Comparable Pavement Cracking Definitions NCHRP 1-57A

By

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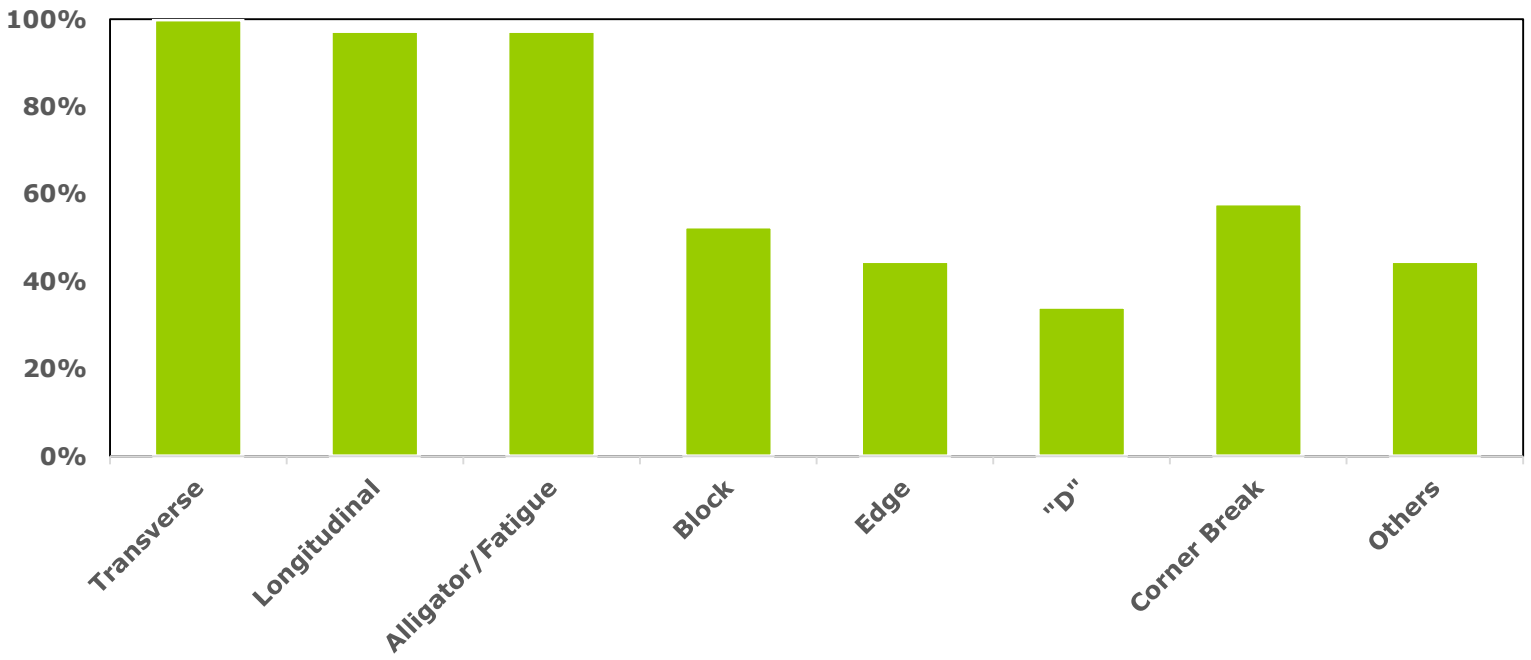
The 2019 RPUG & Pavement Evaluation, Roanoke VA

September 19, 2019

Online Survey

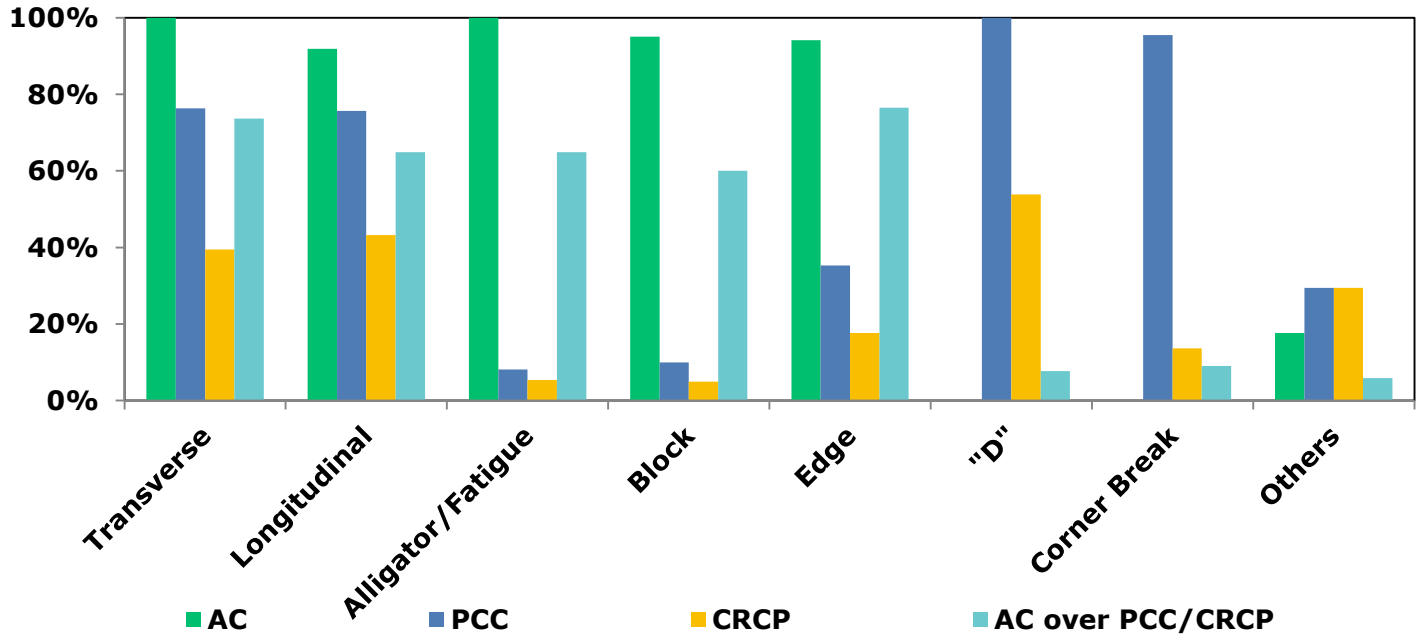
- Five Sections
  - Part I: Cracking data collection, processing, and common issues
  - Part II: Cracking definitions of transverse, longitudinal, alligator/fatigue, block, edge, durability "D" cracking, corner break, and other cracking data
  - Part III: Wheel-path Definitions
  - Part IV: AASHTO PP 67 Applications
  - Part V: General Comments
- Responses from 38 Different SHAs

Cracking Data Desired by SHAs, Overall



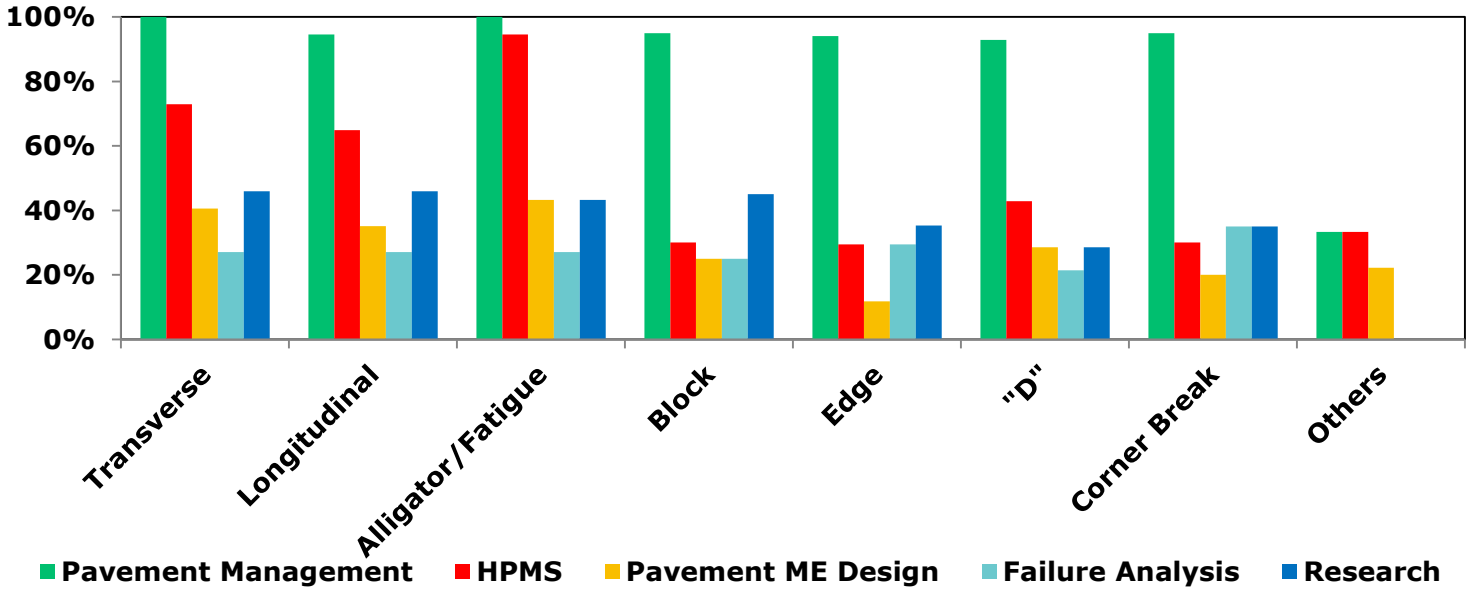
Nearly all SHAs collect transverse, longitudinal, and alligator/fatigue cracking

Cracking Data Desired by SHAs, Surface Types



- Typically collected cracking by SHAs
  - AC: transverse, longitudinal, alligator/fatigue, block, and edge cracking;
  - JPCP: transverse, longitudinal, “D” cracking, corner break;
  - CRCP: transverse, longitudinal, “D” cracking, and shattered slabs.

Cracking Data Desired by SHAs, Applications



- PMS: transverse, longitudinal, alligator/fatigue, block, edge, “D” cracking, and corner break;
- HPMS reporting: transverse, longitudinal, and alligator cracking.

