Addendum to DSB 17-05 on 8/20/2020: Update for Bridge Rating Program

From: Aaron Kemna <Aaron.Kemna@modot.mo.gov>
Sent: Thursday, May 21, 2020 4:20 PM
To: BRSD <BRSD@modot.mo.gov>; BRSSE <BRSSE@modot.mo.gov>; BRLLD <BRLLD@modot.mo.gov>; BRPM <BRPM@modot.mo.gov>; Garrett Calvert <Garrett.Calvert@modot.mo.gov>; Martin A. Brose <Martin.Brose@modot.mo.gov>
Subject: RE: Development Section Bulletin No. 17-05-DSB MDX LFD Live Load Reactions

The below notice referring to Virtis reactions at end bents using the AASHTO engine has an error. The corrected equation is shown in red. I also added an example for clarification.

Thanks,
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From: Aaron Kemna <Aaron.Kemna@modot.mo.gov>
Sent: Wednesday, April 8, 2020 1:37 PM
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Subject: FW: Development Section Bulletin No. 17-05-DSB MDX LFD Live Load Reactions

Bridge Rating, BrR (Virtis) Reactions and Shear Loading:
I found an oddity with the AASHTO LFD engine that does not line up with the previous Development bulletin referenced in this e-mail chain. When the AASHTO LFD engine calculates shears at end bents it is using the Shear at Supports distribution factor. See example values below. This needs to be accounted for when calculating reactions at end bents:

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.143	1.250	1.143	0.500
Multi-Lan	1.455	1.750	1.455	1.000

MoDOT LFD Reactions at Girder:
Truck: R_{LL} = (1/2*Truck Load – ½*Wheel Axle Load)*(Shear DF) + (1/2*Wheel Axle Load)*(Shear at Supports DF)

Thus, reaction at end bent without impact using the AASHTO LFD engine would be calculated accordingly.
Truck: (Reaction from program/SASDF/Imp. – ½*Axle Load)*SDF + (1/2*Axle Load)*SASDF

Example:
Reaction from program is 66.49 kips. ½*Axle Load for an HS20 Truck Loading is 16 kips. Impact is 1.26.

Reaction for Girder without impact = (66.49/1.75/1.26 – 16)*1.455 + 16*1.75 = 48.59k

Note that there are cases where the Shear at Supports DF is smaller than the Shear DF. Also, this only occurs at end bents. AASHTO LFD uses the Shear DF everywhere else on the structure.

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Gregory E. Sanders

From:	Darren Kemna
Sent:	Monday, September 18, 2017 3:04 PM
To:	BRSSE; BRSD; BRPM; BRSLE
Cc:	Gregory E. Sanders
Subject:	Development Section Bulletin No. 17-05-DSB MDX LFD Live Load Reactions

<<Development Section Bulletin – ADDENDUM to No. 16-01-DSB>>

No. 17-05-DSB-MDX LFD Live Load Reactions
Contact: Darren Kemna (author)/Gregory Sanders
Effective: Immediately for Rehab Jobs using LFD Design

Background: (Also see DSB 16-01)
After a recent rehab job where **MDX V6.5.3486** was used to model the superstructure DSB No. 16-01 (copied below) is partially invalid. Updates have been made to the MDX program at an unspecified date. The following equations appear to be used by MDX when calculating reactions for LFD projects.

Truck: R_{LL} = (Wheel Loads not over support)*(MDF) + (Wheel Load)*(End Shear D.F.)
Lane: R_{LL} = (Uniform Load plus Point Load)*(MDF)

The calculated Truck reaction is accurate per AASHTO 2002 LFD 3.23.1.2. The Lane reaction is not calculated per Bridge Office practice which interprets AASHTO 2002 LFD 3.23.1.2 to be applied similarly for the Lane load. Office practice is to apply (End Shear D.F.) to the concentrated load and to apply the MDF to the uniform load as shown below.

Lane: R_{LL} = (Uniform Load)*(MDF) + (Wheel Load)*(End Shear D.F.)

Procedure:
The following is the recommended procedure for determining LFD live load bearing reactions for rehab jobs using MDX:

1. Open the Reactions report in the Rating Output. Go to the listing for Unfactored Reactions.
2. Retrieve the "LL+I Max" reaction and note the controlling live load, L (Lane) or T (Truck).
3. If the Truck load controls ➔ $R_{LL} = R_{LL+I}/I$.
   I. Determine the Impact factor, I , from the Impact Factors report
4. If the Lane load controls ➔ $R_{LL} = [(R_{LL+I})/I/MDF – P_L]MDF + P_L(SDF)$
   I. Determine the Impact factor, I , from the Impact Factors report
   II. Concentrated Load, P_L = 13 k (HS20), 1.25*13 k (HS25)
   III. MDF is calculated per AASHTO LFD Table 3.23.1. Entered as WHEELS in MDX.
   IV. SDF is calculated using the Lever Rule assuming the slab acts as simple spans between girders. Entered as WHEELR in MDX
5. Since MDX is using different distribution factors from office practice it is possible that the controlling load reported is not actually the controlling load. If the truck load or lane load controls for both the exterior and interior girders it is recommended to cross-check your values using the Virtis software (see below). The conflict in controlling load reporting is expected to occur in the 60 to 100 feet span range. If the truck controls for one girder and the lane controls for the other the correct reactions can be back-calculated for both girders.

Note: The above procedure is specific to bearing design, but is also applicable for bearing stiffener and substructure design except that impact is normally included.

INSTRUCTION:

LFD design aspects that require reactions at a support for a Steel Superstructure such as bearing stiffener, bearing replacement or substructure design may use MDX values provided the Truck load controls. When the Lane Load controls, the reactions need to be adjusted to match office practice as described above. For spans between 60 and 100 feet the Virtis program should be used to ensure that the correct controlling load case is being used.

