Development of mortar abrasion test for evaluating fine aggregates and wear resistance of concrete pavements

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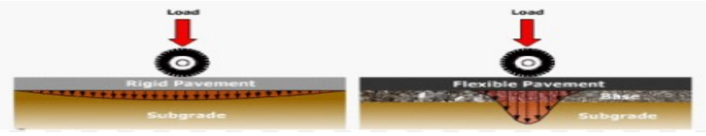
1.0 Introduction

Major highways in southern Ontario are paved:

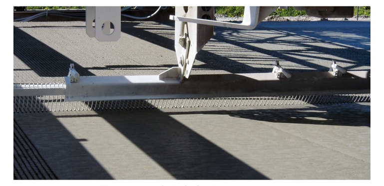

(a) Flexible Asphalt Concrete Pavement


(b) Rigid Portland Cement Concrete Pavement

Rigid/Portland Cement concrete pavement offers:
1) Better load distribution
2) Durability


Load Distribution on rigid PCC and flexible AC pavement (photo credit: Texas Transportation)

However the exposed PCC surface must consider:
- Ongoing maintenance of adequate textural characteristic for providing good surface friction

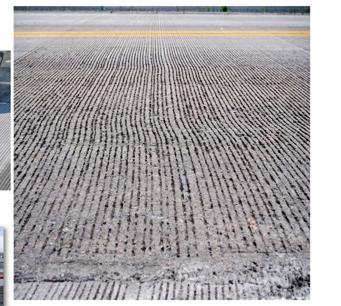

Tining of PCC Pavement

Long and durable pavement's surface texture of both asphalt concrete and Portland cement concrete pavement depends on:
- Composition of Material used in construction
  - specifically aggregates that can resists — Abrasion, Polishing

Texture in Portland Cement Concrete Pavement

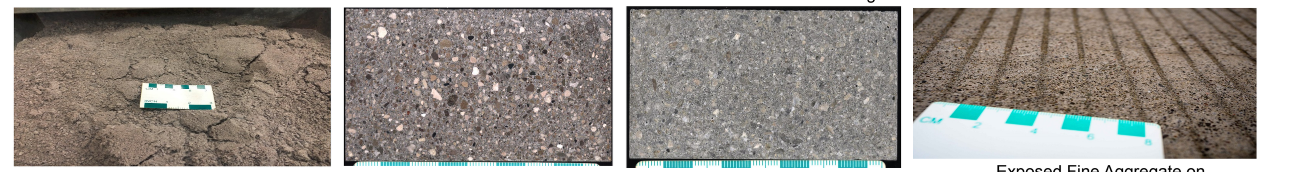
Macro texture :
1) Dragging, tining or grinding or grooving
2) Aggregate's Type
3) Mix Design
4) Workmanship such as placement, curing and tining


Grinding


Loss of surface micro-texture due to abrasion

Micro texture:
1) Fine aggregate - Shape


Hand Tining


Fine Aggregate

Rounded Aggregate in Mortar

Angular Aggregate in Mortar

Exposed Fine Aggregate on Abraded PCC Pavement

Cause of Abrasion :
- Cutting and Rubbing of vehicle's tire on surface of the pavement (shear effect)

Low abrasion resistance of Portland Cement concrete pavement are caused by:
1) Soft Aggregates (Mohs hardness< 4)
2) Inadequate Compressive Strength
3) Improper Curing and Finishing
4) Over Manipulation during finishing

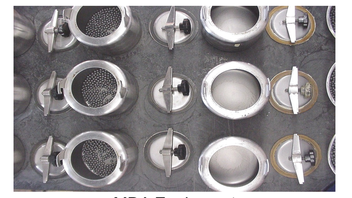
Abrasion Resistance of PCC Pavement depends mainly on:

Fine Aggregate → Physical Properties → Shape → Flat vs. Angular
Fine Aggregate → Chemical Properties → Mineralogy → Mineral's hardness

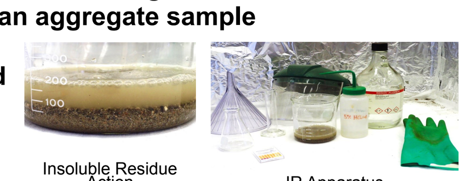
Indirect laboratory test for measuring abrasion

1) Micro-Deval Abrasion Test : Evaluates the fine aggregate's abrasion for use in hot mix asphalt and Portland Cement concrete pavement
   Testing procedure:
   - Aggregate's particles (retained 1.18) are placed in grinding mill along with water and steel ball charge
   - Abrasion resistance = % loss of particles passing 1.18mm sieve

   Problem:
   - Crushing of aggregate's particles during abrasion due to their small grain size distribution