Cracking Data Desired by SHAs, HPMS

- AC or composite pavements: % of total wheel path area exhibiting fatigue-type cracking, all severity levels
- JPCP: % of slabs within the section that exhibiting transverse cracking
- CRCP: % of the area exhibiting longitudinal cracking, punchouts, and patching

Cracking Data Desired by SHAs, MEPDG

HMA Distress Data

IRI[1]	in/mile
Asphalt top/down (longitudinal) cracking	ft/mile
Asphalt bottom/up (alligator) cracking	% cracked per section length
Low temperature thermal cracking (transverse)	ft/mile
Asphalt rutting[2] (permanent deformation)	inches

JPCP Distress Data

IRI[1]	in/mile
Transverse cracking	ft/mile
% slab cracked per section	
Mean joint faulting[2]	inches

Continuously Reinforced Concrete Pavement (CRCP) Distress Data

IRI[1]	in/mile
Number of punchouts	per/mile
Maximum crack width	in
Minimum crack load transfer (transverse)	LTE%
Minimum crack spacing	ft
Maximum crack spacing	ft

[1] International Roughness Index, typical measured every tenth of a mile
[2] Average, standard deviation, COV, maximum, minimum

(AASHTO 2015)

Cracking Data Desired by SHAs, MAP-21

- Support the use of performance measures to drive investment decision-making
- Develop a risk-based asset management plan to improve the asset condition

Surface Type	Metric	Measure Range	Rating
Asphalt Pavement	Cracking_Percent	<5% 5-20% >20%	Good Fair Poor
JPCP	Cracking_Percent	<5% 5-15% >15%	Good Fair Poor
CRCP	Cracking_Percent	<5% 5-10% >10%	Good Fair Poor

Final Rulemaking (FHWA 2017)

Part I: Data Collection, Processing, & Common Issues

- 63% apply 2D/3D automated technologies for cracking data collection and processing
- 68% conduct QA/AC on automated cracking analysis results
- All SHAs collect transverse, longitudinal, & alligator/fatigue cracking
- Protocols: state specific (30%); HPMS Manual (27%), AASHTO R85 (23%); LTPP (17%); ASTM D6433 (3%)
- Cracking severity levels
  - 41% SHAs Use Average Crack Width
  - 18% per the highest severity
  - 15% per predominant crack width

Part II: Definitions, Linear Cracking

- Transverse cracking
  - 61% SHAs use angle orientation to define transverse cracking
  - Extent evaluation: linear length (29%); # transverse cracks (31%); # slabs affected (JPCP only) (25%)
  - Minimum length: 1 ft. (36%); 4ft (17%)
  - Crack width thresholds: ¼”~½” (34%); ¼”~¾” (27%)
- Longitudinal cracking
  - 59% SHAs use angle orientation to define longitudinal cracking
  - Extent evaluation: linear length (55%)
  - Minimum length: 1 ft. (33%)
  - Crack width thresholds: ¼”~½” (23%); ¼”~¾” (27%)

Part II: Definitions, Alligator/Fatigue Cracking

- 50% count the portion of cracking in wheel-path as alligator/fatigue cracking
- Extent evaluation: affected area (52%)
- Minimum length or area: no requirement (49%)
- Severity evaluation: crack width (23%); interconnectivity of cracks (27%)

Part II: Definitions, Other Cracking

- Block cracking
  - 44% of SHAs Collect Block Cracking
  - Extent Evaluation Factors: Linear Length (38%); Affected Area (54%)
- Edge cracking
  - 37% of SHAs Collect Edge Cracking
  - Extent Evaluation Factors: Linear Length (67%)
- Sealed cracking
  - 74% of SHAs Collect Sealed Cracking
  - 90% of SHAs Rate Sealed Cracking as "Low" Severity Level
  - 58% of SHAs Report "Linear Length" for Sealed Cracking
  - 55% of SHAs Do Not Collect and Report Other Cracking Data

Part II: Definitions, Concrete

- Durability ("D") cracking
  - Extent Evaluation Factor: Number of Slabs Affected (50%)
  - Severity Evaluation Factors: Level of Patterns Developed and Amount of Loose or Missing Materials (46%)
- Corner break
  - Extent Evaluation Factor: Number of Corner Breaks (41%); Number of Slabs Affected (45%)
  - Severity Evaluation Factors: Crack Width (31%); Level of Spalling (41%)

Part III: Wheel-Path Definitions

- 97% differentiate wheel-path and non-wheel-path zones
- 61% use 39”-1m as the width for wheel-path

Part IV: AASHTO PP 67 Application

- 73% have not implemented AASHTO PP 67
- Pros
  - Particular for automated cracking collection and analysis
  - Clear and reasonable wheel-path definition
- Cons
  - Do not meet data needs for HPMS reporting, PMS, or Pavement ME Design
  - Inconsistency with the historical data
- Recommendations: add severity levels and cracking density

Core Thinking of New Cracking Definitions

- Automation of cracking survey: consider the capabilities of computers
- Compatible with existing and future practices in both design and management
- Not based on LTPP Distress Manual, PCI definitions, or other manual processes
- Extensions or customizations for project level work

Three Levels of Cracking Definitions (Level 3)

- Level 3: Percent of cracking (baseline performance); Single Value

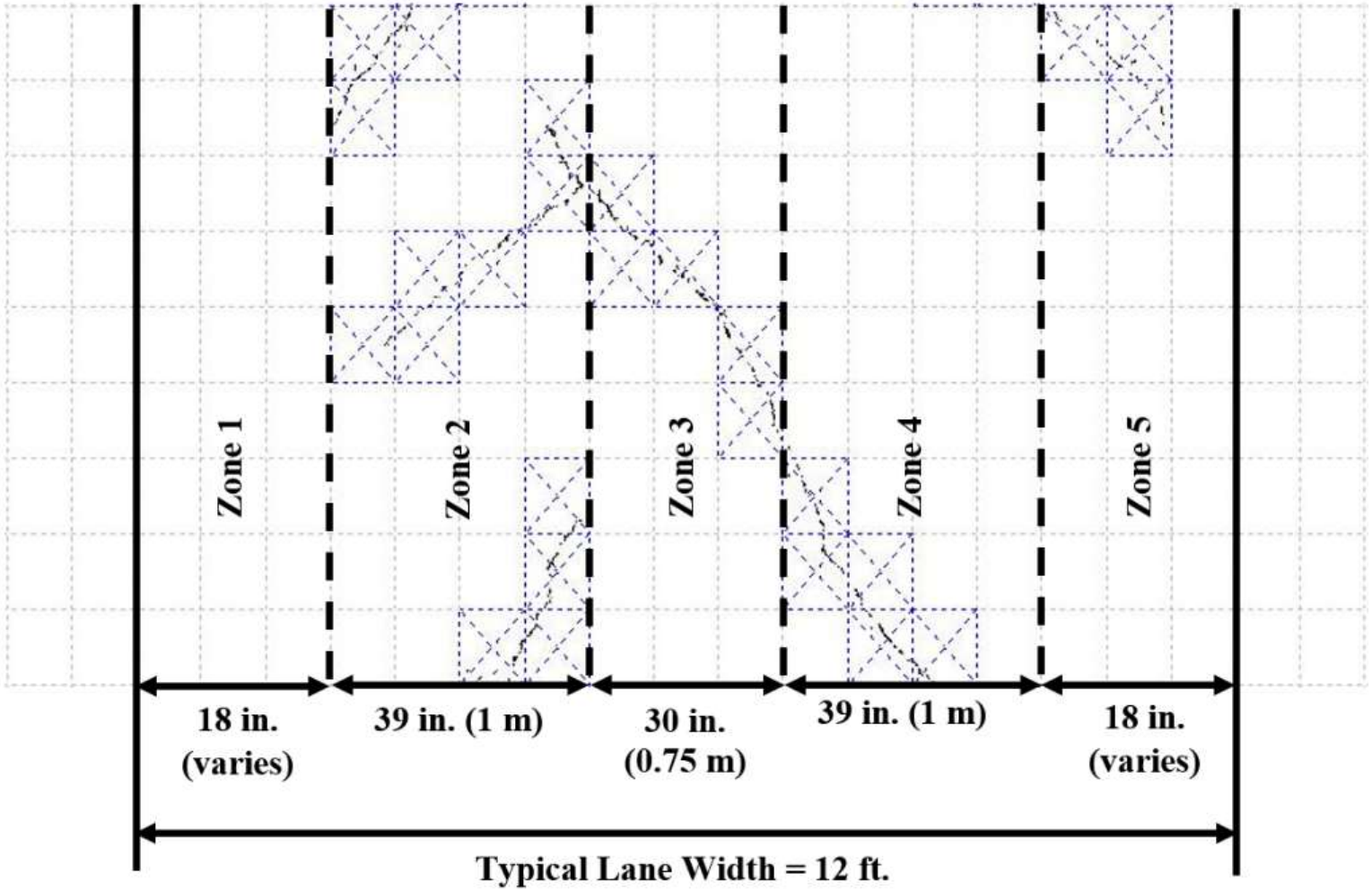
$$Index = \frac{n_c}{N} \times 100\%$$

Where:

n_c: 8 in. × 8 in. (200 mm × 200 mm) grid number containing cracks in one 50 m subsection

N: Total 8 in. × 8 in. (200 mm × 200 mm) grid number in one 164 ft. (50 m) subsection

