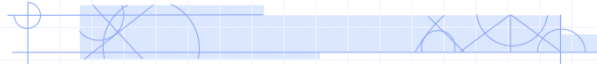
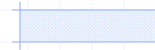




ENGR 59 Final Project:
Investigation of Physical Properties of
Cyanoacrylate-Sodium Bicarbonate Adhesive
Compound



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ENGR 59, 2010
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Presentation Outline

- Introduction to Project & Material
- Testing
 - Preliminary Tests
 - Mechanical Property Tests
- Results
- Conclusions





Introduction

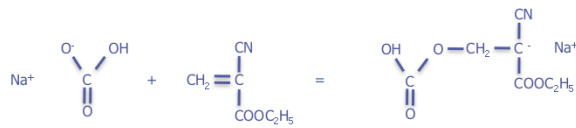
- Project: determine physical properties of superglue-baking soda adhesive filler compound
 - Determine best method of producing compound
 - Determine basic mechanical properties of material, as well as avenues for future work





The Material

- Combination of cyanoacrylate adhesive (superglue) and sodium bicarbonate (baking soda).
 - Sodium bicarbonate is an *activator* for superglue – initiates the curing process.
 - Chemical formula: $\text{NaHCO}_3 + \text{C}_6\text{H}_7\text{NO}_2$





The Material

- Through layering of cyanoacrylate and sodium bicarbonate, solid blocks can be formed, allowing gap filling & additive construction beyond that allowed by superglue
- Similar in application to commercial products like DEVCON or wood putty





Motivation

- Why superglue and baking soda?
 - Cheap
 - Ubiquitous
 - Relatively safe materials
 - Easy to work
- Why should we test this?
 - Rigorous determination of physical properties will allow material to be used in engineering applications - especially useful for engineering students!
 - Prototyping
 - 3D Printing
 - Can this material be produced to have repeatable properties?



Tests

- Phase I: Preliminary Work
 - Determine best method for producing material
 - Can material be machined into test specimens?
 - Determine which formal tests should be conducted
 - Three tests selected from: compressive strength test, flexural strength test, tensile strength test parallel to layer plane, tensile strength test perpendicular to layer plane
 - Anisotropy?

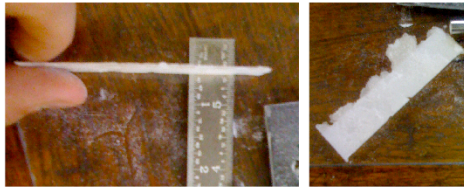




Tests

- Phase I Tests: Production Methods
 - Layering and flushing

Flushing



Layering



Flushing does not penetrate deeply enough, even with low-viscosity superglue

Layering Production Methodology:

Lay down layer of glue

Completely submerge in baking soda

Tamp baking soda

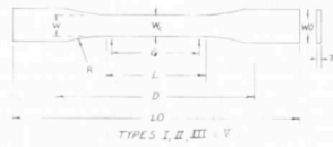
Uncover, repeat.

Layers are roughly .025"



Tests

- Phase I Tests: Testing of Properties
 - Tensile Strength Test - ASTM D 638
 - Type I Specimen: 6.5 in. x .5 in. x .13 in.



Tensile Test Specimen [ASTM D 638, p.161]

- Loading: At .2 in/min or as slow as possible to achieve fracture within 1/2 to 5 min.
- Load measured using machine gage: extension measured with mechanical strain gage

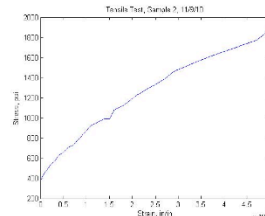
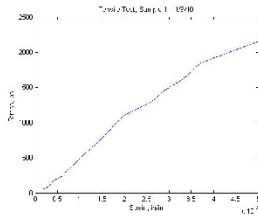
Initially, loading was too slow – tests took closer to 15 min.

Resolution of strain gage is only .001”



Tests

- Phase I Tests: Testing of Properties
 - Tensile Testing: 3 tests conducted, 2 successful
 - Load parallel to layer plane



- Average ultimate strength: \approx 2750 PSI



Test failed due to machine error



Tests

- On to Phase II!
 - Because of layers in material, anisotropy is a concern
 - Superglue is expensive: for statistically sound tests, sufficient material for only 2 sets of tests
 - Tests conducted:
 - Tensile test parallel to layer plane – 10 specimens
 - Tensile test perpendicular to layer plane – 10 specimens

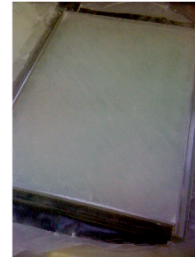


Layers would not have been an issue with flushed samples: however, these proved impossible to produce.



Tests

- Phase II: Material Production
 - Tension Parallel to Layer Plane
 - 15" x 11" x .18" plate produced
 - Cyanoacrylate: Permabond 268
 - Ethyl-2 cyanoacrylate
 - High viscosity, deep gap fill
 - Shear Strength: 3000 psi (grit-blasted steel)
 - Stored in dehydration chamber between applications
 - Production method: as developed earlier
 - Temperature and humidity recorded during production
 - Cure for 2 hours – problems removing!