MDA Equipment

2) Insoluble Residue Test: uses a chemical reaction as a means of assessing the amount of carbonate minerals (and inversely, the amount of non-carbonate material) in an aggregate sample
   Testing procedure:
   - Carbonate ion, $(CO_3)^{-2}$ readily reacts with hydrochloric acid (HCl) to form carbon dioxide gas (CO_2), water (H_2O) and other soluble salts
   - Siliceous rock and minerals, i.e., based on oxides of silica (Si) are inert to the effects of HCl


Insoluble Residue Action

IR Apparatus

MTO current specification requires a minimum IR value of 60% for fine aggregates used in exposed concrete pavements

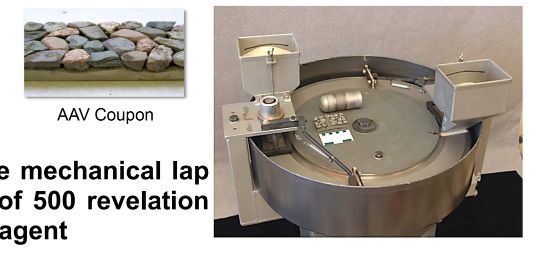
Problem:
- IR does not define the abrasion resistance of the total PCC mixture

Problem and Objective of this experimental investigation
- MTO does not have an adequate test to directly measure the abrasion resistance of concrete as a function of the fine aggregate component
- Conducted experimental testing of alternative abrasion resistance of concrete mortars using a variety of fine aggregates as a means of gaining a more effective evaluation of microtexture retention and frictional performance of PCC pavements

Development and results of a testing program that involved the adaptation of the Aggregate Abrasion Value (AAV) test (British Standard EN1097-8 2009)

AAV Test

1) Abrasion test for coarse aggregates
2) Exposes aggregates to grinding by direct shear on a large mechanical lap wheel that rotates at 30 revolution per minutes for a total of 500 revelation while Silica Sand is fed through the machine as an abrasive agent
3) AAV= (3x Δmass loss)/relative density
   AAV– Average abrasion index of two specimen


AAV Coupon

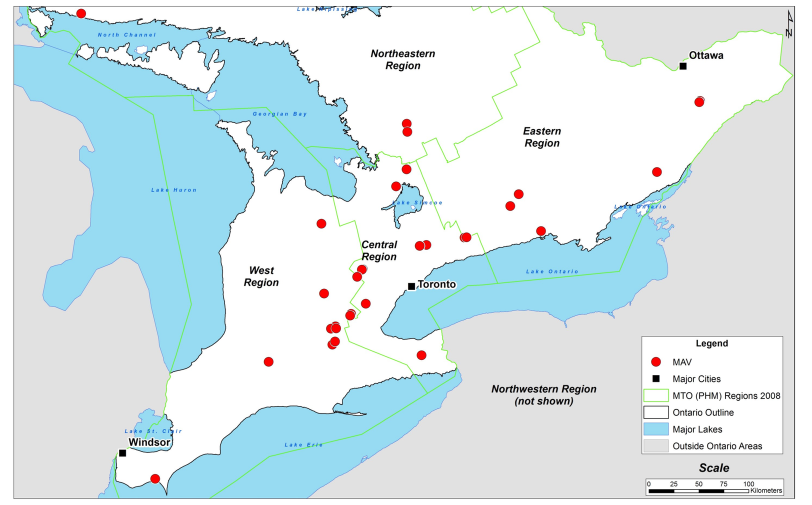
MAV/ AAV Apparatus

2.0 Materials

- Fine aggregate samples were obtained from stockpiles of processed concrete sands

Fine Aggregate Sample Summary

Sample	MTO Sample Number	Deposit Type	Geological Setting
W01	101 (A)	Pit	Ice Contact
W05	105 (A)	Pit	Outwash
W06	106 (A)	Pit	Outwash
W09	109 (A)	Pit	Ice Contact
C01	201 (A)	Pit	Outwash
C02	202 (A)	Pit	Outwash
C03	203 (A)	Pit	Outwash
C04	204 (A)	Pit	Ice Contact
C05	205 (A)	Pit	Ice Contact
C06	206 (A)	Pit	Ice Contact
C07	207 (A)	Pit	Outwash Terrace
C08	208 (A)	Pit	Outwash
C09	209 (A)	Pit	Ice Contact
C11	211 (A)	Pit	Outwash
C12	212 (A)	Pit	Outwash
C13	213 (A)	Pit	Ice Contact
C14	214 (A)	Quarry	Quarry
C15	215 (A)	Pit	Outwash
C16	216 (A)	Pit	Outwash
C17	217 (A)	Pit	Outwash
C19	219 (A)	Quarry	Quarry
E01	301 (A)	Pit	Outwash/Ice Contact
E02	302 (A)	Pit	Beach
E05	305 (A)	Pit	Beach
E06	306 (A)	Pit	Beach
E07	307 (A)	Pit	Beach
E10	310 (A)	Pit	Ice Contact
NE01	401 (A)	Pit	Outwash
NE02	402 (A)	Quarry	Quarry
NE03	403 (A)	Pit	Delta


