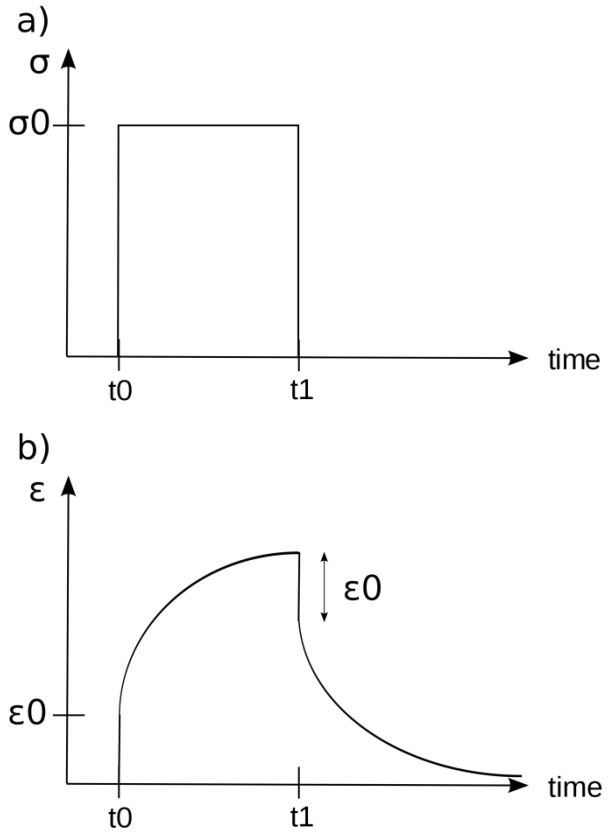
What is Creep?

- Unlike elastic response which is instantaneously in most cases.
- …is the time-dependent deformation of a solid material under a certain applied load.



Creep in Civil Engineering

Cementitious materials have a time dependent response.

