AASHTOWare Bridge Design and Rating Version 6.5

AASHTO Engine Performance Parametric Study
Summary of Results

The primary objective of the performance study is to measure the relative difference in the performance of the AASHTO Engine for different analysis settings and hardware configurations. Both LRFR and LRFD analysis methods are included in this study.

The results of this study enable users to gauge the performance impact of the followings:
- System Configuration (RAM): 4 GB vs. 8 GB vs. 16 GB vs. 32 GB
- System Configuration (Hard drive type): Hard disk drive vs. Solid-state drive
- Analysis Type: Line Girder vs. 3D FEM
- Structure Size: 1-span vs. 2-span vs. 3-span structures
- FE Model Settings: Number and target aspect ratio of shell elements

Measurements:

1. AASHTO Engine analysis time
2. Total size of all the analysis output files

System Configurations:

Processor:	Intel Xeon E5-1607 Quad Core 3.00 GHz 10M Cache
Operating system:	Windows 7 32-bit and 64-bit
Memory:	4GB, 8GB, 16GB and 32GB
	- 4GB DDR3 ECC PC3-10600 1333MHz DIMM
	- 8GB DDR3 ECC PC3-12800 1600MHz DIMM
Virtual memory:	Automatically manage paging file size
Storage:	Hard disk drive (1TB) and Solid-state drive (500GB)
Database:	Local SQL Server Express

Test Results:

See next page.

Conclusions:

1. No difference was observed in the performance between configurations 1A-1D (Windows 7 32-bit, 4GB) and 2A-2D (Windows 7 64-bit, 8GB).
2. Recommend at least 500GB storage device and 16GB RAM for Analysis Settings K and L.
3. Solid-state drive offers significant time savings for Analysis Settings K and L.

Best Practices:

1. 64-bit OS is recommended for 3D FEM analysis.
2. Choose a local folder as the Analysis Output Folder. Writing analysis output to a network folder will degrade the performance of the analysis.
3. Select only the necessary analysis output for the analysis. Disk operations are expensive from the analysis performance perspective.

Test Results:

Test Case				1	2	3	4	5	6	Total Size of Analysis Output Files
Analysis Settings	Analysis Type	Analysis Method	Steel Plate Girder Bridge # Girders = 4	AASHTO Engine Analysis Time						
				32-bit OS	64-bit OS	64-bit OS	64-bit OS	64-bit OS	64-bit OS	
				4GB RAM	8GB RAM	16GB RAM	16GB RAM	32GB RAM	32GB RAM	
				HDD	HDD	HDD	SSD	HDD	SSD	
A	Line Girder	LRFR	1-span 161' Out-to-out deck 47.5'	43 sec	49 sec	44 sec				64MB
B		LRFD		51 sec	52 sec	48 sec				66MB
C		LRFR	2-span 116'-116' Out-to-out deck 25.58'	2.6 min	2.6 min	2.4 min				189MB
D		LRFD		3.1 min	3.1 min	2.8 min				195MB
E	3D FEM*	LRFR	1-span 161' Out-to-out deck 47.5' # Shells = 4, Aspect Ratio = 2 DOF = 5394		12.1 min	11.8 min	12.7 min			4GB
F		LRFD			12.4 min	12.0 min	13.1 min			
G		LRFR	1-span 161' Out-to-out deck 47.5' # Shells = 8, Aspect Ratio = 1 DOF = 24570		183.8 min	147.9 min	125.4 min			24GB
H		LRFD			163.2 min	140.5 min	124.7 min			
I		LRFR	2-curved span 98.68'-112.22' Out-to-out deck 22' # Shells = 4, Aspect Ratio = 2 DOF = 14094		38.8 min	38.8 min	39.9 min	42.2 min	35.5 min	9GB
J		LRFD			38.2 min	39.4 min	40.7 min	40.2 min	37.7 min	
K		LRFR	2-curved span 98.68'-112.22' Out-to-out deck 22' # Shells = 8, Aspect Ratio = 1 DOF = 89358		Out of memory	93.7 hr	43.9 hr	77.4 hr	42.7 hr	249GB
L		LRFD			Out of memory	128.2 hr	43.2 hr	65.4 hr	42.8 hr	
M		LRFR	3-curved span 160'-210'-160' Out-to-out deck 40.5' # Shells = 4, Aspect Ratio = 2 DOF = 22080			4.2 hr	3.6 hr	3.9 hr	3.4 hr	62GB
N		LRFD				4.4 hr	3.6 hr	3.6 hr	3.4 hr	

* Changing the finite element model by adjusting the number of shell elements or aspect ratio may affect the accuracy of the analysis results.
# Shells = Number of shell elements in the deck between girders; Aspect Ratio = Target aspect ratio for shell elements

AASHTOWare Bridge Design and Rating Version 6.5

Additional Study - Performance Impact of Output Settings

The objective of this additional study is to measure the relative difference in the performance of the AASHTO Engine for different analysis output settings.

Output Settings:

1. All - All AASHTO Engine Reports (except Regression Data)
   This is the output settings used in the original study
2. Partial - Summary Influence Line Loading, Capacity Summary, FE Model for DL Analysis, FE Model for LL Analysis, LL Distrib. Factor Summary, Fatigue Stress Ranges and Service II Stress Ranges

Measurement:

1. AASHTO Engine analysis time

System Configuration 1:

Processor:	Intel Xeon E5-2630 v2 2.60 GHz
Operating system:	Windows 8 64-bit
Memory:	32GB - 8GB DDR3 ECC PC3-12800 1600MHz DIMM x 4
Virtual memory:	Automatically manage paging file size
Storage:	Hard disk drive (900GB x 2) - BrDR and the Analysis Output Folder are located on the same drive
Database:	Local SQL Server Express

System Configuration 2:

Processor:	Intel Xeon E5-1650 v3 3.50 GHz
Operating system:	Windows 8.1 64-bit
Memory:	32GB - 8GB DDR4 ECC 2133 1066MHz DIMM x 4
Virtual memory:	Automatically manage paging file size
Storage:	Solid-state drive (512GB x 2) - BrDR and the Analysis Output Folder are located on different drives
Database:	Local SQL Server Express

Test Results: See next page.

Conclusions:

1. Limit the amount of output offers significant time savings.
2. Improve in performance was observed when the Analysis Output Folder is located on the second drive.

Test Results:

Test Case				5	6	Total Size of Analysis Output Files
Analysis Settings	Analysis Type	Steel Plate Girder Bridge # Girders = 4	Output Settings	AASHTO Engine Analysis Time		
				System Configuration 1	System Configuration 2	
I	3D FEM*	2-curved span 98.68'-112.22' Out-to-out deck 22' # Shells = 4, Aspect Ratio = 2 DOF = 14094	All	45.3 min	24.2 min	8GB
I			Partial	15.1 min	9.7 min	1.4GB
K		2-curved span 98.68'-112.22' Out-to-out deck 22' # Shells = 8, Aspect Ratio = 1 DOF = 89358	All	72.6 hr	23.3 hr	232GB
K			Partial	44.2 hr	8.4 hr	48GB

* Changing the finite element model by adjusting the number of shell elements or aspect ratio may affect the accuracy of the analysis results.

Shells = Number of shell elements in the deck between girders

Aspect Ratio = Target aspect ratio for shell elements