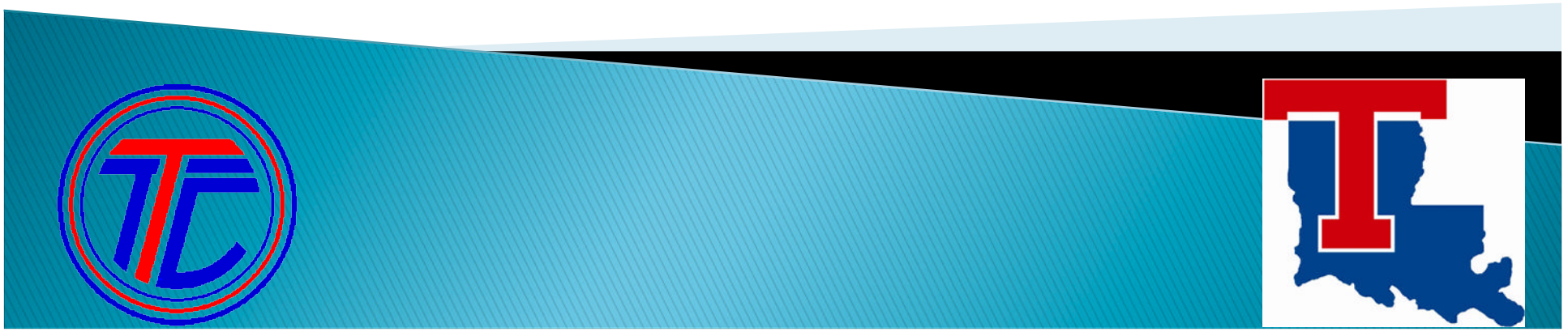
GEOPOLYMER COATING FOR THE REHABILITATION OF CONCRETE-BASED WASTEWATER COLLECTION SYSTEMS

Carlos Montes
Erez Allouche

TRENCHLESS TECHNOLOGY CENTER
LOUISIANA TECH UNIVERSITY

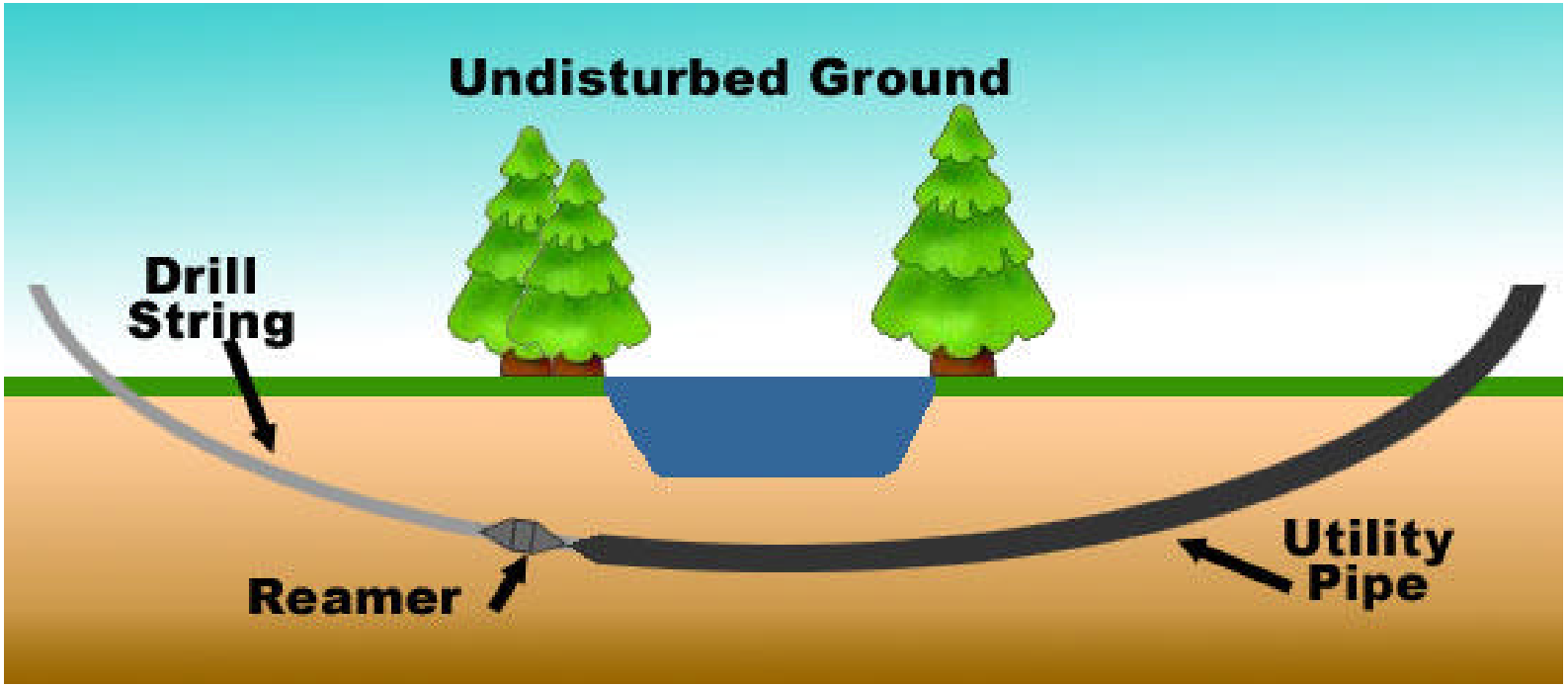


THE TRENCHLESS TECHNOLOGY CENTER

The Trenchless Technology Center located within Louisiana Tech University is the first academic research center to be established in North America to support the growth of trenchless technology through research and education.

