National® Brand

COMPUTATION NOTEBOOK

Department MILLIKEN

Subject RESEARCH

Name PATRICK PETRI

Address M-405

43-648

75 Sheets, 4 x 4 Quad., 11 3/4" x 9 1/4"

scan 12x9

2011-10

0 73333 43648 8

Rediform Inc. • Coppell, TX 75019

Made in Mexico

Master List of Projects

#1 Eminus 9 PM (43" wide line)

#2 Eminus 9 2" (Basement)

#3 Eminus 9 6" (Basement wide die)

#4 Eminus 9 Wide

#5 ~~Aurora~~ Vulcan

#6 Lestrales

#7 Stratocumulus

#8 Eminus Solvent Wash

#9 General

#6 Lestrales - Multisplice version 2 Design

Continuing from page 20973-96, if we opt for the parallel splice arrangement, I would chose option B_3 because it is fairly simple and centers the yarn, or B_1 because it may do a better job of "picking up" the yarn. Try to keep total area constant. Maybe try multiple options.

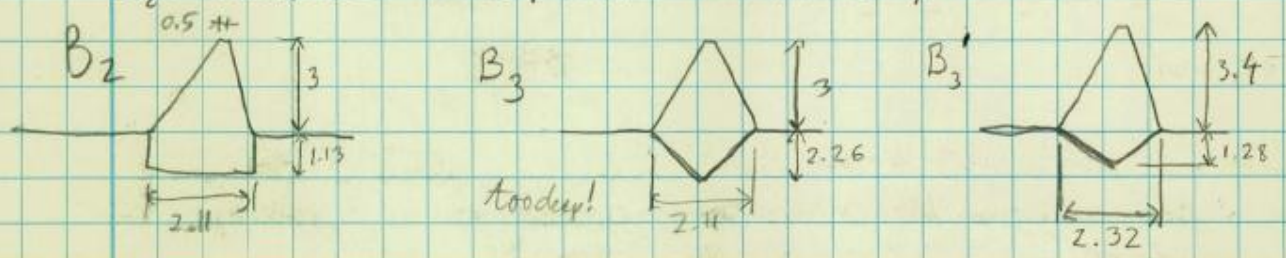
- 134.88 mm² - chamber with current notch
- 141.17 mm² - chamber, no notch

6.29 mm² - total groove area

Shorten groove to 3 mm deep: 137.26 mm², 3.91 mm²

→ Leaves 2.38 mm² for sealing bar side

B_2 would be 2.38 / 2.11 = 1.13 mm deep



~~3.75 mm deep → 135.52 A = 5.65 A_2 = 0.64 0.64/~~ $\xrightarrow{\times 2}$ 1.28

3.4 mm deep → 136.37 A = 4.80 A_2 = 1.49 1.49/2.32 = 0.64

This results in a 122° angle, round to 120°

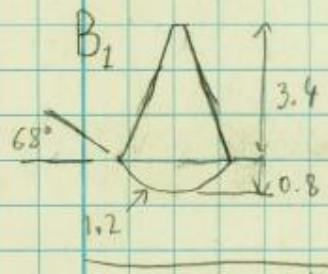
B_1

roughly a parabola → ⅔ of rectangle area

with 3.4 mm groove, R1.4 → A_2 = 1.01 R1.2 → A_2 = 1.54

R1.25 → A_2 = 1.32 1.2 it is...

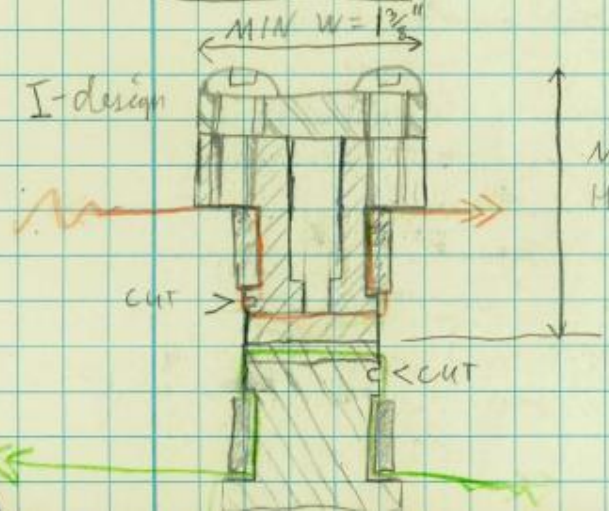
B_1



Air infusion: To run air to slots, need minimum area of 0.127 in² = (0.356 in)²

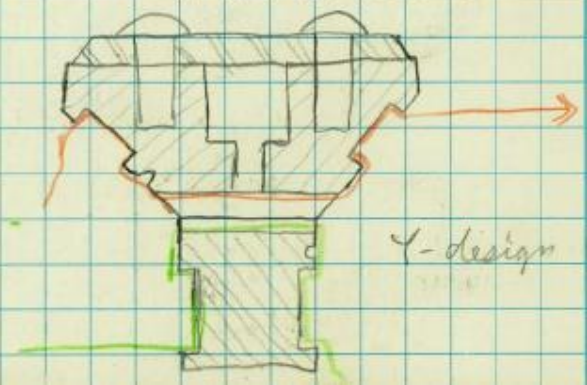
DAVID GREER - PI leader at Lyllikland, owes me a cost savings estimate

I-design



chamber: ⅜" × ¾" = 0.28 in²

6.7 × nozzle area

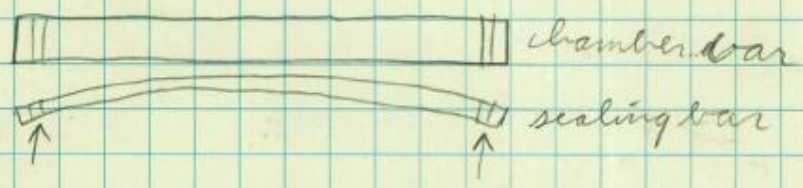


Y-design

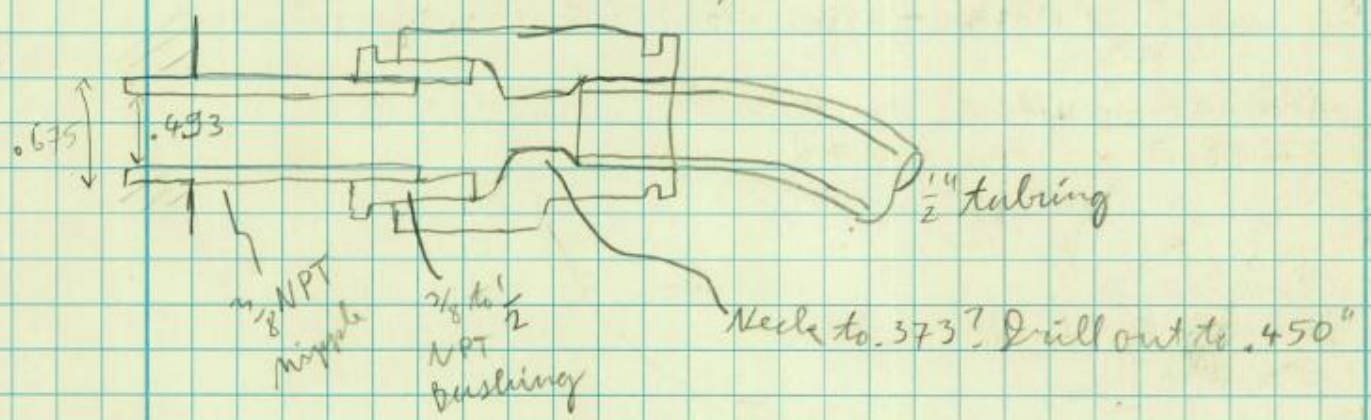
#6 Sestrales – Multisplice Version 2 Design, ctd.

Y-design: chamber = $\frac{1}{2} \times \frac{1}{2} = 0.25$ in^2
$W_c = 2''$ as drawn
$H_c = 1\frac{1}{8}''$

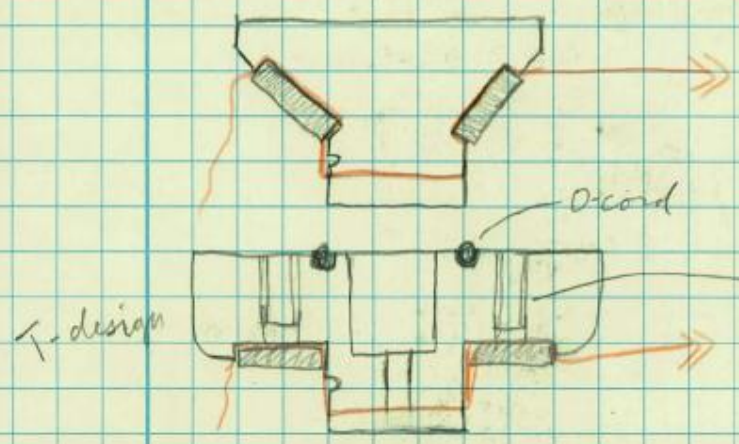
~~Upon~~ Size isn't really a constraint! Full width version may need a lid thick enough to screw in an NPT fitting. Other changes for long term: Make bar of Aluminum, embed a gasket possibly, put in metal plates for magnets, maybe magnets to join chamber bar to sealing bar – or not. Perhaps some curvature?



Also note: $\frac{1}{2}''$ NPT = .840" OD .534" thread
need to be 1" wide to attach fitting! .703 tap
use nipple ... $\frac{1}{2}''$ has 0.622" ID
$\frac{3}{8}''$ has 0.493" ID (Nipple) .675" OD (thread)
$\frac{1}{4}''$ has 0.364" ID .572 tap
$\frac{1}{2}''$ tube to $\frac{1}{2}''$ NPT is only 0.373" ID – but could be drilled out to maybe 0.450"



$\frac{3}{8}''$ tube – Just use $\frac{1}{2}$ NPT to $\frac{3}{8}''$ tube adapter

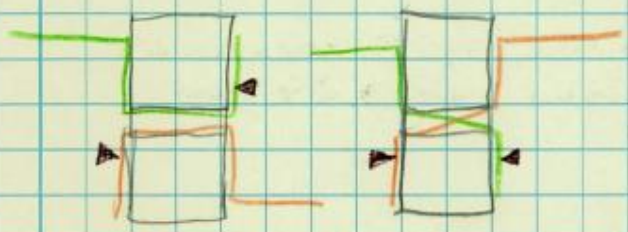


Modified Y-design
↳ utilize comes to get better hold on yarn, less force on magnet
↳ shorter tail

stagger holes away from yarn or drill blind eventually

#6 Testrales - Multisplices v2 Design, ctd.

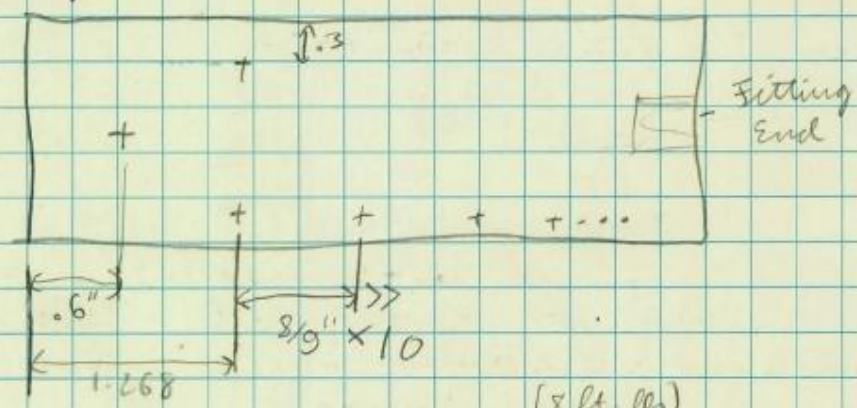
What are my FR's?
- Not ready for beta prototype, objective is ability to measure and test some features.
- Bolt on slot cover. May block some holes to check air flow.
- See what mass will lift up from air impact ↳ separation force
- Try both cross thread and parallel → need to add extra cut grooves!



Min: Just do all 4.

- Y-design so we can pull both ways (Half on incline, half vertical)
- Change fitting to run 3/8" tubing, fitting limits.

Hole pattern:

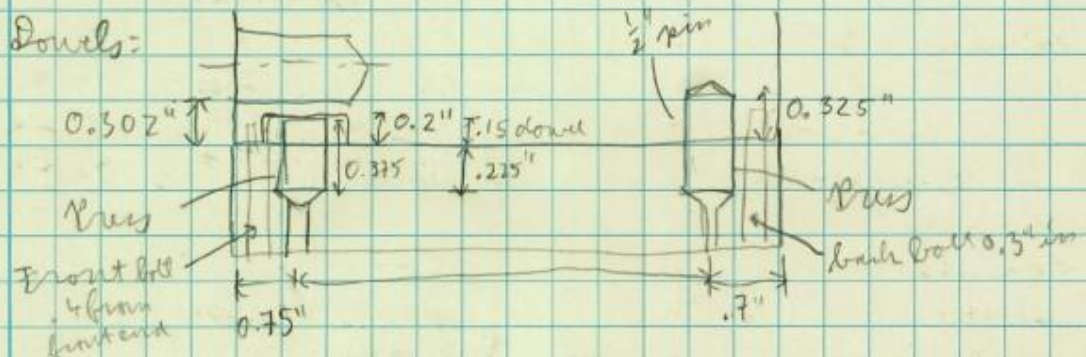


21 Holes on 16.25 in², ¼-20 bolts → 96 in-lbs (8 ft-lbs), ≈ 2850 clamp lbs

"Average" pressure - 3,683 PSI

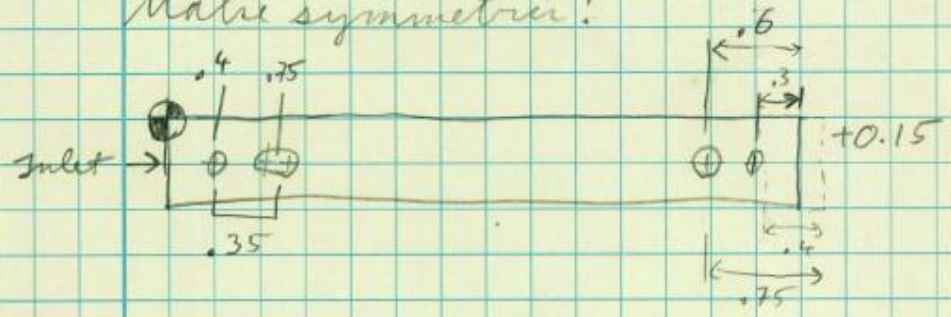
Perfect seal, metal on metal should be 10,000 PSI, but who cares about leaks when we are open to atmospheric and leaking 48 CFM?

Dowels:



#6 Sestrales - Multiplier v2 Design, ctd.

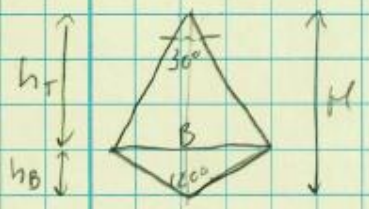
Make symmetric!



(Now 10.15")

Also shorten dowel pin to make equal?

BUT grooves aren't centered anyway...
Keep asymmetric.
MISTAKE: B_3' with 1.28 mm depth gives an 84° angle, not 122°... That would be 0.64 mm.
Change groove depth:



Area = $\frac{1}{2} B \times H$!
Take away ½ mm flat and
$A_{before} = \underset{h_{T,b}}{0.194''} \times \underset{B_{,b}}{0.104''} / 2 = 0.0101 \text{ in}^2$

$$\tan 15° = \frac{B}{2h_T} \qquad \tan 60° = \frac{B}{2h_B}$$

$$\frac{h_T}{h_B} = \frac{\frac{B}{2\tan 15°}}{\frac{B}{2\tan 60°}} = \frac{\tan 60°}{\tan 15°} = 6.464$$

If B were fixed, $h_T + h_B = 0.194''$ $\quad h_T = .194 \cdot \left(\frac{6.464}{7.464}\right)$ .866

$h_T = 0.168''$ $\quad h_B = 0.026''$

But now B = 0.090" area is $\frac{.090}{.104}$ = 87% of previous
make 7.5% bigger ($\sqrt{1/0.87}$)

☆ $h_T = 0.181$ $\quad h_B = 0.028$ $\quad H_{after} = 0.209''$
$B_{after} = 0.097''$ $\quad A_{after} = 1.014 \text{ in}^2 \times 10^{-2}$

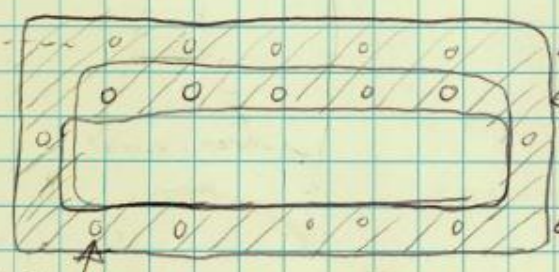
Note h_T - cap = 0.1437" - true groove depth
Move lid holes to .7", 1.368"

	PARTS		MACHINE	
M	⅜ NPT Nipple × 2"	1		
M	⅜ to ½ NPT bushing	1	- Chamber Bar	87929
M	½ NPT to ½ adapter	1	- Sealing Bar	87930
M	½ NPT to ⅜ adapter	1	- Chamber Lid	87931
✓	¼-20 × ½ caps	21		
✓	¼ × ⅜ dowels	2	Disk # 1551	
✓	¼ × 1" caps	2		
M	½" magnet strips	4 × 10"	5693K11 6 lb, 5693K14 4 lb, 5769K22 12 lbs	

#1 Eminus 9 PM - 11/7 Trip Notes

Took out vacuum box - went fairly smoothly except max ht is 37 1/2" vs 37 1/8" opening. (14:17)
Duct clamps have foam lines which is starting to disintegrate
Drive motor guard plate was not installed - just the inside cover plate
Also, need to take snorkel slot cover off to slide in.
14:36 - still waiting ~15:10 start grinding
17:08 - done grinding, belt installed, ready to go
Snorkel slot cover: bolts don't fit under cross beam
0.563" from beam to plenum
↳ 1/4" bolt head, 1/8" plate, 0.188 clearance
but need 0.250 clearance to start bolt
A button head may just fit
Could make a fix-it piece

BEAM



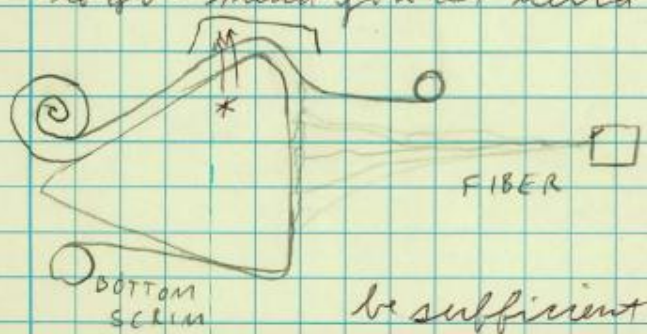
← thin, bolt to current holes
← new set of holes to attach snorkel, thicker section
← thru holes, use existing

hole stripped, thread this on

As drawn, would be on top, but several options
- Plate on top, bolt from top
- Plate on top, drill out & bolt from inside
  ★ may be the best option - could also bolt straight to snorkel
- Plate inside, bolt from inside
- Plate inside, drill out & bolt from outside (why?)

Hood

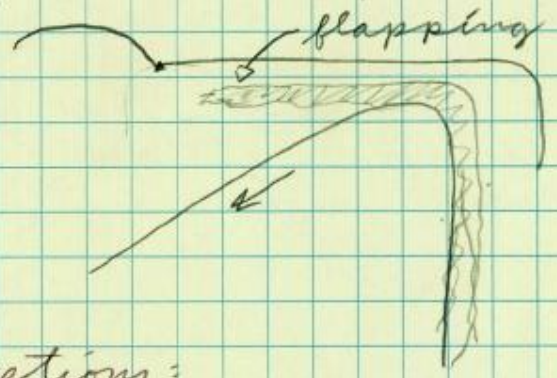
Observation: Double scrim material ran remarkably well, even though air had nowhere to go - mind you at ultra far collection distance (~8')

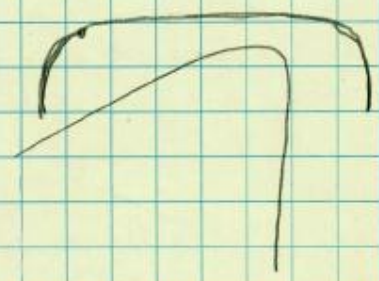


* Also: When running thinner or looser material, air is sucked up thru belt here causing problems. Could use snorkel, but may be sufficient to prevent air flow in.

#1 Emmins 9 PM - 11/7 Trip Notes, ctd.

Final hood issue: heavier air wants to follow hood surface and entrain the fiber blanket, tearing it up. Note, tailgate is up.

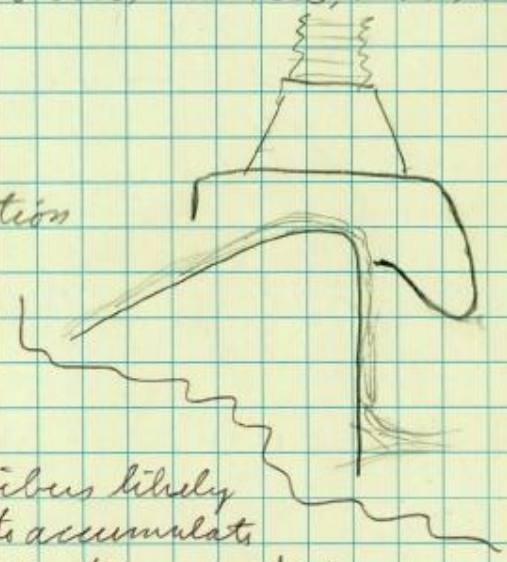




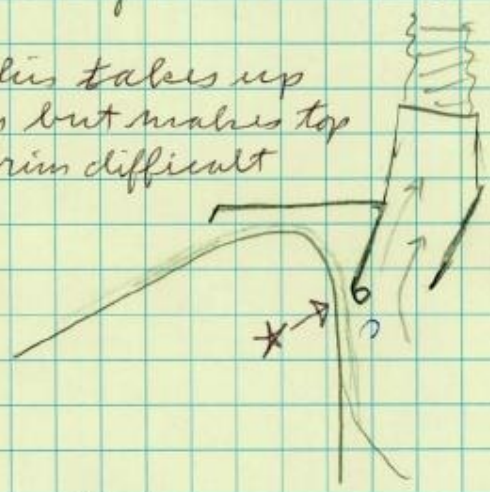
Options:

A) Close tailgate - causes other issues, not ideal

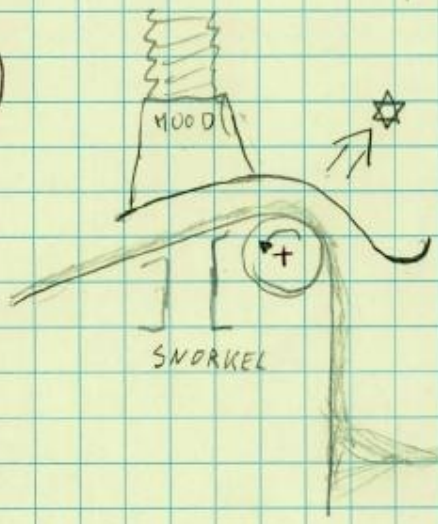
B) Split air on front side
- Mimics top screen
- Air spills on side
- May not even need suction



C) This takes up air but makes top screen difficult



D)

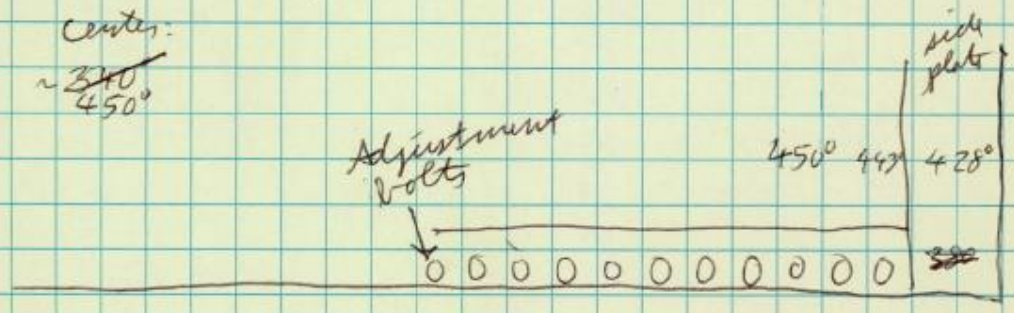


Compromise, should allow screen in and not accumulate fibers. High velocity air flows over surface. Suction counteracted by snorkel. Hood is off if upper screen used.

✡ Allow adjustment, move in this direction to set the gap.

#1 Evening 9 PM - 11/7 Trip Notes, ctd.

8:12 am - Rolling up fiber, getting close to starting samples
Bottom section has more suction than it needs
↳ go to solid plate? 5-10% open?
Just tape up back of current plate.
< 9:15 - run resin with additive (charge enhancing)
10:30 - running PET
die zones are about 1-45% 2-30% 3-30% 4-30% 5-45%
I suspect ends are still cool... probably good to control side plates.



- I don't trust this T/C, but edges are definitely colder

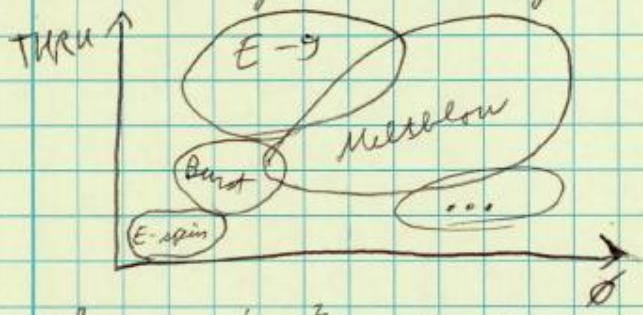
Need to bring good thermocouple probe and measure more carefully.

If changing side plates, get drawings from Allied.

#4 Eminus 9 Wide - 11/10 EOP Meeting

EOP = Eminus options project
Vogt, Korton, Wilson, Sabulandumbi, Wang, Hitchen, Petri, Kentrup

- Review "the deck", then brainstorm Monday - Chris
Tuesday - MPP to Sally
Check out appendix - broke down ranking even further
Dec 9 - Phase 2 committee meeting - present recommendation
(lay out different paths)
Need to lay out clearly Eminus vs other nanofiber



change ¼, ¾ pies to red / yellow / green

Idea: saturated closed cell foam filled with super glue

Paint holding medium to prevent drips and make application easier

#7 Stratocumulus - Early Ideas

Stephen Lucas at Magnolia asked for help with reducing waste at seam jumps on the Cirrus machine. There are many possible approaches:

- change seam strength so it can pass through
- move fabric faster so it can waste less yardage
- move blowing head if that is easier
  - ↳ rotate?
- deflect the air before it lifts the fabric
- block orifice in manifold
- block just before the orifice
- empty entire chamber to reduce pressure
- shut off supply into chamber
  - ↳ possibly reduce chamber size (capacitance)
- cool the air (enough?)
- cover the fabric with heavy duty material
- make fabric heavier and less susceptible
  - ↳ wet? = more mass to move around, cooler
- open slot to suck air away again
  - possibly passive - coanda effect
- add channel wall from other side to prevent flapping
- Bar to pull fabric away (less mass to move than current)
- Blow against air sheet to cancel out (> $P_{manifold}$)

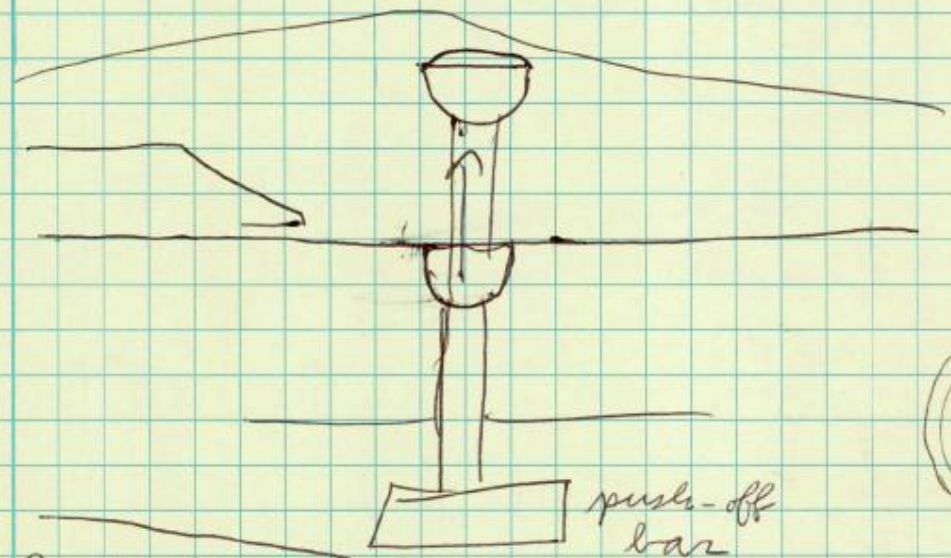
Key questions:

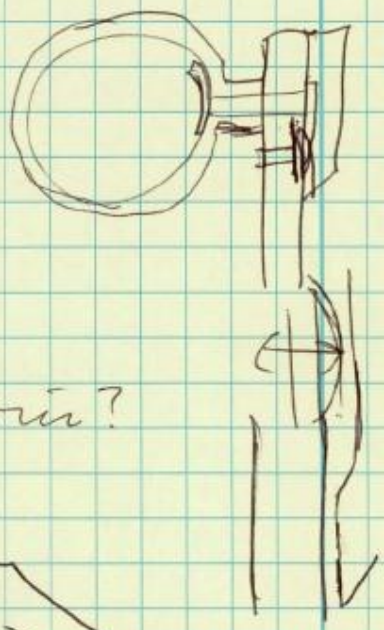
- Air Temperature? Don't know 300°F?
- Line speed? typ. 65 or 80 YPM
- Air volume (CFM)? No 8" Manifold OD
- Manifold pressure? 28 PSI
- Mode of seam failure? seam combing (butt seam)
- Does seam fail cold? yes
- Describe seam jumping procedure. What alerts that seam is coming? Why so slow? (10 yds/20 YPM = 30 sec) 7.5 sec
- How wide? 6', fabric ~65"

- Another possibility: "flutter guard" - prevent cirrus mechanism
  - ↳ May be easier to implement, don't have to block air completely.

#7 Stratocumulus - Early Ideas, ctd.

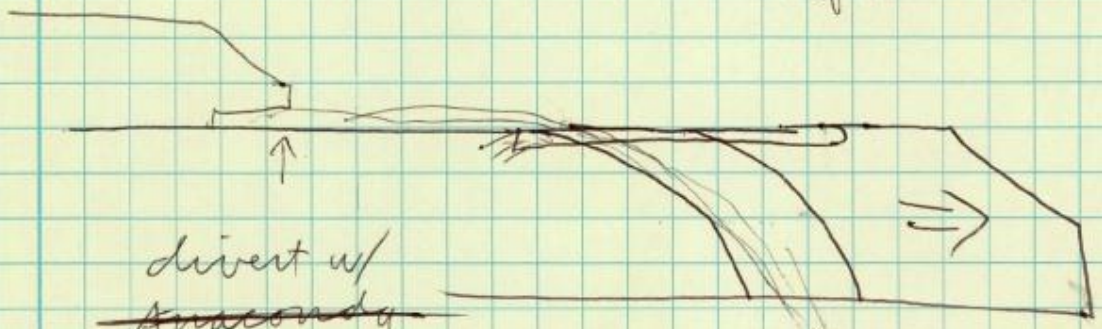
Lucas: detect seam with cheap noncontact device
↳ ~~capacitance~~? 3 sensors IR based
could do better...
operator verifies, but normally sensor driven
Air cylinder moves pivot for fabric
Put in stops to limit travel, reduce time
1" shaft, ~2 ½" bore
share compressor, need 2 of 3 compressors
3 machines, one on FR (More expensive, hand is more critical) may run 3X





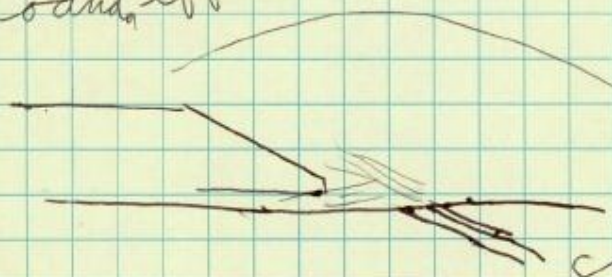
Butterfly valve

catch fabric?



divert w/
~~Anaconda~~
Coanda effect

Mon, Tues
best days

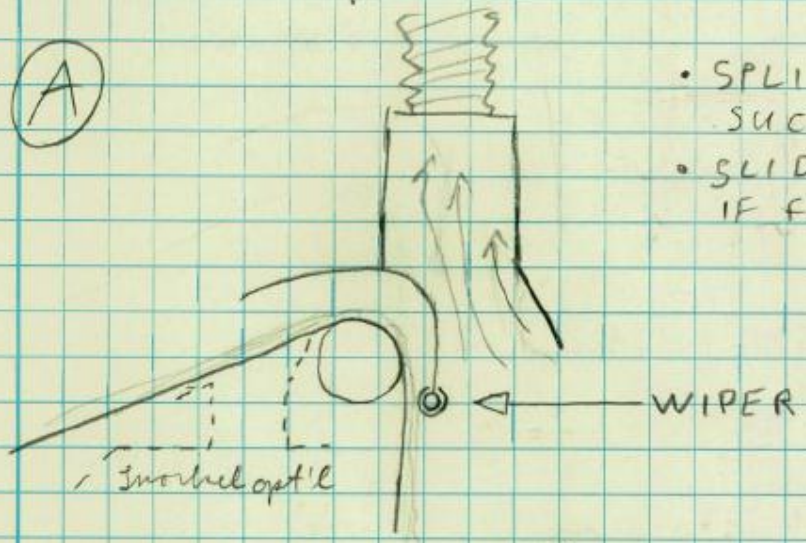


counter-blowing or blow fabric off

#1 Evening 9 PM - Hood & Setoff Concepts 11/11

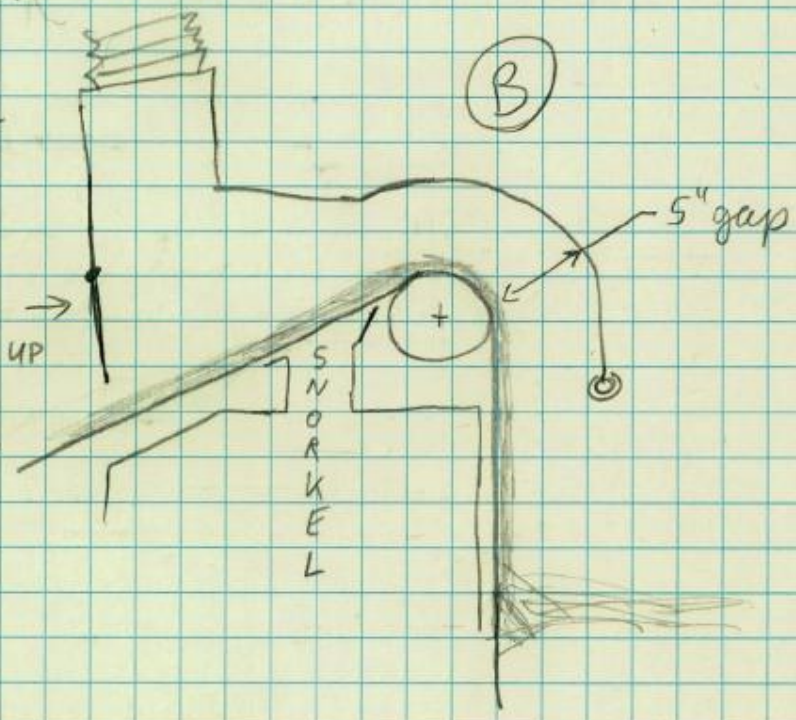
Hood: continued from page 7
combine best features

(A)



- SPLIT AIR & SUCK AWAY
- SLIDE WIPER ACROSS IF FIBERS ACCUMULATE

(B)



- MORE GENTLE TURN
- SNORKEL HOLDS DOWN

HINGE → OR SLIDE UP

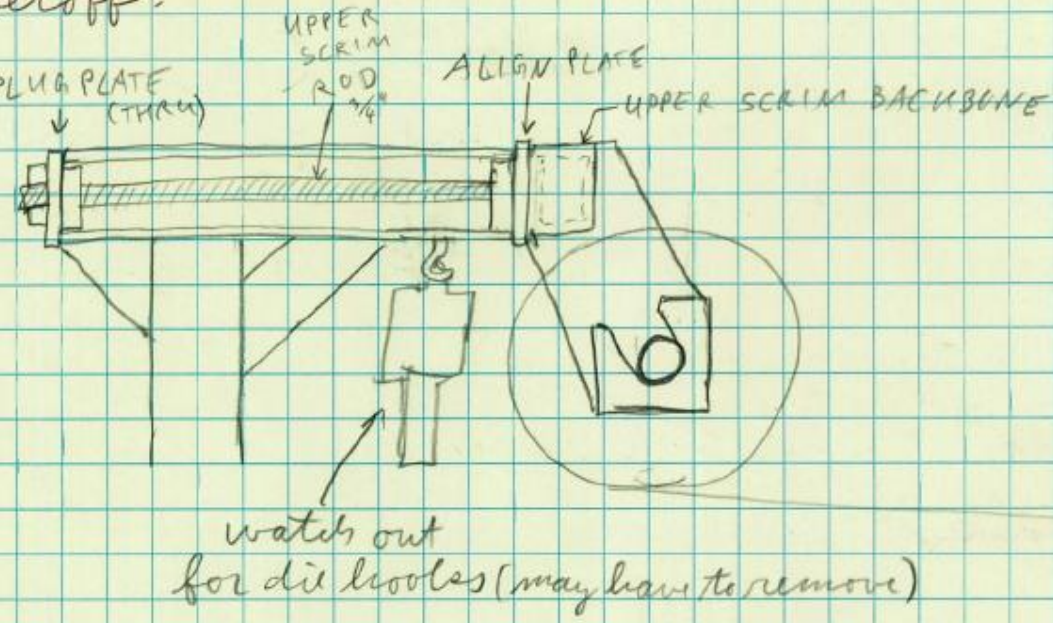
(A) For lofty webs, assume top seam
Able to adjust position, wiper distance from belt
There shouldn't be much air coming out the back. Try to balance weight over support.

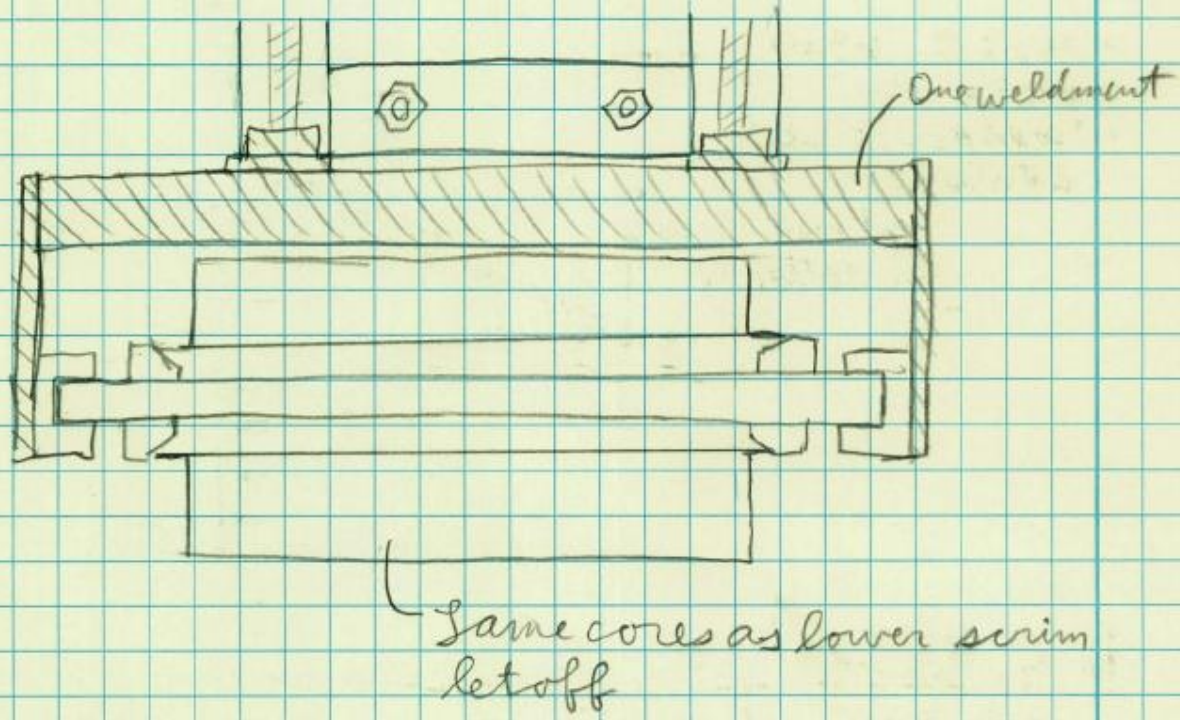
(B) May take up space & run into slitting mechanism
Wiper also optional but probably good idea since much like current hood.

