FHWA Interchange Configuration Safety Comparison Tool

Final - February 2023

Foreword

This spreadsheet tool was developed through FHWA's project Safety Comparison Between Interchange Types. This spreadsheet implements the crash prediction models for diamond, compressed diamond, roundabout diamond, diverging diamond, single-point diamond, tight diamond, and partial cloverleaf (parclo) interchanges. The Instructions worksheet provides useful information about this spreadsheet and should be read prior to first use.

This spreadsheet is intended for use with the project final report. The analyst is encouraged to read the final report so that they will have an understanding of how best to determine input values and interpret output.

Overview

This spreadsheet has been developed to implement the crash prediction models for comparison of common service interchange configurations considered for comparison under Interchange Access Requests.
The contents of this spreadsheet include the following:

Worksheet Name	***Contents***
Welcome	Foreword
Instructions	Current worksheet displaying overview, summary of spreadsheet worksheets, and description of color coding included in the worksheets.
PDO	Analysis worksheet for property damage only crash frequency. User provides inputs on this sheet for crash frequency calculations. Provides summary of total crash frequency.
KABC	Analysis worksheet for fatal and injury crash frequency. Inputs for this sheet are derived from the PDO spreadsheet.
SDF	Analysis worksheet for severity distribution functions. User provides inputs on this sheet for severity distribution calculations.
Charts	Visual representation of predicted crash frequency and 95 percent confidence intervals.

Color Coding in the Worksheets

The worksheets include three specific color options to help users identify locations where input data is required, where crash frequency is reported, and where severity distributions are applied.
The respective color coding is as follows:

Color Used	***Type of Information Required from User***
Dotted Yellow	Required input information.

Color Used	***Type of Information Output***
Left Slanted Lined Green	Crash frequency model results. Not an input.
Right Slanted Lined Blue	Results of severity distribution functions; combined with crash frequency (namely fatal and injury) results. Not an input.
Dotted Gray	Information linked to a different worksheet. Not an input.

Abbreviations Used	***Definition***
AADT	average annual daily traffic
CI	confidence interval
COV	coefficient of variation
DDI	diverging diamond interchange
LB	lower bound
LT	left turn
Parclo	partial cloverleaf interchange
SDF	severity distribution function
SPDI	single-point diamond interchange
TDI	tight diamond interchange
UB	upper bound
V	deterministic component for respective severity level
vpd	vehicles per day
XR	crossroad
#	number
K, A, B, C, PDO	injury ratings based on KABCO scale (K = fatality, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, PDO = property damage only)

Data Needs

The following provides an overview of data needs for crash frequency and severity distribution function models.

PDO Worksheet Inputs	***Description***
Urban area type	This variable is an indicator where 1 = yes and 0 = no if the interchange is found within an urbanized boundary.
Intersection skew angle >30 degrees	This variable is an indicator where 1 = yes and 0 = no if the intersection angle between the freeway mainline and crossroad is less than 60 degrees (or >120 degrees).

PDO Crash Frequency

User Input

Input Characteristic	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
Urban area type *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Intersection skew angle >30 degrees *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Nearest interchange gore distance within 0.5 mi *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Managed lanes on freeway *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Freeway AADT *(value in vehicles/day)*	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Freeway no. of through lanes (bidirectional total) *(no.)*	4	4	4	4	4	4	4
XR AADT *(value in vehicles/day)*	5,000	5,000	5,000	5,000	5,000	5,000	5,000
XR no. of through lanes (bidirectional total) *(no.)*	4	4	4	4	4	4	4
Total ramp AADT *(value in vehicles/day)*	20,000	20,000	20,000	20,000	20,000	20,000	20,000
COV of ramp volumes (see below) *(decimal #; calculation)*	0	0	0	0	0	0	0
Number of LT lanes on the XR at intersections *(no.)*	0	0	0	0	0	0	0

This is the base condition. Analysts must fill out the entire column even if this interchange type is not under consideration.

NOTE: Changes to the table above will be reflected on the KABC worksheet.

Coefficient of Variation (COV) of Ramp Calculation Tool

Ramp 1 AADT =	500
Ramp 2 AADT =	500
Ramp 3 AADT =	500
Ramp 4 AADT =	500
Ramp 5 AADT =	
Ramp 6 AADT =	

Std. Deviation	0.00
Mean	500
COV	0.00

NOTE: range of acceptable COV values is 0 to 1.15.
Use this value for COV inputs in table

NOTE: leave input cells blank for any ramps not included in analysis.

