SPECIFICATIONS FOR THE USE OF NANO-MODIFIED EMULSIONS (NME) WITH NATURALLY AVAILABLE MATERIALS (Jordaan, et al, 2017)

CLASSIFICATION SYSTEM FOR NME MATERIALS

The recommended approach is based on the same principles followed in the nationally approved recommendations for the classification of road building materials, draft TRH14 "Guidelines for Road Construction Materials", (COLTO, 1985). In this document materials such as Crushed stone (G1 – G3), Naturally Available Material (G4 – G10), Cemented materials (C1 to C4) and Bituminous Stabilised Materials (BT1 to BT3) are specified in terms of "strength"/bearing capacity potential for use in pavement structures. The draft TRH14 classification denotes a Class "1" suffix as the best quality material with the highest potential bearing capacity. The potential bearing capacity of any specific material is, off course, a function of the quality of all the layers in the pavement structure and the pavement structure system and balance as a whole, given the assumption that quality control during construction is done in such a way to ensure that the required criteria for the construction of each pavement layer is fully met (COLTO, 1998).

Taking these basic concepts into account, the following Nano-material classification is recommended as used in the attached Table 1:

- NME1- Highest quality stabilised naturally available materials - stabilised with a mineral compatible Nano-Modified Emulsion (can be compared to that of a typical G1 or C1 equivalent material), suitable for upper layers of pavement structures capable of withstanding high axle loadings under conditions of high tyre pressures. If used as a stabilised base, the material to be stabilised must be tested to ensure that the durability of the material will be able to withstand high tyre pressures (refer Table 1 criteria);
- NME2 – High quality stabilised naturally available materials - stabilised with a mineral compatible Nano-Modified Emulsion (can be compared to a typical G2 or C2 equivalent material), suitable of withstanding relatively high traffic loadings and tyre pressures without durability problems;
- NME3 – Medium quality stabilised naturally available materials - stabilised with a mineral compatible Nano-Modified Emulsion (can be compared to a typical G3 of C3 equivalent material) capable of withstanding of material loadings of medium impact, and
- NME4 – Suitably quality stabilised naturally available materials (can be compared to a typical G4 or C4 equivalent material) - stabilised with a mineral compatible Nano-Modified Emulsion using relatively poor quality naturally available materials (normally rejected for use in pavement layers using current criteria). The Nano-Modified Emulsion stabilisation of the "normally unsuitable" material (according to "traditional" criteria), will enable these materials to be to be utilised successfully within the pavement structure, and

NEG5 – Material of a quality less than that of a G5 material modified with a suitable Nano-modification to become water repellent (not subject to failure modes associated with a "wet" condition). With the addition of relatively small percentages of Nano-products, lower quality material (G6/G7/G8, and?) can be modified to become Equivalent G5 material (NEG5) which are chemically enhanced to be water repellent and the bearing capacity improved resulting in an enhanced CBR of 45 at 95% Mod. AASHTO. In this case no UCS or ITS minimum values are specified.

Table 1: Recommended material specifications for naturally available materials stabilised with Nano-Modified Emulsion (NME)

Test or Indicator	Material[1]	Material classification			
		NME1	NME2	NME3	NME4
Minimum material requirements before stabilisation and/or treatment (Natural materials)					
Material spec.(minimum) Unstabilised material: Soaked CBR (%) (Mod. AASHTO)	NG /(CS)	> 45 or > 25 (95%) and ACV < 30% or 10% FACT >110 kN	> 45 or > 25 (95%) and ACV < 30% or 10% FACT >110 kN	> 25 (95%)	> 10 (93%)
Plasticity Index (PI)	CS	< 10	< 10	-	-
	NG	< 12	< 12	< 16	< 16
	GS	-	< 12	< 16	< 16
	SSSC	-	-	-	< 16
PI - 0.075 fraction (test when OMC >8% and/or % passing 0.075 mm sieve >10%)	CS	< 15	< 15	-	-
	NG	< 20	< 20	< 25	< 40
	GS	-	< 20	< 25	< 30
	SSSC	-	-	-	< 30
Grading modulus	NG	> 1.9	> 1.8	> 1.2	> 0.45
	GS	-	>1.8	> 1.2	> 0.75
DCP DN (mm/blow) (Material compacted to spec. before stabilisation)		< 3.0	< 3.6	< 9.0	< 13.5
Material specifications after stabilisation and/or treatment					
MOD AASHTO density		> 100%	> 98%	> 97%	> 95 %
DCP DN (mm/blow) Material compacted to spec. (after stabilisation)		< 1.5	< 1.8	< 3.7	< 5.5
UCS (wet) (rapid curing method: 24h at ambient temp (30°C) + 48h at 40°C - 45°C + 24h cooling + 4h water soaking) (kPa)	150mm Φ Sample	> 2 500	1 500 to 6 000	750 to 4 000	450 to 3000
Friction Angle (°)		> 40	> 40	> 30	> 30
ITS* (dry) (kPa) (rapid curing as per UCS) (no soaking in water)	150mm Φ Sample	> 175	> 140	> 100	> 80
ITS* (wet) (kPa) (rapid curing as per UCS method)	150mm Φ Sample	> 140	> 100	> 80	> 60
Retained Cohesion: ITS: Wet/Dry (%)	All	> 80	> 70	> 65	> 60
Typical Effective Elastic Moduli for pavement design (MPa)**		600 - 300	400 - 250	300 - 200	220 - 180
GE-NANO % to be applied		1.5% – 2.0%	1.0% - 1.5%	0.7% - 1.0%	0.5% - 0.7%

[1]CS – crushed stone; NG – natural gravel; GS – gravel soil, and SSSC – sand, silty sand, silt, clay.
*ITS repeatability is questionable (TG2, 2009) and may be replaced in future by more reliable tests as an indication of the tensile properties of materials (e.g. Mbaraga, Jenkins and Van der Ven, 2014).
** These recommended values could vary considerably and are dependent of various influences including, appropriate mix design, **pavement balance**, quality control during construction, etc.

The minimum requirement for the wearing course of gravel roads is a CBR of 15 at a compaction of 95% Mod. AASHTO (refer draft TRH20, 1990). This minimum requirement eis similar to the minimum requirements of naturally available material (CBR of 10 at 93% Mod. AASHTO) for a NME4 class layer as contained in Table 1. It follows that the criteria contained in Table 1 could possibly also be made applicable for the cost-effective treatment of the wearing course of gravel roads to obtain a layer with enhanced water-repellent and durability characteristics.

References

Jordaan, G.J., Kilian, A., Du Plessis, L. and Murphy, M. (2017), The Development of Cost-effective Pavement Design Approaches using Mineralogy Tests with new Nano-modifications of Materials. Paper prepared for presentation at the South African Transportation Convention (SATC'17).