35	-0.3	-0.45	-0.366666667	0.07637626	-0.25
MaxG4Hor	0.55	0.55	0.45	0.516666667	0.05773503	0.27
MinG4Hor	-0.1	-0.05	-0.125	-0.091666667	0.03818813	0

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 3 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Standing Up and Sitting Down				**Type of AFO:** Solid	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.55	0.55	0.7	0.6	0.08660254
MinG1Ver	-0.1	0	-0.075	-0.0583333	0.05204165
MaxG1Hor	0.025	0.025	0.05	0.0333333	0.014433757
MinG1Hor	-0.2	-0.15	-0.175	-0.175	0.025
MaxG6Ver	0.6	0.8	1.05	0.8166667	0.225462488
MinG6Ver	-0.1	-0.1	-0.125	-0.1083333	0.014433757
MaxG6Hor	0	0.025	0.025	0.0166667	0.014433757
MinG6Hor	-0.09	-0.1	-0.15	-0.1133333	0.032145503
MaxG2Ver	0.025	0.025	0.1	0.05	0.04330127
MinG2Ver	-0.19	-0.17	-0.2	-0.1866667	0.015275252
MaxG2Hor	0.15	0.2	0.225	0.1916667	0.038188131
MinG2Hor	-0.025	0	0	-0.0083333	0.014433757
MaxG7Ver	0.125	0	0.05	0.0583333	0.062915287
MinG7Ver	-0.525	-0.93	-0.875	-0.7766667	0.219677794
MaxG7Hor	0.275	0.35	0.375	0.3333333	0.05204165
MinG7Hor	-0.025	0	-0.05	-0.025	0.025
MaxG3Ver	0.2	0.35	0.4	0.3166667	0.1040833
MinG3Ver	-0.075	-0.27	-0.3	-0.215	0.122167917
MaxG3Hor	0.1	0.15	0.15	0.1333333	0.028867513
MinG3Hor	-0.025	-0.06	0	-0.0283333	0.030138569
MaxG8Ver	0	0	0.05	0.0166667	0.028867513
MinG8Ver	-0.325	-0.61	-0.95	-0.6283333	0.312903073
MaxG8Hor	0.05	0.13	0.1	0.0933333	0.040414519
MinG8Hor	-0.05	-0.09	-0.1	-0.08	0.026457513
MaxG5Ver	0.025	0.05	0.05	0.0416667	0.014433757
MinG5Ver	-0.225	-0.33	-0.4	-0.3183333	0.088081402
MaxG5Hor	0.3	0.42	0.4	0.3733333	0.064291005
MinG5Hor	-0.025	-0.05	-0.025	-0.0333333	0.014433757
MaxG4Ver	0.025	0.09	0.075	0.0633333	0.034034296
MinG4Ver	-0.225	-0.5	-0.475	-0.4	0.152069063
MaxG4Hor	0.35	0.7	0.7	0.5833333	0.202072594
MinG4Hor	-0.025	0	-0.025	-0.0166667	0.014433757

Note: Average and Standard Deviation were obtained from sample size

Table 4 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Standing Up and Sitting Down				**Type of AFO:** Standard		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ve	0.625	0.5	0.8	0.641666667	0.15069284	0.96
MinG1Ver	-0.15	-0.7	-0.275	-0.375	0.28831406	-0.05
MaxG1Ho	0.05	0.15	0.05	0.083333333	0.05773503	0
MinG1Hor	-0.15	-0.1	-0.15	-0.13333333	0.02886751	-0.2
MaxG6Ve	0.15	0.1	0.175	0.141666667	0.03818813	0.125
MinG6Ver	0	0	-0.025	-0.00833333	0.01443376	0
MaxG6Ho	0	0.05	0	0.016666667	0.02886751	0
MinG6Hor	-0.125	-0.05	-0.1	-0.09166667	0.03818813	-0.1
MaxG2Ve	0.5	0.45	0.9	0.616666667	0.24664414	0.45
MinG2Ver	-0.125	-0.6	-0.3	-0.34166667	0.24022559	-0.05
MaxG2Ho	0.125	0.1	0.075	0.1	0.025	0.075
MinG2Hor	-0.025	-0.05	-0.025	-0.03333333	0.01443376	-0.025
MaxG7Ve	0.1	0.05	0	0.05	0.05	0.05
MinG7Ver	-0.05	-0.55	-0.05	-0.21666667	0.28867513	-0.075
MaxG7Ho	0.05	0.45	0.1	0.2	0.21794495	0.11
MinG7Hor	-0.05	-0.025	-0.075	-0.05	0.025	0
MaxG3Ve	0.15	0.05	0.1	0.1	0.05	0.025
MinG3Ver	-0.5	-0.8	-0.085	-0.46166667	0.35903807	-0.4
MaxG3Ho	0.45	0.65	0.6	0.566666667	0.1040833	0.6
MinG3Hor	-0.15	-0.06	-0.1	-0.10333333	0.0450925	-0.025
MaxG8Ve	0	0.025	0	0.008333333	0.01443376	0
MinG8Ver	-0.475	-0.15	-0.275	-0.3	0.16393596	-0.25
MaxG8Ho	0.075	0.25	0.1	0.141666667	0.09464847	0.05
MinG8Hor	-0.05	0	-0.025	-0.025	0.025	-0.05
MaxG5Ve	0	0.05	0.075	0.041666667	0.03818813	0
MinG5Ver	-0.2	-0.15	-0.2	-0.18333333	0.02886751	-0.2
MaxG5Ho	0.1	0.23	0.3	0.21	0.10148892	0.275
MinG5Hor	-0.025	-0.05	-0.075	-0.05	0.025	0
MaxG4Ve	0.1	0.35	0.025	0.158333333	0.17017148	0
MinG4Ver	-0.2	-0.1	-0.15	-0.15	0.05	-0.25
MaxG4Ho	0.275	0.05	0.2	0.175	0.11456439	0.275
MinG4Hor	-0.1	-0.15	-0.05	-0.1	0.05	0

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 5 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Standing Up and Sitting Down				**Type of AFO:** Varus	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.5	0.62	0.6	0.57333333	0.064291005
MinG1Ver	-0.25	-0.21	-0.15	-0.2033333	0.05033223
MaxG1Hor	0.1	0.1	0.05	0.08333333	0.028867513
MinG1Hor	-0.25	-0.25	-0.35	-0.2833333	0.057735027
MaxG6Ver	0.15	0.23	0.325	0.235	0.087607077
MinG6Ver	-0.1	0	-0.075	-0.0583333	0.05204165
MaxG6Hor	0.05	0	0.05	0.03333333	0.028867513
MinG6Hor	-0.1	-0.15	0	-0.0833333	0.076376262
MaxG2Ver	0.25	0.7	0.525	0.49166667	0.226844293
MinG2Ver	-0.1	-0.17	-0.1	-0.1233333	0.040414519
MaxG2Hor	0.05	0.05	0.025	0.04166667	0.014433757
MinG2Hor	-0.05	-0.025	0	-0.025	0.025
MaxG7Ver	0	0	0	0	0
MinG7Ver	-0.175	-0.25	-0.275	-0.2333333	0.05204165
MaxG7Hor	0.1	0.1	0.15	0.11666667	0.028867513
MinG7Hor	0	0	-0.025	-0.0083333	0.014433757
MaxG3Ver	0.025	0.025	0.025	0.025	0
MinG3Ver	-0.075	-0.25	-0.4	-0.2416667	0.162660177
MaxG3Hor	0.125	0.19	0.3	0.205	0.08845903
MinG3Hor	0	-0.025	-0.025	-0.0166667	0.014433757
MaxG8Ver	0	0	0.025	0.00833333	0.014433757
MinG8Ver	-0.425	-0.57	-0.85	-0.615	0.216043977
MaxG8Hor	0.05	0.14	0.25	0.14666667	0.100166528
MinG8Hor	0	0	0	0	0
MaxG5Ver	0.075	0	0.025	0.03333333	0.038188131
MinG5Ver	-0.125	-0.25	-0.25	-0.2083333	0.072168784
MaxG5Hor	0.15	0.3	0.35	0.26666667	0.1040833
MinG5Hor	-0.1	0	-0.05	-0.05	0.05
MaxG4Ver	0.075	0.05	0.075	0.06666667	0.014433757
MinG4Ver	-0.15	-0.1	-0.2	-0.15	0.05
MaxG4Hor	0.45	0.25	0.55	0.41666667	0.152752523
MinG4Hor	-0.15	0	-0.1	-0.0833333	0.076376262

