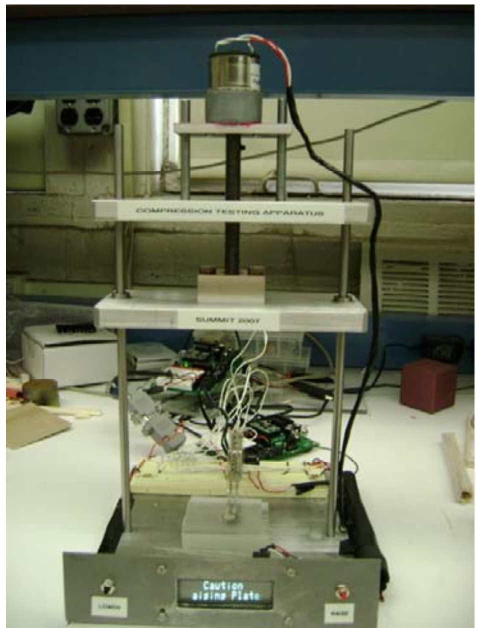
Compression **T**esting **A**pparatus



by

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1-Abstract

The intent of this project is to provide students with a visual demonstration of material tested for compression. This demonstration will be used in technology and physical science classes. The use of electrical part, mechanical parts and computer programming will also provide more interdisciplinary lessons.

2-Introduction

Who among us, really, hasn't crossed a bridge and at least paused over the disconcerting possibility that the structure might collapse into free fall?

"A 600-foot section of an interstate bridge over the Arkansas River collapsed on May 26, 2007 when one of two barges going north on the river rammed a pylon. About a dozen vehicles plunged into the river. Five people were rescued from the water, but authorities are certain that there were fatalities."

"Late July 2007, a 40-year-old interstate highway bridge collapsed in Minneapolis, plunging rush-hour traffic into the Mississippi River 60 feet below."

Truss bridges such as the one in Minneapolis, whose pillars carry loads by tension and compression, long have been the workhorses. They were invented in America to span wide waterways, the Mississippi in particular, and this is the big question today in Minneapolis. Why did the bridge collapse?

While bridge collapses are rare, they remain spectacular and have a lasting impact on people' minds.

As a minimum, the goal is to break that chain of failures by conducting a proactive research program that provides solutions that can be implemented prior to the catastrophic failure. The key to avoid future horrific circumstances will be the use of advanced or enhanced materials, inspection technology, design procedures, construction methods, operational practices, maintenance and rehabilitation technology, and management techniques. We must use technology that permits to test, during the design stage of the bridge, all beams and columns susceptible to keep the bridge safe and stable. The challenge to develop and implement this technology must be undertaken in partnership with the entire highway community -- government at all levels, universities, highway users, the construction industry, and heavy vehicle manufacturers.

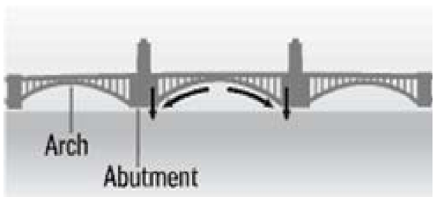
In our summer project with Summit at Polytechnic Institute, as a team, we have opted for an apparatus that will detect and display the maximum force structural material undergoes. Selection for this project falls well into our study scope, as we teach students physics and technology. Both have agreed this venture will benefit our student population back in our schools.

The compression apparatus determines the equilibrium force, which is the maximum load a structural element as a beam or a column can sustain. Loads may include the weight of truck and cars in motion, force of the wind, weight of snow, our compression apparatus is operated in association with a two platen parts which one can move relative to one another. The compression apparatus is formed of at least one compression units having a working chamber and a working element which can move in it.

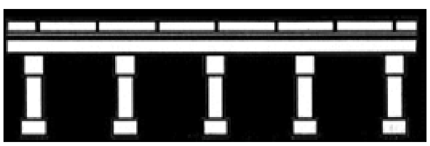
3-- Background information

They are many types of bridges all over the world. What make them different will depend on their purpose, location, environment, length of span, material they are made of and their cost. The most common bridges are:

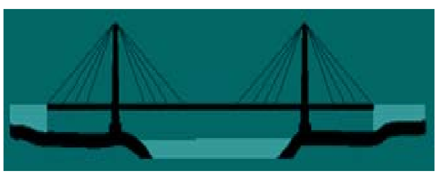
1- Type of bridges



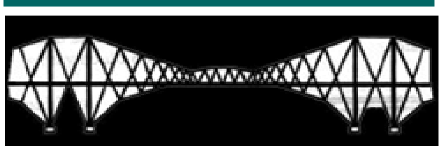
Arch bridges are the earliest one



Beam bridges are the simplest one.