Percent of Cracking Illustration

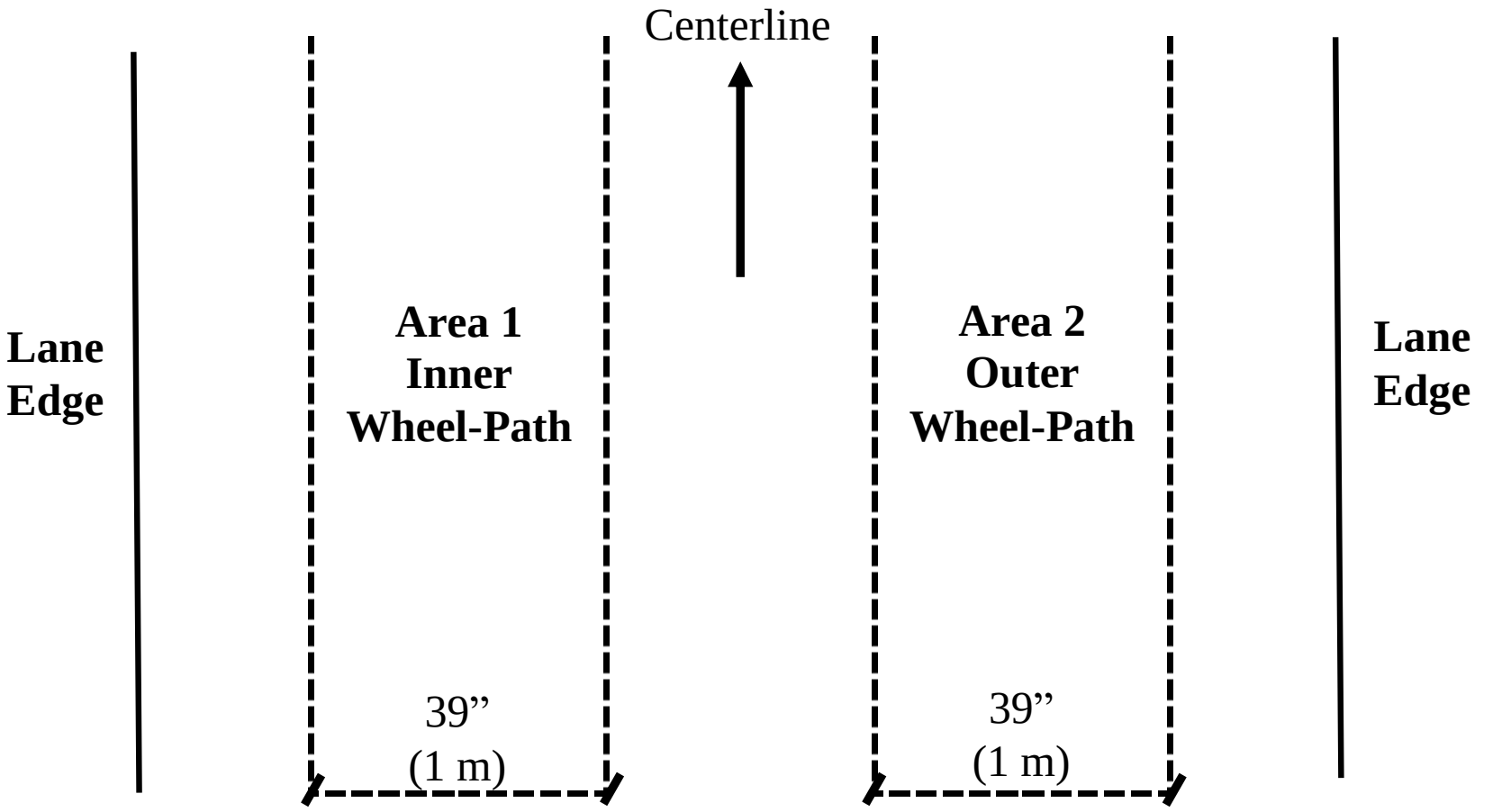


Level 3 with 10 in. 10 in.
(250 mm x 250 mm) grids with wheel paths

Three Levels of Cracking Definitions (Level 2)

- Level 2: Cracking on wheel-paths with severity details (moderate performance)
  - 3 severity levels within 2 wheel-path areas:
  - Severity 1: average crack width less than ¼ in. (6 mm)
  - Severity 2: average crack width between 1/4 in. (6mm) and 1/2 in. (13 mm)
  - Severity 3: average crack width greater than 1/2 in. (13 mm)
- Area 1: Inner wheel-path
- Area 2: Outer wheel-path
- Six Values + One Value from Level 3

Three Levels of Cracking Definitions (Level 2)



Three Levels of Cracking Definitions (Level 1)

- Level 1: Cracking with type, extent, and severity details (highest performance)
- Linear cracking (transverse & longitudinal): determined outside of the two wheel-paths along with their severity levels
- Cracking details in wheel-paths: remain the same as these at Level 2
- Level 1: the most detailed definitions

Preliminary Field Validation

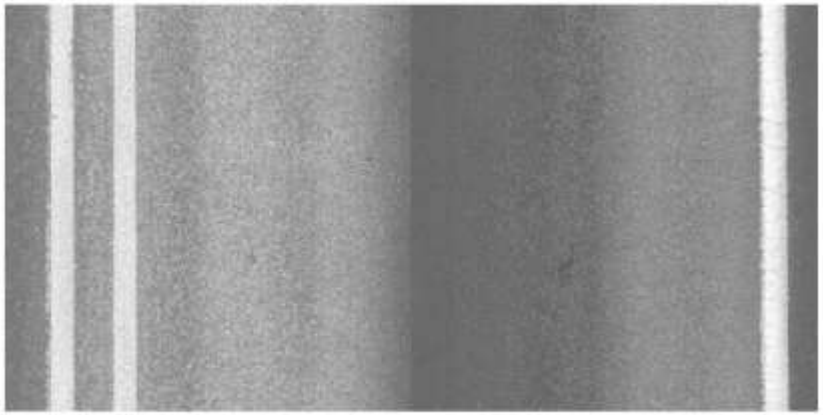
- 12 selected sites
  - Cracking with low, medium, and high severity
  - Flexible & rigid
  - 0.2 miles in length
  - 5 runs per site for repeatability
- 60 data collections in total

Automated Lane Marking Detection

- Automatic lane marking detection: based on 2D images using a matched filter

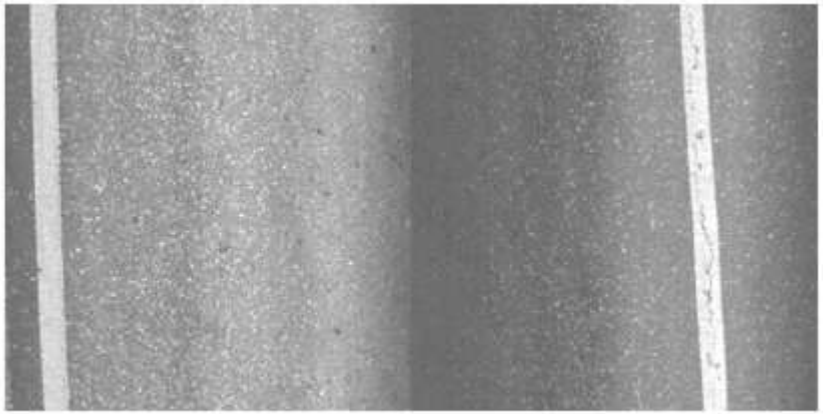
- F-measures: to evaluate the detection accuracy