Location of Fine Aggregate Samples

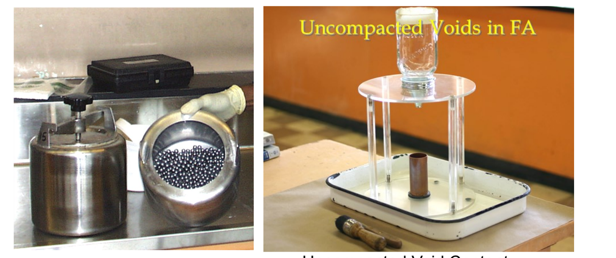

Fine Aggregate

3.0 Testing

- Abrasion test for mortar coupons using 30 different concrete sands from various suppliers in Ontario
- MAV=Average Mass loss of 4 tested coupon abrasion loss for each fine aggregate mortar mix was determined at the ages of 7 days (MAV_7) and 28 days(MAV_{28})

Other tests:

1) Compressive strength of mortar cubes (ASTM C109)
2) Absorption and relative density (MTO LS-605)
3) Insoluble Residue-IR (MTO LS-613)
4) Petrographic Analysis (MTO LS-616)
5) Micro-Deval abrasion loss– MDA (MTO LS-619)
6)Uncompacted void content (MTO LS-628)


MDA Test

Uncompacted Void Content

Physical, chemical and Petrographic Analysis of Fine Aggregate Sample

Sample	Insoluble Residue MTO LS-613 IR_T (%)	Insoluble Residue MTO LS-613 $IR_{R.75}$ (%)	MDA Loss (%) MTO LS-619	Absorption (%) MTO LS-605	Average Bulk Relative Density	Uncompacted Void (%) LS 628	Silicates	Carbonates	Shale, Argillite, Clay, Ochre	Micas	Chert	Cemented Particles
W01	54.7	33.0	11.7	0.99	2.715	43.4	27.0	67.1	0.0	0.5	5.4	0.0
W05	18.9	16.0	13.2	1.06	2.733	41.6	26.4	73.4	0.0	0.1	0.1	0.0
W06	31.9	27.6	13.1	1.48	2.636	41.4	31.0	68.3	0.0	0.2	0.5	0.0
W09	61.7	58.1	11.1	1.45	2.602	40.1	50.3	46.1	0.0	0.3	3.1	0.0
C01	61.9	57.8	8.5	0.67	2.664	40.2	56.3	41.9	0.0	0.5	0.0	1.3
C02	57.4	51.3	12.5	1.33	2.623	41.4	40.9	55.2	0.0	0.2	0.0	3.7
C03	36.7	50.6	15.5	0.82	2.668	41.1	53.6	45.3	0.0	0.4	0.0	0.7
C04	47.5	43.4	8.4	0.45	2.685	39.9	45.3	54.1	0.0	0.6	0.0	0.0
C05	48.3	43.5	8.9	0.40	2.693	40.9	41.2	58.3	0.0	0.4	0.1	0.0
C06	48.1	44.8	9.4	0.56	2.675	40.6	50.7	47.8	0.0	1.2	0.3	0.0
C07	40.3	36.2	15.0	1.35	2.665	42.8	38.3	59.8	0.0	0.4	0.3	1.2
C08	57.0	52.0	9.6	*	*	*	49.6	46.3	0.0	1.3	0.6	2.1
C09	49.3	46.9	8.6	0.59	2.686	41.7	52.2	45.8	0.0	1.3	0.0	0.7
C11	47.2	44.2	9.4	0.58	2.676	40.1	43.8	55.7	0.0	0.5	0.0	0.0
C12	51.1	45.0	11.5	1.00	2.751	44.1	37.4	60.6	0.0	0.0	0.5	1.5
C13	73.3	67.9	15.8	1.88	2.682	45.1	52.8	43.0	0.1	0.0	0.5	3.6
C14	92.6	91.5	6.7	0.31	2.726	47.9	95.8	0.0	0.0	4.2	0.0	0.0
C15	39.7	34.5	12.9	1.07	2.692	41.7	41.1	57.3	0.0	0.6	0.4	0.5
C16	24.5	18.0	11.3	1.02	2.718	41.7	28.7	70.6	0.0	0.7	0.0	0.0
C17	42.3	36.5	10.6	1.23	2.676	42.3	33.6	61.7	0.0	0.6	1.3	2.8
C19	2.9	0.0	15.4	1.36	2.748	47.2	1.4	98.6	0.0	0.0	0.0	0.0
E01	38.5	33.8	14.2	0.87	2.664	41.8	38.2	61.3	0.0	0.5	0.0	0.0
E02	46.0	41.1	8.5	0.55	2.682	40.3	44.2	54.7	0.0	1.1	0.0	0.0
E05	64.9	59.4	14.4	0.71	2.697	31.4	62.8	36.2	0.0	0.9	0.0	0.1
E06	73.7	70.9	10.9	0.98	2.657	42.8	72.1	23.8	0.0	3.4	0.6	0.2
E07	68.8	62.0	14.5	0.92	2.68	42.2	53.9	43.9	0.0	1.8	0.0	0.4
E10	65.7	59.1	11.8	0.81	2.663	43.3	55.8	41.6	0.1	2.5	0.0	0.1
NE01	96.6	95.4	4.6	0.37	2.711	43.4	95.0	0.0	0.0	5.0	0.0	0.0
NE02	95.8	93.5	6.1	0.49	2.79	51.2	89.1	0.0	0.0	10.9	0.0	0.0
NE03	94.5	92.1	4.0	0.46	2.697	41.0	99.5	0.0	0.0	0.5	0.1	0.0