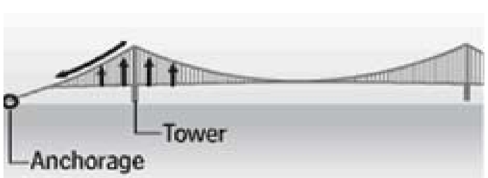
Cable bridges are used for medium span.



Used to span great distance

Tomlinson Lift Bridge

They can open to allow boat to go through



Have the longest span distance

2- Forces acting on bridges:

When designing and constructing a bridge, engineers have to consider many factors. They need to know which material and structure is best for a stable bridge? Many forces act on a bridge. The two most important one are tension and compression bridges.

Compression is a force that acts to compress or shorten the object it is acting on.

Tension is the force that acts to extend or expend the object it is acting on

Tension

Compression

Material can have both tension and compression applied at the same time .A good examples of these are bridges.

In any static structure such as bridges they will be forces acting on it at any point. These forces need to be in equilibrium.
The blue arrows represent tension
The red arrows represent compression
The green arrows represent force of gravity

The structural members of a bridge will react to those acting on them by producing internal forces. They do this by deflecting until the forces they generate balance the one applied on them. If a member reaches its limit of strength before the necessary force is attained, it will bend, snap, twist or break. It is the task of the bridge designer to analyze and study these forces in order to avoid buckling or snapping. Buckling is what happens when the force of compression overcomes an object's ability to handle compression, and snapping is what happens when the force of tension overcomes an object's ability to handle tension

Minneapolis Mississippi Bridge I-35w
The bridge collapse during Minneapolis Rush hour on Wednesday 08-01-07 has raised questions about structural problem

BEFORE

AFTER

Our project is to build a device (compression testing apparatus) that will simulate how materials are tested for their ability to resist compression.

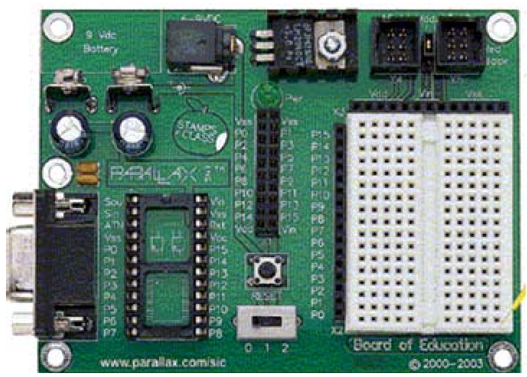
4 Material used;

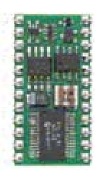
1- flexi Force:

Flexi force sensor and the capacitor are the basic tools in this project.

Flexi Force measures compression exerted versus resistance.

The resistance of flexi force is proportional to weight .



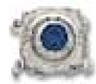


2-Board of education (BOE)

The board of education supplies a regulated +5volts (Vdd) and ground (Vss) as well as a small breadboard for circuit and connector to 16 pins.