TRENCHLESS TECHNOLOGY

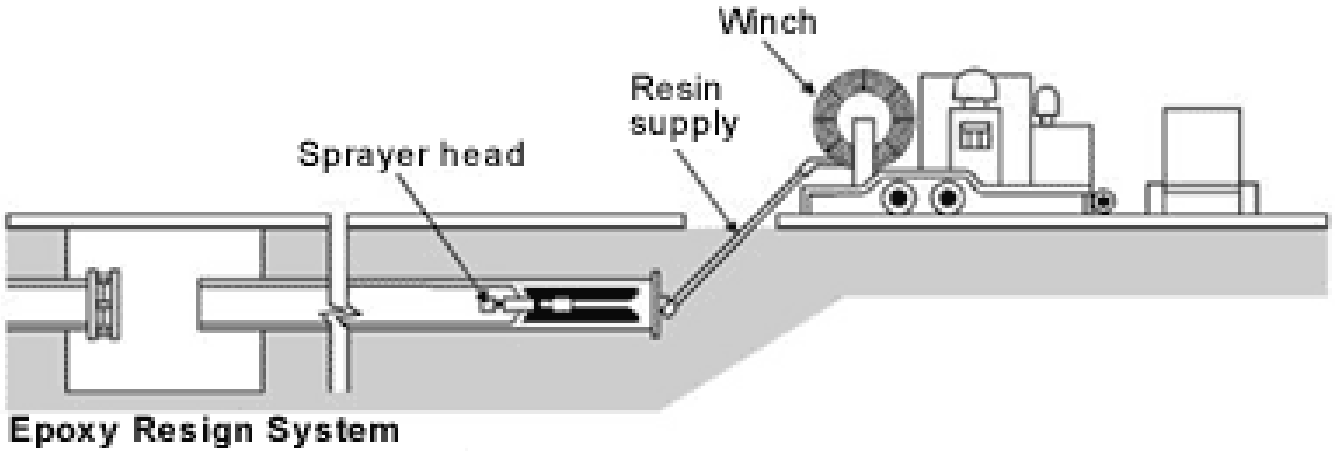
Trenchless Technology is a family of methods for the **installation**, **rehabilitation** and **replacement** of new or existing underground facilities with minimal disruption of land and services, low costs and low environmental impact.



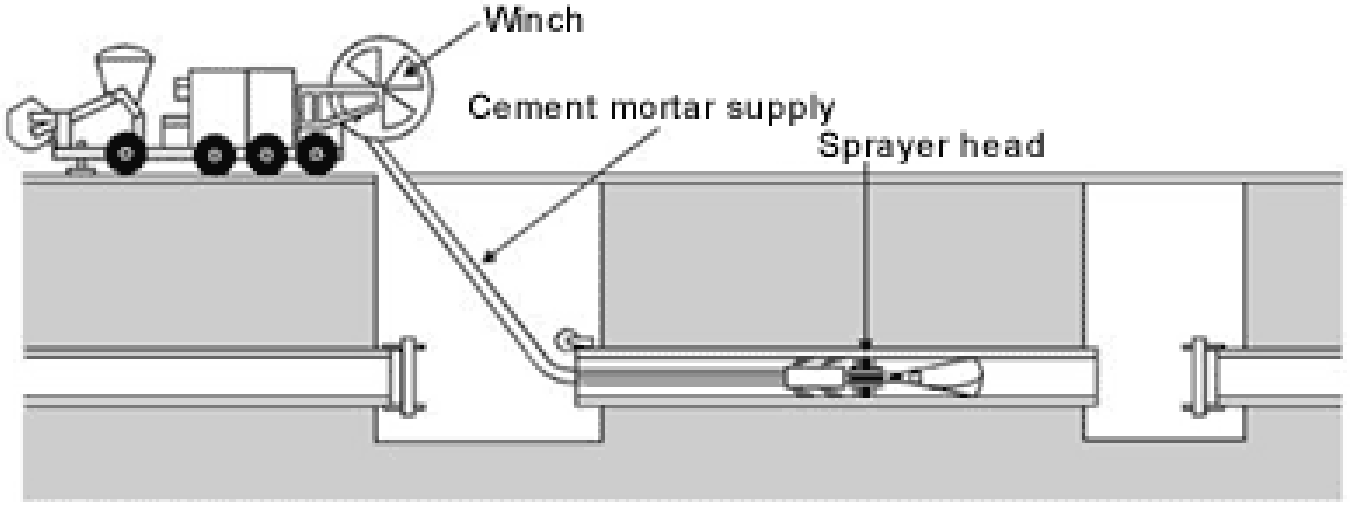
SCOPE OF TTC RESEARCH

One of the main objectives of TTC research is to find novel solutions for the rehabilitation of sewer pipes and other underground utilities like manholes.

THE SPRAY LINING TECHNIQUE



Epoxy Resign System



Cement Mortar System

ACTUAL MATERIALS USED IN TT PROJECTS

EPOXY/POLYMERS

Advantages:

Corrosion resistance

Smooth surface

High strength

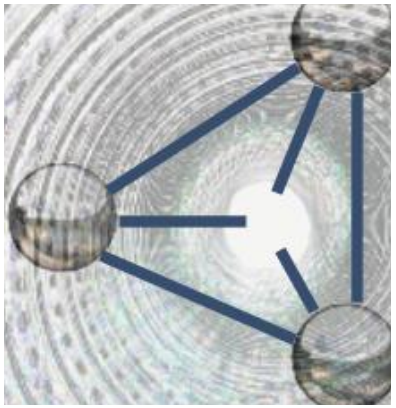
Disadvantages:

Adhesion

Cost

Thermal expansion

GEOPOLYMER!



CEMENTITIOUS

Advantages:

Lower costs

Easy application

Good adhesion

Disadvantages:

Low corrosion resistance

Rough surfaces

Interconnected porosity

Lower density

RESEARCH PLAN

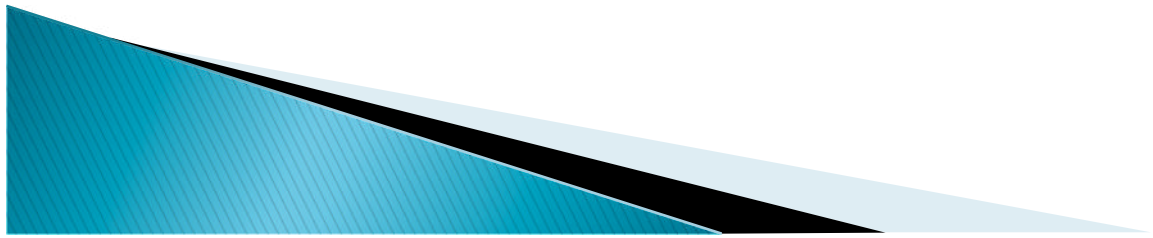
• Study the impact of several variables on the properties of geopolymers:

  • Raw material selection from local sources
  • Composition of the alkaline solution
  • Curing regime

• To enable geopolymer to be applied as a cementitious coating with existing cementitious spray technology.

• To perform field tests in confirmation of lab results.