Automated Lane Marking Detection



Raw Pavement Image #1

Detection Result #1

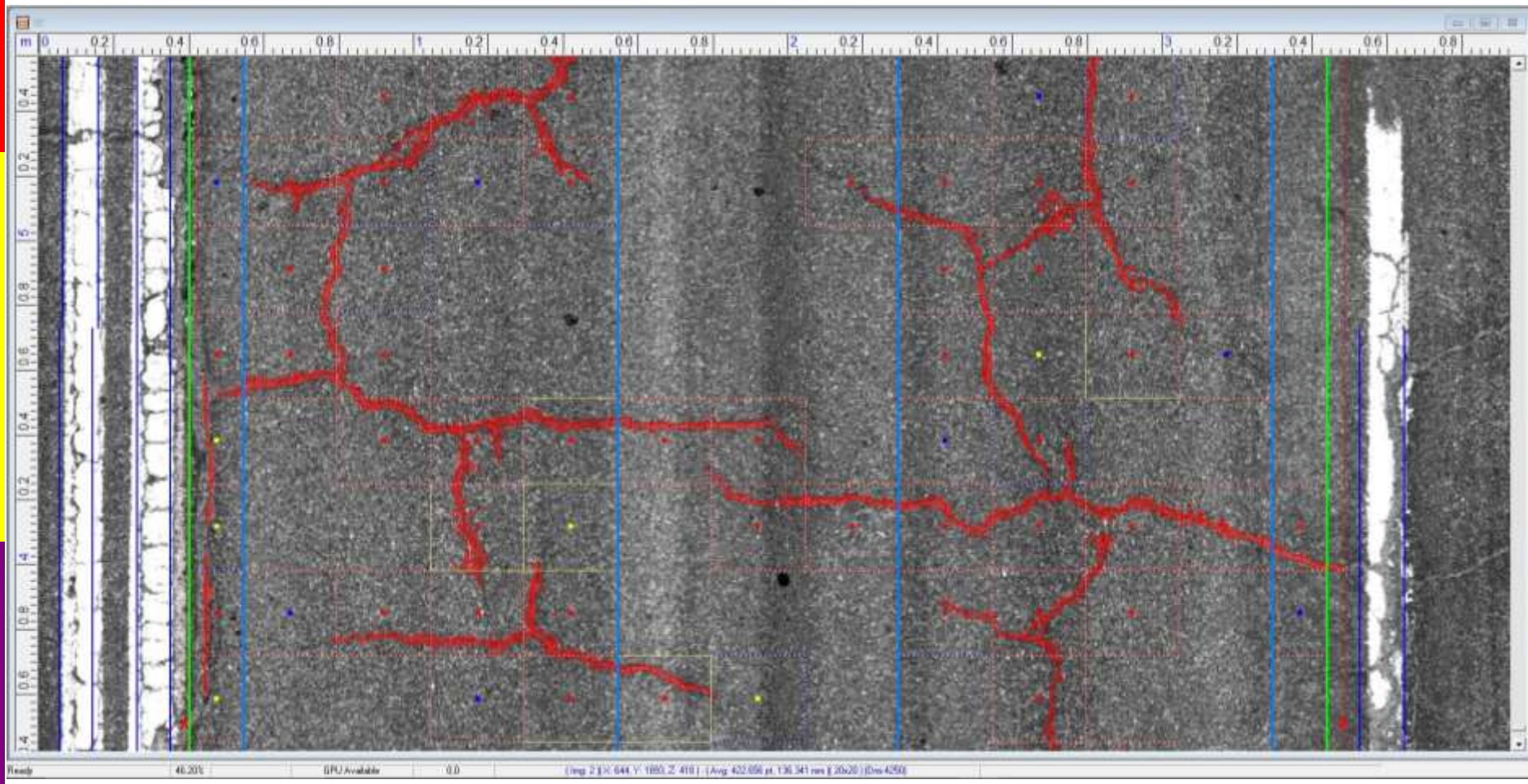


Raw Pavement Image #2

Detection Result #2

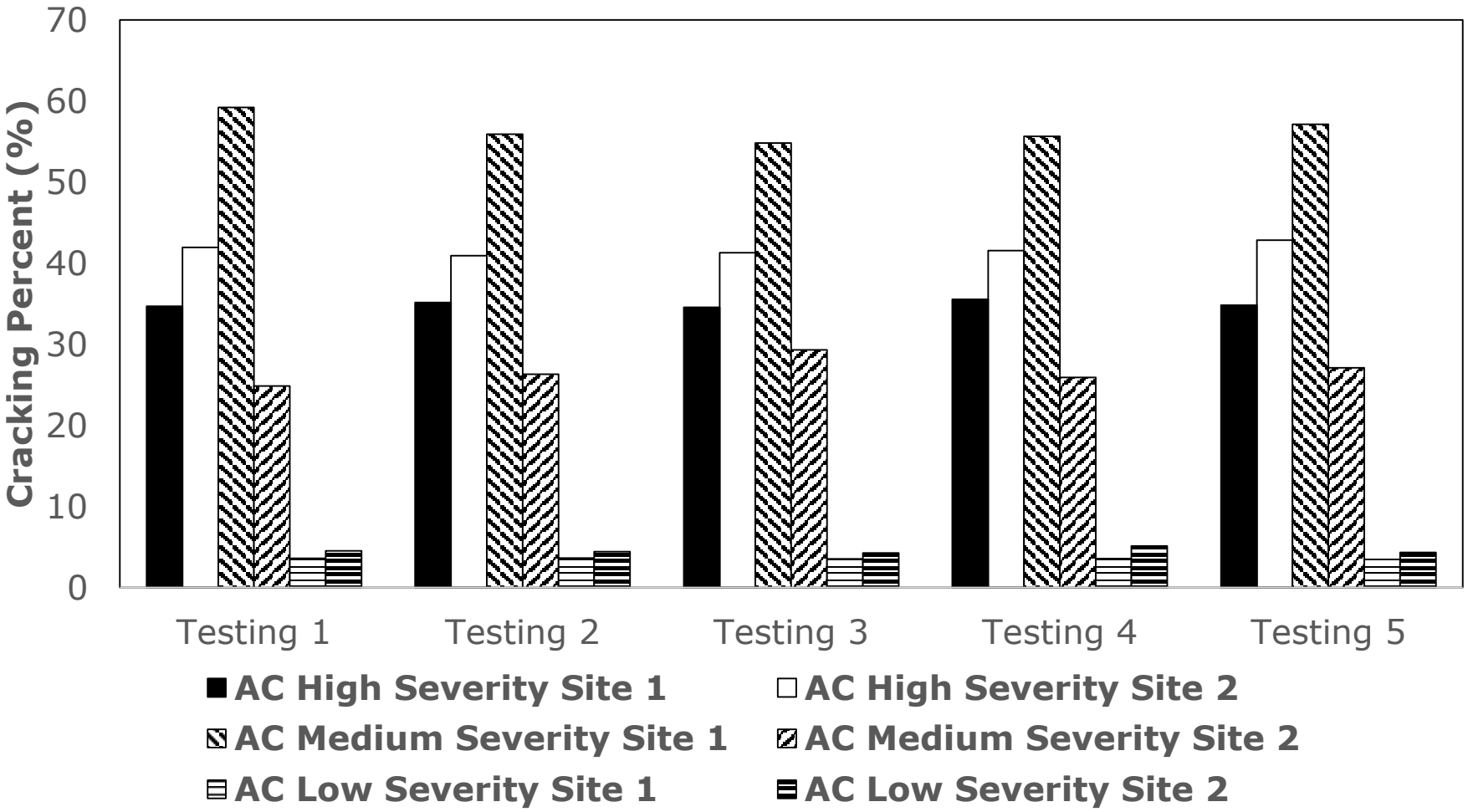
Illustration of lane marking detection

Deep-Learning CrackNet Interface



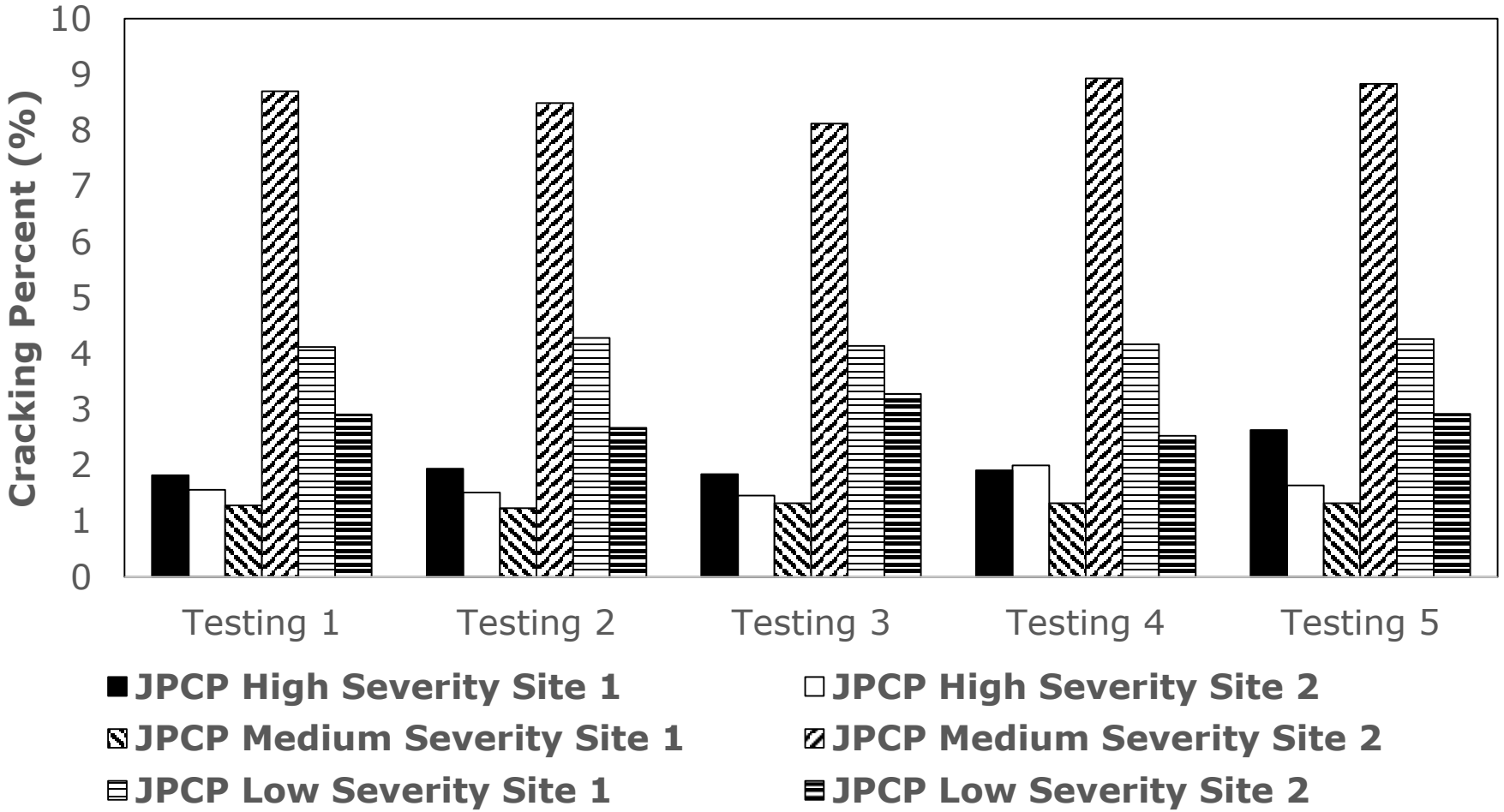
Screenshot of ADA Software

Level 3 Results