3- Piezo Speaker: used as a signal to stat a program

4-motor: used to move the movable piston up a down



5-push button: used to start and stop the program

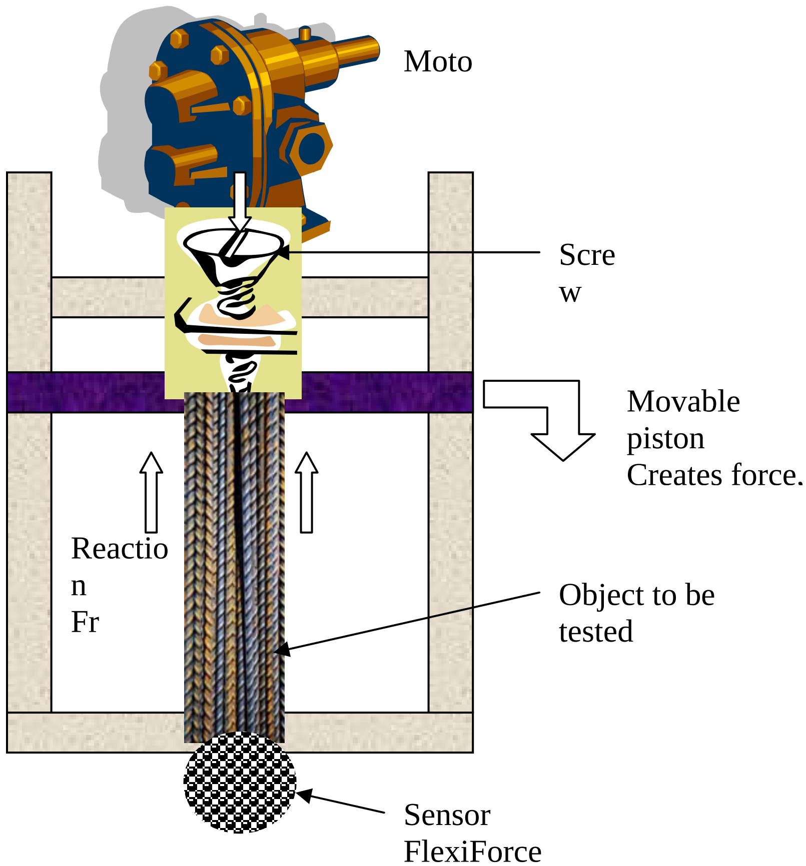
6-capacitor: is connected to the flexi force

7- Pololu motor micro controller: can independently set motor to go forward or backward.