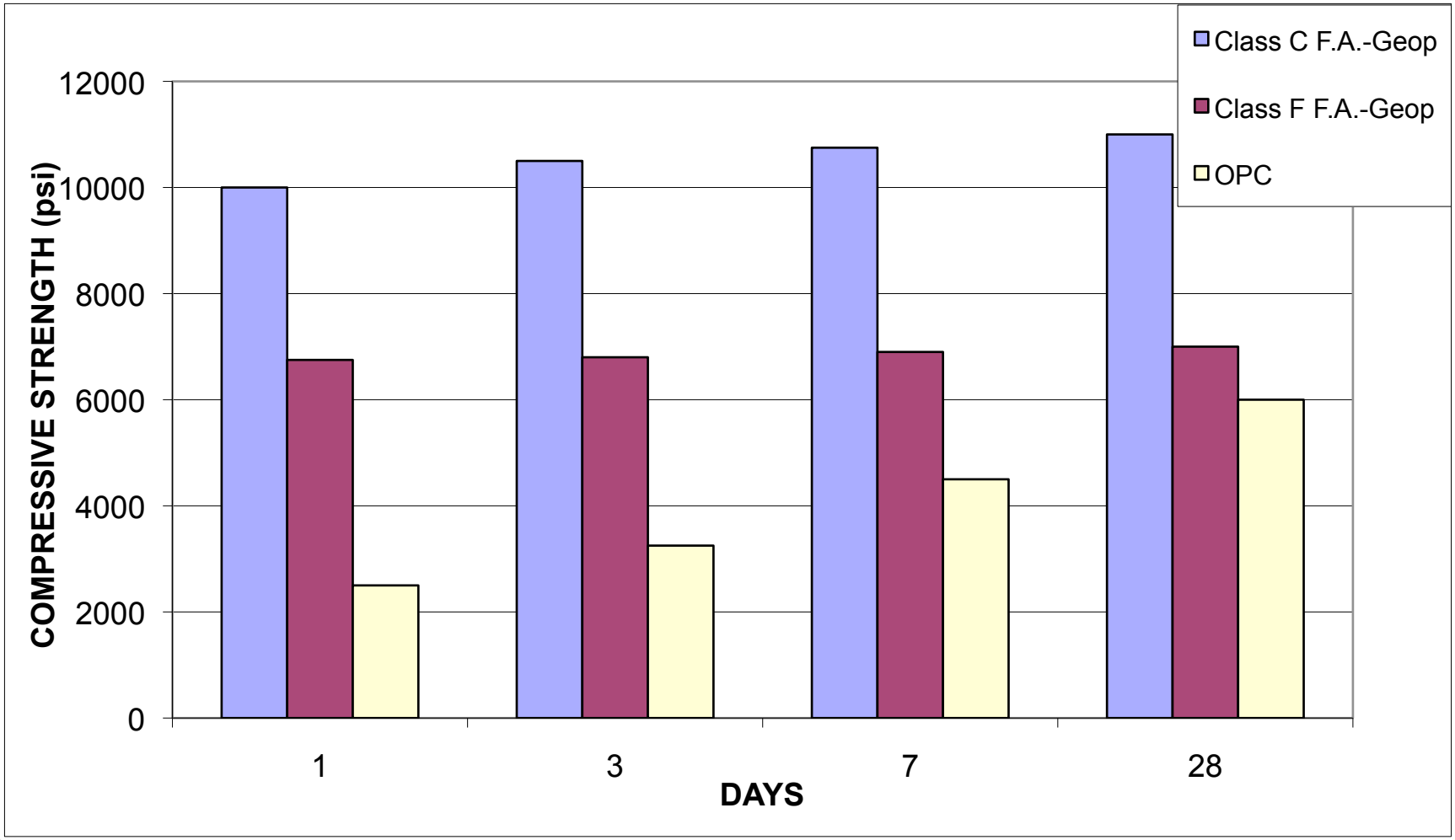
• To produce an optimal formulation to be used in real scale projects.