Note: Average and Standard Deviation were obtained from sample size

Table 6 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Slow Walk Forward				**Type of AFO:** Flex	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.375	0.18	0.45	0.335	0.139373599
MinG1Ver	-0.475	-0.4	-0.45	-0.4416667	0.038188131
MaxG1Hor	0.175	0.09	0.125	0.13	0.042720019
MinG1Hor	-0.09	-0.05	-0.05	-0.0633333	0.023094011
MaxG6Ver	0.6	0.55	0.55	0.56666667	0.028867513
MinG6Ver	-0.4	-0.15	-0.475	-0.3416667	0.170171482
MaxG6Hor	0.175	0.15	0.175	0.16666667	0.014433757
MinG6Hor	-0.075	-0.15	-0.15	-0.125	0.04330127
MaxG2Ver	0.925	0.9	1.2	1.00833333	0.166458203
MinG2Ver	-1.1	-0.9	-1.15	-1.05	0.132287566
MaxG2Hor	0.175	0.14	0.1	0.13833333	0.037527767
MinG2Hor	-0.15	-0.15	-0.225	-0.175	0.04330127
MaxG7Ver	0.175	0.19	0.125	0.16333333	0.034034296
MinG7Ver	-0.25	-0.2	-0.225	-0.225	0.025
MaxG7Hor	0.075	0.08	0.05	0.06833333	0.016072751
MinG7Hor	-0.05	-0.05	-0.1	-0.0666667	0.028867513
MaxG3Ver	0.125	0.45	0.525	0.36666667	0.212622514
MinG3Ver	-0.425	-0.11	-0.775	-0.4366667	0.332653473
MaxG3Hor	0.35	0.05	0.275	0.225	0.15612495
MinG3Hor	-0.5	-0.375	-0.45	-0.4416667	0.062915287
MaxG8Ver	0	0.05	0.05	0.03333333	0.028867513
MinG8Ver	-0.1	-0.15	-0.125	-0.125	0.025
MaxG8Hor	0.1	0.125	0.075	0.1	0.025
MinG8Hor	-0.125	-0.1	-0.3	-0.175	0.108972474
MaxG5Ver	0.2	0.18	0.225	0.20166667	0.022546249
MinG5Ver	-0.1	-0.1	-0.15	-0.1166667	0.028867513
MaxG5Hor	0.15	0.125	0.2	0.15833333	0.038188131
MinG5Hor	-0.25	-0.25	-0.225	-0.2416667	0.014433757
MaxG4Ver	0.3	0.2	0.25	0.25	0.05
MinG4Ver	-0.075	-0.25	-0.35	-0.225	0.139194109
MaxG4Hor	0.15	0.25	0.45	0.28333333	0.152752523
MinG4Hor	-0.3	-0.125	-0.25	-0.225	0.090138782

Note: Average and Standard Deviation were obtained from sample size

Table 7 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Slow Walk Forward				**Type of AFO:** Moderate		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.55	0.5	0.85	0.633333333	0.18929694	0.4
MinG1Ver	-0.55	-0.55	-0.45	-0.516666667	0.05773503	-0.4
MaxG1Hor	0.2	0.2	0.1	0.166666667	0.05773503	0.05
MinG1Hor	-0.15	-0.15	-0.2	-0.166666667	0.02886751	-0.15
MaxG6Ver	0.45	0.56	0.83	0.613333333	0.19553346	0.4
MinG6Ver	-0.475	-0.8	-0.6	-0.625	0.16393596	-0.375
MaxG6Hor	0.3	0.4	0.2	0.3	0.1	0.1
MinG6Hor	-0.2	-0.25	-0.3	-0.25	0.05	-0.15
MaxG2Ver	0.1	0.11	0.15	0.12	0.02645751	0.05
MinG2Ver	-0.25	-0.19	-0.3	-0.246666667	0.05507571	-0.2
MaxG2Hor	0.075	0.1	0.3	0.158333333	0.12332207	0.05
MinG2Hor	-0.075	-0.1	-0.15	-0.108333333	0.03818813	-0.05
MaxG7Ver	0.1	0.15	0.175	0.141666667	0.03818813	0.05
MinG7Ver	-0.25	-0.35	-0.3	-0.3	0.05	-0.3
MaxG7Hor	0.175	0.16	0.15	0.161666667	0.01258306	0.05
MinG7Hor	-0.15	-0.2	-0.2	-0.183333333	0.02886751	-0.1
MaxG3Ver	0.25	0.26	0.3	0.27	0.02645751	0.175
MinG3Ver	-0.2	-0.24	-0.05	-0.163333333	0.10016653	-0.05
MaxG3Hor	0	0.05	0.1	0.05	0.05	0.075
MinG3Hor	-0.225	-0.12	-0.275	-0.206666667	0.07910963	-0.1
MaxG8Ver	0.1	0.19	0.25	0.18	0.07549834	0.05
MinG8Ver	-0.125	-0.1	-0.3	-0.175	0.10897247	-0.1
MaxG8Hor	0.1	0.19	0.15	0.146666667	0.0450925	0.05
MinG8Hor	-0.325	-0.1	-0.3	-0.241666667	0.12332207	-0.05
MaxG5Ver	0.35	0.3	0.125	0.258333333	0.11814539	0.05
MinG5Ver	-0.225	-0.2	-0.375	-0.266666667	0.09464847	-0.265
MaxG5Hor	0.4	0.31	0.4	0.37	0.05196152	0.3
MinG5Hor	-0.225	-0.18	-0.175	-0.193333333	0.02753785	-0.05
MaxG4Ver	0.475	0.4	0.3	0.391666667	0.08779711	0.1
MinG4Ver	-0.325	-0.39	-0.5	-0.405	0.08845903	-0.45
MaxG4Hor	0.35	0.39	0.85	0.53	0.27784888	0.32
MinG4Hor	-0.325	-0.4	-0.35	-0.358333333	0.03818813	-0.175

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 8 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Slow Walk Forward				**Type of AFO:** Solid	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.35	0.33	0.85	0.51	0.294618397
MinG1Ver	-0.35	-0.4	-0.15	-0.3	0.132287566
MaxG1Hor	0.125	0.15	0.025	0.1	0.066143783
MinG1Hor	-0.1	-0.1	-0.2	-0.1333333	0.057735027
MaxG6Ver	0.35	0.38	0.75	0.49333333	0.222785397
MinG6Ver	-0.65	-0.49	-0.5	-0.5466667	0.089628864
MaxG6Hor	0.2	0.1	0.1	0.13333333	0.057735027
MinG6Hor	-0.05	-0.05	-0.15	-0.0833333	0.057735027
MaxG2Ver	0.05	0.09	0.075	0.07166667	0.020207259
MinG2Ver	-0.15	-0.11	-0.2	-0.1533333	0.045092498
MaxG2Hor	0.1	0.1	0.15	0.11666667	0.028867513
MinG2Hor	-0.025	-0.05	-0.025	-0.0333333	0.014433757
MaxG7Ver	0.35	0.35	0.4	0.36666667	0.028867513
MinG7Ver	-0.7	-0.6	-0.95	-0.75	0.180277564
MaxG7Hor	0.175	0.1	0.325	0.2	0.114564392
MinG7Hor	-0.15	-0.11	-0.2	-0.1533333	0.045092498
MaxG3Ver	0.225	0.2	0.25	0.225	0.025
MinG3Ver	-0.2	-0.2	-0.5	-0.3	0.173205081
MaxG3Hor	0.05	0.09	0.2	0.11333333	0.077674535
MinG3Hor	-0.15	-0.15	-0.25	-0.1833333	0.057735027
MaxG8Ver	0.05	0.11	0.175	0.11166667	0.062516664
MinG8Ver	-0.125	-0.34	-0.4	-0.2883333	0.144597142
MaxG8Hor	0.075	0.06	0.125	0.08666667	0.034034296
MinG8Hor	-0.1	-0.11	-0.2	-0.1366667	0.055075705
MaxG5Ver	0.2	0.17	0.175	0.18166667	0.016072751
MinG5Ver	-0.15	-0.1	-0.325	-0.1916667	0.118145391
MaxG5Hor	0.15	0.1	0.35	0.2	0.132287566
MinG5Hor	-0.15	-0.1	-0.15	-0.1333333	0.028867513
MaxG4Ver	0.275	0.39	0.25	0.305	0.074665923
MinG4Ver	-0.25	-0.14	-0.4	-0.2633333	0.130511813
MaxG4Hor	0.225	0.21	0.4	0.27833333	0.105633013
MinG4Hor	-0.175	-0.25	-0.225	-0.2166667	0.038188131

