TxDOT Crash Modification Factors (CMFs)

Guidance for IAJR

Part A: CMF Overview

Overview of CMFs

A Crash Modification Factor (CMF) is a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a countermeasure. CMFs with a value less than 1.0 indicate an expected decrease in crashes. CMFs greater than 1.0 indicate an expected increase in crashes.

$$\textbf{CMF} = \frac{\text{ANTICIPATED CRASHES } \textbf{WITH} \text{ TREATMENT}}{\text{ANTICIPATED CRASHES } \textbf{WITHOUT} \text{ TREATMENT}}$$

CMF = 1.0	Anticipated to have no impact on safety
CMF < 1.0	Anticipated to reduce crashes
CMF > 1.0	Anticipated to increase crashes

Figure 1. Crash Modification Factor Calculation

A Crash Reduction Factor (CRF) is another way of representing the expected effect of a countermeasure in terms of the percentage decrease in crashes. A CRF is equal to 100*(1-CMF).

$$\textbf{CRF} = (1 - \text{CMF}) \times 100$$

Figure 2. Crash Reduction Factor Calculation

CMF Clearinghouse

The CMF Clearinghouse is a comprehensive and searchable database of published CMFs. The CMF Clearinghouse contains all CMFs published from 2010 to the present, in addition to some published before 2010. It provides information on all available CMFs, such as CMF values and details; citations and related information about the study that produced each CMF; and a star rating that provides an indication of the quality of each CMF. (http://www.cmfclearinghouse.org/)

Star Quality Rating System

The star quality rating indicates the quality or confidence in the results of the study that produced the CMF. The star rating is based on a scale of 1 to 5, where a 5 indicates the highest or most reliable rating. The total score for a CMF is calculated by adding points based on different factors, with a maximum possible score of 150. The Clearinghouse team considers various factors for each study type and judges each CMF according to its performance across various factors. More information is available on the following link (http://www.cmfclearinghouse.org/sqr.cfm).

The new CMF rating criteria was developed as part of the NCHRP 17-72 project for the second edition of the Highway Safety Manual (HSM) and CMFs converted to the new rating system as of February 2021.

To minimize the impact, Clearinghouse provides a spreadsheet to compare the legacy star ratings versus the updated star ratings for all the current CMFs (http://www.cmfclearinghouse.org/changes.cfm).

Part B: CMF Selection Criteria

Searching for CMFs on the CMF Clearinghouse

The CMF Clearinghouse search function allows a user to search the database for CMFs related to the topic of interest. A user should enter a search term in the text box on the home page and select an option in the pull-down menu (**Figure 3**). The available types of search fields are countermeasure name, study abstract, study citation, single CMF ID, and all fields. When more than one search term is used, the Clearinghouse applies an AND condition between the words. Therefore, users can search specific CMFs and retrieve fewer results. CMF Clearinghouse User Guide provides details of types of search fields and the search terms. (http://www.cmfclearinghouse.org/collateral/CMF_UserGuide_2021.pdf)

Figure 3: CMF Clearinghouse Search Tool

Identifying Appropriate CMFs

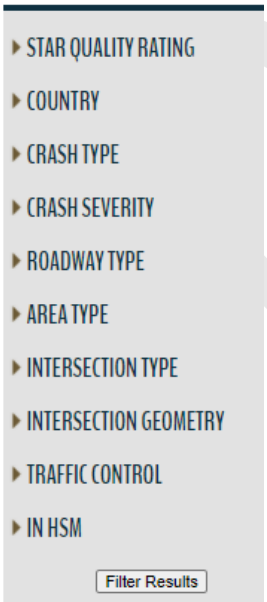


Figure 4: Result Filters

Filtering search results

A search for CMFs in the search tool (**Figure 3**) will return multiple CMF results. The search results page provides filters to enable users to narrow the search results (**Figure 4**). To use the filters, users simply expand the filter by clicking the small triangle icon, check one or more boxes, and click "Filter Results" on the bottom. The search results will reload and return refined CMF results that meet the criteria.