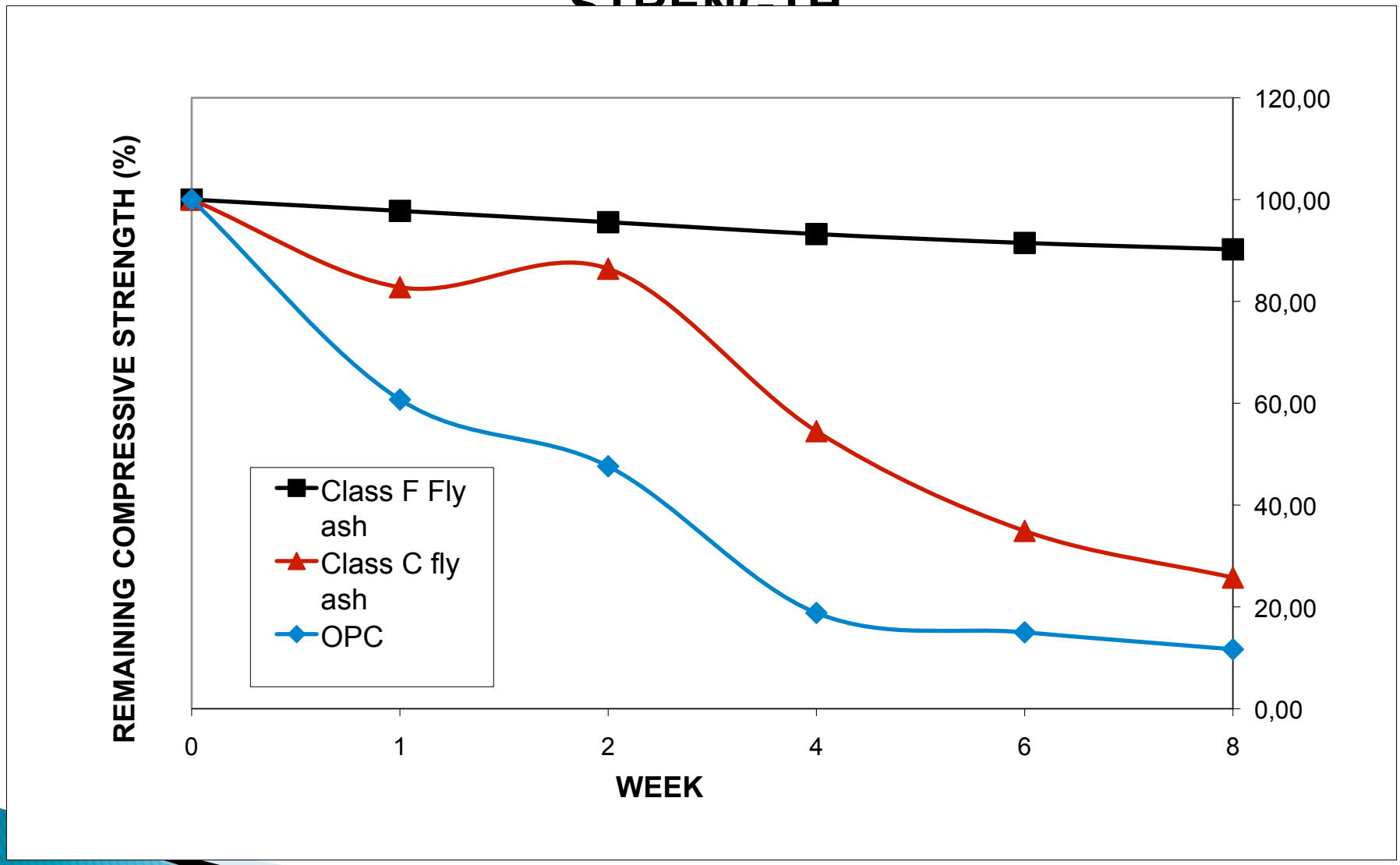
RAW MATERIALS

Oxide	*Metakaolin, wt %*	*Class C Fly Ash, wt %*	*Class F Fly Ash, wt%*	*OPC, wt %*
SiO2	54.26	48.7	50.25	26.12
Al2O3	39.82	16.6	22.56	4.25
Fe2O3	2.91	6.93	20.0	3.65
CaO	0.70	18.72	2.1	58.51
MgO	1.51	3.91	0.00	1.59
SO3	0.01	0.85	0.50	2.36
LOI	0.72	0.49	2.48	2.67
Na2O	0.00	0.00	0.00	0.14
K2O	0.00	0.00	0.00	0.52
Total	**99.93**	**96.2**	**97.89**	**99.8**
SiO2/Al2O3	1.36	2.93	2.23	6.15
SiO2 + Al2O3	94.08	65.30	72.81	30.37