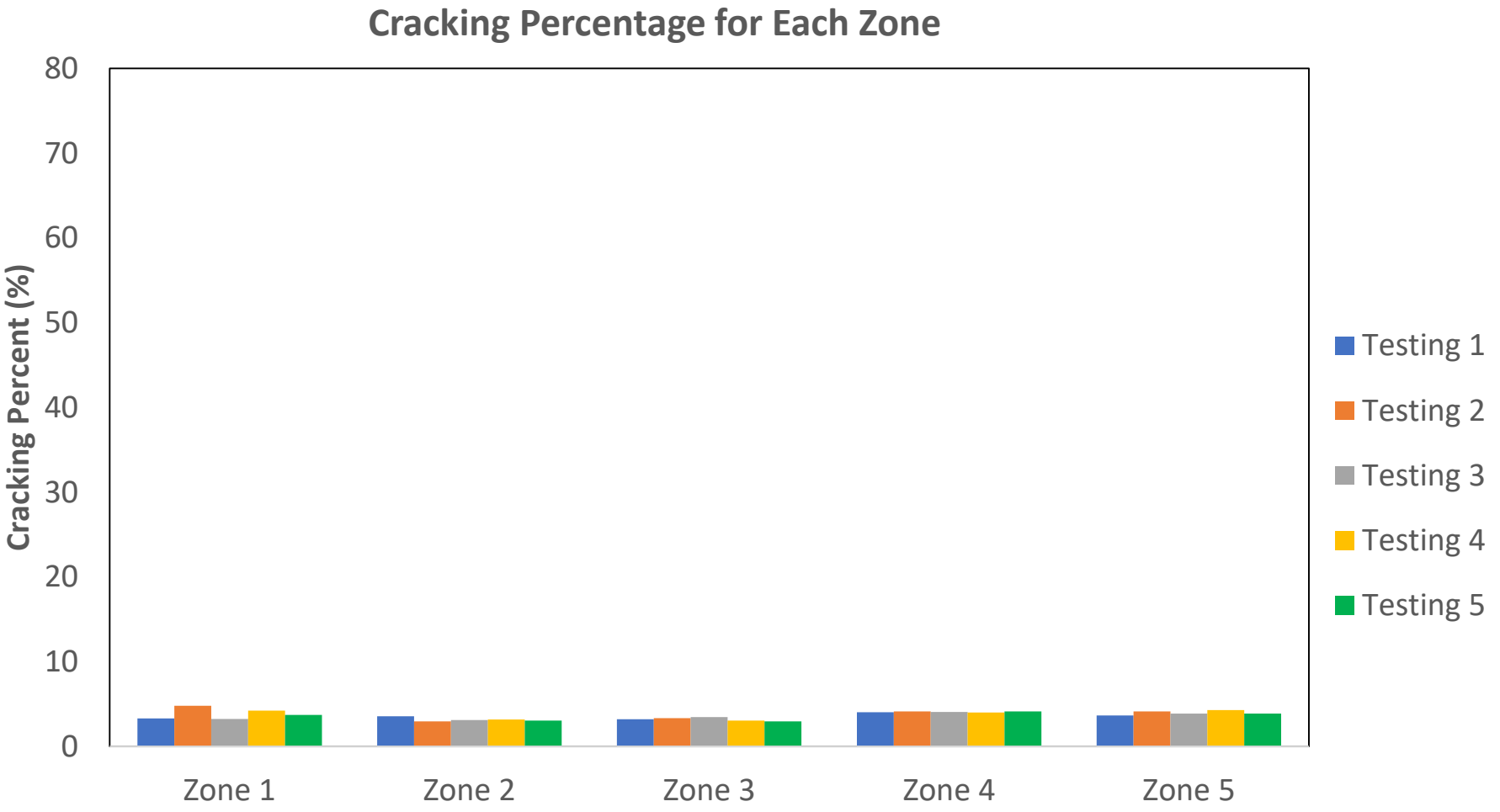
Level 3 Cracking Data for AC Sites

Level 3 Results



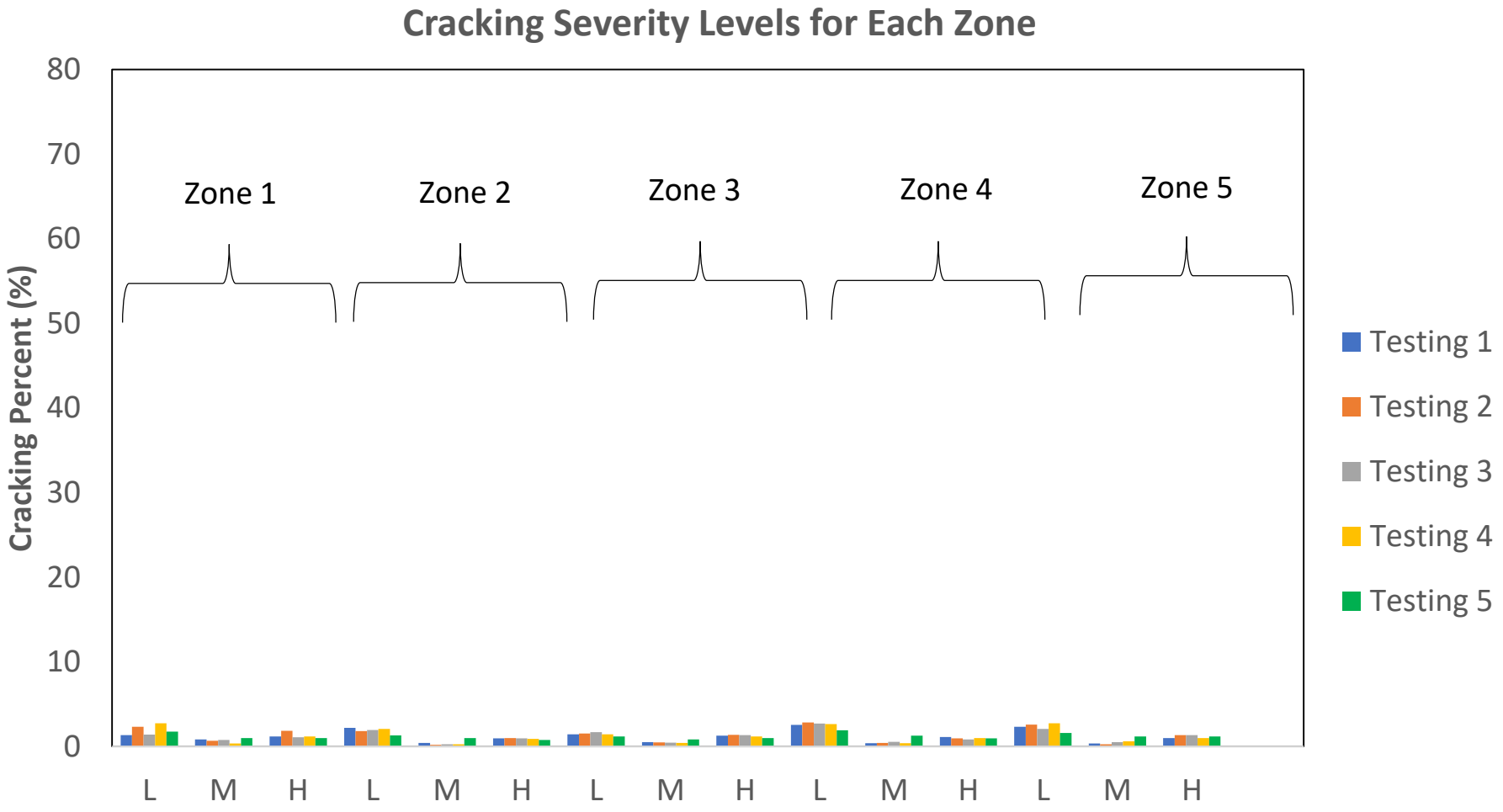
Level 3 Cracking Data for JPCP Sites

Level 2 Results



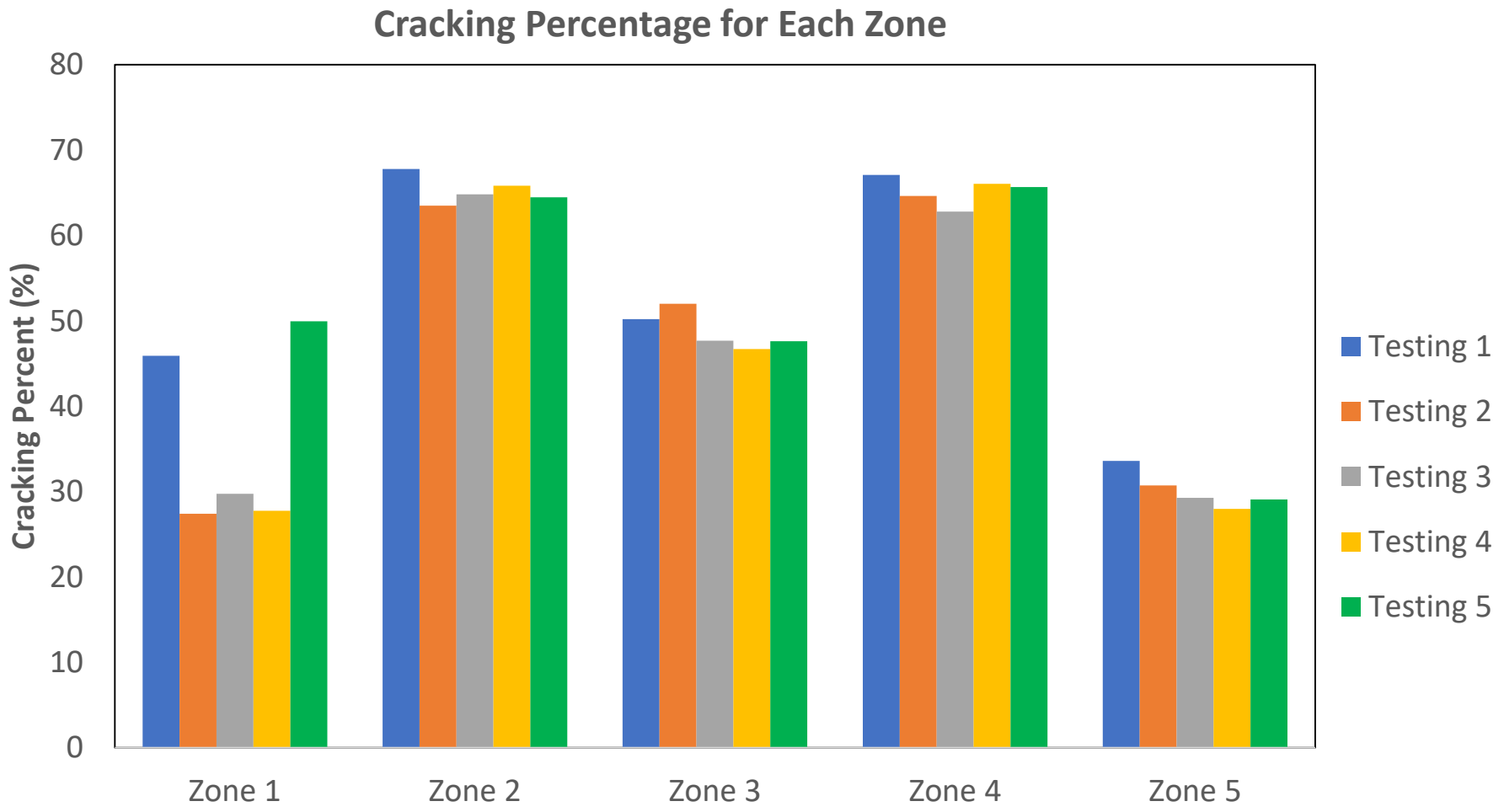
Level 2 Cracking Data for AC Low Severity Site 1

Level 2 Results



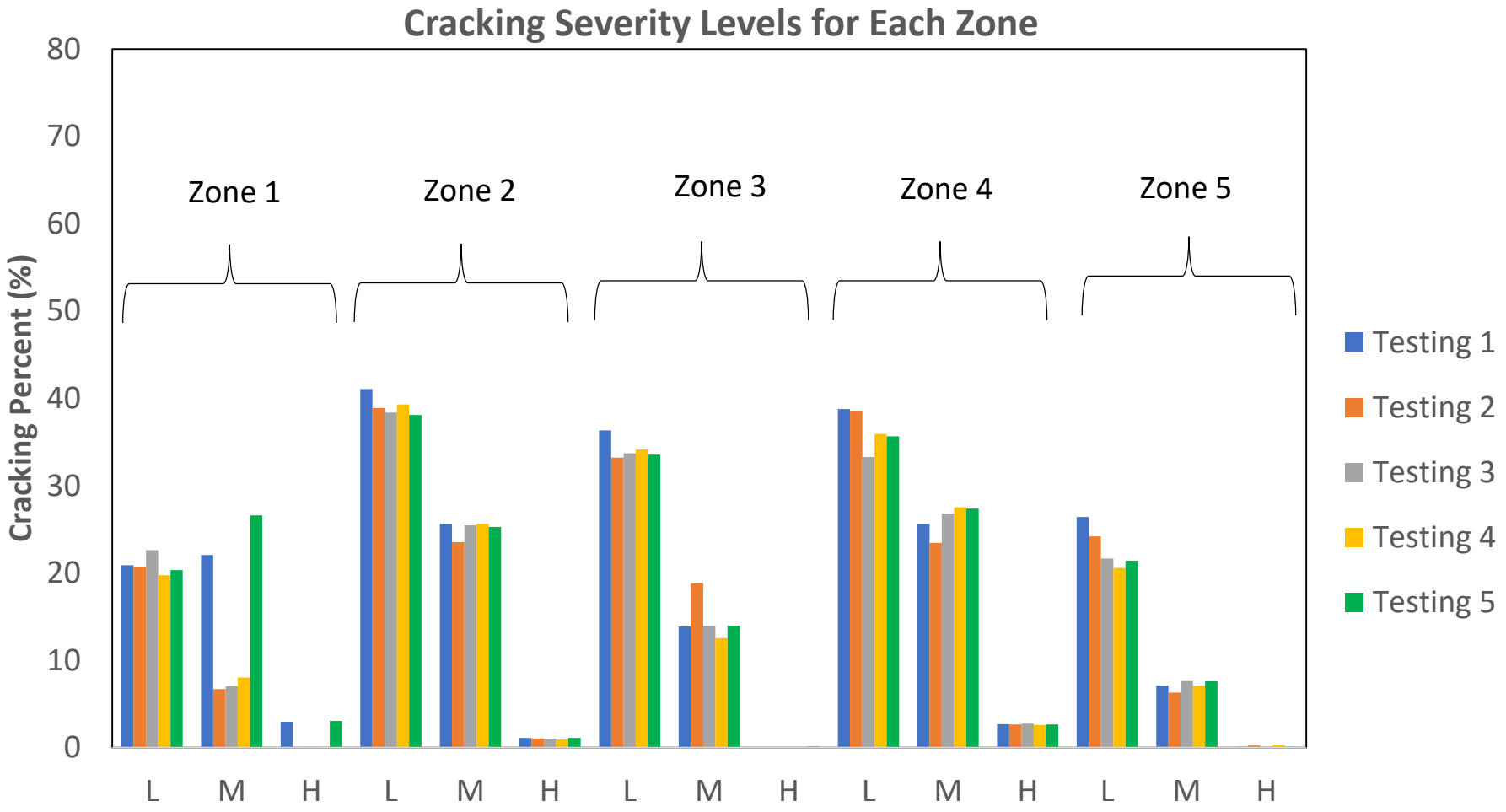
Level 2 Cracking Data for AC Low Severity Site 1