For example, if a user is searching for a CMF related to "Widen Shoulder" on highway crashes in urban areas, the user may use county filer, road type filter, and area type filters to remove all other displayed results. There are 588 CMFs returned on a search for "Widen Shoulder". Next, the user can check the boxes "U.S. & Canada" in the Country filter, "Principal Arterial Interstate" and "Principal Arterial Other Freeways and Expressways" in the Roadway type filter, and "Urban" in the Area type filter, and click "Filter Results" (**Table 4**). Now a user has 51 CMFs for this filter selection (**Figure 5**). A user can export all results to excel file format by clicking "Export All Result to Excel" or find specific CMFs expanding the countermeasure drop-down menu. Video tutorials

for conducting a CMF search and filtering search results are available on the following link (http://www.cmfclearinghouse.org/userguide.cfm).

Table 1: Filtering Example

Country Filter	Roadway Type Filter	Area Type Filter
☑ U.S. & Canada (51) ☐ International (0)	☐ All (0) ☑ Principal Arterial Interstate (48) ☑ Principal Arterial Other Freeways and Expressways (3) ☐ Principal Arterial Other (0) ☐ Minor Arterial (0) ☐ Major Collector (0) ☐ Minor Collector (0) ☐ Local (0) ☐ Not specified (0)	☐ All (0) ☑ Urban (51) ☐ Suburban (0) ☐ Urban and suburban (0) ☐ Rural (0) ☐ Not specified (0)

