Utilization Of Waste Rubber Tire as Cement Replacement in Soil Stabilization

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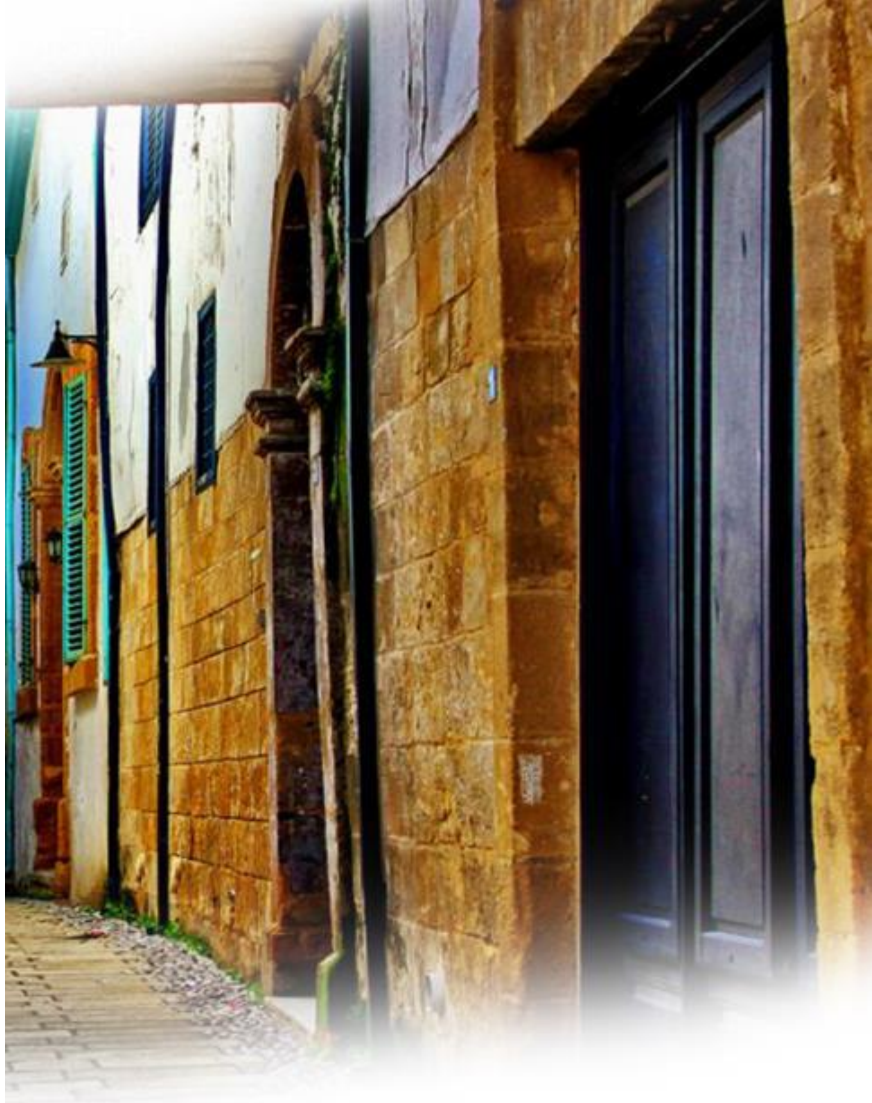


Outline:

Introduction → Literature Review → Materials → Experimental Program → Results

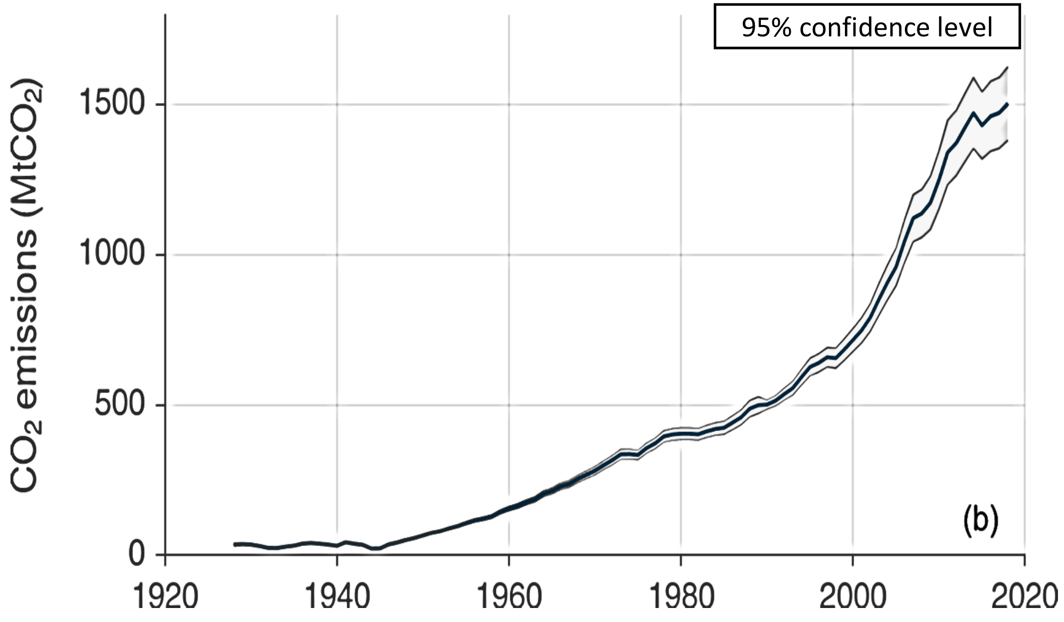
Waste tires

- Solid wastes massive generation.
- 1.5 billion tyre units generated annually[1].
- Two-thirds reach End of life (ELTs)[1].
- Majority of ELTs disposed on landfills.
- Environmental pollution and health risks.