The principles for Bridge Rating (Virtis) Live Load Reactions have not changed from those outlined in DSB 16-01.

<<Development Section Bulletin>>
No. 16-01-DSB-MDX LFD WHEELR Command Error and Bridge Rating (Virtis) Adjustments
Contact: Darren Kemna (author)/Gregory Sanders
Effective: Immediately for Rehab Jobs using LFD Design

Background:
Traditional office practice uses the following equation to determine LFD/ASD live load reactions in a steel or prestressed girder superstructure.

Truck: R_{LL} = (Reaction – Wheel Load)*(MDF) + (Wheel Load)*(Shear at Supports D.F.)

Lane: R_{LL} = (Reaction – Point Load)*(MDF) + (Point Load)*(Shear at Supports D.F.)

$R_{LL+I} = I*R_{LL}$

These equations were used by MDX (LFD line girder rating) until as recently as July 23, 2015.

MDX LFD Reactions: (VOID)
The MDX Steel Girder Design program was updated on December 27, 2015 (V6.5.2929) resulting in changes to the usage of the LFD Reaction Distribution Factor also known as the "WHEELR" command. According to the MDX Help the "WHEELR" factor is used as follows:

> *"A list of the number of wheel loads by supports to be used for computing reactions and shear adjacent to supports (one value for each support.) (See AASHTO 3.23.1.2). Applied to any axle load located within span/20 from the reaction.*
> *The default values are those used for WHEELS."*

Basically, according to the MDX Help, the WHEELR factor will be applied to the axle or point load at the bent and the remaining load from either the Lane or Truck will use the WHEELS factor (*Fig. 1*). To clarify, the WHEELS factor is the distribution factor used for shear and moment throughout the girder line or span. The MDX help statement above is in line with traditional office practice and AASHTO 3.23.1.2. Conservatively and in error, it appears that the WHEELR factor is being applied to the entire Truck or Lane load and not just to the axle or point load at the support. This will cause the reactions to be greater than in previous versions wherever the WHEELR factor is greater than the WHEELS factor (typically interior girders). Conversely, reactions may be smaller in exterior girders or wherever the WHEELR factor is smaller than WHEELS.

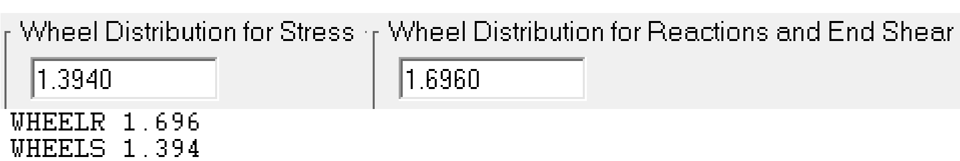

Fig. 1 – Example MDX input for LFD Distribution Factors

Bridge Rating (Virtis) Reactions:
It has been common practice to use the Bridge Rating program (formally known as VIRTIS) on rehab projects to get reaction loads quickly and expedite design. In many cases this is still acceptable. An area that needs further attention is the use of Bridge Rating (or more accurately BRASS LFD or AASHTO LFD engine) reactions. BRASS LFD or AASHTO LFD will not use the "Shear at Supports" distribution factor (*Fig. 2*) to determine reactions. The BR engines will use the value

entered in the "Shear" column which will be equivalent to the "WHEELS" factor in MDX. This results in live load reactions that may be significantly lower than MDX.

Lanes Loaded	Distribution Factor (Wheels)			
	Shear	Shear at Supports	Moment	Deflection
1 Lane	1.095	1.217	1.095	0.500
Multi-Lane	1.394	1.696	1.394	1.000

Fig. 2 – Example Bridge Rating input for LFD Distribution Factors

INSTRUCTION:

MDX software, Inc. has been notified of the error and they are working on it. Until further notice, please adhere to the following simplified albeit conservative workaround:

MDX V6.5.2929: Workaround (VOID)
LFD design aspects that require reactions at a support for a Steel Superstructure such as bearing stiffener, bearing replacement or substructure design may use MDX provided the WHEELR value entered is not less than the WHEELS value. This will protect against artificially low reactions when the WHEELR factor is less than WHEELS. If or when MDX is updated to match the procedure outlined in the Help menu as shown above users will be notified and this workaround may then be discontinued.

Bridge Rating (Virtis): Adjustment Procedure
LFD design aspects that require reactions at a support for a Steel Superstructure such as bearing stiffener, bearing replacement or substructure design may use VIRTIS provided the reported reactions are factored by the value K. **"**K" is equal to the ratio of the "Shear at Supports" distribution factor divided by the "Shear" distribution factor, but shall not be less than 1. If or when MDX is updated the values determined by this procedure will not match the values reported by MDX unless a more refined adjustment analysis is used.

Notes:

Reaction values at hinges are not affected by the WHEELR factor. These are internal forces which are not located at a support. The shear values reported at hinge locations in MDX or Bridge Rating should be similar.

The above workaround for MDX and adjustment procedure for Bridge Rating are not required when LRFD and/or LRFR engines are used respectively.

The traditional office practice is still the preferred method and both MDX and Virtis reactions may be adjusted to give accurate reactions. The adjustments are more complex, but may be necessary if the Shear at Supports distribution factor is considerably larger (say 40%) than the "Shear" distribution factor. The Instruction above is given to simplify adjustments between programs where component design does not become impractical and to avoid discrepancies between designer and checker.

Reference Articles:
AASHTO 2002 LFD 3.23.1.2
AASHTO LRFD Table 4.6.2.2.1-2

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