8-Parallax serial LCD: provides basic text wrapping on the display

5-Experiment

1-The device

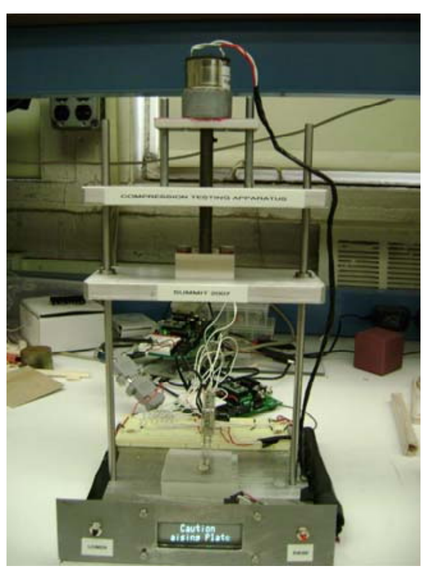


Compression testing apparatus

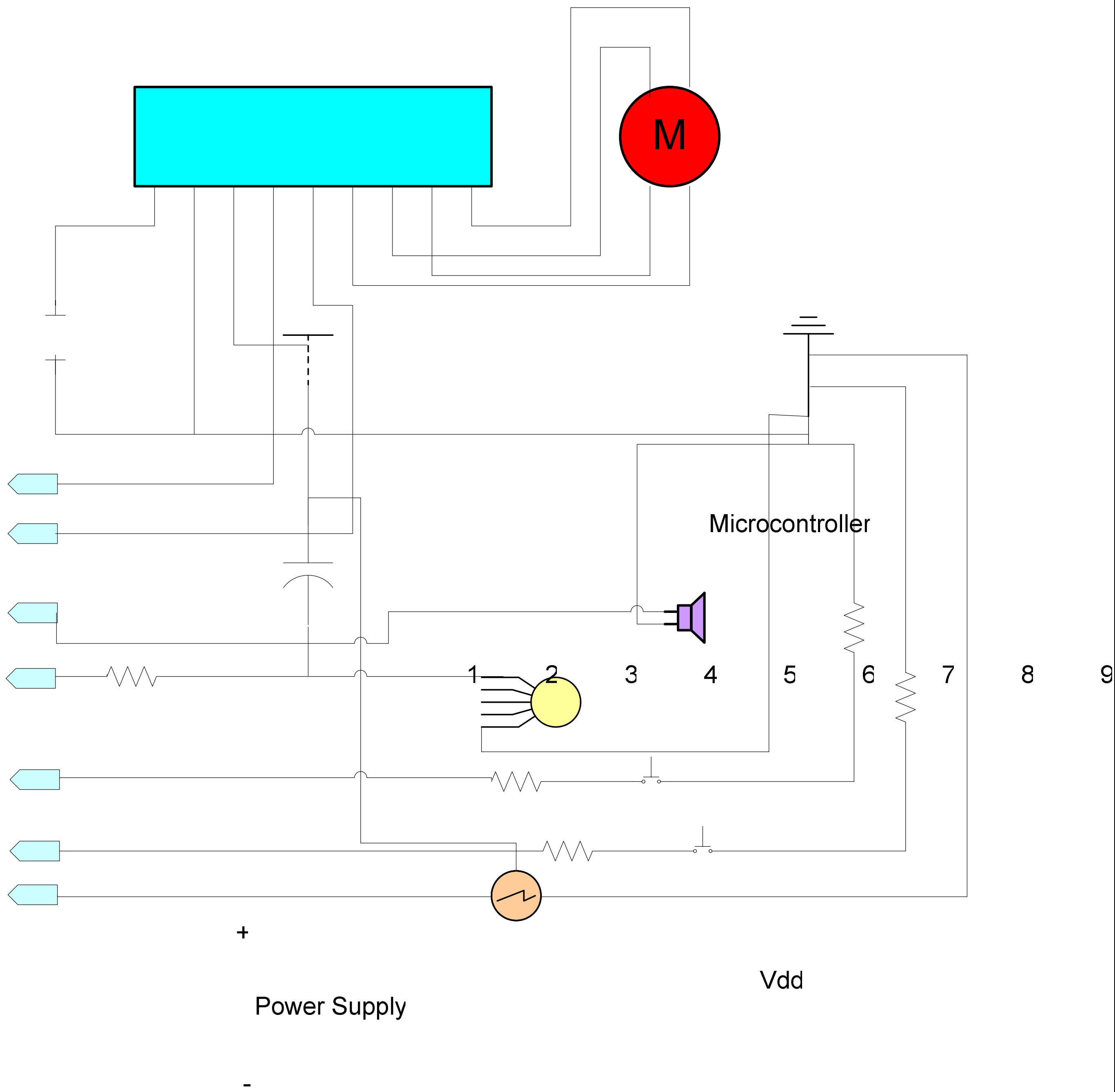
At equilibrium:

Force F = Force Fr IF FORCE F> REACTION FORCE Fr the object will buckle.