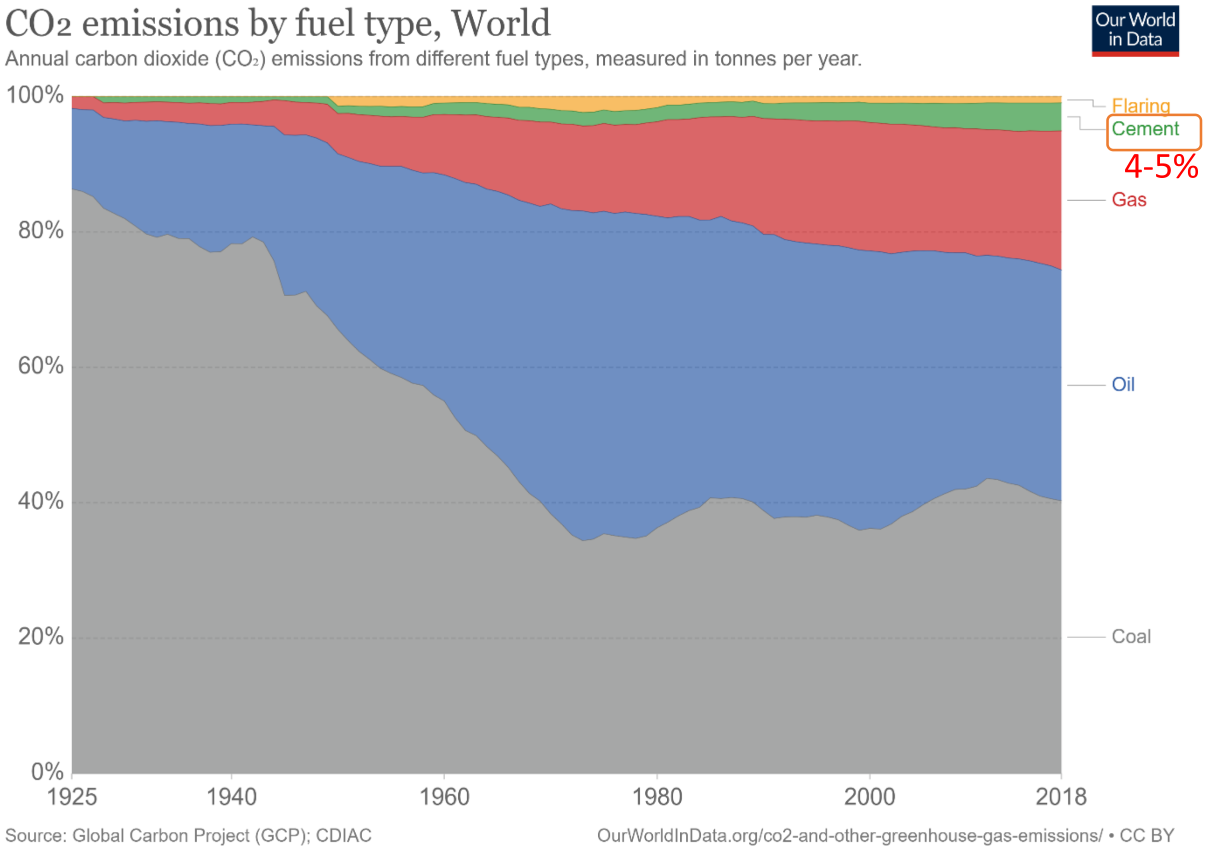
Source: https://www.ewi.ca/tires-process.html

[1] A. Mohajerani *et al.*, "Recycling waste rubber tyres in construction materials and associated environmental considerations: A review," *Resour. Conserv. Recycl.*, vol. 155, no. January, p. 104679, 2020, doi: 10.1016/j.resconrec.2020.104679.

Global CO_2 emissions from cement production



Source: Andrew, R. M. (2019). Global CO2 emissions from cement production, 1928–2018. Earth System Science Data, 11(4).



Problematic Soils

- Low strength.
- Extensive settlement.
- High compressibility.
- Expand and shrink due to wet/dry conditions.

