

Freeze-Thaw Testing:

Correlation and Possible Advantages over Sodium Sulfate Testing

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History:

- Issues in District 12 on I-70



History:

- I-70: Investigation by CTL Group
 - Subbase was a by-product aggregate: Degradation of the aggregate particles was likely a combined result of high level of saturation, the chemical dissolution process and the grinding of the particles against each other under dynamic traffic loading.

- Problems with Sodium sulfate
 - Recycled Concrete Aggregate (RCA): We do not perform sodium sulfate testing on RCA because of the high amount of loss.
 - Weathered Slag aggregate: Due to the existing chemicals in the aggregate, we cannot get full saturation with a sodium sulfate solution in order to mimic freeze-thaw in a roadway situation.
 - More and more recycled products

History:

- Problems with Sodium Sulfate (continued):
 - PTM No. 510: Soundness of Aggregate by use of Sodium Sulfate
 - Stainless steel containers
 - Standard gradation is used for calculating Loss
 - AASHTO T 104: Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
 - Sieves are used
 - Actual gradation is used for calculating Loss
 - Note 2 – Some aggregates containing carbonates or magnesium are attacked chemically by fresh sulfate solution, resulting in erroneously high-measured losses.

History:

- Problems with Sodium Sulfate (continued):
 - AASHTO T 104: Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
 - Precision Indexes
 - Multi-laboratory:
 - » Coefficient of variation (1s) – 41%
 - » Difference between two tests(d2s) – 116% (of average)
 - Single Operator:
 - » Coefficient of variation (1s) – 24%
 - » Difference between two tests(d2s) – 68% (of average)

Research:

- Due to our concerns with using a sodium sulfate solution, we looked for other test methods to check the durability of all products that would be used for subbase.
- We investigated testing done by other DOT's and other countries.
- We settle on a European test method. There were established limits and they had experience with testing by-products.

Research:

- Test method: DIN EN 1367-1 Determination of resistance to freezing and thawing.
 - Similar to AASHTO T 103 (procedure A)
 - Reduce sample – coarse fraction only
 - Soak sample
 - Freeze and thaw sample for 10 cycles
 - Sample is washed prior to weighing back.
 - Percent loss is the actual loss

Research:

- Road and Transportation Research Association
 - Technical Delivery Terms for Aggregates in Road Construction : TL Gestein-StB 04
 - The “TLGestein-StB” contains requirements placed on natural, industrially manufactured and recycled aggregates that are used in the production of surfacings made of bituminous mixtures, concrete hydraulically bound and unbound mixtures, cobble and slab paving, slurry surfacing and surface treatment.

Research:

- TL Gestein-StB 04
 - 2.2.14.2 Resistance to Freeze-Thaw Attack
 - If required, the resistance to freeze-thaw attack according to DIN EN 1367-1 may be determined. It must fulfil the requirements of one of the categories in Table 19.

