The Applications of Non-Standard Stabilizers to the Base Course of Rural Roads

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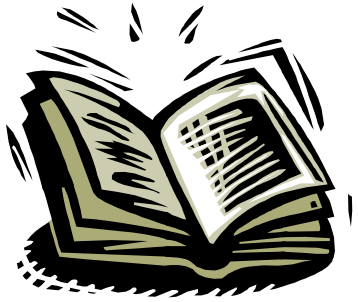


1. Introduction

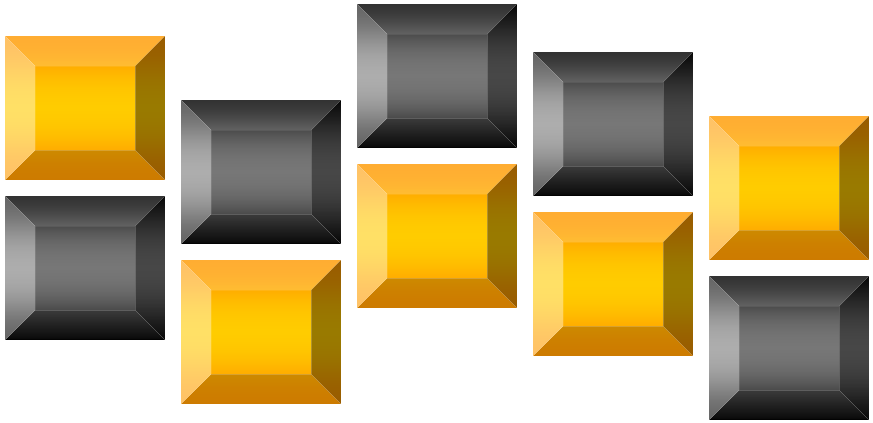
- **High intensive investments to the national truck roads in past years in China**
- **For examples, in Year 2003, new roads – 46,000 km including 4,600kg expressway; new/rehabilitated/re-constructed rural roads – 102,000km.**
- **More attentions to the rural roads in the Western China at low-cost by using local materials, such as the in-situ soils**

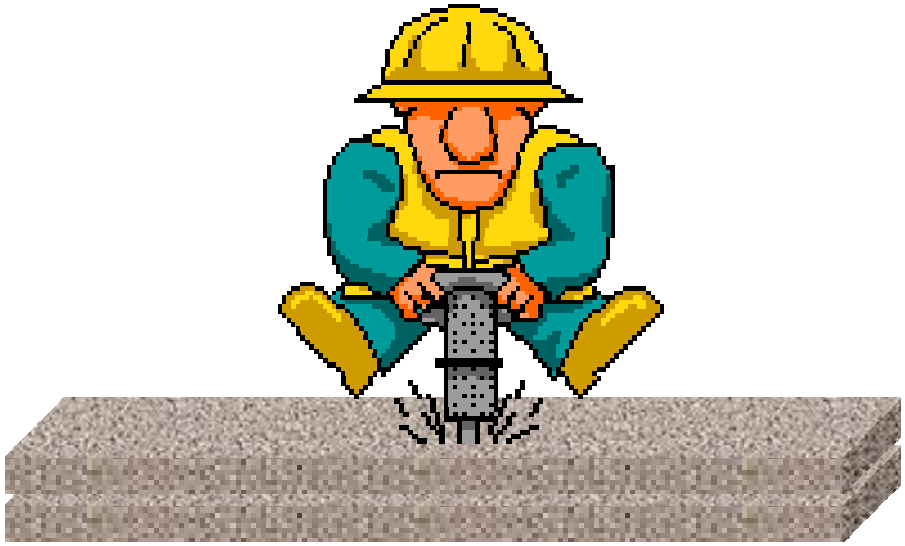
1. Introduction

- Soil stabilization with “Standard” and/or “Non-Standard” chemical stabilizers
- Studies and applications of the non-standard chemical stabilizers have been concentrated for past ten years in china
- The national transportation research project on – “Construction Technologies of Low-Cost Rural Roads in Western China”
- In the project, comprehensive laboratory tests and 4 full trials roads (3-5km long each) have been conducted over the years