Compression testing Apparatus model Design



2--Electrical circuit



P2

6- Computer Program

```
' Compression Testing Machine - CompressionMachine.bs2
' Progrsm Listing
' Programmers: Lindrick Outerbridge
'              Sabah
' {$STAMP BS2}
' {$PBASIC 2.5}
' -----[ Revision History ]--------------------------------------------
' 8/1/07
' 8/9/07 VFD Display shows realtime force values. Shows greatest value at the
end.
' -----[ Declarations ]------------------------------------------------

rawForce        VAR     Word       ' Stores raw output
sensorPin       CON     1         ' Flexiforce sensor circuit
calibration     CON     6000     ' Calibration raw Flexiforce equivalent to 1
kg mass
calibtimesgrav  CON     58860    ' calibration times 9.81 gravity constant
counter         VAR     Word
ForceInteger    VAR     Byte
ForceDecimal    VAR     Byte
speed           VAR     Byte        ' DC motor speed
Force           VAR     Byte
LargestForce    VAR     Byte
LFInteger       VAR     Byte
LFDecimal       VAR     Byte
' -----[ I/O Definitions ]---------------------------------------------

VFD             PIN      5       'VFD Serial I/O PIN

' *********** CHECK YOUR WIRING BEFORE POWERING UP THE VFD ***********


' -----[ Constants ]---------------------------------------------------

Baud            CON     6               ' 38.4 Kbps (BS2)

' These are constants for common control characters on the display.
' Remember, some are already defined in the editor, like CR and LF.

BS              CON     $08             ' Back Space
HT              CON     $09             ' Horizontal Tab
HOM             CON     $0B             ' Home Position
CLR             CON     $0C             ' Display Clear


' -----[ Variables ]---------------------------------------------------

index           VAR     Byte            ' Index Variable


' -----[ Initialization ]----------------------------------------------

HIGH VFD                                ' Initialize I/O Pin
PAUSE 200                               ' Allow Time To Settle
```

```
' This command resets the display settings to deafult values, but the input
' buffer is not affected (contents remain).

SEROUT VFD, Baud, [$1B, $40, $0C]       ' Initialize Display
PAUSE 200                               ' Allow Time To Settle

' You need to set this if you plan to write to the non-visible display
' memory.  Write Screen Mode Select: 0=Display Screen, 1=All Screen

SEROUT VFD, Baud, [$1F, $28, $77, $10, $01]
' This digit is the one to change       ^^

' -----[ Program Code ]----------------------------------------------------

Main:
  SEROUT VFD, Baud, ["Compression Test", CR, LF, "    Apparatus"] ' Title
Screen
  PAUSE 3000
  SEROUT VFD, Baud, [CLR]               ' Clear The Display
  SEROUT VFD, Baud, ["Outerbridge, L.", CR, LF, " Sabah Ayoub"]
  PAUSE 2000

  DO
   GOSUB Display_On_Off                ' Do Display On/Off Demo
   GOSUB Wait_For_Start                ' Do Wait for Button Press

  LOOP                                  ' Loop Forever

' -----[ Subroutines ]-----------------------------------------------------

Display_On_Off:
  SEROUT VFD, Baud, [CLR]               ' Clear The Display
  SEROUT VFD, Baud, ["  SUMMIT 2007", CR, LF, " PolyTechnic U."]
   PAUSE 2000

  RETURN

' -------------------------------------------------------------------------

Wait_For_Start:
' Prepare motor for operation
    HIGH 2           ' take serial line high
    LOW 3            ' reset motor controller
    HIGH 3
    PAUSE 100        ' motor controller startup time
    SEROUT VFD, Baud, [CLR]               ' Clear The Display
    SEROUT VFD, Baud, ["Model CTA-OA-07 ", CR, LF, "START     ADJUST"]
  LargestForce = 0

  DO
  LOOP UNTIL IN0 = 1  OR IN4 = 1    ' wait for any button press

  IF IN0 = 1 THEN ' Start compression testing
     GOSUB Start_Machine
     RETURN
  ENDIF
```

```
  IF IN4 = 1 THEN    ' Config mode to adjust height
      SEROUT VFD, Baud, [CLR]               ' Clear The Display
      SEROUT VFD, Baud, ["  Load Length", CR, LF, "LOWER      RAISE"]
      PAUSE 100
      DO
      LOOP UNTIL IN0 = 1 OR IN4 = 1
      FREQOUT 6, 200, 2000   ' Beep sound
   IF IN0 = 1 THEN     ' move down until black button is pressed again
      FREQOUT 6, 200, 2000   ' Beep sound
      SEROUT VFD, Baud, [CLR]               ' Clear The Display
      SEROUT VFD, Baud, ["    Caution", CR, LF, "Lowering Plates"]
      DO
       SEROUT 2,84,[$80, 0, 1,127]
       PAUSE 20
     LOOP UNTIL IN0 = 1
     FREQOUT 6, 200, 2000   ' Beep sound
   ENDIF

   IF IN4 = 1 THEN       ' move up until red button is pressed again

      FREQOUT 6, 200, 2000   ' Beep sound
      SEROUT VFD, Baud, [CLR]               ' Clear The Display
      SEROUT VFD, Baud, ["    Caution", CR, LF, " Raising Plates"]
      DO
        SEROUT 2,84,[$80, 0, 0,127]
        PAUSE 20
      LOOP UNTIL IN4 = 1
      FREQOUT 6, 200, 2000   ' Beep sound

   ENDIF

   RETURN
  ENDIF

  DEBUG CLS
  RETURN

' -------------------------------------------------------------------------

Start_Machine:
   LargestForce = 1
    ' Starting Sound - a beep
    FREQOUT 6, 200, 2000
    ' Run Motor
    HIGH 2            ' take serial line high
    LOW 3             ' reset motor controller
    HIGH 3
    PAUSE 100         ' motor controller startup time


    ' Apparatus is engaged - Caution!
  SEROUT VFD, Baud, [CLR]               ' Clear The Display
  SEROUT VFD, Baud, ["Keep Clear", CR, LF, "At All Times"]
 DO
    ' Read FlexiForce Sensor
  HIGH sensorPin                        ' Discharge the capacitor
```

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```
  PAUSE 2
  RCTIME sensorPin,1,rawForce           ' Measure RC charge time

  DEBUG  "Flexiforce raw output = ", DEC rawForce,CR
  SEROUT VFD, Baud, [CLR]               ' Clear The Display