Model Output (Do Not Edit)

Predicted Crash Frequency	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
95 percent CI LB *(crashes/year)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expected PDO crash frequency *(crashes/year)*	19.74	15.52	15.74	20.95	17.11	16.38	17.17
95 percent CI UB *(crashes/year)*	41.28	32.83	33.27	43.71	36.02	34.55	36.14
95 percent CI LB *(crashes/year)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Expected KABC crash frequency (from KABC sheet) *(crashes/year)*	6.47	4.95	5.96	7.58	7.12	4.77	3.98
95 percent CI UB *(crashes/year)*	14.46	11.42	13.43	16.67	15.75	11.05	9.47
95 percent CI LB *(crashes/year)*	3.23	1.99	2.63	4.02	3.44	1.91	1.41
Expected total crash frequency (KABC + PDO) *(crashes/year)*	26.21	20.47	21.69	28.53	24.23	21.14	21.15
95 percent CI UB *(crashes/year)*	49.18	38.95	40.75	53.04	45.02	40.37	40.90

Calculations (Do Not Edit)

Calculation	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
Constant term (accounting for interchange type)	-6.642	-6.882	-3.408	-5.398	-5.600	-10.880	-9.560
Freeway/ramp exposure term	0.415	0.415	0.237	0.354	0.354	0.622	0.557
XR exposure term	0.215	0.215	0.215	0.215	0.215	0.215	0.215

Expected KABC crash frequency considering exposure (only)	19.737	15.516	15.736	20.950	17.111	16.378	17.169
Freeway lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
XR lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Area type adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Intersection skew adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Nearby interchange adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Managed lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ramp variation adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
XR LT lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Overdispersion parameter	0.260	0.260	0.260	0.260	0.260	0.260	0.260

KABC Crash Frequency

User Input (Do Not Edit)

Input Characteristic	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
Urban area type *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Intersection skew angle >30 degrees *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Nearest interchange gore distance within 0.5 mi *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Managed lanes on freeway *(1 = yes, 0 = no)*	0	0	0	0	0	0	0
Freeway AADT *(Value in vehicles/day)*	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Freeway no. of through lanes (bidirectional total) *(no.)*	4	4	4	4	4	4	4
XR AADT *(Value in vehicles/day)*	5,000	5,000	5,000	5,000	5,000	5,000	5,000
XR no. of through lanes (bidirectional total) *(no.)*	4	4	4	4	4	4	4
Total ramp AADT *(Value in vehicles/day)*	20,000	20,000	20,000	20,000	20,000	20,000	20,000
COV of ramp volumes *(no.)*	0	0	0	0	0	0	0
Number of LT lanes on the XR at intersections *(no.)*	0	0	0	0	0	0	0

NOTE: Inputs are linked to the PDO worksheet. Do not make changes to this worksheet.

Model Output (Do Not Edit)

Predicted Crash Frequency by Severity	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
Expected KABC crash frequency *(crashes/year)*	6.47	4.95	5.96	7.58	7.12	4.77	3.98
KA crash frequency (SDF Model 2) *(crashes/year)*	0.34	0.82	0.15	0.62	0.20	0.52	0.15
B crash frequency (SDF Model 2) *(crashes/year)*	1.08	0.13	0.48	0.21	0.78	0.17	0.46
C crash frequency (SDF Model 2) *(crashes/year)*	5.05	4.00	5.32	6.75	6.14	4.07	3.38

Calculations (Do Not Edit)

Calculation	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
Constant term (accounting for interchange type)	-6.814	-7.082	-6.897	-6.656	-6.718	-12.377	-9.879
Freeway/ramp exposure term	0.376	0.376	0.376	0.376	0.376	0.590	0.376
XR exposure term	0.189	0.189	0.189	0.189	0.189	0.340	0.551
Expected KABC crash freq. considering exposure (only)	6.470	4.951	5.956	7.579	7.120	4.766	3.983
Freeway lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
XR lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Area type adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Intersection skew adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Nearby interchange adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Managed lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ramp variation adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000
XR LT lane adjustment	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Overdispersion parameter	0.242	0.242	0.242	0.242	0.242	0.242	0.242