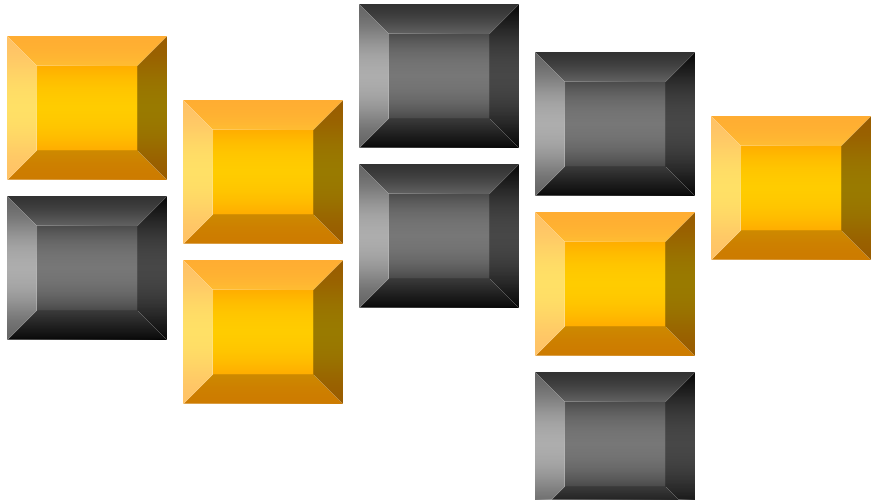
2. Brief Review of Soil Stabilizing Materials

2-1. Standard Stabilizing Agents, such as:





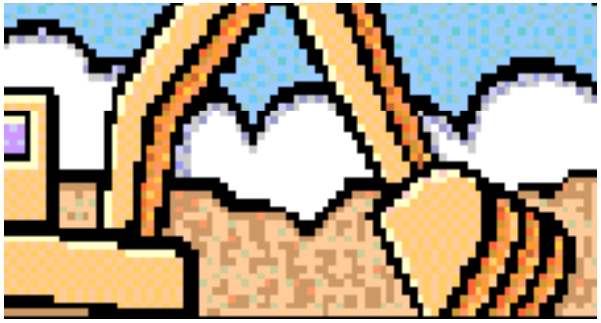
- Cement
- Lime



2. Brief Review of Soil Stabilizing Materials

2-2. Non-Standard Stabilizing Agents, such as:

- **Chemical Modified Cement - / Lime-Base Stabilizers in Powder Form**



- **Enzyme-Base Stabilizers in Liquid Form**

- **Various compound chemical stabilizers**

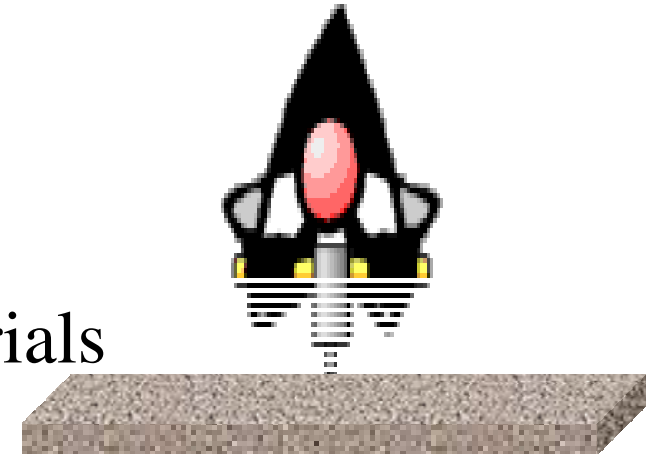
3. Basic Stabilizing Mehanism of Non-Standard Stabilizers

3-1. Non-Standard Stabilizers in Powder Form

- Chemical Reactions
- Physical-Chemical Reactions
- Physical Reactions

3-2. Non-Standard Stabilizers in Liquid Form

- Changing of Surface Energy
- Exchange of Irons
- Setting up Net-Shape Structure
- Forming of Water-Repellent Materials