☆ A is our winner! NOTE: needs seam set-off

#1 Eminus 9 PM - Hood & Letoff Concepts, ctd. 11/11

Letoff:

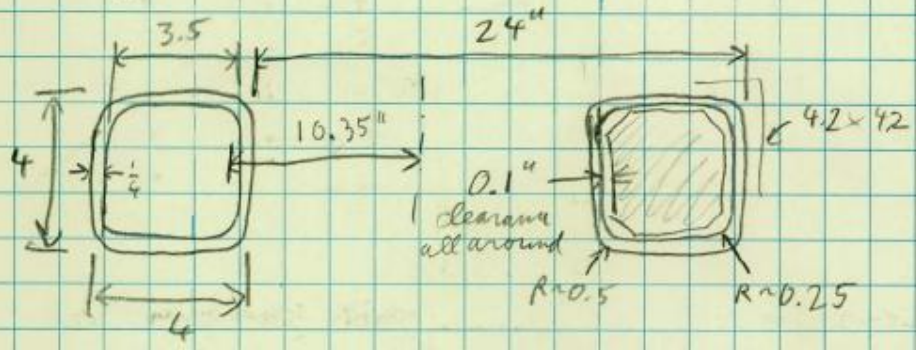




Issues: lifting heavy roll, having roll above hot die, roll blocking collection from coming close to extruder, etc...
Long term, could install 6' roll on mezzanine
Could remove hood and put 3' roll above the collection carriage
For now, limit to 12" to 18" max rolls and keep simple.

#1 Emiens 9 PM - Hood & Petoff Concepts, ctd 11/11

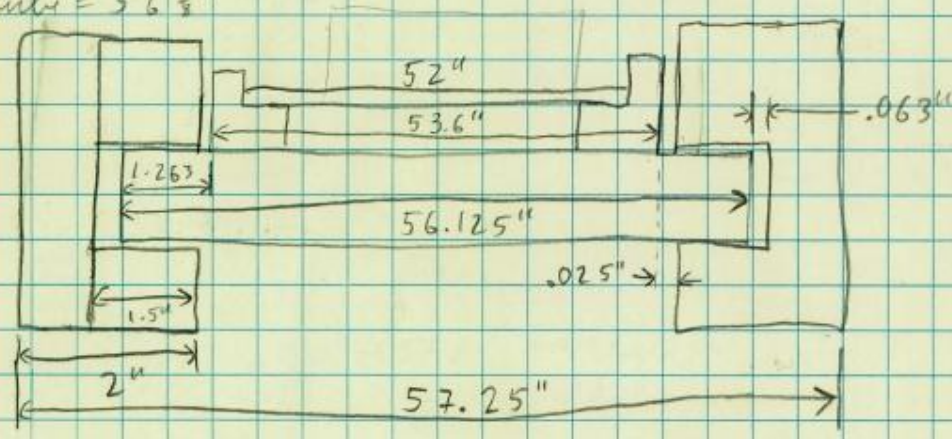
Tubing:



current roll mount = 57.25" w/ 2 × 1/16" clearance .125
57.125" = ZERO clearance
up to .1 → 57.325" between arms
(length of backbone)

.025" clearance w/ adapters set
core ⇒ 5.2" + 2 × 0.6" adapters + 2 × 2" socket + 2 × 0.025" adapters clearance
= 57.25" wall to wall space
to increase play, make deeper pockets in socket
"screw harness block" → "core socket block"
current 1/16" play @ 1.500" add 1/16" to 1.563"
core tube = 56 1/8"

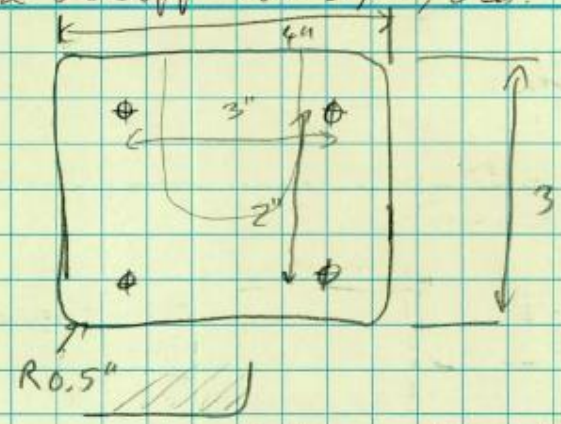
CURRENT



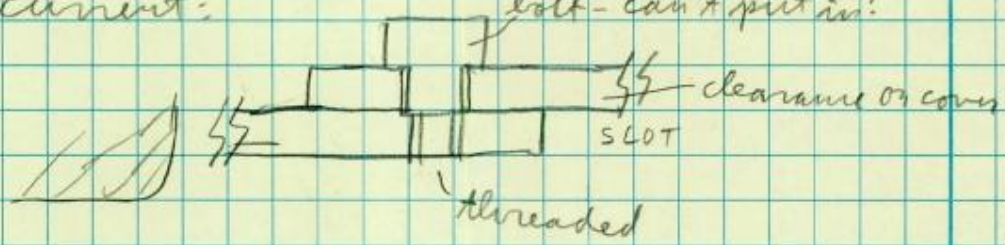
1.263" - min engaged is 1.213"
Keep same harness blocks, but increase 57.25" by 2 × .1" to 57.45"
→ min engage is 1.013"
→ gap (each side) = 0.125"
→ end gap = 0.163"

#1 Eminus DPM - Hood & setoff concepts, ctd.

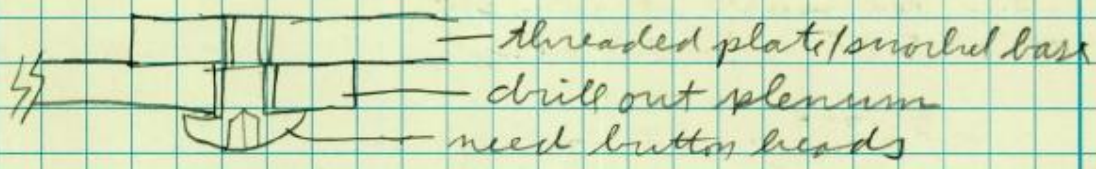
Harness Block:



Snorkel: current:



Plan:

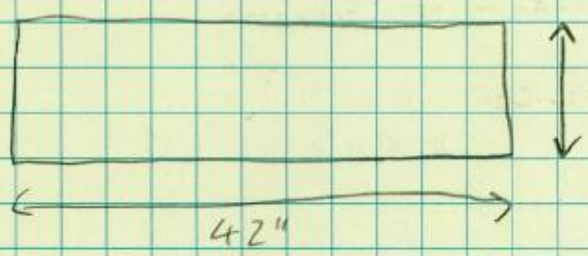


→ Have to take belt off to remove plate, but would be tough now.

Snorkel slot:

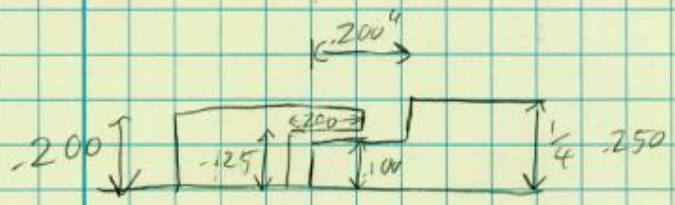
change to 3 7/8" for clearance!

change to 5.93"

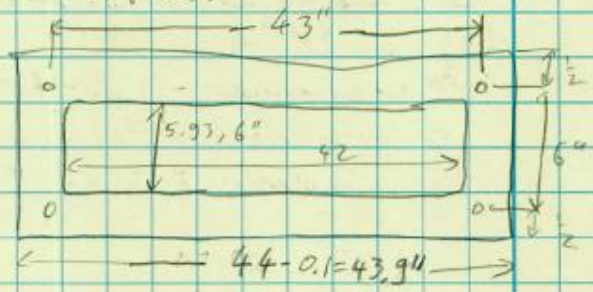


Top: 6.07"

Cover plate: Make Aluminum, 1/4" thick



surface:

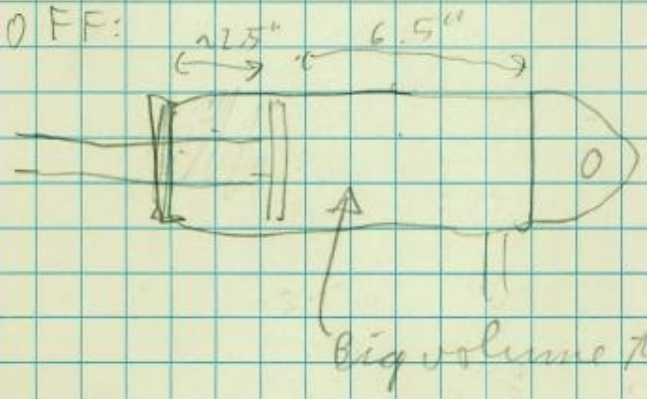


#7 Stratocumulus - Magnolia Visit 11/14

3 Machines running Cirrus
Cylinders take ~7.5 seconds
2.5" OD, ~9" length between ends

1.3 sec give or take to open, 6.2 to close
most of the time just sitting there

OFF:



What is cylinder pressure? 85 PSI?
Why is big a cylinder on a flimsy pivot?
Probably oversized!
Auto seam - timed 8.6 sec (inexact)
Ferris Jones - production manager. Can't always rely on numbers.
seam test - 85 VPM
distance from detector to treat:
seems to be set pretty well based on waste

air hose 3/8" OD, 0.063" wall (calipers) → 0.250" ID

Volumes:

9" cylinder - 44.2 in^3

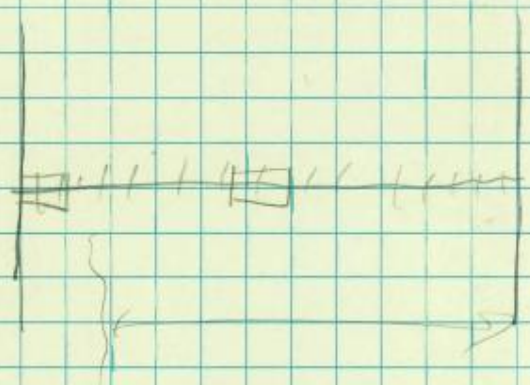
2.5" cylinder - 12.3 in^3

15 ft of air tubing - 8.8 in^3

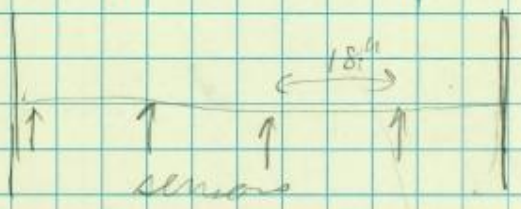
If tubing were limiting factor, piston would fill in 0.07 sec
→ clearly have big enough tubes, throttled by restrictor.

#7 Stratocumulus - Magnolia Visit, ctd. 11/14

Have metal detector for seam tape



full width for Panoptes



Everett Martin
↳ Factory Engineer

Bimba cylinder: Model C-502 5-DXP
= ⊗ ⊥

travel = 2.5" (est) OD ≈ $2\frac{3}{4}$"

← Possible piston rod extension

Video analysis:
0:21 - light comes on
↓ 30 frames = 1.0 sec
valve actuates
↓ 9 frames
rod mostly done moving
↓ 16 frames
0:23 rod completely done moving
0:30 start reengaging
↓ 24 frames (9 then pause, about 8 frames, 5 more frames)
piston moves back ↳ 22 total but only 14 moving

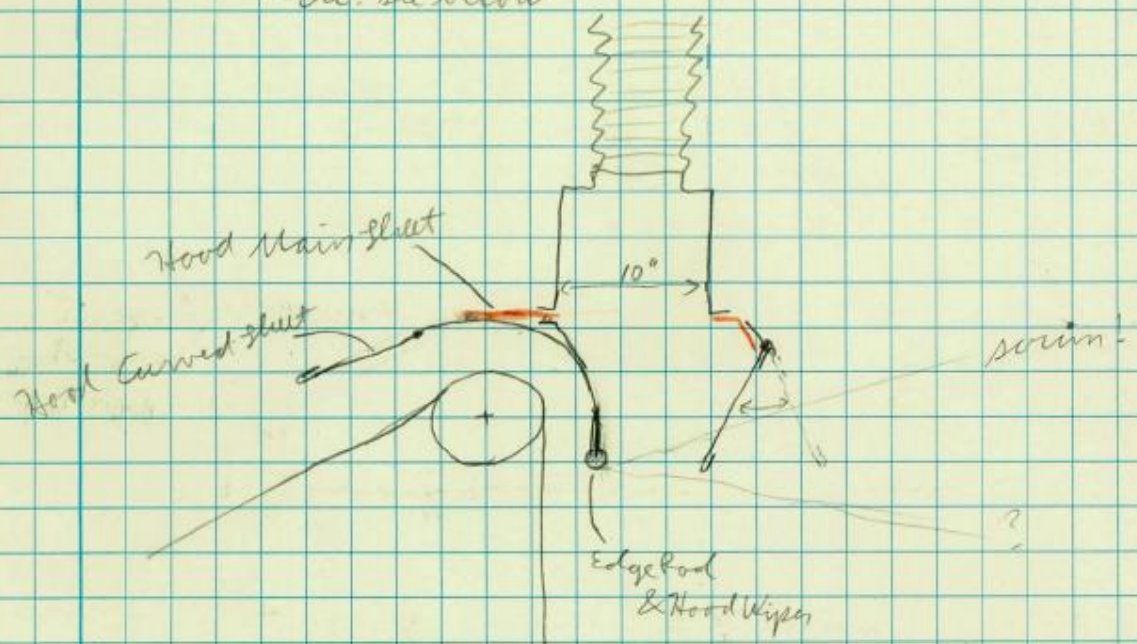
Cirrus scrap sample:
0": dark line in fabric
1.25": end of dark line
2": start of light ripples
5": closely spaced ripples
6": normal heavy ripples
~0.12 seconds @ 85 rpm

C-50 2.5-DXP Cushioned, 2.5" bore, 2.5" stroke, double acting, universal mounting pivot $\frac{1}{2}$"-20 rod
catalog page 80

#1 Eminus 9 PM - Hood Design 11/15-11/23

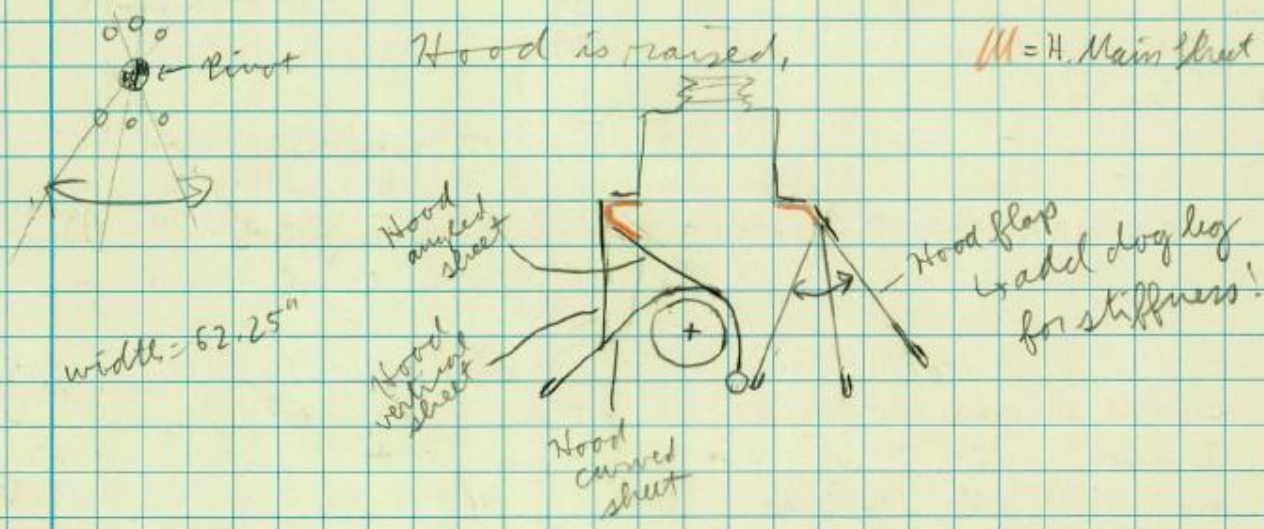
Flush out concept Ⓐ from page 12.

A_ 43in. Eminus Line PM
- Final Plant Assy Web v3
  - Hood Assy v3
    - Ducts & blast gates } reuse
    - Intake Hood 10"
    - Hood Shell weldment v2 → v3
      - Hood Main Sheet v3
      - Etc. see below



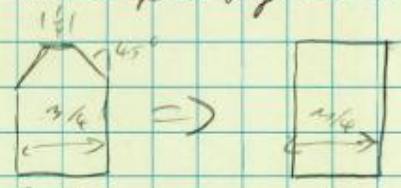
Problem: 10" opening forces front of hood too far forward, need to raise Intake Hood & Main Sheet, push back

Need to pivot arms out of the way! And to adjust for 6", 12", 18" rolls vs collection distance.



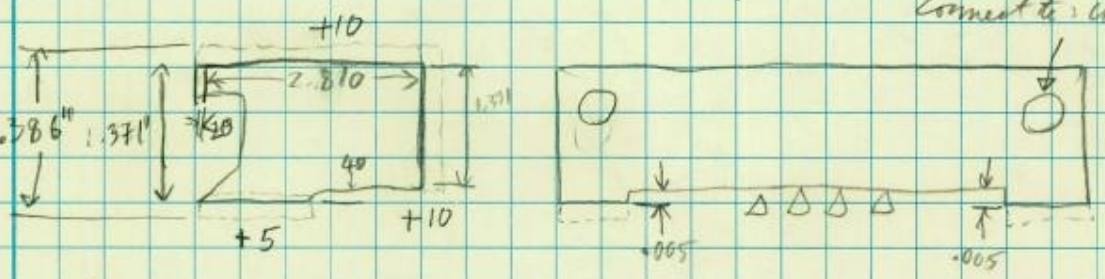
#1 Eminus 9 PM - Upper Lip Insert Redesign 11/17

- change gap to 0.005" for lower flow / lower viscosity polymer
- while we're at it, drill manifold instead of milling - simplify & drill
- Island:

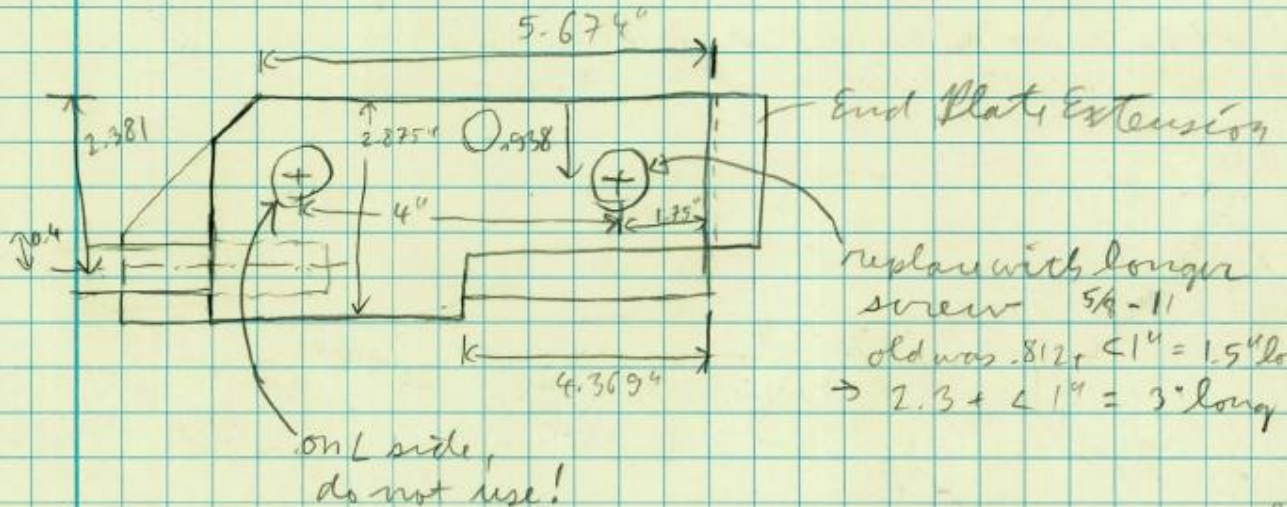


current slot max = 43.6"

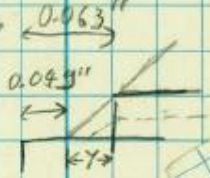
* went back & forth between patch job and parametric fix → kept parametric, not too bad.
Saved previous as Upper_Lip_Insert_as_installed.ipt
- Need grind print see p. 2094-8
  → Final height = 1.331", length = 2.810", gap = 0.005"
  → grind gap down to get uniform, start larger
  → relax tolerances for milling



1. Grind top -10 parallel to △△△△ to 1.336"
2. Grind sides -5 to 5 mil gap (each)
3. Grind back -10 to 2.810



* Overall length: 2.810 must be to step, which makes real thickness 2.830" - ground from original 2.854" (-2.4)
gap = 0.049" + Y Y before = 1.4 Y @ 0.005 = 7
→ need to make 7 mil shorter, so target 2.827" + 10
→ continue p 22



#6 Lestrales - Presentation Outline 11/19

1) • Title slide w/ photo
Patrick Vetz, David Martin, Dominique Lizzet

• Value Proposition
Gilliland (DM)
- 66 change-overs period 12
- 12 H labor + 15 H wait per CO (797, 993)
- Volume, wait per CO trending up
- $10,361 in pure labor in pd 12

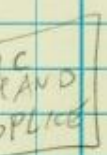
Roiselle (DC)
- 1300 labor hours / year
- $20,000 USD
- knotters saved $26,000 a year already 80% time 612 h/year
- Concerns about ergonomics, tedious labor

• Idea
- Invent device for parallel air splicing of warps to facilitate changeovers and improve quality
- Current process is manual air splicing of each end
+ considerable thread-up work
- knots can't pass thru machine
(Roiselle: double knots no, single loops too weak)

• Knotting vs Splicing
Knotting: machine exist that walk across
& knots get stuck in reed
Splicing: individual ends
a little faster
30% of strength

• Concept: - Bar with parallel air chambers
- Grooves to cut yarns
- magnet strips to hold
- crosses parallel threadups

• Exploration - air usage = 2.8 CFM/chamber
- about 28 ends per 3/8" line
- have to cut! - 0.5 sec blast



• Evaluation: - ∥ threadups much easier
- mag strips↑ grooves↓ (loading!)

#6 Bestrales - continued 11/19

get compressor from P-lab? Video!

chamber design for 11 thread.. equal area
↳

next steps:
notches on ends

actually splice

Slides:
- Title
- Knotting & Splicing basics (video)
- Idea (Challenge)
- Value Proposition
- Exploration
- Concept (Idea) sketch, CAD
- Evaluation (video)
- Next Steps

Stratocumulus? Save for next year!

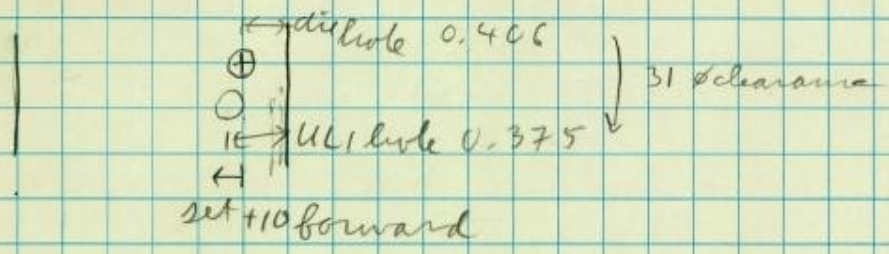
Images/Videos needed:
2: video of air splice ✓
5: hand splice tails ✓ 487
8: thread dup video ...

1 = mag 1 & 2 479
2 = join 480
3 = cut 482
4 = disassemble 485

Videos
479 - 1 slow, decent alignment, bad slack.. OK
480 - last 2, could use but cut some
481 - 1 strip slips.. doing so well! ✓
482 - step 3 cut cut ~ 1:10 - 1:23 4 → OK, use other
↳ not bad, just cut some sections
484 - smooth ... end a bit rocky
485 - nice & succinct step 4 ✓ USE

#1 Emmins 9PM - ULI redesign notes 11/22

Figure out lip length, continue p. 19
CURRENT STATE:
CAD Model trim w = 2.840"
ground, measured to lip: (w = 2.810")
ground, +20 mil offset = w = 2.830"
↳ 10 mil undersized
Lip length = 0.063" original one BGT
dinged LLI wasn't as predicted, ended up (p.66)
having right length... forget that for now
current CAD: lip length = 0.067" ??
AGI thickness = 0.236"
lip is 4 mil shorter but should be 10 shorter... plus
effect of LLI discrepancy... assume that's 6.
2.830 → 0.063" lip
goal is 0.050" lip to be safe Δ = 13
0.050" ← 2.843" finished
Plus, +10 for grinding... W = 2.853" rough
But put bolt offset



Back bolt: 0.313 + 20 Side clamp 2.184 + 20
← offset is 1.871 →
corner hole bolt: 0.107 offset to side clamp bolt
eliminate manifold dowels
new lip is 0.065" (CAD) ??? Must have been a mistake before
change w/ to 2.840 → grind 2.830 → lip = 0.078"
was ULI seated on underwat ?? off by 25 → 0.063 is 0.088

★ AGI sits 0.020" low, AGI seal is 0.025" low
↳ ULI 5 low, leave as is ↳ move hole 5 low, can slide up AGI

Emmus 9 - Wilson Group Meeting 11/23

Markets: 1 - Medical wipes < roll good / component

2 - Protective Apparel < RG / C

3 - Air Filtration <

4 - Water Filtration <

5 - Auto NW <

6 - Other ?

7 - Lorbens

8 - battery separator

9 - SMS → SNS

Market criteria

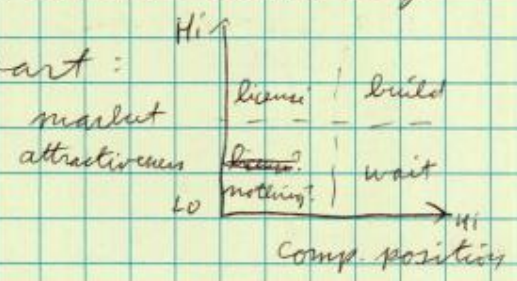
1) Size
2) Profitability
3) Competitive intensity

Milliken & Emmus

Competitive Position

1) Tech. Adv. ← IP, know-how
2) Go to market
← relationships?

Goal is chart:



bubble size = market size ?

Probably build clusters of related parts

Build a business

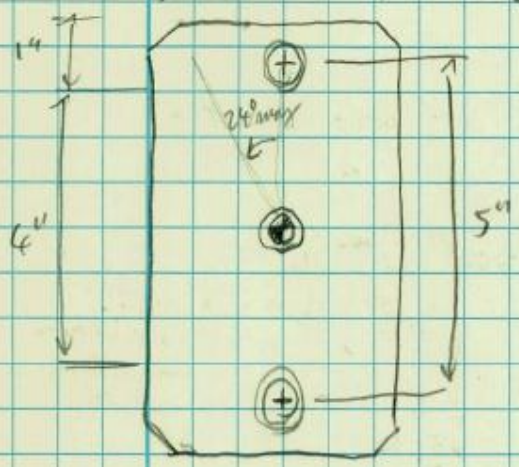
Get everything data-fied [in a spreadsheet] - Greg Norton

Who is best in market? Why?

#1 Eminus 9 CM - ~~Hood Design II~~ Setoff Design 11/28

Continue from page 18

Pivot geometry: (screw setoff)
Pivot on ¼" dowel (press into fixed plate)
Moment? 5" Ø should be plenty



Pivot: Max angle that will fit w/o extending plate = ±31° → 62° span

Better: Pivot on shoulder bolt
↳ arms could fall off!
2× 90298A791
¼-13 thread, 5/8" shoulder, 5/8" long
BCIT! holder lits heater at -26°
Is be safe, ~24°
Keep even: 0°, -24°, +24°
OK, ±22° so plastic doesn't char

Setoff parts list:

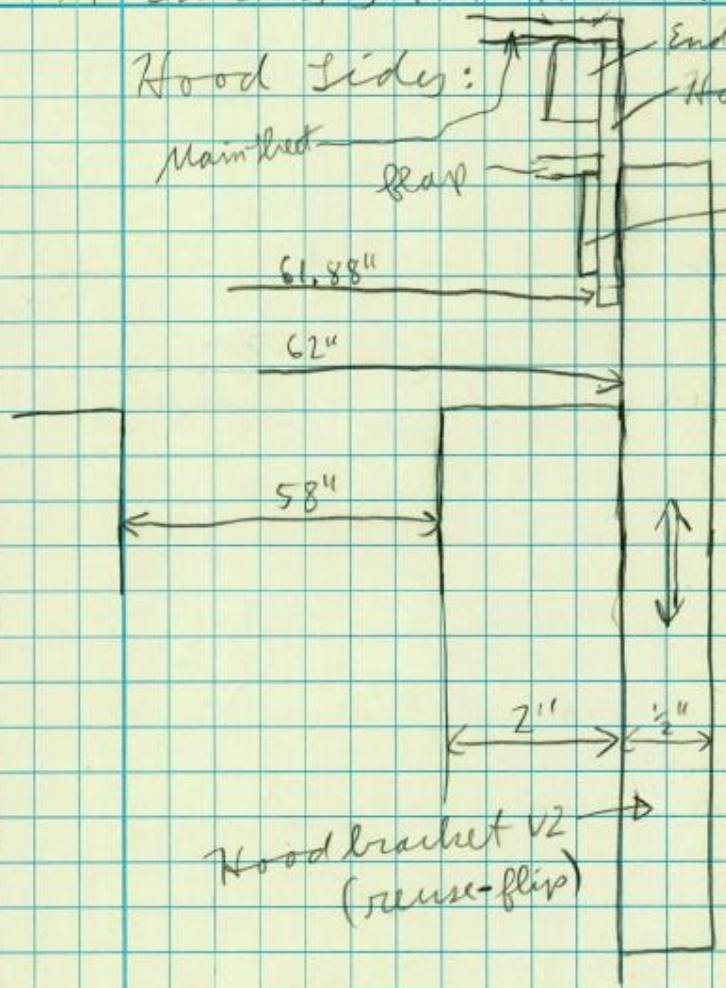
shop bought ✓	¾-10 threaded rod, SS, 28" × 2	shop? McM: 18-8 is 824 × 2	
M ✓	¾-10 hex nuts, need 4 or 6	attach US rod	
M ✓	¾ washers × 2	" " "	
M ✓	½-13 shoulder bolt w/ 5/8 × 5/8 shoulder × 2	US arms	
drw: → ✓	½-13 × 1" hex bolts × 4	" "	
✓	½" washers × 4	" "	
M ✓	¼-20 × 2" (8) *	harness block	
WO 12/9	screw core tube	(1 or 2, can use spare)	
WO 12/9	screw roll adapter	(2 or 4, can use spare)	
add! → ✓	¼-20 set screw < 1" long × 2	(actual ¾")	

Also see p. 30

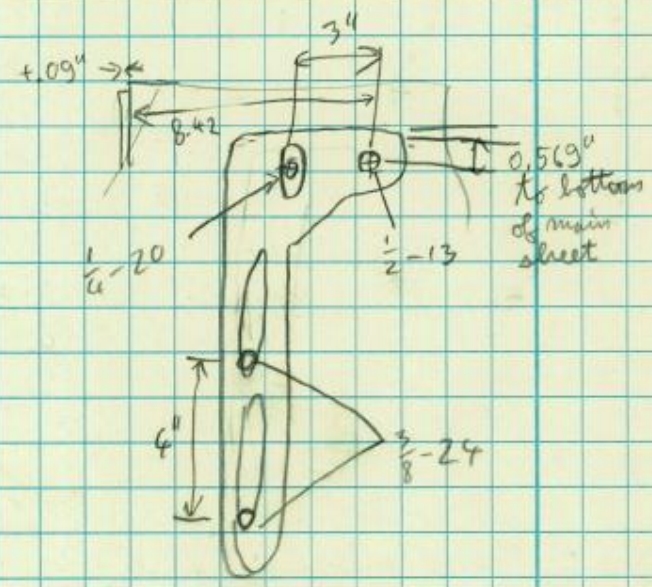
*: Same hole style, but old harness block had nuts pressed into block and flat head screws
This block will have cap screws going into a threaded plate.

#1 Evening 9 PM - Hood V3 Design 11/29

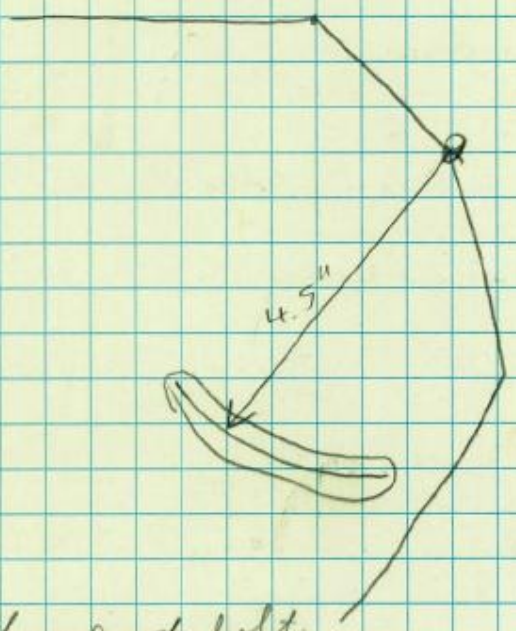
Hood Sides:



Hood Bracket:

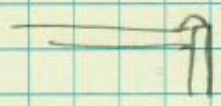


Hinge offset: 0.94 (centered)



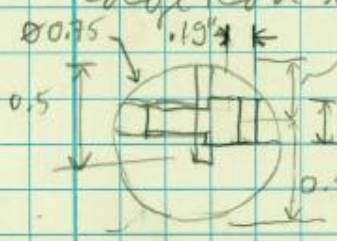
Don't allow hinge to close completely?
- Bolt may not hold it anyway, need stoppers

Main sheet: weld from top so sides stay smooth!



Pull w/ 1/2" hook

Edge rod bolt:



Rod L = 60" 58" usable

56", 2" offset
14" x 4 gaps
x 5 bolts

#10 = 5/32 = 0.313, + clearance → 0.35"
depth 0.375

0.609" max

use spring pins
3/16" x 1/2"
no holes in sheet!

#9 General-Safety Meeting Notes 11/30

Present: Me, Jeff Lane, Brad Heminger, Jimmy Henson (8:10), Bobby Jackson, David Vaughn, Kathi, Rudy Ridgeway (8:23), Bedford Fitzgerald (8:29), Qi (8:36)

Corporate gave Bedford pat on back for safety training - thank you!

Brad is new safety chair
Mike Sullivan will handle OSHA record keeping

Elaine Hare helps Mike

OSHA VPP in March

Training makeups did GEM training because they could not make any of the proposed makeup dates.

"Safety should never be our goal, because we are safe."

JL: - let Mike lay out VPP plans, what needs to be done by when
- re-writing safety manual?
  ↳ Feb 1 deadline to complete
  ↳ Have Ryan give updates
- safety committee: up to Brad on how to structure it
- think ahead to October safety training

Brad - would keep committee like it is

Libby, Philip, Peter, Mike (vacation) absent

Rudy: heard about changes, no more lift truck recertification every year (have every other year driving test)

Kathi: behavior based audits, 6 questions, once a week

Bobby: MOC audits revamped, good dry run, waiting on chemical group (Kathi: no need to wait)

#9 General - continued... 11/30

Release now? Need some more feedback

QIT Meeting Jan 13

Next Meeting? Usually every other Wednesday

Current (Period 1) audits should try new form

→ e-mailed to Brad & group 9:45am

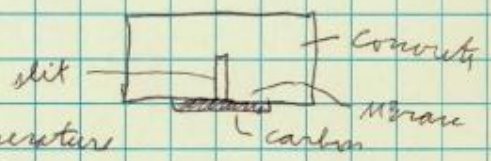
#9 General - Deep Science 12/1 12/1

Ryan - Cadence: enhance composite fatigue (E-glass in PET for wind turbines)
- focus on fatigue measurements
- use nanotechnology coating to make VE, PET as good as epoxy
- have 3 concepts that meet or come close to epoxy performance
- failure is at matrix - fiber interface
- second phase added has complex effect

Xin - continues, coatings - can be surface of fiber
- HIPS anti-solvent coating method - add water to crash out ABS particles, dispersed

Kumar - modeling (numerical) 3-layer coating, etc.
strain is in resin, not fibers
enhancement schemes reduce strain but increase stress a bit.

Jeff - Vulcan: rehab concrete structures
MBrace epoxy
cube rotate slide transition
3-point bend test



peak load plummets with temperature
↳ fraction of strength at 90°C
Potential solution: silicate - results poor so far
POSS - Resin had wrong data sheet, poor performance
Epoxy Novolak: high T_G
solution must let water escape in the "thermal event?"
DEN pultruded rods doing well

Qi (& Kally) nanoporous composite insulation
Aerogel pore size is 10-100 nm
Have chemical freeze dries in chemical division
Best structure from flash freezing
Freeze dried at Kulis, Inc in Columbus, Ohio 44" x 15" x 1 3/4"
Hi-temp glass fibers. Belcotex (1100°C) ~~Isofrax~~ Isofrax (ceramic)

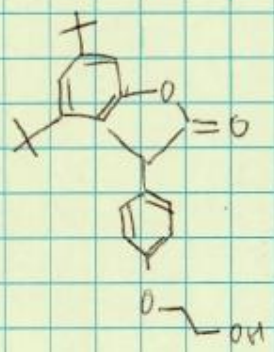
Robert: Excalibur 2 year anniversary
Launch "Linen" all Excalibur carpet Q1 2012
added temperature & viscosity control - big improvement
Larry: high color resolution in orange (CMC)
Use Raleigh distribution $\Delta E_{CMC} \sim 1$
Pretty powerful diagnostic: bases ink vs tile..
Working towards digital color QC

Jonathan: ink buildup on deflection plates
Jeff Lillie: how to capture the mist

#9 General - Deep Science 12/1, ctd. 12/1

Adam - Symphony
↳ visualize carpet design layouts
= competitors are all doing it... with FLASH
- High resolution online, just not on our projector
Jeff: Steve Cox did some disturbing visual representations
ISOS - nice new interface for one new style only
↳ starting slowly

Rita - AOX 1 (PBC effort)
sharing data with customers next week
met target of < 1 yellowing
slide 7 - ask "how about" bisnefite & bisurea reduction"?