Note: Average and Standard Deviation were obtained from sample size

Table 9 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Slow Walk Forward				**Type of AFO:** Standard		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.3	0.55	1.3	0.716666667	0.5204165	0.575
MinG1Ver	-0.7	-0.6	-0.55	-0.616666667	0.07637626	-0.425
MaxG1Hor	0.175	0.13	0.125	0.143333333	0.02753785	0.2
MinG1Hor	-0.075	-0.25	-0.3	-0.208333333	0.11814539	-0.125
MaxG6Ver	0.025	0.12	0.25	0.131666667	0.11295279	0.075
MinG6Ver	-0.425	-0.25	-0.2	-0.291666667	0.11814539	-0.5
MaxG6Hor	0.15	0.16	0.15	0.153333333	0.0057735	0.05
MinG6Hor	-0.025	-0.1	-0.1	-0.075	0.04330127	-0.05
MaxG2Ver	0.35	0.83	1.55	0.91	0.60398675	0.65
MinG2Ver	-0.725	-0.49	-0.625	-0.613333333	0.1179336	-0.475
MaxG2Hor	0.025	0.15	0.075	0.083333333	0.06291529	0.05
MinG2Hor	-0.025	-0.5	-0.5	-0.341666667	0.27424138	-0.05
MaxG7Ver	0.05	0.26	0.1	0.136666667	0.10969655	0.05
MinG7Ver	-0.15	-0.55	-0.1	-0.266666667	0.24664414	-0.05
MaxG7Hor	0.15	0.4	0.225	0.258333333	0.12829004	0.1
MinG7Hor	-0.025	-0.35	-0.1	-0.158333333	0.17017148	-0.15
MaxG3Ver	0.2	0.29	0.35	0.28	0.07549834	0.25
MinG3Ver	-0.35	-0.425	-1.5	-0.758333333	0.64339594	-0.425
MaxG3Hor	0.25	0.39	0.75	0.463333333	0.25794056	0.25
MinG3Hor	-0.3	-0.3	-0.3	-0.3	5.2684E-09	-0.29
MaxG8Ver	0.025	0.3	0.1	0.141666667	0.14215602	0.125
MinG8Ver	-0.15	-0.22	-0.275	-0.215	0.06264982	-0.15
MaxG8Hor	0.15	0.22	0.175	0.181666667	0.03547299	0.1
MinG8Hor	-0.025	-0.25	-0.1	-0.125	0.11456439	0
MaxG5Ver	0.15	0.19	0.15	0.163333333	0.02309401	0.075
MinG5Ver	-0.1	-0.15	-0.2	-0.15	0.05	-0.09
MaxG5Hor	0.15	0.19	0.3	0.213333333	0.07767453	0.15
MinG5Hor	-0.2	-0.25	-0.15	-0.2	0.05	-0.15
MaxG4Ver	0.25	0.31	0.15	0.236666667	0.08082904	0.1
MinG4Ver	-0.125	-0.21	-0.35	-0.228333333	0.11361485	-0.125
MaxG4Hor	0.125	0.31	0.45	0.295	0.1630184	0.15
MinG4Hor	-0.25	-0.35	-0.175	-0.258333333	0.08779711	-0.15

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 10 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Slow Walk Forward				**Type of AFO:** Varus	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.475	0.35	0.55	0.4583333	0.101036297
MinG1Ver	-0.4	-0.5	-0.375	-0.425	0.066143783
MaxG1Hor	0.2	0.23	0.1	0.1766667	0.068068593
MinG1Hor	-0.075	-0.25	-0.3	-0.2083333	0.118145391
MaxG6Ver	0.2	0.16	0.4	0.2533333	0.12858201
MinG6Ver	-0.15	-0.25	-0.125	-0.175	0.066143783
MaxG6Hor	0.125	0.19	0.1	0.1383333	0.046457866
MinG6Hor	-0.15	-0.11	-0.25	-0.17	0.072111026
MaxG2Ver	0.175	0.25	0.35	0.2583333	0.087797115
MinG2Ver	-0.05	-0.41	-0.275	-0.245	0.181865335
MaxG2Hor	0.05	0.05	0.05	0.05	0
MinG2Hor	-0.025	0	0	-0.0083333	0.014433757
MaxG7Ver	0.05	0.025	0.1	0.0583333	0.038188131
MinG7Ver	-0.075	-0.19	-0.25	-0.1716667	0.08892881
MaxG7Hor	0.075	0.08	0.025	0.06	0.030413813
MinG7Hor	-0.025	-0.025	-0.25	-0.1	0.129903811
MaxG3Ver	0.025	0.1	0.2	0.1083333	0.087797115
MinG3Ver	-0.2	-0.05	-0.225	-0.1583333	0.094648472
MaxG3Hor	0.2	0.09	0.1	0.13	0.060827625
MinG3Hor	-0.1	-0.05	-0.225	-0.125	0.090138782
MaxG8Ver	0.15	0.09	0.225	0.155	0.067638746
MinG8Ver	-0.2	-0.4	-0.6	-0.4	0.2
MaxG8Hor	0.05	0.07	0.15	0.09	0.052915026
MinG8Hor	-0.05	-0.1	-0.125	-0.0916667	0.038188131
MaxG5Ver	0.1	0.19	0.1	0.13	0.051961524
MinG5Ver	-0.15	-0.12	-0.3	-0.19	0.096436508
MaxG5Hor	0.2	0.15	0.4	0.25	0.132287566
MinG5Hor	-0.2	-0.25	-0.15	-0.2	0.05
MaxG4Ver	0.2	0.2	0.2	0.2	0
MinG4Ver	-0.25	-0.08	-0.15	-0.16	0.085440037
MaxG4Hor	0.275	0.2	0.4	0.2916667	0.101036297
MinG4Hor	-0.25	-0.23	-0.325	-0.2683333	0.050083264

Note: Average and Standard Deviation were obtained from sample size

Table 11 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Fast Walk Forward				**Type of AFO:** Flex	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.425	0.25	0.325	0.33333333	0.087797115
MinG1Ver	-0.4	-0.23	-0.575	-0.4016667	0.172506039
MaxG1Hor	0.1	0.15	0.15	0.13333333	0.028867513
MinG1Hor	-0.1	-0.025	-0.05	-0.0583333	0.038188131
MaxG6Ver	0.5	0.45	0.425	0.45833333	0.038188131
MinG6Ver	-0.45	-0.225	-0.625	-0.4333333	0.200520157
MaxG6Hor	0.225	0.21	0.175	0.20333333	0.025658007
MinG6Hor	-0.05	-0.1	-0.15	-0.1	0.05
MaxG2Ver	0.775	0.85	0.95	0.85833333	0.087797115
MinG2Ver	-0.775	-0.7	-1.35	-0.9416667	0.355609805
MaxG2Hor	0.1	0.1	0.1	0.1	0
MinG2Hor	-0.1	-0.14	-0.2	-0.1466667	0.05033223
MaxG7Ver	0.1	0.2	0.175	0.15833333	0.05204165
MinG7Ver	-0.05	-0.2	-0.275	-0.175	0.114564392
MaxG7Hor	0.05	0.08	0.125	0.085	0.037749172
MinG7Hor	-0.05	-0.05	-0.075	-0.0583333	0.014433757
MaxG3Ver	0.1	0.35	0.55	0.33333333	0.225462488
MinG3Ver	-0.3	-0.29	-0.7	-0.43	0.233880311
MaxG3Hor	0.375	0.05	0.225	0.21666667	0.162660177
MinG3Hor	-0.3	-0.45	-0.5	-0.4166667	0.1040833
MaxG8Ver	0.05	0.05	0.05	0.05	0
MinG8Ver	-0.05	-0.15	-0.1	-0.1	0.05
MaxG8Hor	0.05	0.11	0.1	0.08666667	0.032145503
MinG8Hor	-0.2	-0.1	-0.5	-0.2666667	0.2081666
MaxG5Ver	0.19	0.13	0.2	0.17333333	0.037859389
MinG5Ver	-0.175	-0.1	-0.2	-0.1583333	0.05204165
MaxG5Hor	0.15	0.11	0.25	0.17	0.072111026
MinG5Hor	-0.25	-0.2	-0.25	-0.2333333	0.028867513
MaxG4Ver	0.275	0.39	0.325	0.33	0.057662813
MinG4Ver	-0.15	-0.13	-0.3	-0.1933333	0.092915732
MaxG4Hor	0.3	0.19	0.45	0.31333333	0.130511813
MinG4Hor	-0.175	-0.25	-0.325	-0.25	0.075