*Insufficient material for testing

3.1 Mortar Mix Design

- Mix used for this investigation was adopted from the requirements the MTO Method of Test for Accelerated Detection of Potential Deleterious Alkali-Silica Reactive Aggregate by Expansion of Mortar Bars, LS-620, with a water/cement= 0.44, Fineness Modulus of 2.9.
- General Use Type 10 cement provided by St.Mary
- Mortar quantities for 8 MAV coupon and 6 compressive strength cube

Design Quantities of Individual Mortar Mixes for Test Specimens

Material		*Mass (g)	Cumulative % Retained
Aggregate (By Retained Sieve Size)	2.36 mm	269.2	10
	1.18 mm	673.0	35
	600 µm	673.0	60
	300 µm	673.0	85
	150 µm	403.8	100
Water		526.4	-
GU Cement		1196.4	-

Properties of cement used for mortar mix

Composition	Value
SiO_2	19.6 (%)
Al_2O_3	4.9 (%)
Fe_2O_3	3.1 (%)
CaO	61.4 (%)
MgO	3 (%)
SO_3	3.6 (%)
Alkalis (as Na_2O)	0.7 (%)
Loss on Ignition	2.3 (%)
Specific Gravity	3.15


GU Type 10 Cement

3.2 Mixing, Casting and curing of mortar coupons

- Mortar coupons were prepared using the AAV molds
- Mold dimensions are 92±0.1 mm in length, 54±0.1 mm in width and 16±0.1 mm in depth
- Depth of the specimen was reduced to 15±0.1 mm to diminish the breakage of the mortar during demolding


MAV/AAV Mold

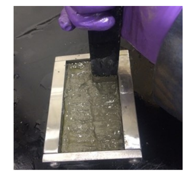
ASTM C305 mixing procedure →

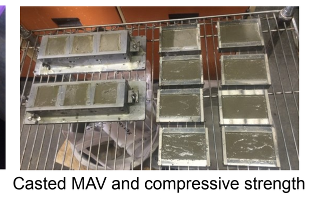

Adding Water

Adding Cement

Adding Fine Aggregate

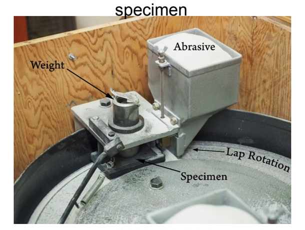
- Mix was casted into MAV and compressive strength molds in 2 lifts and each lift was compacted 36 times
- Specimens were placed in curing room until test dates


Compaction


Casted MAV and compressive strength specimen

3.3 MAV Testing

1) Specimen were surface dried using a towel after removal of curing room
1) Initial weight of specimen was measured prior to test
2) A weight is placed centrally on top of the specimen on wheel lap to prevent movement
1) Use of Ottawa silica sand as an abrasive agent
2) After testing the final mass was recorded.
3) Average mass loss of 4 specimens for each aggregate was reported as test result