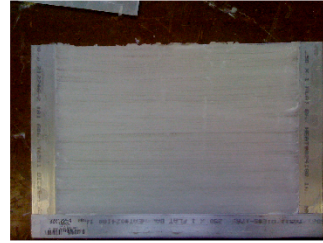
Humidity range during production: Max = 45.7%,
Min = 39.6%

Temperature range during production: Max =
23.9°C, Min = 22.5°C



Tests

- Phase II: Material Production
 - Tension Perpendicular to Layer Plane
 - 10" x 7" x .25" plate produced
 - Cyanoacrylate: Permabond 268
 - Production method:
 - Temperature and humidity recorded
 - Cure for 16 hours – believed to be thicker layers
 - True – up to .125" thick
 - Voids in sample from .01" to .1"



Mold held vertically in vise

Glue poured into mold, ensuring that no glue gets on the sides of mold.

Glue spread with steel rod

Flushed with baking soda.

Soda allowed to sit momentarily, then dumped out and remnants blown out/brushed out with steel rod.

Temperature Range: 23.4° C to 22.8° C

Humidity Range: 50.7% to 40.2%



Tests

- Phase II: Testing
 - Tension Testing
 - 10 tests per material conducted using Tinius-Olsen UTM, 600 LB scale
 - Hand-tight preload (= 5 lbs)
 - Extension rate: .028 in/min
 - Mechanical strain gage applied at start of test: removed once maximum strain had been reached
 - Percent elongation at rupture recorded from dial indicator measuring lower head of UTM





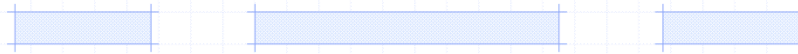
Results

– Tension Perpendicular to Layer Plane

- Modulus of Elasticity: $\mu = 17.149$ KSI, $\sigma = 2.703$ KSI, C.O.V = 15.7%
- Ultimate Strength: $\mu = 1.038$ KSI, $\sigma = 0.295$ KSI, C.O.V = 28.4%
- Percent Elongation at Rupture: 2.52%

– Tension Parallel to Layer Plane

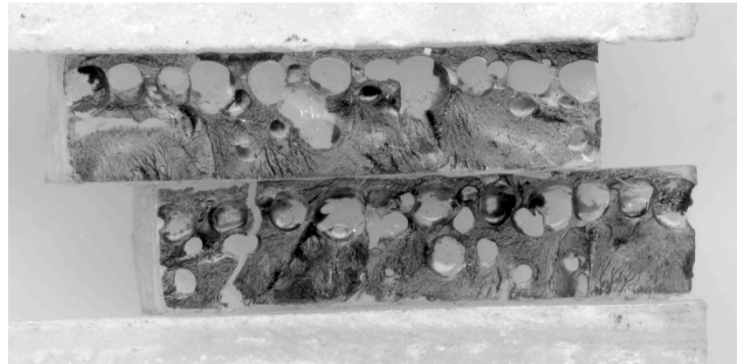
- Modulus of Elasticity: $\mu = 27.514$ KSI, $\sigma = 4.773$ KSI, C.O.V = 17.3%
- Ultimate Strength: $\mu = 2.487$ KSI, $\sigma = 0.292$ KSI, C.O.V = 11.7%
- Percent Elongation at Rupture: 2.27%





Results

Perpendicular to layer plane



Serious voids

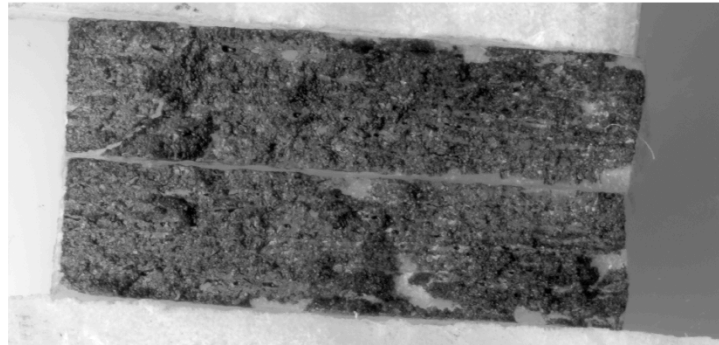
Fracture mainly in superglue – 40% of tests (30% in baking soda, 30% between both)

Typically, fractures occurred around voids



Results

Parallel to layer plane



Much more homogenous surface
Small voids, but closer to .01" than .1"



Conclusions

- Unclear if difference in measured values is due to anisotropic effects or due to poor material production methods
 - Difference in tensile strengths of wood is <90%: difference in cyanoacrylate compound is only 59%
 - Higher C.O.V of perpendicular tests indicative of lower quality samples
 - Test set including only perpendicular-loaded samples that broke at mixed baking soda-cyanoacrylate interface still only yields maximum strength of 1.293 KSI, modulus of elasticity of 17.031 KSI
- Refinements of production method and further testing needed
- However, useful information on tensile strength of material collected

Point 1: Anisotropic effects or low-quality samples?

Point 2: Low quality samples

Point 3: However, best samples still underperform. But is this due to layer thickness?



Conclusions

- Thanks to:
 - Prof. Siddiqui and Smitty for assistance throughout project
 - Charlie Loeffler at Permabond for technical consultation
 - Permabond for donation of superglue



Conclusions

Questions?

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