4. Laboratory Test Results

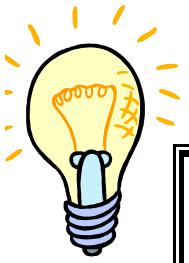


Table 1. Physical Properties of Tested Soil Samples

Sample No	Name	Location	LL	PL	PI
S1	Silt	Nei Monggol	21.4	17.5	3.9
S2	Clay	Beijing	34	21	13
S3	Sand	Beijing	0	0	0

Table 2. Physical Properties of Tested Soil Samples

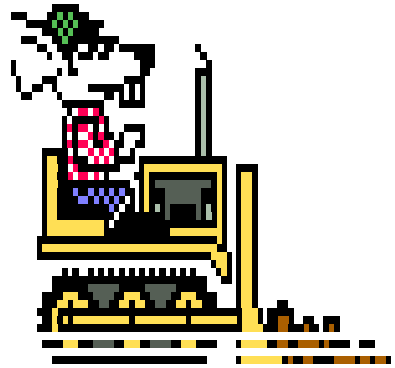
Sample No	Grain Size Distribution (%)				
	2 ~ 5 mm	0.5 ~ 2 mm	0.25 ~ 0.5 mm	0.074 ~ 0.25 mm	< 0.074 mm
S1	0.2	0.2	0.4	4.5	94.5
S2	1.2	0.4	2.9	7.9	84.8
S3	0	0	0.2	57.5	47.3

4. Laboratory Test Results

Table 3. Selected Soil Stabilizers and Their Codes

Category	Product Name	Country of Origin	Chemical Base/Grade	Code Name
Non-Standard Stabilizer	Chemilink SS-108 Soil Stabilizing Agent	Singapore	Modified cementitious	SS
In Powder form	LG Stabilizers*	China	Lime-cement Lime	CZN CZH
Non-Standard	ISS Stabilizer	Australia	Surface active agent	IS
Stabilizer	Perma-Zyme Stabilizer	USA	Organic bio-enzyme	PM
In Liquid Form	Better-Base Stabilizer	USA	Organic salt	SB
Standard	Lime	China	Grade 3	SH
Stabilizer	Ordinary Portland Cement	China	Grade 325	SN

* Note: The specific formulas of LG Stabilizers were especially designed for the particular tested soils.



4. Laboratory Test Results

Table 4. Mixing Ratios and Compaction Test Results

Stabilizer Code Name	Mixing Powder Form	Ratio Liquid Form	Compaction Test Results For S1 MDD (t/m³)	S1 OMC (%)	For S2 MDD (t/m³)	S2 OMC (%)	For S3 MDD (t/m³)	S3 OMC (%)
SS	3%	0	1.87	14	1.89	16	1.75	14
CZN	3%	0	1.84	15	1.85	16	1.80	16
CZH	3%	0	1.80	16	1.87	15	1.72	16
PM+SH	3%	1:1000	1.81	16	1.84	17	1.74	14
PM+SN	3%	1:1000	1.87	14	1.89	14	1.77	13
SB+SH	3%	0.5L/m³	1.81	16	1.84	17	1.74	14
SB+SN	3%	0.5L/m³	1.87	14	1.89	14	1.77	13
IS+SH	3%	1:100	1.81	16	1.84	17	1.74	14
IS+SN	3%	1:100	1.87	14	1.89	14	1.77	13
SH	3%	0	1.81	16	1.84	17	1.74	14
SN	3%	0	1.87	14	1.89	14	1.77	13