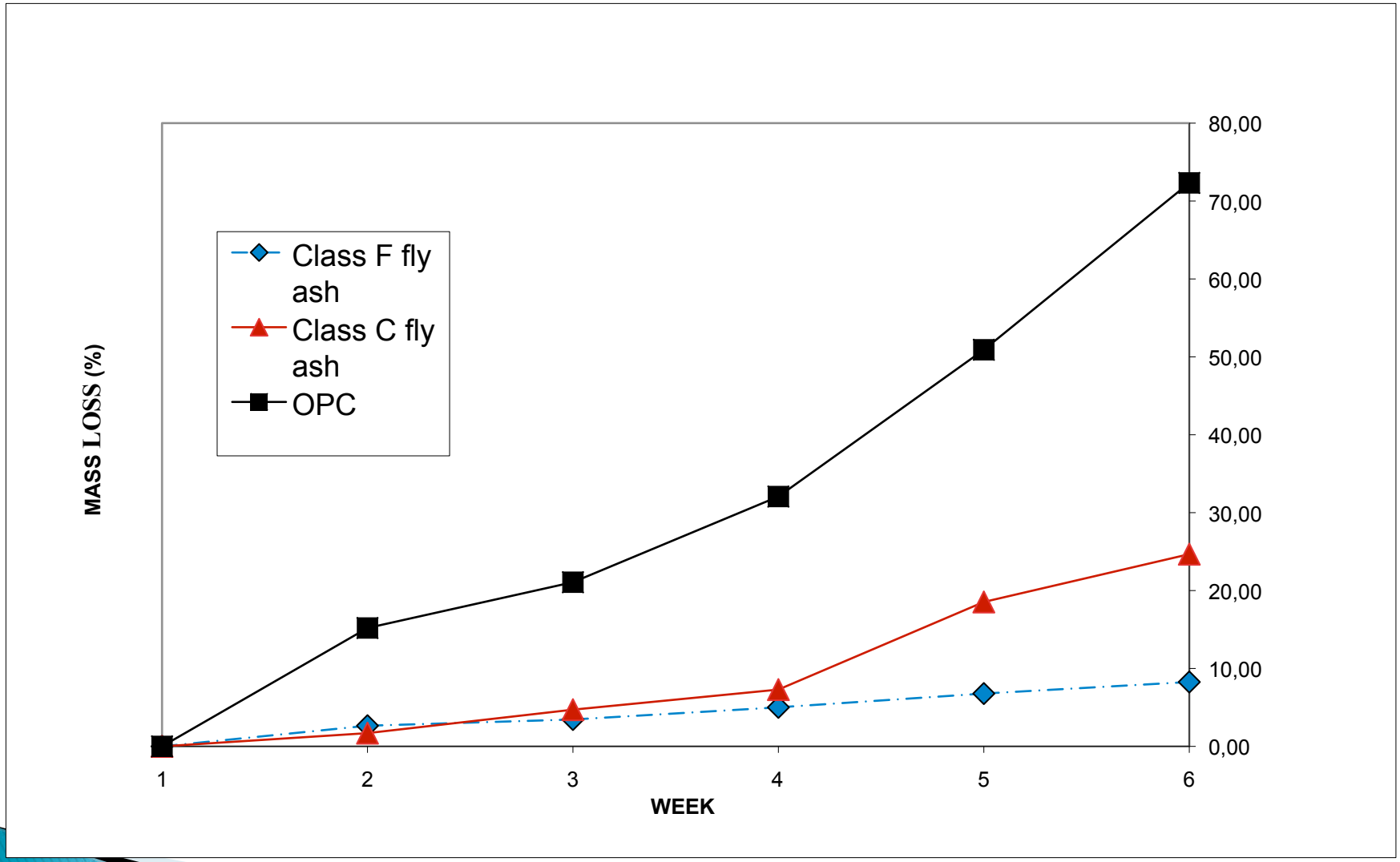
COMPRESSIVE STRENGTH



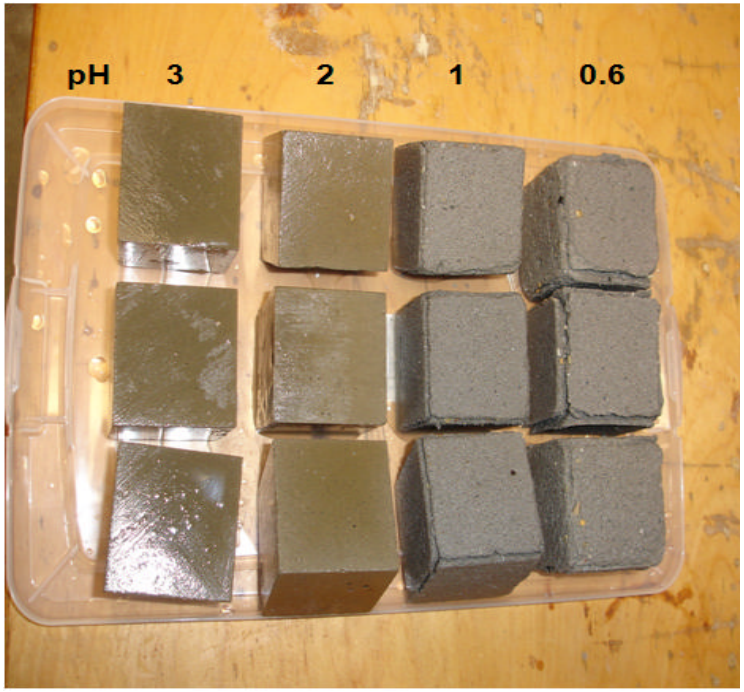
REMAINING COMPRESSIVE STRENGTH

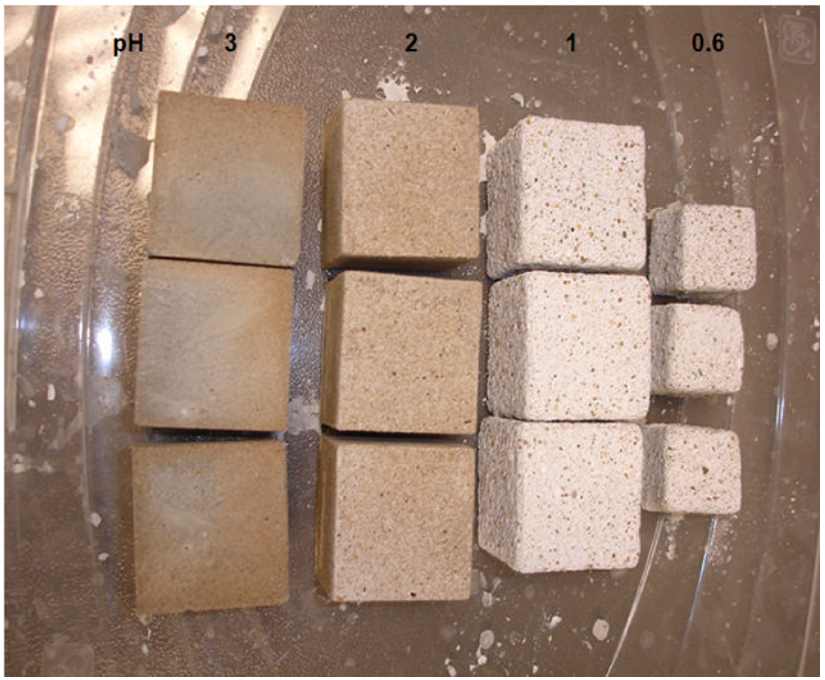


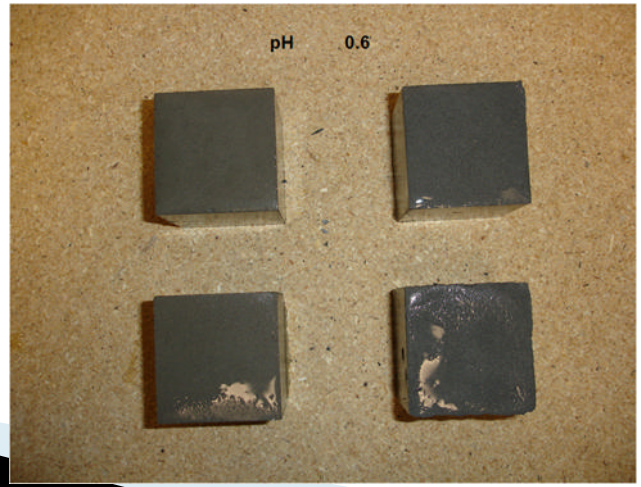
MASS LOSS


MASS LOSS (%)
80,00
70,00
60,00
50,00
40,00
30,00
20,00
10,00
0,00
Class F fly ash
Class C fly ash
OPC
1
2
3
4
5
6
WEEK