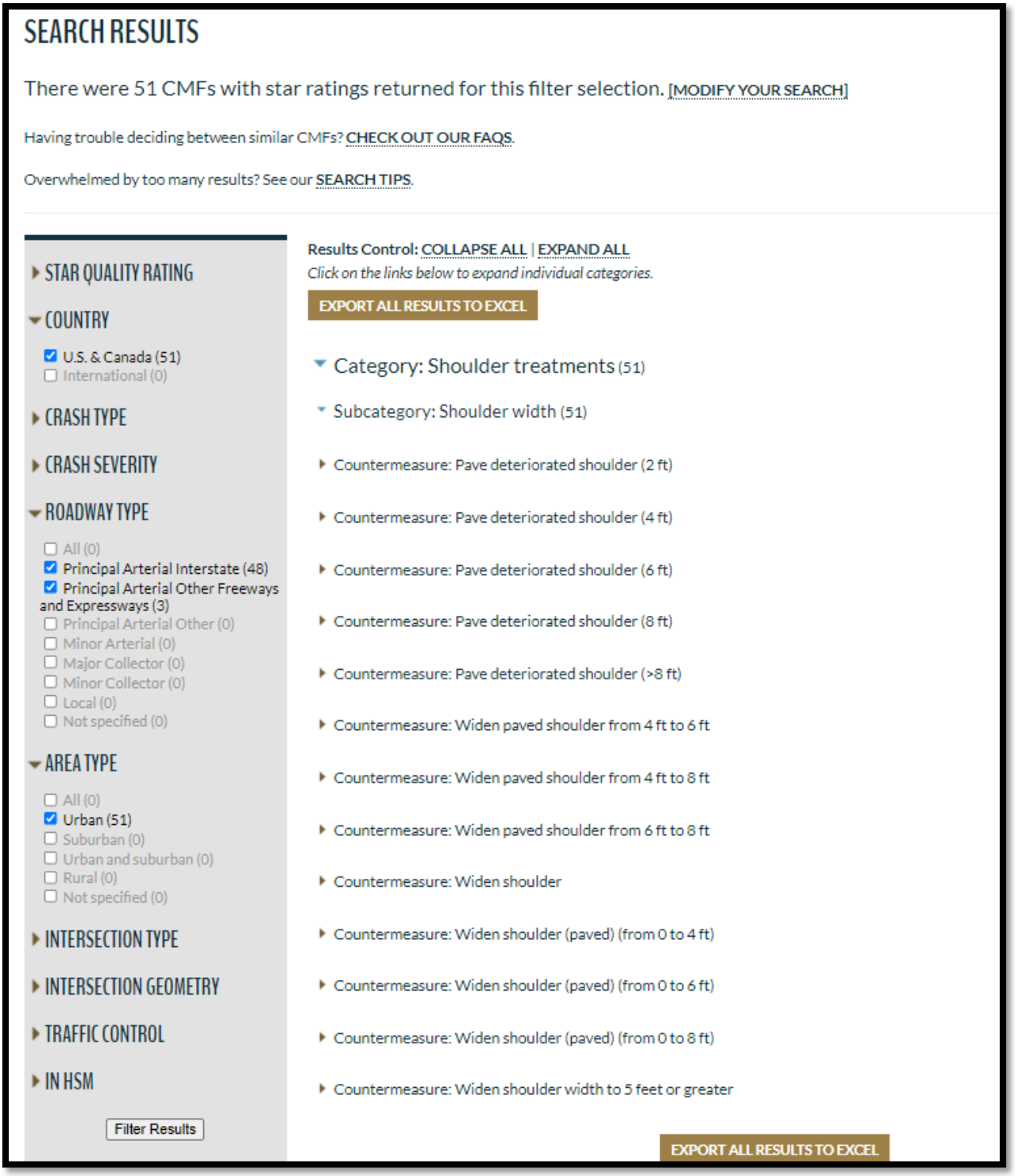


Figure 5: Example of the Filtering Results

Matching on Major Factors

Even after filtering CMF results, users may still have more than one CMF result. Users should select the CMF that is most applicable to the situation in which it will be applied. That is, the major characteristics

associated with the CMF (e.g., crash type, crash severity, roadway type, or area type) should closely match the characteristics of the scenario at hand.

Figure 6 shows part of the results for the "Widen Shoulder" countermeasure search. The four CMFs listed in the figure all have 3-star ratings. However, the CMF values are all different. All four CMFs are similar in crash type and area type, however, crash severity is different. The first CMF (CMF of 0.74) and the third CMF (CMF of 0.64) are identified as being developed for serious injury, minor injury, and possible injury crashes. Their major factors in the results page are identical, but CMF is different. Similarly, the second CMF (CMF of 0.83) and the fourth CMF (CMF of 0.85) are identified as being developed for property damage only crashes and their major factors are identical.

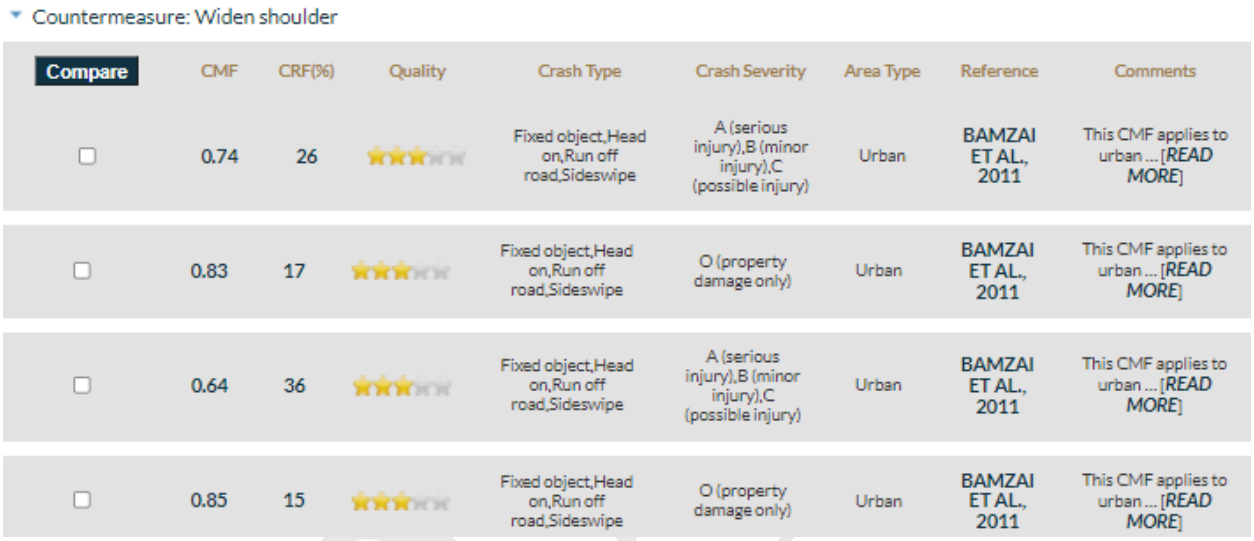


Figure 6: Example of Widen Shoulder CMFs

All information given on the search results page is identical for the first and third, and the second and third CMF, respectively. Therefore, it is necessary to examine the details of each CMF by clicking on the CMF value to go to the details page. When the details of each CMF (CMF of 0.74 and 0.64) are examined, it can be seen that the CMF of 0.74 is intended for AADT under 30,000, and the CMF of 0.64 is intended for AADT between 5,000 and 10,000 (**Table 5**). A user should select a CMF based on the appropriate AADT condition.