Note: Average and Standard Deviation were obtained from sample size

Table 12 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Fast Walk Forward				**Type of AFO:** Moderate		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.6	0.57	0.8	0.656666667	0.12503333	0.65
MinG1Ver	-0.55	-0.61	-0.475	-0.545	0.06763875	-0.29
MaxG1Hor	0.1	0.19	0.125	0.138333333	0.04645787	0.1
MinG1Hor	-0.175	-0.15	-0.175	-0.16666667	0.01443376	-0.15
MaxG6Ver	0.6	0.69	0.85	0.713333333	0.1266228	0.61
MinG6Ver	-0.6	-0.6	-0.4	-0.53333333	0.11547005	-0.525
MaxG6Hor	0.3	0.3	0.125	0.241666667	0.1010363	0.2
MinG6Hor	-0.3	-0.3	-0.35	-0.31666667	0.02886751	-0.225
MaxG2Ver	0.1	0.55	0.175	0.275	0.24109127	0.05
MinG2Ver	-0.2	-0.45	-0.45	-0.36666667	0.14433757	-0.2
MaxG2Hor	0.1	0.05	0.175	0.108333333	0.06291529	0.1
MinG2Hor	-0.1	-0.05	-0.125	-0.09166667	0.03818813	0
MaxG7Ver	0.175	0.19	0.175	0.18	0.00866025	0.2
MinG7Ver	-0.275	-0.28	-0.4	-0.31833333	0.07076958	-0.375
MaxG7Hor	0.15	0.1	0.25	0.166666667	0.07637626	0.2
MinG7Hor	-0.175	-0.2	-0.175	-0.18333333	0.01443376	-0.125
MaxG3Ver	0.15	0.26	0.35	0.253333333	0.10016653	0.2
MinG3Ver	-0.225	-0.21	-0.1	-0.17833333	0.06825198	-0.05
MaxG3Hor	0.025	0.09	0.1	0.071666667	0.04072264	0.075
MinG3Hor	-0.15	-0.16	-0.58	-0.29666667	0.2454248	-0.075
MaxG8Ver	0.15	0.18	0.175	0.168333333	0.01607275	0.1
MinG8Ver	-0.15	-0.15	-0.3	-0.2	0.08660254	-0.15
MaxG8Hor	0.1	0.15	0.475	0.241666667	0.2036132	0
MinG8Hor	-0.4	-0.15	-0.225	-0.25833333	0.12829004	0
MaxG5Ver	0.35	0.33	0.2	0.293333333	0.08144528	0.1
MinG5Ver	-0.2	-0.25	-0.35	-0.26666667	0.07637626	-0.24
MaxG5Hor	0.375	0.3	0.4	0.358333333	0.05204165	0.25
MinG5Hor	-0.175	-0.23	-0.2	-0.20166667	0.02753785	-0.15
MaxG4Ver	0.6	0.55	0.2	0.45	0.21794495	0.225
MinG4Ver	-0.4	-0.45	-0.6	-0.48333333	0.1040833	-0.425
MaxG4Hor	0.4	0.5	0.725	0.541666667	0.1664582	0.45
MinG4Hor	-0.4	-0.31	-0.3	-0.33666667	0.05507571	-0.325

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 13 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Fast Walk Forward				**Type of AFO:** Solid	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.4	0.55	0.575	0.50833333	0.094648472
MinG1Ver	-0.425	-0.39	-0.25	-0.355	0.092601296
MaxG1Hor	0.15	0.1	0.075	0.10833333	0.038188131
MinG1Hor	-0.125	-0.12	-0.175	-0.14	0.030413813
MaxG6Ver	0.5	0.55	1.2	0.75	0.390512484
MinG6Ver	-0.575	-0.36	-0.325	-0.42	0.135369864
MaxG6Hor	0.125	0.09	0.075	0.09666667	0.025658007
MinG6Hor	-0.075	-0.08	-0.2	-0.1183333	0.070769579
MaxG2Ver	0.05	0.12	0.175	0.115	0.06264982
MinG2Ver	-0.125	-0.1	-0.3	-0.175	0.108972474
MaxG2Hor	0.125	0.15	0.275	0.18333333	0.080363756
MinG2Hor	-0.05	-0.05	-0.05	-0.05	0
MaxG7Ver	0.275	0.35	0.2	0.275	0.075
MinG7Ver	-0.55	-0.48	-0.85	-0.6266667	0.19655364
MaxG7Hor	0.25	0.35	0.45	0.35	0.1
MinG7Hor	-0.075	-0.1	-0.1	-0.0916667	0.014433757
MaxG3Ver	0.275	0.55	0.7	0.50833333	0.215541953
MinG3Ver	-0.225	-0.35	-0.225	-0.2666667	0.072168784
MaxG3Hor	0.05	0.14	0.15	0.11333333	0.055075705
MinG3Hor	-0.075	-0.14	-0.4	-0.205	0.171973835
MaxG8Ver	0.075	0.1	0.15	0.10833333	0.038188131
MinG8Ver	-0.15	-0.39	-0.75	-0.43	0.301993377
MaxG8Hor	0.05	0.05	0.15	0.08333333	0.057735027
MinG8Hor	-0.05	-0.1	-0.225	-0.125	0.090138782
MaxG5Ver	0.175	0.15	0.1	0.14166667	0.038188131
MinG5Ver	-0.25	-0.22	-0.475	-0.315	0.139373599
MaxG5Hor	0.25	0.24	0.55	0.34666667	0.176162803
MinG5Hor	-0.1	-0.1	-0.05	-0.0833333	0.028867513
MaxG4Ver	0.25	0.1	0.525	0.29166667	0.215541953
MinG4Ver	-0.325	-0.1	-0.525	-0.3166667	0.212622514
MaxG4Hor	0.325	0.4	0.625	0.45	0.15612495
MinG4Hor	-0.15	-0.1	-0.2	-0.15	0.05