Source: https://en.wikipedia.org/wiki/Leaning_Tower_of_Pisa

Source: https://www.in.gov/indot/div/aviation/pavement-inspection/pci-review/distresses-ac/swelling.html

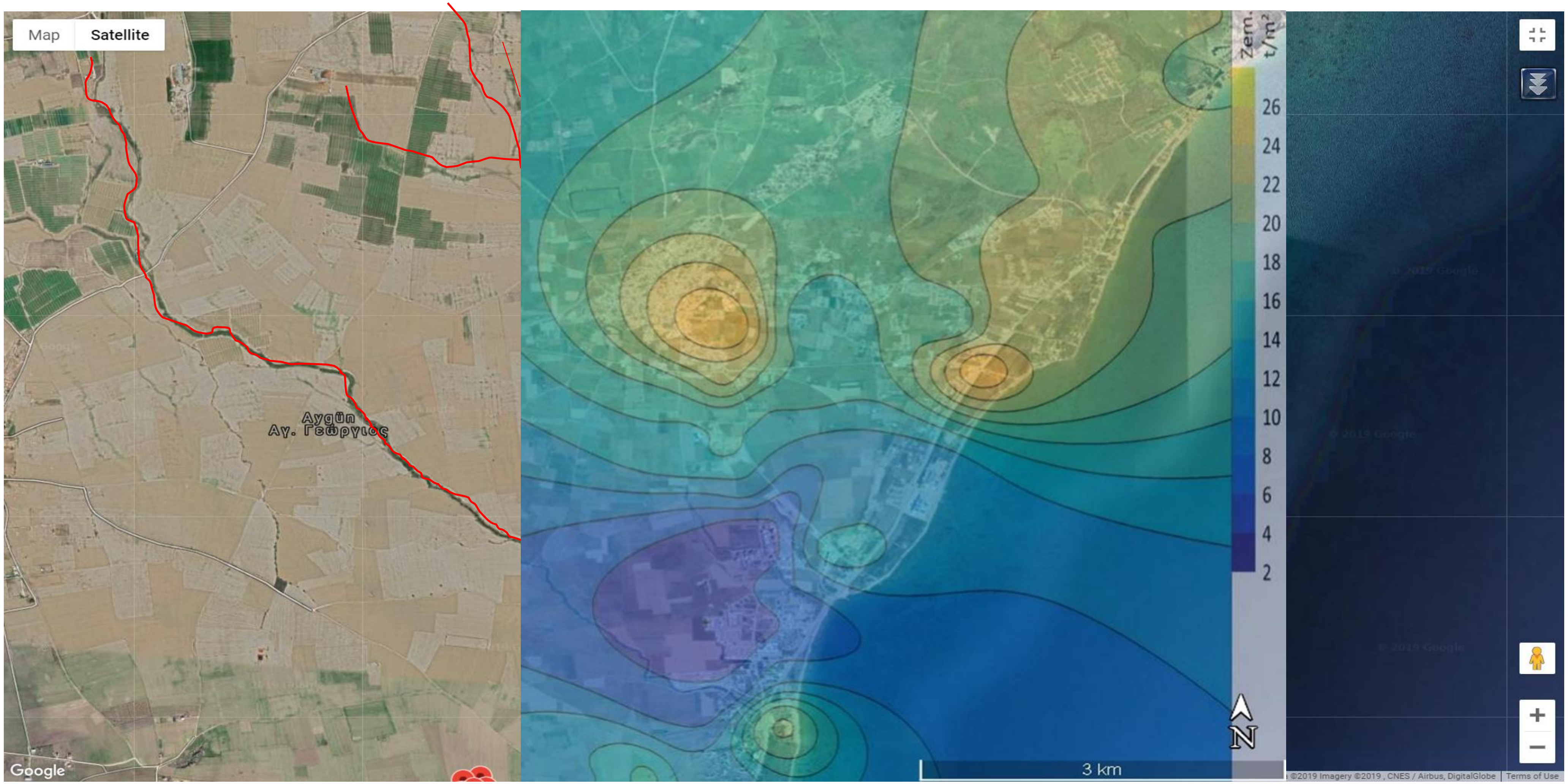
Source: M. Rezaei, R. Ajalloeian, and M. Ghafoori, "Geotechnical Properties of Problematic Soils Emphasis on Collapsible Cases," Int. J. Geosci., vol. 03, no. 01, pp. 105–110, 2012, doi: 10.4236/ijg.2012.31012.

Utilization of waste tires in cemented - clay

Study	Clay – Tire rubber type used	Tire rubber (%)	Cement % - curing days	Main Findings
Chan (2012a)	CH – Granular 6mm size	1, 2, and 4	2, and 4 – (1-8 days)	• Decreasing in strength and stiffness with RT addition. • Increasing in ductility and failure strain.
Kim and Kang(2013)	CL – Crumbles (0.1-30 mm)	0, 25, 75, and 100	20 (28 days)	• Decrease in strength, and shear modulus when RT% rises.
Otoko and Pedro (2014)	CL , and CH– Fibres (10-20mm) length	5, 10, and 15	2, and 4 – (4, 7, and 8 d)	• UCS increases with curing time, but decrease with RT% rises.
Wang and Song (2015)	CL – Rubber powder (30/40 mesh and 6/80 mesh)	5, 10,15, and 20	5, 15, 20,and 25– (7,28, and 90d)	• UCS drops when %RT increases. • No significant difference of both RT types in UCS.
Yadav and Tiwari, (2017)	CH – Chips 4.75-2mm size	2.5, 5, 7.5, and 10	3, and 6 – (7, 14, and 28 d)	• UCS drops when %RT increases. • Change in brittleness behavior. • 5 RT% inclusion can be obtain as optimum. • Rubber tyre inclusion reduces the durability.