Table 2: Example of Applicability

Applicability	**CMF 0.74, CMF ID: 6705**	**CMF 0.64, CMF ID: 6723**
Crash Type	Fixed object, Head on, Run off road, Sideswipe	Fixed object, Head on, Run off road, Sideswipe
Crash Severity	A (serious injury), B (minor injury), C(possible injury)	A (serious injury), B (minor injury), C(possible injury)
Roadway Types	Principal Arterial Interstate	Principal Arterial Interstate
Number of Lanes	-	-
Road Division Type	Divided by Median	Divided by Median
Speed Limit	45-65	45-65

Applicability	CMF 0.74, CMF ID: 6705	CMF 0.64, CMF ID: 6723
Area Type	Urban	Urban
Traffic Volume	Maximum of 30000 AADT	Minimum of 5000 to Maximum of 10000 AADT
Average Traffic Volume	-	-
Time of Day	All	All

Selecting a CMF when Major Factors are the Same

There may be the case where multiple CMFs are the same with respect to crash and roadway or intersection applicability. In these cases, it would be necessary to examine some of the other fields to decide which CMF to use:

1. Star quality rating
2. Score details
3. Similarity in locality of data used
4. Traffic volume range
5. Age of data
6. Original study report

When selecting CMFs for use in analysis from the CMF Clearinghouse, the CMF IDs must be documented, and the CMF detail summary page provided. This information should be saved as a PDF and included as an appendix or attachment to the analysis documentation. It is critical that engineering judgment be used when selecting CMFs. Additional guidance on selecting CMFs is available in the following link: http://www.cmfclearinghouse.org/userguide_identify.cfm

Part C Example: How to Select CMF

Step 1: Enter search terms in the searching tool

- In the example, use "widen shoulder" to find CMF of shoulder measurement.

- After processing, Clearinghouse will return 588 potential CMFs on "widen shoulder".

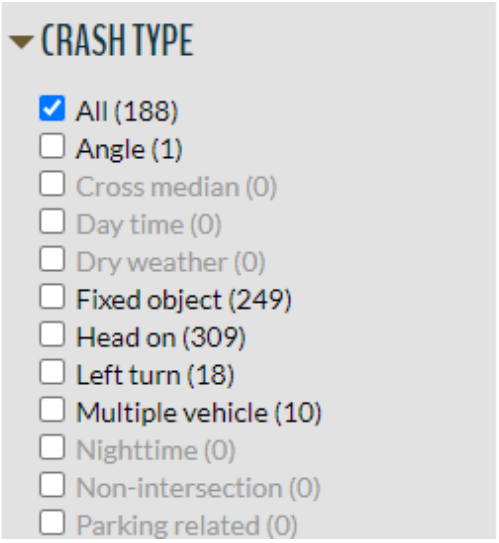
Step 2: Filtering CMFs

Select filters that specifically match your project. In this example, searching a CMF for all crash types with all severities on urban areas in the U.S. If you apply too many filters in this step, clearinghouse will return any results. Therefore, select major characteristics first, then apply more filters later if there are too many results.