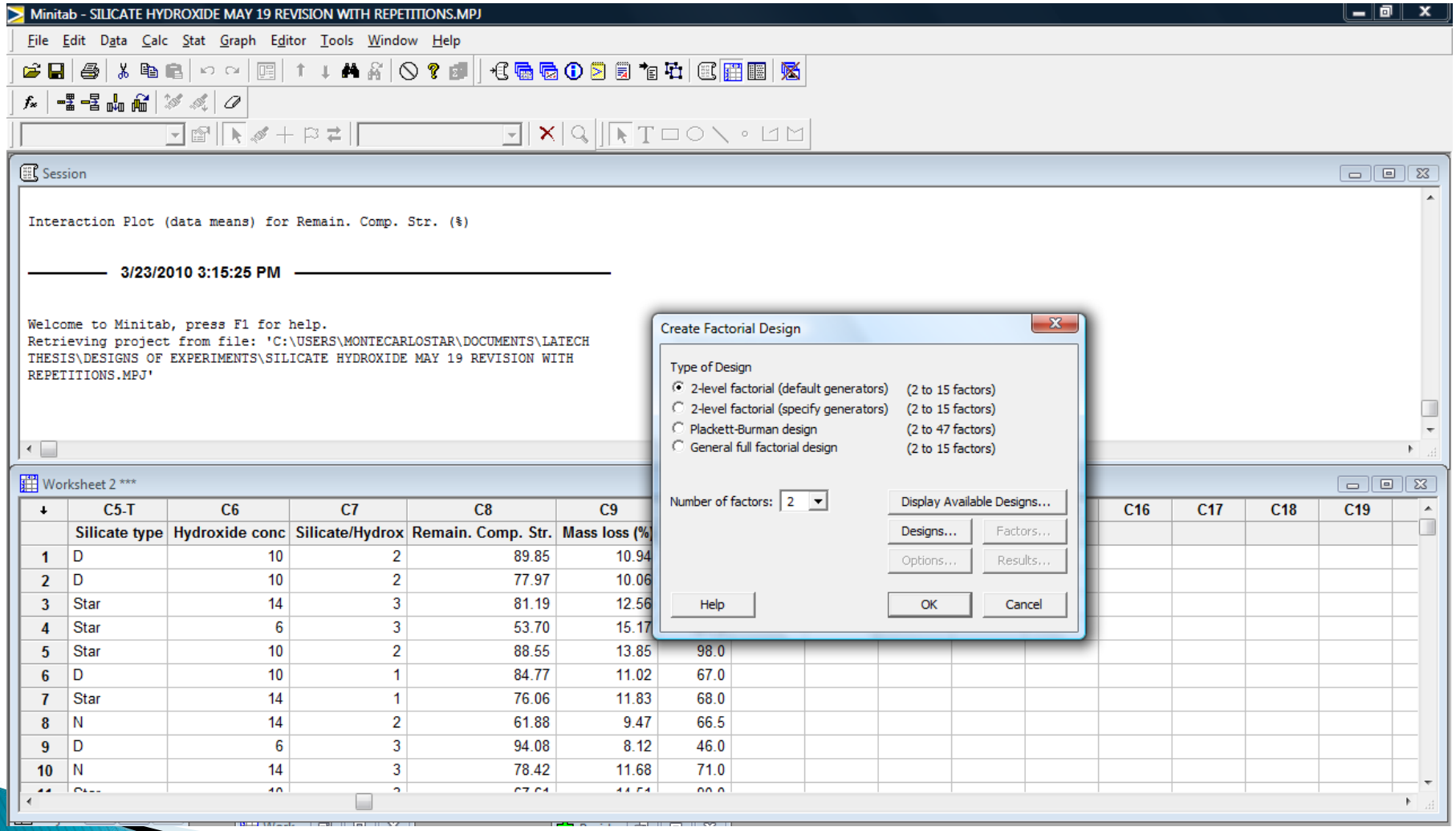
VISUAL APPEARANCE







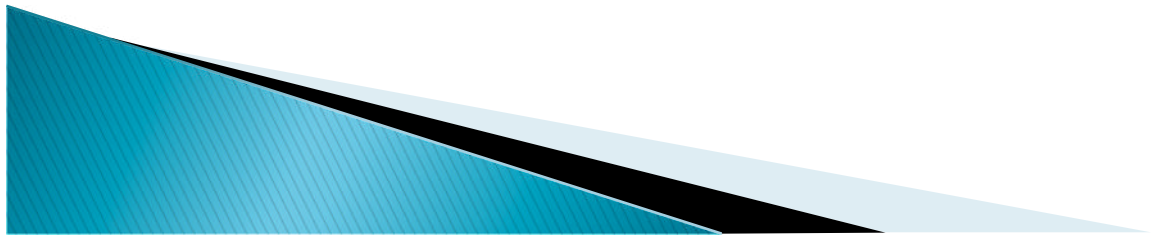
OPTIMIZATION OF THE ACTIVATOR SOLUTION



	C5-T	C6	C7	C8	C9		C16	C17	C18	C19
	Silicate type	Hydroxide conc	Silicate/Hydrox	Remain. Comp. Str.	Mass loss (%					
1	D	10	2	89.85	10.94					
2	D	10	2	77.97	10.06					
3	Star	14	3	81.19	12.56					
4	Star	6	3	53.70	15.17					
5	Star	10	2	88.55	13.85	98.0				
6	D	10	1	84.77	11.02	67.0				
7	Star	14	1	76.06	11.83	68.0				
8	N	14	2	61.88	9.47	66.5				
9	D	6	3	94.08	8.12	46.0				
10	N	14	3	78.42	11.68	71.0				

DESIGN OF EXPERIMENTS

RESEARCH VARIABLE	**LEVELS**
Silicate type	D, N and Star
Hydroxide molarity	6, 10 and 14
Silicate/Hydroxide ratio	1, 2, 3
FIXED PARAMETERS	
Fly ash type	Class F
Fly ash:sand ratio	1:1
RESPONSE VARIABLE	**NORM**
Compressive strength in cubes	ASTM C-109
Remaining compressive strength	ASTM C-267
Mass loss	ASTM C-267
Flow	ASTM C-1437



SPRAYING TESTS

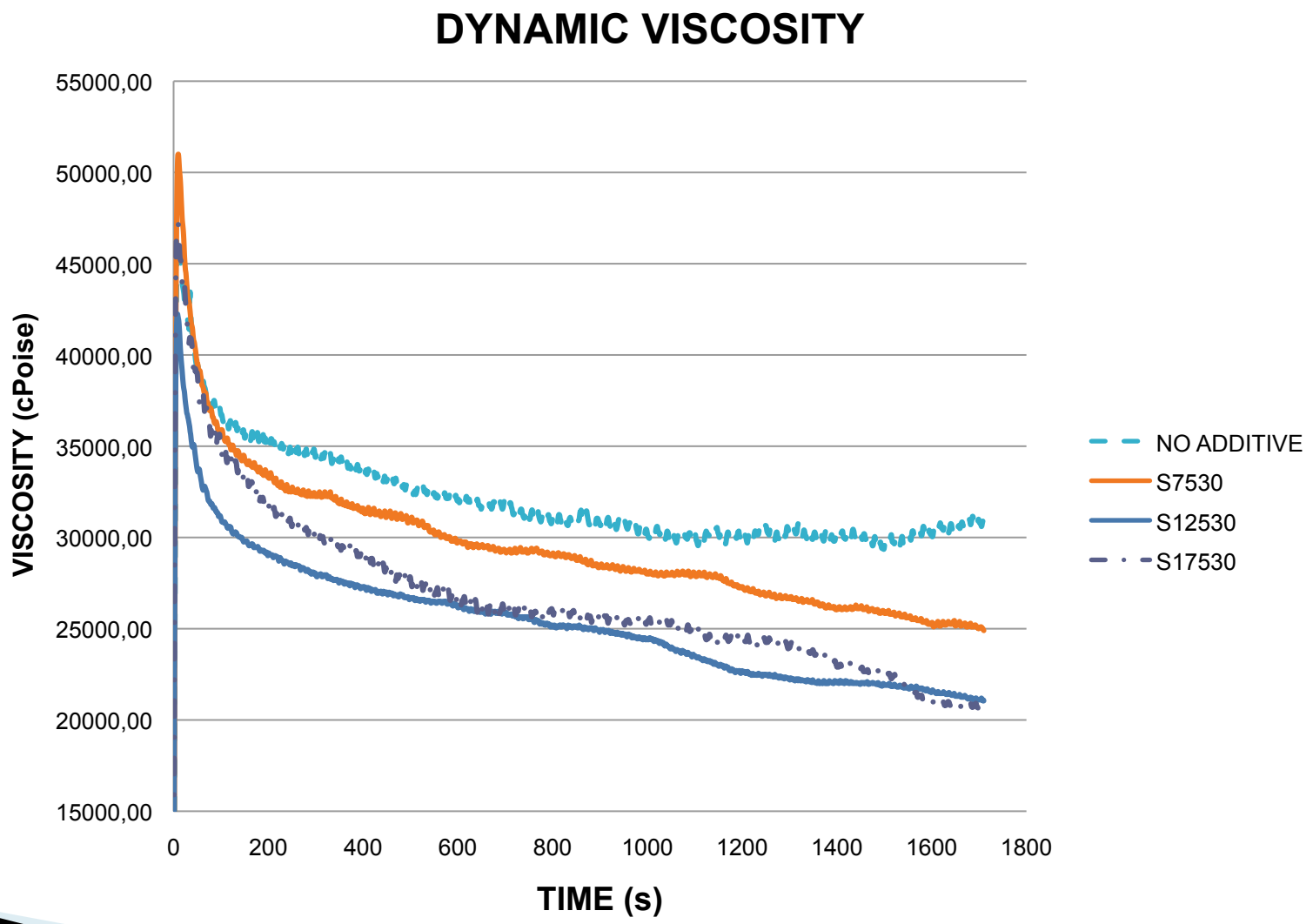
• A number of additives was tried to evaluate their effect on geopolymer's viscosity and other rheological parameters.