4. Laboratory Test Results

Fig. 1. Test Results of Unconfined Compressive Strength (UCS) after 7-Day Curing

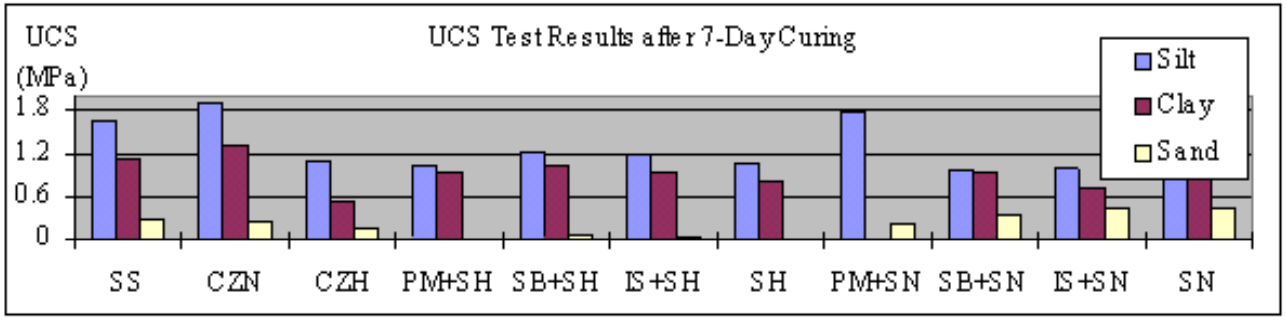
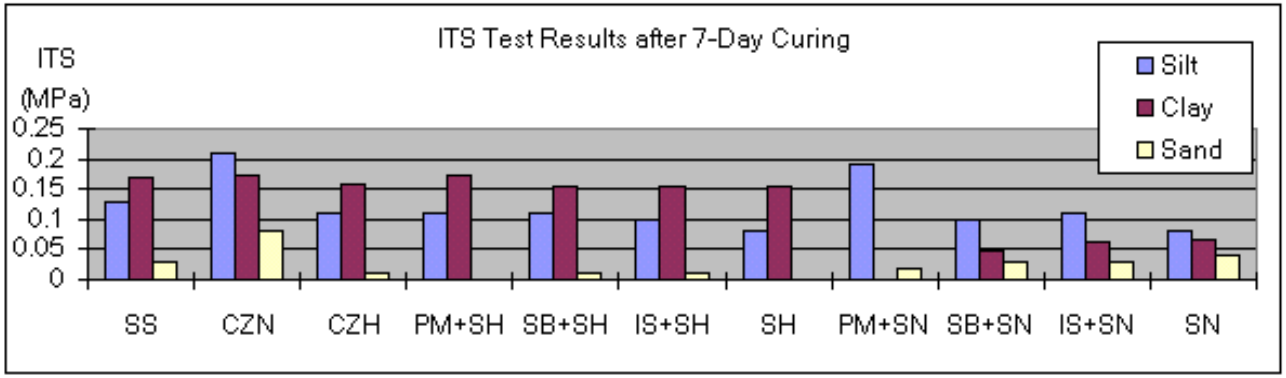
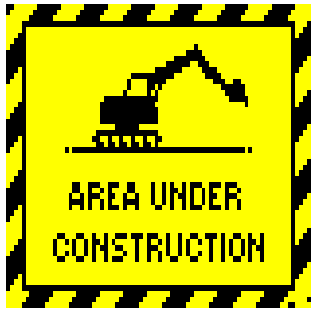


Fig. 2. Test Results of Indirect Tensile Strength (ITS) after 7-Days Curing





4. Laboratory Test Results

Important Conclusions derived from both strength test results :

i) The non-standard modified cement-base stabilizers in powder form have outstanding performances in strengths among the whole stabilizer family which includes the standard ones and non-standard ones;

4. Laboratory Test Results

Important Conclusions derived from both strength test results :

ii) The strengths of the non-standard stabilizers in powder form with three types of soils are much higher than those of cement-soils or lime-soils and generally better than those of the combined stabilizers; and

4. Laboratory Test Results

Important Conclusions derived from both strength test results :

iii) To add the stabilizers in liquid form into cement-soils or lime-soils cannot significantly improve their compressive strengths and even make them worse (except the case of PM stabilizer with cement-silt with surprising), while the adding of the stabilizers in liquid form looks partially useful for increasing of the elasticity of the mixtures;