Note: Average and Standard Deviation were obtained from sample size

Table 14 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Fast Walk Forward				**Type of AFO:** Standard		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.55	0.7	1.4	0.88333333	0.45368859	0.775
MinG1Ver	-0.7	-0.75	-0.55	-0.6666667	0.1040833	-0.45
MaxG1Hor	0.2	0.19	0.1	0.16333333	0.05507571	0.075
MinG1Hor	-0.125	-0.15	-0.2	-0.1583333	0.03818813	-0.15
MaxG6Ver	0.075	0.19	0.4	0.22166667	0.16479786	0.11
MinG6Ver	-0.3	-0.2	-0.05	-0.1833333	0.12583057	-0.075
MaxG6Hor	0.15	0.14	0.025	0.105	0.06946222	0.05
MinG6Hor	-0.05	-0.1	-0.125	-0.0916667	0.03818813	-0.06
MaxG2Ver	0.55	0.6	1.15	0.76666667	0.33291641	0.9
MinG2Ver	-0.75	-0.65	-0.6	-0.6666667	0.07637626	-0.45
MaxG2Hor	0	0.05	0.075	0.04166667	0.03818813	0.05
MinG2Hor	-0.05	-0.05	-0.1	-0.0666667	0.02886751	-0.05
MaxG7Ver	0.325	0.15	0.1	0.19166667	0.11814539	0.075
MinG7Ver	-0.475	-0.5	-0.05	-0.3416667	0.25289985	0
MaxG7Hor	0.375	0.45	0.275	0.36666667	0.08779711	0.125
MinG7Hor	-0.3	-0.2	-0.025	-0.175	0.13919411	-0.125
MaxG3Ver	0.325	0.2	0.45	0.325	0.125	0.2
MinG3Ver	-0.45	-0.5	-1.175	-0.7083333	0.40491769	-0.64
MaxG3Hor	0.425	0.46	0.6	0.495	0.0926013	0.4
MinG3Hor	-0.275	-0.3	-0.3	-0.2916667	0.01443376	-0.225
MaxG8Ver	0.25	0.3	0.05	0.2	0.13228757	0.075
MinG8Ver	-0.2	-0.3	-0.3	-0.2666667	0.05773503	-0.125
MaxG8Hor	0.25	0.35	0.2	0.26666667	0.07637626	0.2
MinG8Hor	-0.275	-0.2	-0.125	-0.2	0.075	-0.2
MaxG5Ver	0.2	0.15	0.05	0.13333333	0.07637626	0.05
MinG5Ver	-0.1	-0.15	-0.175	-0.1416667	0.03818813	-0.15
MaxG5Hor	0.15	0.2	0.25	0.2	0.05	0.2
MinG5Hor	-0.3	-0.2	-0.075	-0.1916667	0.11273124	-0.05
MaxG4Ver	0.2	0.3	0.1	0.2	0.1	0.1
MinG4Ver	-0.2	-0.25	-0.3	-0.25	0.05	-0.2
MaxG4Hor	0.25	0.3	0.3	0.28333333	0.02886751	0.225
MinG4Hor	-0.3	-0.35	-0.125	-0.2583333	0.11814539	-0.125

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 15 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Fast Walk Forward				**Type of AFO:** Varus	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.575	0.34	0.9	0.605	0.281202774
MinG1Ver	-0.45	-0.5	-0.375	-0.4416667	0.062915287
MaxG1Hor	0.2	0.21	0.175	0.195	0.018027756
MinG1Hor	-0.2	-0.15	-0.15	-0.1666667	0.028867513
MaxG6Ver	0.2	0.24	0.325	0.255	0.063835727
MinG6Ver	-0.1	-0.2	-0.15	-0.15	0.05
MaxG6Hor	0.075	0.15	0.1	0.10833333	0.038188131
MinG6Hor	-0.15	-0.15	-0.2	-0.1666667	0.028867513
MaxG2Ver	0.2	0.31	0.925	0.47833333	0.390715156
MinG2Ver	-0.15	-0.45	-0.35	-0.3166667	0.152752523
MaxG2Hor	0.05	0.09	0.025	0.055	0.032787193
MinG2Hor	-0.025	-0.075	-0.05	-0.05	0.025
MaxG7Ver	0.05	0.025	0.05	0.04166667	0.014433757
MinG7Ver	-0.15	-0.15	-0.25	-0.1833333	0.057735027
MaxG7Hor	0.125	0.025	0.05	0.06666667	0.05204165
MinG7Hor	-0.075	-0.05	-0.3	-0.1416667	0.137689264
MaxG3Ver	0.025	0.09	0.1	0.07166667	0.040722639
MinG3Ver	-0.2	-0.26	-0.175	-0.2116667	0.043684475
MaxG3Hor	0.2	0.1	0.2	0.16666667	0.057735027
MinG3Hor	-0.15	-0.09	-0.225	-0.155	0.067638746
MaxG8Ver	0.15	0.15	0.1	0.13333333	0.028867513
MinG8Ver	-0.35	-0.28	-0.65	-0.4266667	0.19655364
MaxG8Hor	0.1	0.05	0.2	0.11666667	0.076376262
MinG8Hor	-0.05	-0.13	-0.075	-0.085	0.040926764
MaxG5Ver	0.1	0.15	0.05	0.1	0.05
MinG5Ver	-0.15	-0.2	-0.225	-0.1916667	0.038188131
MaxG5Hor	0.25	0.29	0.35	0.29666667	0.05033223
MinG5Hor	-0.1	-0.2	-0.075	-0.125	0.066143783
MaxG4Ver	0.25	0.21	0.15	0.20333333	0.05033223
MinG4Ver	-0.2	-0.17	-0.2	-0.19	0.017320508
MaxG4Hor	0.4	0.3	0.4	0.36666667	0.057735027
MinG4Hor	-0.3	-0.2	-0.175	-0.225	0.066143783

Note: Average and Standard Deviation were obtained from sample size

Table 16 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Walk Backward			**Type of AFO:** Flex		
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.35	0.23	0.25	0.2766667	0.064291005
MinG1Ver	-0.125	-0.45	-0.6	-0.3916667	0.242813371
MaxG1Hor	0.05	0.12	0.2	0.1233333	0.075055535
MinG1Hor	-0.075	-0.05	-0.05	-0.0583333	0.014433757
MaxG6Ver	0.25	0.45	0.675	0.4583333	0.212622514
MinG6Ver	-0.5	-0.4	-0.45	-0.45	0.05
MaxG6Hor	0.09	0.2	0.225	0.1716667	0.071821538
MinG6Hor	-0.1	-0.1	-0.075	-0.0916667	0.014433757
MaxG2Ver	0.74	0.9	1	0.88	0.13114877
MinG2Ver	-0.55	-0.7	-0.8	-0.6833333	0.125830574
MaxG2Hor	0.075	0.15	0.1	0.1083333	0.038188131
MinG2Hor	-0.01	-0.15	-0.1	-0.0866667	0.070945989
MaxG7Ver	0.13	0.15	0.2	0.16	0.036055513
MinG7Ver	-0.45	-0.3	-0.225	-0.325	0.114564392
MaxG7Hor	0.05	0.13	0.125	0.1016667	0.044814432
MinG7Hor	-0.075	-0.05	-0.05	-0.0583333	0.014433757
MaxG3Ver	0.525	0.44	0.45	0.4716667	0.046457866
MinG3Ver	-0.14	-0.25	-0.3	-0.23	0.081853528
MaxG3Hor	0.03	0.075	0.15	0.085	0.060621778
MinG3Hor	-0.45	-0.3	-0.45	-0.4	0.08660254
MaxG8Ver	0.05	0.05	0.075	0.0583333	0.014433757
MinG8Ver	-0.125	-0.14	-0.05	-0.105	0.048218254
MaxG8Hor	0.125	0.15	0.09	0.1216667	0.030138569
MinG8Hor	-0.2	-0.1	-0.275	-0.1916667	0.087797115
MaxG5Ver	0.09	0.11	0.225	0.1416667	0.07285831
MinG5Ver	-0.19	-0.12	-0.075	-0.1283333	0.057951129
MaxG5Hor	0.275	0.15	0.15	0.1916667	0.072168784
MinG5Hor	-0.125	-0.25	-0.3	-0.225	0.090138782
MaxG4Ver	0.25	0.26	0.225	0.245	0.018027756
MinG4Ver	-0.2	-0.3	-0.2	-0.2333333	0.057735027
MaxG4Hor	0.375	0.3	0.25	0.3083333	0.062915287
MinG4Hor	-0.18	-0.1	-0.25	-0.1766667	0.075055535