 Force = calibtimesgrav / rawforce
 ForceInteger = Force
 ForceDecimal =  (calibtimesgrav) // rawforce
 IF ForceInteger > LargestForce THEN
 DEBUG "hello"
   LargestForce = ForceInteger
   LFInteger = ForceInteger
   LFDecimal = ForceDecimal
 ENDIF
  SEROUT VFD,Baud, ["Specimen Testing:",CR,LF]
  SEROUT VFD, Baud, [DEC3 ForceInteger,".", DEC2 ForceDecimal,"N"]
  SEROUT 2,84,[$80, 0, 1,50]
  PAUSE 20
 LOOP UNTIL IN0 = 1
 FREQOUT 6, 200, 2000   ' Beep sound
' Slow motor down to complete stop
   FOR speed = 127 TO 0
       SEROUT 2,84,[$80, 0, 0,speed]
       PAUSE 20
   NEXT
  SEROUT VFD, Baud, [CLR]
  SEROUT VFD,Baud, ["Max. Strength:",CR,LF]
  SEROUT VFD, Baud, [DEC3 LFInteger,".", DEC2 LFDecimal,"N"]

 PAUSE 5000
 DO
 LOOP UNTIL (IN0 = 1 OR IN4 = 1)
 FREQOUT 6, 200, 2000   ' Beep sound