Concrete

tbt.scietech.en

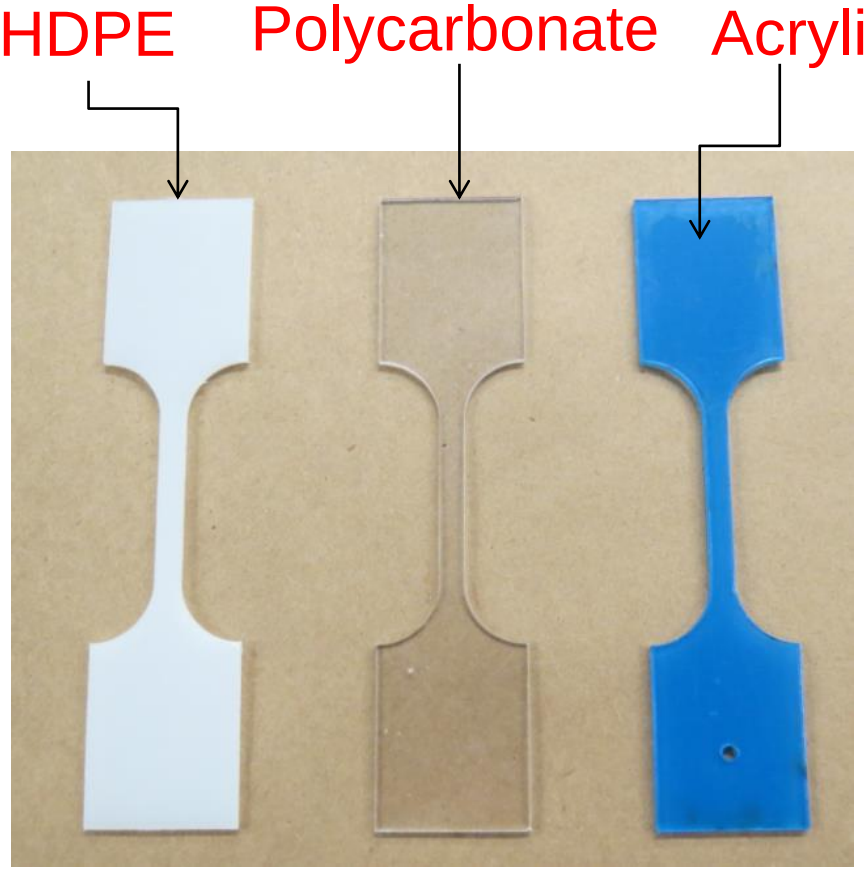
Asphalt

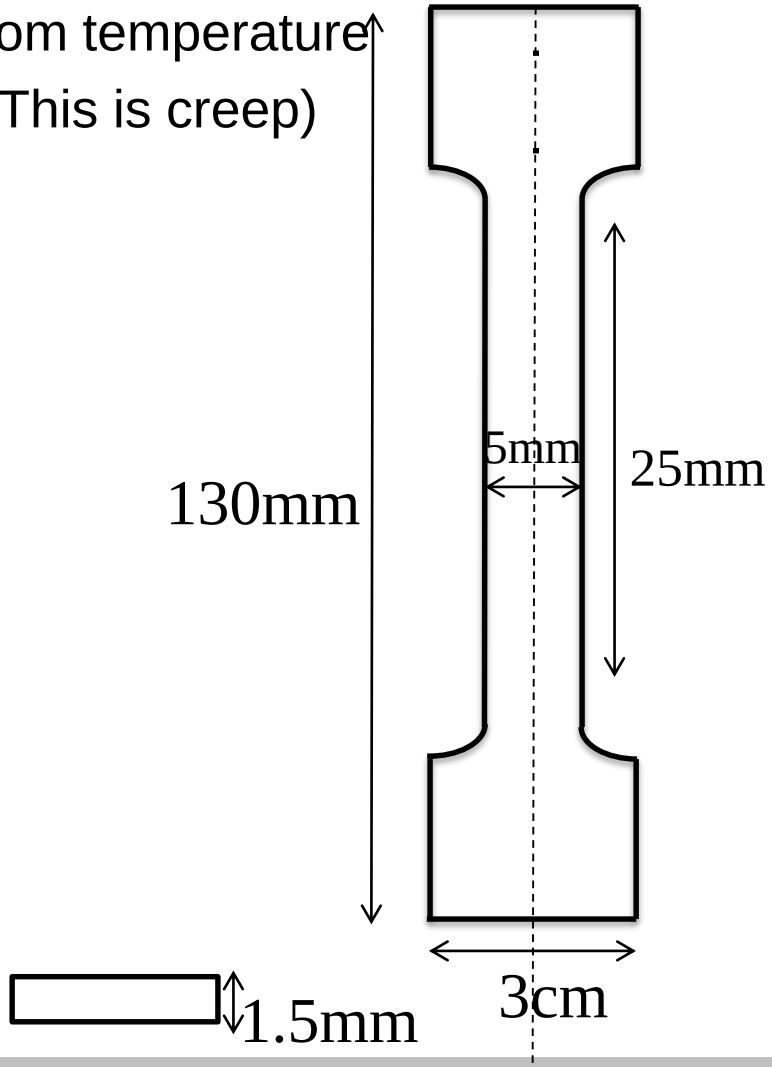
Objectives of the Viscoelastic Lab

- Become familiar with 4-element Burger's Model
- Obtain parameters that describe three polymers (acrylic, polycarbonate and HDPE) at room temperature undergoing creep