Level 2 Results



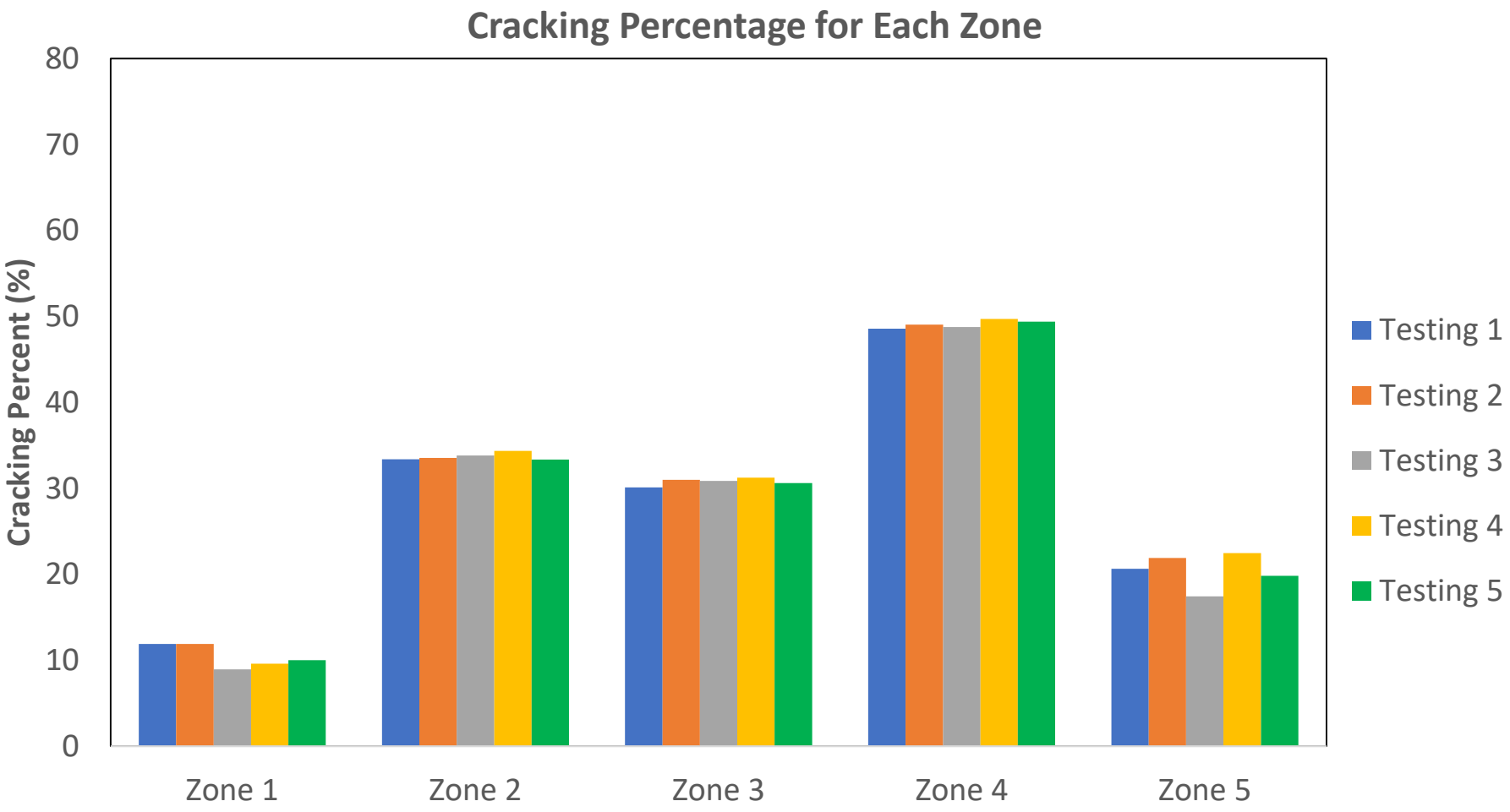
Level 2 Cracking Data for AC Medium Severity Site 1

Level 2 Results



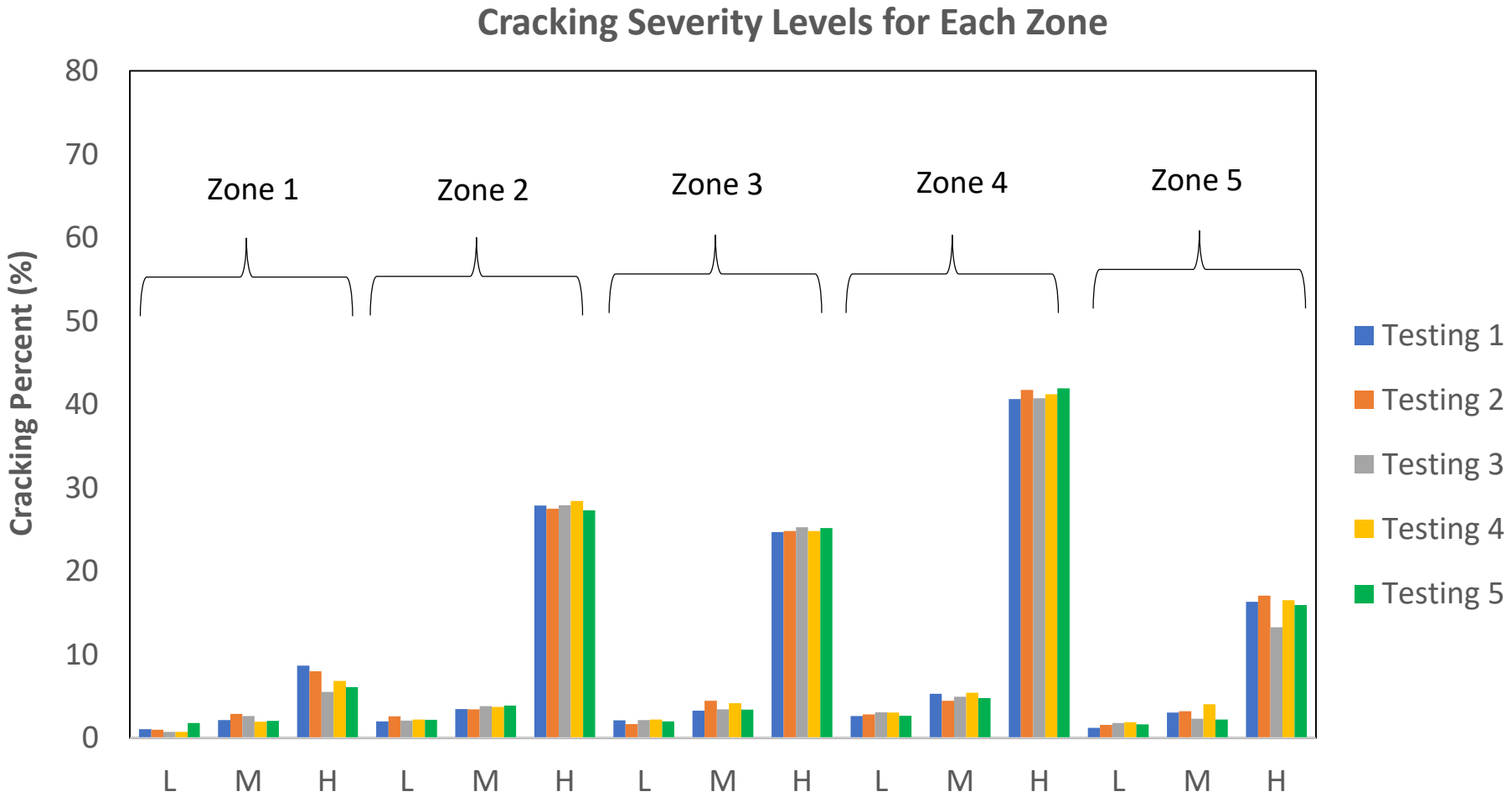
Level 2 Cracking Data for AC Medium Severity Site 1

Level 2 Results



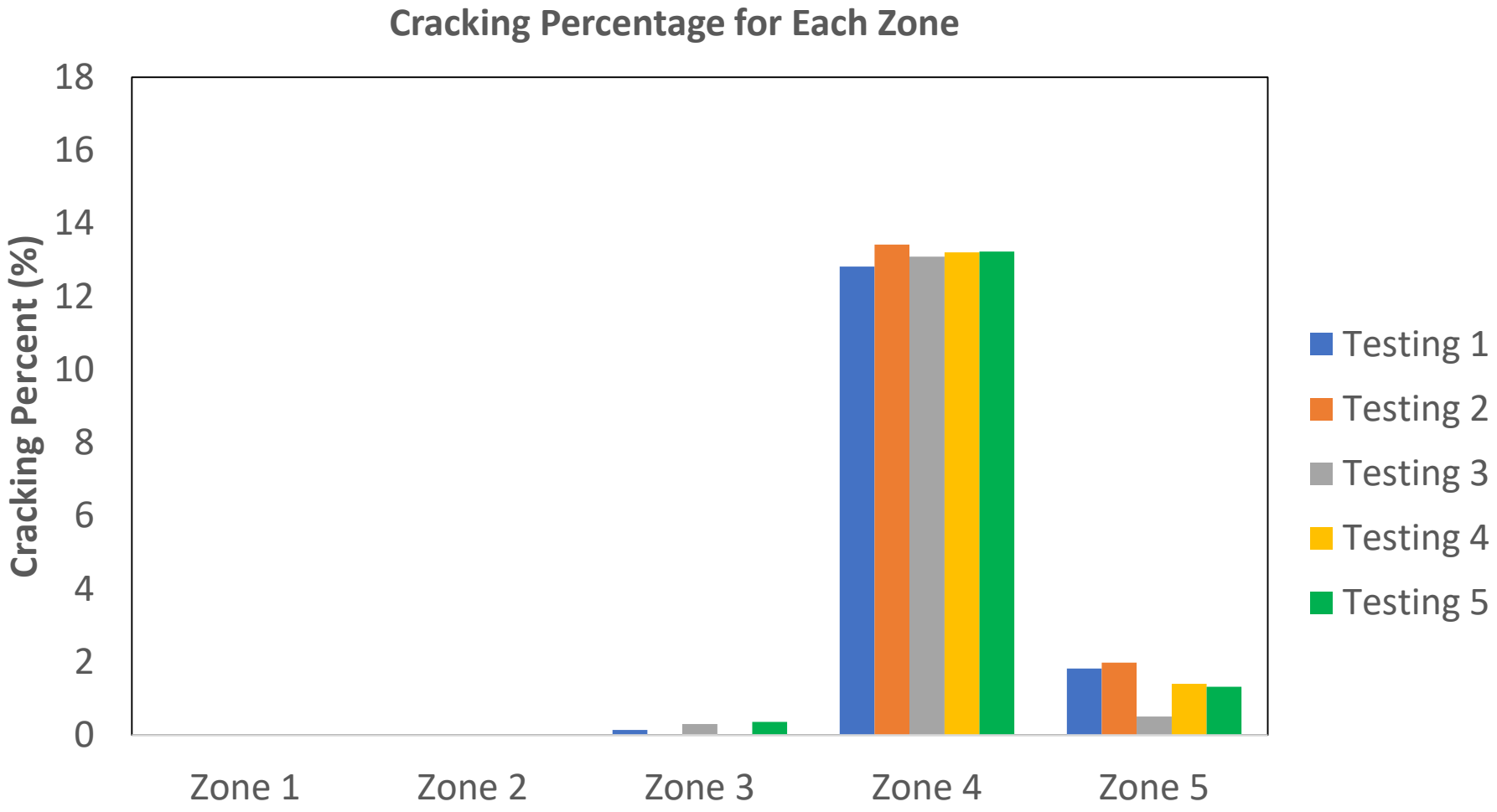
Level 2 Cracking Data for AC High Severity Site 1