  RETURN

' -------------------------------------------------------------------------
```

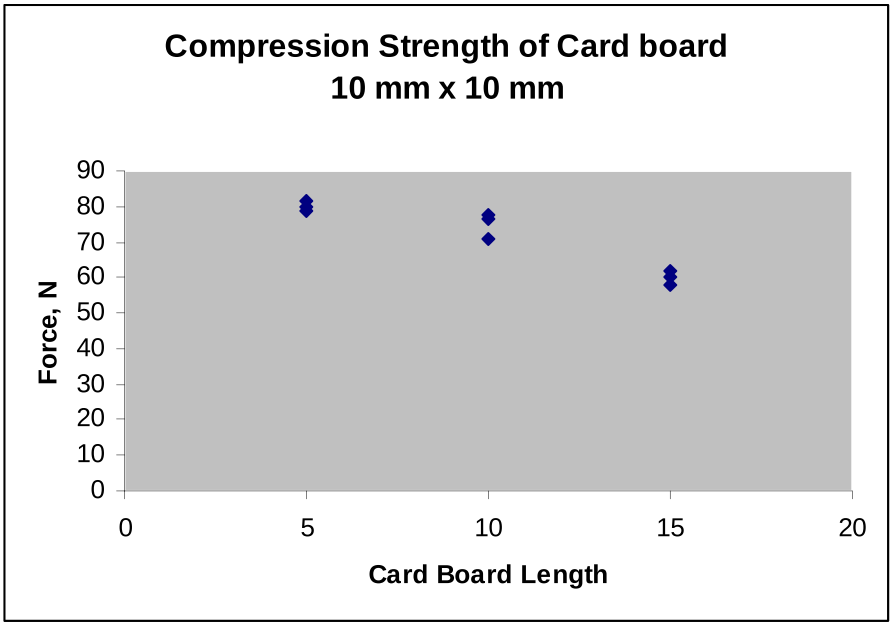
7-How it works:

The flexi force whish is connected to a capacitor acts like a resistor. When the sensor is unloaded its resistance is very high (the rctime will be low). When a force is applied to the sensor, its resistance decreases (the rctime will be).

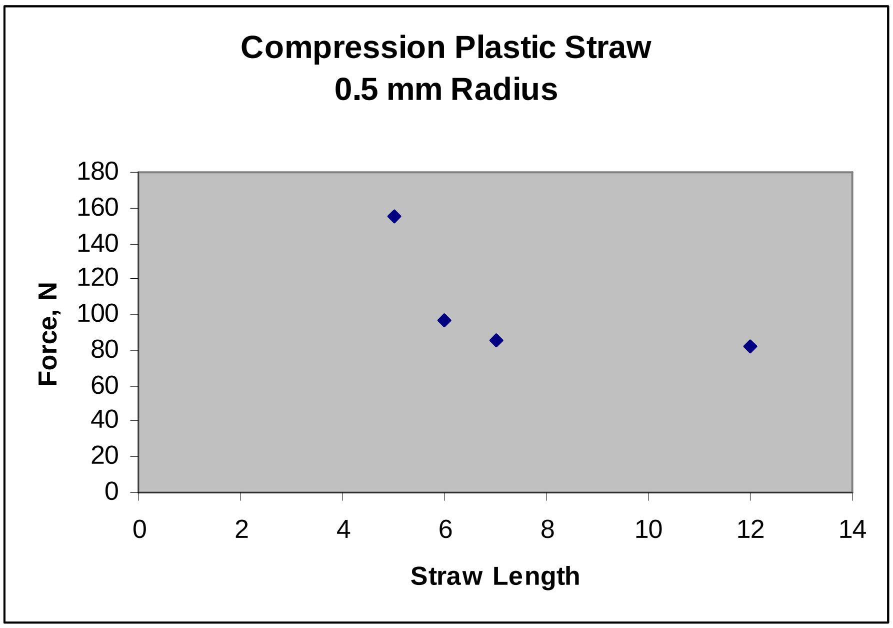
The computer will read the input from the flexi force as raw number. A command in the programming will change this raw number into a Newton. Using a the rctime of a known mass (in our case 1 Kg)
The black push button starts the motor that will rotate forward turning the screw the pushes the piston down.
The red push button will end the program and will make the motor rotate backward making the piston go up.
The motor that is controlled by the microcontroller will increase the compression on the load (object tested) until the object buckles.
The result (the highest compression) is displayed in the LCD

8-Results

Test Number	Size	Length	Compressive Strength
	(mm)	(cm)	(N)
C1	10 x 10	5	79.63
C1	10 x 10	5	78.48
C1	10 x 10	5	81.54
C2	10 x 10	10	70.71
C2	10 x 10	10	77.84
C2	10 x 10	10	76.72
C3	10 x 10	15	60.2
C3	10 x 10	15	62.15
C3	10 x 10	15	58.12
C4	6 x 10	5	
C4	6 x 10	5	
C4	6 x 10	5	
C5	6 x 10	10	39.55
C5	6 x 10	10	
C5	6 x 10	10	
C6	6 x 10	15	
C6	6 x 10	15	
C6	6 x 10	15	



Plastic Straws	**Radius**	**Length**	
	cm	**cm**	
circular	0.5	5	155.14
circular	0.5	6	96.4
circular	0.5	7	85.38
circular	0.5	12	82.42
Triangle		6	32.7
Triangle		12	11.97
Wood	**Radius**	**Length**	
circular	0.5	6	52.4
Triangle		6	36.5



9- Conclusion

Throughout this project, our goal was to provide students with a visual demonstration of the procedure engineers use to test materials for their strength using a compressor. Our compression testing apparatus is a smaller scale model that operates and replicates what actual compressors run and test in the industry standards. We believe this experiment conducted in our school lab will confer our students with clear idea of the actual procedures, and hence will help them make decisions and planning regarding their what-about their would be exposed later if they were to opt for this rapidly growing engineering field.

10--Future work

Design a device that will test how much an object can extend (measure tension) and see if there is any type of relation between the compression and the tension of a same object

11-Activities

1- Explain that when forces on an object are balanced, the motion of the object does not change.
2- Identify all the forces acting on a single object.
3- Determine what factors need to be considered in building stable object.
4- Determine what structure is more suitable for building a stable bridge.
5- Compare and contract the pros and the cons of various bridge building materials.
6- Draw a graph.
7- Newton third law of motion : for every action there is an equal and opposite reaction
8- Analyze data

12-Curriculum Correlation: NY State standards

1-PHYSICS

STANDARD **4:** investigate the use of common forces (push and pull) on objects.

Standards 5: matter is made up of particles whose properties determine the observable characteristics of matter and its reactivity

2--Technology:

Standard 5: students will apply technology knowledge and skills to design, construct, use and evaluate product and systems to satisfy human and environmental needs

3-Interdisciplinary

Standard 6: students will understand the relationships and common themes that connect mathematics, science and technology.

Standard 7: student will use the knowledge of thinking skill of mathematics, science and technology to address real life problems and make informed decisions.

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References

1- 32.brinkster.com
2- Glenbrook.k12.il.us/GBSSCI/physic.
3- www.En.wikipedia.org/wiki/surface
4- Parallax.com
5- www.popolu.com
6- www.stampsinclass.com
7- What is a microcontroller .by Andy Lindsy. Version 2.2
8- Basic stamp syntax and reference manual version 2.2
9-