• Lab tests modifying the **concentration** and **% of addition** were performed to help tune the amount and type of additive to be used.

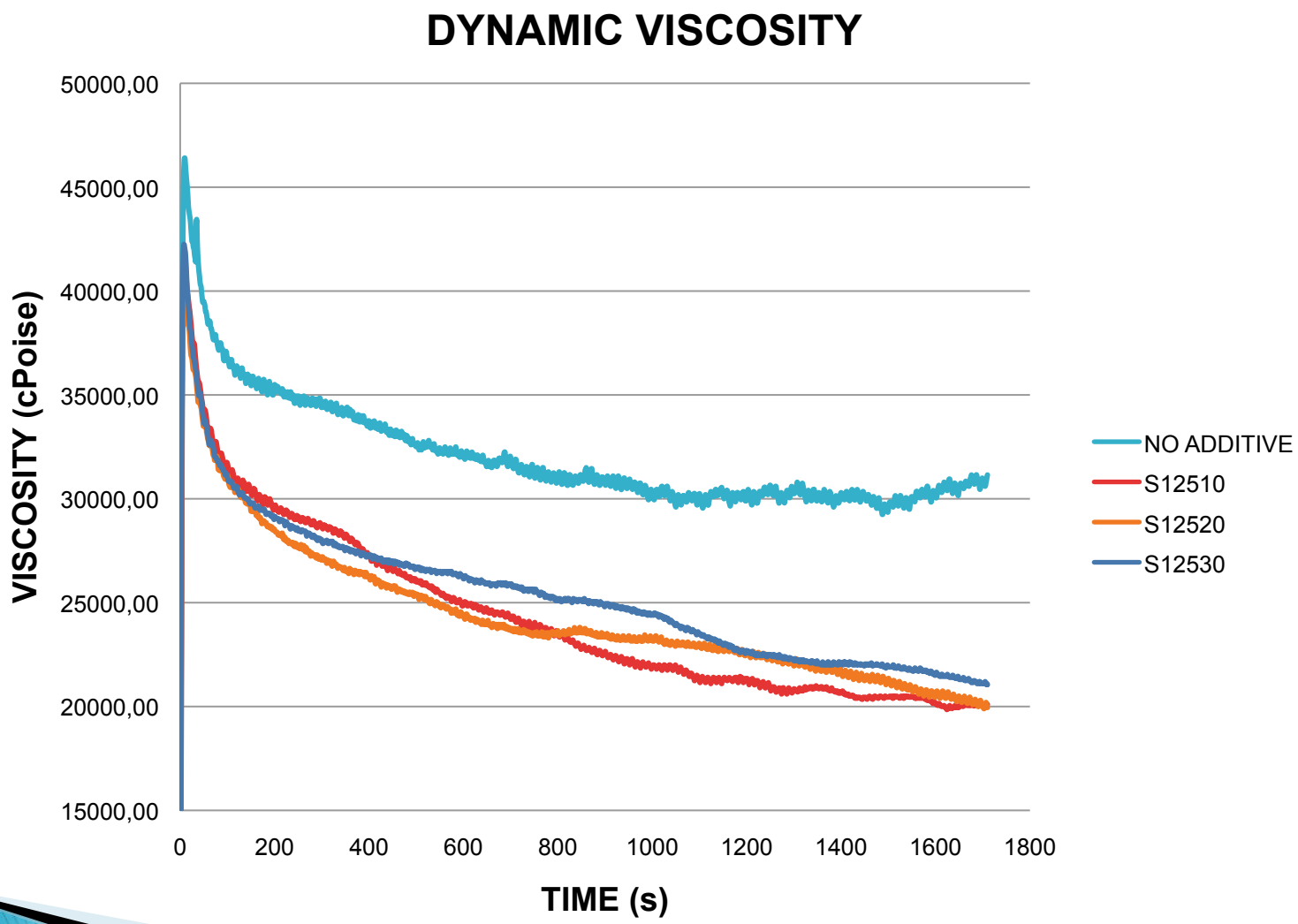
• An important control in geopolymer's viscous behavior was obtained after a number of tests.

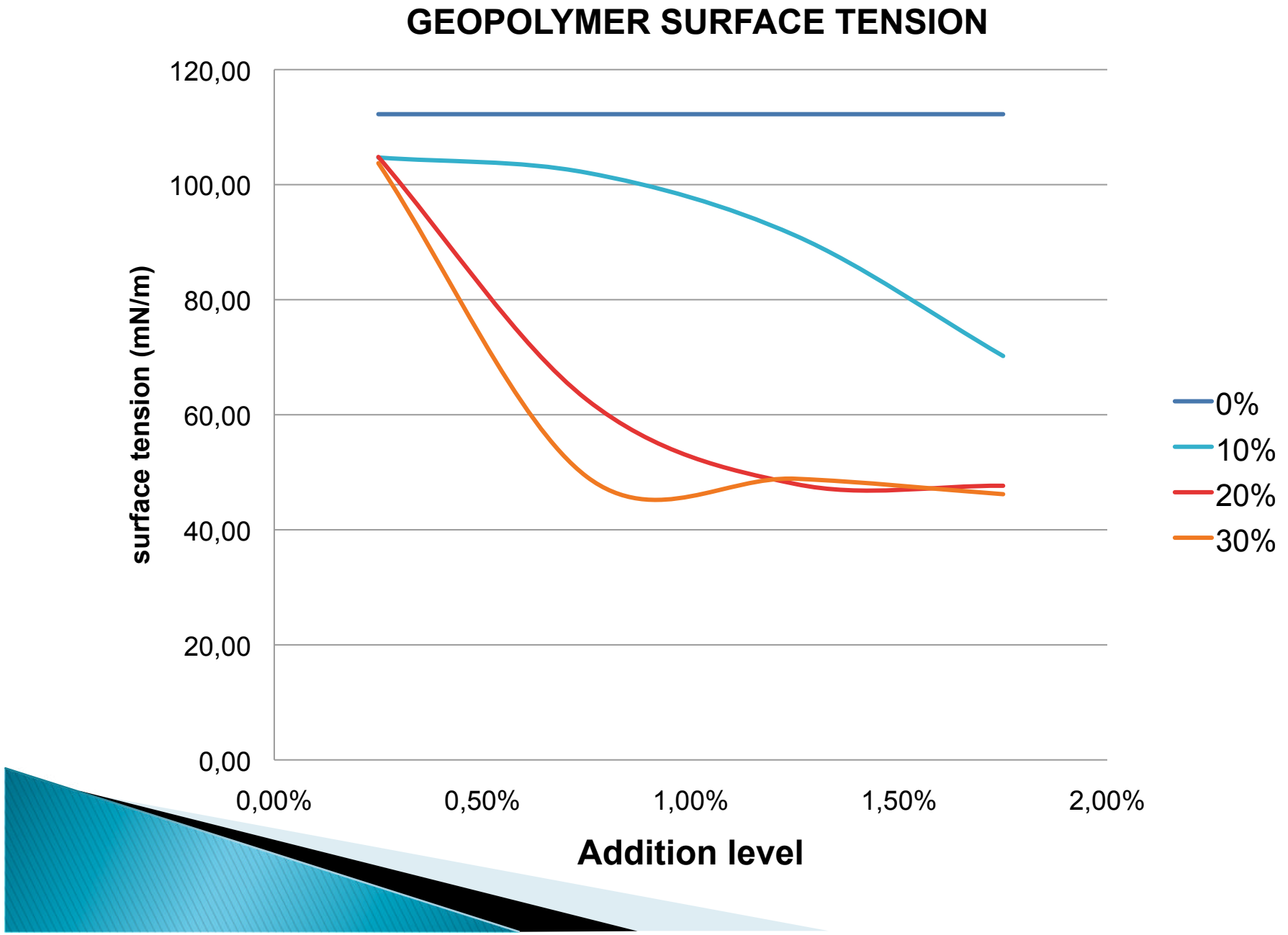
• Field tests were conducted to prove results obtained in the lab.