Used Ca Stearate acid scavenger
↳ Zinc Stearate works but not practical
↳ Adipic acid fixed it (Ad + CaSt)

Brent: DOE
"Model here was complete"
Try to match HP136 performance

Sasha & Warren - UV absorption, light stabilization chemistry

Paul Wesson - Project Titanium
Ready to use body poly
- no need to rotate and splice
- have non-elastic yarns near cords, allows range processing
- issue is too high add-on, window painting, too high tack from dip and nip coating
working with Joe Royer?
does a good job of coating one side only, so OK to touch rollers on uncoated side
add-on pretty linear with dip roller speed
Bradys - Emmons
quality factor $QF = \frac{-\ln(1-\eta)}{\Delta P}$
why does IPA wash improve efficiency?
Function of solvent surface tension
Dan: try sonicating

#1 Emmins 9 PM - Hood, Snorkel, & ULI Parts 12/5

Hood ✓ 3 parts Also see p. 24 Setoff Parts

✓ M Hinge
✓ M End Rod
✓ M Polycarb Wiper
✓ M Glass-filled PTFE sheet
Reuse Hood Bracket & bolts,
Reuse Intake hood × 2 & bolts & gasket
find ✓ ¼-20 × 1" button × 2 (have caps) for flaps } ALT: phenolic
~~find~~ M ✓ ¼" wing nuts × 2 flaps } wing screw
✓ ¼" lock washer × 2
find ✓ ¼" hook - shorter!
✓ 10-32 × ¼" stop bolts × 2 ⅞ long
✓ M Roll pin 3/16" × ½" (5)

Snorkel Parts
✓ ¼-20 × ½ bolts (reuse, augment) caps! × 20
M ✓ ¼-20 × ⅜ bolts (cover) (4)

ULI parts
M ✓ ½-13 × 3.5" cap - same as before (2) buy anyway
✓ ½-13 × 3.5" hex head - reuse (17)
✓ Corner lock bolts - reuse
✓ Edge seal bolts - reuse
✓ 5/8" × 1.5" cap (1) - reuse
M ✓ 5/8" × 3" cap (4) -

Parts ordered 12/ and 12/9

#8 Eminus Solvent Wash - Feasibility 12/6

Current HEPA is 80 gsm E-glass, 10-12 ¢/ft²
→ $6 to $7/pound
25 mm water pressure drop, 99.97% efficiency

80 or 90% Methanol + H_2O gives 99.984%
17.5 mm pressure drop ↑ from 93%
80 gsm PP sample

Needs to be laminated to pleatable substrate

got 30 gsm up to 96% ← from 71%
→ 70 gsm 30¢ per square meter cost

~1 mm Eminus + ~0.3 mm spunbond PP or PET

could use IPA or EtOH perhaps
Picks up ~20× weight
let it sit
Oven temp tried is 110°C - 2 minute was more than enough

IPM - C.M
↳ 4PM
Julian

Electrospinning does solvent recovery
Formic acid, EtOH, Toluene <10% polymer
↳ Nylon

Water filtration?
E-glass 650 nm is Johns Manville $10/kg

To see an effect on TANDEC meltblowns
100 gsm sample 4A had 32% penetration → 68% η
washed in 100% IPA goes to 96%

Keith: could easily catch 95-98% Air Products
"cryo system"
need to stay out of flammability limits
may be able to burn or expel - Jeff Slusher
↳ what's the rule?
Methanol cost: 9¢ a pound (2002 - 9 years ago, in bulk)
Millad recycles Methanol: 0.4¢/lb to recover, variable
July 2011 Methanol cost: $1.10/gallon, $375/metric ton
↳ 17¢/lb, recycle cost probably 1¢
Explosive limits: 6% < pow < 36%
80% volume = 72% weight 80% wt = 85% volume

8 Emirus Solvent Wash - Feasibility, ctd. 12/6

I made spreadsheet to compute the numbers (Emirus solvent wash.xls)
→ cost is \$0.26/lb of product for solvent @ 80% methanol, 20x wet pickup, 95% recovery, \$0.17/lb pure methanol, \$0.01/lb methanol recovery

Now figure cost of scrim per lb product, cost of PP, margin vs glass, and scrim absorbancy.

Note: margin = profit/price = π/P

$$\pi = P - C$$
$$M = (P-C)/P = 1 - C/P$$
$$C/P = 1 - M$$
$$P/C = 1/(1-M)$$
$$P = C/(1-M) = C \cdot 1.67$$
$$\cancel{M = 1 - C/C}$$
$$\$M = M \cdot P = P - C$$
$$P = C/(1-M)$$
$$M = C/(1-M) - C = C \cdot \left(\frac{1}{1-M} - 1\right) = C \cdot 67\%$$

Sample before = 1.06 g 80 gsm Emirus
in 80% MeOH / water by volume

17.0 g ~~soaking wet~~	16.1X	(15.1X+1)
14.50 with 1 minute drip	13.7X	↑pickup ↑substrate
11.48 horizontal "nip"	10.8X	
8.95 g on 30° incline "nip"	8.4X	
8.10 g nip again	7.6X	
16.1 g - re-soak + brief drip	15.2X	
9.0 g - re-nip	8.5X	

Test scrim: 85 gsm PP spunbond

1.17 g fresh	
2.93 g soak with brief drip	2.5X
2.10 g nip - but most loss from contact	1.8X
2.48 g re-soak + 30 sec drip	2.1X *
2.18 g just touch board	1.9X

Bigger sample

2.70 g fresh		
38.60 g 30 sec drip	14.3X	* use this number
28.00 nip - 3 layers thick	23.9X	
23.20 g nip again - 1 layer	8.6X *	

38.8 g re-soaked 30 sec drip 14.4X

First sample after 1 min: 4.80 g 4.5X
scrim 1.37 g 1.2X 2nd 16.1 g 13.0X

#9 General - Vulcan Meeting 12/6

Allen Jacoby, Greg Blaszak, Philip Wilson, Bernie, Venkat, Qi, Jeff Strahan team members
not here: Kevin Kein
Discussion about 4 hour rating vs 1, 2
Edge ~~is~~ has a "me-too" product (company for sale)

Testing is expensive, have to paid for...
Milliken has to provide support in order to maintain the high margins

ASTM E119 Fire Standard

Learnings in Dresden
Fife or Edge - not engineering firm
Concrete International - magazine, could advertise
Concrete rehab market: $1400 MM in 2020
↳ Fire Proof is $500 MM => => seems high
Material + installation
concept by 1st Quarter, develop by 3rd quarter, scale up & launch by 4th quarter
Current goal: 1st full scale beam fire test @ MS4 ($75K) in Q2
Assumption: do some work at Monarch first
FRP goals Q1 - 10+ interviews, business case for Edge acquisition
Q2 - prioritized list of acquisitions
Q3 - Demo system with an FR contractor
Q4 - 2nd full scale beam demo in external lab
- finalize vision/strategy for business
Gregg: need to add cost target
Target 2015 sales
Hitting hi temp lap shear was big accomplishment
Minimum bend radius is 5-10"
ICRI - March conference - validate interest?
Is performance lost at T_g? Gregg: add more reinforc? may be better than adding insulation
Bernie - would like to see better oven
Focus on beam - do column also?
$75K bump 4 tests x 2
Dresden made U-wraps with concrete, beautiful
Gregg: start selling in 2013 to non-FR projects
product needs to have basic durability
Geocrete vs Phosrete - can't put up Phosrete right now

#9 General - Vulcan Meeting 12/6, ctd 12/6

Sammy Rizzalo - professor at NC State

Adjacencies:
What are possibly exceeding goals?
Possible skunk works
Gregg: be able to test bigger slabs
peel and stick (Barry Plastics glass product)
Allan: self-supporting tank
inflatable tank lining for underground gas
tank repair - customer wants to try it
FR concrete canvas
Gregg: When we have Edge, go into pipe
Alan: We may tell tank guy to go away
Randy Kohlman is overwhelmed with concrete canvas
Need short term requirements document
Concrete canvas has quick turnaround

Dec 19 - decision on Emims
go to Eng Mtg Dec 19, get Dale
test recent samples of 80 gsm

have only done over dry 4/17
need to do 80% Methanol
at different temps

12/8 Vulcan call with Prof. Hodur
Fortran code model
concrete stiffness is nonlinear
thermal is linear, radiation is significant
for insulation but not in inside
↳ only for boundary condition
K(T) Concrete is isotropic
Rectangular elements only
3 mm x 3 mm mesh, some 1x1
30-40 minutes to run 4H simulation
ANSYS - debonding not well defined
FRP =
RC = reinforced concrete
Steel is guaranteed 60 ksi but may do 70 or 80
Need FRP stress-strain at room temp, hi temp
modulus, strength
don't consider anisotropy in FRP
Hodur can measure α up to 1000°C TMA
Stage I: define material inputs state of the art
II: modeling approach / method, mesh, failure
III:

#8 Emmins Solvent Wash - Evaporation 12/9

Evaporation Rate calculation
/welwormpc.blogspot.com/2010/03/quick-estimate-evaporation-rate-from.html = US EPA method

$$E = (0.284 \cdot U^{0.78} \cdot MW^{2/3} \cdot A \cdot P_v) / (82.05\ T)$$

- T → liquid temp °K
- P_v → Vapor pressure at temp mmHg
- A → surface area ft^2
- MW → Molecular weight (g/mol)
- U → Wind speed (m/s)
- E → Evaporation rate (lbs/min)

See Emmins solvent wash v3.xlsx
2 m/s air speed, both faces exposed, 45°C, squeezed, 80 gsm fiber on 70 gsm spunbond → 48 sec @10 m/min = 8 meters
oven is 12 meters long
Also note: LEL for methanol is 6% vs 1.1% Toluene and 3% Ethanol. Standardizing by molecular weight, factors are ~~Toluene: 0.0119 MeOH~~
Toluene: 101 g/mol air MeOH 192 g/mol air EtOH: 138 g/mol

Run some drying experiments:
- ★ - evaporation rate at room temp (monitor T!) Wt vs time
  - ↳ air speed!
- ★ - filtration vs dry temp
- - evap vs dry temp?
- ★ - aging a few weeks → filter
- ★ - Methanol vs Ethanol
- ★ - Recent sample vs stuff in Vradip's lab
- - filtration vs weight (gsm)
- ★ - filtration vs squeezing ... η & ΔP

Quick evaporation test: lie flat on scale

#1 Sample: 1.66 g fresh (80 gsm Emmins) RT = 23.5°C
26.41 g wet, 30 sec drip 15.9x

1:42:00	26.25 g	on PTFE on scale			
1:43:00	25.76 g	15.5°C surface temp			
:44:00	25.30				
:45	24.85	12.8°C	:49	23.22 g	13.5°C
:46	24.46	12.0°C	:50	22.85	13.8°C
:47	24.08	11.9°C	:51	22.50 g	13.3°C
:48	23.67	13.5°C	2:04	18.51 g	13.7°C

#8 Eminus solvent wash - Evaporation, ctd 12/12

Continued:

2:08 17.51g 13.7°C
2:17 15.32g 15.1°C → take off plate

49°C setpoint → 40° plate → 32° with sample
Heated substrate tare for above sample 149 cm²
#2 sample = 1.19g
sample + plate = 387.03 + 16.88 = 403.91

149x 17.74g 421.65	@ 2:51:40	37°C @ plate	32°C center
416.33	2:54:40	31.0°C center	33.6° edge of plate
415.55	2:57:40	32.1°C	
413.15	3:00:40	31.2°C	
410.89	3:03:40	32.5°C	
408.92	3:06:40	34.9°C	
407.37	3:09:40	33.9°C	
406.27	3:12:40	32.5°C	→ contact T/C
405.51	3:15:40	32°	31.6°
404.77	3:18:40	32°	→ probe on AL plate
404.31	3:21:40	32°	
403.87	3:24:40	32°	
403.66	3:27:40	33°	
403.67	3:30:40	34°	DONE
403.66	3:33:40		

#3 Sample = 1.32g 404.06 w/plate
surface set to 50°C → plate @ 90°C!

422.90	3:57:00	46.1° / 43°

NOTE: bubbles form under web - may insulate

411.44	4:00:00	55.0° / 46°C → 43° after
405.70	4:02:00	42.9° / 42 after
404.51	4:03:30	48°
404.10	4:05:00	51° / 51°
404.04	4:07:00	60°

#4 Sample = 1.15g 403.93 w/plate set to 60°C

417.80	4:21:00	46° 54.0° corner boils! on start
409.20	4:23:00	54° → 52° after
406.01	4:24:00	
404.44	4:25:00	52° (45.8° corner)
403.89	4:26:15	

#8 Eminus solvent wash – Evaporation, ctd. 12/12

Weigh 1.25 g after → 1.18 @ 4:28

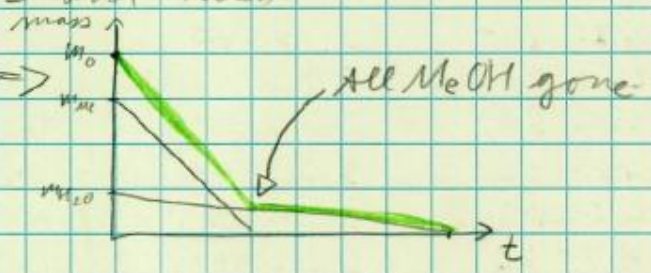
Sample #5 – corner cuts 1.86 g
↳ 30.60 g wet + rip

Sample #6 – 2.76 g
↳ 44.17 g wet (30 sec drip)

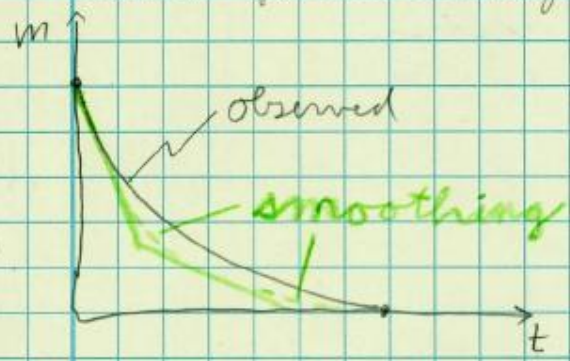
Also test: Eminus on screen, ultrasonic agitation
12/13
Samples: notched
#1 = 2.13 g 2 min degas? 1 min sonicate
$\eta = 99.991\%$
#2 = 1.95 g 1 min sonicate
$\eta = 99.530\%$
#3 = 2.00 g control wet in bag
$\eta = 99.935\%$

= Evaporating 80/20 Methanol – MeOH evaporates faster!
Take η, T, A as constant then

$E \propto MW^{2/3} \cdot P_v$ ⇒



↳ This model would not explain the gradual change in slope that was observed. I would expect the ends to level out because some material is bound by greater attraction to the fibers, but only at the ends – fiber binding may be significant.



Try spraying with a mist of solvent rather than soaking drenching wet.

Edge effects may also round off the curve → A is not constant as edges dry faster.

Finally, EPA equation is for liquid "at or near the ambient temp" which is doubtful for sample 4 and even 3.

#9 General - ANSYS Webinar 12/13

~~Kumar~~ Vinay is substitute presenter for sick presenter ~~Glenn~~ Polish
Jeff Burdick - host Organized by Kumar/Wilson
On-site: Glenn Lipe
Vinay Carpenter - works out of India
Modeling material non-linearity in ANSYS
Composite modeling
iteration based
discrete/smeared reinforcement
↳ define fiber reinforcement, multiple fibers in one command
layered solids need finer meshes than shells
can capture/model debonding failure, fracture
Release 14.0 will have progressive damage analysis
↳ came out last week
Model bird strike on a wing
Nonlinear stress-strain curves (steel, rubber)
↳ also geometric (large strain) and states (contact)
Plasticity: elastic-plastic with strain hardening
Von Mises yield criterion
Flow rule: how strain develops with yielding
Hardening rules - Kinematic vs Isotropic
Viscoelasticity - rate dependency
↳ uses hereditary integral
Prony series: sum of decaying exponentials
↳ like a Laplace decomposition of the response
G - deviatoric stress K - volumetric stress
Thermorheologically simple: temperature just shifts the time/rate response $t' = \ln(t)$
Viscoplasticity: Perzyna & Peirce models
Hyperelasticity: fully incompressible $\lambda_3 = \frac{1}{\lambda_1 \lambda_2}$
went too fast, all new to me
Me: would like to see specific case study
Qi: temp dependent material properties

#8 Eminus Solvent Wash - 12/14 Tests 12/14

Use Precision™ oven in Dan's lab (#12)
Air speed - peak ≈ 75 ft/min @ sample location
22.9 m/min, 0.38 m/s
Dry a small sample - 297 mg fresh ~~wh~~ to monitor, but measure sample #5 → 6.47% pen. 17.6 resist
First condition: 90% MeOH, 30°C
stand = ~50 mg with air on
2:53 PM wt = 2,283 mg

:54	2.80 g
:56	2.45 g
:58	2.13 g
3:03	1.33 g
3:05	1.12 g
3:09	0.88 g
3:12	0.74 g
3:16	0.57 g
3:18	0.50
3:20	0.42
3:23	0.35 g
3:25	0.31 g (flutter)
3:27	0.305 g oven off

Room Temp - 27°C
Oven temp - using Fluke multimeter = 29.6°C
Filtration: 99.779%

Next sample: 40°C use #18

3:33	2.40 g monit. weight but ~same 0.205 g - after
3:35	2.06 g
3:37	1.61 g
3:39	1.20 g
3:41	0.90
3:43	0.73
3:45	0.58
3:48	0.38 (lots flutter)
3:49	0.37 - add clip
3:50	0.33 + clip
3:52	0.32 + clip

clip = 0.297 g
Filtration: 99.740%

Next sample: 50°C use #11 0.222 g

4:02	2.40 g		
4:04	2.00 g	4:14	0.44
4:06	1.50 g	4:16	0.31
4:07	1.30	4:18	0.27
4:08	1.14		
4:10	0.80 unsteady		
4:12	0.58		

Filtration: 99.782%

#8 Eminus Solvent Wash - 12/14 Tests, ctd. 12/14

Use sample # ~~B~~24 fresh 0.232 g 60°C

4:25 2.65 g
4:27 1.90 g
4:29 1.32 g
4:31 0.85 g
4:33 0.51 g
4:35 0.32 g
4:37 0.24 g unsteady

η = 99.866%

sample #3 → 50°C with mist only
before = 2.04 g
squirt bottle = ~~163.6 → 0~~
220.0 → 0
8.60 g (

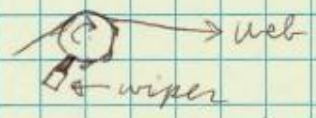
η = 99.00%

4:47 0.46 g
4:49.5 0.27 g
4:51 0.265 g
4:53 0.267 should be done, leave 8 min
4:55 → out ~0.260

Re-measure air speed
50-75 ft/min with door open
~200 ft/min with door closed, anemometer on stand

Just to clearly state the idea:

- Rather than a full soak, spray a mist of solvent until desired add-on is reached. This should be more ~~dest~~ gentle than using a nip. In my case, sample #3 had only 3.2× add-on but it also did not perform as well.
- "Slapping" got a good amount of the loose solvent off, giving me 7× to 10× initial add-on. This could be replicated by running over a roll with a wiper blade on the back side.



- Another idea is to heat more aggressively at the start, then taper down the temperature.
- Why are numbers lower in general? Test on support substrate.

#8 Eminus Solvent Wash - 12/15 Tests 12/15

Dry samples on screen. Also use Kirk's oven
All samples with 90% Methanol

Sample #2 on screen, 104° → 40° C
2:23 2.90 g (0.26 fresh)
2:25 2.30 g
2:27 1.80 g
2:31 1.0 g ?? ("about")
2:33 0.82 ~18 min to dry? → 2:41
2:40 X fulsdry
2:43 take out

η = 99.901

Sample #3 on screen, 122°F → 50° C
2:49 3.20 (3.55 weigh before) 0.244g fiber + screen = 0.63g
2:51 2.36
2:53 1.80
2:55.5 1.18
2:57 1.00
2:59 0.80
3:01 0.71 (flapping)
3:03 0.63 "
3:05 0.63 take out confirm 0.63

η = 99.960

Sample #5 50°C, fuzzy side out
3:08 3.10 reuse same flag
3:10 2.3 g
3:12 1.6 g
3:14 1.16
3:16 0.9
3:18 0.69
3:20 0.63 (flutter)
3:22 0.63
3:24 0.63

η = 99.961

Sample #4 60° C, normal, reuse flag
3:27:30 3.05
3:29.5 2.16
3:31.5 1.4
3:33:33 0.87
3:35:30 0.69 (unsteady
3:37:30 0.63
3:39:30 0.63 done

η = 99.975

#8 Eminus Solvent Wash - 12/15 Tests, ctd.

Move to Blue M oven - ~150 FPM open, 75 closed
Sample #6 @ 50°C

4:15	3.10 g	some dripping
4:17	2.3 g	unsteady
4:19	1.8 g	
4:21	1.3 g	
4:23	1.0 g	
4:25:20	0.8	
4:27	0.63	
4:29	0.63	* corners are still damp

$\eta = 99.776$

Sample #7 2.14g before @ 60°C

4:32:30	3.10 g
4:34:30	2.3 g
4:37:00	1.44
4:38:30	1.0
4:40:30	0.7 g
4:42:30	0.63

$\eta = 99.961$

12/16

Sample #8 2.08 g before 93.0%
4.90 g w/ scrim & staple $\eta = 99.894$
30.83 g soaking wet
2:34 pm → oven @ 40°C
25.93 g pickup → 12.5 X add-on to Eminus (some in scrim)
2:44 weight check (< 30 sec)
~~12.60 g~~ gross
7.70 g pickup left
2:54 weight = 7.28 g (+ 2.38 g, 1.15X)
3:04 weight = 4.97 g 30 min dry

Sample #9 - 2.05 g → 4.66 g cover =
#10 - 2.07 g → 4.74 g
#10: target 8 X pickup → 16.56 g, total 21.3 g $\eta = 99.555$
↳ actual 21.90 g @ 3:12 (spray) + 17.16, 8.3X
#9: 32.1 g w/ >1 g on scale .. 31 g +26.34, 12.8 X ↑ 4 min less?
in @ 3:14:30 on lower ring
12.94 g @ 3:24:30 $\eta = 99.765$
3:32 → #10 in 4.70 g
3:38:30 → #9 out 5.05 g oops ~25 min to dry

8 Eminus Solvent Wash - 12/16 Tests, ctd

Sample #12 - 2.12 g → 4.78 g final
Heat to 60°C 32 g - 1.3 g η = 99.509
in @ 3:43 but dropped ☹
4:03 → 4.77 g
#13 2.19 → 4.89 g
29.8 g η = 99.906
60°C in @ 3:49
should be < 25 minutes Try 20 → 4:03 & 4:09
#12 was plenty dry, try #13 @ 4:07
4.89 g .. dry in < 18 minutes

Then do #11 @ 80°C for 10 min
2.15 g → 4.76 g
wet wt = 33.35 - 1.9
In @ 4:13:45 temp drop to 170°F
4:14:45 → back to 174°F
out @ 4:23:45 → 5.17 g
back in @ 4:24:15 η = 99.603
out @ 4:25:15 → 4.78 g

#1 Emmus 9 PM - 12/19 Pine Mountain Trip 12/19

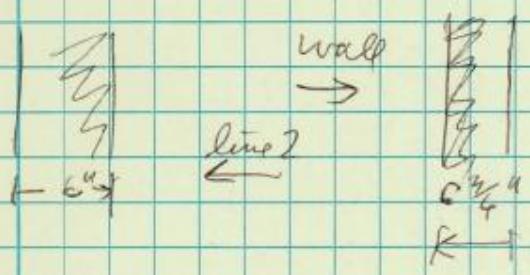
Startup Procedure:
- Line 1 Fuse → light on (upstairs panel)
- breakers up x 2 in walkway
- check valves: horizontal closed (no bypass)
  2x vertical open - cooling to extruder
- reset alarms on console
- F8 heat control - 300 F (check)
- enable air & heat F3, F4
- vacuum on
- check currents are on...
- pump air cooling on

Objective: make samples for New Rig
some samples for HEPA
check out sistem conv belt
↳ disaster - endless loop, useless

2:10 PM - at 625°F except melt pump dropped to 318°

! We still need cardboard for punching samples.

We may need to cover up edge of collection zone because fibers get stuck from feathering and doesn't release.



9:03 PM - cooling down, done with samples

I ~~made~~ made: all on HEPA pleatable scrim

9"	60	70	80	90	100	95 gsm
12"			80			
15"	60	70	80	90	100	

+ 80 gsm @ 12", no scrim

For Dale / New Rig: 2x 100 gsm (250 ft)
Dale: 80 gsm on stabilon 2x 200 gsm "
Dale: 600 gsm, 1200 gsm 2x 400 gsm (125 ft)

+ 30 gsm + some unbonded lighter stuff (hard to slit)

#8 Emmus Solvent Wash - Valway scouting

Max temp is 170°C **Valway**

Jerry Mickle

Ross Murphy - Range 7 PI & R8, R9

Inlet - have belting for roll letoff (Delt)
↳ bought by a bankrupt company

Running 16 YPM, 74" wide fabric currently
Max is 80" ← pushing it

Range has tons of talk

Probably min tension ~50 lbs ~4" rolls

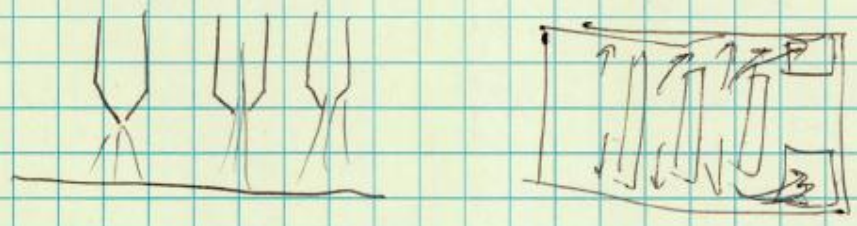
Thermal oxidizer @ 1400°F → next to boiler (blue)
~95% of energy is natural gas
~3' + dust

Could have vacuum knife on back of screen

Beta gauges currently not functional but fixable

Arch over - carried thru on Kevlar belt
Nasty gouge in roll

Air:



Jerry will get me air flow rate info
Could do takeup right after arch over before take outs

#5 Vulcan – Vulcan Talk 1/6/12 1/6

Discussion with Philip Wilson
- get up to speed
- involved in goal setting

2011 - learn
Now - focus on one approach, but still explore
Q2 - full scale beam test @ NSY
Q4 - field installations
2013 - execution mode to get it done, 2012 transition

<u>Work streams</u>
Lead product development - rod JS ↔ resin formulation
textile PP
mortar VR
insulation QiL

Modeling - macroscopic beam model
concrete has irreversible property changes

Goal is keeping building standing for 2-4 hours

Insulation goes thru a phase transition

5-10 product level concepts

Bernie - mortar installation (somewhat up in the air)
→ going to World of Concrete soon
→ also doing testing

Competitive assessment → business team, but we help
↳ Greg Blaszak & Kevin Klein (also IP...)

Writing design guideline - simplified analytical approach
↳ critical for introduction

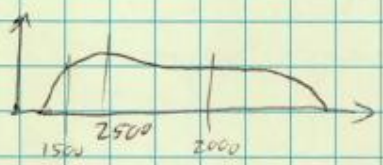
ACI 440 - rehab guidelines
building codes are local (city level!)
Dade county FL (Miami) - strong wind requirements
team meetings every Monday
BOX meeting next Thursday - nail down goals

#6 Lestrales - V2 Prototype Evaluation 1/6

Air compressor: Speedair 5F238 1.5 HP
up to 125 PSI
air delivery: 5.6 CFM @ 40 PSI
4.4 CFM @ 90 PSI
Size of tank x 2.5 ft³ ← 11 gallons! ← F to M to coupling
Air hose = ¼ NPT to ¼" quick disconnect
through extension to ¼" NPT male
to F-F to M - ¼" hose to machine
3:58 @ 0 PSI 3:58:20 @ 20 PSI
58:40 @ 40 PSI 59:03 @ 60 4:00:05 @ 110 PSI
4:00:26 full charge (2.5 minutes)

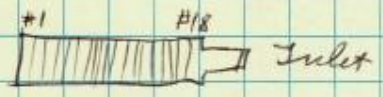
Wolf's setpoint: 70 PSI
← 26 seconds to bleed to 60 PSI
redo: start @ 118 PSI 7:10 7:26 → 80 PSI (16 sec)
7:41 → 50 PSI (31 sec)

Back to ½" line (wall)
4" away: 1500 FPM up to



air speed measurement - not meaningful
last 2 notches seem weaker
air pressure able to lift notch bar easily
↳ add 20 lbs (2×10) just enough
10 lbs definitely not
force feels reasonably even
leave yarns in tool cart cabinet (G5 side)

1/9 Iake splice to comparator
Typical slot: 0.026" wide



#1	0.026" × 0.125" slight burrs	#10	27 × 125 good
#2	0.026"	11	big end burr
#3	0.026" × 0.125 side burrs	12	med end
#4	0.026" × 0.124 big end burr Photo 109-0680		big end
5	0.026" × 0.123 side burrs	14	med. end
6	0.025 × 0.123 end & side	15	rough edges
7	0.026 × 0.121 huge end burr	16	⬯ 26×121 but oval! * Photo 681
8	0.027 × 0.123" med end burr	17	oval .037"
9	0.027" × 0.125" slight end burr	18	oval 0.040+ burr
			↑ photos 682-684

*: 0.039" wide max!

#6 Testable - V2 Prototype Evaluation, ctd. 1/9

Slots were cleaned with a bent paper clip and a stick pin (thumb tack with fancy head)
→ no major burrs left, tried to rub smooth so filaments can't catch.

Holes 16, 17, 18 plugged with goop (the bulging ones) leaving 13 open slots.

Bolt torque: grade II ¼-20's = plain = 8 ft-lbs
= 96 in-lbs

Also note: dowel was slot 1 is misaligned 0.038" at end

Trials: if air is turned on slowly, it just blows out the yarn before it entangles. Need fast actuation!
Also, 90° turn tends to pull yarn out
Sharp bends tend to crimp the yarn - try to round

Loose yarns tend to blow out one side or the other

Long tails → filaments get cut on sharp edges

¼" tails - held pretty well

Cut while air is blowing → no!
Air flow empty: #5 & #14 are pulsing!

Cross threading, cut upper → no (1300 den)
cut lower → no

Poster: Focus on work stream

#9 General - Pall Filtration Seminar 1/10

Eric

Filtration, Separation, Solution. Separation → split fluid streams

Interception, Bridging (2+ particles jam a hole)

chemical adsorption (electrostatic)

inertial impaction

Surface vs depth media → lots of dirt holding capacity

Fixed pore vs non-fixed pore → non-fixed has pressure limit

Tapered pore vs uniform pore

↳ captures larger particles upstream

↳ works well in depth media

$$\Delta P = \frac{Q \mu q}{K A}$$

Nominal filters gain pressure faster than absolute

Nominal rating is fairly ~~at~~ arbitrary - skewed by large particles

Military specified absolute rating

↳ largest opening in the filter

started with glass beads

β-rated performance

$$\beta_x = \frac{\#_x \text{ upstream}}{\#_x \text{ downstream}} \qquad \text{efficiency} = \frac{\beta - 1}{\beta}$$

can be different β for every particle size

Liquid filtration is not as standardized

Time is another factor

Melt blowing room is big secret, can change nozzle to mandrel distance etc. to tailor β(x) curves (steeper sloping)

Dead end filter vs cross-flow filter (RO, pigment purifying)

cross flow: hollow fiber membranes

drinking water is 0.1 micron filtered 5 year guarantee, 10 years for water

may reject 5% of water

Millipore - our filters last 2 months

Pall does not sell "just the membranes"

- performance monitoring, backwash, chemical cleaning

may have 70-micron prefilter (rocks and fishes)

↳ all integrated in the unit

Pall has rental units or small trial units

Melt blown fibers are physically bonded - melted together. Fibers less than 4 micron diameter

#9 General - Pall Filtration Seminar, ctd. 11/10

Juan Palazo - focus on ink filtration
Extruded fibrous, wet laid fibrous, micro filtration media
↳ PP, PA, ~~PET~~, PPS, other
↳ ☆ most common
Make hybrids between depths & pleated modules (L/d ~ 5)
"last chance" filter
Pleated media better suited for narrow distribution
glass & pleated immediately, depths & hybrid lasted 20x longer
10:20 some very specific discussion of Millipore ink filtration

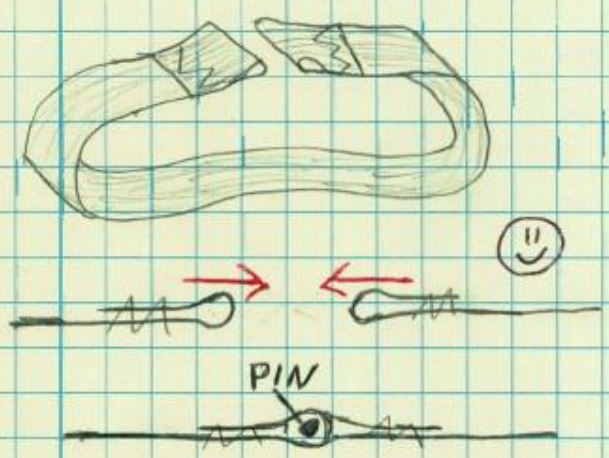
↓ leave for Vulcan box meeting and to work on my innovation fair poster

#1 Eminus 9 PM - Sistem Bant Illustration

Iuncay ferret at Sistem Bant requested a sketch of what the problem is. Here goes...

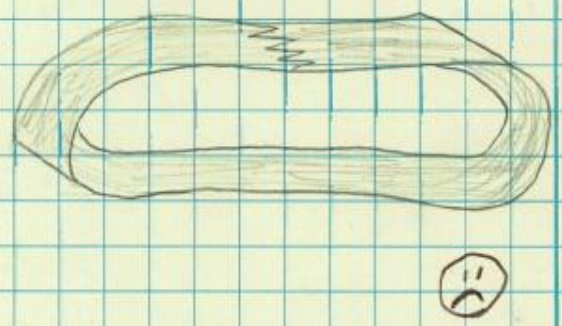
Requested:

PIN SEAM

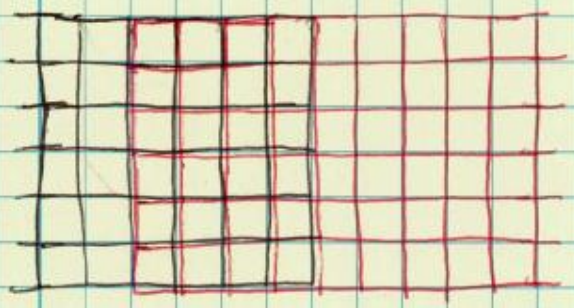


Sent by Sistem Bant:

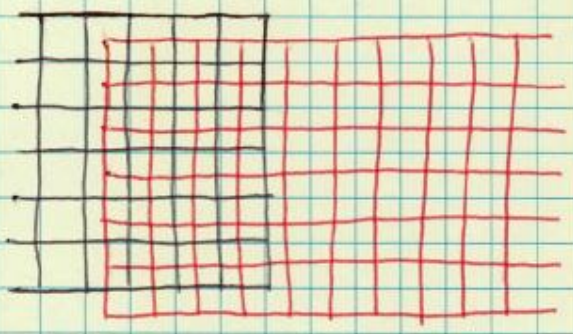
ENDLESS



ALIGNMENT:



YES!



NO

#5 Vulcan - Project Meetings 1/12

Box Meeting Prep with Vulcan team, Gregg Blazzar
Bernie late
Review 2012 quarterly milestones, PERL goals, first product options, work streams
PERL goals finalized next Wednesday
Total solution should be ≤2" thick
Cost effective or cost competitive?
Dale, etc. agree we need to explore technical space first, may add cost to Q4 goal
Pass ASTM E84 flame spread
Durability AC125
Surface preparation ICRI CSP-3 or less
↳ No special equipment ↖ see rubber pads
Gregg: install in half the time would be great
Gregg:
Steel reinforcement would have to be mounted deeper to prevent corrosion - even if rods are epoxy coated or stainless
Do we bring 40' rods into the installation?
★ How much steel would be required to be equivalent performance to carbon?
Intumescent - 3M Fire Dam or Albi Clad TF
Next milestones
→ Rizkala review
Installations at Monarch

"Work your way into a new way of thinking, rather than think yourself into a new way of working" - Bernie
Sammy Rizkala - professor at NC State, knows fire, FRP, concrete
OPC - ordinary portland cement
only invention record filed was Venkat's Damascus stuff a week ago

Box Meeting with team, Jeff Lane,
DEN = Dow epoxy Novolak resin
MBrace - BASF wallpaper
DEN resin on rod but different epoxy to hold sand
Like grooves better than screws - less work?
Jeff - are grooves acceptable for business
Gregg has Q1 goal of business case to acquire company X
Jeff - wants to see QFD layout re buy decision
Publish results from MSU to create buzz (Jeff)
Allen Jacoby - pushing hard on cost

#5 Vulcan - Project Meetings, ctd. 1/12

Philip - some constraints are not just cost
Jeff - I'd rather extend the date and have more rigorous around cost
Philip - we can create cost models
Jeff - can we accelerate time to market? Would trump any capabilities (like passing the test)
Bow, Emerald, Momentive - 3 players in epoxies
Bernie: Shotcrete shot for 2 hours, work 30-40 minute with 20% drop-off vs
Vhoscrete for 3 minutes, 10 min work, 50% ↓
Qi: Boards for insulation are safe, but limitations
Intumescent coating is gaining popularity, but engage above 200°
Blankets are niche, durability concern

Next box Feb 24
- completed installation at Monarch (Bernie)
- develop cost model (Jeff S)
- preliminary plan for MSU (Gale)
- IR filed (Philip)

Jeff - business should help write goal around cost
- include must haves and cannot haves

Me - shouldn't be afraid to test boundaries with the MSU test

Allen - translate civil engineering → mat science
- one business goal: peel & stick rehab solution
: automated carbon pipe repair
Samir Kaifeh → where is he now?
↳ 3D weaving (structural concrete canvas)
Allen Jacoby - interested in having a second project
Jeff - maybe when we've done hard part on Vulcan (end of 2012) Q3?
End of ~~Et~~ Feb. 2012 → get Eyfe
Philip: skunk works around Edge - generate new products

Reading:
application is critical, companies use licensed contractors
considerable time spent ensuring good bond surface
Primer seeps up to ½" into concrete - peel & stick difficult?
Use epoxy novolac in extreme settings. Insulation up to 4 hours fire.

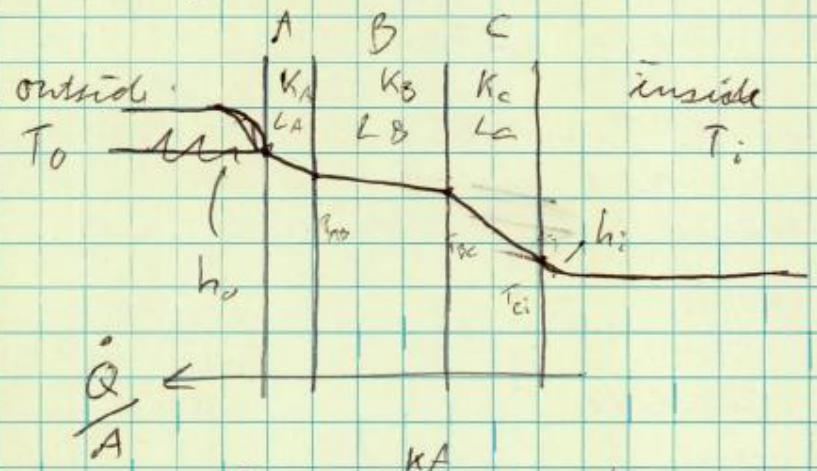
#5 Vulcan - Weekly Meeting 1/16 1/16

Weekly meeting 1/16
Milestone plans
TRB = Transportation research board - meeting for Kenbeat
World of Concrete - has Milliken booth on c. canvas
Phillip: will send out list of invention records
Bernie: AMC - Aluminum matrix composite - temps up to 350°C
(85% of strength)
got equipment - concrete saw, grouting gun
Gregg: typical rods are 3/8" thick
or 1.5 × 10 mm strips
me: custom or special blade profile?
→ where to get / buy?
Gregg - use off the shelf blades
Dixie - concrete cutting
Dale: interface with Rizkala, Sammy
One critical question - how much steel to cast into next
2 beams
Hodes said 3 months but took 6
$20K to make 4 beams, $57K to test
Met with Qi on insulation options
Each person should define "what's my role?"
Qi: looking at hi temps insulation for industrial use
buildings - steel structures - separate recommendation
spray, foam, intumescent, boards
→ to determine material, need specs
(what they recommended)
E119 rating - temp inside beam
Bernie - column tests (compression)
- put slab on gantry in basement
Not much going on next week

#5 Vulcan - Discussion with Qi 1/16

Steady state 1D heat transfer

$$\alpha = \frac{k}{\rho c_p}$$



$$R_{TH} = \frac{kA}{L} \text{ or } hA$$

$$R_{overall} = \Sigma R = \frac{K_A A}{L_A} + \frac{K_B A}{L_B} + \frac{K_C A}{L_C} + h_o A + h_i A$$

$$\dot{Q} = \frac{\Delta T}{R_{overall}} \qquad \frac{\dot{Q}}{A} = \Delta T \cdot \left[\frac{1}{R_{overall}}\right]$$

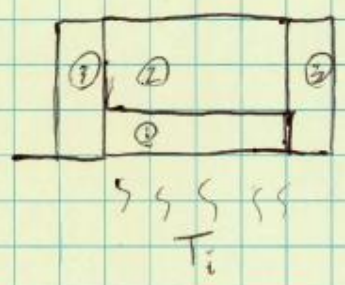
$$\dot{Q} = \dot{Q}_A = \dot{Q}_B = \dot{Q}_C$$

T_{AB} & T_{BC} → $\dot{Q}$ calculate heat flux

then

T_{BC} & T_{Ci} → K_B figure out conductivity

T_o



① = K = 0.0723 W/m·K
② concrete K = 0.4 to 0.7
③ mineral wool K = 0.05
(0.04 @ RT up to 0.20) @1100°F

Intumescent coating is \$120/ft² vs \$11 for board
~~Paper~~: Qi: current thinking is Unifrax board
does not have cost for spray-on VG
Boards attached with screws or staples
Qi - hasn't considered mineral wool
Al melts around 660°C Unifrax rated to 1260°C
George Macaw - Gregg's contact
→ ask engineering about spray on hydrated gypsum cost
Dale: does E119 specify heat input?