Chan, C.M., 2012a. Strength and stiffness of a cement-stabilised lateritic soil with granulated rubber addition. Ground Improv. 165, 41–52. http://dx.doi.org/10.1680/grim.2012.165.1.41.T
Kim, Y.T., Kang, H.S., 2013. Effects of rubber and bottom ash inclusion on geotechnical characteristics of composite geomaterial. Mar. Georesources Geotechnol. 31, 71–85.http://dx.doi.org/10.1080/1064119X.2012.667867.
Otoko, G.R., Pedro, P.P., 2014. Cement stabilization of laterite and Chikoko soils using waste rubber fibre. Int. J. Eng. Sci. Res. Technol. 3, 130–136.
Wang, F.C., Song, W., 2015. Effects of crumb rubber on compressive strength of cementtreated soil. Arch. Civ. Eng. LXI. http://dx.doi.org/10.1515/ace-2015-0036..
Yadav, J.S., Tiwari, S.K., 2017. A study on the potential utilization of crumb rubber in cement treated soft clay. J. Build. Eng. 9, 177–191. http://dx.doi.org/10.1016/j.jobe. 2017.01.001.

❑Soil. (Alluvial Soils): Iskele District, Long Beach area of Cyprus.



Source: UCCTEA Chamber of Civil Engineers (Soil Profile Database). Online: https://www.ktimo.org/Zemin (Accessed :12 Dec. 2020)

❑Cement.

- Ordinary Portland cement type I .

❑ Waste Tire Rubber.

- Two types used:

i. Tire Rubber Powder (TRP)
   - Less than 0.475 mm.

ii. Tire Rubber Fiber (TRF)
   - Length (4 mm -20 mm)

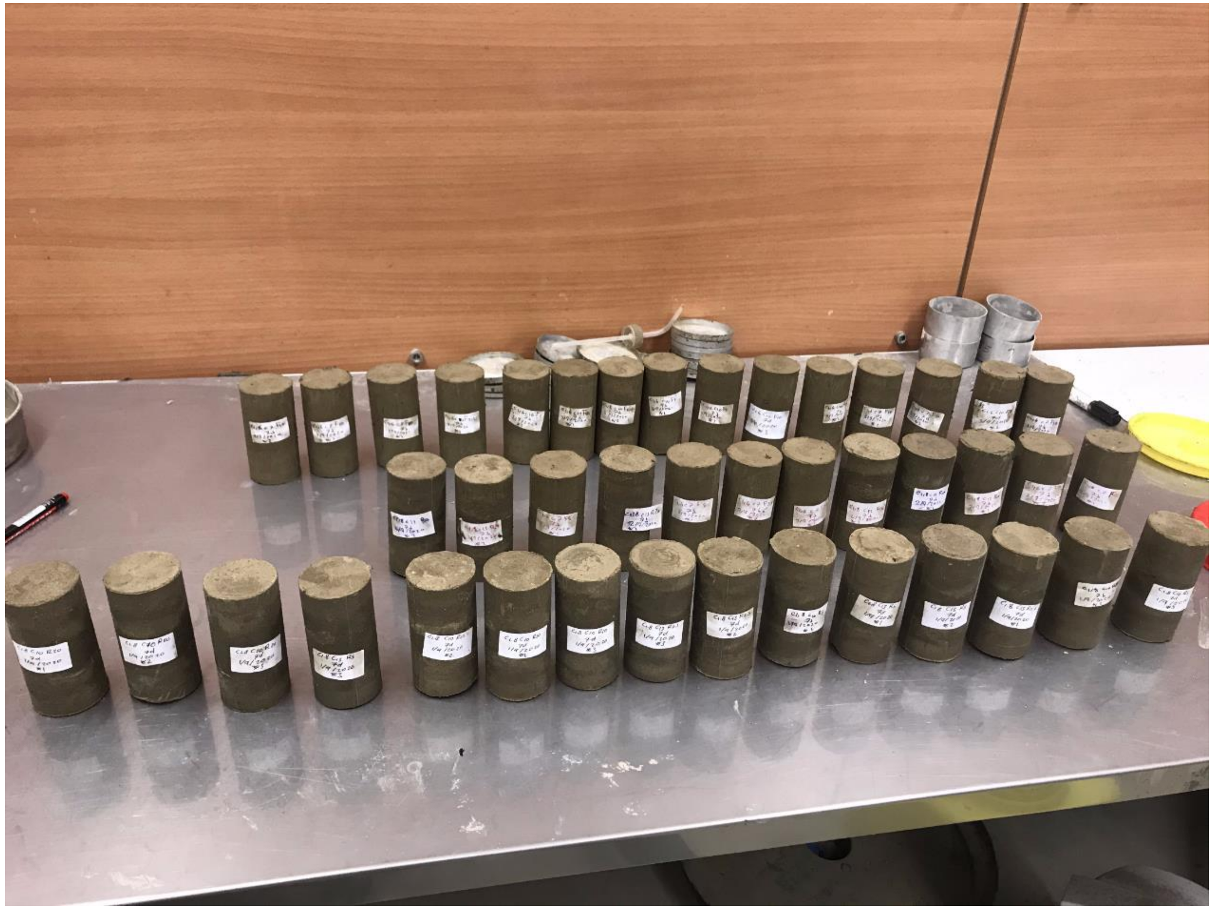
TRP

TRF

Samples

Parameter	No.
Rubber Tyre (%) (0, 2.5, 5, 10, 20)	5
Cement (%) (7, 10 , 13)	3
Dry Density (kg/m^3) (1600, 1800)	2
Rubber Type (TRP, TRF)	2
Curing Days (7, 28, 60)	3