Close view of MAV/AAV Apparatus

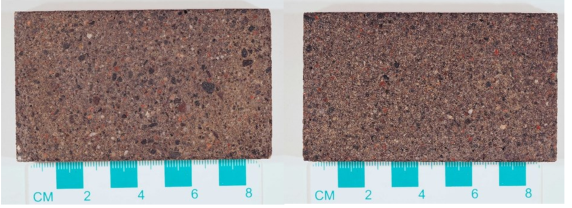
4.0 Results and Discussion

4.1 MAV Results

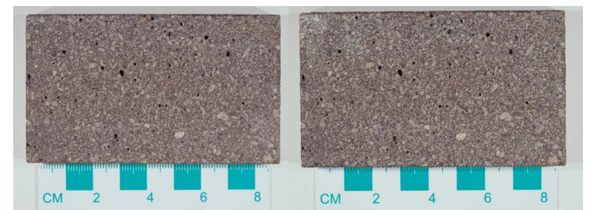
- MAV= Average mass loss of 4 coupon for each designated aggregate source
- Outliers were eliminated if average MAV differed by more than 0.2
- Compressive strength results were reported as per ASTM C109 Standard

7 and 28-day Compressive Strength and MAV (Mass Loss) results

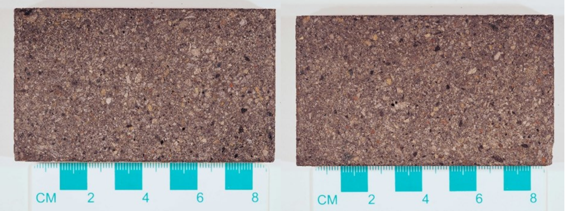
Sample	7-Day Compressive Strength (MPa)	7-Day MAV_7 (g)	7-Day s	7-Day Max	7-Day Min	28-Day Compressive Strength (MPa)	28-Day MAV_{28} (g)	28-Day s	28-Day Max	28-Day Min
W01	50.5	10.95	1.85	12.6	9.3	59.8	10.27	0.51	10.7	9.7
W05	48.4	12.58	1.38	13.8	10.7	57.1	11.08	1.03	12.0	9.6
W06	48.3	11.6	0.70	12.5	11.0	52.6	10.50	1.03	11.7	9.2
W09	47.7	11.75	0.97	12.7	10.5	53.1	10.08	1.70	12.5	8.8
C01	45.7	10.65	1.40	12.3	9.3	56.9	10.28	0.94	11.4	9.4
C02	43.9	10.70	1.34	12.3	9.5	61.0	9.80	0.27	10.0	9.5
C03	49.4	9.87	0.32	10.1	9.5	55.7	9.33	0.77	10.3	8.5
C04	38.7	10.08	0.34	10.4	9.6	51.9	9.68	0.81	10.4	8.6
C05	46.0	12.20	0.61	12.9	11.7	54.8	11.30	0.51	11.8	10.6
C06	46.4	12.15	0.92	12.8	9.4	55.9	10.60	0.80	11.5	9.8
C07	47.9	11.93	0.85	12.8	11.1	60.3	10.83	0.90	12.1	10.2
C08	46.1	10.90	1.14	12.6	10.2	61.5	10.10	0.62	10.6	9.2
C09	45.8	11.18	0.68	11.9	10.5	61.4	10.93	0.67	11.5	10.2
C11	42.3	10.20	0.36	10.5	9.8	60.2	9.90	0.27	10.1	9.5
C12	54.7	11.80	0.96	12.5	10.4	66.4	11.45	0.39	11.8	10.9
C13	53.4	10.24	0.82	10.9	9.4	63.9	9.76	0.92	10.5	9.1
C14	47.7	11.35	0.83	12.1	10.4	54.0	10.28	0.25	10.6	10.0
C15	49.7	12.58	0.67	13.5	11.9	55.6	9.83	0.55	10.2	9.2
C16	50.9	13.45	0.58	14.3	13.1	55.7	11.65	0.86	12.4	10.5
C17	39.7	11.53	0.92	12.7	10.7	56.1	10.33	0.82	11.3	9.3
C19	42.0	14.8	1.67	16.0	9.1	52.7	11.18	1.63	12.8	9.4
E01	42.1	11.10	0.52	11.7	10.8	52.4	10.23	0.59	10.8	9.4
E02	44.9	11.50	1.50	13.0	10.0	53.7	11.70	0.84	12.6	10.8
E05	52.7	11.70	0.53	12.4	11.2	60.9	10.67	0.67	11.1	9.9
E06	43.3	12.60	0.70	13.4	12.1	51.0	10.05	0.99	11.4	9.3
E07	48.9	11.90	0.56	12.5	11.4	52.1	10.50	0.37	10.9	10.1
E10	51.2	10.53	0.60	11.3	10.0	52.9	11.53	0.49	11.1	10.2
NE01	50.5	11.10	0.98	11.9	10.0	57.4	10.73	0.46	11.0	10.2
NE02	38.9	13.71	0.77	14.9	12.5	47.5	12.76	0.49	13.6	12.0
NE03	48.2	9.90	1.25	11.2	8.7	61.9	8.75	0.93	9.4	7.4
Average	46.9	11.55	-	-	-	56.5	10.54	-	-	-
Max	54.7	14.80	-	-	-	66.4	12.76	-	-	-
Min	38.7	9.88	-	-	-	47.5	8.75	-	-	-
Range	16.0	4.93	-	-	-	18.9	4.01	-	-	-
Standard Deviation	4.1	1.13	-	-	-	4.3	0.80	-	-	-