#5 Vulcan - Allen Plant Installation 1/17

David Evans

Cyprus (Allen Plant, Blacksburg near Magnolia)

- used Pyrocrete 241 from Carboline NOT!

~ ½" insulation Building BB (last one) and BA (first)

Job #079

John Christy - contractor (Rockrock builders)

sprayed on with metal scaffold

bought from company in Charlotte 2 companies

some kind of gypsum

sometimes come back & patch it (trolling)

BA - sprayed Metal deck

WARCO - do product & install (704) 521-5200

3-story or 4-story, metal deck or formed in place

Fireproofing: Jim Tolman bid

work done in '04 ~~or '03~~ July 2003 → end of '03 Aug - See build

Similar to last time

↳ hard to do square foot pricing

escalate 5% a year

very expensive system

columns (steel H) boxed in with metal, sprayed

then trolled it smooth (keeps clean, wash down)

Probably 2 hour rating

JTOLMAN@Warcoconstruction.com

Print:

2 hour rated walls

Structural Frame incl columns, girders, trusses 3 HR

Roof supporting frame 2 hr

Walls 3 H...

4000 PSI concrete on floor steel 50KSI

~~Fireproof~~ Fireproofing may have been later

Jim Price worked on this now at O'Neal Engineering

Jim Tolman: 2003 cost was $300K, with 5 x 5% = 25%

increase would be $375K

Area = 55' x 125' = 6875' 4 floors => 27,500 ft²

also did columns 28 per floor, 25' high

28 x 4 x 25 = 2800' of column

Paul Pruitt: fire loss prevention class

W2; columns 27'5" + 25'4" + 25'4" + 19' hts bottom → top

or W12's 10" in concrete, W21x248 from 621' to 678'10"

then W21x122 from 678'10" to 719'1"

loss a little going thru each floor

columns rated 2H, floor 3H

#5 Vulcan - Allen Plant Installation, cts 1/18

28 Main columns + 8 smaller for stairway
W12x72 all the way & W12x65 (4 of each)
subtract 4x 7" ~~bel~~ going thru ceilings

→ create spreadsheet "Allen fireproofing cost.xls"

Chip Baker - Carboline
$160K vs $1,000 material
↑ Thyrotex ↑ intumescent
cementitious

2 inches
intumescent - 310 mils

Fireproofing vs heat transmission
concrete parking decks - fill in flutes in concrete
Need metal lath directly on concrete
UL guideline
get different UL design #'s for each test
cellulosic fire ???
lath required to keep insulation from falling off
exterior requires top coats (Urethane)
sometimes concrete used in place of fireproofing
sprayed with roto-stator or piston pump
usually drop 15-20%
may need intumescent when column is too close to wall
alternative: rock wool solvent borne
cementitious - 12 products 15 lbs/ft³
pick by interior vs exterior
241 is ~~over 40~~ 55 lbs/ft³
higher density does better in exterior exposure
↳ put on a topcoat
uses OPC
prefer unprimed steel
intumescent is on approved primer
higher density thickness is probably less
1709 hydrocarbon fires - lower density won't stand up
Type 5 & 7 are tough to trowell, made to be sprayed
241 uses less water
lightweight gypsum is most common (sprayed)
trowelling labor cost with lath - $4/ft² for 1½ to 1⅞
contractors check thickness ∥ spray - 75 to 200 bags a day
vertical is much faster than overhead
clips hold up lath on steel... concrete → Hilti gun + washer
have "brows" to apply

#5 Vulcan - Chip Baker

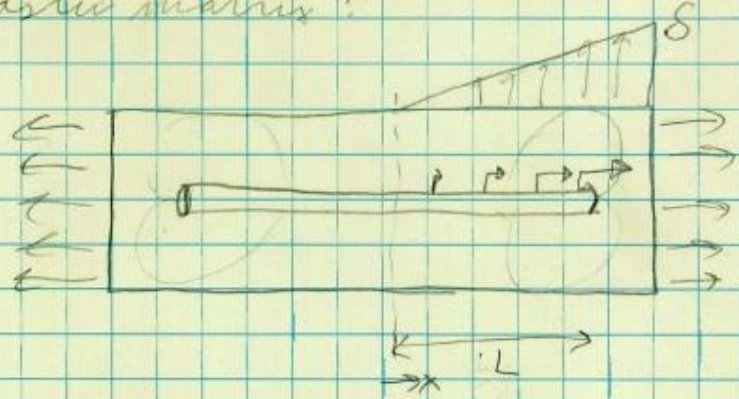
1 hour is a different ballgame
most jobs are 1 to 2.5 hours
↳ how is it specified
can design with heavy enough steel
above 25' doesn't have to be fireproofed in cellulosic
because ... not sure ... not enough to sustain
Hydrocarbon 1709 temp rise is much quicker
1709 coatings are tested to an explosion
fasten every 12" or 24"
$20,000 for spraying equipment
- contractor must have it to get certified
↳ would typically have it to be in fireproofing business
also used for concrete pumping
need to monitor density
Have to mix full bag at a time
Has a thermal barrier spray-applied liquid membrane
R-value probably low 30-120 mils
May not withstand temps
IBC 2006 fire code → hour rating (David Evans)
rejected 2009
insurance company may have input
stick to UL
applicator assumes the liability
constantly running tests
Cafco & Grace Warco's certified by Carboline
Southern Fireproofing - Travis Kitchens
↳ doing job at Duke Power

David: getting UL certification → public

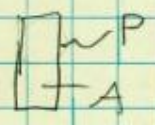
Intumescent: 90 mil is 3 to 6 coats
up to 300 mils 10 to 12 coats

#5 Vulcan – Reinforcement Rod Analysis 1/23

What is the stress field around a stiff rod in an elastic matrix?



rod length 2L



This may be simplistic, but if $\tau = \tau_{max} \cdot \frac{x}{L}$ $|x \le L$ and $F(L) = 0$, (long rod)

$$w(x) = \tau(x) \cdot P = \tau_{max} \cdot \frac{xP}{L}$$

$$F(x) = -\int_0^x w\, dx' = -\int_0^x \frac{\tau_{max}}{L} \cdot P \cdot x'\, dx' = -\frac{\tau_{max} P}{2L} \cdot x^2 + C$$

$$\sigma_T = F(x)/A \qquad F(L) = -\tau_{max} \frac{P}{2L} \cdot L^2 + C = 0$$

$$C = \frac{\tau_{max} PL}{2} = \tau_{max} \frac{P}{2L} (L^2)$$

$$F(x) = \frac{\tau_{max} P}{2L} (L^2 - x^2)$$

$$\sigma_T(0) = \sigma_Y = \frac{\tau_{max} P}{2LA} (L^2 - 0) = \frac{\tau_{max} PL}{2A}$$

$$\tau_{max} = \frac{2A}{LP} \sigma_Y$$

$$L_{crit} = \frac{2A}{P} \cdot \frac{\sigma_Y}{\tau_{max}}$$

round: $\frac{2\pi D^2}{4\pi D} = \frac{D}{2} = \frac{2A}{P}$ $\qquad L_{crit} = \frac{D}{2} \cdot \frac{\sigma_Y}{\tau_{max}}$

rectangular: $\frac{2\, bh}{2(b+h)} = \frac{bh}{b+h} = \frac{b}{\frac{b}{h}+1}$

☆ get σ_Y and τ_{max} for rod failure & rod slippage samples from lap shear tests.

☆ Also look at τ_{grout} → grout fails in concrete boundary

#9 General - Innovation Fair 2011 1/23

Held on 1/23/2012 and 1/24
Joe Salley - approach to innovation
Scope, Competitive Advantage, Objective
- Floor Covering
- Performance Materials } our focus
- Specialty Chemicals
Advantage
↳ innovation excellence, double GDP
Objective - >10% ROIC, growth, global leadership
Play = inspired passionate engagement in unique insights, deep science, & meaningful design to do good, create new experiences for customers, and build for the future
THURSDAY - open innovation gallery
Millad ... PP is sustainable & green
Unique insight - proprietary discoveries that identify the problems to be solved
Washable markers are great
meaningful design - change the way people think
Ethics - reject 1 of 6 ideas because not in our morals
(2x2 matrix market attractiveness vs comp. advantage)
Made $100M investments in acquisitions, computer systems
Powerball lottery - get back 60 cents on the dollar
negatively asymmetric bet
Change since Roger retired - values the same, excellence ethics leadership
- how we operate has changed, more growth
Jay Xu: How do we measure successful innovation
↳ ROIC & growth, global leadership (time lag)
→ Joe's favorite: expectations on gross margins
< 30% : ☹
30% - 60% : 😐
> 60% : ☺
Salley: we invest more than our competitors
WSJ article: commodities from 50% → < 30%, outperformed S&P since 2008

Joseph DeSimone - joint professor, 300 publications, 130 patents
Innovation Process: Harnessing Ideas from Multiple Disciplines
CO_2 polymer processing diversity promotes insights
- spun out Liquidia ↳ assign "the red team" (contrarian)
Cancer cells are softer, bacteria are elongated
use computer production techniques to make medicine
8086 - 29K transistors Pentium IV - several million
deposition dissolvable film

#9 General - Innovation Fair 2011, ctd. 1/23

- dry powder inhalers
  no inhalable antibodies on the market
  learning to ~~nebulize~~ interface on animals (mice)
  Body filters out old blood cells (stiff)
Vaccines: 1st gen - dead cells
  2nd gen - take surface components
  3rd gen - recombine into previous shape
  ~~trying~~ trying to get to $1 a dose for poor countries
  Amphiphilic particles
Liotta: today's academics are more cognizant of society
  Chinese students have different perspective - cheapest way to do things, know how to change a tire

New speaker: Steven Meister - Big Bang industrial design
  - designed Zip-Loc, Cuisinart
can you draw - 5th graders say 100% yes
  flunked out of ME → Industrial design → GE, XRX
Big Bang - 2 person startups
  ↳ every product interaction should be memorable
  30% discovery, 70% implementation
  worked with 30 diverse companies
Golden Circle:

few companies know "why" they do things

Obsess over your customers - meet often
★ Have we met with FRP contractors much?
Ames - make drywall "bazooka"
Distinguish vision from illusion, don't state as fact
Fail fast, failing isn't failure
Bill LaFontaine - IBM
  GTO = global technology output Work in Africa
  go big or go home
Ginny Rometty - IBM's 9th CEO, female, very client oriented
  "the world's most necessary company" - make successful
GTO - add 20% on top of work that's already done
  1-2 2-3 3-4 4-5 5-6 6-1 1-3 3-5 5-1 1-4
  2-4 4-6 6-2 ∴2-5, ∴3-6
Managing Uncertain Data at Scale
  ↳ spawned new projects

#9 General - Innovation Fair 2011, ctd 1/23

Marla Capozzi - McKinsey innovation expert

World's best violinist in subway - noone stopped to listen
Curve - took > 3 years to take off
Anchoring bias - $50 million ± 7
Innovation requires disciplined thinking
Innovation is connecting things
94% of executives are unsatisfied with innovation performance
loser focus on wrong strategic choice
leadership is the greatest predictor of innovation outcomes
- integrated into the team
- take time to manage
- protect innovation, failures
- talk about it in staff meetings, once a month...
Apple is only company with market creation
↳ very focused
Google - lots of copying (Hotmail → GMail)
HP - overinvest in core (~~70%~~) from 95% to 70%
↳ add 20% adjacency, 10% new growth
P&G, IBM have 3 of 4 innovation strategies
Staffing a team with "believers" is key
External "sponsors" were less successful than projects led by their originators
4 modes of innovation
1) Adjacency innovation
2) Business Model "
3) Distinctive asset (out-execute)
4) Reverse innovation

Posters session
- Alex Rapp, Pendleton - not really interested
- John Sollars - airbag is 98 gauge (OPW)
Louie - Kingsley duct tape - 35 gauge
Prometheus - upstairs at Gilleland

1/24 De Souza - need to be inspired, engaged, & passionate (Sally)
- who do you want us to be? One negative = 1000 positives
- Assume success - Put yourself out of comfort zone
- likes the "Red Team" idea: OK to speak up
Blue Mango Innovation: Doug Wilson & David Phillips
"you ARE the traffic" ↖ annoying corny jokes

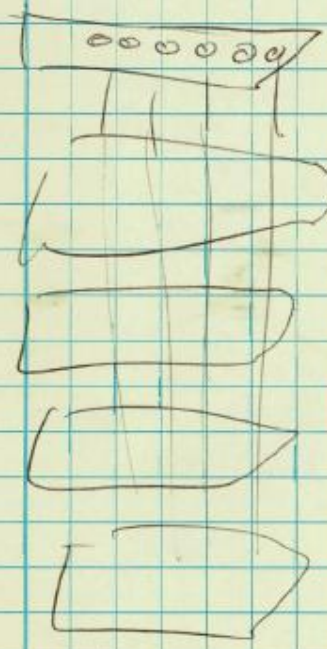
#9 General - Innovation Fair 2011, ctd 1/23

Holistic SPROC
↳ strategy process ~~results in~~ resources org & culture
3 Organizational conditions
1. Physical workspace 13:1 good ideas come from random events
↳ separated < 30m, no barriers
2. Organizational diversity
↳ L/R brain Daniel Pink - A whole new mind
conceptual age HBDI balance
"Polymath" - intermediate expertise in many areas
Starters vs finishers. Sow had mostly starters >> ⅔
3. Incentives and Metrics (beyond compensation)
if too competitive, no collaboration
intrinsic motivation can be suppressed by extrinsic
↳ fees for late day care had opposite effect
impact on risk taking? Can't be afraid to be wrong
~~educates~~ out of creativity
4 Behaviors
Sir Winston Churchill - "Success is the ability to go from one failure to another with no loss of enthusiasm"
failure tolerant VC's ~~are~~ make better IPO firms
"unexpected outcome" as learning opportunities
punish inaction
"get it right the first time" mentality doesn't work
Pixar - daily progress reviews, team tears apart ideas
dedicated staff to open innovation
3 Questions: ~~What~~ is the problem?
What are we trying to accomplish?
How might we . . . ?
What else?
How many passes does the team in white make?
Competitors Rules And Practices (Commerce Bank)
Design Competition (Build bridge)
Roster Session
Sage, Cushman may be interested
Z Abingville (Mark)
Johann Peschek - some other styles @ Roiselle

#9 General - Innovation Fair 2014, ctd 1/24

Danny Moseley (at Hillside)

Creel weaving @ Pine Mtn



Conveyor belting

3 creel machines

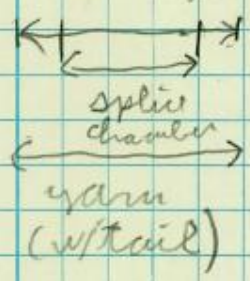
Met Thursday

About 24 gauge, 5000 denier
Probably Nylon

Machines 67, 68, 66 near the Pori Reis loom

Air splicer: chamber about 0.1" wide, square!
Trigger side is cut, chamber not closed until activated, pinchers hold yarns while splicing

Pinch - seal - cut - ~~splice~~ pull in! - splice
cut is ~ 3/4" out, but puller places end ~ 1/2" from end of chamber



Could do one set of ~ 30 at a time at the creel

#9 General - Safety Mtg 1/25 1/25

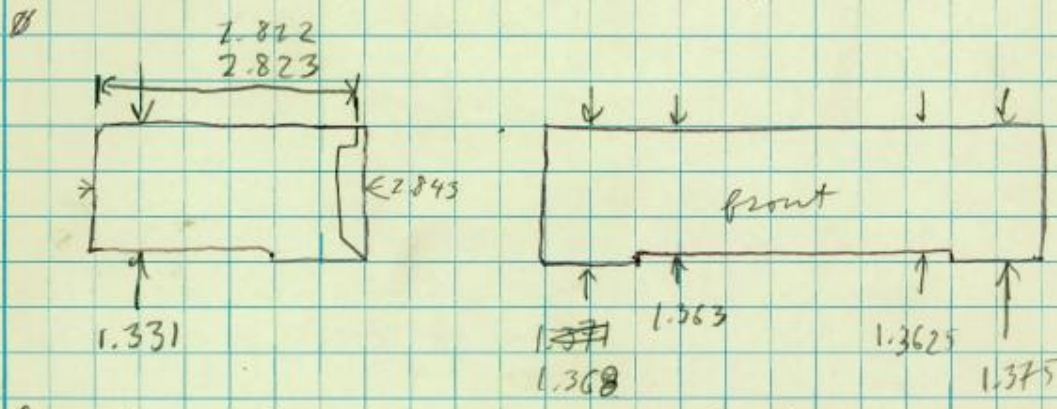
Wilson, Jackson, Ellis, Moseley, Ridgeway, Henson, Srivastava, Hemingway, Liao, Petri

Next Friday: practice audit
Henson - want to get checklist
Brad: may actually be this Friday
Kathi: clean eye glasses
Wilson: should do a walkthrough
Elaine looking at chemical handling at the docks, probably need to train Rudy
Rudy has choice - refuse or unload
Water runoff from B - ~~docks~~ dock not treated
could send to dock F - main mail room
C - dock would need a new fork lift ~ $25K
↳ doesn't have water treatment either
Kelly Edwards made non-decision
Rudy not always there
Spill kit is OK with OSHA, have been able to slow it down before it hits the creek
Brad will follow up with Bobby

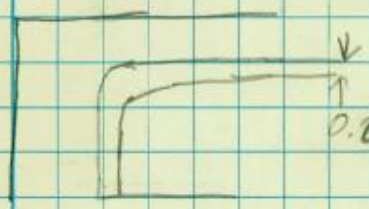
#1 Emmins 9 PM - 1/26 Trip

1/26

New 5 mil ULI installation



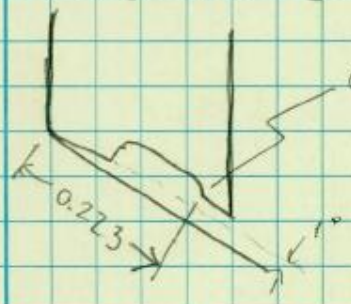
Gap is ~ 42 mil
compare p. 22 - apparently 2.823 (undercut) → 42 mil gap
undercut is 0.020", correct 2.843 overall
but specified 2.843" overall



0.023" gap @ top of AGI now

Air Flow: from 2000 rpm @ 5 PSI to 3000 @ 1 PSI
Now 10 PSI - 117 CFM - 493°F air
- 116 505°F
43 PSI die pressure @ 2 RPM 91 PSI at inlet 1/2 CFM air
used to be 60 PSI @ 20 RPM

Air flow does not Δ with die pressure
Dale believes 35° angle may be off



opening - 3.8 mils! (beyond the intended)

streaks at 2 RPM, but looks pretty good at 10 - was before tuning - see 109-732 (7" collection)

Go back to original ULI
- gap is 0.048, 0.053 hot
lip

Wiping: idea not bad but wiper streaks in a few places, fibers stick to wooden stick.

#1 Emims 9 PM - 1/26 Snips, ctd 1/27

Baffles at 5, still blowing air out the back - but no loose fibers
12:22 - roll not properly mounted on adapter, left side is loose & roll thick at that end.
R side also a bit thicker but not as much
Hood seems to work OK, especially on light weight.
Wiped material gets sucked up into hood - not bad.
We went back to the spiral belt - doing well
→ Not a sample, just taking up material

On roll: 100 gsm on outside, then 80, 20
all at 9" collection

Ran HEPA for me = 60, 80, 100 gsm
on 70 gsm PP spunbond & 149 gsm spunbond
↳ plenty of space in between as "control"
stay a few feet clear of boundary (esp before) on 149 gsm samples.

#5 Vulcan - Various Meetings 1/30

MBrace 1" wide = 4.2 KIPS per inch per ply
(10 yarns @ 12K tow
rods are 24K 4.4 at room temp
4.7 at 250°C

search for DEN 438
lap shear with mortar:
no sand: 1800 lbs 3 rods, 3" embedded
with sand: 2300 lbs but concrete failure
Home-baked rods

1/30 Team meeting
Rich Gibson
PW: Invention Records list
Qi has IP landscape tech report
→ would like first pass by end of the week
records due Feb 4th
Strahan: cost model
Tack point blade - cut mortar out between bricks (Bernie)
→ 4" wide and ½" deep
Me: spraying cost at Cypress
PW: fire rating based on 550°C on steel, not the same
Qi: cost per lb about the same, need higher density
PW: spraying is messy
Jeff: cutting is free-hand, hook up to shop vac
Gregg: ICRI - int'l concrete research institute
Bernie: may do install at Drayton
Bernie, Phillip: have ruled out spray on insulation
Gregg: do need to know cost
Interest - could help with design loads
I'm concerned about fastening - nail gets hot, slabs fall out vs lath attached horizontally

ACI 318 - development lengths

George McCall 1/31
Start with code
Industrial or offices?
If sprinkled - decrease rating
3 hours is magic number (fire separation) IBC code book
← max high rise: 60-70 stories have tougher rating

#5 Vulcan - Various Meetings, ctd. 1/31

Room of origin contains the fire
A = assembly E = educational I = institutional (hospital (prison))
R = residential (hotel etc...) F = factory
S = storage B = business H = hazardous (chem plant) 1-5
sprinkled vs non-sprinkled M = mercantile
only 4 is A, E, F2, S2, U non-sprinkled
just about all sprinkled are I's except hazardous

PW: repair parking garage
George → concern for spray is durability
Parking garage is S2
IFC code Ch. 1 has a lot of "crap" pages 3-10 permits
CA needed funding, 7 pages of permits = fee for each job
permit → another set of eyes looks at it, protects public
H2 = deflagration hazard class I, II, IIIA pressurized >15 psi
egress: 5% is > 2 hours
can get info from local bldg codes
can get unlimited space if far enough away
Ch. 5 - need to be > 60 ft away ... not exact #
can also build a 2-hour rated wall, door, etc.
NES = national evaluation ~~sys~~ series
- maintained by ICC int'l code council
- tested systems alternative to UL ← most common
UL is expensive
- may find existing insulation product in NES catalog
Toughness is not codified, assume perfect maintenance
"It's incredible, nobody cares"
Tampa FL public courthouse - Tam sts.
Bubba installed flanges in barlewand
contractor missed lots of issues design firm had immunity
sprinkling is usually cheaper
George's role - market and/or technical
"magic poolsey" insulation
alternative tear it down
covered malls are "out"
Bridges - have their own standards, CE matter
Market: federal courthouse, 18 stories, can't implode it
each floor must have separation esp in pre-stressed
concrete 5/8" sheetrock is 2 hours rated
Factory Mutual does lots of research but doesn't share info
- sign up as design professional, see website
normal evacuation is 2 minutes (based on WW II London!)

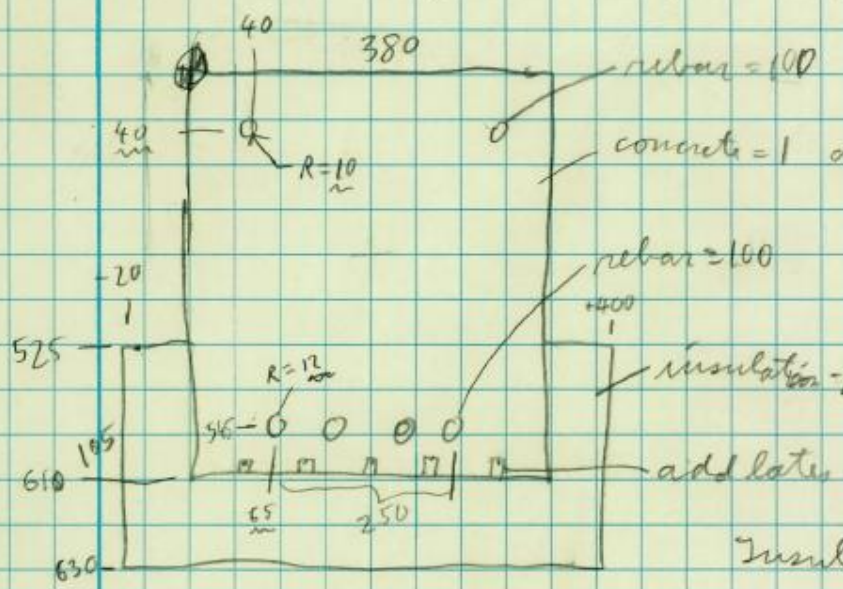
#5 Vulcan - Various Meetings, ctd. 2/3

Firemen get fire out in x hours
Twin Towers exempted from code b/c not NYC jurisdiction
1st tower retrofitted, lasted 2 hours, 2nd lasted 1 hour, not retrofitted yet
ESFR - early suppression fast response
↳ special type of sprinkler head
normal 25-30 gallons $Q = K\sqrt{P}$
↳ $K = 5.6$ $P \sim 49$ PSI 7×5.6
ESFR 16 to 25 $P \sim 100$ → 250 gal/min suppresses fire
at least 12 heads + 2 (obstruction)

What is type IA construction?

Drexel beams: 174" x 16.5" x 20.5" (girder)
↳ big flat one
174" x 12" ← normal girder
92" span ← joists
198" spans, 168" x 12"
← columns 12 x 12

Build MSU Beam ← BAD DIM'S!



MSU 1.mp
material file

Also see
ANSYS notes.docx
Clone 77

Insulated on top

4H = 14400 sec step = 5 sec 2880 steps max
save every 12 steps = 1 min 25 steps?? 575

#9 General - Pipe Medic Quakenwas Session 213

Mo Ehsani Ph.D., P.E., S.E. pioneered FRP repair
Ex-professor at U of Arizona from Iran
200PSI - maybe 2 layers of carbon
Turnkey solution provider
1980's - Wet layup, lots of competition
2009 - Superlaminates
2010 - Stif Pipe
Wet Layup: mix blue + yellow = green
Blast protection - 200 kg TNT blast
Largest pipe is 18' Ø
If >2 layers, need ~~robot~~ robot
Money is in pressure pipes sewer - gravity water - pressurized
Most around 50-150PSI, gas is higher
Alternative: insert steel pipe, weld or expand
↳ then spray ½" of mortar to protect

Superlaminates: glass - uni C - bias C - glass
~155KSI σ_T thickness = 0.01" to 0.025"
can make bigger widths up to 5'
used in pipes - Pipemedic cannot handle bends
Gas lines have drip pots because of condensation, new pipes don't need them Gas lines leak a lot!
Get clogged up to 40% of diameter
Star Liner - German company - only product
↳ need to bridge drip pot
very nice solution for 16", 12" pipes
test at 250PSI - liner would fail, pipe good to 800PSI
Pipe bursting - break old pipe & take it out
Next: robot for full length installation
Peel backing off dry sticky tape - big advantage
→ could open up huge markets
- university student work
not relying on host pipe for structure
challenge: nonuniform Ø, shape
me: stretch - broken materials? - ~~[illegible]~~ not familiar with this
also see ↓
could also do cylinder rather than spiral
me: 45° bias cut fabric? Try to get away from cure in place
steel pipe needs veil of glass b/c galvanic action
Perhaps separate solution for bend
Pigs sent down pipes to clean it - spinning bottle brush
Wrap square columns then fill with concrete
Pipe Medic Trying to ~~fol~~ make gap underwater

#9 General- Pipemedic Quakewrap Session, ctd. 2/3

Huge market - $600 to $1500 per foot of repair,
6-7 ft splash zone, 100,000 piles in one job
Apply to any size column
- innovation is in the technique
  eliminated need for divers
What is next: sheet with protrusions (cheap)
  wrap around column, then wrap fabric
  ↳ for people with doctes
Robot for tall bridges
Need pipes that take traffic load, 11 layers, $20/ft²
Stiff Pipe - honeycomb, carbon on inside & outside,
add filler material
Join w/ 45° tapes, put some epoxy at joint
0.05" thickness adds 75 PSI rating
Can do work offsite, $15/hour vs $80
cost: $6.5M → $1.5M 20,500 hours vs $3,500
collapsible would be nice; dry connecting joint;
automated construction
Mile long seamless pipe
Saudi Arabia: concrete wave roof design

#5 Vulcan - Ideas 2/3

Dale Hitchen and I just had a fruitful discussion around Vulcan.
Dale had previously suggested that one could insulate the ends where the carbon fibers are anchored. I agreed that the center span doesn't really matter in that case.
He then asked about anchoring the ends of the rods mechanically. I had already talked to Venkat about this but concluded that it would be difficult to crimp something on with 1000 lbs of holding force that sits in the groove.
We then brainstormed a number of solutions to better anchor the rods.
I suggested using plain carbon tow that just had a non-snag finish on it but left it flexible. This could run back & forth in grooves. Dale said this could even happen on the surface! The key is proper anchoring of the ends in an insulated fashion.
A number of possible anchors involve wrapping around a round stud to exploit the capstan effect - like a guitar or piano string.
I suggested post-tensioning the carbon, which should be very effective (~~seated~~ need to check CTE's). For now, we don't really need that.
We also burned a pultruded rod, finding that the epoxy actually burns with a flame, leaving behind a flexible bunch of strings. This opens up a whole set of possibilities around solid rods that are bent at the ends.
Question: when does carbon lose 50% of strength? May be higher than steel.
I drew a few specialized "nails" with a shoulder that could be driven in with a Hilti gun, then used to wrap/anchor carbon on.
Dale had some ideas around a "peg board" that had pegs for every string
I suggested going back & forth with a single tow, only anchoring 2 places. ???
Monday we will ~~?~~ make a beam with reinforcement and test it (room temp, end-clamped rods).

#5 Vulcan - End Anchoring Notes 2/6

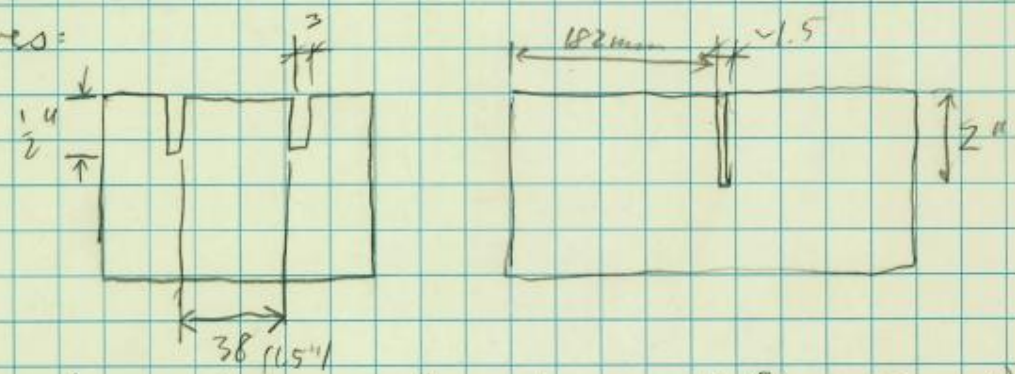
AM - make concrete bar with plain clamped carbon rods. Rods slipped in clamps. Concrete broke at 600 lbs, then rods slipped at 900-1000 lbs
Existing NSM - all one size
Aslan 500 is 5/8" wide
Tuck point blades are 1/4" wide - can use 1/8" thick ribbons
Philip - do practice run
Sushi Mat - issue is water trapped in concrete
Install on 2/16 Tuesday - Grayton plan
PW: IR, meeting with Cheryl Wednesday
↳ bump 4 into first IR
Modus - Dale, Philip & J going on 20th

Reinforced Beam:

1/4" bolt: lubed 6 ft-lbs = 2850 lbs ⟺ 12 ft-lbs plain
so 40-80 lbs per in-lb of torque
CAD model: create cement OPC
tensile modulus = 11.2 GPa compressive = 2.92 GPa!

Hexcel carbon fiber σ_{UTS} = 590KSI 4070 MPa E = 428 GPa
In resin rod, 40% resin - σ = 363 KSI ⟺ plain carbon 637 KSI
Equivalent 24K tow: 0.042" Ø

Grooves:



With carbon rods: 1000 lbs → δ = 0.0367" (lips and fixed)
→ center disp = 0.0031 + .0367/2 = 0.02145
slot stress = 1.13 KSI max = 40KSI in carbon (due to notch?
open field carbon stress = 27 KSI @ 0.89 mm²
27 KSI ⟺ 37 lbf tension 17.2× safety factor break @ 17,200 lbs
concrete: 5KSI? → 4.4× safety factor → break @ 4,425 lbs
Bonded: (carbon fiber on surface - tangent = OK!
make square, 0.037×0.037", bond to surface δ_{cable} = 0.013"
→ groove stress = 0.6 KSI, rod = 200KSI to 260 KSI in center
(concrete) 8,300 lbs 3,200 lbs ☆ includes bending

Vulcan - End Anchoring Notes, ctd / ACI 440 2/7

200K SI / 0.00138 in² = 276 lbs / KIP (each rod)
4 rods would scale to

Clamps

400 lbs preload
200 lbs → 40 lbs/in-lb × 5 in lbs
something less than 15 - probably broke them

Could put tensioning bolts on top to even out, pull in tip.
Holes in plate to keep bolts from walking
Carbon failed at clamping point
Initial slope is very steep
@ .014" → 500 lbs
@ 650 lbs @ 0.010"
→ 20120207 24K × 2 tension end clamped. MSS in Dale Kitchen folder

—

Read ACI 440.2R-08 Guide for... externally bonded FRP systems for... concrete
p. 3 - "data for FRP is often less"
p. 4 - Critical temp should be lowest Tg of components.
stay at Tg - 27°F
Reliability Index may be bad if hi ratio of FRP
$\phi R_n \geq 1.1 S_{DL} + 0.75 S_{LL}$ statistical mean is $0.5 S_{LL}$
Avoid strain of debonding NSM: $\varepsilon_{fd} = 0.6\varepsilon_{fu}$ to $0.9\varepsilon_{fu}$ (0.7 rec.)
development length Ch 13
p. 26 - assume concrete $\sigma_T = 0$, Plane sections & transformed sec'n analysis... check strain in steel
Assume neutral axis → find strains → find stresses → balance forces — ↑(adjust)
$C = A_s f_{s=steel} + A_f f_{fe=FRP}$ force equilibrium (moments)

$\alpha_1 f'_c \beta_1 b$ ← Whitney stress block, equivalent moment
$\alpha_1 = 0.85$ β_1 see ACI 318-05

recommend groove ≥ 1.5 d_b depth & width includes d_b so gap is $0.5 d_b/2$ on each side ($0.25 d_b$) why? ask Richard
groove spacing ≥ 2 × depth
p. 39 - recommend τ_b = 1000 PSI res. for FRP bond strength
$l_{db} = \frac{d_b}{4\tau_b} \cdot f_{fd}$

$C = \frac{5 \to 180 + 46}{43.8}$ FRP

$\frac{3'' \cdot 60 + 1'' \times 48}{\$12'' \times 5 \times 8} = 52''$ h = 22"

#5 Vulcan - ACI 440 2/7

Why is c so high? For one, ignoring concrete below the neutral axis completely...
$f = E\varepsilon$

$$F_{st} + F_{FRP} = F_{conc} = \sigma_c \cdot b_c \cdot c'$$

height = part above neutral axis $\times 0.85$

this is in concrete gets crushed condition...
F_{conc} is reduced at top
hence neutral axis in elastic regime will be even higher!
Adding FRP will lower the neutral axis.
☆ Even though concrete is not assumed to carry any load, it needs to be there to ensure proper strain levels in the FRP & steel.

Design of Reinforced Concrete 8th edition - ACI 318 McCormack

FTC concrete CDC pretty p. lab work.

$$l_d = d_b \cdot \frac{3}{40} \frac{f_y}{\lambda\sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s}{\left(\frac{c_b + K_{tr}}{d_b}\right)}$$

ψ location, coating, size

l_d: development length; d_b: bar ϕ; $\frac{3}{40}$ in US; λ: lightweight aggregate (worse)

cover or ctr-ctr

$\frac{c_b + K_{tr}}{d_b}$ } confinement term

max 2.5, usually 2.1.5

transverse reinforcement

$K_{tr} = \frac{40 A_{tr}}{sn}$ ☆

$\sqrt{f'_c}_{max} = 100$

Typical: $l_d = 44 d_b$ to $67 d_b$

Take $f'_c = 5000$ PSI, $f_y = 363000$ (Applied to FRP...)

$$l_d/d_b = \frac{3}{40} \cdot \frac{363}{1 \cdot \sqrt{5000}} \cdot \frac{1 \cdot 1 \cdot 1}{\frac{c_b}{d_b}} = 154$$

#9 - Safety Meeting 2/8 2/8

Present: Wilson, Ellis, Moseley, Ridgeway, Petri, Liao, Hemmings, Sullivan, Valdario, Lane

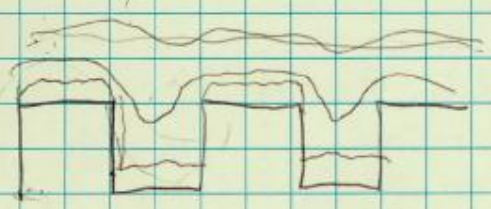
Mike: VPP practice audit (Union & Riddelmber)
Union big on appearance - indicator of attitude and safety
* Guards need to be in place and used properly, easy to catch
* Blocked exits, electrical panels, & fire extinguishers
→ very easy to catch

Will ask questions again, send out practice question
Big inspection on May 3rd
* PPE has individual's name on it
* Do not daisy chain power strips
* Nothing on tops of flammable cabinet!
* Flammable cabinets must be grounded
* Propane stored away from other flammables
Lane: do walk-through with Tony Union in late April
Wilson: CDL is a mess, costs $4M to fix floor (Parkett)
- Mike to have Tony inspect CDL
Brad: close hoods, fans off, no odors
suggestion: wear safety shoes May 3rd
Some hoods need to be replaced
VWR is repairing chemical hoods

Safety inspections need to change
• waste containers not in hood but in dedicated area
• practice new sheets next week (Brad & Bobby)
• chemical labeling
Qi: common storage areas are concern, lab 2, 27 not all properly labeled
Me: replace safety Q's (Paddy system, cut glove) with "pull up an MSDS", spot check a few chemicals
Brad: chemicals not always stored in proper location
↳ not a safety issue
Rudy to take chemical handling training
Elaine working on chemical drop-off at B-docks
Brad to show explosive hazard from dust
Me: store metal chips in steel drums?