Level 2 Results



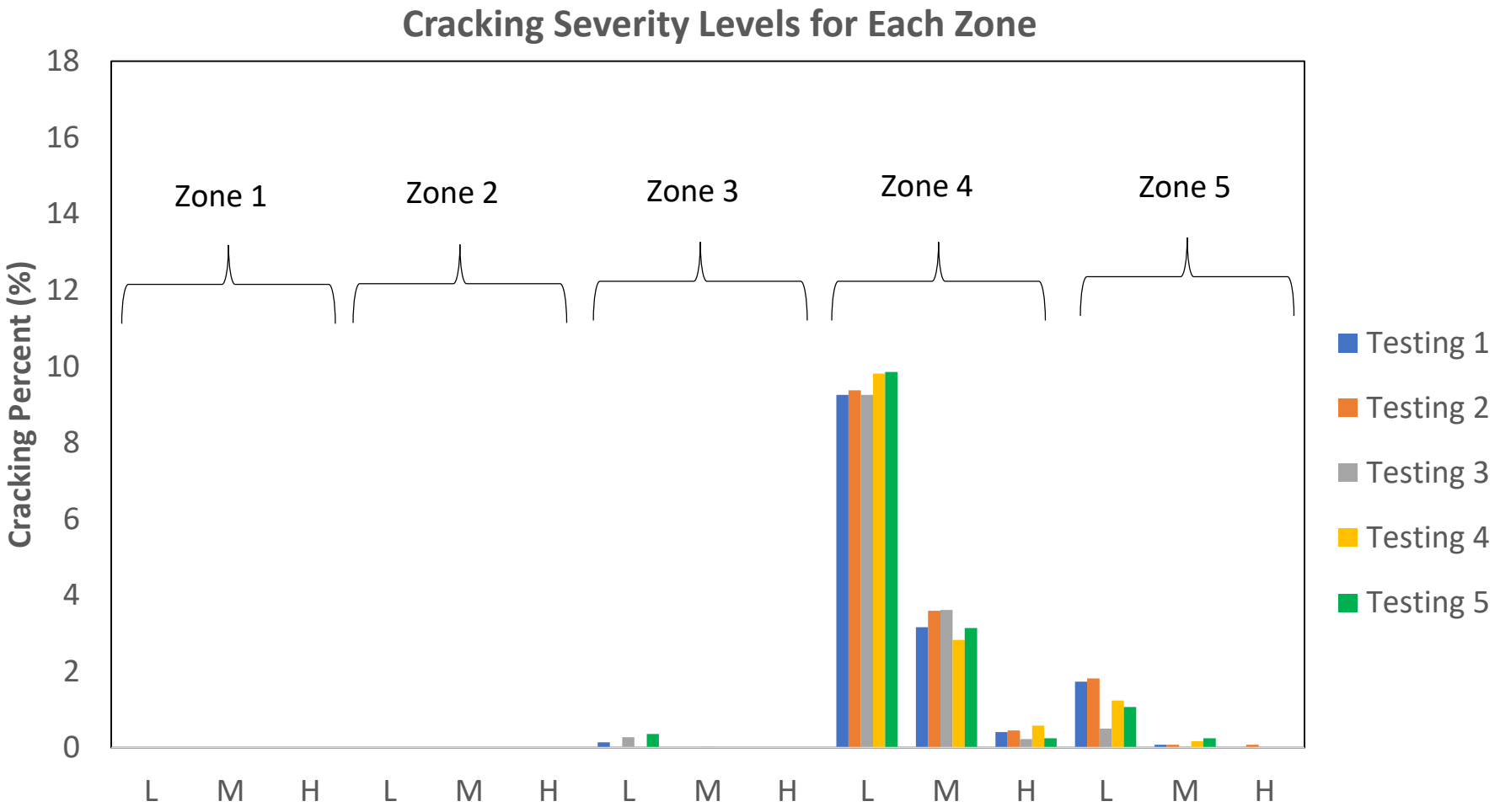
Level 2 Cracking Data for AC High Severity Site 1

Level 2 Results



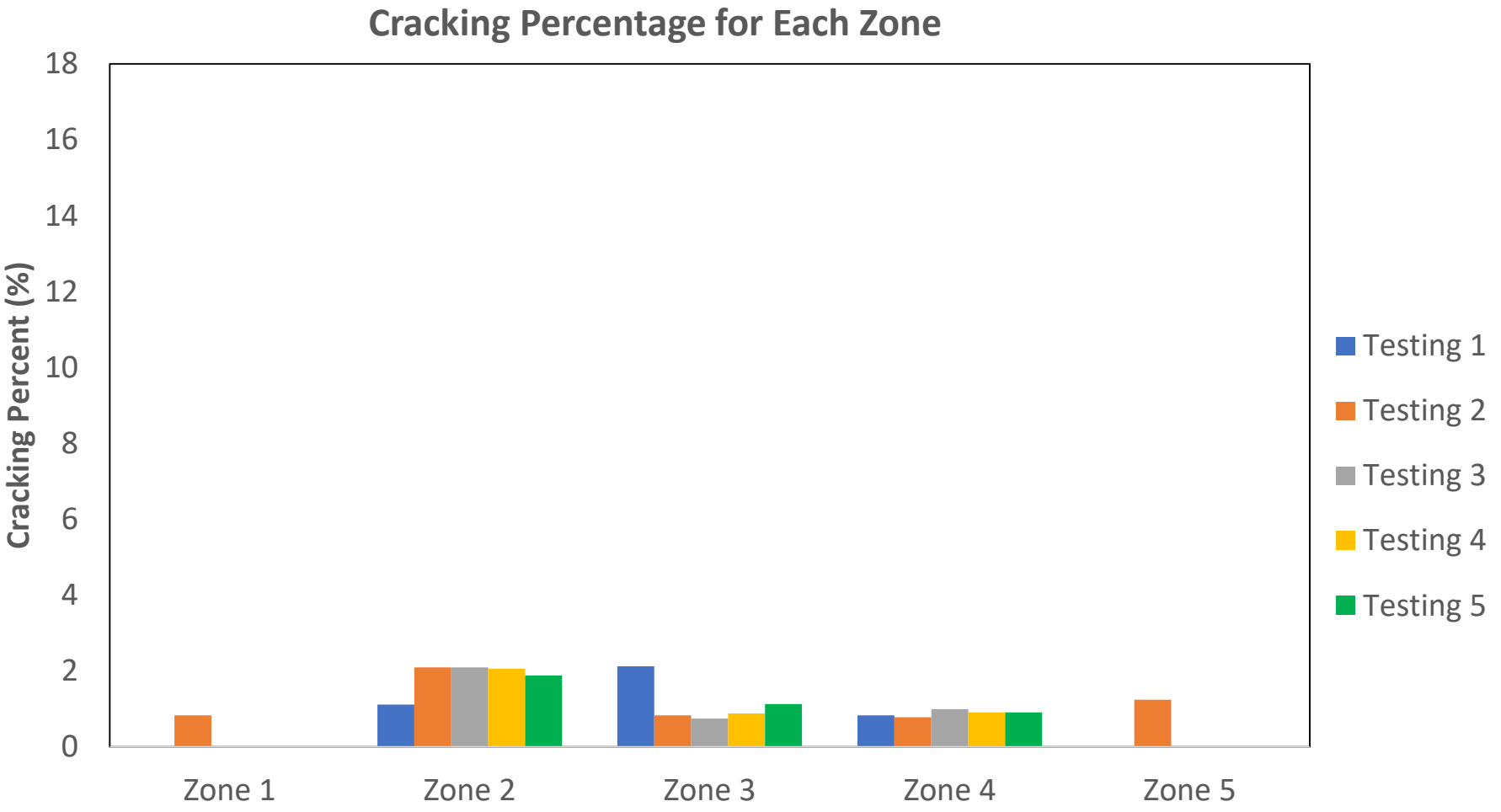
Level 2 Cracking Data for JPCP Low Severity Site 1