Table 17 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Walk Backward				**Type of AFO:** Moderate		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.75	0.6	0.75	0.7	0.08660254	0.65
MinG1Ver	-0.525	-0.6	-0.3	-0.475	0.15612495	-0.525
MaxG1Hor	0.15	0.11	0.1	0.12	0.02645751	0.15
MinG1Hor	-0.2	-0.11	-0.2	-0.17	0.05196152	-0.17
MaxG6Ver	0.6	0.54	0.475	0.53833333	0.06251666	0.55
MinG6Ver	-0.625	-0.8	-0.95	-0.7916667	0.16266018	-0.45
MaxG6Hor	0.3	0.36	0.3	0.32	0.03464102	0.35
MinG6Hor	-0.35	-0.24	-0.2	-0.2633333	0.07767453	-0.4
MaxG2Ver	0.1	0.22	0.1	0.14	0.06928203	0.09
MinG2Ver	-0.2	-0.15	-0.25	-0.2	0.05	-0.1
MaxG2Hor	0.2	0.16	0.2	0.18666667	0.02309401	0.1
MinG2Hor	-0.05	-0.09	-0.1	-0.08	0.02645751	-0.05
MaxG7Ver	0.15	0.19	0.2	0.18	0.02645751	0.25
MinG7Ver	-0.55	-0.33	-0.25	-0.3766667	0.15534907	-0.6
MaxG7Hor	0.3	0.24	0.15	0.23	0.07549834	0.35
MinG7Hor	-0.125	-0.24	-0.11	-0.1583333	0.07112196	-0.15
MaxG3Ver	0.15	0.31	0.25	0.23666667	0.08082904	0.09
MinG3Ver	-0.2	-0.14	-0.15	-0.1633333	0.0321455	-0.2
MaxG3Hor	0	0.05	0.1	0.05	0.05	0.05
MinG3Hor	-0.2	-0.1	-0.2	-0.1666667	0.05773503	-0.1
MaxG8Ver	0.125	0.2	0.15	0.15833333	0.03818813	0.075
MinG8Ver	-0.35	-0.15	-0.45	-0.3166667	0.15275252	-0.25
MaxG8Hor	0.1	0.13	0.2	0.14333333	0.05131601	0.1
MinG8Hor	-0.475	-0.15	-0.25	-0.2916667	0.1664582	-0.35
MaxG5Ver	0.3	0.26	0.15	0.23666667	0.07767453	0.35
MinG5Ver	-0.4	-0.3	-0.25	-0.3166667	0.07637626	-0.45
MaxG5Hor	0.6	0.37	0.3	0.42333333	0.1569501	0.55
MinG5Hor	-0.2	-0.14	-0.125	-0.155	0.03968627	-0.25
MaxG4Ver	0.45	0.6	0.6	0.55	0.08660254	0.35
MinG4Ver	-0.525	-0.35	-0.325	-0.4	0.10897247	-0.55
MaxG4Hor	0.7	0.5	0.4	0.53333333	0.15275252	0.6
MinG4Hor	-0.3	-0.41	-0.425	-0.3783333	0.06825198	-0.27

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 18 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Walk Backward				**Type of AFO:** Solid	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.6	0.24	0.425	0.4216667	0.180023147
MinG1Ver	-0.4	-0.1	-0.4	-0.3	0.173205081
MaxG1Hor	0.125	0.12	0.125	0.1233333	0.002886751
MinG1Hor	-0.15	-0.09	-0.125	-0.1216667	0.030138569
MaxG6Ver	0.9	0.49	0.85	0.7466667	0.223681321
MinG6Ver	-0.5	-0.25	-0.15	-0.3	0.180277564
MaxG6Hor	0.15	0.05	0.025	0.075	0.066143783
MinG6Hor	-0.1	-0.1	-0.125	-0.1083333	0.014433757
MaxG2Ver	0.125	0.08	0.05	0.085	0.037749172
MinG2Ver	-0.15	-0.05	-0.15	-0.1166667	0.057735027
MaxG2Hor	0.15	0.05	0.1	0.1	0.05
MinG2Hor	-0.025	-0.05	-0.05	-0.0416667	0.014433757
MaxG7Ver	0.35	0.41	0.15	0.3033333	0.136137186
MinG7Ver	-0.775	-0.3	-0.525	-0.5333333	0.237609624
MaxG7Hor	0.4	0.1	0.05	0.1833333	0.189296945
MinG7Hor	-0.1	-0.05	-0.28	-0.1433333	0.120968315
MaxG3Ver	0.375	0.23	0.55	0.385	0.160234204
MinG3Ver	-0.175	-0.15	-0.3	-0.2083333	0.080363756
MaxG3Hor	0.15	0.05	0.05	0.0833333	0.057735027
MinG3Hor	-0.1	-0.2	-0.125	-0.1416667	0.05204165
MaxG8Ver	0.05	0.15	0.2	0.1333333	0.076376262
MinG8Ver	-0.725	-0.15	-0.425	-0.4333333	0.287590565
MaxG8Hor	0.1	0.05	0.11	0.0866667	0.032145503
MinG8Hor	-0.125	-0.11	-0.175	-0.1366667	0.034034296
MaxG5Ver	0.225	0.1	0	0.1083333	0.112731244
MinG5Ver	-0.3	-0.2	-0.25	-0.25	0.05
MaxG5Hor	0.4	0.16	0.3	0.2866667	0.120554275
MinG5Hor	-0.075	-0.07	0	-0.0483333	0.041932485
MaxG4Ver	0.3	0.33	0.825	0.485	0.29483046
MinG4Ver	-0.45	-0.24	-0.45	-0.38	0.121243557
MaxG4Hor	0.55	0.24	0.35	0.38	0.157162336
MinG4Hor	-0.225	-0.27	-0.3	-0.265	0.037749172

Note: Average and Standard Deviation were obtained from sample size

Table 19 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of four samples

Type of Motion: Walk Backward				**Type of AFO:** Standard		
Gage #	Peak Stress (MPa)			Average	Standard Dev	P. Stress
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs			Sample 4(F) 100 lbs
MaxG1Ver	0.75	1.2	0.35	0.76666667	0.42524503	0.4
MinG1Ver	-0.45	-0.85	-0.65	-0.65	0.2	-0.54
MaxG1Hor	0.1	0.2	0.15	0.15	0.05	0.1
MinG1Hor	-0.15	-0.26	-0.075	-0.1616667	0.09305017	-0.1
MaxG6Ver	0.1	0.16	0.05	0.10333333	0.05507571	0.05
MinG6Ver	-0.25	-0.15	-0.275	-0.225	0.06614378	-0.125
MaxG6Hor	0.15	0.12	0.125	0.13166667	0.01607275	0.175
MinG6Hor	-0.05	-0.09	-0.05	-0.0633333	0.02309401	-0.05
MaxG2Ver	0.825	1.1	0.4	0.775	0.3526684	0.6
MinG2Ver	-0.5	-0.75	-0.75	-0.6666667	0.14433757	-0.575
MaxG2Hor	0.05	0.15	0.05	0.08333333	0.05773503	0.025
MinG2Hor	-0.025	-0.025	-0.075	-0.0416667	0.02886751	-0.075
MaxG7Ver	0.05	0.15	0.025	0.075	0.06614378	0.05
MinG7Ver	-0.1	-0.63	-0.1	-0.2766667	0.30599564	-0.2
MaxG7Hor	0.25	0.34	0.125	0.23833333	0.10797376	0.3
MinG7Hor	-0.05	-0.26	-0.05	-0.12	0.12124356	-0.15
MaxG3Ver	0.15	0.25	0.55	0.31666667	0.2081666	0.1
MinG3Ver	-0.45	-0.4	-0.325	-0.3916667	0.06291529	-0.475
MaxG3Hor	0.375	0.35	0.2	0.30833333	0.09464847	0.4
MinG3Hor	-0.25	-0.26	-0.275	-0.2616667	0.01258306	-0.275
MaxG8Ver	0.075	0.35	0.05	0.15833333	0.1664582	0.075
MinG8Ver	-0.3	-0.25	-0.1	-0.2166667	0.1040833	-0.325
MaxG8Hor	0.1	0.23	0.2	0.17666667	0.06806859	0.05
MinG8Hor	-0.05	-0.2	-0.05	-0.1	0.08660254	-0.1
MaxG5Ver	0.15	0.17	0.1	0.14	0.03605551	0.15
MinG5Ver	-0.15	-0.2	-0.1	-0.15	0.05	-0.175
MaxG5Hor	0.2	0.28	0.075	0.185	0.10331989	0.25
MinG5Hor	-0.2	-0.24	-0.2	-0.2133333	0.02309401	-0.25
MaxG4Ver	0.25	0.3	0.15	0.23333333	0.07637626	0.15
MinG4Ver	-0.3	-0.22	-0.125	-0.215	0.08760708	-0.325
MaxG4Hor	0.4	0.29	0.1	0.26333333	0.15176737	0.45
MinG4Hor	-0.25	-0.25	-0.125	-0.2083333	0.07216878	-0.2

Note: Average and Standard Deviation were obtained from sample 1, 2 and 3.