Sample NE03 after abrasion testing – 7-day (left) and 28 day (right)

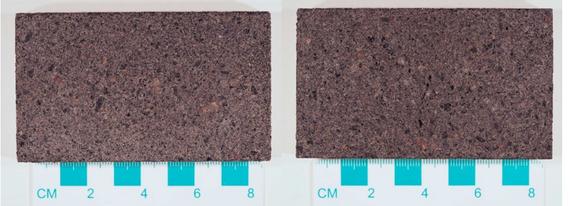
- Surface Texture for NE03 Specimen containing 99.5% silicate mineral aggregate as determined by petrographic analysis and 94.5% IR_T
- MAV_7 specimen has a rough texture with exposed aggregates on the surface, while an evenly abraded surface is visualized for MAV_{28} coupon


Sample C19 after abrasion testing – 7-day (left) and 28 day (right)

- Surface Texture for C19 Specimen with 98.6% carbonate mineral and 2.4% IR_T
- No observable surface texture variation between the tested coupons for 7 day and 28 day curing
- Both coupons have a very smooth surface texture with evenly abraded surface

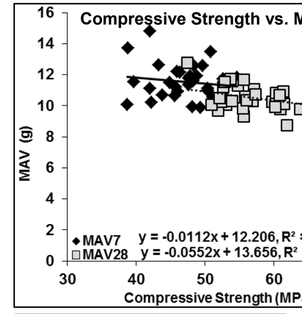

Sample C06 after abrasion testing – 7-day (left) and 28 day (right)

- Surface Texture for C06 Specimen with intermediate silicate and carbonate mineral - LS-616 silicate =50.7%, IR_T = 48.7%
- Small difference in terms of MAV_7 and MAV_{28} surface texture
- Both specimens are abraded evenly but the MAV_7 coupon has a slightly rougher texture with respect to MAV_{28}

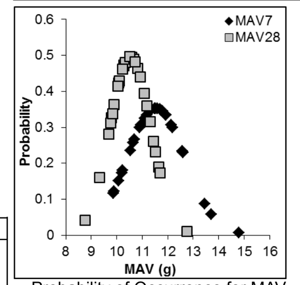

Sample NE02 after abrasion testing – 7-day (left) and 28 day (right)

- Surface texture for NE02 Specimen with 89.9% silicate and by 10.9% Mica mineral (IR_T = 95.8%)
- MAV_7 exhibits a rough surface texture with some coarser aggregates being abrade
- Even abraded surface texture may be seen on the MAV_{28} coupon, with fewer coarser aggregates being abraded.

4.2 Compressive Strength



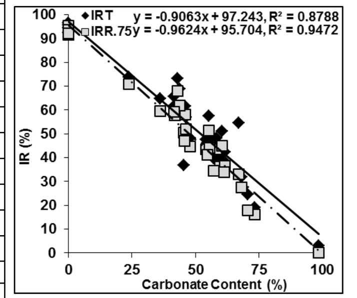
- 7 day compressive strength ranged from 38.7MPa to 54.7MPa and 28 days compressive strength ranged from 47.5 MPa to 66.4 MPa
- Higher compressive strengths resulted in lower MAV mass loss, although both 7 day and 28 day strengths show little correlation with MAV test results
- Both data sets show similar patterns - 28 day curing resulted in lower MAV losses, which is assumed to be a result of improved bond development due to prolonged cement hydration
- Significant Variation in compressive strength for both 7 and 28 days even though the same W:C ratio, fineness modulus and same casting and curing regime was used for all mixes