Level 2 Results



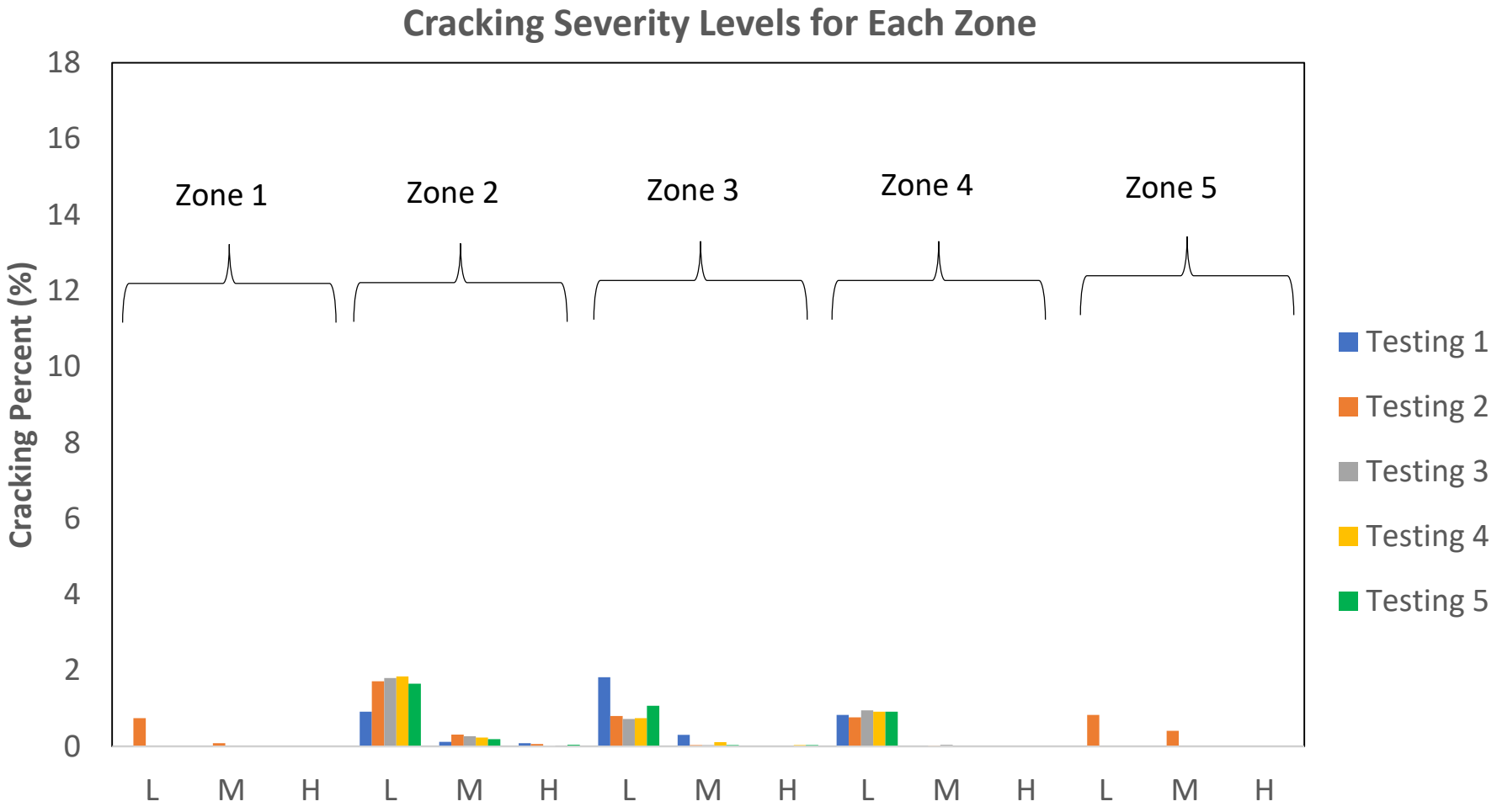
Level 2 Cracking Data for JPCP Low Severity Site 1

Level 2 Results



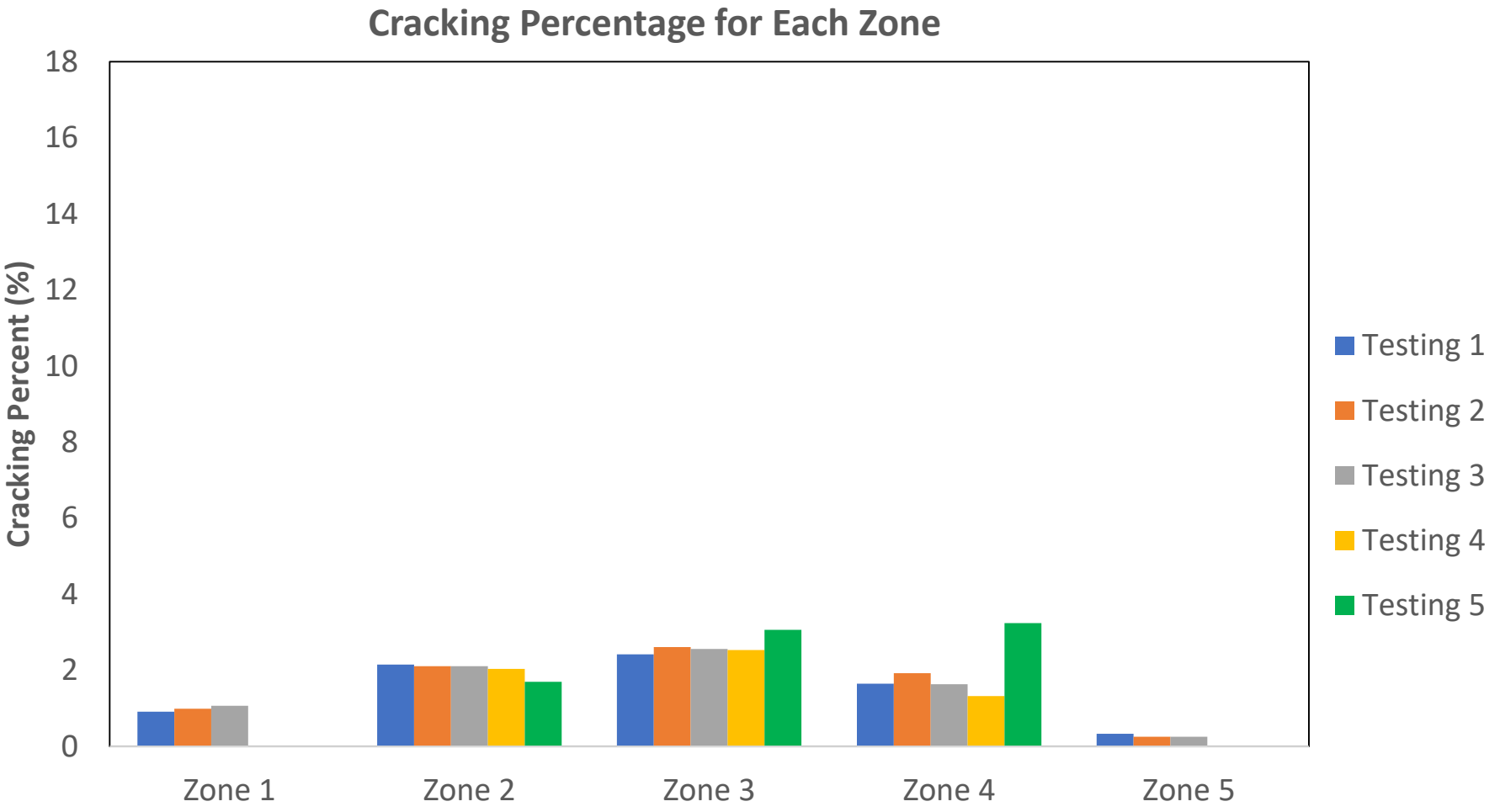
Level 2 Cracking Data for JPCP Medium Severity Site 1

Level 2 Results



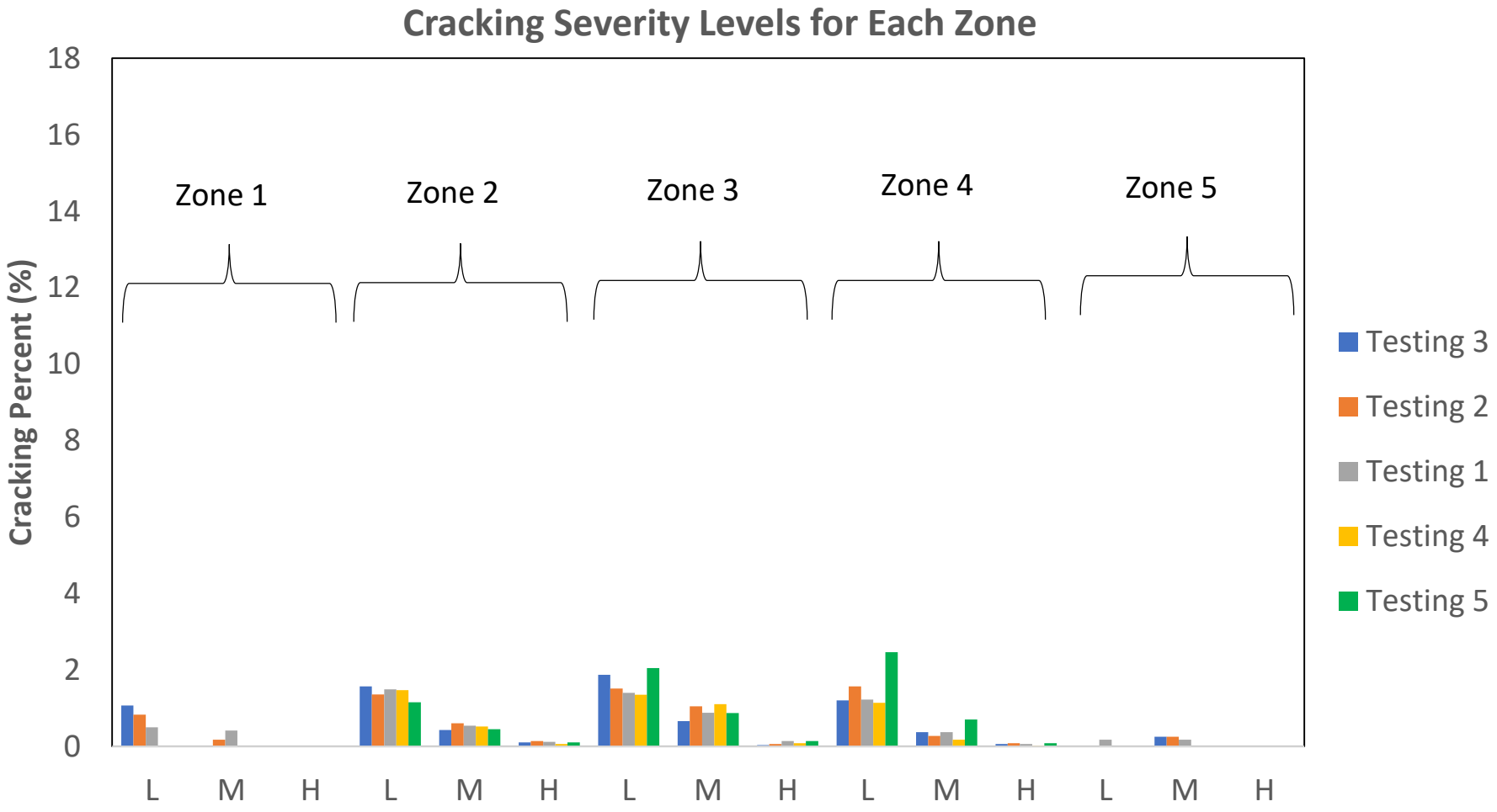
Level 2 Cracking Data for JPCP Medium Severity Site 1

Level 2 Results



Level 2 Cracking Data for JPCP High Severity Site 1

Level 2 Results



Level 2 Cracking Data for JPCP High Severity Site 1

Conclusions

- Performed SHA survey
  - Many in common: manual or semi-automated based; cracking types collected; severity definitions; wheel-path dimensions, etc
  - Also significant different:
- Proposed three levels of cracking definitions: targeting for automated systems
- Field evaluation: satisfactory repeatability
- Remaining work in 2019: more validation desired, final report