Table 20 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Walk Backward				**Type of AFO:** Varus	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.15	0.25	0.45	0.2833333	0.152752523
MinG1Ver	-0.225	-0.025	-0.45	-0.233333	0.212622514
MaxG1Hor	0.35	0.05	0.3	0.2333333	0.160727513
MinG1Hor	-0.225	-0.25	-0.2	-0.225	0.025
MaxG6Ver	0.3	0.19	0.175	0.2216667	0.068251984
MinG6Ver	-0.1	-0.18	-0.175	-0.151667	0.044814432
MaxG6Hor	0.1	0.13	0.125	0.1183333	0.016072751
MinG6Hor	-0.15	-0.12	-0.125	-0.131667	0.016072751
MaxG2Ver	0.35	0.09	0.45	0.2966667	0.185831465
MinG2Ver	-0.2	-0.25	-0.45	-0.3	0.132287566
MaxG2Hor	0.15	0.15	0.0025	0.1008333	0.085159165
MinG2Hor	-0.2	-0.1	0	-0.1	0.1
MaxG7Ver	0.05	0.025	0	0.025	0.025
MinG7Ver	-0.35	-0.1	-0.2	-0.216667	0.125830574
MaxG7Hor	0.2	0.05	0.1	0.1166667	0.076376262
MinG7Hor	0	-0.025	-0.125	-0.05	0.066143783
MaxG3Ver	0.025	0.05	0.05	0.0416667	0.014433757
MinG3Ver	-0.35	-0.1	-0.2	-0.216667	0.125830574
MaxG3Hor	0.2	0.05	0.3	0.1833333	0.125830574
MinG3Hor	0	-0.05	-0.25	-0.1	0.132287566
MaxG8Ver	0.1	0.18	0.15	0.1433333	0.040414519
MinG8Ver	-0.95	-0.14	-0.5	-0.53	0.405832478
MaxG8Hor	0.05	0.11	0.15	0.1033333	0.05033223
MinG8Hor	-0.35	-0.05	-0.1	-0.166667	0.160727513
MaxG5Ver	0.1	0.16	0.1	0.12	0.034641016
MinG5Ver	-0.2	-0.1	-0.15	-0.15	0.05
MaxG5Hor	0.3	0.16	0.225	0.2283333	0.070059499
MinG5Hor	-0.15	-0.22	-0.15	-0.173333	0.040414519
MaxG4Ver	0.075	0.25	0.2	0.175	0.090138782
MinG4Ver	-0.925	-0.05	-0.15	-0.375	0.478931102
MaxG4Hor	0.25	0.15	0.25	0.2166667	0.057735027
MinG4Hor	-0.05	-0.17	-0.25	-0.156667	0.100664459

Note: Average and Standard Deviation were obtained from sample size

Table 21 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Lifting a 25 Pound Object				**Type of AFO:** Flex	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0	0.3	0.275	0.19166667	0.166458203
MinG1Ver	-0.45	-0.3	-0.25	-0.3333333	0.1040833
MaxG1Hor	0.05	0.1	0.075	0.075	0.025
MinG1Hor	0	-0.06	0	-0.02	0.034641016
MaxG6Ver	0.25	0.32	0.025	0.19833333	0.154137385
MinG6Ver	-0.075	-0.4	-0.06	-0.1783333	0.192115417
MaxG6Hor	0	0.05	0.05	0.03333333	0.028867513
MinG6Hor	-0.1	-0.05	-0.025	-0.0583333	0.038188131
MaxG2Ver	0.15	0.85	0.6	0.53333333	0.354729944
MinG2Ver	-0.8	-0.4	-0.3	-0.5	0.264575131
MaxG2Hor	0.075	0.025	0	0.03333333	0.038188131
MinG2Hor	-0.05	-0.15	-0.2	-0.1333333	0.076376262
MaxG7Ver	0.225	0.25	0	0.15833333	0.137689264
MinG7Ver	0	-0.1	-0.325	-0.1416667	0.166458203
MaxG7Hor	0	0.025	0.04	0.02166667	0.020207259
MinG7Hor	-0.06	-0.05	0	-0.0366667	0.032145503
MaxG3Ver	0.1	0.15	0.25	0.16666667	0.076376262
MinG3Ver	-0.09	-0.23	-0.275	-0.1983333	0.096479704
MaxG3Hor	0.09	0.13	0.15	0.12333333	0.030550505
MinG3Hor	-0.2	-0.1	-0.2	-0.1666667	0.057735027
MaxG8Ver	0	0	0	0	0
MinG8Ver	-0.1	-0.1	-0.05	-0.0833333	0.028867513
MaxG8Hor	0.15	0.09	0.075	0.105	0.03968627
MinG8Hor	0	-0.025	0	-0.0083333	0.014433757
MaxG5Ver	0.025	0.07	0.025	0.04	0.025980762
MinG5Ver	-0.025	-0.09	-0.15	-0.0883333	0.062516664
MaxG5Hor	0.025	0.12	0.175	0.10666667	0.075883683
MinG5Hor	-0.025	-0.1	0	-0.0416667	0.05204165
MaxG4Ver	0.1	0.14	0.1	0.11333333	0.023094011
MinG4Ver	0	-0.09	-0.25	-0.1133333	0.126622799
MaxG4Hor	0.05	0.06	0.35	0.15333333	0.170391706
MinG4Hor	-0.05	-0.06	-0.125	-0.0783333	0.040722639

Note: Average and Standard Deviation were obtained from sample size

Table 22 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Lifting a 25 Pound Object				**Type of AFO:** Moderate	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.525	0.2	0.15	0.29166667	0.203613195
MinG1Ver	-0.1	-0.2	-0.15	-0.15	0.05
MaxG1Hor	0.025	0.05	0.05	0.04166667	0.014433757
MinG1Hor	-0.15	-0.05	-0.025	-0.075	0.066143783
MaxG6Ver	0.475	0.15	0.4	0.34166667	0.170171482
MinG6Ver	-0.05	-0.1	-0.125	-0.0916667	0.038188131
MaxG6Hor	0.05	0.05	0.05	0.05	0
MinG6Hor	-0.175	-0.09	-0.15	-0.1383333	0.043684475
MaxG2Ver	0.025	0.05	0	0.025	0.025
MinG2Ver	-0.15	-0.05	-0.075	-0.0916667	0.05204165
MaxG2Hor	0.125	0.07	0.075	0.09	0.030413813
MinG2Hor	0	-0.025	0	-0.0083333	0.014433757
MaxG7Ver	0	0.05	0.1	0.05	0.05
MinG7Ver	-0.175	-0.08	-0.25	-0.1683333	0.085195853
MaxG7Hor	0.05	0.11	0.375	0.17833333	0.172940259
MinG7Hor	-0.025	-0.025	-0.075	-0.0416667	0.028867513
MaxG3Ver	0	0.025	0.025	0.01666667	0.014433757
MinG3Ver	-0.2	-0.14	-0.125	-0.155	0.03968627
MaxG3Hor	0.2	0.1	0.025	0.10833333	0.087797115
MinG3Hor	0	-0.06	-0.025	-0.0283333	0.030138569
MaxG8Ver	0	0.025	0.4	0.14166667	0.224072161
MinG8Ver	-0.05	-0.09	-0.125	-0.0883333	0.037527767
MaxG8Hor	0.05	0	0.05	0.03333333	0.028867513
MinG8Hor	-0.05	0	-0.15	-0.0666667	0.076376262
MaxG5Ver	0.05	0.12	0.09	0.08666667	0.035118846
MinG5Ver	-0.2	-0.05	-0.025	-0.0916667	0.094648472
MaxG5Hor	0.25	0.1	0.1	0.15	0.08660254
MinG5Hor	-0.05	-0.1	-0.05	-0.0666667	0.028867513
MaxG4Ver	0.1	0.09	0.075	0.08833333	0.012583057
MinG4Ver	-0.225	-0.06	-0.275	-0.1866667	0.112509259
MaxG4Hor	0.25	0.17	0.4	0.27333333	0.116761866
MinG4Hor	-0.075	-0.1	-0.075	-0.0833333	0.014433757