- **Leave star quality rating unselected.**

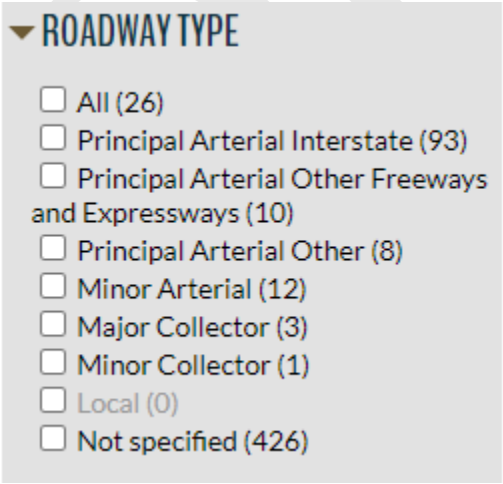
- **Select U.S. & Canada.**

- **Select "All" for Crash type.**

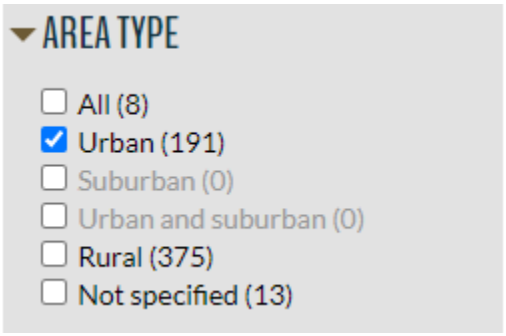


- **Select "All" for Crash Severity.**

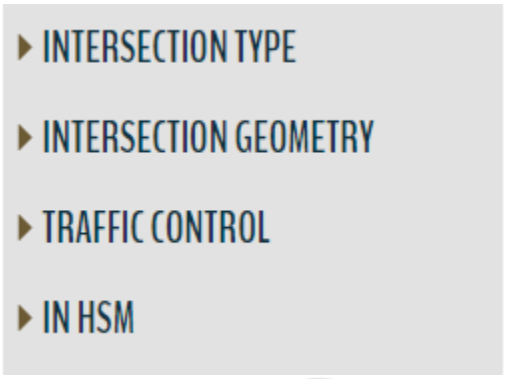
- **Leave Roadway type unselected.** In this specific example, it is better to not select roadway type for filtering because most of the CMFs' roadway type are not specified.



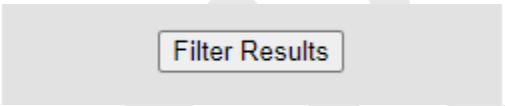
- **Select "Urban" for Area Type.**



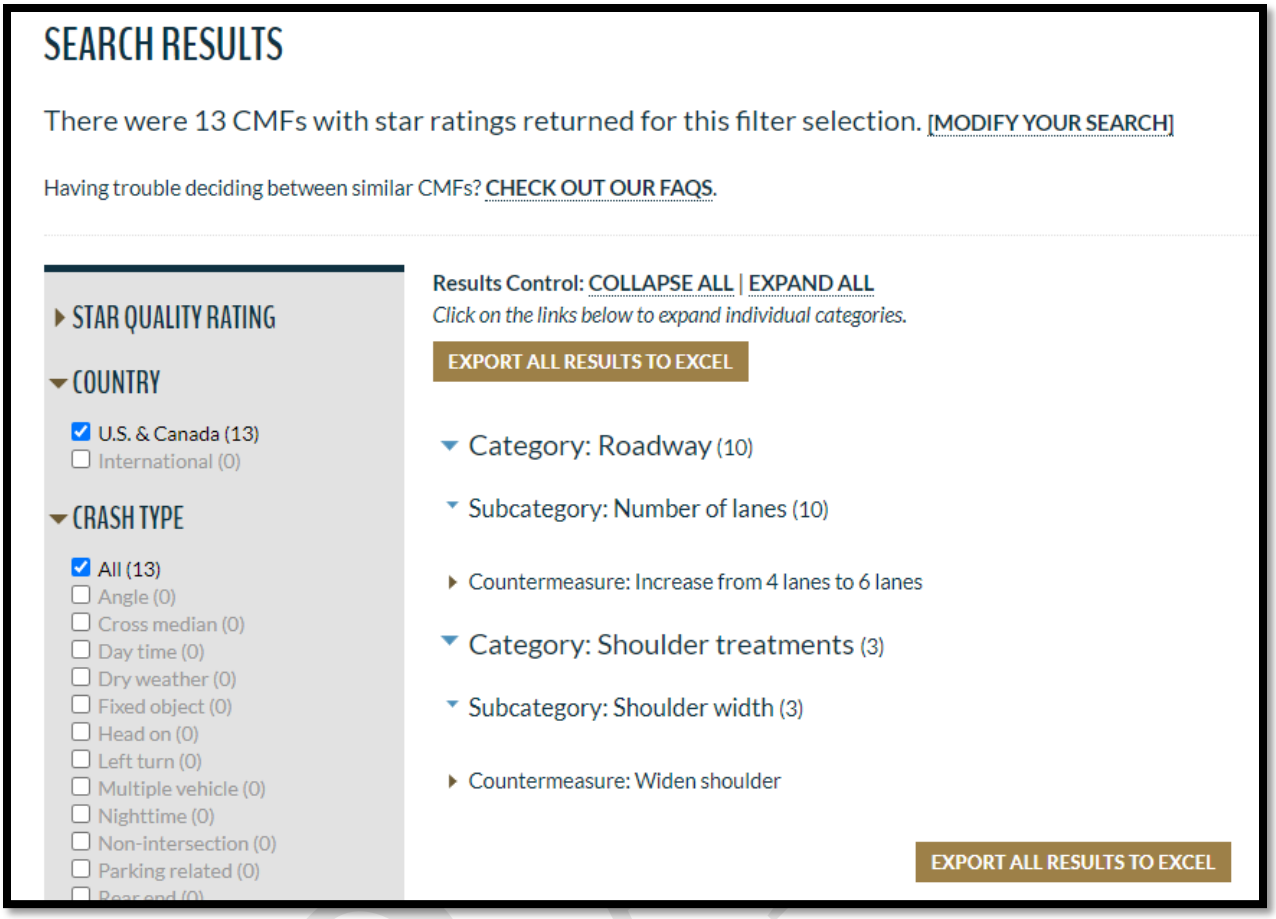
- **Select other filters as applicable.** In this example, leave them blank. If you select too many filters, it is possible that no results are returned.