Table 19: Requirements for Resistance to Freeze-Thaw Attack

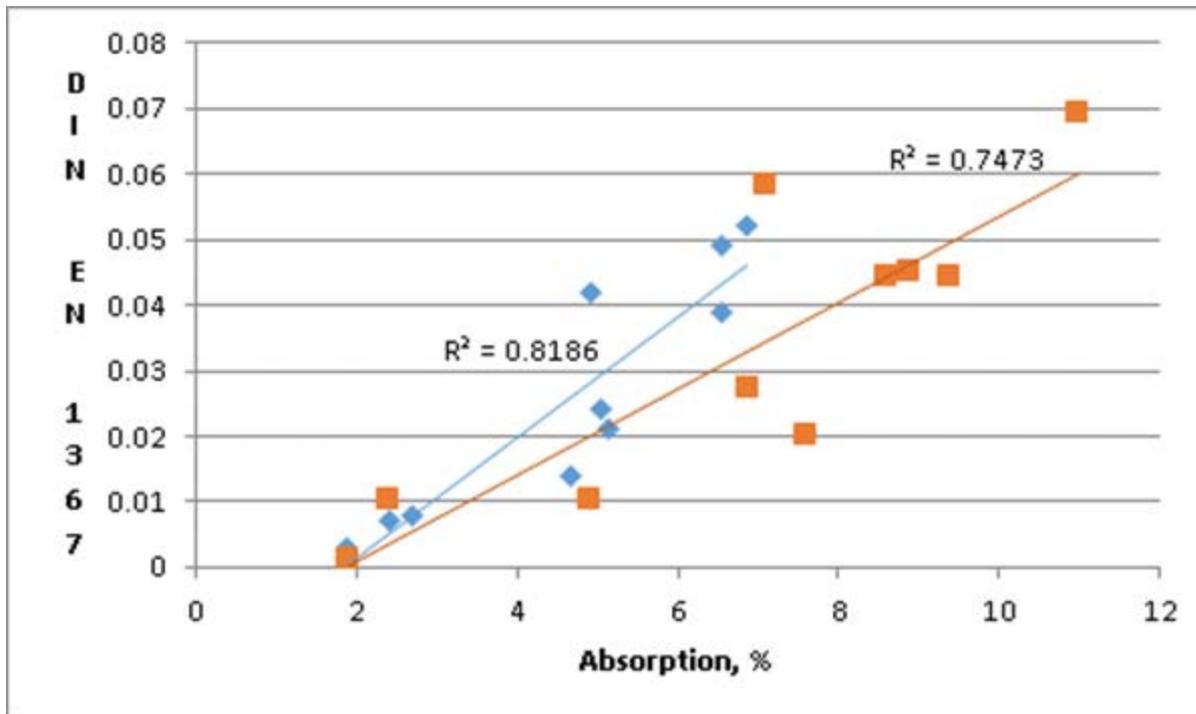
Frost Resistance (loss in wt. %)	Category F
≤ 1	F ₁
≤ 2	F ₂
≤ 4	F ₄
> 4	F _(declared)

Research:

- TL Gestein-StB 04 (continued):
 - 2.2.14 Freeze-Thaw Attack
 - Proof of sufficient resistance to freeze-thaw attack is to be obtained indirectly by determining water absorption and, if required, by subsequently determining the resistance to freeze-thaw attack. The resistance to freeze-thaw attack may also be determined directly.

Testing:

- Test results of high absorptive aggregate:



Special Provision:

- Currently using for subbase:

In accordance with Section 350 and as follows:

Revise Section 350.2(a) Aggregates. to read as follows:

(a) Aggregate - Provide Type C or better, No. 2A material with freeze thaw resistance according to European Standard DIN EN 13242 with a maximum freeze/thaw loss of 2% as determined by European Standard DIN EN 1367-1 for all slag aggregates and any natural aggregate whose absorption exceeds 2%. Test for thermal and weathering properties of aggregates, Part 1 : Determination of resistance to freezing and thawing.

Testing:

- Continue testing and research
 - Equipment
 - Test method
 - Limits

Testing:

- Purchased new equipment

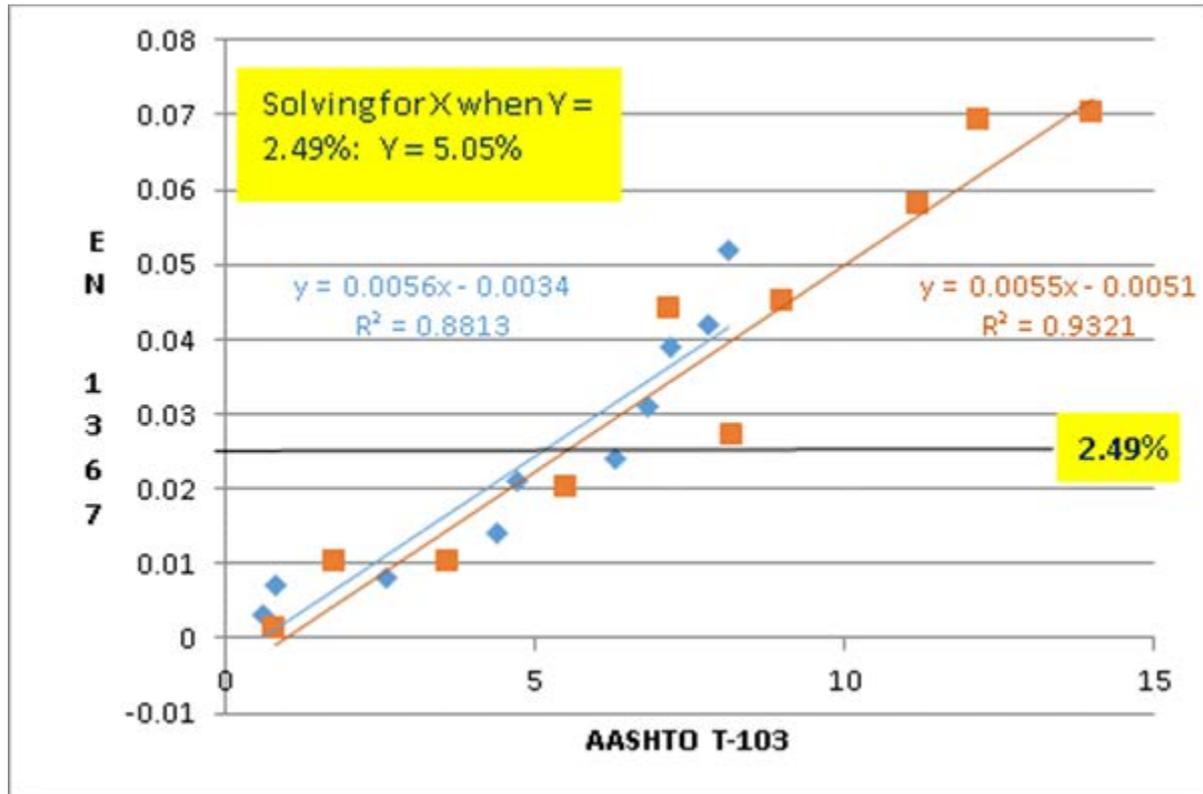


Research:

	AASHTO T-103 (Procedure A)	EN 1367-1
Sample Containers	flexible containers (plastic, rubber), sufficient size to hold samples	sheet metal cans (seamless) 0.6mm thick, 2000mL capacity, id. 120mm - 140mm, ih. 170mm - 220mm
sieves (coarse)	(1) 9.5mm - 4.75mm 300 ± 5 g	(1) 8mm - 4mm 1000 ± 50g
	(2) 19.0mm - 9.5mm 1000 ± 30 g	(2) 16mm - 8mm 2000 ± 100g
	12.5mm - 9.5mm 330 ± 5 g	
	19.0mm - 12.5mm 670 ± 10 g	
	(3) 37.5mm - 19.0mm 1500 ± 50 g	(3) 32mm - 16mm 4000 ± 200g
	25.0mm - 19.0mm 500 ± 30 g	
	37.5mm - 25.0mm 1000 ± 50 g	
	(4) 63mm - 37.5mm 5000 ± 300 g	(4) 63mm - 32mm 6000 ± 300g
	50mm - 37.5mm 2000 ± 200 g	
	63mm - 50mm 3000 ± 300 g	
fine aggregate	yes	no
soaking	24±4 hrs at 23° ± 3°C	24 hrs at 20° ± 3°C
freeze cycles	23° ± 3°C to -23° ± 3°C	20° ± 3°C to 0°C in 2.5 ± 0.5 hrs
	hold for a minimum of 2 hrs	hold for 3.5 ± 0.5 hrs
		0°C to -17.5° ± 2.5°C in 3 ± 0.5 hrs
		hold for a minimum of 4 hrs
thaw cycles	"-23° ± 3°C to 21° ± 3°C (in air)	"-17.5° ± 2.5°C to 20° ± 3°C (in water)
	hold for a minimum of 0.5 hrs	hold for a maximum of 10 hrs
freeze/thaw cycle	should not exceed 24 hrs	should not exceed 24 hrs
	25 cycles	10 cycles
after completion of cycles	dry to constant mass, sieve, weigh	wash and sieve, dry to a constant mass, weigh
sieves for determining loss	(1) 4.0mm	(1) 2mm
	(2) 8.0mm	(2) 4mm
	(3) 16.0mm	(3) 8mm
	(4) 31.5mm	(4) 16mm
calculation of loss	weighted against gradation of sample	actual loss

Testing:

- Testing of EN 1367 vs AASHTO T-103



Future:

- Continue testing subbase material and tweak specification
- Started testing AASHTO #8 and #57 about a year ago
- Look at setting limits for AASHTO #8 and # 57