4. Laboratory Test Results

Fig. 3. Relationship between Drying-Shrinkage Index and Loss of Water

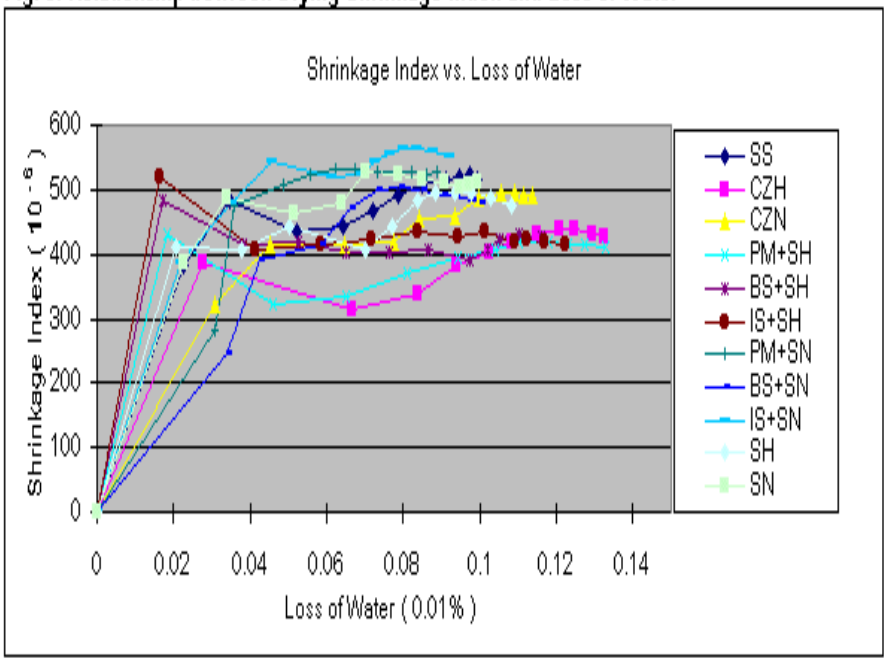
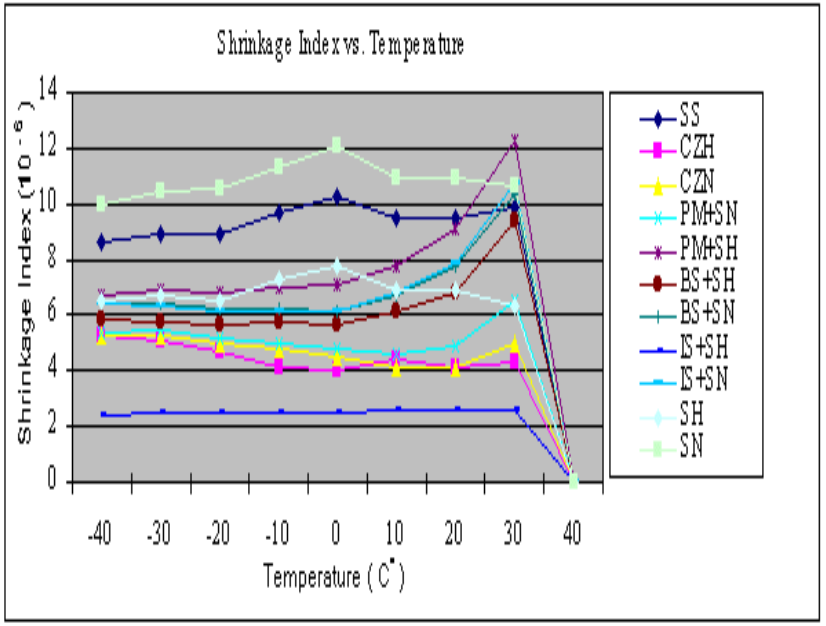


Fig. 4. Relationship between Thermo-Shrinkage Index and Temperature



- **The drying – shrinkage due to loss of water is primary**
- **The shrinkage caused by temperature is only 1%-2% of that caused by loss of water**

5. Field Trial Roads with Various Stabilizers

5-1. Stabilization Methods

* **In-Situ mixing**

Preparation

Spreading of the powder

Mixing of the powder

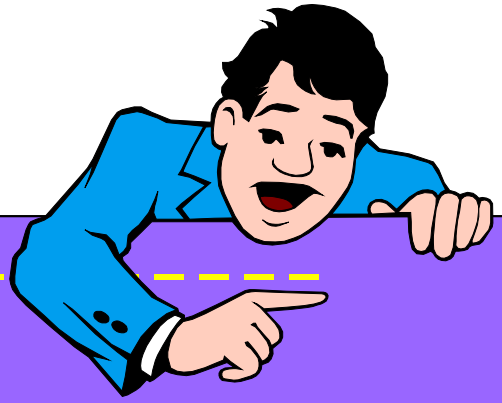
Compaction Spreading & Mixing of the Liquid

Curing Stabilized Base after Curing

* **Central Plant Mixing**

5. Field Trial Roads with Various Stabilizers

5-3. Field Test Results



Test Results

- 4 Trial roads with 3-5 km long in Sichuan (South-West China), Nei Monggol (North-West China) and Xinjiang (Western China).
- A lot of field tests/measurements have been conducted.
- The measured deflection values from the trial road – Nei Monggol are taken as example.