- **Click "Filter Result" button on the bottom of the filters.**



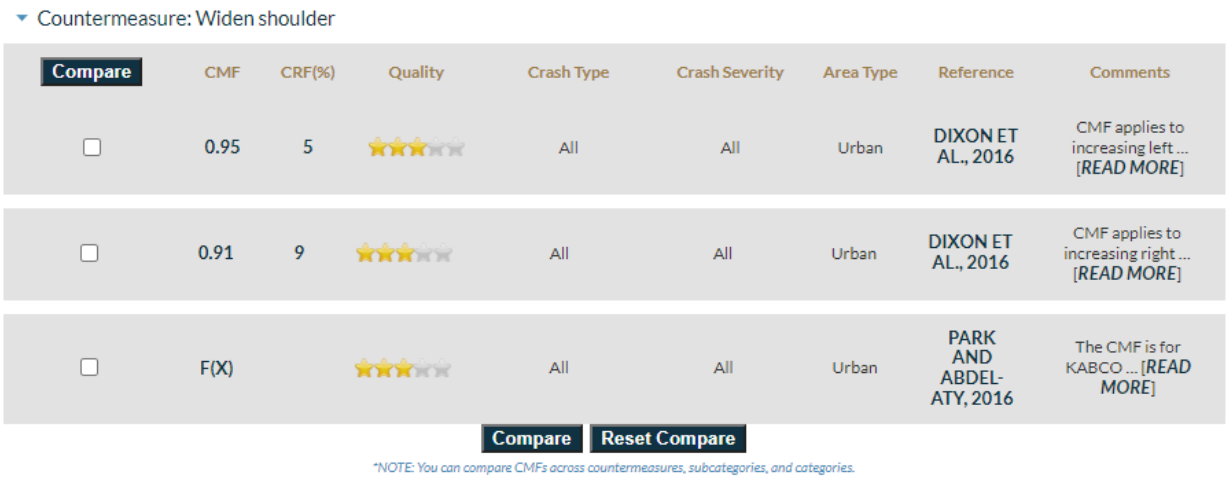
There are 13 CMFs with star ratings returned for this filter selection. In this example, we are looking for a CMF related to widen shoulder. There are three CMFs under the shoulder treatments category that will be considered as applicable.