SDF Model

User Input

Input Characteristic	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo (All Types)	SPDI	TDI
Freeway AADT ≥ 200,000 vpd *(1 = yes, 0 = no; Value in vpd)*	0	0	0	0	0	0
XR AADT ≥ 30,000 vpd *(1 = yes, 0 = no; Value in vpd)*	0	0	0	0	0	0
Freeway posted speed limit *(Value in mph)*	55	55	55	55	55	55
XR posted speed limit *(Value in mph)*	45	45	45	45	45	45
Nearest XR adjacent intersection (signal or roundabout) within 0.10 mi of ramp terminal *(1 = yes, 0 = no)*	0	0	0	0	0	0
Nearest interchange gore distance within 0.25 mi *(1 = yes, 0 = no)*	0	0	0	0	0	0
Number of pedestrian crossings conflicting with right-turning vehicles across interchange *(Ranges from 0 to 7)*	0	0	0	0	0	0
Freeway has eight or more lanes (bidirectional total) *(1 = yes, 0 = no)*	0	0	0	0	0	0
XR has four or more lanes (bidirectional total) *(1 = yes, 0 = no)*	1	1	1	1	1	1
Type A or B parclo interchange (includes A2/A4/B2/B4) *(1 = yes, 0 = no)*				1		
Type AB parclo interchange (includes AB2/AB4) *(1 = yes, 0 = no)*				0		

This is the base condition. Analysts must fill out the entire column even if this interchange type isn't under consideration.

SDF Model Output (Do Not Edit)

Crash Severity Probability	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo	SPDI	TDI
Probability of KA severity outcome	0.0527	0.0258	0.0276	0.0366	0.0276	0.0276
Probability of B severity outcome	0.1662	0.0813	0.1094	0.1155	0.1094	0.1094
Probability of C severity outcome	0.7811	0.8929	0.8630	0.8479	0.8630	0.8630

Calculations (Do Not Edit)

Calculation	Diamond/ Compressed KA	Diamond/ Compressed B	Roundabout Diamond KA	Roundabout Diamond B	DDI KA	DDI B	Parclo (All Types) KA	Parclo (All Types) B	SPDI KA	SPDI B	TDI KA	TDI B
Constant	-3.1043	-1.9561	-3.1043	-1.9561	-3.1043	-1.9561	-3.1043	-1.9561	-3.1043	-1.9561	-3.1043	-1.9561
Freeway AADT ≥ 200,000 vpd	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
Crossroad AADT ≥ 30,000 vpd	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
Freeway posted speed limit is 65 mph or greater	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
XR posted speed limit is 45 mph or greater	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314	0.2314
Type A or B parclo interchange (includes A2/A4/B2/B4)							-0.4463	-0.4463				
Type AB parclo interchange (includes AB2/AB4)							0.0000	0.0000				
SPDI, DDI, or TDI					-0.7454	-0.5181			-0.7454	-0.5181	-0.7454	-0.5181
Roundabout diamond interchange			-0.8484	-0.8484								
Nearest XR adjacent intersection (signal or roundabout) within 0.10 mi of ramp terminal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Nearest interchange gore distance within 0.25 miles	0.0000		0.0000		0.0000		0.0000		0.0000		0.0000	
Number of pedestrian crossings conflicting with right-turning vehicles across interchange	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Freeway has eight or more lanes (bidirectional total)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
XR has four or more lanes (bidirectional total)	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772	0.1772
V	0.0675	0.2128	0.0289	0.0911	0.0320	0.1267	0.0432	0.1362	0.0320	0.1267	0.0320	0.1267

Information pulls from pdo tab

Column 1	Diamond/ Compressed	Roundabout Diamond	DDI	Parclo B, AB	Parclo A	SPDI	TDI
PDO	19.7367	15.5160	15.7360	20.9496	17.1110	16.3783	17.1694
	21.5455	17.3101	17.5312	22.7611	18.9117	18.1762	18.9703
KABC	6.4698	4.9515	5.9562	7.5792	7.1204	4.7660	3.9828
	7.9874	6.4678	7.4758	9.0864	8.6328	6.2803	5.4826
KABCO	22.9784	18.4790	19.0586	24.5078	20.7889	19.2306	19.7467
	22.9784	18.4790	19.0586	24.5078	20.7889	19.2306	19.7467