Test Setup

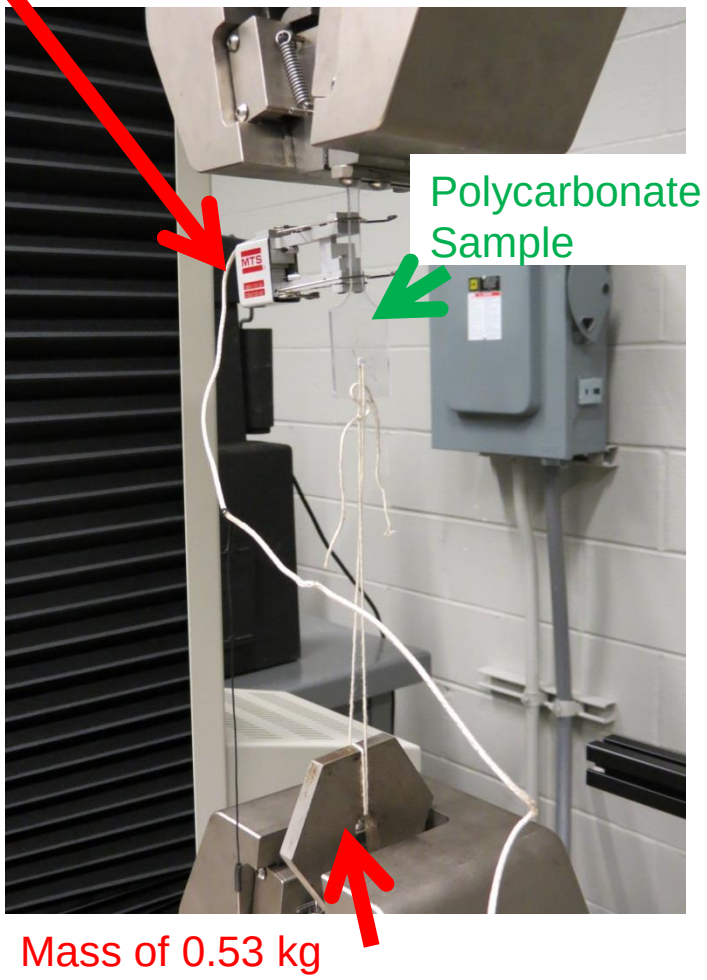
- Three different polymers will be tested at room temperature
- A constant mass of 0.53 kg will be applied (This is creep)



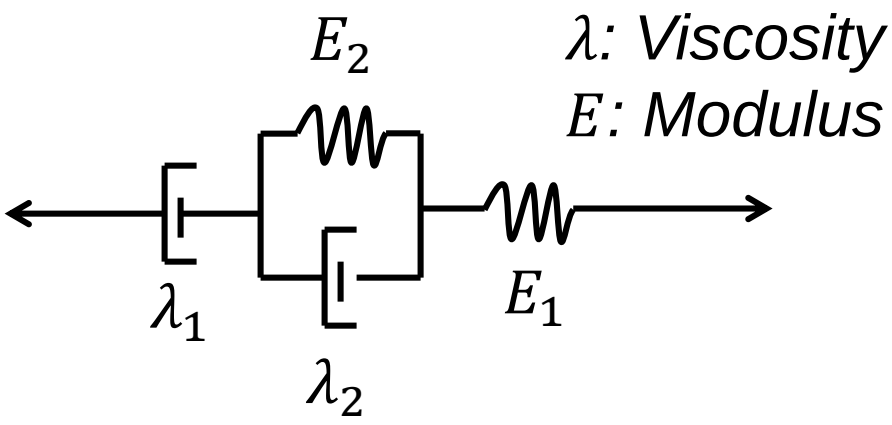


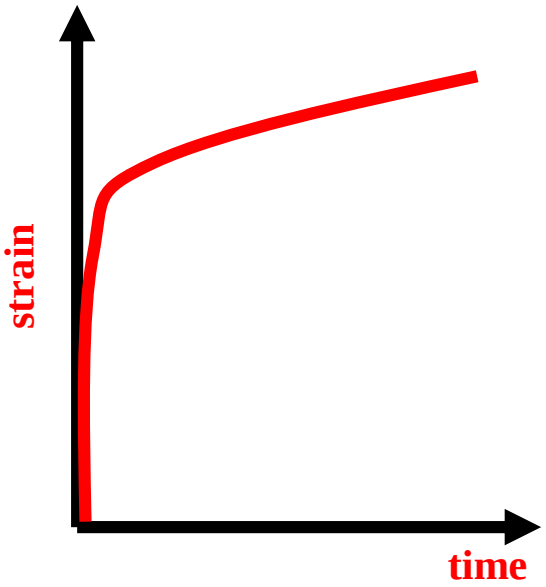
Test Setup and Procedure

- Identify the three distinct polymers in the lab
- Set the extensometer at the center of the dog bones (Lo = 1”)
- Gently release weight avoiding out of plane movement.
- In the MTS computer you will acquire data that relates the measured strain and time.