- Total No of samples = **540**



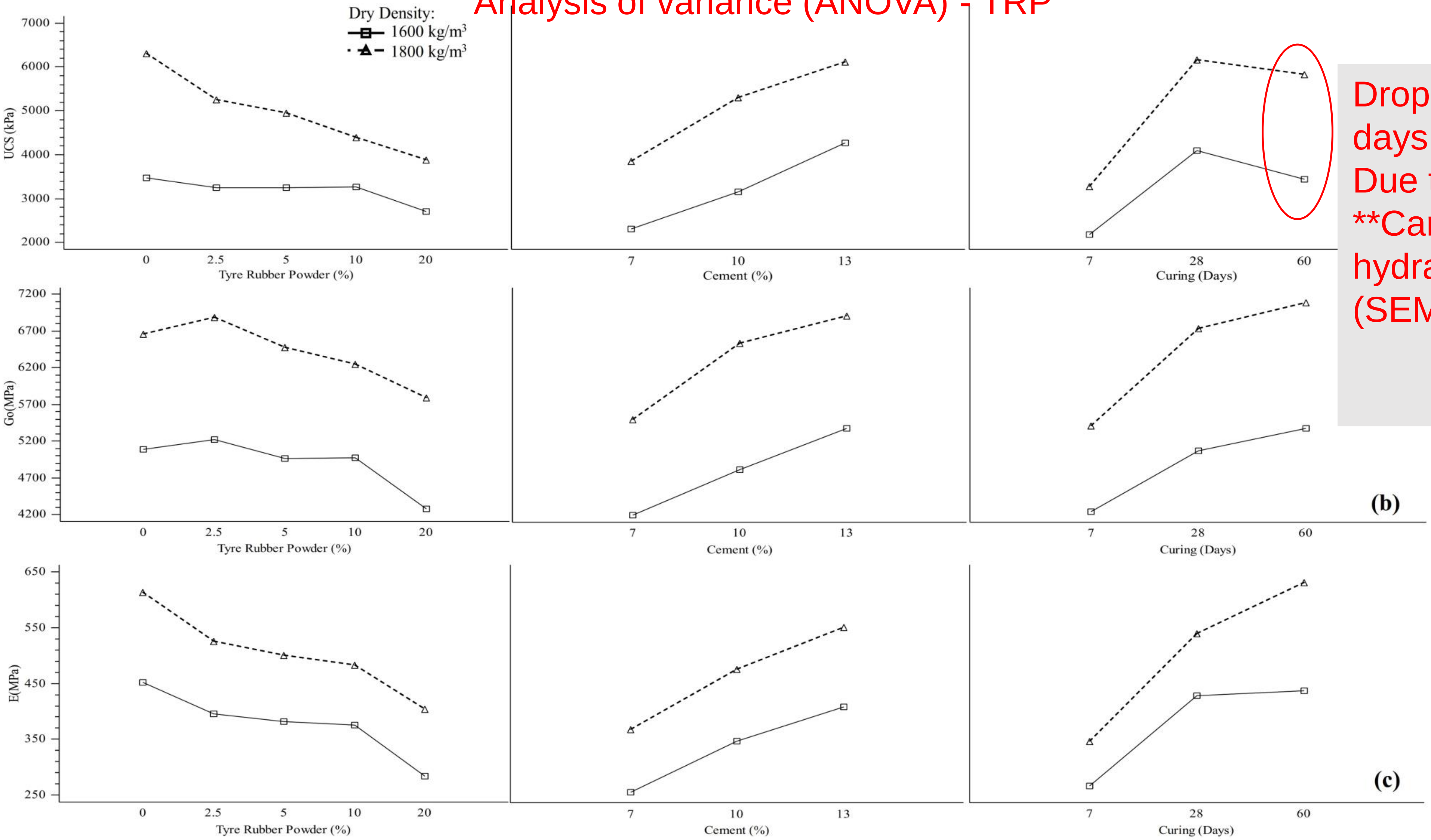
Testing Program

- ❑ Ultrasonic Pulse Velocity Test (ASTM C597-02).
- ❑ Unconfined Compressive Strength (UCS).
- ❑ Durability (Wet/Dry cycles test) (ASTM D559/D559M – 15)
- ❑ Microstructural Tests (METU – Ankara)
  - Scanning Electron Microscopy (SEM).
  - X-ray diffraction analysis (XRD).
  - X-ray fluorescence spectrometry (XRF).