Note: Average and Standard Deviation were obtained from sample size

Table 23 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Lifting a 25 Pound Object				**Type of AFO:** Solid	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.025	0.05	0.6	0.225	0.325
MinG1Ver	-0.125	-0.11	-0.09	-0.1083333	0.017559423
MaxG1Hor	0.075	0.05	0.025	0.05	0.025
MinG1Hor	0	-0.025	-0.15	-0.0583333	0.080363756
MaxG6Ver	0.15	0.2	0.775	0.375	0.3473111
MinG6Ver	-0.125	-0.1	-0.1	-0.1083333	0.014433757
MaxG6Hor	0.05	0.05	0.025	0.04166667	0.014433757
MinG6Hor	-0.05	-0.025	-0.125	-0.0666667	0.05204165
MaxG2Ver	0.1	0.05	0.025	0.05833333	0.038188131
MinG2Ver	0	-0.075	-0.2	-0.0916667	0.101036297
MaxG2Hor	0	0.025	0.175	0.06666667	0.094648472
MinG2Hor	-0.05	-0.025	0	-0.025	0.025
MaxG7Ver	0.075	0.25	0.05	0.125	0.108972474
MinG7Ver	-0.35	-0.2	-0.575	-0.375	0.188745861
MaxG7Hor	0.125	0.05	0.3	0.15833333	0.128290036
MinG7Hor	-0.05	-0.075	-0.06	-0.0616667	0.012583057
MaxG3Ver	0.1	0.15	0.525	0.25833333	0.232289331
MinG3Ver	-0.075	-0.14	-0.1	-0.105	0.032787193
MaxG3Hor	0.05	0.075	0.05	0.05833333	0.014433757
MinG3Hor	-0.025	-0.1	-0.05	-0.0583333	0.038188131
MaxG8Ver	0	0.05	0	0.01666667	0.028867513
MinG8Ver	-0.175	-0.09	-0.425	-0.23	0.174140748
MaxG8Hor	0	0.05	0	0.01666667	0.028867513
MinG8Hor	-0.075	0	-0.05	-0.0416667	0.038188131
MaxG5Ver	0.05	0.05	0.06	0.05333333	0.005773503
MinG5Ver	-0.05	-0.12	-0.3	-0.1566667	0.128970281
MaxG5Hor	0.075	0.1	0.25	0.14166667	0.094648472
MinG5Hor	-0.05	-0.05	-0.025	-0.0416667	0.014433757
MaxG4Ver	0.05	0.15	0.11	0.10333333	0.05033223
MinG4Ver	-0.075	-0.31	-0.08	-0.155	0.134257216
MaxG4Hor	0.125	0.36	0.6	0.36166667	0.237504386
MinG4Hor	-0.05	-0.15	-0.05	-0.0833333	0.057735027

Note: Average and Standard Deviation were obtained from sample size

Table 24 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Lifting a 25 Pound Object				**Type of AFO:** Standard	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0.05	0.4	0.6	0.35	0.278388218
MinG1Ver	-0.4	-0.37	-0.075	-0.2816667	0.17960605
MaxG1Hor	0.075	0.09	0	0.055	0.048218254
MinG1Hor	-0.025	-0.09	-0.125	-0.08	0.050744458
MaxG6Ver	0.25	0.15	0.075	0.15833333	0.087797115
MinG6Ver	-0.05	-0.025	0	-0.025	0.025
MaxG6Hor	0.025	0.025	0	0.01666667	0.014433757
MinG6Hor	-0.125	-0.05	-0.05	-0.075	0.04330127
MaxG2Ver	0.05	0.35	0.75	0.38333333	0.351188458
MinG2Ver	-0.4	-0.3	-0.1	-0.2666667	0.152752523
MaxG2Hor	0	0.05	0.05	0.03333333	0.028867513
MinG2Hor	0	-0.05	0	-0.0166667	0.028867513
MaxG7Ver	0.05	0.13	0.025	0.06833333	0.054848276
MinG7Ver	0	-0.43	-0.025	-0.1516667	0.241367631
MaxG7Hor	0.15	0.26	0.15	0.18666667	0.06350853
MinG7Hor	0	-0.15	0	-0.05	0.08660254
MaxG3Ver	0.05	0.14	0.05	0.08	0.051961524
MinG3Ver	-0.35	-0.3	-0.525	-0.3916667	0.118145391
MaxG3Hor	0.3	0.27	0.4	0.32333333	0.068068593
MinG3Hor	-0.075	-0.1	-0.025	-0.0666667	0.038188131
MaxG8Ver	0	0.05	0	0.01666667	0.028867513
MinG8Ver	-0.15	-0.1	-0.175	-0.1416667	0.038188131
MaxG8Hor	0.075	0.15	0.05	0.09166667	0.05204165
MinG8Hor	0	-0.05	-0.025	-0.025	0.025
MaxG5Ver	0.05	0.05	0	0.03333333	0.028867513
MinG5Ver	-0.2	-0.06	-0.1	-0.12	0.072111026
MaxG5Hor	0.25	0.1	0.15	0.16666667	0.076376262
MinG5Hor	-0.05	-0.05	0	-0.0333333	0.028867513
MaxG4Ver	0.025	0.025	0	0.01666667	0.014433757
MinG4Ver	-0.15	-0.15	-0.15	-0.15	2.63418E-09
MaxG4Hor	0.2	0.17	0.175	0.18166667	0.016072751
MinG4Hor	-0.025	-0.1	0	-0.0416667	0.05204165

Note: Average and Standard Deviation were obtained from sample size

Table 25 The maximum and minimum peak stress of each channel of each strain gages obtained from the measurement of three samples

Type of Motion: Lifting a 25 Pound Object				**Type of AFO:** Varus	
Gage #	Peak Stress (MPa)			Average	Standard Dev
	Sample 1(M) 125 lbs	Sample 2(M) 162 lbs	Sample 3(M) 192 lbs		
MaxG1Ver	0	0.18	0.4	0.19333333	0.200333056
MinG1Ver	-0.1	-0.25	-0.05	-0.1333333	0.1040833
MaxG1Hor	0.175	0.1	0.025	0.1	0.075
MinG1Hor	0	-0.06	-0.175	-0.0783333	0.08892881
MaxG6Ver	0.25	0.11	0.275	0.21166667	0.08892881
MinG6Ver	0	-0.025	0	-0.0083333	0.014433757
MaxG6Hor	0	0	0	0	0
MinG6Hor	-0.125	-0.1	-0.2	-0.1416667	0.05204165
MaxG2Ver	0.25	0	0.3	0.18333333	0.160727513
MinG2Ver	0	-0.025	0	-0.0083333	0.014433757
MaxG2Hor	0	0.025	0	0.00833333	0.014433757
MinG2Hor	-0.125	-0.025	0	-0.05	0.066143783
MaxG7Ver	0	0	0	0	0
MinG7Ver	-0.125	-0.05	-0.2	-0.125	0.075
MaxG7Hor	0.125	0.05	0.125	0.1	0.04330127
MinG7Hor	0	-0.05	0	-0.0166667	0.028867513
MaxG3Ver	0.025	0.025	0	0.01666667	0.014433757
MinG3Ver	-0.025	-0.05	-0.1	-0.0583333	0.038188131
MaxG3Hor	0	0.05	0.125	0.05833333	0.062915287
MinG3Hor	-0.125	-0.05	0	-0.0583333	0.062915287
MaxG8Ver	0	0.075	0	0.025	0.04330127
MinG8Ver	-0.45	-0.1	-0.525	-0.3583333	0.226844293
MaxG8Hor	0.125	0.075	0.1	0.1	0.025
MinG8Hor	-0.05	-0.05	-0.025	-0.0416667	0.014433757
MaxG5Ver	0.05	0.05	0	0.03333333	0.028867513
MinG5Ver	-0.1	-0.05	-0.225	-0.125	0.090138782
MaxG5Hor	0.15	0.07	0.3	0.17333333	0.116761866
MinG5Hor	0	-0.06	0	-0.02	0.034641016
MaxG4Ver	0.025	0.07	0.05	0.04833333	0.022546249
MinG4Ver	-0.025	-0.08	-0.2	-0.1016667	0.089489292
MaxG4Hor	0.1	0.1	0.35	0.18333333	0.144337567
MinG4Hor	-0.1	-0.1	-0.025	-0.075	0.04330127

Note: Average and Standard Deviation were obtained from sample size

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