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The Influence of Soil Composition on the Strength of Stabilized Soil

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Background

- Karnal, Haryana (1948)
- Soil Cement Rammed Earth House
- 2.5% Cement – Soil Stabilization

PC: Prof. K S Jagadish, IISc

Background

- Local soil with about 5% Cement was used for stabilization
- Buildings of ASTRA (IISc) were built with SMB (1985) with 6% cement & 30% clay

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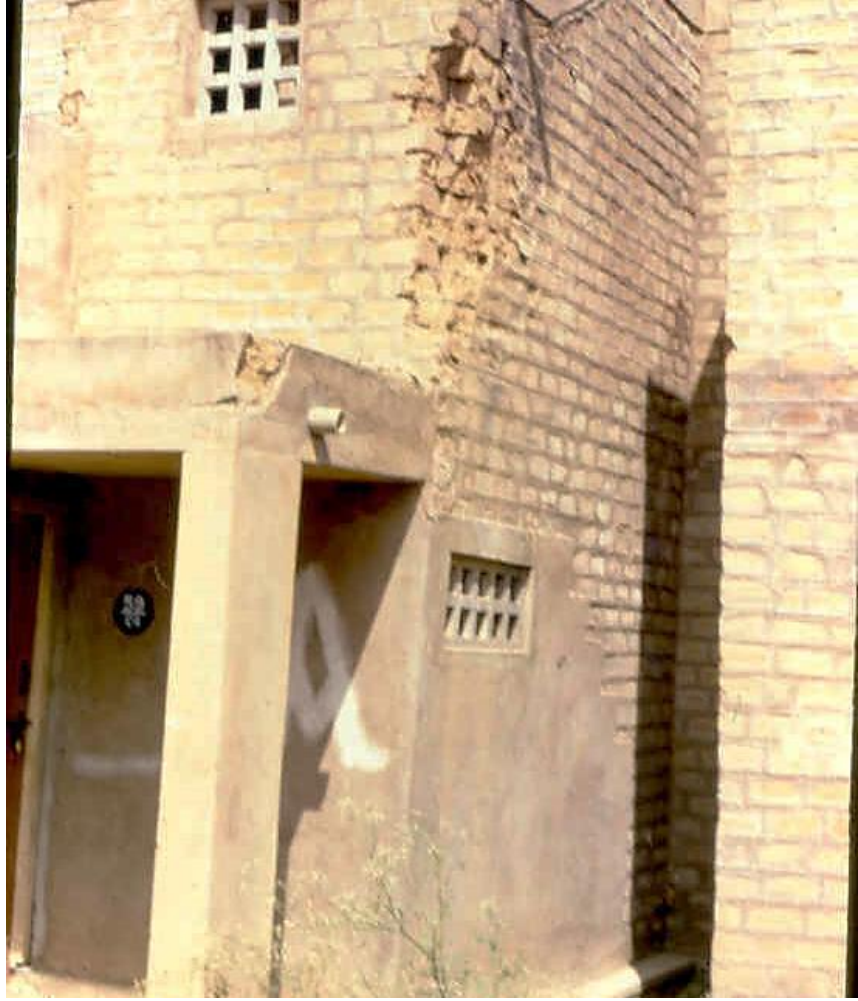

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Motivation

KARNATAKA HOUSING BOARD IN YELAHANKA (1992)

Motivation

- Houses for KHB, Yelahanka (1988-89) [1]
- Influence of Sand Addition
  - Reduction of Clay content by addition of Sand
  - Six different soils; Cement 5 & 10%;
  - Increased Strength - Sand content beyond 65% & Clay 10-15%
  - Study showcased importance of high sand and low clay content for SMB
- Further experiments concluded clay of 16% exhibited best strength [2]
- This approach considered *Silt content has no bearing on WCS*

Objective & Scope

- Influence of combination of Sand, Silt and Clay contents
  - Variation of Sand, Silt and Clay
  - Two types of Soils with addition of Sand and Silt fractions [3-4]
  - Sand Fractions – Quarry Dust
  - Silt Fractions – Granite Fines
  - Cement content 4 & 8%
  - New parameters – Sand/Fines & Silt/Clay
- This approach considered to understand the influence of *Soil Composition*

Experimental Program

Table 1: Composition of Soil samples studied [3-4]