QUANTA 400F Field Emission SEM

Source: http://labs.mete.metu.edu.tr/sem/

Analysis of variance (ANOVA) - TRP

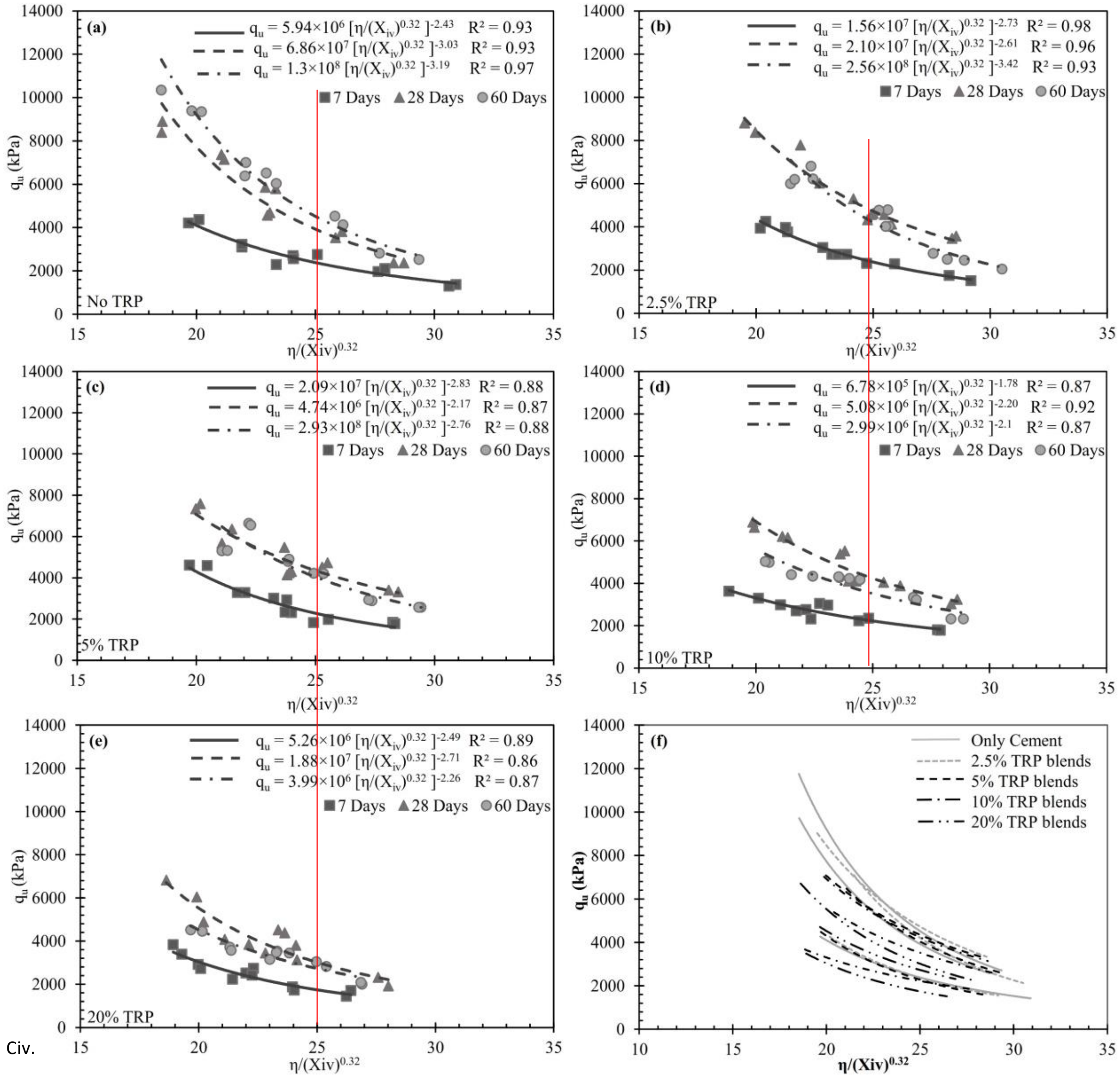


Drop in the strength after 60 days of curing
Due to:
**Carbon in TRP slow down hydration reaction of cement (SEM)

Consoli *et al.* (2007) Proposed $C_{iv} = \frac{V_C}{V}$

$X_{iv} = \frac{V_C+V_{TRP}}{V}$ inspired from Ekinci *et al.* (2019)