Burger's model





We can solve the differential constitutive equation for a creep case:

$$\epsilon(t) = \sigma\left[\frac{1}{E_1} + \frac{1}{\lambda_1}t + \frac{1}{E_2}\left(1 - \exp\left(-\frac{E_2}{\lambda_2}t\right)\right)\right]$$

Burger's model: Behavior

At $t = 0$

$$\epsilon = \sigma\left[\frac{1}{E_1} + \frac{1}{\lambda_1}t + \frac{1}{E_2}\left(1 - \exp\left(-\frac{E_2}{\lambda_2}t\right)\right)\right]$$

$$\epsilon(0) = \frac{\sigma}{E_1}$$

"Elastic Strain"

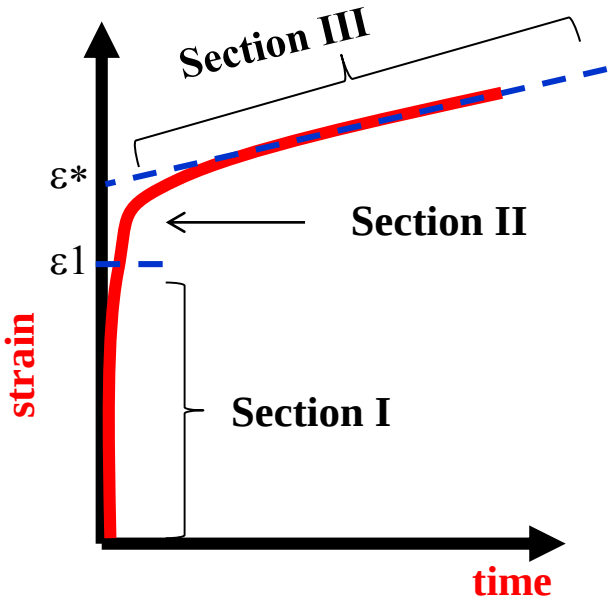
At $t \to \infty$

$$\epsilon = \sigma\left[\frac{1}{E_1} + \frac{1}{\lambda_1}t + \frac{1}{E_2}\left(1 - \exp\left(-\frac{E_2}{\lambda_2}t\right)\right)\right]$$

$$\varepsilon = \sigma\left[\frac{1}{E_1} + \frac{1}{\lambda_1}t + \frac{1}{E_2}\right]$$

Parameters

How to calculate E and λ?



$$\epsilon(t) = \sigma\left[\frac{1}{E_1} + \frac{1}{\lambda_1}t + \frac{1}{E_2}\left(1 - \exp\left(-\frac{E_2}{\lambda_2}t\right)\right)\right]$$

Section I - Instantaneous elastic response

$$E_1 = \frac{\sigma}{\epsilon_1}$$

Section III - Long-term viscous flow of the material

$$\lambda_1 = \frac{\sigma}{\dot{\epsilon}_\infty}$$

λ_2 controls the curvature of section II and can be obtained by using Excel solver and minimizing least squares

E_2 is a function of the delayed strain in section II:

$$E_2 = \frac{\sigma}{\epsilon^* - \epsilon_1}$$

What to Report (Rubric on BB)