#9 General - Geotrec Session 2/9

"Interesting startup" - a year old - 2 guys.
Scott - VP, cement guy
Amir ~~Hoda~~ - President & CEO, Pakistani
Primarily pipe rehab, large (>30") pipe storm water
Tons of money lost from downtime, some hard to quantify
Material have 50% better abrasion resistance
cost comparison - lower ~~above~~ >30"
CIPP - cast in place - cost is quadratic, use steam
IPR - partner, big contractor
use waste material - fly ash, etc.
CIPP needs access, Geotrec uses manholes
faster to deploy
consent decree - $20B allocated
Spray on concrete lines ¼" to 3" thick (radial spray)
Mixing is critical - high shear
20% of pipes > 30" - by length?
Geospray, Geoskin, GeoAer,
2500 PSI in 1 day, 28 days 8000 PSI
4-5% air entrapped
Geoskin: penetrating seal (liquid glass) w/ antimicrobial
Geospray AMS - combine both
lasts indefinitely, works perfectly
Brent: "MIT people don't read, they just do math"
Bacteria produce H_2S ... also looking at better acid resistance because acid will be there eventually
MIC - microbially influenced corrosion
~~Geo~~ GeoAer - lightweight aerated concrete 8KSI in 28 days
can make 30 lbs/ft³ stronger than compacted soil 130 lbs/ft³
which is 200 PSI
claim the 30 PCF version can still be impermeable
Slowing down is not a problem
30 min → 2 h working time ... going back to original formulation
great void filling
Nozzle - 4 mm × 20 mm slots

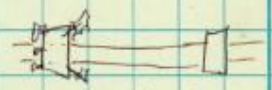


#5 Vulcan - End Anchoring II 2/9 - 2/10

Continue Inventor FEA - suppress slot (see p. 74)

Bonded rod: center = 0.0072/2 + 0.0035 = 0.007
(vs. .013!) ↑ Max next to center, ignore local
carbon stress = 15KSI (vs 200 bonded, 27 unbonded)
↳ 21 lbs tension, fail at 42,437 lbf
cement stress = 0.26KSI excluding contact stress
↳ 5KSI is 19.2 KIPS, but tensile strength?

End-mounted rod: center = 0.0089/2 + 0.0026 = 0.0115"
stiffer?? Due to End Plates?
Max C stress is still 15 KSI, concrete 0.26"
Note: C rod is in bending not tension

Plain carbon: did not break at 50 ft-lbs (punch)
when wrapped carefully
AND did not slip with wraps + finger tight!
some fiber moved at 36 in-lbs on 4 bolts
with a straight clamp
Torqued to 60 in-lbs, 2 strands, straight thru
- slip at < 4 in lbs on push bolts
→ torque to 10 ft-lbs
↳ Start breaking some fibers at < 4 in-lbs
uneven fiber loading
Wrapped, 10 ft-lbs clamp
↳ bolts bottomed out, then push down
→→ about ¼ of fibers broke, rest slipped
Continue 2/10 stretch 6 ½" of tow
shrink wrapped, 1 strand, (red), straight thru, 10 ft-lbs
middle > 10 ft-lbs
tension 3 in lbs OK, 4✓ 6✓ broke < 9
Carbon broke in the clamp, where I had overtorqued
40 lbs tension / in-lb torque 2 strands, 4 bolts
6 × 4/2 · 40 = 480 lbs 9 × 80 = 720 lbs
fail between 480 & 720
solid rod, 5-ft-lbs clamps (lots round) 
4 - OK 6 - right broke left - broke just under 8
→ no big break, but must have slipped
4× tows 60 in-lbs clamps 4 OK, 8 slip
→ 10 ft lbs, 10 OK✓ 12✓ 14✓ 18✓ 20 ... slip
→ 15 ft 20✓ 22✓ 24✓ 26✓ bottom out
→ 20 ft 32✓ 34 - one slips

#5 Vulcan - End Anchoring & MSU Analysis.xls 2/10 - 2/13

After lunch:

24" → 24 turns in vise, 21 3/4" after done
Set with shrink wraps
#2: 22 3/4" → 21 3/4" second strand twisted better
clamp to 10 ft-lbs, Hope it holds > 20 in-lbs
4V 8V 12V 14V ... #1 is more stretchy
16- bottomed out & slipping
25 ft-lbs, slips 1/8", 8V 10V 12- broken
Based on these tests, twisting does not appear to help. Stretchiness goes down and slip was actually worse. The twist was supposed to lock carbon fibers in place. However, a production quality process may eventually prove advantageous.

Now working with Bernie's spreadsheet
monarch beam CFRP analysis.xlsx
→ MSU beam CFRP analysis.xlsx
change beam dims, make circular reference for automatic iteration

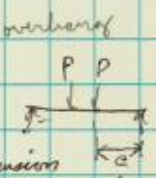
this is for fancy, "realistic" beam loading

$M_{DL} = \frac{9}{128} \cdot w_{DL} \cdot l^2 + \frac{5}{32} P \cdot l$ at Monarch (Bernie)

$M_{LL} = \frac{49}{512} \cdot \overset{k/ft}{w_{LL}} \cdot \overset{ft}{l}^2$ [k-ft]

Handbook for fixed ends: $M_{DL} = \frac{1}{12} w_{DL} l^2 + \frac{1}{8} P \cdot l$
Model: between supports, 13' total
beam is 12' x 10" x 16" high $d_{stee} = 14.5"$
$f'_c = 7386$ PSI $f_y = 61.8$ KSI $f_u = 97.2$ KSI
Distributed load: weight of concrete
Point load P in two places
Normal concrete density = 2400 kg/m³ or 145 lbs/ft³
* concrete must be 143.8 lbs/ft³ not lbs/yd³
Rebar: # = 1/8"s of diameter if solid. #8 ⇒ 8/8 = 1" dia
Dead load moment: Machinery handbook p. 2 34 #5
Center stress = $\frac{W}{2Z_L}(c^2 - \frac{1}{4}l^2) = \frac{M}{Z}$ $W = wL$

$M_{DL} = \frac{wL}{2L}(c^2 - \frac{1}{4}l^2) = \frac{w}{2}(\frac{1}{4}l^2 - c^2)$ $(l > 2c)$



Deadload: case 9 stress = $\frac{W/L}{Z} \frac{Pc}{Z}$. $M = P \cdot c$ c = dimension
"c" = 55.2" - 6" = 49.2" Note: total load 2P!
if total load = P, then $M = \frac{1}{2} P c$ or $P = 2M / c$-moment
Note: concrete weight gives 2.9 vs 143.5 kip-ft

#5 Vulcan - Team Meeting 2/13

Start with FR insulation SFRM = spray-applied FR Mat'l
Qi - insulation results
~~bay~~ ~~Bay~~ hydrogel fell apart
ceramic beats glass fiber
funny jumps in Monocoat
used 1-D model to get properties from test (α)
Greg: see what thickness would be for regular FRP
installation cost estimates based on Qi's gut
Alli dry-lad - 50 mm but cheap
using 600 ft^2 project
Dale: why does anyone use hydrocrete if cost is so high (and chart is accurate)?
Me: talk to Warco? Jim Price or decision maker?
Bernie: Parnell - does NSM get NDA
will bring in **contractor**
Warco: Jim Solman (704) 521-5200
Dale - normally insulate steel beams - not concrete
— see Warco call Patentsafe entry —

Calculations, continued:
assumed that dead load strain is baked into FRP, but not live load!

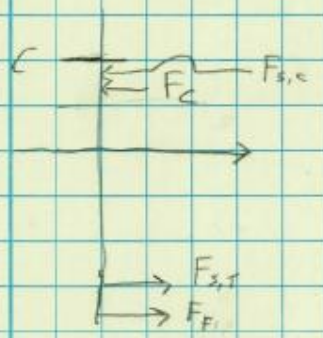
Mill	#'s	Mill	grade → alt. 2 lines, 1,0
H	6	S	60

Rebar should be marked H 6 S 60 see p. 27
According to spreadsheet, beam will break at 70 ~~kips~~ kips. In fact, max design load ϕM_n @ 52 kips

$$\phi M_n = \phi A_s f_y d \left(1 - 0.59\left(\frac{\rho_s f_y}{f'_c}\right)\right)$$

does this assume a neutral axis location? typical geometry? ~~may just be unit conversion factor??~~

$\sigma = E\varepsilon$
$\varepsilon = \frac{\sigma}{E} = \frac{F}{E}$



$$A_s F_s + \cancel{A_{FRP} F_{FRP}}^{\,0} = \alpha_1 f'_c \beta_1 b \cdot c + A_{s,c} F_{s,c}$$

$$F_{s,T} + \cancel{F_{FRP}}^{\,0} = F_c + F_{s,c}$$

$$c = \frac{F_{s,T} - F_{s,c}}{\alpha_1 f'_c \cdot \beta_1 b}$$

$$M_{n,before} = M_{s,c} + M_c + M_{s,T} + M_{FRP}$$

$\phi M_n = in^2 \cdot kips/in^2 \cdot in \cdot [1 - 0.59($

#5 Vulcan - FEA Model

2/27

Work through spreadsheet Vulcan\~~FEA~~ANSYS\
Model properties.xLS
$f'_c, T = 0$ at 917.2°C
Note: offset temperature TOFFST internally added to all temps in ANSYS
creep moded T
Data:
Concrete $\sigma - \varepsilon$: $\sigma(\varepsilon, T)$ family of curves
$\rho \cdot C$ vs T, ρ from Eurocode
$K_c(T)$ given
ε_{TH} given $\varepsilon_{TH} = \sim T^2 + \sim T$
$\varepsilon_{CR} = c_1 \sigma t^{\frac{1}{2}} \cdot e^{d(T-293)}$
Modified time hardening model would fit coefficients given pg 9/10

$$\varepsilon_{TR} = K_2 \frac{\sigma}{f_{c,20}} \varepsilon_{TH}$$

$$= c_1 \sigma \left[T + c_2 T^2 \right]$$

	f_c	E	$\rho(T)$	$c_p(T)$	$K_c(T)$	ε_{TH} (a)	ε_{CR}	ε_{TR}	ε_P
concrete tens:									
concrete comp:	✓	✓	✓	✓	✓	✓	✓	✓	
steel:	✓	✓		✓	✓	✓			
upper insulation:			✓	✓	✓	✓			
FRP:	✓	✓	✓	✓	✓				

Need initial slope (E) from $\sigma - \varepsilon$

$$\sigma(\varepsilon, T) = f'_{c,T}\left(1 - \left(\frac{\varepsilon - \varepsilon_{max}(T)}{\varepsilon_{max}(T)}\right)^2\right) \qquad \sigma = E\varepsilon \qquad E = \left.\frac{d\sigma}{d\varepsilon}\right|_{\varepsilon=0}$$

$$\sigma = f'_{c,T}\left(1 - \left(\frac{\varepsilon}{\varepsilon_m}\right)^2 + 2\frac{\varepsilon}{\varepsilon_m} - 1\right) = f'_c\left(\varepsilon \cdot \frac{2}{\varepsilon_m} - \varepsilon^2 \cdot \left(\frac{1}{\varepsilon_m}\right)^2\right)$$

$$\frac{d\sigma}{d\varepsilon} = 2\frac{f'_{c,T}}{\varepsilon_m} - 2 \cdot \cancel{\varepsilon}^{\to 0} \cdot [\ m\ ] = \boxed{2\ f'_{c,T} / \varepsilon_{max,T} = E_0} \text{ concrete}$$

Steel: $E = \left.\frac{d\sigma}{d\varepsilon}\right|_0 = \frac{f(T, 0.001)}{0.001}$ I suspect it could really be $\lim_{x \to 0}(f(T, x))$ but that is OK

3/2 continuing:

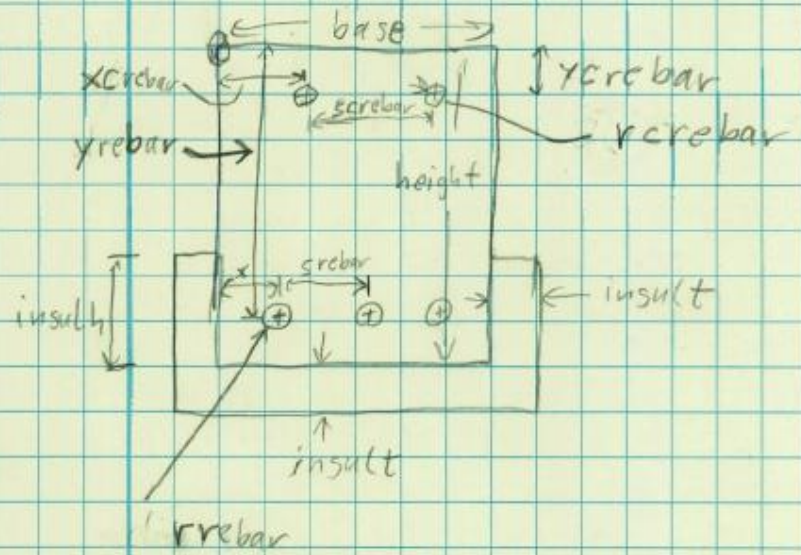
	concrete = 1	steel = 100	uniax = 200	polymeric carbon = 300
density	$\rho(T)$ ✓	$\rho(T)$ ✓	ρ_0 ✓	
specific heat	$c_p(T)$ ✓	c_p - const. ✓	c_{p0} ✓	
linear iso	$E(T)$ ✓ ν_0 ✓	$E(T)$ ✓ ν_0 ✓		
thermal exp	$\varepsilon_{TH}(T)$ ✓	$\varepsilon_{TH}(T)$ ✓	α_0	
thermal cond.	$K(T)$ ✓	K - const ✓	$K(T)$ ✓	
multilinear iso	$\sigma(\varepsilon, T)$ ✓	$\sigma(\varepsilon, T)$ ✓		

#5 Vulcan - FEA Model, ctd. 3/5

Nonlinear - inelastic - rate independent - isotropic - linear
multilinear = MISO
select units - MKS! (m, kg, s, °C)
Unifrax: using ALPHX = α for thermal exp.

Saved to MSU2.mp → crit → will not work
Now does "save all" work
Trial - MCInput - 1.mp
Read from file
File - clear & start new

Start working with script laptop
Job Name = MSU Beam01.db Vulcan\ANSYS\MSUBeams



*: xrebar
Nrebar = 3

```
for i = 0: Nrebar-1                    *DO
    x = xrebar + i*srebar
    y = yrebar
next                                   *ENDDO
```

3/13 Table: %tabnam%, use *DIM to define.
film coefficient = h $q/A = h(T_S - T_F)$
tutorials used: CMU, ANSYS thermal tutorial in help menu
define temps: BLRebarN (bottom left rebar ~~temp~~ node) 5448 → 4113
BeamCoolerN 3969
BeamBCSN ~~Beam Cooler ST~~ ~~surface~~ bottom cooler surface ~~temp~~ Node 4002
PLVAR 2, 3, 4 ... works for cube every substep!
→ ctd page 96

#5 Vulcan - Reinforced Concrete Reading Notes

Read design of reinforced concrete

Stages: 1) tension concrete cracks, steel stretches @ M_{CR} to $\frac{1}{2}f'_c$

2) steel yields, compression concrete crushed

p. 35 - neutral axis moves upward as cracks grow

Stage 1: no crack } crack moment exceeded

2: steel stretches } f_y exceeded

3: steel yields

Calculate cracking moment as

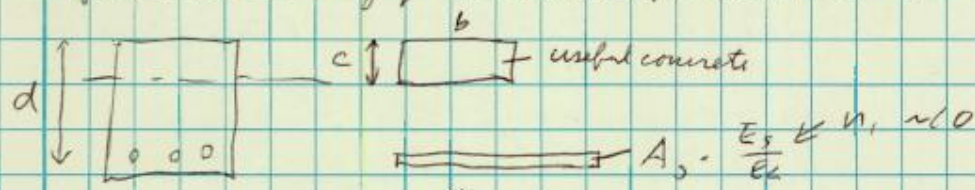
$$M_{CR} = \frac{f_r I_g}{y_t} \quad \text{with } f_r = 7.5\lambda\sqrt{f'_c} \leftarrow \text{in PSI}$$

λ for NSC

ignores steel completely!

$\frac{1}{2}h$ if rectangular, c on tens side

After cracking, use transformed area



moment balance: $bc \cdot \frac{c}{2} = nA_s \cdot (d - c)$

$$\frac{b}{2}c^2 = nA_s d - nA_s c$$

$$\frac{b}{2}c^2 + nA_s c - nA_s d = 0$$

$$c = \frac{-nA_s + \sqrt{n^2A_s^2 + 2bnA_s d}}{b} \quad \star \text{ - a cure formula}$$

with FRP - change nA_s to $nA_s + mA_{FRP}$?

compression steel makes "appreciably smaller beams"

↳ double area due to concrete creep! $(2n-1)A_s$

Framework is $\frac{1}{3}$ to $\frac{2}{3}$ of cost - 50% on average

90% of US buildings are 3 stories or less

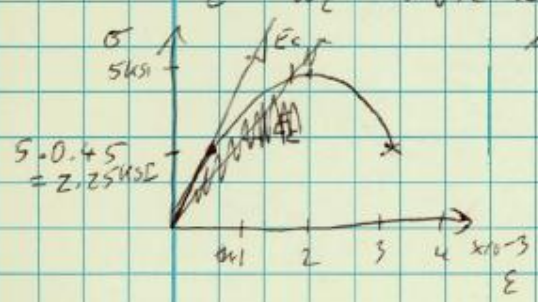
★ Superplasticizers - increased working time (Admixture)

f'_{CR} = actual concrete strength >> f'_c to account for variability. (ACI 5.3.1.1) $f'_{CR} = 3000$ $f'_c = 2000$

strength is parabolic, peak at $\varepsilon = 0.002$, fail at $\varepsilon = 0.003$

$E_c = w_c^{1.5} \cdot 33\sqrt{f'_c}$ is secant modulus at $0.45f'_c$!

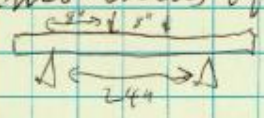
initial modulus ~ 20-40% greater $\nu = 0.16$



Shrinkage is from unreacted water evaporating, leaving cracks. Hence, minimize water! Usually use 2 × the amount for hydration. Avoid absorbant aggregate.

#5 Vulcan - Reinforced Concrete Reading Notes, ctd.

75% of creep in first year, final δ = 2 to 3x initial δ
creep accelerates rapidly if $f > 0.5 f'_c$
Max creep at around 150° F
Large members creep less - related to shrinkage
(f_t) $\sigma_T \approx$ 8% to 15% f'_c but vary with $\sqrt{f'_c}$
modulus of rupture measured on 6 x 6 x 30 beam



$f_R = \frac{Mc}{I}$ at failure but not very accurate

→ use $7.5 \lambda \sqrt{f'_c}$

Shear strength is $\frac{1}{3} f'_c$ to $\frac{4}{3} f'_c$ → very conservative code
★ - Silica Fume particle, creates strength (or fly ash) by reacting with calcium
Superplasticizer = formaldehyde + sulphuric acid
latex - increased adhesion, strength, freeze-thaw
fibers (steel) increase toughness
Rebar #9, 10, 11 from square bars #14, 18 very large
welded wire: W4 is smooth, 0.04" in² area D = deformed
D max = D31 WWF 6 x 12 - W16 x 8 page 23 to decipher
Rail steel = rolled from old train rails (crap)
If bar strength > 60 KSI, ~~yield~~ strain to 0.35%
max 75 KSI - greater approaching concrete strength, lose the ductility
80 KSI steel - $\varepsilon_y \approx \varepsilon'_c$ ultimate
More concrete cover in corrosive environment
tensile reinforced:

$$bc \cdot \frac{c}{2} + 2nA_c \cdot (c - d_c) = nA_s(d - c)$$

$$\frac{b}{2} c^2 + (nA_s + 2nA_c)c - (nA_s d + 2nA_c d_c) = 0$$

$$c = \frac{-\overbrace{A'}^{A'} + \sqrt{A'^2 + 2b\overbrace{(Ad)'}^{(Ad)'}}}{b}$$

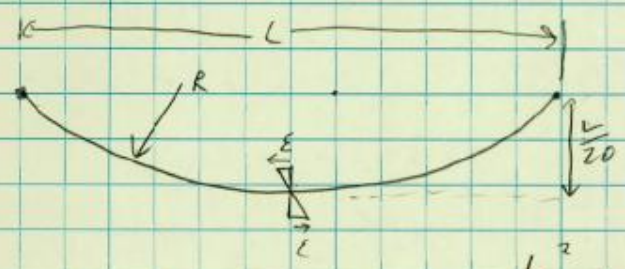
$I = \ldots \quad f = \frac{Mc}{I}$

Ultimate strength: assume steel is yielded, drawn plastically AND concrete now crushed

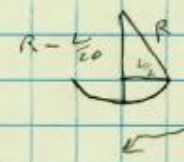
Equation on John Wiley website - Ch. 7

#5 Vulcan - E119 Deflection Criterion 2/20

How bad is $\delta_{mid} = \frac{L}{20}$? $\varepsilon = yk = \frac{y}{R}$



$$\left(\frac{L}{2}\right)^2 + \left(R - \frac{L}{20}\right)^2 = R^2$$



$L^2/4$

$$\frac{L^2}{4} + \cancel{R^2} - \frac{RL}{10} + \frac{L^2}{400} = \cancel{R^2}$$

$$100L^2 - 40RL + L^2 = 0$$

$$101L = 40R$$

$$R = \frac{40}{101}L$$

$$\varepsilon = \frac{y}{R} = \frac{101y}{40L} \approx 2.5 \cdot \frac{y}{L}$$

$L = 12.0\,ft = 144''$ $y = ?$

monolithic → $y = 16/2 = 8''$ $\varepsilon = 0.14$!!!

c, worst case $= 1.5''$ $\varepsilon_c = 0.026$

steel → $13.4 - 1.5 = 12$ $\varepsilon_s = 0.208$

Beam w/ 20 mm deflect, 50% longer: 19' long = 5791 mm

$$\delta = \frac{L}{290}$$

$$\frac{L^2}{4} + \left(R - \frac{L}{290}\right)^2 = R^2$$

$$\frac{L^2}{4} + \cancel{R^2} - \frac{RL}{145} + \cancel{\frac{L^2}{84100}} = \cancel{R^2}$$

$$R = \frac{145L}{4} = 36.25L$$

$$\varepsilon = \frac{8}{5770} = 0.0015$$

#5 Vulcan - MSU Visit 2/21

Jim - grad student Sia - lab manager
Rebar about 14.75" down in 16" beam
Monitoring slabs for bridge deck during curing
Huge columns - test under sideways load 27' high
Did tests on steel creep @ temperature
Furnaces 10 x 10 x 8 up to 2000°F
6 nat gas burners
Top of beam is insulated
2 small - 55 Kip actuators
1 - 600 Kip big
8.5' - 9' is heated
90 T/C channels, 18 strain gauges, 8 displacement
Manual temp control
Oven temp within 5° F maybe less
12 actuators for slab testing
usually load to 50% of room temp rating
Baolin ~ 60 Kips two small should be
reinforcement has to end inside the furnace
literature saw 7-800°C carbon survive
they saw fibers break around 600°C
2 small actuators : 34" apart
carbon separated span = 8' 2"
Most insulation falls off - Baolin
could fold board around edges?

- Bath

use spacer blocks ~ 2 x 2 x 1.5"

anchor CF rebar specimen in metal tube, glued with epoxy

Thermal Mechanical Analyzer - cut tiny pieces ~ 1/4" x 1/4" x 3/4" long

Hot Disc - sandwich between two squares

After 3 hours concrete is 300°C at most, Steel is at 593°C & 60 KSI → 25 to 30 KSI
Fyfe - 1" insulation 250°C at 180 min but much hotter on the other side of the FRP
Water pressure blows off insulation (FRP)?

#5 Kulkan - MSU Visit, ctd. 2/22

Rodrigo meeting: end-constrained is very sensitive to boundary conditions. Unconstrained is more conservative
concrete is fine, steel weakens, FRP
~~most m~~ at most, FRP adds 40-50%, at end adds 5-10%
FRP loses ability to transfer the load
95% of heat is from radiation
25-35 is convective heat transfer coefficient
9 on top - little bit of convection
oven uniformity: if bottom is 800°C, top is 1000°C
↳ curve is matched to average of 8 thermocouples
top 1/4 of oven will be w/in 30-40°C
only one beam can be restrained
test on April 15th
Insulate 1.5" of Cafco (spray cementitious)
Fiber blankets - bad health effects
could use Ultra or gypsum board
Have not tested individual
Up to 90 minute - thermal strain dominates
creep dominates > 240
2D thermal model but assume ambient for outside middle 8'
use K_{FRP} in cross direction
ANSYS has good steel creep
real stress strain has creep built in
could ignore for now
★ Rodrigo: σ-ε for rebar
★ Steel creep
concrete stress curves good to 800°C
strain in FRP - not much work, can ignore this
ASCE is good
complex to model insulation falling off
↳ will send reference
metal lath not needed if done right - water content...
many times did not fall off
moisture content in concrete is about 70%
↳ similar up to 15 KSI (80-85%)
Spalling: driven by low porosity, temperature gradient
HSC loses strength faster
α - probably not constant 0-300°C
Eurocode has creep built in, >600°C extra creep
α is large but ε_{pl} rises 0.003 → 0.008 but, also confinement ↑ε_{cu}

#5 Vulcan - Box Prep Mtg 2/28

Start Drayton at 7? Ansell & Carney St
Rizkala - do 3-point bend
Vaughn @ Ole Miss 1/3" x 1" smallest piece standard
Use Sin-Dow chemical resins Tg > 200° (Dow)
→ need 55 packages
Glass Forms in Birmingham - possible alternative
Deneef - may have old rods
MSU test ≤ 6/30 1 week
↑ ~~[illegible]~~ prep beams (2 wk) grout cure fast?
↑ have rods
↑ know what rods to make (NC State) 6 weeks
prep plan for MSU - heat grout overnight
do contracts install

Aslan 500 1/3 x 5/8 product

28 days to cure grout
2 weeks to run beam tests! 1 week cool-down

Validate mechanical with low Tg resins at NC State on slabs

File provisional patent before NC State

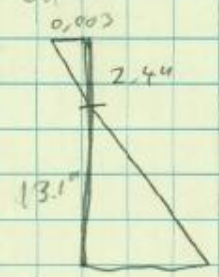
Have reinforcement by May 7
Goal: install NC SU by end of March 3/30
↳ don't care about resin, no insulation
3/15 get form factor from and
↳ development length, spacing, etc.
test for Lo by 3/30 (Venkat
room temp rods by 3/30
500 tape ordered by Bernie
Deneef, Aslan,

#9 General - TU Dresden Teleconference 3/1

Video conference with TU Dresden - Kiletos Mechtcherine
RC concept patent 1855 by Lambot
TRC = Textile reinforcement 2-3 GPa strength of filaments
glass has alkali durability problems
concrete ~50% sand
fabric has polymer infusion
lighter element than RC, thinner
Armchair made of TRC, electric heating
sculpture, bridge segments, building panels, water vessels,
wound onto a pipe (plastic/concrete) no real bond
rheology - flat for ~500 sec, hard @ 2500 sec (40 min)
2-4 layers of textile, symmetric
crack at 6 MPa, fail at 10-14 MPa
infuse filaments → uniform stress carry in yarn bundle
pullout: 0.4 kN uncoated → 1.2 to 1.6 coated (carbon)
Nanoparticles in coating (clay) gives higher stiffness &
strength w/o slip
Add alkali resistant short fiber to concrete - >2X σ_y
Roof reinforce: lay mortar, put in fabric, more mortar
→ 3 layers of textile = 15 mm
Gregg: why better than carbon epoxy?
↳ polymer has delamination, fire resistance, "many others"
Bradip: seaming in large repairs
TRC compatible with substrate,
standard carbon is 600-800 ter on 7 mm space 300 g/sm
Advanced Fiber Reinforced Cementitious Materials
SHCC = strain hardened concrete composite
PVA (or PE) fibers in concrete
Fiber-Bond matrix lost in aging (to glass)
M. Butler, B. Hempel, Kiletos - strength in low alkali environment
to Carbon is better
Frost resistance - need > 50% Portland cement to "pass"
Durability design - problem is data & experience
Frank Altman - fuzzy probabilistic approach
TRC prevents water absorption into cracked concrete,
slows down - lower capillary forces
After break: fibers arrest crack propagation, bridging
$l_{crit} = \alpha \frac{f}{4\tau} \cdot d$ Meso level crack modeling
fiber stresses - partial delamination
big statistical mess - may need to rely on empirical data
40 μm fibers, 8-12 mm long PVA PE is 20 μm & 6-8 mm
joint link slab - able to flex SHCC beats UHPC w/steel fibers on impact

#5 Vulcan - Strain in a reinforced beam

$\varepsilon_{cu} = 0.003$ $c = 2.4''$ $d = 13.4''$ $d_b = 16''$ - groove
$d_b \approx 15.5''$



$d_b - c = 13.1''$

$\varepsilon_b = 0.003 \cdot \frac{13.1}{2.4} = 0.016$

$\varepsilon_{carbon,\ ultimate} \approx 0.019$! OK

$\sigma = E\varepsilon = 540\ ksi$

$F = \sigma \cdot A = 50\%$ of $F_{steel} = 41.2$ kips

$A = 0.076\ in^2$

$A = N \cdot \pi D^2/4$ $D = \sqrt{\frac{4A}{N\pi}}$

Ideas: - cut down rectangles
- cut spiral groove in rods
- heat & bend a hook

Jim ≥ 10am
Tha

#5 Vulcan - Myriad Meetings 3/6

Venkat & Philip & Gregg went to U Kentucky
met Prof. Harris, Issam
rods made by students in lab - regular pultrusion
↳ 4 feet long for installation
get up to 50% of strength 40% resin by volume
install with 6" overlap
shown on TV in October 2011
didn't like coils, doing the overlap
Jim Farrell - contractor install Atlanta
↳ discuss overhead cutting, guidance
→ stop by Thursday?
Gregg - drill holes & tap in to mount insulation
Di - get second oven - find something bigger
Gregg: get to 100°C ? 250°C ?
↳ wants Roder.

Diversified

- will send 7 4mm rod 8' long
☆ → may need 9-10!

3/7 Sami Rizkalla seminar
NC State - CFL lab
Partners: Freyssinet, Grancrete - small company
$50K to be partner, then only 10% overhead vs 50%
Loads in 3 directions up to 3 M lbs 3000 kips
PC Ledge Beam - huge, M, T & shear
In practice: New construction, repair & strengthening
FRP grids with embedded optic sensors
Highway dowels - gone in 5 years if steel → glass fiber
Kevin: cost is 20x higher, why not taking off!
Sami: should come with time, code changes
Main selling point: no corrosion
Every bridge has to be inspected ≤ 2 years
Structural Health Monitoring - hot field
Concrete filled FRP piles ½ the wt utility pole
SCC - self consolidated concrete - no vibration
Normally 3 years to get adopted
Insulated sandwich panel - include foam - good R_{TH}
↳ Metamount (Gregg worked with them)
20 to 100% strengthening of girders with FRP
"strips much better than bars" 3/4 to 1" deep × ½ to ¾" wide
can put FRP on sides of beam - good point

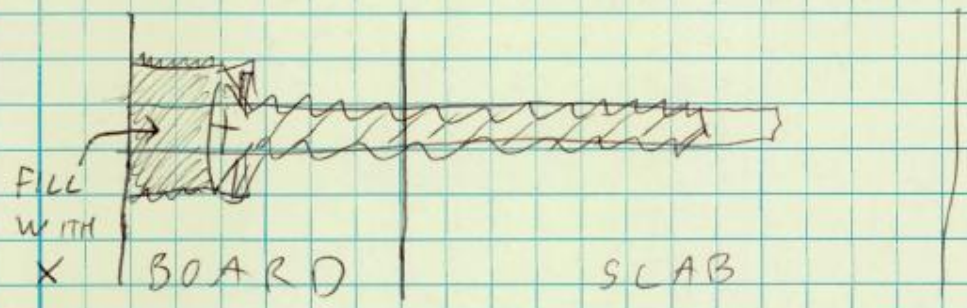
#5 Vulcan - Myriad Meetings, ctd. 3/7

SPS, Fyfe - epoxy mounted NSM rods in slab
In Canada - Ed Fyfe doesn't like NSM
cut groove diameter + $\frac{1}{8}$"
Bars better if surface isn't straight
Aesthetic of groove is better than sheets
Added 4-6% air for freeze-thaw resistance, 30-40 years ago had problems
Shear reinforcement may have anchors
NSM on a timber bridge - common in museums ... tricky
Casting adds minimum 3", probably 4", costly
Just adding cover doesn't protect steel because cracks just get bigger
Florida banned epoxy because it melted
Venkat: steel doesn't bond well to concrete
Current work:
- steel structures: hi modulus carbon (230KSI vs 60KSI) and failure near steel yield - no ductility
designed to not collapse under service load - old strength sufficient (ultimate) to carry on
Reduce peel stress with tapes cut
Masonry reinforcement - needs to be properly anchored or it's useless
Japan makes PET reinforcement 9.6 PSI = 3.2 x tensile
Anchors: shear keys, mechanical plate, fiber anchor, embedded bar, overlapped sheet
SSC - still needed to be pushed in
IUCA - hi strength cables - lightweight
3D composites - FRP bridge decks Matomarinta - failed
↳ sandwich panel used in FRP trailer platform
3D woven bridge decks with balsa wood - much like Δ Force
use grid to attach ~~FRP~~ to granite
epoxy bond is too strong - lose ductility, concentrate stress
~~pre~~ post-tension unbonded: distributed, much larger failure strain (similar phenomenon)
0.014" max crack under service load, interior → taken out of code
— after lunch
can't see debonding if insulated
DOT's function is to minimize complaints from public
5 year politicians - trend to turnkey solutions is only way to be long-term responsible
Sami - inject into plexiglass 21% water in granite is ideal

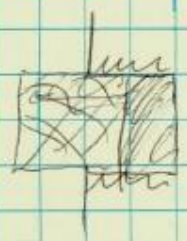
#5 Vulcan - Myriad Meetings, ctd.

★ Need to know true strength & modulus of Diversified rods

Discussion of flowable grouts, Venkat's chart



Intumescent plug - will it push itself out of the hole?



S.R: Not supposed to move granite or it comes down
Buried up layers slowly by spraying

S.R: Does not care much for small tests
↳ Grout pullout, 4x4 beams
Maybe OK for comparison, but need bigger test

2:20 still talking about grouts

S.R: thinks granite should be strong, skeptical of OPC

3/12 Team Meeting

Patent filing - Dale - discussing claims with Cheryl this am
need CDA at NCSU?
2 slabs at NCSU, 2 slabs → MSU heated
tested exactly as Sami says
Max Diversified microrod is 0.156" = 3.96 mm
Dale - research fire fastening

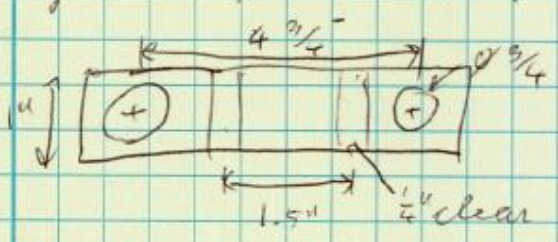
★ Need to know insulation tinsul for 270, 220, 60°C
Development

#5 Vulcan - Ole Miss Trip

Composite Materials Laboratory

Die is quite simple, but machined straight + chrome plated. Exits 1 3/4" off surface, 36" x 4" x 3.5"
Plenty of 10 Amp outlets on back of line
20 amps ??
Carbon from 1988 Pultruded carbon 1/8 x 1 x 5' 6/9/'92
A couple of 3/8" rods - check that, lots
Also 5/16, 5/32"
68mm ↳ 3.97mm "5 ends"
2 x 4 mm = 1 x 5.64 mm

Could use 50K tow
Heat metal tub with water at 200°F
↳ would get silicone oil
remove metal covers on grips after starting
Box section: floating mandrel
IR spotlight bulb
Preform plates
could do some inline post-cure but normally offline
"don't want"
Zinc Stearate - old now use Phosphate Fatty Acid
Esters - as release agent
Bond test - check for bond
Die pressure is 200-300 PSI at inlet
Pre-squeeze is 20-40% above
↳ holes go straight into die, first plate
center slot is level
1 1/2" 1/4-20 bolts 1.5" apart bolts into die
↳ long ↳ two bolts
current block is 1", rods up 1/2" (centered)
guide rods are 3/4"



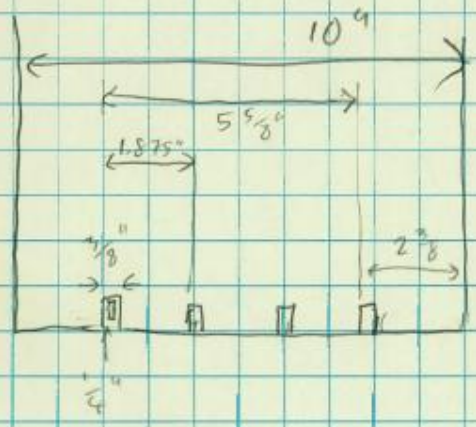
Release agent companies?
Frank Axel (ret) son John
(800) 332-2935 Woodside NY
Axel corp 3-4 common ones
Dow should know
use 12 lb in 40 min (6-7 to start)
↳ 75-100 ft

Hi temp pull test, may do not labs temp up to 600°F
↳ less variable ↳ highest @ 350°F
2 environmental ovens -80 to +250°C freeze thaw
→ standard cycle time is too short DSC 250K IR Inst SEM

#5 Vulcan - 2D Beam Thermal Ansys model

Analysis results 2 hours, no radiation; 1100°C
rebar → 78.5°C Beam BCST → 175°C Beam ↳T → 392°C
(250°C at 2692 = 45 min)

Add radiation $h_r = \varepsilon\sigma(T^2 - T_\infty^2)(T + T_\infty)$
Add temp at reinforcement (xrod1, -Yrods) & xrod2



xrod1 = 2.125" = 0.0540
xrod2 = 4.00" = 0.1016
Yrods = 15.75" = 0.4001

Rod 1 N = 5748 NOTE: grid closest point is 8 mm up (0.32")
Rod 2 N = 5754

→ Result Rod1T = 207 (All 2H)
Rod2T = 163

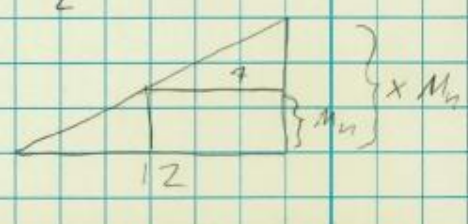
With radiation ($\varepsilon = 0.9$) rebar = 7 T offset = 273??
Continue to get 392°C with radiation - model not working
- change to 1000°C → corner = 337°, rebar = 71°, BCST = 153°, Rod1 = 180 R2 = 142

= Add E119 heat profile
→ corner = 309°, Bcentr = 137°, rebar = 59°, rod1 = 158°, R2 = 126°
"Equivalent" to constant temperature at? ...
1100 → 392° 1000 → 337° ? → 309°
Δ=100 Δ = 55 Δ≈51 ⟸ Δ=28
should be close to 950°C
→ corner = 311° Bcentr = 142° rebar = 67° rod1 = 167°, R2 = 132°
apply E119 profile to surface temp
→ corner = 369° Bcentr = 167° rebar = 81° rod1 = 194° R2 = 154°
all to Rodar, $h_c = 25\ W/m^2C$
$h_r = \varepsilon\sigma(T^2 - T_\infty^2)(T + T_\infty)$ $\varepsilon = 5.0704 \times 10^{-8}\ W/m^2K^4$
T = 20 T_∞ = 1000 → h_r = 123
T = 20 T_∞ = 500 → h_r = 28 ∴ on order of h_c
T = 800 T_∞ = 1000 → h_r = 56
... But may still be a decent model, given result above
all of which had 1.5" insulation

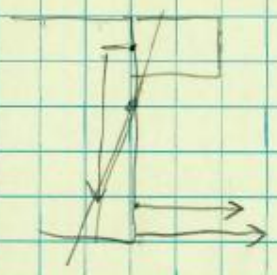
Max length that can be strengthened: $\frac{7}{2}$ vs $\frac{12}{2}$ = 56%

$\frac{x M_n}{12} = \frac{M_n}{12-7}$

$x = \frac{12}{12-7}$



A9 General - Lines Net talks 3/16



Jim Stratford
Luke Bisby) Edinburgh
Maurizio Guadagnini - Sheffield
Antony Darby - U Bath

Gregg Blaszak: ask questions

Jim - Younger
Low impact materials and innovative engineering solutions research network
Focus on composites, concrete, renewables
All structural/~~con~~ civil backgrounds
Worked on glass composite bridge
↳ not going mainstream, difficult acceptance
Gregg: catastrophic failure?
Lose strength around 50° w/ Tg @ 65°C
start to drop at 40, really down 45° ... Tg - 20 sounds reasonable
Burnt an actual apartment w/ FRP beams
Bisby: E119 is nowhere close, no cooling phase
PP micro fibers - melt to prevent spalling
Luke Bisby - 503°C critical temp in E119
@ service load = ¼ ultimate, @ 593° lose 50% strength
- hold service load, no passage of flame, not too hot
"not sensible" - most of E119 isn't
WTC collapsed from fire - burns on 3 floors
→ increase buckling length, 1/10th of capacity
assumption is fire contained to 1 floor, style is changing
"codes are decades behind innovations in construction"
risk of fire is much less than it used to be
industry is ridiculously conservative
sociology study into why
Reaction to fire: flame spread, smoke, toxicity
Stiffness drops at Tg, but retain some strength way beyond!
BUT also lose bond strength
cold anchoring, low CTE → pre-stressing
Fire load: apply 1.1 x service load
"FRP is held to a higher standard"
Worried about alkaline effects on FRP, while we know steel is bad
reconvene @ 2 P.M in Horizon
Architects are powerful, push thru code violations
constructability as a driver vs economics?