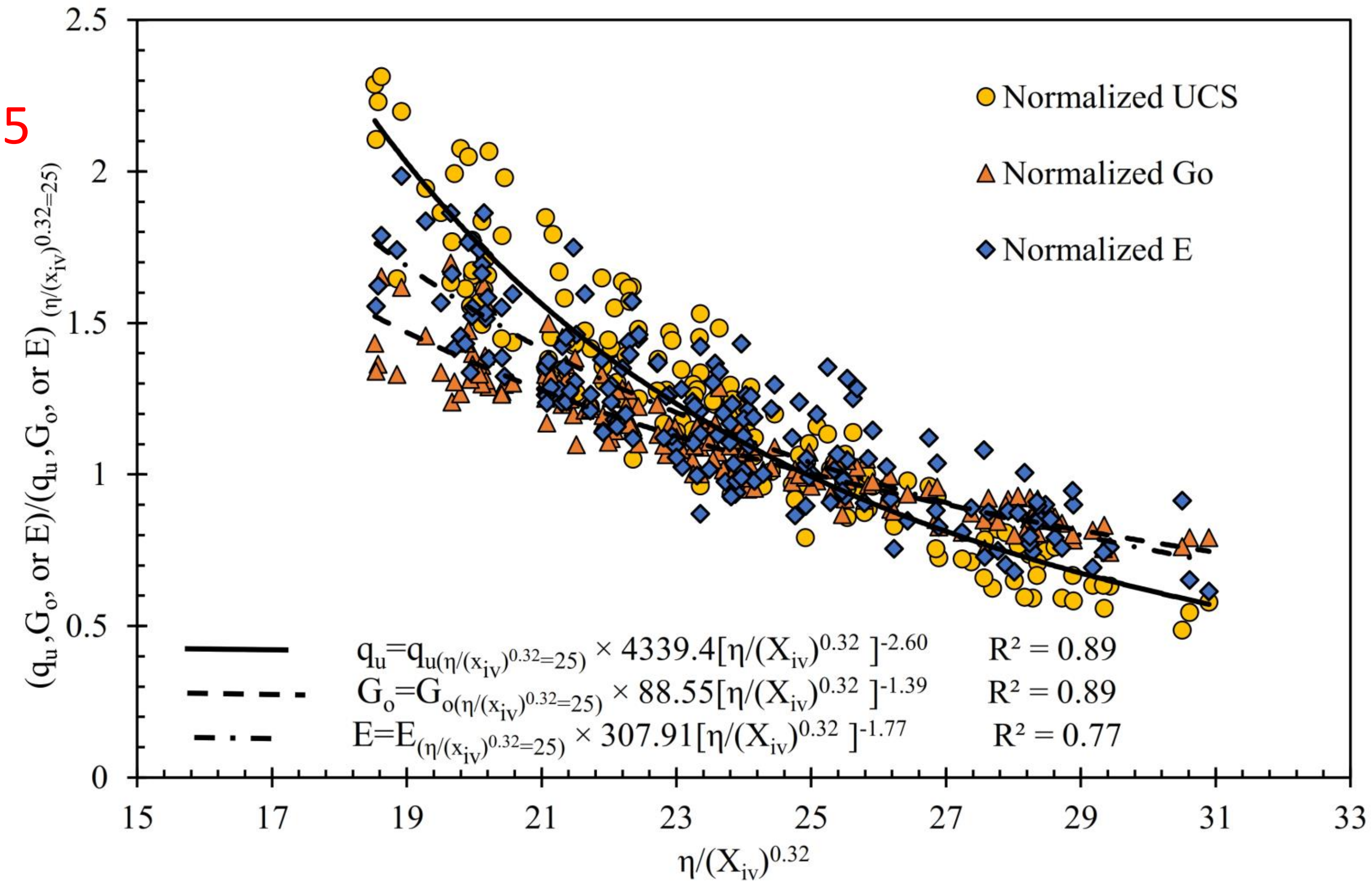
- ❑ Adjusted porosity/binder index = $\frac{\eta}{(X_{iv})^{0.32}}$
- Better Evaluation of strength and stiffness



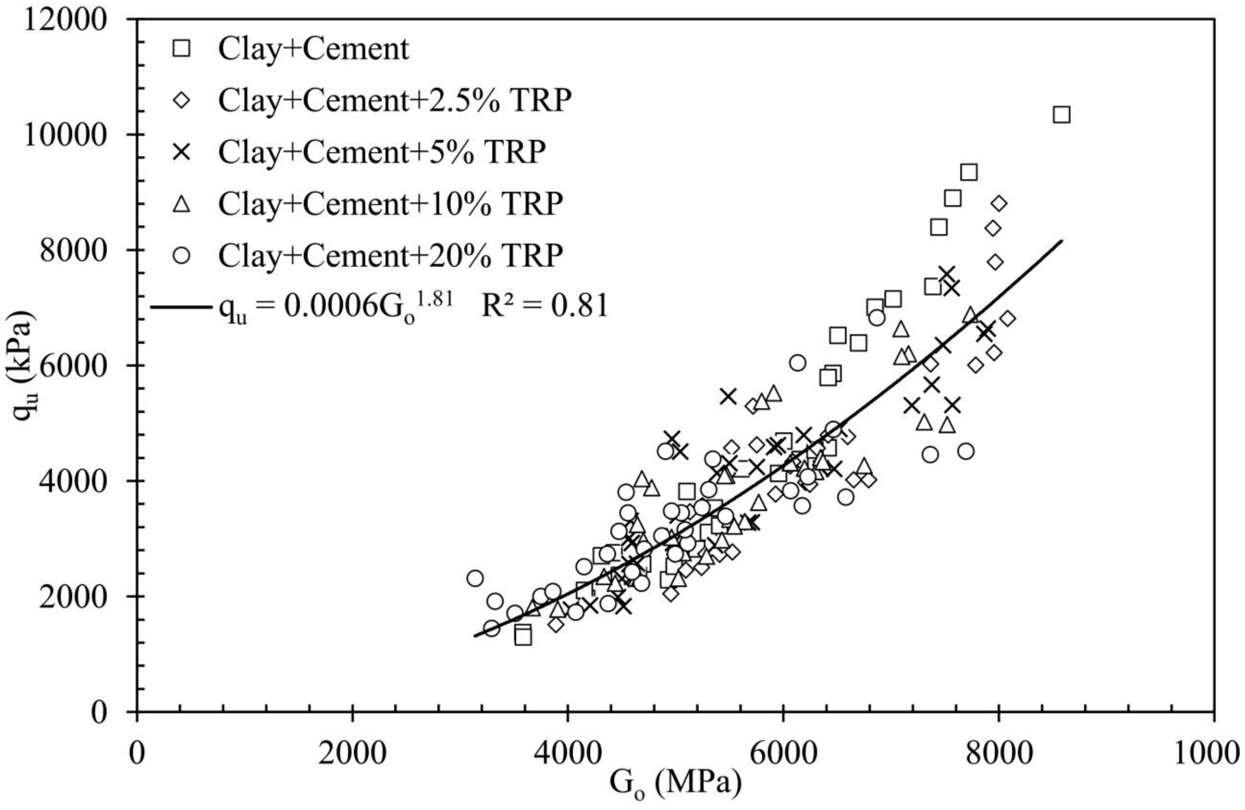
N.C. Consoli, D. Foppa, L. Festugato, K.S. Heineck, Key Parameters for Strength Control of Artificially Cemented Soils, J. Geotech. Geoenvironmental Eng. 133 (2007) 197–205. https://doi.org/10.1061/(asce)1090-0241(2007)133:2(197).
. Ekinci, H.C. Scheuermann Filho, N.C. Consoli, Copper Slag-Hydrated Lime-Portland Cement Stabilized Marine Deposited Clay, Proc. Inst. Civ. Eng. Improv. (2019) 1–30.