5. Field Trial Roads with Various Stabilizers

Table 5. The Measured Deflection Values of Aohan Trial Road in Nei Monggol, China

Foundation Type*	Test Nos.	Ave. BS Value (1% mm)	Max. BS Value (1% mm)	Min. BS Value (1% mm)	Cv (%)	Representing BS Value** (1% mm)	Remarks
Lime+Gravel	84	28.63	70	0	37	44	Fair
Natural sub-grade	102	66.73	122	10	34	101	
Cement+Lime +Gravel	118	20.08	48	0	42	33	Good
Natural sub-grade	148	64.37	138	0	45	108	
SS+Silt	16	22.25	32	12	26	31	Good
Natural sub-grade	20	58.40	103	0	40	94	
CZH+Silt	44	24.61	72	8	45	41	Fair
Natural sub-grade	52	64.08	121	25	28	91	
CZN+Silt	42	27.19	48	8	34	41	Fair
Natural sub-grade	44	59.00	181	0	57	110	
PM+Lime+Gravel	74	32.27	70	10	27	45	Fair
Natural sub-grade	74	63.84	176	0	61	123	
PM+Gravel	58	39.71	89	15	40	64	Poor
Natural sub-grade	62	71.02	176	0	68	144	
Stabilized base for whole trial sections	436	27.63	89	0	44	46	Overall average
Natural sub-grade for whole trial sections	502	64.85	181	0	49	113	

Note: *-- 200mm thick for all stabilized bases and **-- weighted average value

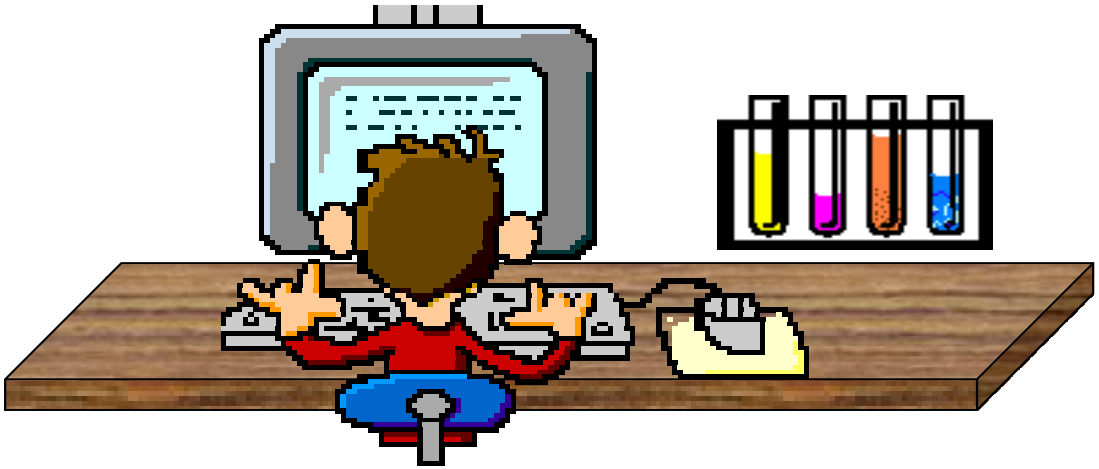
Design Deflections

- **21.8 (1%mm) – A real expressway in Northeast China with 15 years working life and 720mm thick pavement**

- **39.04 (1%mm) – An assumed high-grade road with 50% traffic volume of the real expressway and the same other conditions**