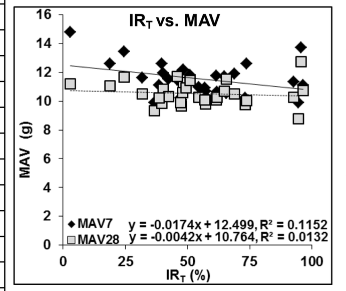
Probability of Occurrence for MAV

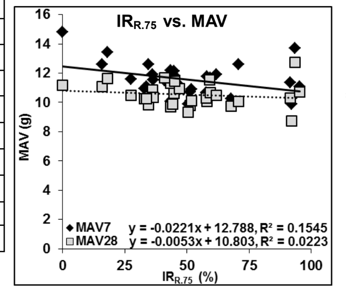
- Probability of occurrence for MAV losses at 7 and 28 days using Microsoft Excel
- Individual MAV data point and statistical mean and standard deviation (s) were inputted into the NORM distribution function to generate probability of occurrence
- Function determines the probability of each MAV losses with respect to the mean loss of the data set
- 35% and 50% probability of occurrence around the mean value for MAV_7 and MAV_{28}
- Higher probability for MAV_{28} test data demonstrates a lower mass loss, and subsequent higher resistance to abrasion with increasing age and curing time

4.3 IR and Petrographic Analysis

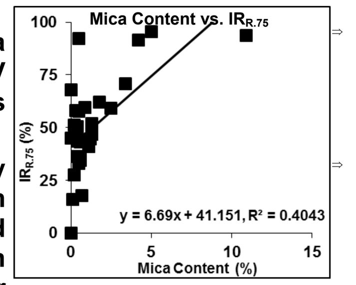


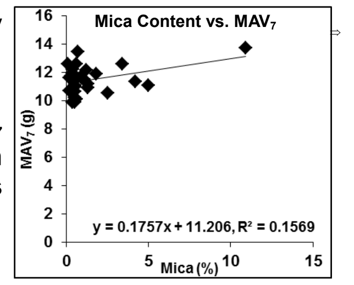
- IR_T reports the total residue left behind after digestion with HCl while $IR_{R.75}$ results only include the residue retained on the 75µm sieve after washing
- Material passing the 75µm sieve is silt and clay sized particles, which may be comprised of a significant amount of silicate clays minerals. Difference in IR_T and $IR_{R.75}$ may be used as an estimate of the clay component of carbonate rocks.
- Both IR and carbonate content determined by petrographic analysis correlate well, but a better correlation is demonstrated between the $IR_{R.75}$ results and carbonate minerals - both of these tests examine the retained 75µm fraction



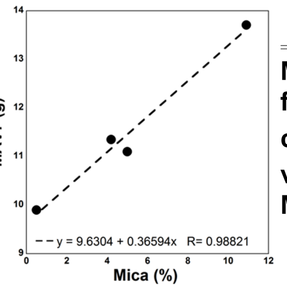


- Increasing IR(%), there is a general decrease in MAV losses even though R^2 is low
- MAV_7 results shows slightly improved correlation with respect to both IR_T and $IR_{R.75}$ results in comparison with MAV_{28} due to the lower bond strength of the 7 day samples
- R^2 coefficient for $IR_{R.75}$ results with respect to MAV_7 was improved by 34% in comparison with IR_T results demonstrating a better relationship

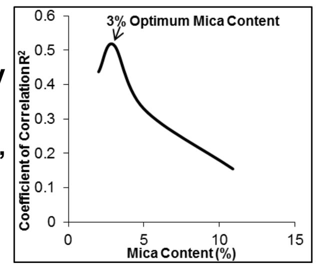


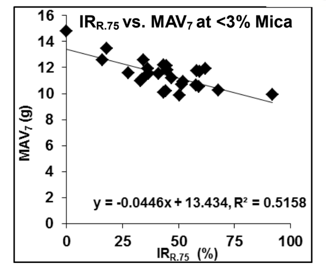


- The Increase in mica mineral content (LS-616), $IR_{R.75}$ increases with R^2 of 0.4043
- Mica is a silicate mineral that resist dissolving in HCL but only possess a Mohs hardness of 2.5
- With Increasing mica content, MAV_7 loss increases thus demonstrating the influence that mica has in decreasing abrasion resistance



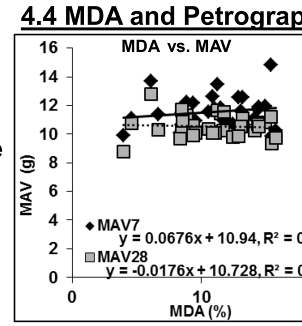
- Strong R^2 between Mica content and MAV for samples that contained high IR_T(%), variable Mica and MAV Loss