	Component	Criteria: Marginal (1)	Criteria: Acceptable (2)	Criteria: Exceptional (3)	NOTES
1	**Summary**				
	1. Describes the goals of the experiment	Identifies one goal of the lab	Identifies most of the goals	Clearly identifies the goals of the laboratory	
	2. Describe the materials and methodology	Describes one of the items	Describes two of the items	Accurately describes the materials and methods. Identify some of the challenges in viscoelasticity testing	
	3. Describe the model we are using in the experiment and how to calculate each parameter	Partially describes one.	Accurately describes one of the items	Accurately describe the model; BRIEF overview on how to calculate each parameter	
	4. Identify the major findings of the experiment	Identify one major items	Identify two major items	Identify the major findings	
2	**Results**				
	1. Figure 1: provide the strain time response of the three materials	Doesn't convert values to strain	Values are incorrect, but shape is correct.	Values and shape of the curves are correct.	Table captions = above Figure captions = below Summary table should be memo, figures should be in appendix To convert from displacment to strain, divide by intial length (for clip gage this is 25.4mm) Remember to cite sources for Literature Young's Modulus
	2. Provide excel sheets in the appendix that calculation of 4 viscoelastic parameters for each material	Trends are correct, but values are incorrect	Calculates at least one of the compoenents correctly	Accurately calculates the parameters for the different materials	
	3. Table 1: the parameters calculated and compare E1 to literature values for Young's modulus	Poor table formatting	Does not compare to literature values	Prepares table of the parameters; compares E to literature values of Young's Modulus	
3	**Format and Clearly Organized**	Not organized clearly. More than one page	Not formatted as a memo, but is well structured	Proper memo format; good organization. ONE PAGE OR LESS	
4	**Format, Units, General**	Poor formatting. Mixed units. Improper use of significant figures.	Average formatting. Proper units. Improper use of significant figures.	Professional formatting. Proper units. Proper significant figures.	

The total for this lab report is 27 points.

Parameters: Excel Example

Creep-example - Excel

Robert Spragg

Time (s)	Extensometer (nm)	Strain (με)	Burger's Model	Error²
0	0.0	0	505	
0.2	433.4	17	506	
0.4	160.0	6	507	
0.6	828.2	33	508	
0.8	1878.3	74	509	
1	2773.5	109	510	
1.2	3195.7	126	511	
1.4	4547.1	179	512	
1.6	5733.2	226	513	
1.8	7393.3	291	513	
2	8848.6	348	514	27532
2.2	11215.0	442	515	5424
2.4	12702.8	500	516	254
2.6	12828.7	505	517	140
2.8	13058.7	514	518	13
3	13141.7	517	519	2
3.2	13124.2	517	519	8
3.4	13217.2	520	520	0
3.6	13236.7	521	521	0
3.8	13499.4	531	522	91
4	13372.8	526	523	14
4.2	13368.1	526	524	7
4.4	13409.5	528	524	13
4.6	13540.6	533	525	63
4.8	13400.9	528	526	3
5	13531.0	533	527	36
5.2	13538.3	533	528	30
5.4	13646.2	537	528	81
5.6	13544.0	533	529	18
5.8	13574.9	534	530	22

* drag down these columns to match the bottom of the data set

Experimental Givens		
l_0	25.4	mm
σ	0.693	MPa

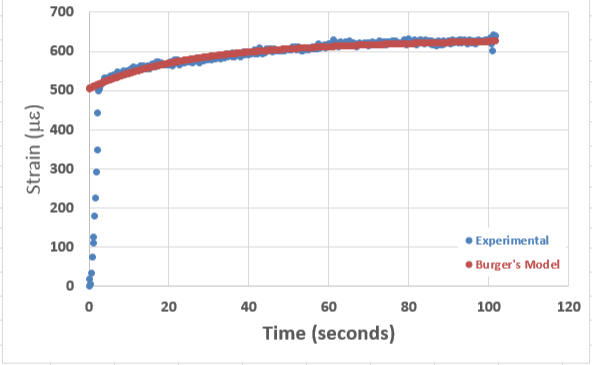
Experimental Determinations (using Engineering Judgement)		
ε_1	505.1	με
Δε/Δt (later a	0.195	με/sec
ε*	607.3	με

Calculation of Berger's Model Components		
E_1	1373	MPa
λ_1	3556128	MPa·s
E_2	6782	MPa
λ_2	149948	MPa·s

Solver Calculations	
Sum Error²	4.62E+04

Solver Instructions

1. Install Solver, check internet if you don't know how to do this
2. Set "Sum Error²" to min by changing "λ_2"



Example

READY