Soil Designation		Sand (%)	Silt (%)	Clay (%)	Sand/Fines	Silt/Clay
A	MS 1.0	70.0	24.0	6.0	2.33	4.00
	MS 2.0	70.1	18.0	11.9	2.34	1.51
	MS 3.0	67.8	16.3	15.9	2.11	1.03
	MS 4.0	59.0	21.0	20.0	1.44	1.05
B	MS 5.0	66.5	25.0	8.5	1.99	2.94
	MS 6.0	59.5	30.0	10.5	1.47	2.86
	MS 7.0	57.0	35.0	8.0	1.33	4.38
	MS 8.0	60.0	17.0	23.0	1.50	0.74

Table 2: Characteristics of Stabilized Mud Blocks [3-4]

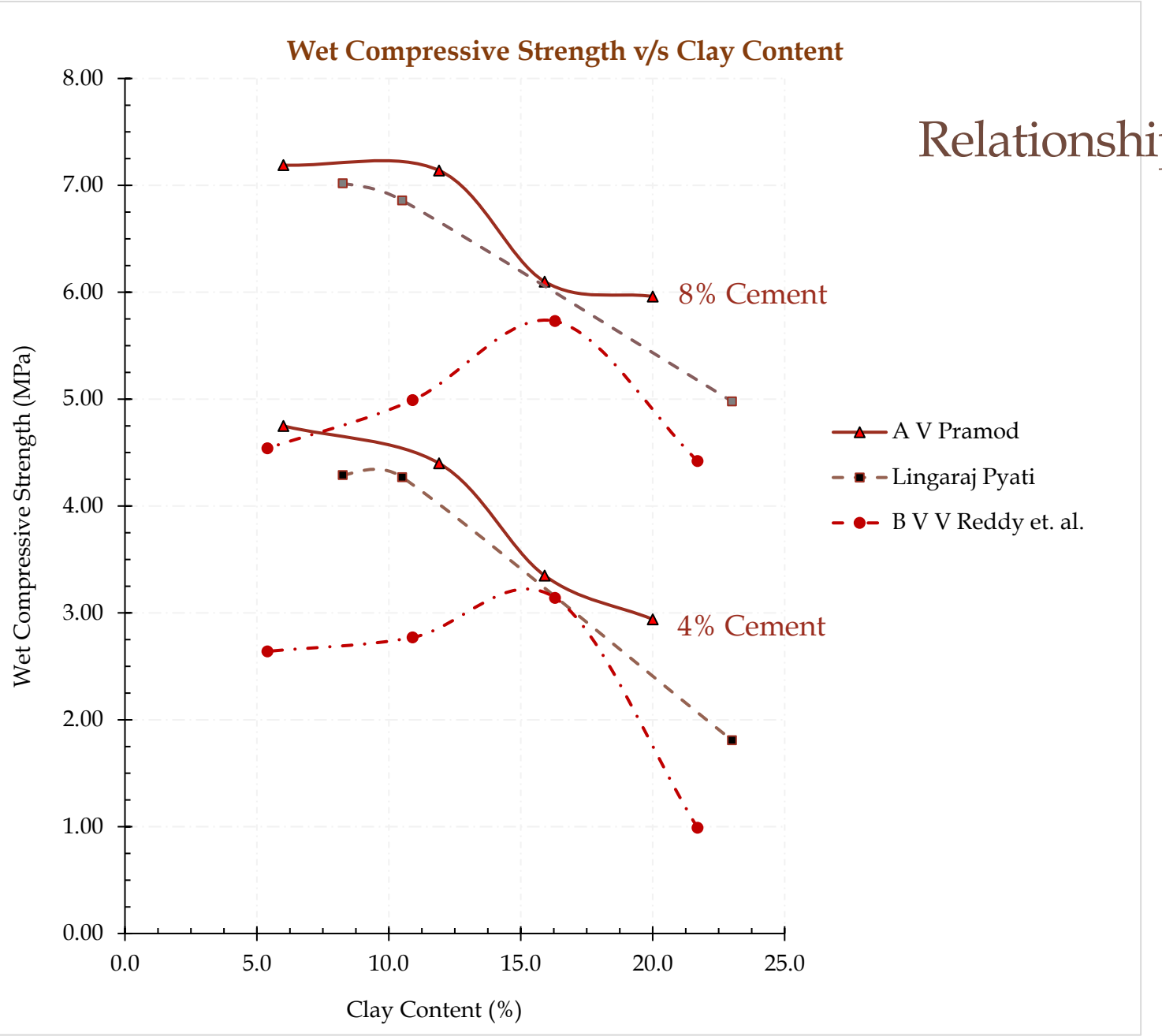
Soil Designation	Sand/Fines	Silt/Clay	Cement (%)	WCS (MPa)	Dry Density (g/cc)	IRA (kg/m²/min)
MS 1.0	2.33	4.00	4.0	4.75	1.90	1.090
			8.0	7.19	1.90	0.500
MS 2.0	2.34	1.51	4.0	4.40	1.82	0.915
			8.0	7.14	1.82	0.343
MS 3.0	2.11	1.03	4.0	3.35	1.88	1.470
			8.0	6.10	1.90	0.560
MS 4.0	1.44	1.05	4.0	2.94	1.85	1.530
			8.0	5.96	1.87	0.912
MS 5.0	1.99	2.94	4.0	4.08	1.86	-
			8.0	6.88	1.88	-
MS 6.0	1.47	2.86	4.0	4.27	1.84	-
			8.0	6.86	1.86	-
MS 7.0	1.33	4.38	4.0	4.50	1.82	-
			8.0	7.16	1.80	-
MS 8.0	1.50	0.74	4.0	1.81	1.81	-
			8.0	4.98	1.85	