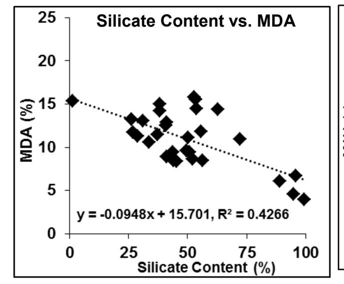


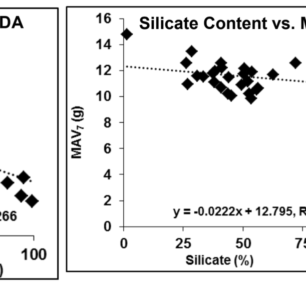
- <3% Mica Content –0.5158 R^2 correlation between $IR_{R.75}$ and MAV_7

4.4 MDA and Petrographic Analysis

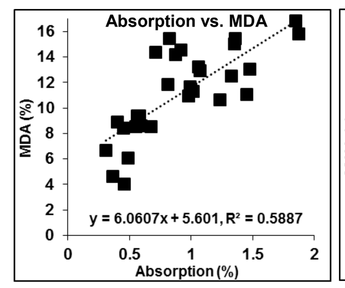


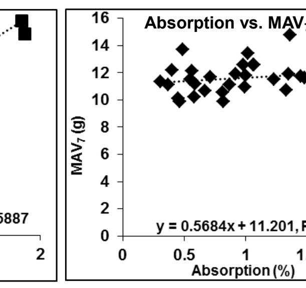
- 7 and 28 days MAV do not show any significant correlation with MDA
- MAV_7 loss has slightly improved relationship in comparison to MAV_{28}
- MDA and MAV tests are fundamentally different in how abrasion loss is simulated. MDA test produces abrasion by tumbling motion within a rotating jar while MVA test abrades the test specimen by shear attrition.
- Aggregate samples in this experiment meet the MDA requirements of MTO's current specifications of 20% maximum loss for concrete sands exposed on pavement surfaces





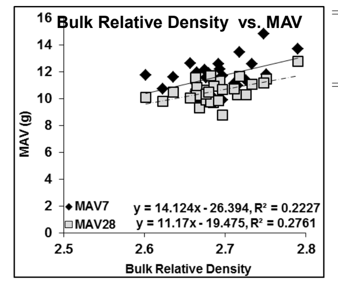
- Abrasion loss for MDA and MAV depends on aggregate's hardness and strength
- As Silicate content (LS-616) increases, the MDA and MAV_7 losses decrease for the data range in this experiment
- MDA has a significantly higher R^2 than MAV_7 due to influence of cement bond development that led to increased resistance of total mix against abrasion for MAV results





- R^2 between MDA and absorption is much stronger in compare to MAV
  - Aggregates in MDA tests are unbound in saturated environment whereas MAV test is conducted in dry on bound particles

4.5 Relative Density



- MAV_7 and MAV_{28} values increase with increasing bulk relative density of aggregates with R^2 values of 0.2227 and 0.2761 respectively
- Denser aggregates would result in higher mass loss for the same volume of material abraded.

5.0 Summary

- MAV test examined the response to abrasion of a total mortar mix using a modification of existing equipment used by MTO to measure the abrasion resistance of coarse aggregates by (AAV)
- Mortar mix design provided a low w:c ratio - led to relatively high compressive strength cured specimens. High compressive strengths represent a strong frictional bonding between the aggregate and the cement paste, which may led to the small range of abrasion loss for the various aggregate types
- Increased curing time the abrasion loss measurement loses its sensitivity with respect to the aggregate's hardness and becomes more dependent on the performance and bonding development of the cement paste as it has been demonstrated through the reduction of MAV
- Abrasion of mortars in the AAV apparatus reflected properties of both the mineral and the cement paste. Abrasion resistance as a function of the individual aggregate properties was not measured
- Increases in carbonate minerals by IR test resulted in increased in MAV test results indicating a lower resistance to abrasion
- Presence of micaceous minerals were identified as being significant in determining resistance to abrasion of the cement mortars. Aggregates containing high mica content showed low resistance to abrasion. Aggregates with less than 3% mica content led to an increase in R^2 between the MAV and IR results
- No relationship was demonstrated between MDA test (measures abrasion of a wet aggregate, and MAV test (measures abrasion of a mortar with the same aggregate). In general increasing silicate mineral content resulted in higher resistance to abrasion. However, MAV was less sensitive to this parameter
- No significant relationship between MAV losses and an aggregate's absorption capacity
- Test results identifies the positive effects of proper curing on abrasion resistance concrete pavement

6.0 Future Directions

- This specific MAV test method requires further investigation to increase the sensitivity of aggregates against abrasion by: i) Reducing the curing time - reduce the overall cement hydration, and corresponding bond strength; ii) Modification to the water to cement ratio - reducing bond strength effects iii) Variability of fine aggregate's strength in terms of higher MDA loss (>20%) beyond the acceptable limit of concrete pavement specification

Acknowledgements

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Thank you