Step 3: Matching Major Factors

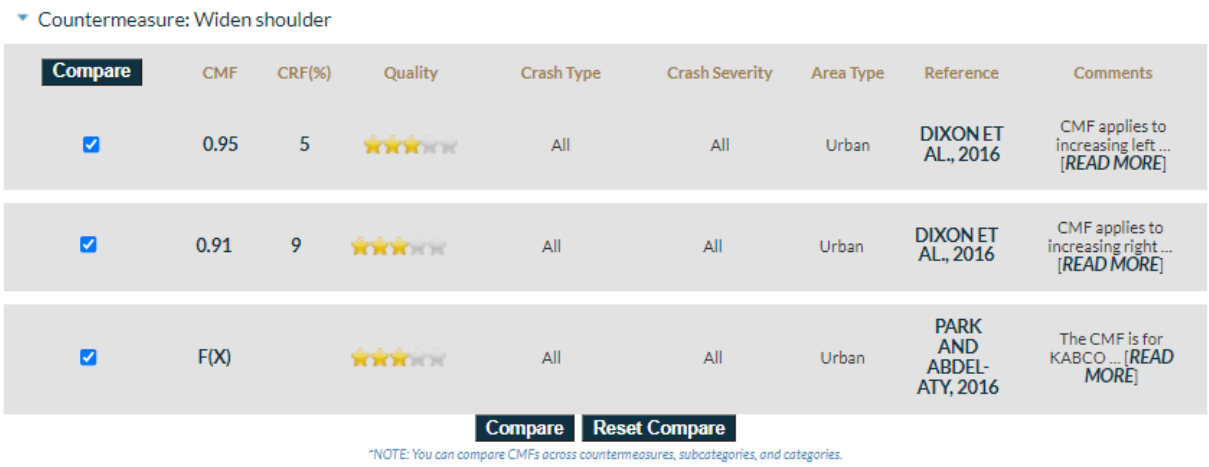
In order to find the most appropriate CMFs for the project, the major characteristics associated with the CMF (e.g., crash type, crash severity, roadway type, or area type) should closely match the characteristics of the scenario be evaluated.

In this example, all three CMFs have the same major characteristics, so a comparison of detailed characteristics to select one CMF should be done.



Step 4: Compare all characteristics

- Compare the detailed characteristics of the CMFs using the "Compare" tool. Check the CMF checkboxes to compare then the system will display the CMF Comparison table.



In the CMF Comparison table, the system highlights, boldens, and italicizes the row containing differences. In this example, two CMFs are developed from one study (Dixon 2016) and one CMFunction is developed from the other study (Park and Abdel, 2016). They have different road characteristics, speed limit, study years, and traffic volume. Select the most appropriate CMFs for the project.

CMF COMPARISON

Below you will find comparisons for the CMFs you chose.
Please note that the rows *highlighted and bold/italic* contain the differences in the selected CMFs.

>

Countermeasure Name	Widen shoulder	Widen shoulder	Widen shoulder
CMF ID	8341	8342	8711
CMF	0.95	0.91	
Study Reference	DIXON ET AL., 2016	DIXON ET AL., 2016	PARK AND ABDEL-ATY, 2016
Unadjusted Standard Error CMF	***0.021***	***0.046***	
CMFunction			
Star Rating			
Rating Score Total	***80***	***80***	***105***
Crash Type	All	All	All
Crash Severity	All	All	All
Crash Time of Day	All	All	All
Area Type	Urban	Urban	Urban
Road Division Type	***Divided by Median***	***Divided by Median***	***All***
Road Type	***Principal Arterial Other Freeways and Expressways***	***Principal Arterial Other Freeways and Expressways***	***Principal Arterial Other***
Number of Lanes	***2-5***	***2-5***	***2-8***
Intersection Type			
Intersection Geometry			
Traffic Control			
Speed Limit	***>50***	***>50***	***20-65***

Study Type	7	7	7
Years From	***2010***	***2010***	***2008***
Years To	***2013***	***2013***	***2012***
Traffic Volume Unit	Annual Average Daily Traffic (AADT)	Annual Average Daily Traffic (AADT)	Annual Average Daily Traffic (AADT)
Min Traffic Volume	***200***	***200***	***1000***
Max Traffic Volume	***281450***	***281450***	***94500***
Min Major Rd Volume			
Max Major Rd Volume			
Min Minor Rd Volume			
Max Minor Rd Volume			
Avg Traffic Volume	***152163***	***152163***	***31880***
Avg Major Rd Volume			
Avg Minor Rd Volume			
State of Origin	TX	TX	FL
Municipality	***Dallas, Houston, San Antonio***	***Dallas, Houston, San Antonio***	
Country	USA	USA	USA
Comments	***CMF applies to increasing left shoulder by 1 foot.***	***CMF applies to increasing right shoulder by 1 foot.***	***The CMF is for KABCO crashes. CMF applies to urban arterials.***

Part D: List of preferred CMFs for IAJR project

To be added later

References

The U.S Department of Transportation Federal Highway Administration, CMF Clearinghouse User Guide, accessed 3 February 2022, <http://www.cmfclearinghouse.org/collateral/CMF_UserGuide_2021.pdf>.

Texas Department of Transportation. (2022). Traffic and Safety Analysis Procedures Manual (Draft)

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