#9 General - Lime Net talk, ctd. 3/16

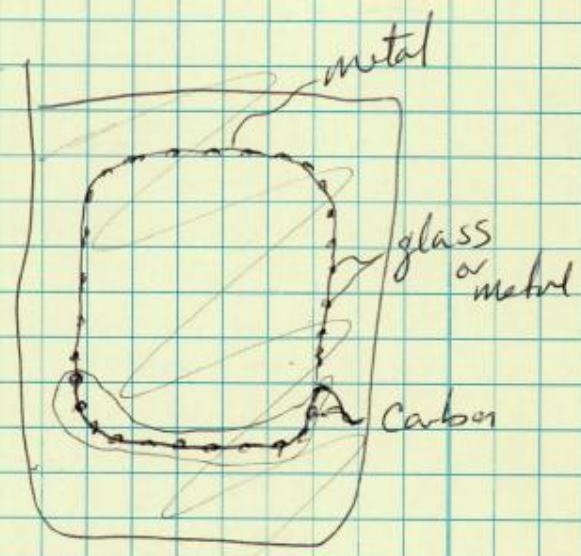
Zürich - Sämbach prestressed carbon system
60 mm Aluminum L - structure, 5 mm pultruded
= Mario: earthquakes, etc.
shear behavior
bent rebar in urban light transport
? do you do NSM with section enlargement
pre-stressed confinement with expansive grout
= use tire waste for concrete reinforcement - steel fiber
Bally - Batt - Resilience blast & impact
high velocity → get shear failure
wrapping in FRP - maintain integrity
deep embedment of bars → high bond strength, works really well
drill all the way thru concrete beats surface mount
40% of concrete is non-structural, cast as optimized shape
= use fabric as form work
Ian & Luke do temp testing up to 670°C
radiant heat tests, convection is ignored
E119 - time history of heat flux
↳ smoke opacity, etc. affect test results/reproducibility
- for profit test labs don't want to change
→ more severe than it needs to be
- architects specify fire ratings
- send best person to build fire wall, mark with calipers
UK - tests FRP-only beams
contractor handles implementation of fire ratings
Eurocode has parabolic fire curves
Bernie: "the high road of E119"
basalt - "hasn't been optimized" but as of now, not worth it
↳ good bond to cementitious mortar, could use in mortar
→ good deal of manufacturer's propaganda
Fabriforms - not for concrete cloth
Typical design life: 50, 75, 100 years "word cloud"
ASCE - pushing infrastructure repair
Matrix - want wonder resin
Spalling is poorly understood
FRP - ease of installation, latent cost to shut down bridge
Fire requirements are starting to become show stoppers
"Resilience" is good buzzword for funding
Funding was strong mid-90's & 2005, eclipsed by green movement
Strengthening is growing, internal reinforcement is stalled
PP: Add 3-5 kg/m³ concrete reduces spalling

#9 General - Lunes Net talk, etc. 3/16

Bendable FRP bar: my idea: bundle of spaghetti
bend and lock down
have on site if bar doesn't have the proper shape
- use 1 mm microrods in a sleeve
- lock down with zip ties, pour glue around it, etc. as desired or practical

P. Wilson sketch →

idea: create ~~containment~~ confinement



Me: circle is ideal confined shape, square secondary part of matrix strengthened

#5 Vulcan - Weekly Meeting 3/19 3/19

Weekly meeting -
Test NCSU on May 1
Ole Miss on 27th/28th go no matter what
Jerry should have 240-260°C resin
(260°C anhydride - $19/lb)
Philip - may test 2+" slabs at NCSU (no
Boards: water durability is concern
Edge may not go through
Plan to start with non-FR ~~FRP~~ FRP, start selling
Some amount of engagement for the team
~~Ban~~ Plan to go ahead with "off the shelf" material

* focus on understanding reinforcement with short rod
→ Dale: have 6, 12, 18, 2+" different rods

NC State criteria: X strengthening
Y development length

Read Sami thesis → current data

Develop method for sanding

ME: anticipate NCSU results
help Qi on surface treatment

What determines slippage vs rupture?

#9 General - Safety Meeting 3/21

Present: Sudhanshu, Mark V., Jimmy H., Henninger, Vetri, B. Jackson, Sullivan, P. Wilson, Ridgeway, Mosley

New inspection sheets - 50 found last period - more than 2X
Bobby did awesome job
ipads - effort stalled a bit - Adam Fields is busy
Bobby: commercial software didn't cut it
does furniture meet code? Hell!
rules on fire extinguishers?
help/explanations? Get paired with knowledgable person
me: repeat infractions flagged - check on last month's
Brad will look into cost
Reconciliation audit on chemical labeling
Jimmy: got bigger label printer
Rudy safety training needs to get completed
Change meeting to Monday at 8? No
Mike: inspection with teamleads in progress
- everyone must find MSDS on computer
Philip: have QIT 6 safety meeting before MSDS
↳ Mike will organize
Brad: power to exhaust hoods
↳ will be informed if power is cut for maintenance
- sash was replaced which triggered a switch
~~- flow rate fell~~
- 3 random hoods went down for an hour
Next meeting in 2 weeks

TRANSCRIBE!

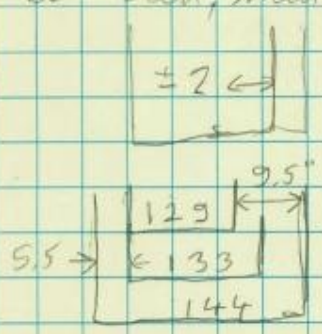
#5 Vulcan - Salting Design 3/23

Salted rod: Diversified 220°C 0.157" rods with Venhat's sand & MEraze epoxy salted in mug fixture 0.166" clearance + 0.180" ~~fill~~ film
diameter no sand: 0.1615" - 0.168" one spot
drip Ø → 0.183"
No sand flaking off
salted Ø mostly ~ 0.200" but high spots to 0.225"
slightly more
Rods weigh 8.1g and 8.1g length = 12.1"
plain rod 5.8g for 12.0 in

Widened grooves to 3/8", flowed much better
The 2 Sikagrout samples on salted rods were foaming considerably... I tapped it down
No cracking in Masterflow - good sign
~10:45 finished Sika Master was ~10 min before that
plan to fill voids at 2:30 pm

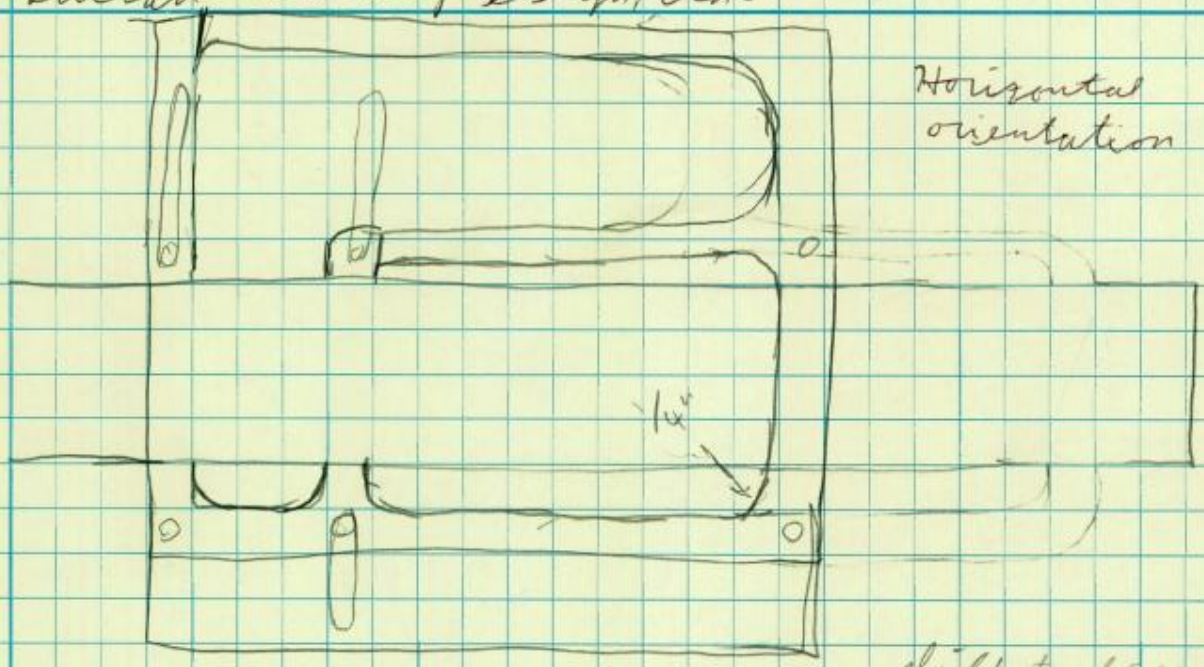
0.157" but didn't fit thru 0.160" because of irregularities so went to 0.166" and 0.180" resin hole
→ time diametric gap is 0.023"... too big!
radial: 0.0115"

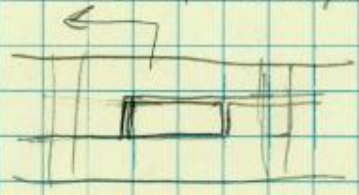
Rectangular is 0.1295", just clears 0.130" even the parts are 0.125"
↳ use 0.133" slot width
0.148" would be equivalent gap - too much (0.023)
we are starting with up to 0.008" already, hopefully centered, min 0.004"



shoot for 0.016" gap
- gives worst case 0.006/0.010"
thus 0.146" gap @ dosage
really 0.128" wide on average
↳ 0.144" gap
min gap 5.5, max gap 12.5
sorry, will have to optimize later, have centering mechanism...

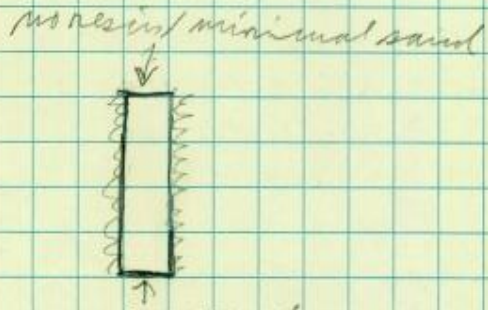
#5 Vulcan- Salting Design, ctd.

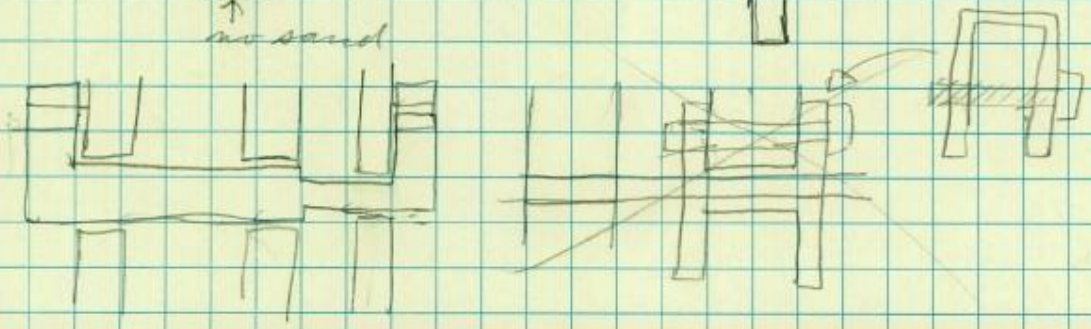




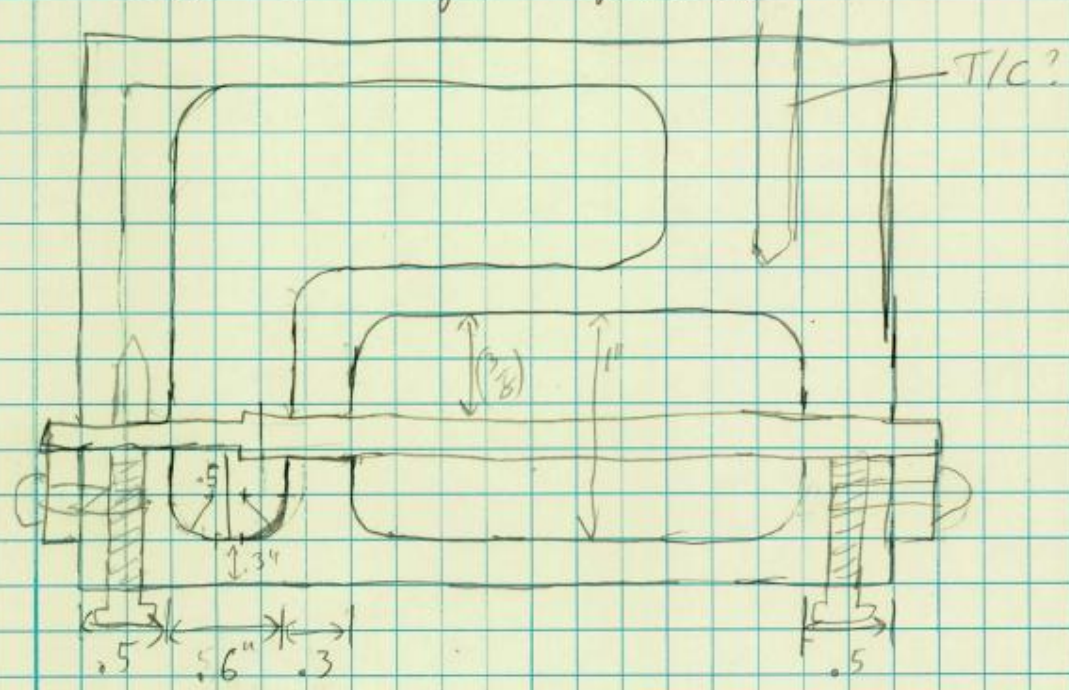
Adjust from ¼" to 1" wide strips
desired gap: 0.0

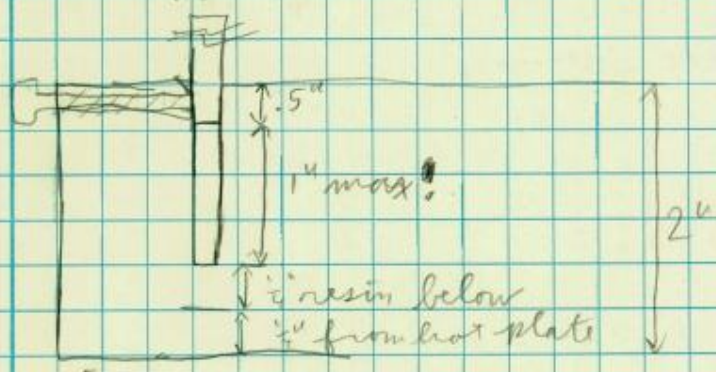
Push vertical to facilitate sand application!





#5 Vulcan - Salting Design, ctd.





#5 Vulcan - Ole Miss 3/27 3/27

combin A&B 9:30 am tieing in last few strands
(~~200~~ 160K outside tows) 9:10 am - having minor trouble
Prof. Lackey getting flustered
dry: puller force = 1302 lbs @ 12"/min
clamp force = 8738 lbs
9:30 Pour resin into pan
puller = 1250 lbs @ 4"/min dry
size: startup 0.1285 x 0.998" perfect!
MK01 Startup - shorter the arrow end
writing is from aisle side, top
tiny bit of stuffing - Ellen to splice in 1 more piece
↳ on front top edge
pull force = 1587 @ 4", steady ⇐ BAD
10:28 speed up to 12"/min
stuffing stopped once going faster
10:42 still messing with splicing in of ends
pull force = 2700 @ 12"/min ⇐ REALLY BAD
10:44 pause for splice 10:48 still paused
10:49 cut tow completely
10:56 open up die
kept: 1st piece @ 4" good (11')
transition piece ... OK but shorter
almost 11' @ 12" - breakout last 4 ft or so
12:25 finish bends, dies not threaded yet
only top 2 rows thru eyelets - that's right / all
fiber spools: ~4 lbs, 50K 0.084g / inch for 50K
1816 g → 1800 ft
$1 per 50' of 24K tow $2 × 18 → $36 for startup
$2 × 24 → $48
12:40 starting pull, 12:45 slow to 4", resin in die
12:54 first solid emerged from die 12:56 → 12"/min
Now 1205 lbs pulling 12"/min with resin
(re-calibrated)
1:15 first good 12" er coming out
1:56 cut off #3 5 hours tiger
2:30 stop for jam, have 5 good pieces #6 is questionable
3:00 still tieing in, conference call
3:45 in resin, not thru die yet, going 4" a minute
4:38 MK03-01 is 2' out of die ... part is really
not in equilibrium, pull force still rising, 345°F
someone forgot to turn on the heat, resin not curing
Finish with 4 pieces, should be OK once post-cured, ~~only 1 out~~ only 2 cut out

#5 Vulcan - Ole Miss 3/28 3/28

Remark 7.5' pieces MK03-3, -4, -5
-5 is slightly questionable
(stuffing on end, 160K tow ran out somewhere
7:55 am Jeff stirring resin, Tim splicing yarn
8:30 stop mixing resin, add to bath
8:50 start solid @ 4"/min
9:00 pull force 1755, temps @ setpoint
↳ reset to 1036
MK04-00 start piece ~51"
MK04-01 going 4"/min, 11'
9:30 force is 1600, just a few more feet on 04-01
9:40 finish MK04-01 piece
01 to 02 transition: 53.5"
now making 02 9:45 12"/min, 8.5'
after 05, should have ~~47"~~ to runout of 150K
~~8.5' 47" = 4.5'~~
4' + 7' = 11' - 8.5' = 2.5' of good before 150K out
MK04-06 is really 3' ~~and~~ but have 5 pieces now
10:28 pause, start wetting again
10:50 MK04-07 is suspect, lots of stuff & lii
~~tear~~ pull force, bunching in back
go to 200K tow now total tear-out, open die
MK05 - Jeff is skeptical 12:50
12:55 at temps 12~~#~~ lbs
1:30 half way thru 05-04 going steady
05-07 still ~~steady~~ 01 to 05 over 8.5' 06 & 07 11'
2:15 humming along, on #9, last resin returns
2:40 on #11, recycling resin starting to look ugly
3:30 bars in car, wrapping up

#5 Vulcan - Box Prep Meeting 3/29

Greg Norton - ME undergrad, Price Waterhouse Coopers
FRFRP: challenge is speed to market
desired product line: beam & slab, column, beam/col shear, equipment
Me: biggest risk is rushing to market with a faulty product that ruins our reputation
Q4 2012 - basic system with off the shelf
Q3 2013 - improved cost position - hybrid board
Q1-3 2014 - hi-Tg resin?
★ would require pouring beams now (6 months)
decision to go ahead with UL
Bernie: test turbulent flame testing on insulation
Philip: jump to slide 212 pumpable even though we get more data tomorrow
1-2 slides on key learnings

3/30 Box meeting

Full scale UL is 65K to 100K
★ need to read patent
Drayton next week
★ sand 5", clear 1", sand... then put spacers in gaps
↳ or wipe it off ¼" wide every so often
... test some T-beams?
Jeff Lane - seemed slightly reluctant to go to 14 day cure
"bad data"
9:35 - Greg & Gregg arrive
↳ have product by Q4 2012 → V3 might have different grout???
↳ left in shear reinforcement for slab
↳ still advertising 3/8" round rod on version 0
don't need 10,000 hours for rods & grout system but crucial for wet layup
Varnell pumping equipment is for crack filling
Drayton - only slabs, beams not accessible
Jim Varnell won't be there
Jeff - bring someone w/ outside experience to reinment gave cutting
bring ladder?
"commercial" means I bid to install where they don't pay us
after mid-May, ~~th~~ work on columns

#9 General - Safety 4/4

Present: Mike Sullivan, Mayernik, Sudhanshu, Hemmingse, Ridgeway, Linda Jewell - legal, now on QITC safety committee, Ellis, Kaldaris, Lane

Minutes attached to meeting agenda

Richard - reconcile chemical inventory
print out all location codes for cabinets (LS ---)
scan ~~every item~~ shelf code, then all items on that shelf. can break down by sublocation
late: Hanson
can dispose of things if not found
goal to do it sometime this year
665 chemicals in 5 hours - Shulong's lab
estimate at least 3 hours to do a normal lab
old labels will not scan
large
Will not be done by VPP
Chemicals assigned someone to do it Neils, Beth, Rino (lab3)
Lane: avoid assigning ~~avoid~~ responsibility to someone else
Brad: safe or unsafe is no longer necessary
- only mark infractions
Kathi - behavior audit has 6 questions (Liberty Mutual)
done once a week by "audit inspections committee"
Questions will be changing at some frequency
Mike: team lead inspection last Friday of FTC, concrete lab
- actually in good shape, Jimmy Hanson got this area beta
Brad will look into communicating the incident
Mike: April 18 - walk thru w/ Tony Union
Rudy still not trained
New rule: no more headphones in ~~the~~ labs, one earbud allowed
Absent: Wilson, Qi, Mosley, Bobby Jackson
Mike: PPE needs to be labeled with a name

#5 Vulcan Meeting 4/9 & 4/16 4/9

Drayton: 5/8" x 5/8" slots 2 days to cut, mostly chisel
cut into 20 rebar
1 day to put up insulation
1 day to pump - blew off insulation

9000 feet in 2 months of NSM work

Libra 212 - tore apart insulation, filled ~ 4 feet 3ft?
grout bonded well to insulation fibers

Blaszac - wants to give up on NSM, wet layup much faster

Formwork, mortar flow, cutting difficulty
Cutting
↳ overhead
↳ ½" cover on slabs is common
Wilson: 3 topics
- improve NSM - BZ
- make ext. bond work - JS
- something else - PW

NC State - Jeff Lane is the holdup! - use data for ed. purpose
- delay a week

Tomorrow 8:30 - Improve NSM

Meeting 4/16 start 8:42

~~Today~~ ~~Tomorrow~~: 2 PM review plan with Lane/Jacoby
Proposal: ~~April 30~~ May 7 Milestone review NC State Concepts
- very specific materials by mfg, methods, tools, supporting data, prototypes - unless impractical, plan to install
Performance ↳ show installability

Come to meeting with: what must happen today
what we need help with
Dale making 22 x 6 x 1.75" mini-slabs - find available? Cemex

#5 Vulcan – Cutting Stand Design

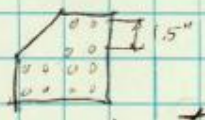
4/16

Air supply – easily reached ~ 55PSI w/ open ½" hose

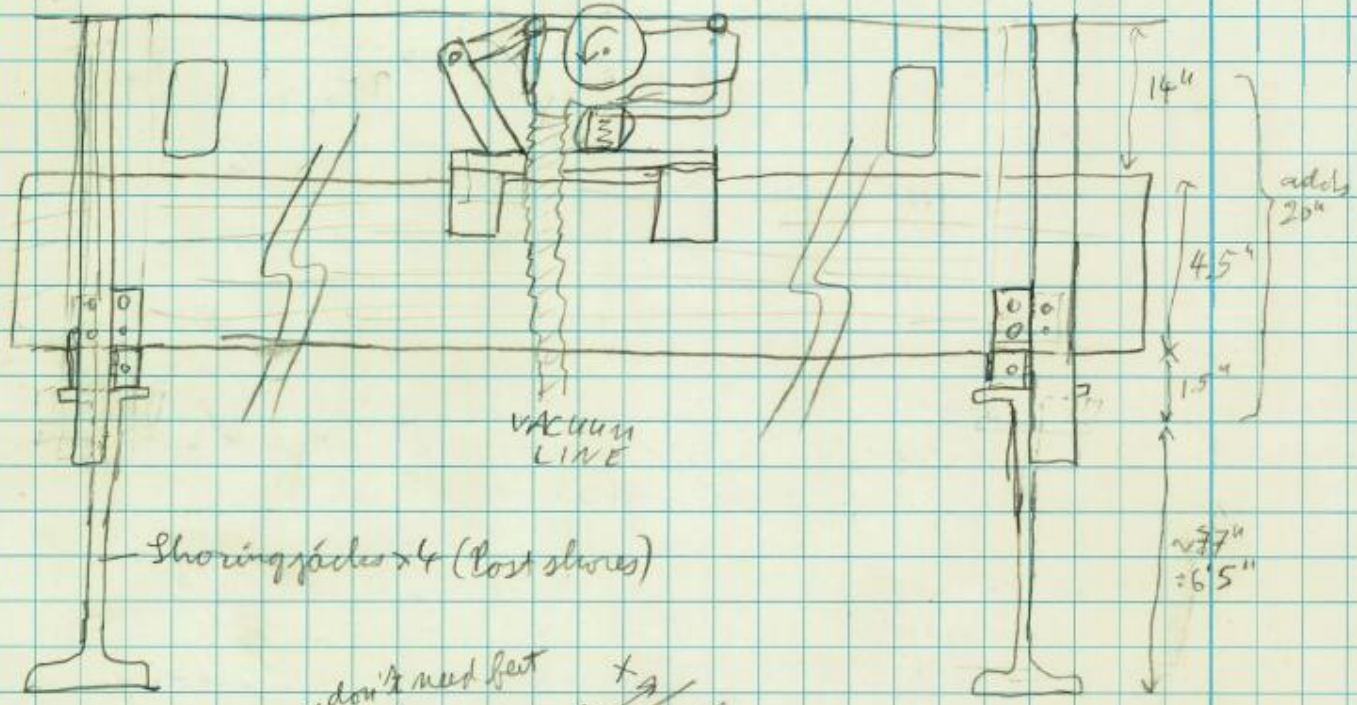
Fibo flowed ~ 24' + 11' = 35' before clog due to dry head on grout column

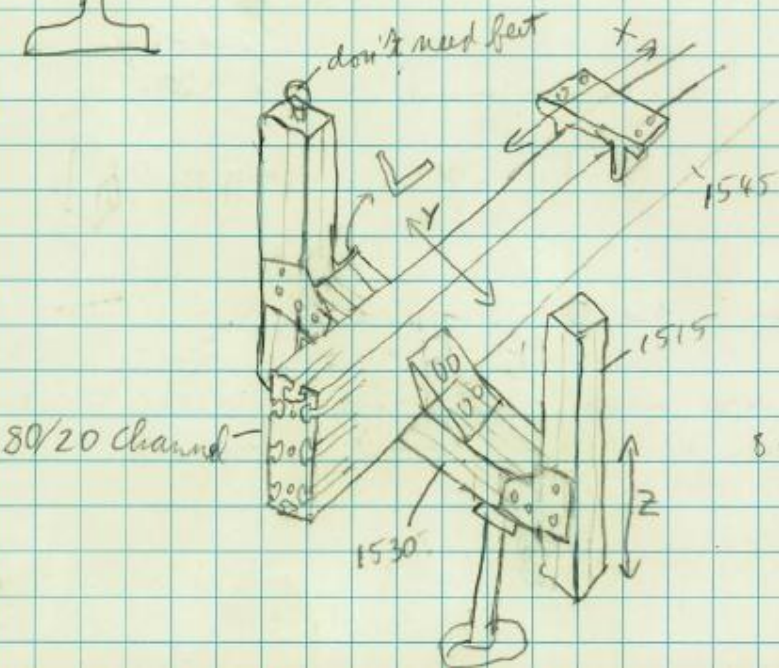
Masterflow 1205 – same thing, head is aggregate-rich

80/20: have a few short lengths, buy sticks tons of



Plan for support structure:





Parts:

			pg.
4 × top flat carriage	6825		30
2 × top vert carriage	6815		30
12' 1545 beam	1545		
12' 1515 beam	1515		
12' 1530 beam	1530		
4 × 4 hole plate	4350		
8 + 16 × 2 hole strip	~~3355~~		
4 × 8 hole ⊿ 3"	4338		153
2 × 1545 end caps	2046		252
4 × 2 hole L	4302		150
4 × T-nut (1/16")	3278		

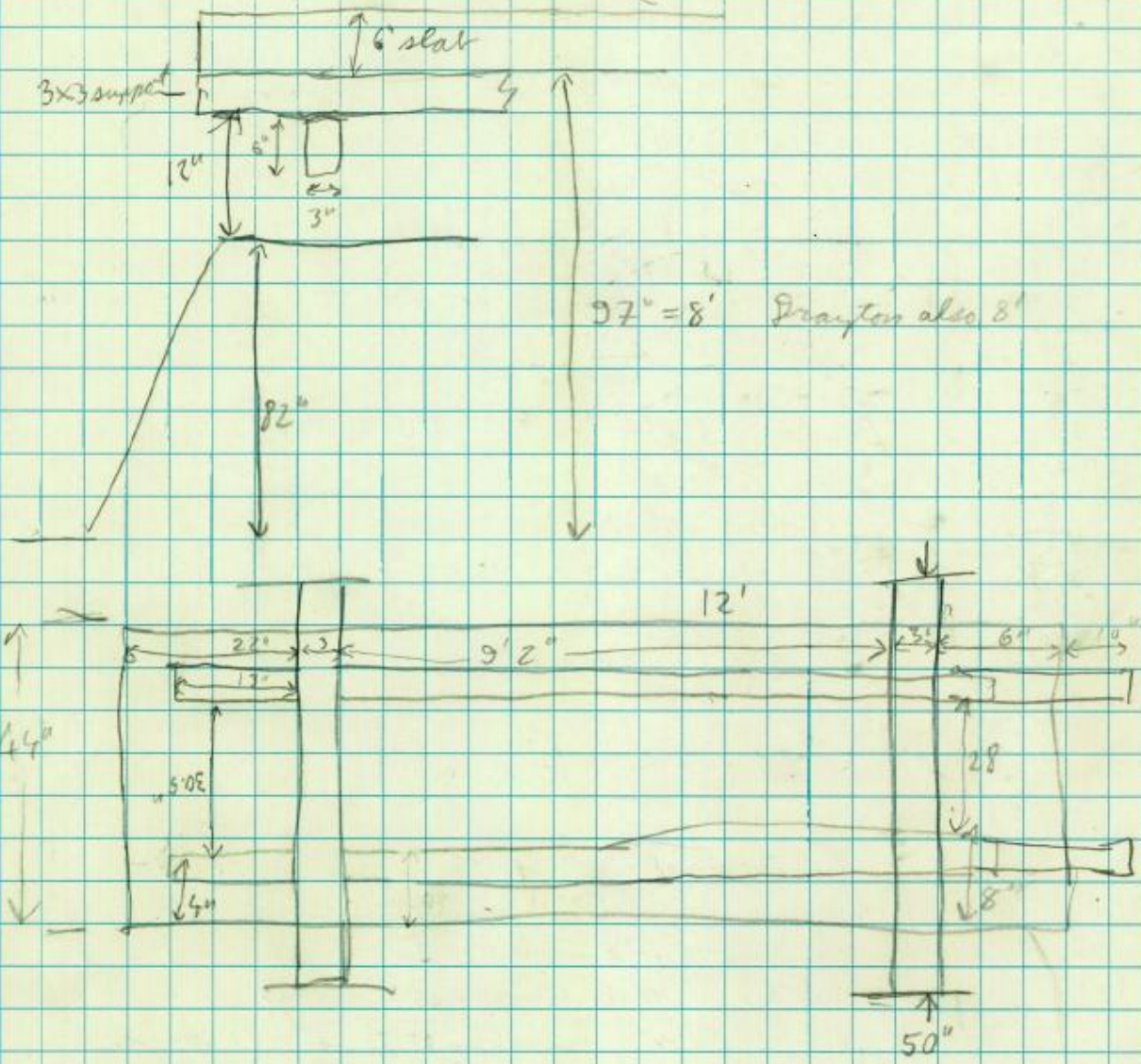
#5 Vulcan - Cutting Stand Design, ctd. 4/16

Vertical braces: McMaster p.

6'2" to 11'1" $157.46 4.5 ton - 2.5 ton capacity

Hi capacity: 5'8" - 8'4" for 7'4" to 10' ceiling
~~3'4" - 5'4"~~ too short
~~2'1" - 3'5"~~
~~1'4" - 2'0"~~

ends in 4" x 4" plate
$113.19



Bought #0 & #1 Post shores @ Scaffold store con Stew

#0	3'6" - 6'	10,100 lbs	24 lbs	$34.95	x4
#1	5'9" - 10'3"	min 6100 lbs	wt 37 lbs	$39.95	x4

$299.60 + $112 ship = $412.06 4/13 + 2 days from Houston

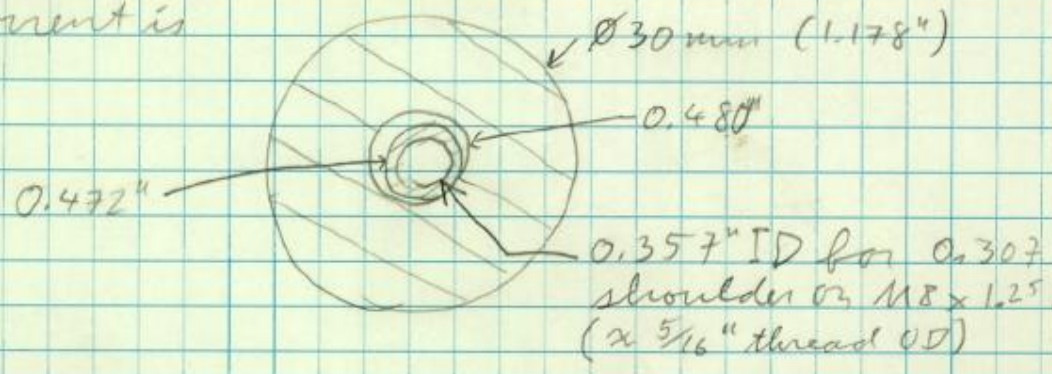
← Bought

#5 Vulcan - Guide Wheel / Settling Tests

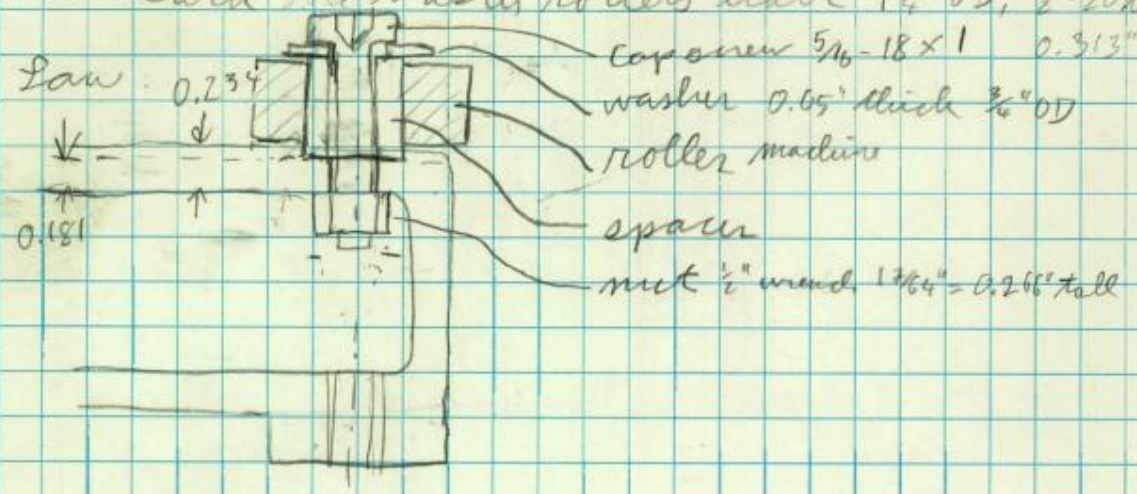
4/16

Guide wheel:

Current is

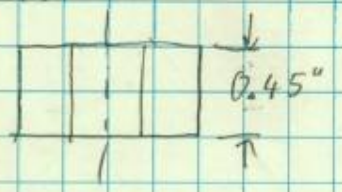


Standard McMaster rollers have 1 1/4" OD, 1/2"-20 thread

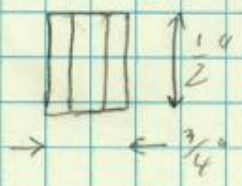


roller:

0.05 + 0.206 + 0.181 = 0.497" total



spacer:



Get handles < 4.5" tall? 2 flow valves ✓
→ current ones 3 9/16"
Teflon tape for lab

quick connect fitting
↳ 1/2 industrial FC 3/4" NPT male

Buy mules tape x 2

Mix Libra 212 + 16% water 1:43 pm
dump 1:45 some air foam on top but no visible settling (1:48 1:355g + jar, flowed fine
material is very thixotropic - like latex dump.
Also likes to clump together - agitation should help
Mix at 2:10 pm 28% water - 300 mes about 2x 312
2:15 → jar

#5 Vulcan - Settling Tests, ctd 4/17

could barely mix with screwdriver, then turned to condensed milk... maybe warm honey.
2:43 pour out, left is 237g - jar
225g - jar - longer drips then
Jar = 214g
Libra 300: "continue to agitate for best flow"
→ to 300: 11g residue vs 141g
↳ 20 mins ↳ in 3 mins
Total amount was 455g + water

Libra 212 recommends 6, 6.5, and 8.5 pints
12.5%, 13.6%, 17.7% by weight

Libra 300 says 11.5 pints to 13 pints
↳ 24% ↳ 27.1%

Libra 212 is 30-60% OPC assume 50%
so 1% FX 330 superplasticizer ~~for~~ OPC is
0.3-0.6% per 212 mix

Mix 500g Libra 212, 17.7% water = 88.5g water
0.3% FX 330 = 1.5g
0.6% FX 330 = 3g
Mix 2:59 Libra 212 + water, wait 3 min
191g left in beaker
579g - lost a few scraping arm add 1.5g FX 330
→ Mix 3:07 to 3:08, wait to 3:11, pour over
→ 258g left, strange fluid comes off first
add 1.5g more, mix 1 min
Now at 566g 3:15:30 settle to 3:18:30
then pour, 466g left → worse! or wasted?
seems to make water separate even more
Mix 1 30 sec, 49g left.
Mix again, immediate pour → 43g left
Did additive make any difference?
Libra 212 - redo, methodically
500g powder, 24% water = 120g
3:55:30 done mixing pour @ 58:30 33g left
back & forth: 604g (16g lost)
deposit ~~lot~~ film on wall, but very little to no settling 4 PM - let settle some more
~~At~~ 4:20 pour - 75g left (30 sec) 30g (∞)

#9 General-safety 4/18 4/18

Present: Lane, Liao, Hemmings, Srivastava, Hanson, Mosley, Ridgeway, Sullivan, Wilson, Petri

Tony Union here today for a walk-through with all former team leads

Roll-up doors in CDL need look at base of chain? Mike will check... powered with manual backups

~~Behavior audit form~~
Inspection forms
Qi: put alternate shading white/gray
Philip: seems unbalanced, 6 points for loading dock, 4 for extension cords, 1 for PPE
Patrick: we once suggested more open ended, make-you-think questions. Behavior audits don't appear to capture that either
Jeff: what if we see unsafe situation walking in parking lot, someone not wearing safety glasses
Maybe record all unsafe observations

Kathi needs to add legal to inspection teams

Legal has their own separate safety meetings

Philip to suggest revising inspection form
There is monthly and biannual set of questions

#5 Kulman - Settling Tests II, Flow Tests

... Now add 27.1% water to 500 g Silica 300
→ 135.5 g
start settle at 4:08:30 Pour at 4:11:30
→ 16 g w/ 30 sec drip
11.4 g with longer drip
619 g left at 4:13:36, settle to 4:33:30

75 g left on 300 w/ 24% water
30 g with long drip

27% water → 20 min drip (30 sec) leaves 41.7 g
∞ drip 15.5 g

Flow test

4/18, ½" tube, Silica 300, 24% water

#1	963 g in	2 min	15 PSI
#2	905 g	2 min	
#3	835 g	2 min	

4/19, ½" tube, Silica 300, 24% water

#1	864 g	60 sec	17 PSI
#2	949.6 g	60 sec	20 PSI

same batch recycle

4/19, ¼" tube, Silica 300, 24% water

#1	316.1 g	60 sec	20 PSI
2	466.2 g	"	30 PSI
3	702.9 g	"	40 PSI

no flow around 15-20 PSI

4/20: Get another Silica sample to Kathi
Bernie: limit to 15 PSI, make a large groove
don't waste time on practice cutting
Dale: try cutting on foam feels good!