Table 3: Stabilized Soils studied by Reddy et. al [2]

Soil Designation	Sand	Silt	Clay	Sand / Fines	Silt / Clay	Cement	Wet Compressive Strength	Dry Density	Initial Rate of Absorption
	(%)	(%)	(%)			(%)	(MPa)	(g/cc)	(kg/m^2/min)
NS	60.6	17.7	21.7	1.54	0.82	4.0	0.99	1.75	1.93
						8.0	4.42	1.75	1.47
NS 1	68.3	15.4	16.3	2.15	0.94	4.0	3.14	1.75	2.20
						8.0	5.73	1.75	1.85
NS 2	76.0	13.1	10.9	3.17	1.20	4.0	2.77	1.75	2.79
						8.0	4.99	1.75	2.50
NS 3	83.7	10.9	5.4	5.13	2.02	4.0	2.64	1.75	4.50
						8.0	4.54	1.75	3.20

Result Analysis

- Hyog-Moon Kwon et al [5]
  - Soil stabilization with Cement (10%) and Blast Furnace Slag
  - Highest strength and dry density was obtained for Soil: Sand – 35: 65
  - Sand Fractions – 72.00%
  - Silt Fractions – 15.43%
  - Clay Fraction – 12.50%
  - Sand/Fines Ratio – 2.57 &
  - Silt/Clay Ratio -1.23



Relationship between WCS and clay content

Practical Considerations

Table 4: Stabilized Adobe with Demolished Brick Masonry Waste (Cement 9%) [10]

Soil Designation	Gravel	Sand	Silt	Clay	Sand / Fines	Silt / Clay	Cement	WCS	Dry Density	IRA
	(%)	(%)	(%)	(%)			(%)	(MPa)	(g/cc)	(kg/m²/min)
A	0.66	54.56	30.58	14.20	1.22	2.15	9.0	3.36	1.62	1.80
B	0.62	68.18	25.20	6.00	2.19	4.20	9.0	5.23	1.81	1.26
C	0.12	69.08	24.50	6.00	2.26	4.08	9.0	5.37	1.81	0.90
D	0.52	72.56	21.92	5.00	2.70	4.38	9.0	5.15	1.76	0.96

Conclusions

- Cement stabilized soil may be considered as a kind of low strength concrete
- WCS depends primarily on its dry density and the cement content
- Further, the dry density is dependent on the ratio of sand to fines (silt + clay) in soil
- The range of the Sand/Fines ratios is between 1.50 and 2.50
- This also means the sand content must be between 60 and 72%, Clay 10-12%
- In addition to the appropriate sand to fines ratio, the silt to clay ratio of the stabilized soil must be above 1.50
- Results will hold good for SMB and/or SAB

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