❑ Steps to get UCS, Go, and E:

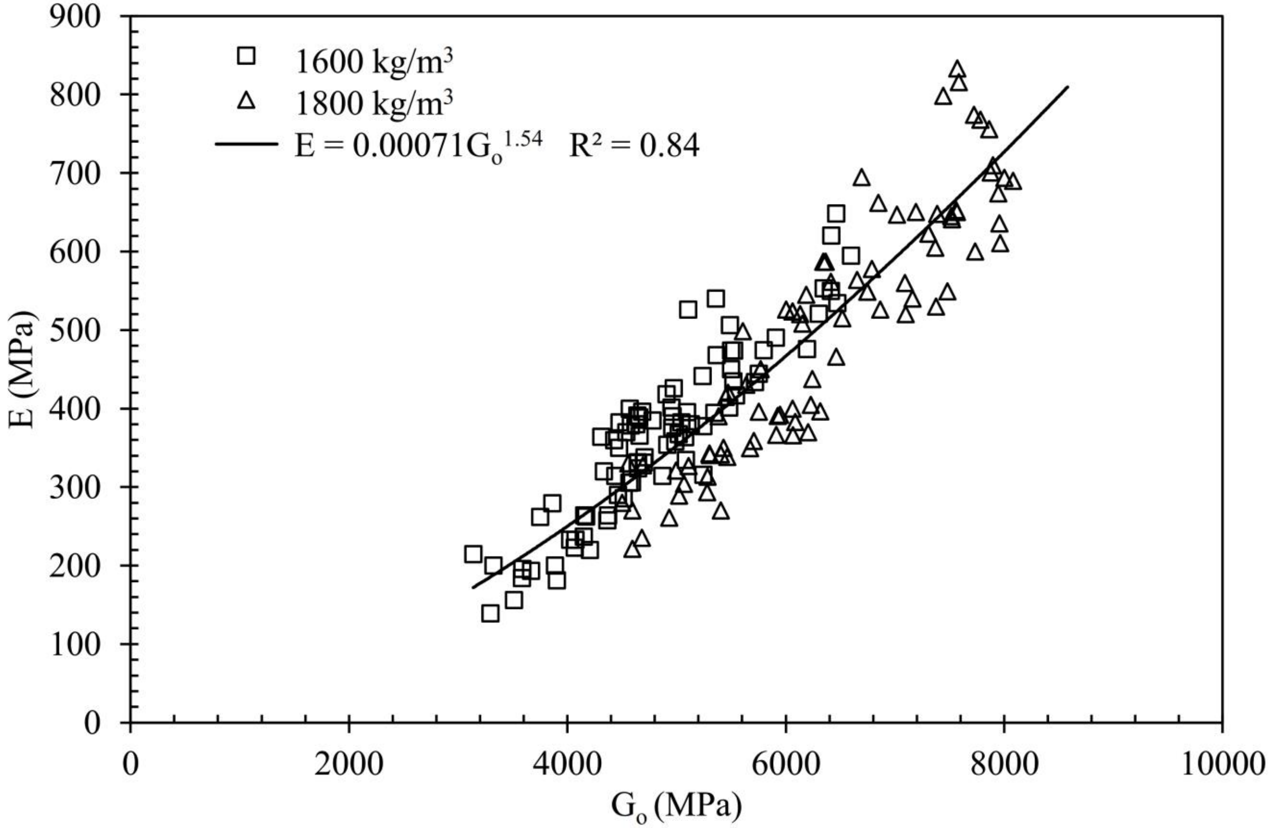
- Prepare three samples at $\frac{\eta}{(X_{iv})^{0.32}}$ =25
- Perform Pundit and UCS tests
- Determine E, Go, UCS from the results
- Use the equations to get the UCS, Go, and E of any mix



Use ONLY one test (pundit) at $\frac{\eta}{(X_{iv})^{0.32}}$ =25



Non-destructive test



Journal article: L. Al-Subari, A. Ekinci, E. Aydin"The influence of Waste Rubber Tire Powder on the Mechanical Behavior of Alluvial Clay Treated with Cement" Construction of Building Materials – under review

Thank You !

Any Questions

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