4/20: Mix Silica 300

2867 g
+ 1855 g
4722 + 296 = 5,018 g

+ 24% water = 1200 g
11:45 start mixing 3 min mix
11:50 start drill

15 PSI	107.8 g
20	122.7
40	241.9
60	422.6
80	589.0
30	235.3

#5 Vulcan - Flow Tests, ctd. 4/20

☆ · Sika 300 w/ 24% in ½" hose
☆ · Sika 300 w/ 27% in ½" hose 27% in ½" if time
☆ · Sika 212 agitated in ½" hose etc.
· Sika 300 w/ 24% in ½" hose in 10' ~~ft~~ hose

SIKA 300 - 24% - ½" line

1st dump 2091 gm
2nd " 2106 gm
3rd dump 11997 gm

.24 x 6194 gm = 1486 gm H20
wt gm Time

20 PSI	791 gm	in one Min
40 PSI	1497 gm	one Min
60 PSI	1853 gm	one Min

Note Battery in agitator died during the run.

SIKA 300 - 27% - ¼" line

1st dump 1951 gm
2nd dump 2044 gm
3rd dump 823 gm
4818 gm Total dry x .27 = 1301 gm H20

Note: This mix stalled @ the beginning & I had to step on the hose ~1 min before it flowed again.

Pressure PSI	wt (gm)	Time Min
20	201	1
40	387	1
60	587	1

Actual dia:
small = 0.25"
medium = 0.375"
large = 0.93 x 0.4 oval

Note: New Battery stalled @ end of this Run.

New Batt Batteries dead one is charging

$$\cancel{\frac{P}{\rho} + \frac{v^2}{2} = \text{const}} \qquad \cancel{\frac{-\Delta P}{\rho} - \frac{v^2}{2} = 0}$$

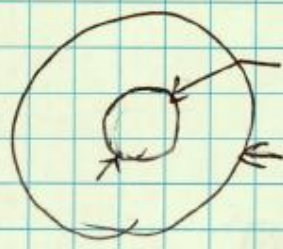
$$\cancel{\Delta P = \frac{8\rho\mu L Q^2}{\pi^2 D^5}}\ ?? \qquad \cancel{\Delta P = \frac{\rho v^2}{2}}$$

$$\Delta P = \frac{128\mu L Q}{\pi d^4} \qquad 1.5^4 = 5.06 \quad 2^4 = 16$$

$$\cancel{\mu = \frac{\Delta P \pi^2 D^5}{8\rho L Q^2}} \qquad \mu = \frac{\Delta P \pi d^4}{128 L Q} \qquad d^4 = \frac{128\mu L Q}{\pi \Delta P}$$

#5 Vulcan – Eibenstock spacers, Flow Tests 4/24

Eibenstock washer



0.877" (22.24mm) 0.876"

1.646" not important

stack is 0.460 – 0.480 shaft 22.17 mm 0.873"

Blade thickness: 0.087" base ~~0.060~~ 0.056"

spacers: 2, 3, 4, 5, 10 mm, 17

0.555" for 4 + 5 mm spacers
gaps 0.161 & 0.132"

20PSI works fine for saw
groove: 0.567 start
0.565 mid
0.568 end

4/24/12

Bottom of groove = 0.450"
L side Biggest chunk → 0.299"
actually one is 0.270"
R side worst is 0.370" but breaks right out

Desired width: 0.550" so 0.015" less than current
~~2 × 0.081~~ 2 × 0.056 + 1 × 0.087 + 9/25.4 = 0.553" ✓
desire 0.540" – 3 × 0.056 – 1 × 0.087 = 0.285" total gap / 3
= 0.095" spacers

Four new grouts: Euco Cable Grout PTX
~~567g~~ ~~47~~ 3606g + 1868g = 5474g
28% water ⇒ 1533g water 3:03 start mix

3/8" {
233.9 g in 60 sec @ 20PSI
979 g @ 40PSI
680 g @ 60PSI in 15–25 seconds

1/4" hose 80.4g @ 20PSI
191.5g @ 40PSI
311.3 g @ 60
417.0 @ 80 – not sure if 60 sec
458.8 g @ 80 #2
191.4g @ 30 in 2 min

guideline:
0.85–0.95 plastic
0.95–1.1 flowable
1.1–1.3 fluid
5 min mix
try 1.2 gal
= 9.6 pints
= 20.0% Water

Euclid Hi Flow 2475g + 1763 + 749g
= 5007g + 1001g water

#5 Vulcan - Flow Tests, ctd 4/24

pump the Euclid Hi Flow, record time & cumulative weight in bucket
Start mix 4:45
4:52 turn on pressure ¼" hose
no flow coming up to 80 PSI
5:03 turn on air 03:20 in bucket 20PSI
5:04 720 g
5:05:00 1773
5:30 2102
5:40 3615 40PSI done

5:28 start another Euclid Hi Flow
4017 g + 995 g = 5012 g
20% water = 1002 g
start 5:33:30 stir
plug again
flowing now 20PSI 368.1 g
40PSI 931.5 g
60PSI 1543.1 g

first batch: lots of sediment observed
second batch: some fairly coarse aggregate ~1/16"

Hi Flow does not get my vote altho viscosity is pretty low.

4/25

configure saw - 4 blades 0.095" spacers
no stagger! 0.6" cut depth
cut length 7.5' (90")

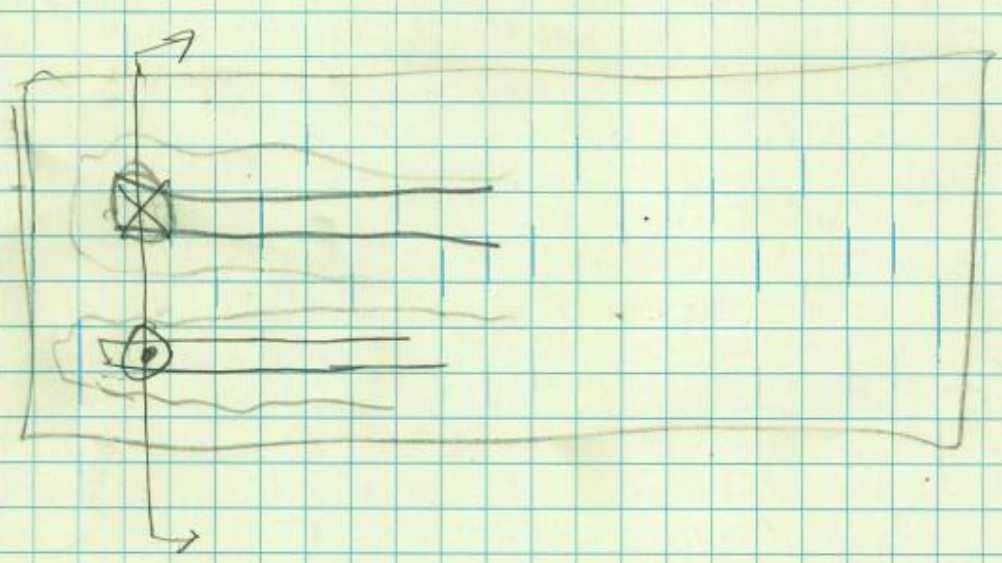
Now pump Masterflow 1205
4018 g + 1007 g = 5025 g 27.2 - 31.6%
30% water → 1508 g

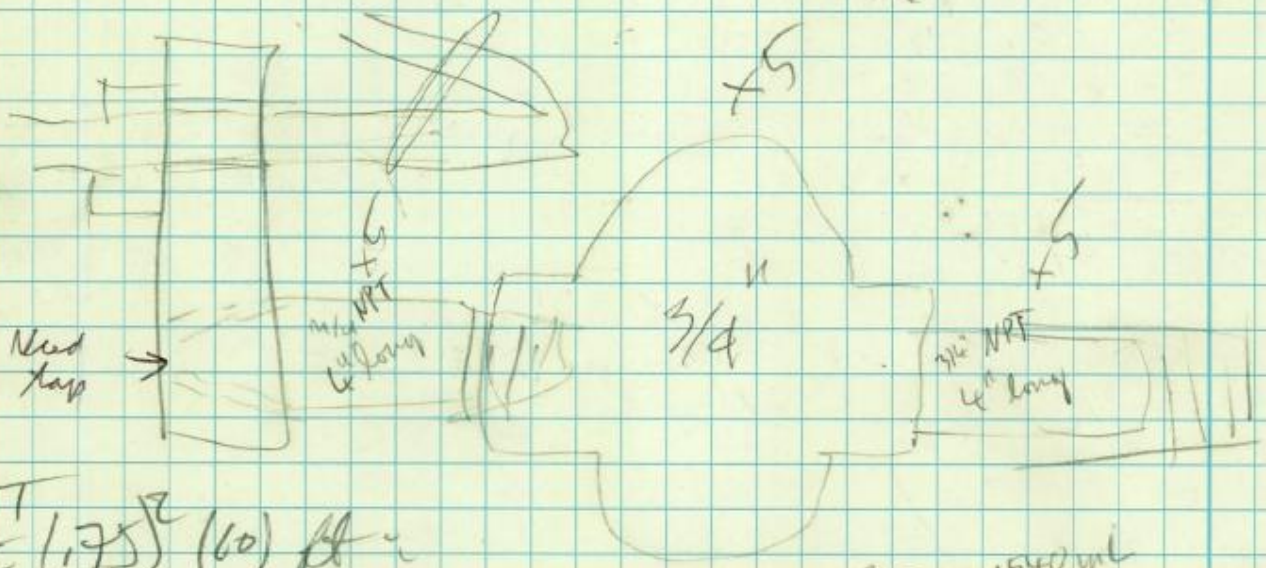
¼" hose 60 sec 20PSI 463.4 g
" 30PSI 624.4 g
" 40PSI 924.6 g
" 60PSI 1514.8 g
⅜" hose w/ 3/16" tube insert 20PSI 30 sec 383.3 g
40PSI 30 sec 1041.1 g

#5 Vulcan - Flow Tests, ctd.

4/25 Another batch for ½" hose Masterflow 1205
use 27.1% water
1 4073g + 1904 = 5977g, 1538g water

3/8" hose, 60 sec, 20 PSI - 1304g
30 sec, 40 PSI - 1568.2g
15 sec 60 PSI - 1776.8g

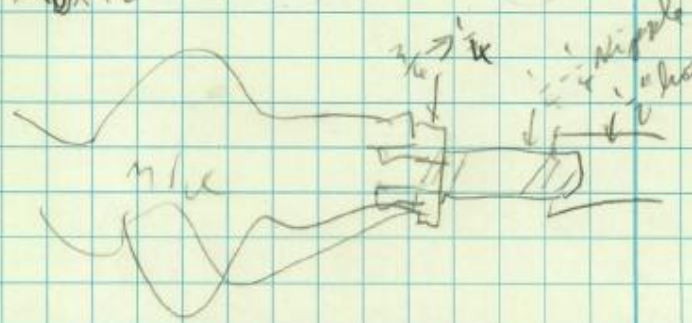




$\frac{\pi}{4}(.75)^2(60)$ ft³

$1 in^2 \cdot \frac{\pi}{4} = 0.75 in^2$ area × 12 = ~~42.4 in³~~ = ~~696 ml~~ 94 in³ = 1540 ml

Supply:
1" NPTF → Bush 1 → 3/4 → ¾ NPT → 1" TUBE
1" NPTF → " 5 ¾ → ¾ TUBE



#5 Vulcan - Beam Modeling

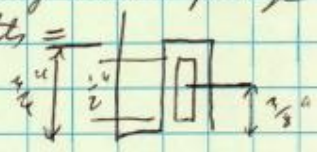
5/9

Rizkalla - Ben Mielke thesis → $E_{carbon@60\%} = 24{,}910$ KSI

Hi strength { carbon properties: Area = 0.00165 $F_{RUPTURE} = 547$ lbs $\sigma_u = 332$
$\epsilon_{UTS} = 0.0173$ $E = 14{,}946$ KSI very linear

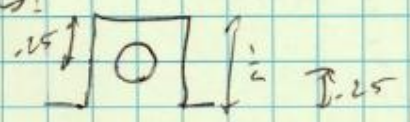
Hi Mod { $A = 0.0195$ $F_{UTS} = 233$ lbs $\sigma_{UTS} = 121$ KSI $\epsilon_{UT} = 0.0038$
$E = 31{,}273$ KSI also linear

Control: (unstrengthened)
crack @ 3000 lbs, yield 12767 lbs, fail 14678 lbs
Phase I strengthening: page 78
Phase II control: 3000 / 12814 / 13751
good summary last page
strips: depths =



$6 - \frac{3}{8} = 5\frac{5}{8}$"

rods:

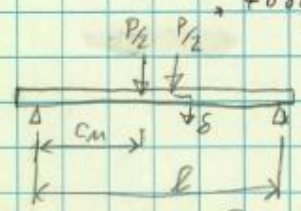


$d = 5.75$" sushi: $d = 6.25$"

our carbon: Toltek Pamex 50K: 600 KSI strength, 35 MSI E
compare to hi strength HT-G-E-3
(hi tensile grout external on 3" spacing
Gramrete PCW -

Cutting blades: .137 spacing gives .681 groove (4 blades)
.488 groove (3 blades)

5/15 Beam deflection:



$\delta = \frac{Wa^2}{6EI}(3\ell - 4a)$ $\ell = \ell$ $a = c_m$ $W = P/2$

$\delta = \frac{P c_m^2}{12EI}(3\ell - 4c_m)$ Assuming constant "I"

I will change due to end of reinforcement
Then, after cracking, as a function of M
Compare I_{center} to I_{sides}
Need to find edge of cracked zone...
Exact solution is pretty tricky!

#5 Vulcan - NC State 5/23

Cut Mold for 0.125" rods
diameter = 0.123"-0.124" very round!

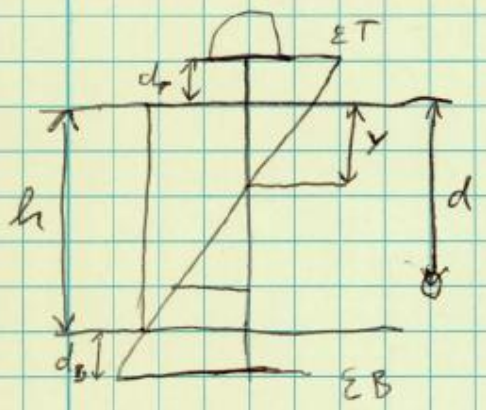
0.032 was 0.107 ~~of~~ resin, 0.104 then
obviously very spiraled

Could guide 0.1285", 0.136" resin
↳ works, jams due to sand sometimes

5/23 NC State Log
Slab "B" is loaded (½" ribbons), should test today
A, C are cracked basically to the steel
C has 2 cleanouts of EB, D has 3

(B) Marked ± 3 ¾' where frp should end
3:42 /
3:46 start 4:16 22,400 heard click
shear crack (45°) forms near 23-24 before UTS
looks like FRP broke under right support

5/24 Strain gauge offset = ⅛" on both sides



$$\frac{\varepsilon_T}{\varepsilon_T - \varepsilon_B} = \frac{y + d_T}{h + d_T + d_B}$$

$$y = \frac{\varepsilon_T \cdot (h + d_T + d_B)}{\varepsilon_T - \varepsilon_B} - d_T$$

neutral axis location

D fail at 18 kips, 1.8" or so deflection
IC induced debonding (crack below R support)
9 am - now loading C - has big crack in middle
9:55 almost ready for C - started
10:12 start to remove C peak was <14 kips
12:06 Slab A failed rupture near R support at very first crack

Steel strain = $\cancel{\frac{d-y}{y+d_T}} \cdot \varepsilon_T$ OR $\frac{d - y}{h - y + d_B} \cdot \varepsilon_B$

Steel stress $\sigma = E\varepsilon$ to yield frp: $d \to d_T$

#5 Vulcan - NC State, etc. 5/24

At failure in slab B line 2397

	top	bottom	steel	Frp	Y	conc
ε	-7.2	16.98	12.3	14.28	1.69"	-6.283
			↳ 94KSI			

concrete surface: $\varepsilon = \frac{Y}{Y+d_T} \cdot \varepsilon_T$

based on

0.255" rod: 14 kips, 274KSI, 0.090 strain @F } unofficial
14.6 ~~at~~ 1.4%?

first ribbon (#2): computer crashed, reboot @ 7 kips and retest

Official:

0.255"	14.67 kips	14,821 με	288KSI
" #2	14.54 kips	14,916 με	285KSI

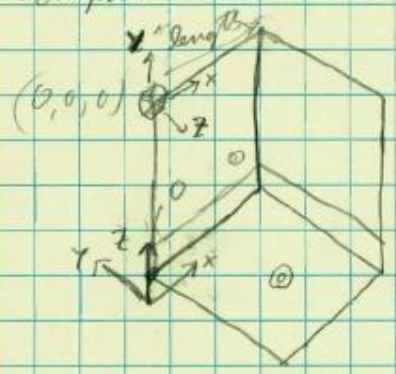
ribbon: 16
14.2

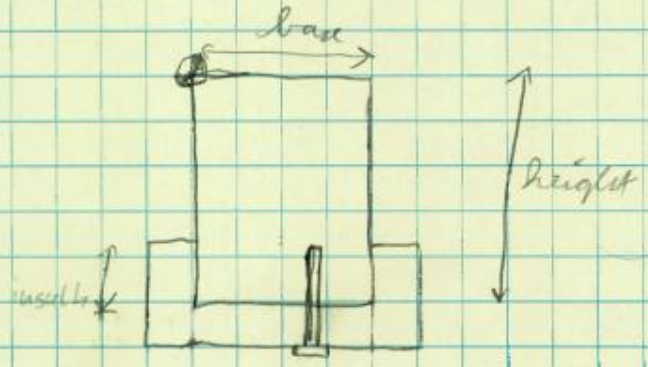
#5 Vulcan - ANSYS Model of screw 5/30

ANSYS model of screw in slab

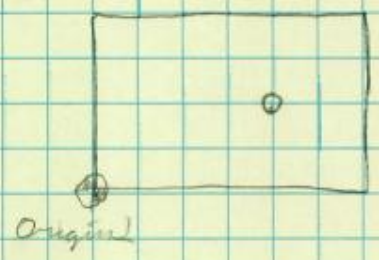
Element type? try SOLID 70 - thermal cubes
SOLID 164 - explicit version -

compare

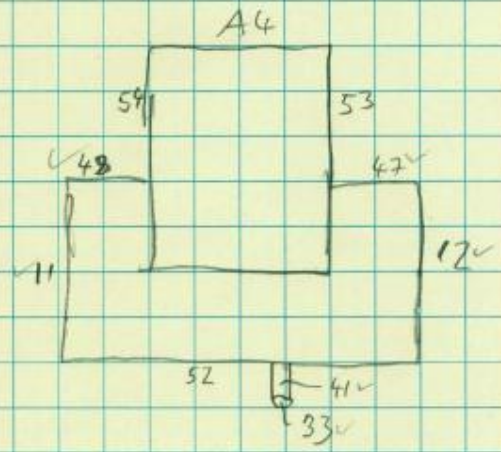




See screen...
V1 = concrete
V2 = insulation
V3, V4 = bottom rebar
V5, 6, 7 = top rebar
V8 = screw
overlaps
V13 = top concrete
V14 = bottom concrete
Guessing V9, 10, 11 = screw 9 = in ins. 10 = head 11 = end
so 3 - 7 still steel
12 = insulation consumed = 1, 2, 8



Boundaries: (flattened)



11, 12 ... 33 ... 41 ... 47, 48 ... 52-54

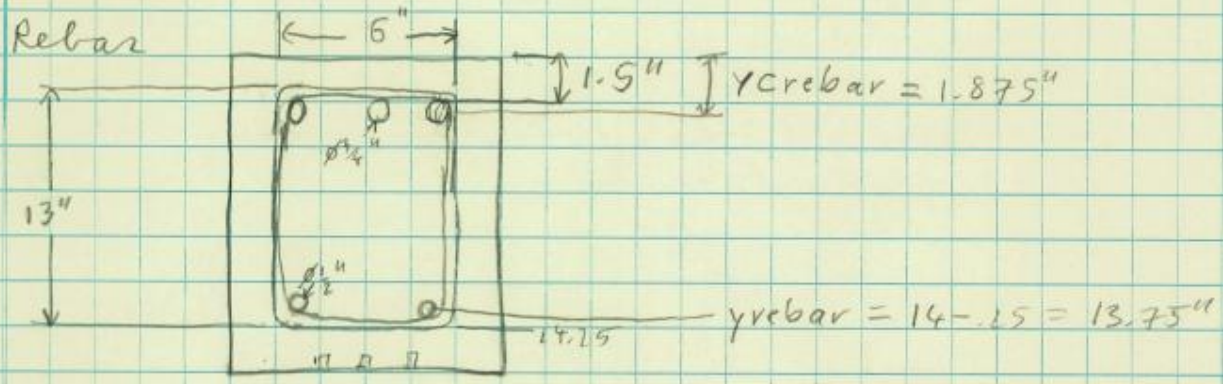
cross section: CAP (5)

start 30min simulation 9:37
begin 271 sec @ 2:28 PM
finish @ 3:02 AM T=1800
→ 17 hours for 30 min
5 hours for <45 min
estimate 12 hours for 25 min Δ

@ 30 min, 70°C section is $0.5'' \times \frac{10}{9} = 0.55''$

Lia: (517) 432-4913

#5 Vulcan - Ansys Model of Screw, ctd.



compare p. 83 Volumes: 1 = concrete 2 = ins.
3 - 4 = rebar 5 - 7 = compression rebar
8 - 10 = frp 11 = screw

screw x = 1" right of FRP = 2.5 - 0.8 - 0.1 - 0.1 = 1.5"
leaving 1.4" clearance

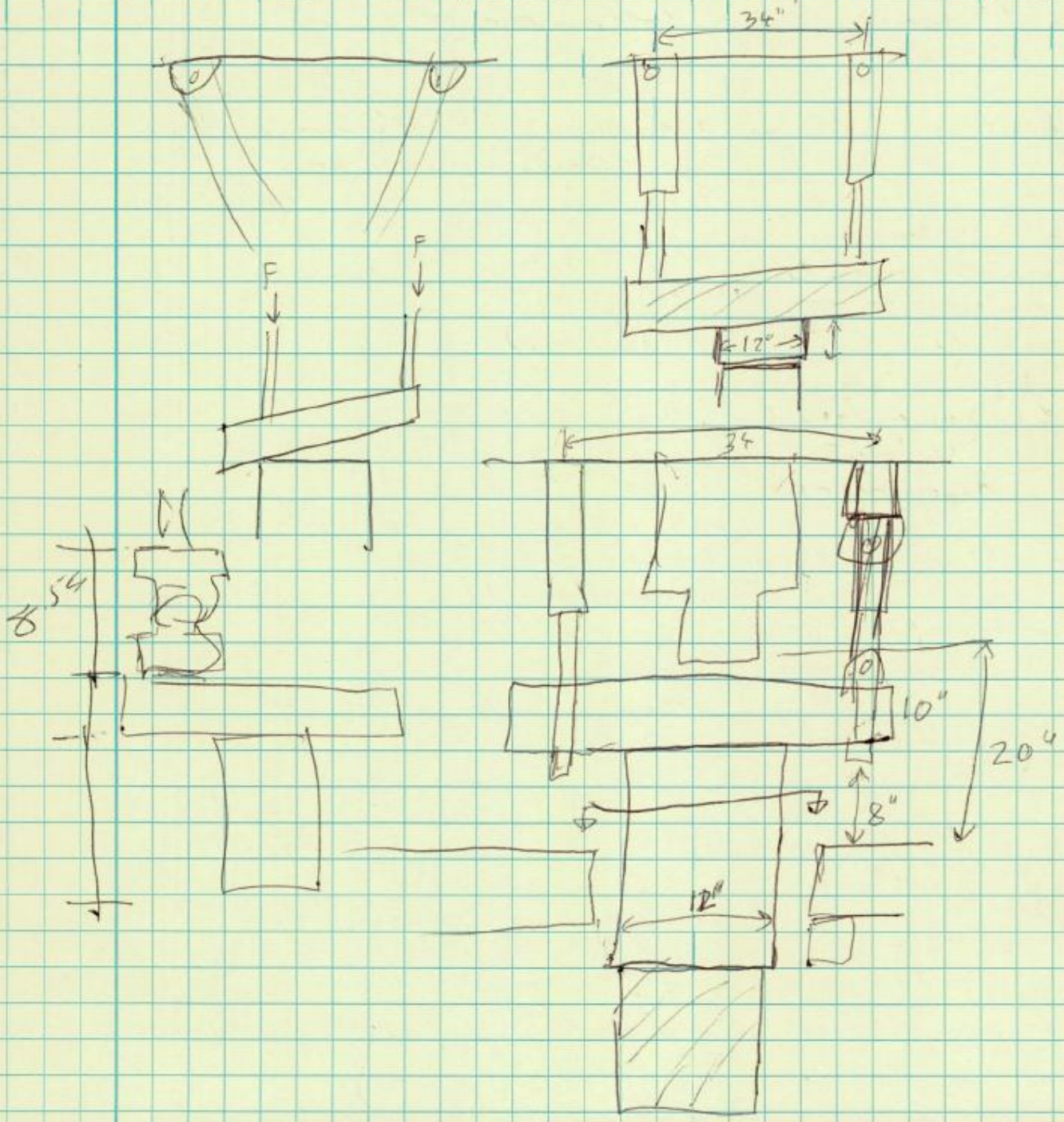
12 - 14 = screw?
15 = ins?
16, 17 = concrete

Extend: 3 - 7 = rebar
14, 16, 18 stick out
19 = tapcon head 20 = tapcon tail
21 = insulation
22 = top concrete 23 = ends

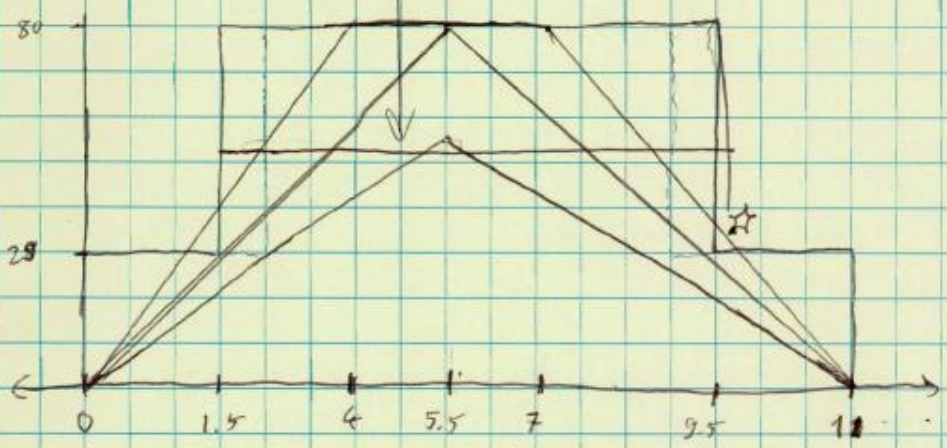
#5 Vulcan - MSU Installation Trip 6/13

Check deflection of beam under 3-point load

6:20PM continue work after discussion with Professor Kodur
"He's done 100's of test and 4-point works fine"
"Baolin needs to run the equipment & his wife is due on the 27th"
"need at least 3 days to move the beam in place"
"Baolin is project manager"
↳ it's his thesis!
3 point: strobe is 6" in center, 12" on sides



#5 Vulcan - MSU Installation Trip, ctd. 6/14



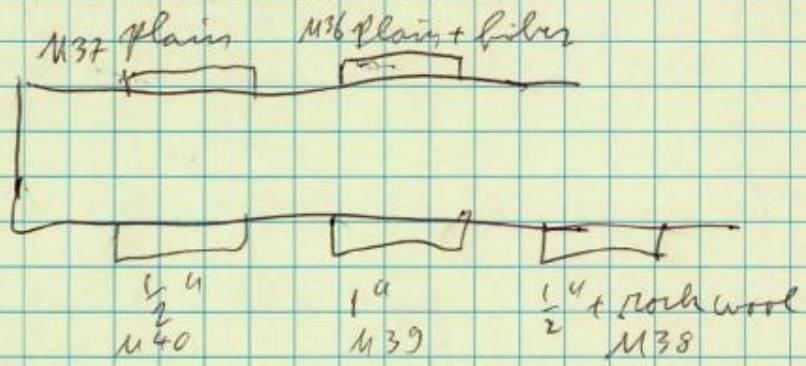
6/14 Nice older man in green shirt - Chuck
table saw fuse is on bottom right can do nice 45° cuts
10am

6/15 10:20 am - finished 3 top panels, 2 side panels, & drilled last 2 side panels on control

Control may have turned out slightly better due to practice
but has some biggy gaps - filled with intumescent
10:43 Qi painting, all panels on

Plan for 8 x 8's:

☆ • ½" with Geopolymer
☆ • 1" with Geo
• 1.5" with Geo - use beam as control
☆ • 1.5" with fiberglass compressible
☆ • 1.5" with ~~[illegible]~~ just bolts
☆ • ½" with rock wool (1")



11:56 - put up all the boards 12:10 last bit of cleanup

#9 General - Advanced Materials Meeting

Mentors & skills development
Milliken University to be revived
Ryan: should be forced to go outside for some education, cross-polination
Housekeeping - Chris to do a walk-thru each period
↳ storage on top of shelves
↳ keep chemicals in central storage
↳ neater workspaces
↳ piles of stuff = bad, proper storage
more storage to be set up
need to purge roll storage
"Doing fine on budget" company is behind YTD, but no changes yet... schedule travel & education soon

Qi: we made offer to a technician last week, her husband may be a candidate
Dale & Bradley are hiring a technician

Technician management
↳ weekly work reports (activity)?
↳ end of year review process: ratings are inconsistent
↳ group to look @ daily mgt practices - RJ, VR, PW
↳ another to look @ year end review scheduling
- set dates for reviews PB & DK

Team meeting
- trip summary
- Agree to pay for 3-point load hardware work
- Will revisit other options for subsequent testing

Debate about load level
- want clear and distinct failure
- must keep over running after control fails
↳ check with Sin... when to turn load off?

Test controller/PC tomorrow Pat/Mushotl/Jans
5:17 PM - struggled with balls, gave up, will cut out all the threads, try to run today... work to 10 if we're lucky. Uffff...

#5 Vulcan – Queen's Beams ANSYS

Beams C and D in Hollingshead thesis
- similar to if not identical to V-G spray (material 210)

$\rho = 351.$ $c \approx 1.176$ $K \approx 0.1158$

↳ 0-100°C = 351

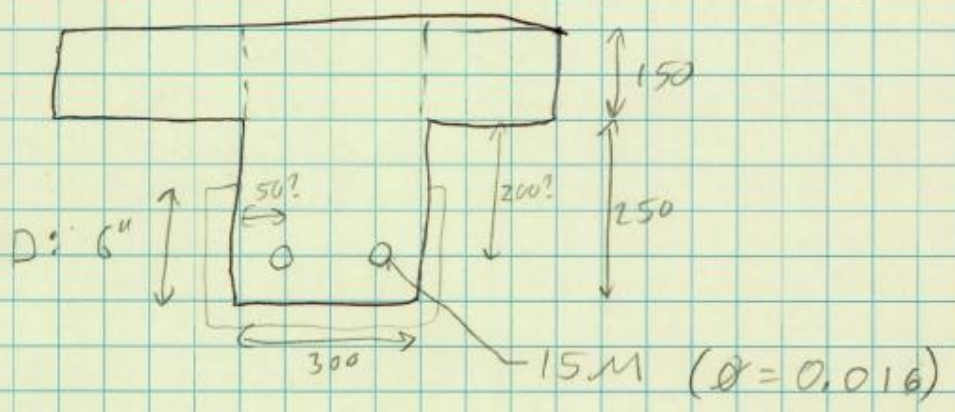
≥ 200°C = 287

ρ✓ c✓ K✓

C: 0-20°C = 1.1763
78°C = 1.3058
125°C = 6.9066
137°C = 1.3722
153°C = 1.0136
610°C = 0.8509
663°C = 1.6976
≥ 690°C = 0.9167

K: 0-100°C = 0.1158
101°C = 0.0726
400°C = "
800°C = 0.1224
~~1200°C = 0.295~~ *
* probably max @ 1000°C
1000°C = 0.2087
→ set to constant
1200°C = 0.2087

insult: 15 mm on beam C, 20 on D



set min time step to 1 sec to converge

	MSU Beam 02	3H	½H	1H	2H
TC8	4652 = top center	= 399°	161°	224°	314°
TC1	4677 = top 25"	= 471°	176°	264°	379°
TC7	13961 = lower left web	= 152°C	21°	30°	82°
M35	54 = BCSN	138°C	34°	67°	129°
	28 = M32 edge of fabric	230°C	35°	73° ☆	152°
	3783 = Rod 1	173°C	26°	49°	106°
	3770 = Rod 2	204°C	27°	55°	128°
	1 = Beam C N	385°	65°	161°	288°

#5 Vulcan - Jim Parnell meeting 6/21

Overhead Track System Discussion
Austin, Jim Parnell, Cesar, Bernie, me

"Moving extremely fast"
"12 ft would be on the money"
like the rules to set position
Jim: Job in Charlotte
- post tensioning ... not a straight run
- bush hammer to roughen up, breaks concrete too much
"extremely helpful"
scare fire more aggressive
- grinding, cutting, prep, or drilling
Scare Fire: Laurand Electric Cleaning tool Mod. N
6.9 Amps Aurand Scarifier MS-13
Has nice guide rollers, not a good attachment point

Longitudinal or Transverse on bridges
Inspection vehicle hangs over side of bridge,
telescope out - over water or inaccessible
there is bounce in that unit, need cable to tie to fixed bridge
Austin: fiber work on a beam
Jim 5, 1, 2 are excellent
Adjustability? Office building has sc ceiling up in those ceilings have to be done by hand
Other situation: bring bldg up to seismic code
↳ bldg was gutted, clear shot
Bottom of a beam or flat concrete ceiling
"conventional pan type waffled ceiling" but
stay on the joist, bottom of joist
Most office structures are pan
12 would work good on bottom of beams
10 ft is typical, sometimes 20 $2000, have 2
Metal detectors: Elcometer tells you depth & size of rebar
Precast is pretty standard - conventional & prestressed (cover)
overhead is conventional
Elcometer "Protovate" 0.05" resolution
rarely painted
fire protection hangs down 6-12" as does mechanical
electrical & vents up on ceiling industrial is pretty clear

5 Vulcan - Jim Lamale meeting, ctd 6/21

Office jobs don't use much material
80% of material use in places with little in the Bernie
Parking decks, sides of bridges, warehouses
office: just 1 section typical
Needle scaler is most common
or media blasting not w/ sand "Black Beauty" coal slag
gotten tough on silica
Media blast would have to cover areas not lines XY
↳ "tough to do"

Lawand - want full width treatment
single drum is smaller → handle bolt on with 5/16"? or 1/4"
How deep could we do? 7/16" hex head
Width varies all over.
Normal cutting for VSU
Prep work is for surface laminates & wrap
core drill
2-3 ft 4-width seems great
Bridge done on I-85 with carbon fiber, gets coated elastomeric
Acrylic for UV
could we do vertical guiding?
bolt in place is a pain, "it's a bear, try not to do it"
profile side of beam for U-wraps
drill tons of holes in columns to set anchors for
seismic retrofit
↳ anchors to hold cage 1/2" to 5/8"φ, 4-6" deep
columns 12-14" tall mostly square
also need to prep the surface
Hydroblasting - 20KSI - wouldn't want to hold it when
doing overhead - This is an outside process - too messy
to do inside

Bernie's unsanctioned
unsolicited comment

$\frac{2 \cdot M}{B^{48}}$ - B189 Mw

#5 Vulcan - MSU Burn Trip 6/25

Arrived @ 1PM. Wiring spreadsheet very helpful.
Added 5 T/C's on top of each beam, some insulation at edges of panels and, on one panel screw. 1¼" tapcon
intumescent paint

5:20 PM - putting on the lid, almost done one half
T/C wires twisted but laid parallel to beam

6/26

Loading:

K-ft	kips	200in² pressure PSI	event
~~20.5~~	~~3.9~~		cracking start
18.3	5.1	~~15.5~~ 25.4	cracking
27.5	8.2	~~30.8~~ 40.7	unstr. yield 62KSI
33.3	10.1	~~40.5~~ 50.2	" y @ 75KSI, rebar
38.5	11.8	~~49.1~~ 58.9	" ult @ 84KSI
36.5	11.2	55.6	strengthened yield 62KSI
☆ 37.5	11.3	57.2	service load ± 4PSI
35.0	10.7	53.1	service load LC
40.0	12.3	61.3	service upper limit
58.4	18.5	91.9	control fail ACI-safe
64.4	20.5	101.8	control fail ACI
80.5	25.8	128.5	NSM fail

Problem: getting bolt screwed on - 10:50 am still struggling
Computer is windows XP Type K thermocouples
T/C 3-8 are over sample every 5 sec
→ set to 1 sec @ loading
strain gauges calibrated to zero - not yet connected b/c people working there
"other channels" = pressure, LVDT displacement, strain gauges
9:19 one more reboot, ready to start load
file name 12-178MIL125 ~~status data~~ RT data NSM
control beam has loose sleeve
accidentally up to 24
briefly hit 60
Soak @ 54, crept up to 66 on both beams
→ reset to 48/50 before test
12 AM - still trying to light fire 12:04 burner briefly on
12:14 - ? problems? 12:21 - "takes ½ hour to light" - Leo
12:24 start P=80 → 50 but no flame
12:31 false start, reset other to 12:40 still waiting
76/54 → 48/54 @ 12:48 // just started all 6 on
12:52 temp flatline @ 273

#5 Vulcan - MSU Burn Trip, ctd. 6/27

CTL NSU CTL

iam: 123 = -3.707 124 = 2.384 125 = -4.618 126 = -2.12 in
about 0.01" movement

1:05 - flames on for real
1:22 reached 73°C on control
1:34 control still 65°C on edge
1:39 control failing

@start: 123 = 3.8 124 = 126 = -2.2

beam wants to be @ 48 start @ 12:46am = TO next check
2:23 am 1 h 37 min run time
2:35 back column now steaming 2:00 both steam
→ # CH running low on water
3:10 crack in bottom of NSU insulation
3:50 still up!
fit = 12 - 179 mil 236. csv
pop @ 98 PSI 100 - 4:12 am another

6/28 Postmortem
balls have 0.011" clearance as per Bernie, base of thread still sticking out, catching male tip of thread
Control beam: most T/C wires completely bare, showing wires. both to panel & to ins
Geopolymer, screws all worked as planned
side panels - ½" is warped, rest looks good
I think screws + fiberglass blanket is fine if beam is smooth. panel on beam was OK but I don't trust perfect smooth
Clear crack in middle, carbon connected but wavy in center
NSU beam - T/C wires looks a little better
screws in loose holes → head breaks off
looks like either geopolymer or non-intumesced paint, probably geopolymer, used to protect
Failure: slow cracking to end of rod on left side
15" from edge of oven, 22" over edge → end of beam
on street side 22¼" on other side 13' beam 156"
111" span = 9'3" 15" in is to 40.5" from center = 3' 4.5"
geopolymer bond to concrete needed chiseling, but it came off the MGrace/layers/sand with no effort.
middle of 8x8 (5" to 6" Ø) still dark, didn't get that hot, thermocouple placed nicely
Strange marks around cracks - may be water escaping ⇒ TBCout.