SPRAYING TESTS



SPRAYING TESTS




GEOPOLYMER SURFACE TENSION
120,00
100,00
80,00
60,00
40,00
20,00
0,00
surface tension (mN/m)
0,00%
0,50%
1,00%
1,50%
2,00%
Addition level
0%
10%
20%
30%

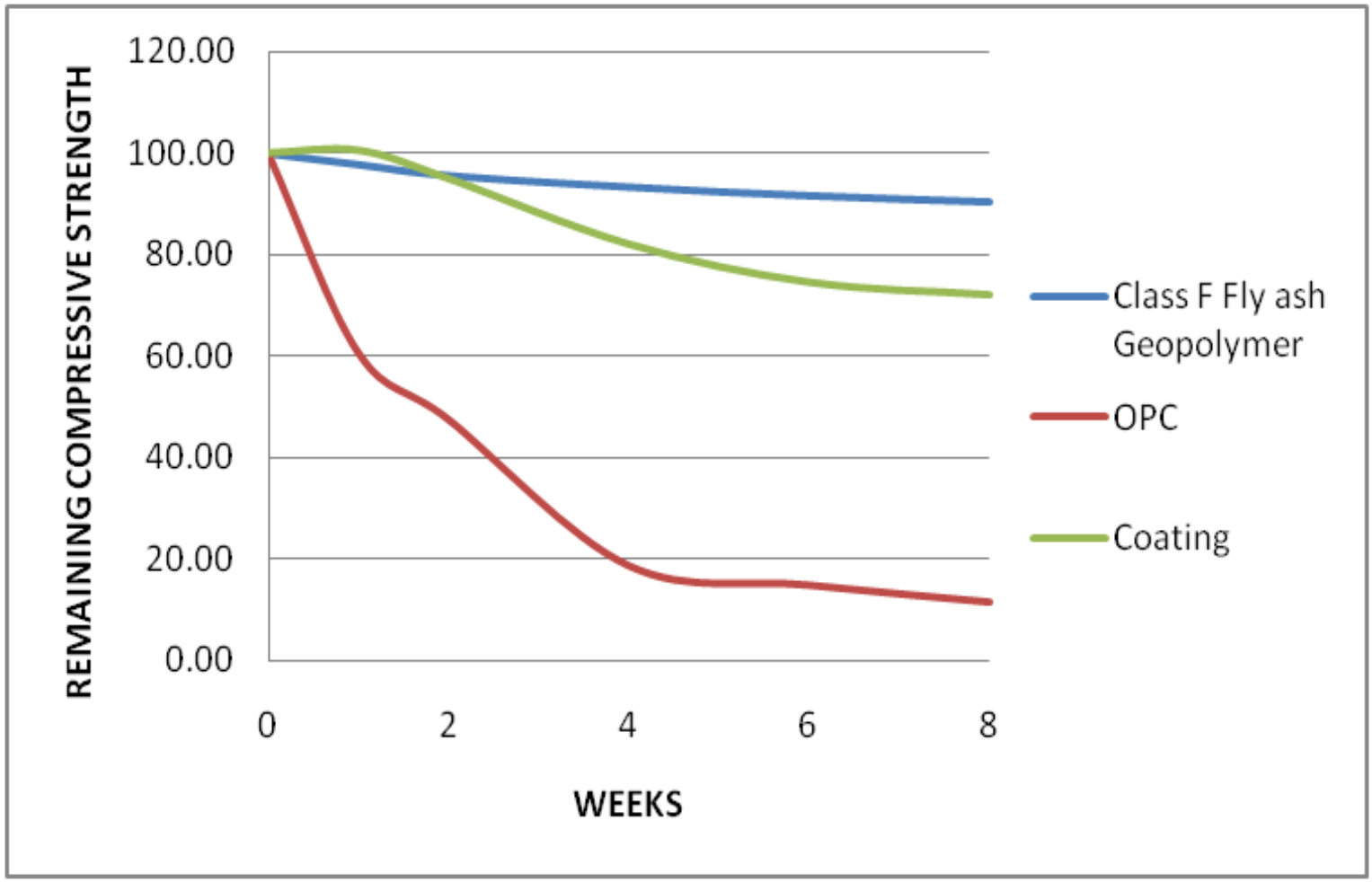
RESULTS – FIELD TESTS

RESULTS – FIELD TESTS

RESULTS – FIELD TESTS

- Geopolymer samples stored inside manhole in Pensacola, FL
- Manhole is re-coated every six months with Portland cement.
- Geopolymer samples did not experience mass loss in six months.

CORROSION RESISTANCE



TAKING GEOPOLYMER TO THE FIELD

- Currently working to take prototype to the field
- Short term goals to reduce curing time and increase thickness of spray
- First real manhole applications within the next months.
- These tests will take place in the cities of Cincinnati and St. Louis.

SUMMARY AND CONCLUSIONS

• A novel geopolymer-based cementitious product prototype was developed at Louisiana Tech as an alternative material for Trenchless rehabilitation projects.

• This represents the first time that geopolymers are considered for Trenchless rehabilitation projects.

• The modification of geopolymer's surface tension proved to be a substantial aid to solve geopolymer workability problems.

• Real life manhole rehabilitation projects will be performed during this year.

• We expect geopolymer to gain reputation as an excellent rehabilitation material and to be used by contractors as one of their choices when bidding for projects.