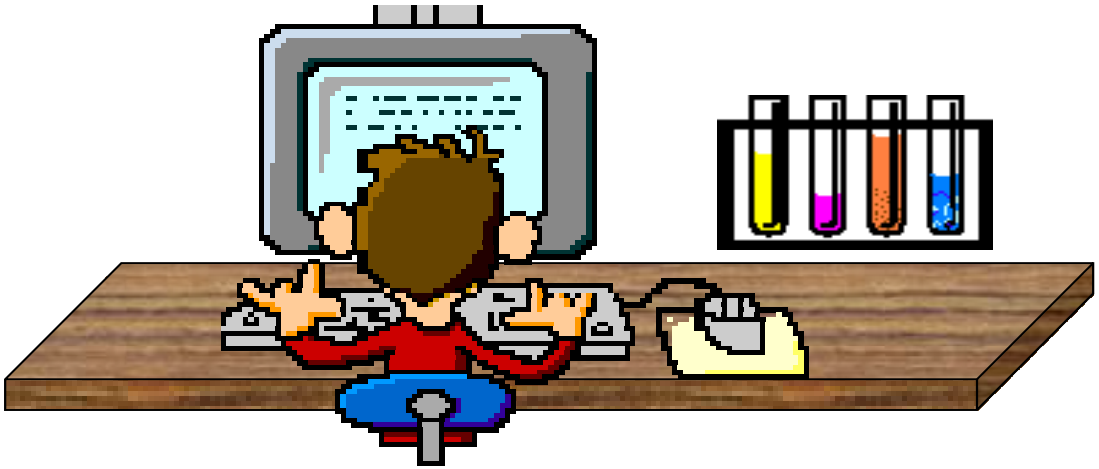
CONCLUSIONS

1) A national research project on construction technologies of low-cost rural roads for Western China has been carried out and the non-standard soil stabilizers have been studied, as a part of this project, from the development history, basic stabilizing mechanisms, comprehensive laboratory tests to the large-scale field road trials with a lot of rich results.



CONCLUSIONS

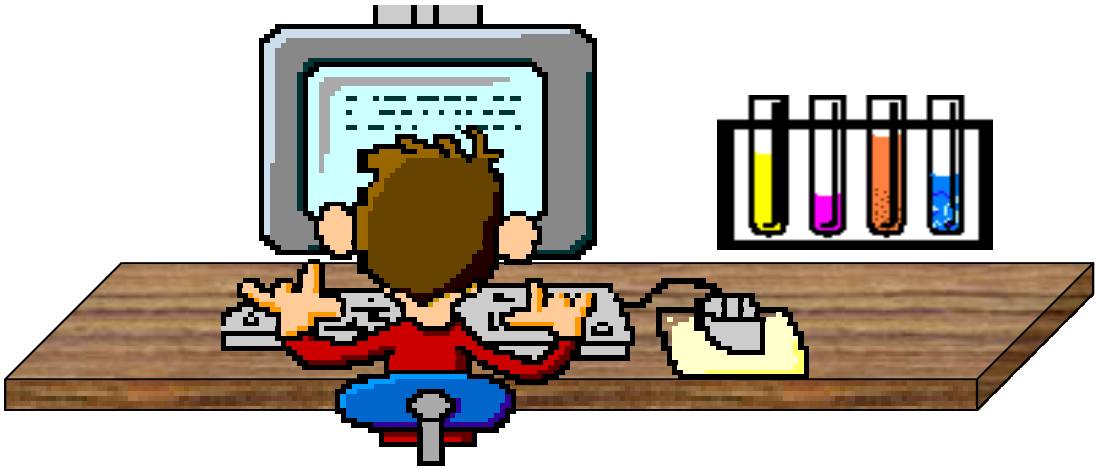
2) The laboratory and field tests results have proven that the non-standard stabilizers in powder form are generally more effective than the standard stabilizers for soil stabilizations. The non-standard stabilizers in liquid form are generally ineffective in improving the strengths of the stabilized sols but they may have some effects on improving some properties of cement-soil and lime-soil.



CONCLUSIONS

3) The soil stabilization with the non-standard stabilizers in powder form is a technically reliable and practically applicable construction method for rural roads and it could be cost-effective for those areas where there are lacking in good quarry materials.

4) In order to achieve better and cost-effective results, it is very important to select the proper soil stabilizer based on various stabilization mechanisms, different types of soils and localized conditions.



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