#9 General - Prof. Li Discussion 6/27

Professor Victor Li - "Crazy Concrete"
- demo projects for MI DOT
↳ jointless bridge, thermal expansion
↳ replace joint once a year
cost is 2-3x normal concrete more like mortar
no aggregate starting to commercialized in Japan
- former student running a company - 3 tall buildings
lower system cost - less material, etc.
ECC - engineered cementitious composites
60 story bldg in Osaka, 2 in Tokyo
no more antiseismic devices - superframe
9 ft high beams cast in place
save on square feet ~~ground~~ floor print
use on coupling beams, targeted places
also save on maintenance cost
could use for road overlay on top of bad material
"reflective cracking"
ECC has larger drying shrinkage b/c no coarse aggregate (could be designed away)
ECC has 5% strain capacity vs 0.01% for concrete
Normal fiber reinforced concrete - fiber slows down crack propagation/opening - tension softening
ECC trick: controlled damage by spreading over a larger volume same as wave layers
similar as steel - strain hardening - due to platelets in microstructure - layers of bricks (calcium carbonate)
sample - 7% PP - tons of tiny cracks makes it stronger
20 nm coating Li used to teach at MIT course 1
Stanley Becker - Dupont
Brittle material is flaw sensitive - controlled by energy
Standard bond test is bad theoretically...
ECC does really well
cracks in interface goes to surface, forming a spall
→ runs out of energy
ECC - Rebar bond is "strong"
Lollipop test - like pullout test PVA fibers
PVA coated because hydrophilic, bonds too well
↳ optimum is a weaker bond vs Ductal → lit σ_c
eliminate flaws, no gaps, tight packing 200 GPa
so brittle, some fibers to save tensile strength 16 x concrete
sometimes requires heat curing, little creep
ECC has intentional defects

#9 General - Prof. Li Discussion, cts.

Super performance in fatigue
Li owns a small company, joint ventures
agreement with BASF for US market
could have different markets/agreement there is lots of space
↳ building space is fairly open
research on smart material version - self-healing
recent patent ... self-thermal regulation
↳ compromise some properties
extrudable version for pipes - project has stopped
↳ more like soil compaction
at best 70-80 MPa compressive strength
↳ recent 160 MPa ~ 20 KSI
have book chapter - can e-mail Concrete Construction Engineering
Chapter 24 most authors are big shots
getting material
↳ requires training, NDA or NAA
LFL & Associates - private company

BERNIES COMMENTS

White Marking cracks on control beam - Observations:
1.) Geopolymer on beam bottom ~50 ½ debonded ~~come off~~ from substrate
concrete
2.) " " beam sides - insulation failed/ripped when insulation was removed
Geopolymer bond to substrate was strong on side
3.) cracks were marked.

NSH Beam:
1.) Geopolymer is solid over 90% of the area ~~tops~~ Bottom
" " ~ ~100% of the side area

2.). failure in insulation

#5 Vulcan - PERL goal discussion 7/2

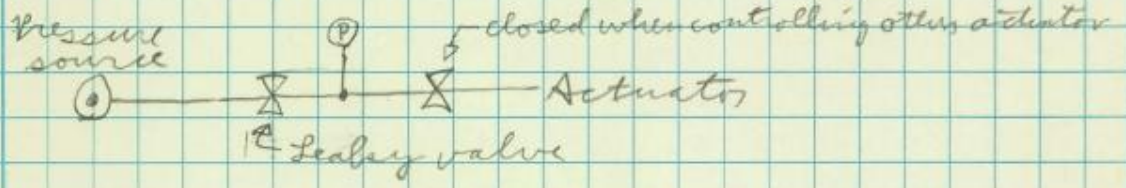
Dal traveling, Ai gone, Greg & Gregg here
also Philip, Caesar, Bernie, Venkat, me
WORLD OF CONCRETE product launch Feb 2013
Greg: be able to bid on a project
"most require columns" - pure guess
Gregg: flexure and shear is very common
50% require columns - any seismic upgrade - guess
need all buildings to have FR rating for $500M market
parking decks - 1 hour
durability not a concern, freeze thaw is (orgpout)
need realistic installation
fatigue not concern except maybe parking deck
has seen columns with 20-30 layers (1-3' ø)
8-10 is higher end
HSC or NSC?
SGH, WJE engineering firms industry leaders
How valuable is deep engineering understanding?
Need meeting to plan needs from MSU - pressure, file #3...
What size rod? 2 sizes?
UL / Intertek testing is a must or SW Research Lab
Is there time between burn & UL stamp of approval?
Provisional patent filed in April - 1 year
Certified contractors
Silva 300 knock-off → needed on all further tests ~~[illegible]~~ 5 Star
↳ need to do some analysis
Gregg: Perl goal testing recommendation
- small/mid-scale internal, big external?
Wet layup - business owns the lead
Runedil - won't license

#5 Vulcan - Intertek call 7/5

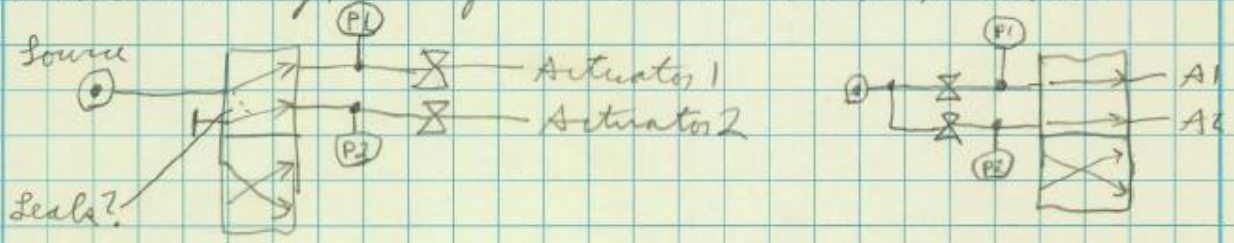
Gregg, Greg, Jeff, Philip, me, Bernie
Sami Rizzella, Mike Day, Tommy Mueller, Tracy Fowler
NDA as needed
Production location - traceability
Prototypes tested, then verify same as prototype
small scale test to show equivalence
new mfg facilities - audit to show same process
load: hydraulic pumps up to 4 beams - 150 kips max
4-point loads 3 actuators per beam

displacement: 13' span, 12' free long direction 19' outside
plan view of supports 7' tall 12' × 18' inside
can rest on furnace, restraining frame preferred
beam length is probably 14'
simply supported, load in middle, maybe 2' span for 4 pt bend
E119 - can't test unrestrained and get restrained rating!
restrained is more universal
temps of reinforcing steel < 1100°F for entire test
3 actuators - equal forces
4 sets of 3
T/C on reinforcing steel based on E119
can add additional 300 channels can do 1000
can turn off load when multiple beams
no internal strain gauges - "useless" (Sami)
columns - not loaded - based on temperatures
monitor pressures
E84 test - discuss under NDA
dry out before at 250° - 300°F for several weeks 18" - a month

Possible MSU control circuit (speculative)



In actuality, may look more complicated



#5 Vulcan - Pizzella conference call

864 503-6569

Strahan, Hitchen, Venkat, Wilson

Sami: 919 513-4336
Column testing - fire under load
↳ NRC in Ottawa can do this Mark Green → Queen
↳ can go directly to the lab
More beams/slabs/etc - need a proposal
Sami: Milliken should think about the future
dealing with weird structures - #3 or #4 bars
30-40 ft span
clips to hold bar
0.002 for axial 0.003 in flexure 0.15
↳ ε is 0.0003 microcracks
get dilation of concrete
go 4X on strain UCSD → 0.008 in confined jacket
Priestley book ... equivalent strain is very high
cannot convert to strain -- DILATION
↳ increase in volume of concrete
ν does not apply
Sami in England rest of the week

Venkat Hodur → preregulator - not changed
Need to plan for next test
students were not happy
from safety standpoint, need to do work beforehand
need to check calculations - load calculations
- full spreadsheet - a couple of days 3 days
In August, students take classes
A lot of test facilities, no observations during test
Jeff - better pressure control 600 kips vs 11 kips
Will check on regulator
Labeling not a major problem - figure it out based
on what signal ~~would be~~ should be
let them prepare the data
no testing lab will let you see all the data
Hodur doesn't have to be there for prep
↳ share info with 1-2 students
do before 2nd - 3rd week of August, away next week
24 hours for cooling, can look at it

#9 General - Safety Minutes 7/11 7/4

Jewell, Ridgeway, Moseley, Wilson, Sullivan, Srivastava, Hemmingsen, Petri

VPP next month - focus on housekeeping
New hire safety training - added optional training that boss can pick

Special guest: Deidre Sandrock & Jason Sprunk (Di's replacement)
- chemicals have now rigorous chemicals checking
- partner with chemical auditor
- Kathi to set next group of auditors today

Near miss writeup on silver nitrate - housekeeping
Jimmy Henson enters
Celebrate 100 safe days - need to work out something
- pizza, deli platters, salad, cookout*, Mr. Gatti's
- beginning of August
New safety glass containers Randy enters
Issue: non-visitors take visitor glasses
- need to remind at QIT meeting
- all labs need to be the same - EXACTLY
- need used & clean bin
- add front pane for vertical mount?
- divider for clean & dirty glasses
- give away straps and/or nicer personal ones

#5 Vulcan - ANSYS with hydrated concrete

7/11

Compare ANSYS to real world data
Top CN = Top QN = 4599?? width = {} = 0! base is width of beam variable Top CN = 4651 Top QN = 4677
Have center & corner of beam, need 2, 3, 4
1 = BCST 2 = (1+3)/2 3 = Rod2x 4 = 3+1.125" 5 = BCOT

$$H = \int \rho c_p(T)\, dT \qquad H(T) = \int_0^T \rho c_p(\tau)\, d\tau$$

$H_{water} = 2.23\times10^6$ J/kg concrete usually 3-5% water
4% adds 89,200 J/kg concrete
If this happens over a 5°C range, equivalent bump in heat capacity is 17,840 J/kg-°C
not as big as the peak around 715°C (calcification?)
but huge effect in the critical 0-400°C range

① Versions: original, top convects to E119
→ script MSU script 11.txt file JRS, MSU 7-5-12 PP mod.xlsx
② top convects to 26°C, standard concrete
MSU script 12.txt, JRS, MSU 7-5-12 PP mod 2.xlsx
film coefficient is 9
③ same as ② with film coefficient = 6 → first try
MSU script 13, JRS, MSU 7.5-12 PP mod 3
~~④ bump~~ → little difference, Top CT → 107, Top QT → 197 ~~@ 98/182~~
before 98/182, actual is 160/275 on NSM, 131/335 control
↳ 219 in one place
try 2 instead → CT = 121, QT = 222, saved in previously mentioned files script 13, PP mod 3
→ not even 1° difference @ rods, 7° @ BL Rebar T
Fits better, but does not have sharp inflection points

④ No top convection at all → CT = 130, QT = 236
~~so~~ need script 13, PP mod 4
Add peak to concrete 95-105 △
$\frac{1}{2} b \cdot h = 89{,}200$ $b = 10°C$ $h = 17840$ add to 1114
$h' = 18954$ material #2
→ solution convergence much more difficult, crash > 190 sec (203 sec)
try square block 97.5-102.5 @ 18954 - not allowed
try wider base - 20°C wide, $h' = 10034$
↳ 241 sec slow but OK, choppy thereafter
⑤ saved in JRS, MSU Data, 7-5-12 PP mod 5 with no top convection

#5 Vulcan - Conference call with NRC

Hussein
Patrick L. not here Dr Nurudan Venishad (sp?)
Intertek certification is its own entity

Located in Ottowa 16x16 & 12x12 square columns
Discuss cost, options
column burn chamber is completely separate from beam & slab chamber
intermediate beam, full scale beam, floor, wall
column: 10 MW, 32 gas burners Max 12.5 ft
↳ 2250 lbs/ft fire is less - 10 ft

All 16x16, 2 have steel fibers, 2 have PP fibers, HSC
fibers should suppress spalling
cost: fabrication about $6 - $6.5K labor & material canadian
thermocouples - 25 is usual 25-30 each $80C
could compare to control if same construction
↳ 30-35 MPa compressive strength NA code
minimum 28 days cure, prefer 2 months 2-3
"you always measure humidity"
DAQ can take 60-70 channels 100 T/C's on floor
Test: $23K $ for a single test UL costs more - calibrate all sensors
↳ depends on quantity
↳ witness mixing
- $4-$5K on NRC's side + UL charge
Usually UL comes once

Slab & beam tests?
4.9 m x 4 m floor test furnace for slabs
could fit 2 T-beams with or without slabs
uniform distributed load - 2,500 kg/m max
25 hydraulic jacks, 70-80 points of contact 90 points
If 6 beam, 6 jacks in one line
Simply supported or restrained
Ran restrained, then released during test
Typically more unrestrained
Beams in 4 m direction 5" at each end not exposed
Fill remaining space with concrete & fiberfrax blankets
Furnace in use for 40 years
Load has digital control system, automatic
E119 - 4 intervals - 25% a minute, 50, 79, 100 let sit ½ hour
Beams & slabs - manually control - set with knobs - display on DAQ
fluctuates 1-2% pump tries to maintain max pressure,
if pressure rises can manually reduce 500 psi ± 5

#5 Vulcan - conference call with NRC, ctd.

At failure, pumps cannot pick up
Max is 18" stroke minus engagement, ~12"
Apply same pressure on both beams
↳ need to raise manually
Cost for 2 almost the same as 1 test, just add
some fiberbrax & instrumentation
$24K for floor test
cheaper to do it all at once
column test @ start of week, floor @ end of week

Multiple columns - save $ on report
↳ data will be provided, all the raw data

7/30 Call NRC - Hossein & Noredin
? what is logic of 7.4.2.2. optional loading
to 1.75 × working load? In place of?
→ they don't do this

Thermocouples on columns?? 7.3.? ?≠2
→ use 7.3.2 as a guideline

Don't change effective lengths → load pushes from bottom

Drill plates for columns
Only plates are touched for column handling
Ship to Canada then move (another place we have
shipped to in the past)
>100 tests done at their furnace
fixed end condition
insulate at Intertek? Damage... insulate at NRC? → 2× visit
Oct 15 → November busy end of Nov - early Dec good time
Storage is no problem
NRC has a customs office

#5 Vulcan - DSC / TGA tests 7/20

See what we get from
- intumescent paint (dried) ✓
- geopolymer (cured) ✓ (7-29-1
- Fiberfrax ✓
- concrete ✓
- benzoic acid ✓
- Silica 300 ✓ (90% certain)

Tests run by Rita Price - can't see the samples

#5 Vulcan - Intertek Conference Call 7/23

call-in 2504 Mike Dey, Vilsto, Josh Vestal
Philip, Jeff, Greg, Gregg
Large scale 13' x 19' 7' tall - extend height for column
can do 8 columns
slab test 2H $15,000 $/floor 3H - add $1500
Forward Vilsto's drawing
beam test - more setup - most is 4 $30,000
4 unique loads
$20 - $25K range
Test plan $175/hour engineering
E119 - various thicknesses, steel
certification - quality control manual
watch product be made ... traceability
could test a beam - create listing report
- option of non-public viewing, listing not public
get parts cast now
PCOR - project changeover request - get started on concrete
solid sections - range of sizes
could increase size of beam if insulation is same
↳ less mass to heat
concept drawing by Millibee came up
need slab to cover entire furnace - thin as possible
aggregate type & minimum strength
accelerated curing - 28 days then accelerated
- critical w/ compressive strength common practice
- cylinders part of quote 3@7, 3@28
- a couple furnaces & insulated rooms for accel. cure
- 300°F at most low 80's no spalling
- grab a curing room
Available 8/9 - 8/10 plenty people around → to send confirmation
Minimum 12' for beams & slabs
Test restrained & get unrestrained rating by standard
↳ temp needs to stay low 1h vs 2h
Worst case installation
Like installed with actual technique
More focus on final result, do technique after that
- share data on pump vs pour
US & Canada? Canada code affects slab design
4.5" NSC w/ 1.5" cover would cover both, Canadian is thicker
↳ Canadian way to calculate
4 quarters w/ steel beams more composite action to steel
Beams sit on furnace ledge max is 12" or 14"

#5 Vulcan-conference calls

What is the max load 150 Kips/beam
Alternate classification based on temperature
E119 mostly written for steel
Design mix for slabs ... minimum strength 4 KSI concrete
Action items for Intertek
- US vs Canada
- side profile of oven
- pricing
- confirm 8/9 or 8/10
- columns w/o load?
- target 3 hours
-

cost of incidentals, fee for drying
certification: ~$10K + $3K - $4K/year
purchasing contact Vella, Diana - lab mgr
account manager Tommy Luna

Intertek restrained vs unrestrained 14x12 Intertek 7/26
restraint frame is 16-18" total height stem to top of slab
either way bottom of stem is on furnace ledge
Lami doesn't like a wide one-way slab
"How would you load it for starters"
slab is only supported on ends
end of T-beam slab is not supported
Tch Lami about width of slab
Limit bands below 300°C - Gregg
Alternative procedure is relevant for steel
Jabes setup to do loaded columns
Fix the columns, cap ends small scale oven would have to be built
Aggregate type
- lightweight is different
- mix design from ACI 216
- silicon & carbonate are the same => normal wt
- lightweight needs to have strength
pour within a week from "go"

NRC Hussein & Pat ← last day 7/27
lab schedule, construction talk to Pat
accelerated curing - no facilities
be careful pouring to not disturb thermocouples
send NDA to Nourredin
end conditions: fixed-fixed 0.6 or 0.65 nonsway
34834x1.5" plates welded to rebar pour from sides 150" mid to end max

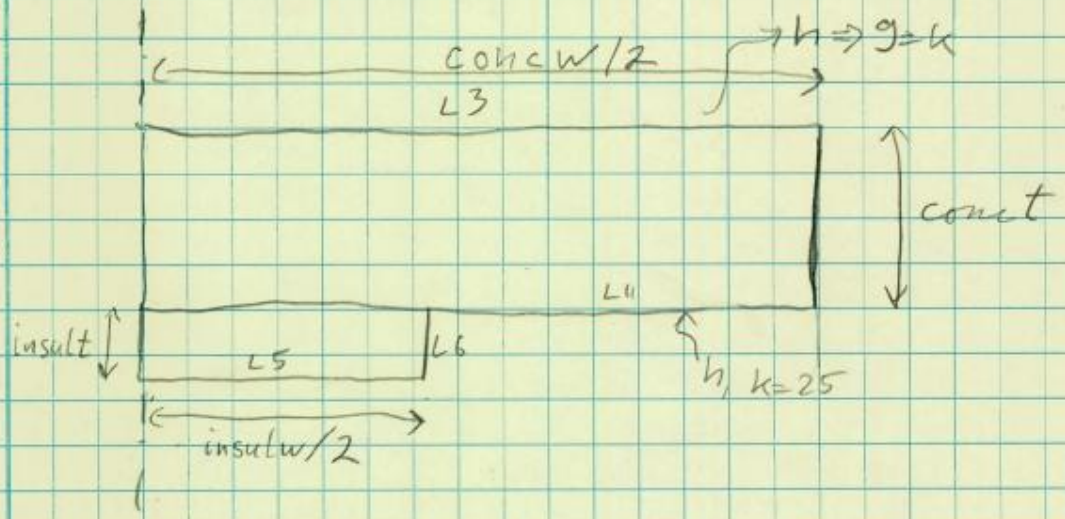
#5 Vulcan - conference calls 7/27

8 holes at top NRC will make drawing
1 ft unexposed at top & bottom unexposed
clamped at bottom bolt plates must be parallel
pour themselves with students?
could use some 36-37 MPa 5,300 PSI
design & have a control
fail by crushing concrete
"quite a few column tests before Christmas"
Normally in fire until fails
Maximum is 8 hours, mostly max is 6 hours
Size: 150" is max length, could have fake column
would do fire test on temperature on small specimen, no load
normally use for thermal only
Measure ¼ down, middle, ¼ up T is very close
b,h capacity of actuator → loaded to design load
used to do 16" column
12x12 is a reasonable small column
could do 8x8 ...
actuator limits: min 160 kips, max 1500 kips ↑ 1000 tons → 600 tons
comfortable
Have 10' insulation to insulation
cost of intermediate test w/ no report, ~$8000
↳ just to get thermal properties?
"not expensive", range of $1000
Intertek could do it too
Talk 1:30 pm on Monday

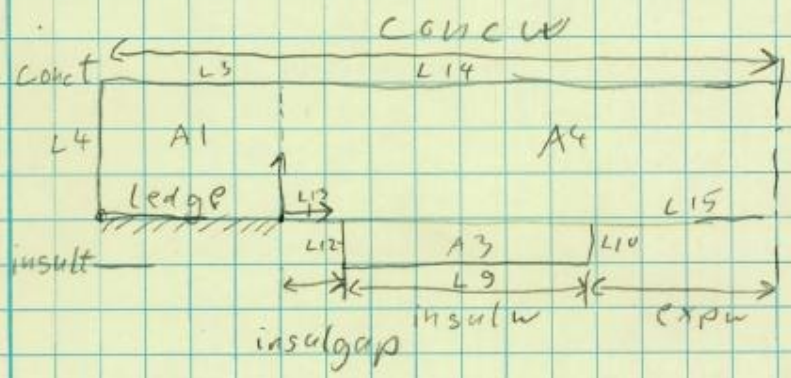
8/2

Intertek - Mike Dey,
Test plan if we want to certify more than what is tested
Test plan may include just one
Other: evaluation after the fact
Normal wt: 4, 6" for 4 hour rating
Test plan typical 20 hours
Mark applied at packaging site
Quality control manual, quarterly inspection
Intertek would accept a greater load
Seem to be on same page
Intertek will do the mixing, concrete recipe
send end plate drawing to Intertek
Exploded

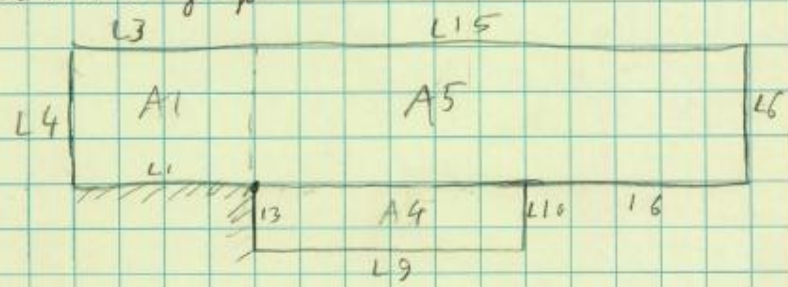
#5 Vulcan - Partial Insulation model



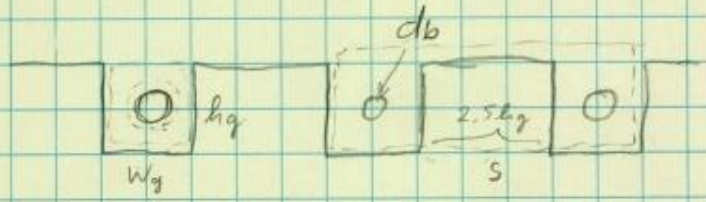
Oven Effects model



with Ø gap:



Groove dimensions: (for design guide)



Rod tension $\le f_{ty} A \le$ rod pullout $\tau_{fg}\, l\, \pi\, d_b$

$\le$ grout shear $\tau_g\, l\, \pi\, d_b$ $\quad \tau_g < \tau_{fg}$ ✓

$\le$ grout pullout $\tau_{gc}(W_g + 2h_g)$ $\quad \tau_{gc} > \tau_c$?

$\le$ concrete breakout $\tau_c(W_g + 2h_g)$

$\le$ " break II $\tau_c(W_g + h_g + \frac{S}{2}) \le \tau_c(W_g + 2.25h_g)$ ✓

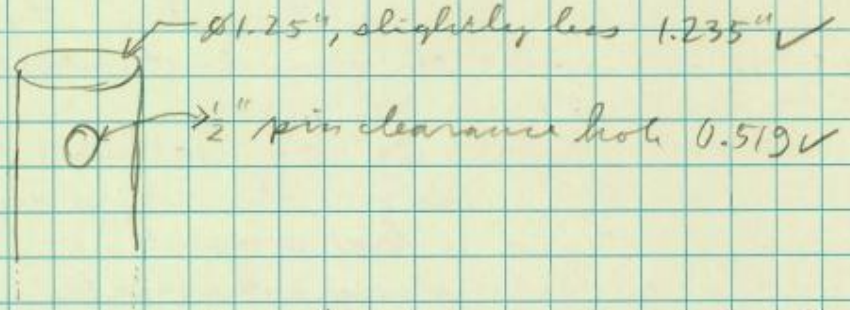
#5 Vulcan - Intertek Visit 8/9

Usually certify products to extend fire rating
Tracie: end goal is certifying criteria on a product and the assembly
design listing says how to construct the assembly
start with audit of manufacturing/assembly facility
looking to confirm QC guide
will use supplier's ~~QC~~ COA but must be relevant
traceability ... no set rule, rely on us to determine what needs to be tested (what properties)
Josh: may do structural & thermal testing
would probably be smart to have Intertek witness concrete mix, cylinder breaks, pics of steel, steel markings, picture of pour to tie together (same steel was used)
test report only: "client supplied product"
Normal process: test plan first
Comfortable with the bigger is OK logic
similar listing: 8 columns, 2-3 beams
guidelines: ASFP yellow book - experiment design
do eight 9-foot columns at once, no load
interpolate but no extrapolate
ANSYS - use for support, not primary
wouldn't need retains - Tracie
prefer 2 week notice on visits/audits
can use parts of ISO 9001
easier is insert parts into Intertek template
QC manual 1 week before audit
Design listing has instructions
Contractor certification?
Design listing can be detailed or vague based on us
Juan - mechanical engineer structural eng. in Vancouver office
"we're not going to fail" the audit → shouldn't need 2nd visit
could accept product directly from supplier
extraneous, developmental tests not necessary
take away tests need justification
? test insulation thickness on edge slab
↳ concern is loading but would go for it
gypsum type 'S' screw cover sit
intumescent paints vary considerably
↳ could test on edge slab
will cure in furnace have several small furnaces 7×7, could do insulation test

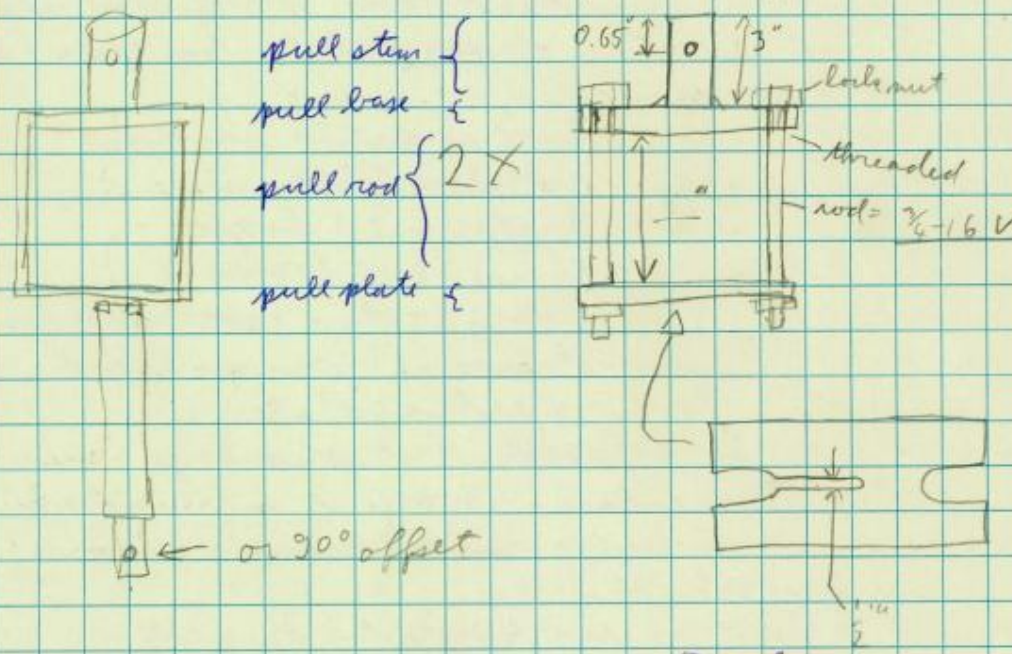
#5 Vulcan - Concrete Cylinder Pullout Test 8/21

Base plate: 8 × (5/16-18 threaded ½" deep) on Ø3.25" circle centered on 5" wide strip, plenty space to go wider

Pull side:



could also do symmetric design using adapter ring



Quick Install:
(Twist)

Results:
5475 lbs max @0.5"
(0.050" wedge + epoxy)
3452 lbs (0.050 + dry)

existing rods: 10½" long 1.6" threaded both ends

FRP Pull Assy, iam × 2 → A_ FRP Pull Test Design

Lami call
columns: 1 @ RT, (0 hour) 1 @ 3H load to failure
use round columns, more repeatable
1 more unstrengthened
check Intertek calibration
CFL is certified by ICC, IAS

#5 Vulcan - Rod Model 8/29

Rod tension, ctd from page 146

$\tau_{max} = \frac{1}{2} |\sigma_{max} - \sigma_{min}|$ so $\tau_u \approx \frac{1}{2} f_u$

$A_s \cdot f_s = l_{db} \cdot \pi d_b \cdot \tau_b$ $\tau_b = \frac{1}{2} \tau_{max}$

$l_{db} = \frac{\pi d_b^2 \cdot f_s}{4 \cdot \pi d_b \cdot \tau_b} = \frac{d_b}{4 \tau_b} f_{sd}$

$F_s = l_{db} \cdot \pi d_b \cdot \tau_b$

Expect grout pullout when

$l_{db,grout} > l_{db,slip}$

$$\frac{F_{design}}{\tau_{gc} \cdot (w_g + 2h_g)} > \frac{F_{design}}{\tau_{slip} \cdot \pi \cdot d_b}$$

$$\tau_{slip} \cdot \pi d_b > \tau_{gc} (w_g + 2h_g)$$

$$\boxed{\tau_{gc} < \tau_{slip} \cdot \frac{\pi d_b}{w_g + 2h_g}}$$

if we use $d_b = \frac{1}{4}''$, $w_g = \frac{1}{2}''$, $h_g = \frac{1}{2}''$

$$\tau_{gc} < \tau_{slip} \cdot \frac{\pi \cdot 0.25}{1.5} = \tau_{slip} \cdot 0.524$$

So if grout - concrete bond is less than half τ_{slip}

Of course this assumes a straight groove!

ACI gives relation to f'_c

$\tau_c \approx \frac{1}{2} \cdot 6 \cdot \lambda \cdot \sqrt{f'_c} = 3 \lambda \sqrt{f'_c}$ $f'_c = \left(\frac{\tau_c}{3\lambda}\right)^2$

#5 Vulcan - Intertek communication

Victor 9/13 - Steel arrived 9/11 @ 3PM all A706 grade 60
→ told to tie it
OK to change 18' to 17'8"
Will do 7x7, then slabs, then beams
need mix design - I thought this was already set
* based on ACI 216 - revised by Alamo
! send schedule to Victor
9/17 - 7x7 & slab are tied, started on beams but
moved to formwork

9/21 Juan 3PM Victor is pouring now (3PM ET)
did not measure exact rebar location on T-beam
kept rebar retains, got concrete cylinders
E119 has method for measuring moisture
RH goal 50-75%
control yield @ 12.5
reinforced @ 16
Dan to review & verify design load
* Review load determination in E119 appendix
The big question:
do we want Intertek to certify "you can get x%
strengthening with your system"

#5 Vulcan

Property comparison

#5 Vulcan - Track System Inventory

Track system inventory:

P-lab: top shelf

1.5 x 4.5 x 12" x 2* (one is dirty - ~~probably our old one~~) both used in 24' setup @ Drayton

1.5 x 1.5 x 12" (brand new)

1.5 x 3.0 x 12" (brand new)

* attached - 3 gusset brackets

Box on bottom shelf: ~20' of ½" tubing

4 x (1x1 bracket) ← new

2 x slide TT need another

(2 x ⊓ slide - not used

2+1+5 x M14-2 x 100

8 x M14-2 x 70

2+15 x 2 bolt nut

10 x M14 nut

7 x ½" quick connect ellbow

(4 x plate)

1 x air quick connect

box 5/16 x ½ socket caps

box 5/16 x 1½ " "

1½" PC rod for roller ~ 6" long

6 x bronze bushings

XM28 rebar

$5.49 for 20' round

$123.33 $123 for 6' - each

3 days

(~~172~~ w/ tax)

182.28

truckload: $2.87/lb + 2400 freight

48 kips cut to length FOB NY

box 5/16 x 1" 8-10 weeks delivery

$140, 160 for thylot

0.376 lbs/ft - online

vs $15 - 16K normal

8x cut but not beat

Concrete lab:

- 1 complete new Eibenstock w/ spacers & rollers & blades
- 1 empty Eib. box w/ spacers only - big allen, ⊏G wrench

Basement:

1+8 x showing jacks - 6' tall (min) 3 missing

2 x end pieces w/ rollers, 1.5x1.5 & 1.5x3.0 +

↳ connected w/ 4 ◺ gussets

+1 more for big rail

4 x short showing jacks 4' +

1 x carriage on metric rail - bad flow regulator?

- big bumper

no TT slides on carriage!

Upper deck:

1 x Eibenstock w/ 4 blades, no rollers, power cable / plug

#5 Vulcan - Track System Inventory, ctd.

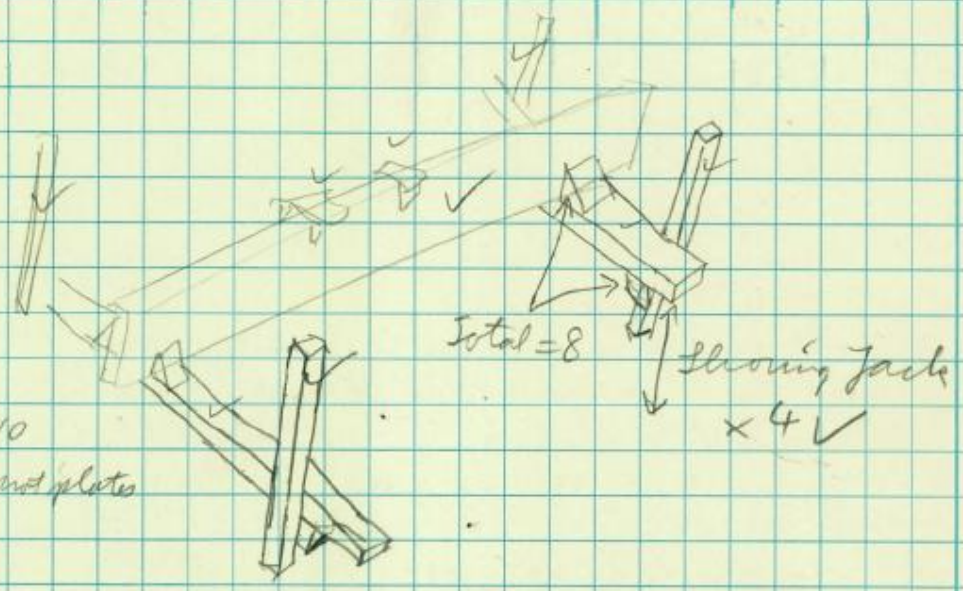
Order 80/20 stuff from Carol Cotter (male) & Don Marbeusen @ Carolina Fluid Components (704) 588-6101

2+8 × 4338 8 hole gusset bracket ~~(upper)~~

8+32 × 3355 2-hole strip (not #!)

2 × 6825 carriage, flat

called in to Eric → EBURKHART@CFCSITE.com



compare p.110
note gussets not plates
on 4 legs

#5 Vulcan - Intertek 7x7 Beam 10/18

Arrive 12:25, still waiting 1:10, 1:15, 1:25, 1:35
Stat fit just fine apparently, is ready to go
No apparent problems Troy looking for Joseph
RH hole? Dead center, ½ depth: 54% 1:40 Joseph here
Start = 78°F Start ~1:48
2:38 - quick data checks look consistent
200°C = 392
Check out Harmathy's 10 rules of fire resistance
- air gap helps but yes/no, dimension unimportant
~85 min in - saw board w/ geopolymer split in half

Jeff: · latest timeline
· cast columns?
· NC State report - not certifying that portion
↳ for structural certification
→ If witness, need to certify to standard method
- standard may be generic
E72? for floors and walls? do in triplicate
ACI 440?
not really spelled out in proposal
needs to be within scope of Intertek expertise
QC template - used by quarterly auditors
↳ Juan to send template

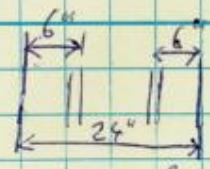
10/19 close inspection
Boards shrank some during test
#4: 0.35 to 0.2" gap on exposed side 0.20" lap gap
#3: no gap, board split but gap closed again
~~#2~~: entire gap ~0.2" w/ geopolymer extruded into it
#2: visible gap under blanket. Edge of blanket turned brittle > ⅛" butt gap 0.16 to 0.2"
#1: board sagging a bit, leaving gap but not as bad as #2 - ~~about~~ hard to measure 2 washers = 0.095"
#8-5: some gaps all around
#3: split exactly 0.5" - as if made in 2 passes
geopolymer that got really hot can be chipped off sometimes taking chunks of concrete off
washer that fell off is in gap between #3 & 4 about 0.3" from gap T/C
#5: geopolymer fell off by itself - except middle patch
#6: shows clear brown edge of 2.6"
#7 does not discolor but blanket did

5 Vulcan - Intertek 7 x 7 Burn, ctd.

#9 cracked by itself
#12 fell, showing laminar structure, split at 0.5"
discoloration in blanket under China board
much less -
Same under B&B #24 - almost white!
#22 seemed weaker, more brittle
#23 much more ductile, like new
#26 screws had best grip - some geopolymer in
threads - needed much more torque
geopolymer layer on #26 is minimal - much
thinner than 1 or 5

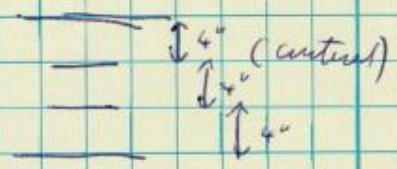
Lightest: 24 B&B
15 1.5" Morgan rigid
14 1.5" China HD
then 15, 16, 21, 22

Vulcan - NCSU Round 1 Install



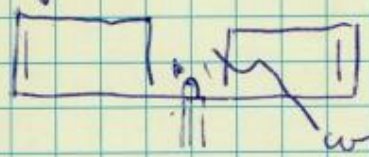
10/22 Saw: - missing 1 handle
- needs zip ties for on/off
- something to remove chaise or cut rebar (grinder)
- a bit tricky to flip around due to scaffold

start cut 2nd groove 3:40 pm - 12' pine bits and squares
- handle would be better in back
4:46 restart w/ handle in back, about 12" cut
3:57 done cutting → move track to beam, mount beam on scaffolding
4:43 ready to start cut on beam
- Italian cutting - no chains
4:56 → first groove done
5:04 start second
5:16 second done



10/23 start ~7:55, unpack
grooves on slab: 136" rod needed, 156" also
beam: 112, 110" ← towards CFL aka front
8:47 2 rods in on slab, one line of tape almost done
need to cut rods to lengths @ Intertek - tool
then tape under clear strip, thick to "patch"
patch after water test - tape doesn't stick to wet
10:40 all rods mounted, tore down tape & washed out
weak layer on surface - could use a wire brush, maybe needle scale - crumbles off and sticks to tape
- air brushed it, then air blow. still dust comes off.
- prime it. 1:46 recommence, tape on clear strip #2

coiling of cables (unwind) ~~carbon rods~~ PT strands come on 12,000 ft spools
grease & wrap
"Basket" double tie @ head & tail
hand made by Jerry



pipe in corner to hold, keep from jumping out
could be fairly open. on trailer axle hub
flip entire basket over
3:55 done, pump purged, wrapping up